CHAPTER XII

MULTICHANNEL RADIO SYSTEM

12.1 MULTICHANNEL RADIO SYSTEM

12.1.1 TYPES OF SYSTEM

Following multichannel radio system are working on Indian Railways:

(a) UHF : 12,24,60,120 channel analog
10,30, 120 channel digital

(b) Microwave: 60,120,300, 960 channel analog
and 2 Mbit, 8 Mbit, (34+2) Mbit digital

12.1.2 APPLICATIONS

(a) UHF multichannel equipments are mainly used for smaller links of 5 to 6 hops.

(b) Analog microwave links from 50 to 60 channel capacities and digital radio of (34+2) Mbits/sec are used for long distance communication for speech and data transmission etc.

(c) 2Mbit/8Mbit digital radio equipments working on 18GHz bands are generally used for station to station communication control working and for local area networks connecting various exchanges in the same locality.

(d) Time Division Multi Access (TDMA) system shall generally be used point to multipoint communications such as computer reservation system, major yards with multiple points etc.

12.1.3 SYSTEM OF WORKING OF MULTICHANNEL ANALOG RADIO EQUIPMENT

a) The multiplex signal is fed to modulate a carrier signal of appropriate frequency and the frequency modulated signal is amplified and fed to the antenna wave guide system through isolators to give the required output power and frequency as per the type of radio equipment.

b) The input signal received from the antenna waveguide system passes through a band pass filter and fed to the demodulator. The output of the demodulator is the base band signal which is amplified by a base band amplifier to bring the amplitude of the base band to appropriate level.

12.1.4 MULTICHANNEL DIGITAL RADIO EQUIPMENTS:

In digital radio system the carrier frequency is modulated by digital multiplex signal. The digital multiplex signals may be 2/8/34/140 Mbits/sec.

In addition to the digital base band signal following additional channels are also inserted in the system.

a) Analog/Digital Orderwire
b) Analog/Digital Express Orderwire
c) Analog/Digital Monitoring and Supervisory channels.
d) Way side Digital Drop Insert Channels.

i) EXPRESS ORDERWIRE;

These are omnibus order wire channels which are dropped at only few important stations for maintenance.

ii) MONITORING & SUPERVISORY CHANNELS:

These channels are utilised for remote monitoring, Supervision and control of all the stations connected in the line. Generally analog channels are used for this purpose. Monitoring, supervision and control are done through appropriate modems.

iii) WAYSIDE DROP INSERT CHANNELS:

For higher capacity equipment like 34 Mbit or 140 Mbit, a low capacity stream (as 2 Mbit in case of 34 Mbit) may be used for drop insert at non important wayside stations requiring only few channels.

12.1.5 BASE BAND SWITCHING

Receivers are generally configured as

(a) Monitored Hot Standby (MHSB)

In this configuration the RF signal is received simultaneously by both the receivers. In manual mode, any one of the receivers can be selected. In automatic mode, the baseband signal having better BER is selected automatically.

(b) SPACE DIVERSITY (SD)

In this configuration, RF signal from main and space diversity antenna are processed separately by the two receivers and the base band signal having better BER is selected automatically.

(c) HITLESS SWITCHING

During automatic changing over from one receiver to another significant data may be lost from the incoming signal. Hitless switching is a system in which suitable buffer memory and phasing arrangements are provided such that no data is lost during changeover.

12.2 SPECIFICATION & PERFORMANCE PARAMETERS

12.2.1 CHANNEL CAPACITY:

The channel capacity and associated modulation types for various systems are given in following table.

TYPE	CHANNEL CAPACITY	MODULATION
ANALOG	12/24/60/120/ 300/960	FM
DIGITAL	(i)10/30/120/480	QPSK
	(ii) 10/30	TDMA

12.2.2 FREQUENCY PLAN

The Frequency plans for multi channel radio system shall be as per the following :

SYSTEM	CHANNEL ARRANGEMENTS TO CCIR-REC.
UHF 24 ANALOG	NFAP PLAN
UHF 60 ANALOG	NFAP PLAN
Microwave 60	CCIR - 385 - 2
Microwave 120	CCIR - 385 - 2
Microwave 300	CCIR - 385 - 2
Microwave 960	CCIR - 386 - 2
2 Mbit digital	CCIR - 385 - 2
8 Mbit Digital	CCIR - 386 - 2

12.2.3 UHF ANTENNA:

The UHF antenna shall be of following types:

(a) YAGI ANTENNA : These are directly fed antennas providing a gain of 8-12 dB depending on the no of elements and frequency.

