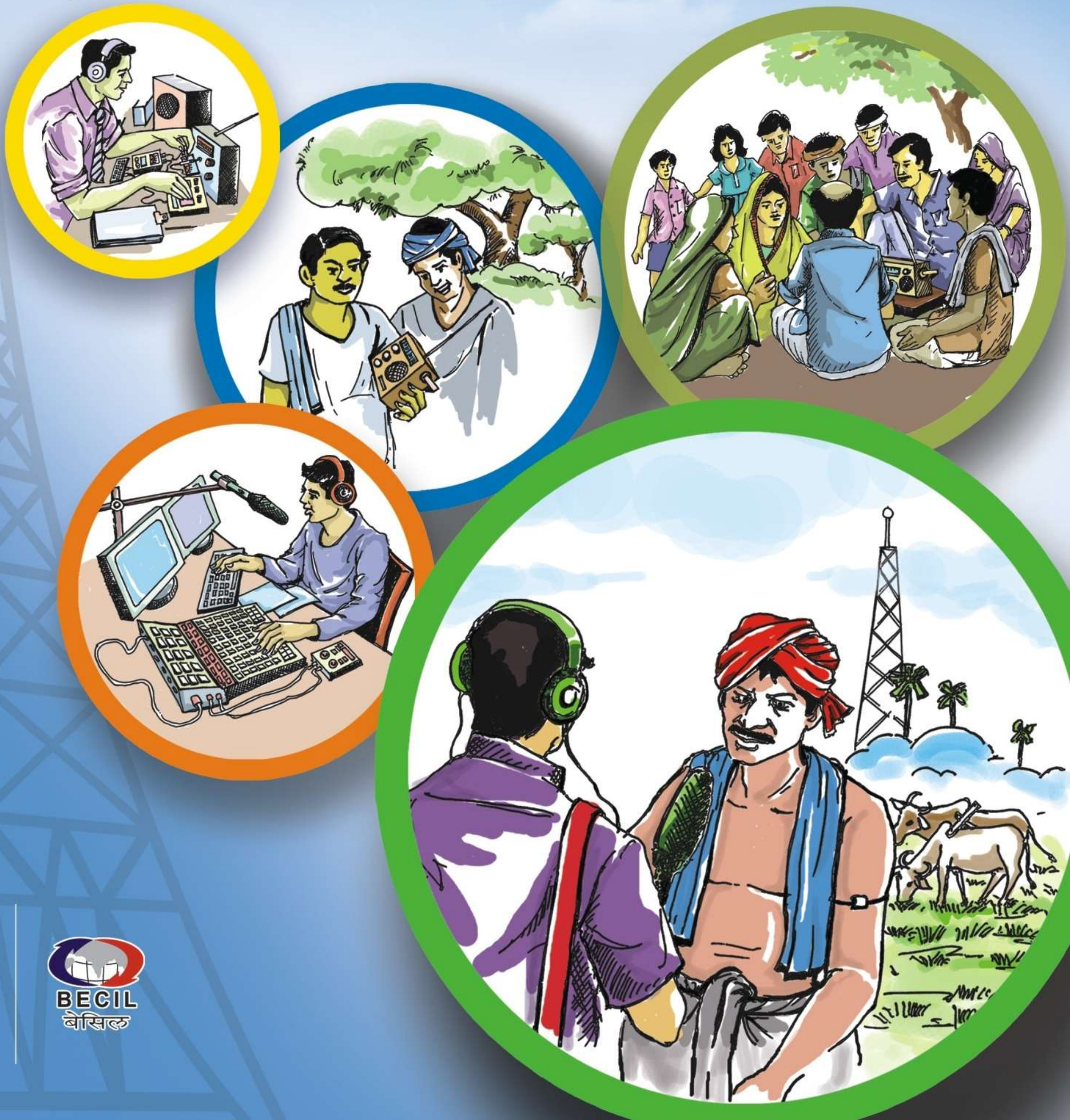
# 1

# Community Radio: An Introduction



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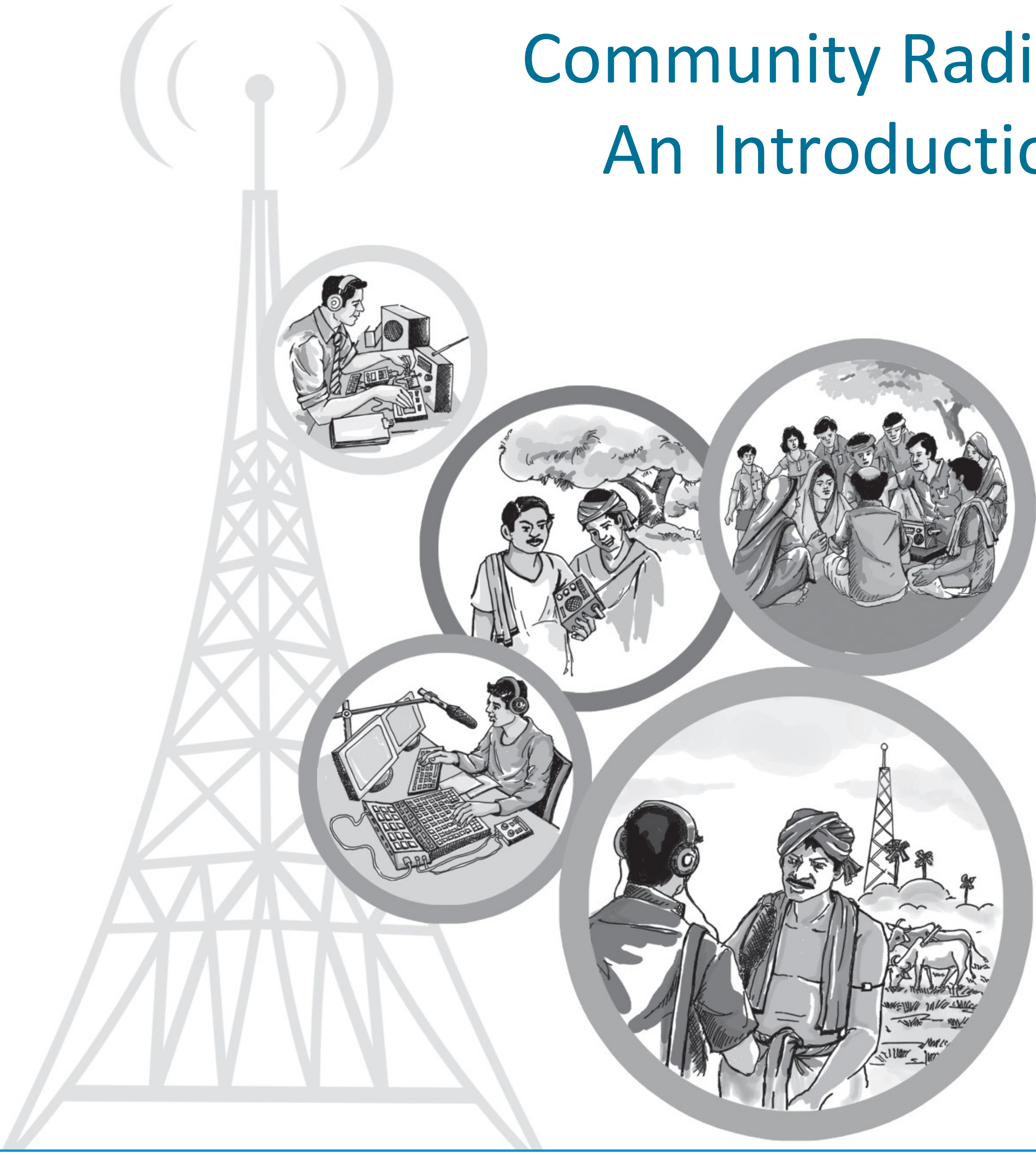
# Module: 1
# Community Radio: An Introduction



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## Module 1 : Community Radio: An Introduction


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# About the Module

## Module Description

This module is first part of the Course – I: Understanding Community Radio, and gives an introduction and overview of Community Radio including its concept and evolution along with the basics of Radio Broadcasting in India.

The first module, *"Community Radio: An Introduction"* has four Units. The first Unit provides you with a historical perspective of the emergence of community radio in India besides giving a brief idea of the other two tiers of broadcasting viz., public service broadcasting and private sector broadcasting.

Community Radio is fundamentally linked to the idea of 'voice-to-voiceless' and is a tool for social change. The second Unit, besides throwing light on these aspects, also introduces you to issues such as developmental implications of Community Radio Stations, freedom of speech, gender equity and provides an opportunity for one to read up a bit more on existing community radio stations and measure them against some of the principles behind the setting up of a CR station.

Third Unit will focus on the existing community radio policy in India and its salient features. You will realise how the policy framework affects the technology and programming of community radio. A background on the campaign for community radio in India and the various actors behind it also find more than a mention in this Unit.

Since the programme is intended to develop technical competencies of those associated with CR stations, the fourth Unit will discuss the fundamental principles and key decisions one will need to take before deciding on the technology. These decision points will be the key to minimising downtime and maximising flexibility of operations.

## Module Objectives

- To provide a historical perspective on the evolution of Community Radio (CR) in India;
- To discuss the principles behind setting up of CR;
- To discuss the policy guidelines and their impact on technology and content of a CR station; and
- To discuss the fundamental principles behind deciding the technology for a CR station.

## Units in the Module

- Community Radio: Concept and Evolution
- Context, Access and Equity
- Community Radio: Policy Guidelines
- Technology for Community Radio: Guiding Principles

# UNIT 1

# Community Radio: Concept and Evolution

## Structure

1.1 Introduction

1.2 Learning Outcomes

1.3 Radio Broadcasting in India

- 1.3.1 Public Service Broadcasting
- 1.3.2 Emergence of Private Radio Sector

1.4 Community Radio: Evolution

- 1.4.1 Concept and Role of CRS
- 1.4.2 Community Radio in India Today

1.5 Some CR Initiatives

1.6 Let Us Sum Up

1.7 Model Answers to Activities

1.8 Additional Reading

## 1.1 Introduction

This Unit will help you to understand community radio as a concept. There are no technology-related topics in this Unit but rather, basic material related to the history of radio in India, and the evolution of community radio.

This Unit will also give you a few case studies of community radio stations across Asia. You will need access to select reading materials, and a visit to the nearest community radio station is highly recommended.

You will need at least four hours to complete this Unit including carrying out some of the activities mentioned below.

## 1.2 Learning Outcomes

After going through this Unit, you will be able to:

- discuss the basics of radio broadcasting in Asia – including history and evolution of community radio;
- explain the evolution and emergence of community radio, especially in India; and
- discuss a few model community radio stations across Asia.

## 1.3 Radio Broadcasting in India

This section will introduce you to the history of radio broadcasting in India, including a history of the public service broadcasting sector – All India Radio, and the emergence of the private radio sector. It will not only give you a historical perspective on both these sectors, but will also help you distinguish these sectors from community radio.

Radio came to India during its infancy in the Western part of India. For much of its history, it has remained a part of the government, with private broadcasters commencing operation only in the early 2000s (though many were regularly purchasing airtime by the mid-1990s.)

In British India, radio broadcasting began, in a small way, in July 1923 with programmes by the Radio Club of Bombay and other radio clubs. However, on a larger scale, radio broadcasting was started in India by a private company *viz*., Indian Broadcasting Company Ltd. (IBC) in 1927, which was authorized by the government vide an agreement of July 23, 1927 to operate two radio stations : the Bombay Station began on 23 July 1927, and the Calcutta station followed on 26

August 1927. On 1 March 1930, however, the company went into liquidation. The government took over the broadcasting facilities and started running the service as the Indian State Broadcasting Service (ISBS) from 1st April 1930 (on an experimental basis for two years, and permanently from May 1932). On June 8, 1936, the ISBS was renamed All India Radio (AIR).

On 1 October 1939 the AIR launched its External Service with a broadcast in Pushtu. It was intended to counter radio propaganda from Germany directed to Afghanistan, Iran and the Arab nations. When India became independent in 1947, the AIR network had only six stations (in Delhi, Bombay, Calcutta, Madras, Lucknow, and Tiruchi) and the total number of radio sets in the country at that time was about 275,000.

In the interim period, Radio Ceylon, based in Colombo, captured Indian hearts and wallets by broadcasting Hindi (Bollywood) songs. Radio Ceylon was started in 1923, and quickly set high standards for broadcasting. But it came into its own at the end of the Second Wold War, when Allied Forces – who had been using it for wartime broadcasts – handed it back to the Govt. of Ceylon. The 1950s and 1960s were the golden age of Hindi film music and Radio Ceylon played plenty of it with the result that Radio Ceylon's powerful transmissions began to be the preferred listening service in South Asia. It made household names of several of its producers and comperes and gave rise to popular programmes like the *Binaca Geet Mala* and *Lipton Ke Sitare.* Advertising revenue streamed from India to Ceylon in vast quantities. On 3 October 1957 the Vividh Bharati Service was launched by All India Radio to compete with Radio Ceylon. Television broadcasting which began in Delhi in 1959 as part of AIR, was split off from the All India Radio network and became independent TV public service broadcasting network – Doordarshan on 1 April 1976.

Today, All India Radio's Home Service consists of 403 stations across the country, broadcasting in 23 languages and 146 dialects. All India Radio covers 92% of the terrain and 99% of the population of the country.

*Formation of Prasar Bharati*

From the day it was started, the radio service was run by the Government of India, whether it was the British or the Indian government after Independence. This meant that all the people working in the radio stations were government employees, and all the money required for setting up and running the radio stations was provided by the government. In 1975, however, India saw a brief period during which content on the radio and television was alleged to be only about those topics that the government approved. As a result, a great public debate ensued for making All India Radio and Doordarshan totally separate and independent of the Government and thus function truly as a Public Broadcaster. It was argued that the objective of the public service broadcasting sector is to cover issues which would be in public interest and not for profit or only entertainment. Moreover, public service broadcasting is aimed at programmes catering to all sections of the population – rich or poor, urban or rural, men or women.

A bill *viz.,* Prasar Bharati Bill was, accordingly, introduced in the Parliament to bring the above mentioned objective into effect. The Prasar Bharati Bill was debated in Parliament at great length to come to a consensus as to how this public service broadcasting sector would operate. Finally, in 1997, the Prasar Bharati Act was passed by Parliament, and a separate organization was incorporated which was known as Prasar Bharati. It was to be an independent public service oriented corporation, which would manage both All India Radio and Doordarshan. The funds, staff and programming would be managed by this corporation. Prasar Bharati is, however, still not able to generate adequate funds and has to be rescued by the Government. The Chief of Prasar Bharati is appointed by the Ministry of Information and Broadcasting of the Government of India, but is given special protection in order to provide functional autonomy.

## 1.3.1 Public Service Broadcasting

Public service broadcasting in India today is probably one of the largest of all such operations in the world. All India Radio has a wide range of home services which cater to every part of the country, and almost all the officially recognized languages and dialects. The service is very popular, especially in remote and rural areas, where there is no other media penetration – including private FM radio (explained in the next sub-section) or television. The programmes cater even to rural audiences including programmes on agriculture, local culture, livelihood, and folk music. The All India Radio service has one national service which broadcasts from Delhi and can be picked up by the regional stations in each state. Each state also has a number of regional services which include one main station, usually in the capital of the state, and then smaller stations installed in specific districts. The regional and smaller stations may also relay programmes from larger stations, such as the national service. For example, the Bangalore AIR station relays news or music programmes from AIR Bombay on certain occasions. The relay service is also useful in broadcasting national news which would be the same for all the stations. In terms of modes of transmission, All India Radio in FM, MW and SW mode. The Medium Wave services are mostly the regional stations which cover entire districts or states, and cater to a wide range of audience, while FM Services mostly work as local radios. You will find that both FM and MW are explained in more detail in later chapters.

## Activity 1.1

Try tuning into a FM or AM (MW and SW) service of AIR broadcasting. Try to list down the kind of programmes that are covered in both types of service. Is there any difference between AIR and other kinds of radio programmes which you can hear in your location? This exercise should take you about 45 minutes.

### 1.3.2 Emergence of Private Radio Sector

The private radio broadcasting sector, as the name suggests, is primarily distinguished from public service broadcasting in terms of ownership of the radio. While public service broadcasting was first owned by government and then by Prasar Bharti, private broadcasting is owned by private companies. Ministry of Information and Broadcasting, in the early 90s, felt that while All India Radio programmes were being heard in large part of the country, there was a need to diversify content by bringing in private players on AIR's platform.

AIR thus began selling airtime blocks on its FM services to private broadcasters and producers, who then broadcast these programmes over AIR FM Channels. Among the first private entities to enter this business was Times FM, which commenced operations in 1993. So much was the popularity gained by Times FM, that there was a clamour for allotment of airtime slots by many other entities. This led to litigations which forced AIR to withdraw the scheme. Meanwhile, there was a landmark Supreme Court judgement in the case of West Bengal Cricket Association v/s Union of India, which held that the airwaves are public property, with the government's role restricted to management and regulation. The implication was that private parties had an equal right to broadcast in India.

The Government of India, vide its notification made on 1 July 1999, opened the doors of FM broadcasting to private operators by offering to allot 108 channels in 40 cities. Alongside, it also earmarked a channel for education in each of the 40 cities. As a result, a number of private stations began to come up, the first of which was Radio City, in Bangalore, in 2001. Even though ultimately only 22 channels could get operationalized covering 12 cities, they revolutionized radio listening in the country thus creating a demand of more channels in Phase II.

Responding to the demand for more channels, FM Policy Phase II was notified in 2005 during which 225 additional FM channels came up across India, raising the total number of channels to 245 in 86 cities. As things stand today, Phase III policy has already been notified in 2011, with the intention of raising the total number of stations to 839 across 294 cities in India but its roll-out is awaited.

## 1.4 Community Radio: Evolution

Community radio is the third tier of radio broadcasting in India – the first two being public service and private broadcasting. Thus community radio is that sector of radio which is owned by localized geographical communities, wherein participation, ownership and daily management of the radio station is by the same community the radio seeks to serve.

A typical community radio station is characterized by programmes which are produced by local people, in the local language or dialect, and talks about locally relevant issues. It is different from public radio because public service radio typically caters to a much larger audience, and most of the programming is done by broadcasting professionals. In community radio, the audience is limited to a few villages or localities, and the programming is done by local people, who mostly have had no prior experience in radio. Finally, community radio is a medium which is recognized globally, in helping the community/marginalized people express their opinion on various matters concerning the community, as well as talk about local development issues. Both of which, private and public service radio can only do to a very limited extent.

Community Radios had already become a reality in many parts of the world. The 1995 Supreme Court judgement that airwaves are public property also generated a discussion within civil society organizations working on community driven media. Neighbouring nations such as Nepal had already experimented with community radio since the early 1990s, and many CR stations were doing sterling work by then. Could India not have a process to set up CR stations?

Civil society activism resulted in a joint activism and advocacy agenda called the Pastapur Declaration in 1998. The declaration was so named after the venue – Pastapur in Medak District, Andhra Pradesh - where discussions were held and the declaration adopted. This became the framework for further discussion with the Government.

Sustained advocacy with the Government of India resulted in the first Community Radio Policy in 2002, which allowed educational institutions across the country to set up small scale local radio station. Supported by several international agencies such as UNESCO and UNDP, civil society organizations and government functionaries continued thrashing out revisions to the 2002 policy, which was only partially enabling. This resulted in the revised CR Policy Guidelines of November 2006, which allowed registered civil society organizations also to apply for CR licenses; and which forms the current framework for CR in India.

### 1.4.1 Concept and Role of CRS

The Indian sector of community radio is perhaps the only one in Asia which is separate and distinct from private and public radio broadcasting. This sector, as per current policy guidelines is mainly framed in terms of development and improving quality of life for communities radio seeks to serve. This includes women's issues, health, education, culture, local music, economic and social development, to name a few. The details about the Community Radio Policy in India are given in Unit 3 of this module.

*Concept of Community Radio*

The key concept of Community Radio (CR) is that of giving the voiceless a voice. Even in places where there is extreme poverty, it has been shown through many studies that what people value the most is to have a voice. This means that they value their right to speak out on what is affecting them, speak out on their identity, and speak to document their ways of life, cultures and traditions. Therefore, community radio is often seen as giving a voice to those who are often voiceless. This means that community radio should always prefer those who are marginalised in society and give them an opportunity to speak. For example, in India, community radios could provide opportunities to communities belonging to the Dalits, minorities, sex workers, people with disabilities, senior citizens, tribals, etc..

In addition to this, the concept of community radio is strongly associated with many other values including that of better governance, documenting and using languages, oral histories and cultures, promoting gender equality and sensitivity, as well as educating and entertaining its community.

Finally, the concept of community radio can be summed up in the words of Louie Tabing, a community radio pioneer from the Philippines, who said community radio can give a community member the opportunity to “Be you, Be New and Be True”.

*Playing diverse roles – A global picture*

One of the first community radio stations to be started in the world was a radio station started by miners in Bolivia in the 1940s. The radio station was mainly supposed to represent the issues related to the mining industry in Bolivia from the workers point of view. Since then, community radio has spread rapidly to most parts of the world, with South Asian countries (like India, Pakistan, Sri Lanka, Afghanistan, Bhutan) being relatively late entrants.

In Latin American countries like Brazil, Guatemala, Argentina, community radio stations are heavily political in nature. They are connected to people’s movements, which are usually connected to issues concerning people’s rights on topics such as the right to choose a political candidate, right to education, etc. Further, the social and developmental role of the church has been recognized, and religious institutions like the church have been allowed to broadcast on radio. In European countries, the community radio movement has been mainly seen as a strong alternative to mainstream media. Often these community radio stations represent view points and opinions of the people on the street, which are often missing in mainstream and private media. These radio stations also give opportunities to independent musicians and folk artistes who do not get a chance to play their music on other media. In Africa and now in Asia, community radio has been largely seen as a medium which can help in development of the people and improve their quality of life.

## 1.4.2 Community Radio in India Today

At present, there are about 145 functioning community radio stations in India. At present Delhi and Tamilnadu have maximum number of community radio stations and the numbers are slowly increasing in Uttar Pradesh and Bihar. Of the total number of community radio stations, about 100 of them are licensed to educational institutions or agricultural centres (Krishi Vigyan Kendras). The rest of them are licensed to community-based organizations or civil society institutions. There are many community radio stations that are broadcasting only fresh content on a daily basis, but majority of them are repeating content from the same day or previous day broadcast.

There are government advertisements (from various ministries) available, but CR stations have to empanel themselves with the Directorate of Audio Visual Publicity (DAVP) to avail of the advertisements. Sponsored programmes are also available via DAVP. In addition, CR stations can also broadcast commercials related to local goods and services. Ministry of Information and Broadcasting is planning to introduce a centrally administered scheme to fund community radio stations through various activities including setting up and capacity building.

One of the problems with community radio stations in India is its uneven distribution across the geography of the country. Most of the community radio stations are located in urban centres or semi-urban centres. There are none, or very few, community radio stations in very remote, rural, conflict, border and coastal areas of the country. For example, at present there are no community radio stations in Jharkhand, or large parts of the North East.

### Activity 1.2

This activity is meant to enable you to identify and recognise the three tiers of radio broadcasting in India. You may need about 45 minutes to one hour to complete this activity. Tune into your radio set on AM and FM separately and list out available radio stations of each of the following categories:

a) Public Service

b) Private FM radio stations and,

c) Community radio stations

## 1.5 Some CR Initiatives

This section uses a few examples of community radio from around the world to illustrate some basic principles and/or some processes that could be beneficial to community radio stations in any part of the world. (For the purpose of more detailed study, case studies of these community radio initiatives have been included as 'Additional Reading' material).

*The Tambuli Project in the Philippines*

Tambuli project is a typical example of Community Radio Station at a place (Olutanga Island) where Government services related to community welfare such as education, health, law enforcement, banking facilities and communication system are poor. Visitors to the island are therefore astonished to find that this island, eight hours away by boat from the city of Zamboanga, operates a radio station. The islanders, themselves, were incredulous when the Tambuli project proposed the facility to them in 1993. They became even more doubtful when full control of the station was given to them.

The station runs mainly news and public affairs programmes anchored by a main personality. Other producers and reporters join in with features, news, tips and regular programme segments. It was surprising that inspite of the poverty of the island, large number of people owned portable VHF amateur transceivers. These transceivers are being gainfully employed for most of inputs concerning news and public affair programmes.

This project is easily recognized as one of the earliest promoters and pioneers of community radio in Asia. Louie Tabing, one of the founders of the Tambuli project has written a case study which demonstrates one of the most fundamental aspects of community radio stations – community participation, management and ownership. In this case study, Mr. Tabing involved community participation and opinions on even whether there should be a community radio established in their region at all. After multiple rounds of discussion in the community, the project also facilitated the establishment of a separate council called the Community Media Council with its own management.

From that step onwards, the case study is very useful to showcase how community groups can be involved in every step of operationalizing a community radio station. The project involved community groups in identifying the location of the studio, building the studio, and finally building capacities of local people to work as staff for the new radio station. The programming which resulted in this radio station is also a model example in terms of how it involved ordinary community people from various class, literacy and religious backgrounds.

*The Radio Sagarmatha Project in Kathmandu*

This project, like Tambuli, is also perhaps one of the most well-known and pioneering initiatives in the sub-continent. The Nepal Forum for Environmental Journalism (NEFEJ) was one of the driving forces behind the creation of Radio Sagarmatha. Astonishingly, even today, Nepal does not have an explicit policy for community radio. However, due to a liberalization of the airwaves, community groups as well as private corporations are allowed to apply for licenses on equal terms. From 1993 to 1997, Radio Sagarmatha existed as a physical space with audio equipment, trained staff and a bank of local programming. It was only after Radio Sagarmatha threatened to go live without a license that the government of

Nepal granted them a license. The Sagarmatha case study illustrates the power of advocacy organizations, the utility of community radio in an urban setting, and also the benefit of a structured radio station in terms of social and financial sustainability. The radio station is headed by a seven member board with representation from all partner NGOs. It has a staff of a programme director, six full time producers, two technicians, a music librarian, an engineer, an accounts officer and a station helper. Additionally, at the time of writing, the station also had about 26 volunteers, who are reimbursed for actual expenses and/or paid a small honorarium.

Unlike the Tambuli project, the Radio Sagarmatha also functions as an effective public service broadcaster. The Tambuli project did indeed provide public service through its operations but was much more focused on its own community. Radio Sagarmatha on the other hand provided a much more universalist kind of programming which suited its urban presence.

*The Radio Ujjas Project in Kutch, Gujarat*

Radio Ujjas is an initiative by the Kutch Mahila Vikas Sanghatan (KMVS), a non-profit organization based in Gujarat, India. This model is partly similar to the Radio Sagarmatha project to the extent that it was also operating without an operational and explicit community radio policy. However, Ujjas Radio was one of the first initiatives to produce locally relevant programming but distribute the programmes via the local All India Radio station in Bhuj.

The Ujjas Radio initiative is known for its strong emphasis on women participation as well as focus on gender in its programming. This is reflected in the focus on women's participation in the parent organization KMVS itself. They work in Kutch District, one of the largest districts in India, but also with one of the lowest literacy levels. The radio station has been known to make effective use of local folk songs, traditions, art and culture in their radio programmes to create a strong bridge with their listeners.

The radio station requires its reporters and volunteers to organize community level meetings and discussions where the community places forward its requirements, needs and concerns. Based on this information, the Radio Ujjas team produces programmes in the local language and dialect. After the programme has been aired, the reporters collect feedback through personal interactions, letters, phone calls etc. Of late, the radio station is also known to air programmes on governance, utilization of welfare resources, disaster management and other such areas. This case study is effective in understanding how women's participation can play a strong role in activating a community radio's presence and sustainability. It is also useful to get a glimpse into how arts, culture, local language and dialects can be leveraged usefully by a community radio station.

## 1.6 Let Us Sum Up

In this Unit, you have learnt to distinguish between public service radio, private radio and community radio. Further, you have also learnt how community radio came about in India, including what role it plays and what is its concept. You have also come to know about the history of development of radio broadcasting in the country including a brief idea about the various modes of broadcasting including that of Private Broadcasting & Community Radio.

## 1.7 Model Answers to Activities

The information gathered in the activities presented in this module should be your own experiences. Both activities are hands-on activities.

## 1.8 Additional Reading


- UNESCO (2001). *Community Radio Handbook*. Retrieve from http://www.unesco.org/webworld/publications/community_radio_handbook.pdf
- Radio Ujjas: Giving Voice to the Women of Kutch, Best Practice Documentation (2001), Retrieve from http://tinyurl.com/nv8edde
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# UNIT 2

# Context, Access and Equity

## Structure

2.1 Introduction

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2.3 Developmental Implications of CR
- 2.3.1 Concept of Development
- 2.3.2 CR and Social Change

2.4 Freedom of Speech
- 2.4.1 Voice for the Marginalised
- 2.4.2 Right To Information

2.5 Community Participation
- 2.5.1 Gender Equity
- 2.5.2 Culture and Identity

2.6 Let Us Sum Up

2.7 Model Answers to Activities

## 2.1 Introduction

In this Unit you will develop further on the basic understanding of community radio, which you studied in Unit 1 earlier. You will go deeper into how community radio is fundamentally linked to concepts of development and tool for social change. Further, you will also study how the concept of local participation is central to community radio.

This Unit is, like the previous one, purely theoretical and to complete this Unit, you will need to familiarize yourself with concepts of development, community participation, voice to the voiceless and gender equity. As a special activity you will be reading up on existing community radio stations and try to measure them against concepts which are mentioned in this Unit.

## 2.2 Learning Outcomes

After going through this Unit, you will be able to:

- define community radio in the context of development, voice to the voiceless and community participation.
- list and describe how communities can participate in community radio with respect to gender equity and culture and identity.
- analyse community radio with respect to voice for the marginalised and the Right to Information.
- appreciate the conceptual underpinnings of community radio in terms of larger concepts such as development, free speech, gender equity and notions of participation.

## 2.3 Developmental Implications of CR

In this section, you will study about the theme of development and how it can be linked to the community radio sector. You will further study about the concept of development itself, and how community radio can be used for social change.

### 2.3.1 Concept of Development

Development, in this case, refers to human development. It was perhaps the renowned economist Amartya Sen, who first laid out a framework for human development. In the 1980s the leading development approach closely linked a country's economic progress to the increase in its citizens' quality of life. The Human Development approach arose partly as a result of growing criticism to this approach. The need for an alternative approach to human development became clear due to several reasons - the wealth created with economic progress was not ‘trickling down’ to the poorer sections of the society; crime, ill-health and lack of education continued to spread in many countries in spite of economic growth.

Amartya Sen said, “Human development, as an approach, is concerned with what I take to be the basic development idea: namely, advancing the richness of human life, rather than richness of the economy in which human beings live, which is only part of it.”

In 1990, the United Nations Development Programme (UNDP) published their Human Development Report, known as HDR 1990. The publication of this report expanded the understanding of the term development and sharpened the discourse on human development.

Over the years, the UNDP along with prominent economists like Mahbub Ul Haq, developed the Human Development Index (HDI), a measure of human development primarily based on indices of life expectancy, education and income.

It is worth pausing how community radio can contribute to human development either through the primary indices of the HDI or through other contextually relevant indices – ranging from human rights or civil liberties to cultural rights and so on.

The fundamental assumption within the community radio sector is very closely tied to the capabilities approach developed by Amartya Sen. Community radio, as a key enabler of people’s voices and their participation in their affairs, allows communities to exercise their choices by giving them a voice and an agency. A community radio station, in an ideal scenario, will work together with its community to identify and refine locally relevant indices of human development, and prioritize the most pressing needs of the community.

## 2.3.2 CR and Social Change

While social change is a term often bandied about in the communication for development sector, it is rarely defined in specific terms for community radio stations to apply the concept on the ground. It is widely accepted that some of the terms and concepts, central to the notion of human development, are economic growth, participation and freedom, equity, security, social progress and sustainability. While these terms could be applied to virtually any community, it must be remembered that community radio is a concept which is applied at a local level. Therefore it is insufficient to work with such broad concepts and terms while trying to use community radio to bring about social change.

How then, does one go about using community radio for social change?

*Participatory Research*

Community radio stations involve their communities in a process of participatory research (mostly ethnographic action research) using tools such as focus group discussions, interviews, public meetings and so on. The people living in the coverage area of the radio are expected to contribute with a list of the main problems which obstruct their quality of life and development. Sometimes, the issues could be related to transparent governance while at other times it could be lack of health or education infrastructure. The staff of the community radio stations should have enough skills to engage their communities in a fruitful dialogue and discussion to accurately identify the most pressing of the people's problems.

*Participatory Programming*

Once the problems are identified, the community radio station then initiates a multi-stakeholder process by involving them in production programming. Most social problems are complex and involve the cooperation of various stakeholders – different community members, government departments/agencies, civil society organizations and so on. Community radio stations can either produce one-off programmes or develop a campaign wherein different dimensions of the same social problem can be addressed in depth through the participation of the various stakeholders

*Feedback from the Community*

While the programmes are being aired, it is vital for a community radio station to gauge the response from its listeners. Most traditional media outlets take feedback from their audiences after the programme is completed, and some media outlets publish the responses as well. However, due to the localised nature of a community radio station, it is imperative that audiences be engaged with the programming on a continuous basis, so that all programming is shaped by community responses as much as possible. This not only gives a sense of ownership to the community, but also ensures that the programming done is locally relevant and contextual.

## 2.4 Freedom of Speech

All citizens of India are granted the fundamental right to freedom of speech and expression as enshrined under the Article 19 (1) A of the Indian Constitution. Traditionally, the discourse of human development was seen as separate from that of political rights and civil liberties, including that of freedom of speech. However, more recent trends have included the right to free speech as an important part of the development process.

Community radio, as an independent, objective, and non-profit medium, is expected to provide a platform educating people about the various aspects of Freedom of Speech.

Let us now look at two ways in which freedom of speech or giving a voice to the voiceless can be seen as development within the community radio context.

### 2.4.1 Voice for the Marginalised

Communities of interest or those defined by geography, are never uniform or homogenous. Even within a small village, there are poor and rich people, people of different castes, men and women, senior citizen and children, able and disabled people. While some people may have the power and the resources to be articulate, it is very often the case, that those without the resources, or those who have been historically, socially, or culturally marginalised tend to remain silent.

The role of community radio is not only to ensure the participation of the community in general terms, but also to give a special priority to the marginalised groups and/or individuals within a given community.

Similar to the process of participatory research mentioned above in the previous section, community radio stations should identify the most marginalised groups and individuals within a community. This process of identification can be done by mapping information flows, caste-based spatial understanding of a community, interviews, statistical data gathered from government agencies, and so on.

Once marginalised groups and individuals are identified, it is the duty of community radio stations to ensure that they are given a voice on the platform of radio. Dalits, tribals, women, people with disabilities, sexual minorities, senior citizens, minority religions, children and people below the poverty line are some of the commonly marginalised groups in most communities. However, community radio stations should get more specific with the identification of these groups through a thorough research process and provide a voice to them.

Having a voice, or the ability to speak out is power in itself, and when community radio gives power to the people who have remained voiceless, these marginalised communities are transformed into valid citizens and a valid constituency whose needs must be recognized and acted upon.

### 2.4.2 Right To Information

The Right to Information Act has come into force in late 2005, and is a landmark piece of legislation. Prior to this Act, most government related information was not readily available to the general public, as it was protected under the Official Secrets Act, 1923. However, after the passing of the Right to Information Act, all government departments were asked to be transparent with their information, and provide information to any member of the public who requests it.

The Right to Information Act is applicable to both the Central government as well as the State government and their respective agencies, bodies, ministries etc. As part of the Act, any citizen of India can request any government body or public authority for information. The said body is mandated to provide the information within a maximum period of 30 days.

Community radio stations often function as community hubs for dialogue and as meeting spaces. Community radio stations can play a valuable role by educating the community members about the RTI Act and helping them to use the facility whenever necessary.

## 2.5 Community Participation

Community participation is a concept that is fundamental and central to community radio. The participation of the community is one of the main features through which this radio can be distinguished from private mainstream radio or public service radio. However, community participation is a complex concept which has many dimensions, all of which need to be adhered and addressed to.

*Full time staff*

It is fairly common for community radio stations to have full time staff who are retained with salaries, supported either through donors or through community funding. The staff may comprise either members of the community or media professionals hired from outside the community. Even if the full time staff are from the community, it complicates the notion of participation. The staff think that they are representing the community when they go out into the field, but the community may see them as representatives of the radio station, which in turn is represented by an educational institution or a non-profit organization. Thus, community participation is only partially fulfilled even when community members join the radio on a full time basis.

*Production*

Another common pattern is to involve the community members in the production of radio programmes. As you will see from Units later in the module, the production of radio programmes has two aspects – technical and content. A radio station can involve the community in technical aspects by inviting them to handle the microphones, mixing console, digital audio workstation etc. The content aspect pertains to involving community members who lend their voices to programmes – be it a radio drama or an interview. However, even within production, the participation of the community can be enhanced beyond these aspects. With respect to the technical aspect, the radio station can invest in a capacity building process, where community members are not only just involved in handling the equipment but are also empowered to maintain the equipment and make informed choices about new equipment or upgrading existing equipment. With respect to the content aspect, the radio station can involve the community members in decision making regarding the topic of the programme, the format of the programme, lending their voices to the programme, identifying niche audiences for the programme, and finally selecting an appropriate time to broadcast the programme.

*Management*

A key feature of community radio is the management of the radio station by the community that it seeks to serve. Most community radio stations make do with a program advisory committee which 'advises' the community radio station on matters related to programming. Of course, the management of a community radio station goes beyond programming. The other aspects of management are administrative, personnel, technical, financial and social. A community radio can seek to be true to its name only when it appoints a management committee which retains complete control over all these aspects of management. Community management of the radio station is important in terms of the community feeling empowered, giving them authority, to shape the vision and functioning of the radio station, and finally, ensuring that the priorities of a community radio station remain locally relevant and contextual.

Community radio stations need to constitute a community based management committee which is fair, objective, skilled at management and representative of the community who will not abuse their positions of power. There are no standardized rules, regulations or norms towards constituting a management committee for a community radio station. However, community radio stations, apart from learning from their peers' experiences, can also devise strategies based on their particular context and their community.

Thus it can be said that the concept of participation cannot be limited to the mere presence of the community at specific points of the functioning of a radio station. Instead, participation should be quantitatively and qualitatively enhanced to mean handing over power and decision making to individuals who are representative of the larger community.

### 2.5.1 Gender Equity

While there are many issues which are specific to a particular place (lack of schools, health issues etc), there are other aspects of social change which are universally applicable in any context. In India, one can safely assume the universal aspects of social change worthy of attention to include gender dynamics, caste, class and religion.

While caste and religion may be aspects that are unique to India's diverse population, the issue of gender dynamics is a global issue and cuts across different social contexts. Community radios can play an important role in educating the members of the community about the gender equality but at the same time they have also to ensure that they follow the principle themselves.

Thus, while a community radio station may have done the participatory research, involved community groups at all levels – from research to management - it is still critical for a community radio station to evaluate community participation and its own functioning from a gender perspective.

At every stage, whether it is in terms of focus group discussions towards identifying programming topics, or constituting a management committee, a community radio station may set basic guidelines to ensure gender equity.

### 2.5.2 Culture and Identity

Globally, it is accepted that there is a strong link between culture, identity and the media. The UN Convention (of 2005) on the Protection and Promotion of the Diversity of Cultural Expression states that:

> *"Cultural diversity is strengthened by the free flow of ideas, and that it is nurtured by constant exchanges and interactions between cultures; freedom of thought, expression and information, as well as diversity of the media that enables cultural expressions to flourish within societies"*

One of the most under-explored areas with respect to a community radio station is the area of culture and identity. Both, culture and identity are terms which are often contested and reinterpreted constantly in various contexts. With India gaining independence in 1947, the priority of the national government at the centre was to build a national identity. Prime Minister Jawaharlal Nehru wanted to create a feeling of Indianness through various ways – including the setting up of the All India Radio and Doordarshan, which went a long way in showcasing the cultural, social and political identity of India as a whole. However, it must be acknowledged that India is a diverse country, with more than 25 states, and more than a hundred languages and dialects spoken all over the country. In terms of religion as well, India is one of the most diverse countries. Community radios can, therefore, play a great complimentary role in this direction.

India is also known for diverse landscapes, castes, food cultures, terrains and landscapes, political cultures and so on. At every level of societal formation, if there is one thing that is consistent in India, it is diversity and pluralism. There is hardly any community in India which is completely homogenous in terms of culture and identity. In this context, it is the responsibility of a community radio station to reflect the cultural diversity of its community and respect various identities of its people.

One of the primary tasks of a community radio station is to identify and map the cultures and identities of its communities. This can be done through a mapping of various religions, castes, languages and dialects spoken in the community which the radio station seeks to serve. After this initial layer of mapping, the radio station can add another layer of diversity in terms of cultural practices. Different religions and castes tend to have their own set of cultural practices. Another possible layer could be various practices associated with each culture – including festivals, rituals, folk tales, etc.

This kind of intensive mapping will reveal a wealth of information which is unrelated to the wider paradigm of social development, and is yet extremely relevant to the social fabric of any community.

Community radio stations can embark upon collecting oral histories and testimonies as a way of documenting the culture and identity of its community members. However, the purpose of their oral histories and testimonies should not be to keep these locked up, but to broadcast them and use them in such a way as to keep the culture and identity of a community alive through daily interaction and exchange.

## Activity 2.1

List out 5 programme ideas for community radio stations, based on Right to Information, Gender Equality, and Promotion of Cultural Diversity.

To do this activity, you may need about 90 minutes.

## 2.6 Let Us Sum Up

As you have seen, the concept of community radio is towards serving the interests of the community in which it operates. To serve a community well, it is imperative for the community radio station to understand the social, political and cultural context in which it is operating, and further to be sensitive to this context in its day-to-day working. Further, community radio stations also have a responsibility to promote equality in gender relations and the diversity of cultural expressions within its community.

You have also seen how community radio can be contextualized to framework related to development for social change. Development for social change includes the right to freedom of speech and expression which can become an enabler towards other aspects of social change, including economic development, literacy and well-being, seeking justice and so on.

## 2.7 Model Answers to Activities

2.1 Please fill your ideas against the themes as given below:

| Sl | Programme Ideas | Theme |
|---|---|---|
| 1 | A radio drama on a villager, who wants an information regarding the consumption of electricity in his village. He visits the office of the competent authority, but doesn't get the information. Finally, he gets the information through Right to Information Act, 2005. | Right to Information |
| 2 | | Gender Equality |
| 3 | | Promotion of Cultural Diversity. |

# UNIT 3

# Community Radio: Policy Guidelines

## Structure

3.1 Introduction

3.2 Learning Outcomes

3.3 CR Policy Guidelines and Implications

3.3.1 Historical Background

3.3.2 Policy related to Content

3.3.3 Policy related to Technical Parameters

3.4 Let Us Sum Up

3.5 Model Answers to Activities

## 3.1 Introduction

At the backdrop of what was discussed in the preceding two units, this unit will help you to understand the community radio policy of the Ministry of Information and Broadcasting, Government of India. We have focused on how the policy framework affects the technology of community radio as well as the programming and structure of community radio.

The Unit will also give you a sense of the community radio movement and how the current policy has evolved over the last decade to become what it is now. You will not need to do any hands-on work in this Unit, but it is recommended that you access select reading materials. You may need approximately seven hours to complete the Unit, including working on the three Activities given in Section 3.3.

## 3.2 Learning Outcomes

After going through this Unit, you will be able to:

- examine the basics of the community radio policy in India.
- explain how specific clauses in the community radio policy affects technology as well as content on community radio.
- discuss on how policy has evolved, and what further improvements can be made to the policy framework on community radio.

## 3.3 CR Policy Guidelines and Implications

This section will provide a broad explanation of the current community radio policy framework, how it has evolved over the years, and how policy framework has been shaping community radio sector in India.

### 3.3.1 Historical Background

You have already read in Unit 1 the brief history of radio broadcasting in India including the emergence of Public Service Broadcasting and Private Broadcasting. You have also been introduced to the concept and role of Community Radios and their present position in India. You will now read more about community radios in this Unit from the point of view of policy related to them. As mentioned in Unit 1, in 2002, after various civil society declarations, and multiple consultations with UN organizations and government agencies, Ministry of Information and Broadcasting announced policy guidelines for community radio. However, the community was defined and restricted to educational institutions only. However, this policy did not satisfy the vision articulated by many, and the pressure continued on the government to make the policy more accessible and friendly towards civil society groups. On November 16, 2006, the Ministry released a revised policy guideline which opened up community radio broadcasting to NGOs, educational institutions and agricultural institutions.

*Early days of community radio in India*

Even before Community Radios came up as a result of Government Policy, Community groups were beginning to use community radio in various parts of the country by different means. For example, women's collectives in Karnataka and Andhra Pradesh had started initiatives like Namma Dhwani and Sangam Radio, respectively. In Jharkhand, community groups were using the local All India Radio station to voice their concerns through an initiative called "Chala Ho Gaon Mein". In Uttarakhand, community groups calling themselves "Heval Vaani" and "Mandakini Ki Awaaz" were using WorldSpace satellite radio to express themselves. These groups were also now demanding that they be given licenses to broadcast on FM so that they need not depend on other media.

As a result of the various initiatives as indicated above there was serious evidence that community broadcasting (even if via AIR or WorldSpace) can bring about benefits to the marginalised communities. At the same time, community members were also vigorously advocating for an independent community radio platform. Government examined the various aspects of the issues and came up with a policy in 2002. However, this policy defined community as only educational institutions which were affiliated to State or Central governments. Under this policy, Anna University in Chennai city, became the first "community radio" station in the country in 2004. While this opening up of the airwaves to educational institutions was welcomed, community groups all over the country made it very clear that this was not community radio. According to them, Community Radio meant community ownership of the means of programme production, and until community groups could obtain a license from the government, the definition of community radio would always be incomplete.

In 2006, the government released an amended set of policy guidelines which opened up community radio to three broad sectors – educational institutions, non-profit organizations and agricultural institutions. The basic principles of this policy are as follows:

> *It should be explicitly constituted as a 'non-profit' organisation and should have a proven record of at least three years of service to the local community. The CRS to be operated by it should be designed to serve a specific well-defined local community.*
>
> *It should have an ownership and management structure that is reflective of the community that the CRS seeks to serve.*
>
> *Programmes for broadcast should be relevant to the educational, developmental, social and cultural needs of the community. It must be a*

*Legal Entity i.e. it should be registered under the Registration of Societies Act or any other such Act relevant to the purpose.*

## Activity 3.1

Visit a public, a private and a community radio in your locality and try to compare the merits and demerits of all three categories of radio.

### 3.3.2 Policy related to Content

The policy guidelines contain advisories on content and technical issues related to community radio. This section will take a look at some of the content related advisories for community radio.

- From the policy guidelines given below, it may be seen that the content code is basically the same for all radio stations in the country except that the programme needs to be of relevance to the community:

  1) *The programmes should be of immediate relevance to the community. The emphasis should be on developmental, agricultural, health, educational, environmental, social welfare, community development and cultural programmes. The programming should reflect the special interests and needs of the local community.*
  2) *Atleast 50% of content shall be generated with the participation of the local community, for which the station has been set up.*
  3) *Programmes should preferably be in the local language and dialect(s).*
  4) *The Permission Holder shall have to adhere to the provisions of the Programme and Advertising Code as prescribed for All India Radio.*
  5) *The Permission Holder shall preserve all programmes broadcast by the CRS for three months from the date of broadcast.*
  6) *The Permission Holder shall not broadcast any programmes, which relate to news and current affairs and are otherwise political in nature.*

- Further, the content regulation section also states that there shall be nothing in the programme broadcast which:

  1) *Offends against good taste or decency;*
  2) *Contains criticism of friendly countries;*
  3) *Contains attack on religions or communities or visuals or words contemptuous of religious groups or which either promote or result in promoting communal discontent or disharmony;*

4) *Contains anything obscene, defamatory, deliberate, false and suggestive innuendoes and half truths;*
5) *Is likely to encourage or incite violence or contains anything against maintenance of law and order or which promote anti-national attitudes; contains anything amounting to contempt of court or anything affecting the integrity of the Nation;*
6) *Contains aspersions against the dignity of the President / Vice President and the Judiciary;*
7) *Criticises, maligns or slanders any individual in person or certain groups, segments of social, public and moral life of the country;*
8) *Encourages superstition or blind belief;*
9) *Denigrates women;*
10) *Denigrates children ;*
11) *May present/depict/suggest as desirable the use of drugs including alcohol, narcotics and tobacco or may stereotype, incite, vilify or perpetuate hatred against or attempt to demean any person or group on the basis of ethnicity, nationality, race, gender, sexual preference, religion, age or physical or mental disability.*

- The Permission Holder shall ensure that due care is taken with respect to religious programmes with a view to avoid:

1) Exploitation of religious susceptibilities; and
2) Committing offence to the religious views and beliefs of those belonging to a particular religion or religious denomination.

One of the major controversies that the policy has generated is related to the restrictions on broadcasting of news and current affairs on community radio. However, in practice it is informally understood that broadcast of any non-political information will not be penalized. The Government's hesitation in allowing political programming on community radio is based on the fact that community radio stations can inflame passions by broadcasting wrong information or handling the situations insensitively.

## Activity 3.2

What are the strengths and weaknesses of the policy related to content regulation. What changes would you make and why? Discuss in your own words in about 350 words.

*To complete this activity, you may need about 90 minutes.*

### 3.3.3 Policy related to Technical Parameters

Community radio operates in the FM (Frequency Modulation) band, and purely on technical terms, it is no different from those AIR stations and private radio stations that also operate on FM.

Earlier, All India Radio used to operate only in MW (Medium Wave)-AM (Amplitude Modulation) band of the spectrum. While, at this point, it may not be important to fully understand the technical difference between AM and FM bands it would suffice to know that FM band-2 in which FM broadcasting takes place in India, is between 87-108 MHz and Medium Wave (MW) band for broadcasting is between 562.5-1606.5 KHz. While various aspects of Radio Wave propagation would be discussed in detail in Module 2, it would be of interest to know that FM has many advantages over MW(AM). It is because of these advantages that it is increasingly being used by AIR in conjunction with MW for domestic broadcasting and has also been chosen for private and community broadcasting. These advantages are:

- High fidelity
- Stereophonic quality
- Uniform day and night coverage
- Freedom from noise
- Capture effect
- Saving in power requirements
- Value added services possible

Within the FM band, let us look at the technology related conditions that are stipulated in the policy guidelines:

> *CRS shall be expected to cover a range of 5-10 km. For this, a transmitter having maximum Effective Radiated Power (ERP) of 100 Watts would be adequate. However, where the applicant organisation is able to establish that it needs to serve a larger area or the terrain so warrants, higher transmitter wattage with maximum ERP upto 250 Watts can be considered on a case-to-case basis, subject to availability of frequency and such other clearances necessary from the Ministry of Communication & IT. Requests for higher transmitter power above 100 Watts and upto 250 Watts shall also be subject to approval by the Committee constituted under the Chairmanship of Secretary, Ministry of Information & Broadcasting.The maximum height of antenna permitted above the ground for the CRS shall not exceed 30 meters. However, minimum height of Antenna above ground should be at least 15 meters to prevent possibility of biological hazards of radiofrequency (RF) radiation. Universities, Deemed Universities and other educational institutions shall be permitted to locate their transmitters and antennae only within their main campuses. For NGOs and others, the transmitter and antenna shall be located within the geographical area of the community*

*they seek to serve. The geographical area (including the names of villages / institution etc ) should be clearly spelt out along with the location of the transmitter and antenna in the application form.*

## Activity 3.3

Log on to the internet and download the following documents. They are community radio policies of India and the neighbouring country Bangladesh.·

- Indian policy: http://tinyurl.com/ozc8ccu·
- Bangladesh policy: http://tinyurl.com/nwxso8y

Now, compare the two policy documents and list out the similarities and differences. Discuss the relative strengths and weaknesses of each policy document in terms of basic principles, content and technical regulation.

## 3.4 Let Us Sum Up

In this Unit, you have learnt the basic policy of Community Radios in India including the regulatory sections related to both content and technology. You now have a good idea of the basic principles governing community radio in India. You have also learnt what are the areas of programming that are allowed and what is not. Further, you have got a basic understanding of what kind of technology is allowed to operationalise community radio in India.

## 3.4 Model Answers to Activities

The information gathered in the activities presented in this module should be your own experiences. All the activities are hands-on activities.

# UNIT 4

# Technology for Community Radio: Guiding Principles

## Structure

4.1 Introduction

4.2 Learning Outcomes

4.3 CR Technology and Equipment: The Basis of Selection

- 4.3.1 Technological Options
- 4.3.2 The Importance of Robust and Low Cost Equipment
- 4.3.3 Current Availability of Equipment, Space and Infrastructure
- 4.3.4 The Station's Programme/Content Mix
- 4.3.5 Budgetary and Cost Factors
- 4.3.6 Serviceability and Maintenance Support
- 4.3.7 Modularity and Redundancy
- 4.3.8 Indigenous or Imported? Authorized Dealer or Grey Market?

4.4 More on Maintenance and Servicing

- 4.4.1 Warranties
- 4.4.2 Annual Maintenance Contracts (AMCs)
- 4.4.3 Back-ups and Fail-safes

4.5 Let Us Sum Up

4.6 Model Answers to Activities

## 4.1 Introduction

In this Unit, we will discuss the core principles of community radio technology, including the key decisions that have to be taken by the CR technician responsible for setting up and managing the technological setup and process within a CRS.

The Unit will present a systematic set of decision points on the basis of which equipment must be selected by the CR technician. Such selection is to ensure the continued viability of the station by minimizing downtime and maximizing flexibility of operations.

## 4.2 Learning Outcomes

After completing this Unit, you will be able to:

- examine the availability of different types of technology for Community radio.
- differentiate between indigenous and imported equipment.
- explain the serviceability of these equipment.
- analyze the issues related to warranty and back-up.
- assess the cost factors involved in selecting appropriate technology for CRS.

## 4.3 CR Technology: The Basis of Selection

In the previous Units, you have already examined the philosophy and guiding principles of community radio, as well as some examples of community radio from around the world. You would also have understood the key components of the community radio guidelines that govern the establishment of CR in India. But how do all these impact the decisions we make regarding the technology and the equipment that we will use in the CR station? What must we keep in mind when we select equipment? How do we decide the technologies that will most suit our CR station and the community that will own, run and manage it?

In this section, we will examine the fundamental decisions we will have to make when we proceed to set up a CR station. We will understand how we must weigh different technological options available to us considering our needs and budget, and then, within that framework the basic principles for making a choice of technical equipment to be used at our station.

### 4.3.1 Technological Options

Selection of technology is an important step in the planning for any project, what to say of Community Radio Stations, which are low cost ventures. The very first aspect which has to be taken into consideration, while going for a technology, is whether it is a proven one or is only at a teething stage. Secondly, it has to be ensured that the chosen technology not only meets the requirements but is also suited to the environment in which it is to be used.

In the case of Community Radio, however, the choice of technology is not that far and wide taking into consideration the stipulations in the Government policy in respect of transmission mode and a very wide usage of certain type of technology on the programme production side. On the transmission side, it is already mandated that they would be on FM in Analog mode. Moreover, because of low permissible ERP, Community Radios broadcast mono and thus use only mono-compatible transmitters. As far as programme recording and production is concerned, the use of digital technologies and computer aided broadcasting setups have become universal. Digital Audio Workstations (DAWs), which are computer based systems designed to record, edit and playback audio, are thus being used by all the radio stations including Community Radios. Even for field recordings of audio and other events outside the studio environment, portable digital recorders are being used. As such the choice before a CRS planner boils down to the selection of equipment within the framework of technology.

### 4.3.2 The Importance of Robust and Low Cost Equipment

While we keep in mind the social and cultural impact of community radio, it is important to remember that radio is a technological medium: Everything that is going to be said or heard over radio passes through a series of technological steps that creates the scientific miracle of modern day broadcasting. Of course, this also means that if a single link in that chain fails, the entire process may come to a grinding halt!

It is true that modern digital technologies and the computerization in broadcasting has made this challenge less daunting. Computers now let us perform functions that in earlier times would have required several devices. You can now use a computer to record sound in a studio, as well as adjust the audio and edit it. But this can also, sometimes, cause problems. A few years ago, the failure of a specific component, meant replacing it with a new one. Today, the fact that a variety of functions are handled by a single computerized unit means that we will have to suspend all the activities on that unit while the problem is fixed.

Community Radio seeks to provide a voice to the voiceless and the marginalized, and lets communities to share information within themselves. In line with this philosophy, community radio stations are often located in areas that have lower media penetration, and where economically weaker communities may reside –

since these are precisely the areas and communities that are most in need of such a medium in order to express themselves. Often, as a result, CR stations operate in remote areas, in places where availability of electrical supply and repair facilities present a continuous challenge; and where exposure to disaster – floods, fires, landslides – may be a reality in the life of the people who live there. Simultaneously, CR is typically a low cost activity, often funded by community contributions, and managed and run by volunteers from the community.

So, here we have a practical challenge: not only do we have to select technologies and processes that cost less to purchase and maintain (since funds are scarce) but we also have to find technical equipment that are also inherently less prone to breakdowns, and which will continue to work under stressful climatic and usage conditions! Figure 4.1 illustrates the search for the elusive sweet spot between these two decision points.

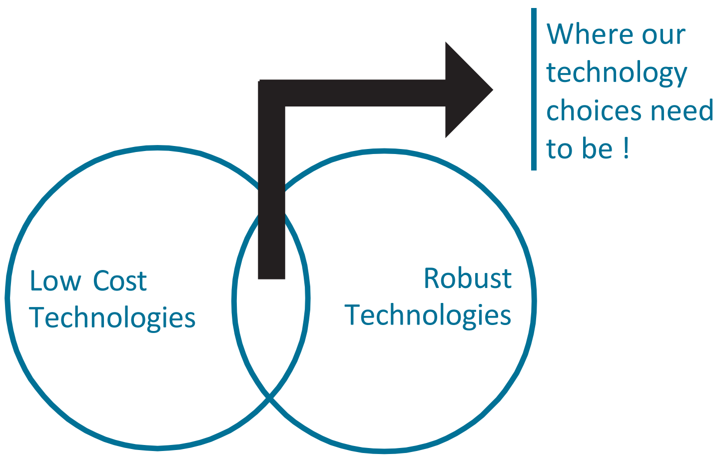


*Figure 4.1:* The twin challenges of robustness and cost

So, as you can see, the choice of technologies and equipment is critical to the process of community radio. It is for this reason that we will continuously examine and evaluate every piece of equipment and technological process on the basis of five key considerations:

a. The availability of any existing equipment, and that of space within the proposed station site for installation, along with that of electrical and civil infrastructure.
b. The kind of programmes that the station intends to produce and broadcast.
c. The funds at the station's disposal (for the initial investment, and recurring expenses).
d. The availability of trained maintenance manpower and/or repair facilities for the equipment.
e. The pros and cons of buying locally manufactured equipment versus imported equipment; and of selecting between authorized dealers and the unauthorized ("grey") market.

Let us now look at each of these considerations in some detail, so that we can understand the implications of each of these factors.

### 4.3.3 Current Availability of Equipment, Space and Infrastructure

The very first part of our decision-making process is to review the status of available equipment and space to set up our studios so that we can make optimum use of the available resources in terms of space and equipment. We also have to analyse possible equipment choices in terms of what is physically available in the market and what other stations are using for their setups. Asking around, and consulting resources on the internet – perhaps even conducting a few site visits to other stations may help to fix our ideas.

In other words, we have to start by asking ourselves:

a. Do we currently have any equipment that could be used for the CRS? (recorders, computers, furniture)
b. Do we currently have access to a space where we can set up transmitting, recording and editing spaces? (If yes, how much space is this, how do we want to utilize this and what is the minimum we can make do with)
c. What is everyone else using? Why? How much does it cost? Is any of it clearly redundant?

Hopefully, if you are careful and honest in asking yourself these questions, you will realize that there are items you can spare from other processes, or which could easily be donated for the CR process by friends and well-wishers (computers, for instance). You will also understand the reasons why other CR stations have acquired the equipment and setups that they have; where they made their purchases from, and how much it cost them. You can use this information to build an equipment and infrastructure wishlist.

At this stage, don't worry about how realistic your wishlist is. It is likely that you will have much more on that list than you will eventually be able to acquire. It will give you a place to start from in terms of continuing your assessment, and whittling down to a list that actually fits within your other plans and budgets. The important thing will be to have a clear list of items you require, with a clear understanding of their purpose within your setup – and the understanding is the critical part of this initial investigation. If we buy equipment A from this manufacturer, do we necessarily have to buy equipment B from the same manufacturer to ensure compatibility? What grade of cable did Station X buy, and how much better did it do than the one bought by station Z? Which one complained more about frequent cable replacement? Did Station Y buy this just because it looks good, or because it offered best value for money?

Similarly, it is best to assess possible space and infrastructural availability right away. Computerization has meant that large working spaces are no longer the norm for a radio station, with accessibility and placement within a community being of greater importance. But, if a lot of production work must go on at the same time when a studio recording is taking place, multiple editing and recording setups are vital. No matter how small, multiple computers will take up some space!

Again, if one expects to record a lot of folk music and local singers, a larger studio will be required, because local troupes often consist of several members. And if the programming hours are likely to be for several hours right from the start, then a second working space may be called for, as other production work cannot stop when the broadcast is happening. Additional construction and waterproofing work may also be called for if an existing structure is poorly built.

Needless to say, electrical infrastructure is also key to the whole process, and it is important to assess how much the electrical demands of our station is likely to be, both from the point of view of the raw consumption, and from the point of view of the costs we are likely to incur. This is intricately linked to our decisions regarding working flexibility (two studios are likely to result in a greater electrical load, as are multiple editing setups, for instance).

Assuming an electrical connection is available, and once we have assessed the basic load we are likely to place on this connection, it is important to assess whether electricity is available on a continuous basis or not. If not, we may have to provide for electrical backup system and depending on the type of system one selects, this may place additional consumption loads on the connection (in the case of inverters and UPS systems); or may require fuel and maintenance (direct generation systems); or large capital investments (for solar power systems or wind energy systems, for instance.)

Once you have this basic information organized, you can begin to think of some of the other factors outlined below, so that you can hone your list into a more workable and practical list.

## Activity 4.1

Visit or speak to at least three community radio stations, and enquire about the field recording units that they are using. Find out the following details in each case:

1. What make and model are the units?
2. What media do their recorder units record on? (cassette, SD card, internal memory?)
3. Why did they select this make and model? (What are the key features that they like in it?)

4. What has their experience with the equipment been? (Have there been any failures or repairs? Would they buy something else if they could?)
5. Which dealer did they buy the recorders from? How did they identify this dealer?
6. What is the cost of the recorder unit(s)?

Create a table reflecting this information so that you can compare the recorder units.

### 4.3.4 The Station's Programme/Content Mix

At first glance, it may appear a bit confusing. Aren't we jumping too far ahead? Doesn't programme production come *after* we have everything in place? How could the programmes we intend to make possibly be related to the specific technological choices we make? As it happens, the two are linked in a very fundamental way.

Every CRS is unique in its choice of the kind of programming that it develops and broadcasts. Some stations depend totally on live studio situations, and prefer to broadcast directly from the studio or the field. Such stations tend to require less by way of equipment for recording and editing, since most of their programming does not need editing. It should be obvious that buying several computer workstations for the purposes of editing content would be pointless in such a situation.

Other stations may depend more on pre-developed ('pre-produced' or 'canned') programming, with fewer programmes going directly out of the studio as live programmes. Not having an adequate number of editing setups in such a situation would be equally counterproductive.

Similarly, some CRS setups may come up in communities where the availability of mobile phones is high. In such cases, making interactive programmes where the listeners can call in and participate in programmes, or leave feedback, becomes an important way for the station to connect to its audience. On the other hand, creating an elaborate infrastructure for live 'call-ins' becomes pointless if the local availability of mobile phones is low, and there is no one who could call in!

The first step, therefore, to deciding what kind of equipment to acquire is to assess the content that will be developed. Depending on the kind of content, we will then decide to invest in a greater proportion of field equipment or more editing systems (where we expect to do a larger proportion of pre-edited programming), or more telephone lines (where we expect to do more phone-in programmes), or even additional studio spaces (where we expect to do a lot of studio-based productions or live programming).

It is worth noting that this is not a one time process – content evolves over time, and may require changes in technical infrastructure to keep in step with changing realities. To continue our previous example, if the number of mobile phones within the station's listenership goes up over time, one must plan for the incorporation of systems that allow the station to connect with these listeners as mobile phones become more commonly available.

### 4.3.5 Budgetary and Cost Factors

Deciding how much you want to spend on the CRS's technology infrastructure is central to our decision-making process on CR technology. In some ways, it's like building a house. You can build a one room cottage, or a 20 room mansion, and both would be houses - though of very different kinds. So which one should you aim for?

The 20 room mansion always looks attractive – but are you really going to use the extra room? On the other hand, the one room cottage may be easy to build with the funds you have right now. But, you can't get over the feeling that you might run out of space soon. What a quandary!

As always, it helps to be systematic and rational while taking this call. To continue the house analogy that we used, the key is to deciding how much space you need to live right now and how much you can build right now with available funds. You can then plan for the space you will need in future, and plan your immediate construction in a way that lets you expand it as time and money allow in future.

One way to work this out where equipment for a CRS is concerned is to draw up a phased budget for equipment and studio infrastructure. Ask yourself these four questions:

a. How much money is available immediately from the funds in hand?
b. How much can we borrow or receive from somewhere for this purpose and is the rate at which we will have to return it reasonable?
c. How much do we expect to spend each year on repairs and maintenance?
d. How much can we dedicate each year for upgrades and new equipment/ infrastructure?

Answering these questions will give you clues to two parts of your phased budget: (a) and (b) will help you understand how much you can spend right now; and (b), (c) and (d) will let you plan your recurring costs – the costs that you will undertake on a monthly or annual basis as part of your station's running costs in order to expand and modify your technical setup. As a general rule, you might like to spend 15% less than what you have budgeted, so that you can make some funds available for related accessories, budget over-runs and fluctuations in prices.

At this point, a word of caution is in order. Many people tend to see the available budget as the only deciding factor in selecting technical equipment for a CRS. In some ways, this is true. It is a fact of life that we can only purchase something if we have the money to buy it with or can arrange for the money, in a way that allows us to pay it back from our income. But to look at affordability alone would be a mistake. Buying the lowest cost item often means ignoring factors like audio quality and robustness, both of which are vital considerations to small setups with limited means. Would you buy the cheapest motorcycle on the market if you also knew that it gave the least mileage, or if it had a reputation for breaking down twice a month? Of course not. You would choose the motorcycle that has the best reputation for toughness and fuel economy, even if it costs a little more. You would then decide the maximum you could spend without stretching yourself so far that you would be deep in debt, or could not afford other necessities in life. In short, your decision would be based on the total cost of ownership, rather than the up-front cost.

Decisions regarding technical equipment are decided on a similar basis: a lifecycle cost for each piece of equipment, rather than the basic cost. Audio recorder X may be available for half the price of recorder Y but may also fail thrice as fast, making it much more expensive to run across a period of time. Computer A may be cheaper than Computer Y, but may consume more electricity, making it costlier to run in the long run.

### 4.3.6 Serviceability and Maintenance Support

A key component of our decision-making will also be based on the twin concepts of serviceability and availability of maintenance support for the technical equipment we acquire.

