



# CDM™ and PRO SERIES™

Mobile Radios

As Dedicated As You Are

contact



control



Detailed  
Service Manual

# Professional Radio

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## 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 jewelry, 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.

# TABLE OF CONTENTS

## Chapter 1 *Introduction*

|       |                                            |     |
|-------|--------------------------------------------|-----|
| 1.1   | Scope of Manual .....                      | 1-1 |
| 1.2   | Warranty and Service Support .....         | 1-1 |
| 1.2.1 | Warranty Period .....                      | 1-1 |
| 1.2.2 | Return Instructions .....                  | 1-1 |
| 1.2.3 | After Warranty Period .....                | 1-1 |
| 1.3   | Related Documents .....                    | 1-2 |
| 1.4   | Technical Support .....                    | 1-2 |
| 1.5   | Warranty and Repairs.....                  | 1-2 |
| 1.6   | Radio Model Chart and Specifications ..... | 1-4 |
| 1.7   | Radio Model Information .....              | 1-4 |

## Chapter 2 *Theory of Operation*

|         |                                                             |      |
|---------|-------------------------------------------------------------|------|
| 2.1     | Overview.....                                               | 2-1  |
| 2.2     | Controller Section .....                                    | 2-1  |
| 2.2.1   | Radio Power Distribution .....                              | 2-2  |
| 2.2.2   | Automatic On/Off .....                                      | 2-3  |
| 2.2.3   | Emergency.....                                              | 2-4  |
| 2.2.4   | Mechanical On/Off .....                                     | 2-4  |
| 2.2.5   | Ignition .....                                              | 2-4  |
| 2.2.6   | Microprocessor Clock Synthesizer.....                       | 2-5  |
| 2.2.7   | Serial Peripheral Interface (SPI) .....                     | 2-5  |
| 2.2.8   | SBEP Serial Interface .....                                 | 2-6  |
| 2.2.9   | General Purpose Input/Output.....                           | 2-6  |
| 2.2.10  | Normal Microprocessor Operation.....                        | 2-7  |
| 2.2.11  | Static Random Access Memory (SRAM) .....                    | 2-8  |
| 2.3     | Controller Board Audio and Signalling Circuits .....        | 2-8  |
| 2.3.1   | Audio Signalling Filter IC with Compander (ASFIC CMP) ..... | 2-8  |
| 2.3.2   | Transmit Audio Circuits.....                                | 2-9  |
| 2.3.3   | Microphone Input Path .....                                 | 2-9  |
| 2.3.3.1 | PTT Sensing and TX Audio Processing .....                   | 2-10 |
| 2.3.3.2 | TX Secure Audio (optional) .....                            | 2-10 |
| 2.3.3.3 | Option Board Transmit Audio .....                           | 2-10 |
| 2.3.4   | Transmit Signalling Circuits .....                          | 2-11 |
| 2.3.4.1 | Sub-Audible Data (PL/DPL) .....                             | 2-11 |
| 2.3.4.2 | High Speed Data .....                                       | 2-12 |
| 2.3.4.3 | Dual Tone Multiple Frequency (DTMF) Data .....              | 2-12 |
| 2.3.5   | Receive Audio Circuits.....                                 | 2-13 |
| 2.3.5.1 | Squelch Detect .....                                        | 2-13 |
| 2.3.5.2 | Audio Processing and Digital Volume Control .....           | 2-14 |
| 2.3.5.3 | Audio Amplification Speaker (+) Speaker (-) .....           | 2-14 |
| 2.3.5.4 | Handset Audio .....                                         | 2-15 |
| 2.3.5.5 | Filtered Audio and Flat Audio .....                         | 2-15 |
| 2.3.5.6 | RX Secure Audio (Optional) .....                            | 2-15 |

|         |                                                             |      |
|---------|-------------------------------------------------------------|------|
| 2.3.5.7 | Option Board Receive Audio                                  | 2-15 |
| 2.3.6   | Receive Signalling Circuits.....                            | 2-16 |
| 2.3.6.1 | Sub-audible Data (PL/DPL) and High Speed Data Decoder ..... | 2-16 |
| 2.3.6.2 | Alert Tone Circuits .....                                   | 2-16 |
| 2.3.6.3 | Voice Storage (Optional) .....                              | 2-17 |
| 2.4     | UHF (403-470 MHz) Receiver Front-End .....                  | 2-17 |
| 2.4.1   | Front-End Band-Pass Filters & Pre-Amplifier.....            | 2-19 |
| 2.4.2   | First Mixer and 1st Intermediate Frequency (IF).....        | 2-19 |
| 2.4.3   | 2nd Intermediate Frequency (IF) and Receiver Back-End.....  | 2-19 |
| 2.5     | Transmitter Power Amplifier (PA) 40 W .....                 | 2-20 |
| 2.5.1   | Power Controlled Stage .....                                | 2-20 |
| 2.5.2   | Pre-Driver Stage .....                                      | 2-20 |
| 2.5.3   | Driver Stage .....                                          | 2-21 |
| 2.5.4   | Final Stage .....                                           | 2-21 |
| 2.5.5   | Bi-Directional Coupler .....                                | 2-21 |
| 2.5.6   | Antenna Switch .....                                        | 2-21 |
| 2.5.7   | Harmonic Filter .....                                       | 2-21 |
| 2.5.8   | Power Control .....                                         | 2-21 |
| 2.6     | Frequency Synthesis .....                                   | 2-22 |
| 2.6.1   | Reference Oscillator.....                                   | 2-22 |
| 2.6.2   | Fractional-N Synthesizer .....                              | 2-22 |
| 2.6.3   | Voltage Controlled Oscillator (VCO) .....                   | 2-23 |
| 2.6.4   | Synthesizer Operation.....                                  | 2-25 |
| 2.7     | VHF (136-174MHz) Receiver Front-End .....                   | 2-26 |
| 2.7.1   | Front-End Band-Pass Filters and Pre-Amplifier .....         | 2-27 |
| 2.7.2   | First Mixer and 1st Intermediate Frequency (IF).....        | 2-27 |
| 2.7.3   | 2nd Intermediate Frequency (IF) and Receiver Back-End.....  | 2-27 |
| 2.8     | Transmitter Power Amplifier (PA) 45 W .....                 | 2-28 |
| 2.8.1   | Power Controlled Stage .....                                | 2-28 |
| 2.8.2   | Pre-Driver Stage .....                                      | 2-28 |
| 2.8.3   | Driver Stage .....                                          | 2-29 |
| 2.8.4   | Final Stage .....                                           | 2-29 |
| 2.8.5   | Directional Coupler.....                                    | 2-29 |
| 2.8.6   | Antenna Switch .....                                        | 2-29 |
| 2.8.7   | Harmonic Filter .....                                       | 2-29 |
| 2.8.8   | Power Control .....                                         | 2-30 |
| 2.9     | Frequency Synthesis .....                                   | 2-30 |
| 2.9.1   | Reference Oscillator.....                                   | 2-30 |
| 2.9.2   | Fractional-N Synthesizer .....                              | 2-30 |
| 2.9.3   | Voltage Controlled Oscillator (VCO) .....                   | 2-32 |
| 2.9.4   | Synthesizer Operation.....                                  | 2-33 |
| 2.10    | Control Head (PRO3100, CDM750) .....                        | 2-34 |
| 2.10.1  | Power Supplies .....                                        | 2-34 |
| 2.10.2  | Power On/Off .....                                          | 2-34 |
| 2.10.3  | Microprocessor Circuit .....                                | 2-34 |
| 2.10.4  | SBEP Serial Interface .....                                 | 2-35 |
| 2.10.5  | Keypad Keys.....                                            | 2-35 |
| 2.10.6  | Status LED and Back Light Circuit.....                      | 2-35 |
| 2.10.7  | Microphone Connector Signals.....                           | 2-36 |
| 2.10.8  | Speaker .....                                               | 2-36 |
| 2.10.9  | Electrostatic Transient Protection .....                    | 2-36 |
| 2.11    | Control Head (PRO5100, PRO7100, CDM1250, CDM1550) .....     | 2-37 |
| 2.11.1  | Power Supplies .....                                        | 2-37 |
| 2.11.2  | Power On / Off .....                                        | 2-37 |



|         |                                          |      |
|---------|------------------------------------------|------|
| 2.11.3  | Microprocessor Circuit .....             | 2-37 |
| 2.11.4  | SBEP Serial Interface .....              | 2-38 |
| 2.11.5  | Keypad Keys.....                         | 2-38 |
| 2.11.6  | Status LED and Back Light Circuit.....   | 2-38 |
| 2.11.7  | Liquid Crystal Display (LCD).....        | 2-39 |
| 2.11.8  | Microphone Connector Signals.....        | 2-39 |
| 2.11.9  | Speaker.....                             | 2-40 |
| 2.11.10 | Electrostatic Transient Protection ..... | 2-40 |

## **Chapter 3      *Maintenance***

|       |                                                |      |
|-------|------------------------------------------------|------|
| 3.1   | Introduction .....                             | 3-1  |
| 3.2   | Preventive Maintenance .....                   | 3-1  |
| 3.2.1 | Inspection.....                                | 3-1  |
| 3.2.2 | Cleaning.....                                  | 3-1  |
| 3.3   | Safe Handling of CMOS and LDMOS .....          | 3-2  |
| 3.4   | General Repair Procedures and Techniques ..... | 3-2  |
| 3.5   | Recommended Test Tools .....                   | 3-5  |
| 3.6   | Transmitter Troubleshooting Chart.....         | 3-6  |
| 3.7   | Receiver Troubleshooting Charts .....          | 3-7  |
| 3.8   | Synthesizer Troubleshooting Charts .....       | 3-9  |
| 3.9   | VCO Troubleshooting Charts.....                | 3-11 |

## **Chapter 4      *Schematic Diagrams, Overlays, and Parts Lists***

|       |                                                  |     |
|-------|--------------------------------------------------|-----|
| 4.1   | Introduction .....                               | 4-1 |
| 4.1.1 | Notes For All Schematics and Circuit Boards..... | 4-1 |

## **List of Figures**

|      |                                                             |      |
|------|-------------------------------------------------------------|------|
| 2-1  | Controller Block Diagram.....                               | 2-1  |
| 2-2  | DC Power Distribution Block Diagram .....                   | 2-3  |
| 2-3  | Transmit Audio Paths .....                                  | 2-9  |
| 2-4  | Transmit Signalling Paths .....                             | 2-11 |
| 2-5  | Receive Audio Paths .....                                   | 2-13 |
| 2-6  | Receive Signalling Paths .....                              | 2-16 |
| 2-7  | UHF Receiver Block Diagram.....                             | 2-18 |
| 2-8  | UHF Transmitter Block Diagram.....                          | 2-20 |
| 2-9  | UHF Synthesizer Block Diagram .....                         | 2-23 |
| 2-10 | UHF VCO Block Diagram .....                                 | 2-24 |
| 2-11 | VHF Receiver Block Diagram .....                            | 2-26 |
| 2-12 | VHF Transmitter Block Diagram .....                         | 2-28 |
| 2-13 | VHF Synthesizer Block Diagram .....                         | 2-31 |
| 2-14 | VHF VCO Block Diagram .....                                 | 2-32 |
| 4-1  | PRO3100/CDM750 Control Head Top Overlay .....               | 4-3  |
| 4-2  | PRO3100/CDM750 Control Head Bottom Overlay .....            | 4-4  |
| 4-3  | PRO3100CDM750 Control Head Schematic Diagram, Sheet 1 ..... | 4-5  |
| 4-4  | PRO3100CDM750 Control Head Schematic Diagram, Sheet 2 ..... | 4-6  |

|      |                                                                            |      |
|------|----------------------------------------------------------------------------|------|
| 4-5  | PRO5100/PRO7100/CDM1250/CDM1550 Control Head Top Overlay .....             | 4-9  |
| 4-6  | PRO5100/PRO7100/CDM1250/CDM1550 Control Head Bottom Overlay .....          | 4-10 |
| 4-7  | PRO5100/PRO7100/CDM1250/CDM1550 Control Head Schematic Diagram .....       | 4-11 |
| 4-8  | PRO5100/PRO7100/CDM1250/CDM1550 Control Head Keypad Schematic Diagram..... | 4-12 |
| 4-9  | PRO5100/PRO7100/CDM1250/CDM1550 Control Head LCD Schematic .....           | 4-13 |
| 4-10 | PRO5100/PRO7100/CDM1250/CDM1550 Control Head Display Schematic .....       | 4-14 |
| 4-11 | Complete Controller Schematic Diagram .....                                | 4-17 |
| 4-12 | Controller Control Schematic Diagram .....                                 | 4-18 |
| 4-13 | Controller I/O Schematic Diagram .....                                     | 4-19 |
| 4-14 | Controller Audio Schematic Diagram .....                                   | 4-20 |
| 4-15 | Controller Supply Voltage Schematic Diagram .....                          | 4-21 |
| 4-16 | UHF (403-470MHz) Voltage Controlled Oscillator Schematic Diagram .....     | 4-25 |
| 4-17 | UHF (403-470MHz) Fractal-N Schematic Diagram .....                         | 4-26 |
| 4-18 | UHF (403-470MHz) Power Amplifier Schematic Diagram .....                   | 4-27 |
| 4-19 | VHF (136-174MHz) Main Board Top Side PCB .....                             | 4-33 |
| 4-20 | VHF (136-174MHz) Receiver Front End Schematic Diagram .....                | 4-34 |
| 4-21 | VHF (136-174MHz) Receiver IF Schematic Diagram .....                       | 4-35 |
| 4-22 | VHF (136-174MHz) Fractal-N Schematic Diagram .....                         | 4-36 |
| 4-23 | VHF (136-174MHz) Voltage Controlled Oscillator Schematic Diagram .....     | 4-37 |
| 4-24 | VHF (136-174MHz) Power Amplifier Schematic Diagram .....                   | 4-38 |

## **List of Tables**

|     |                                                              |      |
|-----|--------------------------------------------------------------|------|
| 1-1 | Radio Model Number .....                                     | 1-3  |
| 3-1 | Recommended Test tools .....                                 | 3-5  |
| 4-1 | PRO3100/CDM750 Control Head Parts List.....                  | 4-7  |
| 4-2 | PRO5100/PRO7100/CDM1250/CDM1550 Control Head Parts List..... | 4-15 |
| 4-3 | Controller Parts List .....                                  | 4-22 |
| 4-4 | UHF B1 Radio Parts List.....                                 | 4-28 |
| 4-5 | VHF (136-174MHz) Radio Parts List .....                      | 4-39 |

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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  
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## 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<br>↑<br>Motorola Internal Use | M<br>↑<br>M = Mobile | 25           | K<br>VHF<br>(136-174MHz)            | H<br>1-25W  | A<br>No Display, No Keypad           | 9<br>Program-mable | AA<br>Conventional | 1<br>4F       | A              | N             |
|                                        |                      |              | R<br>UHF1<br>(403-470MHz)           | K<br>25-40W | C<br>No Display Basic Keypad         |                    | DU<br>LTR          | 2<br>64F      |                |               |
|                                        |                      |              | S<br>UHF2<br>(450-512MHz)           |             | D<br>1-Line Display, Limited Keypad  |                    |                    | 5<br>128F     |                |               |
|                                        |                      |              | B<br>Low Band, R1<br>(29.7-36.0MHz) |             | F<br>1-Line Display, Standard Keypad |                    |                    | 8<br>160F     |                |               |
|                                        |                      |              | C<br>Low Band, R2<br>(36.0-42.0MHz) |             | N<br>4-Line Display, Enhanced Keypad |                    |                    |               |                |               |
|                                        |                      |              | D<br>Low Band, R3<br>(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 ( $\mu$ P), support memory, support logic, signal MUX ICs, on/off circuit, and general purpose input/output circuits.

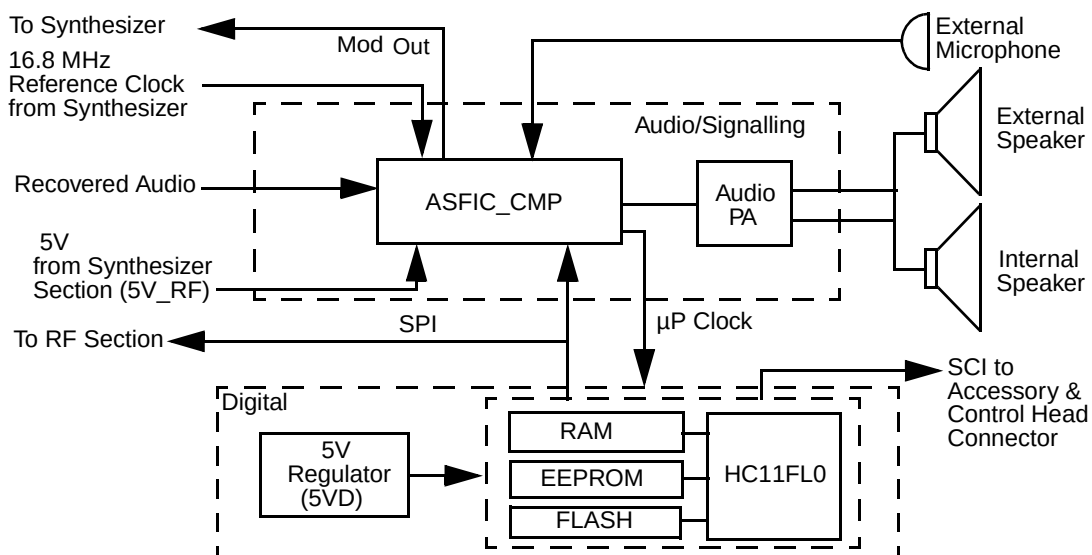


Figure 2-1. Controller Block Diagram

## 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  $\mu P$  enters the wrong mode if the voltage across C0622 is still too low. The regulated 5 volts charges C0622 via diode D0621.



