# THEORY OF OPERATION
# 21-1860

This PLL controlled FRS transceiver provides accurate and stable operation.

The basic functions consist of 8 main sections:

- Power
- Receiver Stage
- Squelch Control
- Transmit Stage
- VCO and PLL
- Microcontroller
- CTCSS
- CALL

- **Power**

The unit is powered with 6.0V (4×AA type) Alkaline type or 4.8V (4×1.2V) Ni-Cd type batteries. The power is spread into four sections.

1 The power for the low battery detect circuitry. This circuit is used to detect the battery capacity and turn on the low battery icon accordingly.

2 The power for the RF-power amplifier.

3 The power for the Audio amplifier section.

4 The 6.0V or 4.8V is regulated to 3.5V by IC6 TK11335 for the power supply to the MCU and its related circuitry. Under the MCU control, Q2 composes as a power switch for transmit and receive circuitry. Q1 and Q6 are for the power supply to VCO and PLL circuitry. For power saving purpose, Q1 and Q6 are turned on and off in a ratio of 1:3, It is 250msec on and 750msec off.

- **Receive Stage**

RF signal is received through the antenna and is passed onto a low pass filter network and amplified by Q101. This allows only the required band signal to pass through the band pass filter (BPF) and the second stage RF amplifier Q102. The mixer Q103 converts the incoming signal down to 21.7MHz. These signals again pass to a 21.7MHz XTAL band pass filter F101. This gives a better channel selectivity. The selected 21.7MHz XTAL signal is amplified by IF amplifier Q104 before it is passed to the second converter IC101 MC3361. This converts the 21.7MHz signal down to 450kHz. This 450kHz signal is sent to discriminator after passed through F102 filter. The signal is demodulated, and outputs an audio signal. The detected audio signal passes through Audio Amplifier unit IC2 LM324, the 300Hz high pass filter and volume control VR1, a final audio amplifier IC106 NJM2070, and then to the speaker. When a call signal is received, the signal is extracted by IC3 LM324 when a call signal is detected. MCU then generates a buzz sound to alert the user.

- **Squelch Control**

Squelch control circuitry consists of IC101 MC3361 and its related circuit. The squelch signal output from IC101 pin 9 pass through filter amplifier circuit composed by pin 10 and pin 11. The signal is detected by D104. D104 established a control voltage to the squelch input: pin 12, 14 of IC101. VR102 is used to control the threshold of the squelch (squelch sensitivity) when pin 12 of IC101 is larger than 0.7V. Pin 14 of IC101 is output a Hi to MCU IC1 pin 50 to indicate an incoming signal is detected.

- **Transmit Stage**

When the PTT switch is pressed, the transceiver is switched into transmit mode through the TX/RX exchange control D102, D103. MCU turns on the power to the transmitter. The voice is picked up by the condenser MIC and passes through the 300Hz high pass filter IC103 NJM3403 and is amplified by IC105 LM324 MIC amplifier circuit, and adjusted by VR101 to obtain a proper audio frequency response. The signal modulates with the carrier in the form of FM modulation. The modulated signal from the VCO goes into the power amplifier unit which consists of a buffer amplifier Q109, a driver amplifier Q108 and the RF power amplifier Q106. The signal then is finally radiated out through antenna. The unit will also be switched into transmit mode when the CALL button is pressed. A dual tone signal of 1.2KHz and 600Hz will be fed into the transmitter for transmission.

- **VCO and PLL**

PLL circuitry is composed by IC102 M64082, the frequency synthesizer PLL and VCO. The channel information from the MCU is sent to the shift register in IC102 from pin 2. A control voltage is generated through the low pass filter to the VCO from pin 8 and is used to control RF frequency from Q112. Q107 is the RX/TX exchange switch. RF signal from the VCO passes through the buffer amplifier Q112 and then is fed back into PLL pin 6 of IC102. IC102 pin 10 output a lock detected to indicate the VCO frequency is in "Lock". In receive mode, the signal is fed to the receiver first mixer Q103, and generate the first intermediate frequency (IF). In transmit mode, this signal modulation with the audio signal or call signal and is passed through to transmit power amplifier unit for transmission.

- **Microcontroller**

The Microcontroller µPD789405 is the main control of the whole transceiver unit. It is also used to drive the LCD to show the status of the unit. On the LCD, there is current working channel display, transmit indication, receive indication, and low battery indication. The MCU scans the keypad to detect key pressed and released, then execute the function accordingly.

- **CTCSS**

The CTCSS consists of transmitter and receiver section. In CTCSS transmission, a CTCSS signal is added to the audio and modulated for transmission. MCU pin OUT1, OUT2, OUT3 and OUT4 output a 16-stage of the digital values. These digital values then are passed through a digital to analog converters R1 and R2. The output is a step waveform, and then is filtered by a low pass filter and mixed with the audio. The receiver section consists of a CTCSS decoder circuit which is used to separate the audio signal and the CTCSS signal for the existing CTCSS signal. The CTCSS signal is filtered and amplified by IC101 MC3361 and reshaped as a square

wave by IC3 LM324. The signal then is input to the MCU and is determined the CTCSS signal value for the valid CTCSS receive.

