



Commercial Series

CM Radios

Detailed Service Manual

6866545D30-O

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Contents

Section 1	Service Maintainability
Section 2	Controlhead Service Information
Section 3	UHF2 Service Information
Section 4	VHF2 Service Information
Section 5	Midband Service Information
Section 6	UHF2 High Power Service Information
Section 7	VHF2 High Power Service Information



MOTOROLA

Commercial Series

CM Radios

Service Maintainability

Issue: December 2003

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Table of Contents

Chapter 1 INTRODUCTION

1.0 Scope of Manual	1-1
2.0 Warranty and Service Support.....	1-1
2.1 Warranty Period and Return Instructions	1-1
2.2 After Warranty Period	1-1
2.3 European Radio Support Centre (ERSC).....	1-2
2.4 Parts Identification and Ordering	1-2
2.5 EMEA Test Equipment Support.....	1-2
2.6 Technical Support.....	1-3
2.7 Related Documents	1-3
3.0 Radio Model Information.....	1-4

Chapter 2 MAINTENANCE

1.0 Introduction	2-1
2.0 Preventive Maintenance	2-1
2.1 Inspection	2-1
2.2 Cleaning	2-1
3.0 Safe Handling of CMOS and LDMOS.....	2-2
4.0 General Repair Procedures and Techniques.....	2-2
5.0 Notes For All Schematics and Circuit Boards	2-5

Chapter 3 SERVICE AIDS

1.0 Recommended Test Tools.....	3-1
2.0 Test Equipment.....	3-2

SAFETY INFORMATION

Read this information before using your radio.

PRODUCT SAFETY AND RF EXPOSURE FOR MOBILE TWO-WAY RADIOS INSTALLED IN VEHICLES OR AS FIXED SITE CONTROL STATIONS.

This document provides information and instructions for the safe and efficient operation of Motorola Mobile Two-Way Radios. The information provided in this document supersedes information contained in user guides published prior to **February 2002**.

COMPLIANCE WITH RF ENERGY EXPOSURE STANDARDS

Note: This Radio is intended for use in occupational/controlled applications, where users have been made aware of the potential for exposure and can exercise control over their exposure. This radio device is NOT authorized for general population, consumer or similar use.

This user safety booklet includes useful information about RF exposure and helpful instructions on how to control your RF exposures.

Your Motorola radio is designed and tested to comply with a number of national and international standards and guidelines regarding human exposure to radio frequency electromagnetic energy. **This radio complies with IEEE and ICNIRP exposure limits for occupational/controlled RF exposure environments at usage factors of up to 50% talk–50% listen.** In terms of measuring RF energy for compliance with the IEEE/ICNIRP exposure guidelines, your radio radiates measurable RF energy only while it is transmitting (during talking), not when it is receiving (listening) or in standby mode.

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

- United States Federal Communications Commission, Code of Federal Regulations; 47 CFR part 2 sub-part J
- American National Standards Institute (ANSI) / Institute of Electrical and Electronic Engineers (IEEE) C95. 1-1992
- Institute of Electrical and Electronic Engineers (IEEE) C95.1-1999 Edition
- International Commission on Non-Ionizing Radiation Protection (ICNIRP) 1998
- Ministry of Health (Canada) Safety Code 6. Limits of Human Exposure to Radiofrequency Electromagnetic Fields in the Frequency Range from 3 kHz to 300 GHz, 1999
- Australian Communications Authority Radiocommunications (Electromagnetic Radiation - Human Exposure) Standard 2001
- ANATEL, Brasil Regulatory Authority, Resolution 256 (April 11, 2001) "additional requirements for SMR, cellular and PCS product certification."

COMPLIANCE AND CONTROL GUIDELINES AND OPERATING INSTRUCTIONS FOR MOBILE TWO-WAY RADIOS INSTALLED IN VEHICLES

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

- To transmit (talk), push the Push-To-Talk (PTT) button; to receive, release the PTT button. Transmit only when people outside the vehicle are at least the minimum lateral distance away from a properly installed, externally-mounted antenna. Table 1 lists the minimum distance for bystanders in an uncontrolled environment from the transmitting antenna at several different ranges of rated radio power for mobile radios installed in a vehicle..

Table 1: Rated Power and Distance

Rated Power of Vehicle-Installed Mobile Two-Way Radio	Minimum Distance from Transmitting Antenna
Less than 7Watts	20 cm (8 Inches)
7 to 15 Watts	30.5 cm (1 Foot)
16 to 50 Watts	61 cm (2 Feet)
51 to 110 Watts	91.5 cm (3 Feet)

- Install mobile antennas at the centre of the roof and centre of the trunk deck. These mobile installation guidelines are limited to metal body vehicles. The antenna installation must additionally be in accordance with:
 - a. The requirements of the antenna manufacturer/supplier
 - b. Instructions in the Radio Installation Manual.
- Use only Motorola-approved supplied or replacement antenna. Use of non-Motorola - approved antennas, modifications, or attachments could damage the radio and may violate IEEE/ICNIRP regulations. For a list of Motorola-approved antennas please see your dealer. Your nearest dealer can be found at the following web site :

<http://www.motorola.com/cgiss/emea/dealerlocator.html>

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

COMPLIANCE AND CONTROL GUIDELINES AND OPERATING INSTRUCTIONS FOR MOBILE TWO-WAY RADIOS INSTALLED AS FIXED SITE CONTROL STATIONS

If mobile radio equipment is installed at a fixed location and operated as a control station or as a fixed unit, the antenna installation must comply with the following requirements in order to ensure optimal performance and compliance with the RF energy exposure in the standards and guidelines listed above:

- The antenna must be mounted outside the building on the roof or a tower if at all possible.
- As with all fixed site antenna installations, it is the responsibility of the licensee to manage the site in accordance with applicable regulatory requirements and may require additional compliance actions such as site survey measurements, signage, and site access restrictions in order to insure that exposure limits are not exceeded.

ELECTROMAGNETIC INTERFERENCE/COMPATIBILITY

NOTE: Nearly every electronic device is susceptible to electromagnetic interference (EMI) if inadequately shielded, designed or otherwise configured for electromagnetic compatibility. It may be necessary to conduct compatibility testing to determine if any electronic equipment used in or around vehicles or near fixed site antenna is sensitive to external RF energy or if any procedures need to be followed to eliminate or mitigate the potential for interaction between the radio transmitter and the equipment or device.

Facilities

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

Vehicles

To avoid possible interaction between the radio transmitter and any vehicle electronic control modules, for example, ABS, engine, or transmission controls, the radio should be installed only by an experienced installer and that the following precautions be used when installing the radio:

1. Refer to the manufacturer's instructions or other technical bulletins or recommendations on radio installation.
2. Before installing the radio, determine the location of the electronic control modules and their harnesses in the vehicle.
3. Route all radio wiring, including the antenna transmission line, as far away as possible from the electronic control units and associated wiring.

Driver Safety

Check the laws and regulations on the use of radios in the area where you drive. Always obey them.

When using your radio while driving, please:

- Give full attention to driving and to the road.
- Pull off the road and park before making or answering a call if driving conditions so require.

OPERATIONAL WARNINGS

For Vehicles With An Air Bag

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

Potentially Explosive Atmospheres

Turn off your radio prior to entering any area with a potentially explosive atmosphere. Sparks in a potentially explosive atmosphere can cause an explosion or fire resulting in bodily injury or even death.

The areas with potentially explosive atmospheres referred to above include 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. Areas with potentially explosive atmospheres are often but not always posted.

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.

For radios installed in vehicles fueled by liquefied petroleum gas, refer to the (U.S.) National Fire Protection Association standard, NFPA 58, for storage, handling, and/or container information. For a copy of the LP-gas standard, NFPA 58, contact the National Fire Protection Association, One Battery Park, Quincy, MA.

Chapter 1

INTRODUCTION

1.0 Scope of Manual

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

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

2.0 Warranty and Service Support

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

2.1 Warranty Period and Return Instructions

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

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

Prior to shipping any radio back to the appropriate Motorola warranty depot, please contact Customer Resources (Please see page 2 and page 3 in this Chapter). All returns must be accompanied by a Warranty Claim Form, available from your Customer Services representative. Products should be shipped back in the original packaging, or correctly packaged to ensure no damage occurs in transit.

2.2 After Warranty Period

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

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

2.3 European Radio Support Centre (ERSC)

The ERSC Customer Information Desk is available through the following service numbers:

Austria:	08 00 29 75 41	Italy:	80 08 77 387
Belgium:	08 00 72 471	Luxemburg:	08 00 23 27
Denmark:	80 88 05 72	Netherlands:	08 00 22 45 13
Finland:	08 00 11 49 910	Norway:	80 01 11 15
France:	08 00 90 30 90	Portugal:	08 00 84 95 70
Germany:	08 00 18 75 240	Spain:	90 09 84 902
Greece:	00 80 04 91 29 020	Sweden:	02 07 94 307
UK :	08 00 96 90 95	Switzerland:	08 00 55 30 82
Ireland:	18 00 55 50 21	Iceland:	80 08 147

Or dial the European Repair and Service Centre:

Tel: +49 30 6686 1555

Please use these numbers for repair enquiries only.

2.4 Piece Parts

Some replacement parts, spare parts, and/or product information can be ordered directly. If a complete Motorola part number is assigned to the part, it is available from Motorola Radio Aftermarket and Accessory 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 Motorola Depot only. If a parts list is not included, this generally means that no user-serviceable parts are available for that kit or assembly.

All part orders should be directed to :

**Motorola GmbH
Customer Care
AM Borsigturm 130
13507 Berlin
Germany.**

2.5 EMEA Test Equipment Support

Information related to support and service of Motorola Test Equipment is available via Motorola Online (Extranet), through the Customer Care organisation of Motorola's local area representation or by calling the the European Repair and Service Centre: Tel: +49 30 6686 1555

2.6 Technical Support

Motorola Product Services is available to assist the dealer/distributors in resolving any malfunctions which may be encountered.

UK/Ireland - Richard Russell
Telephone: +44 (0) 1256 488 082
Fax: +44 01256 488 080
Email: BRR001@email.mot.com

Central/East Europe - Siggy Punzenberger
Telephone: +49 (0) 6128 70 2342
Fax: +49 (0) 6128 95 1096
Email: TFG003@email.mot.com

Scandinavia
Telephone: +46 8 735 9282
Fax: +46 8 735 9280
Email: C14749@email.mot.com

Germany -Customer Connect Team
Telephone: +49 (0) 6128 70 2248
Fax: +49 (0) 6128 95 1082
Email: cgiss.emea@europe.mot.com

France - Lionel Lhermitte
Telephone: +33 1 6929 5722
Fax: +33 1 6929 5904
Email: TXE037@email.mot.com

Italy - Ugo Gentile
Telephone: +39 0 2822 0325
Fax: +39 0 2822 0334
Email: C13864@email.mot.com

Africa & Middle East - Armand Roy
Telephone: +33 1 6929 5715
Fax: +33 1 6929 5778
Email: armand.roy@Motorola.com

2.7 Related Documents

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

Title	Language	Part Number
CM Series Product Manual	English	GMLN1062_
	German	GMLN1063_
	French	GMLN1064_
	Italian	GMLN1065_
	Spanish	GMLN1066_
	Russian	GMLN1067_

3.0 Radio Model Information

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

Table 1-1 Radio Model Number (Example: MDM50FNC9AN2_N)

	Type of Unit	Model Series	Freq. Band	Power Level	Physical Packages	Channel Spacing	Protocol	Feature Level	Model Revision	Model Package
MD ↑ MD = Motorola Internal Use	M ↑ M = Mobile	50	F Midband (66-88MHz) J VHF1 (136-162MHz) K VHF2 (146-174MHz)	N 1-25W	C CM140 CM340	9 Programmable	AA Conventional MDC	1 RF Connector: Mini-UHF	A	N
			Q UHF1 (403-430MHz)	P 25-40W	F CM160 CM360			AN 5 Tone	2 RF Connector: BNC	
			R UHF2 (438-470MHz)	Q 25-45W						
			S UHF3 (465-495MHz)							

Chapter 2

MAINTENANCE

1.0 Introduction

This chapter of the manual describes:

- preventive maintenance
- safe handling of CMOS devices
- repair procedures and techniques

2.0 Preventive Maintenance

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

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.

2.2 Cleaning

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

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

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



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

1. 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.

2. 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).

3.0 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.

4.0 General Repair Procedures and Techniques

IC Pre-Baking

No pre-baking of components is required in the repair of this product.

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" section of this manual.

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 through-plated 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 18-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.

Chip Components

Use either the RLN4062 Hot-Air Repair Station or the Motorola 0180381B45 Repair Station 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 370 °C (700 °F), 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 the hand piece approximately 0.3 cm (1/8") above the component to be removed.
2. Begin applying the hot air. Once the solder reflows, remove the component using a pair of tweezers.
3. Using a solder wick 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 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.
2. Apply a drop of solder paste flux to each pad.
3. Using a pair of tweezers, position the new component in place.
4. Position the hot-air hand piece approximately 0.3 cm (1/8") above the component and begin applying heat.
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 R1070 station with the temperature control set to approximately 215°C (415°F) [230°C (445°F) maximum].

■ To remove the shield:

1. Place the circuit board in the R1070 circuit board holder.
2. Select the proper heat focus head and attach it to the heater chimney.
3. Add solder paste flux 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 0.3 cm (1/8") 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 R1070 circuit board holder.

■ To replace the shield:

1. Add solder to the shield if necessary, using a micro-tipped soldering iron.
2. Next, 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 circuit board holder.
4. Place the shield on the circuit board using a pair of tweezers.
5. Position the heat-focus head over the shield and lower it to approximately 0.3 cm (1/8") above the shield.
6. Turn on the heater and wait for the solder to reflow.
7. Once complete, turn off the heat, raise the heat-focus head and wait approximately one minute for the part to cool.
8. Remove the circuit board and inspect the repair. No cleaning should be necessary.

5.0 Notes For All Schematics and Circuit Boards

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

1. Unless otherwise stated, resistances are in Ohms ($k = 1000$), and capacitances are in picofarads (pF) or microfarads (μF).
2. DC voltages are measured from point indicated to chassis ground using a Motorola DC multimeter or equivalent. Transmitter measurements should be made with a $1.2 \mu\text{H}$ choke in series with the voltage probe to prevent circuit loading.
3. Interconnect Tie Point Legend:

Signal Name	Signal Description
16_8MHz	16.8MHz Reference Frequency from Synthesizer to ASFIG
3V	3V RF regulator
5V	5V RF regulator
5V_CH	Optional 5V for Control Head
9V	Regulated 9.3V Supply Voltage
9R	9V to enable RX_INJ when RX_EN is active
ASFIG_CS	ASFIG Chip Select
B+	13.8V Supply Voltage
BATT_SENSE	Battery Voltage Sense Line
BOOT_EN_IN_CH	Boot Mode Select
BW_SEL	Select BW (12.5 KHz, 25 KHz)
CH_ACT	Channel Activity Indicator Signal (Fast Squelch)
COMM_DATA_SEL_CH	Display Driver Command/ Data Select
D3_V3	Regulated 3.3V supply voltage for Voice Storage
DEMOD	Audio Output Signal from the Receiver IC
DETECTOR_AUDIO_SEND_BRD	Flat Audio to Option Board
DISPLAY_CS_CH	Control Head Chip Select
EMERGENCY_ACCES_CONN	Emergency line to switch on the radio voltage regulators
EMERGENCY_SENSE	Emergency sense to μP
EXTERNAL_MIC_AUDIO_ACCES_CONN	External (from accessory connector) microphone input
F1200	Interrupt line from ASFIG CMP
FILT_SW_B+	Switched 13.8 V supply voltage
FLAT_TX_AUDIO_INPUT_ACCESS_CONN	Flat TX input from accessory connector
HANDSET_RX_AUDIO_CH	Handset Audio Output
HOOK_CH	Hang-up switch input
HSIO	High Speed Clock In / Data Out
IGNITION	Ignition Line to switch on the radio's voltage regulator
KEYPAD_COL_CH	Keypad Matrix Column
LOC_DIST	Enable Attenuator for RX line
LSIO	Low Speed Clock In / Data Out
MIC_AUDIO_CH	Microphone Input

MIC_PTT_CH	Microphone PTT Input
MOD_IN	Modulation Signal from ASFIC
MOD_OUT	Modulation Signal to the Synthesizer
ONOFF_SENSE	On off sense switch
OPT_DATA_R_OPRD	DATA/Ready Request from Option Board
OPT_EN_OPBD	Option Board Chip Select
PA_BIAS	PA Control bias voltage
PA_CURRENT	Not used
POST_LIMITER_TX	Flat TX Input from Option Board
AUDIO_RETURN_OPT_BRD	
PROG x IN ACC y	General Purpose Input x accessory connector Pin y
PROG x INOUT ACC y	General Purpose Input/Output x accessory connector Pin y
PROG x OUT ACC y	General Purpose Input x accessory connector Pin y
PWR_SET	PA Power Control Voltage
RESET	Reset Line
RSSI	Received Signal Strength Indicator
RX	RX signal
RX_AUD RTN	Option Board Input/Output of Receiver Audio Path
RX_AUDIO_OUTPUT_ACCESS_CONN	Flat or filtered audio to accessory connector
RX_EN	Enable Receiving
RX_INJ	RF signal from VCO into the Receiver
SCI_CH	Bi-directional serial communication line
SHIFT_R_CS	SPI Chip select for the Control Head
SPI_CLK	Serial peripheral interface bus CLOCK
SPI_MISO	Serial peripheral interface bus data IN
SPI莫斯I	Serial peripheral interface bus data OUT
SPKR-	Negative Audio PA Speaker Output
SPKR-	Negative Audio PA Speaker Output
SPKR+	Positive Audio PA Speaker Output
SQ_DET	Squelch Detect Signal
SYNTH_CS	Synth Chip Select
SYNTH_LOCK	μ P Clock Lock Signal
TX_AUDIO_RETURN_OPT_BRD	Option Board Output to Transmit Audio Path
TX_AUDIO_SEND_OPT_BRD	Microphone Audio to Option Board
TX_INJ	RF signal from the VCO to transmitter PA
TX_EN	Enable transmitting
UNMUTED_RX_AUDIO_SEND_OPT_BRD	Unmuted filtered audio to option board
μ P_CLK	μ P Clock signal
VoL_INDIRECT	Volume Pot Input
VOX	Voice operated transmit level

VS_AUDIO_SEL	Switch signal to Enable option board audio output signal
VS_GAIN_SEL	Voice Storage Gain Select line
VS_MIC	Voice Storage Audio Signal to microphone path
VS_INT	Voice Storage Interrupt line
VS_RAC	Voice storage Row Address Clock Signal
VSTBY	3.3 V supply for μ P when the radio is switched off

Chapter 3

SERVICE AIDS

1.0 Recommended Test Tools

Table 3.1 lists the service aids recommended for working on the radio. While all of these items are available from Motorola, most are standard workshop equipment items, and any equivalent item capable of the same performance may be substituted for the item listed.

Table 3-1 Service Aids

Motorola Part No.	Description	Application
RLN4460_	Portable Test Set	Enables connection to audio/accessory jack. Allows switching for radio testing.
GMVN5034_	Customer Programming Software (CPS) and Tuner CDROM (MDC)	Programs customer options and channel data. Tunes hardware parameters, front end, power, deviation etc.
GMVN5033_	Customer Programming Software (CPS) and Tuner CDROM (5-Tone)	Programs customer options and channel data. Tunes hardware parameters, front end, power, deviation etc.
RKN4081_	Programming Cable with Internal RIB	Includes radio interface box (RIB) capability.
FKN8096_	Data/Flash Adapter Key	Used with RKN4081 (10 to 8 pin adapter for front Telco connector with Data/Flash switch).
RKN4083_	Mobile Programming/Test Cable	Connects radio to RIB (RLN4008_).via rear accessory connector
FKN8113_	Adapter Cable	Used with RKN4083 (20 to 16 pin adapter for rear accessory connector).
GTF374_	Program Cable	Connects RIB to Radio microphone input.
RLN4008_	Radio Interface Box	Enables communications between radio and computer's serial communications adapter.
HLN8027_	Mini UHF to BNC Adaptor	Adapts radio antenna port to BNC cabling of test equipment.
GPN6133_	Power Supply	Provides the radio with power when bench testing.
EPN4040_	Wall-Mounted Power Supply	Used to supply power to the RIB (UK).
EPN4041_	Wall-Mounted Power Supply	Used to supply power to the RIB (Euro).
8180384N64	Housing Eliminator (25W)	Test Fixture used to bench test the radio pcb.
3080369B71	Computer Interface Cable	Connects the RIB to the Computer (25-pin).

Table 3-1 Service Aids

Motorola Part No.	Description	Application
3080369B72	Computer Interface Cable	Connects the RIB to the Computer (9-pin) (Use for IBM PC AT - other IBM models use the B71 cable above).
6686119B01	Removal Tool	Assists in the removal of radio control head.
6680334F39	Hex Tool	Assists in the removal of antenna connector.
WADN4055A	Portable Soldering Station	Digitally controlled soldering iron.
6604008K01	0.4mm Replacement Tip	For WADN4055A Soldering iron.
6604008K01	0.8mm Replacement Tip	For WADN4055A Soldering iron.
0180386A82	Anti-static Grounding Kit	Used for all radio assembly/disassembly procedures.
6684253C72	Straight Prober	
6680384A98	Brush	
1010041A86	Solder (RMA type)	63/37, 0.5mm diameter, 1lb. spool.

2.0 Test Equipment

Table 3-2 lists test equipment required to service the radio and other two-way radios.

Table 3-2 Recommended Test Equipment

Motorola Part No.	Description	Characteristics	Application
R2600_NT	Comms System Analyzer (non MPT)	This monitor will substitute for items with an asterisk *	Frequency/deviation meter and signal generator for wide-range troubleshooting and alignment
*R1072_	Digital Multimeter		AC/DC voltage and current measurements
*R1377_	AC Voltmeter	100 µV to 300 V, 5Hz-1MHz, 10 Megohm input impedance	Audio voltage measurements
WADN4133	Delay Oscilloscope	2 Channel 40 MHz bandwidth, 5 mV/cm - 20 V/cm	Waveform measurements
R1440_ 0180305F17 0180305F31 0180305F40 RLN4610_ T1013_	Wattmeter, Plug-in Elements Plug-in Elements Plug-in Elements Carry case RF Dummy Load	Thruline 50-Ohm, ±5% accuracy 10W, 25 - 60 MHz 10W, 100 - 250 MHz 10W, 200 - 500 MHz Wattmeter and 6 elements	Transmitter power output measurements
S1339_	RF Millivolt Meter	100mV to 3 VRF, 10 kHz to 1.2 GHz	RF level measurements
R1011_/220V	220V Power Supply	0-40V, 0-40A	Programmable



MOTOROLA

Commercial Series

CM Radios

Controlhead
Service Information

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Table of Contents

Chapter 1 MODEL OVERVIEW

1.0 CM140/CM340 Models	1-1
2.0 CM160/CM360 Models	1-1

Chapter 2 THEORY OF OPERATION

1.0 Introduction	2-1
2.0 Controlhead Model for CM140 and CM340	2-1
2.1 Power Supplies.....	2-1
2.2 Power On / Off.....	2-1
2.3 Microprocessor Circuit.....	2-1
2.4 SBEP Serial Interface.....	2-1
2.5 Keypad Keys	2-1
2.6 Status LED and Back Light Circuit.....	2-3
2.7 Microphone Connector Signals	2-3
2.8 Speaker	2-4
2.9 Electrostatic Transient Protection	2-4
3.0 Controlhead Model for CM160 and CM360	2-4
3.1 Power Supplies.....	2-4
3.2 Power On / Off.....	2-4
3.3 Microprocessor Circuit.....	2-5
3.4 SBEP Serial Interface.....	2-5
3.5 Keypad Keys	2-6
3.6 Status LED and Back Light Circuit.....	2-6
3.7 Liquid Crystal Display (LCD)	2-6
3.8 Microphone Connector Signals	2-6
3.9 Speaker	2-7
3.10 Electrostatic Transient Protection	2-8

Chapter 3 TROUBLESHOOTING CHARTS

1.0 Troubleshooting Chart for Controlhead CM140/340	3-1
1.1 On/Off	3-1
1.2 Microprocessor	3-2
2.0 Troubleshooting Chart for Controlhead CM160/360	3-3
2.1 On/Off	3-3
2.2 Microprocessor	3-4
2.3 Display	3-5
2.4 Backlight	3-6

Chapter 4 CONTROLHEAD PCB/SCHEMATICS/PARTS LISTS

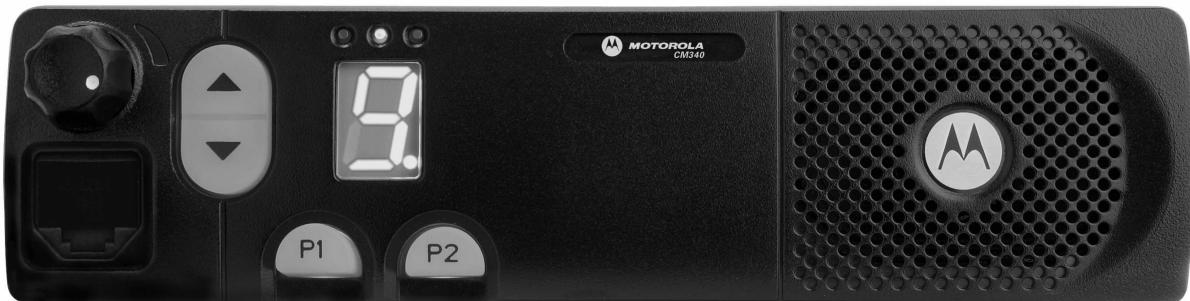
1.0 Allocation of Schematics and Circuit Boards	4-1
2.0 Controlhead CM140/340 - PCB 8488998U01 Schematics	4-3
2.1 Controlhead PCB 8488998U01 - Parts List.....	4-5
3.0 Controlhead CM160/360 - PCB 8489714U01 Schematics	4-6
3.1 Controlhead PCB 8489714U01 - Parts List	4-8

Chapter 1

OVERVIEW

1.0 CM140/CM340 Models

The Controlhead contains the internal speaker, the on/off/volume knob, the microphone connector, several buttons to operate the radio, three indicator Light Emitting Diodes (LED) to inform the user about the radio status, and a single character 7-segment display for numeric information e.g. channel number.



2.0 CM160/CM360 Models

The Controlhead contains the internal speaker, the on/off/volume knob, the microphone connector, several buttons to operate the radio, three indicator Light Emitting Diodes (LED) to inform the user about the radio status, and an 8 character Liquid Crystal Display (LCD) for alpha - numerical information e.g. channel number or call address name.



Chapter 2

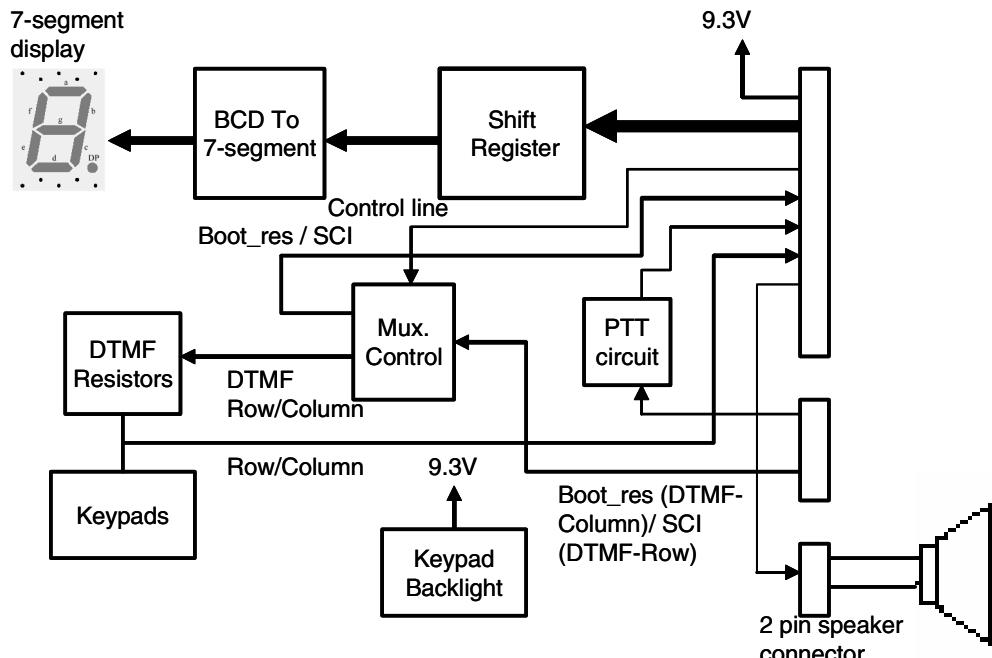
THEORY OF OPERATION

1.0 Introduction

This Chapter provides a detailed theory of operation for the Controlhead circuits. For details of the trouble shooting refer to the related chapter in this section.

2.0 Controlhead Model for CM140 and CM340

The controlhead contains the internal speaker, the on/off/volume knob, the microphone connector, several buttons to operate the radio and three indicator Light Emitting Diodes (LED) to inform the user about the radio status and a 7-segment display for numeric information.



2.1 Power Supplies

The power supply to the control head is taken from the host radio's 9.3V via connector J803-9. The 9.3V is used for the LEDs and back light, the 5V is used for the LCD driver and level shifter. The stabilized 3V is used for the other parts.

2.2 SPI Interface

The host radio (master) communicates with the control head through its SPI bus. Three lines are connected to the shift register (U801):SPI clock (J803-17), SPI MOSI (J803-16) and shift register chip select (J803-15).

When the host radio needs to send data to the shift register, the radio asserts the shift register chip select and the data is loaded to the shift register. For example, the host radio sends data to change display channel or change LED status.

2.3 Keypad Keys

The control head keypad is a four-key design. All keys are configured as two analog lines read by μ P. The voltage on the analog lines varies between 0V and 3.3 V depending on which key is pressed. If no key is pressed, the voltage at both lines is 3.3V. 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 3.3V. 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 μ P (ports PE 6 - 7) and specify the pressed button. To determine which key is pressed, the voltage of both lines must be considered.

The same analog lines also support a keypad microphone. A microphone key press is processed in the same manner like a control head key press.

2.4 Status LED's and Back Light Circuit

All indicator LEDs (red, yellow, and green) are driven by current sources. To change the LED status the host radio sends a data message to the control head shift register via the SPI bus. The control head shift register determines the LED status from the received data and switches the LEDs on or off via Q5-Q7.

The back light for the keypad is always on. The back light current for the keypad is drawn from the 9.3 V source and controlled by two current sources. The LED current is determined by the resistor at the emitter of the respective current source transistor.

2.5 Microphone Connector Signals

The MIC_PTT line (J802-3) is grounded when the PTT button on the microphone is pressed. When released, this line is pulled to 9.3V by R805. Two transistor stages (Q802, Q801 and associated parts) are used to level shift between 9.3V and 3.3V required for the μ P while keeping the same sense (active low for PTT pressed).

Two of the mic socket lines (J802-2,7) have dual functions depending on the type of microphone or SCI lead connected. An electronic switch (U803) is used to switch these two lines between mic keypad operation or SCI operation. The switch (mux) is controlled by the μ P through J803-20 with level shifting (and inversion) provided by transistor Q812. When MUX_CTRL (J803-20) is low the electronic switch is in the mic keypad mode. The mic socket (J802) pin 2 is connected to the keypad row line that goes to J803-13 and pin 7 is connected to the keypad column line that goes to J803-12. When MUX_CTRL (J803-20) is high the electronic switch is in the SCI mode. The mic socket (J802 pin 2) is connected to the SCI line that goes to J803-4 and pin 7 is connected to the BOOT_RES line that goes to J803-11.

The HOOK line (J802-6) is used to inform the μ P which type of microphone or SCI lead is connected to the microphone socket. The voltage of the HOOK line is monitored by the μ P (port PE0, MIC_SENSE) through a resistor divider on the main board. When the HOOK line is grounded (on hook condition) or floating (2.8V nominal), the μ P sets the mux (U803) for keypad operation to allow the use of microphones with a keypad. When the HOOK line is connected to 9.3V, the μ P sets the mux for SCI operation. This mode is also used to select low cost mic operation where the gain of the microphone path is increased (on the main board) to compensate for not having a pre-amp in the low cost mic.

If the BOOT_RES (J802-7) line is connected to >5V (e.g. 9.3V) at turn-on, the uP will start in boot mode instead of normal operation. This mode is used to programme new firmware into the FLASH memory (U404 mainboard).

2.6 Speaker

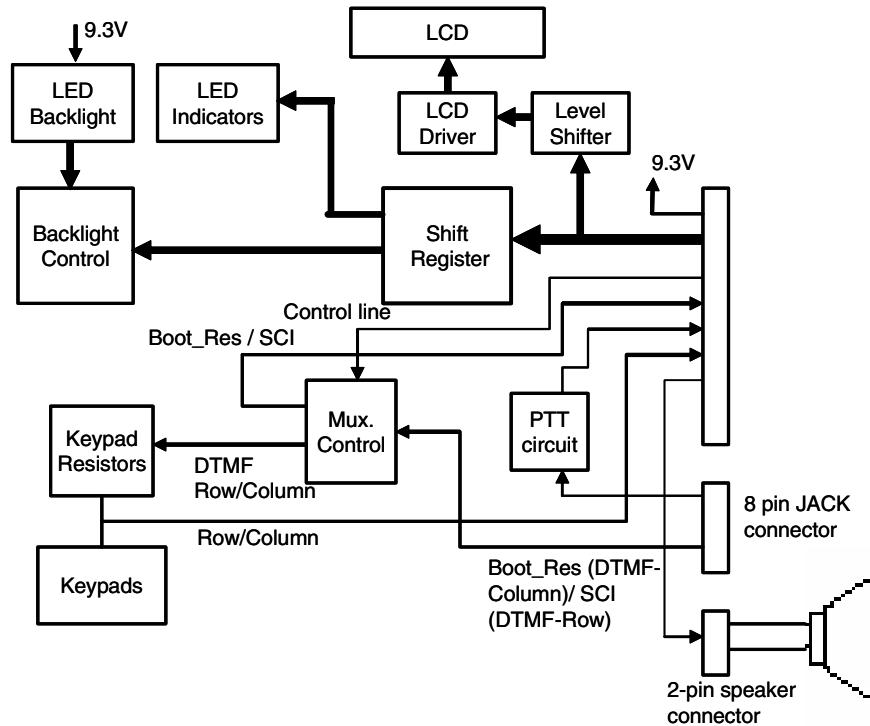
The controlhead contains a speaker for the receiver audio. The receiver audio signal from the differential audio output of the audio amplifier located on the radio's controller is fed via connector J803-1, 2 to the speaker connector P801 pin 1 and pin 2. The speaker is connected to the speaker connector P801. The controlhead speaker can be disconnected if an external speaker, connected on the accessory connector, is used.

2.7 Electrostatic Transient Protection

Electrostatic transient protection is provided for the sensitive components in the controlhead by diodes VR801, VR802, VR803 and VR804. The diodes limit any transient voltages to tolerable levels. The associated capacitors provide Radio Frequency Interference (RFI) protection.

3.0 Controlhead Model for CM160 and CM360

The controlhead contains the internal speaker, the on/off/volume knob, the microphone connector, several buttons to operate the radio, three indicator Light Emitting Diodes (LED) to inform the user about the radio status, and an 8 character Liquid Crystal Display (LCD) for alpha - numerical information e.g. channel number or call address name.



3.1 Power Supplies

The power supply to the control head is taken from the host radio's 9.3V via connector J103-9. The 9.3V is used for the LEDs and back light, the 5V is used for the LCD driver (U3) and level shifter (U4). The stabilized 3V is used for the other parts.

3.2 SPI Interface

The host radio (master) communicates with the control head through its SPI bus. Three lines are connected to the shift register (U8):SPI clock (J103-17), SPI MOSI (J103-16), shift register chip select (J103-15) and LCD driver chip select (J103-18).

When the host radio needs to send date to the shift register, the radio asserts the shift register chip select and the data is loaded to the shift register. For example, the host radio sends data to change display channel or change LED status.

3.3 Keypad Keys

The control head keypad is a four-key design. All keys are configured as two analog lines read by μ P. The voltage on the analog lines varies between 0V and 3.3 V depending on which key is pressed. If no key is pressed, the voltage at both lines is 3.3V. 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 3.3V. 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 μ P (ports PE 6 - 7) and specify the pressed button. To determine which key is pressed, the voltage of both lines must be considered.

The same analog lines also support a keypad microphone. A microphone key press is processed in the same manner like a control head key press.

3.4 LCD Driver

The LCD (36 x 4 segments) is controlled by U3. It has an on onboard clock controlled by R28 (typically 20kHz measured on pin 2). U3 is operated from the 5V supply and is controlled over the SPI bus (SPI_CLK J103-17, SPI_MOSI J103-16, LCD chip select J103-18). Chip select is active low. U2 is used to provide level shifting between the 3.3V logic from the uP and the 5V required by U3.

3.5 Status LED's and Back Light Circuit

All indicator LEDs (red, yellow, and green) are driven by current sources. To change the LED status the host radio sends a data message to the control head shift register via the SPI bus. The control head shift register determines the LED status from the received data and switches the LEDs on or off via Q8-Q10.

Backlighting for the LCD and keys is provided by a matrix of 21 LEDs arranged in 7 columns of 3 rows. The LEDs are driven from a constant current circuit (Q12, U1 and associated parts). There are 4 levels of backlight: off, low, medium and high, which are controlled by two outputs (pins 15, 1) from the shift register (U8). The current is controlled by transistor Q12. The op amp U1 monitors the current by measuring the voltage drop across R26, R27 and adjusting the bias of Q12 to achieve the required level as set by the combined shift register o/p's. When in the off state, Q11 is also turned on to clamp the base of Q12 so as to force it off. This ensures that the LEDs are fully off. Q11 is controlled by pin 3 of the shift register U8.

3.6 Microphone Connector Signals

The MIC_PTT line (J102-3) is grounded when the PTT button on the microphone is pressed. When released, this line is pulled to 9.3V by R33. Two transistor stages (Q14, Q13 and associated parts) are used to level shift between 9.3V and 3.3V required for the uP while keeping the same sense (active low for PTT pressed).

Two of the mic socket lines (J102-2, 7) have dual functions depending on which type of microphone or SCI lead that is connected. An electronic switch (U41) is used to switch these two lines between mic keypad operation or SCI operation. The switch (mux) is controlled by the uP through J103-20 with level shifting (and inversion) provided by transistor Q41. When MUX_CTRL (103-20) is low the electronic switch is in the mic keypad mode. The mic socket (J102) pin 2 is connected to the keypad row line that goes to J103-13 and pin 7 is connected to the keypad column line that goes to 103-12. When MUX_CTRL (103-20) is high the electronic switch is in the SCI mode. The mic socket (J102 pin 2) is connected to the SCI line that goes to J103-4 and pin 7 is connected to the BOOT_RES line that goes to J103-11.

The HOOK line (J102-6) is used to inform the uP which type of microphone or SCI lead is connected to the microphone socket. The voltage of the HOOK line is monitored by the uP (port PE0, MIC_SENSE) through a resistor divider on the main board. When the HOOK line is grounded (on hook condition) or floating (2.8V nominal), the uP sets the mux (U8) for keypad operation to allow the use of microphones with a keypad. When the HOOK line is connected to 9.3V, the uP sets the mux for SCI operation. This mode is also used to select low cost mic operation where the gain of the microphone path is increased (on the main board) to compensate for not having a pre-amp in the low cost mic.

If the BOOT_RES (J102-7) line is connected to >5V (e.g. 9.3V) at turn-on then the uP will start in boot mode instead of normal operation. This mode is used to programme new firmware into the FLASH memory (U404 mainboard).

3.7 Speaker

The controlhead 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 J103-1, 2 to the speaker connector P101 pin 1 and pin 2. The speaker is connected to the speaker connector P101. The controlhead speaker can be disconnected if an external speaker, connected on the accessory connector, is used.

3.8 Electrostatic Transient Protection

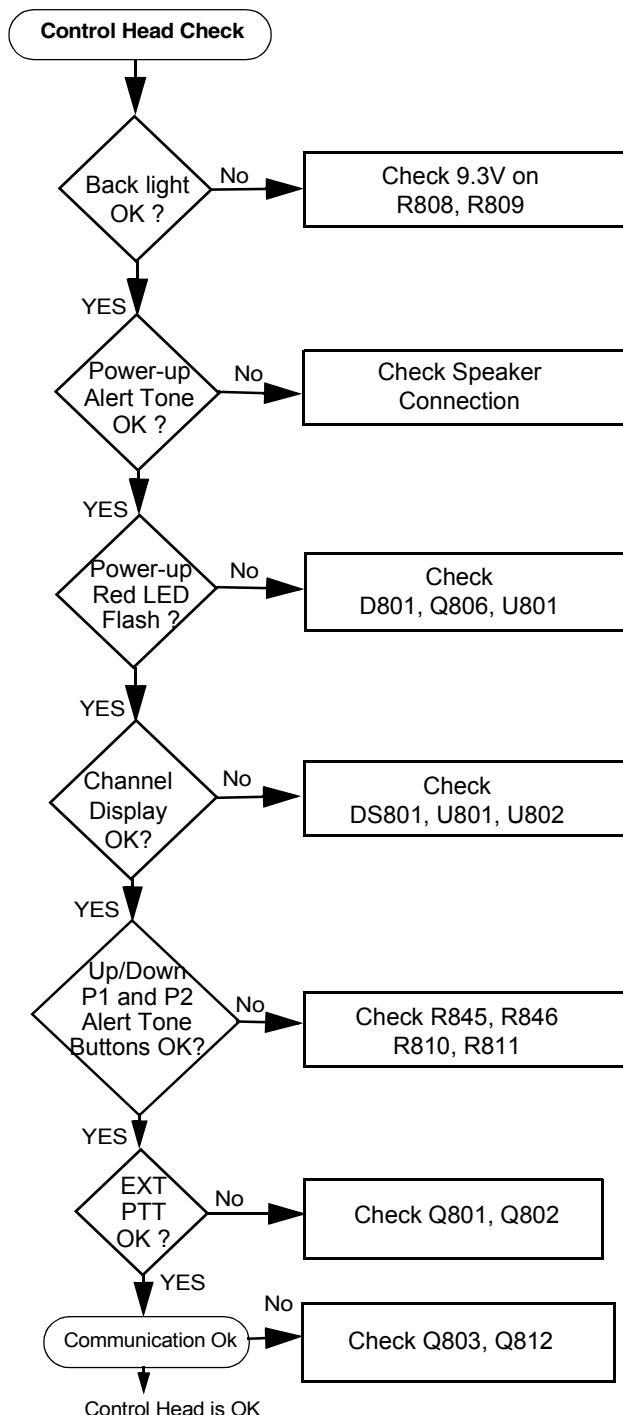
Electrostatic transient protection is provided for the sensitive components in the controlhead by diodes VR1 - VR4. The diodes limit any transient voltages to tolerable levels. The associated capacitors provide Radio Frequency Interference (RFI) protection.

Chapter 3

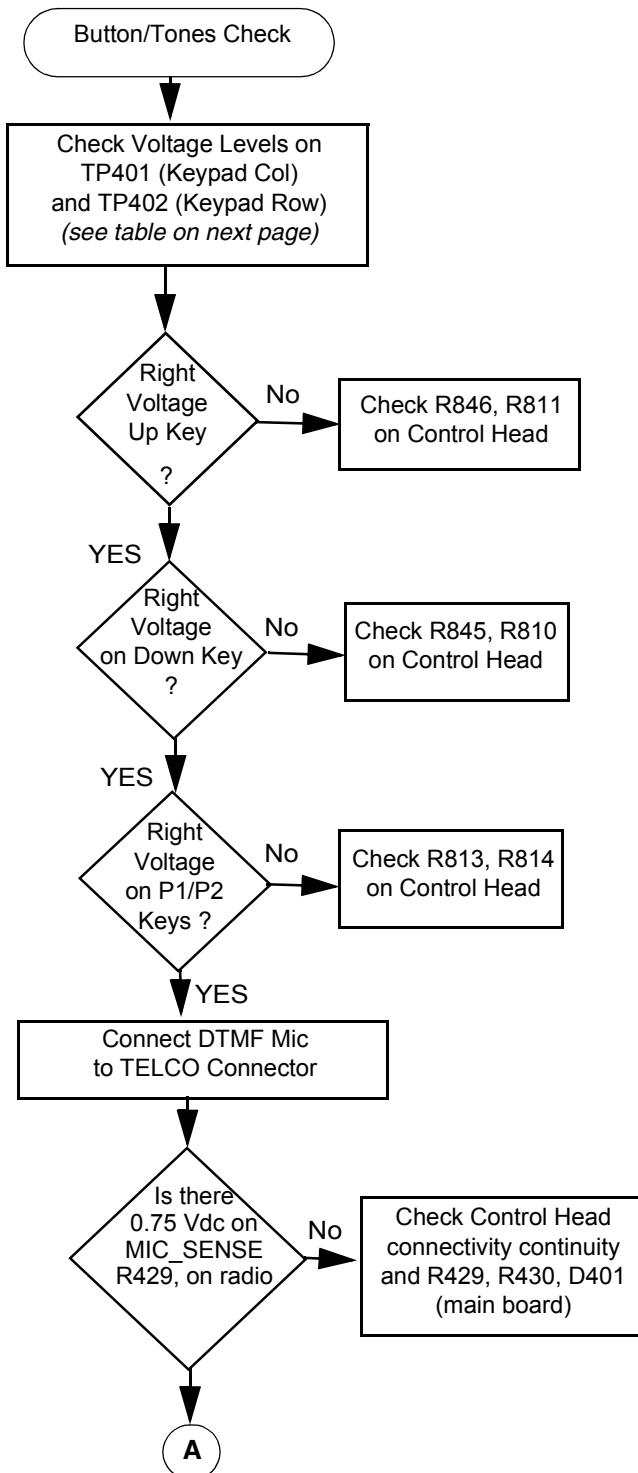
TROUBLESHOOTING CHARTS

1.0 Controlhead CM140/CM340 Troubleshooting Chart

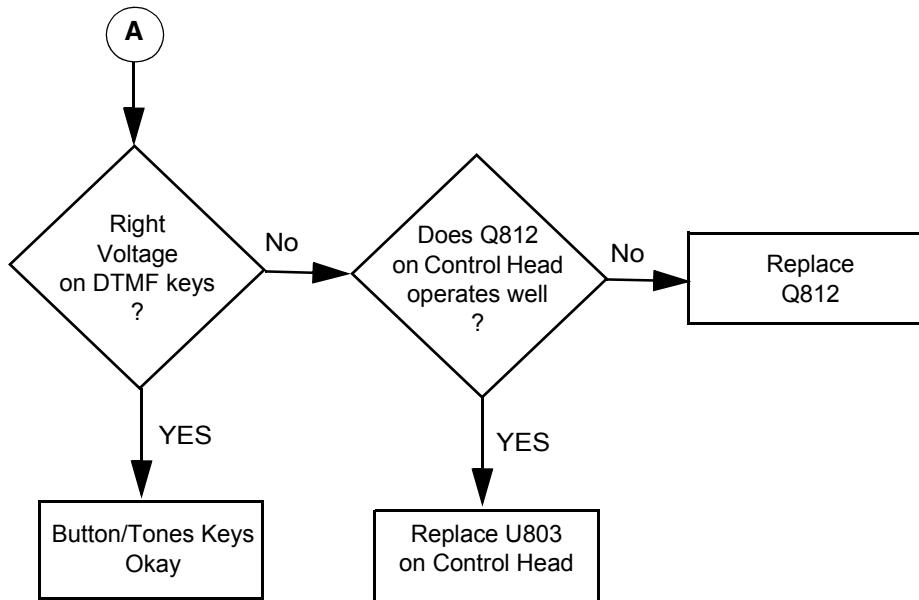
1.1 Control Head Failure



1.2 Button/Tones Select Error (Page 1 of 2)



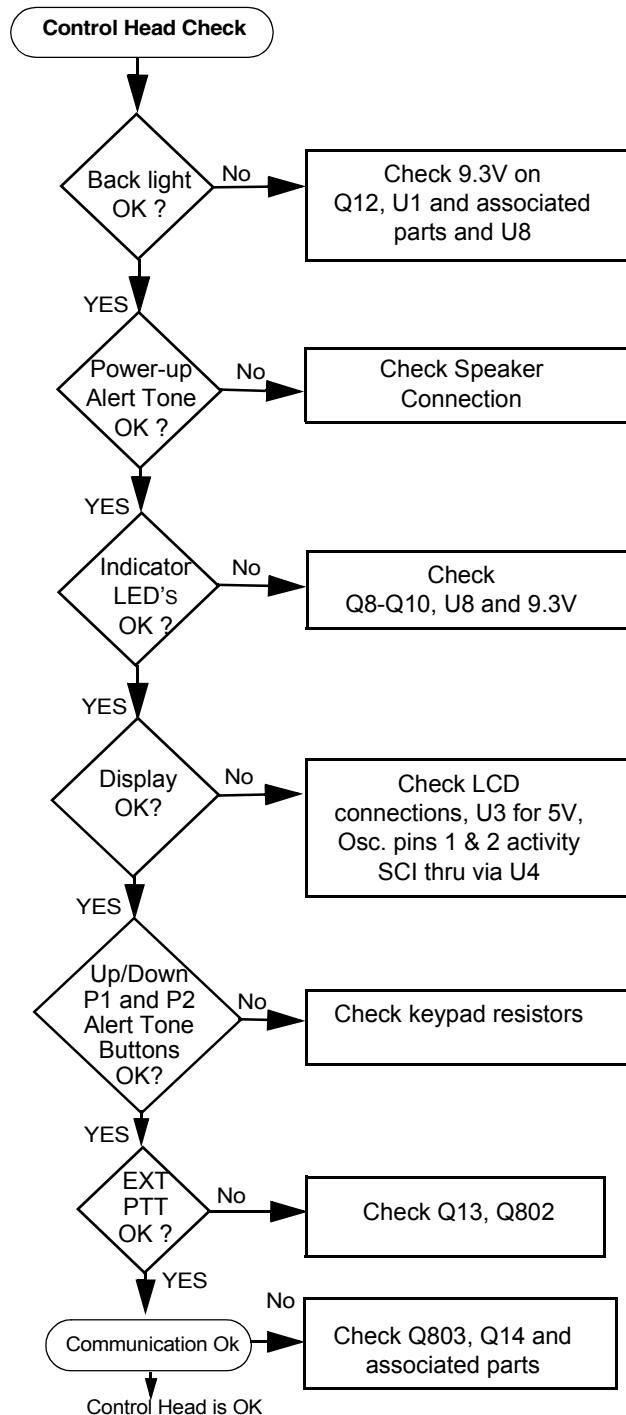
1.3 Button/Tones Select Error (Page 2 of 2)



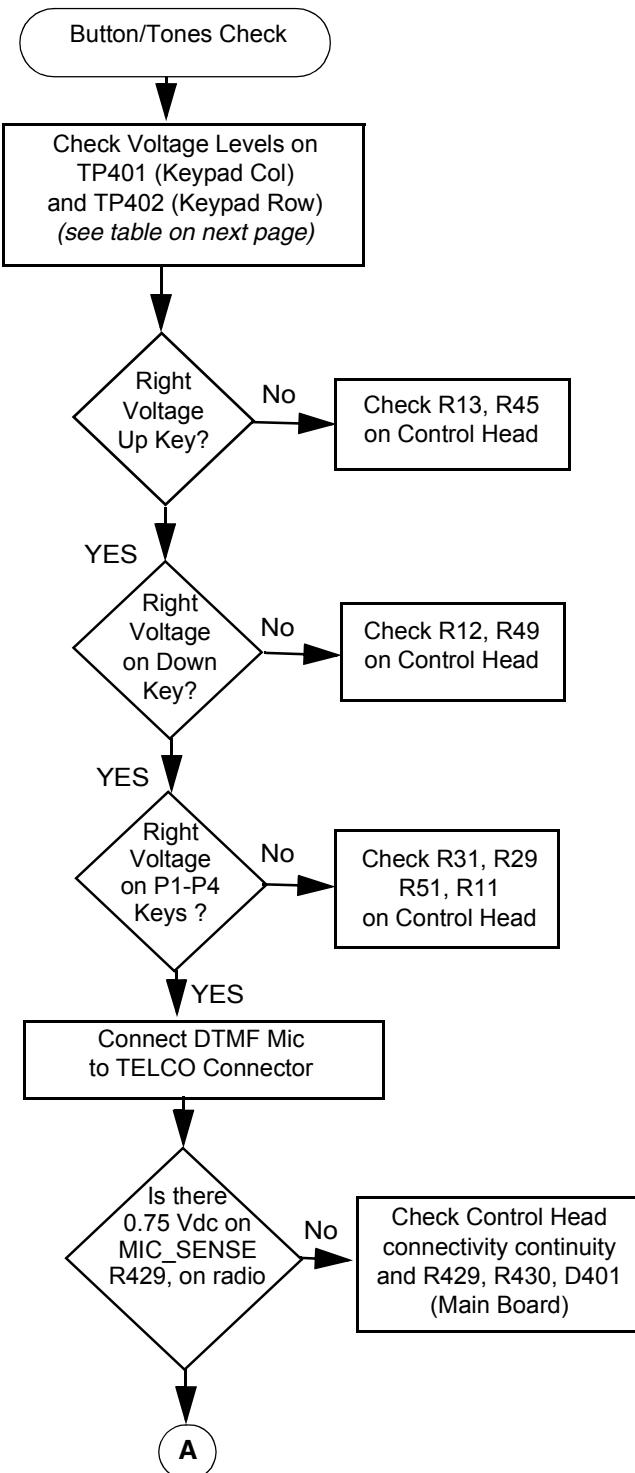
Key_Col Voltage (TP401)	Key_Column Voltage TP401					
	0.008 V	0.675 V	1.346 V	1.997 V	2.650 V	3.300 V
Key_Row Voltage TP402						Up
0.008 V						
0.675 V			1	2	3	
1.346 V		4	5	6	7	
1.997 V		8	9	0	*	
2.650 V		#	C	B	A	
3.300 V	Down	Left Key P1	Right Key P2			Idle

2.0 Controlhead CM160/CM360 Troubleshooting Chart

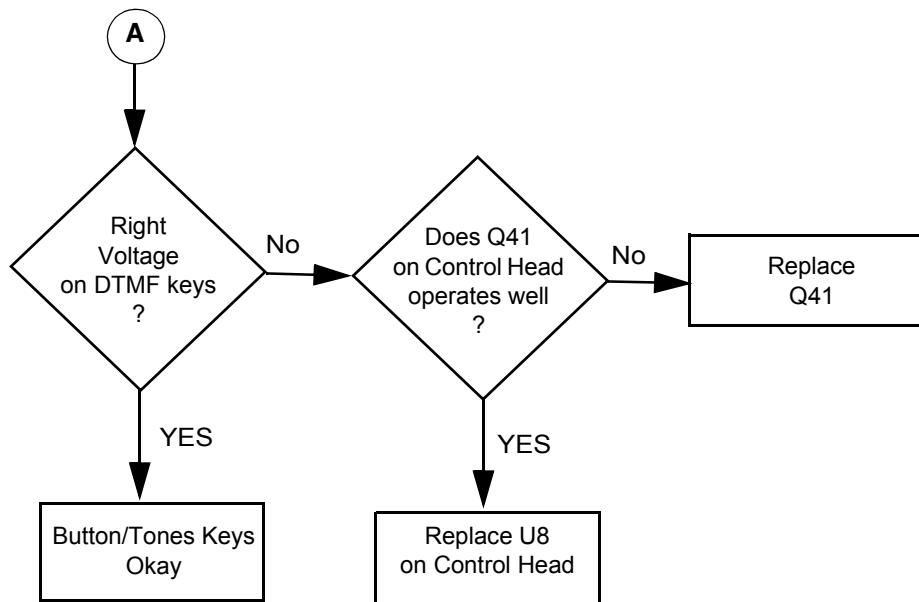
2.1 Control Head Failure



2.2 Button/Tones Select Error (Page 1 of 2)



2.3 Button/Tones Select Error (Page 2 of 2)



Key_Row Voltage TP402	Key_Column Voltage TP401					
	0.008 V	0.675 V	1.346 V	1.997 V	2.650 V	3.300 V
0.008 V						Up
0.675 V			1	2	3	
1.346 V		4	5	6	7	
1.997 V		8	9	0	*	
2.650 V		#	C	B	A	
3.300 V	Down	Left Key P1	Right Key P2	P3	P4	Idle

Chapter 4

CONTROLHEAD PCB / SCHEMATICS / PARTS LISTS

1.0 Allocation of Schematics and Circuit Boards

Table 4-1 Controlhead Diagrams and Parts Lists

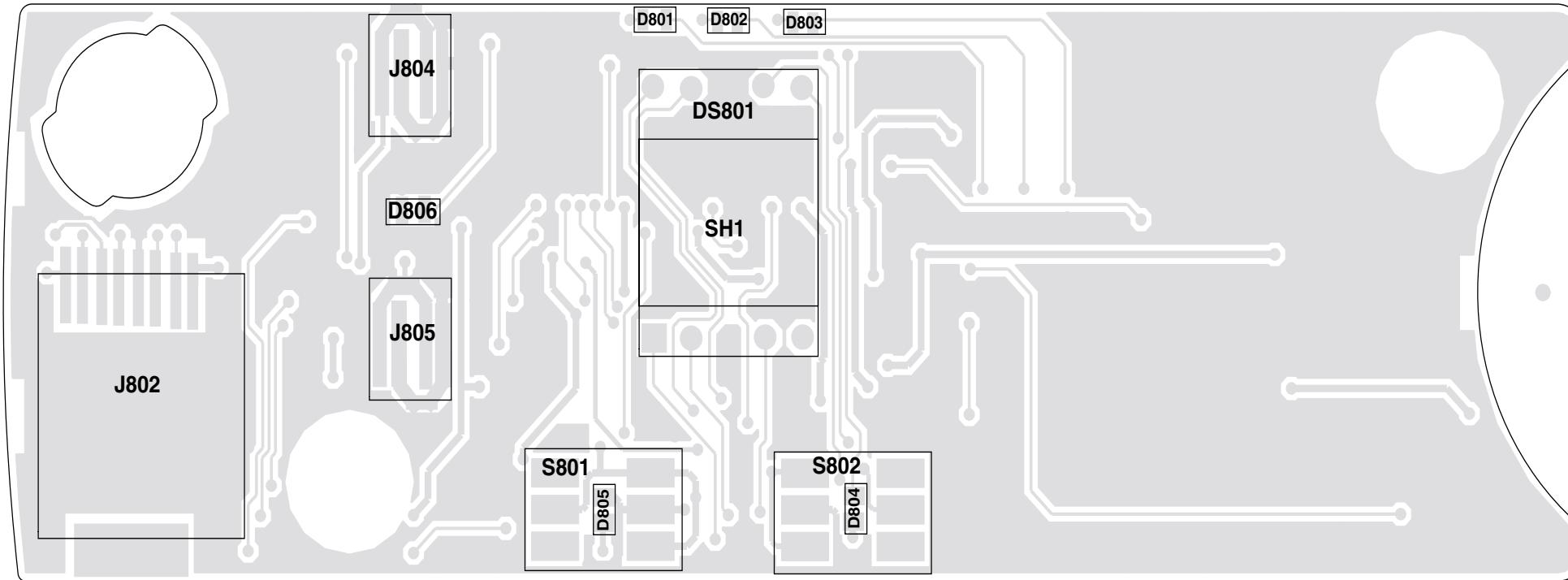
PCB : Controlhead CM140/CM340 8488998U01 Main Board Top Side 8488998U01 Main Board Bottom Side	Page 4-3 Page 4-3
SCHEMATICS Sheet 1 of 1	Page 4-4
Parts List 8488998U01	Page 4-5

Table 4-2 Controlhead Diagrams and Parts Lists

PCB : Controlhead CM160/CM360 8489714U01 Main Board Top Side 8489714U01 Main Board Bottom Side	Page 4-6 Page 4-6
SCHEMATICS Sheet 1 of 1	Page 4-7
Parts List 8489714U01	Page 4-8

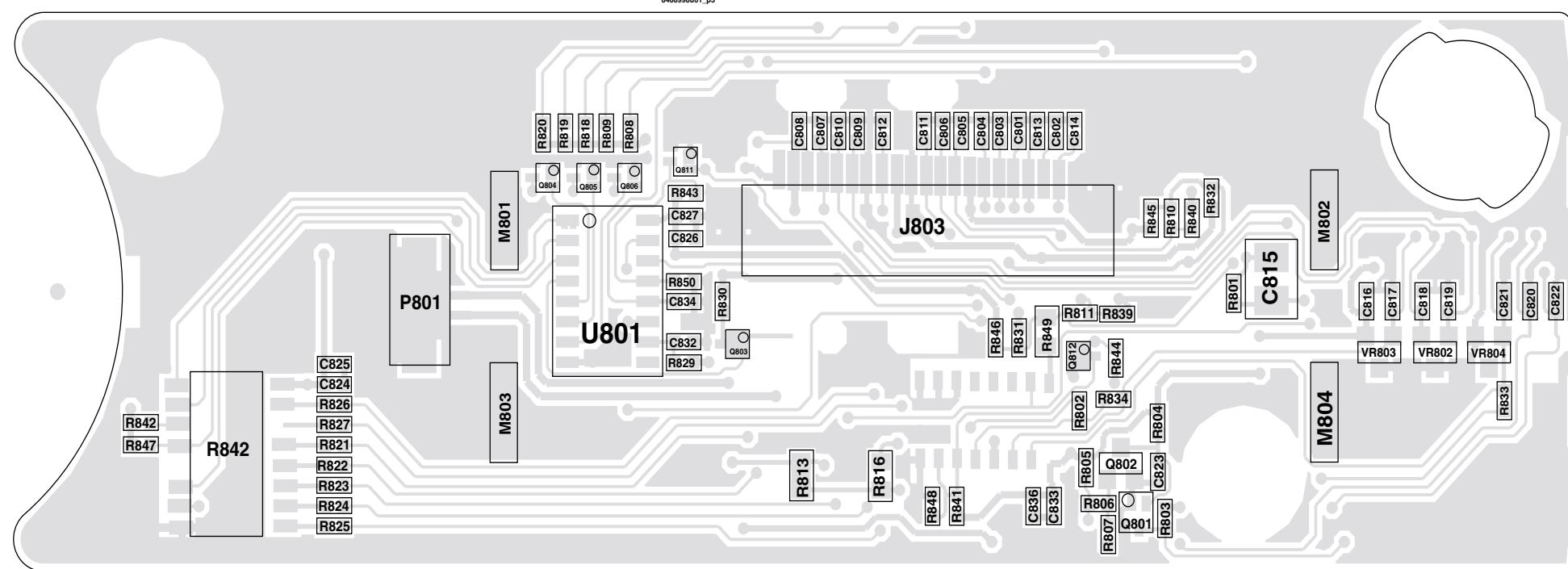
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2.0 Controlhead CM140/CM340 - PCB 8488998U01 / Schematics



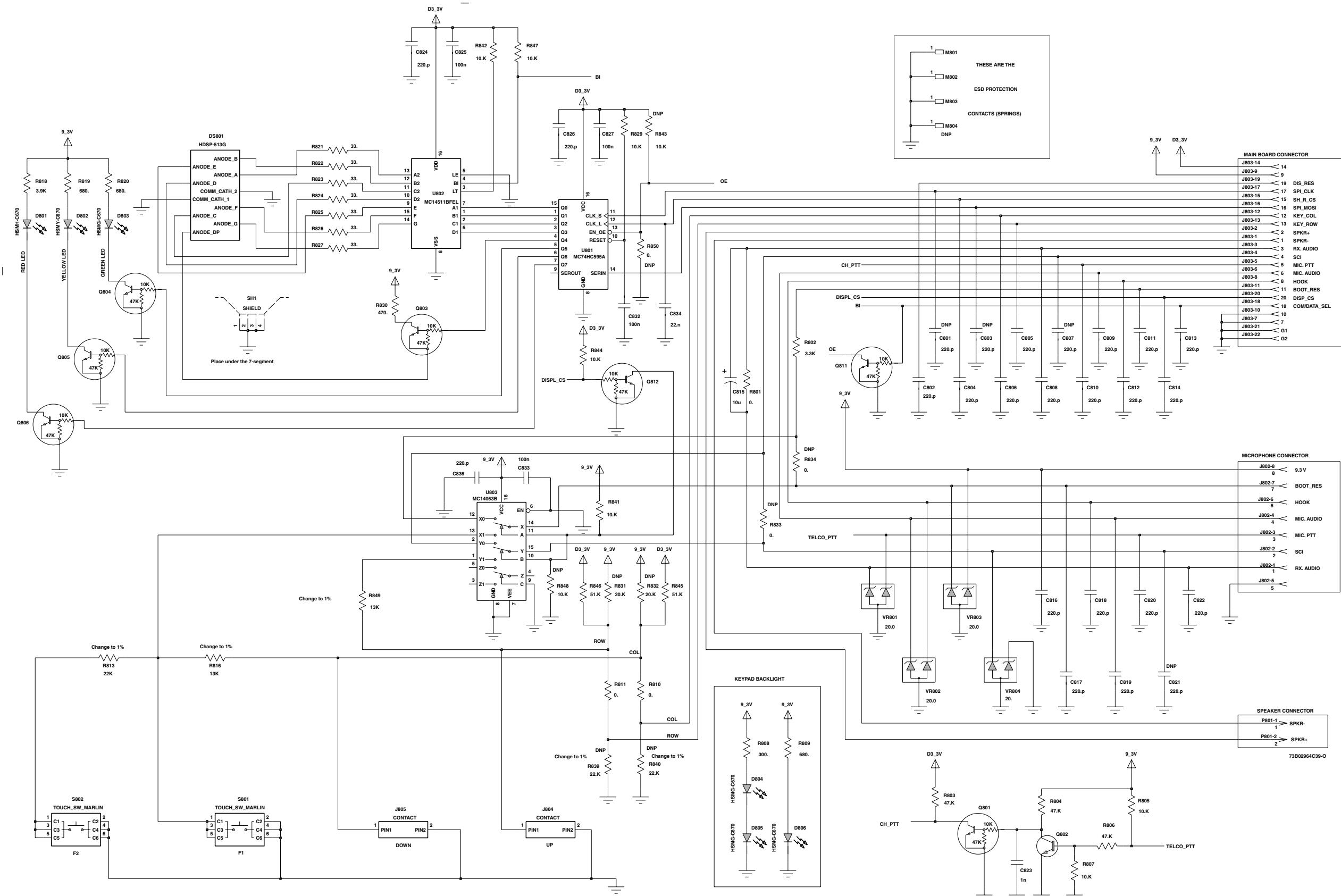
SHOWN FROM SIDE 1

Top Side



SHOWN FROM SIDE 2

**Controlhead CM140/CM340
PCB 8488998U01**



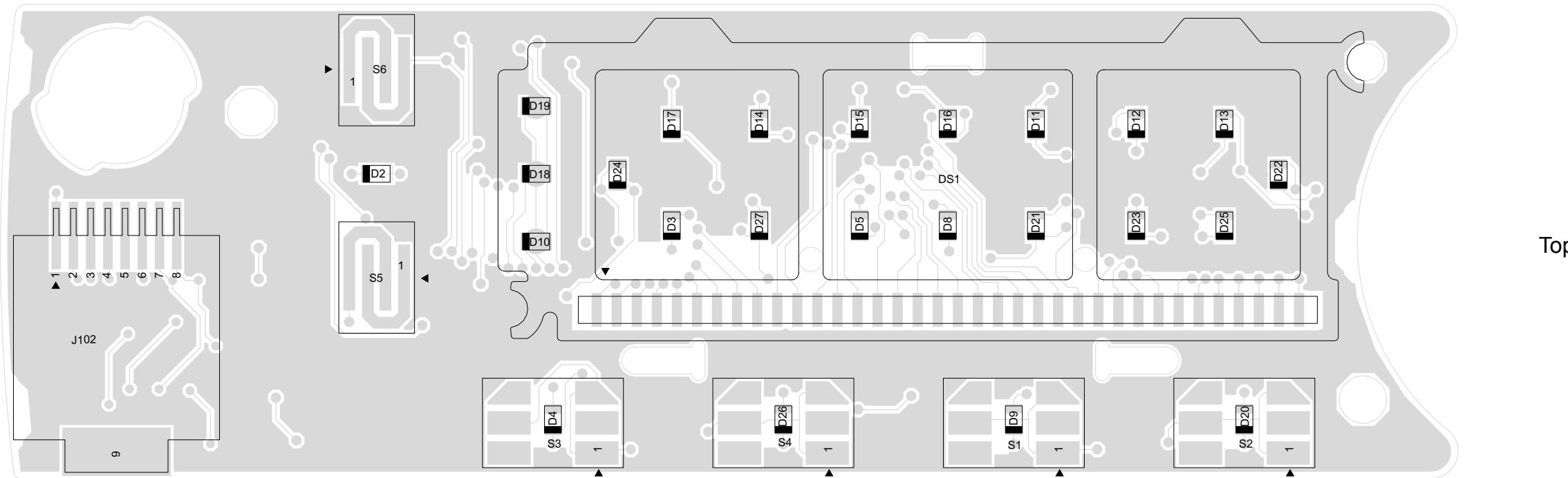
Controlhead CM140/CM340 Schematic

2.1 Controlhead PCB 8488998U01 Parts List

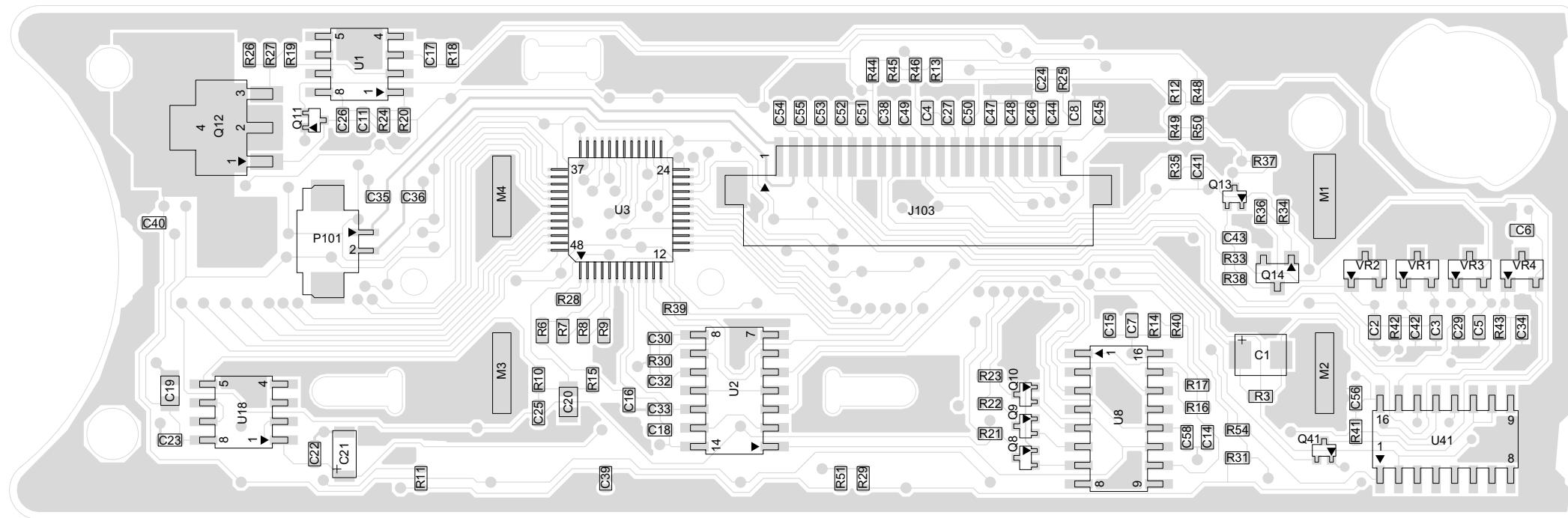
Circuit Ref	Motorola Part No	Description
C802	2113740F59	CAP CHIP REEL CL13
C804	2113740F59	CAP CHIP REEL CL13
C805	2113740F39	CAP CHIP REEL CL1+/-30 33
C806	2113740F39	CAP CHIP REEL CL1+/-30 33
C808	2113740F59	CAP CHIP REEL CL13
C809	2113740F39	CAP CHIP REEL CL1+/-30 33
C810	2113740F39	CAP CHIP REEL CL1+/-30 33
C811	2113740F59	CAP CHIP REEL CL13
C812	2113740F39	CAP CHIP REEL CL1+/-30 33
C813	2113740F59	CAP CHIP REEL CL13
C814	2113740F59	CAP CHIP REEL CL13
C816	2113740F39	CAP CHIP REEL CL1+/-30 33
C817	2113740F39	CAP CHIP REEL CL1+/-30 33
C818	2113740F39	CAP CHIP REEL CL1+/-30 33
C819	2113740F39	CAP CHIP REEL CL1+/-30 33
C820	2113740F39	CAP CHIP REEL CL1+/-30 33
C821	2113740F29	CAP CHIP REEL CL1+/-30 12
C822	2113740F39	CAP CHIP REEL CL1+/-30 33
C823	2113743K15	CER CHIP CAP .100uF
C824	2113740F59	CAP CHIP REEL CL13
C825	2113743K15	CER CHIP CAP .100uF
C826	2113740F59	CAP CHIP REEL CL13
C827	2113743K15	CER CHIP CAP .100uF
C832	2113743K15	CER CHIP CAP .100uF
C833	2113743K15	CER CHIP CAP .100uF
C834	2113743E07	CER CHIP CAP .022uF
C836	2113740F59	CAP CHIP REEL CL13
D801	4805729G74	LED SMT RED HP
D802	4805729G73	LED SMT YEL HP
D803	4805729G75	LED SMT GREEN HP
D804	4805729G75	LED SMT GREEN HP
D805	4805729G75	LED SMT GREEN HP
D806	4805729G75	LED SMT GREEN HP
DS801	5180353L02	7-SEGMENT DISPLAY
J802	0908353Y02	MODULAR 8-PIN STR

Circuit Ref	Motorola Part No	Description
J803	0989241U02	FLEX 20-PIN 1mmTOP NON
M801	7588823L03	PAD GROUNFD LCD
M802	7588823L03	PAD GROUNFD LCD
M803	7588823L03	PAD GROUNFD LCD
M804	7588823L03	PAD GROUNFD LCD
P801	2809926G01	CONN 1.25MM 2PIN SURMT
Q801	4809940E02	TSTR NPN DIG DTC114YE
Q802	4813824A10	TSTR NPN 40V .2A GEN P
Q803	4809940E02	TSTR NPN DIG DTC114YE
Q804	4809940E02	TSTR NPN DIG DTC114YE
Q805	4809940E02	TSTR NPN DIG DTC114YE
Q806	4809940E02	TSTR NPN DIG DTC114YE
Q811	4809940E02	TSTR NPN DIG DTC114YE
Q812	4809940E02	TSTR NPN DIG DTC114YE
R801	0662057A01	CHIP RES 10 OHMS 5%
R802	0662057A61	CHIP RES 330 OHMS 5%
R803	0662057A89	CHIP RES 47K OHMS 5%
R804	0662057A89	CHIP RES 47K OHMS 5%
R805	0662057A73	CHIP RES 10K OHMS 5%
R806	0662057A89	CHIP RES 47K OHMS 5%
R807	0662057A73	CHIP RES 10K OHMS 5%
R808	0662057A36	CHIP RES 300 OHMS 5%
R809	0662057A45	CHIP RES 680 OHMS 5%
R810	0662057B47	CHIP RES 0 OHMS +0.5
R811	0662057B47	CHIP RES 0 OHMS +0.5
R813	0662057D08	CHIP RES 22K OHMS 5%
R816	0662057D03	CHIP RES 13K OHMS 5%
R818	0662057A63	CHIP RES 3900 OHMS 5%
R819	0662057A45	CHIP RES 680 OHMS 5%
R820	0662057A45	CHIP RES 680 OHMS 5%
R821	0662057A13	CHIP RES 33 OHMS 5%
R822	0662057A13	CHIP RES 33 OHMS 5%
R823	0662057A13	CHIP RES 33 OHMS 5%
R824	0662057A13	CHIP RES 33 OHMS 5%
R825	0662057A13	CHIP RES 33 OHMS 5%
R826	0662057A13	CHIP RES 33 OHMS 5%
R827	0662057A13	CHIP RES 33 OHMS 5%
R829	0662057A73	CHIP RES 10K OHMS 5%

3.0 Controlhead CM160/CM360 - PCB 8489714U01 / Schematics

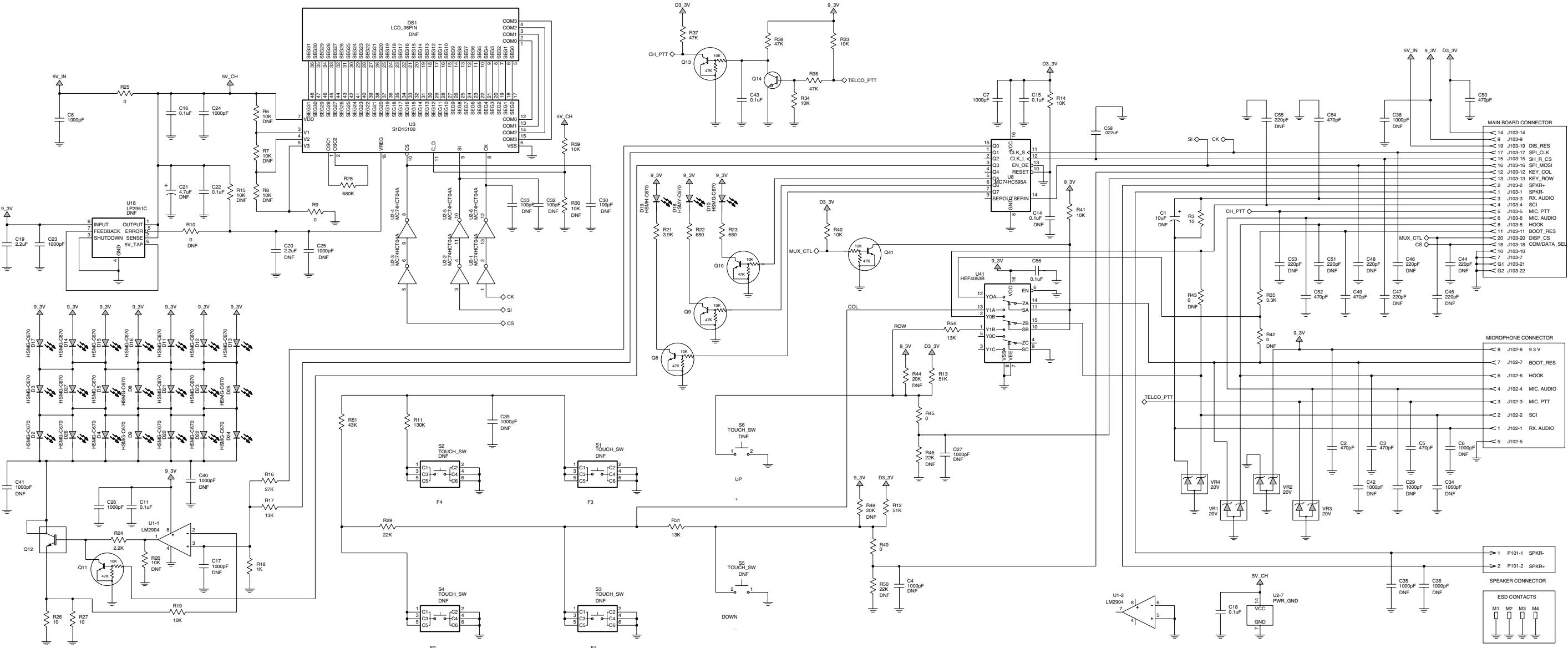


Top Side



Bottom Side

**Controlhead CM160/CM360 PCB
8489714U01**



Controlhead CM160/CM360 Schematic

3.1 Controlhead PCB 8489714U01 Parts List

Circuit Ref	Motorola Part No	Description
C1	NOTPLACED	CAP, 10uF
C2	2113740F67	CAP, 470pF
C3	2113740F67	CAP, 470pF
C4	2113740F12	CAP CHIP REEL CL1 +/-30 12
C5	2113740F67	CAP, 470pF
C6	2113740F12	CAP CHIP REEL CL1 +/-30 12
C7	2113741F25	CAP, 1000pF
C8	2113741F25	CAP, 1000pF
C11	2113743K15	CAP, 0.1uF
C14	NOTPLACED	CAP, 0.1uF
C15	2113743K15	CAP, 0.1uF
C16	2113743K15	CAP, 0.1uF
C17	NOTPLACED	CAP, 1000pF
C18	2113743K15	CAP, 0.1uF
C19	2113743F18	CAP, 2.2uF
C20	NOTPLACED	CAP, 2.2uF
C21	NOTPLACED	CAPP, 4.7uF
C22	2113743K15	CAP, 0.1uF
C23	2113741F25	CAP, 1000pF
C24	2113741F25	CAP, 1000pF
C25	NOTPLACED	CAP, 1000pF
C26	2113741F25	CAP, 1000pF
C27	2113740F12	CAP CHIP REEL CL1 +/-30 12
C29	2113740F12	CAP CHIP REEL CL1 +/-30 12
C30	NOTPLACED	CAP, 100pF
C32	NOTPLACED	CAP, 100pF
C33	NOTPLACED	CAP, 100pF
C34	2113740F12	CAP CHIP REEL CL1 +/-30 12
C35	NOTPLACED	CAP, 1000pF
C36	NOTPLACED	CAP, 1000pF
C38	NOTPLACED	CAP, 1000pF
C39	NOTPLACED	CAP, 1000pF
C40	NOTPLACED	CAP, 1000pF
C41	NOTPLACED	CAP, 1000pF
C42	2113740F12	CAP CHIP REEL CL1 +/-30 12
C43	2113743K15	CAP, 0.1uF

Circuit Ref	Motorola Part No	Description
C44	NOTPLACED	CAP, 220pF
C45	NOTPLACED	CAP, 220pF
C46	NOTPLACED	CAP, 220pF
C47	NOTPLACED	CAP, 220pF
C48	NOTPLACED	CAP, 220pF
C49	2113740F67	CAP, 470pF
C50	2113740F67	CAP, 470pF
C51	2113740F12	CAP CHIP REEL CL1 +/-30 12
C52	2113740F67	CAP, 470pF
C53	2113740F12	CAP CHIP REEL CL1 +/-30 12
C54	2113740F67	CAP, 470pF
C55	NOTPLACED	CAP, 220pF
C56	2113743K15	CAP, 0.1uF
C58	2113743E07	CAP, .022uF
D2	4805729G75	HSMG-C670
D3	4805729G75	HSMG-C670
D4	4805729G75	HSMG-C670
D5	4805729G75	HSMG-C670
D8	4805729G75	HSMG-C670
D9	4805729G75	HSMG-C670
D10	4805729G75	HSMG-C670
D11	4805729G75	HSMG-C670
D12	4805729G75	HSMG-C670
D13	4805729G75	HSMG-C670
D14	4805729G75	HSMG-C670
D15	4805729G75	HSMG-C670
D16	4805729G75	HSMG-C670
D17	4805729G75	HSMG-C670
D18	4805729G73	HSMY-C670
D19	4805729G74	HSMH-C670
D20	4805729G75	HSMG-C670
D21	4805729G75	HSMG-C670
D22	4805729G75	HSMG-C670
D23	4805729G75	HSMG-C670
D24	4805729G75	HSMG-C670
D25	4805729G75	HSMG-C670
D26	4805729G75	HSMG-C670
D27	4805729G75	HSMG-C670
DS1	NOTPLACED	LCD_36PIN
J102	0908353Y02	CONN_J
J103	0989241U02	CONN_J
M1	7588823L03	CONTACT
M2	7588823L03	CONTACT
M3	7588823L03	CONTACT
M4	7588823L03	CONTACT
P101	2809926G01	CONN_P
Q8	4809940E02	DTC114YE
Q9	4809940E02	DTC114YE
Q10	4809940E02	DTC114YE
Q11	4809940E02	DTC114YE
Q12	4813824B01	PZT2222A
Q13	4809940E02	DTC114YE
Q14	4813824A10	MMBT3904
Q41	4809940E02	DTC114YE
R3	0662057A01	RES, 10
R6	NOTPLACED	RES, 10K
R7	NOTPLACED	RES, 10K
R8	NOTPLACED	RES, 10K
R9	0662057B47	RES, 0
R10	NOTPLACED	RES, 0
R11	0662057B01	RES, 130K
R12	0662057A90	RES, 51K
R13	0662057A90	RES, 51K
R14	0662057A73	RES, 10K
R15	NOTPLACED	RES, 10K
R16	0662057A83	RES, 27K
R17	0662057A76	RES, 13K
R18	0662057A49	RES, 1K
R19	0662057A73	RES, 10K
R20	NOTPLACED	RES, 10K
R21	0662057A63	RES, 3.9K
R22	0662057A45	RES, 680
R23	0662057A45	RES, 680
R24	0662057A57	RES, 2.2K
R25	0662057B47	RES, 0
R26	0662057A01	RES, 10
R27	0662057A01	RES, 10
R28	0662057B18	RES, 680K



MOTOROLA

Commercial Series

CM Radios

UHF2 (438-470MHz)

Service Information

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Table of Contents

Chapter 1 MODEL CHART AND TECHNICAL SPECIFICATIONS

1.0 CM140/CM340/CM160/CM360 Model Chart	1-1
2.0 Technical Specifications	1-2

Chapter 2 THEORY OF OPERATION

1.0 Introduction	2-1
2.0 UHF (438-470MHz) Receiver	2-1
2.1 Receiver Front-End	2-1
2.2 Receiver Back-End	2-2
3.0 UHF (438-470MHz) Transmitter Power Amplifier	2-2
3.1 First Power Controller Stage.....	2-2
3.2 Power Controlled Driver Stage	2-3
3.3 Final Stage.....	2-3
3.4 Directional Coupler.....	2-3
3.5 Antenna Switch.....	2-3
3.6 Harmonic Filter	2-4
3.7 Power Control.....	2-4
4.0 UHF (438-470MHz) Frequency Synthesis	2-4
4.1 Reference Oscillator	2-4
4.2 Fractional-N Synthesizer	2-5
4.3 Voltage Controlled Oscillator (VCO)	2-6
4.4 Synthesizer Operation	2-7
5.0 Controller Theory of Operation	2-8
5.1 Radio Power Distribution	2-8
5.2 Protection Devices.....	2-10
5.3 Automatic On/Off	2-10
5.4 Microprocessor Clock Synthesiser	2-11
5.5 Serial Peripheral Interface (SPI).....	2-12
5.6 SBEP Serial Interface	2-12
5.7 General Purpose I/O.....	2-12
5.8 Normal Microprocessor Operation.....	2-13
5.9 Static Random Access Memory.....	2-14
6.0 Control Board Audio and Signalling Circuits	2-14
6.1 Audio Signalling Filter IC and Compander (ASFIC CMP)	2-14
7.0 Transmit Audio Circuits.....	2-15
7.1 Microphone Input Path	2-15
7.2 PTT Sensing and TX Audio Processing	2-16

8.0	Transmit Signalling Circuits	2-17
8.1	Sub-Audio Data (PL/DPL)	2-17
8.2	High Speed Data	2-18
8.3	Dual Tone Multiple Frequency (DTMF) Data	2-18
9.0	Receive Audio Circuits.....	2-19
9.1	Squelch Detect	2-19
9.2	Audio Processing and Digital Volume Control.....	2-20
9.3	Audio Amplification Speaker (+) Speaker (-)	2-20
9.4	Handset Audio	2-21
9.5	Filtered Audio and Flat Audio	2-21
10.0	Receive Audio Circuits	2-21
10.1	Sub-Audio Data (PL/DPL) and High Speed Data Decoder	2-21
10.2	Alert Tone Circuits	2-22

Chapter 3 TROUBLESHOOTING CHARTS

1.0	Troubleshooting Flow Chart for Receiver RF (Sheet 1 of 2).....	3-2
1.1	Troubleshooting Flow Chart for Receiver (Sheet 2 of 2)	3-3
2.0	Troubleshooting Flow Chart for 25W Transmitter (Sheet 1 of 3)	3-4
2.1	Troubleshooting Flow Chart for 25W Transmitter (Sheet 2 of 3)	3-5
2.2	Troubleshooting Flow Chart for 25W Transmitter (Sheet 3 of 3).....	3-6
3.0	Troubleshooting Flow Chart for Synthesizer	3-7
4.0	Troubleshooting Flow Chart for VCO.....	3-8
5.0	Troubleshooting Flow Chart for DC Supply (Sheet 1 of 2)	3-9
5.1	Troubleshooting Flow Chart for DC Supply (Sheet 2 of 2)	3-10

Chapter 4 UHF PCB/SCHEMATICS/PARTS LISTS

1.0	Allocation of Schematics and Circuit Boards	4-1
1.1	UHF2 and Controller Circuits	4-1
2.0	UHF2 1-25W PCB 8488978U01 (Rev. D) / Schematics	4-3
2.1	UHF2 1-25W PCB 8488978U01 (Rev. D) Parts List	4-19

Chapter 1

MODEL CHART AND TECHNICAL SPECIFICATIONS

1.0 CM140/CM340/CM160/CM360 Model Chart

CM Series UHF2 438-470MHz					
Model			Description		
MDM50RNC9AA2_N			CM140 438-470 MHz 1-25W 8-Ch		
MDM50RNC9AN2_N			CM340 438-470 MHz 1-25W 10-Ch		
MDM50RNF9AA2_N			CM160 438-470 MHz 1-25W 64-Ch		
MDM50RNF9AN2_N			CM360 438-470 MHz 1-25W 100-Ch		
Item			Description		
X			FUE1021_	S. Tanapa UHF2 25W 8 Ch BNC	
	X		PMUE2019_	S. Tanapa UHF2 25W 10 Ch BNC	
		X	PMUE1999_	S. Tanapa UHF2 25W 64 Ch BNC	
			X	PMUE2021_	
X	X		FCN6288_	Control Head	
		X	X	FCN5523_	Control Head
X	X	X	X	HKN4137_	Battery Power Cable
X	X	X	X	RMN50188_	Mag One Microphone
		X	X	HMN3596_	Compact Microphone
X	X	X	X	GLN7324_	Low Profile Trunnion
X	X	X	X	6866546D02_	RTTE Leaflet
X	X	X	X	6866537D37_	Safety Leaflet
X				FLE1621AS	Servicing Kit CM140
	X			PMUE2041AS	Servicing Kit CM340
		X		PMUE2027AS	Servicing Kit CM160
			X	PMUE2043AS	Servicing Kit CM360

X = Indicates one of each is required

2.0 Technical Specifications

Data is specified for +25°C unless otherwise stated.

General	
Specification	UHF2
Frequency Range:	438-470 MHz
Frequency Stability (-30°C to +60°C, 25°C Ref.)	±2 PPM
Channel Capacity:	CM140 - 8 CM340 - 10 CM160 - 64 CM360 - 100
Channel Spacing:	12.5/20/25 kHz
Power Output:	1-25W
Power Supply:	13.2Vdc (10.8 - 15.6 Vdc) negative vehicle ground
Dimensions (L X W X H)	118mm X 169mm X 44mm
Weight: Low power (1-25W)	1.02 Kg
Operating Temperature	-30 to 60 ° C
Storage temperature	-40 to 80° C
Shock and Vibration	Meets MIL-STD 810-C,D&E and TIA/EIA 603
Dust	Meets MIL-STD 810-C,D&E and TIA/EIA 603
Humidity	Meets MIL-STD 810-C,D&E and TIA/EIA 603

Transmitter	
Specification	UHF2
Frequency Stability:	+/- 2.5ppm
Modulation Limiting:	$\pm 2.5 \text{ kHz}$ @ 12.5 kHz $\pm 4.0 \text{ kHz}$ @ 20 kHz $\pm 5.0 \text{ kHz}$ @ 20/25 kHz
Current Drain Transmit:	8A (25W)
FM Hum and Noise:	-35 dB@12.5 kHz -40 dB@ 20/25 kHz
Conducted/Radiated Emissions:	-36 dBm < 1 GHz -30 dBm > 1 GHz
Adjacent Channel Power	-60dB @12.5, -70dB @ 20/25kHz
Audio Response: (300 to 3000Hz)	+1, -3dB
Audio Distortion: @ 1000 Hz, 60% Rated Maximum Deviation:	3% Typical

Receiver	
Specification	UHF2
Sensitivity (12dBSINAD): (ETS)	0.35µV (12.5kHz) 0.30µV (25kHz) Typical
Intermodulation : (ETS)	>65dB
Adjacent Channel Selectivity: (ETS)	70 dB @ 25 kHz 60 dB @ 12.5 kHz
Spurious Rejection: (ETS)	70 dB
Rated Audio: (ETS) (Extended audio with 4 Ohm speaker)	4W Internal , 13W External
Audio Distortion @ Rated Audio:	3% Typical
Hum and Noise:	-35 dB @ 12.5 kHz -40 dB @ 20/25 kHz
Audio Response: (300 to 3000Hz)	+1, -3dB
Conducted Spurious Emission per FCC Part 15:	-57 dBm <1 GHz -47 dBm >1 GHz

*Availability subject to the laws and regulations of individual countries.

Chapter 2

THEORY OF OPERATION

1.0 Introduction

This Chapter provides a detailed theory of operation for the UHF circuits in the radio. Details of the theory of operation and trouble shooting for the the associated Controller circuits are included in this Section of the manual.

2.0 UHF (438-470MHz) Receiver

2.1 Receiver Front-End

The received signal is applied to the radio's antenna input connector and routed through the harmonic filter and antenna switch. The insertion loss of the harmonic filter/antenna switch is less than 1 dB. The signal is routed to the first filter (4-pole), which has an insertion loss of 2 dB typically. The output of the filter is matched to the base of the LNA (Q303) that provides a 16 dB gain and a noise figure of better than 2 dB. Current source Q301 is used to maintain the collector current of Q303. Diode CR301 protects Q303 by clamping excessive input signals. Q303 output is applied to the second filter (3-pole) which has an insertion loss of 1.5 dB. In Distance mode, Q304 turns on and causes D305 to conduct, thus bypassing C322 and R337. In Local mode, the signal is routed through C322 and R337, thus inserting 7 dB attenuation. Since the attenuator is located after the RF amplifier, the receiver sensitivity is reduced only by 6 dB, while the overall third order input intercept is raised.

The first mixer is a passive, double-balanced type, consisting of T300, T301 and U302. This mixer provides all of the necessary rejection of the half-IF spurious response. High-side injection at +15 dBm is delivered to the first mixer. The mixer output is then connected to a duplex network which matches its output to the XTAL filter input (FL300) at the IF frequency of 44.85 MHz. The duplex network terminates into a 50 ohm resistor (R340) at all other frequencies.

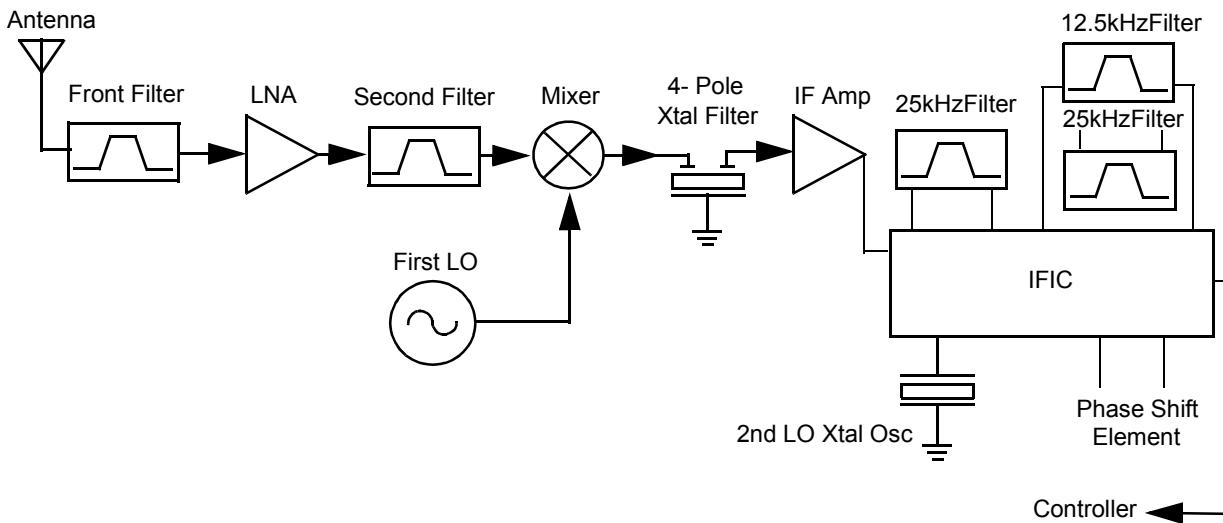


Figure 2-1 UHF Receiver Block Diagram

2.2 Receiver Back End

The IF signal from the crystal filter enters the IF amplifier which provides 20 dB of gain and feeds the IF IC at pin 1. The first IF signal at 44.85 MHz mixes with the second local oscillator (LO) at 44.395 MHz to produce the second IF at 455 kHz. The second LO uses the external crystal Y301. The second IF signal is amplified and filtered by two external ceramic filters (FL303/FL302 for 12.5KHz channel spacing and FL304/FL301 for 25KHz channel spacing). The IF IC demodulates the signal by means of a quadrature detector and feeds the detected audio (via pin 7) to the audio processing circuits. At IF IC pin 5, an RSSI signal is available with a dynamic range of 70 dB.

3.0 UHF Transmitter Power Amplifier (438-470 MHz)

The radio's 25W PA is a three-stage amplifier used to amplify the output from the VCOBIC to the radio transmit level. All three stages utilize LDMOS technology. The gain of the first stage (U101) is adjustable and controlled by pin 7 of U103-2 via U103-3. It is followed by an LDMOS stage Q105 and LDMOS final stage Q100.

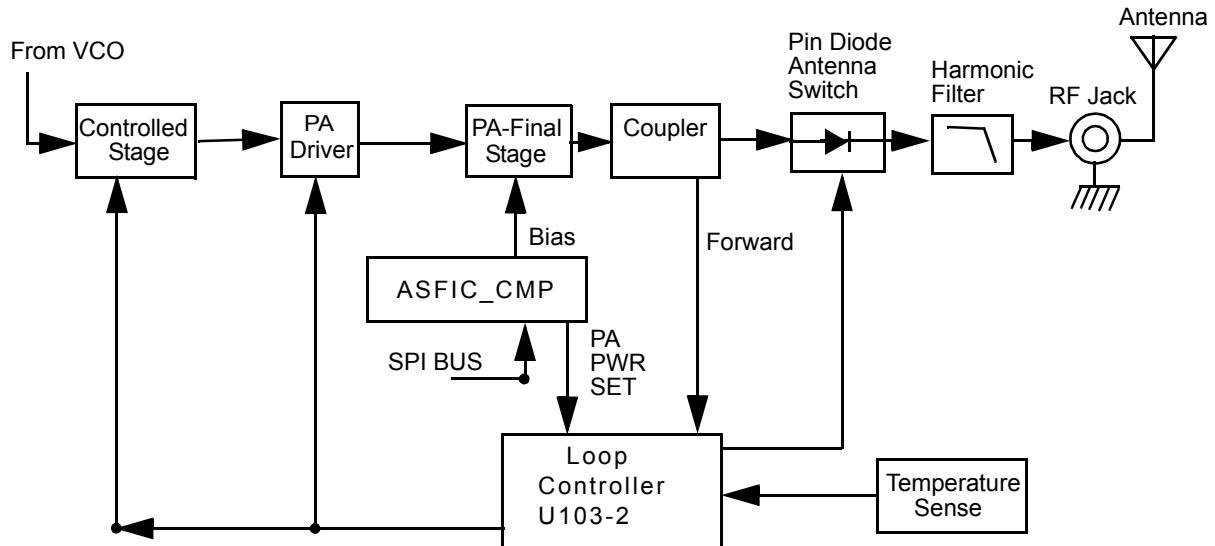


Figure 2-2 UHF Transmitter Block Diagram

Devices U101, Q105 and Q100 are surface mounted. A metal clip ensures good thermal contact between both the driver and final stage, and the chassis.

3.1 First Power Controller Stage

The first stage (U101) is a 20dB gain integrated circuit containing two LDMOS FET amplifier stages. It amplifies the RF signal from the VCO (TX_INJ). The output power of stage U101 is controlled by a DC voltage applied to pin 1 from the op-amp U103-3, pin 8. The control voltage simultaneously varies the bias of two FET stages within U101. This biasing point determines the overall gain of U101 and therefore its output drive level to Q105, which in turn controls the output power of the

PA.Op-amp U103-3 monitors the drain current of U101 via resistor R122 and adjusts the bias voltage of U101.

In receive mode, the DC voltage from RX_EN line turns on Q101, which in turn switches off the biasing voltage to U101.

3.2 Power Controlled Driver Stage

The next stage is an LDMOS device (Q105) which provides a gain of 12dB. This device requires a positive gate bias and a quiescent current flow for proper operation. The bias is set during transmit mode by the drain current control op-amp U102-1, and fed to the gate of Q105 via the resistive network R175, R147.

Op-amp U102-1 monitors the drain current of Q105 via resistors R126-8 and adjusts the bias voltage of Q105.

In receive mode the DC voltage from RX_EN line turns on Q102, which in turn switches off the biasing voltage to Q105.

3.3 Final Stage

The final stage is an LDMOS device (Q100) providing a gain of 12dB. This device also requires a positive gate bias and a quiescent current flow for proper operation. The voltage of the line PA_BIAS is set in transmit mode by the ASFIC and fed to the gate of Q100 via the resistive network R134, R131. This bias voltage is tuned in the factory. If the transistor is replaced, the bias voltage must be tuned using the Tuner. 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, B+, via L117 and L115.

A matching network consisting of C1004-5, C1008, C1021: and two striplines, transforms the impedance to 50 ohms and feeds the directional coupler.

3.4 Directional Coupler

The directional Coupler is a microstrip printed circuit, which couples a small amount of the forward power of the RF power from Q100. The coupled signal is rectified to an output power which is proportional to the DC voltage rectified by diode D105; and the resulting DC voltage is routed to the power control section to ensure that the forward power out of the radio is held to a constant value.

3.5 Antenna Switch

The antenna switch utilizes the existing dc feed (B+) to the last stage device (Q100). The basic operation is to have both PIN diodes (D103, D104) turned on during key-up by forward biasing them. This is achieved by pulling down the voltage at the cathode end of D104 to around 12.4V (0.7V drop across each diode). The current through the diodes needs to be set around 100 mA to fully open the transmit path through resistor R108. Q106 is a current source controlled by Q103 which is turned on in Tx mode by TX_EN. VR102 ensures that the voltage at resistor R107 never exceeds 5.6V.

3.6 Harmonic Filter

Inductors L111 and L113 along with capacitors C1011, C1023, C1020 and C1016 form a low-pass filter to attenuate harmonic energy coming from the transmitter. Resistor R150 along with L126 drains 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 to improve spurious response rejection.

3.7 Power Control

The output power is regulated by using a forward power detection control loop. A directional coupler samples a portion of the forward and reflected RF power. The forward sampled RF is rectified by diode D105, and the resulting DC voltage is routed to the operational amplifier U100. The error output current is then routed to an integrator, and converted into the control voltage. This voltage controls the bias of the pre-driver (U101) and driver (Q105) stages. The output power level is set by way of a DAC, PWR_SET, in the audio processing IC (U504) which acts as the forward power control loop reference.

The sampled reflected power is rectified by diode D107. The resulting DC voltage is amplified by an operational amplifier U100 and routed to the summing junction. This detector protects the final stage Q100 from reflected power by increasing the error current. The temperature sensor protects the final stage Q100 from overheating by increasing the error current. A thermistor RT100 measures the final stage Q100 temperature. The voltage divider output is routed to an operational amplifier U103 and then goes to the summing junction. The Zener Diode VR101 keeps the loop control voltage below 5.6V and eliminates the DC current from the 9.3 regulator U501.

Two local loops for the Pre Driver (U101) and for the Driver (Q105) are used in order to stabilize the current for each stage.

In Rx mode, the two transistors Q101 and Q102 go to saturation and shut down the transmitter by applying ground to the Pre Driver U101 and for the Driver Q105 control.

4.0 UHF (438-470MHz) Frequency Synthesis

The synthesizer consists of a reference oscillator (Y201), low voltage Fractional-N (LVFRAC-N) synthesizer (U200), and a voltage controlled oscillator (VCO) (U201).

4.1 Reference Oscillator

The reference oscillator is a crystal (Y201) controlled Colpitts oscillator and has a frequency of 16.8MHz. The oscillator transistor and start-up circuit are located in the LVFRAC-N (U200) while the oscillator feedback capacitors, crystal, and tuning varactors are external. An analog-to-digital (A/D) converter internal to the LVFRAC-N (U200) and controlled by the microprocessor via SPI sets the voltage at the warp output of U200 pin 25. This sets the frequency of the oscillator. Consequently, the output of the crystal Y201 is applied to U200 pin 23.

The method of temperature compensation is to apply an inverse Bechmann voltage curve, which matches the crystal's Bechmann curve to a varactor that constantly shifts the oscillator back on frequency. The crystal vendor characterizes the crystal over a specified temperature range and codes this information into a bar code that is printed on the crystal package. In production, this crystal code is read via a 2-dimensional bar code reader and the parameters are saved.

This oscillator is temperature compensated to an accuracy of +/- 2.5 PPM from -30 to 60 degrees C. The temperature compensation scheme is implemented by an algorithm that uses five crystal parameters (four characterize the inverse Bechmann voltage curve and one for frequency accuracy of the reference oscillator at 25 degrees C). This algorithm is implemented by the LVFRAC-N (U200) at the power up of the radio.

TCXO Y200, along with its corresponding circuitry R204, R205, R210, and C2053, are not placed as the temperature compensated crystal proved to be reliable.

4.2 Fractional-N Synthesizer

The LVFRAC-N U200 consists of a pre-scaler, programmable loop divider, control divider logic, phase detector, charge pump, A/D converter for low frequency digital modulation, balanced attenuator used to balance the high and low frequency analog modulation, 13V positive voltage multiplier, serial interface for control, and a super filter for the regulated 5 volts.

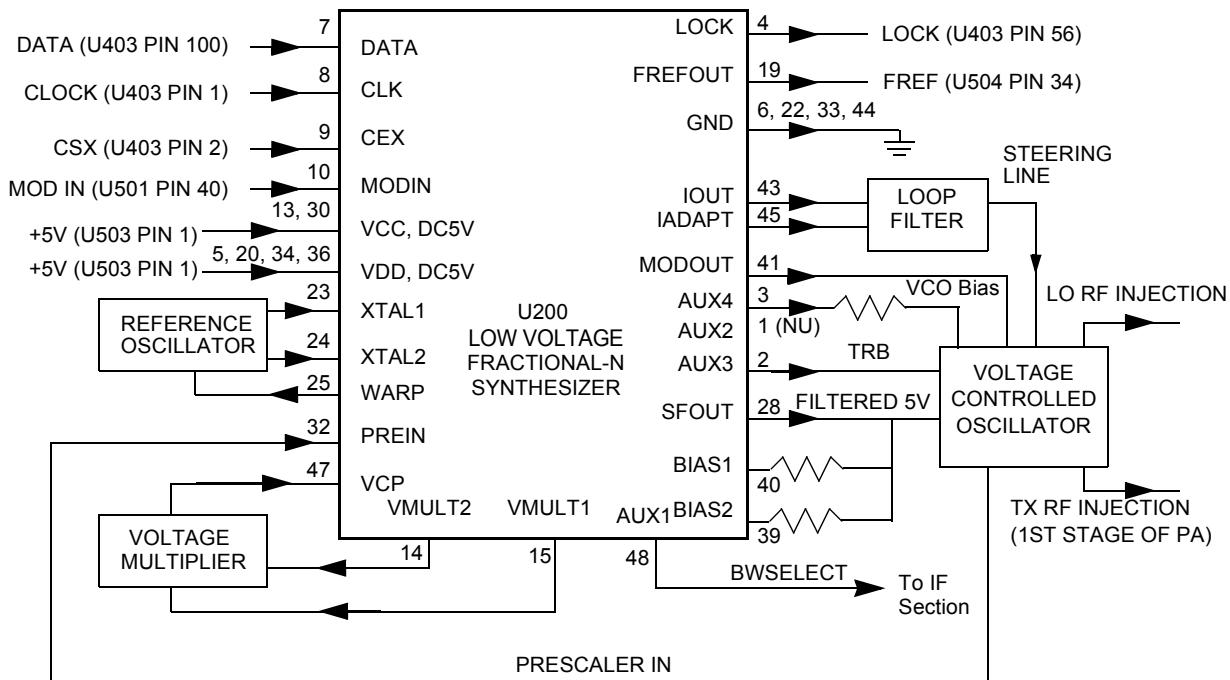


Figure 2-3 UHF Synthesizer Block Diagram

A voltage of 5V applied to the super filter input (U200, pin 30) supplies an output voltage of 4.5Vdc (VSF) at U200, pin 28. This supplies 4.5 V to the VCO Buffer IC U201.

To generate a high voltage to supply the phase detector (charge pump) output stage at pin VCP (U200, pin 47) while using a low voltage 3.3Vdc supply, a 13V positive voltage multiplier is used (D200, D201, and capacitors C2024, 2025, 2026, 2055, 2027, 2001).

Output lock (U200, pin 4) provides information about the lock status of the synthesizer loop. A high level at this output indicates a stable loop. A 16.8 MHz reference frequency is provided at U200, pin 19.

4.3 Voltage Controlled Oscillator (VCO)

The Voltage Controlled Oscillator (VCO) consists of the VCO/Buffer IC (VCOBIC, U201), the TX and RX tank circuits, the external RX buffer stages, and the modulation circuitry.

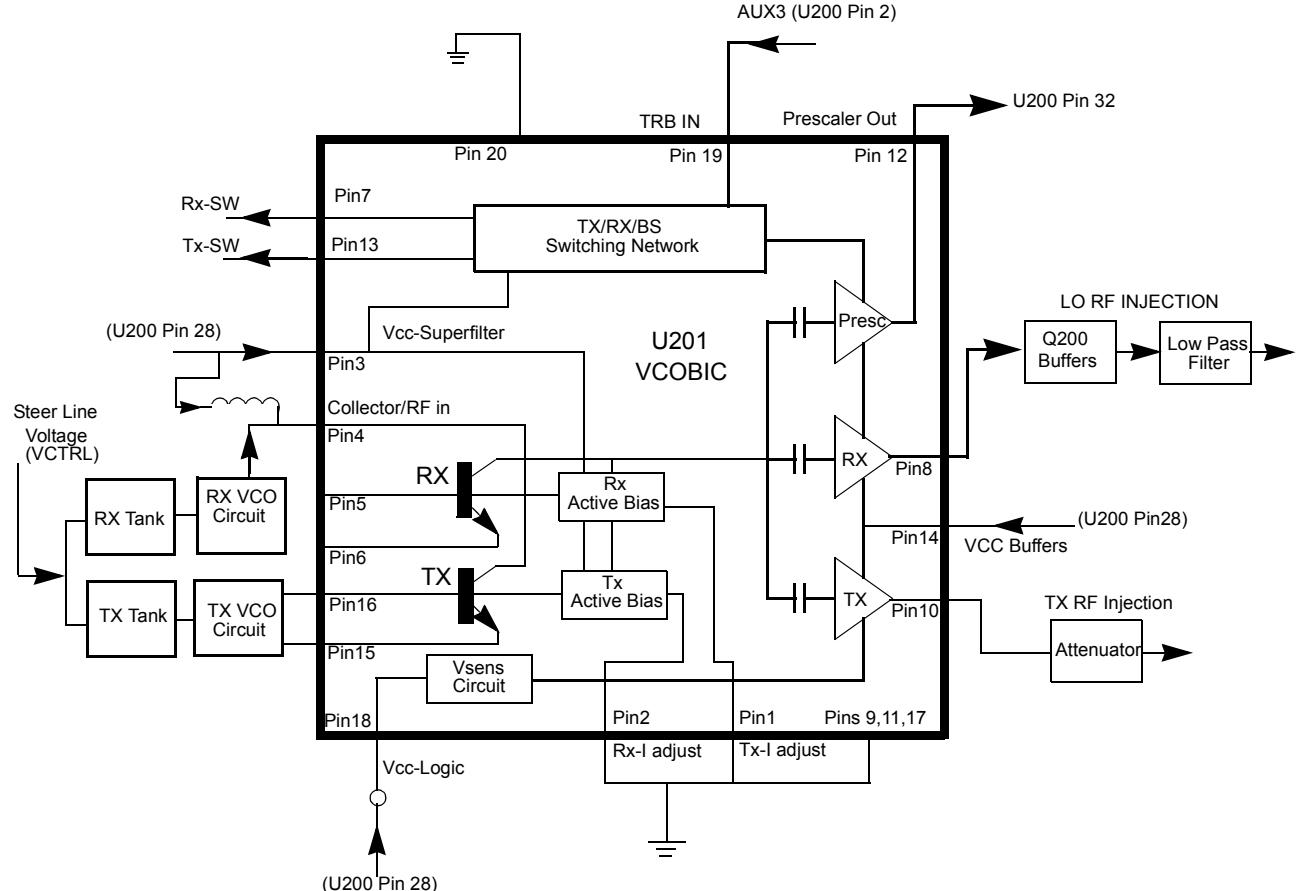


Figure 2-4 UHF VCO Block Diagram

The VCOBIC together with the LVFRAC-N (U200) generate the required frequencies in both transmit and receive modes. The TRB line (U201, pin 19) determines which VCO and buffer is enabled (high being TX output at pin 10, low being RX output at pin 8). A sample of the signal from the enabled output is routed from U201, pin 12 (PRESC_OUT), via a low pass filter to U200, pin 32 (PREIN).

A steering line voltage between 3.0V and 10.0V at varactor D204 tunes the TX VCO through the frequency range of 438-470MHz, and at D203 tunes the RX VCO through the frequency range of 393.15-425.15MHz.

The external RX amplifier is used to increase the output from U201, pin 9 from 3-4 dBm to the required 15dBm for proper mixer operation. In TX mode, the modulation signal from the LVFRAC-N (U200, pin 41) is applied to the VCO by way of the modulation circuit D205, R212, R211, C2073.

4.4 **Synthesizer Operation**

The synthesizer consists of a low voltage FRAC-N IC (LVFRAC-N), reference oscillator, charge pump circuits, loop filter circuit, and DC supply. The output signal (PRESC_OUT) of the VCOBIC (U201, pin 12) is fed to the PREIN, pin 32 of U200 via a low pass filter which attenuates harmonics and provides a correct input level to the LVFRAC-N in order to close the synthesizer loop.

The pre-scaler in the synthesizer (U200) is 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 SPI. 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 (Y201).

The output signal of the phase detector is a pulsed dc signal that is routed to the charge pump. The charge pump outputs a current from U200, pin 43 (IOUT). The loop filter (consisting of R224, R217, R234, C2074, C2075, C2077, C2078, C2079, C2080, C2028, and L205) transforms this current into a voltage that is applied the varactor diodes D203 and D204 for RX and TX respectively. The output frequency is determined by this control voltage. The current can be set to a value fixed in the LVFRAC-N or to a value determined by the currents flowing into BIAS 1 (U200, pin 40) or BIAS 2 (U200, pin 39). The currents are set by the value of R200 or R206 respectively. The selection of the three different bias sources is done by software programming.

To modulate the synthesizer loop, a two-spot modulation method is utilized via the MODIN (U200, pin 10) input of the LVFRAC-N. The audio signal is applied to both the A/D converter (low frequency path) and the balance 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 presented at the MODOUT port of the LVFRAC-N (U200,pin 41) and connected to the VCO modulation varactor D205.

5.0 Controller Theory of Operation

This section provides a detailed theory of operation for the radio and its components. The main radio is a single-board design, consisting of the transmitter, receiver, and controller circuits. A control head is connected by an extension cable. The control head contains LED indicators, a microphone connector, buttons, and speaker.

In addition to the power cable and antenna cable, an accessory cable can be attached to a connector on the rear of the radio. The accessory cable enables you to connect accessories to the radio, such as an external speaker, emergency switch, foot-operated PTT, and ignition sensing, etc.

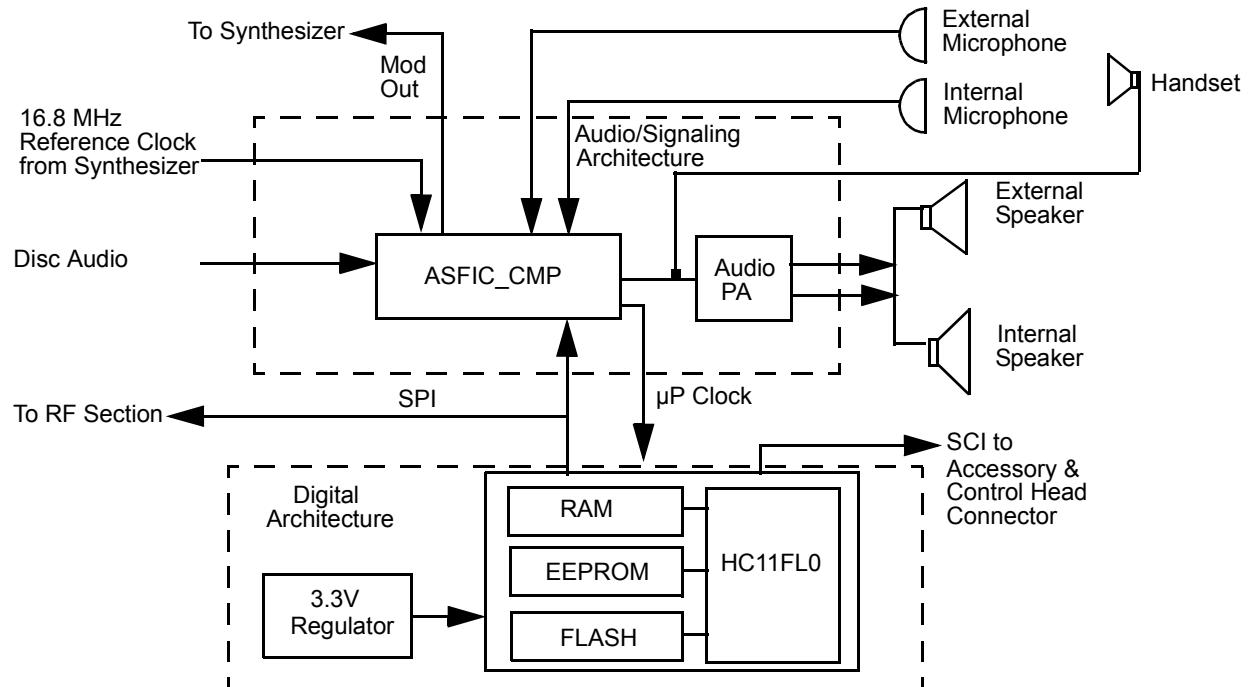


Figure 2-5 Controller Block Diagram

5.1 Radio Power Distribution

Voltage distribution is provided by five separate devices:

- U514 P-ch FET - Batt + (Ext_SWB+)
- U501 LM2941T - 9.3V
- U503 LP2951CM - 5V
- U508 MC 33269DTRK - 3.3V
- U510 LP2986ILDX - 3.3V Digital

The DC voltage applied to connector P2 supplies power directly to the following circuitry:

- Electronic on/off control
- RF power amplifier
- 12 volts P-ch FET -U514
- 9.3 volt regulator
- Audio PA

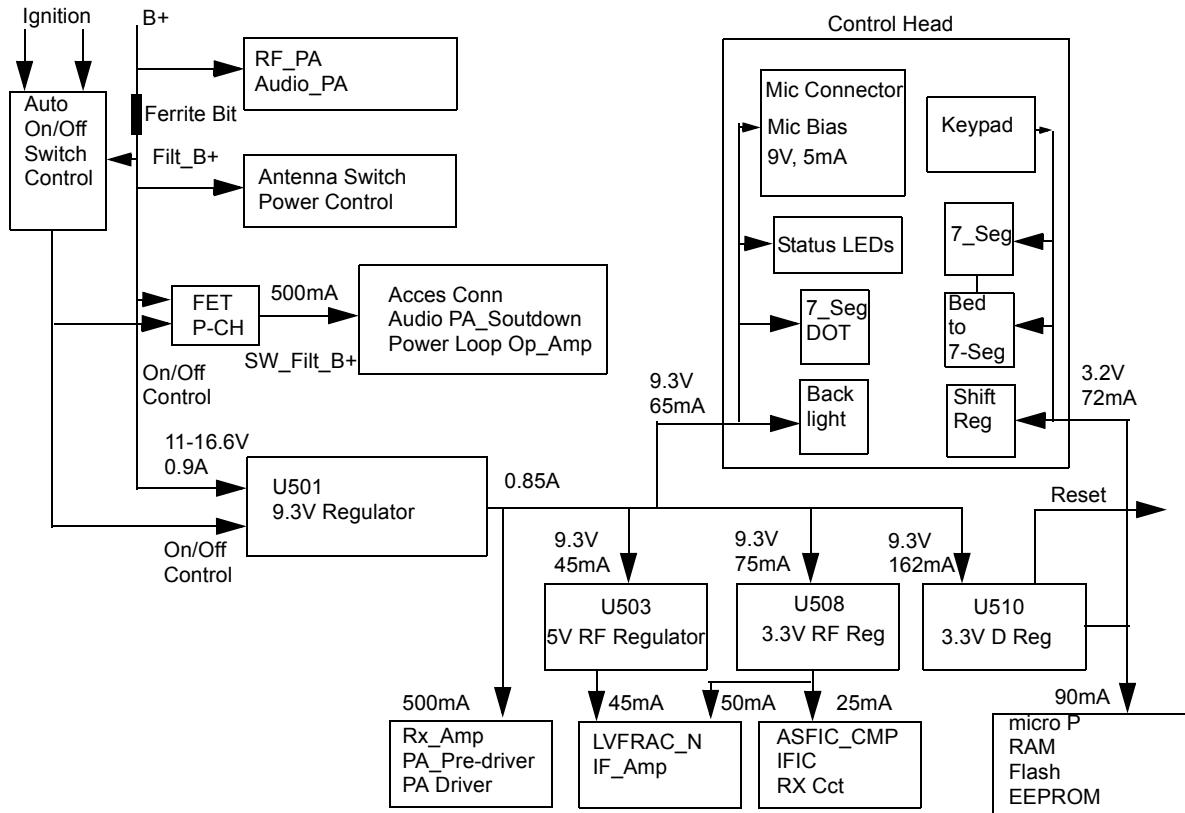


Figure 2-6 DC Power Distribution Block Diagram

Regulator U501 is used to generate the 9.3 volts required by some audio circuits, the RF circuitry and power control circuitry. Input and output capacitors are used to reduce high frequency noise. Resistors R5001 / R5081 set the output voltage of the regulator. This regulator output is electronically enabled by a 0 volt signal on pin 2. Q502, Q505 and R5038 are used to disable the regulator when the radio is turned off.

Voltage regulator U510 provides 3.3 volts for the digital circuitry. Operating voltage is from the regulated 9.3V supply. Input and output capacitors are used to reduce high frequency noise and provide proper operation during battery transients. U510 provides a reset output that goes to 0 volts if the regulator output goes below 3.1 volts. This is used to reset the controller to prevent improper operation.

Voltage regulator U508 provides 3.3V for the RF circuits and ASFIC_CMP. Input and output capacitors are used to reduce the high frequency noise and provide proper operation during battery transients.

Voltage regulator U503 provides 5V for the RF circuits. Input and output capacitors are used to reduce the high frequency noise and provide proper operation during battery transients.

VSTBY is used only for CM360 5-tone radios.

The voltage VSTBY, which is derived directly from the supply voltage by components R5103 and VR502, is used to buffer the internal RAM. Capacitor C5120 allows the battery voltage to be disconnected for a couple of seconds without losing RAM parameters. Dual diode D501 prevents radio circuitry from discharging this capacitor. When the supply voltage is applied to the radio, C5120 is charged via R5103 and D501.

5.2 Protection Devices

Diode VR500 acts as protection against ESD, wrong polarity of the supply voltage, and load dump. VR692 - VR699 are for ESD protection.

5.3 Automatic On/Off

The radio can be switched ON in any one of the following three ways:

- On/Off switch. (No Ignition Mode)
- Ignition and On/Off switch (Ignition Mode)
- Emergency

5.3.1 No Ignition Mode

When the radio is connected to the car battery for the first time, Q500 will be in saturation, Q503 will cut-off, Filt_B+ will pass through R5073, D500, and S5010-pin 6 (On/Off switch). When S5010 is ON, Filt_B+ will pass through S5010-pin5, D511, R5069, R5037 and base of Q505 and move Q505 into saturation. This pulls U501-pin2 through R5038, D502 to 0.2V and turns On U514 and U501 9.3V regulator which supplies voltage to all other regulators and consequently turns the radio on, When U504 (ASFIC_CMP) gets 3.3V, GCB2 goes to 3.3V and holds Q505 in saturation, for soft turn off.

5.3.2 Ignition Mode

When ignition is connected for the first time, it will force high current through Q500 collector, This will move Q500 out of saturation and consequently Q503 will cut-off. S5010 pin 6 will get ignition voltage through R601 (for load dump), R610, (R610 & C678 are for ESD protection), VR501, R5074, and D500. When S5010 is ON, Filt_B+ passes through S5010-pin 5, D511, R5069, R5037 and base of Q505 and inserts Q505 into saturation. This pulls U501-pin 2 through R5038, D502 to 0.2V and turns on U514 and U501 9.3V regulator which supply voltage to all other regulators and turns the radio on, When U504 (ASFIC_CMP) get 3.3V supply, GCB2 goes to 3.3V and holds Q505 in saturation state to allow soft turn off,

When ignition is off Q500, Q503 will stay at the same state so S5010 pin 6 will get 0V from Ignition, Q504 goes from Sat to Cut, ONOFF_SENSE goes to 3.3V and it indicates to the radio to soft turn itself by changing GCB2 to '0' after de registration if necessary.

5.3.3 Emergency Mode

The emergency switch (P1 pin 9), when engaged, grounds the base of Q506 via EMERGENCY _ACCES_CONN. This switches Q506 to off and consequently resistor R5020 pulls the collector of Q506 and the base of Q506 to levels above 2 volts. Transistor Q502 switches on and pulls U501 pin2 to ground level, thus turning ON the radio. When the emergency switch is released R5030 pulls the base of Q506 up to 0.6 volts. This causes the collector of transistor Q506 to go low (0.2V), thereby switching Q502 to off.

While the radio is switched on, the μ P monitors the voltage at the emergency input on the accessory connector via U403-pin 62. Three different conditions are distinguished: no emergency kit is connected, emergency kit connected (unpressed), and emergency press.

If no emergency switch is connected or the connection to the emergency switch is broken, the resistive divider R5030 / R5049 will set the voltage to about 3.14 volts (indicates no emergency kit found via EMERGENCY_SENSE line). If an emergency switch is connected, a resistor to ground within the emergency switch will reduce the voltage on EMERGENCY_SENSE line, and indicate to the μ P that the emergency switch is operational. An engaged emergency switch pulls line EMERGENCY_SENSE line to ground level. Diode VR503 limits the voltage to protect the μ P input.

While EMERGENCY_ACCES_CONN is low, the μ P starts execution, reads that the emergency input is active through the voltage level of μ P pin 64, and sets the DC POWER ON output of the ASFIC CMP pin 13 to a logic high. This high will keep Q505 in saturation for soft turn off.

5.4 Microprocessor Clock Synthesiser

The clock source for the μ P system is generated by the ASFIC CMP (U504). 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 audio circuitry, 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 will generate its default 3.6864MHz CMOS square wave UP CLK (on U504 pin 28) and this is routed to the μ P (U403 pin 90). After the μ 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 the clock source interfering with the desired radio receive frequency.

The ASFIC CMP synthesizer loop uses C5025, C5024 and R5033 to set the switching time and jitter of the clock output. If the synthesizer cannot generate the required clock frequency it will switch back to its default 3.6864MHz output.

Because the ASFIC CMP synthesizer and the μ P system will not operate without the 16.8 MHz reference clock it (and the voltage regulators) should be checked first when debugging the system.

5.5 Serial Peripheral Interface (SPI)

The μ P communicates to many of the IC's through its SPI port. This port consists of SPI TRANSMIT DATA (MOSI) (U403-pin100), SPI RECEIVE DATA (MISO) (U403-pin 99), SPI CLK (U0403-pin1) and chip select lines going to the various IC's, connected on the SPI PORT (BUS). This BUS is a synchronous bus, in that the timing clock signal CLK is sent while SPI data (SPI TRANSMIT DATA or SPI RECEIVE DATA) 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 is used to send serial from a μ P to a device, and SPI RECEIVE DATA is used to send data from a device to a μ P.

There are two IC's on the SPI BUS, ASFIC CMP (U504 pin 22), and EEPROM (U400). In the RF sections there is one IC on the SPI BUS, the FRAC-N Synthesizer. The chip select line CSX from U403 pin 2 is shared by the ASFIC CMP and FRAC-N Synthesizer. Each of these IC's check the SPI data and when the sent address information matches the IC's address, the following data is processed.

When the μ 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 to the various IC's are different; e.g., the ASFIC CMP can receive up to 19 bytes (152 bits). After the data has been sent the chip select line is returned to logic "1".

5.6 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) or the cable with internal RIB. This interface connects to the SCI pin via control head connector (J2-pin 17) and to the accessory connector P1-6 and comprises BUS+. The line is bi-directional, meaning that either the radio or the RIB can drive the line. The μ P sends serial data and it reads serial data via pin 97. Whenever the μ P detects activity on the BUS+ line, it starts communication.

5.7 General Purpose Input/Output

The controller provides six general purpose lines (PROG I/O) available on the accessory connector P1 to interface to external options. Lines PROG IN 3 and 6 are inputs, PROG OUT 4 is an output and PROG IN OUT 8, 12 and 14 are bi-directional. The software and the hardware configuration of the radio model define the function of each port.

- PROG IN 3 can be used as external PTT input, or others, set by the CPS. The μ P reads this port via pin 72 and Q412.
- PROG OUT 4 can be used as external alarm output, set by the CPS. Transistor Q401 is controlled by the μ P (U403 pin 55)
- PROG IN 6 can be used as normal input, set by the CPS. The μ P reads this port via pin 73 and Q411. This pin is also used to communicate with the RIB if resistor R421 is placed.
- DIG IN OUT 8,12,14 are bi-directional and use the same circuit configuration. Each port uses an output Q416, Q404, Q405 controlled by μ P pins 52, 53, 54. The input ports are read through μ P pins 74, 76, 77; using Q409, Q410, Q411

5.8 Normal Microprocessor Operation

For this radio, the µP is configured to operate in one of two modes, expanded and bootstrap. In expanded mode the µP uses external memory devices to operate, whereas in bootstrap operation the µP uses only its internal memory. In normal operation of the radio the µP is operating in expanded mode as described below.

During normal operation, the µP (U403) is operating in expanded mode and has access to 3 external memory devices; U400 (EEPROM), U402 (SRAM), U404 (Flash). Also, within the µP there are 3 Kilobytes of internal RAM, as well as logic to select external memory devices.

The external EEPROM (U400) space contains the information in the radio which is customer specific, referred to as the codeplug. This information consists of items such as: 1) what band the radio operates in, 2) what frequencies are assigned to what channel, and 3) tuning information.

The external SRAM (U402) as well as the µP's own internal RAM space are used for temporary calculations required by the software during execution. All of the data stored in both of these locations is lost when the radio powers off.

The µP provides an address bus of 16 address lines (ADDR 0 - ADDR 15), and a data bus of 8 data lines (DATA 0 - DATA 7). There are also 3 control lines; CSPROG (U403-pin 38) to chip select U404-pin 30 (FLASH), CSGP2 (U403-pin 41) to chip select U404-pin 20 (SRAM) and PG7_R_W (U403-pin 4) to select whether to read or to write. The external EEPROM (U400-pin1).

When the µP is functioning normally, the address and data lines should be toggling at CMOS logic levels. Specifically, the logic high levels should be between 3.1 and 3.3V, and the logic low levels should be between 0 and 0.2V. 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 1us/div. or faster to observe individual pulses. High speed CMOS transitions should also be observed on the µP control lines.

On the µP the lines XIRQ (U403-pin 48), MODA LIR (U403-pin 58), MODB VSTPY (U403-pin 57) and RESET (U403-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 20ms. In the case of shorted lines you may also detect the line periodically at an intermediate level, i.e. around 2.5V when two shorted lines attempt to drive to opposite rails.

The MODA LIR (U403-pin 58) and MODB VSTPY (U403-pin 57) inputs to the µP must be at a logic "1" for it to start executing correctly. After the µP starts execution it will periodically pulse these lines to determine the desired operating mode. While the Central Processing Unit (CPU) is running, MODA LIR is an open-drain CMOS output which goes low whenever the µP begins a new instruction. An instruction typically requires 2-4 external bus cycles, or memory fetches.

There are eight analog-to-digital converter ports (A/D) on U403 labelled within the device block as PEO-PE7. These lines sense the voltage level ranging from 0 to 3.3V 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.

5.9 Static Random Access Memory (SRAM)

The SRAM (U402) 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 U402 (which comes from U403-CSGP2) going low. U402 is commonly referred to as the external RAM as opposed to the internal RAM which is the 3 Kilobytes of RAM which is 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 C402 and C411 serves to filter out any AC noise which may ride on +3.3 V at U402

6.0 Control Board Audio and Signalling Circuits

6.1 Audio Signalling Filter IC and Compander (ASFIC CMP)

The ASFIC CMP (U504) used in the controller has the following four functions:

1. RX/TX audio shaping, i.e. filtering, amplification, attenuation
2. RX/TX signaling, PL/DPL/HST/MDC
3. Squelch detection
4. μ P clock signal generation

The ASFIC CMP is programmable through the SPI BUS (U504 pins-20/21/22), normally receiving 19 bytes. This programming sets up various paths within the ASFIC CMP to route audio and/or signaling signals through the appropriate filtering, gain and attenuator blocks. The ASFIC CMP also has 6 General Control Bits GCB0-5 which are CMOS level outputs and used for the following:

- GCB0 - BW Select
- GCB1 - switches the audio PA On/Off
- GCB2 - DC Power On switches the voltage regulator (and the radio) on and off
- GCB3 - Control on MUX U509 pin 9 to select between Low Cost Mic path to STD Mic Path
- GCB4 - Control on MUX U509 pin 11 to select between Flat RX path to filtered RX path on the accessory connector.
- GCB5 - Control on MUX U509 pin 10 to select between Flat TX path mute and Flat TX path

7.0 Transmit Audio Circuits

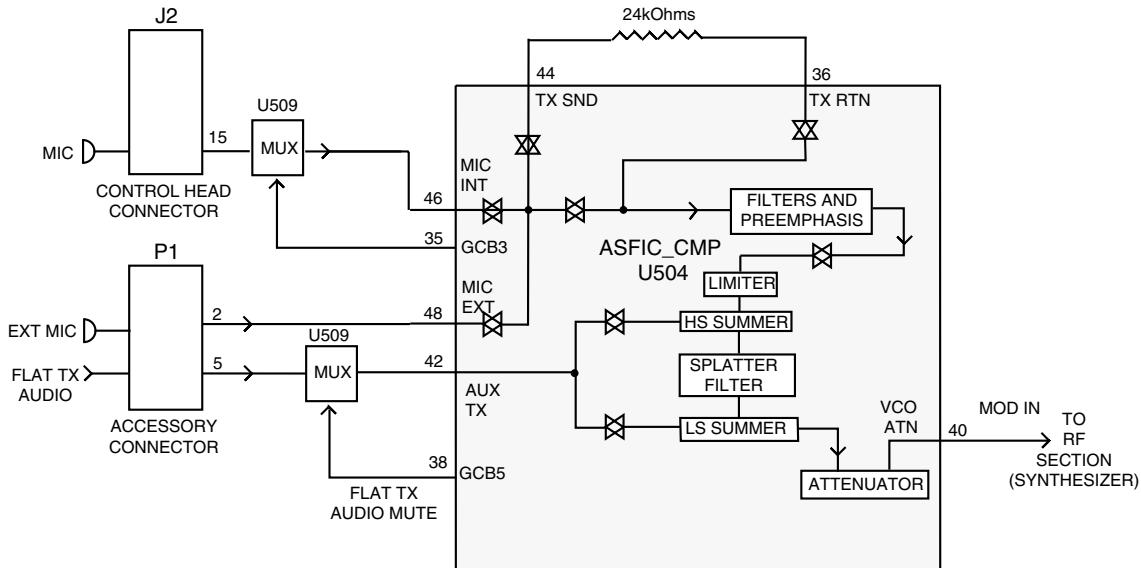


Figure 2-7 Transmit Audio Paths

7.1 Microphone Input Path

The radio supports 2 distinct microphone paths known as internal (from control head J2-15) and external mic (from accessory connector P1-2) and an auxiliary path (FLAT TX AUDIO, from accessory connector P1-5). The microphones used for the radio require a DC biasing voltage provided by a resistive network.

The two microphone audio input paths enter the ASIFC CMP at U504-pin 48 (external mic) and U504-pin 46 (internal mic). The microphone is plugged into the radio control head and connected to the audio DC via J2-pin 15. The signal is then routed via C5045 to MUX U509 that select between two paths with different gain to support Low Cost Mic (Mic with out amplifier in it) and Standard Mic.

7.1.1 Low Cost Microphone

Hook Pin is shorted to Pin 1(9.3V) inside the Low Cost Mic, This routes 9.3V to R429, and creates 2.6V on MIC_SENSE (u.P U403-67) by Voltage Divider R429/R430. U403 senses this voltage and sends command to ASIFC_CMP U504 to get GCB3 = '0'. The audio signal is routed from C5045 via U509-5 (Z0), R5072, U507, R5026, C5091, R5014 via C5046 to U504- 46 int. mic (C5046 100nF creates a159Hz pole with U504- 46 int mic impedance of 16Kohm).

7.1.2 Standard Microphone

Hook Pin is shorted to the hook mic inside the standard Mic. If the mic is out off hook, 3.3V is routed to R429 via R458, D401, and it create 0.7V on MIC_SENSE (u.P U403-67) by Voltage Divider R429/R430. U403 senses this voltage and sends command to ASFIC_CMP U504 to get GCB3 ='1'. The audio signal is routed from C5045 via U509-3 (Z1), R5072, U507, R5026, C5091, R5014 via C5046 to U504- 46 int mic (C5046 100nF create a159Hz pole with U504- 46 int mic impedance of 16Kohm). 9.3VDC is routed via R5077, R5075 to J2-15, It create 4.65V with Mic Impedance. C5010 supplies AC Ground to create AC impedance of 510 Ohms via R5075. and Filter 9.3V DC mic bias supply.

Note: The audio signal at U504-pin 46 should be approximately 12mV for 1.5kHz or 3kHz of deviation with 12.5kHz or 25kHz channel spacing.

The external microphone signal enters the radio on accessory connector P1 pin 2 and is routed via line EXT MIC to R5054. R5078 and R5076 provide the 9.3Vdc bias. Resistive divider R5054/ R5070 divide the input signal by 5.5 and provide input protection for the CMOS amplifier input. R5076 and C5009 provide a 510 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.

C5047 serves as a DC blocking capacitor. The audio signal at U504-pin 48 should be approximately 14mV for 1.5kHz or 3kHz of deviation with 12.5kHz or 25kHz channel spacing.

The FLAT TX AUDIO signal from accessory connector P1-pin 5 is fed to the ASFIC CMP (U504 pin 42 through U509 pin 2 to U509 pin 15 via U506 OP-AMP circuit and C5057.

The ASFIC has an internal AGC that can control the gain in the mic audio path. The AGC can be disabled / enabled by the μ P. Another feature that can be enabled or disabled in the ASFIC is the VOX. This circuit, along with Capacitor C5023 at U504-pin 7, provides a DC voltage that can allow the μ P to detect microphone audio. The ASFIC can also be programmed to route the microphone audio to the speaker for public address operation.

7.2 PTT Sensing and TX Audio Processing

Internal microphone PTT is sensed by μ P U403 pin 71. Radio transmits when this pin is "0" and selects inside the ASFIC_CMP U504 internal Mic path. When the internal Mic PTT is "0" then external Mic PTT is grounded via D402. External Mic PTT is sensed by U403 pin 72 via Q412 circuits. The radio transmits when this pin is "0" and selects inside the ASFIC_CMP U504 External Mic path.

Inside the ASFIC CMP, the mic 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 mic audio is then routed through a summer, which is used to add in signaling 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 U504-pin 40 MOD IN, at which point it is routed to the RF section.

8.0 Transmit Signalling Circuits

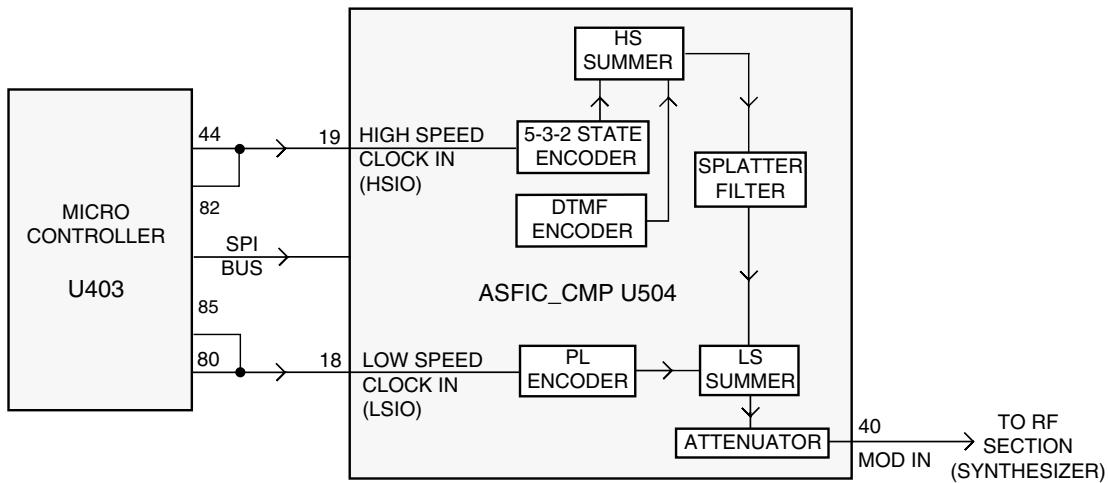


Figure 2-8 Transmit Signalling Path

From a hardware point of view, there are 3 types of signaling:

- Sub-audible data (PL / DPL / Connect Tone) that gets summed with transmit voice or signaling,
- DTMF data for telephone communication in trunked and conventional systems, and
- Audible signaling including MDC and high-speed trunking.

Note: All three types are supported by the hardware while the radio software determines which signaling type is available.

8.1 Sub-Audio Data (PL/DPL)

Sub-audible data implies signaling whose bandwidth 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 U504 (ASFIC CMP) at any one time. The process is as follows, using the SPI BUS, the μ P programs the ASFIC CMP to set up the proper low-speed data deviation and select the PL or DPL filters. The μ P then generates a square wave which strobes the ASFIC PL / DPL encode input LSIO U504-pin 18 at twelve times the desired data rate. For example, for a PL frequency of 103Hz, the frequency of the square wave would be 1236Hz.

This drives a tone generator inside U504 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 U504-pin 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.

8.2 High Speed Data

High speed data refers to the 3600 baud data waveforms, known as Inbound Signaling Words (ISWs) used in a trunking system for high speed communication between the central controller and the radio. To generate an ISW, the μ P first programs the ASFIC CMP (U504) to the proper filter and gain settings. It then begins strobing U504-pin 19 (HSIO) with a pulse when the data is supposed to change states. U504'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 attenuator and then out of the ASFIC CMP to the RF board. MDC is 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 signaling schemes are based on sending a combination of 1200 Hz and 1800 Hz tones only. Microphone audio is muted during high speed data signaling.

8.3 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 μ P (U403-46) strobing U504-19 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 μ P via SPI bus. Inside U504 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 was described for high-speed data.

9.0 Receive Audio Circuits

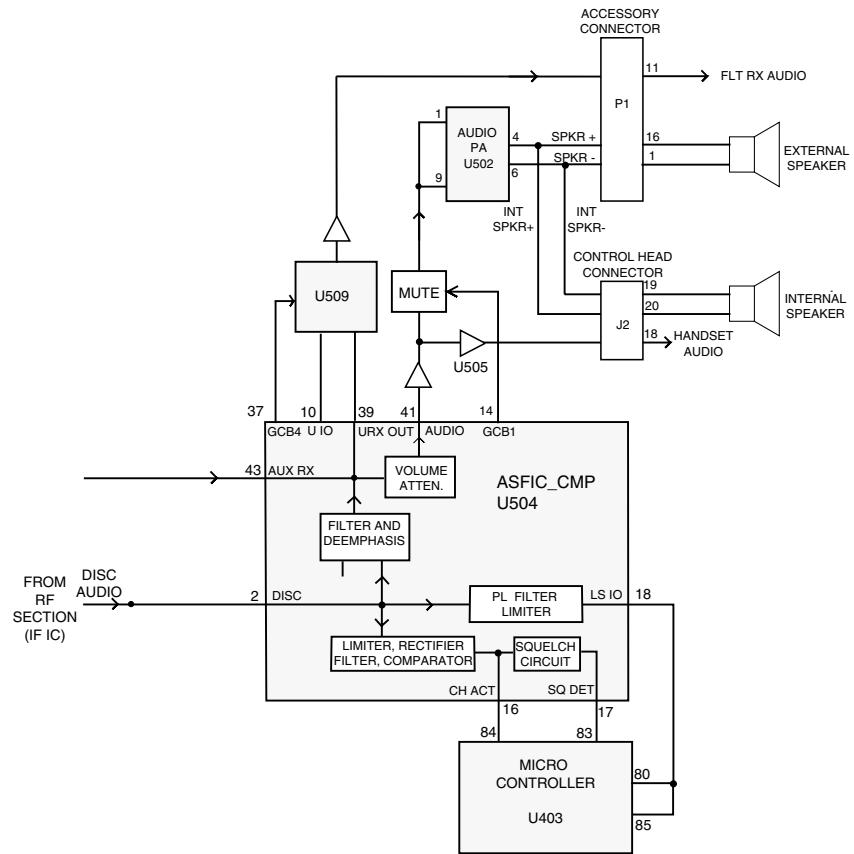


Figure 2-9 Receive Audio Paths

9.1 Squelch Detect

The radio's RF circuits are constantly producing an output at the discriminator (IF IC). This signal (DISC AUDIO) is routed to the ASFiC CMP's squelch detect circuitry input DISC (U504-pin 2). All of the squelch detect circuitry is contained within the ASFiC CMP. Therefore from a user's point of view, DISC AUDIO enters the ASFiC CMP, and the ASFiC CMP produces two CMOS logic outputs based on the result. They are CH ACT (U504-16) and SQ DET (U504-17).

