WRAC/KBC/38160 (TFR/2023/02/0016/23196/RFQ)

FOR THE SUPPLY AND DELIVERY OF RADIO REPEATERS AND LINK RADIOS TO BEACONSFIELD, KIMBERLEY

ANNEXURE B

PLEASE SEE ATTACHED THE FULL SPECIFICATIONS

TRANSNET
freight rail
A Division of Transnet Limited

INFRASTRUCTURE TELECOMS

STANDARD

TECHNICAL SPECIFICATION AND METHODS OF MEASUREMENT FOR ANGLE MODULATED RADIO EQUIPMENT

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CONTENTS

I Distribution

Once updated, a copy of the latest revision will be published in the document management system in use. An e-mail to this effect will be sent to the relevant personnel or heads of department.

II Document Change History

ISSUE NO.	DATE ISSUED	ISSUED BY	HISTORY DESCRIPTION
2.00	January 2004	Quality Assurance, Infrastructure	Revision
3.0	June 2006	QA	Convert to ISO Standard
3.1	June 2007	QA	Revision
4.0	July 2008	QA	Revision
5.0	February 2010	QA	New format & revision
6.0	August 2010	QA	New format & revision
6.1	November 2010	QA	Add measurement
6.2	August 2011	QA	Add information, definitions, supply standards & DC-DC Converter
7.0	January 2012	QA	Revision & add Trunking functional tests
8.0	May 2014	QA	Omit the difference between General and Shunt portables, revise the Loudspeaker sound pressure level & Transmitter microphone sensitivity.
8.1	June 2014	QA	Update clauses Numbers

III Changes Since Last Revision

CLAUSES	DESCRIPTION
IV	Add abbreviations
1.3.3.5	Change specification
1.11	Add trunking
2.4.2.3	Change graph
2.5	Add trunking functional tests
1.12	Omit the difference between General and Shunt portables, revise the Loudspeaker sound pressure level & Transmitter microphone sensitivity.

IV List of Abbreviations and Definitions

ABBREVIATIONS	DESCRIPTION
AC	Alternating Current
AF	Audio Frequency
BS	Base Station
CCITT	Consultative Committee for International Telephone and Telegraph (ITU-T)
CTCSS	Continuous Tone Coded Squelch System
dB	Decibel
dB(A)	Sound pressure A-weighted
dBc	Decibel relative to the carrier power
dBd	Decibel relative to a Dipole antenna
dBm	Decibel relative to 1 mW, impedance 50 Ω (power)
dBm	Decibel relative to 0.775 V_{pd}, impedance 600 Ω (audio frequency)
dB_{MUOP}	Decibel relative to the Maximum Useful Output Power
dB_{SOP}	Decibel relative to the Standard Output Power
DC	Direct Current
EMF	Electromotive Force
ERP	Effective Radiated Power
FFSK	Fast Frequency Shift Keying

FM	Frequency Modulation
GSM	Global System for Mobile communication
Hz	Hertz
ITU-T	International Telecommunication Union – Telecommunication Standardization Sector
kHz	Kilohertz
LBU	Line Branching Unit
LS	Loudspeaker
m	Metre
mA	Milliampere
MHz	Megahertz
mm	Millimetre
ms	Millisecond
mVp-p	Millivolt peak-to-peak
mW	Milliwatt
MUOP	Maximum Useful Output Power
pd	Potential Difference
PM	Phase Modulation
PSTN	Private Switching Telephone Network
RF	Radio Frequency
Rx	Radio receiver
SANS	South African National Standards
SINAD	Signal, Noise & Distortion to Noise & Distortion ratio
SOP	Standard Output Power
SPL	Sound Pressure Level
THD	Total Harmonic Distortion
TSC	Trunk Site Controller
Tx	Radio transmitter
V	Voltage
Vp-p	Voltage peak-to-peak
VSWR	Voltage Standing Wave Ratio
W	Wattage
WiFi	Wireless Fidelity
µV	Microvolt
%	Percentage

DEFINITIONS	**DESCRIPTION**
GENERAL	
Angle Modulation	A term used to encompass both frequency modulation and phase modulation.
Decibel	The decibel is 1/10 of a Bel. Decibel is the logarithm of the ratio between a measured quantity and an agreed reference level.
dBc	The absolute power in decibel with reference to the carrier power.
dBm	The absolute power in decibel with reference to 1 mW.
Land Mobile Radio Services	Radio communication from fixed radio stations to mobile radio stations carried in surface vehicles or portable radio stations, and between mobile and portable radio stations.

DEFINITIONS	DESCRIPTION
Portable Radio Station	A radio station designed to be carried by or on a person.
Mobile Radio Station	A radio station designed for installation in a surface vehicle and capable of operating while the vehicle is in motion and while it is stationary.
Fixed Radio Station	It is a fixed radio station installed in an office or control room, fitted with an external antenna.
Base Station	A radio station designed to be installed in a fixed location and performing the function of a repeater/enhancer.

RADIO RECEIVER	
Adjacent Channel Selectivity and Desensitization Ratio	A measure of the ability of a radio receiver to receive the modulated standard input signal in the presence of modulated signals that differ in frequency from the standard input signal frequency by the spacing of one channel.
Amplitude Characteristics	The relationship between the radio frequency input level of a specified modulated signal and the audio frequency level at a radio receiver output.
Attack Time	The time required to produce an audio output level of – 0.5 dB_{SOP} after application of a RF signal level, 12 dB above usable sensitivity, modulated with standard test modulation.
Audio Frequency Response	The relationship between the modulation factor of a received signal and the audio output level of the demodulated signal at various audio frequencies.
Audio Frequency Total Harmonic Distortion	The change in harmonic content of an audio signal as a result of its passing through the audio frequency and radio frequency circuits of a radio.
Blocking or Desensitisation	A reduction in the wanted audio output power of a radio receiver, or a reduction in the SINAD ratio, owing to an unwanted signal on another frequency.
Co-channel Rejection Ratio	A measure of the capability of a radio receiver to receive a wanted modulated signal without exceeding a given degradation due to the presence of an unwanted modulated signal, both signals being at the nominal frequency of the receiver.
Conducted Spurious Radiation	It is radiation components at any frequency generated by a radio receiver and radiated by the radio's antenna.
Desensitisation	Is a condition where off-channel transmitting energy passes through the front-end of the radio receiver, causing a reduction in receiver gain.
High RF Signal Level Interference	A measure of the ability of a radio receiver to oppose high RF signal levels at frequencies other than the normal frequency of the receiver.
Intermodulation Spurious Response Attenuation/ Rejection	The ability of a radio receiver to receive a modulated standard input signal, in the presence of two interfering signals of which the carrier frequencies are so separated from the standard input signal frequency and from each other that n'th order mixing of the two undesired signals can occur in the non-linear elements of the receiver, producing a third signal whose frequency is equal to that of the standard input signal frequency, or intermediate frequency.
Maximum Useful Output Power	The greatest average audio output power supplied to the rated load, which power does not exceed 10 % of the total harmonic distortion.
Modulation Acceptance Bandwidth	The selectivity characteristic of an angle modulated radio receiver that limits the maximum permissible modulation deviation of the radio frequency input signal that a receiver can accept, without degradation of the 12 dB SINAD ratio, when the radio frequency input signal is 6 dB greater than the usable sensitivity level.
Modulation Factor	The ratio of the maximum positive or negative peak variation of the modulating variable, to the maximum rated system-modulating variable, expressed as a

DEFINITIONS	DESCRIPTION
	percentage.
Signal, Noise & Distortion to Noise & Distortion Ratio	The ratio, expressed in decibels of the signal power, plus noise power, plus distortion power, to noise power plus distortion power produced at the output of a radio receiver resulting from a modulated signal input.
Signal to Hum and Noise Ratio	The ratio of residual receiver audio output power to standard output power.
Spurious Response Attenuation/ Rejection	A measure of the ability of a radio receiver to discriminate between the standard input signal frequency and an undesired signal at any other frequency to which it is also responsive, excluding the two adjacent channels.
Squelch Closing Time	The period of time between the removal of the RF signal and the squelch closure.
Squelch Operating Threshold	The RF signal input level, modulated with standard test modulation, at which the squelch opens and closes.
Standard Output Power	An audio output level 3 dB below maximum useful output power used to define a reference level for test purposes.
Usable Sensitivity	The minimum radio frequency input signal level modulated with standard test modulation that will produce, at a radio receiver, a SINAD ratio of at least 12 dB and an audio output signal power of at least – 3 dB_{SOP}.
RADIO TRANSMITTER	
Adjacent Channel Power	The part of the total power output of a radio transmitter that, under defined conditions of modulation, falls within a specified bandwidth centred on the normal frequency of either of the adjacent channels.
Amplitude Modulation Hum & Noise Level	A measure of the unwanted amplitude modulation of a carrier resulting from hum and noise.
Angle Modulation Hum & Noise Ratio	The ratio of residual angle modulation to standard test modulation.
Audio Frequency Response	The relationship between the modulation factor of a transmitted signal and the input level of the modulating signal at various audio frequencies.
Audio Frequency Total Harmonic Distortion	The change in harmonic content of an audio signal as a result of its passing through the audio frequency and radio frequency circuits of a radio.
Carrier Attack Time	The time required, changing the state of a radio transmitter from standby to a state where the unmodulated carrier voltage level reaches a value 6 dB below the steady state.
Carrier Frequency Error	Is the difference between the measured unmodulated carrier frequency from the assigned frequency.
Carrier Power	The mean power available at the output terminal of a radio transmitter in the absence of modulation.
Conducted Spurious Emissions	Emissions at the antenna terminal of a radio transmitter on a frequency or frequencies that are outside the channel on which the transmitter is operating.
Extreme Transmitter Loads	Conditions under which the radio transmitter operates into an open circuit or short circuit.
Intermodulation Attenuation	The ability of a radio transmitter to attenuate signals generated in its non-linear elements by the presence of the carrier and a parasitic signal arriving at the transmitter through its antenna.
Microphone sensitivity	It is the amount of modulation that the radio transmitter produces when a specified audio signal level is present at the microphone.

DEFINITIONS	**DESCRIPTION**
Mismatch between Transmitter and Antenna System	A condition in which the impedance as presented to the radio transmitter by the transmission line and antenna is not the same as the designed system impedance.
Modulation Limiting (Tx deviation)	A measure of the ability of radio transmitter circuits to prevent a transmitter from producing modulation such that the modulation factor exceeds the maximum rated system modulation factor.

TALK THROUGH SIGNAL	
Modulation Factor Linearity	The relationship between the modulation factor of a received signal and the transmitted modulation factor.
FILTERS	
Duplexer/Combiner	Is a filter system providing RF isolation to allow the sharing of a single antenna for both transmission and reception.
Insertion Loss	It is the amount of loss to a signal passing through a filter at a designated frequency.
Receiver Isolation at Transmitter Frequencies	It is the ability of the duplexer/combiner to suppress the transmitter carrier power at the receiver port. It is also called the selectivity of the duplexer/combiner.
ANTENNAS	
Effective Radiated Power	It is the mean power radiated by the antenna in the direction of maximum radiation.
dBd	The power gain of an antenna in decibel with reference to a Dipole antenna.
TRUNK CONTROL SIGNAL	
Fast Frequency Shift Keying	Bit 0 = 1.8 kHz Bit 1 = 1.2 kHz

AUDIO LINE BRANCHING UNIT	
Common-mode Rejection Ratio	Is the ratio of the differential gain over the common-mode gain.
POWER SUPPLY UNIT, DC-DC CONVERTER AND BATTERY CHARGER	
Noise Voltage	Is irregular amplitude voltages superimposed on the output DC voltage line.
Output Voltage Regulation	It is the ability of a power supply device to keep the output voltage constant over a range of applied loads.
Ripple Voltage	Is AC voltage superimposed on the output DC voltage line.
Variac	A device that supply a variable AC voltage from 0 V to 260 V.
ACOUSTIC	
A-weighted	It is a network that weights an audio signal in a manner, which approximates to an inverted equal loudness contour (it approximates the human ear's response to sound).

DEFINITIONS	DESCRIPTION
Sound Pressure	It is the force (N) of sound on a surface area (m^2) perpendicular to the direction of the sound. SPL is express as N/m^2 or Pascal (Pa).

1. TECHNICAL SPECIFICATION

Where not specifically indicated, this specification only applies for open channel and Trunked radio systems.

1.1 Radio Receiver: 12.5 kHz channel spacing; operating frequency band 450 MHz to 470 MHz.

1.1.1 Normal condition (see clause 2.1.1)

	Characteristics	Portable	Mobile & Fixed Radio Station	Base Station (Repeater)
1.1.1.1	Maximum Useful Audio Output Power	Maximum power not exceeding 10 % THD.		
1.1.1.2	Audio Frequency THD at Low Output Power Level 500 Hz & 1.0 kHz	≤ 5 %	≤ 2 %	≤ 2 %
1.1.1.3	Usable Sensitivity	≤ –115 dBm		
1.1.1.4	Squelch Operating Threshold Open Close	– 115 dBm minimum ≤ 3 dB lower than the opening threshold		See clause 1.3.1.1 ≤ 3 dB lower than the opening threshold
1.1.1.5	Attack Time	≤ 150 ms		
1.1.1.6	Squelch Closing Time	≤ 250 ms		
1.1.1.7	Modulation Acceptance Bandwidth	≥ 3.75 kHz		
1.1.1.8	Adjacent Channel Selectivity and Desensitization Ratio	≥ 60 dB	≥ 65 dB	≥ 70 dB
1.1.1.9	Spurious Response Attenuation/Rejection	≥ 70 dB	≥ 75 dB	≥ 75 dB
1.1.1.10	Intermodulation Spurious Response Attenuation/Rejection	≥ 65 dB	≥ 65 dB	≥ 70 dB
1.1.1.11	Co-channel Rejection Ratio	≤ 12 dB		
1.1.1.12	Blocking	≥ 84 dB		
1.1.1.13	Conducted Spurious Radiation	≤ – 57 dBm		
1.1.1.14	Audio Frequency Response (6 dB/octave) 300 to 900 Hz 1.1 to 2.5 kHz 3.0 kHz	+ 1 dB to – 3 dB + 1 dB to – 3 dB + 1 dB to – 4.5 dB		
1.1.1.15	Signal to Hum and Noise Ratio Squelched Unsquelched	≥ 60 dB ≥ 39 dB		
1.1.1.16	Amplitude Characteristics	≤ 3 dB		

1.1.2 Extreme conditions (see clause 2.1.2)

	Characteristics	Portable	Mobile & Fixed Radio Station	Base Station (Repeater)
1.1.2.1	Power Supply			
1.1.2.1.1	Usable Sensitivity variation	≤ ± 3 dB		
1.1.2.1.2	Adjacent Channel Selectivity and Desensitisation Ratio	≥ 60 dB	≥ 65 dB	≥ 70 dB
1.1.2.2	Temperature			
1.1.2.2.1	Usable Sensitivity variation	≤ ± 3 dB		
1.1.2.2.2	Adjacent Channel Selectivity and Desensitisation Ratio	≥ 60 dB	≥ 65 dB	≥ 70 dB
1.1.2.3	Selectivity at High RF Signal Level			
1.1.2.3.1	Input signal level	– 47 dBm to – 7 dBm		

1.2 **Radio Transmitter:** 12.5 kHz channel spacing; operating frequency band 450 MHz to 470 MHz.

1.2.1 Normal condition (see clause 2.1.1)

	Characteristics	Portable	Mobile & Fixed Radio Station	Base Station (Repeater)
1.2.1.1	Carrier Power (conducted)	≤ ± 1 dB from manufacturer's claim		
1.2.1.2	Conducted Spurious Emissions Operating Standby	 ≤ – 36 dBm ≤ – 57 dBm		
1.2.1.3	Carrier Frequency Error	≤ 1.5 kHz	≤ 1.5 kHz	≤ 1.0 kHz
1.2.1.4	Carrier Attack Time	≤ 100 ms		
1.2.1.5	Adjacent Channel Power	≤ – 60 dBc	≤ – 70 dBc	≤ – 70 dBc
	Or	– 37 dBm maximum.		
1.2.1.6	Intermodulation Attenuation	n.a.	n.a.	≥ 40 dB
1.2.1.7	Modulation Limiting (Tx Deviation) Modulating freq. 0.3 to 2.55 kHz 3 to 6 kHz 6 to 12.5 kHz	 2.5 kHz maximum 0.75 kHz maximum at 6 kHz – 14 dB/octave		
1.2.1.8	CTCSS Deviation	250 Hz		
1.2.1.9	Audio Frequency THD 500 Hz 1.0 kHz	≤ 5 %	≤ 2 %	≤ 2 %

	Characteristics	Portable	Mobile & Fixed Radio Station	Base Station (Repeater)
1.2.1.10	Audio Frequency Response (6 dB/octave) 300 to 900 Hz 1.1 to 2.5 kHz 3.0 kHz	 + 3 dB to – 1 dB + 3 dB to – 1 dB + 4.5 dB to – 1 dB		
1.2.1.11	Angle Modulation Hum & Noise Ratio	≥ 34 dB		
1.2.1.12	Amplitude Modulation Hum & Noise Level	≤ – 34 dB		

1.2.2 Extreme conditions (see clause 2.1.2)

	Characteristics	Portable	Mobile & Fixed Radio Station	Base Station (Repeater)
1.2.2.1	Power Supply			
1.2.2.1.1	Carrier Power Variation	≤ ± 2 dB		
1.2.2.1.2	Conducted Spurious Emissions Operating Standby	 ≤ – 36 dBm ≤ – 57 dBm		
1.2.2.1.3	Carrier Frequency Error	≤ 1.5 kHz	≤ 1.5 kHz	≤ 1.0 kHz
1.2.2.2	Temperature			
1.2.2.2.1	Carrier Power Variation	≤ ± 2 dB		
1.2.2.2.2	Conducted Spurious Emissions Operating Standby	 ≤ – 36 dBm ≤ – 57 dBm		
1.2.2.2.3	Carrier Frequency Error	≤ 1.5 kHz	≤ 1.5 kHz	≤ 1.0 kHz
1.2.2.3	Antenna Terminal Loads			
1.2.2.3.1	Short Circuit and Open Circuit Carrier Power Variation	 ≤ ± 1 dB		

1.3 **Radio Base Station** (Repeater): 12.5 kHz channel spacing; operating frequency band 450 MHz to 470 MHz.

The receiver and transmitter specifications are referred to in clauses 1.1 and 1.2 respectively.

1.3.1 Receiver

Clause	Characteristics	Base Station (Repeater)
1.3.1.1	Squelch operating threshold calculation Open Close	 – 115 dBm minus coaxial cable loss minus duplexer loss plus antenna gain. ≤ 3 dB lower than the opening threshold

1.3.2 Receiver and transmitter

Clause	Characteristics	Base Station (Repeater)
1.3.2.1	Response time	≤ 300 ms

1.3.3 Talk Through Signal

Clause	Characteristics	Base Station (Repeater)
1.3.3.1 1.3.3.1.1 1.3.3.1.2	Audio input and output terminals Impedance Return Loss	 600 Ω balanced ≤ – 25 dB
1.3.3.2 1.3.3.2.1 1.3.3.2.2	Audio Levels RTO & Trunking (local & intersite) Old Trunking Teletra system	 – 10 dBm ± 0.5 dBm – 4 dBm ± 0.7 dBm
1.3.3.3	Audio Frequency Response (With de-emphasis and pre-emphasis) Modulating frequency 300 to 900 Hz 1.1 to 3.0 kHz	 ± 3.0 dB ± 3.0 dB
1.3.3.4	Audio Frequency Response (Without de-emphasis and pre-emphasis) Modulating frequency 300 to 900 Hz 1.1 to 3.0 kHz	 ± 2.0 dB ± 2.0 dB
1.3.3.5	Modulation Factor Linearity Modulation 0.5 kHz 1.0 kHz 1.5 kHz 2.0 kHz 2.5 kHz	 0.5 kHz ± 100 Hz 1.0 kHz ± 100 Hz 1.5 kHz ± 100 Hz 2.0 kHz ± 100 Hz 2.5 kHz – 250 Hz (not to exceed 2.5 kHz)
1.3.3.6	Audio Frequency THD	≤ 5 %

1.4 Filters

1.4.1 Duplexer (Radio Train Order)

	Characteristics	Base Station (Repeater)
1.4.1.1	Insertion Loss (Tx & Rx)	≤ 1.2 dB
1.4.1.2	Rx Isolation at Tx Frequencies	≥ 65 dB (operating band) ≥ 80 dB (single channel)
1.4.1.3	Impedance Matching, 50 Ω (all ports)	VSWR ≤ 1.5:1 Return Loss ≤ – 14 dB
1.4.1.4	* Operating Frequency Band Receiver Transmitter	 465.0500 MHz to 465.9875 MHz 455.0500 MHz to 455.9875 MHz

* Duplexer for link operation is channelized.

1.4.2 Combiner (Trunked)

	Characteristics	Base Station (Repeater)
1.4.2.1	Insertion Loss - Receiver path	0 dB ± 0.5 dB
1.4.2.2	Insertion Loss - Transmit path	≤ 10 dB
1.4.2.3	Rx Isolation at Tx Frequencies	≥ 85 dB
1.4.2.4	Isolation between Rx ports	≥ 20 dB
1.4.2.5	Isolation between Tx ports	≥ 60 dB
1.4.2.6	Impedance Matching, 50 Ω (all ports)	VSWR ≤ 1.5:1 Return Loss ≤ – 14 dB
1.4.2.7	Operating Frequency Band Receiver Transmitter	 465.0000 MHz to 466.6375 MHz 455.0000 MHz to 456.6375 MHz

1.5 Coaxial Cable

	Characteristics	Mobile & Fixed Radio Station	Base Station (Repeater)
1.5.1	Impedance	50 Ω	
1.5.2	Impedance matching	VSWR ≤ 1.5:1 Return Loss ≤ – 14 dB	
1.5.3	Insertion loss	≤ 1 dB	≤ 5 dB

1.6 Antenna

	Characteristics	Various
1.6.1	Impedance	50 Ω
1.6.2	Impedance matching VHF & UHF GSM & WiFi	 VSWR ≤ 1.5:1 Return Loss ≤ – 14 dB VSWR ≤ 2.0:1 Return Loss ≤ – 9.54 dB

Characteristics	Various

1.6.3	* Antenna gain Mobile Fixed station Radio link: Point to point Point to multipoint Base station	 0 dBd ≤ 12 dBd 9 dBd minimum Not specified ≤ 12 dBd
1.6.4	# Antenna vertical separation	≥ 4 λ
1.6.5	* Antenna height above ground level Mobile & Fixed station Radio link: Point to point Point to multipoint Base station	 10 m maximum 20 m maximum 20 m maximum 20 m maximum

\# Based on 20 W ERP and antennae having a Dipole as a live element. Distance measured from centre to centre of dipoles.

