

A8
Depot Manual

6816102H01-A

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	Complete	Incomplete	Correct	Incorrect	Clear	Confusing	Size Adequate	Size Too Small	Not Covered in this Manual
Disassembly Procedures									
Alignment Procedures									
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Exploded View Parts List									

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Manual No.: 6816102H01

DOCUMENT HISTORY

The following major changes have been implemented in this manual since the previous edition:

Edition	Description	Date
6816102H01-A	Initial Edition	Nov. 2005

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Safety Information

Product Safety and RF Energy Exposure Booklet for Portable Two-Way Radios

The information provided in this document supersedes the general safety information contained in user guides published prior to February 2002.



Caution

BEFORE USING THIS RADIO, READ THE FOLLOWING INFORMATION WHICH CONTAINS IMPORTANT OPERATING INSTRUCTIONS FOR SAFE USAGE AND RF ENERGY AWARENESS AND CONTROL INFORMATION AND OPERATIONAL INSTRUCTIONS FOR COMPLIANCE WITH RF ENERGY EXPOSURE LIMITS IN APPLICABLE NATIONAL AND INTERNATIONAL STANDARDS. ALSO READ THE OPERATIONAL INSTRUCTIONS FOR SAFE USAGE. FOR RADIOS THAT HAVE BEEN APPROVED AS INTRINSICALLY SAFE, READ THE INSTRUCTIONS AND INFORMATION ON INTRINSIC SAFETY ON PAGE vii.

RF Energy Exposure Awareness and Control Information and Operational Instructions for Occupational Use

NOTICE: This radio is intended for use in occupational/controlled conditions where users have full knowledge of their exposure and can exercise control over their exposure to meet the occupational limits in FCC and International standards. This radio device is NOT authorized for general population or consumer use.

This two-way radio uses electromagnetic energy in the radio frequency (RF) spectrum to provide communications between two or more users over a distance. It uses radio frequency (RF) energy or radio waves to send and receive calls. RF energy is one form of electromagnetic energy. Other forms include, but are not limited to, sunlight and x-rays. RF energy, however, should not be confused with these other forms of electromagnetic energy, which when used improperly, can cause biological damage. Very high levels of x-rays, for example, can damage tissues and genetic material.

Experts in science, engineering, medicine, health, and industry work with organizations to develop standards for safe exposure to RF energy. These standards provide recommended levels of RF exposure for both workers and the general public. These recommended RF exposure levels include substantial margins of protection.

All Motorola two-way radios are designed, manufactured, and tested to ensure they meet government-established RF exposure levels. In addition, manufacturers also recommend specific operating instructions to users of two-way radios. These instructions are important because they inform users about RF energy exposure and provide simple procedures on how to control it.

Please refer to the following websites for more information on what RF energy exposure is and how to control your exposure to assure compliance with established RF exposure limits:
http://www.fcc.gov/oet/rfsafety/rf-faqs.html
http://www.osha.gov/SLTC/radiofrequencyradiation/index.html

Federal Communication Commission (FCC) Regulations

The FCC rules require manufacturers to comply with the FCC RF energy exposure limits for portable two-way radios before they can be marketed in the U.S. When two-way radios are used as a consequence of employment, the FCC requires users to be fully aware of and able to control their exposure to meet occupational requirements.

Exposure awareness can be facilitated by the use of a product label directing users to specific user awareness information. Your Motorola two-way radio has a RF exposure product label. Also, your Motorola user manual, or separate safety booklet includes information and operating instructions required to control your RF exposure and to satisfy compliance requirements.

Compliance with RF Exposure Standards

Your Motorola two-way radio is designed and tested to comply with a number of national and International standards and guidelines (listed below) for human exposure to radio frequency electromagnetic energy. This radio complies with the IEEE (FCC) and ICNIRP exposure limits for occupational/controlled RF exposure environments at operating duty factors of up to 50% talk-50% listen and is authorized by the FCC for occupational use only.

In terms of measuring RF energy for compliance with these exposure guidelines, your radio generates measurable RF energy only while it is transmitting (during talking), not when it is receiving (listening) or in standby mode.

NOTE: The approved batteries, supplied with this radio, are rated for a 5-5-90 duty factor (5% talk-5% listen-90% standby) even though this radio complies with FCC occupational exposure limits and may operate at duty factors of up to 50% talk.

Your Motorola two-way radio complies with the following RF energy exposure standards and guidelines:

- United States Federal Communications Commission, Code of Federal Regulations; 47CFR part 2 sub-part J
- American National Standards Institute (ANSI) / Institute of Electrical and Electronic Engineers (IEEE) C95. 1-1992
- Institute of Electrical and Electronic Engineers (IEEE) C95.1-1999 Edition
- International Commission on Non-Ionizing Radiation Protection (ICNIRP) 1998
- Ministry of Health (Canada) Safety Code 6. Limits of Human Exposure to Radiofrequency Electromagnetic Fields in the Frequency Range from 3 kHz to 300 GHz, 1999
- Australian Communications Authority Radiocommunications (Electromagnetic Radiation - Human Exposure) Standard, 2003
- ANATEL ANNEX to Resolution No. 303 of July 2, 2002 "Regulation of limitation of exposure to electrical, magnetic and electromagnetic fields in the radio frequency range between 9 KHz and 300 GHz" and "Attachment to resolution # 303 from July 2, 2002"
  "Additional Requirements for SMR, Cellular and PCS Product Certification"

RF Exposure Compliance and Control Guidelines and Operating Instructions

To control your exposure and ensure compliance with the occupational/controlled environment exposure limits, always adhere to the following procedures.

Guidelines:

- Do not remove the RF Exposure Label from the device.
- User awareness instructions should accompany device when transferred to other users.
- Do not use this device if the operational requirements described herein are not met.

Operating Instructions

- Transmit no more than the rated duty factor of 50% of the time. To transmit (talk), push the Push-To-Talk (PTT) button. To receive calls, release the PTT button. Transmitting 50% of the time, or less, is important because this radio generates measurable RF energy exposure only when transmitting (in terms of measuring for standards compliance).
- Hold the radio in a vertical position in front of the face with the microphone (and other parts of the radio including the antenna) at least one inch (2.5 centimeters) away from the nose or lips.



- Antenna should be kept away from the eye. Keeping the radio at a proper distance is important since RF exposures decrease with increasing distance from the antenna.
- When worn on the body, always place the radio in a Motorola-approved clip, holder, holster, case, or body harness for this product. Using approved body-worn accessories is important because the use of non-Motorola-approved accessories may result in exposure levels, which exceed the FCC occupational/controlled environment RF exposure limits.
- If you are not using a body-worn accessory and are not using the radio in the intended use position in front of the face, ensure the antenna and the radio are kept at least one inch (2.5 centimeters) from the body when transmitting. Keeping the radio at a proper distance is important because RF exposures decrease with increasing distance from the antenna.

Approved Accessories

- Use only Motorola-approved supplied or replacement antennas, batteries, and accessories. Use of Non-Motorola approved antennas, batteries, and accessories may exceed the FCC (IEEE) and ICNIRP RF exposure guidelines.
- For a list of Motorola-approved accessories, visit the following website, which lists approved accessories for your radio model: http://www.motorola.com/governmentandenterprise.

Additional Information

For additional information on exposure requirements or other training information, visit http://www.motorola.com/rfhealth.

Electromagnetic Interference/Compatibility

NOTE: Nearly every electronic device is susceptible to electromagnetic interference (EMI) if inadequately shielded, designed, or otherwise configured for electromagnetic compatibility.

Facilities

To avoid electromagnetic interference and/or compatibility conflicts, turn off your radio in any facility where posted notices instruct you to do so. Hospitals or health care facilities may be using equipment that is sensitive to external RF energy.

Aircraft

When instructed to do so, turn off your radio when on board an aircraft. Any use of a radio must be in accordance with applicable regulations per airline crew instructions.

Medical Devices

Pacemakers

The Advanced Medical Technology Association (AdvaMed) recommends that a minimum separation of 6 inches (15 centimeters) be maintained between a handheld wireless radio and a pacemaker. These recommendations are consistent with those of the U.S. Food and Drug Administration.

Persons with pacemakers should:

- ALWAYS keep the radio more than 6 inches (15 centimeters) from their pacemaker when the radio is turned ON.
- Not carry the radio in the breast pocket.
- Use the ear opposite the pacemaker to minimize the potential for interference.
- Turn the radio OFF immediately if there is any reason to suspect that interference is taking place.

