Certificate in Community Radio Technology

FM Transmitter Setup

8

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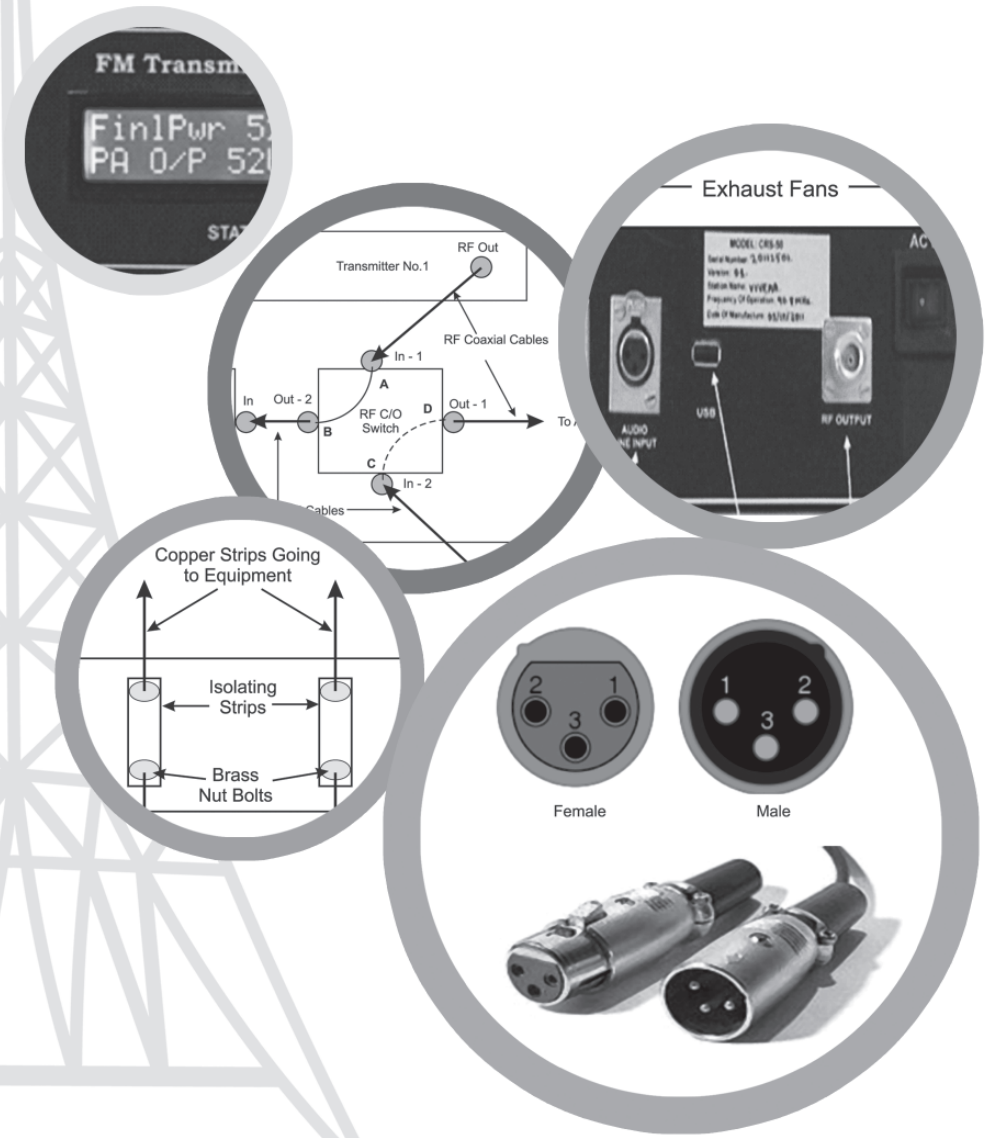
Module: 8
FM Transmitter Setup



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Module 8: FM Transmitter Setup

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Certificate in Community Radio Technology