By serviceability, we mean how easy is it to fix the equipment if something goes wrong with it? And by maintenance support, we mean are there qualified technicians and spare parts available easily nearby to help attend to issues with the equipment in our CRS?

Since many CR stations are likely to be in areas where equipment manufacturers are unlikely to have direct offices, these are very important considerations. Imagine a situation where our primary transmitter unit fails with the closest service centre three days away. It is unlikely for you to resume broadcasting within a week! Similarly, since many of the pieces of equipment you use may be imported, spare parts may be dependent on international shipping schedules – which may mean delays of weeks or months even with a service centre handy.

The ideal situation would be to use equipment that has service support directly from the manufacturer no more than a day’s journey away, and, where simple problems can be attended to easily by individuals within the CRS itself with basic tools and easy fixes. (This is not always possible, of course, but is a factor one must pay attention to while acquiring equipment.)

Thus, an equipment supplier willing to train team members in 'preventive maintenance' – regular maintenance that prevents equipment from suffering major failures – is always to be preferred to one who is merely willing to offer warranty coverage. Similarly, a supplier who offers on-site service at no cost to the station is preferable to those who offer 'carry-in' support. Finally, where warranties and guarantees are concerned, it must be obvious that equipment that carries longer duration coverage or one that covers all (or nearly all) parts is far better than one that offers partial/shorter period coverage.

A linked consideration, in case service support will be hard to come by, is the investment that may be required in training the CRS team members in key maintenance tasks; and in keeping relevant spares in stock.

Preventive maintenance and robust equipment go a long way towards sparing one the shocks of equipment failure and the consequent heartbreak of downtime. Adequate thinking on these counts could make the difference between a station which struggles everyday and one which makes the business of broadcast look as effortless as the process of listening to the radio.

## Activity 4.2

Visit your local market or shopping centre and locate at least three radio and TV repair shops. Discuss the capabilities of the repair technicians at each shop and examine them on the following parameters. Try and score each capability on a scale of 1 to 10.

1. What kind of equipment and utilities can the shop handle repairs for?
2. Is the shop an authorized service centre for any brand or item? (8 points out of 10 for being an authorized centre for any brand; 9 for being authorized by two manufacturers; 10 points for more than that.)
3. Do the repair technicians there have any kind of formal training? (ITI, repair course, training from any branded company?) (7 points for ITI trained; 8 for a diploma from any well known course; 9 for a degree holder.)
4. If they see a new item which they have never handled before, how do they assess whether they can perform the repairs?
5. Are they willing to share the contact details of some customers, so that you can conduct a customer satisfaction check? (5 points if they share; one additional point for each good review.)

If they are willing to respond to point (5), call the individuals whose contact details you have received and ask for their feedback on the shop's performance.

Rank the shops in decreasing order of capability, as revealed by your total points.

### 4.3.7 Modularity and Redundancy

An additional important step to take while planning your CR setup is to plan your equipment in a manner that allows work to continue even if portions of the setup fail. We do this by planning systems and equipment which can perform dual roles, and which can be re-configured if necessary, to cut out the equipment that has failed.

*Modularity*

Within the course materials that you are being provided for this course of study, there are a number of individual 'modules', each covering a specific subject or sub-topic within the larger discussion of technology for CR. As time goes by, specific Units can be revised and updated to keep the course up-to-date. This is more effective in terms of time and effort than revising the whole course matter each time. In other words, the course has been planned in a modular fashion, allowing us to adjust and change individual parts with some flexibility.

In the same way, equipment and technology for CR can be modular at two levels:

a. The individual equipment unit itself could be manufactured in a modular fashion by the manufacturer, allowing one to upgrade sections of it easily to increase its capabilities or fix faulty parts.
b. Our equipment planning can be modular in nature, allowing us to restructure the way different parts of it are connected together in case equipment malfunctions or if we need to expand our setup in future.

The first aspect above, is important from the maintenance and service point of view, as seen in sub-section 4.3.6. If there are sections of the equipment which we can remove and replace with a new part easily, we will be able to get a longer working life out of the unit. From this point of view, you may like to consider assembled computer systems for your work, rather than branded systems. Branded systems often carry proprietary components that are hard to replace or upgrade; or replacing which may need warranties. Assembled systems, on the other hand, allow the flexibility of building a system with components that you can handpick without compromising and which can then be replaced individually for upgrades and repairs.

Planning your equipment setup in a modular fashion is equally important. If your entire setup is set in stone, and nothing can be moved without sacrificing essential functionality, chances are that your process could be crippled if any single part of its goes down. A modular setup allows you to avoid such an event. For example, you may have a computer that plays out your broadcast programming, and a playback unit that plays CDs or USB drives for pre-recorded programming. A good setup would be one where these components are connected through a patch panel, which allows you to bypass the computer if it fails, and play pre-recorded programming directly off a CD or DVD in an emergency.

*Redundancy*

By now, it should be clear that the more modular a piece of equipment, and the more modular your setup is as a whole, the easier it will be to manage and maintain your technical infrastructure. Which brings us to a related concept – redundancy. Redundancy, at its simplest, is to be able to have more than one unit of equipment performing the same function.

At one level, one could consider having as many units of a single item available as the budget and practicality allows, so that you are protected from the failure of one of those units. Thus, if you can afford it, it is always a good idea to have more than one field recorder available. This way, not only can recordings happen at different places simultaneously but it also means that we will never be threatened if any one recorder needs repair or servicing. (Of course, the practicality lies in balancing out the number of units against the budget and a realistic assessment of how many units could ever be needed simultaneously: If there are only two people in the team to conduct field recordings, it may not make very much sense to get 10 field recorders just to be safe!)

At the other level, there are often pieces of equipment which overlap in functionality. A computerized Digital Audio Workstation (or DAW) can be used for recording and editing audio and can also be used as a playback system to play programmes stored on its hard disk drive. Some digital field recorders also have functions where they may be used as a studio microphone to be connected directly to a DAW for recordings. When the need arises, the secondary functionality of such units could be used to fill in when a primary unit fails: the DAW for playback instead of a CD player, for instance.

If our planning for equipment setup can include such multi-functional units, this obviously allows us to mix-and-match our equipment more flexibly, which is a good thing. But it should be noted that this means the equipment needs to be purchased with these features in mind, which calls for a high degree of knowledge about each unit. It also calls for a certain nimbleness of mind, that allows us to see the possibilities for re-deploying a specific unit for a different purpose. Hopefully, after completing this course, you will have both, the knowledge and the insight, to be able to do this successfully!

### 4.3.8 Indigenous or Imported? Authorized Dealer or Grey Market?

If you have successfully negotiated your way through selecting the complement of equipment that you need to acquire, it is time to start thinking about where you will make these purchases from, and considerations linked to this decision.

*Choosing between locally manufactured and imported equipment*

One of the things that a technician working for a CRS has to face continuously is the lack of options with regard to equipment manufacturers for radio. Most manufacturers who make high quality audio equipment are based in the developed world, which means most of the equipment is imported. This means duties and excise charges make equipment very expensive. It also means that repair and maintenance facilities for such equipment may be hard to come by. And this sometimes skews the process of equipment selection.

In some ways, this process has actually become more difficult over the last decade or so. As import procedures and regimes have been eased steadily over the last two decades, and many manufacturers have set up local sales and service offices to support their products, the availability of equipment and brands has certainly gone up. But this has not always translated into efficient after-sales service.

This situation poses a challenge when we source equipment for a CR station, since the larger part of the available equipment is still manufactured abroad. Good quality equipment does not always mean good after-sales service. Can we choose the best equipment for the task, when we know our investment may be doomed if the equipment fails?

A good rule to follow in this case, is to not go by the raw specifications and quality of the equipment, but by its reputation in local conditions. It may be imported, and service may be hard to come by; but some pieces of equipment acquire a good reputation in local conditions and reveal themselves to be hardy and robust when exposed to dust and moist conditions, as are often found in India. In the interests of affording the equipment with the greatest number of features and possibly the highest possible quality for the price, a certain amount of risk may be inevitable during the selection process. Preventive maintenance and a handling protocol that can be taught to individuals handling the equipment – including simple things like cleanliness and checklists for equipment accessories – can go a long way towards mitigating some of these risks and giving years of trouble-free usage.

Alternatively, if you do not wish to risk anything at all, and cannot do without assured repair facilities - all other things being equal - always select the equipment that can be repaired without too much effort.

## Activity 4.3

Locate the closest authorized dealer to your location for the following audio equipment brands:

1. Sennheiser
2. Sony
3. Tascam

Note the contact details for each, and contact each of them to note the following pieces of information:

1. Ordering procedure (Do they need a purchase order? Do they need payment in advance? What is the anticipated delivery time once an order is placed?)
2. Payment mechanism (Do they need 100% payment in advance? Will they accept payment on delivery? How will they accept payment – cheque, demand draft, bank transfer?)
3. What service support and standard warranties do they offer on their equipment?

## 4.4 More on Maintenance and Servicing

In the previous section, we have seen some of the things we must keep in mind when selecting the technical equipment that we will use in our CRS. One of the important considerations, as discussed in Section 4.3.6, is the vital role of service and maintenance backup in keeping the technology humming smoothly.

As you must have already understood, the larger question of adequate service and maintenance support is linked to issues like buying equipment from authorized dealers, and of decisions related to selecting between imported and locally made equipment. Of these, two considerations require special attention from any person tasked with handling the technology in a CRS: Warranties and Annual Maintenance Contracts; and the importance of backups and fail-safes.

### 4.4.1 Warranties

When a manufacturer sells you a piece of equipment, they usually promise to correct manufacturing defects or other faults in the equipment for a specified period of time from the date of sale. This promise is called a warranty.

Warranties may be as short as a couple of months, or as long as 5 or 10 years. The most common durations are 1 to 2 years. For most audio equipment, warranties are limited to 6 months.

Warranties may be limited in which case only specific components or faults may be covered; or comprehensive which means anything which could go wrong will be covered and rectified. Similarly, they may promise onsite service which means you can call the manufacturer or service agent if a fault arises, and they will come to where the equipment is installed at their cost to fix it; or offer carry-in service which means you must take the equipment to the nearest service centre yourself.

An important thing to remember is that warranties are only applicable if there is proof of the date of sale. This means you must always get a bill from the supplier when you buy equipment, so that this provides proof of the start date for the warranty. Some manufacturers require that the warranty card enclosed with the equipment be completed and returned to them with the dealer’s stamp. Others may require you to register the details of your purchase over the internet. Enquire about this at the time of purchase, and keep the bills and warranty cards in safe custody.

### 4.4.2 Annual Maintenance Contracts (AMCs)

Many equipment suppliers and service agencies offer a contract under which they charge a flat annual fee that covers any and all faults and repairs that may arise in a piece of equipment, or an equipment setup as a whole. The amount charged under this contract is calculated on the basis of the likelihood of a fault arising, and the travel and time they would have to invest to fix problems that arise. The amount is charged irrespective of whether a fault arises or not, and is usually payable in advance for the period of coverage. Such contracts are called annual maintenance contracts, or AMCs.

AMCs, it must be noted, only promise to keep the equipment in good running orders. They don’t necessarily promise that any parts that may need replacement will be replaced with original spare parts made by the original manufacturer. So use your judgment before entering into such an arrangement with anybody.

Another thing to remember is that AMCs should only be considered once the basic warranty offered by the manufacturer is over; otherwise the AMC is just a waste of money on repairs that would have been carried out for free anyway.

AMCs are usually a good idea for equipment that undergoes a lot of wear and tear, like battery-based power inverters, or Uninterruptible Power Supply (UPS) units, or air conditioner units. The parts in these units are reasonably standardised and there are usually service agents in most places who can offer AMC services for these items.

AMCs for audio equipment are rare, and it would be wise to check what items and faults are covered by the AMC if such an arrangement is offered. Often, turnkey service providers who set up whole studios offer AMC arrangements on request. Sometimes, manufacturers provide a kind of AMC arrangement directly from the company. You pay a flat fee on an annual basis for an ‘extended warranty’ arrangement, where the company offers to fix faults for a period beyond the original warranty period.

Always check on the background of the person or organization offering the AMC, to ensure that it is has a good history of providing quality service. Talk to existing clients of the agency to verify whether their experience has been good. Extended care or extended warranty plans from the manufacturer, though often expensive, may assure you of original parts and technicians who know the equipment well – so keep that in mind.

### 4.4.3 Back-ups and Fail-safes

In Section 4.3.7, we have already seen the importance of redundancy in equipment, as a method to protect your CRS from failure of equipment. A related concept is the maintenance of backups, and the creation of procedures to fail-safe your technical processes and equipment.

Back-ups can be of two types:

a. Backups for data and content creation; and
b. Backups for essential infrastructure

*Content and data backups*

We must not forget that the key output of a community radio station is the content and programming that it creates. When we produce programmes and broadcast them, we should also provide for mechanisms to keep the produced programmes safe. This includes both pre-recorded programmes, as well as live programmes.

Since most CR stations today use modern digital equipment, where audio is stored as files on computers, it is a good idea to create a regular system by which these files are copied onto an external device or medium as well. A usual practice is to maintain one set of the recordings and programmes on one of the working computer systems in the CRS; and to have a backup on an external hard disk drive, which is attached to the primary computer system on a daily or weekly basis in order to copy the recently created programming and recordings. Some CR stations backup their produced programmes on DVD or CD media as well. This way, if a computer fails ('crashes') or recordings are mistakenly erased from the main systems, there is always a spare copy of the recordings and programmes that you can retrieve from. (Imagine doing an interview with the Prime Minister, and finding that you erased it by mistake!)

Content and programming backup is also important from the point of view of the community radio policy, which mandates that every CRS should preserve the programming broadcast over the previous 90 days. This is mandated so that if there is a complaint received from a listener regarding objectionable content, the programming can be produced before the appropriate authorities for a decision. This makes the continuous and systematic backup of programming doubly important, because the CRS can be penalised for not being able to produce the programme in question.

But don’t make the mistake of assuming only the programmes and recordings need to be backed up: CR stations also store a lot of essential data connected with their programmes. This could include listener data, programme ideas, scripts, volunteer records, financial data, and reports to donors. All of this also needs to be backed up regularly, as losing any of it could be disastrous.

*Backups for essential infrastructure*

Of all the key backups we need from an infrastructural point of view, the most important of all is the provision for electrical backup. Continuous supply of electricity remains a challenge in many parts of the country and even a moment’s loss of electricity for a radio station can mean an abrupt halt in the middle of a broadcast.

CR stations therefore provide for power failures by installing inverters and UPS systems, both of which use batteries to store electricity, and release it when the power gets cut off. Some have additional backup by also installing direct generation systems (DG sets or generators), which run on diesel, petrol or kerosene, and use a motor to generate electricity. In this way, the stations assures itself of having a continuous supply of electricity throughout any kind of interruption which is very important in times of natural disasters, because radio stations often act as information lifelines during emergencies.

Other kinds of infrastructural backup could involve the development of spare studio spaces; or the availability of secondary telephone or internet connections – a wireless internet connection to back up a wired DSL internet connection, for example. A key backup concept could also be the creation of a pool of volunteers or team members within the CRS who can conduct simple repairs and essential maintenance, to avoid dependence on the availability of external assistance.

## Activity 4.4

Visit or speak to at least three community radio stations, and enquire about the electrical backup systems they are using. Find out the following details in each case:

1. What systems are they using currently? (Inverters, UPSs, DG sets, or all three?)
2. Why did they feel the need to install these systems, and how much power backup do they need in a day?

3. What are the challenges they notice for the system(s) they are using?
4. What did the basic setup cost them (raw equipment cost), and what are the recurring costs (replacement of batteries, fuel)?

Draw up a table reflecting the relative merits and demerits of each of these types of electrical backup systems.

## 4.5 Let Us Sum Up

In this Unit, we examined the important principles that we must keep in mind while deciding the technological and equipment setup for a CRS. Our decision must revolve around the twin concepts of low cost and robustness. While deciding what kind of technical equipment to acquire, we need to take into consideration a variety of factors, ranging from what is already available to the station, to the kind of programmes the station intends to make; the funds that can be raised; the availability of service and maintenance facilities and technicians; how modular the systems are; and how much redundancy we can build into our selection of equipment. Choosing between locally manufactured and imported equipment; and authorized and grey market suppliers are also important decision-making points.

Special attention also needs to be given to service and maintenance related concepts like warranties and AMCs, as well as extended warranty processes offered by manufacturers. Most importantly, CR stations must plan for adequate safety of their content, programming and data; as well as the availability of key infrastructure backups like electrical power and technical manpower.

## 4.6 Model Answers to Activities

The information gathered in the activities presented in this module are best presented in the form of tables. This will allow you to compare your results easily. In each case, a sample is filled in for you to see how you can complete each table.

## Activity 4.1

| Sl. No | CRS Name/ Make | Unit Name | Storage | Cost | Dealer | Reason for selection/ remarks |
|---|---|---|---|---|---|---|
| 1. | Radio Awaaz | Zoom H-2 | SD Card (Upto 4 GB) | Rs.13500 | Rivera Digitec Pvt. Ltd.<br>409, Nirman Kendra Off. Dr. Edwin Moses Road, Mumbai 400011, India<br>Tel: (91) 22-24939051<br>Fax: (91) 22-56604461<br>E-mail: rivera@bom3.vsnl.net.in (Contact person: Mr.Subhash Khandelwal, Mobile: 09820075805) | - Recommended by other CR stations when eqnuiries were made<br>- Uses regular AA cells<br>- Easy to use<br>- Accepts external microphones<br>- High quality recording at moderate price |

## Activity 4.2

| Sl. No. | Name of Shop | Can Repair | Autho-rized Service for | Formal Training | Assessment of Capacity | Customer Review | Overall Points |
|---|---|---|---|---|---|---|---|
| 1. | Sarvesh Radio | Radio sets TVs Amplifiers & audio equipment<br>(6 /10) | Philips<br>(8 /10) | Yes / ITI trained electronics repair technicians<br>(7 /10) | Methodical approach to repair. Informs customer about costs before undertaking repair. Willing to learn new technologies, have a plan for updating skills<br>(8 /10) | 2 reviews Good, some times slow in response. Excellent and dependable<br>(7 /10) | 36 /50 |

## Activity 4.3

| Sl. No | Brand | Authorized Dealer/ Service | Order Process | Payment Terms | Standard Warranties & Coverage |
|---|---|---|---|---|---|
| 1. | Tascam | Setron India Private Limited<br>E-2, Greater Kailash Enclave -1, N. Delhi-110048<br>Tel: +91-11-26242250, 26241150/601<br>Fax: +91-11-26242150<br>E-Mail: sales@setronindia .com<br>(Sales + Service) | Purchase order along with advance<br><br>payment (hard copy required)<br><br>Delivery within 15 days of receipt of order by courier | 100% advance by DD/Cheque/ Bank Transfer<br><br>Shipping cost extra (enquire before placing order for quotation) | All equipment warranties as per manufacturer<br><br>Standard warranties are 1 year<br><br>Extended warranty available for specific items: Request for quotation where available |

## Activity 4.4

| Sl. No | Type of power backup | Pros | Cons |
|---|---|---|---|
| 1. | Generator<br>(DG set) | Power capacity high<br>Relatively low maintenance on a day-to-day basis<br>Usable for extended hours<br>Stable power source | Fuel costs high<br>High initial cost<br>Stocking fuel cumbersome<br>Servicing a challenge<br>Cannot be used indoors<br>Larger capacity units will need a lot of space<br>Sometimes noisy + exhaust |

## Additional Readings


- UNESCO (2001). *Community Radio Handbook*. Retrieve from http://www.unesco.org/webworld/publications/community_radio_handbook.pdf
- Tabing, L. (2002). *How to do community radio: a primer for community radio operators.* UNESCO. Retrieve from http://unesdoc.unesco.org/images/0013/001342/134208e.pdf.
- Pavarala, V. and Malik, K. (2007). *Other Voices: The Struggle for Community Radio in India*. Sage Publications

## Glossary

| | |
|---|---|
| AM Radio: | Amplitude Modulation. |
| AMC: | Annual Maintenance Contract. A contract with a repair agency or the original supplier whereby the agency providing the AMC offers to fix all faults that crop up and keep the equipment in running order for a flat annual fee payable irrespective of whether service is actually required or not. |
| Authorized dealer: | A dealer or supplier of equipment permitted officially by the manufacturer to supply their equipment. |
| Backup: | An alternative or safety measure. Used as a term with reference to power supply (meaning inverters, generators, etc.); spare equipment (a second field recorder, say); data (an additional copy of a programme or recording, say); or an alternative plan. |
| Budget: | The allocated amount of funds available for a particular purpose or purchase. |
| Community broadcasting: | Broadcasting, which is owned by communities, and also operated by the very communities it seeks to serve. While community radio stations advance public good and public interest, their scope is usually limited to their communities defined either by geography or communities of specific interests. |
| Effective Radiated Power (ERP): | ERP is a calculated measurement that takes into account the peak output of a transmitter. For example, a transmitter of 50 Watt power can have an ERP of 100 Watts. |
| Extended warranty: | An optional extension to the original warranty period, usually at additional cost to the buyer. |
| Fail-safe: | A secondary or alternate plan, or device or process, in case the primary device or plan fails. |
| FM Radio: | Frequency Modulation. |
| Gender equity: | A concept based on UN Declaration of Human Rights that believes that all genders should be treated equally both in legal and social institutions irrespective of their race, ethnicity, language, degree of ability and income etc. |
| Grey market: | The unauthorized market for equipment, where equipment is usually available through channels that bypass official customs duties and taxes. |

| | |
|---|---|
| Imported equipment: | Equipment that has been manufactured in a foreign country and brought into the country of use. |
| Indian Telegraph Act: | A law that governs the use of telegraphy, phones, communication, radio, telex and fax in India. It gives the Government of India exclusive privileges of establishing, maintaining and working telegraphs. |
| Indigenous manufacture: | Manufacture of an item within the country of use. |
| Low cost equipment: | Equipment that costs less to purchase than other comparable units. |
| Maintenance support: | Availability of technicians to fix problems and keep equipment in good running order. |
| Modularity: | A measure of how a process or equipment setup has been arranged, such that portions or sections can be changed without affecting the rest of the structure. |
| Narrowcasting: | It is a process which involves playback of programmes through loudspeakers, or audio cassettes or any other such medium for a controlled group of people who can then discuss and give feedback on the programmes immediately. |
| Non-profit organisation: | Usually an NGO that uses its surplus revenues to achieve its goals rather than looking it as profit for distribution as dividend. |
| Participatory research: | Research that includes the active involvement of the subjects of research. It involves a systematic inquiry, with the collaboration of those affected by an issue under study. |
| Private radio broadcasting: | Broadcasting, which is owned by private individuals or companies. Programming may be influenced by the owners, and usually are decided on a commercial basis. |
| Programme & content mix: | The proportion of various types of issues and programme formats in a radio station’s broadcast. |
| Public service broadcasting: | Broadcasting, which is funded by public money, works on an autonomous basis and independent of the government, and works towards advancing public interest and public good. |
| Redundancy: | The concept of building in safety margins or alternate processes or equipment into a setup, such that the functions of one unit can be taken over by another in case of emergency or failure. |
| Robust: | (Equipment) Tough, hardy, able to withstand difficult conditions. |

| | |
|---|---|
| Serviceability: | The ease of obtaining repair and maintenance support (for equipment). |
| Social change: | Alteration in the social order of a society including change in social institutions, social behaviour and social relations. Social change is a dynamic concept as against development which suggests that a society has reached a goal. |
| State List: | It is a list of items on which the State governments can take decisions. Examples include law and order, agriculture, prisons, public health etc. A concurrent list is also provided for in the federal nature of the Indian Constitution under which both Central and State governments can take decisions. For example, education. |
| Union List: | It is a list of items on which only the Central government can take decisions. Examples include defence, communications, citizenship, railways, banking etc. |
| Volunteer: | In the context of community radio, these are usually members of the community who work with the community radio. Across the world, there are volunteers who work on paid and non-paid basis. Some volunteers work on technical aspects, while others work on programming, or capacity building, marketing and so on. |
| Warranty: | A written guarantee, issued to the purchaser of an article by its manufacturer, promising to repair or replace it if necessary within a specific period. Usually applies if the fault can be shown to be a manufacturing defect. |
| Women's collectives: | Self-help groups of women, who come together, save small sums of money and help each other out in order to improve the quality of life. |

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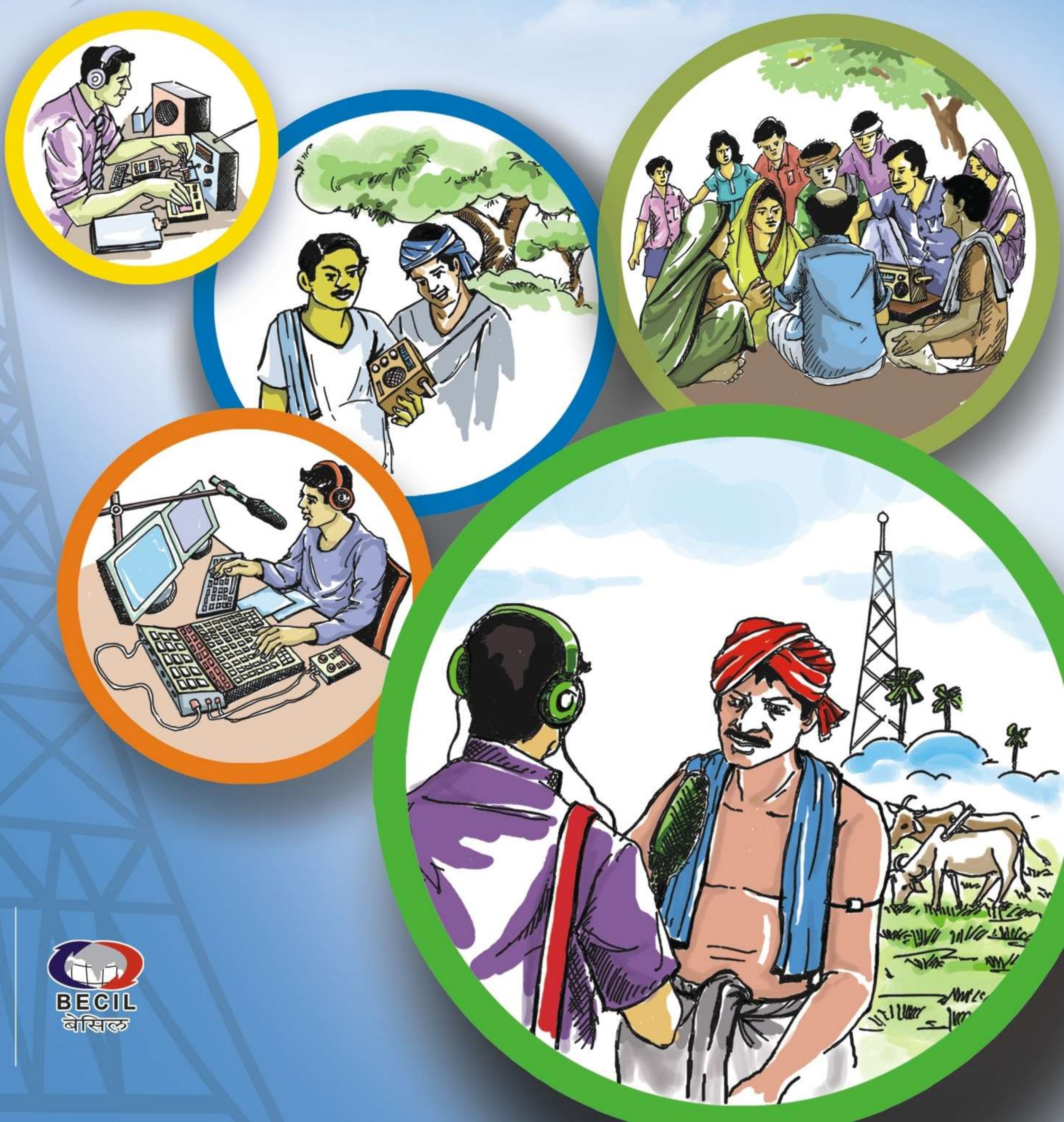
Certificate in Community Radio Technology

# Setting up of CRS

# 2



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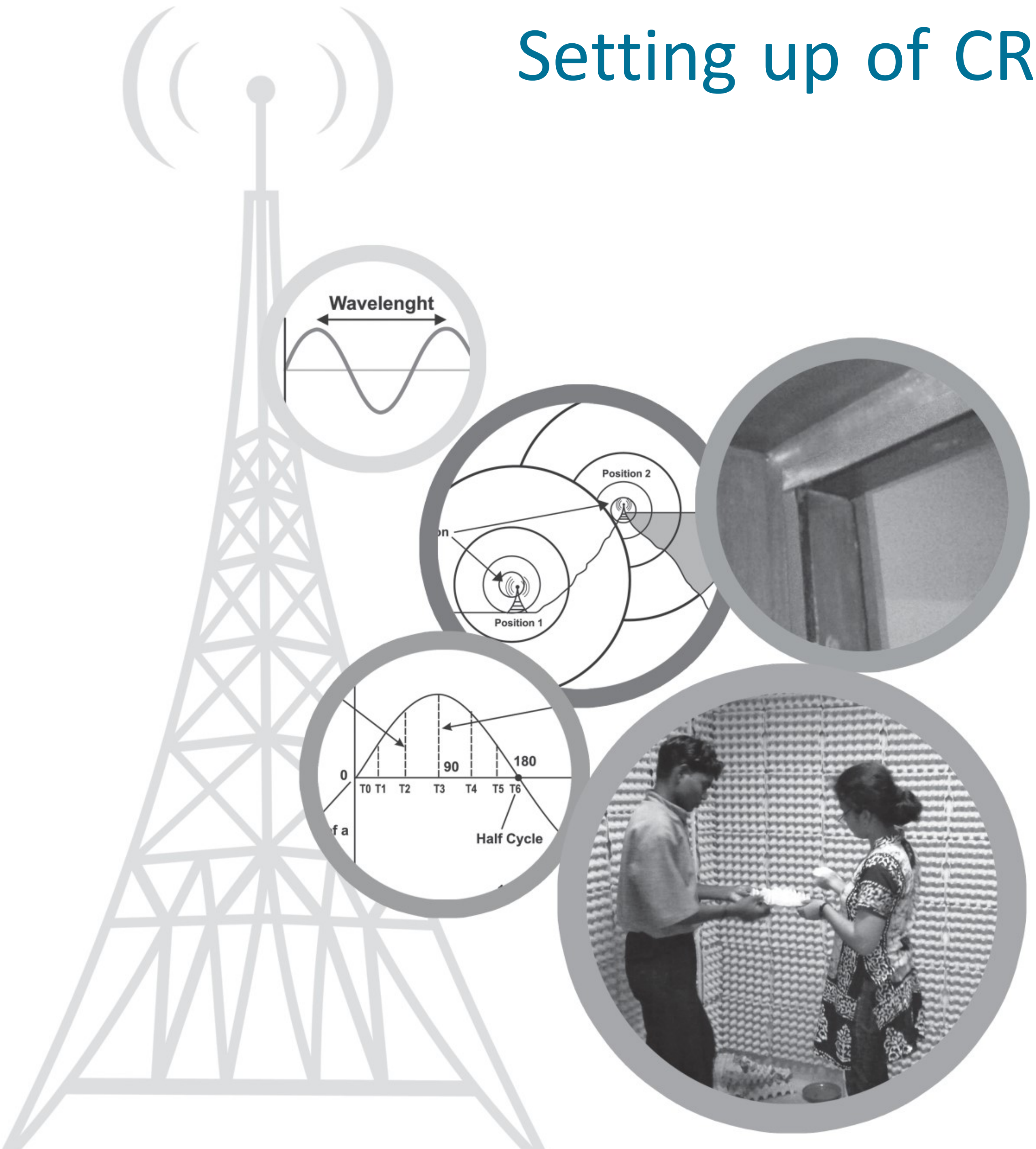
*Course - I*
*Understanding Community Radio*

# Module: 2

# Setting up of CRS

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# About the Module

In the previous module, you would have got not only an introduction to the concept of community radio, but also an idea about some of the guiding principles behind community radio, the basic technology in community radio, how community radio can be used in the context of gender and equity and so on. Now that you have put that behind you, the first step in becoming a technician for community radio is to start thinking about how to set up a community radio. This module gets you started on setting up a community radio, and the basic things you must know before beginning. This module has four units which will provide you with basic knowledge related to setting up of a community radio station.

The components of a CR station are meant for you to understand the basic building blocks of what constitutes a radio station. However, some of the components are explored in-depth in the later modules.

The Unit on radio waves and spectrum will be important for you to get an analytical understanding of the underlying technology of radio. While you may not get an opportunity to put this knowledge to use on a day-to-day basis, you will find this useful in understanding radio at a fundamental level. Remember that competent technicians don't just solve problems, but they know why those problems occur as well!

The Unit on basics of electricity is geared to give you a theoretical understanding of how electricity works. While working as a technician in community radio, it very well may be the case that you will be asked to solve issues which have to deal with power supply or in other words, electricity. Often there are issues like excessive voltage, uneven supply (i.e. dips or surges) of power, frequent power cuts and so on. If you have a good understanding of the concepts behind electricity, then it will equip you to come up with the best solution given the context of a particular community radio.

The last Unit is related to power backup and voltage stabilisation. As noted above, this is a problem which occurs frequently in most rural community radio stations. Choosing the right power backup or voltage stabilisation solution can be a complex task and requires a sound knowledge of how backup and stabilisation can be configured in the context of underlying principles as well as available resources at your disposal. Interestingly the Unit also mentions various alternative energy sources which could be used for power backup. Not only will this knowledge help you to propose environmentally friendly solutions but it could also be an economically viable solution in the long term!

## Module Objectives

- Familiarity with processes and principles involved in setting up a community radio station
- Understanding of the technology behind radio waves and electromagnetic spectrum
- Familiarity with solutions related to power backup and stabilisation of voltage

## Units in the Module

- Components of a CR Station
- Radio Waves and Spectrum
- Basics of Electricity
- Power Backup and Voltage Stabilisation

# UNIT 5

# Components of a CR Station

## Structure

5.1 Introduction

5.2 Learning Outcomes

5.3 The CR Station: Siting and Space Definition
- 5.3.1 Site selection
- 5.3.2 Space allocation

5.4 Studios for Community Radio Stations
- 5.4.1 Sample layouts
- 5.4.2 Acoustics treatment and sound proofing
- 5.4.3 Other considerations

5.5 Equipment for CR (schematic level only)
- 5.5.1 An overview of the programme production process
- 5.5.2 A schematic overview of a field recording setup
- 5.5.3 A schematic overview of a production studio
- 5.5.4 A schematic overview of a broadcast studio
- 5.5.5 A schematic overview of the transmission setup

5.6 Setting up a CRS: Activity and Video

5.7 Let Us Sum Up

5.8 Model Answers to Activities

## 5.1 Introduction

By now, you have already received a broad grounding in the philosophy of community radio, as well as an understanding of the essential decision points according to which we select equipment and technology for a CR station.

This Unit will now discuss the various components of a CRS station, and will provide an overview of how these components are related to each other. It will discuss the key points we need to keep in mind while deciding on a site for the CRS; as well as when we setup the studio and production spaces. Through these discussions, this Unit will provide a broad introduction to the CRS as a whole, details of which you will study in further Units. You may require approximately 40 hours to complete this Unit.

## 5.2 Learning Outcomes

After working through this Unit, you will be able to:

- discuss various components of a CRS;
- describe the issues related to appropriate space and site selection for a CRS;
- describe how to plan the utilization of the available space for the various tasks in a CRS;
- describe the preparatory work in a studio, including acoustic treatment, soundproofing and related arrangements;
- explain the broad interactions between various technical components of a CRS.

## 5.3 The CR Station: Siting and Space Definition

Having understood the philosophy of community radio and the criteria for selection of equipment, it is now time to understand the first steps in actually setting up a CRS i.e. finding a relevant location, and dividing the available space into studio and working spaces.

### 5.3.1 Site selection

One of the most important decisions we have to take for the setting up of a CRS, from a social purpose point of view as well as a technological point of view, is where to locate it. This process is called site selection, or siting, and is based on a number of critical considerations. Let us look at some of the criteria we need to keep in mind:

*The physical location and distribution of the served community*

The core of a community radio station is its listener community, by which we mean the core group of listeners whose information needs the station will serve, and for whom it will provide a platform for expression. Given this, it is important that the station should be in a place where these community members can access it easily, and participate regularly in programme creation. In short, the station should be accessible to every member of the local community, young or old, man or woman, physically sound or differently abled. This is why the Community Radio Guidelines (2006), which lay out the regulations governing CR in India, also make it mandatory to establish the CRS within the geographical area where its potential listener community resides.

We can achieve this by first mapping where the potential listeners of the CRS stay, work and live. Once we have a clear picture of this, we must try to locate the CRS as centrally within this area as possible, so that it is roughly equidistant for all the people who live around it.

Simultaneously, we must also try to situate it in a building or space that is already familiar to the community members, and which they are likely to pass during their daily routine: near the village panchayat, say, or a community centre (if there is one). Some CR stations are set up near key crossroads within the locality, or near market places. Note that this can be a challenge where community residential spaces are clustered by caste or profession: many Indian villages are divided into caste–based and ethnicity–based sectors. It is best to place the CRS in a neutral space, where everyone can be encouraged to participate without hesitation. In keeping with our philosophy of community ownership, the station should be housed in a community donated or provided building. This way, it will become an intrinsic part of the community’s life from the outset. It will also avoid the nuisance value – not to mention financial burden–of paying rent, and being subject to the whims and fancies of a landlord. This is especially important from the point of view of transmission licensing, which locks down your transmitter location to a given physical location for the duration of the license.

*Local geography and terrain*

The second most important criterion to keep in mind is the physical layout of the land: whether it is totally flat, undulating, or whether it has a slope or a depression anywhere.

This is important because the propagation of FM, the radio transmission technology used for community radio broadcasting, is line of sight. This means the transmission can only be heard when the radio receiver set can electronically ‘see’ the transmission antenna, with no or few obstacles. This means we must choose a location for the station (and by extension, the antenna and the mast/ tower it is mounted on) which is not surrounded by tall buildings, or hidden by a hill or mountain – or situated inside a depression in the local landscape. Such obstacles will block the signal and result in no-reception (“shadow”) zones within the transmission area.

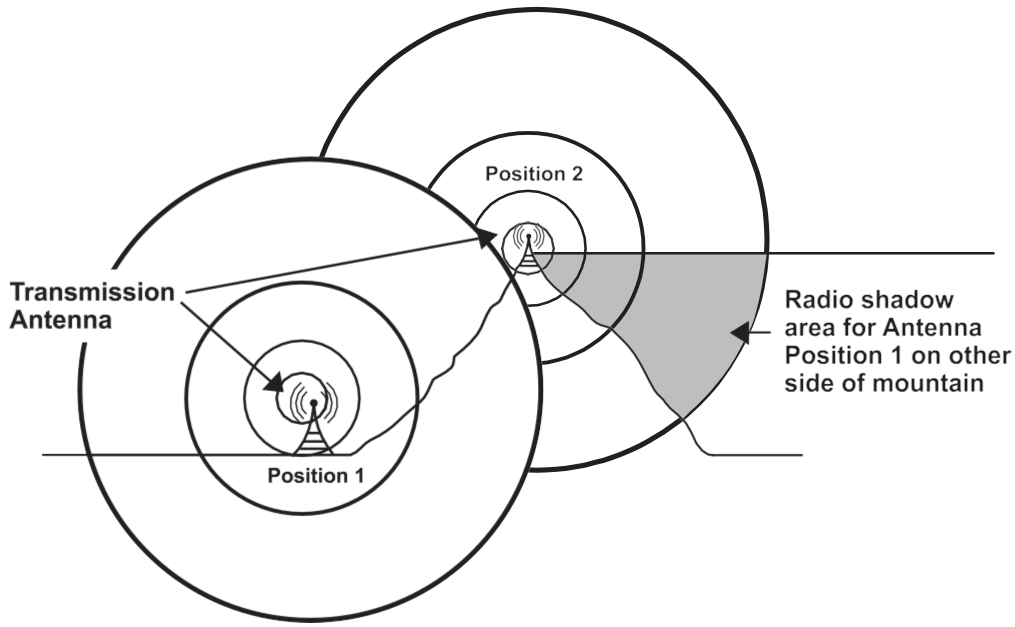



*Figure 5.1: Radio shadow zone caused by a mountain situated near the CRS. Source: CR: A User’s Guide to the Technology, N.Ramakrishnan/UNESCO, 2008*

Of course, this does not mean that we cannot use this phenomenon to our advantage on occasion: CR stations, by design and purpose, are low-output power stations, meant to reach comparatively small areas. But if our community happens to reside in a hilly or mountainous area, setting the CRS on the slope, or at the tallest accessible point in the area may well give it additional range. Just as standing on a hill gives you a vantage point for a commanding view of the surrounding area, such a site could increase your effective range, and reach a larger audience. Such considerations must not, of course, over-ride our primary consideration of accessibility and community participation – so don’t go locating the CRS at a place only a mountaineer or rock climber could access! Moreover, mounting the antenna at a height greater than 30M from the average terrain of the geographical community may pose problems in getting the technical clearance from the authorities.

*Local noise levels*

Even while we try to locate the CRS in an accessible place, as close to community life as possible, we have to try and keep ambient noise levels low. By ‘ambient noise’, we mean the general noise levels in the area. Good recording quality is dependent on having minimum background sound, unless we are trying to create a feel of the area and context. If the ambient noise levels are high, we will have to invest more effort and resources in blocking the external sound from reaching the studio. (This is called “sound proofing” the studio.) On the other hand, if we can find a site that is accessible but where the ambient noise levels are low, we will need to do comparatively little to make the studio spaces suitable for recording audio.

*Transmission signal strength*

Transmission signal strength is a measure of how powerful the Effective Radiated Power (ERP) of the transmission system is. Just as a brighter bulb illuminates a larger area, a transmission system of higher output power can reach a larger area with the signal it transmits. Another factor that affects the signal strength is the effective height of the antenna above the average terrain (EHAAT). At a purely theoretical level, some areas could benefit by an increase in EHAAT, which could overcome physical barriers or geographical factors to some extent.

At a practical level, though, the transmission strength for a CRS is limited to 100 Watts of Effective Radiated Power (ERP) by the Community Radio Guidelines (2006) issued by the Govt of India. So we cannot increase the strength of our signal output in order to reach a greater area. However, the policy guidelines do allow for increase in ERP of up to 250 Watts in special cases such as if the community is sparsely distributed in the region surrounding the proposed site; there are challenges related to broadcasting in hilly or heavily obstructed terrain. In case these conditions exist, it is possible that the station could be allowed a higher transmission output.

*The trade off between siting criteria*

While it is important to keep the four factors we have discussed above in mind, we must also be realistic in understanding that we will rarely find an ideal site that meets all these requirements at the same time. You will have to trade off all these factors against each other, and take a decision that is in the best interests and purpose of the station. Very often, you will find that the decision is only partly in your hands, since the decision may eventually have to be taken on the basis of pure convenience and the availability of adequate space. So keep these criteria in mind to the extent possible when weighing options against each other.

## 5.3.2 Space allocation

Now that we have selected a suitable site for our CRS, it is time to examine how we will divide up the space that we have into suitable work spaces. Again, it is wise to remember that CR stations often work with community donated spaces, and often without the resources to put up a building from scratch. So it requires a bit of ingenuity to adapt the ideas in this section into feasible plans.

Broadly, there are three types of spaces that a CR station needs besides the transmission set up:

a. A broadcast studio (often also called the ‘live’ studio)

b. A production studio (often also called a ’recording’ studio)

c. An office and administrative space

Let us look at these three spaces in detail.

The Broadcast studio is the primary studio space for the station. This is where the broadcast is managed from, and where the announcer or programme compere sits during the broadcast to make announcements. It is often referred to as the ‘live’ studio, because the audio from the studio floor can be played out directly over the transmission system.

The Production studio or the recording studio is the space where recordings are done for programmes that will later be edited and finished. The production studio is usually equipped with a sound booth or a recording floor where audio can be recorded in carefully controlled conditions.

The Office space or administrative area is the place where the volunteers and CRS team members can sit and work on production-related or management-related tasks. It is the space where scripts are written, records are maintained, and where visitors can make enquiries.

But, a small or medium CRS setup may actually have space for only one small studio that has to make do as the broadcast and the production studio. This can sometimes pose practical challenges to time management, because programme editing tasks may have to be suspended when the studio goes ‘live’ for broadcast. If broadcast hours for such a stadium are extended, and take up more than six hours a day, this will leave very little time for other editing work, because editing usually takes far more time than a live programme. In such cases, some CR stations dedicate one or more systems in their administrative areas for editing work when they can be spared.

Beyond these three basic spaces, if there is additional space available, the CRS could use it to set up a training hall, or a spare studio, or even a store where the equipment and recording archives can be maintained. Some CR stations develop outdoor spaces where they can conduct meetings, or hold gatherings and functions. Some have even been able to set up small kitchen spaces, so that everyone can have a cup of tea, or cook small meals as they work.

If it is feasible, it may also help to have a small enclosed area separating the entrance to the broadcast studio from the other spaces, so that you pass through two doors in order to enter the studio proper. Such a space is called a sound lock; and it serves to insulate the studio from external noise, specially when a broadcast is in progress. Opening only one door at a time keeps outside noises from filtering in.

In the next section, we will examine some sample layouts for CR station setups and we will discuss some of the special arrangements that we have to make in studios to ensure good audio quality.

## Activity 5.1

Assume that you have to set up a community radio station in the area you live in. Make a survey of the area, and identify some locations and/or existing buildings where you could possibly set up the CRS. Draw a table as given below, and award each site points to enable you to select the top three locations. Against each criterion, award the site points from 0 to 5, with 0 being 'totally unsuitable' and 5 being 'excellent'. A sample entry has been done for you to show you how to do this. Replace these numbers with the points for your site.

| Site details | Available space | Accessibility | Proximity to community gathering places | Ambient noise levels | Total |
|---|---|---|---|---|---|
| Site 1 (*Name*) | 3 | 4 | 2 | 4 | 13/20 |
| Site 2 (*Name*) | | | | | |
| Site 3 (*Name*) | | | | | |

## 5.4 Studios for CR Stations

In the previous section, we have discussed some of the common space setups and studio arrangements in a CR station. Let us now look at some possibilities in which the studios partition of CRS can be laid out.

### 5.4.1 Sample layouts

*The basic one-room CRS*

As you can see from Figure 5.2, the basic one room CRS, has single space that serves as the broadcast, recording, storage and work space. This kind of a setup

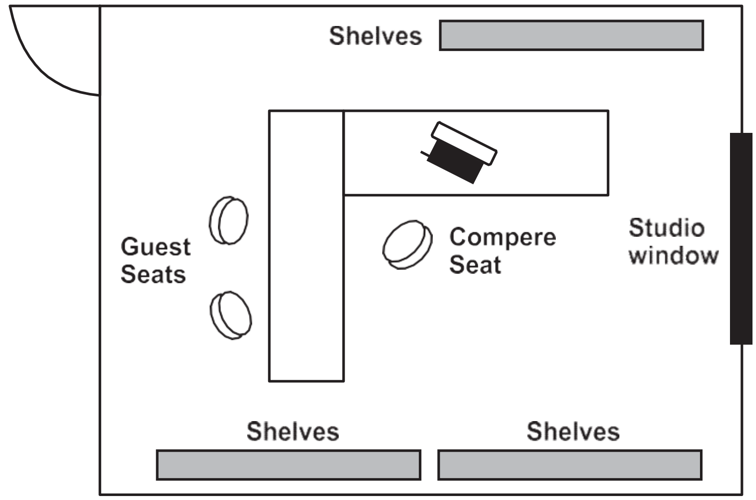



*Figure 5.2: A sample one room CRS layout Source: CR: A User's Guide to the Technology, N.Ramakrishnan/ UNESCO, 2008*

only requires a small area, and very little setup time. On the other hand, with this kind of a setup, it can sometimes be a challenge to do more than pre-recorded or talk based programming, since you may not have space in the studio to record radio drama, or groups of musicians.

*A simple 3 studio CRS*

A CRS layout that allows us the kind of space depicted in Figure 5.3 provides for a better distribution of space, and a better distribution of tasks across the spaces. Note that the door at the bottom of the schematic would lead to the remaining spaces of the station, if such spaces are available. If they are not, this may constitute the CRS in its entirety. The voice booth in the centre can be used flexibly to provide a recording floor for both the production studio on the left and the broadcast studio on the right.

*A full featured CRS: Layout 1*

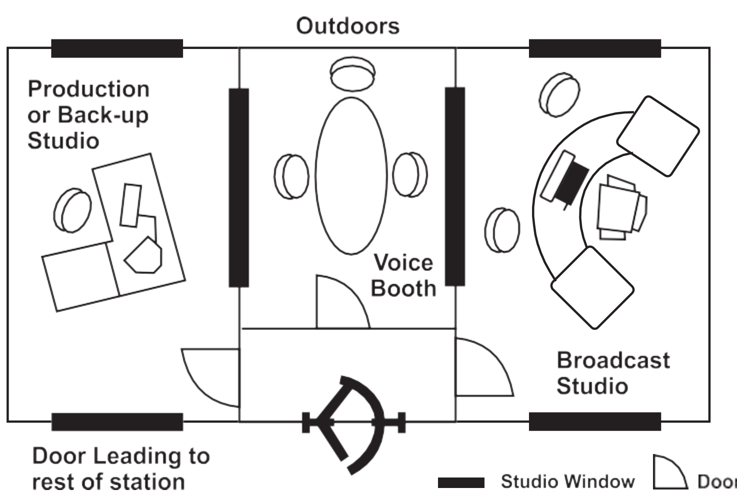



*Figure 5.3 :The three room simple CRS layout gives a little more flexibility. Source: CR: A User's Guide to the Technology: N. Ramakrishnan/ UNESCO, 2008*

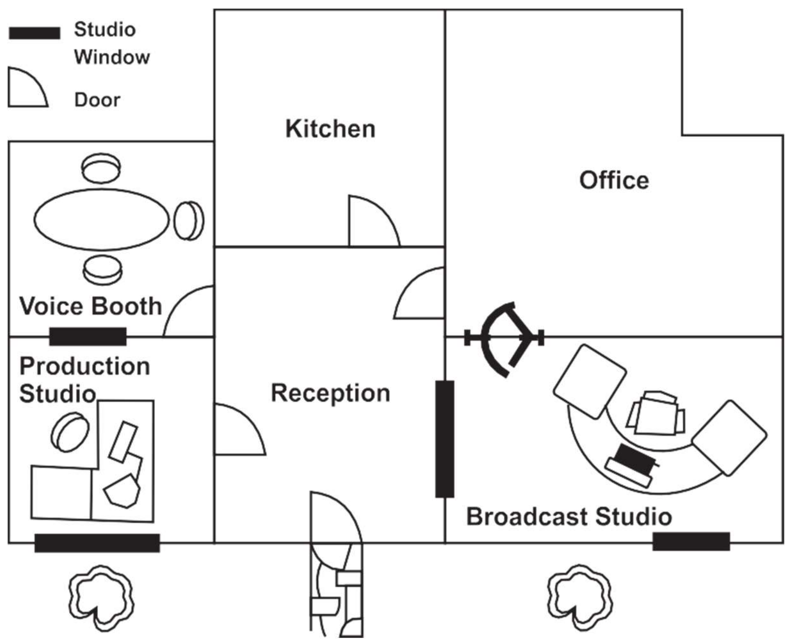



*Figure 5.4: This layout allows us to house a reception area where we can greet guests, as well as an office.*
*Source: CR: A User's Guide to the Technology, N.Ramakrishnan/UNESCO, 2008*

Where we have the space and the resources to be able to establish a more well-equipped CRS, we can set up a station that looks like the one shown in Figure 5.4, Note that we can now accommodate a formal office space, as well as a kitchen and a reception where we can seat and meet guests and visitors. Since the production studio is completely separated from the broadcast studio, programme recordings can carry on even during broadcast hours.

*A full featured CRS: Layout 2*

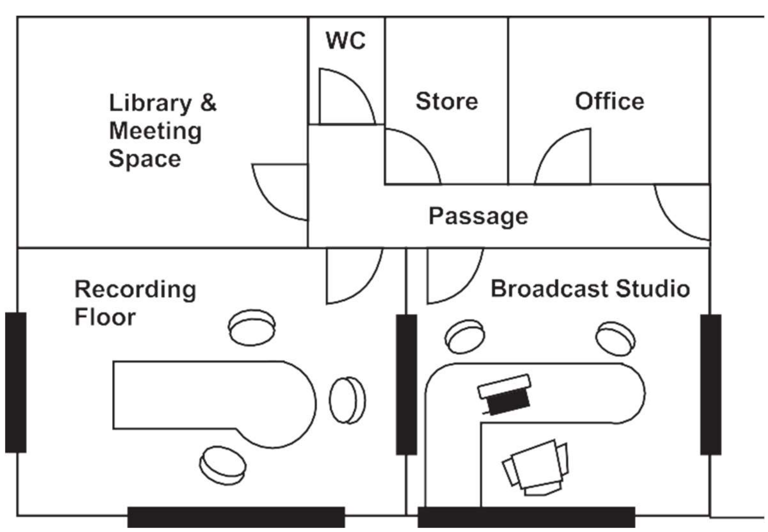



*Figure 5.5: This layout allows us to house a reception area where we can greet guests, as well as an office. Source: CR: A User's Guide to the Technology, N.Ramakrishnan/ UNESCO, 2008*

If we change our priorities slightly and dispense with the kitchen space, we can create a library and meeting/training space for the station, as well as a small store for equipment. In Figure 5.5, we have dispensed with the production studio as well – with recordings done in the broadcast studio when it is free. This may also allow us to have a slightly larger recording floor.

Hence it is important to realize that there is no 'standard' way to set up a CRS space and studios. You have to be very clear about how much space is available, and what the priorities are. While these sample layouts are meant to bring out some of the decisions you will take, on the basis of these, priorities may not be implemented as they are shown! Depending on the resources available, you may like to equip a small one room station to start with, then slowly expand the station by setting up more studio spaces, offices and editing rooms. This will allow you to start small, with comparatively less resources; and also to think about the new spaces as you set them up.

### 5.4.2 Acoustic treatment & sound proofing

*Understanding ambient sound and reverberation/echo*

In any enclosed space, recording audio faces two challenges: unwanted sounds in the background ("ambient noise"); and echo/reverberation.

Ambient noise refers to any background sound that we do not wish to have in our recording. We have already discussed the need to keep ambient noise as low as possible when selecting a station site; but this alone will not guarantee a complete absence of ambient noise. There may be other people working at the station, and there may still be the occasional noisy vehicle passing by outside, which may cause noise that ends up in the recording.

Echo and reverberation, on the other hand, are caused by sound reflecting off the walls and floor of an enclosed space. The reflected sound reaches your ears a fraction of a second after the original, making it sound a little extended, and giving it the 'hollowness' that we associate with empty rooms. (This is especially noticeable in smaller rooms – bathrooms, for instance, since the tiled walls of a bathroom provide hard surfaces that reflect the sound even more. Try singing in the bathroom and see how different it is from when you sing the same song outdoors.)

If the difference between the original sound and the reflected sound is too short for you to perceive them as separate sounds, we call the effect reverberation (or reverb, for short). If, on the other hand, the sounds are perceived distinctly, we call it an echo.

As human beings, we can learn to ignore unwanted sounds and focus on what we want to hear. In a noisy gathering, where a large number of people are talking at the same time, you can still focus on what one of those people are saying. Microphones, on the other hand, are machines, that cannot make this distinction.

Thus, if we record in a space that has high ambient noise or reverb, what you get is an indistinct ('muddy') recording that does not sound clear at all, and which is difficult to edit. It should be clear, then, that if we are to record sound 'cleanly' – that is, we would like the sound to be recorded as faithfully as possible, and with as little unwanted sound and reverb as possible, we must make some special arrangements within the studio spaces to minimize the impact of both.

*Sound proofing*

The easier of the two to address, in some ways, is the ambient noise. We have to find an effective way to block external sounds from coming into the studio. We do this with a variety of different techniques. This can be more easily done in rural areas and sparsely populated areas when compared to urban and densely populated areas.

To start with, the studio spaces should be housed in a building with thick load bearing exterior walls – 9" or more if possible. The masonry itself acts as an effective insulation against sound transmission. It also helps to have a free standing building, because there is a greater chance of sound filtering through the walls in a wall-to-wall construction, where adjoining buildings share walls.

We can also set up a set of double doors at the studio entrance, so that people entering the studio have to open the first door, close it, and then open the second door to come in. The space between the two doors then acts as an additional layer of insulation, and is called a sound lock. The doors themselves can be made of layers of plywood in a wooden frame, with glasswool or thermocol sheets sandwiched between the outer layers. This makes the door thick and sound-absorbing, but light. Rubber gasketing around the edges creates a air-tight and sound-proof seal for the doors, so that sound doesn't enter through any cracks. A glass porthole fitted in the studio doors at eye level allows people to peer in, so that they do not interrupt a running broadcast or recording.

*Figure 5.6 : A studio entrance door. Note how the door fits into the jamb against the blue gasket, making a soundproof seal. Photo courtesy: N.Ramakrishnan/ Ideosync*

Lastly, all windows in the studio area opening on the exterior – and it is a good idea to have them, since this will allow natural light to come in – should be double glazed. This means the windows should have not one, but two panes of glass, each set in a rubber or silicone gasket. Each of the glass panes should ideally be at least 5 mm thick, with a separating air space of 5-8 cm between them. The two panes should be angled slightly towards each other, so that they don't set up any internal reflection of sound between them, causing the panes to buzz.

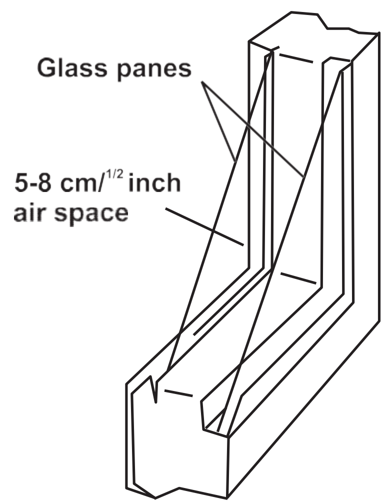



*Figure 5.7: A double glazed window: Cross Section*
*Source: CR: A User's Guide to the Technology, N.Ramakrishnan/UNESCO, 2008*

It is important to remember that sounds enter through the smallest gaps. So ensure that there are no unnoticed cracks or gaps in the studio walls, or any hidden ventilators. Any ducts or pipes passing through the space should be well grouted – that is, the gaps around it should be filled with cement or plaster of paris (POP), so that the gaps are closed.

The large window between the control room – the space where the recording is made – and the studio floor itself also needs some special attention. This is an important window, since the person doing the recording (in the control room) and the artistes or guests in the studio communicate through this window. We follow the same principle as what we saw for the exterior windows to create a double panel window with angled panes. Remember to put in some silica gel between the panes to prevent moisture from condensing between the panes, where it would be difficult to clean.

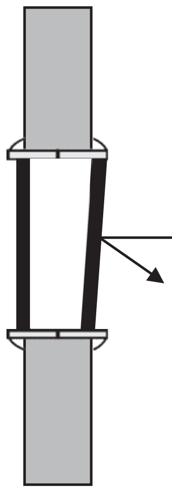



*Figure 5.8: The studio – control room partition (cross section). Note the angled pane which reflects sounds downwards and away from the source.*
*Source: CR: A User's Guide to the Technology, N.Ramakrishnan/UNESCO, 2008*

*Acoustic treatment*

Now it is time to pay attention to the techniques and materials which we will use to cut down (or "dampen") reverberation in the studio space. Some of this will be achieved by the angled window panes themselves, which will cut down sound reflection from the window spaces.

A professional grade studio uses a wooden frame over each wall, fitted with large fibreboard or corkboard tiles. The tiles are fitted over packed layers of glasswool, and each tile has variably sized holes drilled through it. Once fitted, the holes let the sound pass through, where the glasswool dampens it, and absorbs it. Other studios use angled wooden sections fitted to the walls to reflect the sound unevenly. Floors and ceilings may be mounted on absorbent materials like cork, or cushioned by spring systems or rubber runner. All these techniques are quite expensive, and are usually charged by the installers on a 'per square foot area' basis.

Community radio station budgets calls for use of local materials in an intelligent way, so that we can achieve the same purpose with less expense. Note that this does not mean compromising on the quality of acoustic treatment, or the resulting audio quality.

One way to start is to establish the studio area in a space where the walls do not exactly parallel each other on all sides: parallel walls create maximum reflections. Walls that have insets and bends can often help reduce the problem to a great extent.

A simple way to cut reverb down sharply is to attach materials to the wall and break up the hard surface. The low cost and easy way to do this is to use cardboard egg trays – the kind used by grocery shops to store eggs. Use a strong glue to paste these trays on the vertical walls and ceiling in even rows, so that the indented surfaces point inwards facing the studio. The soft papier-mâché material of the tray, along with the uneven surface give a striking reduction in audio reflection from the walls. Remember to treat the trays with a strong insecticide before you paste them on to the walls.

*Figure 5.9: Egg tray covered walls in Gurgaon Ki Awaaz CRS, Gurgaon*
*Photo courtesy: N.Ramakrishnan/Ideosync*

Some studios have successfully used sheets of cane matting hung from the ceiling in front of each wall. Others have used thick curtains on rails all around the studio space – the folds in the curtains and the materials absorb and deflect sound and the curtains can be opened selectively to reveal sections of the reflective wall in order to change the audio characteristics of the space.

While the above description has given you a fair idea about 'acoustic treatment and sound proofing', you will learn about it in detail in Module 3 under the head, "Studio Acoustics".

## Activity 5.2

Visit the following kinds of rooms, and examine the audio reflections and reverberation level in each (you may have to clap or make a sound to check):

1. A tiled bathroom;
2. A regular living room space with furniture and curtains;
3. A large hall (a marriage hall or closed canteen space);
4. An auditorium meant for music performances. Which has the most reverberation? Where do you think the reverberation will be useful, and where is it not so useful?

### 5.4.3 Other considerations

Beyond matters like the layout of the station and studios, and the sound proofing and acoustic treatment of the recording spaces, there are a few further decisions we need to take before we get around to the actual configuration of equipment within the station. Let us look briefly at some of these arrangements.

*Dust-proofing the studio*

One of the greatest challenges of working with technical equipment, especially the electronic ones in tropical countries, is the climatic and environmental conditions that the equipment has to face. And of all these conditions, the biggest enemy of equipment is dirt and dust – so much so, that a large proportion of breakdowns and maintenance issues happens simply because we do not have procedures in place to prevent dust collection.

Since the studio spaces are expected to be used by multiple individuals and members of the community, the only realistic way to keep the spaces dust-free is to encourage a sense of belonging and ownership of the space by everyone, so that keeping it neat like one's home becomes second-nature for everyone. Shoes should be left outside the main entrance – a shoe rack and a signboard there are good ideas. The rubber gaskets we discussed in Section 5.4.2, can also play a dual role: they can provide a seal that prevents dust from entering the studio, if everyone can follow the simple procedure of keeping the doors closed at all times.

Many spaces that are used by CR stations are not originally designed for use as studios and broadcast stations. As a result, they often have inconvenient windows and doors that provide multiple entry points for dust and dirt. If you are faced with this situation, replan your layout so that you minimize entry points into rooms and studios. Windows and doorways can be bricked up, or sealed with double paned glass in order to preserve the natural light. Make the station spaces as easy to clean as possible – leave as few nooks and crannies where dust can gather as possible.

*Air conditioning: Should we or shouldn't we?*

To start with, let us be clear that air conditioning a CRS is not mandatory. It may not even be necessary. If your station is housed in an old traditional building with high ceiling, or one with floors above, or in the hills or by the sea, it may already be cool enough.

However, if your station is set in a building with an exposed terrace, or in a place with a really hot climate, air conditioning may become necessary. This may be compounded by our attempts to keep dust out, as this may mean we may have blocked several natural vents for the circulation of air. Some equipment can also heat up a lot in use – transmitters, for instance, or poorly ventilated computers.

If air conditioning is necessary, the best kind are split AC units, where there is an internal blower unit, and an external compressor unit, with pipes connecting the two. These are better, because the compressor unit is noisy, and by keeping it out of the studio, we are avoiding unnecessary ambient noise. A window AC would not do, since exterior noise would come through the AC's internal mechanism into the studio. Ducted systems that cover the whole station space would be best, but are often too expensive for CR stations.

When installing a split AC within a studio, ensure that the hole in the wall where the piping and tubes go through is properly grouted and sealed. Also ensure that the compressor unit outside is installed with sufficient space around it, and off the ground. Remember that in humid conditions, water can drip from the interior unit. There should be a drainpipe leading out of the unit which is also directed outside the studio along with the other piping.

In conclusion, it may feel good to have cool air within the studio, but AC units come with their own downsides:

1. They consume a lot of power, which can mean large recurring power bills for the station. It also means that if your station is in a power poor area, the investment may not be worth it.
2. They require regular maintenance to run at peak efficiency, which means an additional task for the CRS team – not to mention servicing and maintenance costs.

## Estimating the station's AC requirements

The cooling capacity of ACs are rated in BTUs (British Thermal Units) or more usually in tons (1 ton = 12000 BTU per hour). The ton measure refers to the volume of air that can efficiently be cooled by the AC, and 1 ton, 1.5 ton and 2 ton ACs are most common.

Divide the cubic feet volume of your room by 600 to arrive at the basic tonnage capacity required.

Add 0.5 tonnes for every 10 people occupying the room at the same time.

Similarly add 0.5 tonnes for every 1500 watts of appliances or lighting present in the room (A computer would consume about 300 watts and a regular bulb, 40 to 60 watts).

Calculate the volume of your space on a similar basis for a rough estimate of the AC capacity that you need.

*Selecting appropriate studio furniture*

Installing studio equipment means, of course , that we also need to have some furniture to place our equipment on. Once again, the key concepts to remember are: hard wearing, and modular. Essentially, a CRS needs furniture which can withstand heavy use, and which we can re-order into a different pattern as per our requirements. It would also be best to have a reasonable idea of what equipment you are going to buy before finalizing the furniture, so that we can be sure that the dimensions are correct. Depending on what is more convenient, furniture can be ready-made, or made to order by a carpenter.

Office furniture is probably the easiest to set up and arrange. Plan for a couple of working desks, a few computer tables, and storage units for files, papers and stationery.

Studio furniture needs some special attention in terms of design. The traditional professional studio configuration is to have a half-moon shaped or U-shaped desk, in the middle of which the compere or recordist sits. The idea is to have all parts of the table within easy arm's reach, so that the compere can simultaneously attend to multiple devices as he or she speaks into the microphone. But given our purpose, and the low-cost philosophy, almost any furniture configuration can be put to good use.

## Keep in mind that:

- Even desks carrying various pieces of equipment should allow you at least some working space which you can use to hold notes or write on. If the desk is so covered with equipment that you cannot move for fear of knocking something off, it is hardly a practical arrangement.
- Studio chairs should be sturdy, and must not squeak or groan when sat upon. Most importantly, they should be comfortable to sit on for extended periods of time – so get the best chairs you can.
- In the control room, the furniture should be set up in such a way that the recordist can easily look through the window onto the studio floor without straining or getting up.