Hearing Aids

Some digital wireless radios may interfere with some hearing aids. In the event of such interference, you may want to consult your hearing aid manufacturer to discuss alternatives.

Other Medical Devices

If you use any other personal medical device, consult the manufacturer of your device to determine if it is adequately shielded from RF energy. Your physician may be able to assist you in obtaining this information.

Use of communication devices while driving

Always check the laws and regulations on the use of radios in the areas where you drive.

- Give full attention to driving and to the road.
- Use hands-free operation, if available.
- Pull off the road and park before making or answering a call, if driving conditions or regulations so require.

Operational Warnings



WARNING

For vehicle with air bags

Refer to vehicle manufacturer's manual prior to installation of electronic equipment to avoid interference with air bag wiring.

Do not place a portable radio in the area over an air bag or in the air bag deployment area. Air bags inflate with great force. If a portable radio is placed in the air bag deployment area and the air bag inflates, the radio may be propelled with great force and cause serious injury to occupants of the vehicle.

Potentially Explosive Atmospheres

(Explosive atmospheres refers to hazard classified locations that may contain hazardous gas, vapors, or dusts.)

Turn off your radio prior to entering any area with a potentially explosive atmosphere unless it is a portable radio type especially qualified for use in such areas as Intrinsically Safe (for example, Factory Mutual, CSA, UL, or CENELEC).

Do not remove, install, or charge batteries in such areas. Sparks in a potentially explosive atmosphere can cause an explosion or fire resulting in bodily injury or even death.

The areas with potentially explosive atmospheres referred to above include fueling areas such as below decks on boats, fuel or chemical transfer or storage facilities, and areas where the air contains chemicals or particles such as grain, dust or metal powders. Areas with potentially explosive atmospheres are often, but not always, posted.

Blasting Caps And Blasting Areas

To avoid possible interference with blasting operations, turn off your radio when you are near electrical blasting caps, in a blasting area, or in areas posted: "Turn off two-way radio." Obey all signs and instructions.

Operational Cautions



Caution

Antennas

Do not use any portable radio that has a damaged antenna. If a damaged antenna comes into contact with your skin, a minor burn can result.

Batteries

All batteries can cause property damage and/or bodily injury, such as burns, if a conductive material such as jewelry, keys, or beaded chains touches exposed terminals. The conductive material may complete an electrical circuit (short circuit) and become quite hot. Exercise care in handling any charged battery, particularly when placing it inside a pocket, purse, or other container with metal objects.

Intrinsically Safe Radio Information

The Intrinsically safe approval unit refers to a product that has been approved as intrinsically safe by an approval agency (for example FM Approvals, CSA, UL, or Cenelec) and certifies that a particular product meets the Agency's applicable intrinsic safety standards for specific types of hazardous classified locations. A portable radio that has been approved for intrinsic safety will have Approval label attached to the radio to identify the unit as being Approved for specified hazardous atmospheres. This label specifies the hazardous Class/Division/Group along with the part number of the battery that must be used. The intrinsically safe approval label will be located on the portable radio unit.

Operational Cautions for Intrinsic Safe Equipment



Caution

- Do not operate radio communications equipment in a hazardous atmosphere unless it is a type especially qualified (for example, FM, UL, CSA, or CENELEC approved). An explosion or fire may result.
- Do not operate a radio unit that has been approved as intrinsically safe product in a hazardous atmosphere if it has been physically damaged (for example, cracked housing). An explosion or fire may result.
- Do not replace or charge batteries in a hazardous atmosphere. Contact sparking may occur while installing or removing batteries and cause an explosion or fire.

Warnings for Radios Approved as Intrinsically Safe

Radios must ship from the Motorola manufacturing facility with the hazardous atmosphere capability and the intrinsic safety approval labelling (FM, UL, CSA, CENELEC). Radios will not be upgraded to this capability and labeled once they have been shipped to the field.

A modification changes the unit's hardware from its original design configuration. Modifications can only be made by the original product manufacturer.



WARNING

- **Do not replace or change accessories in a hazardous atmosphere. Contact sparking may occur while installing or removing accessories and cause an explosion or fire.**
- **Turn the radio off before removing or installing a battery or accessory.**
- **Do not disassemble an intrinsically safe product in any way that exposes the internal circuits of the unit.**
- **Failure to use an intrinsically safe approved battery or Approved accessories specifically approved for the radio unit may result in the dangerously unsafe condition of an unapproved radio combination being used in a hazardous location.**
- **Unauthorized or incorrect modification of the intrinsically safe approved Product will negate the approval rating of the product.**
- **Incorrect repair or relabeling of any intrinsically safe Agency approved radio could adversely affect the Approval rating of the unit.**
- **Use of a radio that is not intrinsically safe in a hazardous atmosphere could result in serious injury or death.**

Repair



WARNING

REPAIRS FOR MOTOROLA PRODUCTS WITH INTRINSICALLY SAFE APPROVAL ARE THE RESPONSIBILITY OF THE USER.

- **Repairs to a Motorola FM approved radio product should only be done at a location that has been FM audited under the FM 3605 repairs and service standard.**
- **Contact Motorola for assistance regarding repairs and service of Motorola intrinsically safe equipment.**

A repair constitutes something done internally to the unit that would bring it back to its original condition.

Items not considered as repairs are those in which an action is performed on a unit which does not require the outer casing of the unit to be opened in a manner that exposes the internal electrical circuits of the unit.

Do Not Substitute Options or Accessories

The Motorola communications equipment certified as intrinsically safe by the approving agency, (FM, UL, CSA, CENELEC) is tested as a complete system which consists of the listed agency Approved portable, Approved battery, and Approved accessories or options, or both. This Approved portable and battery combination must be strictly observed. There must be no substitution of items, even if the substitute has been previously Approved with a different Motorola communications equipment unit. Approved configurations are listed by the Approving Agency (FM, UL, CSA, CENELEC).

The intrinsically safe Approval label affixed to radio refers to the intrinsically safe classification of that radio product, and the approved batteries that can be used with that system.

The manual PN referenced on the intrinsically safe approval label identifies the approved Accessories and or options that can be used with that portable radio unit.

Using a non Motorola intrinsically safe battery and or accessory with the Motorola approved radio unit will void the intrinsically safe approval of that radio unit.

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Section 1

INTRODUCTION

1.0 Scope of Manual

This manual is intended for use by service technicians familiar with similar types of equipment. It contains service information required for the equipment described and is current as of the printing date. Changes which occur after the printing date may be incorporated by a complete Manual revision or alternatively as additions.

NOTE Before operating or testing these units, please read the Safety Information Section in the front of this manual.

2.0 Warranty and Service Support

Motorola offers long term support for its products. This support includes full exchange and/or repair of the product during the warranty period, and service/ repair or spare parts support out of warranty. Any "return for exchange" or "return for repair" by an authorised Motorola Dealer must be accompanied by a Warranty Claim Form. Warranty Claim Forms are obtained by contacting an Authorised Motorola Dealer.

2.1 Warranty Period and Return Instructions

The terms and conditions of warranty are defined fully in the Motorola Dealer or Distributor or Reseller contract. These conditions may change from time to time and the following notes are for guidance purposes only.

In instances where the product is covered under a "return for replacement" or "return for repair" warranty, a check of the product should be performed prior to shipping the unit back to Motorola. This is to ensure that the product has been correctly programmed or has not been subjected to damage outside the terms of the warranty.

Prior to shipping any radio back to the appropriate Motorola warranty depot, please contact Customer Resources (Please see page 1-2). All returns must be accompanied by a Warranty Claim Form, available from your Customer Services representative. Products should be shipped back in the original packaging, or correctly packaged to ensure no damage occurs in transit.

2.2 After Warranty Period

After the Warranty period, Motorola continues to support its products in two ways.

1. Motorola's Managed Technical Services (MTS) offers a repair service to both end users and dealers at competitive prices.
2. MTS supplies individual parts and modules that can be purchased by dealers who are technically capable of performing fault analysis and repair.

2.3 Piece Parts

Some replacement parts, spare parts, and/or product information can be ordered directly. If a complete Motorola part number is assigned to the part, it is available from Motorola's Managed Technical Services (MTS). If no part number is assigned, the part is not normally available from Motorola. If the part number is appended with an asterisk, the part is serviceable by Motorola Depot only. If a parts list is not included, this generally means that no user-serviceable parts are available for that kit or assembly.

All orders for parts/information should include the complete Motorola identification number. All part orders should be directed to your local MTS office. Please refer to your latest price pages.

