21-1813 FRS transceiver circuit description

RF Board

21-1813 consists of 2 different PCBs with the small RF board stacks over the main board. The RF board contains all necessary RF circuit. It converts the RF signal picked up by the antenna to demodulated analogue signal for further processing. Besides, the base band analogue signal, including voice and CTCSS tone, will use to FM-modulate the RF carrier during transmission. The main building blocks of the RF board includes a LNA, a SAW filter, a mixer, a VCO, a crystal filter, an IF amplifier, FM-IF detector circuit and power amplifier for transmission. Among those building blocks, the RF circuit can be subdivided into two sections.

A: RX section
This product employs traditional double conversion superheterodyne architecture with the following functional blocks:

1. The LNA with cascode configuration is composed by transistor Q201 and Q202. It has the merits of low noise figure and high insertion gain.

2. The LO signal is generated by VCO which is phase locked with the reference TCXO (X201) at 21.25MHz. The TCXO can stabilize the frequency of the oscillator within 2.5ppm from –30 to +75 degree C. The spurious generated by the VCO will be further filtered by the tank circuit L208 and C273 and slightly coupled to the mixer for RF to IF downconversion. After receiving command from the MCU, the LO frequency is controlled by the PLL (U202, phase locked loop) chip TB31202.

3. The first image rejection filter, F202, is a SAW (surface acoustic wave) device, with the merits of having low insertion loss and high stop band attenuation.

4. The mixer is a common emitter configured transistor Q203. It converts RF signal to an IF of 21.7MHz. This IF will further be filtered by the crystal filter F201.

5. The IF amplifier, Q204, is used to further amplify the IF signal before inputting to the FM-IF (IC3361) chip.

6. Inside the FM-IF chip, the IF signal is further down converted to 450kHz second IF for demodulation. The second LO signal is generated by the reference oscillator of the PLL chip. The second IF signal is also further filtered by the ceramic filter for better adjacent channel rejection response. The second IF signal is then demodulated by the quadrature coil L218. The demodulated audio signal will be transferred to the main board for further processing

7. By tweaking the trim pot VR201, the audio noise signal level to the internal comparator of the FM IF chip 3361 can be varied. Since the comparator output was used to determine the status of received signal quality, and hence the squelch level can be adjusted.

B: TX section

1. The TX carrier is also generated by the VCO with the control from PLL chip. The VCO signal is coupled to amplifier Q210. The amplified signal will feed to the driver stage by Q211. The output signal will be boosted up by the Class-C power amplifier Q212. The harmonics of the carrier will be suppressed by the low-pass filter realised by L215, L216, L201 and the nearby capacitors.

2. The power control is realised by changing the bias of driver stage with the internal switch of the PLL.

Main Board

The main board controlled all the baseband signal including voltage regulation, keyboard input, Call tone generator, CTCSS encode/decode and display.

1. Voltage regulation: The operating voltage of the circuit is stabilised by the voltage regulator U8 and U9. U8 will have a regulated 3V output for all the circuit including baseband, TX and RX section except the VCO and PLL. The S/N of both TX and RX sections will depend on the quality of the VCO. In order to minimise the noise effect, a separate regulator, U9, with 2.7V output is used.

2. Power management: In order to extend the battery life of the unit, unnecessary circuit during different operation modes will be shut down for power saving. The on and off mechanism is controlled by the MCU with the help of some analogue switches which are realised by transistors: They can be classified as:

a)	Q18, Q19	Audio power amplifier
b)	Q9	TX baseband circuit
c)	Q11	RX baseband circuit
d)	Q6	CTCSS low pass filter circuit
e)	Q22	TX RF circuit
f)	Q21	RX RF circuit

3. Display: The channel number, Quiet code, volume setting and TX/RX mode will be prompted to the users by LCD.

There is also a backlit LED for better visual effect under dim environment.

4. Keyboard input: The transceiver had several function keys such as Mode, Call, Power, PTT, Monitor and Detent switch. During the operation, all these function key input will be handled by the MCU.

5. Memory: The memory or setting of the transceiver is stored in the EEPROM U6.

6. Call Tone generator: The call tone generator is realised by Q10 and the frequency of the oscillator is changed by switching the feedback resistance.

7. Low battery detection: It is realised by the internal A/D of the MCU during power save mode.

8. High pass filter, Pre-emphasis, Limiter and Low pass filter: The acoustic input transduced by the microphone will go through a 300Hz High Pass Filter first. This HPF is used to reduced the interference between the user voice and CTCSS tone. This HPF is realised by U7. The pre-emphasis is realised by resistor R59 and C100. The pre-emphasis responses follow the recommendation of EIA standard. After the pre-emphasis stage, limiter and low pass filter are inevitable which are realised by U10.

9. De-emphasis, bandpass filter and volume control: The demodulated baseband signal from RX section needs to be de-emphasised first. Then the signal will pass through the band pass filter for clear audio signal recovery. This section is realised by U3. This signal will feed to the audio amplifier (U4) for power boosting. The volume level is electronically controlled by MCU open-drain port.

10. CTCSS tone generation: It is controlled by the MCU. The required tone, which is in square wave, will pass through the switch capacitor filter U2 for filtration. The pure CTCSS tone will add to the TX audio (U10) for FM modulation.

11. CTCSS tone decode: The demodulated baseband signal from RX section will pass through the same switch capacitor filter U2 as mentioned above by controlling the multiplexer U1. The CTCSS tone received will be transformed to square wave by the internal op-amp of U2. This signal will be used for decoding. The MCU will decode this signal by checking its frequency and duty cycle.

12. MCU internal clock and reset: The reset is realised by Q17. Since the CTCSS tone is reference with the internal clock of the MCU. Therefore 4MHz crystal is used as the main resonator in order to have a better accuracy.

13. Battery charging: This transceiver can cope with its external charger. If this transceiver is put into the charger with proper rechargable battery pack, a charging detection signal (from Q15) will alert the MCU and the transceiver will then be forced to power save mode.

14. Automatic Squelch: The squelch detection signal from RX section will alert the MCU to mute the speaker. The squelch level is controlled by VR201 on the RF board.