

## 5. THEORY OF OPERATION

### Circuit Composition And Operation Theory

The basic explanation for the circuit composition

NFR-200 consists mainly of the one board controlling the analog circuit parts and the digital circuit parts for the other control.

#### Receiver

NFR-200 transmission parts are composed in the double conversion system, which has the 1st IF Frequency of 21.7MHz and the 2nd IF frequency of 450KHz. With the frontend circuit which has an excellent band characteristic and skite characteristic, the 1 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.

#### RF Frontend

The signal received by the antenna will be transmitted to the frontend through the antenna switching circuit consisted of L47, L48, C416, C415 and C418. The frontend consists of the RF amplifier transistor Q11 and input/output band pass filter. Each input/output band pass filter has the bandwidth of approximately 10MHz, primarily diminishes the other signal rather than the 1st IF image and other signal within the reception band and amplifies only the necessary signal within the RF.

#### 1st Mixer

The receiver signal which has been amplified in the RF frontend is provided to the base of the 1st mixer Q12. The 1st I/O signal provided from the PLL circuit is supplied to the emitter of Q12 and converted to the 1st IF 21.7MHz.

#### 1st IF Filter and 1st IF Amplifier

The signal covered by Q12 to 21.7Hz, the 1st frequency, changes its impedance through L15 and then is infused to the fundamental MCF which has the center frequency of 21.7Hz and the hand width of +/-3.75KHz.

Here, the signal reduces the image and other unwanted signal for the 2nd IF, and changes its impedance again through the R108 and C115. Then the signal is infused to the Q13, the 1st IF amplifier. The signal infused to the Q13 is amplified approximately by 20dB in order to acquire the required reception sensitivity, and infused to the IC1 which functions as the 2nd mixer, the 2nd IF amplifier, and the FM detector.

## 2nd Mixer, 2nd IF, FM Detector ( IC11 )

The receiver IF signal of 21.7MHz, which has been infused to IC11 is mixed with the 2nd L/O signal of 21.250MHz, and converted to 450KHz, the 2nd IF frequency. The receiver signal converted to the 2nd IF frequency passed through the CF2, the ceramic filter of 450KHz again. After the limiting inside the IC11 and the FM demodulating by the quarter detector inside the IC11, the signal offers the output through the 9th pin of the IC11.

The 2nd L/O signal of 21.250MHz which infused to the IC11 filters and uses directly the crystal of 21.250MHz. The squelch circuit is composed to detect the noises from the received signal demodulate in the 9th pin of the IC11. For this purpose, the noise filter is using the OP amplifier inside the IC11.

## De-Emphasis

The audio signal which has been FM demodulate in the IC11 supplies to R123, C128, R301, C302 which function as the De-emphasis.

## Audio Power Amplifier ( IC32 )

The received audio signal which has been adjusted to the appropriate volume in the VR1 is supplied to the 2nd pin of the IC32 and amplified approximately by 20dB. Then, it turns up the speaker with the maximum output of 0.3Watts.

The 7th pin of the IC32 is the audio mute terminal. If a voltage supply to the 6th pin of the IC32 is supplied to this terminal, the IC32 stops functioning as the audio power amplifier regardless of the signal supplied to the 2nd pin of the IC32 and there is no sound emitter from the speaker.

## Transmitter

The transmission part of the NFR-200 is designed to amplify the RF signal oscillated and modulated by the synthesizer to approximately below 500mW(ERP) by the power transistor of Q43.

## Pre-emphasis ( IC71 )

The voice signal input from the microphone is pre-emphasized at the IC71A. The signal which comes out of the IC71B is limited to a certain amplitude for the voice signal not to exceed the allowable band width assigned for transmission.

## TX Power ( Q43 )

The transmitted signal of approximately 7mW, combined at the PLL module is supplied to the base of the Q43 amplifier. The transmitted signal amplified to 0.5 Watts here passes the TX LPF of the 2nd characteristic of the L45 and the L46, and RX/TX switching takes place by the D42. After this, the signal is provided to the antenna the TX LPF of the 1st characteristic, consisted of the L47.

## Frequency Synthesizer

### Voltage Control Oscillator ( VCO )

The VCO of the NFR-200 oscillates 462.5625MHz under the transmission condition and 440.8630MHz under the reception condition. The VCO consists of the oscillator of the Q21, and contains the oscillator frequency of approximately 21.7MHz during the transmission / reception conversion. That is since the VCO should oscillate relatively low frequency during reception compared to transmission, the D23 is directly biased by the R205.

Therefore as a result, the C205 is added in parallel to the resonance circuit of the VCO to oscillate a low frequency. During transmission, a relatively high frequency should be oscillated compared to reception. Therefore, the D23 is adversely biased by the R205, and as a result, the C205 which is added in parallel to the resonance circuit of the VCO is removed to oscillate the desired transmission frequency.

The VCO is controlled by the IC21 PLL IC in order to oscillate the accurate frequency. The output frequency of the VCO is supplied to the IC21 PLL IC immediately. At the IC21, TCXO(21.250MHz) by the TCXO-1 is compared to the output frequency of the VCO. The VCO is controlled through the loop filter consisted of the R218, C234 and the C235 in order to oscillate the stable frequency wanted for the radio.

The VCO controlled voltage which has passed the loop filter supplies to the D21 variator diode, and the VCO can oscillate the PLL programmed frequency by the capacity variation in the D21. In addition, the L23 on the VCO circuit functions as frequency for the VCO to be properly controlled by the IC21 PLL IC.

### RX/TX Buffer Amplifier ( Q22, Q41 )

The RF signal oscillated at the VCO is provided to the Q12 RX 1st mixer through the Q22 during the reception, and is provided to the Q42 power driver amplifier through the Q41 during the transmission.

### PLL Frequency Synthesizer ( IC21 )

The PLL synthesizer of the NFR-200 consists of the signal loop PLL circuit with the reference of 6.25KHz. The IC21 PLL IC includes all the functions such as the reference oscillator, the driver, the phase detector, the lock detector, and the programmable divider.

At the reference oscillator, the 21.25MHz TCXO of the TCXO-1 is connected to the pin 11 of the IC21 to oscillate the frequency of 21.25MHz. The TCXO(21.25MHz) is the temperature compensation circuit to maintain the frequency within the allowable error range even under a low temperature of -20°C.

The phase detector sends out the output power to the loop filter through 3rd pin of the IC21. If the oscillation frequency of the VCO is low compared to the referenced frequency, the phase detector sends out the output power in positive pulse. If the oscillation frequency of the VCO is high, phase detector sends out the output power in negative pulse. Therefore, the VCO can maintain the frequency set.

The programmable divider maintains the desired frequency with the control from the CPU. The dividing ratio, "N" to oscillate the desired frequency is as below :

$$N = \text{VCO oscillation frequency} / \text{reference frequency}$$

If the desired frequency is 462.5625MHz

$$N = 462.5625\text{MHz} / 0.00625\text{MHz} = 74010$$

## CPU and Memory

Most of the control functions of the NFR-200 are controlled by the IC51 CPU. The IC51 CPU has the internal ROM in the capacity of 2Kbyte, and the program for the operation of the IC51.