* Licence conditions

1.7 Transmitting Power

	Characteristics	Various
1.7.1	* Conducted power at transmitter terminal Radio link: Point to point Point to multipoint	 1 W maximum 1 W maximum
1.7.2	* Effective Radiated Power (ERP) Mobile & Fixed station Radio link: Point to point Point to multipoint Base station	 20 W maximum 8.2 W maximum 8.2 W maximum 20 W maximum

* Licence conditions

1.8 Receiver Desensing

	Characteristics	Various
1.8.1	Desensing	≤ 1 dB
1.8.2	Desensing at high receiving signal level (radio links only) ≥ – 100 dBm	 ≤ 20 dB

1.9 Audio Line Branching Unit

	Characteristics	Base Station (Repeater)
1.9.1	Audio input and output terminals Impedance Return Loss	 600 Ω balanced ≤ – 25 dB
1.9.2	Input and output audio signal level	– 10 dBm ± 0.5 dB
1.9.3	Audio frequency response 300 Hz to 3 kHz	 ± 0.5 dB
1.9.4	Audio total harmonic distortion (THD)	≤ 0.5 %
1.9.5	Audio signal to hum and noise ratio	≥ 70 dB
1.9.6	Channel cross talk	≥ 60 dB
1.9.7	Common-mode rejection ratio	≥ 60 dB at 1 kHz
1.9.8	E-signal	Up to 50 V DC, 10 mA Opto coupler

	Characteristics	Base Station (Repeater)
		Bi-directional polarity
1.9.9	M-signal	Up to 50 V DC, 10 mA Voltage free contact

1.10 Power Supply Unit, DC-DC Converter and Battery Charger

	Characteristics	Various
1.10.1	Operating conditions Temperature range Relative humidity	 – 10 °C to 60 °C Up to 85 %
1.10.2	Input power AC Voltage Frequency DC Voltage	 220 V AC ± 10 % 50 Hz ± 2 % Nominal ± 10 %
1.10.3	Output voltage regulation (Intermittent & continuous)	13.8 V ± 5 % (12 V system) 27.6 V ± 5 % (24 V system) 55.2 V ± 5 % (48 V system)
1.10.4	Efficiency	≥ 70 %
1.10.5	Output voltage ripple & noise	≤ 200 mVp-p (12 V system) ≤ 400 mVp-p (24 V system) ≤ 800 mVp-p (48 V system)
1.10.6	Radiation of spurious frequencies	≤ – 119 dBm in radio operating band
1.10.7	Desensing of receiver	≤ 1 dB
1.10.8	Load shedding (when required) Shed Restore	 11.0 V (12 V system) 22.0 V (24 V system) 44.0 V (48 V system) 13.0 V (12 V system) 26.0 V (24 V system) 52.0 V (48 V system)

1.11 Trunking

1.11.1 Functional Tests

	Characteristics	Various
1.11.1.1	Registration	Register on instrument Register on trunk system
1.11.1.2	Local call to radio with the same prefix number	Establish call to instrument Establish call through the trunk system
1.11.1.3	Local call to radio with an interprefix number	Establish call to instrument Establish call through the trunk system
1.11.1.4	Local call to radio with the same prefix number using short form dialling	Establish call to instrument Establish call through the trunk system
1.11.1.5	Intersite call to radio with the same prefix number	Establish call through the trunk system
1.11.1.6	Intersite call to radio with an interprefix number	Establish call through the trunk system
1.11.1.7	Intersite call to radio with the same prefix number using short form dialling	Establish call through the trunk system

1.11.1.8	PSTN call	Establish call to instrument Establish call through the trunk system
1.11.1.9	Call the radio under test	Establish call from instrument Establish call through the trunk system
1.11.1.10	Handoff	Reregister on new control channel with Instrument Reregister on new control channel on the trunk system

1.11.2 Control Signal - Trunk Site Controller

	Characteristics	Base Station (Repeater)
1.11.2.1	FFSK level from TSC	1 Vp-p ± 0.2 Vp-p
1.11.2.2	FFSK frequency from TSC	1.2 kHz ± 100 Hz 1.8 kHz ± 100 Hz
1.11.2.3	Tx deviation at FFSK level For channel dragging problem	1.5 kHz ± 100 Hz 800 Hz ± 100 Hz
1.11.2.4	FFSK level from Rx measured at TSC (Modulation 1.5 kHz) (Modulating frequency 1.2 kHz)	1 Vp-p ± 0.2 Vp-p

1.12 Acoustical measurements

	Characteristics	Portable
1.12.1	**Receiver**	
	Loudspeaker sound pressure level	≥ 84 dB(A) at 300 mm
1.12.2	**Transmitter**	
	Transmitter deviation	Between 300 and 500 Hz from a SPL of 80 dB(A) at the microphone

1.13 Co-channel Interference

	Characteristics	Various
1.13.1	**Speech**	
	Level difference between signals	≥ 15 dB

1.13.2	**Data (FFSK)**	
	Level difference between signals	≥ 20 dB

2. METHODS OF MEASUREMENT

Applied Standard

2.1 Normal condition

Temperature	:	23 °C ± 3 °C
Relative Humidity	:	45 to 85 %
Lead acid battery	:	2.3 V per cell
Lithium-ion battery	:	3.6 V per cell
Nickel cadmium	:	1.2 V per cell
Nickel Metal Hydrate battery	:	1.2 V per cell
Mains	:	220 V AC 50 Hz

2.2 Extreme conditions

Temperature	:	– 10 °C and 60 °C
Relative humidity	:	45 to 95 %
Lead acid battery	:	1.8 V minimum & 2.6 V maximum per cell
Lithium-ion battery	:	3.0 V minimum & 4.2 V maximum per cell
Nickel Cadmium battery	:	1.0 V minimum & 1.5 V maximum per cell
Nickel Metal Hydrate battery	:	1.0 V minimum & 1.5 V maximum per cell
Mains	:	220 V AC ± 10 % 50 Hz ± 2 %

Power Supply Systems

12 V system	:	Minimum 11.0 V	Nominal 13.8 V	Maximum 15.6 V
24 V system	:	Minimum 22.0 V	Nominal 27.6 V	Maximum 31.2 V
48 V system	:	Minimum 44.0 V	Nominal 55.2 V	Maximum 62.4 V

2.3 Warm up time

As specified by the manufacturer.

2.4 Temperature stabilising period

One hour minimum.

2.5 Power source tolerance

≤ ± 3 %.

2.6 Standard RF Test Signal

2.6.1 Standard test modulation

Modulating frequency : 1.0 kHz.

Modulation : 1.5 kHz (60 % of maximum rated system deviation).

2.6.2 Standard RF Signal Input Level

– 60 dBm (223.6 μV_{pd} or 447.2 μV_{EMF}).

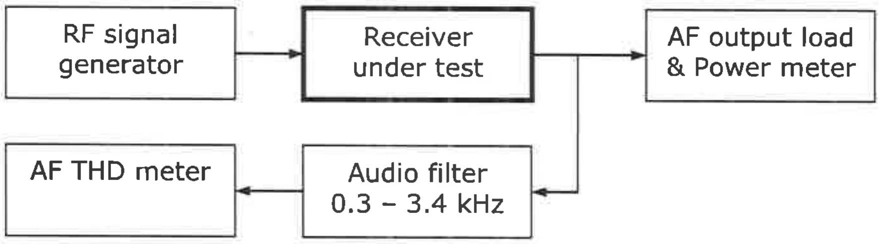
2.7 Audio Output Level

SOP = – 3 dB_{MUOP}.

2.2 Radio Receiver

2.2.1 Maximum Useful Output Power

Connect the equipment as shown below.



2.2.1.1 Inject a standard RF test signal from the RF signal generator.

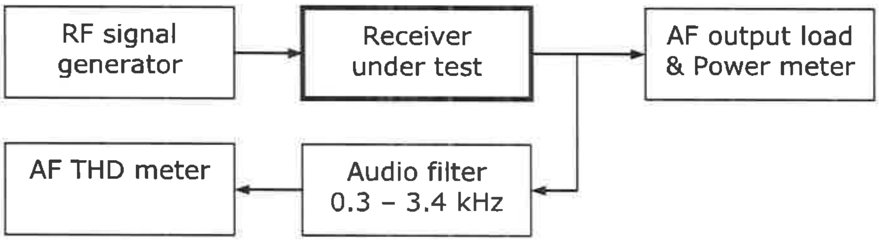
2.2.1.2 Adjust the volume control of the radio until the THD is 10 % or the volume control reaches its maximum travel, whichever occurs first.

2.2.1.3 Measure the audio output power (MUOP).

Note: The impedance of the AF output load must be the same value as the load (loudspeaker) with which the receiver normally operates.

2.2.2 Audio frequency total harmonic distortion

Connect the equipment as shown below.



2.2.2.1 Standard measurement

2.2.2.1.1 Test 1.

2.2.2.1.1.1 Inject a standard RF test signal from the RF signal generator into the receiver.

2.2.2.1.1.2 Adjust the volume control of the radio to obtain SOP.

2.2.2.1.1.3 Measure the THD.

2.2.2.1.2 Test 2.

2.2.2.1.2.1 Change the modulating frequency to 500 Hz using the same modulation factor as in test 1, except that in the case of PM receivers, the modulation factor should be reduced by 50 %.

2.2.2.1.2.2 Repeat the procedure given in test 1.

2.2.2.1.2.3 Measure the THD.

2.2.2.2 600 Ω balanced line

Where a 600 Ω balanced line is provided, the THD must be measured on this line.

2.2.2.2.1 Inject a standard RF test signal from the RF signal generator into the receiver.

2.2.2.2.2 Load the line with a 600 Ω resistive load or equivalent impedance, provided by the measuring instrument.

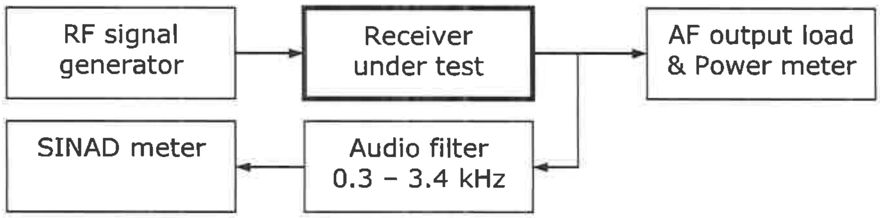
2.2.2.2.3 Adjust the audio signal level to measure –10 dBm on the line.

2.2.2.2.4 Measure the THD.

2.2.2.2.5 Repeat the THD measurement when applying test 2.

2.2.3 **Usable sensitivity**

Connect the equipment as shown below.



2.2.3.1 Adjust the RF signal generator to produce a standard RF input signal level.

2.2.3.2 Adjust the volume control of the radio to obtain SOP.

2.2.3.3 Reduce the RF signal level until the SINAD ratio is 12 dB.

2.2.3.4 Without readjustment of the volume control check whether the audio output level is less than – 3 dB_{SOP}.

2.2.3.5 If the audio output is less that – 3 dB_{SOP}, increase the RF signal level until – 3 dB_{SOP} is obtained.

2.2.3.6 Take the RF signal output level from the signal generator at this setting as the usable sensitivity.

2.2.3.7 The measurement shall be made under the extreme test conditions as well.
Under the extreme test conditions, the receiver audio output power shall be within ±3 dB of the value obtained under normal test condition.

Note: The impedance of the AF output load must be the same value as the load (loudspeaker) with which the receiver normally operates.

2.2.4 **Squelch operating threshold**

Connect the equipment as shown below.

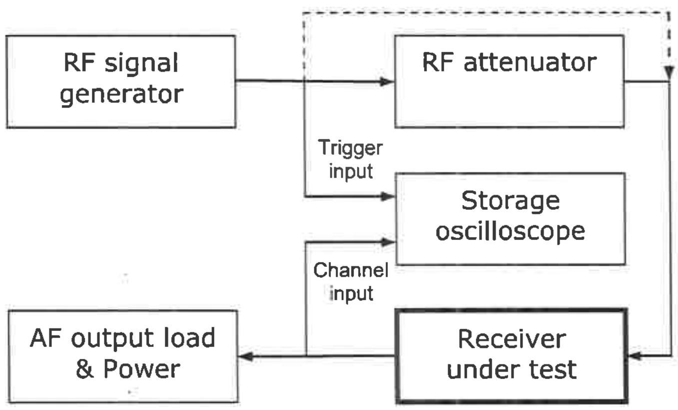
2.2.4.1 Apply a standard RF test signal to the receiver under test and adjust the volume control of the radio to obtain SOP.

2.2.4.2 Reduce the RF signal level **slowly** until the squelch closes and record this RF signal level as the squelch closing level in dBm.

2.2.4.3 Increase the RF signal level **slowly** until the squelch opens and record this RF signal level as the squelch opening level in dBm.

2.2.5 **Attack time**

Connect the equipment as shown below.



2.2.5.1 Apply a standard RF test signal to the receiver under test.

2.2.5.2 Adjust the volume control of the radio to obtain SOP.

2.2.5.3 Determine the usable sensitivity as described in clause 2.2.3.

2.2.5.4 Adjust the squelch to open at a RF signal level of – 115 dBm, measured at the antenna terminal.

2.2.5.5 Set the RF signal level from the signal generator to 0 dBm.

2.2.5.6 Set the value of the RF attenuator to decrease the signal level to 12 dB above the usable sensitivity level, measured at the antenna terminal and switch the output of the signal generator off.

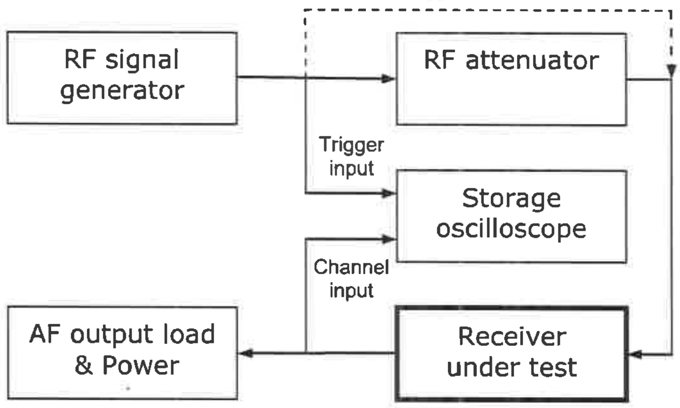
2.2.5.7 Set the storage oscilloscope to single sweep operation.

2.2.5.8 Switch the RF output on and measure the time required for the audio output to reach –0.5 dB_{SOP}.

2.2.5.9 Repeat the measurement three times and take the average of the three measurements as the receiver attack time.

2.2.6 Squelch Closing Time

Connect the equipment as shown below.



2.2.6.1 Apply a standard RF test signal to the receiver under test.

2.2.6.2 Adjust the volume control of the radio to obtain SOP.

2.2.6.3 Determine the usable sensitivity as described in clause 2.2.3.

2.2.6.4 Adjust the squelch to open at a RF signal level of – 115 dBm, measured at the antenna terminal.

2.2.6.5 Set the RF signal level from the signal generator to 0 dBm.

2.2.6.6 Set the value of the RF attenuator to decrease the signal level to 12 dB above the usable sensitivity level, measured at the antenna terminal.

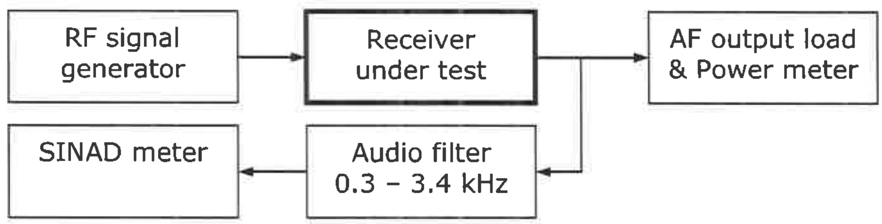
2.2.6.7 Set the storage oscilloscope to single sweep operation.

2.2.6.8 Switch the output of the signal generator off and measure the time required for the audio output to be reduced by 10 dB from the SOP value.

2.2.6.9 Repeat the measurement three times and take the average of the three measurements as the squelch closing time.

2.2.7 Modulation acceptance bandwidth

Connect the equipment as shown below.



2.2.7.1 Apply a standard RF test signal to the receiver under test.

2.2.7.2 Adjust the receiver volume control to obtain SOP.

2.2.7.3 Reduce the RF signal level until the SINAD ratio is 12 dB.

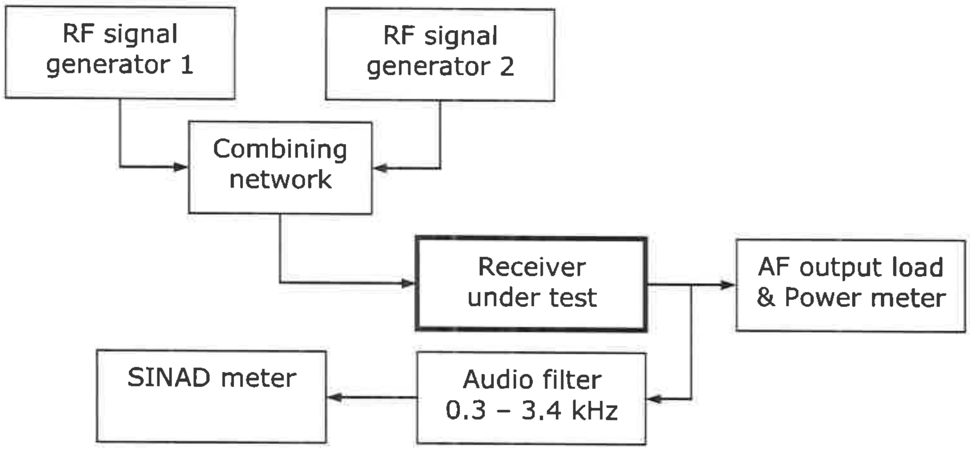
2.2.7.4 Increase the RF signal level by 6 dB.

2.2.7.5 Increase the modulation factor until the SINAD ratio is again 12 dB.

2.2.7.6 Record this value of the modulation factor as the modulation acceptance bandwidth.

2.2.8 Adjacent channel selectivity and desensitization ratio

Connect the equipment as shown below.



2.2.8.1 Switch the RF signal output of signal generator 2 off.

2.2.8.2 RF signal generator 1:

- 2.2.8.2.1 Apply a standard RF test signal to the receiver under test.
- 2.2.8.2.2 Adjust the volume control of the radio to obtain SOP.
- 2.2.8.2.3 Reduce the RF signal until the SINAD ratio is 12 dB (wanted signal).
- 2.2.8.2.4 Note this RF signal level.

2.2.8.3 RF signal generator 2:

- 2.2.8.3.1 Switch the RF signal output on (unwanted signal).
- 2.2.8.3.2 Modulate the RF signal with 400 Hz at the standard modulation factor.
- 2.2.8.3.3 Set the frequency (unwanted signal) to a frequency one-channel width above the assigned frequency (wanted signal).
- 2.2.8.3.4 Adjust the RF signal level such that the SINAD ratio is degraded to 6 dB.
- 2.2.8.3.5 Note this RF signal level.
- 2.2.8.3.6 Repeat for the unwanted signal set to a frequency one-channel width below the assigned frequency.

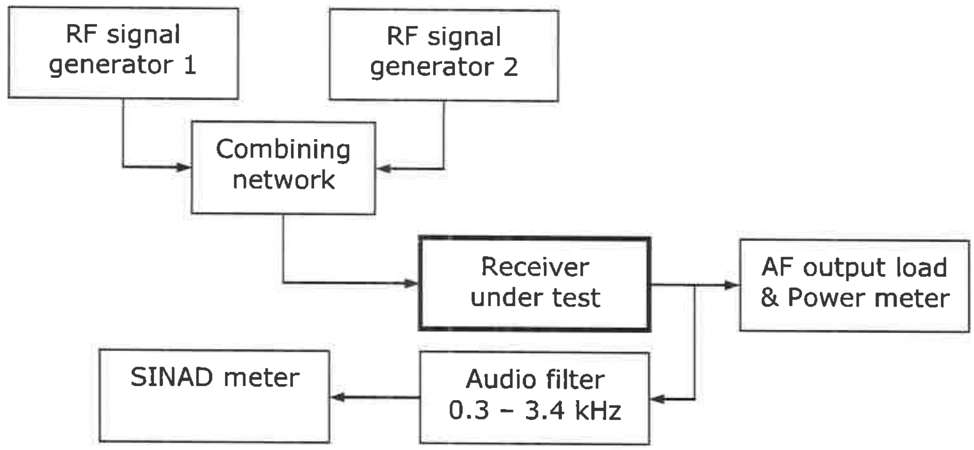
2.2.8.4 Calculate the difference between the unwanted and wanted signal levels in dB, as the adjacent channel selectivity and desensitization ratio.

2.2.8.5 Take the worst case of the two measurements as the result.

2.2.8.6 The measurements shall be made under the extreme test conditions as well.

2.2.9 **Spurious response attenuation/rejection**

Connect the equipment as shown below.



2.2.9.1 Switch the RF signal output of signal generator 2 off.

2.2.9.2 RF signal generator 1:

2.2.9.2.1 Adjust the RF signal generator to produce a standard RF test signal.

2.2.9.2.2 Adjust the volume control of the radio to obtain SOP.

2.2.9.2.3 Reduce the RF signal to the receiver until the SINAD ratio is 12 dB.

2.2.9.3 RF signal generator 2:

2.2.9.3.1 Switch the RF signal output on and adjust the signal level to 80 dB (portable) or 85 dB (mobile and base) higher than that of signal generator 1.

2.2.9.3.2 Modulate the RF signal with 400 Hz at standard modulation factor.

2.2.9.3.3 Slowly sweep the carrier frequency over the range 100 kHz to 1 GHz in 12.5 kHz steps (channels) excluding the assigned channel and the two adjacent channels.

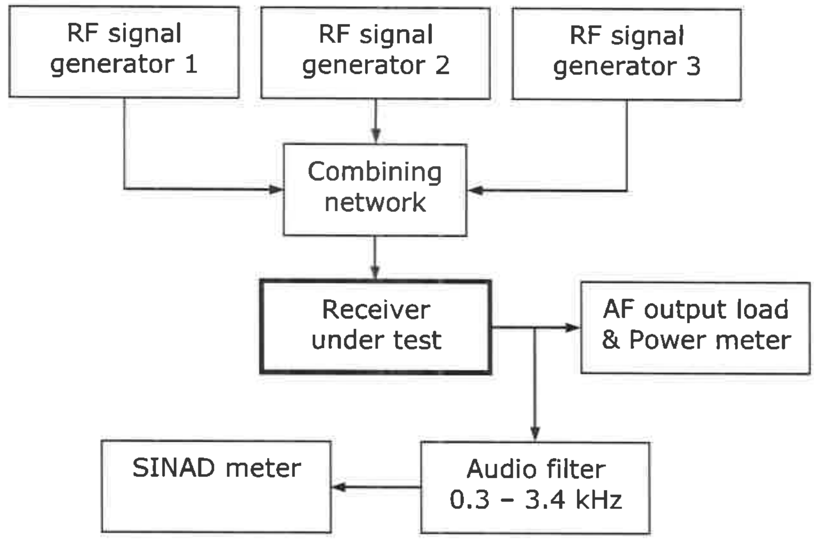
2.2.9.3.4 When the receiver is responsive to a spurious signal, adjust the RF signal level until the SINAD ratio is 6 dB.

2.2.9.4 Note the frequency and the RF signal levels of the two signal generators and take the difference between the two levels expressed in dB as the measure of the spurious response attenuation at that frequency.

Note: Ensure that the measured response is not caused by spurious signals from the RF signal generators or Intermodulation products between the two signals.

2.2.10 **Intermodulation spurious response attenuation/rejection**

Connect the equipment as shown below.



2.2.10.1 Switch the RF signal output of signal generators 2 & 3 off.

2.2.10.2 RF signal generator 1:

2.2.10.2.1 Adjust the RF signal generator to produce a standard RF test signal.

2.2.10.2.2 Adjust the volume control of the radio to obtain SOP.

2.2.10.2.3 Reduce the RF signal to the receiver until the SINAD ratio is 12 dB.

A. 2.2.10.3 RF signal generator 2:

2.2.10.3.1 Adjust the unmodulated frequency of the RF signal generator to the second adjacent channel above the nominal carrier frequency.

2.2.10.4 RF signal generator 3:

2.2.10.4.1 Modulate the RF signal with 400 Hz at standard modulation factor.

2.2.10.4.2 Adjust the frequency of the RF signal generator to the fourth adjacent channel above the nominal carrier frequency.

2.2.10.5 Switch the RF signal output of signal generators 2 & 3 on.

2.2.10.6 Maintain the outputs of RF signal generators 2 & 3 at equal levels.

2.2.10.7 Adjust the RF signal levels to reduce the SINAD ratio to 6 dB.

2.2.10.8 Adjust the frequency of RF signal generator 3 slightly to produce the maximum interfering signal.

2.2.10.9 Note the difference in dB between the RF signal output level from RF signal generator 1 and the RF signal output level from RF signal generators 2 & 3.

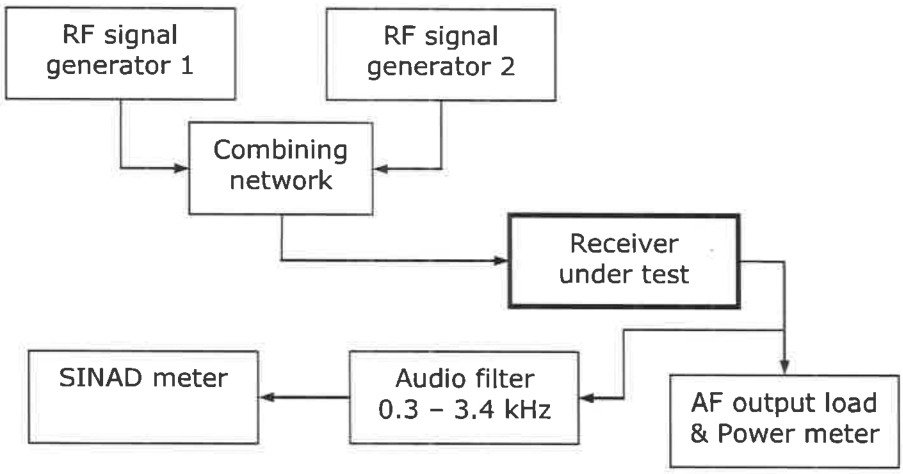
B. 2.2.10.10 Repeat these measurements with RF signal generators 2 & 3 adjusted to the fourth adjacent and eighth adjacent channels above the nominal carrier frequency.

C. 2.2.10.11 The measurements described in A & B shall be repeated with RF signal generators 2 & 3 set to the appropriate channels below the nominal frequency of the receiver.