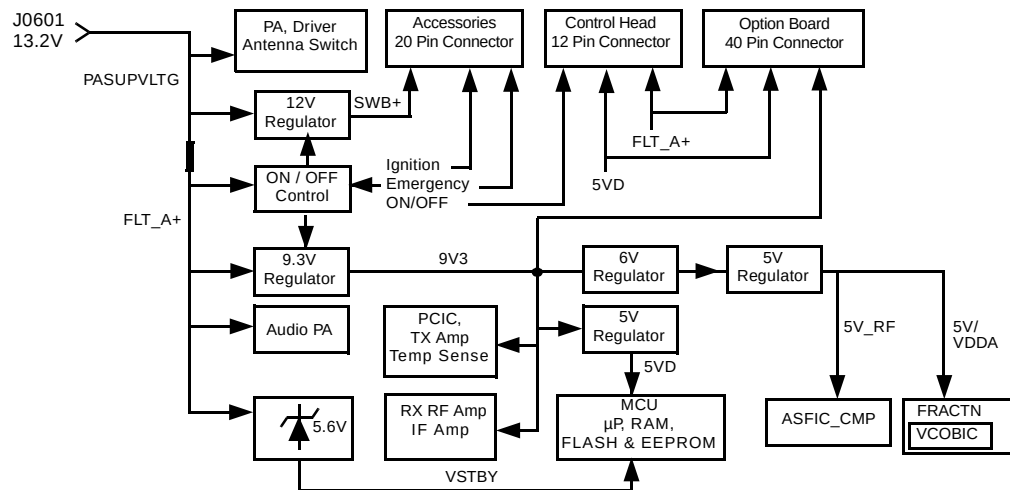


Figure 2-2. DC Power Distribution Block Diagram

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  $\mu$ P through voltage divider R0671/R0672 and the line battery voltage. Diode VR0671 limits the divided voltage to 5.6 volts to protect the  $\mu$ P.

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  $\mu$ P 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  $\mu$ P 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  $\mu$ P 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  $\mu$ P input.

While the EMERGENCY CONTROL signal is low and INT SW B+ is on, the  $\mu$ P 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  $\mu$ P 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  $\mu$ P 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  $\mu$ P 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  $\mu$ P, pin 96. The  $\mu$ P asserts line DC POWER ON via ASFIC CMP, pin 13 high which keeps the radio switched on. The  $\mu$ P 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  $\mu$ P starts execution. The  $\mu$ P is alerted through line GP6 IN ACC10. While the on/off button is pressed, a high signal turns Q0181 on, which pulls  $\mu$ P, 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  $\mu$ P, 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  $\mu$ P 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  $\mu$ P (U0101, pin 90). After the  $\mu$ P 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  $\mu$ P 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  $\mu$ P 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  $\mu$ P 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  $\mu$ P to a device, and SPI RECEIVE DATA is sends data from a device to the  $\mu$ P. 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  $\mu$ P 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  $\mu$ P 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  $\mu$ P, 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  $\mu$ P generates the CLK (J0551, pin 3)
- The main board  $\mu$ P 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  $\mu$ P sends serial data via pin 98 and D0101 and it reads serial data via pin 97. Whenever the  $\mu$ P 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  $\mu$ P, 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  $\mu$ P, pin 96. This indicates that the control head wants to start SBEP communication. The  $\mu$ P 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  $\mu$ P 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  $\mu$ P 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  $\mu$ P via ASFIC CMP, pin 14.

DIG IN 3 is read by  $\mu$ P, pin 63 via resistor R0176

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

DIG IN 6 can be used as normal input, set by the CPS. The  $\mu$ P 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  $\mu$ P, pins 46, 47, 53. The ports are read by  $\mu$ P, pins 75, 54, 76. To use one of the ports as input the  $\mu$ P 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  $\mu$ P is configured to operate in one of two modes: expanded or bootstrap. In expanded mode, the  $\mu$ P uses external memory devices to operate. In bootstrap mode, the  $\mu$ P uses only its internal memory.

During normal operation of the radio, the  $\mu$ P is operating in expanded mode and the  $\mu$ P (U0101) has access to three external memory devices: U0121 (EEPROM), U0122 (SRAM), and U0111 (EEPROM). Also, within the  $\mu$ P 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  $\mu$ P'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  $\mu$ P 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  $\mu$ P using address decoder U0141. The chips ASFIC CMP / FRAC-N / PCIC are selected by line CSX (U0101, pin 2).

When the  $\mu$ P 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 1 $\mu$ s/div. or faster to observe individual pulses. High speed CMOS transitions should also be observed on the  $\mu$ P control lines. On the  $\mu$ P 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  $\mu$ P must be at a logic 1 for it to start executing correctly. After the  $\mu$ P 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  $\mu$ P 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  $\mu$ P. 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
- $\mu$ P 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.

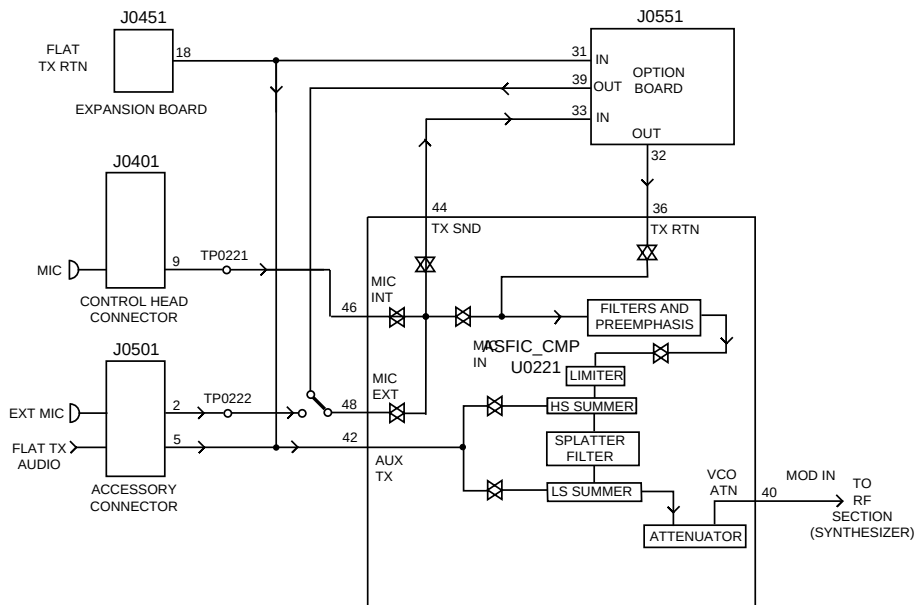


Figure 2-3. Transmit Audio Paths

## 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  $\mu$ P. 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  $\mu$ P 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  $\mu$ P. 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  $\mu$ P 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.

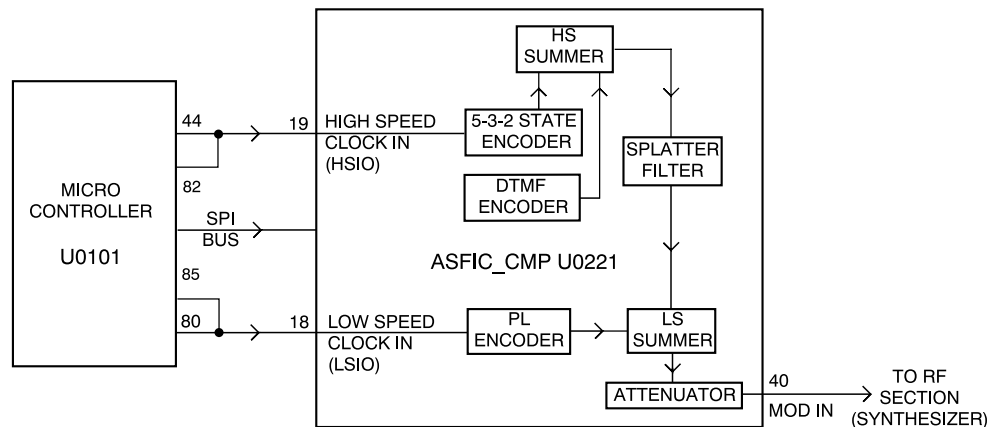


Figure 2-4. Transmit Signalling Paths

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  $\mu$ P programs the ASFIC CMP to set up the proper low-speed data deviation and select the PL or DPL filters. The  $\mu$ P 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  $\mu$ P 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  $\mu$ P (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  $\mu$ P 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.

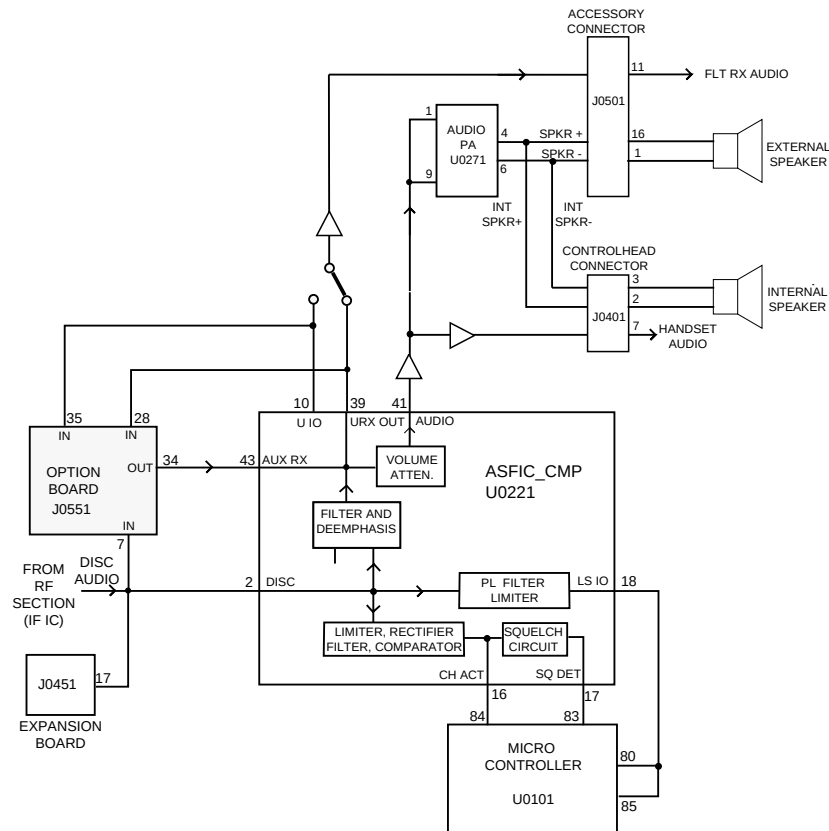


Figure 2-5. Receive Audio Paths

### 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  $\mu$ P 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  $\mu$ P 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  $\mu$ P (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.

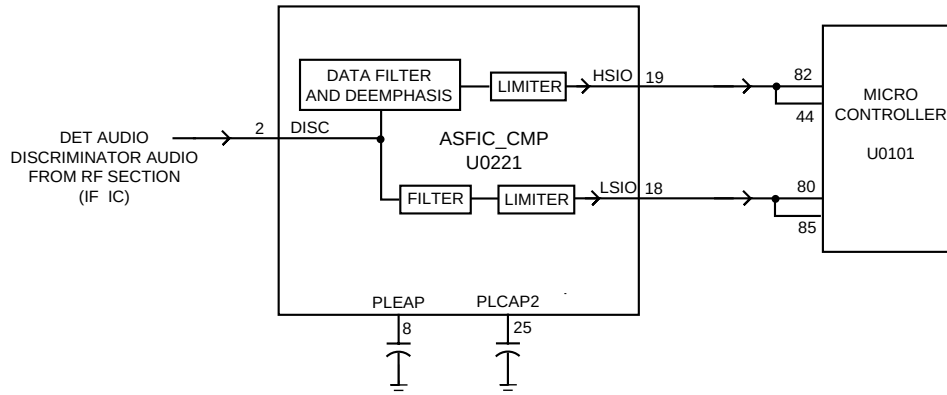


Figure 2-6. Receive Signalling Paths

#### 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  $\mu$ P U0101, pin 82.

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

The low speed data is read by the  $\mu$ P 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  $\mu$ P 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  $\mu$ P can generate any tone within the 100-3000Hz audio band. This is accomplished by the  $\mu$ P 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 be 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  $\mu$ P controls U0301 via SPI bus lines CLK (U0301-8), DATA (U0301-10) and MISO (U0301-11). To transfer data, the  $\mu$ P first selects the U0301 via address decoder U0141, line VS CS and U0301 pin 9. Then the  $\mu$ P 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  $\mu$ P pin 52. A low at pin 5 (INT), which is connected to  $\mu$ P pin 55 indicates that the Voice Storage IC requires service from the  $\mu$ P.

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  $\mu$ P 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  $\mu$ P 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.





### 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 T4501 pin 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  $\mu$ P (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).

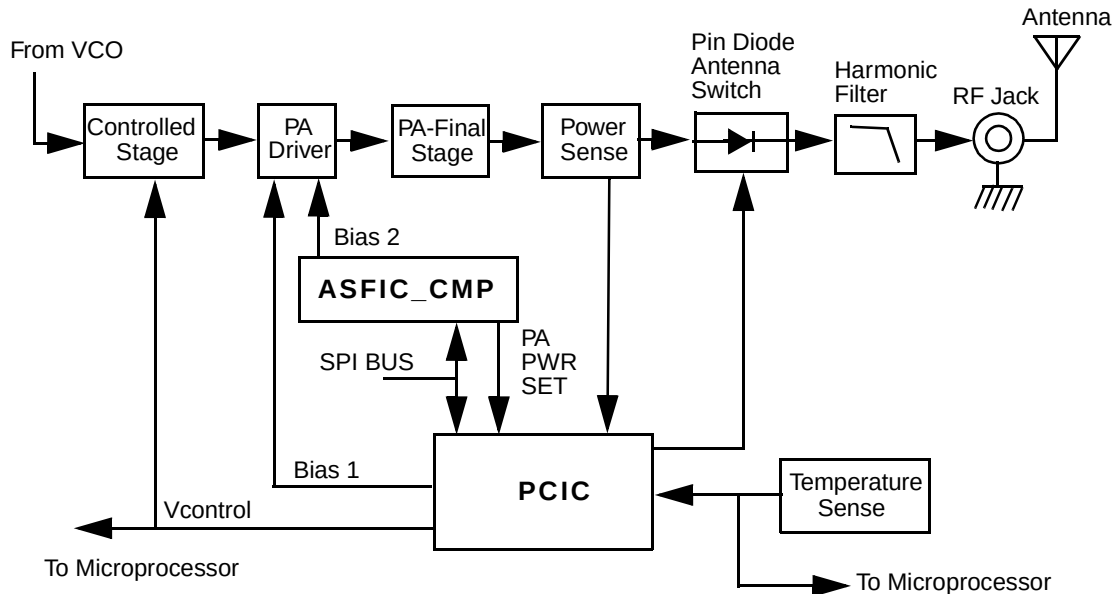


Figure 2-8. UHF Transmitter Block Diagram

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 achieved 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  $\mu$ P 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  $\mu$ F.

### 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).

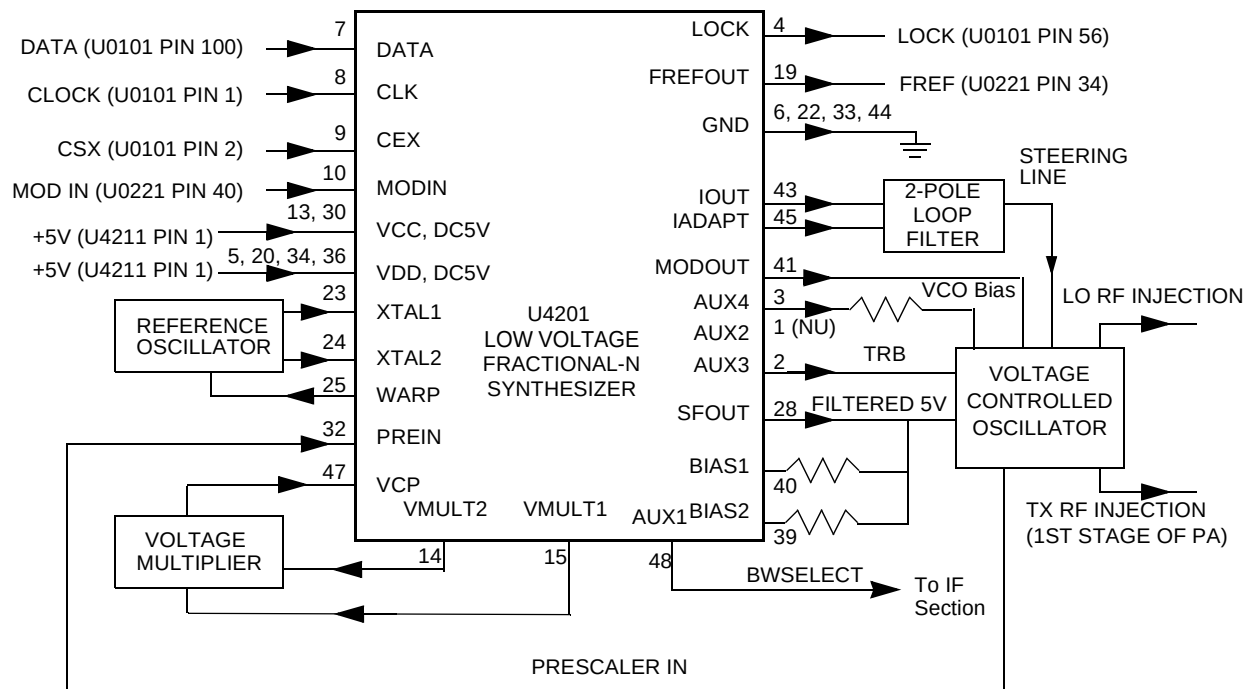


Figure 2-9. UHF Synthesizer Block Diagram

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  $\mu$ P 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.