Courses	Modules	Units
Course I: Understanding Community Radio (3 Credits, 90 Hours)	**Module 1** Community Radio: An Introduction	**Unit 1 :** Community Radio: Concept and Evolution **Unit 2:** Context, Access and Equity **Unit 3:** Community Radio: Policy Guidelines **Unit 4:** Technology for CR: Guiding Principles
	Module 2 Setting up of CRS	**Unit 5:** Components of CR Station **Unit 6:** Radio Waves and Spectrum **Unit 7:** Basics of Electricity **Unit 8:** Power Backup and Voltage Stabilization
Course II: Community Radio Production: System & Technology (5 Credits,150 Hours)	**Module 3** Studio Technology	**Unit 9:** Basics of Sound **Unit 10:** Analog and Digital Audio **Unit 11:** Components of the Audio Chain **Unit 12:** Studio Acoustics
	Module 4 Audio Production	**Unit 13:** Audio Hardware and Field Recording **Unit 14:** Free and Open Source Software **Unit 15:** Telephony for Radio
	Module 5 Audio Post Production	**Unit 16:** Sound Recording and Editing **Unit 17:** Mixing and Mastering **Unit 18:** File Formats and Compression **Unit 19:** Storing and Retrieval
	Module 6 Studio Operations	**Unit 20:** Good Engineering Practices for Studio Setup **Unit 21:** Studio Equipment: Preventive & Corrective Maintenance **Unit 22:** Content Distribution: Alternative Mechanisms
Course III: Community Radio Transmission: System & Technology (2 Credits, 60 Hrs)	**Module 7** Radio Transmission Technology	**Unit 23:** Components of Transmission Chain **Unit 24:** Components of FM Transmitter **Unit 25:** Antenna and Coaxial Cable **Unit 26:** Propagation and Coverage
	Module 8 FM Transmitter Setup	**Unit 27:** Transmitter Setup: Step-by-step **Unit 28:** Transmission System-Preventive and Corrective Maintenance **Unit 29:** Transmission Setup–Good Engineering Practices
Course IV: Technical Internship (2 Credits, 60 Hrs)	**Module 9** Practical Internship Handbook	**Section A:** Introduction **Section B:** Activities to be Conducted During the Practical Internship **Section C:** The Internship Journal and Self-Assessment Paper **Section D:** Assessment of Internship **Section E:** Appendices

Video in the Module:

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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.

Units in the Module

- Unit 27 : Transmitter Setup: Step-by-step
- Unit 28 : Transmitter System: Preventive & Corrective Maintenance.
- Unit 29 : Transmitter Setup: Good Engineering Practices

UNIT 27

Transmitter Setup: Step-by-step

Structure

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).

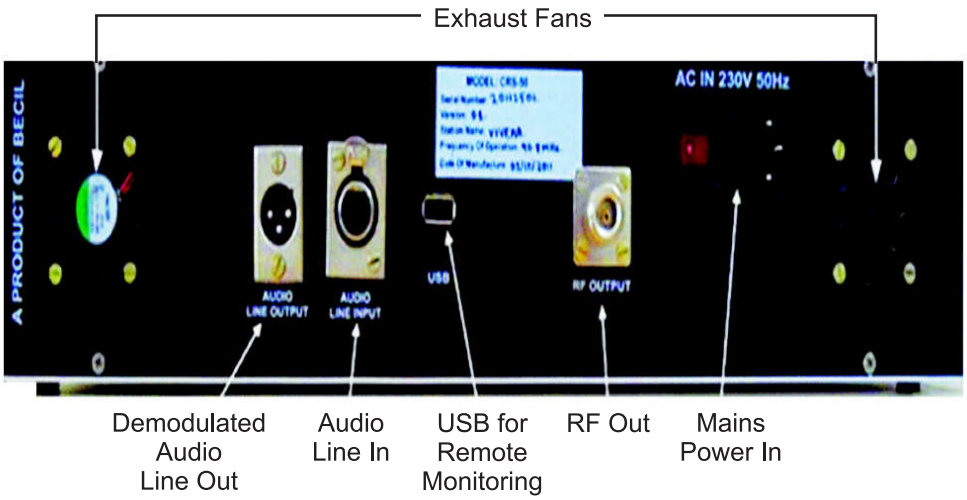


***Figure 27.2**: Back panel view of 50 Watt FM transmitter (BECIL CRS -50)*

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.

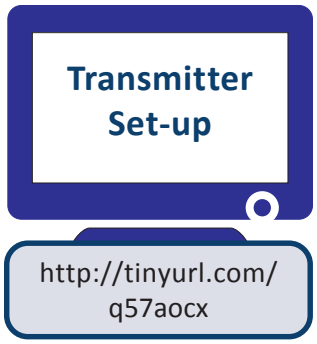
Activity 27.1

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.

