

FRS-460(USA)
SERVICE MANUAL
2-WAY PORTABLE
HANDHELD
RADIOS

WOOJIN E & T, LTD.
FCC ID: M23FRS-460
EXHIBIT #: 8a

WOOJIN E & T

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1. GENERAL

1.1 GENERAL

This equipment, FRS-460 is called 2 way portable handheld radios.
The frequency range is 462~467MHz, UHF operating channels for international 2 way portable radios.

1.2 CHARACTERISTIC

- a) All active device in this radio is composed of semiconductor and high density IC.
- b) To design this radio in compact and weight approximately 100g without battery cell.
- c) CPU of this equipment is TMP87CH21DF from TOSHIBA.
- d) It's power can operate by use of alkaline 4 cell(1.5V AAA) battery or NiMH Battery pack.

1.3 COMPOSITION

This radio is composed of following.

- a) Transmitter
- b) Antenna
- c) Belt clip

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2. SPECIFICATION

2.1 GENERAL SPECIFICATIONS

- a) Frequency Range : 462MHz ~ 467MHz
- b) Output Impedance : 50 Ω Unbalanced
- c) Modulation Type : 8K00F3E
- d) Communication Mode : Half duplex
- e) Channel Capacity : 14 channel
- f) Channel spacing : 12.5 kHz
- g) Power : 6V
- h) Battery Life : > 16 hours (Tx5%, Rx5%, Stand-by 90%)
- i) Operating Temperature : -20°C ~ +60°C
- j) Dimension : 115(H)x 60(W)x 29.5(D)mm
- k) Weight : 150g(with Battery)

2.2 ELECTRICAL SPECIFICATION

a) TRANSMITTER

- 1) Output power : Max 500mW
- 2) Frequency Stability : $\pm 2.5\text{ppm}$ (-20°C ~ +60°C)
- 3) Modulation Method : FM
- 4) Oscillation Method : PLL SYNTHESIZER
- 5) Max. Frequency Deviation : $< \pm 2.5\text{kHz}$ (with tone)
- 6) Cooling Method : air-cooling Method
- 7) Spurious Emission : $< -60\text{dB}$
- 8) FM Hum/Noise : $< -40\text{dB}$ (1kHz 70% modulation)
- 9) Distortion : $< 5\%$ (1kHz 60% modulation)
- 10) Tx Audio Response : 6dB /OCT $\pm 3\text{dB}$ PRE-EMPHASIS(300Hz ~ 2.5kHz)