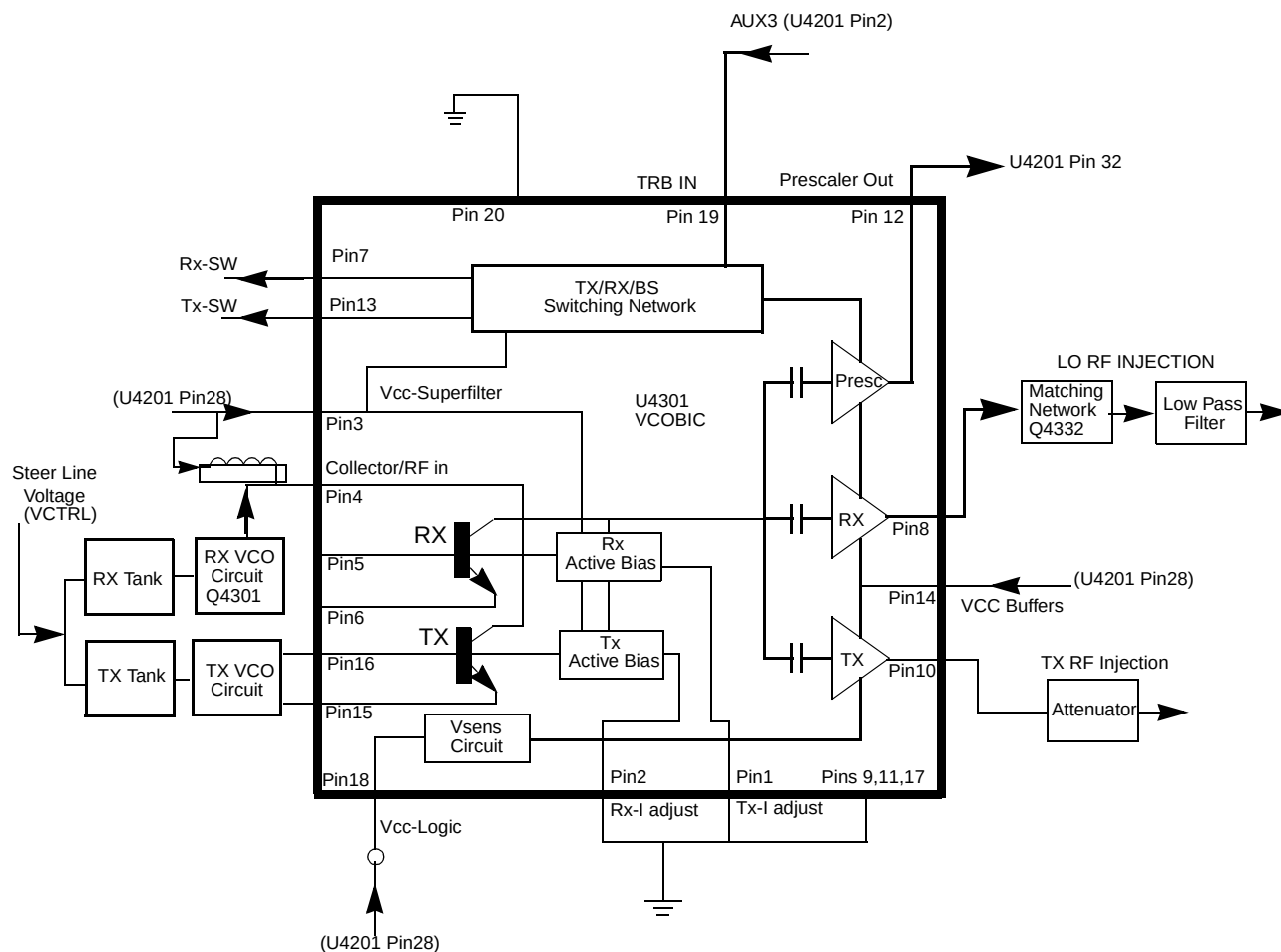


Figure 2-10. UHF VCO Block Diagram

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  $\mu P$ 's ADCs input U101-56. From the voltage the  $\mu P$  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.

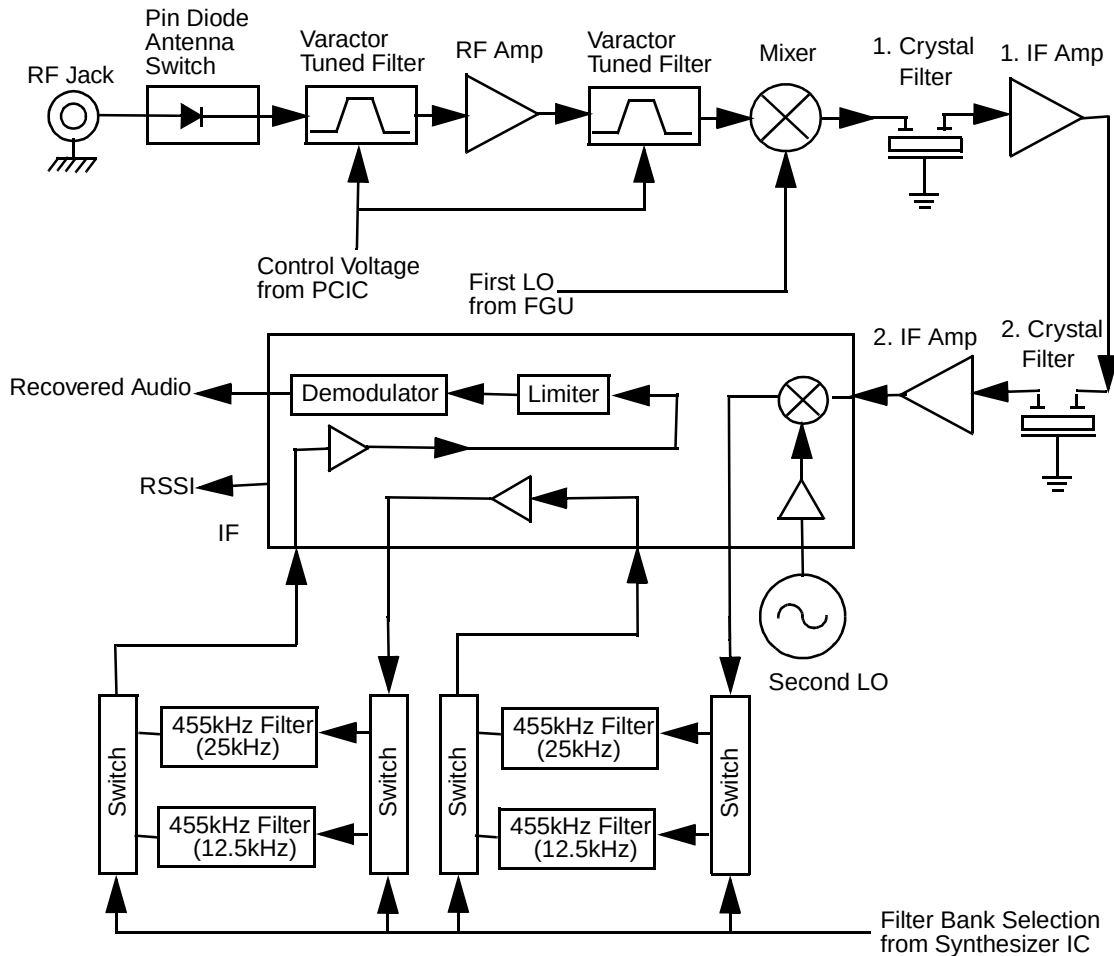


Figure 2-11. VHF Receiver Block Diagram

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  $\mu$ P (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).

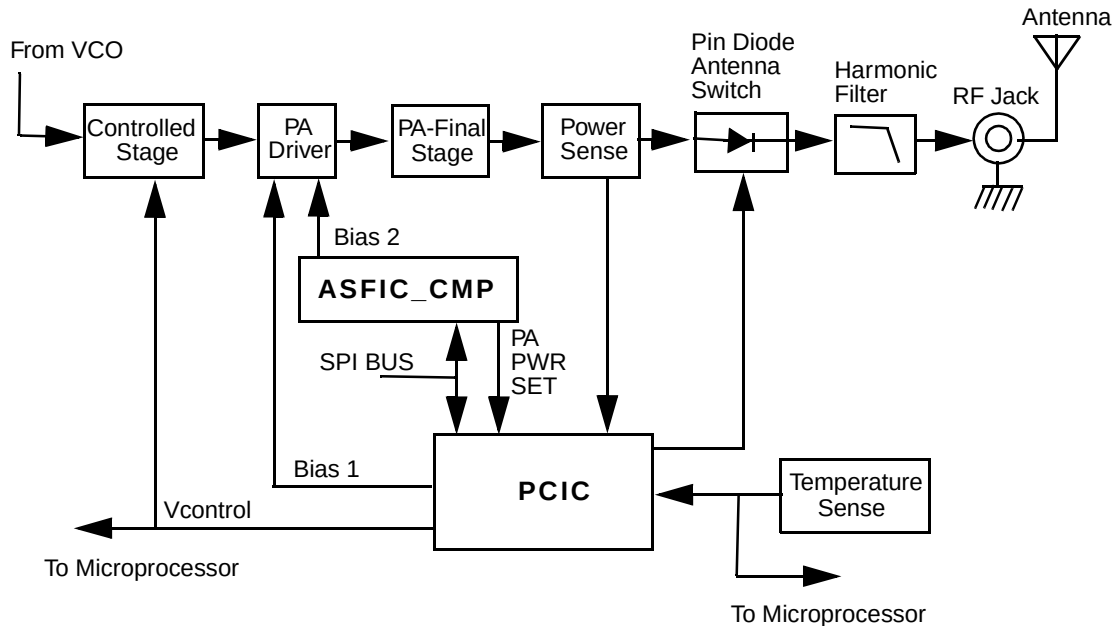


Figure 2-12. VHF Transmitter Block Diagram

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 quarter-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  $\mu$ P 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 where 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  $\mu$ F.

### 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.

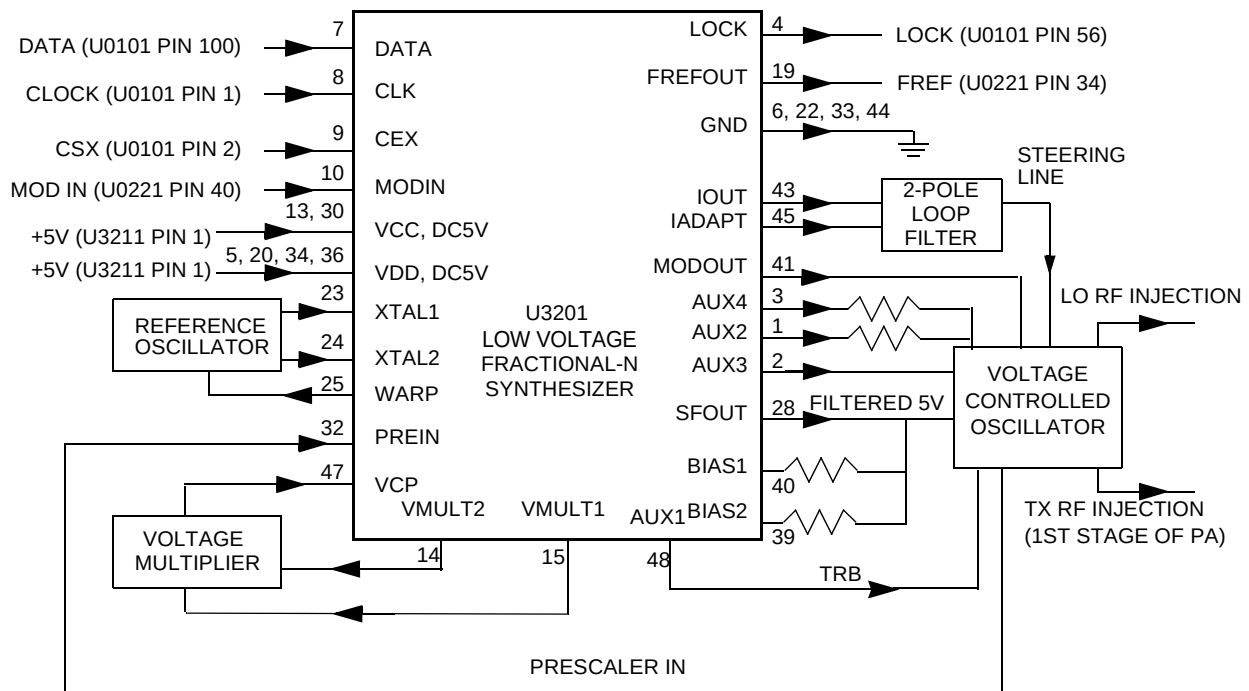


Figure 2-13. VHF Synthesizer Block Diagram

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  $\mu$ P 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.

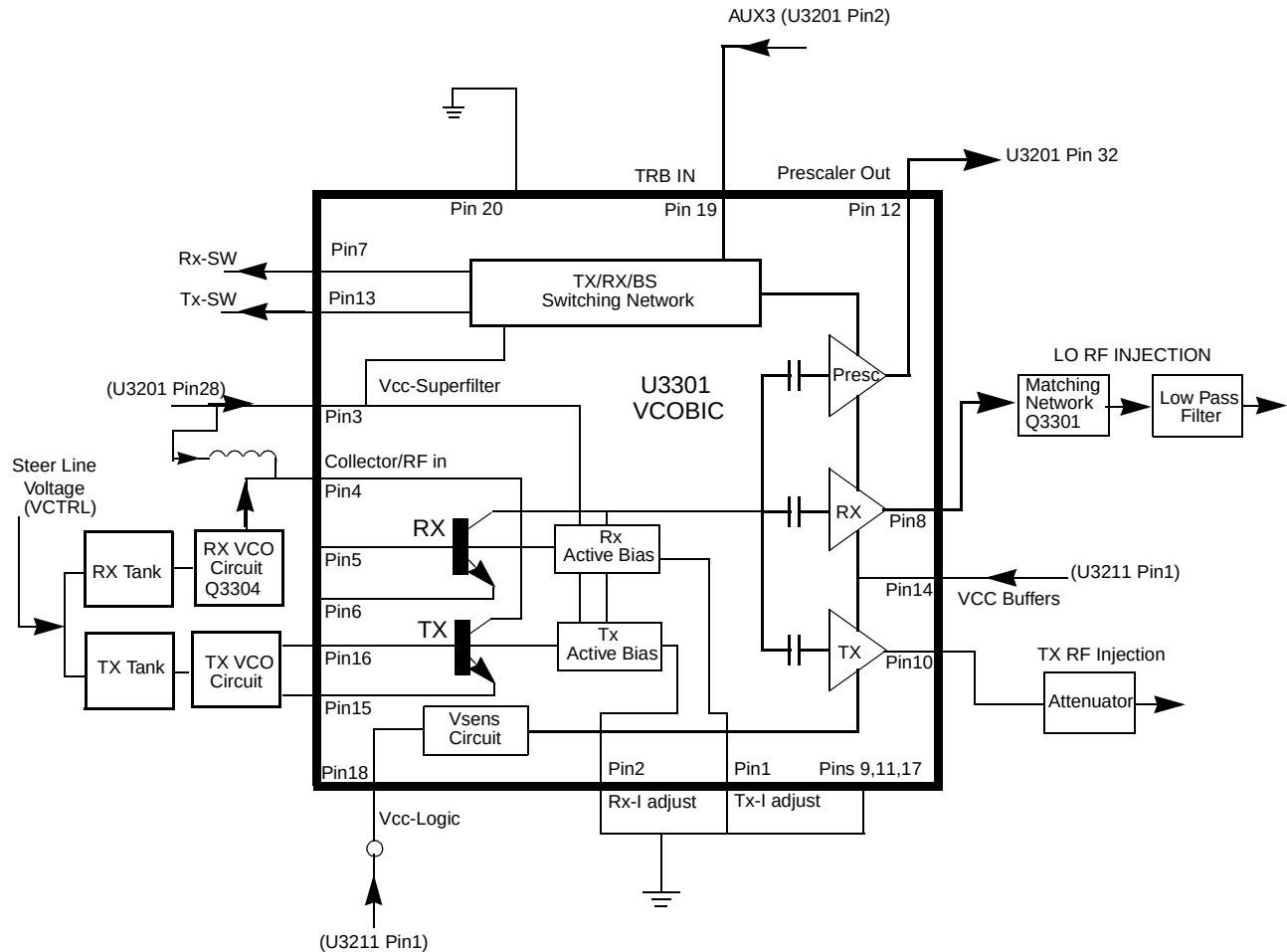


Figure 2-14. VHF VCO Block Diagram

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  $\mu$ P's ADC inputs (U0101-56). From the measured voltage, the  $\mu$ P 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  $\mu$ P.

### 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  $\mu$ P 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  $\mu$ P (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  $\mu$ P 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  $\mu$ P about the pressed knob. The  $\mu$ P 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  $\mu$ P wants to send data via the SBEP bus. When the radio returns a data request message, the  $\mu$ P informs the radio about the pressed knob. If the radio is switched off, the radio's  $\mu$ P 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  $\mu$ P informs the radio about the pressed knob and the radio's  $\mu$ P switches the radio off.

### 2.10.3 Microprocessor Circuit

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

The  $\mu$ P generates its clock using the oscillator inside the  $\mu$ P along with a 8 MHz ceramic resonator (U0833) and R0920.

