MOTOROLA

CDM™ and PRO SERIES™

Mobile Radios

Detailed Service Manual

As Dedicated As You Are

Professional Radio

Computer Software Copyrights

The Motorola products described in this manual may include copyrighted Motorola computer programs stored in semiconductor memories or other media. Laws in the United States and other countries preserve for Motorola certain exclusive rights for copyrighted computer programs, including the exclusive right to copy or reproduce in any form, the copyrighted computer program. Accordingly, any copyrighted Motorola computer programs contained in the Motorola products described in this manual may not be copied or reproduced in any manner without the express written permission of Motorola. Furthermore, the purchase of Motorola products shall not be deemed to grant, either directly or by implication, estoppel or otherwise, any license under the copyrights, patents or patent applications of Motorola, except for the normal non-exclusive royalty-free license to use that arises by operation of law in the sale of a product.

SAFETY INFORMATION

Important information on safe and efficient operation is included in this manual. Read this information before using your radio.

SAFE AND EFFICIENT OPERATION OF MOTOROLA TWO-WAY RADIOS

This document provides information and instructions for the safe and efficient operation of Motorola Portable and Mobile Two-Way Radios.

The information provided in this document supercedes the general safety information contained in user guides published prior to 1st. January 1998.

For information regarding radio use in hazardous areas, please refer to the Factory Mutual (FM) approval manual supplement or Instruction Card which is included with radio models that offer this capability.

EXPOSURE TO RADIO FREQUENCY ENERGY

Your Motorola Two-Way Radio, which generates and radiates radio frequency (RF) electromagnetic energy (EME) is designed to comply with the following National and International Standards and Guidelines regarding exposure of human beings to radio frequency electromagnetic energy:

- Federal Communications Commission Report and Order No. FCC 96-326 (August 1996)
- American National Standards Institute (C95.1 - 1992)
- National Council on Radiation Protection and Measurements (NCRP-1986)
- International Commission on Non-Ionizing Radiation Protection (ICNRP- 1986)
- European Committee for Electrotechnical Standardisation (CENELEC):

ENV 50166-1 1995 E	Human exposure to electromagnetic fields Low frequency (0 Hz to 10 kHz)
ENV 50166-2 1995 E	Human exposure to electromagnetic fields High frequency (10 kHz to 300 GHz)
Proceedings of SC211/B 1996	“Safety Considerations for Human Exposure to EMFs from Mobile Telecommunication Equipment (MTE) in the Frequency Range 30MHz - 6 GHz.” (EMF - Electro-Magnetic Fields)

To assure optimal radio performance and to ensure that your exposure to radio frequency electromagnetic energy is within the guidelines in the above standards, always adhere to the following procedures:

PORTABLE RADIO OPERATION AND EME EXPOSURE

- When transmitting with a portable radio, hold radio in a vertical position with the microphone 2.5 to 5 centimeters (one or two inches) away from the mouth. Keep antenna at least 2.5 centimeters (one inch) from your head or body when transmitting.
- If you wear a portable Two-Way radio on your body, ensure that the antenna is at least 2.5 centimeters (one inch) from the body when transmitting.

ELECTROMAGNETIC INTERFERENCE/COMPATIBILITY

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

- To avoid electromagnetic interference and/or compatibility conflicts, turn off your radio in any facility where posted notices instruct you to do so. Hospital or health facilities may be using equipment that is sensitive to external RF energy.
- When instructed to do so, turn off your radio when on board an aircraft. Any use of a radio must be in accordance with airline regulations or crew instructions.

OPERATIONAL WARNINGS

Vehicles with an air bag

- 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 vehicle.

Potentially explosive atmospheres

- Turn off your Two-Way radio when you are in any area with a potentially explosive atmosphere, unless it is a radio type especially qualified for use in such areas (e.g. FM or Cenelec approved). Sparks in a potentially explosive atmosphere can cause an explosion or fire resulting in bodily injury or even death.

Batteries

- Do not replace or recharge batteries in a potentially explosive atmosphere. Contact sparking may occur while installing or removing batteries and cause an explosion.

Blasting caps and 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.

NOTE The areas with potentially explosive atmospheres referred to above include fuelling areas such as: below decks on boats; fuel or chemical transfer or storage facilities; areas where the air contains chemicals or particles, such as grain, dust or metal powders; and any other area where you would normally be advised to turn off your vehicle engine. Areas with potentially explosive atmospheres are often but not always posted.

OPERATIONAL CAUTIONS

Damaged antennas

- Do not use any portable Two-Way 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 jewelery, keys or beaded chains touch 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

FMRC Approved Equipment

Anyone intending to use a radio in a location where hazardous concentrations of flammable material exist (hazardous atmosphere) is advised to become familiar with the subject of intrinsic safety and with the National Electric Code NFPA 70 (National Fire Protection Association) Article 500 (hazardous [classified] locations).

An Approval Guide, issued by Factory Mutual Research Corporation (FMRC), lists manufacturers and the products approved by FMRC for use in such locations. FMRC has also issued a voluntary approval standard for repair service ("Class Number 3605").

FMRC Approval labels are attached to the radio to identify the unit as being FM 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. Depending on the design of the portable unit,

this FM label can be found on the back of the radio housing or the bottom of the radio housing.Their Approval mark is shown below.

WARNING

WARNING: Do not operate radio communications equipment in a hazardous atmosphere unless it is a type especially qualified (e.g. FMRC Approved) for such use. An explosion or fire may result.

WARNING: Do not operate the FMRC Approved Product in a hazardous atmosphere if it has been physically damaged (e.g. cracked housing). An explosion or fire may result.

WARNING: 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.

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.

WARNING: Do not operate the FMRC Approved Product unit in a hazardous location with the accessory contacts exposed. Keep the connector cover in place when accessories are not used.

WARNING: Turn radio off before removing or installing a battery or accessory.

WARNING: Do not disassemble the FMRC Approved Product unit in any way that exposes the internal electrical circuits of the unit.

Radios must ship from the Motorola manufacturing facility with the hazardous atmosphere capability and FM Approval labeling. Radios will not be “upgraded” to this capability and labeled in the field.

A modification changes the unit’s hardware from its original design configuration. Modifications can only be done by the original product manufacturer at one of its FMRC audited manufacturing facilities.

WARNING

WARNING: Failure to use an FMRC Approved Product unit with an FMRC Approved battery or FMRC Approved accessories specifically approved for that product may result in the dangerously unsafe condition of an unapproved radio combination being used in a hazardous location.

Unauthorized or incorrect modification of an FMRC Approved Product unit will negate the Approval rating of the product.

Repair of FMRC Approved Products

REPAIRS FOR MOTOROLA FMRC APPROVED PRODUCTS ARE THE RESPONSIBILITY OF THE USER.

You should not repair or relabel any Motorola manufactured communication equipment bearing the FMRC Approval label (“FMRC Approved Product”) unless you are familiar with the current FMRC Approval standard for repairs and service (“Class Number 3605).

You may want to consider using a repair facility that operates under 3605 repair service approval.

WARNING

WARNING: Incorrect repair or relabeling of any FMRC Approved Product unit could adversely affect the Approval rating of the unit.

WARNING: Use of a radio that is not intrinsically safe in a hazardous atmosphere could result in serious injury or death.

FMRC's Approval Standard Class Number 3605 is subject to change at any time without notice to you, so you may want to obtain a current copy of 3605 from FMRC. Per the December, 1994 publication of 3605, some key definitions and service requirements are as follows:

Repair

A repair constitutes something done internally to the unit that would bring it back to its original condition Approved by FMRC. A repair should be done in an FMRC Approved facility.

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 which exposes the internal electrical circuits of the unit. You do not have to be an FMRC Approved Repair Facility to perform these actions.

Relabeling

The repair facility shall have a method by which the replacement of FMRC Approval labels are controlled to ensure that any relabeling is limited to units that were originally shipped from the Manufacturer with an FM Approval label in place. FMRC Approval labels shall not be stocked by the repair facility. An FMRC Approval label shall be ordered from the original manufacturer as needed to repair a specific unit. Replacement labels may be obtained and applied by the repair facility providing satisfactory evidence that the unit being relabeled was originally an FMRC Approved unit. Verification may include, but is not limited to: a unit with a damaged Approval label, a unit with a defective housing displaying an Approval label, or a customer invoice indicating the serial number of the unit and purchase of an FMRC Approved model.

Do Not Substitute Options or Accessories

The Motorola communications equipment certified by Factory Mutual is tested as a system and consists of the FM Approved portable, FM Approved battery, and FM 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 in the FM Approval guide published by FMRC, or in the product FM Supplement. This FM Supplement is shipped with FM Approved radio and battery combination from the manufacturer. The Approval guide, or the Approval standard Class Number 3605 document for repairs and service, can be ordered directly through Factory Mutual Research Corporation located in Norwood, Massachusetts.

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Chapter 1

Introduction

1.1 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 that occur after the printing date are 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.**

1.2 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 authorized Motorola dealer must be accompanied by a warranty claim form. Warranty claim forms are obtained by contacting customer service.

1.2.1 Warranty Period

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.

1.2.2 Return Instructions

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 a Motorola warranty depot, please contact the appropriate customer service for instructions. 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.

1.2.3 After Warranty Period

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

Firstly, Motorola's Accessories and Aftermarket Division (ADD) offers a repair service to both end users and dealers at competitive prices.

Secondly, Motorola’s service department supplies individual parts and modules that can be purchased by dealers who are technically capable of performing fault analysis and repair.

1.3 Related Documents

The following documents are directly related to the use and maintainability of this product.

Title	Part Number
Service Manual, Basic, Engl	68P81091C62
Service Manual, Basic, Engl	68P81092C71
Service Manual, Basic, Port	68P81092C73
Service Manual, Basic,Span	68P81092C72
Service Manual, Detailed, Engl	68P81091C63
Service Manual, Detailed, Port	68P81092C76
Service Manual, Detailed, Span	68P81092C75

1.4 Technical Support

Technical support is available to assist the dealer/distributor and self-maintained customers in resolving any malfunction which may be encountered. Initial contact should be by telephone to customer resources wherever possible. When contacting Motorola technical support, be prepared to provide the product model number and the unit's serial number. The contact locations and telephone numbers are listed below.

United States and Puerto Rico: 1-800-694-2161, Options 1, 3

Brasil: 000-811-682-0550

Colombia: 980-12-0451

Mexico: 001-800-694-2161

From other countries: (954)723-3008

1.5 Warranty and Repairs

For warranty and repairs, contact Motorola Technical Support as listed below. Be prepared to provide the product **model number** and the unit's **serial number**.

Some replacement parts, spare parts, and/or product information can be ordered directly. If a complete Motorola part number is assigned to the part, and it is not identified as "Depot ONLY", the part is available from Motorola Accessories and Aftermarket Division (AAD). 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 a 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.Technical Support the product **model number** and the unit's **serial number**.

Parts Order Entry
7:00 A. M. to 7:00 P. M. (Central Standard Time)
Monday through Friday (Chicago, U. S. A.)

To Order Parts in the United States of America:
1-800-422-4210, or 847-538-8023
1-800-826-1913, or 410-712-6200 (U. S. Federal Government)
TELEX: 280127
FAX: 1-847-538-8198
FAX: 1-410-712-4991 (U. S. Federal Government)
(U. S. A.) after hours or weekends:
1-800-925-4357

To Order Parts in Latin America and the Caribbean:
1-847-538-8023
Motorola Parts
Accessories and Aftermarket Division
(United States and Canada)
Attention: Order Processing
1313 E. Algonquin Road
Schaumburg, IL 60196
Accessories and Aftermarket Division
Attention: Latin America and Caribbean

Order Processing
1313 E. Algonquin Road
Schaumburg, IL 60196

Parts Identification
1-847-538-0021 (Voice)
1-847-538-8194 (FAX)

Colombia
Motorola de Colombia
Diagonal 127A 17-64
Santa Fe de Bogota
Columbia
Telefono: 1-615-5759

Brazil
Motorola Do Brasil
Rua Bandeira Paulista, 580
Phone: (11)821-9991
Fax: (11)828-0157

Puerto Rico
Motorola de Puerto Rico
A BE. Chardon, Edificio Telemundo 2
Hato Rey, PR 00918
Telefono: (787)641-4100
Fax: (787)782-3685

Mexico
Motorola De Mexico
Blvd. Manuel Avila Camacho #32, Primer Piso
COL. Lomas de Chapultepec
Mexico D.F. 06700 CP 11000
Mexico
Phone: (5)387-0501
Fax: (5)387-0554

1.6 Radio Model Chart and Specifications

The radio model charts and specifications are located in the Basic Service Manual listed under the Related Documents paragraph of this chapter.

1.7 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 from these numbers. The example below shows one portable radio model number and its specific characteristics.

Table 1-1. Radio Model Number

Example: AAM25RHC9AA1AN

	Type of Unit	Model Series	Freq. Band	Power Level	Physical Packages	Channel Spacing	Protocol	Feature Level	Model Revision	Model Package
AA or LA ↑ Motorola Internal Use	**M** ↑ **M** = Mobile	**25**	**K** VHF (136-174MHz)	**H** 1-25W	**A** No Display, No Keypad	**9** Program-mable	**AA** Conventional	**1** 4F	**A**	**N**
			R UHF1 (403-470MHz)	**K** 25-40W	**C** No Display Basic Key-pad		**DU** LTR	**2** 64F		
			S UHF2 (450-512MHz)		**D** 1-Line Dis-play, Lim-ited Keypad			**5** 128F		
			B Low Band, R1 (29.7-36.0MHz)		**F** 1-Line Dis-play, Stan-dard Keypad			**8** 160F		
			C Low Band, R2 (36.0-42.0MHz)		**N** 4-Line Dis-play, Enhanced Keypad					
			D Low Band, R3 (42.0-50.0MHz)							

Chapter 2

Theory of Operation

2.1 Overview

This chapter provides a detailed theory of operation for the radio and its components. The radio is designed as a single board unit consisting of a transmitter, receiver, and controller circuits. The board also accepts one additional option board that can provide functions such as secure voice/data, voice storage, or a signalling decoder.

A control head mounted directly on the front of the radio or remotely connected by an extension cable provides a user interface for controlling the various features of the radio.The control head contains, LED indicators, microphone connector, and buttons depending on the radio type, display, and speaker.

If a control head is not mounted directly on the front of the radio, an expansion board containing circuits for special applications can be mounted in its place on the front of the radio. An additional control head may be connected using an extension cable.

The rear of the radio provides connections for a power, antenna, and accessory cable. The accessory cable provides connections for items such as an external speaker, emergency switch, foot operated PTT, and ignition sensing, etc.

2.2 Controller

The radio controller, shown in Figure 2-1, is divided into three main functions:

- Digital control
- Audio processing
- Voltage regulation.

The digital control section of the radio consists of a microprocessor (µP), support memory, support logic, signal MUX ICs, on/off circuit, and general purpose input/output circuits.

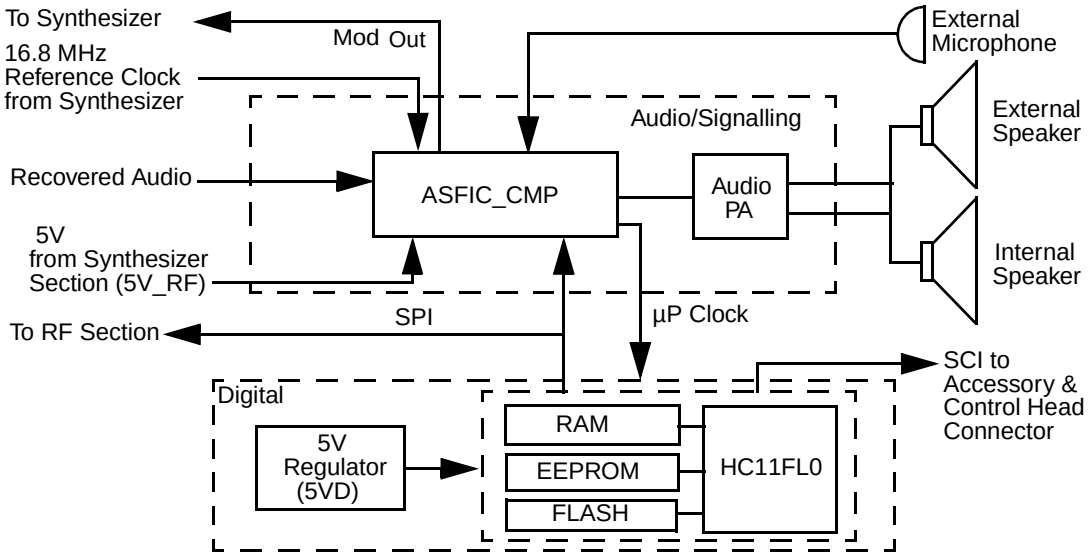


Figure 2-1. Controller Block Diagram

2.2.1 Radio Power Distribution

The dc power distribution throughout the radio board is shown in Figure 2-2. Voltage regulation for the controller is provided by four separate devices:

- U0651 (MC78M05) +5 volts
- U0641 (LM2941) +9.3 volts
- U0611 (LM2941) +12 volts
- VSTBY 5V (a combination of R0621 and VR0621)
- Additional 5 volt regulator located in the RF section.

The dc voltage applied to connector J0601 supplies power directly to the following:

- Electronic on/off control
- RF power amplifier
- 12 volt regulator
- 9.3 volt regulator
- Audio PA
- 5.6 volt stabilization circuit
- 9.3 volt regulator (U0641) supplies power to the 5 volt regulator (U0651) and 6 volt voltage divider Q0681

Regulator U0641 generates the 9.3 volts required by some audio circuits, the RF and power control circuits. Input and output capacitors C0641 and C0644 / C0645 are used to reduce high frequency noise. Resistors R0642 / R0643 set the output voltage of the regulator. If the voltage at pin 1 is greater than 1.3 volts the regulator output decreases and if the voltage is less than 1.3 volts the regulator output increases. This regulator output is enabled by a 0 volt signal on pin 2. Transistors Q0661, Q0641, and R0641 are used to disable the regulator when the radio is turned off.

Voltage regulator U0651 provides 5 volts operating voltage for the digital circuits. Operating voltage is from the regulated 9.3volts supply. Input and output capacitors (C0651 / C0652 and C0654 / C0655) reduce high frequency noise and provide proper operation during battery transients. Voltage sense device U0652 or alternatively U0653 provides a reset output that goes to 0 volts if the regulator output goes below 4.5 volts. This resets the controller to prevent improper operation. Diode D0651 prevents discharge of C0652 by negative spikes on the 9.3 volt supply.

Transistor Q0681 and resistors R0681 / R0682 divide the regulated 9.3 volts down to about 6 volts. This voltage supplies the 5 volt regulator, located on the RF section. By reducing the supply voltage of the regulator, the power dissipation is divided between the RF section and the controller section.

The VSTBY signal, derived directly from the supply voltage by components R0621 and VR0621, buffers the internal RAM. Capacitor C0622 allows the battery voltage to be disconnected for several seconds without losing RAM information. Dual diode D0621 prevents radio circuits from discharging this capacitor. When the supply voltage is applied to the radio, C0622 is charged via R0621 and D0621. When the radio is switched on, the µP enters the wrong mode if the voltage across C0622 is still too low. The regulated 5 volts charges C0622 via diode D0621.

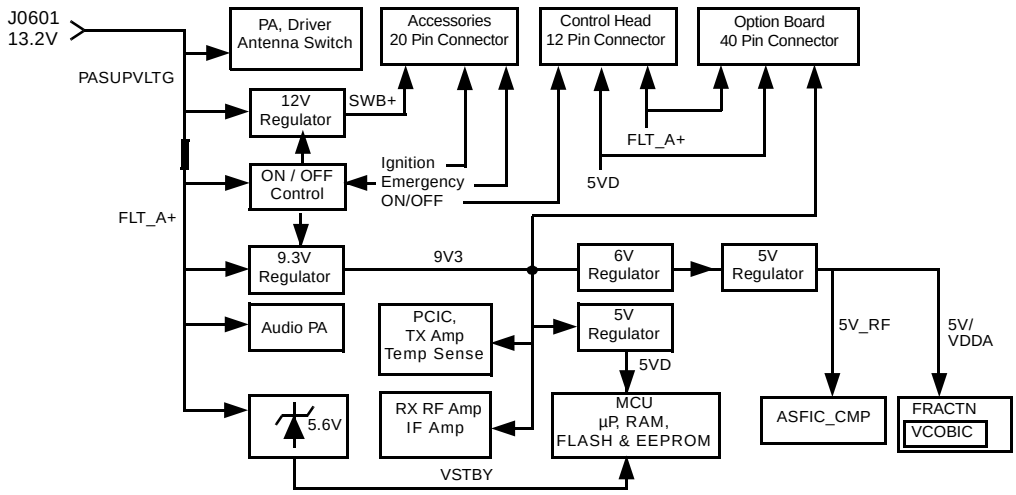


Figure 2-2. DC Power Distribution Block Diagram

The INT SW B+ voltage from switching transistor Q0661 provides power to the circuit controlling the audio PA output. The voltage is monitored by the µP through voltage divider R0671/R0672 and the line battery voltage. Diode VR0671 limits the divided voltage to 5.6 volts to protect the µP.

Regulator U0611 generates the voltage for the switched supply voltage output (SWB+) at accessory connector J0501, pin 13. U0611 operates as a switch with voltage and current limit. Resistors R0611/R0612 set the maximum output voltage to 16.5 volts. This limitation is only active at high supply voltage levels. The regulator output is enabled by a 0 volt signal at Q0661, pin 2. Q0641 and R0641 disable the regulator when the radio is turned off. Input and output capacitors C0603 and C0611/C0612 reduce high frequency noise.

Diode VR0601 protects against transients and reverse polarity of the supply voltage.

2.2.2 Automatic On/Off

The radio software and/or external triggers turn the radio on or off without direct user action. For example, automatic turn on when ignition is sensed and off when ignition is off.

Q0661 provides the INT SW B+ voltage to the various radio circuits and to enable the voltage regulators via transistor Q0641 which contains a pnp and an npn transistor that provide an electronic on/off switch. The switch is on when the collector of the npn transistor within Q0661 is low. When the radio is off the collector is at supply voltage level. This effectively prevents current flow from emitter to collector of the pnp transistor. When the radio is turned on the voltage at the base of the npn transistor is pulled high and the pnp transistor switches on (saturation). With the INT SWB+ voltage now at supply voltage level, transistor Q0641 pulls pin 2 of the voltage regulators U0611 and U 0641 to ground level, enabling their outputs.

The electronic on/off circuits are enabled by the µP through ASFIC CMP port GCB2, line DC POWER ON, emergency switch (line EMERGENCY CONTROL), the mechanical On/Off/Volume knob on the control head (line ON OFF CONTROL), or the ignition sense circuits (line IGNITION CONTROL). If any of the four paths cause a low at the collector of the npn transistor within Q0661, the electronic "ON" is engaged.

2.2.3 Emergency

The emergency switch (J0501, pin 9), when engaged, grounds the base of Q0662 via the EMERGENCY CONTROL line. This switches Q0662 off and resistor R0662 pulls the collector of Q0662 and the base of Q0663 to levels above two volts. Transistor Q0663 then switches on and pulls the collector of the npn transistor within Q0661 to ground level This enables the voltage regulators via Q0641. When the emergency switch is released, R0541 pulls the base of Q0662 up to 0.6 volts causing the collector of transistor Q0662 to go low (0.2 volts), switching Q0663 off.

While the radio is on, the µP monitors the voltage at the emergency input on the accessory connector via pin 60 and the GP5 IN ACC9 line. Three different conditions can exit: no emergency, emergency, and open connection to the emergency switch. If no emergency switch is connected or the connection to the emergency switch is broken, the resistive divider R0541/R0512 sets the voltage to about 4.7 volts. If an emergency switch is connected, a resistor to ground within the emergency switch reduces the voltage on line GP5 IN ACC9 to inform the µP that the emergency switch is operational. An engaged emergency switch pulls line GP5 IN ACC9 to ground level. Diode D0179 limits the voltage to protect the µP input.

While the EMERGENCY CONTROL signal is low and INT SW B+ is on, the µP starts execution, reads that the emergency input is active through the voltage level of line GP5 IN ACC9, and sets the DC POWER ON output of the ASFIC CMP, pin 13 to a logic high. This keeps Q0661 and Q0641 switched to allow a momentary press of the emergency switch to power up the radio. When the µP has finished processing the emergency press, it sets the DC POWER ON line to a logic 0. This turns off Q0661 and the radio turns off. Notice that the µP is alerted to the emergency condition via line GP5 IN ACC9. If the radio is already on when the emergency is triggered, the DC POWER ON signal is already high.

2.2.4 Mechanical On/Off

This refers to the on/off/volume knob located on the control head which is used to turn the radio on and off and control the volume.

If the radio is turned off and the on/off/volume knob is pressed, line ON OFF CONTROL (J0401, pin 11) goes high and switches the radio's voltage regulators on as long as the button is pressed. The µP is alerted through line ON OFF SENSE (U0101, pin 6) which is pulled to low by Q0110 while the on/off/volume knob is pressed. In addition, an interrupt is generated at µP, pin 96. The µP asserts line DC POWER ON via ASFIC CMP, pin 13 high which keeps the radio switched on. The µP switches the radio off by setting DC POWER ON to low via ASFIC CMP pin 13.

2.2.5 Ignition

Ignition sense prevents the radio from draining the vehicle's battery because the engine is not running.

When the IGNITION input (J0501, pin 10) goes above 5 volts, Q0661 is turned on via line IGNITION CONTROL. Q0661 turns on INT SW B+ and the voltage regulators by turning on Q0641 and the µP starts execution. The µP is alerted through line GP6 IN ACC10. While the on/off button is pressed, a high signal turns Q0181 on, which pulls µP, pin 74 to low. If the software detects a low state it asserts DC POWER ON via ASFIC, pin 13 high which keeps Q0661 and Q0641 and the radio switched on.

When the IGNITION input goes below 3 volts, Q0181 switches off and R0181 pulls µP, pin 74 to high. This alerts the software to switch off the radio by setting DC POWER ON to low. The next time the IGNITION input goes above 5 volts the above process is repeated.

2.2.6 Microprocessor Clock Synthesizer

The clock source for the µP system is generated by the ASFIC CMP (U0221). Upon power-up the synthesizer IC (FRAC-N) generates a 16.8 MHz waveform that is routed from the RF section to the ASFIC CMP, pin 34. For the main board controller the ASFIC CMP uses 16.8 MHz as a reference input clock signal for its internal synthesizer. The ASFIC CMP, in addition to the audio circuit, has a programmable synthesizer which can generate a synthesized signal ranging from 1200Hz to 32.769MHz in 1200Hz steps.

When power is first applied, the ASFIC CMP generates its default 3.6864MHz CMOS square wave UP CLK (on U0221, pin 28) and this is routed to the µP (U0101, pin 90). After the µP starts operation, it reprograms the ASFIC CMP clock synthesizer to a higher UP CLK frequency (usually 7.3728 or 14.7456 MHz) and continues operation.

The ASFIC CMP may be reprogrammed to change the clock synthesizer frequencies at various times depending on the software features that are executing. In addition, the clock frequency of the synthesizer is changed in small amounts if there is a possibility of harmonics of this clock source interfering with the desired radio receive frequency.

The ASFIC CMP synthesizer loop uses C0245, C0246 and R0241 to set the switching time and jitter of the clock output. If the synthesizer cannot generate the required clock frequency it switches back to its default 3.6864MHz output.

Because the ASFIC CMP synthesizer and the µP do not operate without the 16.8 MHz reference clock, the synthesizer and the voltage regulators should be checked first in debugging the system.

The µP uses crystal oscillator Y0131 and associated components to form a real time clock used to display the time on control heads (with display) or as time stamp for incoming calls or messages. The real time clock is powered from the voltage VSTBY to keep running while the radio is switched off. If the radio is disconnected from the supply voltage, the time must be reset.

2.2.7 Serial Peripheral Interface (SPI)

The µP communicates to many of the IC's through its SPI port. This port consists of SPI TRANSMIT DATA (MOSI) (U0101, pin 100), SPI RECEIVE DATA (MISO) (U0101, pin 99), SPI CLK (U0101, pin 1) and chip select lines going to the various ICs. The BUS is a synchronous bus, in that the timing clock signal CLK is sent while SPI data (SPI TRANSMIT or RECEIVE) is sent. Therefore, whenever there is activity on either SPI TRANSMIT DATA or SPI RECEIVE DATA there should be a uniform signal on CLK.

The SPI TRANSMIT DATA sends serial data from the µP to a device, and SPI RECEIVE DATA is sends data from a device to the µP. On the controller there are two ICs on the SPI BUS: ASFIC CMP (U0221, pin 22), and EEPROM (U0111, pin 5). In the RF section there are two ICs on the SPI BUS: FRAC-N Synthesizer, and the Power Control IC (PCIC). The SPI TRANSMIT DATA and CLK lines going to the RF section are filtered by L0481/R0481 and L0482/R0482 to minimize noise. The chip select line CSX from U0101, pin 2 is shared by the ASFIC CMP, FRAC-N Synthesizer, and PCIC. Each of these IC's check the SPI data and when the sent address information matches the IC's address, the data that follows is processed. The chip select lines for the EEPROM (EE CS), voice storage (VS CS), expansion board (EXP1 CS, EXP2 CS) and option board (OPT CS) are decoded by the address decoder U0141.

When the µP needs to program any of these IC's it brings the chip select line CSX to a logic 0 and then sends the proper data and clock signals. The amount of data sent varies, for example the ASFIC CMP can receive up to 19 bytes (152 bits) while the PCIC can receive up to 6 bytes (48 bits). After the data is sent, the chip select line is returned to logic 1.

The option board interfaces are different in that the µP can also read data back from devices connected.The timing and operation of this interface is specific to the option connected, but the general pattern is as follows:

- Option board generates a service request via J0551, pin 29, line RDY, and µP, pin 79
- The main board asserts a chip select for that option board via U0141,pin 14, line OPT CS, J0551,pin 30
- The main board µP generates the CLK (J0551, pin 3)
- The main board µP writes serial data via J0551, pin 15 and reads serial data via J0551, pin 16
- When data transfer is complete the main board terminates the chip select and CLK activity

2.2.8 SBEP Serial Interface

The SBEP serial interface allows the radio to communicate with the Customer Programming Software (CPS), or the universal tuner via the Radio Interface Box (RIB). This interface connects to the microphone connector via control head connector (J0401, pin 8) or to the accessory connector J0401, pin 17 and comprises BUS+. The line is bi-directional, meaning that either the radio or the RIB can drive the line. The µP sends serial data via pin 98 and D0101 and it reads serial data via pin 97. Whenever the µP detects activity on the BUS+ line, it starts communication.

In addition, the SBEP serial interface is used to communicate with a connected control head. When a control head key is pressed or the volume knob is rotated, the line ON OFF CONTROL goes high. This turns on transistor Q0110 which pulls line ON OFF SENSE and µP, pin 6 to ground level. In addition, an interrupt is generated via R0109 (for SELECT 5 / MDC models) or R0128, U0125, pins 17/26 (for MPT models) and µP, pin 96. This indicates that the control head wants to start SBEP communication. The µP then reads the registers of the Universal Asynchronous Receiver Transmitter (UART) U0125 to determine whether the interrupt source was the control head or the UART (MPT models only). If the interrupt source was from the control head, the µP requests the data from the control head. The control head starts sending and after all data has been sent, the ON OFF CONTROL line goes low. The control head ignores any data on BUS+ during SBEP communication with the CPS or universal tuner.

2.2.9 General Purpose Input/Output

The controller provides eight general purpose lines (DIG1 through DIG8) available on the accessory connector J0501 to interface the external options. Lines DIG IN 1,3,5,6, are inputs, DIG OUT 2 is an output and DIG IN OUT 4,7,8 are bidirectional. The software and the hardware of the radio model define the function of each port.

DIG IN 1 can be used as external PTT input or others, set by the CPS. The µP reads this port via pin 77 and Q0171.

DIG OUT 2 can be used as normal output or external alarm output, set by the CPS. Transistor Q0173 is controlled by the µP via ASFIC CMP, pin 14.

DIG IN 3 is read by µP, pin 63 via resistor R0176

DIG IN 5 can be used as normal input or emergency input, set by the CPS. The µP reads this port via R0179 and µP, pin 60. Diode D0179 limits the voltage to protect the µP input.

DIG IN 6 can be used as normal input, set by the CPS. The µP reads this port via, pin 74 and Q0181.

DIG IN OUT 4,7,8 are bidirectional and use the same circuit configuration. Each port uses an output transistor Q0177, Q0183, Q0185 controlled by µP, pins 46, 47, 53. The ports are read by µP, pins 75, 54, 76. To use one of the ports as input the µP must turn off the corresponding output transistor.

In addition the signals from DIG IN 1, DIG IN OUT 4 are fed to the option board connector J0551 and the expansion board connector J0451.

2.2.10 Normal Microprocessor Operation

The µP is configured to operate in one of two modes: expanded or bootstrap. In expanded mode, the µP uses external memory devices to operate. In bootstrap mode, the µP uses only its internal memory.

During normal operation of the radio, the µP is operating in expanded mode and the µP (U0101) has access to three external memory devices: U0121 (EEPROM), U0122 (SRAM), and U0111 (EEPROM). Also, within the µP there are three KBs of internal RAM, as well as logic to select external memory devices.

The external EEPROM (U0111) space contains the information in the radio which is customer specific, referred to as the codeplug. This information consists of items such as:

- Band in which the radio operates
- What frequencies are assigned to what channel
- Tuning information.

The external SRAM (U0122) as well as the µP's own internal RAM space are used for temporary calculations required by the software during execution. All of the data stored in both of these locations is lost when the radio powers off (See the particular device subsection for more details).

The µP provides an address bus of 16 address lines (ADDR 0 - ADDR 15), and a data bus of eight data lines (DATA 0 - DATA 7). There are also three control lines: CSPROG (U0101, pin 38) to chip select U0121, pin 30 (EEPROM), CSGP2 (U0101, pin 41) to chip select U0122, pin 20 (SRAM) and PG7 R W (U0101, pin 4) to select whether to read or to write. The external EEPROM (U0111,pin 1), the OPTION BOARD and EXPANSION BOARD are selected by three lines of the µP using address decoder U0141. The chips ASFIC CMP / FRAC-N / PCIC are selected by line CSX (U0101, pin 2).

When the µP is functioning normally, the address and data lines are toggling at CMOS logic levels. Specifically, the logic high levels should be between 4.8 to 5.0 volts, and the logic low levels should be between 0 to 0.2 volts. No other intermediate levels should be observed, and the rise and fall times should be <30ns.

The low-order address lines (ADDR 0 - ADDR 7) and the data lines (DATA 0-DATA 7) should be toggling at a high rate, e. g., you should set your oscilloscope sweep to 1µs/div. or faster to observe individual pulses. High speed CMOS transitions should also be observed on the µP control lines.On the µP the lines XIRQ (U0101, pin 48), MODA LIR (U0101, pin 58), MODB VSTPY (U0101, pin 57) and RESET (U0101, pin 94) should be high at all times during normal operation. Whenever a data or address line becomes open or shorted to an adjacent line, a common symptom is that the RESET line goes low periodically, with the period being in the order of 20msecs. In the case of shorted lines you may also detect the line periodically at an intermediate level, i.e. around 2.5 volts when two shorted lines attempt to drive to opposite rails.

The MODA LIR (U0101, pin 58) and MODB VSTPY (U0101, pin 57) inputs to the µP must be at a logic 1 for it to start executing correctly. After the µP starts execution it periodically pulses these lines to determine the desired operating mode. While the central processing unit (CPU) is running, MODA LIR is an open-drain CMOS output which goes low whenever the µP begins a new instruction. One instruction typically requires 2-4 external bus cycles, or memory fetches.

There are eight analog-to-digital converter ports (A/D) on U0101 labelled within the device block as PE0-PE7. These lines sense the voltage level ranging from 0 to 5V of the input line and convert that level to a number ranging from 0 to 255 which is read by the software to take appropriate action.

For example U0101, pin 67 is the battery voltage detect line. R0671 and R0672 form a resistor divider on INT SWB+. With 30K and 10K and a voltage range of 11V to 17V, that A/D port is 2.74V to 4.24V which is then be converted to ~140 to 217 respectively.

U0101-69 is the high reference voltage for the A/D ports on the µP. Capacitor C0101 filters the +5 volt reference. If this voltage is lower than +5 volt, the A/D reading is incorrect. Likewise U0101, pin 68 is the low reference for the A/D ports. This line is normally tied to ground. If this line is not connected to ground, the A/D readings could be incorrect.

2.2.11 Static Random Access Memory (SRAM)

The SRAM (U0121) contains temporary radio calculations or parameters that can change very frequently, and which are generated and stored by the software during its normal operation. The information is lost when the radio is turned off.

The device allows an unlimited number of write cycles. SRAM accesses are indicated by the CS signal U0122, pin 20 which is the result of U0101-CSGP2 going low. U0122 is commonly referred to as the external RAM as opposed to the internal RAM which is the 3 KBs of RAM (part of the 68HC11FL0). Both RAM spaces serve the purpose. However, the internal RAM is used for the calculated values which are accessed most often.

Capacitor C0122 filters out any ac noise which may ride on +5V at U0122.

2.3 Controller Board Audio and Signalling Circuits

2.3.1 Audio Signalling Filter IC with Compander (ASFIC CMP)

The ASFIC CMP (U0221) used in the controller has the four following functions:

- RX/TX audio shaping, i.e. filtering, amplification, attenuation
- RX/TX signalling, PL/DPL/HST/MDC/MPT
- Squelch detection
- µP clock signal generation

The ASFIC CMP is programmable through the SPI BUS (U0221-20/21/22), normally receiving 19 bytes. This programming sets up various paths within the ASFIC CMP to route audio and/or signalling signals through the appropriate filtering, gain, and attenuator blocks. The ASFIC CMP also has six general control bits (GCB0-5) which are CMOS level outputs and used for NOISE BLANKER (GCB0) in low band radios, EXTERNAL ALARM (GCB1), and DC POWER ON (GCB2) to switch the voltage regulators (and the radio) on and off. GCB3 controls U0251, pin 11 to output either RX FLAT AUDIO or RX FILTERED AUDIO on the accessory connector, pin 11. GCB4 controls U0251, pin 10 to use either the external microphone input or the voice storage playback signal. GCB5 switches the audio PA on and off.

2.3.2 Transmit Audio Circuits

Refer to Figure 2-3 for the descriptions that follow.