b) RECEIVER

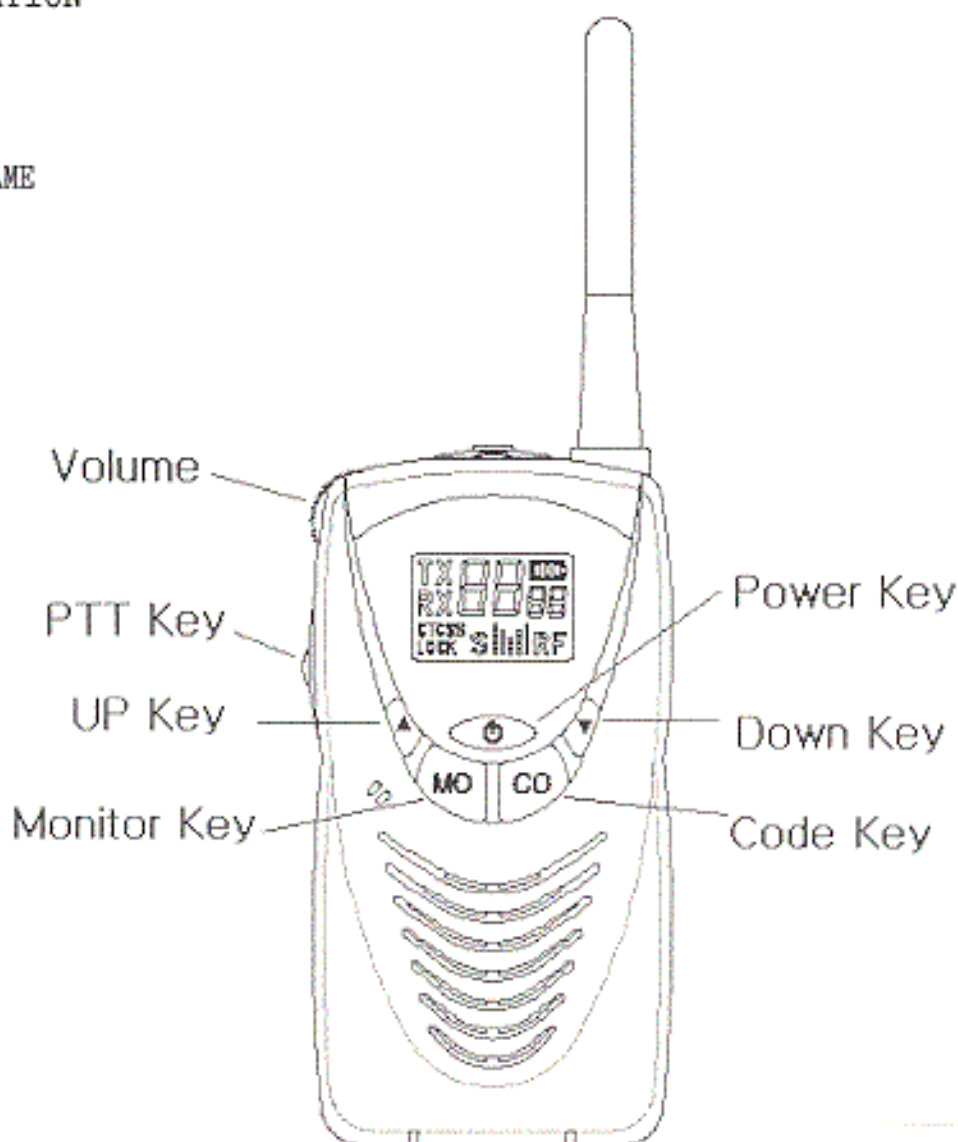
- 1) Receive Method : Double Super Heterodyne
- 2) Receive Sensitivity : $< 0.28\mu\text{V}$ (12dB SINAD)
- 3) Squelch Sensitivity : 6 ~ 8dB(12dB SINAD)
- 4) Bandwidth : $> 3\text{kHz}$ (6dB ATT point)

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- 5) Selectivity : $< -60\text{dB}(12.5\text{kHz})$
- 6) Local Frequency Stability : $\pm 5\text{ppm}(-20^{\circ}\text{C} \sim +60^{\circ}\text{C})$
- 7) Spurious Response : $>70\text{dB}$
- 8) Audio output : $400\text{mW}(\text{Internal } 8\Omega \text{ load THD } 10\%)$
- 9) Distortion : $<5\%(1\text{kHz } 60\% \text{ Modulation})$
- 10) RX Audio Response : $6\text{dB/OCT} \pm 3\text{dB DE-EMPHASIS}(300\text{Hz} \sim 2.5\text{kHz})$
- 11) S/N Ratio : $<-40\text{dB}(1\text{kHz } 70\% \text{ modulation})$
- 12) IF : 1st IF = 21.7MHz
2nd IF = 450kHz
- 13) Local Frequency : 1st Local Frequency = $f_c - 21.7\text{MHz}$
2nd Local Frequency = 21.25MHz

