MOTOROLA

GTX/LCS 2000™

Mobile Radio

Service Manual

Foreword

The information contained in this manual relates to all GTX/LCS 2000™ radios, unless otherwise specified.

Safety Information

Airbag Warning Statement

WARNING

VEHICLES EQUIPPED WITH AIR BAGS

An air bag inflates with great force. DO NOT place objects, including communication equipment, in the area over the air bag or in the air bag deployment area. If the communication equipment is improperly installed and the air bag inflates, this could cause serious injury.

- Installation of vehicle communication equipment should be performed by a professional installer/technician qualified in the requirements for such installations. An air bag's size, shape and deployment area can vary by vehicle make, model and front compartment configuration (e.g., bench seat vs. bucket seats).
- Contact the vehicle manufacturer's corporate headquarters, if necessary, for specific air bag information for the vehicle make, model and front compartment configuration involved in your communication equipment installation.

FCC Safety Information

The Federal Communications Commission (FCC), with its action in General Docket 79-144, March 13, 1985, has adopted a safety standard for human exposure to radio frequency (RF) electromagnetic energy emitted by FCC-regulated equipment. Motorola subscribes to the same safety standard for the use of its products. Proper operation of this radio will result in user exposure substantially below FCC recommended limits.

- DO NOT hold the radio with the antenna very close to, or touching, exposed parts of the body, especially the face, ears, or eyes, while transmitting. Hold the radio in a vertical position with the microphone two to three inches away from the lips.
- DO NOT hold the transmit switch (PTT) on when not actually desiring to transmit.
- DO NOT allow children to play with any radio equipment containing a transmitter.
- DO NOT operate this equipment near electrical blasting caps or in an explosive atmosphere. Under certain conditions, radios can interfere with blasting operations. When you are in the vicinity of construction work, look for, and observe, signs cautioning against radio transmissions. If radio transmission is prohibited, you must not transmit until out of the area. Furthermore, you must turn off your radio to prevent any accidental transmission.
- DO NOT replace or charge batteries in a hazardous atmosphere. Contact sparking may occur while installing or removing batteries and cause an explosion.
- Turn the radio off when removing or installing a battery.

Anyone intending to use a radio in a hazardous area is advised to become familiar with the subject of intrinsic safety and with Section 70 of the National Fire Code, which is commonly referred to as Article 500 of the National Electric Code. Use of anything but factory supplied components may affect the approval and safety of the radio. Likewise, it is advised that servicing should be performed only by qualified personnel who adhere to the following Factory Mutual (FM) required warning:

WARNING

Modification of FM approved intrinsically safe radios will negate Factory Mutual Research Corporation (FMRC) approval.

Manual Revisions

Changes which occur after this manual is printed are described in "FMRs." These FMRs provide complete information on changes including pertinent parts listing data.

Computer Software Copyrights

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REPLACEMENT PARTS ORDERING

ORDERING INFORMATION

When ordering replacement parts or equipment information, the complete identification number should be included. This applies to all components, kits, and chassis. If the component part number is not known, the order should include the number of the chassis or kit of which it is a part, and sufficient description of the desired component to identify it.

Crystal and channel element orders should specify the crystal or channel element type number, crystal and carrier frequency, and the model number in which the part is used.

Orders for active filters, Vibrasender and Vibrasponder resonant reeds should specify type number and frequency, should identify the owner/operator of the communications system in which these items are to be used, and should include any serial numbers stamped on the components being replaced.

MAIL ORDERS

Send written orders to the following addresses:

Replacement Parts/ Test Equipment/Manuals Crystal Service Items: Motorola Inc. Americas Parts Division Attention: Order Processing 1313 E. Algonquin Road Schaumburg, IL 60196	Federal Government Orders: Motorola Inc. Americas Parts Division Attention: Order Processing 7230 Parkway Drive Landover, MD 21076	International Orders: Motorola Inc. Americas Parts Division Attention: International Order Processing 1313 E. Algonquin Road Schaumburg, IL 60196

TELEPHONE ORDERS

Americas Parts Division:
1-800-826-1913 (For Federal Government Orders)
Call: 847-576-8012
1-847-538-8023 (International Orders)

TELEX/FAX ORDERS

Americas Parts Division:FAX:847-538-8198 (Domestic) 847-576-3023 (International) Parts ID: 847-538-8194 Telex: 280127 (Domestic) 403305 (International)	Federal Government Orders: FAX: 410-712-4991

PARTS CUSTOMER SERVICE	PRODUCT CUSTOMER SERVICE
Americas Parts Division: Call: 1-800-422-4210 Parts Identification: Call: 847-538-0021	Customer Response Center (Sales and Service Assistance): Call: 1-800-247-2346 FAX: 1-800-232-9272

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GTX Mobile Radio Model Chart

15 W GTX Mobile Radio, M11UGD6CB1AN

FUF1140	Mobile Radio
GKN6270	DC Power Cable
GLN7317	Installation Kit
HMN3413	Microphone
FLN8752	Manuals
GKN6271	Ignition Cable

KIT BREAKDOWN

FUF1140 Mobile Radio

FBN5767	Bulk Packing
FCN1629	Control Head
FHN5875	Accessory Kit
FUF1290	15 W Unified Chassis

FCN1629 Control Head

FLN8530	Control Head
FLN8531	Control Head Hardware

FUF1290 15 W Unified Chassis

FLF5582	Main Board
FLN8529	Main Board Hardware

GTX Options

Delete Options

B90	All Accessories (except microphone)
B71	Standard Mic (HMN3413 Compact Mic)
B161	Standard Power Cable, 10-A Fuse (GKN6270)
B65	Standard Non-Locking Mounting Bracket (GLN7317)

Service Options

G24	2-Year Express Service Plan
G397	2-Year Express Service Plan plus Preferred Plan

GTX Accessories

Microphones

HMN3413	Compact Microphone
HMN1035	Heavy Duty Palm Microphone
HMN3013	DTMF Non-Backlit Microphone with Hang-Up Clip

Speaker

FSN5510	7.5 W External Speaker

Installation

GLN7317	Trunnion

Cables

GKN6270	15 W Power cable
GKN6271	Ignition Switch Cable
GKN6272	External Alarm Relay and Cable

Antennas

RRA4914	3 dB Gain Roof Mount
RRA4983	3 dB Gain Roof Mount with Teflon Cable
HAF4002	1/4 Wave Roof Mount

Accessory Connectors

HLN5282	Mini-U Connector
HKN9557	Mini-U Antenna Adapter Cable
HLN8027	Mini-U to BNC Adapter

Documentation Kits

User Guides (Operator Manuals)

68P02946C85	Quick Start
68P02946C75	User's Manual

Installation and Accessory Manuals

68P02945C80	Installation Manual
68P02945C70	Service Manual

LCS 2000 Mobile Radio Model Chart

15 W LCS Mobile Radio, M10UGD6DC5AN/F2484

FUF1142	Mobile Radio
GKN6270	DC Power Cable
GLN7317	Installation Kit
HMN3220	Microphone
FLN8753	Manuals
GKN6271	Ignition Cable

KIT BREAKDOWN

FUF1142 Mobile Radio

FBN5767	Bulk Packing
FCN1630	Control Head
FHN5875	Accessory Kit
FUF1290	15 W Unified Chassis

FCN1630 Control Head

FLN8530	Control Head
FLN8544	Control Head Hardware

FUF1290 15 W Unified Chassis

FLF5582	Main Board
FLN8529	Main Board Hardware

LCS 2000 Options

Microphones

B382	ALT: Full Size Mic
B20	ALT: Full Size DTMF, Non-Backlit, Touch Code Mic

Speaker

B18	7.5 W External Speaker

Alarms

B221	ADD: External Alarm Relay and Cable
B668	ADD: Emergency Pushbutton Alarm and Cable
B674	ADD: Emergency Footswitch Alarm and Cable