2.4 Technical Support

Technical support is available to assist the dealer/distributor in resolving any malfunction which may be encountered. Initial contact should be by telephone wherever possible. When contacting Motorola Technical Support, be prepared to provide the product model number and the unit's serial number.

2.5 Further Assistance From Motorola

You can also contact the Customer Help Desk through the following web address.

http://www.motorola.com/governmentandenterprise/contactus

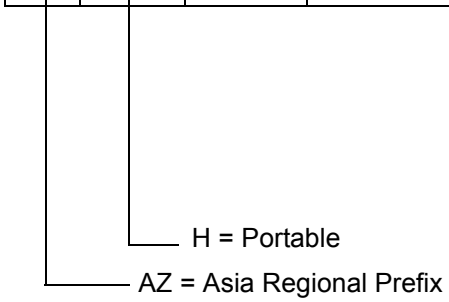
NOTE Only Motorola Service Centers or Approved Motorola Service Dealers can perform these functions. Any tampering by non-authorised Motorola Service Centers voids the warranty of your radio. To find out more about Motorola and its approved Service Centers, please visit http://www.motorola.com/governmentandenterprise/public/functions/home/home.aspx

3.0 Radio Model Information

The model number and serial number are located on a label attached to the back of your radio. You can determine the RF output power, frequency band, protocols, and physical packages. The example below shows one portable radio model number and its specific characteristics.

Table 1-1 Radio Model Number (Example: AZH84KDC8AA3)

	Type of Unit	Model Series	Freq. Band	Power Level	Physical Packages	Channel Spacing	Protocol	Feature Level
AZ	H	84	K (150-174 MHz)	D 5W	C 16-Channel Black	8 12.5/25K	AA Conventional	3 A8
			R (450-470MHz)	C 4W				



4.0 Radio Features

Feature	A8
Normal Operation	
Rx/Tx	X
Radio-CPS-Radio Cloning	X
Radio-to-Radio Cloning	X
Factory Reset	X
Low Battery Indication	X
Self Test	X
Programming Button	
Hi/Lo Power	X
Volume Set	X
Monitor	X
Sticky Monitor	X
Scan Activate	X
Nuisance Channel Delete	X
Repeater / Talkaround	X
PL/DPL	X
Button Lock	X
Battery Save Mode	X
Squelch	X
Unassigned	X
CPS	
Rx Freq	X
Tx Freq	X
RX PL/DPL/IDPL	X
TX PL/DPL/IDPL	X
User Defined PL (TPL1, TPL2, TPL 3)	X
Squelch Type (Normal / Tight)	X
Unmute/Mute Rules	X
Power Level (High/Low)	X
TPL Reverse Burst	X
Turn Off Code	X
Rx Only	X
Busy Channel Lock Out (BCLO)	X
Channel Spacing (25 KHz / 12.5KHz)	X
Talkaround	X

Feature	A8
Time Out Timer	X
Battery Save Mode	X
Quick Key Override	X
Password Protection	X
Scan List	X
Normal Scan	X
Priority Scan	X
Talkback Scan	X

Section 2

VHF BAND 2 INFORMATION (150-174MHZ)

Model Chart

1.0

A8 150-174MHz VHF					
Model					Description
AZH84KDC8AA3					A8 150-174 MHz, 5W, 12.5/25K-16ch, EU Mid-Rate Charger
	Option AZQ341AB				ALT Mid-Rate Charger 240V UK 3-pin
		Option AZQ339AB			ALT Mid-Rate Charger 110V US 2-pin
			Option AZQ358AD		ALT Mid-Rate Charger 220V CN 2-pin
				Item	Description
X	X	X	X	PMUD2085_AA	A8 150-174M 5W 12.5/25K - 16CH
X	X	X	X	PMAD4051_	Mag One 150-174MHz Antenna
X	X	X	X	PMLN4691_	Mag One Spring Belt Clip
X	X	X	X	PMLN4685_	Mag One Mid-Rate Charger Base
X				2515943H01	Mag One Mid-Rate Transformer 230V EU 2-pin
	X			2515942H01	Mag One Mid-Rate Transformer 240V UK 3-pin
		X		2515941H01	Mag One Mid-Rate Transformer 110V US 2-pin
			X	2515944H01	Mag One Mid-Rate Transformer 220V CN 2-pin
X	X	X	X	PMNN4071_	Mag One NiMH Battery 1200mAH
X	X	X	X	PMNN4071_C	Mag One NiMH Battery 1200mAH (Chinese Label)
X	X	X	X	6816189H01	Mag One Mid-Rate Charger Manual
X	X	X		6815549H01	A8 User Guide, APAC English
			X	6815553H01	A8 User Guide, APAC Chinese
X	X	X	X	6816103H01	Mag One Warranty Card
X	X	X	X	6804110J47	Safety Leaflet - Portable 2-Way Radios

2.0 Specifications

General

	VHF
Frequency:	150-174 MHz
Channel Capacity:	16
Power Supply:	7.5 Volts ±20%
Dimensions with Standard High Capacity NiMH Battery:	118mm x 56mm x 37mm
Weight: with Standard High Capacity NiMH Battery:	350g
Sealing:	Passes rain testing per IPX4 (EN60529=1991)
Shock and Vibration:	Meets MIL STD 810C, D E and F
Dust:	Meets MIL STD 810C, D E and F
Humidity:	Meets MIL STD 810C, D E and F

Transmitter

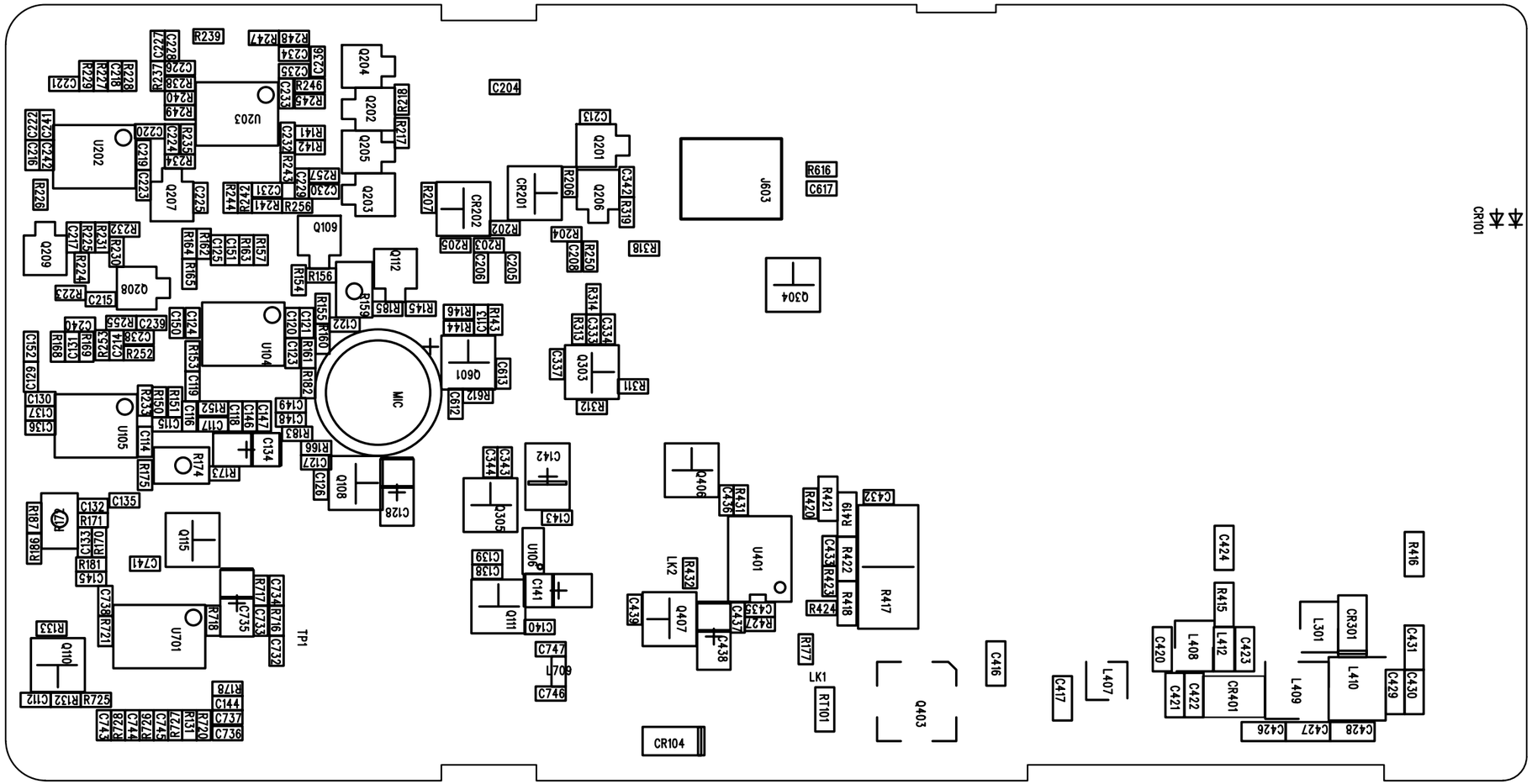
	VHF
Channel Spacing	12.5/25 kHz
Freq. Stability (-30°C to +60°C)	0.00025%
Spurs/Harmonics:	-26 dBm
Audio Response: (from 6 dB/oct. Pre-Emphasis, 300 to 3000Hz)	+1, -3 dB
Audio Distortion: @ 1000 Hz, 60% Rated Max. Dev.	<5%
FM Noise:	36 dB