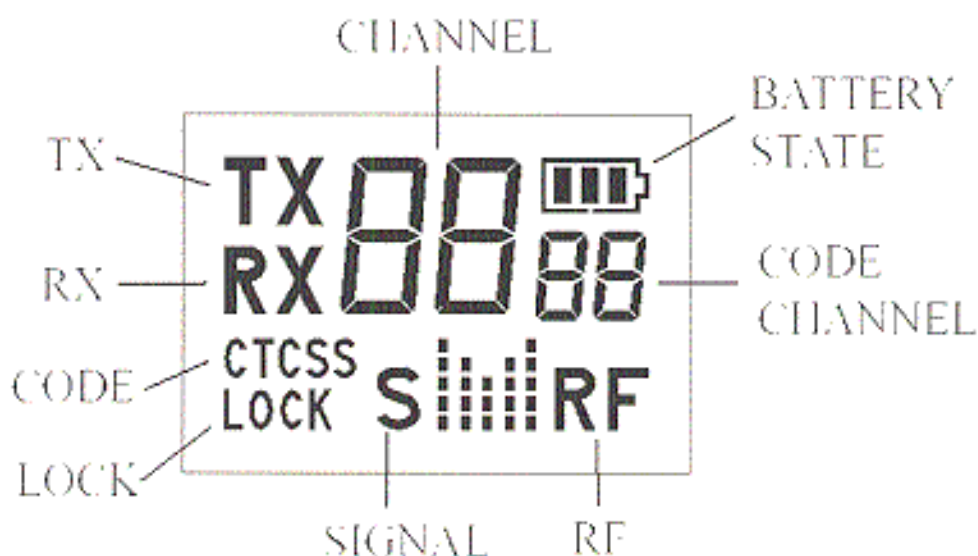
3. OPERATION

3.1 KEY NAME



3.2 ICONS ON LCD

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3.3 KEY FUNCTIONS

a) POWER KEY



ON : POWER key is pressed shortly. Power is turned on with 5 continuous single tone and puts radio in the stand by mode. Last channel No. and CTCSS No. stored memory is displayed on LCD and Power save is started.

OFF : POWER key is pressed for about 1~2 seconds in on state, power is turned off with 2 continuous single tone. Also current channel No. and CTCSS No. store in memory.

b) UP KEY



Whenever the UP key is pressed, the channel number is increased one step by one step. And UP key is pressed long time, the channel number is increased quickly.

In the CTCSS mode : Whenever the UP key is pressed, the code number is increased.

c) DOWN KEY



Whenever the DOWN key is pressed, the channel is decreased one step by one step. And UP key is pressed long time, the channel number is decreased quickly.

In the CTCSS mode : Whenever the DOWN key pressed, the code number is decreased.

d) CODE KEY



1) In the CTCSS mode

CODE key is pressed shortly, it is turned CTCSS Change Mode with key beep tone. And the CTCSS No. icon is flashing on LCD. Then CTCSS No. is changed by Up/Down key. The CODE key is pressed again, CTCSS mode is released.

2) Key Lock Mode

CODE key is pressed over 1 second, keys are locked except PTT and Monitor and LOCK icon is displayed. The CODE key is pressed over 1 second again, Key lock function is released.

e) PTT(Push To Talk) KEY



1) In the state of Rx or Rx-stand by

While PTT key is pressed, it is turned to TX mode. And TX icon and 5 RF Bars is displayed on LCD. PTT key is released, it is turned to stand by mode.

2) Scanning Mode

While PTT key is pressed in the Rx or Scan wait time, it is turned to TX mode. In other cases, PTT key is ignored.

3) Penalty time Mode

PTT key is ignored till Penalty time is finished.

f) MONITOR KEY



1) In the state of Rx or Rx-stand by

While pressing the MONITOR key, the current channel is monitored and the LAMP light is illuminated on LCD for about 5 seconds. Set the key free, it is released.

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2) Scanning mode

If the MONITOR key is pressed in the Rx or Scan wait time,
a current receiving channel is deleted on SCAN list.

3) Tx mode

Monitor key is ignored.

g) Volume Switch

Volume Switch controls speaker sound.

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3.4 SETTING AND OPERATION

a) The points checked before power on.