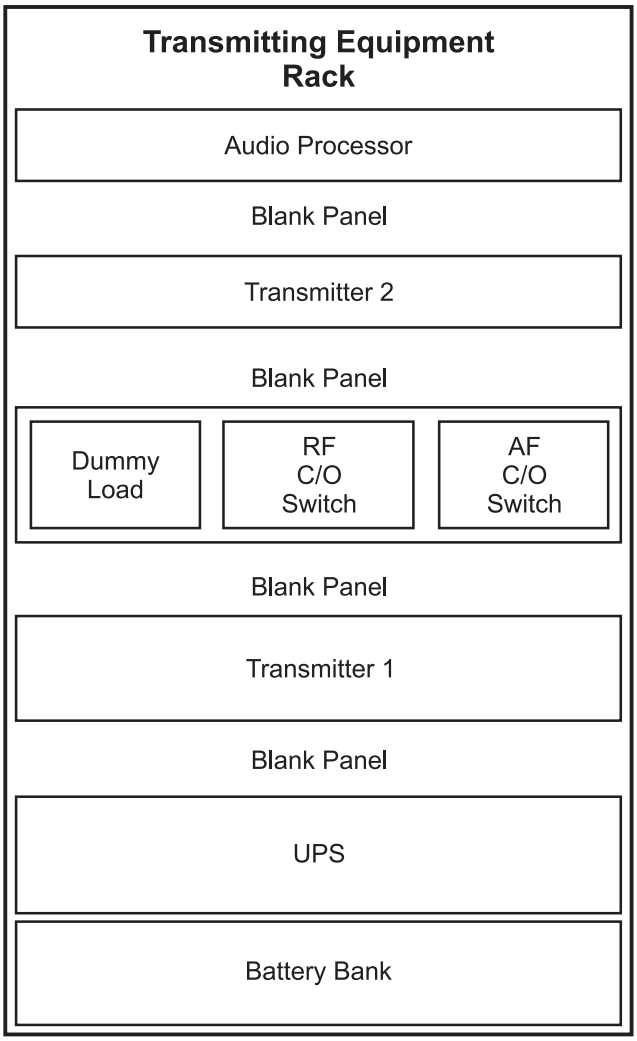


***Figure 27.3**: Suggestive layout plan of transmitters and associated equipment.*

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

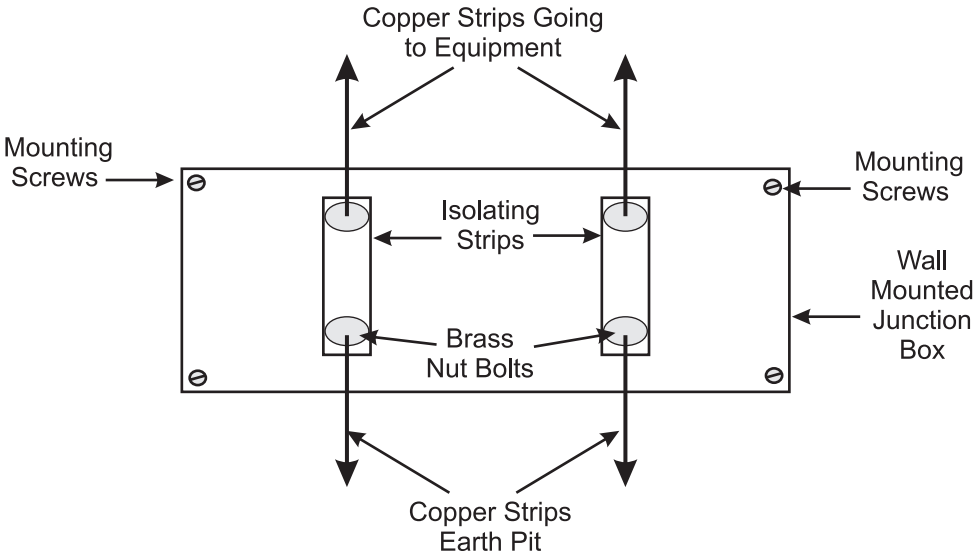


Figure 27.4: *Schematic arrangement of junction box showing distribution of copper strips for earthing.*

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.

