TYPE OF EXHIBIT:	OPERATIONAL DESCRIPTION
FCC PART:	2.1033 (c)(6)
MANUFACTURER:	RITRON, INC. 505 West Carmel Drive Carmel, IN 46032
MODELS:	RQX-456, RQX-456-XT
FCC ID:	AIERIT18-456
DATE:	February 26, 2004

IC STANDARDS:	RSP-100, Issue 8, Section 7.2(b)
INDUSTRY CANADA:	1084A-RIT18456
MODELS:	RQX-456-CANADA, RQX-456-XT-CANADA

Included in this exhibit is a draft of the Maintenance and Operating Manual for the Ritron Models RQX-456 and RQX-456-XT UHF-FM Callbox Transceivers.

Specifically, the manual includes a technical description of the RQX-456 sufficient to establish compliance with the technical standards of the applicable rule part(s).

This includes, but is not limited to, the following items required under FCC Part 2.1033(c):

(2) FCC Identifier.
(3) A copy of the installation and operating instructions.
(4) Type of emission.
(5) Frequency range.
(6) Range of operating power, and means to provide variation in operating power.
(7) Maximum power rating.
(8) DC voltage chart.
(9) Tune-up procedure.
(10) A description of all frequency determining and stabilization circuits. A description of the circuits used to suppress spurious radiation, limiting modulation, and limiting power.
(12) Drawing with labels for controls and complete circuit diagrams.

Signed: Michael A. Pickard

Michael A. Pickard - Project Engineer

RITRON®

Model RQX-456

OUTPOST ™ Wireless Callbox

MAINTENANCE / REPAIR / OPERATING MANUAL

FOR USE BY AUTHORIZED SERVICE/MAINTENANCE PERSONNEL ONLY

RQX-456-MRM Rev. A 02/04

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SCHEMATIC – Microcontroller	RQX-456-schm-B.pdf

Surface Mount Repair

RITRON surface mount products require special equipment and servicing techniques. Improper servicing techniques can cause permanent damage to the printed circuit boards and/or components, which is not covered by RITRON's warranty. If you are not completely familiar with surface mounted component repair techniques, RITRON recommends that you defer maintenance to qualified service personnel.

Precautions for Handling CMOS Devices

This radio contains complementary metal-oxide semiconductor (CMOS) devices, which require special handling techniques. CMOS circuits are susceptible to damage by electrostatic or high voltage charges. Damage can be latent, with no failure appearing until weeks or months later. For this reason, take special precautions any time you disassemble the radio. Follow the precautions below, which are even more critical in low humidity environments.

1) Storage/transport - CMOS devices that will be stored or transported must be placed in conductive material so that all exposed leads are shorted together. CMOS devices must not be inserted into conventional plastic "snow" or plastic trays of the type that are used for other semiconductors.
2) Grounding - All CMOS devices must be placed on a grounded bench surface. The technician that will work on the radio/CMOS circuit must be grounded before handling the radio. Normally, the technician wears a conductive wrist strap in series with a 100K Ohm resistor to ground.
3) Clothing - Do not wear nylon clothing while handling CMOS circuits.
4) Power off - Remove power before connecting, removing or soldering a PC board that contains CMOS devices.
5) Power/voltage transients - Do not insert or remove CMOS devices with power applied. Check all power supplies to be used for testing CMOS devices, making sure that no voltage transients are present.
6) Soldering - Use a grounded soldering iron for soldering CMOS circuitry.
7) Lead-straightening tools - When straightening CMOS leads, provide ground straps for the tool used.

PC Board Removal - Special Tool

RITRON includes a tamper-proof torx head screwdriver to remove the front cover of the RQX-456-XT.

Properly Attach the Synthesizer Shield

The synthesizer shield should not be removed, unless a component must be replaced. This shield is soldered to the main PC board.

Re-assembly - Speaker Magnet

The speaker magnet will pick up clipped leads and other small metal objects from your bench top. Even tiny objects on the diaphragm will cause the speaker to buzz. Make sure the speaker is free of foreign objects before reassembling the radio.

Radio Transmitter Power Measurements

The RQX-456 was designed to produce a maximum of 2.0 Watts of Transmitter power throughout the radio's operating frequency range. The transmitter was designed with close tolerances to prevent RF power output from exceeding specifications.

PCB and Firmware Revisions

Changes in circuit design, component values, and radio firmware are made occasionally to enhance the performance of the RQX-456. In general, the manual will be periodically updated for component value changes without a change in the manual revision level. Always refer to the Schematic for the most recent component values. Changes in circuit design that require printed circuit board revision, or changes in firmware that significantly alter the operating characteristics of the radio, will be covered in a revised manual.

This manual is updated for the following revisions:

RQX-456-MRM	Rev A
PCB Revision	1750380B
Firmware Revision	v18.02

GENERAL

FCC ID:	AIERIT18-456
FCC Rule Parts:	74, 90, 95A
Industry Canada ID:	1084A-RIT18456
Frequency Range:	450 to 470 MHz
Max. Freq. Separation:	20 MHz
RF Channels:	1 Channel with Independent TX/RX frequencies.
Synthesizer Step Size:	12.5 kHz
Frequency Stability:	+/-1.5 PPM (-30 to +60 C) TX/RX
Tone/Code Signaling:	CTCSS (Quiet Call) Digital Coded Squelch (Digital Quiet Call) 2-Tone Paging Decode DTMF ANI Encode
Dimensions:	RQX-456 7.0”H x 5.0”W x 3.0”D RQX-456-XT 11.5”H x 9.5”W x 4.0”D
Weight:	RQX-456 3 lb. 12 oz. with antenna and 6 D-cell batteries RQX-456-XT 9 lb. 10 oz. with antenna and 6 D-cell batteries
Enclosure Material:	Valox® Thermo-plastic
Environmental:	Splash resistant , shock and vibration per RITRON Test
RJ11 Telephone Jack:	Internal RJ11 jack is used for PC programming.
Antenna Fitting:	50Ω BNC connector

RECEIVER

	Wide Mode	Narrow Mode
Modulation Acceptance:	+/- 5.0 kHz	+/- 3.75 kHz
Sensitivity: **(12 dB SINAD)**	0.22 µV	0.20 µV
Adjacent Channel (EIA):	-65 dB	-50 dB
Spurious Rejection:	-60 dB	-60 dB
Image Rejection (EIA):	-65 dB	-65 dB
Intermodulation (EIA):	-65 dB	-65 dB
Noise Squelch Sensitivity:	Programmable per channel, factory set for 12 dB SINAD	
Frequency Response:	300 - 3000 Hz, de-emphasized	
Audio Output	1 Watt into 8 Ω, with less than 5 % THD @ the earphone jack	
Receiving System:	Dual conversion superheterodyne	
I.F. System:	1st - 43.65 MHz 2nd - 450 kHz	
L.O. Injection:	Low side	
QC/DQC Decode Time:	per EIA Standards	

TRANSMITTER

	Wide Mode	Narrow Mode
Emission Designator:	16K0F3E	11K0F3E
Deviation:	+/- 5.00 KHz	+/- 2.50 KHz
FM Hum and Noise:	-40 dB	-37 dB
Audio Distortion:	< 2 %	< 6 %
RF Power Output:	2.0 Watts maximum @ +13 VDC	
Spurious & Harmonics:	-55 dBc	
Audio Response:	Meets FCC and EIA requirements	
Time-out Timer:	60 seconds, programmable	

POWER REQUIREMENTS

Standby:	75 mA
Sleep:	25 mA
Avg. Standby with Power Saver:	30 mA
Receive:	250 mA
Transmit:	475 mA @ 2.0 Watts 375 mA @ 1.0 Watts
Power Supply:	Internal (6) “D” Cell Battery Holder Internal connectors for external 12 VDC supply.

BATTERY LIFE AT 1 WATT

	Alkaline	NiCd
6 D-Cell Batteries:		
Capacity:	14,000 mAH	5,000 mAH
Transmissions:	7000	2500
Receive:	3 seconds	3 seconds
Transmit:	3 seconds	3 seconds
Standby:	10 seconds	10 seconds

CONTROLS

On / PTT:	Radio emits the Transmit Beep when turned on and will transmit as long as the button is pressed.
Program Button:	Internal button is used for field programming the RQX-456.
Programming Display:	Internal display indicates the programming digits when field programming the RQX-456.

GENERAL

RITRON's RQX-456 Call-Box is a small, programmable two-way radio, designed to operate in the 450-470 MHz professional FM communications band. The Call-Box features a transmit push-button, speaker, and microphone conveniently located on the front face of the radio.

Each radio can be "dealer" programmed to contain a unique set of operating frequencies and options. Selective signaling options include Quiet Call (CTCSS), Digital Quiet Call (DCS), DTMF ANI encode, and 2-tone sequential paging decode. Transmitter power, operating bandwidth, and battery saver time are among the programmable options.

Model Identification

The RQX-456 model, serial number, and Identification are displayed on a label located on the front of the radio case.

LICENSING

The FCC requires the radio owner to obtain a station license for his radios before using them to transmit, but does not require an operating license or permit.

The station licensee is responsible for ensuring that transmitter power; frequency and deviation are within the limits specified by the license. The licensee is also responsible for proper operation and maintenance of the radio equipment. This includes checking the transmitter frequency and deviation periodically, using appropriate methods.

How to Obtain an FCC Radio License

- Make application for your FCC license on FCC Forms 600 and 159.
- To have forms and instructions faxed to you by the FCC, call the FCC Fax-On-Demand system at ***202-418-0177*** from your fax machine; request Document 000600 and Form 159.
- To have Document 000600 & Form 159 mailed to you, call the FCC Forms Hotline at ***800-418-3676***.
- For help with questions concerning the license application, contact the FCC at ***888-225-5322***.

EXPOSURE TO RADIO FREQUENCY ENERGY

RQX-456: This product generates radio frequency (RF) energy when the ON/PTT button on the front of the unit is depressed. This product has been evaluated for compliance with the maximum permissible exposure limits for RF energy at the maximum power rating of the unit when using antennas available from RITRON.

For both the AFB-1545 and RAM-1545 antennas, at the 20 cm (7.9 inches) minimum expected separation distance and greater, the maximum RF exposure is well below the General Population/Uncontrolled limits. Antennas other than those available from RITRON have not been tested for compliance and may or may not meet the exposure limits at the distances given. Higher gain antennas are capable of generating higher fields in the strongest part of their field and would, therefore, require a greater separation from the antenna. This product is not to be used by the general public in an uncontrolled environment unless compliance with the Uncontrolled/General Population limits for RF exposure can be assured.

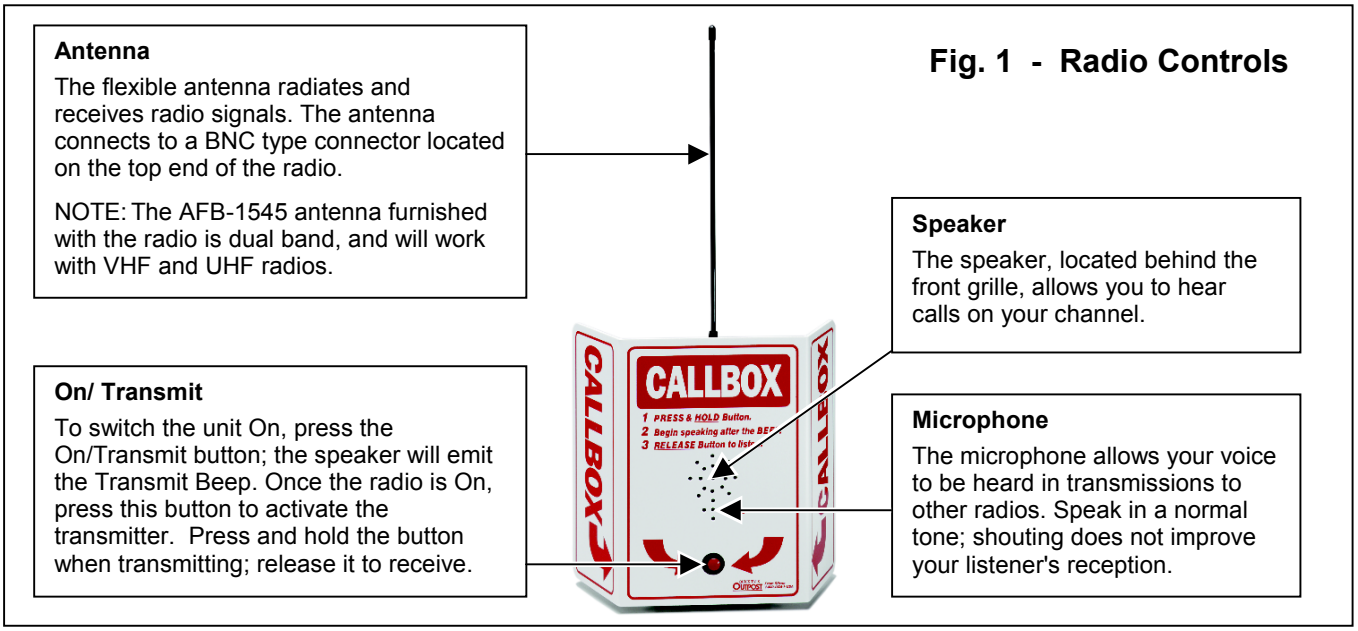
To limit exposure to RF energy to levels below the limit, please observe the following:

- Use only the antenna(s) available from RITRON for these models. **DO NOT** operate the radio without an antenna.
- Keep talk times as short and infrequent as possible. **DO NOT** depress the ON/PTT button when not actually wishing to transmit. These radios are equipped with an internal timer to limit continuous transmit times.
- When transmitting, make certain that the distance limits for the particular model in use are observed.
- **DO NOT** allow children to operate the radio.

