S&T DIRECTORATE

RESEARCH DESIGNSAND STANDARDS ORGANISATION

MANAKNAGAR, LUCKNOW-226011

Title: TEST FORMAT FOR UHF RADIO MODEM

SNo.	Issue	Version	Reason for Amendment
1.	First	1.0	The initial issue
2.			

Prepared by:		Approved by:
Manish Kumar Gupta	SSE/S&T/RDSO/SC	Suresh Kumar, PED/S&T
R. N. Singh	ADE/Signal-V	
M. M. Srivastava	Director Sig-IV	
G Pavan Kumar	Exe Director /Tele-II	

Signature of Firm's Representative with date and designation	Signature of RDSO Representative with date and designation

TYPE TEST FORMAT FOR UHF RADIO MODEM

(ANNEXURE-E1 SPECIFICATION OF KAVACH (THE INDIAN RAILWAY ATP)-UHF RADIO MODEM REQUIREMENTS)

NAME OF THE EQUIPMENT	RADIO MODEM
SPECIFICATION NO:	ANNEXURE E1 OF RDSO/ SPN/196/2020 (VERSION 4.0)
NAME OF THE TEST	TYPE TEST FORMAT FOR HARDWARE
NAME AND ADDRESS OF THE FIRM	
NAME AND SL. NO OF KAVACH EQUIPMENT	
VERSION NO.	

Signature of Firm's Representative with date and designation	Signature of RDSO Representative with date and designation

Abbreviation	**Full Form/Description**
RTS	Request To Send
FSK	Frequency Shift Keying
EUT	Equipment Under Test
OBW	Occupied Bandwidth
RBW	Resolution Bandwidth
VBW	Video Bandwidth
IF	Intermediate Frequency
BER	Bit Error Rate
DTR	Data Terminal Ready
RI	Ring Indicator
CP	Channel Power
ACP	Adjacent Channel Power
MC-ACP	Multi Carrier Adjacent Channel Power

1. Name of PCB Modules & Serial Numbers:

Sample Requirement: Radio Modems- 4 Nos.

(Type test shall be conducted in 2 Nos. of samples and other 2 Nos. samples shall be kept in seal condition).

(Details to be filled up during type testing)

S. No.	Module Name	Module Part Number	Version No	Firmware CRC and version Number
1.				
2.				
3.				
4.				

S. No.	Details of PCB Name	PCB Part Number	Design Software and Hardware DXX SXXX HXX
i.			
ii.			
iii.			
iv.			

Signature of Firm's Representative with date and designation	Signature of RDSO Representative with date and designation

2. Visual Inspection

S.no	SRS CL.no	Reference document CL. no (RDSO/SPN/144)	Test Performed	Observed remarks
1.	--	12.2	All markings/ indications shall be easily legible and durable. Where the marking is by use of labels, the labels shall be metallic and shall be firmly fixed and shall not be capable of being removed by hand. The durability of the marking shall be checked by rubbing the marking by hand with a piece of cloth soaked with petroleum spirit.	
2.	--	12.4	The anodised name plate shall be firmly attached to the equipment and shall show the following information: a. Name of trademark of the manufacturer. b. Serial no. of the unit. c. Name of the equipment. d. Operating voltage: 24 VDC or as appropriate. e. Month and year of manufacture	
3.	25.3.1 (d)	5.2(ii)	Shielding at chassis or rack (enclosure) level is provided	
4.	25.3.1 (d)	5.3	Indications and/or displays are provided for diagnostic purpose	
5.	25.3.1 (d)	5.4	Proper housing of cards	
6.	25.3.1 (d)	---	All plugin connectors shall have lock-in arrangements	

3. Radio Modem Requirements

3.1. Frequency Range: (As per clause 2.3, 2.8 & 2.9 of Annexure –E1)

3.1.1. Test Criteria

RF frequency range: 406-470 MHz

3.1.2. Test equipment required

i. Spectrum Analyser

ii. Attenuator (40 dB)

iii. Power supply

3.1.3. Test Procedure

1. Connect Power supply to Radio Modem Power supply port and Turn on Radio Modem.
2. Connect Radio Modem Data & Config ports to Serial Port of PC COM Ports.
3. Configure Two serial ports in dock light as given below
   a. Baud Rate – 19200 bps
   b. Parity – None
   c. Data Bits – 8
   d. Stop Bits – 1
4. Connect Radio Modem TX port to Spectrum analyser through 40dBm Attenuator and RF Cables.
5. Set frequency & Span in spectrum analyser as required.
6. In dock light send command from Config port to Configure frequency e.g. SET TX_FREQ_DEF 406.125<CR><LF>

7. From Data Port Dock light terminal click on RTS and make RTS High.

8. Observe the Transmitter output frequency as per the configured frequency from 406.125MHz to 469.975MHz.

3.1.4. Test Result

Frequency Range (MHz): 406.000 – 470.000 MHz

S.no	Configure frequency	Observed frequency	Result (Pass/ Fail)
1.	406.125 MHz		
2.	435.500 MHz		
3.	469.975 MHz		

3.2. Channel Bandwidth: (As per clause 2.4 of Annexure –E1)

3.2.1. Test Criteria

RF Channel Bandwidth: 25kHz

3.2.2. Test Procedure

1. Connect Power supply to Radio Modem Power supply port and Turn on Radio Modem.
2. Connect Radio Modem Data & Config ports to Serial Port of PC COM Ports.
3. Configure Two serial ports in dock light as given below
   a. Baud Rate – 19200 bps
   b. Parity – None
   c. Data Bits – 8
   d. Stop Bits – 1
4. Connect Radio Modem TX port to Spectrum analyser through 40dBm Attenuator and RF Cables.
5. Set spectrum analyser settings as given below.
   a. Settings:
      1. Resolution bandwidth (300 Hz)
      2. Video bandwidth: (1 kHz)
      3. Frequency span: (32.9 kHz)
      4. Detector mode: Peak
      5. Trace mode: Max Hold

6. In dock light send command from Config port to configure frequency e.g. SET TX_FREQ_DEF 406.125<CR><LF>
7. In dock light send command from Config port as SET TX_POWER_DEF 10.0<CR><LF>
8. From Data Port Dock light terminal click on RTS and make RTS High.
9. Note the measured value of FSK at 10W at the configure frequency.
10. Verify for two other frequencies at 435.500MHz & 469.975MHz and note down the values.

3.2.3. Test Result

Annex-E1 clause no.: 2.4

S.no	Configure frequency	Bandwidth	Observed Value	Result (Pass/ Fail)
1.	406.125MHz	25KHz		
2.	435.500MHz	25KHz		
3.	469.975MHz	25KHz		

3.3. Mode of Operation: (As per clause 2.5 of Annexure –E1)

3.3.1. Test Criteria

Mode of Operation: Full Duplex

3.3.2. Test equipment required

i. PC with dock light

ii. Attenuator

iii. Power supply

3.3.3. Test Procedure

1. Connect Power supply to Radio Modem Power supply port and Turn on Radio Modem1 and Radio Modem2.
2. In dock light send command from Config port as SET TX_FREQ_DEF 426.675<CR><LF> for Radio Modem1.
3. In dock light send command from Config port as SET TX_FREQ_DEF 462.975<CR><LF> for Radio Modem2.
4. In dock light send command from Config port as SET RX_FREQ_DEF 426.675<CR><LF> for Radio Modem2.
5. In dock light send command from Config port as SET RX_FREQ_DEF 462.975<CR><LF> for Radio Modem1.
6. In dock light send command from Config port as SET TX_POWER_DEF 10.0<CR><LF> for both radios.
7. Now Transmit data on data port from both the radios through dock light simultaneously.
8. Observe both the radios should receive the data with same time stamp. (To be verified in docklight)

3.3.4. Test Result

S.no	Annex-E1 CL.no	Parameter	Specification	Observed Value	Result (Pass/ Fail)
1.	2.5	Full Duplex	Both radios should receive the data simultaneously.		

3.4. Modulation: (As per clause 2.6 of Annexure –E1)

3.4.1. Test Criteria

Modulation: 2FSK at 19200 bps

3.4.2. Test Procedure

1. Connect Power supply to Radio Modem Power supply port and Turn on Radio Modem1 and Radio Modem2.
2. In dock light send command from Config port as SET TX_FREQ_DEF 406.125<CR><LF> for Radio Modem1.
3. In dock light send command from Config port as SET RX_FREQ_DEF 406.125<CR><LF> for Radio Modem2.
4. In dock light send command from Config port as SET TX_POWER_DEF 10.0<CR><LF> for both radios.
5. Configure both radios at 19200bps air baud rate by sending SET DATARATE_DEF 5<CR><LF>.
6. Now Transmit data on data port from Radio Modem1 through dock light.
7. Observe the data received in Radio Modem2.
8. Configure Radio Modem2 at 9600bps air baud rate by sending SET DATARATE_DEF 2<CR><LF>.
9. Now Transmit data on data port from Radio Modem1 through dock light.
10. Observe the data received in Radio Modem2.

3.4.3. Test Result

S.no	Annex-E1 Cl. No.	Parameter	Specification	Observed Value	Result (Pass/ Fail)
1	2.6	Both radios at 19200 baud rate	Data should receive in Radio Modem 2		
2	2.6	One radio at 19200 baud rate and another at 9600 baud rate	Data should not receive in Radio Modem 2		

3.5. Occupied Bandwidth: (As per clause 2.7 of Annexure –E1)

3.5.1. Test Criteria

Occupied Bandwidth :16.35 kHz +/- 0.15 kHz

3.5.2. Test Procedure

1. The spectrum analyser center frequency is set to the nominal EUT channel center frequency. The frequency span for the spectrum analyser shall be set wide enough to capture all modulation products including the emission skirts (typically a span of 1.5 × OBW is sufficient).
2. The nominal IF filter 3 dB bandwidth (RBW) shall be in the range of 1% to 5% of the anticipated OBW, and the VBW shall be set ≥ 3 × RBW.
3. Set the reference level of the instrument as required to prevent the signal amplitude from exceeding the maximum spectrum analyser input mixer level for linear operation.

   NOTE—Step 1, step 2, and step 3 may require iteration to adjust within the specified tolerances.
4. Set the detection mode to peak, and the trace mode to max-hold.
5. If the instrument does not have a 99% OBW function, recover the trace data points and sum directly in linear power terms. Place the recovered amplitude data points, beginning at the lowest frequency, in a running sum until 0.5% of the total is reached. Record that frequency as the lower OBW frequency. Repeat the process until 99.5% of the total is reached and record that frequency as the upper OBW frequency. The 99% power OBW can be determined by computing the difference these two frequencies.
6. OBW can be recorded.

