

Required Test Instruments

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| 1. Radio communication test set | 1 set |
| 2. Digital radio test set(Aeroflex 3920) | 1 set |
| 3. Scanner | 1 set |
| 4. 3A/10V power supply | 1 set |
| 5. Digital voltmeter | 1 set |
| 6. 3A Ammeter | 1 set |
| 7. DMR Tuner Tool Software in PC for X1e | |

Adjustment Procedures

1. Frequencies table for test

Channel	Rx frequency (MHz)	Tx frequency (MHz)	Mode	Power	Channel spacing
7	136.025	136.025	Analog	High	12.5KHz
8	152.000	152.000	Analog	High	12.5KHz
9	173.975	173.975	Analog	High	12.5KHz
10	136.025	136.025	Digital	Low	12.5KHz
11	152.000	152.000	Digital	Low	12.5KHz
12	173.975	173.975	Digital	Low	12.5KHz
13	136.000	146.000	RMO Digital	Low	12.5KHz

2. Adjustment Items

2.1 Procedure before adjustment

Before the radio set adjustment there should be the board test like below which is for the manufacture only.

Check Name	Test Equipments	Test Conditions	Test Points	Specs	Note
FGU Lock Detect	Communication Test Set(CTS) or Frequency Counter	1.Analog mode 2.No signaling 3.SPK ON 4.MIC OFF 5.Low power	1 point, Wideband Tx 174MHz Rx 173.975MHz	1. No unlock alarm in receive and transmit state. 2. Correct CV voltages are observed.(TBD)	Manufacture only To test the unit is programmed to the correct frequency range.
Transmit Path	CTS / Frequency Counter & Power Meter	1.Analog mode 2.TX standby 3.No Signaling 4.SPK OFF 5.MIC ON 6.Low power	1 point, Wideband (e.g.174MHz)	Correct frequency, modulation and power output are observed.	Manufacture only To test the transmitter path is ok.
Receive Path	CTS / Signal Generator & AC Voltmeter	1.Analog mode 2.Receive standby 3.No signaling 4.SPK ON 5.MIC OFF	1 point, Wideband (e.g.173.975MHz)	Receiver PLL locked and output 1kHz single-tone audio.	Manufacture only To test the receiver and audio processing is ok.
2nd Lo CV	DC Voltmeter	1.Analog mode 2.Receive standby 3.No signaling 4.SPK ON 5.MIC OFF	1 point, Wideband (e.g.173.975MHz)	Correct DC voltage (TBD)	Manufacture only

2.2 Tuner items

Enter the DMR Tuner Tool software of X1e you can see tuner items as shown in table below. Select the item to be tuned and drag the moving beam to change the tuning value till getting the proper ones. And then do save the tuning value by clicking the “save” button.

Tuning Name	Tuning Equipments	Test Conditions	Tuning Points	Specs	Note
Transmit					
Reference Oscillator Warp	Communication Test Set(CTS) or Frequency Counter	1.Analog mode 2.No signaling 3.Both SPK OFF 4.Both Mic OFF 5.Low power	1 point Wideband(e.g.174MHz)	$\pm 40\text{Hz}$	In the process of frequency error tuning, no modulation is allowed. Hence, the DSP signal consists only DC offset with no audio carrier.
Transmit Power Calibration	CTS or Power Meter	1.Analog mode 2.No signaling 3.Both SPK OFF 4.Int. Mic on	8 points, Wideband	High Power= $4.7 \pm 0.1\text{W}$ Low Power= $1.2 \pm 0.1\text{W}$	/
DSP-to-Deviation Conversion	CTS or Frequency Counter	1.Analog mode 2.No signaling 3.Both SPK OFF 4.Both Mic OFF 5.Low power	1 point, Wideband, Low-end frequency(e.g.136MHz)	5K	HW team will need to determine if this step is required. If the Max deviation error is small, it can be hard coded and thus will not need this extra step in determining the max deviation.
Modulation Balance	CTS	1.Analog mode 2.Single Tone: 1point, 100Hz(Low Port);5K(High Port) 3.No signaling 4.Both SPK OFF 5.Both MIC OFF 6.Low power	Single Tone: 1 point — 100Hz(Low Port);5K(High Port) Carrier Frequency: 8 points, from low to high band.	Low Port:4.98-5.02K High Port:4.92-4.96K	1.MOD_L_RFCS contributes major deviation at low port (100Hz) while MOD_H contributes major deviation at high port (1kHz~5kHz). 2.The points of single tone is subject to increase depending on the VCO characteristics. 3.Reserve the delay tuning capability in case we need it.