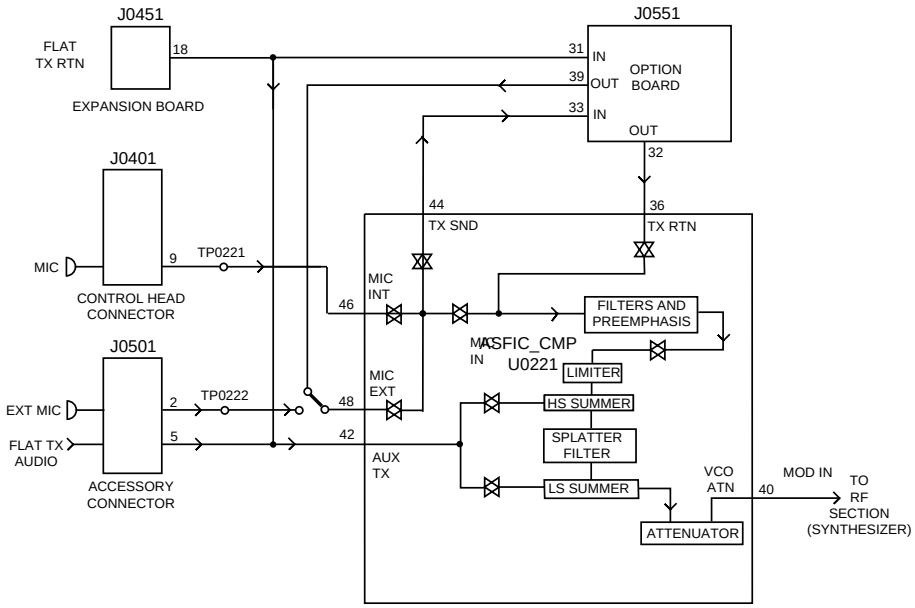


Figure 2-3. Transmit Audio Paths

2.3.3 Microphone Input Path

The radio supports two microphone input paths. One from the control head external microphone accessory connector J0501, pin 2, and one from the microphone auxiliary path (FLAT TX AUDIO) via accessory connector J0501, pin 5. The microphones require a DC biasing voltage provided by a resistive network.

The two microphone audio input paths enter the ASFIC CMP at U0221, pin 48 (external microphone) and U0221, pin 46 (auxiliary microphone).

The microphone is plugged into the radio control head which is connected to the controller board via J0401, pin 9. The signal is then routed via R0409 and line INT MIC to R0205. Resistors R0201 and R0202 provide 9.3Vdc bias. Resistive divider R0205/R0207 divide the input signal by 5.5 and provide input protection for the CMOS amplifier input. R0202 and C0201 provide a 560 ohm AC path to ground that sets the input impedance for the microphone and determines the gain based on the emitter resistor in the microphone's amplifier circuit.

Capacitor C0204 provides dc blocking. The audio signal at U0221, pin 46 (TP0221) is approximately 14mV for 1.5kHz or 3kHz of deviation with 12.5kHz or 25kHz channel spacing.

The external microphone signal enters the radio on accessory connector J0501, pin 5, then it is routed via line EXT MIC to resistor R0206. Resistors R0201 and R0204 provide a 9.3Vdc bias. Resistive divider R0206 / R0208 divide the input signal by 5.5 and provide input protection for the CMOS amplifier input. R0204 and C0201 provide a 560 ohm AC path to ground that sets the input impedance for the microphone and determines the gain based on the emitter resistor in the microphone's amplifier circuit. Capacitor C0254 provides dc blocking.

Multi switch U0251 controlled by ASFIC CMP port GCB4 selects either the external microphone input signal or the voice storage playback signal for entering the ASFIC CMP at pin 48. The audio signal at U0221-48 (TP0222) is approximately 14mVrms for 1.5kHz or 3kHz of deviation with 12.5kHz or 25kHz channel spacing.

The FLAT TX AUDIO signal from accessory connector J0501-5 is fed to the ASFIC CMP (U0221, pin 42) through C0541 and line FLAT TX RTN.

The ASFIC has an internal AGC that controls the gain in the microphone audio path. The AGC can be disabled/enabled by the µP. Another feature that can be enabled/disabled in the ASFIC is the VOX. This circuit, along with the capacitor at U0221, pin 7, provides a dc voltage allows the µP to detect microphone audio. The ASFIC can also be programmed to route the microphone audio to a speaker for public address operation.

2.3.3.1 PTT Sensing and TX Audio Processing

The microphone PTT signal coming from the control head is sent via the SBEP bus to the µP. An external PTT can be generated by grounding pin 3 on the accessory connector if this input is programmed for PTT by the CPS. When microphone PTT is sensed, the µP always configures the ASFIC CMP for the "internal" microphone audio path, and external PTT results in the external microphone audio path being selected.

Inside the ASFIC CMP, the microphone audio is filtered to eliminate frequency components outside the 300-3000Hz voice band, and pre-emphasized if pre-emphasis is enabled. The signal is then limited to prevent the transmitter from over deviating. The limited microphone audio is then routed through a summer, which is used to add in signalling data, and then to a splatter filter to eliminate high frequency spectral components that could be generated by the limiter. The audio is then routed to an attenuator, which is tuned in the factory or the field to set the proper amount of FM deviation. The TX audio emerges from the ASFIC CMP at U0221-40 MOD IN, at which point it is routed to the RF section.

2.3.3.2 TX Secure Audio (optional)

The audio follows the normal transmit audio processing until it emerges from the ASFIC CMP TX SND pin (U0221-44), which is fed to the Secure board residing at option connector J0551-33. The Secure board contains circuits to amplify, encrypt, and filter the audio. The encrypted signal is then fed back from J0551-32 to the ASFIC CMP TX RTN input (U0221-36). The signal level at this pin should be about 65mVrms. The signal is then routed through the TX path in the ASFIC CMP and emerges at MOD IN pin 40.

2.3.3.3 Option Board Transmit Audio

The audio follows the normal transmit audio processing until it emerges from the ASFIC CMP TX SND pin (U0221-44), which is fed to the option board residing at option connector J0551-33. The option board contains circuits to process the audio. The processed signal is then fed back from J0551-32 to the ASFIC CMP TX RTN input (U0221-36). The signal level at this pin is approximately 65mVrms. The signal is then routed through the TX path in the ASFIC CMP and out at MOD IN, pin 40.

2.3.4 Transmit Signalling Circuits

Refer to Figure 2-4 for the descriptions that follow.

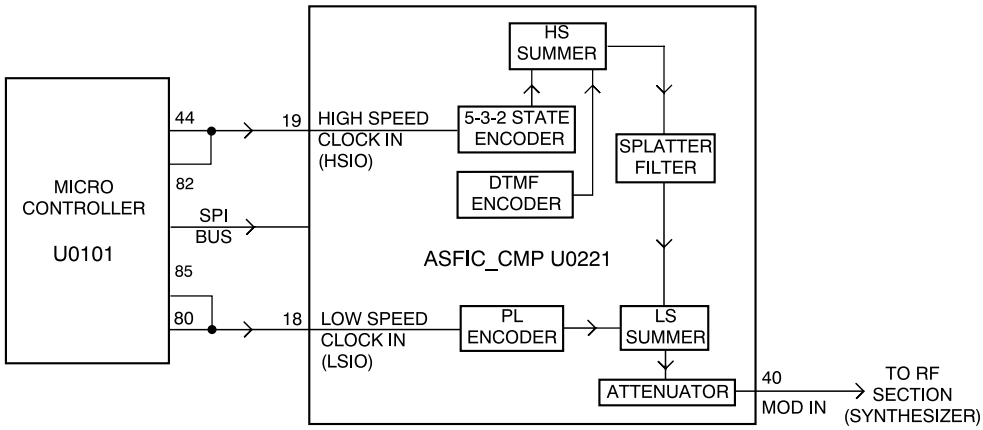


Figure 2-4. Transmit Signalling Paths

The three types of transmit signalling paths are as follows:

- Sub-audible data (PL/DPL/connect tone) summed with transmit voice or signalling
- DTMF data for telephone communication between trunked and conventional systems
- Audible signalling

NOTE All three types are supported by the hardware while the radio software determines which signalling type is available.

2.3.4.1 Sub-Audible Data (PL/DPL)

Sub-audible data implies signalling whose frequency/data rate is below 300Hz. PL and DPL waveforms are used for conventional operation and connect tones for trunked voice channel operation. The trunking connect tone is simply a PL tone at a higher deviation level than PL in a conventional system. Although it is referred to as "sub-audible data," the actual frequency spectrum of these waveforms may be as high as 250 Hz, which is audible to the human ear. However, the radio receiver filters out any audio below 300Hz, so these tones are never heard in the actual system.

Only one type of sub-audible data can be generated by U0221 (ASFIC CMP) at any one time. The process is as follows, using the SPI BUS, the µP programs the ASFIC CMP to set up the proper low-speed data deviation and select the PL or DPL filters. The µP then generates a square wave which strobes the ASFIC PL / DPL encode input LSIO U0221-18 at twelve times the desired data rate. For example, for a PL frequency of 103Hz, the frequency of the square wave is 1236Hz.

This drives a tone generator inside U0221 which generates a staircase approximation to a PL sine wave or DPL data pattern. This internal waveform is then low-pass filtered and summed with voice or data. The resulting summed waveform then appears on U0221-40 (MOD IN), where it is sent to the RF board as previously described for transmit audio. A trunking connect tone would be generated in the same manner as a PL tone.

2.3.4.2 High Speed Data

High speed data refers to the 3600 baud data waveforms, known as inbound signalling words (ISWs) used in a trunking system for high speed communication between the central controller and the radio. To generate an ISW, the µP first programs the ASFIC CMP (U0221) to the proper filter and gain settings. It then begins strobing U0221-19 (HSIO) with a pulse when the data is supposed to change states. U0221's 5-3-2 state encoder, which is in a 2-state mode, is then fed to the post-limiter summer block and then the splatter filter. From that point, it is routed through the modulation attenuators and then out of the ASFIC CMP to the RF board. MPT 1327 and MDC are generated in much the same way as trunking ISW. However, in some cases these signals may also pass through a data pre-emphasis block in the ASFIC CMP. Also these signalling schemes are based on sending a combination of 1200 Hz and 1800 Hz tones only. Microphone audio is muted during high speed data signalling.

2.3.4.3 Dual Tone Multiple Frequency (DTMF) Data

DTMF data is a dual tone waveform used during phone interconnect operation. It is the same type of tones which are heard when using a "Touch Tone" telephone.

There are seven frequencies, with four in the low group (697, 770, 852, 941Hz) and three in the high group (1209, 1336, 1477Hz).

The high-group tone is generated by the µP (U0101-44) strobing U0221-19 at six times the tone frequency for tones less than 1440Hz or twice the frequency for tones greater than 1440Hz. The low group tone is generated by the ASFIC CMP, controlled by the µP via SPI bus. Inside U0221 the low-group and high-group tones are summed (with the amplitude of the high group tone being approximately 2 dB greater than that of the low group tone) and then pre-emphasized before being routed to the summer and splatter filter. The DTMF waveform then follows the same path as described for high-speed data

2.3.5 Receive Audio Circuits

Refer to Figure 2-5 for the descriptions that follow.

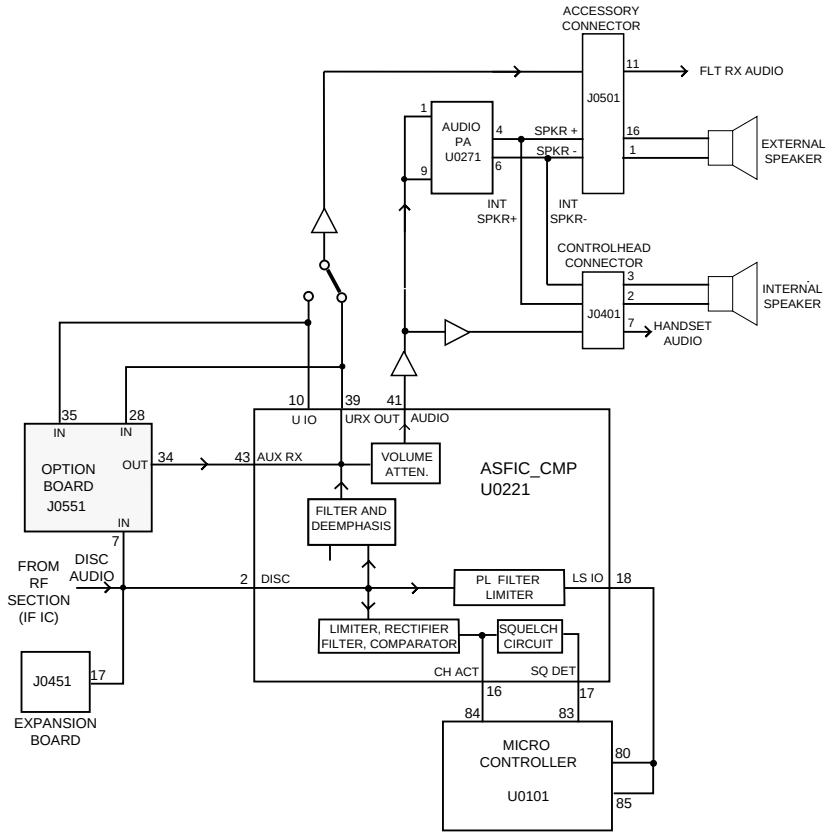


Figure 2-5. Receive Audio Paths

2.3.5.1 Squelch Detect

The squelch detect circuits are all contained within the ASFIC CMP as shown in Figure 2-5. The radio's RF circuits are constantly producing an output (DISC AUDIO) at the discriminator IF IC. The output signal is applied to the ASFIC CMP's squelch detect circuits DISC input (U0221, pin 2). The squelch signal entering the ASFIC CMP is amplified, filtered, attenuated, and rectified. It is then sent to a comparator to produce an active high signal (CH ACT). The squelch circuit produces the SQ DET signal at U0221, pin 17 from the CH ACT input signal. The state of CH ACT and SQ DET go from a low (logic 0) to a high (logic 1) when an RF carrier is detected. The CH ACT and SQ DET signals from the squelch circuit are applied to the µP pins 84 and 83 respectively.

SQ DET is used to determine all audio mute/unmute decisions except for conventional scan. In this case CH ACT is a pre-indicator as it occurs slightly faster than SQ DET.

2.3.5.2 Audio Processing and Digital Volume Control

The receiver audio signal (DISC AUDIO) enters the controller section from the IF IC where it is AC coupled by C0227 before entering the ASFIC CMP via the DISC input at U0221, pin 2. The signal is then applied to both the audio and the PL/DPL paths.

The signal on the audio path is applied to a programmable amplifier, whose setting is based on the channel bandwidth being received, an LPF filter to remove any frequency components above 3000Hz, and HPF filter to strip off any sub-audible data below 300Hz. The recovered audio passes through a de-emphasis filter, if it is enabled, to compensate for pre-emphasis which is used to reduce the effects of FM noise. The audio then goes through the 8-bit programmable attenuator whose level is set depending on the value of the volume control. The resulting filtered audio signal is passed through an output buffer within the ASFIC CMP and exits the ASFIC CMP at the AUDIO output (U0221, pin 41).

The µP programs the attenuator, using the SPI BUS, based on the volume setting. The minimum/ maximum settings of the attenuator are set by codeplug parameters.

Since sub-audible signalling is summed with voice information on transmit, it must be separated from the voice information before processing. Any sub-audible signal enters the ASFIC CMP from the IF IC at DISC U0221, pin 2, then through the PL/DPL path. The signal first passes through one of two low pass filters, either PL low pass filter, or DPL/LST low pass filter. Either signal is then filtered, goes through a limiter, and exits the ASFIC CMP at LSIO (U0221, pin 18). At this point the signal appears as a square wave version of the sub-audible signal the radio received. The µP (U0101, pin 80) decodes the signal directly to determine if it is the tone/code currently active on that mode.

2.3.5.3 Audio Amplification Speaker (+) Speaker (-)

The output of the ASFIC CMP's digital volume pot (U0221, pin 41) is routed through dc blocking capacitor C0256 to a buffer formed by U0211, pin 1. Resistors R0256 and R0268 set the correct input level to the audio PA (U0271). This is necessary because the gain of the audio PA is 46 dB and the ASFIC CMP output is capable of overdriving the PA unless the maximum volume is limited. Resistor R0267 and capacitor C0267 increase frequency components below 350 Hz.

The audio then passes through R0269 and C0272 which provides AC coupling and low frequency roll-off. C0273 provides high frequency roll-off as the audio signal is routed to audio power amplifier U0271, pins 1 and 9 which are both tied to the received audio. The audio power amplifier has one inverted and one non-inverted output that produces the differential audio output SPK+/SPK- (U0271, pins 4 and 6).

The audio PA's dc biases are not activated until the audio PA is enabled at pin 8. The audio PA is enabled via the ASFIC CMP (U0221, pin 38). When the base of Q0271 is low, the transistor is off and U0271-8 is high via pull-up resistor R0273, and the audio PA is ON. The voltage at U0273-8 must be above 8.5Vdc to properly enable the device. If the voltage is between 3.3 and 6.4V, the device is active, but has its input (U0273, pins 1 and 9) off. This is a mute condition used to prevent an audio pop when the PA is enabled.

The SPK+ and SPK- outputs of the audio PA are dc biased and vary proportionately with FLT A+ (U0271, pin 7). FLT A+ of 11V yields a dc offset of 5V, and FLT A+ of 17V yields a dc offset of 8.5V. If either of these lines is shorted to ground, it is possible that the audio PA could be damaged. SPK+ and SPK- are routed to the accessory connector (J0501, pins 1 and 16) and to the control head connector (J0401, pins 2 and 3).

2.3.5.4 Handset Audio

Certain accessories have a self contained speaker which requires a different voltage level than that provided by U0271. For those devices, HANDSET AUDIO is available at control head connector J0401, pin 7.

The received audio from the output of the ASFIC CMP's digital volume attenuator and buffered by U0211, pin 1, is also routed to U0211, pin 9 where it is amplified by 20 dB. This is set by the 10k/ 100k combination of R0261 and R0262. This signal is routed from the output of the op amp U0211 to J0401-7. The control head sends this signal directly out to the microphone jack. The maximum value of this output is 6.6Vp-p.

2.3.5.5 Filtered Audio and Flat Audio

The ASFIC CMP audio output at U0221, pin 39 is filtered and de-emphasized, but has not yet gone through the digital volume attenuator. From ASFIC CMP U0221, pin 39 the signal is routed via R0251 through gate U0251, pin 12 and AC coupled to U0211, pin 2. The gate controlled by ASFIC CMP port GCB3 (U0221, pin 35) selects between the filtered audio signal from the ASFIC CMP at pin 39 (URXOUT) or the unfiltered flat audio signal from the ASFIC CMP, U10, pin 10. Resistors R0251 and R0253 determine the gain of op amp U0211, pin 2 for the filtered audio while R0252 and R0253 determine the gain for the flat audio.The output of U0253, pin 7 is then routed to J0501, pin 11 via dc blocking capacitor C0542. Note that any volume adjustment of the signal on this path must be done by the accessory.

2.3.5.6 RX Secure Audio Option

Discriminator audio, which is now encrypted audio, follows the normal receive audio processing until it is output from the ASFIC CMP UIO (U0221, pin 10), which is fed to the secure audio board at option connector J0551, pin 35. On the secure board, the encrypted signal is converted back to normal audio format, then fed back through J0551, pin 34 to AUX RX of the ASFIC CMP (U0221, pin 43). The signal then follows a path identical to the conventional receive audio, where it is filtered (0.3 - 3kHz) and deemphasized. The signal URX SND from the ASFIC CMP (U0221-39) also routed to option connector J0551, pin 28, is not used for the secure board, but for other option boards.

2.3.5.7 Option Board Receive Audio

Unfiltered audio from the ASFIC CMP (U0221, pin 10) enters the option board at connector J0551, pin 35. Filtered audio from the ASFIC CMP URXOUT (U0221, pin 39) enters the option board at connector J0551, pin 28. On the option board, the signal is processed, then fed back through (J0551, pin 34) to AUX RX of the ASFIC CMP (U0221, pin 43). The signal then follows a path identical to conventional receive audio, where it is filtered (0.3 - 3kHz) and de-emphasized.

2.3.6 Receive Signalling Circuits

Refer to Figure 2-6 for the descriptions that follow.

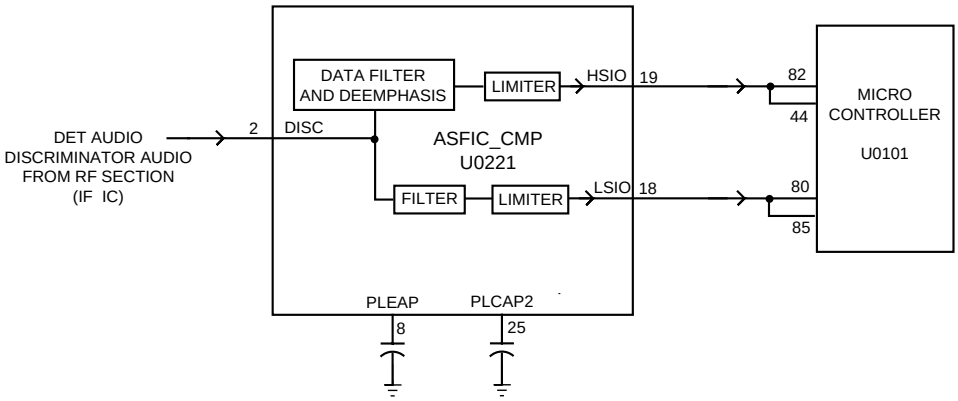


Figure 2-6. Receive Signalling Paths

2.3.6.1 Sub-Audible Data (PL/DPL) and High Speed Data Decoder

The ASFIC CMP (U0221) filters and limits all received data. The data enters the ASFIC CMP at input DISC (U0221, pin 2). Inside U0221 the data is filtered according to data type (HS or LS), then it is limited to a 0-5V digital level. The MDC and trunking high speed data appear at U0221, pin 19, where it connects to the µP U0101, pin 82

The low speed limited data output (PL, DPL, and trunking LS) appears at U0221, pin 18, where it connects to the µP U0101, pin 80.

The low speed data is read by the µP at twice the frequency of the sampling waveform; a latch configuration in the ASFIC CMP stores one bit every clock cycle. The external capacitors C0236, and C0244 set the low frequency pole for a zero crossings detector in the limiters for PL and HS data. The hysteresis of these limiters is programmed based on the type of received data.

2.3.6.2 Alert Tone Circuits

When the software determines that it needs to give the operator an audible feedback for a good key press, or for a bad key press, or radio status (trunked system busy, phone call, circuit failures), it sends an alert tone to the speaker. It does so by sending SPI BUS data to U0221 which sets up the audio path to the speaker for alert tones. The alert tone itself can be generated in one of two ways: internally by the ASFIC CMP, or externally using the µP and the ASFIC CMP.

The allowable internal alert tones are 304, 608, 911, and 1823Hz. In this case a code contained within the SPI BUS load to the ASFIC CMP sets up the path and determines the tone frequency, and at what volume level to generate the tone. (It does not have to be related to the voice volume setting).

For external alert tones, the µP can generate any tone within the 100-3000Hz audio band. This is accomplished by the µP generating a square wave which enters the ASFIC CMP at U0221-19. Inside the ASFIC CMP this signal is routed to the alert tone generator

The output of the generator is summed into the audio chain just after the RX audio de-emphasis block. Inside U0221 the tone is amplified and filtered, then passed through the 8-bit digital volume attenuator, which is typically loaded with a special value for alert tone audio. The tone exits at U0221-41 and is routed to the audio PA like receive audio.

2.3.6.3 Voice Storage Option

The Voice Storage (VS) option can be used to store audio signals coming from the receiver or from the microphone. Any stored audio signal can be played back over the radio's speaker or sent out via the radio's transmitter.

The Voice Storage option can by placed on the controller section or on an additional option board which resides on option board connector J0551. Voice Storage IC U0301 provides all required functionality and is powered from 3.3 volts regulator U0351 which is powered from the regulated 5 volts. Dual shottky diode D0301 reduces the supply voltage for U0301 to 3 volts. The µP controls U0301 via SPI bus lines CLK (U0301-8), DATA (U0301-10) and MISO (U0301-11). To transfer data, the µP first selects the U0301 via address decoder U0141, line VS CS and U0301 pin 9. Then the µP sends data through line DATA and receives data through line MISO. Pin 2 (RAC) of U0301 indicates the end of a message row by a low state for 12.5 ms and connects to µP pin 52. A low at pin 5 (INT), which is connected to µP pin 55 indicates that the Voice Storage IC requires service from the µP.

Audio, either from the radio's receiver or from one of the microphone inputs, emerges the ASFIC CMP (U0221) at pin 43, is buffered by op-amp U0341-1, then enters the voice storage IC U0301 at pin 25. During playback, the stored audio emerges U0301 at pin 20. To transmit the audio signal, it is fed through resistive divider R0344 / R0345 and line VS MIC to input selector IC U0251. When this path is selected by the µP via ASFIC CMP port GCB 4, the audio signal enters the ASFIC CMP at pin 48 and is processed like normal transmit audio. To play the stored audio over the radio's speaker, the audio from U0301 pin 20 is buffered by op-amp U0341-2 and fed via switch U0342 and line FLAT RX SND to ASFIC CMP pin 10 (UIO). In this case, this ASFIC CMP pin is programmed as input and feeds the audio signal through the normal receiver audio path to the speaker or handset. Switch U0342 is controlled by the µP via ASFIC CMP port GCB 4 and feeds the stored audio only to the ASFIC CMP port UIO when it is programmed as input.

2.4 UHF (403-470 MHz) Receiver Front-End

The receiver is able to cover the UHF range from 403 to 470 MHz. It consists of four major blocks: front-end bandpass filters and preamplifier,

- First mixer
- 1st IF
- 2nd IF
- Receiver back-end

Two varactor tuned bandpass filters perform antenna signal pre-selection. A cross over quad diode mixer converts the signal to the 1st IF of 44.85 MHz. Low side first injection is used.

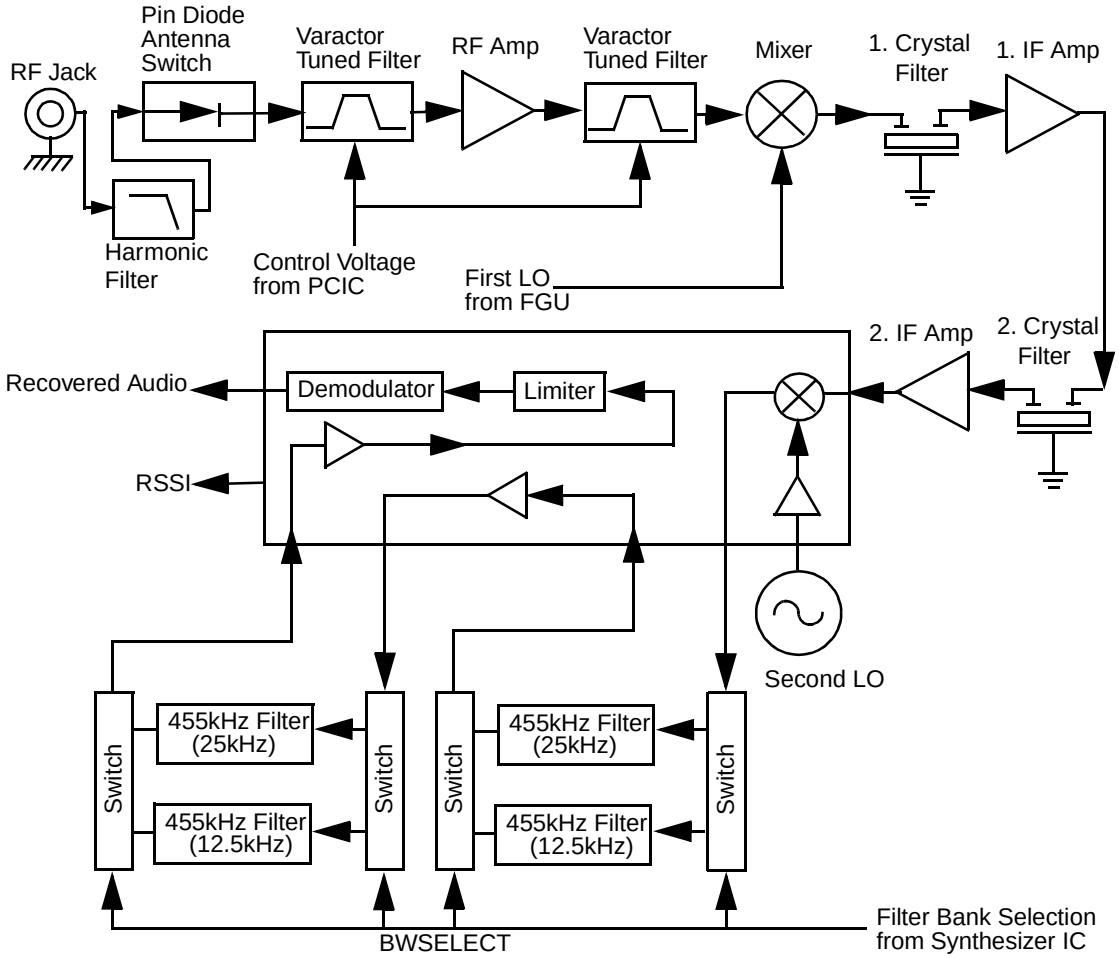


Figure 2-7. UHF Receiver Block Diagram

The 2-pole 44.85 MHz crystal filters in the 1st IF section and two pairs of 455 kHz ceramic filters in the 2nd IF section provide the required adjacent channel selectivity. The correct pair of ceramic filters for 12.5 or 25 kHz channel spacing is selected via control line BWSELECT. The 2nd IF at 455 kHz is mixed, amplified, and demodulated in the IF IC. The processing of the demodulated audio signal is performed by an audio processing IC located in the controller section.

2.4.1 Front-End Band-Pass Filters and Pre-Amplifier

The received signal from the radio's antenna connector is first routed through the harmonic filter and antenna switch, which are part of the RF power amplifier circuits, before being applied to the receiver pre-selector filter (C4001, C4002, D4001 and associated components). The 2-pole pre-selector filter tuned by the varactor diodes D4001 and D4002 pre-selects the incoming signal (RXIN) from the antenna switch to reduce spurious effects to following stages. The tuning voltage (FECTRL_1) ranging from 2 volts to 8 volts is controlled by pin 20 of PCIC (U4501) in the Transmitter section. A dual hot carrier diode (D4003) limits any inband signal to 0 dBm to prevent damage to the pre-amplifier.

The RF pre-amplifier is an SMD device (Q4003) with collector base feedback to stabilize gain, impedance, and intermodulation. The collector current of approximately 11-16 mA is drawn from the 9.3 volt supply via L4003 and R4002. A 3dB pad (R4006,R4007,R4011 and R4008 - R4010) stabilizes the output impedance and intermodulation performance.

A second 2-pole varactor tuned bandpass filter provides additional filtering of the amplified signal. The varactor diodes D4004 and D4005 are controlled by the same signal FECTRL_1, which controls the pre-selector filter. A following 1 dB pad (R4013 - R4015) stabilizes the output impedance and intermodulation performance.

2.4.2 First Mixer and 1st Intermediate Frequency (IF)

The signal coming from the front-end is converted to the first IF (44.85 MHz) using a cross over quad diode mixer (D4051). Its ports are matched for incoming RF signal conversion to the 44.85 MHz IF using low side injection via matching transformers T4051 and T4052. The injection signal (RXINJ) coming from the RX VCO buffer (Q4332) is filtered by the lowpass filter consisting of (L4053, L4054, C4053 - C4055) followed by a matching transformer T4052 and has a level of approximately 15dBm.

The mixer IF output signal (IF) from transformer T4501pin 2 is fed to the first two pole crystal filter FL3101. The filter output in turn is matched to the following IF amplifier.

The IF amplifier Q3101 is actively biased by a collector base feedback (R3101, R3106) to a current drain of approximately 5 mA drawn from the 5 volt supply. Its output impedance is matched to the second two pole crystal filter FL3102. The signal is further amplified by a preamplifier (Q3102) before going into pin 1 of IFIC (U3101).

A dual hot carrier diode (D3101) limits the filter output voltage swing to reduce overdrive effects at RF input levels above -27 dBm.

2.4.3 2nd Intermediate Frequency (IF) and Receiver Back-End

The 44.85 MHz 1st IF signal from the second IF amplifier feeds the IF IC (U3101) at pin1. Within the IF IC the 44.85 MHz high IF signal mixes with the 44.395 MHz second local oscillator (2nd LO) to produce the low IF signal at 455 kHz. The 2nd LO frequency is determined by crystal Y3101. The 2nd IF signal is amplified and filtered by an external pair of 455 kHz ceramic filters (FL3112, FL3114) for 20/25 kHz channel spacing or FL3111 and FL3113/F3115 for 12.5 kHz channel spacing. These pairs are selectable via BWSELECT. The filtered output from the ceramic filters is applied to the limiter input pin of the IF IC (pin 14).

The IF IC contains a quadrature detector using a ceramic phase-shift element (Y3102) to provide audio detection. Internal amplification provides an audio output level of 120 mV rms (at 60% deviation) from U3103 pin 8 (DISCAUDIO) which is fed to the ASFIC_CMP (U0221) pin 2 (part of the Controller circuits).

A received signal strength indicator (RSSI) signal is available at U3101 pin 5, having a dynamic range of 70 dB. The RSSI signal is interpreted by the µP (U0101 pin 63) and is available at accessory connector J0501-15.

2.5 Transmitter Power Amplifier (PA) 40 W

The radio's 40W power amplifier (PA) is a four stage amplifier used to amplify the output from the VCOBIC to the radio transmit level. It consists of the following four stages in the line-up. The first stage is a LDMOS predriver (U4401) that is controlled by pin 4 of PCIC (U4501) via Q4473 (CNTLVLTG). It is followed by another LDMOS stage (Q4421), an LDMOS stage (Q4431), and a bipolar final stage (Q4441).

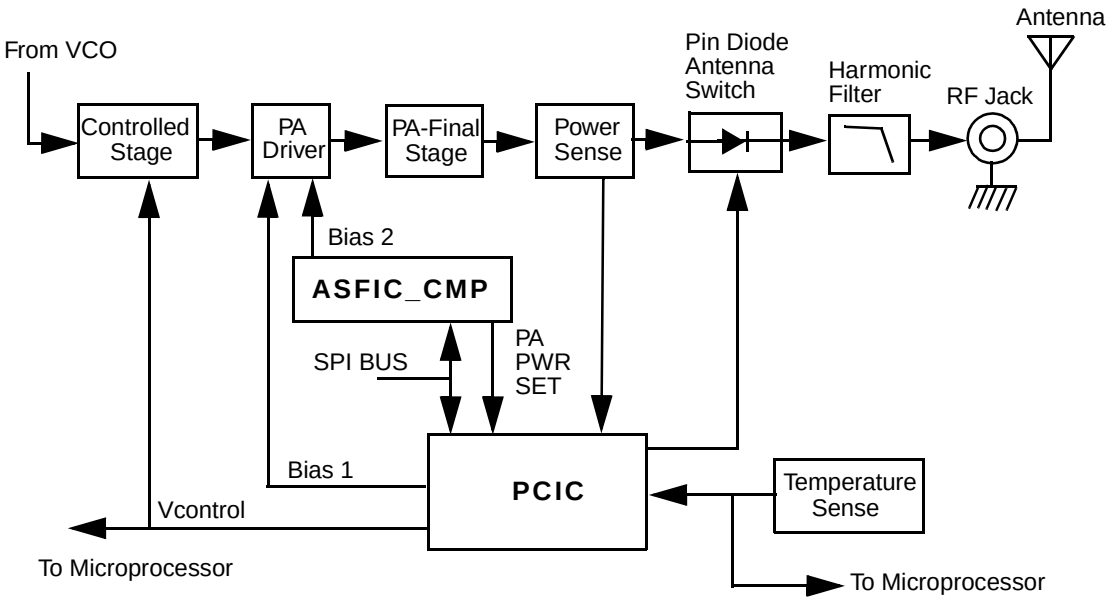


Figure 2-8. UHF Transmitter Block Diagram

Device Q4401 is surface mounted. Q4421, Q4431 and Q4441 are directly attached to the heat sink.

2.5.1 Power Controlled Stage

The first stage (U4401) amplifies the RF signal from the VCO (TXINJ) and controls the output power of the PA. The output power of the transistor U4401 is controlled by a voltage control line feed from the PCIC pin4(U4501). The control voltage simultaneously varies the bias of two FET stages within U4401. This biasing point determines the overall gain of U4401 and therefore its output drive level to Q4421, which in turn controls the output power of the PA.

In receive mode the voltage control line is at ground level and turns off Q4473 which in turn switches off the biasing voltage to U4401.

2.5.2 Pre-Driver Stage

The next stage is a 13dB gain LDMOS device (Q4421) which requires a positive gate bias and a quiescent current flow for proper operation. The voltage of the line PCIC_MOSBIAS_1 is set in transmit mode by PCIC pin 24 and fed to the gate of Q4421 via the resistive network R4407, R4408, R4416 and R4415. The bias voltage is tuned in the factory.

2.5.3 Driver Stage

The following stage is an enhancement-mode N-Channel MOSFET device (Q4431) providing a gain of 10dB. This device also requires a positive gate bias and a quiescent current flow for proper operation. The voltage of the line Bias_2_UHF_PA_1 is set in transmit mode by the ASFIC and fed to the gate of Q4431 via the resistive network R4630, R4631, and R4632. This bias voltage is also tuned in the factory. If the transistor is replaced, the bias voltage must be tuned using the Customer Programming Software (CPS). Care must be taken not to damage the device by exceeding the maximum allowed bias voltage. The device's drain current is drawn directly from the radio's dc supply voltage input, A+, via L4421.

2.5.4 Final Stage

The final stage uses the bipolar device Q4441. The device's collector current is also drawn from the radio's dc supply voltage input. To maintain class C operation, the base is dc-grounded by a series inductor (L4441) and a bead (L4440). A matching network consisting of C5541-C5544 and two striplines transform the impedance to 50 Ohms and feeds the directional coupler.

2.5.5 Bi-Directional Coupler

The Bi-directional coupler is a microstrip printed circuit, which couples a small amount of the forward and reverse power of the RF power from Q4441. The coupled signal is rectified to an output power proportional dc voltage by the diodes D4451 & D4452 and sent to the RFIN of the PCIC. The PCIC controls the gain of stage U4401 as necessary to hold this voltage constant. This ensures the forward power out of the radio is held to a constant value.

2.5.6 Antenna Switch

The antenna switch utilizes the existing dc feed (A+) to the last stage device (Q4441). Basic operation is to have both PIN diodes D4471 and D4472 turns on during key-up by forward biasing them. It is achieve by pulling down the voltage at the cathode end of D4472 to around 11.8V (0.7V drop across each diode). The current through the diodes needs to be set around 80mA to fully open the transmit path through resistor R4496. Q4472 is a current source controlled by Q4471 and is eventually connected to pin ANO of PCIC. VR4471 ensures the voltage at the resistor R4511 never exceeds 5.6V

2.5.7 Harmonic Filter

Inductors L4491, L4492, L4493 and capacitors C4448, C4493,C4494, C4496 and C4498 form a low-pass filter to attenuate harmonic energy from the transmitter. R4491 is used to drain any electrostatic charges that might otherwise build up on the antenna. The harmonic filter also prevents high level RF signals above the receiver passband from reaching the receiver circuits, improving spurious response rejection.