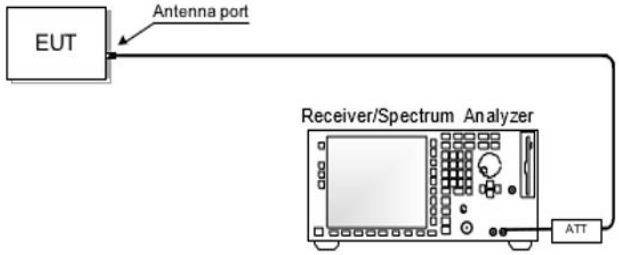


Fig 1: EUT setup configuration

3.5.3. Test Result

S.no	Annex-E1 CL.no	Parameter	Specification	Observed Value	Result (Pass/ Fail)
1	2.7 & 3.1.2	Occupied Bandwidth	16.35kHz ± 0.15 KHz		

3.6. Frequency Stability: (As per clause 2.11 of Annexure –E1)

3.6.1. Test Criteria

Transmitter freq. stability: 1 ppm

3.6.2. Test Procedure

1. Frequency measurements shall be made at the extremes of the 70° C to -30° C temperature range and at intervals of 10° C.
2. A period of 30 minutes to stabilize all of the components of the oscillator circuit at each temperature level shall be allowed prior to frequency measurement.
3. The short-term transient effects on the frequency of the transmitter due to keying and any heating element cycling normally occurring at each temperature level also shall be recorded and indicated in the report.
4. Electronics needed for operation and externally located with the transmitter need to be subjected to the temperature variation test.
5. The power supplies shall part of the voltage variation test. The following procedures shall be used for frequency stability tests.
   a. Supply the EUT with a nominal dc voltage in the EUT.
   b. Turn on the EUT, and tune it to the center frequency of the operating band.
   c. Couple the transmitter output to the measuring instrument through a suitable attenuator and coaxial cable.

      NOTE—An instrument that has less than 1 ppm level of accuracy is recommended.
   d. Turn the EUT off, and place it inside the environmental temperature chamber. For devices that have oscillator heaters, energize only the heater circuit.
   e. Set the temperature control on the chamber to the highest temperature specified in the regulatory requirements for the type of device, and allow the oscillator heater and the chamber temperature to stabilize.
   f. While maintaining a constant temperature inside the environmental chamber, turn on the EUT and allow sufficient time for the EUT temperature to stabilize.

g. Measure the frequency.

h. Switch off the EUT, but do not switch off the oscillator heater.

i. Lower the chamber temperature to the next level that is required by the standard and allow the temperature inside the chamber to stabilize. Unless otherwise instructed by the regulators, this temperature step should be 10 °C.

j. Repeat step g) through step i) down to the lowest specified temperature. Unless otherwise instructed by the regulators, this temperature should be −30 °C. When the frequency stability limit is stated as being sufficient such that the fundamental emissions stay within the authorized bands of operation, a reference point shall be established at the applicable unwanted emissions limit using a RBW equal to the RBW required by the unwanted emissions specification of the applicable regulatory standard. These reference points measured using the lowest and highest channel of operation shall be identified as fl and fh respectively. The worst-case frequency offset determined in the above methods shall be added or subtracted from the values of fl and fh and the resulting frequencies must remain within the band.

k. The following additional information is required for equipment incorporating heater type crystal oscillators to be used in mobile stations except for battery powered, hand carried, and portable equipment having mean output power lower than the threshold specified.

   i. Measurement data showing variation in transmitter output frequency from a cold start and the elapsed time necessary for the frequency to stabilize within the applicable tolerance. Tests shall be made after temperature stabilization at each of the ambient temperature levels required by the standard.

   ii. Beginning at each temperature level specified, the frequency shall be measured within 60 s after application of primary power to the transmitter and at intervals of no more than 60 s thereafter until 10 min have elapsed or until sufficient measurements are obtained to indicate clearly that the frequency has stabilized within the applicable tolerance, whichever time period is greater.

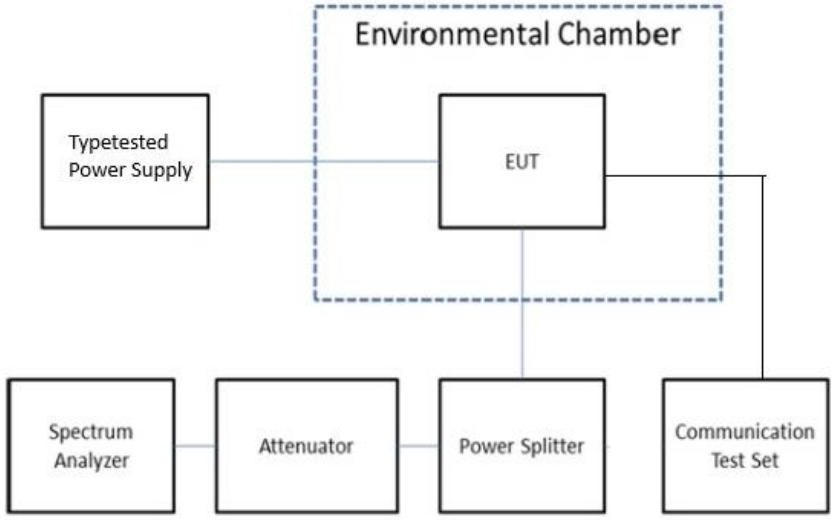


Fig 2: EUT setup configuration

3.6.3. Test Result: Cl. No. 2.11 of Annex-E1

3.6.4. At 406.125 MHZ

#	Temp.	ppm, Stabilization time (1 ppm)										fl (406.121 MHz)	fh (406.129 MHz)	Observed Value	Result (Pass/ Fail)
		1	2	3	4	5	6	7	8	9	10				
1.	70^0C														
2.	60^0C														
3.	50^0C														
4.	40^0C														
5.	30^0C														
6.	20^0C														
7.	10^0C														
8.	0^0C														
9.	-10^0C														
10.	-20^0C														
11.	-30^0C														

3.6.5. At 435.500 MHZ

#	Temp.	ppm, Stabilization time (1 ppm)										fl (435.496 MHz)	fh (435.504 MHz)	Observed Value	Result (Pass/ Fail)
		1	2	3	4	5	6	7	8	9	10				
12.	70^0C														
13.	60^0C														
14.	50^0C														
15.	40^0C														
16.	30^0C														
17.	20^0C														
18.	10^0C														
19.	0^0C														
20.	-10^0C														
21.	-20^0C														
22.	-30^0C														

3.6.6. At 469.975 MHZ

#	Temp.	ppm, Stabilization time (1 ppm)										fl (469.971 MHz)	fh (469.979 MHz)	Observed Value	Result (Pass/ Fail)
		1	2	3	4	5	6	7	8	9	10				
23.	70^0C														
24.	60^0C														
25.	50^0C														
26.	40^0C														
27.	30^0C														
28.	20^0C														
29.	10^0C														
30.	0^0C														
31.	-10^0C														
32.	-20^0C														
33.	-30^0C														

3.7. Channel Switching time: (As per clause 2.12 of Annexure –E1)

3.7.1. Test Criteria

Channel Switching time: not more than 15msec

3.7.2. Test Procedure

1. Radio will be connected to external supply.
2. Connect CRO probe 1 (channel-1) on Rx pin of Config port and configure probe 1 as trigger port.
3. Connect CRO probe 2 (channel-2) on synthesizer lock.
4. Now switch on the power supply and send frequency change command on config port.
5. Record the time between channel 2 rising edge and channel 1 rising edge

3.7.3. Test Result

S.no	Annex-E1 CL.no	Parameter	Specification	Observed Value	Result (Pass/ Fail)
1	2.12	Channel Switching time	< 15msec		

3.8. Carrier Output Power: (As per clause 2.13 of Annexure –E1)

3.8.1. Test Criteria

Carrier Output Power: 1-10 w adjustable through software.

3.8.2. Test Procedure

1. Connect Power supply to Radio Modem Power supply port and Turn on Radio Modem.
2. Connect Radio Modem Data & Config ports to Serial Port of PC COM Ports.
3. Configure Two serial ports in dock light as given below
   a. Baud Rate – 19200 bps
   b. Parity – None
   c. Data Bits – 8
   d. Stop Bits – 1
4. Connect Radio Modem TX port to Spectrum analyser through 40dBm Attenuator and RF Cables.
5. Set frequency & Span in spectrum analyser as required.
6. In dock light send command from Config port as SET TX_FREQ_DEF 406.125<CR><LF>
7. In dock light send command from Config port as SET TX_POWER_DEF 10.0<CR><LF>
8. From Data Port Dock light terminal click on RTS and make RTS High.
9. Observe the Transmitter output Power as per the configured output Power setting from 406.125MHz to 469.975MHz.
10. Observe& Verify the RF Power output at Different output Power configurations from 1W to 10W.

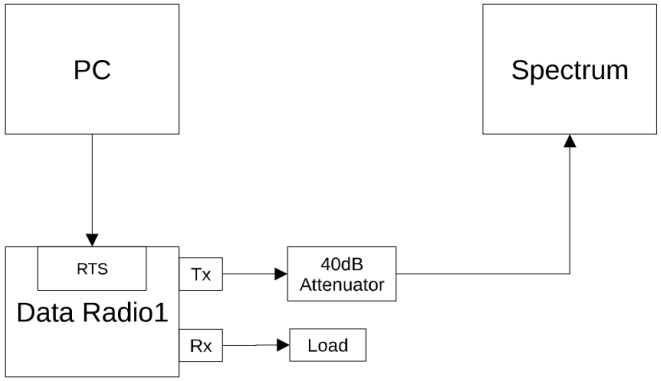


Fig 3: Carrier setup configuration

3.8.3. Test Result

S.no	Annex-E1 CL.no	Parameter	Specification	Observed Value	Result (Pass/ Fail)
1	2.13	406.125MHz	1W		
2	2.13	406.125MHz	5W		
3	2.13	406.125MHz	10W		
4	2.13	435.500MHz	1W		
5	2.13	435.500MHz	5W		
6	2.13	435.500MHz	10W		
7	2.13	469.975MHz	1W		
8	2.13	469.975MHz	5W		
9	2.13	469.975MHz	10W		

3.9. Adjacent Channel Rejection

3.9.1. Test Criteria

Receiver Adjacent Channel Rejection: 70dB at 25kHz

3.9.2. Test Procedure

1. Set the spectrum analyser center frequency to the channel edge frequency 427.625 MHz.
2. Set the span as 75 KHz to capture the fundamental emission closest to the band edge, and to include all modulation products that spill into the immediately adjacent frequency band.
3. Set the number of points in sweep ≥ 2 X span / RBW. i.e number of points in sweep ≥ 500.
4. Sweep time should be auto for peak detection. For rms detection the sweep time should be set as follows:

   a) As the device is configured to transmit continuously (duty cycle ≥ 98%), set the (sweep time) > (number of points in sweep) X (symbol period) (e.g., by a factor of 10 X symbol period X number of points). sweep time > . 10 x 500 x 1/19200.

   b) The test report shall include the plots of the measuring instrument display and the measured data.

3.9.3. Test Result

S.no	Annex-E1 CL.no	Parameter	Specification	Observed Value	Result (Pass/ Fail)
1	2.14	Adjacent Channel Rejection	70dB		

3.10. Receiver Sensitivity: (As per clause 2.15 of Annexure –E1)

3.10.1. Test Criteria

Receiver Sensitivity: 35 micro-volts for 12 dB SINAD / 1 x 10^{-6} BER at -100 dBm Level for 19.2kbps and 25kHz Bandwidth.

3.10.2. Test Procedure

1. Connect the radios as per below diagram.
2. Connect Power supply to Radio Modem Power supply port and Turn on Radio Modem1 and Radio Modem2.
3. In dock light send command from Config port as SET TX_FREQ_DEF 406.125<CR><LF> for Radio Modem1.
4. In dock light send command from Config port as SET TX_FREQ_DEF 411.125<CR><LF> for Radio Modem2.
5. In dock light send command from Config port as SET RX_FREQ_DEF 406.125<CR><LF> for Radio Modem2.
6. In dock light send command from Config port as SET RX_FREQ_DEF 411.125<CR><LF> for Radio Modem1.
7. In dock light send command from Config port as SET TX_POWER_DEF 10.0<CR><LF> for both radios.
8. Now Transmit data on data port from Radio Modem1 and check the received data in Radio Modem2 through dock light.
9. Calculate the BER from no of bytes sent to no of valid bytes received.