When used as directed, this series of radios is designed to comply with the FCC's RF exposure limits for "Uncontrolled/General Population". In addition, they are designed to comply with the following Standards and Guidelines:

- FCC OET Bulletin 65, Edition 97-01, Supplement C, Evaluating Compliance with FCC Guidelines for Human Exposure to Radio Frequency Electromagnetic Fields.
- American National Standards Institute (C95.1-1992), IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz.
- American National Standards Institute (C95.3-1992), IEEE Recommended Practice for the Measurement of Potentially Hazardous Electromagnetic Fields-RF and Microwave.

BASIC RADIO OPERATION



On-Off

To switch on the radio - press the On/Transmit button. The radio will emit the Transmit Beep.

To turn off the radio – the radio will automatically turn off after 30 seconds of inactivity.

Receive

Before the RQX "D-Series" Callbox can receive any signal it must first be turned on.

To hear calls from other users – Once the radio has been turned on, it can receive broadcasts while the On/Transmit button is not being pressed. Whether or not you hear these broadcasts depends upon the squelch setting.

There are three squelch modes that can be used in the RQX "D-Series" Callbox.

- **Carrier squelch** lets you hear all broadcasts on your channel strong enough for the radio to detect, and silences noise.
- **Tone squelch** uses one of the QC or DQC "tone squelch" formats available on the RQX. This allows you to screen out "on-channel" broadcasts that do not carry the correct code programmed for the radio.
- **2-tone paging** can be used in conjunction with either carrier or tone squelch to block out all calls except those sent specifically to your radio. When the unique 2-tone sequence programmed into the radio is decoded, the radio will emit a series of ring tones similar to a telephone.

The radio must programmed for the desired squelch mode. Carrier and Tone squelch may be field programmed, but 2-Tone paging requires PC programming.

To use carrier squelch – field program the radio for No Tone code "44".

To use tone squelch – field program the radio for the desired QC or DQC code.

QC and DQC Tone Codes

Tone codes filter out static, noise and reduce unwanted "chatter" on radio channels. When you operate on a frequency with a tone code, you screen out most interference. This allows you to communicate with less interference and to hear only those users in your radio group.

IMPORTANT! All radios in the talk group must operate on the same frequency and tone code.

2-Tone Paging

To use 2-tone paging the RQX "D-Series" Callbox must be PC programmed for this option, the radio does not operate with 2-tone decoding as it is received from the factory. See your Ritron dealer or contact Ritron directly for PC programming of this option.

When receiving a 2-tone page the radio will emit a "ring" tone similar to a telephone to indicate that a call has been received. You can now proceed with normal two-way communication until 2-tone paging has been reset. The "ring" tone will sound every time a 2-tone page is decoded.

To reset 2-tone paging after receiving a call – 2-tone paging is reset every time the radio is 1st turned on.

2-tone paging can be optionally programmed to:

- Automatically set the radio for 2-tone paging mode whenever it is turned on.
- Automatically reset if a 2-tone page is not answered within 15 seconds.
- Automatically place the receiver into carrier squelch "monitor" mode whenever a 2-tone page has been decoded.
- Transmit a transpond tone to let the paging station know that the page has been received.
- Decode an All Call tone.
- Decode a Group Call if the 1st tone is sent for an extended period of time.

Transmit

To transmit - hold down the On / Transmit button and, with the radio at least 8 inches away, talk into the microphone. Speak in a normal tone, since talking louder will not improve the listener's reception.

Keep talk times as short and infrequent as possible to allow others to use the channel.

Battery Saver

The Callbox has a programmable "battery saver" feature that conserves battery power. The battery saver will turn off the radio after 30 seconds if the On/Transmit button has not been pressed or the radio has not received a signal. Any press of the On/Transmit button or any received signal will restart the 30 second Battery Saver timer.

WHAT THE RADIO ALERT TONES MEAN

The radio responds to certain instructions by sounding a beep or series of tones. These tones can tell you that the radio is working as you expect.

Power On Transmit

When it is first turned on, the radio will emit the Transmit Beep and the transmitter will be activated. The radio is then ready to use.

Error Tones

However, if a diagnostic error is detected, an error tone sounds. The error tone indicates the radio frequency synthesizer is malfunctioning. Turn off the radio and try again. The error tone will also sound if a channel has been programmed for an invalid frequency.

A long, low-pitched tone means the battery voltage is too low to operate the radio. If you cannot correct a problem, consult an authorized Ritron service facility or Ritron.

Transmitter Time Out

A low tone followed by a higher-pitched tone sounds and the transmitter automatically shuts off if you hold down the PTT button longer than 60 seconds. The radio automatically switches to receive mode.

Battery Saver Turn Off

A turn off tone will be heard on the speaker right before the radio automatically turns off.

OPTIONAL RADIO ALERT TONES

The RQX "D-Series" callbox can be programmed using the RITRON PC Programmer for optional alert tones. See your Ritron dealer or contact Ritron directly for programming of these options.

Courtesy Beep

A short tone sounds at the end of each received transmission to indicate that the channel is clear and you may transmit.

Busy Channel TX Inhibit

If a user is transmitting on your radio frequency without your tone, you will not be allowed to transmit. The radio will beep a series of long, low tones while the PTT is held down (like a busy signal).

TROUBLESHOOTING

If you have trouble operating the callbox, review the radio controls and operation sections. If you think the radio is malfunctioning, check the following table.

GENERAL

The radio does not work at all.	• Make sure good batteries are installed.
Operating features do not work exactly as expected.	• The radio has been factory or dealer programmed for customized operation.
Reception is poor.	• Confirm that the proper antenna is connected to the radio. • Use an optional high-gain antenna.
You cannot hear calls from other radios.	• Be sure your radio receives the same frequency that the caller transmits. (Note 2.)
Your calls cannot be heard in other radios.	• Make sure that your radio transmits on the receive frequency of the radio(s) you want to call. (Note 2.)

TONE CODED SQUELCH

You cannot screen out calls from users outside of your tone group.	• Make sure the channel is programmed with tone squelch.
You cannot hear Tone coded messages while in Tone (coded) squelch.	• Confirm that the channel is programmed to detect the same code as the calling radio(s) transmits. (Note 3.)
Others in your tone group cannot hear your tone coded messages.	• Verify that you transmit the same code as the radio(s) you call are programmed to detect. (Note 3.)

ERROR TONES

An error tone sounds when the radio is first turned on.	• See "Error Tones" in the “What the Radio Alert Tones Mean” section.
An error tone sounds while you are talking. (and the transmitter shuts off).	• Refer to “Transmitter Time-out” in the “What the Radio Alert Tones Mean” section.

NOTES

1. Reception can often be improved by moving a short distance. This effect is more noticeable inside of buildings. The maximum range of the RQX “D-Series” Call-Box is approximately one miles, line-of-sight.
2. If you want to hear a call, you must be programmed to receive the caller’s transmit frequency. If you want to call another unit, you must be programmed to transmit the other radio’s receive frequency. However, if you use a repeater, your radio must be programmed to work with the repeater’s transmit and receive frequencies. (A radio channel can hold two separate operating frequencies, one for Receive, the other for Transmit.)
3. In order for radios to communicate using Quiet Call, they must be programmed with the same tone code. Each code is unique, and your radio will respond only to the code programmed.

CALLBOX CONTROLS AND CONNECTORS

Antenna Connector
The antenna radiates radio signals. Before using the OUTPOST Callbox, make sure the antenna is securely fastened into the connector. If the Outpost is to be used outdoors, see page 15 for instructions on properly sealing the antenna connector.

RF Mating Connectors
An internal cable fron the antenna connector is terminated into a phono style conector for connection to the radio circuit board.

Captive Plastic Case Screws
A captive plastic case screw is located in each corner of the case front. These 4 screws are used to secure the case front containing the radio, to the case back that contains the batteries.

Charge Jumper
The charge jumper can be set to trickle charge re-chargeable backup batteries.

+12 VDC Input
Two screw terminal style connectors are used for the "+" and "-" connection of an external +12 VDC input for installation without batteries.

Sensor Input
Two screw terminal style connectors are used for the "+" and "-" connection of an external DC level sensor.

Switch Output
Two screw terminal style connectors are used for the "+" and "-" connections of a 5A switch closure output.

Speaker Connector
The internal speaker is connected to the radio printed circuit board with a polarized connector.

On/PTT Connector
The On/PTT switch is connected to the radio printed circuit board with a polarized connector.

Pre-Drilled Mounting Holes
Mounting holes located in the 4 corners of the case back are pre-drilled for mounting to a plate, wall or post. Once mounted, the case front is secured to the case back through these same threaded holes.

Program Cable Connector
An RJ11 style connector is used to connect the cable from the PC programmer to the radio.

Program Button
A small, momentary pushbutton is used for field programming the OUTPOST Callbox.

Program Display
A single digit LED display is used for field programming the radio.

Battery Holder
The battery holder inside the case back is used for the installation of 6 D-cell alkaline batteries. Refer to the diagram below, or the labels beneath the cells, for correct installation of the batteries.

Battery Mating Connectors
Polarized, 2-pin mating connectors are used to connect the batteries to the radio circuit board.

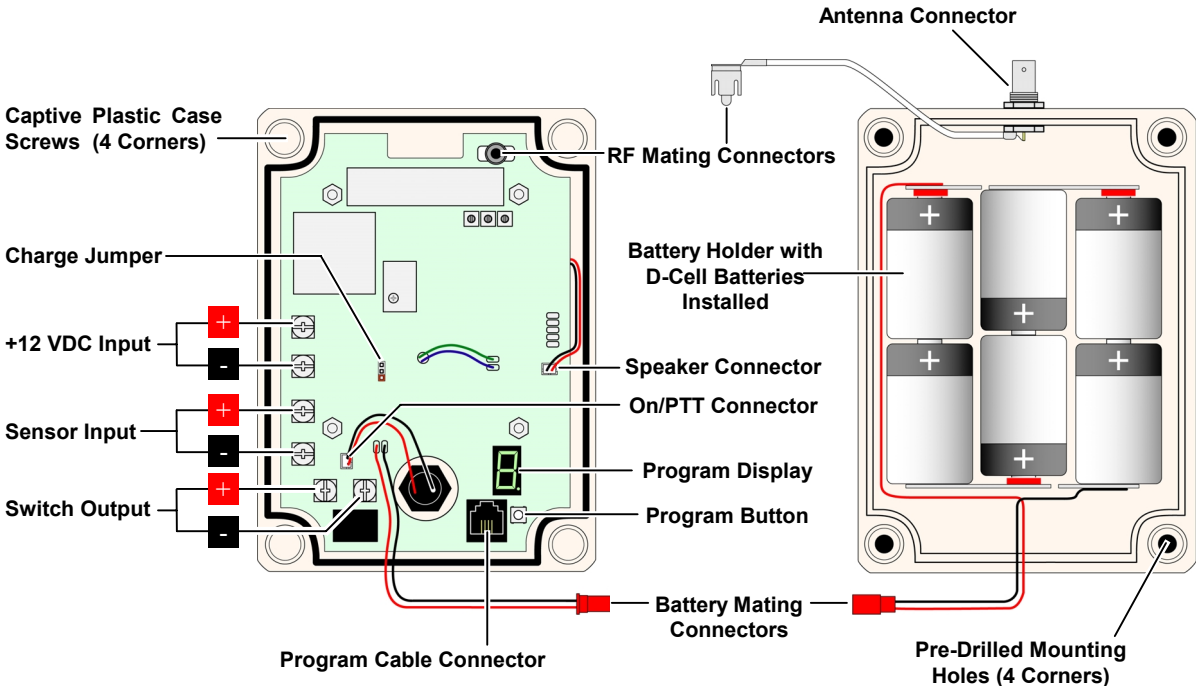


FIG-2: Callbox Assembly, Controls and Connectors

PROGRAMMING METHODS

The RQX-456 may be programmed using the internal program button or an optional RITRON PC programming kit.

FIELD PROGRAMMING allows you to program any channel to one of the radio frequencies listed in Table 1, and any Quiet Call code listed in Table 2 or DQC code listed in Table 3. The radio will transmit and receive on the programmed table frequency and QC code.

PC PROGRAMMING allows you to program any frequency within the band and channel spacing of the radio model. This method also lets you customize the Call-Box with optional operating features.

FIELD PROGRAMMING

Note: If the radio will not enter program / readout mode, this feature has been turned off using the optional PC programming kit.