- 1) Check if the battery is installed firmly on the equipment.
- 2) Check if the channel desired is displayed on LCD.
- 3) If you want the power off, push to power key
- 4) After the power is push on, the radio is in Rx stand-by mode and ready for Transmission.

b) Tx



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- 1) Tx is performed by Tone squelch call method.(option)
(Tone squelch call method is available in the channel with tone frequency.)
- 2) After a desired channel number is selected, while holding the PTT key on the left side of the radio, call up the partner station.
- 3) At this time, Tx icon and RF strength bars are displayed.
- 4) While communicating, talk to microphone 5cm distant from the lips to communicate clearly.

c) Rx



< No Option >



< CTCSS Option >

- 1) When the TX is finished, if the PTT key is released, the radio unit turns to the Rx stand-by.
- 2) When a certain channel is receiving a signal, RX icon is displayed and audio is generated.
- 3) At this time, RSSI(Received signal strength input) level is displayed with 5 steps.
- 4) CTCSS Option : when tone liked set CTCSS Tone is detected, CTCSS correct call icon is displayed and audio is generated.

d) Scanning Operation

1) Scannig Mode Setting

When the Up/Down key isn't pressed over 2 second in the 0 channel, Scan starts. Then Scan Start Channel is a current channel and Scan Speed Time is 200ms. Scan checks a carrier or CTCSS tone during Scan Speed Time. If carrier is checked, a radio receives carrier till carrier disappears. The Up/Down key is pressed again, Scanning Mode is released, and it is turned Rx-stand by of last scan channel.

2) Scan Channel Delete

If the Monitor key is pressed in the Rx or Scan wait time, a current receiving channel is deleted on Scan list and next channel is scan. When scan starts, Scan list is repaired. All channel is deleted in the scan list, Scan mode is released.

e) Tone Scan Operation

If you don't know tone channel of the parter station in the Rx state after channel number set, press the Code Key for 2 second to scan tone channel.

When tone signal is detected in the tone scan, tone channel is memoried automatically and scan is stopped.

f) Key Lock Mode

CODE key is pressed over 1 second, keys are locked except PTT and Monitor and LOCK icon is displayed. The CODE key is pressed over 1 second again, Key lock function is released.



g) Power Save Operation

Radio is under the automatic power saving.

1) Power save on time = 200ms/400ms/800ms

Power save is that RF Board power is turned off during fixed time. If Rx/Tx don't operate in the Rx-stand by, Power Save is adapted 200ms Power Save during first 10 seconds and 400ms Power Save during next 20 seconds. After 20 seconds, Power Save is adapted 800ms Power Save.

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2) Power save off time = 100ms

Power is supplied in RF Board during 100ms and Rx operates.

3) Power save delay time = 2sec

Power save stops for 2 seconds after Rx/Tx operation finish.

h) Battery Check



LOW



MID



HIGH



LOW CELL BLINKING

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1) In the state of Rx or Rx-stand by

Battery is checked every 100ms and displayed 3 step on LCD.

When low battery is checked, cell icon blink every 500ms periodically with beep tone.

2) Tx mode

When Tx is tried in the state of low battery, Tx time is limited into 10 second by Time Out Timer. If Tx is tried over 10 second, it is forbidden during 20 second with Penalty mode beep. Penalty time is displayed on LCD.

i) CALL Operation

PTT key is pressed two times shortly, radio transmits to the parter station Call beep tone.

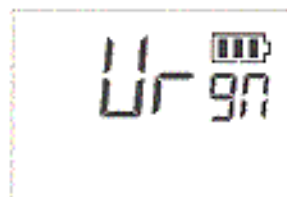
CALL icon is displayed on LCD of the parter station.



j) Emergency Operation

Monitor key is pressed over 3 seconds, alarm sound is generated and Urgn icon is displayed on LCD.

Monitor key is pressed again, Urgency mode is released.