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 on CH ACT. A squelch tail circuit is used to produce SQ DET (U504-17) from CH ACT. The state of CH ACT and SQ DET is high (logic "1") when carrier is detected, otherwise low (logic "0").

CH ACT is routed to the μ P pin 84 while SQ DET is routed to the μ P pin 83.

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.

9.2 Audio Processing and Digital Volume Control

The receiver audio signal (DISC AUDIO) enters the controller section from the IF IC where it is DC coupled to ASFIC CMP via the DISC input U504-pin 2. The signal is then applied to both the audio and the PL/DPL paths

The audio path has a programmable amplifier, whose setting is based on the channel bandwidth being received, an LPF filter to remove any frequency components above 3000Hz, and a HPF to strip off any sub-audible data below 300Hz. Next, 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 IC then passes the audio through the 8-bit programmable attenuator whose level is set depending on the value of the volume control. Finally the filtered audio signal passes through an output buffer within the ASFIC CMP. The audio signal exits the ASFIC CMP at AUDIO output (U504 pin 41).

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

Since sub-audible signaling is summed with voice information on transmit, it must be separated from the voice information before processing. Any sub-audible signaling enters the ASFIC CMP from the IF IC at DISC U504-2. Once inside, it goes through the PL/DPL path. The signal first passes through one of the two low-pass filters, either the PL low-pass filter or the DPL/LST low-pass filter. Either signal is then filtered and goes through a limiter and exits the ASFIC CMP at LSIO (U504-pin 18). At this point, the signal will appear as a square wave version of the sub-audible signal which the radio received. The μP U403 pin 80 will decode the signal directly to determine if it is the tone / code which is currently active on that mode.

9.3 Audio Amplification Speaker (+) Speaker (-)

The output of the ASFIC CMP's digital volume pot, U504-pin 41 is routed through DC blocking capacitor C5049 to the audio PA (U502 pin 1 and 9).

The audio power amplifier has one inverted and one non-inverted output that produces the differential audio output SPK+/SPK- (U502 pins 4 and 6)

The audio PA is enabled via the ASFIC CMP (U504-GCB1). When the base of Q501 is low, the transistor is off and U502-pin 8 is high, using pull up resistor R5041, and the audio PA is ON. The voltage at U502-pin 8 must be above 8.5Vdc to properly enable the device.

If the voltage is between 3.3 and 6.4V, the device will be active but has its input (U502-pins 1/9) off. This is a mute condition which is used to prevent an audio pop when the PA is enabled.

The SPK+ and SPK- outputs of the audio PA have a DC bias which varies proportionately with B+ (U502- pin 7). B+ of 11V yields a DC offset of 5V, and B+ 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 will be damaged. SPK+ and SPK- are routed to the accessory connector (P1-pin 1 and 16) and to the control head (connector J2-pins 19 and 20).

9.4 Handset Audio

Certain handheld accessories have a speaker within them which require a different voltage level than that provided by U502. For these devices HANDSET AUDIO is available at control head connector J2 pin18.

The received audio from the output of the ASIC CMP's digital volume attenuator is routed to U505 pin 2 where it is amplified. This signal is routed from the output of the op-amp U505 to J2-pin 18. From the control head, the signal is sent directly to the microphone jack.

9.5 Filtered Audio and Flat Audio

The ASIC CMP output audio at U504-pin 39 is filtered and de-emphasized, but has not gone through the digital volume attenuator. From ASIC CMP U504-pin 39 the signal is routed via R5034 through gate U509-pin 12 and AC coupled to U505-pin 6. The gate controlled by ASIC CMP port GCB4 selects between the filtered audio signal from the ASIC CMP pin 39 (URXOUT) or the unfiltered (flat) audio signal from the ASIC CMP pin 10 (UIO). Resistors R5034 and R5021 determine the gain of op-amp UU505-pin 6 for the filtered audio while R5032 and R5021 determine the gain for the flat Audio. The output of U505-pin 7 is then routed to P1 pin 11 via DC blocking capacitor C5003. Note that any volume adjustment of the signal on this path must be done by the accessory.

10.0 Receive Signalling Circuits

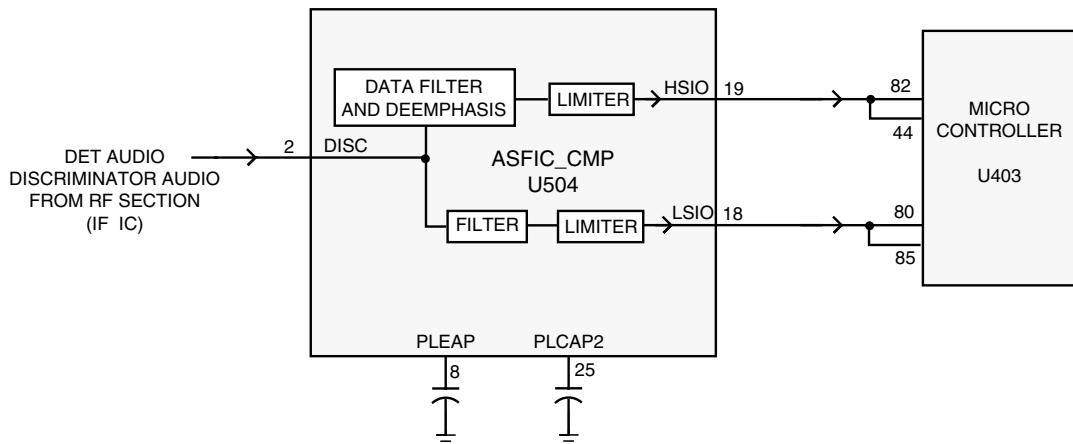


Figure 2-10 Receive Signalling Paths

10.1 Sub-Audio Data (PL/DPL) and High Speed Data Decoder

The ASIC CMP (U504) is used to filter and limit all received data. The data enters the ASIC CMP at input DISC (U504 pin 2). Inside U504 the data is filtered according to data type (HS or LS), then it is limited to a 0-3.3V digital level. The MDC and trunking high speed data appear at U504-pin 19, where it connects to the μ P U403 pin 80.

The low speed limited data output (PL, DPL, and trunking LS) appears at U504-pin18, where it connects to the μ P U403-pin 80.

The low speed data is read by the μ 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 C5028, and C5026 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.

10.2 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 U504 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 μ 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 μ P can generate any tone within the 100-3000Hz audio band. This is accomplished by the μ P generating a square wave which enters the ASFIC CMP at U504 pin 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 U504, 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 U504-pin 41 and is routed to the audio PA like receive audio.

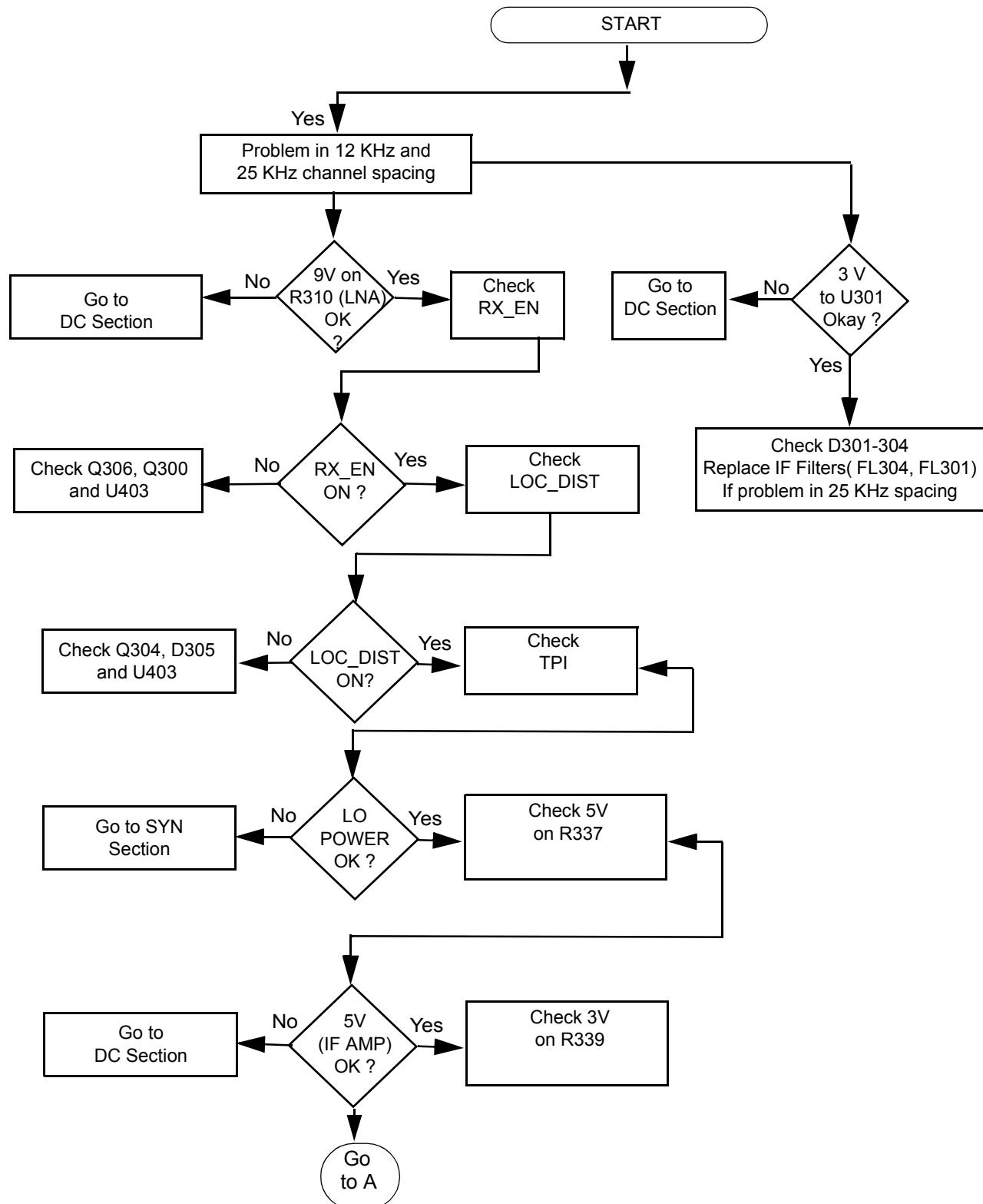
Chapter 3

TROUBLESHOOTING CHARTS

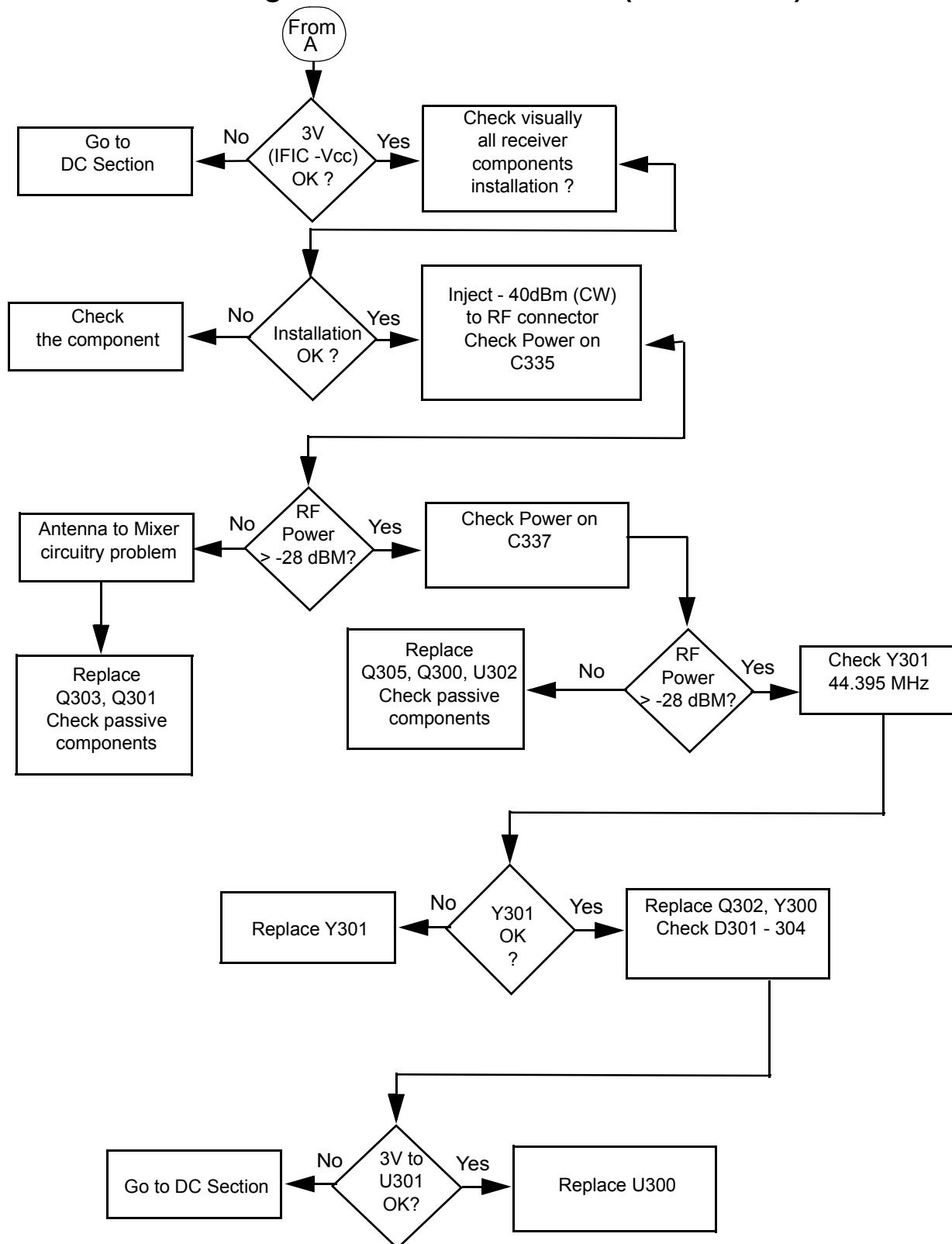
This section contains detailed troubleshooting flowcharts. These charts should be used as a guide in determining the problem areas. They are not a substitute for knowledge of circuit operation and astute troubleshooting techniques. It is advisable to refer to the related detailed circuit descriptions in the theory of operation sections prior to troubleshooting a radio.

Most troubleshooting charts end up by pointing to an IC to replace. It is not always noted, but it is good practice to verify supplies and grounds to the affected IC and to trace continuity to the malfunctioning signal and related circuitry before replacing any IC. For instance, if a clock signal is not available at a destination, continuity from the source IC should be checked before replacing the source IC.

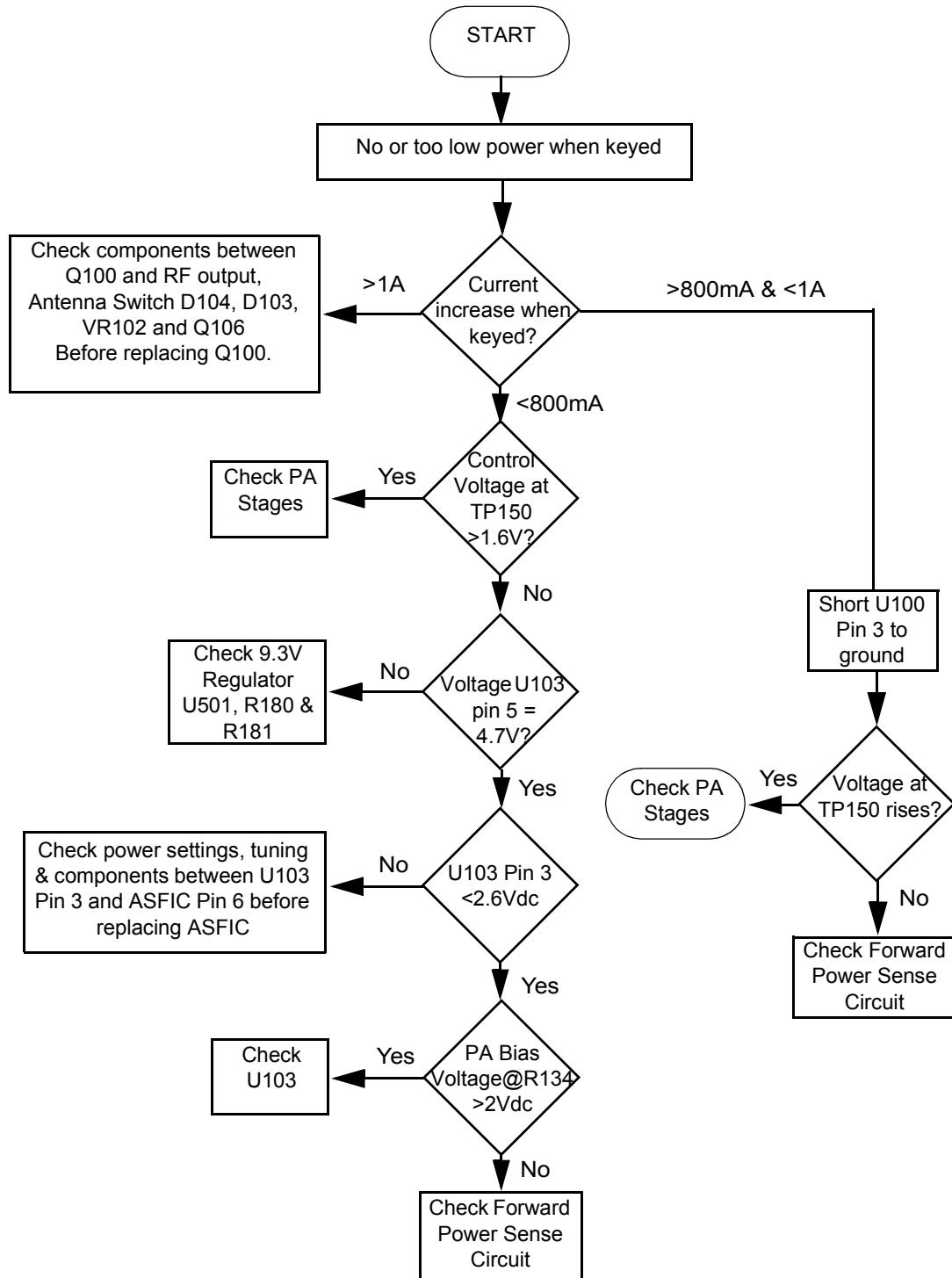
1.0 Troubleshooting Flow Chart for Receiver RF (Sheet 1 of 2)



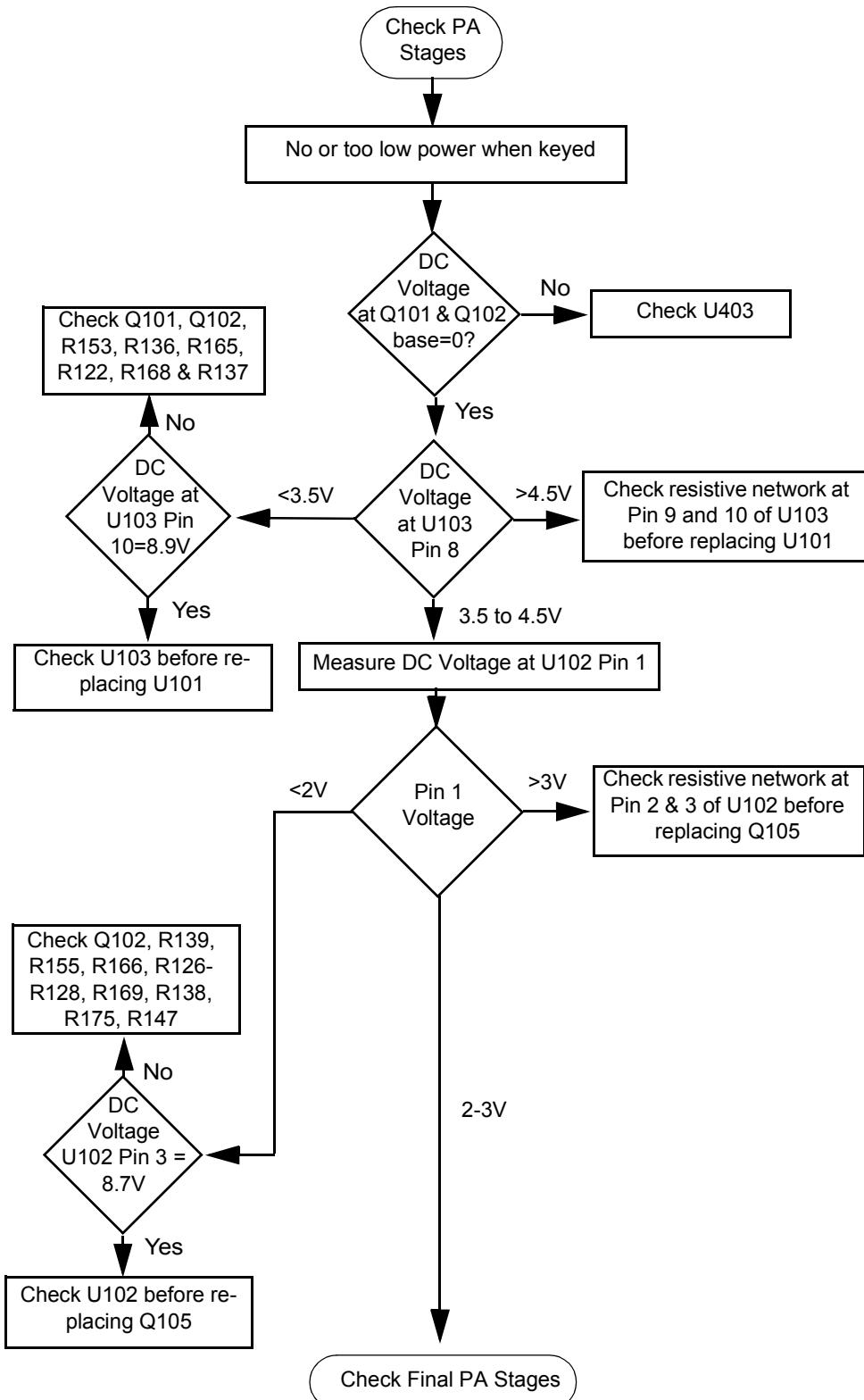
1.1 Troubleshooting Flow Chart for Receiver (Sheet 2 of 2)



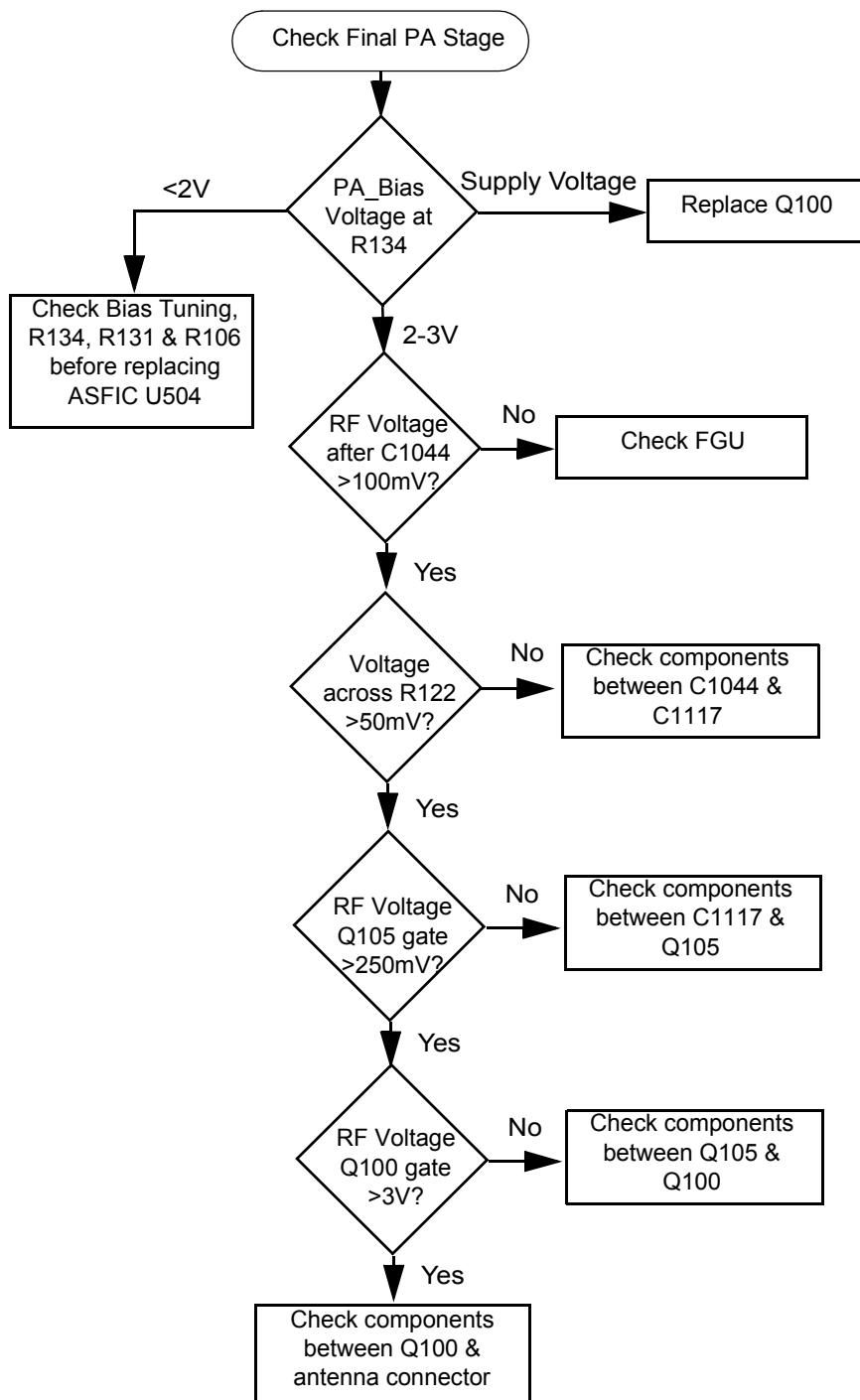
2.0 Troubleshooting Flow Chart for 25W Transmitter (Sheet 1 of 3)



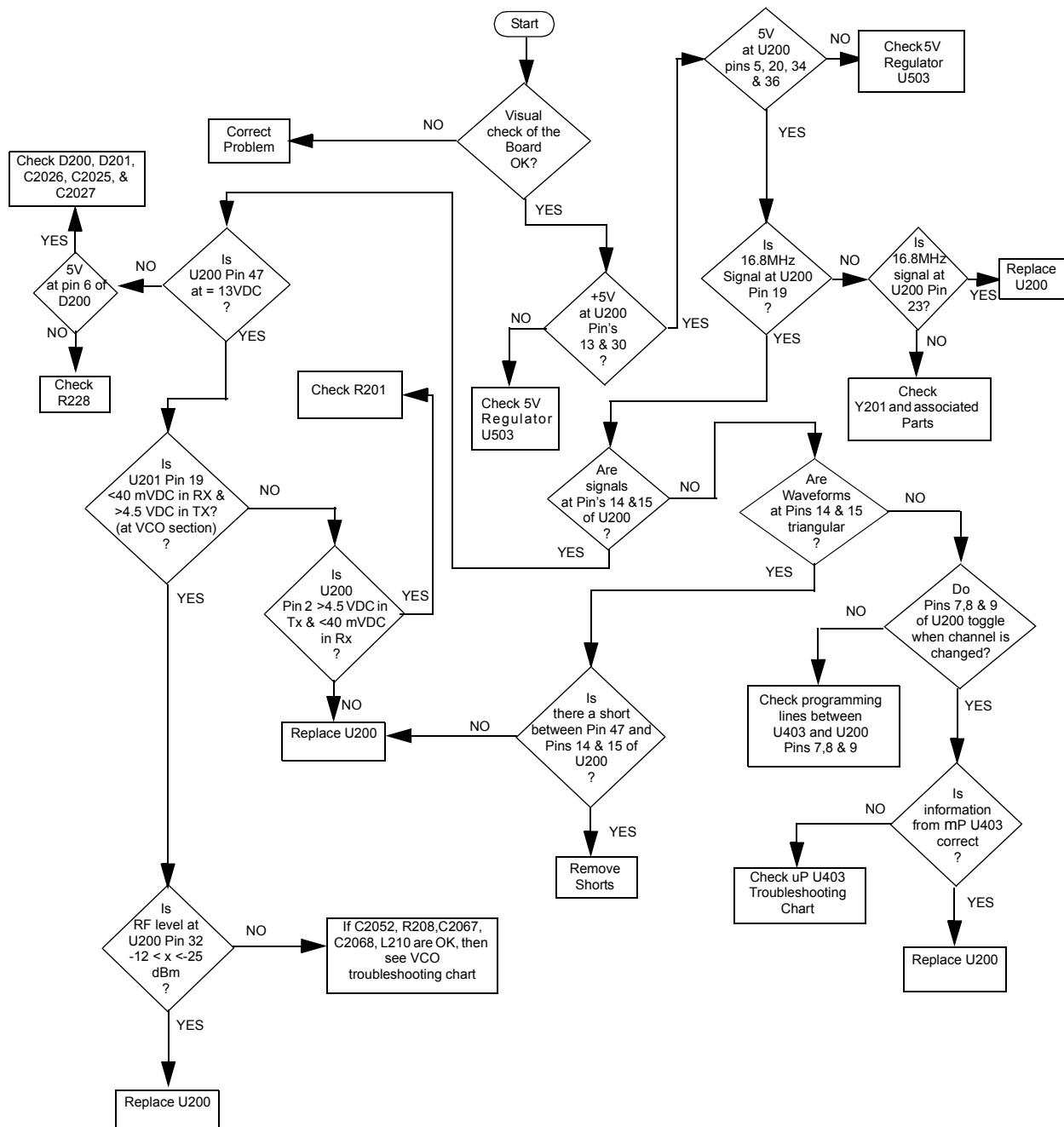
2.1 Troubleshooting Flow Chart for 25W Transmitter (Sheet 2 of 3)



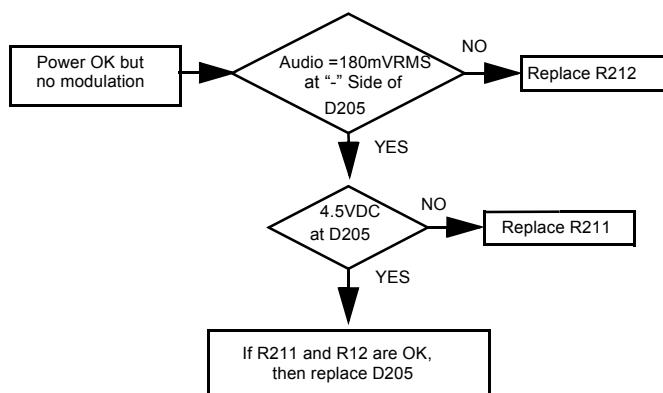
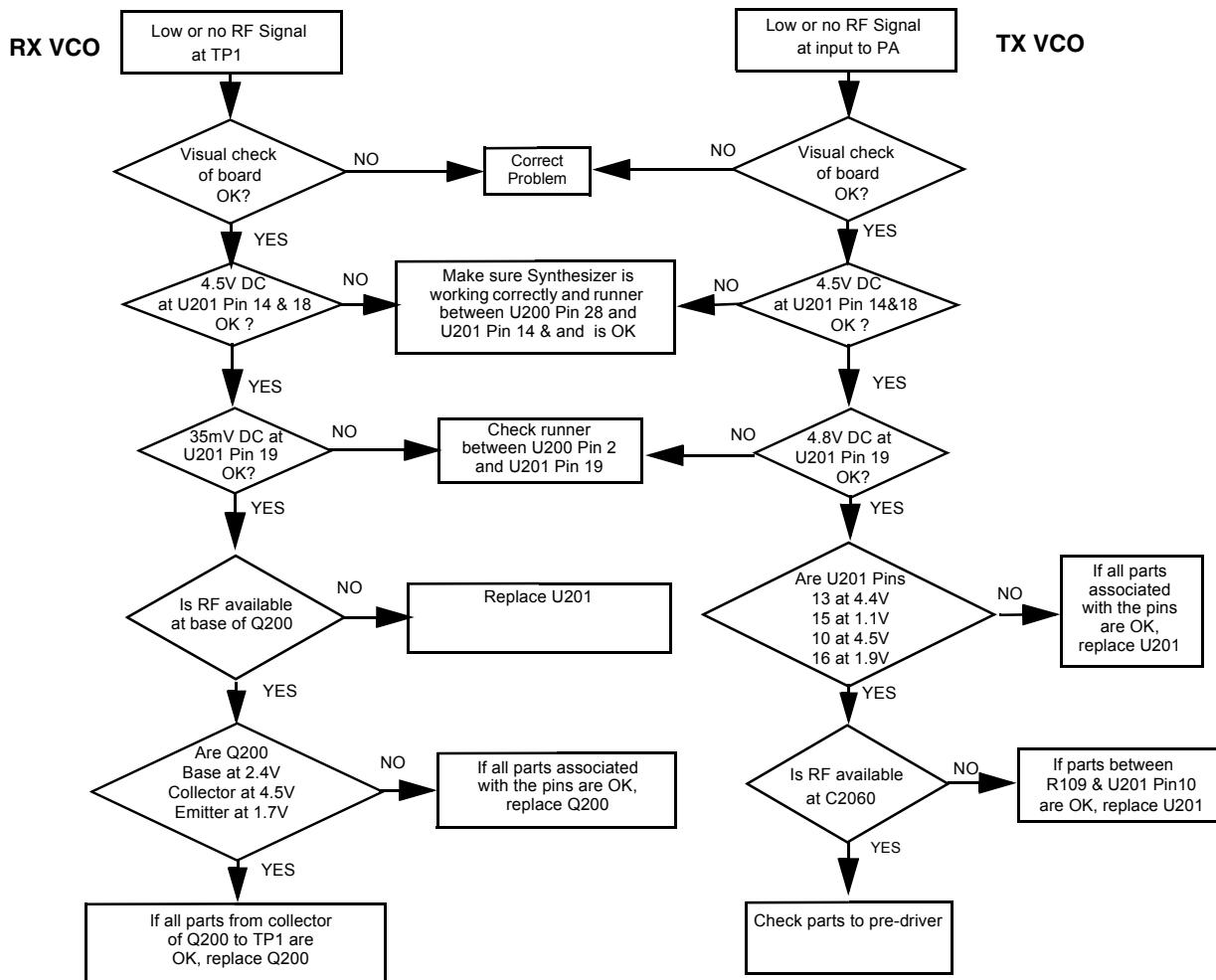
2.2 Troubleshooting Flow Chart for 25W Transmitter (Sheet 3 of 3)



3.0 Troubleshooting Flow Chart for Synthesizer

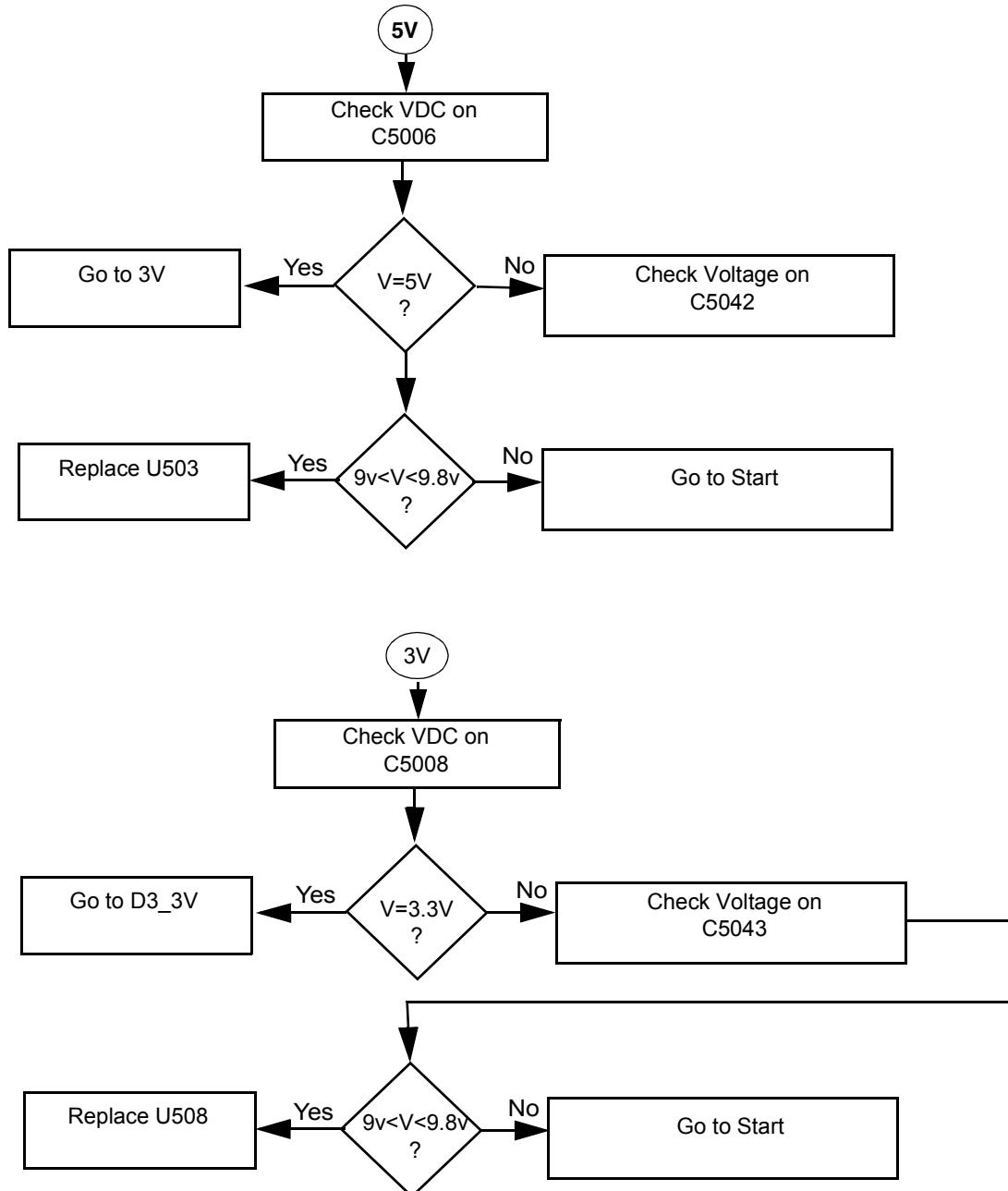


4.0 Troubleshooting Flow Chart for VCO

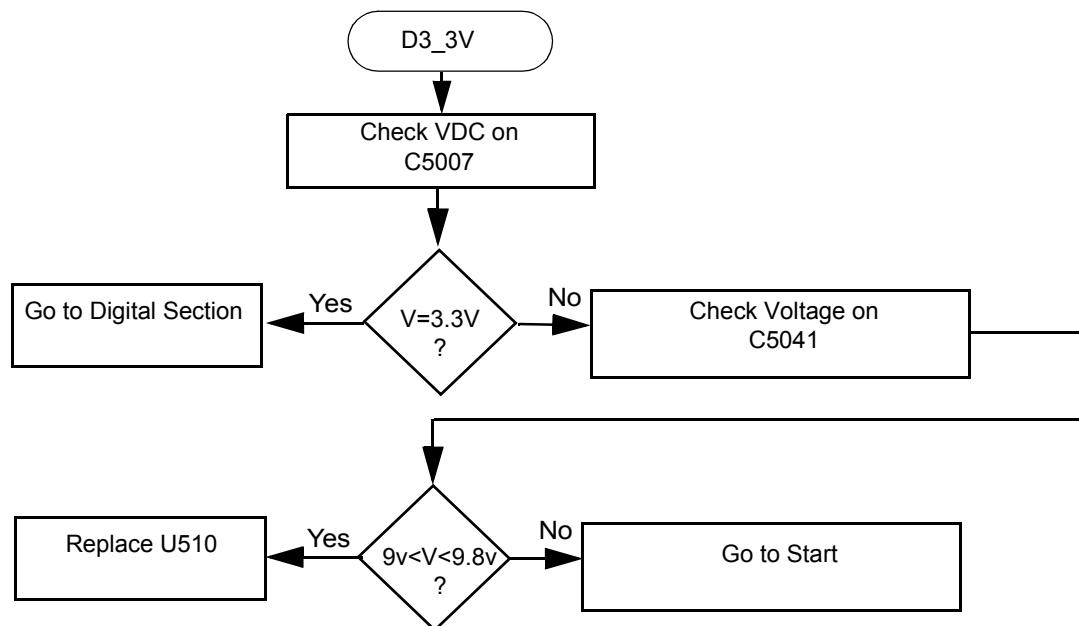


5.0 Troubleshooting Flow Chart for DC Supply (1 of 2)

Since the failure of a critical voltage supply might cause the radio to automatically power down, supply voltages should first be probed with a multimeter. If all the board voltages are absent, then the voltage test point should be retested using a rising-edge-triggered oscilloscope. If the voltage is still absent, then another voltage should be tested using the oscilloscope. If that voltage is present, then the original voltage supply in question is defective and requires investigation of associated circuitry.



5.1 Troubleshooting Flow Chart for DC Supply (2 of 2)



Chapter 4

UHF2 PCB/ SCHEMATICS/ PARTS LISTS

1.0 Allocation of Schematics and Circuit Boards

1.1 UHF2 and Controller Circuits

The UHF circuits are contained on the printed circuit board (PCB) which also contains the Controller circuits. This Chapter shows the schematics for both the UHF circuits and the Controller circuits. The PCB component layouts and the Parts Lists in this Chapter show both the Controller and UHF circuit components. The UHF and Controller schematics and the related PCB and parts list are shown in the tables below.

Table 4-1 UHF2 1-25W Diagrams and Parts Lists

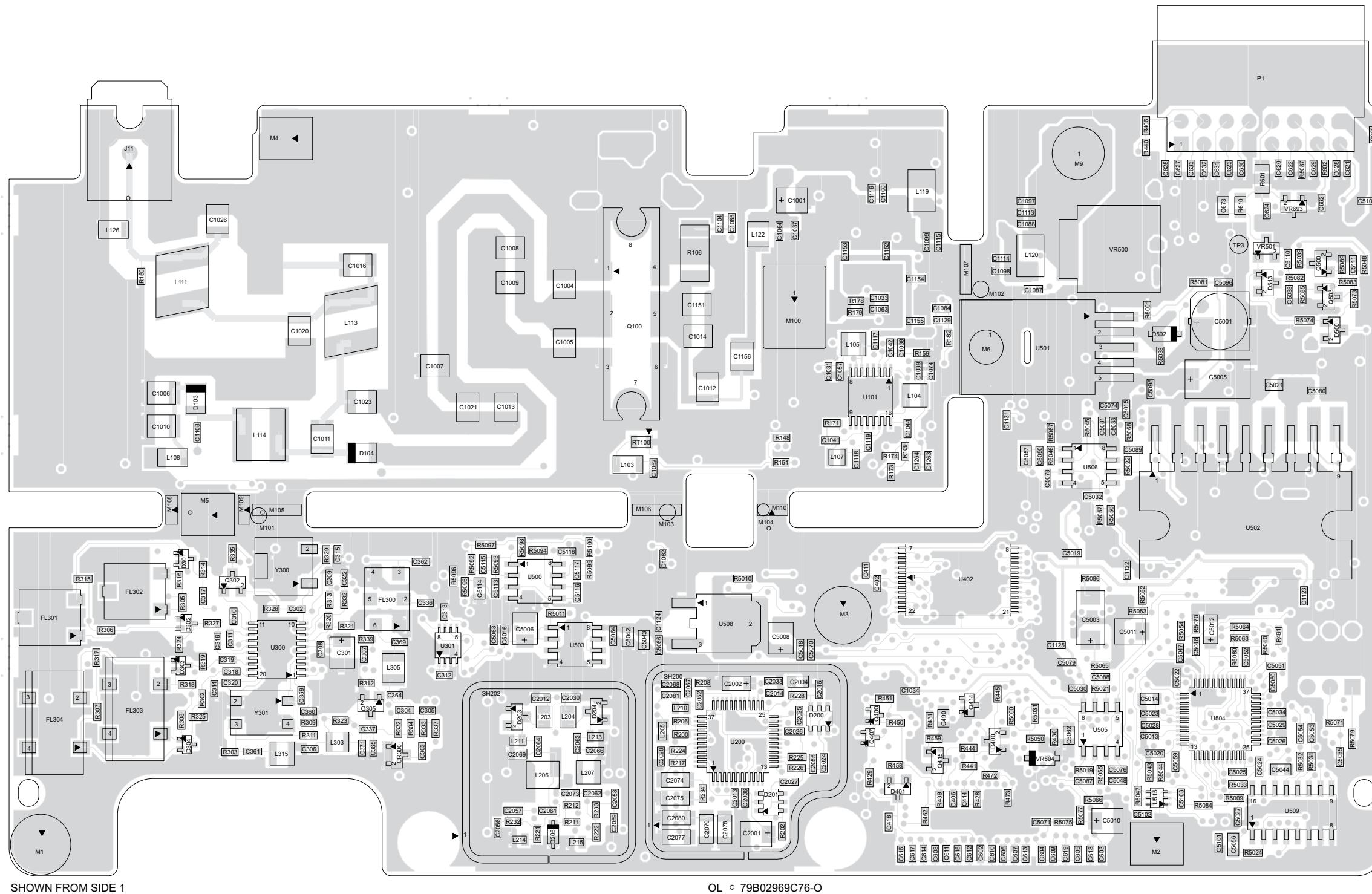
PCB : 8488978U01- D Main Board Top Side 8488978U01- D Main Board Bottom Side	Page 4-4 Page 4-5
SCHEMATICS Main Circuit Transmitter Synthesiser and VCO Receiver Front and Back End DC and Audio Ccts Microprocessor and Controller Ccts Power Control Cct	Page 4-6/Page 4-7 Page 4-8/Page 4-9 Page 4-10/Page 4-11 Page 4-12/Page 4-13 Page 4-14/Page 4-15 Page 4-16/Page 4-17 Page 4-18
Parts List 8488978U01- D	Page 4-19
Controller version is T1	

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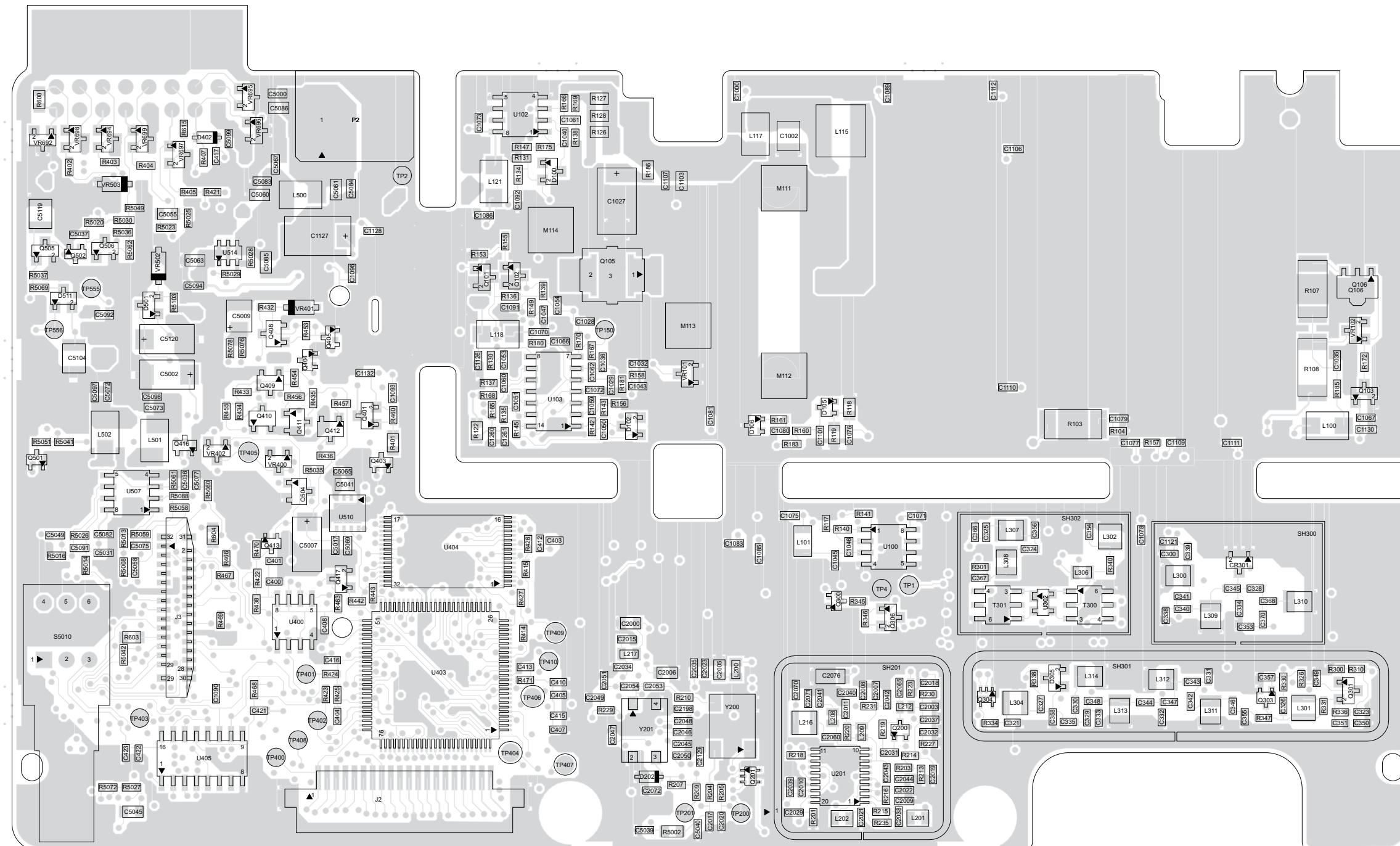
2.0 UHF2 1-25W PCB 8488978U01 (rev. D) / Schematics

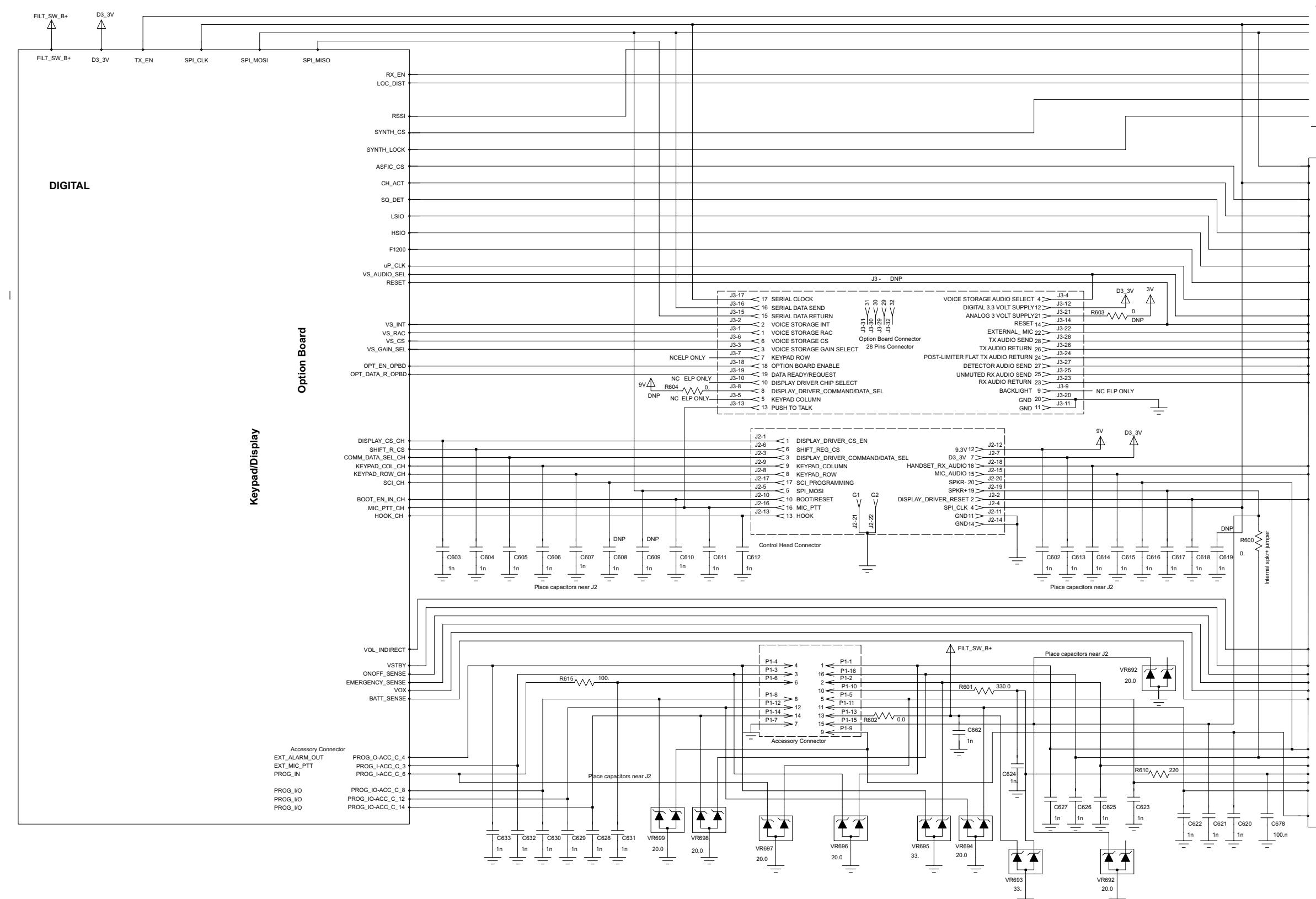


UHF2 Interconnection between Main Board and Power Amplifier Compartment

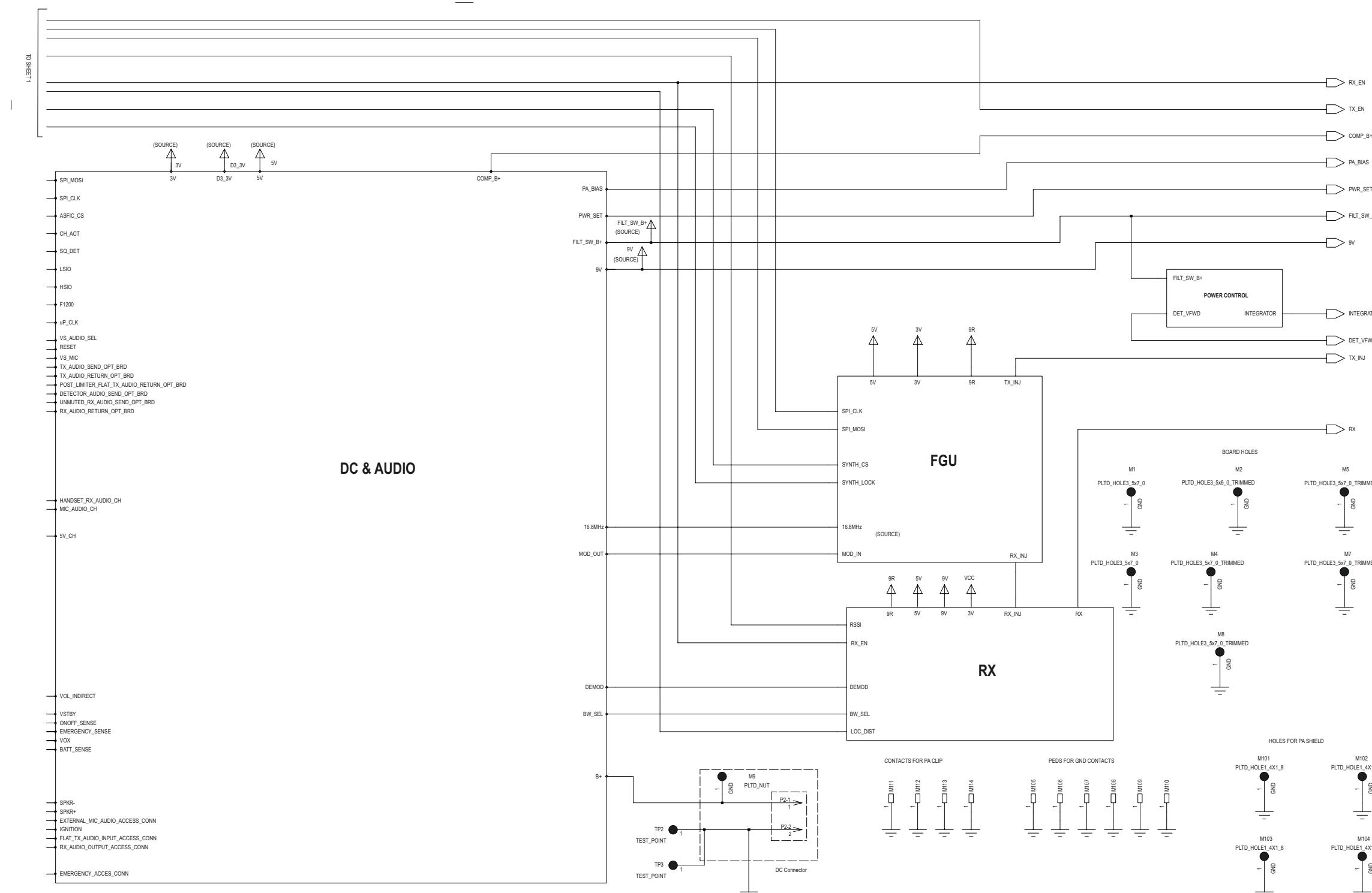


UHF2 (438-470MHz) 1-25W 8488978U01 (rev. D)



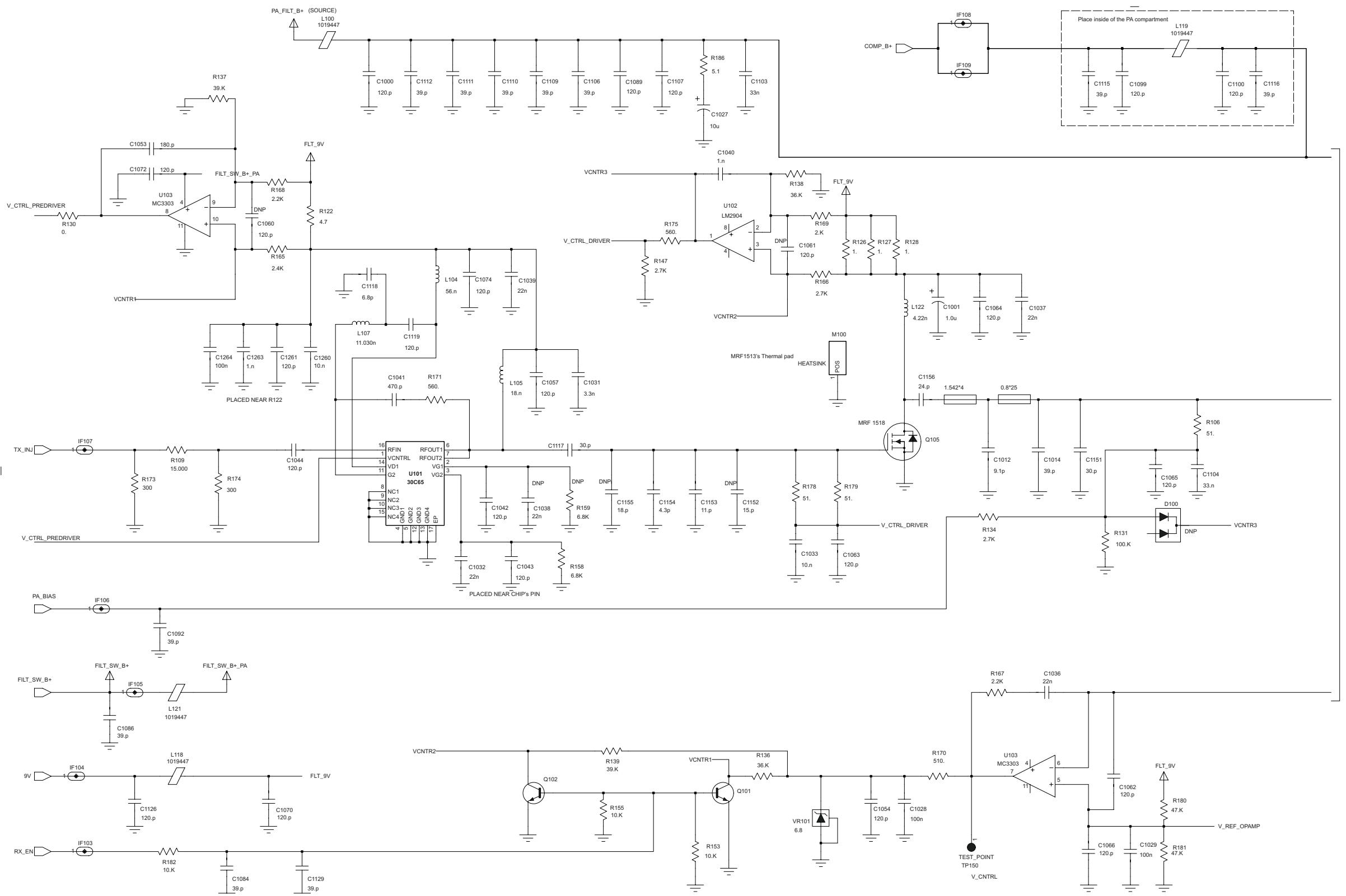


UHF2 (438-470MHz) Main Circuit (Sht 1 of 2)

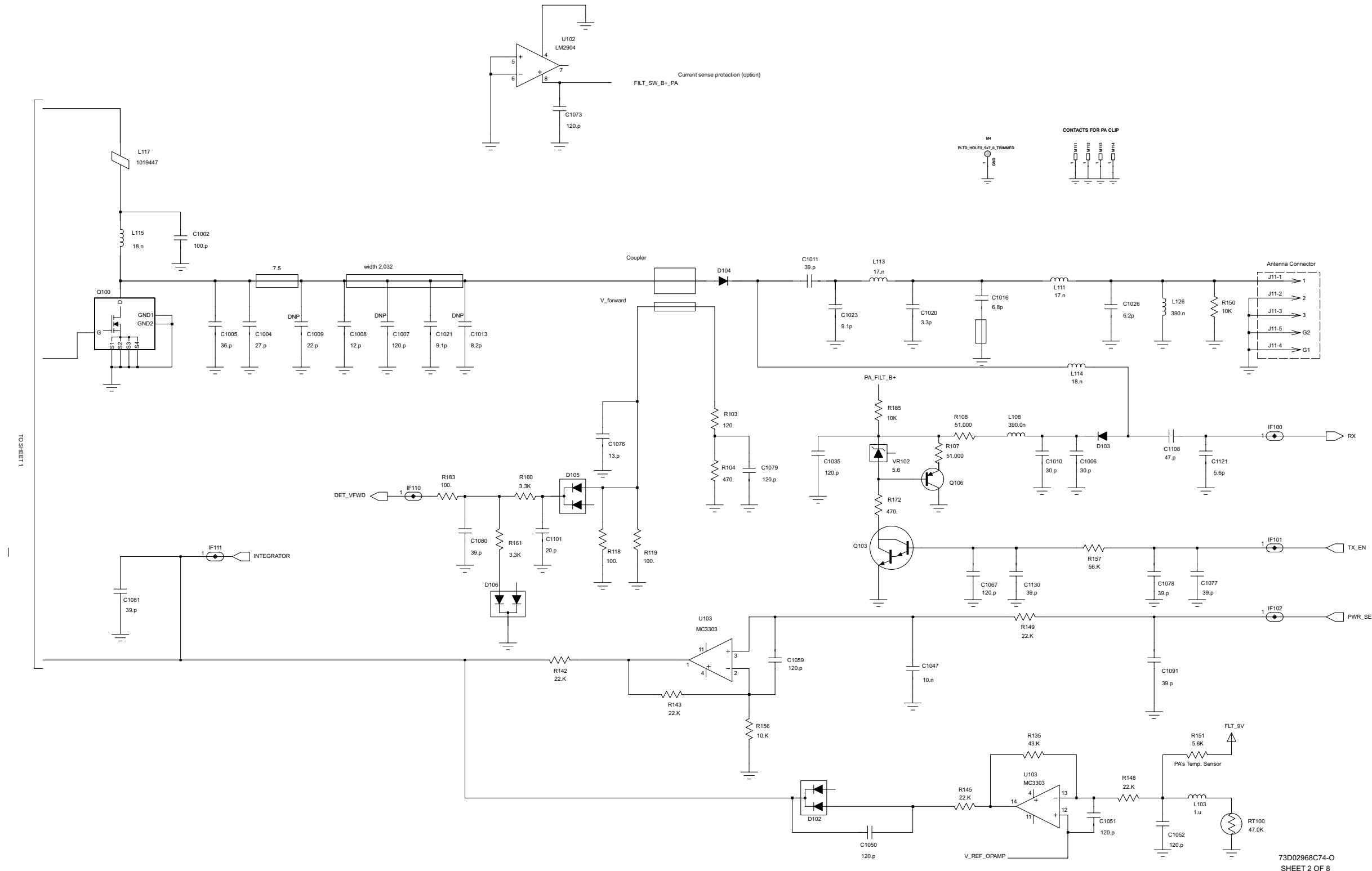


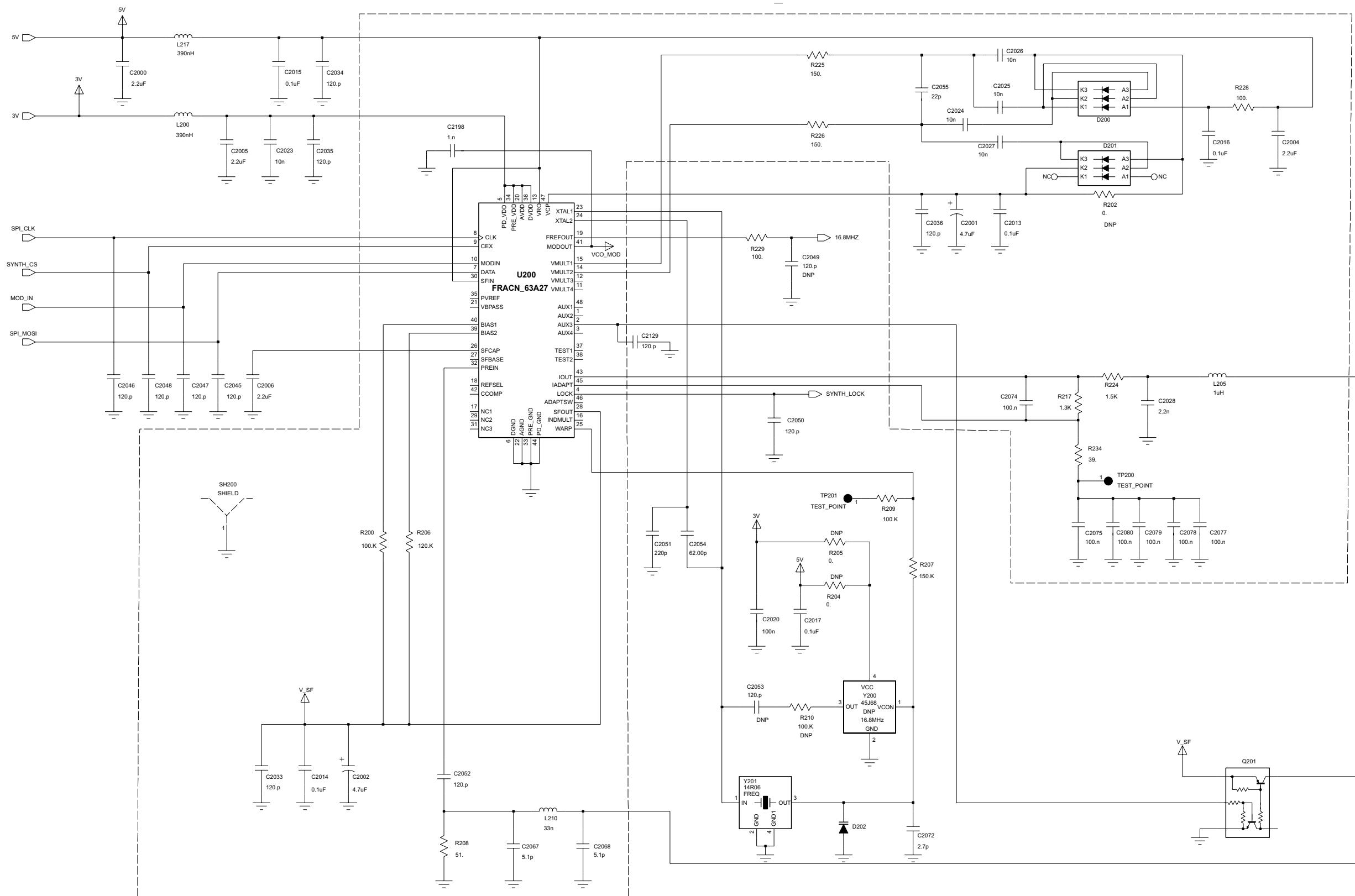
73D02968C74-O
SHEET 4 OF 8

UHF2 (438-470MHz) Main Circuit (Sht 2 of 2)



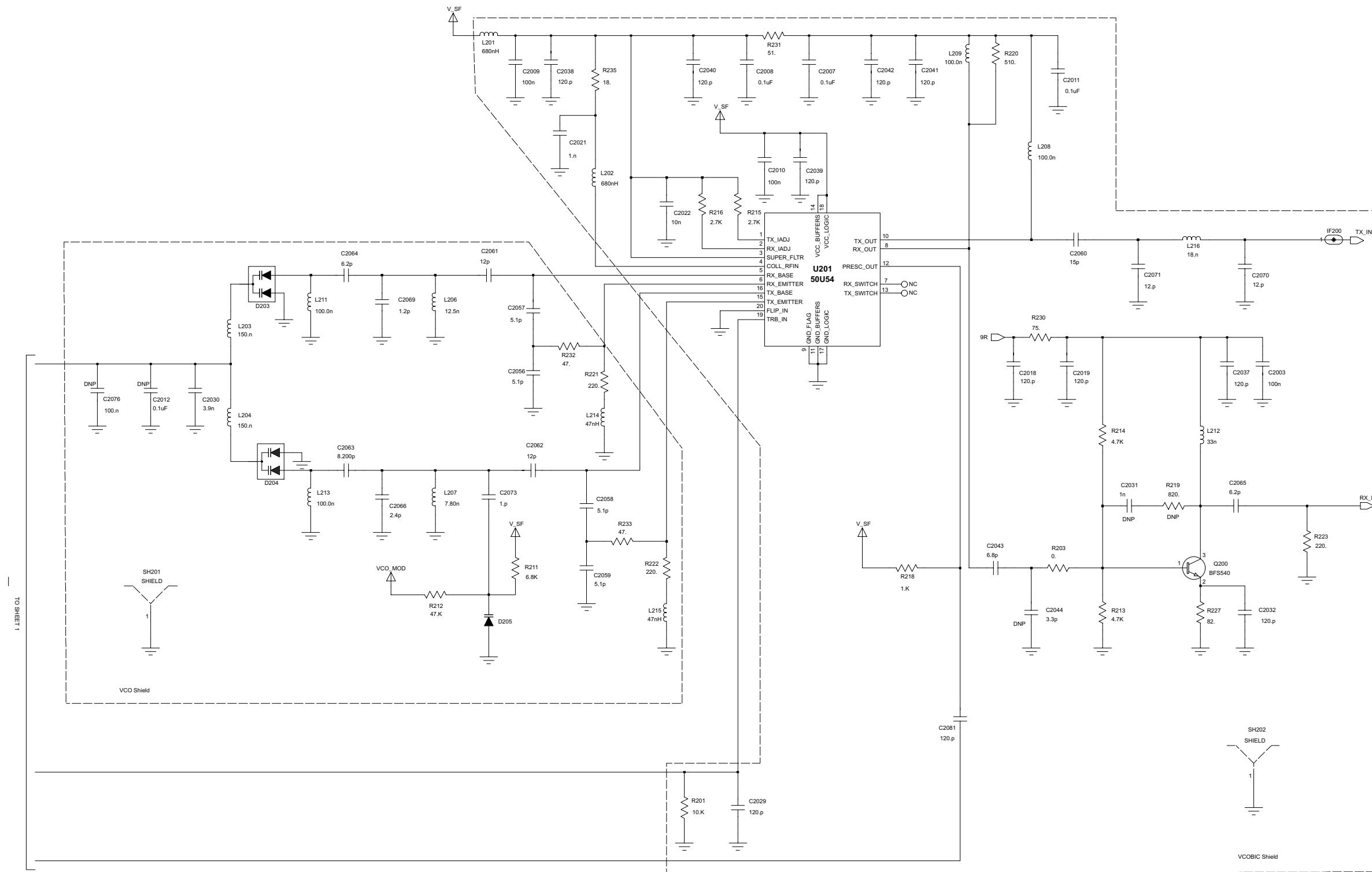
UHF2 (438-470MHz) Transmitter (Sht 1 of 2)



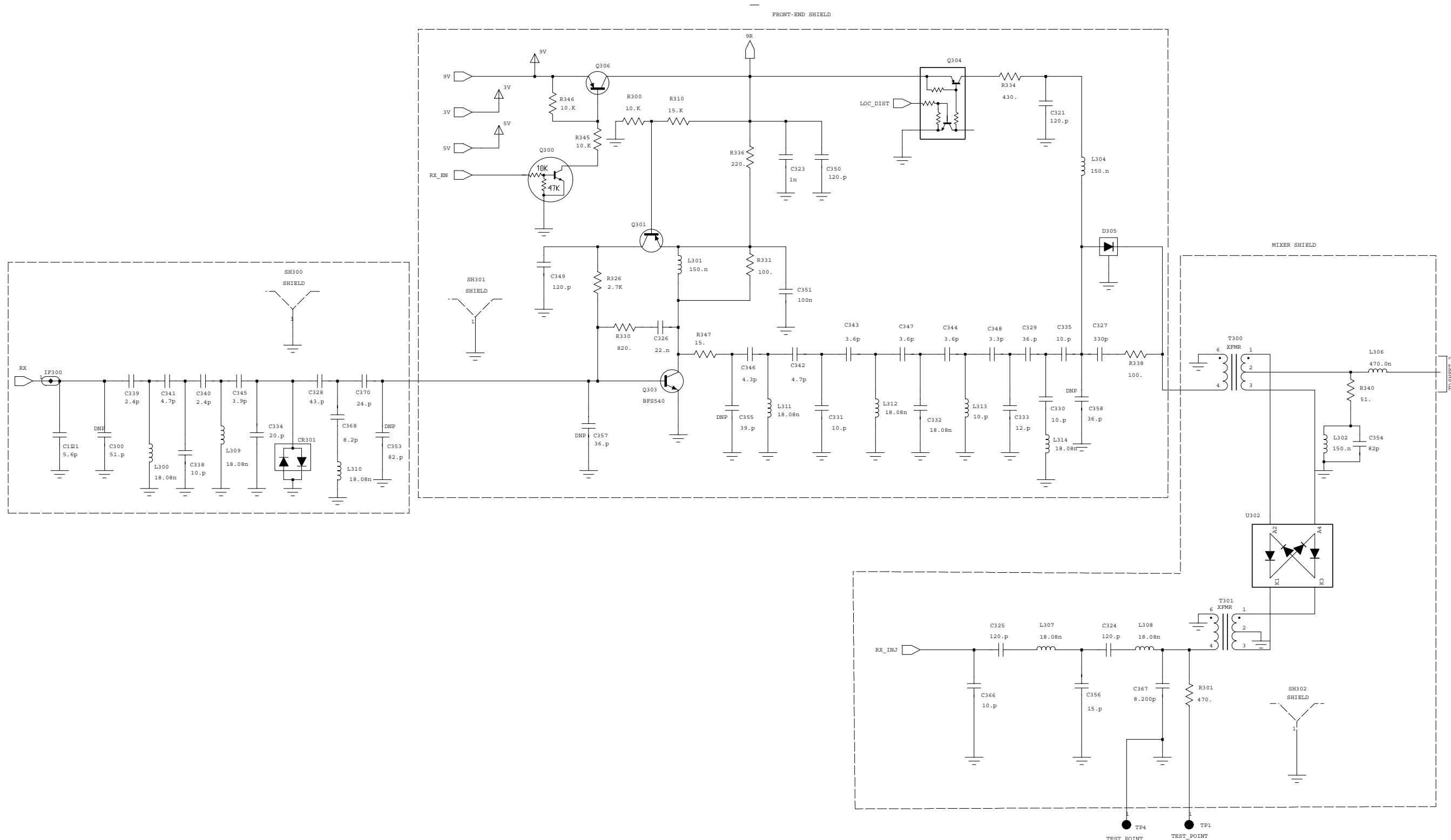


UHF2 (438-470MHz) Synthesiser and VCO (Sht 1 of 2)

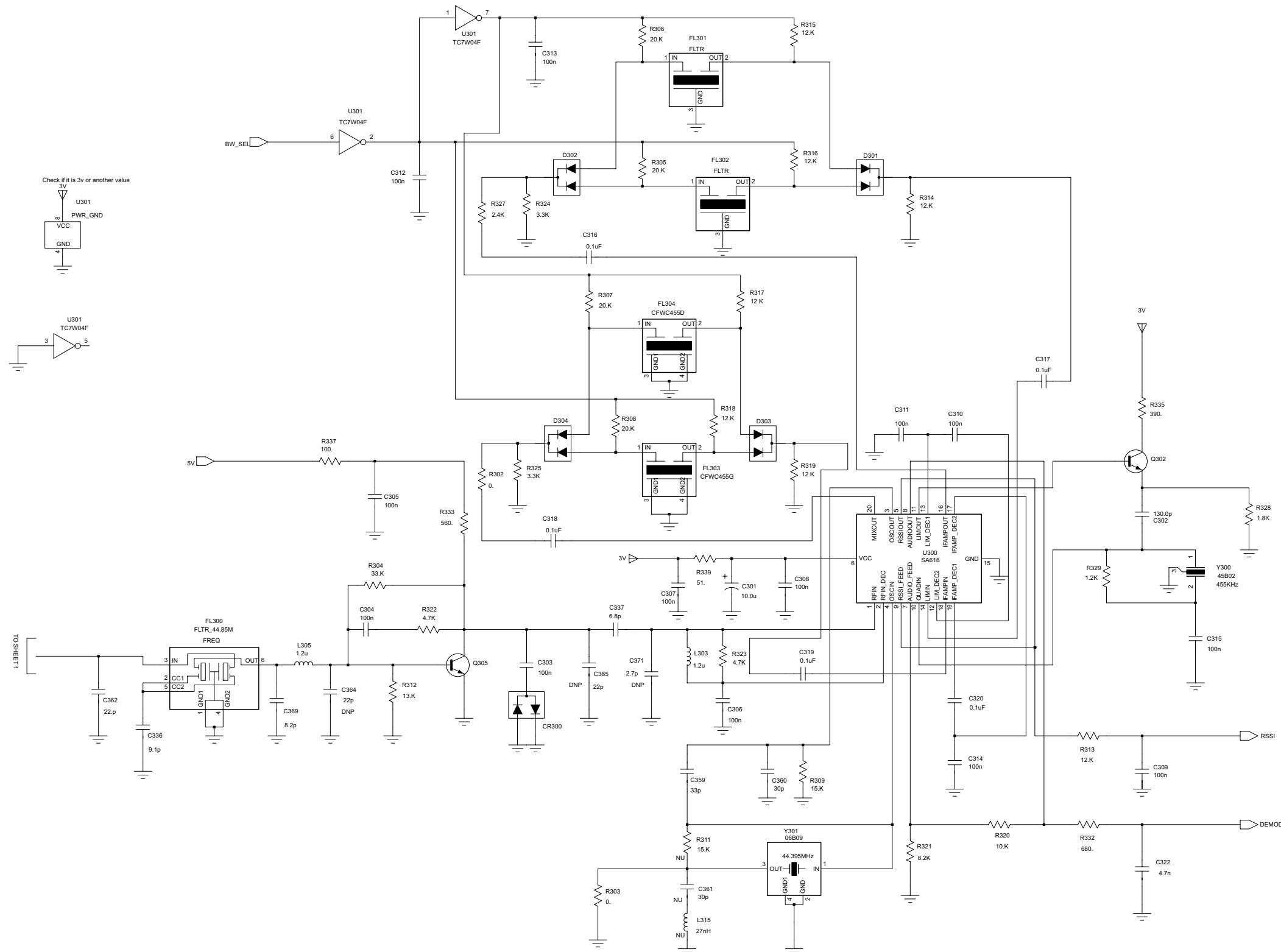
TO SHEET 2



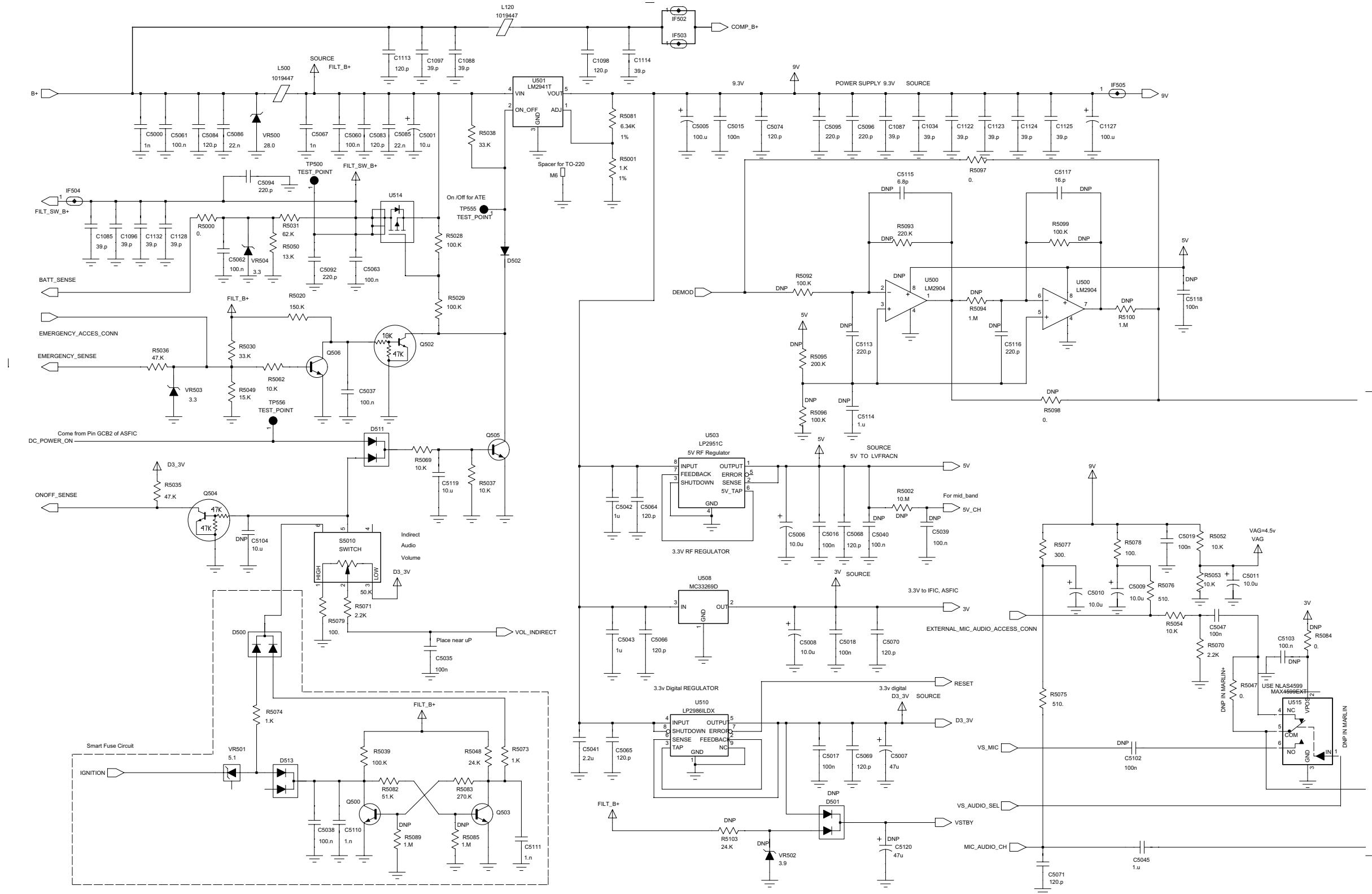
UHF2 (438-470MHz) Synthesiser and VCO (Sht 2 of 2)



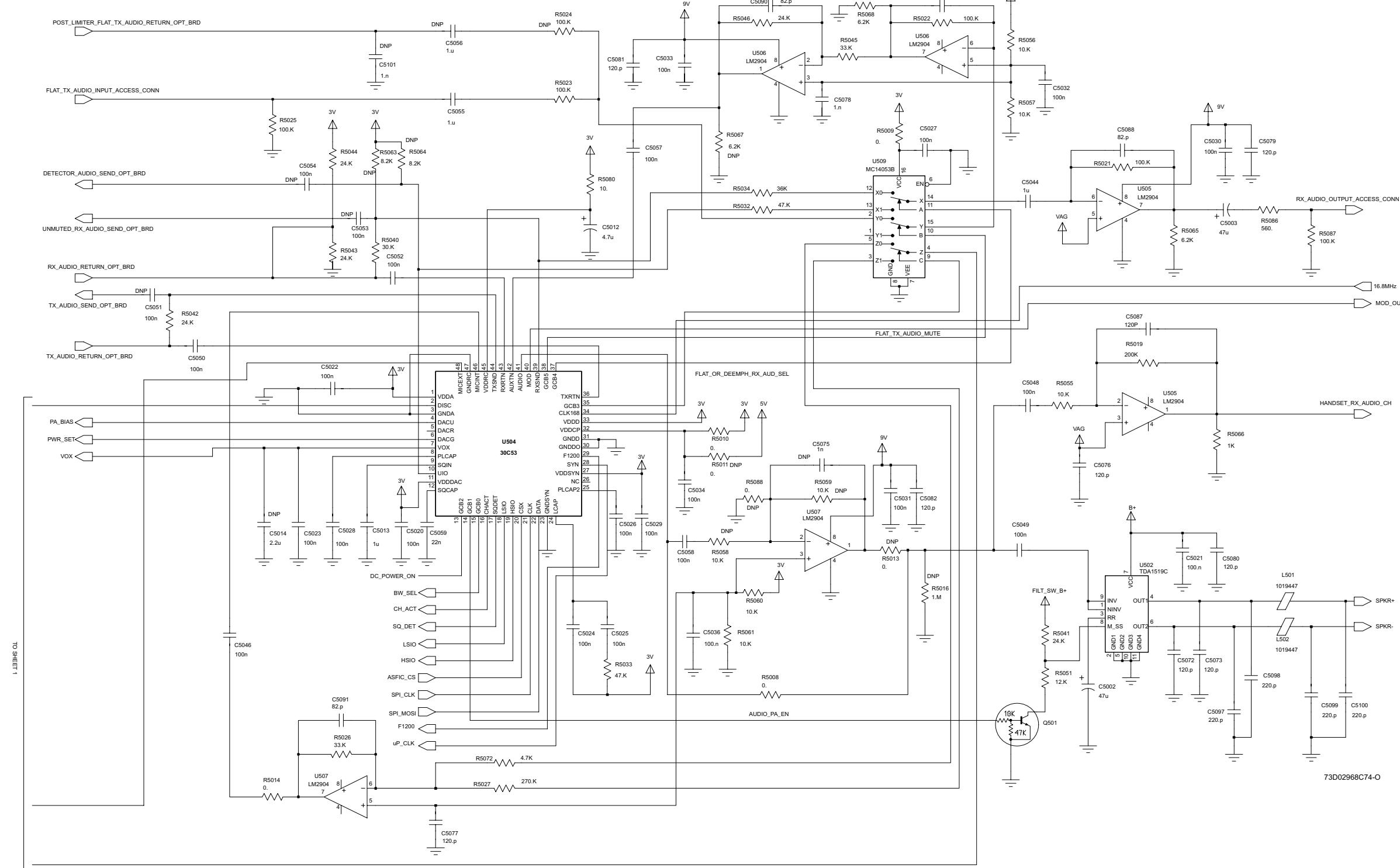
UHF2 (438-470MHz) Receiver Front and Back End (Sht 1 of 2)



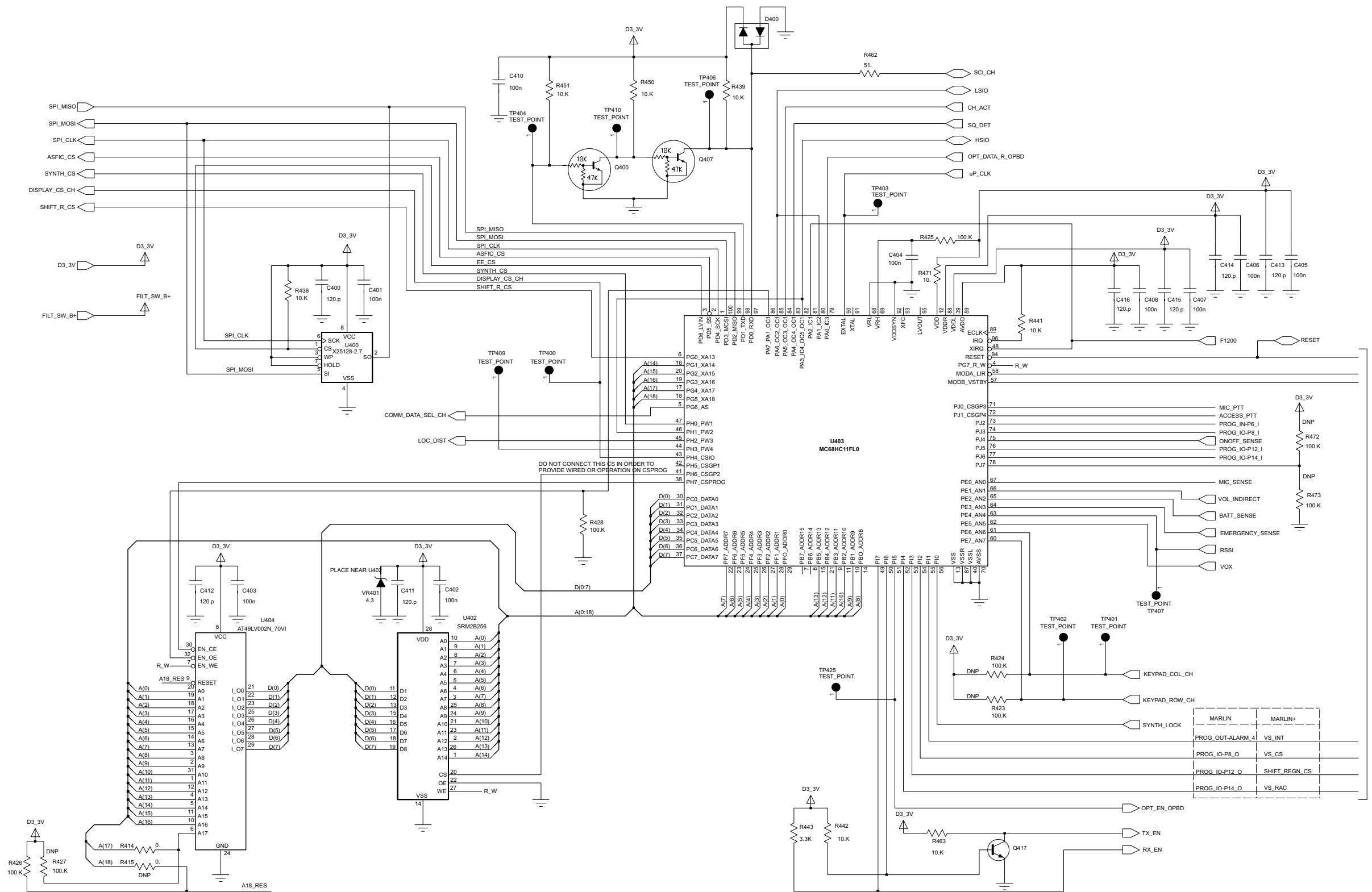
UHF2 (438-470MHz) Receiver Front and Back End (Sheet 2 of 2)



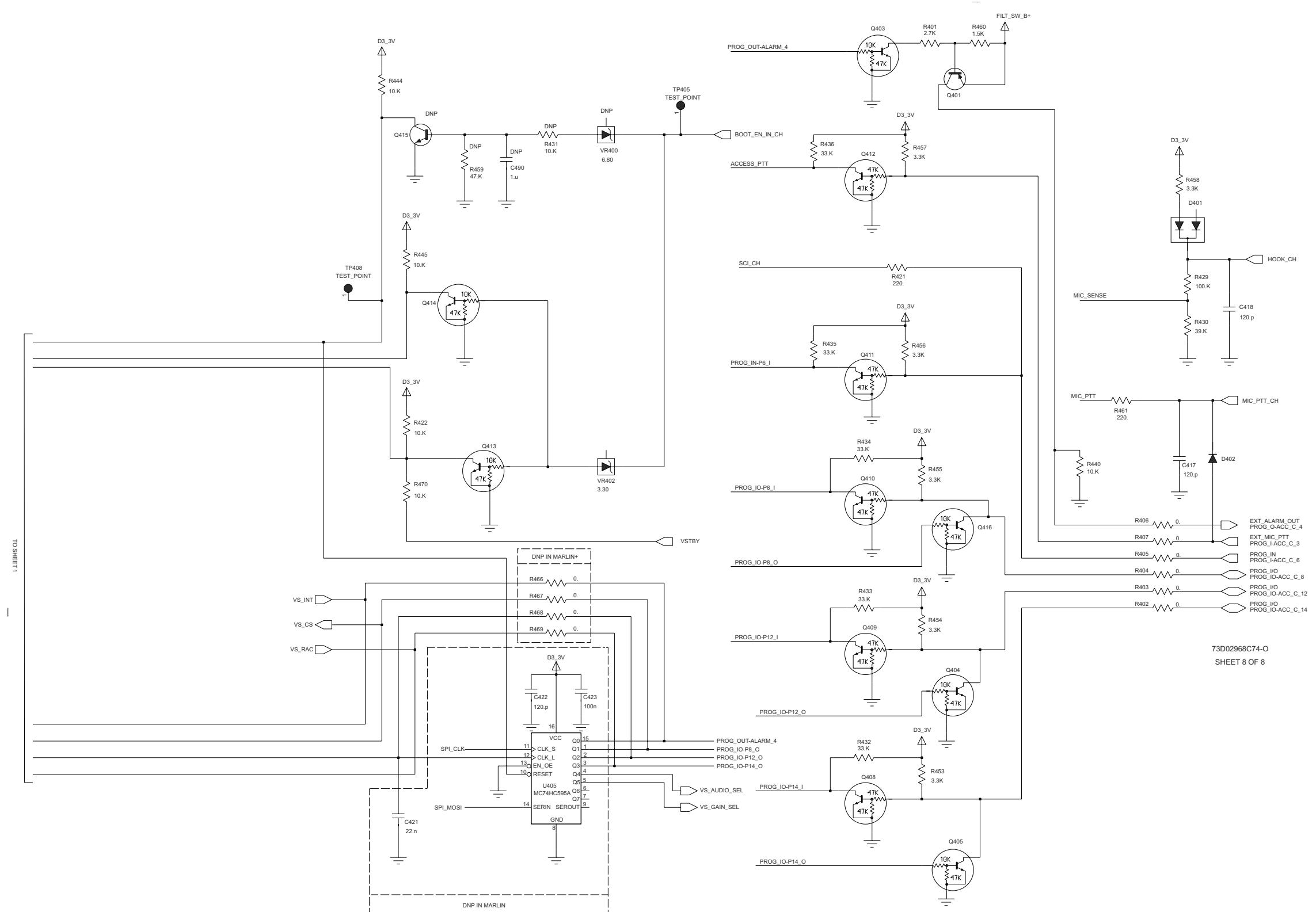
UHF2 (438-470MHz) DC and Audio Circuits (Sht 1 of 2)



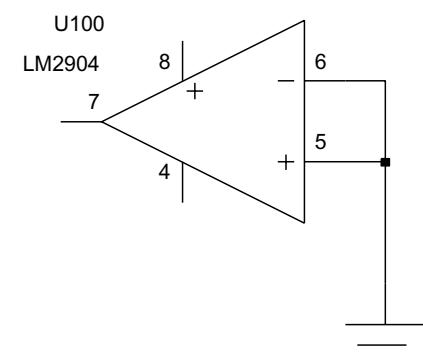
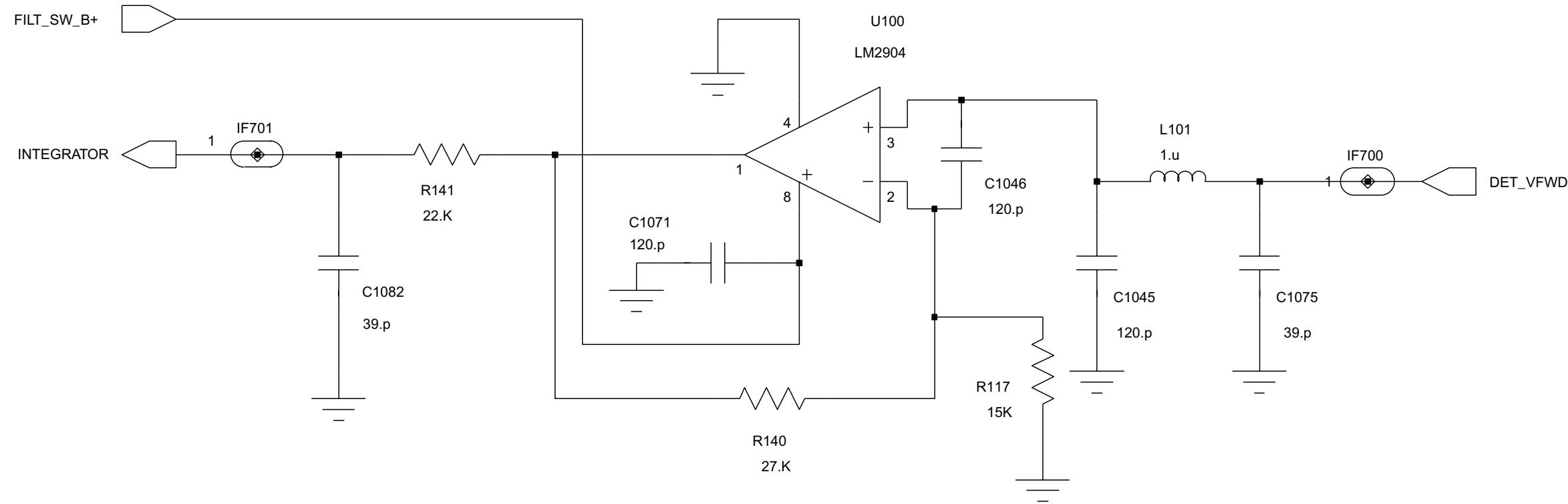
UHF2 (438-470MHz) DC and Audio Circuits (Sht 2 of 2)



UHF2 (438-470MHz) Microprocessor and Controller Circuits (Sht 1 of 2)



UHF2 (438-470MHz) Microprocessor and Controller Circuits (Sht 2 of 2)



UHF2 (438-470MHz) Power Control Circuit

2.1 UHF2 PCB 8488978U01 (rev. D) Parts List 1-25W

Circuit Ref.	Motorola Part No.	Description
C1000	2113740F53	CAP CHIP REEL CL1 +/-30 120
C1001	2311049A08	KEMET CAPS
C1002	2111078B42	CAP CHIP RF 100 5 NPO 100V
C1004	2111078B25	CAP ALT E32
C1005	2111078B31	CHIP CAP 36PF +- 5%
C1006	2111078B27	CAP CHIP RF 30 5 NPO 100V
C1007	NOT PLACED	GCAM DUMMY PART NUMBER
C1008	2111078B15	CAP CHIP RF 12 5 NPO 100V
C1009	NOT PLACED	GCAM DUMMY PART NUMBER
C1010	2111078B27	CAP CHIP RF 30 5 NPO 100V
C1011	2111078B32	CAP ALT E12
C1012	2111078B12	CAP CHIP RF 9.1 .5 NPO 100V
C1013	NOT PLACED	GCAM DUMMY PART NUMBER
C1014	2111078B38	CAP CHIP RF 68 5 NPO 100V
C1016	2111078B09	CAP ALT E17
C1020	2111078B01	CAP CHIP RF 3.3 .25 NPO 100V
C1021	2111078B12	CAP CHIP RF 9.1 .5 NPO 100V
C1023	2111078B12	CAP CHIP RF 9.1 .5 NPO 100V
C1026	2111078B08	CAP CHIP RF 6.2 .25NPO 100V
C1027	2311049A45	CAP TANT CHIP 10 10 35
C1028	2113743K15	CER CHIP CAP .100UF
C1029	2113743K15	CER CHIP CAP .100UF
C1031	2113741F37	CAP CHIP CL2 X7R REEL 3300
C1032	2113743E07	CER CHIP CAP .022UF
C1033	2113741F49	CAP CHIP CL2 X7R REEL 10000
C1034	2113740F41	CAP CHIP REEL CL1 +/-30 39
C1035	2113740F53	CAP CHIP REEL CL1 +/-30 120
C1036	2113743E07	CER CHIP CAP .022UF
C1037	2113743E07	CER CHIP CAP .022UF

Circuit Ref.	Motorola Part No.	Description
C1038	NOT PLACED	GCAM DUMMY PART NUMBER
C1039	2113743E07	CER CHIP CAP .022UF
C1040	2113741F25	CAP CHIP CL2 X7R REEL 1000
C1041	2113740F67	CAP CHIP CL1 +/-30 470 5%
C1042	2113740F53	CAP CHIP REEL CL1 +/-30 120
C1043	2113740F53	CAP CHIP REEL CL1 +/-30 120
C1044	2113740F53	CAP CHIP REEL CL1 +/-30 120
C1045	2113740F53	CAP CHIP REEL CL1 +/-30 120
C1046	2113740F53	CAP CHIP REEL CL1 +/-30 120
C1047	2113743E20	CAP CHIP. 10 UF 10%
C1050	2113740F53	CAP CHIP REEL CL1 +/-30 120
C1051	2113740F53	CAP CHIP REEL CL1 +/-30 120
C1052	2113740F53	CAP CHIP REEL CL1 +/-30 120
C1053	2113740F57	CAP CHIP REEL CL1 +/-30 180
C1054	2113740F53	CAP CHIP REEL CL1 +/-30 120
C1057	2113740F53	CAP CHIP REEL CL1 +/-30 120
C1059	2113740F53	CAP CHIP REEL CL1 +/-30 120
C1060	NOT PLACED	GCAM DUMMY PART NUMBER
C1061	NOT PLACED	GCAM DUMMY PART NUMBER
C1062	2113740F53	CAP CHIP REEL CL1 +/-30 120
C1063	2113740F53	CAP CHIP REEL CL1 +/-30 120
C1064	2113740F53	CAP CHIP REEL CL1 +/-30 120
C1065	2113740F53	CAP CHIP REEL CL1 +/-30 120
C1066	2113740F53	CAP CHIP REEL CL1 +/-30 120
C1067	2113740F53	CAP CHIP REEL CL1 +/-30 120
C1070	2113740F53	CAP CHIP REEL CL1 +/-30 120
C1071	2113740F53	CAP CHIP REEL CL1 +/-30 120
C1072	2113740F53	CAP CHIP REEL CL1 +/-30 120
C1073	2113740F53	CAP CHIP REEL CL1 +/-30 120
C1074	2113740F53	CAP CHIP REEL CL1 +/-30 120
C1075	2113740F41	CAP CHIP REEL CL1 +/-30 39
C1076	2113740F30	CAP CHIP REEL CL1 +/-30 13
C1077	2113740F41	CAP CHIP REEL CL1 +/-30 39
C1078	2113740F41	CAP CHIP REEL CL1 +/-30 39
C1079	2113740F53	CAP CHIP REEL CL1 +/-30 120
C1080	2113740F41	CAP CHIP REEL CL1 +/-30 39
C1081	NOT PLACED	GCAM DUMMY PART NUMBER
C1082	NOT PLACED	GCAM DUMMY PART NUMBER
C1083	2113740F41	CAP CHIP REEL CL1 +/-30 39
C1084	2113740F41	CAP CHIP REEL CL1 +/-30 39
C1085	2113740F41	CAP CHIP REEL CL1 +/-30 39
C1086	2113740F41	CAP CHIP REEL CL1 +/-30 39
C1087	2113740F41	CAP CHIP REEL CL1 +/-30 39
C1088	2113740F41	CAP CHIP REEL CL1 +/-30 39
C1089	2113740F53	CAP CHIP REEL CL1 +/-30 120
C1090	NOT PLACED	GCAM DUMMY PART NUMBER
C1091	NOT PLACED	GCAM DUMMY PART NUMBER
C1092	NOT PLACED	GCAM DUMMY PART NUMBER
C1093	NOT PLACED	GCAM DUMMY PART NUMBER
C1096	2113740F41	CAP CHIP REEL CL1 +/-30 39
C1097	2113740F41	CAP CHIP REEL CL1 +/-30 39
C1098	2113740F53	CAP CHIP REEL CL1 +/-30 120
C1099	2113740F53	CAP CHIP REEL CL1 +/-30 120
C1100	2113740F53	CAP CHIP REEL CL1 +/-30 120
C1101	2113740F34	CAP CHIP REEL CL1 +/-30 20
C1103	2113741A57	CAP CHIP 33K +-5% (2160521A31)
C1104	2113928A02	CAP CERAMIC CHIP .47UF
C1106	2113740F41	CAP CHIP REEL CL1 +/-30 39
C1107	2113740F53	CAP CHIP REEL CL1 +/-30 120
C1108	2113740F43	CAP CHIP REEL CL1 +/-30 47
C1109	2113740F41	CAP CHIP REEL CL1 +/-30 39
C1110	2113740F41	CAP CHIP REEL CL1 +/-30 39
C1111	2113740F41	CAP CHIP REEL CL1 +/-30 39
C1111	2113740F41	CAP CHIP REEL CL1 +/-30 39
C1121	2113740F21	CAP CHIP REEL CL1 +/-30 5.6
C1122	2113740F41	CAP CHIP REEL CL1 +/-30 39
C1123	2113740F41	CAP CHIP REEL CL1 +/-30 39
C1124	2113740F41	CAP CHIP REEL CL1 +/-30 39
C1125	2113740F41	CAP CHIP REEL CL1 +/-30 39
C1126	2113740F53	CAP CHIP REEL CL1 +/-30 120
C1127	2360567A03	CAP TANTALUM
C1128	2113740F41	CAP CHIP REEL CL1 +/-30 39
C1129	2113740F41	CAP CHIP REEL CL1 +/-30 39
C1130	2113740F41	CAP CHIP REEL CL1 +/-30 39
C1131	NOT PLACED	GCAM DUMMY PART NUMBER
C1132	2113740F41	CAP CHIP REEL CL1 +/-30 39
C1151	NOT PLACED	GCAM DUMMY PART NUMBER
C1152	NOT PLACED	GCAM DUMMY PART NUMBER
C1153	2113740F28	CAP CHIP REEL CL1 +/-30 11
C1154	2113740F33	CAP CHIP REEL CL1 +/-30 18
C1155	NOT PLACED	GCAM DUMMY PART NUMBER
C1156	2111078B23	CAP ALT E37
C1260	2113741F49	CAP CHIP CL2 X7R REEL 10000
C1261	2113740F53	CAP CHIP REEL CL1 +/-30 120
C1263	2113741F25	CAP CHIP CL2 X7R REEL 1000
C1264	2113743K15	CER CHIP CAP .100UF
C2000	2113743F18	CAP CHIP 2.2 UF 16V +80-20%
C2001	2311049J11	CAPACITOR TANT 10% 4.7UF

Circuit Ref.	Motorola Part No.	Description
C2002	2311049A72	CAP TANT CHIP 10.0UF 10% 10V
C2003	2113743K15	CER CHIP CAP .100UF
C2004	2113743F18	CAP CHIP 2.2 UF 16V +80-20%
C2005	2113743F18	CAP CHIP 2.2 UF 16V +80-20%
C2006	2113743F18	CAP CHIP 2.2 UF 16V +80-20%
C2007	2113743E20	CAP CHIP. 10 UF 10%
C2008	2113743E20	CAP CHIP. 10 UF 10%
C2009	2113743E20	CAP CHIP. 10 UF 10%
C2010	2113743E20	CAP CHIP. 10 UF 10%
C2011	2113743E20	CAP CHIP. 10 UF 10%
C2012	NOT PLACED	GCAM DUMMY PART NUMBER
C2013	2113743E20	CAP CHIP. 10 UF 10%
C2014	2113743E20	CAP CHIP. 10 UF 10%
C2015	2113743E20	CAP CHIP. 10 UF 10%
C2016	2113743E20	CAP CHIP. 10 UF 10%
C2017	2113743E20	CAP CHIP. 10 UF 10%
C2018	2113740F53	CAP CHIP REEL CL1 +/-30 120
C2019	2113740F53	CAP CHIP REEL CL1 +/-30 120
C2020	2113743E20	CAP CHIP. 10 UF 10%
C2021	2113741F25	CAP CHIP CL2 X7R REEL 1000
C2022	2113741F49	CAP CHIP CL2 X7R REEL 10000
C2023	2113741F49	CAP CHIP CL2 X7R REEL 10000
C2024	2113741F49	CAP CHIP CL2 X7R REEL 10000
C2025	2113741F49	CAP CHIP CL2 X7R REEL 10000
C2026	2113741F49	CAP CHIP CL2 X7R REEL 10000
C2027	2113741F49	CAP CHIP CL2 X7R REEL 10000
C2028	2113741F33	CAP CHIP CL2 X7R REEL 2200
C2029	2113740F53	CAP CHIP REEL CL1 +/-30 120
C2030	2113741F39	CAP CHIP CL2 XTR REEL 3900
C2031	NOT PLACED	GCAM DUMMY PART NUMBER
C2032	2113740F53	CAP CHIP REEL CL1 +/-30 120

Circuit Ref.	Motorola Part No.	Description
C2033	2113740F53	CAP CHIP REEL CL1 +/-30 120
C2034	2113740F53	CAP CHIP REEL CL1 +/-30 120
C2035	2113740F53	CAP CHIP REEL CL1 +/-30 120
C2036	2113740F53	CAP CHIP REEL CL1 +/-30 120
C2037	2113740F53	CAP CHIP REEL CL1 +/-30 120
C2038	2113740F53	CAP CHIP REEL CL1 +/-30 120
C2039	2113740F53	CAP CHIP REEL CL1 +/-30 120
C2040	2113740F53	CAP CHIP REEL CL1 +/-30 120
C2041	2113740F53	CAP CHIP REEL CL1 +/-30 120
C2042	2113740F53	CAP CHIP REEL CL1 +/-30 120
C2043	2113740L14	CAP CER CHIP 6.8PF +/-0.1PF
C2044	NOT PLACED	GCAM DUMMY PART NUMBER
C2045	2113740F53	CAP CHIP REEL CL1 +/-30 120
C2046	2113740F53	CAP CHIP REEL CL1 +/-30 120
C2047	2113740F53	CAP CHIP REEL CL1 +/-30 120
C2048	2113740F53	CAP CHIP REEL CL1 +/-30 120
C2049	NOT PLACED	GCAM DUMMY PART NUMBER
C2050	2113740F53	CAP CHIP REEL CL1 +/-30 120
C2051	2113740F59	CAP CHIP REEL CL1 +/-30 220
C2052	2113740F53	CAP CHIP REEL CL1 +/-30 120
C2053	NOT PLACED	GCAM DUMMY PART NUMBER
C2054	2113740L37	CAP 62.0 PF 50V 2.0%
C2055	2113740F35	CAP CHIP REEL CL1 +/-30 22
C2056	2113740F20	CAP CHIP REEL CL1 +/-30 5.1
C2057	2113740F20	CAP CHIP REEL CL1 +/-30 5.1
C2058	2113740F20	CAP CHIP REEL CL1 +/-30 5.1
C2059	2113740F20	CAP CHIP REEL CL1 +/-30 5.1
C2060	2113740F31	CAP CHIP REEL CL1 +/-30 15
C2061	2113740F29	CAP CHIP REEL CL1 +/-30 12
C2062	2113740F29	CAP CHIP REEL CL1 +/-30 12
C2063	2113740L16	CAP CER CHIP 8.2 PF+/-0.1PF
C2064	2113740L13	CAP CER CHIP 6.2 PF+/-0.1PF

Circuit Ref.	Motorola Part No.	Description
C2065	2113740F53	CAP CHIP REEL CL1 +/-30 120
C2066	2113740L03	CAP CER CHIP 2.4PF +/-0.1PF
C2067	2113740F20	CAP CHIP REEL CL1 +/-30 5.1
C2068	2113740F20	CAP CHIP REEL CL1 +/-30 5.1
C2069	2113740F05	CAP CHIP REEL CL1 +/-30 1.2
C2070	2113740L13	CAP CER CHIP 6.2 PF+/-0.1PF
C2071	2113740L13	CAP CER CHIP 6.2 PF+/-0.1PF
C2072	2113740L04	CAP CER CHIP 2.7 PF+/-0.1PF
C2073	2113740F03	CAP CHIP REEL CL1 +/-30 1.0
C2074	2109720D14	CAP CER CHIP LOW DIST 0.1UF
C2075	2109720D14	CAP CER CHIP LOW DIST 0.1UF
C2076	NOT PLACED	GCAM DUMMY PART NUMBER
C2077	2109720D14	CAP CER CHIP LOW DIST 0.1UF
C2078	2109720D14	CAP CER CHIP LOW DIST 0.1UF
C2079	2109720D14	CAP CER CHIP LOW DIST 0.1UF
C2080	2109720D14	CAP CER CHIP LOW DIST 0.1UF
C2081	2113740F53	CAP CHIP REEL CL1 +/-30 120
C2129	2113740F53	CAP CHIP REEL CL1 +/-30 120
C2198	2113741F25	CAP CHIP CL2 X7R REEL 1000
C300	NOT PLACED	GCAM DUMMY PART NUMBER
C301	2311049A57	CAP TANT CHIP A/P 10UF 10% 16V
C302	2113740F54	CAP CHIP REEL CL1 +/-30 130
C303	2113743K15	CER CHIP CAP .100UF
C304	2113743E20	CAP CHIP. 10 UF 10%
C305	2113743E20	CAP CHIP. 10 UF 10%
C306	2113743E20	CAP CHIP. 10 UF 10%
C307	2113743E20	CAP CHIP. 10 UF 10%

Circuit Ref.	Motorola Part No.	Description
C308	2113743E20	CAP CHIP. 10 UF 10%
C309	2113743E20	CAP CHIP. 10 UF 10%
C310	2113743E20	CAP CHIP. 10 UF 10%
C311	2113743E20	CAP CHIP. 10 UF 10%
C312	2113743E20	CAP CHIP. 10 UF 10%
C313	2113743E20	CAP CHIP. 10 UF 10%
C314	2113743E20	CAP CHIP. 10 UF 10%
C315	2113743E20	CAP CHIP. 10 UF 10%
C316	2113743E20	CAP CHIP. 10 UF 10%
C317	2113743E20	CAP CHIP. 10 UF 10%
C318	2113743E20	CAP CHIP. 10 UF 10%
C319	2113743E20	CAP CHIP. 10 UF 10%
C320	2113743E20	CAP CHIP. 10 UF 10%
C321	2113740F53	CAP CHIP REEL CL1 +/-30 120
C322	2113741F41	CAP CHIP CL2 X7R REEL 4700
C323	2113741F25	CAP CHIP CL2 X7R REEL 1000
C324	2113740F53	CAP CHIP REEL CL1 +/-30 120
C325	2113740F53	CAP CHIP REEL CL1 +/-30 120
C326	2113743E07	CER CHIP CAP .022UF
C327	2113741F13	CAP CHIP CL2 X7R REEL 330
C328	2113740F42	CAP CHIP REEL CL1 +/-30 43
C329	2113740L31	CAP 36.0 PF 50V 2.0 %
C330	2113740L18	CAP CER CHIP 10.0 PF +/--.25PF
C331	2113740L18	CAP CER CHIP 10.0 PF +/--.25PF
C332	2113740L18	CAP CER CHIP 10.0 PF +/--.25PF
C333	2113740L20	CAP 12.0 PF 50V 2.0 %
C334	2113740L25	CAP CER CHIP 20.0 PF +/--.25PF
C335	2113740L18	CAP CER CHIP 10.0 PF +/--.25PF
C336	2113740L17	CAP CER CHIP 9.1 PF+/-0.1PF
C337	2113740L14	CAP CER CHIP 6.8PF +/-0.1PF
C338	2113740L18	CAP CER CHIP 10.0 PF +/--.25PF
C339	2113740L03	CAP CER CHIP 2.4PF +/-0.1PF

Circuit Ref.	Motorola Part No.	Description	Circuit Ref.	Motorola Part No.	Description	Circuit Ref.	Motorola Part No.	Description
C340	2113740L03	CAP CER CHIP 2.4PF +-0.1PF	C402	NOT PLACED	GCAM DUMMY PART NUMBER	C5010	2311049A57	CAP TANT CHIP A/P 10UF 10% 16V
C341	2113740F19	CAP CHIP REEL CL1 +/-30 4.7	C403	2113743K15	CER CHIP CAP .100UF	C5011	2311049A57	CAP TANT CHIP A/P 10UF 10% 16V
C342	2113740F19	CAP CHIP REEL CL1 +/-30 4.7	C404	2113743K15	CER CHIP CAP .100UF	C5012	2311049A56	CAP TAN CHIP A/P 4.7 20 10
C343	2113740L07	CAP CER CHIP 3.6PF +-0.1PF	C405	2113743K15	CER CHIP CAP .100UF	C5013	2113928P04	CAP CER CHIP 1.0UF 20% 6.3V
C344	2113740L07	CAP CER CHIP 3.6PF +-0.1PF	C406	2113743K15	CER CHIP CAP .100UF	C5014	NOT PLACED	GCAM DUMMY PART NUMBER
C345	2113740L08	CAP CER CHIP 3.9 PF+/-0.1PF	C407	2113743K15	CER CHIP CAP .100UF	C5015	2113743K15	CER CHIP CAP .100UF
C346	2113740L09	CAP CER CHIP 4.3 PF +-0.1PF	C408	2113743K15	CER CHIP CAP .100UF	C5016	2113743K15	CER CHIP CAP .100UF
C347	2113740L07	CAP CER CHIP 3.6PF +-0.1PF	C409	2113743K15	CER CHIP CAP .100UF	C5017	2113743K15	CER CHIP CAP .100UF
C348	2113740L06	CAP CER CHIP 3.3 PF+/-0.1PF	C410	2113743K15	CER CHIP CAP .100UF	C5018	2113743K15	CER CHIP CAP .100UF
C349	2113740F53	CAP CHIP REEL CL1 +/-30 120	C411	NOT PLACED	GCAM DUMMY PART NUMBER	C5019	2113743K15	CER CHIP CAP .100UF
C350	2113740F53	CAP CHIP REEL CL1 +/-30 120	C412	2113740F53	CAP CHIP REEL CL1 +/-30 120	C5020	2113743K15	CER CHIP CAP .100UF
C351	2113743E20	CAP CHIP. 10 UF 10%	C413	2113740F53	CAP CHIP REEL CL1 +/-30 120	C5021	2113741M69	CAP CHIP CLS2 100000 PF 20V 10
C353	NOT PLACED	GCAM DUMMY PART NUMBER	C414	2113740F53	CAP CHIP REEL CL1 +/-30 120	C5022	2113743K15	CER CHIP CAP .100UF
C354	2113740F49	CAP CHIP REEL CL1 +/-30 82	C415	2113740F53	CAP CHIP REEL CL1 +/-30 120	C5023	2113743K15	CER CHIP CAP .100UF
C355	NOT PLACED	GCAM DUMMY PART NUMBER	C416	2113740F53	CAP CHIP REEL CL1 +/-30 120	C5024	2113743K15	CER CHIP CAP .100UF
C356	2113740L22	CAP 15.0 PF 50V 2.0 %	C417	2113740F53	CAP CHIP REEL CL1 +/-30 120	C5025	2113743K15	CER CHIP CAP .100UF
C357	NOT PLACED	GCAM DUMMY PART NUMBER	C418	2113740F53	CAP CHIP REEL CL1 +/-30 120	C5026	2113743K15	CER CHIP CAP .100UF
C358	NOT PLACED	GCAM DUMMY PART NUMBER	C419	2113743E07	CER CHIP CAP .022UF	C5027	2113743K15	CER CHIP CAP .100UF
C359	2113740F39	CAP CHIP REEL CL1 +/-30 33	C420	2113740F53	CAP CHIP REEL CL1 +/-30 120	C5028	2113743K15	CER CHIP CAP .100UF
C360	2113740F38	CAP CHIP REEL CL1 +/-30 30	C421	2113743K15	CER CHIP CAP .100UF	C5029	2113743K15	CER CHIP CAP .100UF
C361	NOT PLACED	GCAM DUMMY PART NUMBER	C422	2113740F53	CAP CHIP REEL CL1 +/-30 120	C5030	2113743K15	CER CHIP CAP .100UF
C362	2113740F35	CAP CHIP REEL CL1 +/-30 22	C423	2113743K15	CER CHIP CAP .100UF	C5031	2113743K15	CER CHIP CAP .100UF
C364	NOT PLACED	GCAM DUMMY PART NUMBER	C424	NOT PLACED	GCAM DUMMY PART NUMBER	C5032	2113743K15	CER CHIP CAP .100UF
C365	NOT PLACED	GCAM DUMMY PART NUMBER	C425	2113741F25	CAP CHIP CL2 X7R REEL 1000	C5033	2113743K15	CER CHIP CAP .100UF
C366	2113740L18	CAP CER CHIP 10.0 PF +/-25PF	C426	2389289U01	10UF 50V 20% ALUMINUM SMD	C5034	2113743K15	CER CHIP CAP .100UF
C367	2113740L16	CAP CER CHIP 8.2 PF+-0.1PF	C427	2311049A99	CAP TANT CHIP 47 UF 10V 20%	C5035	2113743K15	CER CHIP CAP .100UF
C368	2113740F25	CAP CHIP REEL CL1+/-30 8.2	C428	2311049A99	CAP TANT CHIP 47 UF 10V 20%	C5036	2113743K15	CER CHIP CAP .100UF
C369	2113740F25	CAP CHIP REEL CL1+/-30 8.2	C429	2311049A99	CAP TANT CHIP 47 UF 10V 20%	C5037	2113743K15	CER CHIP CAP .100UF
C370	2113740L27	CAP 24.0 PF 50V 2.0 %	C430	2311049A57	CAP TANT CHIP A/P 10UF 10% 16V	C5038	2113743K15	CER CHIP CAP .100UF
C371	NOT PLACED	GCAM DUMMY PART NUMBER	C431	2311049A57	CAP TANT CHIP A/P 10UF 10% 16V	C5039	NOT PLACED	GCAM DUMMY PART NUMBER
C400	2113740F53	CAP CHIP REEL CL1 +/-30 120						
C401	2113743K15	CER CHIP CAP .100UF						

Circuit Ref.	Motorola Part No.	Description
C5065	2113740F53	CAP CHIP REEL CL1 +/-30 120
C5066	2113740F53	CAP CHIP REEL CL1 +/-30 120
C5067	2113741F25	CAP CHIP CL2 X7R REEL 1000
C5068	2113740F53	CAP CHIP REEL CL1 +/-30 120
C5069	2113740F53	CAP CHIP REEL CL1 +/-30 120
C5070	2113740F53	CAP CHIP REEL CL1 +/-30 120
C5071	2113741F25	CAP CHIP CL2 X7R REEL 1000
C5072	2113740F53	CAP CHIP REEL CL1 +/-30 120
C5073	2113740F53	CAP CHIP REEL CL1 +/-30 120
C5074	2113740F53	CAP CHIP REEL CL1 +/-30 120
C5075	NOT PLACED	GCAM DUMMY PART NUMBER
C5076	2113740F53	CAP CHIP REEL CL1 +/-30 120
C5077	2113740F53	CAP CHIP REEL CL1 +/-30 120
C5078	2113741F25	CAP CHIP CL2 X7R REEL 1000
C5079	2113740F53	CAP CHIP REEL CL1 +/-30 120
C5080	2113740F53	CAP CHIP REEL CL1 +/-30 120
C5081	2113740F53	CAP CHIP REEL CL1 +/-30 120
C5082	2113740F53	CAP CHIP REEL CL1 +/-30 120
C5083	2113740F53	CAP CHIP REEL CL1 +/-30 120
C5084	2113740F53	CAP CHIP REEL CL1 +/-30 120
C5085	2113741A53	CAP CHIP CL2 X7R REEL 22000
C5086	2113741A53	CAP CHIP CL2 X7R REEL 22000
C5087	2113740F53	CAP CHIP REEL CL1 +/-30 120
C5088	2113740F49	CAP CHIP REEL CL1 +/-30 82
C5089	2113740F49	CAP CHIP REEL CL1 +/-30 82
C5090	2113740F49	CAP CHIP REEL CL1 +/-30 82
C5091	2113740F49	CAP CHIP REEL CL1 +/-30 82
C5092	2113740F59	CAP CHIP REEL CL1 +/-30 220
C5094	2113740F59	CAP CHIP REEL CL1 +/-30 220
C5095	2113740F59	CAP CHIP REEL CL1 +/-30 220
C5096	2113740F59	CAP CHIP REEL CL1 +/-30 220
C5097	2113740F59	CAP CHIP REEL CL1 +/-30 220

Circuit Ref.	Motorola Part No.	Description
C5098	2113740F59	CAP CHIP REEL CL1 +/-30 220
C5099	2113740F59	CAP CHIP REEL CL1 +/-30 220
C5100	2113740F59	CAP CHIP REEL CL1 +/-30 220
C5101	2113741F25	CAP CHIP CL2 X7R REEL 1000 (CM160/CM360)
C5102	2113743E20	CAP CHIP. 10 UF 10% (CM160/CM360)
C5103	2113743K15	CER CHIP CAP .100UF (CM160/CM360)
C5104	NOT PLACED	GCAM DUMMY PART NUMBER
C5110	2113741F25	CAP CHIP CL2 X7R REEL 1000
C5111	2113741F25	CAP CHIP CL2 X7R REEL 1000
C5113	NOT PLACED	GCAM DUMMY PART NUMBER
C5114	NOT PLACED	GCAM DUMMY PART NUMBER
C5115	NOT PLACED	GCAM DUMMY PART NUMBER
C5116	NOT PLACED	GCAM DUMMY PART NUMBER
C5117	NOT PLACED	GCAM DUMMY PART NUMBER
C5118	NOT PLACED	GCAM DUMMY PART NUMBER
C5119	2113743H14	CAP CHIP 10.0 UF 16V +80-20%
C5120	2311049A99	CAP TANT CHIP 47UF 10 (CM340/CM360)
C602	2113740F41	CAP CHIP REEL CL1 +/-30 39
C603	2113740F41	CAP CHIP REEL CL1 +/-30 39
C604	2113740F41	CAP CHIP REEL CL1 +/-30 39
C605	2113740F41	CAP CHIP REEL CL1 +/-30 39
C606	2113740F41	CAP CHIP REEL CL1 +/-30 39
C607	2113740F41	CAP CHIP REEL CL1 +/-30 39
C608	NOT PLACED	GCAM DUMMY PART NUMBER
C609	NOT PLACED	GCAM DUMMY PART NUMBER
C610	2113740F41	CAP CHIP REEL CL1 +/-30 39
C611	2113740F41	CAP CHIP REEL CL1 +/-30 39
C612	2113740F41	CAP CHIP REEL CL1 +/-30 39
C613	2113740F41	CAP CHIP REEL CL1 +/-30 39

Circuit Ref.	Motorola Part No.	Description
C614	2113740F41	CAP CHIP REEL CL1 +/-30 39
C615	2113740F41	CAP CHIP REEL CL1 +/-30 39
C616	2113740F41	CAP CHIP REEL CL1 +/-30 39
C617	2113740F41	CAP CHIP REEL CL1 +/-30 39
C618	2113740F41	CAP CHIP REEL CL1 +/-30 39
C619	NOT PLACED	GCAM DUMMY PART NUMBER
C620	2113740F41	CAP CHIP REEL CL1 +/-30 39
C621	2113740F41	CAP CHIP REEL CL1 +/-30 39
C622	2113740F41	CAP CHIP REEL CL1 +/-30 39
C623	2113740F41	CAP CHIP REEL CL1 +/-30 39
C624	2113740F41	CAP CHIP REEL CL1 +/-30 39
C625	2113740F41	CAP CHIP REEL CL1 +/-30 39
C626	2113740F41	CAP CHIP REEL CL1 +/-30 39
C627	2113740F41	CAP CHIP REEL CL1 +/-30 39
C628	2113740F41	CAP CHIP REEL CL1 +/-30 39
C629	2113740F41	CAP CHIP REEL CL1 +/-30 39
C630	2113740F41	CAP CHIP REEL CL1 +/-30 39
C631	2113740F41	CAP CHIP REEL CL1 +/-30 39
C632	2113740F41	CAP CHIP REEL CL1 +/-30 39
C633	2113740F41	CAP CHIP REEL CL1 +/-30 39
C662	2113740F41	CAP CHIP REEL CL1 +/-30 39
C678	2113741M69	CAP CHIP CLS2 100000 PF 20V 10
CR300	4880154K03	SOT MMBD353 RH DIODE DUAL SCHT
CR301	4880154K03	SOT MMBD353 RH DIODE DUAL SCHT
D100	NOT PLACED	GCAM DUMMY PART NUMBER
D102	4813833C02	DIODE DUAL 70V '5B' COMM CATH
D103	4802482J02	PIN DIODE SMD
D104	4802482J02	PIN DIODE SMD
D105	4805218N57	DIODE DUAL

Circuit Ref.	Motorola Part No.	Description
D106	4805218N57	DIODE DUAL
D200	4802233J09	DIODE TRIPLE SOT25-RH
D201	4802233J09	DIODE TRIPLE SOT25-RH
D202	4862824C03	DIODE VARACTOR
D203	4805649Q13	DIODE VCTR ISV 228
D204	4805649Q13	DIODE VCTR ISV 228
D205	4862824C01	DIODE VARACTOR
D301	4802245J97	Band Switchind Diode, Rohm DAN
D302	4802245J97	Band Switchind Diode, Rohm DAN
D303	4802245J97	Band Switchind Diode, Rohm DAN
D304	4802245J97	Band Switchind Diode, Rohm DAN
D305	4880142L01	SOT MMBV109 RH
D400	4813833C07	DIODE DUAL 100V '5C' SERIES
D401	4813833C02	DIODE DUAL 70V '5B' COMM CATH
D402	4809948D42	DIODE SCHOTTKY RB751V-40 (CM140/CM160)
D500	4813833C02	DIODE DUAL 70V '5B' COMM CATH
D501	4813833C02	DIODE DUAL 70V '5B' COMM CATH (CM340/CM360)
D502	4813825A23	DIODE, DISCRETE SPECIALS VAR&P
D511	4813833C02	DIODE DUAL 70V '5B' COMM CATH
D513	4813833C02	DIODE DUAL 70V '5B' COMM CATH
FL300	9180022M11	XTAL FILTER 44.85MHZ
FL301	9180468V06	SMD455KHZ 4 ELEMENT CER FLTR
FL302	9180468V04	SMD455KHZ 4 ELEMENT CER FLTR

Circuit Ref.	Motorola Part No.	Description	Circuit Ref.	Motorola Part No.	Description	Circuit Ref.	Motorola Part No.	Description
FL303	9180469V03	SMD455KHZ 6 ELEMENT CER FLTR	L206	2484562T11	COIL SURF MNT AIR WOUND	M105	7588823L03	PAD GROUND LCD
FL304	9180469V06	SMD455KHZ 6 ELEMENT CER FLTR	L207	2413923C12	IND CHIP 7.8 NH 2%	M106	7588823L03	PAD GROUND LCD
J11	2889309U01	MINI-UHF PCB R.A	L208	2413926N24	IND CER CHIP 100.0 NH 5%	M107	7588823L03	PAD GROUND LCD
J2	0989241U02	FLEX 20PIN 1MM TOP NON ZIF	L209	2413926N24	IND CER CHIP 100.0 NH 5%	M108	7588823L04	PAD GROUND LCD
J3	0986615Z01	CONN,ZIF,F,28CONT,,TIN,,CBL (CM160/CM360)	L210	2413926N18	IND CER CHIP 33.0 NH 5%	M109	7588823L04	PAD GROUND LCD
L100	7686135U02	FLTR,EMI	L211	2413926N24	IND CER CHIP 100.0 NH 5%	M110	7588823L04	PAD GROUND LCD
L101	2462587T30	IND CHIP 1000NH 5% LOW PRO	L212	2413926N18	IND CER CHIP 33.0 NH 5%	M111	3985994A01	CONTACT, PCB SPEAKER
L103	2462587T30	IND CHIP 1000NH 5% LOW PRO	L213	2413926N24	IND CER CHIP 100.0 NH 5%	M112	3985994A01	CONTACT, PCB SPEAKER
L104	2462587N50	CHIP IND 56 NH 5%	L214	2413926H20	IND CHIP 47.0 NH 5%	M113	3985994A01	CONTACT, PCB SPEAKER
L105	2462587N44	CHIP IND 18 NH 5%	L215	2413926H20	IND CHIP 47.0 NH 5%	M114	3985994A01	CONTACT, PCB SPEAKER
L107	2460591B04	COIL AIR WOUND INDUC 11.03	L216	2462587N44	CHIP IND 18 NH 5%	M9	0289511U01	NUTS
L108	2462587T22	IND. CHIP 390NH 5% LOW PRO	L217	2462587Q42	IND CHIP 390NH 10%	P1	2804503J01	CONNECTOR,ACCY 16 PIN
L111	2460592A01	COIL AW 2 TURN 17 NH	L300	2460591C35	COIL AIR WOUND INDUC 18.08	P2	NOT PLACED	GCAM DUMMY PART NUMBER
L113	2460592A01	COIL AW 2 TURN 17 NH	L301	2462587N55	CHIP IND 150 NH 5%	PCB	8488978U01	MARLIN UHF
L114	2485873L01	ENCAPSULATED AIR WOUND COIL	L302	2462587N55	CHIP IND 150 NH 5%	Q100	4886163B01	LDMOS SMT 35W 520MH 12V
L115	2485873L01	ENCAPSULATED AIR WOUND COIL	L303	2462587X69	IND CHIP LO-PRO 1200 NH 5%	Q101	4813824A10	TSTR NPN 40V .2A GEN PURP
L117	7686135U02	FLTR,EMI	L304	2462587N55	CHIP IND 150 NH 5%	Q102	4813824A10	TSTR NPN 40V .2A GEN PURP
L118	7686135U02	FLTR,EMI	L305	2483411T74	INDUCTOR CHIP SHIELDED	Q103	4813824A06	XSTR NPN 30V DARLINGTON
L119	7686135U02	FLTR,EMI	L306	2413926K31	IND CER CHIP 470.0 NH 5%	Q105	4886212B01	LDMOS PWR TSTR MRF1518
L120	7686135U02	FLTR,EMI	L307	2460591C35	COIL AIR WOUND INDUC 18.08	Q106	4805128M27	SOT TRANS
L121	7686135U02	FLTR,EMI	L308	2460591C35	COIL AIR WOUND INDUC 18.08	Q200	4802245J95	BJT, NPN TRANSISTOR
L122	2460591A01	COIL AIR WOUND INDUC 4.22	L309	2460591C35	COIL AIR WOUND INDUC 18.08	Q201	4809939C04	TSTR DUAL PNP/NPN UMC3
L126	2462587T22	IND. CHIP 390NH 5% LOW PRO	L310	2460591C35	COIL AIR WOUND INDUC 18.08	Q300	4809940E02	TSTR DIG NPN DTC114YE
L200	2462587Q42	IND CHIP 390NH 10%	L311	2460591C35	COIL AIR WOUND INDUC 18.08	Q301	4813824A17	XSTR PNP40V .2A GENPB=100-300
L201	2462587V44	IND CHIP 680 NH 10%	L312	2460591C35	COIL AIR WOUND INDUC 18.08	Q302	4813824A10	TSTR NPN 40V .2A GEN PURP
L202	2462587V44	IND CHIP 680 NH 10%	L313	2460591C35	COIL AIR WOUND INDUC 18.08	Q303	4802245J95	BJT, NPN TRANSISTOR
L203	2462587V36	CHIP IND 150NH 5% 0805	L314	2460591C35	COIL AIR WOUND INDUC 18.08	Q304	4809939C04	TSTR DUAL PNP/NPN UMC3
L204	2462587V36	CHIP IND 150NH 5% 0805	L315	NOT PLACED	GCAM DUMMY PART NUMBER	Q305	4802197J95	RF TRANSISTOR PBR941
L205	2462587Q47	IND CHIP 1000 NH 10%	L500	7686135U02	FLTR,EMI	Q306	4813824A17	XSTR PNP40V .2A GENPB=100-300
			L501	7686135U02	FLTR,EMI	Q400	4809940E02	TSTR DIG NPN DTC114YE
			L502	7686135U02	FLTR,EMI			
			M100	2686201B01	HEAT SPREADER WM			

Circuit Ref.	Motorola Part No.	Description
R122	0662057C19	CHIP RES 4.7 OHMS 5%
R126	0662057C03	CHIP RES 1.0 OHMS 5%
R127	0662057C03	CHIP RES 1.0 OHMS 5%
R128	0662057C03	CHIP RES 1.0 OHMS 5%
R130	0662057B47	CHIP RES 0 OHMS +-0.050 OHMS
R131	0662057A97	CHIP RES 100K OHMS 5%
R134	0662057A59	CHIP RES 2700 OHMS 5%
R135	0662057A88	CHIP RES 43K OHMS 5%
R136	0662057A86	CHIP RES 36K OHMS 5%
R137	0662057A87	CHIP RES 39K OHMS 5%
R138	0662057A86	CHIP RES 36K OHMS 5%
R139	0662057A87	CHIP RES 39K OHMS 5%
R140	0662057A83	CHIP RES 27K OHMS 5%
R141	0662057A81	CHIP RES 22K OHMS 5%
R142	0662057A81	CHIP RES 22K OHMS 5%
R143	0662057A81	CHIP RES 22K OHMS 5%
R145	0662057A81	CHIP RES 22K OHMS 5%
R147	0662057A59	CHIP RES 2700 OHMS 5%
R148	0662057A81	CHIP RES 22K OHMS 5%
R149	0662057A81	CHIP RES 22K OHMS 5%
R150	0662057A73	CHIP RES 10K OHMS 5%
R151	0662057A67	CHIP RES 5600 OHMS 5%
R153	0662057A73	CHIP RES 10K OHMS 5%
R155	0662057A73	CHIP RES 10K OHMS 5%
R156	0662057A73	CHIP RES 10K OHMS 5%
R157	0662057A91	CHIP RES 56K OHMS 5%
R158	0662057A69	RES CHIP 6800 OHM 5 1/8W
R159	NOT PLACED	GCAM DUMMY PART NUMBER
R160	0662057A61	CHIP RES 3300 OHMS 5%
R161	0662057A61	CHIP RES 3300 OHMS 5%
R165	0662057A58	CHIP RES 2400 OHMS 5%

Circuit Ref.	Motorola Part No.	Description
R166	0662057A59	CHIP RES 2700 OHMS 5%
R167	0662057A57	CHIP RES 2200 OHMS 5%
R168	0662057A57	CHIP RES 2200 OHMS 5%
R169	0662057A56	CHIP RES 2000 OHMS 5%
R170	0662057A42	CHIP RES 510 OHMS 5%
R171	0662057A43	CHIP RES 560 OHMS 5%
R172	0662057A41	CHIP RES 470 OHMS 5%
R173	0662057A29	CHIP RES 150 OHMS 5%
R174	0662057A29	CHIP RES 150 OHMS 5%
R175	0662057A43	CHIP RES 560 OHMS 5%
R178	0662057A18	CHIP RES 51 OHMS 5%
R179	0662057A18	CHIP RES 51 OHMS 5%
R180	0660082A89	RES CHIP 47K OHMS 1% 1/16W
R181	0660082A89	RES CHIP 47K OHMS 1% 1/16W
R182	0662057A73	CHIP RES 10K OHMS 5%
R183	0662057A25	CHIP RES 100 OHMS 5%
R185	0662057A73	CHIP RES 10K OHMS 5%
R186	0662057C20	CHIP RES 5.1 OHMS 5%
R200	0662057A97	CHIP RES 100K OHMS 5%
R201	0662057A73	CHIP RES 10K OHMS 5%
R202	NOT PLACED	GCAM DUMMY PART NUMBER
R203	0662057B47	CHIP RES 0 OHMS +-0.050 OHMS
R204	NOT PLACED	GCAM DUMMY PART NUMBER
R205	NOT PLACED	GCAM DUMMY PART NUMBER
R206	0662057A99	CHIP RES 120K OHMS 5%
R207	0662057B02	CHIP RES 150K OHMS 5%
R208	0662057A18	CHIP RES 51 OHMS 5%
R209	0662057A97	CHIP RES 100K OHMS 5%
R210	NOT PLACED	GCAM DUMMY PART NUMBER
R211	0662057A69	RES CHIP 6800 OHM 5 1/8W
R212	0662057A89	CHIP RES 47K OHMS 5%

Circuit Ref.	Motorola Part No.	Description
R213	0662057A65	CHIP RES 4700 OHMS 5%
R214	0662057A65	CHIP RES 4700 OHMS 5%
R215	0662057A62	CHIP RES 3600 OHMS 5%
R216	0662057A59	CHIP RES 2700 OHMS 5%
R217	0662057A52	CHIP RES 1300OHMS 5%05
R218	0662057A49	CHIP RES 1000 OHMS 5%
R219	NOT PLACED	GCAM DUMMY PART NUMBER
R220	0662057A42	CHIP RES 510 OHMS 5%
R221	0662057A33	CHIP RES 220 OHMS 5%
R222	0662057A33	CHIP RES 220 OHMS 5%
R223	0662057A33	CHIP RES 220 OHMS 5%
R224	0662057A53	CHIP RES 1500 OHMS 5%
R225	0662057A29	CHIP RES 150 OHMS 5%
R226	0662057A29	CHIP RES 150 OHMS 5%
R227	0662057A23	CHIP RES 82 OHMS 5%
R228	0662057A25	CHIP RES 100 OHMS 5%
R229	0662057A25	CHIP RES 100 OHMS 5%
R230	0662057A22	CHIP RES 75 OHMS 5%
R231	0662057A18	CHIP RES 51 OHMS 5%
R232	0662057A17	RES CHIP 47 OHMS 5%
R233	0662057A17	RES CHIP 47 OHMS 5%
R234	0662057A15	CHIP RES 39 OHMS 5%
R235	0662057A07	CHIP RES 18 OHMS 5%
R300	0662057A73	CHIP RES 10K OHMS 5%
R301	0662057A41	CHIP RES 470 OHMS 5%
R302	0662057B47	CHIP RES 0 OHMS +-0.050 OHMS
R303	0662057B47	CHIP RES 0 OHMS +-0.050 OHMS
R304	0662057A85	CHIP RES 33K OHM 5%
R305	0662057A80	CHIP RES 20K OHMS 5%
R306	0662057A80	CHIP RES 20K OHMS 5%
R307	0662057A80	CHIP RES 20K OHMS 5%

Circuit Ref.	Motorola Part No.	Description
R308	0662057A80	CHIP RES 20K OHMS 5%
R309	0662057A77	CHIP RES 15K OHMS 5%
R310	0662057A77	CHIP RES 15K OHMS 5%
R311	NOT PLACED	GCAM DUMMY PART NUMBER
R312	0662057A76	CHIP RES 13K OHMS 5%
R313	0662057A75	CHIP RES 12K OHMS 5%
R314	0662057A75	CHIP RES 12K OHMS 5%
R315	0662057A75	CHIP RES 12K OHMS 5%
R316	0662057A75	CHIP RES 12K OHMS 5%
R317	0662057A75	CHIP RES 12K OHMS 5%
R318	0662057A75	CHIP RES 12K OHMS 5%
R319	0662057A75	CHIP RES 12K OHMS 5%
R320	0662057A73	CHIP RES 10K OHMS 5%
R321	0662057A71	CHIP RES 8200 OHMS 5%
R322	0662057A65	CHIP RES 4700 OHMS 5%
R323	0662057A65	CHIP RES 4700 OHMS 5%
R324	0662057A61	CHIP RES 3300 OHMS 5%
R325	0662057A61	CHIP RES 3300 OHMS 5%
R326	0662057A59	CHIP RES 2700 OHMS 5%
R327	0662057A58	CHIP RES 2400 OHMS 5%
R328	0662057A55	CHIP RES 1800 OHM 5%
R329	0662057A51	CHIP RES 1200 OHMS 5%
R330	0662057A47	CHIP RES 820 OHMS 5%
R331	0662057A25	CHIP RES 100 OHMS 5%
R332	0662057A45	CHIP RES 680 OHMS 5%
R333	0662057A43	CHIP RES 560 OHMS 5%
R334	0662057A40	CHIP RES 430 OHMS 5%
R335	0662057A39	CHIP RES 390 OHMS 5%
R336	0662057A33	CHIP RES 220 OHMS 5%
R337	0662057A25	CHIP RES 100 OHMS 5%
R338	0662057A25	CHIP RES 100 OHMS 5%
R339	0662057A18	CHIP RES 51 OHMS 5%

Circuit Ref.	Motorola Part No.	Description	Circuit Ref.	Motorola Part No.	Description	Circuit Ref.	Motorola Part No.	Description	Circuit Ref.	Motorola Part No.	Description
R340	0662057A18	CHIP RES 51 OHMS 5%	R434	0662057A85	CHIP RES 33K OHM 5%	R473	NOT PLACED	GCAM DUMMY PART NUMBER	R5035	0662057A89	CHIP RES 47K OHMS 5%
R345	0662057A73	CHIP RES 10K OHMS 5%	R435	0662057A85	CHIP RES 33K OHM 5%	R5000	0662057B47	CHIP RES 0 OHMS +-0.050 OHMS	R5036	0662057A89	CHIP RES 47K OHMS 5%
R346	0662057A73	CHIP RES 10K OHMS 5%	R436	0662057A85	CHIP RES 33K OHM 5%	R5001	0662057T68	RES CHIP 1.0K 1% 30*60	R5037	0662057A73	CHIP RES 10K OHMS 5%
R347	0662057A05	CHIP RES 15 OHMS 5%	R438	0662057A73	CHIP RES 10K OHMS 5%	R5002	0662057C01	CHIP RES 0 OHMS .050 OHMS (CM160/CM360)	R5038	0662057A85	CHIP RES 33K OHM 5%
R401	0662057C85	CHIP RES 2700 OHMS 5%	R439	0662057A73	CHIP RES 10K OHMS 5%	R5008	0662057B47	CHIP RES 0 OHMS +-0.050 OHMS	R5039	0662057A97	CHIP RES 100K OHMS 5%
R402	0662057B47	CHIP RES 0 OHMS +-0.050 OHMS	R440	0662057A73	CHIP RES 10K OHMS 5%	R5009	0662057B47	CHIP RES 0 OHMS +-0.050 OHMS	R5040	0662057A84	CHIP RES 30K OHMS 5%
R403	0662057B47	CHIP RES 0 OHMS +-0.050 OHMS	R441	0662057A73	CHIP RES 10K OHMS 5%	R5010	0662057B47	CHIP RES 0 OHMS +-0.050 OHMS	R5041	0662057A82	CHIP RES 24K OHMS 5%
R404	0662057B47	CHIP RES 0 OHMS +-0.050 OHMS	R443	0662057A61	CHIP RES 3300 OHMS 5%	R5011	NOT PLACED	GCAM DUMMY PART NUMBER	R5042	0662057A82	CHIP RES 24K OHMS 5%
R405	0662057B47	CHIP RES 0 OHMS +-0.050 OHMS	R444	0662057A73	CHIP RES 10K OHMS 5%	R5013	NOT PLACED	GCAM DUMMY PART NUMBER	R5043	0662057A82	CHIP RES 24K OHMS 5%
R406	0662057B47	CHIP RES 0 OHMS +-0.050 OHMS	R445	0662057A73	CHIP RES 10K OHMS 5%	R5014	0662057B47	CHIP RES 0 OHMS +-0.050 OHMS	R5044	0662057A82	CHIP RES 24K OHMS 5%
R407	0662057B47	CHIP RES 0 OHMS +-0.050 OHMS	R450	0662057A73	CHIP RES 10K OHMS 5%	R5016	NOT PLACED	GCAM DUMMY PART NUMBER	R5045	0662057A85	CHIP RES 33K OHM 5%
R414	0662057B47	CHIP RES 0 OHMS +-0.050 OHMS	R451	0662057A73	CHIP RES 10K OHMS 5%	R5019	0662057B05	CHIP RES 200K OHMS 5%	R5046	0662057A82	CHIP RES 24K OHMS 5%
R415	0662057B47	CHIP RES 0 OHMS +-0.050 OHMS (CM340/CM360)	R453	0662057A61	CHIP RES 3300 OHMS 5%	R5020	0662057B02	CHIP RES 150K OHMS 5%	R5047	0662057B47	CHIP RES 0 OHMS +-0.050 OHMS (CM140/CM340)
R421	0662057A33	CHIP RES 220 OHMS 5%	R454	0662057A61	CHIP RES 3300 OHMS 5%	R5021	0662057A97	CHIP RES 100K OHMS 5%	R5048	0662057A82	CHIP RES 24K OHMS 5%
R422	0662057A73	CHIP RES 10K OHMS 5% (CM140/CM160)	R455	0662057A61	CHIP RES 3300 OHMS 5%	R5022	0662057A97	CHIP RES 100K OHMS 5%	R5049	0662057A77	CHIP RES 15K OHMS 5%
R423	NOT PLACED	GCAM DUMMY PART NUMBER	R456	0662057A61	CHIP RES 3300 OHMS 5%	R5023	0662057A97	CHIP RES 100K OHMS 5%	R5050	0662057A76	CHIP RES 13K OHMS 5%
R424	NOT PLACED	GCAM DUMMY PART NUMBER	R457	0662057A61	CHIP RES 3300 OHMS 5%	R5024	0662057A97	CHIP RES 100K OHMS 5% (CM160/CM360)	R5051	0662057A75	CHIP RES 12K OHMS 5%
R425	0662057A97	CHIP RES 100K OHMS 5%	R458	0662057A61	CHIP RES 3300 OHMS 5%	R5025	0662057A97	CHIP RES 100K OHMS 5%	R5052	0662057A73	CHIP RES 10K OHMS 5%
R426	0662057A97	CHIP RES 100K OHMS 5% (CM140/CM160)	R459	NOT PLACED	GCAM DUMMY PART NUMBER	R5026	0662057A85	CHIP RES 33K OHM 5%	R5053	0662057A73	CHIP RES 10K OHMS 5%
R427	NOT PLACED	GCAM DUMMY PART NUMBER	R460	0662057A53	CHIP RES 1500 OHMS 5%	R5027	0662057B08	CHIP RES 270K OHMS 5%	R5054	0662057A73	CHIP RES 10K OHMS 5%
R428	0662057A97	CHIP RES 100K OHMS 5%	R461	0662057A33	CHIP RES 220 OHMS 5%	R5028	0662057A97	CHIP RES 100K OHMS 5%	R5055	0662057A73	CHIP RES 10K OHMS 5%
R429	0662057A97	CHIP RES 100K OHMS 5%	R462	0662057A18	CHIP RES 51 OHMS 5%	R5029	0662057A97	CHIP RES 100K OHMS 5%	R5056	0662057A73	CHIP RES 10K OHMS 5%
R430	0662057A87	CHIP RES 39K OHMS 5%	R463	0662057A73	CHIP RES 10K OHMS 5%	R5030	0662057A85	CHIP RES 33K OHM 5%	R5057	0662057A73	CHIP RES 10K OHMS 5%
R431	NOT PLACED	GCAM DUMMY PART NUMBER	R466	NOT PLACED	GCAM DUMMY PART NUMBER	R5031	0662057A92	CHIP RES 62K OHMS 5%	R5058	NOT PLACED	GCAM DUMMY PART NUMBER
R432	0662057A85	CHIP RES 33K OHM 5%	R468	NOT PLACED	GCAM DUMMY PART NUMBER	R5032	0662057A89	CHIP RES 47K OHMS 5%	R5059	NOT PLACED	GCAM DUMMY PART NUMBER
R433	0662057A85	CHIP RES 33K OHM 5%	R469	NOT PLACED	GCAM DUMMY PART NUMBER	R5033	0662057A89	CHIP RES 47K OHMS 5%	R5060	0662057A73	CHIP RES 10K OHMS 5%
			R470	0662057A73	CHIP RES 10K OHMS 5% (CM340/CM360)	R5034	0662057A86	CHIP RES 36K OHMS 5%	R5061	0662057A73	CHIP RES 10K OHMS 5%
			R471	0662057A01	CHIP RES 10 OHMS 5%				R5062	0662057A73	CHIP RES 10K OHMS 5%
			R472	NOT PLACED	GCAM DUMMY PART NUMBER				R5063	NOT PLACED	GCAM DUMMY PART NUMBER
									R5064	NOT PLACED	GCAM DUMMY PART NUMBER
									R5065	0662057A68	CHIP RES 6200 OHMS 5%

Circuit Ref.	Motorola Part No.	Description
R5066	0662057A49	CHIP RES 1000 OHMS 5%
R5067	NOT PLACED	GCAM DUMMY PART NUMBER
R5068	NOT PLACED	GCAM DUMMY PART NUMBER
R5069	0662057A73	CHIP RES 10K OHMS 5%
R5070	0662057A57	CHIP RES 2200 OHMS 5%
R5071	0662057A57	CHIP RES 2200 OHMS 5%
R5072	0662057A65	CHIP RES 4700 OHMS 5%
R5073	0662057A49	CHIP RES 1000 OHMS 5%
R5074	0662057A49	CHIP RES 1000 OHMS 5%
R5075	0662057A42	CHIP RES 510 OHMS 5%
R5076	0662057A42	CHIP RES 510 OHMS 5%
R5077	0662057A36	CHIP RES 300 OHMS 5%
R5078	0662057A25	CHIP RES 100 OHMS 5%
R5079	0662057A25	CHIP RES 100 OHMS 5%
R5080	0662057A01	CHIP RES 10 OHMS 5%
R5081	0613952D78	CER CHIP RES 6340 OHM 1% 0603
R5082	0662057A90	CHIP RES 51K OHMS 5%
R5083	0662057B08	CHIP RES 270K OHMS 5%
R5084	0662057B47	CHIP RES 0 OHMS +-0.050 OHMS (CM160/CM360)
R5085	NOT PLACED	GCAM DUMMY PART NUMBER
R5086	0662057A43	CHIP RES 560 OHMS 5%
R5087	0662057A97	CHIP RES 100K OHMS 5%
R5088	0662057B47	CHIP RES 0 OHMS +-0.050 OHMS
R5089	NOT PLACED	GCAM DUMMY PART NUMBER
R5092	NOT PLACED	GCAM DUMMY PART NUMBER
R5093	NOT PLACED	GCAM DUMMY PART NUMBER
R5094	NOT PLACED	GCAM DUMMY PART NUMBER
R5095	NOT PLACED	GCAM DUMMY PART NUMBER
R5096	NOT PLACED	GCAM DUMMY PART NUMBER

Circuit Ref.	Motorola Part No.	Description
R5097	0662057B47	CHIP RES 0 OHMS +-0.050 OHMS
R5098	NOT PLACED	GCAM DUMMY PART NUMBER
R5099	NOT PLACED	GCAM DUMMY PART NUMBER
R5100	NOT PLACED	GCAM DUMMY PART NUMBER
R5103	0662057A82	CHIP RES 24K OHMS 5% (CM340/CM360)
R600	0662057C01	CHIP RES 0 OHMS .050 OHMS
R601	0611077A62	RES CHIP 330 5 1/8W
R602	0662057B47	CHIP RES 0 OHMS +-0.050 OHMS
R603	0662057C01	CHIP RES 0 OHMS .050 OHMS
R604	0662057C01	CHIP RES 0 OHMS .050 OHMS
R610	0662057C59	CHIP RES 220 OHMS 5%
R615	0662057A25	CHIP RES 100 OHMS 5%
RT100	0680361L01	THERMISTOR 47KOHM
S5010	1889288U01	POTENTIOMETER W/SWITCH VOLUME
SH200	2689590U01	VCO SHIELD
SH201	2689589U01	VCO SHIELD
SH202	2689589U01	VCO SHIELD
SH300	2689591U01	MIXER SHIELD
SH301	2689593U01	FRONT ENA SHIELD
SH302	2689591U01	MIXER SHIELD
T300	2580541Z01	BALUN TRANSFORMER
T301	2580541Z01	BALUN TRANSFORMER
U100	5113818A01	IC LOW COST SING SPLY LM2904DR
U101	5185130C65	IC VHF/UHF/800 MHZ LDMOS DRIVE
U102	5113818A01	IC LOW COST SING SPLY LM2904DR
U103	5113819A04	IC QD OP AMP GEN PURP MC3303D

Circuit Ref.	Motorola Part No.	Description
U200	5185963A27	IC TESTED AT25016 48 PIN GFP
U201	5105750U54	IC PKG DIE VCO BUFFER
U300	5186144B01	FM IF IC SA616
U301	5109522E10	IC 3-INV LMOS TC7W04FU
U302	4808612Y05	CROSSOVER QUAD DIODE SMS3928-0
U400	5102463J64	16KX8 SPI SERIAL EEPROM
U402	5102463J36	32KX8 STATIC RAM (CM340/CM360)
U403	5102226J56	68HC11FLO_PASS5 100P IN TQFP
U404	5189233U02	FLASH 2MEG AT49LV002N-70VI (CM140/CM160)
U404	5189233U21	FLASH 4MEG AT49LV040N-70VI (CM340/CM360)
U405	5113805A75	IC 8 BIT SER TO PAR/PAR HC595
U500	NOT PLACED	GCAM DUMMY PART NUMBER
U501	0104016J81	9V REGULATOR ASSEMBLY
U502	5102463J95	AUDIO PA TDA1519C
U503	5105469E65	IC VLTG REGLTR
U504	5185130C53	IC ASFIC_CMP_R1
U505	5113818A01	IC LOW COST SING SPLY LM2904DR
U506	5113818A01	IC LOW COST SING SPLY LM2904DR
U507	5113818A01	IC LOW COST SING SPLY LM2904DR
U508	5113816A30	IC 3.3V LOW DROPOUT POS. REG.
U509	5113806A20	IC MUX/DEMUX TRIPLE 2-CHNL
U510	5104187K94	IC LP2986ILDX-3.3 VLTG REG
U514	4802393L66	MOSFET P-CH
U515	5162852A59	IC CMOS ANALOG SWITCH SPDT (CM360/CM160)

Circuit Ref.	Motorola Part No.	Description
VR101	4813830A18	DIODE 6.8V 5% 225MWMMBZ5235B_
VR102	4813830A15	TSTR 5.6V 5% 20MA 225MW
VR400	NOT PLACED	GCAM DUMMY PART NUMBER
VR401	NOT PLACED	GCAM DUMMY PART NUMBER
VR402	4813830A09	DIODE 3.3V 5% 225MW MMBZ5226B
VR500	4813832C77	TRANS SUP. 24V HIGH PWR
VR501	4813830A14	DIODE 5.1V 5% 225MW MMBZ5231B_
VR502	4813830G09	DIODE 3.3V 5% 'CK' 500MW _4684 (CM340/CM360)
VR503	4813830G09	DIODE 3.3V 5% 'CK' 500MW _4684
VR504	4813830G09	DIODE 3.3V 5% 'CK' 500MW _4684
VR692	4813830A75	DIODE DUAL COM ANODE
VR693	4813830A77	DIODE DL ZENER TVS 33V 1.0A
VR694	4813830A75	DIODE DUAL COM ANODE
VR695	4813830A77	DIODE DL ZENER TVS 33V 1.0A
VR696	4813830A75	DIODE DUAL COM ANODE
VR697	4813830A75	DIODE DUAL COM ANODE
VR698	4813830A75	DIODE DUAL COM ANODE
VR699	4813830A75	DIODE DUAL COM ANODE
Y200	NOT PLACED	GCAM DUMMY PART NUMBER
Y201	4880114R06	CRYSTAL 16.8MHZ
Y300	9186145B02	CER.DISCR. CDBCA455CX36-TC
Y301	4880606B09	2ND OSC XTAL 44.395 MHZ
	0786637Z01	SPRT,REINFORCEMENT,CRS



MOTOROLA

Commercial Series

CM Radios

VHF2 (146-174MHz)
Service Information

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Table of Contents

Chapter 1 MODEL CHART AND TECHNICAL SPECIFICATIONS

1.0 CM140/CM340/CM160/CM360 Model Chart	1-1
2.0 Technical Specifications	1-2

Chapter 2 THEORY OF OPERATION

1.0 Introduction	2-1
2.0 VHF (146-174MHz) Receiver.....	2-1
2.1 Receiver Front-End	2-1
2.2 Receiver Back-End.....	2-2
3.0 VHF (146-174MHz) Transmitter Power Amplifier	2-2
3.1 First Power Controller Stage.....	2-2
3.2 Power Controlled Driver Stage	2-3
3.3 Final Stage.....	2-3
3.4 Directional Coupler.....	2-3
3.5 Antenna Switch.....	2-3
3.6 Harmonic Filter	2-4
3.7 Power Control.....	2-4
4.0 VHF (146-174MHz) Frequency Synthesis	2-4
4.1 Reference Oscillator	2-4
4.2 Fractional-N Synthesizer	2-5
4.3 Voltage Controlled Oscillator (VCO)	2-6
4.4 Synthesizer Operation	2-7
5.0 Controller Theory of Operation	2-8
5.1 Radio Power Distribution	2-8
5.2 Protection Devices.....	2-10
5.3 Automatic On/Off	2-10
5.4 Microprocessor Clock Synthesiser	2-11
5.5 Serial Peripheral Interface (SPI).....	2-12
5.6 SBEP Serial Interface.....	2-12
5.7 General Purpose I/O.....	2-12
5.8 Normal Microprocessor Operation.....	2-13
5.9 Static Random Access Memory.....	2-14
6.0 Control Board Audio and Signalling Circuits	2-14
6.1 Audio Signalling Filter IC and Compander (ASFIC CMP)	2-14
7.0 Transmit Audio Circuits.....	2-15
7.1 Microphone Input Path	2-15
7.2 PTT Sensing and TX Audio Processing	2-16

8.0	Transmit Signalling Circuits	2-17
8.1	Sub-Audio Data (PL/DPL)	2-17
8.2	High Speed Data	2-18
8.3	Dual Tone Multiple Frequency (DTMF) Data	2-18
9.0	Receive Audio Circuits.....	2-19
9.1	Squelch Detect	2-19
9.2	Audio Processing and Digital Volume Control.....	2-20
9.3	Audio Amplification Speaker (+) Speaker (-)	2-20
9.4	Handset Audio	2-21
9.5	Filtered Audio and Flat Audio	2-21
10.0	Receive Audio Circuits	2-21
10.1	Sub-Audio Data (PL/DPL) and High Speed Data Decoder	2-21
10.2	Alert Tone Circuits	2-22

Chapter 3 TROUBLESHOOTING CHARTS

1.0	Troubleshooting Flow Chart for Receiver RF (Sheet 1 of 2).....	3-2
1.1	Troubleshooting Flow Chart for Receiver (Sheet 2 of 2)	3-3
2.0	Troubleshooting Flow Chart for 25W Transmitter (Sheet 1 of 3).....	3-4
2.1	Troubleshooting Flow Chart for 25W Transmitter (Sheet 2 of 3).....	3-5
2.2	Troubleshooting Flow Chart for 25W Transmitter (Sheet 3 of 3).....	3-6
3.0	Troubleshooting Flow Chart for Synthesizer	3-7
4.0	Troubleshooting Flow Chart for VCO	3-8
5.0	Troubleshooting Flow Chart for DC Supply (Sheet 1 of 2)	3-9
5.1	Troubleshooting Flow Chart for DC Supply (Sheet 2 of 2)	3-10

Chapter 4 VHF PCB/SCHEMATICS/PARTS LISTS

1.0	Allocation of Schematics and Circuit Boards	4-1
1.1	VHF2 and Controller Circuits.....	4-1
2.0	VHF2 1-25W PCB 8488977U01 (Rev. C) / Schematics	4-3
2.1	VHF2 1-25W PCB 8488977U01 (Rev. C) Parts List	4-19

Chapter 1

MODEL CHART AND TECHNICAL SPECIFICATIONS

1.0 CM140/CM340/CM160/CM360 Model Chart

CM Series VHF2 146-174MHz					
Model			Description		
MDM50KNC9AA2_N			CM140 146-174 MHz 1-25W 8-Ch		
MDM50KNC9AN2_N			CM340 146-174 MHz 1-25W 10-Ch		
MDM50KNF9AA2_N			CM160 146-174 MHz 1-25W 64-Ch		
MDM50KNF9AN2_N			CM360 146-174 MHz 1-25W 100-Ch		
Item			Description		
X			FUD1183_	S. Tanapa VHF2 25W 8 Ch BNC	
	X		PMUD1879_	S. Tanapa VHF2 25W 10 Ch BNC	
		X	PMUD1874_	S. Tanapa VHF2 25W 64 Ch BNC	
		X	PMUD1881_	S. Tanapa VHF2 25W 100 Ch BNC	
X	X		FCN6288_	Control Head	
		X	FCN5523_	Control Head	
X	X	X	HKN4137_	Battery Power Cable	
X	X	X	RMN50188_	Mag One Microphone	
		X	HMN3596_	Compact Microphone	
X	X	X	GLN7324_	Low Profile Trunnion	
X	X	X	6866546D02_	RTTE Leaflet	
X	X	X	6866537D37_	Safety Leaflet	
X			FLD1934AS	Servicing Kit CM140	
	X		PMUD1889AS	Servicing Kit CM340	
		X	PMUD1883AS	Servicing Kit CM160	
		X	PMUD1891AS	Servicing Kit CM360	

X = Indicates one of each is required

2.0 Technical Specifications

Data is specified for +25°C unless otherwise stated.