HOW TO READOUT CURRENT RADIO PROGRAMMING

1. Loosen the (4) captive screws in the front corners of the case. These screws are captive to the housing; to prevent damaging them, DO NOT remove the screws from the housing.
2. Separate the case front from the case back, leaving the battery connected to the radio. Make sure the unit has batteries installed. **NOTE:** The voltage of the batteries must be greater than 6 VDC to program properly.
3. Press and release the ON/TRANSMIT button on the front of the Callbox to turn the radio on.
4. Press and release the Program button (See **FIG-2** for location). The radio will begin to display a series of four digits; with each digit separated by a hyphen.
5. Write down the four digits. The first two digits indicate the frequency code and the last two digits the tone code; **see Table 1 and Table 2.** In this example an RQX-456 is programmed to operate on the "Brown Dot" frequency of 464.500 MHz (Frequency code "04") with 100.0 Hz tone (Tone code "12").

FREQUENCY CODE **TONE CODE**

6. If a 5th digit is displayed, the channel has been programmed for DQC and the last three digits indicate the DQC code; **see Table 3.** In this example an RQX-456 was programmed to operate on the "Brown Dot" frequency of 464.500 MHz (Frequency code "04") with a DQC code of "723").

FREQUENCY CODE **DQC CODE**

7. If more than 5 digits are displayed, the radio has been programmed for 2-Tone Paging Decode. The frequency and tone codes will be displayed, followed by a "C", then the radio will display the 2-Tone paging code; **see Table 4.** In this example an RQX-456 was programmed to operate on the "Brown Dot" frequency of 464.500 MHz (Frequency code "04") with 100.0 Hz tone (Tone code "12") and 2-tone paging decode frequencies of 330.5 Hz and 569.1 Hz (2-Tone code "91")

FREQUENCY CODE **TONE CODE** **PAGING CODE**

8. If the channel is PC-programmed with any frequency or tone not listed in Table 1, Table 2 or Table 3, the radio will sound the error tone on contents read out and display an "E".

9. Normal radio operation resumes after the programming information has been displayed.

HOW TO FIELD PROGRAM FREQUENCY AND TONE CODES

To match other radios, the owner can select Frequency, Tone and DQC Codes from Table 1, Table 2 and Table 3. In our example we will program an RQX-456 to operate on the "Brown Dot" frequency of 464.500 MHz with 100.0 Hz tone.

04

1. Refer to Table 1 on page 12 to determine the two-digit frequency code and write it down.

12

2. Refer to Table 2 on page 13 to determine the two-digit tone code for 100.0 Hz and write it down.

3. Loosen the (4) captive screws in the front corners of the case. These screws are captive to the housing; to prevent damaging them, DO NOT remove the screws from the housing.

4. Separate the case front from the case back, leaving the battery connected to the radio. Make sure the unit has batteries installed.
NOTE: The voltage of the batteries must be greater than 6 VDC to program properly.

5. Press and release the ON/TRANSMIT button on the front of the unit to turn the radio on.

6. Press and hold the Program Button (See **FIG-2** for location). A "P" will appear on the program display as you enter program mode and the radio will start beep rapidly.

7. Release the program button after the beeping has stopped. The radio will display a series of six characters for Radio Identification, with each character separated by a hyphen.

   The 1st two characters indicate the model number, the 3rd and 4th characters indicate the radio type, and the 5th and 6th characters indicate the firmware revision.

MODEL NUMBER **RADIO TYPE** **FIRMWARE REVISION**

8. After the Radio Identification has been displayed the radio will emit a triple beep indicating that the radio is in program mode.

FREQUENCY CODE

9. Enter the 1st digit of the frequency code by clicking the PTT button until the program display shows the desired number. Pause—the radio will sound a low tone and show a hyphen across the center of the display to indicate that it is ready to accept the next digit.

10. Enter the 2nd digit of the frequency code by clicking the PTT button until the program display shows the desired number. Pause—the radio sounds a low tone and will show a hyphen across the center of the display to indicate that it is ready to accept the next digit.

TONE CODE

11. Enter the 1st digit of the tone code (or 1st digit of the DQC code) by clicking the PTT button until the program display shows the desired number. Pause—the radio sounds a low tone and will show a hyphen across the center of the display to indicate that it is ready to accept the next digit.

12. Enter the 2nd digit of the tone code (or 2nd digit of the DQC code) by clicking the PTT button until the program display shows the desired number. Pause—the radio sounds a low tone and will show a hyphen across the center of the display to indicate that it is ready to accept the next digit.

13. **FOR DQC CODES ONLY** – Enter the 3rd digit of the DQC code by clicking the PTT button until the program display shows the desired number. Pause—the radio sounds a low tone and will show a hyphen across the center of the display to indicate that it is ready to accept the next digit.

14. Press and release the ON/TRANSMIT button to save your programming. A triple beep will sound to indicate that programming was successful and the radio will turn off.
NOTE: An error tone will sound if you attempt to save an incorrect code, an "E" will appear on the display and the radio will turn off. Check the digits you are attempting to enter, then start over.

15. Turn the radio back on for normal operation.

NOTES:

a. YOU MUST enter "44" for "No Code" to match radios not having tone codes. Refer to Table 2 on page 13.

b. If the radio does not sound a confirming triple tone when you attempt to enter Program/ Readout Mode, the radio was factory or dealer customized to disable programming. Consult the radio owner or your dealer.

c. An error tone means that you tried to save an invalid entry. No programming changes are made in this case. A triple tone will sound next indicating that the radio is still in programming mode, and ready for an entry.

d. If you press the PTT five times when you intended four, for example, or if you just lose count, start over by turning the radio off and placing the radio in programming mode again.

HOW TO FIELD PROGRAM 2-TONE DECODE

For special applications, it is desirable to program the Callbox for 2-Tone decode operation. The user is able to field program the radio for one of the 9 pre-determined tone pairs specified in Table 4. These tone pairs correspond to field programmable 2-Tone encode codes available in other RITRON portable and base radios. In our example we will program an RQX-456 to operate with 2-Tone decode frequencies of 389.0 and 669.9 Hz.

NOTE: Field programming frequency and tone codes will remove all 2-Tone programming. If 2-Tone operation is required, the 2-tone code must be re-programmed after field programming of the frequency and tone codes.

94	1. Refer to Table 4 to determine the two-digit code for 2-tone decode on 389.0 and 669.9 Hz and write it down.
	2. Loosen the (4) captive screws in the front corners of the case. These screws are captive to the housing; to prevent damaging them, DO NOT remove the screws from the housing.
	3. Separate the case front from the case back, leaving the battery connected to the radio. Make sure the unit has batteries installed. **NOTE:** The voltage of the batteries must be greater than 6 VDC to program properly.
	4. Press and release the ON/TRANSMIT button on the front of the unit to turn the radio on.
	5. Press and hold the Program Button (See **FIG-2** for location). A "P" will appear on the program display as you enter program mode and the radio will start beep rapidly.
	6. Release the program button after the beeping has stopped. The radio will display a series of six characters for Radio Identification, with each character separated by a hyphen. The 1st two characters indicate the model number, the 3rd and 4th characters indicate the radio type, and the 5th and 6th characters indicate the firmware revision.  **MODEL NUMBER** **RADIO TYPE** **FIRMWARE REVISION**
	7. After the Radio Identification has been displayed the radio will emit a triple beep indicating that the radio is in program mode.
2-TONE CODE 	8. Enter the 1st digit of the 2-Tone code by clicking the PTT button until the program display shows the desired number. Pause—the radio will sound a low tone and show a hyphen across the center of the display to indicate that it is ready to accept the next digit.
	9. Enter the 2nd digit of the 2-Tone code by clicking the PTT button until the program display shows the desired number. Pause—the radio sounds a low tone and will show a hyphen across the center of the display to indicate that it is ready to accept the next digit.
	10. Press and release the ON/TRANSMIT button to save your programming. A triple beep will sound to indicate that programming was successful and the radio will turn off. NOTE: An error tone will sound if you attempt to save an incorrect code, an "E" will appear on the display and the radio will turn off. Check the digits you are attempting to enter, then start over.
	11. Turn the radio back on for normal operation.

HOW TO FIELD PROGRAM RADIO FEATURES

The OUTPOST Callbox can be field programmed for a number of features that include companding, Gate Guard, and speaker volume level. Refer to **Table 5** for the single digit codes available for field programming. In our example we will program an RQX-456 for Gate Guard operation.

NOTE: Field programming frequency and tone codes will turn companding and Gate Guard OFF. If companding or Gate Guard operation is required, the single-digit Radio Feature code must be re-programmed after field programming of the frequency and tone codes.

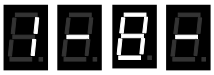
5	1. Refer to Table 5 to determine the single-digit code used to enable Gate Guard.
	2. Loosen the (4) captive screws in the front corners of the case. These screws are captive to the housing; to prevent damaging them, DO NOT remove the screws from the housing.
	3. Separate the case front from the case back, leaving the battery connected to the radio. Make sure the unit has batteries installed. **NOTE:** The voltage of the batteries must be greater than 6 VDC to program properly.
	4. Press and release the ON/TRANSMIT button on the front of the unit to turn the radio on.
	5. Press and hold the Program Button (See **FIG-2** for location). A "P" will appear on the program display as you enter program mode and the radio will start beep rapidly.
	6. Release the program button after the beeping has stopped. The radio will display a series of six characters for Radio Identification, with each character separated by a hyphen. The 1st two characters indicate the model number, the 3rd and 4th characters indicate the radio type, and the 5th and 6th characters indicate the firmware revision.  **MODEL NUMBER**  **RADIO TYPE**  **FIRMWARE REVISION**
	7. After the Radio Identification has been displayed the radio will emit a triple beep indicating that the radio is in program mode.
	8. Enter the single-digit code by clicking the PTT button until the program display shows the desired number. Pause—the radio will sound a low tone and show a hyphen across the center of the display to indicate that it is ready to accept the next digit.
	9. Press and release the ON/TRANSMIT button to save your programming. A triple beep will sound to indicate that programming was successful and the radio will turn off. NOTE: An error tone will sound if you attempt to save an incorrect code, an "E" will appear on the display and the radio will turn off. Check the digits you are attempting to enter, then start over.
	10. Turn the radio back on for normal operation.

TABLE 1: PROGRAMMABLE FREQUENCY CODES

UHF Business Band

Code	Frequency	Color Dot	Bandwidth
01	467.7625	J	25
02	467.8125	K	25
03	464.5500	Yellow Dot	25
04	464.5000	Brown Dot	25
05	467.8500	Silver Star	25
06	467.8750	Gold Star	25
07	467.9000	Red Star	25
08	467.9250	Blue Star	25
09	469.2625		25
10	462.5750	White Dot	25
11	462.6250	Black Dot	25
12	462.6750	Orange Dot	25
13	464.3250		25
14	464.8250		25
15	469.5000		25
16	469.5500		25
17	463.2625		25
18	464.9125		25
19	464.6000		25
20	464.7000		25
21	462.7250		25
22	464.5000	Brown Dot	12.5
23	464.5500	Yellow Dot	12.5
24	467.7625	J	12.5
25	467.8125	K	12.5
26	467.8500	Silver Star	12.5
27	467.8750	Gold Star	12.5
28	467.9000	Red Star	12.5
29	467.9250	Blue Star	12.5
30	461.0375		12.5
31	461.0625		12.5
32	461.0875		12.5
33	461.1125		12.5
34	461.1375		12.5
35	461.1625		12.5
36	461.1875		12.5
37	461.2125		12.5
38	461.2375		12.5
39	461.2625		12.5
40	461.2875		12.5
41	461.3125		12.5
42	461.3375		12.5
43	461.3625		12.5
44	462.7625		12.5
45	462.7875		12.5
46	462.8125		12.5
47	462.8375		12.5
48	462.8625		12.5
49	462.8875		12.5
50	462.9125		12.5
51	464.4875		12.5
52	464.5125		12.5
53	464.5375		12.5
54	464.5625		12.5
55	466.0375		12.5
56	466.0625		12.5
57	466.0875		12.5
58	466.1125		12.5
59	466.1375		12.5
60	466.1625		12.5
61	466.1875		12.5
62	466.2125		12.5

UHF Business Band (continued)

Code	Frequency	Color Dot	Bandwidth
63	466.2375		12.5
64	466.2625		12.5
65	466.2875		12.5
66	466.3125		12.5
67	466.3375		12.5
68	466.3625		12.5
69	467.7875		12.5
70	467.8375		12.5
71	467.8625		12.5
72	467.8875		12.5
73	467.9125		12.5
74	469.4875		12.5
75	469.5125		12.5
76	469.5375		12.5
77	469.5625		12.5
00	**DELETE CODE***		

UHF Business Band – Canada Models

Code	Frequency	Color Dot	Bandwidth
01	458.6625		25
02	469.2625		25
00	**DELETE CODE***		

VHF Business Band

Code	Frequency	Color Dot	Bandwidth
03	151.6250	Red Dot	25
04	151.9550	Purple Dot	25
05	151.9250		25
06	154.5400		25
07	154.5150		25
08	154.6550		25
09	151.6850		25
10	151.7150		25
11	151.7750		25
12	151.8050		25
13	151.8350		25
14	151.8950		25
15	154.4900		25
16	151.6550		25
17	151.7450		25
18	151.8650		25
24	151.7000		12.5
25	151.7600		12.5
26	152.7000		25
00	**DELETE CODE ***		