2.2.10.12 Record the worst ratio in dB as the measure of the intermodulation spurious response attenuation.

2.2.11 **Co-channel rejection ratio**

Connect the equipment as shown below.



2.2.11.1 Switch the RF signal output of signal generator 2 off.

2.2.11.2 RF signal generator 1:

2.2.11.2.1 Adjust the RF signal generator to produce a standard RF test signal.

2.2.11.2.2 Adjust the volume control of the radio to obtain SOP.

2.2.11.2.3 Reduce the RF signal until the SINAD ratio is 12 dB (wanted signal).

2.2.11.3 RF signal generator 2:

2.2.11.3.1 Switch the RF signal output on (unwanted signal).

2.2.11.3.2 Set the frequency to the assigned receiver frequency.

2.2.11.3.3 Modulate the RF signal with 400 Hz at standard modulation factor.

2.2.11.3.4 Adjust the RF signal level such that the SINAD ratio is reduced to 6 dB.

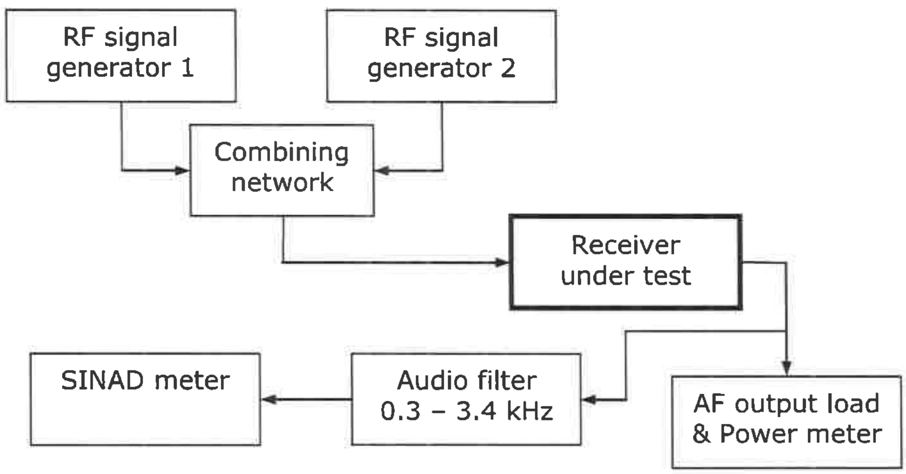
2.2.11.4 Record the co-channel rejection ratio as the difference in dB, between the wanted and unwanted signal levels.

2.2.11.5 Repeat the measurement with signal generator 2 set to frequencies 1.5 kHz and 3.0 kHz above and below the assigned frequency.

2.2.11.6 The highest value of the five measurements shall be recorded as the co-channel rejection ratio.

2.2.12 **Blocking or Desensitisation**

Connect the equipment as shown below.



2.2.12.1 Switch the RF signal output of signal generator 2 off.

2.2.12.2 RF signal generator 1:

2.2.12.2.1 Adjust the RF signal generator to produce a standard RF test signal.

2.2.12.2.2 Adjust the volume control of the radio to obtain SOP.

2.2.12.2.3 Reduce the RF signal until the SINAD ratio is 12 dB (wanted signal).

2.2.12.3 RF signal generator 2:

2.2.12.3.1 Switch the unmodulated RF signal output on (unwanted signal).

2.2.12.3.2 Set the RF signal to a level 84 dB higher than signal generator 1.

2.2.12.3.3 Vary the frequency from 1 MHz to 10 MHz on either side of the assigned carrier frequency.

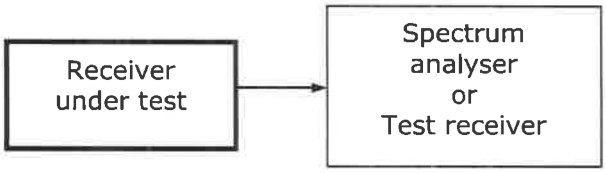
2.2.12.4 Monitor the variation in the audio output level and the SINAD ratio.

2.2.12.5 Record the difference in dB between the signal output levels from the two RF signal generators at which the audio output power decreased with 3 dB or the SINAD ratio decreases to 6 dB, whichever occurs first.

Note: Ensure that the measured response is not caused by spurious signals from the RF signal generators.

2.2.13 Conducted Spurious radiation

Connect the equipment as shown below.



2.2.13.1 Switch the receiver on.

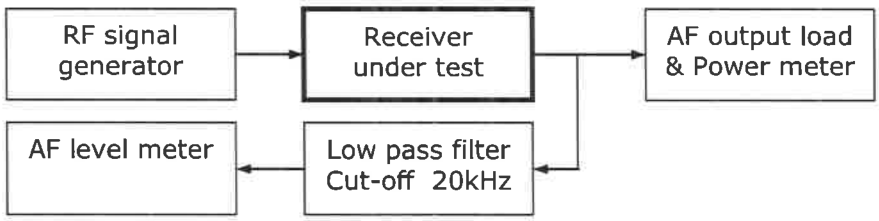
2.2.13.2 The receiver must be in standby mode.

2.2.13.3 Slowly sweep the measuring instrument over the range 9 kHz to 4 GHz.

2.2.13.4 Record the frequencies and measure the absolute levels of the conducted spurious radiation.

2.2.14 Audio frequency response

Connect the equipment as shown below.



2.2.14.1 Standard measurement

2.2.14.1.1 Adjust the RF signal generator to produce a standard RF test signal and inject it into the receiver.

2.2.14.1.2 Adjust the volume control of the radio to obtain SOP.

2.2.14.1.3 Adjust the modulation of the RF signal generator to 20 % of the maximum system deviation.

2.2.14.1.4 While keeping the modulation factor constant vary the modulating frequency over the range 300 Hz to 3 kHz.

2.2.14.1.5 Record the variation of the audio output power over this range in dB with reference to the corresponding level at 1 kHz.

2.2.14.1 600 Ω balanced line

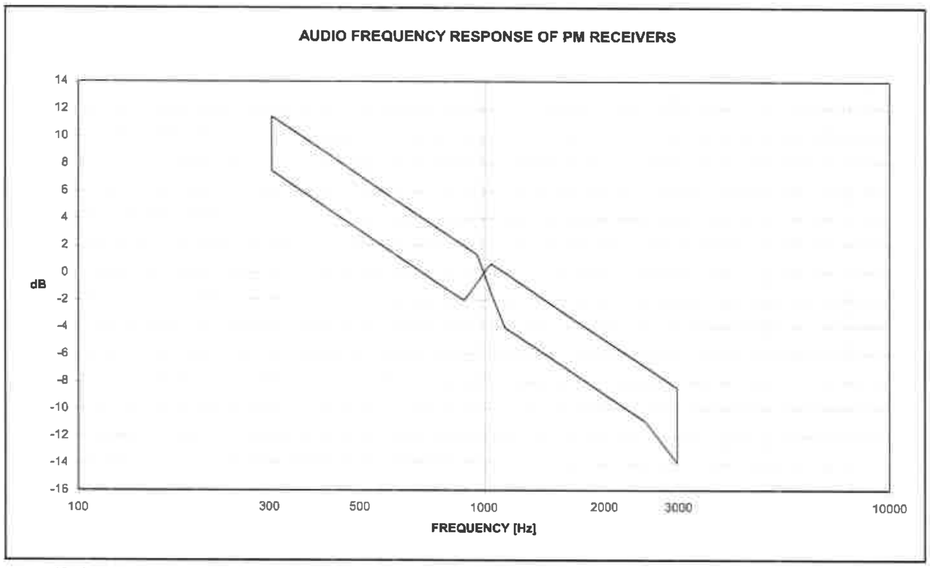
Where a 600 Ω balanced line is provided, the audio frequency response must be measured on this line.

2.2.14.2.1 Inject a standard RF test signal from the RF signal generator into the receiver.

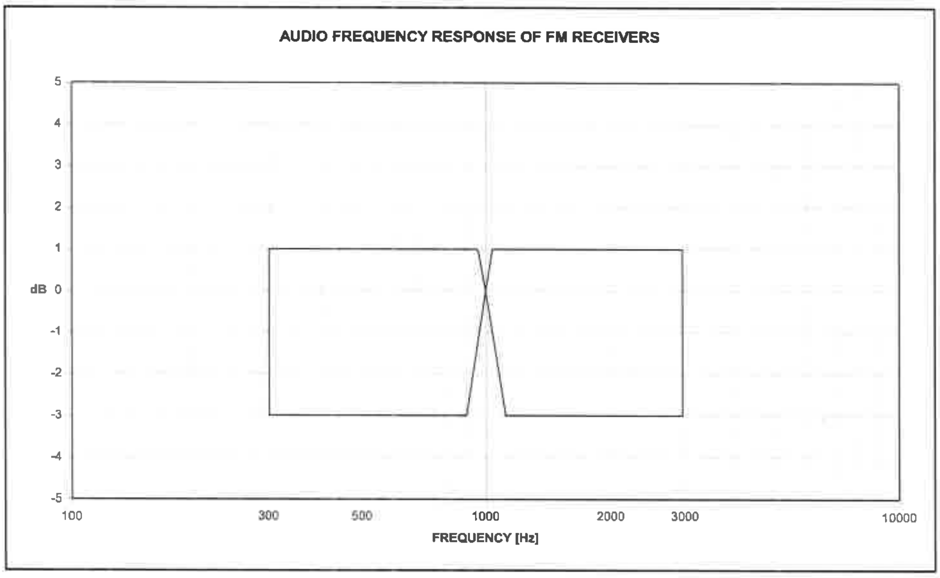
2.2.14.2.2 Load the line with a 600 Ω resistive load or equivalent impedance, provided by the measuring instrument.

2.2.14.2.3 Adjust the audio signal level to measure – 10 dBm on the line.

2.2.14.2.4 Proceed with clauses 2.2.14.1.3 and 2.2.14.1.5.

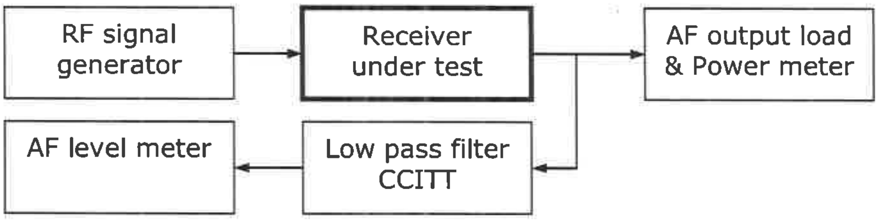


6dB/octave slope



2.2.15 **Signal to hum and noise ratio**

Connect the equipment as shown below.



2.2.15.1 Select the CCITT filter (low pass filter).

2.2.15.2 Adjust the RF signal generator to produce a standard RF test signal.

2.2.15.3 Adjust the volume control of the radio to obtain SOP.

2.2.15.4 Adjust the squelch to its minimum (unsquelched).

2.2.15.5 Remove the modulation and measure the audio output power.

2.2.15.6 Adjust the squelch to its maximum (squelched).

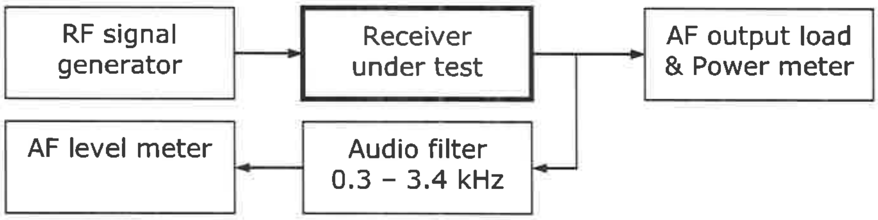
2.2.15.7 If the receiver remains unsquelched remove the RF signal.

2.2.15.8 Measure the audio output power.

2.2.15.9 Record the ratio in dB between the audio output powers without modulation, and the SOP level as the signal to hum and noise ratio.

2.2.16 **Amplitude characteristics**

Connect the equipment as shown below.



2.2.16.1 Adjust the RF signal generator to produce a standard RF test signal.

2.2.16.2 Increase the RF output signal level to – 13 dBm.

2.2.16.3 Adjust the volume control of the radio to obtain SOP.

2.2.16.4 Decrease the RF signal output level from – 13 dBm to – 107 dBm and measure the change in the audio output level in dB.

2.2.17 **High RF signal level interference**

Connect the equipment as shown below.

2.2.17.1 Set the radio to operate on the lowest channel.

2.2.17.2 Adjust the RF signal generator to produce a standard RF test signal.

2.2.17.3 Adjust the squelch to open at a RF signal level of – 115 dBm.

2.2.17.4 Increase the RF signal level to –7 dBm.

2.2.17.5 Scan the frequencies of 132 channels above the receiving channel, excluding the assigned channel and the adjacent channels.

2.2.17.6 Record the channel and the RF signal level, at which the squelch opens in the window of – 47 dBm to – 7 dBm.

2.2.17.7 Set the radio to operate on the highest channel.

2.2.17.8 Scan the frequencies of 132 channels below the receiving channel, excluding the assigned channel and the adjacent channels.

2.2.17.9 Record the channel and the RF signal level, at which the squelch opens in the window of – 47 dBm to – 7 dBm.

Note: Where the interfering channels correspond with the intermodulation free channel groups, interference could occur.

Intermodulation free channel groups

High site channels

Duplex, 5th order, 132 channels

Group A	1	2	6	8	22	37	54	61	79	80	88	91	101	124	129

Duplex, 5th order, 132 channels

Group B	3	4	7	23	45	73	75	85	96	102	120	128

Duplex, 5th order, 132 channels

Group C	16	41	57	59	74	78	83	110	122	123	130

Duplex, 5th order, first 52 channels

Group D	17	18	21	31	40	46	48

Duplex, 5th order, first 52 channels

Group E	19	28	32	43	44	49	51

Duplex, 5th order, first 52 channels

Group F	29	30	35	42	50	52

Duplex, 5th order, first 52 channels

Group G	11	14	24	26

Duplex, 5th order, first 52 channels

Group H	34	36	47

Shunting channels

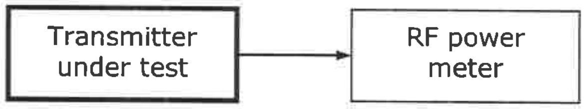
Simplex, 5th order, last 80 channels

Group A	53	56	60	71	97	99	109	118	126	131	132
Group B	55	58	62	63	72	84	112	125			
Group C	64	67	69	76	95	103	116	127			
Group D	68	77	82	90	107	113	114	117			
Group E	65	66	70	94	100	121					
Group F	81	87	89	92	104	108					

2.3 Radio Transmitter

2.3.1 Carrier power (conducted)

Connect the equipment as shown below.

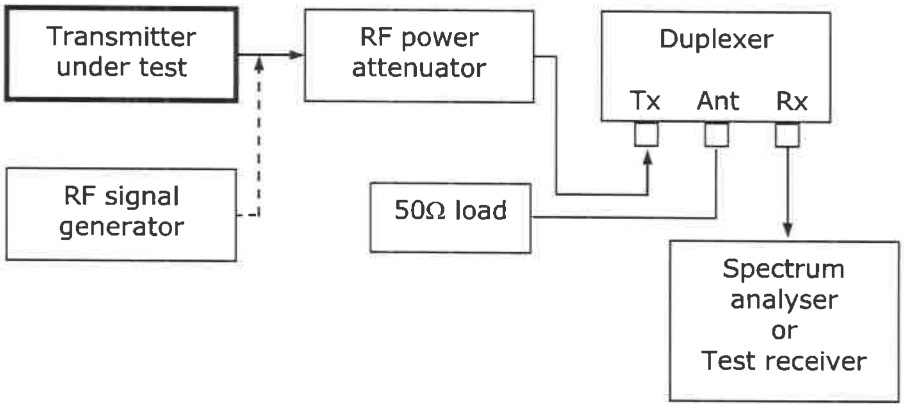


2.3.1.1 Measure the carrier power in the absence of modulation.

2.3.1.2 The measurement shall be made under the extreme test conditions as well.

2.3.2 **Conducted spurious emissions**

Connect the equipment as shown below.



2.3.2.1 The duplexer must be tuned to the operating band. See specifications in clause 1.4.1.

2.3.2.2 The value of the RF attenuator (including the duplexer) must be such to limit the carrier level at the spectrum analyser/test receiver to approximately – 60 dBm.

2.3.2.3 With the transmitter transmitting an unmodulated carrier, measure and record the frequencies and absolute levels of the conducted spurious up to the 5th harmonic.

2.3.2.4 Replace the transmitter with the RF signal generator.

2.3.2.5 Tune the RF signal generator to the recorded frequency and adjust the output level to obtain the recorded level on the spectrum analyser/test receiver.

2.3.2.6 Record the output level of the RF signal generator as the conducted spurious emission at that specific frequency.

2.3.2.7 Repeat 2.3.2.5 & 2.3.2.6 for all the other spurious emissions detected.

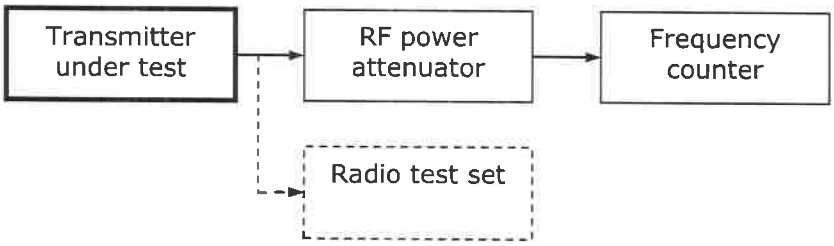
2.3.2.8 Remove the RF attenuator and duplexer and repeat the measurements when the transmitter is in the standby mode.

2.3.2.9 The measurements shall be made under the extreme test conditions as well.

2.3.1.10 With the above circuit the reverse channels can also be tested.

2.3.3 **Carrier frequency error**

Connect the equipment as shown below.



2.3.3.1 Measure the carrier frequency in the absence of modulation.

2.3.3.2 Repeat the measurement on each channel on which the transmitter is equipped to operate.

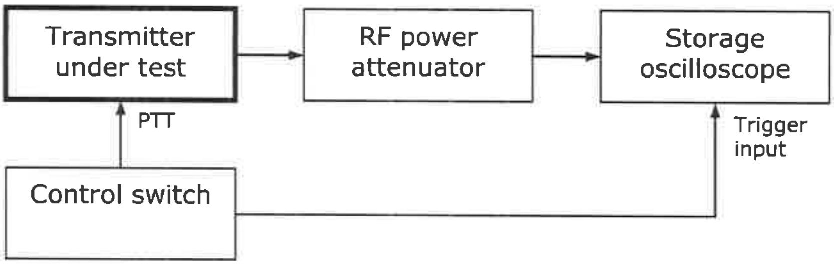
2.3.3.3 Calculate the carrier frequency error as the difference between the assigned frequency and the measured frequency. (Some test instruments can be set to measure the frequency error directly).

2.3.3.4 Record the worst case as the result.

2.3.3.5 The measurement shall be made under the extreme test conditions as well.

2.3.4 **Carrier attack time**

Connect the equipment as shown below.

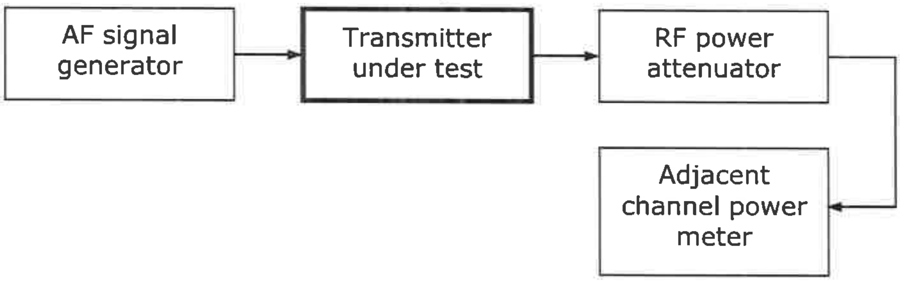


2.3.4.1 Set the storage oscilloscope to single sweep operation.

2.3.4.2 Operate the control switch and measure the time interval for the unmodulated carrier voltage level to reach a value 6 dB (50 %) below the steady state level.

2.3.5 **Adjacent channel power**

Connect the equipment as shown below.



2.3.5.1 Ensure that the modulation limiting (Tx deviation) is set correctly (see clause 2.3.7).

2.3.5.2 Measure the unmodulated carrier power level.

2.3.5.3 Modulate the transmitter with a 1 250 Hz signal at a level 20 dB greater than that required to produce the standard test modulation factor.

2.3.5.4 Measure the mean power produced by the modulation, hum and noise of the transmitter in the adjacent channels.

2.3.5.5 Express the adjacent channel power in dB with reference to the measured carrier power.

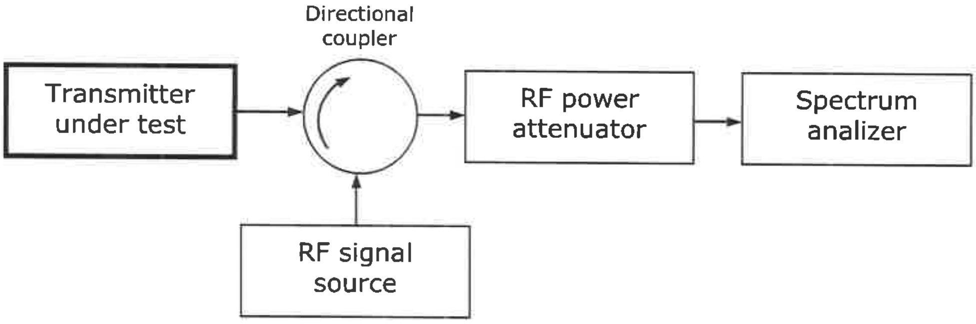
2.3.5.6 Record the worst ratio as the measure of the adjacent channel power.

<u>Or</u>: When the measured level does not comply with the specification:

The adjacent channel power not to exceed a level of – 37 dBm irrespective of the carrier power level.

2.3.6 **Intermodulation attenuation** (fixed radio stations only)

Method A: Connect the equipment as shown below.



2.3.6.1 Set the unmodulated signal level from the RF signal source to give a level, measured at the transmitter output terminal, 30 dB below the output carrier level.

2.3.6.2 With the transmitter transmitting an unmodulated carrier, vary the frequency of the RF signal source between 50 kHz and 100 kHz, above and below the carrier frequency.

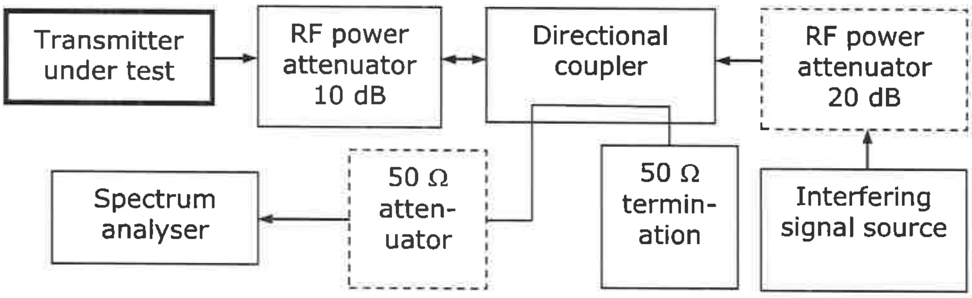
2.3.6.3 Measure the levels of the Intermodulation components.

2.3.6.4 The Intermodulation attenuation is expressed as the ratio of the carrier level to the level of the largest Intermodulation product (third order) observed.

2.3.6.5 Record the worst case as the result.

Note: Ensure that the measured response is not caused by spurious signals from the RF signal source.

Method B: Connect the equipment as shown below.



2.3.6.6 The coupling between the transmitter under test and the 10 dB RF power attenuator must be as short as possible to minimize mismatching.

2.3.6.7 The directional coupler must have an insertion loss of ≤ 1 dB, directivity of ≥ 20 dB and sufficient bandwidth.

2.3.6.8 The transmitter under test and the interfering signal source must have sufficient physical separation to prevent the measurement being influenced by direct radiation.

2.3.6.9 The RF signal level from the interfering signal source must have the same level as that of the transmitter. Alternatively, the RF signal level from the interfering signal source must be 20 dB lower than that of the transmitter – omit the 20 dB RF power attenuator.

2.3.6.10 The transmitter under test shall be unmodulated.

2.3.6.11 The spectrum analyser must be adjusted to give a maximum indication (amplitude) with a frequency scan of 500 kHz.

2.3.6.12 The interfering signal source must be unmodulated and the frequency must be varied between 50 kHz to 100 kHz above and below the frequency of the transmitter under test.