(b) CORNER REFLECTOR ANTENNA: These are used with dipole feeder, providing a gain of 10-15 dB, depending upon the size and frequency.

(c) GRIDPARABOLIC ANTENNA: These antennae are used with dipole feeder and grid parabolic reflector. The gain provided by these antennae are in the range of 12-25 dB depending upon the size and frequency.

12.2.4 MICROWAVE ANTENNA

The microwave antenna may be of following types :

(a) STANDARD PERFORMANCE ANTENNA:(SP)

These are economical type of antenna suitable for low density routes.

(b) LOW VSWR ANTENNA:

These antenna are the same type of parabolic reflectors as a standard performance antenna, but includes especially tuned low VSWR feeds to minimize echo distortion.

(c) HIGH PERFORMANCE ANTENNA (HP)

These antennae use tuned low VSWR feed and high directivity shields called shroud. These are useful in congested areas for proper interference coordination.

(d)RADOMES

Radomes may be used to cover the antenna from dust, fog, rain or any other external objects. The radomes may be flexible or rigid type. All high performance antenna shall be provided with radomes.

12.2.5 SELECTION OF THE ANTENNA

The selection of the antenna shall be based on following factors:

a) Frequency Band
b) Gain
c) Half Power Bandwidth
d) Front to Back Ratio
e) VSWR
f) Cross Polarisation Discrimination
g) Size and Weight
h) Wind load
i) Maximum sustainable wind speed and the beam deflection thereof
j) Economy

12.2.6 UHF FEEDER CABLE:

(a) Flexible coaxial copper cable, air or dielectric types of approved specification shall be used as the feeder cable for UHF specifications. Either 7/8" or 11/8" dia cables are generally recommended for UHF frequencies.

(b) Flexible coaxial jumper cable of about 1M length shall be used at either end of the main feeder cable to connect the antenna and the radio equipment.

(c) The characteristics impedance of the feeder cable shall be same as that of the radio and antenna.

12.2.7 CHARACTERISTICS OF THE FEEDER CABLE:

The selection of the feeder cable shall be passed on the following characteristics:

i) Impedance
ii) Frequency Band
iii) Attenuation
iv) Power rating
v) Size & Weight
vi) Flexibility
vii) Cost

12.2.8 WAVEGUIDE TYPES:

Following types shall be used:
(a) Rectangular
(b) Elliptical
(c) Circular

i) RECTANGULAR WAVEGUIDE

For relatively short runs, where the loss of the waveguide is not critical, rigid rectangular waveguide may be used.

ii) ELLIPTICAL WAVEGUIDE

Flexible elliptical waveguide shall be of cost economically used as the microwave feeder.

iii) CIRCULAR WAVEGUIDE

Circular waveguide shall be used where very low attenuation of feeder or simultaneous transmission of two carrier at different polarisation are envisaged.

iv) FLEXIBLE TWISTABLE WAVEGUIDE

For special angles and twists in the waveguide run and also for connection to the antenna and radio equipment, flexible twistable rectangular waveguide shall be used.

12.2.9 TOWER

i) TYPES

Only self supporting towers shall be used. Other types already in service shall continue till replacement.

ii) SELECTION OF TOWER

The tower, for a given location, shall be selected on following consideration:

a) Antenna type
b) Antenna mounting capacity of the tower
c) Wind pressure zone
d) Antenna mounting restrictions if any
e) Likelihood of future expansion

iii) APPROVAL OF COMPETENT AUTHORITY

Tower designs approved by competent authority shall only be used. Related instructions issued by Railway Board from time to time, shall be followed.

iv) USE OF FLOODLIGHT TOWER

For short haul UHF system, if the antenna height is within 20 M, floodlight tower of approved design may be used. In each such case, approval of competent authority shall be taken.

v) FOUNDATION OF THE TOWER

The foundation shall be designed for the forces and moments given in the tower drawings to suit the bearing capacity of the soil at site

12.2.10 PRESSURIZATION EQUIPMENT

(a) Suitable pressurisation equipment shall be provided for all long haul microwave stations.