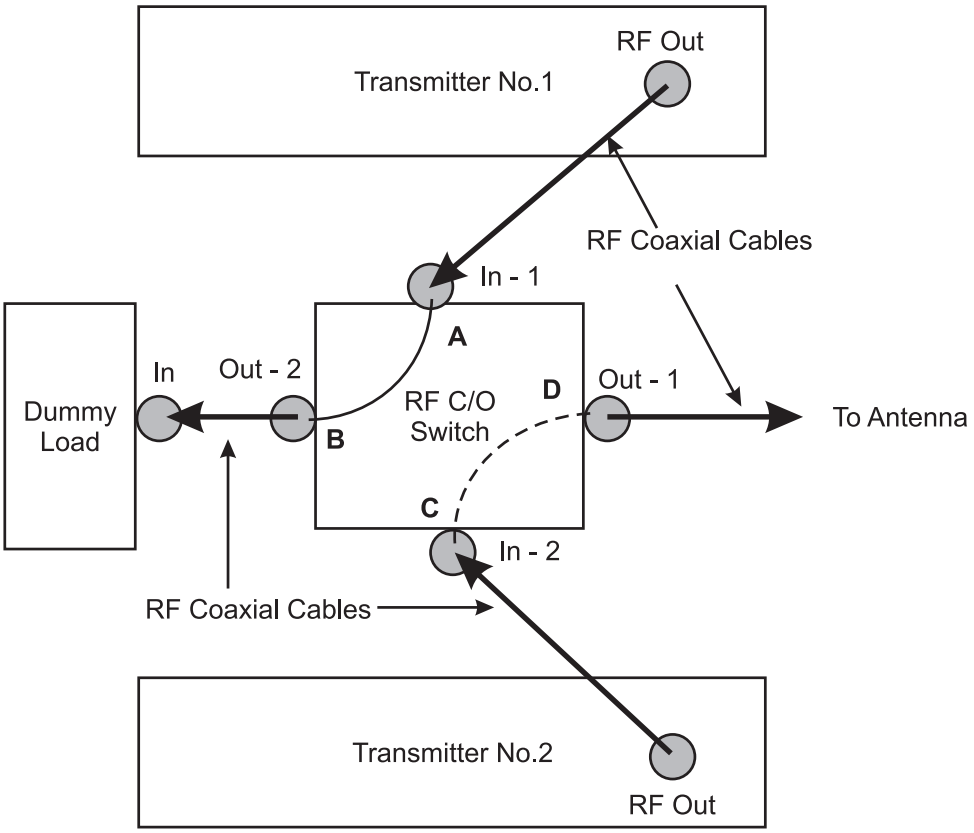


Figure 27.5: *Schematic arrangement indicating the RF interconnection of two transmitters using change-over switch.*

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 28

Transmission System: Preventive and Corrective Maintenance

Structure

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.

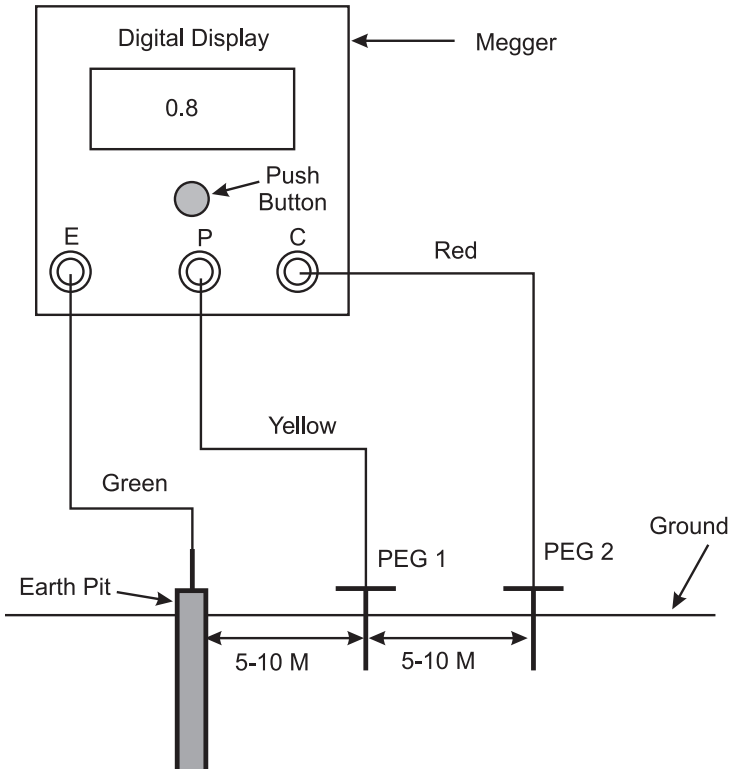


***Figure 28.1**: Checking of Earth conductivity*

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, over charging 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 29

Transmitter Setup: Good Engineering Practices

Structure

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 (Zoc)
- Measure short circuit impedance by shorting other end (Zsc)
- Calculate characteristic impedance (Zo) =$\sqrt{}$(Zoc x Zsc)].