Receiver

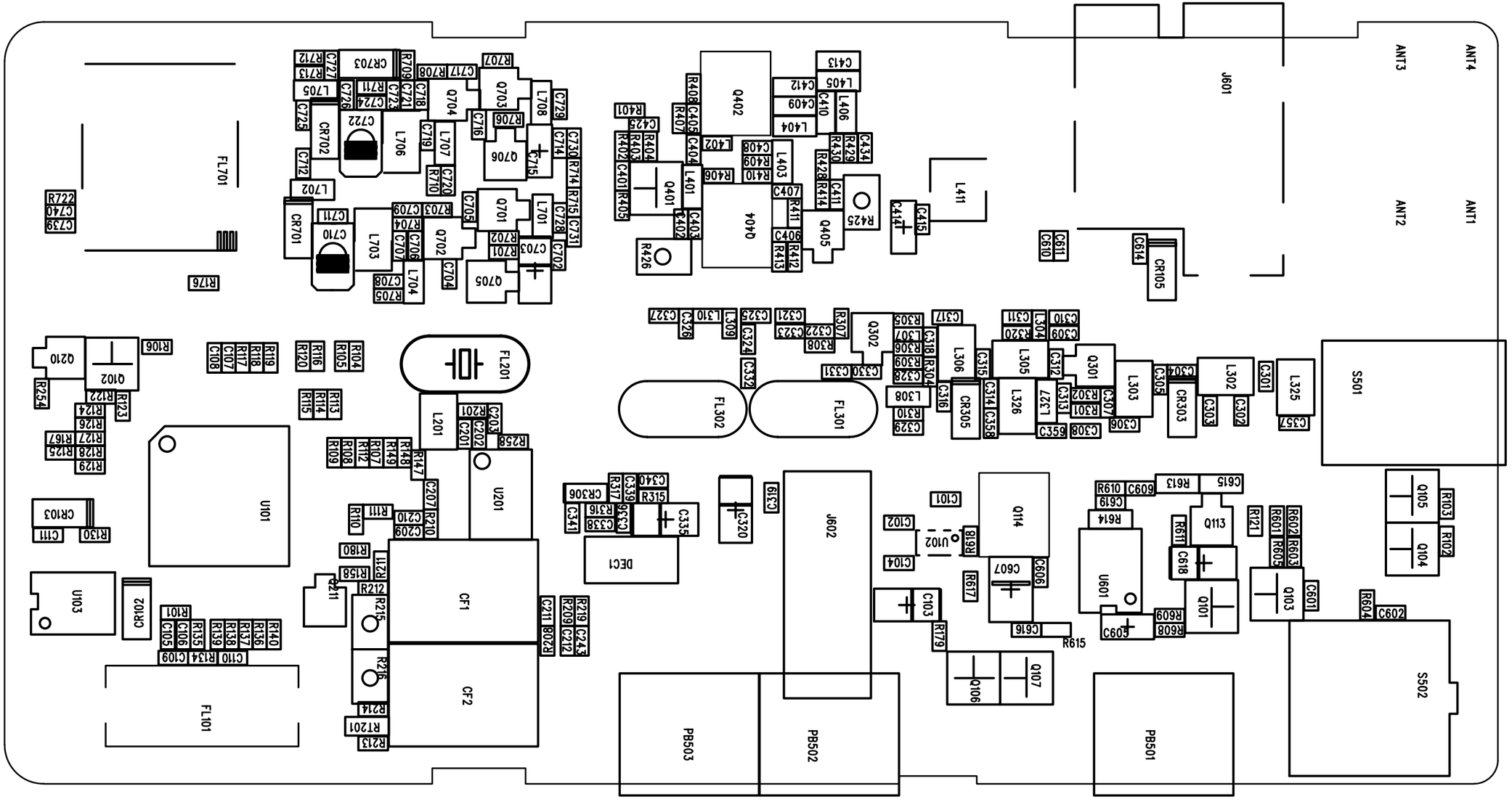
Hum and Noise	40 dB
Audio Distortion	< 5%
Conducted Emmision	-57 dBm
Audio Output @ <5% Distortion	250 mW

All specifications are subject to change without notice.

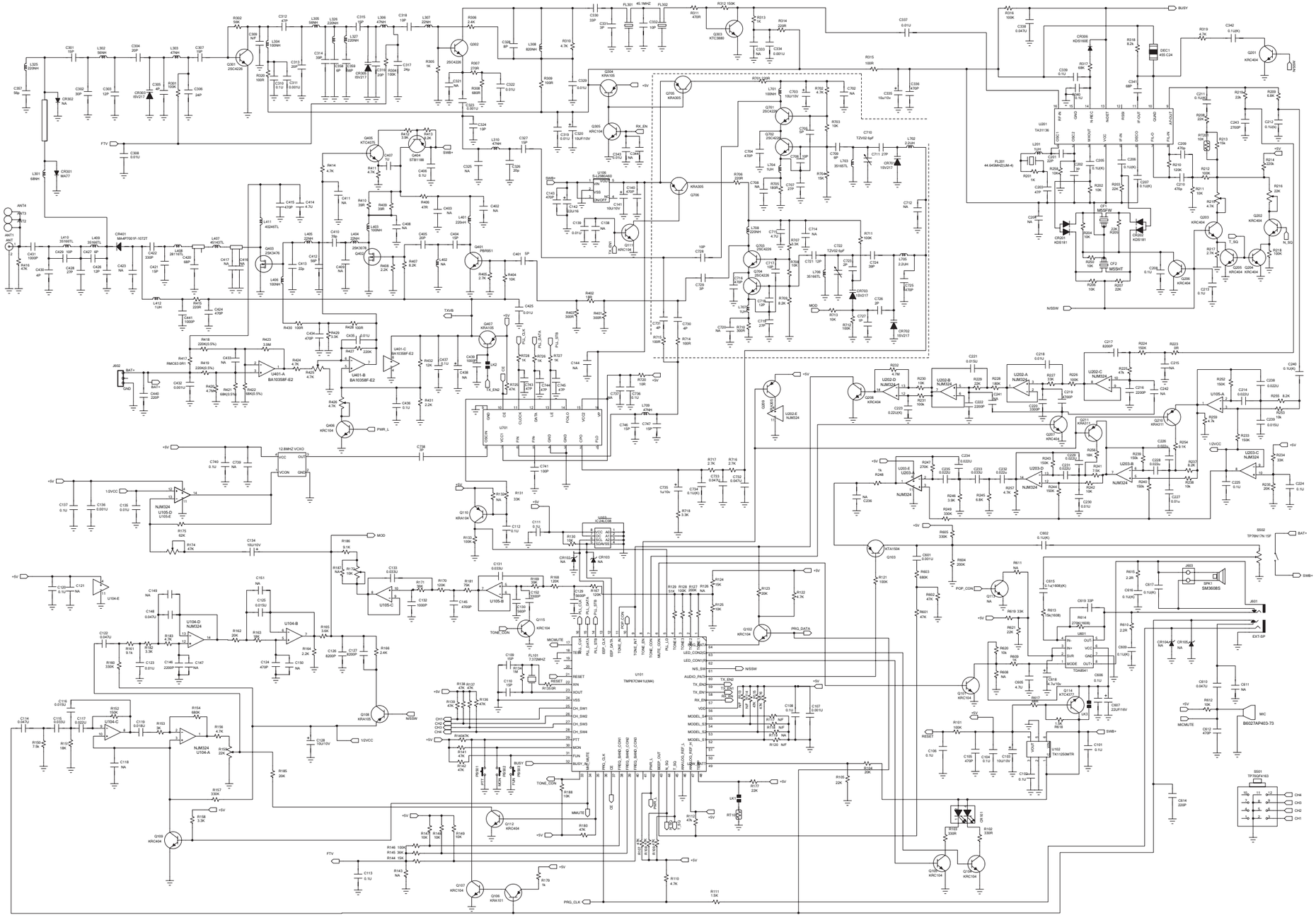
3.0 RF Circuit Board and Schematic Diagram



