



***Programmable UHF FM Repeaters  
for 12.5 kHz and 25 kHz Standards  
RLR-460 Repeaters***



**MAINTENANCE / REPAIR / OPERATING MANUAL**  
*FOR USE BY AUTHORIZED SERVICE/ MAINTENANCE PERSONNEL ONLY*

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# IMPORTANT MAINTENANCE INFORMATION

## Surface Mount Repair:

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

## Precautions For Handling CMOS Devices:

The RRX Repeater boards contain 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 module. 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 being used for other semiconductors. Conductive containers are typically gray or pink in color.
- 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 100 kW resistor to ground.
- 3). **Clothing**-Do not wear nylon clothing while handling CMOS circuits.
- 4). **Power Off**-Remove power before connecting, removing, or soldering on 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 soldering iron with a grounded tip for soldering CMOS circuitry.
- 7). **Lead-Straightening Tools**-When straightening CMOS leads, provide ground straps for the tool used.

### N O T E

Use the original packing material and shipping carton, if possible, when returning the repeater unit for service. Take special care to prevent damage to the rack mounting ears.

# 1. RLR-460 SPECIFICATIONS

## 1.1 GENERAL

RITRON Model No.	RLR-460
Frequency Range	450-470 MHz
FCC ID	AIERIT15-460
RX/TX Separation:	5 MHz
Operational Bandwidth	
Duplexer	50 kHz
Receiver and Transmitter	3 MHz
Synthesizer Step Size	12.5 kHz
Channels	1
Power Requirements	12 VDC nominal @ 1A minimum
Tone/Code signaling	1 CTCSS or 2 DCS
Carrier Dropout Timer	1-7 s, programmable by PC
Squelch Tail Timer	0-7 s, programmable by PC
TX Timeout Timer	0-34 min, programmable by PC
Front Panel Connector	RJ-11
RF Connector	N
Front Panel Indicators	1 Power Green LED 1 TX Red LED
Antenna Impedance	50 ohms resistive, VSWR 1.5:1 or less
Dimensions	8" L x 5.75" W x 2.125" H
Weight	3.5 lbs.
Operating Temperature Range	-30°C to +50°C

## 1.2 RECEIVER

(At antenna connector)

12.5 kHz version                      25 kHz version

Sensitivity (12 dB SINAD)	0.28 uV	0.28 uV
Adjacent Channel Selectivity	65 dB	75 dB
Spurious Response Rejection	75 dB	75 dB
Image Rejection	80 dB	80 dB
Intermodulation Rejection	70 dB	70 dB
Hum and Noise	45 dB	50 dB
Frequency Stability	1.5 ppm	1.5 ppm

## 1.3 TRANSMITTER

(At antenna connector)

Output Power	2 watts	2 watts
Duty Cycle	100% @ 25°C	100% @ 25°C
Frequency Stability	1.5 ppm	1.5 ppm
Spurious and Harmonics	-25 dBm	-25 dBm
Hum and Noise	45 dB	50 dB

## 2.

# INTRODUCTION

### 2.1 GENERAL

The RITRON RLR-460 Repeater is a synthesized tabletop UHF repeater that operates in the 450 to 470 MHz FM communications band with a maximum output power level of 2 watts. The unit receives signals originating at handheld, mobile, or fixed stations on one frequency and simultaneously retransmits the signals on a second frequency. This type of operation is described as full duplex. The unit contains an integral duplexer which allows a single antenna to be used for simultaneous transmission and reception. Full duplex operation with a repeater enables mobile and handheld units to communicate over much greater distance than is possible without a repeater. The Repeater is designed to be powered from an external DC power source.

### 2.2 INSPECTION

Inspect the unit immediately after delivery and report any damages to the shipping company.

### 2.3 MODEL IDENTIFICATION

The Repeater's model, serial number, and FCC identification number appear on a label attached to the rear panel. The two models of RLR-460 are:

<b>RLR-460</b>	2-watt UHF FM Repeater for 12.5 kHz channel bandwidth systems.
<b>RLR-460-W</b>	2-watt UHF FM Repeater for 25 kHz channel bandwidth systems.

In addition, there should be a label identifying the factory-set frequencies and signaling tones/codes, if used. If the desired frequencies differ from the factory-set frequencies by more than 50 kHz, the unit must be re-aligned. See the alignment section for details on the alignment procedure.

### 2.4 ACCESSORIES

The following accessories are available for use with the RLR-460 Repeater (Some may be included):

<b>RPS-1A</b>	12, 1A unregulated Wall-mounted power supply.
<b>AFB-1545</b>	Flexible VHF/UHF hinge-mounted antenna with BNC antenna connector.
<b>02100380</b>	RF adapter, N plug to BNC jack (allows AFB-1545 antenna to connect directly to unit).
<b>RSM-1J</b>	Speaker/Microphone for RLR-460 Repeater.

Contact RITRON for details on purchasing and using the above accessories.

### 2.5 FCC REGULATIONS

The Federal Communications Commission (FCC) requires that the radio owner obtain a station license before using the equipment to transmit. The user is not required to obtain an operating license. The station licensee is responsible for proper operation and maintenance of his radio equipment and for ensuring that transmitter power, frequency, and occupied bandwidth are within the limits specified by the station license. This is effected by aligning the unit per the instructions in the Alignment section of this manual as well as periodically checking that transmitter and deviation.

Because the RLR-460 contains a transmitter, THE REPEATER MUST BE LICENSED BEFORE USE. A RITRON dealer can help with obtaining an FCC license.

## 2.6 RF SAFETY ISSUES

On August 25, 1997, the FCC adopted the second of two Orders finalizing its rules regarding compliance with safety limits for human exposure to radio frequency (RF) emissions. All transmitting facilities, operations and devices regulated by the FCC, including this product, must be in compliance with the RF exposure limits contained in Code of Federal Regulations (CFR) 47 parts 1.1307(b)(1)-(b)(3). It is the responsibility of the licensee or grantee to either take action to bring the facility, operation or device into compliance or file an Environmental Assessment with the FCC. The following precautions should be taken with regard to the use of this equipment:

This product has been evaluated for compliance with the maximum permissible exposure limits for RF energy at the maximum power rating of the unit and with the two antennas sold for use with this product by RITRON. To ensure compliance with the General Population/Uncontrolled maximum exposure limits, please observe the following:

When the AFB-1545 articulated joint dual-band antenna is mounted to the rear of the unit, mount the RLR-460 in such a way, and in a location, that will ensure that all persons will be at least 17 inches (44 cm) away from the antenna. When the RAM-1545 remote magnetic mount antenna is used, mount the antenna in a location that will ensure that all persons will be at least 9 inches (23 cm) away from the antenna.

In addition:

- DO NOT OPERATE THIS EQUIPMENT unless all RF connectors are secure and any open connectors are properly terminated.
- GROUND ALL RADIO EQUIPMENT.
- ALLOW ONLY QUALIFIED SERVICE PERSONNEL to service this product.
- DO NOT ALLOW THIS EQUIPMENT to be set to power levels above its design limit or the licensed maximum.

## 2.7 GMRS OPERATION

The RLR-460 is approved for operation under FCC Rules & Regulations Part 95, Subpart A, General Mobile Radio Service (GMRS). This service is a land mobile radio service available to persons for short-distance two-way communications for licensees and their immediate family members. Important points about operating the RLR-460 in this service:

- A. A license from the FCC is required. Licenses are available to individuals only.
- B. Frequencies in the GMRS service are shared and not assigned for the exclusive use of any licensee.
- C. The frequencies available for transmission from the RLR-460 are: 462.5500, 462.5750, 462.6000, 462.6250, 462.6500, 462.6750, 462.7000, and 462.7250 MHz. The corresponding frequencies available for transmission to the RLR-460 (RLR-460 receive frequencies) are: 467.5500, 467.5750, 467.6000, 467.6250, 467.6500, 467.6750, 467.7000, and 467.7250 MHz.
- D. The licensee is responsible for the proper operation of the GMRS system at all times. The licensee is also responsible for the appointment of a station operator and may limit the use of the repeater to only certain user stations. The licensee or station operator must make any station and/or system records in the GMRS system available to the FCC if requested.