Delete Options

B90	All Accessories (except microphone)
B71	Standard Mic
B161	Standard Power Cable, 10-A Fuse
B65	Standard Non-Locking Mounting Bracket (GLN7317)

Service Option

G24	2-Year Express Service Plan

LCS 2000 Accessories

Mics

HMN3220	Compact Mic with Hang-Up Clip
HMN1035	Full Size Palm Mic
HMN3013	Full Size Mic, Non-Backlit
TDN8310	DTMF Full Size Mic, Backlit

Speakers

FSN5510	7.5 W External Speaker

Installation

GLN7317	Non-Locking Trunnion

Cables

GKN6270	Mobile Power Cable
GKN6271	Ignition Switch Cable

Alarms

GKN6272	External Alarm & Relay Cable
HLN9329	Emergency Pushbutton
GLN7323	Emergency Footswitch

Antennas

RRA4914	3 dB Gain Roof Mount SS Antenna
RRA4990	3 dB Gain Roof Mount BC Antenna
RRA4983	3 dB Gain Roof Mount LL/SS Antenna
RRA4986	3 dB Gain Roof Mount LL/BC Antenna
HAF4002	1/4 Wave Roof Mount

Accessory Connectors

HLN5282	Mini-U Connector
HKN9557	Mini-U Antenna Adapter Cable
HLN8027	Mini-U to BNC Adapter

Documentation Kits

User Guides (Operator Manuals)

68P02945C95	Quick Start
68P02945C90	User's Manual

Installation and Service Manuals

68P02945C80	Installation Manual
68P02945C70	Service Manual

Maintenance Specifications

GENERAL		RECEIVER		TRANSMITTER	
FCC Designation: GTX: LCS 2000:	 AZ492FT5778 AZ492FT5779	Frequency Range: GTX & LCS 2000: LCS 2000:	 851-866 MHz 851-870 MHz	Frequency range: GTX: LCS 2000:	 806-821MHz 851-866MHz 806-825MHz 851-870MHz
Temperature Range: Operating: Storage:	 -30+60˚C -40+85˚C	Max. Frequency Separation: GTX: LCS 2000:	 15 MHz 19 MHz	Max. Freq. Separation: GTX: LCS 2000:	 60 MHz 64 MHz
		Sensitivity (12dB SINAD):	0.35µV max.	RF Power: GTX (LCS 2000):	 15W 806-821 (825) MHz) 10W 851-866 (870) MHz
Power Supply: Nominal: Operating: Current Drain, maximum values: Stand-by: Receive: Transmit (15 W): Off:	 13.6 V 10.8 to 16.3 V 0.45 A 1.7 A with 7.5 W 6.5 A 30 mA	Adj. Channel Selectivity:	-65 dB	Deviation, Max.: GTX: @ 806-821 & 851-866 MHz LCS 2000: @821-825 & 866-870 MHz	 ±5 kHz ±4 kHz
Number of Systems: Talkgroups: Conventional:	10 8 10	Spurious & Image Rejection:	-65dB	Spurious & Harmonics:	-56 dBc
Channel Spacing:	25 kHz	Intermodulation:	-65dB	Audio Response:	6 dB/octave +1/-3 dB at 300-3000 Hz
Mode of Operation:	Semi-Duplex	Selectivity (25kHz Adjacent Channel):	-65dB	Distortion:	5% @ 60% of maximum deviation
Modulation:	FM				
Antenna Impedance:	50 Ω	Conducted Spurious Emission:	per FCC part 90		
Frequency Stability: GTX & LCS 2000: LCS 2000:	 806-821 MHz & 851-866 MHz, ±2.5 ppm 821-824 MHz & 866-869 MHz, ±1.5 ppm	Audio Output:	4 W (internal, 16 Ω) 7.5 W (external, 8 Ω)		
Dimensions: (H X WX D)	 44x168x169 mm; 1.73x6.61x6.67"	Audio Response:	6 dB/octave +1/-3 dB at 300-3000 Hz		
Weight:	1.21 kg (2.67 lbs)				
		Distortion:	5% @ 7.5 W		

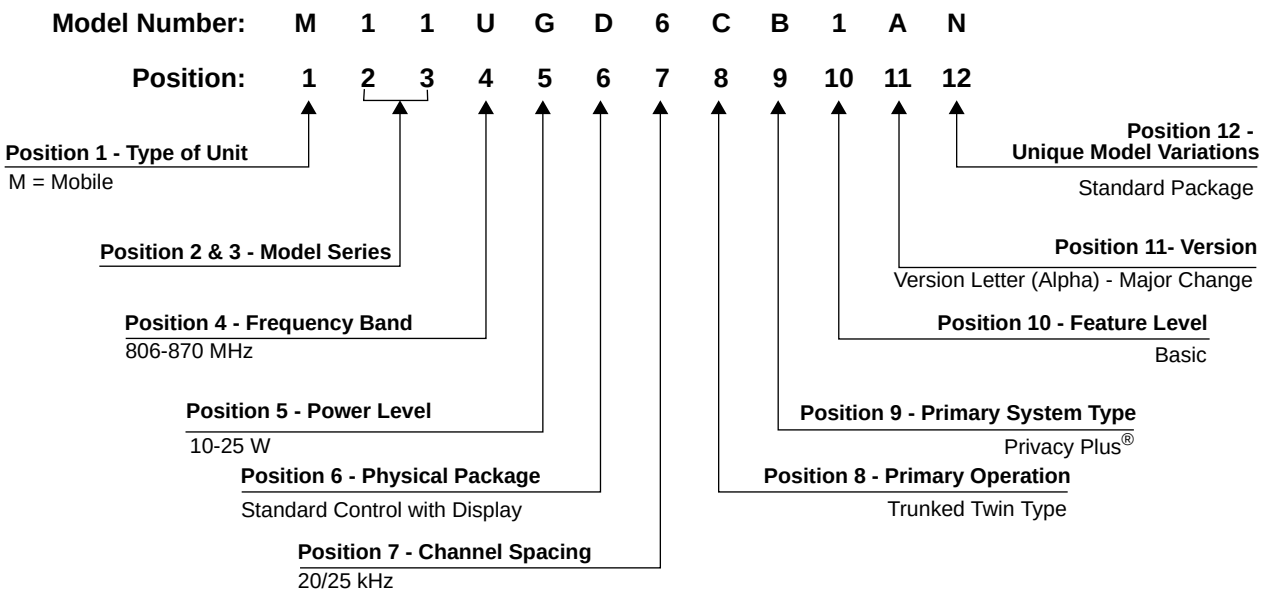
All specifications subject to change without notice.