Modulation Balance (Delay) Development only	CTS	1.Analog mode 2.Single Tone: random points, 100Hz - 6kHz, 100Hz step 3.No signaling 4.Both SPK OFF 5.Both MIC OFF 6.Low power	136M	85/±10000 (VHF)	/
TX CV synthesize for quick locked	multimeter	1.Analog mode 2.No signaling 3.Both SPK OFF 4.Both Mic OFF 5.Low power 6.TX ON	1 point TX 174MHz	±0.5 radix point 3 for △CV	Portable only
Receive					
Front-end Filter	CTS / Signal Generator & Spectrum Analyzer & SINAD Meter	1.Analog mode 2.No signaling 3.Int. SPK ON, internal speaker gain set to Rated Audio 4.Both MIC OFF 5.RX ON 6.Squelch open 7.rate Audio volume	8 points, Wideband	SINAD>14dB @ -118dBm input	Portable / Mobile / Repeater

Rx Front-end Gain	CTS / Signal Generator	1.Analog mode 2.No signaling 3.Int. SPK ON, internal speaker gain set to Rated Audio 4.Both MIC OFF 5.RX ON 6.Squelch open 7.rate Audio volume	8 points, Wideband	RF input = -70dBm	Portable / Mobile / Repeater Pump in known signal level to the radio. Need to tune this parameter for RSSI calculation.
Rated Audio	CTS / Signal Generator & AC Voltmeter	1.Analog mode 2.No signaling 3.Int. SPK ON, internal speaker gain set to Rated Audio 4.Both MIC OFF 5.RX ON	2 points, wideband and narrowband @ 152MHz	Portable: 1.4±0.1V	Portable / Mobile / Repeater
Low Voltage Threshold	DC Voltmeter	1.Analog mode 2.No signaling 3.Int. SPK ON, internal speaker gain set to Rated Audio 4.Both MIC OFF 5.RX ON	1 point, wideband(e.g . 152MHz)	Threshold=6.8V dc	Portable Only
RX CV synthesize for quick locked	multimeter	1.Analog mode 2.No signaling 3.Both SPK OFF 4.Both Mic OFF 5.Low power 6.RX ON	1 point RX 173.975MHz	±0.5 radix point 3 for ΔCV	Portable only

2.3 Test items

Testing Name	Test Equipments	Test Conditions	Testing Points	Specs
Transmit				
Frequency Error	CTS or Frequency Counter	1.Analog mode 2.No signaling 3.Both SPK OFF 4.Both MIC OFF 5.Low power	1 point, Wideband(e.g. 174MHz)	$\leq 100\text{Hz}$
Transmit High Power	CTS or Power Meter	1.Analog mode 2.No signaling 3.Both SPK OFF 4.Int. Mic on 5.High power	3 points, Wideband(e.g. 136/152/174M Hz)	$4.7 \pm 0.3 \text{ W}$
Transmit Low Power	CTS or Power Meter	1.Analog mode 2.No signaling 3.Both SPK OFF 4.Int. Mic on 5.Low power	3 points, Wideband(e.g. 136/152/174M Hz)	$1.2 \pm 0.3 \text{ W}$
Transmit Current Drain(H/L)	CTS or Power Meter	1.Analog mode 2.No signaling 3.Both SPK OFF 4.Int. Mic on 5.High/Low power	3 points, Wideband(e.g. 136/152/174M Hz)	$\leq 1.8\text{A}$ (High power 4.7W) $\leq 1\text{A}$ (Low power 1.2W)
Trasmit 4FSK Max. Deviation	VSA E89441A	1.Digital mode 2.No signaling 3.Both SPK OFF 4.Int. Mic on 5.Low power	3 points, Wideband(e.g. 136/152/174M Hz)	$\pm 3.7\text{kHz}$
Trasmit 4FSK Modulation(Modulation Accuracy)	VSA E89441A	1.Digital mode 2.No signaling 3.Both SPK OFF 4.Int. Mic on 5.Low power	3 points, Wideband(e.g. 136/152/174M Hz)	Deviation of four sequence of 4FSK ① $+1.944\text{kHz} \pm 10\%$; ② $+0.648\text{kHz} \pm 10\%$; ③ $-0.648\text{kHz} \pm 10\%$; ④ $-1.944\text{kHz} \pm 10\%$.