- E. The following communications are permissible:
- Two-way communications concerning the licensee's personal or business activities.
  - Voice messages concerning emergencies, rendering assistance to a motorist, or civil defense drills.
  - Tone messages for identifications or transmitter control in a control link.
  - Sub-audible signaling in conjunction with voice.
  - One-way voice paging to a paging receiver.
- F. The following communications are prohibited:
- Messages for hire.
  - Messages in connection with illegal activities.
  - Coded messages.
  - Intentional interference.
  - Music, whistling, or sound effects meant to amuse.
  - Obscene, profane or indecent words, language or meaning.
  - Advertisements for a political candidate or campaign.
  - Distress signal unless on a ship, aircraft or other vehicle which is in immediate danger.
  - Programs meant for broadcast.
  - Messages to any amateur radio service.
  - Continuous or uninterrupted transmissions.
  - Messages for public address systems.
- G. Additional information may be obtained by contacting the FCC:
- National Call Center at 888-225-5322  
Homepage at <http://www.fcc.gov/wtb/prs>  
In writing: FCC  
Attention GMRS  
1270 Fairfield Rd.  
Gettysburg, PA 17325-7245



### 3.

## INSTALLATION

Installation of the RLR-460 Repeater is fairly straightforward. Holes are provided in the end plate flanges to allow mounting to a suitable surface. Although the Repeater is not especially microphonic, it should not be located in area of vibration.

### 3.1 ANTENNA CONSIDERATIONS

The N connector on the rear of the unit is for connecting an antenna. The antenna should be tuned for the desired transmit frequency. The antenna may be connected to the connector itself for a compact setup, however, best performance is achieved when the antenna can be located such that a good ground plane/counterpoise exists. The overall performance of the Repeater is most strongly dependant upon the location of its antenna. The antenna should be sited in a location which yields good line-of-site to all the units which will be communication through the repeater. Gain antennas can give better performance, but one should ensure that all users are in the main lobe of the antenna. In general, this will be close to vertical plane of the antenna. The antenna cable runs should be kept as short as practical to reduce feedline losses. Cable runs should be kept short, less than 10 ft or low-loss cable such as RG-8, Belden 9913 should be used. The performance of the duplexer is dependent upon the match of the antenna. Antennas with low VSWR will perform better than ones with high VSWR.

### 3.2 CO-LOCATING WITH OTHER REPEATERS AND ELECTRICAL DEVICES

More than one Repeater may be located in a given area if enough distance is provided between their antennas. However, certain combinations of frequencies can be problematic. Specifically, frequencies should be chosen so that other transmitters are not transmitting on a frequency which is halfway between a Repeater's transmit and receive frequency. Also, a transmitter should not be on a frequency which is twice the transmit/receive split away from the Repeater's receive frequency. If the above two precautions are observed, distances of 100 ft or more should be satisfactory. If they are not observed, it may take a greater distance to avoid interference or desense. In addition, any transmitters in the vicinity which have the same frequency spacing from each other as either one to the Repeater's receive should be avoided.

Also, operating near certain electrical equipment can cause interference. Certain types of digital sampling oscilloscopes (DSO's) can create broadband noise when located near the Repeater's antenna which can actually cause the Repeater's receiver to lockup. The Repeater transmits, the DSO creates noise which the receiver hears as a signal and keeps the transmitter keyed. In addition, placing the antenna near fluorescent light fixtures can cause 120 Hz hum to appear on the transmitted signal.

### 3.3 FREQUENCY CHANGES

If it is necessary to change the frequency of the RLR-460 more than 50 kHz, the duplexer must be retuned. If the frequency is changed more than 3 MHz, the entire unit, including the duplexer, should be re-aligned. See the Alignment section of this manual for details on the alignment of the duplexer and the adjustment on the main PCB. See the Programming section of this manual for details on how to program the Repeater for new frequencies, as well as other parameters.

### 3.4 POWER SUPPLY

The RLR-460 may be powered by the RITRON RPS-1A wall cube power module. This module is filtered, but unregulated and will output about 12.5 volts DC at 1 ampere of current. Other power supplies may be used, but they should be capable of delivering 12 volts at a 1 ampere load and be filtered. A regulated supply at 12.0-12.6 volts is even better. See the Operation section of this manual for temperature/duty cycle limits associated with power supplies with output voltages other than 12 VDC. Contact RITRON for information regarding regulated power supplies.



The routing of the power supply cable can have an affect on the hum and noise performance of the transmitter. For best results, the cable from the power supply to the Repeater should be run directly away from the Repeater in a straight line and NOT be routed near the antenna.

## 4.

# OPERATION

### 4.1 GENERAL

Test the Repeater for proper operation as the unit is received before attempting to reprogram and/or retune it. There is no On/Off switch on the unit; it is powered up when a power supply is connected. Standard factory programming is a receive frequency of 469.500 MHz and a transmit frequency of 464.500 MHz.

Retune the internal duplexer if either the receive or transmit frequency are to be changed by more than 50 kHz. Note that the nominal transmit/receive spacing is 5 MHz for this product. Larger spacings may be accommodated, but not smaller. See the Alignment section. Retune (re-align) the entire unit if the receive and/or transmit frequencies are changed by more than 3 MHz. A flashing green LED on the front panel indicates that the receive voltage controlled oscillator (VCO) is out of lock. In normal operation, the green LED should glow continuously.

The Repeater is setup to accept a 12 volt/1amp unregulated source of power and can provide up to 2 watts of output power at the antenna connector. 12 volt regulated supplies may also be used as well as battery supplies. See the duty cycle/temperature limits below. The transmitter power output at the antenna connector can be set internally via a potentiometer to vary from 0.5 watts to the 2-watt maximum.

The RLR-460 has a standard frequency separation of 5 MHz between transmit and receive. The normal configuration is for the receive frequency to be above the transmit frequency. "Inverted" systems are reversed with the transmit frequency higher than the receive frequency. The cables on the duplexer are long enough to allow them to be swapped. Normally, the duplexer cables are tie-wrapped in a loop. The tie-wraps can be cut to allow swapping the connections.

### 4.2 DUTY CYCLE/TEMPERATURE LIMITS

Due to internal heating of the power supply regulators and the RF transmitter components, there is a limit on the maximum duty cycle of the Repeater depending upon temperature, output power and the power supply voltage. These limits are summarized below:

POWER SUPPLY	TEMP (° C)	DUTY CYCLE	
		O/P @ 1W	O/P @ 2W
12 V unregulated power supply (wall module) or 12.6 V battery. (RPS-1A wall module)	25	100%	100%
	50	100%	70%
12 V regulated (power supply)	25	100 %	100%
	50	100 %	100%
14.4 V regulated power supply (auto when running / power supply)	25	100 %	70%
	50	100 %	50%

### 4.3 INDICATORS

There are two LED indicators, one green and one red, on the front panel. Their operation is detailed below:

Green	Power-On	Off Unit Not Powered-up
	Blinking	RX Synthesizer Out-Of-Lock
	Steady	On Normal Operation
Red	Transmit	Off Unit Not Transmitting
	Blinking	TX Synthesizer Out-Of-Lock
	Steady	On Unit Transmitting

Note: If the receiver is out-of-lock (Green LED blinking), the unit will NOT transmit. A synthesizer Out-of-Lock indication usually means that one or both of the voltage controlled oscillators (VCO's) needs to be re-tuned. See the Alignment Section for details on tuning the VCO's.

### 4.4 CONNECTORS

There are three connectors on the Repeater; an antenna connector on the rear panel and a DC power connector and interface connector on the front panel. Their operation is detailed below:

#### 4.4.1 Antenna Connector

On the rear panel is a type N Antenna Connector. An antenna, tuned to a 50 ohm match at the transmit frequency, should be connected to this connector. Although it is permissible to connect a whip antenna directly to the connector, best results are usually obtained by using a quarter-wave ground-plane antenna mounted in an optimum location and connected to the Repeater via a length of low-loss, high quality coaxial cable. The performance of the duplexer is somewhat dependent on the tuning of the antenna. Whip antennas are very sensitive to proximity to metal and other surfaces which can make their operation when directly connected to the Repeater less than optimum. RITRON offers a whip antenna which may be connected via the Ritron 02301380 adapter directly to the Antenna Connector as well as others which may be located away from the Repeater. The whip antenna has an articulated joint to allow the orientation of the antenna to be changed for optimum performance. See the Installation section of this manual for suggestions regarding the location and operation of the antenna.

#### 4.4.2 DC Power Connector

On the right side of the front panel is the DC Power Connector. This connector is a male P-5 type with a 2.11 mm (0.083 in.) inside diameter, 5.51 mm (0.217 in.) outside diameter and a 9.5 mm (0.374 in.) internal length. The positive terminal is on the inside.

#### 4.4.3 Interface Connector

Near the middle of the front panel is the Interface Connector. This connector is a female telephone RJ-12 modular connector which allows local microphone, speaker, Push-to-Talk and programming connections. The RITRON Speaker/Microphone sold for use with the Repeater plugs into this connector.