General	
Specification	VHF2
Frequency Range:	146-174 MHz
Frequency Stability (-30°C to +60°C, 25°C Ref.)	±2 PPM
Channel Capacity:	CM140 - 8 CM340 - 10 CM160 - 64 CM360 - 100
Channel Spacing:	12.5/20/25 kHz
Power Output:	1-25W
Power Supply:	13.2Vdc (10.8 - 15.6 Vdc) negative vehicle ground
Dimensions (L X W X H)	118mm X 169mm X 44mm
Weight: Low power (1-25W)	1.02 Kg
Operating Temperature	-30 to 60 ° C
Storage temperature	-40 to 80° C
Shock and Vibration	Meets MIL-STD 810-C,D&E and TIA/EIA 603
Dust	Meets MIL-STD 810-C,D&E and TIA/EIA 603
Humidity	Meets MIL-STD 810-C,D&E and TIA/EIA 603

Transmitter	
Specification	VHF2
Frequency Stability:	+/- 2.5ppm
Modulation Limiting:	$\pm 2.5 \text{ kHz}$ @ 12.5 kHz $\pm 4.0 \text{ kHz}$ @ 20 kHz $\pm 5.0 \text{ kHz}$ @ 20/25 kHz
Current Drain Transmit:	7A (25W)
FM Hum and Noise:	-40 dB@12.5 kHz -45 dB@ 20/25 kHz
Conducted/Radiated Emissions:	-36 dBm < 1 GHz -30 dBm > 1 GHz
Adjacent Channel Power	-60dB @12.5, -70dB @ 20/25kHz
Audio Response: (300 to 3000Hz)	+1, -3dB
Audio Distortion: @ 1000 Hz, 60% Rated Maximum Deviation:	3% Typical

Receiver	
Specification	VHF2
Sensitivity (12dBSINAD): (ETS)	0.35µV (12.5kHz) 0.30µV (25kHz) Typical
Intermodulation : (ETS)	>65dB
Adjacent Channel Selectivity: (ETS)	75 dB @ 25 kHz 65 dB @ 12.5 kHz
Spurious Rejection: (ETS)	75 dB
Rated Audio: (ETS) (Extended audio with 4 Ohm speaker)	4W Internal , 13W External
Audio Distortion @ Rated Audio:	3% Typical
Hum and Noise:	-40 dB @ 12.5 kHz -45 dB @ 20/25 kHz
Audio Response: (300 to 3000Hz)	+1, -3dB
Conducted Spurious Emission per FCC Part 15:	-57 dBm <1 GHz -47 dBm >1 GHz

*Availability subject to the laws and regulations of individual countries.

Chapter 2

THEORY OF OPERATION

1.0 Introduction

This Chapter provides a detailed theory of operation for the VHF circuits in the radio. Details of the theory of operation and trouble shooting for the the associated Controller circuits are included in this Section of the manual.

2.0 VHF (146-174MHz) Receiver

2.1 Receiver Front-End

The received signal is applied to the radio's antenna input connector and routed through the harmonic filter and antenna switch. The insertion loss of the harmonic filter/antenna switch is less than 1 dB. The signal is routed to the first filter (4-pole), which has an insertion loss of 2 dB typically. The output of the filter is matched to the base of the LNA (Q303) that provides a 16 dB gain and a noise figure of better than 2 dB. Current source Q301 is used to maintain the collector current of Q303. Diode CR301 protects Q303 by clamping excessive input signals. Q303 output is applied to the second filter (3-pole) which has an insertion loss of 1.5 dB. In Distance mode, Q304 turns on and causes D305 to conduct, thus bypassing C322 and R337. In Local mode, the signal is routed through C322 and R337, thus inserting 7 dB attenuation. Since the attenuator is located after the RF amplifier, the receiver sensitivity is reduced only by 6 dB, while the overall third order input intercept is raised.

The first mixer is a passive, double-balanced type, consisting of T300, T301 and U302. This mixer provides all of the necessary rejection of the half-IF spurious response. High-side injection at +15 dBm is delivered to the first mixer. The mixer output is then connected to a duplex network which matches its output to the XTAL filter input (FL300) at the IF frequency of 44.85 MHz. The duplex network terminates into a 50 ohm resistor (R340) at all other frequencies.

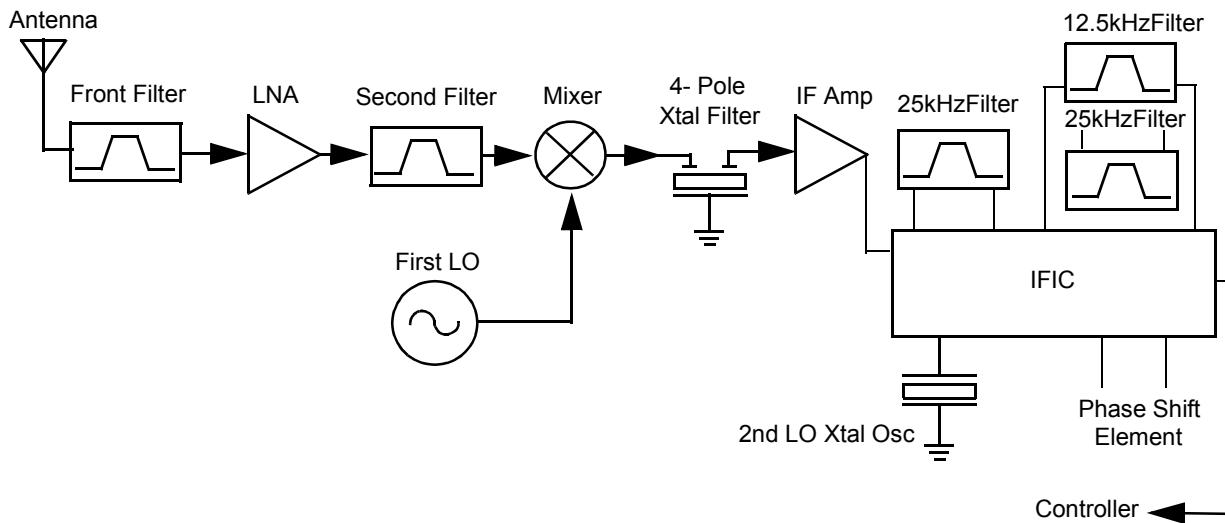


Figure 2-1 VHF Receiver Block Diagram

2.2 Receiver Back End

The IF signal from the crystal filter enters the IF amplifier which provides 20 dB of gain and feeds the IF IC at pin 1. The first IF signal at 44.85 MHz mixes with the second local oscillator (LO) at 44.395 MHz to produce the second IF at 455 kHz. The second LO uses the external crystal Y301. The second IF signal is amplified and filtered by two external ceramic filters (FL303/FL302 for 12.5KHz channel spacing and FL304/FL301 for 25KHz channel spacing). The IF IC demodulates the signal by means of a quadrature detector and feeds the detected audio (via pin 7) to the audio processing circuits. At IF IC pin 5, an RSSI signal is available with a dynamic range of 70 dB.

3.0 VHF Transmitter Power Amplifier (146-174 MHz)

The radio's 25W PA is a three-stage amplifier used to amplify the output from the TX_INJ to the antenna port. All three stages utilize LDMOS technology. The gain of the first stage (U101) and the second stage (Q105) is adjustable and is controlled by pin 7 of U103-2 via U103-3 and U102-1. It is followed by an LDMOS final stage Q100.

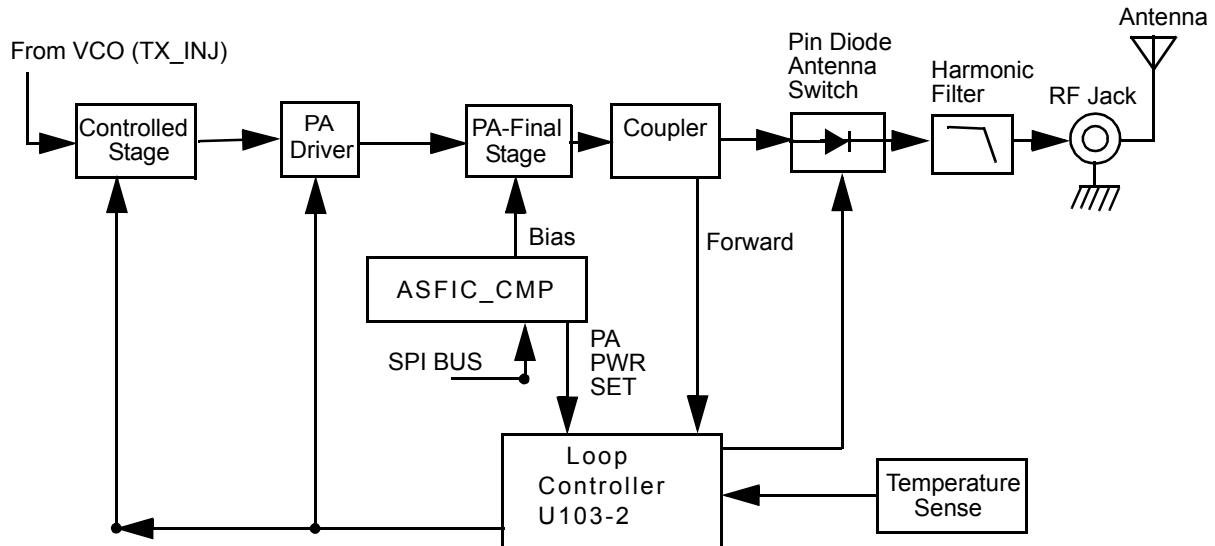


Figure 2-2 VHF Transmitter Block Diagram

Devices U101, Q105 and Q100 are surface mounted. A metal clip ensures good thermal contact between both the driver and final stage, and the chassis.

3.1 First Power Controller Stage

The first stage (U101) is a 20dB gain integrated circuit containing two LDMOS FET amplifier stages. It amplifies the RF signal from the VCO (TX_INJ). The output power of stage U101 is controlled by a DC voltage applied to pin 1 from the op-amp U103-3, pin 8. The control voltage simultaneously varies the bias of two FET stages within U101. This biasing point determines the overall gain of U101 and therefore its output drive level to Q105, which in turn controls the output power of the PA.

Op-amp U103-3 monitors the drain current of U101 via resistor R122 and adjusts the bias voltage of U101.

In receive mode, the DC voltage from RX_EN line turns on Q101, which in turn switches off the biasing voltage to U101.

3.2 Power Controlled Driver Stage

The next stage is an LDMOS device (Q105) which provides a gain of 12dB. This device requires a positive gate bias and a quiescent current flow for proper operation. The bias is set during transmit mode by the drain current control op-amp U102-1, and fed to the gate of Q105 via the resistive network.

Op-amp U102-1 monitors the drain current of Q105 via resistors R126-7 and adjusts the bias voltage of Q105 so that the current remains constant.

In receive mode the DC voltage from RX_EN line turns on Q102, which in turn switches off the biasing voltage to Q105.

3.3 Final Stage

The final stage is an LDMOS device (Q100) providing a gain of 12dB. This device also requires a positive gate bias and a quiescent current flow for proper operation. The voltage of the line PA_BIAS is set in transmit mode by the ASFiC and fed to the gate of Q100 via the resistive network R134, R131. This bias voltage is tuned in the factory. If the transistor is replaced, the bias voltage must be tuned using the Tuner. 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, B+, via L117 and L115.

A matching network consisting of C1004-5, C1008-9, C1021, C1013, C1019, L116: and two striplines, transforms the impedance to 50 ohms and feeds the directional coupler.

3.4 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 Q100. The coupled signal is rectified to an output power which is proportional to the DC voltage rectified by diode D105; and the resulting DC voltage is routed to the power control section to ensure that the forward power out of the radio is held to a constant value.

3.5 Antenna Switch

The antenna switch utilizes the existing dc feed (B+) to the last stage device (Q100). The basic operation is to have both PIN diodes (D103, D104) turned on during key-up by forward biasing them. This is achieved by pulling down the voltage at the cathode end of D104 to around 12.4V (0.7V drop across each diode). The current through the diodes needs to be set around 100 mA to fully open the transmit path through resistor R108. Q106 is a current source controlled by Q103 which is turned on in Tx mode by TX_EN. VR102 ensures that the voltage at resistor R107 never exceeds 5.6V.

3.6 Harmonic Filter

Inductors L111, L112 and L113 along with capacitors C1011, C1024, C1025, C1022, C1020, C1016, C1017 and C1026 form a low-pass filter to attenuate harmonic energy coming from the transmitter. Resistor R150 along with L126 drains 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 to improve spurious response rejection.

3.7 Power Control

The output power is regulated by using a forward power detection control loop. A directional coupler samples a portion of the forward and reflected RF power. The forward sampled RF is rectified by diode D105, and the resulting DC voltage is routed to the operational amplifier U100. The error output current is then routed to an integrator, and converted into the control voltage. This voltage controls the bias of the pre-driver (U101) and driver (Q105) stages. The output power level is set by way of a DAC, PWR_SET, in the audio processing IC (U504), which acts as the forward power control loop reference.

The sampled reflected power is rectified by diode D107. The resulting DC voltage is amplified by an operational amplifier U100 and routed to the summing junction. This detector protects the final stage Q100 from reflected power by increasing the error current. The temperature sensor protects the final stage Q100 from overheating by increasing the error current. A thermistor RT100 measures the final stage Q100 temperature. The voltage divider output is routed to an operational amplifier U103 and then goes to the summing junction. The Zener Diode VR101 keeps the loop control voltage below 5.6V and eliminates the DC current from the 9.3 regulator U501.

Two local loops for the Pre Driver (U101) and for the Driver (Q105) are used in order to stabilize the current for each stage.

In Rx mode, the two transistors Q101 and Q102 go to saturation and shut down the transmitter by applying ground to the Pre Driver U101 and for the Driver Q105 control.

4.0 VHF (146-174MHz) Frequency Synthesis

The synthesizer consists of a reference oscillator (Y201), low voltage Fractional-N (LVFRAC-N) synthesizer (U200), and a voltage controlled oscillator (VCO) (U201).

4.1 Reference Oscillator

The reference oscillator is a crystal (Y201) controlled Colpitts oscillator and has a frequency of 16.8MHz. The oscillator transistor and start-up circuit are located in the LVFRAC-N (U200) while the oscillator feedback capacitors, crystal, and tuning varactors are external. An analog-to-digital (A/D) converter internal to the LVFRAC-N (U200) and controlled by the microprocessor via SPI sets the voltage at the warp output of U200 pin 25. This sets the frequency of the oscillator. Consequently, the output of the crystal Y201 is applied to U200 pin 23.

The method of temperature compensation is to apply an inverse Bechmann voltage curve, which matches the crystal's Bechmann curve to a varactor that constantly shifts the oscillator back on frequency. The crystal vendor characterizes the crystal over a specified temperature range and codes this information into a bar code that is printed on the crystal package. In production, this crystal code is read via a 2-dimensional bar code reader and the parameters are saved.

This oscillator is temperature compensated to an accuracy of +/- 2.5 PPM from -30 to 60 degrees C. The temperature compensation scheme is implemented by an algorithm that uses five crystal parameters (four characterize the inverse Bechmann voltage curve and one for frequency accuracy of the reference oscillator at 25 degrees C). This algorithm is implemented by the LVFRAC-N (U200) at the power up of the radio.

TCXO Y200, along with its corresponding circuitry R204, R205, R210, and C2053, are not placed as the temperature compensated crystal proved to be reliable.

4.2 Fractional-N Synthesizer

The LVFRAC-N U200 consists of a pre-scaler, programmable loop divider, control divider logic, phase detector, charge pump, A/D converter for low frequency digital modulation, balanced attenuator used to balance the high and low frequency analog modulation, 13V positive voltage multiplier, serial interface for control, and a super filter for the regulated 5 volts.

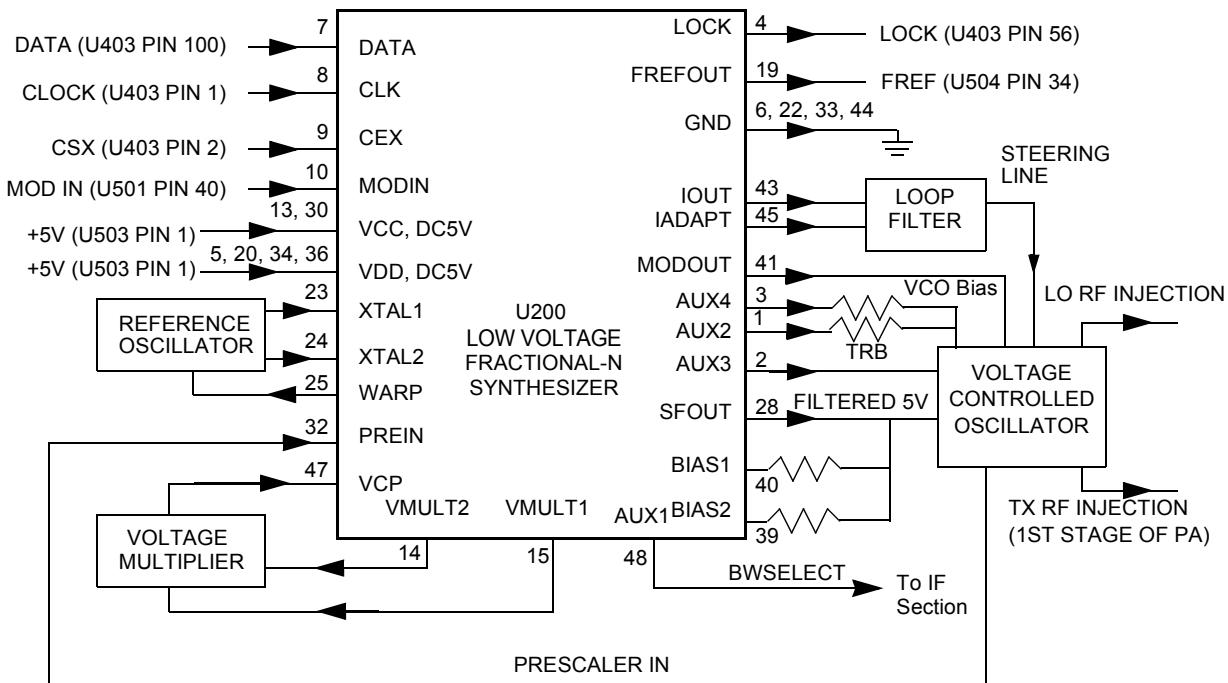


Figure 2-3 VHF Synthesizer Block Diagram

A voltage of 5V applied to the super filter input (U200, pin 30) supplies an output voltage of 4.5Vdc (VSF) at U200, pin 28. This supplies 4.5 V to the VCO Buffer IC U201.

To generate a high voltage to supply the phase detector (charge pump) output stage at pin VCP (U200, pin 47) while using a low voltage 3.3Vdc supply, a 13V positive voltage multiplier is used (D200, D201, and capacitors C2024, 2025, 2026, 2055, 2027, 2001).

Output lock (U200, pin 4) provides information about the lock status of the synthesizer loop. A high level at this output indicates a stable loop. A 16.8 MHz reference frequency is provided at U200, pin 19.

4.3 Voltage Controlled Oscillator (VCO)

The Voltage Controlled Oscillator (VCO) consists of the VCO/Buffer IC (VCOBIC, U201), the TX and RX tank circuits, the external RX amplifier, and the modulation circuitry.

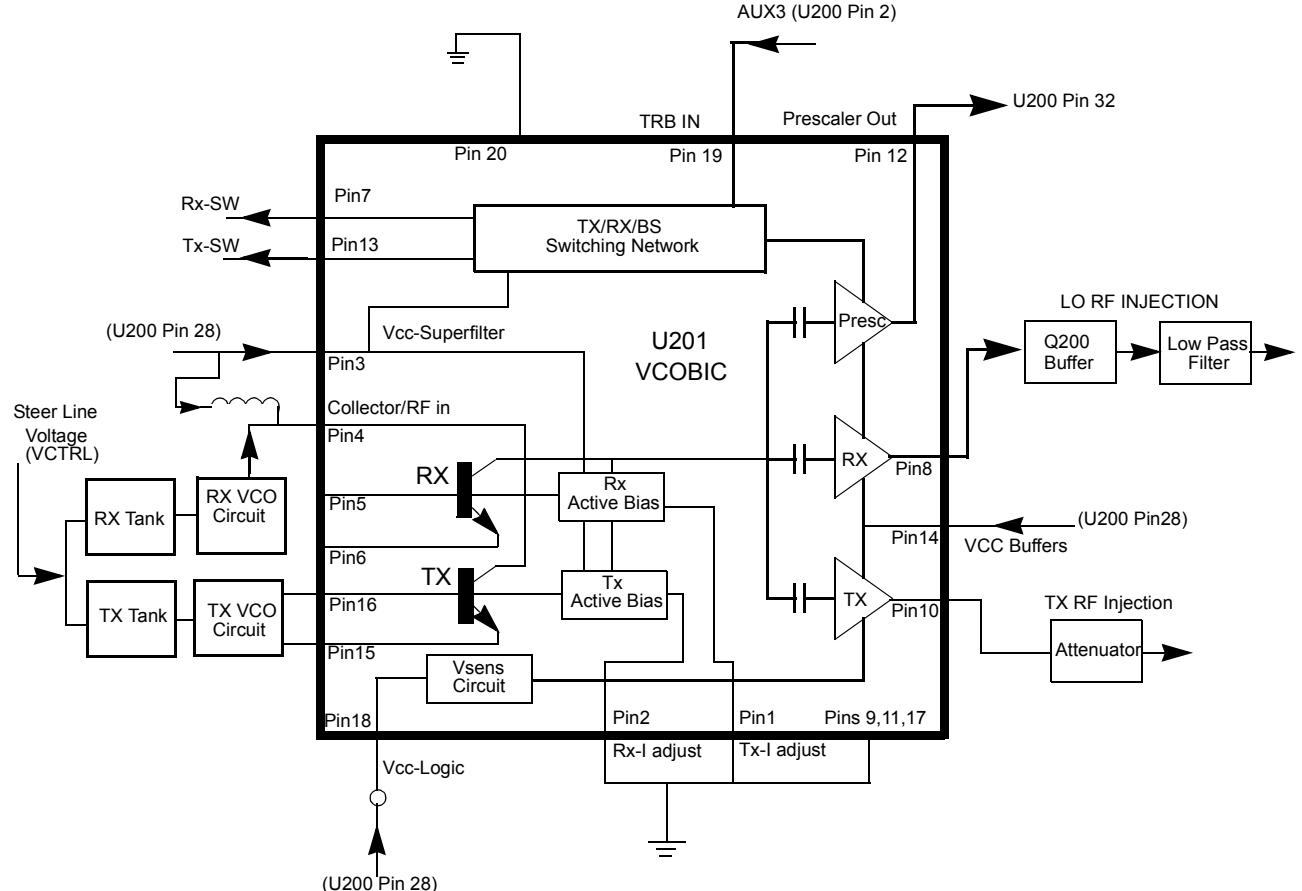


Figure 2-4 VHF VCO Block Diagram

The VCOBIC together with the LVFRAC-N (U200) generate the required frequencies in both transmit and receive modes. The TRB line (U201, pin 19) determines which VCO and buffer is enabled (high being TX output at pin 10, low being RX output at pin 8). A sample of the signal from the enabled output is routed from U201, pin 12 (PRESC_OUT), via a low pass filter to U200, pin 32 (PREIN).

A steering line voltage between 3.0V and 10.0V at varactor D204 tunes the TX VCO through the frequency range of 146-174MHz, and at D203 tunes the RX VCO through the frequency range of 190-219MHz.

The external RX amplifier is used to increase the output from U201, pin 9 from 3-4 dBm to the required 15dBm for proper mixer operation. In TX mode, the modulation signal from the LVFRAC-N (U200, pin 41) is applied to the VCO by way of the modulation circuit D205, R212, R211, C2073.

4.4 Synthesizer Operation

The synthesizer consists of a low voltage FRAC-N IC (LVFRAC-N), reference oscillator, charge pump circuits, loop filter circuit, and DC supply. The output signal (PRESC_OUT) of the VCOBIC (U201, pin 12) is fed to the PREIN, pin 32 of U200 via a low pass filter which attenuates harmonics and provides a correct input level to the LVFRAC-N in order to close the synthesizer loop.

The pre-scaler in the synthesizer (U200) is 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 SPI. 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 (Y201).

The output signal of the phase detector is a pulsed dc signal that is routed to the charge pump. The charge pump outputs a current from U200, pin 43 (IOUT). The loop filter (consisting of R224, R217, R234, C2074, C2075, C2077, C2078, C2079, C2080, C2028, and L205) transforms this current into a voltage that is applied the varactor diodes D203 and D204 for RX and TX respectively. The output frequency is determined by this control voltage. The current can be set to a value fixed in the LVFRAC-N or to a value determined by the currents flowing into BIAS 1 (U200, pin 40) or BIAS 2 (U200, pin 39). The currents are set by the value of R200 or R206 respectively. The selection of the three different bias sources is done by software programming.

To modulate the synthesizer loop, a two-spot modulation method is utilized via the MODIN (U200, pin 10) input of the LVFRAC-N. The audio signal is applied to both the A/D converter (low frequency path) and the balance 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 presented at the MODOUT port of the LVFRAC-N (U200,pin 41) and connected to the VCO modulation varactor D205.

5.0 Controller Theory of Operation

This section provides a detailed theory of operation for the radio and its components. The main radio is a single-board design, consisting of the transmitter, receiver, and controller circuits. A control head is connected by an extension cable. The control head contains LED indicators, a microphone connector, buttons, and speaker.

In addition to the power cable and antenna cable, an accessory cable can be attached to a connector on the rear of the radio. The accessory cable enables you to connect accessories to the radio, such as an external speaker, emergency switch, foot-operated PTT, and ignition sensing, etc.

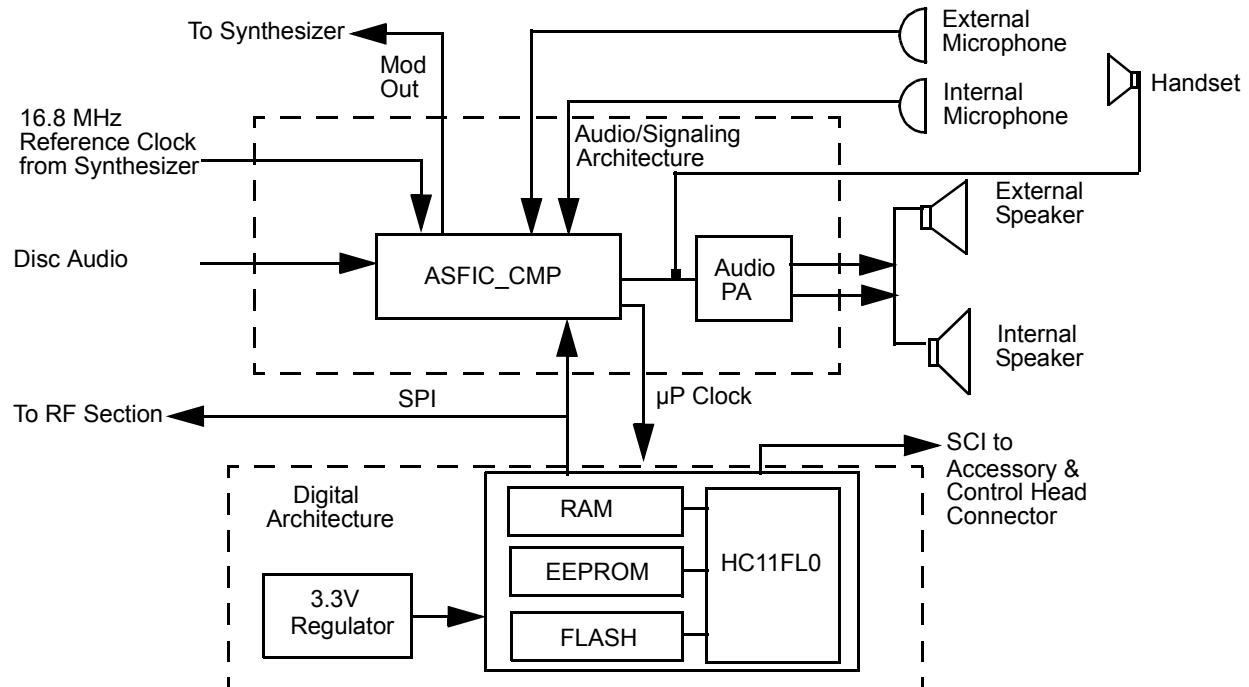


Figure 2-5 Controller Block Diagram

5.1 Radio Power Distribution

Voltage distribution is provided by five separate devices:

- U514 P-ch FET - Batt + (Ext_SWB+)
- U501 LM2941T - 9.3V
- U503 LP2951CM - 5V
- U508 MC 33269DTRK - 3.3V
- U510 LP2986ILDX - 3.3V Digital

The DC voltage applied to connector P2 supplies power directly to the following circuitry:

- Electronic on/off control
- RF power amplifier
- 12 volts P-ch FET -U514
- 9.3 volt regulator
- Audio PA

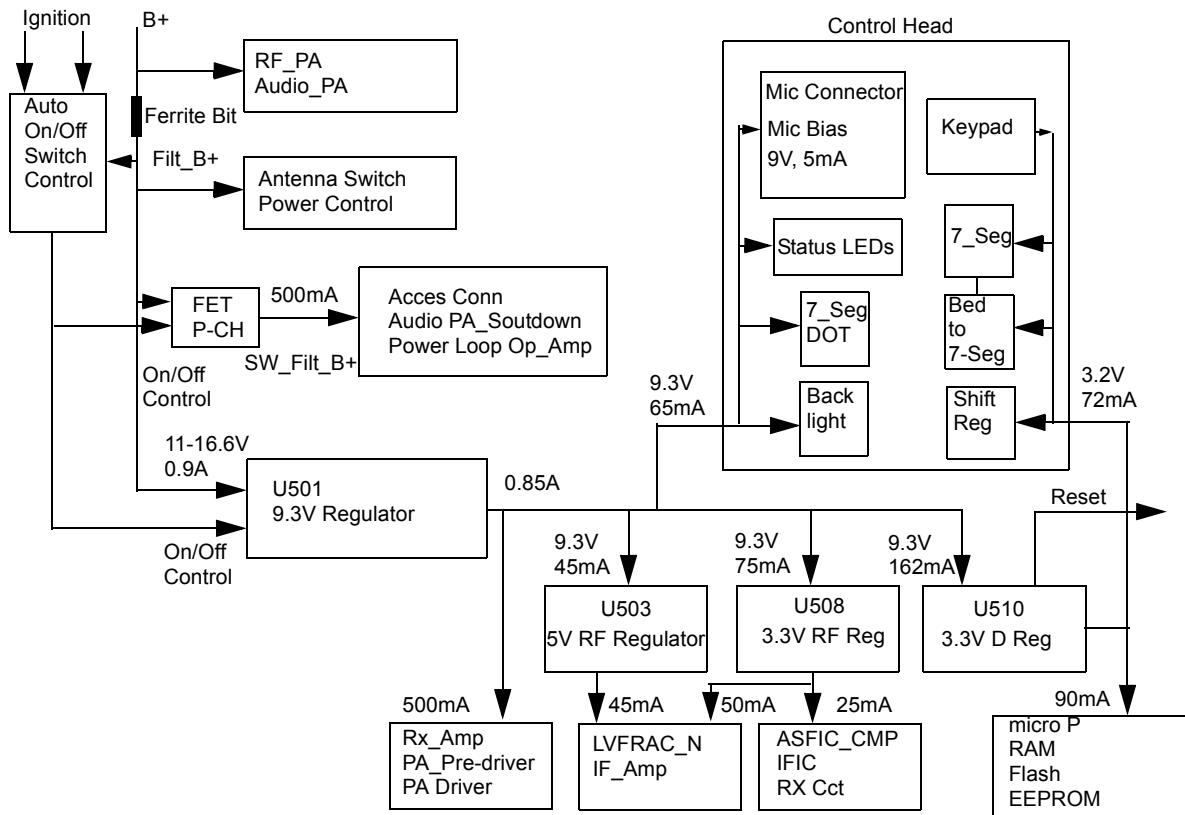


Figure 2-6 DC Power Distribution Block Diagram

Regulator U501 is used to generate the 9.3 volts required by some audio circuits, the RF circuitry and power control circuitry. Input and output capacitors are used to reduce high frequency noise. Resistors R5001 / R5081 set the output voltage of the regulator. This regulator output is electronically enabled by a 0 volt signal on pin 2. Q502, Q505 and R5038 are used to disable the regulator when the radio is turned off.

Voltage regulator U510 provides 3.3 volts for the digital circuitry. Operating voltage is from the regulated 9.3V supply. Input and output capacitors are used to reduce high frequency noise and provide proper operation during battery transients. U510 provides a reset output that goes to 0 volts if the regulator output goes below 3.1 volts. This is used to reset the controller to prevent improper operation.

Voltage regulator U508 provides 3.3V for the RF circuits and ASFIC_CMP. Input and output capacitors are used to reduce the high frequency noise and provide proper operation during battery transients.

Voltage regulator U503 provides 5V for the RF circuits. Input and output capacitors are used to reduce the high frequency noise and provide proper operation during battery transients.

VSTBY is used only for CM360 5-tone radios.

The voltage VSTBY, which is derived directly from the supply voltage by components R5103 and VR502, is used to buffer the internal RAM. Capacitor C5120 allows the battery voltage to be disconnected for a couple of seconds without losing RAM parameters. Dual diode D501 prevents radio circuitry from discharging this capacitor. When the supply voltage is applied to the radio, C5120 is charged via R5103 and D501.

5.2 Protection Devices

Diode VR500 acts as protection against ESD, wrong polarity of the supply voltage, and load dump. VR692 - VR699 are for ESD protection.

5.3 Automatic On/Off

The radio can be switched ON in any one of the following three ways:

- On/Off switch. (No Ignition Mode)
- Ignition and On/Off switch (Ignition Mode)
- Emergency

5.3.1 No Ignition Mode

When the radio is connected to the car battery for the first time, Q500 will be in saturation, Q503 will cut-off, Filt_B+ will pass through R5073, D500, and S5010-pin 6 (On/Off switch). When S5010 is ON, Filt_B+ will pass through S5010-pin5, D511, R5069, R5037 and base of Q505 and move Q505 into saturation. This pulls U501-pin2 through R5038, D502 to 0.2V and turns On U514 and U501 9.3V regulator which supplies voltage to all other regulators and consequently turns the radio on, When U504 (ASFIC_CMP) gets 3.3V, GCB2 goes to 3.3V and holds Q505 in saturation, for soft turn off.

5.3.2 Ignition Mode

When ignition is connected for the first time, it will force high current through Q500 collector, This will move Q500 out of saturation and consequently Q503 will cut-off. S5010 pin 6 will get ignition voltage through R601 (for load dump), R610, (R610 & C678 are for ESD protection), VR501, R5074, and D500. When S5010 is ON, Filt_B+ passes through S5010-pin 5, D511, R5069, R5037 and base of Q505 and inserts Q505 into saturation. This pulls U501-pin 2 through R5038, D502 to 0.2V and turns on U514 and U501 9.3V regulator which supply voltage to all other regulators and turns the radio on, When U504 (ASFIC_CMP) get 3.3V supply, GCB2 goes to 3.3V and holds Q505 in saturation state to allow soft turn off,

When ignition is off Q500, Q503 will stay at the same state so S5010 pin 6 will get 0V from Ignition, Q504 goes from Sat to Cut, ONOFF_SENSE goes to 3.3V and it indicates to the radio to soft turn itself by changing GCB2 to '0' after de registration if necessary.

5.3.3 Emergency Mode

The emergency switch (P1 pin 9), when engaged, grounds the base of Q506 via EMERGENCY _ACCES_CONN. This switches Q506 to off and consequently resistor R5020 pulls the collector of Q506 and the base of Q506 to levels above 2 volts. Transistor Q502 switches on and pulls U501 pin2 to ground level, thus turning ON the radio. When the emergency switch is released R5030 pulls the base of Q506 up to 0.6 volts. This causes the collector of transistor Q506 to go low (0.2V), thereby switching Q502 to off.

While the radio is switched on, the μ P monitors the voltage at the emergency input on the accessory connector via U403-pin 62. Three different conditions are distinguished: no emergency kit is connected, emergency kit connected (unpressed), and emergency press.

If no emergency switch is connected or the connection to the emergency switch is broken, the resistive divider R5030 / R5049 will set the voltage to about 3.14 volts (indicates no emergency kit found via EMERGENCY_SENSE line). If an emergency switch is connected, a resistor to ground within the emergency switch will reduce the voltage on EMERGENCY_SENSE line, and indicate to the μ P that the emergency switch is operational. An engaged emergency switch pulls line EMERGENCY_SENSE line to ground level. Diode VR503 limits the voltage to protect the μ P input.

While EMERGENCY_ACCES_CONN is low, the μ P starts execution, reads that the emergency input is active through the voltage level of μ P pin 64, and sets the DC POWER ON output of the ASFIC CMP pin 13 to a logic high. This high will keep Q505 in saturation for soft turn off.

5.4 Microprocessor Clock Synthesiser

The clock source for the μ P system is generated by the ASFIC CMP (U504). 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 audio circuitry, 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 will generate its default 3.6864MHz CMOS square wave UP CLK (on U504 pin 28) and this is routed to the μ P (U403 pin 90). After the μ 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 the clock source interfering with the desired radio receive frequency.

The ASFIC CMP synthesizer loop uses C5025, C5024 and R5033 to set the switching time and jitter of the clock output. If the synthesizer cannot generate the required clock frequency it will switch back to its default 3.6864MHz output.

Because the ASFIC CMP synthesizer and the μ P system will not operate without the 16.8 MHz reference clock it (and the voltage regulators) should be checked first when debugging the system.

5.5 Serial Peripheral Interface (SPI)

The μ P communicates to many of the IC's through its SPI port. This port consists of SPI TRANSMIT DATA (MOSI) (U403-pin100), SPI RECEIVE DATA (MISO) (U403-pin 99), SPI CLK (U0403-pin1) and chip select lines going to the various IC's, connected on the SPI PORT (BUS). This BUS is a synchronous bus, in that the timing clock signal CLK is sent while SPI data (SPI TRANSMIT DATA or SPI RECEIVE DATA) 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 is used to send serial from a μ P to a device, and SPI RECEIVE DATA is used to send data from a device to a μ P.

There are two IC's on the SPI BUS, ASFIC CMP (U504 pin 22), and EEPROM (U400). In the RF sections there is one IC on the SPI BUS, the FRAC-N Synthesizer. The chip select line CSX from U403 pin 2 is shared by the ASFIC CMP and FRAC-N Synthesizer. Each of these IC's check the SPI data and when the sent address information matches the IC's address, the following data is processed.

When the μ P needs to program any of these ICs 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 to the various IC's are different; e.g., the ASFIC CMP can receive up to 19 bytes (152 bits). After the data has been sent the chip select line is returned to logic "1".

5.6 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) or the cable with internal RIB. This interface connects to the SCI pin via control head connector (J2-pin 17) and to the accessory connector P1-6 and comprises BUS+. The line is bi-directional, meaning that either the radio or the RIB can drive the line. The μ P sends serial data and it reads serial data via pin 97. Whenever the μ P detects activity on the BUS+ line, it starts communication.

5.7 General Purpose Input/Output

The controller provides six general purpose lines (PROG I/O) available on the accessory connector P1 to interface to external options. Lines PROG IN 3 and 6 are inputs, PROG OUT 4 is an output and PROG IN OUT 8, 12 and 14 are bi-directional. The software and the hardware configuration of the radio model define the function of each port.

- PROG IN 3 can be used as external PTT input, or others, set by the CPS. The μ P reads this port via pin 72 and Q412.
- PROG OUT 4 can be used as external alarm output, set by the CPS. Transistor Q401 is controlled by the μ P (U403 pin 55)
- PROG IN 6 can be used as normal input, set by the CPS. The μ P reads this port via pin 73 and Q411. This pin is also used to communicate with the RIB if resistor R421 is placed.
- DIG IN OUT 8,12,14 are bi-directional and use the same circuit configuration. Each port uses an output Q416, Q404, Q405 controlled by μ P pins 52, 53, 54. The input ports are read through μ P pins 74, 76, 77; using Q409, Q410, Q411

5.8 Normal Microprocessor Operation

For this radio, the µP is configured to operate in one of two modes, expanded and bootstrap. In expanded mode the µP uses external memory devices to operate, whereas in bootstrap operation the µP uses only its internal memory. In normal operation of the radio the µP is operating in expanded mode as described below.

During normal operation, the µP (U403) is operating in expanded mode and has access to 3 external memory devices; U400 (EEPROM), U402 (SRAM), U404 (Flash). Also, within the µP there are 3 Kilobytes of internal RAM, as well as logic to select external memory devices.

The external EEPROM (U400) space contains the information in the radio which is customer specific, referred to as the codeplug. This information consists of items such as: 1) what band the radio operates in, 2) what frequencies are assigned to what channel, and 3) tuning information.

The external SRAM (U402) as well as the µP's own internal RAM space are used for temporary calculations required by the software during execution. All of the data stored in both of these locations is lost when the radio powers off.

The µP provides an address bus of 16 address lines (ADDR 0 - ADDR 15), and a data bus of 8 data lines (DATA 0 - DATA 7). There are also 3 control lines; CSPROG (U403-pin 38) to chip select U404-pin 30 (FLASH), CSGP2 (U403-pin 41) to chip select U404-pin 20 (SRAM) and PG7_R_W (U403-pin 4) to select whether to read or to write. The external EEPROM (U400-pin1).

When the µP is functioning normally, the address and data lines should be toggling at CMOS logic levels. Specifically, the logic high levels should be between 3.1 and 3.3V, and the logic low levels should be between 0 and 0.2V. 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 1us/div. or faster to observe individual pulses. High speed CMOS transitions should also be observed on the µP control lines.

On the µP the lines XIRQ (U403-pin 48), MODA LIR (U403-pin 58), MODB VSTPY (U403-pin 57) and RESET (U403-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 20ms. In the case of shorted lines you may also detect the line periodically at an intermediate level, i.e. around 2.5V when two shorted lines attempt to drive to opposite rails.

The MODA LIR (U403-pin 58) and MODB VSTPY (U403-pin 57) inputs to the µP must be at a logic "1" for it to start executing correctly. After the µP starts execution it will periodically pulse these lines to determine the desired operating mode. While the Central Processing Unit (CPU) is running, MODA LIR is an open-drain CMOS output which goes low whenever the µP begins a new instruction. An instruction typically requires 2-4 external bus cycles, or memory fetches.

There are eight analog-to-digital converter ports (A/D) on U403 labelled within the device block as PEO-PE7. These lines sense the voltage level ranging from 0 to 3.3V 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.

5.9 Static Random Access Memory (SRAM)

The SRAM (U402) 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 U402 (which comes from U403-CSGP2) going low. U402 is commonly referred to as the external RAM as opposed to the internal RAM which is the 3 Kilobytes of RAM which is 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 C402 and C411 serves to filter out any AC noise which may ride on +3.3 V at U402

6.0 Control Board Audio and Signalling Circuits

6.1 Audio Signalling Filter IC and Compander (ASFIC CMP)

The ASFIC CMP (U504) used in the controller has the following four functions:

1. RX/TX audio shaping, i.e. filtering, amplification, attenuation
2. RX/TX signaling, PL/DPL/HST/MDC
3. Squelch detection
4. μ P clock signal generation

The ASFIC CMP is programmable through the SPI BUS (U504 pins-20/21/22), normally receiving 19 bytes. This programming sets up various paths within the ASFIC CMP to route audio and/or signaling signals through the appropriate filtering, gain and attenuator blocks. The ASFIC CMP also has 6 General Control Bits GCB0-5 which are CMOS level outputs and used for the following:

- GCB0 - BW Select
- GCB1 - switches the audio PA On/Off
- GCB2 - DC Power On switches the voltage regulator (and the radio) on and off
- GCB3 - Control on MUX U509 pin 9 to select between Low Cost Mic path to STD Mic Path
- GCB4 - Control on MUX U509 pin 11 to select between Flat RX path to filtered RX path on the accessory connector.
- GCB5 - Control on MUX U509 pin 10 to select between Flat TX path mute and Flat TX path

7.0 Transmit Audio Circuits

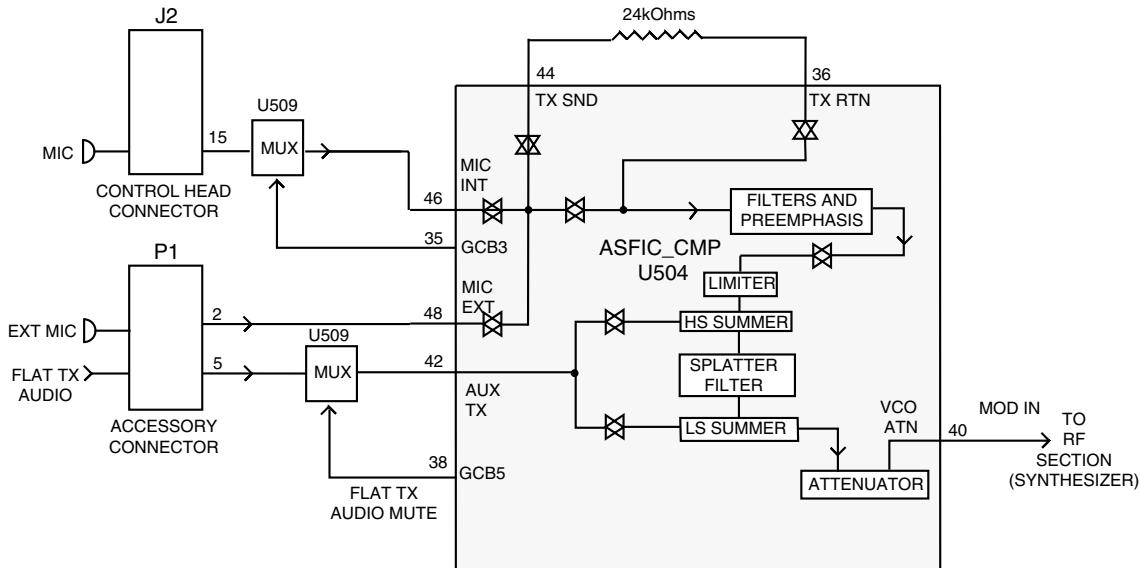


Figure 2-7 Transmit Audio Paths

7.1 Microphone Input Path

The radio supports 2 distinct microphone paths known as internal (from control head J2-15) and external mic (from accessory connector P1-2) and an auxiliary path (FLAT TX AUDIO, from accessory connector P1-5). The microphones used for the radio require a DC biasing voltage provided by a resistive network.

The two microphone audio input paths enter the ASIFC CMP at U504-pin 48 (external mic) and U504-pin 46 (internal mic). The microphone is plugged into the radio control head and connected to the audio DC via J2-pin 15. The signal is then routed via C5045 to MUX U509 that select between two paths with different gain to support Low Cost Mic (Mic with out amplifier in it) and Standard Mic.

7.1.1 Low Cost Microphone

Hook Pin is shorted to Pin 1(9.3V) inside the Low Cost Mic, This routes 9.3V to R429, and creates 2.6V on MIC_SENSE (u.P U403-67) by Voltage Divider R429/R430. U403 senses this voltage and sends command to ASIFC_CMP U504 to get GCB3 = '0'. The audio signal is routed from C5045 via U509-5 (Z0), R5072, U507, R5026, C5091, R5014 via C5046 to U504- 46 int. mic (C5046 100nF creates a159Hz pole with U504- 46 int mic impedance of 16Kohm).

7.1.2 Standard Microphone

Hook Pin is shorted to the hook mic inside the standard Mic. If the mic is out off hook, 3.3V is routed to R429 via R458, D401, and it create 0.7V on MIC_SENSE (u.P U403-67) by Voltage Divider R429/R430. U403 senses this voltage and sends command to ASFIC_CMP U504 to get GCB3 ='1'. The audio signal is routed from C5045 via U509-3 (Z1), R5072, U507, R5026, C5091, R5014 via C5046 to U504- 46 int mic (C5046 100nF create a159Hz pole with U504- 46 int mic impedance of 16Kohm). 9.3VDC is routed via R5077, R5075 to J2-15, It create 4.65V with Mic Impedance. C5010 supplies AC Ground to create AC impedance of 510 Ohms via R5075. and Filter 9.3V DC mic bias supply.

Note: The audio signal at U504-pin 46 should be approximately 12mV for 1.5kHz or 3kHz of deviation with 12.5kHz or 25kHz channel spacing.

The external microphone signal enters the radio on accessory connector P1 pin 2 and is routed via line EXT MIC to R5054. R5078 and R5076 provide the 9.3Vdc bias. Resistive divider R5054/ R5070 divide the input signal by 5.5 and provide input protection for the CMOS amplifier input. R5076 and C5009 provide a 510 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.

C5047 serves as a DC blocking capacitor. The audio signal at U504-pin 48 should be approximately 14mV for 1.5kHz or 3kHz of deviation with 12.5kHz or 25kHz channel spacing.

The FLAT TX AUDIO signal from accessory connector P1-pin 5 is fed to the ASFIC CMP (U504 pin 42 through U509 pin 2 to U509 pin 15 via U506 OP-AMP circuit and C5057.

The ASFIC has an internal AGC that can control the gain in the mic audio path. The AGC can be disabled / enabled by the μ P. Another feature that can be enabled or disabled in the ASFIC is the VOX. This circuit, along with Capacitor C5023 at U504-pin 7, provides a DC voltage that can allow the μ P to detect microphone audio. The ASFIC can also be programmed to route the microphone audio to the speaker for public address operation.

7.2 PTT Sensing and TX Audio Processing

Internal microphone PTT is sensed by μ P U403 pin 71. Radio transmits when this pin is "0" and selects inside the ASFIC_CMP U504 internal Mic path. When the internal Mic PTT is "0" then external Mic PTT is grounded via D402. External Mic PTT is sensed by U403 pin 72 via Q412 circuits. The radio transmits when this pin is "0" and selects inside the ASFIC_CMP U504 External Mic path.

Inside the ASFIC CMP, the mic 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 mic audio is then routed through a summer, which is used to add in signaling 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 U504-pin 40 MOD IN, at which point it is routed to the RF section.

8.0 Transmit Signalling Circuits

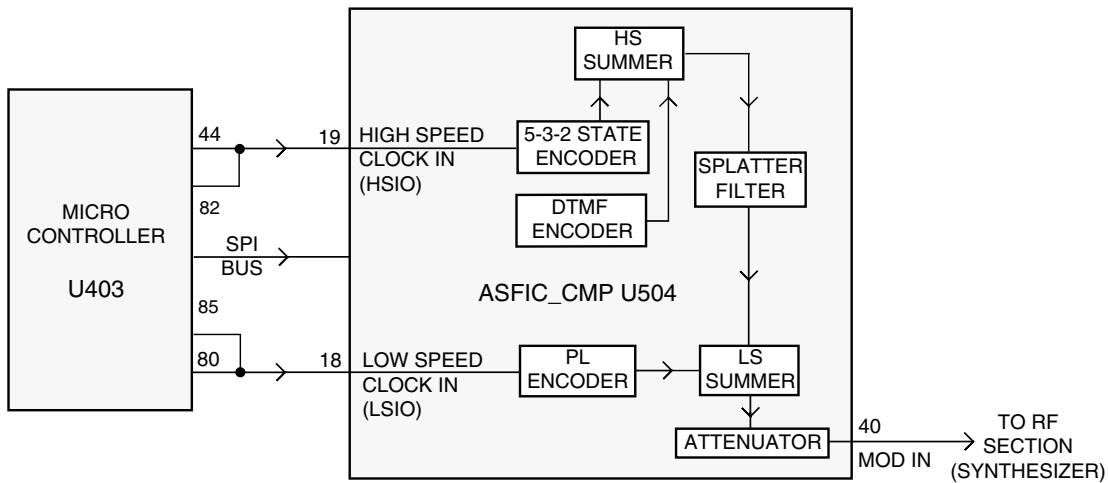


Figure 2-8 Transmit Signalling Path

From a hardware point of view, there are 3 types of signaling:

- Sub-audible data (PL / DPL / Connect Tone) that gets summed with transmit voice or signaling,
- DTMF data for telephone communication in trunked and conventional systems, and
- Audible signaling including MDC and high-speed trunking.

Note: All three types are supported by the hardware while the radio software determines which signaling type is available.

8.1 Sub-Audio Data (PL/DPL)

Sub-audible data implies signaling whose bandwidth 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 U504 (ASFIC CMP) at any one time. The process is as follows, using the SPI BUS, the μ P programs the ASFIC CMP to set up the proper low-speed data deviation and select the PL or DPL filters. The μ P then generates a square wave which strobes the ASFIC PL / DPL encode input LSIO U504-pin 18 at twelve times the desired data rate. For example, for a PL frequency of 103Hz, the frequency of the square wave would be 1236Hz.

This drives a tone generator inside U504 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 U504-pin 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.

8.2 High Speed Data

High speed data refers to the 3600 baud data waveforms, known as Inbound Signaling Words (ISWs) used in a trunking system for high speed communication between the central controller and the radio. To generate an ISW, the μ P first programs the ASFIC CMP (U504) to the proper filter and gain settings. It then begins strobing U504-pin 19 (HSIO) with a pulse when the data is supposed to change states. U504'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 attenuator and then out of the ASFIC CMP to the RF board. MDC is 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 signaling schemes are based on sending a combination of 1200 Hz and 1800 Hz tones only. Microphone audio is muted during high speed data signaling.

8.3 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 μ P (U403-46) strobing U504-19 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 μ P via SPI bus. Inside U504 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 was described for high-speed data.

9.0 Receive Audio Circuits

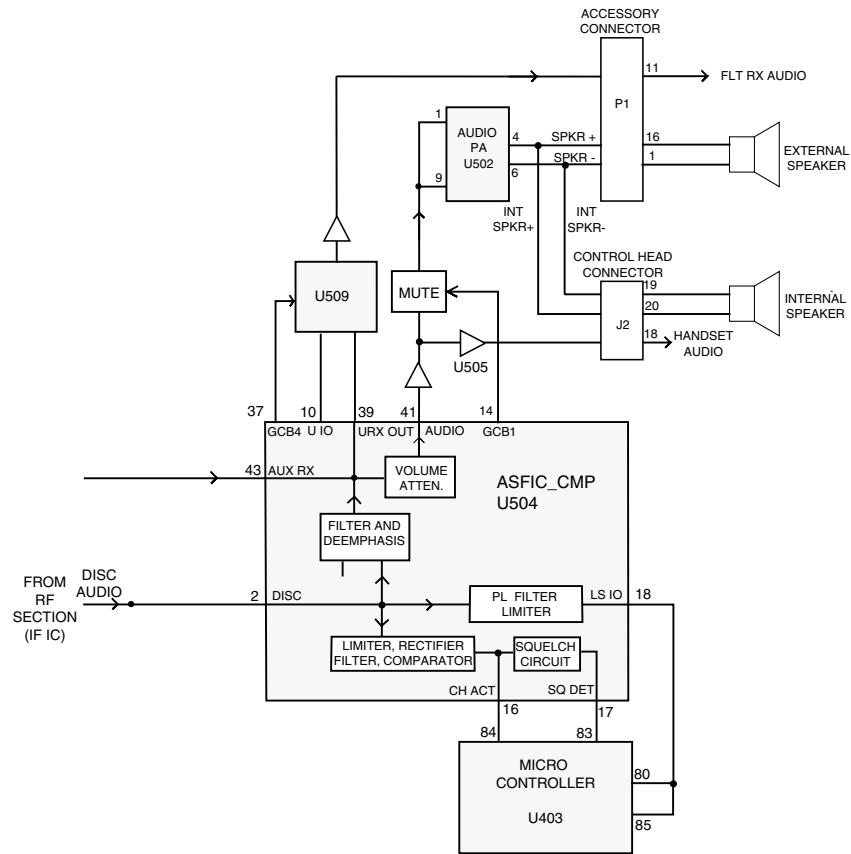


Figure 2-9 Receive Audio Paths

9.1 Squelch Detect

The radio's RF circuits are constantly producing an output at the discriminator (IF IC). This signal (DISC AUDIO) is routed to the ASFiC CMP's squelch detect circuitry input DISC (U504-pin 2). All of the squelch detect circuitry is contained within the ASFiC CMP. Therefore from a user's point of view, DISC AUDIO enters the ASFiC CMP, and the ASFiC CMP produces two CMOS logic outputs based on the result. They are CH ACT (U504-16) and SQ DET (U504-17).

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 on CH ACT. A squelch tail circuit is used to produce SQ DET (U504-17) from CH ACT. The state of CH ACT and SQ DET is high (logic "1") when carrier is detected, otherwise low (logic "0").

CH ACT is routed to the μ P pin 84 while SQ DET is routed to the μ P pin 83.

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.

9.2 Audio Processing and Digital Volume Control

The receiver audio signal (DISC AUDIO) enters the controller section from the IF IC where it is DC coupled to ASFIC CMP via the DISC input U504-pin 2. The signal is then applied to both the audio and the PL/DPL paths

The audio path has a programmable amplifier, whose setting is based on the channel bandwidth being received, an LPF filter to remove any frequency components above 3000Hz, and a HPF to strip off any sub-audible data below 300Hz. Next, 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 IC then passes the audio through the 8-bit programmable attenuator whose level is set depending on the value of the volume control. Finally the filtered audio signal passes through an output buffer within the ASFIC CMP. The audio signal exits the ASFIC CMP at AUDIO output (U504 pin 41).

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

Since sub-audible signaling is summed with voice information on transmit, it must be separated from the voice information before processing. Any sub-audible signaling enters the ASFIC CMP from the IF IC at DISC U504-2. Once inside, it goes through the PL/DPL path. The signal first passes through one of the two low-pass filters, either the PL low-pass filter or the DPL/LST low-pass filter. Either signal is then filtered and goes through a limiter and exits the ASFIC CMP at LSIO (U504-pin 18). At this point, the signal will appear as a square wave version of the sub-audible signal which the radio received. The µP U403 pin 80 will decode the signal directly to determine if it is the tone / code which is currently active on that mode.

9.3 Audio Amplification Speaker (+) Speaker (-)

The output of the ASFIC CMP's digital volume pot, U504-pin 41 is routed through DC blocking capacitor C5049 to the audio PA (U502 pin 1 and 9).

The audio power amplifier has one inverted and one non-inverted output that produces the differential audio output SPK+/SPK- (U502 pins 4 and 6)

The audio PA is enabled via the ASFIC CMP (U504-GCB1). When the base of Q501 is low, the transistor is off and U502-pin 8 is high, using pull up resistor R5041, and the audio PA is ON. The voltage at U502-pin 8 must be above 8.5Vdc to properly enable the device.

If the voltage is between 3.3 and 6.4V, the device will be active but has its input (U502-pins 1/9) off. This is a mute condition which is used to prevent an audio pop when the PA is enabled.

The SPK+ and SPK- outputs of the audio PA have a DC bias which varies proportionately with B+ (U502- pin 7). B+ of 11V yields a DC offset of 5V, and B+ 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 will be damaged. SPK+ and SPK- are routed to the accessory connector (P1-pin 1 and 16) and to the control head (connector J2-pins 19 and 20).

9.4 Handset Audio

Certain handheld accessories have a speaker within them which require a different voltage level than that provided by U502. For these devices HANDSET AUDIO is available at control head connector J2 pin18.

The received audio from the output of the ASIC CMP's digital volume attenuator is routed to U505 pin 2 where it is amplified. This signal is routed from the output of the op-amp U505 to J2-pin 18. From the control head, the signal is sent directly to the microphone jack.

9.5 Filtered Audio and Flat Audio

The ASIC CMP output audio at U504-pin 39 is filtered and de-emphasized, but has not gone through the digital volume attenuator. From ASIC CMP U504-pin 39 the signal is routed via R5034 through gate U509-pin 12 and AC coupled to U505-pin 6. The gate controlled by ASIC CMP port GCB4 selects between the filtered audio signal from the ASIC CMP pin 39 (URXOUT) or the unfiltered (flat) audio signal from the ASIC CMP pin 10 (UIO). Resistors R5034 and R5021 determine the gain of op-amp UU505-pin 6 for the filtered audio while R5032 and R5021 determine the gain for the flat Audio. The output of U505-pin 7 is then routed to P1 pin 11 via DC blocking capacitor C5003. Note that any volume adjustment of the signal on this path must be done by the accessory.

10.0 Receive Signalling Circuits

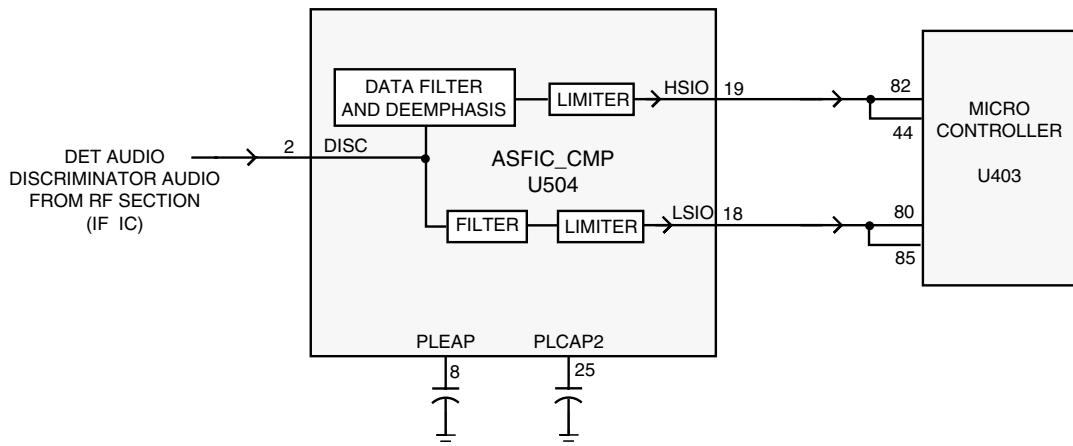


Figure 2-10 Receive Signalling Paths

10.1 Sub-Audio Data (PL/DPL) and High Speed Data Decoder

The ASIC CMP (U504) is used to filter and limit all received data. The data enters the ASIC CMP at input DISC (U504 pin 2). Inside U504 the data is filtered according to data type (HS or LS), then it is limited to a 0-3.3V digital level. The MDC and trunking high speed data appear at U504-pin 19, where it connects to the μ P U403 pin 80.

The low speed limited data output (PL, DPL, and trunking LS) appears at U504-pin18, where it connects to the μ P U403-pin 80.

The low speed data is read by the μ 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 C5028, and C5026 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.

10.2 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 U504 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 μ 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 μ P can generate any tone within the 100-3000Hz audio band. This is accomplished by the μ P generating a square wave which enters the ASFIC CMP at U504 pin 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 U504, 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 U504-pin 41 and is routed to the audio PA like receive audio.

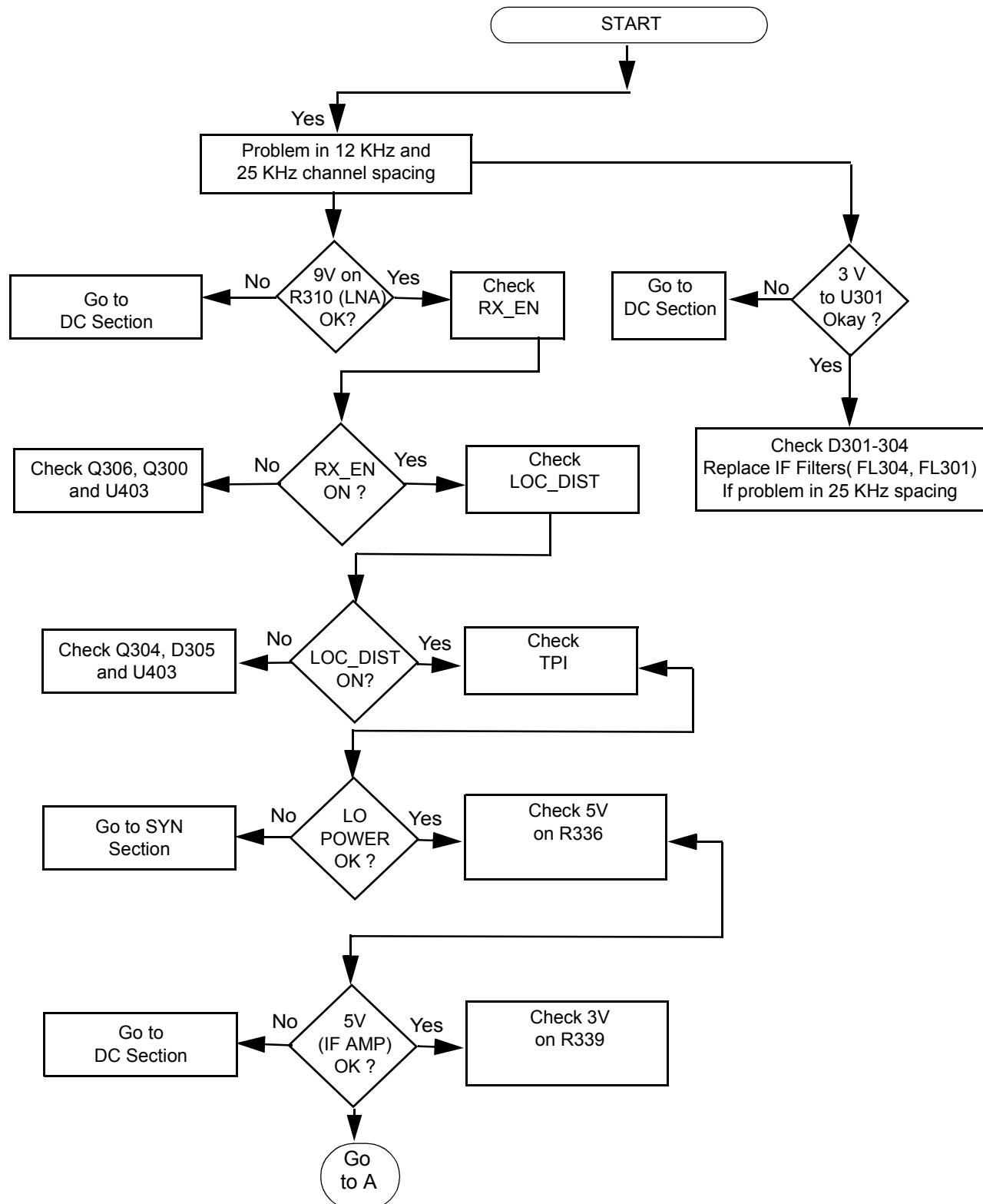
Chapter 3

TROUBLESHOOTING CHARTS

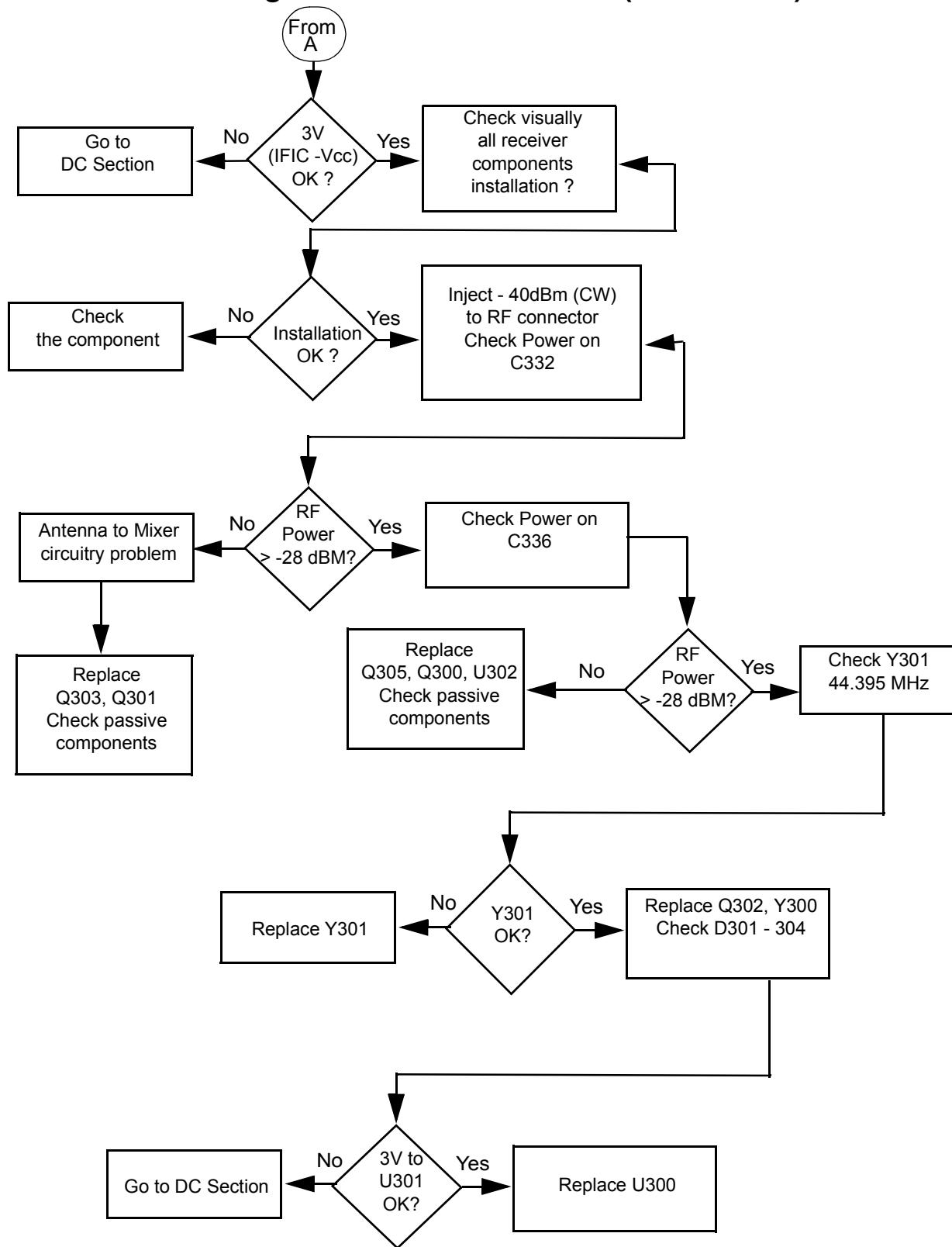
This section contains detailed troubleshooting flowcharts. These charts should be used as a guide in determining the problem areas. They are not a substitute for knowledge of circuit operation and astute troubleshooting techniques. It is advisable to refer to the related detailed circuit descriptions in the theory of operation sections prior to troubleshooting a radio.

Most troubleshooting charts end up by pointing to an IC to replace. It is not always noted, but it is good practice to verify supplies and grounds to the affected IC and to trace continuity to the malfunctioning signal and related circuitry before replacing any IC. For instance, if a clock signal is not available at a destination, continuity from the source IC should be checked before replacing the source IC.

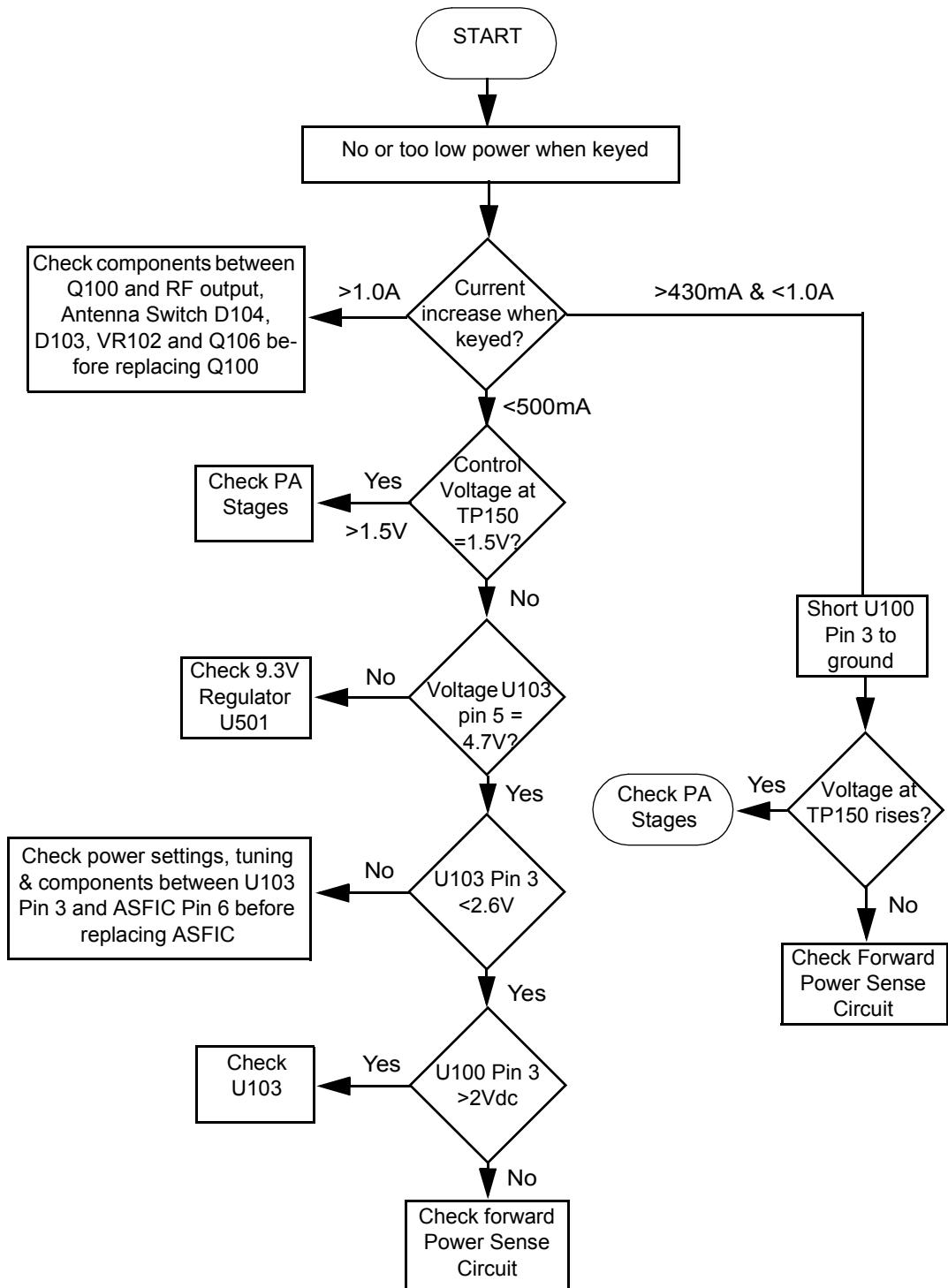
1.0 Troubleshooting Flow Chart for Receiver RF (Sheet 1 of 2)



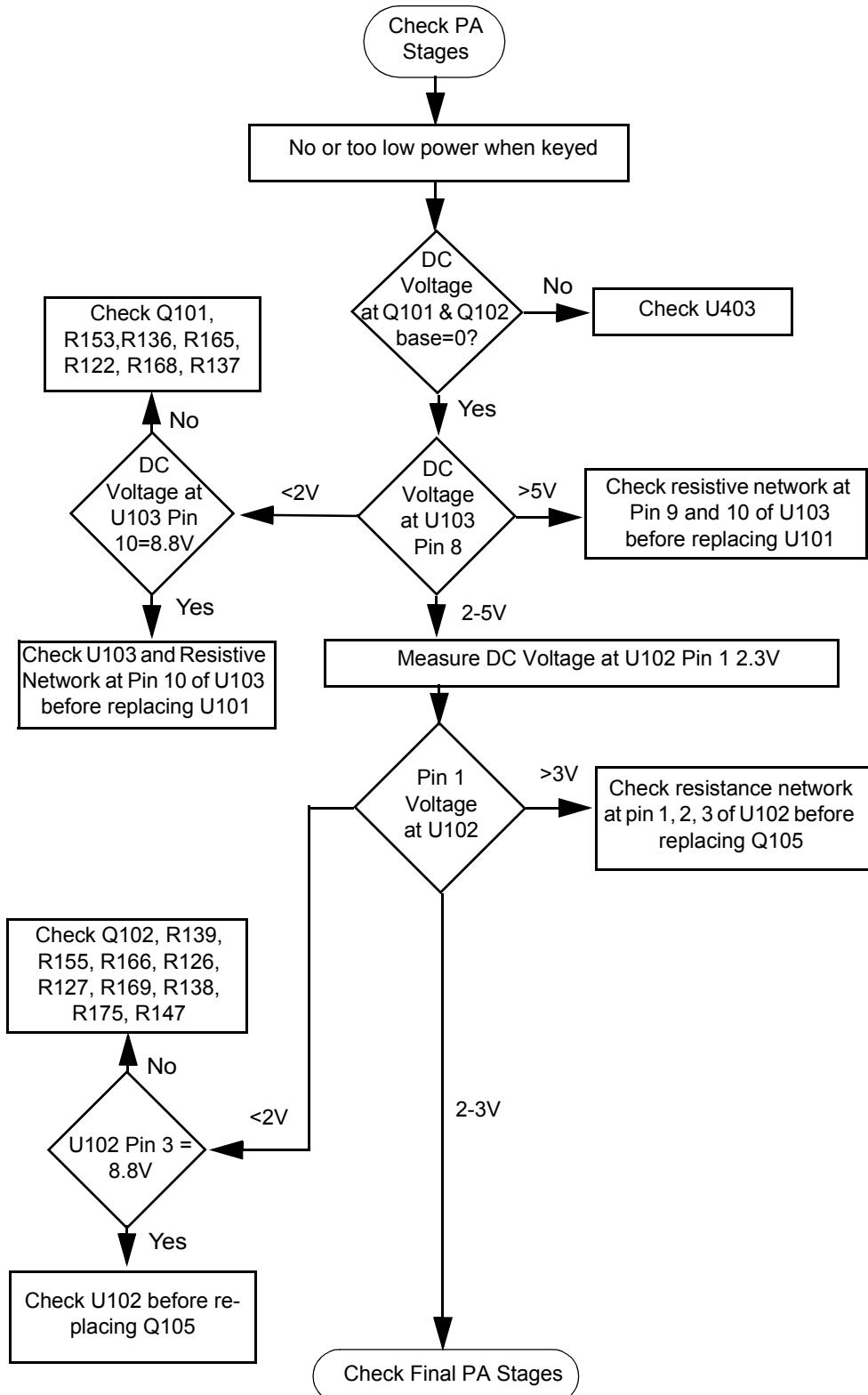
1.1 Troubleshooting Flow Chart for Receiver (Sheet 2 of 2)



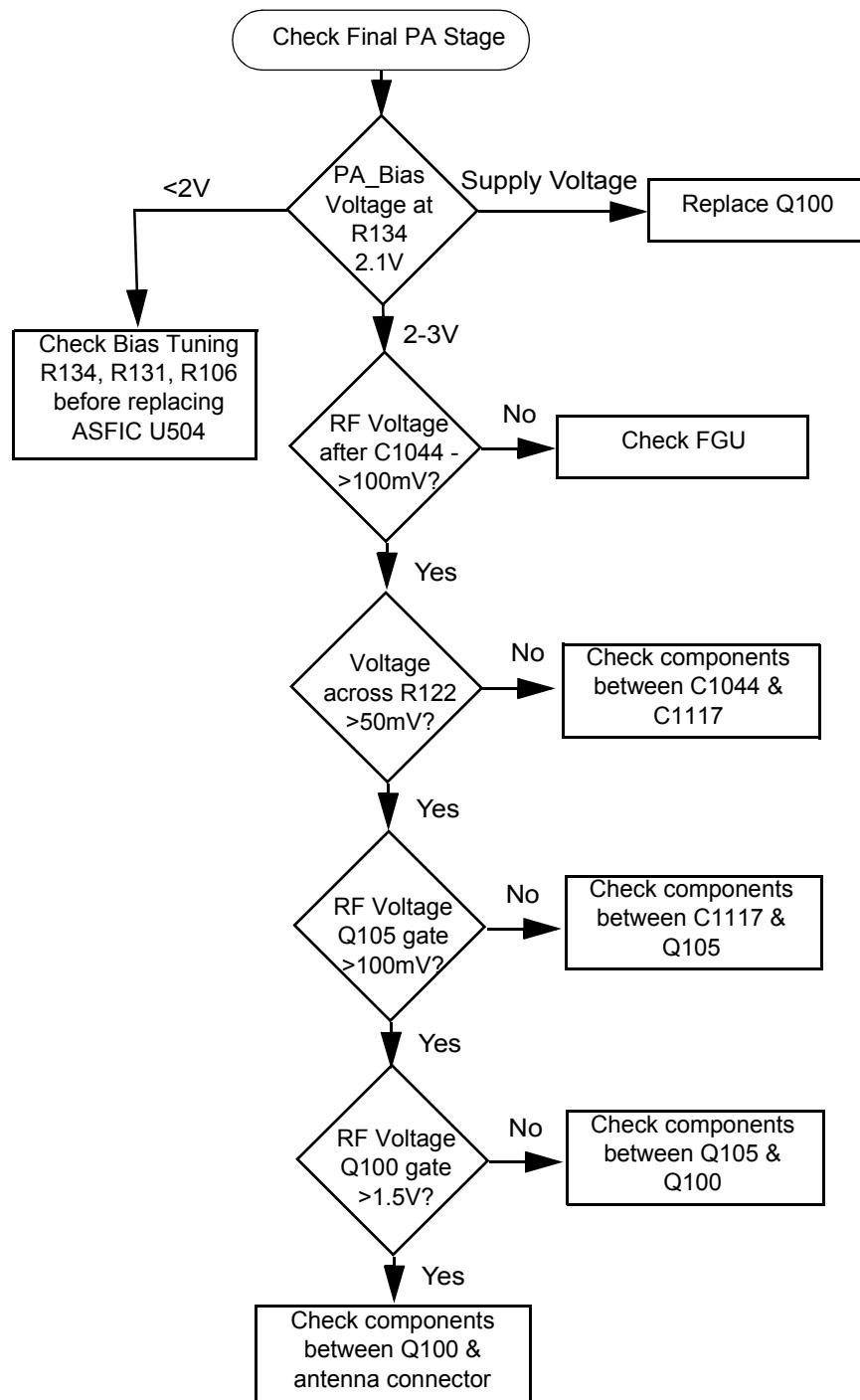
2.0 Troubleshooting Flow Chart for 25W Transmitter (Sheet 1 of 3)



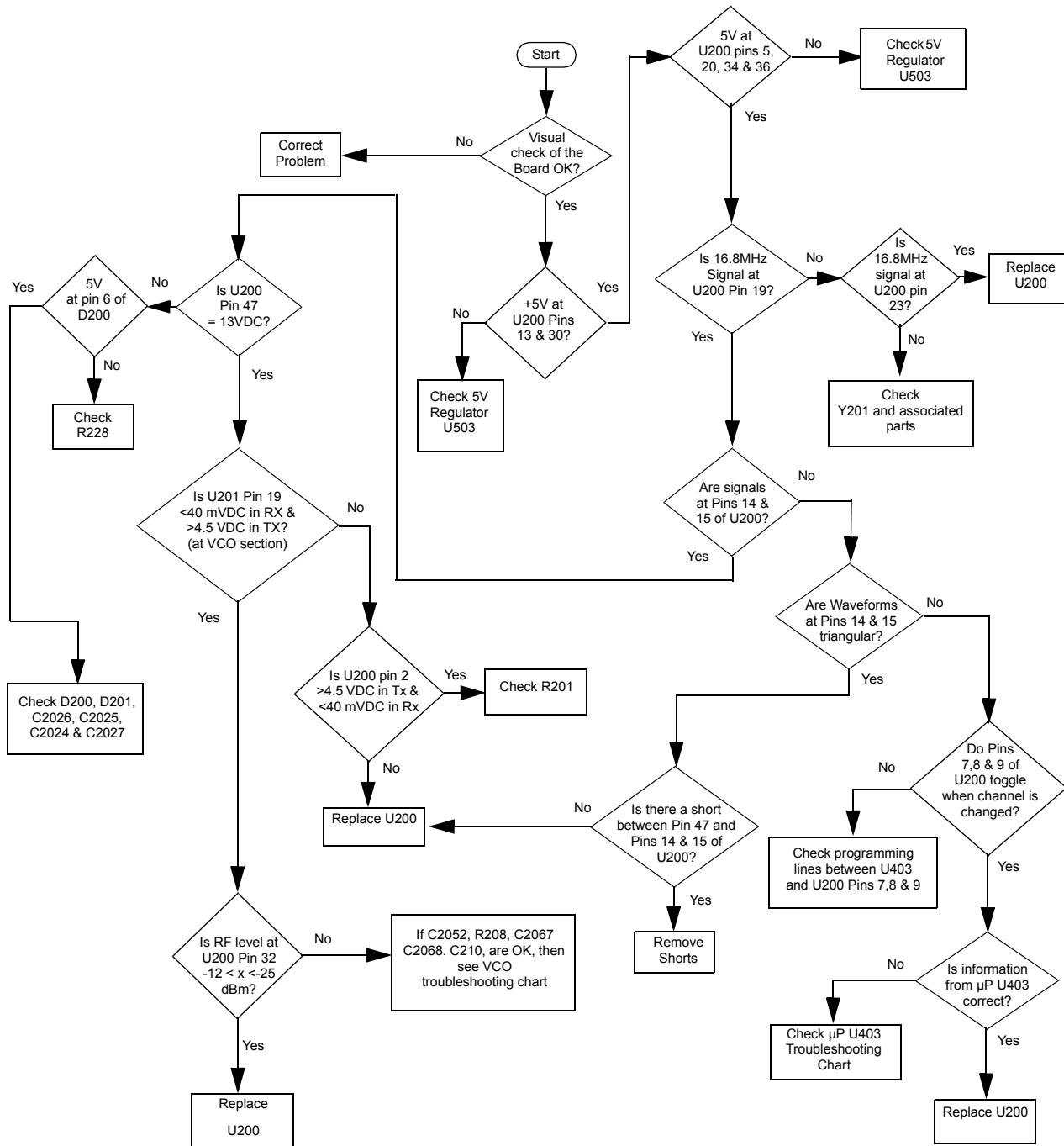
2.1 Troubleshooting Flow Chart for 25W Transmitter (Sheet 2 of 3)



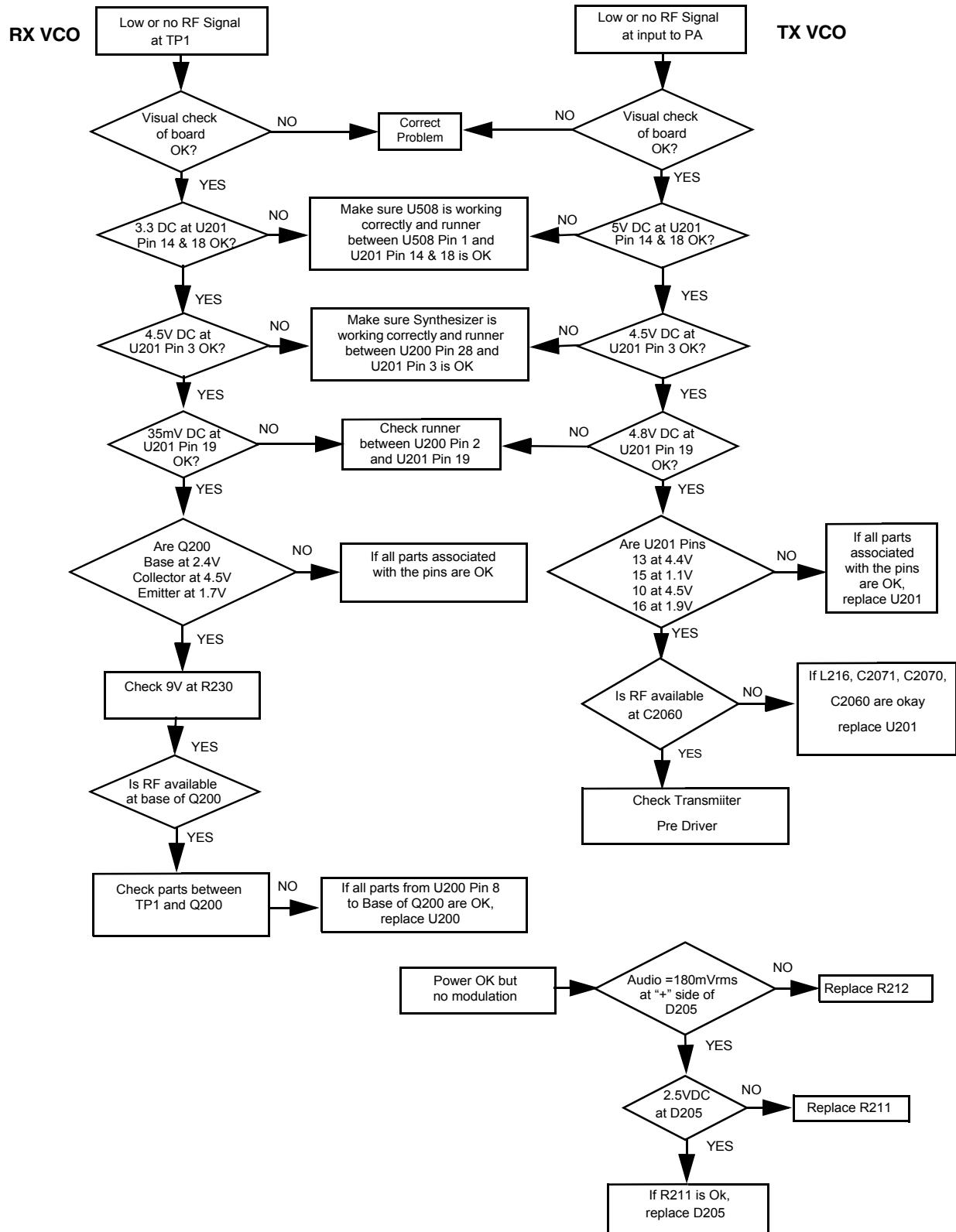
2.2 Troubleshooting Flow Chart for 25W Transmitter (Sheet 3 of 3)



3.0 Troubleshooting Flow Chart for Synthesizer

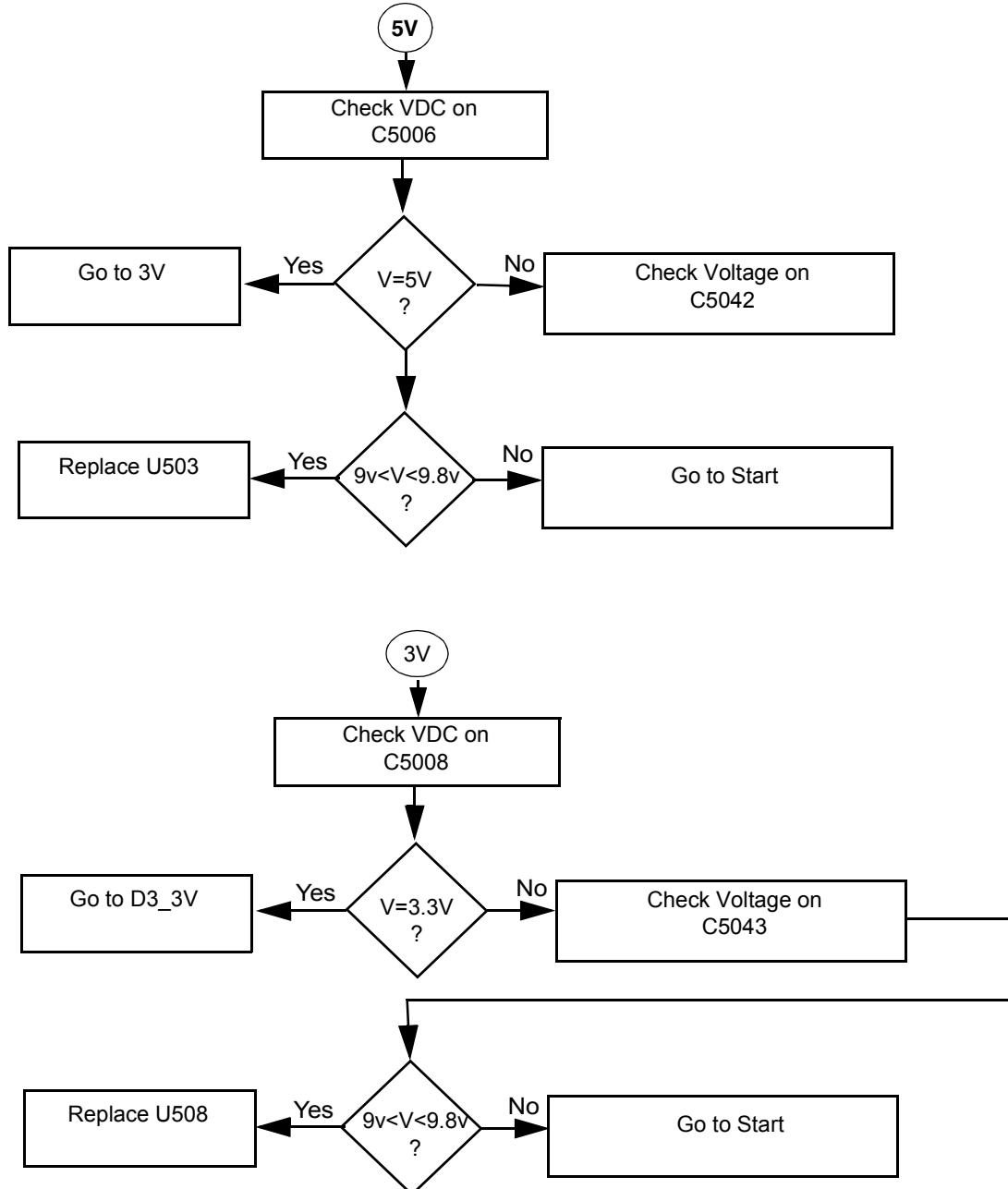


4.0 Troubleshooting Flow Chart for VCO

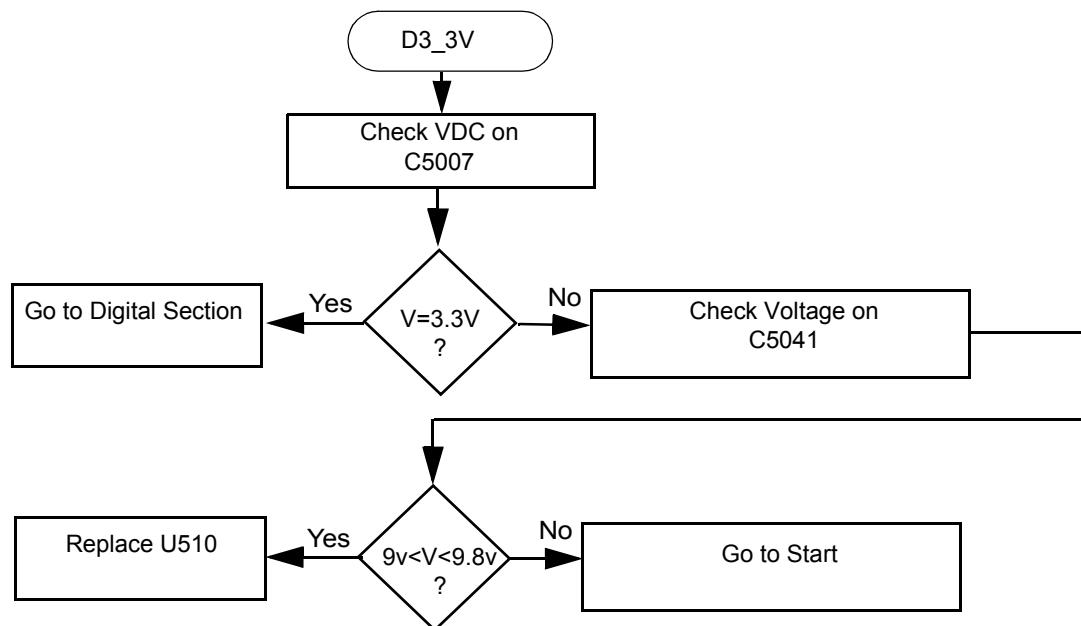


5.0 Troubleshooting Flow Chart for DC Supply (1 of 2)

Since the failure of a critical voltage supply might cause the radio to automatically power down, supply voltages should first be probed with a multimeter. If all the board voltages are absent, then the voltage test point should be retested using a rising-edge-triggered oscilloscope. If the voltage is still absent, then another voltage should be tested using the oscilloscope. If that voltage is present, then the original voltage supply in question is defective and requires investigation of associated circuitry.



5.1 Troubleshooting Flow Chart for DC Supply (2 of 2)



Chapter 4

VHF2 PCB/ SCHEMATICS/ PARTS LISTS

1.0 Allocation of Schematics and Circuit Boards

1.1 VHF2 and Controller Circuits

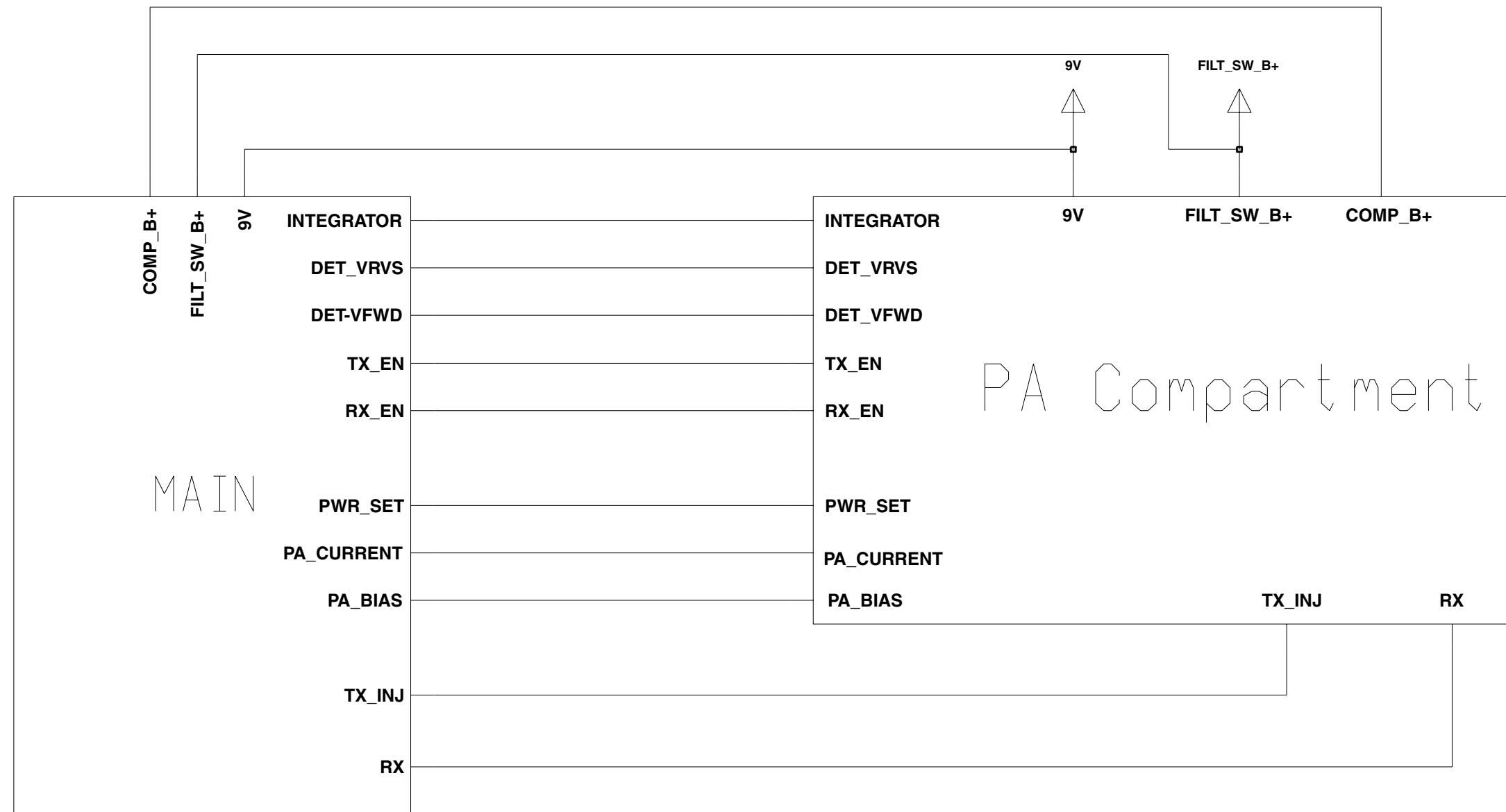
The VHF circuits are contained on the printed circuit board (PCB) which also contains the Controller circuits. This Chapter shows the schematics for both the VHF circuits and the Controller circuits. The PCB component layouts and the Parts Lists in this Chapter show both the Controller and VHF circuit components. The VHF and Controller schematics and the related PCB and parts list are shown in the tables below.

Table 4-1 VHF2 1-25W Diagrams and Parts Lists

PCB : 8488977U01-C Main Board Top Side 8488977U01-C Main Board Bottom Side	Page 4-4 Page 4-5
SCHEMATICS Main Circuit Transmitter Synthesiser and VCO Receiver Front and Back End DC and Audio Ccts Microprocessor and Controller Ccts Power Control Cct	Page 4-6/Page 4-7 Page 4-8/Page 4-9 Page 4-10/Page 4-11 Page 4-12/Page 4-13 Page 4-14/Page 4-15 Page 4-16/Page 4-17 Page 4-18
Parts List 8488977U01-C	Page 4-19
Controller version is T1	

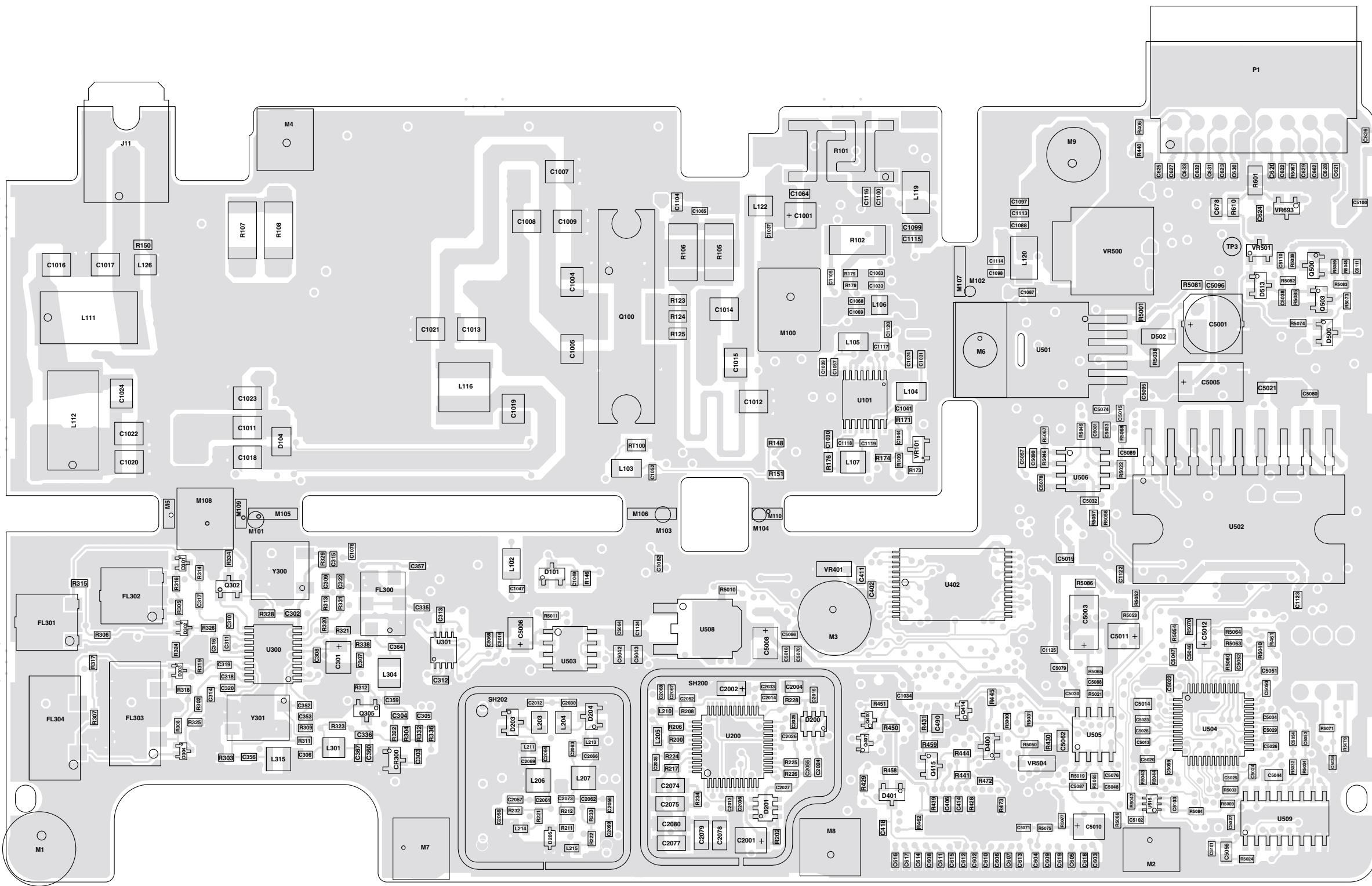
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2.0 VHF2 1-25W PCB 8488977U01 (rev. C) / Schematics



73D02968C63-0

VHF2 Interconnection between Main Board and Power Amplifier Compartment



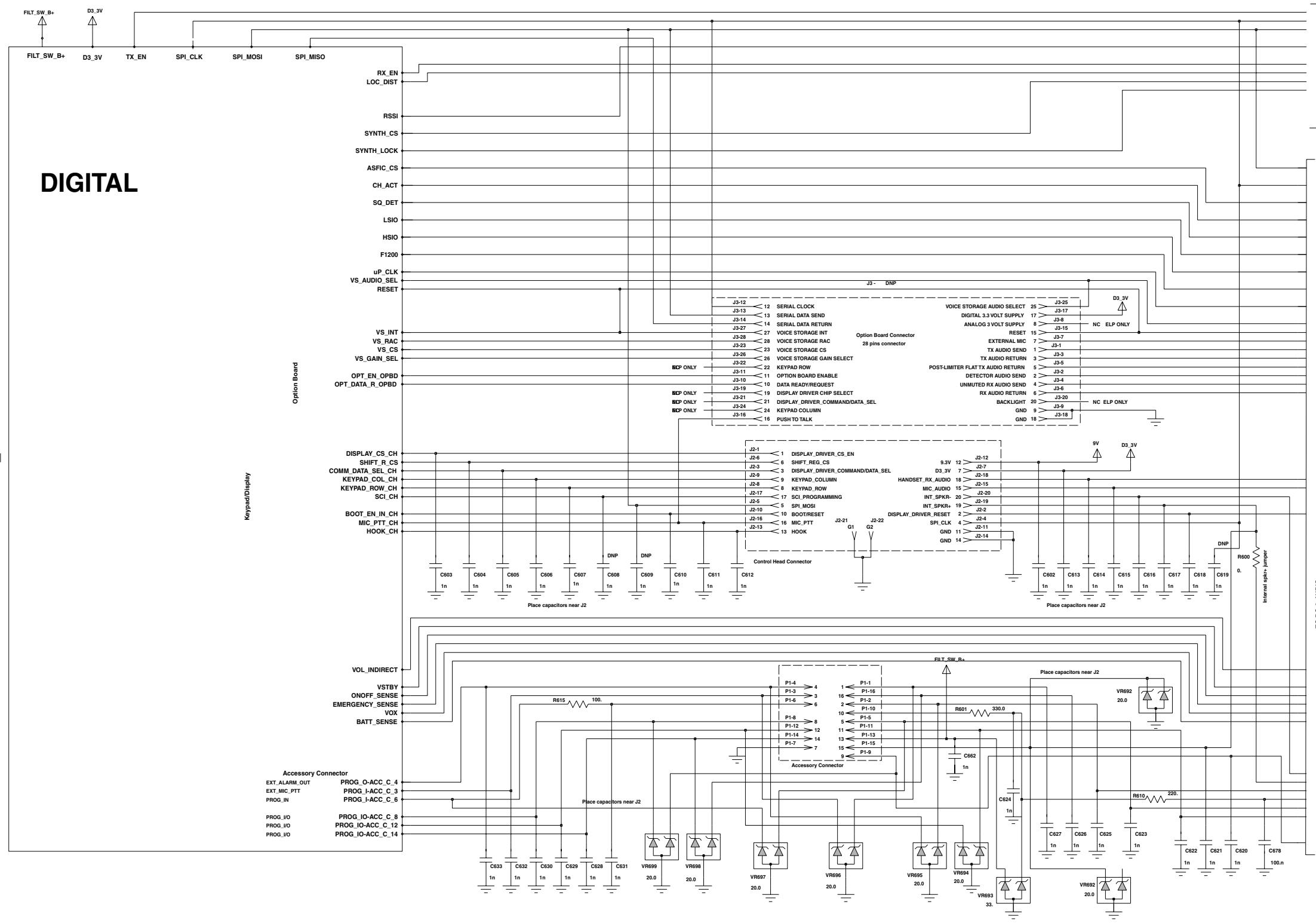
SHOWN FROM SIDE 1

VHF2 (146-174MHz) 1-25W 8488977U01 (rev. C)

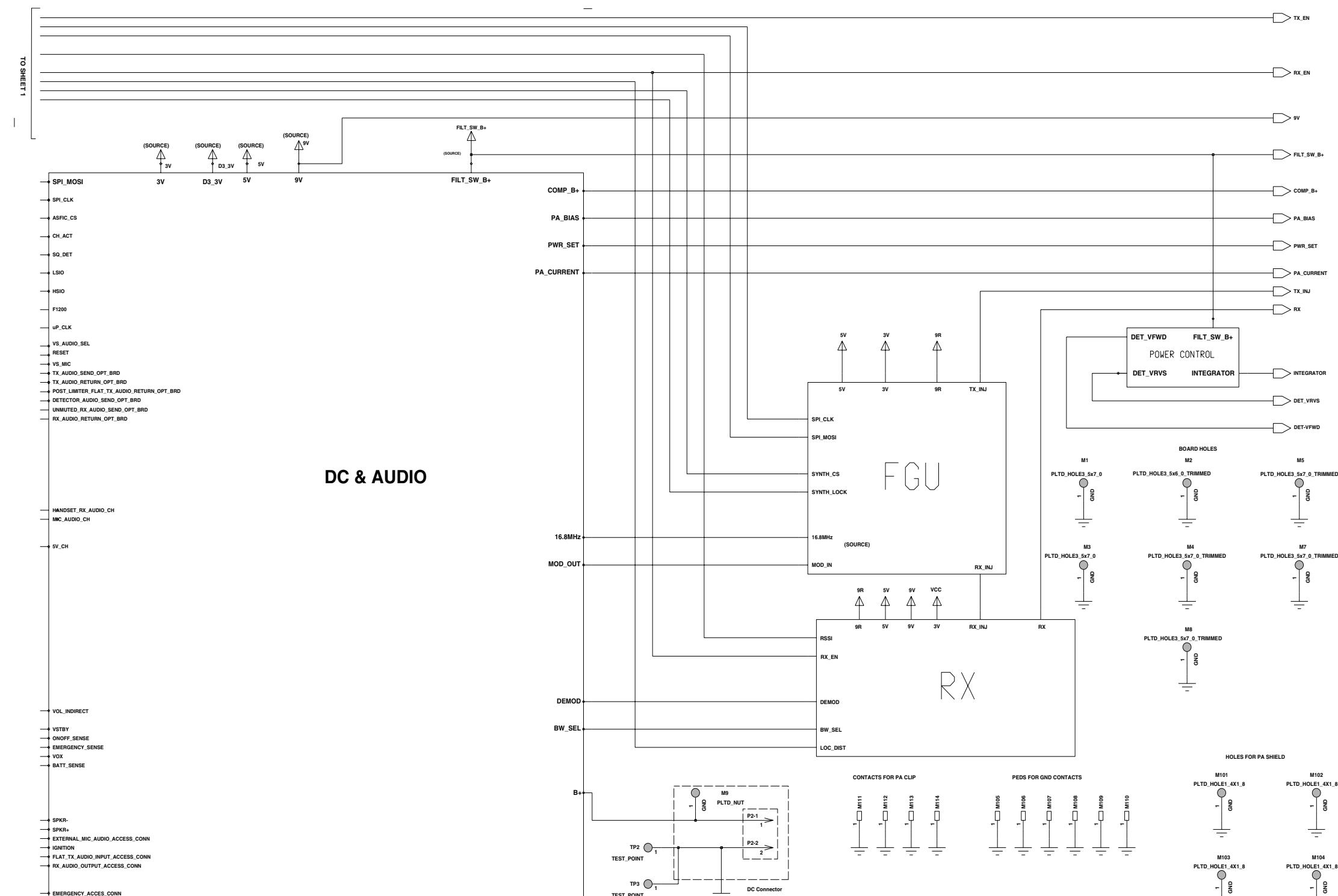


SHOWN FROM SIDE 2

VHF2 (146-174MHz) 1-25W 8488977U01 (rev. C)

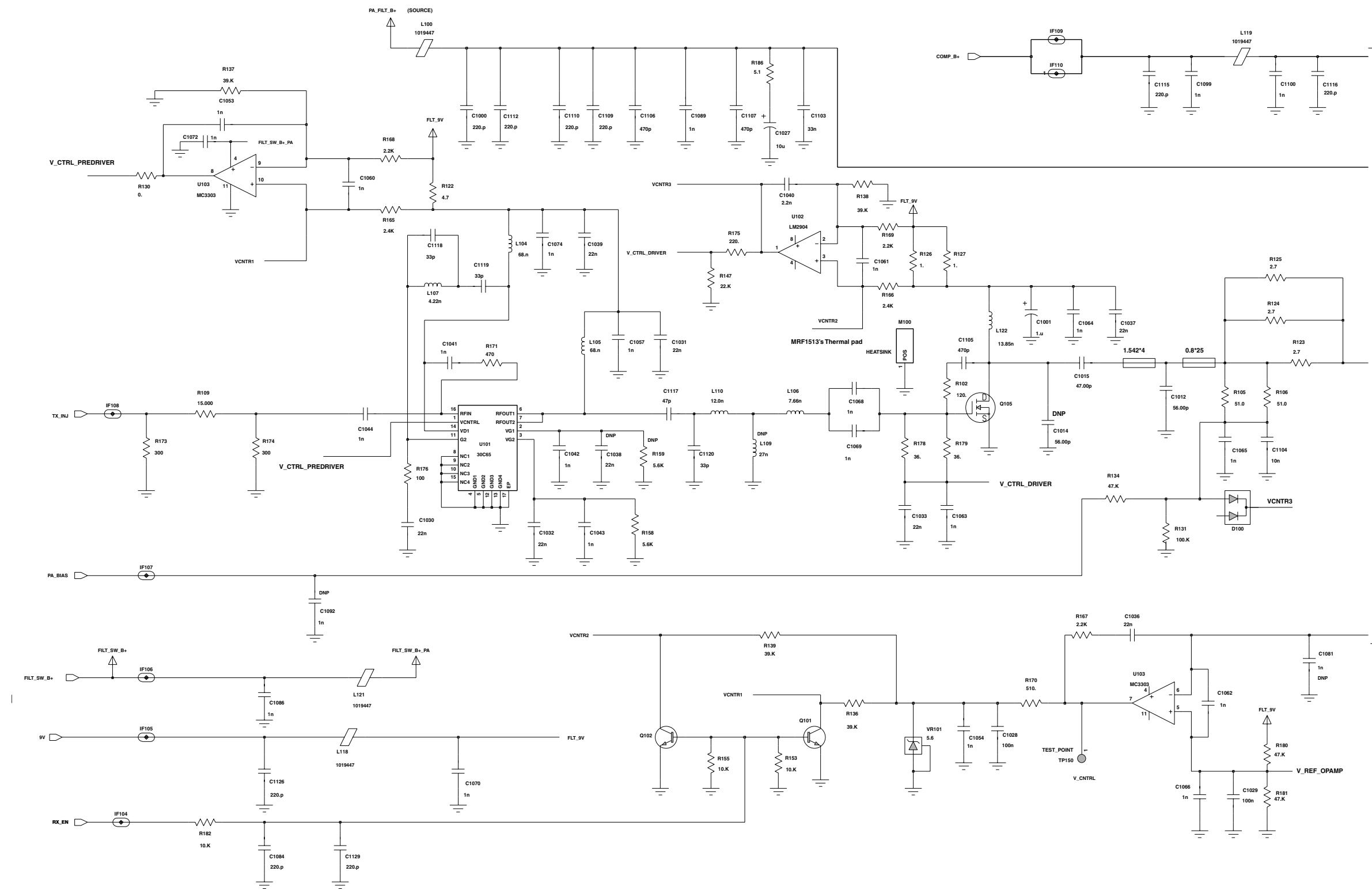


VHF2 (146-174MHz) Main Circuit (Sht 1 of 2)

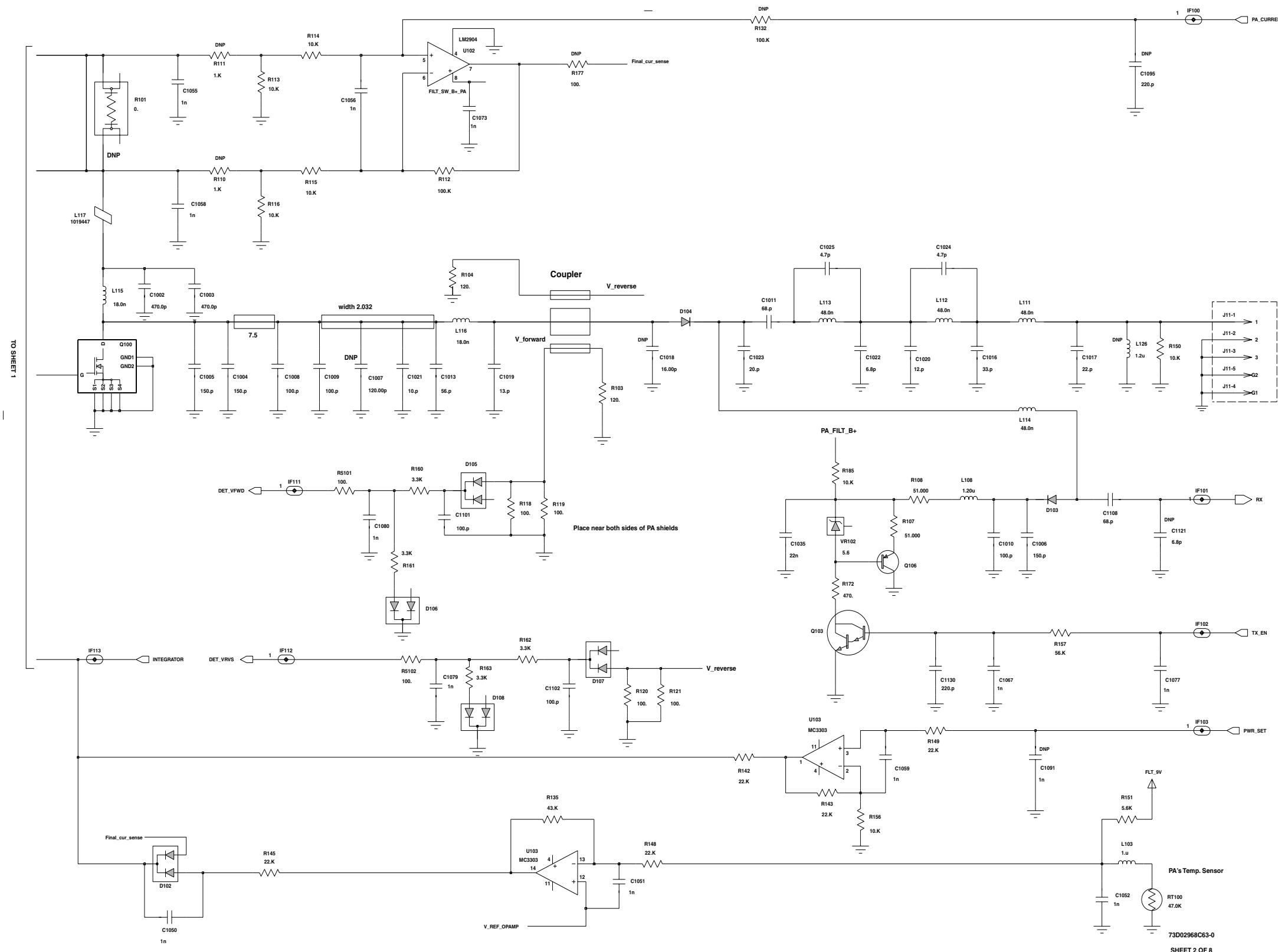


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SHEET 4 OF 8

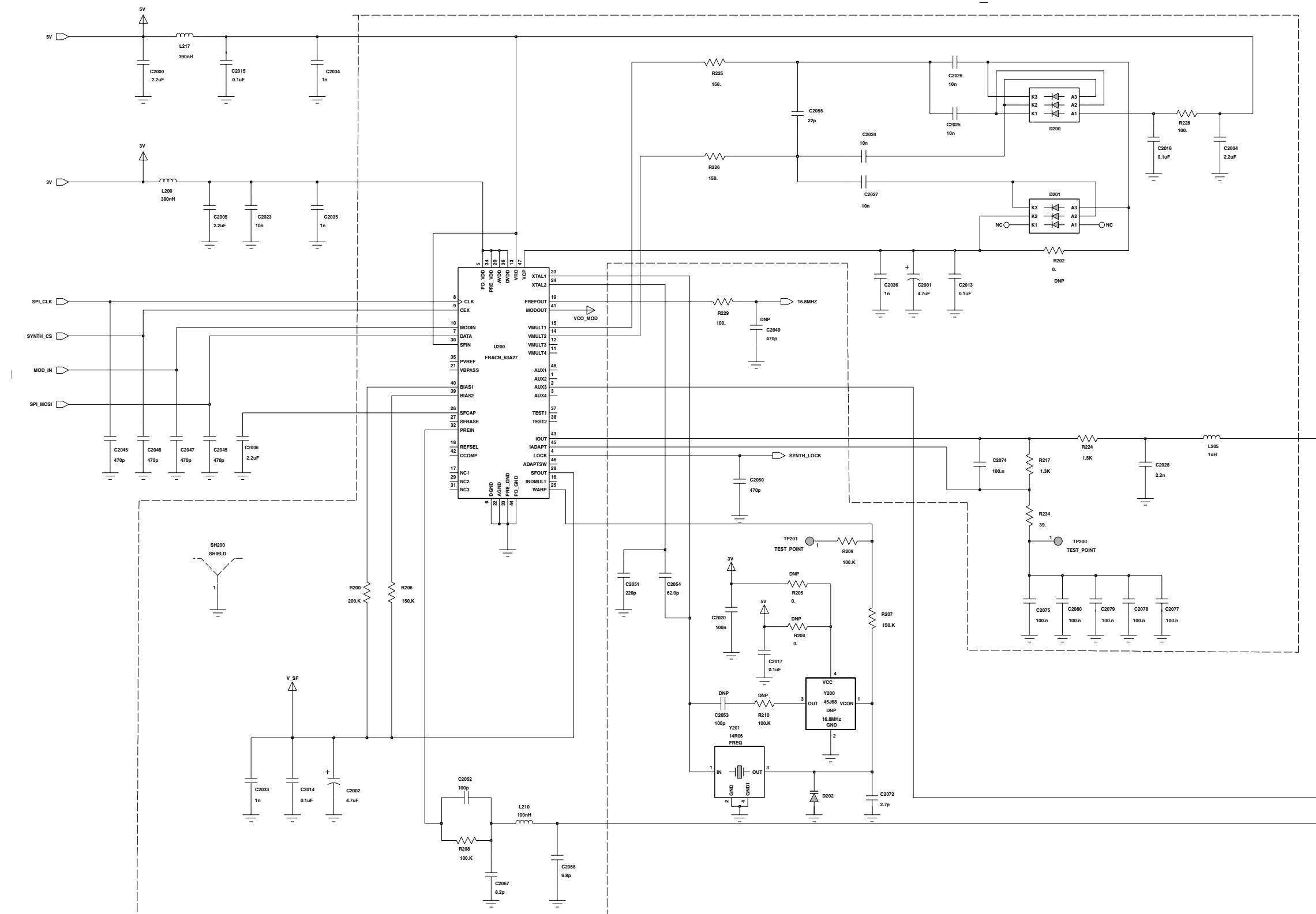
VHF2 (146-174MHz) Main Circuit (Sht 2 of 2)