- **CALL**

When the CALL button is pressed, the transceiver is switched into transmit mode through the MCU and Q105 control. IC104 CD4001 generates a dual tone signal of 1.2kHz and 600Hz which is controlled by MCU. This dual tone signal of 1.2kHz and 600Hz signal is amplified in the MIC amplifier unit and modulated for transmission.

# TROUBLE SHOOTING

Before troubleshooting, prepare your unit as follows:

- Turn volume control fully clockwise so that it is all the way up.
- Install the batteries onto your unit.

| Item. | Symptom | Cause/Remedy |
|---|---|---|
| 1 | LCD No Display | ● Check batteries to see if the voltage is lower than 1.2 V DC. |
| 2 | No sound | ● Check to see if Q1, Q2, Q6, IC6 are defective. |
| 3 | No sound | ● Check to see if the speaker is defective.<br>● Check to see if the external speaker jack is defective.<br>● Check to see if volume control is defective.<br>● Check to see if IC106 is defective.<br>● Check to see if D107 are defective.<br>● Check to see if IC101 is defective. |
| 4 | No RX or audio distorted | ● Check to see if the VCO and LPF circuits are defective.<br>● Check to see if Q101, Q102 or Q103 are defective. |
| 5 | No squelch control | ● Check to see if VR102 is defective. |
| 6 | No LED back light | ● Check to see if LED1, LED2 and Q3 are defective. |
| 7 | Transmit with low modulation | ● Check to see if VR101 is defective. |
| 8 | No function of CALL switch | ● Check to see if the component Q2 Q105 defective.<br>● Check to see if Q111 and IC104 are defective.<br>● Check to see if SW2 is defective. |
| 9 | No TX | ● Check to see if Q2 is defective.<br>● Check to see if Q109, Q108 and Q106 are defective.<br>● Check to see if D102 is defective. |
| 10 | No function of PTT switch | ● Check to see if Q2 is defective.<br>● Check to see if switch SW101 is defective. |
| 11 | No modulation when transmitting with CTCSS on | ● Check to see if R1 and R2 are defective. |
| 12 | No RX with CTCSSS on | ● Check to see if IC101 is defective.<br>● Check to see if IC3 is defective. |

# ADJUSTMENT PROCEDURE

| Step | Item | Adjustment | Procedure |
|---|---|---|---|
| 1 | TX Frequency | VC101 | Adjust VC101 to obtain demanded TX frequency. |
| 2 | TX | L115, L117, L118, L119 | Adjust L115, L117, L118, L119 obtain demanded TX power. |
| 3 | SQL | VR102 | 1. Inject an audio frequency (AF) -20dBm.<br>2. Adjust VR102 to obtain maximum TX deviation ≤2.5kHz.<br>3. Check MIC modulation sensitivity, and it should be 2.5~10mV. |
| 4 | TX. Dev. | VR101 | 1. Set CTCSS 01, CTCSS 12 or CTCSS 38.<br>2. Adjust VR102 to obtain TX deviation with 0.55~0.8kHz. |
| 5 | RX | L101, L103, L104, L105 L106, L107, L108, L109 | Adjust L101, L103, L104, L105, L106, L107, L108 and L109 to obtain demanded receive sensitivity. |
| 6 | RX | L101, L103, L104, L105 L106, L107, L108, L109 | Adjust L101, L103, L104, L105, L106, L107, L108 and L109 to obtain demanded image frequency. |
| 7 | RX | VR102 | Adjust VR101 to obtain demanded squelch sensitivity. |

# ALIGNMENT PROCEDURES

**Important:** The FCC requires that any frequency adjustment on a radiophone must be done by authorized person, who is the holder of a current first or second class radiotelephone license.

This unit has been fully aligned at the factory before shipment and does not normally require further adjustment. When necessary, however, the unit may be aligned as indicated below.

Do not adjust any circuit in this radiotelephone unless you understand the circuit operation and have experience-adjusting radiotelephone. Tampering with the radiotelephone may upset the alignment and lower its performance.

**Test Equipment Required**

- Regulated DC power supply, 0~12V, 1A or higher; or 8.4V, 1A
- Audio signal generator, 10Hz~2KHz
- Digital multimeter
- Deviation meter
- Frequency counter, 0~500MHz high impedance
- Oscilloscope
- RF power meter, 5W
- High frequency standard generator, >160MHz
- Tracking generator, >160MHz
- Distortion analyzer
- Audio level meter
- T-coupler
- Alignment drivers, etc.

# DISASSEMBLY INSTRUCTIONS

To remove the front and rear panels from the main chassis:

1. Remove the four screws from the bottom of the unit.