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6. THEORY OF OPERATION

Refer to RRX-450 schematics while reading the following descriptions.

6.1 POWER SUPPLY

The RRX-450 may be powered by either 110/240 VAC or an +11 to +15 VDC external battery. A detachable 3-conductor power cord applies 110 or 240 VAC to the Repeater via J307, depending upon the voltage selector setting. The input is fuse-protected by F303. VR301 – VR303 help limit overvoltage transients from the AC power line. T301 transforms the 110 (or 240) VAC source to a 36 VAC center-tapped line, for application to a full-wave rectifier (CR303 and CR304) and filter (C306). Fuse F302 protects the DC power supply output. CR307 (30 Volt Zener) further clamps line voltage. IC301 and associated circuitry can apply up to 700 mA of charge current to the DC backup battery.

IMPORTANT: This circuit is not designed for continuous charge at maximum current, which will cause components to overheat. Do not connect an external battery that is completely discharged. A battery that is well below its normal charge capacity should first be fully charged using a high-current fast charger that can deliver continuous current for the required recharge cycle.

R306, Q302 and Q303 form the charge current limiting circuit. Q301 disables this circuit during transmit. IC302 provides the main supply voltage, controlling pass transistor Q306. Each module contains its own voltage regulation. Supply current limiting is sensed across R323 – R325 in the ground return path to T301.

The RRX-450 may be powered by an external +11 to 15 VDC source, applied to J301. F301 and CR301 provide reverse voltage, short circuit and overload-protection for the RRX-450. C317 – C319 aid in filtering. An optional hash choke (L901) may be added to remove noise, such as alternator whine, from the +12 VDC source.

If AC power fails, Q305 and its associated circuitry immediately disengage the relay before Q306 goes out of regulation. This applies the (optional) external battery voltage to the Repeater instead. C319 helps to maintain proper supply voltage to any microprocessor-controlled devices installed on the Repeater. Q304 applies an "AC status" signal to the main processor.

Q307 functions as the DC fan switch.

6.2 DUPLEXER

The purpose of the duplexer is to allow a single antenna to be used for simultaneous Repeater transmission and reception. This is accomplished by combining frequency notch filters into the same structure so that transmitter power is greatly attenuated at the receiver input to prevent receiver overload. Additionally, the RX frequencies are attenuated at the TX output to prevent TX noise on the RX frequency from passing through to the RX input. The duplexer consists of four resonant cavities coupled to a common transmission line, and is referred to as a notch duplexer because of the unique bandpass that it produces.

The RRX-450 is designed to permit the duplexer to be mounted with either the low-pass or the high-pass filter toward the transmitter, to facilitate reverse-frequency operation (inverted mode).

6.3 RECEIVER

The RRX-450 receiver is a fixed tuned Dual-Conversion Superheterodyne with a first Intermediate Frequency (IF) of 21.4 MHz and a second IF of 455 kHz. A multifunction IC provides demodulated output and noise squelch.

6.3.1 VCO/BUFFER AMPLIFIER

Q107, coaxial resonator TL101, varactor CR106 and associated components form the VCO (Voltage Controlled Oscillator), a resonant circuit that oscillates at approximately 450 MHz. C180 sets the voltage at the cathode of CR106, determining the varactor's capacitance, which in turn sets the VCO output frequency. C180 is adjusted to give +4 Volts at test point 9. TL101 will oscillate at each end of the band (450-470 MHz); however, C180 should be readjusted to give +4 volts each time the frequency is changed. +8 VDC is tied to the collector of Q107. C179 and C190 serve as a feedback network. C182 couples the oscillator signal to buffer amplifier Q108. C163 and C165

6.3.6 MIXER CIRCUIT

The RF input signal is applied to the gate of the mixer, Q102, through C112 and a matching network of C113 and L107. A local oscillator signal from R159 drives the source of the FET mixer. Proper mixer biasing is obtained by the current through R106 and is bypassed at 21.4 MHz by C116 and L108. The tuned circuit (L106 and C115) in the drain of Q102 selects the 21.4 MHz output frequency. C114 bypasses the 21.4 MHz signals and C118 bypasses any 450 MHz signals which could be present on the +8 VDC line.