(b)Dry air hand pump may be used for pressurisation if the feeder length is 10-15 M or less.

(c) For larger feeder lengths and also for unmanned stations automatic dehydrators shall be used.

(d) Maximum internal pressure of 0.4 KG/CM^2 shall be maintained in the feeder. The pressure shall not be allowed to fall below 0.1 KG/CM^2.

(e) The automatic dehydrators shall have adequate safety features to prevent over pressurisation and suitable warning for low pressure indication.

12.2.11 PROTECTION OF MICROWAVE/UHF SYSTEM AGAINST DAMAGES DUE TO LIGHTNING

(a) Suitable protective arrangement shall be provided to prevent the damage of the equipments due to lightning and surges.

(b) The lightning risk index of each station shall be calculated and appropriate earthing arrangement shall be provided as per chapter on "Protection of telecom equipments against lightning.

(c) The armour and screen of all the underground cable shall be earthed.

12.3 SYSTEM REQUIREMENTS

12.3.1 Multichannel radio relay system consists of the following sub-assemblies:

(a) Radio Equipment
(b) Antenna
(c) Feeder cable for VHF and waveguides for microwave system
(d) Multiplexing Equipment
(e) Power Plant
(f) Tower
(g) Pressurisation Equipment

12.3.2 REQUIREMENTS OF THE EQUIPMENT ROOMS

(i) The microwave/UHF equipment rooms shall be kept neat clean and free of dust.

(ii) Equipment rooms shall be provided with double panel doors and windows and shall be air conditioned.

(iii) The doors shall be self closing type.

(iv) Windows shall be provided with wire mesh to prevent entry of snakes, lizards, leeches etc.

(v) The ventilation and lighting shall be adequate.

(vi) The floor of the equipment room shall be strictly levelled and the floor level shall be above the highest flood level of the location.

(vii) All inflammable items shall be kept away from the equipment rooms.

(viii) As a precautionary measure against fire, wooden furnitures, tables, racks, shall not be used in the microwave/UHF equipment rooms.

(ix) Each microwave/UHF station shall have a display panel showing the microwave/UHF network with details of the type of equipment, tower heights, type of antenna, hop length, polarisation, frequency etc.

(x) All channel dropping repeater stations shall keep one set of patching cords with suitable attenuator such that in case of extreme urgency it shall be possible to connect the radio equipments in a repeater mode disconnecting the MUX equipment.

(xi) A PSTN telephone shall preferably be provided in the microwave/UHF equipment room, to cater for urgent exchange of information in case of major breakdown of Rly. communication link.

(xii) Each microwave/UHF repeater station shall keep following essential items:

a) First aid box
b) Fire extinguisher
c) Telephone Directory (Rly)
d) Telephone No. of nearest hospitals/Health centre or Doctors.
e) Torch with cells.
f) Tool Box.

(xiii) Adequate measuring equipments shall be available in the equipment room. Following equipments shall positively be available in working condition at all stations.

1. Digital multimeter
2. Selective Level Meter
3. Audio Frequency Oscillator
4. Soldering Kits
5. One set of portable emergency light.
6. One set of patching cords (as mentioned in para (x) above).

12.3.3 LAYOUT

(a) The equipment layout shall be such that adequate space is available for future expansion.

(b) The equipment racks shall be erected 1 M away from the wall to provide easy access from the rear side of the equipment.

(c) The indoor cable shall be drawn through wall mounted ladders or concealed cable ducts. In case of ducts, provisions shall be available for easy access to the cable for repair, maintenance or troubleshooting.

(d) The location of the tower shall be such that the feeder run is minimum.

(e) The battery room shall be adjacent to the equipment room to minimise voltage drop in the cable. The cable shall be so chosen that voltage drop does not exceed 0.5 Volt with full loading.

12.3.4 DIRECTION OF ANTENNA, FEEDER CABLE & WAVEGUIDE

(a) The antenna, feeder cable, waveguide shall be drawn to the top of the tower with the help of hoisting line, pulley and winch system.

(b) The antenna alignment shall be done by adjusting both elevation and by means of adjustment of hardware provided in the antenna mount.