#. Remark

- As you don't want to use this equipment or just keep it, the power should be off

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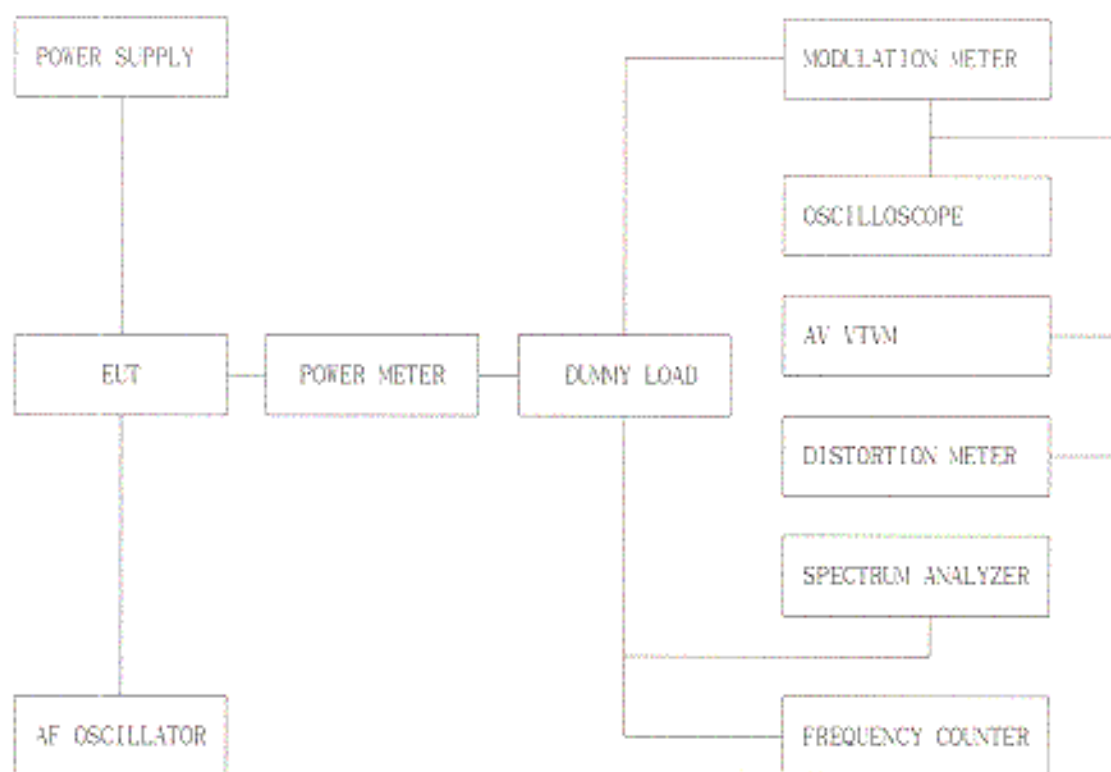
4. ADJUSTMENT

4.1 Frequency synthesizer (PLL)

- After connecting the power meter and dummy load(50 Ω), join the antenna connector of FRS-460 with above equipment.
- Check the voltage between RX1 & GND in digital volt meter.
- Then set the low channel of FRS-460 the lowest frequency.
- After releasing PTT key of FRS-460, trim VC2 for adjusting the lowest frequency of Rx channel to DC 1.0V in the voltage of RX1. And then check if the highest frequency of Rx channel is DC 3.8V in the voltage of RX1.
- After pressing the PTT key, trim VC1 for adjusting the lowest frequency of Tx channel to DC 1.0V in the voltage of TX1 and then check if the highest frequency of Tx channel is DC 3.8V in the voltage of TX1.

4.2 TRANSMITTER

- Connect EUT & measure equipment according to block diagram below.



- b) Connect DC 6.0V. voltage preset to EUT.
- c) Connect "power meter" & "dummy load(50 Ω)".
- d) Adjust Tx frequency according to trimming trimmer VC3.
- e) Connect AF oscillator to mic terminal for conform modulation degree.
- f) Adjust the frequency of AF oscillator to 1kHz and adjust AF level should be 60mV.
- g) Checking oscilloscope and modulation meter. max. frequency deviation should be in ± 2.5 kHz.