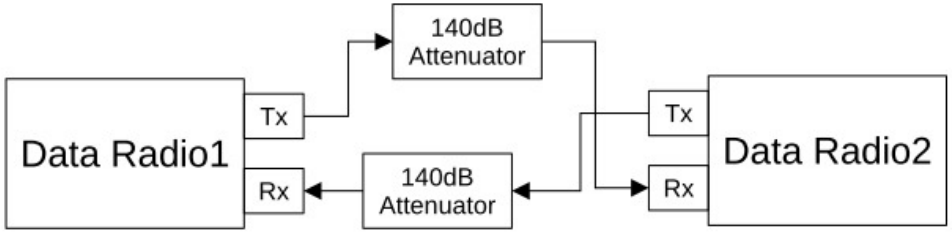


Fig 4: Sensitivity Setup Configuration

3.10.3. Test Result

S.no	Annex-E1 CL.no	Parameter	Specification	Observed Value	Result (Pass/ Fail)
1	2.15, 2.16	Receiver Sensitivity at frequency- 406.125MHz	1 x 10^{-6} BER at -100 dBm		
2	2.15, 2.16	Receiver Sensitivity at frequency -435.500MHz	1 x 10^{-6} BER at -100 dBm		
3	2.15, 2.16	Receiver Sensitivity at frequency 469.975MHz	1 x 10^{-6} BER at -100 dBm		

3.11. Interfaces: (As per clause 2.17 of Annexure –E1)

3.11.1. Test Criteria

1. Interfaces: RS 232/RS 485
2. Set-up and Diagnostic features to be available through separate port RS232/RS485

3.11.2. Test Procedure

1. Connect Radio Modem Data & Config ports to Serial Port of PC COM Ports.
2. Configure Two serial ports in dock light as given below
   a. Baud Rate – 19200
   b. Parity – None
   c. Data Bits – 8
   d. Stop Bits – 1
3. Connect Power supply to Radio Modem Power supply port and Turn on Radio Modem.
4. Observe the version no received in config port docklight.
5. We can conclude that it is following RS232 standard.
6. In dock light send command from Config port in HEX Format as BA 04 FC 00 33 CD
7. Verify the reply from Radio Modem as per the below table

3.11.3. Test Result

Count	Description	Communication Bytes	Physical Measured value	Diagnostic Suggested Value	Test Result (Pass/Fail)
0	START BIT	BA	NA		
1	ML (Message Length)	12	NA		
2	OP CODE	FC	NA		
3	MESSAGE ID	01	NA		
4	SUB OP CODE	33	NA		
5	TEMP in HEX				
6	Receive Control Line Voltage (Divide by 5)				
7	Instantaneous TX rev Power (Divide by 10)				
8	Instantaneous TX Forward Power (Divide by 10)				
9	Transmit control line Voltage (divide by 5)				
10	PA & Driver Supply Voltage				
11	Instantaneous TX PA Current (divide by 10)				
12	Voltage Applied to the Radio Modem				
13	PA Temperature				
14	TX Reverse power From Last Tx Data (Divide by 10)				
15	TX Forward power From Last Tx Data (Divide by 10)				
16	Tx PA Current from Last TX Data (Divide by 10)				

17, 18	RSSI (Divide by 128)				
19	Check Sum				

3.12. Power Supply: (As per clause 2.19 of Annexure –E1)

3.12.1. Test Criteria

Power Supply: 10V-30V DC

3.12.2. Test Procedure

1. Radio has to be powered with external supply of 15V output. Connect the Tx port to spectrum.
2. Select the Radio frequency @435MHz from config port. Configured the radio output power 10w.
3. Vary the supply voltage from 10V-30V and record the output power.

3.12.3. Test Result

#	Annex-E1 CL.no	Variation Voltage	Frequency	RF Power out	Observed Value	Result (Pass/ Fail)
1.	2.19	24 Volts	406.125 MHz	10 Watt (40dBm ±1dBm)		
2.			435.500 MHz	10 Watt (40dBm ±1dBm)		
3.			469.975 MHz	10 Watt (40dBm ±1dBm)		
4.		28.8 Volt	406.125 MHz	10 Watt (40dBm ±1dBm)		
5.			435.500 MHz	10 Watt (40dBm ±1dBm)		
6.			469.975 MHz	10 Watt (40dBm ±1dBm)		

Signature of Firm's Representative with date and designation	Signature of RDSO Representative with date and designation

#	Annex-E1 CL.no	Variation Voltage	Frequency	RF Power out	Observed Value	Result (Pass/ Fail)
7.		30 Volt	406.125 MHz	10 Watt (40dBm ±1dBm)		
8.			435.500 MHz	10 Watt (40dBm ±1dBm)		
9.			469.975 MHz	10 Watt (40dBm ±1dBm)		
10.		19.2 volt	406.125 MHz	10 Watt (40dBm ±1dBm)		
11.			435.500 MHz	10 Watt (40dBm ±1dBm)		
12.			469.975 MHz	10 Watt (40dBm ±1dBm)		
13.		14.4 Volt	406.125 MHz	10 Watt (40dBm ±1dBm)		
14.			435.500 MHz	10 Watt (40dBm ±1dBm)		
15.			469.975 MHz	10 Watt (40dBm ±1dBm)		
16.		10 Volt	406.125 MHz	10 Watt (40dBm ±1dBm)		
17.			435.500 MHz	10 Watt (40dBm ±1dBm)		
18.			469.975 MHz	10 Watt (40dBm ±1dBm)		

3.13. Transmission and Reception: (As per clause 3.2.1, clause 3.3, clause 3.4, clause 3.5 of Annexure –E1)

3.13.1. Test Criteria

1. During bit stream over the air transmission, LSB shall be transmitted first.
2. Encoding
3. Scrambling
4. Receiving

To test the above requirements, we can confirm by interoperability test as mentioned in below procedure

3.13.2. Test Procedure

1. Connect the radios as per below diagram.
2. Connect Power supply to Radio Modem Power supply port and Turn on Radio Modem1 and Calamp 1.
3. In dock light send command from Config port as SET TX_FREQ_DEF 406.125<CR><LF> for Radio Modem1.
4. In dock light send command from Config port as SET TX_FREQ_DEF 411.125<CR><LF> for Calamp 1.
5. In dock light send command from Config port as SET RX_FREQ_DEF 406.125<CR><LF> for Calamp 1.
6. In dock light send command from Config port as SET RX_FREQ_DEF 411.125<CR><LF> for Radio Modem1.
7. In dock light send command from Config port as SET TX_POWER_DEF 10.0<CR><LF> for both radios.
8. Now Transmit data on data port from Radio Modem1 and check the received data in Calamp1 through docklight.
9. Record the output.
10. Now Transmit data on data port from Calamp1 and check the received data in Radio Modem1 through docklight.
11. Record the output.

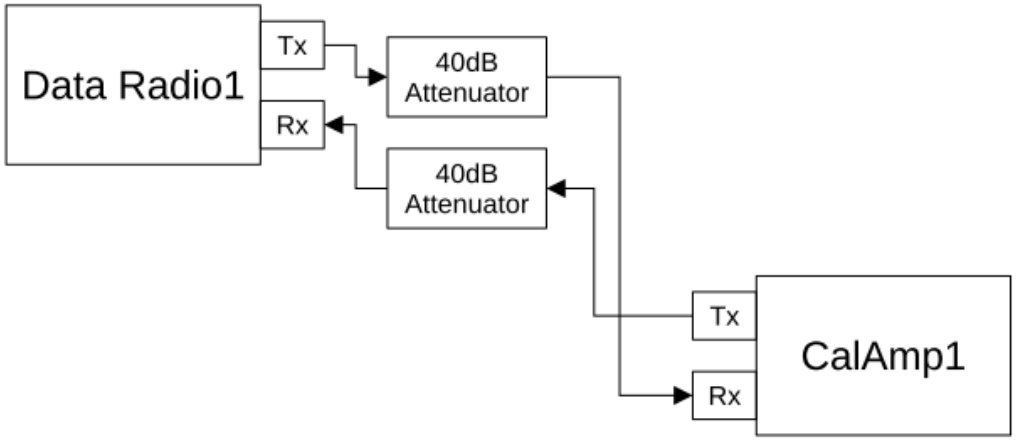


Fig 3: EUT Setup Configuration

3.13.3. Test Result

S.no	Annex-E1 CL.no	Parameter	Specification	Observed Value	Result (Pass/ Fail)	
1	3.2.1, 3.3, 3.4, 3.5	Transmission from firm Radio (DUT) and Reception from RDSO approved Radio MODEM.	Both radios should receive data.	RDSO approved radio shall receive complete packet as transmitted from DUT.	Channel-1	
					Channel-2	
					Channel-3	
					Channel-4	
					Channel-5	
					Channel-6	
					Channe-7	
					Channel-8	
2	3.2.1, 3.3, 3.4, 3.5	Transmission from RDSO approved Radio MODEM and Reception from firm Radio MODEM (DUT).	Both radios should receive data.	Firm radio MODEM shall receive complete packet as transmitted from RDSO approved Radio MODEM.	Channel-1	
					Channel-2	
					Channel-3	
					Channel-4	
					Channel-5	
					Channel-6	
					Channe-7	
					Channel-8	

3.14. Transmission: (As per clause 3.2.2 and 3.2.3 of Annexure –E1)

3.14.1. Test Criteria

1. Transmission shall start within 3ms +/- 1ms after data terminal equipment causes the signal on RTS line to be high.
2. RTS shall be raised before commencement of preamble transmission.

3.14.2. Test Procedure

1. Connect the radio as per below diagram.
2. Connect Power supply to Radio Modem Power supply port and Turn on Radio Modem1.
3. In dock light send command from Config port as SET TX_FREQ_DEF 406.125<CR><LF> for Radio Modem1.
4. In CRO connect channel 1 to RTS pin and channel 2 to TX power output through 20dB attenuator.
5. Set the time scale of CRO 1ms and channel1 as trigger.
6. Now make RTS on in data port from dock light.
7. Record the time between channel1 rising edge and channel rising edge.

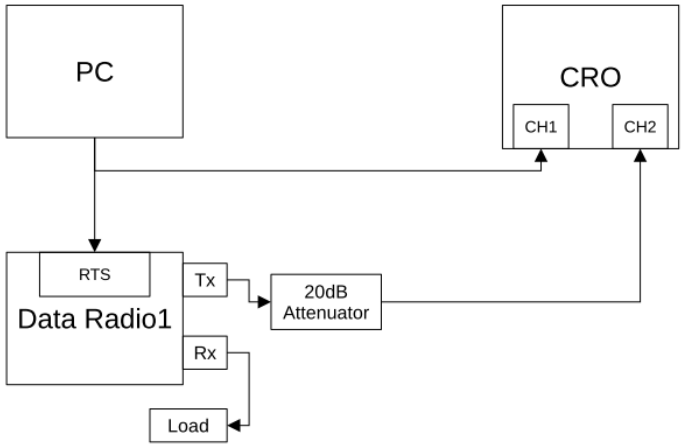


Fig 4: Transmission Setup Configuration

Signature of Firm's Representative with date and designation	Signature of RDSO Representative with date and designation

3.14.3. Test Result

S.no	Annex-E1 CL.no	Parameter	Specification	Observed Value	Result (Pass/ Fail)
1	3.2.2, 3.2.3	Transmission time	Transmission shall start within 3ms +/- 1ms.		