VHF2 (146-174MHz) Transmitter (Sht 1 of 2)

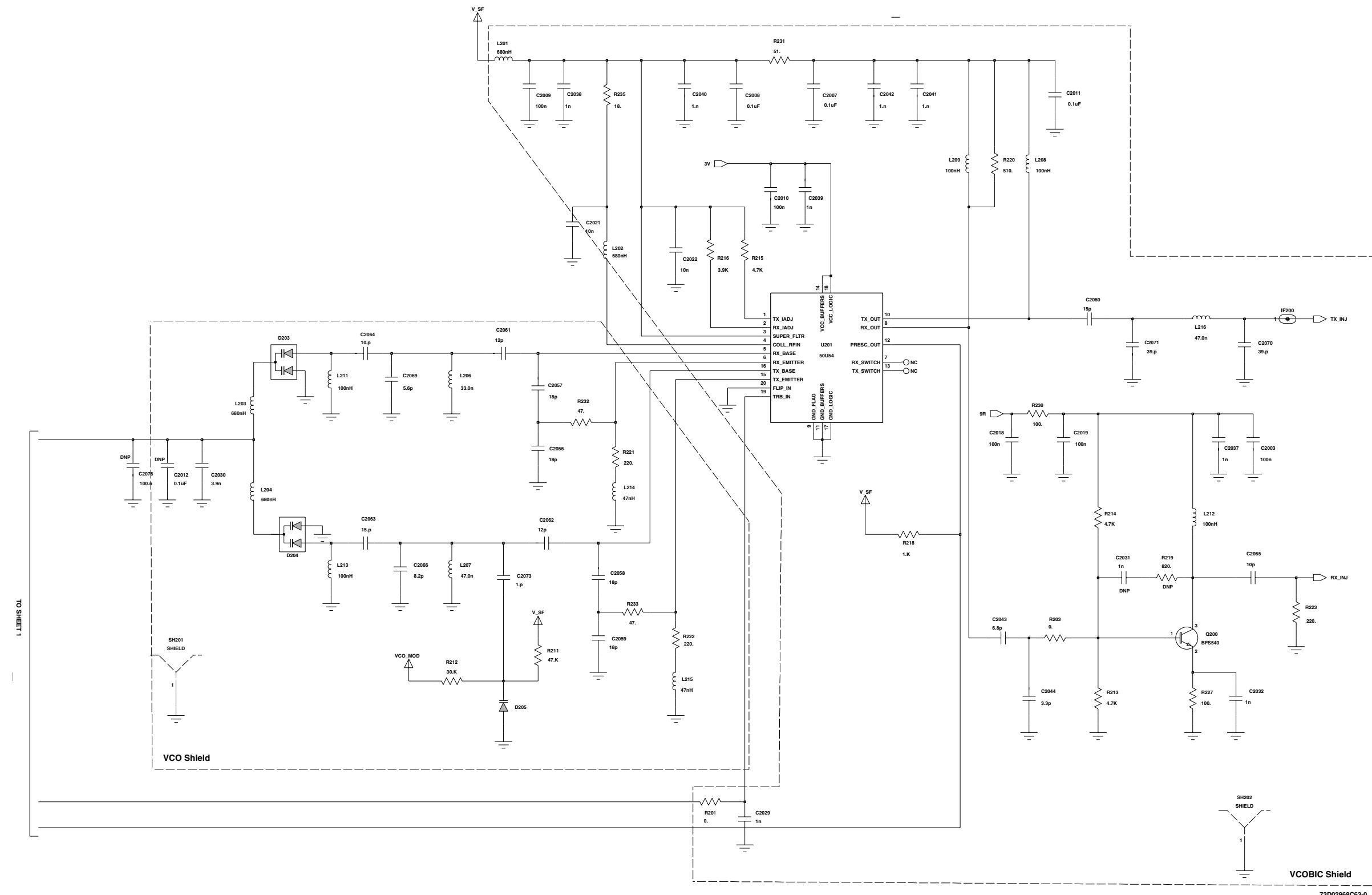


VHF2 (146-174MHz) Transmitter (Sht 2 of 2)

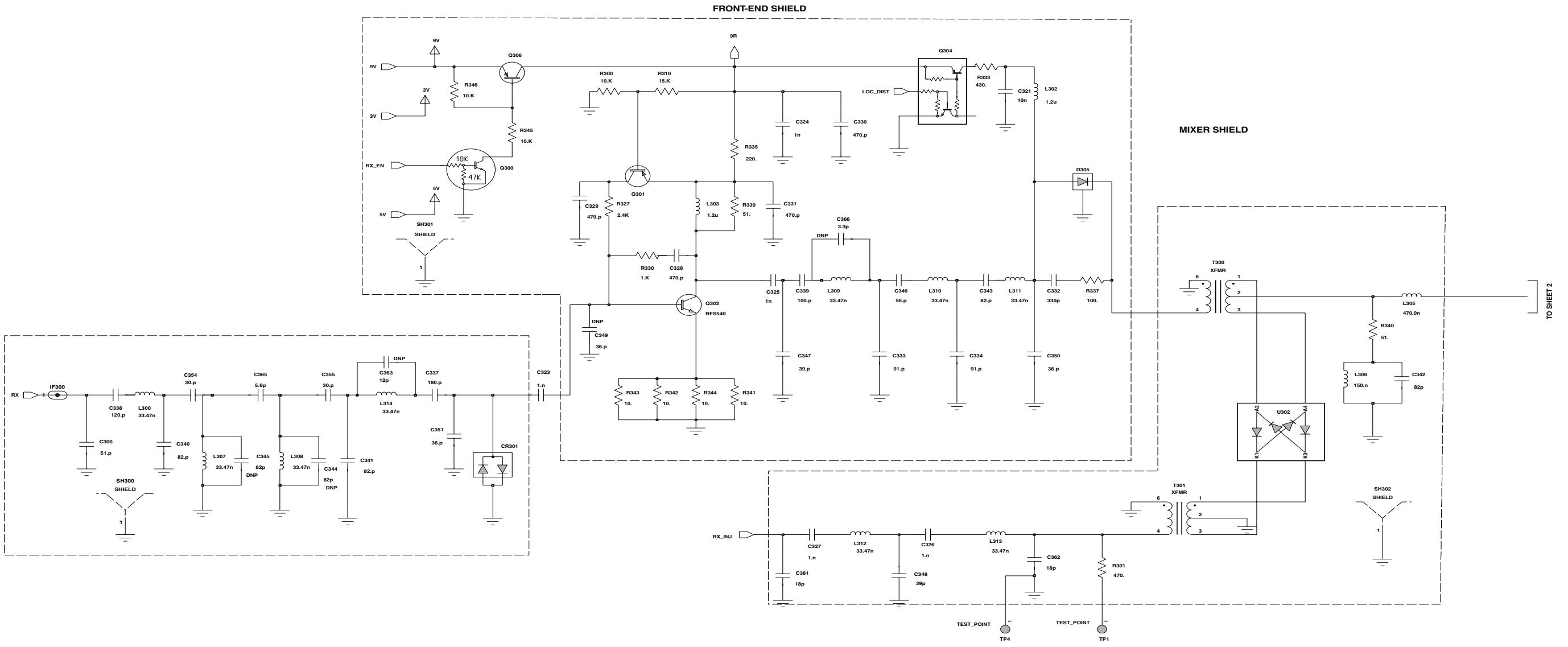


TO SHEET 2

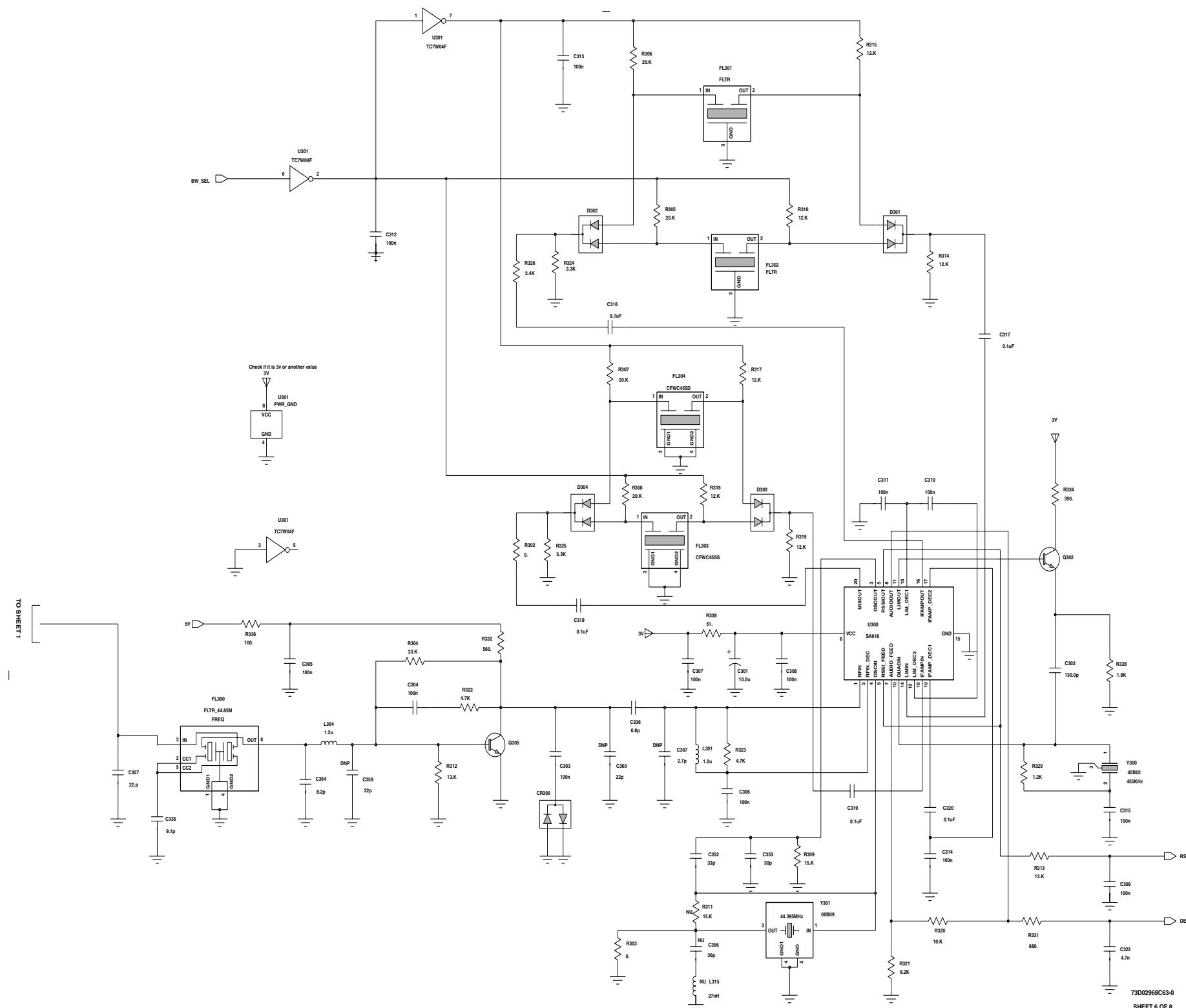
VHF2 (146-174MHz) Synthesiser and VCO (Sht 1 of 2)



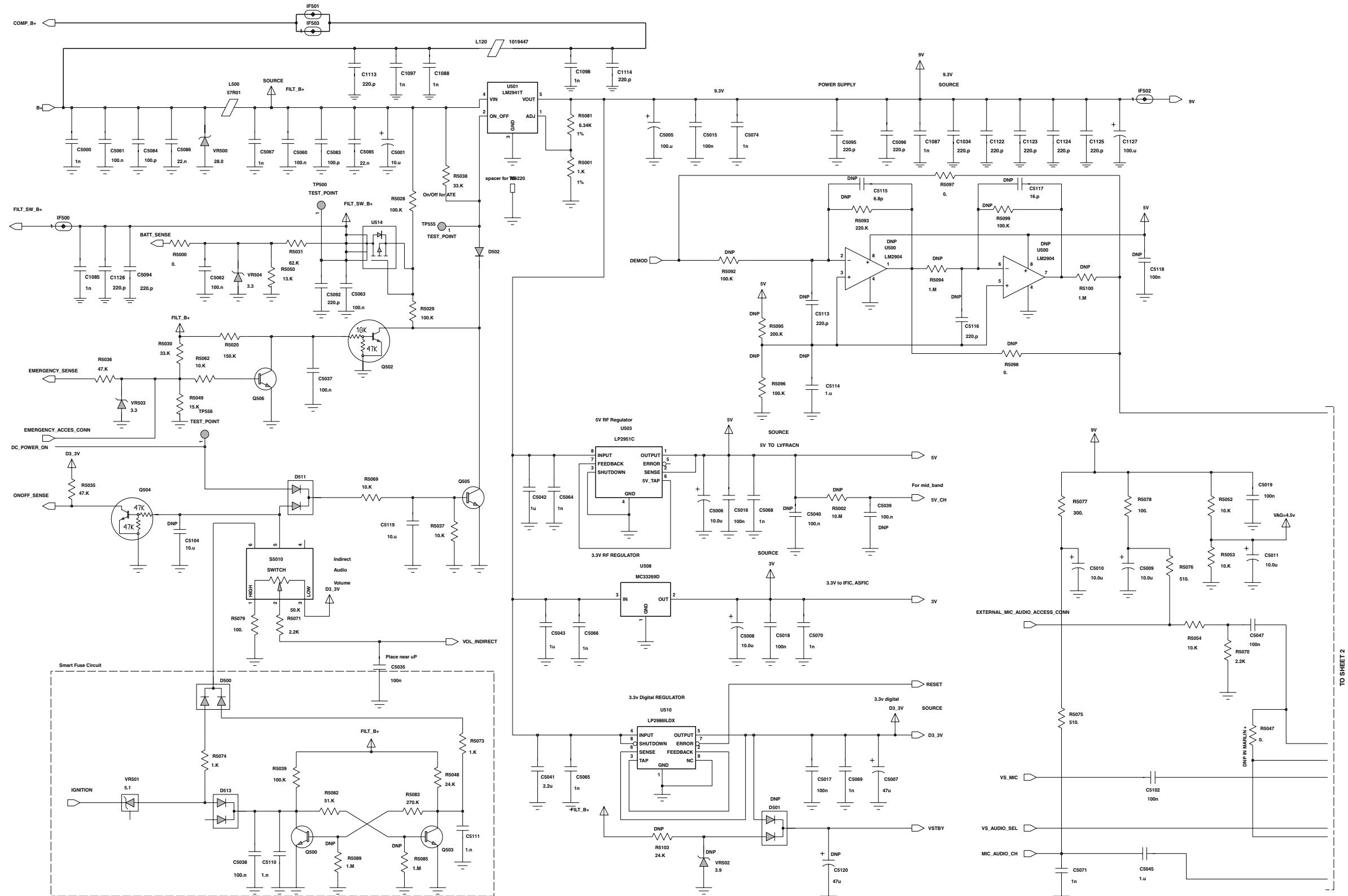
VHF2 (146-174MHz) Synthesiser and VCO (Sht 2 of 2)



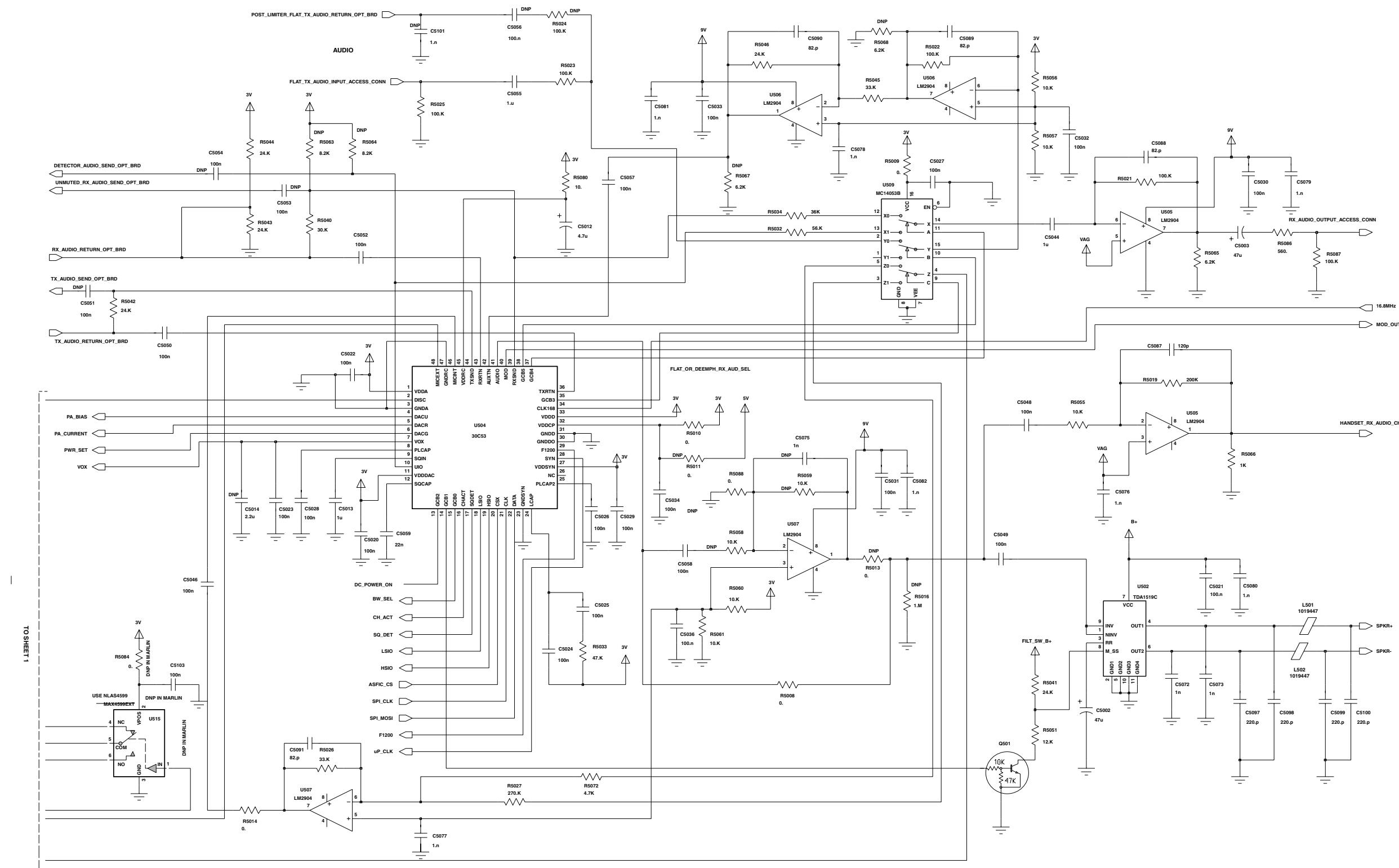
VHF2 (146-174MHz) Receiver Front and Back End (Sht 1 of 2)



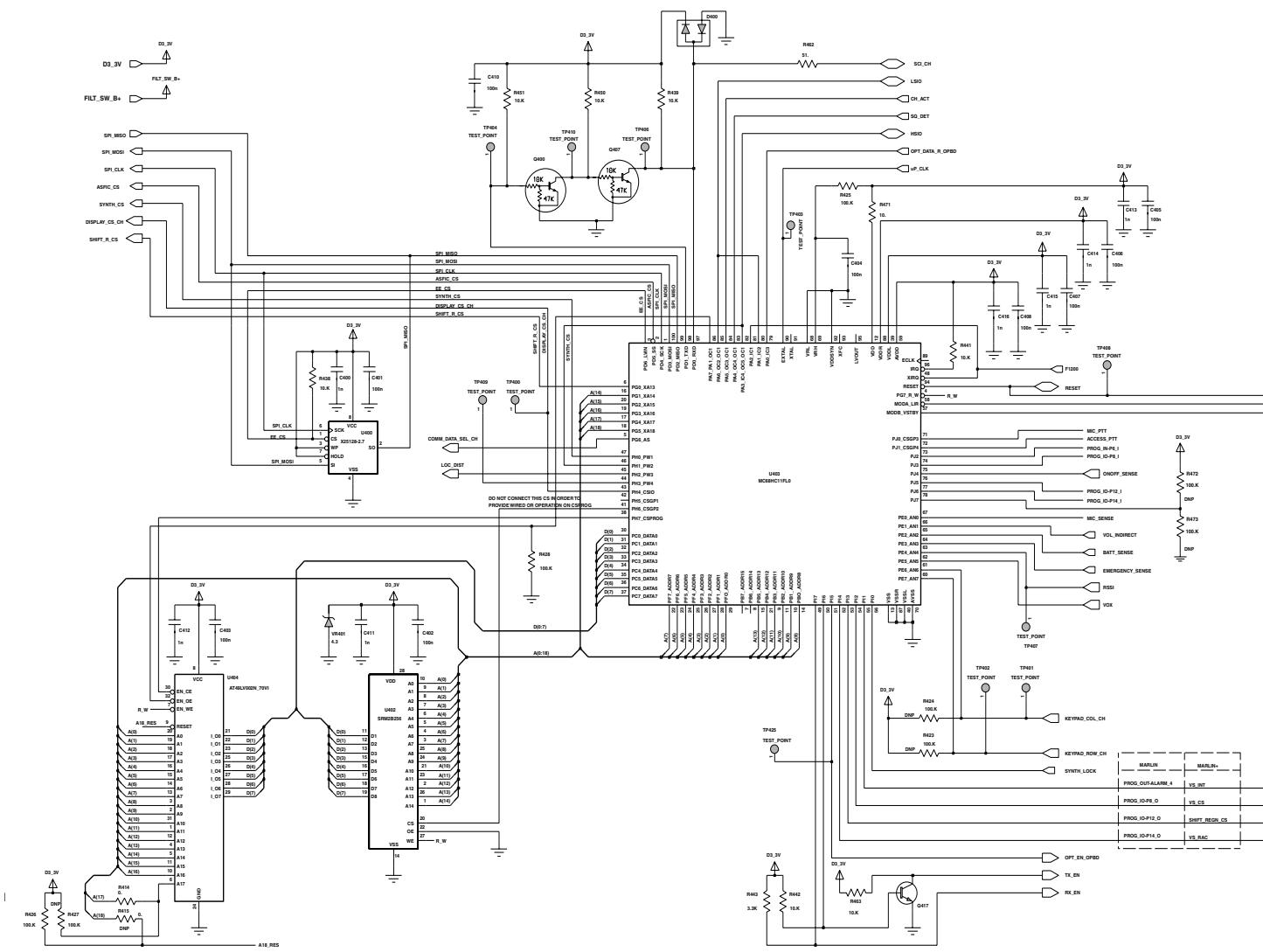
VHF2 (146-174MHz) Receiver Front and Back End (Sht 2 of 2)



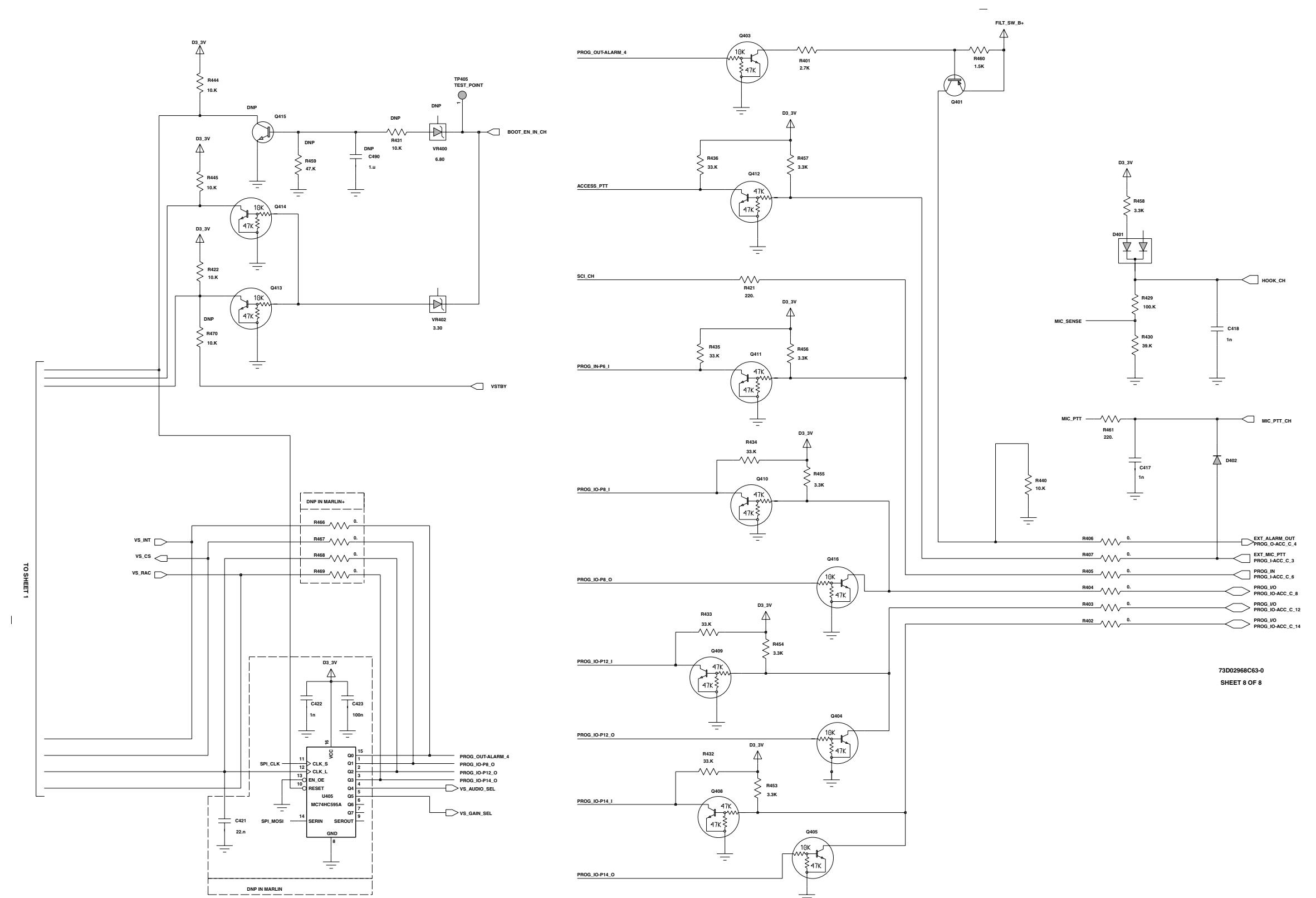
VHF2 (146-174MHz) DC and Audio Circuits (Sht 1 of 2)



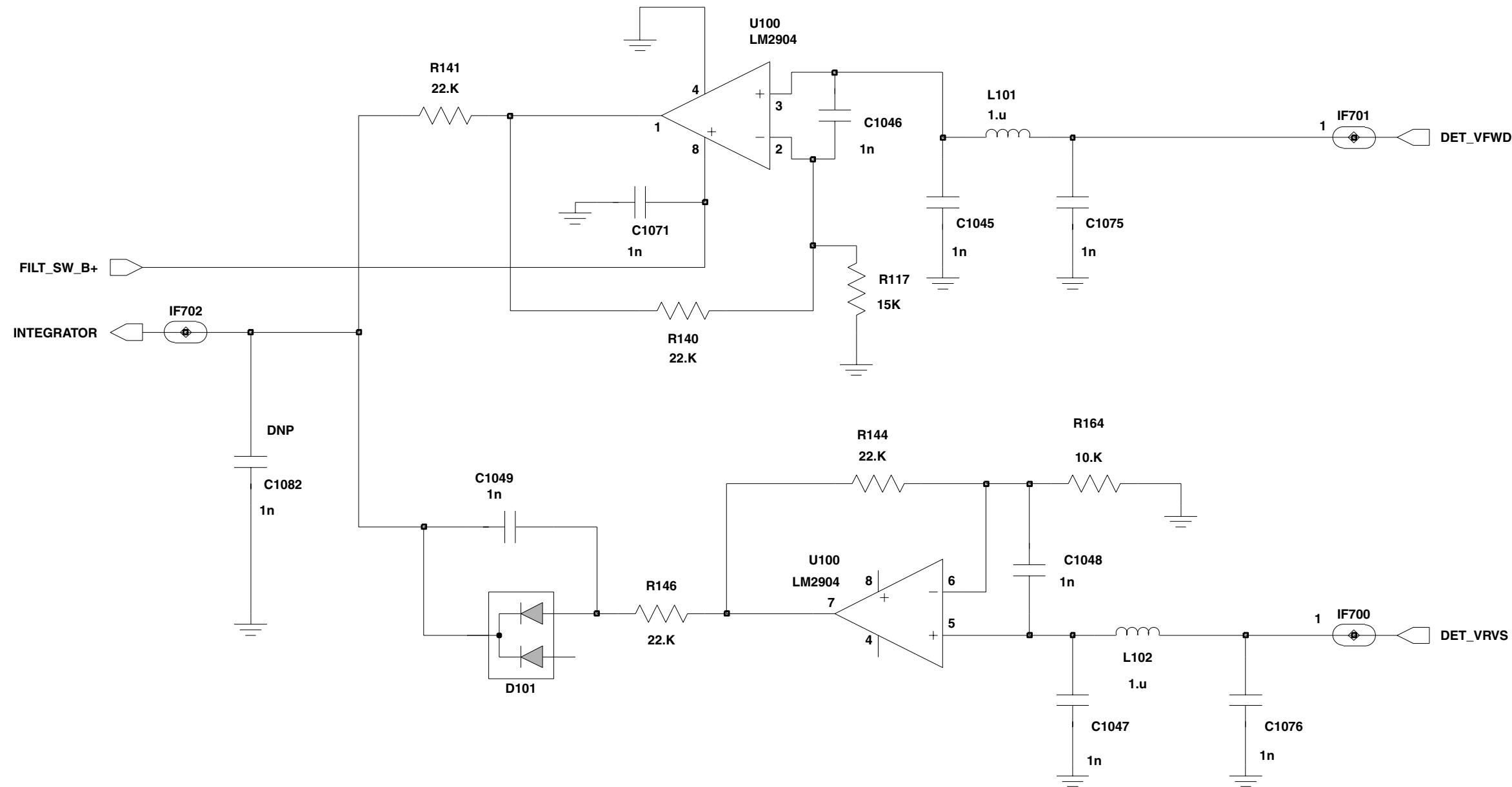
VHF2 (146-174MHz) DC and Audio Circuits (Sht 2 of 2)



VHF2 (146-174MHz) Microprocessor and Controller Circuits (Sht 1 of 2)



VHF2 (146-174MHz) Microprocessor and Controller Circuits (Sht 2 of 2)



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2.1 VHF2 PCB 8488977U01 (rev. C) Parts List 1-25W

Circuit Ref.	Motorola Part No.	Description
C1000	2113740F59	CAP CHIP REEL CL1 +/-30 220
C1001	2311049A08	KEMET CAPS
C1002	2111078B59	CHIP CAP RF 470 5 NPO 100V
C1003	2111078B59	CHIP CAP RF 470 5 NPO 100V
C1004	2111078B47	CAP CHIP RF 150 5 NPO 100V
C1005	2111078B47	CAP CHIP RF 150 5 NPO 100V
C1006	2111078B47	CAP CHIP RF 150 5 NPO 100V
C1007	NOT PLACED	GCAM DUMMY PART NUMBER
C1008	2111078B42	CAP CHIP RF 100 5 NPO 100V
C1009	2111078B42	CAP CHIP RF 100 5 NPO 100V
C1010	2111078B42	CAP CHIP RF 100 5 NPO 100V
C1011	2111078B38	CAP CHIP RF 68 5 NPO 100V
C1012	2111078B36	CAP CHIP RF 56 5 NPO 100V
C1013	2111078B36	CAP CHIP RF 56 5 NPO 100V
C1014	NOT PLACED	GCAM DUMMY PART NUMBER
C1015	2111078B34	CAP CHIP RF 47 5 NPO 100V
C1016	2111078B29	CAP CHIP RF 33 5 NPO 100V
C1017	2111078B22	CAP CHIP RF 22 5 NPO 100V
C1018	NOT PLACED	GCAM DUMMY PART NUMBER
C1019	2111078B16	CAP CHIP RF 13 5 NPO 100V
C1020	2111078B15	CAP CHIP RF 12 5 NPO 100V
C1021	2111078B13	CAP ALT E16
C1022	2111078B09	CAP ALT E17
C1023	2111078B21	CAP ALT E35
C1024	2111078B05	CAP ALT E19
C1025	2111078B05	CAP ALT E19
C1027	2311049A45	CAP TANT CHIP 10 10 35
C1028	2113743K15	CER CHIP CAP .100UF
C1029	2113743K15	CER CHIP CAP .100UF

Circuit Ref.	Motorola Part No.	Description
C1030	2113743E07	CER CHIP CAP .022UF
C1031	2113743E07	CER CHIP CAP .022UF
C1032	2113743E07	CER CHIP CAP .022UF
C1033	2113743E07	CER CHIP CAP .022UF
C1034	2113740F59	CAP CHIP REEL CL1 +/-30 220
C1035	2113743E07	CER CHIP CAP .022UF
C1036	2113743E07	CER CHIP CAP .022UF
C1037	2113743E07	CER CHIP CAP .022UF
C1038	NOT PLACED	GCAM DUMMY PART NUMBER
C1039	2113743E07	CER CHIP CAP .022UF
C1040	2113741F33	CAP CHIP CL2 X7R REEL 2200
C1041	2113741F25	CAP CHIP CL2 X7R REEL 1000
C1042	2113741F25	CAP CHIP CL2 X7R REEL 1000
C1043	2113741F25	CAP CHIP CL2 X7R REEL 1000
C1044	2113741F25	CAP CHIP CL2 X7R REEL 1000
C1045	2113741F25	CAP CHIP CL2 X7R REEL 1000
C1046	2113741F25	CAP CHIP CL2 X7R REEL 1000
C1047	2113743K17	CAP CHIP .330 UF +80-20% 16V
C1048	2113741F25	CAP CHIP CL2 X7R REEL 1000
C1049	2113741F25	CAP CHIP CL2 X7R REEL 1000
C1050	2113741F25	CAP CHIP CL2 X7R REEL 1000
C1051	2113741F25	CAP CHIP CL2 X7R REEL 1000
C1052	2113741F25	CAP CHIP CL2 X7R REEL 1000
C1053	2113741F25	CAP CHIP CL2 X7R REEL 1000
C1054	2113741F25	CAP CHIP CL2 X7R REEL 1000
C1055	2113741F25	CAP CHIP CL2 X7R REEL 1000
C1056	2113741F25	CAP CHIP CL2 X7R REEL 1000
C1057	2113741F25	CAP CHIP CL2 X7R REEL 1000
C1058	2113741F25	CAP CHIP CL2 X7R REEL 1000
C1059	2113741F25	CAP CHIP CL2 X7R REEL 1000
C1060	2113741F25	CAP CHIP CL2 X7R REEL 1000
C1061	2113741F25	CAP CHIP CL2 X7R REEL 1000
C1062	2113741F25	CAP CHIP CL2 X7R REEL 1000
C1063	2113741F25	CAP CHIP CL2 X7R REEL 1000
C1064	2113741F25	CAP CHIP CL2 X7R REEL 1000
C1065	2113741F25	CAP CHIP CL2 X7R REEL 1000
C1066	2113741F25	CAP CHIP CL2 X7R REEL 1000
C1067	2113741F25	CAP CHIP CL2 X7R REEL 1000
C1068	2113741F25	CAP CHIP CL2 X7R REEL 1000
C1069	2113741F25	CAP CHIP CL2 X7R REEL 1000
C1070	2113741F25	CAP CHIP CL2 X7R REEL 1000
C1071	2113741F25	CAP CHIP CL2 X7R REEL 1000
C1072	2113741F25	CAP CHIP CL2 X7R REEL 1000
C1073	2113741F25	CAP CHIP CL2 X7R REEL 1000
C1074	2113741F25	CAP CHIP CL2 X7R REEL 1000
C1075	2113741F25	CAP CHIP CL2 X7R REEL 1000
C1076	2113741F25	CAP CHIP CL2 X7R REEL 1000
C1077	2113741F25	CAP CHIP CL2 X7R REEL 1000
C1078	2113740F59	CAP CHIP REEL CL1 +/-30 220
C1079	2113741F25	CAP CHIP CL2 X7R REEL 1000
C1080	2113741F25	CAP CHIP CL2 X7R REEL 1000
C1081	NOT PLACED	GCAM DUMMY PART NUMBER
C1082	NOT PLACED	GCAM DUMMY PART NUMBER
C1083	2113741F25	CAP CHIP CL2 X7R REEL 1000
C1084	2113740F59	CAP CHIP REEL CL1 +/-30 220
C1085	2113741F25	CAP CHIP CL2 X7R REEL 1000
C1086	2113741F25	CAP CHIP CL2 X7R REEL 1000
C1087	2113741F25	CAP CHIP CL2 X7R REEL 1000
C1088	2113741F25	CAP CHIP CL2 X7R REEL 1000
C1089	2113741F25	CAP CHIP CL2 X7R REEL 1000
C1090	NOT PLACED	GCAM DUMMY PART NUMBER
C1091	NOT PLACED	GCAM DUMMY PART NUMBER
C1092	NOT PLACED	GCAM DUMMY PART NUMBER
C1093	NOT PLACED	GCAM DUMMY PART NUMBER
C1094	NOT PLACED	GCAM DUMMY PART NUMBER
C1095	NOT PLACED	GCAM DUMMY PART NUMBER
C1097	2113741F25	CAP CHIP CL2 X7R REEL 1000
C1098	2113741F25	CAP CHIP CL2 X7R REEL 1000
C1099	2113741F25	CAP CHIP CL2 X7R REEL 1000
C1100	2113741F25	CAP CHIP CL2 X7R REEL 1000
C1101	2113740F51	CAP CHIP REEL CL1 +/-30 100
C1102	2113740F51	CAP CHIP REEL CL1 +/-30 100
C1103	2113741A57	CAP CHIP 33K +/-5% (2160521A31)
C1104	2113741A53	CAP CHIP CL2 X7R REEL 22000
C1105	2113740F67	CAP CHIP CL1 +/-30 470 5%
C1106	2113740F67	CAP CHIP CL1 +/-30 470 5%
C1107	2113740F67	CAP CHIP CL1 +/-30 470 5%
C1108	2113740F47	CAP CHIP REEL CL1 +/-30 68
C1109	2113740F59	CAP CHIP REEL CL1 +/-30 220
C1110	2113740F59	CAP CHIP REEL CL1 +/-30 220
C1112	2113740F59	CAP CHIP REEL CL1 +/-30 220
C1113	2113740F59	CAP CHIP REEL CL1 +/-30 220
C1114	2113740F59	CAP CHIP REEL CL1 +/-30 220
C1115	2113740F59	CAP CHIP REEL CL1 +/-30 220
C1116	2113740F59	CAP CHIP REEL CL1 +/-30 220
C1117	2113740F43	CAP CHIP REEL CL1 +/-30 47
C1118	2113740F39	CAP CHIP REEL CL1 +/-30 33
C1119	2113740F39	CAP CHIP REEL CL1 +/-30 33
C1120	2113740F39	CAP CHIP REEL CL1 +/-30 33
C1121	NOT PLACED	GCAM DUMMY PART NUMBER
C1122	2113740F59	CAP CHIP REEL CL1 +/-30 220
C1123	2113740F59	CAP CHIP REEL CL1 +/-30 220
C1124	2113740F59	CAP CHIP REEL CL1 +/-30 220
C1125	2113740F59	CAP CHIP REEL CL1 +/-30 220
C1126	2113740F59	CAP CHIP REEL CL1 +/-30 220

Circuit Ref.	Motorola Part No.	Description
C1127	2360567A03	CAP TANTALUM
C1128	2113740F59	CAP CHIP REEL CL1 +/-30 220
C1129	2113740F59	CAP CHIP REEL CL1 +/-30 220
C1130	2113740F59	CAP CHIP REEL CL1 +/-30 220
C1131	NOT PLACED	GCAM DUMMY PART NUMBER
C2000	2113743F18	CAP CHIP 2.2 UF 16V +80-20%
C2001	2311049J11	CAPACITOR TANT 10% 4.7UF
C2002	2311049A56	CAP TAN CHIP A/P 4.7 20 10
C2003	2113743K15	CER CHIP CAP .100UF
C2004	2113743F18	CAP CHIP 2.2 UF 16V +80-20%
C2005	2113743F18	CAP CHIP 2.2 UF 16V +80-20%
C2006	2113743F18	CAP CHIP 2.2 UF 16V +80-20%
C2007	2113743E20	CAP CHIP. 10 UF 10%
C2008	2113743E20	CAP CHIP. 10 UF 10%
C2009	2113743E20	CAP CHIP. 10 UF 10%
C2010	2113743E20	CAP CHIP. 10 UF 10%
C2011	2113743E20	CAP CHIP. 10 UF 10%
C2012	NOT PLACED	GCAM DUMMY PART NUMBER
C2013	2113743E20	CAP CHIP. 10 UF 10%
C2014	2113743E20	CAP CHIP. 10 UF 10%
C2015	2113743E20	CAP CHIP. 10 UF 10%
C2016	2113743E20	CAP CHIP. 10 UF 10%
C2017	2113743E20	CAP CHIP. 10 UF 10%
C2018	2113743E20	CAP CHIP. 10 UF 10%
C2019	2113743E20	CAP CHIP. 10 UF 10%
C2020	2113743E20	CAP CHIP. 10 UF 10%
C2021	2113741F49	CAP CHIP CL2 X7R REEL 10000
C2022	2113741F49	CAP CHIP CL2 X7R REEL 10000
C2023	2113741F49	CAP CHIP CL2 X7R REEL 10000
C2024	2113741F49	CAP CHIP CL2 X7R REEL 10000
C2025	2113741F49	CAP CHIP CL2 X7R REEL 10000
C2026	2113741F49	CAP CHIP CL2 X7R REEL 10000

Circuit Ref.	Motorola Part No.	Description
C2027	2113741F49	CAP CHIP CL2 X7R REEL 10000
C2028	2113741F33	CAP CHIP CL2 X7R REEL 2200
C2029	2113741F25	CAP CHIP CL2 X7R REEL 1000
C2030	2113741F39	CAP CHIP CL2 XTR REEL 3900
C2031	NOT PLACED	GCAM DUMMY PART NUMBER
C2032	2113741F25	CAP CHIP CL2 X7R REEL 1000
C2033	2113741F25	CAP CHIP CL2 X7R REEL 1000
C2034	2113741F25	CAP CHIP CL2 X7R REEL 1000
C2035	2113741F25	CAP CHIP CL2 X7R REEL 1000
C2036	2113741F25	CAP CHIP CL2 X7R REEL 1000
C2037	2113741F25	CAP CHIP CL2 X7R REEL 1000
C2038	2113741F25	CAP CHIP CL2 X7R REEL 1000
C2039	2113741F25	CAP CHIP CL2 X7R REEL 1000
C2040	2113741F25	CAP CHIP CL2 X7R REEL 1000
C2041	2113741F25	CAP CHIP CL2 X7R REEL 1000
C2042	2113741F25	CAP CHIP CL2 X7R REEL 1000
C2043	2113740L14	CAP CER CHIP 6.8PF +-0.1PF
C2044	2113740L06	CAP CER CHIP 3.3 PF+-0.1PF
C2045	2113740F67	CAP CHIP CL1 +/-30 470 5%
C2046	2113740F67	CAP CHIP CL1 +/-30 470 5%
C2047	2113740F67	CAP CHIP CL1 +/-30 470 5%
C2048	2113740F67	CAP CHIP CL1 +/-30 470 5%
C2049	NOT PLACED	GCAM DUMMY PART NUMBER
C2050	2113740F67	CAP CHIP CL1 +/-30 470 5%
C2051	2113740F59	CAP CHIP REEL CL1 +/-30 220
C2052	2113740F67	CAP CHIP CL1 +/-30 470 5%
C2053	NOT PLACED	GCAM DUMMY PART NUMBER
C2054	2113740L37	CAP 62.0 PF 50V 2.0%
C2055	2113740F35	CAP CHIP REEL CL1 +/-30 22
C2056	2113740F33	CAP CHIP REEL CL1 +/-30 18
C2057	2113740F33	CAP CHIP REEL CL1 +/-30 18
C2058	2113740F33	CAP CHIP REEL CL1 +/-30 18

Circuit Ref.	Motorola Part No.	Description
C2059	2113740F33	CAP CHIP REEL CL1 +/-30 18
C2060	2113740F31	CAP CHIP REEL CL1 +/-30 15
C2061	2113740F29	CAP CHIP REEL CL1 +/-30 12
C2062	2113740F29	CAP CHIP REEL CL1 +/-30 12
C2063	2113740L22	CAP 15.0 PF 50V 2.0 %
C2064	2113740F32	CAP CHIP REEL CL1 +/-30 16
C2065	2113740F27	CAP CHIP REEL CL1 +/-30 10
C2066	2113740L16	CAP CER CHIP 8.2 PF+-0.1PF
C2067	2113740F25	CAP CHIP REEL CL1 +/-30 8.2
C2068	2113740F23	CAP CHIP REEL CL1 +/-30 6.8
C2069	2113740L12	CAP CER CHIP 5.6PF +-0.1PF
C2070	2113740F41	CAP CHIP REEL CL1 +/-30 39
C2071	2113740F41	CAP CHIP REEL CL1 +/-30 39
C2072	2113740L04	CAP CER CHIP 2.7 PF +-0.1PF
C2073	2113740F03	CAP CHIP REEL CL1 +/-30 1.0
C2074	2109720D14	CAP CER CHIP LOW DIST 0.1UF
C2075	2109720D14	CAP CER CHIP LOW DIST 0.1UF
C2076	NOT PLACED	GCAM DUMMY PART NUMBER
C2077	2109720D14	CAP CER CHIP LOW DIST 0.1UF
C2078	2109720D14	CAP CER CHIP LOW DIST 0.1UF
C2079	2109720D14	CAP CER CHIP LOW DIST 0.1UF
C2080	2109720D14	CAP CER CHIP LOW DIST 0.1UF
C2081	2113740F67	CAP CHIP CL1 +/-30 470 5%
C300	2113740F44	CAP CHIP REEL CL1 +/-30 51
C301	2311049A57	CAP TANT CHIP A/P 10UF 10% 16V
C302	2113740F54	CAP CHIP REEL CL1 +/-30 130
C303	2113743K15	CER CHIP CAP .100UF
C304	2113743E20	CAP CHIP. 10 UF 10%

Circuit Ref.	Motorola Part No.	Description
C305	2113743E20	CAP CHIP. 10 UF 10%
C306	2113743E20	CAP CHIP. 10 UF 10%
C307	2113743E20	CAP CHIP. 10 UF 10%
C308	2113743E20	CAP CHIP. 10 UF 10%
C309	2113743E20	CAP CHIP. 10 UF 10%
C310	2113743E20	CAP CHIP. 10 UF 10%
C311	2113743E20	CAP CHIP. 10 UF 10%
C312	2113743E20	CAP CHIP. 10 UF 10%
C313	2113743E20	CAP CHIP. 10 UF 10%
C314	2113743E20	CAP CHIP. 10 UF 10%
C315	2113743E20	CAP CHIP. 10 UF 10%
C316	2113743E20	CAP CHIP. 10 UF 10%
C317	2113743E20	CAP CHIP. 10 UF 10%
C318	2113743E20	CAP CHIP. 10 UF 10%
C319	2113743E20	CAP CHIP. 10 UF 10%
C320	2113743E20	CAP CHIP. 10 UF 10%
C321	2113741F49	CAP CHIP CL2 X7R REEL 10000
C322	2113741F41	CAP CHIP CL2 X7R REEL 4700
C323	2113741F25	CAP CHIP CL2 X7R REEL 1000
C324	2113741F25	CAP CHIP CL2 X7R REEL 1000
C325	2113741F25	CAP CHIP CL2 X7R REEL 1000
C326	2113741F25	CAP CHIP CL2 X7R REEL 1000
C327	2113741F25	CAP CHIP CL2 X7R REEL 1000
C328	2113740F67	CAP CHIP CL1 +/-30 470 5%
C329	2113740F67	CAP CHIP CL1 +/-30 470 5%
C330	2113740F67	CAP CHIP CL1 +/-30 470 5%
C331	2113740F67	CAP CHIP CL1 +/-30 470 5%
C332	2113741F13	CAP CHIP CL2 X7R REEL 330
C333	2113740L41	CAP 91.0 PF 50V 2.0 %
C334	2113740L41	CAP 91.0 PF 50V 2.0 %
C335	2113740L17	CAP CER CHIP 9.1 PF+-0.1PF
C336	2113740L14	CAP CER CHIP 6.8PF +-0.1PF

Circuit Ref.	Motorola Part No.	Description	Circuit Ref.	Motorola Part No.	Description	Circuit Ref.	Motorola Part No.	Description
C337	2113740F57	CAP CHIP REEL CL1 +/-30 180	C402	2113743K15	CER CHIP CAP .100UF	C5011	2311049A57	CAP TANT CHIP A/P 10UF 10% 16V
C338	2113740F53	CAP CHIP REEL CL1 +/-30 120	C403	2113743K15	CER CHIP CAP .100UF	C5012	2311049A56	CAP TAN CHIP A/P 4.7 20 10
C339	2113740F51	CAP CHIP REEL CL1 +/-30 100	C404	2113743K15	CER CHIP CAP .100UF	C5013	2113928P04	CAP CER CHIP 1.0UF 20% 6.3V
C340	2113740F49	CAP CHIP REEL CL1 +/-30 82	C405	2113743K15	CER CHIP CAP .100UF	C5014	NOT PLACED	GCAM DUMMY PART NUMBER
C341	2113740F49	CAP CHIP REEL CL1 +/-30 82	C406	2113743K15	CER CHIP CAP .100UF	C5015	2113743K15	CER CHIP CAP .100UF
C342	2113740F49	CAP CHIP REEL CL1 +/-30 82	C407	2113743K15	CER CHIP CAP .100UF	C5016	2113743K15	CER CHIP CAP .100UF
C343	2113740F49	CAP CHIP REEL CL1 +/-30 82	C408	2113743K15	CER CHIP CAP .100UF	C5017	2113743K15	CER CHIP CAP .100UF
C344	NOT PLACED	GCAM DUMMY PART NUMBER	C410	2113743K15	CER CHIP CAP .100UF	C5018	2113743K15	CER CHIP CAP .100UF
C345	NOT PLACED	GCAM DUMMY PART NUMBER	C411	2113741F25	CAP CHIP CL2 X7R REEL 1000	C5019	2113743K15	CER CHIP CAP .100UF
C346	2113740F45	CAP CHIP REEL CL1+/-30 56	C412	2113741F25	CAP CHIP CL2 X7R REEL 1000	C5020	2113743K15	CER CHIP CAP .100UF
C347	2113740F41	CAP CHIP REEL CL1 +/-30 39	C413	2113741F25	CAP CHIP CL2 X7R REEL 1000	C5021	2113741M69	CAP CHIP CLS2 100000 PF 20V 10
C348	2113740F41	CAP CHIP REEL CL1 +/-30 39	C414	2113741F25	CAP CHIP CL2 X7R REEL 1000	C5022	2113743K15	CER CHIP CAP .100UF
C349	NOT PLACED	GCAM DUMMY PART NUMBER	C415	2113741F25	CAP CHIP CL2 X7R REEL 1000	C5023	2113743K15	CER CHIP CAP .100UF
C350	2113740F40	CAP CHIP REEL CL1 +/-30 36	C416	2113741F25	CAP CHIP CL2 X7R REEL 1000	C5024	2113743K15	CER CHIP CAP .100UF
C351	2113740F40	CAP CHIP REEL CL1 +/-30 36	C417	2113741F25	CAP CHIP CL2 X7R REEL 1000	C5025	2113743K15	CER CHIP CAP .100UF
C352	2113740F39	CAP CHIP REEL CL1 +/-30 33	C418	2113741F25	CAP CHIP CL2 X7R REEL 1000	C5026	2113743K15	CER CHIP CAP .100UF
C353	2113740F38	CAP CHIP REEL CL1 +/-30 30	C421	2113743E07	CER CHIP CAP .022UF	C5027	2113743K15	CER CHIP CAP .100UF
C354	2113740F38	CAP CHIP REEL CL1 +/-30 30	C422	2113741F25	CAP CHIP CL2 X7R REEL 1000	C5028	2113743K15	CER CHIP CAP .100UF
C355	2113740F38	CAP CHIP REEL CL1 +/-30 30	C423	2113743K15	CER CHIP CAP .100UF	C5029	2113743K15	CER CHIP CAP .100UF
C356	NOT PLACED	GCAM DUMMY PART NUMBER	C490	NOT PLACED	GCAM DUMMY PART NUMBER	C5030	2113743K15	CER CHIP CAP .100UF
C357	2113740F35	CAP CHIP REEL CL1 +/-30 22	C5000	2113741F25	CAP CHIP CL2 X7R REEL 1000	C5031	2113743K15	CER CHIP CAP .100UF
C359	NOT PLACED	GCAM DUMMY PART NUMBER	C5001	2389289U01	10UF 50V 20% ALUMINUM SMD	C5032	2113743K15	CER CHIP CAP .100UF
C360	NOT PLACED	GCAM DUMMY PART NUMBER	C5002	2311049A99	CAP TANT CHIP 47 UF 10V 20%	C5033	2113743K15	CER CHIP CAP .100UF
C361	2113740F33	CAP CHIP REEL CL1 +/-30 18	C5003	2311049A99	CAP TANT CHIP 47 UF 10V 20%	C5034	2113743K15	CER CHIP CAP .100UF
C362	2113740F33	CAP CHIP REEL CL1 +/-30 18	C5005	2360567A03	CAP TANTALUM	C5035	2113743K15	CER CHIP CAP .100UF
C363	NOT PLACED	GCAM DUMMY PART NUMBER	C5006	2311049A57	CAP TANT CHIP A/P 10UF 10% 16V	C5036	2113743K15	CER CHIP CAP .100UF
C364	2113740F25	CAP CHIP REEL CL1+/-30 8.2	C5007	2311049A99	CAP TANT CHIP 47 UF 10V 20%	C5037	2113743K15	CER CHIP CAP .100UF
C365	2113740F21	CAP CHIP REEL CL1+/-30 5.6	C5008	2311049A57	CAP TANT CHIP A/P 10UF 10% 16V	C5038	2113743K15	CER CHIP CAP .100UF
C366	NOT PLACED	GCAM DUMMY PART NUMBER	C5009	2311049A57	CAP TANT CHIP A/P 10UF 10% 16V	C5039	NOT PLACED	GCAM DUMMY PART NUMBER
C367	NOT PLACED	GCAM DUMMY PART NUMBER	C5010	2311049A57	CAP TANT CHIP A/P 10UF 10% 16V	C5040	NOT PLACED	GCAM DUMMY PART NUMBER
C400	2113741F25	CAP CHIP CL2 X7R REEL 1000				C5041	2113743F18	CAP CHIP 2.2 UF 16V +80-20%
C401	2113743K15	CER CHIP CAP .100UF						

Circuit Ref.	Motorola Part No.	Description
C5068	2113741F25	CAP CHIP CL2 X7R REEL 1000
C5069	2113741F25	CAP CHIP CL2 X7R REEL 1000
C5070	2113741F25	CAP CHIP CL2 X7R REEL 1000
C5071	2113741F25	CAP CHIP CL2 X7R REEL 1000
C5072	2113741F25	CAP CHIP CL2 X7R REEL 1000
C5073	2113741F25	CAP CHIP CL2 X7R REEL 1000
C5074	2113741F25	CAP CHIP CL2 X7R REEL 1000
C5075	NOT PLACED	GCAM DUMMY PART NUMBER
C5076	2113741F25	CAP CHIP CL2 X7R REEL 1000
C5077	2113741F25	CAP CHIP CL2 X7R REEL 1000
C5078	2113741F25	CAP CHIP CL2 X7R REEL 1000
C5079	2113741F25	CAP CHIP CL2 X7R REEL 1000
C5080	2113741F25	CAP CHIP CL2 X7R REEL 1000
C5081	2113741F25	CAP CHIP CL2 X7R REEL 1000
C5082	2113741F25	CAP CHIP CL2 X7R REEL 1000
C5083	2113740F51	CAP CHIP REEL CL1 +/-30 100
C5084	2113740F51	CAP CHIP REEL CL1 +/-30 100
C5085	2113741A53	CAP CHIP CL2 X7R REEL 22000
C5086	2113741A53	CAP CHIP CL2 X7R REEL 22000
C5087	2113740F53	CAP CHIP REEL CL1 +/-30 120
C5088	2113740F49	CAP CHIP REEL CL1 +/-30 82
C5089	2113740F49	CAP CHIP REEL CL1 +/-30 82
C5090	2113740F49	CAP CHIP REEL CL1 +/-30 82
C5091	2113740F49	CAP CHIP REEL CL1 +/-30 82
C5092	2113740F59	CAP CHIP REEL CL1 +/-30 220
C5094	2113740F59	CAP CHIP REEL CL1 +/-30 220
C5095	2113740F59	CAP CHIP REEL CL1 +/-30 220
C5096	2113740F59	CAP CHIP REEL CL1 +/-30 220
C5097	2113740F59	CAP CHIP REEL CL1 +/-30 220
C5098	2113740F59	CAP CHIP REEL CL1 +/-30 220
C5099	2113740F59	CAP CHIP REEL CL1 +/-30 220
C5100	2113740F59	CAP CHIP REEL CL1 +/-30 220

Circuit Ref.	Motorola Part No.	Description
C5101	2113741F25	CAP CHIP CL2 X7R REEL 1000 (CM160/CM360)
C5102	2113743E20	CAP CHIP. 10 UF 10% (CM160/CM360)
C5103	2113743K15	CER CHIP CAP .100UF (CM160/CM360)
C5104	NOT PLACED	GCAM DUMMY PART NUMBER
C5110	2113741F25	CAP CHIP CL2 X7R REEL 1000
C5111	2113741F25	CAP CHIP CL2 X7R REEL 1000
C5113	NOT PLACED	GCAM DUMMY PART NUMBER
C5114	2113743F16	CAP CHIP 1.0UF 16V+80-20%
C5115	NOT PLACED	GCAM DUMMY PART NUMBER
C5116	NOT PLACED	GCAM DUMMY PART NUMBER
C5117	NOT PLACED	GCAM DUMMY PART NUMBER
C5118	2113743E20	CAP CHIP. 10 UF 10%
C5119	2113743H14	CAP CHIP 10.0 UF 16V +80-20%
C5120	3211049A99	CAP TANT CHIP 47 UF 10 (CM340/CM360)
C5121	2113741F25	CAP CHIP CL2 X7R REEL 1000
C602	2113741F25	CAP CHIP CL2 X7R REEL 1000
C603	2113741F25	CAP CHIP CL2 X7R REEL 1000
C604	2113741F25	CAP CHIP CL2 X7R REEL 1000
C605	2113741F25	CAP CHIP CL2 X7R REEL 1000
C606	2113741F25	CAP CHIP CL2 X7R REEL 1000
C607	2113741F25	CAP CHIP CL2 X7R REEL 1000
C608	NOT PLACED	GCAM DUMMY PART NUMBER
C609	NOT PLACED	GCAM DUMMY PART NUMBER
C610	2113741F25	CAP CHIP CL2 X7R REEL 1000
C611	2113741F25	CAP CHIP CL2 X7R REEL 1000
C612	2113741F25	CAP CHIP CL2 X7R REEL 1000
C613	2113741F25	CAP CHIP CL2 X7R REEL 1000
C614	2113741F25	CAP CHIP CL2 X7R REEL 1000
C615	2113741F25	CAP CHIP CL2 X7R REEL 1000
C616	2113741F25	CAP CHIP CL2 X7R REEL 1000

Circuit Ref.	Motorola Part No.	Description
C617	2113741F25	CAP CHIP CL2 X7R REEL 1000
C618	2113741F25	CAP CHIP CL2 X7R REEL 1000
C619	NOT PLACED	GCAM DUMMY PART NUMBER
C620	2113741F25	CAP CHIP CL2 X7R REEL 1000
C621	2113741F25	CAP CHIP CL2 X7R REEL 1000
C622	2113741F25	CAP CHIP CL2 X7R REEL 1000
C623	2113741F25	CAP CHIP CL2 X7R REEL 1000
C624	2113741F25	CAP CHIP CL2 X7R REEL 1000
C625	2113741F25	CAP CHIP CL2 X7R REEL 1000
C626	2113741F25	CAP CHIP CL2 X7R REEL 1000
C627	2113741F25	CAP CHIP CL2 X7R REEL 1000
C628	2113741F25	CAP CHIP CL2 X7R REEL 1000
C629	2113741F25	CAP CHIP CL2 X7R REEL 1000
C630	2113741F25	CAP CHIP CL2 X7R REEL 1000
C631	2113741F25	CAP CHIP CL2 X7R REEL 1000
C632	2113741F25	CAP CHIP CL2 X7R REEL 1000
C633	2113741F25	CAP CHIP CL2 X7R REEL 1000
C662	2113741F25	CAP CHIP CL2 X7R REEL 1000
C678	2113741M69	CAP CHIP CLS2 100000 PF 20V 10
CR300	4880154K03	SOT MMBD353 RH DIODE DUAL SCHT
CR301	4880154K03	SOT MMBD353 RH DIODE DUAL SCHT
D100	NOT PLACED	GCAM DUMMY PART NUMBER
D101	4813833C02	DIODE DUAL 70V '5B' COMM CATH
D102	4813833C02	DIODE DUAL 70V '5B' COMM CATH
D103	4802482J02	PIN DIODE SMD
D104	4802482J02	PIN DIODE SMD
D105	4805218N57	DIODE DUAL
D106	4805218N57	DIODE DUAL
D107	4805218N57	DIODE DUAL

Circuit Ref.	Motorola Part No.	Description
D108	4805218N57	DIODE DUAL
D200	4802233J09	DIODE TRIPLE SOT25-RH
D201	4802233J09	DIODE TRIPLE SOT25-RH
D202	4862824C03	DIODE VARACTOR
D203	4805649Q13	DIODE VCTR ISV 228
D204	4805649Q13	DIODE VCTR ISV 228
D205	4862824C01	DIODE VARACTOR
D301	4802245J97	Band Switchind Diode, Rohm DAN
D302	4802245J97	Band Switchind Diode, Rohm DAN
D303	4802245J97	Band Switchind Diode, Rohm DAN
D304	4802245J97	Band Switchind Diode, Rohm DAN
D305	4880142L01	SOT MMBV109 RH
D400	4813833C07	DIODE DUAL 100V '5C' SERIES
D401	4813833C02	DIODE DUAL 70V '5B' COMM CATH
D402	4809948D42	DIODE SCHOTTKY RB751V-40 (CM140/CM160)
D500	4813833C02	DIODE DUAL 70V '5B' COMM CATH
D501	4813833C02	DIODE DUAL 70V '5B' COMM CATH (CM340/CM360)
D502	4813825A23	DIODE, DISCRETE SPECIALS VAR&P
D511	4813833C02	DIODE DUAL 70V '5B' COMM CATH
D513	4813833C02	DIODE DUAL 70V '5B' COMM CATH
FL300	9180022M11	XTAL FILTER 44.85MHZ
FL301	9180468V06	SMD455KHZ 4 ELEMENT CER FLTR
FL302	9180468V04	SMD455KHZ 4 ELEMENT CER FLTR
FL303	9180469V03	SMD455KHZ 6 ELEMENT CER FLTR

Circuit Ref.	Motorola Part No.	Description	Circuit Ref.	Motorola Part No.	Description	Circuit Ref.	Motorola Part No.	Description	Circuit Ref.	Motorola Part No.	Description
FL304	9180469V06	SMD455KHZ 6 ELEMENT CER FLTR	L126	2462587X69	IND CHIP LO-PRO 1200 NH 5%	L313	2460591G24	COIL AIR WOUND INDUC 33.47	Q303	4802245J95	BJT, NPN TRANSISTOR
J11	2889309U01	MINI-UHF PCB R.A	L200	2462587Q42	IND CHIP 390NH 10%	L314	2460591G24	COIL AIR WOUND INDUC 33.47	Q304	4809939C04	TSTR DUAL PNP/NPN UMC3
J2	0989241U02	FLEX 20PIN 1MM TOP NON ZIF	L201	2462587V44	IND CHIP 680 NH 10%	L315	NOT PLACED	GCAM DUMMY PART NUMBER	Q305	4802197J95	RF TRANSISTOR PBR941
J3	0986615Z01	CONN,ZIF,F,28CONT,,TIN,,,CBL (CM160/CM360))	L202	2462587V44	IND CHIP 680 NH 10%	L500	2484657R01	INDUCTOR BEAD CHIP	Q306	4813824A17	XSTR PNP40V .2A GENPB=100-300
L100	2484657R01	INDUCTOR BEAD CHIP	L203	2462587V44	IND CHIP 680 NH 10%	L501	2484657R01	INDUCTOR BEAD CHIP	Q400	4809940E02	TSTR DIG NPN DTC114YE
L101	2462587T30	IND CHIP 1000NH 5% LOW PRO	L204	2462587V44	IND CHIP 680 NH 10%	L502	2484657R01	INDUCTOR BEAD CHIP	Q401	4880141L03	QSTR PNP SOT23 LO PROFILE TAPE
L102	2462587T30	IND CHIP 1000NH 5% LOW PRO	L205	2462587Q47	IND CHIP 1000 NH 10%	M100	2686201B01	HEAT SPREADER WM	Q403	4809940E02	TSTR DIG NPN DTC114YE
L103	2462587T30	IND CHIP 1000NH 5% LOW PRO	L206	2413923C05	IND CHIP 33 NH 2%	M105	7588823L03	PAD GROUND LCD	Q404	4809940E02	TSTR DIG NPN DTC114YE
L104	2462587T13	IND CHIP 68NH 5% LOW PRO	L207	2413923C07	IND CHIP 47 NH 2%	M106	7588823L03	PAD GROUND LCD	Q405	4809940E02	TSTR DIG NPN DTC114YE
L105	2462587T13	IND CHIP 68NH 5% LOW PRO	L208	2413926N24	IND CER CHIP 100.0 NH 5%	M107	7588823L03	PAD GROUND LCD	Q407	4809940E02	TSTR DIG NPN DTC114YE
L106	2460591A11	COIL AIR WOUND INDUC 7.66	L209	2413926N24	IND CER CHIP 100.0 NH 5%	M108	7588823L04	PAD GROUND LCD	Q408	4880048M01	TSTR NPN DIG 47K/47K
L107	2460591A01	COIL AIR WOUND INDUC 4.22	L210	2413926N24	IND CER CHIP 100.0 NH 5%	M109	7588823L04	PAD GROUND LCD	Q409	4880048M01	TSTR NPN DIG 47K/47K
L108	2462587X69	IND CHIP LO-PRO 1200 NH 5%	L211	2413926N24	IND CER CHIP 100.0 NH 5%	M110	7588823L04	PAD GROUND LCD	Q410	4880048M01	TSTR NPN DIG 47K/47K
L109	NOT PLACED	GCAM DUMMY PART NUMBER	L212	2413926N24	IND CER CHIP 100.0 NH 5%	M111	3985994A01	CONTACT, PCB SPEAKER	Q411	4880048M01	TSTR NPN DIG 47K/47K
L110	2462587N42	CHIP IND 12 NH 5%	L213	2413926N24	IND CER CHIP 100.0 NH 5%	M112	3985994A01	CONTACT, PCB SPEAKER	Q412	4880048M01	TSTR NPN DIG 47K/47K
L111	2485873L05	ENCAPSULATED AIR WOUND 48NH	L214	2413926H20	IND CHIP 47.0 NH 5%	M113	3985994A01	CONTACT, PCB SPEAKER	Q413	4809940E02	TSTR DIG NPN DTC114YE
L112	2485873L05	ENCAPSULATED AIR WOUND 48NH	L215	2413926H20	IND CHIP 47.0 NH 5%	M114	3985994A01	CONTACT, PCB SPEAKER	Q414	4809940E02	TSTR DIG NPN DTC114YE
L113	2485873L05	ENCAPSULATED AIR WOUND 48NH	L216	2413926H20	IND CHIP 47.0 NH 5%	M9	0289511U01	NUTS	Q415	NOT PLACED	GCAM DUMMY PART NUMBER
L114	2485873L05	ENCAPSULATED AIR WOUND 48NH	L217	2462587Q42	IND CHIP 390NH 10%	P1	2804503J01	CONNECTOR,ACCY 16 PIN	Q416	4809940E02	TSTR DIG NPN DTC114YE
L115	2485873L01	ENCAPSULATED AIR WOUND COIL	L300	2460591G24	COIL AIR WOUND INDUC 33.47	P2	NOT PLACED	GCAM DUMMY PART NUMBER	Q417	4813824A10	TSTR NPN 40V .2A GEN PURP
L116	2485873L01	ENCAPSULATED AIR WOUND COIL	L301	2462587X69	IND CHIP LO-PRO 1200 NH 5%	PCB	8488977U01	MARLIN VHF	Q500	4813824A10	TSTR NPN 40V .2A GEN PURP
L117	2484657R01	INDUCTOR BEAD CHIP	L302	2462587X69	IND CHIP LO-PRO 1200 NH 5%	Q100	4886163B01	LDMOS SMT 35W 520MH 12V	Q501	4809940E02	TSTR DIG NPN DTC114YE
L118	2484657R01	INDUCTOR BEAD CHIP	L303	2462587N69	CHIP IND 1200 NH 5%	Q101	4813824A10	TSTR NPN 40V .2A GEN PURP	Q502	4809940E02	TSTR DIG NPN DTC114YE
L119	2484657R01	INDUCTOR BEAD CHIP	L304	2483411T74	INDUCTOR CHIP SHIELDED	Q102	4813824A10	TSTR NPN 40V .2A GEN PURP	Q503	4813824A10	TSTR NPN 40V .2A GEN PURP
L120	2484657R01	INDUCTOR BEAD CHIP	L305	2413926K31	IND CER CHIP 470.0 NH 5%	Q103	4813824A06	XSTR NPN 30V DARLINGTON	Q504	4880048M01	TSTR NPN DIG 47K/47K
L121	2484657R01	INDUCTOR BEAD CHIP	L306	2462587N55	CHIP IND 150 NH 5%	Q105	4813828A11	TSTR 520 MHZ 3W, 12.5V RF LDMO	Q505	4813824A10	TSTR NPN 40V .2A GEN PURP
L122	2460591C23	COIL AIR WOUND INDUC 13.85	L307	2460591G24	COIL AIR WOUND INDUC 33.47	Q106	4805128M27	SOT TRANS	Q506	4813824A10	TSTR NPN 40V .2A GEN PURP
			L308	2460591G24	COIL AIR WOUND INDUC 33.47	Q200	4802245J95	BJT, NPN TRANSISTOR	R101	NOT PLACED	GCAM DUMMY PART NUMBER
			L309	2460591G24	COIL AIR WOUND INDUC 33.47	Q300	4809940E02	TSTR DIG NPN DTC114YE	R102	0683962T51	RES CHIP 120 5-1
			L310	2460591G24	COIL AIR WOUND INDUC 33.47	Q301	4813824A17	XSTR PNP40V .2A GENPB=100-300	R103	0683962T51	RES CHIP 120 5-1
			L311	2460591G24	COIL AIR WOUND INDUC 33.47	Q302	4813824A10	TSTR NPN 40V .2A GEN PURP	R104	0683962T51	RES CHIP 120 5-1
			L312	2460591G24	COIL AIR WOUND INDUC 33.47						

Circuit Ref.	Motorola Part No.	Description
R105	0680194M18	RES 51 OHMS 5% 1W
R106	0680194M18	RES 51 OHMS 5% 1W
R107	0680194M18	RES 51 OHMS 5% 1W
R108	0680194M18	RES 51 OHMS 5% 1W
R109	0662057A05	CHIP RES 15 OHMS 5%
R110	NOT PLACED	GCAM DUMMY PART NUMBER
R111	NOT PLACED	GCAM DUMMY PART NUMBER
R112	0662057P95	RES CHIP 100.0K 1% 30X60
R113	0662057P10	RES CHIP 10.0K 1% 30X60
R114	0662057P10	RES CHIP 10.0K 1% 30X60
R115	0662057P10	RES CHIP 10.0K 1% 30X60
R116	0662057P10	RES CHIP 10.0K 1% 30X60
R117	0662057P02	RES. CHIP 15K 1% 30X60
R118	0662057C51	CHIP RES 100 OHMS 5%
R119	0662057C51	CHIP RES 100 OHMS 5%
R120	0662057C51	CHIP RES 100 OHMS 5%
R121	0662057C51	CHIP RES 100 OHMS 5%
R122	0662057C19	CHIP RES 4.7 OHMS 5%
R123	0662057C13	CHIP RES 2.7 OHMS 5%
R124	0662057C13	CHIP RES 2.7 OHMS 5%
R125	0662057C13	CHIP RES 2.7 OHMS 5%
R126	0662057C03	CHIP RES 1.0 OHMS 5%
R127	0662057C03	CHIP RES 1.0 OHMS 5%
R130	0662057B47	CHIP RES 0 OHMS +-0.050 OHMS
R131	0662057A97	CHIP RES 100K OHMS 5%
R132	NOT PLACED	GCAM DUMMY PART NUMBER
R134	0662057A89	CHIP RES 47K OHMS 5%
R135	0662057A88	CHIP RES 43K OHMS 5%
R136	0662057A87	CHIP RES 39K OHMS 5%
R137	0662057A87	CHIP RES 39K OHMS 5%
R138	0662057A87	CHIP RES 39K OHMS 5%

Circuit Ref.	Motorola Part No.	Description
R139	0662057A87	CHIP RES 39K OHMS 5%
R140	0662057A81	CHIP RES 22K OHMS 5%
R141	0662057A81	CHIP RES 22K OHMS 5%
R142	0662057A81	CHIP RES 22K OHMS 5%
R143	0662057A81	CHIP RES 22K OHMS 5%
R144	0662057A81	CHIP RES 22K OHMS 5%
R145	0662057A81	CHIP RES 22K OHMS 5%
R146	0662057A81	CHIP RES 22K OHMS 5%
R147	0662057A81	CHIP RES 22K OHMS 5%
R148	0662057A81	CHIP RES 22K OHMS 5%
R149	0662057A81	CHIP RES 22K OHMS 5%
R150	0662057A73	CHIP RES 10K OHMS 5%
R151	0662057A67	CHIP RES 5600 OHMS 5%
R153	0662057A73	CHIP RES 10K OHMS 5%
R155	0662057A73	CHIP RES 10K OHMS 5%
R156	0662057A73	CHIP RES 10K OHMS 5%
R157	0662057A91	CHIP RES 56K OHMS 5%
R158	0662057A67	CHIP RES 5600 OHMS 5%
R159	NOT PLACED	GCAM DUMMY PART NUMBER
R160	0662057A61	CHIP RES 3300 OHMS 5%
R161	0662057A61	CHIP RES 3300 OHMS 5%
R162	0662057A61	CHIP RES 3300 OHMS 5%
R163	0662057A61	CHIP RES 3300 OHMS 5%
R164	0662057A73	CHIP RES 10K OHMS 5%
R165	0662057A58	CHIP RES 2400 OHMS 5%
R166	0662057A58	CHIP RES 2400 OHMS 5%
R167	0662057A57	CHIP RES 2200 OHMS 5%
R168	0662057A57	CHIP RES 2200 OHMS 5%
R169	0662057A57	CHIP RES 2200 OHMS 5%
R170	0662057A42	CHIP RES 510 OHMS 5%
R171	0662057A41	CHIP RES 470 OHMS 5%
R172	0662057A41	CHIP RES 470 OHMS 5%

Circuit Ref.	Motorola Part No.	Description
R173	0662057A36	CHIP RES 300 OHMS 5%
R174	0662057A36	CHIP RES 300 OHMS 5%
R175	0662057A33	CHIP RES 220 OHMS 5%
R176	0662057A25	CHIP RES 100 OHMS 5%
R177	NOT PLACED	GCAM DUMMY PART NUMBER
R178	0662057A14	RES CHIP 36 OHM 5 1/8W
R179	0662057A14	RES CHIP 36 OHM 5 1/8W
R180	0660082A89	RES CHIP 47K OHMS 1% 1/16W
R181	0660082A89	RES CHIP 47K OHMS 1% 1/16W
R182	0662057A73	CHIP RES 10K OHMS 5%
R185	0662057A73	CHIP RES 10K OHMS 5%
R186	0662057C20	CHIP RES 5.1 OHMS 5%
R200	0662057A99	CHIP RES 120K OHMS 5%
R201	0662057B47	CHIP RES 0 OHMS +-0.050 OHMS
R202	NOT PLACED	GCAM DUMMY PART NUMBER
R203	0662057B47	CHIP RES 0 OHMS +-0.050 OHMS
R204	NOT PLACED	GCAM DUMMY PART NUMBER
R205	NOT PLACED	GCAM DUMMY PART NUMBER
R206	0662057B02	CHIP RES 150K OHMS 5%
R207	0662057B02	CHIP RES 150K OHMS 5%
R208	0662057A18	CHIP RES 51 OHMS 5%
R209	0662057A97	CHIP RES 100K OHMS 5%
R210	NOT PLACED	GCAM DUMMY PART NUMBER
R211	0662057A89	CHIP RES 47K OHMS 5%
R212	0662057A84	CHIP RES 30K OHMS 5%
R213	0662057A65	CHIP RES 4700 OHMS 5%
R214	0662057A65	CHIP RES 4700 OHMS 5%
R215	0662057A65	CHIP RES 4700 OHMS 5%
R216	0662057A63	CHIP RES 3900 OHMS 5%
R217	0662057A52	CHIP RES 1300OHMS 5%05
R218	0662057A49	CHIP RES 1000 OHMS 5%

Circuit Ref.	Motorola Part No.	Description
R219	NOT PLACED	GCAM DUMMY PART NUMBER
R220	0662057A42	CHIP RES 510 OHMS 5%
R221	0662057A33	CHIP RES 220 OHMS 5%
R222	0662057A33	CHIP RES 220 OHMS 5%
R223	0662057A33	CHIP RES 220 OHMS 5%
R224	0662057A53	CHIP RES 1500 OHMS 5%
R225	0662057A29	CHIP RES 150 OHMS 5%
R226	0662057A29	CHIP RES 150 OHMS 5%
R227	0662057A25	CHIP RES 100 OHMS 5%
R228	0662057A25	CHIP RES 100 OHMS 5%
R229	0662057A25	CHIP RES 100 OHMS 5%
R230	0662057A25	CHIP RES 100 OHMS 5%
R231	0662057A18	CHIP RES 51 OHMS 5%
R232	0662057A17	RES CHIP 47 OHMS 5%
R233	0662057A17	RES CHIP 47 OHMS 5%
R234	0662057A15	CHIP RES 39 OHMS 5%
R235	0662057A07	CHIP RES 18 OHMS 5%
R300	0662057A73	CHIP RES 10K OHMS 5%
R301	0662057A41	CHIP RES 470 OHMS 5%
R302	0662057B47	CHIP RES 0 OHMS +-0.050 OHMS
R303	0662057B47	CHIP RES 0 OHMS +-0.050 OHMS
R304	0662057A85	CHIP RES 33K OHM 5%
R305	0662057A80	CHIP RES 20K OHMS 5%
R306	0662057A80	CHIP RES 20K OHMS 5%
R307	0662057A80	CHIP RES 20K OHMS 5%
R308	0662057A80	CHIP RES 20K OHMS 5%
R309	0662057A77	CHIP RES 15K OHMS 5%
R310	0662057A77	CHIP RES 15K OHMS 5%
R311	NOT PLACED	GCAM DUMMY PART NUMBER
R312	0662057A76	CHIP RES 13K OHMS 5%
R313	0662057A75	CHIP RES 12K OHMS 5%

Circuit Ref.	Motorola Part No.	Description	Circuit Ref.	Motorola Part No.	Description	Circuit Ref.	Motorola Part No.	Description	Circuit Ref.	Motorola Part No.	Description
R314	0662057A75	CHIP RES 12K OHMS 5%	R346	0662057A73	CHIP RES 10K OHMS 5%	R438	0662057A73	CHIP RES 10K OHMS 5%	R5002	0662057C01	CHIP RES 0 OHMS .050 OHMS (CM160/CM360)
R315	0662057A75	CHIP RES 12K OHMS 5%	R401	0662057C85	CHIP RES 2700 OHMS 5%	R439	0662057A73	CHIP RES 10K OHMS 5%	R5008	0662057B47	CHIP RES 0 OHMS +-0.050 OHMS
R316	0662057A75	CHIP RES 12K OHMS 5%	R402	0662057B47	CHIP RES 0 OHMS +-0.050 OHMS	R440	0662057A73	CHIP RES 10K OHMS 5%	R5009	0662057B47	CHIP RES 0 OHMS +-0.050 OHMS
R317	0662057A75	CHIP RES 12K OHMS 5%	R403	0662057B47	CHIP RES 0 OHMS +-0.050 OHMS	R441	0662057A73	CHIP RES 10K OHMS 5%	R5010	0662057B47	CHIP RES 0 OHMS +-0.050 OHMS
R318	0662057A75	CHIP RES 12K OHMS 5%	R404	0662057B47	CHIP RES 0 OHMS +-0.050 OHMS	R442	0662057A73	CHIP RES 10K OHMS 5%	R5011	NOT PLACED	GCAM DUMMY PART NUMBER
R319	0662057A75	CHIP RES 12K OHMS 5%	R405	0662057B47	CHIP RES 0 OHMS +-0.050 OHMS	R443	0662057A61	CHIP RES 3300 OHMS 5%	R5013	NOT PLACED	GCAM DUMMY PART NUMBER
R320	0662057A73	CHIP RES 10K OHMS 5%	R406	0662057B47	CHIP RES 0 OHMS +-0.050 OHMS	R444	0662057A73	CHIP RES 10K OHMS 5%	R5014	0662057B47	CHIP RES 0 OHMS +-0.050 OHMS
R321	0662057A71	CHIP RES 8200 OHMS 5%	R407	0662057B47	CHIP RES 0 OHMS +-0.050 OHMS	R445	0662057A73	CHIP RES 10K OHMS 5%	R5016	NOT PLACED	GCAM DUMMY PART NUMBER
R322	0662057A65	CHIP RES 4700 OHMS 5%	R414	0662057B47	CHIP RES 0 OHMS +-0.050 OHMS	R446	0662057A73	CHIP RES 10K OHMS 5%	R5019	0662057B05	CHIP RES 200K OHMS 5%
R323	0662057A65	CHIP RES 4700 OHMS 5%	R415	0662057B47	CHIP RES 0 OHMS +-0.050 OHMS (CM340/CM360)	R447	0662057A73	CHIP RES 10K OHMS 5%	R5020	0662057B02	CHIP RES 150K OHMS 5%
R324	0662057A61	CHIP RES 3300 OHMS 5%	R421	0662057A33	CHIP RES 220 OHMS 5%	R448	0662057A61	CHIP RES 3300 OHMS 5%	R5021	0662057A97	CHIP RES 100K OHMS 5%
R325	0662057A61	CHIP RES 3300 OHMS 5%	R422	0662057A73	CHIP RES 10K OHMS 5% (CM140/CM160)	R449	NOT PLACED	GCAM DUMMY PART NUMBER	R5022	0662057A97	CHIP RES 100K OHMS 5%
R326	0662057A58	CHIP RES 2400 OHMS 5%	R423	NOT PLACED	GCAM DUMMY PART NUMBER	R450	0662057A53	CHIP RES 1500 OHMS 5%	R5023	0662057A97	CHIP RES 100K OHMS 5%
R327	0662057A58	CHIP RES 2400 OHMS 5%	R424	NOT PLACED	GCAM DUMMY PART NUMBER	R451	0662057A61	CHIP RES 3300 OHMS 5%	R5024	0662057A97	CHIP RES 100K OHMS 5% (CM160/CM360)
R328	0662057A55	CHIP RES 1800 OHM 5%	R425	0662057A97	CHIP RES 100K OHMS 5%	R452	0662057A61	CHIP RES 3300 OHMS 5%	R5025	0662057A97	CHIP RES 100K OHMS 5%
R329	0662057A51	CHIP RES 1200 OHMS 5%	R426	0662057A97	CHIP RES 100K OHMS 5% (CM140/CM160)	R453	0662057A61	CHIP RES 3300 OHMS 5%	R5026	0662057A85	CHIP RES 33K OHM 5%
R330	0662057A49	CHIP RES 1000 OHMS 5%	R427	NOT PLACED	GCAM DUMMY PART NUMBER	R454	0662057A61	CHIP RES 3300 OHMS 5%	R5027	0662057B08	CHIP RES 270K OHMS 5%
R331	0662057A45	CHIP RES 680 OHMS 5%	R428	0662057A97	CHIP RES 100K OHMS 5%	R455	0662057A61	CHIP RES 3300 OHMS 5%	R5028	0662057A97	CHIP RES 100K OHMS 5%
R332	0662057A43	CHIP RES 560 OHMS 5%	R429	0662057A97	CHIP RES 100K OHMS 5%	R456	0662057A61	CHIP RES 3300 OHMS 5%	R5029	0662057A97	CHIP RES 100K OHMS 5%
R333	0662057A40	CHIP RES 430 OHMS 5%	R430	0662057A87	CHIP RES 39K OHMS 5%	R457	0662057A61	CHIP RES 3300 OHMS 5%	R5030	0662057A85	CHIP RES 33K OHM 5%
R334	0662057A39	CHIP RES 390 OHMS 5%	R431	NOT PLACED	GCAM DUMMY PART NUMBER	R458	0662057A61	CHIP RES 3300 OHMS 5%	R5031	0662057A92	CHIP RES 62K OHMS 5%
R335	0662057A33	CHIP RES 220 OHMS 5%	R432	0662057A85	CHIP RES 33K OHM 5%	R459	NOT PLACED	GCAM DUMMY PART NUMBER	R5032	0662057A89	CHIP RES 47K OHMS 5%
R336	0662057A25	CHIP RES 100 OHMS 5%	R433	0662057A85	CHIP RES 33K OHM 5%	R460	0662057A73	CHIP RES 10K OHMS 5%	R5033	0662057A89	CHIP RES 47K OHMS 5%
R337	0662057A25	CHIP RES 100 OHMS 5%	R434	0662057A85	CHIP RES 33K OHM 5%	R461	0662057A33	CHIP RES 220 OHMS 5%	R5034	0662057A86	CHIP RES 36K OHMS 5%
R338	0662057A18	CHIP RES 51 OHMS 5%	R435	0662057A85	CHIP RES 33K OHM 5%	R462	0662057A18	CHIP RES 51 OHMS 5%	R5035	0662057A89	CHIP RES 47K OHMS 5%
R339	0662057A18	CHIP RES 51 OHMS 5%	R436	0662057A85	CHIP RES 33K OHM 5%	R463	0662057A73	CHIP RES 10K OHMS 5%	R5036	0662057A89	CHIP RES 47K OHMS 5%
R340	0662057A18	CHIP RES 51 OHMS 5%				R464	NOT PLACED	GCAM DUMMY PART NUMBER	R5037	0662057A73	CHIP RES 10K OHMS 5%
R341	0662057A01	CHIP RES 10 OHMS 5%				R465	NOT PLACED	GCAM DUMMY PART NUMBER	R5038	0662057A85	CHIP RES 33K OHM 5%
R342	0662057A01	CHIP RES 10 OHMS 5%				R466	NOT PLACED	GCAM DUMMY PART NUMBER			
R343	0662057A01	CHIP RES 10 OHMS 5%				R467	NOT PLACED	GCAM DUMMY PART NUMBER			
R344	0662057A01	CHIP RES 10 OHMS 5%				R468	NOT PLACED	GCAM DUMMY PART NUMBER			
R345	0662057A73	CHIP RES 10K OHMS 5%				R469	NOT PLACED	GCAM DUMMY PART NUMBER			
						R470	0662057A73	CHIP RES 10K OHMS 5% (CM340/CM360)			
						R471	0662057A01	CHIP RES 10 OHMS 5%			
						R472	NOT PLACED	GCAM DUMMY PART NUMBER			
						R473	NOT PLACED	GCAM DUMMY PART NUMBER			
						R474	0662057B47	CHIP RES 0 OHMS +-0.050 OHMS			
						R475	0662057T68	RES CHIP 1.0K 1% 30*60			

Circuit Ref.	Motorola Part No.	Description
R5039	0662057A97	CHIP RES 100K OHMS 5%
R5040	0662057A84	CHIP RES 30K OHMS 5%
R5041	0662057A82	CHIP RES 24K OHMS 5%
R5042	0662057A82	CHIP RES 24K OHMS 5%
R5043	0662057A82	CHIP RES 24K OHMS 5%
R5044	0662057A82	CHIP RES 24K OHMS 5%
R5045	0662057A85	CHIP RES 33K OHM 5%
R5046	0662057A82	CHIP RES 24K OHMS 5%
R5047	0662057B47	CHIP RES 0 OHMS +-0.050 OHMS (CM140/CM340)
R5048	0662057A82	CHIP RES 24K OHMS 5%
R5049	0662057A77	CHIP RES 15K OHMS 5%
R5050	0662057A76	CHIP RES 13K OHMS 5%
R5051	0662057A75	CHIP RES 12K OHMS 5%
R5052	0662057A73	CHIP RES 10K OHMS 5%
R5053	0662057A73	CHIP RES 10K OHMS 5%
R5054	0662057A73	CHIP RES 10K OHMS 5%
R5055	0662057A73	CHIP RES 10K OHMS 5%
R5056	0662057A73	CHIP RES 10K OHMS 5%
R5057	0662057A73	CHIP RES 10K OHMS 5%
R5058	NOT PLACED	GCAM DUMMY PART NUMBER
R5059	NOT PLACED	GCAM DUMMY PART NUMBER
R5060	0662057A73	CHIP RES 10K OHMS 5%
R5061	0662057A73	CHIP RES 10K OHMS 5%
R5062	0662057A73	CHIP RES 10K OHMS 5%
R5063	NOT PLACED	GCAM DUMMY PART NUMBER
R5064	NOT PLACED	GCAM DUMMY PART NUMBER
R5065	0662057A68	CHIP RES 6200 OHMS 5%
R5066	0662057A49	CHIP RES 1000 OHMS 5%
R5067	NOT PLACED	GCAM DUMMY PART NUMBER
R5068	NOT PLACED	GCAM DUMMY PART NUMBER
R5069	0662057A73	CHIP RES 10K OHMS 5%

Circuit Ref.	Motorola Part No.	Description
R5070	0662057A57	CHIP RES 2200 OHMS 5%
R5071	0662057A57	CHIP RES 2200 OHMS 5%
R5072	0662057A65	CHIP RES 4700 OHMS 5%
R5073	0662057A49	CHIP RES 1000 OHMS 5%
R5074	0662057A49	CHIP RES 1000 OHMS 5%
R5075	0662057A42	CHIP RES 510 OHMS 5%
R5076	0662057A42	CHIP RES 510 OHMS 5%
R5077	0662057A36	CHIP RES 300 OHMS 5%
R5078	0662057A25	CHIP RES 100 OHMS 5%
R5079	0662057A25	CHIP RES 100 OHMS 5%
R5080	0662057A01	CHIP RES 10 OHMS 5%
R5081	0613952D78	CER CHIP RES 6340 OHM 1% 0603
R5082	0662057A90	CHIP RES 51K OHMS 5%
R5083	0662057B08	CHIP RES 270K OHMS 5%
R5084	0662057B47	CHIP RES 0 OHMS +-0.050 OHMS (CM160/CM360)
R5085	NOT PLACED	GCAM DUMMY PART NUMBER
R5086	0662057A43	CHIP RES 560 OHMS 5%
R5087	0662057A97	CHIP RES 100K OHMS 5%
R5088	0662057B47	CHIP RES 0 OHMS +-0.050 OHMS
R5089	NOT PLACED	GCAM DUMMY PART NUMBER
R5092	0662057A73	CHIP RES 10K OHMS 5%
R5093	0662057A73	CHIP RES 10K OHMS 5%
R5094	NOT PLACED	GCAM DUMMY PART NUMBER
R5095	0662057A82	CHIP RES 24K OHMS 5%
R5096	0662057A73	CHIP RES 10K OHMS 5%
R5097	NOT PLACED	GCAM DUMMY PART NUMBER
R5098	0662057B47	CHIP RES 0 OHMS +-0.050 OHMS
R5099	NOT PLACED	GCAM DUMMY PART NUMBER
R5100	NOT PLACED	GCAM DUMMY PART NUMBER
R5101	0662057A25	CHIP RES 100 OHMS 5%

Circuit Ref.	Motorola Part No.	Description
R5102	0662057A25	CHIP RES 100 OHMS 5%
R5103	0662057A82	CHIP RES 24K OHMS 5% (CM340/CM360)
R600	0662057C01	CHIP RES 0 OHMS .050 OHMS
R601	0611077A62	RES CHIP 330 5 1/8W
R602	0662057B47	CHIP RES 0 OHMS +-0.050 OHMS
R603	0662057C01	CHIP RES 0 OHMS .050 OHMS
R604	0662057C01	CHIP RES 0 OHMS .050 OHMS
R610	0662057C59	CHIP RES 220 OHMS 5%
R615	0662057A25	CHIP RES 100 OHMS 5%
RT100	0680361L01	THERMISTOR 47KOHM
S5010	1889288U01	POTENTIOMETER W/SWITCH VOLUME
SH200	2689590U01	VCO SHIELD
SH201	2689589U01	VCO SHIELD
SH202	2689589U01	VCO SHIELD
SH300	2689591U01	MIXER SHIELD
SH301	2689593U01	FRONT ENA SHIELD
SH302	2689591U01	MIXER SHIELD
T300	2580541Z01	BALUN TRANSFORMER
T301	2580541Z01	BALUN TRANSFORMER
U100	5113818A01	IC LOW COST SING SPLY LM2904DR
U101	5185130C65	IC VHF/UHF/800 MHZ LDMOS DRIVE
U102	5113818A01	IC LOW COST SING SPLY LM2904DR
U103	5113819A04	IC QD OP AMP GEN PURP MC3303D
U200	5185963A27	IC TESTED AT25016 48 PIN GFP
U201	5105750U54	IC PKG DIE VCO BUFFER
U300	5186144B01	FM IF IC SA616
U301	5109522E10	IC 3-INV LMOS TC7W04FU

Circuit Ref.	Motorola Part No.	Description
U302	4808612Y05	CROSSOVER QUAD DIODE SMS3928-0
U400	5102463J64	16KX8 SPI SERIAL EEPROM
U402	5102463J36	16KX8 STATIC RAM IN (CM340/CM360)
U403	5102226J56	68HC11FLO_PASS5 100P IN TQFP
U404	5189233U02	FLASH 2MEG AT49LV002N-70VI
U404	5189233U21	FLASH 4MEG AT49LV040N-70VI (CM340/CM360)
U405	5113805A75	IC 8 BIT SER TO PAR/PAR HC595
U500	5113818A01	IC LOW COST SING SPLY LM2904DR
U501	0104016J81	9V REGULATOR ASSEMBLY
U502	5102463J95	AUDIO PA TDA1519C
U503	5105469E65	IC VLTG REGLTR
U504	5185130C53	IC ASFIC_CMP_R1
U505	5113818A01	IC LOW COST SING SPLY LM2904DR
U506	5113818A01	IC LOW COST SING SPLY LM2904DR
U507	5113818A01	IC LOW COST SING SPLY LM2904DR
U508	5113816A30	IC 3.3V LOW DROPOUT POS. REG.
U509	5113806A20	IC MUX/DEMUX TRIPLE 2-CHNL
U510	5104187K94	IC LP2986ILDX-3.3 VLTG REG
U514	4802393L66	MOSFET P-CH
U515	5162852A59	IC CMOS ANALOG SWITCH SPDT (CM160/CM360)
VR101	4813830A15	TSTR 5.6V 5% 20MA 225MW
VR102	4813830A15	TSTR 5.6V 5% 20MA 225MW
VR400	NOT PLACED	GCAM DUMMY PART NUMBER
VR401	4813830G12	DIODE 4.3V 5% 'CP' 500MW _4687

Circuit Ref.	Motorola Part No.	Description
VR402	4813830A09	DIODE 3.3V 5% 225MW MMBZ5226B
VR500	4813832C77	TRANS SUP. 24V HIGH PWR
VR501	4813830A14	DIODE 5.1V 5% 225MW MMBZ5231B_
VR502	4813830G09	DIODE 3.3V 5% 'CK' 500MW _4684 (CM340/CM360)
VR503	4813830G09	DIODE 3.3V 5% 'CK' 500MW _4684
VR504	4813830G09	DIODE 3.3V 5% 'CK' 500MW _4684
VR692	4813830A75	DIODE DUAL COM ANODE
VR693	4813830A77	DIODE DL ZENER TVS 33V 1.0A
VR694	4813830A75	DIODE DUAL COM ANODE
VR695	4813830A77	DIODE DL ZENER TVS 33V 1.0A
VR696	4813830A75	DIODE DUAL COM ANODE
VR697	4813830A75	DIODE DUAL COM ANODE
VR698	4813830A75	DIODE DUAL COM ANODE
VR699	4813830A75	DIODE DUAL COM ANODE
Y200	NOT PLACED	GCAM DUMMY PART NUMBER
Y201	4880114R06	CRYSTAL 16.8MHZ
Y300	9186145B02	CER.DISCR. CDBCA455CX36- TC
Y301	4880606B09	2ND OSC XTAL 44.395 MHZ



MOTOROLA

Commercial Series

CM Radios

Midband (66-88MHz)
Service Information

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Table of Contents

Chapter 1 MODEL CHART AND TECHNICAL SPECIFICATIONS

1.0 CM340/CM360 Model Chart	1-1
2.0 Technical Specifications	1-2

Chapter 2 THEORY OF OPERATION

1.0 Introduction	2-1
2.0 Midband (66-88MHz) Receiver	2-1
2.1 Receiver Front-End	2-1
2.2 Receiver Back-End	2-2
3.0 Midband (66-88MHz) Transmitter Power Amplifier	2-2
3.1 First Power Controller Stage.....	2-2
3.2 Power Controlled Driver Stage	2-3
3.3 Final Stage.....	2-3
3.4 Bi-Directional Coupler	2-3
3.5 Antenna Switch.....	2-3
3.6 Harmonic Filter	2-4
3.7 Power Control.....	2-4
4.0 Midband (66-88MHz) Frequency Synthesis	2-4
4.1 Reference Oscillator	2-4
4.2 Fractional-N Synthesizer	2-5
4.3 Voltage Controlled Oscillator (VCO)	2-6
4.4 Synthesizer Operation	2-7
5.0 Controller Theory of Operation	2-8
5.1 Radio Power Distribution	2-8
5.2 Protection Devices.....	2-10
5.3 Automatic On/Off	2-10
5.4 Microprocessor Clock Synthesiser	2-11
5.5 Serial Peripheral Interface (SPI).....	2-12
5.6 SBEP Serial Interface	2-12
5.7 General Purpose I/O.....	2-12
5.8 Normal Microprocessor Operation.....	2-13
5.9 Static Random Access Memory.....	2-14
6.0 Control Board Audio and Signalling Circuits	2-14
6.1 Audio Signalling Filter IC and Compander (ASFIC CMP)	2-14
7.0 Transmit Audio Circuits.....	2-15
7.1 Microphone Input Path	2-15
7.2 PTT Sensing and TX Audio Processing	2-16

8.0	Transmit Signalling Circuits	2-17
8.1	Sub-Audio Data (PL/DPL)	2-17
8.2	High Speed Data	2-18
8.3	Dual Tone Multiple Frequency (DTMF) Data	2-18
9.0	Receive Audio Circuits.....	2-19
9.1	Squelch Detect	2-19
9.2	Audio Processing and Digital Volume Control.....	2-20
9.3	Audio Amplification Speaker (+) Speaker (-)	2-20
9.4	Handset Audio	2-21
9.5	Filtered Audio and Flat Audio	2-21
10.0	Receive Audio Circuits	2-21
10.1	Sub-Audio Data (PL/DPL) and High Speed Data Decoder	2-21
10.2	Alert Tone Circuits	2-22

Chapter 3 TROUBLESHOOTING CHARTS

1.0	Troubleshooting Flow Chart for Out-of-Lock Receiver (Sheet 1 of 2).....	3-2
1.1	Troubleshooting Flow Chart for Out-of-Lock Receiver (Sheet 2 of 2)	3-3
2.0	Troubleshooting Flow Chart for 25W Transmitter (Sheet 1 of 4)	3-4
2.1	Troubleshooting Flow Chart for 25W Transmitter (Sheet 2 of 4).....	3-5
2.2	Troubleshooting Flow Chart for 25W Transmitter (Sheet 3 of 4).....	3-6
2.3	Troubleshooting Flow Chart for 25W Transmitter (Sheet 4 of 4).....	3-7
3.0	Troubleshooting Flow Chart for Synthesizer (Reference Oscillator).....	3-8
4.0	Troubleshooting Flow Chart for VCO.....	3-9
5.0	Troubleshooting Flow Chart for Receiver (Sheet 1 of 2)	3-10
5.1	Troubleshooting Flow Chart for Receiver (Sheet 2 of 2)	3-11
6.0	Troubleshooting Flow Chart for DC Supply (Sheet 1 of 2)	3-12
6.1	Troubleshooting Flow Chart for DC Supply (Sheet 2 of 2)	3-13

Chapter 4 MIDBAND PCB/SCHEMATICS/PARTS LISTS

1.0	Allocation of Schematics and Circuit Boards	4-1
1.1	Midband and Controller Circuits	4-1
2.0	Midband 1-25W PCB 8489012U01 (Rev. C) / Schematics	4-3
2.1	Midband 1-25W PCB 8489012U01 (Rev. C) Parts List.....	4-11

Chapter 1

MODEL CHART AND TECHNICAL SPECIFICATIONS

1.0 CM340/CM360 Model Chart

CM Series Midband 66-88 MHz			
Model		Description	
MDM50FNC9AN2_N		CM340 66-88 MHz 1-25W 10-Ch	
MDM50FNF9AN2_N		CM360 66-88 MHz 1-25W 100-Ch	
Item		Description	
X		FUC1601_	S. Tanapa Midband 25W 10 Ch BNC
	X	FUC1603_	S. Tanapa Midband 25W 100 Ch BNC
X		FCN6288_	Control Head
	X	FCN5523_	Control Head
X	X	HKN4137_	Battery Power Cable
X	X	HMN3596_	Compact Microphone
X	X	GLN7324_	Low Profile Trunnion
X	X	6866546D02_	RTTE Leaflet
X	X	6866537D37_	Safety Leaflet
X		PMUC1033AS	Servicing Kit CM340
	X	FUC1605AS	Servicing Kit CM360

X = Indicates one of each is required

2.0 Technical Specifications

Data is specified for +25°C unless otherwise stated.

General	
Specification	Midband
Frequency Range:	66-88 MHz
Frequency Stability (-30°C to +60°C, 25°C Ref.)	±5 PPM
Channel Capacity:	CM340 - 10 CM360 - 100
Channel Spacing:	12.5/20/25 kHz
Power Output:	1-25W
Power Supply:	13.2Vdc (10.8 - 15.6 Vdc) negative vehicle ground
Dimensions (L X W X H)	118mm X 169mm X 44mm
Weight: Low power (1-25W)	1.02 Kg
Operating Temperature	-30 to 60 ° C
Storage temperature	-40 to 80° C
Shock and Vibration	Meets MIL-STD 810-C,D&E and TIA/EIA 603
Dust	Meets MIL-STD 810-C,D&E and TIA/EIA 603
Humidity	Meets MIL-STD 810-C,D&E and TIA/EIA 603

Transmitter	
Specification	Midband
Frequency Stability:	+/- 5ppm
Modulation Limiting:	$\pm 2.5 \text{ kHz}$ @ 12.5 kHz $\pm 4.0 \text{ kHz}$ @ 20 kHz $\pm 5.0 \text{ kHz}$ @ 20/25 kHz
Current Drain Transmit:	8A (25W)
FM Hum and Noise:	-40 dB@12.5 kHz -45 dB@ 20/25 kHz
Conducted/Radiated Emissions:	-36 dBm < 1 GHz -30 dBm > 1 GHz
Adjacent Channel Power	-60dB @12.5, -70dB @ 20/25kHz
Audio Response: (300 to 3000Hz)	+1, -3dB
Audio Distortion: @ 1000 Hz, 60% Rated Maximum Deviation:	3% Typical

Receiver	
Specification	Midband
Sensitivity (12dBSINAD): (ETS)	0.35 μ V (12.5kHz) 0.30 μ V (25kHz) Typical
Intermodulation : (ETS)	>65dB
Adjacent Channel Selectivity: (ETS)	70 dB @ 25 kHz 60 dB @ 12.5 kHz
Spurious Rejection: (ETS)	70 dB
Rated Audio: (ETS) (Extended audio with 4 Ohm speaker)	4W Internal , 13W External
Audio Distortion @ Rated Audio:	3% Typical
Hum and Noise:	-40 dB @ 12.5 kHz -45 dB @ 20/25 kHz
Audio Response: (300 to 3000Hz)	+1, -3dB
Conducted Spurious Emission per FCC Part 15:	-57 dBm <1 GHz -47 dBm >1 GHz

*Availability subject to the laws and regulations of individual countries.

Chapter 2

THEORY OF OPERATION

1.0 Introduction

This Chapter provides a detailed theory of operation for the Midband circuits in the radio. Details of the theory of operation and trouble shooting for the the associated Controller circuits are included in this Section of the manual.

2.0 Midband (66-88MHz) Receiver

2.1 Receiver Front-End

The received signal from the antenna connector is filtered by the harmonic filter (common to both receive and transmit) and routed to the front end via the antenna switch. The signal is routed to 2-pole pre-selector filter tuned by a dual varacter diode D2301, and on to the LNA, Q2301. This is followed by a 3dB attenuator and a 2-pole post selector filter, tuned by varactor D2304. The varactor control voltage is generated by a DAC in the ASIFC (U504-6). An inverting op-amp stage (U517) amplifies the control signal to provide 0-8V. Signal RX_FE_TUNE voltage is increased under software control for higher receive frequencies. Note that the same DAC is used to control the transmitter power. The 9V supply to the LNA (Q2301) is turned on by Q4 when RX_EN is high. Q2302 controls the biasing so that Q2301 is operated with a constant collector current (15mA).

In Local Mode, attenuator R38 improves the intermodulation performance prior to the first mixer. In Distance Mode, normal operation, R38 is bypassed by diode D1, which is forward biassed by Q1 turning on when the LOC_DIST line from the microprocessor (U403-45) is high.

The first mixer is a passive, double-balanced type, consisting of T1, T2 and U1. This mixer provides all of the necessary rejection of the half-IF spurious response. High-side injection at +15 dBm is delivered to the first mixer. The mixer output is then connected to a duplex network which matches its output to the XTAL filter input (FL2201) at the IF frequency of 21.4 MHz. The duplex network terminates into a 50 ohm resistor (R41) at all other frequencies.

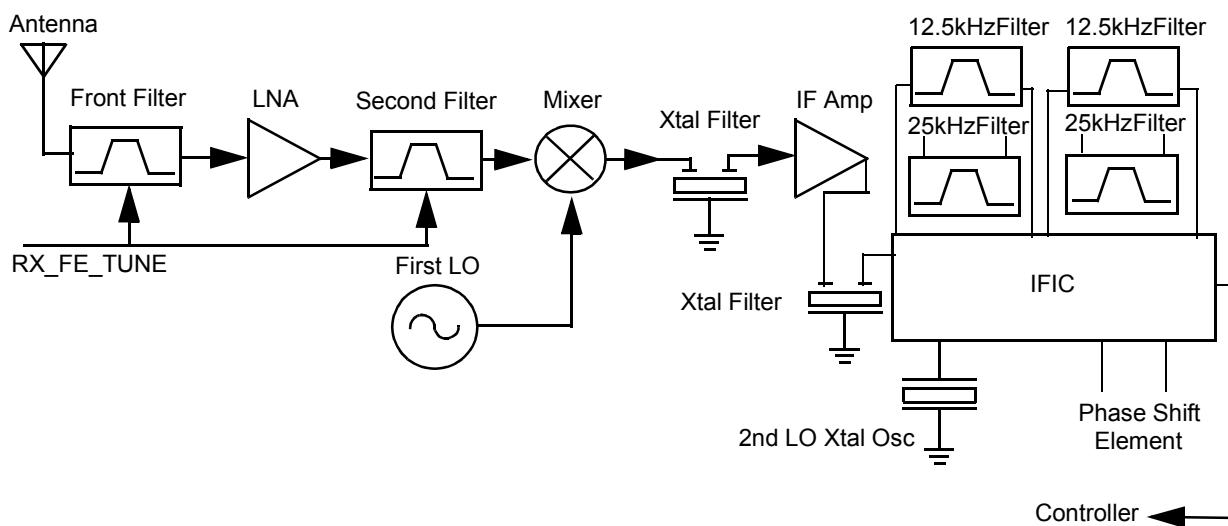


Figure 2-1 Midband Receiver Block Diagram

2.2 Receiver Back End

The IF signal from the crystal filter enters the IF amplifier which provides 20 dB of gain and feeds the IF IC (U2) at pin 1. The first IF signal at 21.4 MHz mixes with the second local oscillator (LO) at 20.945 MHz to produce the second IF at 455 kHz. The second LO uses the external crystal Y2. The second IF signal is amplified and filtered by two external ceramic filters (FL4/FL3 for 12.5KHz channel spacing and FL5/FL2 for 25KHz channel spacing). The IF IC demodulates the signal by means of a quadrature detector and feeds the detected audio (via pin 7) to the audio processing circuits. At IF IC pin 5, an RSSI signal is available with a dynamic range of 70 dB.

3.0 Midband Transmitter Power Amplifier (66-88 MHz)

The radio's 25W PA is a three-stage amplifier used to amplify the output from the TX_INJ to the antenna port. All three stages utilize LDMOS technology. The gain of the first stage (U101) and the second stage (Q105) is adjustable and is controlled by pin 7 of U103-2 via U103-3 and U102-1. It is followed by an LDMOS final stage Q100.

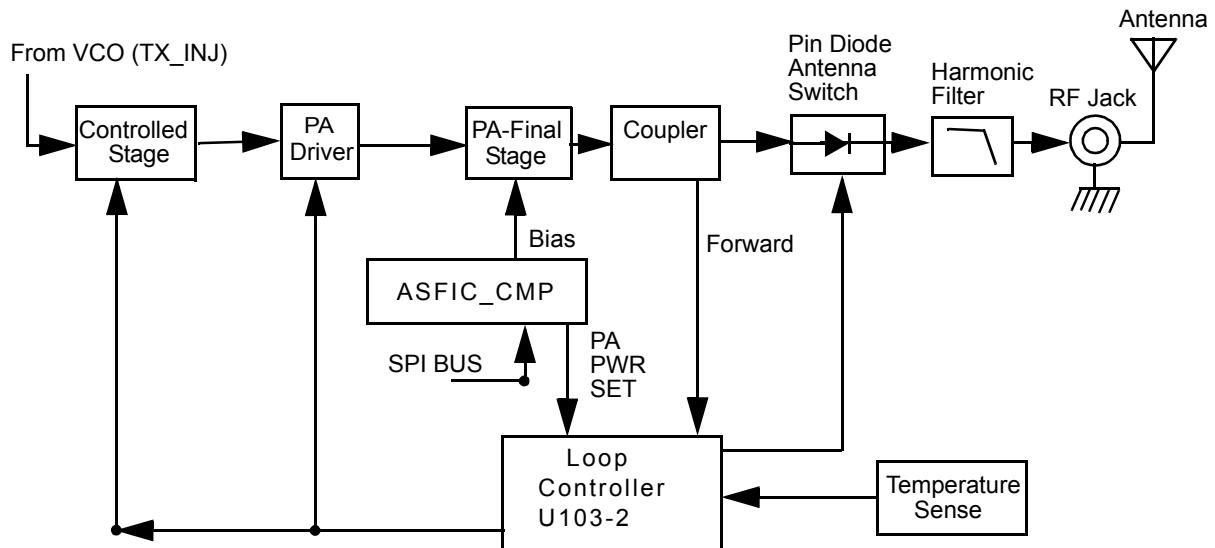


Figure 2-2 Midband Transmitter Block Diagram

Devices U101, Q105 and Q100 are surface mounted. When assembled, Q100 is in direct contact with the chassis. Heat spreader M105 ensures good thermal contact for Q105.

3.1 First Power Controller Stage

The first stage (U101) is a variable gain integrated circuit containing two LDMOS FET amplifier stages which can provide up to 20dB gain. It amplifies the RF signal from the VCO (TX_INJ). The output power of stage U101 is controlled by a DC voltage applied to pin 1 from the op-amp U103-3, pin 8. The control voltage simultaneously varies the bias of two FET stages within U101. This biasing point determines the overall gain of U101 and therefore its output drive level to Q105, which in turn controls the output power of the PA.

For a given control voltage input on VCNTR1, Op-amp U103-3 monitors the drain current of U101 via resistor R122 and adjusts the bias voltage of U101 accordingly.

In receive mode, the DC voltage from RX_EN line turns on Q101, grounding VCNTR1, which in turn switches off the biasing voltage to U101.

3.2 Power Controlled Driver Stage

The next stage is an LDMOS device (Q105) which provides a gain of up to 15dB. This device requires a positive gate bias and a quiescent current flow for proper operation. The bias is set during transmit mode by the drain current control op-amp U102-1, and fed to the gate of Q105 via the resistive network (R175, R147, R178, R179).

For a given control voltage input on VCNTR2, Op-amp U102-1 monitors the drain current of Q105 via resistors R126-7 and adjusts the bias voltage of Q105 so that the current remains constant.

In receive mode the DC voltage from RX_EN line turns on Q102, grounding VCNTR1, which in turn switches off the biasing voltage to Q105.

3.3 Final Stage

The final stage is an LDMOS device (Q100) providing a gain of 12dB. This device also requires a positive gate bias and a quiescent current flow for proper operation. The voltage of the line PA_BIAS is set in transmit mode by the ASIC and fed to the gate of Q100 via the resistive network R134, R131. This bias voltage is tuned in the factory. If the transistor is replaced, the bias voltage must be tuned using the Tuner. 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, B+, via L117 and L115.

The output matching network transforms the impedance to 50 ohms and feeds the directional coupler.

3.4 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 Q100. The coupled signal is rectified to an output power which is proportional to the DC voltage rectified by diode D105; and the resulting DC voltage is routed to the power control section to ensure that the forward power out of the radio is held to a constant value.

3.5 Antenna Switch

The antenna switch utilizes the existing dc feed (B+) to the last stage device (Q100). In transmit mode, both PIN diodes (D103, D104) are forward biased. This is achieved by pulling down the voltage at the cathode end of D104 to around 12.4V (0.7V drop across each diode). The current through the diodes needs to be set at around 100 mA to fully open the transmit path through resistor R108. Q106 is a current source controlled by Q103 which is turned on in Tx mode by TX_EN. VR102 ensures that the voltage at resistor R107 never exceeds 5.6V, limiting the current to approximately 100mA.

3.6 Harmonic Filter

Inductors L1511, L1512, L1513 and L1515 along with capacitors C1518 to C1523, C1528, C1532 to C1535, C1537 to C1539 and C1542 form a 9-element elliptical low-pass filter to attenuate harmonic energy coming from the transmitter. Resistor R152 drains 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 to improve spurious response rejection.

3.7 Power Control

The output power is regulated by using a forward power detection control loop. A directional coupler samples a portion of the forward and reflected RF power. The forward sampled RF is rectified by diode D105, and the resulting DC voltage is routed to the operational amplifier U100. The error output current is then routed to an integrator, and converted into the control voltage. This voltage controls the bias of the pre-driver (U101) and driver (Q105) stages. The output power level is set by way of a DAC, PWR_SET, in the ASFIC (U504), which acts as the forward power control loop reference.

The sampled reflected power is rectified by diode D107. The resulting DC voltage is amplified by an operational amplifier U100 and routed to the summing junction. This detector protects the final stage Q100 from reflected power by increasing the error current. The temperature sensor protects the final stage Q100 from overheating by increasing the error current. A thermistor RT100 measures the final stage Q100 temperature. The voltage divider output is routed to an operational amplifier U103 and then goes to the summing junction. The Zener Diode VR101 keeps the loop control voltage below 5.6V and eliminates the DC current from the 9.3 regulator U501.

Two local loops for the Pre Driver (U101) and for the Driver (Q105) are used in order to stabilize the current for each stage.

In Rx mode, the two transistors Q101 and Q102 go to saturation and shut down the transmitter by applying ground to the Pre Driver U101 and for the Driver Q105 control.

VR103, VR104 and Q104, Q108, Q109 and associated circuitry provide protection during load dump transients.

4.0 Midband (66-88MHz) Frequency Synthesis

The synthesizer consists of a reference oscillator (Y202), low voltage Fractional-N (LVFRAC-N) synthesizer (U200), and a voltage controlled oscillator (VCO) (Q2741/Q2751).

4.1 Reference Oscillator

The reference oscillator is a crystal (Y202) controlled Colpitts oscillator and has a frequency of 16.8MHz. The oscillator transistor and start-up circuit are located in the LVFRAC-N (U200) while the oscillator feedback capacitors, crystal, and tuning varactors are external. An analog-to-digital (A/D) converter internal to the LVFRAC-N (U200) and controlled by the microprocessor via SPI sets the voltage at the warp output of U200 pin 25. This sets the frequency of the oscillator. Consequently, the output of the crystal Y202 is applied to U200 pin 23.

The method of temperature compensation is to apply an inverse Bechmann voltage curve, which matches the crystal's Bechmann curve to a varactor that constantly shifts the oscillator back on frequency. The crystal vendor characterizes the crystal over a specified temperature range and codes this information into a bar code that is printed on the crystal package. In production, this crystal code is read via a 2-dimensional bar code reader and the parameters are saved.

This oscillator is temperature compensated to an accuracy of +/-2.5 PPM from -30 to 60 degrees C. The temperature compensation scheme is implemented by an algorithm that uses five crystal parameters (four characterize the inverse Bechmann voltage curve and one for frequency accuracy of the reference oscillator at 25 degrees C). This algorithm is implemented by the LVFRAC-N (U200) at the power up of the radio.

4.2 Fractional-N Synthesizer

The LVFRAC-N U200 consists of a pre-scaler, programmable loop divider, control divider logic, phase detector, charge pump, A/D converter for low frequency digital modulation, balanced attenuator used to balance the high and low frequency analog modulation, 13V positive voltage multiplier, serial interface for control, and a super filter for the regulated 9 volts.

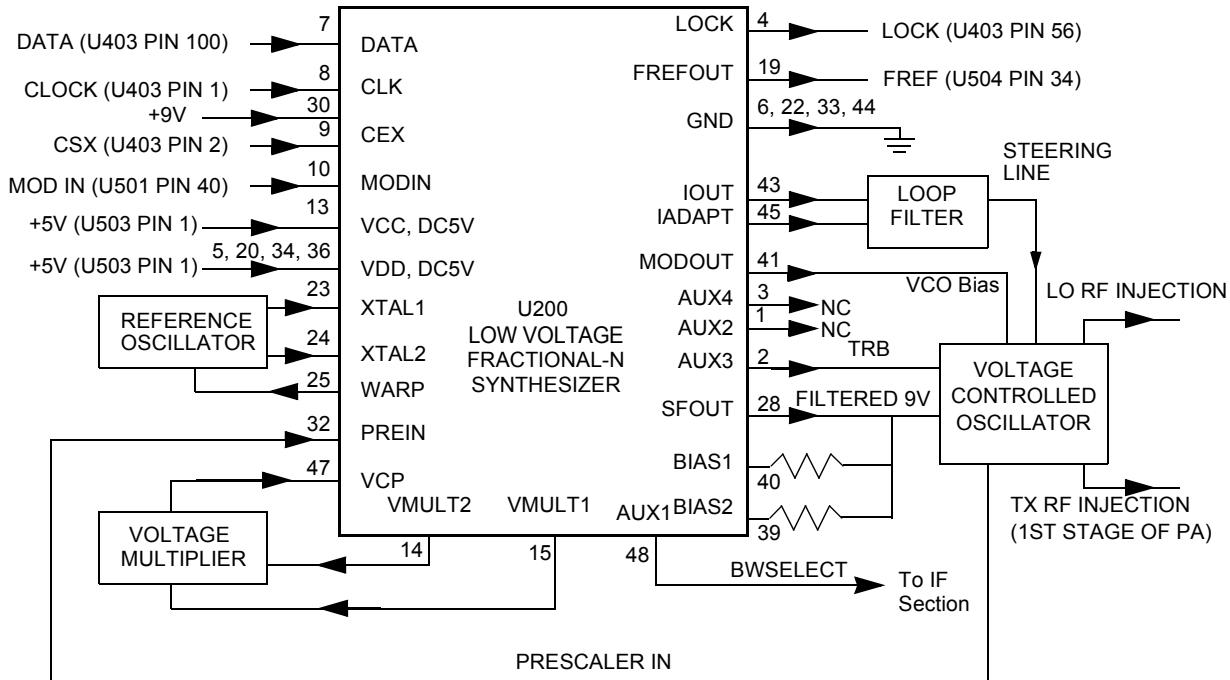


Figure 2-3 Midband Synthesizer Block Diagram

A voltage of 9.3V applied to the super filter input (U200, pin 30) supplies an output voltage of 8.6Vdc (VSF) at U200, pin 28. This supplies 8.6 V to the two VCO circuits.

To generate a high voltage to supply the phase detector (charge pump) output stage at pin VCP (U200, pin 47) while using a low voltage 5Vdc supply, a 13V positive voltage multiplier is used (D200, D201, and capacitors C2024, 2025, 2026, 2055, 2027, 2001).

Output lock (U200, pin 4) provides information about the lock status of the synthesizer loop. A high level at this output indicates a stable loop. A 16.8 MHz reference frequency is provided at U200, pin 19.

4.3 Voltage Controlled Oscillator (VCO)

The Voltage Controlled Oscillator (VCO) uses 2 colpitts oscillators, FET Q2741 for transmit and FET Q2751 for receive. The appropriate oscillator is switched on or off by LVFRAC-N IC output AUX3 (U200-2) using transistors Q2742 and Q2752. In RX mode AUX3 is nearly at ground level and Q2742 enables a current flow from the source of FET Q2751 while Q2752 is switched off. In TX mode AUX3 is about 3.3V DC and Q2742 is switched off. Q2752 is switched on and enables a current flow from the source of FET Q2741 while Q2751 is switched off. When switched on the FETs draw a drain current of 8 mA from the LVFRAC-N IC super filter output. The frequency of the receive oscillator is mainly determined by L2752, L2753, C2752 - C2756 and varactor diodes D2751 / D2752. Diode D2754 controls the amplitude of the oscillator. The frequency of the transmit oscillator is mainly determined by L2734, C2736 - C2740 and varactor diodes D2732 / D2733. Diode D2739 controls the amplitude of the oscillator. With a steering voltage from 3V to 10V at the varactor diodes the RX frequency range from 87.4 MHz to 109.4 MHz and the TX frequency range from 66 MHz to 88 MHz are covered. In TX mode the modulation signal coming from the LVFRAC-N synthesizer IC (U200 pin 41) modulates the TX VCO via varactor diode D2731.

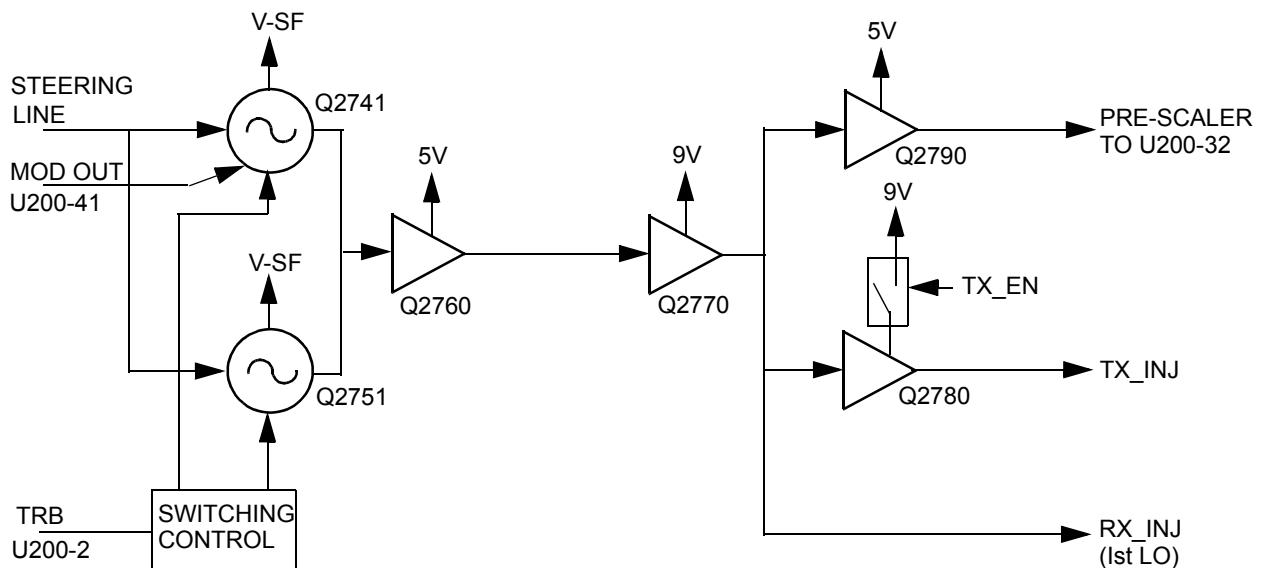


Figure 2-4 Midband VCO Block Diagram

Both oscillator outputs are combined and buffered by the VCO Buffer Q2760. Q2760 draws a collector current of 13 mA from the stabilized 5V and drives the Mixer Buffer Q2770. Q2770 draws a collector current of 19 mA from the 9V3 voltage and drives the PA Buffer Q2780 ($P_{out} = 13\text{dBm}$) and the Pre-scaler Buffer Q2790. Q2790 draws a collector current of 8 mA from the stabilized 5V and drives the pre-scaler internal to the LVFRAC-N IC. In transmit mode, the 9.3V supply for the TX PA Buffer Q2780, is turned on by Q2791. PA Buffer Q2780 draws a collector current of 19mA. The injection signal RX_INJ with a level of 10dBm feeds the mixer through R2774. The buffer stages Q2760, Q2770, Q2780 and the feedback amplifier Q2790 provide the necessary gain and isolation for the synthesizer loop.

4.4 Synthesizer Operation

The synthesizer consists of a low voltage FRAC-N IC (LVFRAC-N), reference oscillator, charge pump circuits, loop filter circuit, and DC supply. The output from the pre-scaler buffer (Q2790) is fed to the PREIN, pin 32 of U200 via a low pass filter which attenuates harmonics and provides a correct input level to the LVFRAC-N in order to close the synthesizer loop.

The pre-scaler in the synthesizer (U200) is 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 SPI. 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 (Y202).

The output signal of the phase detector is a pulsed dc signal that is routed to the charge pump. The charge pump outputs a current from U200, pin 43 (IOUT). The loop filter (consisting of R224, R217, R234, C2074, C2078, C2028, and L205) transforms this current into a voltage that is applied to the varactor diodes D2751, D2752 for Rx and D2732, D2733 for Tx. The output frequency is determined by this control voltage. The current can be set to a value fixed in the LVFRAC-N or to a value determined by the currents flowing into BIAS 1 (U200, pin 40) or BIAS 2 (U200, pin 39). The currents are set by the value of R200 or R206 respectively. The selection of the three different bias sources is done by software programming.

To modulate the synthesizer loop, a two-spot modulation method is utilized via the MODIN (U200, pin 10) input of the LVFRAC-N. The audio signal is applied to both the A/D converter (low frequency path) and the balance 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 presented at the MODOUT port of the LVFRAC-N (U200 pin 41) and connected to the VCO modulation varactor D2731.

5.0 Controller Theory of Operation

This section provides a detailed theory of operation for the radio and its components. The main radio is a single-board design, consisting of the transmitter, receiver, and controller circuits. A control head is connected by an extension cable. The control head contains LED indicators, a microphone connector, buttons, and speaker.

In addition to the power cable and antenna cable, an accessory cable can be attached to a connector on the rear of the radio. The accessory cable enables you to connect accessories to the radio, such as an external speaker, emergency switch, foot-operated PTT, and ignition sensing, etc.

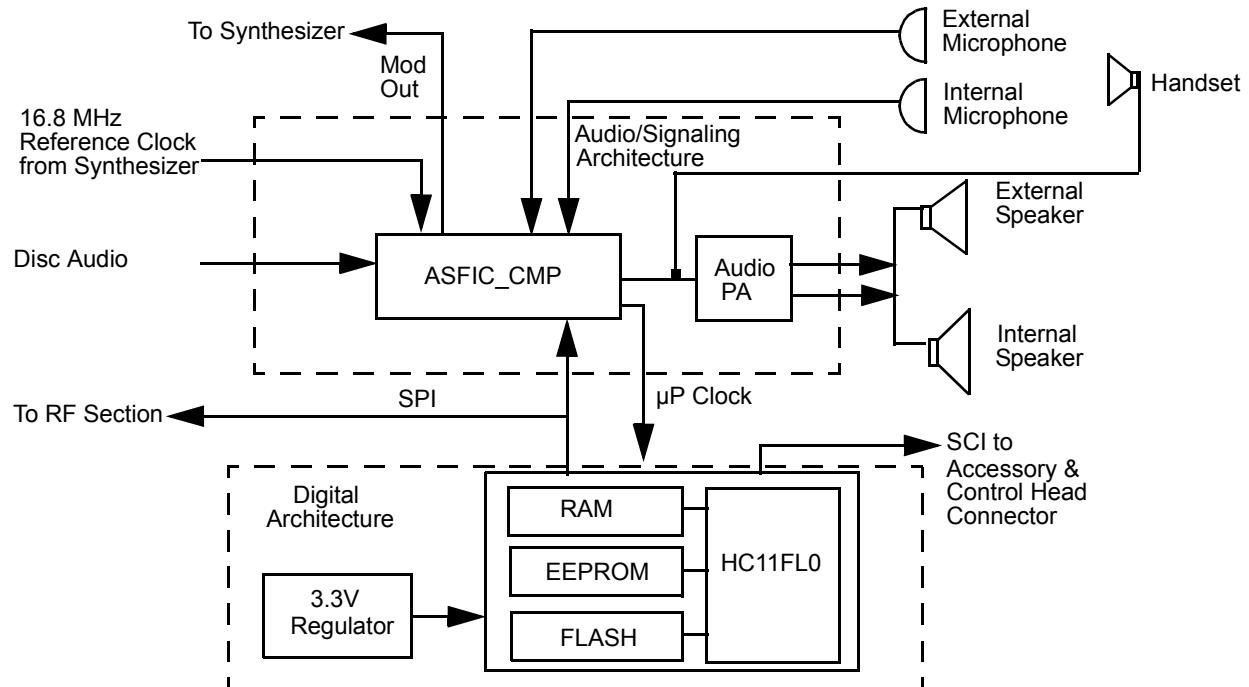


Figure 2-5 Controller Block Diagram

5.1 Radio Power Distribution

Voltage distribution is provided by five separate devices:

- U514 P-ch FET - Batt + (Ext_SWB+)
- U501 LM2941T - 9.3V
- U503 LP2951CM - 5V
- U508 MC 33269DTRK - 3.3V
- U510 LP2986ILDX - 3.3V Digital

The DC voltage applied to connector P2 supplies power directly to the following circuitry:

- Electronic on/off control
- RF power amplifier
- 12 volts P-ch FET -U514
- 9.3 volt regulator
- Audio PA

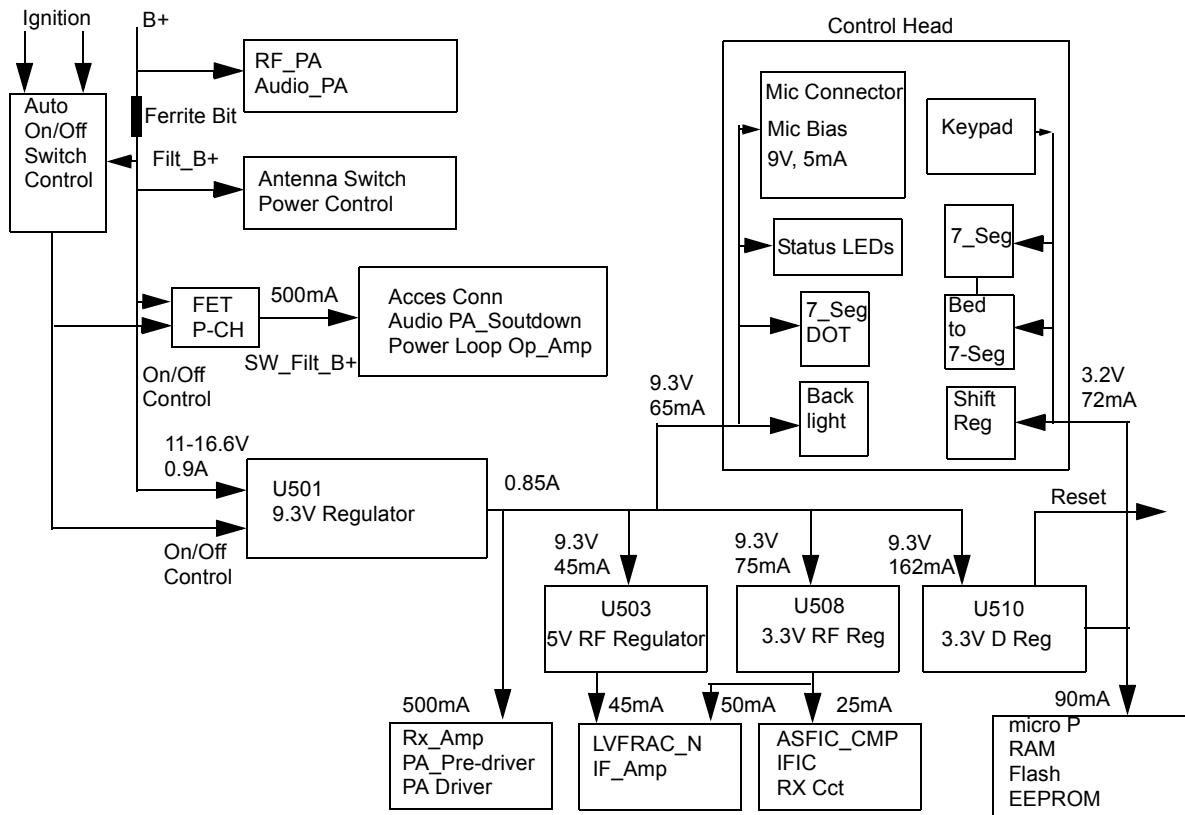


Figure 2-6 DC Power Distribution Block Diagram

Regulator U501 is used to generate the 9.3 volts required by some audio circuits, the RF circuitry and power control circuitry. Input and output capacitors are used to reduce high frequency noise. Resistors R5001 / R5081 set the output voltage of the regulator. This regulator output is electronically enabled by a 0 volt signal on pin 2. Q502, Q505 and R5038 are used to disable the regulator when the radio is turned off.

Voltage regulator U510 provides 3.3 volts for the digital circuitry. Operating voltage is from the regulated 9.3V supply. Input and output capacitors are used to reduce high frequency noise and provide proper operation during battery transients. U510 provides a reset output that goes to 0 volts if the regulator output goes below 3.1 volts. This is used to reset the controller to prevent improper operation.

Voltage regulator U508 provides 3.3V for the RF circuits and ASFIC_CMP. Input and output capacitors are used to reduce the high frequency noise and provide proper operation during battery transients.

Voltage regulator U503 provides 5V for the RF circuits. Input and output capacitors are used to reduce the high frequency noise and provide proper operation during battery transients.

VSTBY is used only for CM360 5-tone radios.

The voltage VSTBY, which is derived directly from the supply voltage by components R5103 and VR502, is used to buffer the internal RAM. Capacitor C5120 allows the battery voltage to be disconnected for a couple of seconds without losing RAM parameters. Dual diode D501 prevents radio circuitry from discharging this capacitor. When the supply voltage is applied to the radio, C5120 is charged via R5103 and D501.

5.2 Protection Devices

Diode VR500 acts as protection against ESD, wrong polarity of the supply voltage, and load dump. VR692 - VR699 are for ESD protection.

5.3 Automatic On/Off

The radio can be switched ON in any one of the following ways:

- On/Off switch. (No Ignition Mode)
- Ignition and On/Off switch (Ignition Mode)
- Emergency

5.3.1 No Ignition Mode

When the radio is connected to the car battery for the first time, Q500 will be in saturation, Q503 will cut-off, Filt_B+ will pass through R5073, D500, and S5010-pin 6 (On/Off switch). When S5010 is ON, Filt_B+ will pass through S5010-pin5, D511, R5069, R5037 and base of Q505 and move Q505 into saturation. This pulls U501-pin2 through R5038, D502 to 0.2V and turns On U514 and U501 9.3V regulator which supplies voltage to all other regulators and consequently turns the radio on, When U504 (ASIC_CMP) gets 3.3V, GCB2 goes to 3.3V and holds Q505 in saturation, for soft turn off.

5.3.2 Ignition Mode

When ignition is connected for the first time, it will force high current through Q500 collector, This will move Q500 out of saturation and consequently Q503 will cut-off. S5010 pin 6 will get ignition voltage through R601 (for load dump), R610, (R610 & C678 are for ESD protection), VR501, R5074, and D500. When S5010 is ON, Filt_B+ passes through S5010-pin 5, D511, R5069, R5037 and base of Q505 and inserts Q505 into saturation. This pulls U501-pin 2 through R5038, D502 to 0.2V and turns on U514 and U501 9.3V regulator which supply voltage to all other regulators and turns the radio on, When U504 (ASIC_CMP) get 3.3V supply, GCB2 goes to 3.3V and holds Q505 in saturation state to allow soft turn off,

When ignition is off Q500, Q503 will stay at the same state so S5010 pin 6 will get 0V from Ignition, Q504 goes from Sat to Cut, ONOFF_SENSE goes to 3.3V and it indicates to the radio to soft turn itself by changing GCB2 to '0' after de registration if necessary.

5.3.3 Emergency Mode

The emergency switch (P1 pin 9), when engaged, grounds the base of Q506 via EMERGENCY _ACCES_CONN. This switches Q506 to off and consequently resistor R5020 pulls the collector of Q506 and the base of Q506 to levels above 2 volts. Transistor Q502 switches on and pulls U501 pin2 to ground level, thus turning ON the radio. When the emergency switch is released R5030 pulls the base of Q506 up to 0.6 volts. This causes the collector of transistor Q506 to go low (0.2V), thereby switching Q502 to off.

While the radio is switched on, the μ P monitors the voltage at the emergency input on the accessory connector via U403-pin 62. Three different conditions are distinguished: no emergency kit is connected, emergency kit connected (unpressed), and emergency press.

If no emergency switch is connected or the connection to the emergency switch is broken, the resistive divider R5030 / R5049 will set the voltage to about 3.14 volts (indicates no emergency kit found via EMERGENCY_SENSE line). If an emergency switch is connected, a resistor to ground within the emergency switch will reduce the voltage on EMERGENCY_SENSE line, and indicate to the μ P that the emergency switch is operational. An engaged emergency switch pulls line EMERGENCY_SENSE line to ground level. Diode VR503 limits the voltage to protect the μ P input.

While EMERGENCY_ACCES_CONN is low, the μ P starts execution, reads that the emergency input is active through the voltage level of μ P pin 64, and sets the DC POWER ON output of the ASFIC CMP pin 13 to a logic high. This high will keep Q505 in saturation for soft turn off.

5.4 Microprocessor Clock Synthesiser

The clock source for the μ P system is generated by the ASFIC CMP (U504). 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 audio circuitry, 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 will generate its default 3.6864MHz CMOS square wave UP CLK (on U504 pin 28) and this is routed to the μ P (U403 pin 90). After the μ 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 the clock source interfering with the desired radio receive frequency.

The ASFIC CMP synthesizer loop uses C5025, C5024 and R5033 to set the switching time and jitter of the clock output. If the synthesizer cannot generate the required clock frequency it will switch back to its default 3.6864MHz output.

Because the ASFIC CMP synthesizer and the μ P system will not operate without the 16.8 MHz reference clock it (and the voltage regulators) should be checked first when debugging the system.

5.5 Serial Peripheral Interface (SPI)

The μ P communicates to many of the IC's through its SPI port. This port consists of SPI TRANSMIT DATA (MOSI) (U403-pin100), SPI RECEIVE DATA (MISO) (U403-pin 99), SPI CLK (U0403-pin1) and chip select lines going to the various IC's, connected on the SPI PORT (BUS). This BUS is a synchronous bus, in that the timing clock signal CLK is sent while SPI data (SPI TRANSMIT DATA or SPI RECEIVE DATA) 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 is used to send serial from a μ P to a device, and SPI RECEIVE DATA is used to send data from a device to a μ P.

There are two IC's on the SPI BUS, ASFIC CMP (U504 pin 22), and EEPROM (U400). In the RF sections there is one IC on the SPI BUS, the FRAC-N Synthesizer. The chip select line CSX from U403 pin 2 is shared by the ASFIC CMP and FRAC-N Synthesizer. Each of these IC's check the SPI data and when the sent address information matches the IC's address, the following data is processed.

When the μ P needs to program any of these ICs 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 to the various IC's are different; e.g., the ASFIC CMP can receive up to 19 bytes (152 bits). After the data has been sent the chip select line is returned to logic "1".

5.6 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) or the cable with internal RIB. This interface connects to the SCI pin via control head connector (J2-pin 17) and to the accessory connector P1-6 and comprises BUS+. The line is bi-directional, meaning that either the radio or the RIB can drive the line. The μ P sends serial data and it reads serial data via pin 97. Whenever the μ P detects activity on the BUS+ line, it starts communication.

5.7 General Purpose Input/Output

The controller provides six general purpose lines (PROG I/O) available on the accessory connector P1 to interface to external options. Lines PROG IN 3 and 6 are inputs, PROG OUT 4 is an output and PROG IN OUT 8, 12 and 14 are bi-directional. The software and the hardware configuration of the radio model define the function of each port.

- PROG IN 3 can be used as external PTT input, or others, set by the CPS. The μ P reads this port via pin 72 and Q412.
- PROG OUT 4 can be used as external alarm output, set by the CPS. Transistor Q401 is controlled by the μ P (U403 pin 55)
- PROG IN 6 can be used as normal input, set by the CPS. The μ P reads this port via pin 73 and Q411. This pin is also used to communicate with the RIB if resistor R421 is placed.
- DIG IN OUT 8,12,14 are bi-directional and use the same circuit configuration. Each port uses an output Q416, Q404, Q405 controlled by μ P pins 52, 53, 54. The input ports are read through μ P pins 74, 76, 77; using Q409, Q410, Q411

5.8 Normal Microprocessor Operation

For this radio, the µP is configured to operate in one of two modes, expanded and bootstrap. In expanded mode the µP uses external memory devices to operate, whereas in bootstrap operation the µP uses only its internal memory. In normal operation of the radio the µP is operating in expanded mode as described below.

During normal operation, the µP (U403) is operating in expanded mode and has access to 3 external memory devices; U400 (EEPROM), U402 (SRAM), U404 (Flash). Also, within the µP there are 3 Kilobytes of internal RAM, as well as logic to select external memory devices.

The external EEPROM (U400) space contains the information in the radio which is customer specific, referred to as the codeplug. This information consists of items such as: 1) what band the radio operates in, 2) what frequencies are assigned to what channel, and 3) tuning information.

The external SRAM (U402) as well as the µP's own internal RAM space are used for temporary calculations required by the software during execution. All of the data stored in both of these locations is lost when the radio powers off.

The µP provides an address bus of 16 address lines (ADDR 0 - ADDR 15), and a data bus of 8 data lines (DATA 0 - DATA 7). There are also 3 control lines; CSPROG (U403-pin 38) to chip select U404-pin 30 (FLASH), CSGP2 (U403-pin 41) to chip select U404-pin 20 (SRAM) and PG7_R_W (U403-pin 4) to select whether to read or to write. The external EEPROM (U400-pin1).

When the µP is functioning normally, the address and data lines should be toggling at CMOS logic levels. Specifically, the logic high levels should be between 3.1 and 3.3V, and the logic low levels should be between 0 and 0.2V. 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 1us/div. or faster to observe individual pulses. High speed CMOS transitions should also be observed on the µP control lines.

On the µP the lines XIRQ (U403-pin 48), MODA LIR (U403-pin 58), MODB VSTPY (U403-pin 57) and RESET (U403-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 20ms. In the case of shorted lines you may also detect the line periodically at an intermediate level, i.e. around 2.5V when two shorted lines attempt to drive to opposite rails.

The MODA LIR (U403-pin 58) and MODB VSTPY (U403-pin 57) inputs to the µP must be at a logic "1" for it to start executing correctly. After the µP starts execution it will periodically pulse these lines to determine the desired operating mode. While the Central Processing Unit (CPU) is running, MODA LIR is an open-drain CMOS output which goes low whenever the µP begins a new instruction. An instruction typically requires 2-4 external bus cycles, or memory fetches.

There are eight analog-to-digital converter ports (A/D) on U403 labelled within the device block as PEO-PE7. These lines sense the voltage level ranging from 0 to 3.3V 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.