6.3.7 21.4 MHZ CRYSTAL FILTER AND IF AMPLIFIER

The IF filter is a 4-pole Chebyshev (YF101, C121 and YF102), and has a passband width of approximately 15 KHz with less than 1 dB of ripple. R107 matches the output of the crystal filter to the base of Q103 which provides gain at 21.4 MHz. C124 couples the amplified 21.4 MHz signal to the FM Subsystem IC.

6.3.8 **FM RECEIVER SUBSYSTEM**

This circuit is built around a multifunction integrated circuit, the MC3371D, IC101. It performs the functions of: 2nd Local Oscillator (20.945 MHz), 2nd Mixer, 2nd IF Amplifier, FM Detector and Noise Amplifier.

The 2nd Local Oscillator is controlled by Y101, a 20.945 MHz crystal, and the feedback capacitors of C125 and C126. The difference frequency is 455 KHz.

The 2nd Mixer's inputs are from the 21.4 MHz signal applied to pin 16 and the output of the 2nd Local Oscillator. Mixer output is present at pin 3 where it is applied to the input of the 455 KHz ceramic filter. This filter provides additional rejection of undesired adjacent channels. The output of the ceramic filter is applied to the input of the 2nd IF Amplifier at pin 5. Pin 6 is the decoupled input to the amplifier and pin 7 is the limited IF output.

The frequency modulated signal is detected by an internal quadrature detector whose center frequency is determined by T101. One input to the quadrature detector is internally connected to the signal at pin 7. The other input is the phase-shifted signal from the quadrature coil at pin 8. The demodulated output is present at pin 9 along with a large amount of 910 KHz signal which must be filtered out by R124 and C140.

R117 – R119, R122, R125, C132, C136 and the internal circuitry of IC101 form an 8 KHz bandpass filter. A voltage-doubling positive peak detector (CR102) detects the noise from pin 11. CR101 acts as a temperature compensation network. C135 integrates the detected signal. C137 and R121 filter the signal and apply it to IC104 pin 2. IC104, a comparator with hysteresis, compares the detected level on pin 2 to the voltage set by squelch control R112 on pin 3. R113 and R115 set hysteresis for the comparator.

When the noise on pin 2 equals the voltage set on pin 3, the comparator output activates Q104. The resulting "low" at the collector of Q108 is applied to IC408 pin 17 on the control board. IC102 and IC105 supply +5 Volts and +8 Volts, respectively.

6.4 **TRANSMITTER**

6.4.1 VCO/BUFFER AMPLIFIER

Q204, L207, varactor CR204 and associated components form the VCO (Voltage Controlled Oscillator), a resonant circuit that oscillates at approximately 450 MHz. Varying the voltage at the cathode of CR204 changes the varactor's capacitance, which in turn alters the VCO output frequency; for example, when CR204 voltage is increased (normally, the charge in C236 – C239 provides this voltage), the capacitance of CR204 is decreased, which increases the VCO output frequency. +8 VDC is tied to the collector of Q204. C242 and C243 serve as a feedback network. C244 couples the oscillator signal to buffer amplifier Q205. C230 and C232 function as RF bypass capacitors. The amplified signal at the collector of Q205 is coupled by C246 and applied both to synthesizer controller IC202 pin 8 (via R236 and C247) and to buffer amplifier Q206. The output of Q206 feeds Q213 (through C235 and C248).

6.4.7 +V TX SUPPLY

This high activates Q210 and Q211, which form a voltage regulator pass configuration that supplies buffer amplifier Q206 and pre-driver transistor Q213. (The TX ENABLE line also controls other circuitry; refer to other paragraphs.) The high at J202 pin 8 is routed to Q210, forward biasing the base-emitter junction and causing current to flow from the +8 Volt line to ground through R248, Q210 and R210. The resulting voltage at Q210 collector switches on Q211, which in turn applies TX +V to Q213 (via R238, R239 and L209).