3.15. Transmission: (As per clause 3.2.4 of Annexure –E1)

3.15.1. Test Criteria

Radio modem shall transmit based on the DTR, RTS and RI signals according to the table shown below.

DTS	RTS	Ring Indicator Status	Radio Modem
Low	*	Low	Won't transmit
High	Low	Low	Receiving or buffering Tx data
High	↑	↑	Transmit all buffered data and incoming data
High	High	High	Send all data in Tx buffer and continue transmitting even when Tx buffer is empty
High	↓	↓	Continue transmitting remaining data in Tx buffer, then unkey

3.15.2. Test Procedure

1. Connect the radios as per below diagram.
2. Connect Power supply to Radio Modem Power supply port and Turn on Radio Modem1 and Radio Modem2.
3. In dock light send command from Config port as SET TX_FREQ_DEF 406.125<CR><LF> for Radio Modem1.
4. In dock light send command from Config port as SET TX_FREQ_DEF 411.125<CR><LF> for Radio Modem2.
5. In dock light send command from Config port as SET RX_FREQ_DEF 406.125<CR><LF> for Radio Modem2.

6. In dock light send command from Config port as SET RX_FREQ_DEF 411.125<CR><LF> for Radio Modem1.
7. In dock light send command from Config port as SET TX_POWER_DEF 10.0<CR><LF> for both radios.
8. Case 1:
    1. Make DTS Low and RTS high.
    2. Now Transmit data on data port from Radio Modem1 and check the received data in Radio Modem2 through docklight.
    3. No data should receive.
9. Case 2:
    1. Make DTS High and RTS low.
    2. Now Transmit data on data port from Radio Modem1 and check the received data in Radio Modem2 through docklight.
    3. No data should receive.
10. Case 3:
    1. Keep DTS High and make RTS High and make it immediately Low.
    2. Now observe the data send by case 2 will be received in Radio Modem2 through docklight.
11. Case 4:
    1. Make DTS High and RTS high.
    2. Now Transmit data on data port from Radio Modem1 and check the received data in Radio Modem2 through docklight.
    3. No data should receive but TXW LED should glow. This indicates radio is sending sync bytes even buffer is empty.
    4. Now Transmit data on data port from Radio Modem1 and check the received data in Radio Modem2 through docklight.
    5. No data should receive.

12. Record the output in each case.

3.15.3. Test Result Cl. No. 3.2.4 of Annex-E1

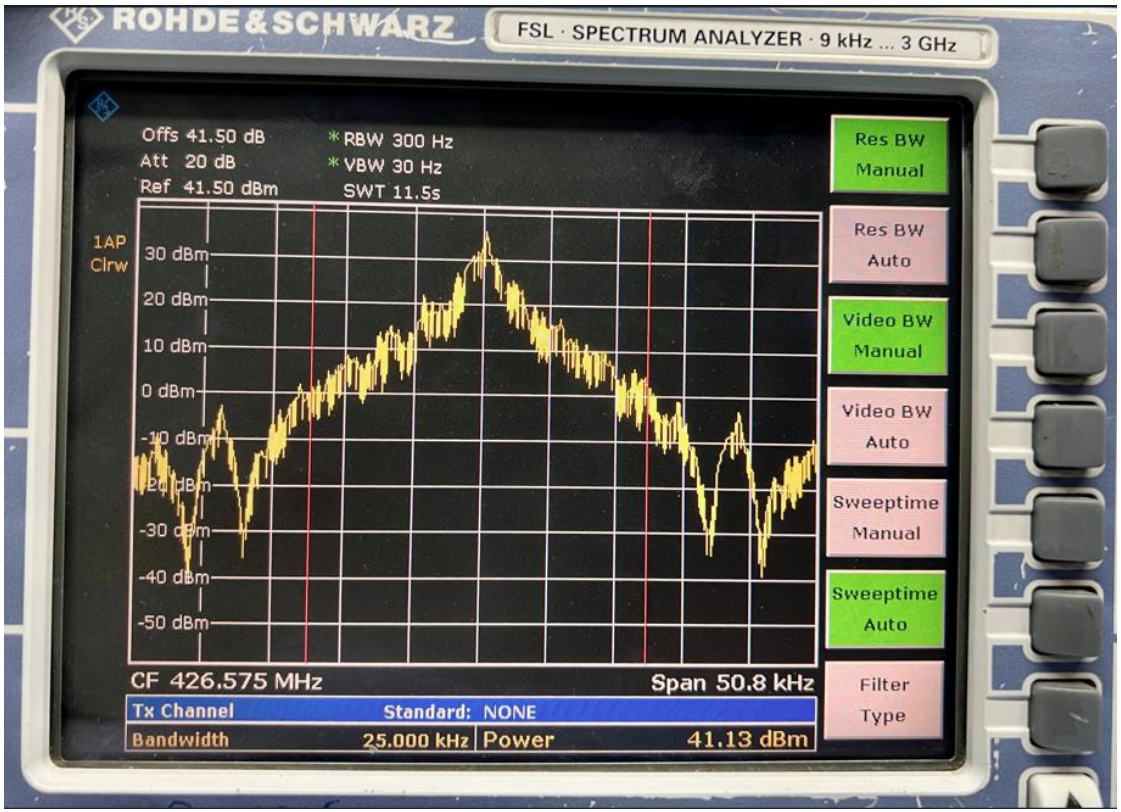
SNo.	Input Specification		Expected Result	Output Result	Result (Pass/Fail)
	DTS	RTS			
1.	Low	High	Now Transmit data on data port from Radio Modem1 and check the received data in Radio Modem2 through docklight.	Data shall not be received in Radio Modem-2.	
2.	High	Low	Now Transmit data on data port from Radio Modem1 and check the received data in Radio Modem2 through docklight.	Data shall not be received in Radio Modem-2.	
3.	High	High and make it immediately Low	Now observe the data send by case 2 will be received in Radio Modem2 through docklight	Data should be received in Radio Modem-2.	
4.	High	High	i) Now Transmit data on data port from Radio Modem1 and check the received data in Radio Modem2 through docklight.	Data shall not be received in Radio Modem-2.	
			ii) No data should receive but Tx LED should glow. This indicates radio is sending sync bytes even buffer is empty.	Tx LED should be glow.	
			iii) Now Transmit data on data port from Radio Modem1 and check the received data in Radio Modem2 through docklight.	Data should be received in Radio Modem-2.	

Signature of Firm's Representative with date and designation	Signature of RDSO Representative with date and designation

3.16. Channel power:

- Connect Power supply to Data Radio Power supply port and Turn on Data Radio.
- Connect Data Radio Data & Config ports to Serial Port of PC COM Ports.
- Configure Two serial ports in dock light as given below

  Baud Rate - 19200 Parity – None, Data Bits – 8, Stop Bits – 1
- Connect Data Radio TX port to Spectrum analyser through 40dBm Attenuator and RF Cables.
- Set the Spectrum analyser mode to Channal power measurement as per the given settings.
  a. Press Measure Button-->select CP, ACP, MC-ACP option-->Select CP/ACP CONFIG option--->select Channel Settings--->Select Channel Bandwidth option.
  b. Select TX in pop up window and Enter Channel bandwidth as 25KHz and press ESC Button.
  c. Press BW button and select Res BW manual and enter RBW as 300Hz.
  d. select Video BW manual and enter VBW as 30Hz.
- Set frequency in spectrum analyser as per test frequency
- In dock light send command from Config port as SET TX_FREQ_DEF 406.125<CR><LF>
- In dock light send command from Config port as SET TX_POWER_DEF 10.0<CR><LF>
- From Data Port Dock light terminal click on RTS and make RTS High.
- Observe the Channel Power in Spectrum Analyser.



S. N.	Frequency channel (MHz)	Bandwidth	Channel Power	Observed value	Remarks (OK/Not OK)
1.	406.125	25KHz	10 Watt (40dBm ±1dBm)		
2.	416.125	25 KHz	10 Watt (40dBm ±1dBm)		
3.	425.025	25KHz	10 Watt (40dBm ±1dBm)		
4.	425.275	25 KHz	10 Watt (40dBm ±1dBm)		

Signature of Firm's Representative with date and designation	Signature of RDSO Representative with date and designation

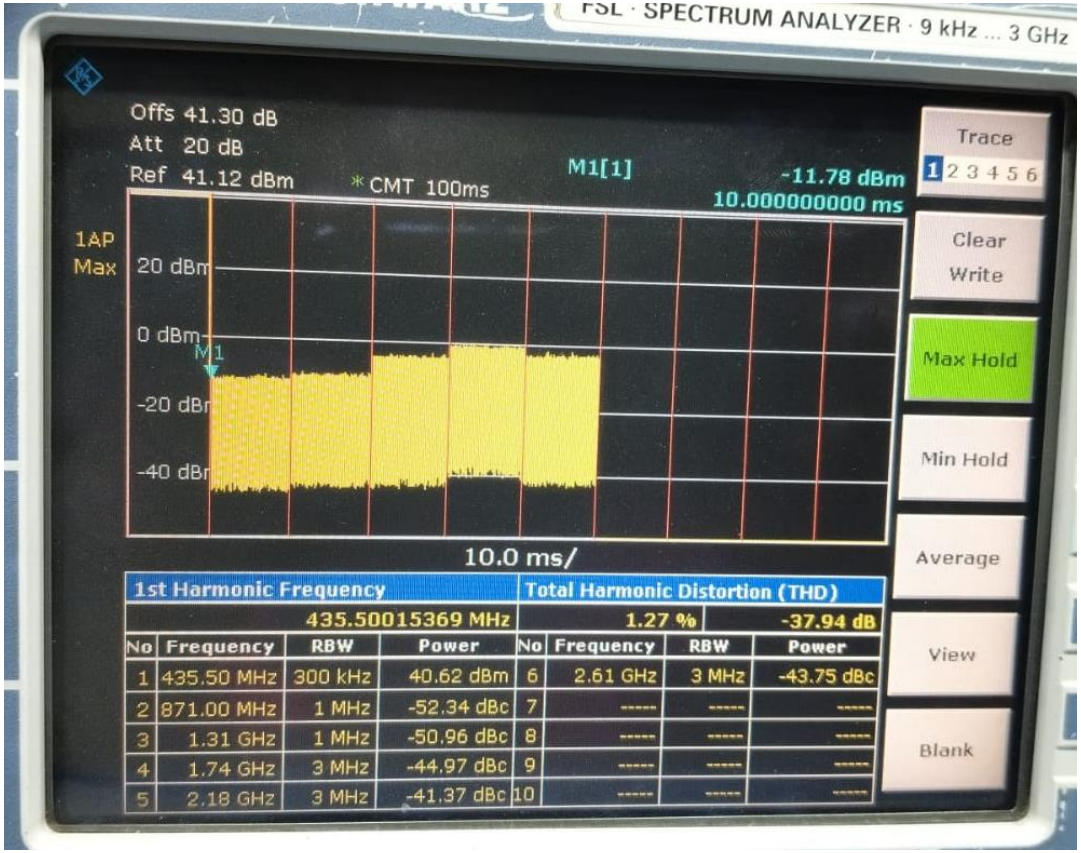
S. N.	Frequency channel (MHz)	Bandwidth	Channel Power	Observed value	Remarks (OK/Not OK)
5.	425.575	25KHz	10 Watt (40dBm ±1dBm)		
6.	425.850	25 KHz	10 Watt (40dBm ±1dBm)		
7.	426.275	25KHz	10 Watt (40dBm ±1dBm)		
8.	426.475	25 KHz	10 Watt (40dBm ±1dBm)		
9.	426.675	25KHz	10 Watt (40dBm ±1dBm)		
10.	427.875	25 KHz	10 Watt (40dBm ±1dBm)		
11.	427.450	25KHz	10 Watt (40dBm ±1dBm)		
12.	428.275	25 KHz	10 Watt (40dBm ±1dBm)		
13.	428.575	25KHz	10 Watt (40dBm ±1dBm)		
14.	428.875	25 KHz	10 Watt (40dBm ±1dBm)		
15.	429.525	25KHz	10 Watt (40dBm ±1dBm)		
16.	429.800	25 KHz	10 Watt (40dBm ±1dBm)		
17.	436.125	25 KHz	10 Watt (40dBm ±1dBm)		
18.	446.125	25 KHz	10 Watt (40dBm ±1dBm)		
19.	456.125	25 KHz	10 Watt (40dBm ±1dBm)		
20.	466.125	25 KHz	10 Watt (40dBm ±1dBm)		
21.	469.975	25 KHz	10 Watt (40dBm ±1dBm)		