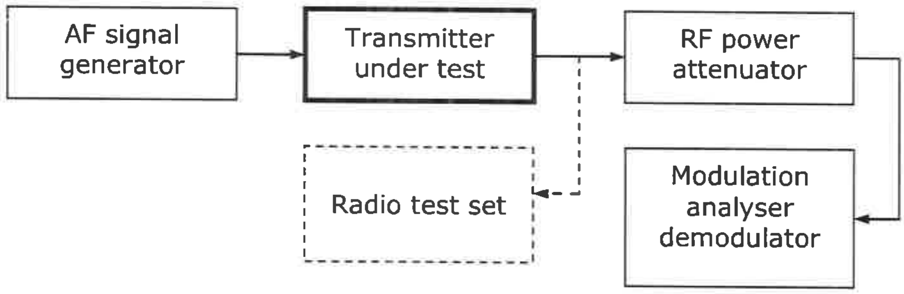
2.3.6.13 Measure the levels of the Intermodulation components on the spectrum analyser and determine the ratio of the carrier level to the level of the largest Intermodulation product (third order) observed, in dB.

2.3.6.14 Record the worst case as the result.

Note: Ensure that the measured response is not caused by spurious signals from the RF signal source.

2.3.7 **Modulation limiting** (Tx deviation)

Connect the equipment as shown below.



2.3.7.1 Ensure that the maximum deviation is set correctly and according to the manufacturer's procedure.

2.3.7.2 Apply electrically a 1 kHz audio test signal to the microphone input of the transmitter at a level sufficient to produce the standard test modulation factor.

(When an electrical input signal cannot be applied this may be replaced by an acoustical signal.)

2.3.7.3 Set the audio filter of the modulation analyser to Low Pass cut-off 15 kHz or 20 kHz.

2.3.7.4 Note the level of the audio test signal (reference).

2.3.7.5 Modulating frequency 0.3 kHz to 2.55 kHz:

2.3.7.5.1 Increase the audio test signal with 20 dB. Ensure that the measured deviation equals the maximum system deviation.

2.3.7.5.2 Without changing the audio input signal level vary the modulating frequency between 300 Hz and 2.55 kHz.

2.3.7.5.3 Record the largest positive or negative peak deviation obtained, as the modulation limit.

2.3.7.6 Modulating frequency 2.55 kHz to 6.0 kHz:

2.3.7.6.1 Decrease the audio test signal to obtain the standard test modulation factor (reference).

2.3.7.6.2 Without changing the audio input signal level vary the modulating frequency between 2.55 kHz and 6.0 kHz.

2.3.7.6.3 Record the largest positive or negative peak deviation obtained, as the modulation limit for the specific modulating frequency band.

Note: The deviation produced by the modulating frequencies between 2.55 kHz and 6.0 kHz must not exceed that of the deviation produced by the modulating frequency 2.55 kHz.

2.3.7.7 Modulating frequency 6.0 kHz to 12.5 kHz:

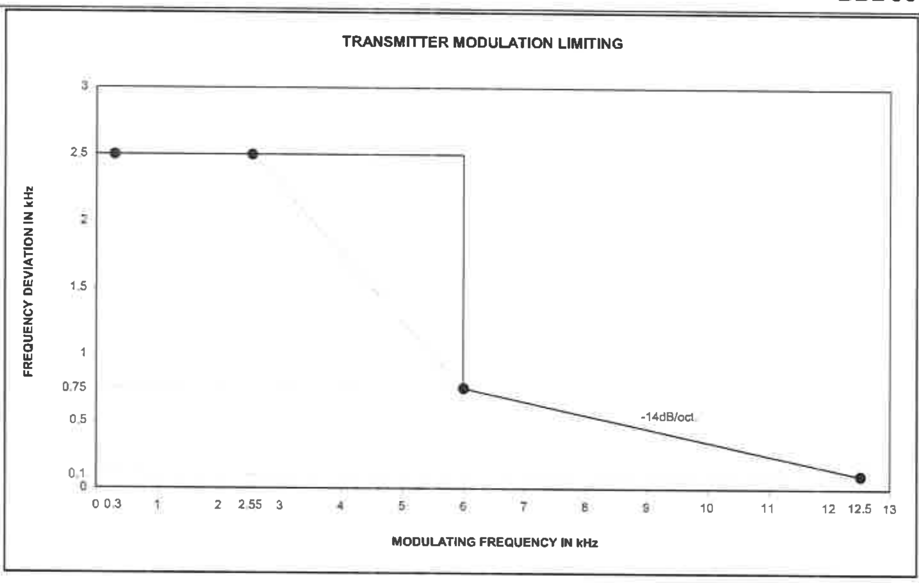
2.3.7.7.1 Obtain the standard test modulation factor (reference).

2.3.7.7.2 Without changing the audio input signal level vary the modulating frequency between 6.0 kHz and 12.5 kHz.

2.3.7.7.3 Record the decrease in the positive or negative peak deviation, as the modulation limit for the specific modulating frequency band.

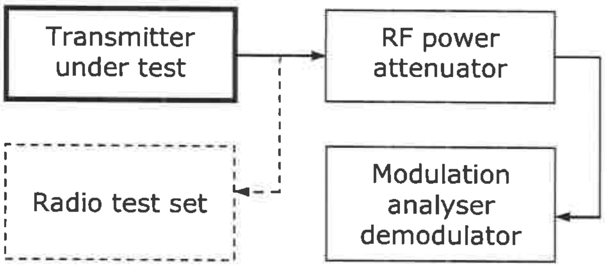
Note: Care must be taken not to generate hum when the audio signal is connected electrically.

It must be ensured that the acoustical audio source has a flat response throughout the bandwidth.



2.3.8 CTCSS deviation

Connect the equipment as shown below.



2.3.8.1 Select the CTCSS frequency and activate the function.

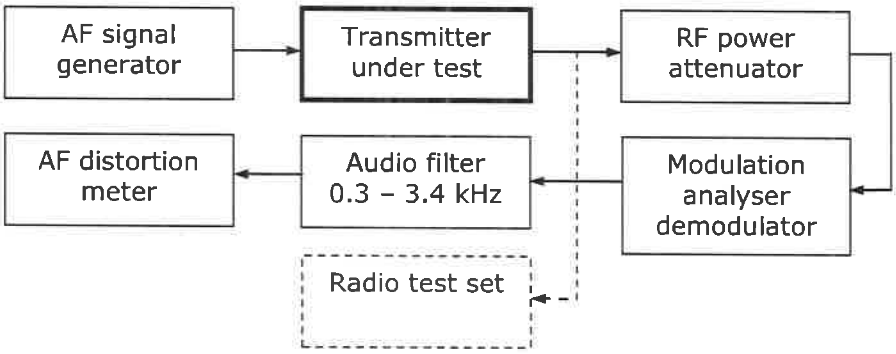
2.3.8.2 Set the audio filter of the modulation analyser to Low Pass cut-off 15 kHz or 20 kHz.

2.3.8.3 In the absence of an audio input signal (modulating signal) transmit a carrier.

2.3.8.4 Measure and record the deviation of the sub-audible tone.

2.3.9 Audio frequency total harmonic distortion (THD)

Connect the equipment as shown below.



2.3.9.1 Standard measurement

2.3.9.1.1 Apply electrically a 1 kHz audio test signal to the microphone input of the transmitter at a level sufficient to produce the standard test modulation factor.

2.3.9.1.2 Record the distortion obtained.

2.3.9.1.3 Adjust the audio signal generator frequency to 500 Hz.

2.3.9.1.4 Set the audio output signal at a level sufficient to produce the standard test modulation factor.

2.3.9.1.5 Record the distortion obtained.

Note: Care must be taken not to generate hum when the audio signal is connected electrically.

2.3.9.2 600 Ω balanced line input

Where a 600 Ω balanced line is provided, the THD must be measured on this line.

2.3.9.2.1 Load the line with a 600 Ω resistive load or equivalent impedance, provided by the test instrument.

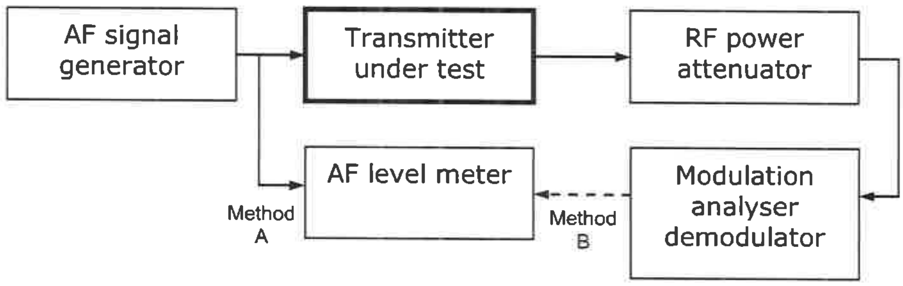
2.3.9.2.2 Inject a 1 kHz audio test signal into the line at a level of –10 dBm.

2.3.9.2.3 Ensure that the transmitting signal deviation comply with the standard test modulation factor.

2.3.9.2.4 Measure and record the THD.

2.3.10 Audio frequency response

Connect the equipment as shown below.



2.3.10.1 Standard measurement

Method A.

2.3.10.1.1 Apply electrically a 1 kHz audio test signal to the microphone input of the transmitter at a level sufficient to obtain 20 % of the maximum system deviation.

2.3.10.1.2 Select the low pass filter (cut-off 20 kHz) at the modulation analyser.

2.3.10.1.3 Vary the modulating frequency (audio signal) from 300 Hz to 3 kHz.

2.3.10.1.4 Adjust the modulating frequency level (audio signal) to maintain the modulation factor constant.

2.3.10.1.5 Record the variation in the audio output level of the AF signal generator in dB with reference to the corresponding level at 1 kHz.

Method B.

2.3.10.1.6 Apply electrically a 1 kHz audio test signal to the microphone input of the transmitter at a level sufficient to obtain 20 % of the maximum system deviation.

2.3.10.1.7 Select the low pass filter (cut-off 20 kHz) at the modulation analyser.

2.3.10.1.8 Keeping the audio signal level constant, vary the frequency from 300 Hz to 3 kHz.

2.3.10.1.9 Record the variation in the audio output level from the demodulator in dB with reference to the corresponding level at 1 kHz.

Note: The + and – signs must be inverted to be able to apply the graph.

2.3.10.2 600 Ω balanced line input

Where a 600 Ω balanced line is provided, the audio frequency response must be measured on this line.

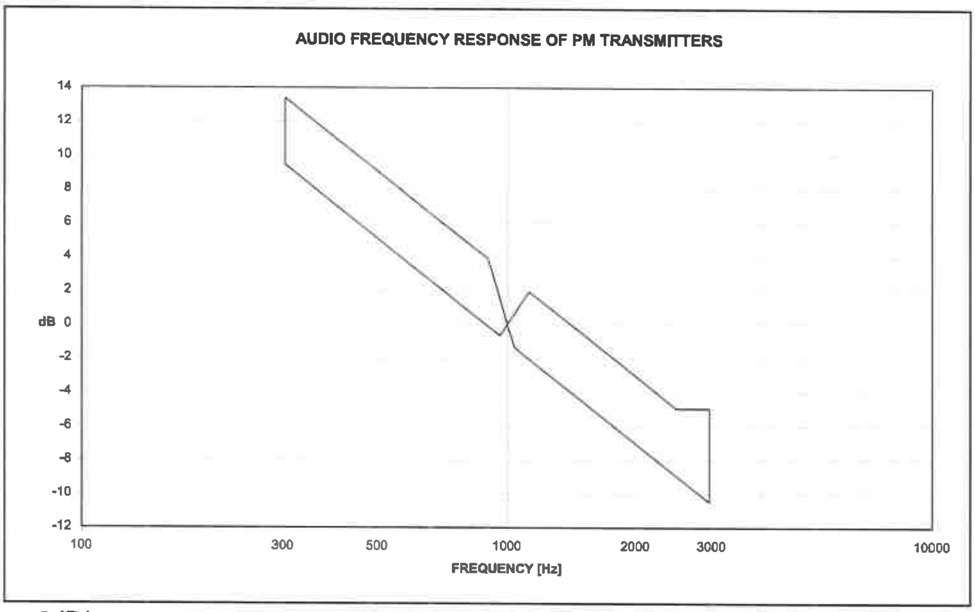
2.3.10.2.1 Load the line with a 600 Ω resistive load or equivalent impedance, provided by the test instrument.

2.3.10.2.2 Inject a 1 kHz audio test signal into the line at a level of – 10 dBm.

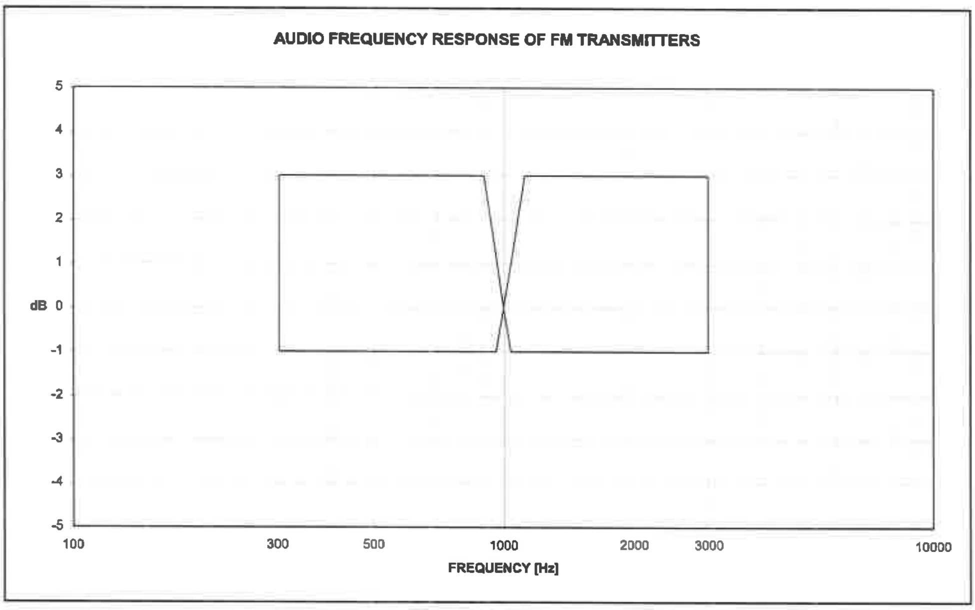
2.3.10.2.3 Ensure that the transmitting signal deviation comply with the standard test modulation factor.

2.3.10.2.4 Reduce the audio signal level to obtain 20 % of the maximum system deviation.

2.3.10.2.5 Proceed with test method A (2.3.10.1.2 to 2.3.10.1.5) or test method B (2.3.10.1.7 to 2.3.10.1.9)

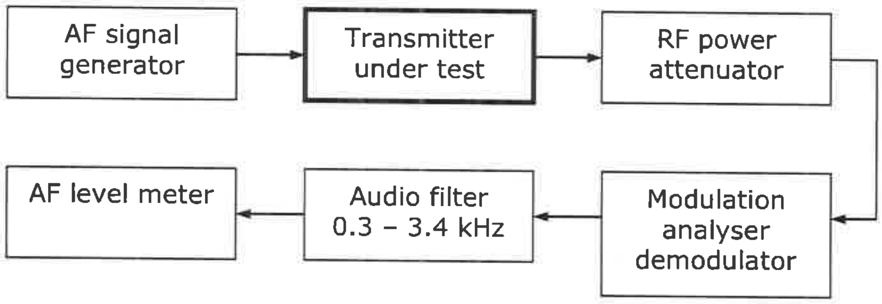


6dB/octave slope



2.3.11 Angle modulation hum and noise ratio

Connect the equipment as shown below.



2.3.11.1 Apply electrically a 1 kHz audio test signal to the microphone input of the transmitter at a level sufficient to produce the standard test modulation factor.

2.3.11.2 Record the audio output level from the modulation analyser demodulator.

2.3.11.3 Remove the modulation from the transmitter.

2.3.11.4 Again record the audio output level from the modulation analyser demodulator.

2.3.11.5 Calculate the angle modulation hum and noise ratio by determining the difference between the two measurements in dB.

Note: Care must be taken not to generate hum when the audio signal is connected electrically.

Short circuit the audio input connections of the radio transmitter when the audio signal is removed.

2.3.12 Amplitude modulation hum and noise level

Connect the equipment as shown below.

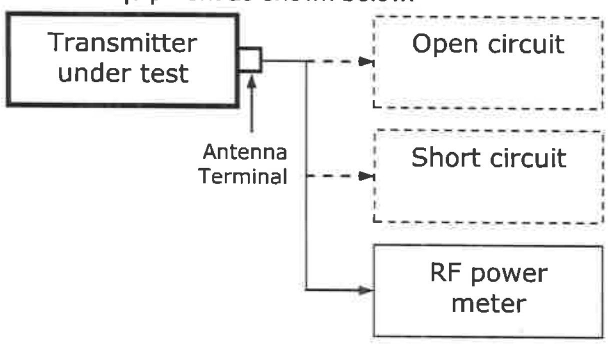
2.3.12.1 Set the modulation analyser to measure the RMS AM modulation factor (m %).

2.3.12.2 In the absence of an audio input signal (modulating signal) measure the modulation factor.

2.3.12.3 Calculate the AM hum and noise level as follow:
AM hum and noise level (dB) = 20Log(2 m/100)

2.3.13 Extreme transmitter loads

Connect the equipment as shown below.



2.3.13.1 Measure the carrier power in the absence of modulation.

2.3.13.2 Operate the transmitter under open and short circuit load conditions for a period of:
2.3.13.2.1 One minute each in the case of a transmitter rated for intermittent duty cycle.
2.3.13.2.2 Five minutes each in the case of a transmitter rated for continuous operation.

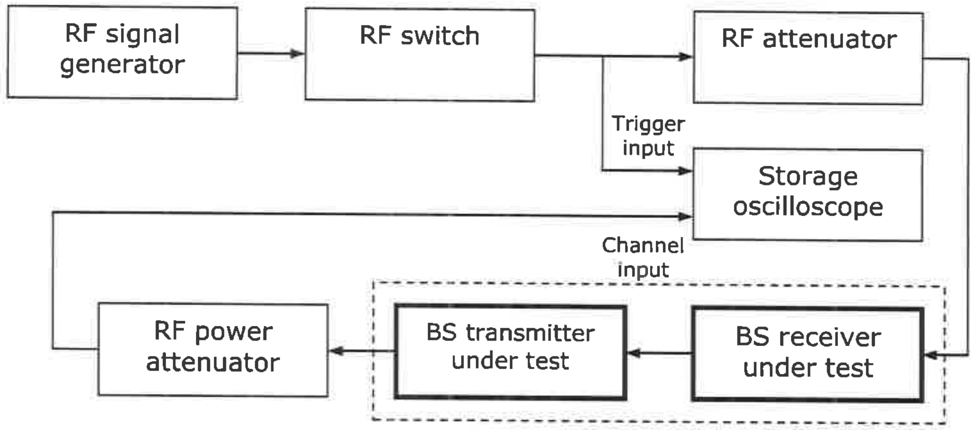
2.3.13.3 After each exposure to the extreme load measure the carrier power in the absence of modulation.

2.3.13.4 Calculate the variation of the carrier power in dB with reference to clause 2.3.13.1.

2.4 High Site Equipment

2.4.1 Radio Base Station Response Time

Connect the equipment as shown below.



2.4.1.1 Apply a standard RF test signal to the receiver under test.

2.4.1.2 Determine the usable sensitivity as described in clause 2.2.3.

2.4.1.3 Adjust the squelch to open at a RF signal level of – 115 dBm, measured at the antenna terminal.

2.4.1.4 Set the RF signal level 12 dB above the usable sensitivity level.

2.4.1.5 Set the storage oscilloscope to single sweep operation.

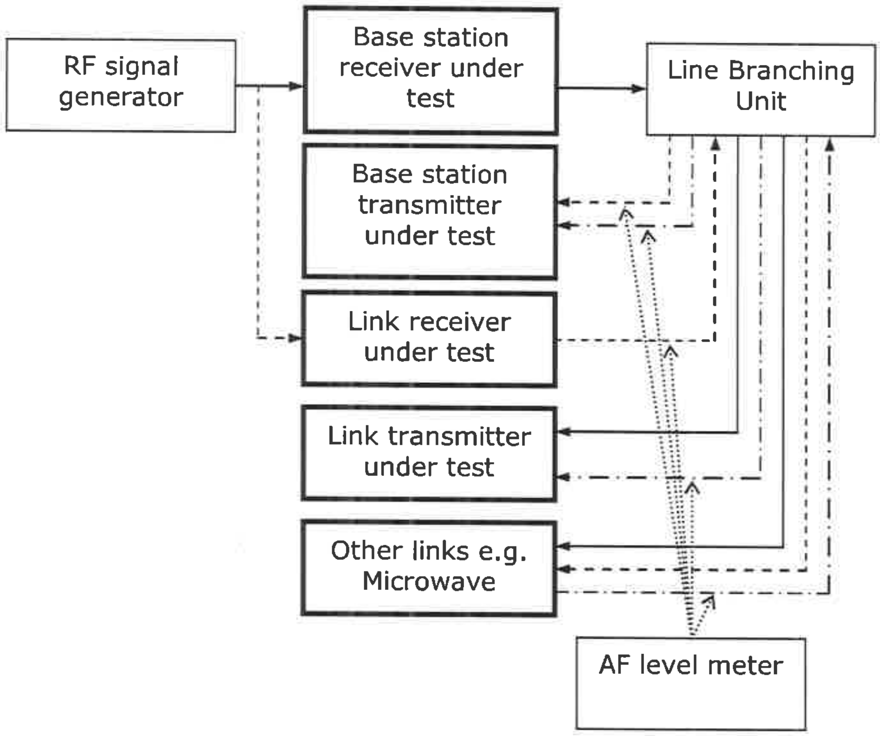
2.4.1.6 Enable the RF switch and measure the time required for the unmodulated transmit carrier voltage level to reach a value 6 dB (50 %) below the steady state level.

2.4.1.7 Repeat the measurement three times and take the average of the three measurements as the repeater attack time.

2.4.2 **Talk Through Signal**

2.4.2.1 **Audio levels**

Connect the equipment as shown below.



2.4.2.1.1 Adjust the RF signal generator to produce the standard RF test signal.

2.4.2.1.2 Connect the audio lines to the units as it would be connected when in operation. This is to ensure that the lines are correctly loaded.

2.4.2.1.3 Set the audio frequency level meter to high impedance/bridge mode. This is to ensure that the level meter does not load the lines.

2.4.2.1.4 Measure the audio level from the source (Rx) first. Adjust the level if necessary.

2.4.2.1.5 Measure all the outgoing lines from the LBU and adjust the levels if necessary.

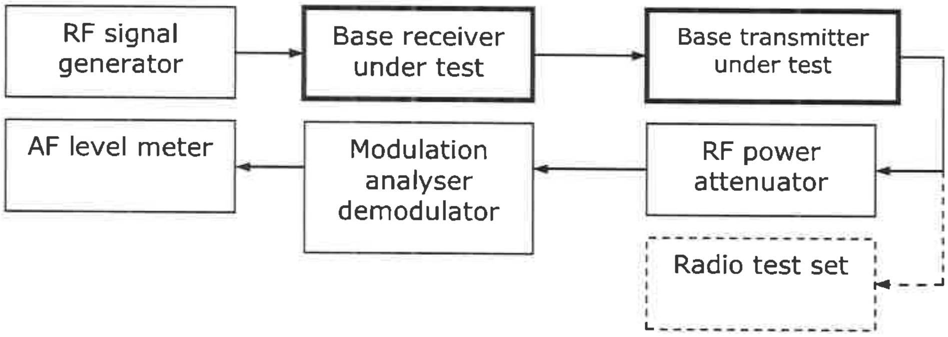
2.4.2.1.6 Use the method described in clauses 2.4.2.1.1 to 2.4.2.1.4 to measure and adjust the audio level from the link receiver.

2.4.2.1.7 Measure the audio level from the microwave and adjust if necessary.

Note: The same measuring method is used on the Trunked radio equipment.

2.4.2.2 Audio Frequency Response

Connect the equipment as shown below.