4.3 TRANSMITTER TEST

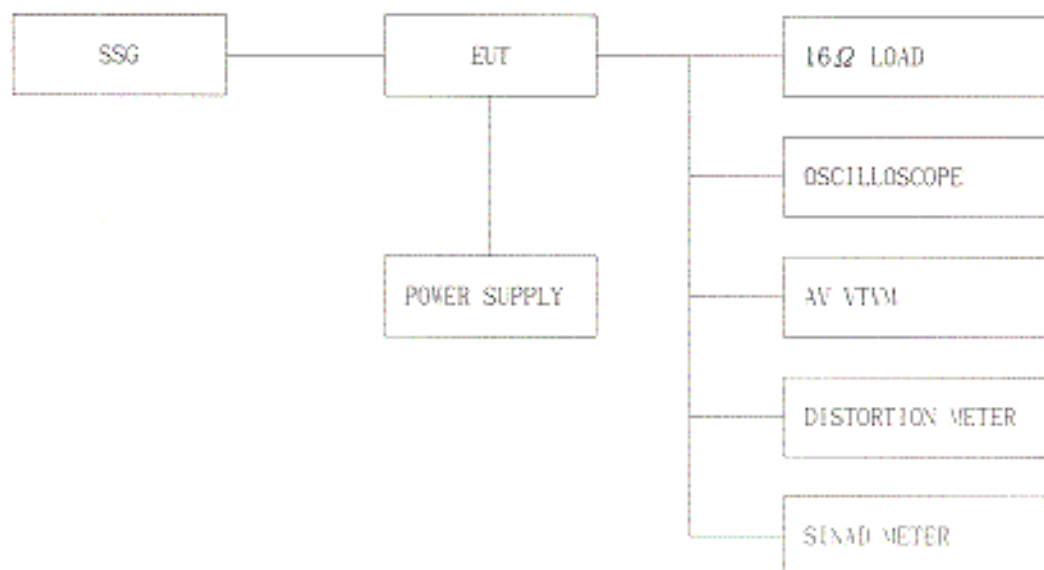
- a) Output power test
power(6.0V DC) should be Max.500mW and in -50% range.
- b) Audio Response
Connect AF oscillator to Mic terminal and then firm the audio level that doesn't distort the wave of oscilloscope in the frequency range, 300Hz~3kHz. Check the audio level for 300Hz~3kHz based on frequency standard, 1kHz.
- c) Modulation degree Test
 - 1) Connect AF oscillator to the MIC terminal and then adjust the level to 60mV
 - 2) Measure the oscilloscope wave and the point needle of modulation meter after pressing PTT key.
 - 3) Sweep gradually the frequency of AF oscilloscope from 300Hz to 3kHz.
 - 4) At this time, the point needle of modulation meter should be in ± 2.5 kHz.
- d) Spectrum Test
 - 1) Antenna is 50 Ω and attenuator degree should be 20dB more.
 - 2) Observe the spectrum with pressing PTT key. The harmonics should be less 60dB than carrier.

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4.4 RECEIVER

- a) Preparation
 - 1) Adjust the power supply to DC 6.0V
 - 2) Adjust Voltage level to 0.7Vrms(8 Ω load) after power on.

b) Connection method



C) Adjustment of Rx sensitivity

- 1) Adjust SSG to channel frequency.
- 2) Adjust modulation frequency, 1kHz to modulation degree, 1.5kHz.
- 3) After adjusting the frequency of SSG to channel frequency, RF level sets to -47dBm.

d) The adjustment of squelch sensitivity

- 1) Set the standard channel.
- 2) In squelch mode, SQ volume VR1 must be turned counterclockwise.
- 3) After adjusting SSG to channel frequency, the RF level of SSG is set on SINAD 6~8dB.
- 4) Turn VR1 counterclockwise after VR1 is turned to the opposite counterclockwise. Adjust carefully until audio is generated from speaker.