6.4.8 POWER AMPLIFIER

Q213 and associated components further amplify the VCO signal at Q206 collector before feeding it via C257 to the 8 Watt, wide-band RF power amplifier. C258 matches the signal to the base of Q207. The output at the collector of Q207 is then coupled into the base of Q209.

The output transistor's impedance is matched to 50 Ω by C279 and C280. A low-pass filter (L215 – L217 and C274 – C277) attenuates residual harmonics of the output frequency below their specified maximums. The low-pass filter output is matched to the duplexer by C277. The transmitter power output may be adjusted by R243, which drives emitter follower Q208 and in turn sets the collector voltage available to Q207. IC201 and IC204 supply +5 and +8 Volts, respectively.

6.5 AUDIO ROUTING (CONTROL BOARD)

Discriminator audio from the receiver is applied through C464 and R475 (RX audio control) to IC410A, a buffer amplifier with gain. If the correct conditions (as determined by IC408) are present, analog switch IC401A is turned ON and audio is routed through the high-pass filter, which is comprised of IC410B, IC410C and associated circuitry. This high-pass filtered signal and flat audio is present at PJ402. If PJ402 is in the A position, flat audio will appear at the accessory connector, J401. Position B will pass audio with the sub-audible signal removed. In any case, R475 is adjusted to give 2.1 Vp-p at J401 pin 1. This assures the proper audio level for any accessory boards.

The flat audio at IC410A pin 1 is also routed to IC405, for the purpose of extracting the sub-audible signal. IC405A and B form a 6-pole low-pass filter that attenuates frequencies above 250 Hz. IC405C is a limiter that squares the signal that drives Q410, which ensures a good square wave input at IC408 pin 11. R468 is adjusted for a 50% duty cycle square wave (from a QC tone) as seen at IC408 pin11.

With the repeat audio path open (IC401A and C are ON), the repeat audio level may be adjusted with R406. The signal is routed to the summing node of IC402B, a summing amplifier. ACC TX audio, Remote TX audio and External MIC audio are all summed at this amplifier, then applied to transmitter modulator IC404A. All ports (with the exception of the repeat audio path) are pre-emphasized. Repeat audio is "non de-emphasized."

IC404, a sixth order Butterworth switched capacitor low-pass filter, accomplishes modulation limiting and filtering. IC404A, with a closed loop gain of 30, drives the input signal into limiting. The maximum transmitted deviation is then set by R426. The final low-pass filtered output is then routed to the transmitter module via IC404C pin 4.

IC408 (pin 5) generates sub-audible encode tones into buffer amplifier IC403A. The output enters a 250 Hz low-pass filter, IC403B. IC408 sets the corner frequency to 250 Hz (IC408 pin 6 in tri-state) or 150 Hz (IC408 pin 6 at ground). This is also the case for the "decode filter," IC405 and IC408 pin 7. R423 sets the amount of tone deviation that is summed with the voice signal and any external sub-audible at the summing node of IC404.

IC402C is the accessory audio amplifier, and IC402D is the amplifier for the remote port, J402.

IC406 is a differential input amplifier that provides about 1 W of audio into 8Ω at J404. Received signals as well as programming and acknowledgment beeps pass through this amplifier.

PIN DESCRIPTION

11 PA1 Filtered QC/DQC Input
This pin is used to feed filtered QC/DQC to the microcontroller so that decode operations in the software can be performed.

12 PA0 Tone Squelch Out
This pin will go high upon QC/DQC decode. The signal is routed to audio gates IC401A and D in order to let audio pass in a normal repeater mode, as well as in a RP-200/multiple tone configuration. (If the "patch" is captured in a multiple tone system, all other tone groups will be locked out until the hang time expires.) The logic high is also inverted by Q401 and applied to any accessory boards via J401 pin 8.

13 PB0 Repeat Audio Enable
This pin will go high when a QC tone required to access the Repeater is decoded. A separate QC tone is required to access an optional RP-200 autopatch accessory. Pin 13 will also go high if an invalid QC tone for the RP-200 (in a multiple tone RP-200 configuration) is received.