VHF MURS **

Code	Frequency	Color Dot	Bandwidth
01	154.6000	Green Dot	25
02	154.5700	Blue Dot	25
19	151.8200	MURS	12.5
20	151.8800	MURS	12.5
21	151.9400	MURS	12.5
22	154.6000	MURS	12.5
23	154.5700	MURS	12.5
00	**DELETE CODE ***		

TABLE 2: PROGRAMMABLE QC TONE CODES

Code	Frequency	Code	Frequency	Code	Frequency	Code	Frequency
01	67.0	14	107.2	27	167.9	40	159.8
02	71.9	15	110.9	28	173.8	41	165.5
03	74.4	16	114.8	29	179.9	42	171.3
04	77.0	17	118.8	30	186.2	43	177.3
05	79.7	18	123.0	31	192.8	44	No Tone
06	82.5	19	127.3	32	203.5	45	183.5
07	85.4	20	131.8	33	210.7	46	189.9
08	88.5	21	136.5	34	218.1	47	196.6
09	91.5	22	141.3	35	225.7	48	199.5
10	94.8	23	146.2	36	233.6	49	206.5
11	97.4	24	151.4	37	241.8	50	229.1
12	100.0	25	156.7	38	250.3	51	254.1
13	103.5	26	162.2	39	69.4	**00**	**Delete**

TABLE 3: PROGRAMMABLE DQC CODES

Code	Code	Code	Code	Code	Code	Code	Code
023	072	152	244	331	423	532	662
025	073	155	245	343	431	546	664
026	074	156	251	346	432	565	703
031	114	162	261	351	445	606	712
032	115	165	263	364	464	612	723
043	116	172	265	365	465	624	731
047	125	174	271	371	466	627	732
051	131	205	306	411	503	631	734
054	132	223	311	412	506	632	743
065	134	226	315	413	516	654	754
071	143	243					

TABLE 4: PROGRAMMABLE 2-TONE CODES

Code	Tone 1	Tone 2
91	330.5	569.1
92	349.0	600.9
93	368.5	634.5
94	389.0	669.9
95	410.8	707.3
96	433.7	746.8
97	457.9	788.5
98	483.5	832.5
99	330.5	600.9

TABLE 5: PROGRAMMABLE FEATURES

Code	Feature
1	Companding ON
2	Companding OFF
3	Volume Level - Medium
4	Volume Level - High
5	Gate Guard ON
6	Gate Guard OFF
7	
8	
9	

NOTE: Companding will compress transmit audio before sending it, and expand receive audio before it is heard on the speaker to reduce the background noise common in radio communications. Companding is not recommended unless all radios in the system are companded.

FIELD PROGRAMMING GATE GUARD

The XT OUTPOST can be field programmed for basic Gate Guard operation, or PC programmed to suit your unique requirements.

To field program the Gate Guard:

1. Program frequency and tone codes per the "How to Field Program Frequency and Tone Codes" instructions.
2. Program the 2-Tone code per the "How to Field Program 2-Tone Decode" instructions.
3. Program the Callbox for Gate Guard operation per the "How to Field Program Radio Features" instructions.

The XT OUTPOST Callbox will now operate in Gate Guard mode as follows:

- The Callbox will be in "Wake-up" mode. The ON/PTT button must 1st be pressed as described in "Operating the OUTPOST Callbox" section before normal two-way communications can be established.
- If the Callbox does not send or receive a signal for more than 10 seconds the Callbox will automatically turn off. The ON/PTT button must be pressed to turn the Callbox back on.
- When the Callbox receives the correct 2-Tone signal the Callbox Switch Output will momentarily close for 1 second. The Callbox will automatically transmit a confirmation tone after the 2-tone has been decoded.

OPTIONAL GATE GUARD PROGRAMMING

The XT OUTPOST can be PC programmed to customize Gate Guard operation.

Intercom (Always On) will leave the Callbox tuned on at all times, allowing Gate Guard operation even if there is no one at the Callbox. The higher current requirements of Intercom mode make it undesirable in battery powered installations.

Battery Saver can be used to reduce battery drain when Intercom (Always On) operation is required on a battery powered installation. With Battery Saver activated, the Callbox will periodically "wake-up" and listen for a received signal before returning to a low current "sleep" state. The time between "wake-up' states can be PC programmed between 1-255 seconds. A longer time between "Wake-up" states will result in increased battery life.

Ring Tone will sound an alert tone on the Callbox speaker, similar to a telephone ring tone, whenever 2-tone has been successfully decoded. This will alert the Callbox user that the gate is being opened or closed.

Inactivity Timer is set from the factory for 10 seconds, but can be PC programmed for 1-255 seconds. A shorter inactivity time will result in increased battery life. In standard "Wake-Up" operation a longer inactivity timer will allow more time for a response before the Callbox turns off.

Gate Guard Latch operation allows programming of separate ON and OFF 2-tone codes. The Outpost will close the Switch Output upon receiving the ON code, and open the Switch Output upon receiving the OFF code.

If the Gate Guard Latch option is used with an ON code only, the Switch Output will automatically turn OFF when the radio:

1. is turned off as a result of the Inactivity Timer in "Wake-Up" mode or,
2. goes to the low current "sleep" state in "Intercom (Always-On)" mode with battery saver enabled.

When reading out the radio programming as described in the "How to Readout Current Radio Programming" section, the ON code will be displayed.

Sensor Output can be programmed to detect a logic level and transmit an Alert tone when a change in logic level is detected. Separate alert tones are used for OPEN (logic level high) and CLOSED (logic level low).

Battery Back-Up Alert is used in installations with an external 12 VDC power supply and internal battery back-up. The OUTPOST can be programmed to send an alert tone at the end of each transmission when the unit is operating on the back-up battery.

Busy Channel TX Inhibit will not allow you to transmit when another user is already transmitting on your radio frequency without your tone. The radio will beep a series of long, low tones while the ON/PTT button is held down (like a busy signal).

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PC COMPUTER PROGRAMMING

RITRON's programming kit allows programming of the RQX-456 model radios using a PC compatible computer. An adapter cable connects the radio to a computer's serial communications port. Once the cable is hooked up, the user inserts the diskette provided into his computer's floppy disk drive and loads a software program.

This program transfers data between radio and computer memory, and includes on-screen instructions and help. Radio data may be saved to the computer's hard disk in order to program other radios.

The PC Programming Kit Includes:

1) Ritron Transceiver programming software, which is contained on CD-ROM.
2) Installation instructions and a registration form.
3) Ritron PC to radio adapter cable, which is terminated at one end with a DB-25F connector, at the other end with a modular plug. The DB-25 plugs into the computer's serial port.

The PC Programming Kit Requires:

A PC compatible computer with Windows 95 or later. The computer must have an RS-232 serial port and a minimum of 2MB available on the hard disk drive for installation.

Programmable Features

The following features may be PC programmed:

Feature	Range	Factory Setting	Programmer Page
Battery Saver Enable	Y - N	N	Personality
Battery Saver Off Time (seconds)	0 – 255	1	Tune
Beep Volume (percent of full volume)	0-100%	25%	Personality
Busy Channel TX Inhibit	Y - N	N	Frequency
Companding	Y – N	N	Frequency
Digital Tone Invert RX	Y - N	N	Frequency
Digital Tone Invert TX	Y - N	N	Frequency
Digital Quiet Call (DCS)	See Table 3	-	Frequency
DTMF ANI (characters)	0-16	none	Frequency
Field Programming Enabled	Y – N	Y	Personality
GateGuard Momentary Time (seconds)	0 – 255	1	Personality
Narrow Band Channel	Y - N	N	Frequency
Programming Password	8 chars	none	Radio ID
Quiet Call (CTCSS)	See Table 2	-	Frequency
RQX Turn-Off Time (seconds)	0 – 255	10	Personality
RX Courtesy Beep	Y - N	N	Frequency
Set Volume Level (percent of full volume)	0 – 100%	50%	Personality
Squelch Tightener	-2 to 5	0	Frequency
Switch Mode	*	No Switch	Personality
Transmit Clear to Talk Beep	Y – N	Y	Frequency
TX Time-Out Time (seconds)	0 – 255	60	Personality
2-Tone Paging Decode	Y – N	N	Frequency
Volume Level (Full or Set)	F-S	S	Personality

Descriptions of Features

Battery Saver Enable	Enabling this option allows the radio to go into battery saver mode when the radio is idle. The power saver begins after a period of inactivity greater than the RQX Turn-Off Time.
Battery Saver Off Time	This is the cycle time that the radio is off in battery saver mode before it checks for a received signal. A long Battery Saver Off Time may cause the user to miss the beginning of the first message when in battery saver mode.
Beep Volume	Sets to volume level of all radio warning beeps to between 0 and 100% of full volume.
Busy Channel TX Inhibit	This will keep the radio from broadcasting if the channel is busy. If you press the ON/PTT button when the channel is busy with a signal not intended for your radio (not carrying your tone code), this feature sounds a "busy" tone in the speaker and keeps the transmitter turned off.
Companding	Companding will compress transmit audio before sending it, and expand receive audio before it is heard on the speaker to reduce the background noise common in radio communications.
Digital Quiet Call RX Invert	The programmed code is inverted for receive mode only.
Digital Quiet Call TX Invert	The code is inverted for transmit mode only.
DTMF ANI	The RQX Callbox can be set to encode an ANI string of up to 16 characters.
Field Programming Mode Enabled	This feature allows programming from tables of pre-determined frequencies and codes using the internal program button.
GateGuard Momentary Time	If Switch Mode is set to GateGuard – Momentary, this sets the time between 0 – 255 seconds that the Switch Outout will be closed after decoding a 2-tone signal.
Narrow Band Channel	The radio can be set for narrow band mode, reducing the transmit deviation to 2.5 kHz.
Programming Password	An 8-character password can be entered to restrict reading of the radio information. Once a password is programmed into the radio access to all programming information will not be possible without first entering this password.
Quiet Call (CTCSS)	Programming a Quiet Call code allows you to screen out transmissions that do not carry your code. Your code is broadcast when you press the PTT to make a call.
Quiet Call Encode Only	The Quiet Call code programmed is transmitted with your calls. However, no Quiet Call code is programmed for receive mode, allowing all traffic on the receive frequency to be heard.
RQX Turn-Off Time	Once the radio is active, either by pressing the ON/PTT button or by receiving a call, the radio will remain active for this period of time without further activity.
Receive Frequency	The radio frequency that receives broadcasts from other units.
RX Courtesy Beep	The receiving radio beeps at the end of each received transmission.
Set Volume Level	When Set Volume Level is used the RQX can be set for a volume level between 0-100%.
Squelch Tightener	This feature reduces distant "co-channel" or other interference for radios that are not programmed with Quiet Call. Carrier squelch is set for maximum sensitivity at the factory, but may be adjusted to mute weak signals.
Switch Mode	Sets the Switch Output to one of seven conditions: 1. No Switch - No switch activity. 2. Switch On When Active - Switch closes whenever the Callbox is turned on by the ON/PTT button. 3. GateGuard Momentary - Switch momentarily closes after 2-tone decode for GateGuard Momentary time. 4. GateGuard Toggle - Switch toggles between closed and open on 2-tone decode. 5. GateGuard On/Off - Switch closes after 2-tone decode of primary code and opens after 2-tone decode of Off code. 6. Switch On When Called - Switch closes when a call is received while the Callbox is in stand-by. 7. Switch On When Active with Turn Off Code - Switch closes whenever the Callbox is Turned on by the ON/PTT button, but opens if the 2-tone Off code is decoded.
Transmit Clear to Talk Beep	A beep is heard in the speaker any time the ON/PTT button is pressed.
Transmit Frequency	The radio frequency that broadcasts to other units.
Transmit Time Out Timer	This feature automatically shuts off the transmitter (ending your call) if you hold down the ON/PTT button continuously for 60 seconds. The radio sounds a tone when the transmitter shuts off.
2-Tone Paging Decode	The RQX Callbox can be set for 2-Tone paging decode. See "2-Tone Paging Options" for the details of 2-Tone programming.
Volume Level (Full or Set)	Sets the RQX Callbox volume level to either 100%, or to the Set Volume Level.

2-Tone Decode Options

The following programmable options are available for 2-Tone paging decode:

1st Tone	Set the frequency and duration of the 1st paging decode tone.
2nd Tone	Set the frequency and duration of the 2nd paging decode tone.
All Call	Enable, and set the frequency and duration of an All Call paging decode tone.
2-Tone Transpond	The radio can transmit a transpond tone after a 2-tone page has been successfully decoded to let the paging dispatcher know that the page has been received.
2-Tone Group Call	Enable Group Call tone decoding. Group Call tone decoding is when the 1st tone is received continuously for over 5 seconds.
2-Tone Monitor Trip	The radio can automatically go into carrier squelch mode any time a 2-tone page is received, and will remain in there until the paging decoder has been reset.