2.5.8 Power Control

The transmitter uses the Power Control IC (PCIC, U4501) to control the power output of the radio. A portion of the forward RF power from the transmitter is sampled by the bi-directional coupler and rectified, to provide a dc voltage to the RFIN port of the PCIC (pin 1) which is proportional to the sampled RF power.

The PCIC has internal digital to analog converters (DACs) which provide the reference voltage of the control loop. The reference voltage level is programmable through the SPI line of the PCIC. This reference voltage is proportional to the desired power setting of the transmitter, and is factory programmed at several points across the frequency range of the transmitter to offset frequency response variations of the transmitter's power detector circuits.

The PCIC provides a dc output voltage at pin 4 (INT) and applied as CNTLVLTG to the power-adjust input pin of the first transmitter stage U4401. This adjusts the transmitter power output to the intended value. Variations in forward or reflected transmitter power cause the dc voltage at pin 1 to change, and the PCIC adjusts the control voltage above or below its nominal value to raise or lower output power.

Capacitors C4502-4, in conjunction with resistors and integrators within the PCIC, control the transmitter power-rise (key-up) and power-decay (de-key) characteristic to minimize splatter into adjacent channels.

U4502 is a temperature-sensing device, which monitors the circuit board temperature in the vicinity of the transmitter driver and final devices, and provides a dc voltage to the PCIC (TEMP, pin 29) proportional to temperature. If the dc voltage produced exceeds the set threshold in the PCIC, the transmitter output power is reduced so as to reduce the transmitter temperature.

2.6 Frequency Synthesis

The synthesizer subsystem consists of the reference oscillator (Y4261 or Y4262), the low voltage fractional-N synthesizer (LVFRAC-N, U4201), and the Voltage Controlled Oscillator VCO.

2.6.1 Reference Oscillator

The reference oscillator (Y4262) contains a temperature compensated crystal oscillator with a frequency of 16.8 MHz. An Analog-to-Digital (A/D) converter internal to U4201 (LVFRAC-N) and controlled by the µP via serial interface (SRL) sets the voltage at the warp output of U4201, pin 25 to set the frequency of the oscillator. The output of the oscillator (pin 3 of Y4262) is applied to pin 23 (XTAL1) of U4201 via an RC series combination.

In applications where less frequency stability is required the oscillator inside U4201 is used along with an external crystal Y4261, varactor diode D4261, C4261, C4262 and R4262. In this case, Y4262, R4263, C4235 and C4251 are not used. When Y4262 is used, Y4261, D4261, C4261, C4262 and R4262 are not used, and C4263 is increased to 0.1 uF.

2.6.2 Fractional-N Synthesizer

The LVFRAC-N synthesizer IC (U4201) consists of a pre-scaler, a programmable loop divider, control divider logic, a phase detector, a charge pump, an A/D converter for low frequency digital modulation, a balanced attenuator to balance the high frequency analog modulation and low frequency digital modulation, a 13V positive voltage multiplier, a serial interface for control, and finally a super filter for the regulated 5 volts.

A voltage of 5V applied to the super filter input (U4201 pin 30) supplies an output voltage of 4.5 Vdc (VSF) at pin 28. It supplies the VCO, VCO modulation bias circuit (via R4322) and the synthesizer charge pump resistor network (R4251, R4252). The synthesizer supply voltage is provided by the 5V regulator U4211.

In order to generate a high voltage to supply the phase detector (charge pump) output stage at pin VCP (U5701-32), a voltage of 13 Vdc is being generated by the positive voltage multiplier circuitry (D4201, C4202, C4203). This voltage multiplier is basically a diode capacitor network driven by two signals (1.05MHz) 180 degrees out of phase (U4201-14 and -15).

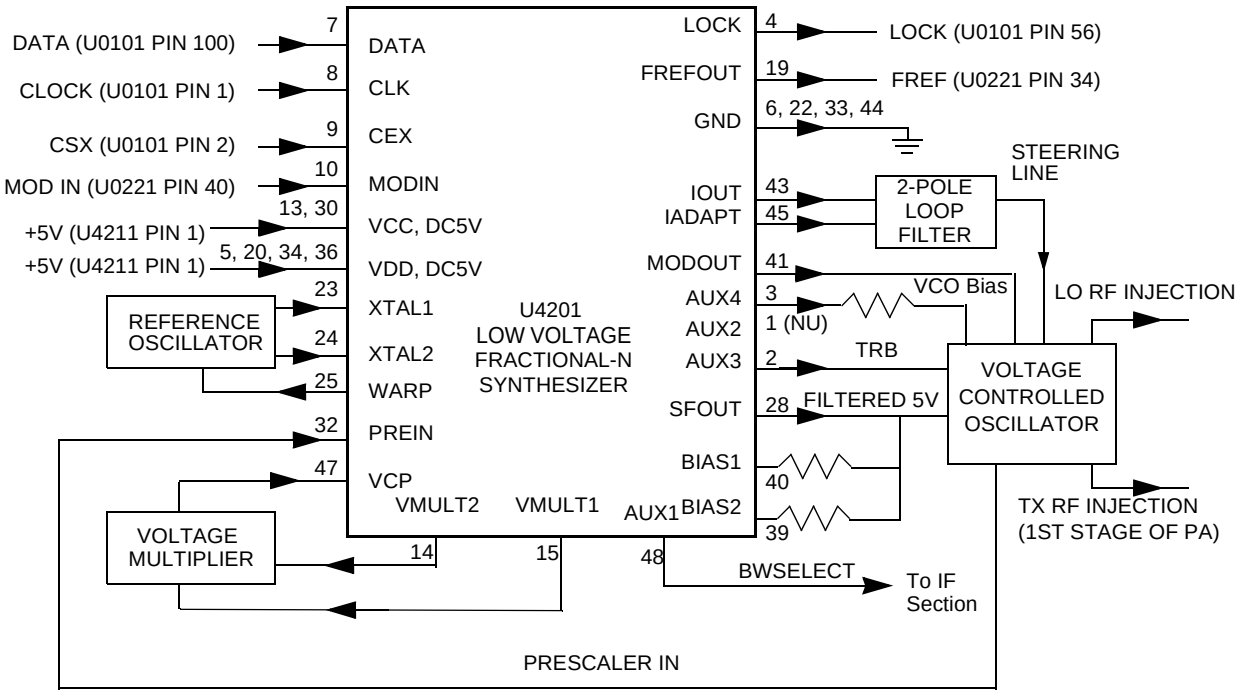


Figure 2-9. UHF Synthesizer Block Diagram

Output LOCK (U4201-4) provides information about the lock status of the synthesizer loop. A high level at this output indicates a stable loop. IC U4201 provides the 16.8 MHz reference frequency at pin 19.

The serial interface (SRL) is connected to the µP via the data line DATA (U4201-7), clock line CLK (U4201-8), and chip enable line CSX (U4201-9).

2.6.3 Voltage Controlled Oscillator (VCO)

The Voltage Controlled Oscillator (VCO) consists of the VCO buffer IC (VCOBIC, U4301), the TX and RX tank circuits, the external RX buffer stages, and the modulation circuits.

The VCOBIC together with Fractional-N synthesizer (U4201) generates the required frequencies in both transmit and receive modes. The TRB line (U4301 pin 19) determines which tank circuits and internal buffers are to be enabled. A high level on TRB enables TX tank and TX output (pin 10), and a low enables RX tank and RX output (pin 8). A sample of the signal from the enabled output is routed from U4301 pin 12 (PRESC_OUT), via a low pass filter, to pin 32 of U4201 (PREIN).

A steering line voltage (VCTRL) between 3.0V and 10.0V at varactor diode CR4311 will tune the full TX frequency range (TXINJ) from 403 MHz to 470 MHz, and at varactor diodes CR4301, CR4302 and CR4303 will tune the full RX frequency range (RXINJ) from 358 MHz to 425 MHz. The tank circuits uses the Hartley configuration for wider bandwidth. For the RX tank circuit, an external transistor Q4301 is used in conjunction with the internal transistor for better side-band noise.

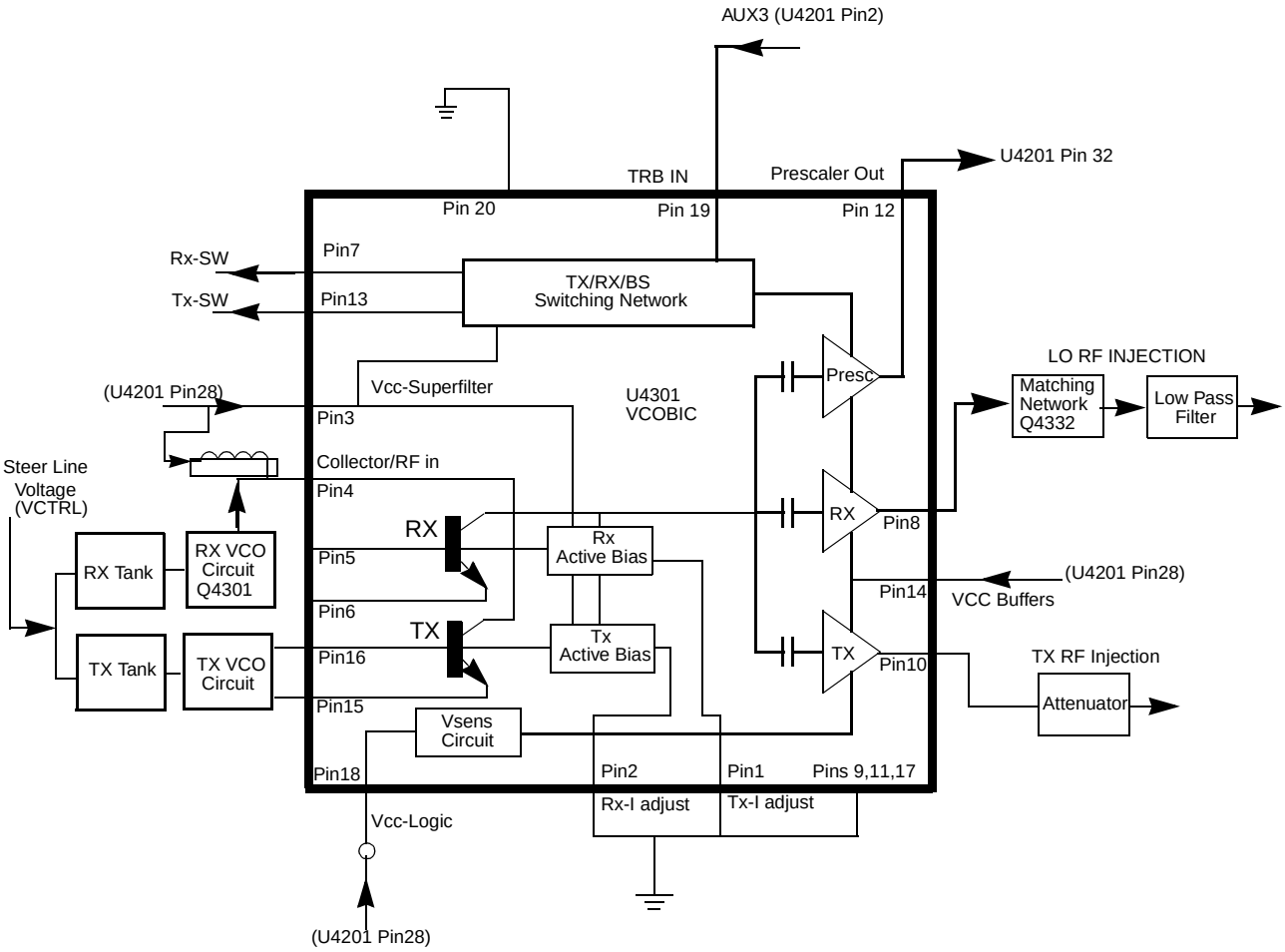


Figure 2-10. UHF VCO Block Diagram

The external RX buffers (Q4332) are enabled by a high at U4201 pin 3 (AUX4) via transistor switch Q4333. In TX mode the modulation signal (VCOMOD) from the LVFRAC-N synthesizer IC (U4201 pin41) is applied to the modulation circuits CR4321, R4321, R4322 and C4324. These modulate the TX VCO frequency via coupling capacitor C4321. Varactor CR4321 is biased for linearity from the VSF.

2.6.4 Synthesizer Operation

The complete synthesizer subsystem comprises mainly of a low voltage FRAC-N (LVFRACN) IC, Reference Oscillator (crystal oscillator with temperature compensation), charge pump circuits, loop filter circuits, and dc supply. The output signal (PRESC_OUT) of the VCOBIC (U4301, pin12) is fed to of U4201, pin 32 (PREIN) via a low pass filter (C4229,L4225,C4226) which attenuates harmonics and provides correct level to close the synthesizer loop.

The pre-scaler in the synthesizer (U4201) is basically a dual modulus pre-scaler with selectable divider ratios. The divider ratio of the pre-scaler is controlled by the loop divider, which in turn receives its inputs via the SRL. The output of the pre-scaler is applied to the loop divider. The output of the loop divider is connected to the phase detector, which compares the loop divider´s output signal with the reference signal.The reference signal is generated by dividing down the signal of the reference oscillator (Y4261 or Y4262).

The output signal of the phase detector is a pulsed dc signal which is routed to the charge pump. The charge pump outputs a current at pin 43 of U4201 (IOUT). The loop filter (which consists of R4221-R4223, C4221-C4225,L4221) transforms this current into a voltage that is applied to the varactor diodes CR4311 for transmit, CR4301, CR4302 & CR4303 for receive and alters the output frequency of the VCO.The current can be set to a value fixed in the LVFRAC-N IC or to a value determined by the currents flowing into BIAS 1 (U4201-40) or BIAS 2 (U4201-39). The currents are set by the value of R4251 or R4252 respectively. The selection of the three different bias sources is done by software programming.

To reduce synthesizer lock time when new frequency data has been loaded into the synthesizer the magnitude of the loop current is increased by enabling the IADAPT (U4201-45) for a certain software programmable time (Adapt Mode). The adapt mode timer is started by a low to high transient of the CSX line. When the synthesizer is within the lock range the current is determined only by the resistors connected to BIAS 1, BIAS 2, or the internal current source. A settled synthesizer loop is indicated by a high level of signal LOCK (U4201-4).

LOCK (U4201-4) signal is routed to one of the µP´s ADCs input U101-56. From the voltage the µP determines whether LOCK is active.

In order to modulate the PLL the two spot modulation method is utilized Via pin 10 (MODIN) on U4201. The audio signal is applied to both the A/D converter (low frequency path) as well as the balanced attenuator (high frequency path). The A/D converter converts the low frequency analog modulating signal into a digital code which is applied to the loop divider, thereby causing the carrier to deviate. The balance attenuator is used to adjust the VCO’s deviation sensitivity to high frequency modulating signals. The output of the balance attenuator is present at the MODOUT port (U4201-41) and connected to the VCO modulation diode CR4321 via R4321, C4325.

2.7 VHF (136-174MHz) Receiver Front-End

The receiver is able to cover the VHF range from 136 to 174 MHz. It consists of four major blocks: front-end bandpass filters and pre-amplifier, first mixer, 1st IF, 2nd IF, and receiver back-end. Two varactor-tuned bandpass filters perform antenna signal pre-selection. A cross over quad diode mixer converts the signal to the first IF of 44.85 MHz. High-side injection is used.

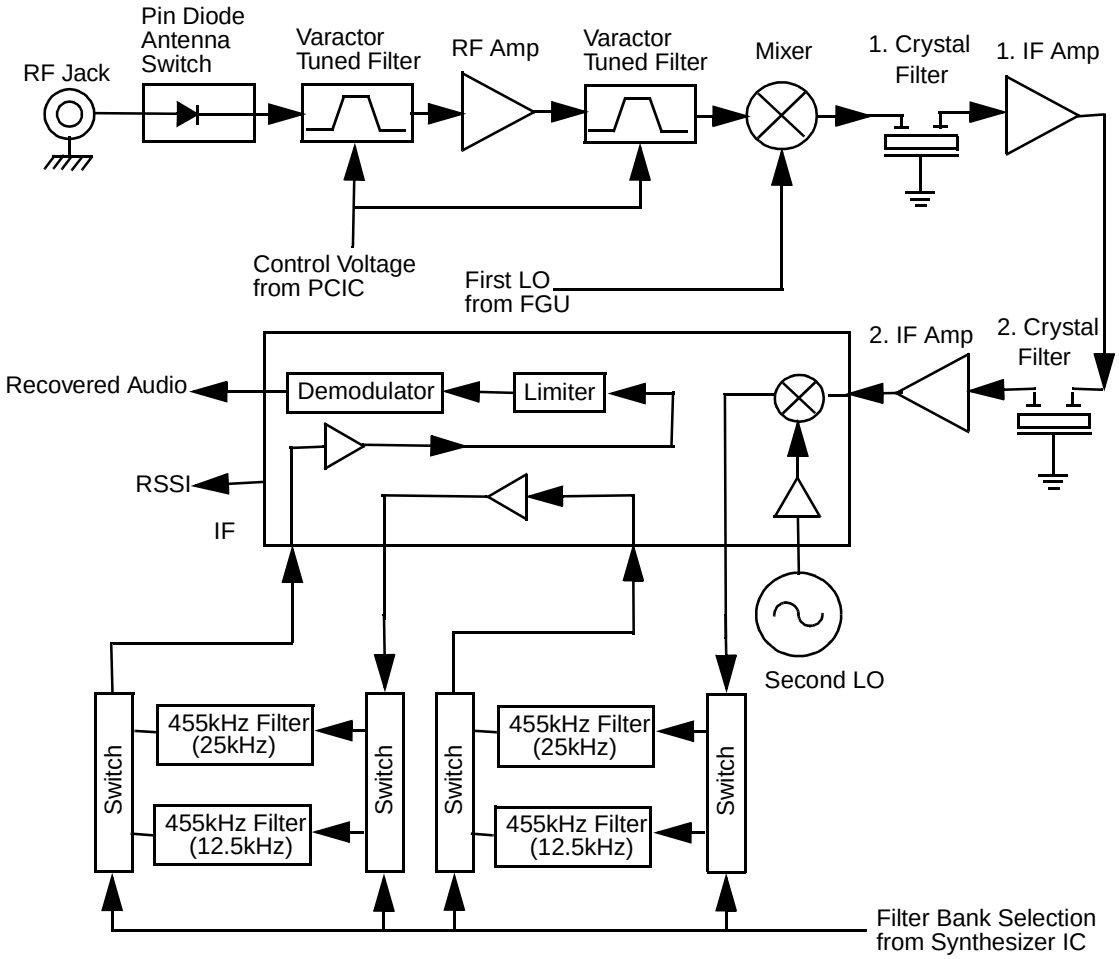


Figure 2-11. VHF Receiver Block Diagram

There are two 2-pole 44.85 MHz crystal filters in the 1st IF section and 2 pairs of 455 kHz ceramic filters in the 2nd IF section to provide the required adjacent channel selectivity. The correct pair of ceramic filters for 12.5 or 25kHz channel spacing is selected via control line BWSELECT. The second IF at 455 kHz is mixed, amplified and demodulated in the IF IC. The processing of the demodulated audio signal is performed by an audio processing IC located in the controller section.

2.7.1 Front-End Band-Pass Filters and Pre-Amplifier

The received signal from the radio's antenna connector is first routed through the harmonic filter and antenna switch, which are part of the RF power amplifier circuits, before being applied to the receiver pre-selector filter (C3001, C3002, D3001 and associated components). The 2-pole pre-selector filter tuned by the dual varactor diode D3001 pre-selects the incoming signal (RXIN) from the antenna switch to reduce spurious effects to following stages. The tuning voltage (FECTRL_1) ranging from 2 volts to 8 volts is controlled by pin 20 of PCIC (U3501) in the Transmitter section. A dual hot carrier diode (D3003) limits any inband signal to 0 dBm to prevent damage to the pre-amplifier.

The RF pre-amplifier is a surface mount device (SMD) Q3001 with collector-base feedback to stabilize gain, impedance, and intermodulation. Transistor Q3002 compares the voltage drop across resistor R3002 with a fixed base voltage from divider R3011, R3000 and R3012, and adjusts the base current of Q3001 as necessary to maintain its collector current constant at approximately 15-20 mA. Operating voltage is from the regulated 9.3V supply (9V3). During transmit, 9.1 volts (K9V1) turns off both transistors Q3002 and Q3001. This protects the RF pre-amplifier from excessive dissipation during transmit mode. A following 3dB pad (R3006 – R3008 and R3016 – R3018) stabilizes the output impedance and intermodulation performance.

A second 2-pole varactor tuned bandpass filter provides additional filtering of the amplified signal. The dual varactor diode D3004 is controlled by the same signal FECTRL_1, which controls the pre-selector filter.

2.7.2 First Mixer and 1st Intermediate Frequency (IF)

The signal coming from the front-end is converted to the 1st IF frequency of 44.85 MHz using a cross over quad diode mixer (D3031). Its ports are matched for incoming RF signal conversion to the 44.85 MHz IF using high side injection. The high-side injection signal (RXINJ) from the frequency synthesizer circuit has a level of approximately +13 dBm and is injected via matching transformer T3002.

The IF output signal (IF) from transformer T3001 pin 2 is fed to the first 2- pole crystal filter FL3101. The filter output in turn is matched to IF amplifier Q3101 which is actively biased by a collector base feedback (R3101, R3106) to a current drain of approximately 5 mA drawn from the 5 volt supply. Its output impedance is matched to the second 2-pole crystal filter FL3102. The signal is further amplified by a preamplifier (Q3102) before going into pin 1 of IFIC (U3101).

A dual hot carrier diode (D3101) limits the filter output voltage swing to reduce overdrive effects at RF input levels above -27 dBm.

2.7.3 2nd Intermediate Frequency (IF) and Receiver Back-End

The 44.85 MHz 1st IF signal from the second IF amplifier feeds the IF IC (U3101) at pin1. Within the IF IC, the 44.85 MHz high IF signal mixes with the 44.395 MHz second local oscillator (2nd LO) to produce the 2nd IF signal at 455 kHz. The 2nd LO frequency is determined by crystal Y3101. The 2nd IF signal is amplified and filtered by an external pair of 455 kHz ceramic filters FL3112, FL3114 for 20/25 kHz channel spacing or FL3111, FL3113/F3115 for 12.5 kHz channel spacing. These pairs are selectable via BWSELECT. The filtered output from the ceramic filters is applied to the limiter input pin of the IF IC (pin 14).

The IF IC contains a quadrature detector using a ceramic phase-shift element (Y3102) to provide audio detection. Internal amplification provides an audio output level of 120 mV rms (at 60% deviation) from U3101 pin 8 (DISCAUDIO) which is fed to the ASFIC_CMP (U0221) pin 2 (part of the Controller circuits).

A received signal strength indicator (RSSI) signal is available at U3101, pin 5, having a dynamic range of 70 dB. The RSSI signal is interpreted by the µP (U0101, pin 63) and in addition is available at accessory connector J0501-15.

2.8 Transmitter Power Amplifier (PA) 45 W

The radio's 45 W PA is a four-stage amplifier used to amplify the output from the VCOBIC to the radio transmit level. The line-up consists of three stages which utilize LDMOS and VMOS technology, followed by a final stage using a bipolar device. The gain of the first stage (U3401) is adjustable, controlled by pin 4 of PCIC (U3501) via Q3501 and Q3502 (VCONT). It is followed by an LDMOS pre-driver stage (Q3421), a VMOS driver stage (Q3431) and a bipolar final stage (Q3441).

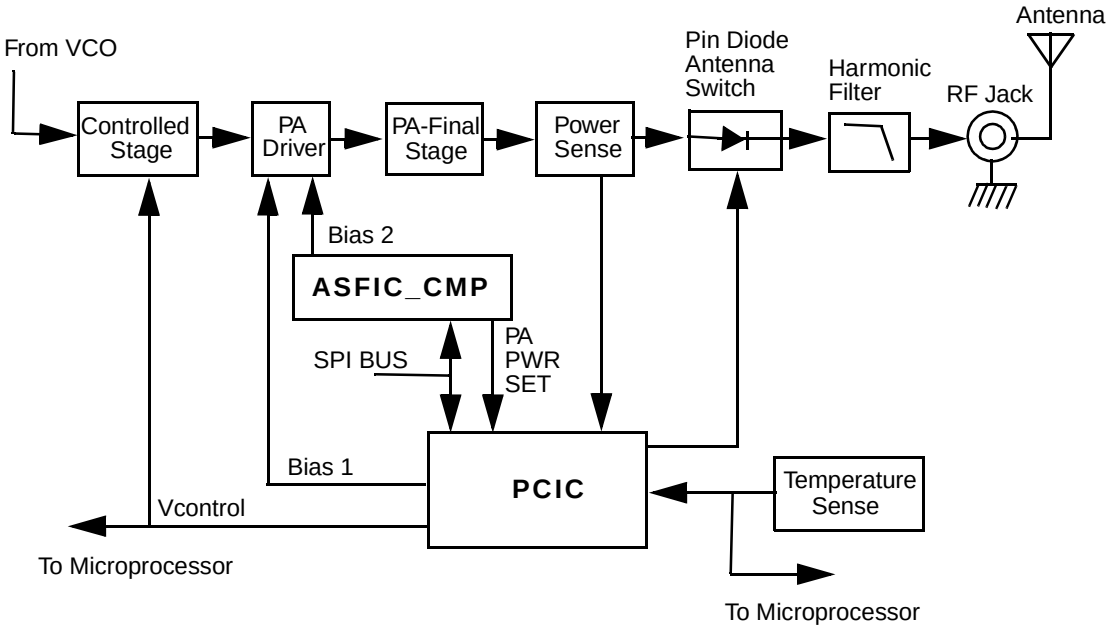


Figure 2-12. VHF Transmitter Block Diagram

Devices U3401 and Q3421 are surface mounted. The remaining devices are directly attached to the heat sink.

2.8.1 Power Controlled Stage

The first stage (U3401) is a 20 dB gain integrated circuit containing two LDMOS FET amplifier stages. It amplifies the RF signal from the VCO (TXINJ). The output power of stage U3401 is controlled by a dc voltage applied to pin 1 from the power control circuit (U3501 pin 4, with transistors Q3501 and Q3502 providing current gain and level-shifting). The control voltage simultaneously varies the bias of two FET stages within U3401. This biasing point determines the overall gain of U3401 and therefore its output drive level to Q3421, which in turn controls the output power of the PA.

In receive mode the voltage control line is at ground level and turns off Q3501-2, which in turn switches off the biasing voltage to U3401.

2.8.2 Pre-Driver Stage

The next stage is an LDMOS device (Q3421) providing a gain of +13 dB. This device requires a positive gate bias and a quiescent current flow for proper operation. The voltage of the line PCIC_MOSBIAS_1 is set during transmit mode by the PCIC pin 24, and fed to the gate of Q3421 via the resistive network R3410, R3415, and R3416. The bias voltage is factory tuned.

2.8.3 Driver Stage

The following stage is an enhancement-mode N-Channel MOSFET device (Q3431) providing a gain of 10 dB. This device also requires a positive gate bias and a quiescent current flow for proper operation. The voltage of the line MOSBIAS_2 is set in transmit mode by the ASFIC and fed to the gate of Q3431 via the resistive network R3404, R3406, and R3431-5. This bias voltage is also tuned in the factory. If the transistor is replaced, the bias voltage must be tuned using the Customer Programming Software (CPS). Care must be taken not to damage the device by exceeding the maximum allowed bias voltage. The device's drain current is drawn directly from the radio's dc supply voltage input, PASUPVLTG, via L3431 and L3432.

2.8.4 Final Stage

The final stage uses bipolar device Q3441. The device's collector current is also drawn from the radio's dc supply voltage input. To maintain class C operation, the base is dc-grounded by a series inductor (L3441) and a bead (L3442). A matching network consisting of C3446-52, C3467, L3444-5, and two striplines, transforms the impedance to approximately 50 ohms and feeds the directional coupler.

2.8.5 Directional Coupler

The directional coupler is a microstrip printed circuit, which couples a small amount of the forward and reflected power delivered by Q3441. The coupled signals are rectified by D3451-2 and combined by R3463-4. The resulting dc voltage is proportional to RF output power and feeds the RFIN port of the PCIC (U3501, pin 1). The PCIC controls the gain of stage U3401 as necessary to hold this voltage constant, thus ensuring the forward power out of the radio to be held to a constant value.

An abnormally high reflected power level, such as may be caused by a damaged antenna, also causes the dc voltage applied to the PCIC to increase, and this will cause a reduction in the gain of U3401, reducing transmitter output power to prevent damage to the final device due to an improper load.

2.8.6 Antenna Switch

The antenna switch consists of two PIN diodes, D3471 and D3472. In the receive mode, both diodes are off. Signals applied at the antenna jack J3401 are routed, via the harmonic filter, through network L3472, C3474 and C3475, to the receiver input. In the transmit mode, the keyed 9 volts turns on Q3471 which enables current sink Q3472, set to 96 mA by R3473 and VR3471. This completes a dc path from PASUPVLTG, through L3473, D3471, L3477, L3472, D3472, L3471, R3474 and the current sink, to ground. Both diodes are forward biased into conduction. The transmitter RF from the directional coupler is routed via D3471 to the harmonic filter and antenna jack. D3472 also conducts, shunting RF power and preventing it from reaching the receiver port (RXIN). L3472 is selected to appear as a broadband guarter-wave transmission line, making the short circuit presented by D3472 appear as an open circuit at the junction of D3472 and the receiver path.

2.8.7 Harmonic Filter

Components L3491-L3494 and C3490-C3498 form a nine-pole Chebychev low-pass filter to attenuate harmonic energy of the transmitter. R3490 is used to drain electrostatic charge that might otherwise build up on the antenna. The harmonic filter also prevents high level RF signals above the receiver passband from reaching the receiver circuits, improving spurious response rejection.

2.8.8 Power Control

The transmitter uses the power control IC (PCIC, U3501) to control the power output of the radio. A portion of the forward and reflected RF power from the transmitter is sampled by the directional coupler, rectified and summed, to provide a dc voltage to the RFIN port of the PCIC (pin 1) which is proportional to the sampled RF power.

The ASFIC contains a digital to analog converter (DAC) which provides a reference voltage of the control loop to the PCIC via R3517. The reference voltage level is programmable through the SPI line of the PCIC. This reference voltage is proportional to the desired power setting of the transmitter, and is factory programmed at several points across the frequency range of the transmitter to offset frequency response variations of the transmitter's power detector circuit.

The PCIC provides a dc output voltage at pin 4 (INT) which is amplified and shifted in dc level by stages Q3501 and Q3502. The 0 to 4 Vdc range at U1503, pin 4 is translated to a 0 to 8.5 Vdc range at the output of Q3501, and applied as VCONT to the power-adjust input pin of the first transmitter stage U3401. This adjusts the transmitter power output to the intended value. Variations in forward or reflected transmitter power cause the dc voltage at pin 1 to change, and the PCIC adjusts the control voltage above or below its nominal value to raise or lower output power.

Capacitors C3502-4, in conjunction with resistors and integrators within the PCIC, control the transmitter power-rise (key-up) and power-decay (de-key) characteristic to minimize splatter into adjacent channels.

U3502 is a temperature-sensing device, which monitors the circuit board temperature in the vicinity of the transmitter driver and final devices, and provides a dc voltage to the PCIC (TEMP, pin 29) proportional to temperature. If the dc voltage produced exceeds the set threshold in the PCIC, the transmitter output power is reduced so as to reduce the transmitter temperature.

2.9 Frequency Synthesis

The frequency synthesizer subsystem consists of the reference oscillator (Y3261 or Y3262), the Low Voltage Fractional-N synthesizer (LVFRAC-N, U3201), and the voltage-controlled oscillators and buffer amplifiers (U3301, Q3301-2 and associated circuits).

2.9.1 Reference Oscillator

The reference oscillator (Y3262) contains a temperature compensated crystal oscillator with a frequency of 16.8 MHz. An analog-to-digital (A/D) converter internal to U3201 (LVFRAC-N) and controlled by the µP via serial interface (SRL) sets the voltage at the warp output of U3201 (pin 25) to set the frequency of the oscillator. The output of the oscillator (U3262 pin 3) is applied to pin 23 (XTAL1) of U3201 via R3263 and C3235.

In applications were less frequency stability is required, the oscillator inside U3201 is used along with an external crystal Y3261, varactor diode D3261, C3261, C3262 and R3262. In this case, Y3262, R3263, C3235 and C3251 are not used. When Y3262 is used, Y3261, D3261, C3261, C3262 and R3262 are not used, and C3263 is increased to 0.1 uF.

2.9.2 Fractional-N Synthesizer

The LVFRAC-N synthesizer IC (U3201) consists of a pre-scaler, a programmable loop divider, control divider logic, a phase detector, a charge pump, an A/D converter for low frequency digital modulation, a balance attenuator to balance the high frequency analog modulation and low frequency digital modulation, a 13 volt positive voltage multiplier, a serial interface for control, and finally a super filter for the regulated 5 volts.

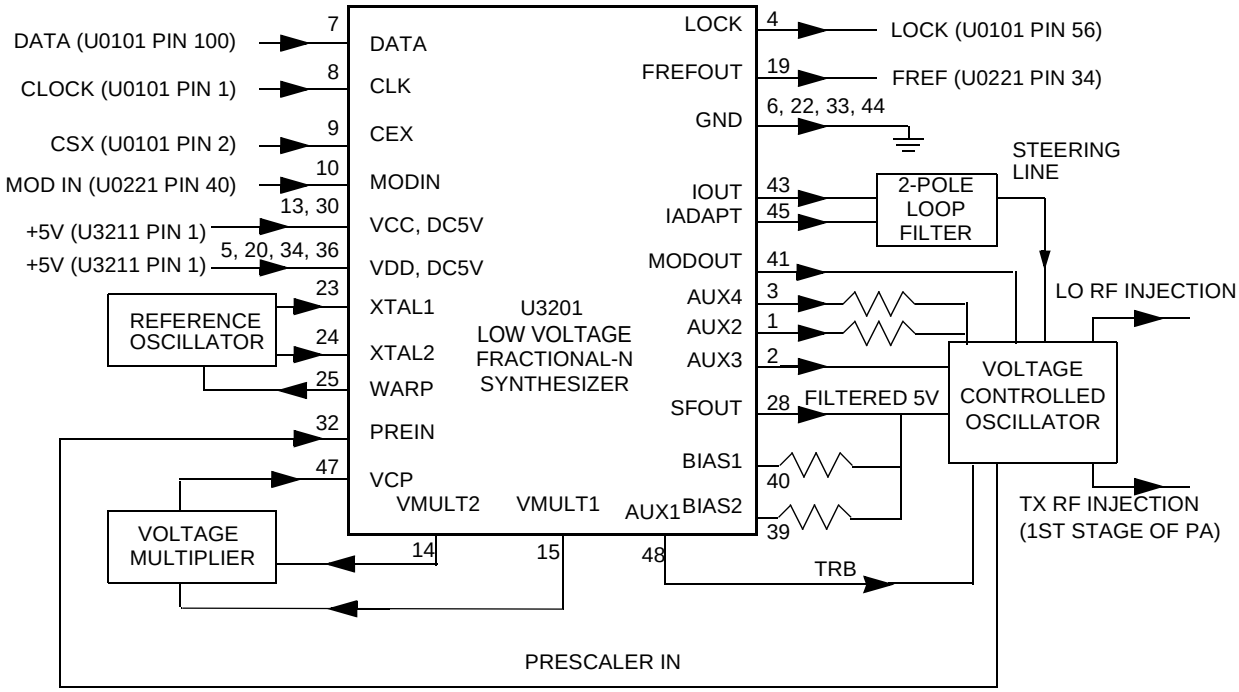


Figure 2-13. VHF Synthesizer Block Diagram

A voltage of 5V applied to the super filter input (U3201 pin 30) supplies an output voltage of 4.5 Vdc (VSF) at pin 28. It supplies the VCO, VCO modulation bias circuit (via R3363) and the synthesizer charge pump resistor network (R3251, R3252). The synthesizer supply voltage is provided by the 5V regulator U3211.

In order to generate a high voltage to supply the phase detector (charge pump) output stage at pin VCP (U3201-47), a voltage of 13 Vdc is being generated by the positive voltage multiplier circuits (D3201, C3202, C3203). This voltage multiplier is basically a diode capacitor network driven by two signals (1.05MHz) 180 degrees out of phase signals (U3201-14 and -15).

Output LOCK (U3201-4) provides information about the lock status of the synthesizer loop. A high level at this output indicates a stable loop. IC U3201 provides the 16.8 MHz reference frequency at pin 19.

The serial interface (SRL) is connected to the µP via the data line DATA (U3201-7), clock line CLK (U3201-8), and chip enable line CSX (U3201-9).

2.9.3 Voltage Controlled Oscillator (VCO)

The Voltage Controlled Oscillator (VCO) consists of the VCO/Buffer IC (VCOBIC, U3301), the TX and RX tank circuits, the external RX buffer stages, and the modulation circuits.

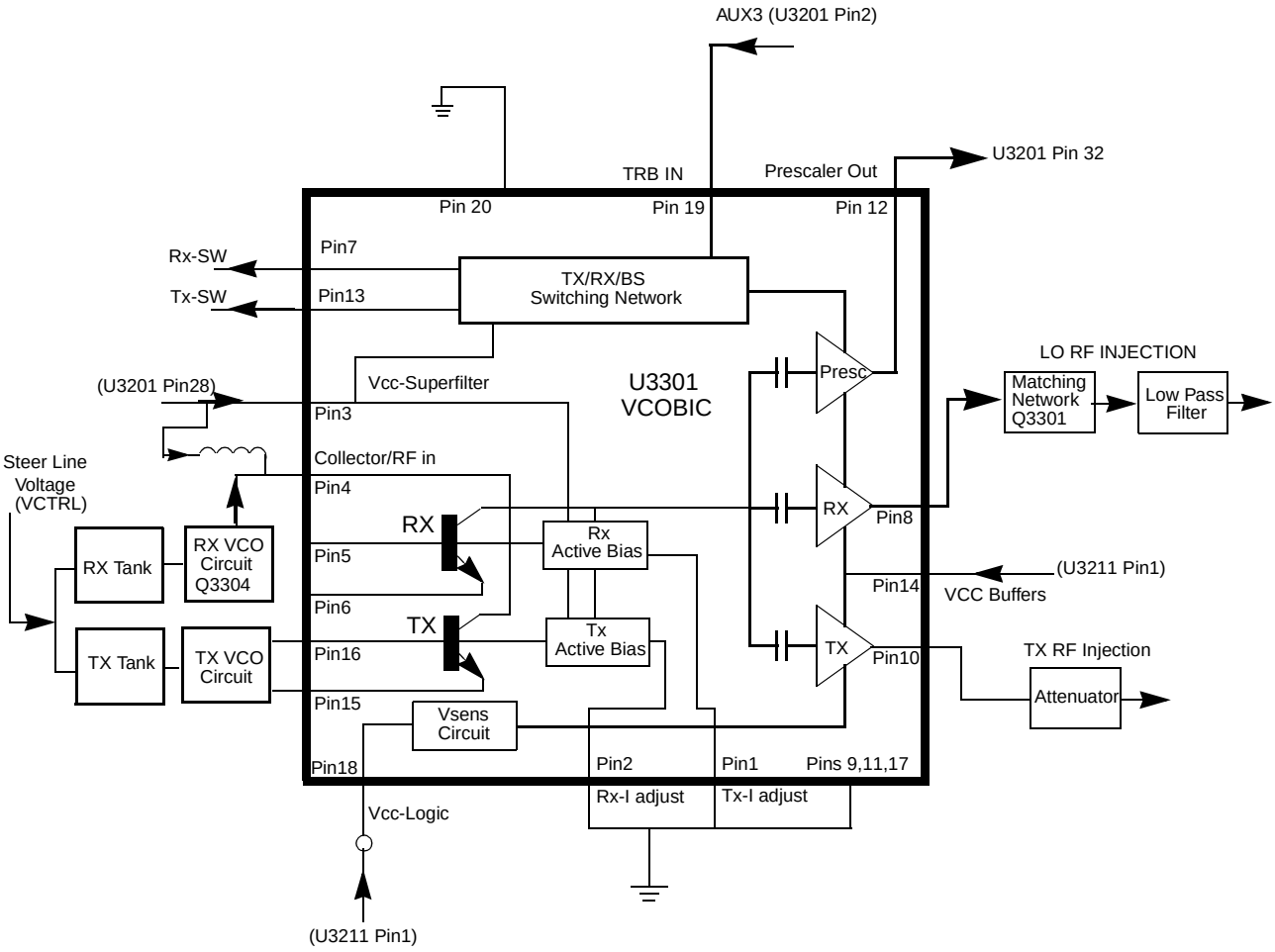


Figure 2-14. VHF VCO Block Diagram

The VCOBIC together with the Fractional-N synthesizer (U3201) generates the required frequencies in both the transmit and receive modes. The TRB line (U3301, pin 19) determines which tank circuits and internal buffers are to be enabled. A high level on TRB enables the TX tank and TX output (pin 10), and a low enables the RX tank and RX output (pin 8). A sample of the signal from the enabled RF output is routed from U3301, pin 12 (PRESC_OUT), via a low pass filter, to U3201, pin 32 (PREIN).