2.4.2.2.1 Ensure that all the audio level settings have been set correctly.

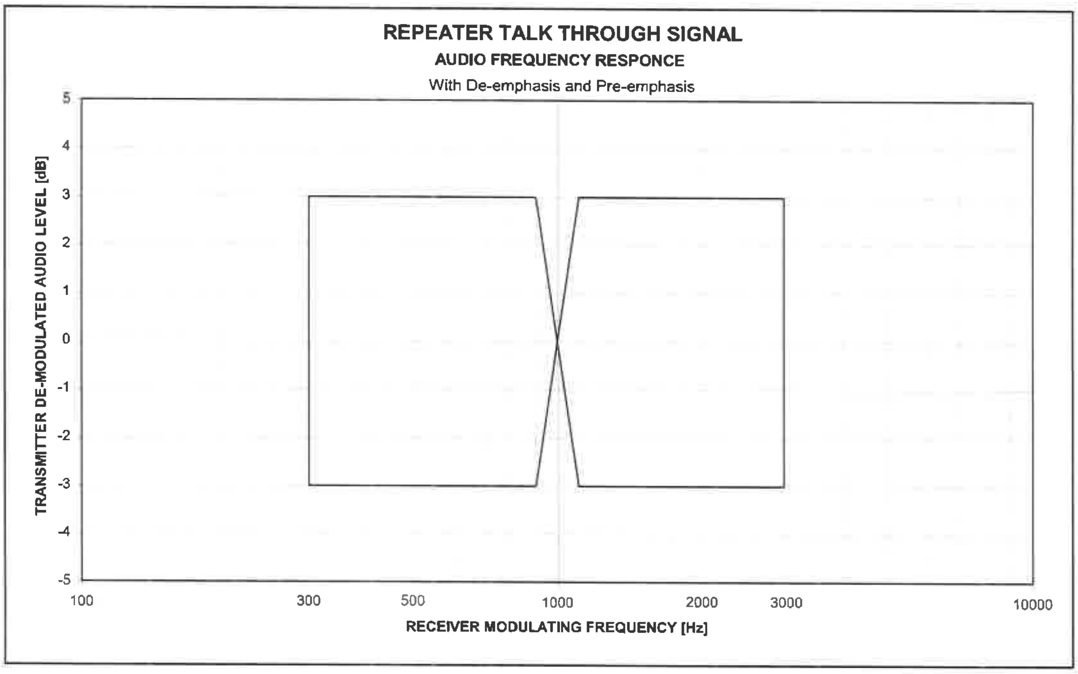
2.4.2.2.2 Adjust the RF signal generator to produce the standard RF test signal.

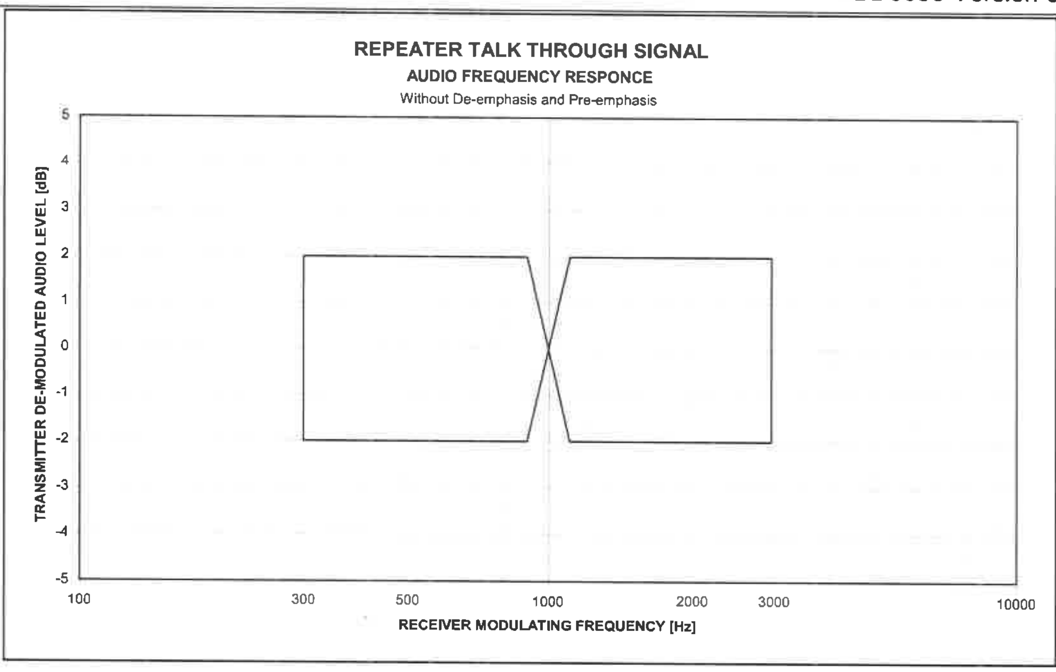
2.4.2.2.3 Select the low pass filter (cut-off 20 kHz) at the modulation analyser.

2.4.2.2.4 While keeping the modulation factor constant vary the modulating frequency over the range 300 Hz to 3 kHz.

2.4.2.2.5 Record the variation in the audio output power from the demodulator over this range in dB with reference to the corresponding level at 1 kHz.

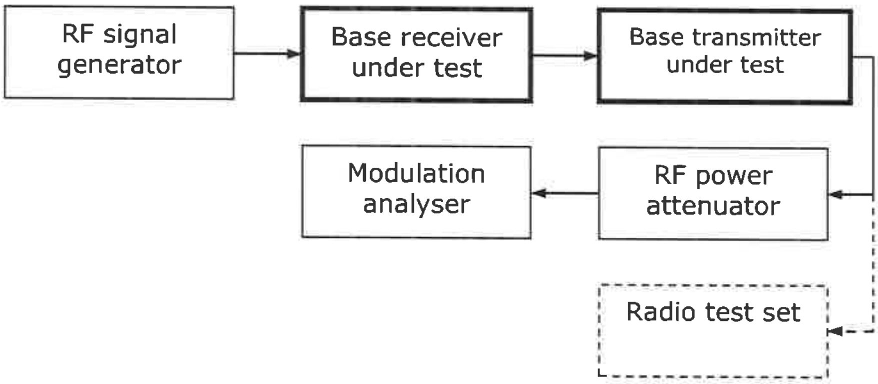
2.4.2.2.6 Branches to the link radio and other links must also be measured.





2.4.2.3 **Modulation factor linearity**

Connect the equipment as shown below.



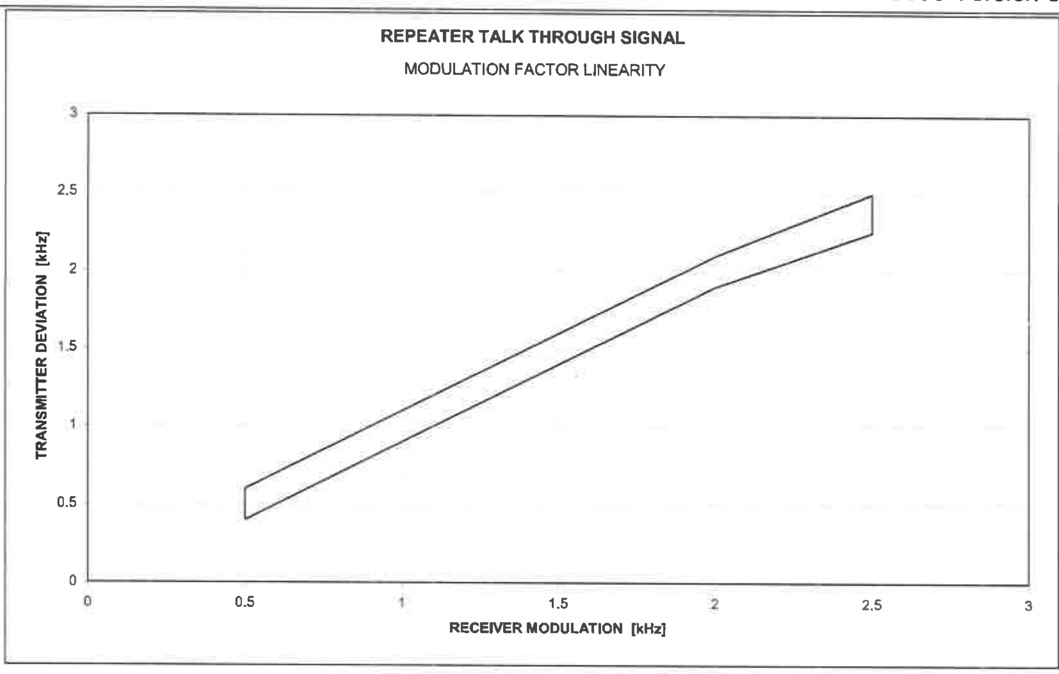
2.4.2.3.1 Ensure that the transmitter modulation limiting (deviation) has been set correctly (see clause 2.3.7).

2.4.2.3.2 Ensure that all the audio levels have been set correctly (see clause 2.4.2.1).

2.4.2.3.3 Apply a standard RF test signal from the RF signal generator to the receiver.

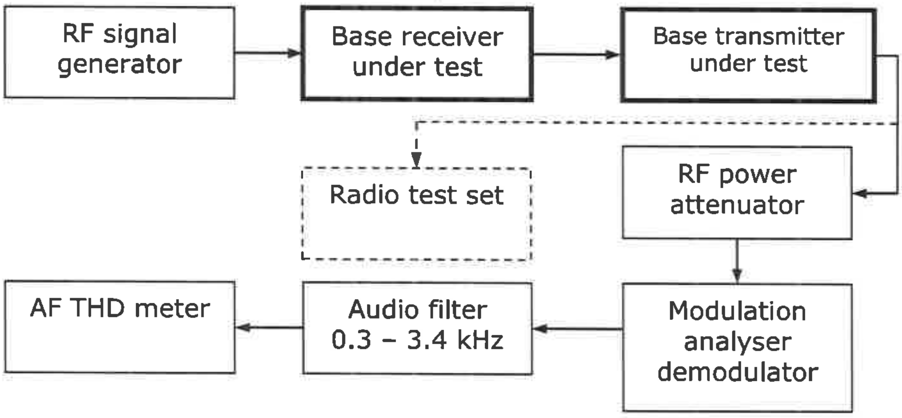
2.4.2.3.4 Vary the modulation of the RF input signal between 0.5 kHz and 2.5 kHz and measure the transmitter deviation.

2.4.2.3.5 Branches to the link radio and other links must also be measured.



2.4.2.4 **<u>Audio frequency THD</u>**

Connect the equipment as shown below.



2.4.2.4.1 Ensure that all the audio levels are set correctly.

2.4.2.4.2 Apply a standard RF test signal to the receiver under test.

2.4.2.4.3 Record the audio total harmonic distortion from the transmitter.

2.4.2.4.4 Branches to the link radio and other links must also be measured.

2.4.3 Filters

2.4.3.1 Duplexer

The best method to check or tune a duplexer is to use a Transmission Line Analyser. This measuring method will not be covered in this document.
If any problem is detected the duplexer/combiner must be send to a facility with the proper equipment and competency. Do not attempt the tune the unit.

A RF signal generator and a test receiver/spectrum analyser could be used to make measurements.

2.4.3.1.1 **Calibration**

2.4.3.1.1.1 Connect the RF signal generator with the two connecting cables to the test receiver or spectrum analyser.

2.4.3.1.1.2 Tune the RF signal generator and the test receiver/spectrum analyser to the in-band receiving/transmitting frequency to be measured.

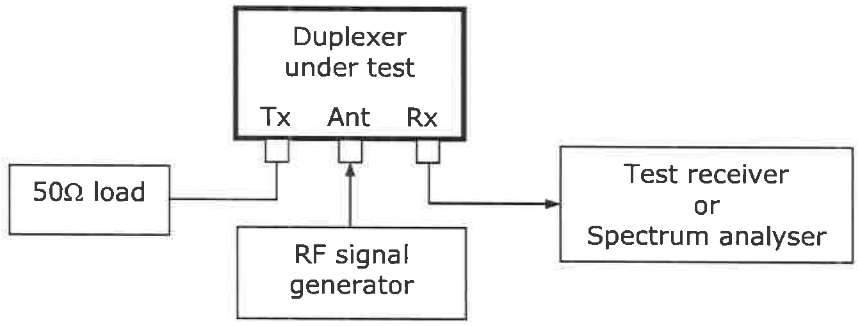
2.4.3.1.1.3 Set the output level of the RF signal generator as required:
e.g. Low-level : ≤ – 60 dBm
High-level : 0 dBm.

2.4.3.1.1.4 Record the difference between the applied and measured signal level. The difference must be included in the calculations.

Note: This method compensates for differences and the connecting cable losses.

2.4.3.1.2 **Insertion loss - Rx**

Connect the equipment as shown below.



2.4.3.1.2.1 Tune the RF signal generator and the test receiver/spectrum analyser to the in-band receiving frequency to be measured.

2.4.3.1.2.2 Inject the signal at the antenna port (low level) and measure the level at the receiving port.

2.4.3.1.2.3 Calculate the insertion loss by determining the difference between the injected signal level and the measured level in dB.

2.4.3.1.2.4 The insertion loss must comply throughout the operating band.

At the high site this measurement can be made in the following way:

2.4.3.1.2.5 Connect the RF signal generator directly to the receiver.

2.4.3.1.2.6 Adjust the RF signal generator to produce a standard RF test signal.

2.4.3.1.2.7 Decrease the RF signal level till the squelch closes.

2.4.3.1.2.8 Increase the RF signal level **slowly** and note the level when the squelch open.

2.4.3.1.2.9 Connect the RF signal generator to the receiver via the duplexer (Ant port).

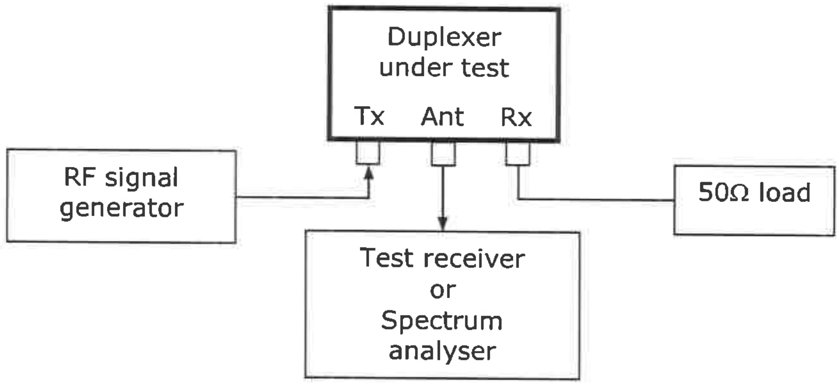
2.4.3.1.2.10 Repeat the procedure from clause 2.4.3.1.2.6 to 2.4.3.1.2.8.

2.4.3.1.2.11 Calculate the insertion loss by determining the difference between the two recorded signal levels in dB.

Note: When the result is within specification, the insertion loss through the coaxial cable between the receiver and duplexer can be ignored.

2.4.3.1.3 **Insertion loss - Tx**

Connect the equipment as shown below.



2.4.3.1.3.1 Tune the RF signal generator and the test receiver/spectrum analyser to the in-band transmitting frequency to be measured.

2.4.3.1.3.2 Inject the signal at the transmitting port (high level) and measure the level at the antenna port.

2.4.3.1.3.3 Calculate the insertion loss by determining the difference between the injected signal level and the measured level in dB.

2.4.3.1.3.4 The insertion loss must comply throughout the operating band.

At the high site this measurement can be made in the following way:

2.4.3.1.3.5 Connect a terminated wattmeter directly to the transmitter.

2.4.3.1.3.6 Measure the un-modulated carrier power from the transmitter.

2.4.3.1.3.7 Connect the same terminated wattmeter to the transmitter via the duplexer (Antenna port).

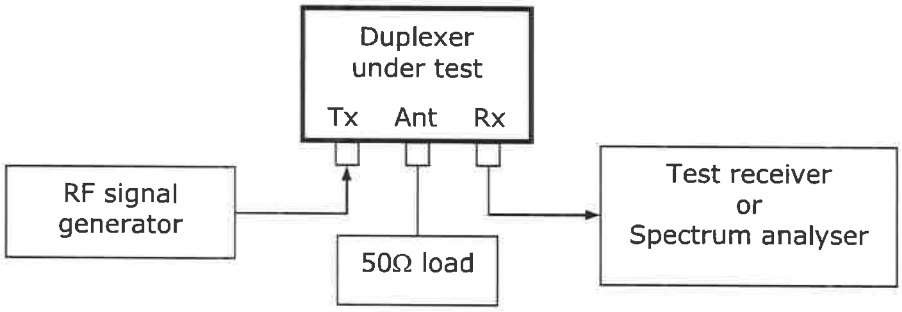
2.4.3.1.3.8 Measure the un-modulated carrier power from the transmitter.

2.4.3.1.3.9 Calculate the insertion loss by determining the difference between the two measured power levels in dB.

Note: When the result is within specification, the insertion loss through the coaxial cable between the transmitter and duplexer can be ignored.

2.4.3.1.4 **Isolation between the transmitting and receiving paths**

Connect the equipment as shown below.



2.4.3.1.4.1 Tune the RF signal generator and the test receiver/spectrum analyser to the in-band transmitting frequency to be measured.

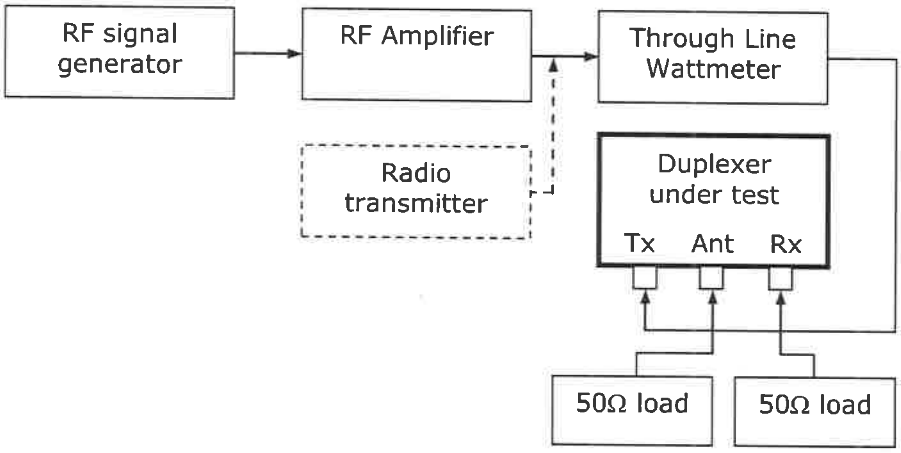
2.4.3.1.4.2 Inject the signal at the transmitting port (high level) and measure the level at the receiving port.

2.4.3.1.4.3 Calculate the isolation by determining the difference between the injected signal level and the measured level in dB.

2.4.3.1.4.4 The isolation must comply throughout the operating band.

2.4.3.1.5 **Impedance matching**

Connect the equipment as shown below.



2.4.3.1.5.1 Tune the RF signal generator to the in-band transmitting frequency to be measured.

2.4.3.1.5.2 Measure the Voltage Standing Wave Ratio (VSWR) with a through line wattmeter.

2.4.3.1.5.3 If the wattmeter does not indicate the VSWR, note the forward and reflected power and calculate the VSWR.

$(1+\sqrt{\text{Power reflected/Power forward}}) / (1-\sqrt{\text{Power reflected/Power forward}})$

2.4.3.1.5.4 The impedance matching must comply throughout the operating band.

2.4.3.1.5.5 Use the same method to measure the impedance at the receiver and antenna terminals.

2.4.3.2 **Combiner**

2.4.3.2.1 **Insertion loss - Rx**

2.4.3.2.1.1 The insertion loss can be measured as explained in clause 2.4.3.1.2.

2.4.3.2.1.2 Fifty-ohm loads must be connected to all open transmitting and receiving ports.

2.4.3.2.1.3 The injected signal level at the antenna port must be low (≤ – 80 dBm) to prevent the RF amplifier in the receiving path being saturated.

2.4.3.2.1.4 All the receiving ports must be measured.

2.4.3.2.1.5 The insertion loss must comply throughout the operating band.

2.4.3.2.2 **Insertion loss - Tx**

2.4.3.2.2.1 The insertion loss can be measured as explained in clause 2.4.3.1.3.

2.4.3.2.2.2 Fifty-ohm loads must be connected to all open transmitting and receiving ports.

2.4.3.2.2.3 All the transmitting ports must be measured.

2.4.3.2.2.4 The insertion loss must comply throughout the operating band.

2.4.3.2.3 **Isolation between the transmitting and receiving paths**

2.4.3.2.3.1 The isolation between the transmitting and receiving paths can be measured as explained in clause 2.4.3.1.4.

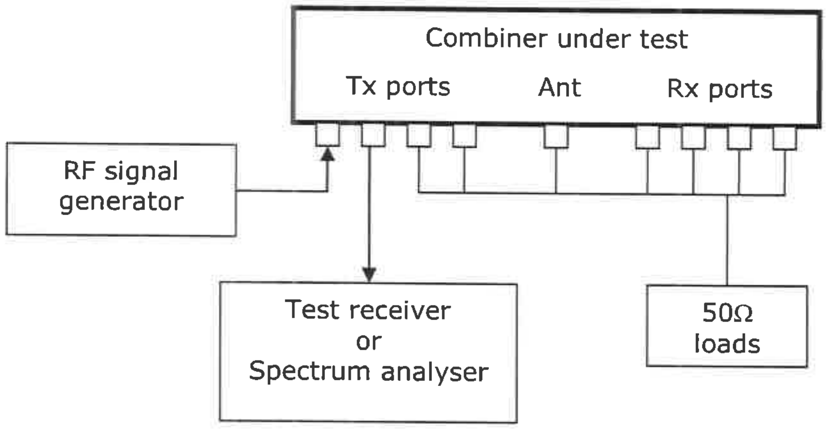
2.4.3.2.3.2 Fifty-ohm loads must be connected to all open transmitting and receiving ports.

2.4.3.2.3.3 All the ports must be measured.

2.4.3.2.3.4 The isolation must comply throughout the operating band.

2.4.3.2.4 **Isolation between the transmitting ports**

Connect the equipment as shown below



2.4.3.2.4.1 Tune the RF signal generator and the test receiver/spectrum analyser to the in-band transmitting frequency to be measured.

2.4.3.2.4.2 Fifty-ohm loads must be connected to the antenna- and all open transmitting and receiving ports.

2.4.3.2.4.3 Inject the signal at the first transmitting port (high level) and measure the level at the other transmitting ports.

2.4.3.2.4.4 Repeat step 2.4.3.2.4.3 when injecting the signal at ports 2 to 4.

2.4.3.2.4.5 Calculate the isolation by determining the difference between the injected signal level and the measured level in dB.

2.4.3.2.4.6 The isolation must comply throughout the operating band.

2.4.3.2.5 **Impedance matching**

2.4.3.2.5.1 The impedance matching can be determined as explained in clause 2.4.3.1.5.

2.4.3.2.5.2 Fifty-ohm loads must be connected to all open transmitting and receiving ports.

2.4.3.2.5.3 All the transmitting ports must be measured.

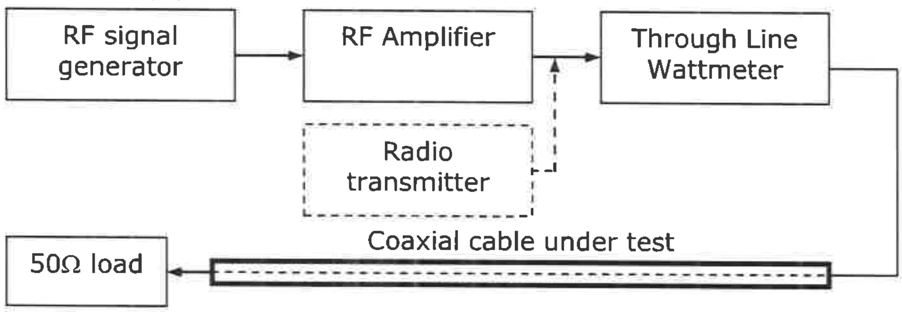
Note: **Do not** use this method to determine the impedance matching at the receiver and antenna terminals. If a problem is suspected, the combiner must be send to a facility with the proper equipment and competency.

2.4.4 Coaxial Cable

2.4.4.1 **Impedance matching**

The best method to measure the impedance and insertion loss of the coaxial cable is to use a Transmission Line Analyser. This measuring method will not be covered in this document.

Connect the equipment as shown below.



2.4.4.1.1 Tune the RF signal generator to the in-band transmitting frequency.

2.4.4.1.2 Measure the Voltage Standing Wave Ratio (VSWR) with a through line wattmeter.

2.4.4.1.3 If the wattmeter does not indicate the VSWR, note the forward and reflected power and calculate the VSWR (see clause 2.4.3.1.5.3).