The studio floor itself can be kept as bare as possible, to allow it to be used flexibly. But a small round table with a couple of chairs is not a bad idea, as it will allow you to conduct interviews there. If you expect your studio floor to regularly be used for panel discussions though, by all means feel free to get a larger table that can seat four or five people.

Studios should also have plenty of shelf space for storage. You can never have enough storage! Shelves should preferably be closed, and must accommodate manuals, cables, accessories, and small ancillary equipment. Expensive items, especially those that are issued to team members on request, should be stored in locked cupboards for safety purposes.

Many modern studio equipment also come in ready– to-fit standard slotted racks. These racks are generally made to standard sizes in multiples of 44 mm (see Figure 5.9 below), allowing the stacking of recorders, patch panels and amplifiers, and making space-use more efficient.

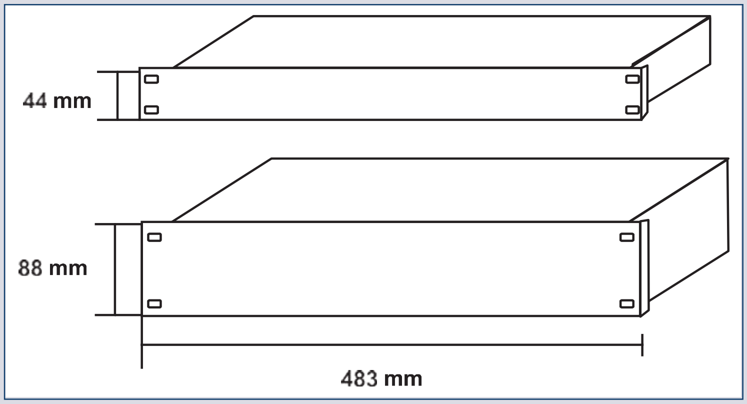



*Figure 5.9: Standard rack mount panels. These can be used to mount CD players and amplifiers vertically one above the other.*
*Source: CR: A User's Guide to the Technology, N.Ramakrishnan/UNESCO, 2008*

Always keep in mind that with imaginative use of furniture, you can easily obtain a far better alternative than buying a great deal of expensive furniture. Good planning, and a sensible carpenter go a long way in terms of making the best use of limited space!

## Activity 5.3

Of the possible sites and spaces that you have identified in activity 5.1, select the best option as per the parameters in that activity. Now draw a plan of the existing structure there, and plan how you would adapt the spaces in order to establish a CRS in that space. Pay special attention to:

1. Creating studio space(s)
2. Creating a small work or office space
3. Existing doors and windows you may need to brick-up or double glaze
4. New windows, walls or access doors you may need to create.

## 5.5 Equipment for CR (schematic level only)

Now that we have learnt how to plan the layout and preparation of the CR stations' various work areas and studios, it is time for us to become familiar with the actual equipment in a CR station.

In this section, we will understand the basic categorization of the various pieces of equipment. We will also see a schematic layout of how the various components connect to each other. In later Units, you will get a detailed understanding of each piece of equipment, its various types, and its functions.

### 5.5.1 An overview of the programme production process

Before we move on to looking at the equipment, we need to understand the process by which a programme is made. This will help us understand the specific purpose of each piece of equipment, and the part it plays in our community radio station.

The process of making a programme is divided into four broad processes:

1. Pre-production: This is the preparatory phase, and includes the time spent on research, scriptwriting, scheduling of recordings, logistical arrangements and so on. This is the least technology based part of the process, as it is mostly about designing the creative inputs for the programme.

2. Production: This includes the actual process of recording the programme, in the field and in the studio. 'Recording' means the act of capturing the audio and storing it in a retrievable fashion on a computer, or SD card or cassette. 'Field recording' means all the portions of the programme that are recorded outside the studio, and usually on battery-operated portable recording units (field recorders). 'Studio recording' refers to all the recording that is conducted within the studio space. Production may be conducted in phases, over several days.
3. Post-production: This is the process of reviewing our recorded content, and editing it into a final programme which includes the various components that we have planned: music, sound effects, interviews, narration and so on. Editing is the process of collating the components in the correct order, as they will appear in the final programme – as well as a process of removing the parts we do not consider necessary. It is usually done on computerized editing systems, using software designed for the task.
4. Mixing and Mastering: This is the process of finalizing the programme, and includes adjusting the audio levels so that they are even throughout the programme ('mixing') and the export of a single, seamless programme from the various components we have stitched together while editing ('mastering').

## 5.5.2 A schematic overview of a field recording setup

Field recording equipment typically consists of a setup like this:

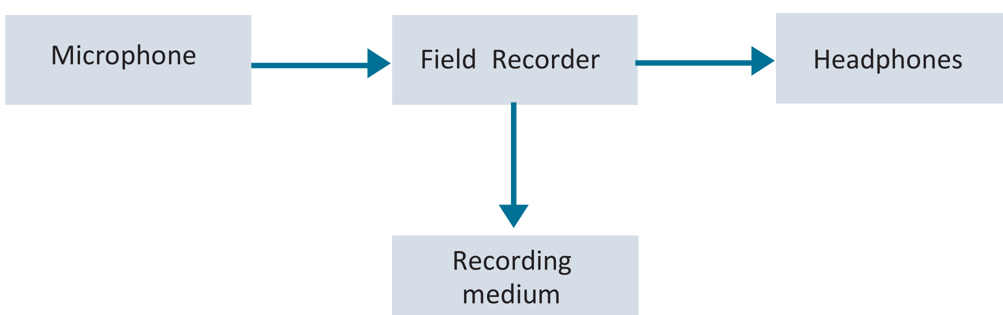



*Figure 5.10: An overview of field recording equipment. The direction of the arrows shows you the direction in which the audio is flowing.*

As you can see from Figure 5.10, the kit usually consists of a microphone; a field recording unit; headphones to listen to the audio as we record it; and a recording medium (also called a storage medium), something we store the recorded audio on. It could be cassettes; digital storage media, like flash memory; or optical media like CDs or DVDs. The direction of the arrows indicates the signal flow.

### 5.5.3 A schematic overview of the production studio

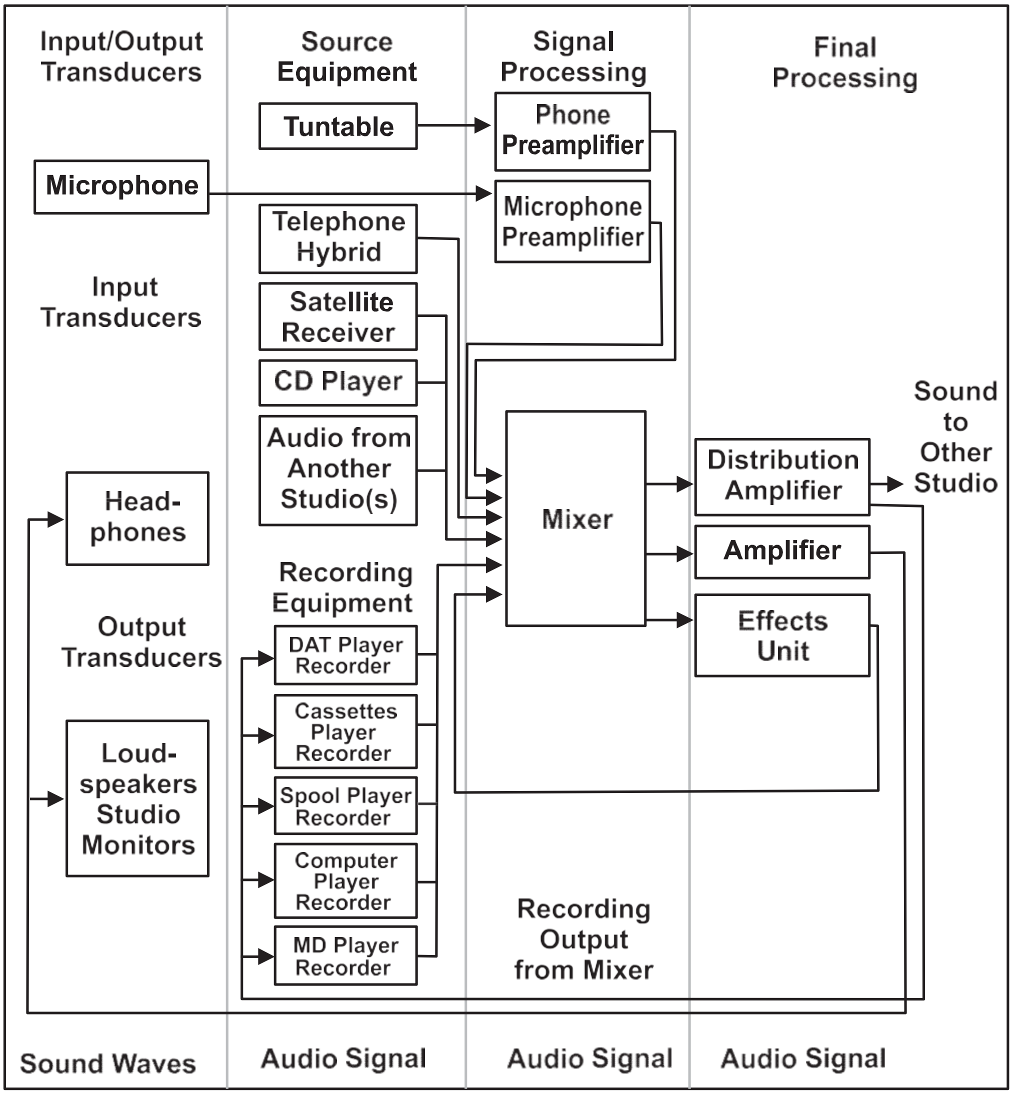



*Figure 5.11: A schematic overview of the production studio*

As we have noted in a previous section, a production studio is a studio setup where we can record programmes and edit them, but which is not connected directly to the transmission or broadcast system.

Within this setup, the equipment falls into six broad categories:

1. Input transducers: This covers all the equipment that converts the sounds we want to record into electrical signals that can be recorded. In practical terms, this includes all the variety of microphones we use to record audio in the studio.

2. Audio source units: This covers all the equipment that we can play recorded audio content from in order to incorporate it into our programme. This includes: CD players, computers, cassette decks, LP turntables, MiniDisc players, and solid state players.
3. Signal processing and management units: This includes all the equipment we could use to combine or modify the audio signal that we are generating in the studio. Of these, the most important is the mixer unit, which lets us control the relative levels of various audio streams, and combine them into one consolidated output. It could also include any pre-amplifier units that we may use to boost signals from a telephone connection or from the microphones before we feed it into the mixer unit.
4. Final processing units: This includes amplifier units that lets us forward the signal to other studios; effects units that lets us add effects to the audio; and distribution amplifiers that lets us split the output audio for recording on multiple devices at one time – or for monitoring on headphones or speaker units.
5. Recording units: This includes any devices that we use to record the finalized audio, and includes computers (or Digital Audio Workstations – DAWs); MD (MiniDisc) or Digital Audio tape recorders; or flash based digital recorders, which record on SD (Secure Digital) cards or CF (Compact Flash) cards. Computer based recording systems are the most common nowadays, since the DAW also lets us do the editing function on the same unit.
6. Output transducers: This includes all the devices we use to listen to the audio that is being generated. It includes headphone units; as well as speaker ("monitor") units.

Look at the diagram in Figure 5.11 carefully to understand how all these components are interconnected, and how the signal flow is achieved. The diagram also shows you what form the audio is in at a given stage: Whether it is still in the form of sound waves, or whether it is in the form of an electrical signal.

## 5.5.4 A schematic overview of the broadcast studio

As we have noted in a previous section, a broadcast studio is a studio setup from where we can conduct programmes that can go live on air; or from which we can playback pre-recorded programmes for transmission. In some cases, the broadcast studio also includes facilities for recording and editing programmes – and in many small stations, there is only one studio which doubles as a production and broadcast studio.

Examine the diagram in Figure 5.12.

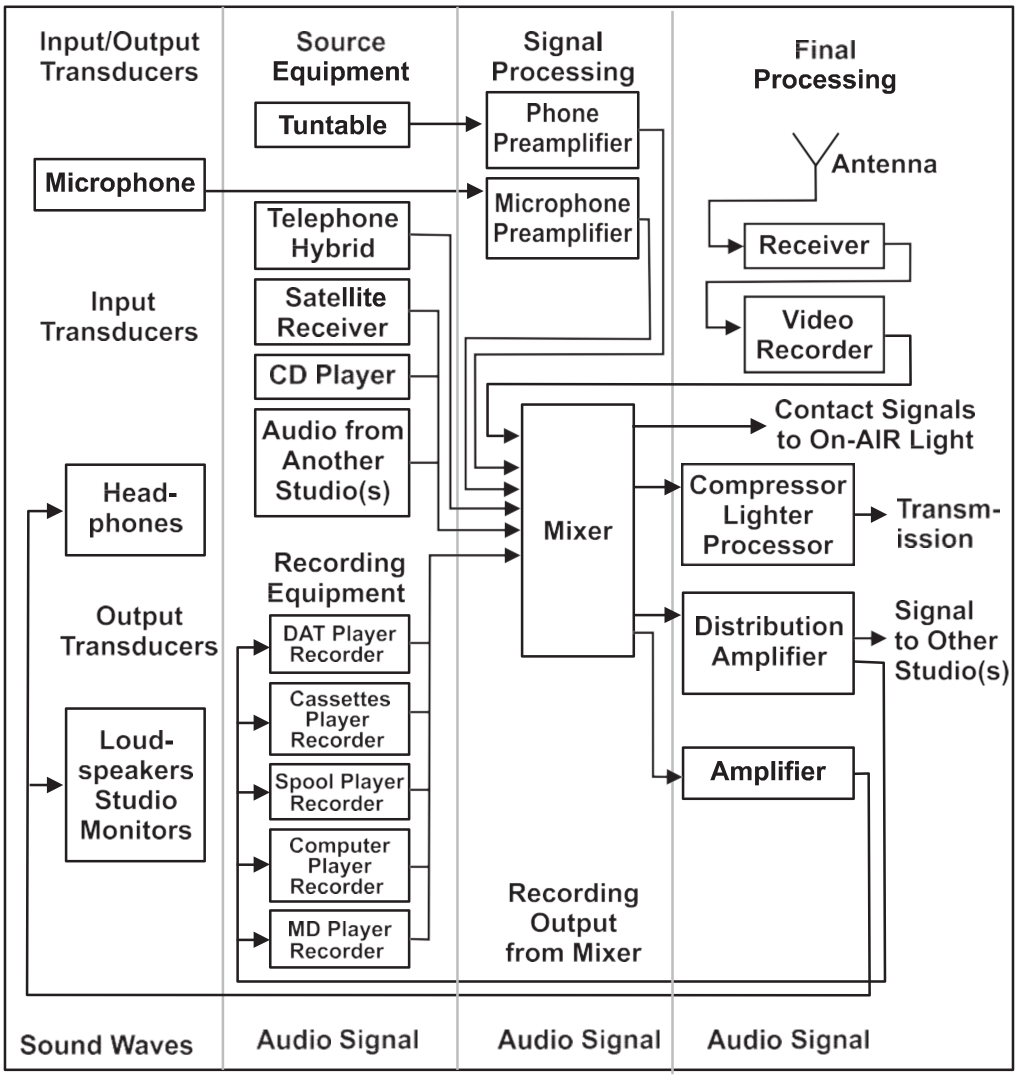



*Figure 5.12: A schematic overview of the broadcast studio*

As you will notice, the basic structure of the devices is very similar to what you saw in the production studio. We have the same input transducers, audio sources, signal processing & management devices, final processing devices, and output transducers. We have only two principal additions in the broadcast studio over the production studio viz. a Compressor/Limiter and feed going to the transmitter.

The Compressor/Limiter is a device that limits the signal when it goes beyond a fixed level; and compresses the audio that exceeds this limit, by squashing it back into the defined limit. These are comparatively rare in CR stations, and are more commonly found in commercial radio stations.

Finally, there is a seventh category of equipment viz., Transmission equipment which transmits the programme on the assigned frequency of the station via the co-axial cable and the antenna. Within the studio, this usually means the transmitter unit, which actually does this task.

### 5.5.5 A schematic overview of the transmission setup

At this point, it is also worth looking briefly at the components of the transmission system itself.

Look at the diagram in Figure 5.13. As you can see, the audio signal from the broadcast mixer unit undergoes final processing, and is then fed through the Studio-Transmitter Link (STL) to the transmitter unit in case the studio and transmitter are not co-located. At most of the Community Radio Stations, however, Studio and Transmitter are co-located. As such ST Link is not required in most of the cases. The transmitter device generates the carrier radio wave, and combines the audio with the carrier so generated before sending it to the antenna unit. The process of combining the audio with the carrier is known as modulation, more details about which are given in Section 6.4.2.

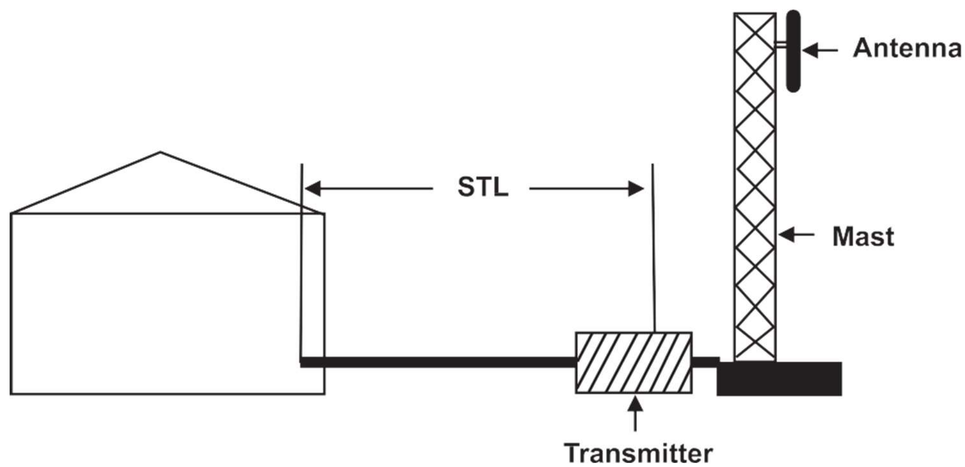



*Figure 5.13: A schematic overview of the transmission setup*

The signal reaches the antenna through the antenna cable, and is then dispersed into the air by the antenna, which is usually mounted on top of a tower or mast. This is shown in Figure 5.14.

At the reception or listener's end, this combined radio signal is received by the radio set, which carries its own little antenna to pick up the radio wave in question. Within the radio set, the radio wave is filtered out, and the audio signal stripped out. This is then fed to the speaker unit on the radio, from where we hear the original audio waves as shown in the second figure of Figure 5.14.

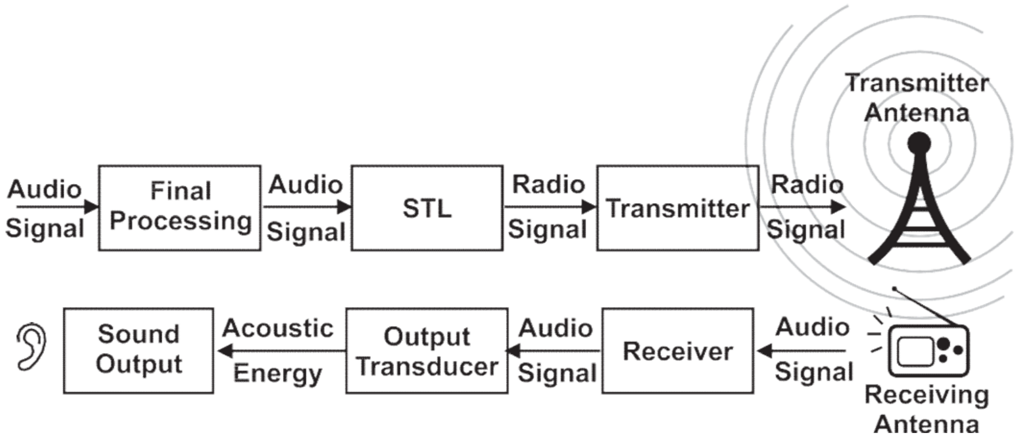
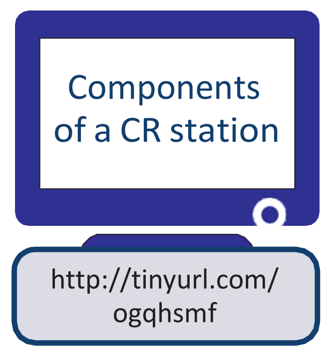



*Figure 5.14: Transmission: From studio to antenna*

## 5.6 Setting up a CRS: Activity and Video




Now that you have a good understanding of the components of a CR station, please see the video titled 'Components of a CR station', which is available at the Youtube site of CEMCA http://tinyurl.com/ogqhsmf.

The video provides you knowledge on the suitable location, studio design and walkthrough of a working CR station (Must Radio, Mumbai). In this video, you will examine the spaces used by the CRS; the studio designs; the acoustic treatment used; and the equipment the CRS is using. You will also see the CR station's transmission setup, including its mast, and the broadcast antenna. You will also see some animation based explanations of some of the key concepts that you have learnt.

Once you have viewed the video, complete the activity below.

### Activity 5.4

With reference to the CRS that you saw in the video study material, write:

1. Three key features of the station that you feel would be appropriate for a CRS in your area;
2. Three key features of the station that you feel would NOT be appropriate for your area.

With each feature, write a short explanation of why you consider this feature appropriate or inappropriate.

## 5.7 Let Us Sum Up

This unit focused on the key decisions we have to take while choosing a location for a CRS, as well as on planning how to divide the available space into working spaces for the station. It also talked about the advantages and disadvantages of some sample layouts presented in the unit, along with the ancillary considerations (air-conditioning, furniture choice, acoustic treatment, soundproofing) that we must keep in mind.

We have also seen overviews of the field recording setup; the production studio; the broadcast studio; and the transmission system. We are also sure that you have understood the process of how the transmitted signal reaches the receiver/listener; and the process of programme production (pre-production, production, post-production, mixing and mastering).

Finally, we viewed a walk-through video of an actual CRS, and understood the practical application of many of these concepts.

## 5.8 Model Answers to Activities

### Activity 5.1

A sample entry has already been completed for you in the table shown in the activity. Use that as a model to frame the rest of your entries.

### Activity 5.2

The spaces with the least reverberations are the living room space and the large hall.

The spaces with the greatest reverbs are the tiled bathroom and the auditorium. The tiled bathroom's reverb is uncontrolled, since it is not designed as a space for audio. The auditorium's reverb is more controlled, since the hall has been designed to control and emphasize the reverb of certain kinds of reverb – typically, vocalists and instrumentalists on the stage.

## Activity 5.3

Since the space that you will redesign in this activity is something you will select from a real location, there is no standard answer that can be presented here. Remember that your diagram/plan should look something like those given in Figures 5.2 – 5.5, and must clearly show what you intend to change and how.

## Activity 5.4

Note: This exercise is based on your practical exposure of a community radio station. Please go through the Video available in the CEMCA's YouTube site and then try to answer from yourself.

# UNIT 6

# Radio Waves and Spectrum

## Structure

6.1 Introduction

6.2 Learning Outcomes

6.3 Electromagnetic Spectrum and Radio Waves

6.3.1 Basic characteristics: amplitude, frequency and wavelength

6.3.2 Radiant energy and the electromagnetic spectrum

6.3.3 The radio spectrum

6.4 Frequency Bands for Radio Broadcasting

6.4.1 Medium Wave (MW) and ShortWave (SW)

6.4.2 Amplitude Modulation (AM) and Frequency Modulation (FM)

6.5 A Brief History of Radio Broadcasting

6.5.1 The international experience

6.5.2 Radio Broadcasting in India

6.6 Regulatory Authorities and Processes

6.7 Let Us Sum Up

6.8 Model Answers to Activities

## 6.1 Introduction

In previous Units, we discussed a range of issues relating to community radio. These issues were about the philosophy guiding the concept of community owned and community managed media; the policies governing the establishment of community radio stations in India; the factors we need to keep in mind while deciding a location for the station; and the various considerations we need to address while designing and setting up a CRS.

It is now time to take a pause and look at a fresh set of basics to sharpen our understanding further: what are radio waves, and where do they come from? How does the process of radio broadcast actually happen? When did it start? In this Unit, you will learn about the science behind radio broadcasting, and the natural phenomenon of electromagnetism. You will also learn about how the usage of radio waves are governed in this country. For studying this Unit, including working on the various Activities, you may need around 40 hours of study.

## 6.2 Learning Outcomes

After working through this Unit, you will be able to:

- discuss radio waves and their implications for CR.
- explain the broadcasting spectrum for radio.
- describe different frequencies of operation of radio broadcasting.
- analyze issues related to regulation of radio waves, spectrum and frequency.

## 6.3 Electromagnetic Spectrum and Radio Waves

Before we begin to understand what radio broadcasting is all about, and how this process takes place, it is important that we first understand some fundamental facts and measures related to the science behind radio broadcasting. For this, we must go back to some of the basic physical properties of waves, energy and radiation.

### 6.3.1 Basic characteristics: Amplitude, Frequency and Wavelength

You must all have thrown a pebble into a pool or puddle of water at some point in your lives. What happens? The stone causes a series of ripples that start at the point where the stone hits water, and spreads out in concentric circles or rings


from that point outwards. Simply put, the energy which the flying pebble possessed at the moment it hit the water surface, has been converted into the up and down movement ('oscillation') of the water particles, which have now formed WAVES. Hope you are now able to visualise the concept of waves. Here, you can watch a small video, which will help you to understand the concept of waves more clearly. Please visit at http://tinyurl.com/p5kykyc for the video titled 'Introduction to Radio Waves'.

So a 'wave' is an up-and-down or side-to-side movement of the particles in a medium. We usually represent waves graphically as given in Figure.6.1.

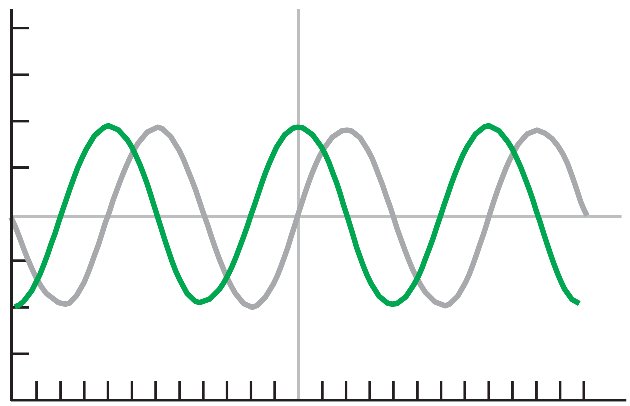


*Figure 6.1: Waves: Shape and propagation.*

Note that the green waveform represents the wave when it starts. The grey waveform shows the same wave an instant later, when it has 'moved' to the right.

There are three key qualities of a wave that we must become familiar with. These are:

1. Amplitude: This is the difference between the highest ('peak') and the lowest portion ('trough') of a wave, and is a measure of the strength of the wave. The larger the amplitude, the higher the energy of the wave, and the greater the distance it will travel. In terms of sound waves or audio waves, the larger the amplitude, the louder the sound. The concept of amplitude and frequency is illustrated in Figure 6.2.

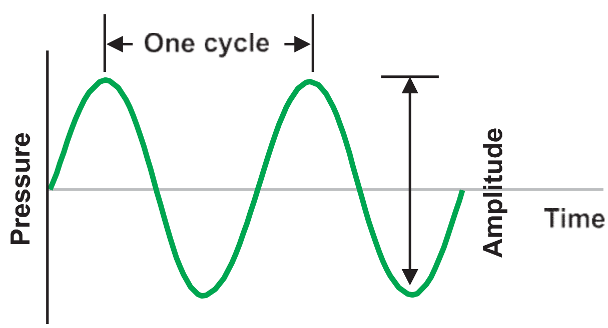



*Figure 6.2: The amplitude of a wave / One 'cycle'*

2. Frequency: Frequency refers to the number of waves that pass through a given point in space every second as shown in Figure 6.3.

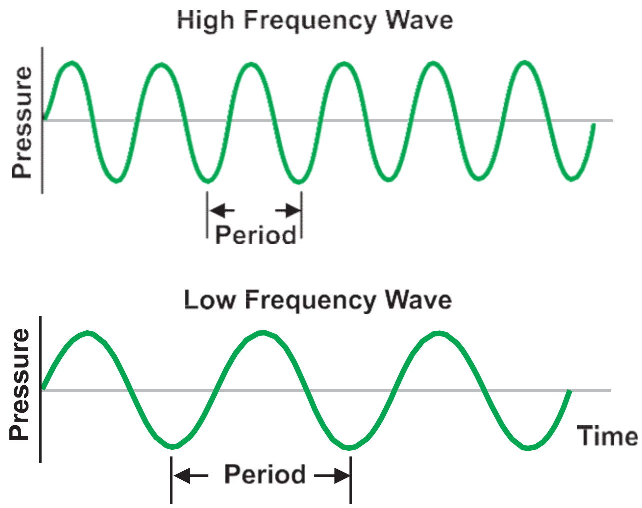



*Figure 6.3: High frequency and low frequency waves*

If you look at the diagram in Figure 6.3, the wave on top has a greater number of cycles within the same distance as compared to the lower wave. Thus, you will see that if we choose any one point on the horizontal line, and imagine both waves moving to the right at the same speed, more cycles of the wave on top will have passed that point after one second than for the lower wave. The upper wave could thus be said to have a 'higher frequency' and the lower wave a 'lower frequency'.

Frequency is measured in Hertz (Hz). One Hertz (1 Hz) corresponds to one cycle crossing at a given point in space every second. (By extension, a wave with a frequency of 100 Hz would have a 100 cycles pass that point every second.)

3. Wavelength: Wavelength refers to the distance between two successive waves, as shown in Figure 6.4.

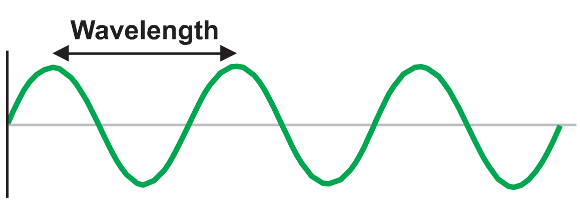



*Figure 6.4: Wavelength of a wave*

This distance can be measured as the difference between two adjoining peaks, or two adjoining troughs.

Frequency and wavelength have an inverse relationship, which means the greater the frequency of a wave, the shorter the wavelength; and vice-versa.

## 6.3.2 Radiant energy and Electromagnetic Spectrum

Have you ever stood in the sunlight and felt its warmth on your skin and face? But the Sun is a ball of hot gas millions of kilometres away from us, across the vast empiness of space. How could its heat reach us across this vast distance and through a vacuum?

The answer is that every object gives off energy in various ways. Objects at a higher temperature give off more energy and objects at a lower temperature give off less. The Sun, being a superhot ball of gas where nuclear reactions are going on continuously, gives off energy in a number of different ways. This 'giving off' of energy is called radiation; and the energy so given off is termed radiant energy.

Radiant energy could be in the form of light, or heat, both of which we can immediately sense with our eyes and our skin respectively. Then again, it could be in the form of such waves that we cannot see or hear, or even feel directly with our limited senses, but which can be detected by devices that we build. One example is X-Rays, the invisble rays that are used by medical science to look through skin and flesh to see parts of our skeleton. Together, all these kinds of radiant energy are often called Electromagnetic Wave Radiation, since the energy is actually radiated in the form of waves, and has properties linked to both, electricity and magnetism. (Electricity is the phenomenon of the flow of charged particles from one point to another in a conducting medium, such as a copper wire; and magnetism is the phenomenon whereby some material can attract or repel other objects.)

Waves in water, or sound in air are both examples of waves which need a medium to travel through: water and air, respectively. Electromagnetic wave radiation, on the other hand, can travel across vacuum, without any medium. (They may, however, be impeded or affected by any electric or magnetic material or conductors in their path.)

Unlike water or air, which can move physically – up and down or side to side – when set in motion, electromagnetic wave radiation does not physically move any particles. Rather, an electromagnetic wave may be understood as the change in the levels of electromagnetic charge in a given point in space over a period of time.

All electromagnetic waves travel at the speed of light in a vacuum. The speed of light is a constant 299,792,498 metres per second – which is very fast indeed! For all practical purposes, over short and medium ranges, this is almost instantaneous, which is why even if a bulb is switched on a long distance away, you see it immediately – because the time taken for the light to reach you is so short that you cannot perceive the gap.

Electromagnetic wave radiation is mostly classified on the basis of the frequency of the waves that are radiated. They range from comparatively low frequency waves (in the KiloHertz or thousands of Hertz range) to comparatively high frequency waves (in the GigaHertz – or millions of Hertz – and TeraHertz – or billions of Hertz, or higher range). Together, all the frequencies of electromagnetic waves are called the electromagnetic spectrum.

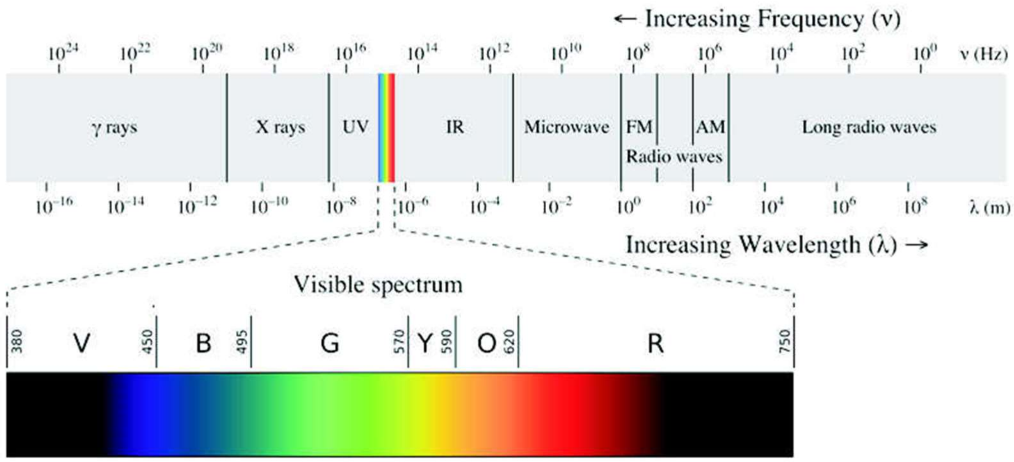



*Figure 6.5: The electromagnetic spectrum, with inset showing visible light. Note the direction of increasing frequency of the electromagnetic waves.*

As you can see from Figure 6.5, Visible light forms one part of the electromagnetic spectrum which is perceivable by us with our eyes. This portion of the electromagnetic spectrum is, appropriately, called the visible spectrum, and is composed of the familiar colours Violet, Indigo, Blue, Green, Yellow, Orange and Red (known by the acronym VIBGYOR), which we see in a rainbow; or when sunlight is split by a prism. In the visible spectrum, red is at the lower frequency end, and violet at the higher frequency end. Above the blue end of visible light – that is at higher frequencies than blue light – lie Ultraviolet Rays, X-Rays and Gamma Rays. Below the red end – that is, at lower frequencies than red light – lie Infra Red Rays, Micro Waves and Radio Waves.

## 6.3.3 The Radio Spectrum

Radio waves are those electromagnetic waves that typically fall within the 3 Kilohertz (kHz) and 300 Gigahertz (GHz) range of frequencies.

They can occur naturally – the Sun and other astronomical bodies, as well as lightning are sources of radio waves. Radio waves are used for location beacons, and to generate direction signals for radio location. They are also used for broadcasting, which means producing them by artificial means, so that they can carry an audio signal of our choice to a distant place.

The following table (sourced from Wikipedia) shows the entire gamut of radio frequencies and how they are categorized.

| DESCRIPTION OF RADIO WAVE BAND | FREQUENCY RANGE |
|---|---|
| Extremely Low Frequency (ELF) | 3 Hz/100 mm – 30 Hz/10 mm |
| Super Low Frequency (SLF) | 30 Hz/10 mm – 300 Hz/1 mm |
| Ultra Low Frequency (ULF) | 300 Hz/1 mm – 3 kHz/100 km |
| Very Low Frequency (VLF) | 3 kHz/100 km – 30 kHz/10 km |
| Low Frequency (LF) | 30 kHz/10 km – 300 kHz/1 km |
| Medium Frequency (MF) | 300 kHz/1 km – 3 MHz/100 m |
| High Frequency (HF) | 3 MHz/100 m – 30 MHz/10 m |
| Very High Frequency(VHF) | 30 MHz/10 m – 300 MHz/1 m |
| Ultra High Frequency (UHF) | 300 MHz/1 m – 3 GHz/100 mm |
| Super High Frequency (SHF) | 3 GHz/100 mm – 30 GHz/10 mm |
| Extremely High Frequency (EHF) | 30 GHz/10 mm – 300 GHz/1 mm |
| Tremendously High Frequency (THF) | 300 GHz/1 mm – 3 THz/0.1 m |

Different frequencies of radio waves have different propagation characteristics in the Earth's atmosphere. Longer waves may cover a part of the Earth very consistently through ground wave propagation. Shorter waves can reflect off the ionospheric magnetic layer of the atmosphere, and travel around the world. Much shorter wavelengths bend or reflect very little and travel on a line of sight.

Different parts of the radio spectrum are used for different radio transmission technologies and applications. Radio spectrum is typically government regulated in developed countries and, in some cases, is sold or licensed to operators of private radio transmission systems (for example, cellular telephone operators or broadcast radio and television stations). Ranges of allocated frequencies are often referred to by their provisioned use (for example, 'cellular spectrum' or 'television spectrum'). Some parts of the radio spectrum are unlicensed – for example, the frequencies used for Wireless Fidelity or WiFi internet, or Citizen Band (CB) radio. Cordless telephones also use an unlicensed part of the radio spectrum.

## Activity 6.1

Visit an office that has a WiFi connection. If there is no such office nearby, you can visit a store that stocks router and computer equipment. Examine the WiFi router available, and check the radio frequency range used by it. Note the name of the router, the WiFi band it is using (802.11b, g or n), and the frequency range.

## 6.4 Frequency Bands for Radio Broadcasting

For practical reasons, radio spectrum is subdivided into smaller sections called Bands, which are further subdivided into specific frequencies called channels. Each of the ranges you see in the table above is actually a Band (VHF Band, UHF Band, and so on).

By international convention, certain bands have been reserved for certain kinds of broadcasting, as we have noted previously. In this section, we will understand the primary bands assigned for radio broadcasting globally.

### 6.4.1 Medium Wave (MW) and Shortwave (SW)

In most countries across the world including India, the band between 535 kHz and 1605 kHz is reserved for Medium Wave radio broadcasting. Medium Wave is often shortened to MW, the letters you see on a radio tuner dial. 'Medium Waves' refers to the size or wavelength of the corresponding radio waves, which range from 560 metres to 187 metres. (This means each wave in a medium radio wave is 187 metres or more in length – upto a maximum of more than half a kilometre!)

One of the key characteristics of medium waves is that their principal mode of propagation is through ground and they follow the curvature of the ground well. They can also get reflected from the atmosphere's ionosphere at night allowing medium-to-long-range broadcasting. Some of the countries of the world are using medium wave transmitters upto 2000 Watts (2 MW) power, covering a range of several hundred kilometres radius. MW transmissions, however, suffer from night time shrinkage of service because of interference from sky wave signal, which is otherwise absent in daytime. All India Radio is making use of the Medium Wave band for its domestic broadcasting and also for service to neighbouring countries with transmitters ranging from 1 KW to 1000 KW.

Shortwave as a medium of radio communication received its name because the wavelengths in this band are shorter than 200 m (1500 kHz) which marked the original upper limit of the medium frequency band first used for radio communications. Short wave is also known as HF (High Frequency) that covers the range of 3-30 MHz for radio broadcasting.

Initially thought to be useless, shortwave radio is used for long distance communication by means of reflection from the ionosphere. This mode of propagation is also known as skywave or skip propagation, allowing communication around the curve of the Earth. It is therefore mostly used for international broadcasts by various countries including India. In India, however, Shortwave (HF) is also used for supplementing its domestic MW services by virtue of special dispensation given to it by being a tropical country.

Medium Wave and Shortwave broadcasting is conducted in Amplitude Modulation (AM), regarding which you will read more in the section below.

## 6.4.2 Amplitude Modulation (AM) & Frequency Modulation (FM)

Radio broadcasting can be categorized not only on the basis of the frequency bands that are used, but also by the precise method used for creating the radio signal. Let us understand this in greater detail.

As we have understood in a previous section, radio broadcasting is achieved by combining the source audio (the audio signal) with a radio carrier wave. A signal is any electronic stream that carries information. A carrier wave, as the name suggests, is a high frequency radio wave on which the audio signal can be mounted, or with which, you can say, it can be combined, in order to carry the audio signal much further than it would otherwise go. (Just as having a vehicle can let you travel comfortably over larger distances, the carrier wave carries the audio signal over a greater distance owing to its higher energy and greater capacity to travel over a distance without being dissipated). The process of combination of the carrier wave with the audio signal is called modulation of the carrier wave.

One of the ways in which this can be done is through amplitude modulation or AM. In AM, the modulation of the carrier wave results in the creation of a wave with the frequency characteristics of the radio wave, but whose amplitude varies according to the audio signal.

Consider the diagrams in Figure 6.6:

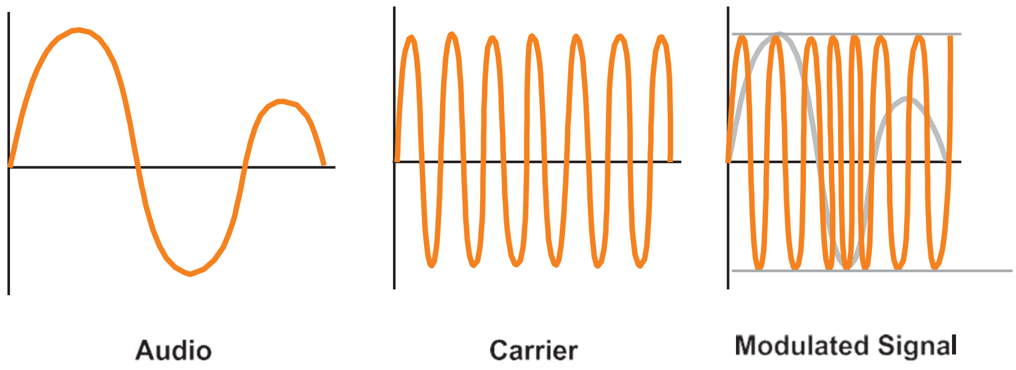



*Figure 6.6: Amplitude Modulation. Note the shape of the final output wave.*

As you can see, the output radio signal continues to have the carrier wave's frequency, but now has an amplitude variation that resembles the original audio. AM broadcasting continues to be the modulation technology used for MW and SW radio broadcasting.

The key challenge of AM broadcasting is that it is easily disturbed by natural phenomena like lightning, or by the sparkplugs from motor cars; or even high tension electrical cables, which generate strong magnetic fields around themselves.

Frequency Modulation, or FM, was a modulation technology that was developed subsequent to the invention of AM. In the case of FM, the modulated wave continues to have the same amplitude as the original carrier wave, but now has variations in frequency that correspond to the frequencies of the audio signal, as shown in Figure 6.7. You will learn more in detail about Frequency Modulation in Module-7, Unit 23.

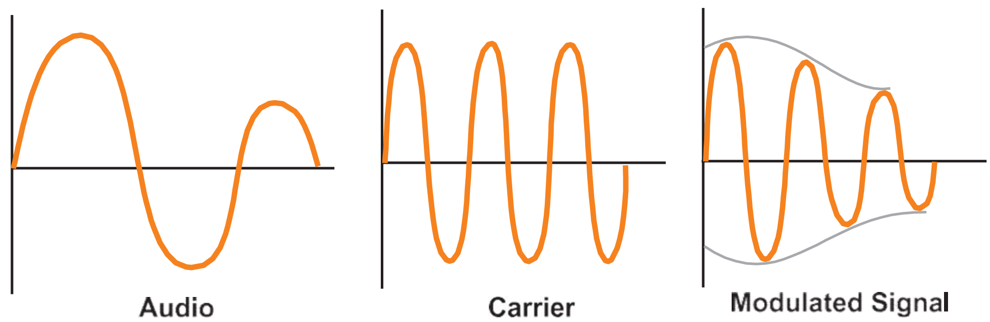



*Figure 6.7: Frequency Modulation. Note the varying frequency of the final output wave.*

Frequency modulation provides excellent high fidelity audio, and the ability to broadcast stereo audio – discrete signals for the left and right speakers – with comparatively few complications. It is also not disturbed by atmospheric or electrical phenomena, making it well suited to urban broadcasting. The advantages of FM over MW (AM) have already been given in Module-1. It is because of those advantages that it has been chosen for Community Radio. FM broadcasting is primarily a line of sight (LOS) propagation, although propagation also takes place beyond LOS by means of diffraction, scatter and ducting. You will learn more about frequency modulation and radio propagation in Module-7, Units 23 & 26. However, the summary of various modes is given below:

| AMPLITUDE MODULATION ( AM) | | | |
|---|---|---|---|
| Mode<br>MF/MW | Total Band<br>300-3000 KHz | B'casting Band<br>526.5-1606.5 KHz | Propagation Ground wave (Day & Night)<br>Sky wave (Night) |
| HF/SW | 3-30MHz | 3-30 MHz | Sky wave ( Day & Night) |
| FREQUENCY MODULATION ( FM) | | | |
| Mode<br>VHF | Total Band<br>30-300 KHz | B'casting Band<br>40-230 MHz<br>FM Band<br>87-108 MHz | Propagation<br>Direct wave with ground reflected wave upto L.O.S. Diffraction, Scatter and Ducting beyond L.O.S. |

## Activity 6.2

Compile a list of all the radio stations that can be heard in your area. Present them as a table divided by type of modulation: FM and AM. Within AM, indicate if the station is MW or SW (if available). Include the frequency of broadcast for each channel.

## 6.5 A Brief History of Radio Broadcasting

Before we conclude this Unit, it is now time to take a quick look at the history of radio and radio broadcasting a part of which you have already learnt in Unit-1.

### 6.5.1 The International Experience

Radio waves were first predicted by the British physicist James Clerk Maxwell as part of his calculations on the wave theory of electromagnetism in 1865. Maxwell suggested that light and electromagnetism were connected phenomena. The first successful radio transmission was made in 1879 by James Edward Hughes but it was only in 1889 that the German physicist Heinrich Hertz proved conclusively that Hughes' experiment involved the transmission of electromagnetic (radio) waves. It is after Heinrich Hertz that our measure of frequency, the Hertz, is named.

By 1892, the physicist Nikola Tesla had demonstrated the transmission of energy through radio waves and predicted that it could be used for the transmission of information. This was subsequently demonstrated by the Italian physicist Guglielmo Marconi, who made the first practical radio transmission system capable of transmitting a signal over a range of one to two kilometres. (Though Marconi is widely regarded as the first radio broadcaster, there were a large number of researchers on radio by then, and this status is disputed. Indian scientist J.C.Bose is now co-credited in many publications as the inventor of radio broadcasting.) Marconi would later set up a company to explore the military and commercial possibilities of radio.

Though there are many claimants to the title, it is often quoted that Reginald Fessenden made the first radio broadcast on Christmas Eve in 1900, from Massachusetts, USA. Shortly thereafter, Marconi made the first experimental radio transmission across the Atlantic Ocean (London to New York) in 1901. Within the next twenty years, formal licensing of stations began on both sides of the Atlantic. Companies like Telefunken in Germany, NESCO in the USA, and British Marconi and American Marconi began to establish strong presence for radio; and radio began to be used for entertainment, music and education.

By the 1930s, Edwin H. Armstrong had invented FM transmission, which overcame several of the issues that plagued AM transmission, as we have seen in the previous section. By the 1940s, FM transmission was a commercial reality in Europe and America. During World War II (1939 – 1945), radio played an important part in propaganda broadcasts, as well as early warning systems for air raids.

By the 1950s, television had begun to replace the radio as the chief source of information and entertainment in the United States. Early TV stations developed during the 1930s, but only became really popular following the war years. But radio received a renewed resurgence in 1960, when Japan's Sony Corporation invented the first transistorized pocket radio, one that could be powered by small AA batteries. Radio suddenly became the portable medium everybody could enjoy as they moved about. And, with the resurgence of popular music in that country, radio became the young people's medium for music.

Radio underwent a decline through the 1980s and 1990s, in the face of changing listening habits. The increasing presence of television globally, as well as the increasing emphasis on live TV coverage of sports and public events meant that radio became a niche music medium. However, Video Cassette Recorders (VCRs) and Compact Discs (CDs) meant media could be increasingly consumed in a non-broadcast per-convenience basis, which disturbed traditional models. FM radio, in particular, began to rely on a core audience of commuters who listened to radio in cars while driving.

However, the 1980s and 90s also saw an increasing sense of localization which meant there was also a new interest in volunteer driven community radio, with countries such as Australia, Bolivia, and Colombia showing a resurgence of small stations broadcasting in local languages. Many countries have reserved frequencies for educational and civil society/non-profit radio.

The 2000s heralded a new beginning in the history of radio with three new developments: streaming radio stations on the internet, which use internet protocols to offer music and content globally; mobile telephones with FM radio receivers built in; and satellite direct-to-receiver broadcasting.

### 6.5.2 Radio Broadcasting in India

As you have learnt in Unit-1, radio broadcasting in India, though initially started as a private enterprise in 1927, had mostly remained in government hands till the year 2000, when it was opened to private broadcasters by offering to allot 108 channels in 40 cities. You have also learnt about the formation of Prasar Bharati and emergence of private Broadcasting & Community Radios in quite some detail there. Here we will recapitulate the brief history of Community Radio Scheme and learn about the technological journey of radio transmissions in brief.

Besides the decision to invite private participation in radio broadcasting as mentioned above, the Government also introduced the scheme of Community

Radio Stations. To start with, the government vide its notification made in December 2002, opened this scheme to established educational institutions/ organizations recognised by the Central and State Governments. Later in 2006, it broadened the policy by bringing it into the ambit of Non-Profit organizations in order to allow greater participation by civil society, specially on issues related to development and social change, thus giving birth to the Community Ratio Stations in their present form, about whose concept and evolution you have already learnt in Unit-1 of Module-1.

In terms of technology, Medium Wave (MW/MF) ably supported by Short Wave (SW/HF) remained the mainstay of domestic broadcasting in the country till FM was introduced on a large scale in All India Radio in late eighties. Although, FM was brought into the AIR network on an experimental basis, between 1977 and 1984 by installing 10 KW transmitters in four metros – the first one coming up in Chennai on 23rd July, 1977 – it was introduced in a big way only in late eighties when it was decided to install 100 FM Transmitters across the country. FM has been assigned as a technology for both Private Broadcasting and also for Community Radios.

### Activity 6.3

How many CR stations are currently operational in India? Compile a current list of operational CR stations. Include details of the name of the licensee and which state the CRS has been set up in.

## 6.6 Regulatory Bodies and Processes

Any discussion of the radio waves would be incomplete without a discussion of the key regulatory bodies that govern broadcasting i.e. use of the radio waves for broadcasting globally and within India.

As we have seen, in the West, radio came up through a series of entrepreneurial and research experiments. By 1926, the government of the United States felt a need to create a regulatory body that could oversee adjudication as well as use of frequencies by competing entities, which resulted in the setting up of the Federal Radio Commission that year. The commission was expected to regulate radio use “as the public interest, convenience, or necessity” required.

By 1934, however, the commission was replaced by the newly constituted Federal Communications Commission which oversaw all communications related decision making from a regulatory and adjudicatory point of view. This was a far reaching thought in the early days of mass communication as we now see it today; and was the core model adopted in many countries as time passed.

Internationally, the UN body known as the International Telecommunications Union (ITU) oversees spectrum allocation agreements and conventions across its member countries. Originally established as the International Telegraphic Union in May 1865 – and thereby predating the UN as an organization – it was envisioned as a cooperative body for establishing standards for the then nascent telegraphic system.

Today, it is a specialized UN agency of the United Nations that is responsible for issues that concern all information and communication technologies. The ITU coordinates the shared global use of the radio spectrum, promotes international cooperation in assigning satellite orbits, works to improve telecommunication infrastructure in the developing world, and assists in the development and coordination of worldwide technical standards.

ITU also organizes worldwide and regional exhibitions and forums, such as ITU TELECOM WORLD, bringing together representatives of government and the telecommunications and ICT industry to exchange ideas, knowledge and technology.

The ITU is active in areas including broadband Internet, latest-generation wireless technologies, aeronautical and maritime navigation, radio astronomy, satellite-based meteorology, convergence in fixed-mobile phone, Internet access, data, voice, TV broadcasting, and next-generation networks. Within it, the ITU-R subgroup is responsible for decisions regarding global radio communications (including the decision on bands allocated for special services, frequency allocations to global zones and individual countries, and so on.)

ITU is based in Geneva, Switzerland. Its membership includes 193 Member States and around 700 Sector Members and Associates.

Within India, the key decision making body is the Wireless Planning and Coordination Wing (WPC) of the Ministry of Communications & Information Technology of the Government of India. The department is responsible for issuing amateur radio licenses, allocating spectrum, and monitoring the use of allotted spectrum. The WPC is headquartered in New Delhi and has regional branches in Mumbai, Chennai, Kolkata and Guwahati. WPC is divided into major sections like Licensing and Regulation (LR), New Technology Group (NTG) and the Standing Advisory Committee on Radio Frequency Allocation (SACFA).

WPC is responsible for the following key functions:

1) To make rules in India for wireless transmission.
2) To follow international wireless communication rules.
3) Conduct radio telephony and telegraphy exams in India.
4) Monitor illegal use of frequencies.
5) Conduct frequency management, i.e. allot frequencies to Indian wireless users and clear interference in wireless.

SACFA makes the recommendations on major frequency allocation issues; formulation of the frequency allocation plan; making recommendations on the various issues related to the International Telecom Union (ITU); and siting clearance of all wireless installations in the country.

As far as community radio is concerned, applicants approach WPC for the allocation of a frequency (issued in the form of a Frequency Allocation or FA letter), and permission to set up a wireless broadcasting station (given in the form of a Wireless Operating License, or WoL). The annual spectrum fee, currently Rs.19,700/- annum, is also payable by the allottee to WPC. Permission to set up a transmission system at a specific location is given by the SACFA wing, in the form of a siting clearance letter.

## 6.7 Let Us Sum Up

Through this Unit, you have been introduced to the concept of waves, and their characteristics: frequency, wavelength and amplitude. You have understood electromagnetism as a natural phenomenon, and the related concepts of radio waves, and radio spectrum. You have also learnt about the division of radio spectrum into bands, and then into channels/frequencies.

We have also seen overviews of the modulation processes used for radio broadcasts: Amplitude Modulation (AM) and Frequency Modulation (FM). Finally, we have understood the role of key regulatory bodies, national and international, that decide issues ranging from frequency allocation to spectrum management: the ITU (and its subsector, the ITU-R); the WPC of the Govt. of India, and its various wings, including the SACFA wing.

## 6.8 Model Answers to Activities

### Activity 6.1

WiFi routers use an unlicensed part of the radio spectrum. These frequencies lie in the 2.4 GHz band, and usually range from 2.4 GHz to 2.4835 GHz.

The router that I checked is a Micronet 980 PS, which can operate on the 802.11 b and g bands, in the 2.4 GHz range.

## Activity 6.2

| S.No. | Station | Frequency Modulated (FM) or Amplitude Modulated (AM) | Frequency of broadcast |
|---|---|---|---|
| 1. | Vividh Bharati (AIR) (Delhi) | AM (MW) | 1368 kHz |
| 2. | Radio Mirchi | FM | 98.3 MHz |
| 3. | Hit FM | FM | 95 MHz |
| 4. | AIR FM Gold | FM | 106.4 MHz |
| 5. | AIR FM Rainbow | FM | 102.6 MHz |

## Activity 6.3

A current list of CRS licenses issued by the Ministry of Information & Broadcasting, Govt. of India, is available at this link: http://www.mib.nic.in/linksthird.aspx. Use this as a basis to make a list as follows:

| S.No | Name of CRS licensee | State |
|---|---|---|
| 1. | Abid Ali Khan Educational Trust Radio Mirchi | Andhra Pradesh |
| 2. | Keshav Memorial Education Society AIR FM Gold | Andhra Pradesh |
| 3. | Boon Education, Environment & Rural Development Society | Andhra Pradesh |
| 4. | Deccan Development Society | Andhra Pradesh |
| 5. | University of Hyderabad | Andhra Pradesh |

# UNIT 7

# Basics of Electricity

## Structure

7.1 Introduction

7.2 Learning Outcomes

7.3 Electrical Basics

- 7.3.1 Electrical current, voltage, and power
- 7.3.2 Phase, neutral and earthing

7.4 AC/DC Current

7.5 Load Distribution

- 7.5.1 Single phase and three phase distribution
- 7.5.2 Balancing Load
- 7.5.3 Circuit Breaker (MCB), Isolator and ELCB

7.6 Power Consumption and Conservation

7.7 Let Us Sum Up

7.8 Model Answers to Activities

## 7.1 Introduction

In Unit 5, you have studied that power supply switch gear is required to connect power to all the audio recording, editing, playback, transmitting and ventilation equipment. Size and ratings of components of power supply switch gear depend on the connected load and number of hours the equipment are kept ON. In the next Unit 8, you will learn about the sources of backup supply and process of voltage stabilization. Knowledge of electrical basics that we will discuss in this Unit shall help in operation, maintenance and servicing of power supply equipment. In this Unit, we shall focus on the following topics:

- Electrical basics
- AC/DC current
- Load distribution
- Power consumption and conservation

In the video on electrical basics and power supply backup systems, you will also get a chance to study the visual representation of these basic concepts including graphical representations of AC/DC voltage and current waves as described in this Unit. The glossary given at the end shall be helpful in understanding the content of this Unit.

You may require about 10 hours to complete this Unit including solving the questions given in the Activities.

## 7.2 Learning Outcomes

After working through this Unit, you will be able to:

- list and describe the fundamentals of electrical basics.
- describe phase, neutral and earthing.
- differentiate between AC/DC currents.
- analyse the colour coding of wiring.
- explain load distribution and balance.

## 7.3 Electrical Basics

Any person, for example, an engineer or a technician dealing with power supply equipment must have a clear understanding of the electrical basics such as current, voltage, and power. Touching any terminal or wire without knowledge may be even fatal. In this section, you will learn the fundamentals of the following terms:

- Electrical Current, Voltage and Power
- Phase, Neutral and Earthing.

Let us now define electrical current, voltage and power.

### 7.3.1 Electrical Current, Voltage and Power

As you are aware that all equipment are specified for its power, voltage and current. For example, a 100 watt bulb means it will consume 100 watt of power when connected to 230 V mains supply. When a particular voltage is applied to the equipment, amount of current flowing through it will depend on its resistance. In this subsection, you will learn about the basic concepts of current, voltage, resistance, power and energy. You will also learn about the fundamental Ohm's law which gives the relation between current, voltage and resistance.

*Current (I)*

The term 'current' is used to denote the rate at which electricity flows. It is the quantity of electricity which passes through a given point in one second. The magnitude of the current depends not only upon its operating voltage but also upon the nature and dimensions of the path through which it circulates. The symbol 'I' is used to denote current and its unit of measurement is called an Ampere (A). The current flows from a point of high potential (+ve) to a point of low potential (-ve).

*Electromotive force (E) / Voltage (V)*

Voltage is defined as electrical pressure or electromotive force which causes the flow of current in any circuit. It is called as Electromotive Force (EMF). Symbol E/V is used to denote it. Voltage is sometimes referred to as potential. The unit of electromotive force/voltage is volt. Volt is defined as the potential difference across a resistance of one ohm carrying a current of one ampere.

*Resistance (R)*

Resistance is defined as that property of a substance which opposes the flow of electricity through it. It is represented by R. The unit of resistance is Ohm (Ω). Ohm is the resistance of a circuit in which one ampere current flows when potential of one volt is applied across its two terminals. Its bigger unit is megaohm which is equal to $10^6$ ohms. Its smaller units are microohm ($10^{-6}$ ohm) and milliohm ($10^{-3}$ ohm).

*Resistance of a Conductor*

Cables and wires are used for connecting voltage to the load which can be any equipment or machine. These conductors or wires have a definite resistance which cause drop in voltage till it reaches the equipment.

Resistance of a conductor varies:

- Directly as its length (i.e. as conductor length increases resistance increases).
- Inversely as its cross section (i.e. as cross section of conductor increases the resistance decreases).
- With temperature depending upon the temperature coefficient of a particular material of a conductor.

*Resistivity (ρ)*

The resistivity of any material is the resistance of a piece of material having a unit length and unit sectional area. Its symbol is ρ (rho) and unit of measurement is ohm-meter.

*Power (P)*

Power is defined as the rate of doing work. The electrical unit of power (P) is the Watt (abbreviation W). Bigger unit of power is called kilowatt (kW) which is equal to 1000 watts.

Power is also defined as the product of voltage and current.

Using the symbols, we can write;

1W = 1Vx1A or W =V x I

*Energy*

Energy can be defined as power x time. Energy = V x I x t, where t is the time in seconds. The unit of energy is Joule, which is equivalent to flow of 1 ampere of current at 1 volt for 1 second. The practical unit for energy is the kilowatt hour and is given by:

Watts x hour/1000 = kWh. 1kWh is equivalent to 1 unit of energy or power consumed.

*Ohm's Law*

Ohm's law is the most fundamental and basic law which defines the relationship between voltage, current and resistance. Ohm's law states that the current in a DC circuit is directly proportional to the applied voltage and is inversely proportional to the resistance of the circuit.

Using the symbols I, V and R to represent the current, voltage and resistance respectively, Ohm's law can be written as: I = V/R or V= I x R

### 7.3.2 Phase, Neutral and Earthing

In this subsection, you will learn the basic concepts of Phase, Neutral and Earthing commonly used in AC power supply distribution system.

*Phase Voltage*

In case of single phase supply, the phase voltage used is 230 Volts with respect to neutral. In case of three phase supply system, the voltage between any one of the three phases with respect to neutral is 230 V. Voltage between any two phases out of three phase is 400 V ($\sqrt{3}$ x 230 V= 1.73x 230 = 400 volts).

The rating and size of switch gear, cables, MCBs etc. depend upon the power, voltage and currents that they can safely handle. You will learn about load distribution on single or three phase supply and circuit breakers in Section 7.5.

*Neutral*

The second or return terminal of each load/equipment is connected to the neutral. When phase supply is connected to the load through a switch, the current flows from phase, passes through the equipment and returns through its neutral.

For small loads like bulbs, fans and tube lights, switches are not provided in the neutral wire. However, for a group or large loads neutral is provided through linked switches/MCBs. For a single phase working, the size of neutral wire is same as that of phase wire. Whereas for three phase balance loads, size of neutral is usually half the size of phase wires.

*Earthing*

Earthing is a process by which all metallic parts of any appliance or instrument are connected to an earth electrode buried deep in the ground to maintain them at zero potential.

Earthing is necessary to:

- Protect operating personnel from electric shock during short circuit or leakage of phase.
- Protect operating personnel, equipment and building during lightning.

Earth resistance is the minimum resistance in ohms provided by the earth system. It should be as low as possible (preferably less than one ohm).

As per Indian Electricity Rules, double earth is to be provided for all those equipment working on three phase supply, power supply switch boards and three phase motors of 5HP and more.

Earth resistance of the earth pit is measured by using the earth tester. You will learn more details on checking the earth conductivity in Unit 28 of Module 8.

## Activity 7.1

To do this activity, you may need about 20 minutes to write down the answers in the space provided. This activity will help you in understanding the basics of electricity including the relationship between the voltage, current, resistance and power.

Question 1: Define power in an electrical circuit. What is its unit of measurement? When a voltage of 100V (DC) is applied to a heater, a current of 10A flows through it. How much do you think will be the power of that heater?

Question 2: A wire has a resistance of 10 ohms. Find out the resistance of another wire of same material but having thrice the length and twice the cross-section area.

Question 3: Define Ohm's law and its application to electrical circuit. A circuit has a resistance of 50 ohms. How much current will flow through it when a voltage of 200 V is applied across it?

Question 4: What is earthing? Why is it necessary to run earth wire along with phase and neutral to connect supply to the equipment rack? What can happen if there is a break in earth wire?

## 7.4 AC/DC Current

In this section, you will learn some of the commonly used electrical basics relevant to AC and DC circuits. Here, you can watch a video at http://tinyurl.com/pdqcrgt. This video is explaning about the basics of electricity, AC-DC currents, electrical phase load balancing, power inversion and voltage stabilisation, colour coding of the wires etc.

Power Backup for CRS

http://tinyurl.com/pdqcrgt

*Alternating Current (AC)*

AC means alternating current in which current or voltage changes its direction and magnitude with time. Variations of current and voltage take the shape of a sinusoidal wave. The graph of the AC voltage is shown in Figure 7.1.

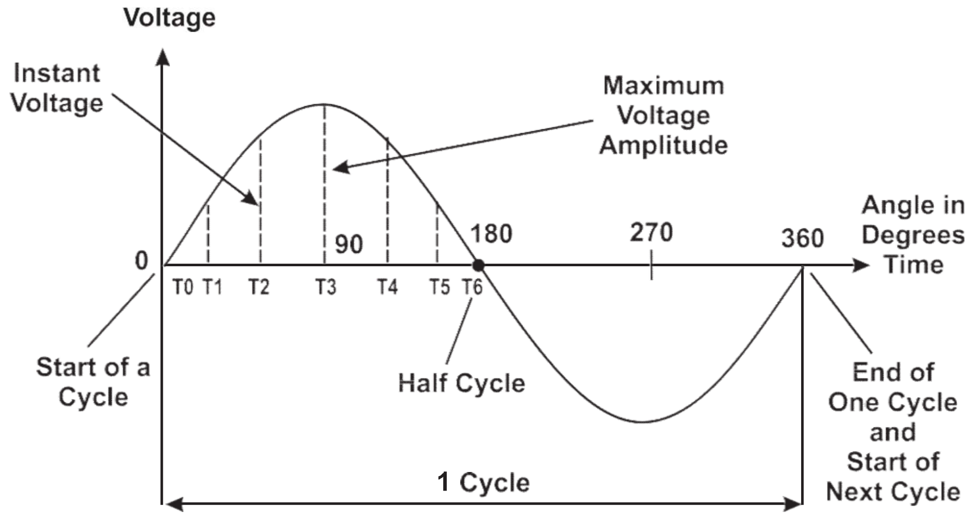



*Figure 7.1: Graphical representation of AC voltage*

As may be seen in Figure 7.1, the X-axis represents the angle in degrees covered in time ‘t’ by a voltage/current wave and Y-axis represents the amplitudes of voltage and current. The voltage varies from zero to maximum (at 90 degrees) and back to zero (at 180 degrees) in half cycle. In the second half cycle, the voltage becomes negative, goes to minimum value (at 270 degrees) and then comes back to zero (at 360 degrees) thereby completing one cycle. The amplitudes $v_1$ to $v_5$ represent the instant values of voltages at times $t_1$ to $t_5$.

The important characteristics of this sinusoidal AC voltage wave with reference to Figure 7.1 are as follows:

- A complete change in value and direction of alternating voltage is called one cycle.
- The time taken to complete one cycle is called its period.
- Number of cycles that this sinusoidal wave travels in one second is called its frequency.
- The frequency of AC supply used in India is 50 cycles/second.
- The maximum value attained by the voltage in half cycle is called its amplitude or maximum value.
- Voltage value at any instant of time in the cycle is called its instantaneous value.