5.9 Static Random Access Memory (SRAM)

The SRAM (U402) 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 U402 (which comes from U403-CSGP2) going low. U402 is commonly referred to as the external RAM as opposed to the internal RAM which is the 3 Kilobytes of RAM which is 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 C402 and C411 serves to filter out any AC noise which may ride on +3.3 V at U402

6.0 Control Board Audio and Signalling Circuits

6.1 Audio Signalling Filter IC and Compander (ASFIC CMP)

The ASFIC CMP (U504) used in the controller has the following four functions:

1. RX/TX audio shaping, i.e. filtering, amplification, attenuation
2. RX/TX signaling, PL/DPL/HST/MDC
3. Squelch detection
4. μ P clock signal generation

The ASFIC CMP is programmable through the SPI BUS (U504 pins-20/21/22), normally receiving 19 bytes. This programming sets up various paths within the ASFIC CMP to route audio and/or signaling signals through the appropriate filtering, gain and attenuator blocks. The ASFIC CMP also has 6 General Control Bits GCB0-5 which are CMOS level outputs and used for the following:

- GCB0 - BW Select
- GCB1 - switches the audio PA On/Off
- GCB2 - DC Power On switches the voltage regulator (and the radio) on and off
- GCB3 - Control on MUX U509 pin 9 to select between Low Cost Mic path to STD Mic Path
- GCB4 - Control on MUX U509 pin 11 to select between Flat RX path to filtered RX path on the accessory connector.
- GCB5 - Control on MUX U509 pin 10 to select between Flat TX path mute and Flat TX path

7.0 Transmit Audio Circuits

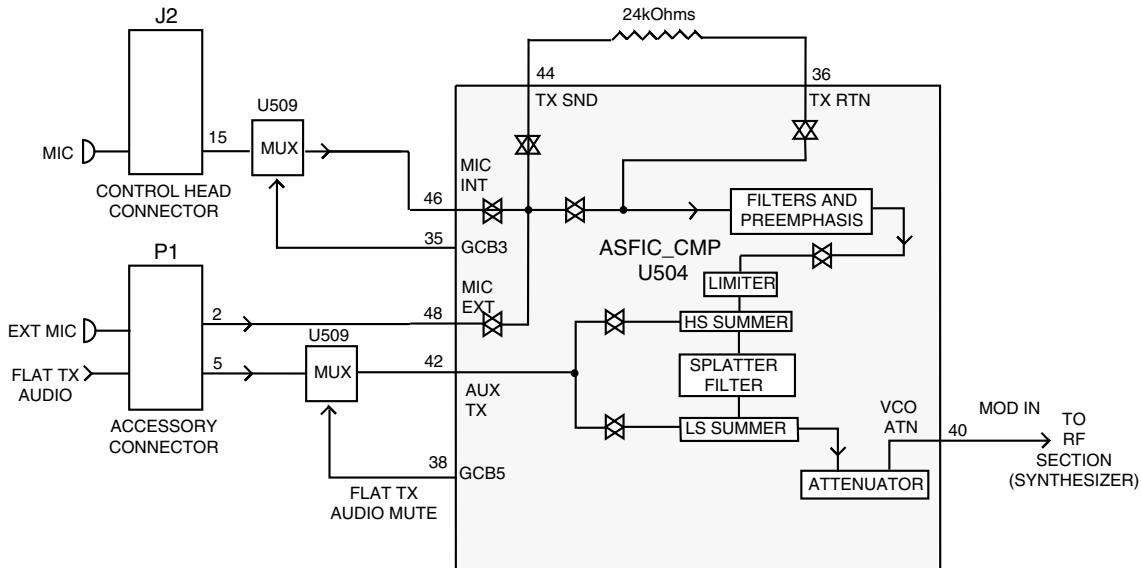


Figure 2-7 Transmit Audio Paths

7.1 Microphone Input Path

The radio supports 2 distinct microphone paths known as internal (from control head J2-15) and external mic (from accessory connector P1-2) and an auxiliary path (FLAT TX AUDIO, from accessory connector P1-5). The microphones used for the radio require a DC biasing voltage provided by a resistive network.

The two microphone audio input paths enter the ASIFC CMP at U504-pin 48 (external mic) and U504-pin 46 (internal mic). The microphone is plugged into the radio control head and connected to the audio DC via J2-pin 15. The signal is then routed via C5045 to MUX U509 that select between two paths with different gain to support Low Cost Mic (Mic with out amplifier in it) and Standard Mic.

7.1.1 Low Cost Microphone

Hook Pin is shorted to Pin 1(9.3V) inside the Low Cost Mic, This routes 9.3V to R429, and creates 2.6V on MIC_SENSE (u.P U403-67) by Voltage Divider R429/R430. U403 senses this voltage and sends command to ASIFC_CMP U504 to get GCB3 = '0'. The audio signal is routed from C5045 via U509-5 (Z0), R5072, U507, R5026, C5091, R5014 via C5046 to U504- 46 int. mic (C5046 100nF creates a 159Hz pole with U504- 46 int mic impedance of 16Kohm).

7.1.2 Standard Microphone

Hook Pin is shorted to the hook mic inside the standard Mic. If the mic is out off hook, 3.3V is routed to R429 via R458, D401, and it create 0.7V on MIC_SENSE (u.P U403-67) by Voltage Divider R429/R430. U403 senses this voltage and sends command to ASFIC_CMP U504 to get GCB3 ='1'. The audio signal is routed from C5045 via U509-3 (Z1), R5072, U507, R5026, C5091, R5014 via C5046 to U504- 46 int mic (C5046 100nF create a159Hz pole with U504- 46 int mic impedance of 16Kohm). 9.3VDC is routed via R5077, R5075 to J2-15, It create 4.65V with Mic Impedance. C5010 supplies AC Ground to create AC impedance of 510 Ohms via R5075. and Filter 9.3V DC mic bias supply.

Note: The audio signal at U504-pin 46 should be approximately 12mV for 1.5kHz or 3kHz of deviation with 12.5kHz or 25kHz channel spacing.

The external microphone signal enters the radio on accessory connector P1 pin 2 and is routed via line EXT MIC to R5054. R5078 and R5076 provide the 9.3Vdc bias. Resistive divider R5054/ R5070 divide the input signal by 5.5 and provide input protection for the CMOS amplifier input. R5076 and C5009 provide a 510 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.

C5047 serves as a DC blocking capacitor. The audio signal at U504-pin 48 should be approximately 14mV for 1.5kHz or 3kHz of deviation with 12.5kHz or 25kHz channel spacing.

The FLAT TX AUDIO signal from accessory connector P1-pin 5 is fed to the ASFIC CMP (U504 pin 42 through U509 pin 2 to U509 pin 15 via U506 OP-AMP circuit and C5057.

The ASFIC has an internal AGC that can control the gain in the mic audio path. The AGC can be disabled / enabled by the μ P. Another feature that can be enabled or disabled in the ASFIC is the VOX. This circuit, along with Capacitor C5023 at U504-pin 7, provides a DC voltage that can allow the μ P to detect microphone audio. The ASFIC can also be programmed to route the microphone audio to the speaker for public address operation.

7.2 PTT Sensing and TX Audio Processing

Internal microphone PTT is sensed by μ P U403 pin 71. Radio transmits when this pin is "0" and selects inside the ASFIC_CMP U504 internal Mic path. When the internal Mic PTT is "0" then external Mic PTT is grounded via D402. External Mic PTT is sensed by U403 pin 72 via Q412 circuits. The radio transmits when this pin is "0" and selects inside the ASFIC_CMP U504 External Mic path.

Inside the ASFIC CMP, the mic 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 mic audio is then routed through a summer, which is used to add in signaling 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 U504-pin 40 MOD IN, at which point it is routed to the RF section.

8.0 Transmit Signalling Circuits

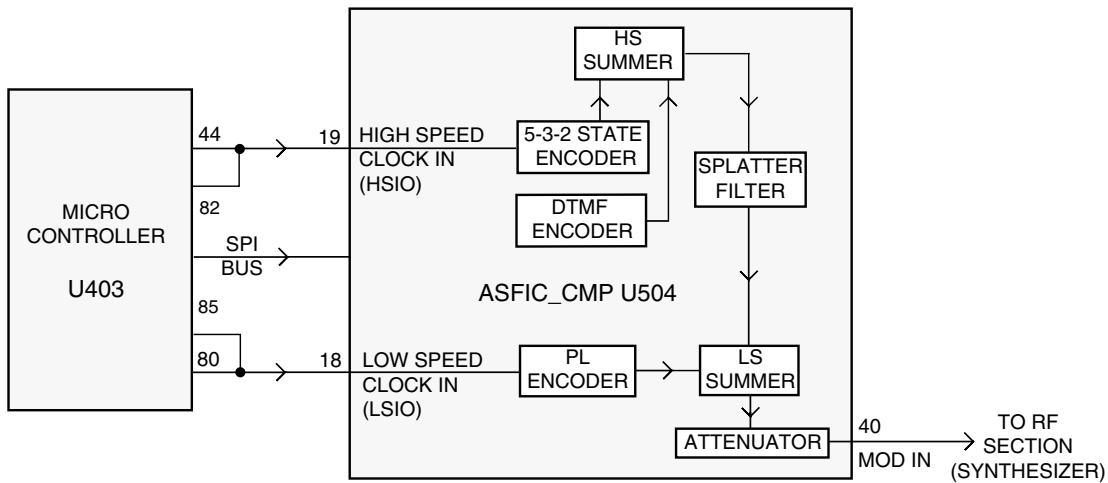


Figure 2-8 Transmit Signalling Path

From a hardware point of view, there are 3 types of signaling:

- Sub-audible data (PL / DPL / Connect Tone) that gets summed with transmit voice or signaling,
- DTMF data for telephone communication in trunked and conventional systems, and
- Audible signaling including MDC and high-speed trunking.

Note: All three types are supported by the hardware while the radio software determines which signaling type is available.

8.1 Sub-Audio Data (PL/DPL)

Sub-audible data implies signaling whose bandwidth 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 U504 (ASFIC CMP) at any one time. The process is as follows, using the SPI BUS, the μ P programs the ASFIC CMP to set up the proper low-speed data deviation and select the PL or DPL filters. The μ P then generates a square wave which strobes the ASFIC PL / DPL encode input LSIO U504-pin 18 at twelve times the desired data rate. For example, for a PL frequency of 103Hz, the frequency of the square wave would be 1236Hz.

This drives a tone generator inside U504 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 U504-pin 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.

8.2 High Speed Data

High speed data refers to the 3600 baud data waveforms, known as Inbound Signaling Words (ISWs) used in a trunking system for high speed communication between the central controller and the radio. To generate an ISW, the μ P first programs the ASFIC CMP (U504) to the proper filter and gain settings. It then begins strobing U504-pin 19 (HSIO) with a pulse when the data is supposed to change states. U504'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 attenuator and then out of the ASFIC CMP to the RF board. MDC is 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 signaling schemes are based on sending a combination of 1200 Hz and 1800 Hz tones only. Microphone audio is muted during high speed data signaling.

8.3 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 μ P (U403-46) strobing U504-19 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 μ P via SPI bus. Inside U504 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 was described for high-speed data.

9.0 Receive Audio Circuits

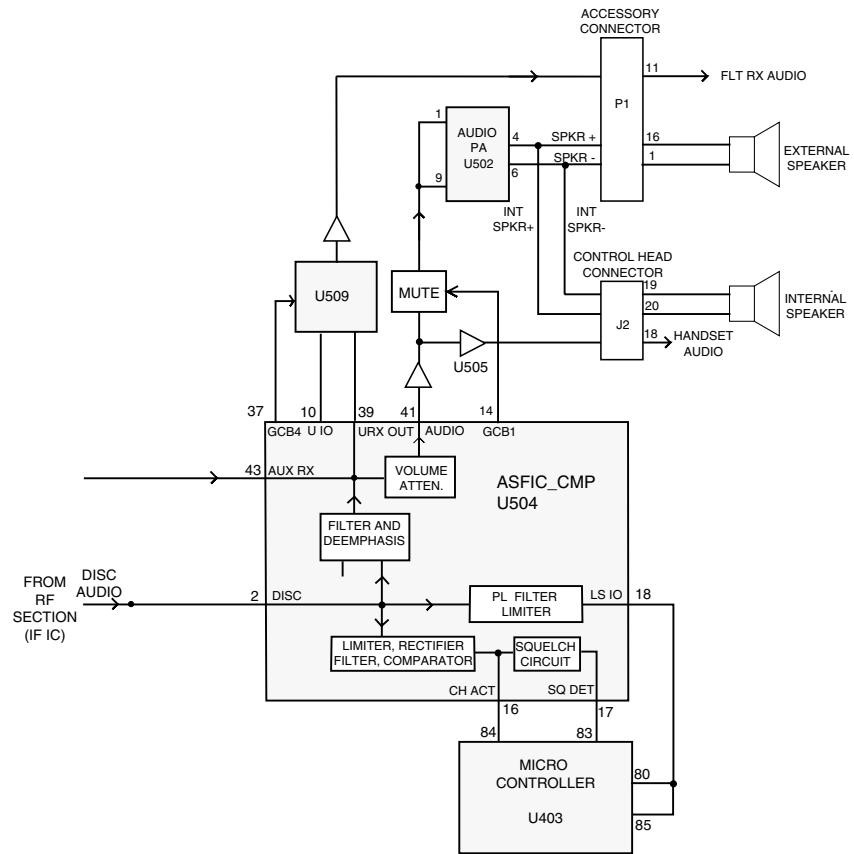


Figure 2-9 Receive Audio Paths

9.1 Squelch Detect

The radio's RF circuits are constantly producing an output at the discriminator (IF IC). This signal (DISC AUDIO) is routed to the ASFiC CMP's squelch detect circuitry input DISC (U504-pin 2). All of the squelch detect circuitry is contained within the ASFiC CMP. Therefore from a user's point of view, DISC AUDIO enters the ASFiC CMP, and the ASFiC CMP produces two CMOS logic outputs based on the result. They are CH ACT (U504-16) and SQ DET (U504-17).

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 on CH ACT. A squelch tail circuit is used to produce SQ DET (U504-17) from CH ACT. The state of CH ACT and SQ DET is high (logic "1") when carrier is detected, otherwise low (logic "0").

CH ACT is routed to the μ P pin 84 while SQ DET is routed to the μ P pin 83.

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.

9.2 Audio Processing and Digital Volume Control

The receiver audio signal (DISC AUDIO) enters the controller section from the IF IC where it is DC coupled to ASFIC CMP via the DISC input U504-pin 2. The signal is then applied to both the audio and the PL/DPL paths

The audio path has a programmable amplifier, whose setting is based on the channel bandwidth being received, an LPF filter to remove any frequency components above 3000Hz, and a HPF to strip off any sub-audible data below 300Hz. Next, 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 IC then passes the audio through the 8-bit programmable attenuator whose level is set depending on the value of the volume control. Finally the filtered audio signal passes through an output buffer within the ASFIC CMP. The audio signal exits the ASFIC CMP at AUDIO output (U504 pin 41).

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

Since sub-audible signaling is summed with voice information on transmit, it must be separated from the voice information before processing. Any sub-audible signaling enters the ASFIC CMP from the IF IC at DISC U504-2. Once inside, it goes through the PL/DPL path. The signal first passes through one of the two low-pass filters, either the PL low-pass filter or the DPL/LST low-pass filter. Either signal is then filtered and goes through a limiter and exits the ASFIC CMP at LSIO (U504-pin 18). At this point, the signal will appear as a square wave version of the sub-audible signal which the radio received. The μP U403 pin 80 will decode the signal directly to determine if it is the tone / code which is currently active on that mode.

9.3 Audio Amplification Speaker (+) Speaker (-)

The output of the ASFIC CMP's digital volume pot, U504-pin 41 is routed through DC blocking capacitor C5049 to the audio PA (U502 pin 1 and 9).

The audio power amplifier has one inverted and one non-inverted output that produces the differential audio output SPK+/SPK- (U502 pins 4 and 6)

The audio PA is enabled via the ASFIC CMP (U504-GCB1). When the base of Q501 is low, the transistor is off and U502-pin 8 is high, using pull up resistor R5041, and the audio PA is ON. The voltage at U502-pin 8 must be above 8.5Vdc to properly enable the device.

If the voltage is between 3.3 and 6.4V, the device will be active but has its input (U502-pins 1/9) off. This is a mute condition which is used to prevent an audio pop when the PA is enabled.

The SPK+ and SPK- outputs of the audio PA have a DC bias which varies proportionately with B+ (U502- pin 7). B+ of 11V yields a DC offset of 5V, and B+ 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 will be damaged. SPK+ and SPK- are routed to the accessory connector (P1-pin 1 and 16) and to the control head (connector J2-pins 19 and 20).

9.4 Handset Audio

Certain handheld accessories have a speaker within them which require a different voltage level than that provided by U502. For these devices HANDSET AUDIO is available at control head connector J2 pin18.

The received audio from the output of the ASIC CMP's digital volume attenuator is routed to U505 pin 2 where it is amplified. This signal is routed from the output of the op-amp U505 to J2-pin 18. From the control head, the signal is sent directly to the microphone jack.

9.5 Filtered Audio and Flat Audio

The ASIC CMP output audio at U504-pin 39 is filtered and de-emphasized, but has not gone through the digital volume attenuator. From ASIC CMP U504-pin 39 the signal is routed via R5034 through gate U509-pin 12 and AC coupled to U505-pin 6. The gate controlled by ASIC CMP port GCB4 selects between the filtered audio signal from the ASIC CMP pin 39 (URXOUT) or the unfiltered (flat) audio signal from the ASIC CMP pin 10 (UIO). Resistors R5034 and R5021 determine the gain of op-amp UU505-pin 6 for the filtered audio while R5032 and R5021 determine the gain for the flat Audio. The output of U505-pin 7 is then routed to P1 pin 11 via DC blocking capacitor C5003. Note that any volume adjustment of the signal on this path must be done by the accessory.

10.0 Receive Signalling Circuits

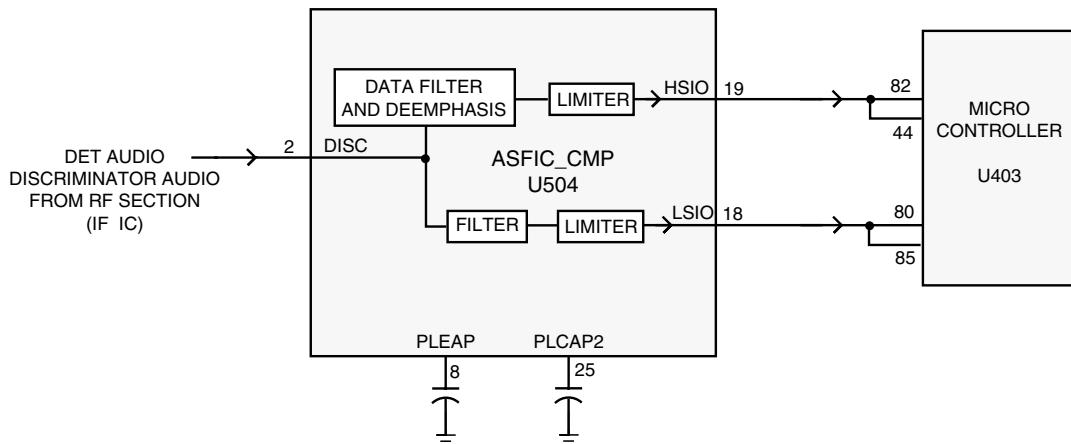


Figure 2-10 Receive Signalling Paths

10.1 Sub-Audio Data (PL/DPL) and High Speed Data Decoder

The ASIC CMP (U504) is used to filter and limit all received data. The data enters the ASIC CMP at input DISC (U504 pin 2). Inside U504 the data is filtered according to data type (HS or LS), then it is limited to a 0-3.3V digital level. The MDC and trunking high speed data appear at U504-pin 19, where it connects to the μ P U403 pin 80.

The low speed limited data output (PL, DPL, and trunking LS) appears at U504-pin18, where it connects to the μ P U403-pin 80.

The low speed data is read by the μ 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 C5028, and C5026 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.

10.2 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 U504 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 μ 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 μ P can generate any tone within the 100-3000Hz audio band. This is accomplished by the μ P generating a square wave which enters the ASFIC CMP at U504 pin 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 U504, 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 U504-pin 41 and is routed to the audio PA like receive audio.

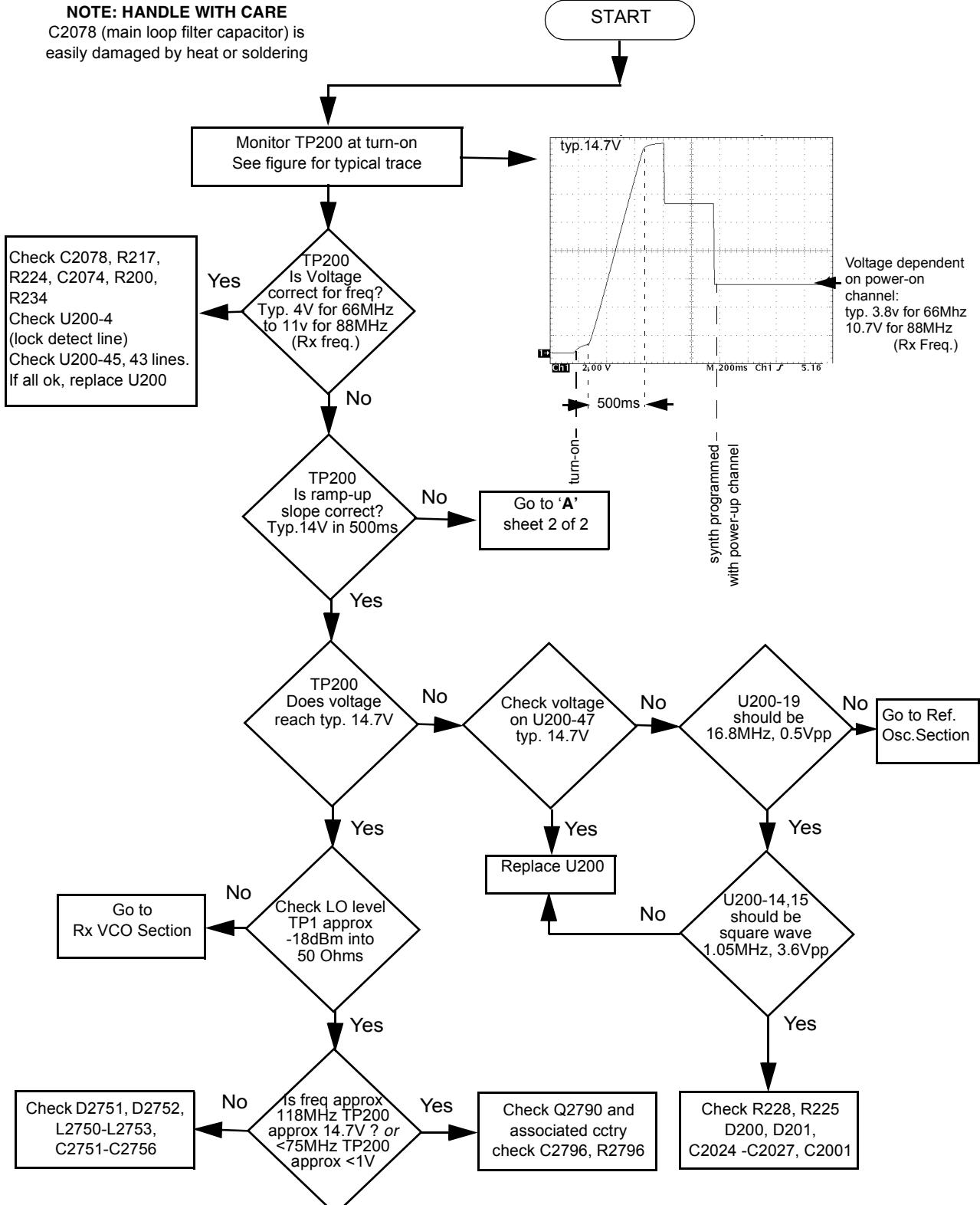
Chapter 3

TROUBLESHOOTING CHARTS

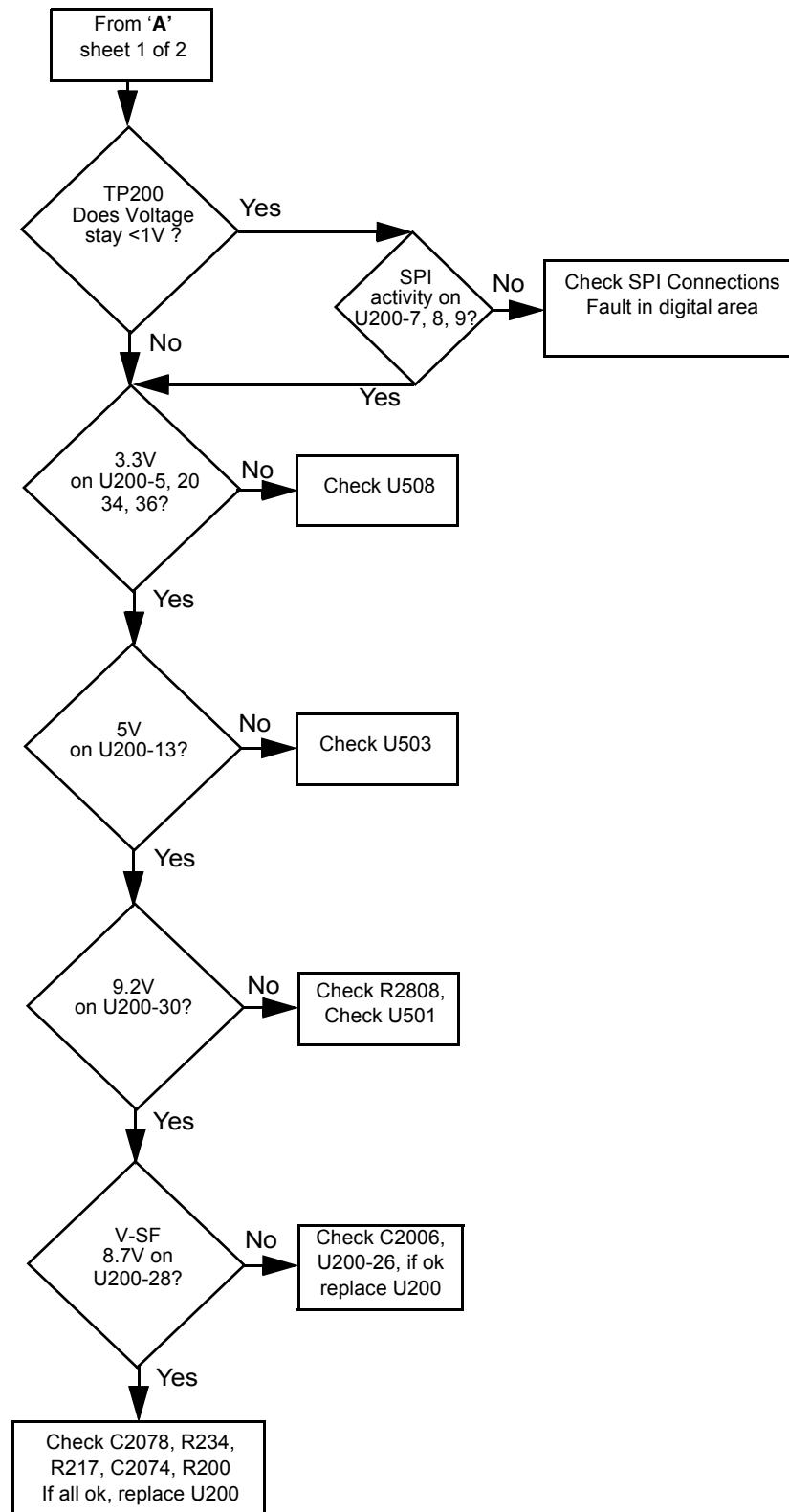
This section contains detailed troubleshooting flowcharts. These charts should be used as a guide in determining the problem areas. They are not a substitute for knowledge of circuit operation and astute troubleshooting techniques. It is advisable to refer to the related detailed circuit descriptions in the theory of operation sections prior to troubleshooting a radio.

Most troubleshooting charts end up by pointing to an IC to replace. It is not always noted, but it is good practice to verify supplies and grounds to the affected IC and to trace continuity to the malfunctioning signal and related circuitry before replacing any IC. For instance, if a clock signal is not available at a destination, continuity from the source IC should be checked before replacing the source IC.

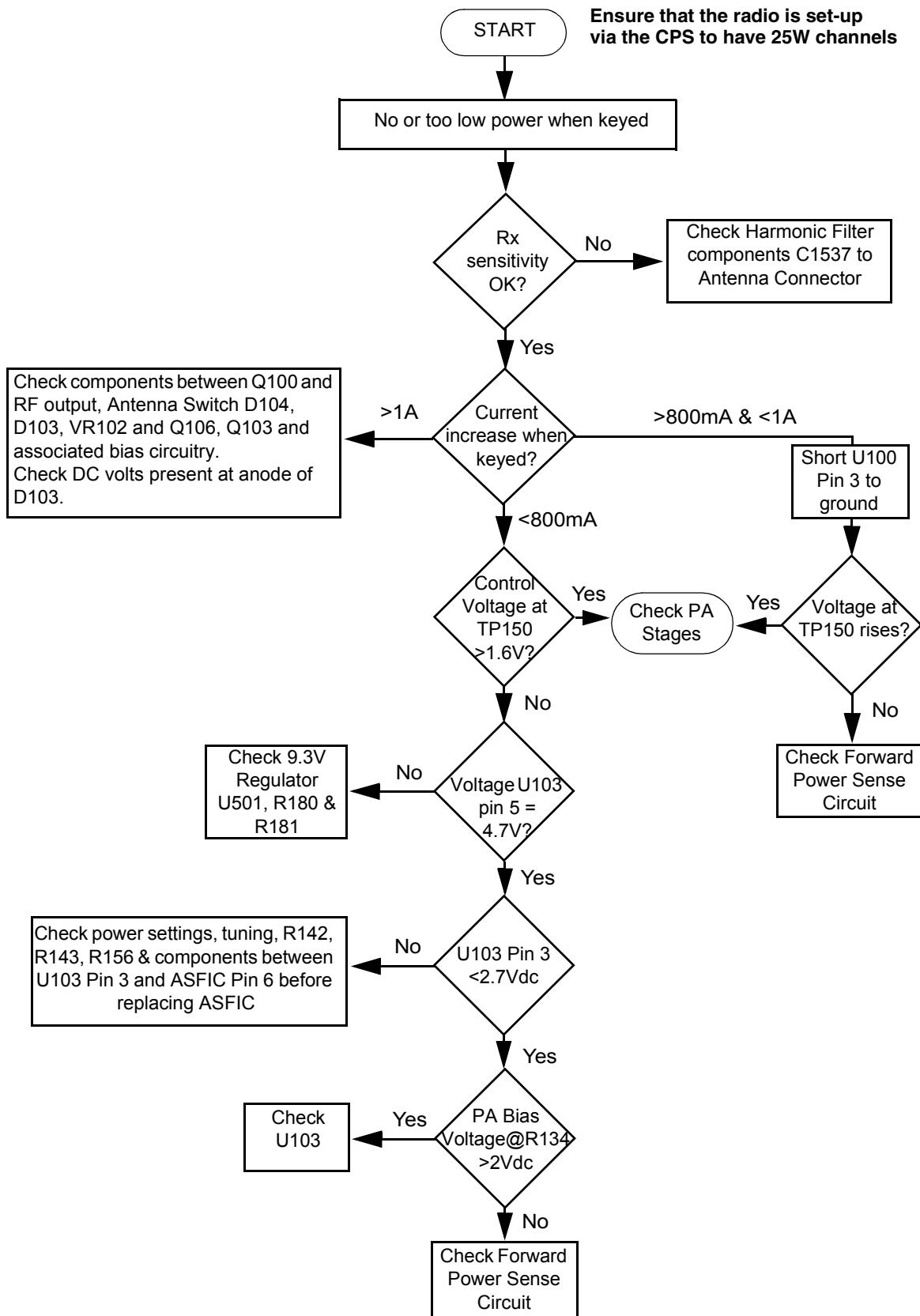
1.0 Troubleshooting Flow Chart for Out-of-Lock Receiver (Sheet 1 of 2)



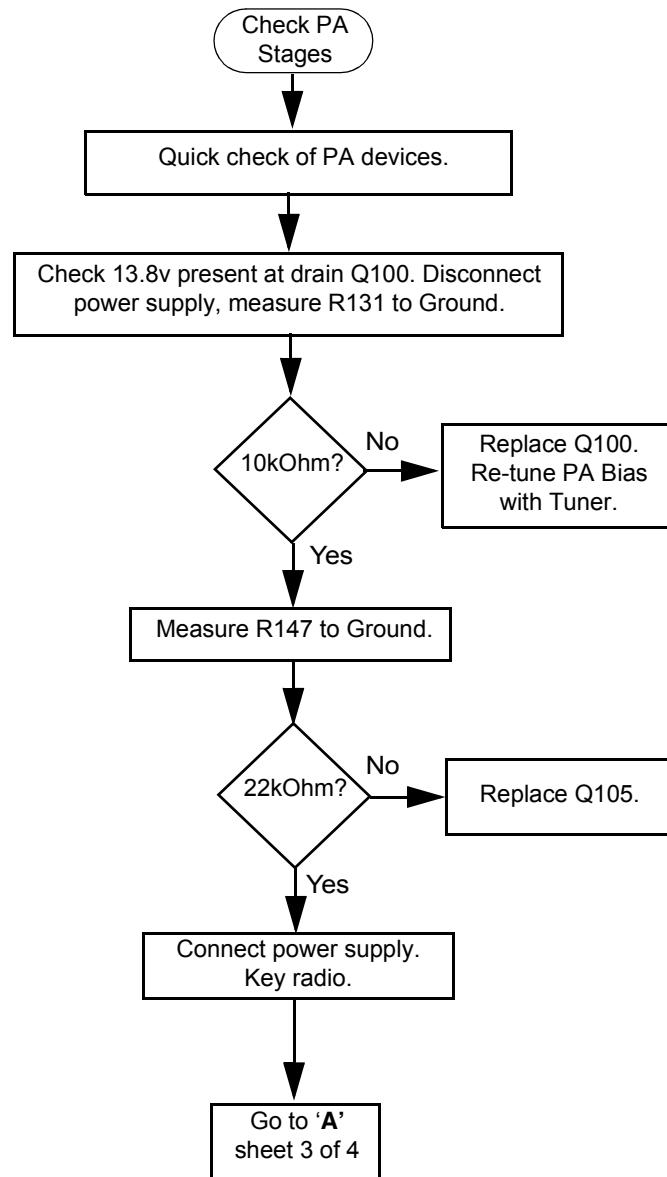
1.1 Troubleshooting Flow Chart for Out-of-Lock Receiver (Sheet 2 of 2)



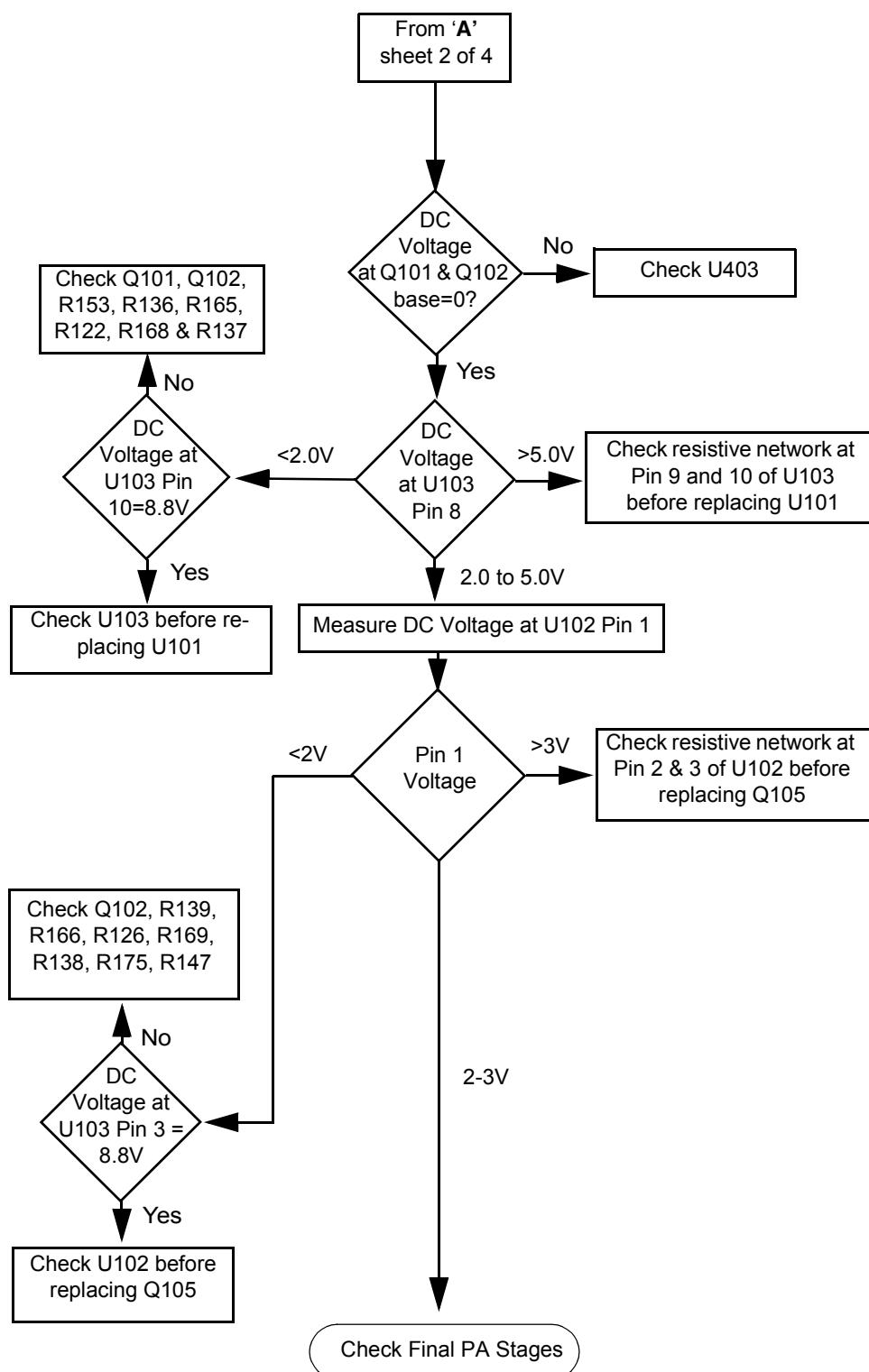
2.0 Troubleshooting Flow Chart for 25W Transmitter (Sheet 1 of 4)



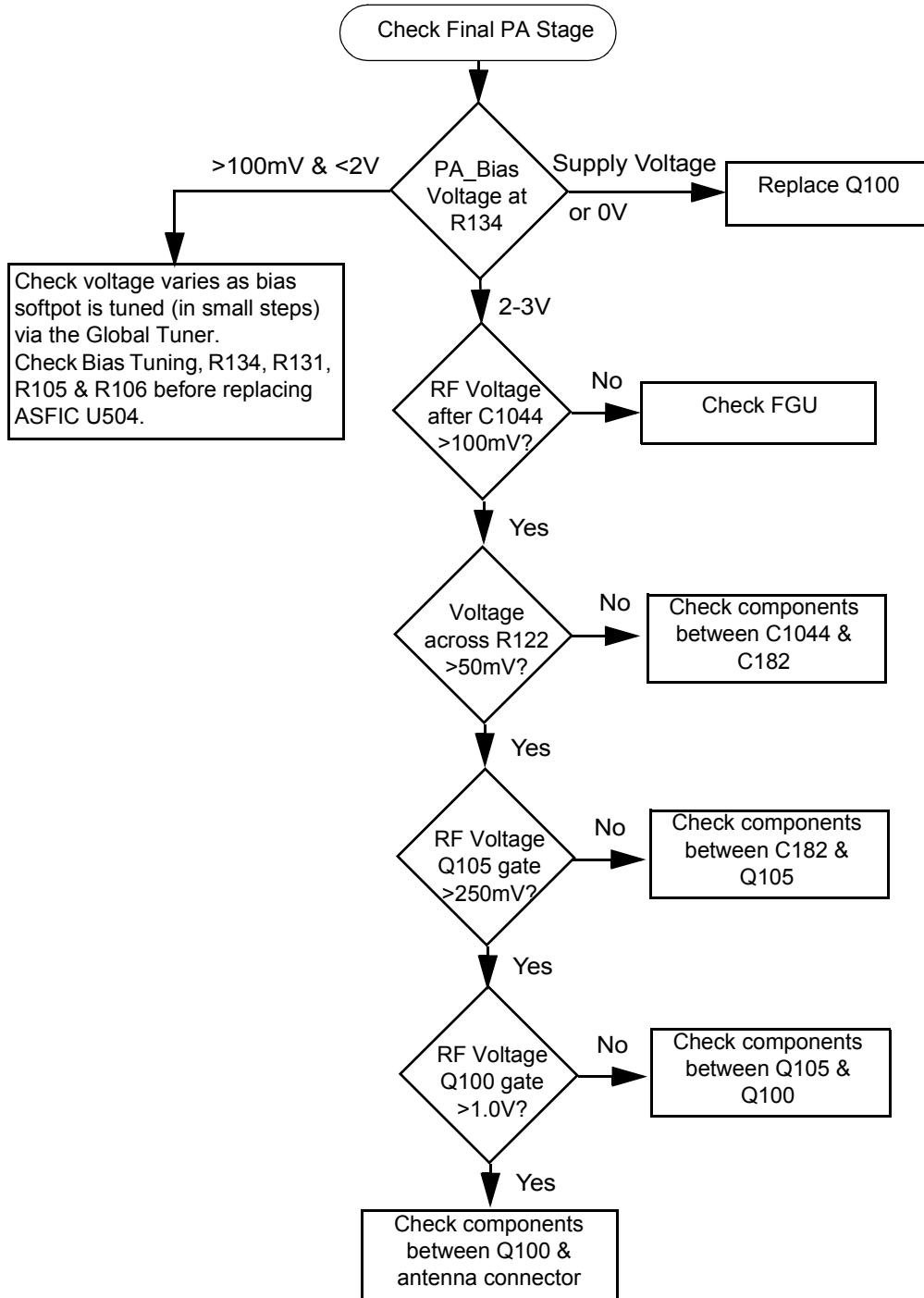
2.1 Troubleshooting Flow Chart for 25W Transmitter (Sheet 2 of 4)



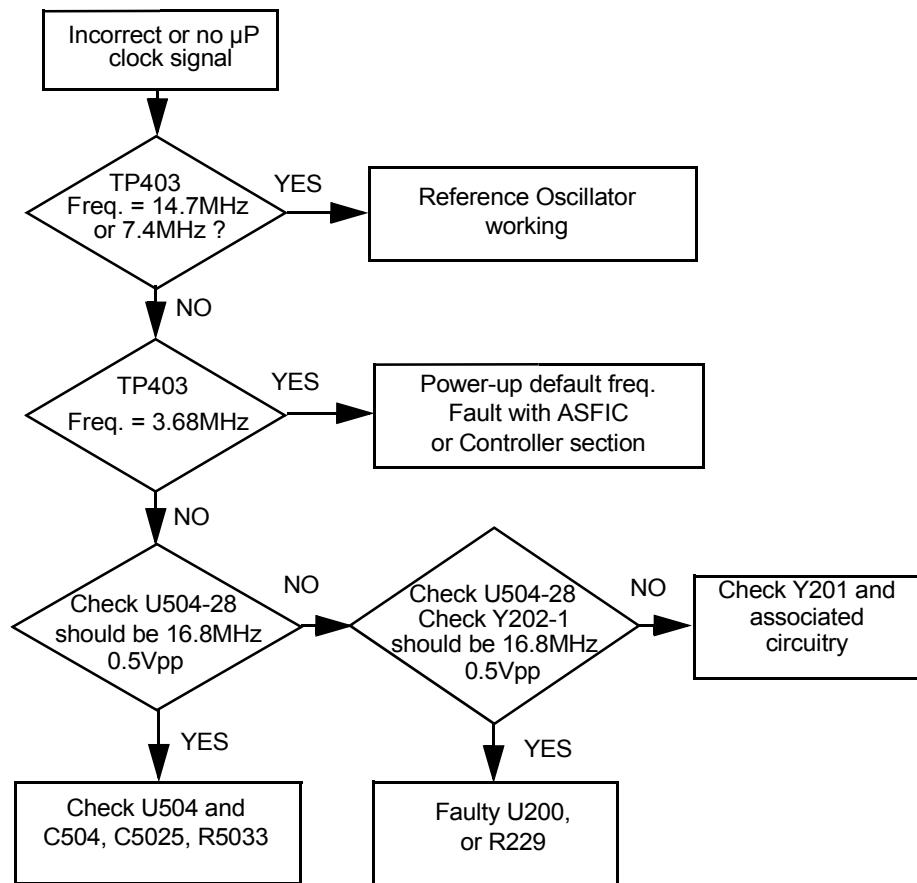
2.2 Troubleshooting Flow Chart for 25W Transmitter (Sheet 3 of 4)



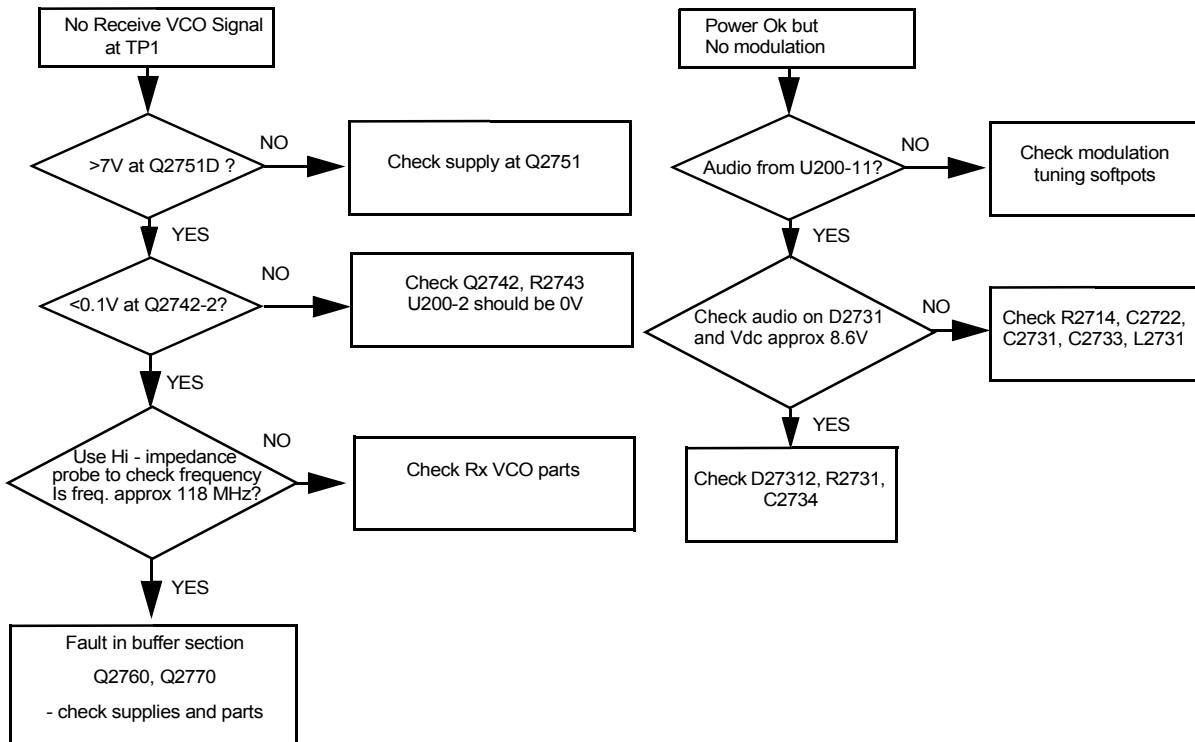
2.3 Troubleshooting Flow Chart for 25W Transmitter (Sheet 4 of 4)



3.0 Troubleshooting Flow Chart for Synthesizer (Reference Oscillator)



4.0 Troubleshooting Flow Chart for VCO



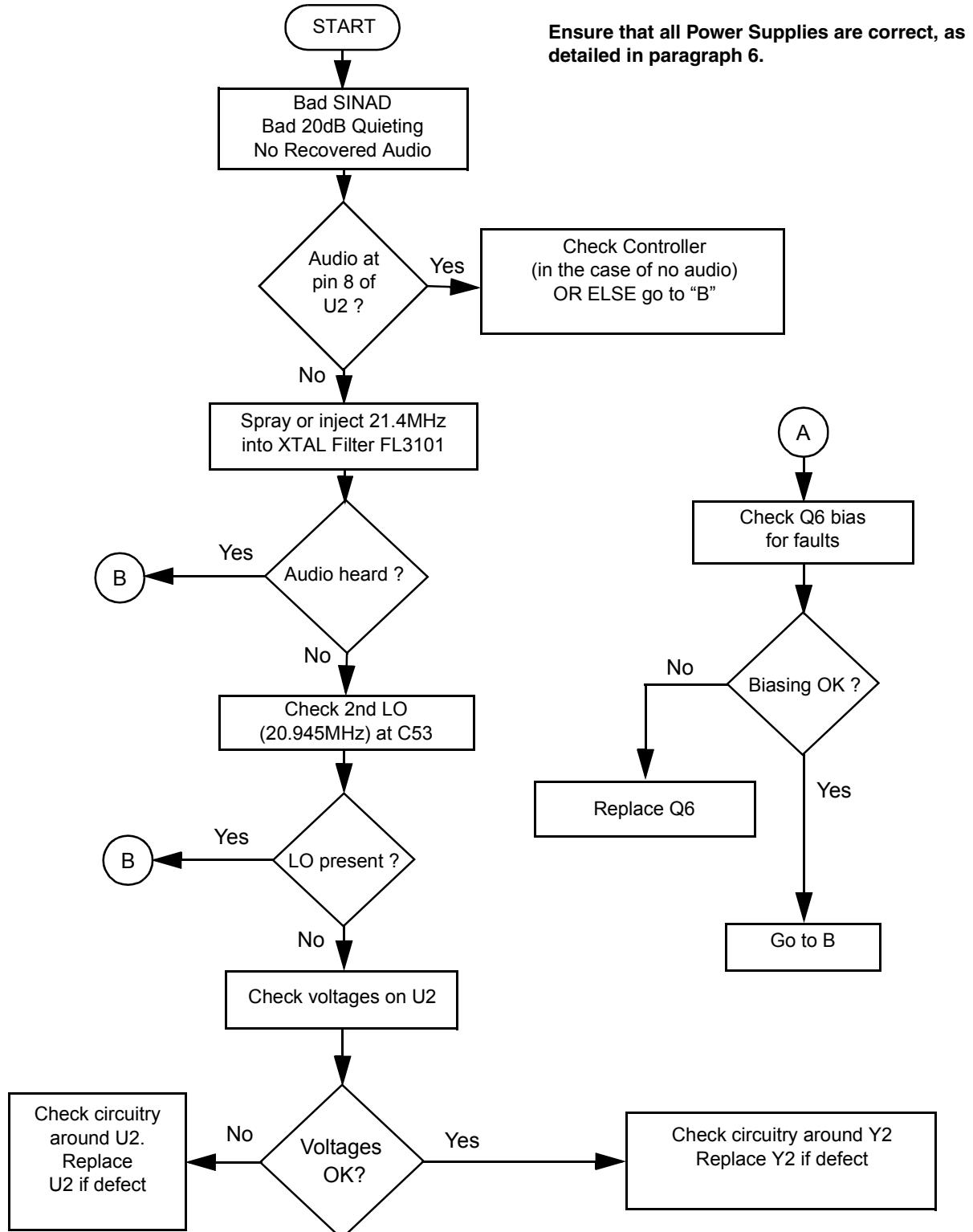
Out-of-Lock in TX

On detection of an out-of-lock in Tx, the radio returns to the Rx mode.

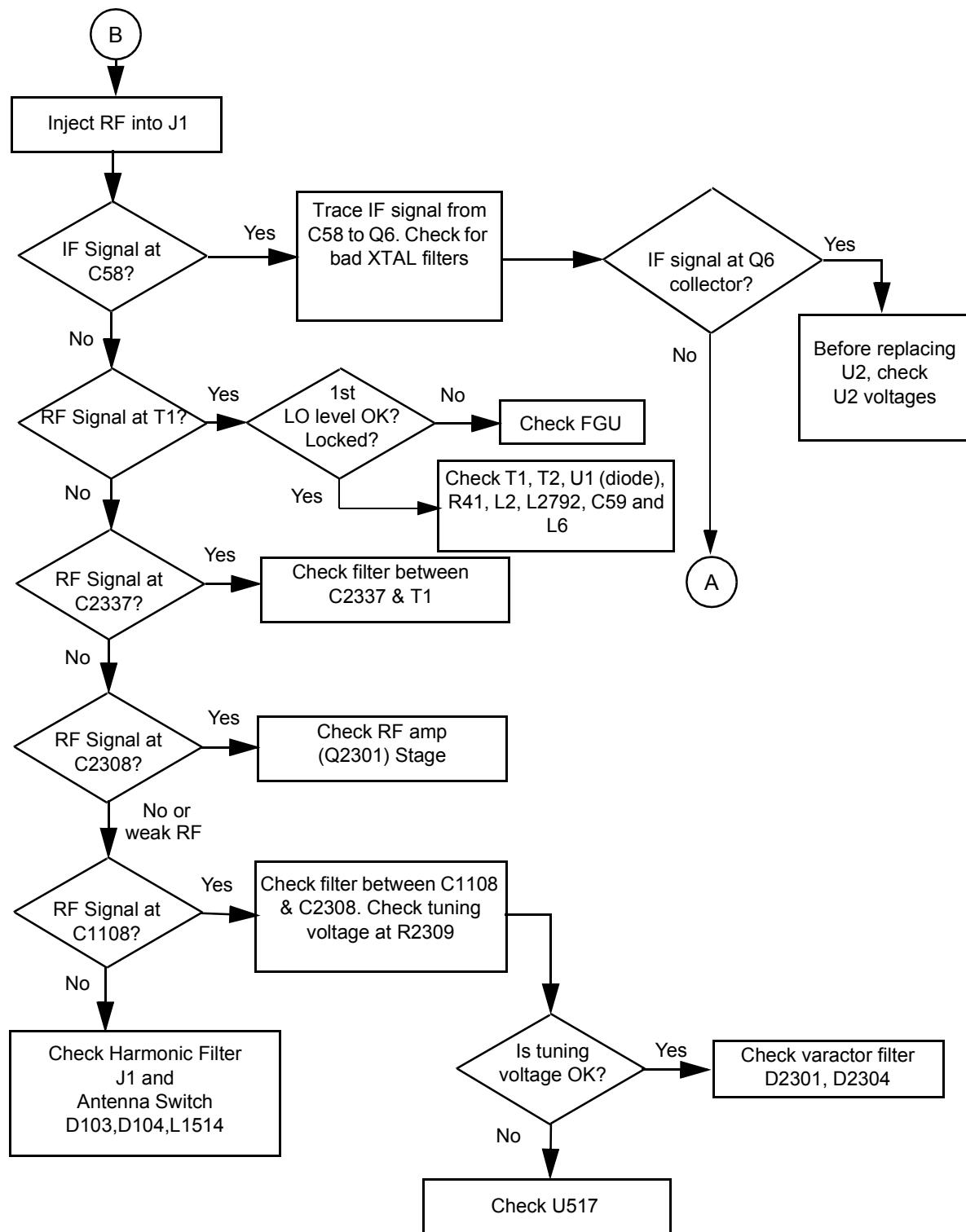
Check Rx - Tx switching
Q2742, Q2752 (should be turned on)
Check Q2741 and associated circuitry.

NOTE:
The TX VCO can be force enabled by grounding Q2742-3

5.0 Troubleshooting Flow Chart for Receiver (Sheet 1 of 2)

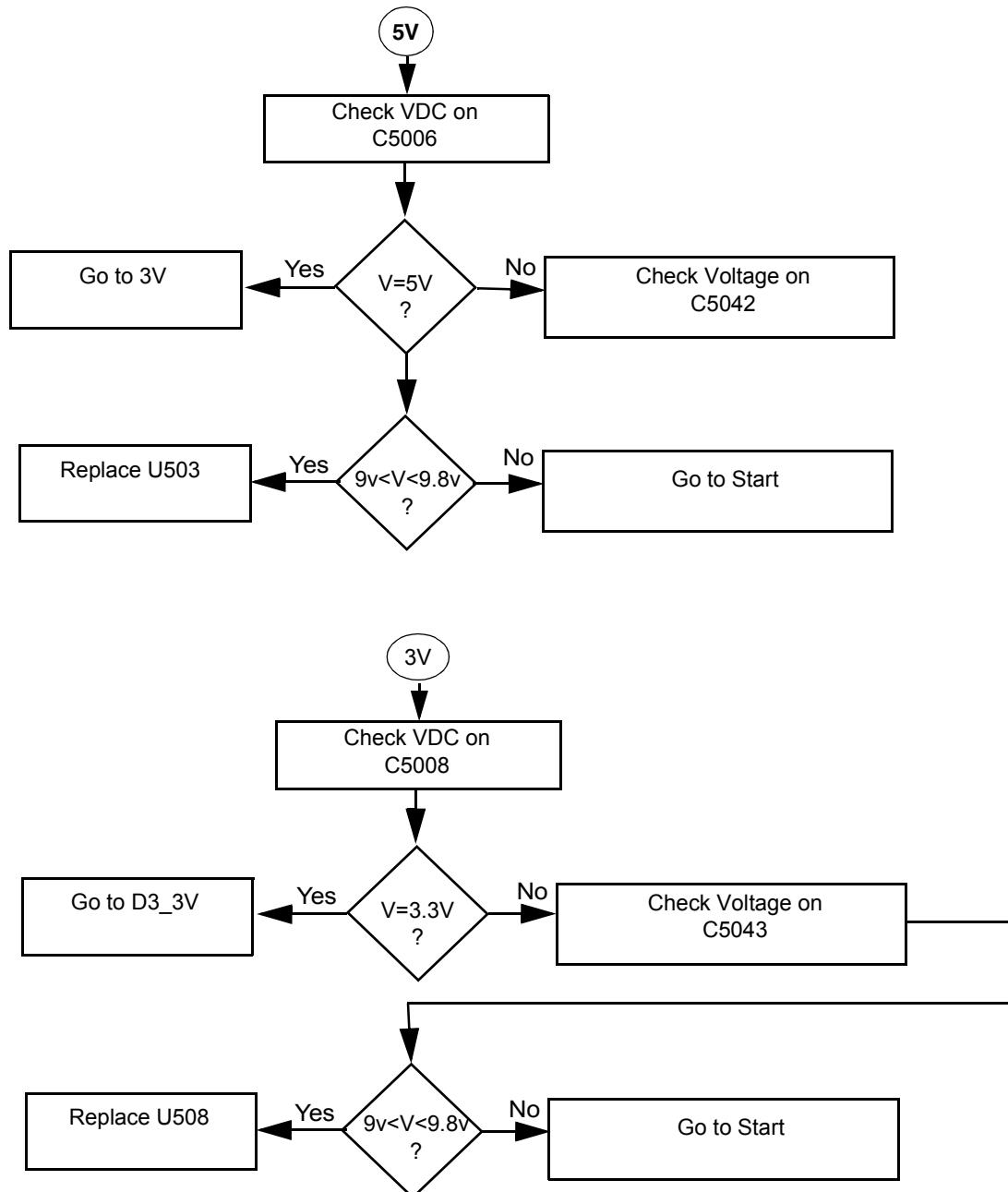


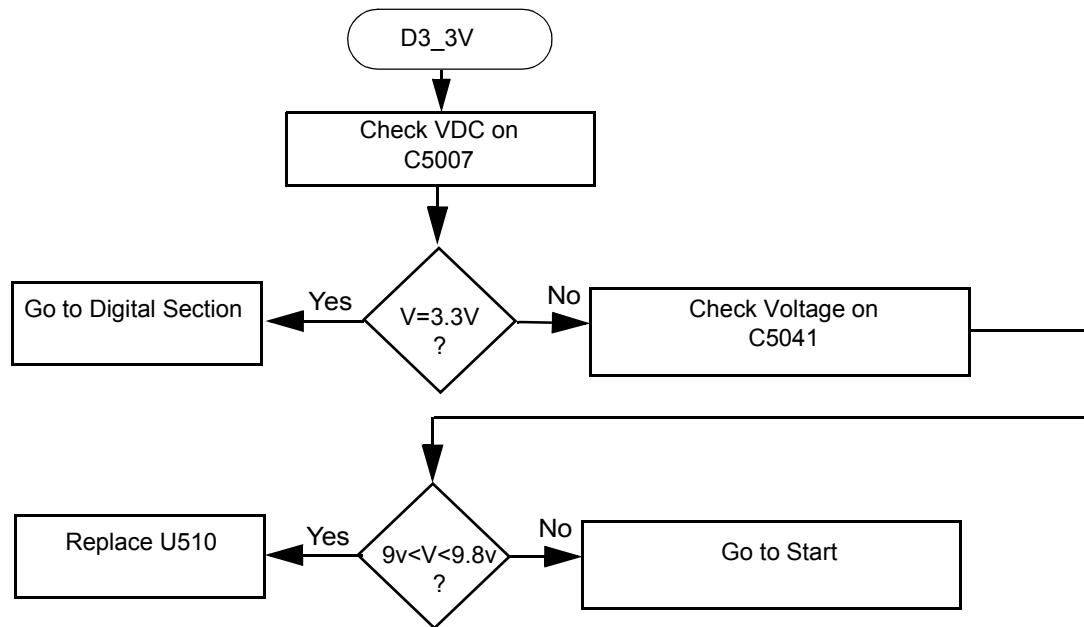
5.1 Troubleshooting Flow Chart for Receiver (Sheet 2 of 2)



6.0 Troubleshooting Flow Chart for DC Supply (1 of 2)

Since the failure of a critical voltage supply might cause the radio to automatically power down, supply voltages should first be probed with a multimeter. If all the board voltages are absent, then the voltage test point should be retested using a rising-edge-triggered oscilloscope. If the voltage is still absent, then another voltage should be tested using the oscilloscope. If that voltage is present, then the original voltage supply in question is defective and requires investigation of associated circuitry.



6.1 Troubleshooting Flow Chart for DC Supply (2 of 2)

Chapter 4

MIDBAND PCB/SCHEMATICS/PARTS LISTS

1.0 Allocation of Schematics and Circuit Boards

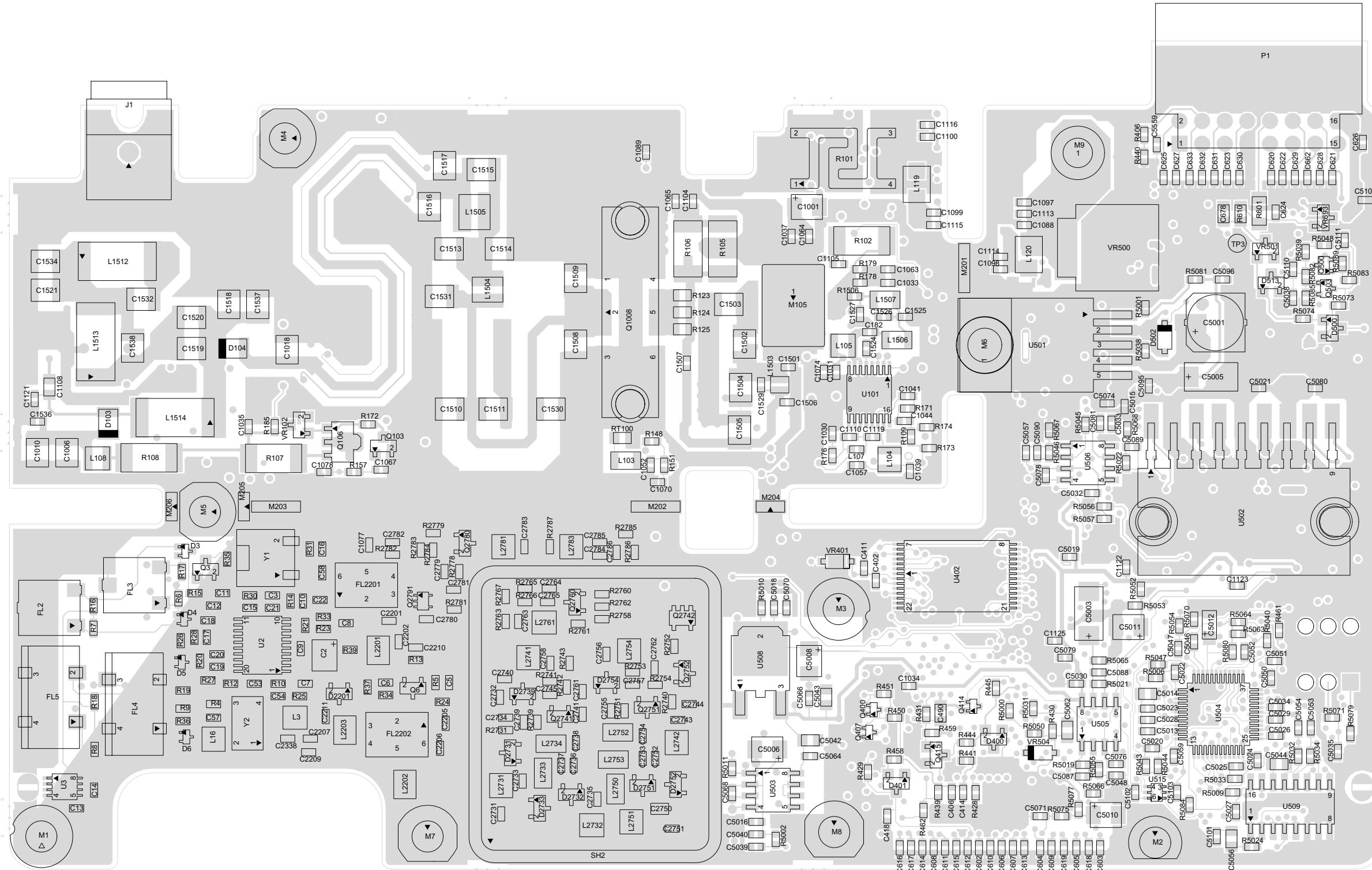
1.1 Midband and Controller Circuits

The Midband circuits are contained on the printed circuit board (PCB) which also contains the Controller circuits. This Chapter shows the schematics for both the Midband circuits and the Controller circuits. The PCB component layouts and the Parts Lists in this Chapter show both the Controller and Midband circuit components. The Midband and Controller schematics and the related PCB and parts list are shown in the tables below.

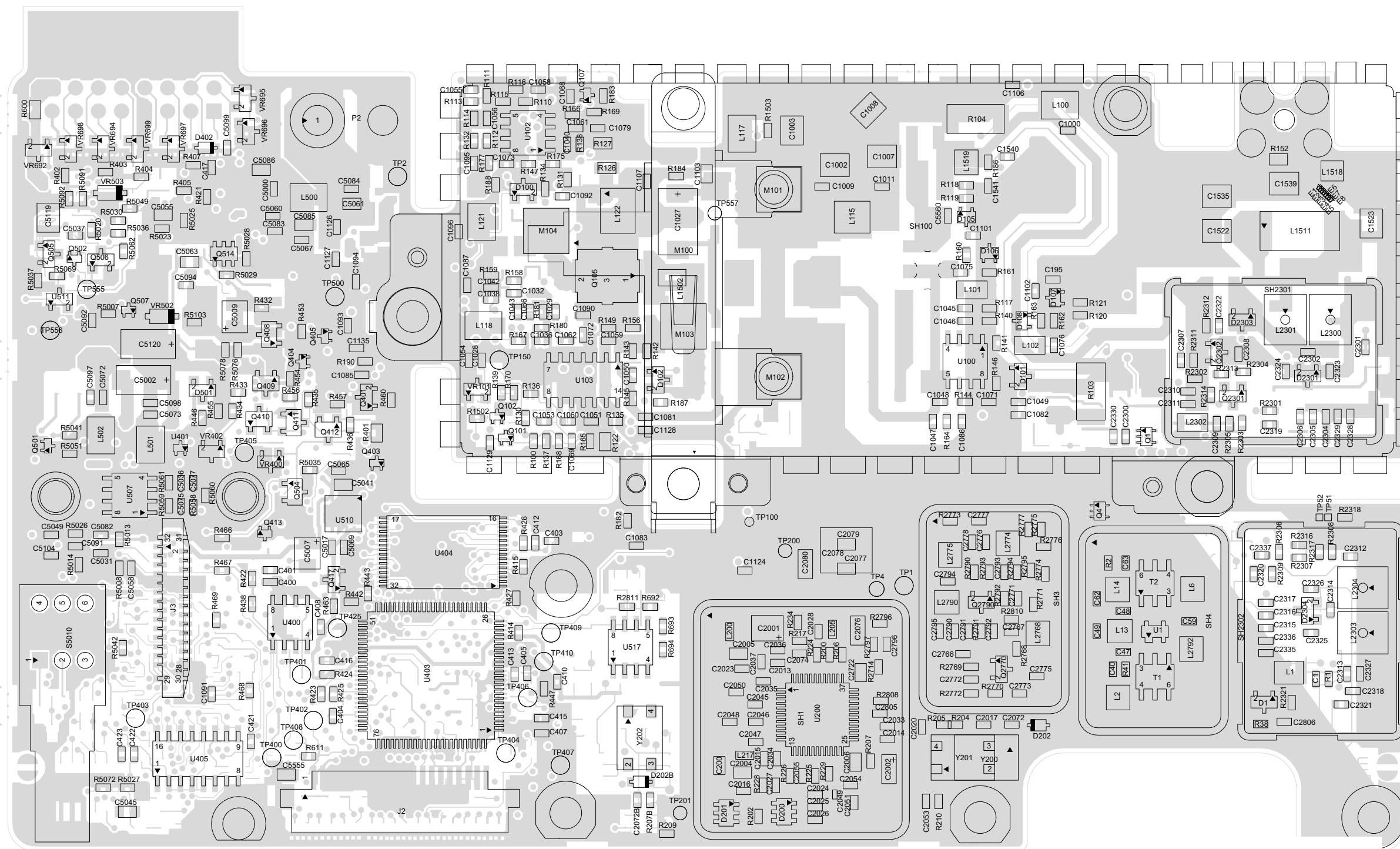
Table 4-1 Midband 1-25W Diagrams and Parts Lists

PCB : Side 8489012U01-C Main Board Top Side 8489012U01-C Main Board Bottom	Page 4-3 Page 4-4
SCHEMATICS Main Circuit Transmitter Synthesiser and VCO Receiver Front and Back End DC and Audio Ccts Microprocessor and Controller Ccts	Page 4-5 Page 4-6 Page 4-7 Page 4-8 Page 4-9 Page 4-10
Parts List 8489012U01-C	Page 4-11
Controller version is T1	

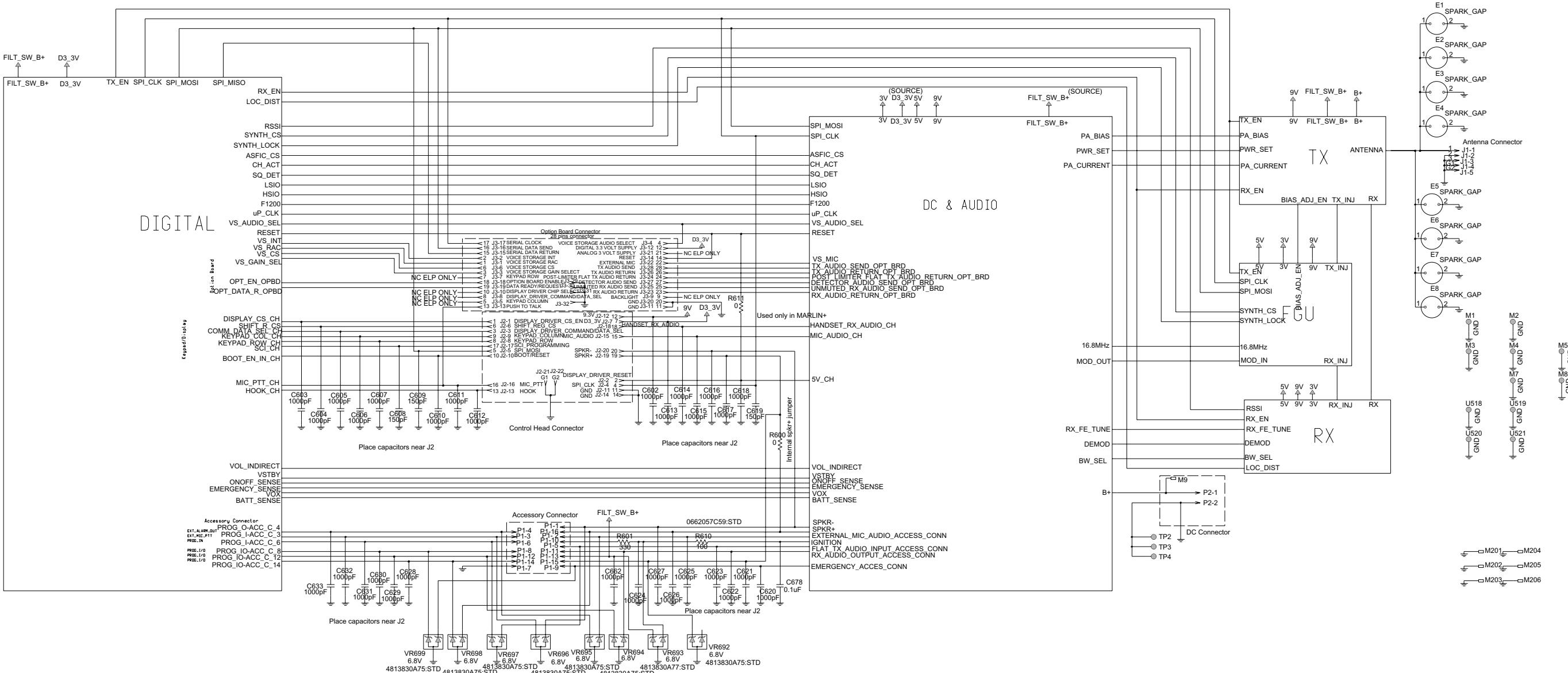
2.0 Midband 1-25W PCB 8489012U01 (rev. C) / Schematics



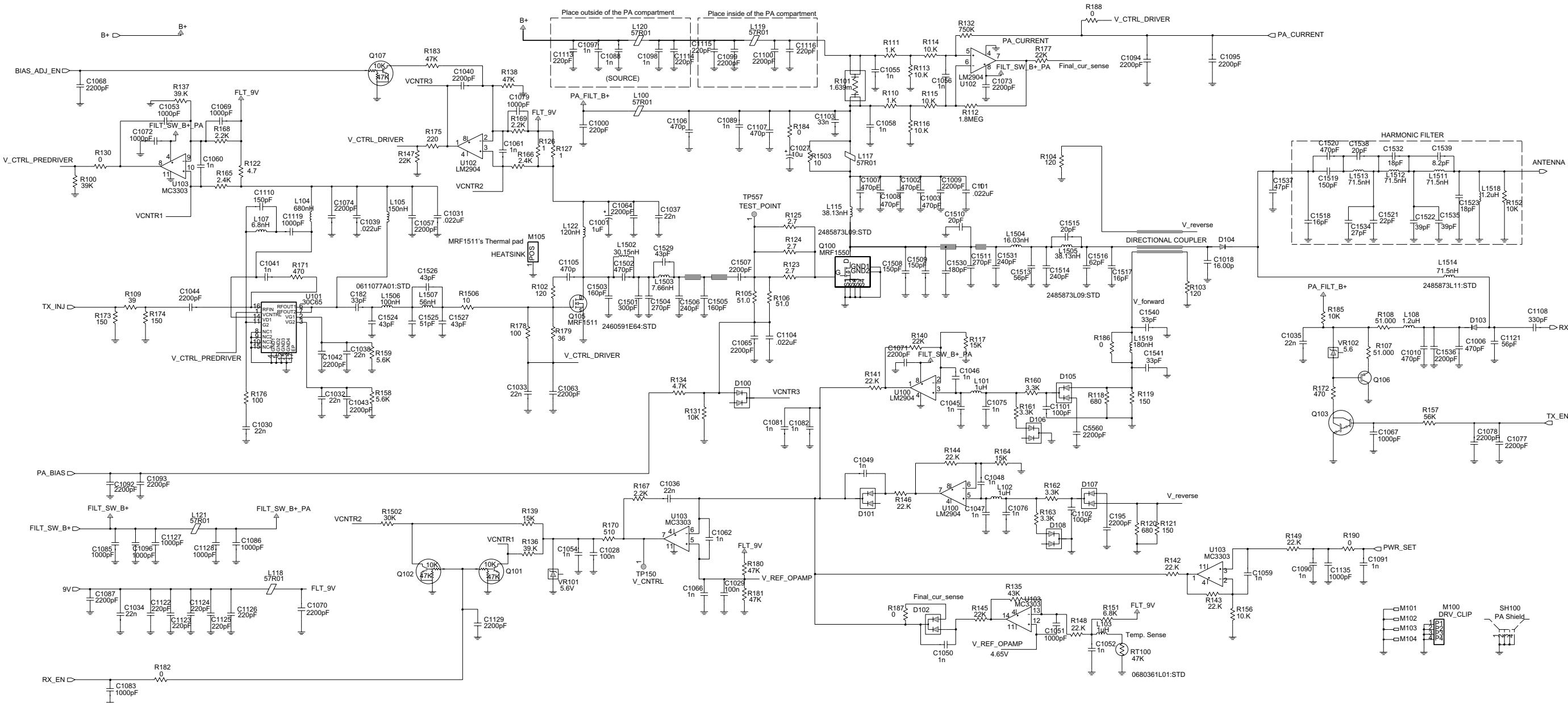
Midband (66-88MHz) 1-25W 8489012U01 (rev. C)

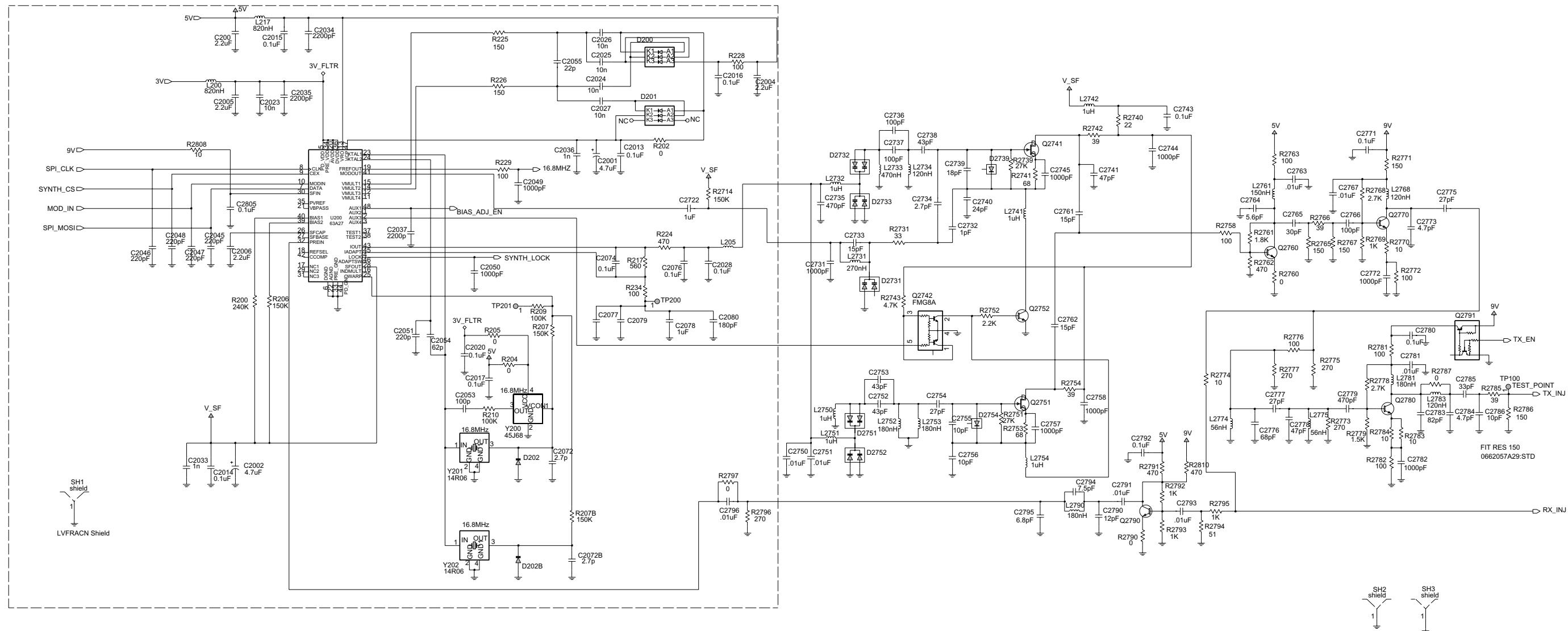


Midband (66-88MHz) 1-25W 8489012U01 (rev. C)

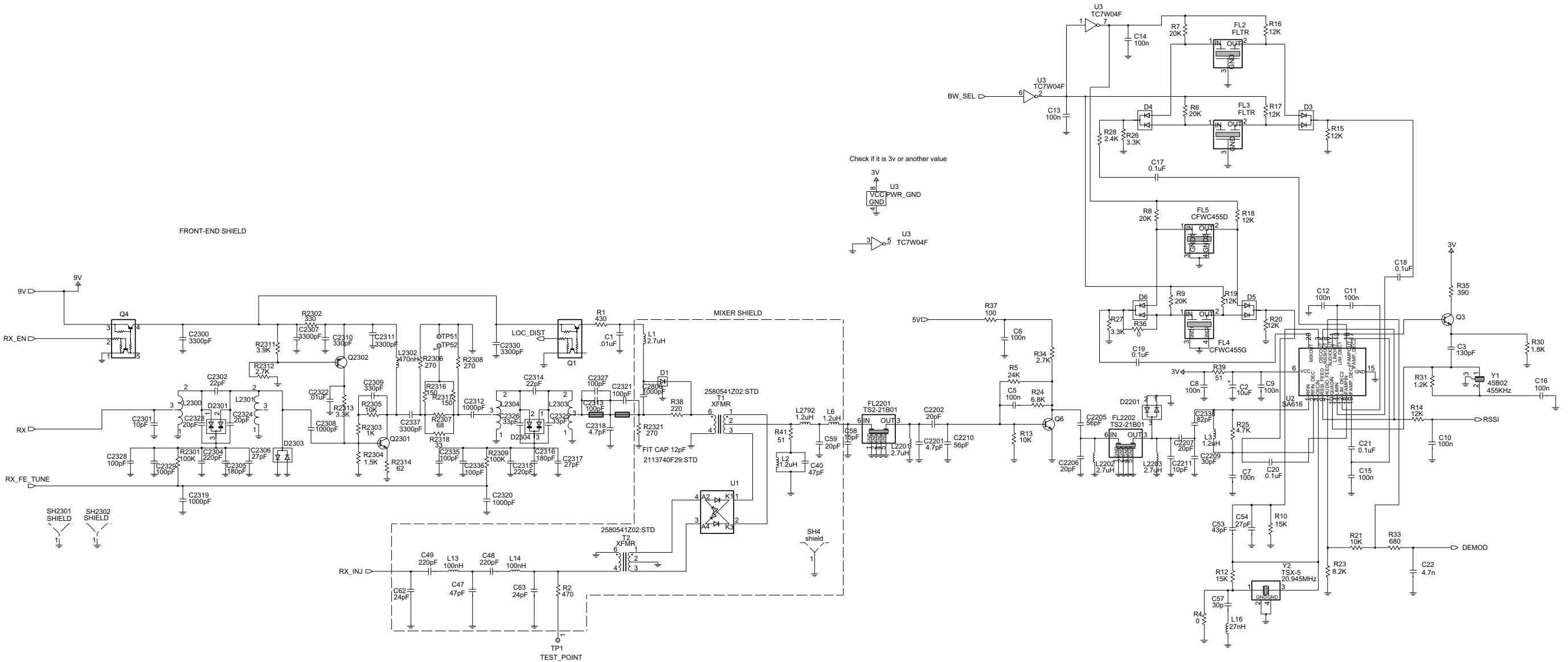


Midband (66-88MHz) Main Circuit

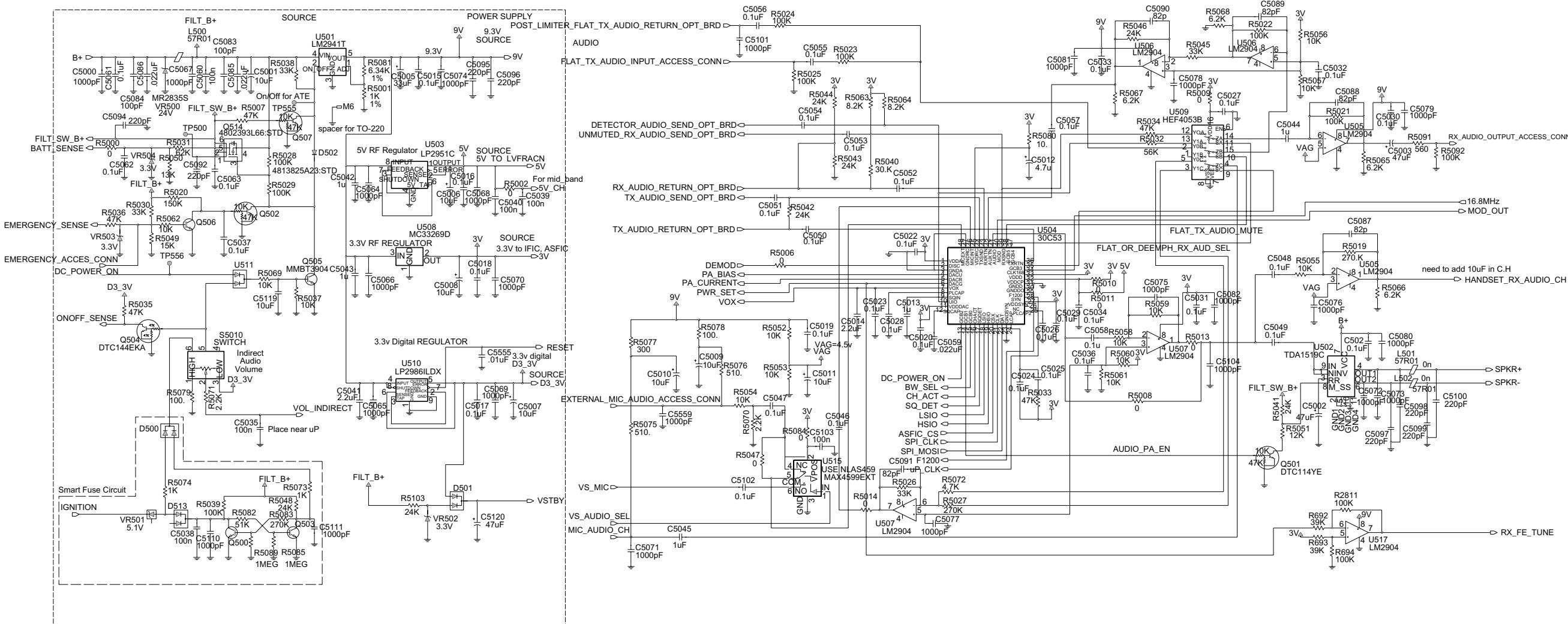
**Midband (66-88MHz) Transmitter**



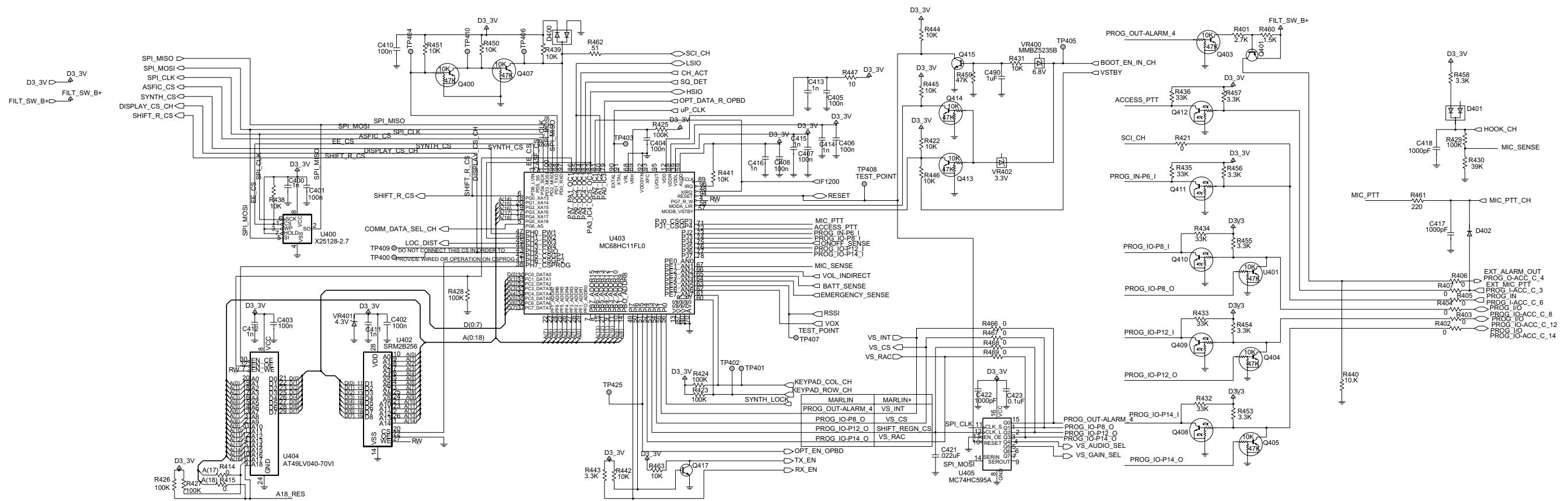
Midband (66-88MHz) Synthesiser and VCO



Midband (66-88MHz) Receiver



Midband (66-88MHz) DC and Audio Circuits



Midband (66-88MHz) Microprocessor and Controller

2.1 MB PCB 8489012U01 (rev. C) Parts List 1-25W

Circuit Ref.	Motorola Part No.	Description
C1	2113741F49	CAP .01uF
C2	2311049A57	CAPP 10uF
C3	2113740F54	CAP130pF
C5	2113743E20	CAP 100n
C6	2113743E20	CAP100n
C7	2113743E20	CAP100n
C8	2113743E20	CAP100n
C9	2113743E20	CAP100n
C10	2113743E20	CAP100n
C11	2113743E20	CAP100n
C12	2113743E20	CAP100n
C13	2113743E20	CAP100n
C14	2113743E20	CAP100n
C15	2113743E20	CAP100n
C16	2113743E20	CAP100n
C17	2113743E20	CAP 0.1uF
C18	2113743E20	CAP 0.1uF
C19	2113743E20	CAP 0.1uF
C20	2113743E20	CAP 0.1uF
C21	2113743E20	CAP 0.1uF
C22	2113741F41	CAP 4.7n
C40	2113740F43	CAP 47pF
C47	2113740F43	CAP 47pF
C48	2113740F59	CAP 220pF
C49	2113740F59	CAP 220pF
C53	2113740F42	CAP 43pF
C54	2113740F37	CAP 27pF
C57	NOT PLACED	CAP 30p
C58	2113740F31	CAP 15pF

Circuit Ref.	Motorola Part No.	Description
C59	2113740F34	CAP 20pF
C62	2113740F36	CAP 24pF
C63	2113740F36	CAP 24pF
C182	2113740F39	CAP 33pF
C195	2113741F33	CAP 2200pF
C200	2113743F18	CAP 2.2uF
C400	2113741F25	CAP1n
C401	2113743K15	CAP100n
C402	2113743K15	CAP100n
C403	2113743K15	CAP100n
C404	2113743K15	CAP100n
C405	2113743K15	CAP100n
C406	2113743K15	CAP100n
C407	2113743K15	CAP100n
C408	2113743K15	CAP100n
C410	2113743K15	CAP100n
C411	2113741F25	CAP1n
C412	2113741F25	CAP1n
C413	2113741F25	CAP1n
C414	2113741F25	CAP1n
C415	2113741F25	CAP1n
C416	2113741F25	CAP1n
C417	2113741F25	CAP1000pF
C418	2113741F25	CAP1000pF
C419	NOT PLACED	CAP.01uF
C421	2113743E07	CAP.022uF
C422	2113741F25	CAP1000pF
C423	2113743K15	CAP0.1uF
C490	NOT PLACED	CAP 1uF
C602	2113741F25	CAP1000pF
C603	2113741F25	CAP1000pF
C604	2113741F25	CAP1000pF
C605	2113741F25	CAP1000pF
C606	2113741F25	CAP1000pF
C607	2113741F25	CAP1000pF
C608	NOT PLACED	CAP150pF
C609	NOT PLACED	CAP150pF
C610	2113741F25	CAP1000pF
C611	2113741F25	CAP1000pF
C612	2113741F25	CAP1000pF
C613	2113741F25	CAP1000pF
C614	2113741F25	CAP1000pF
C615	2113741F25	CAP1000pF
C616	2113741F25	CAP1000pF
C617	2113741F25	CAP1000pF
C618	2113741F25	CAP1000pF
C619	NOT PLACED	CAP150pF
C620	2113741F25	CAP1000pF
C621	2113741F25	CAP1000pF
C622	2113741F25	CAP1000pF
C623	2113741F25	CAP1000pF
C624	2113741F25	CAP1000pF
C625	2113741F25	CAP1000pF
C626	2113741F25	CAP1000pF
C627	2113741F25	CAP1000pF
C628	2113741F25	CAP1000pF
C629	2113741F25	CAP1000pF
C630	2113741F25	CAP1000pF
C631	2113741F25	CAP1000pF
C632	2113741F25	CAP1000pF
C633	2113741F25	CAP1000pF
C662	2113741F25	CAP1000pF
C678	2113741M69	CAP 0.1uF
C1000	NOT PLACED	CAP220pF
C1001	2311049A08	CAP 1uF
C1002	2111078B59	CAP 470pF
C1003	2111078B59	CAP 470pF
C1006	2111078B59	CAP 470pF
C1007	2111078B59	CAP 470pF
C1008	2111078B59	CAP 470pF
C1009	NOT PLACED	CAP 2200pF
C1010	2111078B59	CAP470pF
C1011	NOT PLACED	CAP .022uF
C1018	NOT PLACED	CAP16.00p
C1027	NOT PLACED	CAP10u
C1028	2113743K15	CAP 100n
C1029	2113743K15	CAP100n
C1030	2113743E07	CAP 22n
C1031	2113743E07	CAP .022uF
C1032	2113743E07	CAP 22n
C1033	2113743E07	CAP 22n
C1034	2113743E07	CAP 22n
C1035	2113743E07	CAP 22n
C1036	2113743E07	CAP 22n
C1037	2113743E07	CAP 22n
C1038	2113743E07	CAP 22n
C1039	2113743E07	CAP .022uF
C1040	2113741F33	CAP 2200pF
C1041	2113741F25	CAP1n
C1042	2113741F33	CAP 2200pF

Circuit Ref.	Motorola Part No.	Description
C1043	2113741F33	CAP 2200pF
C1044	2113741F33	CAP 2200pF
C1045	2113741F25	CAP1n
C1046	2113741F25	CAP 1n
C1047	2113741F25	CAP 1n
C1048	2113741F25	CAP1n
C1049	2113741F25	CAP1n
C1050	2113741F25	CAP1n
C1051	2113741F25	CAP1000pF
C1052	2113741F25	CAP1n
C1053	2113741F25	CAP1000pF
C1054	2113741F25	CAP1n
C1055	2113741F25	CAP1n
C1056	2113741F25	CAP1n
C1057	2113741F33	CAP 2200pF
C1058	2113741F25	CAP1n
C1059	2113741F25	CAP1n
C1060	2113741F25	CAP1n
C1061	2113741F25	CAP1n
C1062	2113741F25	CAP1n
C1063	2113741F33	CAP 2200pF
C1064	2113741F33	CAP 2200pF
C1065	2113741F33	CAP 2200pF
C1066	2113741F25	CAP1n
C1067	2113741F25	CAP1000pF
C1068	NOT PLACED	CAP 2200pF
C1069	2380090M24	CAPP10uF
C1070	2113741F33	CAP 2200pF
C1071	2113741F33	CAP 2200pF
C1072	2113741F25	CAP1000pF

Circuit Ref.	Motorola Part No.	Description
C1073	2113741F33	CAP 2200pF
C1074	2113741F33	CAP 2200pF
C1075	2113741F25	CAP1n
C1076	2113741F25	CAP1n
C1077	2113741F33	CAP 2200pF
C1078	2113741F33	CAP 2200pF
C1081	2113741F25	CAP1n
C1082	2113741F25	CAP1n
C1083	NOT PLACED	CAP1000pF
C1084	NOT PLACED	CAP 2200pF
C1085	2113741F25	CAP 1000pF
C1086	2113741F25	CAP1000pF
C1087	NOT PLACED	CAP 2200pF
C1088	2113741F25	CAP1n
C1089	2113741F25	CAP1n
C1090	2113741F25	CAP1n
C1091	2113741F25	CAP1n
C1092	NOT PLACED	CAP 2200pF
C1093	NOT PLACED	CAP 2200pF
C1094	2113741F33	CAP 2200pF
C1095	2113741F33	CAP 2200pF
C1096	2113741F25	CAP1000pF
C1097	2113741F25	CAP1n
C1098	2113741F25	CAP1n
C1099	2113741F33	CAP 2200pF
C1100	2113741F33	CAP 2200pF
C1101	2113740F51	CAP100pF
C1102	2113740F51	CAP100pF
C1103	2113741A57	CAP 33n
C1104	2113743E07	CAP.022uF

Circuit Ref.	Motorola Part No.	Description
C1105	2113740F67	CAP 470p
C1106	2113740F67	CAP 470p
C1107	2113740F67	CAP 470p
C1108	2113740A67	CAP 330pF
C1110	2113740F55	CAP150pF
C1113	2113740F59	CAP 220pF
C1114	2113740F59	CAP 220pF
C1115	2113740F59	CAP 220pF
C1116	2113740F59	CAP 220pF
C1119	2113741F25	CAP1000pF
C1121	2113740F43	CAP 47pF
C1122	NOT PLACED	CAP 220pF
C1123	NOT PLACED	CAP 220pF
C1124	NOT PLACED	CAP 220pF
C1125	NOT PLACED	CAP 220pF
C1126	NOT PLACED	CAP 220pF
C1127	2113741F25	CAP1000pF
C1128	2113741F25	CAP1000pF
C1129	NOT PLACED	CAP 2200pF
C1130	2113741F33	CAP 2200pF
C1131	2113741F33	CAP 2200pF
C1132	2113741F33	CAP 2200pF
C1133	2113741F33	CAP 2200pF
C1135	NOT PLACED	CAP 1000pF
C1501	2113740F62	CAP 300pF
C1502	NOT PLACED	CAP 470pF
C1503	2111078B48	CAP160pF
C1504	NOT PLACED	CAP 270pF
C1505	NOT PLACED	CAP160pF
C1506	2113740F60	CAP 240pF

Circuit Ref.	Motorola Part No.	Description
C1507	2113741F33	CAP 2200pF
C1508	2111078B47	CAP150pF
C1509	2111078B47	CAP150pF
C1510	2111078B21	CAP 20pF
C1511	NOT PLACED	CAP 270pF
C1513	2111078B36	CAP 56pF
C1514	NOT PLACED	CAP 240pF
C1515	NOTPLACED	CAP 20pF
C1516	2111078B37	CAP 62pF
C1517	NOT PLACED	CAP16pF
C1518	NOT PLACED	CAP16pF
C1519	2111078B47	CAP150pF
C1520	NOT PLACED	CAP 470pF
C1521	2111078B34	CAP 47pF
C1522	2111078B38	CAP 68pF
C1523	2111078B39	CAP 75pF
C1524	NOT PLACED	CAP 43pF
C1525	NOT PLACED	CAP 51pF
C1526	NOT PLACED	CAP 43pF
C1527	NOT PLACED	CAP 43pF
C1528	2111078B34	CAP 47pF
C1529	NOT PLACED	CAP 43pF
C1530	2111078B49	CAP180pF
C1531	2111078B52	CAP 240pF
C1532	2111078B18	CAP15pF
C1534	NOT PLACED	CAP 27pF
C1535	NOT PLACED	CAP 39pF
C1536	2113741F33	CAP 2200pF
C1537	2111078B34	CAP 47pF
C1538	2111078B16	CAP13pF

Circuit Ref.	Motorola Part No.	Description	Circuit Ref.	Motorola Part No.	Description	Circuit Ref.	Motorola Part No.	Description	Circuit Ref.	Motorola Part No.	Description
C1539	2111078B05	CAP 4.7pF	C2049	NOT PLACED	CAP 1000pF	C2309	2113741F13	CAP 330pF	C2734	2113740F13	CAP 2.7pF
C1540	2113740F39	CAP 33pF	C2050	2113741F25	CAP 1000pF	C2310	2113741F13	CAP 330pF	C2735	2113741F17	CAP 470pF
C1541	2113740F39	CAP 33pF	C2051	2113740F54	CAP130pF	C2311	2113741F37	CAP 3300pF	C2736	2113740F51	CAP 100pF
C1542	NOT PLACED	CAP 8.2pF	C2053	2113740F51	CAP100p	C2312	2113741F25	CAP 1000pF	C2737	2113740F51	CAP 100pF
C2001	2311049J11	CAPP 4.7uF	C2054	2113740F45	CAP 56pF	C2313	2113740F51	CAP 100pF	C2738	2113740F42	CAP 43pF
C2002	2311049A56	CAPP 4.7uF	C2055	2113740F35	CAP 22p	C2314	2113740F35	CAP 22pF	C2739	2113740F33	CAP 18pF
C2004	2113743F18	CAP 2.2uF	C2072	NOT PLACED	CAP 2.7p	C2315	2113740F59	CAP 220pF	C2740	2113740F36	CAP 24pF
C2005	2113743F18	CAP 2.2uF	C2074	2113743E20	CAP 0.1uF	C2316	2113740F57	CAP 180pF	C2741	NOT PLACED	CAP 47pF
C2006	2113743F18	CAP 2.2uF	C2076	NOT PLACED	CAP 0.1uF	C2317	NOT PLACED	CAP 27pF	C2743	2113743E20	CAP 0.1uF
C2013	2113743E20	CAP 0.1uF	C2077	NOT PLACED	CAP DNF	C2318	NOT PLACED	CAP 4.7pF	C2744	2113741F25	CAP 1000pF
C2014	2113743E20	CAP 0.1uF	C2078	0886629Z02	CAP 1uF	C2319	2113741F25	CAP 1000pF	C2745	2113741F25	CAP 1000pF
C2015	2113743E20	CAP 0.1uF	C2079	NOT PLACED	CAP DNF	C2320	2113741F25	CAP 1000pF	C2750	NOT PLACED	CAP .01uF
C2016	2113743E20	CAP 0.1uF	C2072B	2113740F21	CAP 5.6pF	C2321	NOT PLACED	CAP 100pF	C2751	2113741F49	CAP .01uF
C2017	2113743E20	CAP 0.1uF	C2080	NOT PLACED	CAP 180pF	C2322	2113741F49	CAP .01uF	C2752	2113740F42	CAP 43pF
C2020	2113743K15	CAP 0.1uF	C2201	NOT PLACED	CAP 4.7pF	C2323	2113740F34	CAP 20pF	C2753	2113740F42	CAP 43pF
C2023	2113741F49	CAP 10n	C2202	2113740F34	CAP 20pF	C2324	2113740F34	CAP 20pF	C2754	2113740F37	CAP 27pF
C2024	2113741F49	CAP 10n	C2205	2113740F45	CAP 56pF	C2325	2113740F39	CAP 33pF	C2755	2113740F27	CAP 10pF
C2025	2113741F49	CAP 10n	C2206	NOT PLACED	CAP 20pF	C2326	2113740F39	CAP 33pF	C2756	2113740F27	CAP 10pF
C2026	2113741F49	CAP 10n	C2207	2113740F34	CAP 20pF	C2327	2113740F51	CAP 100pF	C2757	2113741F25	CAP 1000pF
C2027	2113741F49	CAP 10n	C2209	2113740F38	CAP 30pF	C2328	NOT PLACED	CAP 100pF	C2758	2113741F25	CAP 1000pF
C2028	2113743E20	CAP 0.1uF	C2210	2113740F45	CAP 56pF	C2329	NOT PLACED	CAP 100pF	C2761	2113740F31	CAP 15pF
C2033	2113741F25	CAP1n	C2211	NOT PLACED	CAP 10pF	C2330	2113741F37	CAP 3300pF	C2762	2113740F31	CAP 15pF
C2034	2113741F33	CAP 2200pF	C2300	2113741F37	CAP 3300pF	C2335	NOT PLACED	CAP 100pF	C2763	2113741F49	CAP .01uF
C2035	2113741F33	CAP 2200pF	C2301	2113740F27	CAP 10pF	C2336	NOT PLACED	CAP 100pF	C2764	2113740F21	CAP 5.6pF
C2036	2113741F25	CAP1n	C2302	2113740F35	CAP 22pF	C2337	2113741F37	CAP 3300pF	C2765	2113740F38	CAP 30pF
C2037	NOT PLACED	CAP 2200pF	C2304	2113740F59	CAP 220pF	C2338	2113740F49	CAP 82pF	C2766	2113740F51	CAP 100pF
C2045	2113740F59	CAP 220pF	C2305	2113740F57	CAP 180pF	C2722	2113743A31	CAP 1uF	C2767	2113741F49	CAP .01uF
C2046	2113740F59	CAP 220pF	C2306	NOT PLACED	CAP 27pF	C2731	2113741F25	CAP 1000pF	C2771	2113743E20	CAP 0.1uF
C2047	2113740F59	CAP 220pF	C2307	2113741F37	CAP 3300pF	C2732	NOT PLACED	CAP 1pF	C2772	2113741F25	CAP 1000pF
C2048	2113740F59	CAP 220pF	C2308	2113741F25	CAP 1000pF	C2733	2113740F31	CAP 15pF	C2773	NOT PLACED	CAP 4.7pF

Circuit Ref.	Motorola Part No.	Description
C2775	2113740F37	CAP 27pF
C2776	2113740F47	CAP 68pF
C2777	2113740F37	CAP 27pF
C2778	2113740F43	CAP 47pF
C2779	2113741F17	CAP 470pF
C2780	2113743E20	CAP 0.1uF
C2781	2113741F49	CAP .01uF
C2782	2113741F25	CAP 1000pF
C2784	2113740F19	CAP 4.7pF
C2785	2113740F39	CAP 33pF
C2790	2113740F29	CAP 12pF
C2791	2113741F49	CAP .01uF
C2792	2113743E20	CAP 0.1uF
C2793	2113741F49	CA .01uF
C2794	2113740F24	CAP 7.5pF
C2795	2113740F23	CAP .8pF
C2796	2113741F49	CAP VALUE
C2805	2113743E20	CA 0.1uF
C2806	2113741F25	CAP 1000pF
C5000	2113741F25	CAP 1000pF
C5001	2380090M24	CAPP 10uF
C5002	2311049A99	CAPP 47uF
C5003	2311049A99	CAPP 47uF
C5005	2311049A97	CAPP 33uF
C5006	2311049A57	CAPP 10uF
C5007	2311049A57	CAPP 10uF
C5008	2311049A57	CAPP 10uF
C5009	2311049A57	CAPP 10uF
C5010	2311049A57	CAPP 10uF
C5011	2311049A57	CAPP 10uF

Circuit Ref.	Motorola Part No.	Description
C5012	2311049A56	CAPP 4.7u
C5013	2113928P04	CAP 1u
C5014	NOT PLACED	CAP 2.2uF
C5015	NOT PLACED	CAP 0.1uF
C5016	NOT PLACED	CAP 0.1uF
C5017	NOT PLACED	CAP 0.1uF
C5018	NOT PLACED	CAP 0.1uF
C5019	2113743K15	CAP 0.1uF
C5020	2113743K15	CAP 0.1uF
C5021	2113743K15	CAP 0.1uF
C5022	2113743K15	CAP 0.1uF
C5023	2113743K15	CAP 0.1uF
C5024	2113743K15	CAP 0.1uF
C5025	2113743K15	CAP 0.1uF
C5026	2113743K15	CAP 0.1uF
C5027	2113743K15	CAP 0.1uF
C5028	2113743K15	CAP 0.1uF
C5029	2113743K15	CAP 0.1uF
C5030	2113743K15	CAP 0.1uF
C5031	2113743K15	CAP 0.1uF
C5032	2113743K15	CAP 0.1uF
C5033	2113743K15	CAP 0.1uF
C5034	2113743K15	CAP 0.1uF
C5035	2113743K15	CAP100n
C5036	2113743K15	CAP 0.1uF
C5037	2113743K15	CAP 0.1uF
C5038	2113743K15	CAP 100n
C5039	NOT PLACED	CAP 100n
C5040	NOT PLACED	CAP 100n
C5041	2113743F18	CAP 2.2uF

Circuit Ref.	Motorola Part No.	Description
C5042	2113743F16	CAP 1u
C5043	2113743F16	CAP 1u
C5044	2113743F16	CAP 1u
C5045	2113743F16	CAP 1uF
C5046	2113743E20	CAP 0.1uF
C5047	2113743E20	CAP 0.1uF
C5048	2113743E20	CAP 0.1uF
C5049	2113743E20	CAP 0.1uF
C5050	2113743E20	CAP 0.1uF
C5051	2113743E20	CAP 0.1uF (CM360)
C5052	2113743E20	CAP 0.1uF
C5053	2113743E20	CAP 0.1uF (CM360)
C5054	2113743E20	CAP 0.1uF (CM360)
C5055	2113741M69	CAP 0.1uF
C5056	2113741M69	CAP 0.1uF (CM360)
C5057	2113743E20	CAP 0.1uF
C5058	NOT PLACED	CAP 0.1uF
C5059	2113743E07	CAP .022uF
C5060	2113743K15	CAP 100n
C5061	2113741M69	CAP 0.1uF
C5062	2113741M69	CAP 0.1uF
C5063	2113741M69	CAP 0.1uF
C5064	NOT PLACED	CAP1000pF
C5065	NOTPLACED	CAP 1000pF
C5066	NOT PLACED	CAP 1000pF
C5067	2113741F25	CAP 1000pF
C5068	NOT PLACED	CAP 1000pF
C5069	NOT PLACED	CAP 1000pF
C5070	NOT PLACED	CAP 1000pF
C5071	2113741F25	CAP 1000pF

Circuit Ref.	Motorola Part No.	Description
C5072	2113741F25	CAP 1000pF
C5073	2113741F25	CAP 1000pF
C5074	NOT PLACED	CAP 1000pF
C5075	NOT PLACED	CAP 1000pF
C5076	2113741F25	CAP 1000pF
C5077	2113741F25	CAP 1000pF
C5078	2113741F25	CAP 1000pF
C5079	2113741F25	CAP 1000pF
C5080	2113741F25	CAP 1000pF
C5081	2113741F25	CAP 1000pF
C5082	2113741F25	CAP 1000pF
C5083	2113740F51	CAP 100pF
C5084	2113740F51	CAP 100pF
C5085	2113741A53	CAP .022uF
C5086	2113741A53	CAP .022uF
C5087	2113740F49	CAP 82p
C5088	2113740F49	CAP 82pF
C5089	NOT PLACED	CAP 82pF
C5090	2113740F49	CAP 82p
C5091	2113740F49	CAP 82pF
C5092	NOT PLACED	CAP 220pF
C5094	NOT PLACED	CAP 220pF
C5095	NOT PLACED	CAP 220pF
C5096	NOT PLACED	CAP 220pF
C5097	2113740F59	CAP 220pF
C5098	2113740F59	CAP 220pF
C5099	2113740F59	CAP 220pF
C5100	2113740F59	CAP 220pF
C5101	2113741F25	CAP 1000pF (CM360)
C5102	2113743E20	CAP 0.1uF (CM360)

Circuit Ref.	Motorola Part No.	Description	Circuit Ref.	Motorola Part No.	Description	Circuit Ref.	Motorola Part No.	Description	Circuit Ref.	Motorola Part No.	Description
C5103	2113743K15	CAP100n (CM360)	D500	4813833C02	MMBD6100	L14	2462587N53	IDCTR 100nH	L1513	2485873L12	IDCTR 71.5nH
C5104	2113741F25	CAP 1000pF	D501	4813833C02	MMBD6100	L16	NOT PLACED	IDCTR 27nH	L1514	2485873L12	IDCTR 71.5nH
C5110	2113741F25	CAP 1000pF	D502	4813825A23	MMSD301T1	L100	2484657R01	57R01	L1515	2485873L12	IDCTR 71.5nH
C5111	2113741F25	CAP 1000pF	D513	4813833C02	MMBD6100	L101	2462587T30	IDCTR 1uH	L1518	NOT PLACED	IDCTR 1.2uH
C5119	2113743H14	CAP 10uF	D2201	4880154K03	MMBD353	L102	2462587T30	IDCTR 1uH	L1519	2462587N56	IDCTR 180nH
C5120	2311049A99	CAPP 47uF	D2301	4805649Q13	1SV228	L103	2462587T30	IDCTR 1uH	L2201	2462587M23	IDCTR 2.7uH
C5555	2113741A45	CAP .01uF	D2303	4880154K03	MMBD353	L104	2462587N64	IDCTR 680nH	L2202	NOT PLACED	IDCTR 2.7uH
C5559	2113741F25	CAP 1000pF	D2304	4805649Q13	1SV228	L105	2462587N55	IDCTR 150nH	L2203	2462587M23	IDCTR 2.7uH
C5560	2113741F33	CAP 2200pF	D2731	4805649Q13	1SV228	L107	2409377M03	IDCTR 6.8nH	L2302	2462587T23	IDCTR 470nH
D1	4880142L01	MMBV3401LT	D2732	4805649Q13	1SV228	L108	2462587N69	IDCTR 1.2uH	L2731	2462587N58	IDCTR 270nH
D3	4802245J97	DAN235ETL	D2733	4805649Q13	1SV228	L115	2485873L09	IDCTR 38.13nH	L2732	2462587N68	IDCTR 1uH
D4	4802245J97	DAN235ETL	D2739	4813825A05	MMBD301	L117	2484657R01	57R01	L2733	2462587T23	IDCTR 470nH
D5	4802245J97	DAN235ETL	D2751	4805649Q13	1SV228	L118	2484657R01	57R01	L2734	2462587T16	IDCTR 120nH
D6	4802245J97	DAN235ETL	D2752	4805649Q13	1SV228	L119	2484657R01	57R01	L2741	2462587N68	IDCTR 1uH
D100	NOT PLACED	MMBD6100	D2754	4813825A05	MMBD301	L120	2484657R01	57R01	L2742	2462587N68	IDCTR 1uH
D101	4813833C02	MMBD6100	FL2	9180468V06	FLTR	L121	2484657R01	57R01	L2750	2462587T30	IDCTR 1uH
D102	4813833C02	MMBD6100	FL3	9180468V04	FLTR	L122	2408384A10	IDCTR 120nH	L2751	2462587N68	IDCTR 1uH
D103	4802482J02	MA4P959	FL4	9180469V03	CFWC455G	L200	2462587Q46	IDCTR 820nH	L2752	2462587T18	IDCTR 180nH
D104	4802482J02	MA4P959	FL5	9180469V06	CFWC455D	L205	2462587Q47	IDCTR1uH	L2753	2462587T18	IDCTR 180nH
D105	4805218N57	RB715F	FL2201	9166509A01	TS2-21B01	L217	2462587Q46	IDCTR 820nH	L2754	2462587N68	IDCTR 1uH
D106	4805218N57	RB715F	FL2202	9166509A01	TS2-21B01	L500	2484657R01	57R01	L2761	2462587N55	IDCTR150nH
D107	4805218N57	RB715F	J1	2889309U01	CONN_P	L501	2484657R01	57R01 0n	L2768	2462587N54	IDCTR 120nH
D108	4805218N57	RB715F	J2	0989241U02	CONN_J 20 PIN	L502	2484657R01	57R01 0n	L2774	2462587N50	IDCTR 56nH
D200	4802233J09	IMN10	J3	0986615Z01	CONN 28PIN ZIF (CM360)	L1502	2460591E64	IDCTR 30.51nH	L2775	2462587N50	IDCTR 56nH
D201	4802233J09	IMN10	L1	2462587M23	IDCTR 2.7uH	L1503	2460591A11	IDCTR 7.66nH	L2781	2462587N56	IDCTR 180nH
D202	NOT PLACED	1SV232	L2	2462587N69	IDCTR 1.2uH	L1504	2460591L29	IDCTR 16.03nH	L2790	2462587N56	IDCTR 180nH
D202B	4862824C03	1SV232	L3	2462587N69	IDCTR 1.2uH	L1505	2485873L09	IDCTR 38.13nH	L2792	2462587N69	IDCTR 1.2uH
D400	4813833C07	MMBD7000	L6	2462587N69	IDCTR 1.2uH	L1507	2462587T12	IDCTR 56nH	M9	0289511U01	NUT
D401	4813833C02	MMBD6100	L13	2462587N53	IDCTR 100nH	L1511	2485873L12	IDCTR 71.5nH	M100	NOT PLACED	DRV_CLIP
D402	NOT PLACED	RB751V40				L1512	2485873L12	IDCTR 71.5nH	M101	NOT PLACED	CONTACT

Circuit Ref.	Motorola Part No.	Description
M102	NOT PLACED	CONTACT
M103	NOT PLACED	CONTACT
M104	NOT PLACED	CONTACT
M105	2680499Z01	HEATSINK
M201	7588823L03	CONTACT
M202	7588823L03	CONTACT
M203	7588823L03	CONTACT
M204	7588823L04	CONTACT
M205	7588823L04	CONTACT
M206	7588823L04	CONTACT
PCB	8489012U01	
P1	2804503J01	CONN_P
P2	NOT PLACED	CONN_P
Q1	4809939C04	UMC3
Q3	4813824A10	MMBT3904
Q4	4809939C04	UMC3
Q6	4802197J95	PBR941
Q100	4886136B01	MRF1550
Q101	4809940E02	DTC114YE
Q102	4809940E02	DTC114YE
Q103	4813824A06	MMBTA13
Q104	4813824A10	MMBT3904
Q105	4813828A08	MRF1511
Q106	4805128M27	BSR33
Q107	4809940E02	DTC114YE
Q108	NOT PLACED	MMBT3904
Q109	4813824A10	MMBT3904
Q110	4809940E02	DTC114YE
Q400	4809940E02	DTC114YE
Q401	4880141L03	BCW68G

Circuit Ref.	Motorola Part No.	Description
Q403	4809940E02	DTC114YE
Q404	4809940E02	DTC114YE
Q405	4809940E02	DTC114YE
Q407	4809940E02	DTC114YE
Q408	4880048M01	DTC144EKA
Q409	4880048M01	DTC144EKA
Q410	4880048M01	DTC144EKA
Q411	4880048M01	DTC144EKA
Q412	4880048M01	DTC144EKA
Q413	4809940E02	DTC114YE
Q414	4809940E02	DTC114YE
Q415	NOT PLACED	MMBT3904
Q417	4813824A10	MMBT3904
Q500	4813824A65	MMBT3904WT1
Q501	4809940E02	DTC114YE
Q502	4809940E02	DTC114YE
Q503	4813824A65	MMBT3904WT1
Q504	4880048M01	DTC144EKA
Q505	4813824A10	MMBT3904
Q506	4813824A10	MMBT3904
Q507	NOTPLACED	DTC114YE
Q514	4802393L66	SI3455ADV
Q2301	4802197J95	PBR941
Q2302	4813824A17	MMBT3906
Q2741	4813823A05	MMBFU310L
Q2742	4805921T09	FMG8A
Q2751	4813823A05	MMBFU310L
Q2752	4813824A10	MMBT3904
Q2760	4802197J95	PBR941
Q2770	4802197J95	PBR941

Circuit Ref.	Motorola Part No.	Description
Q2780	4802197J95	PBR941
Q2790	4802197J95	PBR941
Q2791	4809939C04	UMC3
R1	0662057A40	RES 430
R2	0662057A41	RES 470
R4	0662057B47	RES 0.
R5	0662057A82	RES 24K
R6	0662057A80	RES 20.K
R7	0662057A80	RES 20.K
R8	0662057A80	RES 20.K
R9	0662057A80	RES 20.K
R10	0662057A77	RES15.K
R12	NOT PLACED	RES 15.K
R13	0662057A73	RES 10K
R14	0662057A75	RES 12.K
R15	0662057A75	RES 12.K
R16	0662057A75	RES 12.K
R17	0662057A75	RES 12.K
R18	0662057A75	RES 12.K
R19	0662057A75	RES 12.K
R20	0662057A75	RES 12.K
R21	0662057A73	RES 10K
R23	0662057A71	RES 8.2K
R24	0662057A69	RES 6.8K
R25	0662057A65	RES 4.7K
R26	0662057A61	RES 3.3K
R27	0662057A61	RES 3.3K
R28	0662057A58	RES 2.4K
R30	0662057A55	RES 1.8K
R31	0662057A51	RES 1.2K

Circuit Ref.	Motorola Part No.	Description
R33	0662057A45	RES 680.
R34	0662057A59	RES 2.7K
R35	0662057A39	RES 390.
R36	NOT PLACED	RES 0
R37	0662057A25	RES 100.
R38	0662057A33	RES 220
R39	0662057A18	RES 51.
R41	0662057A18	RES 51.
R100	NOT PLACED	RES 39K
R101	1705603W01	SHUNT 1.639m
R102	0683962T51	RES 120
R103	0683962T51	RES 120
R104	0683962T51	RES 120
R105	0680194M18	RES 51.0
R106	0680194M18	RES 51.0
R107	0680194M18	RES 51.000
R108	0680194M18	RES 51.000
R109	0662057A15	RES 39
R110	0662057P10	RES 10K
R111	0662057P10	RES 10K
R112	0662057T21	RES 332K
R113	0662057P10	RES 10.K
R114	0662057P10	RES 10.K
R115	0662057P10	RES 10.K
R116	0662057P10	RES 10.K
R117	0662057A77	RES 15K
R118	0662057A45	RES 680
R119	0662057A29	RES 150
R120	0662057A45	RES 680
R121	0662057A29	RES 150

Circuit Ref.	Motorola Part No.	Description	Circuit Ref.	Motorola Part No.	Description	Circuit Ref.	Motorola Part No.	Description	Circuit Ref.	Motorola Part No.	Description
R122	0662057C19	RES 4.7	R159	0662057A67	RES5.6K	R190	0662057B47	RES 0	R403	0662057B47	RES 0.
R123	0662057C13	RES 2.7	R160	0662057A61	RES 3.3K	R191	0662057A73	RES 10K	R404	0662057B47	RES 0.
R124	0662057C13	RES 2.7	R161	0662057A61	RES 3.3K	R192	0662057A61	RES 3.3K	R405	0662057B47	RES 0.
R125	0662057C13	RES 2.7	R162	0662057A61	RES 3.3K	R193	0662057A73	RES 10K	R406	0662057B47	RES 0.
R126	0662057C03	RES 1	R163	0662057A61	RES 3.3K	R194	0662057A86	RES 36K	R407	0662057B47	RES 0.
R127	0662057C03	RES 1	R164	0662057A74	RES 11K	R195	0662057A73	RES 10K	R414	0662057B47	RES 0.
R130	0662057B47	RES 0	R165	0662057A58	RES 2.4K	R196	NOT PLACED	RES 3.3K	R415	0662057B47	RES 0.
R131	0662057A73	RES 10K	R166	0662057A58	RES 2.4K	R197	NOT PLACED	RES 10K	R421	0662057B47	RES 0
R132	0662057T38	RES 750K	R167	0662057A57	RES 2.2K	R198	NOT PLACED	RES 100K	R422	NOT PLACED	RES10K
R134	0662057A65	RES 4.7K	R168	0662057A57	RES 2.2K	R199	NOT PLACED	RES 0	R423	NOT PLACED	RES 100.K
R135	0662057A88	RES 43K	R169	0662057A57	RES 2.2K	R200	0662057B07	RES 240K	R424	NOT PLACED	RES 100.K
R136	0662057A87	RES 39.K	R170	0662057A42	RES 510.	R201	0662057A73	RES 10K	R425	0662057A97	RES 100.K
R137	0662057A87	RES 39.K	R171	0662057A41	RES 470	R202	NOT PLACED	RES 0.	R426	NOT PLACED	RES 100.K
R138	0662057A89	RES 47K	R172	0662057A41	RES 470.	R204	NOT PLACED	RES 0	R427	NOT PLACED	RES 100.K
R139	0662057A89	RES 47K	R173	0662057A29	RES 150	R205	NOT PLACED	RES 0	R428	0662057A97	RES 100.K
R140	0662057A81	RES 22K	R174	0662057A29	RES 150	R206	0662057B02	RES 150K	R429	0662057A97	RES 100K
R141	0662057A81	RES 22.K	R175	0662057A33	RES 220	R207	NOT PLACED	RES 150.K	R430	0662057A87	RES 39K
R142	0662057A81	RES 22.K	R176	0662057A25	RES 100	R209	0662057A97	RES 100.K	R431	NOT PLACED	RES 10K
R143	0662057A81	RES 22.K	R177	NOT PLACED	RES 22K	R207B	0662057B02	RES 150.K	R432	0662057A85	RES 33.K
R144	0662057A81	RES 22K	R178	0662057A25	RES 100	R210	0662057A97	RES 100.K	R433	0662057A85	RES 33.K
R145	0662057A81	RES 22K	R179	NOT PLACED	RES 36.	R217	0662057A43	RES 560	R434	0662057A85	RES 33.K
R146	0662057A81	RES 22.K	R180	0662057A89	RES 47K	R224	0662057A41	RES 470	R435	0662057A85	RES 33.K
R147	0662057A81	RES 22K	R181	0662057A89	RES 47K	R225	0662057A29	RES 150.	R436	0662057A85	RES 33.K
R148	0662057A81	RES 22.K	R182	0662057B47	RES 0	R226	0662057A29	RES 150.	R438	0662057A73	RES 10.K
R149	0662057A81	RES 22.K	R183	NOT PLACED	RES 47K	R228	0662057A25	RES 100.	R439	0662057A73	RES 10.K
R151	0662057A69	RES 6.8K	R185	0662057A73	RES 10K	R229	0662057A25	RES 100.	R440	0662057A73	RES 10.K
R152	0662057C99	RES 10K	R186	NOT PLACED	RES 0	R234	0662057A25	RES 100	R441	0662057A73	RES 10.K
R156	0662057A73	RES 10.K	R187	NOT PLACED	RES 0	R235	NOT PLACED	RES 0	R442	0662057A73	RES 10.K
R157	0662057A91	RES 56K	R188	NOT PLACED	RES 0	R401	0662057C85	RES 2.7K	R443	0662057A61	RES 3.3K
R158	0662057A67	RES 5.6K	R189	0662057A61	RES 3.3K	R402	0662057B47	RES 0.	R444	0662057A73	RES 10.K

Circuit Ref.	Motorola Part No.	Description
R445	0662057A73	RES 10.K
R447	0662057A01	RES 10
R450	0662057A73	RES 10.K
R451	0662057A73	RES 10.K
R453	0662057A61	RES 3.3K
R454	0662057A61	RES 3.3K
R455	0662057A61	RES 3.3K
R456	0662057A61	RES 3.3K
R457	0662057A61	RES 3.3K
R458	0662057A61	RES 3.3K
R459	NOT PLACED	RES 47K
R460	0662057A53	RES 1.5K
R461	0662057A33	RES 220
R462	0662057A18	RES 51
R463	0662057A73	RES 10K
R466	NOT PLACED	RES 0
R467	NOT PLACED	RES 0
R468	NOT PLACED	RES 0
R469	NOT PLACED	RES 0
R470	0662057A73	RES 10.K
R472	NOT PLACED	RES 100K
R473	NOT PLACED	RES 100K
R600	0662057C01	RES 0
R601	0611077A62	RES 330
R610	0662057C59	RES 220
R611	NOT PLACED	RES 0
R612	0662057C01	RES 0
R613	0662057C01	RES 0
R692	0662057A87	RES 39K
R693	0662057A87	RES 39K

Circuit Ref.	Motorola Part No.	Description
R694	0662057A97	RES 100K
R1502	0662057B47	RES 0
R1503	0662057A01	RES 10
R1506	0662057A01	RES 10
R1507	0611077A01	RES 0
R2301	0662057A97	RES 100K
R2302	0662057A37	RES 330
R2303	0662057A49	RES 1K
R2304	0662057A53	RES 1.5K
R2305	NOT PLACED	RES 10K
R2306	0662057A35	RES 270
R2307	0662057A21	RES 68
R2308	0662057A35	RES 270
R2309	0662057A97	RES 100K
R2311	0662057A63	RES 3.9K
R2312	0662057A59	RES 2.7K
R2313	0662057A61	RES 3.3K
R2314	0662057B67	RES 6.2
R2316	0662057A29	RES 150
R2317	0662057A29	RES 150
R2318	0662057A13	RES 33
R2321	2113740F29	RES 12pF
R2714	0662057B02	RES 150K
R2731	0662057A13	RES 33
R2739	0662057A83	RES 27K
R2740	0662057A09	RES 22
R2741	0662057A21	RES 68
R2742	0662057A15	RES 39
R2743	0662057A65	RES 4.7K
R2751	0662057A83	RES 27K

Circuit Ref.	Motorola Part No.	Description
R2752	0662057A57	RES 2.2K
R2753	0662057A21	RES 68
R2754	0662057A15	RES 39
R2758	0662057A25	RES 100
R2760	0662057B47	RES 0
R2761	0662057A55	RES 1.8K
R2762	0662057A41	RES 470
R2763	0662057A25	RES 100
R2765	0662057A29	RES 150
R2766	0662057A15	RES 39
R2767	0662057A29	RES 150
R2768	0662057A59	RES 2.7K
R2769	0662057A49	RES 1K
R2770	0662057A01	RES 10
R2771	0662057A29	RES 150
R2772	0662057A25	RES 100
R2773	0662057A35	RES 270
R2774	0662057A01	RES 10
R2775	NOT PLACED	RES 270
R2776	0662057A25	RES 100
R2777	0662057A35	RES 270
R2778	0662057A59	RES 2.7K
R2779	0662057A53	RES 1.5K
R2781	0662057A25	RES 100
R2782	0662057A25	RES 100
R2783	NOT PLACED	RES 10
R2784	0662057A01	RES 10
R2785	0662057A15	RES 39
R2786	0662057A29	RES 150
R2788	0662057A29	RES 150

Circuit Ref.	Motorola Part No.	Description
R2790	0662057B47	RES 0
R2791	0662057A41	RES 470
R2792	0662057A49	RES 1K
R2793	NOT PLACED	RES 1K
R2794	0662057A18	RES 51
R2795	0662057A49	RES 1K
R2796	0662057A35	RES VALUE
R2797	NOT PLACED	RES 0
R2808	0662057A01	RES 10
R2810	NOT PLACED	RES 470
R2811	0662057A97	RES 100K
R5000	0662057B47	RES 0
R5001	0662057T68	RES 1K
R5002	0662057B47	RES 0 (CM360)
R5006	0662057B47	RES 0
R5007	0662057A89	RES 47K
R5008	0662057B47	RES 0
R5009	0662057B47	RES 0
R5010	0662057B47	RES 0
R5011	NOT PLACED	RES 0
R5013	NOT PLACED	RES 0
R5014	0662057B47	RES 0
R5019	0662057B08	RES 270.K
R5020	0662057B02	RES 150K
R5021	0662057A97	RES 100K
R5022	0662057A97	RES 100K
R5023	0662057A97	RES 100K
R5024	0662057A97	RES 100K (CM360)
R5025	0662057A97	RES 100K
R5026	0662057A85	RES 33K

Circuit Ref.	Motorola Part No.	Description	Circuit Ref.	Motorola Part No.	Description	Circuit Ref.	Motorola Part No.	Description	Circuit Ref.	Motorola Part No.	Description
R5027	0662057B08	RES 270K	R5057	0662057A73	RES 10K	R5091	0662057A43	RES 560	U502	5102463J95	TDA1519C
R5028	0662057A97	RES 100K	R5058	NOT PLACED	RES 10K	R5092	0662057A97	RES 100K	U503	5105469E65	LP2951C
R5029	0662057A97	RES 100K	R5059	NOT PLACED	RES 10K	R5103	0662057A82	RES 24K	U504	5185130C53	30C53
R5030	0662057A85	RES 33K	R5060	0662057A73	RES 10K	RT100	0680361L01	THERM 47K	U505	5113818A01	LM2904
R5031	0662057A92	RES 62K	R5061	0662057A73	RES 10K	S5010	1889288U01	SWITCH	U506	5113818A01	LM2904
R5032	0662057A91	RES 56.K	R5062	0662057A73	RES 10K	SH1	2602023X12	shield	U507	5113818A01	LM2904
R5033	0662057A89	RES 47K	R5063	NOT PLACED	RES 8.2K	SH2	2602641Y02	shield	U508	5113816A30	MC33269D
R5034	0662057A89	RES 47K	R5064	NOT PLACED	RES 8.2K	SH3	2602023X10	shield	U509	5184704M60	HEF4053B
R5035	0662057A89	RES 47K	R5065	0662057A68	RES 6.2K	SH4	2602023X10	shield	U510	5104187K94	LP2986ILDX
R5036	0662057A89	RES 47K	R5066	0662057A68	RES 6.2K	SH100	NOT PLACED	PA Shield	U511	4813833C02	MMBD6100
R5037	0662057A73	RES 10K	R5067	NOT PLACED	RES 6.2K	SH2301	2605915V01	SHIELD	U515	5162852A59	MAX4599EXT (CM360)
R5038	0662057A85	RES 33K	R5068	NOT PLACED	RES 6.2K	SH2302	NOT PLACED	SHIELD	U517	5113818A01	LM2904
R5039	0662057A97	RES 100K	R5069	0662057A73	RES 10K	T1	2580541Z02	XFMR	VR101	4813830A15	MMBZ5232B
R5040	0662057A84	RES 30.K	R5070	0662057A57	RES 2.2K	T2	2580541Z02	XFMR	VR102	4813830A15	MMBZ5232B
R5041	0662057A82	RES 24K	R5071	0662057A57	RES 2.2K	U1	4808612Y05	SMS3928_023	VR103	4813830A33	MMBZ5250B
R5042	0662057A82	RES 24K	R5072	0662057A65	RES 4.7K	U2	5186144B01	SA616	VR104	4813830A33	MMBZ5250B
R5043	0662057A82	RES 24K	R5073	0662057A49	RES 1K	U3	5109522E10	TC7W04F	VR400	NOT PLACED	MMBZ5235B
R5044	0662057A82	RES 24K	R5074	0662057A49	RES 1K	U100	5113818A01	LM2904	VR401	4813830G12	MMSZ4687T1
R5045	0662057A85	RES 33K	R5075	0662057A42	RES 510.	U101	5185130C65	30C65	VR402	4813830A09	MMBZ5226B
R5046	0662057A82	RES 24K	R5076	0662057A42	RES 510.	U102	5113818A01	LM2904	VR500	4813832C77	MR2835S
R5047	0662057B47	RES 0 (CM340)	R5077	0662057A36	RES 300	U103	5113819A04	MC3303	VR501	4813830A14	MMBZ5231B
R5048	0662057A82	RES 24K	R5078	0662057A25	RES 100.	U200	5185963A27	63A27	VR502	4813830G09	MMSZ4684
R5049	0662057A77	RES 15K	R5079	0662057A25	RES 100.	U400	5102463J64	X25128-2.7	VR503	4813830G09	MMSZ4684
R5050	0662057A76	RES 13K	R5080	0662057A01	RES 10.	U401	4809940E02	DTC114YE	VR504	4813830G09	MMSZ4684
R5051	0662057A75	RES 12K	R5081	0613952D78	RES 6.34K	U402	5102463J36	SRM2B256	VR692	4813830A75	MMBZ20VAL
R5052	0662057A73	RES 10K	R5082	0662057A90	RES 51K	U403	5102226J56	MC68HC11FL0	VR693	4813830A77	MMBZ33VAL
R5053	0662057A73	RES 10K	R5083	0662057B08	RES 270K	U404	5189233U21	FLASH 4 MEG AT49LV040-70VI	VR694	4813830A75	MMBZ20VAL
R5054	0662057A73	RES 10K	R5084	0662057B47	RES 0 (CM360)	U405	5113805A75	MC74HC595A	VR695	4813830A77	MMBZ33VAL
R5055	0662057A73	RES 10K	R5085	NOT PLACED	RES 1MEG	U501	0104016J81	LM2941T	VR696	4813830A75	MMBZ20VAL
R5056	0662057A73	RES 10K	R5089	NOT PLACED	RES 1MEG				VR697	4813830A75	MMBZ20VAL

Circuit Ref.	Motorola Part No.	Description
VR698	4813830A75	MMBZ20VAL
VR699	4813830A75	MMBZ20VAL
Y1	9186145B02	45B02
Y2	4866541A01	TSX-5
Y200	NOT PLACED	45J68
Y201	NOT PLACED	14R06
Y202	4880114R06	14R06



MOTOROLA

Commercial Series

CM Radios

UHF2 (438-470MHz) High Power

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Table of Contents

Chapter 1 MODEL CHART AND TECHNICAL SPECIFICATIONS

1.0 CM140/CM160 Model Chart	1-1
2.0 Technical Specifications	1-2

Chapter 2 THEORY OF OPERATION

1.0 Introduction	2-1
2.0 UHF (438-470MHz) Receiver	2-1
2.1 Receiver Front-End	2-1
2.2 Receiver Back End	2-2
3.0 UHF Transmitter Power Amplifier (438-470 MHz)	2-2
3.1 First Power Controller Stage	2-2
3.2 Power Controlled Driver Stage	2-3
3.3 Final Stage	2-3
3.4 Directional Coupler	2-3
3.5 Antenna Switch.....	2-3
3.6 Harmonic Filter	2-4
3.7 Power Control.....	2-4
4.0 UHF (438-470MHz) Frequency Synthesizer	2-4
4.1 Reference Oscillator	2-4
4.2 Fractional-N Synthesizer	2-5
4.3 Voltage Controlled Oscillator (VCO).....	2-6
4.4 Synthesizer Operation	2-7
5.0 Controller Theory of Operation	2-8
5.1 Radio Power Distribution	2-8
5.2 Protection Devices.....	2-10
5.3 Automatic On/Off	2-10
5.4 Microprocessor Clock Synthesiser	2-11
5.5 Serial Peripheral Interface (SPI).....	2-12
5.6 SBEP Serial Interface	2-12
5.7 General Purpose Input/Output.....	2-12
5.8 Normal Microprocessor Operation.....	2-13
5.9 Static Random Access Memory (SRAM).....	2-14
6.0 Control Board Audio and Signalling Circuits	2-14
6.1 Audio Signalling Filter IC and Compander (ASFIC CMP)	2-14
7.0 Transmit Audio Circuits	2-15
7.1 Microphone Input Path	2-15
7.2 PTT Sensing and TX Audio Processing	2-16

8.0	Transmit Signalling Circuits	2-17
8.1	Sub-Audio Data (PL/DPL)	2-17
8.2	High Speed Data	2-18
8.3	Dual Tone Multiple Frequency (DTMF) Data	2-18
9.0	Receive Audio Circuits.....	2-19
9.1	Squelch Detect	2-19
9.2	Audio Processing and Digital Volume Control.....	2-20
9.3	Audio Amplification Speaker (+) Speaker (-)	2-20
9.4	Handset Audio	2-21
9.5	Filtered Audio and Flat Audio	2-21
10.0	Receive Signalling Circuits	2-21
10.1	Sub-Audio Data (PL/DPL) and High Speed Data Decoder	2-21
10.2	Alert Tone Circuits.....	2-22

Chapter 3 TROUBLESHOOTING CHARTS

1.0	Troubleshooting Flow Chart for Receiver RF (Sheet 1 of 2).....	3-2
1.1	Troubleshooting Flow Chart for Receiver (Sheet 2 of 2).....	3-3
2.0	Troubleshooting Flow Chart for 40W Transmitter (Sheet 1 of 3)	3-4
2.1	Troubleshooting Flow Chart for 40W Transmitter (Sheet 2 of 3).....	3-5
2.2	Troubleshooting Flow Chart for 40W Transmitter (Sheet 3 of 3).....	3-6
3.0	Troubleshooting Flow Chart for Synthesizer.....	3-7
4.0	Troubleshooting Flow Chart for VCO.....	3-8
5.0	Troubleshooting Flow Chart for DC Supply (1 of 2).....	3-9
5.1	Troubleshooting Flow Chart for DC Supply (2 of 2)	3-10

Chapter 4 UHF2 PCB/ SCHEMATICS/ PARTS LISTS

1.0	Allocation of Schematics and Circuit Boards	4-1
1.1	UHF2 and Controller Circuits	4-1
2.0	UHF2 25-40W PCB 8486577Z01 / Schematics.....	4-3
2.1	UHF2 PCB 8486577Z01 Parts List 40W	4-19

Chapter 1

MODEL CHART AND TECHNICAL SPECIFICATIONS

1.0 CM140/CM160 Model Chart

CM Series, UHF2, 438-470 MHz		
Model	Description	
MDM50RPC9AA2	CM140 438-470 MHz, 40W, 8CH, BNC	
MDM50RPF9AA2	CM160 438-470 MHz, 40W, 64CH, BNC	
Item	Description	
X PMUE2008_	CM140 Super Tanapa UHF2, 40W, 8CH, BNC	
X PMUE2011_	CM160 Super Tanapa UHF2, 40W, 64CH, BNC	
X PMUE2033_	CM140 Tanapa UHF2, 40W, 8CH, BNC	
X PMUE2035_	CM160 Tanapa UHF2, 40W, 64CH, BNC	
X FCN6288_	Control Head	
X FCN5523_	Control Head	
X PMUE2033_S	CM140 UHF2 U/C BNC Service Board	
X PMUE2035_S	CM160 UHF2 U/C BNC Service Board	
X X RMN5018	Mag One Microphone	
X X 6866546D02_	RTTE Leaflet	
X X 6866537D37_	Safety Leaflet	
X X GLN7324_	Low Profile Trunnion	

x = Indicates one of each is required.

2.0 Technical Specifications

Data is specified for +25°C unless otherwise stated.

General	
Specification	UHF2
Frequency Range:	438-470 MHz
Frequency Stability (-30°C to +60°C, 25°C Ref.)	±2.5 PPM
Channel Capacity:	CM140 - 8 CM160 - 64
Channel Spacing:	12.5/25 kHz
Power Supply:	13.6 Vdc (10.88 Vdc - 16.32 Vdc) negative Vehicle ground
Dimensions (L x W x H)	118mm X 169.5mm X 44mm (4.65" X 6.67" X 1.73")
Weight	1.01 kg (2.22 lbs)
FCC Description	ABZ99FT4048
Operating Temperature	-30 to 60° C (Display only -20°C to 60°C)
Storage Temperature	-40 to 85° C
Thermal Shock	-40 to 80° C
High Humidity	95% RH @ 50° C for 8 hrs
ESD	15KV air discharge
Packing Test	Impact Test

Transmitter	
Specification	UHF2
Power Output	25-40W
Conducted/Radiated Emissions:	-36 dBm < 1 GHz -30 dBm > 1 GHz
Audio Response: (from 6 dB/oct. Pre-Emphasis, 300 to 3000Hz)	TIA603 and CEPT
Tx Audio Distortion	< 3%
Modulation Limiting:	±2.5 kHz @ 12.5 kHz ±4.0 kHz @ 20 kHz ±5.0 kHz @ 25 kHz
FM Hum and Noise:	-35 dB@12.5 kHz -40 dB@25 kHz

Receiver	
Specification	UHF2
Sensitivity (12 dB SINAD):	0.35 µV @ 12.5 kHz 0.3 µV @ 25 kHz
Intermodulation:	60 dB@12.5 kHz 70 dB@25 kHz
Adjacent Channel Selectivity:	60 dB @ 12.5 kHz 70 dB @ 25 kHz
Spurious Response	70 dB
Rated Audio Power	4 W (typ.) Internal 7.5 W @ 5 % External
Audio Distortion	< 5 %
Hum and Noise:	-35 dB @ 12.5 kHz -40 dB @ 25 kHz
Audio Response	TIA603 and CEPT
Conducted Spurious Emission per FCC Part 15:	-57 dBm <1 Ghz -47 dBm >1 Ghz

Specifications subject to change without notice. All electrical specifications and methods refer to EIA/TIA 603 standards.

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Chapter 2

THEORY OF OPERATION

1.0 Introduction

This Chapter provides a detailed theory of operation for the UHF circuits in the radio. Details of the theory of operation and trouble shooting for the the associated Controller circuits are included in this Section of the manual.

2.0 UHF (438-470MHz) Receiver

2.1 Receiver Front-End

The received signal is applied to the radio's antenna input connector and routed through the harmonic filter and antenna switch. The insertion loss of the harmonic filter/antenna switch is less than 1 dB. The signal is routed to the first filter (3-pole), which has an insertion loss of 2 dB typically. The output of the filter is matched to the base of the LNA (Q303) that provides a 16 dB gain and a noise figure of better than 2 dB. Current source Q301 is used to maintain the collector current of Q303. Diode CR301 protects Q303 by clamping excessive input signals. Q303 output is applied to the second filter (4-pole) which has an insertion loss of 1.5 dB. In Distance mode, Q304 turns on and causes D305 to conduct, thus bypassing C322 and R337. In Local mode, the signal is routed through C322 and R337, thus inserting 7 dB attenuation. Since the attenuator is located after the RF amplifier, the receiver sensitivity is reduced only by 6 dB, while the overall third order input intercept is raised.

The first mixer is a passive, double-balanced type, consisting of T300, T301 and U302. This mixer provides all of the necessary rejection of the half-IF spurious response. Low-side injection at +10 dBm is delivered to the first mixer. The mixer output is then connected to a duplex network which matches its output to the XTAL filter input (FL300) at the IF frequency of 44.85 MHz. The duplex network terminates into a 50 ohm resistor (R340) at all other frequencies.