(c) The antenna alignment is to be checked carefully to avoid alignment at side lobes. The achieved signal strength shall be matched with the calculated figure.

(d) The antenna and radio equipment shall be erected prior to the erection of feeder line.

(e) The connector shall be fitted to the antenna end of the waveguide/coaxial cable protective cover shall be placed over the connector to prevent damage during hoisting.

(g) The waveguide/coaxial cable shall be unreeled from the line, using pulley and winch system.

(h) The waveguide/coaxial cable shall be clamped with the vertical members of the tower by waveguide hangers/cable clamps at intervals not exceeding 1 meter.

(i) The feeder run from tower base to the equipment room shall be supported by horizontal ladder and shall be fastened to the horizontal member at intervals not exceeding 1 meter.

(j) The waveguide/coaxial cable feeder shall be earthed by providing good electrical connection between the outer metallic surface of the feeder and the tower or support structure by means of grounding/earthing strap.

(k) The feeder line through the wall/roof of the equipment room shall be drawn with standard feed through bits.

12.4 MAINTENANCE

12.4.1 GENERAL MAINTENANCE PRECAUTIONS.

(a) The power supply switch of the equipment shall be turned OFF before replacement of any module, subassembly or coaxial cable.

(b) The equipment shall not be switched ON with antenna port short circuited or open circuited.

(c) Module extractor shall always be used for pulling out any module from the equipment rack.

(d) All electrostatically sensitive devices (ESD) shall be handled with protective gloves.

(e) During measurement and testing, proper connectors , coaxial cable, sensors, adapter etc shall be used.

(f) Adjustment of vital parameter such as power, frequency, modulation shall be done by SE in charge or higher officials.

(g) To clean the face of the modules, dry clothes shall be used. Liquids like benzene or toluene should never be used, because the coating and print of the module may be damaged.

(h) Bay shell covers of the equipment shall always be kept closed to protect it from dust and other foreign particles.

(i) Any defective fuse shall be replaced only with fuse of exactly same capacity and rating.

(j) Measuring instruments shall be warmed up for at least 30 minutes and calibration checked before actual use.

(k) The equipments shall be kept in AUTO mode of operation, unless otherwise instructed.

12.4.2 MAINTENANCE OF ANALOG RADIO EQUIPMENTS

The preventive maintenance schedule of the multichannel analog radio equipments may be different for different types of equipments. However, as a general guideline following schedule is recommended:

(i) MEASUREMENT OF SUPPLY VOLTAGE OF THE EQUIPMENT AND SUB UNITS	WEEKLY
(ii) MONITORING OF THE EQUIPMENT PARAMETERS WITH INBUILT METERS	WEEKLY
(iii) TESTING THE PERFORMANCE OF VARIOUS ALARMS AND INDICATIONS	WEEKLY
(iv) MEASUREMENT OF TRANSMITTER POWER OUTPUT	MONTHLY
(v) MEASUREMENT OF TRANSMITTER FREQUENCY	MONTHLY
(vi) MEASUREMENT OF THE BASEBAND LEVEL	QUARTERLY
(vii) MEASUREMENT OF FREQUENCY DEVIATION	HALF YEARLY
(viii) MEASUREMENT OF IF AND CALIBRATION OF AGC CHARACTERISTICS	HALFYEARLY
(ix) MEASUREMENT OF BASEBAND FREQUENCY RESPONSE	YEARLY
(x) MEASUREMENT OF NOISE POWER RATIO	YEARLY

(NPR) AND CHANNEL SIGNAL TO NOISE
RATIO (S/N)

12.4.3 MEASUREMENT OF FREQUENCY DEVIATION:

(a) In the test of checking frequency deviation , a tone of appropriate level and frequency is injected in the base band input point of the modulator and output spectrum is checked for carrier null with the help of spectrum analyser. Sample calculations for the determining appropriate level and frequency of the test tone is given in the Annexure -A.

b) If carrier is not completely suppressed with above tone, the deviation is not as per specification and adjustments of modulator to be done as per manufacturers instruction.

12.4.4 MEASUREMENT OF IF AND CALIBRATION OF AGC CHARACTERISTICS

(i) Disconnect the coaxial cable from the branching equipment to the RF input (RF-IN) of the receiver .