Radio Model Numbering System

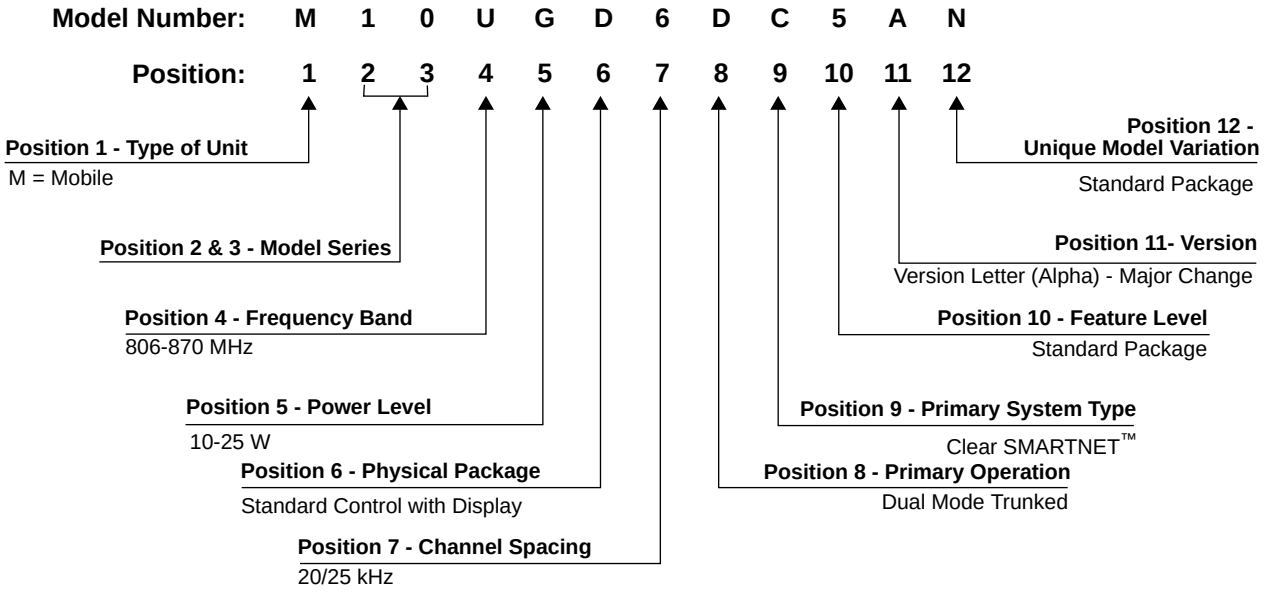
The model number, serial number, and Motorola FCC designation number are all on a label attached to the back of your radio.

All GTX/LCS 2000 radio models are synthesized, 8-channel units that come standard with Tone Private-Line (TPL)/Digital Private-Line (DPL) coded squelch or carrier squelch, which may be enabled/disabled on a per channel basis. Programming changes can be made by your local dealer.

GTX



LCS 2000



Introduction

1

Notational Conventions

Throughout the text in this publication, you will notice the use of warnings, cautions, and notes. These notations are used to emphasize that safety hazards exist, and care must be taken and observed.

Warning

WARNING
Indicates a potentially hazardous situation which, if not avoided, COULD result in death or serious injury.

Caution

CAUTION
Indicates a potentially hazardous situation which, if not avoided, MAY result in minor or moderate injury. CAUTION may also be used to alert against unsafe practices and property-damage-only accident hazards.

Note

An operational procedure, practice, or condition, etc., which it is essential to emphasize.

Scope of this Manual

This manual includes model/kit information, specifications, disassembly/reassembly procedures, maintenance, alignment, troubleshooting, and all theory, schematic diagrams, printed circuit board details and parts lists for all parts in the equipment described.

CAUTION
This manual is intended for use by experienced technicians who are familiar with similar types of equipment.

Safety information

Every radio, when transmitting, radiates energy into the atmosphere which may, under certain conditions, causes the generation of a spark.

All users of vehicles fitted with radios should be aware of the following warnings:

WARNING
- **Do not** operate the radio near flammable liquids or in the vicinity of explosive devices.
- During normal use, the radio will subject you to radio energy substantially below the level where any kind of harm is reported.

To ensure personal safety, please observe the following simple rules:

WARNING

- **Do not** transmit when the antenna is very close to, or touching, exposed parts of the body, especially the face and eyes.
- **Do not** hold the transmit (PTT) key in when not desiring to transmit.
- **Check** the laws and regulations on the use of two-way mobile radios in the areas where you drive. Always obey them. Also, when using your radio while driving, please:

  give full attention to driving,

  use hands-free operation, if available, and

  pull off the road and park before making or answering a call if driving conditions so require.

Air Bag Warning

WARNING

Vehicles equipped with air bags.
An air bag inflates with great force. **Do not** place objects, including communication equipment, in the area over the air bag or in the air bag deployment area. If the communication equipment is improperly installed and the air bag inflates, this could cause serious injury.

Installation of vehicle equipment should be performed by a professional installer/technician qualified in the requirements for such installations.

An air bag's size, shape and deployment area can vary by vehicle make, model and front compartment configuration (e.g., bench seat vs. bucket seats). Contact the vehicle manufacturer's corporate headquarters, if necessary, for specific air bag information for the vehicle make, model and front compartment configuration involved in your communication equipment installation.

LP Gas Warning

WARNING

It is mandatory that radios installed in vehicles fueled by liquefied petroleum gas conform to the National Fire Protection Association standard NFPA 58, which applies to vehicles with a liquid propane (LP) gas container in the trunk or other sealed off space within the interior of the vehicle. The NFPA 58 requires the following:

- Any space containing radio equipment shall be isolated by a seal from the space in which the LP gas container and its fittings are located.
- Removable (outside) filling connections shall be used.
- The container space shall be vented to the outside.

Basic Maintenance

2

Introduction

This section of the manual describes preventive maintenance, safe handling of CMOS devices, and repair procedures and techniques. Each of these topics provides information vital to the successful operation and maintenance of your radio.

Preventive Maintenance

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

Inspection

Check that the external surfaces of the radios are clean, and that all external controls and switches are functional. A detailed inspection of the interior electronic circuitry is not needed or desired.

Cleaning

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

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 and assembly. These surfaces should be cleaned whenever a visual inspection reveals the presence of smudges, grease, and/or grime. 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 mild dishwashing detergent in water. the only factory recommended liquid for cleaning the printed circuits boards and their components is isopropyl alcohol (70% by volume).

Plastic Surfaces

The detergent 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, lint-free 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.

Circuit Boards and Components

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

CAUTION
Alcohol is a high-wetting liquid and can carry contamination into unwanted places if an excessive quantity is used.

Make sure that controls or tunable components are not soaked with the liquid. Do not use high-pressure air to hasten the drying process. This could cause the liquid to puddle and collect in unwanted places. Upon completion of the cleaning process, use a soft, absorbent, lint-free 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 isopropyl alcohol and a clean container to prevent contamination by dissolved material from previous usage.

Safe Handling of CMOS Devices

Complementary metal-oxide semiconductor (CMOS) devices are used in this family of radios. While the attributes of CMOS are many, their 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.

CAUTION

Do not attempt to disassemble the radio without observing the following handling precautions.

Precautions

1. Eliminate static generators (plastics, stryofoam, etc. in the work area.
2. Remove nylon or double-knit polyester jackets, roll up long sleeves, and remove or tie back loose hanging neckties.
3. Store and transport all static-sensitive devices in ESD-protective containers.
4. If at all possible, handle CMOS devices by the package and not by the leads. Prior to touching the unit, touch an electrical ground to remove any static charge that you may have accumulated. The package and substrate may be electrically common. If so, the reaction of a discharge to the case would cause the same dame as touching the leads.
5. Disconnect all power from the unit before ESD-sensitive components are removed or inserted unless otherwise noted.
6. Use a static safeguarded workstation, which can be accomplished through the use of an anti-static kit (Motorola part number 0180386A82). This kit includes a writ strap, two ground cords, a static-control table mat and a static-control floor mat. For additional information, refer to Service and Repair Note SRN F1052, “Static Control Equipment for Servicing ESD Sensitive Products”, available form Motorola Literature Distribution 2290 Hammond Drive Schaumburg, IL 60173 (708) 576-2826.

   When these items are not readily available, observing the following techniques will minimize chance of damage.

   - If a static-sensitive device is to be temporarily set down, use a conductive surface for placement of the device.