3.17. Total Harmonic Distortion:

- Connect Power supply to Data Radio Power supply port and Turn on Data Radio.
- Connect Data Radio Data & Config ports to Serial Port of PC COM Ports.
- Configure Two serial ports in dock light as given below

- Baud Rate – 19200 Parity – None, Data Bits – 8, Stop Bits – 1

- Connect Data Radio TX port to Spectrum analyser through 40 dBm Attenuator and RF Cables.
- Set the Spectrum analyser mode to Channal power measurement as per the given settings. Press Measure Button-->select More-->More--> select Harmonic distortion.
- Set frequency in spectrum analyser as per test frequency.
- In dock light send command from Config port as SET TX_FREQ_DEF 406.125<CR><LF>
- In dock light send command from Config port as SET TX_POWER_DEF 10.0<CR><LF>
- From Data Port Dock light terminal click on RTS and make RTS High.
- Observe the Harmonic distortion in Spectrum Analyser.



S. N.	Frequency channel (MHz)	Bandwidth	Observed value	Remarks
1.	406.125	25KHz		
2.	416.125	25 KHz		

Signature of Firm's Representative with date and designation	Signature of RDSO Representative with date and designation

S. N.	Frequency channel (MHz)	Bandwidth	Observed value	Remarks
3.	425.025	25KHz		
4.	425.275	25 KHz		
5.	425.575	25KHz		
6.	425.850	25 KHz		
7.	426.275	25KHz		
8.	426.475	25 KHz		
9.	426.675	25KHz		
10.	427.875	25 KHz		
11.	427.450	25KHz		
12.	428.275	25 KHz		
13.	428.575	25KHz		
14.	428.875	25 KHz		
15.	429.525	25KHz		
16.	429.800	25 KHz		
17.	436.125	25 KHz		
18.	446.125	25 KHz		
19.	456.125	25 KHz		
20.	466.125	25 KHz		
21.	469.975	25 KHz		

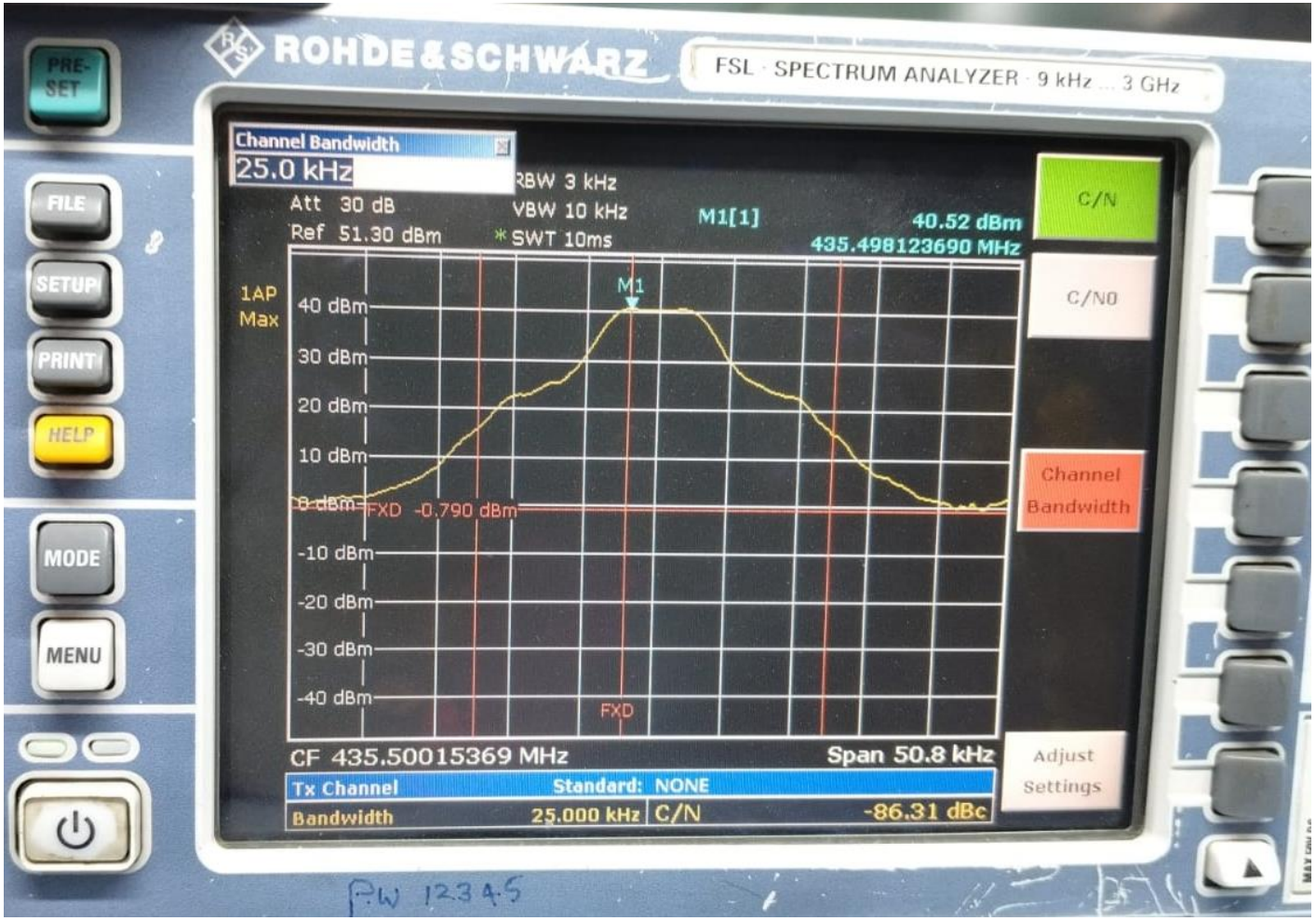
3.18. Carrier to Noise (C/N) Ratio:

- Connect Power supply to Data Radio Power supply port and Turn on Data Radio.
- Connect Data Radio Data & Config ports to Serial Port of PC COM Ports.
- Configure Two serial ports in dock light as given below

  Baud Rate - 19200, Parity – None, Data Bits – 8, Stop Bits – 1
- Connect Data Radio TX port to Spectrum analyser through 40dBm Attenuator and RF Cables.
- Set frequency & Span in spectrum analyser as required.
- Set the spectrum analyser to C/N mode.
- In dock light send command from Config port as SET TX_FREQ_DEF 406.125<CR><LF>
- In dock light send command from Config port as SET TX_POWER_DEF 10.0<CR><LF>
- From Data Port Dock light terminal click on RTS and make RTS High.

S. N.	Frequency channel (MHz)	Bandwidth	Carrier to noise Ratio	Observed value	Remarks (OK/Not OK)
22.	406.125	25KHz	Less than -70 dBc		
23.	416.125	25 KHz	Less than -70 dBc		
24.	425.025	25KHz	Less than -70 dBc		
25.	425.275	25 KHz	Less than -70 dBc		
26.	425.575	25KHz	Less than -70 dBc		
27.	425.850	25 KHz	Less than -70 dBc		
28.	426.275	25KHz	Less than -70 dBc		
29.	426.475	25 KHz	Less than -70 dBc		

S. N.	Frequency channel (MHz)	Bandwidth	Carrier to noise Ratio	Observed value	Remarks (OK/Not OK)
30.	426.675	25KHz	Less than -70 dBc		
31.	427.875	25 KHz	Less than -70 dBc		
32.	427.450	25KHz	Less than -70 dBc		
33.	428.275	25 KHz	Less than -70 dBc		
34.	428.575	25KHz	Less than -70 dBc		
35.	428.875	25 KHz	Less than -70 dBc		
36.	429.525	25KHz	Less than -70 dBc		
37.	429.800	25 KHz	Less than -70 dBc		
38.	436.125	25 KHz	Less than -70 dBc		
39.	446.125	25 KHz	Less than -70 dBc		
40.	456.125	25 KHz	Less than -70 dBc		
41.	466.125	25 KHz	Less than -70 dBc		
42.	469.975	25 KHz	Less than -70 dBc		



Signature of Firm's Representative with date and designation	Signature of RDSO Representative with date and designation

3.19. Functional Test: shall be carried out as per attached Annexure-A & Annexure-B.

3.20. MTBF: (As per clause 23.1.8 of System Requirement Specification of RDSO/SPN/196/2020)

Note: MTBF of Radio Modems shall be submitted by the OEM for minimum 1,00,000 Hrs.

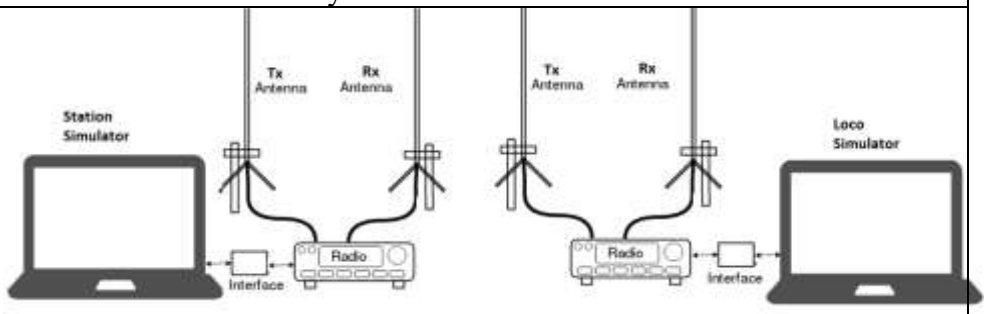
<table>
<tr><td>Test ID- 1.</td><td>KAVACH_AnnexeC1_1: Testing of Full Duplex communication without RF Channel Attenuator</td></tr>
<tr><td>Purpose</td><td>This test is to verify that the UHF radio modems support full-duplex operations simultaneously in all 68 timeslots of width 22.5ms (432 bits or 54 bytes) and spaced 5ms (96 bits or 12 bytes) apart.</td></tr>
<tr><td>Methodology</td><td>1. One UHF radio modem shall be connected to Station Simulator.
2. One UHF radio modem shall be connected to Onboard Simulator.
3. The Station shall be permanently tuned to transmit a f_{sx} frequency (pair 1 / 8) and Onboard shall be permanently tuned to receive on the same frequency.
4. The Onboard shall be permanently tuned to transmit a f_{mx} frequency (pair 1 / 8) and Station shall be permanently tuned to receive on the same frequency.
5. The arrangement shall be as shown in the figure.
6. The following counters shall be maintained on each side and logged:
a. Number of Packets transmitted.
b. Number of bytes transmitted.
c. Number of Packets received.
d. Number of valid packets received.
e. Number of bytes received.
f. Number of valid bytes received.</td></tr>
<tr><td>Setup configuration</td><td> 