A steering line voltage (VCTRL) between 2.5 volts and 11 volts at varactor diode D3361 tune the full TX frequency range (TXINJ) from 136 MHz to 174 MHz, and varactor diode D3341 tunes the full RX frequency range (RXINJ) from 181 MHz to 219 MHz. The RX tank circuit uses a Hartley configuration for wider bandwidth. For the RX tank circuit, an external transistor Q3304 is used for better side-band noise.

The external RX buffers (Q3301 and Q3302) are enabled by a high at U3301, pin 7 (RX_SWITCH) via transistor switch Q3303. In the TX mode, the modulation signal (VCOMOD) from the LVFRAC-N synthesizer IC (U3201 pin 41) is applied to varactor diode D3362, which modulates the TX VCO frequency via capacitor C3362. Varactor D3362 is biased for linearity from the VSF.

2.9.4 Synthesizer Operation

The complete synthesizer subsystem consists of the low voltage FRAC-N (LVFRACN), reference oscillator (a crystal oscillator with temperature compensation), charge pump circuit, loop filter circuit and a dc supply. The output signal PRESC from the VCOBIC (U3301 pin 12) is fed to U3201 pin 32 (PREIN) via a low pass filter (C3318, L3318 and C3226) which attenuates harmonics and provides the correct level to close the synthesizer loop.

The pre-scaler in the synthesizer (U3201) is a dual modulus type with selectable divider ratios. The divider ratio of the pre-scaler is controlled by the loop divider, which in turn receives its inputs via the SRL. The output of the pre-scaler is applied to the loop divider. The output of the loop divider is connected to the phase detector, which compares the loop divider´s output signal with the reference signal. The reference signal is generated by dividing down the signal of reference oscillator Y3261 or Y3262.

The output signal of the phase detector is a pulsed dc signal which is routed to the charge pump. The charge pump outputs a current at U3201 pin 43 (IOUT). The loop filter (which consists of R3221-R3223 and C3221-C3224) transforms this current into a voltage that is applied to the varactor diodes (D3361 for transmit, D3341 for receive) to alter the output frequency of the appropriate VCO. The current can be set to a value fixed within the LVFRAC-N IC, or to a value determined by the currents flowing into BIAS 1 (U3201-40) or BIAS 2 (U3201-39). The currents are set by the value of R3251 and R3252 respectively. The selection of the three different bias sources is done by software programming.

To reduce synthesizer lock time when new frequency data has been loaded into the synthesizer, the magnitude of the loop current is increased by enabling the IADAPT pin (U3201-45) for a certain software programmable time (adapt mode). The adapt mode timer is started by a low to high transient of the CSX line. When the synthesizer is within the lock range, the current is determined only by the resistors connected to BIAS 1 and BIAS 2, or by the internal current source. A settled synthesizer loop is indicated by a high level signal at U3201-4 (LOCK).

The LOCK signal is routed to one of the µP´s ADC inputs (U0101-56). From the measured voltage, the µP determines whether LOCK is active.

To modulate the PLL, the two spot modulation method is utilized. Via U3201, pin 10 (MODIN), the audio signal is applied to both the A/D converter (low frequency path) as well as the balance attenuator (high frequency path). The A/D converter changes the low frequency analog modulating signal into a digital code that is applied to the loop divider, thereby causing the carrier to deviate. The balance attenuator is used to adjust the VCO’s deviation sensitivity to high frequency modulating signals. The output of the balance attenuator is present at the MODOUT port (U3201-41) and connected to the VCO modulation diode D3362 via R3364.

2.10 Control Head (PRO3100, CDM750)

ThE Control Head Contains the internal speaker, the on/off/volume knob, the microphone connector, several buttons to operate the radio and several indicator Light Emitting Diodes (LED) to inform the user about the radio status. To control the LED's and to communicate with the host radio the control head uses the Motorola 68HC11E9 µP.

2.10.1 Power Supplies

The power supply to the control head is taken from the host radio's FLT A+ voltage via connector J0801, pin 3 and the regulated +5V via connector J0801 pin 7. The voltage FLT A+ is at battery level and is used for the LED's, the back light and to power up the radio via on / off / volume knob. The stabilized +5 volt is used for µP and the keypad buttons. The voltage USW 5V derived from the FLT A+ voltage and stabilized by the series combination of R0822, VR0822 is used to buffer the internal RAM of the µP (U0831). C0822 allows the battery voltage to be disconnected for a couple of seconds without losing RAM parameters. Dual diode D0822 prevents radio circuits from discharging this capacitor. When the supply voltage is applied to the radio, C0822 is charged via R0822 and D0822. To avoid the µP entering the wrong mode if the radio is switched on while the voltage across C0822 is still too low, the regulated 5 volt supply charges C0822 via diode D0822.

2.10.2 Power On/Off

The on/off/Volume knob, when pressed, switches the radio's voltage regulators on by connecting line ON OFF CONTROL to line UNSW 5V via D0821. Additionally, 5 volts at the base of digital transistor Q0822 informs the control head's µP about the pressed knob. The µP asserts pin 62 and line CH REQUEST low to hold the line ON OFF CONTROL at 5 volts via Q0823 and D0821. The high line ON OFF CONTROL also informs the host radio that the control head's µP wants to send data via the SBEP bus. When the radio returns a data request message, the µP informs the radio about the pressed knob. If the radio is switched off, the radio's µP switches it on and vice versa. If the on/off/ volume knob is pressed while the radio is on, the software detects a low state on line ON OFF SENSE, the radio is alerted via line ON OFF CONTROL and sends a data request message. The control head µP informs the radio about the pressed knob and the radio's µP switches the radio off.

2.10.3 Microprocessor Circuit

The control head uses the Motorola 68HC11E9 microprocessor (µP) (U0831) to control the LED's and to communicate with the host radio. RAM and ROM are contained within the µP.

The µP generates it's clock using the oscillator inside the µP along with a 8 MHz ceramic resonator (U0833) and R0920.

The µP's RAM is always powered to maintain parameters such as the last operating mode. This is achieved by maintaining 5V at uP, pin 25. Under normal conditions, when the radio is off, USW 5V is formed by FLT A+ running to D0822. Capacitor C0822 allows the battery voltage to be disconnected for a couple of seconds without losing RAM parameters. Diode D0822 prevents radio circuits from discharging this capacitor.

There are eight analog-to-digital converter ports (A/D) on the uP. They are labeled within the device block as PE0-PE7. These lines sense the voltage level ranging from 0 to 5 volts of the input line and convert that level to a number ranging from 0 to 255 which can be read by the software to take appropriate action.

The Pin VRH Pin is the high reference voltage for the A/D ports on the uP. If this voltage is lower than +5V the A/D reading is incorrect. The VRL signal is the low reference for the A/D ports. This line is normally tied to ground. If this line is not connected to ground, the A/D readings could be incorrect.

The µP determines the used keypad type and the control head ID by reading the levels at ports PC0 – PC7. Connections JU0852/3/4 are provided by the individual keypads.

The MODB / MODA input of the µP must be at a logic 1 to start executing correctly. The XIRQ and the IRQ pins should also be at a logic 1.

Voltage sense device U0832 provides a reset output that goes to 0 volts if the regulated 5 volts goes below 4.5 volts. This is used to reset the controller to prevent improper operation.

2.10.4 SBEP Serial Interface

The host radio (master) communicates to the control head µP (slave) through its SBEP bus. This bus uses only line BUS+ for data transfer. The line is bi-directional meaning that either the radio or the control head µP can drive the line. The µP sends serial data via pin 50 and D0831 and it reads serial data via pin 47. Whenever the µP detects activity on the BUS+ line, it starts communication.

When the host radio needs to communicate to the control head uP, it sends data via line BUS+. Any transition on this line generates an interrupt and the µP starts communication. The host radio may send data like LED and back light status or it may request the control head ID or the keypad ID.

When the control head µP wants to communicate to the host radio, the uP brings the request line CH REQUEST to a logic 0 via µP pin 62. This switches on Q0823, which pulls line ON OFF CONTROL high through diode D0821. A low to high transition on this line informs the radio, that the control head requires service. The host radio then sends a data request message via BUS+ and the control head uP replies with the data it wanted to send. This data can be information like which key has been pressed or that the volume knob has been rotated.

The control head uP monitors all messages sent via BUS+, but ignores any data communication between the host radio and CPS or universal tuner.

2.10.5 Keypad Keys

The control head keypad is a 6-key design. All keys are configured as two analog lines read by µP pins 13 and 15. The voltage on the analog lines varies between 0 volts and +5 volts depending on which key has been pressed. If no key is pressed, the voltage at both lines is 5 volts. The key configuration can be thought of as a matrix, where the two lines represent one row and one column. Each line is connected to a resistive divider powered by +5 volts. If a button is pressed, it will connect one specific resistor of each divider line to ground level and thereby reduce the voltages on the analog lines The voltages of the lines are A/D converted inside the µP (ports PE 0 - 1) and specify the pressed button. To determine which key is pressed, the voltage of both lines must be considered.

An additional pair of analog lines and A/D µP ports (PE 3 – 2) are available to support a keypad microphone, connected to the microphone connector J0811. Any microphone key press is processed the same way as a key press on a control head.

2.10.6 Status LED and Back Light Circuit

All indicator LED’s (red, yellow, green) are driven by current sources. To change the LED status the host radio sends a data message via SBEP bus to the control head µP. The control head µP determines the LED status from the received message and switches the LED’s on or off via port PB 7 – 0 and port PA4. The LED status is stored in the µP’s memory. The LED current is determined by the resistor at the emitter of the respective current source transistor.

The back light for the keypad is controlled by the host radio the same way as the indicator LED’s using uP port PA 5. The µP can switch the back light on and off under software control. The keypad back light current is drawn from the FLT A+ source and controlled by 2 current sources. The LED current is determined by the resistor at the emitter of the respective current source transistor.

2.10.7 Microphone Connector Signals

Signals BUS+, PTT IRDEC, HOOK, MIC, HANDSET AUDIO, FLT A+, +5V, and two A/D converter inputs are available at the microphone connector J0811. Signal BUS+ (J0811-7) connects to the SBEP bus for communication with the CPS or the Universal Tuner. Line MIC (J0811-5) feeds the audio from the microphone to the radio's controller via connector J0801-4. The Line HANDSET AUDIO (J0811-8) feeds the receiver audio from the controller (J0801-6) to a connected handset. FLT A+, which is at supply voltage level, and +5V are used to supply any connected accessory like a microphone or a handset.

The two A/D converter inputs (J0811-9/10) are used for a microphone with keypad. A pressed key changes the dc voltage on both lines. The voltages depend on which key is pressed. The µP determines from the voltage on these lines which key is pressed and sends the information to the host radio.

Line PTT IRDEC (J0811-6) is used to key µP the radio's transmitter. While the PTT button on a connected microphone is released, line PTT IRDEC is pulled to +5 volts level by R0843. Transistor Q0843 is switched on and causes a low at µP port PA2. When the PTT button is pressed, signal PTT IRDEC is pulled to ground level. This switches off Q0843 and the resulting high level at µP port PA2 informs the µP about the pressed PTT button. The µP informs the host radio about any status change on the PTT IRDEC line via SBEP bus.

When line PTT IRDEC is connected to FLT A+ level, transistor Q0821 is switched on through diode VR0821 and thereby pulls the level on line ON OFF CONTROL to FLT A+ level. This switches on the radio and puts the radio's µP in bootstrap mode. Bootstrap mode loads the firmware into the radio's flash memory.

The HOOK input (J0811-3) informs the µP when the microphone´s hang-up switch is engaged. Depending on the CPS programming, the µP may take actions like turning the audio PA on or off. While the hang µp switch is open, the line HOOK is pulled to +5 volts level by R0841. Transistor Q0841 is switched on and causes a low at µp port PA1. When the HOOK switch is closed, the HOOK signal is pulled to ground level. This switches off R0841and the resulting high level at µp port PA1 informs the µp about the closed hang µp switch. The µp informs the host radio about any status change on the HOOK line via SBEP bus.

2.10.8 Speaker

The control head contains a speaker for the receiver audio. The receiver audio signal from the differential audio output of the audio amplifier located on the radio's controller, is fed via connector J0801-10, 11 to the speaker connector P0801, pins 1 and 2. The speaker is connected to the speaker connector P0801. The control head speaker can be disconnected only if an external speaker, connected on the accessory connector, is used.

2.10.9 Electrostatic Transient Protection

Electrostatic transient protection is provided for the sensitive components in the control head by diodes VR0811 VR00812 VR0816 - VR0817. The diodes limit any transient voltages. The associated capacitors provide radio frequency interference (RFI) protection.

2.11 Control Head (PRO5100, PRO7100, CDM1250, CDM1550)

The control head contains the internal speaker, the on/off/volume knob, the microphone connector, several buttons to operate the radio, several indicator light emitting diodes (LEDs) to inform the user about the radio status, and a 14 character liquid crystal display (LCD) for alpha - numerical information, e.g. channel number or call address name. To control the LED's and the LCD, and to communicate with the host radio the control head uses the Motorola 68HC11E9 µP.

2.11.1 Power Supplies

The power supply to the control head is taken from the host radio's FLT A+ voltage via connector J0801 pin 3 and the regulated +5V via connector J0801 pin 7. The voltage FLT A+ is at battery level and is used for the LED's, the back light and to power up the radio via on / off / volume knob. The stabilized +5 volt is used for the µP, display, display driver, and keypad buttons. The voltage USW 5V derived from the FLT A+ voltage and stabilized by the series combination of R0822, VR0822 is used to buffer the internal RAM of the µP (U0831). C0822 allows the battery voltage to be disconnected for a couple of seconds without losing RAM parameters. Dual diode D0822 prevents radio circuits from discharging this capacitor. When the supply voltage is applied to the radio, C0822 is charged via R0822 and D0822. To avoid that the µp enters the wrong mode when the radio is switched on while the voltage across C0822 is still too low, the regulated 5V charge C0822 via diode D0822.

2.11.2 Power On / Off

The on/off/volume knob when pressed switches the radio's voltage regulators on by connecting line ON OFF CONTROL to line UNSW 5V via D0821. Additionally, 5 volts at the base of digital transistor Q0822 informs the control head's µP about the pressed knob. The µP asserts pin 62 and line CH REQUEST low to hold line ON OFF CONTROL at 5 volts via Q0823 and D0821. The high line ON OFF CONTROL also informs the host radio, that the control head's µP wants to send data via SBEP bus. When the radio returns a data request message, the µP informs the radio about the pressed knob. If the radio was switched off, the radio's µp switches it on and vice versa. If the on/off/volume knob is pressed while the radio is on, the software detects a low state on line ON OFF SENSE, the radio is alerted via line ON OFF CONTROL and sends a data request message. The control head µp will inform the radio about the pressed knob and the radio's µp switches the radio off.

2.11.3 Microprocessor Circuit

The control head uses the Motorola 68HC11E9 microprocessor (µp) (U0831) to control the LED's and the LCD and to communicate with the host radio. RAM and ROM are contained within the µP itself.

The µP generates it's clock using the oscillator inside the µP along with a 8 MHz ceramic resonator (U0833) and R0920.

The µP's RAM is always powered to maintain parameters such as the last operating mode. This is achieved by maintaining 5 volts at µp, pin 25. Under normal conditions, when the radio is off, USW 5V is formed by FLT A+ running to D0822. C0822 allows the battery voltage to be disconnected for a couple of seconds without losing RAM parameters. Diode D0822 prevents radio circuits from discharging this capacitor.

There are eight analog-to-digital converter ports (A/D) on the µp. They are labeled within the device block as PE0-PE7. These lines sense the voltage level ranging from 0 to 5V of the input line and convert that level to a number ranging from 0 to 255 which can be read by the software to take appropriate action.

Pin VRH is the high reference voltage for the A/D ports on the µP. If this voltage is lower than +5V the A/D reading is incorrect. Likewise pin VRL is the low reference for the A/D ports. This line is normally tied to ground. If this line is not connected to ground, the A/D readings could be incorrect.

The µP determines the used keypad type and the control head ID by reading the levels at ports PC0 – PC7. Connections JU0852/3/4 are provided by the individual keypads.

The MODB / MODA input of the µP must be at a logic 1 for it to start executing correctly. The XIRQ and the IRQ pins should also be at a logic 1.

Voltage sense device U0832 provides a reset output that goes to 0 volts if the regulated 5 volts goes below 4.5 volts. This is used to reset the controller to prevent improper operation.

2.11.4 SBEP Serial Interface

The host radio (master) communicates to the control head µP (slave) through its SBEP bus. This bus uses only line BUS+ for data transfer. The line is bi-directional, meaning that either the radio or the control head µP can drive the line. The µP sends serial data via pin 50 and D0831 and it reads serial data via pin 47. Whenever the µP detects activity on the BUS+ line, it starts communication.

When the host radio needs to communicate to the control head µP, it sends data via line BUS+. Any transition on this line generates an interrupt and the µP starts communication. The host radio may send data like display information, LED and back light status or it may request the control head ID or the keypad ID.

When the control head µP wants to communicate to the host radio, the µP brings request line CH REQUEST to a logic 0 via µP, pin 62. This switches on Q0823, which pulls line ON OFF CONTROL high through diode D0821. A low to high transition on this line informs the radio, that the control head requires service. The host radio then sends a data request message via BUS+ and the control head µP replies with the data it wanted to send. This data can be information such as a key is pressed or the volume knob rotated.

The control head µP monitors all messages sent via BUS+, but ignores any data communication between host radio and CPS or Universal Tuner.

2.11.5 Keypad Keys

The control head keypad is a 6-key keypad (Model B) or a 10- key keypad (model C). All keys are configured as two analog lines read by µP, pins 13 and 15. The voltage on the analog lines varies between 0 volts and +5 volts depending on which key has been pressed. If no key is pressed, the voltage at both lines is 5 volts. The key configuration can be thought of as a matrix, where the two lines represent one row and one column. Each line is connected to a resistive divider powered by +5 volts. If a button is pressed, it will connect one specific resistor of each divider line to ground level and thereby reduce the voltages on the analog lines The voltages of the lines are A/D converted inside the µP (ports PE 0 - 1) and specify the pressed button. To determine which key is pressed, the voltage of both lines must be considered.

An additional pair of analog lines and A/D µP ports (PE 3 – 2) is available to support a keypad microphone, connected to the microphone connector J0811. Any microphone key press is processed the same way as a key press on the control head.

2.11.6 Status LED and Back Light Circuit

All the indicator LED’s (red, yellow, green) are driven by current sources. To change the LED status the host radio sends a data message via SBEP bus to the control head µP. The control head µP determines the LED status from the received message and switches the LED’s on or off via port PB 7 – 0 and port PA4. The LED status is stored in the µP’s memory. The LED current is determined by the resistor at the emitter of the respective current source transistor.

The back light for the LCD and the keypad is controlled by the host radio the same way as the indicator LED’s using µP port PA 5. This port is a Pulse Width Modulator (PWM) output. The output signal charges capacitor C0843 through R0847. By changing the pulse width under software control, the dc voltage of C0843 and thereby, the brightness of the back light can be changed in four steps.

The keypad back light current is drawn from the FLT A+ source and controlled by transistor Q0933. The current flowing through the LED's cause a proportional voltage drop across the parallel resistors R0947, R0948. This voltage drop is amplified by the op-amp U0931-2. U0931-2 and Q0934 form a differential amplifier. The voltage difference between the base of Q0934 and the output of U0931-2 determines the current from the base of the LED control transistor Q0933 and in turn the brightness of the LED's. The µP controls the LED's by changing the dc level at the base of Q0934. If the base of Q0934 is at ground level, Q0934 is switched off and no current flows through Q0933 and the LED's. If the base voltage of Q0934 rises a current flows through Q0934 and in turn through Q0933 causing the LED's to turn on and a rising voltage drop across R0947, R0948. The rising voltage causes the output of the op-amp to rise and to reduce the base to emitter voltage of Q0934. This decreases the current of Q0933 until the loop has settled.

2.11.7 Liquid Crystal Display (LCD)

The LCD H0971 uses the display driver U0971. The display is a single-layer super-twist pneumatic (STN) LCD display. It has 14 characters with a 5*8 dot matrix for displaying alpha - numerical information and a line with 21 pre - defined icons above the dot matrix

The driver contains a data interface to the µP, an LCD segment driver, an LCD power circuit, an oscillator, data RAM and control logic. At power up the driver's control logic is reset by a logic 0 at input SR2 (U0971-15). The driver's internal oscillator is set to about 20 kHz and can be measured at pin 22. The driver's µP interface is configured to accept 8 bit parallel data input (U0971-D0-D7) from the control head µP (U0831 port PC0-PC7).

To write data to the driver's RAM the µP sets chip select (U0971-20) to logic 0 via U0831-11, RD (U0971-18) to logic 1 via (U0831-10) and WR (U0971-17) to logic 0 via U0831-9. With input A0 (U0971-21) set to logic 0 via U0831-12 the µP writes control data to the driver. Control data includes the RAM start address for the following display data. With input A0 set to logic 1 the µP then writes the display data to the display RAM. When data transfer is complete the µP terminates the chip select, RD, and WD activities.

The display driver's power circuit provides the voltage supply for the display. This circuit consists of a voltage multiplier, voltage regulator and a voltage follower. The external capacitors C0971 - C0973 configure the multiplier to double the supply voltage. In this configuration the multiplier output VOUT (U0971-8) supplies a voltage of -5V (2* -5V below VDD). The multiplied voltage VOUT is sent to the internal voltage regulator. To set the voltage level of the regulator output V5 (U0971-5) this voltage is divided by the resistors R0973 and R0974 and fed back to the reference input VR (U0971-6). In addition the regulator output voltage V5 can be controlled electronically by a control command sent to the driver. With the used configuration the voltage V5 is about –2V. The voltage V5 is resistively divided by the driver's voltage follower to provide the voltages V1 - V4. These voltages are needed for driving the liquid crystals. The level of V5 can be measured by one of the µP's analog-to-digital converters (U0831-20) via resistive divider R0975, R0976. To stabilize the display brightness over a large temperature range the µP measures the temperature via analog-to-digital converter (U0831-18) using temperature sensor U0834. Dependent on the measured temperature the µP adjusts the driver output voltage V5, and in turn the display brightness, via parallel interface.

2.11.8 Microphone Connector Signals

Signals BUS+, PTT IRDEC, HOOK, MIC, HANDSET AUDIO, FLT A+, +5V and 2 A/D converter inputs are available at the microphone connector J0811. Signal BUS+ (J0811-7) connects to the SBEP bus for communication with the CPS or the Universal Tuner. Line MIC (J0811-5) feeds the audio from the microphone to the radio's controller via connector J0801-4. Line HANDSET AUDIO (J0811-8) feeds the receiver audio from the controller (J0801-6) to a connected handset. FLT A+, which is at supply voltage level, and +5V are used to supply any connected accessory like a microphone or a handset.

The two A/D converter inputs (J0811-9/10) are used as a microphone with keypad. A pressed key changes the dc voltage on both lines. The voltages depend on which key is pressed. The µP determines, from the voltage on these lines, which key is pressed and sends this information to the host radio.

Line PTT IRDEC (J0811-6) is used to key up the radio's transmitter. While the PTT button on a connected microphone is released, line PTT IRDEC line is pulled to a +5 volts level by R0843. Transistor Q0843 is then switched on causing a low at µP port PA2. When the PTT button is pressed, signal PTT IRDEC is pulled to ground level. This switches off Q0843 and the resulting high level at µP port PA2 informs the µP about the pressed PTT button. The µP informs the host radio about any status change on the PTT IRDEC line via the SBEP bus.

When line PTT IRDEC is connected to FLT A+ level, transistor Q0821 is switched on through diode VR0821 pulling the level on the line ON OFF CONTROL to FLT A+ level. This switches on the radio and puts the radio's µP in bootstrap mode. Bootstrap mode is used to load the firmware into the radio's flash memory.

The HOOK input (J0811-3) is used to inform the µP when the microphone´s hang-up switch is engaged. Dependent on the CPS programming the µP may take actions like turning the audio PA on or off. While the hang up switch is open, line HOOK is pulled to +5 volts level by R0841. Transistor Q0841 is switched on causing a low at µP port PA1. When the HOOK switch is closed, signal HOOK is pulled to ground level. This switches off R0841 and the resulting high level at µP port PA1 informs the µP about the closed hang up switch. The µP informs the host radio about any status change on the HOOK line via SBEP bus.

2.11.9 Speaker

The control head contains a speaker for the receiver audio. The receiver audio signal from the differential audio output of the audio amplifier located on the radio's controller is fed via connector J0801-10, -11 to the speaker connector P0801, pins 1 and 2. The speaker is connected to the speaker connector P0801. The control head speaker can only be disconnected if an external speaker, connected on the accessory connector, is used.

2.11.10 Electrostatic Transient Protection

Electrostatic transient protection is provided for the sensitive components in the control head by diodes VR0811 VR00812 and VR0816 - VR0817. The diodes limit any transient voltages. The associated capacitors provide radio frequency interference (RFI) protection.

Chapter 3

Maintenance

3.1 Introduction

This chapter of the manual describes:

- Preventive maintenance
- Safe handling of CMOS and LDMOS devices
- Repair procedures and techniques

3.2 Preventive Maintenance

The radios do not require a scheduled preventive maintenance program; however, periodic visual inspection and cleaning is recommended.

3.2.1 Inspection

Check that the external surfaces of the radio are clean, and that all external controls and switches are functional. It is not recommended to inspect the interior electronic circuitry.

3.2.2 Cleaning

The following procedures describe the recommended cleaning agents and the methods to be used when cleaning the external and internal surfaces of the radio. External surfaces include the front cover, housing assembly, and battery case. These surfaces should be cleaned whenever a periodic visual inspection reveals the presence of smudges, grease, and/or grime.

NOTE **Internal surfaces should be cleaned only when the radio is disassembled for servicing or repair.**

The only recommended agent for cleaning the external radio surfaces is a 0.5% solution of a mild dishwashing detergent in water. The only factory recommended liquid for cleaning the printed circuit boards and their components is isopropyl alcohol (70% by volume).

CAUTION: The effects of certain chemicals and their vapors can have harmful results on certain plastics. Aerosol sprays, tuner cleaners, and other chemicals should be avoided.

Cleaning External Plastic Surfaces

The detergent-water solution should be applied sparingly with a stiff, non-metallic, short-bristled brush to work all loose dirt away from the radio. A soft, absorbent, lintless cloth or tissue should be used to remove the solution and dry the radio. Make sure that no water remains entrapped near the connectors, cracks, or crevices.

Cleaning Internal Circuit Boards and Components

Isopropyl alcohol may be applied with a stiff, non-metallic, short-bristled brush to dislodge embedded or caked materials located in hard-to-reach areas. The brush stroke should direct the dislodged material out and away from the inside of the radio. Make sure that controls or tunable components are

not soaked with alcohol. Do not use high-pressure air to hasten the drying process since this could cause the liquid to collect in unwanted places. Upon completion of the cleaning process, use a soft, absorbent, lintless cloth to dry the area. Do not brush or apply any isopropyl alcohol to the frame, front cover, or back cover.

NOTE **Always use a fresh supply of alcohol and a clean container to prevent contamination by dissolved material (from previous usage).**

3.3 Safe Handling of CMOS and LDMOS

Complementary metal-oxide semiconductor (CMOS) devices are used in this family of radios. CMOS characteristics make them susceptible to damage by electrostatic or high voltage charges. Damage can be latent, resulting in failures occurring weeks or months later. Therefore, special precautions must be taken to prevent device damage during disassembly, troubleshooting, and repair.

Handling precautions are mandatory for CMOS circuits and are especially important in low humidity conditions. DO NOT attempt to disassemble the radio without first referring to the CMOS CAUTION paragraph in the Disassembly and Reassembly section of the manual.

WARNING

CAUTION: This radio contains static-sensitive devices. Do not open the radio unless you are properly grounded. Take the following precautions when working on this unit:

- Store and transport all CMOS devices in conductive material so that all exposed leads are shorted together. Do not insert CMOS devices into conventional plastic “snow” trays used for storage and transportation of other semiconductor devices.
- Ground the working surface of the service bench to protect the CMOS device. We recommend using the Motorola Static Protection Assembly (part number 0180386A82), which includes a wrist strap, two ground cords, a table mat, and a floor mat.
- Wear a conductive wrist strap in series with a 100k resistor to ground. (Replacement wrist straps that connect to the bench top covering are Motorola part number RSX-4015.)
- Do not wear nylon clothing while handling CMOS devices.
- Do not insert or remove CMOS devices with power applied. Check all power supplies used for testing CMOS devices to be certain that there are no voltage transients present.
- When straightening CMOS pins, provide ground straps for the apparatus used.
- When soldering, use a grounded soldering iron.
- If at all possible, handle CMOS devices by the package and not by the leads. Prior to touching the unit, touch an electrical ground to remove any static charge that you may have accumulated. The package and substrate may be electrically common. If so, the reaction of a discharge to the case would cause the same damage as touching the leads.

3.4 General Repair Procedures and Techniques

Parts Replacement and Substitution

When damaged parts are replaced, identical parts should be used. If the identical replacement component is not locally available, check the parts list for the proper Motorola part number and order

the component from the nearest Motorola Communications parts center listed in the Piece Parts Availability section of this manual (See Chapter 1). You also need to review Motorola’s Rework and Repair Technical Reference manual, P/N 6880309G53, which can be ordered from AAD at 1-800-422-4210.

Rigid Circuit Boards

The family of radios uses bonded, multi-layer, printed circuit boards. Since the inner layers are not accessible, some special considerations are required when soldering and unsoldering components.

The printed-through holes may interconnect multiple layers of the printed circuit. Therefore, care should be exercised to avoid pulling the plated circuit out of the hole.

When soldering near the 20-pin and 40-pin connectors:

- Avoid accidentally getting solder in the connector.
- Be careful not to form solder bridges between the connector pins.
- Closely examine your work for shorts due to solder bridges.
- Do not exceed 210 degrees C when reworking boards.
- Do not exceed 5 degrees temperature ramp rate.

Flexible Circuits

The flexible circuits are made from a different material than the rigid boards and different techniques must be used when soldering. Excessive prolonged heat on the flexible circuit can damage the material. Avoid excessive heat and excessive bending.

For parts replacement, use the ST-1087 R1319A Temperature-Controlled Solder Station with a 600-700 degree tip for OMPAC (BGA) CSP, micro BGA and connectors. Use digital tweezers for all other component. Use small diameter solder such as ST-633. The smaller size solder will melt faster and require less heat to be applied to the circuit.

To replace a component on a flexible circuit:

1. Grasp the edge of the flexible circuit with seizers (hemostats) near the part to be removed.
2. Pull gently.
3. Apply the tip of the soldering iron to the component connections while pulling with the seizers.

NOTE **Do not attempt to puddle out components. Prolonged application of heat may damage the flexible circuit.**

Chip Components

Use either the RLN-4062 R1319A Chipmaster Hot-Air Repair Station or the Motorola 0180381B45 Repair Station R1364a digital heated tweezer system for chip component replacement. When using the 0180381B45 Repair Station, select the TJ-65 mini-thermojet hand piece. On either unit, adjust the temperature control to 700 degrees F. (370 degrees C), and adjust the airflow to a minimum setting. Airflow can vary due to component density.

To remove a chip component:

1. Use a hot-air hand piece and position the nozzle of hand piece R1319A approximately 1/8" (0.3 cm) above the component to be removed.
2. Begin applying the hot air. Once the solder reflows, remove the component using the pair of tweezers contained in the SMD tool kit shipped with the R1319A.
3. Using a solder wick (Motorola P/N 6680334B25) and a soldering iron or a power desoldering station, remove the excess solder from the pads.

To replace a chip component using a soldering iron:

1. Select the appropriate micro-tipped soldering iron and apply fresh solder paste (Motorola P/N 6680333E72) to one of the solder pads.
2. Using a pair of tweezers, position the new chip component in place while heating the fresh solder.
3. Once solder wicks onto the new component, remove the heat from the solder.
4. Heat the remaining pad with the soldering iron and apply solder until it wicks to the component. If necessary, touch up the first side. All solder joints should be smooth and shiny.

To replace a chip component using hot air:

1. Use the hot-air hand piece and reflow the solder on the solder pads to smooth it. For components having two or three solder connections, apply a dot of NO-CLEAN solder paste to the lead joints before removal.
2. Apply a drop of solder paste flux to each pad. For dual leaded devices such as SOICs, TSOPs, and quad leaded devices less than 20 leads, such as PLCCs and QFPs, apply a bead of solder paste.
3. Using a pair of tweezers, position the new component in place. As component is removed, it will carry away excess solder, leaving the ideal amount on the pads for their surface area.
4. Position the hot-air hand piece approximately 1/8” (0.3 cm) above the component and begin applying heat. For an extensive discussion of chip component rework and other technical procedures, order manual 6880309G53 from Motorola AAD.
5. Once the solder wicks to the component, remove the heat and inspect the repair. All joints should be smooth and shiny.

Shields

Removing and replacing shields will be done with the R-1070 R1319A station with the temperature control set to approximately 415°F (215°C) [445°F (230°C) maximum].

To remove the shield:

1. Place the circuit board in the R-1070’s holder.
2. Select the proper heat focus head and attach it to the heater chimney.
3. Add paste flux (Motorola P/N 6680333E71) around the base of the shield.
4. Position the shield under the heat-focus head.
5. Lower the vacuum tip and attach it to the shield by turning on the vacuum pump.
6. Lower the focus head until it is approximately 1/8” (0.3 cm) above the shield.
7. Turn on the heater and wait until the shield lifts off the circuit board.
8. Once the shield is off, turn off the heat, grab the part with a pair of tweezers, and turn off the vacuum pump.
9. Remove the circuit board from the R-1070’s circuit board holder.

To replace the shield:

1. Add solder to the shield if necessary, using a micro-tipped soldering iron.
2. Rub the soldering iron tip along the edge of the shield to smooth out any excess solder. Use solder wick and a soldering iron to remove excess solder from the solder pads on the circuit board.
3. Place the circuit board back in the R1070’s R1319A circuit board holder.
4. Place the shield on the circuit board using a pair of tweezers.
5. Place a small bead of no-clean flux (Motorola P/N 6680333E71) around the tinned surface.
6. Position the heat-focus head over the shield and lower it to approximately 1/8” (0.3 cm) above the shield.
7. Turn on the heater and wait for the solder to reflow. The R1319A will record removal time, add 30 to 40 seconds for replacement.
8. Once complete, turn off the heat, raise the heat-focus head and wait approximately one minute for the part to cool.
9. Remove the circuit board and inspect the repair. No cleaning should be necessary.

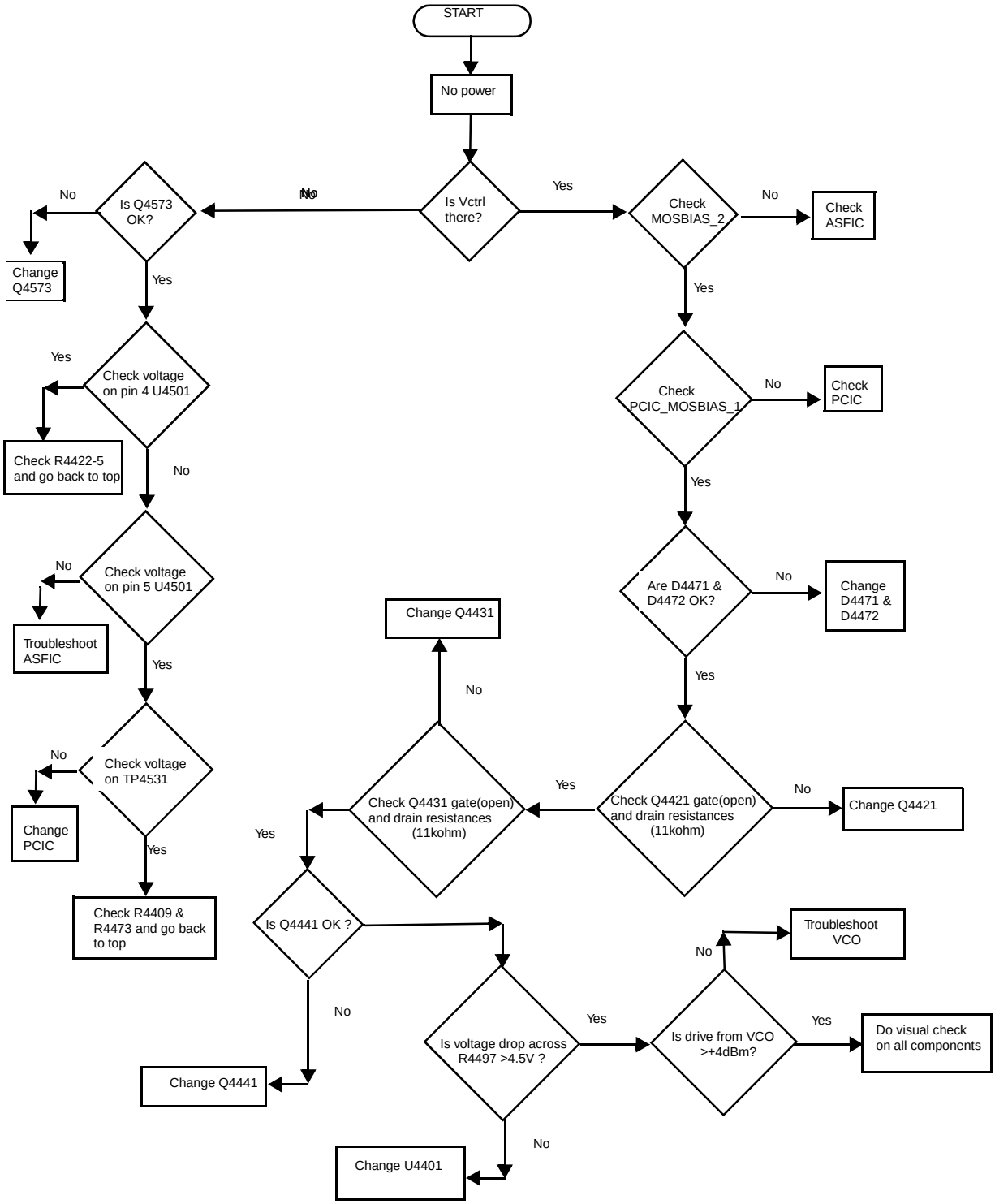
3.5 Recommended Test Tools

Table 3-1 lists the recommended tools used for maintaining this family of radios. These tools are also available from Motorola.