(ii) Connect RF signal generator and adjust the frequency to the receiver frequency.

(iii) Adjust the level of the signal generator to -40 dB.

(iv) Check the IF output level (IF OUT) by inbuilt meter or external level meter.

(v) Check the AGC bias voltage/current by in-built meter or external meter.

(vi) Reduce the RF signal generator output from -40 dBm to -80dBm in steps of 5 dB and from -80dBm to the threshold level in steps of 2 dB.

(vii) For each setting of the RF signal generator measure and record the IF level and AGC bias voltage/current.

(viii) Plot IF level and AGC voltage/current against input RF level to get the AGC characteristics of the equipment.

(ix) For any deviation from the specified characteristics, adjustments shall be done as per manufacturer's instructions.

12.4.5 MEASUREMENT OF NOISE POWER RATIO (NPR) AND CHANNEL SIGNAL TO NOISE RATIO (S/N)

i) The noise generator is calibrated before commencement of the tests.

ii) One high pass and one low pass filter of the noise generator is switched in to give the noise bandwidth equal to base band width of the equipment under test.

iii) After switching off all band stop filters of the noise generator, the noise output is adjusted to correct level. for example if base band input level of the equipment = - 25dbr and channel capacity 120 then the noise generator level shall be adjusted to -25+7.3 = 17.7 dbm)(Details in Annexure B)

iv) The output of the noise generator is then connected to the input of the noise receiver and the proper band (say 60 KHz- 552KHz for 120 ch equipment) is selected in the receiver. The needle of the noise receiver is brought to the reference mark indication by means of attenuator provided inside the noise receiver and calibration is completed.

v) For measurement of the noise power ratio (NPR) of the link, all multiplexing equipments are disconnected from the link and the equipments arranged in purely repeater mode.

vi) The output of the noise transmitter is connected to the base band input of the radio equipment of the near end.

vii) The base band output of the near end radio equipment is connected to the input of the noise receiver.

viii) A quite channel is simulated by switching on a band pass filter in the noise generator.

ix) The attenuator in the noise receiver is reduced to bring the needle of the noise receiving to the same reference mark.

x) The difference in the attenuator position is equal to the NPR.

12.4.6 MAINTENANCE OF DIGITAL RADIO SYSTEMS

For efficient and trouble free operation of the digital radio relay systems, the technical state of the equipment as well as the equipment characteristics shall be tested periodically. Following schedule may be adopted as a general guideline.

i) MONITORING EQUIPMENT STATUS FROM MONITORING POINTS WITH INBUILT OR EXTERNAL METERS	MONTHLY
ii) MEASUREMENT OF THE SUPPLY VOLTAGES OF THE EQUIPMENT	MONTHLY
iii) TESTING OF ALARMS AND INDICATIONS	MONTHLY
iv) MEASUREMENT OF THE TRANSMITTER OUTPUT POWER	QUARTERLY
v) MEASUREMENT OF THE TRANSMITTER LOCAL OSCILLATOR FREQUENCY	QUARTERLY
vi) MEASUREMENT OF THE RECEIVER LOCAL OSCILLATOR FREQUENCY	QUARTERLY
vii) MEASUREMENT OF IF LEVEL AND FREQUENCY	QUARTERLY
viii) MEASUREMENT AND CALIBRATION OF AGC CHARACTERISTICS	YEARLY
ix) MEASUREMENT OF THRESHOLD FOR BER 10 E-3	YEARLY
x) MEASUREMENT OF THERESIDUAL JITTER OF A HOP	YEARLY

xi) MEASUREMENT OF THE RESIDUAL JITTER END TO END OF A LINK	YEARLY
xii) MEASUREMENT OF CHARACTERISTICS OF ANALOG AND DIGITAL SERVICE CHANNELS	YEARLY

12.4.7 MEASUREMENT OF THRESHOLD FOR BER 10 E-3

(a) The received signal level at the RF input point of the receiver is measured by spectrum analyser.

(b) A 60 dB variable attenuator is inserted in the receive path between the branching network output and the RF input point of the receiver.

(c) The attenuator is initially set at 0 dB.

(d) Pseudo random signal of appropriate bit rate is fed in to the distant end of the hop. A BER meter is connected at the Multiplexing output point of the receiver.