INTRODUCTION

The RQX-456 is a single-channel callbox transceiver built on a single multi-layer printed circuit board. All components are placed on the top side of the printed circuit board.

The RQX-456 is frequency synthesized, with all functions of the radio controlled by microcontroller.

POWER SUPPLY AND VOLTAGE DISTRIBUTION

There are two ways an RQX-456 callbox radio can be powered:

- from a +12VDC external power supply through J501 and J502, a pair of screw terminals mounted on the pcb.
- from 6 D-cell batteries contained within the RQX-456 enclosure. The D-cell batteries are installed in a battery holder that is secured to the case back and connected to the pcb through P501.

When externally powered, an AC line filter consisting of L501, L502, L503, L504, L505, L506, and associated components strip 60 Hz hum off the supply line. F501 is a 3A fuse in series with the supply line for short circuit protection. Darlington pass transistor Q504, C510 and zener diode CR502 provide additional AC filtering, regulate supply voltage at 12 VDC, and prevents a high voltage from being applied to the radio circuitry. The front panel ON//PTT button, connected to the pcb through P502, is pressed to turn on the RQX-456. This turns on voltage pass transistor Q503 via CR503A and R505, applying turn-on voltage to the base of Q504. The emitter output of Q504 applies the +VBATT voltage to the input of +5 VDC regulator U502.

When powered with the 6 D-Cell batteries voltage is routed through F502, a 3A fuse in series with the supply line for short circuit protection, to pass transistor Q505. The front panel ON//PTT button, connected to the pcb through P502, is pressed to turn on the RQX-456. This turns on pass transistor Q505 via R507, and the collector output applies the +VBATT voltage to the input of +5 VDC regulator U502.

When the front panel ON/PTT button is pressed to apply voltage to the input of +5 VDC regulator U502 as described above, pass transistor Q510 is turned on through CR503, turning on Q511 to pull the pin 3 On/Off input of U502 low and turn it on. The +5 VDC regulator output provides power to microcontroller U501. Pin 5 of U501 turns on Q506 to keep Q505 turned on in battery powered applications after SW301 has been released. Pin 5 of U501 also turns on Q502, which keeps Q504 turned on in externally powered applications and keeps Q510 on for +5VDC regulator output.

Power is removed from the RQX-456 when the programmable time-out timer expires. Pin 5 of U501 turns OFF Q502 to turn off pass transistor Q504, turns off Q506 to turn off pass transistor Q505, and turns off Q511 to set the U502 regulator to the OFF condition.

+5 VDC regulator U502 supplies power directly to microcontroller U501, audio gates U301, reference oscillator Y301, synthesizer U401, output port expansion U504, 7-segment LED display driver U505, and EEPROM U503.

The T/R output at Pin 5 of U504 lets Q101 switch the regulated +5 VDC to the receiver. Voltage from digital pot U305B will turn on Q202, which turns on voltage pass transistor Q201. With Q201 emitter connected to the +VBATT battery supply, the collector output is connected to the base of Q207 through voltage divider R203/R216. Q207 collector is tied to the +VBATT supply and the emitter is tied to the emitter of Q202 with R202 to ground, allowing the voltage at the base of Q202 to adjust the TX+V voltage from +6 to +8 VDC for TX power control.

Low Voltage Detection

Supply voltage is measured at A/D input Pin 17 of U501 through voltage divider R509/R510. The radio will transmit a low battery beep at the end of each transmission if low supply voltage is detected, and will turn the radio off if the voltage drops below +5.2 VDC. This is to protect the microcontroller and its EE memory from corruption due to low supply voltage.

Power Strobe

The RQX-456 callbox includes a power strobe feature for battery powered installations where the radio must be on all the time. Power strobe reduces battery current drain by periodically removing voltage from part of the radio. The strobe off cycle time is programmable using the PC Programming Kit. The +5V SW power strobe output at Pin 24 of U501 controls Q507, which switches the regulated +5 VDC to the audio processing circuitry and the synthesizer circuitry. This includes:

- U302A 2.5 VDC voltage reference (Vag) for bias on audio processing circuitry
- U302C audio high pass filter
- U304 and U303A audio low pass filter for sub-audible frequencies
- U302B audio limiting amplifier
- U305 digital potentiometers
- U303B audio summing node amplifier

- U302D audio low pass filter
- U303D amplifier for 2-tone decoding
- U303C AGC microphone amplifier

REFERENCE OSCILLATOR

Reference oscillator Y301 is a 1.5 ppm temperature controlled, voltage controlled oscillator (TCVCXO) operating at 14.4 MHz. The Pin 4 output of the TCVCXO provides a reference for the frequency synthesizer U401 at Pin 8, and is amplified by Q509 to provide a clock signal at microcontroller U501 pin 32. The Y301 pin 4 output is also multiplied up to 43.2 MHz by Q105 and its associated circuitry to provide a receiver 2nd local oscillator signal.

SYNTHESIZER

The RQX-456 callbox is built around a common phase-locked loop (PLL) that consists of a voltage-controlled oscillator (VCO) and a frequency synthesizer. The PLL generates both the receiver 1st local oscillator and transmitter carrier signals. Control signals from microcontroller U501 and Reference oscillator Y301 are routed to frequency synthesizer U401 per the following chart:

Pin Numbers

	Clock	Data	Latch	Lock Detect	REF IN	+5 SW	+5V
U501	14	7	25	14	32	24	10, 20, 28
U401	11	12	13	14	8	10	7, 15, 16
Y301	-	-	-	-	4	-	2

Q404, CR403, C414 and associated components provide a filtered supply for the VCO oscillator and buffer amplifiers.

Prescaler Divider / Synthesizer Controller

U401 contains both a prescaler and synthesizer controller. The prescaler squares and divides the VCO output present at pin 6 by either 8 or 9, determined by a synthesizer controller logic signal. The exact number of times the prescaler is instructed to change divisors is determined by the channel frequency.

U401 contains a digital phase detector that works as follows: when an operating channel is changed or the receive/transmit mode switched, a new synthesizer operating frequency is selected. Microcontroller U501 clocks new data into U401 internal buffer in synchronization with clock pulses. The channel information is stored in EE memory of U503 and is loaded into RAM when the channel is selected.

Once new data is loaded into the buffer, a single pulse from U501 appears at U401 to instruct the synthesizer controller to latch and execute the new data. U401 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 6 to the 14.4 MHz reference oscillator at Pin 8. U401 produces an output signal at Pin 2, a single-ended phase/frequency detector output, proportional to the phase difference between the two input signals.

The loop filter C429, C427, R419, R420, R418, and C426 transform the Pin 2 output signal to a DC voltage for application to the VCO tuning varactor CR402. The synthesizer system is “locked” when the phase and frequency of both the reference and the divided VCO signal are the same.

VCO / Buffer Amplifiers

Q403, L401, CR402 and associated components form the VCO (Voltage Controlled Oscillator), a resonant circuit that oscillates at frequencies from 406 MHz in receive (receive frequency - 43.65 MHz) to 470 MHz in transmit. Varying the voltage at CR402 changes the varactor capacitance, which in turn alters the VCO output frequency.

When in transmit mode a +5 VDC T/RSW signal is applied to Q406, which turns on Q405 to draw current through pin diode CR404 and L403. With CR404 biased on, L402 is effectively shorted to ground, shifting the VCO frequency up 43.65 MHz.

Q401 and Q402 are buffer amplifiers, with Q402 feeding in the input of the synthesizer at Pin 6 and Q401 feeding the receiver 1st local oscillator and the transmitter pre-amplifier.

Oscillator Modulation

When the RQX-456 is in transmit, modulation balance control U305E passes TX audio through to the VCO modulation input at R416. TX audio is applied to varactor CR401 to modulate the VCO. TX audio is also routed to the Pin 1 input of TCVCXO reference oscillator Y301. Low frequency tones modulate the reference oscillator because the synthesizer is not able to track them.

DIGITAL POTENTIOMETERS

U305 contains 6 digital potentiometers programmed by U501, sharing the same clock and data outputs used by the synthesizer and a separate Digital Pot Latch signal from Pin 3. The digital potentiometers are used in conjunction with U303B, a summing node amplifier used for modulating the VCO and reference oscillator. U305A, B, D, E, and F can only be changed through serial programming, and can only be performed by an authorized licensed RF technician.

U305A is connected through R346 to the Pin 6 input of U303B. U305A adjusts the DC output of U303B to tune the reference oscillator frequency.

U305B is connected to the base of Q202 for transmit power control. Q201, Q202, Q207, R202, R203, and R216 adjust the supply voltage to the transmitter.

Volume control U305C applies the processed voice band signals at U307C to audio amplifier U306 when in receive mode. The volume control is set through serial programming, or can be set by the user to one of two preset levels.

Transmitter tone deviation control U305D applies the output of the selective signaling low-pass filter U304 to the Pin 6 input of U303B through R347. U305D is completely closed in receive mode.

Transmitter modulation balance control U305E is used to apply the Pin 7 output of U303B to the VCO modulation input. This will set the ratio of the modulating signal applied to the VCO and the reference oscillator. U305E is completely closed in receive mode.

Transmitter voice deviation control U305F applies the processed voice band signals at U302D to the Pin 6 input of U303B through R345. U305F is completely closed in receive mode.

RECEIVER

As mentioned before, Q101 switches the regulated +5 VDC to the receiver. The RX +V receiver voltage is switched at the strobe duty cycle if programmed for power strobe.

RF Amplifier

A received signal from the antenna passes through a low-pass filter (C218, C217, L211, C101, and C202) to the receiver headend. L101 and the associated capacitors form a bandpass filter ahead of low-noise RF amplifier Q102. L101 and C103 provide a notch at the image frequency, 87.3 MHz below the receive frequency. The amplified RF signal is applied to a 2-pole bandpass filter consisting of L103, L104, and associated capacitors. This circuit is tuned for 450 to 470 MHz.

1st Mixer

The amplified received input signal is applied to the Pin 3 input of mixer U102. The 1st local oscillator signal from the synthesizer module is applied to the Pin 1 LO input of U102. L106, C117 and C118 tune the Pin 4 output of U102 to 43.65 MHz and apply it to YF101, a 43.65 MHz two-pole crystal filter. Q104 and associated components amplify the 43.65 MHz IF signal and apply it to the input of the 2nd mixer at Pin 16 of U101.

FM Receiver Subsystem

A multi-function integrated circuit, U101 and associated components for the FM-receiver subsystem. The subsystem performs the following functions: 1) 2nd mixer, 2) 2nd IF amplifier, 3) FM detector, and 4) noise amplifier.

The Pin 4 output of 14.4 MHz reference oscillator Y301 is multiplied up to 43.2 MHz by Q105 and associated components. This signal is applied to the 2nd local oscillator input at Pin 1 of U101. The 43.65 MHz signal at Pin 16 and the 2nd local oscillator are mixed, with the resulting 450 kHz output signal appearing at Pin 3. This signal is filtered by a 450 kHz 6-pole ceramic filter YF102 and applied to the input of the limiting IF amplifier at Pin 5. U101 Pin 6 is the de-coupled input to the IF amplifier. An internal quadrature detector, whose center frequency is determined by 450 kHz ceramic discriminator Y101, detects the FM IF signal. Q107 is turned on by shift register U504 Pin 6 to place R117 across Y101, decreasing the demodulated audio at Pin 9 on wideband channels. One input of the quadrature detector is connected internally to the IF signal, while the other input is the phase-shifted signal from U101 at Pin 10.

Demodulated audio appears at Pin 9, where a low-pass filter (R116, C130) removes spurious quadrature output prior to application to the voice/tone conditioning audio circuitry. Demodulated audio from Pin 9 is applied to the Pin 7 input of a noise filter/amplifier consisting of R112, C123, C124, R111, R114, R115, and C129. The Pin 14 output of the noise amplifier is applied to a biased noise detector CR103, with the output connected to an A/D input of U501 at Pin 19. The RQX-456 is serial programmed to set the squelch threshold and hysteresis.

Voice / Tone Conditioning in Receive Mode

RQX-456 audio conditioning filter circuits are shared with the transmitter. The same high-pass filter/amplifier (U302C and associated components) used in receive voice band conditioning is used in the transmit band. Similarly, the low-pass filter (U304 and associated components) used for selective signal tone decode filtering is also used for selective signal encoding. Altering circuit configuration with analog switches U301A, B, C and D permits the use of the same audio filtering system for both transmit and receive modes.

After R116 and C130 remove the 450 kHz element from the demodulated audio output at Pin 9 of U101, C331 couples the audio signal to analog switch U301A for subaudible tone detection, then through U301D for voice band audio processing.

Voice Band

Bilateral switch U301D passes the received audio signal to the input of U302C, which along with its associated components for a high-pass filter/amplifier circuit that attenuates audio signals below 300 Hz.

The output of U302C is applied to the input of U302B limiting amplifier. Analog switch U301C removes R324 from the Pin 6 input to reduce the gain and prevent limiting.

The output from U302B is applied to the input of U302D, which along with its associated components form an 18dB/octave low-pass filter for frequencies above 3000 Hz.