14 PB1 Auxiliary Tone Decode 1 Input
An optional RTS-6P module applies a logic signal to this pin. If no tone board will be installed, the Repeater's microcontroller must be programmed to ignore this input. If a tone board is installed and the microcontroller is programmed to recognize this, a high at pin 14 indicates a valid decode. (Q502 in the RTS-6P shuts off and pin 19 is pulled up to +5 V by R490.)

15 PB2 Auxiliary Tone Decode 2 Input
A high at this pin occurs when the RTS-6P module decodes a received QC tone.

16 PB3 Auxiliary Tone Decode 3 Input
A high at this pin occurs when the RTS-6P module decodes a received QC tone.

17 Carrier Detect
A low present at this pin represents the correct carrier frequency being detected.

19 PB5 Monitor Input
Without an RWR-10 connected, this line will remain high. The microcontroller ignores this input, unless programmed for operation with a RWR-10. If a RWR-10 is installed, remove the 10 KΩ pull-up resistor (R633, 12 V) in the RWR-10. A low indicates an on-hook condition. A high means the handset is off-hook. A high on this pin tells the microcontroller to place a high on pin 12, which turns on the audio gate (IC401) to allow for monitoring RX audio before transmitting.

20 PB6 Synthesizer Lock Detect Input
As long as the synthesizers are locked, this input will remain low.

21 PB7 QC Encode Inhibit Input
If an external accessory (such as the RP-200) applies a low to this pin, the microcontroller will inhibit sub-audible encode.

22 VSS GROUND

24 PC7 EEPROM Clock
This pin will toggle in the middle of each bit period sent via the serial data line (pin 28), and clock data to and from the EEPROM.

6.7 SUMMARY OF MICROCONTROLLER PIN DESCRIPTIONS

PIN	PORT	PORT TYPE	DESCRIPTION
1	Reset	Fixed	Reset (-)
2	IRQ	Fixed	Transmit Enable Input
3	NC	Fixed	No Connection
4	NC	Fixed	No Connection
5	PA7	I/O	CTCSS/DQC Encode Output
6	PA6	I/O	Low Pass Filter Shift I/O
7	PA5	I/O	Low Pass Filter Shift I/O
8	PA4	I/O	Repeat Disable
9	PA3	I/O	Beep Output
10	PA2	I/O	Fan Enable
11	PA1	I/O	Filtered CTCSS/DQC Input
12	PA0	I/O	Tone Squelch Out
13	PB0	I/O	Repeat Audio Enable
14	PB1	I/O	Auxiliary Tone Decode 1 Input
15	PB2	I/O	Auxiliary Tone Decode 2 Input
16	PB3	I/O	Auxiliary Tone Decode 3 Input
17	PB4	I/O	Carrier Detect
18	NC	Fixed	No Connection
19	PB5	I/O	Monitor Input
20	PB6	I/O	TX/RX Synth Lock Detect Input
21	PB7	I/O	CTCSS Encode Inhibit Input
22	VSS	Fixed	Ground
23	NC	Fixed	No Connection
24	PC7	I/O	EEPROM Clock
25	PC6	I/O	TX Synth Latch/Program Mode Switch Input
26	PC5	I/O	RX Synth Latch
27	PC4	I/O	TX/RX Synth Clock
28	PC3	I/O	Data, TX/RX Synth and EEPROM
29	PC2	I/O	NOT USED
30	PC1	I/O	Transmit Enable LED Output
31	PC0	I/O	Out Of Lock/Checksum LED Output
32	PD0/RDI	Fixed	Received Serial Data
33	PD1/TDO	Fixed	Transmitted Serial Data
34	MISO	SPI	Not Used
35	MOSI	SPI	Not Used
36	SCK	SPI	Not Used
37	SS	SPI	Not Used
38	TCMP	Fixed	Not Used
39	PD7	Input Only	AC Mains Status Input
40	NC	Fixed	No Connection
41	TCAP	Fixed	No Connection
42	OSC2	Fixed	Oscillator Xtal Output
43	OSC1	Fixed	Oscillator Xtal Input
44	VDD	Fixed	Positive Supply

7. ALIGNMENT PROCEDURE

This alignment procedure is correct for the following RRX-450 Repeater systems:

- Standard Repeater
- Repeater with Autopatch
- Telenexus

7.1 RECOMMENDED TEST EQUIPMENT

1. FM service monitor (to 470 MHz)
2. Oscilloscope (to 20 MHz)
3. FM deviation meter
4. RF Wattmeter, 10 Watts full scale
5. Frequency counter (to 470 MHz)
6. VTVM or DMM
7. SINAD measuring device
8. RSM-3X remote speaker/microphone
9. T-10 Torx Driver (for Top & Front panel screws)
10. Xcelite XST-100 Phillips screwdriver or equivalent

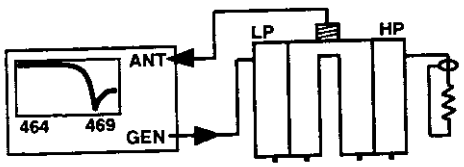
NOTE: A special "Test Mode" is available to check Repeater sensitivity and desense. Key the TX to lock the synthesizer on frequency (VCO runs at 37.5 KHz below normal frequency during standby). Then before expiration of hangtime, press the front panel programming button to defeat the tone decode function and allow audio to pass out to the SINADDER. The transmitter will key only by bringing the external key line low – PTT on the RSM-3X. **NOTE: This test mode works only on a "standard unit" with standard programming; any type of accessory board disrupts the test mode operation by shorting pins 3 to 4 on the accessory connector, which invokes repeat disable function.**

7.2 DUPLEXER

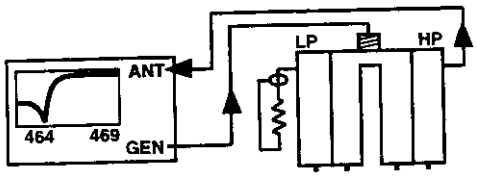
A normal repeater frequency split has the transmit frequency low and the receive frequency high. The LP end of the duplexer connects to the transmitter and the HP end connects to the receiver. By convention, F-low is the TX frequency and F-high is the RX frequency in a NORMAL setup. In a Telenexus or any other "RF LINK" system (INVERTED setup), the inverse of this arrangement appears at the other end, so F-low is the RX frequency and F-high is the TX frequency.

1. Remove the 5 screws securing the enclosure lid.
2. Unplug the two RF cables connecting the transmitter and the receiver to the duplexer.
3. Connect a UHF signal generator to the duplexer LP cable (RCA male).
4. Connect a spectrum analyzer to the antenna connector (UHF) on the rear panel of the RRX-450. Connect a 50Ω load to the HP cable.
5. Tune the signal generator and spectrum analyzer to the F-high frequency.
6. Using a 1/4" open-end wrench, carefully loosen the locking nuts on the tuning screws of the LP cavities; watch the analyzer while turning the screws to tune the notch.
7. While keeping the locking nut snug, fine-tune one of the LP tuning screws to achieve minimum transmission of the F-high frequency as seen on the analyzer. Repeat this procedure for the other LP screw. The LP side notch should be about -73 dB deep and within 50 KHz of the desired notch.

DUPLEXER TUNING: TX SIDE



DUPLEXER TUNING: RX SIDE



8. Put the 50Ω load on the LP cable, GEN(erator) to UHF connector, and HP cable to the ANALYZER input connections. Tune the signal generator to the F-low frequency.
9. Repeat steps 6 and 7 for the HP side. The HP notch should be about -63 dB deep and within 50 KHz of the desired notch.

PIN DESCRIPTION

25 **PC6 TX Synthesizer Latch**
Following an operating frequency change, pin 25 will send a single positive pulse to the TX synthesizer to latch the serial data. If this pin is low at power on, the Repeater will enter programming mode. Repeater functions do not operate in this mode.

26 **PC5 RX Synthesizer Latch**
Following an operating frequency change, pin 26 will send a single positive pulse to the RX synthesizer to latch the serial data.

27 **PC4 TX/RX Synthesizer Clock**
This pin will toggle in the middle of each bit period sent via the serial data line (pin 28), and clock data to and from the TX and RX synthesizers.