   - Make skin contact with a conductive work surface first and maintain this contact when the device is set down or picked up.

7. Always wear a conductive strip when servicing this equipment. the Motorola part number for a replacement wrist strap that connects to the table mat is 42-80385A59.
8. When straightening CMOS pins, provide ground straps for apparatus used.
9. When soldering, use a grounded soldering iron.

Repair Procedures and Techniques

The radio support center is at the following address:
Motorola Radio Support Center
3651 South Central Avenue
Rockford, Ill, 61102
Telephone: (800) 227-6772
(815) 874-1400

Refer to the Disassembly and Reassembly section of the manual for pertinent information prior to replacing and substituting parts.

Parts Replacement

Special care should be taken to be as certain as possible that a suspected component is actually the one at fault. This special care will eliminate unnecessary unsoldering and removal of parts, which could damage or weaken other components or the printed circuit board itself.

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 office.

Rigid Circuit Boards

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

CAUTION
Therefore, care should be exercised to avoid pulling the plated circuit out of the hole.

When soldering near the 16 or 18-pin connector, use care to avoid accidentally getting solder in the connector.

CAUTION
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 700˚ F (370˚ C), and adjust the airflow to a minimum setting. Airflow can vary due to component density.

Chip Component Removal

To remove a chip component, select a hot-air hand piece and position the nozzle of the hand piece approximately 1/8” above the component to be removed. Begin applying the hot air. Once the solder reflows, remove the component using a pair of tweezers. Using solder wick and a soldering iron or a power desoldering station, remove the excess solder from the pads.

Chip Component Replacement

To replace a chip component using a soldering iron, select the appropriate micro-tipped soldering iron and apply fresh solder to one of the solder pads. Using a pair of tweezers, position the new chip component in place while heating the fresh solder. Once solder wicks onto the new component, remove the heat from the solder. 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, select the hot-air hand piece and reflow the solder on the solder pads to smooth it. Apply a drop of solder paste flux to each pad. Using a pair of tweezers, position the new component in place. Position the hot- air hand piece approximately 1/8" above the component and begin applying heat. Once the solder wicks to the component, remove the heat and inspect the repair. All joints should be smooth and shiny.

Over-Molded Pad-Array Carrier (OMPAC)

ASFIC U0201 is an OMPAC. It must be kept in a sealed bag with dessicant in the bag (in a "dry box" as supplied by the Motorola Parts Department prior to use. If the OMPAC is ambient for an unknown amount of time or for more than 96 hours, then it must be baked for at least eight hours at 260 ˚ F (185˚ C).

If neighboring OMPAC components are heated above 365˚ F (185˚ C), they will suffer die-bond delamination and possible "popcorn" failure.

During all repair procedures, heating neighboring components can be minimized by:

- Using upper heat only. using the correct size heat-focus head, approximately the same size as the carrier being replaced.
- Keeping the heat-focus head approximately 1/8" (0.3cm) above the printed circuit board when removing or replacing the device.

OMPAC Removal

To remove the OMPAC, select the R-1070A Air-Flow Station and the appropriate heat- focus head (approximately the same size as the OMPAC. Attach the heat-focus head to the chimney heater. Adjust the temperature control to approximately 415˚ F (215˚ C) 445˚ F (230˚ C) maximum. Adjust the airflow slightly above the minimum setting. Apply the solder paste flux around the edge of the OMPAC. Place the circuit board in the R-1070A's circuit board holder, and position the OMPAC under the heat-focus head. Lower the vacuum tip and attach it to the OMPAC by turning on the vacuum pump. Lower the heat-focus head until it is approximately 1/8" (0.3cm) above the carrier. Turn on the heater and wait until the OMPAC lifts off the circuit board. Once the part is off, grab it with a pair of tweezers and turn off the vacuum pump. Remove the circuit board from the R-1070A's circuit board holder.

OMPAC Replacement

To replace the OMPAC, the solder pads on the board must first be cleaned of all solder to ensure alignment of the new chip carrier. Prepare the sight by using solder wick and a soldering iron to remove all solder from the solder pads on the circuit board. If a power desoldering tool is available, it can be used instead of the solder wick. Clean the solder pads with alcohol and a small brush. Dry and inspect. Ensure that all solder is removed.

Once the preparation is complete, place the circuit board back in the R-1070A's circuit board holder. Add solder paste flux in the trench of the flux block and spread it using a one-inch putty knife. Flux the OMPAC by placing it in the trench of the flux block. Once the flux is applied, place the OMPAC on the circuit board, making certain that it is oriented correctly on the board. Position the heat-focus

head over the OMPAC and lower it to approximately 1/8” (0.3cm) over the carrier. Using the same heat and airflow setting used to remove the OMPAC, turn on the heater and wait for the carrier to reflow (heating and reflow should take longer than 60 seconds).

Once the carrier reflows, raise the heat-focus head and wait approximately one minute for the part to cool. Remove the circuit board and inspect the repair. No cleaning should be necessary.

Shields

Removing and replacing the shields will be done with the R-1070A, using the same heat and airflow profile used to remove and replace OMPAC components.

Shield Removal

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

Shield Replacement

To replace the shield, add solder to the shield if necessary, using a micro-tipped soldering iron. 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. Place the circuit board back in the R-1070A's circuit board holder. Place the shield on the circuit board using a pair of tweezers. Position the heat-focus head over the shield and lower it to approximately 1/8” above the shield. Turn on the heater and wait for the solder to reflow.

Once complete, turn off the heat, raise the heatfocus head, and wait approximately one minute for the part to cool. Remove the circuit board and inspect the repair. No cleaning should be necessary.

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3

Test Equipment, Service Aids, and Tools

Test Equipment

The list in Table 3-1 includes all standard test equipment required for servicing two-way mobile radios. Battery-operated test equipment is recommended when available. The “Characteristics” column is included so that equivalent equipment may be substituted; however, when no information is provided in this column, the specific Motorola model listed is either a unique item or no substitution is recommended.

Table 3-1 Recommended Test Equipment

Model No.	Description	Characteristics	Application
R2000 Series with trunking option	Communications System Analyzer		Frequency/deviation meter and signal generator for wide-range troubleshooting and alignment
R1053	Dual Trace Oscilloscope	200 MHz bandwidth, 5 mV/cm -20 Mv/cm	For waveform measurements
FLUKE 8012	Digital Multimeter		AC/DC voltage and current meter
T1013A	Load resistor	0-1000MHz, 300 W	For use with wattmeter
S1339A	RF Millivolt Meter 10kHz to 1.2 GHz	100µV to 3V rf	RF level measurements
R1011B	DC Power Supply	0-40Vdc, 30 Amps	Bench supply for 13.8Vdc current limited

Field Programming

The radio can be aligned and programmed in the field. This requires specific equipment and special instructions. refer to the Radio Service Software User's Manual for complete field programming information.

Table 3-2 Service Aids

PART No.	DESCRIPTION	APPLICATION
RLN4008B	Radio Interface Box	Enables communications between the radio and the computer's serial communications adapter.
EPN4040A	Power Supply	Used to supply power to the RIB (240 VAC).
0180358A56	Power Supply	Used to supply power to the RIB (220 VAC).
0180357A57	110V AC-to-DC Adapter	Used to supply power to the RIB (110 VAC).
3080070N01	Combined Interface Cable	Connects radio to RLN4008B RIB.
GKN6270A	DC Power Cable for radio	Interconnects radio to power supply.
3080369B72	Computer Interface Cable	Connects the computer's serial communications adapter (9 pin) to the RIB.
3080369B71	Computer Interface Cable	Connects the computer's serial communications adapter (25 pin) to the RIB.
RLN4438A	Adapter	25 pin (F) to 9 pin (M) adapter, for use with 3080369B72 for AT applications.
RVN4150	Radio Service Software (RSS)	For GTX radio programming.
RVN4156	Radio Service Software (RSS)	For LCS 2000 radio programming.
68P02945C70	Service Manual, 800MHz	Provides detailed technical information for the radio.
68P02946C20	RSS User's Guide	Provides detailed instruction on RSS use.
RLN4460A	Test Fixture	For radio testing
3008566C12	Test Cable	For connecting between the radio and RLN4460A.