VHF 150-174 MHz Main Board Top Side



VHF 150-174 MHz Main Board Bottom Side



VHF Band 2 (150-174MHz) Schematic Diagram

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Section 3

UHF BAND 2 INFORMATION (450-470MHZ)

1.0 Model Chart

A8 450-470MHz 4W 12.5/25K-16C	
Model	Description
AZH84RCC8AA3	A8 450-470 MHz, 4W, 12.5/25K-16ch, Black, APAC
Option AZQ453AB	ALT Mid-Rate Charger 240V UK 3-pin
Option AZQ454AB	ALT Mid-Rate Charger 110V US 2-pin
Option AZQ455AB	ALT Mid-Rate Charger 220V CN 2-pin
Item	Description
PMUE2384_AA	A8 450-470MHz 5W 12.5/25K-16CH
PMAE4020_	Mag One 450-470MHz Antenna
PMLN4691_	Mag One Spring Belt Clip
PMLN4685_	Mag One Mid-Rate Charger Base
2515943H01	Mag One Mid-Rate Transformer 230V EU 2-pin
2515942H01	Mag One Mid-Rate Transformer 240V UK 2-pin
2515941H01	Mag One Mid-Rate Transformer 110V US 2-pin
2515944H01	Mag One Mid-Rate Transformer 220V CN 2-pin
PMNN4071_	Mag OneNiMH Battery, 1200mAH
PMNN4071_C	Mag OneNiMH Battery, 1200mAH, Chinese Label
6816189H01	Mag One Mid-Rate Charger Manual
6815549H01	A8 User Guide, APAC English
6815553H01	A8 User Guide, APAC Chinese
6816103H01	Mag One Warranty Card
6804110J47	Safety Leaflet - Portable 2-Way Radios

2.0 Specifications

General

	UHF
Frequency:	450-470 MHz
Channel Capacity:	16
Power Supply:	7.5 Volts ±20%
Dimensions with Standard High Capacity NiMH Battery:	107mm x 58mm x 37mm
Weight: with Standard High Capacity NiMH Battery:	350g
Sealing:	Passes rain testing per IPX4 (EN60529=1991)
Shock and Vibration:	Meets MIL STD 810C, D E and F
Dust:	Meets MIL STD 810C, D E and F
Humidity:	Meets MIL STD 810C, D E and F

Transmitter

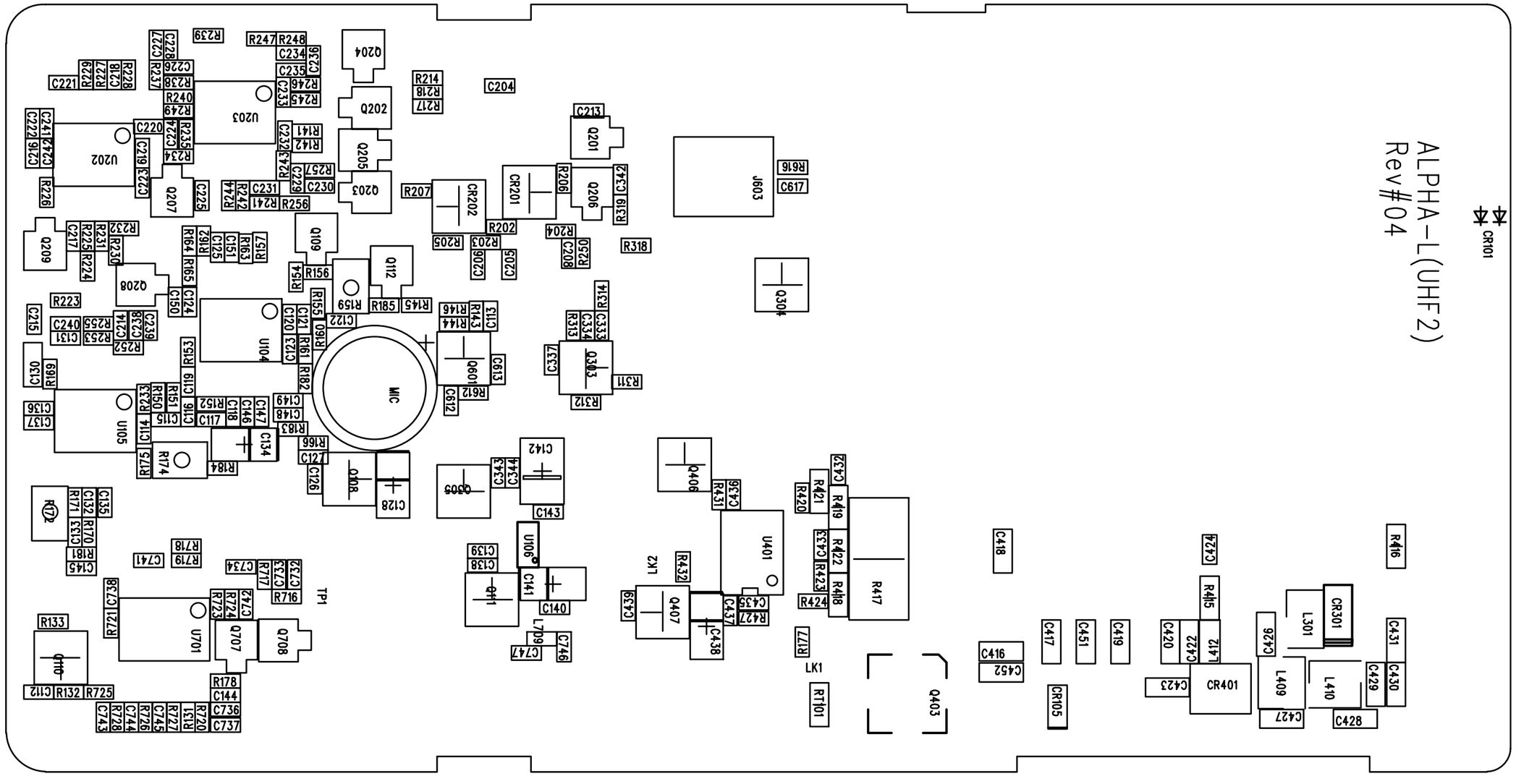
	UHF
Channel Spacing	12.5/25 kHz
Freq. Stability (-30×C to +60×C)	0.00025%
Spurs/Harmonics:	-27 dBm
Audio Response: (from 6 dB/oct. Pre-Emphasis, 300 to 3000Hz)	+1, -3 dB
Audio Distortion: @ 1000 Hz, 60% Rated Max. Dev.	<5%
FM Noise:	36 dB