28 **PC3 Data Line for the TX/RX Synthesizers and EEPROM**
This port provides data in and out from TX/RX synthesizers and EEPROM.

29 **PC2 Temperature Sense Control (Not Used)**

30 **PC1 TX Enable/Status Indicator Driver**
If the microcontroller determines to activate the transmitter, this pin will go high and bring pin 31 (PCO) low. This will provide the transmitter module with the TX enable logic signal and turn on the "red" transmit indicator. A slow green flashing indicates a EEPROM checksum error. A green flashing about every second indicates a synthesizer is out of lock.

31 **PC0 TX Inhibit Indicator Driver**
If a transmit inhibit condition is present (checksum or out of lock condition), pin 30 will go low. Pin 31 will pulse high every second to flash the green inhibit indicator.

32, 33
RDI, TDO Received, Transmitted Serial Data
Pins 32 and 33 link the microcontroller to communications from an external data terminal, or to a PC compatible computer running the custom RRX-450 Programming software. Data is transmitted or received via these pins.

34 **PD2 MISO, Pin 35-PD3 MOSI, Pin 36-PD4 SCK and Pin 37-PD5 SS**
Not Used

39 **PD7 AC Mains Status Input**
Pin 39 will be low if the power supply is "on line." If this pin goes high, battery switch-over has occurred.
NOTE: On battery backup cutover, if the Repeater is transmitting, the transmitter will momentarily unkey, come back up, and a short alert beep will be heard along with the transmitted audio. Then as long as the Repeater is on battery, a beep will be heard every 8 seconds during a continuous transmission.

41 **TCAP Temperature Sense Input**
Not Used

42 **OSC2 Oscillator Xtal Output**

43 **OSC1 Oscillator Xtal Input**

44 **VDD Positive Power Supply, +5 VDC**

Q411 and associated circuitry make up the "BEEP" generator, a twin-T oscillator that generates the programming and system beeps at about 900 Hz.

Up to three CTCSS decoders (RTS-6P) can be added by installing them into J407, J408 and J409 and programming the EEPROM (IC409) accordingly. (A total of four CTCSS decoder/encoders are available, since the Repeater microcontroller is also programmed with tone decode/encode.)

IC410D provides a very sturdy Vag (Voltage audio ground) for proper op amp biasing. IC501 and IC407 provide the necessary regulated voltages for the audio routing circuitry.

6.6 MICROCONTROLLER (IC408) PIN DESCRIPTIONS

Microprocessor IC408 (MC68HC705C8) controls circuit operation in the RRX-450 Repeater.

PIN DESCRIPTION

1 RESET (low)
To prevent erroneous microcontroller operation when the unit has been on a battery backup for an extended period of time, this pin should be pulled low if and when V+ drops below on-board regulator dropout specifications. Q402 and associated components will disconnect V+ when V+ drops below +9.0 VDC. R435 then pulls pin 1 low.

2 IRQ (low)
This line will go low if either the external TX key line (J401, pin 10), the remote key line (J402, pin 5) or the PTT on the RSM-3X hand microphone are activated. These control signals will override any current operations. If this line goes low (pin 2), the microcontroller will apply a high to the TX enable line (Pin 30).

5 PA7 CTCSS/DQC Encode Output
If a correct CTCSS or DQC code is detected, either by the internal algorithm or an external RTS-6P decoder/encoder module, the microcontroller will generate the appropriate output signal via this port.

6 PA6 LPF Slew Control
Pin 6 will have a tri-stated waveform for CTCSS tones above 142 Hz, and a low for QC tones below 142 Hz and DQC signals. Pin 6 is tied to IC403 via C410.

7 PA5 LPF Slew Control
Pin 7 will have a tri-stated waveform for QC tones above 142 Hz, and a low for QC tones below 142 Hz and DQC signals. Pin 7 is tied to IC405 via C428.

8 PA4 Repeat Disable
(EXTERNAL KEY TIMEOUT DISABLE = EXTERNAL CONTROLLER ENABLE)
If this line is low, the microcontroller will allow the transmitter to be keyed as long as the external key line is low. This function is required for accessory board operation. Main audio at IC401 will not be passed unless tone is present and the key line is low. This DOES NOT defeat the timeout function in normal repeater mode (Tone Control). Do not confuse RRX-450 with previous Ritron Repeaters.