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4.5 RECEIVER TEST

a) Rx sensitivity test

SSG should be adjusted to 12dB(with CCITT) of SINAD's point needle seeing wave of oscilloscope as SSG sets in 1kHz with 1.5kHz frequency deviation. At this time, normal RF level is -118dBm~-121dBm.

b) Audio Distortion Test

- 1) SSG should be adjusted like way of point a) and RF level sets to -47dBm.
- 2) Adjust to 1Vrms(8Ω load) seeing Audio wave.
- 3) Read the needle of distortion meter(normal condition would be less than 5% distortion.)

c) Squelch Test

After RF level of SSG should be set to the least level, RF level should be gradually increased until speaker makes audio sound. At this point, check RF level(Check if the SINAD is 6~8dB)

4.6 Symptoms, Check point & Correction

a) Diagnosis method

- 1) Check each switch to work well.
- 2) Check voltage of battery.
- 3) Problem develops from transmitter or receiver?

b) Troubleshooting

1) Transmitter

- ① Power key is on condition but does not work.
 - Ⓐ Battery could completely discharge.
 - Ⓑ Battery cell twist...
 - Ⓒ Touch problem come between Battery and Radio.
- ② Fail to transmit
 - Ⓐ Run out of battery or charge problem.
 - Ⓑ Fault of PTT key.
 - Ⓒ Fault of Q3, Q4.
- ③ Transmitter works but frequency is unmatched.
 - Ⓐ Out of order in frequency synthesizer.
 - Ⓑ Out of order in X-tal(X2).
- ④ Audio does not sound(Tx power and Tx frequency are normal)
 - Ⓐ Problem of microphone or mic connector.
 - Ⓑ IC U6,7C/D problem.
 - Ⓒ Connector problem of RF PCB and Control PCB.
- ⑤ Tx is set when switch is on.
 - Ⓐ Tx switch problem

2) RECEIVER

- ① Rx does not work
 - Ⓐ Speaker line open problem or connector problem.
 - Ⓑ Receiver power circuit problem.
 - Ⓒ Audio filter IC U7A/B, Audio amplifier IC U4 problem.
- ② Only noise sound
 - Ⓐ U14 problem.
 - Ⓑ VCO problem.
- ③ Rx sensitivity is weak
 - Ⓐ Antenna mounting problem.
 - Ⓑ Front-End circuit problem.
 - Ⓒ Local oscillation frequency deviation.
 - Ⓓ SFl saw filter fail.
 - Ⓔ VCO problem.
- ④ Squelch does not work
 - Ⓐ U14 problem.
 - Ⓑ Squelch volume problem.
 - Ⓒ Control logic problem.

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5. DESCRIPTION OF RADIO CIRCUIT

5.1 Frequency synthesizer

Frequency synthesizer consists of VCO, PLL IC(built in PRESCALER) and loop filter.

a) VCO

VCO is composed of TX VCO and RX VCO. Oscillation circuit takes colpitts oscillation circuit using variable Diode.

1) Tx VCO

Tx VCO is composed of D1,Q1,C5,C6,VC1,L1,C7.

VCO control voltage through loop filter adjusts frequency and Microphone signal through Modulation terminal makes modulation.

2) Rx VCO

Rx VCO consists of D2,Q6,C39,L2,C41,VC2,C42.

control voltage through loop filter adjusts frequency.

b) PLL IC

PLL IC is adjustable IC to produce the wished frequency which VCO provides through loop filter. It has internal counter using 21.25MHz reference frequency to make 6.25kHz as reference signal. VCO frequency from prescaled input is divided signal is compared with Reference signal phase in phase comparator. Built-in charge pump changes voltage (until two signals are in phase) and charged voltage supplies VCO through loop filter to produce the desired frequency.

Frequency data associated with channel goes to PLL IC by CPU through CLOCK, DATA. PLL IC enables by enable line of CPU.

c) Loop Filter

Loop filter is composed of TX:C1,R1,C2 RX:C36,R22,C37 and changes pulse from pin3,14 to DC and eliminates harmonic component in pulse. It helps VCO oscillate clearly as DC voltage is supplied into Varicap.