The pinout and description of the pins of this connector are as follows:

<u>Pin No.</u>	<u>Name</u>	<u>Description</u>
1	GND	Circuit ground and common point for other pins.
2	AUDIO IN	Pre-emphasized audio input pin. Approximately 25 mV @ 1 kHz required for 60 % rated maximum deviation. Input impedance approximately 3 k-ohm.
3	PTT/MIC	Combination microphone input and Push-to-Talk input. When the voltage on this input is taken below approximately 2 volts, the unit will transmit. This input is also coupled to the transmitter audio circuitry. When an electret microphone is connected to this input it is powered by the PTT circuitry and the audio from the microphone is transmitted.
4	MON	When taken to 1 volt or lower, depending upon how the unit was programmed, either carrier squelch is overridden, or tone squelch is overridden.
5	AUDIO OUT	The output of the audio power amplifier. The output level is set by R330 and it is capable of driving 8-ohm loads.
6	PROG	Bi-directional pin for connection to the RITRON programmer.

Note: There is no internal muting on the two audio input pins, AUDIO IN and PTT/MIC. Ensure that no active signal is present on these inputs unless it is desired for that signal to be transmitted.

#### 4.5 RECEIVER DESENSE

Receiver desense is a condition where the Repeater's receive sensitivity decreases when the transmitter is enabled. It is affected by the tuning of the duplexer and to a lesser extent, by noise generating equipment in the vicinity of the antenna. For the duplexer to perform correctly, the antenna match must be close to 50 ohms at the frequency of operation. A poor match can cause the duplexer notch depths to decrease which could cause a desense problem. With the antenna available from RITRON, receiver desense should be less than 1 dB. A perfect 50 ohm, non-radiating load should show desense less than 0.5 dB.

Certain types of electronic equipment can generate noise when in the vicinity of radio transmitters. This noise can cause desense and, in some cases, lock up the Repeater. The Repeater hears spurious signals from the electronic equipment and stays keyed up. Certain types of digital oscilloscopes are prone to causing this problem. The Repeater should be setup and tested thoroughly to prevent this kind of issue.

#### 4.6 SIGNALLING TONES

The RLR-460 is capable of supporting one QC (CTCSS) or two DQC (CDCSS/DCS) tones/codes. This is in addition to the tone which the transmitter generates when the PTT line is enabled. Programming of these tones/codes is detailed in the Programming section of this manual. The choice of QC tone can have an impact on the operation of the Repeater system. The lower frequency tones are the slowest to decode. This can be an issue in a Repeater system since the tone must be decoded twice in sequence, one by the Repeater and then by the unit receiving the

Repeater. Higher tones decode faster but can also be problematic since they are closer to the voice audio range. Voice components can interfere with the tone decoders causing a condition known as voice talk-off i.e. the unit mutes audio once a person starts talking. In addition, if the tone is too high, it can be heard in the receiver as a constant hum or drone. A tone between 100 and 150 Hz appears to be an optimum tradeoff.

## 5.

# PROGRAMMING

The RLR-460 Repeater may be programmed with a transmit frequency, receive frequency, QC tone, DQC code, and a variety of other features. Some of these other features are:

### **Transmit time-out timer**

This feature determines how long the unit may transmit continuously before the transmitter automatically shuts off.

### **Tone signaling turn-off time**

This is the time (in addition to “hang-time” with tone) that no tone is transmitted after the Repeater ceases to detect an incoming carrier.

### **Morse code identifier**

The repeater can be programmed to transmit a Morse code identifier at a specified time interval after activity.

## **5.1 PROGRAMMING SETUP**

RITRON Programming kit RPT-PCPK supports programming the RLR-460 Repeater using a PC compatible computer. To use the programming software, connect the Repeater to the computer serial port with the RITRON adapter cables. You can program added Repeaters identically by saving data to the computer hard drive. It is recommended that the programming software be copied to the computer hard drive for future programming.

### **5.1.1 Programming Kit Contents**

- a. RITRON Repeater Programming Software, complete on two 3.5" diskettes.
- b. RITRON PC-to-Repeater adapter cable, terminated at one end with a DB-25F connector for plugging into the computer serial port. The other end terminates in a modular plug. This modular plug does NOT plug into the Repeater, even though it will fit.
- c. Modular jack to modular plug adapter cable. This cable acts as an interface between the modular plug on the DB-25F connector and the modular jack on the Repeater. To avoid damage to the DB-25F internal circuitry, the Repeater, or both, this cable must be used.
- d. An adapter for converting the DB-25F connector to a DB-9F connector. Used when the serial port connector on the host computer is a 9-pin, rather than a 15-pin connector.

### **5.1.2 PC Programming Software Kit Requirements**

The computer must run on Windows 95 or later, and have an RS-232 serial port available. A hard drive is recommended.

## **5.2 COMPUTER SOFTWARE COPYRIGHTS**

The RITRON, Inc. products described in this manual include copyrighted RITRON, Inc. computer programs. Laws in the United States and other countries grant to RITRON, Inc. certain exclusive rights in its copyrighted computer programs, including the exclusive right to distribute copies of the programs, make reproductions of the programs, and prepare derivative works based on the programs. Accordingly, any computer programs contained in RITRON, Inc. products may not be copied or reproduced in any manner without the express written permission of RITRON.

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### 5.3 PROGRAMMING THE REPEATER

1. Remove power from the Repeater.
2. Insert the modular plug on the end of the cable from the DB-25F connector to the modular jack on the adapter cable. Then, insert the modular plug on the adapter into the modular jack on the front of the Repeater.
3. Insert disc 1 into the computer's floppy drive and open the menu for that drive. Double click on "install" and then follow the on-screen instructions. When instructed to insert disk 2, remove disk 1 and insert disk 2. On-screen instructions are provided for loading the programming software onto the host computer's internal hard drive.

### 5.4 USING THE PROGRAMMER

To use the programmer, the unit should be powered down and the programming cable should be connected to the Repeater and the computer. The Repeater should be powered up and the Programmer selected on the computer.

#### 5.4.1 Drop-Down Menus

At the top of the programmer screen is a set of drop-down menus. Their functions are detailed below:

##### **File:**

##### **Open File**

Allows an already stored configuration to be opened. This would be used to make one Repeater the same as another in terms of its programmable frequencies and features. Note that if the new frequency(ies) is(are) different from what was previously loaded into the Repeater, realignment may be required.

##### **Save File**

Allows the parameters as shown on the screen to be saved as a configuration file. This could be later used to make other Repeaters the same as the one just programmed.

##### **Print**

Prints a copy of the on-screen parameters.

##### **Quit**

Exits the programmer.

##### **Radio:**

##### **Read**

Reads the configuration stored inside the Repeater. This command is normally the first to be executed so that the current radio configuration may be edited.

##### **Program Radio**

Sends the configuration as shown on the screen to the Repeater.

*Note that a progress bar at the bottom right of the programmer screen will be displayed during the Read and Program operations. It typically takes about five seconds to send a file to or from the Repeater.*

##### **Terminal Mode**

Allows the user to communicate with the Repeater in terminal mode.



**Comm Port**

Sets the communications port of the computer to match the port where the programmer hardware is actually connected.

**5.4.1 Editing the Programmer Fields**

The functions of the individual fields of the programmer screen are described below.

Note:

- a. It is not necessary to hit "Enter" after a given entry. One may just click to another field and begin editing that field.
- b. No changes are made to the actual Repeater's configuration until, and unless, a "Program Radio" command is issued.

**Model:**

This programmer may allow programming of a variety of different RITRON products. The model choice is made via the arrow at the right of the window and must agree with the model of the unit being programmed.

**Customer ID Number:**

Allows an ID number to be stored in the Repeater's memory to identify a customer, site, etc.

**Repeater Transmit Frequency:**

Allows programming of the transmit frequency of the Repeater.

Note that the Repeater's transmit frequency is the receive frequency of the radios using the Repeater.

**Repeater Receive Frequency:**

Allows programming of the receive frequency of the Repeater.

Note that the Repeater's receive frequency is the transmit frequency of the radios using the Repeater.

Notes on frequency selection:

- The frequencies selected must be within the correct frequency band. For the RLR-460 this is 450-470 MHz.
- The frequencies must be on 12.5 kHz spacing i.e. must be divisible by 12.5 kHz. If not, the programmer will round to the nearest 12.5 kHz frequency. Note that all 25 kHz frequencies are acceptable since they would be divisible by 12.5 kHz.
- The transmit and receive frequencies must not be closer than 5 MHz to each other.
- If the frequencies are changed by more than 50 kHz of what the duplexer was tuned to, the duplexer must be retuned. In addition, if the frequencies are changed by more than 3 MHz from what the main PCB was tuned to, the unit must be realigned. See the Alignment section for details.

**Squelch Options:**

Via the arrow key at the right of the squelch boxes, signaling tones/codes may be chosen for use with the Repeater.

Notes on signaling tones/codes:

- One QC (CTCSS) tone or two DQC (CDCSS) codes may be chosen. A combination of QC and DQC may not be chosen.
- When two DQC codes are chosen, the transmit encoded code will be the same as the decoded code.