Figure 1 Setup Configuration</td></tr>
<tr><td>Operation</td><td>Transmission of packets from Station side
a) The PKT_TYPE shall be set to 0x1001 (Stn2Onboard Regular Pkt). [O]
b) PKT_LENGTH shall be set to 34 bytes.[M]
c) FRAME_NUM field shall be set as per the normal calculations (based on the PC). [O]
d) DESTN_ONBOARD_ID shall be set to 666666. [O]
e) The rest of the fields shall be set to random values except for CRC. [O]</td><td>Transmission of packets from Onboard side
a) The PKT_TYPE shall be set to 0x1010 (Onboard2Stn Regular Pkt).[O]
b) PKT_LENGTH shall be set to 29 bytes.[M]
c) FRAME_NUM field shall be set as per the normal calculations (based on the PC). [O]
d) DEST-STN_IBS_LC_ID shall be set to 44444.[O]
e) The rest of the fields shall be set to random values except for CRC. [O]
f) The data is to be buffered to Radio Modem in the guard band and</td></tr>
</table>

Test ID- 1.	**KAVACH_AnnexeC1_1: Testing of Full Duplex communication without RF Channel Attenuator**	
	f) The data is to be buffered to Radio Modem in the guard band and RTS to be made high2ms before the end of guard band. RTS shall be made low after the entire buffering is completed.[**S**]	RTS to be made high 2ms before the end of guard band. RTS shall be made low after the entire buffering is completed. [**S**]
Expected Result	The Bit Error Rate shall be less than 10^{-6} and all the data in 68 time slots shall be received without fail.	
Test Result (Pass/Fail)		

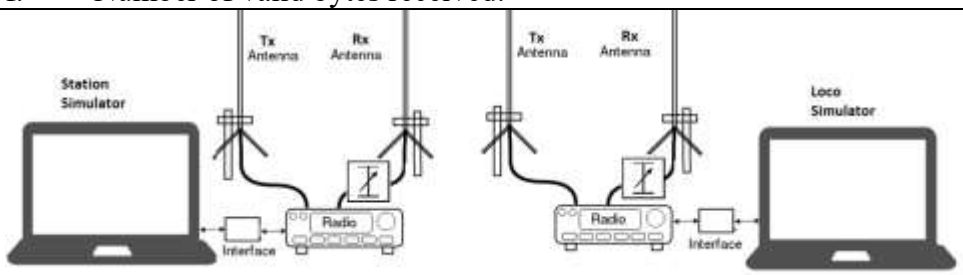
<table>
<tr><td>Test ID- 2.</td><td colspan="2">KAVACH_AnnexeC1_2: Testing of Full Duplex communication with RF Channel attenuator</td></tr>
<tr><td>Purpose</td><td colspan="2">This test is to verify that the UHF radio modems support full-duplex operations simultaneously in all 68 timeslots of width 22.5ms (432 bits or 54 bytes) and spaced 5ms (96 bits or 12 bytes) apart. The RF channel attenuator shall be placed in Rx channel and the attenuator shall be varied from 0dbm to such dbm level where the RF Signal reception starts failing.</td></tr>
<tr><td>Methodology</td><td colspan="2">1. The same setup as shown in figure 1 shall be set up, except of adding channel attenuators in the reception antenna.
2. The following counters shall be maintained on each side and logged:
a. Number of Packets transmitted.
b. Number of bytes transmitted.
c. Number of Packets received.
d. Number of valid packets received.
e. Number of bytes received.
f. Number of valid bytes received.</td></tr>
<tr><td>Setup configuration</td><td colspan="2"> 

Figure 2 Setup Configuration</td></tr>
<tr><td>Operation</td><td>Transmission of packets from Station side
a) The data is to be buffered to Radio Modem in the guard band and RTS to be made high 2ms before the end of guard band. RTS shall be made low after the entire buffering is completed. [S]
b) The RF channel attenuator shall be varied till the RF Signal reception is failed. [M]</td><td>Transmission of packets from Onboard side
a) The data is to be buffered to Radio Modem in the guard band and RTS to be made high 2ms before the end of guard band. RTS shall be made low after the entire buffering is completed. [S]
b) The RF channel attenuator shall be varied till the RF Signal reception is failed. [M]</td></tr>
<tr><td>Expected Result</td><td colspan="2">The Bit Error Rate shall be less than 10^{-6} and all the data in 68 time slots when the total channel attenuation is less than -105 dbm. The channel attenuation at which transmission is getting distorted to be noted.</td></tr>
<tr><td>Test Result (Pass/Fail)</td><td colspan="2"></td></tr>
</table>

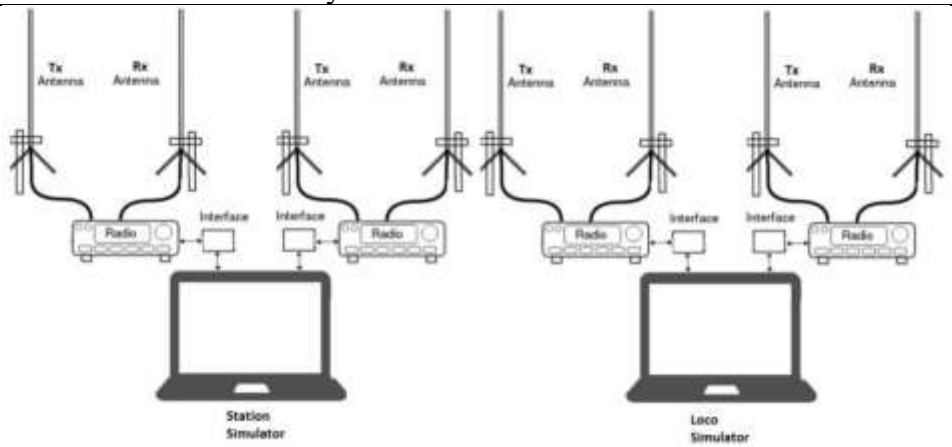
<table>
<tr><td>Test ID- 3.</td><td colspan="2">KAVACH_AnnexeC1_3: Testing of Full Duplex communication with two UHF radios (Single radio transmission).</td></tr>
<tr><td>Purpose</td><td colspan="2">This test is to verify that the reception of two UHF radio modems support full-duplex operations simultaneously in all 68 timeslots of width 22.5ms (432 bits or 54 bytes) and spaced 5ms (96 bits or 12 bytes) apart.</td></tr>
<tr><td>Methodology</td><td colspan="2">3. The setup as shown in figure 3 shall be set up, except of adding channel attenuators in the reception antenna.
4. The following counters shall be maintained on each side and logged:
a. Number of Packets transmitted.
b. Number of bytes transmitted.
c. Number of Packets received.
d. Number of valid packets received.
e. Number of bytes received.
f. Number of valid bytes received.</td></tr>
<tr><td>Setup configuration</td><td colspan="2"> 

Figure 3 Dual Radio Setup Configuration</td></tr>
<tr><td>Operation</td><td>Transmission of packets from Station side
a) The data is to be transmitted only on one radio and receiving shall be enabled in both the radios. [S]
b) Both the radios shall receive the same packets. [M]</td><td>Transmission of packets from Onboard side
a) The data is to be transmitted only on one radio and receiving shall be enabled in both the radios. [S]
b) Both the radios shall receive the same packets. [M]</td></tr>
<tr><td>Expected Result</td><td colspan="2">The Bit Error Rate shall be less than 10^{-6} and all the data in 68 time slots by both the radios at station and Onboard side shall be same.</td></tr>
<tr><td>Test Result (Pass/Fail)</td><td colspan="2"></td></tr>
</table>

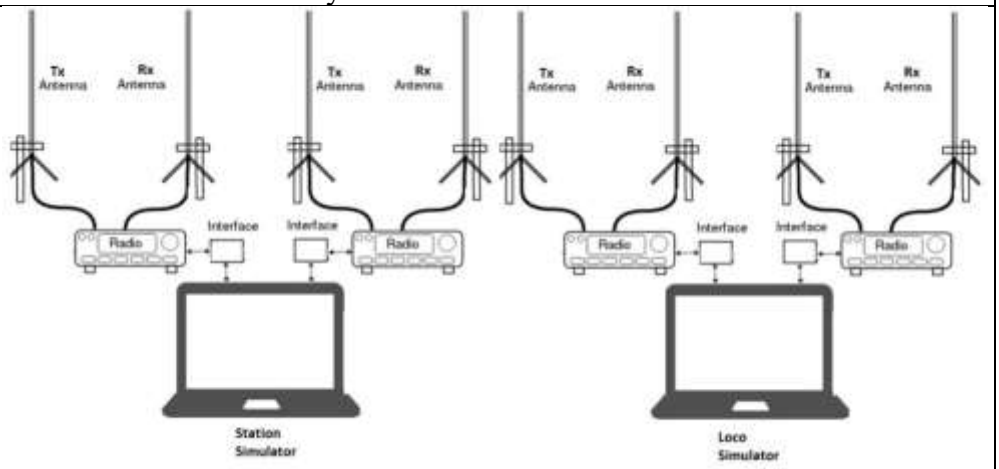
<table>
<tr><td>Test ID- 4.</td><td colspan="2">KAVACH_AnnexeC1_4: Testing of Full Duplex communication with two UHF radios (Alternate transmission).</td></tr>
<tr><td>Purpose</td><td colspan="2">This test is to verify that the reception of two UHF radio modems support full-duplex operations simultaneously in all 68 timeslots of width 22.5ms (432 bits or 54 bytes) and spaced 5ms (96 bits or 12 bytes) apart when alternate radio modems transmit in each cycle.</td></tr>
<tr><td>Methodology</td><td colspan="2">1. The setup as shown in figure 3 shall be set up, except of adding channel attenuators in the reception antenna.
2. The following counters shall be maintained on each side and logged:
a. Number of Packets transmitted.
b. Number of bytes transmitted.
c. Number of Packets received.
d. Number of valid packets received.
e. Number of bytes received.
f. Number of valid bytes received.</td></tr>
<tr><td>Setup configuration</td><td colspan="2"> 

Figure 3Dual Radio Setup Configuration</td></tr>
<tr><td>Operation</td><td>Transmission of packets from Station side
a) The data is to be transmitted on alternate radios each cycle and receiving shall be enabled in both the radios. [S]
b) Both the radios shall receive the same packets. [M]</td><td>Transmission of packets from Onboard side
c) The data is to be transmitted on alternate radios each cycle and receiving shall be enabled in both the radios. [S]
d) Both the radios shall receive the same packets. [M]</td></tr>
<tr><td>Expected Result</td><td colspan="2">The Bit Error Rate shall be less than 10^{-6} and all the data in 68 time slots by both the radios at station and Onboard side shall be same.</td></tr>
<tr><td>Test Result (Pass/Fail)</td><td colspan="2"></td></tr>
</table>