5.2 RECEIVER

This is composed of Dual Conversion Super Heterodyne. First IF is 21.7MHz. Local oscillator frequency is lower in 1st IF than Rx frequency. It is called low side injection. Second IF is 450kHz. 2nd local oscillator frequency comes to 21.25MHz.

a) Rx/Tx conversion circuit

Rx signal goes to Rx/Tx conversion circuit through FIXED antenna connector, low pass filter(L6,L7,L8,C31,C33,C34,C35) and receiver resonance circuit composed of L9, C54. When transmitting, voltage at PIN diode D3 through D4,R18 supplies. D4 of receive input is short and Tx is on condition. When PIN diode is off in condition of Rx, L9 and C54 resonate serially and make impedance matching at receiver band pass filter.

b) Front End

Front-End has Q8 to provide a high sensitivity and low noise feature. It employs L15,16,17,C56,57,106,59,60,61,62 as band pass filter to eliminate image frequency and to produce enough pass band by Q8 input and output.

c) Mixer

Mixer has one base 2SC4226(Q9) to feature high low noise quality. It has RF signal through Q8 and L19,L21,SF1 and RF signal from Local oscillator mixed. It develops 1st IF, 21.7MHz. 1st IF goes to 1st IF amplifier Q11(BFR92AW) base through X-tal filter XF1. IF of mixing signals is selected and taken into X-tal filter. Output impedance of mixer is direct matched with input impedance of X-tal filter.

Matching of filter satisfies pass bandwidth of filter, ripple elimination with in pass band, and attenuation characteristic of stop band.

X-tal filter is composed of two 2 pole monolithic X-tal filter. 8kHz of IF bandwidth R44 is used as impedance matching with 1st IF Amp Q11.

e) IF AMP and Detection

1st IF AMP Q11 supplies IF(U4) mixer input pin16 through output resistor R42 and C73 to need gain in insertion loss of X-tal filter and last stage circuit. Multi-use IF IC makes up of mixer IF AMP. pin1 2nd local frequency to produce.

It supplies mixer of internal IC. Mixer output of IC through pin 3 passes 450kHz ceramic filter, supplies 2nd IF AMP, amplifies, and limits.

After 2nd IF AMP has a process of enough gain and AM rejection, it comes to quadrature detection. Demodulated audio signal by CR1(RESONATOR) is amplified and comes out to pin9. Detected audio signal through R49 and input in IC U7A/B. U4 of control board through C136.

f) Squelch Circuit

Noise component of detected outputs has amplification Squelch threshold is controlled by the SQ VOLUME(VR1)

g) Audio high pass filter and Audio amplifier

Demodulated audio signal enters to AUDIO HPF IC(U7A/B) and the signal entered to Pin 3 of U4. After above signal amplifies in U4 pin 3 through R132. It comes out to pin 5. Then, It reaches at speaker.

5.3 Transmitter

When Tx develops with pressing PTT switch, VCO output amplifies through Q3,Q4 and Q5 and transmits by antenna through low pass filter.

Transmitter keeps stable.

a) Power amplification and low pass filter

Tx RF signal produced from Tx VCO is amplified by Pre-Driver Q3 and enters to driver Q4 through C25 and entered Q5 POWER TR input terminal with final amplification.

After this stage, the signal is emitted at antenna through 50Ω STRIP matching low pass filter(L11,L12,L13,C31,C33,C34,C35) to eliminate harmornic.

b) Audio modulation and Audio amplification.

Audio signal produced by internal microphone, limits amplification by HPF IC U6C/D, U7C/D. It enters to VCO through low pass filter.

Max. Frequency modulation deviation is adjusted by R158,R120 keeps noise and audio from entering to VCO at time of Tx. Audio modulation and Audio Amplification has characteristic of 6dB/OCT pre-emphasis by U6C/D, U7C/D.