The  $\mu$ P's RAM is always powered to maintain parameters such as the last operating mode. This is achieved by maintaining 5V at  $\mu$ P, 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  $\mu$ P. 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  $\mu$ P. 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  $\mu$ P 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  $\mu$ P 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  $\mu$ P (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  $\mu$ P can drive the line. The  $\mu$ P sends serial data via pin 50 and D0831 and it reads serial data via pin 47. Whenever the  $\mu$ P detects activity on the BUS+ line, it starts communication.

When the host radio needs to communicate to the control head  $\mu$ P, it sends data via line BUS+. Any transition on this line generates an interrupt and the  $\mu$ P 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  $\mu$ P wants to communicate to the host radio, the  $\mu$ P brings the request line CH REQUEST to a logic 0 via  $\mu$ P 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  $\mu$ P 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  $\mu$ P 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  $\mu$ P 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  $\mu$ P (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  $\mu$ P 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  $\mu$ P. The control head  $\mu$ P 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  $\mu$ P'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  $\mu$ P port PA 5. The  $\mu$ P 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  $\mu$ P 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  $\mu$ P 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  $\mu$ P 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  $\mu$ P port PA2 informs the  $\mu$ P about the pressed PTT button. The  $\mu$ P 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  $\mu$ P in bootstrap mode. Bootstrap mode loads the firmware into the radio's flash memory.

The HOOK input (J0811-3) informs the  $\mu$ P when the microphone's hang-up switch is engaged. Depending on the CPS programming, the  $\mu$ P may take actions like turning the audio PA on or off. While the hang  $\mu$ p switch is open, the line HOOK is pulled to +5 volts level by R0841. Transistor Q0841 is switched on and causes a low at  $\mu$ p port PA1. When the HOOK switch is closed, the HOOK signal is pulled to ground level. This switches off R0841 and the resulting high level at  $\mu$ p port PA1 informs the  $\mu$ p about the closed hang  $\mu$ p switch. The  $\mu$ p 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 VR0812 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  $\mu$ P.

### 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  $\mu$ P, 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  $\mu$ P (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  $\mu$ P 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  $\mu$ P about the pressed knob. The  $\mu$ P 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  $\mu$ P wants to send data via SBEP bus. When the radio returns a data request message, the  $\mu$ P informs the radio about the pressed knob. If the radio was switched off, the radio's  $\mu$ P 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  $\mu$ P will inform the radio about the pressed knob and the radio's  $\mu$ P switches the radio off.

### 2.11.3 Microprocessor Circuit

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

The  $\mu$ P generates its clock using the oscillator inside the  $\mu$ P along with a 8 MHz ceramic resonator (U0833) and R0920.

The  $\mu$ P's RAM is always powered to maintain parameters such as the last operating mode. This is achieved by maintaining 5 volts at  $\mu$ P, 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  $\mu$ P. 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  $\mu$ P. 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  $\mu$ P 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  $\mu$ P 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  $\mu$ P (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  $\mu$ P can drive the line. The  $\mu$ P sends serial data via pin 50 and D0831 and it reads serial data via pin 47. Whenever the  $\mu$ P detects activity on the BUS+ line, it starts communication.

When the host radio needs to communicate to the control head  $\mu$ P, it sends data via line BUS+. Any transition on this line generates an interrupt and the  $\mu$ P 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  $\mu$ P wants to communicate to the host radio, the  $\mu$ P brings request line CH REQUEST to a logic 0 via  $\mu$ P, 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  $\mu$ P 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  $\mu$ P 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  $\mu$ P, 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  $\mu$ P (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  $\mu$ P 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  $\mu$ P. The control head  $\mu$ P 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  $\mu$ P'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  $\mu$ P 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  $\mu$ P 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  $\mu$ P, 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  $\mu$ P interface is configured to accept 8 bit parallel data input (U0971-D0-D7) from the control head  $\mu$ P (U0831 port PC0-PC7).

To write data to the driver's RAM the  $\mu$ P 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  $\mu$ P 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  $\mu$ P then writes the display data to the display RAM. When data transfer is complete the  $\mu$ P 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 ( $2 \times$  -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  $\mu$ P's analog-to-digital converters (U0831-20) via resistive divider R0975, R0976. To stabilize the display brightness over a large temperature range the  $\mu$ P measures the temperature via analog-to-digital converter (U0831-18) using temperature sensor U0834. Dependent on the measured temperature the  $\mu$ P 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  $\mu$ P 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  $\mu$ P 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  $\mu$ P port PA2 informs the  $\mu$ P about the pressed PTT button. The  $\mu$ P 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  $\mu$ P 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  $\mu$ P when the microphone's hang-up switch is engaged. Dependent on the CPS programming the  $\mu$ P 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  $\mu$ P 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  $\mu$ P port PA1 informs the  $\mu$ P about the closed hang up switch. The  $\mu$ P 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 VR0812 and VR0816 - VR0817. The diodes limit any transient voltages. The associated capacitors provide radio frequency interference (RFI) protection.

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# 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).



WARNING

**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.

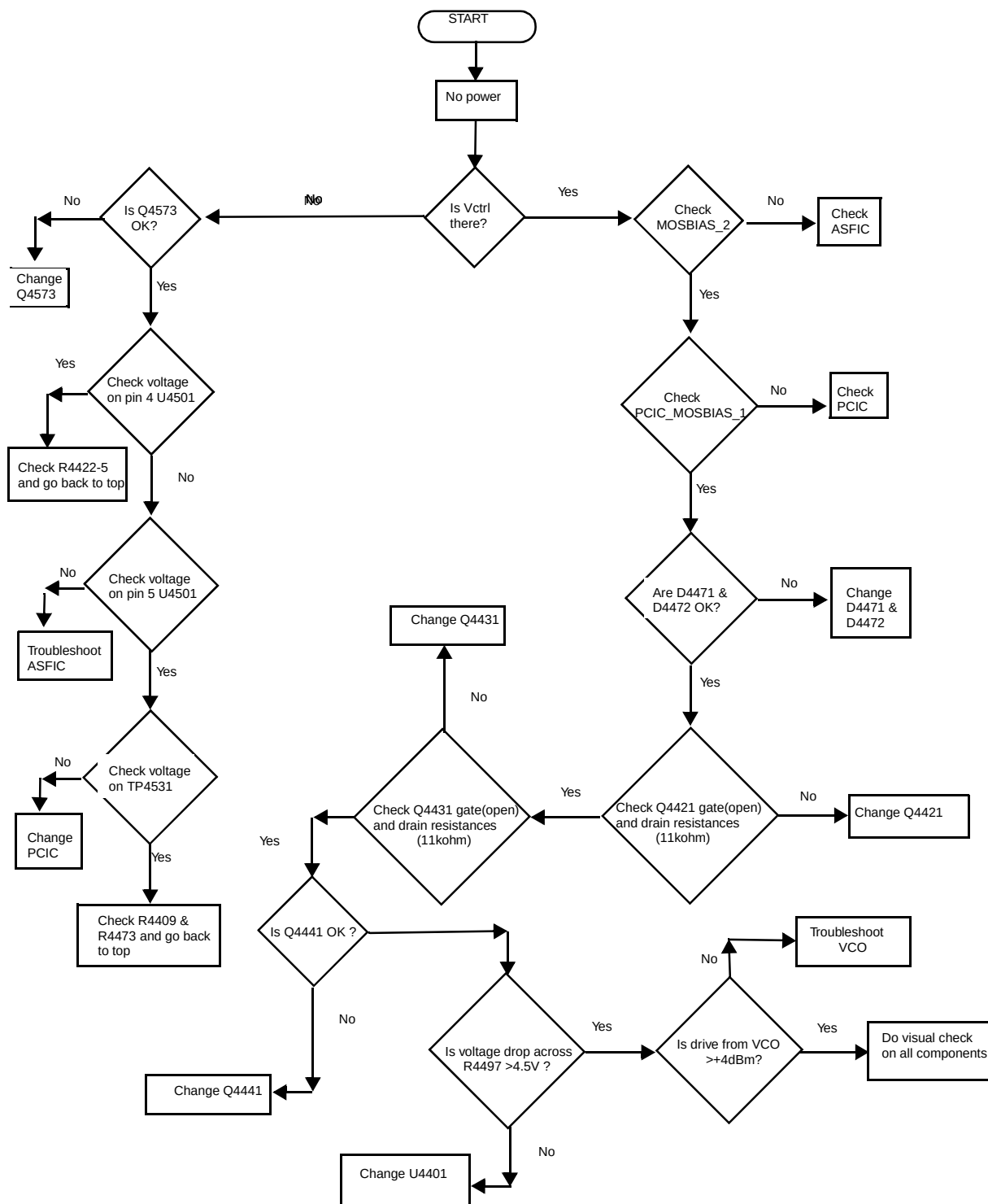
### 3.5 Recommended Test Tools

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

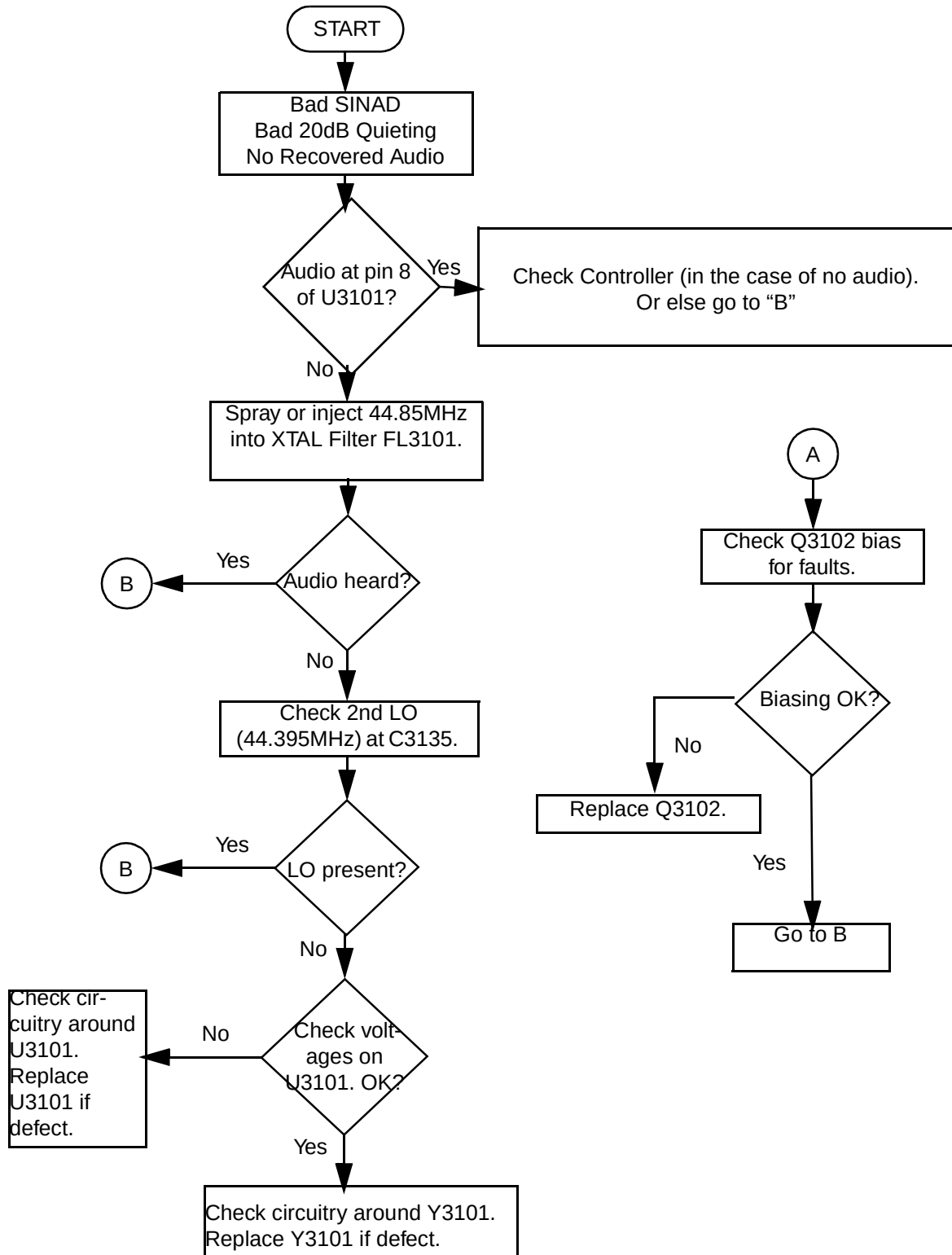
*Table 3-1. Recommended Test Tools*

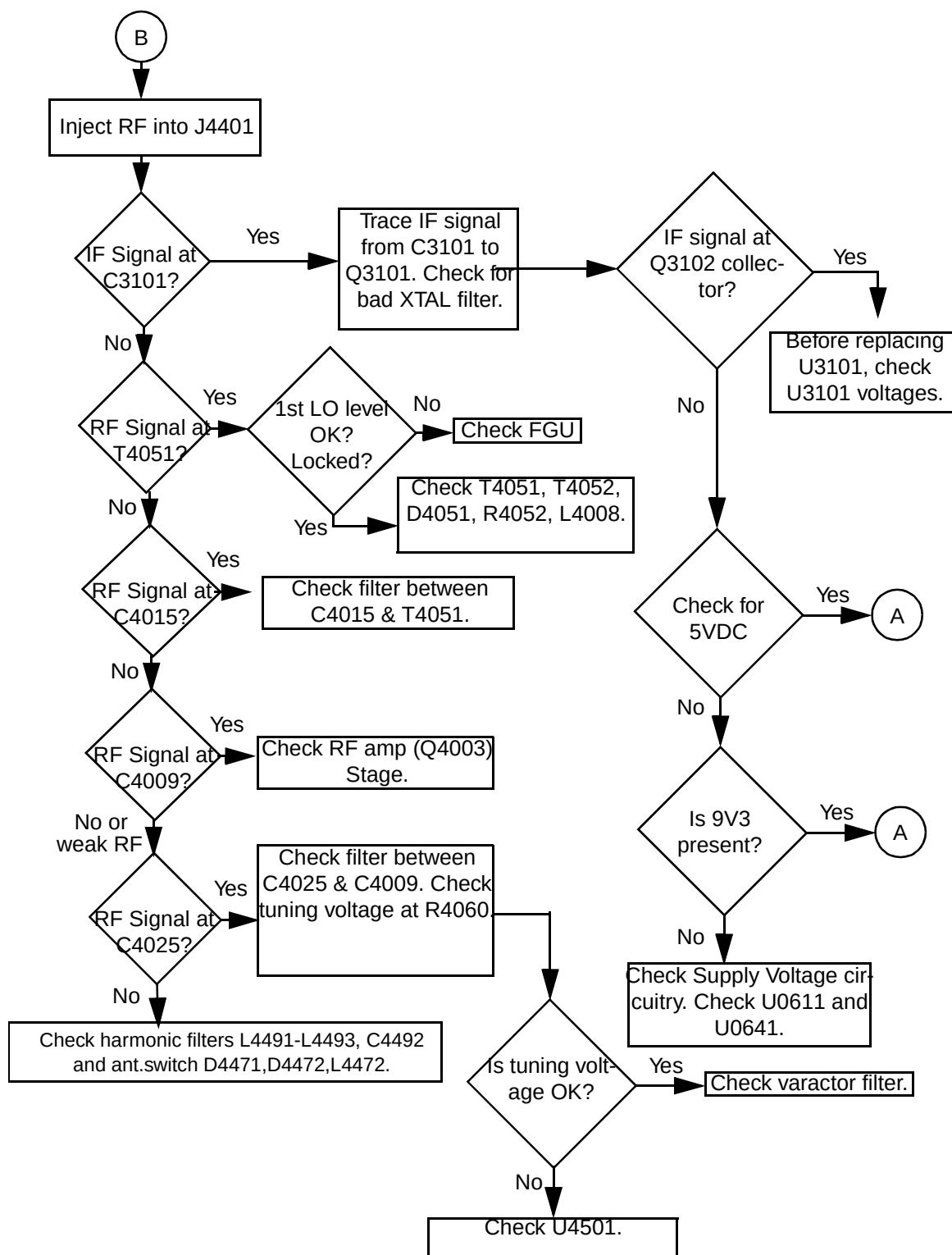
| Motorola Part Number                                                                                                                                                               | Description                                                                                                                                                                                                                                         | Application                                                                                    |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------|
| RSX4043                                                                                                                                                                            | Torx Driver                                                                                                                                                                                                                                         | Tighten and remove chassis screws                                                              |
| 6680387A70                                                                                                                                                                         | T-6 Torx Bit                                                                                                                                                                                                                                        | Removable Torx driver bit                                                                      |
| WADN4055A<br>6604008K01<br>6604008K02                                                                                                                                              | Portable soldering station<br>0.4mm replacement tip<br>0.8mm replacement tip                                                                                                                                                                        | Digitally controlled soldering Iron<br>For WADN4055A soldering Iron                            |
| 0180386A78                                                                                                                                                                         | Illuminated magnifying glass with lens attachment.                                                                                                                                                                                                  |                                                                                                |
| 0180302E51                                                                                                                                                                         | Illuminated Magnification System                                                                                                                                                                                                                    | Illuminated and magnification of components                                                    |
| 0180386A82<br><br>6684253C72<br>6680384A98<br>1010041A86<br><br>0180303E45                                                                                                         | Anti-static grounding kit<br><br>Straight prober<br>Brush<br>Solder (RMA type), 63/37, 0.5mm diameter<br>1 lb. spool<br>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<br>6680334B50<br>6680334B51<br>6680334B52<br>6680334B53<br>6680370B51<br>6680370B54<br>6680370B57<br>6680370B58<br>6680371B15<br>6680371B74<br>6680332E45<br>6680332E46 | 0.410" x 0.410"<br>0.430" x 0.430"<br>0.492" x 0.492"<br>0.572" x 0.572"<br>0.670" x 0.790"<br>0.475" x 0.475"<br>0.710" x 0.710"<br>0.245" x 0.245"<br>0.340" x 0.340"<br>0.460" x 0.560"<br>0.470" x 0.570"<br>0.591" x 0.315"<br>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