*Relation between voltage and currents in AC circuits*

When a sinusoidal AC voltage is applied to the equipment, the current varies according to the type of load. The load may be resistive, inductive or capacitive. Figure 7.2 shows the graphical representation of relationship between the applied voltage and the resultant current produced by it for various types of loads.

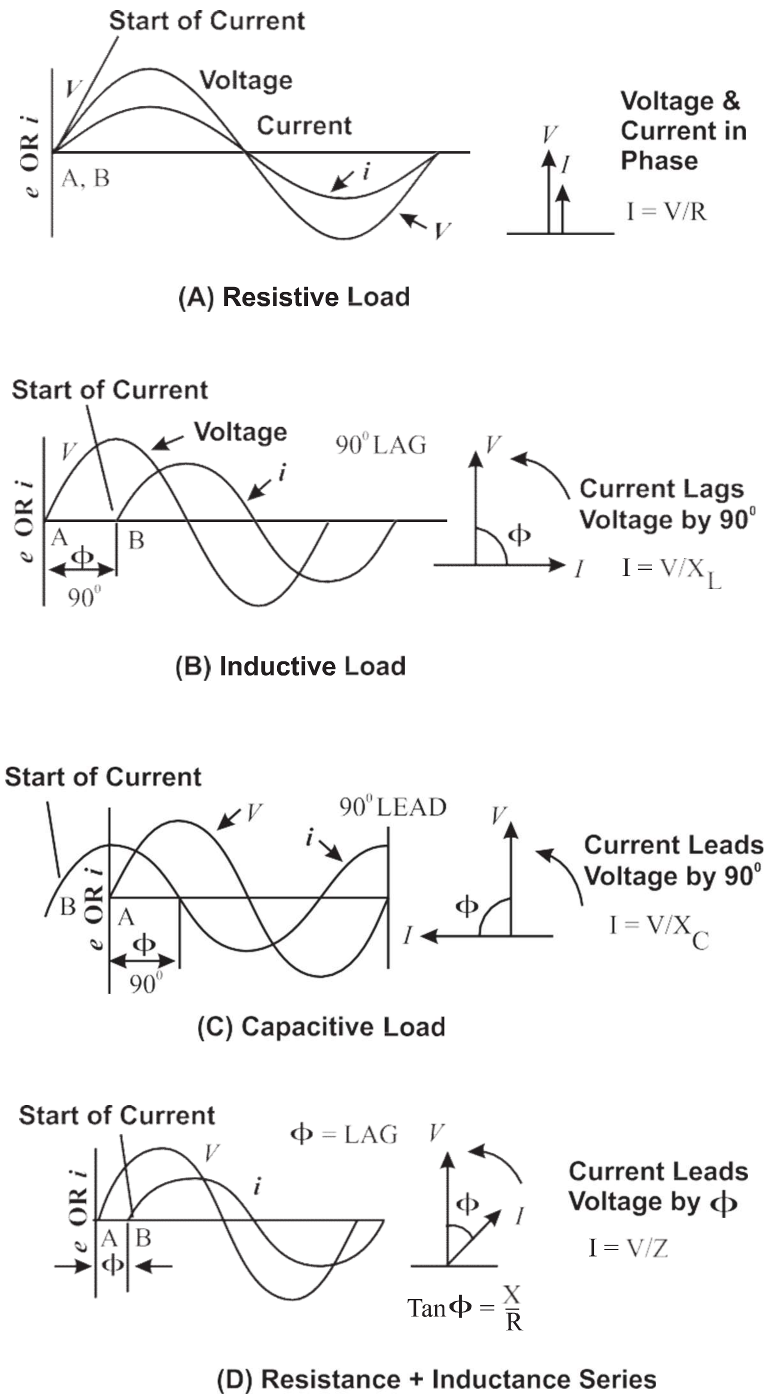



*Figure 7.2: Graphical representation of voltage for different types of load.*

In Figure 7.2(A) to 2(D), X-axis represent the angle travelled in degrees and Y-axis represent the amplitudes of both voltage and current waves. The location of start of voltage cycle (point A) and start of current cycle (point B) in Figure 7.2(A) to 2(D) may be *noted* for different types of loads. When the load is pure resistive, the current is in phase with the applied voltage (*both A and B are together*). If load is a pure inductive, the current lags behind the voltage by 90 degrees (*B starts after a delay*). If load is a pure capacitive, the current will lead the voltage by 90 degrees *(B starts before A*). Figure (D) illustrates the practical case where the load used is a combination of resistance and inductance, which is found in almost all the equipment. Here also current starts after a delay by an *angle ö* which depends on ratio of resistance to its impedance value.

*Power factor*

As seen in the Figure 7.2 above, when AC voltage is applied to any load which is not purely resistive, the current produced may not be in phase with the applied voltage. Current may lead or lag from the applied voltage by some angle. Usually the angle is represented by symbol ϕ (phi). *Cosine of this angle (cosϕ) is called the power factor of that load.* Ideally, power factor (P.F) is unity for a pure resistive load ($\phi=90^0$, cos 90 = 1). It is less than unity for reactive (non resistive) loads. Low power factor reduces the true power thereby reducing the efficiency of the system.

*Direct Current (DC)*

DC means Direct Current. It does not change its direction and magnitude and is steady at all the times. For example, the voltage generated by battery cells, accumulators and dynamos is pure DC. Most of the modern equipment such as portable recorders, small power transmitters and computers work with regulated DC power supplies. This DC power supply is however, obtained by rectifying the AC supply by use of AC to DC adaptors. Equipment operating on 2-wire DC requires a source of supply which can give constant desired rated voltage. Conventional current flows from positive (+) terminal marked red to negative (-) terminal marked black or blue. All the relations between current, voltage and power including ohm's law mentioned above in section 7.3 are fully applicable to DC circuits.

## Activity 7.2

To do this activity, you may need about 15 minutes to write down the answers in the space provided. This activity will help you understand the difference between AC and DC supplies and their applications.

Question 1: What do you understand by AC or DC supply? Give one example of each type.

Question 2: Explain the difference between average current and RMS current. Which of these currents is used for calculating the power in AC circuit?

Question 3: What do you mean by the term power factor in AC supply? What is its ideal value? How power factor can be improved.

## 7.5 Load Distribution

Before applying for power supply connection, it is necessary to estimate the total load requirements of a Radio Station. Based on this load, a single phase or three phase power supply connection is obtained. Load distribution circuit is planned by using suitably rated cables, switches and circuit breakers. In this section and the sub-sections that follow, you will learn the following:

- Single Phase and Three Phase Distribution
- Balancing of Loads
- Circuit Breaker(MCB), Isolator and ELCB

Let us first proceed with single phase and three phase distribution system.

### 7.5.1 Single Phase and Three Phase Distribution

*Single phase distribution*

As the power supply load requirement of a Community Radio Station is small, of the order of 5 to 10kW, single phase distribution is normally used. In this system, all the equipments of the station are divided into different groups and the single phase supply (240V) is connected to respective equipment of the group through properly rated switches. The size and rating of cables and MCBs depend on the amount of current flowing through them. Figure 7.3 illustrates a single phase power supply distribution arrangement for a typical Community Radio Station.

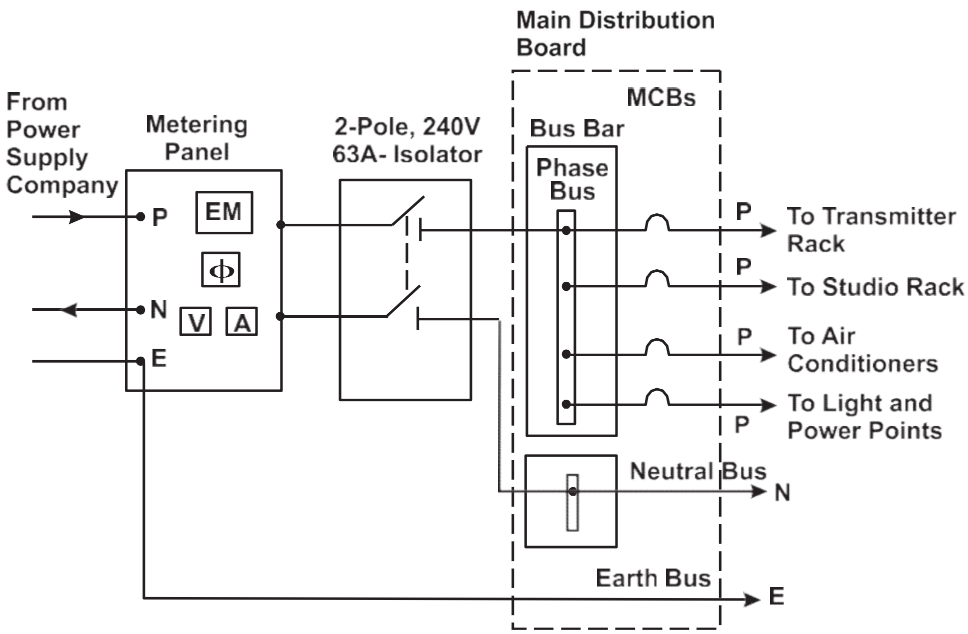



*Figure 7.3: Schematic showing the single phase load distribution*

In Figure 7.3, you will note that in case of single phase distribution, the input supply is terminated at the metering panel having energy meter, voltmeter and an ammeter. The output of metering panel is connected to main distribution board via an isolator switch. This switch is used to disconnect the power supply to the distribution board while servicing or making connections in bus-bar for further distribution. The output of the main distribution board is divided into different groups such as transmitter, studio, air conditioner, light and power loads by use of properly rated MCBs. The further distribution to each equipment is given through three-pin sockets or individual switches. This type of distribution reduces the size and rating of cables, MCBs etc. You may also note that neutral and earth wire to individual equipment is not provided through switches.

*Three phase distribution*

In large installations, where the total connected load is more, it is advantageous to take 3 phase supply from the electric company. Three phase 3-wire system is suitable if the load is fully balanced (such as three phase motors). However, in most of the cases, the station load is mixed i.e. some of the equipment including lights and fans may operate on single phase whereas some others may operate on three phase supply. In such cases, three phase 4-wire system is usually used. In this system, there are three 'lines' and a neutral. The voltage between any one 'line' and neutral is 240V and voltages between the 'lines' is 415V. Figure 4 illustrates the three phase 4-wire distribution system for a typical Radio Station.

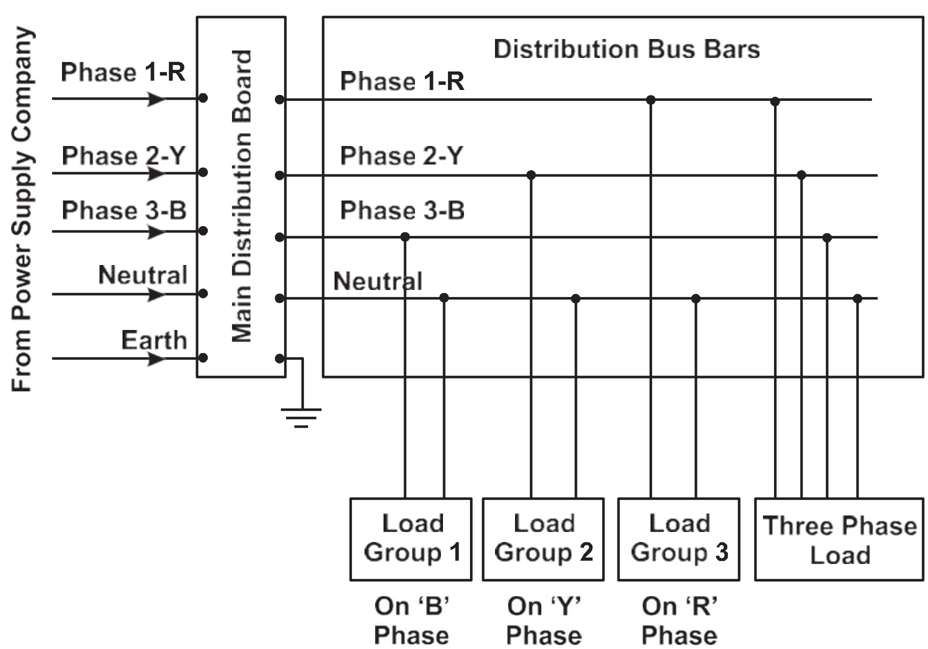



*Figure 7.4: Schematic of three phase 4-wire distribution*

As seen in Figure 7.4, three phases and neutral are first terminated on a metering panel similar to that of single phase distribution. The output of metering panel is connected to a bus-bar system through an isolator switch. The output of bus-bars is connected to a distribution board having MCBs for each group of load. The equipment and machines operating on single-phase are connected to one of the phase (R, Y, or B) and neutral. Equipment working on three phase supplies such as high power transmitters and motors are connected to three lines marked 1, 2, 3, and neutral. While distributing the loads, it is necessary that all electrical wiring at any installation is done in accordance with the relevant Code of Practices issued by Bureau of Indian Standards. Separate insulated and colour coded wires and cables are used for phase, neutral and earthing.

The colour code used for identification of these wires in case of single phase distribution is as follows:

- Red for phase
- Black for Neutral
- Green for Earth

In case of a three phase power supply distribution system, the colour code for three phases is R (Red), Y (Yellow) and B (Blue). Black and Green are used for neutral and the earth respectively.

### 7.5.2 Balancing Load

In this sub-section you will learn what is balancing of loads.

In case of three phase distribution system, if the power factors and the phase (or line) currents of the three phases are not equal then the load is called unbalanced load. It is therefore, necessary that all the equipment operating on single phase are connected to each phase in such a way that phase (or line) currents of each phase are nearly equal. Inductive loads reduce the power factor, therefore, special care is taken for balancing the inductive loads. This is done by checking the current and power factor of each phase separately. Low power factor, if noted, is to be improved by providing suitably rated power factor correction capacitors.

### 7.5.3 Circuit Breaker (MCB), Isolator and ELCB

In this section, you will learn the functions and use of the following:

- Circuit Breaker (MCB)
- Isolator
- ELCB

Let us start first with Circuit Breakers.

*Circuit Breaker (MCB)*

A circuit breaker is a device which connects the phase (phases) of supply to the distribution boards or individual equipment under normal conditions. However, during overloads and fault conditions the circuit breaker automatically trips the power supply to whole or part of the circuit depending upon its position in the distribution circuit. It can be reset manually once the fault is cleared.

Miniature Circuit Breakers (MCBs) are now being used widely as protective devices in consumer premises for group switching and individual circuits. MCBs are available in a wide range (0.5A to 100A) for the desired applications.

Selection of MCB for a particular application depends on the following:

- Power rating of load (i.e. Wattage indicated on equipment/ appliance)
- Switching currents
- Normal running currents
- Breaking currents
- Operating time requirements

*Isolators*

Isolators are conventionally used switches which are provided at input of main distribution board. They are usually manually operated switches and are used to isolate the main supply while doing repairs and servicing. For example, a TPN (Three Phase Neutral) switch is provided at the first input stage of the Main Distribution Board to isolate/switch off the supply before doing any repair or maintenance in the Distribution Board.

*ELCB (Earth Leakage Circuit Breaker)*

ELCB is a special type of a circuit breaker which detects the unwanted potential in the earth circuit. All the metallic components of any switch or distribution board are connected to earth and there is no potential or voltage at these points. However, due to some fault or leakage, if a sufficient potential (usually greater than 50 V) is developed in the earth circuit, then ELCB detects this fault (normally called earth leakage fault) and trips the main supply before it causes any damage to the equipment and the personnel.

## Activity 7.3

To do this activity, you may need about 20 minutes to write down the answers in the space provided. This activity will help you understand the difference between AC and DC supplies and their applications.

Question 1: Why three phase distribution is better than single phase for higher and balanced loads?

Question 2: How can we know that the loads in three phase system are not balanced?

Question 3: What is the difference between MCB, Isolator and ELCB with respect to their field of application?

We will now proceed to learn the practical aspects of calculating power consumption and steps to conserve power as required in field.

## 7.6 Power Consumption and Conservation

In this section, you will learn what is power consumption and conservation.

Power consumption means the amount of power (energy) consumed by the user. Monthly consumption is noted from the energy meter installed by the electric company at the premises of the user. Power consumption is noted in number of units. One kilowatt hour is equivalent to one unit. For example, if one kilowatt of load is kept on for one hour, power consumed will be equal to one unit.

The power consumption of a Radio Station depends on the following points:

- Total connected load or contract demand.
- Maximum demand (load of all those equipment which are kept on simultaneously during transmissions).
- Duration for which the loads are kept on.
- Power factor of the load.

Consumption is calculated by noting how much load was kept for how many hours. Calculations for connected load and maximum demand can be clearly understood from the data given in Activity 7.4 for a typical CR Station. Power consumption and bill can also be worked out.

*Power Conservation*

Power conservation means saving energy by using highly efficient and energy saving techniques. Some electric companies motivate energy users to reduce their consumption by giving certain concessions.

Since the transmitter and most of the studio equipment are all solid state, the power consumption is very small. Most of the consumption is due to air-conditioning units and lights and fans. Power consumption can be reduced by taking suitable measures as described in the following page.

Steps for conserving power:

- Use minimum possible air-conditioners and that too with energy saver modes.
- Use Compact Fluorescent Lights (CFL) instead of incandescent light bulbs.
- Switch off all equipment such as mixers, recorders, computers and other equipment when not in use.
- Use transmission time efficiently.
- Use maximum possible natural light.
- Use thermally insulated walls and ceiling to have a maximum efficiency of cooling system.
- Use slogans to remind people to be cautious in conserving energy, such as
- Help conserve energy. Turn off lights when leaving.

## Activity 7.4

Power supply loads of a particular CRS are given in the Table below. On the basis of load and hours of operation shown against each item, calculate the total daily and monthly consumption. Also calculate the monthly power supply bill by taking rate at Rs 5 per unit (1 kWh).

| Sl. No. | Equipment | Load (Wattage) | Qty. | Hours of Operation | Total consumption in kWh (units) per day | Total monthly consumption (30 days) |
|---|---|---|---|---|---|---|
| 1 | 50 W Transmitter operating at 50% efficiency | 100 W | 1 | 10 | | |
| 2 | Equipment rack with audio processor/ exhaust fan and power amplifier etc. | 500 W | 1 | 10 | | |
| 3 | Audio mixers/ consoles | 500 W | 1 | 10 | | |

| | | | | | |
|---|---|---|---|---|---|
| 4 | Computers/ audio work stations | 500 W | 2 | 10 | |
| 5 | Air conditioners (1ton) | 1500 W | 2 | 10 | |
| 6 | Tube lights | 40 W | 8 | 10 | |
| 7 | Fans/exhaust fans | 60 W | 2 | 10 | |
| 8 | Street light/ office lights/ corridor lights | 60 W | 4 | 12 | |
| 9 | Total monthly consumption | | | | |
| 10 | Total monthly Bill @ Rs 5 per unit | | | | |

To do this activity you may need about 30 minutes to write down the answers in the space provided. This activity will help you in calculating and analyzing the power consumption bills. Proper analysis will help you in understanding the importance of power conservation. By taking suitable measures you can conserve a lot of power.

## 7.7 Let Us Sum Up

In this Unit on Electrical Basics you have learnt:

- That knowledge of electrical basics is essentially required for understanding the operation, maintenance and safety of equipment and operating personnel.
- The definitions of basic terms such as current, voltage, resistance and power. When any voltage is applied to the equipment current flows through it. The quantity of current depends on the power rating of that equipment.
- That the Ohm's law is a most fundamental law which decides the relation between current, voltage and the resistance offered by the equipment. According to this law the current in any circuit is directly proportional to the applied voltage and inversely proportional to the resistance of a circuit.

- That in case of single phase 2-wire system, supply from the electric company is connected to the consumer's premises by two wires. One wire which is having a potential of 240 V is called a phase wire or a 'live' wire. The second wire is called the neutral or the return wire. In order to protect equipment and the operating personnel from electric shocks due to leakage or short circuits, a third wire called earth wire is also provided.
- To differentiate between AC/DC currents and their applications. Generation, transmission and distribution are much easier and economical on AC supplies. (However, DC supply is more suitable for DC motors, battery chargers etc.)
- Load distribution on single phase and three phase systems along with identification of colour codes of wiring. (The specifications and code of practice have been standardized by Bureau of Indian Standards).
- To balance the loads in case of three phase distribution system.
- Method to calculate the power consumption for a typical Community Radio Station. (A Lot of power can be saved by using efficient and energy conservation techniques).

## 7.8 Model Answer to Activities

### Activity 7.1

Question 1: Power is defined as rate of doing work. Its unit of measurement is watt. Power = voltage x current = 100x10 =1000watt =1kW

Question 2: Resistance of second wire = Resistance of first wire x ratio of length / ratio of cross-section

= 10 x 3 /2 = 5 ohm

Question 3: Ohm's law states that current in a circuit is directly proportional to the applied voltage and inversely proportional to its resistance provided other conditions like temperature are same.

I= V/R = 200V/50 ohms = 4 Amp.

Question 4: Connecting a metallic part of a body of equipment to the low resistance earth pit is called earthing. It is necessary to keep the equipment at zero potential. If earth wire breaks, voltage can develop on metallic parts. Any person touching the rack can get electric shock during leakage or short circuit faults.

## Activity 7.2

Question 1: In AC supply, its voltage and current alternate in magnitude and direction at a certain frequency with time. In DC supply, voltage and current are of constant value and do not vary with time. Power supply received from Electric Company is AC where as a car battery gives DC supply.

Question 2: Average current is the mean value of instant currents in half cycle of AC supply and is equal to sum of instant values divided by number of instant values. RMS current is the root mean square value of an alternating current. RMS value is used for calculating power in AC circuits.

Question 3: Power factor is the cosine of angle of lead or lag of current from the voltage in the non resistive equipment like induction motor. Its ideal value is one. Power factor can be improved by connecting suitably rated capacitors in parallel to non resistive load.

## Activity 7.3

Question 1: Power consumption in three phase system is less for same load. Transmission and distribution losses are less. Size of the conductors required are smaller.

Question 2: If the power factors and the phase (or line) currents of the three phases are not equal, we can say the loads are unbalanced.

Question 3: MCBs are used to trip the power supply under overload conditions. Isolators are used to isolate supply during servicing or repairs. ELCBs are used to protect the system during earth leakage faults.

## Activity 7.4

| Sl. No. | Consumption per day in kWh (Units) | Consumption per month in kWh (Units)(30 days) |
|---|---|---|
| 1 | 1000 watt-hours = 1kWh | 30 kWh =30 units |
| 2 | 5000 watt-hours = 5kWh | 150kWh = 150 units |
| 3 | 5000 watt-hours = 5kWh | 150 kWh = 150 units |
| 4 | 10000 watt-hours = 10kWh | 300kWh = 300 units |
| 5 | 30000 watt-hours = 30 kWh | 900 kWh = 900 units |
| 6 | 3200 watt-hour = 3.2 kWh | 96 kWh = 96 units |
| 7 | 1200 watt-hour = 1.2 kWh | 36 kWh = 36 units |
| 8 | 2880 watt-hour = 2.88 kWh | 86.4 kWh= 86 units |
| 9 | | Total consumption per month = 1748 units |
| 10 | | Total monthly bill @Rs. 5/unit = Rs 8740 |

# UNIT 8

# Power Backup and Voltage Stabilisation

## Structure

8.1 Introduction

8.2 Learning Outcomes

8.3 Power Backup and Voltage Stabilization

- 8.3.1 Inverter
- 8.3.2 Uninterrupted Power Supply (UPS)
- 8.3.3 Generator Sets
- 8.3.4 Voltage Stabilisers and CVTs

8.4 Alternative Sources of Energy

- 8.4.1 Solar Energy System
- 8.4.2 Wind Turbines
- 8.4.3 Hybrid Power System

8.5 Let Us Sum Up

8.8 Model Answers to Activities

## 8.1 Introduction

In Unit 7, you have learnt about electrical basics including current, voltages, and power, and the difference between AC/DC currents. You have also studied about load distribution and balancing of loads with regular power supply input. In this Unit, you will learn about the sources of power backup and voltage stabilisation and their necessity in a Community Radio Station. You will also learn how power distribution gets modified by adding backup power supplies. In the sections/ subsections that follow, the need for backup supply and various sources of backup supply will be described under the following heads:

- Power Backup and Voltage Stabilisation
- Inverter
- UPS
- Generating Sets
- Voltage Stabilisers and CVTs
- Alternative Sources of Energy (solar, wind, hybrid)

In the video on electrical basics and power backup system, you will get a chance to study the visual representation of electrical basics which you have studied in Unit 7 such as AC/DC voltages and currents, load balancing, and colour coding of wires through graphics and animation. Video will also include the explanation of power backup systems, power inversion and voltage stabilization including alternate power generation systems which you are going to learn in this Unit. Glossary given at the end of this Unit will help you in understanding the content of this Unit.

You may require about 10 hours to complete this Unit including solving the questions given in the Activities.

## 8.2 Learning Outcomes

After going through this Unit, you will be able to:

- define various terms used in connection with backup supplies.
- list and describe the backup supplies used at a typical Community Radio Station.
- examine the process of UPS, Inverter and Genset and use them in CRS.
- analyze and compare the pros and cons of using different types of backup supplies.
- access various alternative sources of energy and apply some of these sources at the CRS.

## 8.3 Power Backup and Voltage Stabilization

In this section and the subsequent subsections that follow you will learn about the following:

- Power Backup and Voltage Stabilisation
- Inverter
- UPS
- Gen-sets
- Voltage Stabilisers and CVTs


Before going to start with Power Backup, you can again watch the video, which you have already got the reference in the previous unit (http://tinyurl.com/ pdqcrgt). This video gives explanation of key electrical concepts and power backup systems through graphics and animation. The video also explains alternate power generation systems including photovoltaic, solar, thermal and wind.

As you are aware, the AC main input supply provided by the State Electricity Boards at most of the stations is not stable and reliable. Large variations and fluctuations in voltages are very common. In order to run a smooth transmission without any breakdown in service, it is necessary to have a standby or backup source of power supply which can be used during failures of AC main input supply. Similarly, voltage stabilisers are necessary to control the variations and fluctuations in incoming voltages.

In Unit 7, you have also learnt that before applying for power supply connection with the Electricity Department, you have to intimate the connected load and maximum demand required for Community Radio Station. Power supply load is usually calculated in terms of KVA (Kilo Volt Ampere) or in KW (Kilo Watt). Since generation of electricity through generators and other alternate sources is costlier than the supply received from Electricity Departments, it is therefore, necessary to know the minimum essential load that has to be switched on during mains supply failures.

In a typical Community Radio Station, essential load is of the order of about 3KVA (Kilo Volt Ampere). The second criterion is to know the duration for which the backup system should be able to generate 3KVA output. It is a normal practice to plan a battery backup for about an hour or two depending upon the failure rate of AC mains supply at that station. If the durations of power supply failure are longer and frequent, provision of diesel generator becomes more economical.

Figure 8.1 shows the block schematic of single phase power supply distribution along with power back interconnection for a typical Community Radio Station.

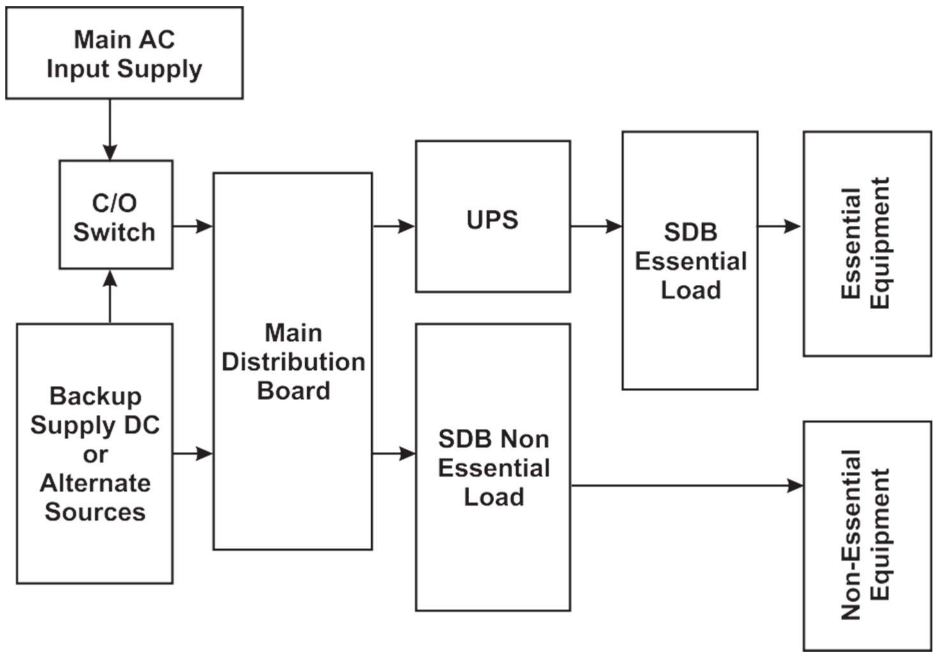



*Figure 8.1: Block schematic showing single phase power supply distribution including backup*

As may be seen in Figure 8.1, UPS system is added only for the essential loads. During prolonged failure of mains supply, standby supply can be extended through a second feeder, inverter, diesel generator or any alternate source. In subsections that follow, you will learn more about various backup power sources in detail.

Let us begin with the Inverter.

## 8.3.1 Inverter

In this subsection, you will learn about the inverter. An inverter is a device that converts DC voltage supplied either by a rectifier or the battery into AC voltage. Inverters are also used to supply AC power from various DC sources such as solar panels or wind turbines. Inverters are classified into different categories according to the output wave form generated by it. The main types include: square wave, modified sine wave and the pure sine wave. Square wave and modified sine wave inverters have high harmonic content and therefore, are not suitable for electronic equipment like tape recorders and transmitters. Pure sine wave inverters produce nearly perfect sine wave and are compatible with AC mains supply. The design is more complex and per unit power costs more.

Figure 8.2 below shows the schematic arrangement of the inverter which will help you in understanding its principle of operation.

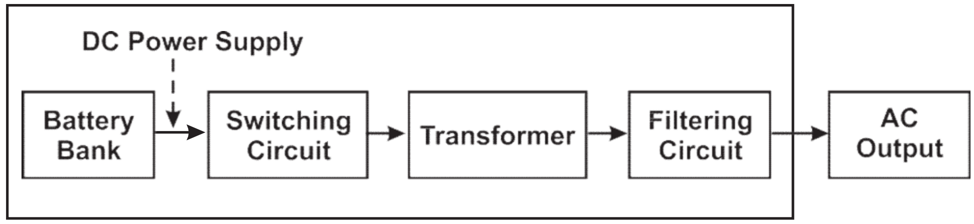



*Figure 8.2: Schematic arrangement of Inverter.*

It can be seen from Figure 8.2 that inverters are made up of appropriate transformers, switching and control circuits to give required output voltage at 50 Hz. A filtering circuit is provided at the output to remove the harmonics and to get the pure sine wave.

The DC power is connected to the centre tap of primary of a transformer through a switch. The switch is turned on and off at a specific frequency to produce alternating pulses in the primary winding. The alternations in the primary winding induce alternating current in the secondary winding. Primary to secondary turn ratio of the transformer decides the AC output voltage of the inverter and filtering circuit is used to remove harmonies.

Solid state inverters have no moving parts and are used widely for applications to computers and other electronic equipment. In case of electronic inverters, the 'On/Off' switching operation is performed by transistors and other forms of semiconductor devices. Inverters are also the main component in the UPS.

Inverters are normally specified in terms of KVA ratings and back up durations. The backup time for which the inverter can provide rated output depends on the ampere-hour capacity of the battery used in the inverter. The ampere-hour capacity is the maximum current it can deliver for one hour (see Box 1 below).

## Box 1

For example, if capacity of a typical maintenance free 12 V battery is 50 Ah (ampere-hours), it means it can deliver 50 A of current for one hour or 25 A for two hours or 12.5 A for four hours. Series parallel combination of number of such batteries is used to give the desired backup period for the rated load. Putting two batteries in series doubles the voltage whereas Ah capacity remains the same. Putting two batteries in parallel keeps the voltage same but doubles the Ah capacity.

## Activity 8.1

What is an Inverter? What are its important components? Briefly describe the function of each component. To do this activity, you may need about 15 minutes to write down the answers, in about 150 words, in the space provided. This activity will help you in understanding the principle of operation of the inverter.

### 8.3.2 Uninterrupted Power Supply (UPS)

In the preceding subsection you have learnt about the inverter. In this subsection, you will learn the most important backup source called UPS in which inverter is the main component. UPS, as the name suggests is a system of power supply that can continue to give uninterrupted power supply in the event of mains failure to various equipment connected to it for the duration it has been designed.

Uninterrupted Power Supply (UPS) systems have now become an essential requirement for almost all the Community Radio Stations so as to maintain continuity of broadcast transmission during failures or shut downs of regular power supply. It also acts as a buffer for voltage variations and fluctuations.

The capacity of UPS is normally specified in VA (volt amperes) or KVAs (kilo-volt amperes) and requirement is based on the essential load to be kept on during power supply failures. Standard low power units of 1KVA to 5KVA rating which are suitable for CRS are available in the market.

Power rating/capacity of UPS depends on maximum load of all equipment that are essentially to be kept switched 'ON' and for how much duration. As most of the CRSs are located in remote localities where AC mains supply is either not available during most of the time or it is erratic with a lot of fluctuations and variations in voltages, UPS becomes a necessity and are to be procured according to the requirement. It must be remembered that higher the rating of UPS, higher will have to be the battery capacity and therefore the cost increases. At places, such as university campus where power supply is fairly steady and breakdowns are minimum or places having a diesel generator backup, the size and rating of UPS can be small.

*Components of UPS*

A UPS system comprises of following essential components:

- A Rectifier and filtering circuit
- A Battery Bank
- A separate battery charger
- An Inverter

- On/Off and By-pass switches
- Harmonic Suppression Circuit
- Control and Protection Circuits
- Status and Fault Indicators

The functions of all the above components of UPS are explained in the paragraph given below and also in the paragraphs giving the description of types of UPS.

Input AC mains supply to UPS is first stepped down and rectified. It is filtered to remove the ripples and connected to a DC bus where battery is also connected. A separate charger is also provided for charging the batteries. The DC output from rectifier or the battery is connected to the inverter which converts the DC voltage back to AC voltage. Harmonic Suppression filter removes the harmonics to give a pure sine wave output voltage. Control and protection circuits are used to protect the UPS and the equipment against short circuits and over loads. Bypass switches are also provided to isolate batteries and input power supply during trouble shooting and maintenance. Applications of UPS vary depending on the type of UPS and method of use.

*Types of UPS*

Depending upon the required application, Uninterruptible Power Supply units can broadly be divided into three categories:

- On-line UPS
- Off-line UPS
- Line-interactive UPS

Let's briefly describe each of the three types of UPS.

*On-line UPS*

In On-line UPS, the load is always connected at the output of Inverter. The schematic arrangement showing the principle of operation is illustrated in Figure 8.3.

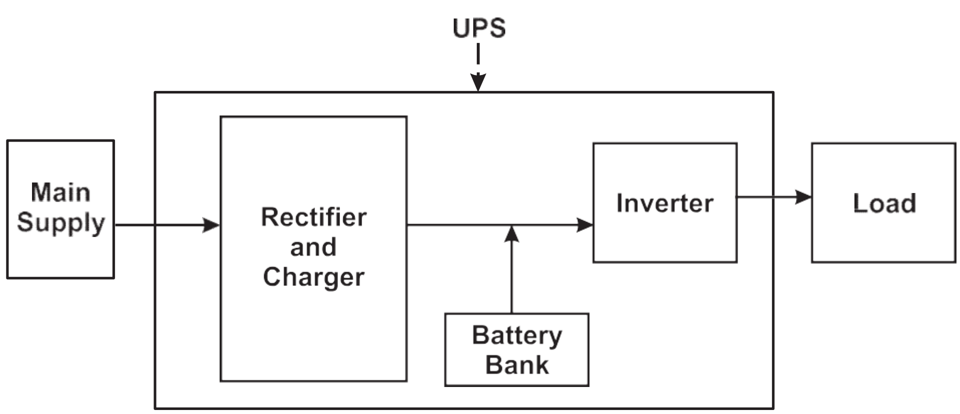



*Figure 8.3: Block schematic of on-line UPS*

As seen in Figure 8.3, AC main supply is first rectified and filtered to remove the harmonics or ripples and is connected in parallel to a battery bank. DC output of a rectifier and a battery is connected to the inverter circuit which reconverts the DC supply to AC supply. When main supply is off, DC supply of battery remains connected to the Inverter unit which continues to supply AC power supply to transmitter or studio equipment without any interruption. In this system, the transmitter or equipment remain on till the battery gets discharged.

The salient features of on-line UPS are:

- Inverter is on all the time and supplies output power even if main AC supply is available.
- Running time of the inverter on battery is generally less (half an hour to one hour) and depends on ampere hour capacity of battery.
- Batteries remain charged as long as AC main is through. It gets discharged during mains failure and gets recharged on restoration of main supply.

*Off-line UPS*

As seen in Figure 8. 4, the equipment is kept energized with mains supply. A charger operating from AC mains keeps the battery charged. The output of the inverter is normally not connected to the load. It gets connected to load through a manual or automatic change over switch as desired.

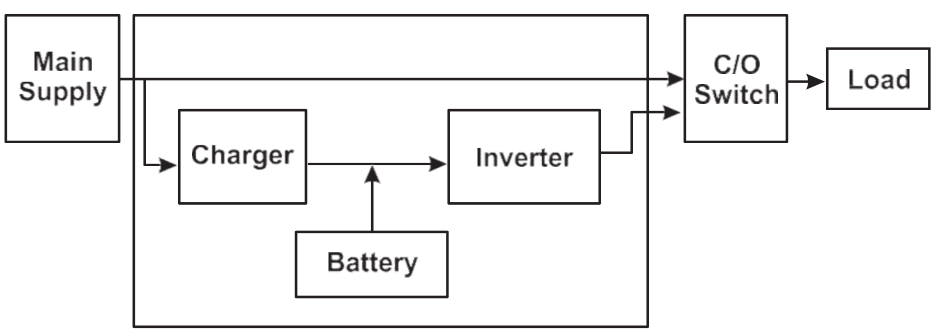



*Figure 8.4: Schematic arrangement of off-line UPS*

The salient features of off-line UPS are::

- Power for equipment is directly derived from AC Mains.
- Inverter is off when the mains supply is present.
- Batteries remain charged.
- Inverter turns on only when the mains supply goes off.
- Off-line UPSs provide no inherent protection from spikes which are dangerous for electronic equipment.

- They are more appropriate for areas with minimal power problems.
- They are the cheapest among the three types in terms of costs.

*Line-Interactive UPS*

A schematic arrangement showing the working of line-interactive UPS is illustrated in Figure 8.5.

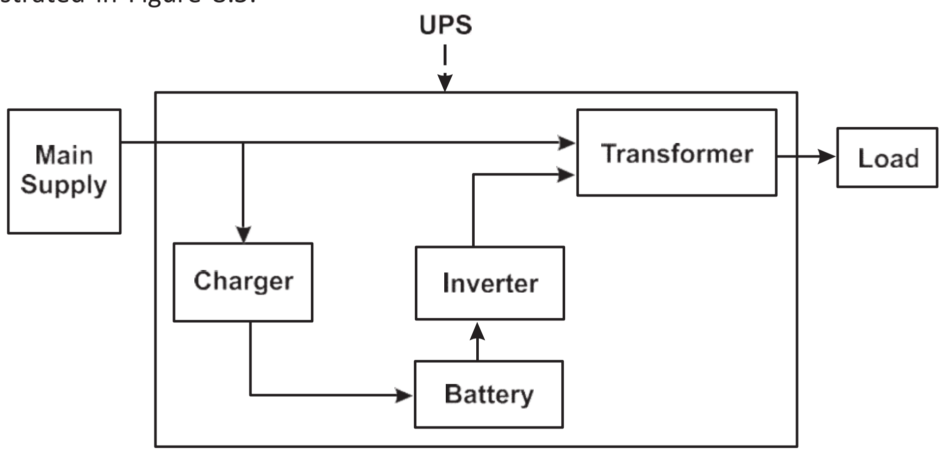



*Figure 8.5: Schematic arrangement of line-Interactive UPS*

As shown in Figure 8.5, AC supply is directly connected to the load via a transformer. Battery is not connected in parallel. However, it gets charged through a separate charger operated from the mains. Inverter supply is also on and connected to the load. Both the supplies are sharing the load. In case of mains failure, inverter continues to keep the system on. It is called line-interactive because it corrects the line voltages or switches to backup supply when variations are more and beyond the correction range.

The salient features of line-interactive UPS are:

- Battery power is only utilized when mains supply is not available.
- Line-interactive UPS is useful when voltage fluctuations are of more concern than breakdowns.
- An electronic circuit monitors the dips and spikes of mains input supply.

## Activity 8.2

You are working in a Community Radio Station where power supply breakdowns are frequent. You are asked to suggest a suitable UPS for your station. What are the important points which you must consider before suggesting a particular type of UPS for your station? To do this activity you may take about 15 minutes, to write down the answers in about 150 words, in the space provided. This activity will help you in understanding the requirements and functioning of various types of UPS.

### 8.3.3 Generator Sets

In this subsection, you will learn another important back up source called Genset. The 'generator' is opposite of 'motor'. A motor converts electrical energy into mechanical energy whereas the *generator* converts mechanical energy produced by fossil fuels to electrical energy.

Because of the limitations of Ah (ampere hour) capacity of batteries, UPS cannot deliver output voltages especially when the power supply breakdowns are for longer durations, since the batteries get discharged.

Alternative source of AC supply is therefore, necessary. UPS with higher capacity of batteries become very expensive. Initial cost of generator may also be high but they are essential where breakdowns in power supply are for longer durations.

Generators of various sizes and types are available. Like UPS, generators are specified by KVA (Kilo-Volt Amperes) ratings. Portable generators can generate electricity by using kerosene, petrol or diesel. However, higher rated generators usually run on Diesel and hence are named as diesel generator.

Rating of DG set is decided on the load of CRS. If CRS is an independent isolated set up, the rating of DG is decided on the basis of maximum load requirement of equipment that are to be kept on during failure of normal power supply. However, when CRS is a part of a larger set up like university campus, where higher capacity DG sets may already be available, separate smaller DG sets may not be required. A separate line for DG supply can be extended.

*Principle of operation of DG set*

Every generator set has got basically two parts; the engine and the alternator. Like any other car engine, fuel energy is converted to mechanical energy which rotates a magnet. This rotating magnet, called the rotor, turns within a stationary set of conductors wound in coils on an iron core, called the stator. The rotating magnetic field induces an AC voltage in the stator windings. An automatic voltage control device controls the field current to keep output voltage constant. The output frequency of an alternator depends on the number of poles and the rotation speed used.

The salient features of Gen-sets are:

- Most commonly used as standby sources where power supply breakdowns are of longer durations.
- Suitable where fuels required for the Gen-set are available.
- Emit harmful exhaust gases.
- Initial costs are high.

## Activity 8.3

Under what conditions do you feel Gen-set is necessary even if UPS has been provided at a particular Community Radio Station? Compare the functions and limitations of each.

To do this activity, you may need about 15 minutes to write the answers, in about 100 words in the space provided. This activity will help you in understanding the functioning and necessity of Gen-sets as well as UPS.

### 8.3.4 Voltage Stabilisers and CVTs

You might have observed that electronic equipment get damaged due to fluctuations in power supply.

In order to protect them, it is essential to use Voltage Stabilisers. In this subsection, you will learn functions and use of Voltage Stabilisers and Constant Voltage Transformers (CVTs).

Voltage stabilisers are the devices which control the variations/fluctuations of the main AC input power supply.

Basically three types of voltage stabilisers are used:

1. AVRs (Automatic Voltage Regulators)
2. CVTs (Constant Voltage Transformers)
3. EVRs (Electronic Voltage Regulators)

*Automatic Voltage Regulators (AVRs)*

In AVRs, input voltage is sensed and a control circuit provides a command to a motor which changes the tapping on the secondary winding to set it to the preset value. AVR has got certain limitations. It takes finite time to sense the variation and then to change the tapping of transformer. Its response time is therefore, higher. Presently servo stabilisers are most commonly used. Single-phase stabilisers usually employ only one variable auto-transformer driven by a motor and one sensing circuit. Servo mechanism automatically controls the tap changes in auto transformer by moving wiper on taps of transformer.

*Constant Voltage Transformers (CVTs)*

CVTs are also used to give constant voltage output. Its principle of operation is different from that of AVR. It works on the principle of magnetic saturation. When the iron core of a transformer is in saturation, large changes in winding current due to variations in input supply, result in small changes in output voltages. These transformers use LC (Inductor–Capacitor) 'tank circuit' tuned to the AC frequency of the supply to filter out the harmonics.

Saturating transformers provide a simple rugged method to stabilize an AC power supply. However, the operation in saturated region has the disadvantage of poor efficiency and sine wave distortion.

*Electronic Voltage Regulators (EVRs)*

EVRs use power semiconductor devices for regulation and are better than mechanical voltage regulators because of higher performance and speed of regulation. They are suitable for low voltage (< 600 V). A large range of EVRs are available in the market giving variety of useful features (see Box 2 below).

## Box 2

Specifications of a typical Electronic Voltage Regulator:

- Microprocessor based closed loop control system.
- Digital voltmeter to read input and output voltages.
- Digital ammeter to read out current.
- Timer with delay of usually 5-10 seconds to avoid nuisance tripping.
- Output cutoff protection for over voltage and under voltage.
- Efficiency better than 98%.
- Use of Semiconductor devices in place of relays and switches.
- No effect of load power factor

## Activity 8.4

Differentiate between the working principles of an Automatic Voltage Regulator (AVR), a Constant Voltage Transformer (CVT) and Electronic Voltage Regulator. Why Electronic Voltage Regulators are more suitable for CRS than AVRs and CVTs?

To do this activity, you may need about 15 minutes to write down the answers in about 150 words in the space provided. This activity will help you in understanding the functioning of different types of voltage stabilisers.

## 8.4 Alternative Sources of Energy

In this section, you will learn about the alternative sources of energy that can be used for generating power at places where regular power supply is either not available or very unreliable. Because of the depleting fossil fuels and increasing fuel costs, Government of India is giving special incentives/concessions for the development and use of alternative energy sources. The use of renewable power generation systems reduces the use of expensive fuels, allows cleaner generation of electric power and also improves the standard of living of many people in remote areas.

These alternative sources of power generating systems include:

- Solar Energy System
- Wind Turbines
- Hybrid Power System

Let us start with solar systems.

### 8.4.1 Solar Energy System

In this system, electricity is generated by using the light energy of the sun. A solar cell or photovoltaic cell is a device that converts light into electric current using photovoltaic effect. Solar cells produce direct current (DC) power, which fluctuates with the sunlight intensity. For practical use, this usually requires conversion to certain desired voltages or alternating current (AC) through the use of inverters. Multiple solar cells are connected inside the modules. Modules are wired together to form arrays connected to an inverter, which produces power at the desired voltage.

In developing countries like India, batteries or additional power generators are often added as backups to the solar power.

Such stand-alone power systems permit operations at night and other times of limited sunlight.

Concentrated photovoltaic (CPV) systems employ sunlight concentrators to focus more light on the surface of photovoltaic cells. Solar concentrators of all varieties are used, and these are often mounted on a solar tracker in order to keep the focal point upon the cell as the sun move across the sky. Concentrated Photovoltaics are useful as they can improve efficiency of PV solar panels drastically.

The salient features of solar power generators are:

- Photovoltaic systems use no fuel.
- Modules typically last for 25 to 40 years.
- Cost of installation is almost the only cost, as there is very little maintenance required.
- Unlike fossil fuel based technologies, solar power does not lead to any harmful emissions during operation.
- Solar power is seasonal, suggesting the need for long term storage system.
- Use of solar energy for operating CRS at a remote location is the most feasible option where making availabie, of mains supply, is not economical.

### 8.4.2 Wind Turbines

Wind is another alternate source of energy which is used to generate electricity. Wind turbine is a device that converts kinetic energy of the wind into mechanical energy and then to electrical energy. You might have seen a large number of turbines rotating especially near the sea coasts where high winds are continuously blowing throughout the year. These are called wind farms. A large wind farm consists of hundreds of individual wind turbines which are connected to electric power transmission network.

*Principle of operation*

Large size blades mounted atop a tower are connected to a turbine via a gear box. When a strong wind blows, the turbine rotates a rotor of an induction generator causing production of an alternating current. The mechanism in the gear box controls the movement of rotor at a constant speed. The output from a single turbine can vary greatly and rapidly as local wind speeds vary. When more turbines are installed over a large area and connected together, the average power output becomes less variable. The electricity generated by each turbine is coupled to transmission lines for distributing to the users.

The salient features of wind power are:

- Generation of electricity through wind is restricted to the areas/zones where constant winds are blowing during most of the time.
- It is a source of clean energy without any harmful emissions.
- The effects on the environment are generally less problematic than those from other power sources.
- It has low ongoing costs, but a moderate capital cost.
- With the improvements in wind turbine technology, the generation costs have also considerably reduced.

Small domestic wind turbines can be used to provide electricity to isolated locations normally not connected by regular power supplies. Isolated communities, that otherwise rely on diesel generators can use wind turbine as an alternative source. Individuals may purchase these systems to reduce their dependence on grid electricity for economic reasons. Wind turbines have been used for household electricity generation in conjunction with battery storage over many decades in remote areas.

### 8.4.3 Hybrid Power System

As you are aware, generation of electricity both from solar and wind energies is intermittent due to seasonal changes. As such they can't be accepted as a reliable supply. Wind power and solar power can, however, be profitability used as complementary to each other due to there being more wind in winter and more sun in summer.

On daily to weekly time scales, high pressure areas tend to bring clear skies and low pressure winds, whereas low pressure areas tend to be windy and cloudy. This effect has led to use of a hybrid power system using both solar and wind energies simultaneously. A combination of both Hybrid power systems by definition contain a number of other power generation devices such as photovoltaic, micro hydro and/or fossil fuel generators. In addition battery banks can also be used in parallel to store the energy for its later use.

Figure 8.6 illustrates the schematic diagram of a small scale hybrid power station. They are generally independent of large centralized electric grids and are used in remote areas as stand–alone projects.

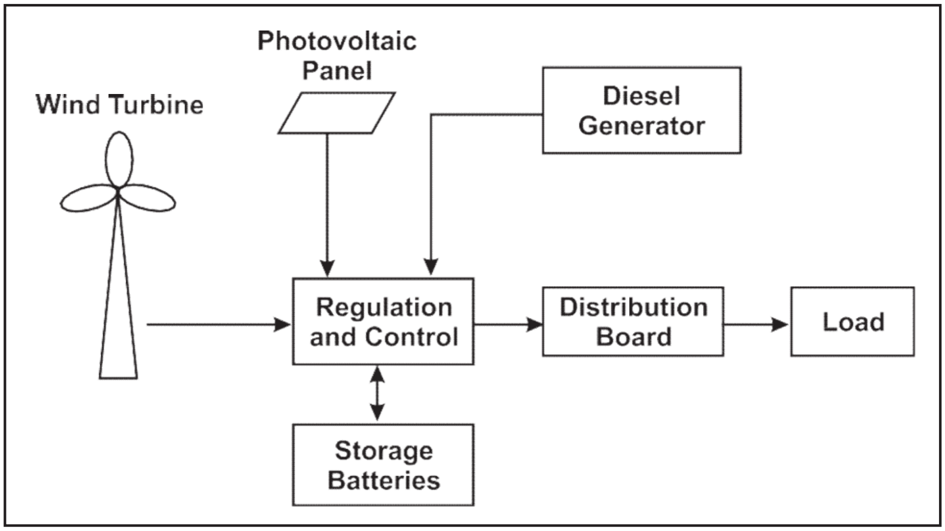



*Figure 8.6: Schematic showing the hybrid power system*

As seen in the Figure 8.6, electricity generated by the wind turbine, photovoltaic and diesel generator has been combined along with storage batteries. At a time, any of the sources can be used depending upon the availability of wind, sunlight or the diesel. In some remote areas even the electricity generated by micro hydro system can be combined with either the wind or solar power.

These hybrid power systems are very useful and suitable for community radio stations, media centres and repeaters for mobile towers especially for remote and isolated locations where extending of centralized electric grids are not feasible due to economic reasons.

## Activity 8.5

What is hybrid system of power Generation? Enumerate the conditions where the use of hybrid power generation system is more reliable than any other single alternate source of energy.

To do this activity, you may need about 15 minutes to write down the answers in about 150 words in the space provided. This activity will help you in understanding the functioning and importance of alternate sources of energy.

## 8.5 Let Us Sum Up

In this Unit on 'Power Backup and Voltage Stabilisation', you have learnt that:

AC mains power supply provided at most of the remote locations is either not available or is not steady. In order to broadcast continuous transmissions from a Community Radio Station without any interruption, backup power supply sources are necessary. Most commonly used backup power sources include: inverter, UPS and Gen-sets. In remote locations where extending of centralized supply grid is economically not feasible, alternate energy sources such as wind and solar energy can be used to generate required power. Fortunately, the power consumption of a typical Community Radio Station is very less, therefore, conventional backup supply sources such as Inverters, UPS and Gen-sets as well as alternate sources like Sun and Wind power can easily be used. Inverter converts DC power supply of battery to AC voltage required for operating the electronic equipment. Voltage regulators are used to control variations in the input AC supply to give steady supply. UPS provides uninterrupted power supply to equipment at the rated voltage during failure of main supply. You have learnt three types of UPS along with their salient features depending upon their applications. Small DG sets are used to supply power when the duration of break downs in main supply are longer and beyond the capacity of UPS battery. Batteries are the critical components of Inverters and UPS. Capacity of battery is specified in terms of Ampere-hour which means how much maximum current the battery can supply for one hour before getting discharged. Backup durations of Inverter and UPS are therefore, limited to the Ampere-hour capacity of battery bank.

You have also learnt the process of power generation by alternate sources like Sun and Wind. In solar power systems, light energy of the sun is converted into electrical energy by use of Photovoltaic cells. Wind turbines convert kinetic energy of wind into electrical energy. Since both the Sun and Wind power systems provide intermittent supply due to seasonal variations, a hybrid power system combining power generated by two or more sources can provide a constant supply to meet the load requirements of a Community Radio Station.

## 8.6 Model Answers to Activities

### Activity 8.1

Inverter is a device that converts DC voltage of battery to 240 V/50 Hz AC supply.

Important components of an Inverter with their functions are given below:

(i) Battery Bank acts as a source of DC supply.

(ii) Switching circuit interrupts the DC supply at a specific fixed frequency to produce alternate pulses in the primary winding of a transformer.

(iii) Transformer converts the changes in primary to give 240V/50 Hz AC supply in the secondary by using its fixed primary to secondary turn ratio.

(iv) Filtering circuit at the output of the transformer removes the harmonics to give pure sine wave output.

## Activity 8.2

Following important points are to be considered before deciding the type and rating of UPS:

(i) Total essential load in KVA that is to be powered through UPS to decide the power rating of UPS.

(ii) Pattern of power supply failures to decide the duration for which the uninterrupted power supply is required.

(iii) Ampere-hour capacity of battery bank to decide how much load in KVA is to be kept ‘ON’ and for how many hours.

(iv) Salient features of each type of UPS to suit to the specific requirement. Since the breakdowns are for longer durations in this case, on-line UPS will be more suitable.

(v) Availability of metering, control and protection circuits.

(vi) Availability of a rated capacity UPS from a branded company providing adequate Guarantee/Warranty and after-sale service.

(vii) Cost factor to suit to available budget.

## Activity 8.3

Provision of the Gen-set is necessary at all those isolated or remotely located stations where the regular AC main supply is either not available or is not reliable due to low voltages and frequent variations. Gen-set works as a standby back-up source during non availability of regular power supply. Gen-set is required even to charge the battery of UPS which might have got discharged after a few hours of use during mains failure. The limitations of Gen-set include: pollution, noise, wear and tear, and necessity to store enough fuel.

The function of UPS is different than that of Gen-set. UPS is provided to give a constant voltage supply to the system under normal working conditions as well as during power fluctuations and failures. The limitation of UPS is its Ampere-hour capacity. It requires charging of battery after each discharge. Life of battery is limited.

## Activity 8.4

An Automatic Voltage Regulator (AVR) works on the principle of automatically changing the tapping of the secondary winding of a transformer depending upon the input voltage to give a preset rated output voltage. Since it is a mechanical regulator its response time is higher.

A Constant Voltage Transformer (CVT) works on the principle of magnetic saturation. Here, an iron core of the transformer works in a saturated condition where the output voltage remains practically constant even with a large change in the input supply voltage.

An Electronic Voltage Regulator (EVR) uses semiconductor devices to control the variations in the input. They are very fast in response as compared to mechanical regulators using motorized tap-changers. The efficiency and performance of an EVR is much better than an AVR and a CVT. The EVR is therefore, more suitable for the protection of the electronic equipment used in a CRS.

## Activity 8.5

Generation of electricity by alternate sources such as sun and wind is mostly intermittent due to seasonal changes in environment. In hybrid system, two or more alternate power generation sources are connected in parallel. Either of the two is sufficient to give the required power supply. Usually battery bank is also used to store the energy for later use. The hybrid system can give uninterrupted power supply throughout the year.

The use of hybrid power generation is more suitable under following conditions:

i. Where the AC main supply is either not available or completely unreliable.
ii. Where the supply generated by a single alternate source is intermittent due to seasonal changes.
iii. Where maintenance of continuous supply using alternate sources is required throughout the year.
iv. Where extending the centralized grid to isolated or remotely located places is either not feasible or economical.

# Glossary

| | |
|---|---|
| Siting | The process of deciding a location for a community radio station, or for the transmission setup within a CRS. |
| Radio shadow zone | An area where a radio signal cannot be received, usually on account of a geographical or man-made obstacle that blocks radio waves. |
| Ambient noise | Any unwanted sound in an area where a recording is conducted. |
| Effective Radiated Power (ERP) | The net output power of a transmission system, usually a combination of the basic output strength of the transmitter, adjusted for the gains and losses provided by the transmission cable and antenna system. |
| Broadcast studio | A studio space dedicated for the purposes of conducting 'live' broadcasts, or from which programmes may be transmitted. |
| Production studio | A studio space dedicated to conducting recordings which can be edited later on. |
| Reverberation | The phenomenon of perceived extension of a sound due to reflection from nearby surfaces. Typically, the phenomenon is called reverberation when the reflection time is 0.1 – 1 milliseconds. Also see Echo. |
| Echo | The phenomenon of hearing a succession of reflections of an original sound that steadily decrease in amplitude. Typically there is a clearly perceptible gap between the original sound and its reflection. |
| Acoustic treatment | The process of reducing reflection of audio in a given space, through the use of audio absorbing materials. |
| Sound proofing | The process of using materials and construction techniques to keep ambient noise out of a recording space. |
| 'Clean' and 'muddy' sound | 'Clean sound' refers to sound where there is clarity throughout the frequencies it is made up of. Muddy sound refers to sound where the constituent frequencies are indistinct, leading to a perceived loss of clarity in the sound. |
| Sound lock | A space created between a studio room's internal and external doors, in order to minimize the intrusion of external noises. |

| | |
|---|---|
| Double glazing | The technique of using two panes of glass or acrylic sheet in a window, with an air space sandwiched inbetween. Used for minimizing the transmission of external sounds, as well as temperature control. |
| "Dampening" reverberation | The process of using sound absorbent materials to absorb or reduce ('dampen') reverberation in a space. |
| Dust proofing | The process of preventing the penetration of dust into a device or a space. |
| Air conditioning | The process of controlling the temperature in an enclosed space through the use of refrigeration or heating devices. |
| Programme production | The process of making an audio programme.<br>*Pre-production:* Preparatory work, including scripting.<br>*Production:* The actual recording of the programme in the field and in the studio.<br>*Post-production:* Including editing and the addition of components like music and sound effects.<br>*Mixing:* The act of adjusting the relative levels of all the audio components so that the programme is easy to hea.r<br>*Mastering:* The act of combining all the components into a single mixed audio file or programme. |
| Field recorder | A portable recording instrument for conducting recordings in the field. |
| Microphone | An instrument to convert acoustic (sound) energy into electrical signals that can be recorded onto a medium. |
| Recording medium | Any medium (magnetic tape, flash memory, magnetic disks) which can be used to record and retain a set of electronic or digital information for playback at a later time. |
| Headphones | A pair of wearable speaker (or audio monitor) units, typically fitted on a band that can be worn over one's head. |
| Input transducer | A device that can convert an input sound or audio signal to another form of energy. The most common type of input transducer is a microphone, which converts audio (acoustic) energy into an electrical signal. |
| Audio source | Any object or individual which can act as a generator of acoustic energy. A singer in a studio and a CD player are both audio sources. |
| Audio management | The process of controlling, manipulating and directing an audio signal. |

| | |
|---|---|
| Signal processing | The manipulation of an audio signal in order to adjust various parameters including its mix of frequencies, amplitude, and level of reverb (to name a few). |
| Final processing | The process of making final adjustments to an audio signal before the conclusion of editing or mastering work. |
| Output transducer | A device to convert an audio signal to a different type of energy for monitoring or transmission. A transmitter and a speaker are both examples of output transducers. |
| Audio monitors | A device to hear an audio signal being edited or manipulated within a audio device. These could be headphones or speaker units. |
| Compressor | A device or software used to reduce the amplitude of the audio signal within a system in order to keep it within a pre-defined upper limit. |
| Limiter | A device or software control used to limit or cut off an audio signal at a pre-defined upper limit |
| Transmission system | A combination of transmitter, transmission cable and antenna typically used for broadcasting audio or video content using a broadcast medium. |
| Transmitter | A device that generates a carrier wave and combines it with a supplied signal in order to broadcast a combined signal. |
| Mast | A tall (usually metal) vertical pole or segmented structure on which an antenna can be mounted. |
| Antenna | A device to radiate radio frequency energy into the atmosphere; or to receive radio frequency energy from the atmosphere. |
| Studio-Transmitter Link (STL) | The connection between the studio and the transmitter. At its most basic, this is the cable connecting the audio output from the studio to the transmitter input. A more complex version uses a microwave connection between the studio and a remotely placed transmission system. |
| Carrier radio wave | The radio frequency wave on which the audio signal is mounted or combined to facilitate the broadcasting of radio signal. |
| Receiver | A device to receive radio signals, usually through an antenna. |
| Sound waves | The way acoustic energy spreads from its source in a repeating pattern of high-pressure and low-pressure regions |

| | |
|---|---|
| | moving through a medium. This is usually represented in the form of a wave. |
| Audio signal | Any stream of energy that carries the equivalent of an information bearing sound. Thus speech is an audio signal. |
| Waves | The phenomenon by which energy passes through a medium by the upward and downward or side to side oscillation of particles in that medium. |
| Frequency | The property of a wave that denotes the number of complete waves that cross a given point in space in one second. |
| Hertz | A unit named after the scientist Heinrich Hertz, indicative of one wave crossing a point in space every second. |
| Wavelength | A measure of the physical distance between two adjoining peaks or troughs of a wave. |
| Amplitude | A property of a wave indicative of the physical distance between the peak and the trough of the wave. |
| Radiant energy | The phenomenon by which energy is conveyed or radiated from one point to another, with or without a medium. |
| Electromagnetic Wave Radiation | The phenomenon whereby electromagnetic waves (radio waves, light) are propagated. |
| Electromagnetic spectrum | The range of all frequencies of electromagnetic waves. |
| Visible spectrum | The range of electromagnetic frequencies that humans perceive as visible light of all colours. |
| Radio Spectrum | The range of all radio frequency electromagnetic waves |
| Radio Wave Bands | The classification of radio frequency waves by groups of frequencies. (UHF, VHF etc.) |
| Medium Wave (MW) | Amplitude Modulated waves in the range from 560 metres to 187 metres. |
| Short Wave (SW) | Radio communication using the upper MF (medium frequency) and all of the HF (high frequency) portion of the radio spectrum, between 1,800–30,000 kHz. |
| Modulation | The process of combining two waves to result in a wave that has some properties of both of its constituents. |
| Amplitude Modulation (AM) | Modulation that results in a wave with the frequency properties of one wave (the carrier wave) and the varying amplitude characteristics of the second (audio signal). |

| | |
|---|---|
| Frequency Modulation (FM) | Modulation that results in a wave with the amplitude properties of one wave (the carrier wave) and the varying frequency characteristics of the second (audio signal). |
| Transistorized portable radio | A small portable radio receiver that uses electronic components called transistors. |
| Community radio | Radio stations owned, managed and run by community groups, focusing on local issues, local culture, and local dialects. |
| Streaming radio | The process of using internet protocols to transmit audio over the internet. |
| Mobile phones | Portable telephone units that work on cellular radio technologies. Also known as cell phones. |
| Satellite direct-to-receiver radio | Radio broadcast directly from satellites to radio units equipped with satellite antennas. Popular services like Sirius, XM and Worldspace (now closed) are examples. |
| Siting Clearance | Permissions from the Dept. of Telecommunications in India allowing the placement of a radio transmitter at a fixed location |
| Wireless Operating License (WoL) | Permissions from the Dept. of Telecommunications in India formally allowing a radio station to start broadcasting. |
| Apparatus | Electrical apparatus that includes all equipment, machines, fittings and other accessories using power supply for its operation. |
| Circuit | An arrangement of conductor or conductors for conveying energy. |
| Circuit Breaker | A device capable of making or breaking the circuit under all conditions and are designed to break the current automatically under abnormal conditions. |
| Conductor | Any wire, cable or plate used for conducting energy. |
| Cutout | A fusible cutout used for interrupting the transmission of power supply to the building or equipment. |
| Earth electrode | A pipe or plate buried deep in the pit to provide a low resistance earth connectivity for earthing the equipment. |
| Earthing system | An electrical system in which all the conductors are earthed. |
| Lightning arrestor | A device used for protecting the equipment, personnel or building during lightning. |

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| Linked switch | A switch with all the poles mechanically linked so as to operate simultaneously. |
| AC mains supply | The normal AC (alternating current) supply connection provided by electricity department or company. |
| Ampere-hour | The unit to specify the capacity of battery. |
| Backup supply | Supply generated locally at a station to operate the equipment or appliances during failure or shutdown of normal AC mains supply. |
| Battery bank | The set of batteries used in series-parallel combination to give desired ampere-hour capacity from a backup power system. |
| Connected load | The total power consumption (as per name plate on the equipment) of all the equipment installed at a station. |
| Maximum demand | The maximum units of electricity required to operate the equipment simultaneously at any instant of time. |
| Power rating | Of an Inverter, UPS or Generator is the maximum kilo-volt ampere load it can deliver. |
| Ripple | The small unwanted residual periodic variations present in the DC supply after rectification. |
| Solar array | The set of number of solar panels used to generate electricity. |
| Wind farm | The area where a large number of wind turbines are located to generate electricity from wind. |

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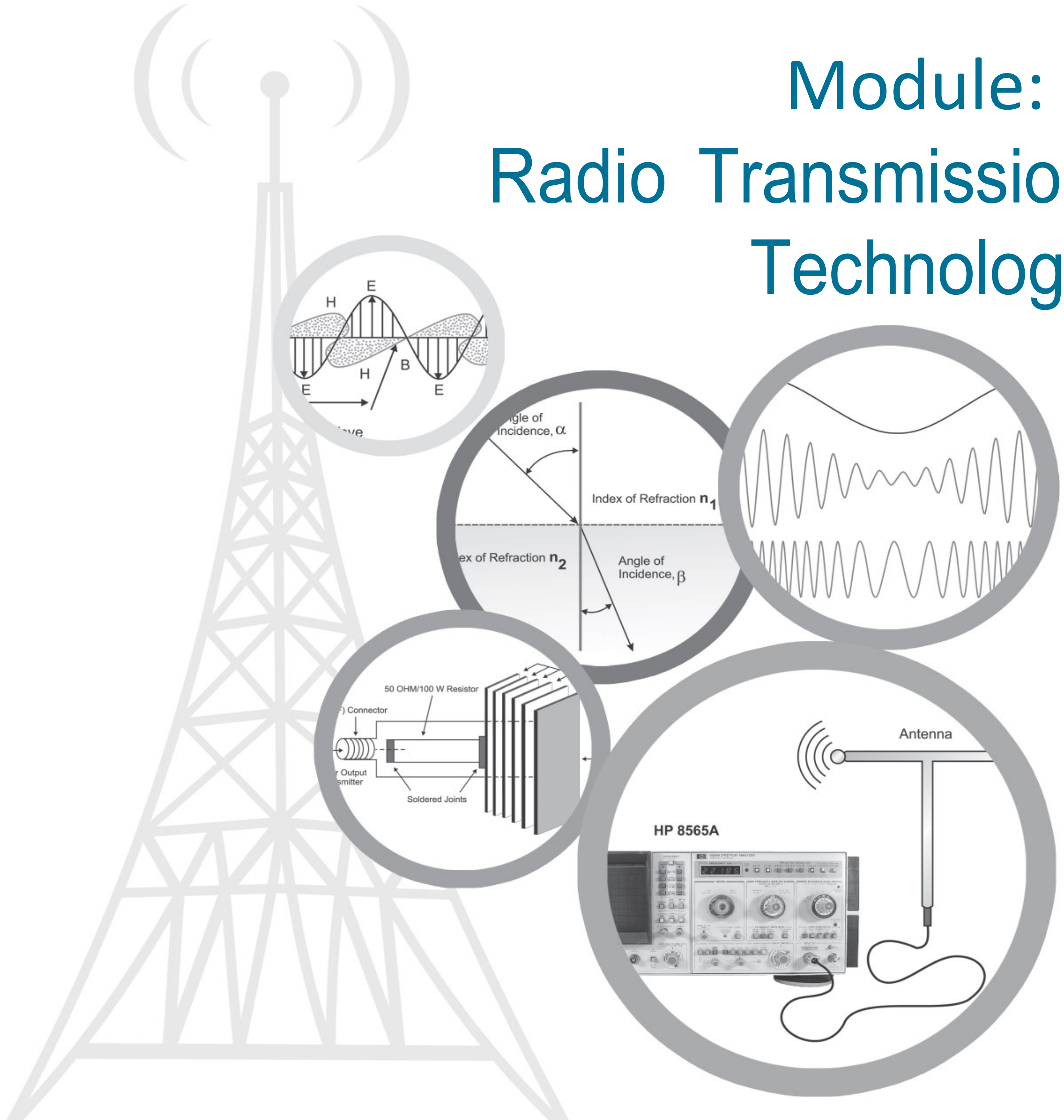
# Module: 3
# Radio Transmission Technology

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# About the Module

## Module Description

The first module of Course III: CR Transmission: System & Technology deals with the transmission technology used in the broadcast of community radio (CR) programmes/signals generated at the studio of the CR station. In Courses I and II, you studied about basic CR and studio production of CR programmes. In this unit, you will learn how these programmes are broadcast by a frequency modulation (FM) transmitter using radio frequency (RF) signals in FM-band for reception by FM radio receivers. The first module of Course III is on Radio Transmission Technology, which has four units. These four units cover the basic components of the transmission chain and their features and applications (Unit 23), important components of the FM transmitter (Unit 10) and FM antenna (Unit 11) as well as the propagation and coverage of FM radio frequency signals (Unit 12). This module would need about 12 hrs of study. As a part of this module, a video of antenna installation aspects is also included. After getting a good idea of FM transmission technology through this module, you will further study the practical aspects of transmitter set-up in the next module, that is, Module 8. A good understanding of the basic concepts of this module will help you learn and grasp better the practical aspects of transmitter set-up.