- The tone/code chosen for transmit encoding when the PTT is activated may be separate from the one(s) chosen for decoding and re-transmission.
- A custom QC tone may be created by entering the frequency in the custom tone box and selecting custom tone on the squelch menu.
- Carrier squelch-only mode may be selected by clicking on no tone.

#### **MORSE Code ID, ID transmit interval, ID with tone:**

The Morse code ID call sign may be entered in the MORSE Code ID box. How soon after transmitter activity it is to be transmitted is entered in the ID transmit interval box. One may also select whether one wants the signaling tone/code to be transmitted with the ID.

#### **Notes on ID:**

- A value of zero for the interval time and/or no ID entered in the ID box will disable the MORSE code ID, i.e. none will ever be transmitted.
- The interval timer starts with activity on the channel. If activity ceases after the ID is sent, the timer will not restart until activity resumes.
- The ID will not be transmitted while a conversation is in progress. If the timer times out and the Repeater is transmitting, the Repeater will wait until the transmission stops before sending the ID.
- While the ID is being transmitted, audio from the receiver is muted. A person transmitting on the Repeater's receive frequency will not be heard until the conclusion of the ID. Audio from the local microphone will, however, be heard since it is never muted.
- One has the option of transmitting the ID without tone/code, even if the Repeater has been programmed for tones/codes. This is to prevent users from being annoyed by the repetitive ID being heard in their receivers. Conversely, if the ID is selected to be sent with tone/code, all users will hear the ID when it is sent. Normal practice is to transmit the ID without tone/code.

#### **TX Time Out Timer:**

The number selected for this parameter is the longest length of time that the transmitter is allowed to transmit continuously. When the limit is reached, the transmitter is unkeyed by the Repeater and will not transmit again until, and unless, the receive signal disappears and then reappears. Note that a time of zero defeats the timer i.e. the transmitter can transmit continuously. The range of values for this parameter can range from 0 to 34 minutes. Note, however, that a value of zero defeats the time out timer i.e. the transmitter may be keyed continuously. A typical time for the time out timer is 3 minutes.

#### **Transmit Hang Time:**

This is the length of time that the transmitter will stay keyed with tone/code (if selected) after the receive signal disappears. This is to allow users to talk back and forth without the Repeater unkeying after each transmission.

The range of values for this parameter can range from 1 to 7 seconds in 1/32 increments. (Typically, the value would be entered in tenths and the programmer will round to the nearest 1/32 second.) A typical time for transmit hang time is 2 seconds.

#### **Squelch Tail Mute Time:**

This is the length of time that the transmitter stays keyed after the end of the transmit hang time, but without tone/code. This is to give the users' receivers squelch decoders time to sense the loss of tone/code during the transmit hang time before dropping the transmitter. The range of values for

this parameter can range from 0 to 7 seconds in 1/32 increments. (Typically, the value would be entered in tenths and the programmer will round to the nearest 1/32 second.) A typical squelch tail mute time might be one-half second.

Note that for DQC operation, a 0.1 second turn-off code is also transmitted just after the transmit hang time interval and before the squelch tail mute time starts. No QC reverse burst turn-off signal is supported in the RLR-460.

**Monitor Mode:**

When taken to ground, the monitor line on the front panel input connector allows the Repeaters audio squelch circuit to be overridden. By clicking on the appropriate box, one has the option of completely overriding the squelch and allowing all receive audio to be heard, even with no activity on the channel, or of simply defeating any tone/code which may have been programmed into the unit. In actual operation, overriding tone/code is more common, but overriding carrier may be an advantage during alignment.

## 5.5 QUIET-CALL CODES AND FREQUENCIES

<u>QC Code</u>	<u>Tone Code</u>	<u>Freq. (Hz)</u>	<u>QC Code</u>	<u>Tone Code</u>	<u>Freq. (Hz)</u>	<u>QC Code</u>	<u>Tone Code</u>	<u>Freq. (Hz)</u>
01	XZ	67.0	18	3Z	123.0	35	M4	225.7
02	XA	71.9	19	3A	127.3	36	—	233.6
03	WA	74.4	20	3B	131.8	37	—	241.8
04	XB	77.0	21	4Z	136.5	38	—	250.3
05	SP	79.7	22	4A	141.3	39	—	69.4
06	YZ	82.5	23	4B	146.2	40	—	159.8
07	YA	85.4	24	5Z	151.4	41	—	165.5
08	YB	88.5	25	5A	156.7	42	—	171.3
09	ZZ	91.5	26	5B	162.2	43	—	177.3
10	ZA	94.8	27	6Z	167.9	44	—	—
11	ZB	97.4	28	6A	173.8	45	—	183.5
12	1Z	100.0	29	6B	179.9	46	—	189.9
13	1A	103.5	30	7Z	186.2	47	—	196.6
14	1B	107.2	31	7A	192.8	48	—	199.5
15	2X	110.9	32	M1	203.5	49	—	206.5
16	2A	114.8	33	M2	210.7	50	—	229.1
17	2B	118.8	34	M3	218.1	51	—	254.1
						53	—	Custom

## 5.6 DIGITAL QUIET-CALL CODES

<u>Normal</u>	<u>Invert</u>	<u>Normal</u>	<u>Invert</u>	<u>Normal</u>	<u>Invert</u>	<u>Normal</u>	<u>Invert</u>
023	047	143	412	315	423	532	343
025	244	152	115	331	465	546	132
026	464	155	731	343	532	565	103
031	627	156	265	346	612	606	631
032	051	162	503	351	243	612	346
043	445	165	251	364	131	624	632
047	023	172	036	365	125	627	031
051	032	174	074	371	734	631	606
054	413	205	263	411	226	632	624
065	271	223	134	412	143	654	743
071	306	226	411	413	054	662	466
072	245	243	351	423	315	664	311
073	506	244	025	431	723	703	565
074	174	245	072	432	516	712	114
114	712	251	165	445	043	723	431
115	152	261	732	464	026	731	155
116	754	263	205	465	331	732	261
125	365	265	156	466	662	734	371
131	364	271	065	503	162	743	654
132	546	306	071	506	073	754	116
134	223	311	664	516	432		

## 6.

## ALIGNMENT

### 6.1 DISASSEMBLY

The unit is disassembled for alignment/service by removing the six T-10 torx screws from the end plate with the antenna connector. The cover with the other end plate is then slid off. Be sure to remove the power and interface connectors before disassembling the unit.

### 6.2 DUPLEXER

The duplexer allows the Repeater to simultaneously transmit and receive. To accomplish this, in the receive input path, the transmitter signal must be notched or suppressed by 65 dB or more. In addition, on the transmit path, transmitter noise on the receive frequency must be also suppressed by about 65 dB. The duplexer contains four cavities, two for each path to achieve the necessary notch depth. Because the notches are very narrow, the duplexer must be re-tuned if the frequency of operation is changed by more than 50 kHz. Follow the procedure below to tune the duplexer:

1. Connect the antenna to be used to the antenna connector on the Repeater. If possible, the antenna should be positioned in a way that matches the actual configuration as close as possible. If the antenna requires tuning, tune it to the transmit frequency. If an antenna is not available, connect a low VSWR 50-ohm load instead.
2. Unplug the two RF cables connecting the duplexer to the main PCB.
3. A spectrum analyzer with tracking generator or a network analyzer should be used to sweep the duplexer. If one is not available, a spectrum analyzer and an RF signal generator can be used. The duplexer should be swept from one RCA plug to the other; it doesn't matter which end goes to the generator or the spectrum analyzer.
4. One should see at least two, and maybe as many as four notches. Carefully loosen the nuts on the two duplexer cavities underneath the transmitter portion of the main PCB. Adjust the two cavity screws for the deepest notch possible at the RECEIVE frequency (normally the higher frequency). Tighten the nuts being careful not to de-tune the notch frequency. Also, do not over tighten. Do the same for the two screws on the cavities underneath the receiver portion of the main PCB, but tune for a notch at the TRANSMIT frequency (normally the lower frequency). When finished, one should see two notches, one at the transmit frequency and one at the receive frequency. These two notches are very narrow and special attention should be paid to ensuring that they are at the correct frequencies. The two notches should be about 70 dB deep compared to a straight-through connection.

### 6.3 PRELIMINARY

1. Alignment of the RLR-460 Repeater requires that surface-mount potentiometers be adjusted. These potentiometers do not have end stops so one must pay special attention to the wiper position for maximum clockwise and counterclockwise settings. Also, one should be careful never to set the wiper in the dead band between maximum and minimum.
2. Alignment of the Repeater requires connection to the pins on the front panel modular jack.
3. The frequency deviation numbers shown are for narrow (12.5 kHz channel spacing) operation. Double the values for wide (25 kHz channel spacing) operation. The RLR-460 does not support both narrow and wide bandwidth operation in the same model. Separate models exist for each; the RLR-460 for narrow, the RLR-460-W for wide.