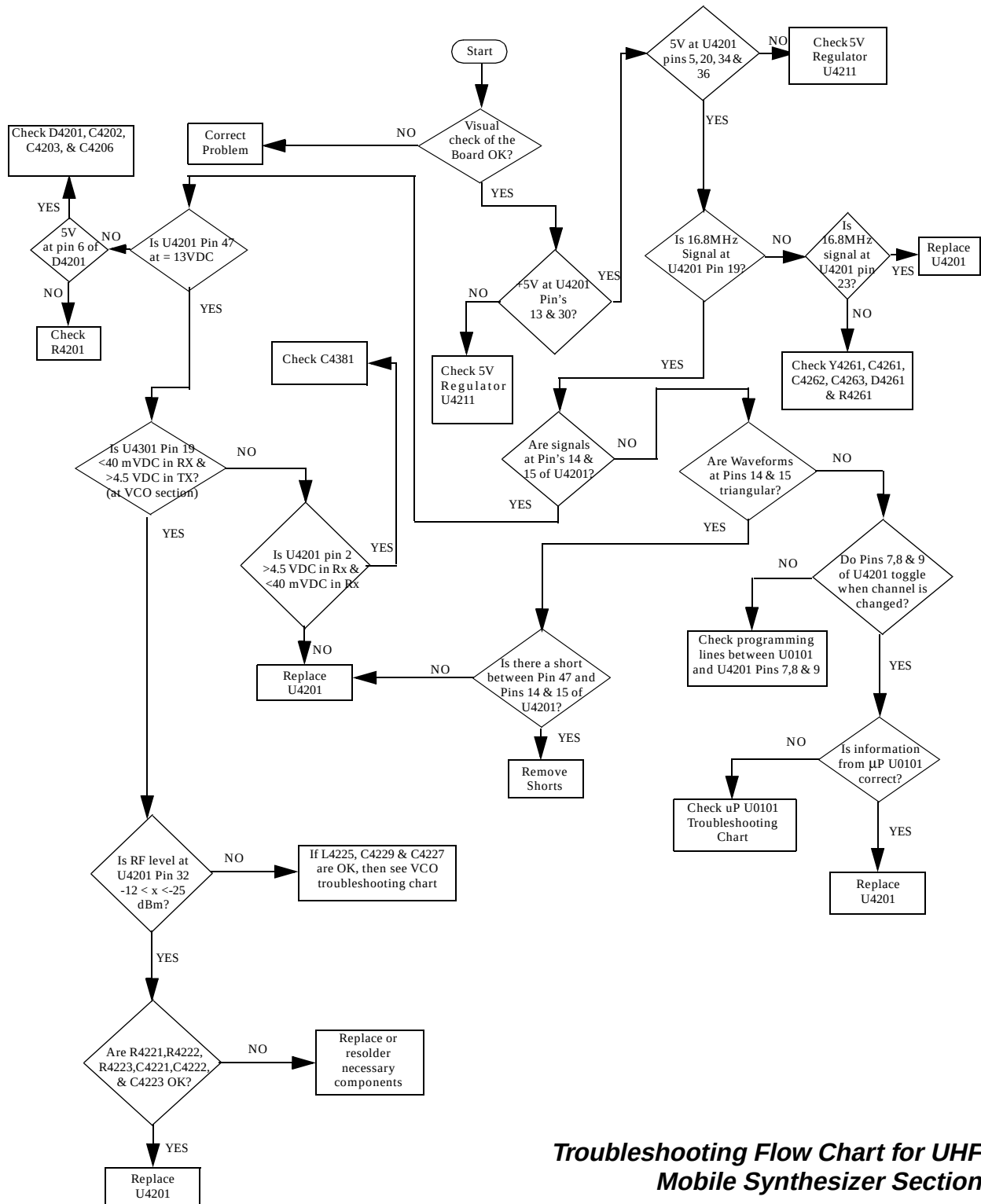
### 3.7 Receiver Troubleshooting Chart





**Troubleshooting Flow Chart for Receiver (Sheet 2 of 2)**

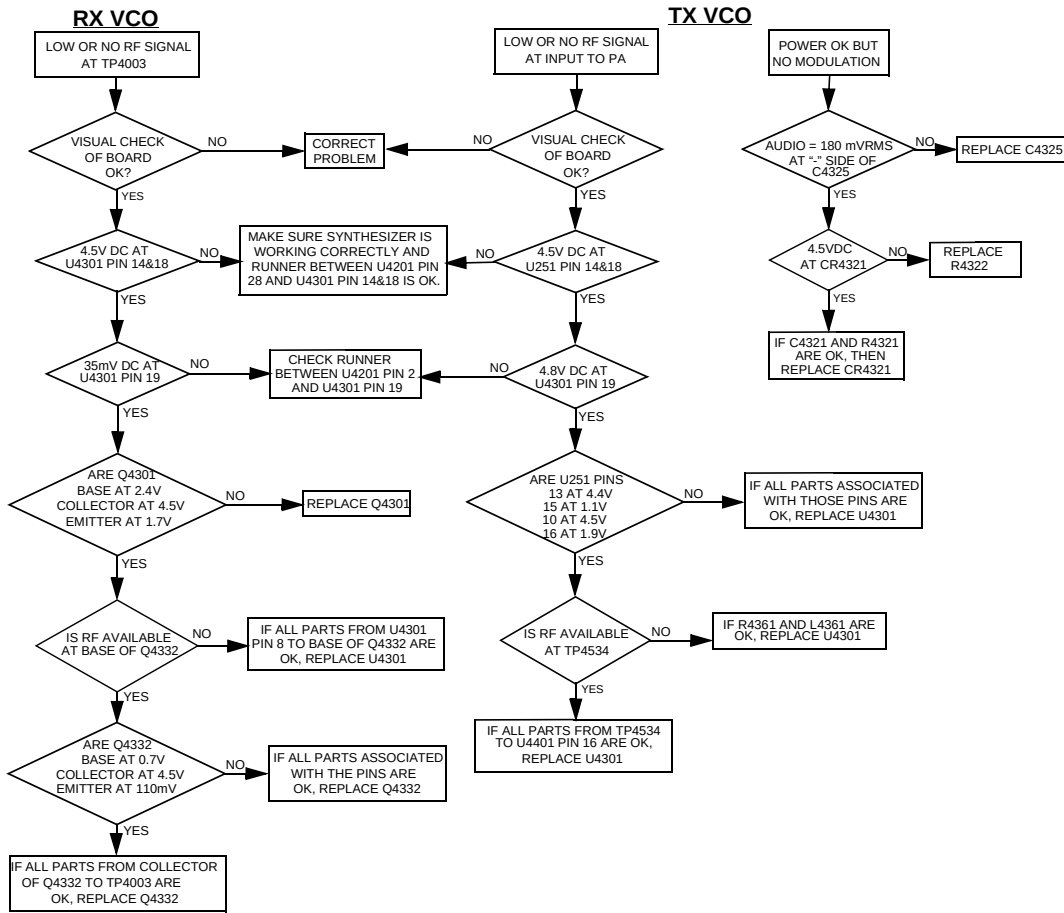
### 3.8 Synthesizer Troubleshooting Chart



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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 ( $\mu F$ ).
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  $1.2 \mu H$  choke in series with the voltage probe to prevent circuit loading.
3. Reference Designators are assigned in the following manner:

800-900 = Control Heads

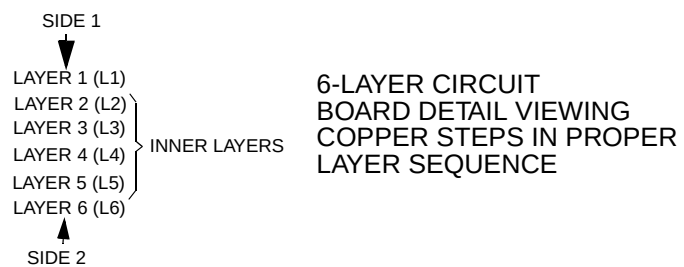
100/200/400/500/600 Series = Controller

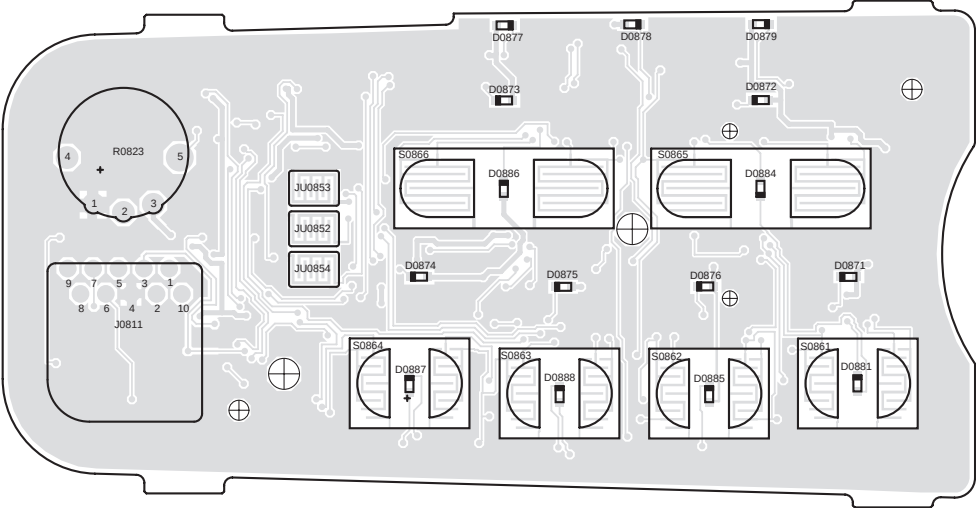
100/200/400/500/600/3000/4000 Series = UHF Transmitter

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                                         |

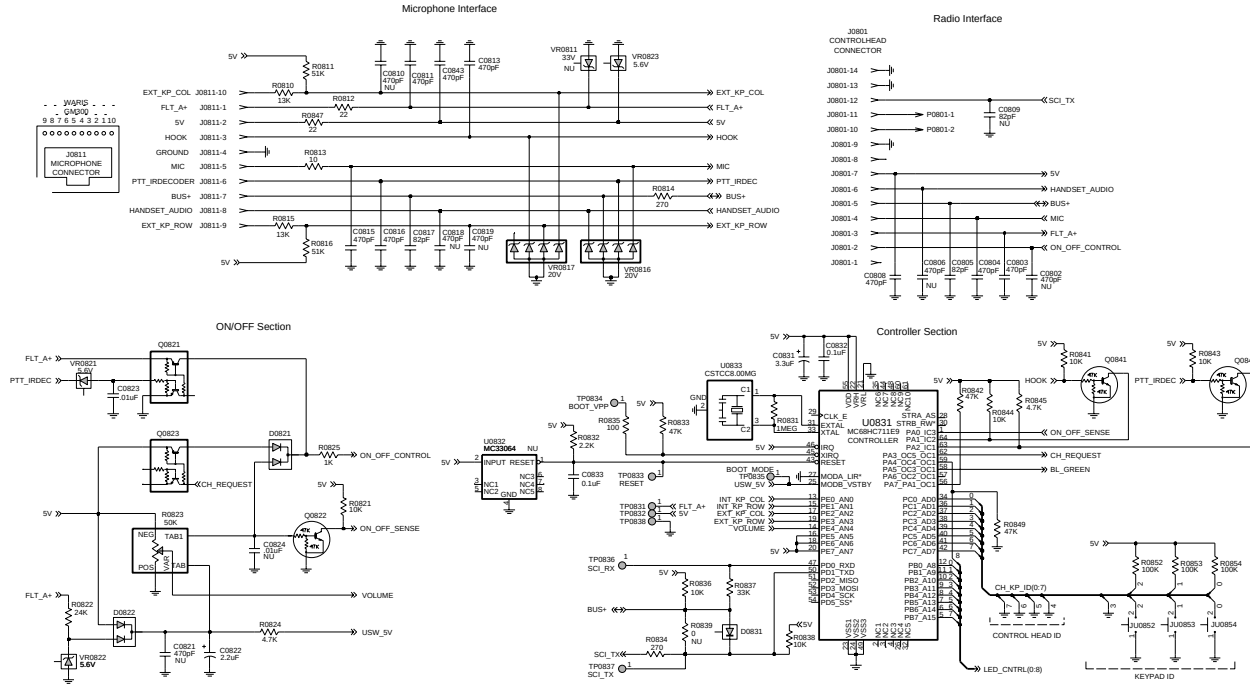




ZWG0130114

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





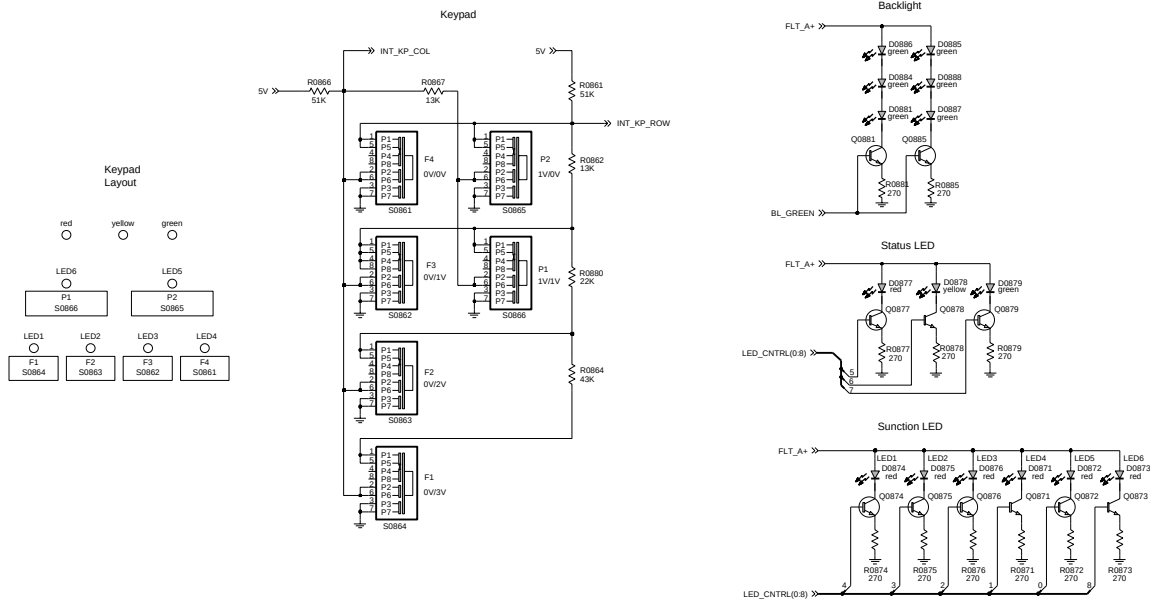


Figure 4-4. PRO3100/CDM750 Control Head Schematic Diagram, Sheet 2



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  |

| Reference Designator | Motorola Part No. | Description     |
|----------------------|-------------------|-----------------|
| 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    |

| Reference Designator | Motorola Part No. | Description  |
|----------------------|-------------------|--------------|
| VR0817               | 4805656W09        | Diode, Zener |
| VR0821               | 4813830A15        | Diode, 5.6V  |
| VR0822               | 4813830A15        | Diode, 5.6V  |
| VR0823               | 4813830A15        | Diode, 5.6V  |

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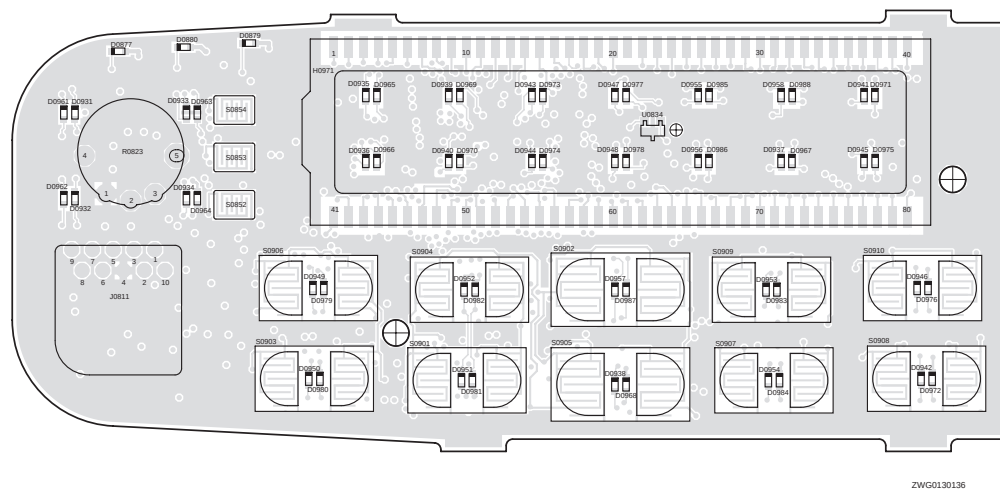
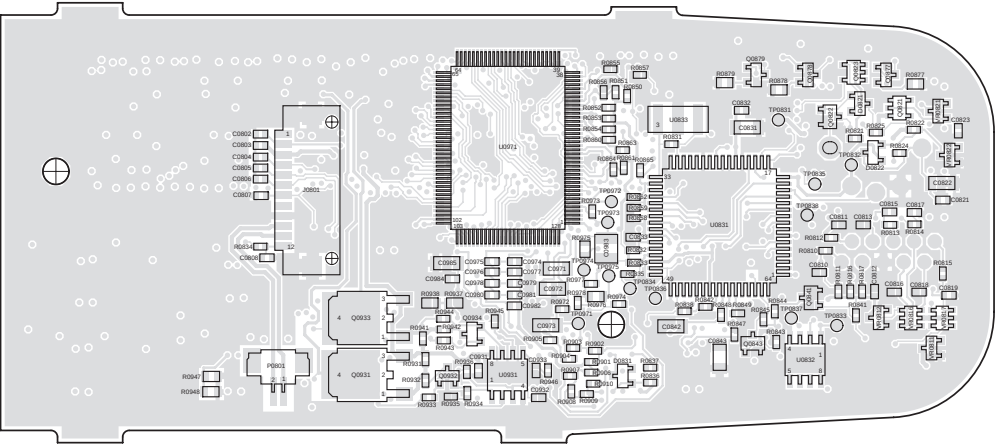