## Module Objectives

After going through this module, you should be able to:

- Enumerate various components of the FM transmission chain and its features and applications.
- Explain various components of a typical FM transmitter as used for CRS-FM transmission.
- Describe different types of FM antenna particularly those used for CRS transmitters, their features and the coaxial cable used to connect with the transmitter.
- Explain propagation and coverage of RF signals in special reference to FM propagation.

# UNIT 9

# Components of Transmission Chain

## Structure

- ✓ Introduction
- ✓ Learning Outcomes
- ✓ Transmission Chain Overview
- ✓ Live Transmission (Live Console)
- ✓ Pre-recorded Transmission (Radio Automation/Scheduling)
- ✓ Connectivity (from Studio to Transmitter)
- ✓ Audio Processor/Limiter (if not Processed through the PC)
- ✓ FM Transmitter
- ✓ Principles of FM Transmission
- ✓ Antenna (Types and Polarization)
- ✓ Let Us Sum Up
- ✓ Model Answers to Activities

## 23.1 Introduction

In Units 5, 11 and 13, you learnt about the functions and use of audio mixers and audio work stations as a part of studio chain. In this unit, you will learn about various components of the transmission chain and the functions performed by each of these. The components of a transmission chain, which will be described in this unit, include the following:

- Transmission chain overview
- Live transmission (live console)
- Pre-recorded transmission (radio automation/scheduling)
- Connectivity (from studio to transmitter)
- Audio processor/limiter
- FM transmitter
- Principles of FM transmission
- Antenna (types and polarization)

We shall discuss the above components in the order as given.

You will learn in detail about FM transmitter and antenna in the next two units.

You may require about 6 hours to complete this unit including answering questions in various activities.

## 23.2 Learning Outcomes

After going through this unit, you will be able to:

- list and describe various components of a transmission chain such as mixer, workstation, processor, transmitter and antenna.
- describe their features and application in respect of CR stations.
- describe the requirements of connectivity between a studio and the transmitter.
- explain the necessity of using an audio processor in the transmission chain.
- explain the basic terms and concepts used in FM transmissions.
- explain different types of antennae and polarizations.

## 23.3 Transmission Chain Overview

The function of transmission chains is to transmit the programmes by routing them through the playback console to the studio-transmitter link, on to the audio processor and then to the transmitter, and further on to the antenna for broadcast of RF signals on air. The main components of the chain are shown in Figure 23.1. Details of all these components of a transmission chain are described in the sections below.

## 23.4 Live Transmission (Live Console)

In this section, you will learn the difference between a live console and a production console, and also the salient features of a live console.

A console that is used for feeding the programmes to the transmitter during transmissions is called a live console. Here the announcer selects one of the many programmes which is scheduled for transmission. He plays the selected programme from the playback equipment and routes the output of the console to the input of the transmitter through the processor. On the other hand, a production console is used for producing the programmes by mixing two or more source signals to record the requisite programme. Its output is recorded and kept for later transmission as per schedule.

Figure 23.1 illustrates a typical transmission chain used at almost all the CR stations.

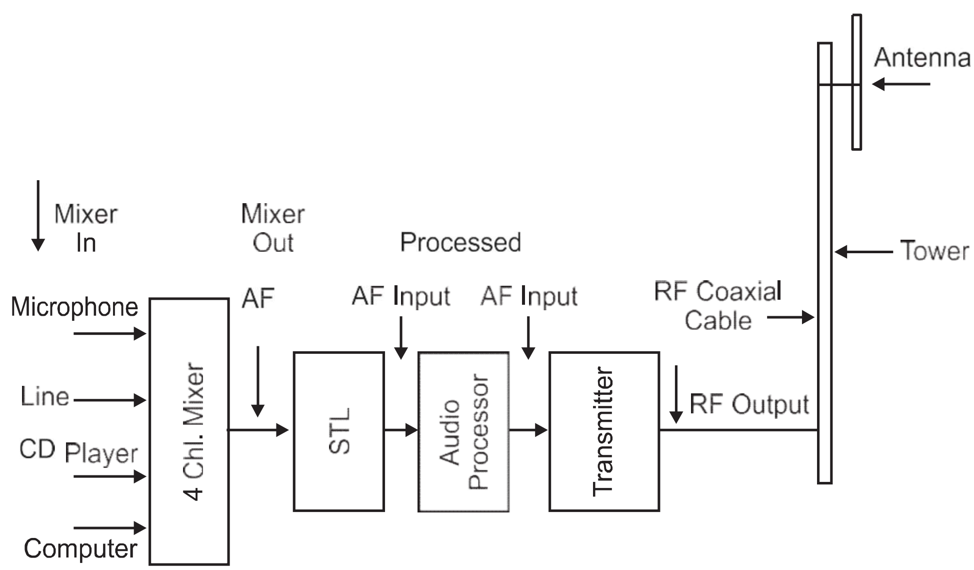



*Figure 23.1: Schematic diagram illustrating the components of transmission chain*

You may note the sequence in which the components of the transmission chain are connected in Figure 23.1. Each stage and the type of signal available at the input and output of that stage are labelled for the purpose of understanding the process. The audio mixer/console selects one out of the four input channels that is to be broadcast. A studio transmitter link (STL) feeds the selected channel to the audio processor. An STL is, however, not required where the studio and the transmitter are co-located, which is generally the case with most CR stations. The audio processor processes the audio signals to increase the average modulation and at the same time limits the audio level to protect the transmitter from over-modulation. The output of this processor is fed to the input of the transmitter. The transmitter then converts the processed audio signals into frequency modulated (FM) radio frequency (RF) signals at the rated output power. The output of the transmitter is connected to the antenna system mounted on top of the tower via an RF coaxial cable. An antenna system converts the RF out of the transmitter to electromagnetic (EM) waves travelling in all directions.

All the components of the transmission chain will be discussed in detail in this section as also subsequent sections.

Let us now begin with the first component of the chain, that is, audio mixer/ console, which is used as a live or transmission console. You have already studied about audio mixer/console in the unit on studio chain. We will here recapitulate these concepts to refresh your memory.

An audio mixer/console used in broadcast or transmission studio is an electronic device which is used to select and route one out of a number of playback equipment connected to it as input channels. The input playback equipment can be anything from the list below:

- A microphone
- A CD player
- A playback deck
- A line feed having a live programme
- A computer or a workstation

All these pieces of equipment, called the input channels, are connected to the audio mixer. An Audio Mixer is identified according to the number of input channels. For example, a 4-channel mixer will have facility to connect four channels as input channels and any one of them can be selected as output for feeding it to the next stage. These channels can be mono or stereo, digital or analog as per requirement.

Audio mixers/consoles of various models and ranges are available in the market. Prominent manufactures being Behringer, Soundcraft, Studer, Yamaha, Sonifex, etc. Cost may vary depending on the number of input and output channels, mono or stereo, analog or digital and additional features/facilities provided by the manufacturers. Since the CR stations have low budgets, simple 4/6 channel consoles are mostly used depending upon their specific requirements. Whatever may be the type/model or brand used, the principle of operation remains the same.

A typical analog mixer has three main sections, as follows.

*1. Channel Inputs*

All the input channels are terminated on the mixer generally through good quality audio cables by using XLR connectors. Each channel has its own switch and a fader or a knob to control its volume level. The selected channel is connected to the input bus. Some channels (like microphones) are connected to the input bus via pre-amplifiers to boost their levels.

*2. Master Output*

The selected channel is connected to another set of switch, fader and amplifier, called the master output channel, which feeds the selected programme to the next stage in the transmission chain after adjusting its output to a desired level. All other input channels remain isolated by keeping the switches/faders in the 'Off' position.

*3. Audio Level Metering and Monitoring Facility*

Audio level metering facilities are provided to monitor and control the output level to its nominal level. Usually, there are one or more volume units (VU) or peak meters to indicate the levels of each channel and the master output. Generally, a split of input or output signal is extended on a separate jack/connector (called Aux. Out) to facilitate connecting of auxiliary equipment for monitoring and measurement.

Apart from the essential components discussed above, the number of additional features is also provided in these consoles, such as

- Audio oscillator for calibration and level adjustments
- Phantom supplies for microphones
- Equalizers for correcting the frequency response
- Colour coding for quick identification of the operator

In order to maintain proper transmission standards, the output level and impedance of each equipment must match with the input level and impedance of the next stage. For example, the nominal level set at the output of audio console is 0VU (+4dBu). Audio levels in consoles are displayed in VU (see Box 1) or in decibels (see Box 2).

## Note It

### Box 1

**VU meter**

A volume unit (VU) meter is a device used for displaying the signal level in audio equipment.

The VU meter normally measures the average level of the signal. It averages the peaks and troughs of short durations and thus reflects the perceived loudness of the signal.

A value of 0VU corresponds to a voltage level of 1.23 Volts (RMS) of an alternating frequency of 1,000Hz measured across 600 ohm load. This is equal to +4 dBu (on a decibel scale with reference to 0.775V).

## Note It

### Box 2

**Decibel (dB)**

The decibel is a logarithmic unit that indicates the ratio of a physical quantity (usually power, voltage level of any signal) relative to a specified reference level. In electronics, the gains of amplifiers, attenuation of signals, and signal to noise ratios are often expressed in decibels.

A decibel symbol is often qualified with a suffix that indicates which reference quantity has been used.

For example, dBm indicates a reference level of one milliwatt, while dBu is referred to 0.775 volts RMS.

Mathematically,

Power gain in dB = $10 \log_{10} (P_1 / P_0)$, where $P_1$ is the power level to be measured and $P_0$ is the reference power.

Voltage gain in dB = $20 \log_{10} (V_1 / V_0)$, where $V_1$ is the voltage level to be measured and $V_0$ is the reference voltage.

## Activity 23.1

To complete this activity, you may need about 15 minutes including writing down the answers in the space provided.

This activity will help you understand the concepts and functions of the components of a transmission chain in a CR station. This will also help you in understanding the representation of audio levels in volume units and decibel units.

Question: 1 How is a live console functionally different from a production console?

Question: 2 A VU (volume unit) question meter connected at the output of an audio mixer displays a level of '0' VU on its scale. What does '0' VU correspond to?

Question: 3 What is the decibel (dB) unit used for audio levels? Why is a decibel symbol often written with a suffix? What is the difference between $dB_m$ and $dB_u$?

## 23.5 Pre-recorded Transmission (Radio Automation/ Scheduling)

In this section, you will learn about pre-recorded transmissions, radio automation and scheduling.

In CRS set-ups, most of the programmes are pre-recorded either in the studio or in the field. They are played from the playback or transmission studios. Nowadays, a large variety of digital audio workstations (DAW) using radio automation software are available in the market but the one that best meets the requirements is used by a particular CR station. You learnt about the details of audio workstation in Unit 13 including its recording, editing and other features. In this section, you will learn about the functional requirements as far as scheduling and automatic transmission of pre-recorded programmes are concerned.

An audio workstation is a computer-based system which is solely designed to work as an all-in-one machine. It is able to record, edit, store, retrieve and play back as desired. With the help of a customized radio automation package, the operator can schedule the transmission for a day on real-time basis. It can automatically transmit the scheduled programmes on air.

Some of the features mostly available in almost all the software are:

- Semantically searchable records from library
- Retrieval of records from the stored data
- Preview of selected programme(s)
- Scheduling (auto transmission on real-time basis)
- Automatic fault diagnosis
- Logging and certification of all audio/data
- Master fader for control of transmission levels

As you learnt in the previous section of this unit, the most important parameter is to control the output levels of the selected programme (which may be either from the workstation or any other playback channel selected by the operator) to ensure that we do not overload the chain beyond the specified levels.

## Activity 23.2

To complete this activity, you may need about 15 minutes including writing down the answer in about 100 words in the space provided.

This activity will help you in understanding the concept and function of digital workstations.

Question: What is an audio workstation? Why is it becoming more popular to use it in CRS? Briefly describe its main functions.

Let us now move to the second component of the chain, that is, connectivity from the studio to the transmitter.

## 23.6 Connectivity (from Studio to Transmitter)

Your next step is to feed the output of the transmission studio to the transmitter, which may or may not be located in the same room. For this purpose, a suitable connectivity is required between the studio and the transmitter. In this section, you will learn about the various modes of connectivity used from the studio to the transmitter.

In most CR stations, studio and transmitter are co-located, may be in the same room or adjoining rooms. But in some of the situations, it is not possible to locate the transmitter with antenna and tower at a place where the studio is located. In such situations, it becomes necessary to provide a suitable connectivity between them.

The various modes of connectivity are as follows:

1. *Dedicated Physical Cable Pairs*

   In most of the CR stations, the distance between the studio and the transmitter may not be so much that it requires hiring telephone or leased lines. The transmitter may be located in the same campus but at a small distance from the studio. In such cases, a good quality shielded audio cable is laid locally to provide the connectivity. The cable must be passed through suitable conduits or pipes to avoid getting damaged.

2. *Telephone Lines or Leased Lines*

   The Department of Telecommunication is having a large network of telephone cables or lines laid in all the cities for providing telephone connections to the subscribers. This department provides and extends any number of pairs between two locations (studio and transmitter in our case) on demand. These are the easiest and cheapest modes of connectivity. However, the technical quality of this pair may or may not be up to the mark. It has limited bandwidth. Moreover, if the distance is more between the studio and the transmitter, the loss due to use of cable is huge. Nowadays, good quality broadband ISDN or leased lines are also available but they are costlier.

3. *VHF or Microwave Links*

   The connectivity between the studio and the transmitter can also be provided by use of point-to-point VHF or microwave links if the distance is more. Technically, the quality through this link is much better, but it has got a lot of limitations and restrictions. Separate siting and frequency clearances from Wireless Planning and Coordination (WPC) are necessary like a CRS. It involves extra spectrum fees apart from cost of towers and link equipment. The option is simply not cost effective for a low-budget CR station.

Laying of dedicated physical pairs for providing connectivity from the studio to the transmitter is the best possible option. The losses due to length of the cable can easily be compensated at the input transmitter.

## 23.7 Audio Processor/Limiter (if not Processed through the PC)

In Unit 17, you learnt about adjusting and balancing of levels at the mixer output. In this section, you will learn why it is necessary to process these audio signals again before feeding them to the transmitter.

Normally, the audio signals received from the broadcast studio are already processed and level controlled through the transmission console. However, since live consoles use different types of live or pre-recorded programmes, the recording levels may not be uniform.

An audio processor/limiter is needed to:

- Protect the transmitter against over modulation
- Increase average modulation or loudness

A large variety of audio processors are available in the market with varying range of features. The prominent ones are Orban, Alto pro, Behringer and Veronica. Whatever may be the type and brand of processor, the basic functions remain the same.

Every audio processor has the following three components:

- The compressor
- The limiter
- The peak clipper

The compressor is used to compress the large dynamic range of signals in a programme. It increases the average modulation level and thereby loudness in the programme.

The limiter limits the peaks in programmes beyond a set level to protect the transmitter from over-modulation.

The peak clipper cuts very high peaks, which are otherwise beyond the limiting level.

Various controls are provided in every processor to set the compression ratio, attack time, release time and thresholds of limiting and clipping. These are to be adjusted in accordance with the procedures given in the operating manual of each processor. The points to be kept in mind are:

- Nominal input levels of transmitters to get desired deviation.
- Quality of programme may not get deteriorated due to over-setting of compression and limiting.

You will learn about setting of controls and alignment of a transmission chain in practical workshop.

## 23.8 FM Transmitter

The next component of the tranmitter chain is the main FM transmitter, which is used to generate the frequency modulated RF signal of required power for feeding the transmission antenna for broadcast of RF signals. The FM transmitter is generally a stand-alone unit housed in a rack mountable box. Generally, a transmitter with 50 or 100 watt of power is used for CRS. The output of the transmitter is fed to the transmitting antenna mounted on the pole or tower. You will learn more about FM transmitters in the next unit.

## Activity 23.3

To complete this activity, you may need about 15 minutes including writing down the answers in the space provided.

This activity will help you learn the necessity and functions of connectivity and audio processor in the transmission chain.

Question: 1 Why is connectivity required from a studio to a transmitter?

Question: 2 What are the essential technical requirements which the connectivity link must fulfil?

Question: 3 Differentiate briefly between the functions of a compressor and a limiter in an audio processor.

## 23.9 Principles of FM Transmission

The next and the most important component in the transmission chain is the FM transmitter. An FM transmitter converts processed audio signals to frequency modulated RF signals before feeding them to the antenna system. In Unit 10, you will learn in detail about the functions and descriptions of each subunit within the transmitter. In Unit 6, you were introduced to frequency bands used in FM radio broadcasting. In this section, you will recapitulate/learn various terms used in understanding the basic principles of FM transmission.

*Frequency Modulation*

Frequency modulation is a type of modulation in which the frequency of the carrier wave is changed by the instantaneous amplitude of the modulating signal, whereas frequency of the modulating signal changes the rate of change of the carrier wave. In this process, the amplitude of the modulated carrier wave is kept constant, which is the most important feature of frequency modulation.

*Modulating Signal*

Audio frequency signal containing the information or content of the programme (output of mixer), which is to be transmitted, is called modulating signal. This signal is a complex wave containing frequencies varying from 30 Hz to 15 kHz with varying amplitudes. In case of stereo transmissions, about which you will learn later in this section, the maximum frequency of the modulating signal can go up to 53 kHz.

### *Carrier Wave*

It is the radio wave that acts as a carrier to transmit the message/information contained in the modulating signal to the listeners through the electromagnetic wave radiated by the antenna. The frequency of the carrier wave is the frequency that is allotted to a particular radio station in the VHF band (88 to 108 MHz). For example, if 90.4 MHz is allotted to a particular CR station, then 90.4 MHz is called the carrier frequency for that station. Each radio station is identified by its allotted carrier frequency. If frequency of this carrier wave is varied with the modulating signal, frequency modulated wave is obtained.

Figure 23.2 illustrates the principle of frequency modulation (FM).

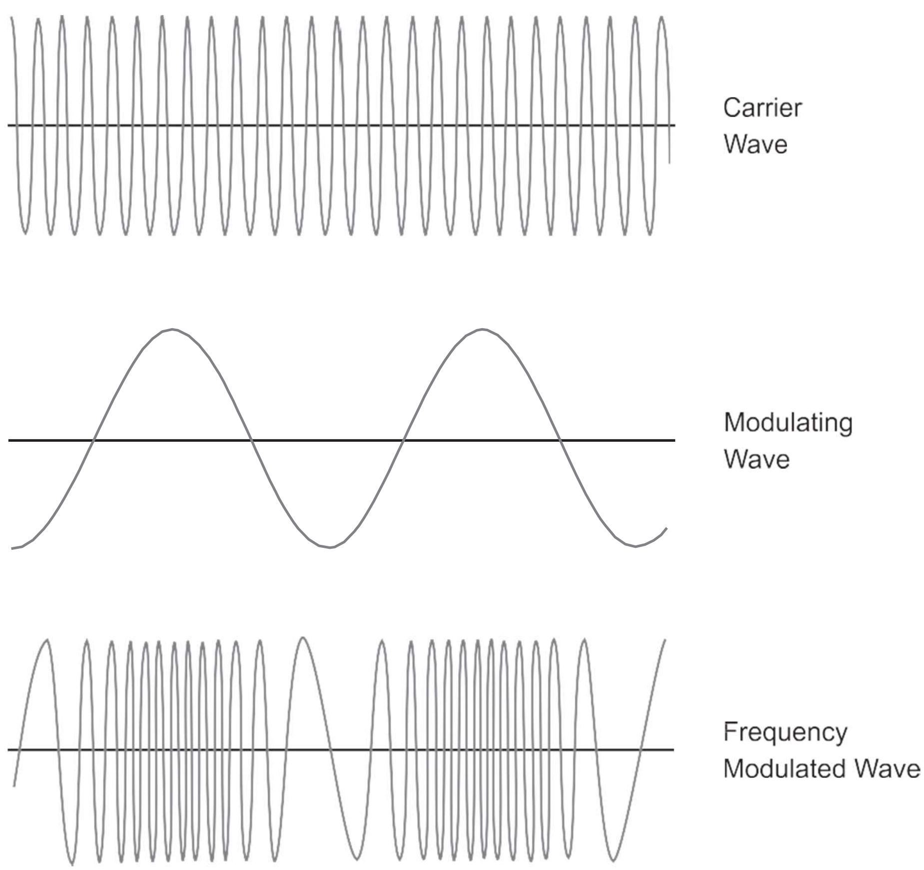



*Figure 23.2: The principle of frequency modulation*

Figure 23.2 shows three types of waves, namely carrier wave, modulating signal and the frequency modulated output wave. You should note the difference in wave shapes of the three waves. In all the three waves, the X-axis represents the time (i.e., number of cycles travelled by a wave in one second) and the Y-axis represents the amplitude. The first wave on the top is the un-modulated carrier wave. It represents the frequency of the radio station. Its amplitude and frequency remain constant. The middle one represents the audio signal, also known as the modulating signal. It is the signal that changes the frequency of carrier wave to get the FM wave (bottom wave). An important point to note here is that as the amplitude of modulating signal increases (during positive half cycle of modulating signal), the frequency of carrier wave also increases. As the amplitude of modulating signal decreases (during negative half cycle of modulating signal), the frequency of carrier wave also decreases. Another point which you should note here is that the amplitude of the carrier wave remains the same before and after modulation.

### *Frequency Deviation*

The amplitude of the modulating signal causes the carrier frequency to deviate (shift) on both sides of its central frequency by a certain amount. This amount of deviation is measured in kHz. Deviation is proportional to the amplitude of the modulating voltage. If we increase the amplitude of the modulating signal, the deviation also increases. In the Indian system of FM broadcasting, the maximum deviation allowed is +/- 75 kHz, which is treated as equivalent to 100% modulation in case of amplitude modulated (AM) transmissions.

Example:

If 0.5V level of audio signal deviates the FM carrier frequency by 10 kHz, then the deviation produced by 2V level of audio signal will be 40 kHz {(10/0.5)x2 = 40}.

### *Deviation Ratio*

The ratio of maximum deviation from the carrier frequency to the maximum frequency in the modulating signal is called the deviation ratio.

Deviation ratio = Maximum frequency deviation/Maximum frequency in the audio signal

A deviation ratio of 5 (75 kHz/15kHz = 5) is the maximum allowed in case of FM broadcasting.

### *Modulation Index*

The rate at which the carrier frequency shifts from its centre frequency to give a certain deviation depends on the frequency of modulating signal. The ratio of frequency deviation to the frequency of modulating signal is called the modulating index.

Modulation index = Frequency deviation in kHz/ Modulating frequency in kHz.

For example, If 5 kHz audio frequency (1V level) causes a frequency deviation of 20 kHz, the modulation index will be 4 (20 kHz/5kHz =4).

## Note It

Note that the change in modulating frequency (with same amplitude) does not change the deviation; however, it changes the modulation index.

### *Bandwidth in FM*

In FM broadcasting, bandwidth is the frequency band around carrier frequency containing sidebands of significant amplitudes. Bandwidth is dependent on the number of sidebands produced by the modulating signal and varies with modulation index. It is a complex process. In practice, it is determined by a rule of thumb called Carson's Rule.

#### Carson's Rule

It states that the bandwidth of modulated FM wave is twice the sum of deviation and the highest modulating frequency. For example, if the maximum deviation is 75 kHz and the maximum modulating frequency present in the modulating AF frequency is 15 kHz, then according to Carson's Rule, bandwidth works out to be 180 kHz [2 ( 75 + 15) = 180 kHz].

To prevent adjacent channel interference, a guard band of 20 kHz is provided. Thus, the maximum permissible bandwidth in FM broadcasting is 200 kHz.

### *Pre-emphasis*

In speech and music, amplitude levels of high frequencies are always much weaker than those of low frequencies. Therefore, high frequencies with low amplitude are not able to cause sufficient deviation in FM. This effect causes reduction of signal to noise ratio at high frequencies.

In order to overcome this problem, high frequencies in the programme content are boosted by passing them through an RC network having a time constant of 50 or 75 microseconds. In India, pre-emphasis with 50 microsecond time constant has been adapted.

*De-emphasis*

A corresponding attenuation to high frequencies is necessary to be given in the receiver to get back the original level of high frequencies. This process is called de-emphasis. The time constant of de-emphasis has to be same as that of pre-emphasis, that is, 50 microseconds. By now, you might have understood why it is necessary to follow the same standards for a transmitter and a receiver to be compatible.

*Mono/Stereo Transmissions*

Most of the programmes broadcast by the CR stations are monophonic. However, FM transmitters are capable of transmitting stereo programmes. For this, the transmitter has to be equipped with an inbuilt stereo encoder card to enable L and R channels of stereo signals to be broadcast on a single channel transmitter. The encoder combines the three components, namely mono signal (30 Hz to 15 kHz), stereo signal (23 kHz to 53 kHz) and pilot frequency (19 kHz) to give multiplexed output signal called 'MPX' signal. This composite MPX signal is then used to frequency modulate the carrier to give a frequency deviation of +/- 75 kHz. In order to standardize the transmissions, a pilot tone system is used for stereophonic transmissions. Here, a pilot frequency (19 kHz) is added (at a low level of about 10%) along with monophonic and stereophonic signals. This pilot tone is used by the receivers to detect the stereo broadcast.

*Transmission of Radio Data System (RDS)/Subsidiary Channel Authorization (SCA)*

Radio text data (like station code, auto tuning, traffic information) and a supplementary speech quality channel (like support commentary) can also be transmitted simultaneously in addition to monophonic and stereophonic programmes by using subcarriers of 57 kHz and 67 kHz respectively. With the addition of RDS and SCA signals, the composite multiplexed output signal gets modified as shown in Figure 23.3.

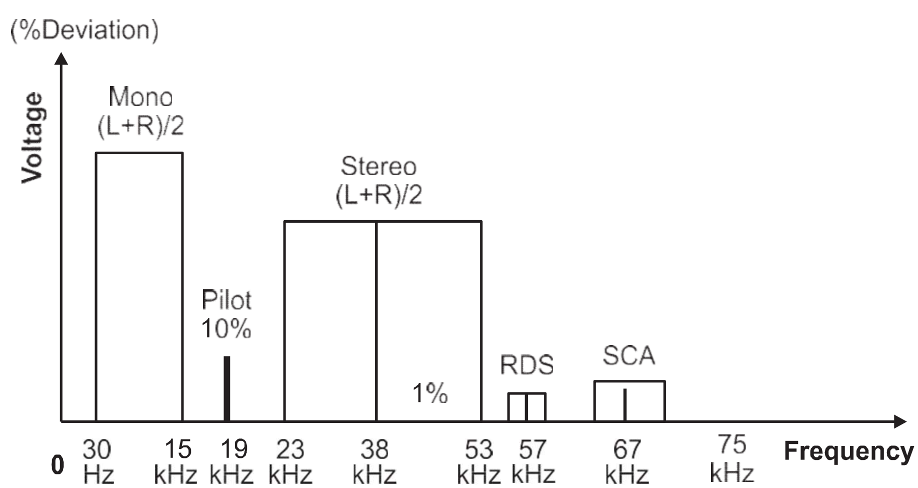



*Figure 23.3: Stereo multiplex baseband with RDS and SCA signals*

In Figure 23.3, the X-axis represents the frequency and the Y-axis represents the voltage or the percentage of deviation produced on each wave. Here also, you should note the relative placements of monophonic, stereophonic, RDS and SCA channels in the final composite multiplexed (MPX) output, called baseband signal. As can be seen in Figure 23.3, the monophonic transmission occupies the frequency band from 30 Hz to 15 kHz, whereas stereophonic transmission occupies a frequency band from 23 kHz to 53 kHz. Additional information to be broadcast using RDS and SCA is placed at 57 kHz and 67 kHz, respectively. The composite MPX output level is maintained in such a way that the maximum deviation due to this signal does not exceed +/- 75 kHz. Because of this feature of placement of frequencies, all these programmes can be simultaneously transmitted in FM. The listeners can receive any number of the programmes or data depending upon the availability of receivers/encoders with them.

*Transmission Standards*

In order to ensure compatibility of the transmitting and the receiving equipment, it is essential to have well-defined standards. Serious difficulties are felt by receiver manufacturers if uniform transmission standards are not adopted by the broadcasters. CCIR recommendation 450-1 defines the transmission standards for both monophonic and stereophonic transmissions (see Box 3).

## Note It

## Box 3

Transmission Standards for FM Broadcasting in India

1. Frequency Band = 88–108 MHz
2. Frequency Spacing = 100 kHz
3. Channel Bandwidth = 180 kHz
4. Max Frequency Deviation = +/- 75 kHz
5. Pre-emphasis Characteristics = 50 microseconds

A. Monophonic transmissions

   1. Modulating frequency range (AF) = up 15 kHz

B. Stereophonic, RDS and SCAtransmissions

   1. Pilot tone system using frequency of 19 kHz

2. Sub carrier frequency for stereo = 38 kHz
3. Amplitude modulated with suppressed subcarrier system is used
4. Sidebands = +/–15 kHz of 38 kHz
5. Stereo channel (L – R difference signal)bandwidth = 30 kHz ( 23 kHz–53 kHz)
6. RDS sub carrier = 57 kHz (Deviation +/–2.2 kHz)
7. SCA sub carrier = 67 kHz (Deviation +/–5 kHz)

## Activity 23.4

To complete this activity, you may need about 15 minutes including writing down the answers in the space provided.

This activity will help you in learning and understanding the basic principles of FM transmission.

Question: 1 What is frequency modulation (FM)? How does it differ from amplitude modulation (AM)?

Question: 2 What is meant by the term 'frequency deviation'? How much change in frequency deviation do you expect if the level of modulating audio signal is doubled?

Question: 3 Why are transmission standards necessary in FM broadcasting?

## 23.10 Antenna (Types and Polarization)

In this section, you will learn about the types of antenna and polarization used in CR stations. While only the functional details will be described in this section, more details of these components will be given in Unit 11.

The frequency modulated output of the transmitter is fed to the FM antenna via a low-loss coaxial cable.

Antenna is the final component in the transmission chain which actually converts the modulated FM carrier into electromagnetic waves.

### *Types of Antennae and Polarization*

Different types of antenna are used in FM broadcasting. Practical antennae are classified into different types on the basis of their size, shape, method of mounting and the polarization used. The shape can be straight, folded, loop or helix. The basic type of antenna used is the dipole antenna. When the total length of two parts of the dipole antenna is equal to a half wavelength, it is called a half-wave dipole. When a number of radiating elements are mounted one above the other, it is called an antenna array. This increases the gain of the antenna. In most CR stations, 2-bay antennae are used.

Polarization is defined as the orientation of electric field component of the electromagnetic wave with respect to the ground plane. Three types of polarizations are used in FM broadcasting, namely,

- Horizontal
- Vertical
- Circular

Vertical polarization is most commonly used in CR stations especially because of its ability of providing higher and better signals in the case of portable radios.

Transmitter output is connected to an antenna through a coaxial cable. You will learn about the details regarding this in the next unit.

## Activity 23.5

To complete this activity, you may need about 10 minutes including writing down the answers in the space provided. This activity will help you in understanding the functional characteristics of antenna system.

Question: 1 What is the function of an antenna in a transmission chain? Which type of antenna is commonly used in CR stations? What will happen if a 4-bay antenna is used instead of a 2-bay antenna?

Question: 2 Write down the names of three types of antenna polarizations used in FM broadcasting. Which type of polarization is preferred for a CR station?

(i) ..........................................................................................................

(ii) ..........................................................................................................

(iii)..........................................................................................................

## 23.11 Let Us Sum Up

In this unit on 'Components of Transmission Chain', you have learnt that:

- A transmission chain starts with an audio mixer through which the presenter plays back the selected pre-recorded or live programme and connects it to the next stage after controlling its levels.
- Pre-recorded transmissions can also be sent to the next stage automatically as scheduled by the operator by use of audio workstations.
- Physical cable pairs provide connectivity between the studio and the transmitter.
- In order to maintain proper transmission standards, the output level and impedance of each equipment must match with the input level and impedance of the following stage.
- An audio processor is used to process and control the signal levels before feeding them to the transmitter. Basically, it performs two functions. It compresses the signal to increase average modulation or loudness and limits the peaks that exceed beyond safe limit.
- An FM transmitter is a device that converts audio signals to frequency modulated (FM) radio frequency (RF) signals. The amplifier stages in the transmitter boost the level of RF signal to the desired output power (e.g., 50 or 100 Watts).
- Frequency modulation (FM) is the type of modulation through which the message contained in the audio signals is superimposed on the carrier wave by changing its frequency. The amount of shift in the carrier wave (called deviation) is proportional to the amplitude of the audio frequency. In FM broadcasting, the maximum deviation allowed is +/- 75 kHz.
- In case of stereo transmissions, a pilot tone system is followed in which a pilot frequency of 19 kHz is transmitted at a low level along with mono and stereo signals.
- The output of transmitter is fed to an antenna system by the use of a low-loss coaxial cable. The final component of the chain is the antenna, which converts the RF power output of the transmitter into electromagnetic (EM) waves.

## 23.12 Model Answers to Activities

Answers to Questions from Activities 23.1 to 23.5.

### Activity 23.1

1 A console, which is used for transmission of different programmes simultaneously on air, is called a live or transmission console, whereas a normal production console is used in studios to record a new programme.

2 A VU (volume unit) meter normally measures the average level of audio signals in volume units. A '0' VU corresponds to a voltage level of 1.23 volts (RMS) of an alternating frequency of 1,000 Hz measured across 600 ohm load. This is equal to + 4 $dB_u$ on a decibel scale with reference to 0.775 volts.

3 A decibel (dB) is a logarithmic unit indicating the ratios of the audio levels relative to specified reference level. A decibel symbol is often written with a suffix that indicates which quantity has been used as reference. A $dB_m$ indicates that 1 milliwatt is taken as reference, whereas $dB_u$ means 0.775 V (RMS) has been taken as reference.

### Activity 23.2

An audio workstation is a computer-based system that is designed to work as an all-in-one machine. It can be used for recording, editing, storing, retrieving and playing back any programme at any time. Selecting a desired programme from a library of stored programmes has become as fast as a click of a mouse. Because of these features, the use of audio workstations is becoming more popular in CRS. Apart from the above mentioned functions, other important features include auto-scheduling, logging of time/date and programme information, and automatic fault diagnostics.

### Activity 23.3

1 A suitable line or link connectivity is required for feeding the programmes from the output of transmission studio to the input of the transmitter.

2 Connectivity (line or link) should not offer any attenuation (loss) to the audio signals. Its frequency response should be flat up to 15 kHz. It should not have any noise, distortion or break.

3 A compressor circuit compresses the dynamic range of the programme according to the preset ratio to increase the average modulation level (loudness). The limiter circuit limits the peaks in the programmes to protect the transmitter from over-modulation.

## Activity 23.4

1 In frequency modulation (FM), the frequency of the carrier wave is changed in accordance with the instantaneous amplitude of the modulating signal. In amplitude modulation (AM), the amplitude of the carrier wave is changed in accordance with the instantaneous amplitude of the modulating signal.

2 The amplitude of the modulating signal causes the carrier frequency to deviate (shift) on both sides of its central frequency by certain amount expressed in kHz. This shift in frequency is called frequency deviation. If amplitude of the modulating signal is doubled, the deviation produced will also be doubled.

3 Transmission standards are necessary to ensure compatibility of transmitting and receiving equipment. For example, a receiver manufacturer must know the system of modulation used in the transmitter.

## Activity 23.5

1 The function of an antenna is to emit the RF output of the transmitter as electromagnetic (EM) waves into the air medium. A 2-bay vertically polarized antenna is commonly used in CRS. By using a 4-bay antenna, the antenna gain will increase, thereby increasing the coverage.

2 Three types of antenna polarizations used are horizontal, vertical and circular polarizations. Vertical polarization is commonly used in CRS.

# UNIT 10

# Components of FM Transmitter

## Structure

- ✓ Introduction
- ✓ Learning Outcomes
- ✓ FM Transmitter Overview
- ✓ Power Supply
  - Alternate Current
  - Switch Mode Power Supply (SMPS)
- ✓ Audio Processing
  - Compressor/Limiter
  - Stereo Encoder
- ✓ Exciter
  - Phase-locked Loop (PLL)
  - Audio Modulation
  - First Stage Amplification
- ✓ Amplifier
  - SMPS
  - RF Input
  - Main Pallet (Circuit Board)
  - Heat Sink
  - Main Output Transistor
  - Standing Wave Ratio (SWR) Mismatch and Thermal Protection
- ✓ 10.7.7. Display Panel
  - Filter
  - Switchover Panel
- ✓ Transmitter Maintenance and Fault Diagnosis
- ✓ Let Us Sum Up
- ✓ Model Answers to Activities
- ✓ Additional Readings

## 10.1 Introduction

As you know by now, the FM transmitter is one of the most critical components in the transmission chain. It is a piece of equipment without which a CR station cannot exist. A technician engaged in running a CR station must understand the FM transmitter in a greater detail, with its general designing concepts, various blocks and functions, areas of vulnerability, precautionary maintenance and troubleshooting. In this unit, you will learn about the various components of an FM transmitter. Many of these components are essentially used in community broadcast, while some of the components that you will find here may not be found in transmitters used in community broadcast systems. However, it is necessary for you to understand how an FM transmitter in its totality looks like. After understanding the basic transmitter in this unit, you will learn about transmitting antenna and propagation in the subsequent units.
Thereafter, you will get an opportunity to have hands-on practical on a transmitter to get familiarized with practical aspects. You will take about eight hours to complete this unit.

## 10.2 Learning Outcomes

After going through this unit, you will be able to:

- identify various parts of an FM transmitter.
- clearly explain its functions and understand its criticality.
- identify faults and suggest remedial measures.
- outline the basic maintenance of a transmitter.

## FM Transmitter Overview

An FM transmitter comprises the following main units:

- Power supply
- Exciter
- Modulator
- Amplifier
- Filter

A block diagram of the transmitter is shown in Figure 24.1.

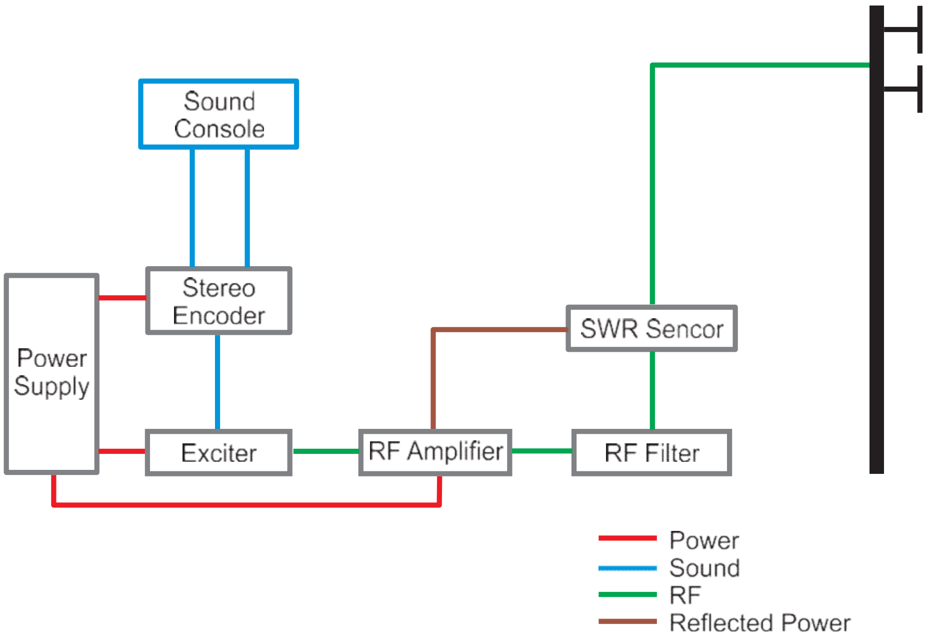



*Figure 10.1: Block diagram of an FM transmitter*

*Opened out details of the transmitter*

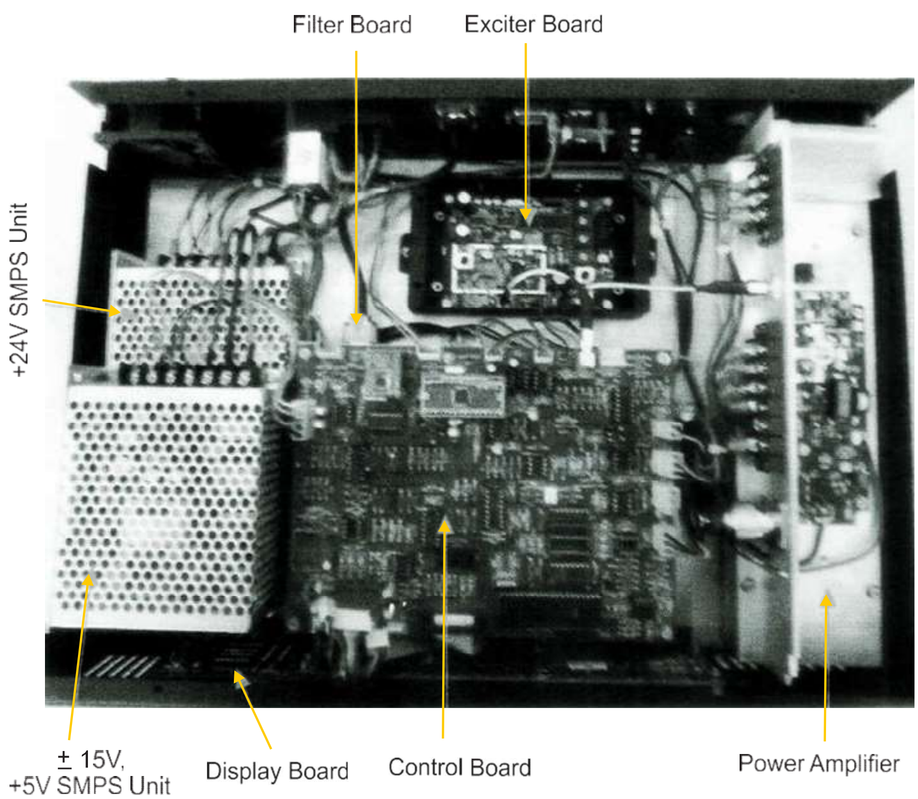



*Figure 10.2: Opened out details of a transmitter*

Detailed descriptions of the different units of a transmitter are given in the sections below.

## 24.4 Power Supply

It is very important to understand power supply in greater detail for proper handling of the transmission system. It has been observed that malfunctioning of power supply is responsible for different troubles that creep into the transmission system. To understand power supply, you have to first understand alternate current, its conversion to direct current and supply of different voltages to the transmission system.

### 24.4.1 Alternate Current

You have learnt about alternate current in the unit titled 'Basics of Electricity'. Alternating current supply, as you may know, approximates 230 V in 50 Hertz cycle that powers most of the appliances in our homes. When you plug in any home appliance like TV or washing machine, you don't know what is really flowing out of the wall socket as you assume that it would be a supply of 230 V.

However, when you power in a sophisticated and critical component like an FM transmitter, it is important to know whether what is flowing out of the wall socket is appropriate for the system.

How to check the wall socket is a subject that you have already learnt in the unit on Basics of Electricity, but here it is necessary to ascertain whether the quality of the cable and the plug that supplies 230 V AC power to the transmitter is proper and supplies consistent power to the transmitter. Generally, the cable is supplied by the transmitter manufacturer based on the flow of current required by the transmitter. An engineer's job is to ascertain that the same and not a similar cable is used for this purpose. If for some reason the cable is misplaced or has become faulty, which is highly unlikely, it is necessary to check with the manufacturer the type of cable that should be used.

In many cases you must have seen that the cable that has a three pin plug on one end does not fit properly in the socket due to use of a non-standard socket. In such cases, do not use any temporary measures and arrange for a proper cable.

### 24.4.2 Switch Mode Power Supply (SMPS)

Since most of the units of the transmitter require DC supply for its operation, almost all the transmitters convert 230 V AC power to DC power of various voltages as per the requirement of the transmitter. This function is carried out by a Switch Mode Power Supply (SMPS). SMPS is used in almost everything in our day-to-day life. Take any electronic device that is handy to you right now, for example, your mobile phone. The charger of your mobile phone is an SMPS. It takes 230 V AC from your wall socket and supplies the required DC current to your mobile battery for charging. Similarly, the charger of a laptop is also an SMPS. If you open a computer box, you will find an SMPS inside, supplying power to the various components of the computer like mother board, DVD ROM, or hard disk.

In a normal FM transmitter, there is a requirement of different DC voltages for different functions. In some transmitters, a single SMPS supplies different voltages, whereas in some transmitters, different voltages are supplied by different SMPS.

All SMPS units have both input and output. In most cases, the input would be 230 V AC current, whereas the output will differ based on the design of the transmitter or a specific function that the SMPS is expected to carry out.

## 24.5 Audio Processing

### 24.5.1 Compressor/Limiter

In many transmitters, especially designed for low-powered and low-cost community radio transmitters, the compressor is found within the transmitter box. You have learnt about the function of compressors in greater details in Unit 23 titled “Component of Broadcast Chain”. The limiter or compressor that is found inside the transmitter box or sometimes even part of the exciter has no or very little manual control. These limiter exciters are optimized at 100 per cent for broadcast. That means it will give a consistent level of sound without over-modulating the transmitter.

As you already know, compressor/ limiter is an automatic volume/level control or, let us say, programmed volume/level control that keeps the audio level at a consistent loudness. When someone speaks too loud, it will automatically reduce the volume and when someone speaks too softly, it will automatically increase the volume.

### 24.5.2 Stereo Encoder

You have studied about stereo sound in Unit 9 on Basics of Sound. Stereo is a sound that is divided into left and right channels given to different speakers. Now you may wonder what if you want to broadcast stereo sound (two L and R channels) through your transmitter. The problem here is that the transmitter works only on one frequency and cannot carry two different channels-left and right-in the stereo.

The solution is that you combine the two channels into one signal and feed it to the transmitter. This process is called multiplexing/encoding. Any stereo tuner receiving this signal decodes the multiplex back into separate left and right audio signals. The stereo coder and the receiver decoder synchronize with each other using a 19 kHz pilot tone, which is also added to the multiplex signal. Thus, the decoded signal will play out of a stereo radio in two separate channels-left and right-with two speakers attached to the radio.

Please note that most transmitters used in CR stations transmit it mono. There are two reasons for this. The most important reason is that most of the radio receivers used by the community members are low-cost mono. So, even if a CR transmits stereo signals, a majority of its listeners are going to listen it in mono. Second, reception of stereophonic signal requires higher signal. As a result, a stereo transmitter may have smaller coverage area as compared to a mono transmitter of the same power.

## 24.6 Exciter

Exciter is a very important part of the transmission system. The exciter, as its name suggests, excites the transmission system. In this part, radio signals of low power are generated, locked to a frequency and then modulated with audio frequency. This clearly means that there are three processes taking place here simultaneously. To understand the functioning of an exciter, you need to study radio signal generation, locking it to a frequency and modulating it to carry the audio signal.

It would be sufficient here to know that radio signals are generated through oscillation at a desired frequency. To achieve the desired frequency, all modern transmitters use a technology called phase-locked loop. This technology is used to ensure that oscillation does not deviate from the desired frequency.

### 24.6.1 Phase-locked Loop (PLL)

PLL is the abbreviation of phase-locked loop, a concept that is widely used in any kind of synchronization process. In a transmitter, it is used to achieve a steady frequency, say 90.4 MHz, at which a transmitter would radiate.

In the world of electronics, it is quite a complex concept, but for our purpose let us try and understand with an example. Every household in your neighborhood will have a wall clock and you must have noticed many of them showing slightly different time. Now, if these clocks are left to themselves, your neighborhood will never know what the accurate time is. So, you need to introduce one reference time, which could be Indian Standard Time (IST). Thus, every time a clock deviates, the owner of the clock can adjust the time to IST. Now imagine this process is automatized. Every time a clock deviates from the IST, it corrects itself. This kind of mechanism can be put in place with PLL.

In the case of CR transmitters, every time a frequency oscillator deviates from a set frequency–let us say, 90.4 MHz–an electronic circuit brings the oscillation back to 90.4 MHz. Thus, frequency generation with PLL becomes rock steady.

## 24.6.2 Audio Modulation

Now, your exciter has generated the frequency that needs to be modulated with sound. Remember the full form of FM-frequency modulation. As you know, sound broadcasting can be carried by two different modes. One is called amplitude modulation (AM) and the other is called frequency modulation (FM). You have already learnt about them in Unit 10. For recapitulation, however, the wave forms of both these types of modulated signals are reproduced in Figure 10.3.

In an exciter, there is a process of modulating radio frequency with audio signals in frequency modulation mode. It is here that the signal to noise ratio is determined and so also the level of modulation. It is also here that where the modulation level is generally adjusted.

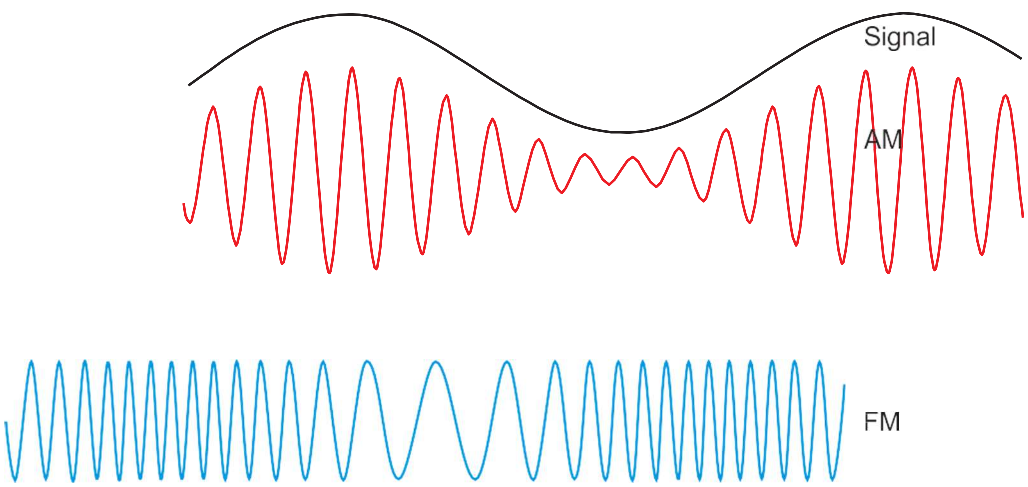



*Figure 10.3: AM and FM modulation*

## 24.6.3 First Stage Amplification

The modulated frequency generated with the help of PLL is generally very low in terms of power. It may be sometimes in a few milliwatts. Before the RF power is supplied to the amplifier, it needs to be pre-amplified to a level suitable for the amplifier design. For example, if your amplifier is designed to give 20 dB gain (You may find this in detail in the technical specification document provided by your transmitter manufacturer), then 1 W of RF power will be amplified to 100 W. That makes it necessary for the exciter to generate 1 W, so that an amplifier can amplify it to 100 W.

## Activity 10.1

Answer the following questions:

Question-1: What is the role of a PLL circuit?

Question 2: Draw a diagram showing amplitude modulation and frequency modulation and briefly explain the difference between the two.

Question 3: If possible, visit the nearest CR station and check power output of the exciter. You may refer to the manufacturer's literature. Write your observations.

## 24.7 Amplifier

RF amplification is a complex process. To begin with, it requires a low power radio signal that will have to pass through the final stage output transistor and induction coils. Also required is a filter circuit to cut out spurious and harmonics. Here, we will discuss the important components/process of amplification.

### 24.7.1 SMPS

As discussed earlier, the amplifier of the transmitter will require DC voltage. The power unit inside your transmitter box, known as SMPS, would be giving necessary DC voltage to the amplifier. In any transmitter, this would be the most critical and vulnerable component. If you find your amplifier not working, the first thing you need to check if the SMPS output voltage being supplied to the amplifier.

### 24.7.2 RF Input

The main function of an amplifier is to take small amount of RF power and amplify it to the necessary levels. That means there would be an RF power inlet in the amplifier. Different amplifiers have different input sockets: some use SO239 or UHF type sockets; some may use N type sockets; and some amplifiers use BNC types. If your exciter unit and amplifier unit are in the same box, the connectivity may differ. But remember that RF power is never carried anywhere without shielded cables. So, from the exciter unit to the amplifier you will see a coaxial cable, which transports the RF power to the amplifier.

### 24.7.3 Main Pallet (Circuit Board)

The main pallet is the printed circuit board that handles the entire amplification process. On this board you will find various coils, trimmers, RF chokes and other electronic components. Unless you are in a position to understand the whole process in great detail, it is most advisable to refrain from touching this part of the amplifier in the absence of proper tools and testing equipment.

### 24.7.4 Heat Sink

Most of the amplifier pallets are mounted on a heat sink, which is made of high grade aluminium blocks designed in such a way that it has the maximum surface area in a small form factor to absorb and radiate maximum heat. As the amplifier will generate radio frequency signals, it will also generate heat in proportion to the RF power. This heat has to be captured and thrown away from the amplifier unit. The heat sinks are used to capture all the heat that the amplification process generates.

The heat sink is supplemented by DC fans. In some transmitters, the fans are used to bring in cool air from outside in the transmitter box to keep the heat sink cooler. In some cases, the fans are used for throwing out hot air. But in many transmitters the fans work in both directions, that is, bring in cool air and throw out hot air. Fans are the only moving parts in the transmitter and quite likely to develop snag. These fans have ball bearings that can be damaged by their close proximity to RF.

### 24.7.5 Main Output Transistor

This output transistor is the core of your entire transmission system. It is this electronic part that generates the power output. It is one of the most expensive and vulnerable parts in the transmitter. It can easily be destroyed and, once damaged, it cannot be repaired. It is advisable not to touch or fiddle with it during maintenance

### 24.7.6 Standing Wave Ratio (SWR) Mismatch and Thermal Protection

Advanced transmitters available in the market have built-in protection for high SWR and thermal overloads. The function of the SWR protection circuit is to ensure that the transmitter is protected against very high SWR by switching off the transmitter (You will learn about it in the unit on Antenna). This circuit will fold up the power of the transmitter if it detects a very high SWR. The high SWR could be caused by many conditions such as damage to the antenna, break in the feeder cable or malfunctioning of connectors. If this condition persists, the reflected power will damage or sometimes even destroy the main output transistor.

Similarly, if the cooling mechanism of the transmitter fails, the transmitter will start getting heated up due to RF power. Thermal overload protection is provided to take care of this eventuality and shut down the transmitter.

## 24.7.7. Display Panel

Though it is not absolutely necessary, it is quite useful to have a display panel on the transmitter. This panel displays operating parameters of a transmitter when switched on. It could display the following parameters:

- Operating Frequency
- Output Power
- Reflected Power

*Audio Levels or Modulation Levels*

There are many advanced transmitters that provide the facility of changing certain parameters like frequency. But all transmitters do not let the user change the parameters from the control panel.

Please note that parameters shown in the display are for reference only. Sometimes the actual parameters measured with calibrated test equipment, which you may otherwise not find in a CR station, could differ from what is displayed in the built-in display panel.

## 24.7.8 Filter

Every oscillation process generates spurious signals, which are not intended to be generated. These signals could be anywhere in the radio frequency spectrum. They could even be harmonics in the exact multiple of the operating frequency but in a completely different band of spectrum. The spurious signals do not affect your transmission as much as it affects other equipment that may be using RF spectrum. Any transmitter that generates a spurious beyond the prescribed limit is known as a “dirty transmitter”.

ITU(R) and other national regulatory bodies have specified limits for spurious and harmonic radiations. It is, therefore, necessary that a transmitter filters out such radiations. For this purpose, all transmitters have a filter that suppresses the spurious and harmonious signals. There are different designs of filters but all of them are located at the last stage before the RF signals go out to the antenna through the feeder cable.

## 24.7.9 Switchover Panel

There is a general practice in radio stations to always keep a back-up transmitter. If one of the transmitters fails, the broadcast could be switched over to the spare transmitter. A community FM transmitter can use an automatic switchover system or a manual switchover system for this purpose. In an automatic system, both the transmitters are kept simultaneously switched on. The power of one transmitter is sent to the antenna system, while the second transmitter power would be sent to a dummy load that will convert the power into heat and absorb.

In the case of a manual system, you have to physically disconnect the malfunctioning transmitter from the audio and antenna system and connect the spare transmitter.

If your station is well-designed and you are well versed with the process of switching over, it may take less than a minute.

Please remember that automatic switchover panel would consume a bit of power. In high-powered systems, like that of a commercial radio station, this loss of power could be considered negligible, but in a CR station where the permitted power is just 50 W, even a single watt loss is undesirable. For this reason, most CR stations prefer manual switchover.

## 24.8 Transmitter Maintenance and Fault Diagnosis

After getting an idea about the components of an FM transmitter and the functions of its parts, it will be desirable to have an idea about the basic maintenance of an FM transmitter and fault diagnosis techniques. These are detailed below:

### Note It

### Box-1

#### Transmitter Maintanance and Checkup

A transmitter is very critical and perhaps one of the most expensive pieces of equipment in a CR station. Experience shows that an FM transmitter can run flawlessly for years if it is installed properly and maintained with meticulous regularity. Here are some of the maintenance tasks that should be carried out on daily, weekly and monthly bases.

#### Daily Tasks:

1. Ensure that the transmitter area/room is properly cleaned and no dust is allowed to settle in any corner.
2. Check the power and reflected power on the front panel and make a note of it in a log book so that if any fault is developing you have a historic perspective.

3. Check the modulation levels on the front panel and audio quality on a standard radio receiver. Look out for any hum or unusual sound.
4. Check all the connectors for any visible sign of stress, heat or any abnormality.
5. Give a visual check of the antenna system and see if there is any misalignment.

Weekly Tasks:

1. Take a weekly maintenance shutdown if your radio station is running 24 hours.
2. Check the phase, neutral and earthing of your AC power supply. Use multi meter for the purpose.
3. In monsoon season ensure that humidity level is under control in the transmitter area

Monthly Task

1. If you have manually switchable 1+1 configuration, then switch the operational transmitter from A to B or the reverse.
2. De-dust the transmitter with an air blower. Remember to necessarily open the lead of the transmitter. An electric blower (not the one used for hair styling) is generally used for cleaning.

## Note It

## Box 2

Troubleshooting:

If one fine morning, or not so fine morning, you start receiving calls from your listeners that they cannot hear anything, or you switch on the transmitter and the power indicator does not show power or shows inadequate power, the first thing you should do is not to panic. Please follow the diagnosis methodology as mentioned here.

- First of all, tune your radio to the frequency of your radio station. If you hear complete silence, it means the transmitter is working fine but the trouble is with your speech input equipment. Check your mixer or the source output and also the connectivity between your audio source and the transmitter.

- If your callers say they cannot hear anything, please calm them down and ask the following questions:
  - Ascertain if they cannot hear anything or they can hear your station with a lot of noise.
  - Ask what kind of radio receiver they are using.
  - Ask since when they have been facing this trouble.
- Give a quick look at the front panel power meter on your transmitter. Check the forward and reflected power. You may come across the following situations:
  - Power is very less than stipulated 50 W: In this circumstance, first check the reflected power. If it shows more than 1.8 SWR, you know that the trouble is with your antenna system. Check all connectivity and the antenna alignment. In such circumstances, it is advisable to switch off the transmitter or switch over to a back-up transmitter.
  - You may see there is no power at all: In this situation, tune in your radio receiver close to the transmitter, if you cannot hear your station at all, then the origin of the fault could be at the exciter level. But if you can hear your station well, it means the amplification process is notworking due to some fault in the amplifier.

Even if you find the fault, do not carry out any repair before talking to the supplier of your transmitter. Please call your supplier, explain the problem and discuss your diagnosis before you carry out any repair.

## Activity 10.2

Answer the following questions

Question 1: What is the function of an RF filter?

Question 2: Draw a block diagram of a transmitter describing the generation of an RF carrier, modulation and process of amplification.

## 24.9 Let Us Sum Up

Now we know that an FM transmitter is divided mainly in two sections, namely an exciter and an amplifier. Both the sections could be in one box or separate boxes. Both the sections will require separate DC power current, which is provided by a Switch Mode Power Supply (SMPS).

The exciter generates small amount of RF power and supplies it to the amplifier, which in turn amplifies the power and propagates it through an antenna. This simple process also involves modulation of frequency with sound and filtration of spurious and harmonics. All transmitters have front panel display that shows some of the basic parameters like operating frequency, output power, reflected power, modulation levels, etc. A good transmitter must have a thermal and SWR protection.

Remember a transmitter does not require much tweaking once installed correctly. All that a technician is expected to do is to keep the transmitter in a clean and dust-free environment and regularly monitor its operations.

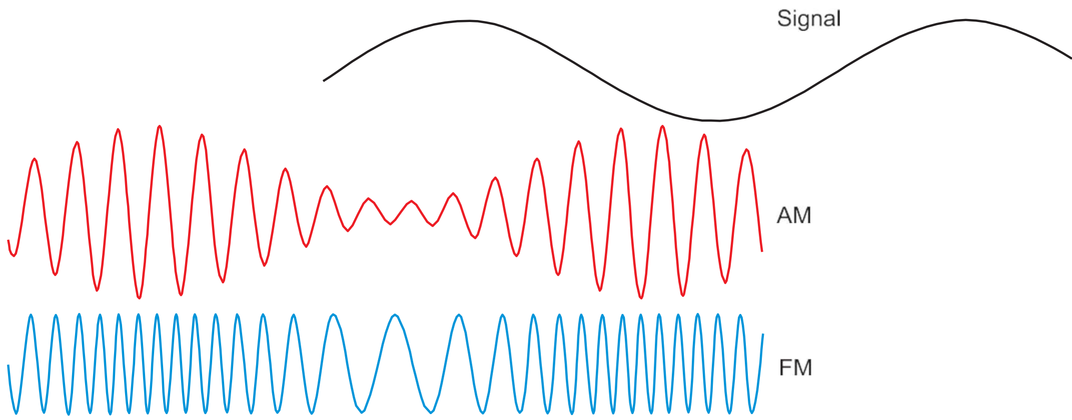
## 10.10 Modal Answers to Activities

### Activity 10.1

1. A phase-locked loop (PLL) is a control system that generates output based on input reference signal. A PLL circuit comprises a variable frequency oscillator and phase detector. The circuit takes the phase of an output oscillator and compares its frequency with the phase of the input and its frequency. On any variation it corrects the frequency of output phase.

   In a CR transmitter, the PLL is used at the exciter stage to lock the exciter frequency to the desired frequency allocated to the radio station by the government (WPC, DOT).

   PLLs are widely used in many types of electronic applications including radio, telecommunications and computers.



2. As can be seen in the diagram, in the case of AM the sound signal affects the amplitude of the carrier wave, whereas in FM the frequency of the carrier itself is modulated with the sound wave. The difference is that AM can travel very long distance but the sound quality is not as good, whereas in FM, though it travels comparatively shorter distance, it produces a very good sound quality.

## Activity: 10.2

1. As we all know, the oscillation process produces some amount of spurious and harmonics. Spurious is a frequency not deliberately created but gets generated in the process of oscillation. Any other signal that a transmitter generates outside its desired frequency is called harmonics. There are international standards for spurious and harmonics.