The output of U302D is connected to volume control U305C through analog switch U307C. U307C is used to switch audio to the volume control directly from U302D or through the audio expander circuit formed by U308A, U308B and associated components. R365 and C362 provide de-emphasis at the output of U307C, and is then routed to the top of the volume pot U305C through C363.

The output of U302D is also connected to U305F voice deviation control, which is completely closed in receive mode to prevent received signals from modulating the VCO and reference oscillators.

The output of U302D is also connected to the input of U303D, which along with its associated components amplify audio band signals prior to connection to an A/D input of U501 at Pin 12 for 2-tone decoding. An internal digital signal processing routine programmed into microcontroller U501 is used to decode the correct audio band tone.

Audio frequency tones from Pins 11 and 23 of microcontroller U501 are applied to the Pin 6 input of U302B to provide the RQX-456 alert tones.

Audio Companding

U308 is an integrated compandor circuit that compresses transmit microphone audio prior to audio processing and expands receive audio after audio processing. Pin 1 of U504 controls analog switches U307A, B and C; connecting normal audio when low and audio from compandor U308 when high. In receive mode operation, the output of U302D is connected to volume control U305C through analog switch U307C.

In normal operation, audio from U302D is routed through C364, U307C, de-emphasis circuit R365 and C362, and C363 to volume control U305C.

In compandor operation, audio from U302D is connected to the pin 4 input of expander U308B through C364. The pin 6 output of U308B is amplified by U308A, then routed through C358, U307C, de-emphasis circuit R365 and C362, and C363 to volume control U305C.

Sub-Audible

Analog switch U301A passes the received audio signal to the input of U303A, which amplifies the signal and applies it to the Pin 2 input of U304, a 5-pole low-pass filter that attenuates frequencies above 250 Hz.

The output at Pin 5 is applied to an A/D input of U501 at Pin 18 for tone decoding. An internal digital signal processing routine programmed into microcontroller U501 is used to decode the correct selective signaling code. The output at Pin 5 of U304 is also connected to tone deviation control U305D, which is completely closed in receive mode to prevent received subaudible tone signals from modulating the VCO and reference oscillators.

Audio Amplifier

Receive audio from volume control U305C is applied to the Pin 2 input of U306, a 1 Watt audio amplifier. C351 couples the Pin 5 output to the internal 8Ω speaker SP301 via P302.

Shift register U504 Pin 15 will switch DC power to the audio amplifier by turning on Q303, which then turns on pass transistor Q304 to apply supply voltage to Pin 6 of the audio amp.

ANTENNA SWITCHING / LOW PASS FILTER

A low-pass filter comprised of L208, C213, C214, C 215, L209, C 216, C217, L211, and C218 removes harmonics from the transmitter output before applying the RF signal to the antenna. Received signals pass through the low-pass filter before entering the receiver RF amplifier circuitry.

Two PIN diodes (CR201, CR101) and associated components form the antenna switching circuit. With the RQX-456 in receive mode, no voltage is applied to the PIN diodes and they do not conduct. This reverse biases CR201 to prevent the transmitter amplifier from affecting the receiver tuning and removes CR101 from the receiver input. Incoming signals from the antenna pass through the low-pass filter, then L211 and C102 to the receiver headend.

When the RQX-456 is switched into transmit mode, transmitter supply voltage is switched on by Q201 and Q202 and applied to R209. Current flows through R209, L210, CR201, L211 and then CR101 to ground, forward biasing the PIN diodes.

CR201 passes transmitter RF power to the antenna while CR101 shunts the receiver RF amplifier input to ground. L211 provides sufficient impedance to isolate the transmitter power from the receiver RF amplifier.

TRANSMITTER

Keying

The RQX-456 transmitter is keyed when the front panel ON/PTT button is depressed. When depressed the On/PTT input at Pin 17 of microcontroller U501 is pulled low. The T/R output at Pin 5 of U504 is then set to go high and turn on Q406 for VCO transmit operation, and U305B is set to turn on Q202, which turns on pass transistor Q201 to apply voltage to the transmitter as described previously.

+VTX Supply

With the transmitter enabled as described above, the +VTX voltage from Q201 is applied to transmitter RF amplifiers Q203, Q204 and Q205. +VTX supply also forward biases the PIN switching diodes CR201 and CR101 as previously described.

The T/R output at Pin 5 of U504 can be PC programmed to hold the transmitter on after the PTT switch has been released to allow tone related turn-off codes for squelch tail elimination.

Power Amplifier

Q203, Q204 and associated components amplify the VCO signal and apply it to the input of RF Final amplifier transistor Q205. The collector output of Q205 is matched to the antenna switching circuitry and applied to the antenna through the low-pass filter.

Voice / Tone Conditioning in Transmit Mode

RQX-456 audio conditioning filter circuits are shared with the receiver. The same high-pass filter/amplifier (U302C and associated components) used in receive voice band conditioning is used in the transmitter voice band. Similarly, the low-pass filter (U304 and associated components) used for sub-audible tone decode filtering is also used for tone encode. Altering circuit configuration with analog switches U301A, B, C, and D permits the use of the same audio filtering system for both transmit and receive modes.

AGC Microphone Amplifier

M301 microphone audio is applied to the input of AGC amplifier U303C at Pin 10. The Pin 8 output of U303C is connected to the normally closed input of analog switch U307A through C310. Q301, Q302, and associated components adjust the gain of AGC amplifier U303C to provide a fixed audio output level, regardless of input signal level.

Audio Companding

U308 is an integrated compandor circuit that compresses transmit microphone audio prior to audio processing and expands receive audio after audio processing. Pin 1 of U504 controls analog switches U307A, B and C; connecting normal audio when low and audio from compandor U308 when high. In transmit mode operation, the AGC amplified microphone audio from U303C is routed through analog switches U307A and U307B to U301B, an analog gate that is used to connect transmit audio to the voice band audio circuitry.

In normal operation, microphone audio from U303C is routed through C310, U307A, and U307B to U301B.

In compandor operation, microphone audio from U303C is routed through C310 and U307A to the pin 13 input of compressor U308C. The pin 14 output of U308C is amplifier by U308D, then routed through C355 and U307B to U301B.

Voice Band

AGC amplified, M301 microphone audio is switched by U301B to the input of U302C, which along with its associated components form a high-pass filter/amplifier circuit that attenuates audio signals below 300 Hz. The output of U302C is applied to the input of U302B limiting amplifier. Analog switch U301C switches R324 in parallel with R325, raising the gain of limiting amplifier U302B for full limiting of the transmitter voice audio. The output of U302B is applied to the input of U302D, which along with its associated components form an 18 dB/octave low-pass filter for frequencies above 3 kHz. The output of U302D is applied to voice deviation control U305F, which sets the level of the processed transmitter audio applied to summing node amplifier U303B used to modulate the VCO and reference oscillator.

Sub-Audible

Microcontroller U501 generates the sub-audible selective signaling encode waveforms at Pin 13 and applies them to the input of buffer amplifier U303A. The output of U303A is applied to the input of U304, a 5-pole low-pass filter that attenuates frequencies above 250 Hz. C336 and C337 set the corner frequency of the low-pass filter, with C336 switched in by Pin 27 of U501 to lower the corner frequency for lower tones. The output of U304 is applied to tone deviation control U305D, which sets the level of the transmitter sub-audible encode tones applied to summing node amplifier U303B used to modulate the VCO and reference oscillator.

MICROCONTROLLER

The RQX-456 callbox transceiver is electronically controlled by U501, an 8-bit microcontroller. U501 has eight 8-bit A/D inputs for processing analog signals.

PIN	DESCRIPTION
1	RESET is connected to ground through C516 to start the radio in a known state on power up.
2	EXT +V is pulled low by Q501 when the radio is powered through the external +12V IN terminals to indicate that the radio is being powered externally.
3	DIGITAL POT LATCH sends a single positive pulse after data has been sent to U305 to latch the new data and change the digital potentiometers to the new programmed settings.
4	PROGRAM BUTTON input is pulled LOW when SW501 is pressed to put the radio in field programming mode.
5	+V SW output is HIGH when the radio is turned on, keeping pass transistor Q505 turned on via Q506 to supply battery power to the radio. It is also keeps pass transistor Q504 on via Q502 and Q503 for external +12 VDC power to the radio.
6	SWITCH OUTPUT goes high to energize relay K501 via Q508, providing a switch closure between J503 and J504.
7	DATA output sends serial data to frequency synthesizer U401 to program frequency information, U503 EEPROM memory, U305 to set the digital potentiometers, U504 output multiplexer, and to U505 for the LED program display.
8	DISPLAY LATCH goes high to latch the outputs of U505 shift register used to light the program display.
9	GROUND
10	+5 VDC V_{DD} supply voltage.
11	DTMF 1 output generates the radio alert tones heard in the speaker and the DTMF column tones for DTMF encoding.
12	2-TONE PAGING DECODE input accepts voice band tones after signal processing for decode analysis.
13	TONE ENCODE outputs generate the QC (CTCSS) and DQC (DCS) encode waveforms for signal processing prior to modulating the VCO in transmit mode.
14	CLOCK output sends serial data clock pulses to frequency synthesizer U401, digital potentiometers U305 U504 output multiplexer, and to U505 for the LED program display.
15	EECLOCK output sends serial data clock pulses to EEPROM U503 when reading or writing.
16	SENSOR INPUT is an A/D input connected to J505 that may be used in special applications.
17	ON/PTT/BATTERY input is used to measure the supply voltage for low and dead battery detection. This A/D input is also pulled LOW when the front panel ON/PTT button is pressed to turn on the radio and activate the transmitter.
18	TONE DECODE input is an A/D that accepts the received QC (CTCSS) and DQC (DCS) waveforms after signal processing for decode analysis.
19	RSSI input is an A/D used to measure the output voltage of the noise filter for squelch detection.
20	V_{REFH} sets the upper reference level for the A/D and is connected to the regulated +5 VDC.
21	GROUND
22	SERIAL DATA INPUT links the microcontroller to communications from an external data terminal via RJ11 program jack J507. This allows programming of the RQX-456 EEPROM memory used to store channel frequency and configuration information.
23	DTMF2 generates the row tones for DTMF encoding.
24	+5V SW output goes HIGH at a programmable periodic rate to remove the +5VSW supply from various circuits in the radio, thus conserving battery life. In normal transmit or receive mode this output is LOW.
25	SYNTH LATCH output goes LOW to allow serial data to frequency synthesizer U401 and goes HIGH to latch the data, allowing the synthesizer to execute the new frequency information.
26	MULTIPLEXER LATCH goes high to latch the outputs of shift register U504 used for output multiplexing.
27	LOW-PASS CUT-OFF output goes LOW to lower the cut-off frequency of U304 when the radio is on a channel programmed for a CTCSS tone below 150 Hz. This output is in a tri-state OPEN condition for all other tones.
28	+5 VDC V_{DD} supply voltage.
29	GROUND
30	NO CONNECTION
31	NO CONNECTION
32	REFERENCE OSCILLATOR INPUT has the amplified 14.4 MHz reference signal.

PROGRAMMING

The Program Display CR506 is a 7-segment LED display driven by the outputs of U505, an 8-bit shift register. The display data from pin 7 of Microcontroller U501 is sent to pin 14 of U505 in synchronization with the clock pulses from U501 pin 14 that are connected to U505 pin 11. Pin 8 of U501 is connected to pin 12 of U505 to latch the shift register outputs.

When SW501 is held down, pin 4 of U501 is pulled low and the radio is placed in field program mode, lighting the Program Display.

Serial data from the PC programmer is routed through program jack J507 to pin 22 of U501. This allows programming of U503 EEPROM memory used to store channel frequency and radio configuration information.

RADIO I/O

J503 and J504 are pcb mounted screw terminals connected to the 1 amp relay contacts of K501. Pin 6 of U501 turns on Q508 to energize K501. This serves as a microprocessor controlled switch closure, user programmable to a variety of conditions.

J505 is a pcb mounted screw terminal connected to an A/D input at pin 16 of U501. J506 is a companion screw terminal connected to ground for DC reference. This serves as a 0-5 VDC sensor, user programmable to respond to a number of conditions.

RECOMMENDED TEST EQUIPMENT

1) RF Communications Test Set (to 470 MHz) with:
   - FM Deviation Meter
   - RF Wattmeter
   - Frequency Counter (to 470 MHz)
   - SINAD Measuring Device
2) Oscilloscope (to 20 MHz)
3) VTVM or DMM
4) RITRON PC Programming Kit
5) 0 to +15 VDC, 2A current-limited power supply

RADIO PREPARATION

1) Connect the power supply to the RQX-456 +12 VDC Input and set it to +12 VDC.
2) Connect the serial programming cable from the PC computer (with the RITRON PC programming kit software installed) to the RJ11 program jack.
3) Remove the RQX-456 antenna and connect the FM communications test set to the BNC antenna connector.
4) Turn on the radio to place it in operating mode.
5) From the PC Programmer on-screen menu, select “Tune Radio” to display the Alignment screen.
6) Set the RF Communications Test set to the Alignment Frequency indicated on the Alignment screen.
7) Press the appropriate “Select” button on the Alignment screen to make the following adjustments:

SELECT	Alignment	SELECT	Alignment
Frequency	Transmit frequency	Tone	QC/DQC tone encode deviation wide and narrow band
Mod Bal	Modulation balance	Voice	Voice deviation with no tone wide and narrow band Voice deviation with tone wide and narrow band

8) After you have completed alignment of the RQX-456, turn the radio off. This will remove the test frequencies and return to operation on the customer’s programmed frequencies.