Service Tools

The following table lists the tools recommended for working on the radio; these are also available from Motorola. Note that the R-1070A workstation requires the use of a specific “heat focus head” for each of the components on which this item is used. Each of these heat focus heads must be ordered separately.

Table 3-3 Service Tools

PART No.	DESCRIPTION	APPLICATION
0180381B45 110 VAC or 0180300E06 220 VAC	MBT250 Surface-mount/ through-hole repair station	Temperature-controlled, self-contained soldering/ desoldering repair station for installation and removal of surface-mounted devices.
8180369E97	Flux holder/applicator	Allows for the proper amount of flux to be applied to pad grid arrays for repair.
1105139W02	30cc plastic syringe and flux paste	For use with flux holder/applicator 8180369E97.
0180386A81	Miniature digital read-out soldering station (includes 1/64” micropoint tip)	
0180386A78	Illuminated magnifying glass with lens attachment	
0180386A82	Anti-static grounding kit	Used during all radio assembly and disassembly procedures
6684253C72	Straight prober	
6680384A98	Brush	
1010041A86	Solder (RMA type), 63/37, 0.020” diameter, 1 lb. spool	
R-1070A (superseded by R1319A)	Shields and surface-mounted component - IC removal/rework station	Removal of surface-mounted integrated circuits
R1319A (supersedes R-1070A) 6680332E82 6680332E83 6680332E84 6680333E28	Surface-Mounted Device Rework Station R1319A Reflow Nozzle R1319A Reflow Nozzle R1319A Reflow Nozzle R1319A Reflow Nozzle	Removal of surface-mounted integrated circuits For IC removal (approximate size 0.8 in. x 0.8 in.) For IC removal (approximate size 0.6 in. x 0.6 in.) For IC removal (approximate size 0.5 in. x 0.5 in.) For removal of RF PA

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Test Mode and Error Codes

4

Front Panel Test Mode

The functions of the radio controls for the Front Panel Test Mode are as follows:

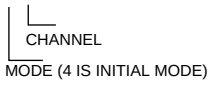
Test Mode/Entry

Test Mode allows radio checks to be performed in the field. To provide a level of protection to the Test Mode entry, proceed according to the following sequence:

1. Place radio in TRUNKING operation mode and wait for 6 seconds. (See Quick Start card for instructions on how to enter that mode.)
2. Turn radio off.
3. Verify that RIB is off.
4. Turn radio power supply (13.6 V DC) on .
5. Turn radio on.

The radio enters Test Mode operation:

- Speaker unmutes.
- One beep is heard to indicate operation on the first test frequency (default).
- Display shows "4 1" .



Test Mode/Channel Selection

Use the PTT switch for channel selection. A short press and de-press on the PTT switch (button-like push) will advance the radio to the next channel (cyclical) . Seven channels are available during test mode, as shown in the table below.

Table 4-1 Test Mode/Channel Selection

Channel Number	Rx Frequency	Tx Frequency	Display
1	851.0125 MHz	806.0125 MHz	“M 1” (2)
2	869.9875 MHz	824.9875 MHz	“M 2” (2)
3	860.5125 MHz	815.5125 MHz	“M 3” (2)
4	CC1 (1)	CC1-45 MHz	“M 4” (2)
5	CC2 (1)	CC2-45 MHz	“M 5” (2)
6	CC3 (1)	CC3-45 MHz	“M 6” (2)
7	CC4 (1)	CC4-45 MHz	“M 7” (2)

(1). CC1-CC4 are control channels programmed in association with the selected trunking system.

(2). M stands for modulation type (0-3). See Table 4-2.

Test Mode/Tx Modulation

Use PTT switch for modulation type selection. A continuous press will advance the radio to the next modulation test (cyclic scroll) and perform Tx test until PTT is released. The modulation selection is described in the table below.

Table 4-2 Test Mode/Tx Modulation

Modulation Type	Internal Speaker Audio Signaling	Internal Microphone Status	Display
CSQ	None	On	“0 C” (1)
Low Speed	Busy Channel	On	“1 C” (1)
High Speed	Call Back	Off	“2 C” (1)
DTMF “#”	DTMF “#”	Off	“3 C” (1)

(1). C stands for the selected channel (1-7). See Table 4-1.

Fail Mode

The radio will enter Fail Mode upon detecting one of the following errors:

- Application startup self check error
- Codeplug information check error

There are two categories of errors: critical and non-critical. Critical errors will stop radio normal operation.

Table 4-3 Fail Mode

Error number	Failure Description	Display	Critical	Tone Sound
1	Internal RAM	F 01	Yes	Illegal tone
2	External RAM	F 02	Yes	Illegal tone
5	OTP checksum	F 05	Yes	Illegal tone
6	Codeplug checksum	E 06	Yes	Illegal tone
7 (1)	Codeplug personality	E 06	No	Illegal Tone (when selected personality has checksum error)
8	Codeplug tuning error	E 06	Yes	Ilegal tone

(1). For error no. 7, personality (system) change is allowed although the illegal tone is heard. For error no. 8 the temporary illegal tone is heard. (See the Quick Start card for instructions on how to change personality.) To exit fail mode, power radio off.

Non-critical errors will be temporarily indicated as described in the table above.

Exiting Test Mode

To exit Test Mode, proceed as follows:

- Turn radio off.
- Turn RIB on.
- Turn radio on.

5 Disassembly & Reassembly

This chapter explains, step by step, how to disassemble and assemble the radio, to board level.

Disassemble the Radio

Remove the Control Head

1. Turn the radio upside down.
2. Insert a small flat blade screw driver, or similar, in the recess between the control head and the main board.
3. Press until the side of the control head releases.
4. Pull the control head away from the main board.
5. Remove the flat cable from the socket on the radio side.

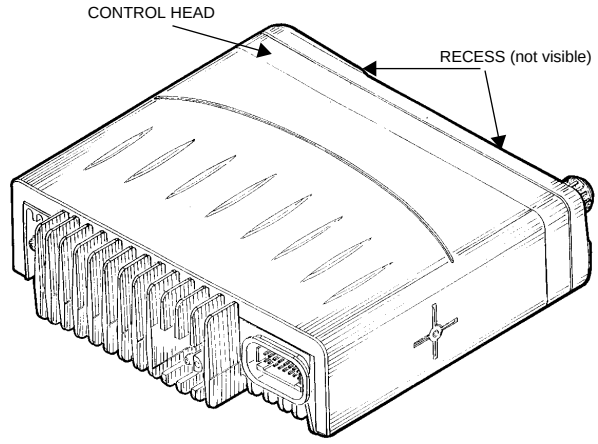


Figure 5-1 Control Head Removal

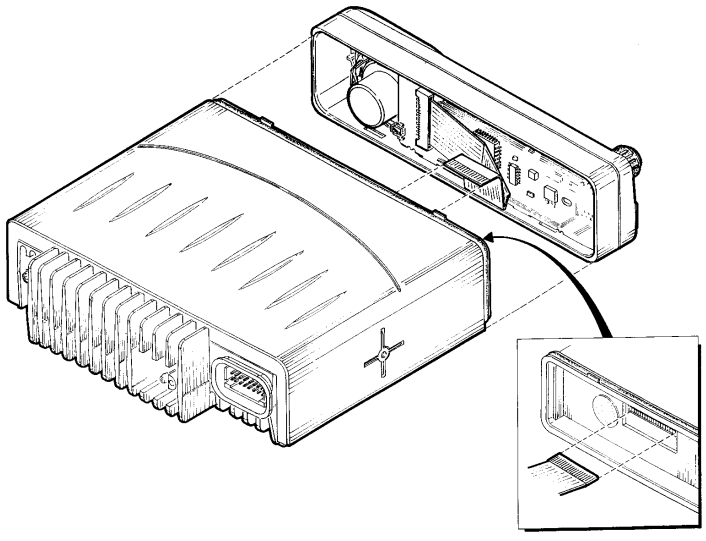


Figure 5-2 Flat Cable Removal

Remove the Top Cover

1. Insert a small flat blade screw driver in the side recess of the radio chassis. Repeat the operation on the opposite side of the radio.
2. Lift the top cover over the chassis.