   An RF filter is designed to filter out these spurious and harmonics so that a transmitter does not generate a signal that can interfere with other devices. In short, it keeps the spectrum clean.

## 10.11 Additional Readings


- Gibilisco, S. (2002). *Teach yourself electricity and electronics*. New York: McGraw Hill.
- Noll, A. Michael. (2001). *Principles of modern communications technology.* Artech House.
- HYPERLINK "http://www.itu.int/rec/R-REC-BS.450-3-200111-I/en"Transmission standards for FM sound broadcasting at VHFHYPERLINK "http://www.itu.int/rec/R-REC-BS.450-3-200111-I/en". *ITU Rec. BS.450*. International Telecommunications Union.

# UNIT 11

# FM Antenna and Coaxial Cable

## Structure

25.1 Introduction

25.2 Learning Outcomes

25.3 Dummy Load

25.4 Coaxial Cables and Connectors

25.5 Antenna System

- 25.5.1 Types of Antennae
- 25.5.2 Gain of Antenna
- 25.5.3 Polarization
- 25.5.4 Radiation Patterns

25.6 Types of Mast/Tower

- 25.6.1 Location
- 25.6.2 Tower and Foundation
- 25.6.3 Mounting of Antenna and Cable on Tower
- 25.6.4 VSWR

25.7 Lightning Arrestor

25.8 Grounding

25.9 Let Us Sum Up

25.10 Model Answers to Activities

## 25.1 Introduction

In Unit 23, you learnt about the components of a transmission chain. Then in Unit 10, you learnt about the main component of the transmission chain, the FM transmitter. The output of the transmitter is connected to the antenna for on-air broadcast of RF signals. You were introduced to the types of antenna and polarization in Unit 23. In this unit, you will learn about the constructional details, technical specifications, functions and application aspects of the following components of the complete antenna system.

- Dummy load
- Coaxial cable
- Antenna system
- Supporting structure of antenna system
- Lightning arrestor
- Grounding system

As a part of this unit, in the video on "Types of Antenna and Installation", you will see the different types of antennae and their mounting arrangements on towers/ poles. You will also see how tower foundations, grounding and lightning arrestor arrangements are provided in a typical CR station.

You will learn about propagation and coverage aspects linked with the different types of antennae in the next unit, that is Unit 12, on propagation and coverage aspects.

You may need about 6 hours to complete this unit including answering the questions given in the activities.

## 11.2 Learning Outcomes

After reading this unit, you will be able to:

- list and describe the types of dummy load, coaxial cables, FM antennae and supporting towers used in a typical CR station.
- describe the constructional details of dummy load and its application.
- describe the constructional details of coaxial cables and their characteristics.
- identify and describe different types of FM antennae.
- define polarization and underline the significance of different types of polarization.

- differentiate between horizontal and vertical radiation patterns produced by practical antennae.
- list and describe different types of towers used in CR stations.
- explain the meaning and significance of VSWR.
- justify the necessity of lightning arrestor and grounding system.

We will begin with dummy load.

## 25.3 Dummy Load

In this section, you will learn about the purpose, constructional details and working principle of dummy loads provided in CR stations.

Dummy load is a device that is used to test the working of a transmitter before its output is connected to a cable and an antenna. The difference between a dummy load and an antenna is that a dummy load converts the RF energy into heat and not into electromagnetic waves, as is done by an antenna. Dummy loads are available in different types depending upon their power handling capacities. Dummy loads used for testing of high-power transmitters require forced air or water cooling. Since the power of a transmitter to be tested in CR stations is of the order of only 50 to 100 W, a small dummy load capable of dissipating a power of 100 W with convection cooling is sufficient.

Figure 11.1 shows the cut-out details of a typical dummy load capable of dissipating 100 W power, which is commonly used in CR stations.

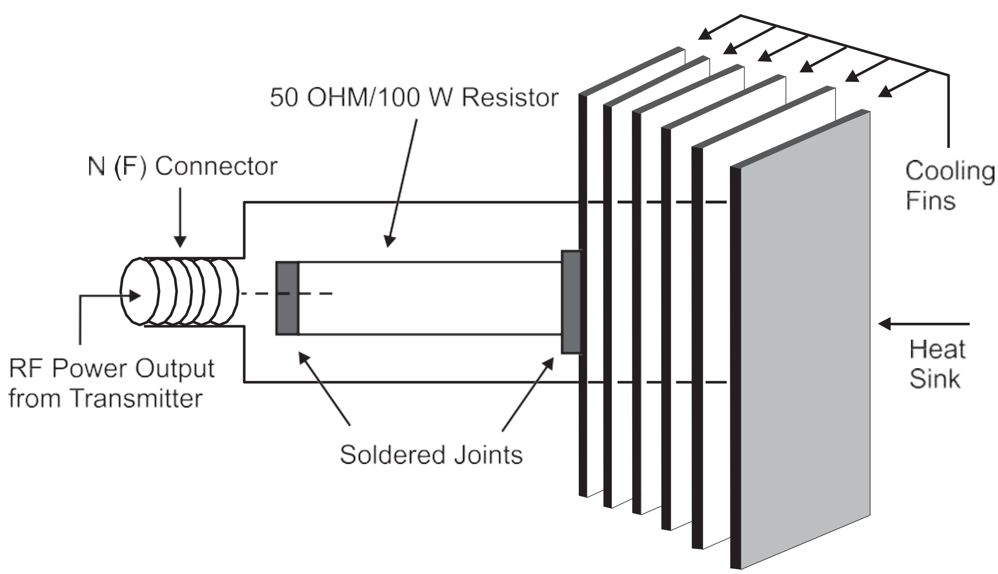



*Figure 11.1: Cut-out details of dummy load*

As can be seen in Figure 11.1, a dummy load consists of a 50 ohm/100 W non-inductive carbon resistor mounted on a heat sink having a large surface area and fins to dissipate the heat. One terminal of the resistor is connected to an 'N' (Female) type of connector and the other terminal is connected to the body of heat sink. When RF power of transmitter is connected to a dummy load via 'N' connector, it gets heated like any other heater. The heat produced in the resistor is dissipated in air by the heat sink. The surface area of heat sink is large enough to dissipate heat generated in the resistor to the surrounding air without raising its temperature.

The basic technical specifications/requirements of a dummy load are as follows:

- It should be purely resistive.
- It should not radiate RF energy in the air medium.
- Its power dissipation capacity must not be less than that of transmitter power.
- Its impedance should remain constant and should not vary with application of RF power.
- VSWR (Voltage Standing Wave Ratio, which will be explained later) of a perfectly matched dummy load is unity (1:1) but should not exceed 1.05:1.

Specifications of different models supplied by different firms vary according to the design of their products but you have to see that the minimum specified requirements are met while selecting a dummy load.

## Activity 11.1

To complete this activity, you may need about 10 minutes including writing down the answers in the space provided. This activity will help you in understanding the constructional and functional details of the dummy loads.

Question 1: What is the purpose of providing a dummy load in a CR station?

Question 2: Why are non-inductive resistors used in the construction of a dummy load?

Question 3: Why are fins and a large surface area provided in a dummy load?

Question 4: What should be the input impedance of a dummy load?

Question 5: Why are water-cooled/oil-cooled dummy loads used with high-power FM transmitters?

Now let us discuss the next important component of a transmission chain, that is, a coaxial cable and connectors.

## 25.4 Coaxial Cables and Connectors

In this section, you will learn about the purpose, constructional details and characteristics of the types of coaxial cables commonly used in CR stations.

The cables used for connecting the RF output of a transmitter to the antenna system are called coaxial cables. They come in different sizes and ratings. The size and type of coaxial cable depends on the power of the transmitter and attenuation (loss) of cable at the operating frequency. Since CRS set-up consists of a low power transmitter of the order of 50 W to 100 W, a low-loss cable of ½" size having foam dielectric is sufficient. Figure 11.2 shows the constructional details of a typical coaxial cable.

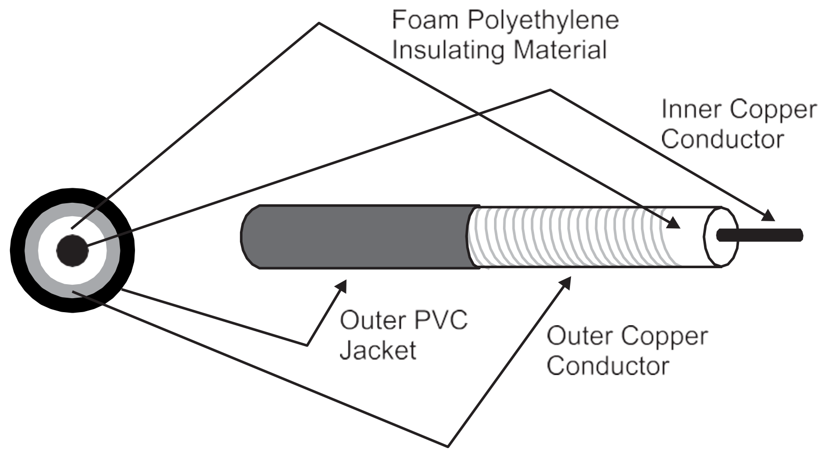



*Figure 11.2: Schematic diagram showing construction of coaxial cable*

As can be seen in Figure 11.2, a coaxial cable is made of two conductors, called the inner conductor and the outer conductor. The inner conductor is usually made of aluminium or copper and the outer conductor is made of corrugated copper sheet. The inner conductor is held in central position of the outer tubular conductor throughout the length of the cable by use of a uniform layer of insulating foam polyethylene dielectric material. A protective layer of PVC jacket is provided over the outer conductor to avoid any possible damage during handling and use.

Materials used for making inner and outer conductors may vary from manufacturer to manufacturer. However, the constructional design remains the same. Higher sized cables (Cables of size higher than 7/8") are available with air or foam dielectric which can be procured as desired by the user. Cables with air dielectric require pressurization to avoid entry moisture in them.

Important terms/specifications commonly used in identification and selection of coaxial cables are as follows:

### *Characteristic Impedance*

The characteristic impedance of a coaxial cable, usually denoted as $Z_{0,}$ is defined as the ratio of the voltage to the current for a single propagating wave (frequency). Its unit of measurement is ohms. The characteristic impedance of a coaxial cable normally used in CRS is 50 ohms.

### *Power Rating*

The power rating of a cable is the average power that it can transfer continuously to the antenna system without any heating and change in its designed parameters at its operating frequency. It is frequency dependent. The average power rating decreases as the operating frequency increases. Its unit of measurement is watts or kilowatts.

### *Attenuation*

When any RF signal travels in a coaxial cable, its power gets attenuated over the length of the coaxial cable. This attenuation or loss is expressed in dB (decibels) per 100 metre length.

See Box 1 for its mathematical formula.

## Box 1

The attenuation ($\alpha$) of RF cables is defined as follows:

$$\alpha = 10 \log (P_1/P_2) \text{ in dB/100m}$$

*where,*

$P_1$ = Input power fed into a cable terminated with the nominal value of its characteristic impedance

$P_2$ = Power reached at the end of the cable

Attenuation is the frequency dependent and is expressed as dB per unit of length. It increases as the frequency increases.

The material used in construction of the cable affects all the three parameters of a coaxial cable, as mentioned above.

Cables are normally received with end connectors connected to them. In case, if it is necessary to fix connectors on site, appropriate connectors as recommended by the manufacturer are to be used. You will learn more about the method of fixing these connectors in Unit 29 and practical workshop.

## Activity 11.2

To complete this activity, you may need about 10 minutes including writing down the answers in the space provided.This activity will help you in understanding the characteristics of an RF coaxial cable.

Question 1: Why should we use a low-loss cable in a CRS?

Question 2: What type of dielectric material is used between inner and outer conductors of a typical ½” coaxial used in CRS?

Question 3: What do you mean by the term characteristic impedance of a coaxial cable?

Question 4: 50 W output of a transmitter is fed to an antenna. Calculate the attenuation in decibel units if only 25 W reaches the antenna?

Question 5: What is the relation between average power rating and frequency of operation in an RF coaxial cable?

Now we move to the last and most important component in a transmission chain in a CR station, that is, its antenna system.

## 25.5 Antenna System

In previous sections, you learnt about dummy loads and coaxial cables. The RF output from the transmitter is fed to the antenna system via a coaxial cable. It is the antenna that converts the RF output of the transmitter into electromagnetic waves received by listeners through their receivers. It is, therefore, the antenna that plays a major role in affecting the coverage of the station. In this section and the subsections that follow, you will learn in detail about the following characteristics of antennae:

- Types of antennae
- Gain of antennae
- Polarization
- Radiation patterns

Let us begin with the types of antennae commonly used in CR stations.

### 25.5.1 Types of Antennae

FM antennae come in different sizes and shapes. They are usually classified into different types according to their size, shape and number of radiating elements, type of polarization and mounting arrangements used depending upon the technical specifications required. The basic radiating element is a dipole of half wavelength in different shapes like straight, folded, loop, helix or slot depending upon the design. The thickness and type of material decide the mechanical strength, impedance and power handling capacity of the antenna. When a number of radiating elements are mounted one above the other, the gain of the antenna increases, thereby increasing the coverage area. In the subsections that follow, you will learn in detail about the different types of antennae depending upon their mounting arrangements, number of elements used and type of polarization.

### *Side Mounted and Panel Antennae*

Besides the basic design aspects, there is another classification of antennae, which is based on their mounting on tower and which is more relevant to the user. Under this classification, antennae can be categorized into the following two categories:

- Side-mounted antennae
- Panel antennae

However, in the case of CR stations, only the former type, that is, side-mounted antennae are used because of their lower costs and ease of mounting. As such, only these will be discussed here.

### *Mounting of Side-mounted Antenna*

An antenna can be mounted on the top of the tower or side of a tower section, as illustrated in Figure 11.3.

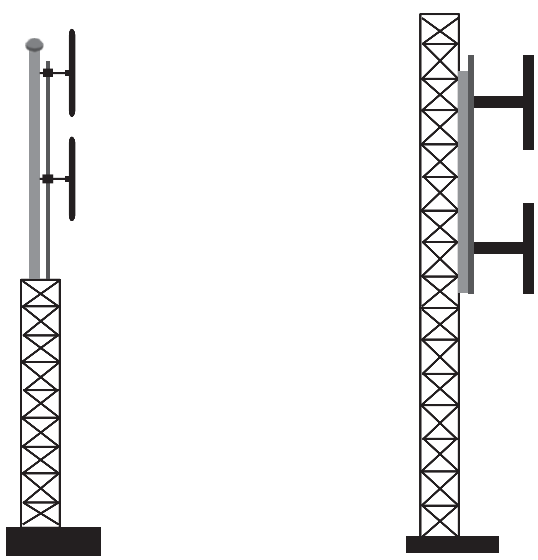


*Figure 11.3: (A)* Pole-mounted antenna *(B)* Side-mounted antenna

Figure 11.3 (A) shows the mounting arrangement of an antenna on the top of the tower. In this arrangement, two dipoles are mounted on a pole, which is fixed on the top of the tower. The thickness of the pole is smaller than the size of a cross section of the tower. In this case, the horizontal radiation pattern is nearly omni-directional. Figure 11.3 (B) shows an antenna mounted on the side of the tower. In this case too, the dipoles are mounted on a pole (called supporting structure) and the pole is clamped to the tower at a suitable distance. Even though the size of the supporting structure section is chosen to be much less as compared to the size of the supporting tower, the radiation pattern gets some directivity (pattern gets elongated due to more signal strength) in a particular direction due to presence of reflecting surface of the tower section. The type of mounting can be decided based upon the conditions existing at the site. Irrespective of the mounting, the most commonly used antenna in CR stations is described below.

### *Most Commonly Used Antenna in CRS – 2-Bay Vertically Polarized Antenna*

Now you will learn more about a typical 2-bay vertically polarized FM antenna, which is most commonly used in CR stations. Only physical construction and technical specifications will be described here, whereas radiation, propagation and coverage aspects will be described in Unit 12.

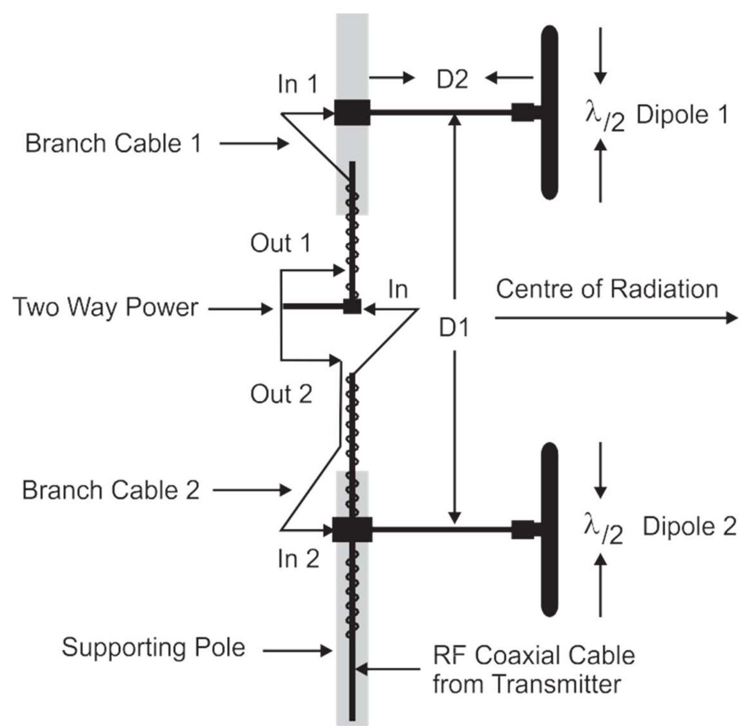



*Figure 11.4: Schematic diagram of 2-bay vertically polarized antenna*

Figure 11.4 illustrates a schematic diagram showing two dipoles of half wavelength each mounted on the pole. The output of the transmitter is connected to the input of a two way power divider, which gives two outputs equal in amplitude and phase that are fed to two dipoles through branch feeder cables. The spacing between two dipoles (D1) is very important and decides the gain and bandwidth. The material and thickness of dipoles decide the power handling capacity. With this type of antenna configuration, antenna gain of 3 dB (two times the power) and nearly omni-directional pattern is possible. Basic technical specifications and requirements of CR stations can easily be achieved with this type of antennae.

See Box 2 for relation between wavelength (denoted by λ, read as Lamda) and the operating frequency.

## Box 2

> Wavelength (λ) in meters = c/f
>
> Where c is the velocity of light in vacuum = $3 \times 10^8$ m/s and f is the frequency of operation in Hertz.

Now we will discuss the types of antennae with reference to polarization.

### 25.5.2 Gain of Antenna

Gain of antenna is the gain that a particular antenna gives with reference to a standard single half dipole. It is expressed in dB. Normally CRS deploys a 2-bay vertically polarized antenna, which has a gain of 3 dB.

### 11.5. Polarization

In Unit 23, you were introduced to the basic idea of some types of polarizations. In this subsection, you will learn in detail about the concept of polarization and the types of polarization. Each type of polarization will be discussed with its application in a practical antenna.

Figure 11.5 illustrates the graphical representation of an EM (electromagnetic) wave.

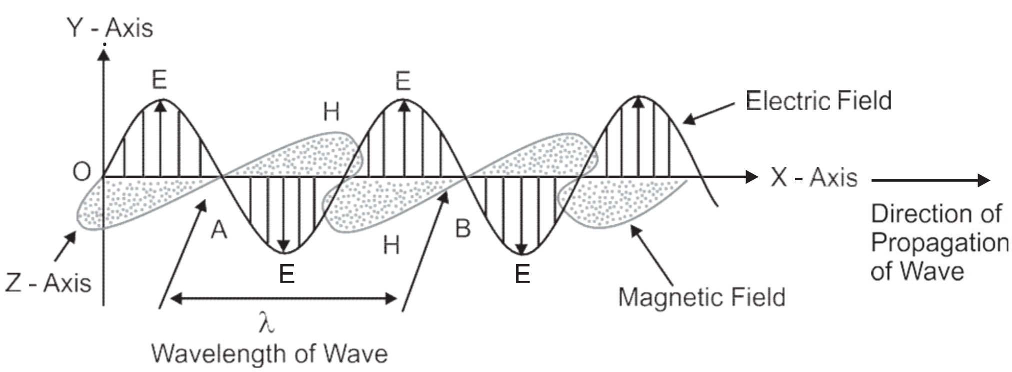



*Figure 11.5: Graphical representation of a plane wave*

As can be seen in Figure 11.5, an electromagnetic wave has two components, electric field E and magnetic field H, which are perpendicular to each other. Both are also perpendicular to the direction of travel of the wave. The direction of each component of electromagnetic wave should be noted. In this figure, direction of travel of wave is along X-axis, direction of E component is along Y-axis and that of H component is along Z-axis. *The plane of electric field E with respect to the ground is called the plane of polarization.* The wave shown in this figure is a vertically polarized wave.

### *Types of Polarization*

Basically, three types of polarization are used in FM broadcasting:

1. Horizontal polarization
2. Vertical polarization
3. Circular polarization

#### *Horizontal Polarization*

When the plane of electric field component E is parallel to the ground, it is called horizontal polarization.

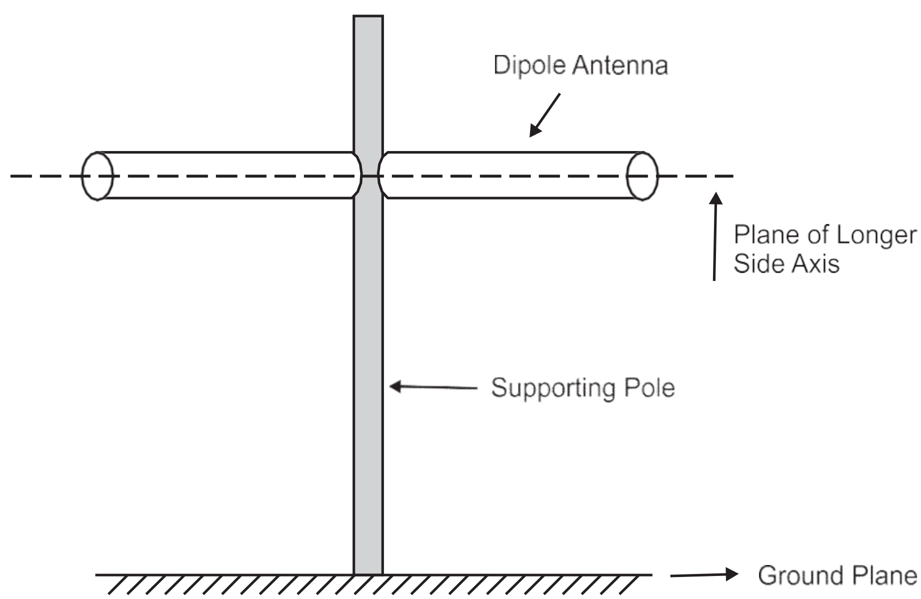



*Figure 11.6: Horizontally polarized antenna*

Figure 11.6 shows a horizontally polarized antenna. Note the direction of mounting of the longer side axis of the antenna. Physically, the radiating dipole element is mounted parallel to the ground and therefore, the antenna is called horizontally polarized antenna.

### *Vertical Polarization*

If the orientation of electric field E is perpendicular to the ground, it is called vertical polarization.

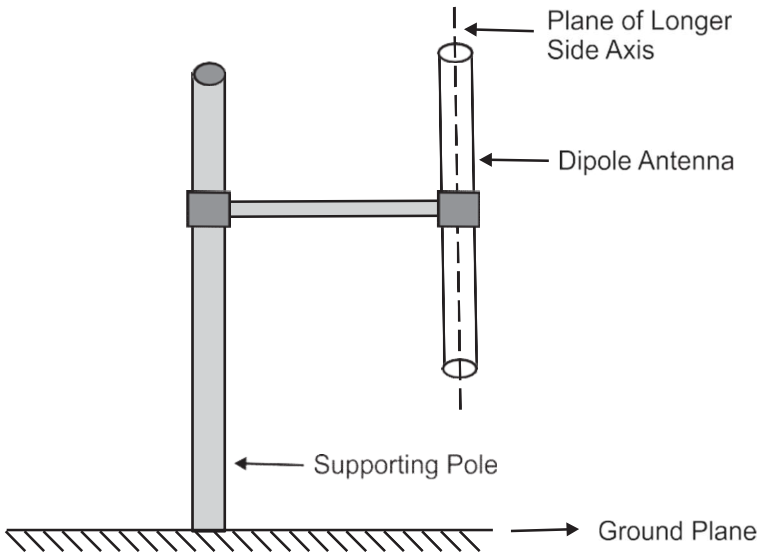



*Figure 11.7: Vertically polarized antenna*

As can be seen in Figure 11.7, the radiating dipole element is mounted perpendicular to the ground and the antenna is, therefore, called a vertically polarized antenna.

### *Circular Polarization*

In circular polarization, two radiating dipole elements are mounted perpendicular to each other as shown in Figure 11.8. As a result, the E component of electromagnetic wave radiated by each dipole will be at right angle to each other. The resultant vector E of these two electric fields produced by each antenna travels in a circle. Such type of a wave is called circularly polarized wave.

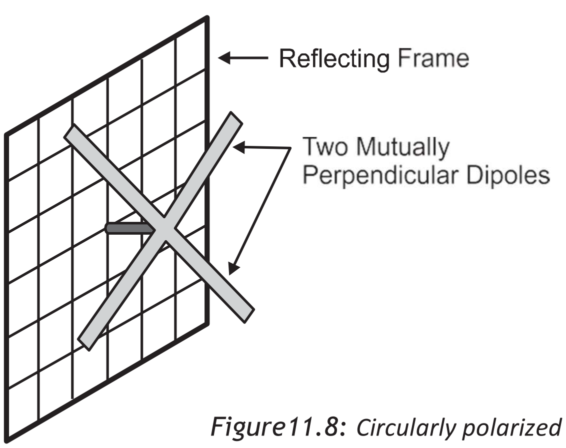



*Figure11.8: Circularly polarized antenna using crossed dipoles*

Figure 11.8 shows the mounting arrangement of a circularly polarized antenna. Here also note the mounting arrangement of two dipoles. These are mounted mutually perpendicular to each other. Practically, a circularly polarized antenna can be made in different forms and combinations by bending the dipoles, fixing the dipoles in right crossed or in crossed V shapes.

*Choice of Polarization*

Almost all the FM broadcasters in India, operating on high power, are using circularly polarized antennae to cater to both fixed and vehicular reception. However, in case of CRS which are operating on low power, a vertically polarized antenna is usually preferred because it is better suited for portable receivers and offers better antenna gain than the circularly polarized antenna.

Now, in the subsection that follows, you will learn an important characteristic of antenna called radiation pattern.

## 11.5.4 Radiation Patterns

When an RF output of the transmitter is fed to an antenna, it radiates electromagnetic waves in all directions producing different types of patterns. You will learn more details on radiation patterns in Unit 12. In this section, you will learn about the two important performance patterns produced by FM antennae called horizontal and vertical patterns.

*Horizontal Pattern (Azimuthal Pattern)*

A dipole antenna when mounted in a vertical position produces a horizontal pattern like a sphere radiating in all the radial directions. This pattern is used for calculating the field strength radiated along various radial directions.

*Vertical Patterns*

Vertical patterns of an antenna give the values of fields produced by the antenna in various angles of radiation in the vertical plane. The shape of pattern depends upon the length of the dipole and inter-bay spacing in terms of wavelength. As the length of dipole is increased from half wavelength to one wavelength or more, apart from the main lobe (Vertical Radiation Pattern), a number of side lobes also get generated. Study of these lobes gives a fair idea of formation of nulls in particular directions. The nulls can be filled by shifting the phase of the currents in one or more dipole elements of the array.

Horizontal and vertical patterns produced by a half-wave dipole are illustrated in Figure 11. 9.

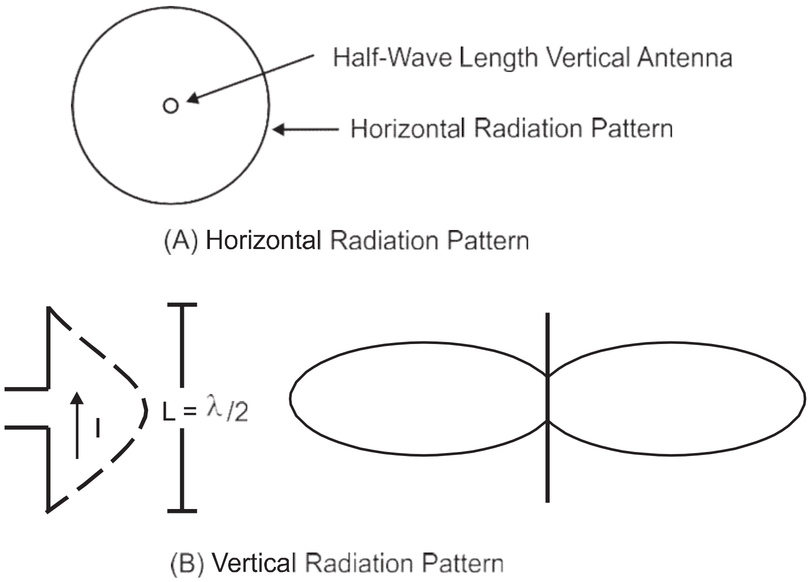
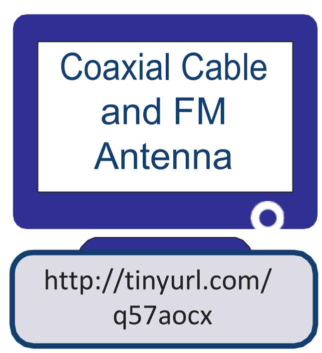



*Figure 11.9: Horizontal and vertical patterns of a half-wave dipole antenna*

Figure 11.9 (A) shows the top view of the horizontal pattern produced by a half-wave dipole antenna. Here, the dipole antenna is located in the centre. Horizontal pattern is a circular pattern giving signal levels in all azimuthal directions. Interpretation of horizontal pattern helps in knowing the field strength received along various radials while plotting coverage contours of any radio station. Figure 11.9 (B) shows the vertical pattern of a half-wave dipole. The main lobe of the vertical pattern looks like the number '8' spread horizontally. As can be seen in the figure, radiation along the vertical axis is practically nil. Vertical pattern helps in understanding the formation of side lobes and taking necessary action in taking care of nulls in the coverage area.

Hope you have already got an idea regarding the coaxial cable and antenna in the aforementioned sections of this unit. To make it easily understandable and before we will proceed further to study about the types of masts that are required for mounting the antenna, let us watch a video on antenna and coaxial cable. To watch this video, please visit the CEMCA YouTube site in this URL- http://tinyurl.com/q57aocx .




## Activity 11.3

To complete this activity, you may need about 10 minutes including writing down the answers in the space provided. This activity will help you in understanding the important characteristics of an antenna on the basis of its type, mounting arrangement and the polarization used.

Question 1: Name the types of information available if we say an antenna used in a CR station is '2-bay vertically polarized pole-mounted dipole antenna'.

Question 2: What will be the type of polarization called if we mount two dipoles perpendicular to each other on the side of a tower and feed them with equal power?

Question 3: What information can we draw from the interpretation of a horizontal radiation pattern of an antenna?

Question 4: How can we get the same coverage if we use a single antenna instead of a 2-bay antenna?

Question 5: If your station is working at 100 MHz, what will be its wavelength in metres? What will be the length of a half-wave dipole used in the station?

## 25.6 Types of Mast/Tower

In the previous section, you learnt about the various types of antennae, polarization and the radiation patterns produced by them. You also learnt that mounting arrangement affects the pattern and the height of mast affects the coverage. In this section, you are going to learn about the following aspects of masts used for mounting an antenna:

1. Types of masts
2. Location
3. Foundation
4. Mounting of antenna on tower
5. VSWR

You will learn all these aspects of tower in the order they are given above. Let us begin with types of masts.

### *Types of Masts/Towers*

The coverage of a CR station depends on the height of the antenna above the ground level. Higher the antenna, larger is the coverage. Masts or towers are required for supporting the antenna system at a desired height.

The towers for FM broadcast fall into two categories:

1. Self-supporting towers
2. Stayed or guyed masts

Self-supporting towers occupy a small area of ground and are therefore, attractive when the available open site area is restricted. They are usually of lattice construction. They require relatively less maintenance.

Stayed masts, also called guyed masts, occupy a considerable large space for anchoring the guys. They may be tubular or lattice.

Steel towers are more economical and less prone to twisting or bending.

Examples of self-supporting towers and guyed masts are shown in Figure 11.10.

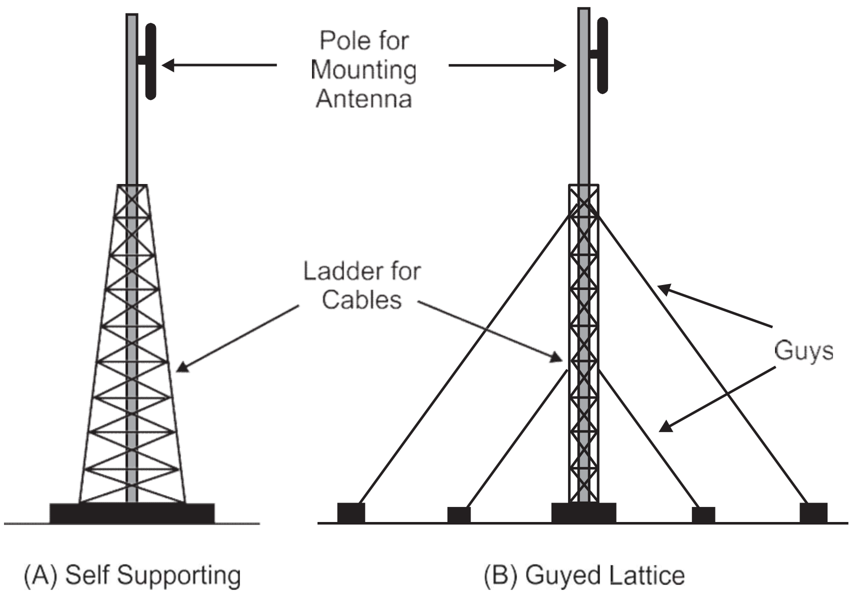



*Figure 11.10: Types of towers*

As seen in Figure 11.10, poles are mounted on top of both types of towers. Note the difference between the two types. The base and dimensions of tower sections are wider in case of a self-supporting tower, whereas a guyed tower is thinner but guys spread over a large area are required for supporting the tower.

Whatever may be the type of tower, essential technical requirements are as follows:

1. Towers must be strong enough to withstand the maximum wind speeds recorded in that area.
2. Clamping of antenna must be done properly to avoid any bending or twist of dipoles.
3. Galvanizing of steel members (coated with zinc) by the 'hot-dip' process and painting must be done at regular interval to avoid rusting and corrosion.
4. Provision should be made for lightning arrestor, ladders for climbing and cable routing.
5. Provision must be made for aviation obstruction lights as per rules in force.

### 25.6.1 Location

In this subsection, you will learn about the location of towers. Location of towers is important from the point of view of foundation and the coverage.

Since the objective of CR stations is to serve to a particular community residing in a small concentrated area or an institution like a university campus, the choice of location of the site is to a large extent limited to the available area. However, important points worth noting for deciding the location are as follows:

- Location should be at the centre of the service area and preferably at the elevated place.
- Location should be on firm ground.
- Land should not be low lying or marshy.
- An open space of about 6 x 6 M is required for the tower.
- The location of tower should be as near to the transmitter room as possible.
- Location of guy anchors should be exactly at 120 degrees from each other.

### 25.6.2 Tower and Foundation

In this subsection, you will learn about the points to be considered while deciding the tower and its foundation.

While erecting any tower, whether guyed or self-supporting, the design aspects relating to the structural stability, dead load of tower and antenna system and the wind speed must be considered.

It is a general practice that all the foundation and erection drawings are supplied by the firm delivering the tower. Technicians/engineers supervising the erection work must ensure that foundation and erection drawings are followed. The quality of material used by the contractor should also be strictly checked to avoid any untoward incident in future.

### 25.6.3 Mounting of Antenna and Cable on Tower

In this subsection, you will learn about the mounting of antenna and cable on tower. Mounting of antenna is a highly skilled job. All personnel required to work on high structures must undergo training before doing so. Normally, all the antenna and other accessories are shipped in dismantled condition, which are assembled on site.

The following instructions/guidelines must be followed while assembling and mounting of an antenna:

- Personnel should be equipped with protective clothing, hard hats and safety belts.

- Drawings and instructions for assembling on site must be understood clearly.
- Spacing between the dipoles must be maintained as per the drawings supplied by the manufacturer.
- A proper branch feeding cable for the respective dipole must be used as per drawing.
- The supervisor at ground must explain and confirm that the rigger/mast technician understands the instructions and guidelines in his language properly.
- Proper connectors supplied by the manufacturer must be fixed correctly as per instructions. Any wrong connector used or improperly fixed results in mismatch and correspondingly a loss of RF power.
- For supporting the RF cables, horizontal and vertical racks must be used.
- The cable must be clamped at every metre of the length with cable clamps of appropriate size.
- There should not be any sharp bends in RF cables. These bends may damage the cables.

### 25.6.4 VSWR

Now let us discuss a very important parameter called VSWR (Voltage Standing Wave Ratio), which is a measure of mismatch between the antenna and the cable. Our main purpose is to transfer all the output power of the transmitter to the antenna. To make this maximum power transfer possible, the characteristic impedance of the coaxial cable should match with the input impedance of the antenna.

When the impedance of the antenna differs from the specified value, part of the energy is reflected back towards the transmitter as reflected wave. The interaction between the forward and reflected waves sets up a voltage pattern in the cable, which varies between maximum and minimum values as shown in Figure 11.11.

VSWR is the ratio between the maximum and minimum values of voltage of the standing wave.

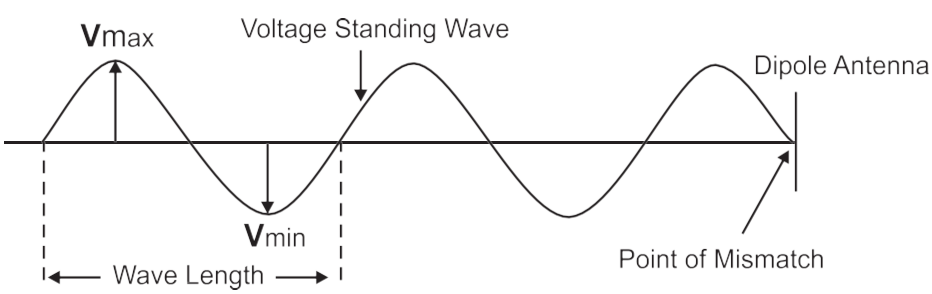



*Figure 11.11: Voltage Standing Wave Ratio*

Figure 11.11 shows a graphical representation of a standing wave formed by interaction of the incident wave and the reflected wave at the point of mismatch. The voltage standing wave has got a point of maxima and a point of minima. The ratio of Vmax to Vmin is called the VSWR. If this matching is perfect, no power is reflected back and VSWR is equal to unity (1:1).

You will learn more about VSWR measurements of antenna in Unit 29.

In the next section, you are going to learn about the protection of towers against lightning.

## 25.7 Lightning Arrestor

In this section, you will learn about lightning arrestor, which is provided on top of every tower to protect the tower, antenna system, coaxial cable, transmitter and operating personnel from lightning.

Virtually, all masts are subject to lightning strikes, and in tropical areas this incidence is high. The effects of lightning are well-known and the high levels of electrical energy that are generated can result in severe damage to a transmitting installation and even to the staff. It is not possible, of course, to prevent occurrence of lightning strikes but their effects can be minimized by careful design. Lightning tends to strike the highest well-defined point in an area. Masts or towers, particularly those sited on hills, are more vulnerable. The discharge of electrical energy associated with a lightning strike takes the form of a high-current pulse that passes from the point of strike (the top of mast) to the point of lower potential (usually the ground). The route taken by the discharge current can be via more than one path. It is very difficult to predict the path taken by lightning current. However, this path can be channelized by putting lightning arrestor on top of the tower. Lightning arrestor is of a very highly conductive material and connected to the nearest earth pit via copper strap. The earth pit is preferably provided in the wettest part of the site between the mast and the building. The purpose is to provide a low resistance path so that the voltage induced in the arrestor due to lightning is immediately connected to the earth before causing any damage to the equipment and staff. To ensure that lightning currents flow directly to earth without damaging the equipment and staff, it is essential that a transmitting station must have comprehensive grounding system. You will learn about this grounding system in the next section.

## 25.8 Grounding

In this section, you are going to learn about the grounding system, which is an essential requirement for protection of the equipment and the staff against lightning.

The objectives of grounding are to:

1. Provide safety to the equipment and personnel against lightning.
2. Reduce losses in radiating antenna system.

### *Earthing System*

The earthing system consists of an ordinary plate or an extensive network of driven conductors and plates (called electrodes), buried deep into the soil. For this purpose, earth pits giving very low resistance value are made. Different types of earth pits are used. The most commonly used is GI Pipe earthing.

Alternate layers of salt and charcoal are added along with good earth to retain moisture and achieve good conductivity. The purpose is to get very low-resistance value of the order of less than 1 ohm. Where the ground is rocky, it may not be possible to excavate a pit to sufficient depth and in that case several smaller pits joined by copper straps should be used.

You will learn about the method of making earth connections and measurement of earth conductivity in Unit 28 and in practical workshop.

## Activity 11.4

During your visit to a CR station, take a look at the dummy load, coaxial cable, antenna system, tower, lightning arrestor and grounding system used at that station. Note down the specifications for the important parameters of items studied in this unit. Fill in the details in the proforma given below. This will help you identify the types of these items and visualize their significance. You can refer to manufacturers' manuals in this regard.

### A. Dummy load

| Sl. No. | Parameter | Specification |
|---|---|---|
| 1 | Make | |
| 2 | Model no. | |
| 3 | Power rating | |
| 4 | Input impedance | |
| 5 | Type of cooling | |

## B. Coaxial cable

| Sl. No. | Parameter | Specification |
|---|---|---|
| 1 | Size of cable | |
| 2 | Length of cable | |
| 3 | Make4Model no. | |
| 5 | Power rating | |
| 6 | Characteristic impedance | |
| 7 | Type of connectors | |

## C. Types of antenna

| Sl. No. | Parameter | Specification |
|---|---|---|
| 1 | Type | |
| 2 | Make | |
| 3 | Model | |
| 4 | Number of radiating elements used | |
| 5 | Polarization used | |

## D. Supporting towers and mounting of antenna system

| Sl. No. | Parameter | Specification |
|---|---|---|
| 1 | Type of tower | |
| 2 | Height of tower | |
| 3 | Height of antenna | |
| 4 | Mounting of antenna | |
| 5 | Foundation of tower | |

## E. Lightning arrestor and grounding system

| Sl. No. | Parameter | Observations |
|---|---|---|
| 1 | Number of earth pits used | |
| 2 | Type of earth pit | |
| 3 | Watering arrangement | |
| 4 | Use of lightning arrestor | |
| 5 | Grounding of tower | |

## 25.9 Let Us Sum Up

In this unit on FM antenna and coaxial cable, you have learnt that:

- Dummy load is required for testing the transmitter before it is connected to the antenna. The dummy load converts the RF power into heat without any RF radiations. The power rating of dummy load should not be less than the transmitter output power.
- RF coaxial cable is used to transfer transmitter output power to the antenna system. Feeder cables mostly used are low-loss cables. Power rating and attenuation are both frequency dependent. Power rating decreases as the frequency increases, whereas attenuation increases with increase in frequency.
- The antenna system is required to convert RF output of the transmitter into electromagnetic waves. We have also discussed various types of antennae and classified them into different categories according to design, construction and mounting arrangements. Important parameters of FM antennae are horizontal and vertical radiation patterns and the VSWR (Voltage Standing Wave Ratio). VSWR is the measure of degree of mismatch at the input of the antenna.
- Towers are required to mount the antenna system. We have, discussed two types of towers, namely self-supporting and guyed towers. Self-supporting towers are more stable and require smaller area for foundation. Foundation and structural designs are based on height of tower, dead load and wind load of antennae.
- To protect tower, antenna cable and operating staff from lightning, use of lightning arrestor and grounding of tower and cable is necessary. The tower, cable and body of the transmitter and electrical panels should be connected to the nearest earth pit by use of double copper strips. The location of the earth pit should be preferably in the wettest place to retain moisture and as near to the tower as possible. The earth resistance of earth pit should be less than one ohm.

## 25.10 Model Answers to Activities

Answers to questions given in Activities 11.1 to 11.3.

### Activity 11.1

1. Dummy load is provided to check the output and performance of the transmitter before it is connected to the antenna.
2. Non-inductive resistors are used in the construction of a dummy load because dummy load should dissipate the RF power into heat and not radiate into air medium.
3. Large surface area and the fins help quick transfer of heat produced in the resistor of dummy loads into the room with raising the temperature.
4. Input impedance of the dummy load should be equal to the output impedance of the transmitter. It is equal to 50 ohms normally.
5. When the high power transmitters are tested on the dummy load, the heat transfer rate of convection or air cooled is not fast. Water-cooled or oil-cooled dummy loads are more efficient in quick transfer of heat.

### Activity 11.2

1. The attenuation offered by low-loss cable is very less and as a result maximum power of transmitter can be fed into the antenna.
2. The dielectric material usually used is foam polyethylene.
3. The characteristic impedance of a coaxial cable is the ratio of voltage to the current for a single propagating wave (frequency).
4. Attenuation of a coaxial cable = 10 log $P_1$/ $P_2$ where $P_1$ is input power and $P_2$ is the power reaching at other end. Substituting the given values, we get attenuation = 10 log 50/11 = 10 log 2 =10x 0.3010 = 3 dB
5. The average power rating of a cable is inversely proportional to the frequency of operation. If frequency increases, average power decreases and vice versa.

### Activity 11.3

1. It indicates that two dipoles have been used. It is a pole mounted antenna. Its polarization is vertical.

2. It will be called circular polarization.
3. From the interpretation of horizontal pattern, we can know the field strength in all the radial direction from the location of the antenna.
4. With a single antenna, the transmitter power required will be double than what is used with a 2-bay antenna for the same coverage.
5. Using the equation, Wavelength = Velocity of light in meters/frequency in Hz = $3x\ 10^8$ / 100 X $10^6$ = 300/100 = 3 m. Length of half-wave dipole = ½ x 3 = 1.5 m

## Activity 11.4

The information gathered in the activity should be your own and hand-on experiences.

# UNIT 12

# Propagation and Coverage

## Structure

26.1 Introduction
26.2 Learning Outcomes
26.3 What is Spectrum?
26.4 Layers of Atmosphere and Radio Wave Propagation
26.4.1 Troposphere
26.4.2 Stratosphere
26.4.3 Ionosphere
26.4.4 Ground Wave/Sky Wave/Space Wave
26.4.5 Effects of Wave Propagation in Different Medium
26.5 Factors Affecting Coverage and Shadow Areas
26.5.1 Factors Affecting Coverage
26.5.2 What is ERP?
26.5.3 Shadow Areas
26.6 Topography
26.7 Signal Requirements and Coverage Planning Parameters
26.7.1 Transmission Characteristics (ITU-R BS-450-2)
26.7.2 Channel Spacing
26.7.3 Minimum Usable Field Strength ($E_{min}$)
26.7.4 Radio Frequency Protection Ratio
26.8 Field Strength Measurements and Drawing an Actual Coverage Map
26.8.1 Field Strength Meter
26.8.2 Drawing an Actual Coverage Map of an FM Transmitter
26.9 Let Us Sum Up
26.10 Model Answers to Activities
26.11 Additional Readings

## 26.1 Introduction

In the previous unit ‘FM-Antenna on RF Cable’, you learnt about the components, which are used after the output stage of transmitter. These include dummy loads used for internal testing of transmitter; type of coaxial cable that connects the transmitter output to the antenna; types of antenna used for radiation of RF signal; tower and mounting of an antenna; VSWR; lightning arrestor; grounding; etc. The coaxial cable, also known as RF feeder line, carries the transmitter power from its output up to the antenna, which is normally mounted on top of the tower, and from there the RF propagates in various directions.

In this unit, you will learn about propagation and coverage of RF signals, particularly, FM broadcasting in VHF band. In order to have better understanding on propagation, we need to know about various RF frequency bands and their ranges, which are described under Section 12.3. The RF signals are radiated from the antenna and they propagate in different directions. RF signals, depending upon their frequency band, propagate through various layers of atmosphere. In Section 12.4, you will learn what the various layers of atmosphere are and how different RF signal behaves while passing through these layers. This section also mentions about phenomena like reflection, refraction, diffraction, ducting, etc., which RF signal encounters while propagating through various layers of atmosphere. In Section 12.5, you will learn about radio coverage and how it is affected by various factors like frequency, power of transmitter, gain of antenna, height of antenna, terrain condition, presence of environmental noise and also effective radiated power (ERP), which is a very common term used in planning of coverage. This section also defines shadow areas/shadow zones, which occur when RF signals are blocked by terrain condition or poor availability of signal. Shadow regions can be minimized and radio coverage can be maximized by proper selection of site where the antenna can be located at the highest available point/place. Such locations can be identified by examining the topography of the area and analysing toposheets of that particular region. In Section 12.6, you will learn about topography including toposheets and their usage. For planning of FM radio coverage, it is essential to understand the ITU-defined planning parameters, like channel spacing, minimum usable field strength, protection ratio, etc. These parameters are defined in Section 12.7. Field strength measurement is very commonly carried out for checking availability of radio coverage around a transmitter. Learning this in Section 12.8 and also drawing a radio coverage map by plotting the minimum required field strength measured around the transmitter antenna will help you have good understanding of the FM transmitter of a CR station.

You will take about 6 hours to complete this unit.

## 26.2 Learning Outcomes

After going through this unit, you will be able to:

- define:
  - (i) RF spectrum and various bands.
  - (ii) Various layers of atmosphere and what kind of radio waves propagates through them.
  - (iii) The parameters used for coverage planning of FM radio network.
- list and describe:
  - (i) The factors responsible for affecting radio coverage and creation of shadow region.
  - (ii) Various parameters used for planning of RF coverage network.
- analyse:
  - (i) the toposheet for selection of optimal location for transmitter tower to provide better coverage.
  - (ii) the field strength measurement data and check availability of desired signal for adequate radio coverage.
- undertake field strength measurements survey and draw a coverage map.

## 26.3 What is Spectrum?

Radio wave and spectrum subjects have already been described in detailed under Sections 6.3 and 6.4 of Unit 6 (Module 2). However, to refresh your memory, a brief overview on this subject is given below.

Electromagnetic spectrum is used to carry electromagnetic signals through space. The radio frequency spectrum, which is a part of electromagnetic spectrum, is shared by various radio communication services for variety of applications including public telecommunication services, aeronautical/maritime safety communications, radio and television broadcasting, radars, seismic surveys, rocket and satellite launching, earth exploration, natural calamities forecasting, etc.

The whole of the electromagnetic spectrum covers a huge range of frequencies. Radio frequencies themselves extend over a very large range as well. The range is further divided into different frequency bands as given in Table 1. Frequencies above 1 GHz are normally known as microwaves. As per National Frequency Allocation Plan (NFAP), 87–108 MHz band is used for FM radio broadcasting in India.

*Table 1: RF Spectrum Bands*

| From | To | RF spectrum band |
|---|---|---|
| 3 kHz | 30 kHz | Very low frequency (VLF) |
| 30 kHz | 300 kHz | Low frequency (LF) |
| 300 kHz | 3 MHz | Medium frequency (MF) |
| 3 MHz | 30 MHz | High frequency (HF) |
| 30 MHz | 300 MHz | Very high frequency (VHF)<br>(FM Band 87 – 108 MHz) |
| 300 MHz | 3 GHz | Ultra high frequency (UHF) |
| 3 GHz | 30 GHz | Super high frequency (SHF) |
| 30 GHz | 300 GHz | Extra high frequency (EHF) |

Some bands used in microwaves:

| Bands | Frequency range | Bands | Frequency range |
|---|---|---|---|
| L band | 1 to 2 GHz | $K_u$ band | 12 to 18 GHz |
| S band | 2 to 4 GHz | K band | 18 to 26.5 GHz |
| C band | 4 to 8 GHz | $K_a$ band | 26.5 to 40 GHz |
| X band | 8 to 12 GHz | | |

RF spectrum is a valuable, scarce and finite natural resource that is needed for various services and applications. Therefore, its utilization is to be planned scientifically and carefully so that the scarce resource is managed effectively and optimally.

## Activity 12.1

To complete this activity, you may need about 10 minutes including writing down the answers in the space provided below.

Question: 1 What is a microwave? Name some radio services that operate in microwave bands.

Question: 2 What is NFAP? Who is responsible for preparing this document?

## 26.4 Layers of Atmosphere and Radio Wave Propagation

The atmosphere consists of several layers. These layers are further divided based on the characteristics of the gases found in them. Each layer in the atmosphere is also referred to as a sphere. Radio waves, which are divided in different frequency bands, propagate differently in various layers of the atmosphere. This section describes layers of atmosphere, their distance from the surface of the earth, and how radio waves behave while propagating in these layers due to change in ionization and density of gases present.

Though the transmission of RF waves from a CR station's FM transmitter follow VHF propagation, learning about propagation of other waves MW, SW, microwaves will be helpful.

### 26.4.1 Troposphere

The first layer of the atmosphere is called the troposphere. It is the lowest part of atmospheric layer, extending from the earth's surface up to the bottom of the stratosphere. It starts from the surface of the ground and extends up to 10 km above the surface, as shown in Figure 12.1. The troposphere is the layer that we live in. The boundary between the troposphere and the stratosphere is called the 'tropopause'. The troposphere is characterized by decreasing temperature with height (at an average rate of $6.5^{o}$ C per kilometer).

Most of the radio transmissions operate in the lower layers of the earth's atmosphere, which is the troposphere. Some of the radio systems operating in this sphere are point-to-point, point-to-multi point, line-of-sight radio links in VHF and UHF bands, mobile radio networks in VHF and UHF bands, TV and FM broadcasting, etc.

It has been observed that the troposphere has an increasing effect on radio signals and radio communications systems, particularly, on frequencies above 30 MHz with the result that the radio signals are able to travel over greater distances beyond the line of sight.

The reason for radio signals travelling longer distance is that the refractive index of the air closer to the ground is slightly higher than that higher up. As a result, the radio signals are bent towards the area of higher refractive index, which is closer to the ground. It thereby extends the range of the radio signals.

### 26.4.2 Stratosphere

The next layer of atmosphere is called the stratosphere. It is the second layer of the atmosphere, as one moves upward from earth's surface. The stratosphere is above the troposphere and below the ionosphere. The top of the stratosphere occurs at a height of 50 km from ground. The boundary between the stratosphere and the ionosphere is called the stratopause. These are indicated in Figure 12.1. The stratosphere has either constant or slowly increasing temperature with height.

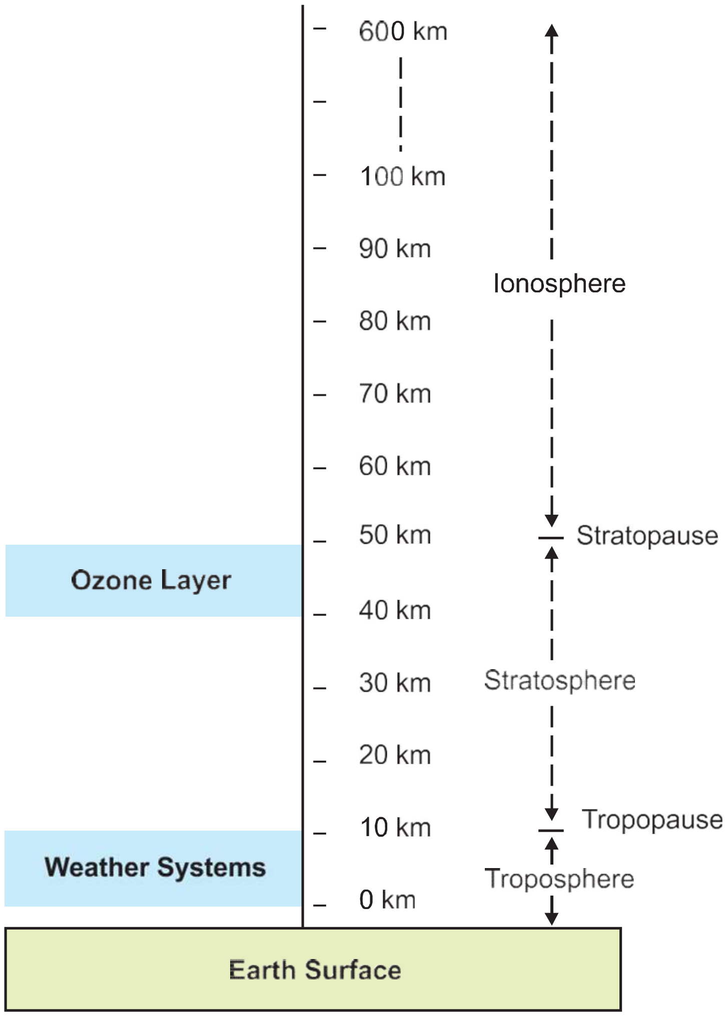



*Figure 12.1: Layers of atmosphere and their distances from earth surface*

## 26.4.3 Ionosphere

The ionosphere is the third layer of the atmosphere, as one moves upward from earth's surface. This layer is ionized by solar wind. It has practical importance because, among other functions, it influences radio propagation to distant places on the earth. This layer basically starts from the height of 50 km above the earth and extends up to the height of about 600 km. In case of radio waves passing through this layer or somehow penetrating into it, they will be affected by the specific phenomena of this layer. Some of the communication systems that experience these effects are those working in MF and HF radio transmission bands as well as satellite and space communication systems where one or both end point terminals are located on the ground. The ionosphere is sub-divided into several layers as described below and also shown in Figure 12.2.

### *D Layer*

The D layer is located above the stratosphere. It is the innermost layer of ionosphere. Its range is from 50 km to 115 km with reference to the surface of the earth. The intensity of ionization is higher in the D layer because it is composed of the heavier gasses. High-frequency (HF) radio waves are not reflected by the D layer but suffer loss of energy therein. This is the main reason for absorption of HF radio waves, particularly, at 10 MHz and below with progressively smaller absorption as the frequency gets higher. The absorption is small at night and greatest about midday. The layer reduces greatly after sunset. A common example of the D layer in action is the disappearance of distant MW broadcast band stations in the daytime.

### *E Layer*

The E layer is located above the D layer. It is the middle layer of ionosphere. Its range is from 115 to 160 km from the surface of the earth. The intensity of ionization is lesser in the E layer as compared to D layer because it is composed of less heavy gasses. This layer can only reflect radio waves having frequencies lower than about 10 MHz and may contribute a bit to absorption on frequencies above.

### *Sporadic-E ($E_s$)*

The $E_s$ layer (sporadic E layer) is characterized by small and thin clouds of intense ionization. Sporadic-E events may last from just a few minutes to several hours. This propagation occurs most frequently during summer months.

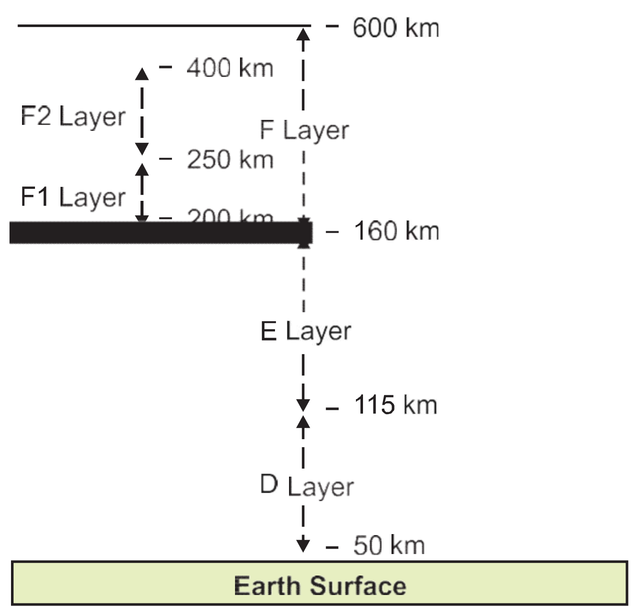



*Figure 12.2: Layers of ionosphere and distances from the earth surface*

*F Layer*

The F layer extends from about 200 km to about 600 km above the surface of the earth. It is the densest point of the ionosphere, which implies signals penetrating this layer will escape into space. The F layer consists of one layer at night, but during the day, a deformation often forms in the profile that is labelled as F1 and the other part as F2.

*F1 Layer*

The F1 layer is located above the E layer. Its range is from 200 to 250 km with respect to the earth. The intensity of ionization is lesser in the F1 layer with respect to E layer.

*F2 Layer*

This layer is located above the F1 layer. Its range is from 250 km to 400 km with respect to the earth. The intensity of ionization is lesser in F2 layer with respect to F1 layer. The F2 layer remains by day and night responsible for most skywave propagation of radio waves, facilitating high frequency (HF, or shortwave) radio communications over long distances.

### 26.4.4 Ground Wave/Sky Wave/Space Wave

Radio waves travel from one point to another (e.g.,a transmitter to a receiver) by different ways. These are mainly ground waves, sky waves and space or tropospheric waves.

The ground waves travel closer to the surface of the earth. The sky wave propagation, usually called ionospheric propagation, results due to bending of wave-path through ionosphere. This method of propagation accounts for long distance radio communication through shortwave both, during day and night time and also through medium wave during night.

Space wave represents energy that travels from the transmitting to the receiving antenna through earth's troposphere. Space wave propagation becomes essential in VHF bands because ground wave is attenuated to a negligible amplitude within a few hundred metres, while the ionosphere is not able to reflect any energy back to the earth in VHF range.

### 26.4.5 Effects of Wave Propagation in Different Media

When lights travel from one medium to another, three things happen: (i) some lights are reflected, (ii) some lights are absorbed and (iii) some get refracted.

Similarly, when radio wave propagates, the following can occur when the wave passes from one medium to another:

i) Reflection: some waves get reflected back into the same medium.
ii) Absorption: some waves get absorbed by the medium.
iii) Refraction: some waves get transmitted into the second medium at a different direction and velocity.

However, when a radio wave encounters an obstacle on its propagation path, it may bend around the obstacle. This bending phenomenon is called diffraction. Also, when a wave propagates in troposphere, another special phenomenon 'ducting' occurs due to temperature inversion.

*Reflection*

Reflected waves are neither transmitted nor absorbed, but are reflected from the surface of the medium they encounter. The basic analogy is similar to reflection of light by a mirror. If a wave is directed against a mirror, the wave that strikes the surface is called the incident wave, and the one that bounces back is called the reflected wave. This also occurs when a wave is transmitted skyward, reflect off the ionosphere, and returns to a receiving station. The angle of reflection equals the angle of incidence. Reflection of wave is illustrated in Figure 12.3, where the incident wave forms angle i to normal reflected at an angle r and travels in a different direction.

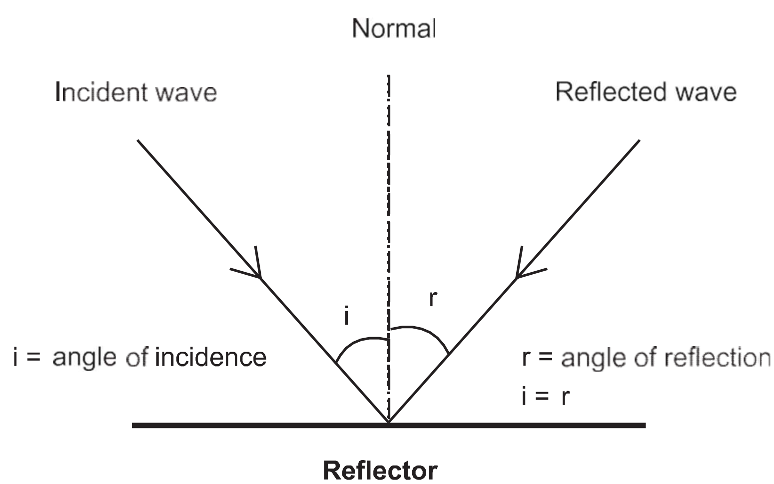



*Figure 12.3: Reflection of wave*

*Refraction*

The radio waves propagating in the earth's atmosphere always experience the wave refraction phenomenon. As the height increases, the air density and consequently its refractive index decreases. This non-homogeneous characteristic of air in the atmosphere causes deviation in the wave propagation path, so that they do not travel further in a straight direction. When the rate of refractive index changes linearly, the ray path would be an arc of a circle. Figure 12.4a shows a simple case of refraction where the refracted wave bends inward when it travels from one medium into another. The bending phenomenon is clearly visible. In Figure 12.4b, the same phenomenon is described in detail where the wave from medium 1 having refractive index $n_1$ travels to medium 2 with refractive index $n_2$. If the refractive index of medium 2 is higher than medium 1 then the wave will bend inward. If the refractive index of medium 2 is lower, it would bend outward. If we draw a normal at the point where the wave from medium 1 enters into medium 2, then it forms an angle $\alpha$ known as angle of incidence. In medium 2, the refracted wave bends inward forming angle of refraction $\beta$.

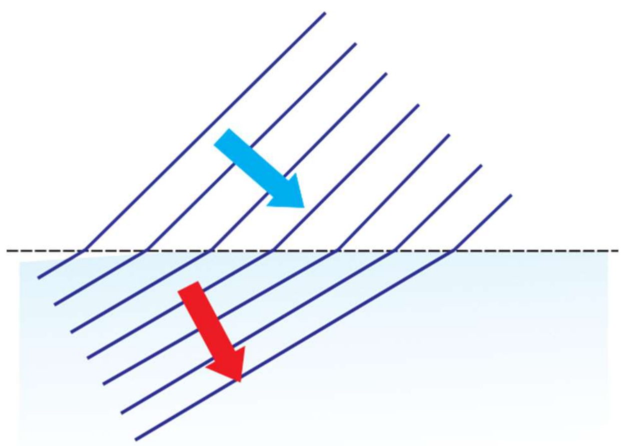


*Figure 12.4a: Refraction of wave*

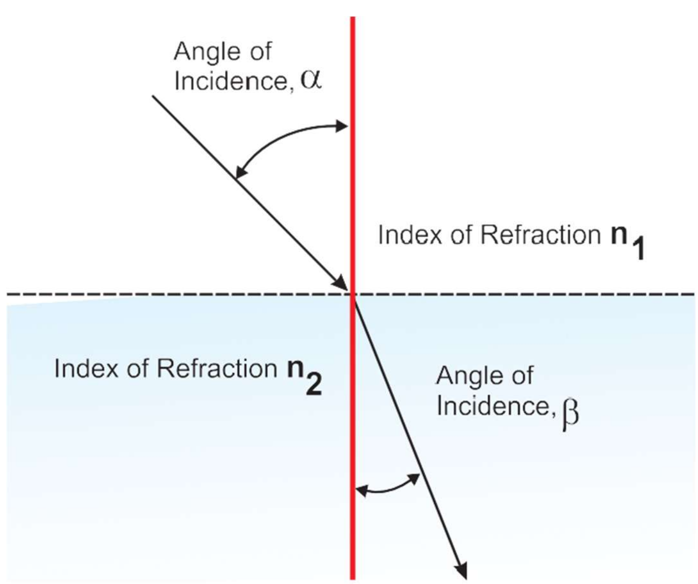



*Figure 12.4b: Refraction of wave with angle of refraction β*

Figure 12.4c shows how short wave frequencies get refracted from the ionosphere and return to the earth's surface at a longer distance. Because of this phenomenon, short wave signals travel several thousands of kilometres.