Transmit FSK and Magnitude Error	VSA E89441A	1.Digital mode 2.No signaling 3.Both SPK OFF 4.Int. Mic on 5.Low power	3 points, Wideband(e.g. 136/152/174M Hz)	FSK Error ≤5% Magnitude Error ≤1%
Transmit BER	VSA E89441A	1.Digital mode 2.No signaling 3.Both SPK OFF 4..Int. Mic on 5.Low power	3 points, Wideband(e.g. 136/152/174M Hz)	<0.01%
Maximum Analog Transmit Deviation w/o subtone	CTS -- TX TEST HPF:20Hz LPF:15kHz	1.Analog mode 2.No signaling 3.Both SPK OFF 4.Both MIC ON 5.Low power	6 points (3 points H/M/L for W/N respectively)	Wideband: 4.8kHz Narrowband: 2.4kHz
Modulation Sensitivity	CTS -- TX TEST HPF:20Hz LPF:15kHz	1.Analog mode 2.No signaling 3.Both SPK OFF 4..Int. Mic on 5.Low power	6 points (3 points H/M/L for W/N respectively)	6-12mV
PL Deviation	CTS -- TX TEST HPF:20Hz LPF:300Hz	1.Analog mode 2.Signaling:PL 3.Both SPK OFF 4.Both MIC OFF 5.Low power	6 points (3 points H/M/L for W/N respectively)	Wideband: 750±50Hz Narrowband: 350±50Hz
DPL Deviation	CTS -- TX TEST HPF:20Hz LPF:300Hz	1.Analog mode 2.Signaling:DP L 3.Both SPK OFF 4.Both MIC OFF 5.Low power	6 points (3 points H/M/L for W/N respectively)	Wideband: 750±50Hz Narrowband: 350±50Hz
Maximum Transmit Deviation w/ PL	CTS -- TX TEST HPF:20Hz LPF:15KHz	1.Analog mode 2.Signaling:PL 3.Both SPK OFF 4..Int. Mic on 5.Low power	6 points (3 points H/M/L for W/N respectively)	Wideband: ≤5kHz Narrowband: ≤2.5kHz

Maximum Transmit Deviation w/ DPL	CTS -- TX TEST HPF:20Hz LPF:15kHz	1.Analog mode 2.Signaling:DP L 3.Both SPK OFF 4..Int. Mic on 5.Low power	6 points (3 points H/M/L for W/N respectively)	Wideband: $\leq 5\text{kHz}$ Narrowband: $\leq 2.5\text{kHz}$
2(5)-Tone Deviation	CTS -- TX TEST HPF:20Hz LPF:15kHz	1.Analog mode 2.Signaling:2(5)-Tone 3.Both SPK OFF 4.Both MIC OFF 5.Low power	6 points (3 points H/M/L for W/N respectively)	Wideband: $3.2\pm 0.1\text{kHz}$ Narrowband: $1.8\pm 0.1\text{kHz}$
MSK Deviation	CTS -- TX TEST HPF:20Hz LPF:15kHz	1.Analog mode 2.Signaling:MSK 3.Both SPK OFF 4.Both MIC OFF 5.Low power	6 points (3 points H/M/L for W/N respectively)	Wideband: $3.2\pm 0.1\text{kHz}$ Narrowband: $1.8\pm 0.1\text{kHz}$
CWID Deviation	CTS -- TX TEST HPF:20Hz LPF:15kHz	1.Analog mode 2.Signaling:CW ID 3.Both SPK OFF 4.Both MIC OFF 5.Low power	6 points (3 points H/M/L for W/N respectively)	Wideband: $2.0\pm 0.2\text{kHz}$ Narrowband: $1.0\pm 0.1\text{kHz}$
Transmit S/N ratio	CTS -- TX TEST HPF:300Hz LPF:3kHz	1.Analog mode 2.No signaling 3.Both SPK OFF 4.Int. Mic on 5.Low power	6 points (3 points H/M/L for W/N respectively)	$3\text{K} \setminus 1.5\text{K}(\text{W/N})$ $\geq 45\text{dB}(\text{W})/40\text{dB}(\text{N})$
Modulation Distortion	CTS -- TX TEST HPF:300Hz LPF:3kHz	1.Analog mode 2.No signaling 3.Both SPK OFF 4..Int. Mic on 5.Low power	2 points, W/N, 152MHz	$3\text{K} \setminus 1.5\text{K}(\text{W/N})$ $\leq 3\%$
Receive				

Receiver Sensitivity - Analog	CTS -- RX TEST HPF:300Hz LPF:3kHz	1.Analog mode 2.No signaling 3.Int.SPK on 4.Both MIC OFF 5.RX ON 6.Squelch open 7.rate Audio volume	6 points (3 points H/M/L for W/N respectively)	SINAD>14dB @ ≤ -118 dBm
Receiver Maximum Usable Sensitivity - Digital	ESG signal generator with 0.153 voice super frame bursted test pattern	1.Digital mode 2.No signaling 3.Int.SPK on 4.Both MIC OFF 5.RX ON	3 points H/M/L	5% BER: ≤ -116 dBm 1% BER: ≤ -110 dBm
High RF Input BER	ESG signal generator with 0.153 voice super frame bursted test pattern	1.Digital mode 2.No signaling 3.Int.SPK on 4.Both MIC OFF 5.RX ON	3 points H/M/L	BER=0% @ +5dBm
Receiver Ultimate (BER) Sensitivity	ESG signal generator with 0.153 voice super frame bursted test pattern	1.Digital mode 2.No signaling 3.Int.SPK on 4.Both MIC OFF 5.RX ON	3 points H/M/L	BER=0% @ -85dBm
Dynamic Faded (BER) Sensitivity	ESG signal generator with 0.153 voice super frame bursted test pattern	1.Digital mode 2.No signaling 3.Int.SPK on 4.Both MIC OFF 5.RX ON	3 points H/M/L	5% BER @ ≤ -108 dBm(for 8 and 100Km/hr Rayleigh Fading)