4. A communications service monitor capable of duplex operation is required to set R328 (REPEAT AUDIO LEVEL). Other alignment steps can use individual pieces of equipment (RF signal generator, RF wattmeter, etc.), although communications service monitors tend to include all the functions necessary to align this product.
5. Ensure that the Repeater is properly programmed for the correct transmit and receive frequencies and the correct QC/DQC tones/codes. Even if a transmit tone is not to be used (unusual), one should program one anyway to get the transmit tone deviation properly set. This parameter is, however, set at the factory.
6. Refer to the RLR-460 ALIGNMENT POINTS diagram for the location of alignment points and adjustments.

## 6.4 RECEIVER

1. Apply power to the Repeater. The green front panel LED should be illuminated, but may be blinking.
2. Connect the MON input (modular jack pin 4) to ground (modular jack pin 1). This will override the tone squelch operation and also inhibit the transmitter.

### 6.4.1 Receive VCO Tuning

1. Connect a high impedance oscilloscope probe to an oscilloscope set for 1 V/div, DC coupled. The sweep speed is not important.
2. Connect the ground lead of the probe to the PCB ground. The mounting legs of the receiver input connector J100 can be used. Touch the probe tip to TP101 and note the voltage on the oscilloscope. This point is very sensitive and the synthesizer may go out of lock. Even if out of lock (green LED flashing), the voltage can still be adjusted.
3. Using an insulated tuning tool, adjust C135 inside the VCO/synthesizer (RX VCO TUNE) shield for 2.5 +/-0.25 volts at TP101. The green front panel LED should be illuminated continuously (not blinking) when the probe is removed. Replace the foil over the tuning hole.

### 6.4.2 Local Oscillator Trim

1. Connect a test probe from a frequency counter or frequency measuring device to test point TP103. The receiver 1<sup>st</sup> local oscillator signal at approximately -12 dBm is present at this point. The correct frequency at this point is the receive frequency minus the 1<sup>st</sup> IF frequency of 43.65 MHz ( $f_{LO} = f_{RX} - 43.65$ ).

Using a tuning tool, adjust R134 (RX FREQ TRIM) for the correct frequency +/-100 Hz.

### 6.4.3 Receiver Front-End Tuning

Note: To prevent the squelch circuit from muting the receiver, turn R312 counterclockwise or change the Monitor mode via the programmer to "override carrier" and ground the monitor input line.

1. Connect a SINAD meter to the AUDIO OUT output (pin 5). Set R330 (SPEAKER AUDIO LEVEL) to mid rotation.
2. Connect an RF signal generator to the antenna connector. The generator frequency should be set to the desired receive frequency modulated with a 1 kHz tone at 1.5 kHz deviation. The RF level should be set to 7uV (-90 dBm).
3. If the SINAD meter reads greater than 12 dB, reduce the RF signal generator output level until 12 dB SINAD is reached. Adjust L100 through L104 for best SINAD while reducing the RF signal generator output level to keep the SINAD near 12 dB. The RF output level for 12 dB SINAD should be 0.25 uV (-119 dBm) or less. Note that all of the inductors have a very broad tuning characteristic, except L103. Adjust the inductors in the middle of this broad range.

#### 6.4.4 Squelch

1. Set the RF signal generator output level to produce a SINAD reading where the squelch is desired to unmute, typically 12-14 dB.
2. Rotate R312 (SQUELCH) to the maximum counterclockwise point. Connect an oscilloscope probe to TP104. The voltage at TP104 should be 5 VDC. Adjust R312 clockwise until the TP104 voltage drops to zero. Then, slowly adjust R312 counterclockwise to the point where the TP104 voltage again goes to 5 volts. Conversely, if "override tone" is set for squelch mode in the programmer menu, one can listen for the presence or absence of audio at the audio output to determine the squelch point.

#### 6.4.5 Audio Output Level

1. Increase the RF signal generator output level to 7  $\mu$ V (-90 dBm). The SINAD reading should be close to 20 dB or so. Connect an oscilloscope to the AUDIO OUT (pin 5) on the modular jack. The SINAD meter is already connected to this point.
2. Adjust R330 (SPEAKER AUDIO LEVEL) for the desired output level.

### 6.5 TRANSMITTER

1. Apply power to the Repeater.
2. Set R115 (TX POWER) to the full counterclockwise position. This is the minimum power point.
3. Connect a 50-ohm RF dummy load capable of handling 2 watts or more to the Antenna connector. Provisions should be made to couple the RF output signal to a demodulator, a frequency counter, and an RF wattmeter. The demodulated output must be viewable on an oscilloscope.
4. The transmitter will be keyed by taking pin 3 of the modular jack (PTT/MIC) to ground.
5. Ensure that the signal generator output of the service monitor is set to a very low level to prevent the receive squelch from unmuting. This will prevent the transmitter from keying due to receiving a valid carrier. Having a receive QC/DQC tone/code programmed will help greatly in preventing nuisance keying.

#### 6.5.1 Transmit VCO Tuning

1. Connect a high impedance oscilloscope probe to an oscilloscope set for 1 V/div, DC coupled. The sweep speed is not important.
2. Connect the ground lead of the probe to the PCB ground. The mounting legs of the transmitter output connector J101 can be used. Key the transmitter, touch the probe tip to TP102 and note the voltage on the oscilloscope. This point is very sensitive and the synthesizer may go out of lock (red LED blinking).
3. Using an insulated tuning tool, adjust C203 inside the VCO/synthesizer shield (TX VCO TUNE) for 2.5  $\pm$  0.25 volts at TP102. The red front panel LED should be illuminated continuously (not blinking) after the probe is removed. Unkey the transmitter. Replace the foil over the tuning hole.

#### 6.5.2 Transmitter Output Power

1. Set R115 (TX POWER) to mid-rotation. Key the transmitter and note the output power. Adjust C180 and C183 for maximum output power. If the output power is too low, adjust R115 (TX POWER) clockwise and readjust C180 and C183. Adjust R115, C180, and C183 until the desired output power is reached. For 2 watts, R115 would typically remain at mid-rotation.
2. Unkey the transmitter.



### 6.5.3 Modulation Balance and Deviation

1. An audio generator should be connected to the AUDIO IN (pin 2) input of the modular jack. The audio frequency should be 500 Hz and the level should be 10 mV rms or lower.
2. Set R347 (TONE DEVIATION) to the full counterclockwise position.
3. The RF output should be routed to an FM demodulator and the demodulated output made visible on an oscilloscope. The filtering on the demodulator should be 15 kHz or higher on the lowpass filter and below 50 Hz on the highpass filter. It is important that minimal or NO highpass filtering be in place in the demodulation path.
4. While observing the oscilloscope, key the transmitter. Increase the audio generator level until the 500 Hz sinewave becomes visible on the oscilloscope. Increase the generator level until a significant amount of clipping on the top and bottom of the sinewave is evident (typically 250 mv rms).
5. Carefully adjust R337 (BALANCE) so that the clipped portion of the observed waveform is flat i.e. not tilted up or down.
6. Adjust R350 (VOICE DEVIATION) for +/- 2.35 kHz deviation.
7. Unkey the transmitter.

### 6.5.4 Transmitter Frequency Trim

1. Remove the audio generator connection.
2. Key the transmitter and note the frequency of the RF output signal. Adjust R339 (TX FREQ TRIM) for the correct transmit frequency +/- 100 Hz.
3. Unkey the transmitter.

### 6.5.5 Tone Deviation

1. Key the transmitter and adjust R347 (TONE DEVIATION) for the desired tone/code deviation, typically 400 Hz.
2. Unkey the transmitter.

### 6.5.6 Repeat Audio Level

1. For this adjustment, the service monitor must be able to generate an RF signal and simultaneously demodulate an incoming RF signal.
2. Set the RF signal generator for the correct receive frequency with 1.5 kHz deviation of a 1 kHz tone and modulated with the correct tone/code, if used. The RF output level should be set for 7 uV (-90 dBm) The demodulator should be set to display deviation.
3. The transmitter should automatically key (red LED illuminated). Adjust R328 (REPEAT AUDIO LEVEL) for +/- 1.8 kHz deviation.
4. Reduce the RF signal generator level to minimum to unkey the transmitter.



## 7.

# THEORY OF OPERATION

### 7.1 DUPLEXER

The duplexer allows for simultaneous transmission and reception of RF signals. There is a receive path and a transmit path which connect to the RF input and output of the main PCB and a common point at the antenna connector.

In the receive path is a two-cavity notch filter. This filter allows the receive signal from the antenna connector to pass through with about 1.5 dB loss, but notches the transmitter RF output signal by 70 dB or more to prevent overloading the receiver. The transmit path also contains a two-cavity notch filter, this one tuned to the receive frequency. This filter removes transmitter noise which exists at the receive frequency and which would interfere with the desired receive signal, if not removed.