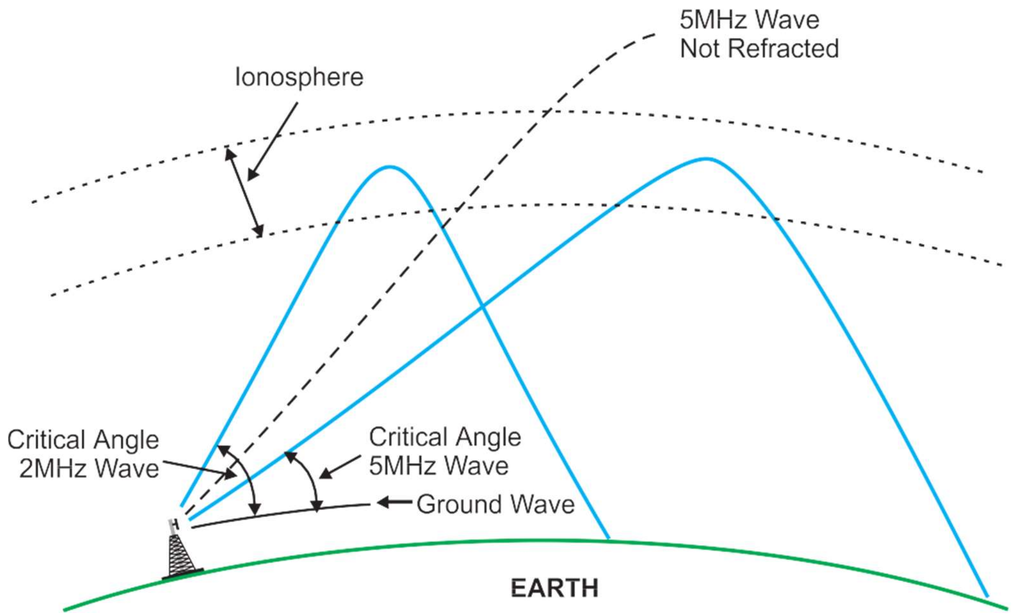



*Figure 12.4c: Short wave frequencies get refracted by ionosphere and travel longer distance*

### *Diffraction*

When a radio wave encounters an obstacle in its path, it bends around the obstacle. This bending is called diffraction, and results in a change of direction of part of the energy from the normal line-of-sight path. Figure 12.5 shows a wave that is diffracted after it came across a partial obstructed object. When a wave front strikes the edge of an object, as shown in the figure, it bends inward and travels further in a different direction. Before reaching the object, the wave front was travelling in a horizontal direction and after passing through the edge of the object, it started travelling downward. This phenomenon is called diffraction.

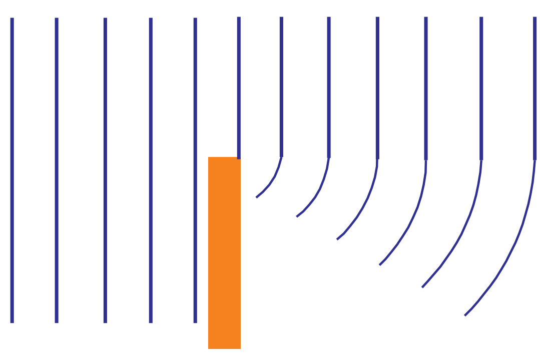


*Figure 12.5: Diffraction of wave*

*Ducting*

Ducting is one of the propagation phenomena that happen in the troposphere. Tropospheric ducting occurs when a radio signal is reflected off the troposphere and continues on a path that allows the signal to travel much farther than it normally would. This occurs when the temperature in the atmosphere experiences an inversion. When a temperature inversion occurs, radio waves that would normally continue into space beyond the earth's atmosphere are instead reflected and they continue to follow the curvature of the earth. Radio waves have been able to travel in excess of 1,000 km because of tropospheric ducting. TV signals travel longer distance over sea surface because of ducting. Figure 12.6 shows how the radio waves propagate because of total internal reflection between two layers forming a duct above the surface of the earth.

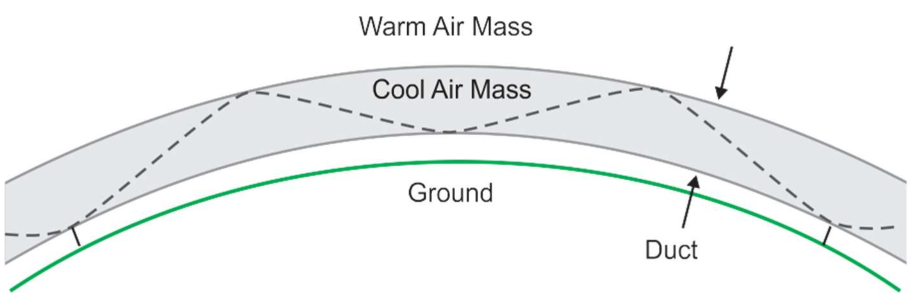



*Figure 12.6: Ducting*

## Activity 12.2

To complete this activity, you may need about 15 minutes including writing down answers in the space provided below.

Question: 1 Name various types of radio communication systems that operate in VHF band in India.

Question: 2 What are the various effects that take place when VHF signal propagates in the troposphere?

## 26.5 Factors Affecting Coverage and Shadow Areas

RF signals are transmitted from the antenna of radio transmitters. These RF signals, depending on the frequency of operation, propagate through different layers of the atmosphere and reach various places. Radio receivers help in detecting these signals and reproduce the audio frequencies after demodulating them. However, the receiver can only be able to detect the signals that are above the minimum usable field strength. Availability of the area around the transmitting station which gets the signal of this strength or more is known as radio coverage area. Places where these signals do not reach from the transmitter due to obstruction of propagation condition are called shadow zones or shadow areas. The following sections explain these phenomena in detail.

## 26.5.1 Factors Affecting Coverage

Transmitter antenna radiate energy in all directions. Depending upon the design of antenna (e.g., directional or omni-directional), the intensity of energy radiation varies in different directions with respect to distance. As the distance from the location of the antenna increases, the intensity of the received signal decreases. The distance where the strength of received signal is just sufficient for the receiver to detect it without any interference is called radio coverage range. These distances from the transmitter/antenna in different directions around the antenna define radio coverage range.

RF coverage or availability of desired level of RF signal in a particular target area gets affected by various factors. Some of these major factors that affect the coverage of RF signals are as follows:

- The frequency on which the transmitter is operating
- The effective radiated power of the transmitting station, that is, ERP
- The type and design of antenna
- The height and location of the antenna
- The terrain profile and condition
- The amount of electromagnetic noise

Each of these above factors affects radio coverage and is taken into consideration in determining how far the radio signal would be able to provide effective coverage.

### *Frequency on which the transmitter is operating*

Frequencies in higher order bands cover lesser area. In case of medium wave transmissions, the lower order band, e.g., around 600 kHz, provides wider coverage than higher order bands, say at 1500 kHz, under similar ground conditions (conductivity). An FM transmitter operating in VHF FM band (87 – 108 MHz) provides almost similar coverage.

### *Effective rated power of the transmitter*

As a general rule, it can be said that the coverage of radio transmitter increases with its output power. The higher the power, greater is the coverage distance. Also since VHF is a line-of-sight propagation, the coverage is restricted by availability of line-of-sight. As such, increasing transmitter power beyond a certain point may not be able to increase its coverage range. However, in actual terms, it is the effective radiated power (ERP) of the transmitting station (which includes the contribution of the antenna system) that determines the coverage and not the transmitter power alone. You will learn about ERP in detail later in this subsection.

*Type and design of antenna*

The type and design of an antenna decide its gain. This gain increases the ERP, e.g., a 10 kW FM transmitter having an antenna of gain 3 dB would radiate 20 kW as ERP. A directional antenna has more gain in a particular direction, and thereby increases the range or coverage in that direction.

*Antenna height and location*

The most critical coverage factor is the height and location of the antenna. This is because the range of a radio coverage is theoretically limited to the radio horizon as reached by the radio antenna. Basically, the higher the height of the antenna, the greater the area it will cover. Therefore, FM antennae installed on hilltops provide wider coverage.

*Terrain profile and condition*

As radio waves follow a line-of-sight path, terrain variations can cause obstruction to propagation. Hills and valleys or any kind of high-rise structure that come in the direction of the line-of-sight path obstruct propagation. In such cases, if we increase the antenna height, we can reduce such obstruction, and thereby increase coverage.

*Amount of electromagnetic noise*

Presence of electromagnetic noise, industrial noise, or environmental noise around the receiver affects detection of weak RF signals and thereby affects radio coverage.

## 26.5.2 What is ERP?

Most of us are well aware of transmitter power, which the transmitter delivers to the feeder/RF cable that is connected to the antenna. However, this power may not be the same what the antenna delivers or radiates. It is mainly because of two factors: (i) the feeder/RF cable including multiplexer/diplexer/connectors causes some losses and (ii) the antenna may provide some gain depending upon its design. This gain of antenna varies with its type and directivity. Therefore, the ERP includes all gain and loss factors on the transmitting side and usually expressed in dBm, or dBw, or dBkw, etc. In fact, ERP is the product of the transmitter output power and antenna gain in the desired direction taking into account all losses caused by the RF feeder, connectors, etc.

Mathematically, ERP can be calculated as:

ERP = (Transmitter Power – Feeder/RF cable loss) x Antenna gain

For example, a 100w FM transmitter having a 30-meter long RF feeder cable causes a loss of 1dB and the gain of antenna is 4dB. Then, its ERP will be:

Transmitter power – Feeder cable loss + Antenna gain (all in dB)

= 100w (or 20 dBw) – 1 dB + 4 dB

= 23 dBw

= 200w (3 dB gain doubles the power)

### 26.5.3 Shadow Areas

In FM broadcasting network, reception of radio service gets hampered because of inadequate signal or any obstruction between the transmitting station and the targeted areas. These areas are called shadow zones or shadow areas. As an example, if the transmitter in a valley is located on one side of a hill, the other side will have no RF signal and thereby creates shadow areas.

## Activity 12.3

To complete this activity, you may need about 5 minutes.

Qestion: 1 Find out the ERP of a transmitter having output power 200 w, losses due to feeder cable and joints 1.5 dB and antenna gain 4.5 dBi.

## 26.6 Topography

Topography is a broad term used to describe the detailed study of the earth's surface. It is a detailed description of a place or region located on a map. While topography includes vegetative and man-made features, it more commonly refers to a horizontal point of latitude and longitude. This includes changes in the surface such as mountains and valleys as well as features such as rivers, roads and buildings. Topography is closely linked to the practice of surveying, which is the practice of determining and recording the position of points in relation to one another.

*Toposheet*

India, with an area of 32,87,263 $km^2$, is covered by both topographical and geographical maps. The topographical maps are on sufficiently large scale of 1:25,000, 1:50,000, which are ideally suited for the professional work of geologists, geographers, foresters, engineers, planners, tourists, mountaineers, etc. On the other hand, the geographical maps are on such a small scale of less than 1:2,50,000 that they are useful mainly for synoptic views.

India is covered by nearly 385 toposheets on 1:2,50,000 scale, which are also called degree sheets. Each degree sheet has 16 toposheets of 1:50,000 scale and the whole of the country is covered by 1:50,000 rigorous metric surveys in more than 5,000 toposheets. Each 1:50,000-scale sheet contains four 1:25,000-scale sheets. Guide maps on scale of 1:10,000 and smaller are available for towns and cities in various states.

Topographic maps provide the graphical portrayal of objects present on the surface of the earth. These maps provide the preliminary information about a terrain and thus are very useful for engineering works, including planning of radio coverage network. For most part of India, topographic maps are available, which are prepared by the Survey of India. To identify a map of a particular area, a map numbering system has been adopted by the Survey of India.

For broadcast radio network planning, toposheets are useful for locating highest points where an antenna can be installed so that maximum coverage is achieved. However, since CR stations have to be located near the area of the target community, the coverage planning has to take into account the topography of a target area with a smaller community, which may not have much variation in topology.

## 26.7 Signal Requirements and Coverage Planning Parameters

The coverage planning of an FM transmitter in VHF band-II (for FM broadcasting in India it is 87–108 MHz) is a complex process. Preparation on planning of FM network requires understanding of minimum usable field strength, protection of wanted signal from other transmitters, noise protection requirements for city and rural areas, etc. To get a clear understanding of coverage planning, these parameters are explained below.

### 26.7.1 Transmission Characteristics (ITU-R BS-450-2)

ITU has defined FM transmission characteristics as per its recommendation BS-450-2. These characteristics define permissible range of parameters like AF bandwidth, maximum deviation, bandwidth of emission, pre-emphasis, maximum spurious emission, etc. These terms were defined and explained in Unit 23. However, for easy reference, these are summarized below:

| | | |
|---|---|---|
| AF bandwidth | : | 15 kHz |
| Maximum deviation | : | ± 75 kHz (Stereo Multiplex Signal) |
| Bandwidth of emission | : | 180 kHz |
| Pre-emphasis | : | 50 µ sec |
| Frequency tolerance | : | 2000 Hz |
| Maximum spurious emission | : | – 60 dBc (60 dB below carrier) |

## 26.7.2 Channel Spacing

Channel spacing is the difference in frequency between successive FM carriers. It is measured in kHz.

- Monophonic reception : optimum between 75 kHz and 100 kHz
- Stereophonic reception : optimum between 100 kHz and 150 kHz
- Optimum channel spacing : 100 kHz (used in India)
- Minimum frequency separation between transmitters co-located in the same city is 400 kHz (theoretically). But in India 800 kHz separation is presently being used between two transmitters operating in the same city in most of the places.

## 26.7.3 Minimum Usable Field Strength ($E_{min}$)

For FM radio broadcasting, ITU has given, vide its Recommendation BS-450, different level of signal strength that are required for providing coverage to different geographical locations (Rural, Urban and Semi-Urban). ITU has also defined these parameters according to the type of reception, that is, mono or stereo as given in Table 2. While working out these recommendations, noise levels in different set of locations namely rural, urban and large city have been taken into consideration.

*Table 2: Minimum Usable Field Strength*

| | Monophonic Reception | Stereophonic Reception |
|---|---|---|
| Rural Area | 48 dB(mv/m) | 54 dB(mv/m) |
| Urban Area | 60 dB(mv/m) | 66 dB(mv/m) |
| Large City | 70 dB(mv/m) | 74 dB(mv/m) |

The field strength received from a given transmitter varies not only with location, but also with time. Therefore, FM radio services are normally planned to be available for 99% of the time in the case of national networks and 95% of the time for local services.

## 26.7.4 Radio Frequency Protection Ratio

A protection ratio is the required difference in field strength between a wanted and an interfering signal, and is normally expressed in dB. The required ratio falls as the frequency separation between the two stations increases, and is tabulated in Table 3.

*Table 3: Protection Ratio*

| Frequency Spacing | Monophonic | | Stereophonic | |
|---|---|---|---|---|
| *(kHz)* | *Steady* | *Troposphere* | *Steady* | *Troposphere* |
| 0 | 36 | 28 | 45 | 37 |
| 100 | 12 | 12 | 33 | 25 |
| 200 | 6 | 6 | 7 | 7 |
| 300 | –7 | –7 | –7 | –7 |
| 400 | –20 | –20 | –20 | –20 |

## 26.7.5 CRS Frequencies

For proper operation of CR stations, WPC has identified specific frequency spots. These are 90.4, 90.8 and 107.8 MHz. As such, normally a CRS is allotted one frequency out of these frequencies. In addition, 91.2 MHz is also allotted wherever it is possible to do so.

## Activity 12.4

To complete these activities, you may need about 10 minutes including writing down the answers in the space provided below.

Question:1 What is the channel spacing in VHF FM broadcasting? In USA, UK, Japan and India, what channel spacing is used in FM channels?

Question:2 Define protection ratios for co-channels (channels with same frequency repeated and at a different location) for stereophonic transmission in steady state.

# 26.8 Field Strength Measurements and Drawing an Actual Coverage Map

Measurement of field strength is important and essential to ensure effective planning and coverage of radio services, be it SW, MW or FM. Field strength meters measure the strength of RF signal available, which indicates whether the strength is good enough for desired reception. A field strength meter is quite commonly used for this purpose and therefore it is necessary to understand its operation and use. Also, it is necessary to learn the process of plotting and preparing of actual coverage map from these readings.

## 26.8.1 Field Strength Meter

A field strength meter is a microvolt meter or test receiver coupled with a suitable pick-up device (antenna) for measuring electrical and magnetic field strength.In broadcasting, it is used for propagation measurements, determination of coverage, radiation patterns of antennae, etc.

*Basic Principles*

A field strength meter comprises the following three essential parts:

- Pick-up device or transducer (antenna)
- Voltage measuring device
- Built-in calibration oscillator

Field strength is measured by comparing the voltage induced in the antenna circuit with the output of the built-in calibration oscillator.

*Field Strength Measurement*

A typical field strength measurement set-up is shown in Figure 12.7. It comprises a field strength meter, an antenna and a connecting cable. The antenna is connected to the input of the field strength meter through a cable. The measurement is carried out in two steps:

- First, the detector output of the receiver is adjusted up to certain indication $E_o$ dB (μv/m) with the help of the attenuator.
- Second, the known output from calibration oscillator is fed to the receiver and the attenuator value is adjusted so as to get same output in the indicating device, that is, $E_o$ dB (μv/m).

Measurement Range: Typical range –10 to + 160 dBμ

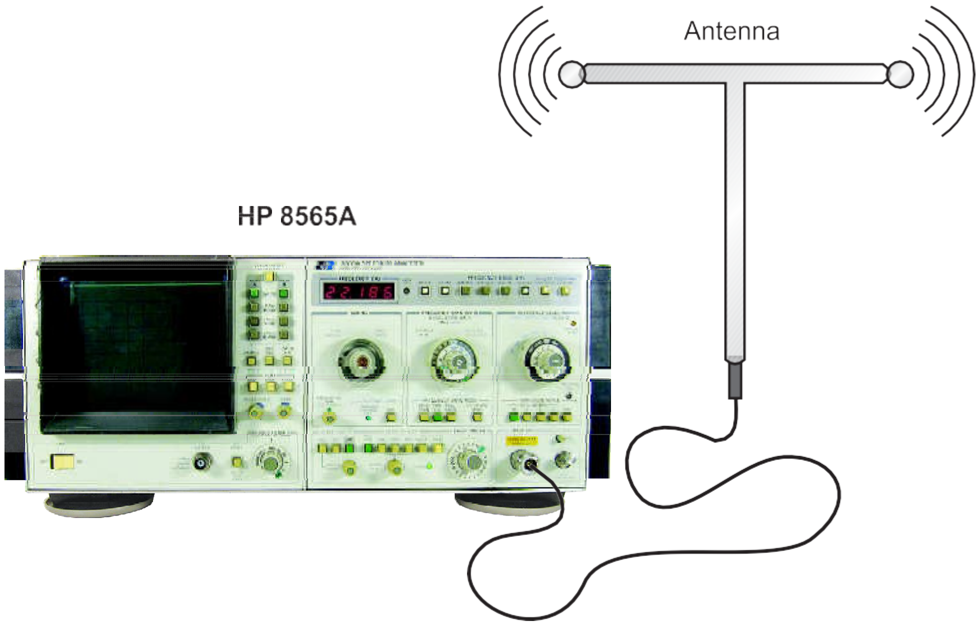



*Figure 12.7: Field strength measurement set-up*

Normally, field strength measurements are recorded when the CR station is set up or there is an issue of coverage not being satisfactory.

## 26.8.2 Drawing an Actual Coverage Map of an FM Transmitter

Let us carry out field strength measurement survey of a 300 w FM transmitter located in North-West Delhi to ascertain stereo and monophonic FM coverage. Since Delhi is an urban city, the desired field strength value should be 74 dB μv/m and 70 dB μv/m, respectively, for stereophonic and monophonic transmissions. These field strength values are measured and verified in a given direction at a particular distance from the FM transmitter. These distances for both stereo and mono transmissions are noted as shown in Table 4.

*Table 4: Field strength measurement and coverage distance of 300 w FM transmitter*

| | Angle/Direction | Distance in km for | |
|---|---|---|---|
| | | Stereo (74 dB μv/m) | Mono (70 dB μv/m) |
| 1 | 0° / East | 6.1 | 9.2 |
| 2 | 45° / North-East | 6 | 8.9 |
| 3 | 90° / North | 6.7 | 10.1 |
| 4 | 135° / North-West | 6.2 | 10.3 |

| | | | |
|---|---|---|---|
| 5 | 180° / West | 6.2 | 10.2 |
| 6 | 225° / South-West | 6.1 | 10.4 |
| 7 | 270° / South | 5.9 | 10 |
| 8 | 315° / South-East | 5.8 | 9.8 |

Distances noted above (Table 4) for stereo and mono field strength values are plotted around the transmitter on a map, as shown in Figure 12.8. For stereophonic FM coverage, distances from the transmitter are marked in double line red colour around the transmitter. Areas under this double line red contour show coverage of stereo service. Similarly, areas under single line in grey colour contour around the transmitter show coverage map for mono service.


*Figure 12.8: Actual coverage map of a 300 w FM transmitter*

## Activity 12.5

To complete this activity, you may need about 10 minutes including writing down the answer in the space given below.

Question: 1 Explain the procedures for measurement of field strength?

## 26.9 Let Us Sum Up

RF spectrum is defined in the range from 3 kHz to 300 GHz. This is further divided into various bands known as VLF, LF, HF, VHF, UHF, SHF and EHF. A spectrum over 1 GHz is known as a microwave.

Propagation of RF waves takes place in various layers of the atmosphere. These layers are known as troposphere, stratosphere and ionosphere. Most of the communication systems operate in troposphere. However, HF propagation through ionosphere helps in providing SW broadcast to longer distances.

Radio waves, while propagating in various medium (e.g., in troposphere), encounter reflection, refraction, diffraction, ducting, etc. These effects help operation of different types of communication systems for various purposes, e.g., refraction of HF by ionosphere facilitates short-wave broadcasting to longer distances, whereas troposphere/ducting extends microwave communication over longer distances.

Radio signals from FM transmitters propagate from the antenna and travel in different directions. These signals provide radio coverage but get attenuated with distance while travelling. The distance from the antenna at which the signal is attenuated to just minimum value, which is receivable by the receiver, defines radio coverage range. Radio coverage is affected by various parameters like frequency, transmitter power, antenna design and gain, antenna height and location, terrain condition, presence of noise, etc. Effective radiated power (ERP), which is the net output power radiated from the antenna after taking into account all losses and gain of the antenna, affects radio coverage. Radio coverage is normally not uniform around the transmitter because of terrain condition, which may cause obstruction to its propagation path. Such areas where radio signal strength is poor or is not available are called shadow areas.

Selection of antenna location is important, particularly when the terrain profile is not uniform and comprises hills and valleys. Proper selection of site helps in providing maximum radio coverage and minimizes shadow areas. Therefore, for site selection, knowledge on topography and use of toposheets are essential.

Understanding of planning parameters like channels spacing, minimum usable field strength, protection ratio, etc. is essential for FM radio coverage calculations and network planning. These parameters are defined in ITU-R recommendations. While planning FM radio coverage, one has to ensure that minimum usable field strengths are available within the targeted area and the wanted signal is protected from interference from other existing FM transmitters.

Field strength measurement survey is conducted to find out actual radio coverage of FM transmitters. When plotted over a map, these values indicate coverage of that radio service.

## 12.10 Model Answers to Activities

### Activity 12.1

1. Microwave refers to electromagnetic energy having a frequency higher than 1 GHz, corresponding to wavelength shorter than 30 centimetres.

   Various radio services operate in microwave bands:

   i) Microwave links used for radio communication; for sending programme from the studio to the transmitter through STL (Studio-Transmitter Link)

   ii) Satellite communication: Up-linking to satellite, down-linking from satellite, satellite broadcasting (DTH service)

   iii) Telecommunications services

2. NFAP is the abbreviation of National Frequency Allocation Plan. This plan defines allocation of various services in different frequency bands. All spectrum users plan their services as per the provision given in the NFAP. Wireless Planning and Coordination (WPC) Wing of the Ministry of Communication and IT is responsible for preparing this plan. This plan is reviewed periodically, once in two years, in consultation with major spectrum users.

### Activity 12.2

1. i) FM radio broadcasting (87–108 MHz)

   ii) Television broadcasting 54–68 MHz in Band-I; 174-230 MHz in Band-II

   iii) VHF radio links

   iv) VHF communications, walkie-talkie, etc.

   v) Aeronautical services

2. When VHF signal propagates in the troposphere, it may get reflected, absorbed, refracted or diffracted.

   When there is a temperature inversion, particularly over ocean, ducting may take place.

## Activity 12.3

1. ERP = Transmitter power –Feeder cable loss + Antenna gain

   Transmitter power = 200 w = 23 dBw

   (1w = 0 dBw; 10w = 10 dBw; 100w = 20 dBw, 200w = 23 dBw), (3 dB gain doubles the power)

   Losses = 1.5 dB

   Gain = 4.5 dBi

   ERP = 23 dBw – 1.5 dB + 4.5 dBi = 26 dBw = 400 w

## Activity 12.4

1. Channel spacing is the spacing between the main carrier frequency and the next immediate carrier. In FM broadcasting, FM channel carriers are separated by 100 kHz. For example, carrier of FM Gold in Delhi is 106.4 MHz and the next adjacent carrier frequency would be 106.5 MHz.

   Channel spacing for FM broadcasting in USA is 200 kHz, in UK it is 100 kHz, in Japan it is 100 kHz and in India it is 100 kHz.

2. Protection ratio is a value that ensures protection of wanted signals from unwanted signals. When co-channel frequencies of FM transmitters are repeated at different locations, within the coverage area of the wanted FM transmitter must be protected by the other FM transmitters operating in the same frequency at a different location. Protection ratio for these co-channels will depend on the type of coverage, that is, mono or stereo/steady or tropospheric. These values for co-channels or adjacent channels are defined in ITU-R, BS-450-2. According to the ITU rec, protection ratio for co-channel stereophonic transmission in steady state is 45 dB.

## Activity 12.5

1. The field strength measurement set-up comprises a field strength meter/spectrum analyser, a calibrated antenna and a connecting cable. The antenna is connected to the input of the field strength meter through a cable. When measuring with a field strength meter, it is

important to use a calibrated antenna such as the standard antenna supplied with the meter. For precision measurements, the antenna must be at a standard height. A value of standard height frequently employed for VHF and UHF measurements is 10 metres.

The measurement is carried out as mentioned below:

- Calibrated antenna is to be installed at a standard height.
- Antenna is connected to the field strength meter.
- Meter is calibrated.
- Field strength readings are taken and corresponding distance from the transmitter is also noted.

## 12.11 Additional Readings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## Glossary

| | |
|---|---|
| Antenna | is a device (transducer) that converts guided waves in cables into free space waves or vice versa. |
| Antenna Aperture (physical) | is a measure of the actual physical size of the antenna (physical cross section perpendicular to direction of propagation). |
| Antenna Gain | is the ability of the antenna system to give more field strength at a point in comparison to that would have been given by a single half-wave dipole when fed with the same power as that of the antenna system. |
| Antenna Efficiency | is the ratio of the radiated power to that of the input power supplied to the antenna. |
| Beam Width | of the antenna is a measure in degrees on the main lobe of the radiation pattern between the points where the radiated power has fallen to half of its maximum value. |
| CCIR | stands for Consultative Committee on International Radio-Regulations. |
| Dipole | is a pair of electric charges or magnetic poles that have equal magnitudes but opposite signs and are separated by a small distance. |
| Dynamic Range | is the difference between the lowest and the highest levels of notes produced by any musical instrument or a frequency operating system. |
| ERP | (Effective Radiated Power) means the total output power thrown in the air by the antenna system. This is generally calculated with a mathematical formula that takes into account the output power, cable loss and antenna gain. |
| ERP (Effective Radiated Power) | is the product of input power to the antenna and antenna gain. The power fed to the antenna as used here is equal to the transmitter power minus the losses in a coaxial cable. |
| Equalization | is a process through which the frequency response of any equipment is adjusted to the desired value. |
| Exciter | is the first stage of FM broadcasting where the RF signal is generated and modulated. |
| Free space | is a space that does not interfere with normal radiation and propagation of radio waves. |

| | |
|---|---|
| Half-wave Dipole | is an antenna whose length of its longer side is equal to half the wavelength at the frequency of operation. |
| Isotropic Radiator | is a radiator that radiates energy uniformly in all directions. |
| ITU | stands for International Telecommunication Union. |
| Heat Sink | is a specially designed aluminum plate to absorb heat. |
| Layers of Atmosphere | include troposphere, stratosphere, and ionosphere. The atmosphere consists of these layers. Ionosphere is further divided into D layer, E layer and F layer. |
| Minimum Usable Field Strength: | In case of FM radio broadcasting, different levels of signal strength is required for providing coverage to different geographical locations (rural, urban, semi-urban, etc). ITU defined these parameters according to the type of reception, that is, mono or stereo for different geographical condition, e.g., for stereophonic reception in rural areas it is 54 dB (mv/m). |
| NFAP (National Frequency Allocation Plan) | The Wireless Planning and Coordination (WPC) Wing of the Ministry of Communication and IT is responsible for preparing this plan. This plan is reviewed periodically, once in two years, in consultation with major spectrum users. This plan defines allocation of various services in different frequency bands. All spectrum users plan their services as per the frequency provisions in the NFAP. |
| Nominal Level | is the operating level at which the electronic equipment is designed to operate. |
| Output Power | is the total output that is measured at the transmitter equipment output. |
| Protection Ratio | is the required difference in field strength between a wanted and an interfering signal, and is normally expressed in dB. |
| Phantom supply | is a dc supply required for the operation of certain microphones for polarizing their transducer elements. |
| PLL (Phase Lock Loop) | is an electronic concept that helps devices to stick to a desired frequency. |
| RF Amplifier | is a device that amplifies the RF signal before sending it to the antenna. |
| RF Filter | is an electronic device that cuts out spurious and harmonics from radio frequency signals. |
| Reflected Power | is a portion of the output power thrown by the antenna system back to the transmitter. |

| | |
|---|---|
| Standing Wave Ratio (SWR) | is the ratio between the output power and the reflected power. |
| Shadow Areas | are the uncovered areas between transmitters or within the targeted areas of a transmitter due to unavailability of the desired level of RF signal because of obstruction or poor signal strength. |
| Signal to Noise Ratio (SNR) | is the ratio of nominal signal level to the noise level present in it. |
| SMPS (Switch Mode Power Supply) | converts alternate current into direct current and produces regulated supply. |
| Wavelength | is the length (in metres) of one cycle of the frequency of operation. |
| WPC (Wireless Planning and Coordination) | is a Wing of the Department of Telecommunications, which is responsible for planning of wireless services in the country. WPC issues the licence for operating frequency of a CR station. |

CEMCA

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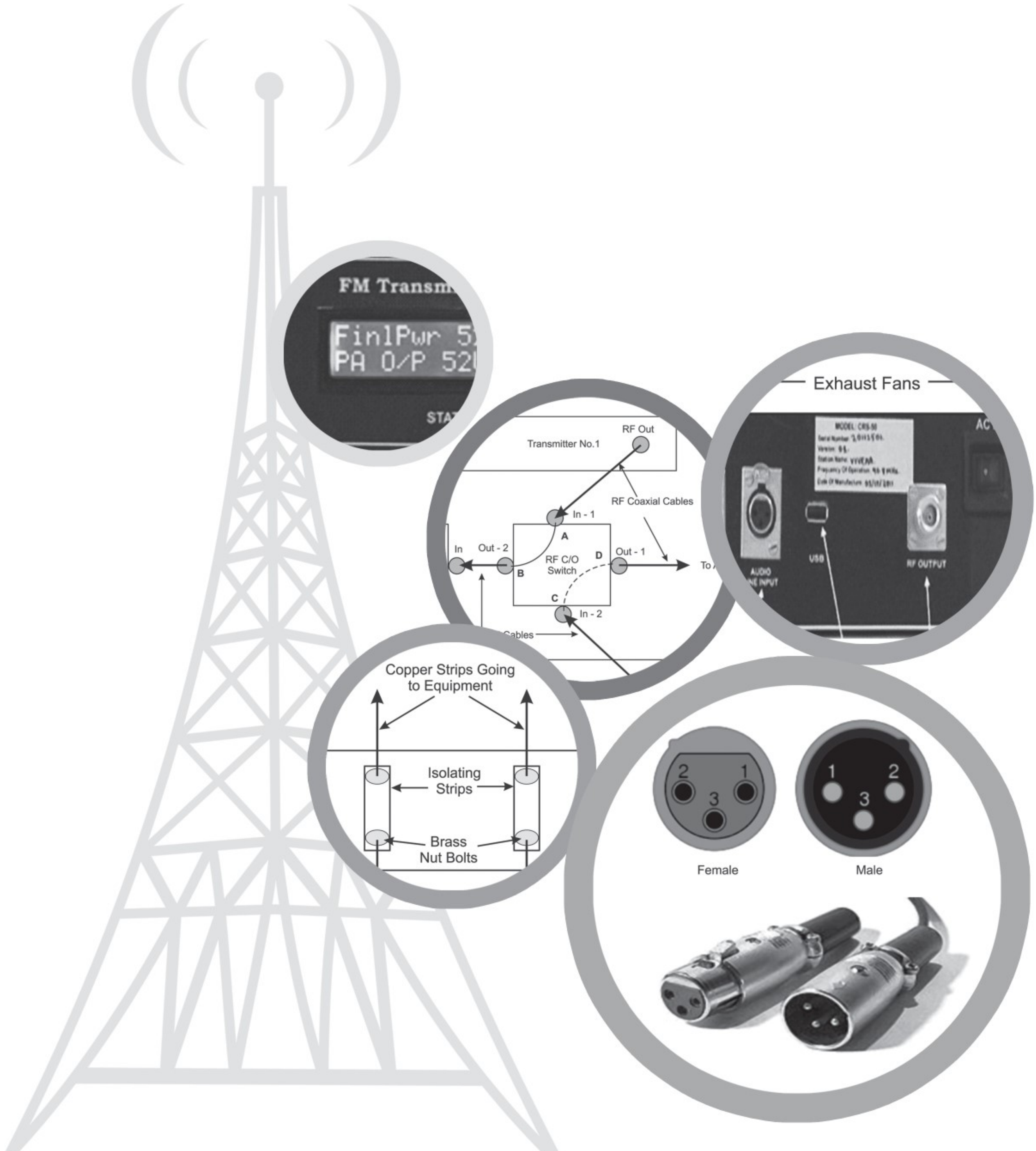
# Module: 4
# FM Transmitter Setup

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# Module 8: FM Transmitter Setup


## Curriculum Design Experts

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## About the Module

### Module Description

This module is the second part of Course III - "CR Transmission: System & Technology". It deals with the practical aspects of the Transmitter setup. After studying the basics of transmission system in Units 23-26, it is imperative to learn the practical aspects of the transmitter setup and have some hands-on experience of the same to familiarise yourself with the actual practice at CR Stations. This module involves 32 hours of learning. It has three Units and covers the practical aspects of operation of a typical FM transmitter setup, handling and operating of the FM transmitter and also the preventive and corrective maintenance of the setup at CR Stations. Lessons about proper use of test and measuring equipment at the transmitter setup and installing and maintaining the transmitter with good engineering practices has also been included in this module. A video presentation is included as a part of this module (Unit 27), which is expected to give you a better understanding of the practical situation at a CR Station. The assignments in this module give you an opportunity to work on an actual transmission site at a convenient location nearby. This will give the confidence of working on a transmitter installation of a Community Radio Station. After completion of this module you will complete the study of Course III.

### Module Objectives

After completion of this module the learner should be able to:

- Explain important aspects to be kept in mind while handling of a FM transmitter setup following step-by-step approach.
- Undertake preventive and corrective maintenance of the transmitter setup including main FM transmitter as well as ancillary equipment.
- Properly assist in installation and operation of the transmitter setup at CRS using good engineering practices.

# UNIT 13

# Transmitter Setup: Step-by-step

## Structure

- ✓ Introduction
- ✓ Learning Outcomes
- ✓ Connecting Audio Feed to the Transmitter
- ✓ Back Panel Connectors
- ✓ Mounting and Connecting the Transmitter
  - Connecting the coaxial cable
  - Warming up the transmitter
- ✓ Interpretation of the Transmitter Meter Readings and Indications
- ✓ Transmitters with 1+1 Operation Along with Changeover Unit
- ✓ Let Us Sum Up
- ✓ Model Answers to Activities

## 27.1 Introduction

In Unit 23, you learnt about the components of transmission chain and in Unit 24, you learnt about the components of the transmitter. FM transmitters, suitable for Community Radio setup are available from number of suppliers. Each type/model may vary from the design point of view, but basic installation procedures are same. In this Unit you will learn about the step-by-step procedure to inter-connect the components of transmission chain, mount (install) the transmitter and make it operational.

The procedures/guidelines given in this Unit are by and large general. However, at places a specific reference to a FM transmitter type – CRS-50 of BECIL make has been made to explain the details. These procedures/guidelines can easily be used for any model with slight variations depending upon the type of Input/ Output connectors provided in that transmitter.

During the 5-day Hands-on Workshop, you will get a chance to identify the input and output connectors and other wiring of the transmitter.

In the video presentation on FM Transmitters, you will have a chance to see clips from various CRSs showing different types and models of transmitters, dummy loads and other components manufactured and supplied by different firms. In the video, you should specifically note the back panel connectors, meters, and status as well as alarm indicators. Hand-outs plus video clips will help you in understanding the variations in different types and models of FM transmitter.

You may need about 6 hours to study this Unit including answering the questions given in the activities.

The step-by-step procedures for the following activities will be covered in this Unit:

- Connecting audio feed to the transmitter
- Back panel connectors
- Mounting the transmitter
- Interpretation of the transmitter meter readings and indications
- Transmitters with 1+1 operation along with changeover unit.

## 27.2 Learning Outcomes

After working through this Unit, you will be able to:

- connect audio feed to the transmitter by using suitable cables and connectors.

- use back panel connectors after identifying them and using mating connectors.
- mount the transmitter as per suggestive layout given by the firm.
- connect the RF coaxial cable coming from antenna to the transmitter output
- warm up the transmitter and make it operational.
- undertake interpretation of the transmitter, meter readings and indications.

Let us begin with connecting audio feed to the transmitter.

## 27.3 Connecting Audio Feed to the Transmitter

In Unit 23, while learning the components of transmission chain, you noted that audio output from transmission console is to be connected to the input of transmitter via studio-transmitter link and audio processor. In Unit 24, you learnt that every transmitter requires a specified audio input connector to feed the audio signal into the transmitter. Nominal and maximum input levels and the input impedance are also specified to get the desired deviation. In this section, you will learn the method of connecting audio feed to the transmitter.

In most of the transmitters, 3-pin XLR connector is usually provided at the rear side of the panel for connecting the Audio cable. In the technical specifications of the transmitter, type of connector, balanced or unbalanced, input impedance and nominal level for getting +/- 75 KHz deviation are also specified.

Follow the following step-by-step procedure for connecting the audio feed to the transmitter.

1. Decide the route and number of cables to be laid and estimate the length of each piece of audio cable required. (Make sure to consider all bends and extra loops before cutting the cable. The length of cable should not be unnecessarily large).
2. Identify the type of connectors at the output of Audio Mixer, Input and Output of Audio Processor (if provided) and at the Input of Transmitter.
3. Take required lengths of good quality shielded audio cable and number of 'Cable Type Mating Connectors' (see Figure 27.1).
4. Lay the cables either in conduit or in overhead tray as per decided route. (The route of cable should not foul with movements and crossing over power cables).
5. Identify and mark the cables.
6. Lace the cables properly.

7. Check the continuity of each wire in the cable with multi-meter.
8. Connect the type of connector required at each end by identifying the pins properly (see Box 1 for details).
9. Recheck the continuity again to ensure no shorting of any pins/wires has taken place while soldering.
10. Connect the connectors to the respective equipment.

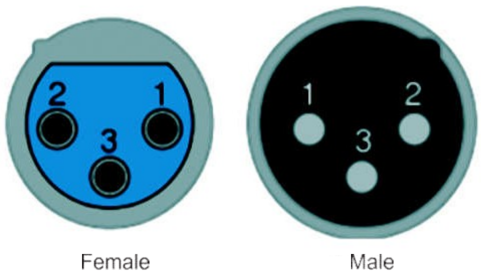



*Figure 27.1: Types of XLR connectors (female/male)*

Figure 27.1 shows two types of XLR connectors, namely, panel mounting and cable end types. Both the types are available in Female and Male types. You have to be careful while selecting a connector. Usually for Audio Input, panel type XLR (female) connector is provided at the back panel of transmitter. Therefore, the mating cable type XLR (male) connector is to be used on audio cable for feeding the audio signals into the transmitter.

## Box 1

### XLR Connectors

3-Pin balanced XLR connectors are usually provided in all Audio equipment.

Types of Connectors

1. Chassis/Panel Mounting type
   a. Male type
   b. Female type

2. Cable Type
   a. Male type
   b. Female type

Pin connections

Pin 1 - Chassis ground (cable shield)

Pin 2 – Positive polarity for balance audio circuit (red – also called hot)

Pin 3 – Negative polarity for balanced audio circuit (white – also called cold)

## 27.4 Back Panel Connectors

Every transmitter manufacturer provides a number of input and output connectors on back panel to facilitate inter-connections from audio, power supply, RF equipment etc. In this section, you will know about various types of connectors provided on back panel of transmitter along with their functions.

Types of Input/Output connectors may slightly vary from manufacturer to manufacturer but their functions remain the same. Following back panel connectors (Chassis types) are usually provided by almost all the manufacturers to maintain uniformity. Types of connector with their functions are given below:

1. AUDIO LINE IN (XLR - F) - for feeding the audio signals to the input of transmitter.
2. AUDIO LINE OUT (XLR-M) - demodulated output for monitoring and measurements.
3. 3-Pin AC Mains socket for connecting 230/50HZ power supply with On/Off switch.
4. RF OUTPUT (N-F) - for connecting to RF Coaxial Cable.
5. USB OUTPUT - for remote monitoring and logging.

Figure 27.2 illustrates the back panel connectors of a typical 50 Watt FM transmitter (BECIL CRS-50).

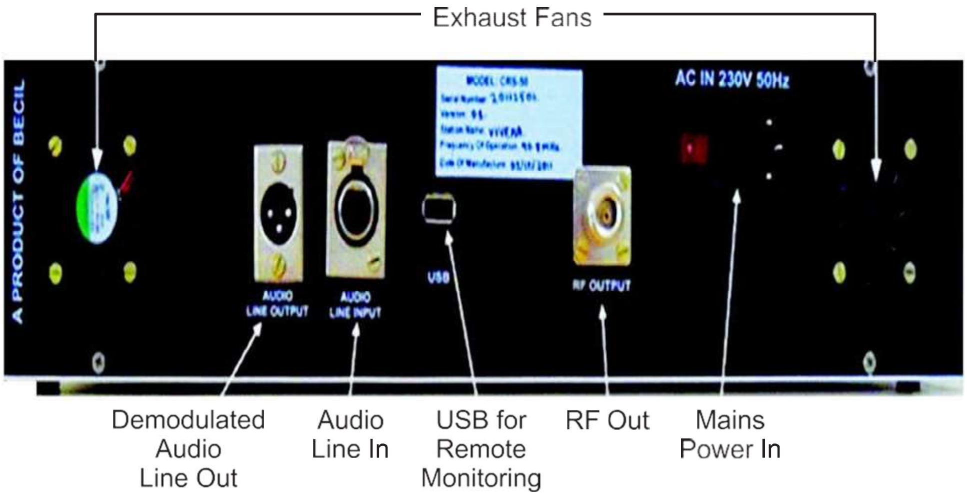



*Figure 27.2: Back panel view of 50 Watt FM transmitter (BECIL CRS -50)*

Looking into the Figure 27.2, you should note that XLR (F) connector has been provided for 'Audio Line In' whereas XLR (M) connector has been provided for demodulated audio output. This demodulated output is provided for monitoring and measurement purposes. Also note that for RF output, N (F) type of connector has been provided. USB connector has also been provided in this transmitter for remote metering and monitoring purpose.

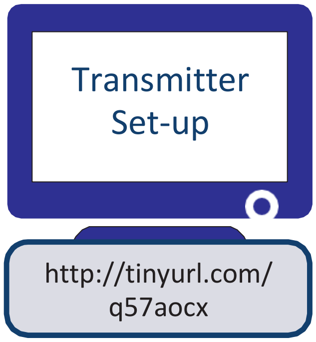
## Activity 27.1

During "Hands-on Workshop" use the hand-outs given as step-by-step procedures in this Unit and try to identify and learn the following. Note the details in your words in the space provided. This Activity will help you in gaining the confidence for connecting audio feed to the transmitter.

Question1: Please write down various types of audio and RF connectors with their pin details.

Question 2: Identify and write down various types of audio, power supply and RF cables depending upon their applications.

1. Identify and write down the methods of fixing connectors to each type of cable keeping specific attention to removing the length of insulating material and soldering the pins.
2. Identify and write down the types of various back panel connectors provided in transmitter and the types of mating connectors and cables required for interconnection.
3. Identify and write down the type of connector for demodulated audio output connector and the type of cable used.




## 27.5 Mounting and Connecting the Transmitter

Having learnt the details of the back panel connectors of the transmitter in previous section, our next job is to mount (install) the transmitter. Here, you can watch a video on the transmitter setup. It will help you to articulate the entire process for setting up a transmitter. It is available in the CEMCA YouTube page at http://tinyurl.com/q57aocx. After going through the video material, now you may feel more comfortable to comprehend the technology of a transmitter. In this section and the sub-sections that follow, you will learn step-by-step procedure for following activities.

- Mounting of Transmitter
- Connecting the coaxial cable
- Warming up the transmitter.

Let us start with mounting of transmitter.

Considering the requirement and demand of Community Radio stations and the level of operating personnel, most of the manufacturers have developed their transmitter to make it simple, easy to operate and maintain by using plug and broadcast type of design.

However, if adequate precautions are not taken at the time of installation of transmitter and associated equipment, it may result in frequent failures and damage to transmitter.

Most of the CR stations prefer to work in 1+1 system with RF change-over unit. Normally, the equipment racks are received pre-wired with proper supporting frames and trays fixed during the fabrication process as per details of the order. Mounting of transmitter and associated components of rack is done at site as per the layout plan provided by the supplier.

Step-by-step procedure given in the Installation Manual, supplied by the firm, should therefore, be followed strictly.

However, a suggestive lay-out plan for mounting the equipment is shown in Figure 27.3 for the purpose of proper understanding. Optional items like UPS, Audio Processor and Auto Change-over switch have also been shown.

*Caution:*

1. Before starting the mounting process, ensure that all the power supply switches in the Main Distribution Board are kept in 'Off' position to avoid any shock or hazard due to accidental touch of live wires.
2. Even battery terminal to UPS should be kept disconnected.

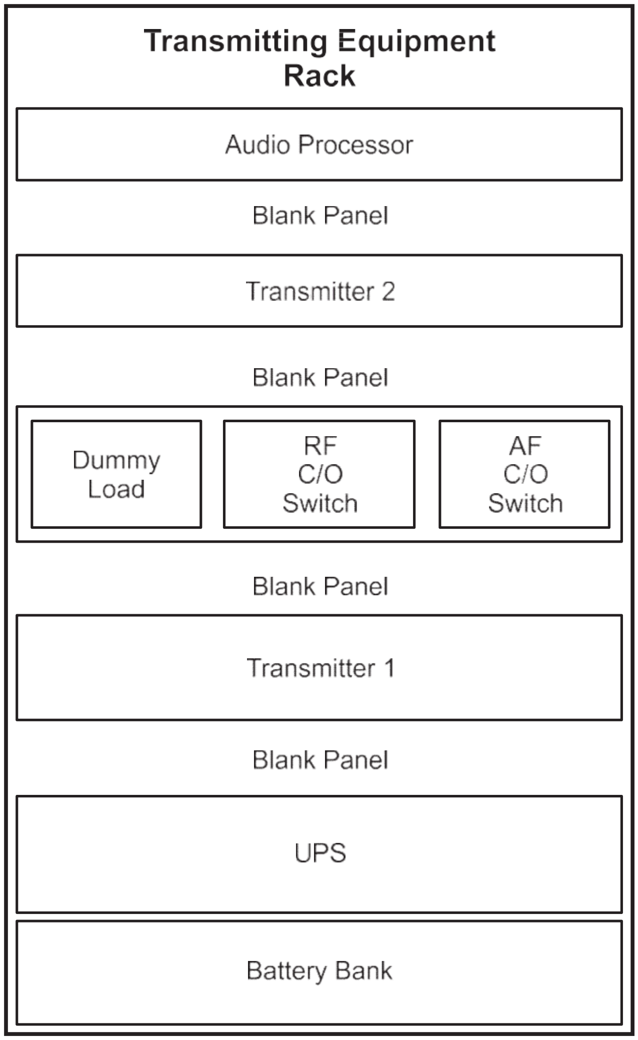



*Figure 27.3: Suggestive layout plan of transmitters and associated equipment.*

As may be seen in Figure 27.3, note the position of transmitters and other components in the rack. Battery bank has been provided at the bottom followed by UPS over it. A blank panel has been provided between equipments for proper air circulation and ease of removal while servicing. Dummy load and change over switch has been provided in the centre. Audio processor has been mounted on the top section.

Follow the following step-by-step procedure for mounting the transmitters:

Steps:

1. *Decide the Lay-out Plan and place the rack*
   - Decide the location of transmitter rack. Normally a separate room adjoining Transmission studio is preferred. The room should be fully ventilated.

- In some cases it becomes necessary to keep the transmitter in transmission studio itself. In that case, the transmitter rack should be put in one corner so that the acoustic noise of exhaust fan is not picked up by the microphone during live announcements.
- The rack should be placed on a leveled surface and at least at a distance of 3' from the wall to facilitate change of connections during servicing and maintenance.

2. *Grout the rack*
   - Grout the rack with foundation screws in all the four corners so that the rack does not shake during taking out or putting back the components.

3. *Lay copper strips for earthing the equipment rack*
   - Bring two copper strips (25mm wide x 3mm thick) from the earth pit via conduits buried deep in ground.
   - Terminate them on insulating plate (Bakelite or so) mounted on the wall.
   - Always use double brass nut bolts and facility to isolate the equipment during measurement of earth resistance. The arrangement is shown in Figure 27.4.
   - Connect copper strips from junction box on both sides of the rack with brass nut bolts and tighten them properly

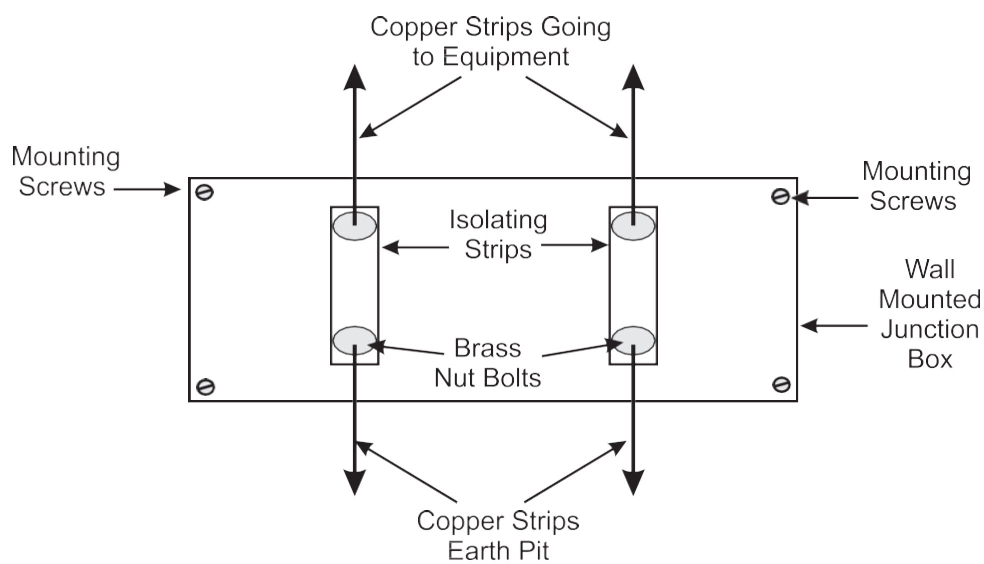



*Figure 27.4: Schematic arrangement of junction box showing distribution of copper strips for earthing.*

Figure 27.4 indicates that two copper strips have been brought from two separate earth pits and terminated on the wall mounted junction box. Two copper strips are taken out from this junction box through isolating plates and are connected to the equipment racks. Note that copper isolating plates can be removed for isolating the equipment before taking measurements.

Caution:

Equipment should never remain connected to earth pit while taking the resistance measurement of the earth pit. The voltage generated by Earth tester can damage the equipment.

4. *Mount the Transmitter and Associated equipment in rack*
   - Follow the lay-out plan issued by the supplier otherwise use the suggestive lay-out plan given in Figure 27.3 above.
   - Mount the heavy components like 'On-line UPS' with battery bank on the base of rack.
   - Mount a small power distribution board with 4 to 5 standard good quality three - pin (5A) sockets for connecting UPS output supply to transmitters and processor etc. It is always preferable to have one or two additional sockets. The input supply to this distribution board should be connected via fuse and indicating lamp.
   - Mount the Dummy Load, RF Change-over switch and AF switch along with control circuit PCB (if provided).
   - Mount the transmitters and Audio processor (if provided).
   - Fix all the units with mounting screws and tighten them properly.
5. *Connect all interconnecting cables between various units*
   - Connect power supply cables of all the equipment to power distribution board at UPS output.
   - Connect Input/Output audio cables to all the equipment such as Mixer output to Audio Processor input, Audio Processor output to AF switch input (if used) and AF switch outputs to both the transmitter Inputs.
   - Connect ribbon cables carrying the control commands from control circuit PCB to AF and RF switches (if auto changeover is provided).
   - Connect USB cables supplied along with the transmitters from USB ports of transmitters to Remote Switch or the computer.
   - Take three small lengths of RF cables connected with N (Male) connectors on both ends (usually supplied along with transmitters) and make connections as illustrated in Figure 27.5.
     - Connect RF Output of 'Transmitter 1' to 'IN 1' of RF changer-over switch.
     - Connect RF Output of 'Transmitter 2' to 'IN 2' of RF change-over switch.
     - Connect RF 'OUT 2' of change-over switch to Input connector of dummy load.

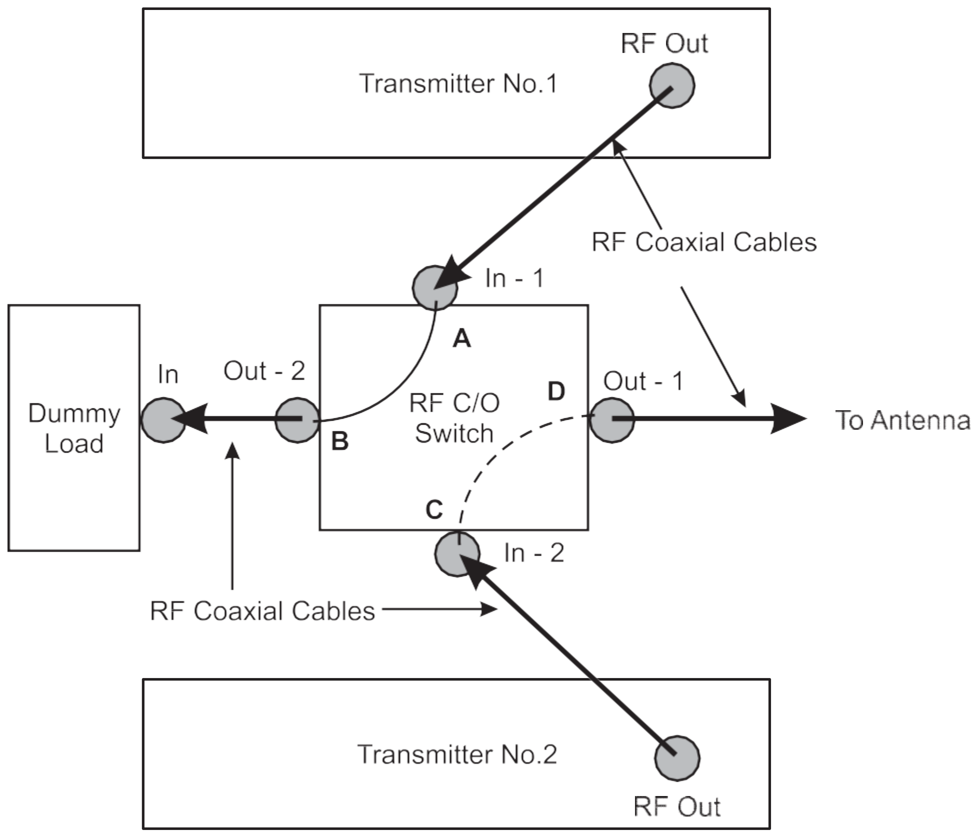



*Figure 27.5: Schematic arrangement indicating the RF interconnection of two transmitters using change-over switch.*

Looking at Figure 27.4, you can see that RF outputs of both the transmitters are connected to the RF input ports of RF switch. Transmitter and Dummy load are connected to two RF output ports of RF switch. Note the connections of RF switch. In position '1' (A is connected to B and C is connected to D), Transmitter 1 is connected to dummy load and Transmitter 2 is connected to antenna. When RF switch is changed to position '2' (A-D, B-C), transmitter 1 gets connected to antenna and transmitter 2 to dummy load.

Note: RF 'OUT-1' of changeover switch will be connected to RF coaxial cable going to the antenna. You will do this connection in the next sub-section that follows.

## 27.5.1 Connecting the coaxial cable

In Unit 25, you were given instructions and guidelines to be followed while mounting of antenna and cable on tower. You also learnt about the Voltage Standing Wave Ratio (VSWR) of antenna and the need to keep it within specified limit. You will learn the method of measurement and adjustment of antenna

VSWR in Unit 29. In this section, you will learn the method of connecting the coaxial cable to the transmitter.

Let us now proceed with the method of connecting the coaxial cable.

After having mounted the antenna and cable on tower, the other end of the cable is to be taken inside the building. Follow the following steps given below.

Steps:

1. Ensure that coaxial cable is properly connected and supported on tower by use of adequate number of clamps.
2. Ensure that cable connector and all the connectors of antenna system are tight and sealed and there is no chance of moisture entering the cable.
3. Connect the bottom end of coaxial cable with RF cable connector if the cable is not received with pre-connected connector.
4. Bring the cable inside the building either through underground pipe or by making a small opening in the rear-side wall of transmitter.
5. Check VSWR measurements of cable and antenna to ensure that there is no fault in antenna system.
6. Ensure there is no pull or tension at the end connector of RF coaxial cable.
7. Now connect the cable connector to the output of RF change-over switch (RF Out-1 as indicated in Figure 27.5).

Having made all the interconnections, our next job is to test the transmitter on power.

### 27.5.2 Warming up the transmitter

In the previous sections, you learnt how to mount the transmitter and connect the inter-connecting cables.

In this section, you will learn step–by-step procedures for warming up the transmitter.

#### Note It

Ensure RF outputs of Transmitters are properly connected to Antenna or Dummy load through the RF change-over switch.

Caution:

For warming up the transmitter follow the steps given below.

Steps:

1. Ensure that all the connections are proper and power supply to rack is off.
2. Select transmitter 1 to Dummy load (A-B) and Transmitter 2 to Antenna (C-D).
3. Keep the 'power raise control' of transmitter (if provided) to minimum position.
4. Switch on power supply from Sub Distribution Board and check the availability of supply at the input and output of UPS. Wait for few minutes to check the abnormality (if any).
5. Now switch on the power supply to transmitter 1.
    - Check that the exhaust fans get switched on.
    - Check that there is no Alarm indication.
    - Slowly raise the power of transmitter by 'Power Raise Control' (if provided).
    - Note the readings on panel meters. Observe the output and reflected power readings.
    - Wait for some time and to let it get warm up and stable.
    - Feed 1 KHz tone from Audio mixer and check the deviation.
    - Feed the programme from Audio mixer and check the deviation.
    - Adjust the output level from the processor/mixer to ensure that deviations do not cross the limit of +/- 75 KHz.
    - Run for at least an hour to observe abnormality, if any.
    - If no abnormality is observed, remove the audio programme.
    - Switch 'OFF' transmitter 1.
    - Feel the components and observe symptoms of over-heating, if any.
6. Select Transmitter 2 to Dummy load (C-B) and Transmitter 1 to Antenna (A-D) through RF change-over switch.
7. Now switch 'ON' power supply of transmitter 2 and repeat the checks as per step 5 above.
8. Select transmitter 1 on Antenna and test it as per step 5. Observe output and reflected powers. The readings should not be more than the specified limits.
9. Select transmitter 2 on antenna and test it as per step 8.
10. Switch 'Off' the system completely and ask the rigger/mast technician to check the antenna and cable system for heating etc.

Now both the transmitters are ready for operation.

## Activity 27.2

To do this activity, you may need about 10 minutes to write down the answers in the space provided. This activity will help you appreciate the significance of necessary precautions to be taken for the safety of operating personnel and the equipment before warming up the transmitter.

Question 1: What precaution must be taken while connecting the UPS output to the transmitter?

Question 2: Why isolating plates are used in junction box providing earth connectivity to equipments?

Question 3: What can happen if power supply to FM Transmitter is switched ON before connecting its RF output either to Dummy load or Antenna?

Question 4: Why is it necessary to seal RF connectors of coaxial cable?

Question 5: What precaution is necessary while changing faulty transmitter with good one?

Having warmed up the transmitters, now let us see what panel meter readings indicate.

## 27.6 Interpretation of the Transmitter Meter Readings and Indications

In the previous section, you learnt that while warming up the transmitter, panel meter readings of transmitter were noted. In this section, you will learn about the interpretation of these meter readings and indications and know their significance. All the manufacturers of transmitters provide some meters and indications to indicate the status or health of the transmitter or its subunits on the front panel of the transmitter. Some use LCD or bar-graph displays for important parameters such as Forward and Reflected power. Others may provide analogue meters. Apart from status monitoring, discrete LEDs are used to indicate the fault conditions such as over temperature and VSWR. Interpretation of panel meter readings and alarms help us to identify the faulty unit and take necessary preventive measures to isolate and repair the faulty unit.

Generally following panel meter readings and alarm indications are provided in most of the transmitters.

A. Panel meter readings
   1. Forward or output power of transmitter going to the antenna.
   2. Reflected power received back to the transmitter due to mismatch of antenna or cable.
   3. Frequency Deviation to indicate the modulation level in transmitter.

B. Alarm Indications
   1. VSWR or high reflection alarm to indicate the fault in antenna system.
   2. High temperature alarm to indicate insufficient cooling or ventilation fault.
   3. Output power failure alarm to indicate that RF output is below set limit.
   4. DC power supply failure alarm to indicate the failure of power supply to power amplifier (PA).
   5. Overload or high current alarm to indicate that Power amplifier is drawing higher current than normal value.

Figure 27.5 shows the panel meter readings and the alarms in BECIL FM transmitter type CRS -50. Different FM transmitter may have different types of panel indicators.


*Figure 27.5: Shows the front panel view of BECIL 50 watt FM transmitter type CRS-50*

Details of panel meter readings and alarms as shown in Figure 27.5 are explained in Box 2 along with their interpretations.

## Box 2

Panel meter readings and alarms provided in BECIL CRS -50

1. Alpha Numeric LCD display indicates the status of following parameters;·

   - “FinlPwr” – (45 W-55W) – Final power delivered to Antenna·
   - “FinlRefl” – (0 W) – Power reflected from antenna·
   - “PA O/P” – (45-60 W) – Power delivered by Power amplifier·
   - “PA Refl” – ( 0 W) – Power reflected to Power amplifier

2. Bar-graph display indicates the frequency deviation at any instant of time due to audio signals. (+/- 75 KHz corresponding to 100% of modulation).

3. Discrete LED indications indicate the status/alarm of following 8 parameters. Blinking of LEDs indicate the faulty/alarm condition to draw the attention of the operator when the parameters exceeds the pre-set limits.

- (i) "FinlPwr" - (It lights if the final power of transmitter going to antenna is less than 45 W or exceeds 55W).
- (ii) "FinlRefl" - (It lights if the reflected power from antenna due to mismatch exceeds 2 watt).
- (iii) "PA O/P" - (It lights if the output power delivered by PA (Power Amplifier) stage is not between 45 W to 60 W).
- (iv) "PA Refl" - (It lights if the reflected power due to mismatch in filter circuit, cable or antenna exceeds 2 watts).
- (v) "Temp" - (It lights if the temperature of heat sink exceeds $45^0$ C).
- (vi) "$V_{DD}$ Volt" - (It lights if the DC power supply of PA varies from 27+/- 2V).
- (vii) "$I_{DD}$ Amp" - (It lights if the current drawn by power amplifier from DC supply is not within 4.0+/- 0.2A).
- (viii) "Gate V" - (It lights if internal gate voltage applied to MOSFET is not within +4.0 to 4.5 V for 50 Watt).

## Activity 27.3

To do this activity, you may need about 10 minutes to write down the answers in the space provided. This activity will help you appreciate the significance of displaying the panel meter readings and will give you confidence in isolating the faulty unit or stage.

Question 1: What will happen if important meter readings are not provided on front panel of the transmitter?

Question 2: Write the names of three important parameters which are usually displayed on all the transmitters.

(i) ……………………………………………………………………………………….

(ii) ……………………………………………………………………………………….

(iii) ……………………………………………………………………………………….

Question 3: Write the names of three important alarms which are usually provided on all transmitters.

(i) ……………………………………………………………………………………

(ii) ……………………………………………………………………………………

(iii) ……………………………………………………………………………………

Question 4: What does an increase in reflected power on transmitter panel indicate?

Question 5: What does blinking of 'Temp' LED indicate?

## 27.7 Transmitter with 1+1 Operation Along with Changeover Unit

In the previous section, you learnt that a number of panel meters are provided on each transmitter. Health of the transmitter can be monitored by interpretation of these meter readings. In this section you will learn the concept of using transmitter with 1+1 operation.

In this concept, two transmitters each of 50 Watt output power along with change-over switch are used. One of the transmitters is normally 'ON' and is used for broadcasting the programmes. In case of fault in working (normal) transmitter, the second transmitter is selected through an RF change-over unit and is put on air to maintain continuity of broadcast service. This concept is well illustrated in Figure 27.5. Outputs of both the transmitters are connected to the two input ports of change-over switch. Dummy load and Antenna are connected to two output ports. In position '1' (A-B & C-D), transmitter 1 is connected to Dummy load and transmitter 2 to Antenna. When RF switch is changed to position '2' (A-D & B-C), Transmitter 1 gets connected to Antenna and transmitter 2 gets connected to Dummy load.

Two types of change-over switches are available such as;

- Auto Change-over Switch
- Manual Change-over Switch

In case of auto change-over, a control circuit PCB detects the fault in the working transmitter and selects the second transmitter by giving following commands in sequence.

- Switches off the faulty transmitter
- Disconnects faulty transmitter from antenna and connects it to dummy load. Disconnects good transmitter from dummy load and connects it to antenna. (By RF change-over switch).