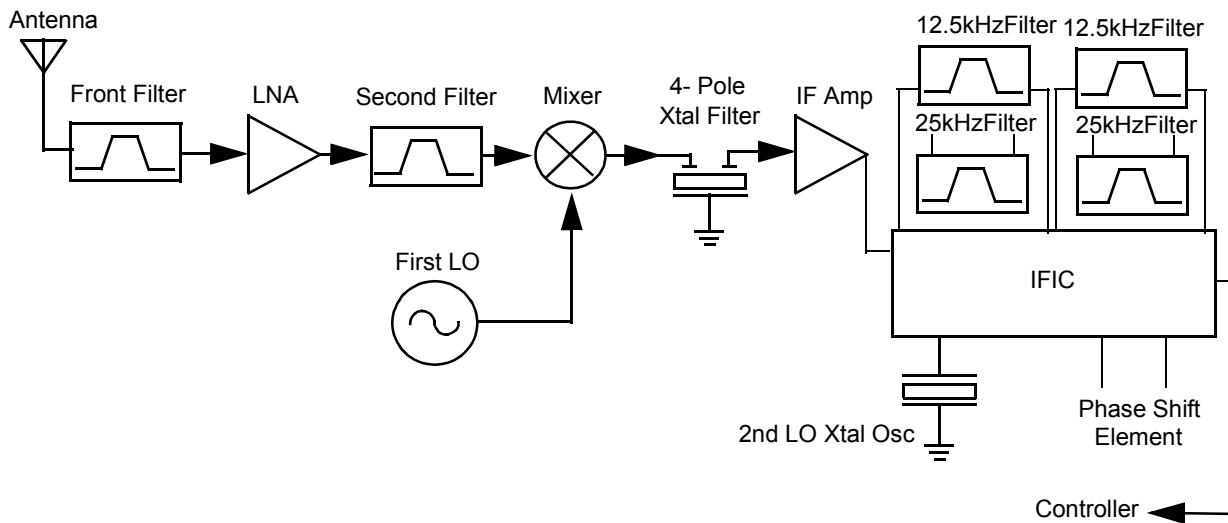


Figure 2-1 UHF Receiver Block Diagram

2.2 Receiver Back End

The IF signal from the crystal filter enters the IF amplifier which provides 20 dB of gain and feeds the IF IC at pin 1. The first IF signal at 44.85 MHz mixes with the second local oscillator (LO) at 44.395 MHz to produce the second IF at 455 kHz. The second LO uses the external crystal Y301. The second IF signal is amplified and filtered by two external ceramic filters (FL303/FL302 for 12.5KHz channel spacing and FL304/FL301 for 25KHz channel spacing). The IF IC demodulates the signal by means of a quadrature detector and feeds the detected audio (via pin 7) to the audio processing circuits. At IF IC pin 5, an RSSI signal is available with a dynamic range of 70 dB.

3.0 UHF Transmitter Power Amplifier (438-470 MHz)

The radio's 40W PA is a three-stage amplifier used to amplify the output from the VCOBIC to the radio transmit level. All three stages utilize LDMOS technology. The gain of the first stage (U101) is adjustable and controlled by pin 7 of U103-2 via U103-3. It is followed by an LDMOS stage Q105 and LDMOS final stage Q100.

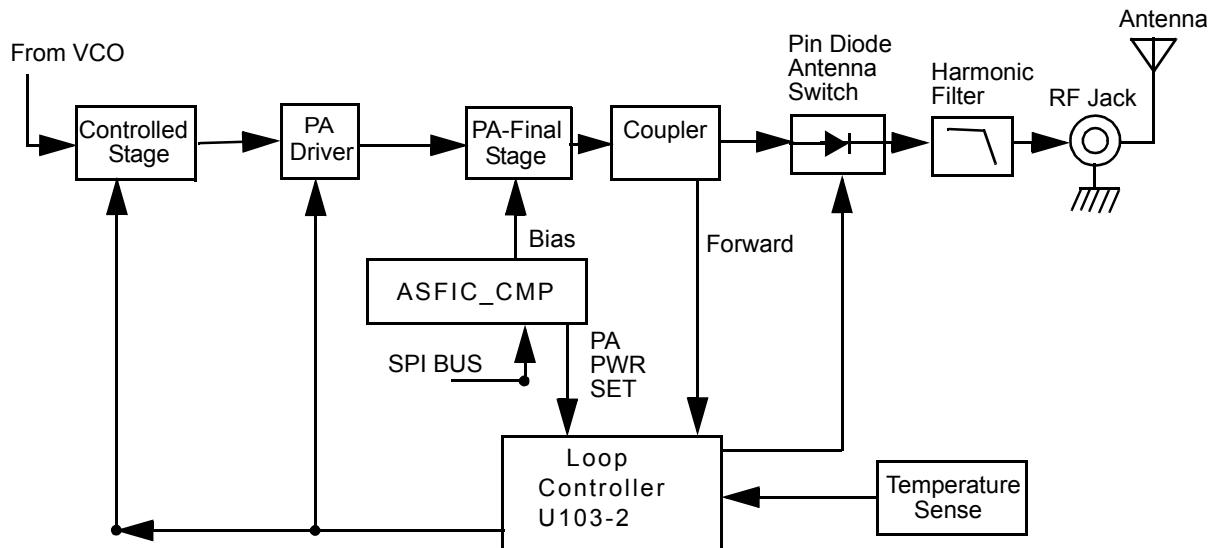


Figure 2-2 UHF Transmitter Block Diagram

Devices U101, Q105 and Q100 are surface mounted. Q100 is screwed down to the chassis to ensure good thermal contact. This scheme also ensures sufficient thermal contact between driver and chassis.

3.1 First Power Controller Stage

The first stage (U101) is a 24dB gain integrated circuit containing two LDMOS FET amplifier stages. It amplifies the RF signal from the VCO (TX_INJ). The output power of stage U101 is controlled by a DC voltage applied to pin 1 from the op-amp U103-3, pin 8. The control voltage simultaneously varies the bias of two FET stages within U101. This biasing point determines the overall gain of U101 and therefore its output drive level to Q105, which in turn controls the output power of the

PA.Op-amp U103-3 monitors the drain current of U101 via resistor R122 and adjusts the bias voltage of U101.

In receive mode, the DC voltage from RX_EN line turns on Q101, which in turn switches off the biasing voltage to U101.

3.2 Power Controlled Driver Stage

The next stage is an LDMOS device (Q105) which provides a gain of 12dB. This device requires a positive gate bias and a quiescent current flow for proper operation. The voltage of the PA_CURRENT is set in transmit mode by ASFIC (U504 pin 5) and fed to the gate of Q105 via resistive network R186, R187. This bias voltage is tuned in the factory. If the transistor is replaced, the bias voltage must be tuned using Global Tuner. Care must be taken so that the transistor is not tuned exceeding the allowed bias voltage. This device directly drains current from B+ via L122.

3.3 Final Stage

The final stage is an LDMOS device (Q100) providing a gain of 12dB. This device also requires a positive gate bias and a quiescent current flow for proper operation. The voltage of the line PA_BIAS is set in transmit mode by ASFIC (U504 pin 4) and fed to the gate of Q100 via the resistive network R134, R131. This bias voltage is tuned in the factory. If the transistor is replaced, the bias voltage must be tuned using the Global Tuner. 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, B+, via L117, L115, L124 and L125.

A matching network consisting of C1005, C1017, C1004, C1009, C1008, C1007, C1274, C1279, C1275, C1276, C1277, C1278, C1021, C1280, C1013, L126, L127 and two striplines, transforms the impedance to 50 ohms and feeds the directional coupler.

3.4 Directional Coupler

The directional Coupler is a microstrip printed circuit, which couples a small amount of the forward power of the RF power from Q100. Coupled power is rectified by diode D105 to produce a proportional DC voltage; and the resulting DC voltage is routed to the power control section to ensure that the forward power out of the radio is held to a constant value.

3.5 Antenna Switch

The antenna switch utilizes the existing dc feed (B+) to the last stage device (Q100). The basic operation is to have both PIN diodes (D103, D104) turned on during key-up by forward biasing them. This is achieved by pulling down the voltage at the cathode end of D104 to around 12.4V (0.7V drop across each diode). The current through the diodes needs to be set around 100 mA to fully open the transmit path through resistor R108. Q106 is a current source controlled by Q103 which is turned on in Tx mode by TX_EN. VR102 ensures that the voltage at resistor R107 never exceeds 5.6V.

3.6 Harmonic Filter

Inductors L111, L113 and L128 along with capacitors C1011, C1023, C1020, C1016, C1025 and C1026 form a low-pass filter to attenuate harmonic energy coming from the transmitter. Resistor R150 along with L130 drains 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 to improve spurious response rejection.

3.7 Power Control

The output power is regulated by using a forward power detection control loop. A directional coupler samples a portion of the forward and reflected RF power. The forward sampled RF is rectified by diode D105, and the resulting DC voltage is routed to the operational amplifier U100. The error output current is then routed to an integrator, and converted into the control voltage. This voltage controls the bias of the pre-driver (U101) stage. The output power level is set by PWR_SET at ASFIG (U504 pin 6) which acts as the reference for forward power control loop.

The reflected coupled power is rectified by diode D107. The resulting DC voltage is amplified by an operational amplifier U100 and routed to the summing junction. This detector protects the final stage Q100 from reflected power by increasing the error current. The temperature sensor protects the final stage Q100 from overheating by increasing the error current. A thermistor RT100 measures the final stage Q100 temperature. The voltage divider output is routed to an operational amplifier U103 and then goes to the summing junction. The Zener Diode VR101 keeps the loop control voltage below 5.6V and eliminates the DC current from the 9.3 regulator U501.

One local loop for the Pre Driver (U101) is used in order to stabilize the current for each stage.

In Rx mode, the two transistors Q101 and Q102 go to saturation and shut down the transmitter by applying ground to the Pre Driver U101.

4.0 UHF (438-470MHz) Frequency Synthesizer

The synthesizer consists of a reference oscillator (Y201), low voltage Fractional-N (LVFRAC-N) synthesizer (U200), and a voltage controlled oscillator (VCO) (U201).

4.1 Reference Oscillator

The reference oscillator is a crystal (Y201) controlled Colpitts oscillator and has a frequency of 16.8MHz. The oscillator transistor and start-up circuit are located in the LVFRAC-N (U200) while the oscillator feedback capacitors, crystal, and tuning varactors are external. An analog-to-digital (A/D) converter internal to the LVFRAC-N (U200) and controlled by the microprocessor via SPI sets the voltage at the warp output of U200 pin 25. This sets the frequency of the oscillator. Consequently, the output of the crystal Y201 is applied to U200 pin 23.

The method of temperature compensation is to apply an inverse Bechmann voltage curve, which matches the crystal's Bechmann curve to a varactor that constantly shifts the oscillator back on frequency. The crystal vendor characterizes the crystal over a specified temperature range and codes this information into a bar code that is printed on the crystal package. In production, this crystal code is read via a 2-dimensional bar code reader and the parameters are saved.

This oscillator is temperature compensated to an accuracy of +/- 2.5 PPM from -30 to 60 degrees C. The temperature compensation scheme is implemented by an algorithm that uses five crystal

parameters (four characterize the inverse Bechmann voltage curve and one for frequency accuracy of the reference oscillator at 25 degrees C). This algorithm is implemented by the LVFRAC-N (U200) at the power up of the radio.

TCXO Y200, along with its corresponding circuitry R204, R205, R210, and C2053, are not placed as the temperature compensated crystal proved to be reliable.

4.2 Fractional-N Synthesizer

The LVFRAC-N U200 consists of a pre-scaler, programmable loop divider, control divider logic, phase detector, charge pump, A/D converter for low frequency digital modulation, balanced attenuator used to balance the high and low frequency analog modulation, 13V positive voltage multiplier, serial interface for control, and a super filter for the regulated 5 volts.

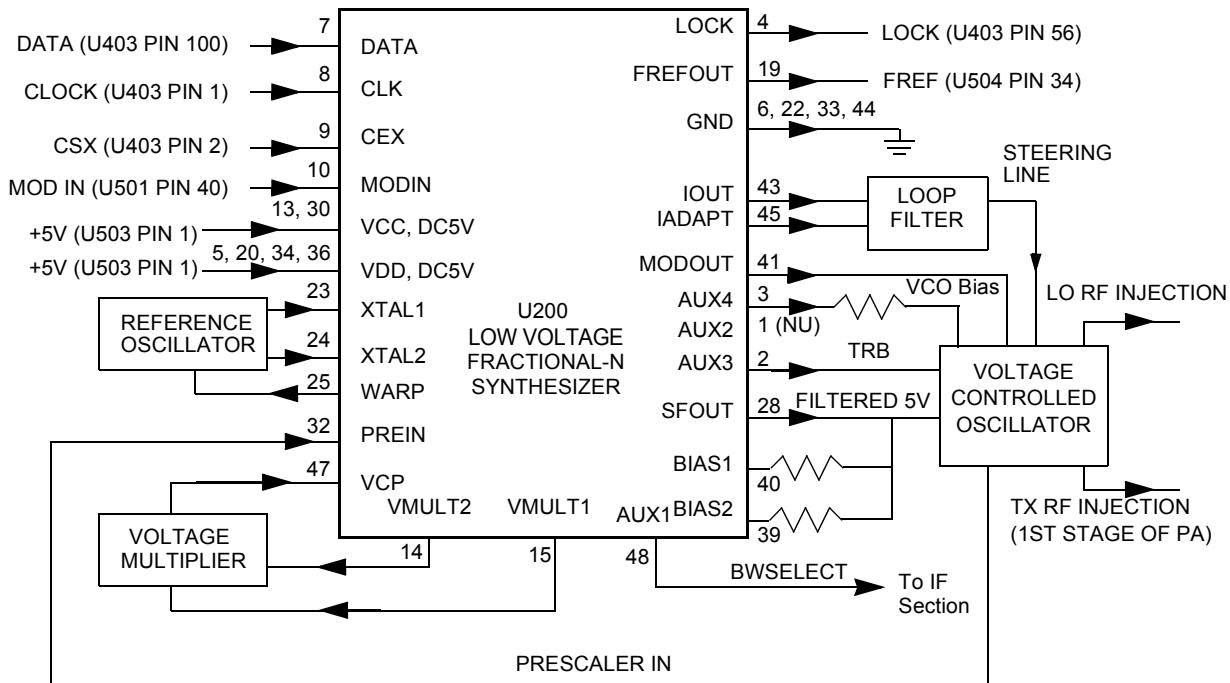


Figure 2-3 UHF Synthesizer Block Diagram

A voltage of 5V applied to the super filter input (U200, pin 30) supplies an output voltage of 4.5Vdc (VSF) at U200, pin 28. This supplies 4.5 V to the VCO Buffer IC U201.

To generate a high voltage to supply the phase detector (charge pump) output stage at pin VCP (U200, pin 47) while using a low voltage 3.3Vdc supply, a 13V positive voltage multiplier is used (D200, D201, and capacitors C2024, 2025, 2026, 2055, 2027, 2001).

Output lock (U200, pin 4) provides information about the lock status of the synthesizer loop. A high level at this output indicates a stable loop. A 16.8 MHz reference frequency is provided at U200, pin 19.

4.3 Voltage Controlled Oscillator (VCO)

The Voltage Controlled Oscillator (VCO) consists of the VCO/Buffer IC (VCOBIC, U201), the TX and RX tank circuits, the external RX buffer stages, and the modulation circuitry.

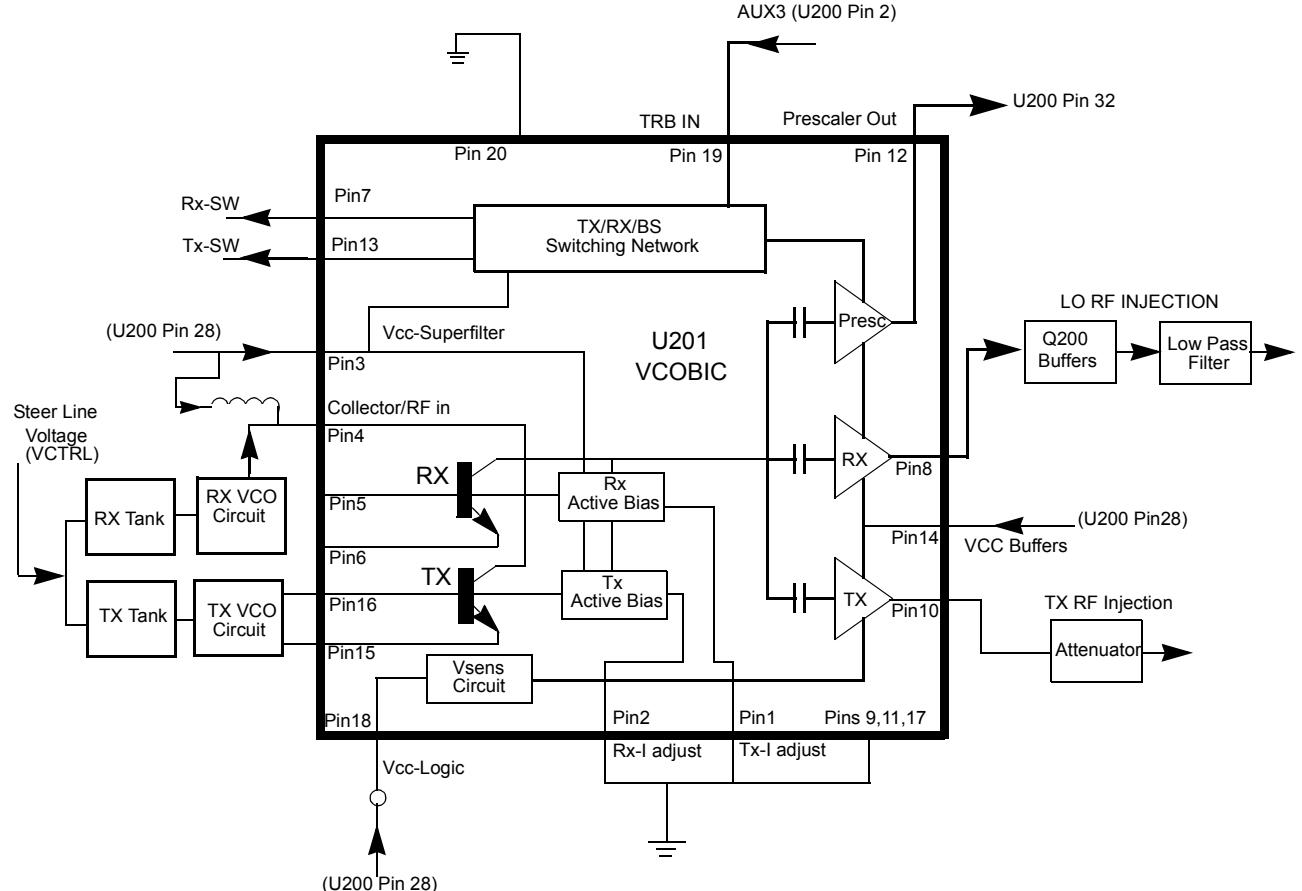


Figure 2-4 UHF VCO Block Diagram

The VCOBIC together with the LVFRAC-N (U200) generate the required frequencies in both transmit and receive modes. The TRB line (U201, pin 19) determines which VCO and buffer is enabled (high being TX output at pin 10, low being RX output at pin 8). A sample of the signal from the enabled output is routed from U201, pin 12 (PRESC_OUT), via a low pass filter to U200, pin 32 (PREIN).

A steering line voltage between 3.0V and 10.0V at varactor D204 tunes the TX VCO through the frequency range of 438-470MHz, and at D203 tunes the RX VCO through the frequency range of 393.15-425.15MHz.

The external RX amplifier is used to increase the output from U201, pin 8 from 3-4 dBm to the required 10dBm for proper mixer operation. In TX mode, the modulation signal from the LVFRAC-N (U200, pin 41) is applied to the VCO by way of the modulation circuit D205, R212, R211, C2073.

4.4 Synthesizer Operation

The synthesizer consists of a low voltage FRAC-N IC (LVFRAC-N), reference oscillator, charge pump circuits, loop filter circuit, and DC supply. The output signal (PRESC_OUT) of the VCOBIC (U201, pin 12) is fed to the PREIN, pin 32 of U200 via a low pass filter which attenuates harmonics and provides a correct input level to the LVFRAC-N in order to close the synthesizer loop.

The pre-scaler in the synthesizer (U200) is 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 SPI. 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 (Y201).

The output signal of the phase detector is a pulsed dc signal that is routed to the charge pump. The charge pump outputs a current from U200, pin 43 (IOUT). The loop filter (consisting of R224, R217, R234, C2074, C2078, C2028, and L205) transforms this current into a voltage that is applied the varactor diodes D203 and D204 for RX and TX respectively. The output frequency is determined by this control voltage. The current can be set to a value fixed in the LVFRAC-N or to a value determined by the currents flowing into BIAS 1 (U200, pin 40) or BIAS 2 (U200, pin 39). The currents are set by the value of R200 or R206 respectively. The selection of the three different bias sources is done by software programming.

To modulate the synthesizer loop, a two-spot modulation method is utilized via the MODIN (U200, pin 10) input of the LVFRAC-N. The audio signal is applied to both the A/D converter (low frequency path) and the balance 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 presented at the MODOUT port of the LVFRAC-N (U200,pin 41) and connected to the VCO modulation varactor D205.

5.0 Controller Theory of Operation

This section provides a detailed theory of operation for the radio and its components. The main radio is a single-board design, consisting of the transmitter, receiver, and controller circuits. A control head is connected by an extension cable. The control head contains LED indicators, a microphone connector, buttons, and speaker.

In addition to the power cable and antenna cable, an accessory cable can be attached to a connector on the rear of the radio. The accessory cable enables you to connect accessories to the radio, such as an external speaker, emergency switch, foot-operated PTT, and ignition sensing, etc.

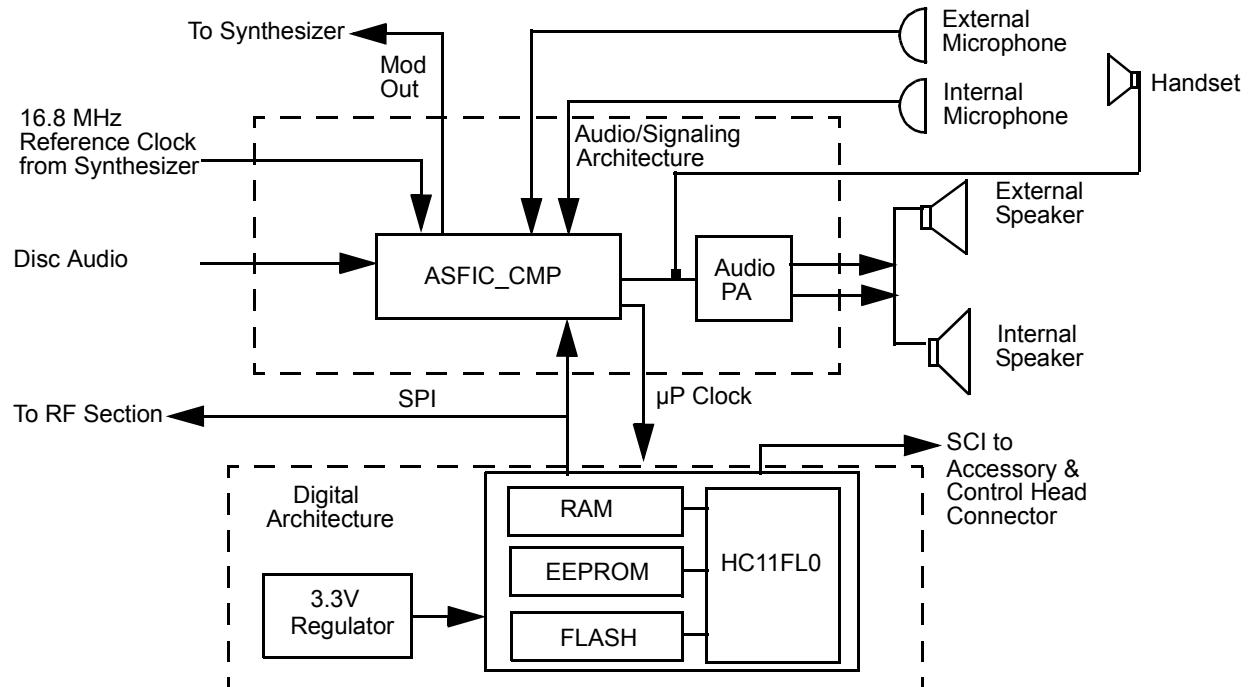


Figure 2-5 Controller Block Diagram

5.1 Radio Power Distribution

Voltage distribution is provided by five separate devices:

- U514 P-ch FET - Batt + (Ext_SWB+)
- U501 LM2941T - 9.3V
- U503 LP2951CM - 5V
- U508 MC 33269DTRK - 3.3V
- U510 LP2986ILDX - 3.3V Digital

The DC voltage applied to connector P2 supplies power directly to the following circuitry:

- Electronic on/off control
- RF power amplifier
- 12 volts P-ch FET -U514
- 9.3 volt regulator
- Audio PA

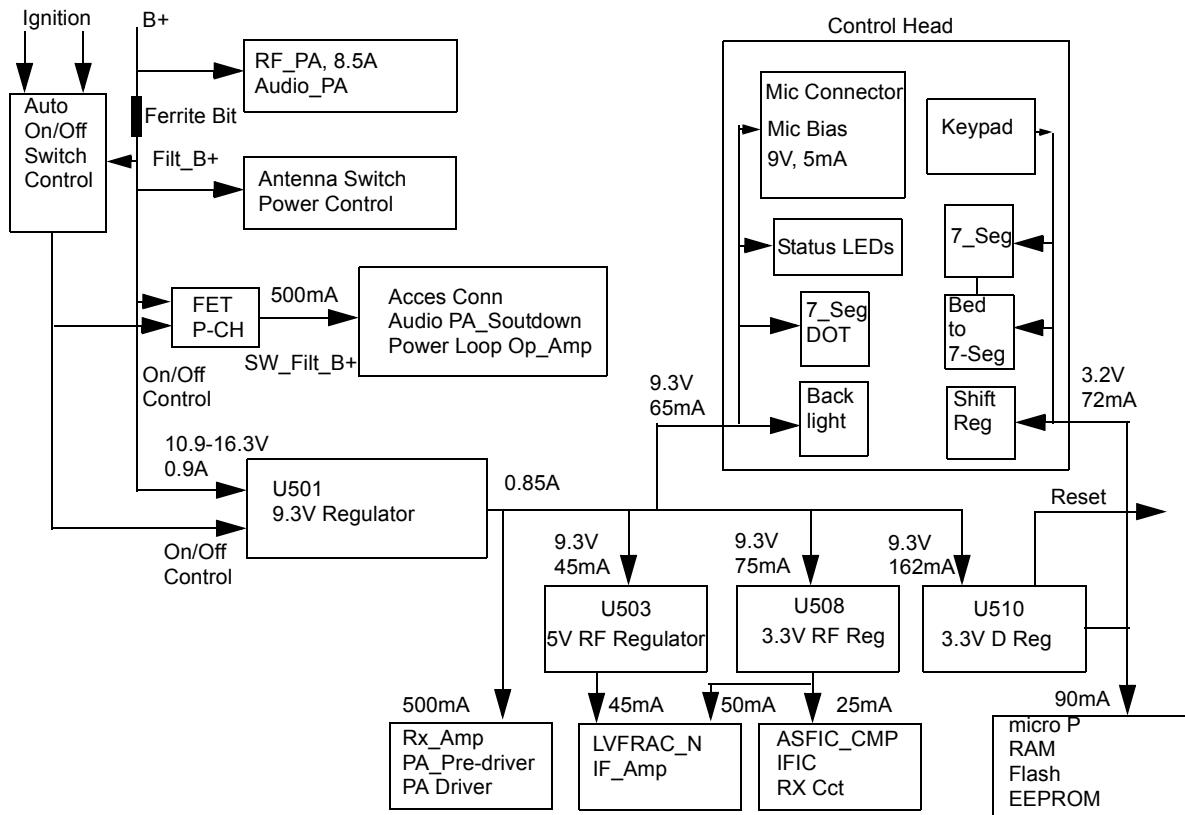


Figure 2-6 DC Power Distribution Block Diagram

Regulator U501 is used to generate the 9.3 volts required by some audio circuits, the RF circuitry and power control circuitry. Input and output capacitors are used to reduce high frequency noise. Resistors R5001 / R5081 set the output voltage of the regulator. This regulator output is electronically enabled by a 0 volt signal on pin 2. Q502, Q505 and R5038 are used to disable the regulator when the radio is turned off.

Voltage regulator U510 provides 3.3 volts for the digital circuitry. Operating voltage is from the regulated 9.3V supply. Input and output capacitors are used to reduce high frequency noise and provide proper operation during battery transients. U510 provides a reset output that goes to 0 volts if the regulator output goes below 3.1 volts. This is used to reset the controller to prevent improper operation.

Voltage regulator U508 provides 3.3V for the RF circuits and ASFIC_CMP. Input and output capacitors are used to reduce the high frequency noise and provide proper operation during battery transients.

Voltage regulator U503 provides 5V for the RF circuits. Input and output capacitors are used to reduce the high frequency noise and provide proper operation during battery transients.

VSTBY is used only for GM3689 5-tone radios.

The voltage VSTBY, which is derived directly from the supply voltage by components R5103 and VR502, is used to buffer the internal RAM. Capacitor C5120 allows the battery voltage to be disconnected for a couple of seconds without losing RAM parameters. Dual diode D501 prevents radio circuitry from discharging this capacitor. When the supply voltage is applied to the radio, C5120 is charged via R5103 and D501.

5.2 Protection Devices

Diode VR500 acts as protection against ESD, wrong polarity of the supply voltage, and load dump. VR692 - VR699 are for ESD protection.

5.3 Automatic On/Off

The radio can be switched ON in any one of the following three ways:

- On/Off switch. (No Ignition Mode)
- Ignition and On/Off switch (Ignition Mode)
- Emergency

5.3.1 No Ignition Mode

When the radio is connected to the car battery for the first time, Q500 will be in saturation, Q503 will cut-off, Filt_B+ will pass through R5073, D500, and S5010-pin 6 (On/Off switch). When S5010 is ON, Filt_B+ will pass through S5010-pin5, D511, R5069, R5037 and base of Q505 and move Q505 into saturation. This pulls U501-pin2 through R5038, D502 to 0.2V and turns On U514 and U501 9.3V regulator which supplies voltage to all other regulators and consequently turns the radio on, When U504 (ASFIC_CMP) gets 3.3V, GCB2 goes to 3.3V and holds Q505 in saturation, for soft turn off.

5.3.2 Ignition Mode

When ignition is connected for the first time, it will force high current through Q500 collector, This will move Q500 out of saturation and consequently Q503 will cut-off. S5010 pin 6 will get ignition voltage through R601 (for load dump), R610, (R610 & C678 are for ESD protection), VR501, R5074, and D500. When S5010 is ON, Filt_B+ passes through S5010-pin 5, D511, R5069, R5037 and base of Q505 and inserts Q505 into saturation. This pulls U501-pin 2 through R5038, D502 to 0.2V and turns on U514 and U501 9.3V regulator which supply voltage to all other regulators and turns the radio on, When U504 (ASFIC_CMP) get 3.3V supply, GCB2 goes to 3.3V and holds Q505 in saturation state to allow soft turn off,

When ignition is off Q500, Q503 will stay at the same state so S5010 pin 6 will get 0V from Ignition, Q504 goes from Sat to Cut, ONOFF_SENSE goes to 3.3V and it indicates to the radio to soft turn itself by changing GCB2 to '0' after de registration if necessary.

5.3.3 Emergency Mode

The emergency switch (P1 pin 9), when engaged, grounds the base of Q506 via EMERGENCY _ACCES_CONN. This switches Q506 to off and consequently resistor R5020 pulls the collector of Q506 and the base of Q506 to levels above 2 volts. Transistor Q502 switches on and pulls U501 pin2 to ground level, thus turning ON the radio. When the emergency switch is released R5030 pulls the base of Q506 up to 0.6 volts. This causes the collector of transistor Q506 to go low (0.2V), thereby switching Q502 to off.

While the radio is switched on, the μ P monitors the voltage at the emergency input on the accessory connector via U403-pin 62. Three different conditions are distinguished: no emergency kit is connected, emergency kit connected (unpressed), and emergency press.

If no emergency switch is connected or the connection to the emergency switch is broken, the resistive divider R5030 / R5049 will set the voltage to about 3.14 volts (indicates no emergency kit found via EMERGENCY_SENSE line). If an emergency switch is connected, a resistor to ground within the emergency switch will reduce the voltage on EMERGENCY_SENSE line, and indicate to the μ P that the emergency switch is operational. An engaged emergency switch pulls line EMERGENCY_SENSE line to ground level. Diode VR503 limits the voltage to protect the μ P input.

While EMERGENCY_ACCES_CONN is low, the μ P starts execution, reads that the emergency input is active through the voltage level of μ P pin 64, and sets the DC POWER ON output of the ASFIC CMP pin 13 to a logic high. This high will keep Q505 in saturation for soft turn off.

5.4 Microprocessor Clock Synthesiser

The clock source for the μ P system is generated by the ASFIC CMP (U504). 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 audio circuitry, 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 will generate its default 3.6864MHz CMOS square wave UP CLK (on U504 pin 28) and this is routed to the μ P (U403 pin 90). After the μ 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 the clock source interfering with the desired radio receive frequency.

The ASFIC CMP synthesizer loop uses C5025, C5024 and R5033 to set the switching time and jitter of the clock output. If the synthesizer cannot generate the required clock frequency it will switch back to its default 3.6864MHz output.

Because the ASFIC CMP synthesizer and the μ P system will not operate without the 16.8 MHz reference clock it (and the voltage regulators) should be checked first when debugging the system.

5.5 Serial Peripheral Interface (SPI)

The μ P communicates to many of the IC's through its SPI port. This port consists of SPI TRANSMIT DATA (MOSI) (U403-pin100), SPI RECEIVE DATA (MISO) (U403-pin 99), SPI CLK (U0403-pin1) and chip select lines going to the various IC's, connected on the SPI PORT (BUS). This BUS is a synchronous bus, in that the timing clock signal CLK is sent while SPI data (SPI TRANSMIT DATA or SPI RECEIVE DATA) 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 is used to send serial from a μ P to a device, and SPI RECEIVE DATA is used to send data from a device to a μ P.

There are two IC's on the SPI BUS, ASFIC CMP (U504 pin 22), and EEPROM (U400). In the RF sections there is one IC on the SPI BUS, the FRAC-N Synthesizer. The chip select line CSX from U403 pin 2 is shared by the ASFIC CMP and FRAC-N Synthesizer. Each of these IC's check the SPI data and when the sent address information matches the IC's address, the following data is processed.

When the μ P needs to program any of these ICs 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 to the various IC's are different; e.g., the ASFIC CMP can receive up to 19 bytes (152 bits). After the data has been sent the chip select line is returned to logic "1".

5.6 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) or the cable with internal RIB. This interface connects to the SCI pin via control head connector (J2-pin 17) and to the accessory connector P1-6 and comprises BUS+. The line is bi-directional, meaning that either the radio or the RIB can drive the line. The μ P sends serial data and it reads serial data via pin 97. Whenever the μ P detects activity on the BUS+ line, it starts communication.

5.7 General Purpose Input/Output

The controller provides six general purpose lines (PROG I/O) available on the accessory connector P1 to interface to external options. Lines PROG IN 3 and 6 are inputs, PROG OUT 4 is an output and PROG IN OUT 8, 12 and 14 are bi-directional. The software and the hardware configuration of the radio model define the function of each port.

- PROG IN 3 can be used as external PTT input, or others, set by the CPS. The μ P reads this port via pin 72 and Q412.
- PROG OUT 4 can be used as external alarm output, set by the CPS. Transistor Q401 is controlled by the μ P (U403 pin 55)
- PROG IN 6 can be used as normal input, set by the CPS. The μ P reads this port via pin 73 and Q411. This pin is also used to communicate with the RIB if resistor R421 is placed.
- DIG IN OUT 8,12,14 are bi-directional and use the same circuit configuration. Each port uses an output Q416, Q404, Q405 controlled by μ P pins 52, 53, 54. The input ports are read through μ P pins 74, 76, 77; using Q409, Q410, Q411

5.8 Normal Microprocessor Operation

For this radio, the µP is configured to operate in one of two modes, expanded and bootstrap. In expanded mode the µP uses external memory devices to operate, whereas in bootstrap operation the µP uses only its internal memory. In normal operation of the radio the µP is operating in expanded mode as described below.

During normal operation, the µP (U403) is operating in expanded mode and has access to 3 external memory devices; U400 (EEPROM), U402 (SRAM), U404 (Flash). Also, within the µP there are 3 Kilobytes of internal RAM, as well as logic to select external memory devices.

The external EEPROM (U400) space contains the information in the radio which is customer specific, referred to as the codeplug. This information consists of items such as: 1) what band the radio operates in, 2) what frequencies are assigned to what channel, and 3) tuning information.

The external SRAM (U402) as well as the µP's own internal RAM space are used for temporary calculations required by the software during execution. All of the data stored in both of these locations is lost when the radio powers off.

The µP provides an address bus of 16 address lines (ADDR 0 - ADDR 15), and a data bus of 8 data lines (DATA 0 - DATA 7). There are also 3 control lines; CSPROG (U403-pin 38) to chip select U404-pin 30 (FLASH), CSGP2 (U403-pin 41) to chip select U404-pin 20 (SRAM) and PG7_R_W (U403-pin 4) to select whether to read or to write. The external EEPROM (U400-pin1).

When the µP is functioning normally, the address and data lines should be toggling at CMOS logic levels. Specifically, the logic high levels should be between 3.1 and 3.3V, and the logic low levels should be between 0 and 0.2V. 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 1us/div. or faster to observe individual pulses. High speed CMOS transitions should also be observed on the µP control lines.

On the µP the lines XIRQ (U403-pin 48), MODA LIR (U403-pin 58), MODB VSTPY (U403-pin 57) and RESET (U403-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 20ms. In the case of shorted lines you may also detect the line periodically at an intermediate level, i.e. around 2.5V when two shorted lines attempt to drive to opposite rails.

The MODA LIR (U403-pin 58) and MODB VSTPY (U403-pin 57) inputs to the µP must be at a logic "1" for it to start executing correctly. After the µP starts execution it will periodically pulse these lines to determine the desired operating mode. While the Central Processing Unit (CPU) is running, MODA LIR is an open-drain CMOS output which goes low whenever the µP begins a new instruction. An instruction typically requires 2-4 external bus cycles, or memory fetches.

There are eight analog-to-digital converter ports (A/D) on U403 labelled within the device block as PEO-PE7. These lines sense the voltage level ranging from 0 to 3.3V 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.

5.9 Static Random Access Memory (SRAM)

The SRAM (U402) 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 U402 (which comes from U403-CSGP2) going low. U402 is commonly referred to as the external RAM as opposed to the internal RAM which is the 3 Kilobytes of RAM which is 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 C402 and C411 serves to filter out any AC noise which may ride on +3.3 V at U402

6.0 Control Board Audio and Signalling Circuits

6.1 Audio Signalling Filter IC and Compander (ASFIC CMP)

The ASFIC CMP (U504) used in the controller has the following four functions:

1. RX/TX audio shaping, i.e. filtering, amplification, attenuation
2. RX/TX signaling, PL/DPL/HST/MDC
3. Squelch detection
4. μ P clock signal generation

The ASFIC CMP is programmable through the SPI BUS (U504 pins-20/21/22), normally receiving 19 bytes. This programming sets up various paths within the ASFIC CMP to route audio and/or signaling signals through the appropriate filtering, gain and attenuator blocks. The ASFIC CMP also has 6 General Control Bits GCB0-5 which are CMOS level outputs and used for the following:

- GCB0 - BW Select
- GCB1 - switches the audio PA On/Off
- GCB2 - DC Power On switches the voltage regulator (and the radio) on and off
- GCB3 - Control on MUX U509 pin 9 to select between Low Cost Mic path to STD Mic Path
- GCB4 - Control on MUX U509 pin 11 to select between Flat RX path to filtered RX path on the accessory connector.
- GCB5 - Control on MUX U509 pin 10 to select between Flat TX path mute and Flat TX path

7.0 Transmit Audio Circuits

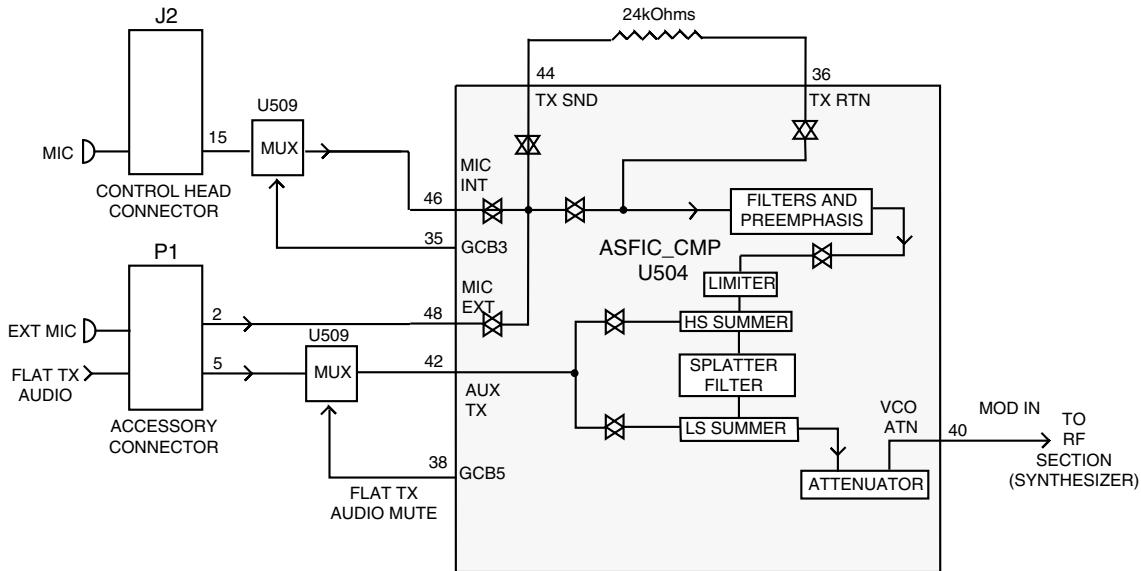


Figure 2-7 Transmit Audio Paths

7.1 Microphone Input Path

The radio supports 2 distinct microphone paths known as internal (from control head J2-15) and external mic (from accessory connector P1-2) and an auxiliary path (FLAT TX AUDIO, from accessory connector P1-5). The microphones used for the radio require a DC biasing voltage provided by a resistive network.

The two microphone audio input paths enter the ASIFC CMP at U504-pin 48 (external mic) and U504-pin 46 (internal mic). The microphone is plugged into the radio control head and connected to the audio DC via J2-pin 15. The signal is then routed via C5045 to MUX U509 that select between two paths with different gain to support Low Cost Mic (Mic with out amplifier in it) and Standard Mic.

7.1.1 Low Cost Microphone

Hook Pin is shorted to Pin 1(9.3V) inside the Low Cost Mic, This routes 9.3V to R429, and creates 2.6V on MIC_SENSE (u.P U403-67) by Voltage Divider R429/R430. U403 senses this voltage and sends command to ASIFC_CMP U504 to get GCB3 = '0'. The audio signal is routed from C5045 via U509-5 (Z0), R5072, U507, R5026, C5091, R5014 via C5046 to U504- 46 int. mic (C5046 100nF creates a159Hz pole with U504- 46 int mic impedance of 16Kohm).

7.1.2 Standard Microphone

Hook Pin is shorted to the hook mic inside the standard Mic. If the mic is out off hook, 3.3V is routed to R429 via R458, D401, and it create 0.7V on MIC_SENSE (u.P U403-67) by Voltage Divider R429/R430. U403 senses this voltage and sends command to ASFIC_CMP U504 to get GCB3 ='1'. The audio signal is routed from C5045 via U509-3 (Z1), R5072, U507, R5026, C5091, R5014 via C5046 to U504- 46 int mic (C5046 100nF create a159Hz pole with U504- 46 int mic impedance of 16Kohm). 9.3VDC is routed via R5077, R5075 to J2-15, It create 4.65V with Mic Impedance. C5010 supplies AC Ground to create AC impedance of 510 Ohms via R5075. and Filter 9.3V DC mic bias supply.

Note: The audio signal at U504-pin 46 should be approximately 12mV for 1.5kHz or 3kHz of deviation with 12.5kHz or 25kHz channel spacing.

The external microphone signal enters the radio on accessory connector P1 pin 2 and is routed via line EXT MIC to R5054. R5078 and R5076 provide the 9.3Vdc bias. Resistive divider R5054/ R5070 divide the input signal by 5.5 and provide input protection for the CMOS amplifier input. R5076 and C5009 provide a 510 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.

C5047 serves as a DC blocking capacitor. The audio signal at U504-pin 48 should be approximately 14mV for 1.5kHz or 3kHz of deviation with 12.5kHz or 25kHz channel spacing.

The FLAT TX AUDIO signal from accessory connector P1-pin 5 is fed to the ASFIC CMP (U504 pin 42 through U509 pin 2 to U509 pin 15 via U506 OP-AMP circuit and C5057.

The ASFIC has an internal AGC that can control the gain in the mic audio path. The AGC can be disabled / enabled by the μ P. Another feature that can be enabled or disabled in the ASFIC is the VOX. This circuit, along with Capacitor C5023 at U504-pin 7, provides a DC voltage that can allow the μ P to detect microphone audio. The ASFIC can also be programmed to route the microphone audio to the speaker for public address operation.

7.2 PTT Sensing and TX Audio Processing

Internal microphone PTT is sensed by μ P U403 pin 71. Radio transmits when this pin is "0" and selects inside the ASFIC_CMP U504 internal Mic path. When the internal Mic PTT is "0" then external Mic PTT is grounded via D402. External Mic PTT is sensed by U403 pin 72 via Q412 circuits. The radio transmits when this pin is "0" and selects inside the ASFIC_CMP U504 External Mic path.

Inside the ASFIC CMP, the mic 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 mic audio is then routed through a summer, which is used to add in signaling 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 U504-pin 40 MOD IN, at which point it is routed to the RF section.

8.0 Transmit Signalling Circuits

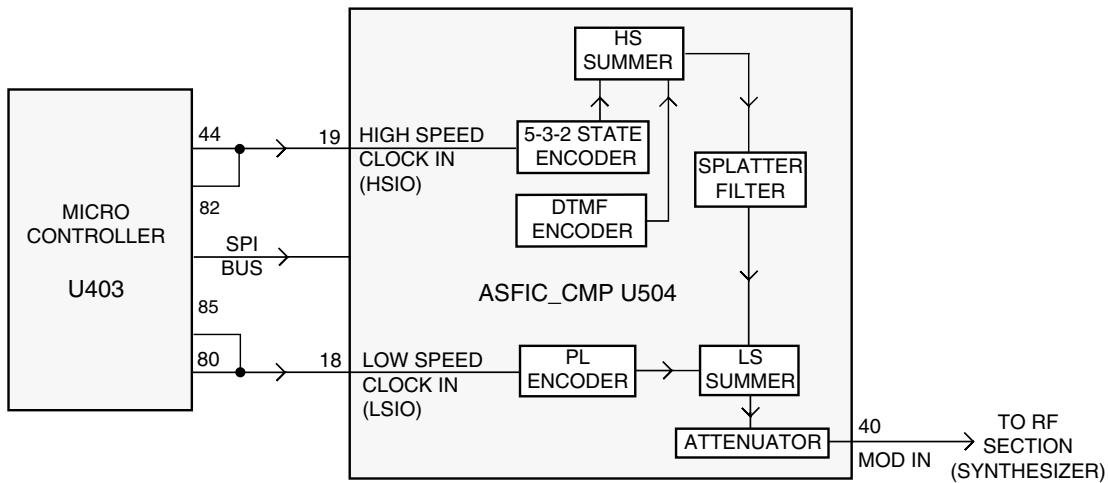


Figure 2-8 Transmit Signalling Path

From a hardware point of view, there are 3 types of signaling:

- Sub-audible data (PL / DPL / Connect Tone) that gets summed with transmit voice or signaling,
- DTMF data for telephone communication in trunked and conventional systems, and
- Audible signaling including MDC and high-speed trunking.

Note: All three types are supported by the hardware while the radio software determines which signaling type is available.

8.1 Sub-Audio Data (PL/DPL)

Sub-audible data implies signaling whose bandwidth 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 U504 (ASFIC CMP) at any one time. The process is as follows, using the SPI BUS, the µP programs the ASFIC CMP to set up the proper low-speed data deviation and select the PL or DPL filters. The µP then generates a square wave which strobes the ASFIC PL / DPL encode input LSIO U504-pin 18 at twelve times the desired data rate. For example, for a PL frequency of 103Hz, the frequency of the square wave would be 1236Hz.

This drives a tone generator inside U504 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 U504-pin 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.

8.2 High Speed Data

High speed data refers to the 3600 baud data waveforms, known as Inbound Signaling Words (ISWs) used in a trunking system for high speed communication between the central controller and the radio. To generate an ISW, the μ P first programs the ASFIC CMP (U504) to the proper filter and gain settings. It then begins strobing U504-pin 19 (HSIO) with a pulse when the data is supposed to change states. U504'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 attenuator and then out of the ASFIC CMP to the RF board. MDC is 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 signaling schemes are based on sending a combination of 1200 Hz and 1800 Hz tones only. Microphone audio is muted during high speed data signaling.

8.3 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 μ P (U403-46) strobing U504-19 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 μ P via SPI bus. Inside U504 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 was described for high-speed data.

9.0 Receive Audio Circuits

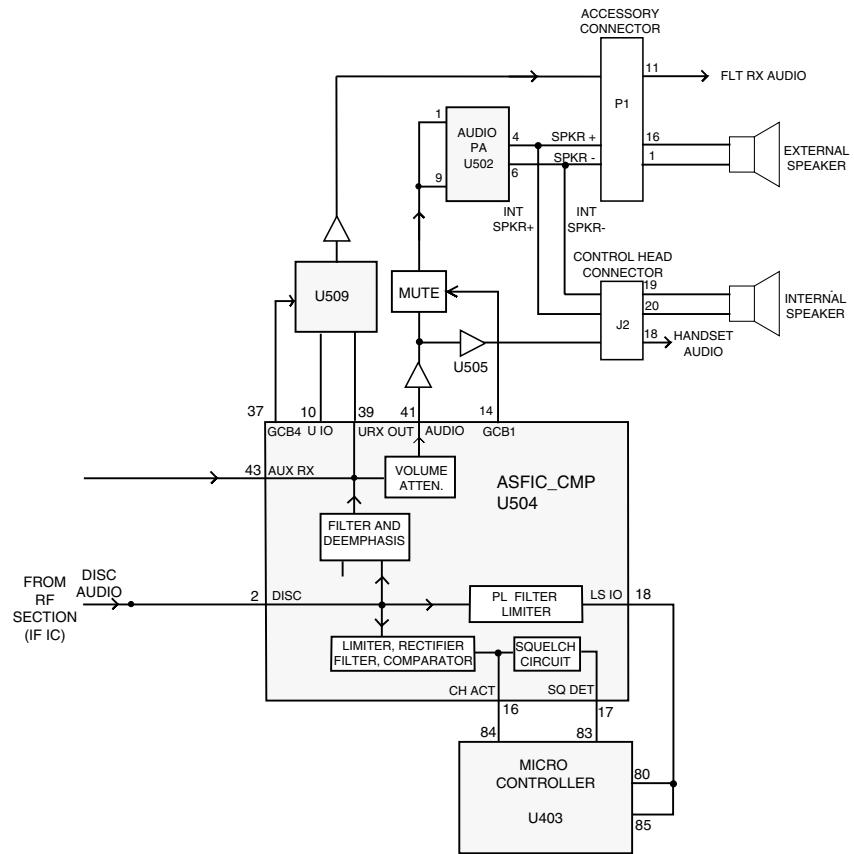


Figure 2-9 Receive Audio Paths

9.1 Squelch Detect

The radio's RF circuits are constantly producing an output at the discriminator (IF IC). This signal (DISC AUDIO) is routed to the ASFiC CMP's squelch detect circuitry input DISC (U504-pin 2). All of the squelch detect circuitry is contained within the ASFiC CMP. Therefore from a user's point of view, DISC AUDIO enters the ASFiC CMP, and the ASFiC CMP produces two CMOS logic outputs based on the result. They are CH ACT (U504-16) and SQ DET (U504-17).

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 on CH ACT. A squelch tail circuit is used to produce SQ DET (U504-17) from CH ACT. The state of CH ACT and SQ DET is high (logic "1") when carrier is detected, otherwise low (logic "0").

CH ACT is routed to the μ P pin 84 while SQ DET is routed to the μ P pin 83.

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.

9.2 Audio Processing and Digital Volume Control

The receiver audio signal (DISC AUDIO) enters the controller section from the IF IC where it is DC coupled to ASFIC CMP via the DISC input U504-pin 2. The signal is then applied to both the audio and the PL/DPL paths

The audio path has a programmable amplifier, whose setting is based on the channel bandwidth being received, an LPF filter to remove any frequency components above 3000Hz, and a HPF to strip off any sub-audible data below 300Hz. Next, 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 IC then passes the audio through the 8-bit programmable attenuator whose level is set depending on the value of the volume control. Finally the filtered audio signal passes through an output buffer within the ASFIC CMP. The audio signal exits the ASFIC CMP at AUDIO output (U504 pin 41).

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

Since sub-audible signaling is summed with voice information on transmit, it must be separated from the voice information before processing. Any sub-audible signaling enters the ASFIC CMP from the IF IC at DISC U504-2. Once inside, it goes through the PL/DPL path. The signal first passes through one of the two low-pass filters, either the PL low-pass filter or the DPL/LST low-pass filter. Either signal is then filtered and goes through a limiter and exits the ASFIC CMP at LSIO (U504-pin 18). At this point, the signal will appear as a square wave version of the sub-audible signal which the radio received. The µP U403 pin 80 will decode the signal directly to determine if it is the tone / code which is currently active on that mode.

9.3 Audio Amplification Speaker (+) Speaker (-)

The output of the ASFIC CMP's digital volume pot, U504-pin 41 is routed through DC blocking capacitor C5049 to the audio PA (U502 pin 1 and 9).

The audio power amplifier has one inverted and one non-inverted output that produces the differential audio output SPK+/SPK- (U502 pins 4 and 6)

The audio PA is enabled via the ASFIC CMP (U504-GCB1). When the base of Q501 is low, the transistor is off and U502-pin 8 is high, using pull up resistor R5041, and the audio PA is ON. The voltage at U502-pin 8 must be above 8.5Vdc to properly enable the device.

If the voltage is between 3.3 and 6.4V, the device will be active but has its input (U502-pins 1/9) off. This is a mute condition which is used to prevent an audio pop when the PA is enabled.

The SPK+ and SPK- outputs of the audio PA have a DC bias which varies proportionately with B+ (U502- pin 7). B+ of 11V yields a DC offset of 5V, and B+ 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 will be damaged. SPK+ and SPK- are routed to the accessory connector (P1-pin 1 and 16) and to the control head (connector J2-pins 19 and 20).

9.4 Handset Audio

Certain handheld accessories have a speaker within them which require a different voltage level than that provided by U502. For these devices HANDSET AUDIO is available at control head connector J2 pin18.

The received audio from the output of the ASIC CMP's digital volume attenuator is routed to U505 pin 2 where it is amplified. This signal is routed from the output of the op-amp U505 to J2-pin 18. From the control head, the signal is sent directly to the microphone jack.

9.5 Filtered Audio and Flat Audio

The ASIC CMP output audio at U504-pin 39 is filtered and de-emphasized, but has not gone through the digital volume attenuator. From ASIC CMP U504-pin 39 the signal is routed via R5034 through gate U509-pin 12 and AC coupled to U505-pin 6. The gate controlled by ASIC CMP port GCB4 selects between the filtered audio signal from the ASIC CMP pin 39 (URXOUT) or the unfiltered (flat) audio signal from the ASIC CMP pin 10 (UIO). Resistors R5034 and R5021 determine the gain of op-amp UU505-pin 6 for the filtered audio while R5032 and R5021 determine the gain for the flat Audio. The output of U505-pin 7 is then routed to P1 pin 11 via DC blocking capacitor C5003. Note that any volume adjustment of the signal on this path must be done by the accessory.

10.0 Receive Signalling Circuits

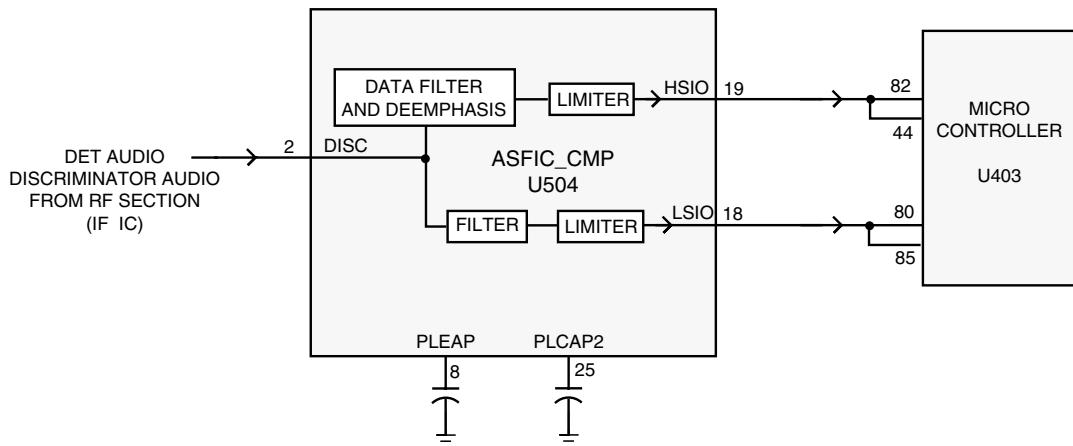


Figure 2-10 Receive Signalling Paths

10.1 Sub-Audio Data (PL/DPL) and High Speed Data Decoder

The ASIC CMP (U504) is used to filter and limit all received data. The data enters the ASIC CMP at input DISC (U504 pin 2). Inside U504 the data is filtered according to data type (HS or LS), then it is limited to a 0-3.3V digital level. The MDC and trunking high speed data appear at U504-pin 19, where it connects to the μ P U403 pin 80.

The low speed limited data output (PL, DPL, and trunking LS) appears at U504-pin18, where it connects to the μ P U403-pin 80.

The low speed data is read by the μ 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 C5028, and C5026 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.

10.2 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 U504 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 μ 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 μ P can generate any tone within the 100-3000Hz audio band. This is accomplished by the μ P generating a square wave which enters the ASFIC CMP at U504 pin 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 U504, 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 U504-pin 41 and is routed to the audio PA like receive audio.

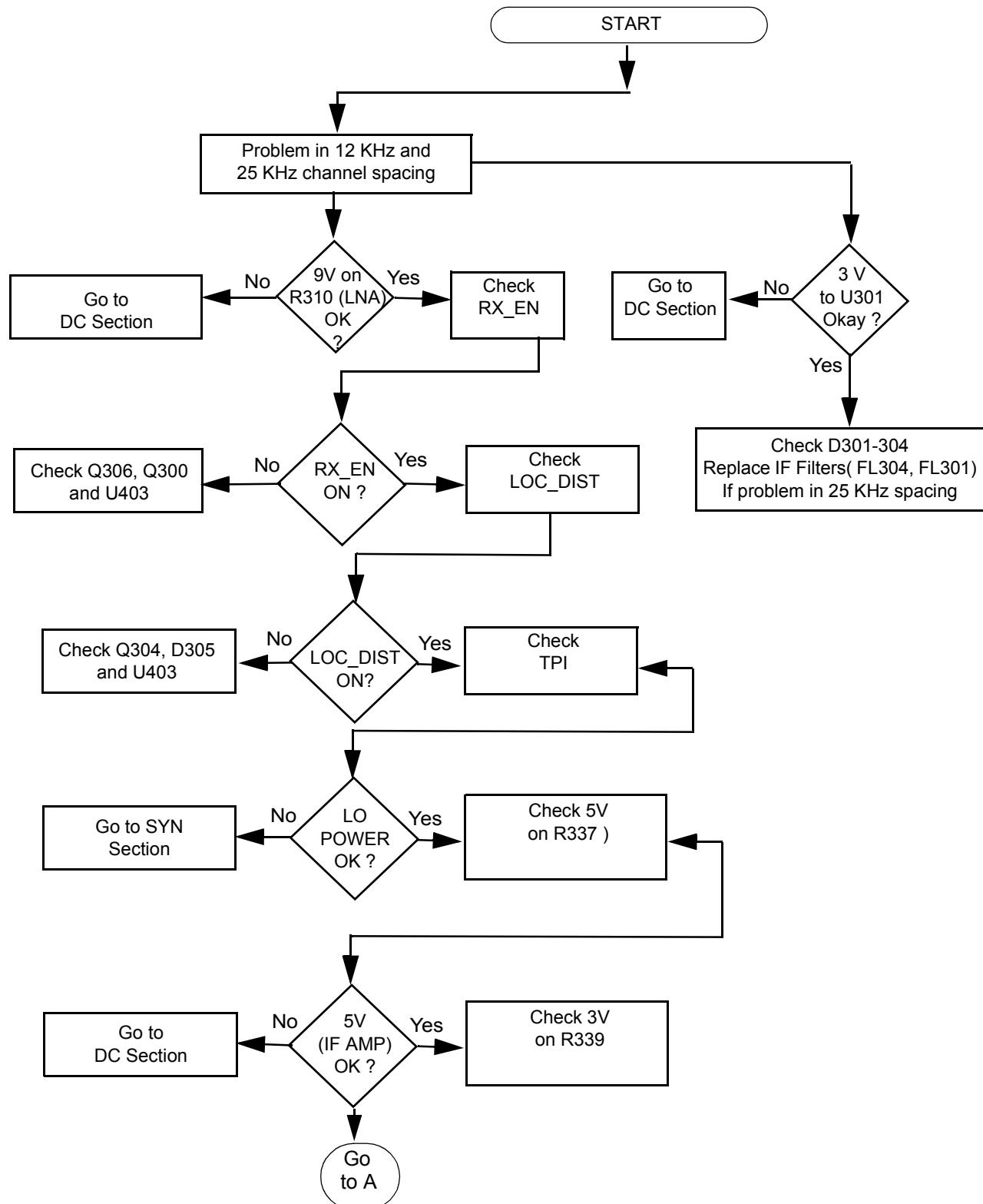
Chapter 3

TROUBLESHOOTING CHARTS

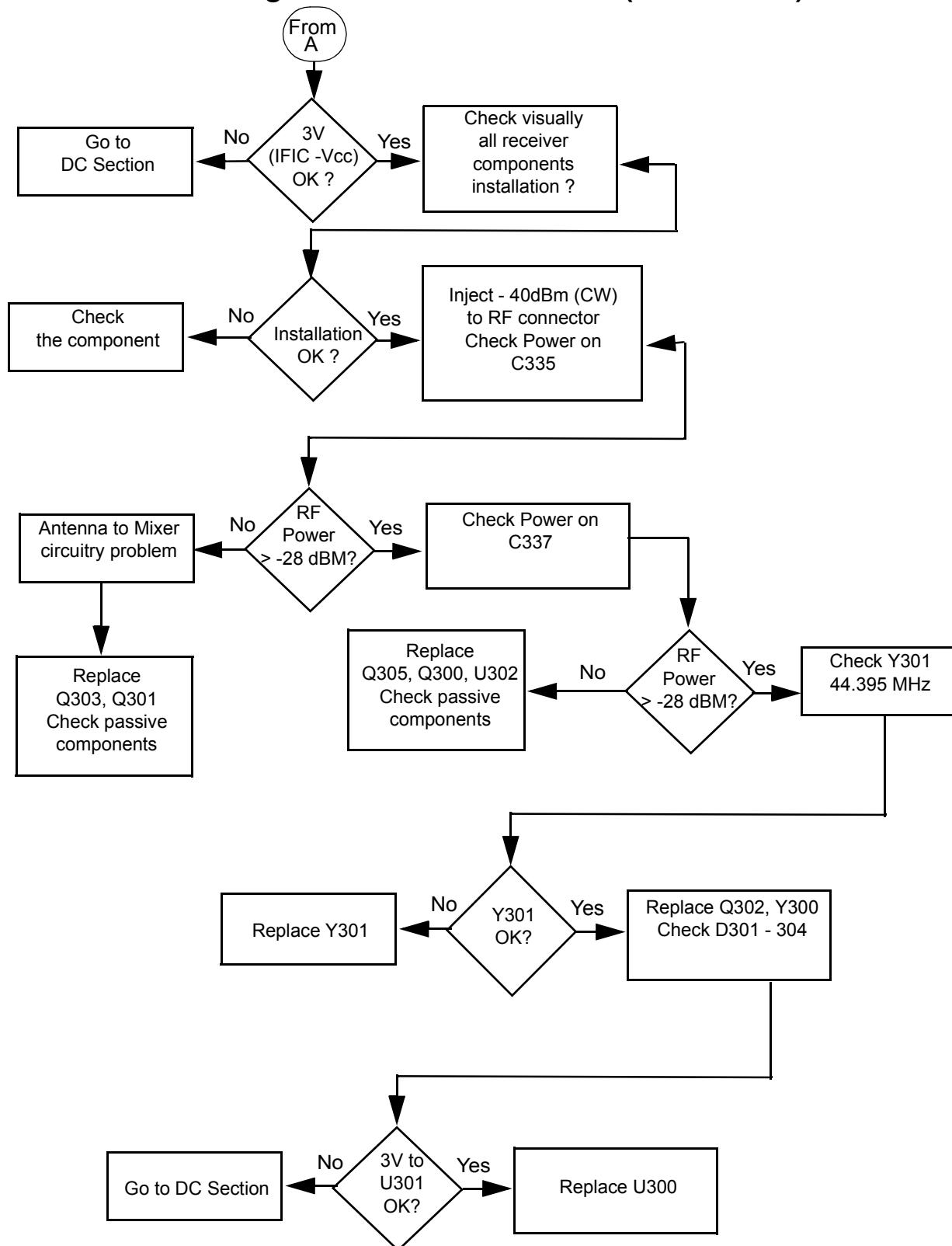
This section contains detailed troubleshooting flowcharts. These charts should be used as a guide in determining the problem areas. They are not a substitute for knowledge of circuit operation and astute troubleshooting techniques. It is advisable to refer to the related detailed circuit descriptions in the theory of operation sections prior to troubleshooting a radio.

Most troubleshooting charts end up by pointing to an IC to replace. It is not always noted, but it is good practice to verify supplies and grounds to the affected IC and to trace continuity to the malfunctioning signal and related circuitry before replacing any IC. For instance, if a clock signal is not available at a destination, continuity from the source IC should be checked before replacing the source IC.

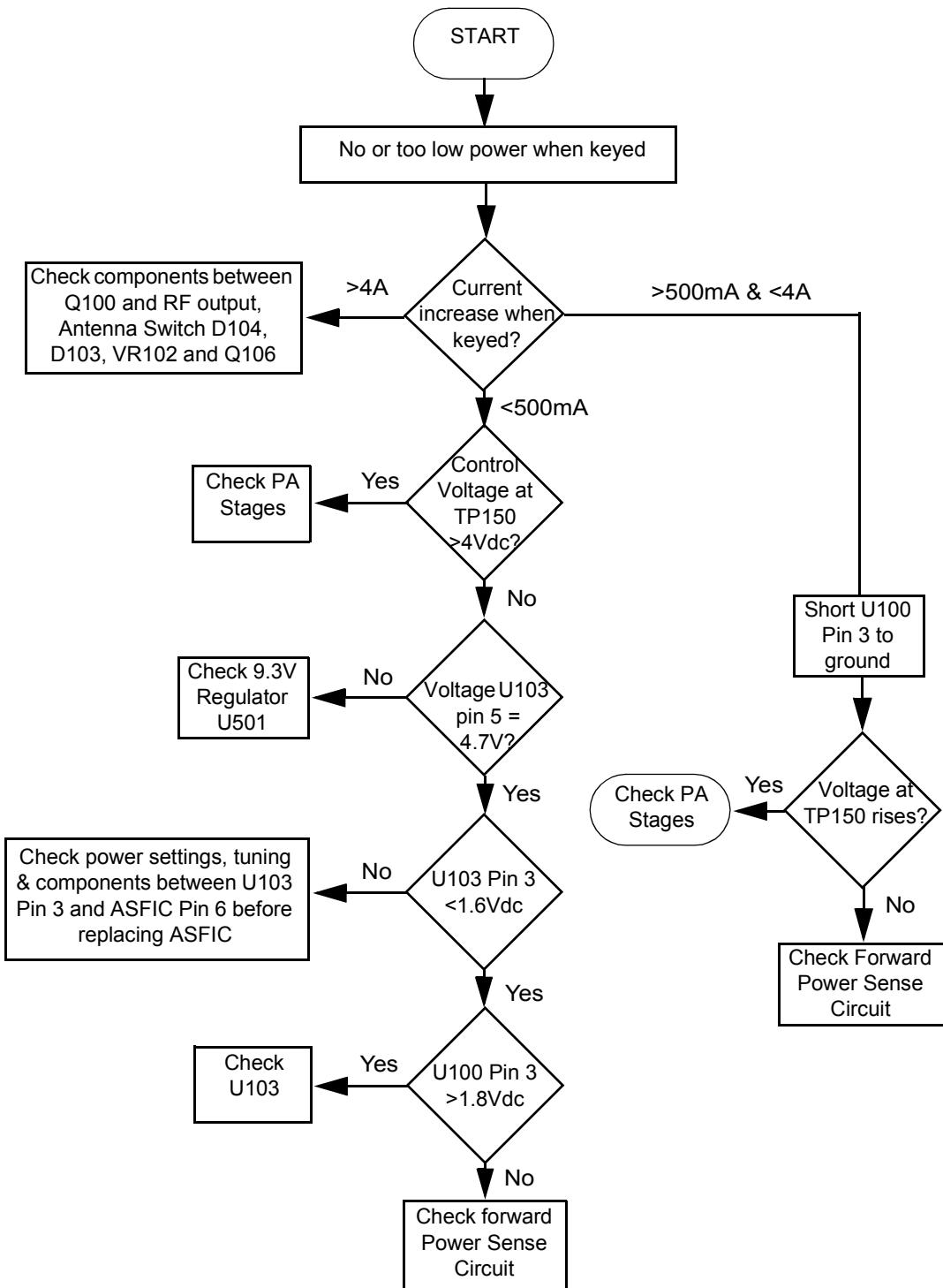
1.0 Troubleshooting Flow Chart for Receiver RF (Sheet 1 of 2)



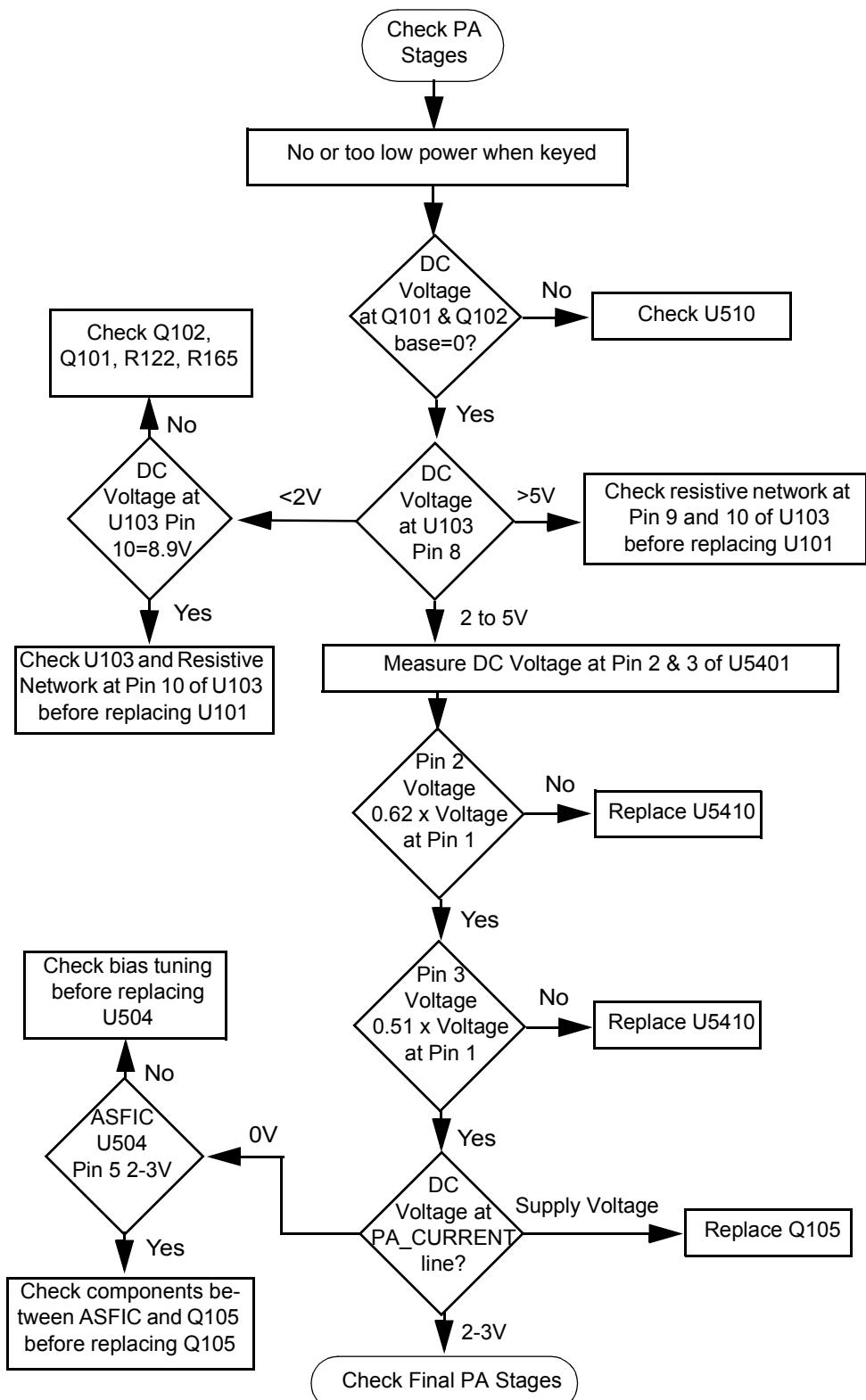
1.1 Troubleshooting Flow Chart for Receiver (Sheet 2 of 2)



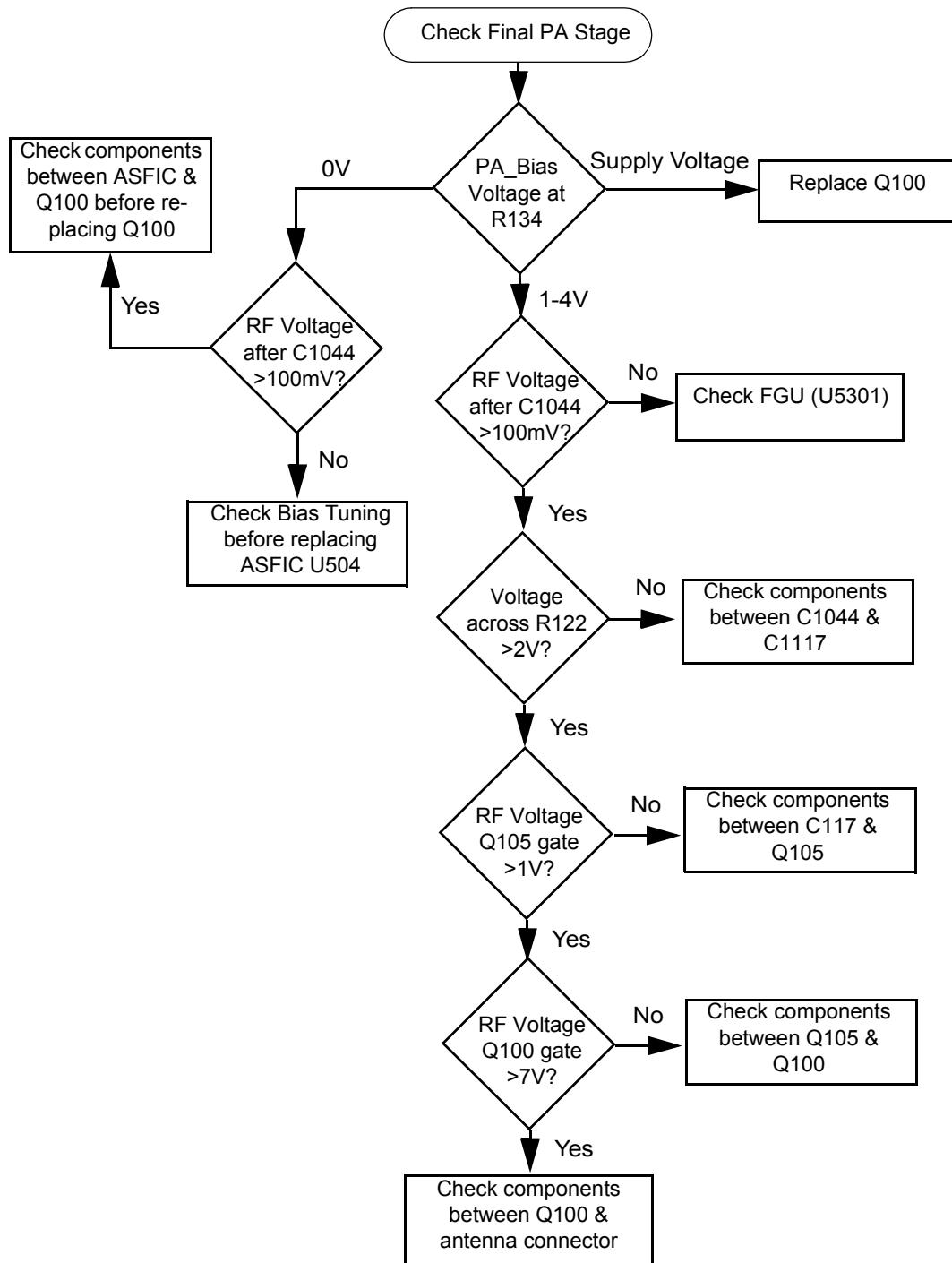
2.0 Troubleshooting Flow Chart for 40W Transmitter (Sheet 1 of 3)



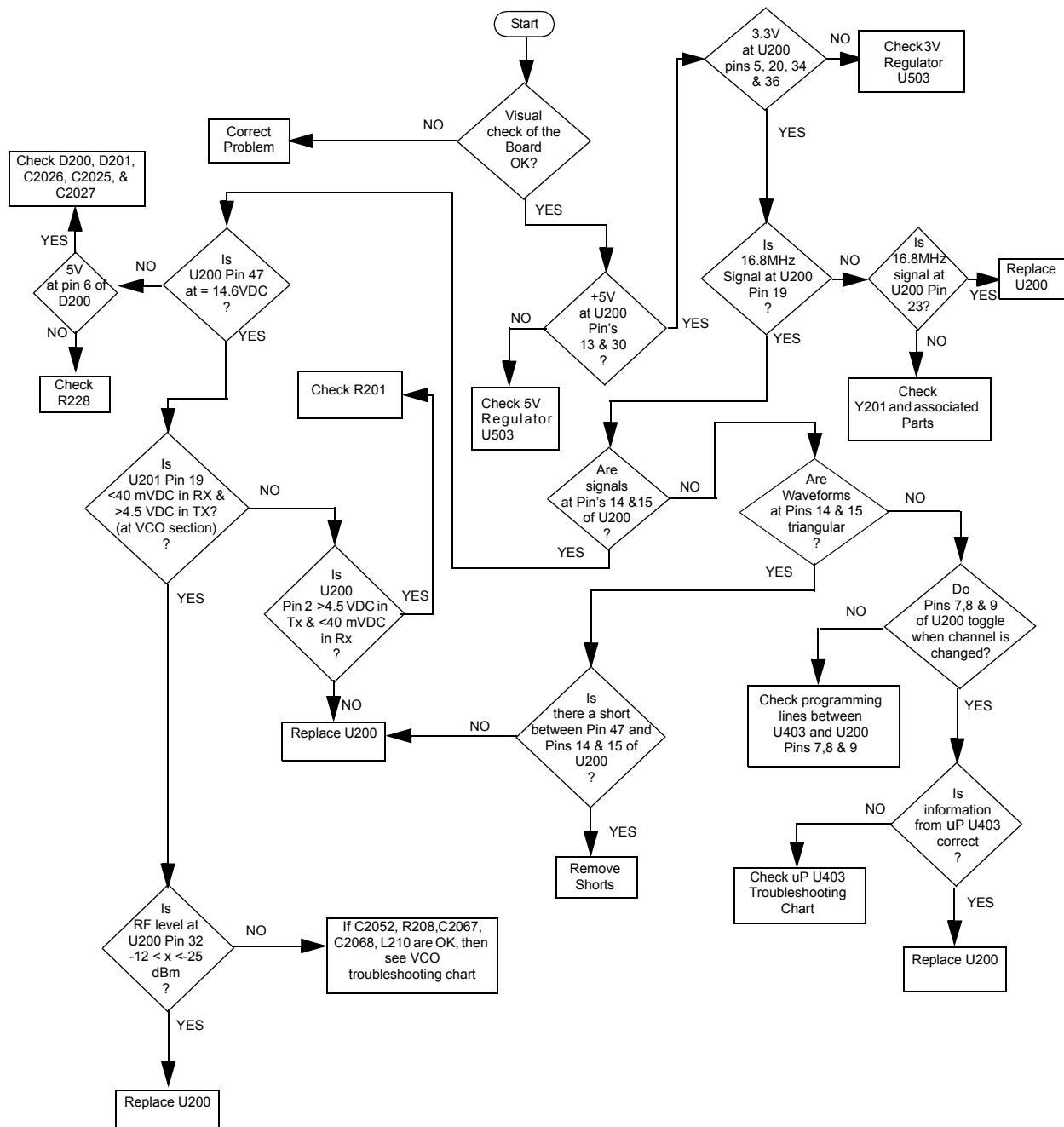
2.1 Troubleshooting Flow Chart for 40W Transmitter (Sheet 2 of 3)



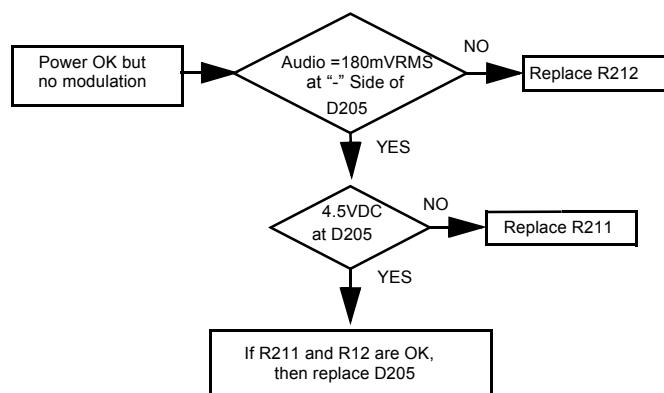
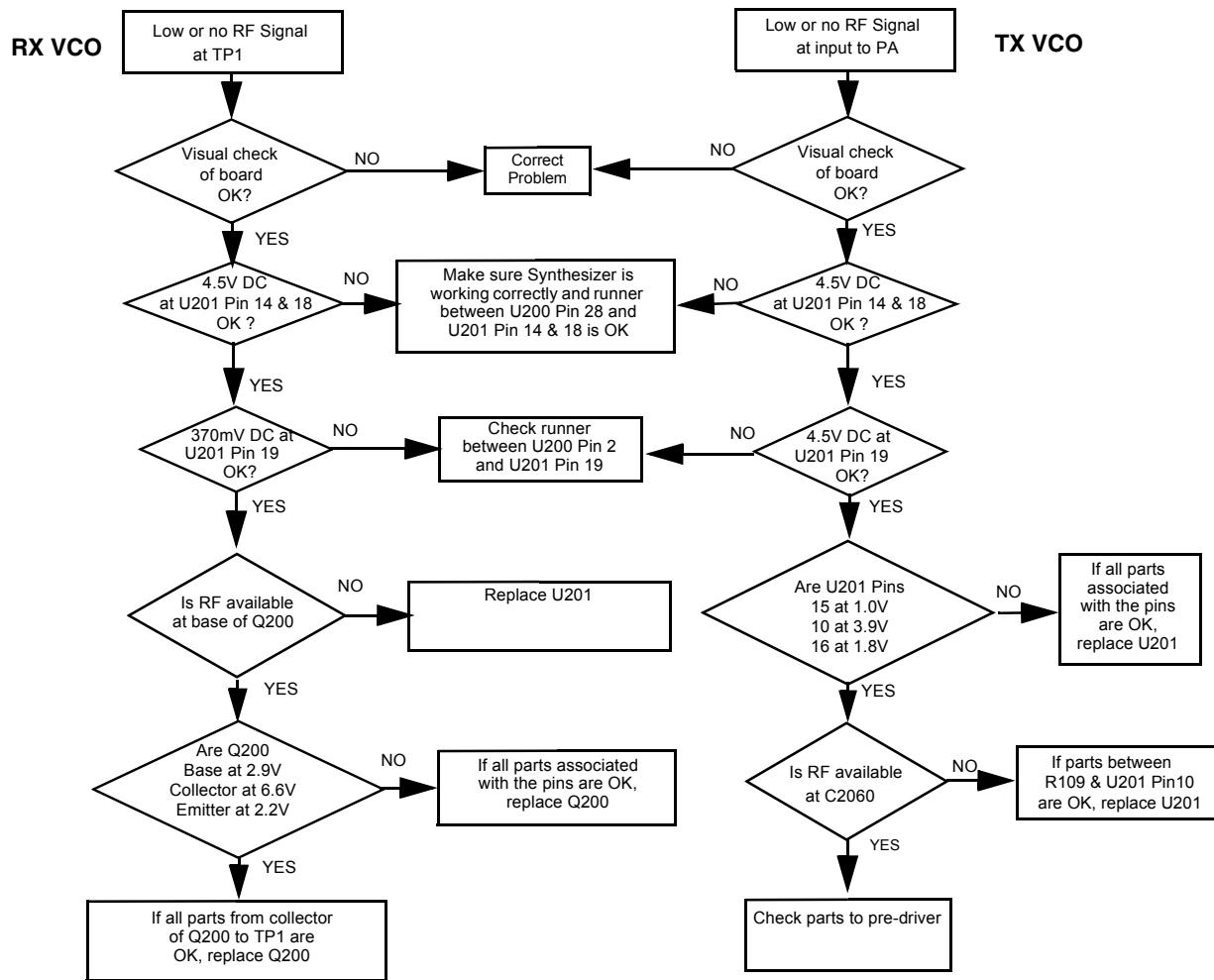
2.2 Troubleshooting Flow Chart for 40W Transmitter (Sheet 3 of 3)



3.0 Troubleshooting Flow Chart for Synthesizer

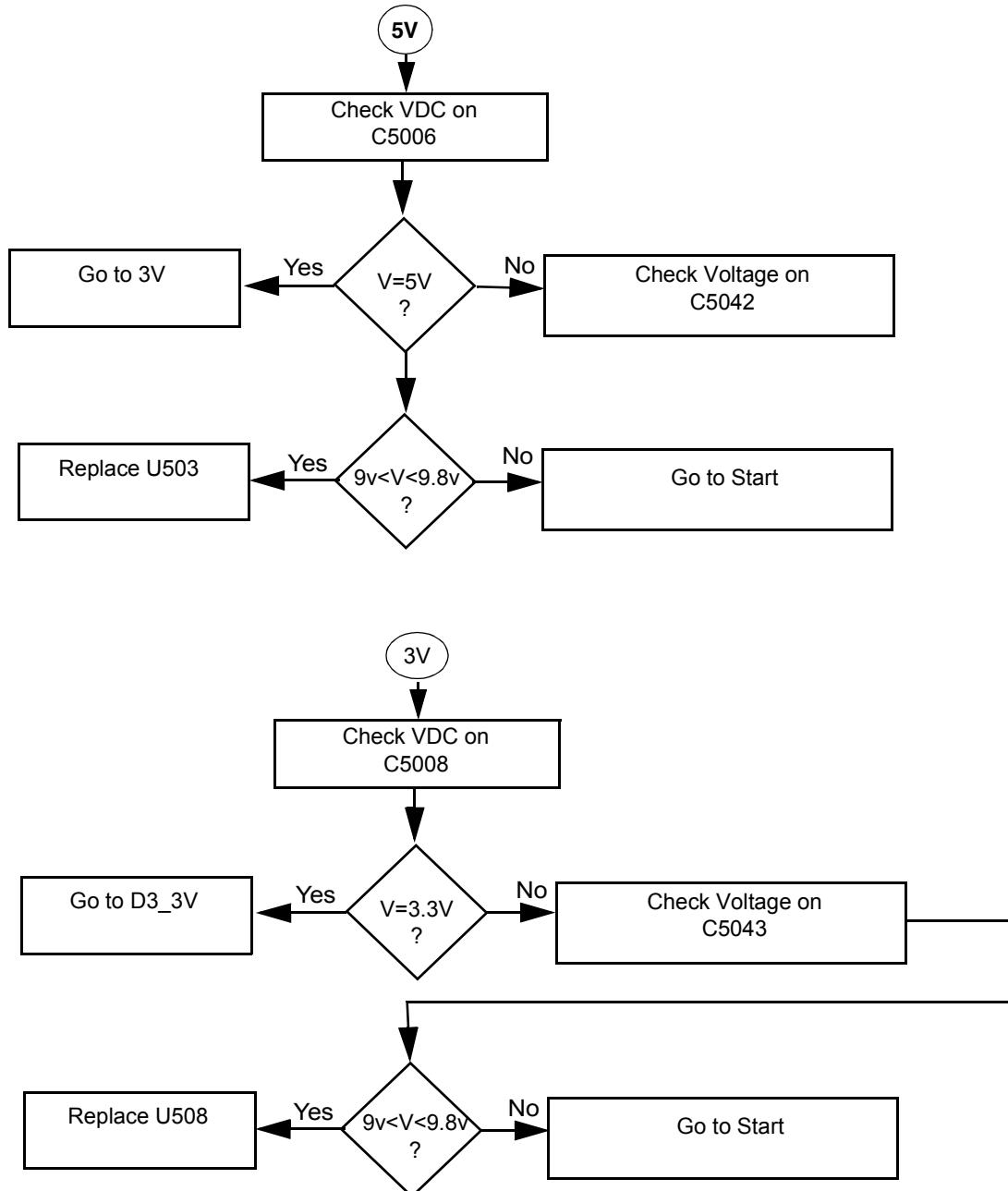


4.0 Troubleshooting Flow Chart for VCO

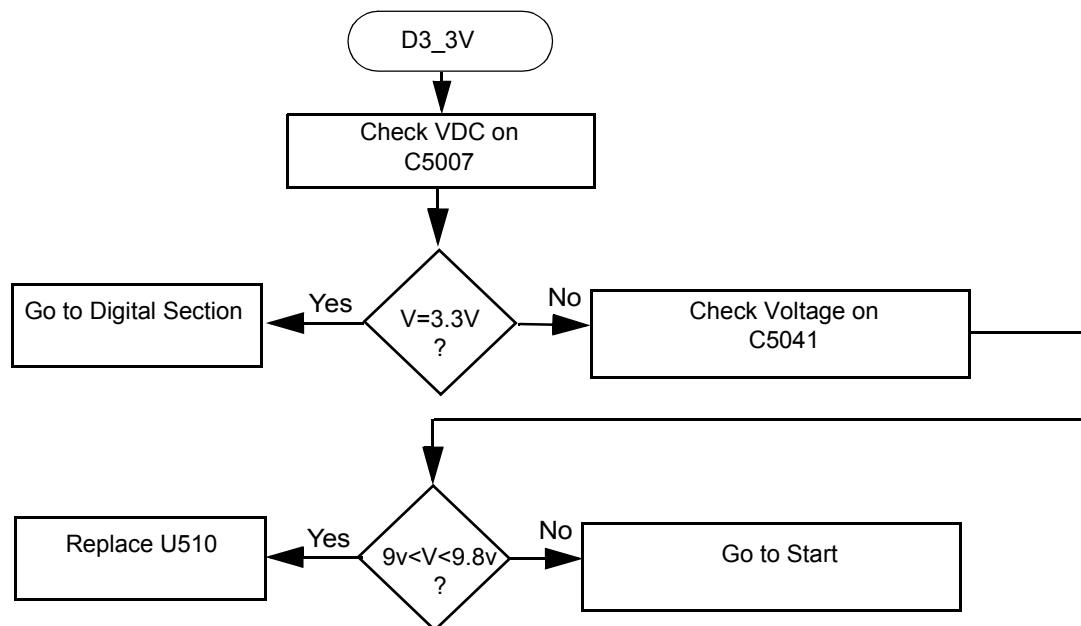


5.0 Troubleshooting Flow Chart for DC Supply (1 of 2)

Since the failure of a critical voltage supply might cause the radio to automatically power down, supply voltages should first be probed with a multimeter. If all the board voltages are absent, then the voltage test point should be retested using a rising-edge-triggered oscilloscope. If the voltage is still absent, then another voltage should be tested using the oscilloscope. If that voltage is present, then the original voltage supply in question is defective and requires investigation of associated circuitry.



5.1 Troubleshooting Flow Chart for DC Supply (2 of 2)



Chapter 4

UHF2 PCB/ SCHEMATICS/ PARTS LISTS

1.0 Allocation of Schematics and Circuit Boards

1.1 UHF2 and Controller Circuits

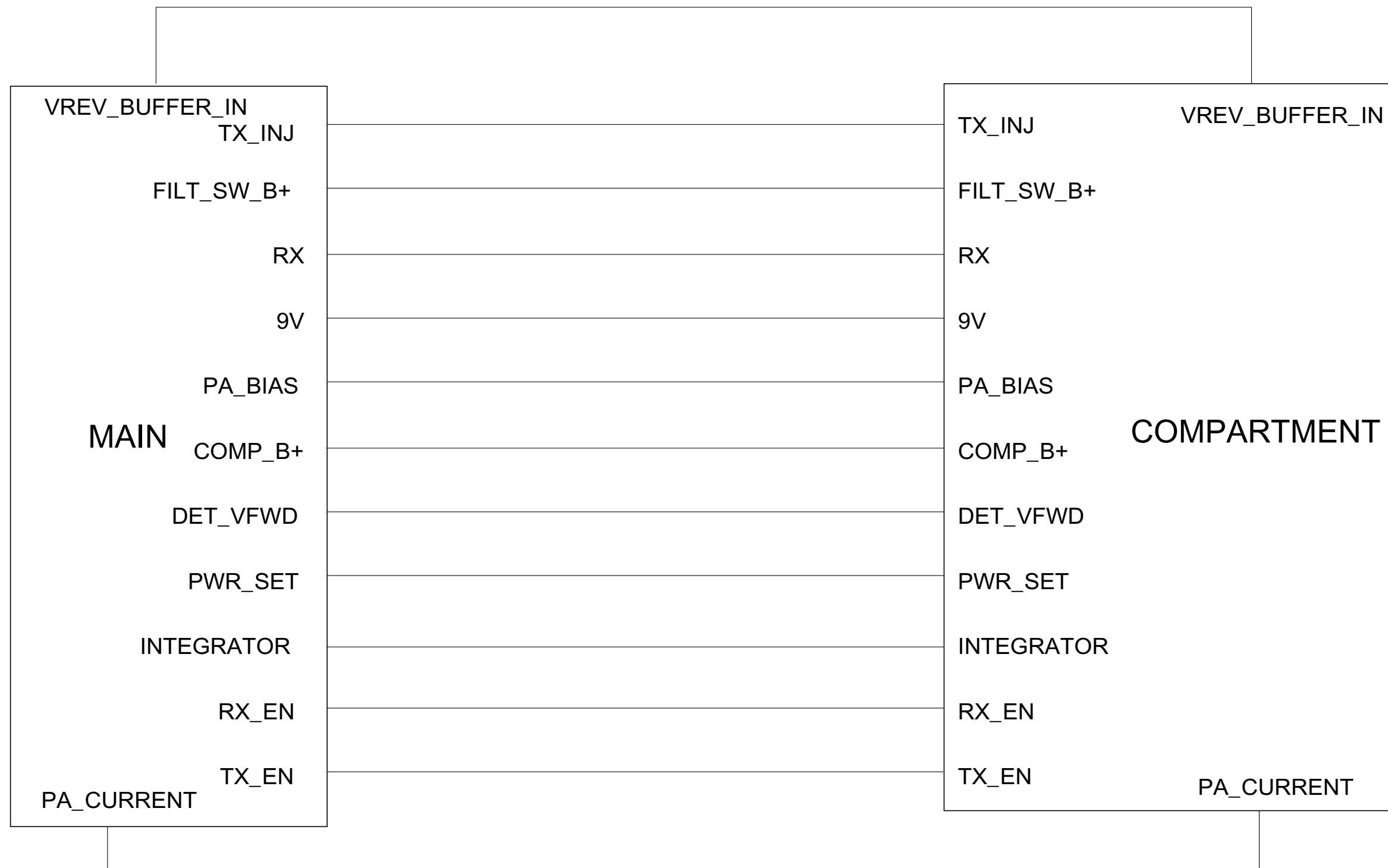
The UHF circuits are contained on the printed circuit board (PCB) which also contains the Controller circuits. This Chapter shows the schematics for both the UHF circuits and the Controller circuits. The PCB component layouts and the Parts Lists in this Chapter show both the Controller and UHF circuit components. The UHF and Controller schematics and the related PCB and parts list are shown in the tables below.

Table 4-1 UHF2 25-40W Diagrams and Parts Lists

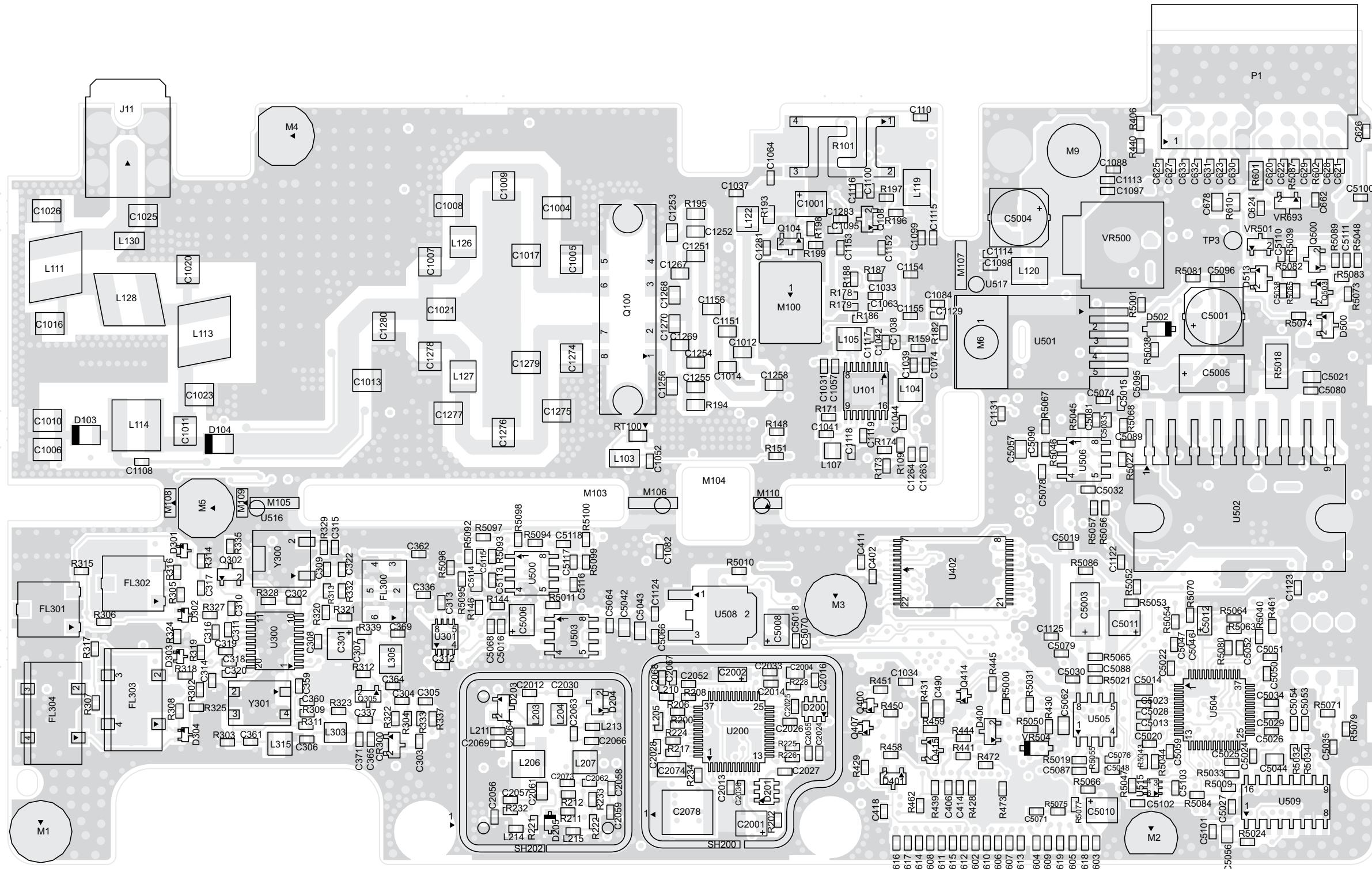
PCB : 8486577Z01 Main Board Top Side 8486577Z01 Main Board Bottom Side	Page4-4 Page4-5
SCHEMATICS Main Circuit Transmitter Synthesiser and VCO Receiver Front and Back End DC and Audio Ccts Microprocessor and Controller Ccts Power Control Cct	Page4-6/Page 4-7 Page 4-8/Page 4-9 Page 4-10/Page 4-11 Page 4-12/Page 4-13 Page 4-14/Page 4-15 Page 4-16/Page 4-17 Page 4-18
Parts List 8486577Z01	Page 4-19
Controller version is T1	

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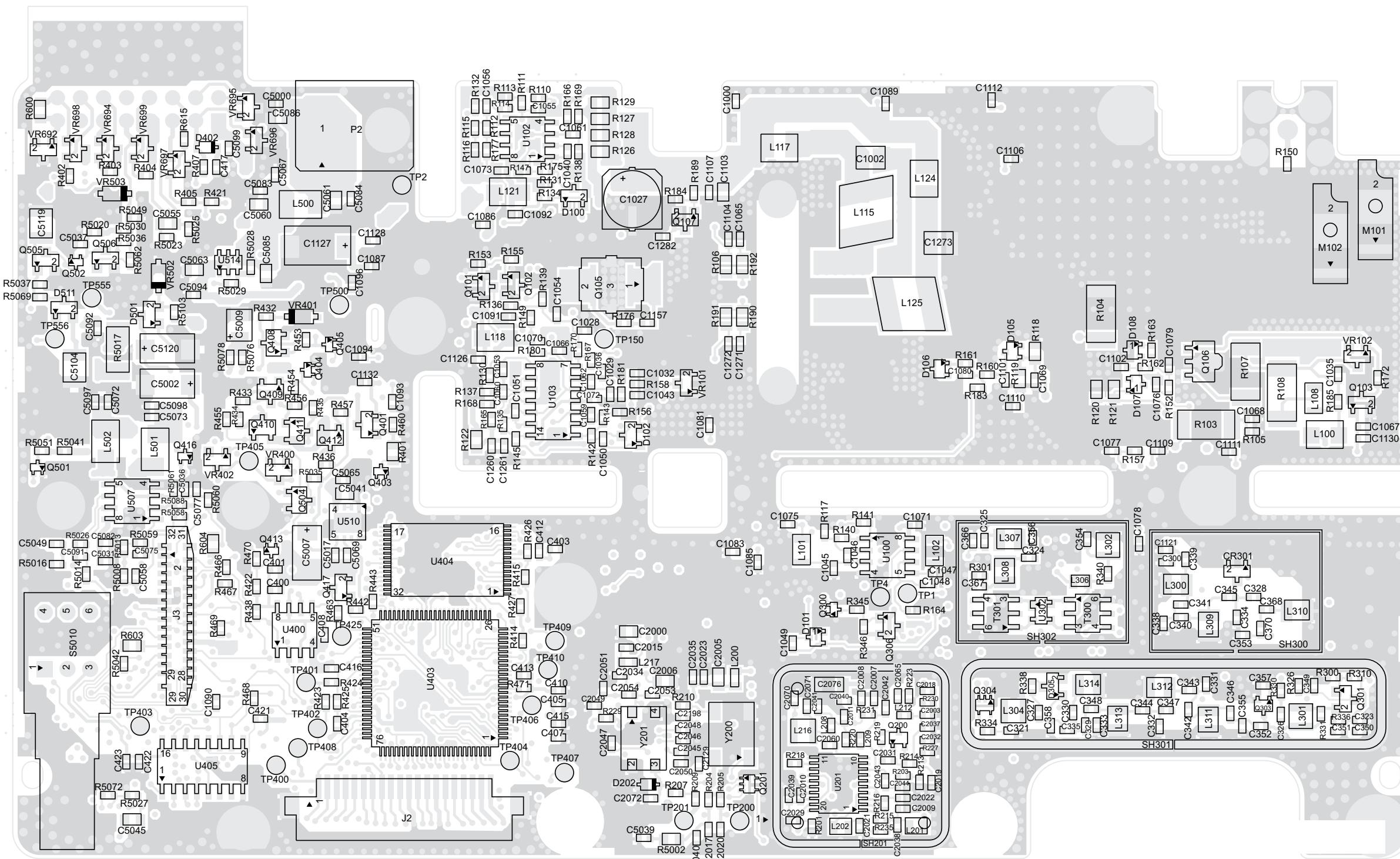
2.0 UHF2 25-40W PCB 8486577Z01 / Schematics



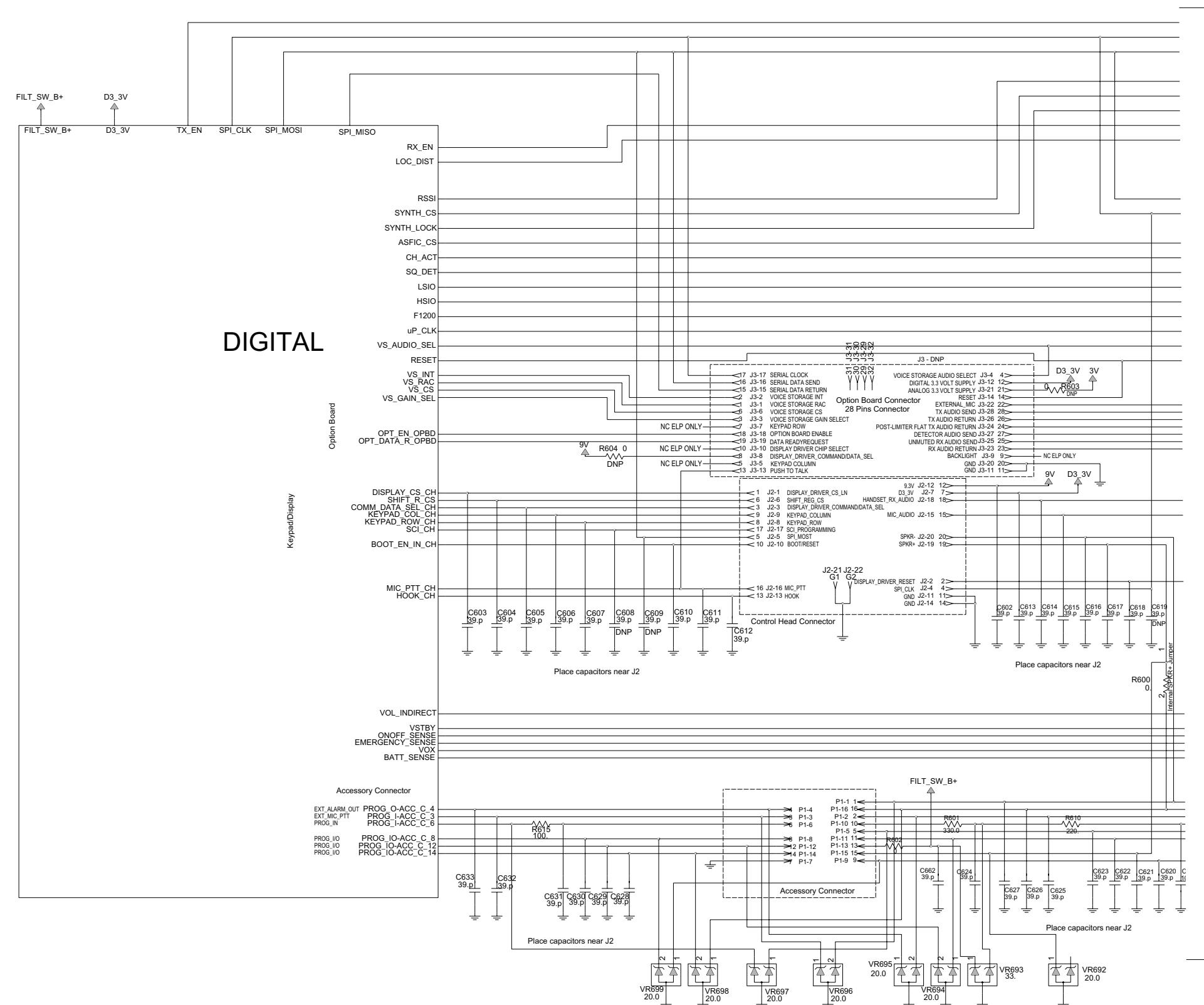
UHF 2 Interconnection between Main Board and Power Amplifier Compartment



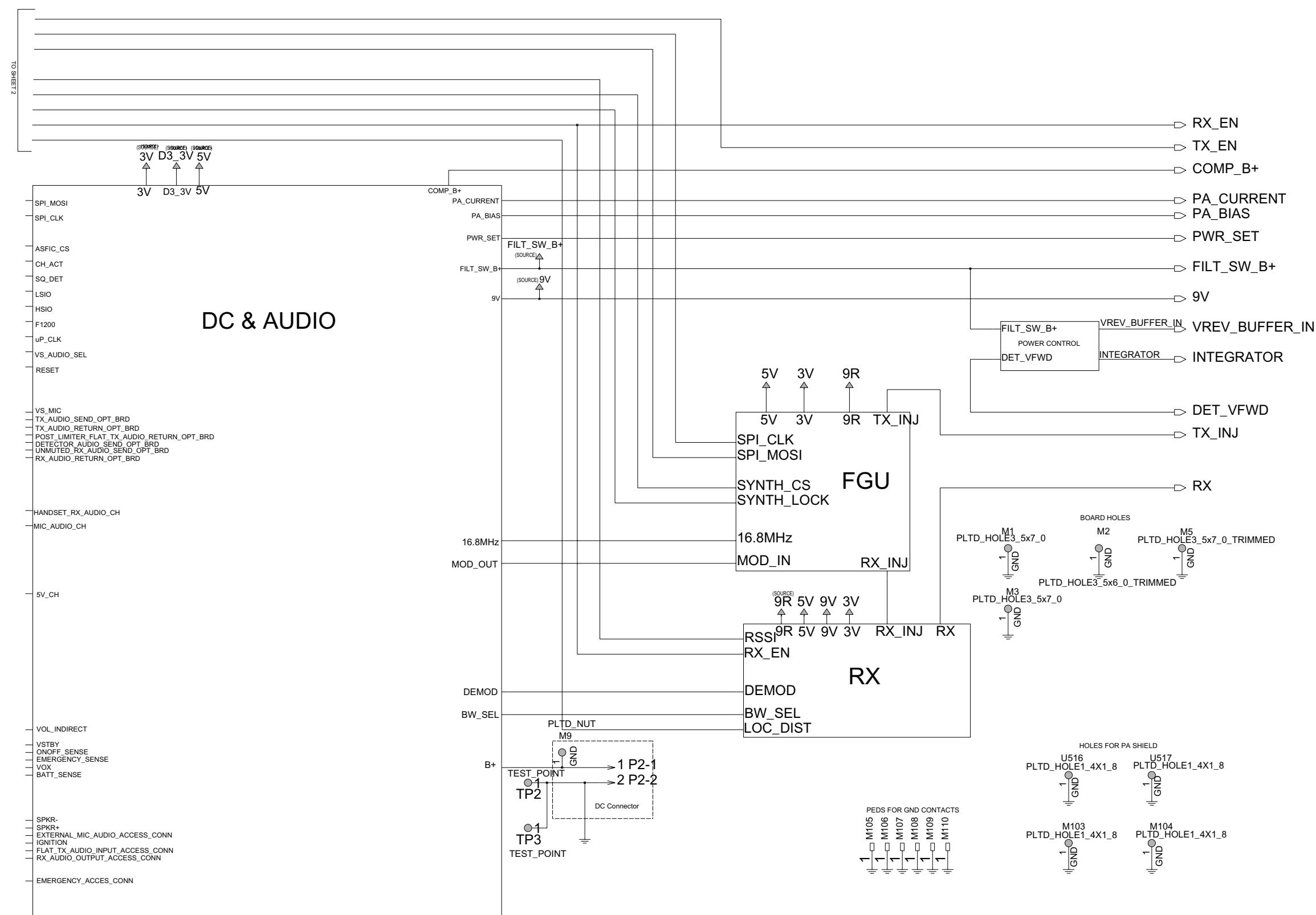
UHF 2 (438-470MHz) 25-40W 8486577Z01



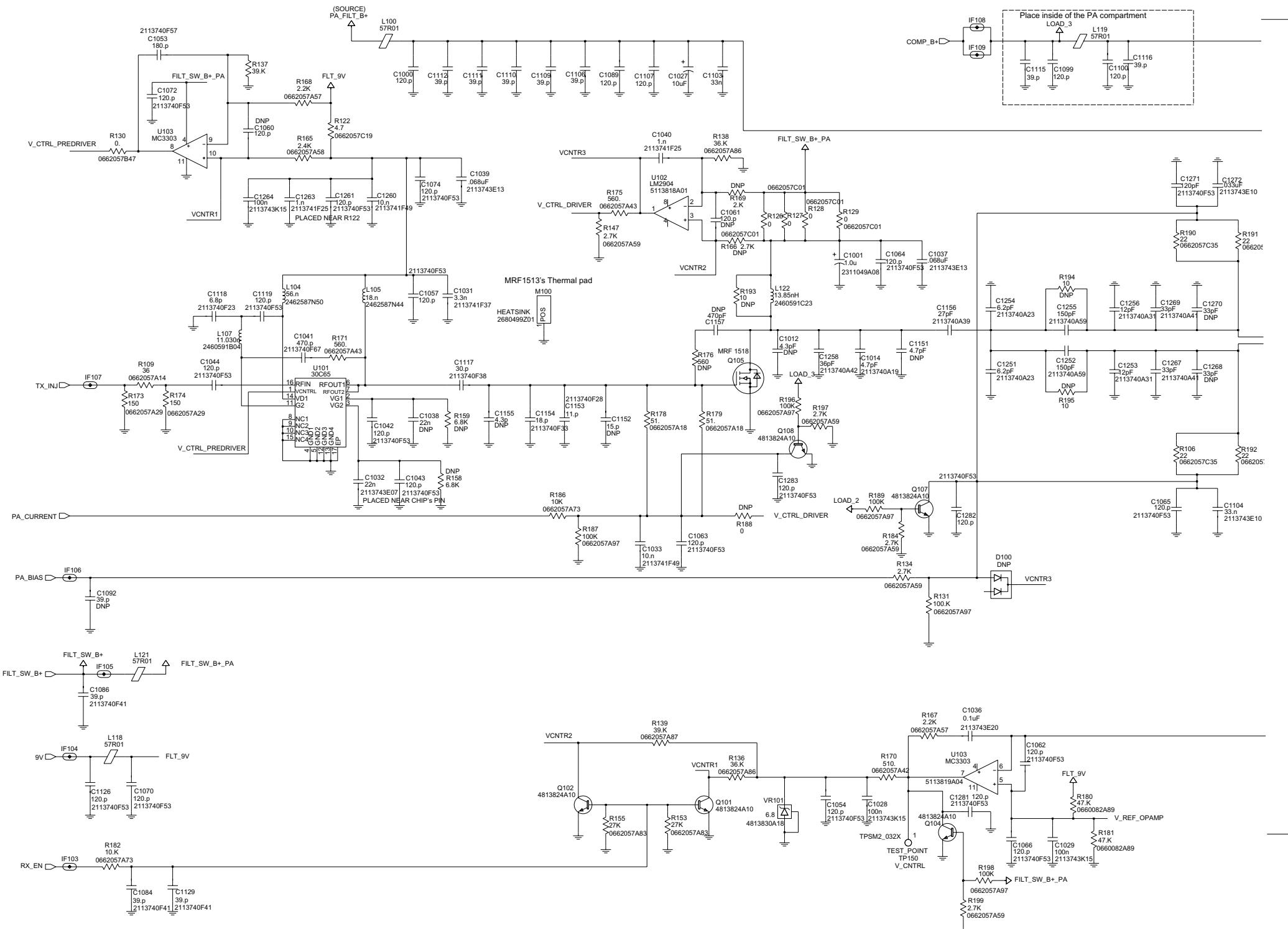
UHF2 (438-470MHz) 25-40W 8486577Z01



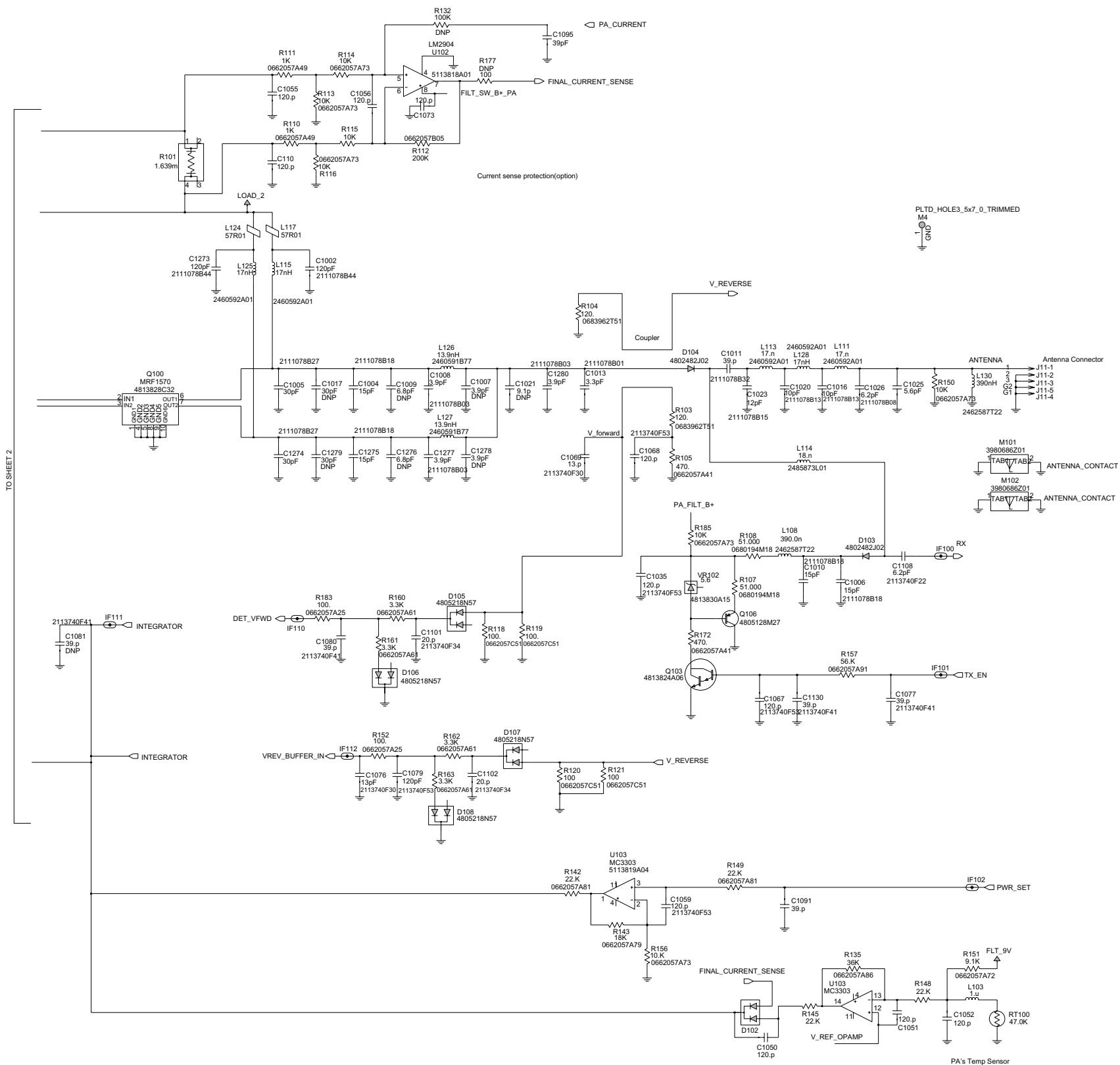
UHF2 (438-470MHz) Main Circuit (Sht 1 of 2)

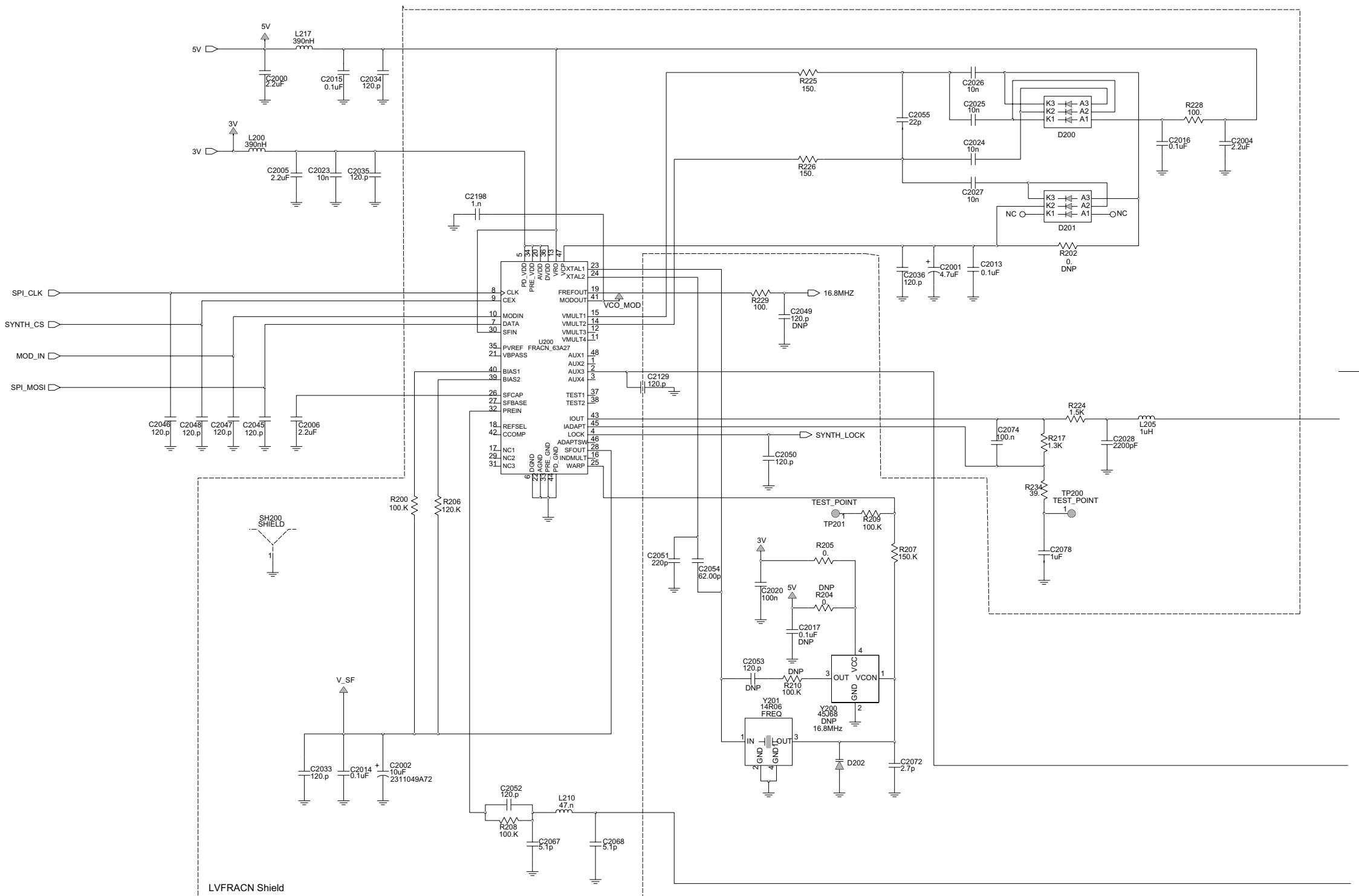


UHF2 (438-470MHz) Main Circuit (Sht 2 of 2)



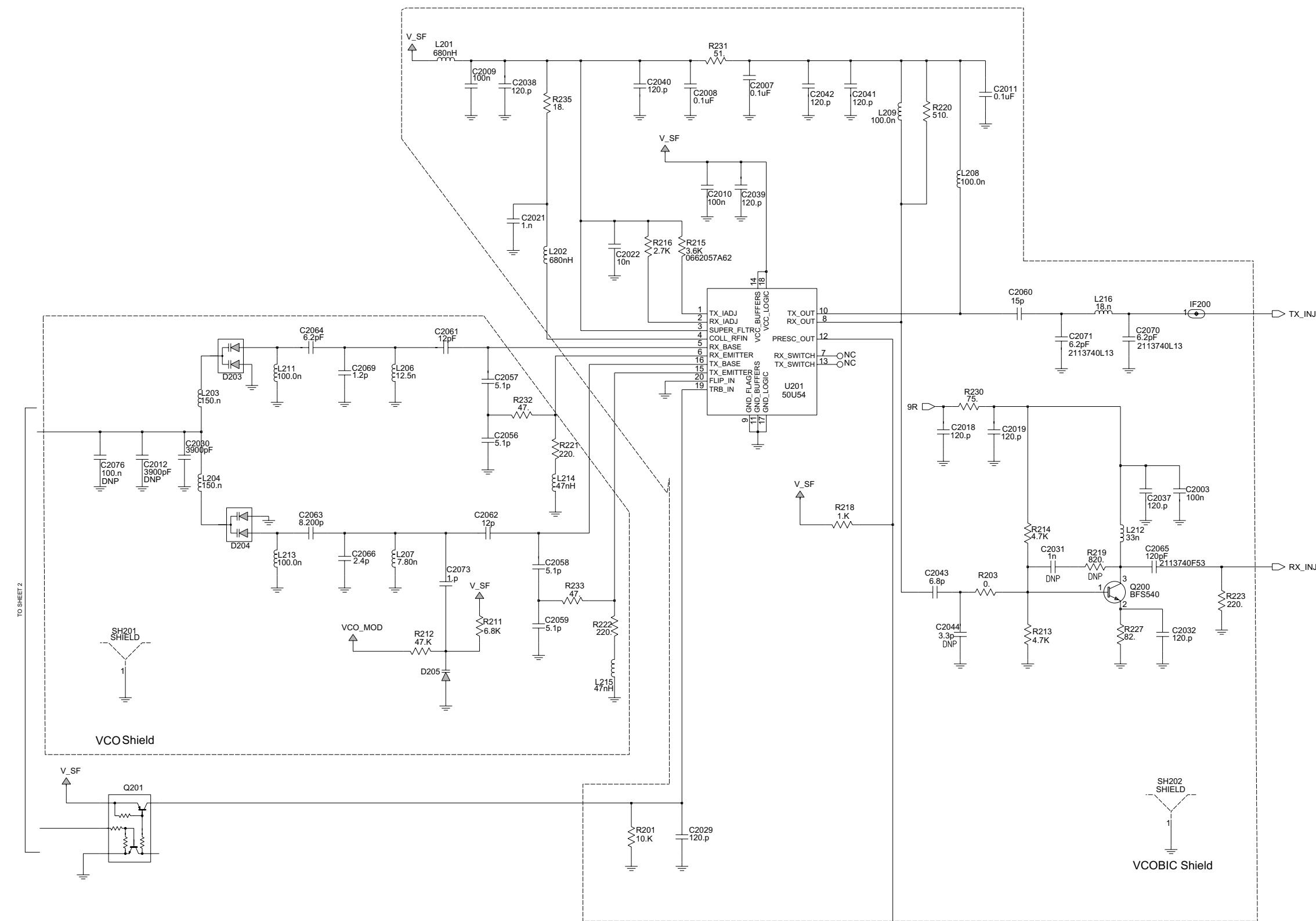
UHF2 (438-470MHz) Transmitter (Sht 1 of 2)

**UHF2 (438-470MHz) Transmitter (Sht 2 of 2)**

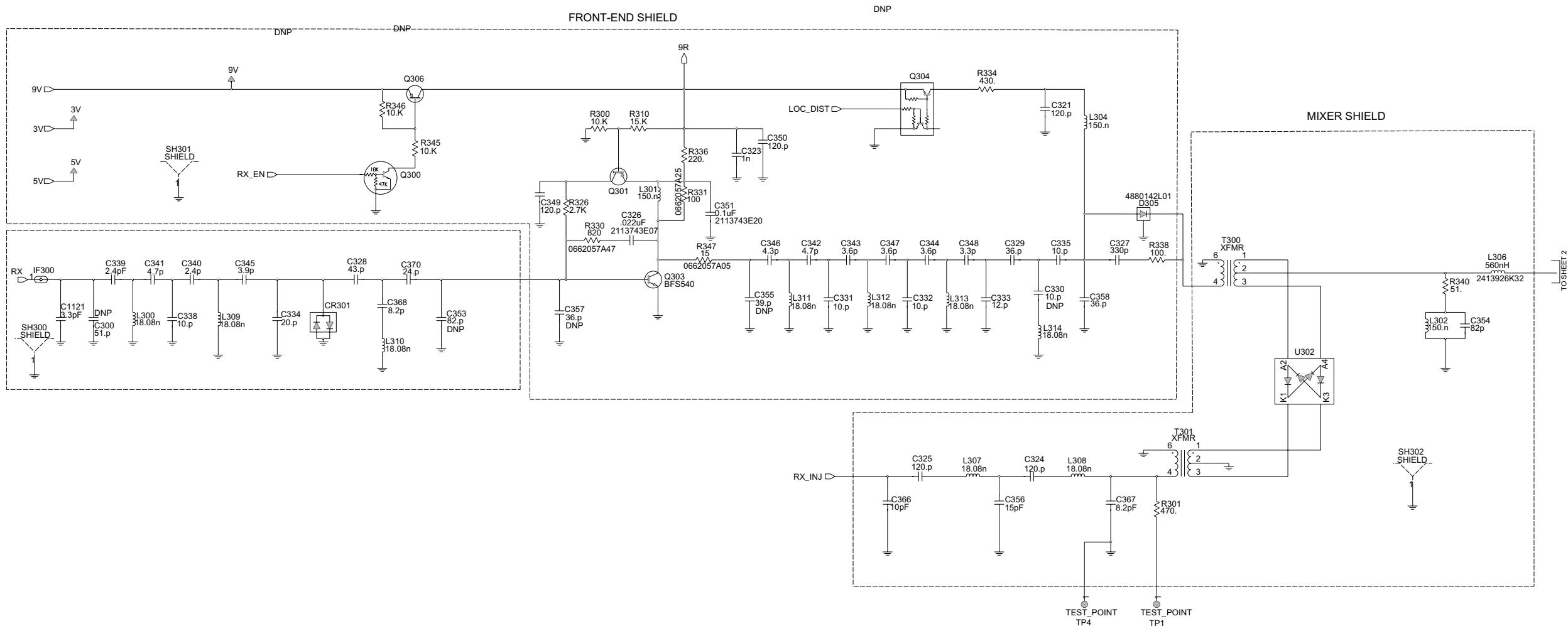


TO SHEET 1

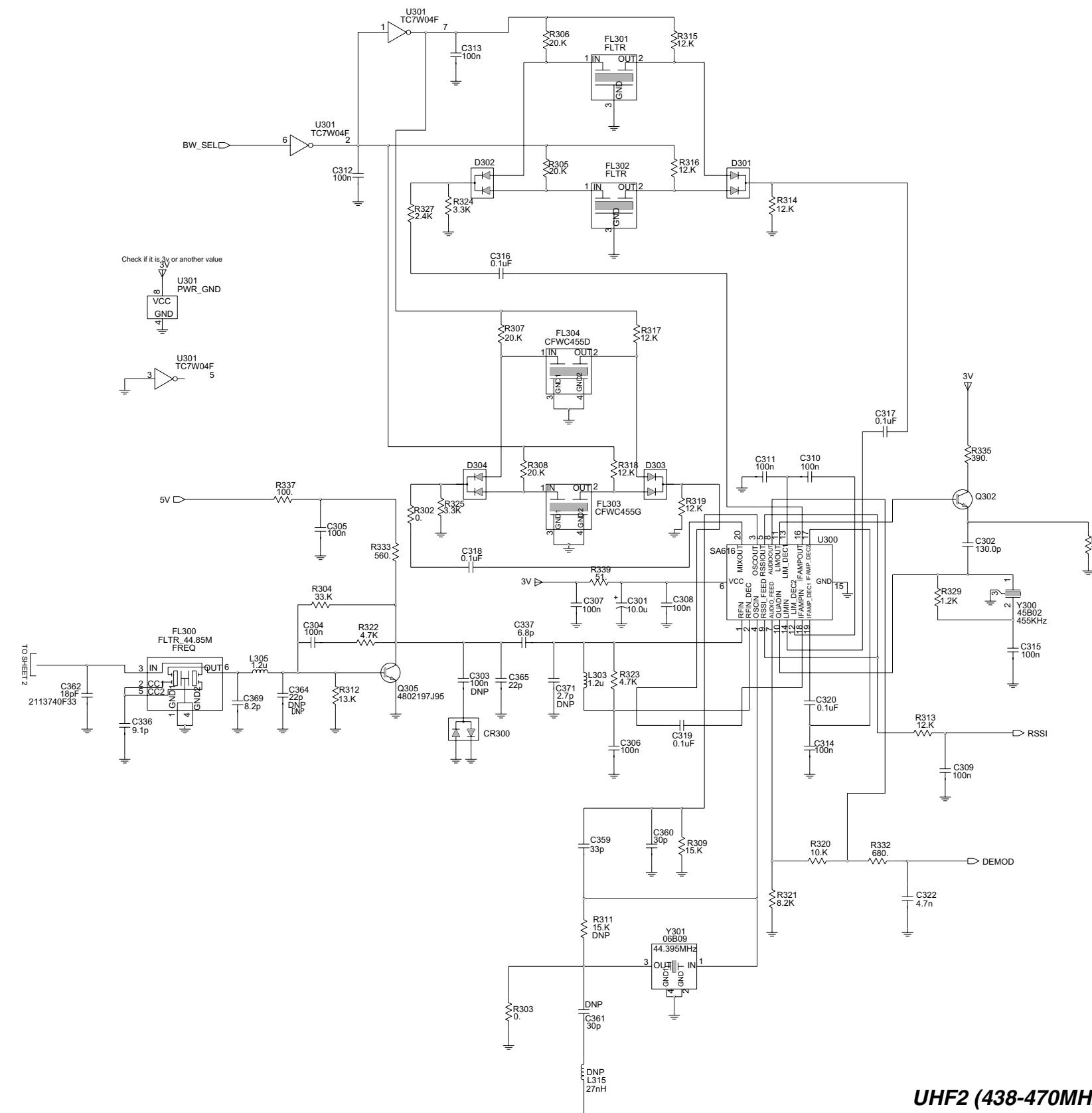
UHF2 (438-470MHz) Synthesiser and VCO (Sht 1 of 2)

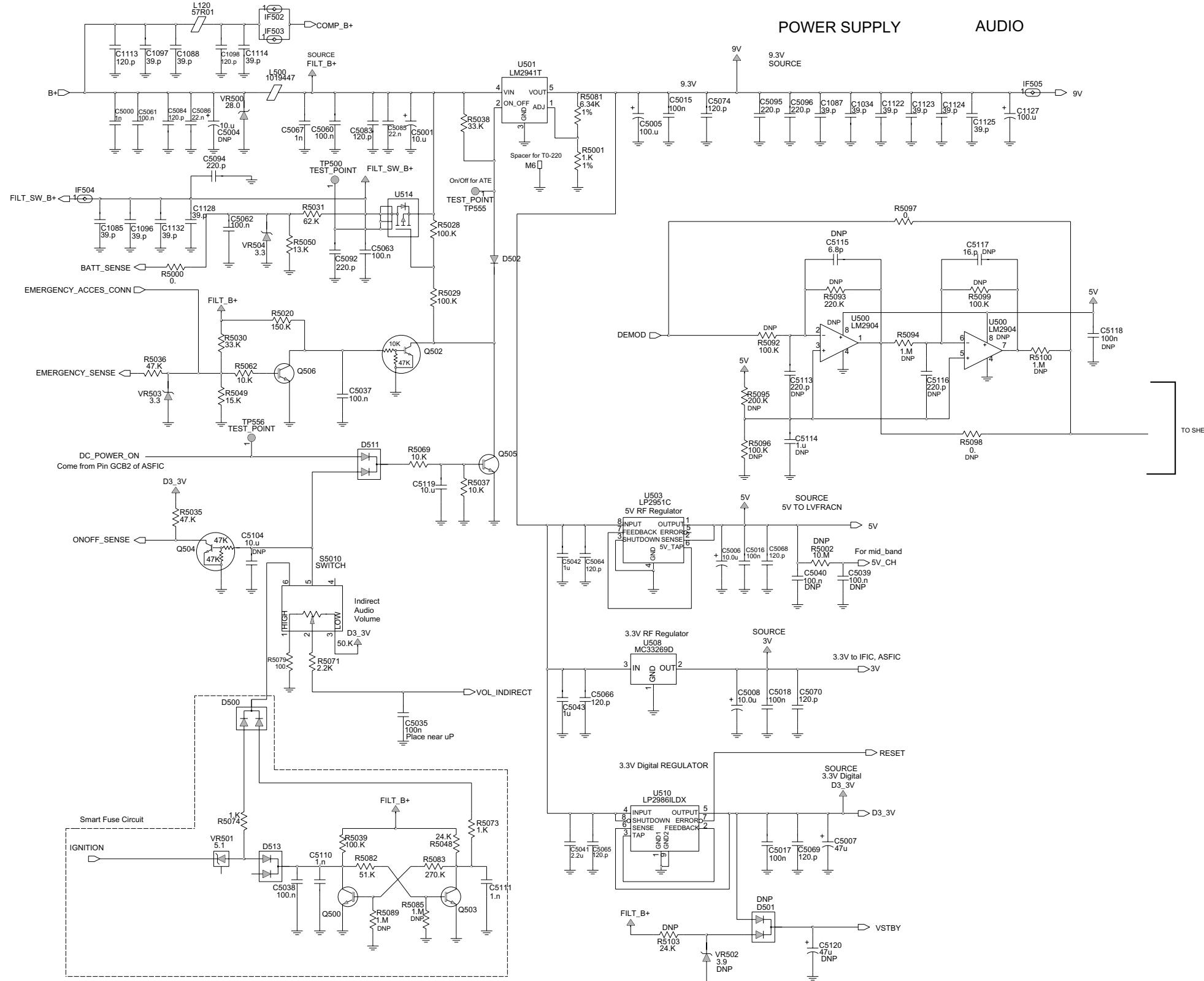


UHF2 (438-470MHz) Synthesiser and VCO (Sht 2 of 2)

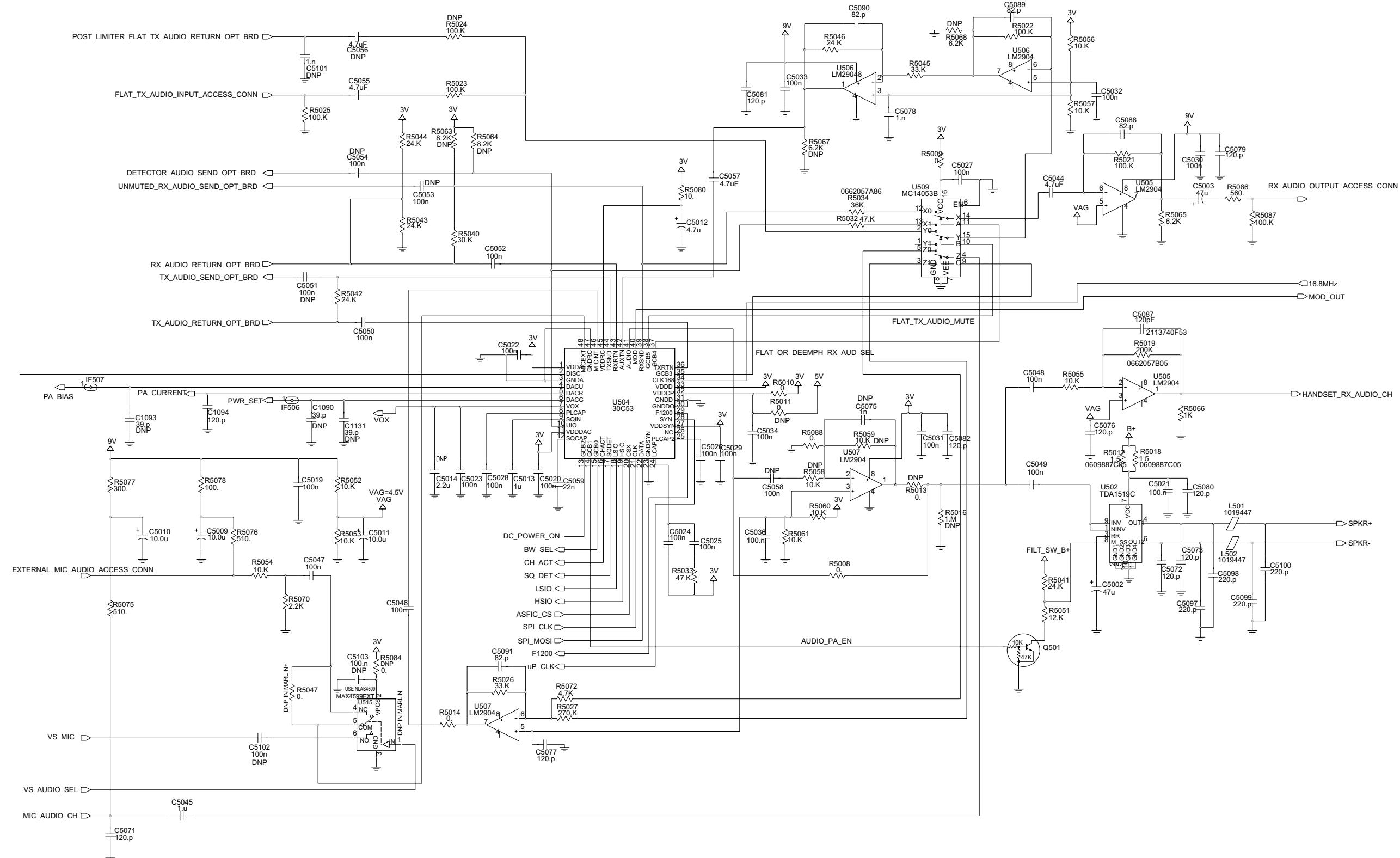


UHF2 (438-470MHz) Receiver Front and Back End (Sht 1 of 2)

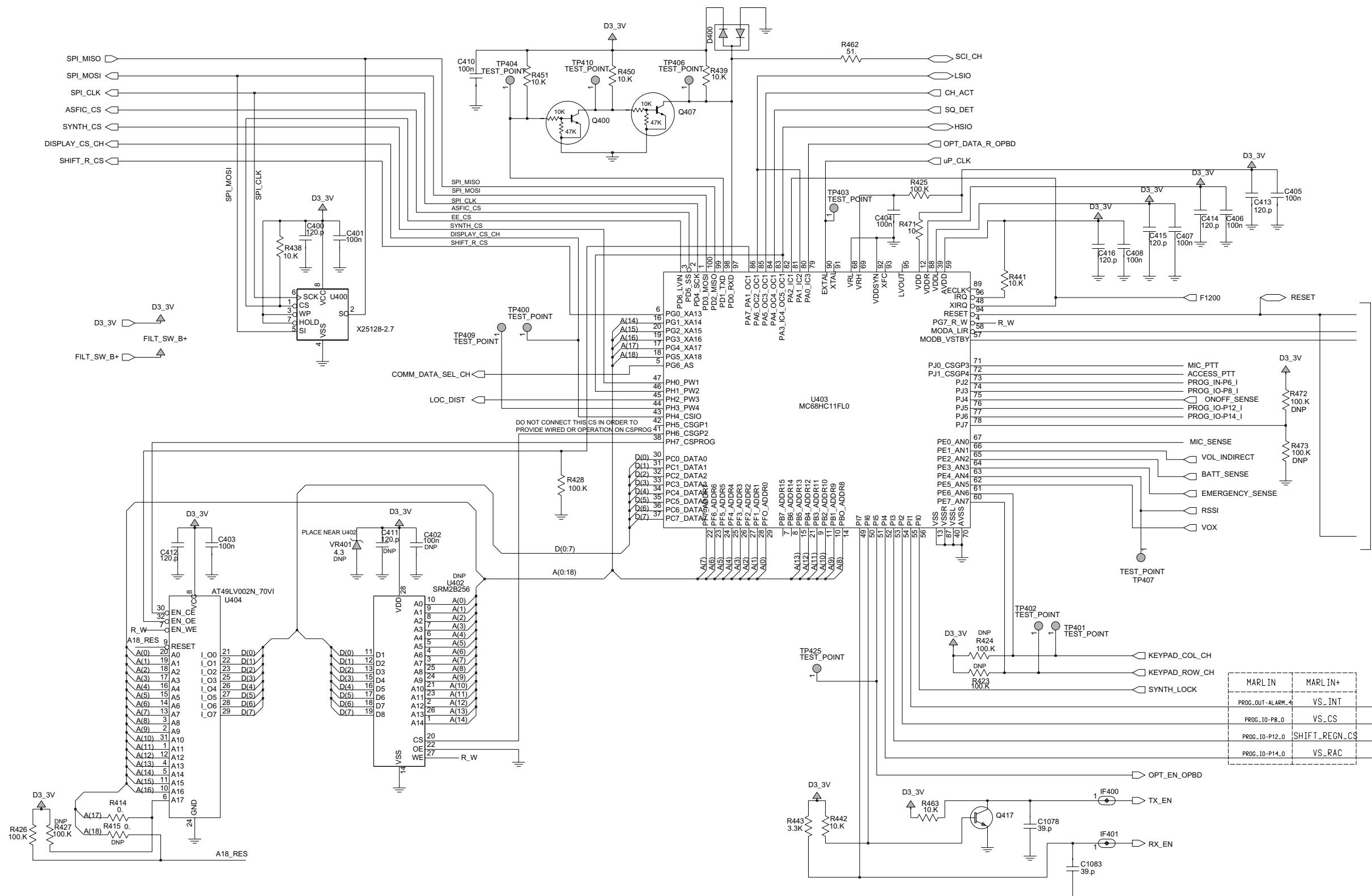
**UHF2 (438-470MHz) Receiver Front and Back End (Sht 2 of 2)**