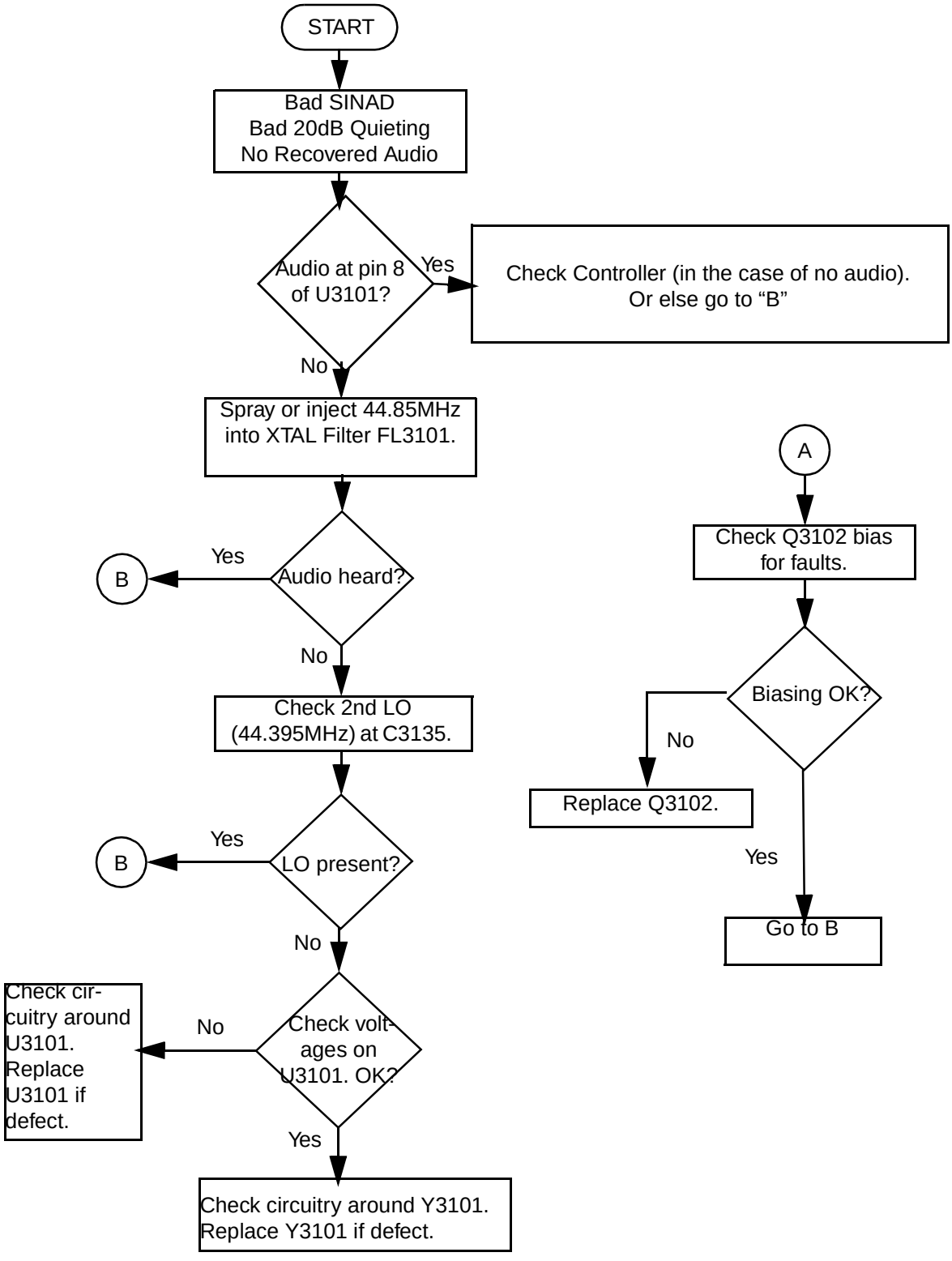
Table 3-1. Recommended Test Tools

Motorola Part Number	Description	Application
RSX4043	Torx Driver	Tighten and remove chassis screws
6680387A70	T-6 Torx Bit	Removable Torx driver bit
WADN4055A 6604008K01 6604008K02	Portable soldering station 0.4mm replacement tip 0.8mm replacement tip	Digitally controlled soldering Iron For WADN4055A soldering Iron
0180386A78	Illuminated magnifying glass with lens attachment.	
0180302E51	Illuminated Magnification System	Illuminated and magnification of components
0180386A82 6684253C72 6680384A98 1010041A86 0180303E45	Anti-static grounding kit Straight prober Brush Solder (RMA type), 63/37, 0.5mm diameter 1 lb. spool SMD tool kit (Include with R1319A)	Used during all radio assembly and disassembly procedures
R-1321A R1319A	Shields and surface-mounted component and IC removal/rework station (order all heat-focus heads separately)	Removal and assembly of surface-mounted integrated circuits and shields. Includes five nozzles
6680334B49 6680334B50 6680334B51 6680334B52 6680334B53 6680370B51 6680370B54 6680370B57 6680370B58 6680371B15 6680371B74 6680332E45 6680332E46	0.410” x 0.410” 0.430” x 0.430” 0.492” x 0.492” 0.572” x 0.572” 0.670” x 0.790” 0.475” x 0.475” 0.710” x 0.710” 0.245” x 0.245” 0.340” x 0.340” 0.460” x 0.560” 0.470” x 0.570” 0.591” x 0.315” 0.862” x 0.350”	Heat-focus heads for R-1319A work station
R1364A	Digital Heated Tweezer System	Chip component removal
R1427A	Board Preheater	Reduces heatsink on multi-level boards
6680309B53	Rework Procedures Manual	Contains Application notes, procedures, and technical references regarding rework equipment

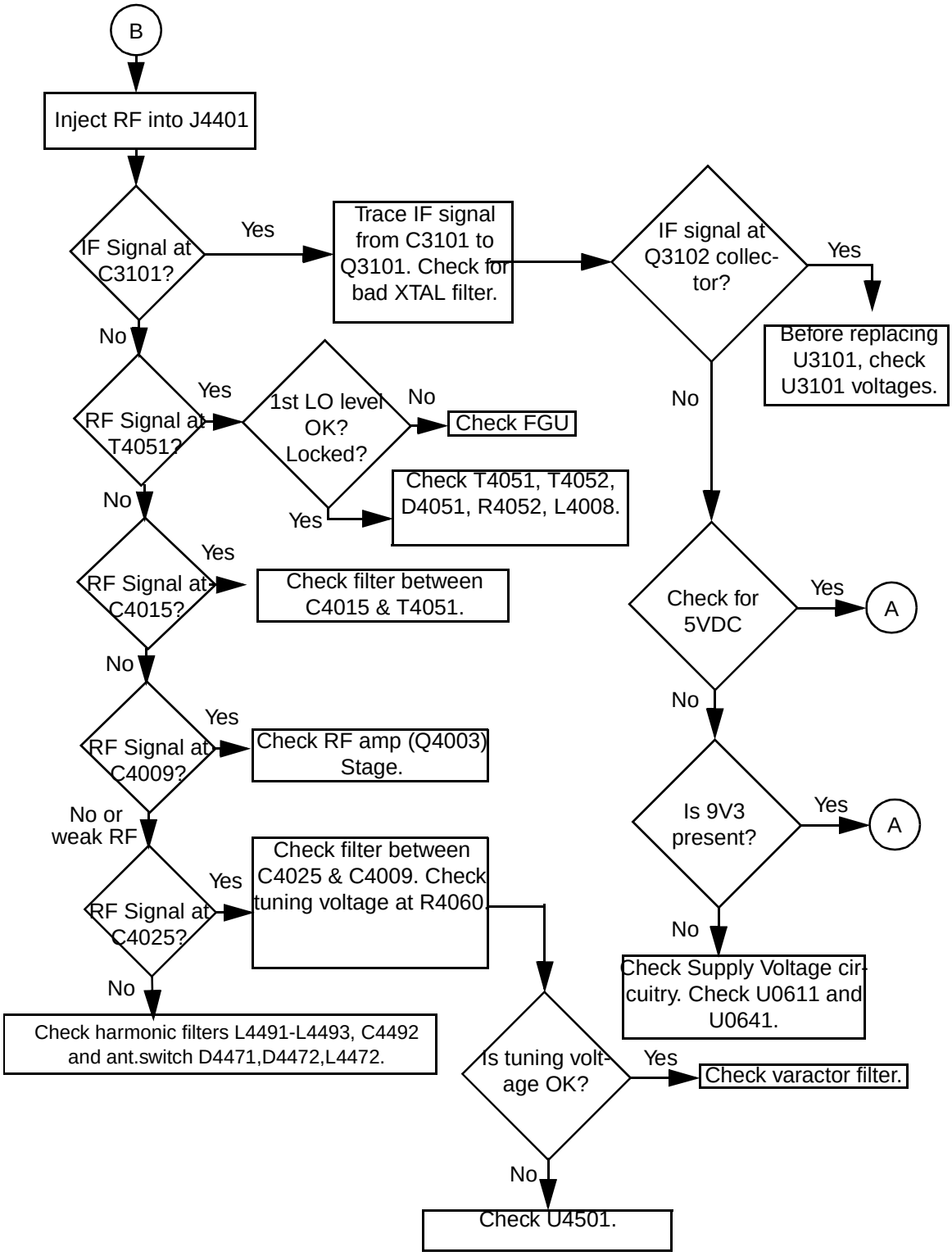
3.6 Transmitter Troubleshooting Chart



3.7 Receiver Troubleshooting Chart

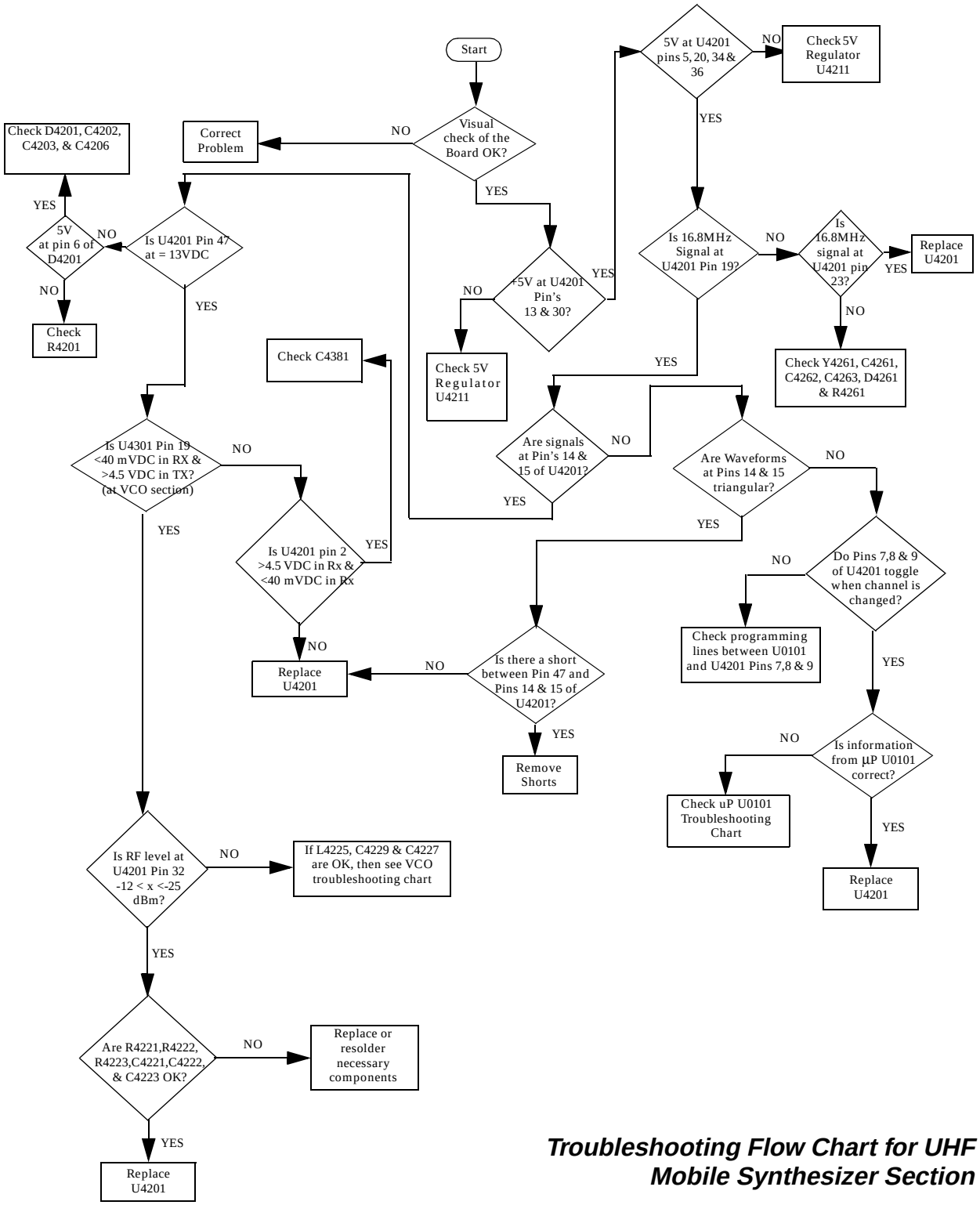


Troubleshooting Flow Chart for Receiver (Sheet 1 of 2)



Troubleshooting Flow Chart for Receiver (Sheet 2 of 2)

3.8 Synthesizer Troubleshooting Chart



Troubleshooting Flow Chart for UHF Mobile Synthesizer Section

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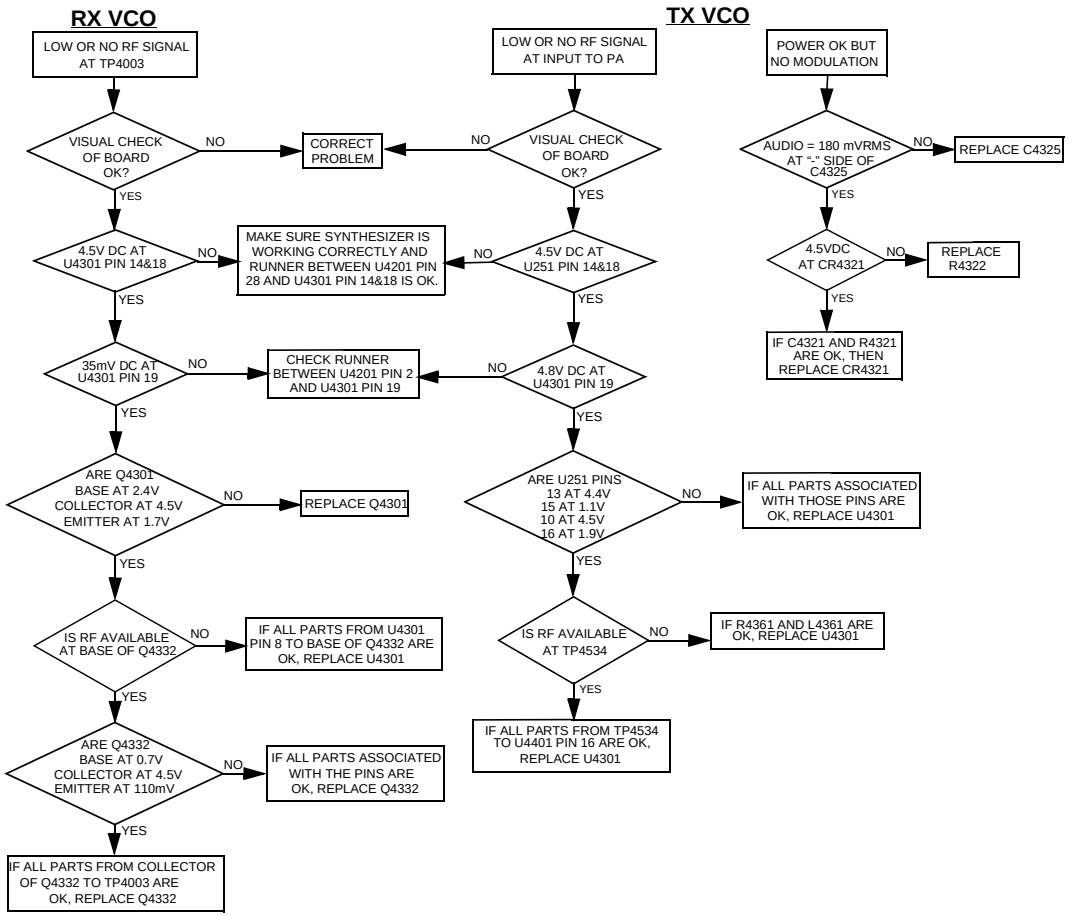
3.9 VCO Troubleshooting Chart



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Chapter 4

Schematic Diagrams, Overlays, and Parts Lists

4.1 Introduction

This chapter provides schematic diagrams, overlays, and parts lists for the radio circuit boards and interface connections.

4.1.1 Notes For All Schematics and Circuit Boards

* Component is frequency sensitive. Refer to the Electrical Parts List for value and usage.

1. Unless otherwise stated, resistances are in Ohms (k = 1000), and capacitances are in picofarads (pF) or microfarads (µF).

2. DC voltages are measured from point indicated to chassis ground using a Motorola DC multimeter or equivalent. Transmitter measurements should be made with a 1.2 µH choke in series with the voltage probe to prevent circuit loading.

3. Reference Designators are assigned in the following manner:

800-900 = Control Heads

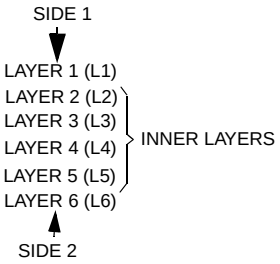
100/200/400/500/600 Series = Controller

100/200/400/500/600/3000/4000 Series = UHF Transmitter

3000 Series = VHF Transmitter

4. Interconnect Tie Point Legend:

UNSWB+	=	Unswitched Battery Voltage (12V)
SWB+	=	Switched Battery Voltage (12V)
R5	=	Receiver Five Volts
CLK	=	Clock
Vdda	=	Regulated 5 Volts (for analog)
Vddd	=	Regulated 5 Volts (for digital)
CSX	=	Chip Select Line (not for LVZIF)
SYN	=	Synthesizer
DACRX	=	Digital to Analog Voltage (For Receiver Front End Filter)
VSF	=	Voltage Super Filtered (5 volts)
VR	=	Voltage Regulator



6-LAYER CIRCUIT
BOARD DETAIL VIEWING
COPPER STEPS IN PROPER
LAYER SEQUENCE

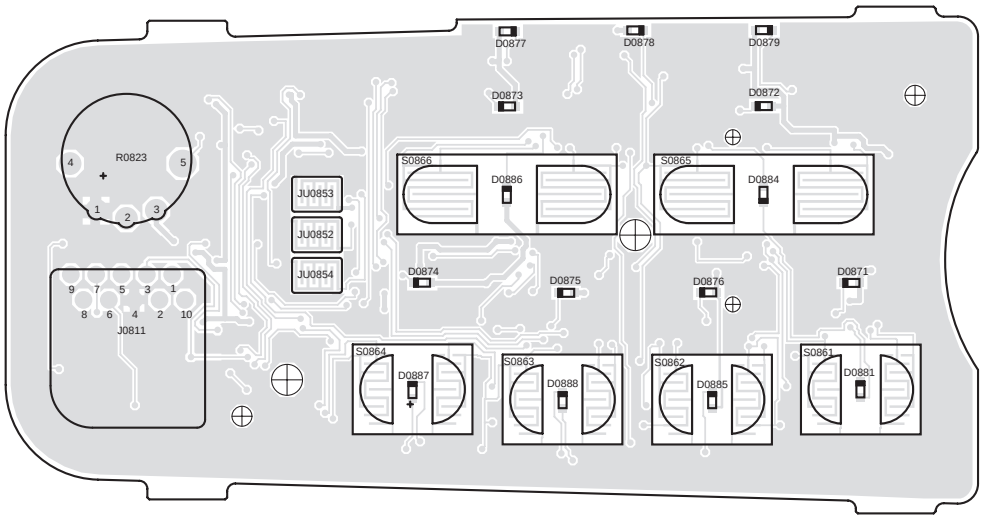


Figure 4-1. PRO3100/CDM750 Control Head Top Overlay

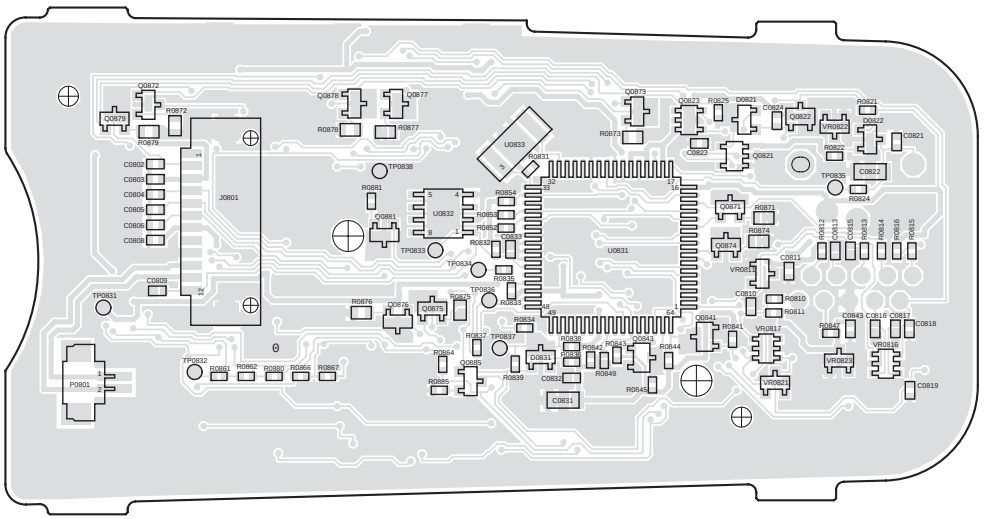


Figure 4-2. PRO3100/CDM750 Control Head Bottom Overlay

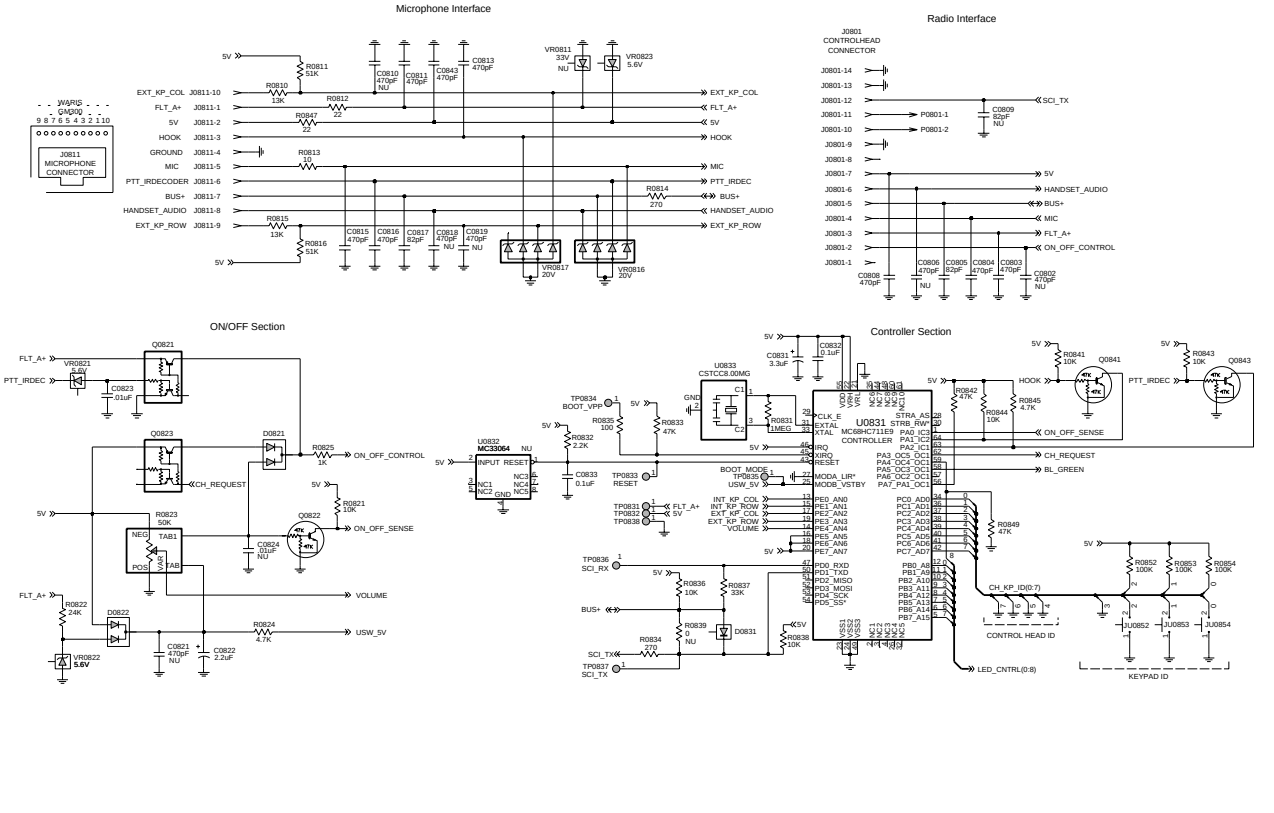


Figure 4-3. PRO3100/CDM750 Control Head Schematic Diagram, Sheet 1

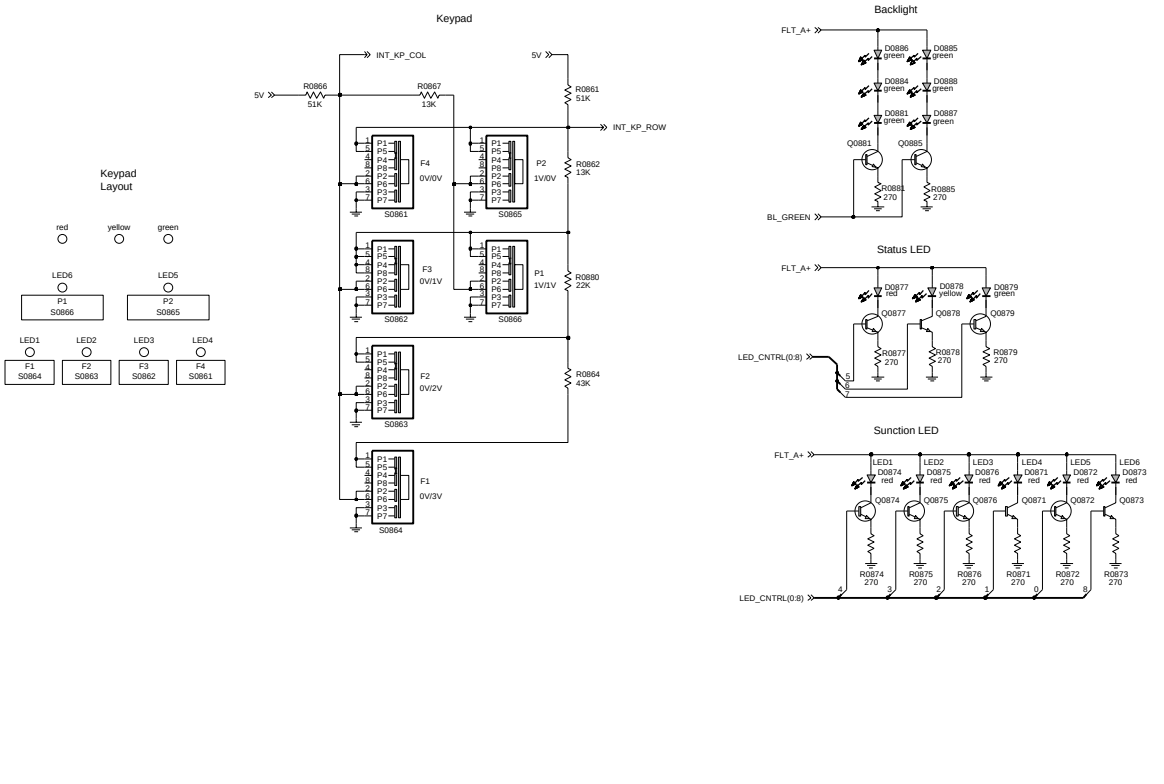


Figure 4-4. PRO3100/CDM750 Control Head Schematic Diagram, Sheet 2

Table 4-1. PRO3100/CDM750 Control Head Parts List

Reference Designator	Motorola Part No.	Description
C0803	2113741F17	470pF
C0804	2113741F17	470pF
C0805	2113740F49	100pF
C0808	2113741F17	470pF
C0811	2113741F17	470pF
C0813	2113741F17	470pF
C0815	2113741F17	470pF
C0816	2113741F17	470pF
C0817	2113740F49	82pF
C0822	2311049A40	2.2uF
C0823	2113741F49	10nF
C0831	2311049A42	3.3uF
C0832	2113743E20	100nF
C0833	2113743E20	100nF
C0843	2113741F17	470pF
D0821	4813833C02	Dual Schottky
D0822	4813833C02	Dual Schottky
D0831	4880236E05	Schottky
D0871	4886171B01	LED, Red
D0872	4886171B01	LED, Red
D0873	4880479B01	LED, Red
D0874	4886171B01	LED, Red
D0875	4886171B01	LED, Red
D0876	4886171B01	LED, Red
D0877	4886171B01	LED, Red
D0878	4886171B03	LED, Yellow
D0879	4886171B04	LED, Green
D0881	4886171B04	LED, Green
D0884	4886171B04	LED, Green
D0885	4886171B04	LED, Green
D0886	4886171B04	LED, Green
D0887	4886171B04	LED, Green
D0888	4886171B04	LED, Green
J801	0902636Y02	12-Pin Connector
J811	2864287B01	10-Pin Jack
Q0821	4805921T02	Transistor, Dual
Q0822	4880048M01	Transistor, NPN
Q0823	4805921T02	Transistor, Dual
Q0841	4880048M01	Transistor, NPN
Q0843	4880048M01	Transistor, NPN
Q0871	4813824A10	Transistor, NPN
Q0872	4813824A10	Transistor, NPN
Q0873	4813824A10	Transistor, NPN
Q0874	4813824A10	Transistor, NPN
Q0875	4813824A10	Transistor, NPN
Q0876	4813824A10	Transistor, NPN
Q0877	4813824A10	Transistor, NPN
Q0878	4813824A10	Transistor, NPN
Q0879	4813824A10	Transistor, NPN
Q0881	4813824A10	Transistor, NPN
Q0885	4813824A10	Transistor, NPN
R0810	0662057A76	13K
R0811	0662057A90	51K
R0812	0662057A09	22
R0813	0662057A01	10
R0814	0662057A35	270
R0815	0662057A76	13K
R0816	0662057A90	51K
R0821	0662057A73	10K
R0822	0662057A82	24K
R0823	1805911V01	Volume Pot
R0824	0662057A65	4K
R0825	0662057A49	1K
R0831	0662057B22	1M
R0832	0662057A57	2K
R0833	0662057A89	47K
R0834	0662057A35	270
R0835	0662057A25	100
R0836	0662057A73	10K
R0837	0662057A85	33K
R0838	0662057A73	10K
R0841	0662057A73	10K
R0842	0662057A89	47K
R0843	0662057A73	10K
R0844	0662057A73	10K
R0845	0662057A65	4K
R0847	0662057A09	22
R0849	0662057A89	47K
R0852	0662057A97	100K
R0853	0662057A97	100K
R0854	0662057A97	100K
R0861	0662057A90	51K
R0862	0662057A76	13K
R0864	0662057A88	43K
R0866	0662057A90	51K
R0867	0662057A76	13K
R0871	0660076A35	270
R0872	0660076A35	270
R0873	0660076A35	270
R0874	0660076A35	270
R0875	0660076A35	270
R0876	0660076A35	270
R0877	0660076A35	270
R0878	0660076A35	270
R0879	0660076A35	270
R0880	0662057A81	22K
R0881	0662057A35	270
R0885	0662057A35	270
U0831	5113802A24	IC
U0833	4886061B01	8 MHz
VR0816	4805656W09	Diode, Zener
VR0817	4805656W09	Diode, Zener
VR0821	4813830A15	Diode, 5.6V
VR0822	4813830A15	Diode, 5.6V
VR0823	4813830A15	Diode, 5.6V

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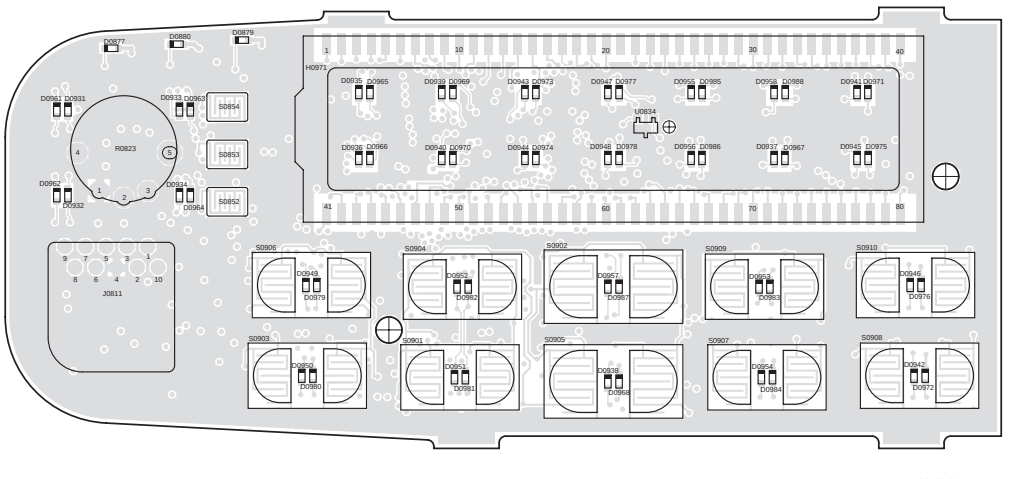


Figure 4-5. PRO5100/PRO7100/CDM1250/CDM1550 Control Head Top Overlay

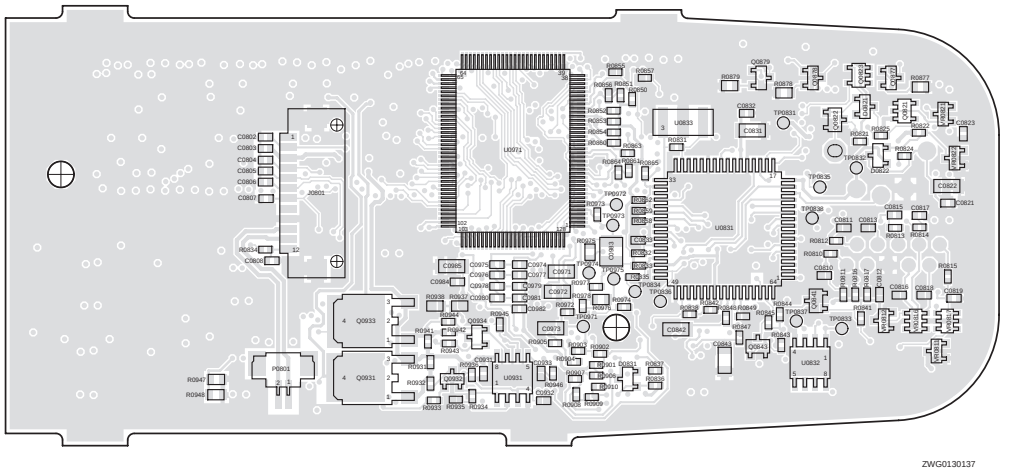
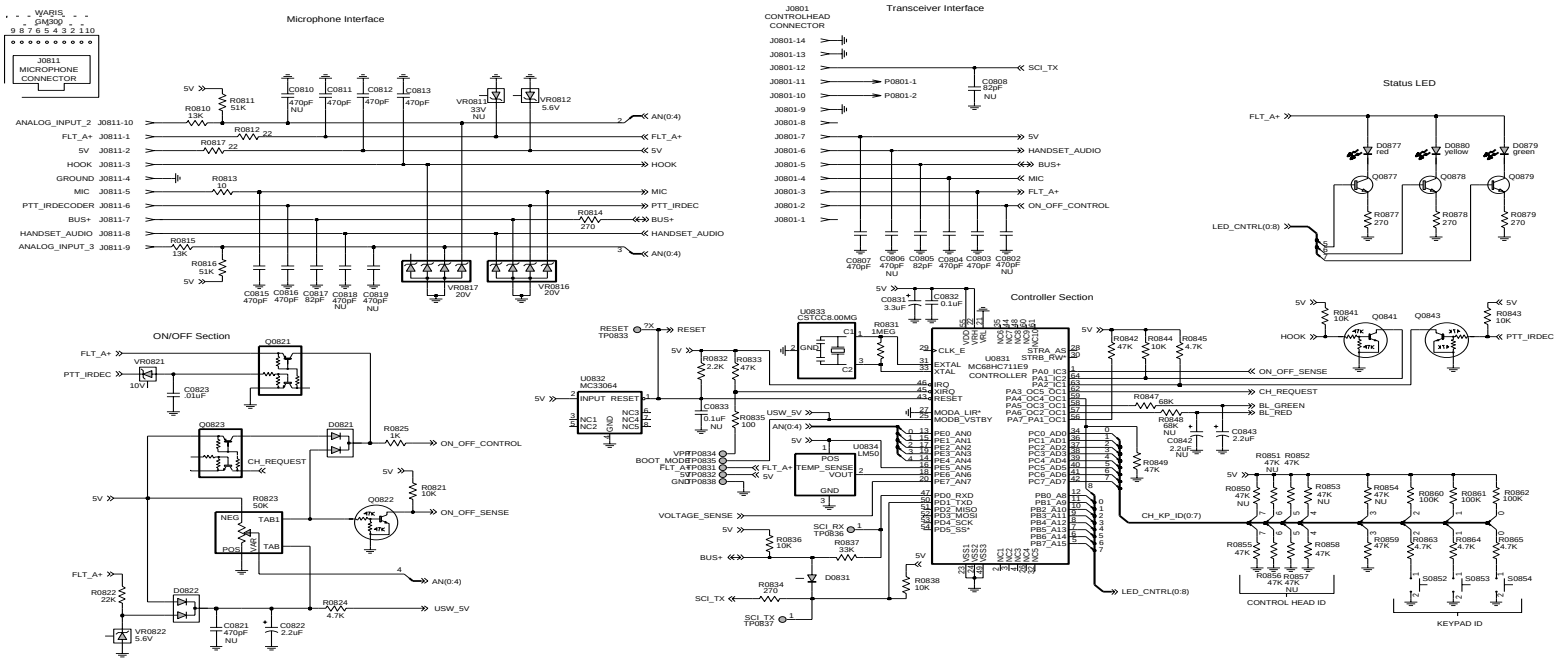
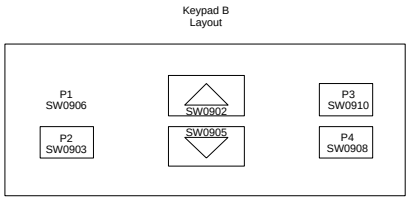