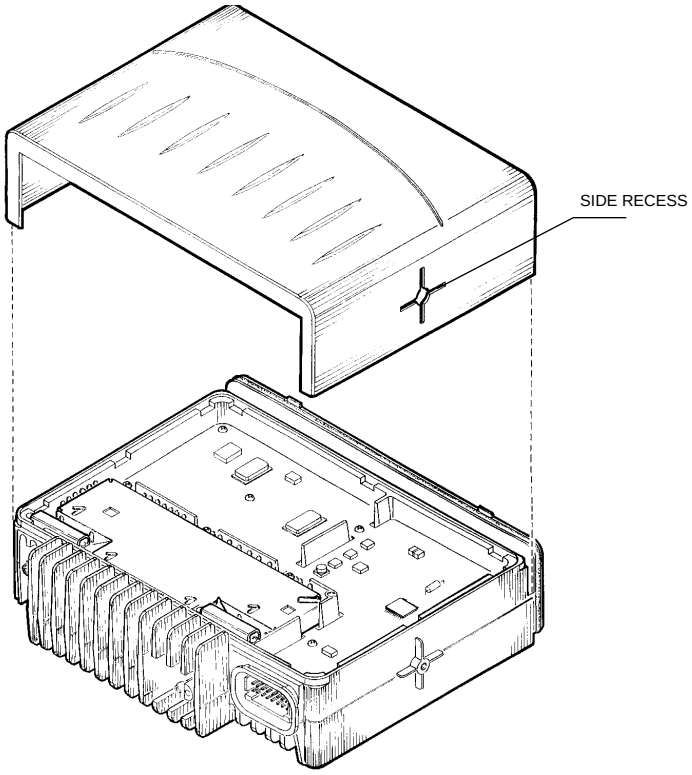


Figure 5-3 Top Cover Removal

Remove the Main Board

1. Remove the power and antenna connector retaining clips by inserting a small flat blade screw driver between the clip and the top of the chassis wall and gently prying the clip upwards.
2. Remove the 3 screws of the PA shield using a T8 TORX driver. Remove the PA shield by gently prying up each corner of the shield.
3. Remove the 8 screws securing the main board to the radio chassis.
4. Carefully remove the main board by rotating it out of the chassis.
5. Slowly lift the board on the front edge, the side with the connector that mates with the control head, and pull gently toward the front of the radio.

CAUTION
The thermal grease can act as an adhesive and cause the leads of the heat dissipating devices to be over stressed if the board is lifted too quickly.

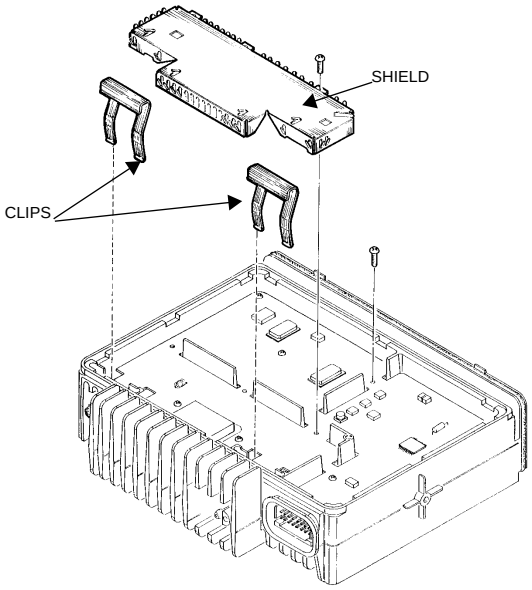


Figure 5-4 Main Board Removal

Disassemble the Control Head

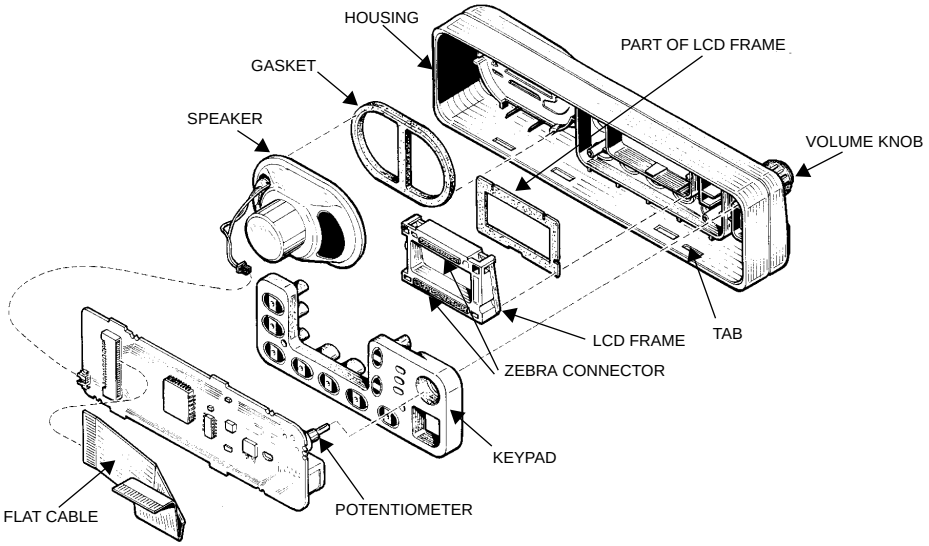


Figure 5-5 Control Head Removal

1. To pull out the printed circuit board from the control head housing, insert a small blade screw driver in the side groove near the four protruding tabs. Remove the board from the control head housing.
2. Disconnect the board from the speaker by removing it from the socket.
3. Remove the keypad from the control head housing by lifting it up from the board. Care should be taken not to touch or get other contaminates on the conductive pads on the under side of the keypad or conductive contacts on the printed circuit board.
4. Take the LCD frame out of the control head.

Assemble the Radio

Assemble the Control Head

1. Insert the LCD frame with LCD and Zebra connectors into its place.
2. Place the keypad onto the board assembly, making sure the keypad is flush with the board.
3. Rotate the potentiometer counterclockwise. Rotate the volume knob counterclockwise. This will allow you to insert the potentiometer smoothly into its place in the volume knob.
4. Make sure the speaker including the gasket is well positioned.
5. Connect the printed circuit board to the speaker.
6. During the installation of the printed circuit board, ensure the four protruding tabs snap into the recesses.

Replace the Main Board

1. Inspect and if necessary, reapply thermal grease to the heatsinking pads in the chassis.
2. Install the 8 screws with 0.4 -07 NM (4-6 in lbs) of torque using a T8 TORX driver.
3. Before installing the connector retaining clips, ensure that the board is sitting flush on the chassis mounting surface.
4. Install the PA shield and secure it with 3 screws.