Receiver

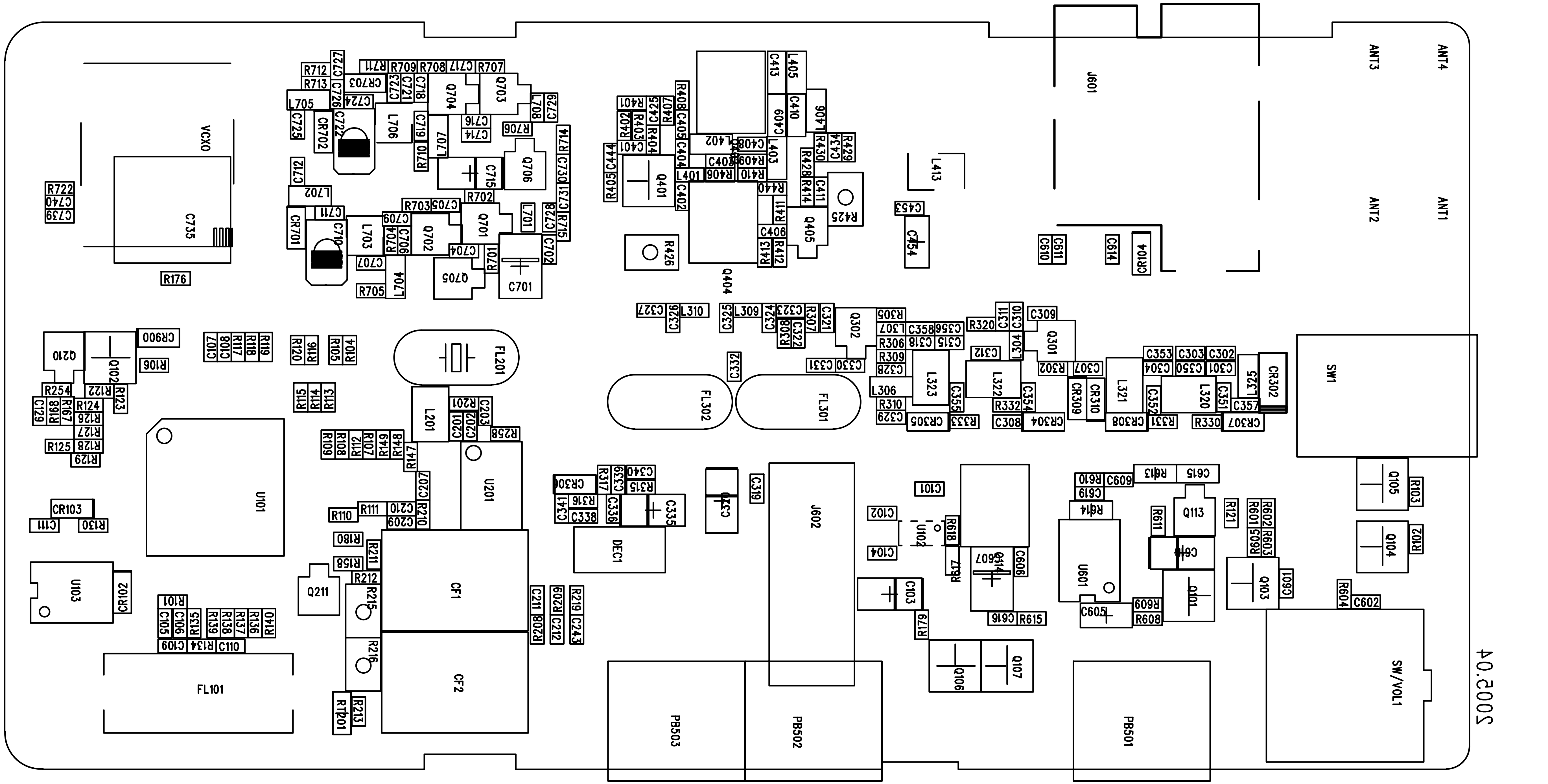
Hum and Noise	40 dB
Audio Distortion	< 5%
Conducted Emmision	-57 dBm

All specifications are subject to change without notice.

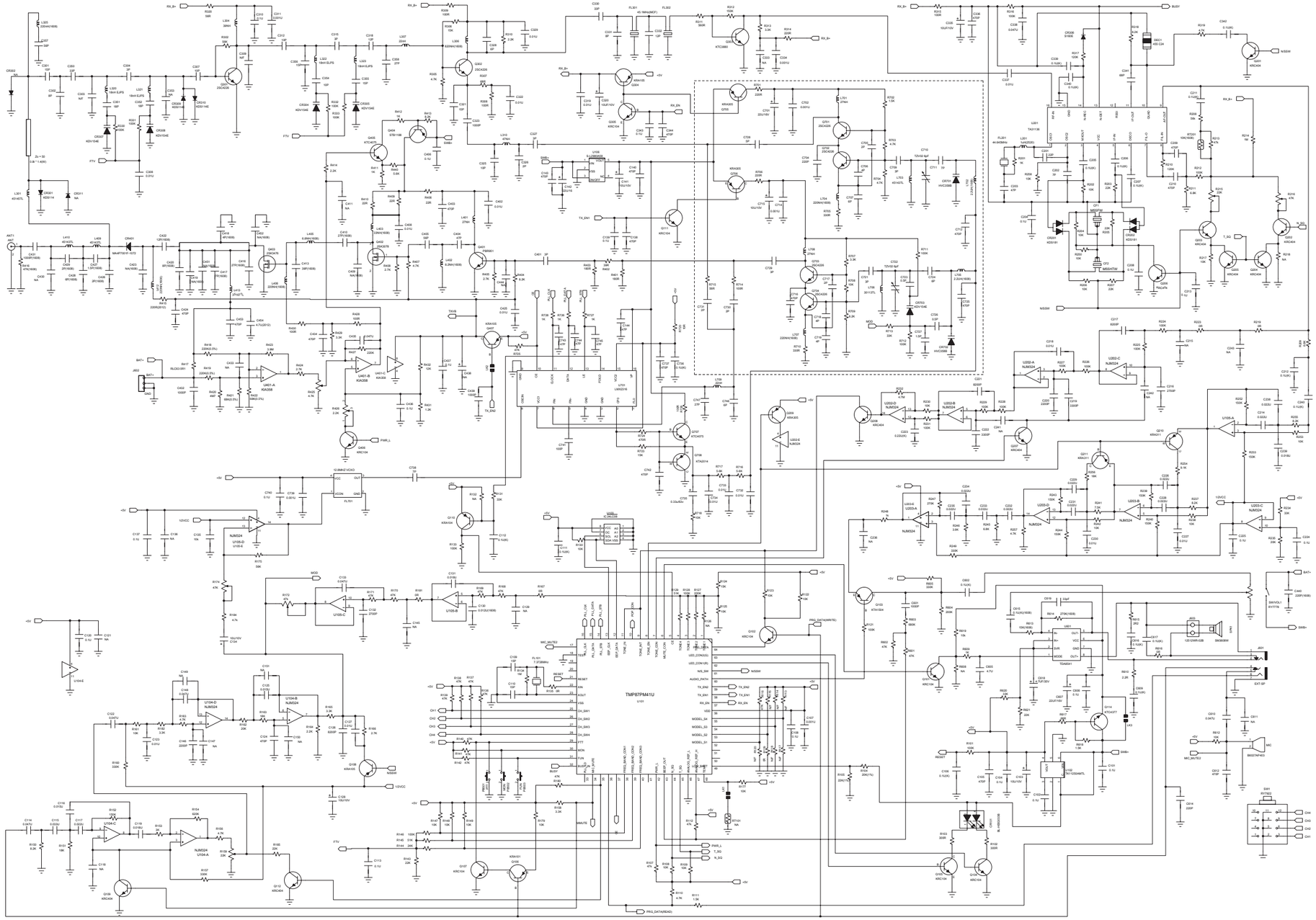
3.0 RF Circuit Board and Schematic Diagrams



UHF2 450-470 MHz Main Board Top Side



UHF2 450-470 MHz Main Board Bottom Side



UHF2 450-470 MHz Schematic Diagram

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Section 4

THEORY OF OPERATION

1.0 Overview

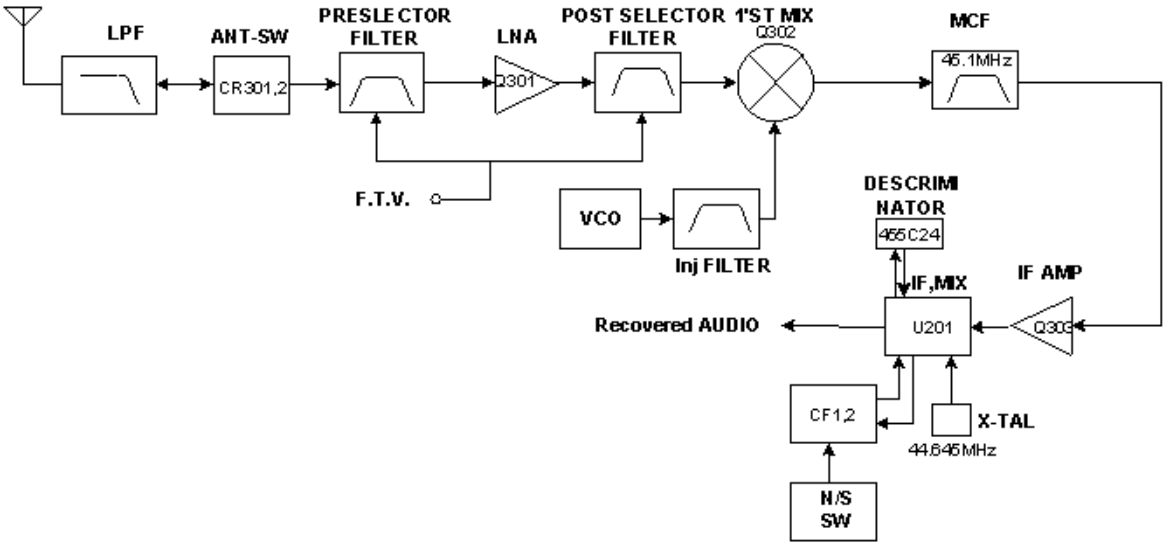
1.1 Purpose

This section defines the theory of operation (or the Circuit Description) for the radio. At the same time, it provides a description of the circuit theory and analysis of the radio hardware design.