2.4.4.1.4 Tune the RF signal generator to the in-band receiving frequency.

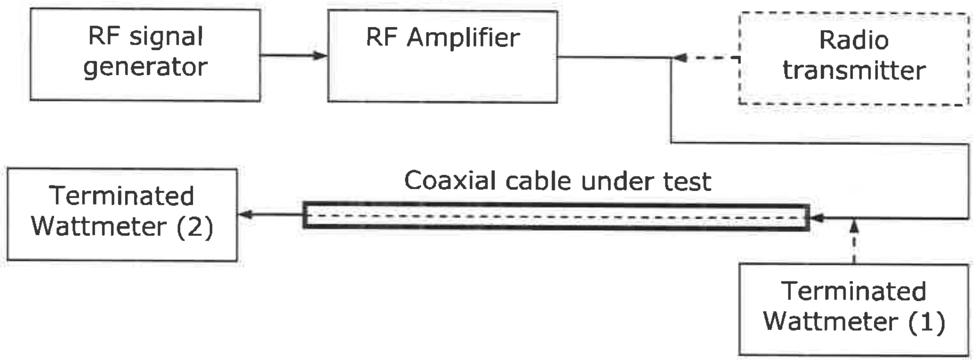
2.4.4.1.5 Measure the Voltage Standing Wave Ratio as above.

2.4.4.1.6 The impedance matching must comply throughout the operating band.

2.4.4.1.7 Record the worst case as the impedance matching.

2.4.4.2 Insertion loss

Connect the equipment as shown below.



2.4.4.2.1 Tune the RF signal generator to the in-band transmitting frequency.

2.4.4.2.2 Measure the power at the near end of the coaxial cable using the terminated wattmeter (1).

2.4.4.2.3 Measure the power at the far end of the coaxial cable using the same terminated wattmeter (2).

2.4.4.2.4 Calculate the insertion loss by determining the difference between the power levels measured in dB.

2.4.4.2.5 Tune the RF signal generator to the in-band receiving frequency.

2.4.4.2.6 Repeat the measurements as above.

2.4.4.2.7 The insertion loss must comply throughout the operating band.

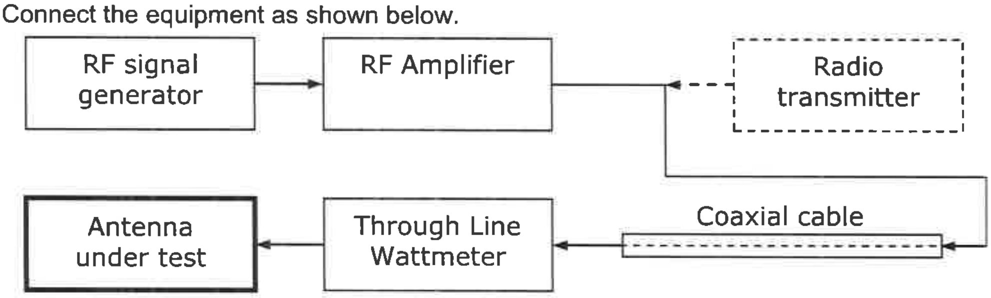
2.4.4.2.8 Record the highest loss measured, as the insertion loss.

2.4.5 Antenna

2.4.5.1 Impedance matching

The best method to measure the impedance of the antenna is to use a Transmission Line Analyser. This measuring method will not be covered in this document.

Connect the equipment as shown below.



2.4.5.1.1 The impedance matching of the coaxial cable (clause 2.4.4.1) must be measured first.

2.4.5.1.2 Tune the RF signal generator to the in-band transmitting frequency.

2.4.5.1.3 Measure the Voltage Standing Wave Ratio (VSWR) with a through line wattmeter.

2.4.5.1.4 If the wattmeter does not indicate the VSWR, note the forward and reflected power and calculate the VSWR (see clause 2.4.3.1.5.3).

2.4.5.1.5 Tune the RF signal generator to the in-band receiving frequency.

2.4.5.1.6 Measure the Voltage Standing Wave Ratio as above.

2.4.5.1.7 The impedance matching must comply throughout the operating band.

2.4.5.1.8 Record the worst case as the impedance matching.

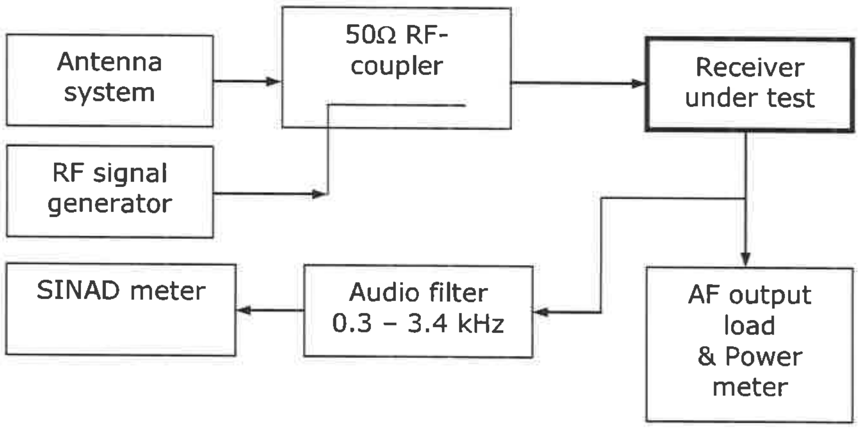
2.4.5.2 Effective Radiated Power (ERP)

2.4.5.2.1 The effective radiated power is calculated as follows:
The RF power measured into a 50 Ω load that replaces the antenna, times the gain of the antenna with reference to a Dipole antenna (dBd).

2.4.5.2.2 The following calculation could also be used:
Antenna gain (dBd) - Duplexer/combiner insertion loss (dB) - Coaxial cable insertion loss (dB) + Transmitting power at transmitter (dBm). Convert the result to Watts (0.001 x Antilog(dB/10)).

2.4.6 **Receiver Desensitisation** (Desensing)

Connect the equipment as shown below.



2.4.6.1 The transmitting power of all the transmitters must be set correctly.

2.4.6.2 The insertion loss of the RF-coupler must be ≤ 1 dB.

2.4.6.3 Adjust the RF signal generator to produce the standard test signal and apply it to the receiver via the RF-coupler.

2.4.6.4 Reduce the RF signal output level until the SINAD ratio is 12 dB.

2.4.6.5 Note the RF signal level at which the 12 dB SINAD is obtained.

2.4.6.6 Transmit from the other transmitters situated on the site.

2.4.6.7 Note if the SINAD ratio is degrading.

2.4.6.8 If so, while transmitting increase the RF signal output from the generator to obtain a SINAD ratio of 12 dB.

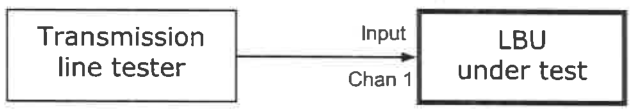
2.4.6.9 Note the RF signal level.

2.4.6.10 Calculate the desensing level by determining the difference between the two measurements in dB.

2.4.7 **Audio Line Branching Unit (LBU)**

2.4.7.1 Impedance matching

Connect the equipment as shown below.



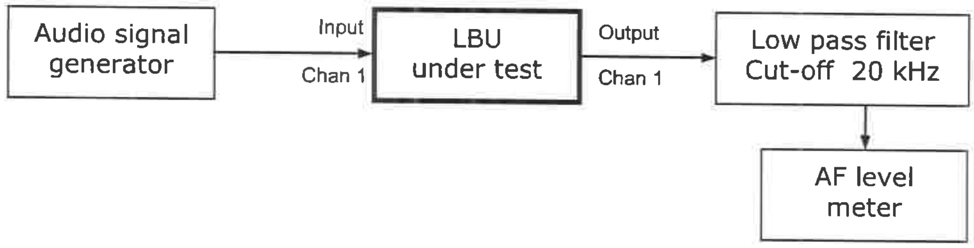
2.4.7.1.1 Switch the power of the LBU on.

2.4.7.1.2 Measure the return loss of the input transformer to determine the impedance matching.

2.4.7.1.3 Repeat the measurement to determine the impedance matching of the other input and output terminals.

2.4.7.2 **Audio levels**

Connect the equipment as shown below.



2.4.7.2.1 Ensure that the audio signal generator and audio level meter are set to the correct impedance.

2.4.7.2.2 Route all the input terminals to all the output terminals. This is required for the tests that follow.

2.4.7.2.3 Apply a 1 kHz signal at a level of – 10 dBm into channel 1 of the LBU.

2.4.7.2.4 Measure the signal level at the output terminals of the LBU.

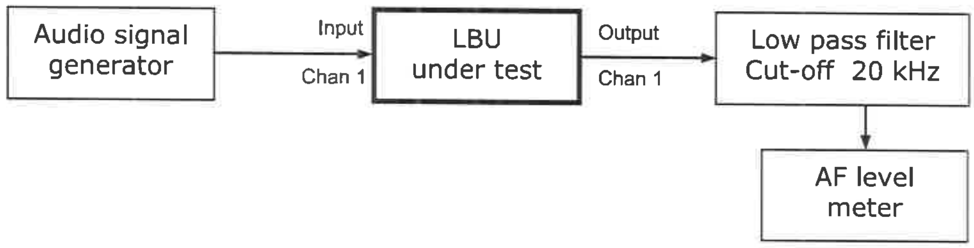
2.4.7.2.5 Adjust the output levels to obtain – 10 dBm if necessary.

2.4.7.2.6 Repeat the measurements with the audio signal applied to the other input terminals.

2.4.7.2.7 All output levels should be – 10 dBm without readjustment.

2.4.7.3 **Audio frequency response**

Connect the equipment as shown below.



2.4.7.3.1 Ensure that all the audio levels are set correctly.

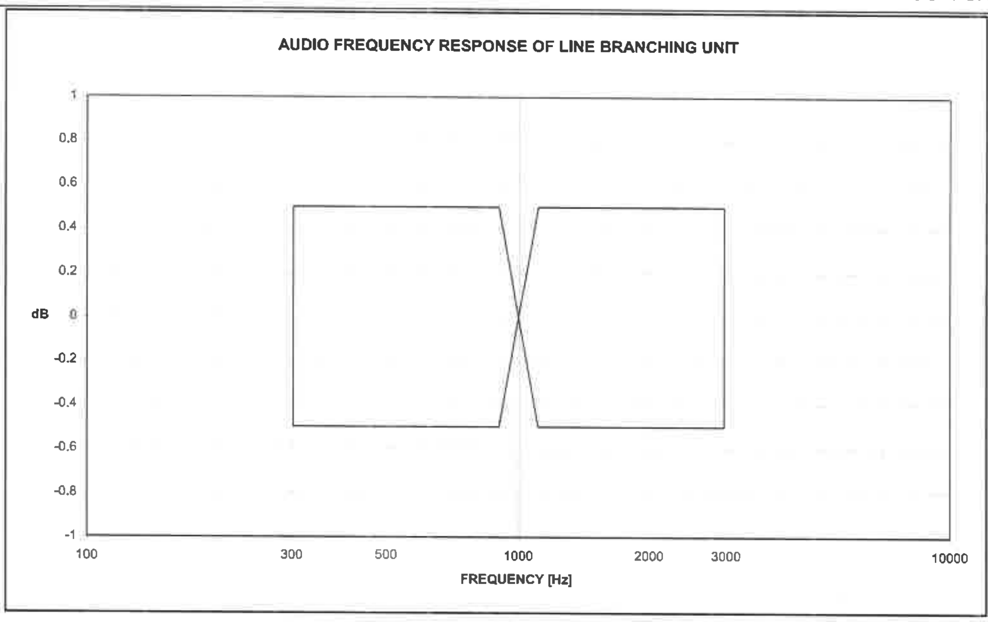
2.4.7.3.2 Apply a 1 kHz signal at a level of – 10 dBm into channel 1 of the LBU.

2.4.7.3.3 Measure the signal level at the output terminal of channel 1.

2.4.7.3.4 While keeping the audio signal level constant vary the frequency from 300 Hz to 3 kHz.

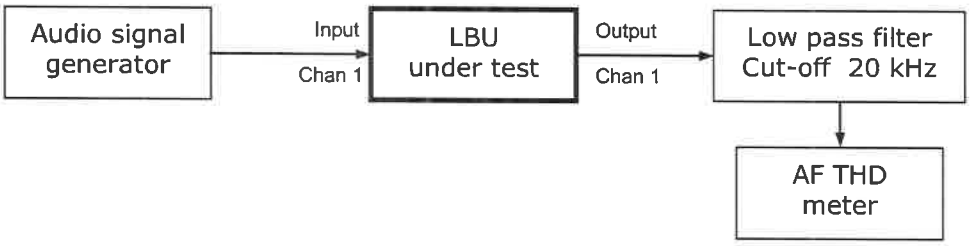
2.4.7.3.5 Record the variation of the audio output level in dB with reference to the corresponding level at 1 kHz.

2.4.7.3.6 Repeat the measurements with the audio signal applied to the other input terminals.



2.4.7.4 **Audio total harmonic distortion** (THD)

Connect the equipment as shown below.



2.4.7.4.1 Ensure that all the audio levels are set correctly.

2.4.7.4.2 Route all the input terminals to all the output terminals.

2.4.7.4.3 Ensure that the audio signal generator and THD meter are set to the correct impedance.

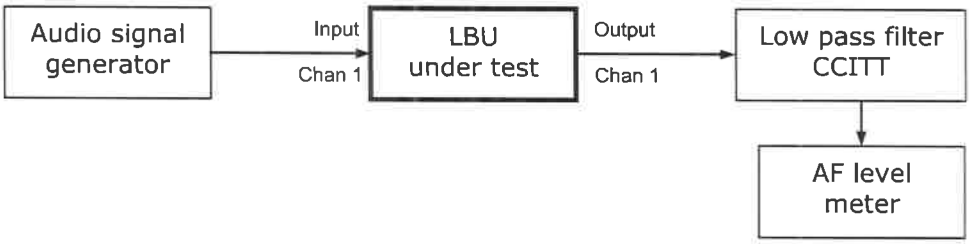
2.4.7.4.4 Apply a 1 kHz signal at a level of – 10 dBm into channel 1 of the LBU.

2.4.7.4.5 Record the audio total harmonic distortion obtained at the output terminals.

2.4.7.4.6 Repeat the measurements with the audio signal applied to the other input terminals.

2.4.7.5 **Audio signal to hum and noise ratio**

Connect the equipment as shown below.



2.4.7.5.1 Ensure that all the audio levels are set correctly.

2.4.7.5.2 Route all the input terminals to all the output terminals.

2.4.7.5.3 Apply a 1 kHz signal at a level of – 10 dBm into channel 1 of the LBU.

2.4.7.5.4 Short-circuit all the other input terminals.

2.4.7.5.5 Measure the signal level at the output terminals of the LBU.

2.4.7.5.6 Remove the audio signal generator and short circuit the input terminal (1) of the LBU.

2.4.7.5.7 Measure the signal level at the output terminals of the LBU.

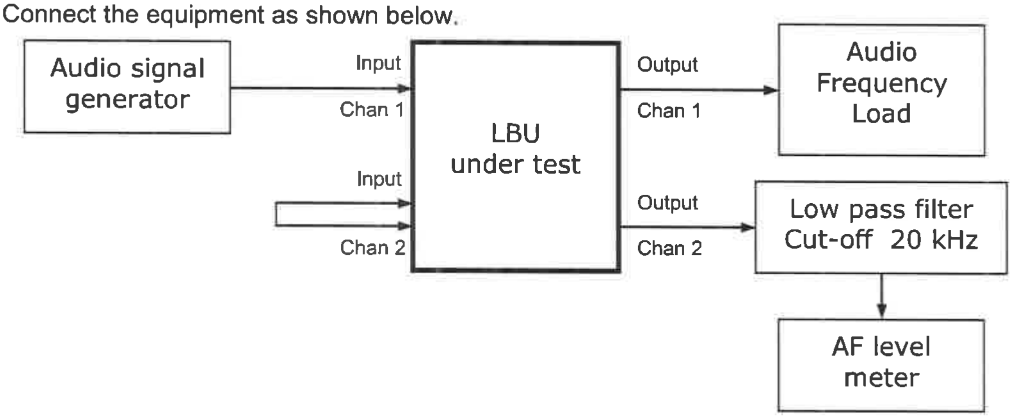
2.4.7.5.8 Calculate the ratio in dB between the audio output levels obtained with and without the applied audio signal, as the signal to hum and noise ratio.

2.4.7.5.9 Repeat the measurements with the audio signal applied to the other input terminals.

2.4.7.5.10 Record the lowest ratio as the result.

2.4.7.6 **Channel cross talk**

Connect the equipment as shown below.



2.4.7.6.1 Route all the channels to operate separately e.g. Channel 1 input terminal to channel 1 output terminal; channel 2 input terminal to channel 2 output terminal; etc.

2.4.7.6.2 Ensure that all the level settings are correct for each channel.

2.4.7.6.3 Inject a 1 kHz signal at a level of – 10 dBm into channel 1 of the LBU.

2.4.7.6.4 Short-circuit all the other input terminals.

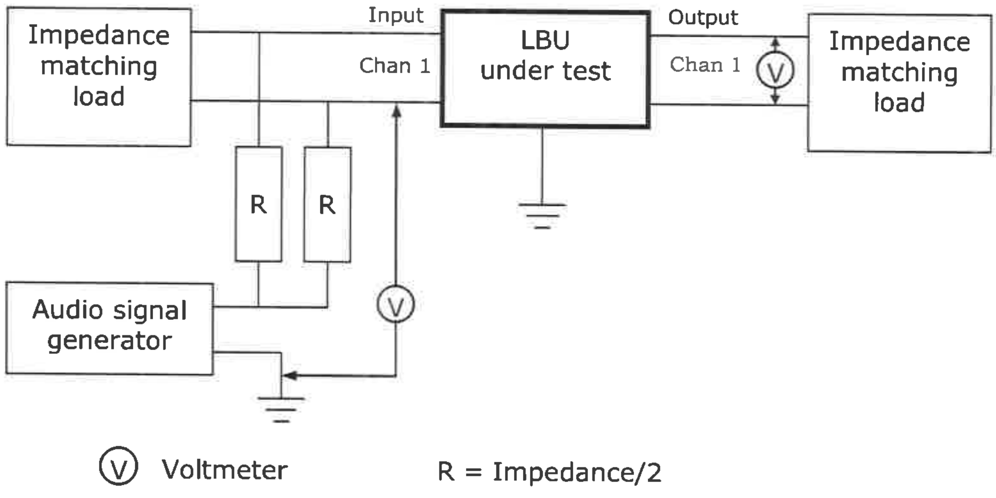
2.4.7.6.5 Calculate the ratio in dB between the audio input signal level and that measured at the other output terminals, except that of channel 1.

2.4.7.6.6 Repeat the measurements with the audio signal injected into the other input terminals.

2.4.7.6.7 Record the worst case as the result.

2.4.7.7 **Common-mode rejection ratio**

Connect the equipment as shown below.



2.4.7.7.1 Adjust the amplification of the LBU to unity gain.
If the gain cannot be adjusted, measure the input and output voltage levels and calculate the gain.

2.4.7.7.2 Set the audio signal generator frequency to 1 kHz and set the output impedance to HIGH.

2.4.7.7.3 Increase the signal output level of the audio generator till the level measured on the output line of the LBU, also increases.

2.4.7.7.4 Record the input and output signal voltage levels.

2.4.7.7.5 If the LBU is set for unity gain, calculate the ratio in dB between the audio input signal level and that measured on the output line of the LBU.

OR

2.4.7.7.6 If the LBU has a gain, calculate the ratio by dividing the input voltage level by the output voltage level.

Multiply the calculated ratio with the gain of the LBU under tests and express the ratio in dB.

e.g. Input voltage/Output voltage = R:1

R x Gain = T:1

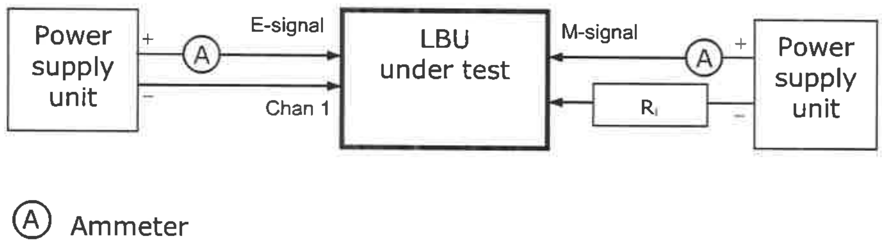
dB = $20Log_{10}(T/1)$

2.4.7.7.7 Repeat the measurement on the other channels.

2.4.7.7.8 Record the worst case as the result.

2.4.7.8 **E & M-signalling**

Connect the equipment as shown below.



2.4.7.8.1 Route the E-signal of channel 1 to activate the M-signal of all the channels.

2.4.7.8.2 The value of the load resistor R_L must be such to permit a current flow of 8 mA to 10 mA.

2.4.7.8.3 Apply a DC voltage at the appropriate level to the M signal terminal.

2.4.7.8.4 Apply a DC voltage at the appropriate level to the E signal terminal and measure the current.

2.4.7.8.5 Measure the current flow at all the M-signal terminals.

2.4.7.8.6 Reverse the voltage polarity at the E & M-signal terminals and repeat the test.

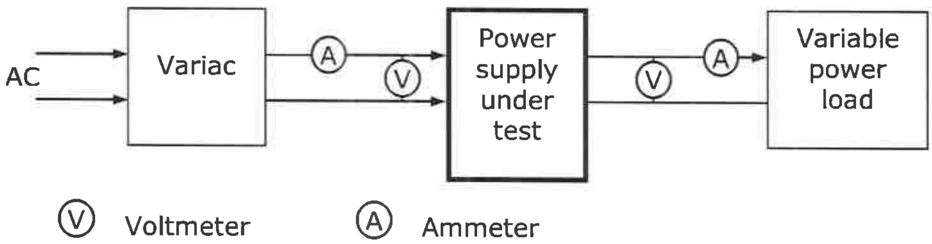
2.4.7.8.7 Repeat the above tests with other routing combinations.

2.4.7.8.8 Measure the resistance between the E & M-signal terminals and the LBU earth. The resistance must be infinity.

2.4.8 Power Supply & Battery Charger Unit

2.4.8.1 **Output voltage regulation**

Connect the equipment as shown below.



2.4.8.1.1 Intermittent:

2.4.8.1.1.1 Adjust the Variac to obtain the nominal input voltage to the power supply/battery charger.

2.4.8.1.1.2 Vary the power load to obtain a current drain from 0 ampere to maximum current while recording the output voltage.

2.4.8.1.1.3 The measurement shall be made under the extreme test conditions as well.

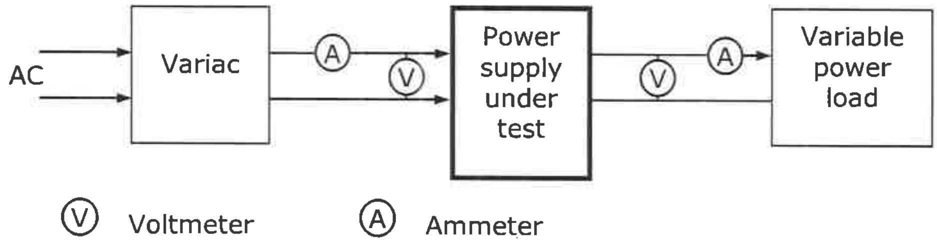
2.4.8.1.2 Continuous:

2.4.8.1.2.1 Adjust the Variac to obtain the nominal input voltage to the power supply/battery charger.

2.4.8.1.2.2 Set the power load to obtain the maximum current drain and record the output voltage level for a period of four hours.

2.4.8.2 **Efficiency**

Connect the equipment as shown below.



2.4.8.2.1 Adjust the Variac to obtain the nominal input voltage to the power supply/battery charger.

2.4.8.2.2 Vary the power load to obtain a current drain from 0 ampere to maximum current while recording the input and output voltages and currents.

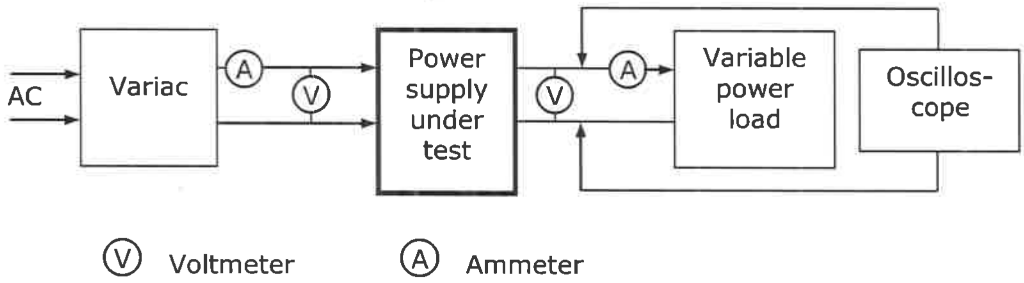
2.4.8.2.3 Calculate the efficiency in percentage.
Efficiency = (Power out/Power in) x 100 %

2.4.8.2.4 Repeat the test with the specified minimum and then the maximum input voltage to the power supply/battery charger.

2.4.8.2.5 Record the worst case as the result.

2.4.8.3 **Output voltage ripple**

Connect the equipment as shown below.