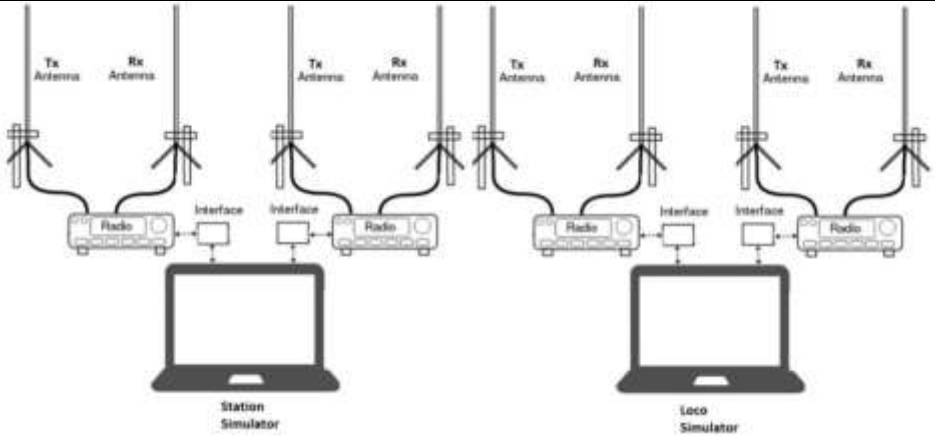
<table>
<tr><td>Test ID- 5.</td><td colspan="2">KAVACH_AnnexeC1_5: Testing of Full Duplex communication with two UHF radios to verify minimum data transmission time.</td></tr>
<tr><td>Purpose</td><td colspan="2">This test is to verify to record the minimum data transmission time to radio modem and RTS when alternate radio modems transmit in each cycle.</td></tr>
<tr><td>Methodology</td><td colspan="2">1. The setup as shown in figure 3 shall be set up, except of adding channel attenuators in the reception antenna.
2. The following counters shall be maintained on each side and logged:
a. Number of Packets transmitted.
b. Number of bytes transmitted.
c. Number of Packets received.
d. Number of valid packets received.
e. Number of bytes received.
f. Number of valid bytes received.</td></tr>
<tr><td>Setup configuration</td><td colspan="2"> 

Figure 3Dual Radio Setup Configuration</td></tr>
<tr><td>Operation</td><td>Transmission of packets from Station side
a) The data is to be transmitted on alternate radios each cycle and receiving shall be enabled in both the radios. [S]
b) The data transmission shall be at kept at 20ms, 15 ms, 10 ms, 5ms, 2ms before raising RTS. [S]
c) Both the radios shall receive the same packets. [M]</td><td>Transmission of packets from Onboard side
a) The data is to be transmitted on alternate radios each cycle and receiving shall be enabled in both the radios. [S]
b) The data transmission shall be at kept at 20ms, 15 ms, 10 ms, 5ms, 2ms before raising RTS. [S]
c) Both the radios shall receive the same packets. [M]</td></tr>
<tr><td>Expected Result</td><td colspan="2">The Bit Error Rate shall be less than 10^{-6} and all the data in 68 time slots by both the radios at station and Onboard side shall be same. The minimum data transmission for successful transmission shall be recorded.</td></tr>
<tr><td>Test Result (Pass/Fail)</td><td colspan="2"></td></tr>
</table>

<table>
<tr><td>Test ID- 1.</td><td colspan="2">KAVACH_AnnexeC1_6: Testing of Processing of Various Packet Types by Onboard KAVACH</td></tr>
<tr><td>Purpose</td><td colspan="2">This test is to verify the Onboard Kavach do not process (or reject) the packet received for various Packet types</td></tr>
<tr><td>Methodology</td><td colspan="2">1. The following counters shall be maintained on each side and logged:
a. Number of Packets transmitted.
b. Number of bytes transmitted.
c. Number of Packets received.
d. Number of valid packets received.
e. Number of bytes received.
f. Number of valid bytes received.</td></tr>
<tr><td rowspan="4">Operation</td><td>Transmission of packets from Station side</td><td>Reception of packets at Onboard side</td></tr>
<tr><td>a) Stationary KAVACH should send a packet with PKT_TYPE as 1000 (Reserved) followed by complete packet.</td><td>The Onboard KAVACH should receive the packet and shall be available in the log. The Onboard KAVACH should not process the packet.</td></tr>
<tr><td rowspan="2">b) Stationary KAVACH should send a packet with PKT_TYPE as 1010 followed by complete packet.</td><td>The Onboard KAVACH should receive the packet and shall be available in the log. The Onboard KAVACH should not process the packet, if Access Authority is not received.</td></tr>
<tr><td>The Onboard KAVACH should receive the packet and shall be available in the log. The Onboard KAVACH should not process the packet, if Access Authority is already received.</td></tr>
<tr><td>c) Stationary KAVACH should send a packet with PKT_TYPE as 1011 (Access Authority Packet) followed by complete packet.</td><td>The Onboard KAVACH should receive the packet and shall be available in the log. The Onboard KAVACH should process the packet, if it is not received earlier and is in the timeslot meant for its reception.
<table>
<tr><td>P57</td><td></td></tr>
<tr><td>P58</td><td></td></tr>
<tr><td>P69</td><td></td></tr>
<tr><td>P70</td><td></td></tr>
</table>
The Onboard KAVACH should receive the packet and shall be available in the log. The Onboard KAVACH should not process the packet for any other time slots.</td></tr>
</table>

<table>
<tr><td>Test ID- 1.</td><td colspan="2">KAVACH_AnnexeC1_6: Testing of Processing of Various Packet Types by Onboard KAVACH</td></tr>
<tr><td rowspan="4"></td><td>d) Stationary KAVACH should send a packet with PKT_TYPE as 1100 (Additional Emergency Packet) followed by complete packet.</td><td>The Onboard KAVACH should receive the packet and shall be available in the log. The Onboard KAVACH should process the packet, if it is in the timeslot meant for its reception.
<table><tr><td>P55</td><td></td></tr><tr><td>P56</td><td></td></tr><tr><td>P65</td><td></td></tr><tr><td>P66</td><td></td></tr></table>The Onboard KAVACH should receive the packet and shall be available in the log. The Onboard KAVACH should not process the packet for any other time slots.</td></tr>
<tr><td>Transmission of packets from Onboard side</td><td>Reception of packets at Station side</td></tr>
<tr><td>1. Onboard KAVACH should send a packet with PKT_TYPE as 1010 followed by complete packet. Onboard KAVACH should process the packet received only in the slot allocated by Stationary KAVACH.</td><td>Stationary KAVACH should process the packet received only in the slot allocated by it.</td></tr>
<tr><td>2. Onboard KAVACH should send a packet with PKT_TYPE as 1101 followed by complete packet.

When the onboard KAVACH is in block section.</td><td>The Stationary KAVACH should receive the packet and shall be available in the log. The Stationary KAVACH should process the packet, if it is in the timeslot meant for its reception.
<table><tr><td>P47</td><td>P48</td><td>P49</td><td>P50</td></tr><tr><td>P51</td><td>P52</td><td>P59</td><td>P60</td></tr><tr><td>P61</td><td>P62</td><td>P63</td><td>P64</td></tr></table>The Onboard KAVACH should receive the packet and shall be available in the log. The Onboard KAVACH should not process the packet for any other time slots.</td></tr>
<tr><td></td><td>3. Onboard KAVACH should change the time slot every 2 seconds for sending PKT_TYPE as 1101 in</td><td>Timeslots allocated by Onboard Kavach
Cycle1:_____
Cycle2:_____</td></tr>
</table>

<table>
<tr><td>Test ID- 1.</td><td colspan="2">KAVACH_AnnexeC1_6: Testing of Processing of Various Packet Types by Onboard KAVACH</td></tr>
<tr><td></td><td>block section or when it is not registered.</td><td>Cycle3:_____
Cycle4:_____
Cycle5:_____
Cycle6:_____
Cycle7:_____
Cycle8:_____
Cycle9:_____
Cycle10:_____
Cycle11:_____
Cycle12:_____
If the slot is repeated for more than 3 times in 12 cycles, the test is to be considered as fail.</td></tr>
<tr><td></td><td>4. Place two onboard Kavach in the Same TIN and in block section.</td><td>Timeslots allocated by Onboard Kavach
<table>
<tr><td>Cycle</td><td>OVK1</td><td>OVK2</td></tr>
<tr><td>Cycle1:_</td><td></td><td></td></tr>
<tr><td>Cycle2:_</td><td></td><td></td></tr>
<tr><td>Cycle3:_</td><td></td><td></td></tr>
<tr><td>Cycle4:_</td><td></td><td></td></tr>
<tr><td>Cycle5:_</td><td></td><td></td></tr>
<tr><td>Cycle6:_</td><td></td><td></td></tr>
<tr><td>Cycle7:</td><td></td><td></td></tr>
<tr><td>Cycle8:_</td><td></td><td></td></tr>
<tr><td>Cycle9:_</td><td></td><td></td></tr>
<tr><td>Cycle10:</td><td></td><td></td></tr>
<tr><td>Cycle11:</td><td></td><td></td></tr>
<tr><td>Cycle12:</td><td></td><td></td></tr>
</table>
If the slot is repeated found same for both Onboard Kavach units for more than 3 times in 12 cycles, the test is to be considered as fail.</td></tr>
</table>

<table>
<tr><td>Test ID- 1.</td><td colspan="2">KAVACH_AnnexeC1_6: Testing of Processing of Various Packet Types by Onboard KAVACH</td></tr>
<tr><td></td><td>5. Onboard KAVACH should send a packet with PKT_TYPE as 1101 followed by complete packet.

When the onboard KAVACH is in station section and communication is not established with the station.</td><td>Repeat 3,4 and 5</td></tr>
<tr><td></td><td>6. Onboard KAVACH should send a packet with PKT_TYPE as 1101 followed by complete packet.

When the onboard KAVACH is in block section and when Emergency_Status is 0.</td><td>Repeat 3,4 and 5</td></tr>
<tr><td></td><td>7. Onboard KAVACH should send a packet with PKT_TYPE as 1101 followed by complete packet.

When the onboard KAVACH is in block section and when Emergency_Status is 1.</td><td>The Stationary KAVACH should receive the packet and shall be available in the log. The Stationary KAVACH should process the packet, if it is in the timeslot meant for its reception
<table><tr><td>P53</td><td>P54</td><td>P65</td><td>P66</td></tr></table></td></tr>
<tr><td></td><td>8. Onboard KAVACH should send a packet with PKT_TYPE as 1101 followed by complete packet.

When the onboard KAVACH is in station section and when Emergency_Status is 1.</td><td>The Stationary KAVACH should receive the packet and shall be available in the log. The Stationary KAVACH should process the packet, if it is in the timeslot meant for its reception
<table><tr><td>P53</td><td>P54</td><td>P65</td><td>P66</td></tr></table></td></tr>
<tr><td>Expected Result</td><td colspan="2">The Onboard KAVACH should receive the packet and shall be available in the log. The Onboard KAVACH should not process the unintended packet.</td></tr>
<tr><td>Test Result (Pass/Fail)</td><td colspan="2"></td></tr>
</table>

Test ID- 2.	KAVACH_AnnexeC1_7: Testing for Processing of Various Packet Types by Onboard KAVACH
Purpose	This test is to verify the Stationary Kavach do not process (or reject) the packet received for various Packet Types.
Methodology	1. The following counters shall be maintained on each side and logged: a. Number of Packets transmitted.

