1. THEORY OF OPERATIONS

1-1. Circuit Composition and Operation Theory

The basic explanation for the circuit composition GMRS-310 consists mainly of the one board controlling the analog circuit parts and the digital circuit parts for the other control.

1-2. Receiver

GMRS-310 transmission parts is composed in the double conversion system, which has the 1st IF frequency of double 21.7 MHz and the 2nd IF frequency of 450 KHz. With the RF fronted which has an excellent band characteristics and skirt characteristics, the 2 pole MCF used in the 1st IF, and the 3 pole ceramic filter in the 2nd IF, the reception interrupting factors such as the image and the sensitivity repression are reduced for the more stable reception.

1-2-1. RF Front-end

The signal received by the antenna will be transmitted to the band pass filter through the antenna switching circuit consisted of L607, D601, D602. The front RF amplifier transistor Q101 consists of the C101, C102, C103, C105 input band pass filter and SAW101 output band pass filter, primarily diminishes the other signal rather than the 1st IF image and other signal within the reception band and amplifier only the necessary signal within the RF

1-2-2. 1st Mixer

The receiver which has been amplifier in the RF front-end is provided to the base of the 1st mixer Q102. The 1st L/O signal provide from the VCO is supplied to the emitter of Q102 and Converted to the 1st IF 21.7 MHz

1-2-3. 1st IF Filter and 1st IF Amplifier

The signal covered by Q102 to 21.7 MHz, the 1st frequency, change its impedance through C114, L105 and then is infused to the fundamental MCF which has the center frequency of 21.7 MHz and the width of +/- 3.75 KHz.
Here, the signal reduces the image and other unwanted signal for the 2nd IF , and changes its impedance again through the R124. Then the signal is infused to the Q103, the 1st IF amplifier. The signal infused to the Q103 is amplifier approximately by 20 dB in other to acquire the required reception sensitivity, and infused to the IC101 which functions as the 2nd mixer, the 2nd IF amplifier, and the FM detector.

1-2-4. 2nd Mixer, and IF, FM Detector (IC101)

The receiver IF signal of 21.7 MHz, which has been infused to IC101 is mixed with the 2nd L/O converted to 450 KHz, the 2nd IF frequency. The receiver signal converted to the 2nd IF signal frequency passed through the CF101, the ceramic filter of 450 KHz again. After the limiting inside the IC101 and the FM demodulating by the quadrature detector inside the IC101, the signal offers the output through the 9th pin of IC101.
The squelch circuit is composed to detect the noises from the received signal demodulate in the 9th pin of the IC101. For this purpose, the noise filter is using the OP amplifier inside the IC101.

1-2-6. De-Emphasis and 300Hz HPF (U801)

The audio signal which has been FM demodulate in the IC101 is supplies to the IC401C, IC402D which function as the De- emphasis and 300Hz HPF.
Since the IC401C has the 300Hz HPF with the 1st characteristics and the De-emphasis characteristics with the corner frequency of approximately 200Hz, and IC402D has the 300Hz HPF with the 4th characteristics, they function as a normal De-emphasis and also reduce the signal such as CTCSS to unwanted noises from the speaker.

1-2-6. Audio Power Amplifier (IC201)

The receiver audio signal, which has been adjusted to the appropriate volume by IC201 supplied to the 2nd pin of the IC201 and amplified approximately by 20 dB.
Then, it turns up the speaker with the maximum output of 0.5 watts.
The 6th pin of IC201 is the audio mute terminal. If a voltage supply to the 6th pin of the IC201 is not supplied to this terminal, the IC201 stops functioning as the audio power amplifier regardless of the signal supplied to the 2nd pin of the IC201, and there is no sound emitter from the speaker.

1-3. Transmitter

The transmitter parts of the GMRS-310 is designed to amplify the RF signal oscillated and modulated by the synthesizer to approximately 2.0W by the power transistor of Q603.

1-3-1. Pre-emphasis (IC401D)
The voice signal input from the microphone is pre-emphasized at the IC401D. The signal which comes out of the IC401D is limited to a certain amplitude for the voice signal not to exceed the allowable band width assigned for transmission.

1-3-2. KHz LPF (IC401A,B)
After passing the IC401D limiter, the signal is combined with the CTCSS tone at the digital circuits, and is supplied to the 3KHz LPF has the 4th characteristics and adjusts the assigned frequency band width not to exceed the allowable range.

1-3-3. Tx Power (Q603)

The transmitted signal of approximately 0dBm, combined at the at the VCO buffer amplifier Q302 is supplied to the drain of the Q603 amplifiers, through pre-amplifier(Q601) and driver amplifier(Q602) . The transmitted signal amplifier to 2.0W here passes the TX LPF of the 2nd characteristics of the L605 and the C607, C608 and RX/TX switching takes place by the D601. After this, the signal is provided to the antenna the TX LPF of the 1st characteristics consisted of the C612, C613, C614, C615, C616, C617, C618, L608, L609, L611.