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 (**Bal**ance to **Un**balance)] 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 (**Bal**ance to **Un**balance). 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

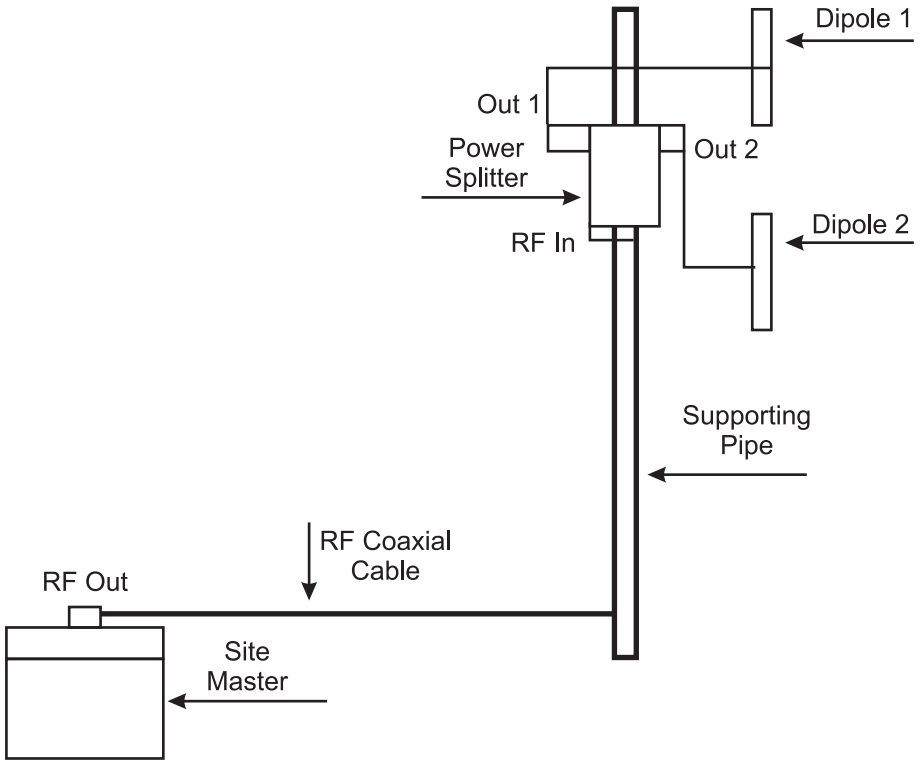


***Figure 29.1**: Test set up for VSWR measurement*

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.

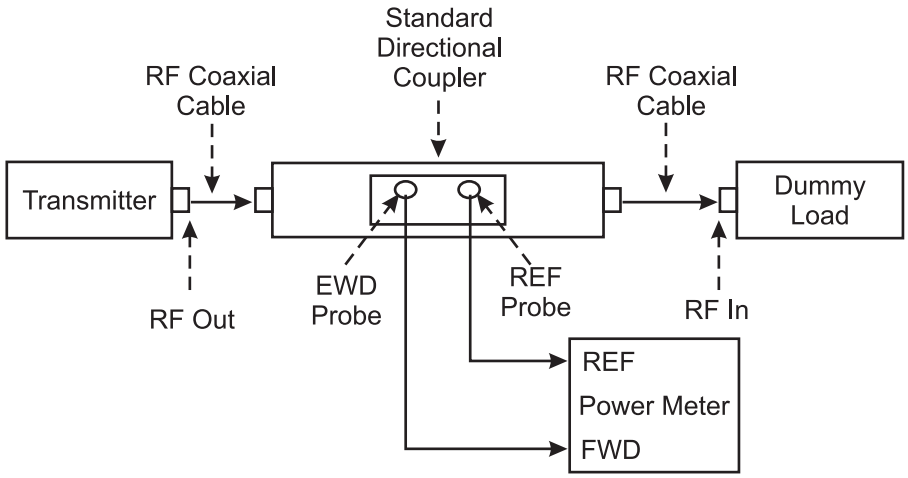


Figure 29.2: *Test set up for measurement of forward and reflected power*

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.

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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