Receiver S/N radio	CTS -- RX TEST HPF:300Hz LPF:3kHz	1.Analog mode 2.No signaling 3.Int.SPK on 4.Both MIC OFF 5.RX ON	6 points (3 points H/M/L for W/N respectively)	$\geq 45\text{dB(W)}/40\text{dB(N)}$
Receiver Audio Distortion	CTS -- RX TEST HPF:300Hz LPF:3kHz	1.Analog mode 2.No signaling 3.Int.SPK on 4.Both MIC OFF 5.RX ON	2 points (1 point for W/N respectively)	$< 3\%$
Maximum Audio Output Power	CTS -- RX TEST HPF:20Hz LPF:15kHz	1.Analog mode 2.No signaling 3.Int.SPK on 4.Both MIC OFF 5.RX ON	2 points (1 point for W/N respectively)	$\geq 2.2\text{V}$
Normal Level Squelch Open	CTS -- RX TEST HPF:300Hz LPF:3kHz	1.Analog mode 2.No signaling 3.Int.SPK on 4.Both MIC OFF 5.RX ON	6 points (3 points H/M/L for W/N respectively)	$\geq -120\text{dBm}$
Normal Level Squelch Off	CTS -- RX TEST HPF:300Hz LPF:3kHz	1.Analog mode 2.No signaling 3.Int.SPK on 4.Both MIC OFF 5.RX ON	6 points (3 points H/M/L for W/N respectively)	$\leq -126\text{dBm}$
Tight Level Squelch Open	CTS -- RX TEST HPF:300Hz LPF:3kHz	1.Analog mode 2.No signaling 3.Int.SPK on 4.Both MIC OFF 5.RX ON	6 points (3 points H/M/L for W/N respectively)	HP8921 RF Output = -112dBm
Tight Level Squelch Off	CTS -- RX TEST HPF:300Hz LPF:3kHz	1.Analog mode 2.No signaling 3.Int.SPK on 4.Both MIC OFF 5.RX ON	6 points (3 points H/M/L for W/N respectively)	HP8921 RF Output = -114dBm
Receive PL/DPL Decode Time	CTS -- RX TEST, Oscilloscope	1.Analog mode 2.No signaling 3.Int.SPK on 4.Both MIC OFF 5.RX ON	6 points, Wideband and Narrowband, 3 PL with each carrier frequency.	TPL Decode Time $\leq 240\text{ms}$ DPL Decode Time $\leq 275\text{ms}$

3. Operations of Special Test Mode and Objectives

Mode	detail
1. Digital and analog TX trigger Mode	<ol style="list-style-type: none">1. Enter this mode: In user mode press SK1 key 2 times and then press SK2 key 2 times in 10 second when power on2. when PTT on the GPIO11(Portable) output a trigger signal, If the current is digital channel then output TDMA pluse signal else output a high level signal3. Only can exit this mode by power off, when channel changed then output the correlative trigger signal
2. ACTP Test Mode	<ol style="list-style-type: none">1. This Mode is design for ACTP testing.2. Enter this mode: In user mode press SK1 key 2 times and then press SK2 key 3 times in 10 second when power on3. Output TDMA slot carry without 4FSK modulation and digital TDMA trigger singal on correlative GPIO for Portable when PTT on in digital channel4. Output carry without FM modulation and analog high level signal trigger singal on correlative GPIO for Portable when PTT on in analog channel5. Only can exit this mode by power off, when channel changed then output the correlative carry signal
3. TX 0.153 Ber Test Mode	<ol style="list-style-type: none">1.Enter this mode: In user mode press SK1 key 2 times and then press SK2 key 4 times in 10 second when power on, then enter the TX 0.153 Ber Test Mode2. Output the TDMA slot carry with 0.153 4FSK modulation when PTT on in digital channel3.Output normal carry when PTT on in analog channel4.Only can exit this mode by power off
4. RX 0.153 Ber Test Mode	<ol style="list-style-type: none">1. Enter this mode: In user mode press SK1 key 2 times and then press SK2 key 5 times in 10 second when power on, then enter the RX 0.153 Ber Test Mode.2.Keep the normal states in analog channel3.Only can exit this mode by power off