2.4.8.3.1 Adjust the Variac to obtain the nominal input voltage to the power supply/battery charger.

2.4.8.3.2 Vary the power load to obtain a current drain from 0 ampere to maximum current while recording the output voltage ripple with the oscilloscope.

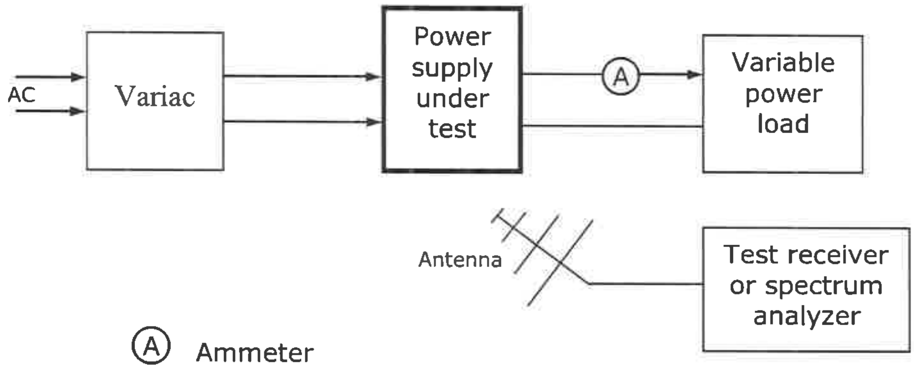
2.4.8.3.3 The measurement shall be made under the extreme test conditions as well.

2.4.8.3.4 Record the worst case as the result.

Note: Some battery chargers apply high instantaneous pulses of short duration. In a Lead-acid battery, this breaks down lead-sulphate crystals, thus extending the battery service life.
This function must be noted.

2.4.8.4 **Radiation of spurious frequencies**

Connect the equipment as shown below.



2.4.8.4.1 This test has to be performed inside a Faraday cage (RF shielding).

2.4.8.4.2 All the instruments and electrical equipment inside the cage not used for the test have to be switched off to prevent interference with the frequencies to be scanned. Ideally, all the equipment except the power supply under test and the antenna should be on the outside of the cage.

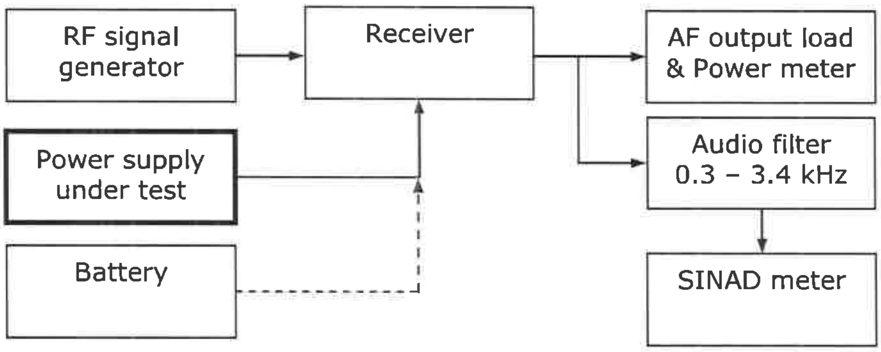
2.4.8.4.3 The measuring antenna to be placed 1 m from the power supply/battery charger.

2.4.8.4.4 Vary the power load to obtain a current drain from 0 ampere to maximum current while scanning the radio-operating band (455.0000 MHz to 467.0000 MHz).

2.4.8.4.5 Record the frequencies and levels of all the detected signals.

2.4.8.5 **Desensing of receiver** (conductive)

Connect the equipment as shown below.



2.4.8.5.1 Use a battery to power the receiver.

2.4.8.5.2 Adjust the RF signal generator to produce a standard RF test signal.

2.4.8.5.3 Adjust the volume control of the radio to give SOP.

2.4.8.5.4 Reduce and record the RF signal input level at which 12 dB SINAD ratio is obtained.

2.4.8.5.5 Replace the battery with the power supply under test.

2.4.8.5.6 The length of the power leads to the radio must be 1.0 m.

2.4.8.5.7 Place the power supply as far as possible from the radio.

2.4.8.5.8 Readjust and record the RF signal output level at which 12 dB SINAD ratio is obtained.

2.4.8.5.9 Record the difference in dB between the recorded RF signal levels as the receiver desensing.

2.5 Trunking functional tests

Programme the radio under test with the correct trunking parameters and with a validated number on the trunk network.

1.5.1 On instrument

Connect the radio under test to the trunk enabled instrument.

1.5.1.1 Registration
Switch the radio on and ensure that it register on the instrument. The radio will display a registered indication and the instrument will display the radio's trunking number.

1.5.1.2 Make a call with the same prefix number (e.g. 2052001203 to 2052001204).
The instrument will display the called radio's prefix and the *derived* identification number.

1.5.1.3 Make a call with the interprefix number (e.g. interfleet call: 2052001203 to 2142001301).
The instrument will display the called radio's prefix and the *derived* identification number.

1.5.1.4 Short form dialling (e.g. 204)
Repeat 1.5.1.2 using the short form dialling.

1.5.1.5 PSTN call (e.g. 0117748227)
The dialled number must be presided with 0 (e.g. 00117748227). The instrument will display the called number.

1.5.1.6 Call the radio under test
Make a call to the radio from the instrument.

1.5.1.7 Handoff
Change the control channel on the instrument and ensure that the radio re-register on the new channel.

1.5.2 On trunk system

Two trunk radios and a PSTN telephone must be available and dedicated to the tests.
One trunk radio must be programmed with the same prefix number as the radio under test and the second radio with an interprefix number.

1.5.2.1 Registration
Switch the radio under test on and ensure that it register on the trunk system.
The radio will display a registered indication.

1.5.2.2 **Local call**

Ensure that all the trunk radios are registered on the same local site.

1.5.2.2.1 Call a radio with the same prefix number
Call the radio having the same prefix number. Have a conversation with the second party.

1.5.2.2.2 Call a radio with an interprefix number
Call the radio having the interprefix number. Have a conversation with the second party.

1.5.2.2.3 Short form dialling
Repeat 1.5.2.2.1 using the short form dialling. Have a conversation with the second party.

1.5.2.2.4 Call the radio under test
Make a call to the radio under test from the other radios.

1.5.2.3 **Intersite call**

Move the radio under test to a distant site.
Ensure that the radio is registered on that site.

1.5.2.3.1 Call a radio with the same prefix number
Call the radio having the same prefix number. Have a conversation with the second party.

1.5.2.3.2 Call a radio with an interprefix number
Call the radio having the interprefix number. Have a conversation with the second party.

1.5.2.3.3 Short form dialling
Repeat 1.5.2.3.1 using the short form dialling. Have a conversation with the second party.

1.5.2.3.4 PSTN call
Call the PSTN telephone. Have a conversation with the second party.

1.5.2.3.5 Call the radio under test
Call the radio under test from the other radios. Have a conversation with the second party.

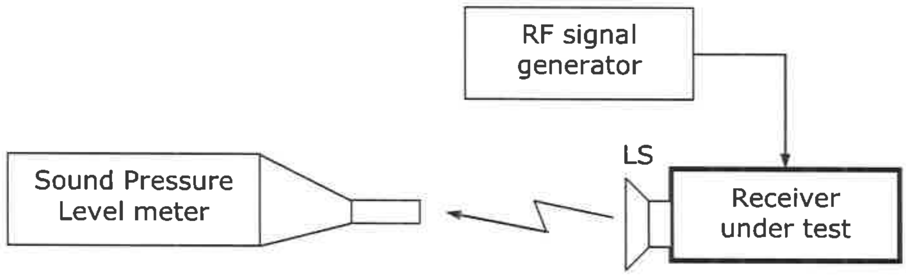
1.5.2.3.6 Handoff
Travel between sites and ensure that the radio under test re-register on the different sites.

Note: Call failures must be confirmed through different trunk sites.

2.6 Acoustical Measurements

2.6.1 Receiver loudspeaker sound pressure level

Connect the equipment as shown below.

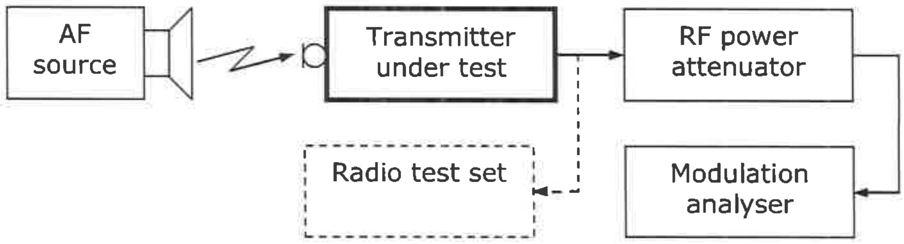


2.6.1.1 Adjust the RF signal generator to produce a standard RF test signal.
2.6.1.2 Increase the modulation to 2.5 kHz (maximum system modulation).
2.6.1.3 Adjust the volume control of the radio to obtain MUOP.
2.6.1.4 Place the Sound Pressure Level (SPL) meter at a distance of 300 mm in front of the radio loudspeaker.
2.6.1.5 Record the SPL in dB(A).

Note: Sound wave reflections should be kept to a minimum by measuring in an open area.

2.6.2 Transmitter modulation (deviation)

Connect the equipment as shown below.



2.6.2.1 Ensure that the transmitter modulation limiting has been set correctly (see clauses 2.3.7).
2.6.2.2 Generate a 1 kHz tone with the AF source at a level of 80 dB(A), measured at the radio microphone.
2.6.2.3 Transmit and record the measured deviation.

Note: Sound wave reflections should be kept to a minimum by measuring in an open area.

3. RELEVANT DOCUMENTATION

APPLICABLE

DOCUMENT NO.	DESCRIPTION	LOCATION
SANS 300086-1:2005	Electromagnetic compatibility and Radio Spectrum Matters (ERM); Land Mobile Service; Radio equipment with an internal or external RF connector intended primarily for analogue speech Part 1: Technical characteristics and methods of measurement.	External

RELEVANT

DOCUMENT NO.	DESCRIPTION	LOCATION

END OF DOCUMENT

TRANSNET
freight rail

May 2022

SCHEDULE OF REQUIREMENTS FOR UHF LINK RADIO EQUIPMENT

1. **SCOPE**

   The schedule covers the requirements of Transnet for the supply of UHF Link Radio Equipment that will be installed along the Manganese railway line. This document must be read in conjunction with ***Specification SPC-01233***, for UHF Link Radio Equipment. The equipment must comply with the specifications and requirements of both documents.

2. **OPERATING FREQUENCY BAND** (Item 5.1.6 of the specification)

   2.1. All the equipment will operate in the 440 to 470 MHz frequency band.

   2.2. The correct frequencies will be supplied after adjudication of the contract.

3. **TYPE OF COMMUNICATION** (Items 5.1.7 of the specification)

   Simplex operation is required

4. **OPERATING VOLTAGE** (Item 5.1.11 of the specification)

   4.1. The repeater equipment supplied must operate from 13.8 Volt DC.

   4.2. The equipment must be negative earthed.

5. **TRANSMITTER OUTPUT POWER** (Item 5.2.1 of the specification)

   The equipment supplied must be 5 Watt continues rated as a minimum requirement.

6. **4-Wire E&M Audio Interface** (Item 5.6.2 and 5.6.3 of the specification)

   M-lead output state level: -10dBm

   E-lead input state level: -10dBm

8. **OTHER REQUIREMENTS**

   8.1. The equipment quoted on must comply with ***Specification SPC-01233*** and this "***Schedule of Requirement***". Please provide a compliance document with your quotation.

8.2. Transnet reserves the right to call for samples of equipment offered.

8.3. All radio equipment provided must be ICASA approved.

8.4. UHF Link Radio supplied that have not been tested and approved by the Transnet Test Center will require this approval and the supplier will have to carry the cost of such an approval process.

7. QUANTITIES OF EQUIPMENT AND SERVICES TO SUPPLY

Please refer to Bill of Quantity attached.

This is the end of the schedule of requirements.

TRANSNET freight rail

May 2022

SCHEDULE OF REQUIREMENTS FOR UHF REPEATER STATIONS

1. **SCOPE**

The schedule covers the requirements of Transnet for the supply of UHF Radio Repeater Stations that will be installed along the Ore railway line. This document must be read in conjunction with ***Specification SPC-00851***, for Radio Repeater Stations. The equipment must comply with the specifications and requirements of both documents.

2. **OPERATING FREQUENCY BAND** (Item 5.1.18 of the specification)

2.1. All the equipment will operate in the 440 to 470 MHz frequency band.

2.2. The correct frequencies will be supplied after adjudication of the contract.

3. **DUPLEXERS** (Items 5.1.20 and 5.5.1 of the specification)

It is not required for the repeater equipment to be supplied with Duplexers.

4. **OPERATING VOLTAGE** (Item 5.1.22 of the specification)

4.1. The repeater equipment supplied must operate from 13.8 Volt DC.

4.2. The equipment must be negative earthed.

5. **TRANSMITTER OUTPUT POWER** (Item 5.2.2 of the specification)

The equipment supplied must be 50 Watt continues rated as a minimum requirement.

6. **AUDIO OUTPUT** (Item 5.3.8 of the specification)

An audio output, 600 ohm balanced line option will be required with an adjustable output from –15 dBm to +5dBm.

7. **DIAGNOSTICS AND REMOTE MONITORING** (Item 11 of the specification)

7.1. Must be supplied with an onboard diagnostic system with remote monitoring capabilities.

7.2. The monitoring connection point to the diagnostic system must be via a TCP/IP (LAN) interface.

7.3. The diagnostic system must have the following additional functionality as a minimum requirement:

7.3.1. Must give the actual values of transmitter power, reflected power and VSWR.

7.3.2. Must also be able to give the RSSI values.

7.3.3. Must give you the input and output audio levels.

7.3.4. Must be able to remotely control the repeater transmitter and receiver.

8. OTHER REQUIREMENTS

8.1. The equipment quoted on must comply with ***Specification SPC-00851*** and this "***Schedule of Requirement***". Please provide a compliance document with your quotation.

8.2. Transnet reserves the right to call for samples of equipment offered.

8.3. All radio equipment provided must be ICASA approved.

8.4. UHF Repeater stations supplied that have not been tested and approved by the Transnet Test Center will require this approval and the supplier will have to carry the cost of such an approval process.

9. QUANTITIES OF EQUIPMENT AND SERVICES TO SUPPLY

Please refer to the bill of quantity.

This is the end of the schedule of requirements.

TRANSNET
freight rail

SPECIFICATION FOR RADIO REPEATER

SPC-OO851

June 2011

Revision 4

SPC-00851

TRANSPORT TELECOMMUNICATIONS

SPECIFICATION

SPECIFICATION FOR RADIO REPEATER STATIONS

FUNCTION	TITLE & DIVISION	NAME	SIGNATURE	DATE
Author:	HOD Access, Transport Telecoms	Graeme Daly		19/07/2011
Author:	Engineer in Training	M Mmbengwa		19/07/2011
Approved:	Quality Assurance, Transport Telecoms	Pierre du Plessis		19/07/2011
Approved:	Manager Access, Transport Telecoms	Robert Yates		20/07/2011
Approved:	Frequency Spectrum Management, Transport Telecoms	Freddie Visser		19/07/2011
Approved:	Manager Transmission, Transport Telecoms	ML Nuttall		2011/7/19
Approved:	Chief Engineer Transport Telecommunication	Danie Botha		19 July 2011

Circulation Restricted To:

TFR Infra Telecommunications

Transnet Freight Rail

Transnet and Relevant Third Parties

TABLE OF CONTENTS

I. DISTRIBUTION

Once updated, a copy of the latest revision will be published in the document management system in use. E-mail to this effect will be sent to the relevant personnel or heads of department.

II. DOCUMENT CHANGE HISTORY

ISSUE NO.	DATE ISSUED	ISSUED BY	HISTORY DESCRIPTION
1.00		Graeme Daly	New document
3.3	18 July 2011	M Mmbengwa	Amended document

III. CHANGES SINCE LAST REVISION

CLAUSES	DESCRIPTION
5.1.4	Change the reference from sub-clause 5.1.2 to 5.1.3
5.1.3	Change cabinet to casing/housing
5.2.2	Power will be indicated on the schedule of requirements.
Clause 5.5	Include combiner
10.1	Include hysteresis clause on load shed

IV. ABBREVIATIONS, ACRONYMS AND DEFINITIONS

ABBREVIATIONS AND ACRONYMS	DESCRIPTION
CD	Compact Disk
CTCSS	Continuous Tone Coded Squelch System
dB	decibel
dB(C)	decibel relative to the carrier power
DC	Direct Current
Hz	Hertz
kHz	Kilohertz
ICASA	Independent Communication Authority of South Africa
ISO	International Standards Organisation
LBU	Line Branching Unit
LED	Light Emitting Diode
MHz	Megahertz
ms	Millisecond
PC	Personal Computer
RF	Radio Frequency
RSSI	Receive signal strength indication
Rx	Radio receiver
SANS	South African National Standard
SINAD	Signal, noise & distortion to noise and distortion ratio
Tx	Radio Transmitter
UHF	Ultra High Frequency
VSWR	Voltage Standing Wave Ratio

DEFINITIONS	DESCRIPTION
Flat response	No variation from the reference value.
Angle Modulation	A term used to encompass both frequency modulation and phase modulation.

V. RELEVANT DOCUMENTATION

The following standards are referred to in this specification:

APPLICABLE

DOCUMENT NO.	DESCRIPTION	LOCATION
ISO 9000	Quality management systems.	
BS 3939	Graphics symbols for electrical, power, telecommunications and electronic diagrams.	External
SANS 10313	Protection of dwelling houses against lightning.	External
SANS 61643-1	Surge arrestors for low voltage distribution systems.	External
BBD8635	Technical Specification and Methods of Measurement for Angle Modulated Radio Equipment	TFR, Infrastructure Telecoms.

The latest issues of the abovementioned standards must apply.

RELEVANT

DOCUMENT NO.	DESCRIPTION	LOCATION
SPC-00851	Old specification No. SCEH-59	Document Control Centre

1. SCOPE

This specification covers the requirements of Transnet for the supply of a radio repeater station, operating in the UHF frequency band with 12.5 kHz channel spacing.

2. COMPLIANCE

2.1 Tenderers must indicate clause by clause, either that their offers comply in every respect with this specification, or, if not, precisely how they differ.

2.2 Failure to complete a clause-by-clause compliance in the mentioned manner will result in disqualification.

2.3 Offers which include deviations of a minor nature, not departing greatly from the specification, will be considered at the discretion of Transnet

2.4 Tenderers may offer alternatives for consideration. Alternative offers are to be reflected on a separate schedule and the following particulars are to be provided

2.4.1 A fully detailed technical description in English explaining functioning of the individual components, the operation of the items of equipment as well as the procedure to be followed in clearing faults and maintenance.

2.4.2 Drawings and brochures supporting the offer.

2.4.3 Details of deviations from the specifications of Transnet

2.4.4 The value of imported and local components of complete items is to be stated separately.

3. SERVICE CONDITIONS

3.1 The equipment must be suitable for continuous operation under the following conditions:

Altitude:	0 to 1 800 metres above sea level
Ambient temperatures:	- 10 °C to + 60 °C
Air pollution:	Heavily saline laden industrial and locomotive fumes
Relative humidity:	As high as 95 %
Lightning:	Severe

3.2 All component parts, including wiring, etc. must be manufactured and processed to ensure reliable operation under these conditions.

4. SCHEDULE OF REQUIREMENTS

4.1 Where only equipment in terms of this specification is required by Transnet, a Schedule of Requirements will accompany this specification. Where a system, including other equipment, is to be supplied, a main specification will be included in the tender documents together with a Schedule of Requirements for all the equipment.

4.2 The equipment required is listed in the Schedule of Requirements. The equipment must comply with the details therein, in addition to the requirements of the relevant clauses of this specification.

4.3 The Tenderers statement of compliance as per clause 2 must also cover the relevant clause of the Schedule of Requirements.

5. REPEATER

5.1 General

5.1.1 The equipment provided must be ICASA type approved.

5.1.2 The equipment provided must be TFR QA type approved.

5.1.3 The repeater equipment must comprise of a transmitter, receiver, associated electronic equipment, duplexer and power supply mounted in a corrosion resistant metal casing/housing, which must be suitable for indoor installation.

5.1.4 The equipment described in sub-clause 5.1.3 must be available as standard production items. Tenderers for equipment which cannot meet this requirement will not be considered.

5.1.5 Provision must be made for the inclusion, in the case of a conventional repeater: of a Line Branching Unit between the transmitter and receiver. Controlling by E & M signalling. The audio lines shall be balanced 600 Ω and the nominal audio signal level -10 dBm at 60 % modulation. The return loss shall be ≤ −25 dB. Detailed specification for the LBU will be provided when the unit is required.

5.1.6 The repeater must be suitable to be installed into a 19” rack.

5.1.7 Provision must be made for the inclusion, in the case of trunked repeater; compatibility to Fylde MPT1327 network.

5.1.8 Supplier must provide interface cable connection diagrams for connection from repeater to Fylde Trunking equipment.

5.1.9 The repeater provided must be provided with a migration plan from analogue to digital.

5.1.10 It must be possible to control the repeater station by all of the following methods.

5.1.10.1 Extended local control, where the repeater is connected to a control console by means of a multi-core cable up to 100 metres in length.

5.1.10.2 Remote control, where the equipment is connected to a control console by means of a single telephone cable pair up to 10 kilometres in length.

5.1.10.3 Line controlled over telephone carrier channels on a 6-wire basis with E and M signalling. This method will require the use of a line branching unit or a line terminating unit.

5.1.10.4 Remote monitoring, configuration and diagnostics via dial-up modem and Ethernet connections.

5.1.11 The RF power, line levels and frequency should be software controlled; there should be no need to open up the equipment to change settings.

5.1.12 All indicators and connection points must be clearly labelled.

5.1.13 The equipment used to configure the repeater unit should be specified (e.g. PC using Windows platform or proprietary hand held device).

5.1.14 The equipment must be designed and rated for continuous transmission duty cycle at maximum rated power.

5.1.15 An engineering panel must be provided for local control and testing of the repeater and line interface equipment. Facilities to key the transmitter and monitor the received audio must be included. A monitor loudspeaker with volume control must be provided. A handset with a dynamic microphone must be provided as part of the engineering panel for speech transmission from the repeater. The engineering panel must have no affect (level, distortion, frequency response) on the 600 Ω balanced audio lines.

5.1.16 Pre-emphasis of 6 dB per octave must be used in the transmitter with de-emphasis in the receiver. Provision must be made to switch to flat frequency response.

5.1.17 The repeater must be angle modulated and be suitable for operating in frequency bands using 12.5 kHz channel spacing.

5.1.18 The equipment must be supplied complete for operation in the frequency band specified in the Schedule of Requirements.

5.1.19 The successful tenderer will be advised of the actual frequencies once the order has been placed.

5.1.20 The repeater must be suitable for transmitting and receiving on a single antenna. The antenna duplexer must be included in the equipment cabinet.

5.1.21 The operating voltage and negative or positive earth of the equipment shall be as indicated in the Schedule of Requirements.

5.1.22 The equipment must be able to operate in the following DC voltage ranges without degrading the performance.

For a 12 volt system	Nominal operating voltage 13,8 volt Operating range 10,8 volt to 15,6 volt
For a 24 volt system	Nominal operating voltage 27,6 volt Operating range 21,6 volt to 31,2 volt
For a 48 volt system	Nominal operating voltage 55,2 volt Operating range 43,2 volt to 62,4 volt

5.1.23 The terminals for the connection of the DC voltage must be clearly marked and the equipment protected against incorrect polarity, short-circuiting, and over voltage. Full particulars of all protective devices offered must be submitted.

5.1.24 All RF terminals must be N-Type connectors.

5.1.25 Tenderers must guarantee that there will be no cross-coupling or any other degradation in radio equipment performance due to a common battery and charger combination being used to supply the repeater.

5.1.26 The equipment must be of fully solid-state design.

5.1.27 Tenderers are to submit their recommendations for earthing of the equipment.

5.1.28 All the miscellaneous items such as plugs, connectors and cables, necessary for a complete installation, must be supplied with the equipment.

5.1.29 The RF switching bandwidth of the equipment offered must be 1.7 MHz without degradation in transmitter or receiver performance. The tenderer must state the degradation in receiver sensitivity, transmitter power and any other parameter for the switching bandwidth 2.0 MHz.

5.1.30 The repeater must be able to reverse the operating channels (e.g. Tx low, Rx high and Tx high, Rx low) without degradation in performance.

5.1.31 The transmitter circuitry must incorporate protective devices to protect the output circuitry when the transmitter is operated with the antenna open circuit or, short-circuit, or for any excessive voltage standing wave ratio (VSWR) on the antenna feeder cable.