1.2 General Description

The radio comprises of one main PCB board. The main PCB contains a receiver, a transmitter, a phase-locked loop (PLL) frequency synthesizer, control circuits and power supply circuits.

2.0 Receiver System



The receiver is a double conversion super heterodyne with 1st IF 45.1MHz and 2nd IF 455kHz.

2.1 Front-End

Front-end consists of low pass filter, pre-selector filter, RF amplifier, post-selector filter. The receive signal from antenna is applied to TX LPF (L409, L410, C426, C427, C428, C429, C430) and routed to an RF amplifier (Q301) after passing transmit / receive switch (CR401, CR301, CR302) and pre-selector. The signal from pre-selector is amplified around 13dB at RF AMP(Q301) and filtered again by post-selector before applying to Mixer. The pre-selector and post-selector are band-shift type filters designed to remove unwanted signals.

2.2 First Mixer

The signal from receiver front-end is channeled into the Mixer (Q302) base and heterodyned with the first local signal generated from the VCO to be the first IF frequency (45.1MHz). The first IF frequency is resonated at tank circuit C328, L308 (VHF) or L306 (UHF) and channeled into the pair of crystal filters.

2.3 IF Amplifier

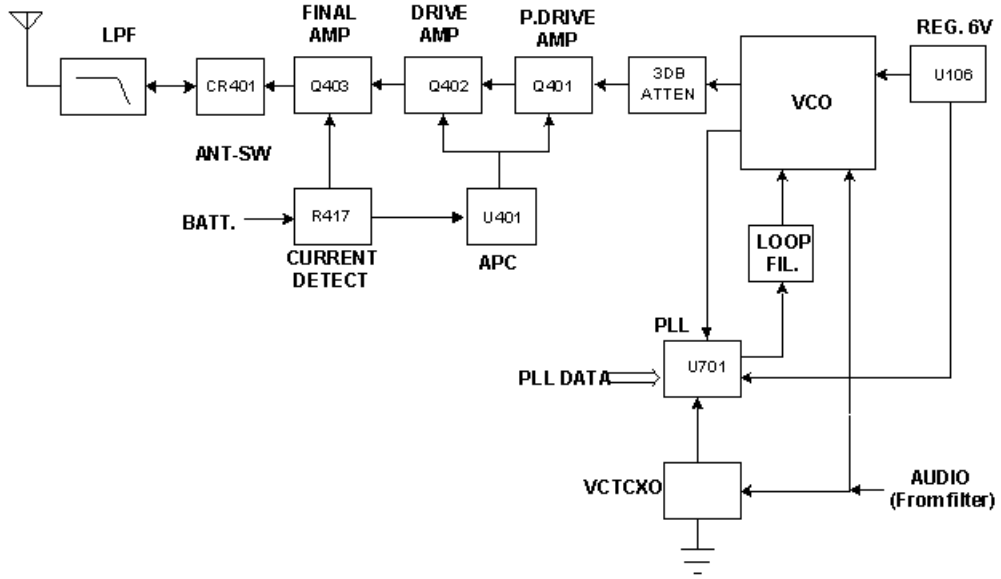
The first IF signal is amplified about 15dB using the IF amp Q303 and channelled into IF IC (U201) to be mixed with the second local frequency (44.645MHz). The first IF frequency (45.1MHz) and second local frequency (44.645MHz) are mixed in U201 to produce the second IF frequency (455KHz). The second IF frequency is sent through the ceramic filter (CF1, CF2) to eliminate undesired signal and demodulated by demodulator in U201.

The 455Khz ceramic filter consist of a wide(CF1) and narrow(CF2) filter. The filtering is changed to wide and narrow band by the switch (SW).

2.4 Squelch

U201 has a filter that filters noise and an internal amplifier that amplifies the noise and make it a DC voltage in order to control the squelch system. So if the noise level is under a threshold, the microprocessor (U101) in the radio detects the DC level and un-mutes the radio. If the noise level is over a threshold, the microprocessor mutes the radio.

3.0 Transmitter System and PLL Synthesizer



The transmitter consists of a Microphone, Pre-emphasis, Modulator, Drivers, Power Amplifier, Low-Pass Filter, Antenna Switch and an Auto-Power Control.

3.1 TX Power Stage

TX VCO output signal is inputted by TX power stage via attenuator. The attenuator is a pie style resister attenuator, and is used for isolation between the VCO and power amps.

TX Power stage consist of pre-drive (Q401), drive amp (Q402) and final amp (Q403). The -4dBm TX RF signal from attenuator is increased to around +25dBm by pre-drive and drive amp.

TX signal from drive amp is amplified by final amp, Q403. It passes through a strip line for impedance matching and low pass filter to suppress unwanted harmonics via antenna switch.

3.2 Antenna Switch

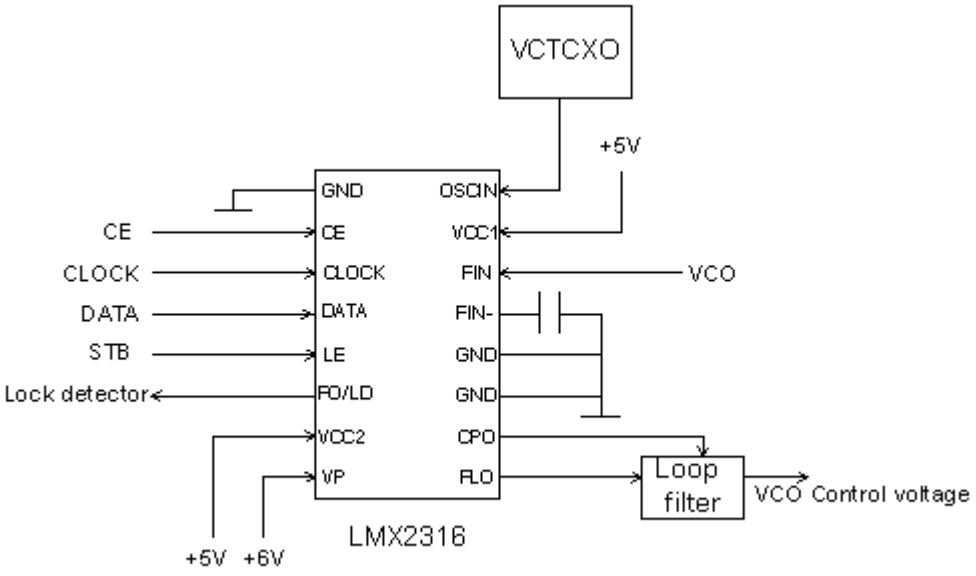
In transmit mode, PIN diode (CR401, CR301, CR302) are forward biased and enable the RF signal to pass to the antenna.

3.3 Low Pass Filter

TX Low Pass Filter consist of 5th Chebyshev filter and reduces the unwanted spurious for TX output power from final Amp. : C426~430, L409, L410.

3.4 Auto-Power Control

The voltage difference across R417 is amplified through U401 by the ratio of R423 to R417. The differential signal at the output of U401 is channelled into Q404 and Q405 which then produce a constant power output to the antenna. If the current is changed due to a change of battery voltage or load, APC controls the gate voltage of Q403 and the collector voltage of Q401 and 402 to keep the TX power stable. This circuit stabilizes the TX power at a pre-determined level adjusted by R425 (High Power) and R426(Low Power).



3.4.1 12.8 MHz VCTCXO

Reference frequency is 12.8Mhz VCTCXO (Voltage Controlled Temperature Compensated Crystal Oscillator). Main frequency can be adjusted by chip trimmer of VCTCXO. This frequency provides a reference to the PLL. It has a frequency stability of +/-2.5PPM at -30^{o} to +60^{o}.

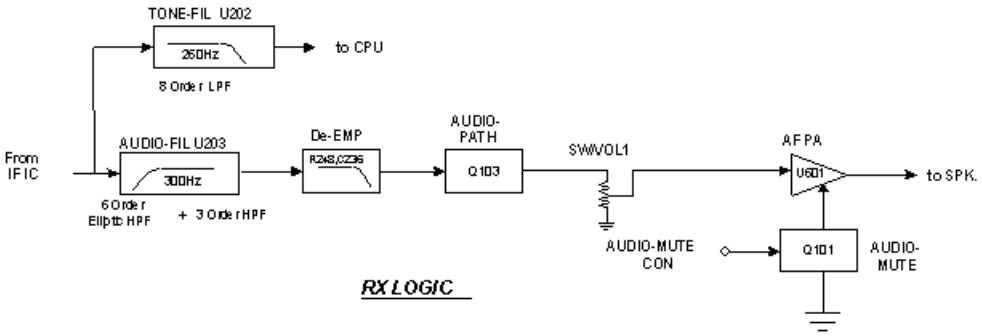
3.4.2 PLL IC and Loop Filter .