Figure 4-5. PRO5100/PRO7100/CDM1250/CDM1550 Control Head Top Overlay



ZWG0130137

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

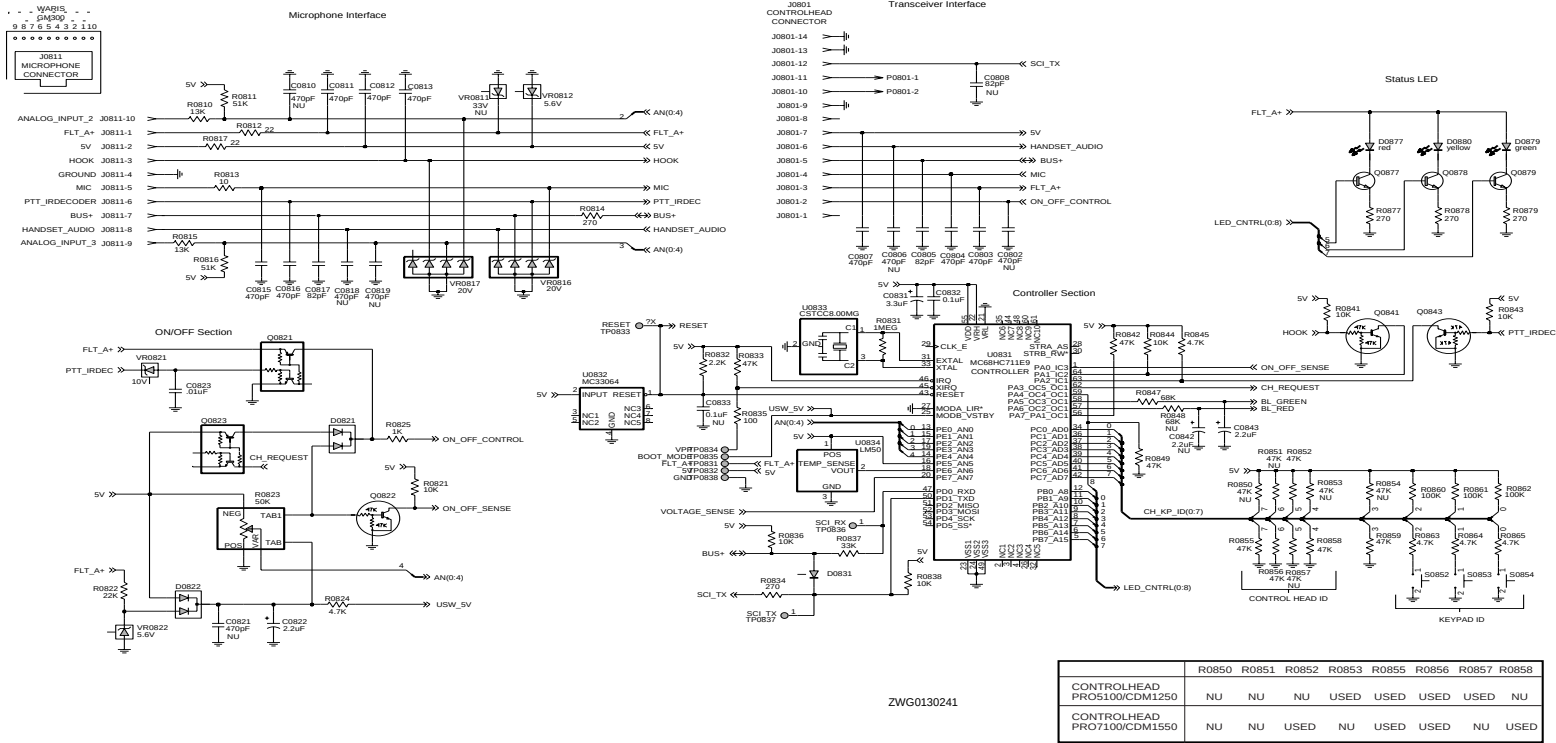


Figure 4-7. PRO5100/PRO7100/CDM1250/CDM1550 Control Head Schematic Diagram

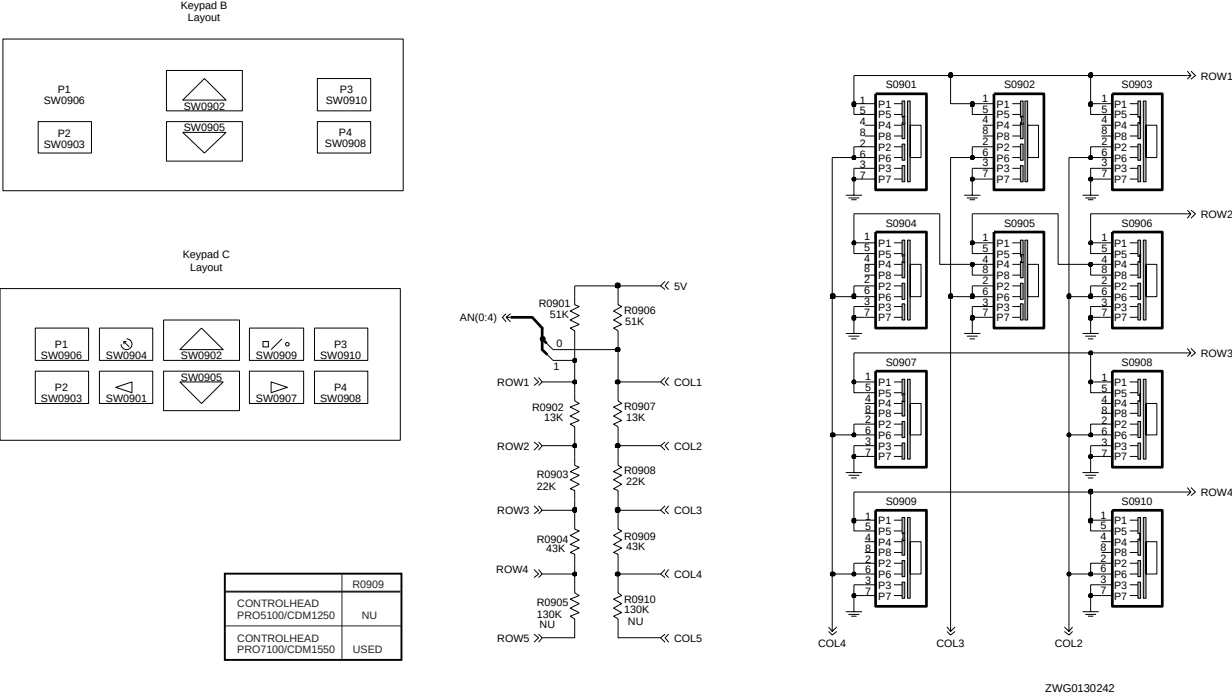
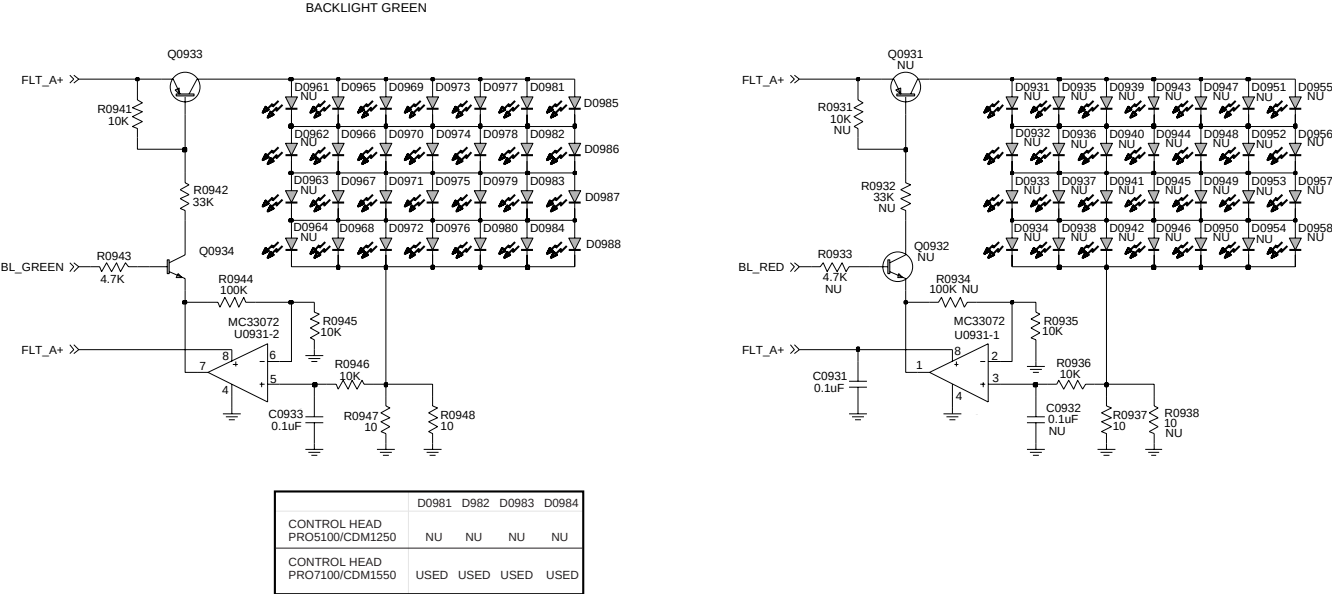


Figure 4-8. PRO5100/PRO7100/CDM1250/CDM1550 Control Head Keypad Schematic



ZWG0130243

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

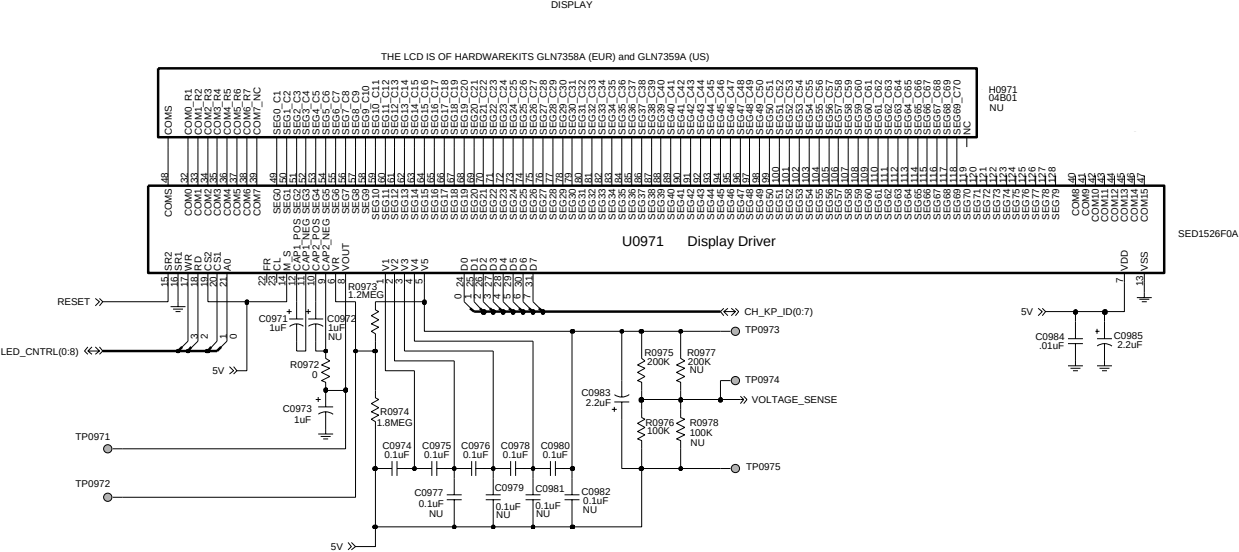


Figure 4-10. PRO5100/PRO7100/CDM1250/CDM1550 Control Head Display Schematic



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    |

| Reference Designator | Motorola Part No. | Description      |
|----------------------|-------------------|------------------|
| 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               |

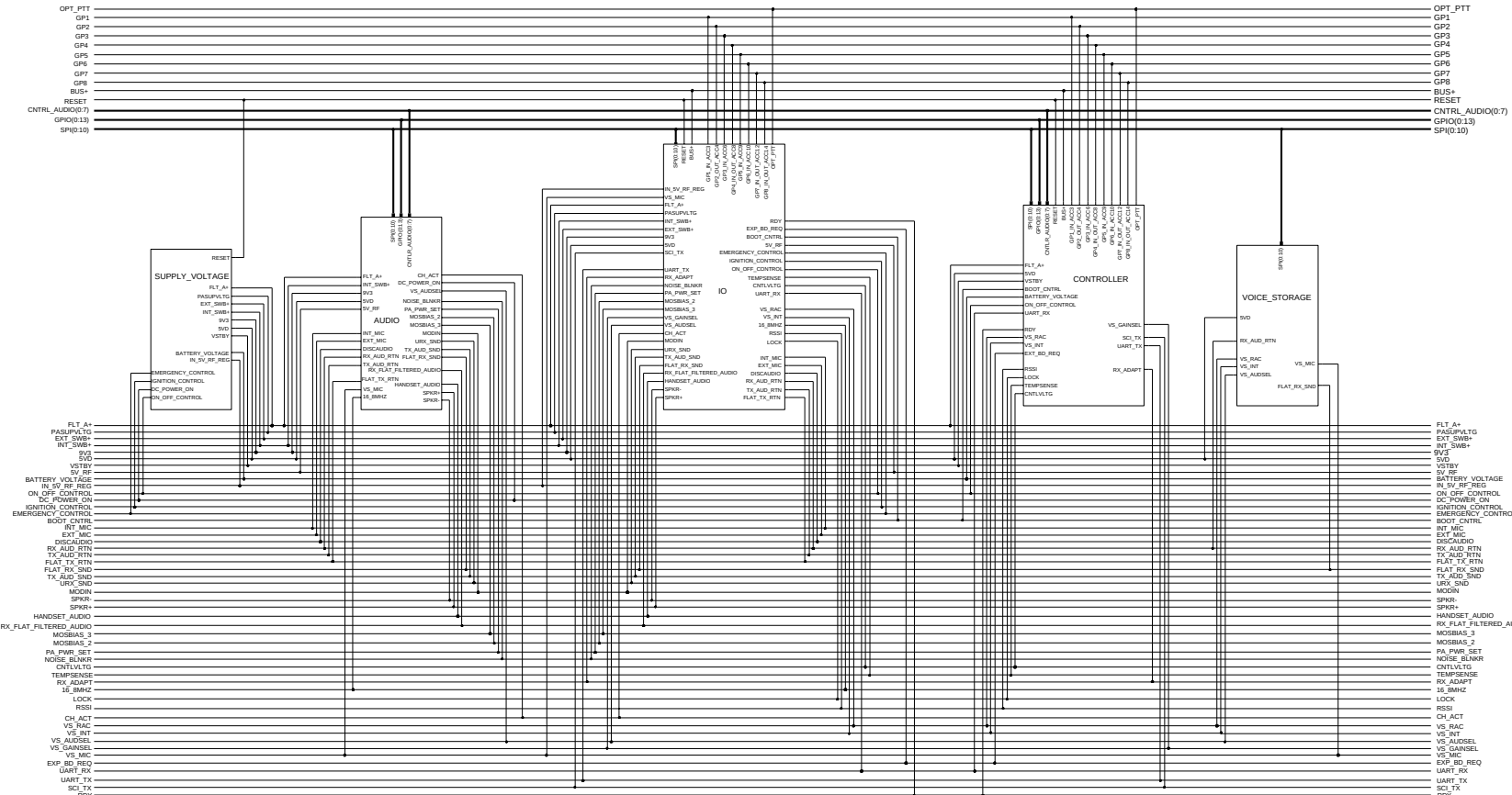
| Reference Designator | Motorola Part No. | Description        |
|----------------------|-------------------|--------------------|
| R0847                | 0662057A93        | 22                 |
| R0849                | 0662057A89        | 47K                |
| R0852*               | 0662057A89        | 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       |

| Reference Designator | Motorola Part No. | Description  |
|----------------------|-------------------|--------------|
| 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*