(e) The attenuator is gradually increased till the BER of 10 E-3 is reached. At his position the attenuator value is noted.

(f) The threshold level is calculated by subtracting the attenuator value from the received level measured under step (b) above.

12.4.8 MEASUREMENT OF THE RESIDUAL JITTER OF A HOP

(a) Pseudo random signal of appropriate bit rate is fed in the radio equipment at one end of the hop.

(b) A BER meter is connected to the mux output point of the radio equipment at the other end of the hop.

(c) Recommended low pass and high pass filters are selected in the BER meter and the corresponding jitter levels are measured.

(d) The frequency band and the corresponding maximum limits of the residual jitter are given in CCITT Rec.921.

12.4.9 MEASUREMENT OF THE RESIDUAL JITTER END TO END OF A LINK.

(a) All multiplexing equipment of the intermediate stations shall be disconnected and the equipment shall be configured in the repeater mode.

(b) The residual jitter from end to end of the link shall be measured in the same manner as described under para 12.4.8 above.

(c) The maximum limits of the residual jitter in a link is given in CCITT Rec.823.

12.4.10 MEASUREMENT OF CHARACTERISTICS OF ANALOG AND DIGITAL SERVICE CHANNELS.

Following parameters of analog and digital service channels shall be measured with suitable channel analyser.

(a) Channel output level
(b) Channel frequency response
(c) Channel distortion
(d) Idle channel noise
(e) Gain vs. frequency

The measured values shall be checked with respect to the specified limits of the equipment parameters.

12.4.11 MEASURING INSTRUMENTS

Following meters are recommended for maintenance of multichannel radio systems.

1. POWER METER (100 KHZ-22 GHZ) WITH SENSORS, HP 4378 OR SIMILAR	1 FOR 10 STATIONS
2. FREQUENCY COUNTER HP 5350B OR SIMILAR	DO
3. SPECTRUM ANALYSER HP 8592 A OR SIMILAR	1 FOR EACH RAILWAY
4. FIXED ATTENUATOR 20 dB NARDA OR SIMILAR	2 FOR EACH RAILWAY
5. VARIABLE ATTENUATOR 0-60dB NARDA, PRD OR SIMILAR	1 FOR EACH RAILWAY
6. MW SIGNAL GENERATOR, ANRITSU ME724 OR SIMILAR	DO
7. UHF SIGNAL GENERATOR	2 FOR EACH RAILWAY
8. SELECTIVE LEVEL METER APLAB 2037A OR SIMILAR	1 FOR EACH CHANNEL DROPPING STATION
9. AUDIO OSCILLATOR APLAB 2002 OR SIMILAR	DO
10.WHITE NOISE TEST SET MARCONI OA 2090 OR SIMILAR (FOR ANALOG LINKS ONLY)	1 FOR EACH RAILWAY
11. DIGITAL TRANSMISSION ANALYSER WITH JITTER GENERATOR, ANRITSU ME 5208 & MH 370A OR SIMILAR (FOR DIGITAL LINKS ONLY)	ONE FOR EACH DIV.
12. PCM CHANNEL ANALYZER/ PCM TEST SET	AT EACH CHANNEL DROPPING STATION
13. DIGITAL MULTIMETER	1 FOR EACH STATION

12.4.12 INSPECTION & REPORT

1. The SE in-charge shall visit the MW/UHF station periodically and shall ensure that the measurements are taken periodically and proper records are maintained.

2(a) Weekly schedules shall be carried out by the Telecom Supervisor.

(b) Quarterly and yearly scheduled shall be carried out under the supervision of the Telecom Supervisor in-charge.

(c) Critical tests such as (1) Frequency deviation (2) NPR measurement (3) Receive calibration (4) Threshold measurement (5) Jitter measurement shall be done in presence of ASTE/DSTE/Dy.CSTE.