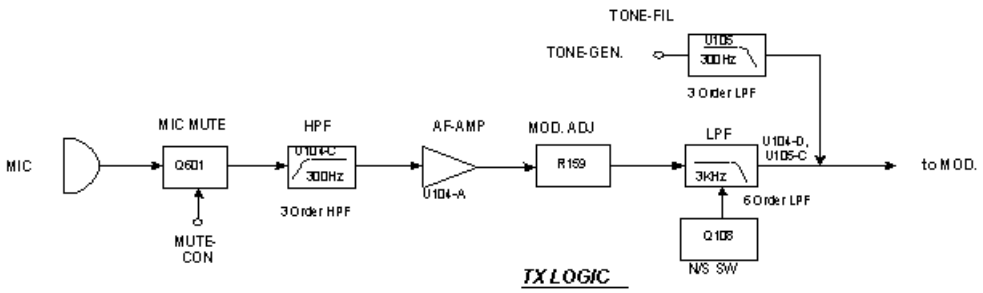
The input frequency of 12.8Mhz is channelled into the PLL IC (U701) pin 8. It is divided to 6.25Khz or 5Khz by a reference counter, R. The RF signal input from the VCO is divided by prescaler (32/33), N counter in PLL IC. The internal phase comparator compares signal from the VCO with the reference frequency. The regulator 6V is thing to increase internal charge pump voltage of PLL IC. The LPF contains C735, C734 and R718. This also reduces the residual side-band noise for the best signal-to-noise ratio.

3.4.3 Dual VCO

The dual VCO module contains a RX VCO and a TX VCO. They are configured as Colpits oscillators and connected to power through cascade buffers. Only one VCO is selected at a time. The power source to each block is switched by transistors Q305 and Q111, and is dependent on the states of TX_EN1 and RX_EN. The varicap diodes CR701 and CR702 produce a change in frequency with a change in voltage. L703 and L706 are resonant tuning coils, which adjust the operating frequency with specific DC tuning voltage applied. The audio signals from the low pass filter (U105-C) is applied to the CR703 varicap diode in TX VCO to be the modulated TX RF signal.

4.0 Audio and Control Circuit





4.1 RX Audio

RX audio signal comes through the de-emphasis pass 6 order elliptic 300 Hz HPF and 3 order 300Hz HPF. This 300Hz High Pass Filter (U203) removes all signals under 300Hz to keep any undesired signal from being heard from speaker. After passing through this filter, audio signal is de-emphasized by R248 and C236 to get 6db/oct response. The de-emphasized audio signal passes through volume control (SW/VOL1) and is amplified to a sufficient level to drive a loud speaker by U601 Audio AMP. U601 has mute/un-mute function by audio-mute control in CPU. If U601 pin 2 is low, the audio amp goes into active mode. If the pin 2 is high, the IC goes into mute mode.

4.2 RX Sub-Audible Decode Circuit

The 260Hz 8 order LPF, U202, passes through the CTCSS and CDCSS signals and block all other signals. The signal that passes through this LPF filter changes the sub-tone to logic signal in Q208 and subsequently passes through the comparator (U202-D). Then, the microprocessor can decode CTCSS and CDCSS correctly.

4.3 TX Audio

If users push PTT button, the microprocessor activates the whole transmitter chain including the microphone. The audio signal from the microphone passes through the 3 order 300Hz HPF and limiting amp (U104-C,A) that has 6db/oct pre-emphasis function. The pre-emphasized audio signal is adjusted to a proper level by R159 and passes through 6 order 3KHz LPF (U104-D,U105-C) before being modulated. Wide and narrow channel spacing are controlled by N/S switch (Q108).

4.4 TX Sub-Audible Encode Circuit

The encode circuit of CTCSS and CDCSS mixes signals from four ports of microprocessor. The mixed signal passes through 3 order 300Hz LPF (U105-B) to obtain clear CTCSS and CDCSS signals.

4.5 Microprocessor

U101 controls all functions of the radio as a Microprocessor. It is operated by an external 7.3728MHz crystal. It detects external activities such as pressing PTT, muting/un-muting, changing channel and making the radio operate accordingly.

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GLOSSARY OF TERMS

Term	Definition
Busy Channel Lockout (BCLO)	If BCLO is activated, the radio will check for channel activity before transmitting. If activity is detected, transmission is prohibited. For carrier squelch mode, radio will not transmit, if it is receiving carrier. For coded squelch mode, it will not transmit, if it is receiving carrier with different PL/DPL code.
Carrier	An electromagnetic signal that is transmitted on a selected frequency for the purpose of carrying voice or data transmissions along with it. Carrier can then be received by all radios listening on that frequency.
CD	Compact Disk.
Channel	A single path separated by frequency or time divisions used for transmitting and/or receiving voice and/or data.
Codeplug	A solid-state chip inside a radio where the radio's personality data is stored.
CPS	Acronym for Customer Programming Software. Licensed Motorola software used to program two-way radios with a unique set of features.
Frequency	(a) The location of the center of a channel of operation in the radio spectrum. Measured in Megahertz (MHz). (b) A computer speed. Measured in Megahertz (MHz).
Model Number	The model number identifies the type of radio. This information is stored in the radio's codeplug.
Normal Scan	For Normal Scan, the radio assigns equal priority to all members in the Scan List selected for the current channel. When the radio is scanning a Scan List (Active Scan), all scan list members (including the Home Channel) will be allocated equal time to be scanned. For example, if the Home Channel is H1, and the Scan List Members are Nn, then the scanning sequence is: N1, N2, N3, ..., H1, N1, N2, ..., etc.
PLL	Phase-Locked Loop: a circuit in which an oscillator is kept in phase with a reference, usually after passing through a frequency divider.
Priority Scan	For Priority Scan, the radio assigns the highest priority to the channel defined in the CPS as Priority Channel. When the radio is scanning a Scan List (Active Scan), 50% of the scans are targeted at the Priority Channel. For example, if the Priority Channel is P1, and the non-priority Scan List Members are Nn, then the scanning sequence is: P1, N1, P1, N2, P1, N3, P1, N4, P1, N5, etc.
Program	The transfer of CPS information from the computer's temporary memory (RAM) to the radio.
PTT	Push-To-Talk: the switch located on the left side of the radio which, when pressed, causes the radio to transmit.
RESET	Reset line: an input to the microcontroller that restarts execution.
Reverse Burst / Turn Off Code	Causes a Tone Private Line (TPL) or Digital Private Line (DPL) code to be transmitted at the end of a transmission - once PTT is released, and while operating on the current channel. This sub-audible tone causes the receiving radio to mute its speaker before loss of a carrier is detected. Muting the speaker eliminates unwanted noise (squelch tail) during loss of carrier detection.

Term	Definition
ROM	Read Only Memory.
Scan List	The Scan List determines which channels the radio scans, when operating in the Scan Mode, on the current channel.
Scan List Member	The Scan List allows you to select the grouping of channels that make up the current Scan List Member channels. This grouping of Scan List Member channels can then be scanned for transmission activity - one at a time, when the radio is in Scan Mode. A Scan List can have a maximum of 16 Scan List Members. Scan List Member scanning priority is definable.
Scan Mode	When the radio is in one of the two Scan States: Active Scan and Landed Scan. This mode is initiated when the programmable SCAN button is pressed.
Serial Number	Each radio has its own unique serial number. This information is stored in the radio's codeplug.
Software	Computer programs, procedures, rules, documentation, and data pertaining to the operation of a system.
Squelch	Muting of audio circuits when received signal levels fall below a pre-determined value.
Tone Private Line (TPL)	Transmitted when the receiving radio is to only receive calls from radios with specific TPL codes, this creates communications groups while operating in Conventional Dispatch mode. TPL allows for more use and privacy on a frequency. TPL is transmitted at a sub-audible (not able to be heard) frequency. Also known as *CTCSS*.
Tx Frequency	A designated frequency used when transmitting carrier for the current channel.
µC	Microcontroller.
UHF	Ultra High Frequency.
VHF	Very High Frequency.