WARNING!

An authorized RF service technician must perform test and alignment of the RQX-456. Do not attempt service of the RQX-456 if not completely familiar with the operation of frequency synthesized radio operation. The RQX-456 can operate in both Narrow Band (2.5 KHz deviation) and Wide Band (5 KHz deviation) systems.

REFERENCE FREQUENCY

1) Make sure the unit has been switched on and is at room temperature (approximately +25° C)
2) Select “Frequency” from the PC Programmer “Alignment” screen.
3) Set the RF communications test set to the Alignment Frequency on the “Alignment” screen.
4) Press the “Tune” button on the “Alignment” screen to activate the transmitter.
5) Transmitter frequency error should be less than +/- 500 Hz.
6) If frequency adjustment is required, press the left arrow on the tuning bar to lower the frequency or the right arrow to raise the frequency.
7) Press the “Save” button to store the new alignment setting or “Cancel” to leave setting unchanged.

MODULATION BALANCE

Transmitter modulation balance has been set at the factory and should not require adjustment.

1) Select “Mod Bal” from the PC Programmer “Alignment” screen.
2) Set the RF communications test set to the Alignment Frequency on the “Alignment“ screen.
3) Press the “Tune” button on the “Alignment” screen to activate the transmitter.
4) Check the de-modulated waveform for a 20 Hz square wave.
5) If adjustment of the modulation balance is required, press the left arrow on the tuning bar to flatten the top of the waveform or the right arrow to reduce overshoot.
6) Press the “Save” button to store the new alignment setting or “Cancel” to leave setting unchanged.

TRANSMITTER TONE DEVIATION

Transmitter tone deviation has been set at the factory and should not require adjustment.

1) Select “Tone” from the PC Programmer “Alignment” screen.
2) Set the RF communications test set to the transmit frequency on the screen.
3) Select either “Wide Band” or “Narrow Band” by pressing the desired option button.
4) Press the “Tune” button on the Alignment screen to activate the transmitter.
5) If adjustment of the tone deviation is required, press the left arrow on the tuning bar to lower deviation or the right arrow to raise deviation.
6) Press the “Save” button to store the new alignment setting or “Cancel” to leave setting unchanged.

TRANSMITTER VOICE DEVIATION

Transmitter voice deviation has been set at the factory and should not require adjustment.

1) Select “Voice” from the PC Programmer “Alignment” screen.
2) Set the RF communications test set to the transmit frequency on the screen.
3) Select “Voice Only - Wide Band“, “Voice Only - Narrow Band”, “Voice & Tone – Wide Band”, or “Voice & Tone – Narrow Band” by pressing the desired option button.
4) Press the “Tune” button on the Alignment screen to activate the transmitter.
5) If adjustment of the voice deviation is required, press the left arrow on the tuning bar to lower deviation or the right arrow to raise deviation.
6) Press the “Save” button to store the new alignment setting or “Cancel” to leave setting unchanged.

RECEIVER SENSITIVITY

The RQX-456 receiver is factory tuned for a frequency range of 450 - 470 MHz.

1) Program the radio to a receive frequency in the middle of the desired band.
2) Set the RF communications test set generator to a frequency exactly 87.3 MHz below the programmed receive frequency at a RF level of approximately –40 dB. Modulate the RF signal with a 1 kHz tone at 3 kHz deviation for wide band, 1.5 kHz deviation for low band.
3) Disconnect the programming cable from the audio accessory jack and connect an 8-Ohm speaker.
4) Adjust L101 for the minimum received signal at this image frequency.
5) Set the RF Communications Test Set’s generator to the programmed receive frequency at a RF level of –122 dB. Modulate the RF signal with a 1 kHz tone at 3 kHz deviation for wide band, 1.5 kHz deviation for low band.
6) Adjust L103 and L104 for the best receiver SINAD as measured across the 8-Ohm speaker.

7) Check receiver sensitivity at the lowest and highest operating frequencies and make slight adjustment to L103 and L104 to balance between the two, if necessary.

RECEIVER NOISE SQUELCH

The noise squelch sensitivity is set at the factory for a 12dB SINAD signal at a "Squelch Tightener" number of 0. Using the PC Programmer, squelch sensitivity can be adjusted by setting the "Squelch Tightener" number to between –2 and 5. The higher number will require a stronger received signal to open squelch.

1) Select "Radio Frequency" from the PC Programmer "Edit" menu on the main screen.

2) Set the RF communications test set to the receive frequency on the screen.

3 Enter a Squelch Tightener number between –2 and 5.

4) Select "Program Radio" from the PC Programmer "Radio" menu to save all setting changes.

SYNTHESIZER

The synthesizer is preset at the factory for operation between 450 and 470 MHz. There is no manual adjustment to center the control voltage, with all adjustment performed by the factory selection of fixed capacitor C413. Do not attempt to adjust the synthesizer control unless a key component in the synthesizer has been replaced. Key components do not include the Y301 reference frequency TCVCXO or U401 synthesizer IC. Synthesizer alignment errors cause poor operation at temperature extremes.

Should adjustment of the VCO control voltage be necessary, the radio must first be disassembled and powered up at 12 VDC. The following procedure defines testing of the VCO control voltage:

1) Program the radio for the lowest receive frequency.

2) Measure the VCO control voltage at Test Point 1. This voltage should be no less than 0.5 VDC.

3) Program the radio for the highest receive frequency and measure Test Point 1. The control voltage should be no higher than 4.5 VDC.

4) a) If adjustment of the VCO control voltage is required, remove the synthesizer shield top.

   b) Replace C413 with a capacitor value that allows VCO control voltages between 0.5 and 4.5 VDC for the operating frequencies desired. Decreasing the value of C413 will raise the operating frequency of the VCO while increasing the value will lower the VCO frequency.

   c) Replace the top of the synthesizer shield.

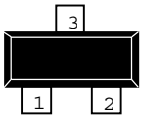
Measurement Conditions

Supply voltage at 12 VDC through J501 and J502, radio in operating mode, volume control at minimum, power strobe enabled, transmitter set for full power.

IMPORTANT: Because the RQX-456 callbox is constructed with grounding sub-planes, use a system ground in the same proximity as the circuit being measured. All readings indicated as GND are true system ground.

KEY: All measurements are in VDC unless indicated otherwise.

NC = No connection
GND = Ground
* = Voltage is strobed in Power Saver mode
→ = See note in right column



SOT-23

REF	PIN	TX	RX	SB	DESCRIPTION
CR101	1	0.7	0.0	0.0	TX/RX switching
	2	NC	NC	NC	
	3	GND	GND	GND	
CR102	1	GND	GND	GND	Voltage clamp
	2	GND	GND	GND	
	3	0.0	0.0	*	
CR103	1	0.0	2.2	*	RX Squelch detection
	2	NC	NC	NC	
	3	0.0	1.5	*	
CR201	1	1.4	0.0	0.0	TX/RX switching
	2	NC	NC	NC	
	3	0.7	0.0	0.0	
CR301	1	GND	GND	GND	Voltage clamp
	2	NC	NC	NC	
	3	0.7	0.7	*	
CR401	1	GND	GND	GND	VCO modulation
	2	NC	NC	NC	
	3	2.4	2.4	*	
CR402	C	→	→	*	VCO tuning
	A	GND	GND	GND	→ 1 to 4.6 VDC VCO tuning voltage
CR403	1	5.0	5.0	*	Biasing
	2	4.8	4.8	*	
	3	NC	NC	NC	
CR404	1	0.8	0.0	*	TX/RX VCO switching
	2	NC	NC	NC	
	3	0.0	4.8	*	
CR501	C	0.0	0.0	0.0	Battery charging
	A	0.0	0.0	0.0	
CR502	C	12.0	12.0	12.0	Voltage regulation
	A	GND	GND	GND	
CR503	1	0.7	4.0	0.0	Turn-on detection
	2	0.0	0.0	11.5	
	3	0.0	9.5	11.0	
CR504	1	GND	GND	GND	Voltage clamp
	2	5.0	5.0	5.0	
	3	5.0	5.0	5.0	
CR505	1	GND	GND	GND	Voltage clamp
	2	5.0	5.0	5.0	
	3	5.0	5.0	5.0	
CR506	1	5.0	5.0	5.0	7-Segment LED display (all segments lit)
	2	5.0	5.0	5.0	
	3	GND	GND	GND	
	4	NC	NC	NC	
	5	NC	NC	NC	
	6	5.0	5.0	5.0	
	7	5.0	5.0	5.0	
	8	5.0	5.0	5.0	
	9	NC	NC	NC	
	10	5.0	5.0	5.0	
	11	5.0	5.0	5.0	
	12	NC	NC	NC	
	13	5.0	5.0	5.0	
	14	GND	GND	GND	
CR507	C	5.0	5.0	5.0	Reverse voltage protection
	A	5.0	5.0	5.0	
Q101	1	5.0	4.3	*	RX +V switching
	2	5.0	5.0	*	
	3	0.0	4.9	*	
Q102	1	0.0	0.7	*	RX RF amplifier
	2	GND	GND	GND	
	3	0.0	3.0	*	
Q104	1	0.0	0.7	*	RX IF amplifier
	2	GND	GND	GND	
	3	0.0	1.2	*	
Q105	1	0.0	0.7	*	RX 2nd LO multiplier/amp
	2	GND	GND	GND	
	3	0.0	4.4	*	
Q107	1	0.0	4.7	*	RX Wide / Narrow switching
	2	0.0	4.7	*	
	3	0.0	→	*	→ 0 VDC wide, 5 VDC narrow
Q201	1	9.3	10.0	10.0	TX +V switching
	2	7.0	0.0	0.0	
	3	10.0	10.0	10.0	
	4	7.0	0.0	0.0	
Q202	1	2.5	0.0	0.0	TX +V switching
	2	1.8	0.0	0.0	
	3	9.3	10.0	10.0	
Q203	1	0.7	0.0	0.0	TX RF amplifier
	2	GND	GND	GND	
	3	5.6	0.0	0.0	
Q204	1	0.7	0.0	0.0	TX RF driver amplifier
	2	GND	GND	GND	
	3	7.0	0.0	0.0	
Q205	1	GND	GND	GND	TX RF Final amplifier
	2	0.0	0.0	0.0	
	3	7.0	0.0	0.0	
Q207	1	2.5	0.0	0.0	TX +V switching
	2	1.8	0.0	0.0	
	3	10.0	10.0	10.0	
Q301	1	5.0	5.0	*	Audio AGC switch
	2	5.0	5.0	*	
	3	4.5	4.5	*	