### 7.2 RECEIVER

#### 7.2.1 Front-End

The receiver front-end comprises the RF amplifier stages with associated filters and the first mixer. The input signal from the J100 (RX IN) passes through a two-pole bandpass filter formed around L100 and L101. This filter is narrow enough at 10 MHz to protect the receive RF amplifier, but wide enough to keep its insertion loss low at 2.3dB. This filter stage is followed by the RF amplifier. The RF amplifier stage has a gain of about 12 dB and a noise figure of 1.5 dB. This stage, along with the first filter, are largely responsible for the sensitivity of the Repeater. The RF amplifier is followed by a three-pole bandpass filter formed around L102 through L104. This filter is somewhat narrower than the two-pole filter and thus has a higher insertion loss at 4 dB. The total filtering action is to limit the number of off-channel interfering signals that the receiver might be exposed to and to remove signals at the spurious response frequencies of the mixer which follows.

The job of the 1<sup>st</sup> mixer, U100 is to convert signals at the receive frequency to that of the 1<sup>st</sup> IF at 43.65 MHz. It does this by mixing the incoming signal with the 1<sup>st</sup> local oscillator signal at a frequency 43.65 MHz below that of the desired receive frequency to the IF frequency of 43.65 MHz. The 43.65 MHz output of U100 exits at pin 4 and is routed to the 1<sup>st</sup> IF filter. U100 has a conversion gain of 12 dB and a noise figure of 6 dB. This performance in combination with the front-end RF amplifier stage determines the sensitivity of the receiver.

#### 7.2.2 1<sup>st</sup> IF

The 1<sup>st</sup> IF stage consists of two two-pole monolithic crystal filters separated by an amplifier. The two filters are YF101 and YF102. These filters are bandpass in response with a bandwidth of 12 kHz and an insertion loss of 1.5 dB. To overcome the losses of the filters and to prevent interaction between them, they are separated by an amplifier formed around Q102.

#### 7.2.3 2<sup>nd</sup> IF Sub-System

IC U101 is responsible for converting signals at the 1<sup>st</sup> IF to the 2<sup>nd</sup> IF where additional filtering and amplification take place. The 43.65 MHz signal enters U101 at pin 16. It is then mixed with the 2<sup>nd</sup> local oscillator signal at pin 1 to produce a signal at the 2<sup>nd</sup> IF of 450 kHz at pin 3. The 2<sup>nd</sup> IF signal at pin 3 is filtered by the YF103, the 2<sup>nd</sup> IF filter. This filter is a bandpass filter with a bandwidth of 7.5 kHz and an insertion loss of 5 dB. The output of the filter re-enters U101 at pin 5 where it is amplified and then limited to remove any amplitude modulation components. The limited signal is then mixed against a 90° phase shifted version of itself and filtered by Y102. This acts as an FM demodulator. The demodulated output exits U101 at pin 9.

U101 also provides for squelch operation. The presence of a carrier is sensed by noting that ultrasonic noise on the demodulated output decreases when a carrier is present. An amplifier between pins 7 and 8 of U101 and associated external parts form an audio bandpass filter at

3.5 kHz. The output of this filter is internally rectified and exits at pin 14. This signal passes through a temperature compensation network formed around CR105. The result is a signal whose DC level drops with increasing carrier level.

#### **7.2.4 1<sup>ST</sup> Local Oscillator/Receive Synthesizer**

The local oscillator signal for the 1<sup>st</sup> mixer is generated by the receive synthesizer. The receive synthesizer is based around a voltage controlled oscillator (VCO) and a synthesizer sub-system IC which handles the digital portion of the synthesizer. The voltage-controlled oscillator is an oscillator whose frequency can be controlled by a voltage. The receive voltage controlled oscillator is formed around Q104 with varactor diode CR100 electronically controlling the frequency. The oscillator frequency is sampled by R128 and C148 and sent to U102, an integrated monolithic Phase-Locked Loop (PLL) synthesizer IC. Inside U102, the VCO frequency is divided by programmable digital dividers to 12.5 kHz. Y100, the 14.4 MHz receive reference oscillator's frequency is also divided down to 12.5 kHz. A phase/frequency detector compares the two divided down frequencies and generates an error signal at U102, pin 2 which is filtered and used to pull the VCO on frequency. By controlling the VCO divider number, the locked frequency can be changed in 12.5 kHz steps. The divider numbers are loaded into U102 by the microprocessor. The tuning range of the VCO is set by C135. Because the VCO is locked to the receive reference oscillator, Y100, the frequency stability of Y100 determines the frequency stability of the VCO and thus the 1<sup>st</sup> local oscillator.

The output of the VCO is amplified by Q105 and Q106 to about 0 dBm to drive the 1<sup>st</sup> mixer. For alignment purposes, a sample of the 1<sup>st</sup> local oscillator is available at TP103. For proper mixing operation, the VCO is made to oscillate at a frequency 43.65 MHz below the receive frequency.

#### **7.2.5 2<sup>ND</sup> Local Oscillator**

To convert the 1<sup>st</sup> IF signals at 43.65 MHz to the 2<sup>nd</sup> IF frequency of 450 kHz requires a 2<sup>nd</sup> local oscillator frequency of 43.2 MHz (43.65 – 0.450). This is created by multiplying the 14.4 MHz output frequency of Y100 by three in Q107.

### **7.3 TRANSMITTER**

#### **7.3.1 Transmit Synthesizer**

The transmit synthesizer operates similar to the receive synthesizer except that the oscillator is locked to the transmit frequency rather than offset by the 1<sup>st</sup> IF frequency. The transmit VCO is formed around Q117 and electronically tuned by CR102. The oscillator frequency is sampled by R175 and C192 and routed to U103, the transmit synthesizer IC. The oscillator frequency is divided down to 12.5 kHz and compared in phase and frequency to the divided transmit reference oscillator signal. The error signal is filtered and sent to the varactor diode CR102 to lock the VCO on frequency. The 12.5 kHz reference is created by dividing down the transmit reference oscillator frequency of 14.4 MHz from Y101. To modulate the transmitter, the VCO must allow for frequency modulation other than what is required to put it on frequency. This is effected by CR103. The tuning range of the VCO is set by C203. Q119 is an electronic switch which keeps the transmit VCO turned off when the unit is not transmitting.

#### **7.3.2 RF Power Amplifier Stages**

The output of the VCO buffer stage, Q114 is at a level of about 0 dBm. This is amplified to the 2 watt level by Q111, Q110, Q109, and Q108. Q112 and Q113 are electronic switches which only allow the amplifier stages to be turned on after the transmit VCO is locked and on frequency. The output power can be adjusted by R115, which set the bias voltage on the final power stage. Q108 is followed by an impedance matching network and a low-pass filter to remove transmitter frequency harmonics.

## **7.4 AUDIO**

### **7.4.1 Receiver**

Discriminator audio from U101 passes to U301-A where it is buffered and then sent to the tone signaling filter and the voice highpass filter. U302, a 5-pole switched capacitor low-pass filter is used to remove voice and other components from the discriminator audio and leave only signaling tones. The output passes to comparator U300-A where it is converted to square waves for the microcontroller. U301-B and U301-C are used to form a 6-pole high-pass filter which removes signaling tones from the voice audio signal. Its output is routed through two analog switches and then to the audio power amplifier and to the transmit audio chain.

U300-B is the squelch comparator. This IC compares the DC voltage from the carrier detect circuits of U101 to the squelch setting and generates a logic output, which represents the state of the carrier detection circuitry. Squelch hysteresis, to prevent chattering, is provided by R313.

### **7.4.2 Transmitter**

Audio input signals from J300 are amplified by U305-A and then fed through the pre-emphasis network R356 and C339 to the modulation limiter. The modulation limiter is formed around U305-B which is an op-amp that can clip against its supply rails in a controlled manner. Also summed into the input of the clipper are the audio from the receiver to be transmitted and the Morse code ID tone from the microprocessor. The output of the limiter is fed through a 5-pole low-pass filter which removes audio harmonics caused by the modulation limiting. Signaling tones are also added at this point. The output of the limiter filter is passed to the transmit VCO and also the transmit reference oscillator. Sending the filtered transmit audio to both ensures that the transmitter audio frequency is flat to DC.

## **7.5 POWER DISTRIBUTION**

DC supply voltage for the Repeater enters the unit at J301. The internal regulator is formed around pass transistor Q300 and a zener voltage reference, CR306. This regulator nominally regulates to 11 volts from a 12 volt or higher source. If the voltage falls below 12 volts, the regulator will no longer regulate, but will filter the incoming source. The incoming source is used to power directly the RF power amplifier and driver stages of the transmitter. For the digital portions of the Repeater, a 5-volt regulator, U310 is provided. The audio circuits are powered from U311, a low noise, high precision 5-volt regulator.