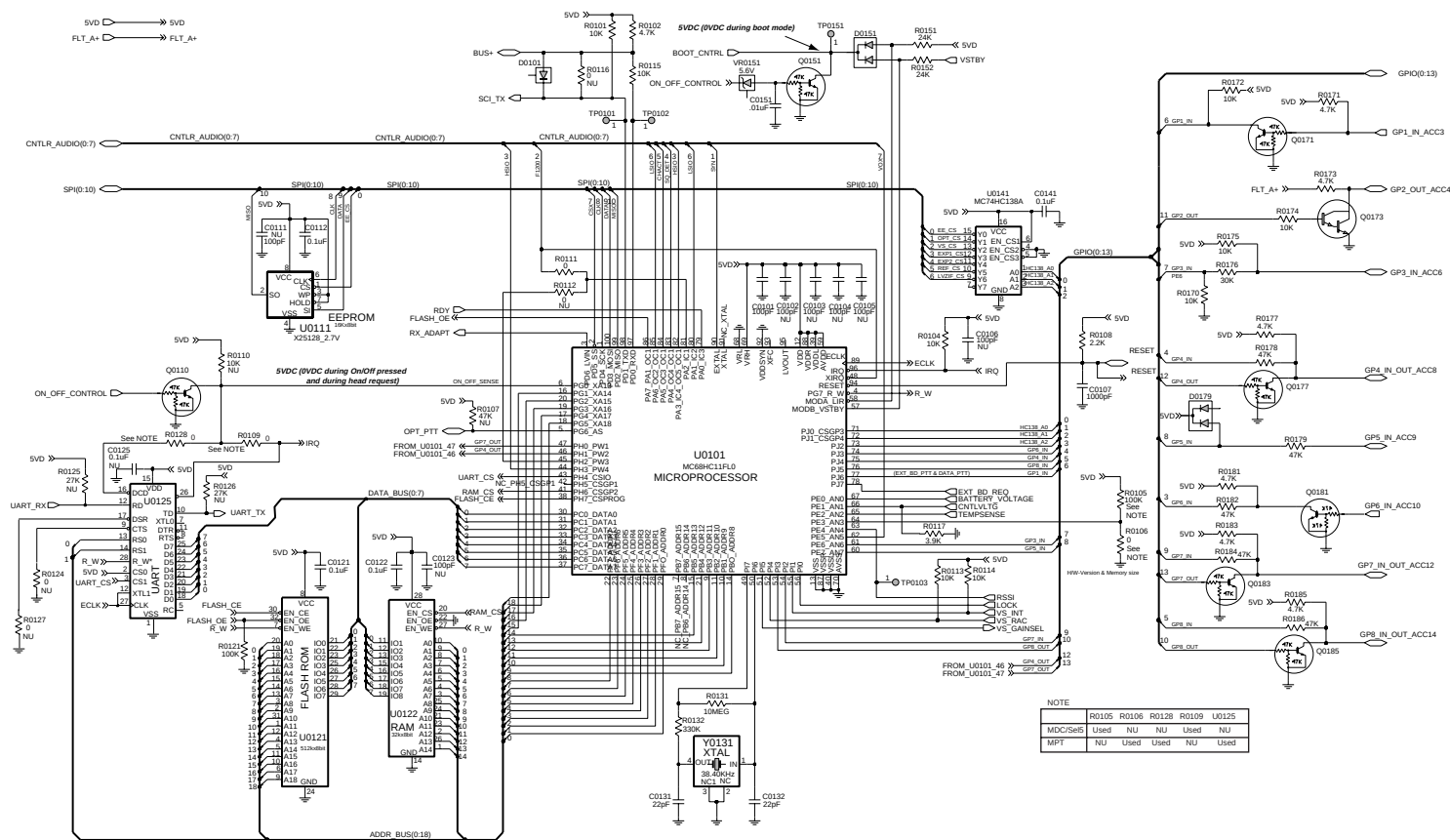


Figure 4-12. Controller Control Schematic Diagram

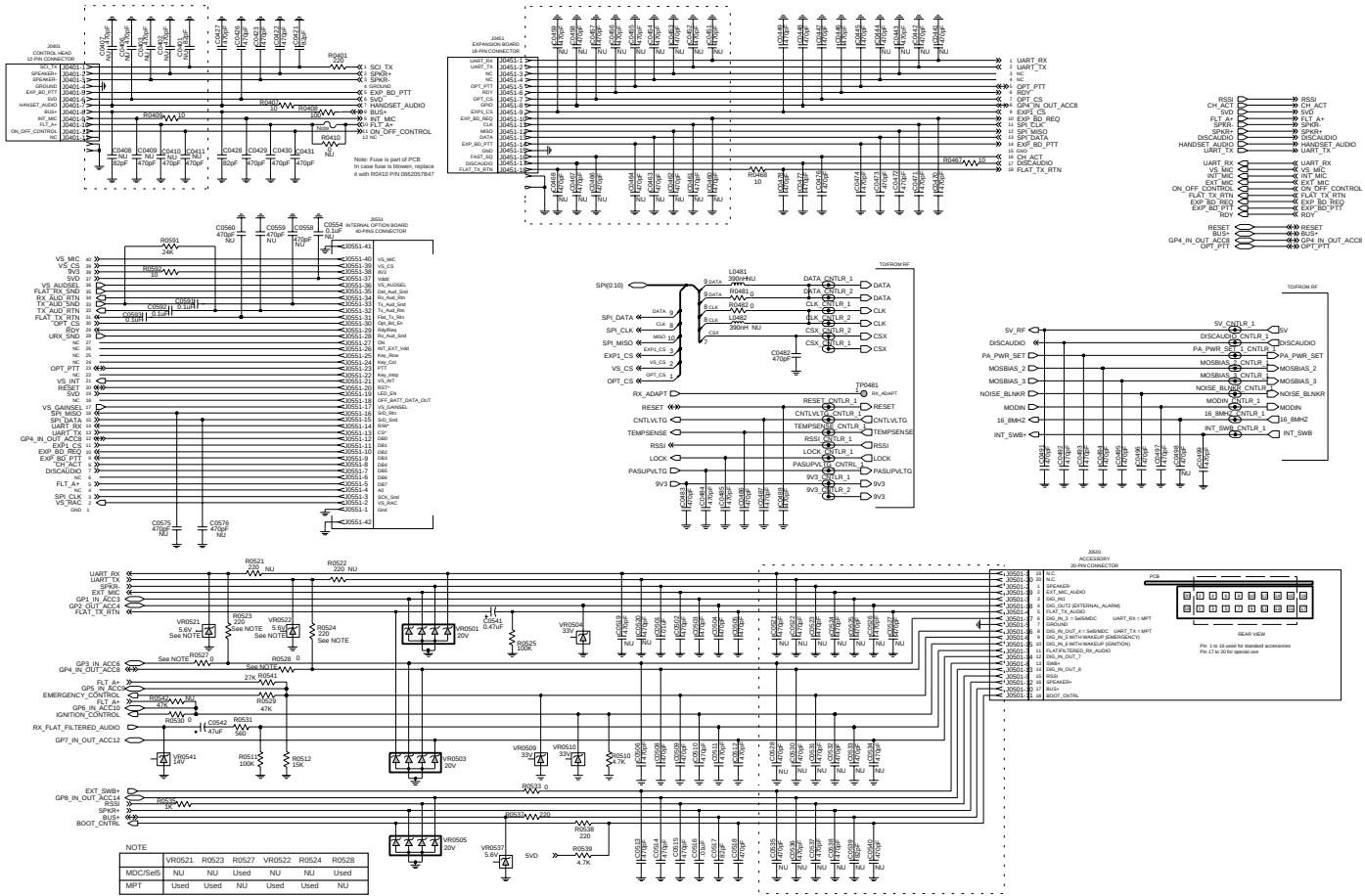


Figure 4-13. Controller I/O Schematic Diagram

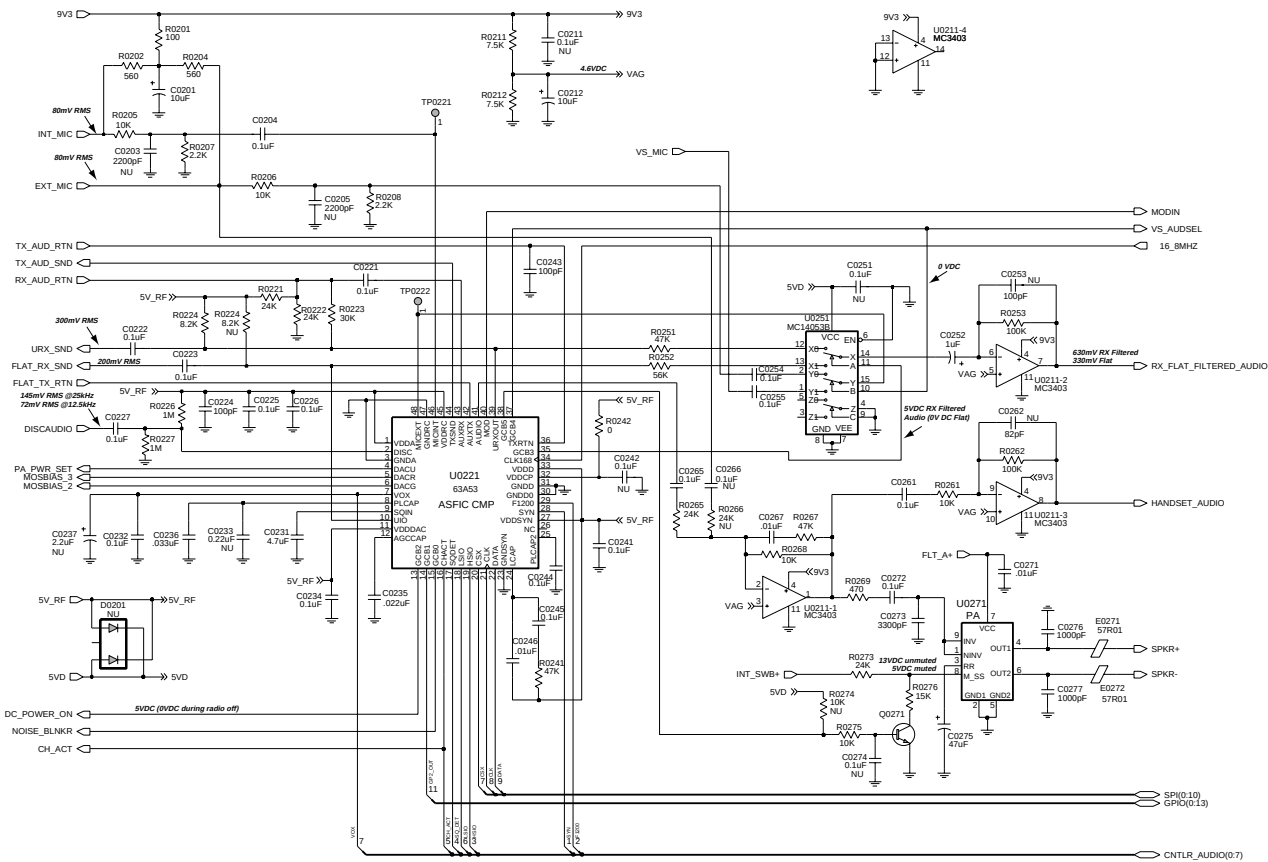
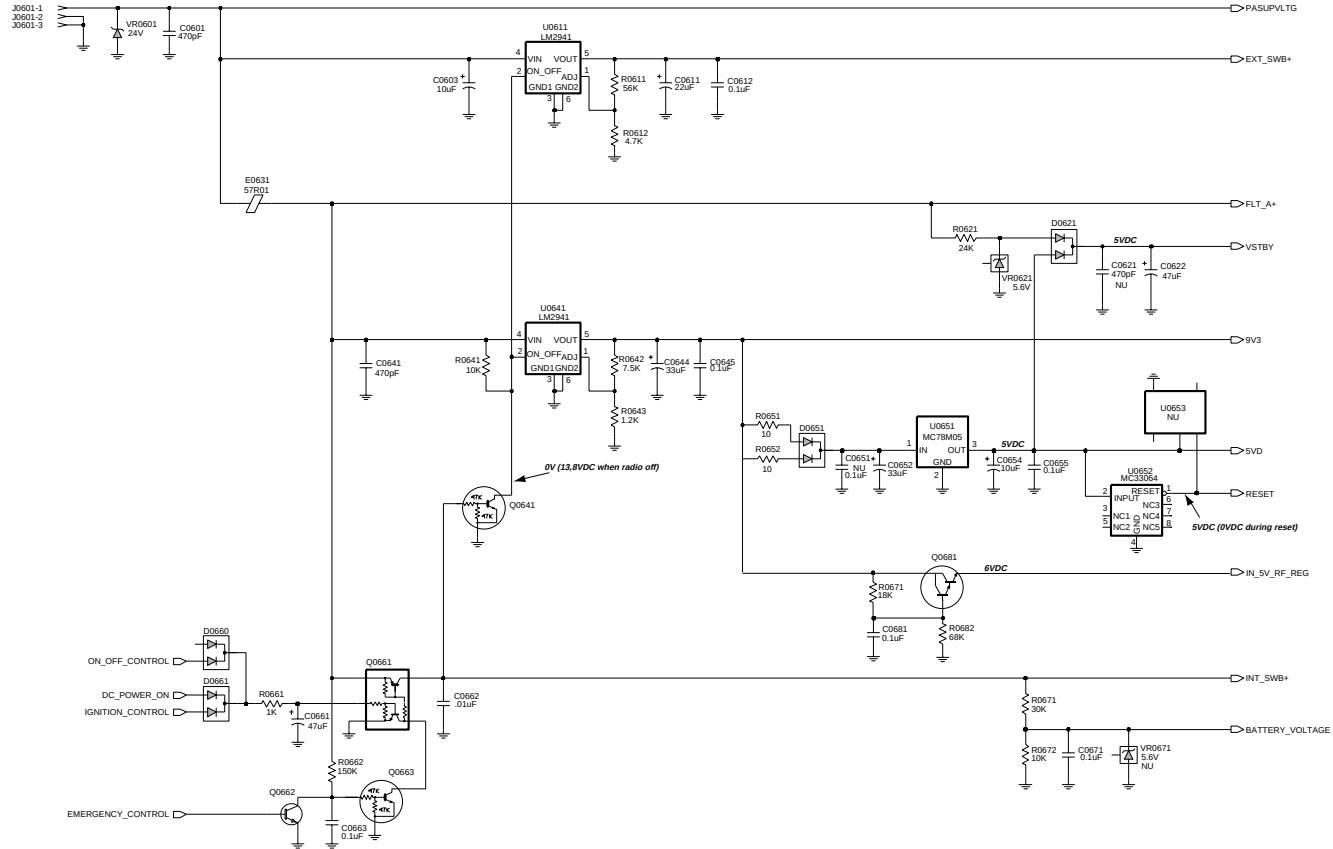


Figure 4-14. Controller Audio Schematic Diagram



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       |

| Circuit Ref | Motorola Part No. | Description |
|-------------|-------------------|-------------|
| 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       |

| Circuit Ref | Motorola Part No. | Description                 |
|-------------|-------------------|-----------------------------|
| 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                        |

| Circuit Ref | Motorola Part No. | Description |
|-------------|-------------------|-------------|
| 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     |

| Circuit Ref | Motorola Part No. | Description                  |
|-------------|-------------------|------------------------------|
| 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 Suppressor         |
| 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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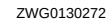


Figure 4-16. UHF (403-470MHz) Voltage Controlled Oscillator Schematic Diagram

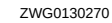
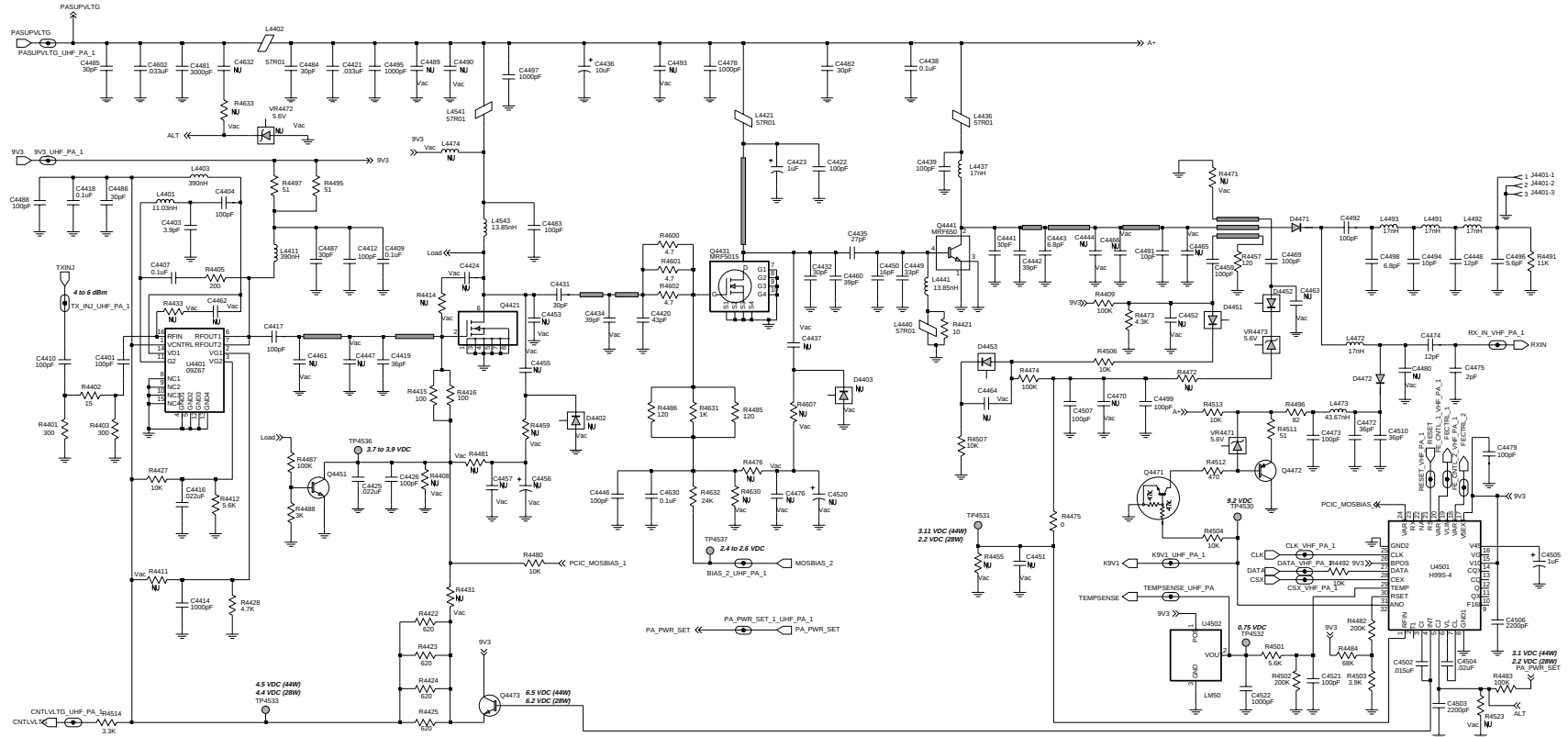