9 PA3 Beep Out
This pin will enable acknowledgment or alerting tones to the local audio amplifier or to the modulator for transmission. These tones will be the general programming mode beeps and battery cutover/AC Mains failure alert beeps. This pin will be high unless the microcontroller is generating beeps.

10 FAN CONTROL
This pin goes high to turn on the DC Fan.

6.4.2 PRESCALER DIVIDER/SYNTHESIZER CONTROLLER

IC202 contains both a prescaler and synthesizer controller. The prescaler squares and divides the VCO output tied to pin 8 by either 64 or 65, determined by a synthesizer controller logic signal. A logic high instructs the prescaler to divide the VCO frequency by 64, a low by 65. The exact number of times the prescaler is instructed to change divisors is determined by the channel frequency. +5 VDC is supplied to IC202 at pin 4.

IC202 contains a digital phase detector that works as follows: Microcontroller IC408 (pin 28) clocks data into IC202's internal buffer (pin 10) in synchronization with clock pulses applied to IC202 pin 9. (Signals from the microcontroller are usually too fast to observe with an oscilloscope.)

Once all data is loaded into the buffer, a single pulse from IC408 appears at IC202 pin 11 that instructs the synthesizer controller to latch and execute the data. IC202 utilizes internal circuitry to determine whether the present VCO output frequency is correct by comparing the phase and frequency of the VCO signal (at pin 8) and the 16.0125 MHz reference oscillator. IC202 produces a pulse output signal proportional to the phase difference between the two input signals. If the VCO output frequency is too high, pin 16 pulses high. If the frequency is too low, pin 15 pulses low.

The charge pump (Q202, Q203 and associated components) and loop filter (C236 – C239, R231 – R233 and L206) transform the synthesizer controller output into a DC voltage for application to the VCO. The synthesizer system is "locked" when the phase and frequency of the reference and the divided VCO signal are the same.

NOTE: To achieve fast attack times, the TX VCO is continuously oscillating (standby). To avoid possible close-proximity interference with carrier-only radios or radios in monitor mode, the VCO idles off-frequency by 37.5 KHz.

6.4.3 REFERENCE OSCILLATOR

The 16.0125 MHz reference oscillator connected to IC202 pin 1 is built around crystal Y201, C205, varactor CR202 and tuning capacitor C208. A temperature compensation circuit (R201 – R202, R269, CR201 and variable thermistors R204 and R268) provides the synthesizer controller with a constant 16.0125 MHz reference frequency. A tightly graded crystal maintains +/- 2.5 PPM frequency stability from -30 to +60° C.

The RRX-452 contains a modular TCVCXO Reference Oscillator in place of Y201, to achieve +/-1.5PPM frequency stability.

6.4.4 OSCILLATOR MODULATION

When the unit is in transmit, TX modulation is passed to the reference oscillator via C202, and to the VCO via R219. R219 routes modulation through C225 and R220 to the cathode of varactor CR203. Because CR203 is coupled to the VCO through C227, modulation causes the VCO frequency to vary. C202 applies modulation to the reference crystal to provide for the addition of any Quiet Call or Digital Quiet Call signals. If modulation was not applied to the reference, QC and DQC encode tones would be distorted as the synthesizer attempted to track them.

On RRX-452, TX modulation voltage is applied to pin 1 of the reference TCVCXO.

To provide a proper setting for QC or DQC, adjust R219 to provide a slightly peaked (i.e.: over-shot) leading edge on a DQC encode tone.

6.4.5 CHARGE PUMP/LOOP FILTER

The charge pump, Q202, Q203 and associated components, processes the phase detector (IC202) pulses to yield a signal that the loop filter can smooth into a DC voltage. R215 applies the pulses to Q202, which turns ON, applying a voltage "burst" to the loop filter (C236 – C239, R231 – R233, L206) and charging C236 – C239 one pulse at time toward + 8 Volts. The loop filter provides the DC level at CR204 that governs the VCO frequency.