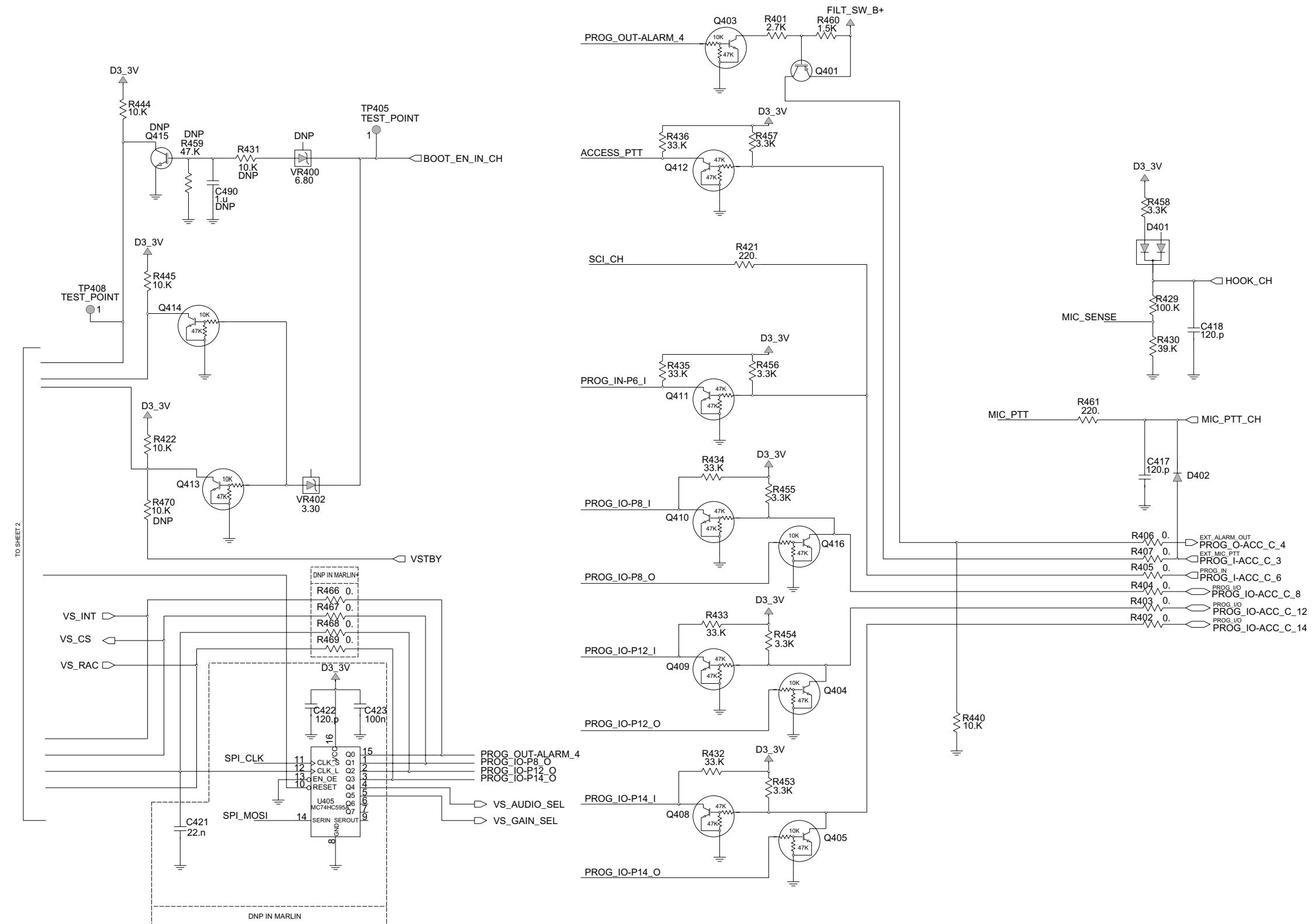
UHF2 (438-470MHz) DC and Audio Circuits (Sht 1 of 2)



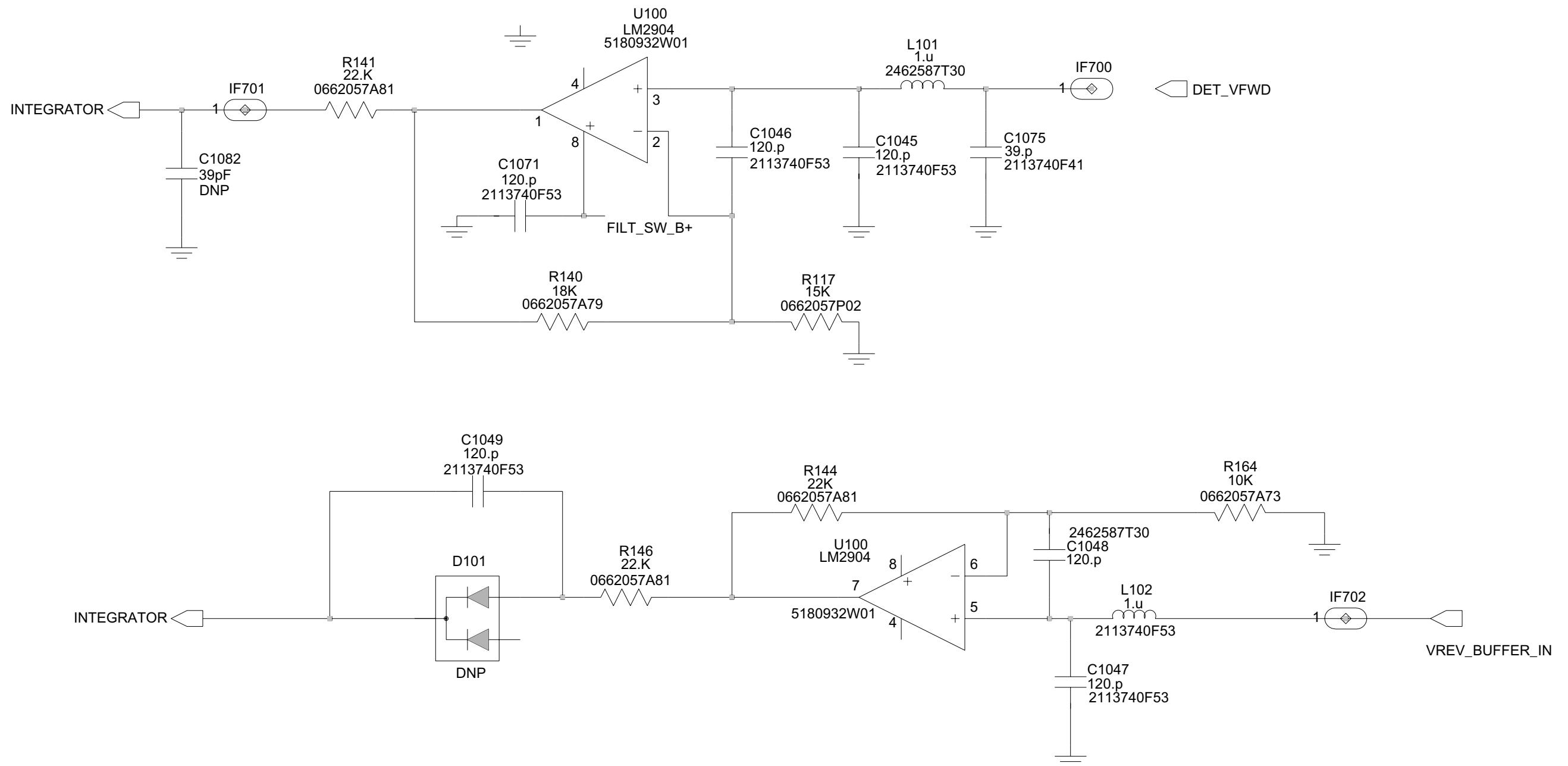
UHF2 (438-470MHz) DC and Audio Circuits (Sht 2 of 2)



UHF2 (438-470MHz) Microprocessor and Controller Circuits (Sht 1 of 2)



UHF2 (438-470MHz) Microprocessor and Controller Circuits (Sht 2 of 2)

**UHF2 (438-470MHz) Power Control Circuit**

2.1 UHF2 PCB 8486577Z01 Parts List 40W

Circuit Ref.	Motorola Part No.	Description
C1000	2113740F53	CAP CHIP REEL CL1 +/-30 120
C1001	2311049A08	KEMET CAPS
C1002	2111078B44	CAP CHIP RF 120 5 NPO 100V
C1004	2111078B18	CAP CHIP RF 15 5 NPO 100V
C1005	2111078B27	CAP CHIP RF 30 5 NPO 100V
C1006	2111078B18	CAP CHIP RF 15 5 NPO 100V
C1007	NOT PLACED	GCAM DUMMY PART NUMBER
C1008	2111078B03	CAP CHIP RF 3.9.25 NPO 100V
C1009	NOT PLACED	GCAM DUMMY PART NUMBER
C1010	2111078B18	CAP CHIP RF 15 5 NPO 100V
C1011	2111078B32	CAP ALT E12
C1012	NOT PLACED	GCAM DUMMY PART NUMBER
C1013	2111078B01	CAP CHIP RF 3.3 .25 NPO 100V
C1014	2113740A19	CAP CHIP REEL CL1 +/-30 4.7
C1016	2111078B13	CAP ALT E16
C1017	NOT PLACED	GCAM DUMMY PART NUMBER
C1020	2111078B13	CAP ALT E16
C1021	NOT PLACED	GCAM DUMMY PART NUMBER
C1023	2111078B15	CAP CHIP RF 12 5 NPO 100V
C1025	NOT PLACED	GCAM DUMMY PART NUMBER

Circuit Ref.	Motorola Part No.	Description
C1026	2111078B08	CAP CHIP RF 6.2 .25NPO 100V
C1027	2389289U01	10UF 50V 20% ALUMINUM SMD
C1028	2113743K15	CHIP CAP, CER 0.1UF
C1029	2113743K15	CHIP CAP, CER 0.1UF
C1031	2113741F37	CAP CHIP CL2 X7R REEL 3300
C1032	2113743E07	CER CHIP CAP .022UF
C1033	2113741F49	CAP CHIP CL2 X7R REEL 10000
C1034	2113740F41	CAP CHIP REEL CL1 +/-30 39
C1035	2113740F53	CAP CHIP REEL CL1 +/-30 120
C1036	2113743E20	CAP CHIP. 10 UF 10%
C1037	2113743E13	CAP CHIP 0.068UF
C1038	NOT PLACED	GCAM DUMMY PART NUMBER
C1039	2113743E13	CAP CHIP 0.068UF
C1040	2113741F25	CAP CHIP CL2 X7R REEL 1000
C1041	2113740F67	CAP CHIP CL1 +/-30 470 5%
C1042	2113740F53	CAP CHIP REEL CL1 +/-30 120
C1043	2113740F53	CAP CHIP REEL CL1 +/-30 120
C1044	2113740F53	CAP CHIP REEL CL1 +/-30 120
C1045	2113740F53	CAP CHIP REEL CL1 +/-30 120
C1046	2113740F53	CAP CHIP REEL CL1 +/-30 120
C1047	2113740F53	CAP CHIP REEL CL1 +/-30 120
C1048	2113740F53	CAP CHIP REEL CL1 +/-30 120
C1049	2113740F53	CAP CHIP REEL CL1 +/-30 120
C1050	2113740F53	CAP CHIP REEL CL1 +/-30 120
C1051	2113740F53	CAP CHIP REEL CL1 +/-30 120
C1052	2113740F53	CAP CHIP REEL CL1 +/-30 120
C1053	2113740F57	CAP CHIP REEL CL1 +/-30 180
C1054	2113740F53	CAP CHIP REEL CL1 +/-30 120
C1055	2113740F53	CAP CHIP REEL CL1 +/-30 120
C1056	2113740F53	CAP CHIP REEL CL1 +/-30 120
C1057	2113740F53	CAP CHIP REEL CL1 +/-30 120
C1059	2113740F53	CAP CHIP REEL CL1 +/-30 120
C1060	NOT PLACED	GCAM DUMMY PART NUMBER
C1061	NOT PLACED	GCAM DUMMY PART NUMBER
C1062	2113740F53	CAP CHIP REEL CL1 +/-30 120
C1063	2113740F53	CAP CHIP REEL CL1 +/-30 120
C1064	2113740F53	CAP CHIP REEL CL1 +/-30 120
C1065	2113740F53	CAP CHIP REEL CL1 +/-30 120
C1066	2113740F53	CAP CHIP REEL CL1 +/-30 120
C1067	2113740F53	CAP CHIP REEL CL1 +/-30 120
C1068	2113740F53	CAP CHIP REEL CL1 +/-30 120
C1069	2113740F30	CAP CHIP REEL CL1 +/-30 13
C1070	2113740F53	CAP CHIP REEL CL1 +/-30 120
C1071	2113740F53	CAP CHIP REEL CL1 +/-30 120
C1072	2113740F53	CAP CHIP REEL CL1 +/-30 120
C1073	2113740F53	CAP CHIP REEL CL1 +/-30 120
C1074	2113740F53	CAP CHIP REEL CL1 +/-30 120
C1075	2113740F41	CAP CHIP REEL CL1 +/-30 39
C1076	2113740F30	CAP CHIP REEL CL1 +/-30 13
C1077	2113740F41	CAP CHIP REEL CL1 +/-30 39
C1078	2113740F41	CAP CHIP REEL CL1 +/-30 39
C1079	2113740F53	CAP CHIP REEL CL1 +/-30 120
C1080	2113740F41	CAP CHIP REEL CL1 +/-30 39
C1081	NOT PLACED	GCAM DUMMY PART NUMBER
C1082	NOT PLACED	GCAM DUMMY PART NUMBER
C1083	2113740F41	CAP CHIP REEL CL1 +/-30 39
C1084	2113740F41	CAP CHIP REEL CL1 +/-30 39
C1085	2113740F41	CAP CHIP REEL CL1 +/-30 39
C1086	2113740F41	CAP CHIP REEL CL1 +/-30 39
C1087	2113740F41	CAP CHIP REEL CL1 +/-30 39

Circuit Ref.	Motorola Part No.	Description
C1088	2113740F41	CAP CHIP REEL CL1 +/-30 39
C1089	2113740F53	CAP CHIP REEL CL1 +/-30 120
C1090	NOT PLACED	GCAM DUMMY PART NUMBER
C1091	NOT PLACED	GCAM DUMMY PART NUMBER
C1092	NOT PLACED	GCAM DUMMY PART NUMBER
C1093	NOT PLACED	GCAM DUMMY PART NUMBER
C1094	2113740F53	CAP CHIP REEL CL1 +/-30 120
C1095	2113740F41	CAP CHIP REEL CL1 +/-30 39
C1096	2113740F41	CAP CHIP REEL CL1 +/-30 39
C1097	2113740F41	CAP CHIP REEL CL1 +/-30 39
C1098	2113740F53	CAP CHIP REEL CL1 +/-30 120
C1099	2113740F53	CAP CHIP REEL CL1 +/-30 120
C110	2113740F53	CAP CHIP REEL CL1 +/-30 120
C1100	2113740F53	CAP CHIP REEL CL1 +/-30 120
C1101	2113740F34	CAP CHIP REEL CL1 +/-30 20
C1102	2113740F34	CAP CHIP REEL CL1 +/-30 20
C1103	2113741A57	CAP CHIP 33K +/-5% (2160521A31)
C1104	2113743E10	CAP CHIP .033 UF 10% X 7R
C1106	2113740F41	CAP CHIP REEL CL1 +/-30 39
C1107	2113740F53	CAP CHIP REEL CL1 +/-30 120

Circuit Ref.	Motorola Part No.	Description
C1108	2113740F22	CAP CHIP REEL CL1 +/-30 6.2
C1109	2113740F41	CAP CHIP REEL CL1 +/-30 39
C1110	2113740F41	CAP CHIP REEL CL1 +/-30 39
C1111	2113740F41	CAP CHIP REEL CL1 +/-30 39
C1112	2113740F41	CAP CHIP REEL CL1 +/-30 39
C1113	2113740F53	CAP CHIP REEL CL1 +/-30 120
C1114	2113740F41	CAP CHIP REEL CL1 +/-30 39
C1115	2113740F41	CAP CHIP REEL CL1 +/-30 39
C1116	2113740F41	CAP CHIP REEL CL1 +/-30 39
C1117	2113740F38	CAP CHIP REEL CL1 +/-30 30
C1118	2113740F23	CAP CHIP REEL CL1 +/-30 6.8
C1119	2113740F53	CAP CHIP REEL CL1 +/-30 120
C1121	2113740F15	CAP CHIP REEL CL1 +/-30 3.3
C1122	2113740F41	CAP CHIP REEL CL1 +/-30 39
C1123	2113740F41	CAP CHIP REEL CL1 +/-30 39
C1124	2113740F41	CAP CHIP REEL CL1 +/-30 39
C1125	2113740F41	CAP CHIP REEL CL1 +/-30 39
C1126	2113740F53	CAP CHIP REEL CL1 +/-30 120
C1127	2360567A03	CAP TANTALUM
C1128	2113740F41	CAP CHIP REEL CL1 +/-30 39

Circuit Ref.	Motorola Part No.	Description
C1129	2113740F41	CAP CHIP REEL CL1 +/-30 39
C1130	2113740F41	CAP CHIP REEL CL1 +/-30 39
C1131	NOT PLACED	GCAM DUMMY PART NUMBER
C1132	2113740F41	CAP CHIP REEL CL1 +/-30 39
C1151	NOT PLACED	GCAM DUMMY PART NUMBER
C1152	NOT PLACED	GCAM DUMMY PART NUMBER
C1153	2113740F28	CAP CHIP REEL CL1 +/-30 11
C1154	2113740F33	CAP CHIP REEL CL1 +/-30 18
C1155	NOT PLACED	GCAM DUMMY PART NUMBER
C1156	2113740A39	CAP CHIP REEL CL1 +/-30 27
C1157	NOT PLACED	GCAM DUMMY PART NUMBER
C1251	2113740A23	CAP CHIP REEL CL1 +/-30 6.2
C1252	2113740A59	CHIP CAPACITORS 150PF +/-30%
C1253	2113740A31	CAP CHIP REEL CL1 +/-30 12
C1254	2113740A23	CAP CHIP REEL CL1 +/-30 6.2
C1255	2113740A59	CHIP CAPACITORS 150PF +/-30%
C1256	2113740A31	CAP CHIP REEL CL1 +/-30 12
C1258	2113740A42	CAP CHIP REEL CL1 +/-30 36
C1260	2113741F49	CAP CHIP CL2 X7R REEL 10000

Circuit Ref.	Motorola Part No.	Description
C1261	2113740F53	CAP CHIP REEL CL1 +/-30 120
C1263	2113741F25	CAP CHIP CL2 X7R REEL 1000
C1264	2113743K15	CHIP CAP, CER 0.1UF
C1267	2113740A41	CAP CHIP REEL CL1 +/-30 33
C1268	NOT PLACED	GCAM DUMMY PART NUMBER
C1269	2113740A41	CAP CHIP REEL CL1 +/-30 33
C1270	NOT PLACED	GCAM DUMMY PART NUMBER
C1271	2113740F53	CAP CHIP REEL CL1 +/-30 120
C1272	2113743E10	CAP CHIP .033 UF 10% X 7R
C1273	211078B44	CAP CHIP RF 120 5 NPO 100V
C1274	211078B27	CAP CHIP RF 30 5 NPO 100V
C1275	211078B18	CAP CHIP RF 15 5 NPO 100V
C1276	NOT PLACED	GCAM DUMMY PART NUMBER
C1277	211078B03	CAP CHIP RF 3.9.25 NPO 100V
C1278	NOT PLACED	GCAM DUMMY PART NUMBER
C1279	NOT PLACED	GCAM DUMMY PART NUMBER
C1280	211078B03	CAP CHIP RF 3.9.25 NPO 100V
C1281	2113740F53	CAP CHIP REEL CL1 +/-30 120
C1282	2113740F53	CAP CHIP REEL CL1 +/-30 120
C1283	2113740F53	CAP CHIP REEL CL1 +/-30 120

Circuit Ref.	Motorola Part No.	Description
C2000	2113743F18	CAP CHIP 2.2 UF 16V +80-20%
C2001	2311049J11	CAPACITOR TANT 10% 4.7UF
C2002	2311049A72	CAP TANT CHIP 10.0UF 10% 10V
C2003	2113743K15	CHIP CAP, CER 0.1UF
C2004	2113743F18	CAP CHIP 2.2 UF 16V +80-20%
C2005	2113743F18	CAP CHIP 2.2 UF 16V +80-20%
C2006	2113743F18	CAP CHIP 2.2 UF 16V +80-20%
C2007	2113743E20	CAP CHIP. 10 UF 10%
C2008	2113743E20	CAP CHIP. 10 UF 10%
C2009	2113743E20	CAP CHIP. 10 UF 10%
C2010	2113743E20	CAP CHIP. 10 UF 10%
C2011	2113743E20	CAP CHIP. 10 UF 10%
C2012	NOT PLACED	GCAM DUMMY PART NUMBER
C2013	2113743E20	CAP CHIP. 10 UF 10%
C2014	2113743E20	CAP CHIP. 10 UF 10%
C2015	2113743E20	CAP CHIP. 10 UF 10%
C2016	2113743E20	CAP CHIP. 10 UF 10%
C2017	2113743E20	CAP CHIP. 10 UF 10%
C2018	2113740F53	CAP CHIP REEL CL1 +/-30 120
C2019	2113740F53	CAP CHIP REEL CL1 +/-30 120
C2020	2113743E20	CAP CHIP. 10 UF 10%
C2021	2113741F25	CAP CHIP CL2 X7R REEL 1000
C2022	2113741F49	CAP CHIP CL2 X7R REEL 10000
C2023	2113741F49	CAP CHIP CL2 X7R REEL 10000

Circuit Ref.	Motorola Part No.	Description
C2024	2113741F49	CAP CHIP CL2 X7R REEL 10000
C2025	2113741F49	CAP CHIP CL2 X7R REEL 10000
C2026	2113741F49	CAP CHIP CL2 X7R REEL 10000
C2027	2113741F49	CAP CHIP CL2 X7R REEL 10000
C2028	2113741F33	CAP CHIP CL2 X7R REEL 2200
C2029	2113740F53	CAP CHIP REEL CL1 +/-30 120
C2030	2113741F39	CAP CHIP CL2 XTR REEL 3900
C2031	NOT PLACED	GCAM DUMMY PART NUMBER
C2032	2113740F53	CAP CHIP REEL CL1 +/-30 120
C2033	2113740F53	CAP CHIP REEL CL1 +/-30 120
C2034	2113740F53	CAP CHIP REEL CL1 +/-30 120
C2035	2113740F53	CAP CHIP REEL CL1 +/-30 120
C2036	2113740F53	CAP CHIP REEL CL1 +/-30 120
C2037	2113740F53	CAP CHIP REEL CL1 +/-30 120
C2038	2113740F53	CAP CHIP REEL CL1 +/-30 120
C2039	2113740F53	CAP CHIP REEL CL1 +/-30 120
C2040	2113740F53	CAP CHIP REEL CL1 +/-30 120
C2041	2113740F53	CAP CHIP REEL CL1 +/-30 120
C2042	2113740F53	CAP CHIP REEL CL1 +/-30 120

Circuit Ref.	Motorola Part No.	Description
C2043	2113740L14	CAP CER CHIP 6.8PF +-0.1PF
C2044	NOT PLACED	GCAM DUMMY PART NUMBER
C2045	2113740F53	CAP CHIP REEL CL1 +/-30 120
C2046	2113740F53	CAP CHIP REEL CL1 +/-30 120
C2047	2113740F53	CAP CHIP REEL CL1 +/-30 120
C2048	2113740F53	CAP CHIP REEL CL1 +/-30 120
C2049	NOT PLACED	GCAM DUMMY PART NUMBER
C2050	2113740F53	CAP CHIP REEL CL1 +/-30 120
C2051	2113740F59	CAP CHIP REEL CL1 +/-30 220
C2052	2113740F53	CAP CHIP REEL CL1 +/-30 120
C2053	NOT PLACED	GCAM DUMMY PART NUMBER
C2054	2113740L37	CAP 62.0 PF 50V 2.0%
C2055	2113740F35	CAP CHIP REEL CL1 +/-30 22
C2056	2113740F20	CAP CHIP REEL CL1 +/-30 5.1
C2057	2113740F20	CAP CHIP REEL CL1 +/-30 5.1
C2058	2113740F20	CAP CHIP REEL CL1 +/-30 5.1
C2059	2113740F20	CAP CHIP REEL CL1 +/-30 5.1
C2060	2113740F31	CAP CHIP REEL CL1 +/-30 15
C2061	2113740A31	CAP CHIP REEL CL1 +/-30 12
C2062	2113740F29	CAP CHIP REEL CL1 +/-30 12

Circuit Ref.	Motorola Part No.	Description
C2063	2113740L16	CAP CER CHIP 8.2 PF+-0.1PF
C2064	2113740A23	CAP CHIP REEL CL1 +/-30 6.2
C2065	2113740F53	CAP CHIP REEL CL1 +/-30 120
C2066	2113740L03	CAP CER CHIP 2.4PF +-0.1PF
C2067	2113740F20	CAP CHIP REEL CL1 +/-30 5.1
C2068	2113740F20	CAP CHIP REEL CL1 +/-30 5.1
C2069	2113740F05	CAP CHIP REEL CL1 +/-30 1.2
C2070	2113740L13	CAP CER CHIP 6.2 PF+-0.1PF
C2071	2113740L13	CAP CER CHIP 6.2 PF+-0.1PF
C2072	2113740L04	CAP CER CHIP 2.7 PF +-0.1PF
C2073	2113740F03	CAP CHIP REEL CL1 +/-30 1.0
C2074	2109720D14	CAP CER CHIP LOW DIST 0.1UF
C2076	NOT PLACED	GCAM DUMMY PART NUMBER
C2078	0886629Z02	CAP,FILM,1UF,+10%,--10%,63V-D
C2129	2113740F53	CAP CHIP REEL CL1 +/-30 120
C2198	2113741F25	CAP CHIP CL2 X7R REEL 1000
C300	NOT PLACED	GCAM DUMMY PART NUMBER
C301	2311049A57	CAP TANT CHIP A/P 10UF 10% 16
C302	2113740F54	CAP CHIP REEL CL1 +/-30 130
C303	2113743K15	CHIP CAP, CER 0.1UF

Circuit Ref.	Motorola Part No.	Description
C304	2113743E20	CAP CHIP. 10 UF 10%
C305	2113743E20	CAP CHIP. 10 UF 10%
C306	2113743E20	CAP CHIP. 10 UF 10%
C307	2113743E20	CAP CHIP. 10 UF 10%
C308	2113743E20	CAP CHIP. 10 UF 10%
C309	2113743E20	CAP CHIP. 10 UF 10%
C310	2113743E20	CAP CHIP. 10 UF 10%
C311	2113743E20	CAP CHIP. 10 UF 10%
C312	2113743E20	CAP CHIP. 10 UF 10%
C313	2113743E20	CAP CHIP. 10 UF 10%
C314	2113743E20	CAP CHIP. 10 UF 10%
C315	2113743E20	CAP CHIP. 10 UF 10%
C316	2113743E20	CAP CHIP. 10 UF 10%
C317	2113743E20	CAP CHIP. 10 UF 10%
C318	2113743E20	CAP CHIP. 10 UF 10%
C319	2113743E20	CAP CHIP. 10 UF 10%
C320	2113743E20	CAP CHIP. 10 UF 10%
C321	2113740F53	CAP CHIP REEL CL1 +/-30 120
C322	2113741F41	CAP CHIP CL2 X7R REEL 4700
C323	2113741F25	CAP CHIP CL2 X7R REEL 1000
C324	2113740F53	CAP CHIP REEL CL1 +/-30 120
C325	2113740F53	CAP CHIP REEL CL1 +/-30 120
C326	2113743E07	CER CHIP CAP .022UF
C327	2113741F13	CAP CHIP CL2 X7R REEL 330
C328	2113740F42	CAP CHIP REEL CL1 +/-30 43
C329	2113740L31	CAP 36.0 PF 50V 2.0 %
C330	2113740L18	CAP CER CHIP 10.0 PF +/- .25PF

Circuit Ref.	Motorola Part No.	Description
C331	2113740L18	CAP CER CHIP 10.0 PF +/- .25PF
C332	2113740L18	CAP CER CHIP 10.0 PF +/- .25PF
C333	2113740L20	CAP 12.0 PF 50V 2.0 %
C334	2113740L25	CAP CER CHIP 20.0 PF +/- .25PF
C335	2113740L18	CAP CER CHIP 10.0 PF +/- .25PF
C336	2113740L17	CAP CER CHIP 9.1 PF+-.1PF
C337	2113740L14	CAP CER CHIP 6.8PF +-.1PF
C338	2113740L18	CAP CER CHIP 10.0 PF +/- .25PF
C339	2113740L03	CAP CER CHIP 2.4PF +-.1PF
C340	2113740L03	CAP CER CHIP 2.4PF +-.1PF
C341	2113740F19	CAP CHIP REEL CL1 +/-30 4.7
C342	2113740F19	CAP CHIP REEL CL1 +/-30 4.7
C343	2113740L07	CAP CER CHIP 3.6PF +-.1PF
C344	2113740L07	CAP CER CHIP 3.6PF +-.1PF
C345	2113740L08	CAP CER CHIP 3.9 PF+-.1PF
C346	2113740L09	CAP CER CHIP 4.3 PF +-.1PF
C347	2113740L07	CAP CER CHIP 3.6PF +-.1PF
C348	2113740L06	CAP CER CHIP 3.3 PF+-.1PF
C349	2113740F53	CAP CHIP REEL CL1 +/-30 120
C350	2113740F53	CAP CHIP REEL CL1 +/-30 120

Circuit Ref.	Motorola Part No.	Description
C351	2113743E20	CAP CHIP. 10 UF 10%
C352	0662057A05	CHIP RES 15 OHMS 5%
C353	NOT PLACED	GCAM DUMMY PART NUMBER
C354	2113740F49	CAP CHIP REEL CL1 +/-30 82
C355	NOT PLACED	GCAM DUMMY PART NUMBER
C356	2113740L22	CAP 15.0 PF 50V 2.0 %
C357	NOT PLACED	GCAM DUMMY PART NUMBER
C358	NOT PLACED	GCAM DUMMY PART NUMBER
C359	2113740F39	CAP CHIP REEL CL1 +/-30 33
C360	2113740F38	CAP CHIP REEL CL1 +/-30 30
C361	NOT PLACED	GCAM DUMMY PART NUMBER
C362	2113740F33	CAP CHIP REEL CL1 +/-30 18
C364	NOT PLACED	GCAM DUMMY PART NUMBER
C365	NOT PLACED	GCAM DUMMY PART NUMBER
C366	2113740L18	CAP CER CHIP 10.0 PF +/- .25PF
C367	2113740L16	CAP CER CHIP 8.2 PF+-.1PF
C368	2113740F25	CAP CHIP REEL CL1 +/-30 8.2
C369	2113740F25	CAP CHIP REEL CL1 +/-30 8.2
C370	2113740L27	CAP 24.0 PF 50V 2.0 %
C371	NOT PLACED	GCAM DUMMY PART NUMBER
C400	2113740F53	CAP CHIP REEL CL1 +/-30 120

Circuit Ref.	Motorola Part No.	Description
C401	2113743K15	CHIP CAP, CER 0.1UF
C402	NOT PLACED	GCAM DUMMY PART NUMBER
C403	2113743K15	CHIP CAP, CER 0.1UF
C404	2113743K15	CHIP CAP, CER 0.1UF
C405	2113743K15	CHIP CAP, CER 0.1UF
C406	2113743K15	CHIP CAP, CER 0.1UF
C407	2113743K15	CHIP CAP, CER 0.1UF
C408	2113743K15	CHIP CAP, CER 0.1UF
C410	2113743K15	CHIP CAP, CER 0.1UF
C411	NOT PLACED	GCAM DUMMY PART NUMBER
C412	2113740F53	CAP CHIP REEL CL1 +/-30 120
C413	2113740F53	CAP CHIP REEL CL1 +/-30 120
C414	2113740F53	CAP CHIP REEL CL1 +/-30 120
C415	2113740F53	CAP CHIP REEL CL1 +/-30 120
C416	2113740F53	CAP CHIP REEL CL1 +/-30 120
C417	2113740F53	CAP CHIP REEL CL1 +/-30 120
C418	2113740F53	CAP CHIP REEL CL1 +/-30 120
C421	2113743E07	CER CHIP CAP .022UF
C422	2113740F53	CAP CHIP REEL CL1 +/-30 120
C423	2113743K15	CHIP CAP, CER 0.1UF
C490	NOT PLACED	GCAM DUMMY PART NUMBER
C5000	2113741F25	CAP CHIP CL2 X7R REEL 1000
C5001	2389289U01	10UF 50V 20% ALUMINUM SMD

Circuit Ref.	Motorola Part No.	Description	Circuit Ref.	Motorola Part No.	Description	Circuit Ref.	Motorola Part No.	Description	Circuit Ref.	Motorola Part No.	Description
C5002	2311049A99	CAP TANT CHIP 47 UF 10V 20%	C5026	2113743K15	CHIP CAP, CER 0.1UF	C5053	2113743E20	CAP CHIP. 10 UF 10% (CM160)	C5073	2113740F53	CAP CHIP REEL CL1 +/-30 120
C5003	2311049A99	CAP TANT CHIP 47 UF 10V 20%	C5027	2113743K15	CHIP CAP, CER 0.1UF	C5054	2113743E20	CAP CHIP. 10 UF 10% (CM160)	C5074	2113740F53	CAP CHIP REEL CL1 +/-30 120
C5004	NOT PLACED	GCAM DUMMY PART NUMBER	C5028	2113743K15	CHIP CAP, CER 0.1UF	C5055	2113928C04	CAP CER CHIP 4.7UF 6.3V10%080	C5075	NOT PLACED	GCAM DUMMY PART NUMBER
C5005	2360567A03	CAP TANTALUM	C5029	2113743K15	CHIP CAP, CER 0.1UF	C5056	2113741M69	CAP CHIP CLS2 100000 PF 20V 1 (CM160)	C5076	2113740F53	CAP CHIP REEL CL1 +/-30 120
C5006	2311049A57	CAP TANT CHIP A/P 10UF 10% 16	C5030	2113743K15	CHIP CAP, CER 0.1UF	C5057	2113928C04	CAP CER CHIP 4.7UF 6.3V10%080	C5077	2113740F53	CAP CHIP REEL CL1 +/-30 120
C5007	2311049A99	CAP TANT CHIP 47 UF 10V 20%	C5031	2113743K15	CHIP CAP, CER 0.1UF	C5058	NOT PLACED	GCAM DUMMY PART NUMBER	C5078	2113741F25	CAP CHIP CL2 X7R REEL 1000
C5008	2311049A57	CAP TANT CHIP A/P 10UF 10% 16	C5032	2113743K15	CHIP CAP, CER 0.1UF	C5059	2113743E07	CER CHIP CAP .022UF	C5079	2113740F53	CAP CHIP REEL CL1 +/-30 120
C5009	2311049A57	CAP TANT CHIP A/P 10UF 10% 16	C5033	2113743K15	CHIP CAP, CER 0.1UF	C5060	2113741M69	CAP CHIP CLS2 100000 PF 20V 1	C5080	2113740F53	CAP CHIP REEL CL1 +/-30 120
C5010	2311049A57	CAP TANT CHIP A/P 10UF 10% 16	C5034	2113743K15	CHIP CAP, CER 0.1UF	C5061	2113741M69	CAP CHIP CLS2 100000 PF 20V 1	C5081	2113740F53	CAP CHIP REEL CL1 +/-30 120
C5011	2311049A57	CAP TANT CHIP A/P 10UF 10% 16	C5035	2113743K15	CHIP CAP, CER 0.1UF	C5062	2113741M69	CAP CHIP CLS2 100000 PF 20V 1	C5082	2113740F53	CAP CHIP REEL CL1 +/-30 120
C5012	2311049A56	CAP TAN CHIP A/P 4.7 20 10	C5036	2113743K15	CHIP CAP, CER 0.1UF	C5063	2113741M69	CAP CHIP CLS2 100000 PF 20V 1	C5083	2113740F53	CAP CHIP REEL CL1 +/-30 120
C5013	2113928P04	CAP CER CHIP 1.0UF 20% 6.3V	C5037	2113743K15	CHIP CAP, CER 0.1UF	C5064	2113740F53	CAP CHIP REEL CL1 +/-30 120	C5084	2113740F53	CAP CHIP REEL CL1 +/-30 120
C5014	NOT PLACED	GCAM DUMMY PART NUMBER	C5038	2113743K15	CHIP CAP, CER 0.1UF	C5065	2113740F53	CAP CHIP REEL CL1 +/-30 120	C5085	2113741A53	CAP CHIP CL2 X7R REEL 22000
C5015	2113743K15	CHIP CAP, CER 0.1UF	C5039	NOT PLACED	GCAM DUMMY PART NUMBER	C5066	2113740F53	CAP CHIP REEL CL1 +/-30 120	C5086	2113741A53	CAP CHIP CL2 X7R REEL 22000
C5016	2113743K15	CHIP CAP, CER 0.1UF	C5040	NOT PLACED	GCAM DUMMY PART NUMBER	C5067	2113741F25	CAP CHIP CL2 X7R REEL 1000	C5087	2113740F53	CAP CHIP REEL CL1 +/-30 120
C5017	2113743K15	CHIP CAP, CER 0.1UF	C5041	2113743F18	CAP CHIP 2.2 UF 16V +80-20%	C5068	2113740F53	CAP CHIP REEL CL1 +/-30 120	C5088	2113740F49	CAP CHIP REEL CL1 +/-30 82
C5018	2113743K15	CHIP CAP, CER 0.1UF	C5042	2113743F16	CAP CHIP 1.0UF 16V+80-20%	C5069	2113740F53	CAP CHIP REEL CL1 +/-30 120	C5089	2113740F49	CAP CHIP REEL CL1 +/-30 82
C5019	2113743K15	CHIP CAP, CER 0.1UF	C5043	2113743F16	CAP CHIP 1.0UF 16V+80-20%	C5070	2113740F53	CAP CHIP REEL CL1 +/-30 120	C5090	2113740F49	CAP CHIP REEL CL1 +/-30 82
C5020	2113743K15	CHIP CAP, CER 0.1UF	C5044	2113928C04	CAP CER CHIP 4.7UF 6.3V10%080	C5071	2113740F53	CAP CHIP REEL CL1 +/-30 120	C5091	2113740F49	CAP CHIP REEL CL1 +/-30 82
C5021	2113741M69	CAP CHIP CLS2 100000 PF 20V 1	C5045	2113743F16	CAP CHIP 1.0UF 16V+80-20%	C5072	2113740F53	CAP CHIP REEL CL1 +/-30 120			
C5022	2113743K15	CHIP CAP, CER 0.1UF	C5046	2113743E20	CAP CHIP. 10 UF 10%						
C5023	2113743K15	CHIP CAP, CER 0.1UF	C5047	2113743E20	CAP CHIP. 10 UF 10%						
C5024	2113743K15	CHIP CAP, CER 0.1UF	C5048	2113743E20	CAP CHIP. 10 UF 10%						
C5025	2113743K15	CHIP CAP, CER 0.1UF	C5049	2113743E20	CAP CHIP. 10 UF 10%						
			C5050	2113743E20	CAP CHIP. 10 UF 10%						
			C5051	2113743E20	CAP CHIP. 10 UF 10% (CM160)						
			C5052	2113743E20	CAP CHIP. 10 UF 10%						

Circuit Ref.	Motorola Part No.	Description
C5092	2113740F59	CAP CHIP REEL CL1 +/-30 220
C5094	2113740F59	CAP CHIP REEL CL1 +/-30 220
C5095	2113740F59	CAP CHIP REEL CL1 +/-30 220
C5096	2113740F59	CAP CHIP REEL CL1 +/-30 220
C5097	2113740F59	CAP CHIP REEL CL1 +/-30 220
C5098	2113740F59	CAP CHIP REEL CL1 +/-30 220
C5099	2113740F59	CAP CHIP REEL CL1 +/-30 220
C5100	2113740F59	CAP CHIP REEL CL1 +/-30 220
C5101	2113741F25	CAP CHIP CL2 X7R REEL 1000 (CM160)
C5102	2113743E20	CAP CHIP. 10 UF 10% (CM160)
C5103	2113743K15	CHIP CAP, CER 0.1UF (CM160)
C5104	NOT PLACED	GCAM DUMMY PART NUMBER
C5110	2113741F25	CAP CHIP CL2 X7R REEL 1000
C5111	2113741F25	CAP CHIP CL2 X7R REEL 1000
C5113	NOT PLACED	GCAM DUMMY PART NUMBER
C5114	NOT PLACED	GCAM DUMMY PART NUMBER
C5115	NOT PLACED	GCAM DUMMY PART NUMBER
C5116	NOT PLACED	GCAM DUMMY PART NUMBER
C5117	NOT PLACED	GCAM DUMMY PART NUMBER

Circuit Ref.	Motorola Part No.	Description
C5118	NOT PLACED	GCAM DUMMY PART NUMBER
C5119	2113743H14	CAP CHIP 10.0 UF 16V +80-20%
C5120	NOT PLACED	GCAM DUMMY PART NUMBER
C602	2113740F41	CAP CHIP REEL CL1 +/-30 39
C603	2113740F41	CAP CHIP REEL CL1 +/-30 39
C604	2113740F41	CAP CHIP REEL CL1 +/-30 39
C605	2113740F41	CAP CHIP REEL CL1 +/-30 39
C606	2113740F41	CAP CHIP REEL CL1 +/-30 39
C607	2113740F41	CAP CHIP REEL CL1 +/-30 39
C608	NOT PLACED	GCAM DUMMY PART NUMBER
C609	NOT PLACED	GCAM DUMMY PART NUMBER
C610	2113740F41	CAP CHIP REEL CL1 +/-30 39
C611	2113740F41	CAP CHIP REEL CL1 +/-30 39
C612	2113740F41	CAP CHIP REEL CL1 +/-30 39
C613	2113740F41	CAP CHIP REEL CL1 +/-30 39
C614	2113740F41	CAP CHIP REEL CL1 +/-30 39
C615	2113740F41	CAP CHIP REEL CL1 +/-30 39
C616	2113740F41	CAP CHIP REEL CL1 +/-30 39
C617	2113740F41	CAP CHIP REEL CL1 +/-30 39

Circuit Ref.	Motorola Part No.	Description
C618	2113740F41	CAP CHIP REEL CL1 +/-30 39
C619	NOT PLACED	GCAM DUMMY PART NUMBER
C620	2113740F41	CAP CHIP REEL CL1 +/-30 39
C621	2113740F41	CAP CHIP REEL CL1 +/-30 39
C622	2113740F41	CAP CHIP REEL CL1 +/-30 39
C623	2113740F41	CAP CHIP REEL CL1 +/-30 39
C624	2113740F41	CAP CHIP REEL CL1 +/-30 39
C625	2113740F41	CAP CHIP REEL CL1 +/-30 39
C626	2113740F41	CAP CHIP REEL CL1 +/-30 39
C627	2113740F41	CAP CHIP REEL CL1 +/-30 39
C628	2113740F41	CAP CHIP REEL CL1 +/-30 39
C629	2113740F41	CAP CHIP REEL CL1 +/-30 39
C630	2113740F41	CAP CHIP REEL CL1 +/-30 39
C631	2113740F41	CAP CHIP REEL CL1 +/-30 39
C632	2113740F41	CAP CHIP REEL CL1 +/-30 39
C633	2113740F41	CAP CHIP REEL CL1 +/-30 39
C662	2113740F41	CAP CHIP REEL CL1 +/-30 39
C678	2113741M69	CAP CHIP CLS2 100000 PF 20V 1
CR300	4880154K03	SOT MMBD353 RH DIODE DUAL SCH

Circuit Ref.	Motorola Part No.	Description
CR301	4880154K03	SOT MMBD353 RH DIODE DUAL SCH
D100	NOT PLACED	GCAM DUMMY PART NUMBER
D101	NOT PLACED	GCAM DUMMY PART NUMBER
D102	4813833C02	DIODE DUAL 70V '5B' COMM CATH
D103	4802482J02	PIN DIODE SMD
D104	4802482J02	PIN DIODE SMD
D105	4805218N57	DIODE DUAL
D106	4805218N57	DIODE DUAL
D107	4805218N57	DIODE DUAL
D108	4805218N57	DIODE DUAL
D200	4802233J09	DIODE TRIPLE SOT25-RH
D201	4802233J09	DIODE TRIPLE SOT25-RH
D202	4862824C03	DIODE VARACTOR
D203	4805649Q13	DIODE VCTR ISV 228
D204	4805649Q13	DIODE VCTR ISV 228
D205	4862824C01	DIODE VARACTOR
D301	4802245J97	Band Switchind Diode, Rohm DA
D302	4802245J97	Band Switchind Diode, Rohm DA
D303	4802245J97	Band Switchind Diode, Rohm DA
D304	4802245J97	Band Switchind Diode, Rohm DA
D305	4880142L01	SOT MMBV109 RH
D400	4813833C07	DIODE DUAL 100V '5C' SERIES
D401	4813833C02	DIODE DUAL 70V '5B' COMM CATH
D402	4809948D42	DIODE SCHOTTKY RB751V-40

Circuit Ref.	Motorola Part No.	Description
D500	4813833C02	DIODE DUAL 70V '5B' COMM CATH
D501	NOT PLACED	GCAM DUMMY PART NUMBER
D502	4813825A23	DIODE, DISCRETE SPECIALS VAR&
D511	4813833C02	DIODE DUAL 70V '5B' COMM CATH
D513	4813833C02	DIODE DUAL 70V '5B' COMM CATH
FL300	9180022M11	XTAL FILTER 44.85MHZ
FL301	9180468V06	SMD455KHZ 4 ELEMENT CER FLTR
FL302	9180468V04	SMD455KHZ 4 ELEMENT CER FLTR
FL303	9180469V03	SMD455KHZ 6 ELEMENT CER FLTR
FL304	9180469V06	SMD455KHZ 6 ELEMENT CER FLTR
J11	2889309U01	MINI-UHF PCB R.A
J2	0989241U02	FLEX 20PIN 1MM TOP NON ZIF
J3	0986615Z01	CONN,ZIF,F,28CONT,,TIN,,, CBL (CM160)
L100	7686135U02	FLTR,EMI
L101	2462587T30	IND CHIP 1000NH 5% LOW PRO
L102	2462587T30	IND CHIP 1000NH 5% LOW PRO
L103	2462587T30	IND CHIP 1000NH 5% LOW PRO
L104	2462587N50	CHIP IND 56 NH 5%
L105	2462587N44	CHIP IND 18 NH 5%
L107	2460591B04	COIL AIR WOUND INDUC 11.03
L108	2462587T22	IND. CHIP 390NH 5% LOW PRO
L111	2460592A01	COIL AW 2 TURN 17 NH

Circuit Ref.	Motorola Part No.	Description
L113	2460592A01	COIL AW 2 TURN 17 NH
L114	2485873L01	ENCAPSULATED AIR WOUND COIL
L115	2460592A01	COIL AW 2 TURN 17 NH
L117	7686135U02	FLTR,EMI
L118	7686135U02	FLTR,EMI
L119	7686135U02	FLTR,EMI
L120	7686135U02	FLTR,EMI
L121	7686135U02	FLTR,EMI
L122	2460591C23	COIL AIR WOUND INDUC 13.85
L124	7686135U02	FLTR,EMI
L125	2460592A01	COIL AW 2 TURN 17 NH
L126	2460591B77	COIL AIR WOUND INDUC 13.90
L127	2460591B77	COIL AIR WOUND INDUC 13.90
L128	2460592A01	COIL AW 2 TURN 17 NH
L130	2462587T22	IND. CHIP 390NH 5% LOW PRO
L200	2462587Q42	IND CHIP 390NH 10%
L201	2462587V44	IND CHIP 680 NH 10%
L202	2462587V44	IND CHIP 680 NH 10%
L203	2462587V36	CHIP IND 150NH 5% 0805
L204	2462587V36	CHIP IND 150NH 5% 0805
L205	2462587Q47	IND CHIP 1000 NH 10%
L206	2484562T11	COIL SURF MNT AIR WOUND
L207	2413923C12	IND CHIP 7.8 NH 2%
L208	2413926N24	IND CER CHIP 100.0 NH 5%
L209	2413926N24	IND CER CHIP 100.0 NH 5%
L210	2413926H20	IND CHIP 47.0 NH 5%
L211	2413926N24	IND CER CHIP 100.0 NH 5%
L212	2413926N18	IND CER CHIP 33.0 NH 5%

Circuit Ref.	Motorola Part No.	Description
L213	2413926N24	IND CER CHIP 100.0 NH 5%
L214	2413926H20	IND CHIP 47.0 NH 5%
L215	2413926H20	IND CHIP 47.0 NH 5%
L216	2462587N44	CHIP IND 18 NH 5%
L217	2462587Q42	IND CHIP 390NH 10%
L300	2460591C35	COIL AIR WOUND INDUC 18.08
L301	2462587N55	CHIP IND 150 NH 5%
L302	2462587N55	CHIP IND 150 NH 5%
L303	2462587X69	IND CHIP LO-PRO 1200 NH 5%
L304	2462587N55	CHIP IND 150 NH 5%
L305	2483411T74	INDUCTOR CHIP SHIELDED
L306	2413926K32	IND CER CHIP 560.0 NH 5%
L307	2460591C35	COIL AIR WOUND INDUC 18.08
L308	2460591C35	COIL AIR WOUND INDUC 18.08
L309	2460591C35	COIL AIR WOUND INDUC 18.08
L310	2460591C35	COIL AIR WOUND INDUC 18.08
L311	2460591C35	COIL AIR WOUND INDUC 18.08
L312	2460591C35	COIL AIR WOUND INDUC 18.08
L313	2460591C35	COIL AIR WOUND INDUC 18.08
L314	2460591C35	COIL AIR WOUND INDUC 18.08
L315	NOT PLACED	GCAM DUMMY PART NUMBER
L500	7686135U02	FLTR,EMI
L501	7686135U02	FLTR,EMI
L502	7686135U02	FLTR,EMI
M100	2680499Z01	HEAT SPREADER

Circuit Ref.	Motorola Part No.	Description
M101	3980686Z01	CONTACT (ANTENNA)
M102	3980686Z01	CONTACT (ANTENNA)
M105	7588823L03	PAD GROUND LCD
M106	7588823L03	PAD GROUND LCD
M107	7588823L03	PAD GROUND LCD
M108	7588823L04	PAD GROUND LCD
M109	7588823L04	PAD GROUND LCD
M110	7588823L04	PAD GROUND LCD
M9	0289511U01	NUTS
P1	2804503J01	CONNECTOR,ACCY 16 PIN
P2	NOT PLACED	GCAM DUMMY PART NUMBER
PCB	8486577Z01	Main PC Board, UHF Band 2 40W
Q100	4813828C32	TSTR UHF 70W 12.5V LDMOS
Q101	4813824A10	TSTR NPN 40V .2A GEN PURP
Q102	4813824A10	TSTR NPN 40V .2A GEN PURP
Q103	4813824A06	XSTR NPN 30V DARLINGTON
Q104	4813824A10	TSTR NPN 40V .2A GEN PURP
Q105	4886212B01	LDMOS PWR TSTR MRF1518
Q106	4805128M27	SOT TRANS
Q107	4813824A10	TSTR NPN 40V .2A GEN PURP
Q108	4813824A10	TSTR NPN 40V .2A GEN PURP
Q200	4802245J95	BJT, NPN TRANSISTOR
Q201	4809939C04	TSTR DUAL PNP/NPN UMC3
Q300	4809940E02	TSTR DIG NPN DTC114YE

Circuit Ref.	Motorola Part No.	Description
Q301	4813824A17	XSTR PNP40V .2A GENPB=100-300
Q302	4813824A10	TSTR NPN 40V .2A GEN PURP
Q303	4802245J95	BJT, NPN TRANSISTOR
Q304	4809939C04	TSTR DUAL PNP/NPN UMC3
Q305	4802197J95	RF TRANSISTOR PBR941
Q306	4813824A17	XSTR PNP40V .2A GENPB=100-300
Q400	4809940E02	TSTR DIG NPN DTC114YE
Q401	4880141L03	QSTR PNP SOT23 LO PROFILE TAP
Q403	4809940E02	TSTR DIG NPN DTC114YE
Q404	4809940E02	TSTR DIG NPN DTC114YE
Q405	4809940E02	TSTR DIG NPN DTC114YE
Q407	4809940E02	TSTR DIG NPN DTC114YE
Q408	4880048M01	TSTR NPN DIG 47K/47K
Q409	4880048M01	TSTR NPN DIG 47K/47K
Q410	4880048M01	TSTR NPN DIG 47K/47K
Q411	4880048M01	TSTR NPN DIG 47K/47K
Q412	4880048M01	TSTR NPN DIG 47K/47K
Q413	4809940E02	TSTR DIG NPN DTC114YE
Q414	4809940E02	TSTR DIG NPN DTC114YE
Q415	NOT PLACED	GCAM DUMMY PART NUMBER
Q416	4809940E02	TSTR DIG NPN DTC114YE
Q417	4813824A10	TSTR NPN 40V .2A GEN PURP
Q500	4813824A10	TSTR NPN 40V .2A GEN PURP
Q501	4809940E02	TSTR DIG NPN DTC114YE
Q502	4809940E02	TSTR DIG NPN DTC114YE
Q503	4813824A10	TSTR NPN 40V .2A GEN PURP

Circuit Ref.	Motorola Part No.	Description
Q504	4880048M01	TSTR NPN DIG 47K/47K
Q505	4813824A10	TSTR NPN 40V .2A GEN PURP
Q506	4813824A10	TSTR NPN 40V .2A GEN PURP
R101	1705603W01	RES SMT SHUNT
R103	0683962T51	RES CHIP 120 5-1
R104	0683962T51	RES CHIP 120 5-1
R105	0662057A41	CHIP RES 470 OHMS 5%
R106	0662057C35	CHIP RES 22 OHMS 5%
R107	0680194M18	RES 51 OHMS 5% 1W
R108	0680194M18	RES 51 OHMS 5% 1W
R109	0662057A14	RES CHIP 36 OHM 5 1/8W
R110	0662057A49	CHIP RES 1000 OHMS 5%
R111	0662057A49	CHIP RES 1000 OHMS 5%
R112	0662057B05	CHIP RES 200K OHMS 5%
R113	0662057A73	CHIP RES 10K OHMS 5%
R114	0662057A73	CHIP RES 10K OHMS 5%
R115	0662057A73	CHIP RES 10K OHMS 5%
R116	0662057A73	CHIP RES 10K OHMS 5%
R117	0662057P02	RES. CHIP 15K 1% 30X60
R118	0662057C51	CHIP RES 100 OHMS 5%
R119	0662057C51	CHIP RES 100 OHMS 5%
R120	0662057C51	CHIP RES 100 OHMS 5%
R121	0662057C51	CHIP RES 100 OHMS 5%
R122	0662057C19	CHIP RES 4.7 OHMS 5%
R126	0662057C01	CHIP RES 0 OHMS .050 OHMS
R127	0662057C01	CHIP RES 0 OHMS .050 OHMS
R128	0662057C01	CHIP RES 0 OHMS .050 OHMS
R129	0662057C01	CHIP RES 0 OHMS .050 OHMS

Circuit Ref.	Motorola Part No.	Description
R130	0662057B47	CHIP RES 0 OHMS +-0.050 OHMS
R131	0662057A97	CHIP RES 100K OHMS 5%
R132	NOT PLACED	GCAM DUMMY PART NUMBER
R134	0662057A59	CHIP RES 2700 OHMS 5%
R135	0662057A86	CHIP RES 36K OHMS 5%
R136	0662057A86	CHIP RES 36K OHMS 5%
R137	0662057A87	CHIP RES 39K OHMS 5%
R138	0662057A86	CHIP RES 36K OHMS 5%
R139	0662057A87	CHIP RES 39K OHMS 5%
R140	0662057A79	CHIP RES 18K OHMS 5%
R141	0662057A81	CHIP RES 22K OHMS 5%
R142	0662057A81	CHIP RES 22K OHMS 5%
R143	0662057A79	CHIP RES 18K OHMS 5%
R144	0662057A81	CHIP RES 22K OHMS 5%
R145	0662057A81	CHIP RES 22K OHMS 5%
R146	0662057A81	CHIP RES 22K OHMS 5%
R147	0662057A59	CHIP RES 2700 OHMS 5%
R148	0662057A81	CHIP RES 22K OHMS 5%
R149	0662057A81	CHIP RES 22K OHMS 5%
R150	0662057A73	CHIP RES 10K OHMS 5%
R151	0662057A72	CHIP RES 9100 OHMS 5%
R152	0662057A25	CHIP RES 100 OHMS 5%
R153	0662057A83	CHIP RES 27K OHMS 5%
R155	0662057A83	CHIP RES 27K OHMS 5%
R156	0662057A73	CHIP RES 10K OHMS 5%
R157	0662057A91	CHIP RES 56K OHMS 5%
R158	NOT PLACED	GCAM DUMMY PART NUMBER
R159	NOT PLACED	GCAM DUMMY PART NUMBER
R160	0662057A61	CHIP RES 3300 OHMS 5%

Circuit Ref.	Motorola Part No.	Description
R161	0662057A61	CHIP RES 3300 OHMS 5%
R162	0662057A61	CHIP RES 3300 OHMS 5%
R163	0662057A61	CHIP RES 3300 OHMS 5%
R164	0662057A73	CHIP RES 10K OHMS 5%
R165	0662057A58	CHIP RES 2400 OHMS 5%
R166	NOT PLACED	GCAM DUMMY PART NUMBER
R167	0662057A57	CHIP RES 2200 OHMS 5%
R168	0662057A57	CHIP RES 2200 OHMS 5%
R169	NOT PLACED	GCAM DUMMY PART NUMBER
R170	0662057A42	CHIP RES 510 OHMS 5%
R171	0662057A43	CHIP RES 560 OHMS 5%
R172	0662057A41	CHIP RES 470 OHMS 5%
R173	0662057A29	CHIP RES 150 OHMS 5%
R174	0662057A29	CHIP RES 150 OHMS 5%
R175	0662057A43	CHIP RES 560 OHMS 5%
R176	NOT PLACED	GCAM DUMMY PART NUMBER
R177	NOT PLACED	GCAM DUMMY PART NUMBER
R178	0662057A18	CHIP RES 51 OHMS 5%
R179	0662057A18	CHIP RES 51 OHMS 5%
R180	0660082A89	RES CHIP 47K OHMS 1% 1/16W
R181	0660082A89	RES CHIP 47K OHMS 1% 1/16W
R182	0662057A73	CHIP RES 10K OHMS 5%
R183	0662057A25	CHIP RES 100 OHMS 5%
R184	0662057A59	CHIP RES 2700 OHMS 5%
R185	0662057A73	CHIP RES 10K OHMS 5%
R186	0662057A73	CHIP RES 10K OHMS 5%
R187	0662057A97	CHIP RES 100K OHMS 5%

Circuit Ref.	Motorola Part No.	Description
R188	NOT PLACED	GCAM DUMMY PART NUMBER
R189	0662057A97	CHIP RES 100K OHMS 5%
R190	0662057C35	CHIP RES 22 OHMS 5%
R191	0662057C35	CHIP RES 22 OHMS 5%
R192	0662057C35	CHIP RES 22 OHMS 5%
R193	NOT PLACED	GCAM DUMMY PART NUMBER
R194	NOT PLACED	GCAM DUMMY PART NUMBER
R195	NOT PLACED	GCAM DUMMY PART NUMBER
R196	0662057A97	CHIP RES 100K OHMS 5%
R197	0662057A59	CHIP RES 2700 OHMS 5%
R198	0662057A97	CHIP RES 100K OHMS 5%
R199	0662057A59	CHIP RES 2700 OHMS 5%
R200	0662057A97	CHIP RES 100K OHMS 5%
R201	0662057A73	CHIP RES 10K OHMS 5%
R202	NOT PLACED	GCAM DUMMY PART NUMBER
R203	0662057B47	CHIP RES 0 OHMS +-0.050 OHMS
R204	NOT PLACED	GCAM DUMMY PART NUMBER
R205	NOT PLACED	GCAM DUMMY PART NUMBER
R206	0662057A99	CHIP RES 120K OHMS 5%
R207	0662057B02	CHIP RES 150K OHMS 5%
R208	0662057A97	CHIP RES 100K OHMS 5%
R209	0662057A97	CHIP RES 100K OHMS 5%
R210	NOT PLACED	GCAM DUMMY PART NUMBER
R211	0662057A69	RES CHIP 6800 OHM 5 1/8W
R212	0662057A89	CHIP RES 47K OHMS 5%
R213	0662057A65	CHIP RES 4700 OHMS 5%

Circuit Ref.	Motorola Part No.	Description
R214	0662057A65	CHIP RES 4700 OHMS 5%
R215	0662057A62	CHIP RES 3600 OHMS 5%
R216	0662057A59	CHIP RES 2700 OHMS 5%
R217	0662057A52	CHIP RES 1300OHMS 5%05
R218	0662057A49	CHIP RES 1000 OHMS 5%
R219	NOT PLACED	GCAM DUMMY PART NUMBER
R220	0662057A42	CHIP RES 510 OHMS 5%
R221	0662057A33	CHIP RES 220 OHMS 5%
R222	0662057A33	CHIP RES 220 OHMS 5%
R223	0662057A33	CHIP RES 220 OHMS 5%
R224	0662057A53	CHIP RES 1500 OHMS 5%
R225	0662057A29	CHIP RES 150 OHMS 5%
R226	0662057A29	CHIP RES 150 OHMS 5%
R227	0662057A23	CHIP RES 82 OHMS 5%
R228	0662057A25	CHIP RES 100 OHMS 5%
R229	0662057A25	CHIP RES 100 OHMS 5%
R230	0662057A22	CHIP RES 75 OHMS 5%
R231	0662057A18	CHIP RES 51 OHMS 5%
R232	0662057A17	RES CHIP 47 OHMS 5%
R233	0662057A17	RES CHIP 47 OHMS 5%
R234	0662057A15	CHIP RES 39 OHMS 5%
R235	0662057A07	CHIP RES 18 OHMS 5%
R300	0662057A73	CHIP RES 10K OHMS 5%
R301	0662057A41	CHIP RES 470 OHMS 5%
R302	0662057B47	CHIP RES 0 OHMS +-0.050 OHMS
R303	0662057B47	CHIP RES 0 OHMS +-0.050 OHMS
R304	0662057A85	CHIP RES 33K OHM 5%
R305	0662057A80	CHIP RES 20K OHMS 5%
R306	0662057A80	CHIP RES 20K OHMS 5%
R307	0662057A80	CHIP RES 20K OHMS 5%

Circuit Ref.	Motorola Part No.	Description
R308	0662057A80	CHIP RES 20K OHMS 5%
R309	0662057A77	CHIP RES 15K OHMS 5%
R310	0662057A77	CHIP RES 15K OHMS 5%
R311	NOT PLACED	GCAM DUMMY PART NUMBER
R312	0662057A76	CHIP RES 13K OHMS 5%
R313	0662057A75	CHIP RES 12K OHMS 5%
R314	0662057A75	CHIP RES 12K OHMS 5%
R315	0662057A75	CHIP RES 12K OHMS 5%
R316	0662057A75	CHIP RES 12K OHMS 5%
R317	0662057A75	CHIP RES 12K OHMS 5%
R318	0662057A75	CHIP RES 12K OHMS 5%
R319	0662057A75	CHIP RES 12K OHMS 5%
R320	0662057A73	CHIP RES 10K OHMS 5%
R321	0662057A71	CHIP RES 8200 OHMS 5%
R322	0662057A65	CHIP RES 4700 OHMS 5%
R323	0662057A65	CHIP RES 4700 OHMS 5%
R324	0662057A61	CHIP RES 3300 OHMS 5%
R325	0662057A61	CHIP RES 3300 OHMS 5%
R326	0662057A59	CHIP RES 2700 OHMS 5%
R327	0662057A58	CHIP RES 2400 OHMS 5%
R328	0662057A55	CHIP RES 1800 OHM 5%
R329	0662057A51	CHIP RES 1200 OHMS 5%
R330	0662057A47	CHIP RES 820 OHMS 5%
R331	0662057A25	CHIP RES 100 OHMS 5%
R332	0662057A45	CHIP RES 680 OHMS 5%
R333	0662057A43	CHIP RES 560 OHMS 5%
R334	0662057A40	CHIP RES 430 OHMS 5%
R335	0662057A39	CHIP RES 390 OHMS 5%
R336	0662057A33	CHIP RES 220 OHMS 5%
R337	0662057A25	CHIP RES 100 OHMS 5%
R338	0662057A25	CHIP RES 100 OHMS 5%

Circuit Ref.	Motorola Part No.	Description
R339	0662057A18	CHIP RES 51 OHMS 5%
R340	0662057A18	CHIP RES 51 OHMS 5%
R345	0662057A73	CHIP RES 10K OHMS 5%
R346	0662057A73	CHIP RES 10K OHMS 5%
R401	0662057C85	CHIP RES 2700 OHMS 5%
R402	0662057B47	CHIP RES 0 OHMS +-0.050 OHMS
R403	0662057B47	CHIP RES 0 OHMS +-0.050 OHMS
R404	0662057B47	CHIP RES 0 OHMS +-0.050 OHMS
R405	0662057B47	CHIP RES 0 OHMS +-0.050 OHMS
R406	0662057B47	CHIP RES 0 OHMS +-0.050 OHMS
R407	0662057B47	CHIP RES 0 OHMS +-0.050 OHMS
R414	0662057B47	CHIP RES 0 OHMS +-0.050 OHMS
R415	NOT PLACED	GCAM DUMMY PART NUMBER
R421	0662057A33	CHIP RES 220 OHMS 5%
R422	0662057A73	CHIP RES 10K OHMS 5%
R423	NOT PLACED	GCAM DUMMY PART NUMBER
R424	NOT PLACED	GCAM DUMMY PART NUMBER
R425	0662057A97	CHIP RES 100K OHMS 5%
R426	0662057A97	CHIP RES 100K OHMS 5%
R427	NOT PLACED	GCAM DUMMY PART NUMBER
R428	0662057A97	CHIP RES 100K OHMS 5%
R429	0662057A97	CHIP RES 100K OHMS 5%
R430	0662057A87	CHIP RES 39K OHMS 5%
R431	NOT PLACED	GCAM DUMMY PART NUMBER

Circuit Ref.	Motorola Part No.	Description
R432	0662057A85	CHIP RES 33K OHM 5%
R433	0662057A85	CHIP RES 33K OHM 5%
R434	0662057A85	CHIP RES 33K OHM 5%
R435	0662057A85	CHIP RES 33K OHM 5%
R436	0662057A85	CHIP RES 33K OHM 5%
R438	0662057A73	CHIP RES 10K OHMS 5%
R439	0662057A73	CHIP RES 10K OHMS 5%
R440	0662057A73	CHIP RES 10K OHMS 5%
R441	0662057A73	CHIP RES 10K OHMS 5%
R442	0662057A73	CHIP RES 10K OHMS 5%
R443	0662057A61	CHIP RES 3300 OHMS 5%
R444	0662057A73	CHIP RES 10K OHMS 5%
R445	0662057A73	CHIP RES 10K OHMS 5%
R450	0662057A73	CHIP RES 10K OHMS 5%
R451	0662057A73	CHIP RES 10K OHMS 5%
R453	0662057A61	CHIP RES 3300 OHMS 5%
R454	0662057A61	CHIP RES 3300 OHMS 5%
R455	0662057A61	CHIP RES 3300 OHMS 5%
R456	0662057A61	CHIP RES 3300 OHMS 5%
R457	0662057A61	CHIP RES 3300 OHMS 5%
R458	0662057A61	CHIP RES 3300 OHMS 5%
R459	NOT PLACED	GCAM DUMMY PART NUMBER
R460	0662057A53	CHIP RES 1500 OHMS 5%
R461	0662057A33	CHIP RES 220 OHMS 5%
R462	0662057A18	CHIP RES 51 OHMS 5%
R463	0662057A73	CHIP RES 10K OHMS 5%
R466	NOT PLACED	GCAM DUMMY PART NUMBER
R467	NOT PLACED	GCAM DUMMY PART NUMBER
R468	NOT PLACED	GCAM DUMMY PART NUMBER

Circuit Ref.	Motorola Part No.	Description
R469	NOT PLACED	GCAM DUMMY PART NUMBER
R470	NOT PLACED	GCAM DUMMY PART NUMBER
R471	0662057A01	CHIP RES 10 OHMS 5%
R472	NOT PLACED	GCAM DUMMY PART NUMBER
R473	NOT PLACED	GCAM DUMMY PART NUMBER
R5000	0662057B47	CHIP RES 0 OHMS +-0.050 OHMS
R5001	0662057T68	RES CHIP 1.0K 1% 30*60
R5002	0662057C01	CHIP RES 0 OHMS .050 OHMS (CM160)
R5008	0662057B47	CHIP RES 0 OHMS +-0.050 OHMS
R5009	0662057B47	CHIP RES 0 OHMS +-0.050 OHMS
R5010	0662057B47	CHIP RES 0 OHMS +-0.050 OHMS
R5011	NOT PLACED	GCAM DUMMY PART NUMBER
R5013	NOT PLACED	GCAM DUMMY PART NUMBER
R5014	0662057B47	CHIP RES 0 OHMS +-0.050 OHMS
R5016	NOT PLACED	GCAM DUMMY PART NUMBER
R5017	0609887C05	RES CHIP 1.5 OHM 1/2W 2010
R5018	0609887C05	RES CHIP 1.5 OHM 1/2W 2010
R5019	0662057B05	CHIP RES 200K OHMS 5%
R5020	0662057B02	CHIP RES 150K OHMS 5%
R5021	0662057A97	CHIP RES 100K OHMS 5%
R5022	0662057A97	CHIP RES 100K OHMS 5%
R5023	0662057A97	CHIP RES 100K OHMS 5%

Circuit Ref.	Motorola Part No.	Description
R5024	0662057A97	CHIP RES 100K OHMS 5% (CM160)
R5025	0662057A97	CHIP RES 100K OHMS 5%
R5026	0662057A85	CHIP RES 33K OHM 5%
R5027	0662057B08	CHIP RES 270K OHMS 5%
R5028	0662057A97	CHIP RES 100K OHMS 5%
R5029	0662057A97	CHIP RES 100K OHMS 5%
R5030	0662057A85	CHIP RES 33K OHM 5%
R5031	0662057A92	CHIP RES 62K OHMS 5%
R5032	0662057A89	CHIP RES 47K OHMS 5%
R5033	0662057A89	CHIP RES 47K OHMS 5%
R5034	0662057A86	CHIP RES 36K OHMS 5%
R5035	0662057A89	CHIP RES 47K OHMS 5%
R5036	0662057A89	CHIP RES 47K OHMS 5%
R5037	0662057A73	CHIP RES 10K OHMS 5%
R5038	0662057A85	CHIP RES 33K OHM 5%
R5039	0662057A97	CHIP RES 100K OHMS 5%
R5040	0662057A84	CHIP RES 30K OHMS 5%
R5041	0662057A82	CHIP RES 24K OHMS 5%
R5042	0662057A82	CHIP RES 24K OHMS 5%
R5043	0662057A82	CHIP RES 24K OHMS 5%
R5044	0662057A82	CHIP RES 24K OHMS 5%
R5045	0662057A85	CHIP RES 33K OHM 5%
R5046	0662057A82	CHIP RES 24K OHMS 5%
R5047	0662057B47	CHIP RES 0 OHMS +-0.050 OHMS (CM160)
R5048	0662057A82	CHIP RES 24K OHMS 5%
R5049	0662057A77	CHIP RES 15K OHMS 5%
R5050	0662057A76	CHIP RES 13K OHMS 5%
R5051	0662057A75	CHIP RES 12K OHMS 5%
R5052	0662057A73	CHIP RES 10K OHMS 5%
R5053	0662057A73	CHIP RES 10K OHMS 5%
R5054	0662057A73	CHIP RES 10K OHMS 5%

Circuit Ref.	Motorola Part No.	Description
R5055	0662057A73	CHIP RES 10K OHMS 5%
R5056	0662057A73	CHIP RES 10K OHMS 5%
R5057	0662057A73	CHIP RES 10K OHMS 5%
R5058	NOT PLACED	GCAM DUMMY PART NUMBER
R5059	NOT PLACED	GCAM DUMMY PART NUMBER
R5060	0662057A73	CHIP RES 10K OHMS 5%
R5061	0662057A73	CHIP RES 10K OHMS 5%
R5062	0662057A73	CHIP RES 10K OHMS 5%
R5063	NOT PLACED	GCAM DUMMY PART NUMBER
R5064	NOT PLACED	GCAM DUMMY PART NUMBER
R5065	0662057A68	CHIP RES 6200 OHMS 5%
R5066	0662057A49	CHIP RES 1000 OHMS 5%
R5067	NOT PLACED	GCAM DUMMY PART NUMBER
R5068	NOT PLACED	GCAM DUMMY PART NUMBER
R5069	0662057A73	CHIP RES 10K OHMS 5%
R5070	0662057A57	CHIP RES 2200 OHMS 5%
R5071	0662057A57	CHIP RES 2200 OHMS 5%
R5072	0662057A65	CHIP RES 4700 OHMS 5%
R5073	0662057A49	CHIP RES 1000 OHMS 5%
R5074	0662057A49	CHIP RES 1000 OHMS 5%
R5075	0662057A42	CHIP RES 510 OHMS 5%
R5076	0662057A42	CHIP RES 510 OHMS 5%
R5077	0662057A36	CHIP RES 300 OHMS 5%
R5078	0662057A25	CHIP RES 100 OHMS 5%
R5079	0662057A25	CHIP RES 100 OHMS 5%
R5080	0662057A01	CHIP RES 10 OHMS 5%
R5081	0613952D78	CER CHIP RES 6340 OHM 1% 0603

Circuit Ref.	Motorola Part No.	Description	Circuit Ref.	Motorola Part No.	Description	Circuit Ref.	Motorola Part No.	Description	Circuit Ref.	Motorola Part No.	Description
R5082	0662057A90	CHIP RES 51K OHMS 5%	R603	NOT PLACED	GCAM DUMMY PART NUMBER	U403	5102226J56	68HC11FLO_PASS5 100P IN TQFP	VR501	4813830A14	DIODE 5.1V 5% 225MW MMBZ5231B
R5083	0662057B08	CHIP RES 270K OHMS 5%	R604	NOT PLACED	GCAM DUMMY PART NUMBER	U404	5189233U02	FLASH 2MEG AT49LV002N-70VI	VR502	NOT PLACED	GCAM DUMMY PART NUMBER
R5084	0662057B47	CHIP RES 0 OHMS +-0.050 OHMS (CM160)	R610	0662057C59	CHIP RES 220 OHMS 5%	U405	5113805A75	IC 8 BIT SER TO PAR/PAR HC595	VR503	4813830G09	DIODE 3.3V 5% 'CK' 500MW _468
R5085	NOT PLACED	GCAM DUMMY PART NUMBER	R615	0662057A25	CHIP RES 100 OHMS 5%	U500	NOT PLACED	GCAM DUMMY PART NUMBER	VR504	4813830G09	DIODE 3.3V 5% 'CK' 500MW _468
R5086	0662057A43	CHIP RES 560 OHMS 5%	RT100	0680361L01	THERMISTOR 47KOHM	U501	0104016J81	9V REGULATOR ASSEMBLY	VR692	4813830A75	DIODE DUAL COM ANODE
R5087	0662057A97	CHIP RES 100K OHMS 5%	S5010	1889288U01	POTENTIOMETER W/ SWITCH VOLUME	U502	5102463J95	AUDIO PA TDA1519C	VR693	4813830A77	DIODE DL ZENER TVS 33V 1.0A
R5088	0662057B47	CHIP RES 0 OHMS +-0.050 OHMS	SH200	2689590U01	VCO SHIELD	U503	5105469E65	IC VLTG REGLTR	VR694	4813830A75	DIODE DUAL COM ANODE
R5089	NOT PLACED	GCAM DUMMY PART NUMBER	SH201	2689589U01	VCO SHIELD	U504	5185130C53	IC ASFIC_CMP_R1	VR695	4813830A77	DIODE DL ZENER TVS 33V 1.0A
R5092	NOT PLACED	GCAM DUMMY PART NUMBER	SH202	2689589U01	VCO SHIELD	U505	5113818A01	IC LOW COST SING SPLY LM2904D	VR696	4813830A75	DIODE DUAL COM ANODE
R5093	NOT PLACED	GCAM DUMMY PART NUMBER	SH300	2689591U01	MIXER SHIELD	U506	5113818A01	IC LOW COST SING SPLY LM2904D	VR697	4813830A75	DIODE DUAL COM ANODE
R5094	NOT PLACED	GCAM DUMMY PART NUMBER	SH301	2689593U01	FRONT ENA SHIELD	U507	5113818A01	IC LOW COST SING SPLY LM2904D	VR698	4813830A75	DIODE DUAL COM ANODE
R5095	NOT PLACED	GCAM DUMMY PART NUMBER	SH302	2689591U01	MIXER SHIELD	U508	5113816A30	IC 3.3V LOW DROPOUT POS. REG.	VR699	4813830A75	DIODE DUAL COM ANODE
R5096	NOT PLACED	GCAM DUMMY PART NUMBER	T300	2580541Z01	BALUN TRANSFORMER	U509	5113806A20	IC MUX/DEMUX TRIPLE 2-CHNL	Y200	NOT PLACED	GCAM DUMMY PART NUMBER
R5097	0662057B47	CHIP RES 0 OHMS +-0.050 OHMS	T301	2580541Z01	BALUN TRANSFORMER	U510	5104187K94	IC LP2986ILDX-3.3 VLTG REG	Y201	4880114R06	CRYSTAL 16.8MHZ
R5098	NOT PLACED	GCAM DUMMY PART NUMBER	U100	5113818A01	IC LOW COST SING SPLY LM2904D	U514	4802393L66	MOSFET P-CH	Y300	9186145B02	CER.DISCR. CDBCA455CX36-TC
R5099	NOT PLACED	GCAM DUMMY PART NUMBER	U101	5185130C65	IC VHF/UHF/800 MHZ LDMOS DRIV	U515	5162852A59	IC CMOS ANALOG SWITCH SPDT (CM160)	Y301	4880606B09	2ND OSC XTAL 44.395 MHZ
R5100	NOT PLACED	GCAM DUMMY PART NUMBER	U102	5113818A01	IC LOW COST SING SPLY LM2904D	VR101	4813830A18	DIODE 6.8V 5% 225MWMMBZ5235B_		0786637Z01	SPRT,REINFORCE-MENT,CRS
R5103	NOT PLACED	GCAM DUMMY PART NUMBER	U103	5113819A04	IC QD OP AMP GEN PURP MC3303D	VR102	4813830A15	TSTR 5.6V 5% 20MA 225MW			
R600	0662057C01	CHIP RES 0 OHMS .050 OHMS	U200	5185963A27	IC TESTED AT25016 48 PIN GFP	VR400	NOT PLACED	GCAM DUMMY PART NUMBER			
R601	0611077A62	RES CHIP 330 5 1/8W	U201	5105750U54	IC PKG DIE VCO BUFFER	VR401	NOT PLACED	GCAM DUMMY PART NUMBER			
R602	0662057B47	CHIP RES 0 OHMS +-0.050 OHMS	U300	5186144B01	FM IF IC SA616	VR402	4813830A09	DIODE 3.3V 5% 225MW MMBZ5226B			
			U301	5109522E10	IC 3-INV LMOS TC7W04FU	VR500	4813832C77	TRANS SUP. 24V HIGH PWR			
			U302	4808612Y05	CROSSOVER QUAD DIODE SMS3928-						
			U400	5102463J64	16KX8 SPI SERIAL EEPROM						
			U402	NOT PLACED	GCAM DUMMY PART NUMBER						



MOTOROLA

Commercial Series

CM Radios

VHF2 (146-174MHz) High Power
Service Information

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Table of Contents

Chapter 1 MODEL CHART AND TECHNICAL SPECIFICATIONS

1.0 CM140/CM160 Model Chart	1-1
2.0 Technical Specifications	1-2

Chapter 2 THEORY OF OPERATION

1.0 Introduction	2-1
2.0 VHF (146-174MHz) Receiver.....	2-1
2.1 Receiver Front-End	2-1
2.2 Receiver Back-End.....	2-2
3.0 VHF (146-174MHz) Transmitter Power Amplifier	2-2
3.1 First Power Controller Stage.....	2-2
3.2 Power Controlled Driver Stage	2-3
3.3 Final Stage.....	2-3
3.4 Directional Coupler.....	2-3
3.5 Antenna Switch.....	2-3
3.6 Harmonic Filter	2-4
3.7 Power Control.....	2-4
4.0 VHF (146-174MHz) Frequency Synthesis	2-4
4.1 Reference Oscillator	2-4
4.2 Fractional-N Synthesizer	2-5
4.3 Voltage Controlled Oscillator (VCO)	2-6
4.4 Synthesizer Operation	2-7
5.0 Controller Theory of Operation	2-8
5.1 Radio Power Distribution	2-8
5.2 Protection Devices.....	2-10
5.3 Automatic On/Off	2-10
5.4 Microprocessor Clock Synthesiser	2-11
5.5 Serial Peripheral Interface (SPI).....	2-12
5.6 SBEP Serial Interface.....	2-12
5.7 General Purpose I/O.....	2-12
5.8 Normal Microprocessor Operation.....	2-13
5.9 Static Random Access Memory.....	2-14
6.0 Control Board Audio and Signalling Circuits	2-14
6.1 Audio Signalling Filter IC and Compander (ASFIC CMP)	2-14
7.0 Transmit Audio Circuits.....	2-15
7.1 Microphone Input Path	2-15
7.2 PTT Sensing and TX Audio Processing	2-16

8.0	Transmit Signalling Circuits	2-17
8.1	Sub-Audio Data (PL/DPL)	2-17
8.2	High Speed Data	2-18
8.3	Dual Tone Multiple Frequency (DTMF) Data	2-18
9.0	Receive Audio Circuits.....	2-19
9.1	Squelch Detect	2-19
9.2	Audio Processing and Digital Volume Control.....	2-20
9.3	Audio Amplification Speaker (+) Speaker (-)	2-20
9.4	Handset Audio	2-21
9.5	Filtered Audio and Flat Audio	2-21
10.0	Receive Audio Circuits	2-21
10.1	Sub-Audio Data (PL/DPL) and High Speed Data Decoder	2-21
10.2	Alert Tone Circuits	2-22

Chapter 3 TROUBLESHOOTING CHARTS

1.0	Troubleshooting Flow Chart for Receiver RF (Sheet 1 of 2).....	3-2
1.1	Troubleshooting Flow Chart for Receiver (Sheet 2 of 2)	3-3
2.0	Troubleshooting Flow Chart for 45W Transmitter (Sheet 1 of 3)	3-4
2.1	Troubleshooting Flow Chart for 45W Transmitter (Sheet 2 of 3).....	3-5
2.2	Troubleshooting Flow Chart for 45W Transmitter (Sheet 3 of 3).....	3-6
3.0	Troubleshooting Flow Chart for Synthesizer	3-7
4.0	Troubleshooting Flow Chart for VCO	3-8
5.0	Troubleshooting Flow Chart for DC Supply (Sheet 1 of 2)	3-9
5.1	Troubleshooting Flow Chart for DC Supply (Sheet 2 of 2)	3-10

Chapter 4 VHF PCB/SCHEMATICS/PARTS LISTS

1.0	Allocation of Schematics and Circuit Boards	4-1
1.1	VHF2 25-45W and Controller Circuits	4-1
2.0	VHF2 25-45W PCB 8486487Z03-B / Schematics	4-3
2.1	VHF2 25-45W PCB 8486487Z03-B Parts List	4-19

Chapter 1

MODEL CHART AND TECHNICAL SPECIFICATIONS

1.0 CM140/CM160 Model Chart

CM Series, VHF2, 146-174 MHz		
Model	Description	
	Item	Description
MDM50KQC9AA2		CM140 146-174 MHz, 45W, 8CH, BNC
MDM50KQF9AA2		CM160 146-174 MHz, 45W, 64CH, BNC
X	PMUD1848_	CM140 Super Tanapa VHF2, 45W, 8CH, BNC
X	PMUD1894_	CM160 Super Tanapa VHF2, 45W, 64CH, BNC
X	PMUD1885_	CM140 Tanapa VHF2, 45W, 8CH, BNC
X	PMUD1887_	CM160 Tanapa VHF2, 45W, 64CH, BNC
X	FCN6288_	Control Head
X	FCN5523_	Control Head
X	PMUD1885_S	CM140 UHF2 U/C BNC Service Board
X	PMUD1887_S	CM160 UHF2 U/C BNC Service Board
X X	RMN5018	Mag One Microphone
X X	6866546D02_	RTTE Leaflet
X X	6866537D37_	Safety Leaflet
X X	GLN7324_	Low Profile Trunnion

x = Indicates one of each is required.

2.0 Technical Specifications

Data is specified for +25°C unless otherwise stated.

General	
Specification	VHF2
Frequency Range:	146-174 MHz
Frequency Stability (-30°C to +60°C, 25°C Ref.)	±2 PPM
Channel Capacity:	CM140 - 8 CM160 - 64
Channel Spacing:	12.5/20/25 kHz
Power Output:	25-45W
Power Supply:	13.2Vdc (10.8 - 15.6 Vdc) negative vehicle ground
Dimensions (L X W X H)	118mm X 169mm X 44mm
Weight: Low power (1-25W)	1.02 Kg
Operating Temperature	-30 to 60 ° C
Storage temperature	-40 to 80° C
Shock and Vibration	Meets MIL-STD 810-C,D&E and TIA/EIA 603
Dust	Meets MIL-STD 810-C,D&E and TIA/EIA 603
Humidity	Meets MIL-STD 810-C,D&E and TIA/EIA 603

Transmitter	
Specification	VHF2
Frequency Stability:	+/- 2.5ppm
Modulation Limiting:	±2.5 kHz @ 12.5 kHz ±4.0 kHz @ 20 kHz ±5.0 kHz @ 20/25 kHz
Current Drain Transmit:	7A (25W)
FM Hum and Noise:	-40 dB@12.5 kHz -45 dB@ 20/25 kHz
Conducted/Radiated Emissions:	-36 dBm < 1 GHz -30 dBm > 1 GHz
Adjacent Channel Power	-60dB @12.5, -70dB @ 20/25kHz
Audio Response: (300 to 3000Hz)	+1, -3dB
Audio Distortion: @ 1000 Hz, 60% Rated Maximum Deviation:	3% Typical

Receiver	
Specification	VHF2
Sensitivity (12dBSINAD): (ETS)	0.35µV (12.5kHz) 0.30µV (25kHz) Typical
Intermodulation : (ETS)	>65dB
Adjacent Channel Selectivity: (ETS)	75 dB @ 25 kHz 65 dB @ 12.5 kHz
Spurious Rejection: (ETS)	75 dB
Rated Audio: (ETS) (Extended audio with 4 Ohm speaker)	4W Internal , 13W External
Audio Distortion @ Rated Audio:	3% Typical
Hum and Noise:	-40 dB @ 12.5 kHz -45 dB @ 20/25 kHz
Audio Response: (300 to 3000Hz)	+1, -3dB
Conducted Spurious Emission per FCC Part 15:	-57 dBm <1 GHz -47 dBm >1 GHz

*Availability subject to the laws and regulations of individual countries.

Chapter 2

THEORY OF OPERATION

1.0 Introduction

This Chapter provides a detailed theory of operation for the VHF circuits in the radio. Details of the theory of operation and trouble shooting for the the associated Controller circuits are included in this Section of the manual.

2.0 VHF (146-174MHz) Receiver

2.1 Receiver Front-End

The received signal is applied to the radio's antenna input connector and routed through the harmonic filter and antenna switch. The insertion loss of the harmonic filter/antenna switch is less than 1 dB. The signal is routed to the first filter (4-pole), which has an insertion loss of 2 dB typically. The output of the filter is matched to the base of the LNA (Q303) that provides a 16 dB gain and a noise figure of better than 2 dB. Current source Q301 is used to maintain the collector current of Q303. Diode CR301 protects Q303 by clamping excessive input signals. Q303 output is applied to the second filter (3-pole) which has an insertion loss of 1.5 dB. In Distance mode, Q304 turns on and causes D305 to conduct, thus bypassing C322 and R337. In Local mode, the signal is routed through C322 and R337, thus inserting 7 dB attenuation. Since the attenuator is located after the RF amplifier, the receiver sensitivity is reduced only by 6 dB, while the overall third order input intercept is raised.

The first mixer is a passive, double-balanced type, consisting of T300, T301 and U302. This mixer provides all of the necessary rejection of the half-IF spurious response. High-side injection at +15 dBm is delivered to the first mixer. The mixer output is then connected to a duplex network which matches its output to the XTAL filter input (FL300) at the IF frequency of 44.85 MHz. The duplex network terminates into a 50 ohm resistor (R340) at all other frequencies.

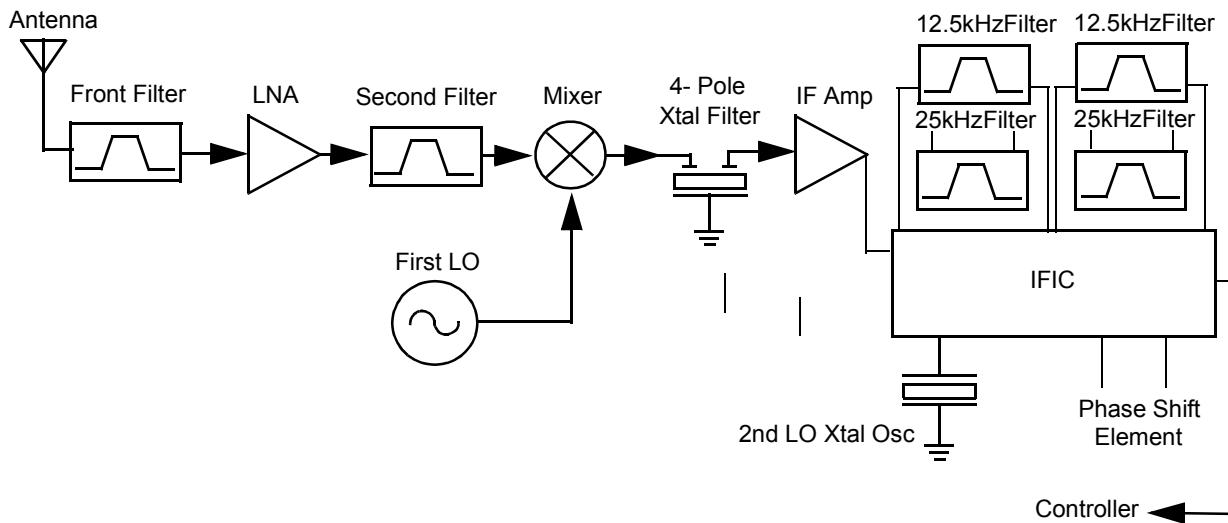


Figure 2-1 VHF Receiver Block Diagram

2.2 Receiver Back End

The IF signal from the crystal filter enters the IF amplifier which provides 20 dB of gain and feeds the IF IC at pin 1. The first IF signal at 44.85 MHz mixes with the second local oscillator (LO) at 44.395 MHz to produce the second IF at 455 kHz. The second LO uses the external crystal Y301. The second IF signal is amplified and filtered by two external ceramic filters (FL303/FL302 for 12.5KHz channel spacing and FL304/FL301 for 25KHz channel spacing). The IF IC demodulates the signal by means of a quadrature detector and feeds the detected audio (via pin 7) to the audio processing circuits. At IF IC pin 5, an RSSI signal is available with a dynamic range of 70 dB.

3.0 VHF Transmitter Power Amplifier (146-174 MHz)

The radio's 45W PA is a three-stage amplifier used to amplify the output from the TX_INJ to the antenna port. All three stages utilize LDMOS technology. The gain of the first stage (U101) is adjustable and is controlled by pin 7 of U103-2 via U103-3 and U102-1. It is followed by an LDMOS driver Q105 and final stage Q100.

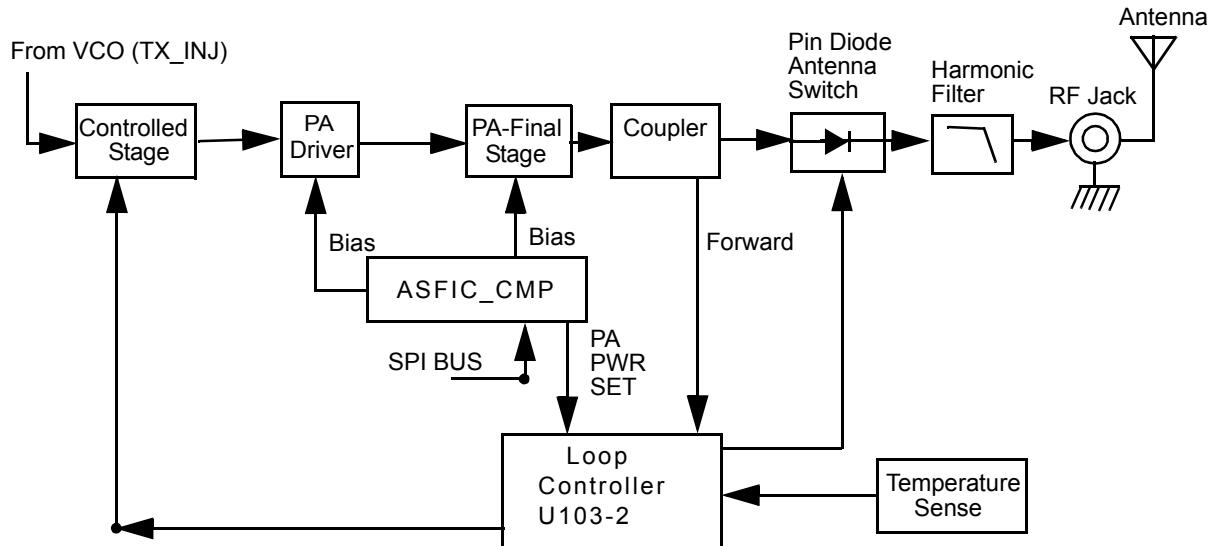


Figure 2-2 VHF Transmitter Block Diagram

Devices U101, Q105 and Q100 are surface mounted. Two screws with Belleville washers provide direct pressure ensuring good thermal contact between both the driver and final stage, and the chassis.

3.1 First Power Controller Stage

The first stage (U101) is a 20dB gain integrated circuit containing two LDMOS FET amplifier stages. It amplifies the RF signal from the VCO (TX_INJ). The output power of stage U101 is controlled by a DC voltage applied to pin 1 from the op-amp U103-3, pin 8. The control voltage simultaneously varies the bias of two FET stages within U101. This biasing point determines the overall gain of U101 and therefore its output drive level to Q105, which in turn controls the output power of the PA.

Op-amp U103-3 monitors the drain current of U101 via resistor R122 and adjusts the bias voltage of U101.

In receive mode, the DC voltage from RX_EN line turns on Q101, which in turn switches off the biasing voltage to U101.

3.2 Power Controlled Driver Stage

The next stage is an LDMOS device (Q105) which provides a gain of 12dB. This device requires a positive gate bias and a quiescent current flow for proper operation. The bias is set during transmit mode by the V_ctrl_driver which is set to provide 100-150mA of quiescent current by the factory, and fed to the gate of Q105 via the resistive network.

The V_ctrl_driver is directly controlled by the ASIC CMP. In receive mode, the ASIC CMP (U504) sets V_ctrl_driver to 0V (DPCR pin 5).

3.3 Final Stage

The final stage is an LDMOS device (Q100) providing a gain of 12dB. This device also requires a positive gate bias and a quiescent current flow for proper operation. The voltage of the line PA_BIAS is set in transmit mode by the ASIC and fed to the gate of Q100 via the resistive network R134, R131. This bias voltage is tuned in the factory. If the transistor is replaced, the bias voltage must be tuned using the Tuner. 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, B+, via L117 and L115.

A matching network consisting of C1004-5, C1007-9, C1096, C1021, C1013, C1019, L116: and two striplines, transforms the impedance to 50 ohms and feeds the directional coupler.

3.4 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 Q100. The coupled signal is rectified to an output power which is proportional to the DC voltage rectified by diode D105; and the resulting DC voltage is routed to the power control section to ensure that the forward power out of the radio is held to a constant value.

3.5 Antenna Switch

The antenna switch utilizes the existing dc feed (B+) to the last stage device (Q100). The basic operation is to have both PIN diodes (D103, D104) turned on during key-up by forward biasing them. This is achieved by pulling down the voltage at the cathode end of D104 to around 12.4V (0.7V drop across each diode). The current through the diodes needs to be set around 100 mA to fully open the transmit path through resistor R108. Q106 is a current source controlled by Q103 which is turned on in Tx mode by TX_EN. VR102 ensures that the voltage at resistor R107 never exceeds 5.6V.

3.6 Harmonic Filter

Inductors L111, L112, L124 and L113 along with capacitors C11321, C1022, C1020, C1137, C1018 and C1017 form a low-pass filter to attenuate harmonic energy coming from the transmitter. Resistor R150 drains 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 to improve spurious response rejection.

3.7 Power Control

The output power is regulated by using a forward power detection control loop. A directional coupler samples a portion of the forward and reflected RF power. The forward sampled RF is rectified by diode D105, and the resulting DC voltage is routed to the operational amplifier U100. The error output current is then routed to an integrator, and converted into the control voltage. This voltage controls the bias of the pre-driver (U101) stage. The output power level is set by way of a DAC, PWR_SET, in the audio processing IC (U504), which acts as the forward power control loop reference.

The sampled reflected power is rectified by diode D107. The resulting DC voltage is amplified by an operational amplifier U100 and routed to the summing junction. This detector protects the final stage Q100 from reflected power by increasing the error current. The temperature sensor protects the final stage Q100 from overheating by increasing the error current. A thermistor RT100 measures the final stage Q100 temperature. The voltage divider output is routed to an operational amplifier U103 and then goes to the summing junction. The Zener Diode VR101 keeps the loop control voltage below 5.6V and eliminates the DC current from the 9.3 regulator U501.

A local loop for the Pre Driver (U101) is used in order to stabilize the current for each stage.

In Rx mode, the two transistors Q101 and Q102 go to saturation and shut down the transmitter by applying ground to the Pre Driver U101.

4.0 VHF (146-174MHz) Frequency Synthesis

The synthesizer consists of a reference oscillator (Y201), low voltage Fractional-N (LVFRAC-N) synthesizer (U200), and a voltage controlled oscillator (VCO) (U201).

4.1 Reference Oscillator

The reference oscillator is a crystal (Y201) controlled Colpitts oscillator and has a frequency of 16.8MHz. The oscillator transistor and start-up circuit are located in the LVFRAC-N (U200) while the oscillator feedback capacitors, crystal, and tuning varactors are external. An analog-to-digital (A/D) converter internal to the LVFRAC-N (U200) and controlled by the microprocessor via SPI sets the voltage at the warp output of U200 pin 25. This sets the frequency of the oscillator. Consequently, the output of the crystal Y201 is applied to U200 pin 23.

The method of temperature compensation is to apply an inverse Bechmann voltage curve, which matches the crystal's Bechmann curve to a varactor that constantly shifts the oscillator back on frequency. The crystal vendor characterizes the crystal over a specified temperature range and codes this information into a bar code that is printed on the crystal package. In production, this crystal code is read via a 2-dimensional bar code reader and the parameters are saved.

This oscillator is temperature compensated to an accuracy of +/- 2.5 PPM from -30 to 60 degrees C. The temperature compensation scheme is implemented by an algorithm that uses five crystal parameters (four characterize the inverse Bechmann voltage curve and one for frequency accuracy of the reference oscillator at 25 degrees C). This algorithm is implemented by the LVFRAC-N (U200) at the power up of the radio.

4.2 Fractional-N Synthesizer

The LVFRAC-N U200 consists of a pre-scaler, programmable loop divider, control divider logic, phase detector, charge pump, A/D converter for low frequency digital modulation, balanced attenuator used to balance the high and low frequency analog modulation, 13V positive voltage multiplier, serial interface for control, and a super filter for the regulated 5 volts.

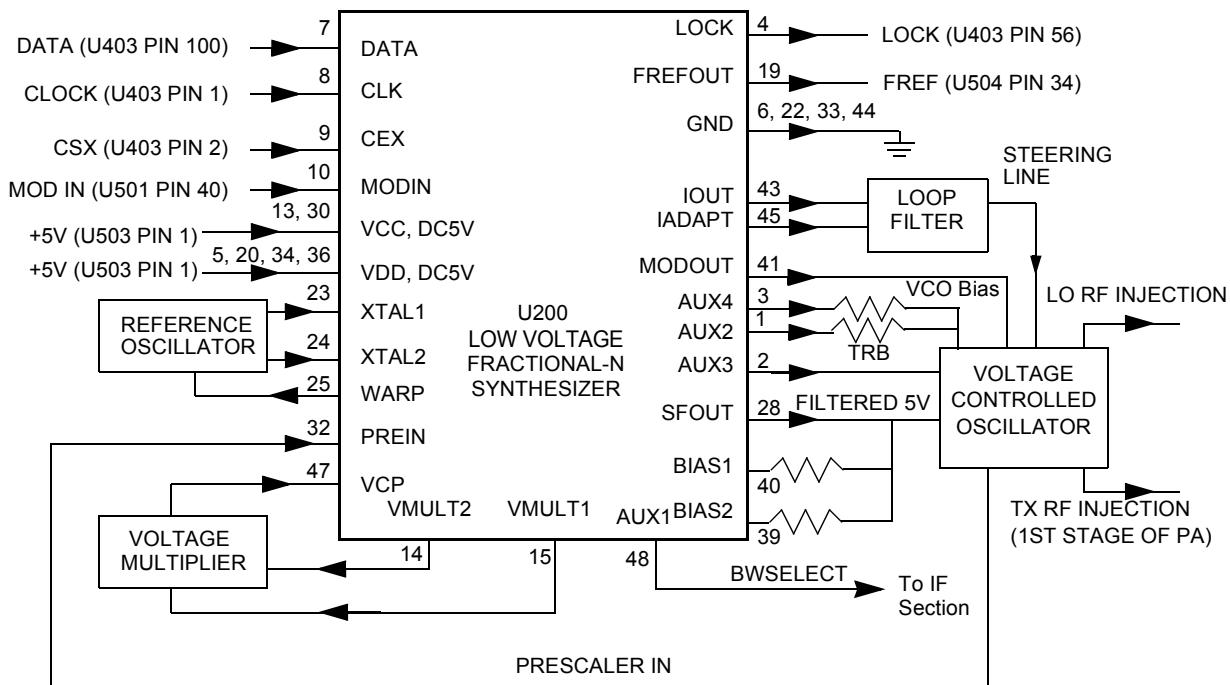


Figure 2-3 VHF Synthesizer Block Diagram

A voltage of 5V applied to the super filter input (U200, pin 30) supplies an output voltage of 4.5Vdc (VSF) at U200, pin 28. This supplies 4.5 V to the VCO Buffer IC U201.

To generate a high voltage to supply the phase detector (charge pump) output stage at pin VCP (U200, pin 47) while using a low voltage 3.3Vdc supply, a 13V positive voltage multiplier is used (D200, D201, and capacitors C2024, 2025, 2026, 2055, 2027, 2001).

Output lock (U200, pin 4) provides information about the lock status of the synthesizer loop. A high level at this output indicates a stable loop. A 16.8 MHz reference frequency is provided at U200, pin 19.

4.3 Voltage Controlled Oscillator (VCO)

The Voltage Controlled Oscillator (VCO) consists of the VCO/Buffer IC (VCOBIC, U201), the TX and RX tank circuits, the external RX amplifier, and the modulation circuitry.

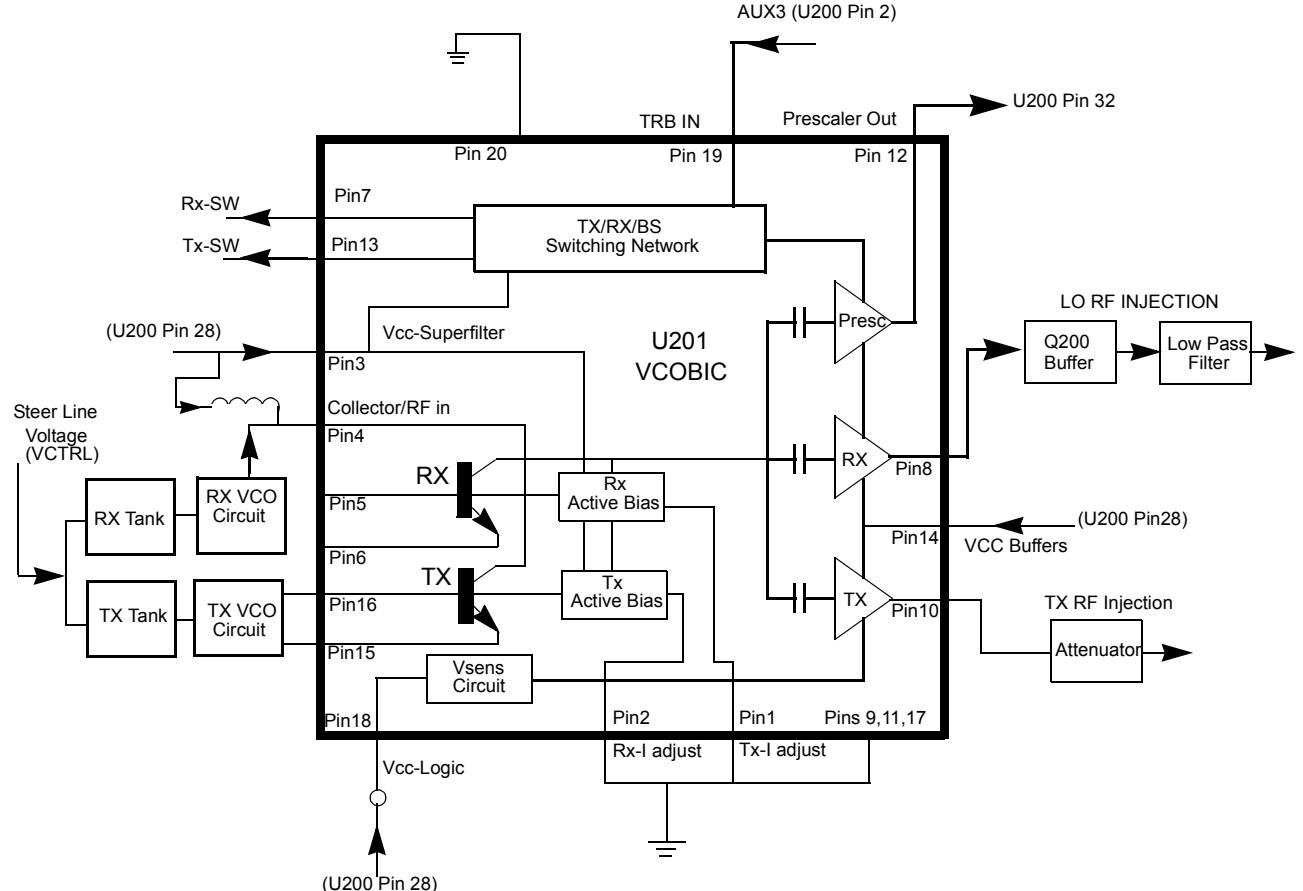


Figure 2-4 VHF VCO Block Diagram

The VCOBIC together with the LVFRAC-N (U200) generate the required frequencies in both transmit and receive modes. The TRB line (U201, pin 19) determines which VCO and buffer is enabled (high being TX output at pin 10, low being RX output at pin 8). A sample of the signal from the enabled output is routed from U201, pin 12 (PRESC_OUT), via a low pass filter to U200, pin 32 (PREIN).

A steering line voltage between 3.0V and 10.0V at varactor D204 tunes the TX VCO through the frequency range of 146-174MHz, and at D203 tunes the RX VCO through the frequency range of 190-219MHz.

The external RX amplifier is used to increase the output from U201, pin 9 from 3-4 dBm to the required 15dBm for proper mixer operation. In TX mode, the modulation signal from the LVFRAC-N (U200, pin 41) is applied to the VCO by way of the modulation circuit D205, R212, R211, C2073.

4.4 **Synthesizer Operation**

The synthesizer consists of a low voltage FRAC-N IC (LVFRAC-N), reference oscillator, charge pump circuits, loop filter circuit, and DC supply. The output signal (PRESC_OUT) of the VCOBIC (U201, pin 12) is fed to the PREIN, pin 32 of U200 via a low pass filter which attenuates harmonics and provides a correct input level to the LVFRAC-N in order to close the synthesizer loop.

The pre-scaler in the synthesizer (U200) is 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 SPI. 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 (Y201).

The output signal of the phase detector is a pulsed dc signal that is routed to the charge pump. The charge pump outputs a current from U200, pin 43 (IOUT). The loop filter (consisting of R224, R217, R234, C2074, C2075, C2077, C2078, C2079, C2080, C2028, and L205) transforms this current into a voltage that is applied the varactor diodes D203 and D204 for RX and TX respectively. The output frequency is determined by this control voltage. The current can be set to a value fixed in the LVFRAC-N or to a value determined by the currents flowing into BIAS 1 (U200, pin 40) or BIAS 2 (U200, pin 39). The currents are set by the value of R200 or R206 respectively. The selection of the three different bias sources is done by software programming.

To modulate the synthesizer loop, a two-spot modulation method is utilized via the MODIN (U200, pin 10) input of the LVFRAC-N. The audio signal is applied to both the A/D converter (low frequency path) and the balance 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 presented at the MODOUT port of the LVFRAC-N (U200,pin 41) and connected to the VCO modulation varactor D205.

5.0 Controller Theory of Operation

This section provides a detailed theory of operation for the radio and its components. The main radio is a single-board design, consisting of the transmitter, receiver, and controller circuits. A control head is connected by an extension cable. The control head contains LED indicators, a microphone connector, buttons, and speaker.

In addition to the power cable and antenna cable, an accessory cable can be attached to a connector on the rear of the radio. The accessory cable enables you to connect accessories to the radio, such as an external speaker, emergency switch, foot-operated PTT, and ignition sensing, etc.

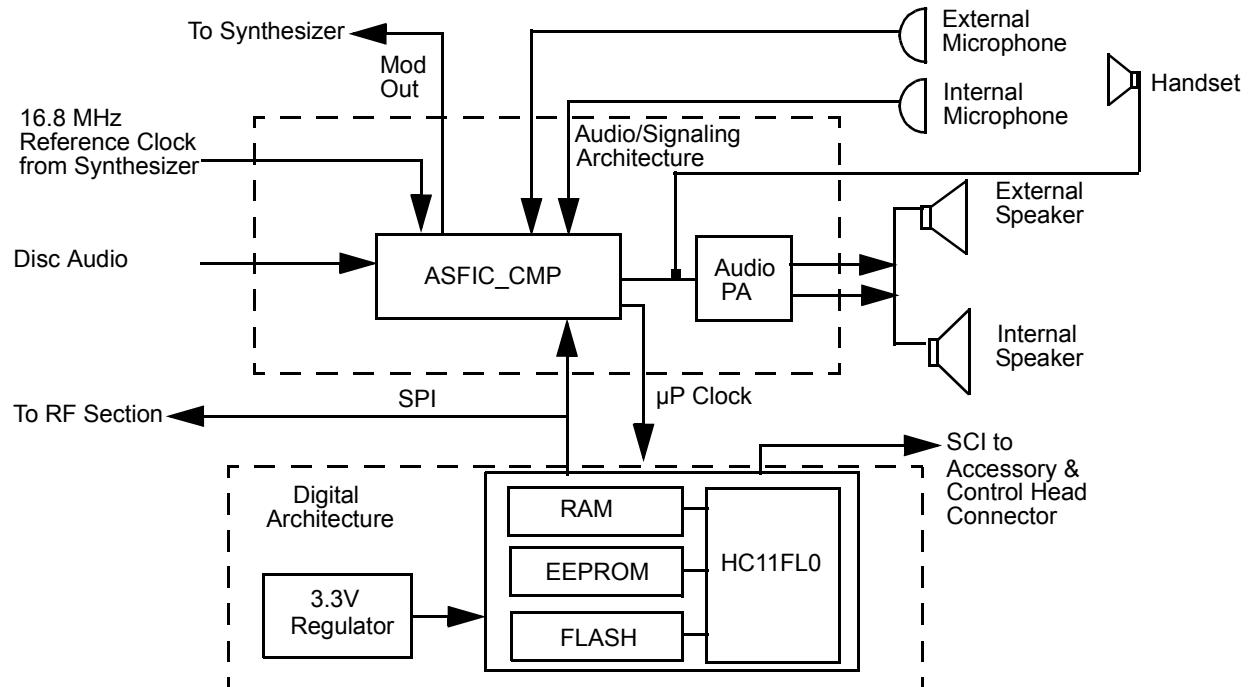


Figure 2-5 Controller Block Diagram

5.1 Radio Power Distribution

Voltage distribution is provided by five separate devices:

- U514 P-ch FET - Batt + (Ext_SWB+)
- U501 LM2941T - 9.3V
- U503 LP2951CM - 5V
- U508 MC 33269DTRK - 3.3V
- U510 LP2986ILDX - 3.3V Digital

The DC voltage applied to connector P2 supplies power directly to the following circuitry:

- Electronic on/off control
- RF power amplifier
- 12 volts P-ch FET -U514
- 9.3 volt regulator
- Audio PA

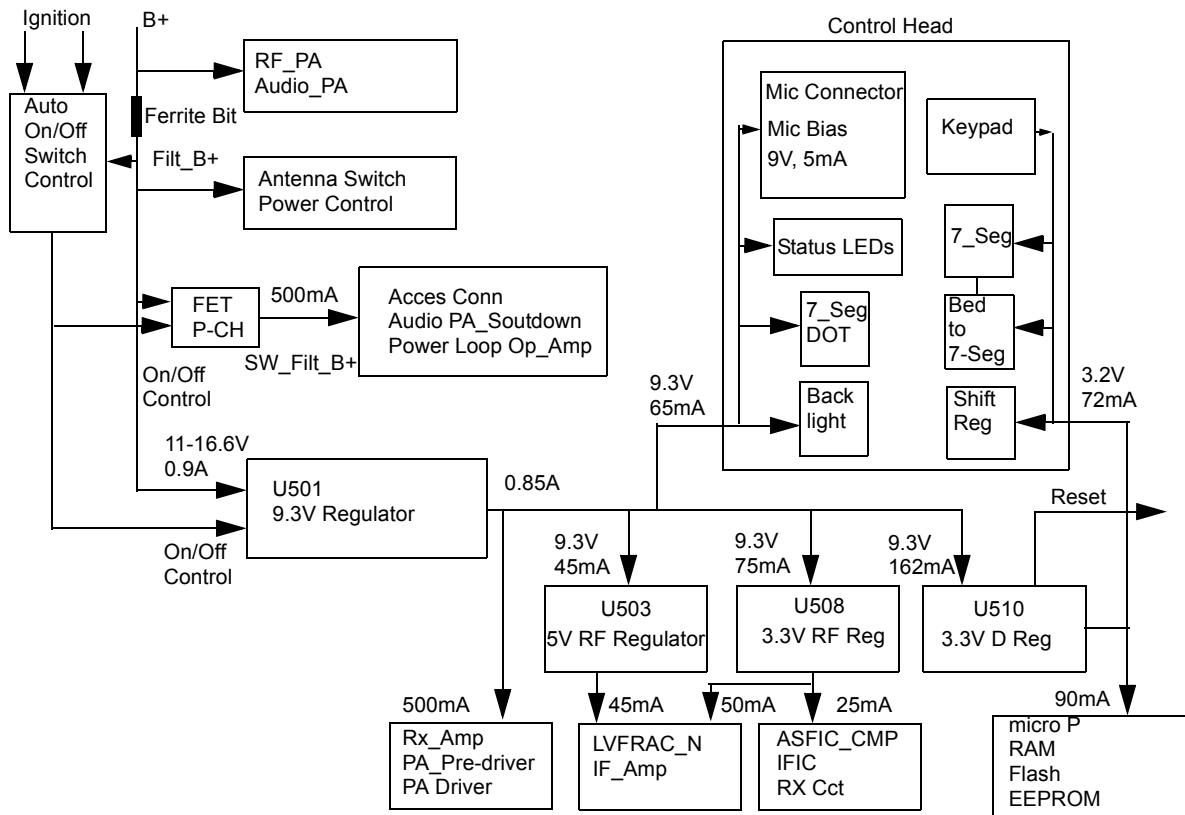


Figure 2-6 DC Power Distribution Block Diagram

Regulator U501 is used to generate the 9.3 volts required by some audio circuits, the RF circuitry and power control circuitry. Input and output capacitors are used to reduce high frequency noise. Resistors R5001 / R5081 set the output voltage of the regulator. This regulator output is electronically enabled by a 0 volt signal on pin 2. Q502, Q505 and R5038 are used to disable the regulator when the radio is turned off.

Voltage regulator U510 provides 3.3 volts for the digital circuitry. Operating voltage is from the regulated 9.3V supply. Input and output capacitors are used to reduce high frequency noise and provide proper operation during battery transients. U510 provides a reset output that goes to 0 volts if the regulator output goes below 3.1 volts. This is used to reset the controller to prevent improper operation.

Voltage regulator U508 provides 3.3V for the RF circuits and ASFIC_CMP. Input and output capacitors are used to reduce the high frequency noise and provide proper operation during battery transients.

Voltage regulator U503 provides 5V for the RF circuits. Input and output capacitors are used to reduce the high frequency noise and provide proper operation during battery transients.

VSTBY is used only for CM360 5-tone radios.

The voltage VSTBY, which is derived directly from the supply voltage by components R5103 and VR502, is used to buffer the internal RAM. Capacitor C5120 allows the battery voltage to be disconnected for a couple of seconds without losing RAM parameters. Dual diode D501 prevents radio circuitry from discharging this capacitor. When the supply voltage is applied to the radio, C5120 is charged via R5103 and D501.

5.2 Protection Devices

Diode VR500 acts as protection against ESD, wrong polarity of the supply voltage, and load dump. VR692 - VR699 are for ESD protection.

5.3 Automatic On/Off

The radio can be switched ON in any one of the following three ways:

- On/Off switch. (No Ignition Mode)
- Ignition and On/Off switch (Ignition Mode)
- Emergency

5.3.1 No Ignition Mode

When the radio is connected to the car battery for the first time, Q500 will be in saturation, Q503 will cut-off, Filt_B+ will pass through R5073, D500, and S5010-pin 6 (On/Off switch). When S5010 is ON, Filt_B+ will pass through S5010-pin5, D511, R5069, R5037 and base of Q505 and move Q505 into saturation. This pulls U501-pin2 through R5038, D502 to 0.2V and turns On U514 and U501 9.3V regulator which supplies voltage to all other regulators and consequently turns the radio on, When U504 (ASFIC_CMP) gets 3.3V, GCB2 goes to 3.3V and holds Q505 in saturation, for soft turn off.

5.3.2 Ignition Mode

When ignition is connected for the first time, it will force high current through Q500 collector, This will move Q500 out of saturation and consequently Q503 will cut-off. S5010 pin 6 will get ignition voltage through R601 (for load dump), R610, (R610 & C678 are for ESD protection), VR501, R5074, and D500. When S5010 is ON, Filt_B+ passes through S5010-pin 5, D511, R5069, R5037 and base of Q505 and inserts Q505 into saturation. This pulls U501-pin 2 through R5038, D502 to 0.2V and turns on U514 and U501 9.3V regulator which supply voltage to all other regulators and turns the radio on, When U504 (ASFIC_CMP) get 3.3V supply, GCB2 goes to 3.3V and holds Q505 in saturation state to allow soft turn off,

When ignition is off Q500, Q503 will stay at the same state so S5010 pin 6 will get 0V from Ignition, Q504 goes from Sat to Cut, ONOFF_SENSE goes to 3.3V and it indicates to the radio to soft turn itself by changing GCB2 to '0' after de registration if necessary.

5.3.3 Emergency Mode

The emergency switch (P1 pin 9), when engaged, grounds the base of Q506 via EMERGENCY _ACCES_CONN. This switches Q506 to off and consequently resistor R5020 pulls the collector of Q506 and the base of Q506 to levels above 2 volts. Transistor Q502 switches on and pulls U501 pin2 to ground level, thus turning ON the radio. When the emergency switch is released R5030 pulls the base of Q506 up to 0.6 volts. This causes the collector of transistor Q506 to go low (0.2V), thereby switching Q502 to off.

While the radio is switched on, the μ P monitors the voltage at the emergency input on the accessory connector via U403-pin 62. Three different conditions are distinguished: no emergency kit is connected, emergency kit connected (unpressed), and emergency press.

If no emergency switch is connected or the connection to the emergency switch is broken, the resistive divider R5030 / R5049 will set the voltage to about 3.14 volts (indicates no emergency kit found via EMERGENCY_SENSE line). If an emergency switch is connected, a resistor to ground within the emergency switch will reduce the voltage on EMERGENCY_SENSE line, and indicate to the μ P that the emergency switch is operational. An engaged emergency switch pulls line EMERGENCY_SENSE line to ground level. Diode VR503 limits the voltage to protect the μ P input.

While EMERGENCY_ACCES_CONN is low, the μ P starts execution, reads that the emergency input is active through the voltage level of μ P pin 64, and sets the DC POWER ON output of the ASFIC CMP pin 13 to a logic high. This high will keep Q505 in saturation for soft turn off.

5.4 Microprocessor Clock Synthesiser

The clock source for the μ P system is generated by the ASFIC CMP (U504). 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 audio circuitry, 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 will generate its default 3.6864MHz CMOS square wave UP CLK (on U504 pin 28) and this is routed to the μ P (U403 pin 90). After the μ 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 the clock source interfering with the desired radio receive frequency.

The ASFIC CMP synthesizer loop uses C5025, C5024 and R5033 to set the switching time and jitter of the clock output. If the synthesizer cannot generate the required clock frequency it will switch back to its default 3.6864MHz output.

Because the ASFIC CMP synthesizer and the μ P system will not operate without the 16.8 MHz reference clock it (and the voltage regulators) should be checked first when debugging the system.

5.5 Serial Peripheral Interface (SPI)

The μ P communicates to many of the IC's through its SPI port. This port consists of SPI TRANSMIT DATA (MOSI) (U403-pin100), SPI RECEIVE DATA (MISO) (U403-pin 99), SPI CLK (U0403-pin1) and chip select lines going to the various IC's, connected on the SPI PORT (BUS). This BUS is a synchronous bus, in that the timing clock signal CLK is sent while SPI data (SPI TRANSMIT DATA or SPI RECEIVE DATA) 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 is used to send serial from a μ P to a device, and SPI RECEIVE DATA is used to send data from a device to a μ P.

In the controller section, there are two IC's on the SPI BUS, ASIC CMP (U504 pin 22), and EEPROM (U400). In the RF sections there is one IC on the SPI BUS, the FRAC-N Synthesizer. The chip select line CSX from U403 pin 2 is shared by the ASIC CMP and FRAC-N Synthesizer. Each of these IC's check the SPI data and when the sent address information matches the IC's address, the following data is processed.

When the μ 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 to the various IC's are different; e.g., the ASIC CMP can receive up to 19 bytes (152 bits). After the data has been sent the chip select line is returned to logic "1".

5.6 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) or the cable with internal RIB. This interface connects to the SCI pin via control head connector (J2-pin 17) and to the accessory connector P1-6 and comprises BUS+. The line is bi-directional, meaning that either the radio or the RIB can drive the line. The μ P sends serial data and it reads serial data via pin 97. Whenever the μ P detects activity on the BUS+ line, it starts communication.

5.7 General Purpose Input/Output

The controller provides six general purpose lines (PROG I/O) available on the accessory connector P1 to interface to external options. Lines PROG IN 3 and 6 are inputs, PROG OUT 4 is an output and PROG IN OUT 8, 12 and 14 are bi-directional. The software and the hardware configuration of the radio model define the function of each port.

- PROG IN 3 can be used as external PTT input, or others, set by the CPS. The μ P reads this port via pin 72 and Q412.
- PROG OUT 4 can be used as external alarm output, set by the CPS. Transistor Q401 is controlled by the μ P (U403 pin 55)
- PROG IN 6 can be used as normal input, set by the CPS. The μ P reads this port via pin 73 and Q411. This pin is also used to communicate with the RIB if resistor R421 is placed.
- DIG IN OUT 8,12,14 are bi-directional and use the same circuit configuration. Each port uses an output Q416, Q404, Q405 controlled by μ P pins 52, 53, 54. The input ports are read through μ P pins 74, 76, 77; using Q409, Q410, Q411

5.8 Normal Microprocessor Operation

For this radio, the µP is configured to operate in one of two modes, expanded and bootstrap. In expanded mode the µP uses external memory devices to operate, whereas in bootstrap operation the µP uses only its internal memory. In normal operation of the radio the µP is operating in expanded mode as described below.

During normal operation, the µP (U403) is operating in expanded mode and has access to 3 external memory devices; U400 (EEPROM), U402 (SRAM), U404 (Flash). Also, within the µP there are 3 Kilobytes of internal RAM, as well as logic to select external memory devices.

The external EEPROM (U400) space contains the information in the radio which is customer specific, referred to as the codeplug. This information consists of items such as: 1) what band the radio operates in, 2) what frequencies are assigned to what channel, and 3) tuning information.

The external SRAM (U402) as well as the µP's own internal RAM space are used for temporary calculations required by the software during execution. All of the data stored in both of these locations is lost when the radio powers off.

The µP provides an address bus of 16 address lines (ADDR 0 - ADDR 15), and a data bus of 8 data lines (DATA 0 - DATA 7). There are also 3 control lines; CSPROG (U403-pin 38) to chip select U404-pin 30 (FLASH), CSGP2 (U403-pin 41) to chip select U404-pin 20 (SRAM) and PG7_R_W (U403-pin 4) to select whether to read or to write.

When the µP is functioning normally, the address and data lines should be toggling at CMOS logic levels. Specifically, the logic high levels should be between 3.1 and 3.3V, and the logic low levels should be between 0 and 0.2V. 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 1us/div. or faster to observe individual pulses. High speed CMOS transitions should also be observed on the µP control lines.

On the µP the lines XIRQ (U403-pin 48), MODA LIR (U403-pin 58), MODB VSTPY (U403-pin 57) and RESET (U403-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 20ms. In the case of shorted lines you may also detect the line periodically at an intermediate level, i.e. around 2.5V when two shorted lines attempt to drive to opposite rails.

The MODA LIR (U403-pin 58) and MODB VSTPY (U403-pin 57) inputs to the µP must be at a logic "1" for it to start executing correctly. After the µP starts execution it will periodically pulse these lines to determine the desired operating mode. While the Central Processing Unit (CPU) is running, MODA LIR is an open-drain CMOS output which goes low whenever the µP begins a new instruction. An instruction typically requires 2-4 external bus cycles, or memory fetches.

There are eight analog-to-digital converter ports (A/D) on U403 labelled within the device block as PEO-PE7. These lines sense the voltage level ranging from 0 to 3.3V 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.

5.9 Static Random Access Memory (SRAM)

The SRAM (U402) 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 U402 (which comes from U403-CSGP2) going low. U402 is commonly referred to as the external RAM as opposed to the internal RAM which is the 3 kilobytes of RAM which is 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 C402 and C411 serves to filter out any AC noise which may ride on +3.3 V at U402

6.0 Control Board Audio and Signalling Circuits

6.1 Audio Signalling Filter IC and Compander (ASFIC CMP)

The ASFIC CMP (U504) used in the controller has the following four functions:

1. RX/TX audio shaping, i.e. filtering, amplification, attenuation
2. RX/TX signaling, PL/DPL/HST/MDC
3. Squelch detection
4. μ P clock signal generation

The ASFIC CMP is programmable through the SPI BUS (U504 pins-20/21/22), normally receiving 19 bytes. This programming sets up various paths within the ASFIC CMP to route audio and/or signaling signals through the appropriate filtering, gain and attenuator blocks. The ASFIC CMP also has 6 General Control Bits GCB0-5 which are CMOS level outputs and used for the following:

- GCB0 - BW Select
- GCB1 - switches the audio PA On/Off
- GCB2 - DC Power On switches the voltage regulator (and the radio) on and off
- GCB3 - Control on MUX U509 pin 9 to select between Low Cost Mic path to STD Mic Path
- GCB4 - Control on MUX U509 pin 11 to select between Flat RX path to filtered RX path on the accessory connector.
- GCB5 - Control on MUX U509 pin 10 to select between Flat TX path mute and Flat TX path

7.0 Transmit Audio Circuits

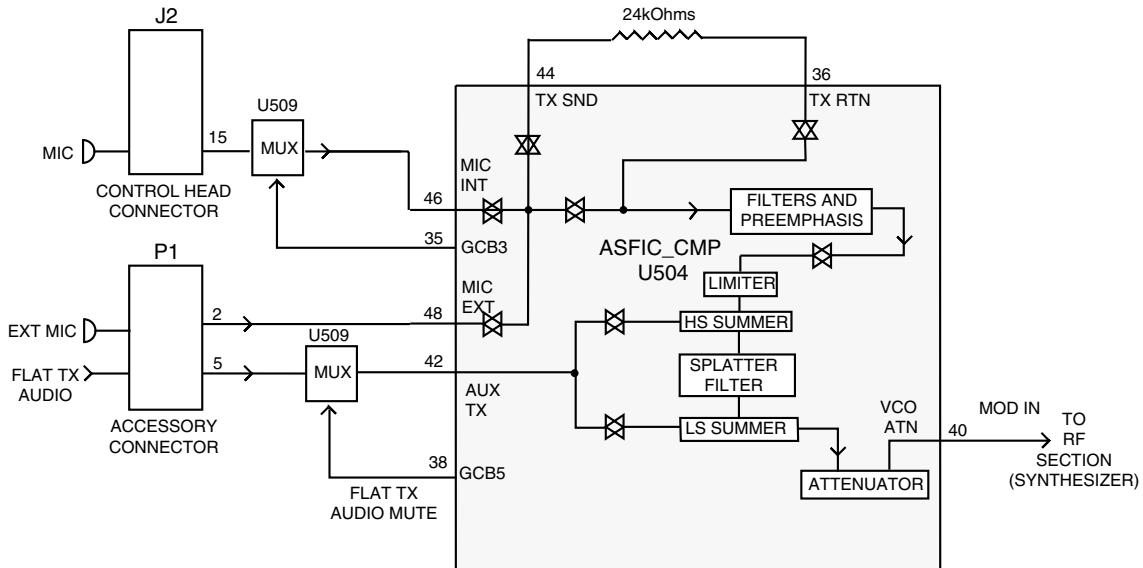


Figure 2-7 Transmit Audio Paths

7.1 Microphone Input Path

The radio supports 2 distinct microphone paths known as internal (from control head J2-15) and external mic (from accessory connector P1-2) and an auxiliary path (FLAT TX AUDIO, from accessory connector P1-5). The microphones used for the radio require a DC biasing voltage provided by a resistive network.

The two microphone audio input paths enter the ASIFC CMP at U504-pin 48 (external mic) and U504-pin 46 (internal mic). The microphone is plugged into the radio control head and connected to the audio DC via J2-pin 15. The signal is then routed via C5045 to MUX U509 that select between two paths with different gain to support Low Cost Mic (Mic with out amplifier in it) and Standard Mic.

7.1.1 Low Cost Microphone

Hook Pin is shorted to Pin 1(9.3V) inside the Low Cost Mic, This routes 9.3V to R429, and creates 2.6V on MIC_SENSE (u.P U403-67) by Voltage Divider R429/R430. U403 senses this voltage and sends command to ASIFC_CMP U504 to get GCB3 = '0'. The audio signal is routed from C5045 via U509-5 (Z0), R5072, U507, R5026, C5091, R5014 via C5046 to U504- 46 int. mic (C5046 100nF creates a 159Hz pole with U504- 46 int mic impedance of 16k ohm).

7.1.2 Standard Microphone

Hook Pin is shorted to the hook mic inside the standard Mic. If the mic is out off hook, 3.3V is routed to R429 via R458, D401, and it create 0.7V on MIC_SENSE (u.P U403-67) by Voltage Divider R429/R430. U403 senses this voltage and sends command to ASFIC_CMP U504 to get GCB3 ='1'. The audio signal is routed from C5045 via U509-3 (Z1), R5072, U507, R5026, C5091, R5014 via C5046 to U504- 46 int mic (C5046 100nF create a159Hz pole with U504- 46 int mic impedance of 16Kohm). 9.3VDC is routed via R5077, R5075 to J2-15, It create 4.65V with Mic Impedance. C5010 supplies AC Ground to create AC impedance of 510 Ohms via R5075. and Filter 9.3V DC mic bias supply.

Note: The audio signal at U504-pin 46 should be approximately 12mV for 1.5kHz or 3kHz of deviation with 12.5kHz or 25kHz channel spacing.

The external microphone signal enters the radio on accessory connector P1 pin 2 and is routed via line EXT MIC to R5054. R5078 and R5076 provide the 9.3Vdc bias. Resistive divider R5054/ R5070 divide the input signal by 5.5 and provide input protection for the CMOS amplifier input. R5076 and C5009 provide a 510 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.

C5047 serves as a DC blocking capacitor. The audio signal at U504-pin 48 should be approximately 14mV for 1.5kHz or 3kHz of deviation with 12.5kHz or 25kHz channel spacing.

The FLAT TX AUDIO signal from accessory connector P1-pin 5 is fed to the ASFIC CMP (U504 pin 42 through U509 pin 2 to U509 pin 15 via U506 OP-AMP circuit and C5057.

The ASFIC has an internal AGC that can control the gain in the mic audio path. The AGC can be disabled / enabled by the μ P. Another feature that can be enabled or disabled in the ASFIC is the VOX. This circuit, along with Capacitor C5023 at U504-pin 7, provides a DC voltage that can allow the μ P to detect microphone audio. The ASFIC can also be programmed to route the microphone audio to the speaker for public address operation.

7.2 PTT Sensing and TX Audio Processing

Internal microphone PTT is sensed by μ P U403 pin 71. Radio transmits when this pin is "0" and selects inside the ASFIC_CMP U504 internal Mic path. When the internal Mic PTT is "0" then external Mic PTT is grounded via D402. External Mic PTT is sensed by U403 pin 72 via Q412 circuits. The radio transmits when this pin is "0" and selects inside the ASFIC_CMP U504 External Mic path.

Inside the ASFIC CMP, the mic 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 mic audio is then routed through a summer, which is used to add in signaling 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 U504-pin 40 MOD IN, at which point it is routed to the RF section.

8.0 Transmit Signalling Circuits

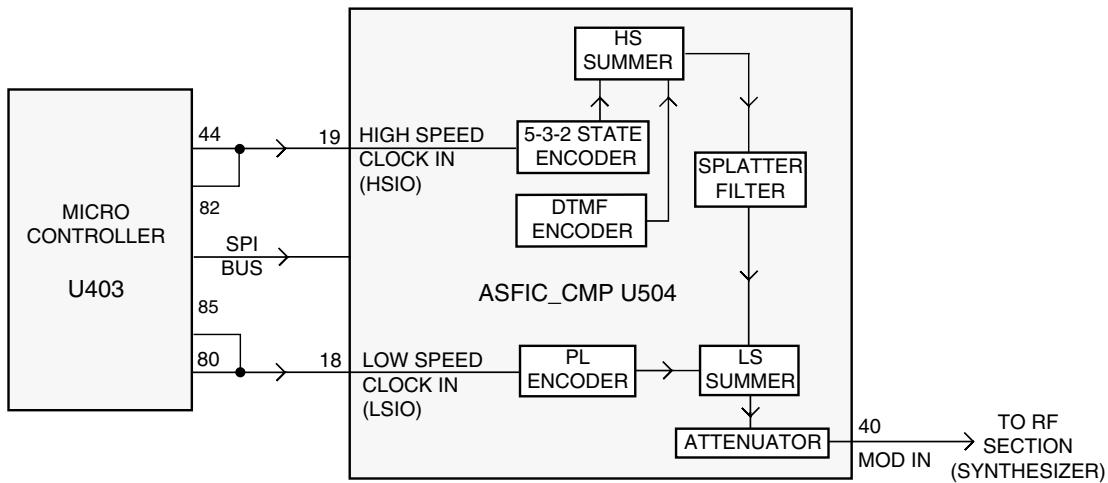


Figure 2-8 Transmit Signalling Path

From a hardware point of view, there are 3 types of signaling:

- Sub-audible data (PL / DPL / Connect Tone) that gets summed with transmit voice or signaling,
- DTMF data for telephone communication in trunked and conventional systems, and
- Audible signaling including MDC and high-speed trunking.

Note: All three types are supported by the hardware while the radio software determines which signaling type is available.

8.1 Sub-Audio Data (PL/DPL)

Sub-audible data implies signaling whose bandwidth 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 U504 (ASFIC CMP) at any one time. The process is as follows, using the SPI BUS, the μ P programs the ASFIC CMP to set up the proper low-speed data deviation and select the PL or DPL filters. The μ P then generates a square wave which strobes the ASFIC PL / DPL encode input LSIO U504-pin 18 at twelve times the desired data rate. For example, for a PL frequency of 103Hz, the frequency of the square wave would be 1236Hz.

This drives a tone generator inside U504 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 U504-pin 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.

8.2 High Speed Data

High speed data refers to the 3600 baud data waveforms, known as Inbound Signaling Words (ISWs) used in a trunking system for high speed communication between the central controller and the radio. To generate an ISW, the μ P first programs the ASFIC CMP (U504) to the proper filter and gain settings. It then begins strobing U504-pin 19 (HSIO) with a pulse when the data is supposed to change states. U504'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 attenuator and then out of the ASFIC CMP to the RF board. MDC is 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 signaling schemes are based on sending a combination of 1200 Hz and 1800 Hz tones only. Microphone audio is muted during high speed data signaling.

8.3 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 μ P (U403-46) strobing U504-19 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 μ P via SPI bus. Inside U504 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 was described for high-speed data.

9.0 Receive Audio Circuits

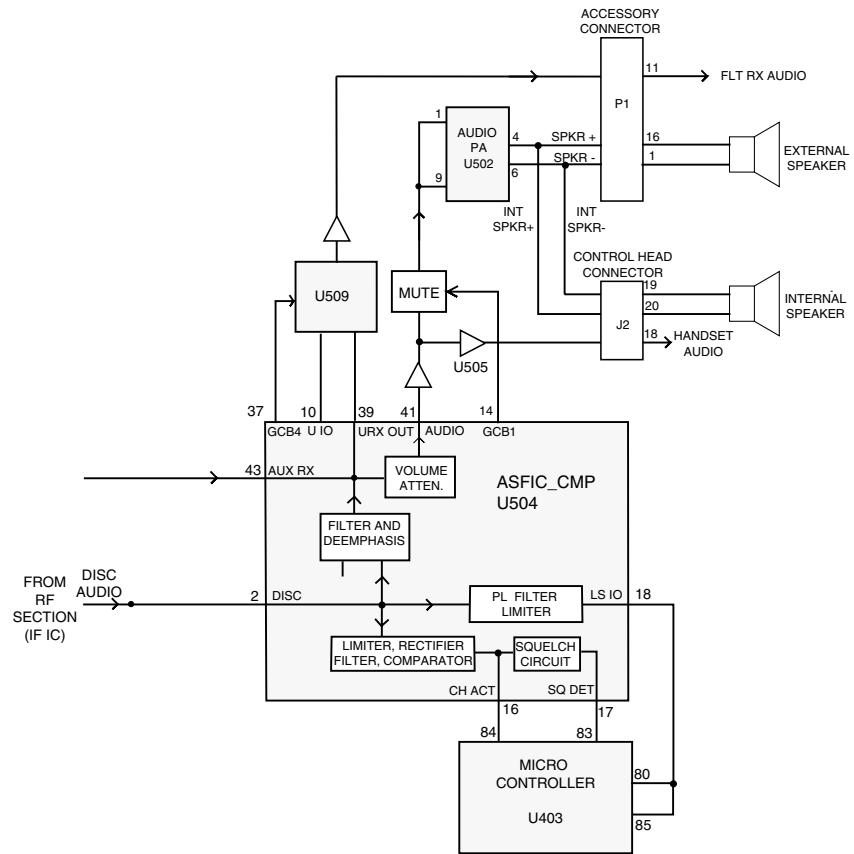


Figure 2-9 Receive Audio Paths

9.1 Squelch Detect

The radio's RF circuits are constantly producing an output at the discriminator (IF IC). This signal (DISC AUDIO) is routed to the ASFiC CMP's squelch detect circuitry input DISC (U504-pin 2). All of the squelch detect circuitry is contained within the ASFiC CMP. Therefore from a user's point of view, DISC AUDIO enters the ASFiC CMP, and the ASFiC CMP produces two CMOS logic outputs based on the result. They are CH ACT (U504-16) and SQ DET (U504-17).

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 on CH ACT. A squelch tail circuit is used to produce SQ DET (U504-17) from CH ACT. The state of CH ACT and SQ DET is high (logic "1") when carrier is detected, otherwise low (logic "0").

CH ACT is routed to the μ P pin 84 while SQ DET is routed to the μ P pin 83.

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.

9.2 Audio Processing and Digital Volume Control

The receiver audio signal (DISC AUDIO) enters the controller section from the IF IC where it is DC coupled to ASFIC CMP via the DISC input U504-pin 2. The signal is then applied to both the audio and the PL/DPL paths

The audio path has a programmable amplifier, whose setting is based on the channel bandwidth being received, an LPF filter to remove any frequency components above 3000Hz, and a HPF to strip off any sub-audible data below 300Hz. Next, 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 IC then passes the audio through the 8-bit programmable attenuator whose level is set depending on the value of the volume control. Finally the filtered audio signal passes through an output buffer within the ASFIC CMP. The audio signal exits the ASFIC CMP at AUDIO output (U504 pin 41).

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

Since sub-audible signaling is summed with voice information on transmit, it must be separated from the voice information before processing. Any sub-audible signaling enters the ASFIC CMP from the IF IC at DISC U504-2. Once inside, it goes through the PL/DPL path. The signal first passes through one of the two low-pass filters, either the PL low-pass filter or the DPL/LST low-pass filter. Either signal is then filtered and goes through a limiter and exits the ASFIC CMP at LSIO (U504-pin 18). At this point, the signal will appear as a square wave version of the sub-audible signal which the radio received. The μP U403 pin 80 will decode the signal directly to determine if it is the tone / code which is currently active on that mode.

9.3 Audio Amplification Speaker (+) Speaker (-)

The output of the ASFIC CMP's digital volume pot, U504-pin 41 is routed through DC blocking capacitor C5049 to the audio PA (U502 pin 1 and 9).

The audio power amplifier has one inverted and one non-inverted output that produces the differential audio output SPK+/SPK- (U502 pins 4 and 6)

The audio PA is enabled via the ASFIC CMP (U504-GCB1). When the base of Q501 is low, the transistor is off and U502-pin 8 is high, using pull up resistor R5041, and the audio PA is ON. The voltage at U502-pin 8 must be above 8.5Vdc to properly enable the device.

If the voltage is between 3.3 and 6.4V, the device will be active but has its input (U502-pins 1/9) off. This is a mute condition which is used to prevent an audio pop when the PA is enabled.

The SPK+ and SPK- outputs of the audio PA have a DC bias which varies proportionately with B+ (U502- pin 7). B+ of 11V yields a DC offset of 5V, and B+ 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 will be damaged. SPK+ and SPK- are routed to the accessory connector (P1-pin 1 and 16) and to the control head (connector J2-pins 19 and 20).

9.4 Handset Audio

Certain handheld accessories have a speaker within them which require a different voltage level than that provided by U502. For these devices HANDSET AUDIO is available at control head connector J2 pin18.

The received audio from the output of the ASIC CMP's digital volume attenuator is routed to U505 pin 2 where it is amplified. This signal is routed from the output of the op-amp U505 to J2-pin 18. From the control head, the signal is sent directly to the microphone jack.