Figure 4-17. UHF (403-470MHz) Fractal-N Schematic Diagram



ZWG0130271

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      |

| Circuit Ref | Motorola Part No. | Description |
|-------------|-------------------|-------------|
| 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       |

| Circuit Ref | Motorola Part No. | Description |
|-------------|-------------------|-------------|
| 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        |

| Circuit Ref | Motorola Part No. | Description |
|-------------|-------------------|-------------|
| 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        |

| Circuit Ref | Motorola Part No. | Description |
|-------------|-------------------|-------------|
| 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        |

| Circuit Ref | Motorola Part No. | Description     |
|-------------|-------------------|-----------------|
| 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 |

| Circuit Ref | Motorola Part No. | Description                     |
|-------------|-------------------|---------------------------------|
| 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                      |

| Circuit Ref | Motorola Part No. | Description |
|-------------|-------------------|-------------|
| 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         |

| 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         |
| R3101       | 0662057A75        | 12K         |
| R3102       | 0662057A01        | 10          |
| R3105       | 0662057A25        | 100         |
| R3106       | 0662057A83        | 27K         |
| R3107       | 0662057A69        | 6.8K        |

| Circuit Ref | Motorola Part No. | Description |
|-------------|-------------------|-------------|
| 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

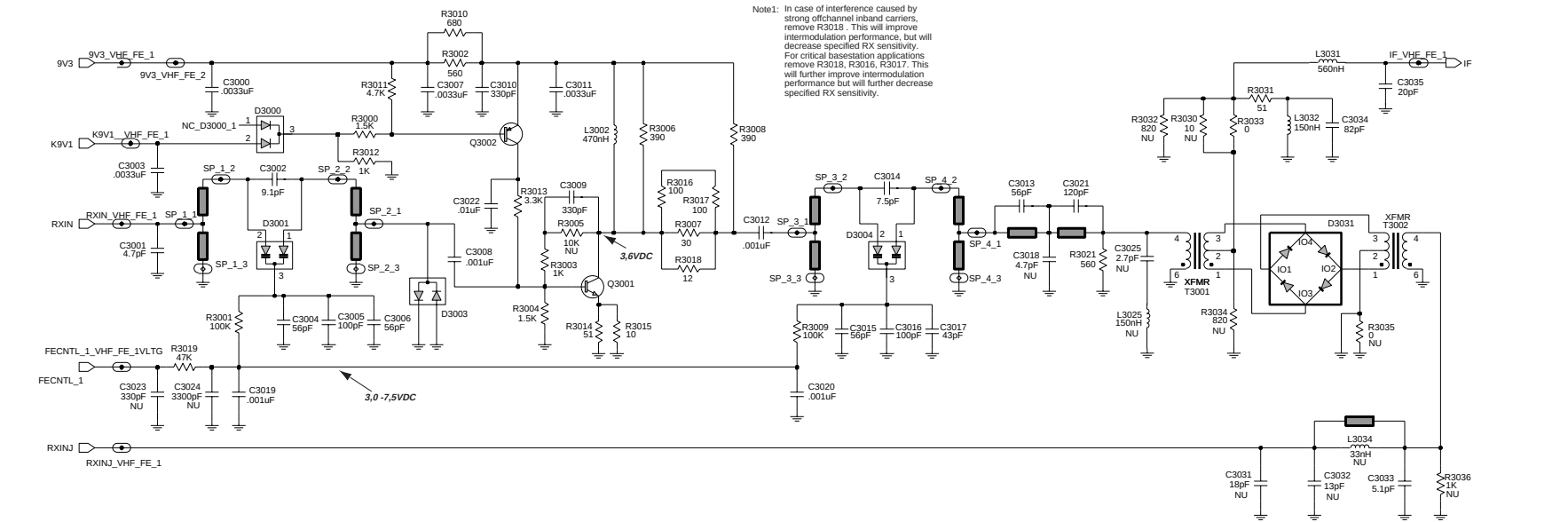


Figure 4-20. VHF (136-174MHz) Receiver Front End Schematic Diagram

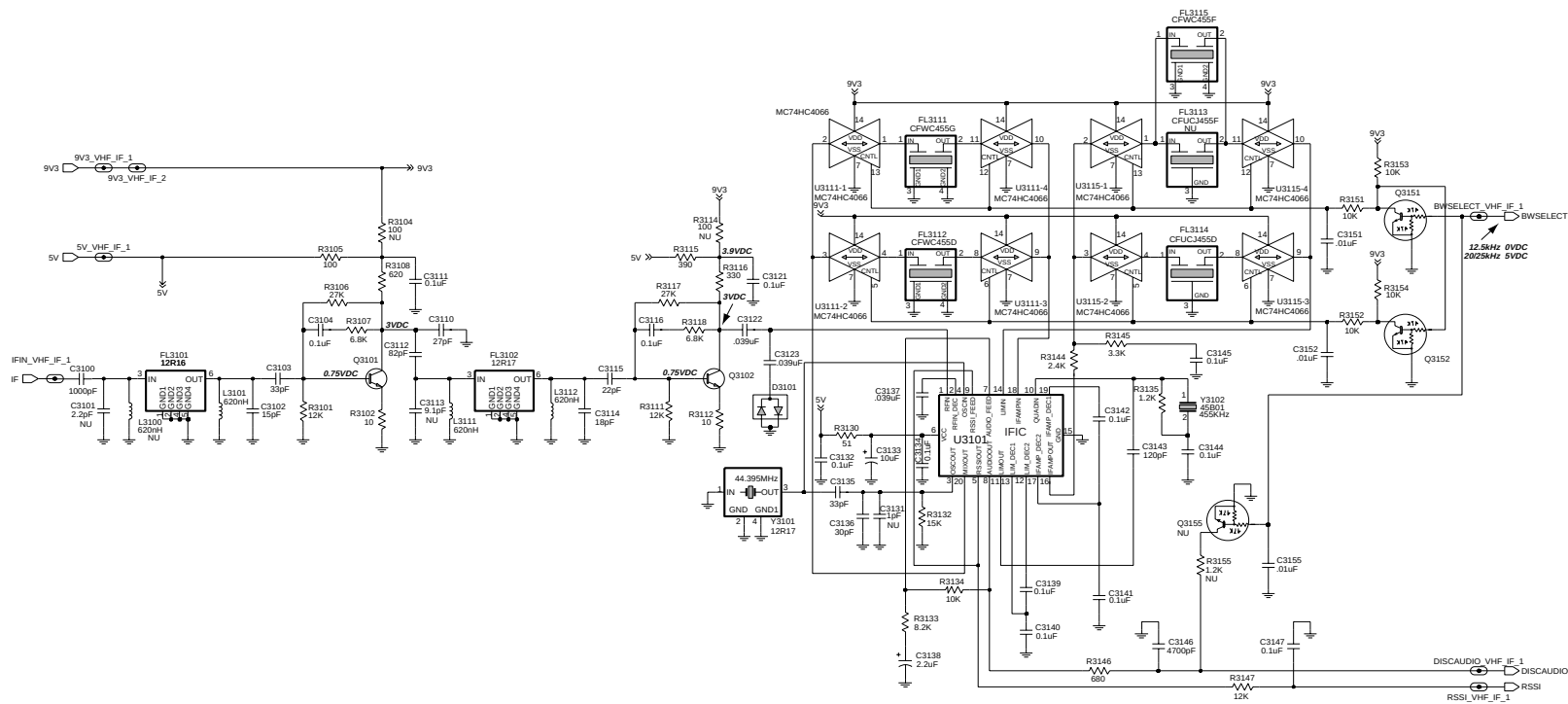
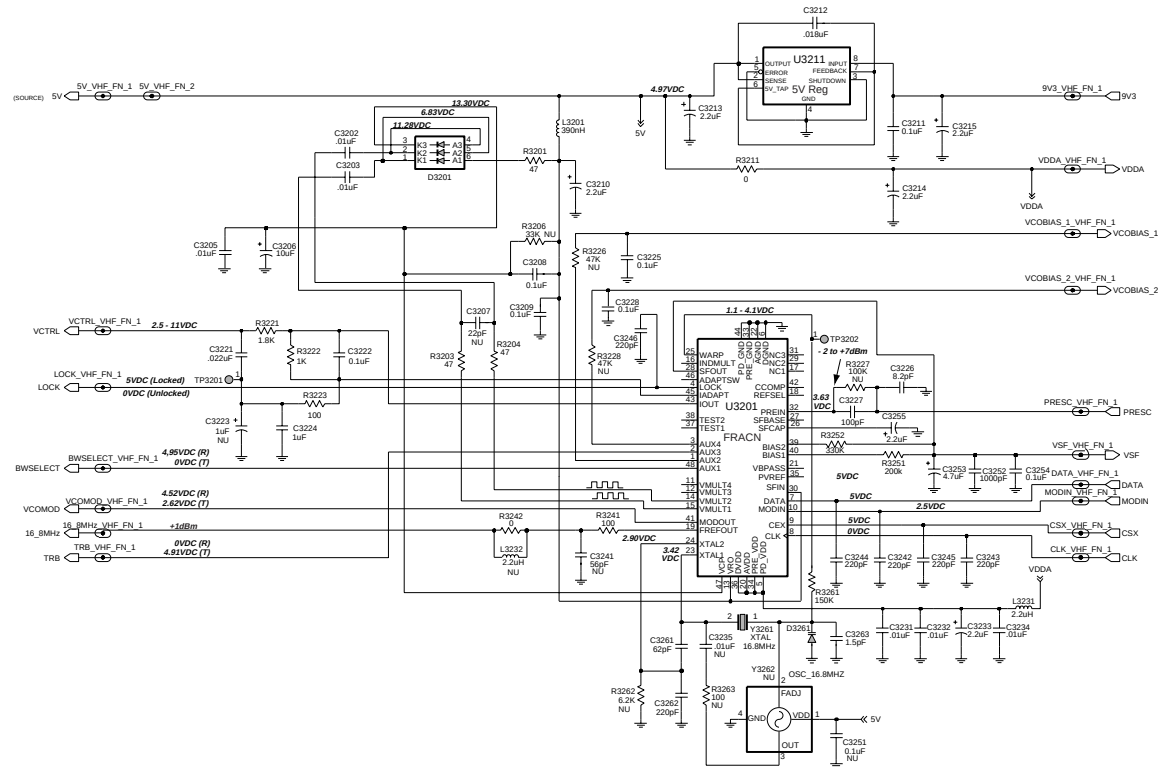


Figure 4-21. VHF (136-174MHz)Receiver IF Schematic Diagram



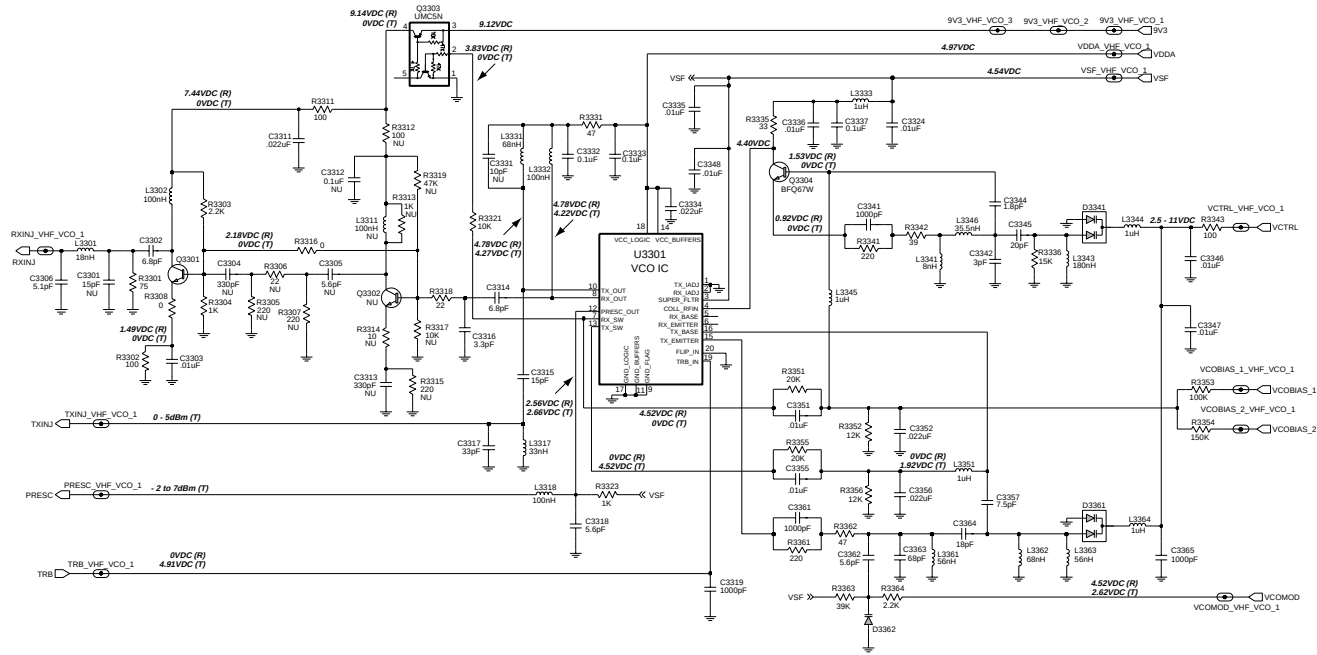


Figure 4-23. VHF (136-174MHz) Voltage Controlled Oscillator Schematic Diagram

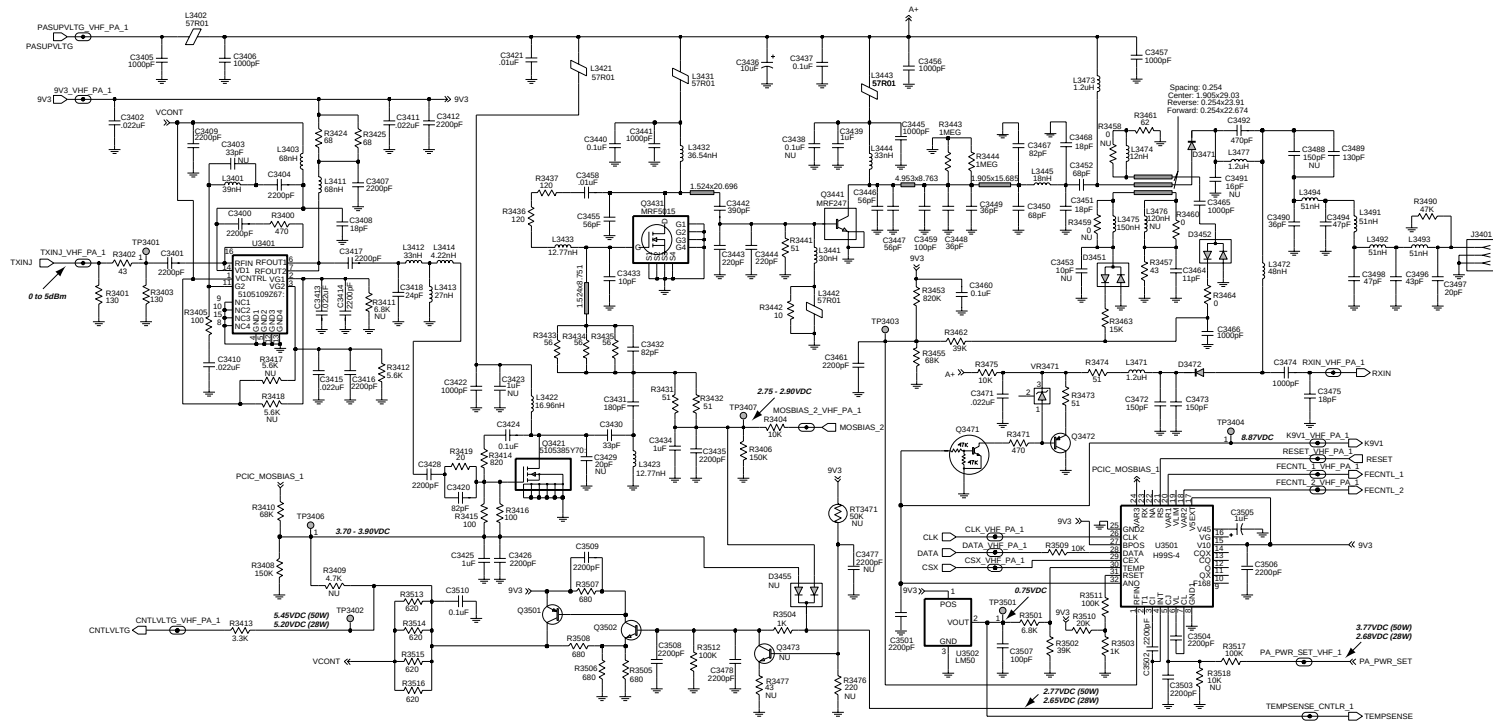




Table 4-5. VHF (136-174MHz) Radio Parts List

| 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       |

| Circuit Ref | Motorola Part No. | Description |
|-------------|-------------------|-------------|
| 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       |

| Circuit Ref | Motorola Part No. | Description |
|-------------|-------------------|-------------|
| 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       |

| Circuit Ref | Motorola Part No. | Description |
|-------------|-------------------|-------------|
| 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 Cath-ode |
| 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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