R228 routes the signal from IC202 pin 16 to Q203. Q203 turns ON and discharges C236 – C239 one pulse at a time, the resulting DC voltage applied to CR204.

6.4.6 KEYING

The transmitter is activated when the microcontroller applies a "high" to J202 pin 8.

function as RF bypass capacitors. The amplified signal at the collector of Q108 is coupled by C166 and applied both to synthesizer controller IC103 pin 8 (via R152 and C171) and to buffer amplifier Q109. The buffered VCO signal at the collector of Q109 then feeds through C170 and R159 as local oscillator injection into the source of Q102, the receiver 1st mixer.

PRESCALER DIVIDER/SYNTHESIZER CONTROLLER

6.3.2

IC103 contains both a prescaler and synthesizer controller. The prescaler squares and divides the VCO output tied to pin 8 by either 64 or 65, determined by a synthesizer controller logic signal. A logic high instructs the prescaler to divide the VCO frequency by 64, a low by 65. The exact number of times the prescaler is instructed to change divisors is determined by the channel frequency. +5 VDC is supplied to IC103 at pin 4.

IC103 contains a digital phase detector that works as follows: Microcontroller IC408 (pin 28) clocks data into IC103's internal buffer (pin 10) in synchronization with clock pulses applied to IC103 pin 9. (Signals from the microcontroller are usually too fast to observe with an oscilloscope.)

Once data is loaded into the buffer, a single pulse from IC408 appears at IC103 pin 11 that instructs the synthesizer controller to latch and execute the data. IC103 utilizes internal circuitry to determine whether the present VCO output frequency is correct by comparing the phase and frequency of the VCO signal (at pin 8) and the 16.0125 MHz reference oscillator (at pin 1). IC103 produces a pulse output signal proportional to the phase difference between the two input signals. If the VCO output frequency is too high, pin 16 pulses high. If the frequency is too low, pin 15 pulses low.

The charge pump (Q105, Q106 and associated components) and loop filter (C173 – C176, R141 – R143 and L111) transform the synthesizer controller output into a DC voltage for application to the VCO. The synthesizer system is "locked" when the phase and frequency of the reference and the divided VCO signal are the same.

REFERENCE OSCILLATOR

6.3.3

The 16.0125 MHz reference oscillator connected to IC103 pin 1 is built around crystal Y102, C201, varactor CR107 and tuning capacitor C206. A temperature compensation circuit (R164 – R168 and CR108) provides the synthesizer controller with a constant 16.0125 MHz reference frequency. A tightly-graded reference crystal maintains +/- 2.5 PPM frequency drift over temperature. NOTE: THE RECEIVER PERFORMANCE WILL DEGRADE AND FCC TYPE ACCEPTANCE IS VOIDED IF THE CRYSTAL IS NOT REPLACED WITH A RITRON FACTORY PART.

CHARGE PUMP/LOOP FILTER

6.3.4

The charge pump, Q105, Q106 and surrounding parts, processes the phase detector (IC103) pulses to yield a signal that the loop filter can smooth into a DC voltage. R136 applies the pulses to Q105. Q105 turns ON, applying a voltage "burst" to the loop filter (C173 – C176, R141 – R143 and L111) and charging C173 – C176 one pulse at time toward +8 Volts. The loop filter provides the DC level at CR106 that governs the VCO frequency.

R137 routes the signal from IC103 pin 16 to Q106. Q106 turns ON and discharges C173 – C176 one pulse at a time, the resulting DC voltage applied to CR106.

RF FILTERS AND AMPLIFIER

6.3.5

The output from the duplexer is applied to a pair of double-tuned RF bandpass filters tuned to the desired receive frequency. These filters reject unwanted signals and provide approximately 80 dB of rejection at the image-frequency [F(Rx) - 42.8 MHz]. The first pair consists of C101, L101, C102, C103 and L102. C104 matches the output of the filter to transistor Q101, which provides gain at the receive frequency. The second filter of C109, L104, C110, C111 and L105 further reduces the input bandwidth to approximately 2 MHz.