5.1.32 The repeater must be provided with standard multipin sockets and plugs for the easy interconnection of control consoles, carrier circuits, batteries and any other devices stated in the schedule of requirements.

5.1.33 Tenderers must state the DC current consumption at the nominal operating voltage of all equipment offered under transmit, receive and stand-by conditions.

5.1.34 The equipment will be used where severe lightning and voltage surges occur. The repeater must therefore be provided with adequate line protection devices. Voltage transient surge protection must be provided in the AC mains supply input.

5.2 Transmitter

5.2.1 For the parameters required for the transmitter refer to BBD8635 specification.

5.2.2 The output power of the transmitter will be indicated in the schedule of requirements.

5.2.3 The transmitter must be able to transmit CTCSS signals.

5.2.4 When provision must be made for an audio input (e.g. from a land line) to the transmitter, the audio frequency response must be within -1 to +3 dB of a true 6 dB per octave pre-emphasis characteristic between 300 and 3 000 Hz (reference level 0 dB at 1 000 Hz) at a modulation factor of 20% of maximum rated system deviation.

5.2.5 The transmitter shall operate into a 50 Ω impedance antenna system.

5.2.6 In the event of a high VSWR the transmitter should reduce power to prevent damage to equipment.

5.3 Receiver

5.3.1 For the parameters required for the receiver refer to BBD8635 specification.

5.3.2 Receiver must be able to receive CTCSS signals.

5.3.3 The receiver must be provided with an electronic squelch control the sensitivity of which must be adjustable. The squelch control specification must adhere to BBD8635.

5.3.4 The audio power output into the built-in monitor loudspeaker must be at least 500 milliwatts at less than 5% harmonic distortion.

5.3.5 When provision must be made for an audio output (e.g. to a land line) from the receiver, the audio frequency response must be within + 1 dB to -3 dB of a true 6 dB per octave de-emphasis characteristic from 300 Hz to 3 000 Hz at a modulation factor of 20% of maximum rated system deviation. It will be stated in the Schedule of Requirements if an audio output is required.

5.3.6 The frequency stability must be at least ±0.0002 % over the temperature range of -10 °C to + 60 °C (reference temperature +25 °C).

5.3.7 Tenderers must state what protection will be provided, and what maximum RF signals the receiver will be protected against without damage.

5.3.8 The impedance of the antenna terminal shall be 50 Ω.

5.3.9 The blocking shall be ≥84 dB.

5.3.10 A RSSI output terminal must be provided.

5.4 Through Signals

5.4.1 Refer to Specification BBD8635.

5.5 Antenna Duplexer/Combiner

5.5.1 The repeater equipment must be supplied complete with antenna duplexer/combiner to obviate the use of two antennas.

5.5.2 For detailed specification on antenna duplexer/combiner see Specification BBD8635.

5.5.3 The antenna duplexer/combiner must be capable of handling the transmitter RF output power.

5.5.4 The Tenderer must state the change in characteristics over the temperature range of -10 °C to + 60 °C.

6. QUALITY OF MATERIAL

6.1 Preference will be given to manufacturers who guarantee that they comply with the provisions of the code of practice for quality management systems as set out in ISO 9000.

6.2 Tenderers must note that the technical personnel of Transnet will carry out inspections to determine whether the code of practice has been adhered to.

6.3 Tenderers must submit details of procedures they intend to adopt to comply with ISO 9000.

6.4 Materials which may, under the influence of heat, light or pressure, decompose or liberate elements or compounds likely to corrode or affect other materials or cause electrolytic corrosion will not be acceptable.

6.5 Mounting screws, where used, must not be self-tapping. Bushes and threaded inserts must be used.

6.6 All covers, jacks, sockets etc. must be provided with adequate seals.

6.7 The functions of all controls, switches, etc. must be clearly engraved or otherwise permanently marked by means of approved symbols or English wording.

6.8 All components must be suitably rated for the function they have to perform without interference to neighbouring material.

6.9 Resistors and restive components must not rise in temperature so that mounting boards or markings thereon are burnt or discoloured.

6.10 Fuses must be rated to give adequate protection to the circuit served while not rupturing prematurely.

6.11 The equipment layout must be constructed to facilitate fault clearance and maintenance.

6.12 All components must be clearly marked and must be capable of easy reference to circuit diagrams and handbooks that are supplied with the equipment.

7. ACCEPTANCE TESTS

7.1 Transnet will conduct acceptance tests on the equipment. The equipment will not be accepted nor will the payment be authorised until these tests have been completed and it has been confirmed that the equipment supplied is fully in accordance with the requirements of this specification and/or the stated claims of the tenderer as accepted by Transnet.

The following equipment must be submitted for acceptance tests.

7.1.1 Radio repeater sample.

7.1.2 Technical specification of repeater to be tested.

7.1.3 Technical service manual.

7.1.4 Software to program the repeater and to set technical parameters, with passwords if needed (technician level). Software that requires an internet connection is not acceptable.

7.1.5 Programming cables should be included.

7.1.6 Test box, cables and adapters for RF and electrical measurements.

7.2 All parameters shall be measured as specified in the controlled document BBD8635 Technical Specification and Methods of Measurement for Angle Modulated Radio Equipment.

7.3 The successful tenderer must agree to rectify any defects at no cost to Transnet, where the equipment does not meet the tender requirements and/or the stated claims made by the tenderer.

7.4 All samples submitted for the quality assurance process will remain in the possession of Transnet for references:

7.4.1 Unsuccessful tender, three months after the tender was awarded.

7.4.2 Successful tenderer, twelve months after the equipment has been delivered.

8. MAINTENANCE AND SERVICE

8.1 The tenderer must give full particulars of the maintenance, spare parts and service facilities which will be available in the Republic of South Africa. The names and addresses of the companies concerned must be furnished.

8.2 The tenderer must list the major centres where maintenance facilities can be provided and must state if repairs under guarantee can be undertaken at these centres.

8.3 Tenderers must state what provision will be made to ensure an adequate supply of locally available spare components for a period of 10 years after the order is placed.

8.4 Transnet will not consider tenders from Tenderers who cannot provide an efficient spares and maintenance service. Tenderers must state whether they are prepared to agree to an inspection of their maintenance premises by the engineering personnel of Transnet.

9. TECHNICAL HANDBOOKS

9.1 Technical handbooks must be clearly and professionally printed in English on quality paper. Photostat copies will not be acceptable unless it simulates professional printing quality and in colour where applicable.

9.2 Technical information (handbooks) on CD is acceptable.

9.3 The technical handbooks must be packed with the equipment.

9.4 Each set of handbooks must include the following:

9.4.1 Operating instructions.

9.4.2 Complete maintenance instructions.

9.4.3 Complete and detailed alignment procedures in a proven and easy to follow order.

9.4.4 A detailed technical description of the equipment.

9.4.5 Complete circuit diagrams, drawings and photographs of the equipment. The photographs and drawings must clearly indicate component and module location in the equipment. All component numbers must be clearly indicated.

9.4.6 A list of parts, giving the values of all components, i.e. resistive, capacitive, inductive, integrated circuit and semi-conductor numbers for each schematic, drawing.

9.4.7 Detailed printed circuit board wiring diagrams showing component numbers and positions and the wiring itself. Multilayer board wiring must be shown to include all layers of printed wiring clearly and discernible.

9.4.8 Voltage levels, current values and test points, must be clearly indicated on circuit diagrams and printed circuit board layouts.

9.4.9 Complete circuit diagrams of all individual modules.

9.5 All symbols and notations used on drawings and circuit diagrams preferably comply with the requirements laid down in BS 3939. Where symbols and notations do not comply with these requirements, each drawing shall be accompanied by a legend clearly detailing BS 3939 equivalents.

9.6 No hand-written notes and numbers must appear in a handbook supplied by a tenderer. All writing must be of proper printed form.

9.7 Transnet reserves the right to reproduce in whole or in part, by any means whatsoever, any technical handbook or instruction manual supplied by the successful Contractor. Any such reproductions will be for the sole use of Transnet.

10. POWER SUPPLY

10.1 Should the equipment be supplied with a mains power supply/charger; the battery charging circuit must be provided with load shed. The load shed circuitry must have hysteresis to prevent unnecessary switching, as the battery normalises after the shedding of the load.

10.2 The equipment must be able to operate with a supply of 12V, 24V or 48V. The supply required will be indicated in the Schedule of Requirements.

10.3 In case of trunking application the equipment must have a power distribution unit (PDU) for use with Fylde equipment.

10.4 The power supply should have a separate Power management unit with the following requirements:

10.4.1 The Power management unit (PMU) must be a removable module.

10.4.2 The module must have indicators for the following conditions:

10.4.2.1 When it's working properly.
10.4.2.2 When there is a fault condition.
10.4.2.3 Provide an alarm when is fault condition exist.

11. ALARMS

11.1 The repeater should have an LED indicating alarm condition. The alarms should be software enabled and user configurable. The alarm conditions included are :

11.1.1 Temperature alarm.
11.1.2 Alarm log/history.
11.1.3 Alarm reporting.

11.2 Transmitter Alarms

- 11.2.1 Tx Low Power alarm
- 11.2.2 Tx High Power alarm
- 11.2.3 VSWR high alarm

11.3 Power Supply alarm

- 11.3.1 Mains failure
- 11.3.2 Load shed
- 11.3.3 Battery Low Non-urgent Alarms depending on supply voltage used are as follows
  - 11.3.3.1 For 12V volt system
    - 11.3.3.1.1 Low Non-urgent alarm is 12 volt
    - 11.3.3.1.2 Low urgent alarm is 11 volt
  - 11.3.3.2 For 24 volt system.
    - 11.3.3.2.1 Low Non-urgent alarm is 24 volt.
    - 11.3.3.2.2 Low urgent alarm is 22 volt
  - 11.3.3.3 For 48 volt system.
    - 11.3.3.3.1 Low Non-urgent alarm is 48 volt.
    - 11.3.3.3.2 Low urgent alarm is 43 volt

12. LINE INTERFACE

The line interface should be totally isolating all external equipment, both signalling and audio.

13. GENERAL

The tenderer must submit technical specification pamphlets and schematic diagrams covering the equipment offered. Photographs and complete drawings clearly displaying the external dimensions and physical appearance of the equipment must also be submitted with the tender.

When the tenderer provides software to work with the repeater, it must be specified what licences will be provided.

END OF DOCUMENT

TRANSNET

freight rail

SPECIFICATION FOR UHF LINK RADIO EQUIPMENT

SPC-01233

MAY 2011.

Revision 3.00

DOCUMENT AUTHORISATION

FUNCTION	NAME	TITLE & DIVISION	SIGNATURE	DATE
Compiled by:	*S Mchunu*	*Transmission* Engineering	*S Mchunu*	02/11/2006
Updated by:	*ML Nuttall*	*Divisional Manager* Transmission	Nuttall	2011/5/5
Reviewed by:	*P du Plessis*	*Technologist* Quality Assurance	[illegible]	4/05/2011.
Authorised by:	*DF Botha*	*Chief Engineer* Technology		

I DISTRIBUTION

Once updated, the latest revision will be published in the document management system in use. E-mail to this effect will be sent to relevant personnel or heads of department

II DOCUMENT CHANGE HISTORY

ISSUE NO.	DATE ISSUED	ISSUED BY	HISTORY DESCRIPTION
1.00	August 2005	Transmission Engineering	New document
2.00	October 2006	Transmission Engineering	Converted to ISO 9000 Standard
3.00	April 2011	Transmission Engineering	Converted to TFR standard and modernised

III CHANGES SINCE LAST REVISION

CLAUSES	DESCRIPTION
All clauses	Converted to ISO standard
	Additions/changes and upgrades to the existing specifications to allow the unit to be more universal

IV ABBREVIATIONS, ACRONYMS AND DEFINITIONS

ABBREVIATIONS AND ACRONYMS	DESCRIPTION
FM	Frequency Modulation
CD	Compact Disk
Hz	Hertz
ISO	International Standards Organization
LED	Light Emitting Diode
DC	Direct Current
dB(W)	decibel relative to Watts
AC	Alternating current
dB	decibel
dB(C)	decibel relative to the carrier
RF	Radio Frequency
SANS	South African National Standard
VSWR	Voltage Standing Wave Ratio
Tx	Transmit

V RELEVANT DOCUMENTATION

DOCUMENT NO.	DESCRIPTION	LOCATION
ISO 9000	Quality Management Systems	External
BS 3939 Graphic symbol for Electrical Power	Telecommunications and Electronic Diagrams	External
SANS 62305 parts 1 & 4	Protection against Lightning	External
BBD 8635 Revision 6 or later	Angle Modulated Radio Equipment	Internal

1. SCOPE

This specification covers the requirements of Transnet Freight Rail for the supply of radio link equipment, operating in the UHF frequency band with 12,5 kHz channel spacing. The radio would be used to link several radio repeaters to provide wide area radio coverage.

2. COMPLIANCE

2.1 Tenderers must submit their main offers in terms of this specification, and must indicate in their document of "COMPLIANCE" to this specification whether their offer is fully in COMPLIANCE with this specification or not. Where additional information must be furnished by the tenderer, this may be given on a separate sheet attached to the statement of COMPLIANCE, with the page and paragraph number of the additional information given together with a "YES" or "NO" in the COMPLIANCE" column of this specification; which will then form the STATEMENT OF COMPLIANCE.

2.2 Offers, which include deviations of a minor nature, not departing greatly from the specification, will be considered at the discretion of Transnet Freight Rail

2.3 Tenderers may offer alternatives for consideration. Alternative offers are to be reflected on a separate schedule and the following particulars are to be provided

2.3.1 A fully detailed technical description in English explaining the functioning of the individual components, the operation of the items of equipment as well as the procedure to be followed in clearing faults and maintenance.

2.3.2 Drawings and brochures supporting the offer.

2.3.3 Details of deviations from the specifications of Transnet.

2.3.4 The values of imported and local components of complete items are to be stated separately.

3. SERVICE CONDITIONS

3.1 The equipment must be suitable for continuous operation under the following conditions:

- Altitude: 0 to 1 800 metres above sea level.
- Ambient temperatures: Minus 10 °C to plus 60 °C
- Air pollution: Dust, heavily saline laden industrial and locomotive fumes
- Relative humidity: As high as 95%.
- Lightning: Severe

3.2 All component parts, including wiring, etc. must be manufactured and processed to ensure reliable operation under continuous operation.

4. SCHEDULE OF REQUIREMENTS

4.1 Where only equipment in terms of this specification is required by Transnet Freight Rail, a SCHEDULE OF REQUIREMENTS or Bill of Quantities will accompany this specification. Where a system, including other equipment, is to be supplied, a main specification will be included in the tender document together with a Schedule of Requirements for all the equipment.

4.2 The equipment required is listed in the Schedule of Requirements. The equipment must comply with the details therein, in addition to the requirements of the relevant clauses of this specification.

4.3 The tenderers statement of compliance as per clause 2 must also cover the relevant clause of the SCHEDULE OF REQUIREMENTS.

5. LINK RADIO

5.1 General Requirements

5.1.1 The radio link equipment must comprise of a transmitter, receiver, associated electronic equipment, internal duplexer and 4-wire E&M 600 ohm audio interface

5.1.2 The equipment must be designed and rated for continuous transmission duty.

5.1.3 An USB or RS232 interface must be provided for local control and testing of the Link Radio, by means of software on a laptop computer. Facilities to key the transmitter and monitor received audio must be included. A monitor loudspeaker with volume control must be provided. A handset with a dynamic microphone must be, provided as part of the engineering panel for speech transmission from the link radio.

5.1.4 Pre-emphasis of 6 dB per octave must be used in the transmitter with de-emphasis in the receiver. Provision must be made to switch to flat frequency response.

5.1.5 The equipment must be suitable for operating in frequency bands using 12,5 kHz channel spacing.

5.1.6 The equipment must be supplied complete for operation in the frequency band specified in the SCHEDULE OF REQUIREMENTS.

5.1.7 The link radio must be a full duplex radio. When simplex or half duplex operation is required, it would be as indicated in the SCHEDULE OF REQUIREMENTS.

5.1.8 The equipment must be 19" rack mountable. Tenderers must submit alternative sizes offered.

5.1.9 The actual operating frequencies must be set up by a laptop computer.

5.1.10 The Link Radio must be suitable for transmitting and receiving on a single antenna.

5.1.11 The equipment must be able to operate in the following DC voltage ranges without degrading the performance. The operating voltage and negative or positive earth of the equipment shall be as indicated in the Schedule of Requirements.

- For a 12 volt system: Nominal operating voltage 13,8 volt.
- Operating range 10,8 volt to 15,6 volt.
- For a 24 volt system: Nominal operating voltage 27,6 volt.
- Operating range 21,6 volt to 30,5 volt.
- For a 48 volt system: Nominal operating voltage 53,5 volt.
- Operating range 43,2 volt to 56,8 volt.

5.1.12 Tenderers must guarantee that there will be no cross-coupling or any other degradation in radio equipment performance due to a common battery and charger combination being used to supply the link radio.

5.1.13 The equipment must be of fully solid-state design.

5.1.14 Tenderers are to submit their recommendations for earthling of the equipment.

5.1.15 All the miscellaneous items such as plugs, connectors and cables, necessary for a complete installation, must be supplied with the equipment.

5.1.16 The transmitter circuitry must incorporate protective devices to protect the output circuitry when the transmitter is operated with the antenna open circuit or, short-circuit, or for any excessive VOLTAGE STANDING WAVE RATIO on the antenna feeder cable.

5.1.17 The link radio must be provided with standard multipin sockets and plugs for the easy interconnection of control consoles, carrier circuits, batteries and any other devices stated in the SCHEDULE OF REQUIREMENTS.

5.1.18 Tenderers must state the DC current consumption at the nominal operating voltage of all equipment offered under transmit, receive and stand-by conditions.

5.1.19 The parameters for the transmitter, receiver, talk through signal level and duplexer must be measured according to Specification BBD8635.

5.2 Transmitter

5.2.1 The Transmitter RF power output must be adjustable. The adjustable range must be as indicated in the SCHEDULE OF REQUIREMENTS.

5.3 Receiver

5.3.1 The minimum usable sensitivity for a 12 dB Sinad ratio must be -115 dBm or better, without the duplexer.

5.3.2 The receiver must be provided with an electronic squelch control the sensitivity of which must be adjustable. The hysteresis of the opening and closing threshold levels must not be greater than 3 dB

5.3.3 Receiver parameters must be measured according to Specification BBD8635.

5.4 Through Signals

5.4.1 Refer to Specification BBD8635.

5.5 Antenna Duplexer

5.5.1 The repeater equipment must be supplied complete with internal antenna duplexer to obviate the use of two antennas

5.5.2 The performance of the duplexer must meet Specification BBD8635.

5.6 4-Wire E&M Audio Interface

5.6.1 Audio inputs and outputs must meet Specification BBD8635.

5.6.2 M-lead control signal:

The M-lead output state level or voltage must be as indicated in the SCHEDULE OF REQUIREMENTS.

5.6.3 E-lead control signal

The E-lead input state level or voltage must be as indicated in the SCHEDULE OF REQUIREMENTS.

5.6.4 Provision must be made for allowing the E-lead and M-lead states to be swapped (e.g. selecting E-lead to be either "low" of "high" and M-lead to be either "low" or "high")

5.6.5 The interface connector shall be a RS232 DB15 female connector.

6. QUALITY OF MATERIALS

6.1 Preference will be given to manufacturers who guarantee that they comply with the provisions of the code of practice for quality management systems as set out in ISO 9000.

6.2 Tenderers must note that the technical personnel of Transnet may carry out inspections to determine whether the code of practice has been adhered to

6.3 Materials which may, under the influence of heat, light or pressure, decompose or liberate elements or compounds likely to corrode or affect other materials or cause electrolytic corrosion will not be acceptable.

6.4 Mounting screws, where used, must not be self-tapping. Bushes and threaded inserts must be used.

6.5 All covers, jacks, sockets etc. must be provided with adequate seals

6.6 Printed circuit boards must be fitted with robust plugs and sockets or another approved manner of connecting the boards reliably to the wiring. Edge connectors may be used provided that:

6.6.1 A suitable tolerance for the correct fitting of the board between guides and the wiring socket can be guaranteed

6.6.2 Sufficient contact area is provided to guarantee reliable contact.

6.6.3 Sufficient contact pressure is provided to ensure contact but not to remove precious metal from the contacts.

6.6.4 In the final protective coating of the boards, no varnish or other protective material is permitted to cover the contacts.

6.6.5 After 500 insertions and withdrawals, there must be no noticeable deterioration of the contacts of either the board or socket

6.7 All subassemblies and printed circuit boards must be permanently marked with an identification code.

6.8 Test points must be provided on all units, subunits and printed circuit boards for the measurement of all important circuit characteristics without the unsoldering of wires. Such test points must be clearly marked and identified in the equipment.

6.9 All wiring and terminations between subassemblies must be identified.

6.10 The functions of all controls, switches, etc. must be clearly engraved or otherwise permanently marked in English, or by means of approved symbols

6.11 Fuses must be rated to give adequate protection to the circuit served while rupturing prematurely

6.12 All components must be clearly marked and must be capable of easy reference to circuit diagrams and handbooks to be supplied with the equipment

6.13 Equipment using plug-in modules must be fitted with guides for the insertion of modules. It must not be possible to incorrectly insert a module.

7. ACCEPTANCE TESTS

7.1 Transnet Freight Rail will conduct acceptance tests on the equipment. The equipment will not be accepted nor payment authorised until these tests have been completed and it has been confirmed that the equipment supplied is fully in accordance with the requirements of this specification and/or the stated claims of the tenderer as accepted by Transnet Freight Rail.

7.2 The successful tenderer must agree to rectify any defects at no cost to Transnet Freight Rail, where the equipment does not meet the tender requirements and/or the stated claims of compliance.

8. MAINTENANCE AND SERVICE

8.1 The tenderer must give full particulars of the maintenance, spare parts and service facilities which will be available in the Republic of South Africa. The names and addresses of the companies concerned must be furnished.

8.2 The tenderer must list the major centres where maintenance facilities can be provided and must state if repairs under guarantee can be undertaken at these centres.

8.3 Tenderers must state what provision will be made to ensure an adequate supply of locally available spare components for a period of 10 years after the order is placed.

8.4 Transnet will not consider tenders from tenderers who cannot provide an efficient spares and maintenance service. Tenderers must state whether they are prepared to agree to an inspection of their maintenance premises by the engineering personnel of Transnet Freight Rail

9. TECHNICAL HANDBOOKS

9.1 Technical handbooks, in CD format, must be clearly and professionally described in English.

9.2 The technical handbooks must be packed with the equipment.

9.3 Each set of handbooks must include the following:

9.3.1 Operating instructions.

9.3.2 Complete maintenance instructions.

9.3.3 Complete and detailed alignment procedures in a proven and easy to follow order.

9.3.4 A detailed technical description of the equipment.

9.3.5 Complete circuit diagrams, drawings and photographs of the equipment. The photographs and drawings must clearly indicate component and module location in the equipment. All component numbers must be clearly indicated.

9.3.6 A list of parts, giving the values of all components, i.e. resistive, capacitive, inductive, integrated circuit and semi-conductor numbers for each schematic, drawing.

9.3.7 Detailed printed circuit board wiring diagrams showing component numbers and positions and the wiring itself. Multilayer board wiring must be shown to include all layers of printed wiring clearly and discernible.

9.3.8 Voltage levels, current values and test points, clearly indicated on circuit diagrams and printed circuit board layouts.

9.3.9 Complete circuit diagrams of all individual modules.

9.4 All symbols and notations used on drawings and circuit diagrams preferably comply with the requirements laid down in BS 3939. Where symbols and notations do not comply with these requirements, each drawing shall be accompanied by a legend clearly detailing BS 3939 equivalents.

9.5 No hand-written notes and numbers must appear in a handbook supplied by a tenderer. All writing must be of proper printed form.

9.6 Transnet Freight Rail reserves the right to reproduce in whole or in part, by any means whatsoever, any technical handbook or instruction manual supplied by the successful Contractor. Any such reproductions will be for the sole use of Transnet Freight Rail

10. ALARMS

10.1 Provision must be made for the monitoring of the following alarms:

- Transmitter alarms.
- Tx VSWR alarm.
- Tx Low Power alarm.
- Loss of received signal

11. POWER SUPPLY

Should the equipment be supplied with a mains power supply/charger, the battery charging circuit must be provided with load shed. The load-shed threshold must be adjustable.

12. GENERAL

The tenderer must submit technical specification pamphlets and schematic diagrams covering the equipment offered. Photographs and complete drawings clearly displaying the external dimensions and physical appearance of the equipment must also be submitted with the tender.

END OF DOCUMENT