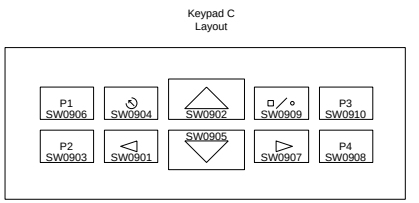
Figure 4-6. PRO5100/PRO7100/CDM1250/CDM1550 Control Head Bottom Overlay



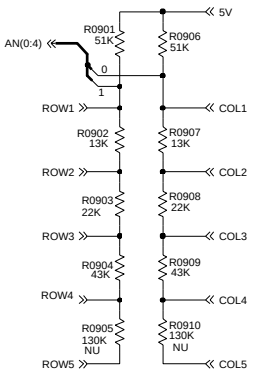
	R0850	R0851	R0852	R0853	R0855	R0856	R0857	R0858
CONTROLHEAD PRO5100/CDM1250	NU	NU	NU	USED	USED	USED	USED	NU
CONTROLHEAD PRO7100/CDM1550	NU	NU	USED	NU	USED	USED	NU	USED

Figure 4-7. PRO5100/PRO7100/CDM1250/CDM1550 Control Head Schematic Diagram





	R0909
CONTROLHEAD PRO5100/CDM1250	NU
CONTROLHEAD PRO7100/CDM1550	USED



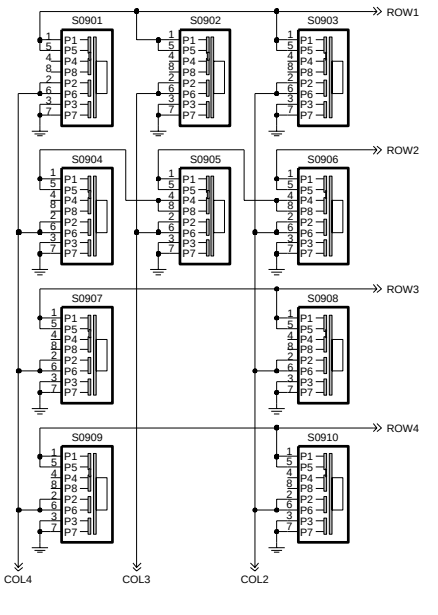
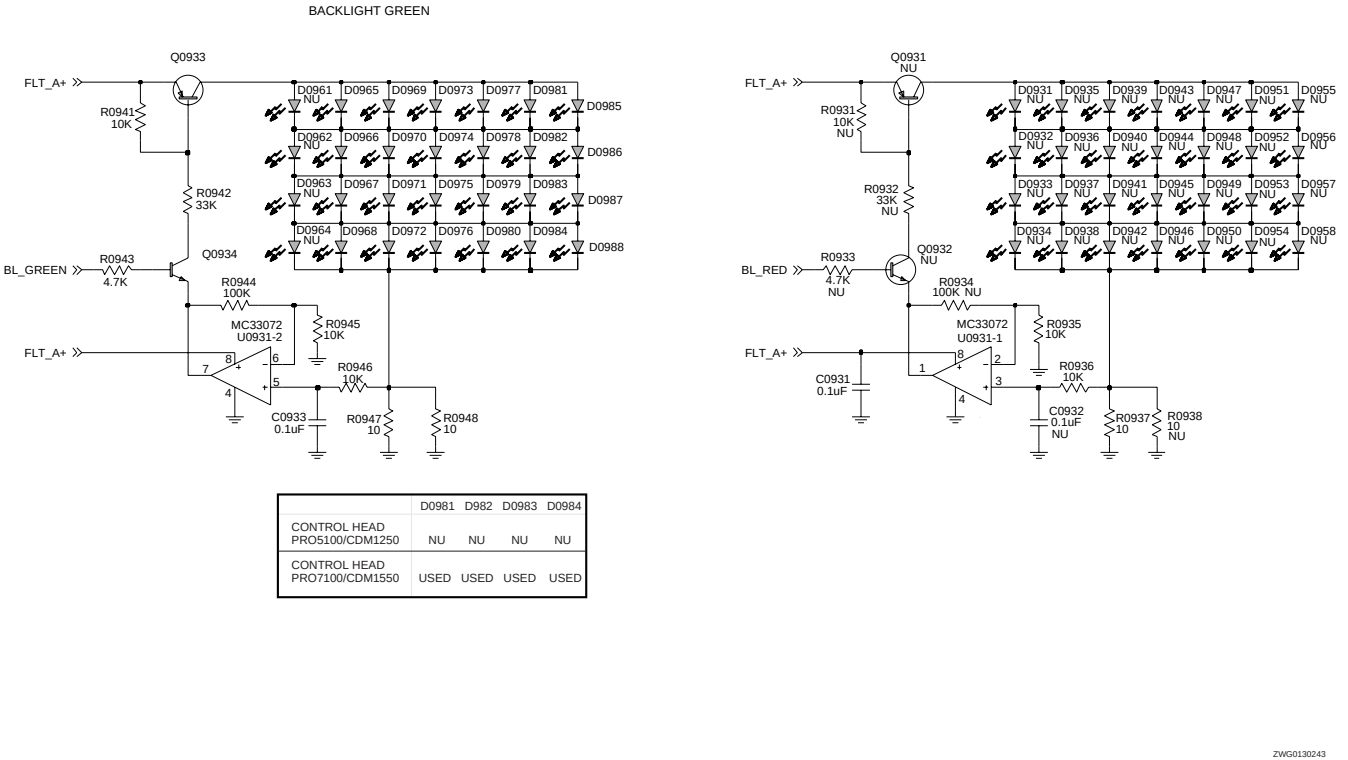


Figure 4-8. PRO5100/PRO7100/CDM1250/CDM1550 Control Head Keypad Schematic



	D0981	D0982	D0983	D0984
CONTROL HEAD PRO5100/CDM1250	NU	NU	NU	NU
CONTROL HEAD PRO7100/CDM1550	USED	USED	USED	USED

Figure 4-9. PRO5100/PRO7100/CDM1250/CDM1550 Control Head LCD Schematic

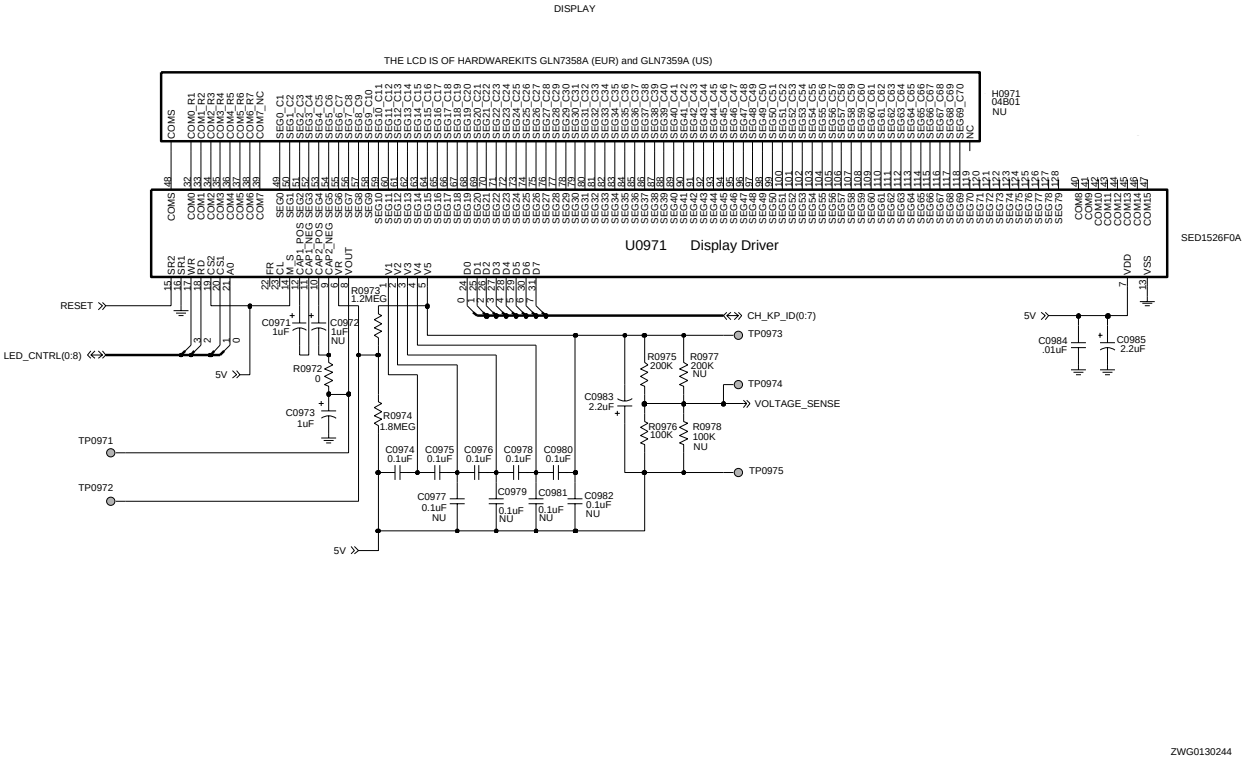


Figure 4-10. PRO5100/PRO7100/CDM1250/CDM1550 Control Head Display Schematic

Table 4-2: PRO5100/PRO7100/CDM1250/CDM1550 Control Head Parts List

Reference Designator	Motorola Part No.	Description
C0803	2113741F17	470pF
C0804	2113741F17	470pF
C0805	2113740F49	100pF
C0807	2113741F17	470pF
C0811	2113741F17	470pF
C0812	2113741F17	470pF
C0813	2113741F17	470pF
C0815	2113741F17	470pF
C0816	2113741F17	470pF
C0817	2113740F49	82pF
C0822	2311049A40	2.2uF
C0823	2113741F49	10nF
C0831	2311049A42	3.3uF
C0832	2113743E20	100nF
C0843	2311049A40	470pF
C0931	2113743E20	100nF
C0933	2113743E20	100nF
C0971	2311049A07	1uF
C0973	2311049A07	1uF
C0974	2113743E20	100nF
C0975	2113743E20	100nF
C0976	2113743E20	100nF
C0978	2113743E20	100nF
C0980	2113743E20	100nF
C0983	2311049A09	2.2uF
C0984	2113741F49	10nF
C0985	2311049A40	2.2 uF
D0821	4813833C02	Dual Schottky
D0822	4813833C02	Dual Schottky
D0831	4880236E05	Schottky
D0877	4886171B01	LED, Red
D0879	4886171B04	LED, Green
D0880	4886171B03	LED, Yellow
D0951*	4886171B02	LED, Orange
D0952*	4886171B02	LED, Orange
D0953*	4886171B02	LED, Orange
D0954*	4886171B02	LED, Orange
D0965	4886171B04	LED, Green
D0966	4886171B04	LED, Green
D0967	4886171B04	LED, Green
D0968	4886171B04	LED, Green
D0969	4886171B04	LED, Green
D0970	4886171B04	LED, Green
D0971	4886171B04	LED, Green
D0972	4886171B04	LED, Green
D0973	4886171B04	LED, Green
D0974	4886171B04	LED, Green
D0975	4886171B04	LED, Green
D0976	4886171B04	LED, Green
D0977	4886171B04	LED, Green
D0978	4886171B04	LED, Green
D0979	4886171B04	LED, Green
D0980	4886171B04	LED, Green
D0981*	4886171B04	LED, Green
D0982*	4886171B04	LED, Green
D0983*	4886171B04	LED, Green
D0984*	4886171B04	LED, Green
D0985	4886171B04	LED, Green
D0986	4886171B04	LED, Green
D0987	4886171B04	LED, Green
D0988	4886171B04	LED, Green
J801	0902636Y02	12-pin connector
J811	2864287B01	10-pin connector
P0801	2809926G01	2-pin connector
Q0821	4805921T02	Transistor, dual
Q0822	4880048M01	Transistor, NPN
Q0823	4805921T02	Transistor, dual
Q0841	4880048M01	Transistor, NPN
Q0843	4880048M01	Transistor, NPN
Q0877	4813824A10	Transistor, NPN
Q0878	4813824A10	Transistor, NPN
Q0879	4813824A10	Transistor, NPN
Q0933	4813824A08	Transistor, PNP
Q0934	4813824A10	Transistor, NPN
R0810	0662057A76	13K
R0811	0662057A90	51K
R0812	0662057A09	22
R0813	0662057A01	10
R0814	0662057A35	270
R0815	0662057A76	13K
R0816	0662057A90	51K
R0817	0662057A09	22
R0821	0662057A73	10K
R0822	0662057A82	24K
R0823	1805911V01	Volume Pot
R0824	0662057A65	4K
R0825	0662057A49	1K
R0831	0662057B22	1M
R0832	0662057A57	2K
R0833	0662057A89	47K
R0834	0662057A35	270
R0835	0662057A25	100
R0836	0662057A73	10K
R0837	0662057A85	33K
R0838	0662057A73	10K
R0841	0662057A73	10K
R0842	0662057A89	47K
R0843	0662057A73	10K
R0844	0662057A73	10K
R0845	0662057A65	4K
R0847	0662057A93	22
R0849	0662057A89	47K
R0852*	0662057A89	47K
R0853**	0662057A89	47K
R0855	0662057A89	47K
R0856	0662057A89	47K
R0857**	0662057A89	47K
R0858*	0662057A89	47K
R0859	0662057A89	47K
R0860	0662057A97	100K
R0861	0662057A97	100K
R0862	0662057A97	100K
R0863	0662057A65	4K
R0864	0662057A65	4K
R0865	0662057A65	4K
R0877	0660076A35	270
R0878	0660076A35	270
R0879	0660076A35	270
R0901	0662057A90	51K
R0902	0662057A76	13K
R0903	0662057A81	22K
R0904	0662057A88	43K
R0906	0662057A90	51K
R0907	0662057A76	13K
R0908	0662057A81	22K
R0909*	0662057A88	43K
R0935	0662057A73	10K
R0936	0662057A73	10K
R0937	0660076A01	10
R0941	0662057A73	10K
R0942	0662057A85	33K
R0943	0662057A65	4K
R0944	0662057A97	100K
R0945	0662057A73	10K
R0946	0662057A73	10K
R0947	0660076A01	10
R0948	0660076A01	10
R0972	0662057B47	0
R0973	0662057B24	1.2M
R0974	0662057B28	1.8M
R0975	0662057G29	200K
R0976	0662057G13	100K
U0831	5113802A24	IC
U0832	5113815A02	Voltage Sensor
U0833	4886061B01	8 MHz
U0834	5185963A15	Temperature Sensor
U0931	5113818A03	IC
U0971	5186158B01	LCD Driver
VR0812	4813830A15	
VR0816	4805656W09	Diode, Zener
VR0817	4805656W09	Diode, Zener
VR0821	4813830A23	Diode, 5.6V
VR0822	4813830A15	Diode, 5.6V

* Models PRO7100/CDM1550 Only

** Models PRO5100/CDM1250 Only

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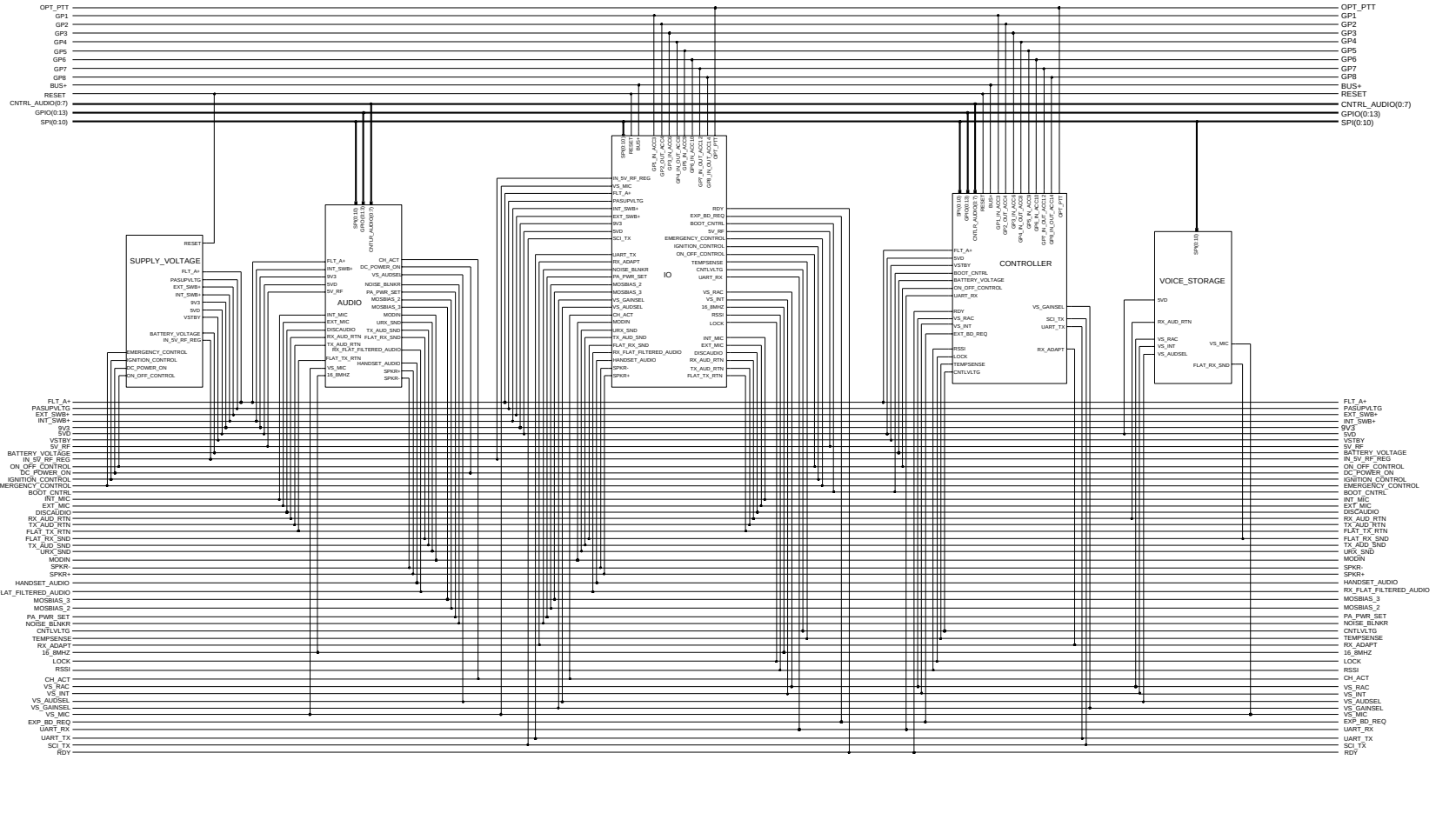


Figure 4-11. Complete Controller Schematic Diagram

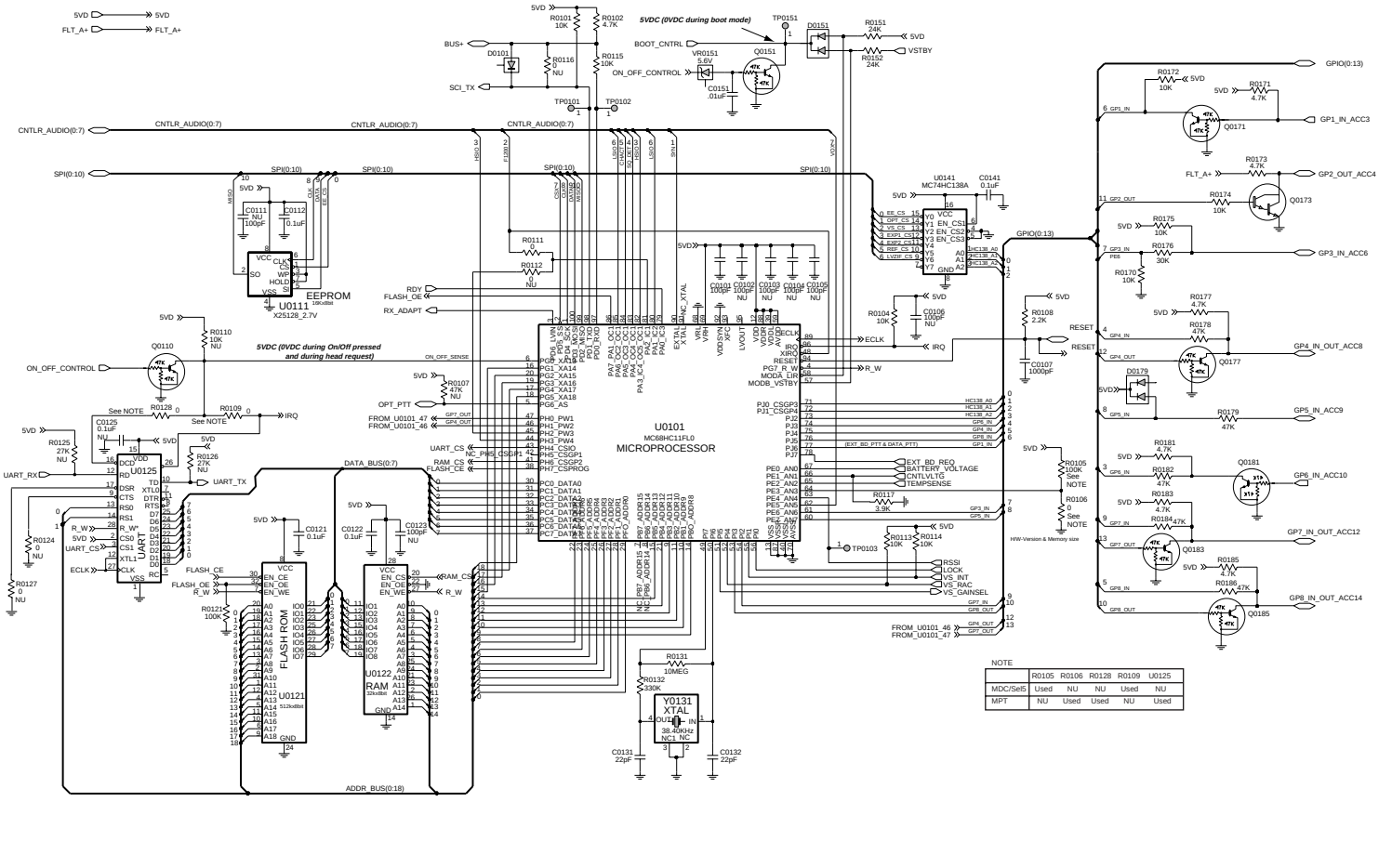


Figure 4-12. Controller Control Schematic Diagram

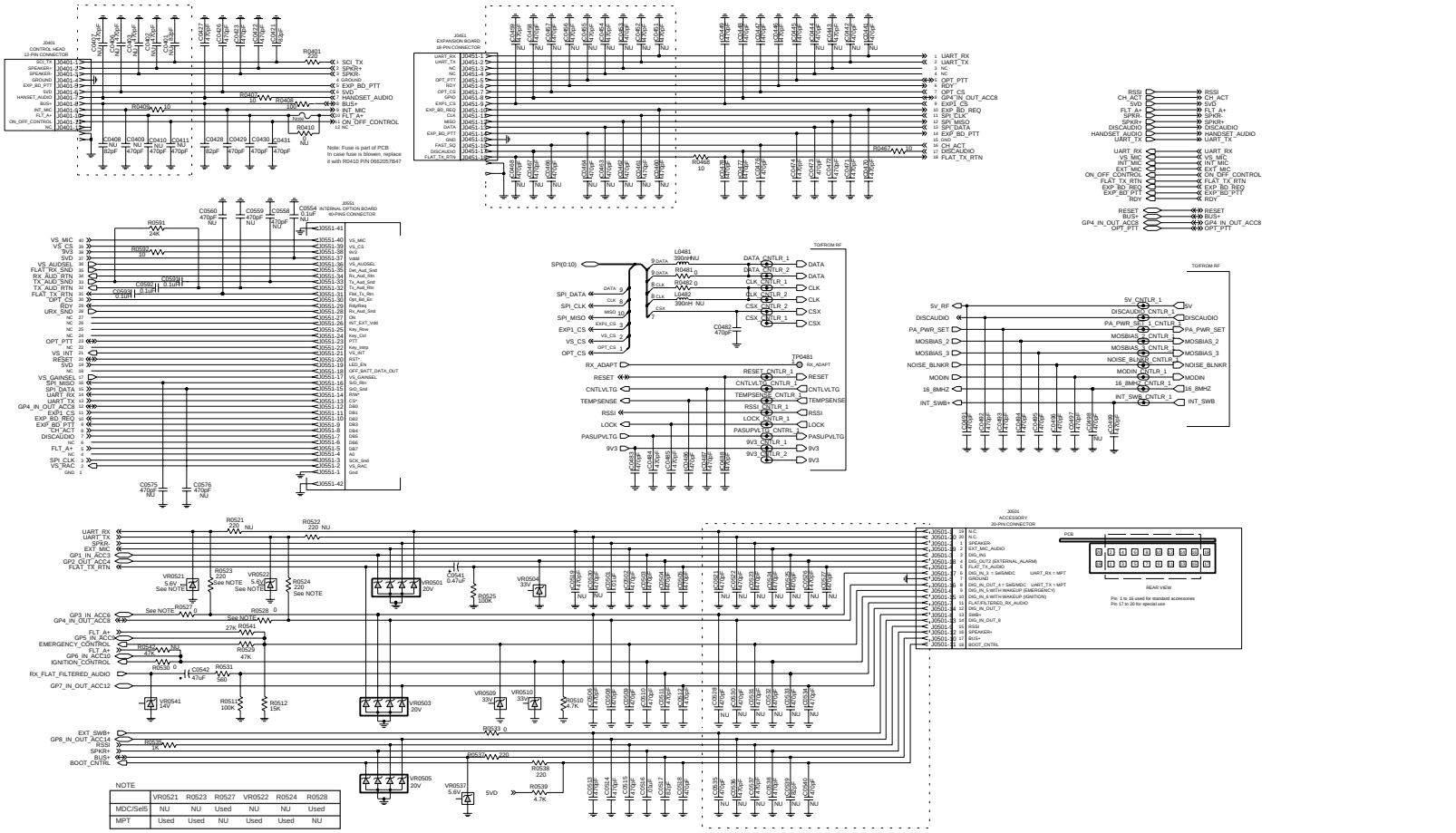


Figure 4-13. Controller I/O Schematic Diagram

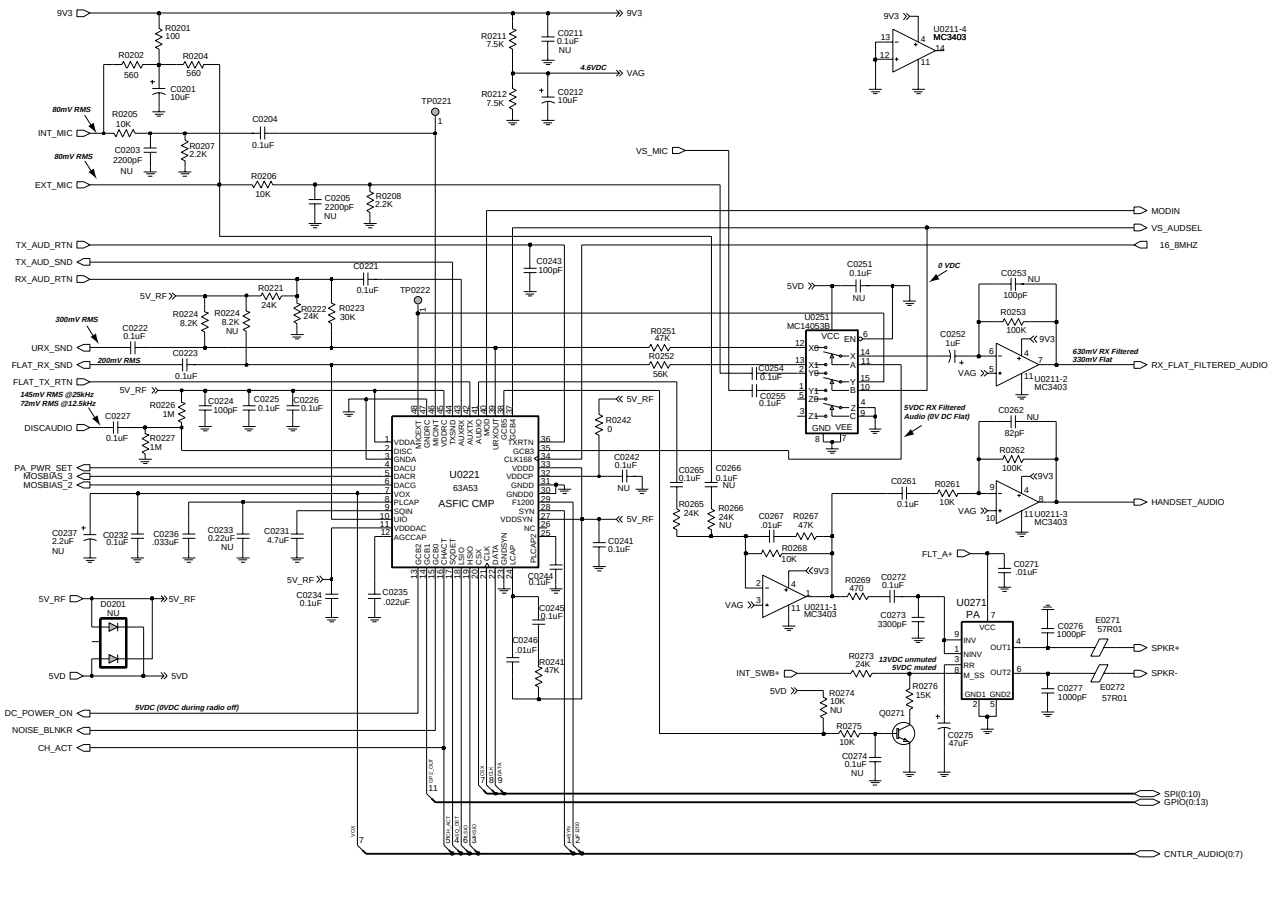
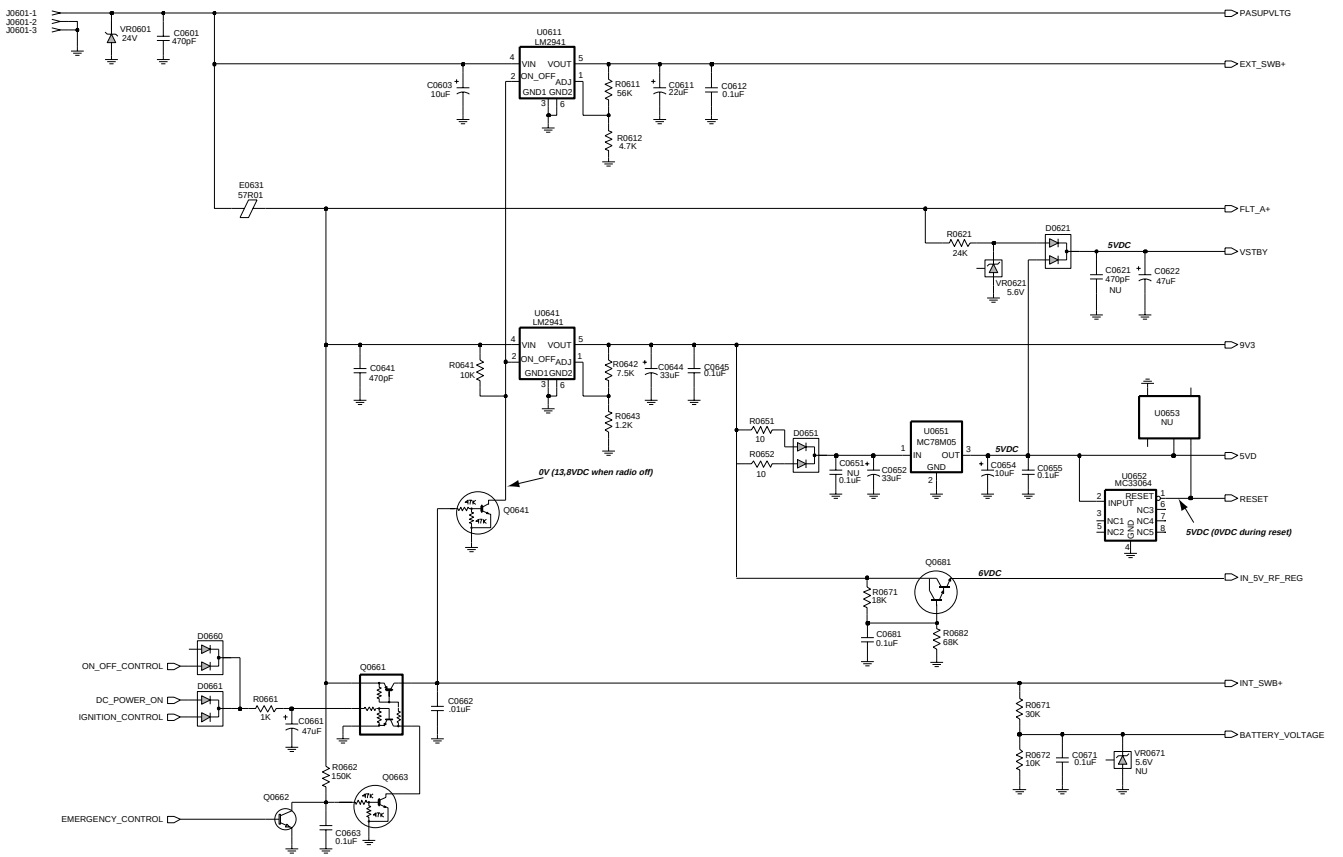


Figure 4-14. Controller Audio Schematic Diagram



ZWG0130232-A

Figure 4-15. Controller Supply Voltage Schematic Diagram

Table 4-3. Controller Parts List

Circuit Ref	Motorola Part No.	Description
C0101	2113740F51	100pF
C0107	2113741F25	1nF
C0112	2113743E20	100nF
C0121	2113743E20	100nF
C0122	2113743E20	100nF
C0131	2113740F35	22pF
C0132	2113740F35	22pF
C0141	2113743E20	100nF
C0151	2113741F49	10nF
C0201	2311049A57	10uF
C0204	2113743E20	100nF
C0212	2311049A57	10uF
C0221	2113743E20	100nF
C0222	2113743E20	100nF
C0223	2113743E20	100nF
C0224	2113740F51	100pF
C0225	2113743E20	100nF
C0226	2113743E20	100nF
C0227	2113743E20	100nF
C0231	2113743B29	1UF
C0232	2113743E20	100nF
C0234	2113743E20	100nF
C0235	2113743E07	22nF
C0236	2113743E10	33nF
C0241	2113743E20	100nF
C0243	2113740F51	100pF
C0244	2113743E20	100nF
C0245	2113743E20	100nF
C0246	2113741F49	10nF
C0252	2311049A07	1uF
C0254	2113743E20	100nF
C0255	2113743E20	100nF
C0261	2113743E20	100nF
C0262	2113740F49	82pF
C0265	2113743E20	100nF
C0267	2113741F49	10nF
C0271	2113741F49	10nF
C0272	2113743E20	100nF
C0273	2113741F37	3.3nF
C0275	2311049A99	47uF
C0276	2113741F25	1nF
C0277	2113741F25	1nF
C0421	2113743N48	82.0pF
C0422	2113741F17	470pF
C0423	2113741F17	470pF
C0426	2113743L09	470pF
C0427	2113743L09	470pF
C0428	2113743N48	82pF
C0429	2113743L09	470pF
C0430	2113741F17	470pF
C0431	2113741F17	470pF
C0445	2113743L09	470pF
C0446	2113743L09	470pF
C0447	2113743L09	470pF
C0448	2113743L09	470pF
C0449	2113743L09	470pF
C0470	2113743L09	470pF
C0471	2113743L09	470pF
C0472	2113743L09	470pF
C0473	2113743L09	470pF
C0474	2113743L09	470pF
C0476	2113743L09	470pF
C0477	2113743L09	470pF
C0478	2113743L09	470pF
C0482	2113743L09	470pF
C0483	2113743L09	470pF
C0484	2113741F17	470pF
C0485	2113743L09	470pF
C0486	2113743L09	470pF
C0487	2113743L09	470pF
C0488	2113743L09	470pF
C0490	2113743L09	470pF
C0491	2113743L09	470pF
C0492	2113743L09	470pF
C0493	2113743L09	470pF
C0494	2113743L09	470pF
C0495	2113743L09	470pF
C0496	2113743L09	470pF
C0497	2113743L09	470pF
C0499	2113743L09	470pF
C0501	2113741F49	10nF
C0502	2113743L09	470pF
C0503	2113743L09	470pF
C0504	2113743L09	470pF
C0505	2113743L09	470pF
C0506	2113743L09	470pF
C0508	2113743L09	470pF
C0509	2113743L09	470pF
C0510	2113741F17	470pF
C0511	2113743L09	470pF
C0512	2113743L09	470pF
C0513	2113741F17	470pF
C0514	2113743L09	470pF
C0515	2113743L09	470pF
C0516	2113741F49	10nF
C0517	2113743N48	82pF
C0518	2113743L09	470pF
C0541	2311049A05	470nF
C0542	2311049A99	47uF
C0591	2113743E20	100nF
C0592	2113743E20	100nF
C0593	2113743E20	100nF
C0601	2113741F17	470pF
C0603	2380090M24	10uF
C0611	2311049C06	22uF
C0612	2113743E20	100nF
C0622	2311049A99	47uF
C0641	2113741F17	470pF
C0644	2311049A97	33uF
C0645	2113743E20	100nF
C0652	2311049A97	33uF
C0654	2311049A57	10uF
C0655	2113743E20	100nF
C0661	2311049C05	47uF
C0662	2113741F49	10nF
C0663	2113743E20	100nF
C0671	2113743E20	100nF
C0681	2113743E20	100nF
D0101	4880236E05	Diode, Schottky
D0151	4813833C02	Diode, Dual
D0179	4813833C02	Diode, Dual
D0621	4813833C02	Diode, Dual
D0651	4813833C02	Diode, Dual
D0660	4813833C02	Diode, Dual
D0661	4813833C02	Diode, Dual
E0271	2484657R01	Ferrite Bead
E0272	2484657R01	Ferrite Bead
E0631	2484657R01	Ferrite Bead
J0401	0902636Y02	Connector, Flex, 12-pin
J0451	0902636Y01	Connector, Flex, Side Entry
J0501	0986105B01	Connector, SMD, 20-Pin
J0551	0905505Y04	Connector, Zif, Horizontal
J0601	0986165B01	DC Power Connector
Q0110	4880048M01	NPN
Q0151	4880048M01	NPN
Q0171	4880048M01	NPN
Q0173	4880052M01	NPN, Dalington
Q0177	4880048M01	NPN
Q0181	4880048M01	NPN
Q0183	4880048M01	NPN
Q0185	4880048M01	NPN
Q0271	4813824A10	NPN
Q0641	4880048M01	NPN
Q0661	4805921T02	Dual
Q0662	4813824A10	NPN
Q0663	4880048M01	NPN
Q0681	4880052M01	NPN, Dalington
R0101	0662057A73	10k 1/16W 5%
R0102	0662057A65	4k7 1/16W 5%
R0104	0662057A73	10K
R0105	0662057A97	100K
R0108	0662057A57	2K
R0109	0662057B47	0
R0111	0662057B47	0
R0113	0662057A73	10K
R0114	0662057A73	10K
R0115	0662057A73	10K
R0117	0662057A63	3K
R0121	0662057A97	100K
R0131	0662057B46	10M
R0132	0662057B10	330K
R0151	0662057A82	24K
R0152	0662057A82	24K
R0170	0662057A73	10K
R0171	0662057A65	4K
R0172	0662057A73	10K
R0173	0662057A65	4K
R0174	0662057A73	10K
R0175	0662057A73	10K
R0176	0662057A84	30K
R0177	0662057A65	4K
R0178	0662057A89	47K
R0179	0662057A89	47K
R0181	0662057A65	4K
R0182	0662057A89	47K
R0183	0662057A65	4K
R0184	0662057A89	47K
R0185	0662057A65	4K
R0186	0662057A89	47K
R0201	0662057A25	100
R0202	0662057A43	560
R0204	0662057A43	560
R0205	0662057A73	10K
R0206	0662057A73	10K
R0207	0662057A57	2K
R0208	0662057A57	2K
R0211	0660076E70	7.5K
R0212	0660076E70	7.5K
R0221	0662057A82	24K
R0222	0662057A82	24K
R0223	0662057A84	30K
R0224	0662057A71	8K
R0226	0662057B22	1M
R0227	0662057B22	1M
R0241	0662057A89	47K
R0242	0662057B47	0
R0251	0662057A89	47K
R0252	0662057A91	56K
R0253	0662057A97	100K
R0261	0662057A73	10K
R0262	0662057A97	100K
R0265	0662057A82	24K