Replace the Top Cover and Control Head

1. Position the top cover over the chassis and replace. Ensure that the crosses snap into the recesses.
2. Connect the control head to the radio by the flex.
3. Press the control head onto the radio chassis until the protruding taps on the chassis snap into the recesses inside the control housing.

6

Radio Tuning Procedure

Radio Tuning Procedure

General

An IBM PC (personal computer) and RSS (Radio Service Software) are required to align the radio. Refer to the applicable RSS Manual for installation and setup procedures for the software.

To perform the alignment procedures, the radio must be connected to the PC, RIB (Radio Interface Box), and Test Set as shown in Figure 6-6.

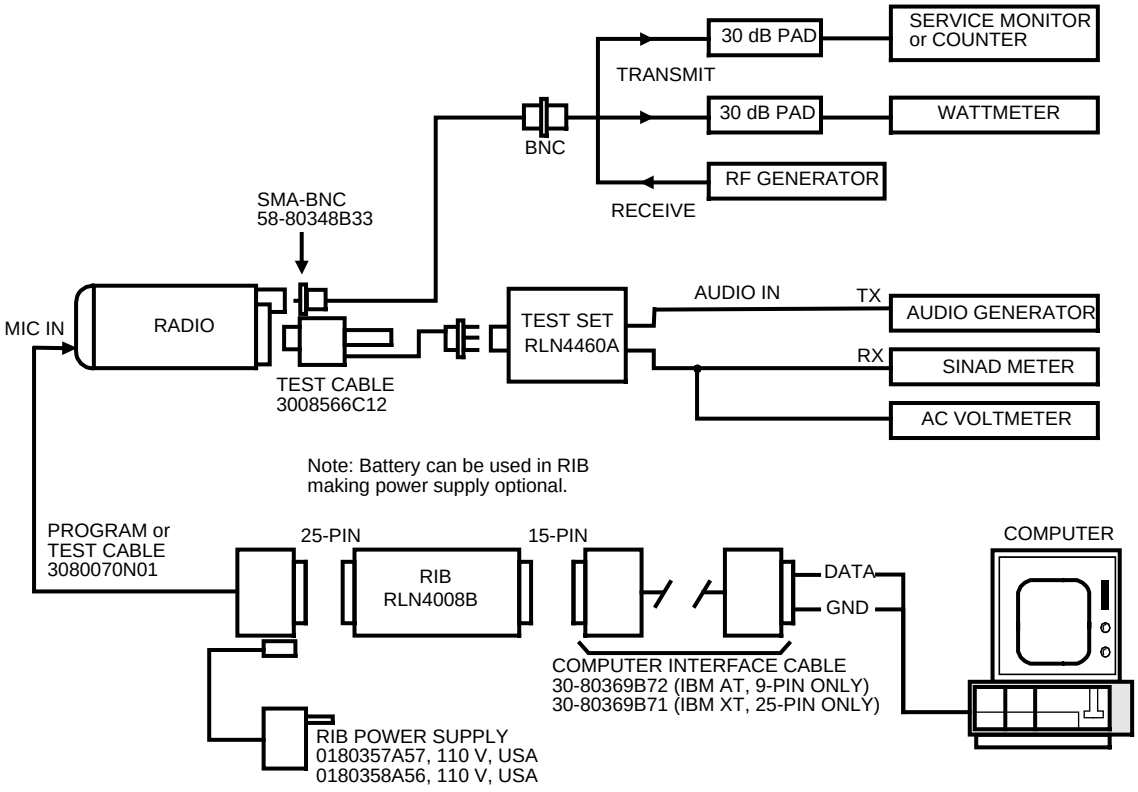


Figure 6-6 Radio Alignment Test Setup

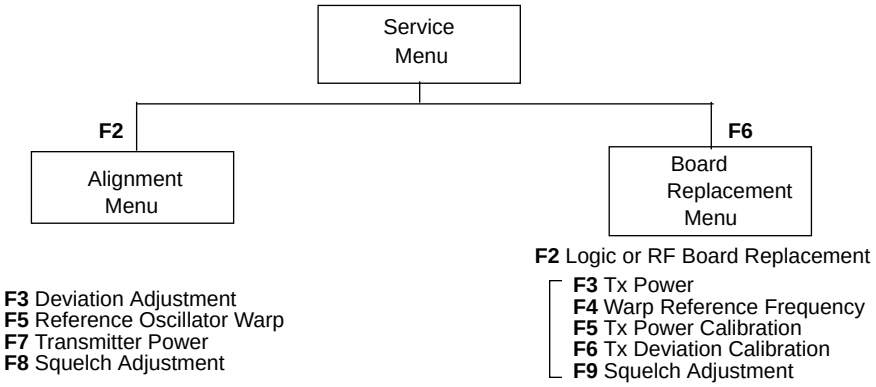


Figure 6-7 Service Menu Structure

All SERVICE screens read and program the radio codeplug directly; you do NOT have to use the RSS GET/SAVE functions to program new tuning values.

CAUTION

Do NOT switch radios in the middle of any SERVICE procedure. Always use the EXIT key to return to the MAIN menu screen before disconnecting the radio. Improper exits from the SERVICE screens may leave the radio in an improperly configured state and result in seriously degraded radio or system performance.

The SERVICE screens use the concept of the “Softpot”, an analog SOFTware controlled POTentiometer used for adjusting all transceiver alignment controls.

Each SERVICE screen provides the capability to increase or decrease the ‘softpot’ value with the keyboard UP/DOWN arrow keys respectively. A graphical scale is displayed indicating the minimum, maximum, and proposed value of the softpot, as shown in Figure 6-8.

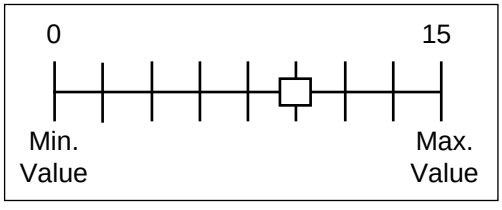


Figure 6-8 Softpot Concept

Tuning Procedure

Starting the Tuning Procedure

1. From the SERVICE menu, press F6 to select BOARD REPLACEMENT.
2. Press F2 for LOGIC OR RF BOARD replacement.

Note: Perform the following procedures in the sequence indicated.

Reference Crystal Data

1. Press F2 to select REFERENCE CRYSTAL DATA.
2. Press F8 for PROGRAM VALUE.

Tx Power

1. Press F3 to select Tx POWER.
2. Press F6 to key the radio. The screen will indicate that the radio is transmitting.
3. Adjust the transmit power value with the UP/DOWN arrow keys.
4. Press F6 again to dekey the radio, and then press F8 to program the softpot value.

Reference Oscillator Alignment

Adjustment of the reference oscillator is critical for proper radio operation. Improper adjustment will not only result in poor operation, but also a misaligned radio that will interfere with other users operating on adjacent channels. For this reason, the reference oscillator should be checked every time the radio is serviced. The frequency counter used for this procedure must have a stability of 0.1 ppm (or better).

1. Press F4 to select the REFERENCE OSCILLATOR softpot.
2. Press F6 to key the radio. The screen will indicate that the radio is transmitting.
3. Measure the transmit frequency that appears on the screen of your frequency counter.
4. Use the UP/DOWN arrow keys to adjust the reference oscillator.
5. Press F6 again to dekey the radio and then press F8 to program the softpot value.