## **7.6 MICROCONTROLLER**

U308 is the microcontroller which controls the operation of the Repeater. Its internal clock is controlled by Y300, a 4 MHz crystal. U309 is a non-volatile memory IC used to store frequency, tone, and control information. This information is retained even when the Repeater is powered down.

## 8.0

## MAINTENANCE AIDS

### 8.1 MICROCONTROLLER PIN-OUTS

The pin-outs and description for U308, the microprocessor follow.

Note that a logic low (0) is a voltage below 0.5 volts while a logic high (1) is a voltage above 3.5 volts.

#### **Pin 1 RESET**

Active low pin used to place the microcontroller in the reset state. This pin is driven by U307, a commercial microprocessor supervisory IC which is designed to go low after power supply voltage glitches and power-up. Normal state for this pin is logic high.

#### **Pin 2 IRQ**

Active low external interrupt input. When this pin goes low, the microcontroller jumps to a pre-determined internal software subroutine. This pin is tied to the PTT input. Normal state is high except when driven low by an external PTT signal at J300, pin 3.

#### **Pin 3 NC**

Not used.

#### **Pin 4 Vpp**

Programming power supply pin. Not used once the part is in the Repeater.

#### **Pin 5 TX TONE**

This output is the signaling tone to be transmitted. For QC, it is a square wave at the tone frequency. For DQC, it is the unfiltered DQC waveform.

#### **Pin 6 TX TONE SHIFT**

This output controls the corner frequency of the transmitter tone filter, U306. It shifts between open circuit (tri-state) when the corner frequency is to be high to low when the corner frequency is to be shifted downward for the lower set of QC tones.

#### **Pin 7 RX TONE SHIFT**

This output controls the corner frequency of the receiver tone filter, U302. It shifts between open circuit (tri-state) when the corner frequency is to be high to low when the corner frequency is to be shifted downward for the lower set of QC tones.

#### **Pin 8 VCO EN**

This output enables the transmit VCO. This pin is high when the VCO is to be enabled in order for the repeater to transmit and low otherwise.

#### **Pin 9 TX PA EN**

This output enables the last three transmitter power amplifier stages. This pin goes low to enable these stages when the Repeater is to transmit and high otherwise. This pin would normally go low about 20 ms after pin 8 above goes high when transmit is initiated.

#### **Pin 10 RX TONE**

This input is the square wave from the receive tone filter and comparator, U300-A. This waveform would normally be a square wave version of a received QC or DQC tone/signal.

**Pin 11 SPKR EN**

This output enables the audio gate which drives the audio PA for speaker audio. It is active low when speaker audio is to be present.

**Pin 12 REPEAT AUDIO EN**

This output enables the audio gate which routes receive voice audio to the transmit audio chain. It is active low when audio is to be routed to the transmitter.

**Pins 13, 14**

Not Used

**Pin 15 BEEP/ID TONE LSB**

This output is the least significant bit of a two bit output for generating tones to be transmitted.

**Pin 16 EEPROM Enable**

This output is used to control the U309, the memory IC.

**Pins 17, 18 SQUELCH**

This input is the output of U300-B. It is high when a valid carrier is detected. Note that this input considers only the presence of a carrier, not whether the correct signaling tone is present.

**Pin 19 MON**

This input is from J300, pin 4 and is low when it is desired to have speaker audio present. The unit will not transmit when this input is taken low, even if a valid signal is received or the PTT line is taken low.

**Pin 20 RX LD**

This input is the receiver synthesizer lock detect output. It is high when the receive synthesizer is in lock.

**Pin 21 TX LD**

This input is the transmit synthesizer lock detect output. It is high when the transmit synthesizer is in lock. This would be the normal state for transmit, but this input should be low otherwise.

**Pin 22 GROUND****Pin 23 Not Connected****Pin 24 DATA**

This output is the data line from the microcontroller to the synthesizer IC's.

**Pin 25 TX SYN EN**

This output enables the transmitter synthesizer IC, U103 to receive data from the microprocessor. This pin will change states when the transmitter synthesizer is to be loaded. This would occur just before the Repeater is to transmit.

**Pin 26 RX SYN EN**

This output enables the receiver synthesizer IC, U102 to receive data from the microprocessor. This pin will change states when the receive synthesizer is to be loaded. This would occur just after microprocessor reset.



**Pin 27 CLOCK**

This output is the clock line from the microprocessor to the various peripherals in the Repeater, including the memory IC and the synthesizer IC's.

**Pin 28 EEPROM DATA**

This input/output is the data line to and from the memory IC, U309.

**Pin 29 BEEP/ID TONE MSB**

This output is the most significant bit of a two bit output for generating tones to be transmitted.

**Pin 30 POWER LED**

This active low output drives the power (green) front panel LED.

**Pin 31 TX LED**

This active low output drives the transmit (red) front panel LED.

**Pins 32, 33 PROG**

This input/output is used to communicate with the external programmer.

**Pin 34**

Not Used

**Pins 35-38**

Not Used

**Pins 39, 40**

Connected together, but not used

**Pin 41**

Not Used

**Pins 42, 43 OSC1, OSC2**

These two pins support the external crystal for generating the internal microprocessor clock.

**Pin 44 Vdd**

This is the 5-volt supply pin for the microprocessor. Normal voltage is 5 volts when powered up.

## 8.2 CONTROLS AND ADJUSTMENTS SUMMARY

Below is a summary of the controls and adjustments on the Repeater. Most, if not all are covered in the alignment section, but are included here for reference.

**L100-L104**

These are the adjustable front-end bandpass filter inductors. Since the front-end has a bandwidth of about 10-12 MHz, these should be re-adjusted when the receive frequency is moved by 3 MHz or more. Turning the slugs clockwise tunes the filter higher in frequency. A non-metallic tuning tool should be used.

**C135 RX VCO TUNE**

This is a trimmer capacitor inside the receive synthesizer/VCO shield. It is accessible via a hole in the top of the shield. This trimmer adjusts the tuning range of the receiver so that it is centered around the receive frequency. It is typically re-adjusted when the receive frequency is changed by more than 3 MHz.

**R134 RX FREQ TRIM**

This potentiometer trims the receive reference oscillator to the correct frequency. It is typically adjusted while observing the frequency at TP103. There are no stops on this potentiometer and one must avoid the dead band between the maximum and minimum points on the rotation. Clockwise rotation increases the frequency.

**R312 SQUELCH**

This potentiometer sets the carrier detect point for the receiver. A carrier at the RF level required for a given SINAD output is set and this control is adjusted until the squelch comparator changes states. There are no stops on this potentiometer and one must avoid the dead band between the maximum and minimum points on the rotation.

**R347 TONE DEVIATION**

This potentiometer sets the level of transmitted QC/DQC signals. Clockwise rotation increases deviation with the maximum to about 1 kHz (2 kHz for 25 kHz version). There are no stops on this potentiometer and one must avoid the dead band between the maximum and minimum points on the rotation.

**R339 TX FREQ TRIM**

This potentiometer sets the frequency trim of the transmit reference oscillator. It is typically set with no modulation and the transmitter transmitting. Clockwise rotation increases frequency. There are no stops on this potentiometer and one must avoid the dead band between the maximum and minimum points on the rotation.

**R350 VOICE DEVIATION**

This potentiometer sets the maximum voice deviation of the transmitter. (Signaling tones are added after modulation limiting.) Clockwise rotation increases deviation with the maximum at about 5 kHz deviation (10 kHz on 25 kHz version). Deviation tends to increase in direct proportion to transmit frequency, thus this potentiometer should be reset if the transmit frequency is changed by 3 MHz or more. There are no stops on this potentiometer and one must avoid the dead band between the maximum and minimum points on the rotation.

**R337 BALANCE**

This potentiometer sets the balance between the transmit audio signal sent to the transmit reference oscillator and the signal sent to the VCO. This is required to achieve a flat transmit audio frequency response. This adjustment tends to need re-adjustment if the transmit frequency is changed by 3 MHz or more. There are no stops on this potentiometer and one must avoid the dead band between the maximum and minimum points on the rotation.

**R328 REPEAT AUDIO LEVEL**

This potentiometer sets the level of audio from the receiver to be sent to the transmit audio chain. Clockwise rotation increases deviation. Typically a 60% modulated signal is sent to the receiver and this adjustment is set for 60% transmit deviation. There are no stops on this potentiometer and one must avoid the dead band between the maximum and minimum points on the rotation.

**R350 SPEAKER AUDIO LEVEL**

This potentiometer sets the level of speaker audio. Clockwise rotation increases the speaker audio level. There are no stops on this potentiometer and one must avoid the dead band between the maximum and minimum points on the rotation.