Circuit Ref	Motorola Part No.	Description
R0267	0662057A89	47K
R0268	0662057A73	10K
R0269	0662057A41	470
R0273	0662057A82	24K
R0275	0662057A73	10K
R0276	0662057A77	15K
R0401	0662057A33	220
R0407	0662057M26	10
R0408	0662057A25	100
R0409	0662057M26	10
R0467	0662057M26	10
R0468	0662057M26	10
R0481	0662057B47	0
R0482	0662057B47	0
R0510	0662057A65	4K
R0511	0662057A97	100K
R0512	0662057A77	15K
R0525	0662057A97	100K
R0527	0662057B47	0
R0528	0662057B47	0
R0529	0662057A89	47K
R0530	0662057B47	0
R0531	0662057A43	560
R0533	0662057B47	0
R0535	0662057A49	1K
R0537	0662057A33	220
R0538	0662057A33	220
R0539	0662057A65	4K
R0541	0662057A83	27K
R0591	0662057A82	24K
R0592	0662057A01	10
R0611	0662057A91	56K
R0612	0662057A65	4k
R0621	0662057A82	24K
R0641	0662057A73	10k
R0642	0660076E70	7.5K
R0643	0660076E51	1.2K
R0651	0662057A01	10
R0652	0662057A01	10
R0661	0662057A49	1K
R0662	0662057B02	150K
R0671	0662057A84	30K
R0672	0662057A73	10K
R0681	0662057A79	18K
R0682	0662057A93	68K
U0101	5102226J56	Microprocessor
* U0111	5102463J64	EEPROM
* U0121	5186137B01	512KX8 ROM
U0122	5185963A21	32KX8 SRAM
U0141	5113805A30	Remux
U0211	5183222M49	Quad Opamp
U0221	5185963A53	ASFIC
U0251	5113806A20	Mux/Demux
U0271	5109699X01	Audio Power Amplifier
U0611	5183308X01	Adjustable Voltage Regulator
U0641	5183308X01	Adjustable Voltage Regulator
U0651	5113816A07	Regulator, +5V
U0652	5113815A02	Under Voltage Sensor
VR0151	4813830A15	Diode, 5.6V
VR0501	4805656W09	Zener Quad
VR0503	4805656W09	Zener Quad
VR0504	4813830A40	Auto Shutdown
VR0505	4805656W09	Diode Zener Quad
VR0509	4813830A40	Auto Shutdown
VR0510	4813830A40	Auto Shutdown
VR0537	4813830A15	Diode, 5.6V
VR0541	4813830A27	Diode, 14V
VR0601	4813832C77	Transient Supressor
VR0621	4813830A15	Diode, 5.6V
Y0131	4880113R19	Crystal 38.4KHz

* Motorola Depot Servicing only

Reference designators with an asterisk indicate components which are not field replaceable because they need to be calibrated with specialized factory equipment after installation. Radios in which these parts have been replaced in the field will be off-frequency at temperature extremes.

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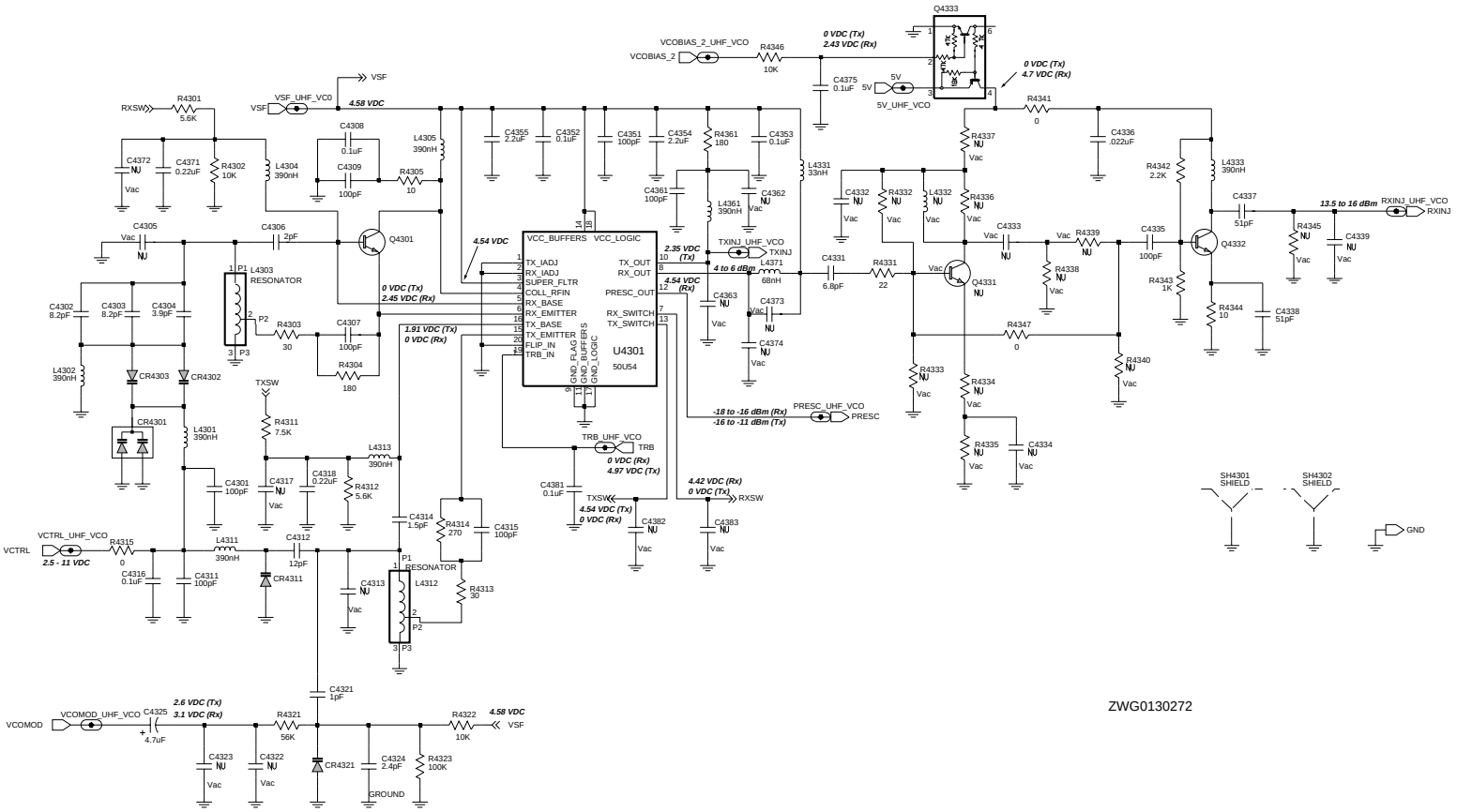

Figure 4-16. UHF (403-470MHz) Voltage Controlled Oscillator Schematic Diagram

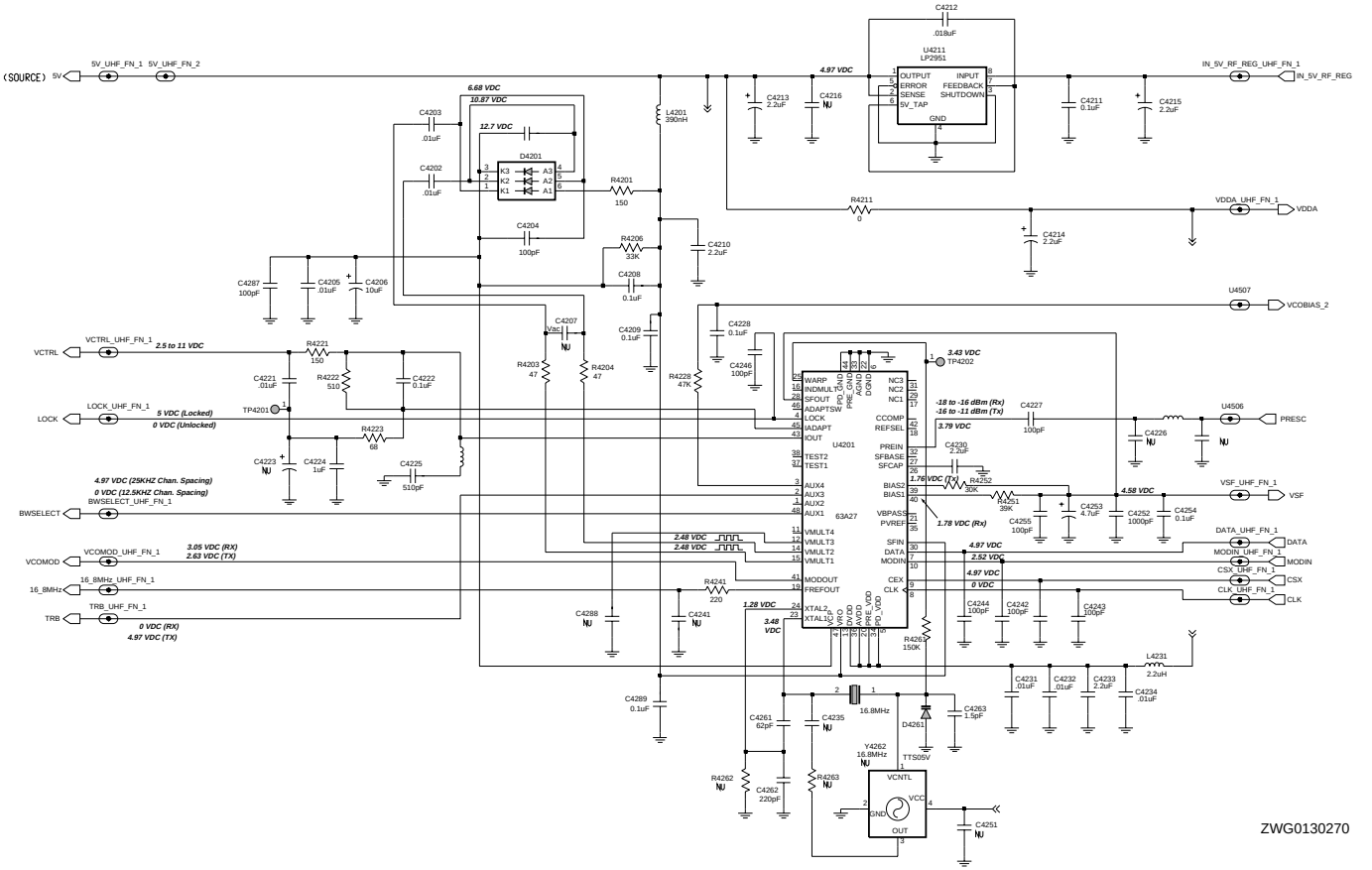

Figure 4-17. UHF (403-470MHz) Fractal-N Schematic Diagram

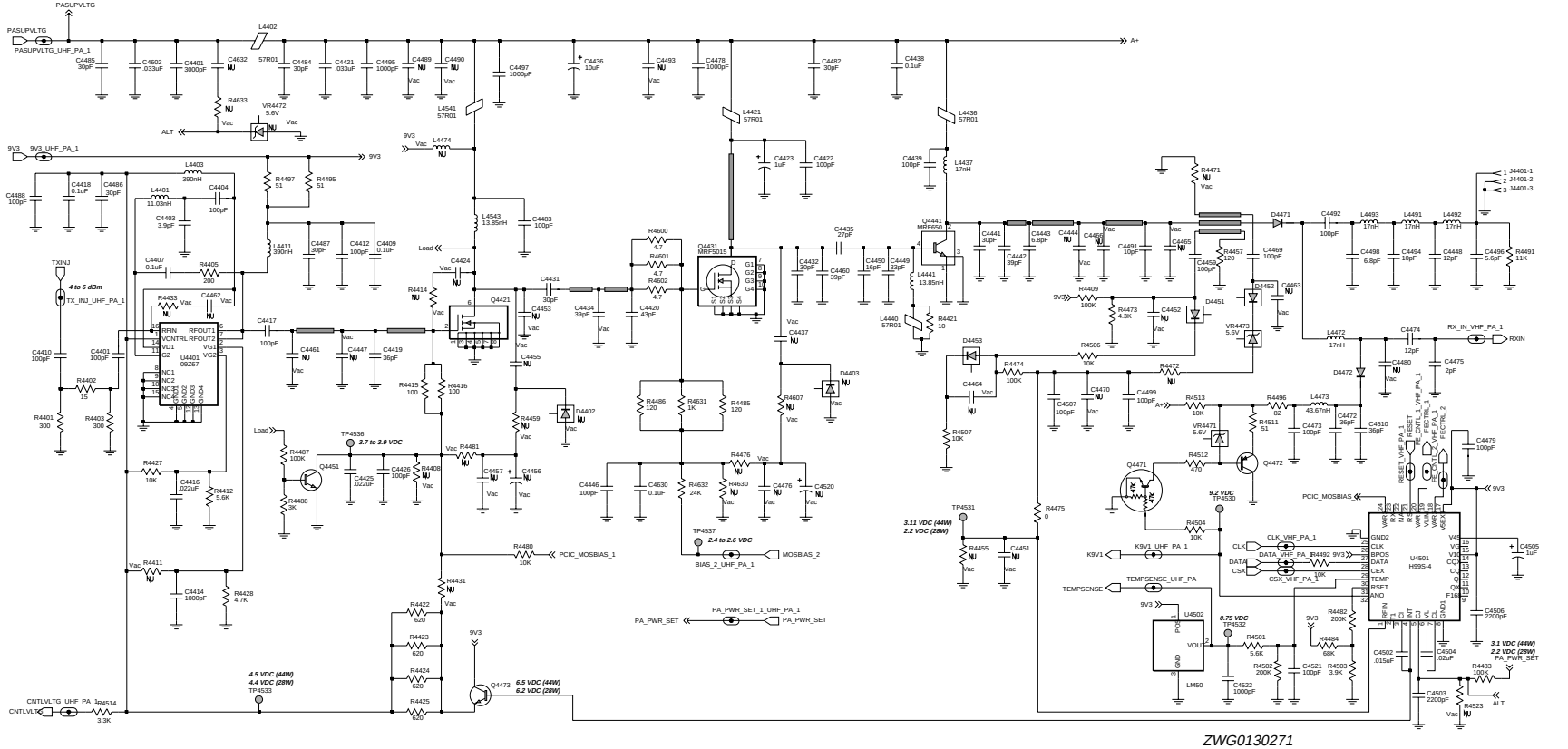

Figure 4-18. UHF (403-470MHz) Power Amplifier Schematic Diagram

Table 4-4. UHF B1 Radio Parts List

Circuit Ref	Motorola Part No.	Description
C0101	2113740F51	100pF
C0107	2113741F25	1nF
C0112	2113743E20	100nF
C0121	2113743E20	100nF
C0122	2113743E20	100nF
C0131	2113740F35	22pF
C0132	2113740F35	22pF
C0141	2113743E20	100nF
C0151	2113741F49	10nF
C0201	2311049A57	10uF
C0204	2113743E20	100nF
C0212	2311049A57	10uF
C0221	2113743E20	100nF
C0222	2113743E20	100nF
C0223	2113743E20	100nF
C0224	2113740F51	100pF
C0225	2113743E20	100nF
C0226	2113743E20	100nF
C0227	2113743E20	100nF
C0231	2113743B29	1uF
C0232	2113743E20	100nF
C0234	2113743E20	100nF
C0235	2113743E07	22nF
C0236	2113743E10	33nF
C0241	2113743E20	100nF
C0243	2113740F51	100pF
C0244	2113743E20	100nF
C0245	2113743E20	100nF
C0246	2113741F49	10nF
C0252	2311049A07	1uF
C0254	2113743E20	100nF
C0255	2113743E20	100nF
C0261	2113743E20	100nF
C0262	2113740F49	82pF
C0265	2113743E20	100nF
C0267	2113741F49	10nF
C0271	2113741F49	10nF
C0272	2113743E20	100nF
C0273	2113741F37	3.3nF
C0275	2311049A99	47uF
C0276	2113741F25	1nF
C0277	2113741F25	1nF
C0421	2113743N48	82.0pF
C0422	2113741F17	470pF
C0423	2113741F17	470pF
C0426	2113743L09	470pF
C0427	2113743L09	470pF
C0428	2113743N48	82.0pF
C0429	2113743L09	470pF
C0430	2113741F17	470pF
C0431	2113741F17	470pF
C0445	2113743L09	470pF
C0446	2113743L09	470pF
C0447	2113743L09	470pF
C0448	2113743L09	470pF
C0449	2113743L09	470pF
C0470	2113743L09	470pF
C0471	2113743L09	470pF
C0472	2113743L09	470pF
C0473	2113743L09	470pF
C0474	2113743L09	470pF
C0476	2113743L09	470pF
C0477	2113743L09	470pF
C0478	2113743L09	470pF
C0482	2113743L09	470pF
C0483	2113743L09	470pF
C0484	2113741F17	470pF
C0485	2113743L09	470pF
C0486	2113743L09	470pF
C0487	2113743L09	470pF
C0488	2113743L09	470pF
C0490	2113743L09	470pF
C0491	2113743L09	470pF
C0492	2113743L09	470pF
C0493	2113743L09	470pF
C0494	2113743L09	470pF
C0495	2113743L09	470pF
C0496	2113743L09	470pF
C0497	2113743L09	470pF
C0499	2113743L09	470pF
C0501	2113741F49	10nF
C0502	2113743L09	470pF
C0503	2113743L09	470pF
C0504	2113743L09	470pF
C0505	2113743L09	470pF
C0506	2113743L09	470pF
C0508	2113743L09	470pF
C0509	2113743L09	470pF
C0510	2113741F17	470pF
C0511	2113743L09	470 PF
C0512	2113743L09	470 PF
C0513	2113741F17	470pF
C0514	2113743L09	470 PF
C0515	2113743L09	470pF
C0516	2113741F49	10nF
C0517	2113743N48	82pF
C0518	2113743L09	470pF
C0541	2311049A05	470nF
C0542	2311049A99	47uF
C0591	2113743E20	100nF
C0592	2113743E20	100nF
C0593	2113743E20	100nF
C0601	2113741F17	470pF
C0603	2380090M24	10uF
C0611	2311049C06	22uF
C0612	2113743E20	100nF
C0622	2311049A99	47uF
C0641	2113741F17	470pF
C0644	2311049A97	33 UF
C0645	2113743E20	100nF
C0652	2311049A97	33 UF
C0654	2311049A57	10uF
C0655	2113743E20	100nF
C0661	2311049C05	47uF
C0662	2113741F49	10nF
C0663	2113743E20	100nF
C0671	2113743E20	100nF
C0681	2113743E20	100nF
C3100	2113741F25	1nF
C3102	2113740F31	15pF
C3103	2113740F39	33pF
C3104	2113743E20	100nF
C3110	2113740F37	27pF
C3111	2113743E20	100nF
C3112	2113740F49	82pF
C3114	2113740F33	18pF
C3115	2113740F35	22pF
C3116	2113743E20	100nF
C3121	2113743E20	100nF
C3122	2113743E11	39nF
C3123	2113743E11	39nF
C3132	2113743E20	100nF
C3133	2311049A57	10uF
C3134	2113743E20	100nF
C3135	2113740L30	33pF
C3136	2113740L29	30pF
C3137	2113743E11	39nF
C3138	2311049A40	2.2uF
C3139	2113743E20	100nF
C3140	2113743E20	100nF
C3141	2113743E20	100nF
C3142	2113743E20	100nF
C3143	2113740F53	120pF
C3144	2113743E20	100nF
C3145	2113743E20	100nF
C3146	2113741F41	4.7nF
C3147	2113743E20	100nF
C3151	2113741F49	10nF
C3152	2113741F49	10nF
C3155	2113741F49	10nF
C4001	2113740F09	1.8pF
C4002	2113740F39	33pF
C4003	2113740F41	39pF
C4004	2113740F42	43pF
C4005	2113740F42	43pF
C4006	2113740F42	43pF
C4007	2113740F41	39pF
C4008	2113741F25	1nF
C4009	2113740F51	100pF
C4010	2113741F13	330pF
C4011	2113741F37	3.3nF
C4012	2113741F13	330pF
C4013	2113741F37	3.3nF
C4014	2113740F51	100pF
C4015	2113740F51	100pF
C4017	2113740F09	1.8pF
C4018	2113740F29	12pF
C4019	2113740F35	22pF
C4020	2113740F40	36pF
C4021	2113740F40	36pF
C4021	2113740F51	100pF
C4022	2113740F40	36pF
C4023	2113740F35	22pF
C4024	2113741F25	1nF
C4025	2113740F11	2.2pF
C4026	2113740F09	1.8pF
C4027	2113740F09	1.8pF
C4029	2113740F09	1.8pF
C4030	2113740F09	1.8pF
C4031	2113740F30	13pF
C4051	2113740F27	10pF
C4052	2113740F49	82pF
C4053	2113740F32	16pF
C4054	2113740F32	16pF
C4202	2113741F49	10 nF
C4203	2113741F49	10 nF
C4204	2113740F51	100pF
C4205	2113741F49	10nF
C4206	2311049J25	10uF
C4208	2113743E20	100nF
C4209	2113743E20	100nF
C4210	2104993J02	2.2uF
C4211	2113743E20	100nF
C4212	2113743E05	1.8nF
C4213	2311049A09	2.2uF
C4214	2311049A09	2.2uF
C4215	2311049A09	2.2uF
C4221	2109720D01	100nF

Circuit Ref	Motorola Part No.	Description
C4222	2109720D14	100nF
C4224	0882422W23	1.0uF
C4225	2113741F18	510pF
C4227	2113740F51	100pF
C4228	2113743E20	100nF
C4230	2104993J02	2.2uF
C4231	2113741F49	10nF
C4232	2113741F49	10nF
C4233	2104993J02	2.2uF
C4234	2113741F49	10nF
C4242	2113740F51	100pF
C4243	2113740F51	100pF
C4244	2113740F51	100pF
C4245	2113740F51	100pF
C4246	2113740F51	100pF
C4252	2113741F25	1nF
C4253	2311049A56	4.7uF
C4254	2113743E20	100nF
C4255	2113740F51	100pF
C4261	2113740L37	62pF
C4262	2113740F59	220pF
C4263	2113740F07	1.5pF
C4287	2113740F51	100pF
C4289	2113743E20	100nF
C4301	2113740F51	100pF
C4302	2113740L16	8.2pF
C4303	2113740L16	8.2pF
C4304	2113740L08	3.9pF
C4305	2113740F03	1pF
C4306	2113740L01	2pF
C4307	2113740F51	100pF
C4308	2113743E20	100nF
C4309	2113740F51	100pF
C4311	2113740F51	100pF
C4312	2113740F29	12pF
C4313	2113740F03	1pF
C4314	2113740F07	1.5pF
C4315	2113740F51	100pF
C4316	2109720D14	100nF
C4317	2113740F51	100pF
C4318	2113743K16	220nF
C4321	2113740F03	1pF
C4322	2113740F51	100pF
C4323	2113741F25	1.0nF
C4324	2113740L05	3pF
C4325	2311049A56	4.7uF
C4331	2113740L14	6.8pF
C4332	2113743E20	100nF
C4333	2113740F44	51pF
C4334	2113740F44	51pF
C4335	2113740F51	100pF
C4336	2113743E07	22nF
C4337	2113740F44	51pF
C4338	2113740F44	51pF
C4339	2113740F03	1pF
C4351	2113740F51	100pF
C4352	2113743E20	100nF
C4353	2113743E20	100nF
C4354	2104993J02	2.2uF
C4355	2104993J02	2.2uF
C4361	2113740F51	100pF
C4362	2113743K16	220nF
C4363	2113740F03	1pF
C4371	2113743K16	220nF
C4372	2113740F51	100pF
C4373	2113740F03	1pF
C4374	2113740F03	1pF
C4375	2113743E20	100nF
C4381	2113743E20	100nF
C4382	2113740F51	100pF
C4383	2113740F51	100pF
C4401	2113740F51	100pF
C4403	2113740F17	3.9pF
C4404	2113740F51	100pF
C4407	2113743E20	100nF
C4409	2113743E20	100nF
C4410	2113740F51	100pF
C4412	2113740F51	100pF
C4414	2113741F25	1nF
C4416	2113743E07	22nF
C4417	2113740F51	100pF
C4418	2113743E20	100nF
C4419	2113740F40	36pF
C4421	2113741A57	33nF
C4422	2113740A55	100pF
C4423	2311049A08	1uF
C4425	2113743E07	22nF
C4426	2113740F51	100pF
C4431	2113740A40	30pF
C4432	2111078B27	30pF
C4435	2111078B25	27pF
C4436	2311049A45	10uF
C4438	2113743E20	100nF
C4439	2111078B42	100pF
C4441	2180464E40	30pF
C4442	2180464E34	39pF
C4443	2111078B09	6.8pF
C4446	2113740F51	100pF
C4448	2180464E65	12pF
C4449	2111078B23	24pF
C4450	2111078B19	16pF
C4459	2113740A55	100pF
C4460	2111078B32	39pF
C4472	2111078B31	36pF
C4473	2113740F51	100pF
C4474	2113740F23	6.8pF
C4475	2113740F10	2.0pF
C4479	2113740F51	100pF
C4482	2113740F38	30pF
C4483	2113740A55	100pF
C4484	2113740F38	30pF
C4485	2113740F38	30pF
C4486	2113740F38	30pF
C4487	2113740F38	30pF
C4488	2113740F51	100pF
C4491	2111078B13	10pF
C4492	2111078B42	100pF
C4494	2180464E63	10pF
C4496	2111078B07	5.6pF
C4498	2111078B09	6.8pF
C4499	2113740F51	100 pF
C4502	2113743E03	15nF
C4503	2113741F33	2.2nF
C4504	2113743E06	22nF
C4505	2311049A07	1uF
C4506	2113741F33	2.2nF
C4507	2113740F51	100pF
C4510	2111078B31	36pF
C4521	2113740F51	100pF
C4602	2113741A57	33nF
C4630	2113743E20	100nF
C4632	2113741F25	1.0nF
CR4301	4805649Q13	Diode, Varactor
CR4302	4862824C01	Diode, Varactor
CR4303	4862824C01	Diode, Varactor
CR4311	4802245J22	Diode, Varactor
CR4321	4862824C01	Diode, Varactor
D0101	4880236E05	Diode Schottky
D0151	4813833C02	Diode Dual
D0179	4813833C02	Diode Dual
D0621	4813833C02	Diode Dual
D0651	4813833C02	Diode Dual
D0660	4813833C02	Diode Dual
D0661	4813833C02	Diode Dual
D3101	4880154K03	Diode Schottky
D4001	4862824C01	Diode, Varactor
D4002	4862824C01	Diode, Varactor
D4003	4880154K03	Dual Schottky
D4004	4862824C01	Diode, Varactor
D4005	4862824C01	Diode, Varactor
D4051	4886143B01	Diode Mixer
D4201	4802233J09	Diode Tripple
D4261	4802245J22	Diode, Varactor
D4451	4880236E05	Diode Schottky
D4452	4880236E05	Diode Schottky
D4453	4880236E05	Diode Schottky
D4471	4802482J02	Diode
D4472	4802482J02	Diode
E0271	2484657R01	Ferrite Bead
E0272	2484657R01	Ferrite Bead
E0631	2484657R01	Ferrite Bead
FL3101	9180112R16	2-Pole Crystal Filter, 44.85MHz
FL3102	9180112R16	2-Pole Crystal Filter, 44.85MHz
FL3111	9180469V04	Filter, 455kHz
FL3112	9180469V06	Filter, 455kHz
FL3114	9180468V06	Filter, 455kHz
FL3115	9180469V03	Filter, 455kHz
J0401	0902636Y02	12-Pin Flexible Connector
J0451	0902636Y01	Flexible Connector, Side Entry
J0501	0986105B01	20-Pin Connector
J0551	0905505Y04	Connector, Zif Horizontal
J0601	0986165B01	DC Power Connector
J4401	0986166B02	Mini-UHF RF Connector
L3101	2462587T25	620nH
L3111	2462587T25	620nH
L3112	2462587T25	620nH
L4003	2462587T23	470nH
L4008	2462587T23	470nH
L4051	2462587T17	150nH
L4053	2462587X46	27nH
L4054	2462587X43	15nH
L4201	2462587Q42	390nH
L4221	2462587P25	12uH
L4225	2462587T40	33nH
L4231	2462587Q20	2.2uH
L4301	2462587T22	390nH
L4302	2462587T22	390nH
L4303	2460593C01	Teflon Resonator
L4304	2462587T22	390nH
L4305	2462587T22	390nH
L4311	2462587T22	390nH
L4312	2460593C01	Teflon Resonator
L4313	2462587T22	390nH
L4331	2462587T09	33nH
L4332	2462587T36	15nH
L4333	2462587T22	390nH
L4361	2462587T22	390nH

Circuit Ref	Motorola Part No.	Description
L4371	2462587T13	68nH
L4401	2460591B04	Airwound Coil, 4-turns
L4402	2484657R01	Ferrite Bead
L4403	2462587T22	390nH
L4411	2462587T22	390nH
L4421	2484657R01	Ferrite Bead
L4436	2484657R01	Ferrite Bead
L4437	2460592A01	Airwound Coil, 3-turns
L4440	2484657R01	Ferrite Bead
L4441	2460591C23	Airwound Coil, 5-turns
L4472	2460592A01	Airwound Coil, 3-turns
L4473	2460591N36	Airwound Coil, 5-turns
L4491	2460592A01	Airwound Coil, 3-turns
L4492	2460592A01	Airwound Coil, 3-turns
L4493	2460592A01	Airwound Coil, 3-turns
L4543	2460591C23	Airwound Coil, 5-turns
Q0110	4880048M01	NPN
Q0151	4880048M01	NPN
Q0171	4880048M01	NPN
Q0173	4880052M01	NPN Darlington
Q0177	4880048M01	NPN
Q0181	4880048M01	NPN
Q0183	4880048M01	NPN
Q0185	4880048M01	NPN
Q0271	4813824A10	NPN
Q0641	4880048M01	NPN
Q0661	4805921T02	DUAL
Q0662	4813824A10	NPN
Q0663	4880048M01	NPN
Q0681	4880052M01	NPN Darlington
Q3101	4813827A07	NPN
Q3102	4813827A07	NPN
Q3151	4880048M01	NPN DIG
Q3152	4880048M01	NPN DIG
Q4003	4813827A07	NPN
Q4301	4805218N63	Diode Dual Schottky
Q4331	4813827A07	NPN
Q4332	4813827A07	NPN
Q4333	4802245J50	NPN
Q4421	5105385Y91	LDMOS Power Amplifier
Q4431	4805537W01	Bipolar Power Amplifier
Q4441	4880225C30	Bipolar Power Amplifier
Q4471	4880048M01	NPN
Q4472	4805128M27	PNP
Q4473	4813824A10	MMBT3904
R0101	0662057A73	10K
R0102	0662057A65	4K
R0104	0662057A73	10K
R0105	0662057A97	100K
R0108	0662057A57	2K
R0109	0662057B47	0
R0111	0662057B47	0
R0113	0662057A73	10K
R0114	0662057A73	10K
R0115	0662057A73	10K
R0117	0662057A63	3k9
R0121	0662057A97	100K
R0131	0662057B46	10M
R0132	0662057B10	330k
R0151	0662057A82	24K
R0152	0662057A82	24K
R0170	0662057A73	10K
R0171	0662057A65	4K
R0172	0662057A73	10k
R0173	0662057A65	4K
R0174	0662057A73	10K
R0175	0662057A73	10K
R0176	0662057A84	30K
R0177	0662057A65	4K
R0178	0662057A89	47K
R0179	0662057A89	47K
R0181	0662057A65	4k
R0182	0662057A89	47K
R0183	0662057A65	4k
R0184	0662057A89	47K
R0185	0662057A65	4k
R0186	0662057A89	47K
R0201	0662057A25	100
R0202	0662057A43	560
R0204	0662057A43	560
R0205	0662057A73	10K
R0206	0662057A73	10K
R0207	0662057A57	2K
R0208	0662057A57	2K
R0211	0660076E70	7.5K
R0212	0660076E70	7.5K
R0221	0662057A82	24K
R0222	0662057A82	24K
R0223	0662057A84	30K
R0224	0662057A71	8K
R0226	0662057B22	1M
R0227	0662057B22	1M
R0241	0662057A89	47K
R0242	0662057B47	0
R0251	0662057A89	47K
R0252	0662057A91	56K
R0253	0662057A97	100K
R0261	0662057A73	10K
R0262	0662057A97	100K
R0265	0662057A82	24K
R0267	0662057A89	47K
R0268	0662057A73	10K
R0269	0662057A41	470
R0273	0662057A82	24K
R0275	0662057A73	10K
R0276	0662057A77	15K
R0401	0662057A33	220
R0407	0662057M26	10
R0408	0662057A25	100
R0409	0662057M26	10
R0467	0662057M26	10
R0468	0662057M26	10
R0481	0662057B47	0
R0482	0662057B47	0
R0510	0662057A65	4K
R0511	0662057A97	100K
R0512	0662057A77	15K
R0525	0662057A97	100K
R0527	0662057B47	0
R0528	0662057B47	0
R0529	0662057A89	47K
R0530	0662057B47	0
R0531	0662057A43	560
R0533	0662057B47	0
R0535	0662057A49	1K
R0537	0662057A33	220
R0538	0662057A33	220
R0539	0662057A65	4K
R0541	0662057A83	27K
R0591	0662057A82	24K
R0592	0662057A01	10
R0611	0662057A91	56K
R0612	0662057A65	4K
R0621	0662057A82	24K
R0641	0662057A73	10K
R0642	0660076E70	7.5K
R0643	0660076E51	1.2K
R0651	0662057A01	10
R0652	0662057A01	10
R0661	0662057A49	1K
R0662	0662057B02	150K
R0671	0662057A84	30K
R0672	0662057A73	10K
R0681	0662057A79	18K
R0682	0662057A93	68K
R3101	0662057A75	12K
R3102	0662057A01	10
R3105	0662057A25	100
R3106	0662057A83	27K
R3107	0662057A69	6.8K
R3108	0662057A44	620
R3111	0662057A75	12K
R3112	0662057A01	10
R3115	0662057A39	390
R3116	0662057A37	330
R3117	0662057A83	27K
R3118	0662057A69	6.8K
R3130	0662057A18	51
R3132	0662057A77	15K
R3133	0662057A71	8.2K
R3134	0662057A73	10K
R3135	0662057A51	1.2K
R3144	0662057A58	2.4K
R3145	0662057A61	3.3K
R3146	0662057A45	680
R3147	0662057A75	12K
R3151	0662057A73	10K
R3152	0662057A73	10K
R3153	0662057A73	10K
R3154	0662057A73	10K
R4001	0662057A97	100K
R4002	0662057A37	330
R4003	0662057A63	3.9K
R4004	0662057A59	2.7K
R4005	0662057A73	10K
R4006	0662057A35	270
R4007	0662057A21	68
R4008	0662057A13	33
R4009	0662057A29	150
R4010	0662057A29	150
R4011	0662057A35	270
R4012	0662057A97	100K
R4013	0662057A35	270
R4014	0662057A01	10
R4022	0662057B47	0
R4051	0662057A18	51
R4052	0662057B47	0
R4060	0662057B10	330K
R4201	0662057A29	150
R4203	0662057A17	47
R4204	0662057A17	47
R4206	0662057A85	33K
R4211	0662057B47	0
R4221	0662057A29	150
R4222	0662057A42	510
R4223	0662057A21	68
R4228	0662057A89	47K
R4241	0662057A33	220
R4251	0662057A87	39K
R4252	0662057A84	30K

Circuit Ref	Motorola Part No.	Description
R4261	0662057B02	150K
R4301	0662057A67	5.6K
R4302	0662057A73	10K
R4303	0662057A12	30
R4304	0662057A31	180
R4305	0662057A01	10
R4311	0662057A70	7.5K
R4312	0662057A67	5.6K
R4313	0662057A12	30
R4314	0662057A35	270
R4315	0662057B47	0
R4321	0662057A91	56K
R4322	0662057A73	10K
R4323	0662057A73	10K
R4331	0662057A09	22
R4332	0662057A81	22K
R4333	0662057A73	10K
R4334	0662057B47	0
R4335	0662057A01	10
R4336	0662057A49	1K
R4337	0662057B47	0
R4338	0662057A33	220
R4339	0662057A09	22
R4340	0662057A33	220
R4341	0662057B47	0
R4342	0662057A57	2.2K
R4343	0662057A49	1K
R4344	0662057A01	10
R4345	0662057B47	0
R4346	0662057A73	10K
R4347	0662057B47	0
R4361	0662057A31	180
R4401	0662057A36	300
R4402	0662057A05	15
R4403	0662057A36	300
R4405	0662057A32	200
R4409	0662057A97	100K
R4412	0662057A67	5.6K
R4415	0662057A25	100
R4416	0662057A25	100
R4421	0680194M01	10
R4422	0611079A69	620
R4423	0611079A69	620
R4424	0611079A69	620
R4425	0611079A69	620
R4427	0662057A73	10K
R4428	0662057A65	4.7K
R4457	0683962T51	120
R4473	0662057A64	4K
R4474	0662057A97	100K

Circuit Ref	Motorola Part No.	Description
R4475	0662057B47	0
R4480	0662057A73	100K
R4482	0662057B05	200K
R4483	0662057A97	100K
R4484	0662057A93	68K
R4485	0662057C53	120
R4486	0662057C53	120
R4491	0662057A74	11K
R4492	0662057A73	10K
R4495	0680195M18	51
R4496	0680194M23	82
R4497	0680195M18	51
R4501	0662057A67	5.6K
R4502	0662057B65	200K
R4503	0662057A63	3.9K
R4504	0662057A73	10K
R4506	0662057A73	10K
R4507	0662057A73	10K
R4511	0680194M18	51
R4512	0662057A41	470
R4513	0662057A73	10K
R4514	0662057A61	3.3K
R4600	0662057C19	4.7
R4601	0662057C19	4.7
R4602	0662057C19	4.7
R4631	0662057A49	1K
R4632	0662057A82	24K
SH4301	2605782V03	VCO Shield
SH4302	2605782V03	VCO Shield
T4051	2505515V03	Mixer 4:1
T4052	2505515V04	Mixer 5:1
U0101	5102226J56	Microprocessor
* U0111	5102463J64	EEPROM
* U0121	5186137B01	ROM
U0122	5185963A21	SRAM
U0141	5113805A30	REMUX
U0211	5183222M49	Quad Opamp
U0221	5185963A53	ASFIC
U0251	5113806A20	MUX/DEMUX
U0271	5109699X01	AUDIO PA
U0611	5183308X01	Adjustable Voltage Regulator
U0641	5183308X01	Adjustable Voltage Regulator
U0651	5113816A07	5V Regulator
U0652	5113815A02	Under-Voltage Sensor
U3101	5186144B01	IF IC
U3111	5113805A86	CMOS Switch
U3115	5113805A86	CMOS Switch
U4201	5185963A27	Fract-N
U4211	5185963A33	Voltage Regulator
U4301	5105750U54	VCO

Circuit Ref	Motorola Part No.	Description
U4401	5105109Z67	LDMOS
U4501	5185765B01	PC
U4502	5185963A15	Temperature Sensor
VR0151	4813830A15	Diode
VR0501	4805656W09	Zener Quad
VR0503	4805656W09	Zener Quad
VR0504	4813830A40	Diode
VR0505	4805656W09	Zener Quad
VR0509	4813830A40	Diode
VR0510	4813830A40	Diode
VR0537	4813830A15	Diode
VR0541	4813830A27	Diode
VR0601	4813832C77	Transient Suppressor
VR0621	4813830A15	Diode
VR4471	4813830a15	Zener Diode
Y0131	4880113R19	Crystal Oscillator, 38.4 kHz
Y3101	4880606B09	Crystal Oscillator
Y3102	9186145B02	455 kHz Discriminator
Y4261	4880114R04	Crystal Oscillator, 16.8 MHz

* Motorola Depot Servicing only

Reference designators with an asterisk indicate components which are not field replaceable because they need to be calibrated with specialized factory equipment after installation. Radios in which these parts have been replaced in the field will be off-frequency at temperature extremes.