Test ID- 2.	KAVACH_AnnexeC1_7: Testing for Processing of Various Packet Types by Onboard KAVACH	
	b. Number of bytes transmitted. c. Number of Packets received. d. Number of valid packets received. e. Number of bytes received. f. Number of valid bytes received.	
Operation	**Transmission of packets from Onboard side**	**Reception of packets at Station side**
	a) Onboard KAVACH should send a packet with PKT_TYPE as 1001 (Station to Onboard Regular Packet) followed by complete packet.	The Stationary KAVACH should receive the packet and shall be available in the log. The Stationary KAVACH should not process the packet for any other time slots.
Expected Result	The Stationary KAVACH should receive the packet and shall be available in the log. The Stationary KAVACH should not process the unintended packets.	
Test Result (Pass/Fail)		

<table>
<tr><td>Test ID- 3.</td><td colspan="2">KAVACH_AnnexeC1_8: Testing for Processing of Various Packet Length by Stationary KAVACH.</td></tr>
<tr><td>Purpose</td><td colspan="2">This test is to verify Stationary KAVACH receive valid packet length (PKT_LENGTH).</td></tr>
<tr><td>Methodology</td><td colspan="2">1. The setup as shown in figure 3 shall be set up, except of adding channel attenuators in the reception antenna.
2. The following counters shall be maintained on each side and logged:
a. Number of Packets transmitted.
b. Number of bytes transmitted.
c. Number of Packets received.
d. Number of valid packets received.
e. Number of bytes received.
f. Number of valid bytes received.</td></tr>
<tr><td></td><td>Transmission of packets from Station side
1. Stationary KAVACH should send a packet with PKT_TYPE as 1001 followed by complete packet and valid packet length (PKT_LENGTH).
2. Packet length range is between 0000000000 (1byte) to 1111111111 (1024bytes).
3. If the Packet length is xx bytes, the data sent here shall be xx-1.
4. Use the onboard to station regular packet tool and check for the correct packet length for at least five combinations.</td><td><table><tr><th>#</th><th>Tool output</th><th>Skavach output</th></tr><tr><td>1</td><td></td><td></td></tr><tr><td>2</td><td></td><td></td></tr><tr><td>3</td><td></td><td></td></tr><tr><td>4</td><td></td><td></td></tr><tr><td>5</td><td></td><td></td></tr></table></td></tr>
<tr><td></td><td>Stationary KAVACH shall send the packet in burst mode to all the registered locos one by one.</td><td>Simulate the scenarios for one loco, two locos, three locos and up to forty locos and record the output in the log.</td></tr>
<tr><td>Expected Result</td><td colspan="2">The Stationary KAVACH Output should match with the output of the tool.</td></tr>
<tr><td>Test Result (Pass/Fail)</td><td colspan="2"></td></tr>
</table>

<table>
<tr><td>Test ID- 4.</td><td colspan="2">Testing of Processing of the allotted TDMA Time Slot by Onboard KAVACH in Access Authority Packet.</td></tr>
<tr><td>Purpose</td><td colspan="2">This test is to verify Onboard KAVACH Processes its onboard to station regular packet based on the allotted TDMA Time Slot</td></tr>
<tr><td>Methodology</td><td colspan="2">1. The following counters shall be maintained on each side and logged:
• Number of Packets transmitted.
• Number of bytes transmitted.
• Number of Packets received.
• Number of valid packets received.
• Number of bytes received.
• Number of valid bytes received.
2. Configure that stationary KAVACH transmission is allotted from P31 to P38.</td></tr>
<tr><td rowspan="3">Operation</td><td>Transmission of packets from Stationary KAVACH side
1. Stationary KAVACH should send a packet with Allotted TDMA time slot as 0 followed by complete packet, when it has received ARP packet through other mode of radio communication.</td><td>Reception of packets at Onboard KAVACH side
1. The Onboard KAVACH should receive the packet and shall be available in the log. The Onboard KAVACH should not process the invalid packets.</td></tr>
<tr><td>2. Stationary KAVACH should send a packet with Allotted TDMA time slot as 0 followed by complete packet, when it has allotted all the slots to other KAVACH equipped trains.</td><td>2. The Onboard KAVACH should receive the packet and shall be available in the log. The Onboard KAVACH should not process the invalid packets.</td></tr>
<tr><td>3. Stationary KAVACH shall allot only unallotted slots to the OVK seeking new registration. Simulate a scenario where three locos are allotted with P31, P36 and P38.
<table><tr><td>P31</td><td>P32</td><td>P33</td><td>P34</td></tr><tr><td>P35</td><td>P36</td><td>P37</td><td>P38</td></tr></table>
Stationary KAVACH shall allot one of the free slots randomly, to the new OVK requesting for registration.</td><td>3. Onboard KAVACH shall ensure that RTS is raised such that the data is transmitted over the air at the correct slot as shown below in Oscilloscope:
<table><tr><th>Slot marker</th><th>Time (ms)</th></tr><tr><td>P31</td><td>842.5</td></tr><tr><td>P32</td><td>870</td></tr><tr><td>P33</td><td>897.5</td></tr><tr><td>P34</td><td>925</td></tr><tr><td>P35</td><td>952.5</td></tr><tr><td>P36</td><td>980</td></tr><tr><td>P37</td><td>1007.5</td></tr><tr><td>P38</td><td>1035</td></tr></table></td></tr>
</table>

Test ID- 4.	**Testing of Processing of the allotted TDMA Time Slot by Onboard KAVACH in Access Authority Packet.**	
	4. Stationary KAVACH shall measure the RSSI received from the Onboard KAVACH in this slot and shall be sent to NMS.	4.
Expected Result	The Onboard KAVACH should receive the packet and shall be available in the log. The Onboard KAVACH should not process the unintended packets.	
Test Result (Pass/Fail)		

Test ID- 5.	**Testing of Processing of the STN_TDMA Slot by Onboard KAVACH in Access Authority Packet.**	
Purpose	This test is to verify Onboard KAVACH Captures the RSSI based its onboard to station regular packet based on the **Station TDMA** Slot	
Methodology	1. The following counters shall be maintained on each side and logged: • Number of Packets transmitted. • Number of bytes transmitted. • Number of Packets received. • Number of valid packets received. • Number of bytes received. • Number of valid bytes received.	
Operation	**Transmission of packets from Stationary KAVACH side** 1. Stationary KAVACH should transmit it starting time slot number in this field.	**Reception of packets at Onboard KAVACH side** 1. The Onboard KAVACH should receive the packet and shall be available in the log. The Onboard KAVACH should process and use for measuring RSSI received from station with respect to its absolute position and send this to NMS.
Expected Result	The Onboard KAVACH should receive the packet and shall be available in the log. The Onboard KAVACH should not process the unintended packets.	
Test Result (Pass/Fail)		

Test ID- 5.	**Testing of Processing of the STN_TDMA Slot by Onboard KAVACH in Access Authority Packet.**

Test ID- 6.	**Testing for Processing of Various Packet Length by Onboard KAVACH.**
Purpose	This test is to verify Stationary KAVACH receive valid packet length (PKT_LENGTH).
Methodology	1. The setup as shown in figure 3 shall be set up, except of adding channel attenuators in the reception antenna. 2. The following counters shall be maintained on each side and logged: a. Number of Packets transmitted. b. Number of bytes transmitted. c. Number of Packets received. d. Number of valid packets received. e. Number of bytes received. f. Number of valid bytes received.
	Transmission of packets from Station side 1. Stationary KAVACH should send a packet with PKT_TYPE as 1010 followed by complete packet and valid packet length (PKT_LENGTH). 2. Packet length range is between 0000000000 (1byte) to 1111111111 (1024bytes). 3. If the Packet length is xx bytes, the data sent here shall be xx-1. 4. Use the station to onboard regular packet tool and check for the correct packet length for at least five combinations.

#	Tool output	Onboard kavach output
1	28	
2	28	
3	28	
4	28	
5	28	

	Allocated slot by the station is _____. Onboard KAVACH shall send the packet in the allotted slot given by station. This test is to be repeated for five times creating five new sessions.

Test No	Slots allocated by Station	Slots transmitted by Onboard KAVACH
1		
2		
3		
4		
5		

Test ID- 6.	**Testing for Processing of Various Packet Length by Onboard KAVACH.**
Expected Result	The Stationary KAVACH Output should match with the output of the tool.
Test Result (Pass/Fail)	

Test ID- 7.	**Testing of Processing of Various Switching of allotted uplink and down link frequency by Onboard KAVACH in Access Authority Packet.**	
Purpose	This test is to verify Onboard KAVACH switches to allotted uplink and downlink frequency by Onboard KAVACH.	
Methodology	1. The setup as shown in figure 3 shall be set up, except of adding channel attenuators in the reception antenna. 2. The following counters shall be maintained on each side and logged: • Number of Packets transmitted. • Number of bytes transmitted. • Number of Packets received. • Number of valid packets received. • Number of bytes received. • Number of valid bytes received. 3. The Stationary KAVACH may be tuned to the following: a. Band: 406 to 470 MHz b. Base frequency(f_b): 406 MHz c. Channel frequency space is (f_{space}): 0.025 MHz d. Centre frequency (f_c): 427.625 MHz e. Let the station transmission frequency be (f_{Tx}): 426.675 MHz f. Let the station receiving frequency be (f_{Rx}): 429.525 MHz g. The station shall transmit corresponding up link frequency channel (Ch-U) as: $\frac{f_{TX}-f_b}{f_{space}}$ =827 h. The station shall transmit corresponding down link frequency channel as (Ch-D) as: $\frac{f_{RX}-f_b}{f_{space}}$=941	
Operation	**Transmission of packets from Stationary KAVACH side**	**Reception of packets at Onboard KAVACH side**
	1. Stationary KAVACH shall transmit 0 if no FDMA is used.	1. Onboard KAVACH shall have provision for fixed configuration for centre, uplink and down link. Onboard KAVACH shall transmit and receive on these pre-configured values.

Test ID- 7.	**Testing of Processing of Various Switching of allotted uplink and down link frequency by Onboard KAVACH in Access Authority Packet.**	
	2. Stationary KAVACH shall have configuration facility for base frequency, Channel frequency space, Centre frequency.	2. Onboard KAVACH shall have configuration facility for base frequency, Channel frequency space, Centre frequency.
	3. Stationary KAVACH shall transmit allotted Uplink Frequency channel as **827** and down link frequency channel as **941.**	3. The Onboard shall switch its Rx to **426.675** MHz and shall switch its Tx to **429.525** MHz.
	4. Stationary KAVACH shall transmit allotted Uplink Frequency channel as **1160** and down link frequency channel as **2560.**	4. The Onboard shall switch its Rx to **435** MHz and shall switch its Tx to **470** MHz.
	5. For a band of **406** to **470** MHz, and channel spacing of **0.025** MHz Stationary KAVACH shall send uplink frequency channel as **2561** and downlink frequency channel as **2580**	5. Onboard KAVACH shall not process the packet. The packet shall be received and kept in the log.
	6. Stationary KAVACH shall send the packets both in LTE and UHF with *uplink and downlink frequency channel* marked as **4094,** *Allotted TDMA slot* as **0**, and ***STN_TDMA Slot*** as **126.** Stationary KAVACH shall withdraw any slot earmarked for the loco in UHF.	6. If LTE radio is installed (configurable parameter in OVK) and after Successful establishment of communication with KAS and receipt of IP address of SVK, Onboard KAVACH shall sends ARP through LTE. Subsequent to receipt of AAP through LTE, Onboard KAVACH shall process the AAP, AEP, SORP packets received through LTE only. But, Onboard KAVACH shall keep sending/receiving ARP packets in block section in UHF, if UHF radio is healthy for collision detection, even though, it is latched to LTE for regular communication. If UHF radio is installed (configurable parameter in

Test ID- 7.	Testing of Processing of Various Switching of allotted uplink and down link frequency by Onboard KAVACH in Access Authority Packet.	
		OVK) and failed, the system shall enter into system failure mode as it cannot detect collisions.
Expected Result	The Onboard KAVACH should receive the packet and shall be available in the log. The Onboard KAVACH should not process the unintended packets.	
Test Result (Pass/Fail)		