9.5 Filtered Audio and Flat Audio

The ASIC CMP output audio at U504-pin 39 is filtered and de-emphasized, but has not gone through the digital volume attenuator. From ASIC CMP U504-pin 39 the signal is routed via R5034 through gate U509-pin 12 and AC coupled to U505-pin 6. The gate controlled by ASIC CMP port GCB4 selects between the filtered audio signal from the ASIC CMP pin 39 (URXOUT) or the unfiltered (flat) audio signal from the ASIC CMP pin 10 (UIO). Resistors R5034 and R5021 determine the gain of op-amp UU505-pin 6 for the filtered audio while R5032 and R5021 determine the gain for the flat Audio. The output of U505-pin 7 is then routed to P1 pin 11 via DC blocking capacitor C5003. Note that any volume adjustment of the signal on this path must be done by the accessory.

10.0 Receive Signalling Circuits

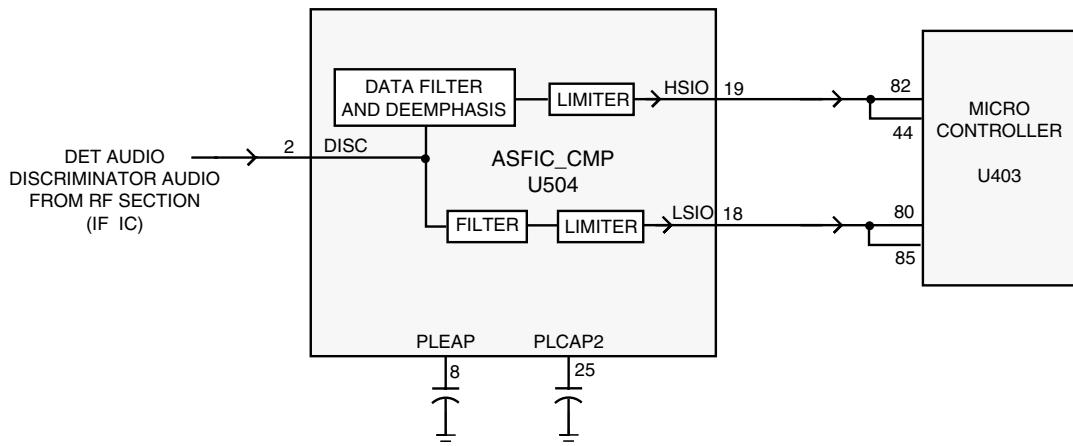


Figure 2-10 Receive Signalling Paths

10.1 Sub-Audio Data (PL/DPL) and High Speed Data Decoder

The ASIC CMP (U504) is used to filter and limit all received data. The data enters the ASIC CMP at input DISC (U504 pin 2). Inside U504 the data is filtered according to data type (HS or LS), then it is limited to a 0-3.3V digital level. The MDC and trunking high speed data appear at U504-pin 19, where it connects to the μ P U403 pin 82.

The low speed limited data output (PL, DPL, and trunking LS) appears at U504-pin18, where it connects to the μ P U403-pin 80.

The low speed data is read by the μ 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 C5028, and C5026 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.

10.2 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 U504 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 μ 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 μ P can generate any tone within the 100-3000Hz audio band. This is accomplished by the μ P generating a square wave which enters the ASFIC CMP at U504 pin 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 U504, 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 U504-pin 41 and is routed to the audio PA like receive audio.

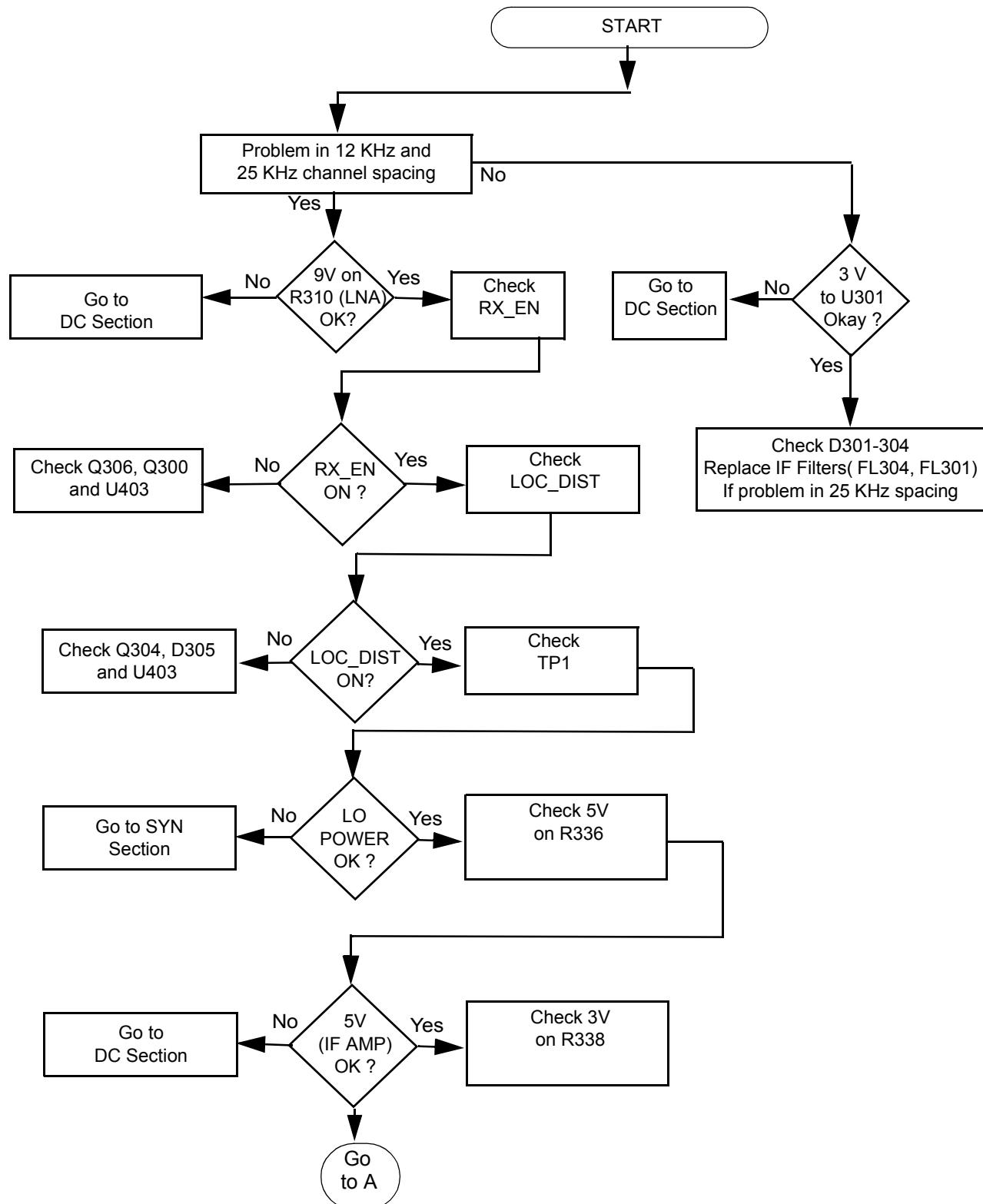
Chapter 3

TROUBLESHOOTING CHARTS

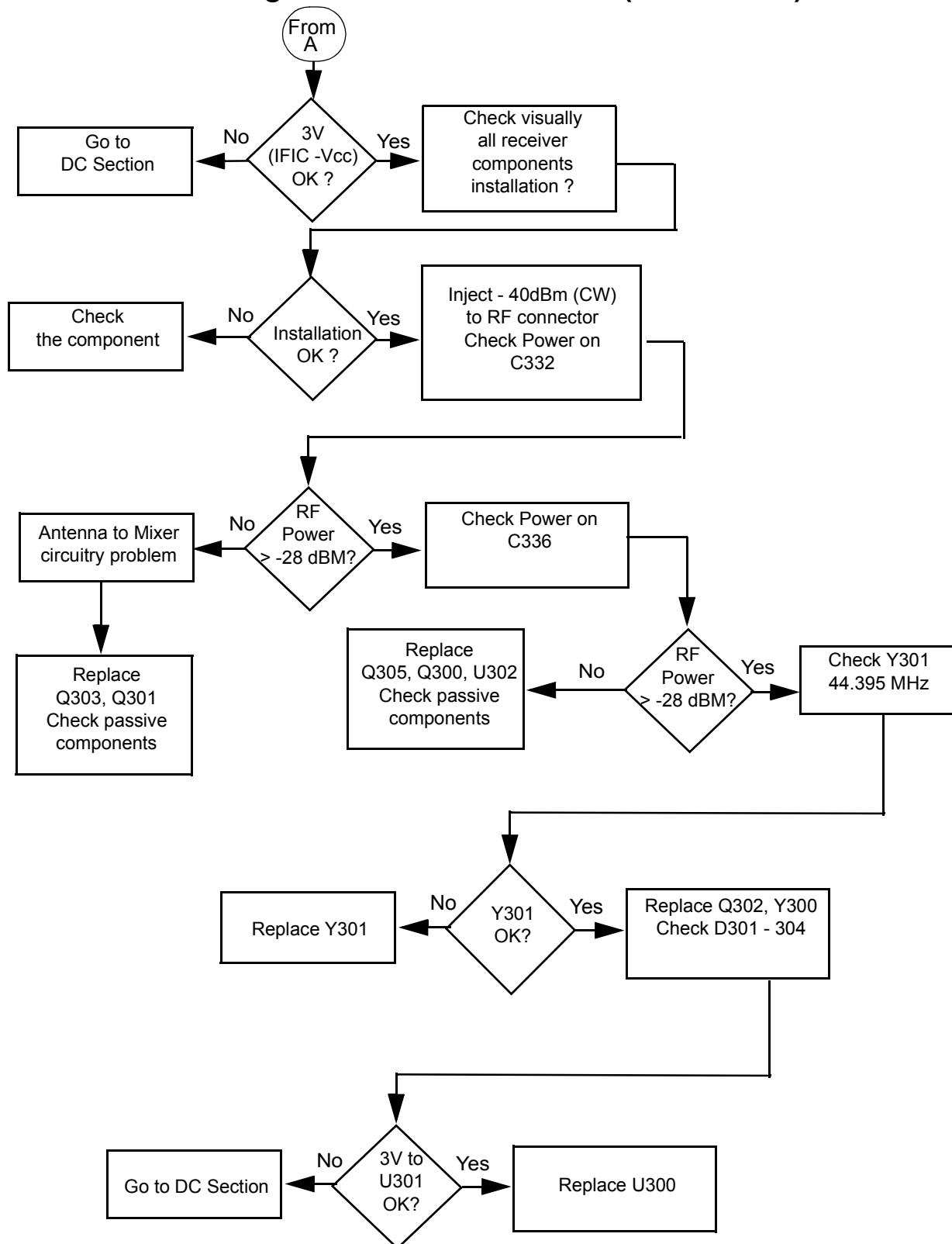
This section contains detailed troubleshooting flowcharts. These charts should be used as a guide in determining the problem areas. They are not a substitute for knowledge of circuit operation and astute troubleshooting techniques. It is advisable to refer to the related detailed circuit descriptions in the theory of operation sections prior to troubleshooting a radio.

Most troubleshooting charts end up by pointing to an IC to replace. It is not always noted, but it is good practice to verify supplies and grounds to the affected IC and to trace continuity to the malfunctioning signal and related circuitry before replacing any IC. For instance, if a clock signal is not available at a destination, continuity from the source IC should be checked before replacing the source IC.

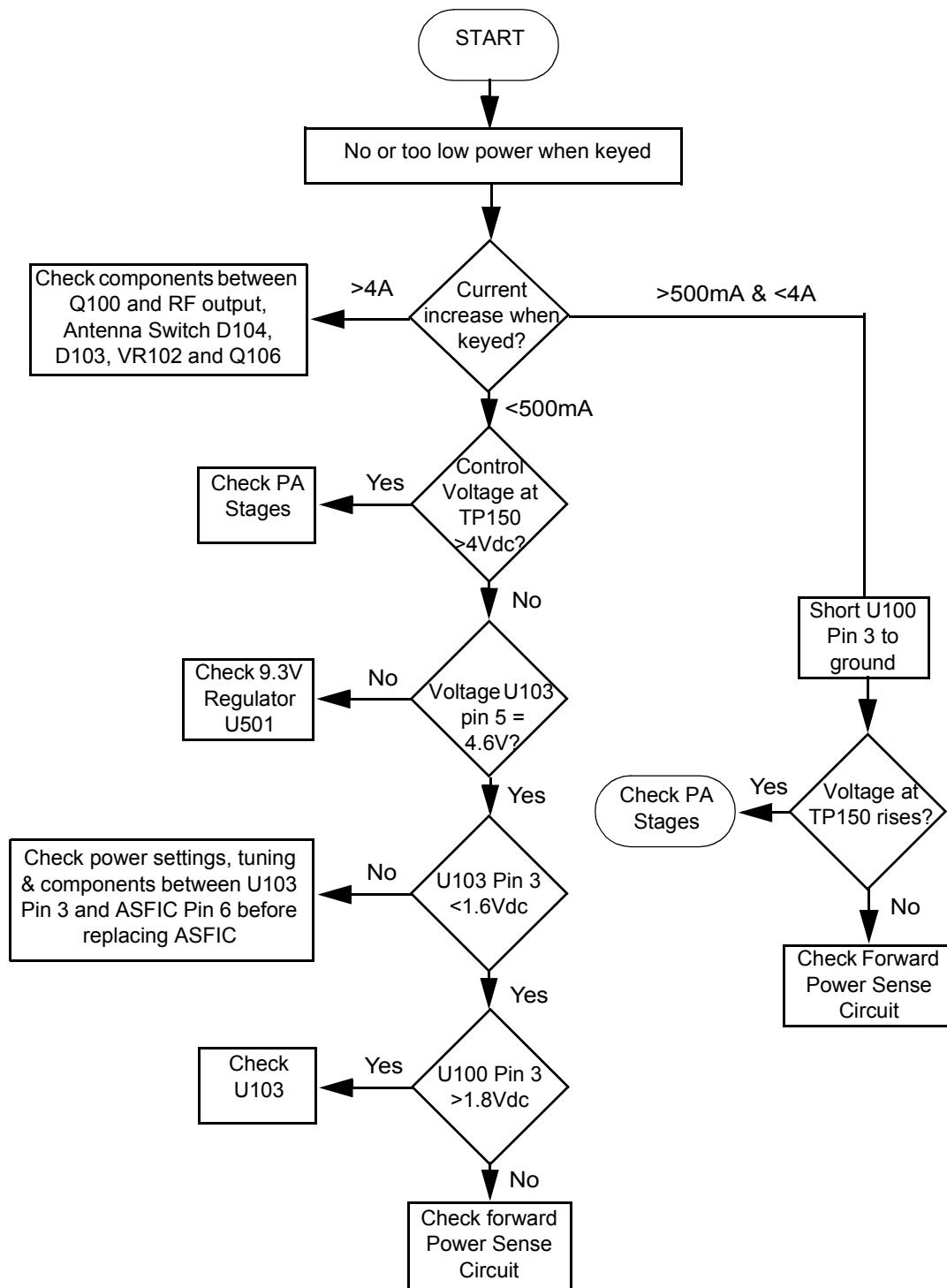
1.0 Troubleshooting Flow Chart for Receiver RF (Sheet 1 of 2)



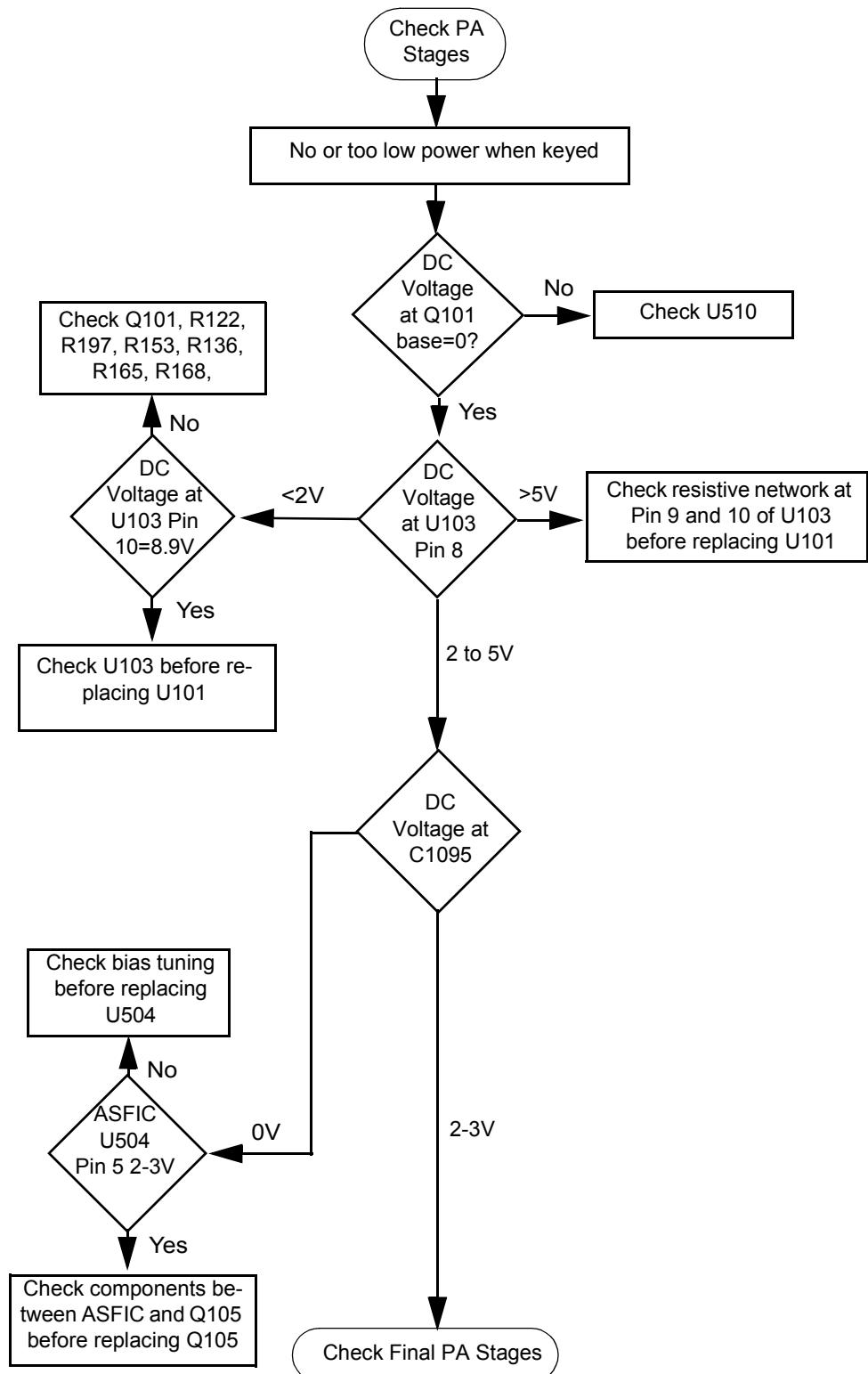
1.1 Troubleshooting Flow Chart for Receiver (Sheet 2 of 2)



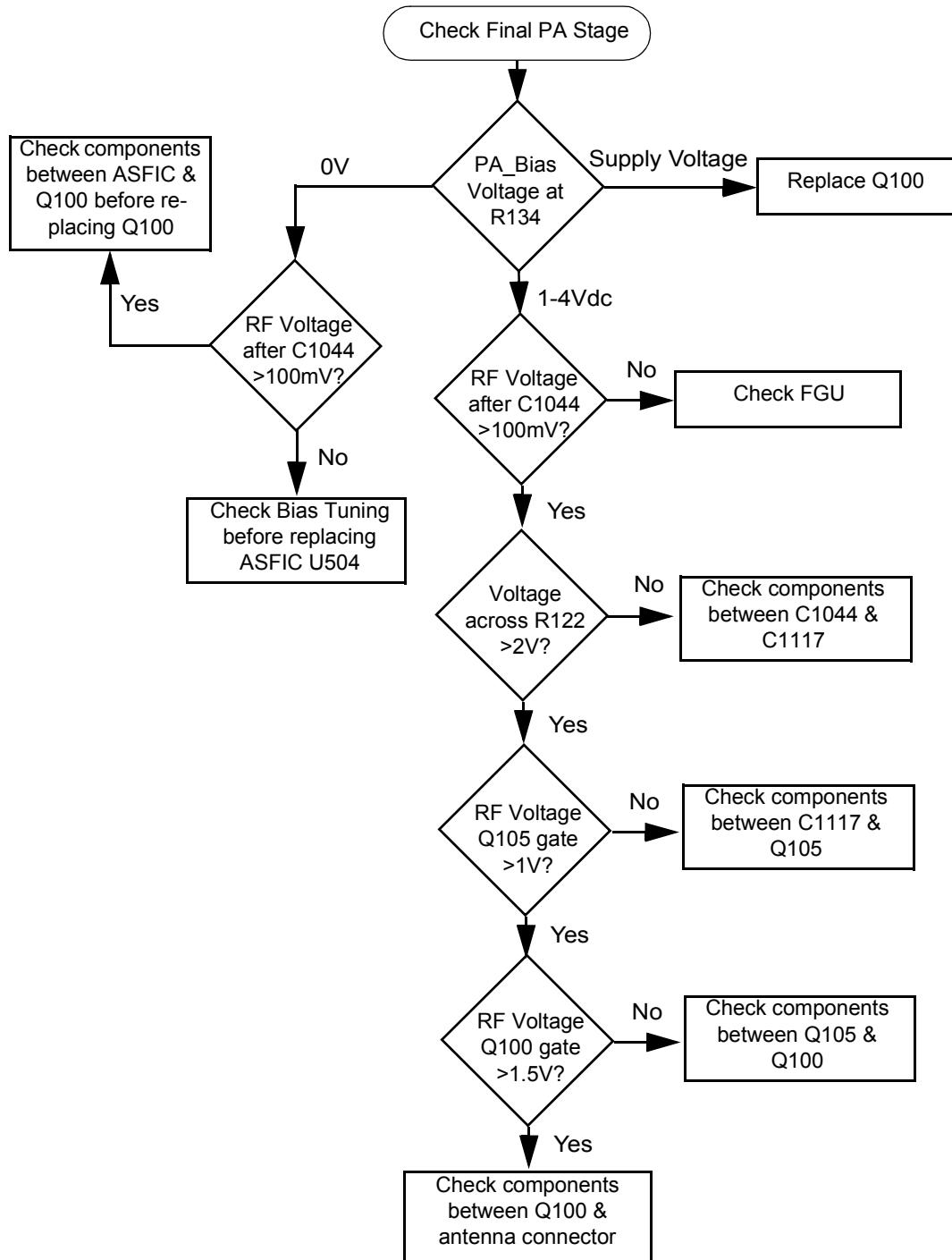
2.0 Troubleshooting Flow Chart for 45W Transmitter (Sheet 1 of 3)



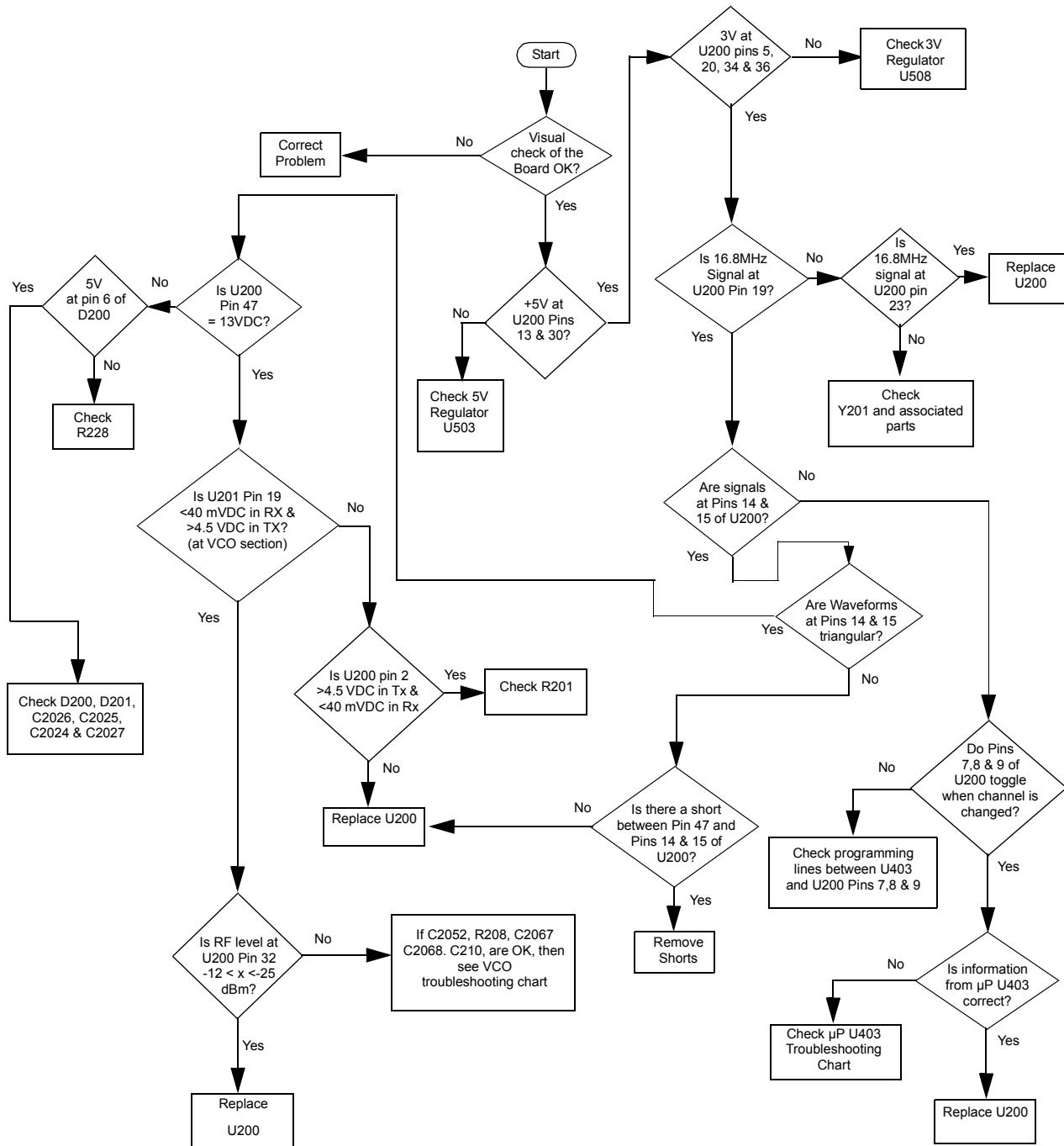
2.1 Troubleshooting Flow Chart for 45W Transmitter (Sheet 2 of 3)



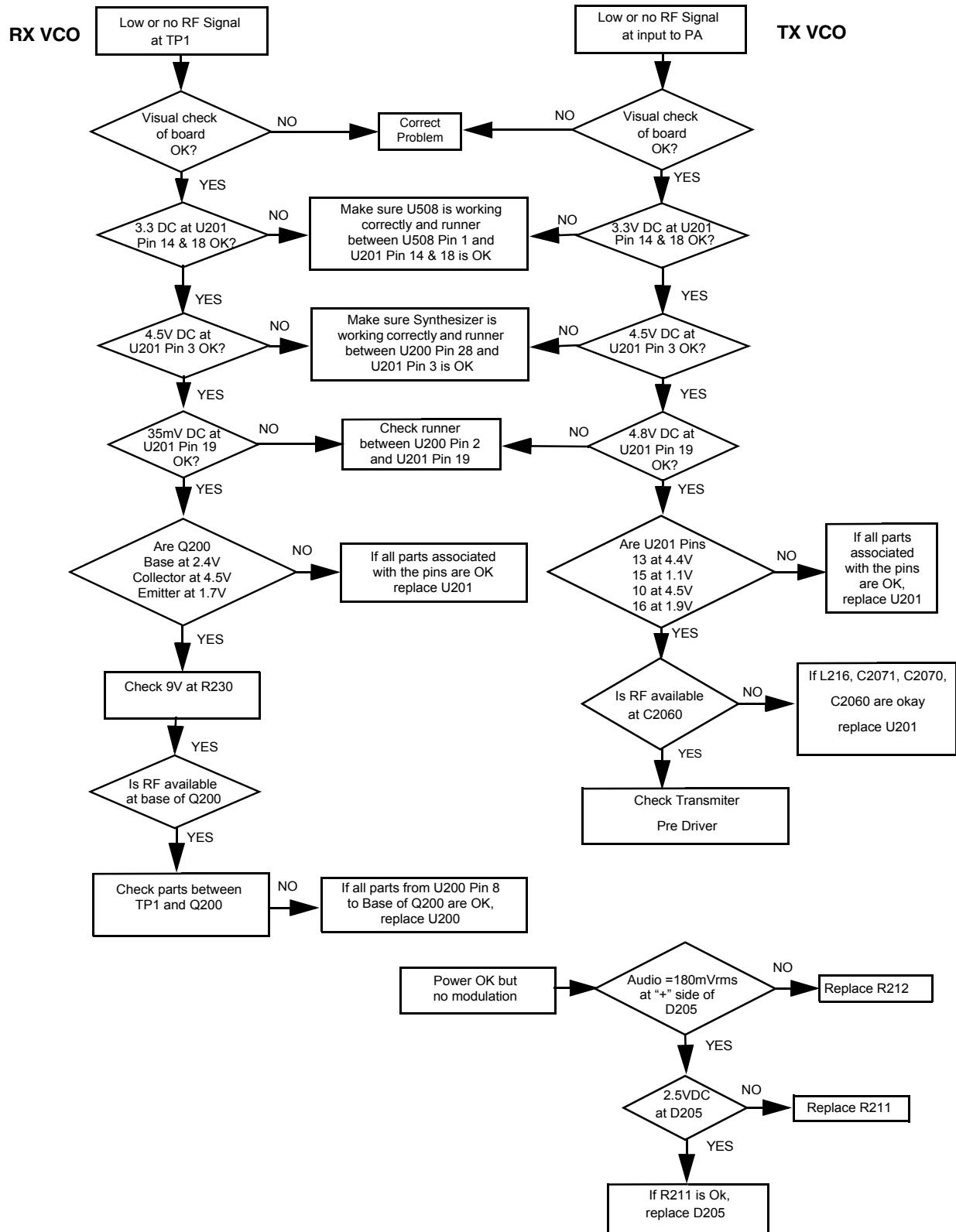
2.2 Troubleshooting Flow Chart for 45W Transmitter (Sheet 3 of 3)



3.0 Troubleshooting Flow Chart for Synthesizer

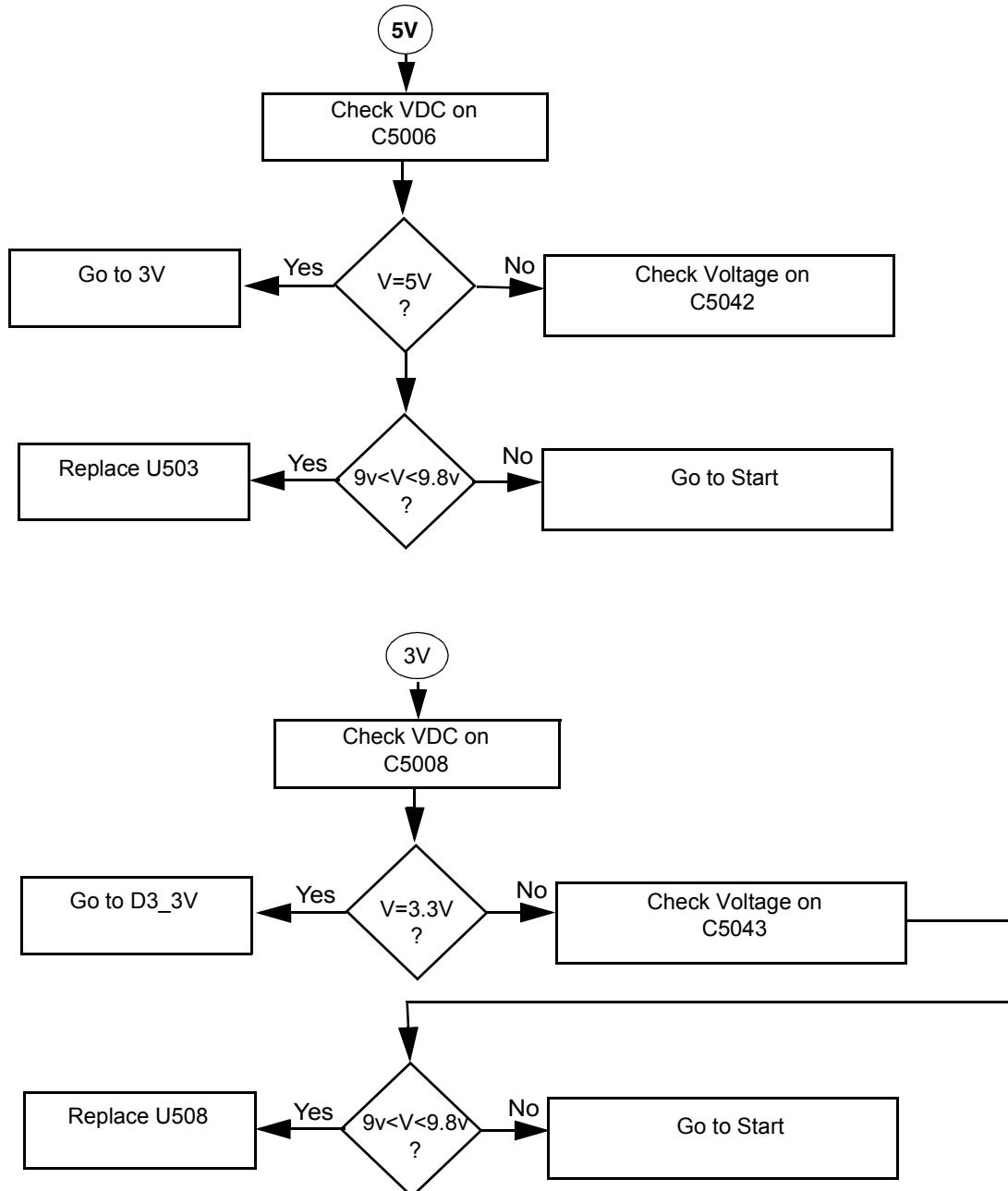


4.0 Troubleshooting Flow Chart for VCO

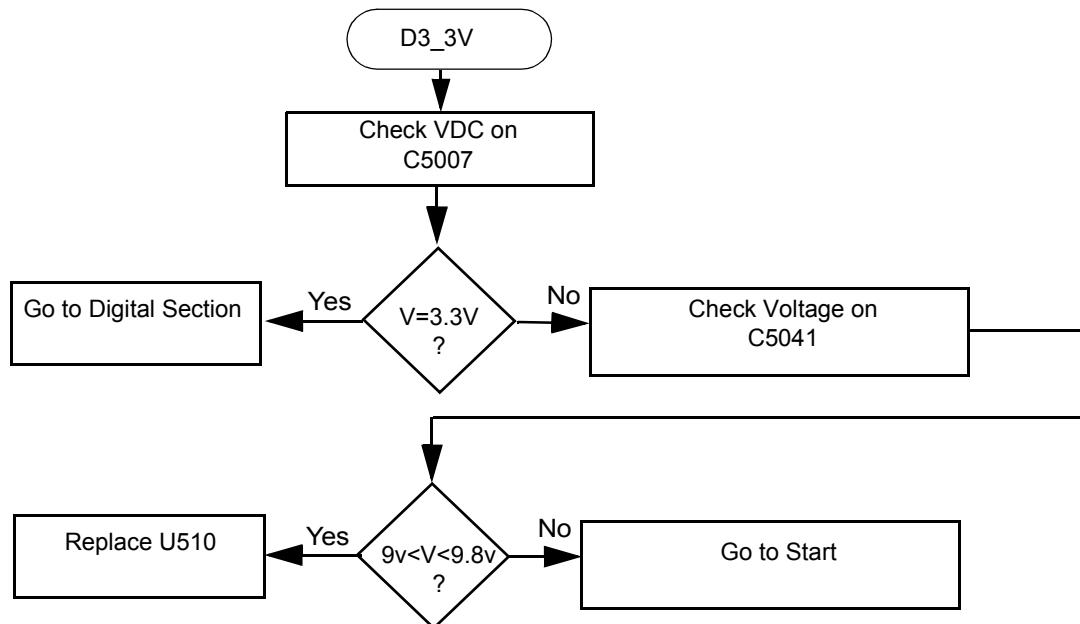


5.0 Troubleshooting Flow Chart for DC Supply (1 of 2)

Since the failure of a critical voltage supply might cause the radio to automatically power down, supply voltages should first be probed with a multimeter. If all the board voltages are absent, then the voltage test point should be retested using a rising-edge-triggered oscilloscope. If the voltage is still absent, then another voltage should be tested using the oscilloscope. If that voltage is present, then the original voltage supply in question is defective and requires investigation of associated circuitry.



5.1 Troubleshooting Flow Chart for DC Supply (2 of 2)



Chapter 4

VHF2 PCB/ SCHEMATICS/ PARTS LISTS

1.0 Allocation of Schematics and Circuit Boards

1.1 VHF2 and Controller Circuits

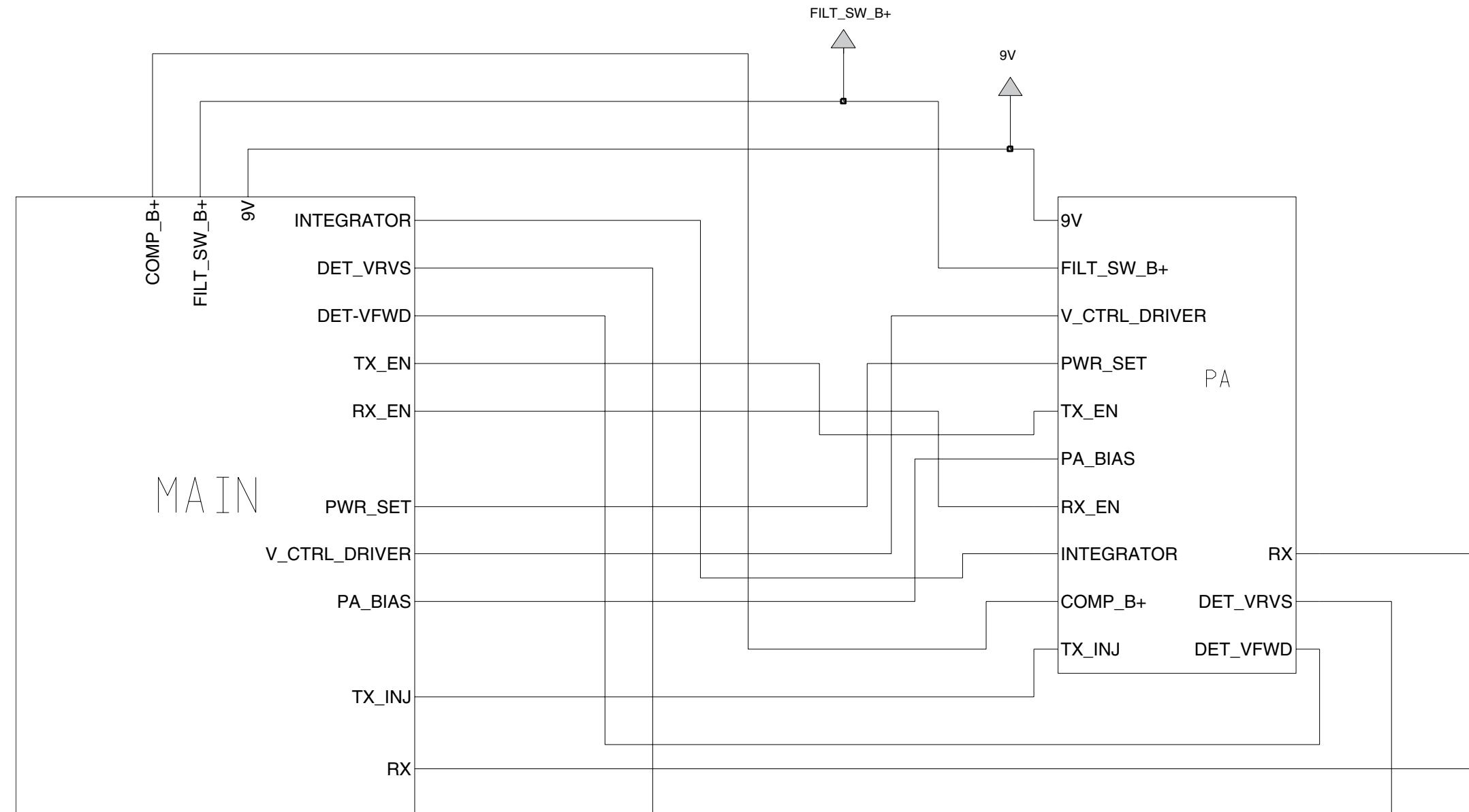
The VHF circuits are contained on the printed circuit board (PCB) which also contains the Controller circuits. This Chapter shows the schematics for both the VHF circuits and the Controller circuits. The PCB component layouts and the Parts Lists in this Chapter show both the Controller and VHF circuit components. The VHF and Controller schematics and the related PCB and parts list are shown in the tables below.

Table 4-1 VHF2 25-45W Diagrams and Parts Lists

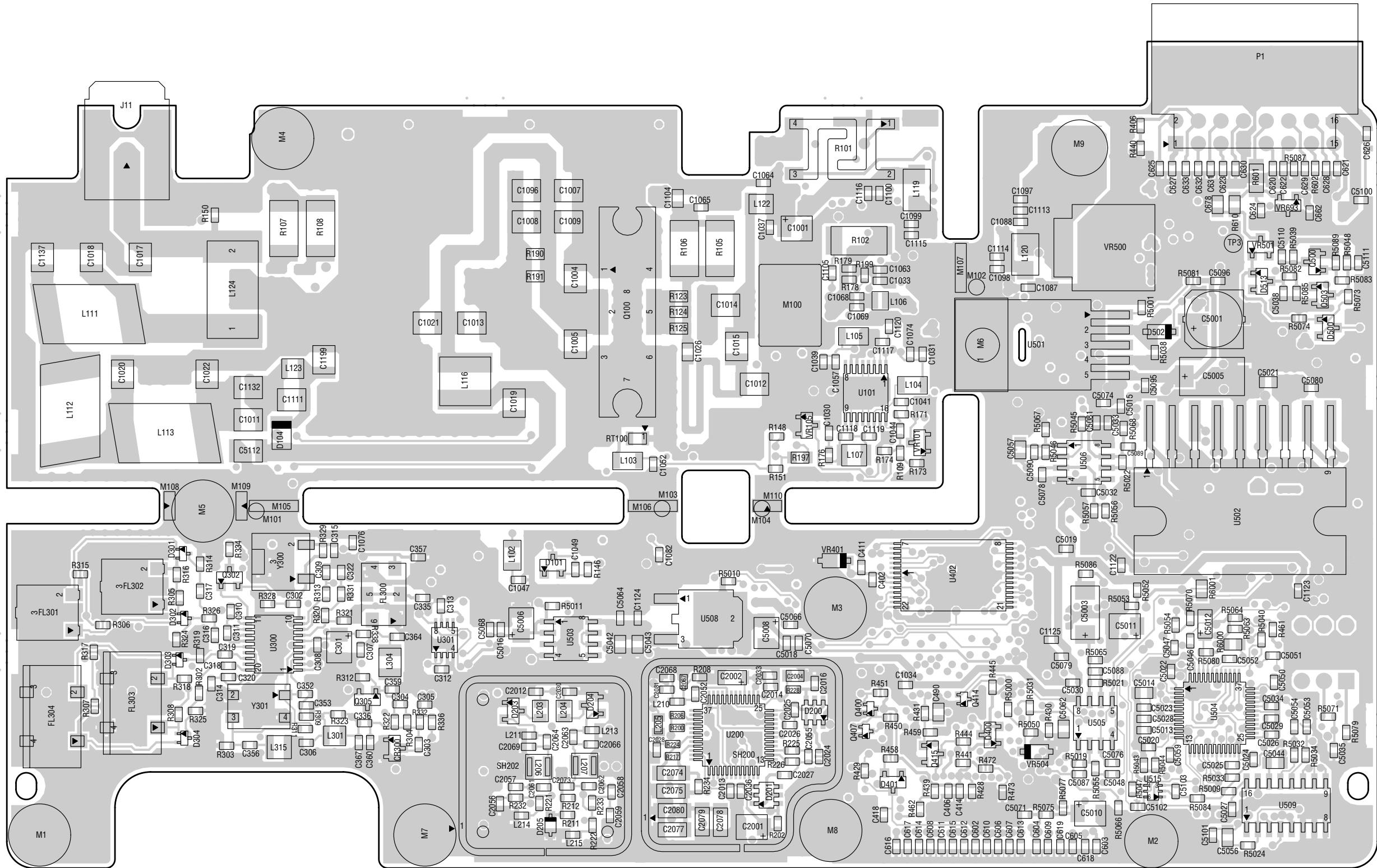
PCB : 8486487Z03-B Main Board Top Side 8486487Z03-B Main Board Bottom Side	Page 4-4 Page 4-5
SCHEMATICS Main Circuit Transmitter Synthesiser and VCO Receiver Front and Back End DC and Audio Ccts Microprocessor and Controller Ccts Power Control Cct	Page 4-6/Page 4-7 Page 4-8/Page 4-9 Page 4-10/Page 4-11 Page 4-12/Page 4-13 Page 4-14/Page 4-15 Page 4-16/Page 4-17 Page 4-18
Parts List 8486487Z03-B	Page 4-19
Controller version is T1	

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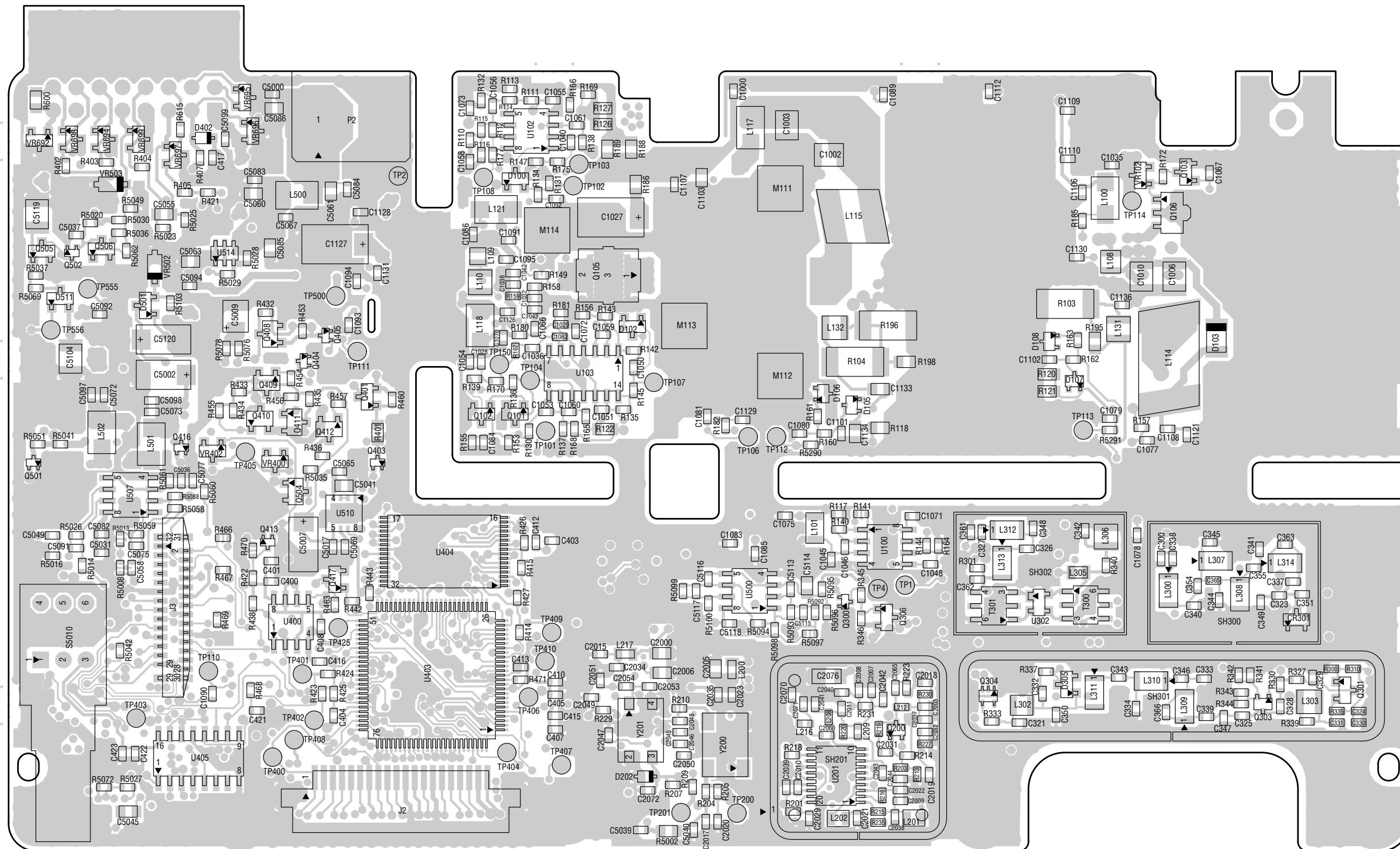
2.0 VHF 25-45W Band 2 PCB 8486487Z03-B / Schematics



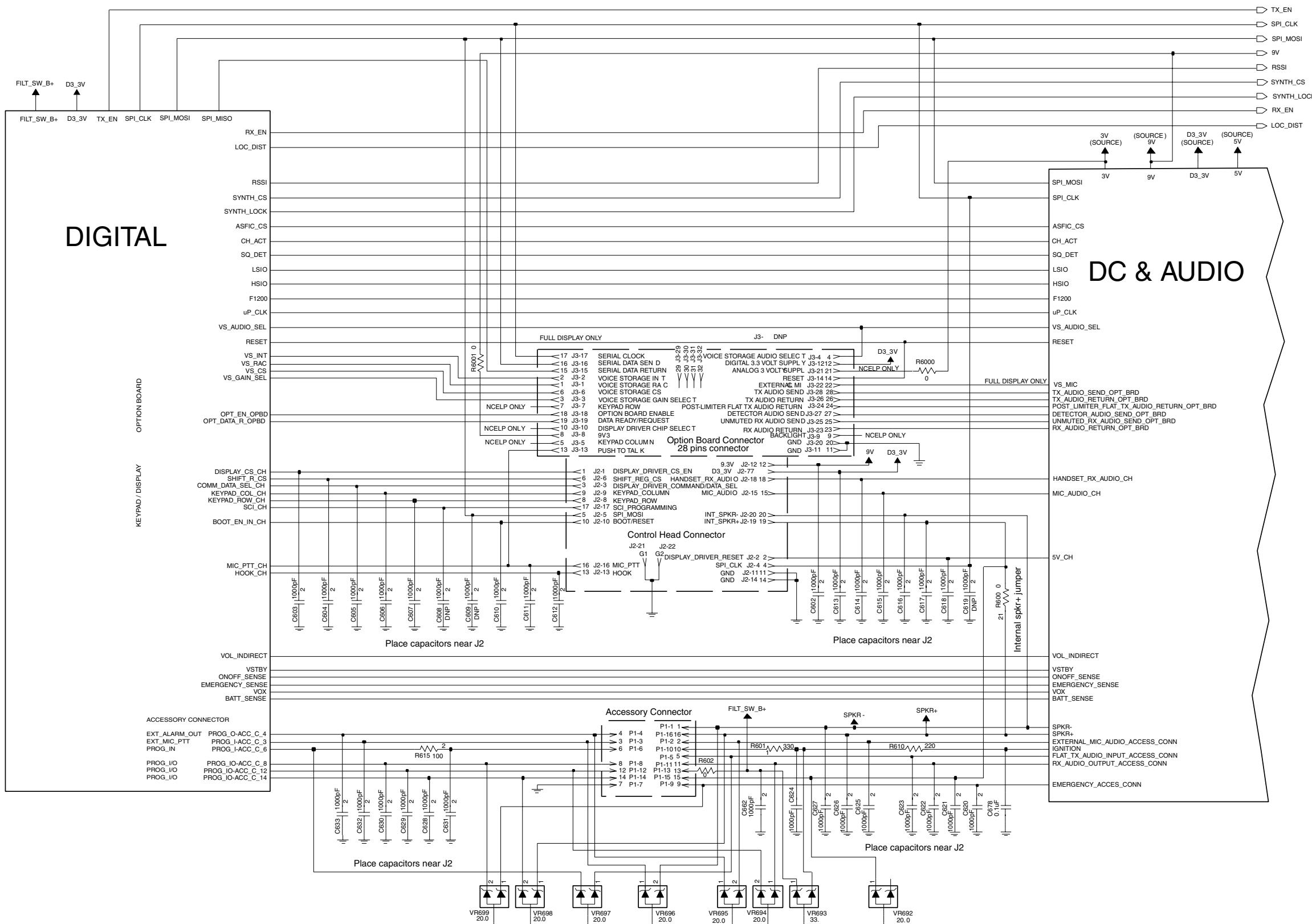
VHF2 Interconnection between Main Board and Power Amplifier Compartment



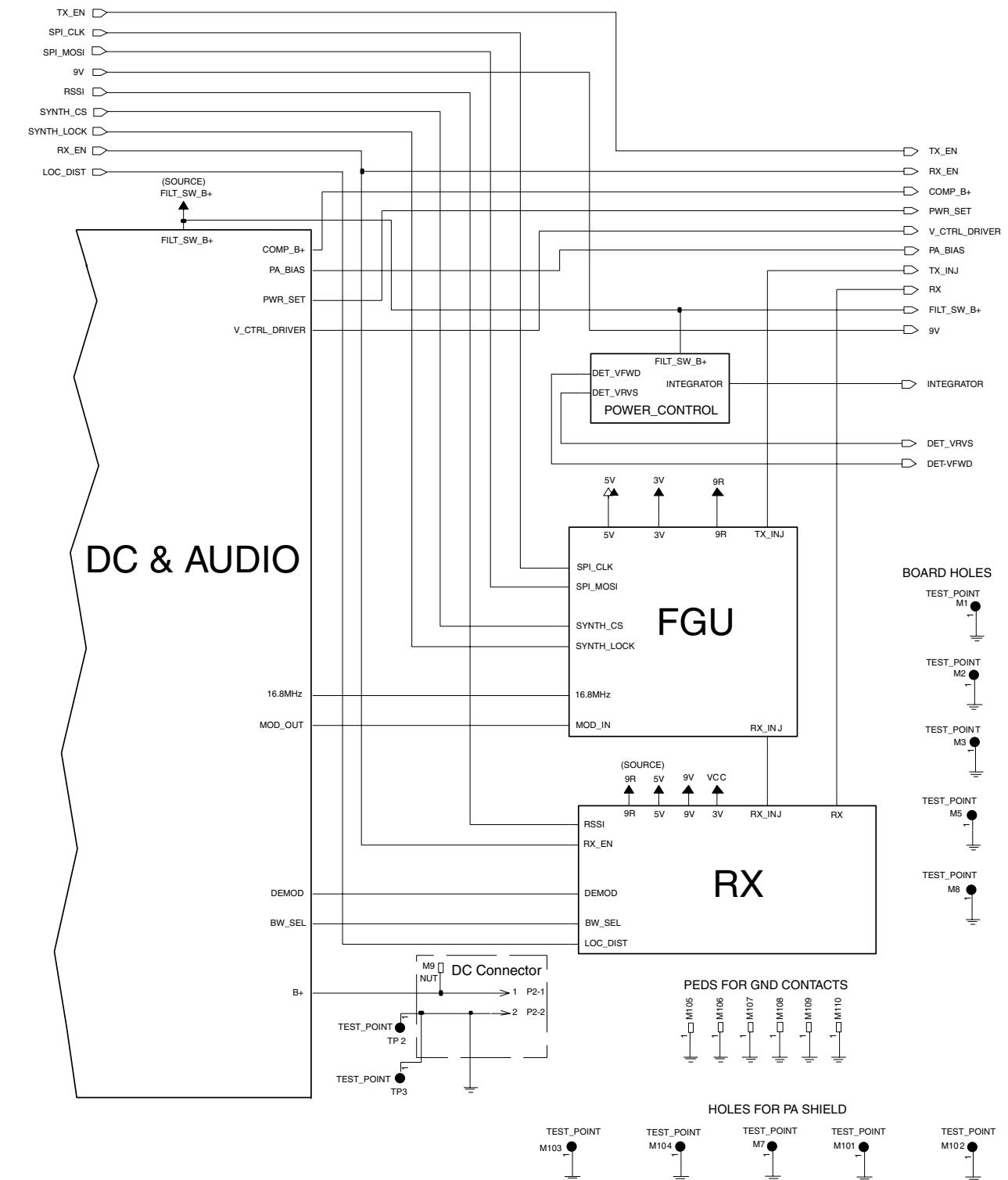
VHF2 (146-174MHz) 25-45W 8486487Z03-B Top Side



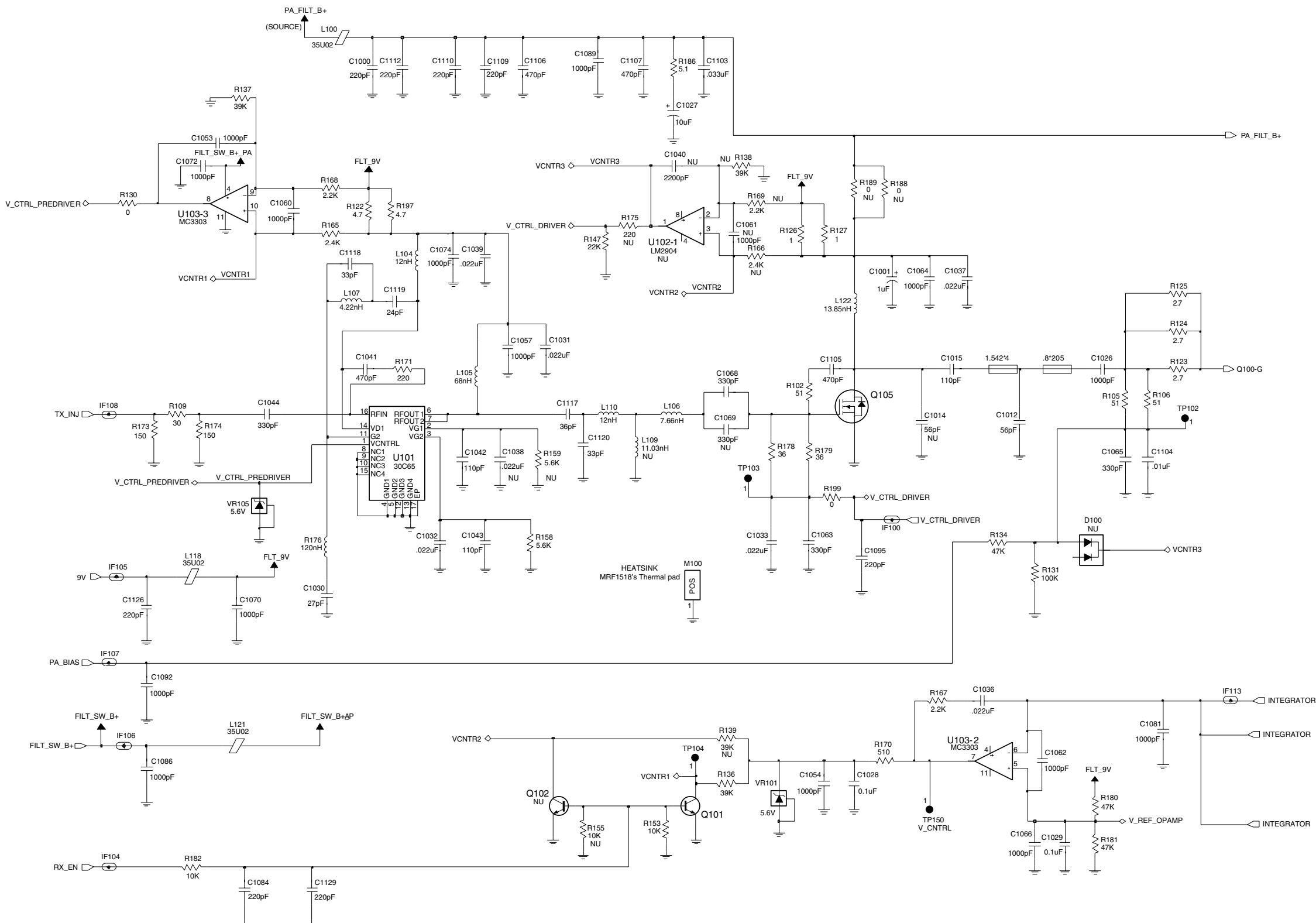
VHF2 (146-174MHz) 25-45W 8486487Z03-B Bottom Side



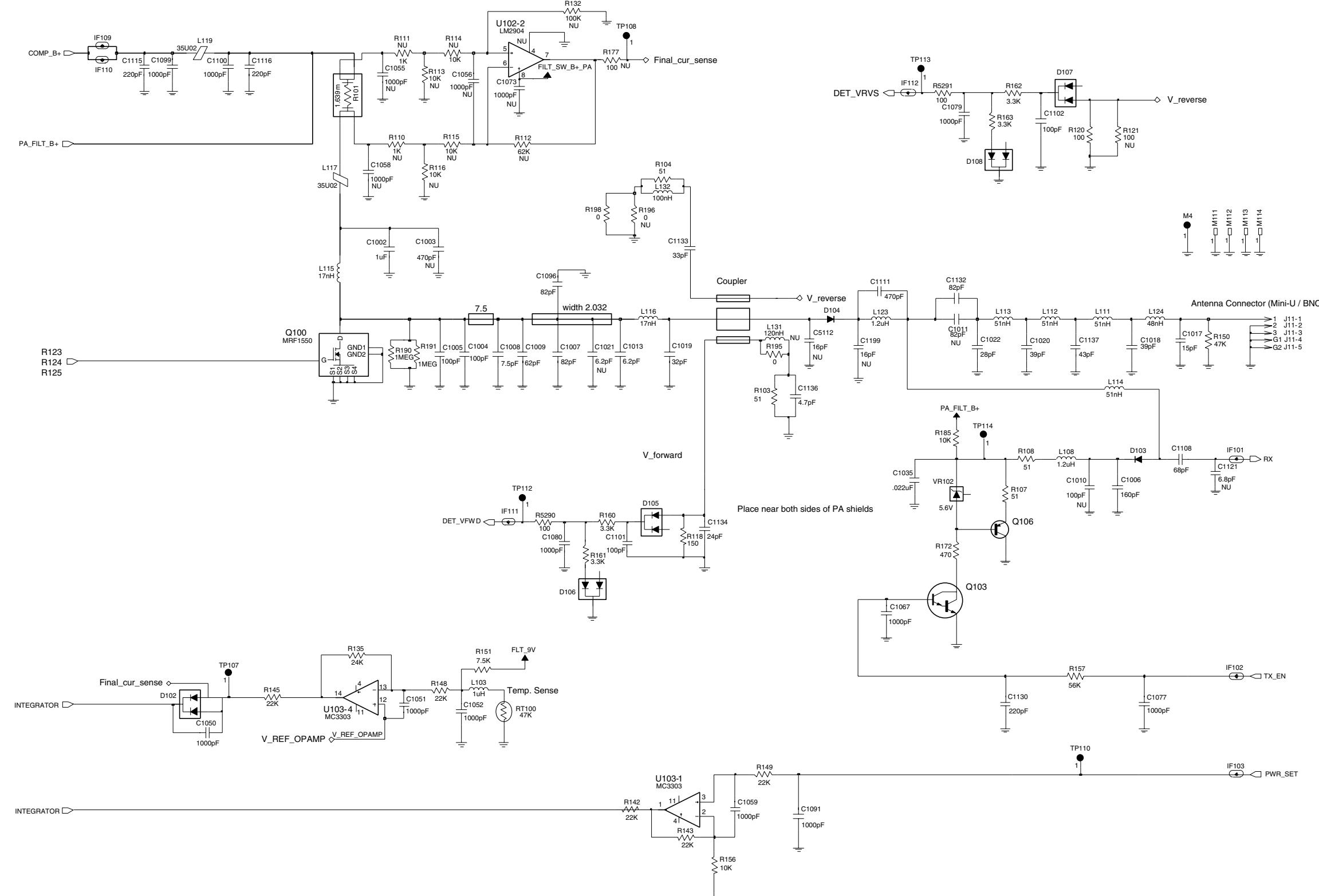
VHF2 (146-174MHz) 25-45W Main Circuit (Sht 1 of 2)



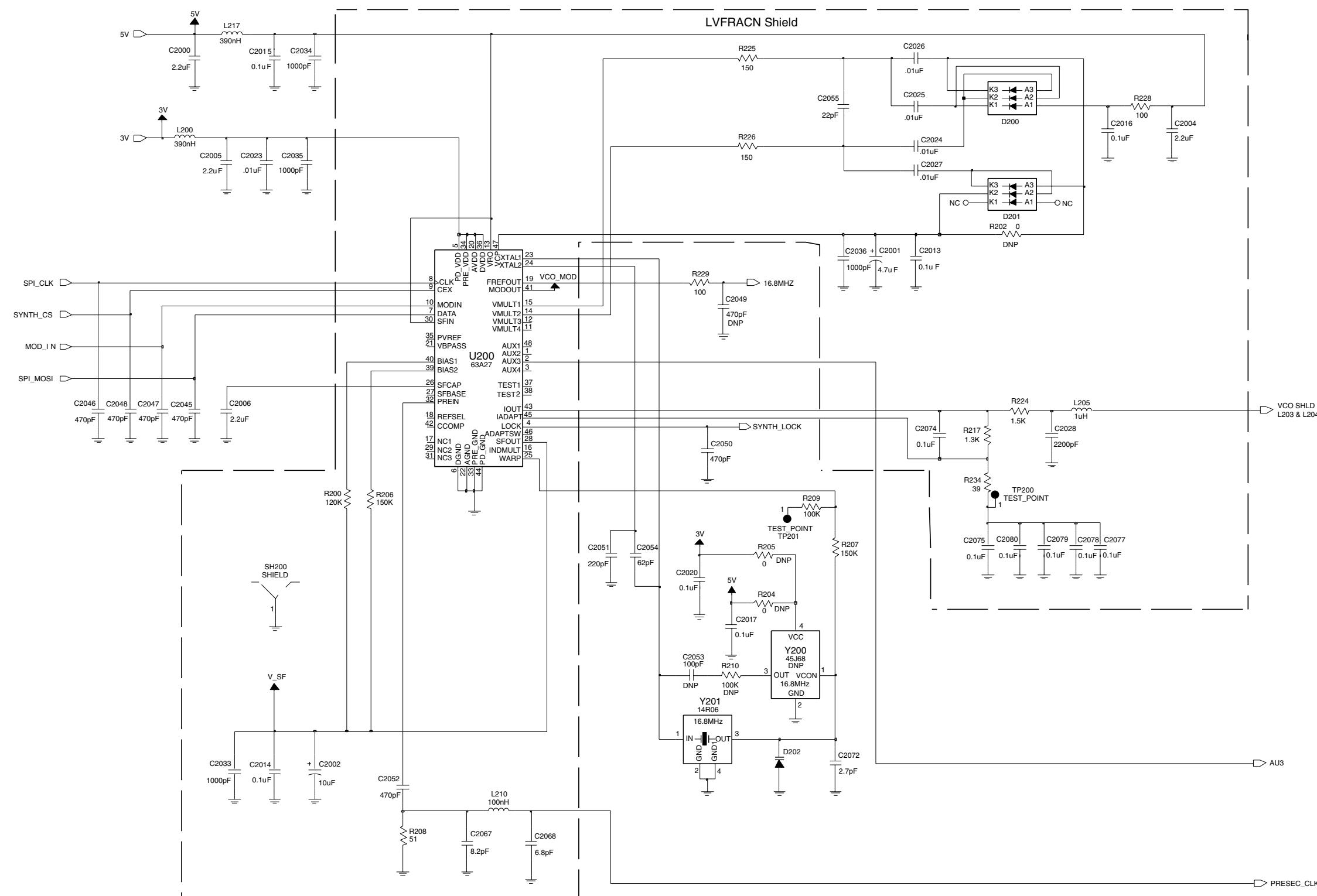
VHF2 (146-174MHz) 25-45W Main Circuit (Sht 2 of 2)



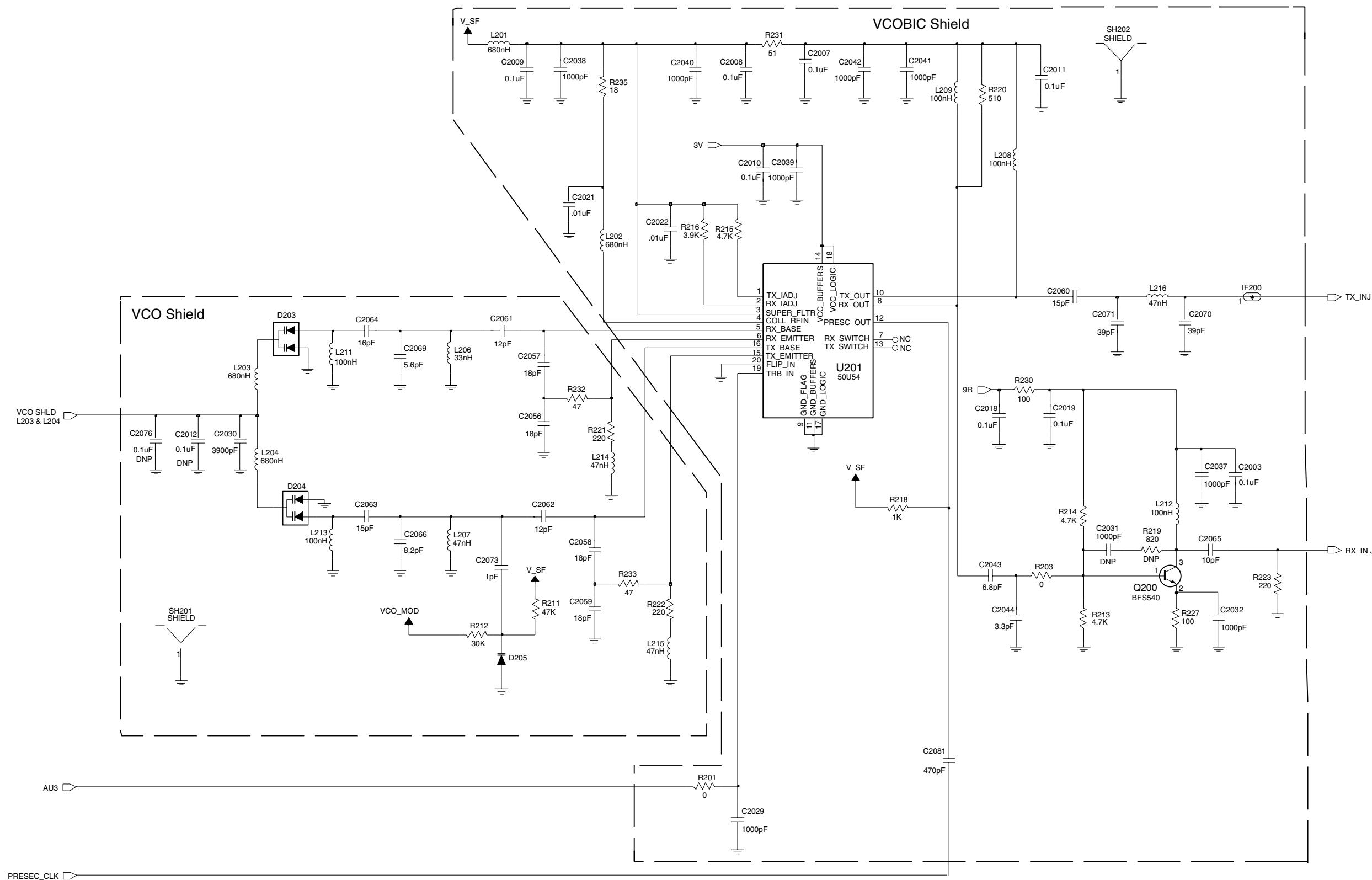
VHF2 (146-174MHz) 25-45WT ransmitter (Sht 1 of 2)



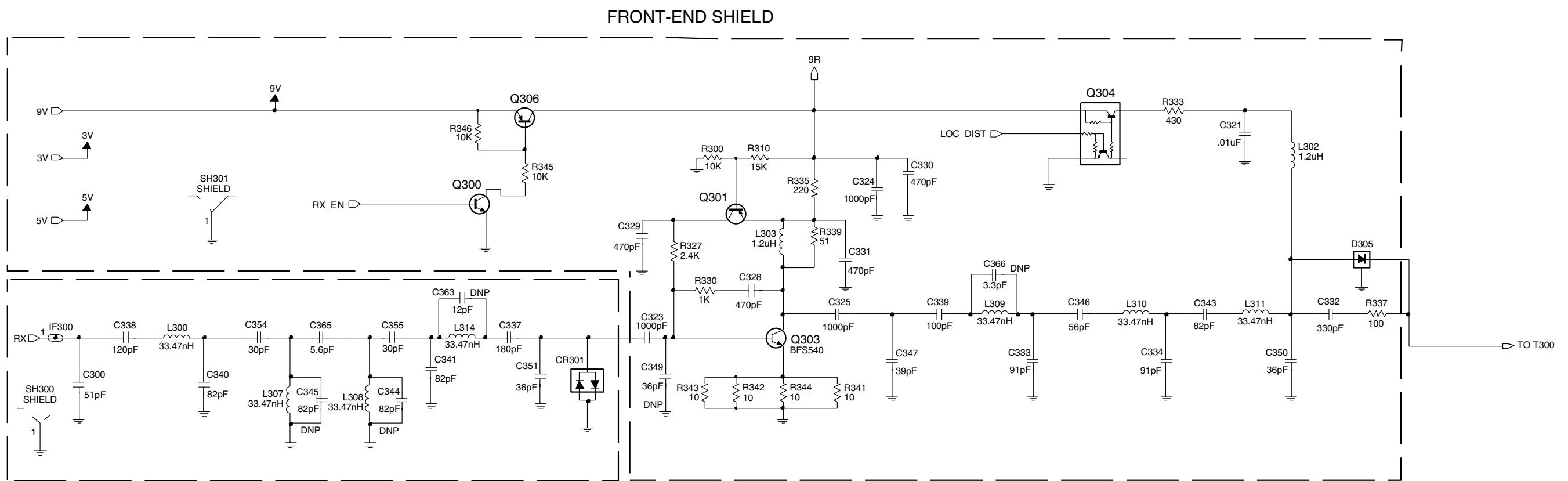
VHF2 (146-174MHz) 25-45W Transmitter (Sht 2 of 2)



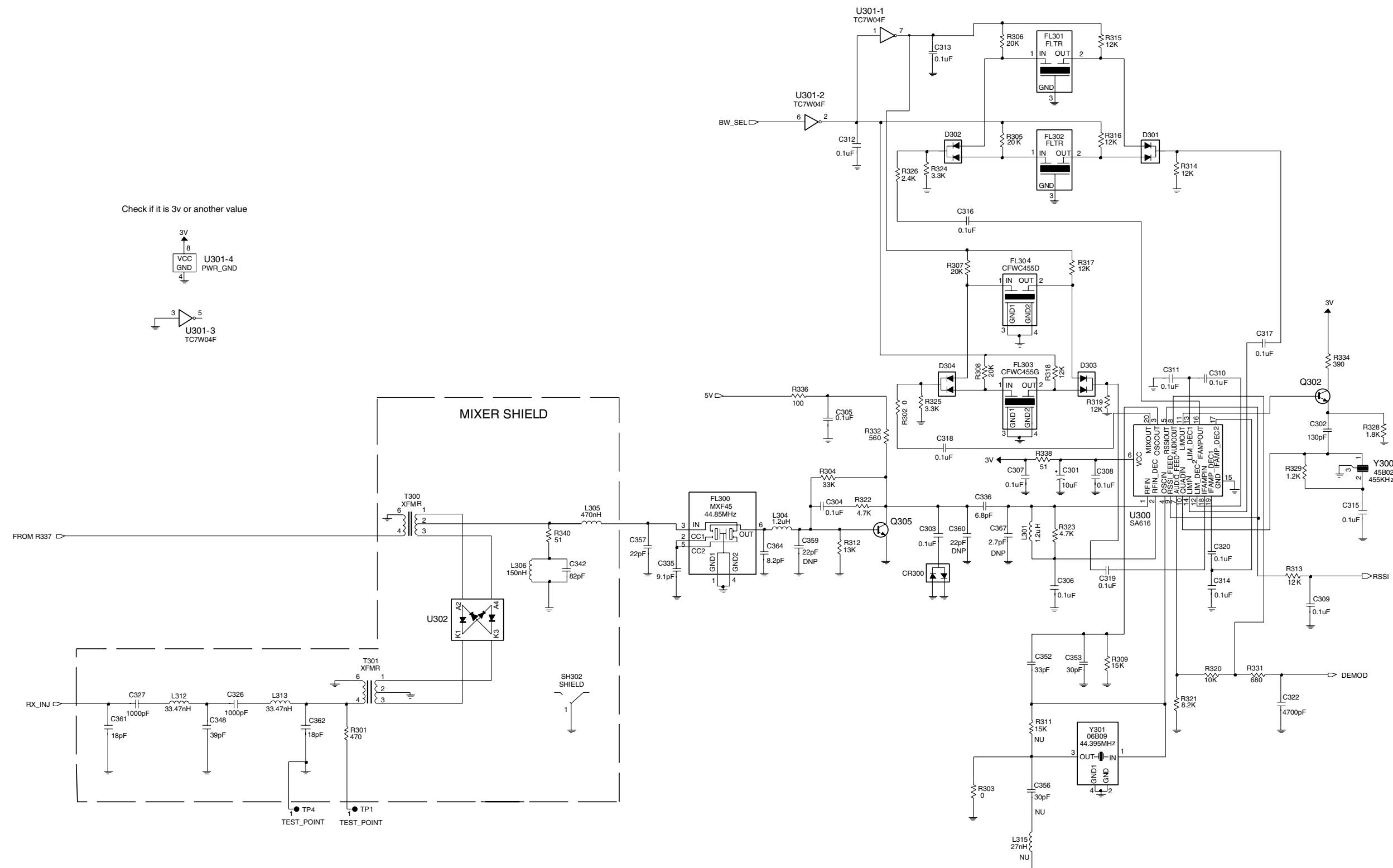
VHF2 (146-174MHz) 25-45W Synthesiser and VCO (Sht 1 of 2)



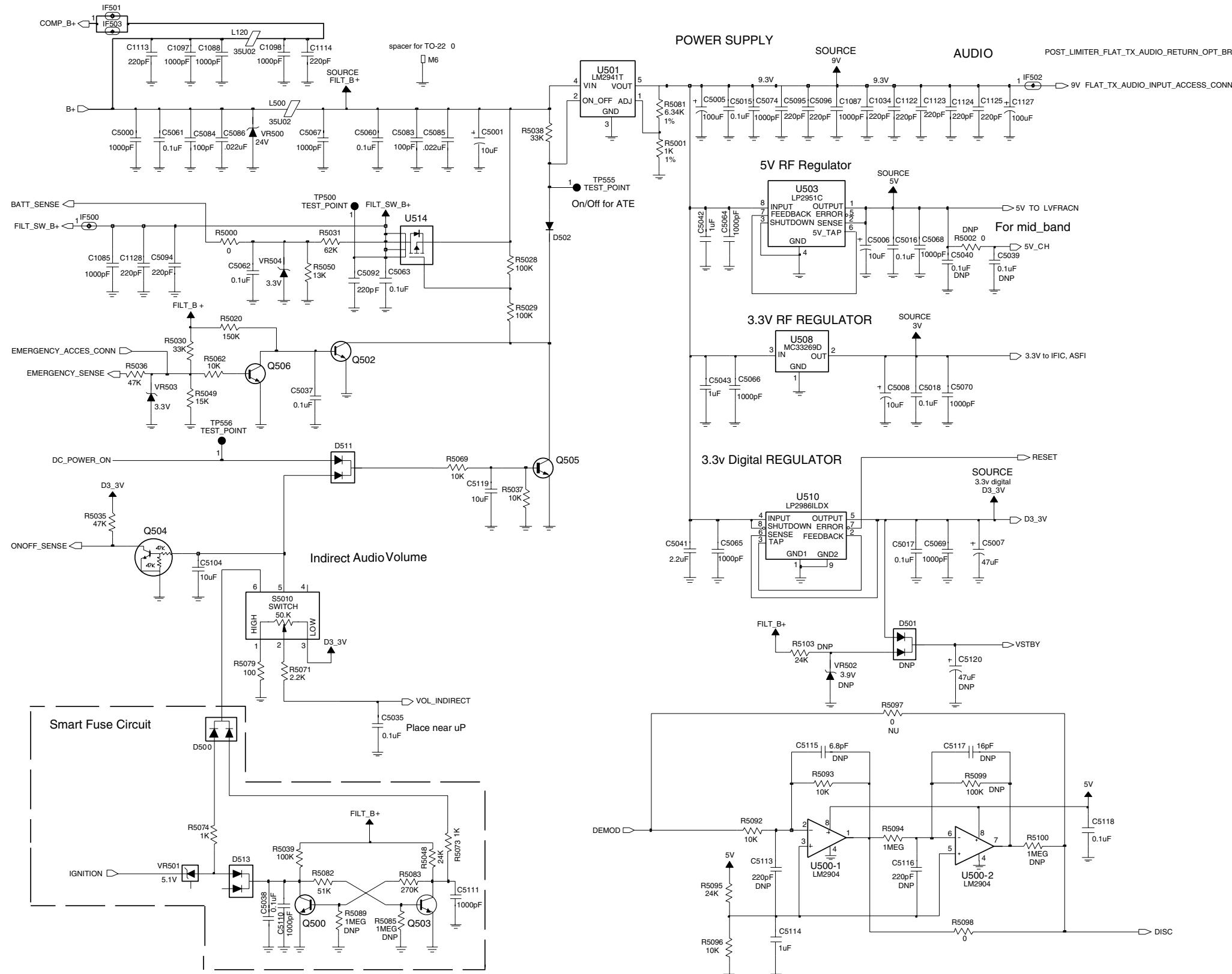
VHF2 (146-174MHz) 25-45W Synthesiser and VCO (Sht 2 of 2)



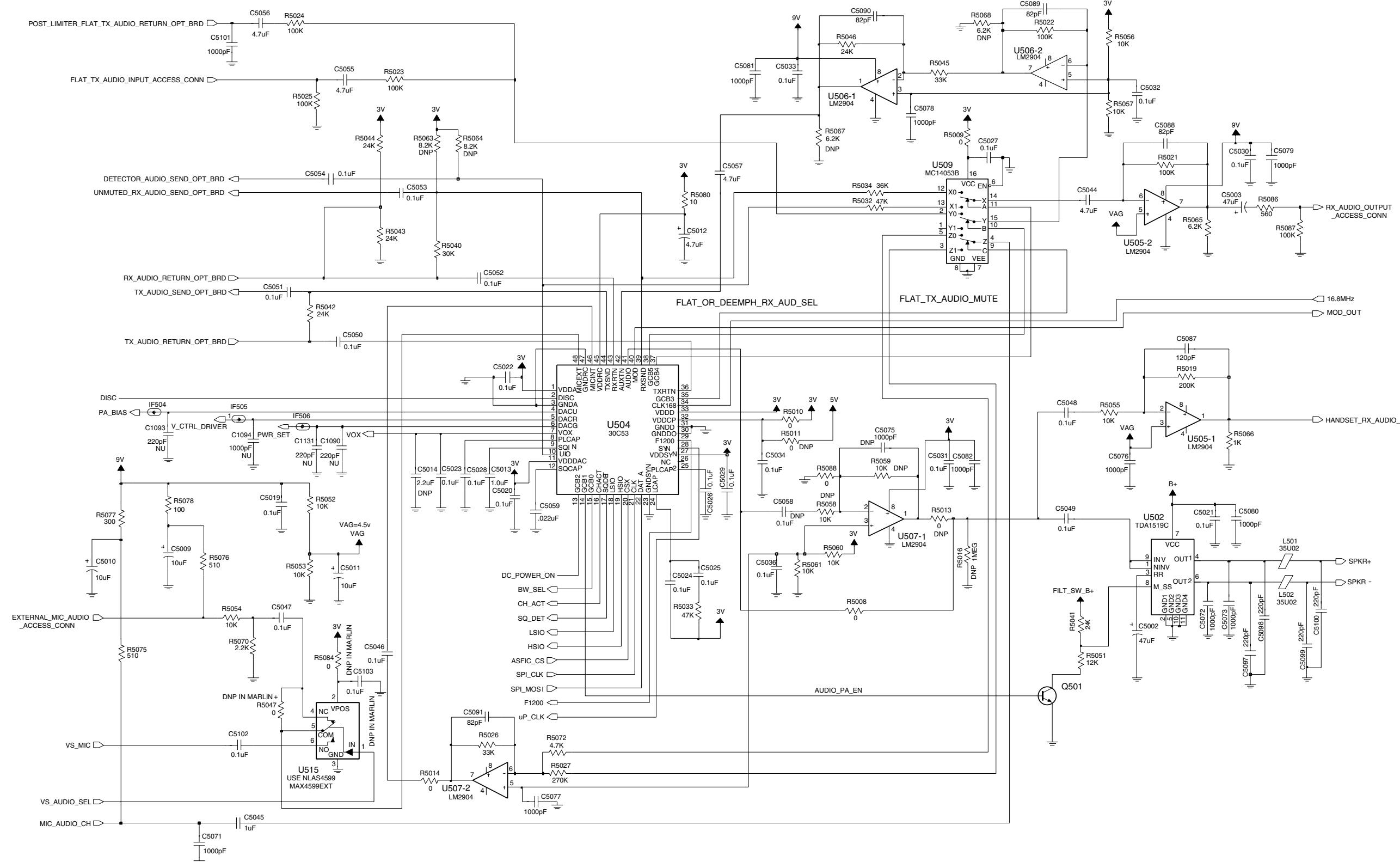
VHF2 (146-174MHz) 25-45W Receiver Front and Back End (Sht 1 of 2)



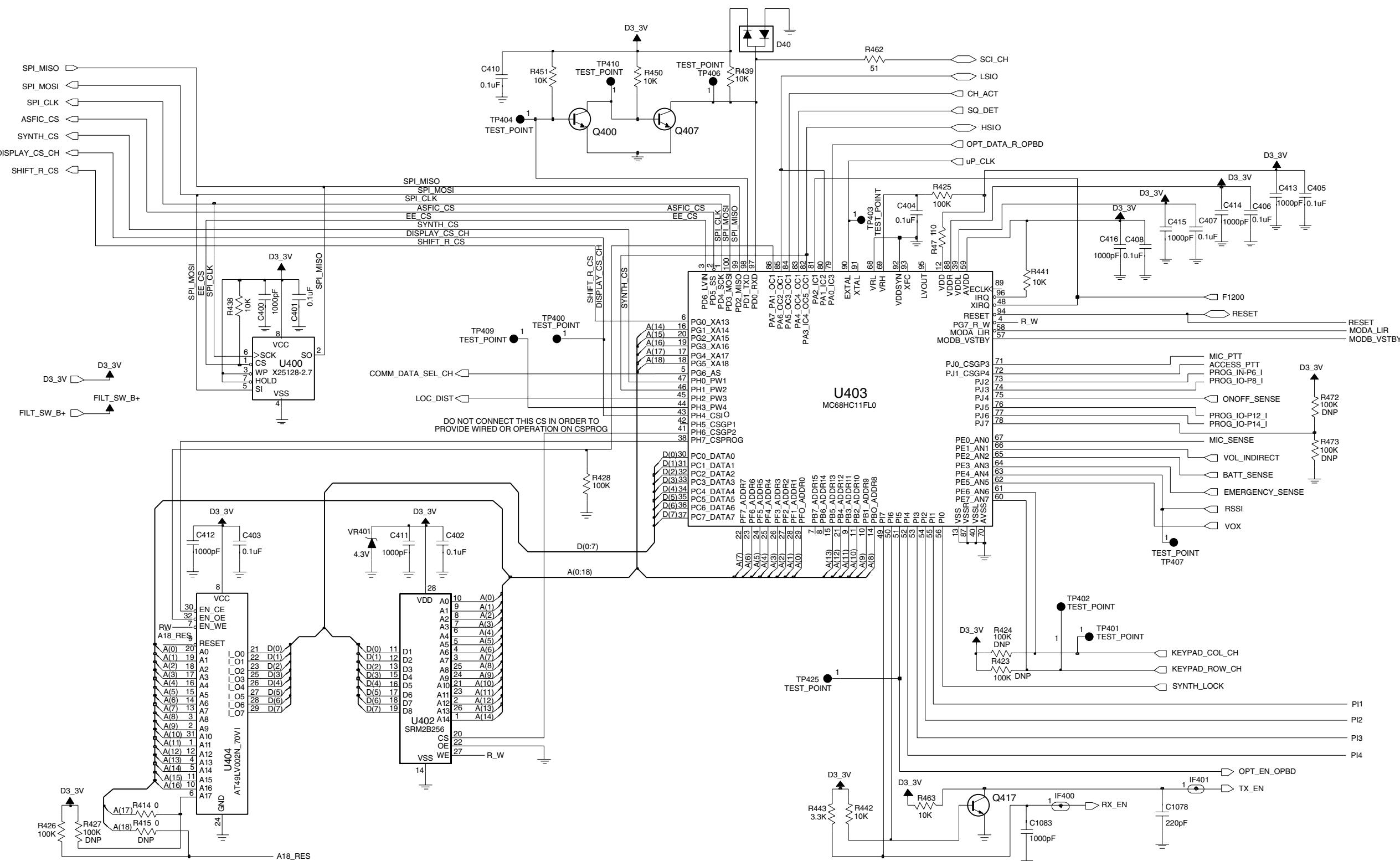
VHF2 (146-174MHz) 25-45W Receiver Front and Back End (Sht 2 of 2)



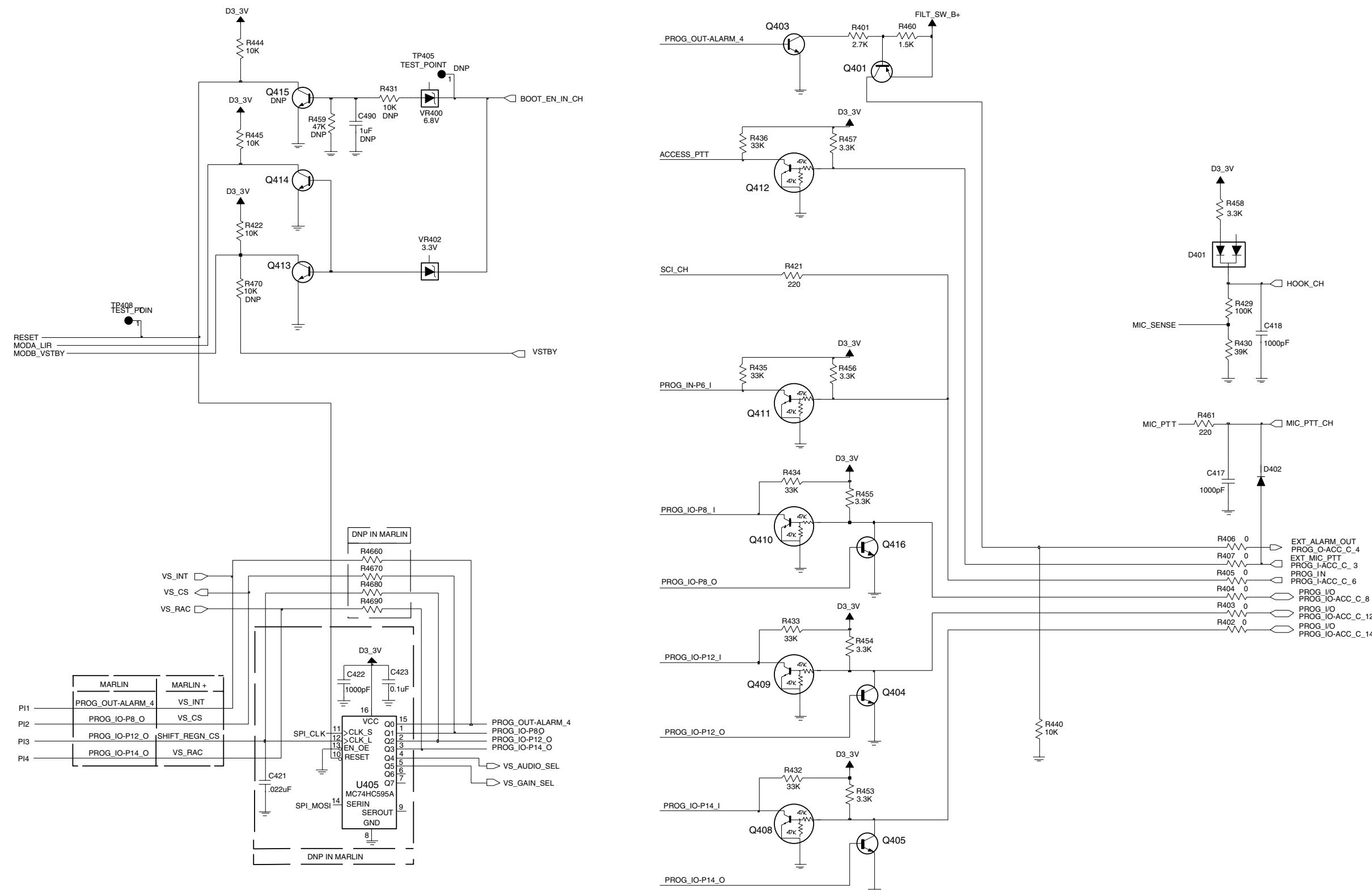
VHF2 (146-174MHz) 25-45W DC and Audio Circuits (Sht 1 of 2)



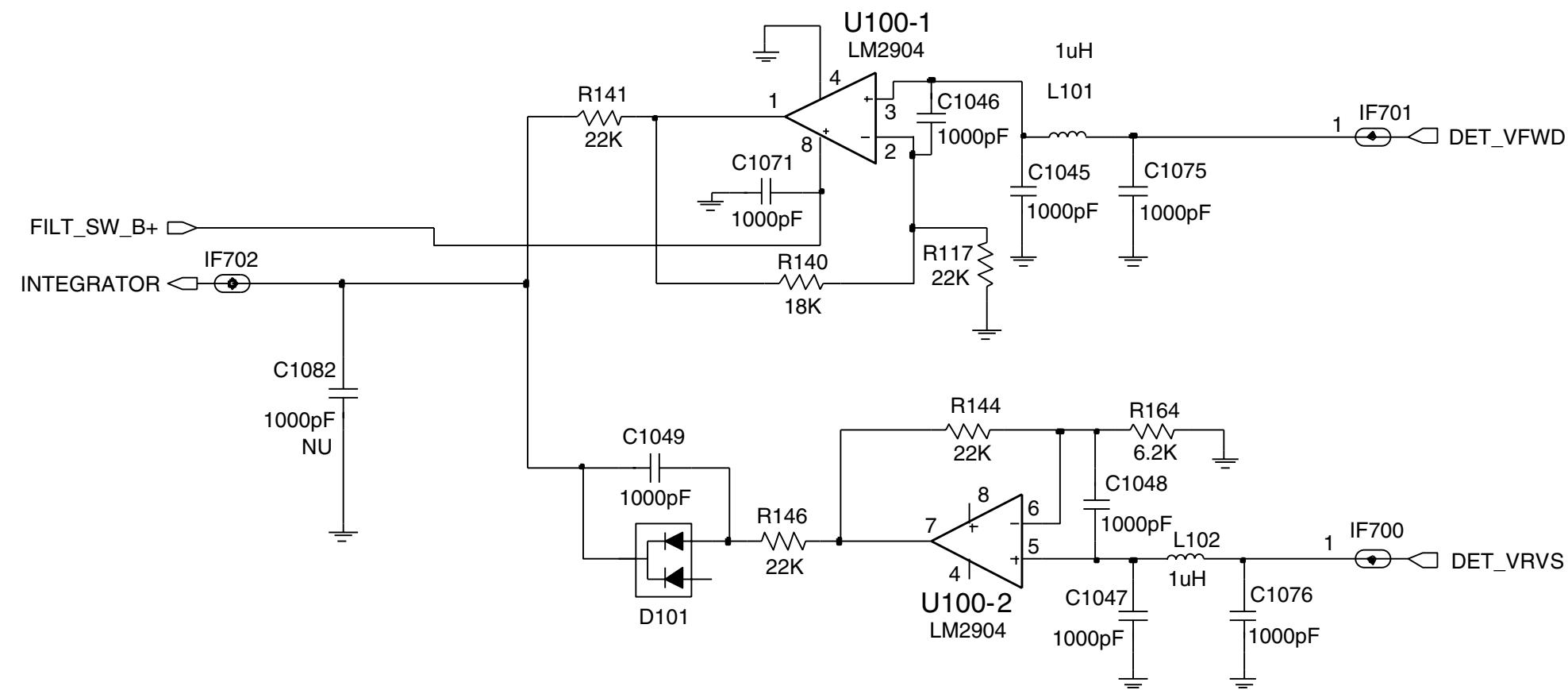
VHF2 (146-174MHz) 25-45W DC and Audio Circuits (Sht 2 of 2)



VHF2 (146-174MHz) 25-45W Microprocessor and Controller Circuits (Sht 1 of 2)



VHF2 (146-174MHz) 25-45W Microprocessor and Controller Circuits (Sht 2 of 2)



VHF2 (146-174MHz) 25-45W Power Control Circuit

2.1 VHF2 PCB 8486487Z03-B Parts List 25-45W

Circuit Ref.	Motorola Part No.	Description
C300	2113740F44	CAP, 51pF
C301	2311049A57	CAP, 10uF
C302	2113740F54	CAP, 130pF
C303	2113743K15	CAP, 0.1uF
C304	2113743E20	CAP, 0.1uF
C305	2113743E20	CAP, 0.1uF
C306	2113743E20	CAP, 0.1uF
C307	2113743E20	CAP, 0.1uF
C308	2113743E20	CAP, 0.1uF
C309	2113743E20	CAP, 0.1uF
C310	2113743E20	CAP, 0.1uF
C311	2113743E20	CAP, 0.1uF
C312	2113743E20	CAP, 0.1uF
C313	2113743E20	CAP, 0.1uF
C314	2113743E20	CAP, 0.1uF
C315	2113743E20	CAP, 0.1uF
C316	2113743E20	CAP, 0.1uF
C317	2113743E20	CAP, 0.1uF
C318	2113743E20	CAP, 0.1uF
C319	2113743E20	CAP, 0.1uF
C320	2113743E20	CAP, 0.1uF
C321	2113741F49	CAP, .01uF
C322	2113741F41	CAP, 4700pF
C323	2113741F25	CAP, 1000pF
C324	2113741F25	CAP, 1000pF
C325	2113741F25	CAP, 1000pF
C326	2113741F25	CAP, 1000pF
C327	2113741F25	CAP, 1000pF
C328	2113740F67	CAP, 470pF

Circuit Ref.	Motorola Part No.	Description
C329	2113740F67	CAP, 470pF
C330	2113740F67	CAP, 470pF
C331	2113740F67	CAP, 470pF
C332	2113741F13	CAP, 330pF
C333	2113740L41	CAP, 91pF
C334	2113740L41	CAP, 91pF
C335	2113740L17	CAP, 9.1pF
C336	2113740L14	CAP, 6.8pF
C337	2113740F57	CAP, 180pF
C338	2113740F53	CAP, 120pF
C339	2113740F51	CAP, 100pF
C340	2113740F49	CAP, 82pF
C341	2113740F49	CAP, 82pF
C342	2113740F49	CAP, 82pF
C343	2113740F49	CAP, 82pF
C344	NOT PLACED	CAP, 82pF
C345	NOT PLACED	CAP, 82pF
C346	2113740F45	CAP, 56pF
C347	2113740F41	CAP, 39pF
C348	2113740F41	CAP, 39pF
C349	NOT PLACED	CAP, 36pF
C350	2113740F40	CAP, 36pF
C351	2113740F40	CAP, 36pF
C352	2113740F39	CAP, 33pF
C353	2113740F38	CAP, 30pF
C354	2113740F38	CAP, 30pF
C355	2113740F38	CAP, 30pF
C356	NOT PLACED	CAP, 30pF
C357	2113740F35	CAP, 22pF
C359	NOT PLACED	CAP, 22pF
C360	NOT PLACED	CAP, 22pF
C361	2113740F33	CAP, 18pF
C362	2113740F33	CAP, 18pF
C363	NOT PLACED	CAP, 12pF
C364	2113740F25	CAP, 8.2pF
C365	2113740F21	CAP, 5.6pF
C366	NOT PLACED	CAP, 3.3pF
C367	NOT PLACED	CAP, 2.7pF
C400	2113741F25	CAP, 1000pF
C401	2113743K15	CAP, 0.1uF
C402	2113743K15	CAP, 0.1uF
C403	2113743K15	CAP, 0.1uF
C404	2113743K15	CAP, 0.1uF
C405	2113743K15	CAP, 0.1uF
C406	2113743K15	CAP, 0.1uF
C407	2113743K15	CAP, 0.1uF
C408	2113743K15	CAP, 0.1uF
C410	2113743K15	CAP, 0.1uF
C411	2113741F25	CAP, 1000pF
C412	2113741F25	CAP, 1000pF
C413	2113741F25	CAP, 1000pF
C414	2113741F25	CAP, 1000pF
C415	2113741F25	CAP, 1000pF
C416	2113741F25	CAP, 1000pF
C417	2113741F25	CAP, 1000pF
C418	2113741F25	CAP, 1000pF
C421	NOT PLACED	CAP, .022uF
C422	NOT PLACED	CAP, 1000pF
C423	NOT PLACED	CAP, 0.1uF
C490	NOT PLACED	CAP, 1uF
C602	2113741F25	CAP, 1000pF
C603	2113741F25	CAP, 1000pF
C604	2113741F25	CAP, 1000pF
C605	2113741F25	CAP, 1000pF
C606	2113741F25	CAP, 1000pF
C607	2113741F25	CAP, 1000pF
C608	NOT PLACED	CAP, 1000pF
C609	NOT PLACED	CAP, 1000pF
C610	2113741F25	CAP, 1000pF
C611	2113741F25	CAP, 1000pF
C612	2113741F25	CAP, 1000pF
C613	2113741F25	CAP, 1000pF
C614	2113741F25	CAP, 1000pF
C615	2113741F25	CAP, 1000pF
C616	2113741F25	CAP, 1000pF
C617	2113741F25	CAP, 1000pF
C618	2113741F25	CAP, 1000pF
C619	NOT PLACED	CAP, 1000pF
C620	2113741F25	CAP, 1000pF
C621	2113741F25	CAP, 1000pF
C622	2113741F25	CAP, 1000pF
C623	2113741F25	CAP, 1000pF
C624	2113741F25	CAP, 1000pF
C625	2113741F25	CAP, 1000pF
C626	2113741F25	CAP, 1000pF
C627	2113741F25	CAP, 1000pF
C628	2113741F25	CAP, 1000pF
C629	2113741F25	CAP, 1000pF
C630	2113741F25	CAP, 1000pF
C631	2113741F25	CAP, 1000pF

Circuit Ref.	Motorola Part No.	Description
C632	2113741F25	CAP, 1000pF
C633	2113741F25	CAP, 1000pF
C662	2113741F25	CAP, 1000pF
C678	2113741M69	CAP, 0.1uF
C1000	2113740F59	CAP, 220pF
C1001	2311049A08	CAPP, 1uF
C1002	2113741W01	CAP, 1uF
C1003	NOT PLACED	CAP, 470pF
C1004	2111078B42	CAP, 100pF
C1005	2111078B42	CAP, 100pF
C1006	2111078B48	CAP, 160pF
C1007	2111078B40	CAP, 82pF
C1008	2111078B10	CAP, 7.5pF
C1009	2111078B37	CAP, 62pF
C1010	NOT PLACED	CAP, 100pF
C1011	NOT PLACED	CAP, 82pF
C1012	2111078B36	CAP, 56pF
C1013	2111078B08	CAP, 6.2pF
C1014	NOT PLACED	CAP, 56pF
C1015	2111078B43	CAP, 110pF
C1017	2111078B18	CAP, 15pF
C1018	2111078B32	CAP, 39pF
C1019	2111078B28	CAP, 32pF
C1020	2111078B32	CAP, 39pF
C1021	NOT PLACED	CAP, 6.2pF
C1022	2111078B26	CAP, 28pF
C1026	2113740A79	CAP, 1000pF
C1027	2311049A45	CAPP, 10uF
C1028	2113743K15	CAP, 0.1uF
C1029	2113743K15	CAP, 0.1uF

Circuit Ref.	Motorola Part No.	Description
C1030	2113740F37	CAP, 27pF
C1031	2113743E07	CAP, .022uF
C1032	2113743E07	CAP, .022uF
C1033	2113743E07	CAP, .022uF
C1034	2113740F59	CAP, 220pF
C1035	2113743E07	CAP, .022uF
C1036	2113743E07	CAP, .022uF
C1037	2113743E07	CAP, .022uF
C1038	NOT PLACED	CAP, .022uF
C1039	2113743E07	CAP, .022uF
C1040	NOT PLACED	CAP, 2200pF
C1041	2113741F17	CAP, 470pF
C1042	2113740F52	CAP, 110pF
C1043	2113740F52	CAP, 110pF
C1044	2113741F13	CAP, 330pF
C1045	2113741F25	CAP, 1000pF
C1046	2113741F25	CAP, 1000pF
C1047	2113741F25	CAP, 1000pF
C1048	2113741F25	CAP, 1000pF
C1049	2113741F25	CAP, 1000pF
C1050	2113741F25	CAP, 1000pF
C1051	2113741F25	CAP, 1000pF
C1052	2113741F25	CAP, 1000pF
C1053	2113741F25	CAP, 1000pF
C1054	2113741F25	CAP, 1000pF
C1055	NOT PLACED	CAP, 1000pF
C1056	NOT PLACED	CAP, 1000pF
C1057	2113741F25	CAP, 1000pF
C1058	NOT PLACED	CAP, 1000pF
C1059	2113741F25	CAP, 1000pF

Circuit Ref.	Motorola Part No.	Description
C1060	2113741F25	CAP, 1000pF
C1061	NOT PLACED	CAP, 1000pF
C1062	2113741F25	CAP, 1000pF
C1063	2113740F63	CAP, 330pF
C1064	2113741F25	CAP, 1000pF
C1065	2113740F63	CAP, 330pF
C1066	2113741F25	CAP, 1000pF
C1067	2113741F25	CAP, 1000pF
C1068	2113741F13	CAP, 330pF
C1069	NOT PLACED	CAP, 330pF
C1070	2113741F25	CAP, 1000pF
C1071	2113741F25	CAP, 1000pF
C1072	2113741F25	CAP, 1000pF
C1073	NOT PLACED	CAP, 1000pF
C1074	2113741F25	CAP, 1000pF
C1075	2113741F25	CAP, 1000pF
C1076	2113741F25	CAP, 1000pF
C1077	2113741F25	CAP, 1000pF
C1078	2113740F59	CAP, 220pF
C1079	2113741F25	CAP, 1000pF
C1080	2113741F25	CAP, 1000pF
C1081	2113741F25	CAP, 1000pF
C1082	NOT PLACED	CAP, 1000pF
C1083	2113741F25	CAP, 1000pF
C1084	2113740F59	CAP, 220pF
C1085	2113741F25	CAP, 1000pF
C1086	2113741F25	CAP, 1000pF
C1087	2113741F25	CAP, 1000pF
C1088	2113741F25	CAP, 1000pF
C1089	2113741F25	CAP, 1000pF

Circuit Ref.	Motorola Part No.	Description
C1090	NOT PLACED	CAP, 220pF
C1091	2113741F25	CAP, 1000pF
C1092	2113741F25	CAP, 1000pF
C1093	NOT PLACED	CAP, 220pF
C1094	NOT PLACED	CAP, 1000pF
C1095	2113740F59	CAP, 220pF
C1096	2111078B40	CAP, 82pF
C1097	2113741F25	CAP, 1000pF
C1098	2113741F25	CAP, 1000pF
C1099	2113741F25	CAP, 1000pF
C1100	2113741F25	CAP, 1000pF
C1101	2113741F01	CAP, 100pF
C1102	2113741F01	CAP, 100pF
C1103	2113741A57	CAP, .033uF
C1104	2113741A45	CAP, .01uF
C1105	2113740F67	CAP, 470pF
C1106	2113740F67	CAP, 470pF
C1107	2113740F67	CAP, 470pF
C1108	2113740F47	CAP, 68pF
C1109	2113740F59	CAP, 220pF
C1110	2113740F59	CAP, 220pF
C1111	2111078B59	CAP, 470pF
C1112	2113740F59	CAP, 220pF
C1113	2113740F59	CAP, 220pF
C1114	2113740F59	CAP, 220pF
C1115	2113740F59	CAP, 220pF
C1116	2113740F59	CAP, 220pF
C1117	2113740F40	CAP, 36pF
C1118	2113740F39	CAP, 33pF
C1119	2113740F36	CAP, 24pF

Circuit Ref.	Motorola Part No.	Description
C1120	2113740F39	CAP, 33pF
C1121	NOT PLACED	CAP, 6.8pF
C1122	2113740F59	CAP, 220pF
C1123	2113740F59	CAP, 220pF
C1124	2113740F59	CAP, 220pF
C1125	2113740F59	CAP, 220pF
C1126	2113740F59	CAP, 220pF
C1127	2360567A03	CAPP, 100uF
C1128	2113740F59	CAP, 220pF
C1129	2113740F59	CAP, 220pF
C1130	2113740F59	CAP, 220pF
C1131	NOT PLACED	CAP, 220pF
C1132	2111078B40	CAP, 82pF
C1133	2113740A41	CAP, 33pF
C1134	2113740A38	CAP, 24pF
C1136	2113740F19	CAP, 4.7pF
C1137	2111078B33	CAP, 43pF
C1199	NOT PLACED	CAP, 16pF
C2000	2113743F18	CAP, 2.2uF
C2001	2311049J11	CAPP, 4.7uF
C2002	2311049A72	CAPP, 10uF
C2003	2113743K15	CAP, 0.1uF
C2004	2113743F18	CAP, 2.2uF
C2005	2113743F18	CAP, 2.2uF
C2006	2113743F18	CAP, 2.2uF
C2007	2113743E20	CAP, 0.1uF
C2008	2113743E20	CAP, 0.1uF
C2009	2113743E20	CAP, 0.1uF
C2010	2113743E20	CAP, 0.1uF
C2011	2113743E20	CAP, 0.1uF

Circuit Ref.	Motorola Part No.	Description
C2012	NOT PLACED	CAP, 0.1uF
C2013	2113743E20	CAP, 0.1uF
C2014	2113743E20	CAP, 0.1uF
C2015	2113743E20	CAP, 0.1uF
C2016	2113743E20	CAP, 0.1uF
C2017	2113743E20	CAP, 0.1uF
C2018	2113743E20	CAP, 0.1uF
C2019	2113743E20	CAP, 0.1uF
C2020	2113743E20	CAP, 0.1uF
C2021	2113741F49	CAP, .01uF
C2022	2113741F49	CAP, .01uF
C2023	2113741F49	CAP, .01uF
C2024	2113741F49	CAP, .01uF
C2025	2113741F49	CAP, .01uF
C2026	2113741F49	CAP, .01uF
C2027	2113741F49	CAP, .01uF
C2028	2113741F33	CAP, 2200pF
C2029	2113741F25	CAP, 1000pF
C2030	2113741F39	CAP, 3900pF
C2031	NOT PLACED	CAP, 1000pF
C2032	2113741F25	CAP, 1000pF
C2033	2113741F25	CAP, 1000pF
C2034	2113741F25	CAP, 1000pF
C2035	2113741F25	CAP, 1000pF
C2036	2113741F25	CAP, 1000pF
C2037	2113741F25	CAP, 1000pF
C2038	2113741F25	CAP, 1000pF
C2039	2113741F25	CAP, 1000pF
C2040	2113741F25	CAP, 1000pF
C2041	2113741F25	CAP, 1000pF

Circuit Ref.	Motorola Part No.	Description
C2042	2113741F25	CAP, 1000pF
C2043	2113740L14	CAP, 6.8pF
C2044	2113740L06	CAP, 3.3pF
C2045	2113740F67	CAP, 470pF
C2046	2113740F67	CAP, 470pF
C2047	2113740F67	CAP, 470pF
C2048	2113740F67	CAP, 470pF
C2049	NOT PLACED	CAP, 470pF
C2050	2113740F67	CAP, 470pF
C2051	2113740F59	CAP, 220pF
C2052	2113740F67	CAP, 470pF
C2053	NOT PLACED	CAP, 100pF
C2054	2113740L37	CAP, 62pF
C2055	2113740F35	CAP, 22pF
C2056	2113740F33	CAP, 18pF
C2057	2113740F33	CAP, 18pF
C2058	2113740F33	CAP, 18pF
C2059	2113740F33	CAP, 18pF
C2060	2113740F31	CAP, 15pF
C2061	2113740F29	CAP, 12pF
C2062	2113740F29	CAP, 12pF
C2063	2113740L22	CAP, 15pF
C2064	2113740F32	CAP, 16pF
C2065	2113740F27	CAP, 10pF
C2066	2113740L16	CAP, 8.2pF
C2067	2113740F25	CAP, 8.2pF
C2068	2113740F23	CAP, 6.8pF
C2069	2113740L12	CAP, 5.6pF
C2070	2113740F41	CAP, 39pF
C2071	2113740F41	CAP, 39pF

Circuit Ref.	Motorola Part No.	Description
C2072	2113740L04	CAP, 2.7pF
C2073	2113740F03	CAP, 1pF
C2074	2109720D14	CAP, 0.1uF
C2075	2109720D14	CAP, 0.1uF
C2076	NOT PLACED	CAP, 0.1uF
C2077	2109720D14	CAP, 0.1uF
C2078	2109720D14	CAP, 0.1uF
C2079	2109720D14	CAP, 0.1uF
C2080	2109720D14	CAP, 0.1uF
C2081	2113740F67	CAP, 470pF
C5000	2113741F25	CAP, 1000pF
C5001	2389289U01	CAPP, 10uF
C5002	2311049A99	CAPP, 47uF
C5003	2311049A99	CAPP, 47uF
C5005	2360567A03	CAPP, 100uF
C5006	2311049A57	CAPP, 10uF
C5007	2311049A99	CAPP, 47uF
C5008	2311049A57	CAPP, 10uF
C5009	2311049A57	CAPP, 10uF
C5010	2311049A57	CAPP, 10uF
C5011	2311049A57	CAPP, 10uF
C5012	2311049A56	CAPP, 4.7uF
C5013	2113928P04	CAP, 1.0uF
C5014	NOT PLACED	CAP, 2.2uF
C5015	2113743K15	CAP, 0.1uF
C5016	2113743K15	CAP, 0.1uF
C5017	2113743K15	CAP, 0.1uF
C5018	2113743K15	CAP, 0.1uF
C5019	2113743K15	CAP, 0.1uF
C5020	2113743K15	CAP, 0.1uF

Circuit Ref.	Motorola Part No.	Description
C5021	2113741M69	CAP, 0.1uF
C5022	2113743K15	CAP, 0.1uF
C5023	2113743K15	CAP, 0.1uF
C5024	2113743K15	CAP, 0.1uF
C5025	2113743K15	CAP, 0.1uF
C5026	2113743K15	CAP, 0.1uF
C5027	2113743K15	CAP, 0.1uF
C5028	2113743K15	CAP, 0.1uF
C5029	2113743K15	CAP, 0.1uF
C5030	2113743K15	CAP, 0.1uF
C5031	2113743K15	CAP, 0.1uF
C5032	2113743K15	CAP, 0.1uF
C5033	2113743K15	CAP, 0.1uF
C5034	2113743K15	CAP, 0.1uF
C5035	2113743K15	CAP, 0.1uF
C5036	2113743K15	CAP, 0.1uF
C5037	2113743K15	CAP, 0.1uF
C5038	2113743K15	CAP, 0.1uF
C5039	NOT PLACED	CAP, 0.1uF
C5040	NOT PLACED	CAP, 0.1uF
C5041	2113743F18	CAP, 2.2uF
C5042	2113743F16	CAP, 1uF
C5043	2113743F16	CAP, 1uF
C5044	2113928C04	CAP, 4.7uF
C5045	2113743F16	CAP, 1uF
C5046	2113743E20	CAP, 0.1uF
C5047	2113743E20	CAP, 0.1uF
C5048	2113743E20	CAP, 0.1uF
C5049	2113743E20	CAP, 0.1uF
C5050	2113743E20	CAP, 0.1uF

Circuit Ref.	Motorola Part No.	Description
C5051	NOT PLACED	CAP, 0.1uF
C5052	2113743E20	CAP, 0.1uF
C5053	NOT PLACED	CAP, 0.1uF
C5054	NOT PLACED	CAP, 0.1uF
C5055	2113928C04	CAP, 4.7uF
C5056	2113928C04	CAP, 4.7uF
C5057	2113928C04	CAP, 4.7uF
C5058	NOT PLACED	CAP, 0.1uF
C5059	2113743E07	CAP, .022uF
C5060	2113741M69	CAP, 0.1uF
C5061	2113741M69	CAP, 0.1uF
C5062	2113741M69	CAP, 0.1uF
C5063	2113741M69	CAP, 0.1uF
C5064	2113741F25	CAP, 1000pF
C5065	2113741F25	CAP, 1000pF
C5066	2113741F25	CAP, 1000pF
C5067	2113741F25	CAP, 1000pF
C5068	2113741F25	CAP, 1000pF
C5069	2113741F25	CAP, 1000pF
C5070	2113741F25	CAP, 1000pF
C5071	2113741F25	CAP, 1000pF
C5072	2113741F25	CAP, 1000pF
C5073	2113741F25	CAP, 1000pF
C5074	2113741F25	CAP, 1000pF
C5075	NOT PLACED	CAP, 1000pF
C5076	2113741F25	CAP, 1000pF
C5077	2113741F25	CAP, 1000pF
C5078	2113741F25	CAP, 1000pF
C5079	2113741F25	CAP, 1000pF
C5080	2113741F25	CAP, 1000pF

Circuit Ref.	Motorola Part No.	Description
C5081	2113741F25	CAP, 1000pF
C5082	2113741F25	CAP, 1000pF
C5083	2113740F51	CAP, 100pF
C5084	2113740F51	CAP, 100pF
C5085	2113741A53	CAP, .022uF
C5086	2113741A53	CAP, .022uF
C5087	2113740F53	CAP, 120pF
C5088	2113740F49	CAP, 82pF
C5089	2113740F49	CAP, 82pF
C5090	2113740F49	CAP, 82pF
C5091	2113740F49	CAP, 82pF
C5092	2113740F59	CAP, 220pF
C5094	2113740F59	CAP, 220pF
C5095	2113740F59	CAP, 220pF
C5096	2113740F59	CAP, 220pF
C5097	2113740F59	CAP, 220pF
C5098	2113740F59	CAP, 220pF
C5099	2113740F59	CAP, 220pF
C5100	2113740F59	CAP, 220pF
C5101	NOT PLACED	CAP, 1000pF
C5102	NOT PLACED	CAP, 0.1uF
C5103	NOT PLACED	CAP, 0.1uF
C5104	NOT PLACED	CAP, 10uF
C5110	2113741F25	CAP, 1000pF
C5111	2113741F25	CAP, 1000pF
C5112	NOT PLACED	CAP, 16pF
C5113	NOT PLACED	CAP, 220pF
C5114	2113743F16	CAP, 1uF
C5115	NOT PLACED	CAP, 6.8pF
C5116	NOT PLACED	CAP, 220pF

Circuit Ref.	Motorola Part No.	Description
C5117	NOT PLACED	CAP, 16pF
C5118	2113743E20	CAP, 0.1uF
C5119	2113743H14	CAP, 10uF
C5120	NOT PLACED	CAPP, 47uF
CR300	4880154K03	MMBD353, SCHOTTKY COMM AK
CR301	4880154K03	MMBD353, SCHOTTKY COMM AK
D100	NOT PLACED	MMBD6100, DUAL COMM CATH
D101	4813833C02	MMBD6100, DUAL COMM CATH
D102	4813833C02	MMBD6100, DUAL COMM CATH
D103	4802482J02	MA4P959, PIN
D104	4802482J02	MA4P959, PIN
D105	4805218N57	RB715F, DUAL COMM CATH
D106	4805218N57	RB715F, DUAL COMM CATH
D107	4805218N57	RB715F, DUAL COMM CATH
D108	4805218N57	RB715F, DUAL COMM CATH
D200	4802233J09	IMN10, 3 DIODE ARRAY
D201	4802233J09	IMN10, 3 DIODE ARRAY
D202	4862824C03	1SV232, VARACTOR
D203	4805649Q13	1SV228, VARACTOR
D204	4805649Q13	1SV228, VARACTOR
D205	4862824C01	1SV229, VARACTOR
D301	4802245J97	DAN235ETL, DUAL COMM CATH
D302	4802245J97	DAN235ETL, DUAL COMM CATH

Circuit Ref.	Motorola Part No.	Description	Circuit Ref.	Motorola Part No.	Description	Circuit Ref.	Motorola Part No.	Description	Circuit Ref.	Motorola Part No.	Description
D303	4802245J97	DAN235ETL, DUAL COMM CATH	L104	2462587T38	IND CHIP 22NH 5% LOW PRO	L207	2413923C07	IDCTR, 47nH	M6	4387454V01	SPACER
D304	4802245J97	DAN235ETL, DUAL COMM CATH	L105	2462587T13	IDCTR, 68nH	L208	2413926N24	IDCTR, 100nH	M9	0289511U01	NUT
D305	4880142L01	MMBV3401LT, PIN	L106	2460591A11	IDCTR, 7.66nH	L209	2413926N24	IDCTR, 100nH	M100	2680499Z01	HEATSINK
D400	4813833C07	MMBD7000, DUAL COMM AK	L107	2460591A01	IDCTR, 4.22nH	L210	2413926N24	IDCTR, 100nH	M105	7588823L03	CONTACT, METAL
D401	4813833C02	MMBD6100, DUAL COMM CATH	L108	2462587X69	IDCTR, 1.2uH	L211	2413926N24	IDCTR, 100nH	M106	7588823L03	CONTACT, METAL
D402	4809948D42	RB751V40, SCHOTTKY	L109	NOT PLACED	IDCTR, 11.03nH	L212	2413926N24	IDCTR, 100nH	M107	7588823L03	CONTACT, METAL
D500	4813833C02	MMBD6100, DUAL COMM CATH	L110	2462587N42	IDCTR, 12nH	L213	2413926N24	IDCTR, 100nH	M108	7588823L04	CONTACT, METAL
D501	NOT PLACED	MMBD6100, DUAL COMM CATH	L111	2460592B01	IDCTR, 51nH	L214	2413926H20	IDCTR, 47nH	M109	7588823L04	CONTACT, METAL
D502	4813825A23	MMSD301T1, SCHOTTKY	L112	2460592B01	IDCTR, 51nH	L215	2413926H20	IDCTR, 47nH	M110	7588823L04	CONTACT, METAL
D511	4813833C02	MMBD6100, DUAL COMM CATH	L113	2460592B01	IDCTR, 51nH	L216	2413926H20	IDCTR, 47nH	M111	NOT PLACED	CONTACT, METAL
D513	4813833C02	MMBD6100, DUAL COMM CATH	L114	2460592B01	IDCTR, 51nH	L217	2462587Q42	IDCTR, 390nH	M112	NOT PLACED	CONTACT, METAL
FL300	9180022M11	MXF45, 44.85MHz BPF	L115	2460592A01	IDCTR, 17nH	L300	2460591G24	IDCTR, 33.47nH	M113	NOT PLACED	CONTACT, METAL
FL301	9180468V06	FLTR, 455kHz, BW 25KHZ	L116	2460592A01	IDCTR, 17nH	L301	2462587X69	IDCTR, 1.2uH	M114	NOT PLACED	CONTACT, METAL
FL302	9180468V04	FLTR, 455kHz, BW 12.5KHZ	L117	7686135U02	FERRITE BEAD	L302	2462587X69	IDCTR, 1.2uH	P1	2804503J01	CONNECTOR, 16 PIN
FL303	9180469V03	FLTR, 455kHz, BW 12.5KHZ	L118	7686135U02	FERRITE BEAD	L303	2462587N69	IDCTR, 1.2uH	P2	NOT PLACED	CONNECTOR, 2 PIN DC
FL304	9180469V06	FLTR, 455kHz, BW 25KHZ	L119	7686135U02	FERRITE BEAD	L304	2483411T74	IDCTR, 1.2uH	Q100	4886136B01	MRF1550, LDMOS RF
J2	0989241U02	CONNECTOR 22 PIN	L120	7686135U02	FERRITE BEAD	L305	2413926K31	IDCTR, 470nH	Q101	4813824A10	MMBT3904, BIPOLAR NPN
J3	NOT PLACED	CONNECTOR 32 PIN	L121	7686135U02	FERRITE BEAD	L306	2462587N55	IDCTR, 150nH	Q102	NOT PLACED	MMBT3904, BIPOLAR NPN
J11	2889309U01	ANTENNA CONNECTOR	L122	2460591C23	IDCTR, 13.85nH	L307	2460591G24	IDCTR, 33.47nH	Q103	4813824A06	MMBTA13, DARLINGTON, NPN
L100	7686135U02	FERRITE BEAD	L123	2462587X69	IDCTR, 1.2uH	L308	2460591G24	IDCTR, 33.47nH	Q105	4886212B01	MRF1518, LDMOS RF
L101	2462587T30	IDCTR, 1uH	L124	2485873L05	IDCTR, 48nH	L309	2460591G24	IDCTR, 33.47nH	Q106	4805128M27	BSR33, BIPOLAR, PNP
L102	2462587T30	IDCTR, 1uH	L131	NOT PLACED	IDCTR, 120nH	L310	2460591G24	IDCTR, 33.47nH	Q200	4802245J95	BFS540, NPN
L103	2462587T30	IDCTR, 1uH	L132	2462587N15	IDCTR, 100nH	L311	2460591G24	IDCTR, 33.47nH	Q300	4809940E02	DTC114YE, NPN
			L200	2462587Q42	IDCTR, 390nH	L312	2460591G24	IDCTR, 33.47nH	Q301	4813824A17	MMBT3906, BIPOLAR PNP
			L201	2462587V44	IDCTR, 680nH	L313	2460591G24	IDCTR, 33.47nH	Q302	4813824A10	MMBT3904, BIPOLAR NPN
			L202	2462587V44	IDCTR, 680nH	L314	2460591G24	IDCTR, 33.47nH	Q303	4802245J95	BFS540, NPN
			L203	2462587V44	IDCTR, 680nH	L315	NOT PLACED	IDCTR, 27nH	Q304	4809939C04	UMC3
			L204	2462587V44	IDCTR, 680nH	L500	7686135U02	FERRITE BEAD			
			L205	2462587Q47	IDCTR, 1uH	L501	7686135U02	FERRITE BEAD			
			L206	2413923C05	IDCTR, 33nH	L502	7686135U02	FERRITE BEAD			

Circuit Ref.	Motorola Part No.	Description
Q305	4802197J95	PBR941, NPN
Q306	4813824A17	MMBT3906, BIPOLAR PNP
Q400	4809940E02	DTC114YE, NPN
Q401	4880141L03	BCW68G, BIPOLAR PNP
Q403	4809940E02	DTC114YE, NPN
Q404	4809940E02	DTC114YE, NPN
Q405	4809940E02	DTC114YE, NPN
Q407	4809940E02	DTC114YE, NPN
Q408	4880048M01	DTC144EKA, BIPOLAR
Q409	4880048M01	DTC144EKA, BIPOLAR
Q410	4880048M01	DTC144EKA, BIPOLAR
Q411	4880048M01	DTC144EKA, BIPOLAR
Q412	4880048M01	DTC144EKA, BIPOLAR
Q413	4809940E02	DTC114YE, NPN
Q414	4809940E02	DTC114YE, NPN
Q415	NOT PLACED	MMBT3904
Q416	4809940E02	DTC114YE, NPN
Q417	4813824A10	MMBT3904, BIPOLAR NPN
Q500	4813824A10	MMBT3904, BIPOLAR NPN
Q501	4809940E02	DTC114YE, NPN
Q502	4809940E02	DTC114YE, NPN
Q503	4813824A10	MMBT3904, BIPOLAR NPN
Q504	4880048M01	DTC144EKA, BIPOLAR
Q505	4813824A10	MMBT3904, BIPOLAR NPN
Q506	4813824A10	MMBT3904, BIPOLAR NPN
R101	1705603W01	SHUNT, 1.639m
R102	0680194M18	RES, 51

Circuit Ref.	Motorola Part No.	Description
R103	0683994M18	RES, 51
R104	0680194M18	RES, 51
R105	0680194M18	RES, 51
R106	0680194M18	RES, 51
R107	0680194M18	RES, 51
R108	0680194M18	RES, 51
R109	0662057A12	RES, 30
R110	NOT PLACED	RES, 1K
R111	NOT PLACED	RES, 1K
R112	NOT PLACED	RES, 62K
R113	NOT PLACED	RES, 10K
R114	NOT PLACED	RES, 10K
R115	NOT PLACED	RES, 10K
R116	NOT PLACED	RES, 10K
R117	0662057A81	RES, 22K
R118	0662057C55	RES, 150
R120	0662057C51	RES, 100
R121	NOT PLACED	RES, 100
R122	0662057C19	RES, 4.7
R123	0662057C13	RES, 2.7
R124	0662057C13	RES, 2.7
R125	0662057C13	RES, 2.7
R126	0662057C03	RES, 1
R127	0662057C03	RES, 1
R130	0662057B47	RES, 0
R131	0662057A97	RES, 100K
R132	NOT PLACED	RES, 100K
R134	0662057A89	RES, 47K
R135	0662057A82	RES, 24K
R136	0662057A87	RES, 39K

Circuit Ref.	Motorola Part No.	Description
R137	0662057A87	RES, 39K
R138	NOT PLACED	RES, 39K
R139	NOT PLACED	RES, 39K
R140	0662057A79	RES, 718K
R141	0662057A81	RES, 22K
R142	0662057A81	RES, 22K
R143	0662057A81	RES, 22K
R144	0662057A75	RES, 12K
R145	0662057A81	RES, 22K
R146	0662057A81	RES, 22K
R147	0662057A81	RES, 22K
R148	0662057A81	RES, 22K
R149	0662057A81	RES, 22K
R150	0662057A89	RES, 47K
R151	0662057A70	RES, 7.5K
R153	0662057A73	RES, 10K
R155	NOT PLACED	RES, 10K
R156	0662057A73	RES, 10K
R157	0662057A91	RES, 56K
R158	0662057A67	RES, 5.6K
R159	NOT PLACED	RES, 5.6K
R160	0662057A61	RES, 3.3K
R161	0662057A61	RES, 3.3K
R162	0662057A61	RES, 3.3K
R163	0662057A61	RES, 3.3K
R164	0662057A68	RES, 6.2K
R165	0662057A58	RES, 2.4K
R166	NOT PLACED	RES, 2.4K
R167	0662057A57	RES, 2.2K
R168	0662057A57	RES, 2.2K

Circuit Ref.	Motorola Part No.	Description
R169	NOT PLACED	RES, 2.2K
R170	0662057A42	RES, 510
R171	0662057A33	RES, 220
R172	0662057A41	RES, 470
R173	0662057A29	RES, 150
R174	0662057A29	RES, 150
R175	NOT PLACED	RES, 220
R176	2413926N25	IDCTR, 120nH
R177	NOT PLACED	RES, 100
R178	0662057A14	RES, 36
R179	0662057A14	RES, 36
R180	0660082A89	RES, 47K
R181	0660082A89	RES, 47K
R182	0662057A73	RES, 10K
R185	0662057A73	RES, 10K
R186	0662057C20	RES, 5.1
R188	NOT PLACED	RES, 0
R189	NOT PLACED	RES, 0
R190	0662057G64	RES, 1MEG
R191	0662057G64	RES, 1MEG
R195	0662057C01	RES, 0
R196	NOT PLACED	RES, 0
R197	0662057C19	RES, 4.7
R198	0662057C01	RES, 0
R199	0662057B47	RES, 0
R200	0662057A99	RES, 120K
R201	0662057B47	RES, 0
R202	NOT PLACED	RES, 0
R203	0662057B47	RES, 0
R204	NOT PLACED	RES, 0

Circuit Ref.	Motorola Part No.	Description	Circuit Ref.	Motorola Part No.	Description	Circuit Ref.	Motorola Part No.	Description	Circuit Ref.	Motorola Part No.	Description
R205	NOT PLACED	RES, 0	R235	0662057A07	RES, 18	R329	0662057A51	RES, 1.2K	R424	NOT PLACED	RES, 100K
R206	0662057B02	RES, 150K	R300	0662057A73	RES, 10K	R330	0662057A49	RES, 1K	R425	0662057A97	RES, 100K
R207	0662057B02	RES, 150K	R301	0662057A41	RES, 470	R331	0662057A45	RES, 680	R426	0662057A97	RES, 100K
R208	0662057A18	RES, 51	R302	0662057B47	RES, 0	R332	0662057A43	RES, 560	R427	NOT PLACED	RES, 100K
R209	0662057A97	RES, 100K	R303	0662057B47	RES, 0	R333	0662057A40	RES, 430	R428	0662057A97	RES, 100K
R210	NOT PLACED	RES, 100K	R304	0662057A85	RES, 33K	R334	0662057A39	RES, 390	R429	0662057A97	RES, 100K
R211	0662057A89	RES, 47K	R305	0662057A80	RES, 20K	R335	0662057A33	RES, 220	R430	0662057A87	RES, 39K
R212	0662057A84	RES, 30K	R306	0662057A80	RES, 20K	R336	0662057A25	RES, 100	R431	NOT PLACED	RES, 10K
R213	0662057A65	RES, 4.7K	R307	0662057A80	RES, 20K	R337	0662057A25	RES, 100	R432	0662057A85	RES, 33K
R214	0662057A65	RES, 4.7K	R308	0662057A80	RES, 20K	R338	0662057A18	RES, 51	R433	0662057A85	RES, 33K
R215	0662057A65	RES, 4.7K	R309	0662057A77	RES, 15K	R339	0662057A18	RES, 51	R434	0662057A85	RES, 33K
R216	0662057A63	RES, 3.9K	R310	0662057A77	RES, 15K	R340	0662057A18	RES, 51	R435	0662057A85	RES, 33K
R217	0662057A52	RES, 1.3K	R311	NOT PLACED	RES, 15K	R341	0662057A01	RES, 10	R436	0662057A85	RES, 33K
R218	0662057A49	RES, 1K	R312	0662057A76	RES, 13K	R342	0662057A01	RES, 10	R438	0662057A73	RES, 10K
R219	NOT PLACED	RES, 820	R313	0662057A75	RES, 12K	R343	0662057A01	RES, 10	R439	0662057A73	RES, 10K
R220	0662057A42	RES, 510	R314	0662057A75	RES, 12K	R344	0662057A01	RES, 10	R440	0662057A73	RES, 10K
R221	0662057A33	RES, 220	R315	0662057A75	RES, 12K	R345	0662057A73	RES, 10K	R441	0662057A73	RES, 10K
R222	0662057A33	RES, 220	R316	0662057A75	RES, 12K	R346	0662057A73	RES, 10K	R442	0662057A73	RES, 10K
R223	0662057A33	RES, 220	R317	0662057A75	RES, 12K	R401	0662057C85	RES, 2.7K	R443	0662057A61	RES, 3.3K
R224	0662057A53	RES, 1.5K	R318	0662057A75	RES, 12K	R402	0662057B47	RES, 0	R444	0662057A73	RES, 10K
R225	0662057A29	RES, 150	R319	0662057A75	RES, 12K	R403	0662057B47	RES, 0	R445	0662057A73	RES, 10K
R226	0662057A29	RES, 150	R320	0662057A73	RES, 10K	R404	0662057B47	RES, 0	R450	0662057A73	RES, 10K
R227	0662057A25	RES, 100	R321	0662057A71	RES, 8.2K	R405	0662057B47	RES, 0	R451	0662057A73	RES, 10K
R228	0662057A25	RES, 100	R322	0662057A65	RES, 4.7K	R406	0662057B47	RES, 0	R453	0662057A61	RES, 3.3K
R229	0662057A25	RES, 100	R323	0662057A65	RES, 4.7K	R407	0662057B47	RES, 0	R454	0662057A61	RES, 3.3K
R230	0662057A25	RES, 100	R324	0662057A61	RES, 3.3K	R414	0662057B47	RES, 0	R455	0662057A61	RES, 3.3K
R231	0662057A18	RES, 51	R325	0662057A61	RES, 3.3K	R415	NOT PLACED	RES, 0	R456	0662057A61	RES, 3.3K
R232	0662057A17	RES, 47	R326	0662057A58	RES, 2.4K	R421	0662057A33	RES, 220	R457	0662057A61	RES, 3.3K
R233	0662057A17	RES, 47	R327	0662057A58	RES, 2.4K	R422	0662057A73	RES, 10K	R458	0662057A61	RES, 3.3K
R234	0662057A15	RES, 39	R328	0662057A55	RES, 1.8K	R423	NOT PLACED	RES, 100K	R459	NOT PLACED	RES, 47K

Circuit Ref.	Motorola Part No.	Description
R460	0662057A53	RES, 1.5K
R461	0662057A33	RES, 220
R462	0662057A18	RES, 51
R463	0662057A73	RES, 10K
R466	0662057B47	RES, 0
R467	0662057B47	RES, 0
R468	0662057B47	RES, 0
R469	0662057B47	RES, 0
R470	NOT PLACED	RES, 10K
R471	0662057A01	RES, 10
R472	NOT PLACED	RES, 100K
R473	NOT PLACED	RES, 100K
R600	0662057C01	RES, 0
R601	0611077A62	RES, 330
R602	0662057B47	RES, 0
R610	0662057C59	RES, 220
R615	0662057A25	RES, 100
R5000	0662057B47	RES, 0
R5001	0662057T68	RES, 1K
R5002	NOT PLACED	RES, 0
R5008	0662057B47	RES, 0
R5009	0662057B47	RES, 0
R5010	0662057B47	RES, 0
R5011	NOT PLACED	RES, 0
R5013	NOT PLACED	RES, 0
R5014	0662057B47	RES, 0
R5016	NOT PLACED	RES, 1MEG
R5019	0662057B05	RES, 200K
R5020	0662057B02	RES, 150K
R5021	0662057A97	RES, 100K

Circuit Ref.	Motorola Part No.	Description
R5022	0662057A97	RES, 100K
R5023	0662057A97	RES, 100K
R5024	NOT PLACED	RES, 100K
R5025	0662057A97	RES, 100K
R5026	0662057A85	RES, 33K
R5027	0662057B08	RES, 270K
R5028	0662057A97	RES, 100K
R5029	0662057A97	RES, 100K
R5030	0662057A85	RES, 33K
R5031	0662057A92	RES, 62K
R5032	0662057A89	RES, 47K
R5033	0662057A89	RES, 47K
R5034	0662057A86	RES, 36K
R5035	0662057A89	RES, 47K
R5036	0662057A89	RES, 47K
R5037	0662057A73	RES, 10K
R5038	0662057A85	RES, 33K
R5039	0662057A97	RES, 100K
R5040	0662057A84	RES, 30K
R5041	0662057A82	RES, 24K
R5042	0662057A82	RES, 24K
R5043	0662057A82	RES, 24K
R5044	0662057A82	RES, 24K
R5045	0662057A85	RES, 33K
R5046	0662057A82	RES, 24K
R5047	0662057B47	RES, 0
R5048	0662057A82	RES, 24K
R5049	0662057A77	RES, 15K
R5050	0662057A76	RES, 13K
R5051	0662057A75	RES, 12K

Circuit Ref.	Motorola Part No.	Description
R5052	0662057A73	RES, 10K
R5053	0662057A73	RES, 10K
R5054	0662057A73	RES, 10K
R5055	0662057A73	RES, 10K
R5056	0662057A73	RES, 10K
R5057	0662057A73	RES, 10K
R5058	NOT PLACED	RES, 10K
R5059	NOT PLACED	RES, 10K
R5060	0662057A73	RES, 10K
R5061	0662057A73	RES, 10K
R5062	0662057A73	RES, 10K
R5063	NOT PLACED	RES, 8.2K
R5064	NOT PLACED	RES, 8.2K
R5065	0662057A68	RES, 6.2K
R5066	0662057A49	RES, 1K
R5067	NOT PLACED	RES, 6.2K
R5068	NOT PLACED	RES, 6.2K
R5069	0662057A73	RES, 10K
R5070	0662057A57	RES, 2.2K
R5071	0662057A57	RES, 2.2K
R5072	0662057A65	RES, 4.7K
R5073	0662057A49	RES, 1K
R5074	0662057A49	RES, 1K
R5075	0662057A42	RES, 510
R5076	0662057A42	RES, 510
R5077	0662057A36	RES, 300
R5078	0662057A25	RES, 100
R5079	0662057A25	RES, 100
R5080	0662057A01	RES, 10
R5081	0613952D78	RES, 6.34K

Circuit Ref.	Motorola Part No.	Description
R5082	0662057A90	RES, 51K
R5083	0662057B08	RES, 270K
R5084	NOT PLACED	RES, 0
R5085	NOT PLACED	RES, 1MEG
R5086	0662057A43	RES, 560
R5087	0662057A97	RES, 100K
R5088	0662057B47	RES, 0
R5089	NOT PLACED	RES, 1MEG
R5092	0662057A73	RES, 10K
R5093	0662057A73	RES, 10K
R5094	NOT PLACED	RES, 1MEG
R5095	0662057A82	RES, 24K
R5096	0662057A73	RES, 10K
R5097	NOT PLACED	RES, 0
R5098	0662057B47	RES, 0
R5099	NOT PLACED	RES, 100K
R5100	NOT PLACED	RES, 1MEG
R5103	NOT PLACED	RES, 24K
R5290	0662057A25	RES, 100
R5291	0662057A25	RES, 100
R6000	NOT PLACED	RES, 0
R6001	NOT PLACED	RES, 0
RT100	0680361L01	THERM, 47K
S5010	1889288U01	SWITCH, 50.K
SH200	2689590U01	SHIELD
SH201	2689589U01	SHIELD
SH202	2689589U01	SHIELD
SH300	2689591U01	SHIELD
SH301	2689593U01	SHIELD
SH302	2689591U01	SHIELD

Circuit Ref.	Motorola Part No.	Description
T300	2580541Z01	XFMR
T301	2580541Z01	XFMR
U100	5180932W01	LM2904
U101	5185130C65	30C65, RF PREDRIVER
U102	NOT PLACED	LM2904, OPAMP
U103	5113819A04	MC3303
U200	5185963A27	63A27, LVFRACN
U201	5105750U54	50U54, VCOBIC
U300	5186144B01	SA616, IFIC
U301	5109522E10	TC7W04F, INVERTER
U302	4808612Y05	SMS3928_023, MIXER
U400	5102463J64	X25128-2.7, EEPROM
U402	5102463J36	SRM2B256, SRAM
U403	5102226J56	MC68HC11FL0, MICRO PROC
U404	5189233U02	AT49LV002N_70VI, FLASH
U405	NOT PLACED	MC74HC595A, SHIFT REG
U500	5180932W01	LM2904, OPAMP
U501	5102190C33	LM2941T, 9.3V REGULATOR
U502	5102463J95	TDA1519C, AUDIO PA
U503	5105469E65	LP2951C, 5V REGULATOR
U504	5185130C53	30C53, ASFIC CMP
U505	5180932W01	LM2904, OPAMP
U506	5180932W01	LM2904, OPAMP
U507	5180932W01	LM2904, OPAMP
U508	5113816A30	MC33269D, 3.3V REGULATOR
U509	5113806A20	MC14053B, MUX

Circuit Ref.	Motorola Part No.	Description
U510	5104187K94	LP2986ILDX, 3.3V REGULATOR
U514	4802393L66	SI3455ADV, 12V P-Ch FET
U515	NOT PLACED	MAX4599EXT, SWITCH
VR101	4813830A15	MMBZ5232B, 5.6V ZENER
VR102	4813830A15	MMBZ5232B, 5.6V ZENER
VR105	4813830A15	MMBZ5232B, 5.6V ZENER
VR400	NOT PLACED	MMBZ5232B, 5.6V ZENER
VR401	4813830G12	MMSZ4687T1, 4.3V ZENER
VR402	4813830A09	MMBZ5226B, 3.3V ZENER
VR500	4813832C77	MR2835S, 24V ZENER
VR501	4813830A14	MMBZ5231B, 5.1V ZENER
VR502	NOT PLACED	MMSZ4686T1, 3.9V ZENER
VR503	4813830G09	MMSZ4684, 3.3V ZENER
VR504	4813830G09	MMSZ4684, 3.3V ZENER
VR692	4813830A75	MMBZ20VAL, 20V DUAL ZENER
VR693	4813830A77	MMBZ33VAL, 33V DUAL ZENER
VR694	4813830A75	MMBZ20VAL, 20V DUAL ZENER
VR695	4813830A77	MMBZ33VAL, 33V DUAL ZENER
VR696	4813830A75	MMBZ20VAL, 20V DUAL ZENER
VR697	4813830A75	MMBZ20VAL, 20V DUAL ZENER

Circuit Ref.	Motorola Part No.	Description
VR698	4813830A75	MMBZ20VAL, 20V DUAL ZENER
VR699	4813830A75	MMBZ20VAL, 20V DUAL ZENER
Y200	NOT PLACED	45J68, TCXO
Y201	4880114R06	14R06, 16.8MHZ XTAL OSC
Y300	9186145B02	45B02, 455KHZ XTAL
Y301	4880606B09	06B09, 44.395MHZ XTAL OSC