- Disconnects audio input from faulty transmitter and connects to good transmitter by use of AF change-over switch.
- Switches 'ON' good transmitter and continues the transmission.

In case of manual change-over, the operation is very simple. On hearing the alarm or noticing the fault, above steps are done manually as follows;

- Switch off the faulty transmitter.
- Select good transmitter to antenna and faulty to dummy load just by moving the knob of RF change-over switch.
- Disconnect audio input cable-connector from transmitter one and connect it to the second transmitter.
- Switch 'ON' second transmitter and resume the service.

Though the automatic change-over operation is good, yet the system becomes complex and costly due to use of additional components such as Control circuit PCB, motorised RF and AF change-over switches. Even the wiring and installation require special skilled techniques. Most of the Community Radio stations have opted for 1+1 operation with Manual Change-over Switch because of simplicity and saving in cost.

## Activity 27.4

Identify and work out the type and quantity of audio cable and connectors required to connect audio feed to transmitter in a typical Community Radio Station. During your visit to a particular Community Radio station identify and work out the following items.

1. Number and type of audio connectors provided at a CRS from the output of Audio mixer to the input of the transmitter.
2. Type and approximate length of audio cable/s used at that station for connecting the audio feed looking into the cable route.
3. Type and make of audio processor (if used).
4. Note the readings of panel meters provided in transmitter used at that station.
5. Note the list of alarms provided in the transmitter along with their function and limits set for alarm.
6. Note the location of all the components mounted in the equipment rack.
7. Note the type of coaxial cable and connectors used including routing of RF cable to bring it inside the building for connecting to the transmitter.

8. Check whether two transmitters have been provided through an RF switch, if so check the method of connections.
9. Identify the type and size of copper strip used for earthing and method of connecting to junction box and to equipment rack.
10. Check the method of fixing the cable trays and laying of RF cable to inside the building.

This activity will help you understand and apply the hand-outs/guidelines given in this Unit.

## 27.8 Let Us Sum Up

In this Unit, you have learnt step-by-step procedure for setting up the transmitter. You have learnt that:

- Identification of type of connector with their pin numbers is necessary before selecting a mating connector for feeding audio to the transmitter. You have also learnt that the type of audio cable to be connected also depends on the type of connector, and whether it is balanced or unbalanced.
- Different manufacturers provide different type of connectors on the back panel of their transmitter. Identification of these connectors is also necessary for selecting appropriate mating connectors with cables for extending the Input/Output feeds to previous or next stage.
- Step-by-step procedure is to be followed for mounting the transmitter including the precautions to be observed at each step. Mistakes or faults committed during mounting procedure are difficult to correct later on. A professionally installed transmitter normally gives a trouble-free service for many years.
- Fixing of RF Connector on coaxial cable is a highly skilled job. Any wrong or improper connections made on coaxial cable or use of wrong connectors result in sparking or mismatch to the transmitter.
- Warming up the transmitter also requires a step-by-step procedure including number of precautions to be taken. You have also learnt that none of the RF Output Connector should be kept open while switching on the transmitter. Secondly, no RF Input/Output connector should be opened when transmitter is 'ON'.
- A panel meter and a number of alarm indicators are provided by each manufacturer on the front panel of the transmitter. Interpretation of the panel meter readings helps you to know the status and health of transmitter.

- Most of the CRSs work on 1+1 mode of operation of transmitters. In this mode one of the two transmitters is connected to the antenna and the second is connected to the dummy load. In case of fault in working transmitter, we can isolate the faulty transmitter and use the second good transmitter to maintain continuity of transmissions.

## 27.9 Model Answers to Activities

Answers to the questions given in Activities 27.2 and 27.3.

### Activity 27.2

1. Input supply and battery connections to Inverter in UPS must be kept 'Off" otherwise 240 V output available in UPS may give an electric shock.
2. Isolating plates are provided to isolate the equipments while doing the earth resistance measurements.
3. The transmitter can get damaged due to high reflection from open RF output port.
4. RF connectors of coaxial cables must be sealed to avoid entry of moisture or water in cable. Moisture or water can cause sparking at connector or in cable resulting in breakdown of transmission.
5. Before changing over the transmitters, power supply to both the transmitters must be switched off first.

### Activity 27.3

1. We will not be able to know the status and health of components inside transmitter. Preventive maintenance to avert failure of transmitter may not be possible.
2. Three important parameters usually displayed on transmitters are:
   (i) Output or forward power of transmitter
   (ii) Reflected power
   (iii) Frequency Deviation
3. Three important alarms usually provided on transmitters are:
   (i) VSWR (High reflected power)
   (ii) High temperature
   (iii) Failure of DC Power supply

4. Increase of reflected power on transmitter indicates mismatch at the output stage of transmitter, in coaxial cable or in antenna system.

5. Blinking of 'Temp' LED indicates increase in temperature due to inadequate cooling/ventilation. It can be due to failure of exhaust fan or choking of filter.

# UNIT 14

# Transmission System: Preventive and Corrective Maintenance

## Structure

- ✓ Introduction
- ✓ Learning Outcomes
- ✓ Ventilation and Preventing Corrosion (and dust, humidity, salt protection)
- ✓ Probable Causes of Failure of Transmitters
    - Connector Issues
    - Power Supply/Voltage Issues
    - Earthing and Earth Loops
- ✓ Reporting on the Basis of Visual Observation
- ✓ Checking Earth Conductivity
- ✓ Fault Diagnostics and Corrective Maintenance (art of isolation)
- ✓ Let Us Sum Up
- ✓ Model Answers to Activities

## 28.1 Introduction

In Unit 27, you learnt about the step-by-step procedure for mounting, warming up and testing of transmitters. In that process, you learnt that the fault in the transmitter can be diagnosed by interpreting various panel meter readings. Based on these readings and indications, you can take necessary preventive and corrective steps which may help you in preventing a major breakdown in transmissions. In this Unit, you are going to learn more about the preventive and corrective maintenance aspects of the transmitters. We will cover this Unit by discussing the following issues:

- Ventilation and preventing corrosion
- Probable causes of failure of transmitters
- Reporting on the basis of visual observation
- Checking earth conductivity
- Fault diagnostics and corrective maintenance

You will see a video showing the preventive and corrective maintenance procedures including testing and measurements on transmitters. Commonly followed practices will help you in troubleshooting the faults in transmitters and accessories. Glossary at the end of module will help you in understanding the terms used in this Unit.

You may require about 6 hours of study to learn this Unit including solving the questions given in the activities.

## 28.2 Learning Outcomes

After working through this Unit, you will be able to:

- discuss issues related to ventilation and connectivity.
- undertake necessary steps to control dust, humidity and corrosion.
- check earth connectivity.
- identify and analyse the probable causes of failure of transmitter.
- report faults on the basis of visual observations.
- diagnose the faults on the basis of panel readings, alarms and observations.
- isolate the faulty stages/units
- undertake preventive steps to avert major breakdowns in service.
- take necessary corrective steps in getting the units repaired.
- run the transmissions with minimum breakdowns.

Let us begin the discussions with issues related to ventilation and preventing corrosion.

## 28.3 Ventilation and Preventing Corrosion

In Unit 27, you learnt that the transmitter must be installed in a well ventilated, dust and humidity-free room. You also learnt that before warming up the transmitter, cooling and exhaust fans must be on. In this section, you will learn various steps to control dust humidity and corrosion. All electronic equipments including transmitters are susceptible to failure due to following adverse environment conditions.

- High temperature
- Insufficient cooling
- Dust
- Humidity
- Corrosion

The situation gets aggravated if the level of humidity is high as in the case of coastal region. Such sultry weather with high temperature adds to formation of corrosion. It is observed that percentage of failure of transmitter due to above causes is quite high. However, the positive side of the picture is that all these faults can be controlled by doing proper preventive maintenance. Preventive maintenance is therefore, necessary to keep these conditions under check as far as possible.

*Maintain a cool dust-free environment*

Though due care is normally taken to ensure provision of proper ventilation at the time of installation, yet preventive maintenance is necessary to maintain these equipments in working order. Since most of the CRSs are located in remote localities, where long break downs in power supply are common, maintaining a cool environment becomes a problem especially in summer.

Given below are certain Do’s and Don’ts. If you follow them, a number of breakdowns can be averted.

*Do’s and Don’ts*

- Service the exhaust fans and ventilation equipment regularly.
- Check blocking of filters to have a clear flow of clean air.
- Clean all equipments mounted in the rack daily with a soft cloth.
- Check that no cobwebs are formed in the rack.
- Clean tag blocks and PCBs with soft brush.
- Use light duty suction type of blower for removing the dust from the rack.
- If equipments are installed in an air-conditioned room, the temperature may not be set too low to cause condensation of vapours. Condensation of water vapours may cause more harm to printed circuit boards than even high temperature.

- De-humidifiers may be used where humidity is more.
- The external exhaust fans must be switched 'ON' at least 10 to 15 minutes before transmission and may be switched 'OFF' at least 10 to 15 minutes after close down.
- Always make a habit to touch the equipment just after close down of transmission to check any symptoms of overheating.
- Take appropriate remedial measures to increase the ventilation or cooling if signs of over-heating persist.
- Ensure working of exhaust fans of transmitter every time when transmitter is switched on.

### Activity 28.1

To do this activity, you may need about 10 minutes to write down the answers in the space provided. This activity will help you understand and appreciate the significance of proper ventilation for the transmitter.

Question 1: Why cool, dust-free and humidity controlled environment is necessary for a transmitter?

Question 2: What steps should be taken to avoid failures due to hot and humid weather?

Question 3: How can we reduce humidity?

Question 4: Why temperature should not be set too low in a transmitter room where air-conditioning unit is provided?

Question 5: How much heat does a 50 watt transmitter approximately dissipate continuously into the room?

Having learnt the importance of dust-free ventilated environment in averting the failure of transmitters in previous section, let us now see the other probable causes of failure of transmitter.

## 28.4 Probable Causes of Failure of Transmitters

In the previous section, you have learnt that transmitters are susceptible to failure in dusty, hot and humid environment. In this section and sub-sections that follow, you will learn probable causes of failure of transmitters. Important probable causes resulting in failure of transmitters are as follows:

- Connector issues
- Power supply/Voltage issues
- Earthing and Earth loops

Let us now begin with connector issues.

### 28.4.1 Connector Issues

Faults due to failure of Connectors account for an appreciable share of the total faults that occur in the transmitter set up. Connectors are mostly treated as weakest links especially in the RF circuits. A small mistake may cause mismatch or even sparking.

Connectors usually fail because of following three reasons:

1. Use of wrong connector
2. Connector not fitted properly
3. Connectors becoming loose due to improper handing or pulling the cables.

In all the three cases referred to above, the connectors become the weak links and account for frequent failures. Fixing a connector is a skilled job which can be learnt by practice only. You will gain this skill in '5-day hands-on Practical Training on community Radio'.

Connector faults are controllable faults. Following steps will help you in averting most of the faults which are due to connectors:

- Always use good quality connectors of reputed make and matching to the size of cables.
- Due care should be taken to fix the connectors properly.
- Instruction sheets are normally supplied by reputed manufactures for fixing the connectors. The lengths of insulating layer or sleeves must be cut as per dimensions specified therein.
- The length of inner connector should not be less. If it is so, it may not make proper contact with inner conductor of mating connector. It should not be too long to get bulged after connection.
- The strands of conductors and the soldering metal should not protrude or touch the other conductor.
- While checking, mounting or removing the connections, the cables should not be pulled. Pulling may result in breaking of inner connector or strands thereby resulting in bad connection.
- Connectors of RF coaxial cables especially used on antenna side must be sealed properly to avoid entry of moisture or water.
- Plug all the entry holes properly with glass wool to avoid entry of rodents. Rats have been found to cut cables especially the small ribbon cables.

Let us now move to the second and the most important issue, that is power supply/voltage.

## 28.4.2 Power Supply/Voltage Issues

Power supply and voltage faults contribute to a major share in the probable causes of failure of transmitters. In this sub-section, you will learn how such issues can be tackled to avoid a breakdown or fault.

The major cause of failure of electronic components is the sudden fluctuations in power supply voltages. Most of the CRS stations are located in remote isolated localities where regular stable power supply is normally not available all the time. Large breakdowns or shut downs and frequent variations in power supply voltages are a common phenomena. It is therefore, necessary to ensure a stable backup power supply source. Maintenance of batteries of the UPS is also a major issue. Life of battery is limited. Even recharging of batteries becomes a problem if mains supply fails for a longer duration. You have learnt about all these aspects on backup sources in Unit 8.

However, by taking following preventive steps, the occurrence of majority of the faults due to power supply can be curtailed.

- Mains input supply must be first regulated by use of Automatic Voltage Regulator (AVR) or Constant Voltage Transformer (CVT).
- Use preferably On-line UPS to operate transmitter and other essential equipment. On-line UPS provides transient free supply. Variations in input supply are practically not allowed to reach the transmitter.
- Have an adequate provision of battery backup which depends on its ampere-hour capacity.
- Ensure proper maintenance and servicing of power supply and backup supply units.
- Though the batteries used are generally maintenance-free batteries, yet they need certain attention. Efficient battery management and care is essential for the overall performance of the UPS.
- Life of battery is limited. Overcharging and deep discharges may be avoided as they reduce the life of battery further.
- Check panel meters displaying Input voltage, Output voltage and Output load Volt Ampere (VA) on batteries. These readings will help you to know the performance of UPS and status of batteries.
- Now-a-days, a number of softwares like Power Manager are available which work on various important parameters to know the status of batteries.

If power supply and voltage issues are maintained properly, the rate of failure of transmitters can be reduced appreciably.

## 28.4.3 Earthing and Earth Loops

Another important probable cause of failure of transmitter is disconnection of earth link (loop). This is a hidden element and is mostly neglected in maintenance, but its effect is felt in many ways such as:

- Non protection of equipment and personnel during lightning.
- Non protection of personnel and equipment during electric short circuit..
- All RF circuits including antenna system are generally unbalanced with earth connectivity providing the return path. Efficiency of these circuits decreases with increase in earth resistance.
- Increase in RF pick up level in equipment thereby deteriorating the quality.

Therefore, a regular maintenance and check up of earth pits and earth connectivity to transmitter and other equipment is essential. Ensuring following steps will help you in preventing the faults arising due to earthing and earth loops:

- Have a periodical visual inspection of earth electrode connections to ensure their rigidity and other signs of deterioration.
- Water the earth pit at regular interval to keep the earth resistance within specified limits.
- Measure the resistance of the earth pit at regular intervals at least once within three months.
- Ensure to disconnect the equipment from junction box while measuring the resistance of earth pit. (Refer the caution mentioned in Unit 27 while describing the mounting of transmitter).
- Check the connections from the earth pit to the equipment at regular intervals for ensuring their continuity.
- Check the continuity of connections with multi-meter at places where sheathed (or sleeved) copper strips or wires are used. This is all the more necessary in coastal areas where chances of breaking the connection are more due to rusting.

Regarding checking of earth conductivity, you will learn more in the following section 28.5.

## Activity 28.2

To do this activity, you may need about 10 minutes to write the answers in the space provided. This activity will help you know and analyse the probable causes of failures of transmitters.

Question 1: Why connectors are usually called as weak links in transmission chain?

Question 2: Why frequent and deep fluctuations are considered more dangerous than the low or high voltages?

Question 3: How the use of UPS reduces the faults due to power supply?

Question 4: Why is efficient battery management essential for the performance of UPS?

Question 5: Why is it necessary to periodically check the continuity of earth wire?

In this section, you have learnt about the probable cause of failure of transmitters. In the next section you will learn the method of reporting faults on the basis of visual observation.

## 28.5 Reporting on the Basis of Visual Observation

So far in this Unit, you have learnt preventive methods like provision of proper ventilation to avoid dust, humidity and rusting. You have also learnt probable causes resulting in failure of transmitters. In spite of adequate care, faults do occur sometimes. In Unit 27, you learnt to interpret the panel meter readings giving the status and health of the transmitter. In this section, you will know how to report the fault on the basis of your visual observations.

During transmissions or while doing regular maintenance, you may observe certain abnormality or fault. For example, during transmission you may suddenly find that no programme is going on air. On checking the panel meter readings, you may notice that forward power has decreased and reflected power has increased. On further checking, you may notice an alarm indication showing high reflected power. In such a situation, you have to report to your seniors (and/or the supplier of transmitter) on the basis of your visual observations. Based on these observations, your senior or the supplier may come to the conclusion that the most probable cause of fault in this case is due to antenna. However, in some cases, you may be asked to give some further observations as well. Hence, it becomes necessary for you to keep your eyes and ears open to know what is happening in the transmitter room. Your reporting should be based on the following aspects:

- What are the panel readings – any abnormality?
- What are the alarm indications that you notice or hear?
- Which are the points where you touch and feel the heating?
- Is there any burning or overheating smell?
- Whether the exhaust fans are working or not?
- Whether any abnormal sound is heard from any moving machinery or part?

- Whether cooling/ventilation is insufficient?
- Whether power supply voltages are normal or more or less?
- Whether programme is being received from studio or not?

Thus, with your correct reporting on the basis of visual observations, it becomes easy for your supervisory officer to analyse the problem and guide you for further action to be taken to identify and isolate the fault. You will learn more on art of isolation in forthcoming section (28.7) on 'Fault diagnostics and corrective maintenance'

Now let us proceed to discuss how earth conductivity can be checked.

## 28.6 Checking Earth Conductivity

In the previous sub-section (28.4.3), you have noticed that increase of earth resistance or breaking of earth connectivity was one of the probable causes of failure of the transmitter. In this section you will learn method of checking earth conductivity or earth resistance as we normally call.

Checking of earth conductivity and connectivity is necessary to ensure protection of equipment and personnel from electric shocks and lightning. It provides a return path for the unbalanced RF circuits including RF coaxial cables and antenna system. Lower the earth resistance better is the efficiency of the antenna system.

The resistance of earth pit is measured by an instrument called 'Megger'. Direct reading meggers with digital display are available in market. They are very simple to operate and can be easily used for checking the earth resistance measurement. Figure 28.1 shows the method of connection and measurement.

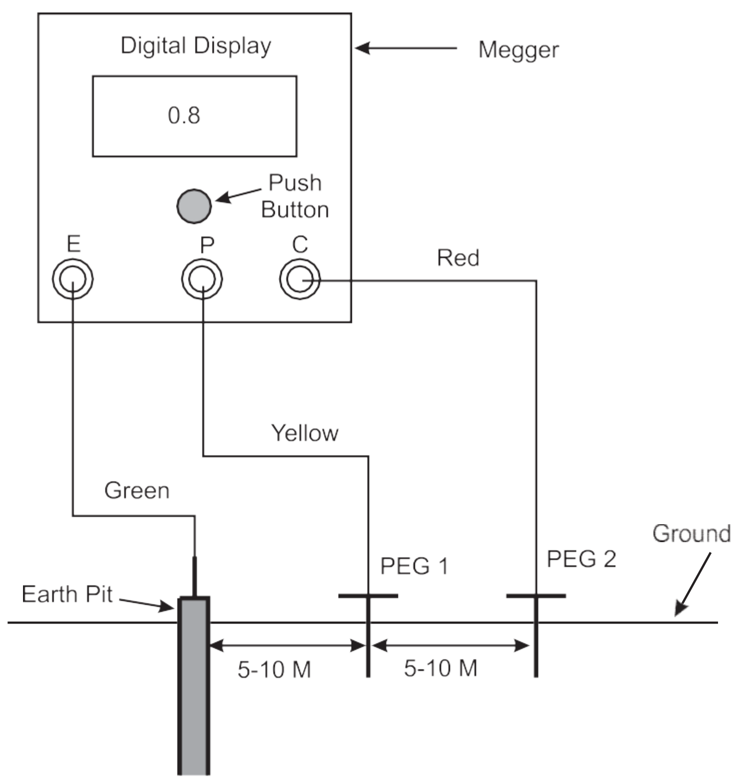



*Figure 28.1: Checking of Earth conductivity*

As we see in Figure 28.1, digital Megger has got three terminals namely E, P, and C. Terminal E is connected to the earth pit. Terminals P and C are connected to two pegs driven in the ground at a distance of 5 to 10 metres from the earth pit. Note the colour code of wires used for each connection. They match the colour of terminals of the Megger. A push button is provided on the meter which when pressed, connects voltage to leads. The digital display directly reads the earth resistance in ohms.

## Note It

Ensure that equipment are disconnected before start of earth resistance measurement.

Follow the steps for measurement:

- Make the connections as shown in Figure 28.1 ensuring the colour code of wires and connectors provided on the megger.
- Drive the two electrodes (pegs) at a distance of about 5 to 10 meters from the earth pit preferably in line.
- Connect the earth (ground) terminal lead to earth pit.
- Press the voltage generator button.
- Read the resistance reading shown on the display.
- The reading should normally be less than 1 Ohm
- If reading is more, check the connections.
- Put water in the pit and repeat the test after one or two days.
- Record the reading/observation in maintenance register.

## Activity 28.3

To do this activity, you may need about 10 minutes to write the answers in the space provided. This activity will help you learn the method of reporting faults on the basis of your observations and the method of checking the earth conductivity.

Question 1: How reporting on the basis of your visual observations helps your superiors?

Question 2: Write any two forms of visual observations provided on the transmitter panel.

(i) ……………………………………………………………

(ii) ……………………………………………………………

Question 3: During transmission you heard an audible alarm. What are the points that you will check before reporting to your seniors?

Question 4: Why checking of earth conductivity and connectivity is necessary?

Question 5: Why the resistance of the earth pit should be as low as possible?

Now you are going to learn a very important part of this Unit which, if practiced, will help you in running trouble-free transmissions.

## 28.7 Fault Diagnostics and Corrective Maintenance

So far you have learnt preventive part of maintenance in this unit. You have also learnt to report the fault on the basis of your visual observations (section 28.5). In this section, you will learn how to diagnose a fault in the event of a breakdown and take necessary corrective steps to isolate and rectify it.

Transmitters provided at CRSs are generally plug-and-operate type transmitters. They are received as pre-tuned at factory and no user controls are generally provided on front panel for changing the operating conditions of the transmitter. Once installed and tested they are supposed to run without any problem provided certain requirements like proper dust-free ventilation, connectivity, power supply voltages and low earth resistance are maintained. These transmitters have got an important feature called "Automatic Power Control" (APC) or fold back facility. In case of any problem in transmitter or antenna, the automatic power control action of transmitter reduces the output power to a safe value to prevent further damage to the transmitter. However, a diagnostic approach method helps the operating staff to timely identify and isolate the faulty unit or section and take necessary corrective measures to get it repaired.

Now let us see what this diagnostic approach is. As all of you are well aware that a doctor diagnoses your disease by visual observations of the affected part of the body and by checking certain parameters such as temperature, blood pressure etc. Likewise, diagnostic approach for checking the health of transmitter involves some visual observations, meter readings and special measurements whenever it is necessary to diagnose the fault logically and systematically.

Diagnostic approach involves following steps to be taken on noticing the fault:

- Check all visible indications and alarms.
- Note panel meter readings.

- Interpret the meter readings and visible observations.
- Identify the faulty unit or circuit.
- Isolate the faulty unit.
- Repair the faulty unit.
- Check working of the repaired unit.
- Take performance measurements to ensure that the transmitter meets the specifications.
- Restore the service.

Now, let us take a few examples of panel meter readings and alarm indications which you have learnt in section 27.6 and try to diagnose the faults. The steps to isolate the faults along with corrective measures have also been explained.

1. *Power Amplifier(PA) output power reduction fault*

    - The normal output power of transmitter was 50 watt. Suddenly you noticed that it has gone down to 40 watts.
    - On checking other panel meter reading you noticed that PA reflected power reading is 0 watt (normal)
    - On checking other visible indications you found PA power low and $V_{DD}$ (DC supply to PA stage) indications are coming.
    - On interpretation, it can be concluded that DC power supply stage in the transmitter is giving low voltage than the desired value.
    - This transmitter should be switched off and second transmitter to be brought on air.
    - The fault along with observations may be reported to seniors/ supplier of transmitter.
    - After repairs of faulty power supply unit, the faulty transmitter should be tested.
    - Note the panel meter readings. P.A. output power meter should again read 50 watt.

2. *High Temperature Alarm*

    - Suddenly, you heard an audible alarm in the transmitter room.
    - On checking the visual indications you found that 'High Temp' LED is blinking.
    - On further checking, you found that exhaust fan is not running.
    - You can conclude that high temperature alarm is coming because of insufficient cooling.
    - Switch OFF the transmitter and take second transmitter on air.
    - On checking you found fan is faulty. Its winding has become open.

- Replace the faulty fan with good one.
- Test the transmitter again to ensure that it is ready for use.

3. *High VSWR Fault*

- Suddenly, you heard an audible alarm in the transmitter.
- On checking the visual indications you found both Forward (final output power) and Reflected power indications are glowing.
- Panel meter readings also indicated low forward power and high reflected power.
- This indicates that fault is in RF cable or antenna system.
- To confirm the fault, switch off the transmitter and connect it to dummy load.
- On switching 'ON' transmitter on dummy load you found that the panel meter readings are normal and no alarm is coming.
- You can conclude that fault is in RF cable or antenna system.
- Take appropriate steps to get the antenna checked.
- On further check up by mast technician, sparking marks were observed on antenna side connector of branch feeder cable.
- Replace the connector.
- Check VSWR of antenna system. (You will learn about VSWR measurement and antenna adjustment issues in Unit 29).
- If VSWR is Ok, test the transmitter on antenna and re-run the transmission.

Now let us take an example of other type of fault not reflected by panel meter readings.

4. *Noise level and distortion fault*

Observation:

While monitoring the transmission you observed that quality of programme is not good. It is noisy and distorted.

Diagnosis:

- Feed the audio input signals directly in transmitter after bypassing the audio chain.
- If fault persists, switch off this transmitter and use second transmitter.
- Check the quality of programme again with second transmitter.

- If quality with second transmitter is good, then first transmitter is suspected.
- Inform your supervisory officer/service Engineer.
- Once it is ensured that the bad quality is due to the transmitter, performance measurements are required to be taken using the test and measuring equipment.

Now let us see the role of performance measurements in diagnosing a fault.

*Performance Measurements*

Deterioration in quality of programmes like noise and distortion can be judged by doing performance measurements. Performance measurements help both in preventive and corrective maintenance. If performance measurements are done periodically, you can easily assess the degradation of quality in advance and take necessary preventive action before the occurrence of fault.

Important periodical measurements which are to be done to ensure the best performance of transmitter include:

- RF Output power
- RF Frequency
- Frequency response
- Noise level
- Total Harmonic Distortion
- Spurious and harmonic radiations
- VSWR measurement of antenna

*Test and Measuring Equipment*

Special test and measuring equipments along with different types of connectors, cables and probes are required to do these measurements. You will also see a video showing preventive and corrective maintenance including use of test and measuring equipment.

List of a few important test and measuring equipments required to do these measurements includes:

- RF power meter
- RF frequency meter
- Audio signal generator
- Modulation Analyser
- Spectrum Analyser
- Network Analyser or Antenna Tester

Other important tools of diagnostic approach which will help you both in preventive and corrective maintenance include:

- Use of logger for recording the live transmissions including faults with date and time information.
- Knowledge of inter-wiring details of transmission chain
- Identification of part number of units and components
- Maintenance of adequate spares
- Contact numbers to avoid delay in calling service engineers.
- Maintenance of history sheets of equipment showing the types of faults and their frequency of occurrence.
- Following the maintenance schedule and keeping the records of maintenance done with symptoms observed.

## Activity 28.4

To do this activity, you may need about 10 minutes to write the answers in the space provided. This activity will help you understand the significance of diagnostic approach and apply it while attending to the transmission duties in Community Radio stations.

Question 1: What is the advantage of using diagnostic approach in troubleshooting a fault in transmitter?

Question 2: Write in your words some steps of diagnostic approach which you may follow on noticing the fault.

(i) ..........................................................................................

(ii) ..........................................................................................

(iii) ..........................................................................................

(iv) ..........................................................................................

(v) ..........................................................................................

Question 3: What probable fault do the following observations indicate?

(i) No ‘PA Output Power’ reading on panel meter
..........................................................................................

(ii) Glowing of ‘PA Reflected Power’ LED
..........................................................................................

(iii) Glowing of ‘Temperature’ LED
..........................................................................................

Question 4: Why performance measurements are necessary for transmitters?

(i) ……………………………………………………………………………………

(ii) ……………………………………………………………………………………

Question 5: Name three important performance measurements which determine the audio quality of the programmes.

(i) ……………………………………………………………………………………

(ii) ……………………………………………………………………………………

(iii) ……………………………………………………………………………………

## 28.8 Let Us Sum Up

In this Unit you have learnt methods and procedures for doing preventive and corrective maintenance. In this process you have learnt that:

- Preventive steps help in controlling rise in temperature, humidity and improving ventilation. It helps in curtailing the occurrence of faults. Maintenance of ventilation equipment and uninterrupted connectivity reduces the breaks in transmissions.
- Earth conductivity and continuity of earth connections can be checked by use of megger and multi-meter respectively. Maintenance of low earth resistance and its proper connectivity to equipment protects working personnel from electric shocks. It also protects equipment and the personnel due to lightning.
- Probable causes resulting in failure of transmitters include use of wrong connectors or wrongly fitted connectors which become loose due to improper handling and pulling. Power supply failures and voltage fluctuations are the major causes resulting in failure of transmitters.
- Use of properly rated UPS systems helps in curtailing faults due to failure or variations in mains supply.
- Though the batteries used are generally maintenance free, they have got a limited life. Avoiding of overcharging and deep discharges increase the life of batteries.
- Visual observations of panel meter readings and alarms help us to identify the faulty stage.
- Diagnostic approach helps in systematic analysis and quick identification

of the faulty unit. Timely action in isolation of faulty unit prevents further damage to equipment. We have studied to use the diagnostic approach by considering some of the practical faults generally encountered in most of the transmitters.

## 28.9 Model Answers to Activities

Model answers to questions given in activities 28.1 to 28.4.

### Activity 28.1

1. To protect solid-state devices which are susceptible to failure due to high temperature, dust and humidity.
2. By placing the transmitter either in an AC room or in a room having dust filters and exhaust fan.
3. By use of dehumidifiers.
4. To prevent condensation of water vapours which are more dangerous to the solid-state devices.
5. A 50 Watt transmitter normally consumes 120 to 130 watt of power supply. Out of which 50 watt is delivered as RF and balance 70 to 80 watts is dissipated as heat in the transmitter hall.

### Activity 28.2

1. Because most of the faults observed in transmission chain, occur at connectors. This is especially the case when connectors are fixed at site and secondly, the power rating capacity of connectors is less than the cables.
2. Because most of the solid state devices used in transmitter are sensitive to transients produced by frequent fluctuations rather than low or high voltages.
3. Output voltages of UPS are constant. Fluctuations in AC mains are not passed on to the equipments connected at the output of UPS.
4. With efficient management system, unbalanced charging, overcharging and deep discharging are prevented. This increases the life of batteries.
5. Because there can be breaks in earth wire due to rusting especially in coastal areas.

## Activity 28.3

1. Reporting on the basis of observations help seniors to visualize the possible cause of failure.
2. (i) Panel meter readings (ii) Alarm indications
3. We will check the following points before reporting:
   - (i) Panel meter readings
   - (ii) Alarm indications
   - (iii) Any other symptoms of overheating, abnormal noise etc.
4. To ensure continuity of earth connectivity to body of equipment and to maintain the body of equipment at zero potential.
5. To provide low resistance path during short circuit or during lightning.

## Activity 28.4

1. Diagnostic approach helps in quick identification of fault or faulty stage.
2. We will:
   - (i) Check all visual indications and alarms.
   - (ii) Note panel meter readings.
   - (iii) Interpret the visual indications and meter readings.
   - (iv) Identify the faulty unit or circuit.
   - (v) Isolate the faulty unit.
3. (i) Faulty Power Amplifier output stage.
   - (ii) Mismatch or VSWR fault in RF cable or Antenna system
   - (iii) Heat sink temperature is higher than set limit due to insufficient ventilation or faulty exhaust fan.
4. (i) To check the quality of programmes.
   - (ii) To ensure that the transmitter meets the claimed specifications.
5. (i) Frequency response measurements.
   - (ii) Noise level measurements.
   - (iii) Distortion measurements.

# UNIT 15

# Transmitter Setup: Good Engineering Practices

## Structure

- ✓ Introduction
- ✓ Learning Outcomes
- ✓ Cable and Connector Issues
- ✓ Input and Output Issues
- ✓ Transmitter Operation and Upkeep Issues
- ✓ Antenna Measurement and Adjustment Issues
  - VSWR measurement of the antenna
  - Measurement of forward and reflected power of transmitter
- ✓ Let Us Sum Up
- ✓ Model Answers to Activities

## 29.1 Introduction

In Unit 24 and Unit 25, you learnt about the basic description of FM transmitter and FM antenna as a part of Radio Transmission Technology. In Unit 27, you learnt about the step-by-step procedures for mounting and testing of transmitter, coaxial cables and antenna system. Further, in Unit 28, you studied about the preventive and corrective maintenance aspects of these components. In this Unit, we shall discuss about the good engineering practices which, if followed, will help you in running a trouble-free transmission service for your Community Radio Station. These good engineering practices cover both for installation and maintenance of transmitter setup.

While studying this Unit you will notice that good Engineering practices involve:

- Proper Planning
- Proper Selection (of equipment)
- Proper Installation
- Proper Maintenance

All the above aspects will be covered in the following sections of this Unit:

- Cable and connector issues
- Input and output issues
- Transmitter operation and upkeep issues
- Antenna adjustment issues

This Unit is presented in Question-Answer format (frequently asked questions - FAQs) so that a number of questions which may arise in your mind while learning this Unit will be answered.

In the Face-to-Face (F 2 F) counselling session, you will get chance to clear your doubts with the help of experts in the field. However, there are some Activities given in each section which you need to work out so as to help you appreciate the aspects of good engineering practices discussed in this Unit.

You will need about 6 hours of study to complete this Unit including the activities given in the Unit.

## 29.2 Learning Outcomes

After working through this Unit, you will be able to follow the good engineering practices to:

- analyse and discuss issues related to cable and connectors.
- list and analyse input and output issues in respect of transmitter.
- operate and upkeep the transmitter and associated equipment in good working condition.
- adjust the antenna and undertake VSWR measurement of the antenna.
- measure forward and reflected power of the transmitter.

It is important for you to go through FAQs carefully to fully understand the information given there, as such information is generally not available in text books. This will help you learn practical tips for becoming more confident and knowledgeable in these areas.

Let’s begin with the issues related to Cable and Connector.

## 29.3 Cable and Connector Issues

In this section, you will learn how best you can apply your basic knowledge gained through the previous Units in tackling the cable and connector issues in the field. You will learn these aspects by going through the answers to the following questions frequently asked by the students.

*Why do we use RF coaxial cable in FM broadcasting?*

The transmission lines are required to feed output power of the transmitter to the antenna located on the top of tower. There are two types of transmission lines.

i) Parallel wire (Balanced lines)
ii) Coaxial cable (Unbalanced line)

In FM broadcasting, RF output of the transmitter is usually unbalanced and the performance characteristics of coaxial cables are much better than parallel lines, therefore, coaxial cables are preferred.

*What are the selection criteria of coaxial cable?*

Selection of type and size of cable is dictated by following three important specifications.

1. Characteristic impedance
2. Power rating
3. Attenuation

*On what factors do characteristic impedance of the cable depend?*

Characteristic impedance of the coaxial cable depends on the following parameters:

- Outer diameter of inner conductor
- Inner diameter of outer conductor
- Dielectric constant of insulating material

*What will happen if we use an RF coaxial cable having a characteristic impedance of 75 ohms instead of 50 ohms?*

Because of the mismatch, there will be high reflection back to the transmitter. Transmitter will see the load impedance of 75 instead of 50 ohms. (VSWR = Load Impedance/output impedance of transmitter. = 75/50 =1.5).

*How can we measure the characteristic impedance if data sheet is not available?*

Characteristic impedance of cable can be measured by use of operating bridge or a site master or network analyser as follows:

- Measure open circuit impedance by keeping other end open ($Z_{oc}$)
- Measure short circuit impedance by shorting other end ($Z_{sc}$ )
- Calculate characteristic impedance ($Z_o$) =$\sqrt{}$( $Z_{oc}$ x $Z_{sc}$)].

*How do we decide the average power rating requirement of coaxial cable?*

Requirement of average power rating is decided on the basis of maximum transmitter output power allowed. Usually a minimum safety margin of 2 is taken. For example, for 100 watt transmitter, select a cable with at least double average power rating that is 200W.

*How do we know the average power rating of coaxial cable?*

The average power rating of cable can be known from the data sheet supplied by the cable manufacturer. The rating must be selected corresponding to the frequency of operation. The average power is specified at ambient temperature of 20 degrees centigrade. Degradation of rating for higher temperature must also be considered.

*How do we know the attenuation of RF cable?*

We can know the attenuation of RF cable from the data sheet supplied by the manufacturer. Attenuation is specified for a range of frequencies per 100 meter of length.

*On what factors do the attenuation of RF cable depend?*

Attenuation of RF coaxial cable primarily depend on:

i) Frequency of operation
ii) Resistance of the conductors
iii) Leakage across the dielectric material
iv) Length of the cable
v) Velocity factor of the material used

*What will happen if the attenuation of RF coaxial cable is more?*

The output power of transmitter reaching the antenna will be reduced by that amount. For example, if attenuation of length of cable used is say 3 dB, then we can say that only half of the power of transmitter will reach antenna. The coverage will correspondingly get reduced.

*What type of connector should be used?*

The original mating connectors (usually N-Male) recommended and supplied along with the cable must be used.

*What precautions should we take while fixing the connectors?*

Fixing of connector is a skilled job. Follow the instruction sheets provided along with the connectors especially while cutting the length of insulation for inner and outer conductor. A loosely fitted connector always remains the weak link. It may lead to overheating or sparking. With practice you can gain the necessary skill.

*Why should we seal the connector and with what compound?*

The connectors especially on antenna side must be sealed properly to avoid entry of moisture or rain water. Usually a sealing tube called 'Plast 2000' supplied along the cable is used.

## Note It

A appropriately installed project requires minimum maintenance and results in minimum breakdowns.

## Activity 29.1

To do this activity, you may need about 10 minutes to write down the answers in the space provided. This activity will help you appreciate the significance of good engineering practice in selection and use of RF coaxial cable and connectors.

Question 1: Why characteristic impedance is considered as the most important parameter while selecting RF coaxial cable?

Question 2: What will be the change in attenuation if the length of cable is changed from 50 m to 100 m?

Question 3: How much power of transmitter will reach its antenna if loss of cable is found to be 3 dB?

Question 4: What may happen if rain water enters the connector of one of the antenna dipole?

Question 5: Why the average power rating of RF coaxial cable shall not be usually less than twice the output power of the transmitter?

## 29.4 Input and Output Issues

In the previous section you have learnt how a good engineering practice helps in reduction of faults arising due to cable and connector issues. In this section, you will learn how good engineering practices can help you in tackling input and output issues in respect of transmitters.

*What are the input issues that need to be tackled in respect of transmitters?*

Following input issues should be tackled in respect of transmitters:

- Ensure proper audio input levels and connectivity: i.e. Audio levels from studio should not be low and there should not be any breaks in connectivity from studio to the transmitter.
- Ensure proper ventilation: i.e. Cooling and exhaust fans of transmitter must be 'ON' before switching on the transmitter.
- Ensure uninterrupted power supply to the transmitter: i.e. Input supply connected to the transmitter must be stable.

*What are the issues related to audio feed to transmitter?*

Issues related to audio feed to the transmitter are:

- Ensuring loss-less connectivity: i.e. Studio to transmitter link should not offer any loss to audio signals.

- Use of Audio Processor: i.e. Audio Processor should be used to increase average modulation and protect transmitter from over-modulation.
- Audio chain alignment: i.e. Audio levels at the input and output of all the equipments from studio to the transmitter should be adjusted to the nominal levels as specified by manufacturer of the equipment.

*What are the points to be considered while connecting the audio feed to the transmitter?*

You should check the following points before connecting the audio feed to the transmitter:

- Type of Input connector provided for audio connection to the transmitter: For example, XLR male or female connector.
- Whether the connector used is balanced or unbalanced type (for example, BNC unbalance or XLR balanced)?
- Input Impedance; i.e. 600 ohms or more than 10k ohm.
- Input sensitivity specified by the transmitter manufacturer: i.e. Minimum audio level with which the transmitter is capable of giving 100 % modulation (for example, - 10 dBm).
- Nominal input level required for giving +/- 75 kHz deviation (for example, +4 dBm)

On the basis of above information, you should select the type of mating connector and audio cable. You should adjust the audio input levels to the transmitter accordingly.

*What type of audio cables should be used?*

You should use good quality shielded balanced/unbalanced audio cable of reputed make specifying the number of strands, gauge and material. Use of balanced or unbalanced cable is to be decided on the basis of type of input and output connectors provided on the equipment to be connected.

*What type of audio connectors should be used?*

Most of the audio equipment such as Mixers, Audio processors and transmitters use 3-pin XLR type of connectors for audio inputs/outputs. Some of the transmitters requiring unbalanced input use BNC (F) connector. Corresponding mating connectors must be used for connecting to the cable ends.

*What should we do if the output of audio processor is balanced and the transmitter input connector is unbalanced?*

By use of repeat coil, you can connect balanced input on one side and unbalanced output from the other side. If impedance is also different, then you can use a matching transformer or a matching pad.

*How do we know the nominal input level required for getting deviation of 75 KHz?*

You can know the nominal level:

- From the technical specifications/data sheet supplied along with the transmitter.
- By feeding 1 KHz tone to the transmitter input and noting the level which gives a deviation of +/- 75 kHz.

*What do we mean by Input Sensitivity of transmitter?*

Input sensitivity of the transmitter is the minimum audio input level with which transmitter can give +/- 75 KHz deviation after adjustment of its input gain control.

*Why do we need Audio processor at the input of the transmitter?*

We need audio processor at input of the transmitter to:

- Increase the average modulation level (i.e. to increase loudness).
- Protect the transmitter against over modulation.

*How do we adjust the audio chain alignment?*

We adjust the audio chain by keeping output levels and input levels of all the equipments in chain as equal to their nominal levels. Usually it is set as +4 $dB_u$ at all points in the chain.

*Why do we limit the deviation to +/- 75 kHz?*

In order to operate number of channels (stations) in the FM band, channel spacing and bandwidth are fixed internationally to have uniform and well defined transmission standards. A maximum modulating frequency of 15 kHz resulting in maximum deviation of +/- 75 kHz correspond to maximum allowed bandwidth of 180 kHz in FM broadcasting. Giving higher deviations can interfere with programmes of adjacent channel.

*What are other important points which must be checked to ensure a good quality transmission?*

You must ensure that;

- Recorded programmes are not noisy and are not having breaks.
- Recorded levels are uniform.
- Modulation levels are adequate and peaks are not causing constant over modulation.

*What are the important output issues in respect of transmitters?*

Important output issues in respect of transmitter are:

- Low or no Output Power
- Increase in Reflected Power
- Coverage not as expected – not reaching the target area
- Performance of output modulated signals not meeting the technical specifications.
- Quality of reception not up to the mark
- Interference to or from other channels

*What should we do if forward power is low or not there?*

Check whether it is due to faulty transmitter or there is no or low power supply. Follow diagnostic procedures learnt in Unit 28 to identify and isolate the fault.

*What does increase in reflected power mean?*

Increase in reflected power means that there is mismatch in cable or antenna system.

*What should we do if reflected power increases?*

Switch off the transmitter if reflected power increases. Check the VSWR of the antenna system (You will have to check the fault in antenna).

*How do we measure VSWR of antenna?*

VSWR of antenna is measured by use of Network analyser or a site master or an antenna tester (You will learn the method in forthcoming section on Antenna adjustment issues of this Unit).

*What is the safe limit for VSWR?*

Every transmitter manufacturer specifies the safe limit for its transmitter. It may be of the order of 1.2:1.

*On what factors coverage area from a transmitter depends?*

Coverage area of the transmitter depends on:

- Power fed to antenna (Transmitter output power minus cable loss)
- Antenna gain
- Height of the antenna above the ground

*What do we mean by the term ERP?*

The term ERP means Effective Radiated Power by the antenna. This is equal to the product of antenna gain and the power fed to the antenna. Power fed to antenna means transmitter output power minus the cable loss.

*What is antenna gain?*

It is the ratio of field strength that is given by antenna system at a particular point which would have been given by an isotropic antenna at the same point with the same input power.

*What does an antenna gain of 3dBi means?*

It is a logarithmic unit of expressing power gain of an antenna with reference to an isotropic antenna. It means antenna will radiate 3dB higher (double) power than that of isotropic antenna.

*What action should we take if quality of reception is reported to be bad?*

We should check the quality of programme step-by-step at the following points:

- Input of the mixer
- Output of mixer
- Output of Studio Transmitter Link
- Demodulated output of transmitter.
- Identify the cause as learnt in diagnostic approach method in Unit 28.
- Take performance measurements of faulty equipment if required.

*Which measurements determine the quality of programmes?*

Following three measurements usually determine the quality of programmes:

- Frequency response
- Signal to noise Ratio
- Total Harmonic Distortion

(You have learnt details about performance measurements in Unit 28).

*What are the possible causes of interference from or to other channel?*

Possible causes are:

- Less channel spacing (separation)
- Antenna problem (tuning not ok)
- Fault in filtering circuit

- Over modulation in adjacent channel
- Spurious radiation
- Poor earthing
- Receiver tuning may not be ok

## Activity 29.2

To do this activity, you may need about 10 minutes to write down the answers in the apace provided. This activity will help you in understanding and solving the input and output issues involved in the transmitters.

Question 1: Why audio chain alignment is necessary?

Question 2: Why Repeat Coils are used in audio circuits?

Question 3: What equipment is used to control audio levels going to the input of transmitter?

Question 4: What does change in VSWR from 1.1 to 1.5 mean?

Question 5: What will happen to coverage if higher antenna gain is used?

## 29.5 Transmitter Operation and Upkeep Issues

So far in the previous sections of this Unit, you have learnt to solve the issues related to cable, connector, input and output. In this section, you will learn certain do's and don'ts which will help you in operation and upkeep of transmitter.

*What are the important points which we must take care before switching on the transmitter?*

You should ensure:

- Proper ventilation.
- Steady regulated power supply.
- RF output of transmitter is properly connected to antenna.
- Power raise control is in minimum position (if provided).
- Second transmitter (if available) is connected to dummy load and is switched 'OFF'.

*What points should we check while switching on the transmitter?*

You should check:

- Running of cooling/exhaust fan.
- Panel meter readings especially the forward and reflected powers.
- Alarm indications, if any.
- Abnormal symptoms for overheating, burning smell, sound etc.
- The deviation/levels once the steady output power is reached.

*What points should we check during transmissions?*

You should check the following points:

- Monitor ongoing programme for quality check.
- Note all panel meter readings including those of power supply and UPS just after start of transmission.
- Keep a watch on modulation level (deviations). Adjust if required.
- Keep a watch on alarms.
- Keep a watch on any symptoms of overheating and burning smell.

*What actions should we take after close down of transmitter?*

You should check the following points:

- Touch and feel the components for overheating.
- Check if there is any loose connection especially at the connector ends. Tighten or repair if required.
- Clean all the equipment with clean soft cloth.
- Clean all the tag blocks.
- Switch off the external fans/AC units at least 10-15 minutes after close-down.

*What precautions should we observe while touching the equipment?*

You must ensure that:

- All the power supply switches are ‘Off’.
- Battery supply to the UPS is also ‘Off’.
- No voltage is available at the point you are going to touch.
- ‘LIVE’ terminals are properly covered with acrylic boxes.
- RF output connectors are not opened when transmitter is ‘ON’.

*What is a periodical maintenance?*

Periodical maintenance means any preventive maintenance done at regular intervals to avert possible breakdowns. It includes a periodical maintenance schedule for doing the type of maintenance.

*What type of periodical maintenance schedule should be followed for up-keeping the Transmitter?*

Periodical maintenance schedule depends on the type of maintenance such as:

- General cleaning, noting panel meter readings, checking tightness of nuts and bolts and overheating symptoms should be done on daily basis.
- Oiling and servicing of moving machinery like fans and AC units etc. should be done on weekly basis.
- Repairing and servicing of mains and backup power supply units should be done on monthly basis.
- Checking of earth resistance, earth connectivity, RF connectors of antenna system, cable clamps, lightning arrestor and aviation lights should also be done on quarterly basis.
- Performance measurements of transmitter must be done at least once a year.

*What precautions should we take while measuring earth resistance?*

Precautions to be taken are:

- Never do earth resistance measurements during transmissions.
- Power supply to equipments must be off.
- Isolate the earth connectivity to equipment before checking earth resistance.

*What are the points to be checked while doing the antenna maintenance?*

Check the following points:

- Tightness of nuts and bolts.
- Change in direction of antenna elements due to wind.
- Change in gap (spacing) between dipole elements.
- Checking of symptoms of rusting if any.
- Loosening or breaking of cable clamps
- Symptoms of overheating.
- Grounding connections of antenna cable and lightning arrestor.

- Checking of aviation lights (if provided).
- Cracks in sealing compound at connector ends.
- Spark marks at connectors, junction points, baluns [a matching device/ circuit which is used to connect balanced input of a dipole to an unbalanced RF coaxial cable (Balance to Unbalance)] and small branch feeder cables.

## Activity 29.3

To do this activity, you may need about 10 minutes to write down the answers in the space provided. This activity will help you in understanding the operation and up-keep issues of transmitters.

Question 1: Why any RF output connector should not be opened when the transmitter is 'ON'?

Question 2: Why earth resistance measurements should not be done when the transmitter is 'ON'?

Question 3: Why should we especially watch reflected power reading while switching on the transmitter?

Question 4: What precaution should we take while touching any point or terminal of any equipment?

Question 5: What is the effect of over modulation in FM transmissions?

## 29.6 Antenna Measurement and Adjustment Issues

In Unit 25, you learnt about various types of antennae, radiation patterns and VSWR. Antenna is the most critical and important component in the transmission chain. Any fault in antenna affects the transmission and coverage. In this section, you will learn various issues affecting the performance of antenna and necessitating repair and adjustment at site.

*When antenna adjustment is necessary at site?*

Though the antennae used in CR station are pre-tuned at factory before supply and do not require any tuning at site, yet after installation or after developing any fault during operations, it becomes necessary to adjust the antenna at site.

*What are the causes of failure of antenna?*

Antenna can fail due to:

- Displacement, bending or falling of dipole elements due to heavy winds.
- Entry of rain water in connectors or junction boxes
- Sparking in connectors or baluns or branch cables
- Lightning

*How can we detect the antenna fault?*

Any fault in antenna can be detected by:

- Checking reflected power on the transmitter panel meter.
- VSWR indication/alarm

Cause of antenna failure can be detected by going up on the tower and inspecting the antenna components

*What is a balun?*

Balun is a matching device/circuit which is used to connect balanced input of a dipole to an unbalanced RF coaxial cable (Balance to Unbalance). It can be a transformer or LC network or a transmission line section.

*What will happen if we use an antenna having an input impedance of 75 ohms instead of 50 ohms?*

It will give high VSWR. VSWR = Impedance of Antenna/Characteristic impedance of cable = 75/50 = 1.5: 1.

*How to sort out antenna related faults?*

For sorting out all these antenna related faults at site, measurement of VSWR is necessary before and after adjustments.

In the subsection that follows you will learn method of VSWR measurement of antenna.

## 29.6.1 VSWR measurement of the antenna

*What instrument is used for VSWR measurement?*

VSWR measurement of antenna can be done by any of the following instruments.

Network Analyser or Antenna Tester or Site Master.

*What are the components needed for doing the measurement?*

Apart from any one of the instruments mentioned above, following components are also required.

- Precision short
- Precision open
- One standard 50 ohm termination

*How do we do actual measurement?*

Follow the step-by-step instructions given in the operating manual of the meter and message appearing on the display. Actual measurement is done as per the following steps generally in most of the Digital Instruments:

Setting frequency range

- Press Mode
- Select VSWR measurement
- Press Enter
- Select Frequency
- Press the starting frequency button F1
- Select the frequency e.g. 88.0 MHz with soft keys
- Press Enter. It will display the frequency
- Press stop frequency button F2
- Select the stop frequency e.g. 108 MHz
- Press Enter. It will display the stop or end frequency

1. Calibration

- Press start Cal button. Message to connect open appears on the display.
- Connect precision open connector at RF out and press Enter.
- Message to connect short will appear on display.
- Connect Precision Short at RF out and press enter.
- Message to connect Termination will appear.
- Connect 50 ohm termination at RF out.
- Message ‘Calibration” completed.

2. Make the test set up as shown in Figure 29.1

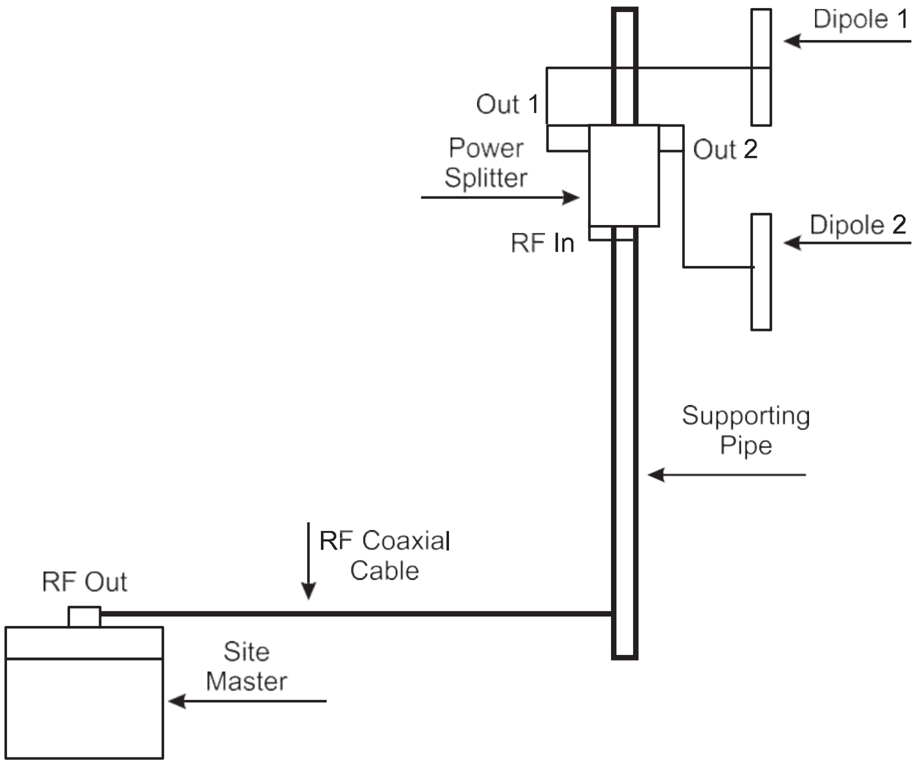



*Figure 29.1: Test set up for VSWR measurement*

Figure 29.1 shows the schematic of Test set up for VSWR measurement. As may be seen in the Figure 29.1, the 'RF OUT' of the Site-master is connected to the input of antenna system mounted on the top of the tower via main RF coaxial cable. (An antenna system consists of a power splitter and two dipoles. The two dipoles are connected to two outputs of power splitter via small RF coaxial cables called branch feeder cables).

3. Do VSWR measurement

- Connect the RF Cable (antenna connected on other side).
- Press Enter.
- Graph showing the VSWR in the entire selected band (88-108MHz) will appear on display.
- Move the marker to station frequency (say for example 90.4MHz).
- The meter will indicate the reading of VSWR at the station frequency.
- Note VSWR reading.

*What will be the range of reading?*

Under ideal matched condition it will be unity (1:1). The reading should not be more than the specified limit, usually 1.15:1.

*What should we do if the reading is more than the specified limit?*

If reading is more than the specified limit, antenna needs thorough check up for the following points:

- Loose connections at cable ends
- Break in continuity especially of inner conductor of connectors and cables
- Faulty balun or disconnection at dipole terminals
- Rusted connections at joints
- Sparking at connectors, balun or small branch feeder cables

*What should we do after repairing the fault?*

You should:

- Check VSWR again
- Normalize the cable connections to the transmitter
- Test transmitter on full power
- The reflected power reading should be either zero or less than 1 watt

### 29.6.2 Measurement of forward and reflected power of transmitter

In the previous section 29.4, you have learnt that one of the output issue was that transmitter may be giving low forward power (output power going to antenna). In this subsection, you will learn the method of measuring forward and reflected power at the transmitter output.

*What is the instrument used for measuring output Power?*

Output or reflected power of transmitter is measured by a power meter calibrated with a standard directional coupler or by using a 'Through-line RF Power meter'.

*What are additional components required for doing the measurements?*

Apart from power meter, following additional components are needed:

- A standard Directional coupler with known coupling ratio
- Forward and Reflected reading probes
- Power meter calibrated with the coupling ratio of standard directional coupler
- Two small lengths of low loss RF coaxial cables with end connectors
- Dummy load

*How do we do actual measurements?*

Follow the step- by-step procedure given below:

- Switch OFF the transmitter.
- Make connections as shown in Figure 29.2.
- Connect transmitter output to Dummy load through a standard Directional coupler.
- Connect power-meter probes at the directional coupler.
- Switch On the transmitter.
- Raise the power to the desired level.
- Read the power meter reading by selecting Forward power switch on meter panel.
- Note the forward power reading.
- Select Reflected power reading switch.
- Meter will now read the reflected power.
- Note the reflected power reading.

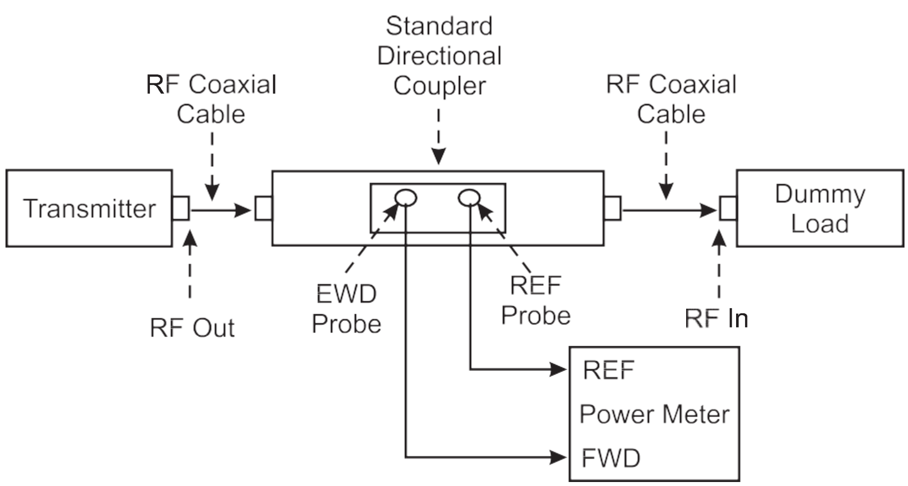



*Figure 29.2: Test set up for measurement of forward and reflected power*

Figure 29.2 shows the schematic of Test set up for measurement of forward and reflected power of a transmitter. As may be seen from the figure, the RF output of the transmitter is connected to the input of a dummy load via a standard directional coupler and small RF cables. Forward and reflected output ports of a standard coupler are connected to the forward and reflected Input ports of RF power meter through two probes.

*How do we measure forward and reflected powers by using Through-line meter?*

Forward and reflected powers can also be measured by use of a through-line meter connected at the output of transmitter or before dummy load. Basically this meter also contains an inbuilt directional coupler and probes for reading forward or reflected power.

*Are there any precautions to be followed while doing the power measurements?*

Yes, following precautions must be observed:

- The meter scale and the probes must match with the coupling ratio of the directional coupler.
- The measuring cables and dummy load must be rated for the power to be measured.
- Power should not be switched on till all the connections are made tight.
- No connector should be opened when transmitter is on.
- Some power meters are calibrated for a mid-band frequency, necessary correction must be used to get the correct reading in that case.

## Activity 29.4

To do this activity, you may need about 10 minutes to write down the answers in the space provided. This activity will help you in understanding the antenna related problems.

Question 1: How can you ensure that high reflected power is due to antenna only?

Question 2: Why Balun is used in antenna?

Question 3: How much VSWR reading would you expect if antenna having an input impedance of 60 ohms is directly connected to a coaxial cable having a characteristic impedance of 50 ohms?

Question 4: Why calibration of Network analyser/site master is necessary before taking VSWR measurement.

Question 5: Why standard coupler is required for doing the forward and reflected power measurements?

## 29.7 Let Us Sum Up

In this Unit on 'Good Engineering Practices', you have learnt that:

- For any project, good engineering practices are necessary for ensuring trouble-free transmission service from the Community Radio Station both from the point of view of installation and maintenance.
- The selection of an RF cable depends on its characteristic impedance, attenuation and power rating capacity. If properly rated low-loss cable of 50 ohm characteristic impedance is not used, a lot of transmitter output power is wasted as heat in the cable self and only balance part of power reaches antenna. This results in reduction of coverage area. Similarly if appropriate connectors are not used or the connectors are not fitted properly, the breakdowns due to failure of connectors increase.
- The input issues include, maintenance of studio to transmitter connectivity, alignment of audio signals suiting to the input specifications of the transmitter.
- The output issues include ensuring of full transmitter output power and zero reflected power. The performance measurements of the transmitter are done to ensure that the transmitter meets all the technical specifications.
- The issues related to operation and upkeep of transmitter include switching On/Off of transmitter, checking symptoms of overheating, regular maintenance of ventilation, power supply and backup supply equipment.
- If VSWR increases, most probable cause of fault is due to antenna system. You have also learnt to undertake the measurement of VSWR of antenna by use of site master/antenna tester or network analyser.
- Measurement of forward or reflected power of transmitter can be done by use of power meter calibrated with the standard directional coupler.

## 29.8 Model Answers to Activities

Model answers to questions given in activities 29.1 to 29.4.

### Activity 29.1

1. Because if cable with wrong characteristic impedance is used, reflection due to mismatch will result in high VSWR. We will not be able to switch on the transmitter.

2. Attenuation will be nearly double.
3. A loss of 3 dB means nearly half of the transmitter output power will reach the antenna.
4. Entry of rain water in antenna reduces impedance of antenna thereby increasing the VSWR. If VSWR is high the transmitter may even trip.
5. Keeping the safety margin, usually the rating of cable is twice the maximum power of the transmitter.

## Activity 29.2

1. Audio chain alignment is necessary to get the best performance from the equipments. If audio input levels to any equipment are low or high than its nominal rated input level, the noise level and distortion may increase.
2. Repeat coils are used in audio circuits to match balanced audio output of any equipment to the unbalanced audio input of other equipment or viceversa.
3. Audio processor is used to set the limit of audio levels going to the input of transmitter.
4. It indicates heavy mismatch fault in antenna system. The reflected power will increase and the transmitter will trip.
5. Coverage depends on the output power of the transmitter and the antenna gain. Increase in antenna gain increases the coverage.

## Activity 29.3

1. The transmitter may get damaged due to mismatch. Connector may spark over and we may even get RF burn.
2. Voltage generated by the earth tester may damage the transmitter. Secondly, the earth resistance measurements due RF pick up may not be accurate.
3. Reflected power meter reading of the transmitter is the most critical reading. It gives the status of the antenna system.
4. We must ensure that there is no dangerous voltage at the point or terminal. We may even get shock.
5. In FM, over modulation may not harm the transmitter but the higher deviation resulting from the over modulation may interfere in the adjacent channel. Quality in receiver may not be good.

## Activity 29.4

1. In order to ensure whether fault is in antenna side or in the transmitter output circuit itself, we can test the transmitter on dummy load.
2. Balun is used to connect balanced input of dipole to the unbalanced output of RF coaxial cable.
3. VSWR is equal to the ratio of antenna impedance to characteristic impedance of cable, i.e. (60/50 =1.2). Therefore, VSWR reading will be equal to 1: 1.2.
4. Calibration of network analyser or site master is necessary to set a reference reading with standard known impedance. For example, if a meter is calibrated to 50 ohms, then the impedance of antenna will be checked with reference to 50 ohms only.
5. A standard coupler gives the known standard coupling ratio matching to probes and the meter scale calibrated for forward and reflected powers of the transmitter

# Glossary

| | |
|---|---|
| Antenna Efficiency | is the ratio of radiated power to that of the input power supplied to the antenna. |
| Antenna tester | is an instrument used for checking VSWR faults of antenna. |
| Attenuation | is the loss offered by the cable to a signal when it travels along its length and is expressed in dB (decibels) per 100 metre length. |
| Audio generator | is an instrument used for generating any frequency in the audio range at the desired output level required during testing of transmitters. |
| Characteristic Impedance ($Z_0$) | is the ratio of the voltage to the current for a single propagating wave (frequency). Its unit of measurement is ohms. |
| Decibel (dB) | is a logarithmic unit that indicates the ratio of a physical quantity (usually power, voltage level of any signal) relative to a specified reference level. |
| Distortion | is the change in wave shape of a signal at the demodulated output of the transmitter with respect to its input wave shape. |
| dBi | indicates gain with reference to an isotropic antenna. |
| $dB_m$ | indicates a level with reference to one milli-watt of audio signal. |
| Forward power | means the final RF output power of transmitter going to the antenna via coaxial cable. |
| Frequency Response | of a transmitter is the plot of graph showing frequency versus amplitude for the range of frequencies. |
| Forward power | means the final RF output power of transmitter going to the antenna via coaxial cable. |
| Harmonic Distortion | is the distortion of wave shape of signal due to presence of harmonics of the signal frequency. |
| Isotropic antenna | is a radiator which radiates energy uniformly in all directions. |
| LCD | is a Liquid Crystal Display used for visual display of various parameters. |

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|---|---|
| LED | is a Light Emitting Diode, a semiconductor device used as indicating lamp. |
| Modulation Analyser | is an instrument used for checking frequency response, noise level, distortion and other modulation analysis. |
| MOSFET | is a Metal Oxide Semiconductor Field Effect Transistor used in power amplifiers. Its three terminals are known as Gate, Source and Drain. |
| Network Analyser | is an instrument used for checking performance of antenna and other networks. |
| Nominal level | is the operating level at which the electronic equipment is designed to operate. |
| Phase Locked Loop (PLL) | is the control system that generates an output signal whose phase is locked to the phase of a reference signal. It provides stability to carrier frequency. |
| Power rating | of the cable is the average power which it can transfer continuously to the antenna system without any heating and change in its designed parameters at its operating frequency. |
| Reflected power | means the RF power reflected back to the transmitter due to mismatch of antenna. |
| Signal-to-Noise Ratio | is the ratio of level of the signal to the level of noise when signal is removed. |
| Spectrum Analyser | is an instrument used for checking frequency modulated side bands and spurious and harmonics emitted by transmitters. |
| Reflected power | means the percentage of RF power reflected back due to mismatch of antenna. |
| Signal to noise ratio | is the ratio of nominal signal level to the noise level present in it. |
| Spurious and Harmonic | radiation is the level of emission of all frequencies other than the frequency of operation. |
| Total Harmonic Distortion (THD) | of a signal is a measurement of total level of harmonics present in the output signal of a transmitter. It is measured as percentage of sum of the powers of all harmonic components to the power of fundamental audio frequency. |
| VSWR (Voltage Standing Wave Ratio) | indicates the degree of mismatch due to antenna or cable. |

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