(3) RECORDS

Each MW/UHF station shall keep following registers:

(a) Log book for on duty TCM/WTM
(b) Failure Register
(c) Fading Register
(d) Diesel Generator Register & fuel register
(e) Power Supply failure register & AC register
(f) Cable Register
(g) Maintenance and line up report of equipment and Earth.
(h) Technical Literature of all communication equipments such as Radio, multiplexing, charger, stabiliser along with circuit diagram.
(i) Tower Register.
(j) Battery Register

ANNEXURE-A

MEASUREMENT OF FREQUENCY DEVIATION

A. PRINCIPLE OF MEASUREMENT:

The frequency deviation can be measured accurately by carrier null method. The principle of the measurement is described below:

In frequency modulation system the term MODULATION INDEX is defined by the ratio of the frequency deviation of the modulated signal to the frequency of the modulating signal and designated as m(f). Thus, if the deviation of the modulated signal is F(d) for a modulating signal of frequency f(m)m then

$$M(f) = F(d) / f(m).$$

If M(f) = 2.404, the carrier frequency will be totally suppressed and there will be no carrier frequency component in the modulated spectrum.

EXAMPLE

BASEBAND INPUT LEVEL =25dBm/CHANNEL

FREQ. DEVIATION =100 KHZ RMS

Therefore peak deviation/channel
= 100 x 1.414 = 141.4;KHz

Let the freq. of test tone be 100 KHz.
Required mod. index for carrier null =2.404

Therefore deviation of the modulated signal

F(d)=2.404x 100= 240.4RMS

Since 141.4 KHz deviation is produced by test tone of -25 dBm, for deviation of 240.4 KHz the level required is:

- 25 + 20 log 240.4/141.4 = -25 + 4.5 = -20.5 dBm.

Therefore at the BB-IN of the modulator a tests tone of 100 KHz - 20.5 dBm is to be inspected for complete carrier null.

ANNEXURE -B

PRINCIPLE OF NOISE LOADING TEST

a) FUNDAMENTAL PRINCIPLES:

i) MEAN POWER IN CHANNELS:

In a multichannel system, overall power in the base band depends on the number of channels as well as activity coefficient which is defined by the ratio of the number of active channels to total no. of channels. If at any instant n no of channels are active and total no of channels = N then the activity coefficient =n/N.

ii) CCITT:

CCITT has recommended that the mean power in a telephone channel shall be - 15 dBm with respect to zero relative point, for a system having channel capacity > = 240.

iii) For N channel system total power of the baseband = - 15dBmo + 10 log N dB.

iv) for a system having channel capacity lying between 12 & 240 the baseband power is given by:

-1 + 4 log N dBmo.

b) WHITE NOISE LOADING TECHNIQUE:

In a multichannel system considerable amount of noise is contributed by channel loading and it is necessary to simulate the loading to check the equipment performance.

During busy hour, large no of voice channels are transmitted over the same radio channel and the modulating spectrum is thus uniform over the base band.

A white noise transmitter generates signal of uniform spectrum which can be used to simulate the base band spectrum with appropriate low and high pass filters. The characteristics of these filters and their nominal cut off frequencies are specified in the CCIR recommendations.

The measurement technique consists of inserting a series of band stop filters introduce 'quiet' channels or slots, at the system which becomes 'noisy' due to the thermal noise and intermodulation distortion as they pass through the system. At the output of the system a narrow band filter measures these noise and distortion in the ideally ' quite' slot frequencies of the noise measuring channels.

c) NOISE POWER RATIO (NPR)

NPR is the ratio in dB of the noise level in a measuring channels with the band fully noise loaded, to the level of the channel with all of the baseband noise loaded except the measuring channel.

d) SIGNAL TO NOISE RATIO (S/N)

NPR indicates the relative indication of the interference of other channels on the measuring channel. Alternatively noise power in a channel may be expressed by the relative level with respect to the signal power in the channel. The channel signal to noise ratio (S/N) is defined

as the ratio of the level of the standard test tone (0dBmo) to the noise in a 3100 Hz bandwidth within test channel.

The NPR and S/N are related as:

NPR = SNR - BWR + NLR where
BWR = Bandwidth ratio = 10 log f/3.1
f = bandwidth of base band in KHZ
NLR = Noise Loading Ratio given in sub para (a) (ii)&(iii)

EXAMPLE

In 120 channel system having base band in 60 - 552 KHZ band,

BWR = 10 log [(552-60)/3.1]
= 20
NLR = -1 +4 log 120
= 7.3
Therefore SNR = NPR + BWR - NLR
= NPR + 14.7 dB.