REF	PIN	TX	RX	SB	DESCRIPTION
Q302	1	0.0	0.0	*	AGC audio detection
	2	GND	GND	GND	
	3	5.0	5.0	*	
Q303	1	0.0	5.0	0.0	Audio amplifier enable
	2	GND	GND	GND	
	3	10.0	9.3	10.0	
Q304	1	10.0	9.3	10.0	Audio amplifier +V switching
	2	10.0	10.0	10.0	
	3	0.0	10.0	0.0	
Q401	1	0.7	0.7	*	VCO buffer amplifier
	2	GND	GND	GND	
	3	2.9	2.9	*	
Q402	1	0.7	0.7	*	VCO buffer amplifier
	2	GND	GND	GND	
	3	2.8	2.8	*	
Q403	1	2.3	2.3	*	VCO oscillator
	2	1.6	1.6	*	
	3	4.3	4.3	*	
Q404	1	4.7	4.7	*	VCO voltage de-coupling
	2	4.3	4.3	*	
	3	5.0	5.0	*	
Q405	1	0.0	4.3	*	TX/RX VCO switching
	2	4.3	4.3	*	
	3	4.2	0.0	*	
Q406	1	0.0	4.3	*	TX/RX VCO switching
	2	GND	GND	GND	
	3	4.3	0.0	*	
Q501	1	0.7	0.7	0.7	External voltage detect
	2	GND	GND	GND	
	3	0.0	0.0	0.0	
Q502	1	5.0	5.0	5.0	External +V switching
	2	GND	GND	GND	
	3	0.0	0.0	0.0	
Q503	1	11.3	11.3	11.3	External +V switching
	2	12.0	12.0	12.0	
	3	12.0	12.0	12.0	
Q504	1	11.3	11.3	11.3	External +V switching
	2	12.0	12.0	12.0	
	3	10.0	10.0	10.0	
	4	12.0	12.0	12.0	
Q505	1	9.3	9.3	9.3	Battery +V switching
	2	10.0	10.0	10.0	
	3	10.0	10.0	10.0	
	4	10.0	10.0	10.0	
Q506	1	5.0	5.0	5.0	Battery +V switching
	2	4.3	4.3	4.3	
	3	9.3	9.3	9.3	
Q507	1	4.3	4.3	5.0	+5V switching
	2	5.0	5.0	5.0	
	3	5.0	5.0	*	
Q508	1	0.0	0.0	0.0	Relay activation
	2	GND	GND	GND	
	3	5.0	5.0	5.0	
Q509	1	0.7	0.7	0.7	14.4 MHz oscillator
	2	GND	GND	GND	
	3	2.2	2.2	2.2	
Q510	1	0.0	0.0	0.0	+5V regulator turn-off
	2	10.0	10.0	10.0	
	3	10.0	10.0	10.0	
Q510	1	10.0	10.0	10.0	+5V regulator turn-off
	2	GND	GND	GND	
	3	0.0	0.0	0.0	
U101	1	0.0	4.7	*	RX FM-IF subsystem
	2	NC	NC	NC	
	3	0.0	3.5	*	
	4	0.0	4.7	*	
	5	0.0	4.4	*	
	6	0.0	4.4	*	
	7	0.0	0.7	*	
	8	0.0	0.6	*	
	9	0.0	→	*	→ 0.8 VDC with RX audio
	10	0.0	4.7	*	
	11	0.0	3.9	*	
	12	NC	NC	NC	
	13	NC	NC	NC	
	14	0.0	0.5	*	
	15	GND	GND	GND	
	16	0.0	0.9	*	
U102	1	0.0	2.0	*	RX 1st IF mixer
	2	GND	GND	GND	
	3	0.0	2.0	*	
	4	0.0	4.7	*	
	5	0.0	4.7	*	
	6	0.0	4.7	*	
U301	1	2.5	2.5	*	Audio signal switching
	2	2.5	2.5	*	
	3	2.5	2.5	*	
	4	2.5	0.0	*	
	5	5.0	0.0	0.0	
	6	5.0	0.0	0.0	
	7	GND	GND	GND	
	8	2.5	2.5	*	
	9	2.5	2.5	*	
	10	2.5	2.5	*	
	11	0.0	2.5	*	
	12	0.0	5.0	5.0	
	13	0.0	5.0	5.0	
	14	5.0	5.0	5.0	
U302	1	2.5	2.5	*	Audio processing
	2	2.5	2.5	*	
	3	2.5	2.5	*	
	4	5.0	5.0	*	
	5	2.5	2.5	*	
	6	2.5	2.5	*	
	7	2.5	2.5	*	
	8	2.5	2.5	*	
	9	2.5	2.5	*	
	10	2.5	2.5	*	
	11	GND	GND	GND	
	12	2.5	2.5	*	
	13	2.5	2.5	*	
	14	2.5	2.5	*	

REF	PIN	TX	RX	SB	DESCRIPTION
U303	1	2.5	2.5	*	Audio processing
	2	2.5	2.5	*	
	3	2.5	2.5	*	
	4	5.0	5.0	*	
	5	2.5	2.5	*	
	6	2.5	2.5	*	
	7	2.5	2.5	*	
	8	2.5	2.5	*	
	9	2.5	2.5	*	
	10	2.5	2.5	*	
	11	GND	GND	GND	
	12	2.5	2.5	*	
	13	2.5	2.5	*	
	14	2.5	2.5	*	
U304	1	2.5	2.5	*	Tone low pass filter
	2	2.5	2.5	*	
	3	GND	GND	GND	
	4	5.0	5.0	*	
	5	2.5	2.5	*	
	6	2.5	2.5	*	
	7	5.0	5.0	*	
	8	3.2	3.2	*	
U305	1	2.8	2.8	*	Audio signal level control
	2	NC	NC	NC	
	3	GND	GND	GND	
	4	0.0	0.0	*	
	5	2.5	2.5	*	
	6	2.5	2.5	*	
	7	2.5	2.5	*	
	8	0.0	0.0	*	
	9	5.0	5.0	*	
	10	GND	GND	GND	
	11	NC	NC	NC	
	12	5.0	5.0	*	
	13	2.4	2.4	*	
	14	2.4	2.4	*	
	15	2.5	2.5	*	
	16	2.4	2.4	*	
	17	0.0	0.0	*	
	18	NC	NC	NC	
	19	5.0	5.0	*	
	20	5.0	5.0	*	
U306	1	0.0	1.2	0.0	Audio amplifier
	2	0.0	0.0	0.0	
	3	GND	GND	GND	
	4	GND	GND	GND	
	5	0.0	5.0	0.0	
	6	0.0	10.0	0.0	
	7	0.0	5.0	0.0	
	8	0.0	1.2	0.0	
U307	1	2.5	2.5	*	Audio signal switching
	2	2.5	0.0	*	
	3	2.5	2.5	*	
	4	2.5	0.0	*	
	5	2.5	0.0	*	
	6	0.0	0.0	*	
	7	0.0	0.0	*	
	8	GND	GND	GND	
	9	0.0	0.0	*	
	10	0.0	0.0	*	
	11	0.0	0.0	*	
	12	2.5	2.5	*	
	13	2.5	2.5	*	
	14	2.5	2.5	*	
	15	2.5	0.0	*	
	16	5.0	5.0	*	

REF	PIN	TX	RX	SB	DESCRIPTION
U308	1	2.5	2.5	*	Audio Compander
	2	2.5	2.5	*	
	3	2.5	2.5	*	
	4	2.5	2.5	*	
	5	1.2	1.9	*	
	6	2.5	2.5	*	
	7	2.5	2.5	*	
	8	2.5	2.5	*	
	9	2.5	2.5	*	
	10	GND	GND	*	
	11	2.5	2.5	*	
	12	2.5	2.5	*	
	13	2.5	2.5	*	
	14	2.5	2.5	*	
	15	1.0	1.0	*	
	16	2.5	2.5	*	
	17	2.5	2.5	*	
	18	2.5	2.5	*	
	19	2.5	2.5	*	
	20	5.0	5.0	*	
U401	1	0.0	0.0	*	Frequency synthesizer
	2	→	→	*	→ 1 to 4.6 VDC VCO tuning voltage
	3	GND	GND	GND	
	4	GND	GND	GND	
	5	1.5	1.5	*	
	6	1.5	1.5	*	
	7	5.0	5.0	5.0	
	8	2.2→	2.2→	*	→ 14.4 MHz reference
	9	GND	GND	GND	
	10	5.0	5.0	*	
	11	5.0	5.0	*	
	12	5.0	5.0	*	
	13	5.0	5.0	5.0	
	14	5.0	5.0	*	
	15	5.0	5.0	5.0	
	16	5.0	5.0	5.0	
U501	1	5.0	5.0	5.0	Microcontroller
	2	0.0	0.0	0.0	
	3	0.0	0.0	0.0	
	4	5.0	5.0	5.0	
	5	5.0	5.0	5.0	
	6	0.0	0.0	0.0	
	7	5.0	5.0	5.0	
	8	0.0	0.0	0.0	
	9	GND	GND	GND	
	10	5.0	5.0	5.0	
	11	0.0	0.0	0.0	
	12	2.5	2.5	*	
	13	→	2.5	*	→ 0-5 VDC tone encode waveform
	14	5.0	5.0	5.0	
	15	0.0	0.0	0.0	
	16	5.0	5.0	5.0	
	17	0.7	4.1	4.1	
	18	2.5	2.5	*	
	19	0.0	2.2	*	
	20	5.0	5.0	5.0	
	21	GND	GND	GND	
	22	5.0	5.0	5.0	
	23	0.0	0.0	0.0	
	24	0.0	0.0	*	
	25	5.0	5.0	5.0	
	26	0.0	0.0	0.0	
	27	0.0	0.0	0.0	
	28	5.0	5.0	5.0	
	29	GND	GND	GND	
	30	NC	NC	NC	
	31	NC	NC	NC	
	32	→	→	→	→ 14.4 MHz clock

REF	PIN	TX	RX	SB	DESCRIPTION
U502	1	5.0	5.0	5.0	+5 VDC voltage regulator
	2	5.0	5.0	5.0	
	3	0.0	0.0	0.0	
	4	GND	GND	GND	
	5	NC	NC	NC	
	6	1.2	1.2	1.2	
	7	1.2	1.2	1.2	
	8	10.0	10.0	10.0	
U503	1	GND	GND	GND	EEPROM
	2	GND	GND	GND	
	3	GND	GND	GND	
	4	GND	GND	GND	
	5	5.0	5.0	5.0	
	6	0.0	0.0	0.0	
	7	GND	GND	GND	
	8	5.0	5.0	5.0	
U504	1	0.0	0.0	0.0	Audio gate control
	2	5.0	0.0	0.0	
	3	0.0	5.0	5.0	
	4	0.0	5.0	5.0	
	5	5.0	0.0	0.0	
	6	0.0	5.0	5.0	
	7	0.0	0.0	0.0	
	8	GND	GND	GND	
	9	0.0	0.0	0.0	
	10	5.0	5.0	5.0	
	11	5.0	5.0	5.0	
	12	0.0	0.0	0.0	
	13	GND	GND	GND	
	14	5.0	5.0	5.0	
	15	0.0	5.0	0.0	
	16	5.0	5.0	5.0	
U505	1	0.0	0.0	0.0	7-Segment LED driver
	2	0.0	0.0	0.0	(all segments lit)
	3	5.0	5.0	5.0	
	4	5.0	5.0	5.0	
	5	5.0	5.0	5.0	
	6	5.0	5.0	5.0	
	7	GND	GND	GND	
	8	0.0	0.0	0.0	
	9	5.0	5.0	5.0	
	10	5.0	5.0	5.0	
	11	5.0	5.0	5.0	
	12	5.0	5.0	5.0	
	13	5.0	5.0	5.0	
	14	5.0	5.0	5.0	

CASE ASSEMBLY PARTS LIST **RQX-456**

RTN#	DESCRIPTION	QTY
ANTENNA CONNECTOR		
02100030	PHONO PLUG W/STRAIN RELIEF	1
02100362	Connector, BNC Bulkhead w/Hardware	1
06001001	COAX; TEFLON RG 178 B/U (INCHES)	5
28323F01	LOCKWASHER, 1/2", INTERNAL TOOTH, SS	1
SPEAKER ASSEMBLY		
05500048	SPEAKER, 45MM, MYLAR CONE, 1 WATT, 8 *	1
2142D020	CONNECTOR CABLE ASSEMBLY, 2-POS SST	1
25603000	FOAM, MOUNTING, SPEAKER,SST	1
ON/PTT BUTTON ASSEMBLY		
05100047	SWITCH, PUSHBUTTON, DPDT,WATER RESISTANT	1
2142D021	CON, CABLE ASSEMBLY,2-POS, JMX/SST	1
25606300	SEAL, RUBBER, SWITCH	1
CASE FRONT ASSEMBLY		
13993042	ENCLOSURE,LO PRO CASE TOP (VM753), RQX	1
14200143	LABEL, FCC SERIAL, RQX-456	1
14290003	BLANK LABEL, 3" X 1", GLOSSY WHITE POLY	1
14290007	BLANK LABEL, 1.5" X .75" WHITE POLYESTER	1
25202500	FASTENER, PLASTIC, MUSHROOM HEAD, ADHES	8
25203800	FASTNER, PLASTIC, CASE, VM753	4
25606400	SEAL, 45MM SPEAKER, ADHESIVE *	1
25606500	SEAL, MEMBRANE, MICROPHONE	1
28151607	SEAL SCREW, 6-32 X 3/8 LG, SS,PASSIVATED	4
28342607	WASHER, FLAT, #5, TYPE B PLAIN, STL,ZINC	4
28722016	STANDOFF,M/F,1/4 HEX, 3/8 LG,6-32 THD	4
PCB MOUNTING		
02802007	6-32 X 5/16~ X 7/64~ HEX NUT	4
02803006	#6 INTERNAL TOOTH LOCKWASHER	4
28340603	WASHER, FLAT BRASS/NICKEL PL #6 .147ID	4
CASE BACK WITH BATTERY HOLDER		
02801005	4-40, 1/4", PHILLIPS PAN	4
02802003	4-40 X 1/4~ X 3/32~ HEX NUT/ZINC PLT.	4
02803004	#4 INTERNAL TOOTH LOCKWASHER	4
02800088	4.0 X .1 PLASTIC CABLE TIE	1
06001054	#22AWG RED STRANDED ; INCHES	6
06002014	1/16 BLK HEATSHRINK; INCHES	1
13994043	ENCLOSURE, CASE BOTTOM (VM753), RQX	1
2141D204	CABLE ASSY, 2-POS RECEPT.	1
25106500	BATTERY HOLDER, 6, D-CELL, OUTPOST	1
25106700	PLATE, MOUNTING, BAT.HLDR OUTPOST	1
25607100	PULL STRAP, BATTERY, RQX	1
28111102	SCREW, #7AB X .375, PPH, STEEL/ZINC	2
PACKED ITEMS		
AFB-1545	ANT,MOLDED, BNC HINGED, 150-170,450-470	1
14540006	WARRANTY REGISTRATION CARD	1
14280012	RQX, PLACARD, OUTPOST CALLBOX*	1
14352005	BOX, CORRUGATED, RQX	1
14500042	MANUAL, OWNERS, RQX-156, -456	1