**C203 TX VCO TUNE**

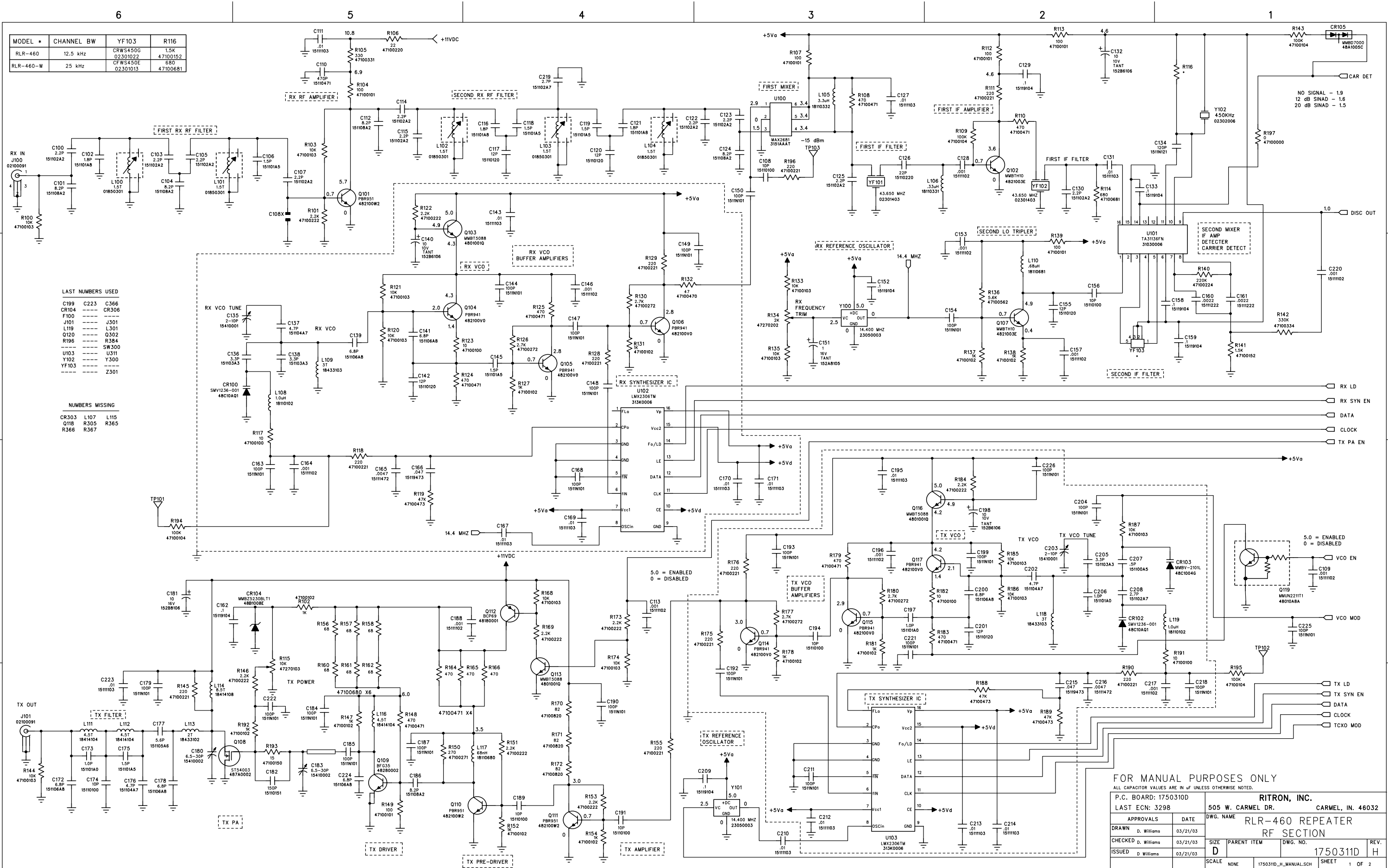
This is a trimmer capacitor inside the transmit synthesizer/VCO shield. It is accessible via a hole in the top of the shield. This trimmer adjusts the tuning range of the transmitter so that it is centered around the transmit frequency. It is typically re-adjusted when the transmit frequency is changed by more than 3 MHz.

**R115 TX POWER**

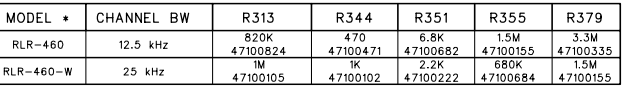
This potentiometer sets the transmit output power level. Clockwise rotation increases output power. This adjustment is set in conjunction with C180 and C183. There are no stops on this potentiometer and one must avoid the dead band between the maximum and minimum points on the rotation.

**C180, C183 TRANSMITTER POWER AMPLIFIER TRIMMERS**

These capacitors trim the matching network for the transmitter power output stage. These would normally need re-adjustment when the transmit frequency is changed by 3 MHz or more or when the power is changed. They should always be peaked before R115 above is adjusted.



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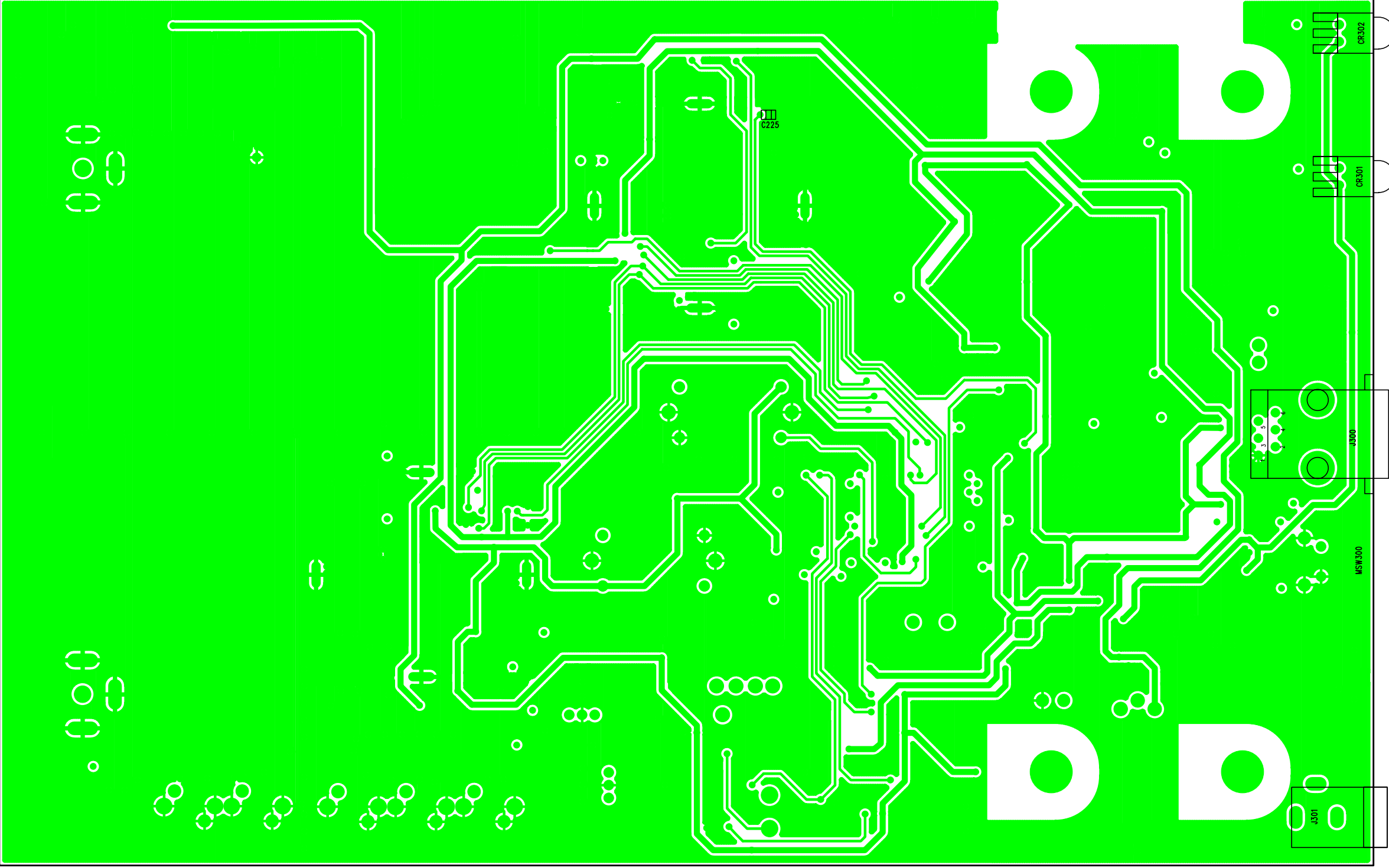


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