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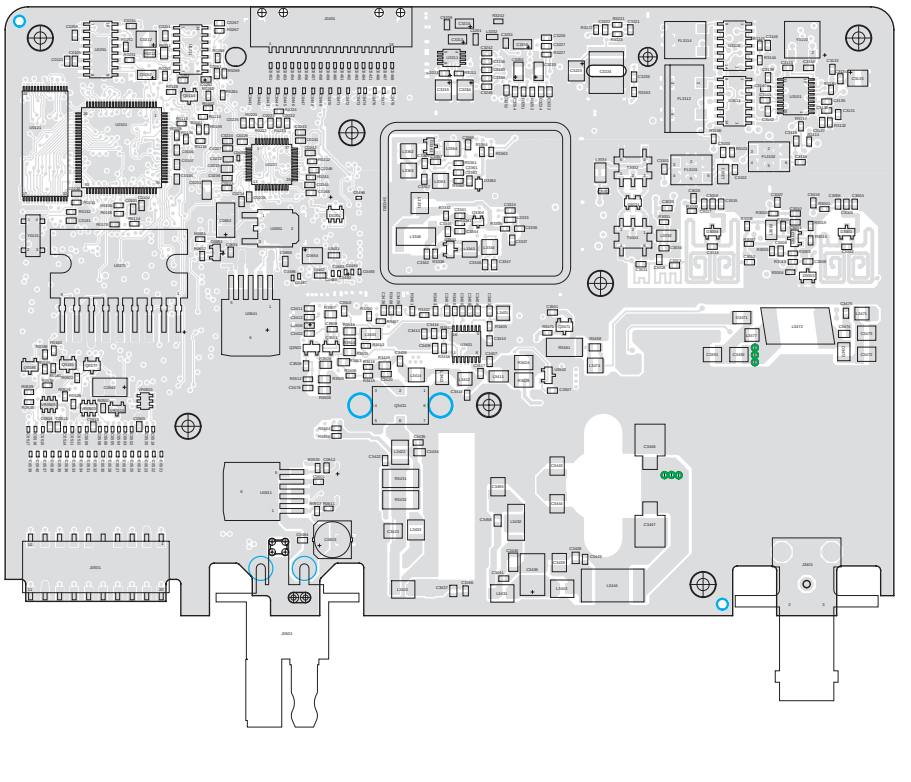

Figure 4-19. VHF (136-174MHz) Main Board Top Side PCB

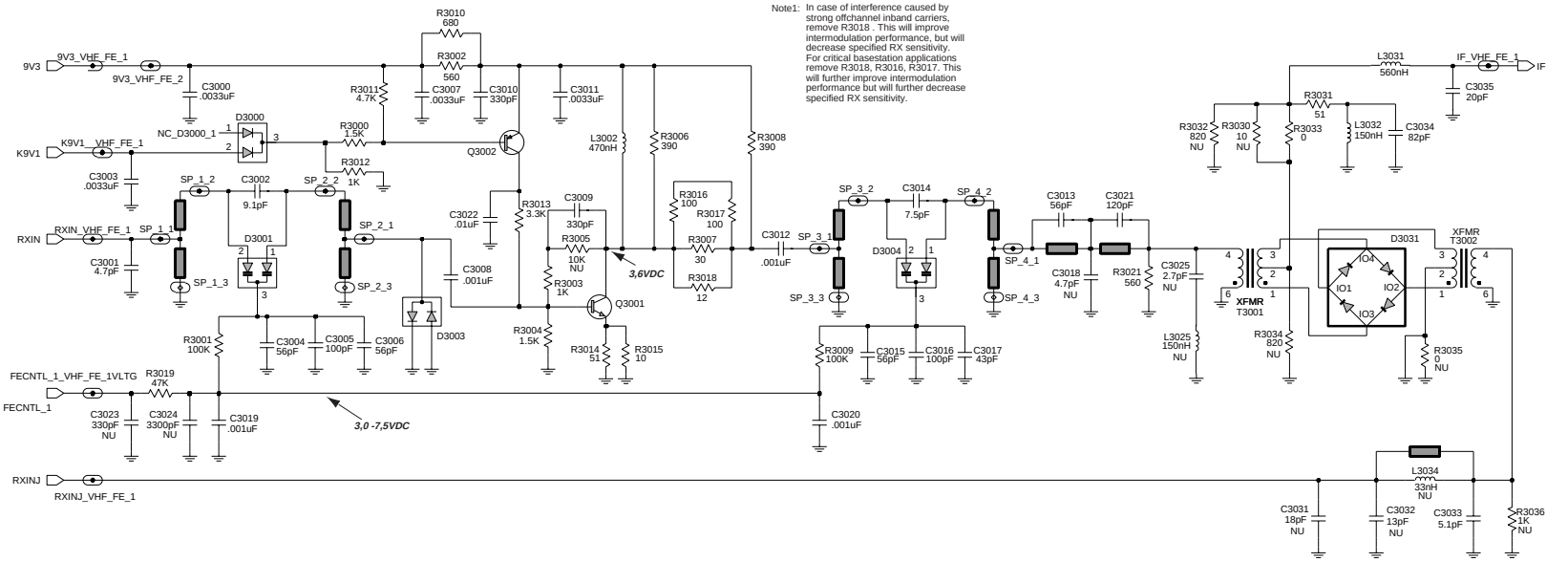

Figure 4-20. VHF (136-174MHz) Receiver Front End Schematic Diagram

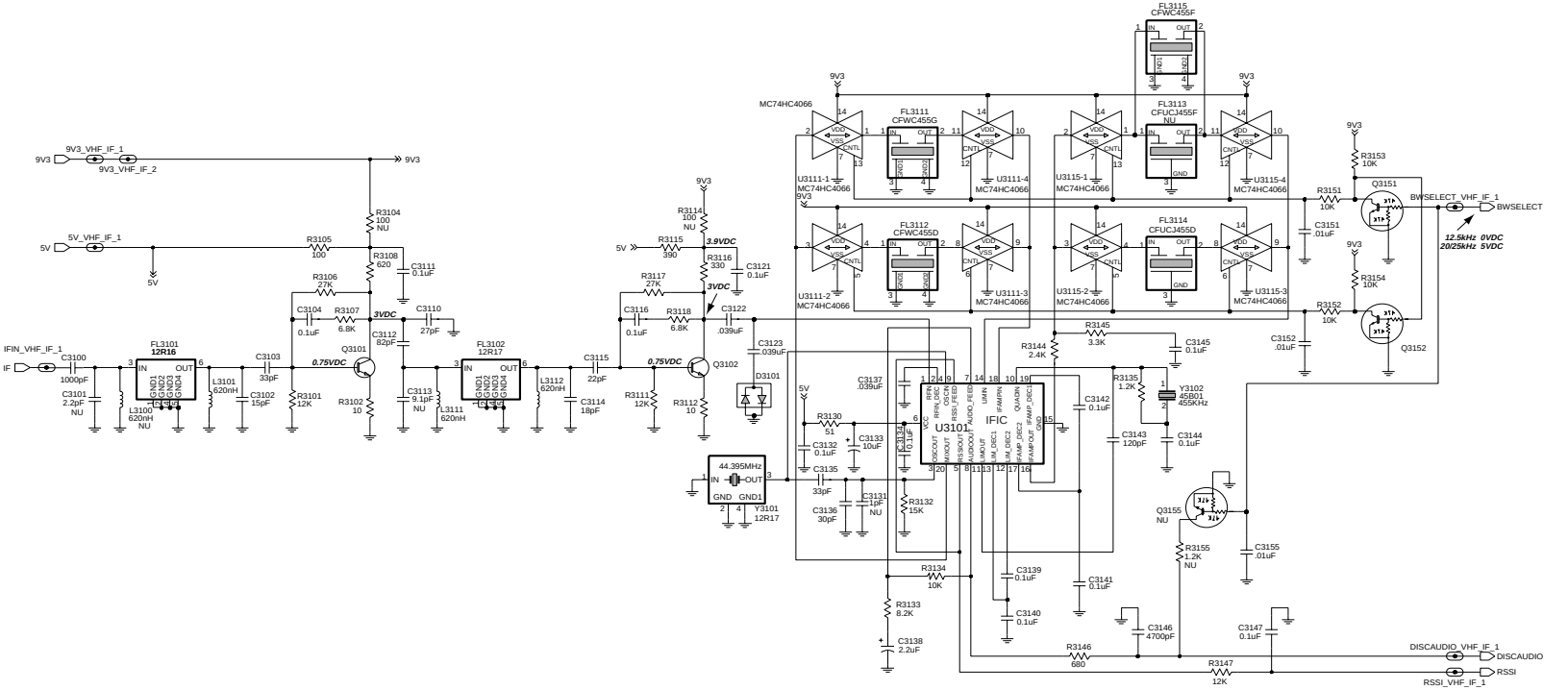

Figure 4-21. VHF (136-174MHz)Receiver IF Schematic Diagram

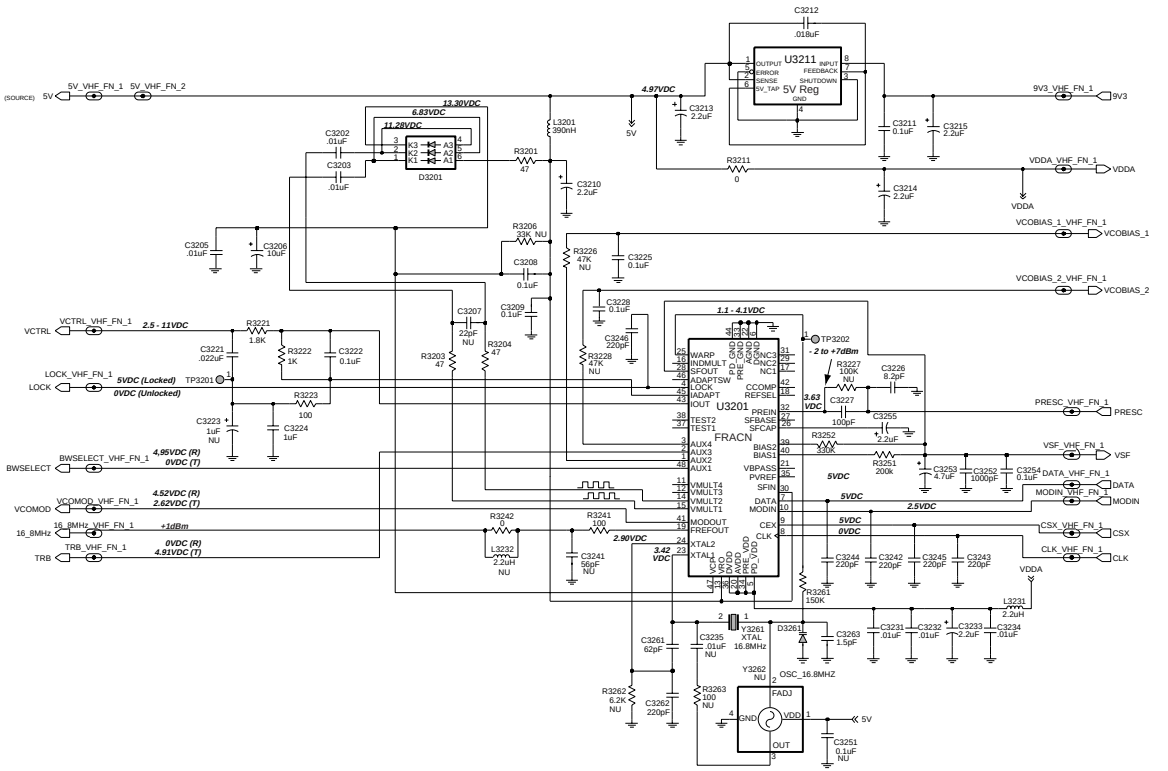

Figure 4-22. VHF (136-174MHz) Fractal-N Schematic Diagram

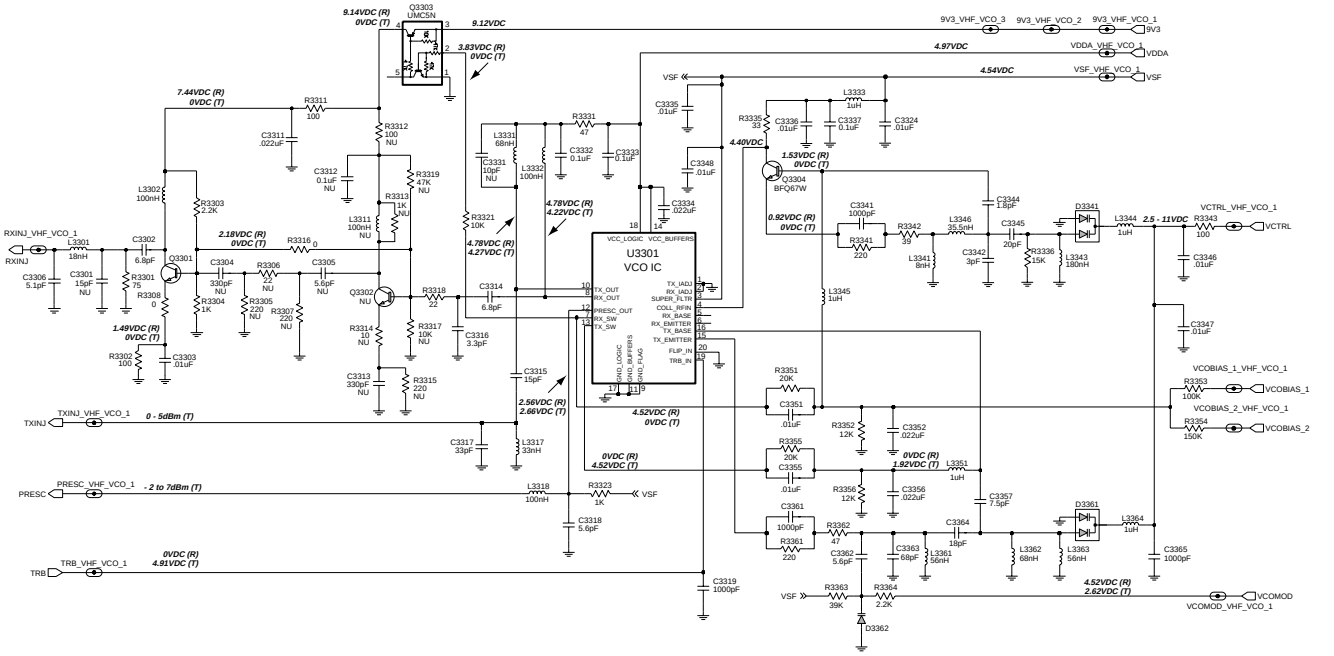

Figure 4-23. VHF (136-174MHz)Voltage Controlled Oscillator Schematic Diagram

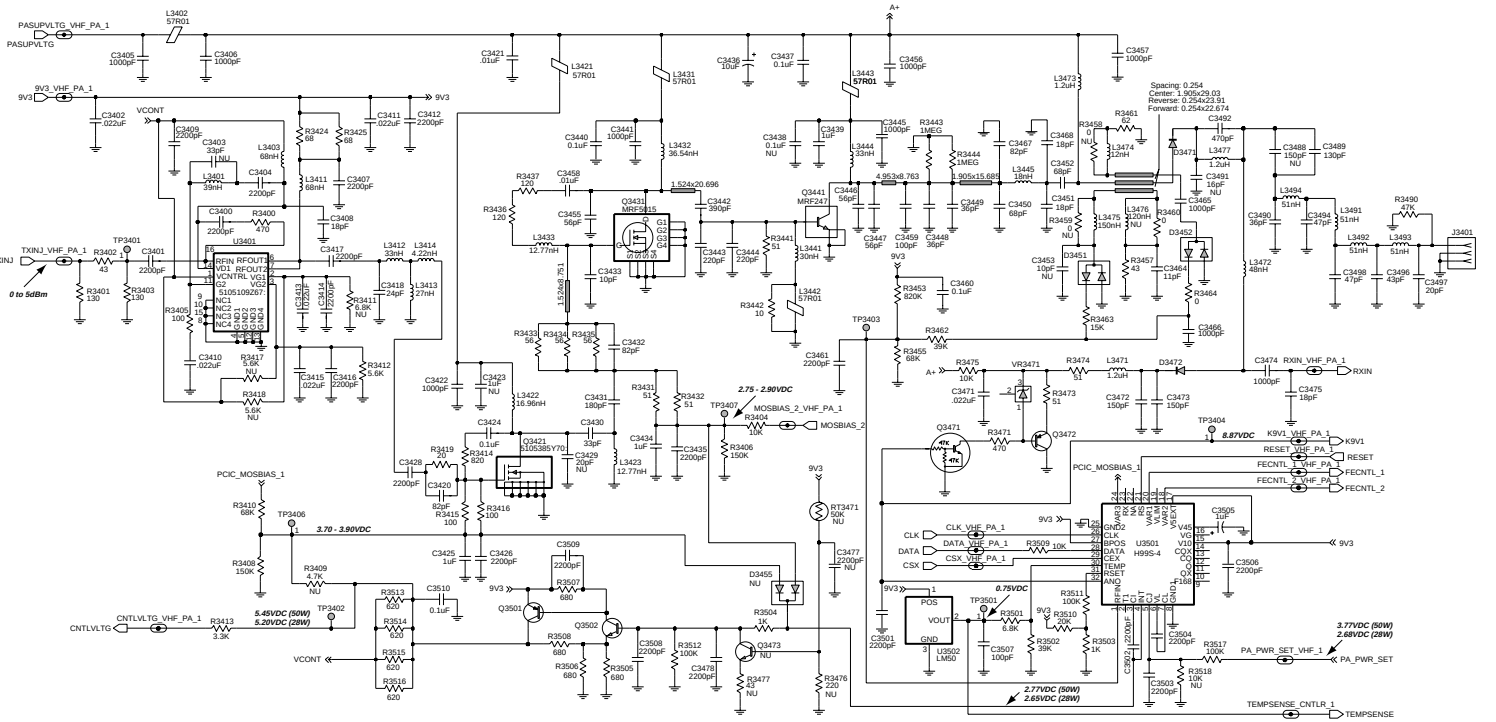

Figure 4-24. VHF (136-174MHz) Power Amplifier Schematic Diagram

Table 4-5. VHF (136-174MHz) Radio Parts List

Circuit Ref	Motorola Part No.	Description
C3000	2113741F37	3.3nF
C3001	2113740F19	4.7pF
C3002	2113740F26	9.1pF
C3003	2113741F37	3.3nF
C3004	2113740F45	56pF
C3005	2113740F51	100pF
C3006	2113740F45	56pF
C3007	2113741F37	3.3nF
C3008	2313741F25	10pF
C3009	2313741F13	330pF
C3010	2313741F13	330pF
C3011	2113741F37	3.3nF
C3012	2313741F25	10pF
C3013	2313740F45	56pF
C3014	2313740F24	7.5pF
C3015	2313740F45	56pF
C3016	2313740F51	100pF
C3017	2313740F42	43pF
C3019	2313741F25	10pF
C3020	2313741F25	10pF
C3021	2313740F53	82pF
C3022	2313740F49	10nF
C3033	2313740F20	5.1pF
C3034	2113740F49	10nF
C3035	2113740F31	15pF
C3101	2113740F32	16pF
C3102	2113740F31	15pF
C3103	2113740F39	33pF
C3104	2113743E20	100nF
C3110	2113740F37	27pF
C3111	2113743E20	100nF
C3112	2113740F49	82pF
C3114	2113740F33	18pF
C3115	2113740F35	22pF
C3116	2113743E20	100nF
C3121	2113743E20	100nF
C3122	2113743E11	0.1uF
C3123	2113743E11	39nF
C3132	2113743E20	39nF
C3133	2311049A57	10uF
C3134	2113743E20	100nF
C3135	2113740L30	33pF
C3136	2113740L29	30pF
C3137	2113743E11	39nF
C3138	2311049A40	2.2uF
C3139	2113743E20	100nF
C3140	2113743E20	100nF
C3141	2113743E20	100nF
C3142	2113743E20	100nF
C3143	2113740F53	120pF
C3144	2113743E20	100nF
C3145	2113743E20	100nF
C3146	2113741F41	4.7uF
C3147	2113743E20	100nF
C3151	2113741F49	10nF
C3152	2113741F49	10nF
C3155	2113741F49	10nF
C3202	2113741F49	10nF
C3203	2113741F49	10nF
C3205	2113741F49	10nF
C3206	2311049A57	10uF
C3207	2113740F35	22pF
C3208	2113743E20	100nF
C3209	2113743E20	100nF
C3210	2311049A40	2.2uF
C3211	2113743E20	100nF
C3212	2113743E05	18nF
C3213	2311049A40	2.2uF
C3214	2311049A09	2.2uF
C3214	2311049A09	2.2uF
C3221	2113743E07	22nF
C3222	2113743E20	100nF
C3224	0882422W33	1uF
C3225	2113743E20	100nF
C3226	2313740F25	8.2pF
C3227	2313740F51	100pF
C3228	2113743E20	100nF
C3231	2113741F49	10nF
C3232	2113741F49	10nF
C3233	2311049A40	2.2uF
C3234	2113741F49	10nF
C3242	2113740F59	220pF
C3243	2113740F59	220pF
C3244	2113740F59	220pF
C3245	2113740F59	220pF
C3246	2113740F59	220pF
C3252	2313741F25	1nF
C3253	2311049A56	4.7uF
C3254	2113743E20	100nF
C3255	2311049A40	2.2uF
C3261	2313740L38	68pF
C3262	2313740F61	270pF
C3263	2313740F07	1.5pF
C3302	2113740F23	6.8pF
C3303	2113741F49	10nF
C3306	2113740F20	5.1pF
C3311	2113743E07	22nF
C3314	2113740F23	6.8pF
C3315	2113740F31	15pF
C3316	2113740F15	3.3pF
C3317	2113740F39	33pF
C3318	2113740F21	5.6pF
C3319	2113741F25	1nF
C3324	2113741F49	10nF
C3332	2113743E20	100nF
C3333	2113743E20	100nF
C3334	2113743E07	22nF
C3335	2113741F49	10nF
C3336	2311041F49	10nF
C3337	2113743E20	100nF
C3341	2113741F25	1nF
C3342	2113740L05	3.0pF
C3344	2113740F09	1.8pF
C3345	2113740L25	20pF
C3346	2311041F49	10nF
C3347	2311041F49	10nF
C3348	2311041F49	10nF
C3351	2311041F49	10nF
C3352	2113743E07	22nF
C3355	2311041F49	10nF
C3356	2113743E07	22nF
C3357	2113740F24	7.5pF
C3361	2113741F25	1nF
C3362	2113740F21	5.6pF
C3363	2113740F47	68pF
C3364	2113740F33	18pF
C3365	2113741F25	1nF
C3400	2113741F33	2.2nF
C3401	2113741F33	2.2nF
C3402	2113743E07	22nF
C3404	2113741F33	2.2nF
C3405	2113740A79	1nF
C3406	2113740A79	1nF
C3407	2113741F33	2.2nF
C3408	2113740F33	18pF
C3409	2113741F33	2.2nF
C3410	2113743E07	22nF
C3411	2113743E07	22nF
C3412	2113741F33	2.2nF
C3413	2113743E07	22nF
C3414	2113741F33	2.2nF
C3415	2113743E07	22nF
C3416	2113741F33	2.2nF
C3417	2113741F33	2.2nF
C3418	2113740F36	24pF
C3420	2113740F49	82pF
C3421	2113741A45	10nF
C3422	2113740A79	1nF
C3424	2113741A45	68pF
C3425	2113928E01	1uF
C3426	2113741F33	2.2nF
C3428	2113741F33	2.2nF
C3430	2113740A41	33pF
C3431	2113740A61	82pF
C3432	2113740A53	220pF
C3433	2113740A29	10pF
C3434	2113741A45	10nF
C3435	2113741F33	2.2nF
C3436	2113741A45	10uF
C3437	2113741M69	0.1uF
C3439	2113741W01	.01uF
C3440	2113741M69	1uF
C3441	2113740A79	1nF
C3442	2111078B57	390F
C3443	2111078B51	
C3444	2111078B51	
C3445	2113740A79	1nF
C3446	2180464E50	56pF
C3447	2180464E50	56pF
C3448	2111078B36	56pF
C3449	2111078B36	56pF
C3450	2111078B38	68pF
C3451	2111078B31	36pF
C3452	2111078B38	68pF
C3455	2111078B36	56pF
C3456	2113740A79	1nF
C3457	2113740A79	1nF
C3458	2113741A45	10nF
C3459	2180464E20	82pF
C3460	2113743E20	100nF
C3461	2113741F33	2.2nF
C3464	2113740F28	11pF
C3465	2113740A79	1nF
C3466	2113740A79	1nF
C3467	2111078B37	62pF
C3471	2113743E07	22nF
C3472	2111078B47	150pF
C3473	2111078B47	150pF
C3474	2113740A79	1nF
C3475	2113741F33	18pF
C3478	2113741F33	18pF
C3489	2111078B45	130pF
C3490	2111078B31	36pF
C3492	2111078B59	470pF
C3494	2111078B34	47pF
C3496	2111078B33	43pF
C3497	2111078B21	20pF
C3498	2111078B34	47pF
C3501	2113741F33	2.2nF
C3502	2113741F33	2.2nF
C3503	2113741F33	2.2nF
C3504	2113741F33	2.2nF

Circuit Ref	Motorola Part No.	Description
C3505	2311049A07	1uF
C3506	2113741F33	2.2nF
C3507	2113740F51	100pF
C3508	2113741F33	2.2nF
C3509	2113741F33	2.2nF
C3510	2113743E20	100nF
CR3301	4802245J42	Ring Quad Diode
CR3302	4805129M96	SMBV1032
CR3303	4880154K03	Dual Common Anode Cathode
CR411	4802245J47	Schottky Diode
CR412	4802245J47	Schottky Diode
CR413	4802245J47	Schottky Diode
CR440	4813833C02	Dual Diode Common Cathode
CR501	4880107R01	Rectifier
CR503	4805729G49	LED Red/Yel
D3000	4813833C02	Diode Dual
D3001	4805649Q13	Varactor
D3003	4880154K03	Diode Dual
D3004	4805649Q13	Varactor
D3031	4886143B01	Diode Mixer
D3101	4880154K03	Triple Diode
D3201	4802233J09	Triple Diode
D3261	4802245J22	Varactor
D3341	4805649Q13	Dual Varactor
D3361	4805649Q13	Dual Varactor
D3362	4862824C01	Varactor
D3451	4882290T02	Diode, Hot Carrier
D3452	4882290T02	Diode, Hot Carrier
D3471	4802482J02	Diode, Pin
D3472	4802482J02	Diode, Pin
FL3101	9180112R16	Crystal Filter, 44.85MHz
FL3102	9180112R16	Crystal Filter, 44.85MHz
FL3111	9180469V04	Filter, 455kHz
FL3112	9180469V06	Filter, 455kHz
FL3114	9180469V06	Filter, 455kHz
FL3115	9180469V03	Filter, 455kHz
L3002	2462587T23	470nH
L3025	2462587T17	150uH
L3032	2462587T17	150uH
L3100	2462587T22	390nH
L3101	2462587T25	620uH
L3111	2462587T25	620nH
L3112	2462587T25	620nH
L3201	2462587T23	390nH
L3231	2462587Q42	2.2uH
L3301	2462587N44	18nH
L3302	2462587N53	100nH
L3317	2462587V28	33nH
L3318	2462587V34	100nH
L3331	2462587H32	68nH

Circuit Ref	Motorola Part No.	Description
L3332	2462587V15	100nH
L3333	2462587Q47	1uH
L3341	2484562T13	8nH
L3343	2462587N56	180nH
L3344	2462587N68	1uH
L3345	2460591N68	1uH
L3346	2484562T18	35.5nH
L3351	2462587N68	1uH
L3361	2462587N50	56nH
L3362	2462587N51	68nH
L3363	2462587N50	56nH
L3364	2462587N68	1uH
L3401	2462587X48	39nH
L3402	2484657R01	Ferrite Bead
L3403	2462587T13	68nH
L3411	2462587T13	68nH
L3412	2462587X47	33nH
L3413	2462587X46	27nH
L3414	2460591A01	4.22nH
L3421	2462587R01	Ferrite Bead
L3422	2460591C73	100nH
L3423	2460591B73	100nH
L3431	2462587R01	Ferrite Bead
L3432	2460591F77	35.5nH
L3433	2460591B73	12.77nH
L3441	2460591E77	30nH
L3442	2462587R01	Ferrite Bead
L3443	2462587R01	Ferrite Bead
L3444	2460591X03	nH
L3445	2460591X01	nH
L3471	2462587X69	1.2uH
L3472	2460591X05	48nH
L3473	2462587X69	1.2uH
L3474	2462587N42	12nH
L3475	2462587N55	150nH
L3477	2462587X69	1.2uH
L3491	2460591B01	51nH
L3492	2460591B01	51nH
L3493	2460591B01	51nH
L3494	2460591B01	51nH
Q3001	4813827A07	NPN
Q3002	4813824A17	PNP
Q3101	4813827A07	NPN
Q3102	4813827A07	NPN
Q3151	4880048M01	NPN
Q3152	4880048M01	NPN
Q3301	4813827A07	NPN
Q3303	4802245J50	Dual NPN/PNP
Q3304	4805218N63	RF
Q3421	5105385Y70	LDMOS
Q3431	4805537W01	MOS

Circuit Ref	Motorola Part No.	Description
Q3441	4884411L04	RF Power
Q3471	480048M01	NPN
Q3472	4805128M27	PNP
Q3501	4813824A17	PNP
Q3502	4813824A10	NPN
R3000	0662057A53	1K
R3001	0662057A97	100K
R3002	0662057A43	560
R3003	0662057A49	1K
R3004	0662057A53	1K
R3006	0662057A39	390K
R3007	0662057A12	30
R3008	0662057A37	390
R3009	0662057A97	100K
R3010	0662057A45	680
R3011	0662057A65	4K
R3012	0662057A49	1K
R3013	0662057A61	3K
R3014	0662057A18	51
R3015	0662057A01	10
R3016	0662057A29	150
R3017	0662057A29	150
R3018	0662057A09	22
R3019	0662057A89	47K
R3021	0662057A43	560
R3031	0662057A18	51
R3033	0662057B47	0
R3101	0662057A75	12K
R3102	0662057A01	10
R3105	0662057A25	100
R3106	0662057A83	27K
R3107	0662057A69	6K
R3108	0662057A44	620
R3111	0662057A75	12K
R3112	0662057A01	10
R3115	0662057A39	390
R3116	0662057A37	330
R3117	0662057A83	27K
R3118	0662057A69	6K
R3130	0662057A18	51
R3132	0662057A77	15K
R3133	0662057A71	8K
R3134	0662057A73	10K
R3135	0662057A51	1K
R3144	0662057A58	2K
R3145	0662057A61	3K
R3146	0662057A45	680
R3147	0662057A75	12K
R3151	0662057A73	10K
R3152	0662057A73	10K
R3153	0662057A73	10K

Circuit Ref	Motorola Part No.	Description
R3154	0662057A73	10K
R3201	0662057A17	47
R3203	0662057A17	47
R3204	0662057A17	47
R3211	0662057B47	0
R3221	0662057A55	1K
R3222	0662057A49	1K
R3223	0662057A25	100
R3227	0662057A97	100K
R3241	0680539A25	100
R3242	0662057B47	0
R3251	0662057B05	200K
R3252	0662057B10	330K
R3261	0662057B02	150K
R3301	0662057A22	75
R3302	0662057A25	100
R3303	0662057A57	2K
R3304	0662057A49	1K
R3308	0662057B47	0
R3311	0662057A25	100
R3316	0662057B47	0
R3318	0662057A09	22
R3321	0662057A73	10K
R3323	0662057A49	1K
R3331	0662057A17	47
R3335	0662057A13	33
R3336	0662057A77	15K
R3341	0662057A33	220
R3342	0662057A15	39
R3343	0662057A25	100
R3351	0662057A80	20K
R3352	0662057A75	12K
R3353	0662057A97	100K
R3354	0662057B02	150
R3355	0662057A80	20K
R3356	0662057A75	12K
R3361	0662057A33	220
R3362	0662057A17	47
R3363	0662057A87	39K
R3364	0662057A57	2K
R3400	0662057A41	470
R3401	0662057A28	130
R3402	0662057A16	43
R3403	0662057A28	130
R3404	0662057A73	10K
R3405	0662057A25	100
R3406	0662057B02	150K
R3408	0662057B02	150K
R3410	0662057A73	10K
R3412	0662057A67	5K
R3413	0662057A61	3K

Circuit Ref	Motorola Part No.	Description
R3414	0662057T71	820
R3415	0662057A25	100
R3416	0662057A25	100
R3419	0662057C34	20
R3424	0662057K21	68
R3425	0662057K21	68
R3431	0662057M18	51
R3432	0662057M18	51
R3433	0662057C45	56
R3434	0662057C45	56
R3435	0662057C45	56
R3436	0662057T51	120
R3437	0662057T51	120
R3441	0662057M18	51
R3442	0662057C27	10
R3443	0662057D48	1M
R3444	0662057D48	1M
R3453	0662057B20	820K
R3455	0662057A93	68K
R3457	0662057M16	
R3460	0662057C01	0
R3461	0662057M20	62
R3462	0662057A87	39K
R3463	0662057D04	15K
R3464	0662057C01	0
R3471	0662057A41	470
R3473	0662057M18	51
R3474	0662057M18	51
R3475	0662057A73	10K
R3490	0662057A89	47K
R3501	0662057A69	6K
R3502	0662057A87	39K
R3503	0662057A49	1K
R3504	0662057A49	1K
R3505	0662057C71	680
R3506	0662057C71	680
R3507	0662057C71	680
R3508	0662057C71	680
R3509	0662057A73	10K
R3510	0662057A80	20K
R3511	0662057A97	100K
R3512	0662057A97	100K
R3513	0662057A69	6K
R3514	0662057A69	6K
R3515	0662057A69	6K
R3516	0662057A69	6K
R3517	0662057A97	100K
T3001	2508396X02	Transformer
T3002	2508397X02	Transformer
U3101	5186144B01	SA616
U3111	5113805A86	Quad Analog Mux/Demux

Circuit Ref	Motorola Part No.	Description
U3115	5113805A86	Quad Analog Mux/Demux
U3201	5185963A27	Ground Fault Protection
U3211	5185963A33	Voltage Regulator
U3301	5105750U54	VCO Buffer
U3401	5105109Z67	LDMOS UHF/VHF Driver
U3501	5105750U54	Power Control
U3502	5185963A15	Temperature Sensor
VR3471	4813830A15	Diode, 5.6V
T3001	2508396X02	Transformer
T3002	2508396X02	Transformer
Y3101	4880606B09	Crystal Oscillator, 44.395MHz
Y3102	9186145B02	Crystal Filter, 45.85MHz
Y3261	4880114R04	Crystal Oscillator, 16.8MHz

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