1-4. “GMRS” Frequency Synthesizer

1-4-1. Voltage Control Oscillator (VCO)

The VCO of oscillates 462.5625 MHz to 462.7250 MHz under the transmission condition and 440.8625 MHz to 441.025 MHz under the reception condition. The VCO consist of the clip oscillator of the Q301 and contains the oscillator frequency of approximately 21.7 MHz during the transmission/reception

conversion. That is since the VCO should oscillate relatively low frequency during reception compared to transmission, the D302 is biased by the Q303.
Therefore as a result, the C323 is added in parallel to the resonance circuit of the VCO to oscillate a low frequency. During transmission, a relatively high frequency should be oscillate compared to reception. Therefore, the D302 is adversely biased by the Q303, and as a result , The C323 which is added unparalleled to the circuit of the VCO is removed to oscillate the desired transmission frequency.
The VCO is controlled by the IC301 PLL IC in order to oscillate accurate frequency. The output frequency of the VCO is supplied to the IC301 PLL IC immediately. At the IC301, Crystal(21.25MHz) is compared to the output frequency of the VCO.
The VCO is controlled the loop filter consisted of the R302, R303 and the C311, C312, C313 in order to oscillate the stable frequency wanted for the radio.
The VCO controlled voltage which as passed the loop filter is supplies to the D301 varactor diode, and the VCO an oscillated the PLL programmed frequency by the capacity variance in the D301. In addition, the L302 on the VCO circuit function as frequency for the VCO to be properly controlled by the IC301 PLL IC.

1-4-2. RX/TX Buffer Amplifier (Q302)

The RF signal oscillate at the VCO is provide to the Q102 RX 1st mixer through the Q302 during the reception, and is provide to the Q601 pre-amplifier through the Q302 during the transmission.

1-4-3. PLL Frequency Synthesizer (IC301)

The PLL synthesizer of the signal loop PLL circuit with the reference of 6.25 KHz. The IC301 PLL IC includes all the function such as the reference oscillator, the driver, the phase detector, the lock detector, and the programmable divider. At the reference oscillator, the 21.25 MHz TCXO is connected to the pin 11 of the IC301 to oscillate the frequency of 21.25 MHz. The crystal(21.25 MHz) is the temperature compensation circuit to maintain the frequency within the allowable error rang even under a low temperature of -30℃. The phase detector send out the output power to the loop filter through 3rd pin of the IC301. If the oscillation frequency of the VCO is low compared to the reference frequency, the phase detector send out output power in positive pulse. If the oscillation frequency of the VCO is high, phase detector send out can maintain the frequency set. The programmable divider maintains the desired frequency with control from the CPU. The dividing ratio, "N" to oscillate the desired frequency is as below :

N = VCO oscillation frequency / reference frequency

If the desired frequency is 462.5625 MHz

a) TX : N = 462.5625 MHz / 0.00625 MHz = 74010

b) RX : N = [462.5625 MHz – 21.7 MHz] / 0.00625 MHz = 70538

1-5. CTCSS Processing

1-5-1. RX CTCSS Tone Processing

The received CTCSS tone is sent out through 9th pin of the IC101, and supplies to the IC402B, IC402C, IC402D Low Pass filter(67Hz~250Hz) through the Q421. The voice band signal which can affecter the reception of the CTCSS tone is decreased enough at the IC402. The cut off frequency at the Q421 is adjusted by the IC801 CPU to suit the characteristics of the CTCSS tone.
The CTCSS tone received at the Q421 is supplies to the 2nd pin of the IC801 CPU, and receives the desired CTCSS tone.

1-5-2. TX CTCSS Tone Processing

CTCSS tone is generated at CPU(pin 14th, 15th, 16th of IC801) using digital to analog converter method. The TX CTCSS tone composed at the IC801 CPU is properly reduce at the R741, R742, C748, C749. TX CTCSS tone is combined with the TX voice signal through the IC401B audio amplifier, and supplies to the RV721 TX deviation control resistor.

1-6. CPU and MEMORY

Most of the control functions of the GMRS-310 are controlled by the IC801 CPU.
The IC801 CPU has the internal ROM in the capacity of 32Kbyte, and the program for the operation of the IC801.
When the power of the GMRS-310 turned on, the IC801 reads the data necessary for the operation from the IC802 EEPROM, and decide the operation channel, frequency, etc.
If the user alters any parameter of the radio, the IC801 updates the altered parameter to the IC802.