Transmitter Power

1. Press F5 to select the Tx POWER calibration softpot. The screen will indicate the transmit test frequencies to be used.
2. Press F6 to key the radio.
3. Use the UP/DOWN arrow keys to adjust the transmit power value.
4. Press ENTER to select next softpot frequency.
5. Repeat steps 3 and 4 for the remaining test frequencies.
6. Press F6 to dekey the radio.
7. Press F8 to program the value.

Transmit Deviation Balance (Compensation) & Deviation Limit

Compensation alignment balances the modulation sensitivity of the VCO and reference modulation (synthesizer low frequency port) lines. Compensation algorithm is critical to the operation of signaling schemes that have very low frequency components (e.g. DPL) and could result in distorted waveforms if improperly adjusted.

1. Press F6 to select TX DEVIATION CALIBRATION. The screen will indicate the transmit test frequencies to be used.
2. Begin with the lowest test frequency shown on the screen.
3. Press F6 to key the radio. Record this measurement.
4. Press F4 to select 2.5 kHz.
5. Use the UP/DOWN arrow keys to adjust the deviation to within 0.5 dB of the value recorded in step 3.
6. Press ENTER to move to next softpot value.
7. Repeat steps 5 and 6 for the remaining frequencies.
8. Press F8 to program the softpot value.

Transmit Deviation Limit

The transmit deviation limit softpot sets the maximum deviation of the carrier. Tuning is performed for 25 kHz channel spacing.

1. Begin with the lowest test frequency shown on the screen.
2. Press F6 to key the radio.
3. With Test Box 4460A: inject a 1 kHz tone, 2000 mVrms.
4. Use the UP/DOWN arrow keys to adjust the deviation to between 4.4 kHz and 4.8 kHz.
5. Press ENTER to move to the next softpot value.
6. Repeat steps 4 and 5 for the remaining frequencies shown on the screen.
7. Press F6 to dekey the radio.
8. Press F8 to program the softpot value.

Squelch

The squelch softpots set the signal to noise ratio at which the squelch opens.

1. Press F9 to select SQUELCH Adjustment.
2. Adjust the UP/DOWN arrow key to the minimum squelch value.
3. Set the RF test generator to the test frequency plus +500 Hz offset.
4. Adjust the UP/DOWN arrow key until the squelch just closes.
5. Monitor for squelch chatter; if chatter is present, continue to adjust the UP/DOWN arrow. Wait 500 msec and repeat step 4.
6. When no chatter is detected, press F8 to program this value.

Ending the Tuning Procedure

1. Press F2 to continue.
2. Press F10, F10 to return to the Service menu.

Theory of Operation

7

This chapter provides theory of operation information for the radio. It starts with a block diagram level functional description of the entire radio. This is followed by a detailed functional description for each of the four major functions that make up the radio.

Introduction

Overview

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.

The control head is mounted directly on the front of the radio. The control head contains a speaker, LED indicators, a microphone connector, buttons which provide the user with interface control over the various features of the radio and a display.

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 provides the necessary connections for items such as external speaker, emergency switch, foot operated PTT, ignition sensing, etc.

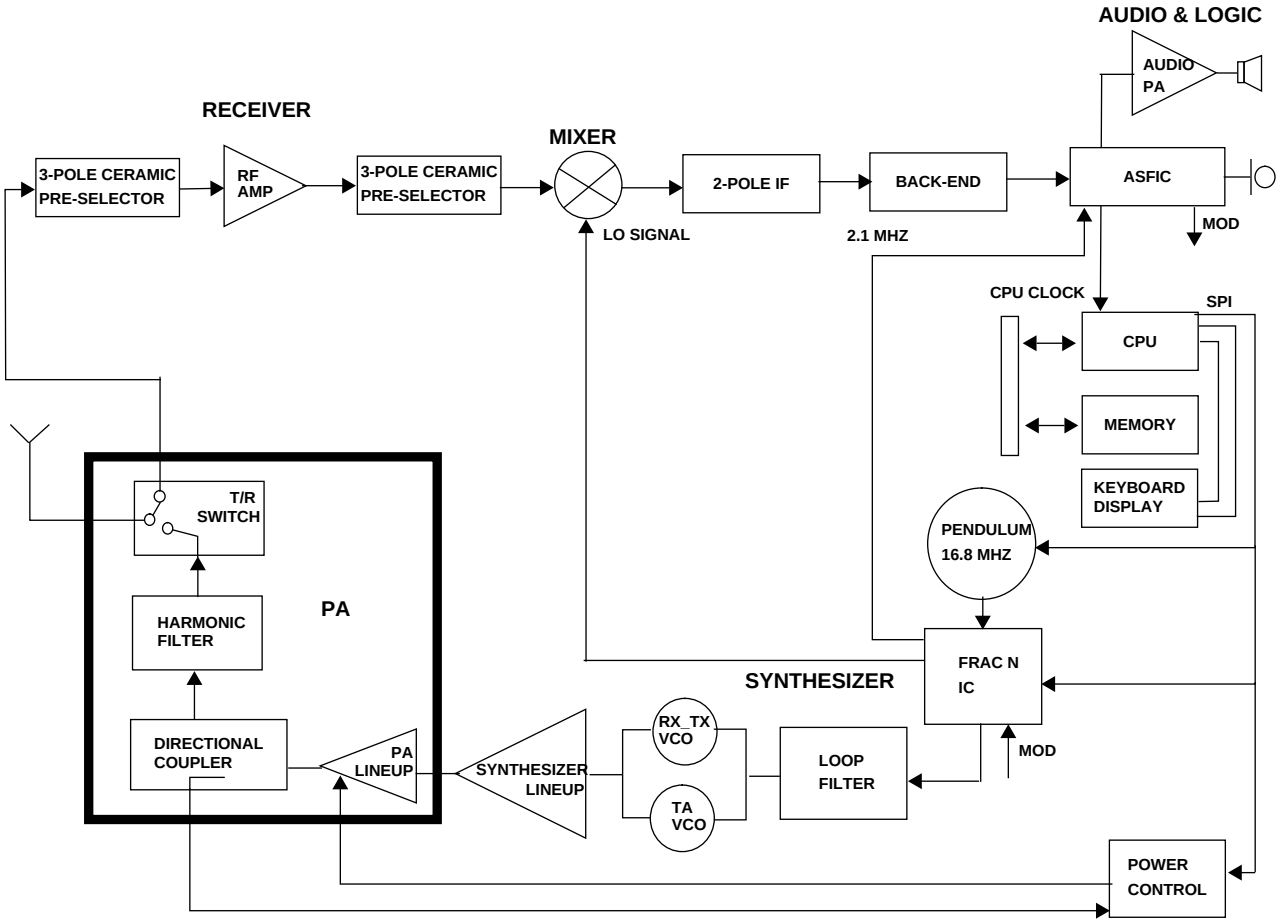


Figure 7-1 800-MHz Radio Functional Block Diagram

Receiver Detailed Functional Description

The receiver is composed of four sections: receiver front end, receiver IF, receiver back end and the audio signal filter IC (ASFIC) that is part of the controller section.

The radio signal from the antenna switch in the PA section enters the first bandpass filter (FL5203). The first bandpass filter has three poles, a 860-MHz center frequency, a 20-MHz wide passband and a 40-dB rejection for image frequencies (761 to 780 MHz).

After the first bandpass filter, the signal passes to a pair of hot-carrier limiting diodes (D5303) placed in front of RF preamplifier Q5301. The hot-carrier diodes limit strong signals to prevent them from overdriving the RF preamplifier and damaging it.

The front end amplifier is a low noise amplifier that consists of Q5301. Its main purpose is to set the noise figure of the receiver. The front end amplifier as well as the IF amplifiers are shut off during transmit by K9.1 line via switch Q5230, to provide isolation in talk-around mode.

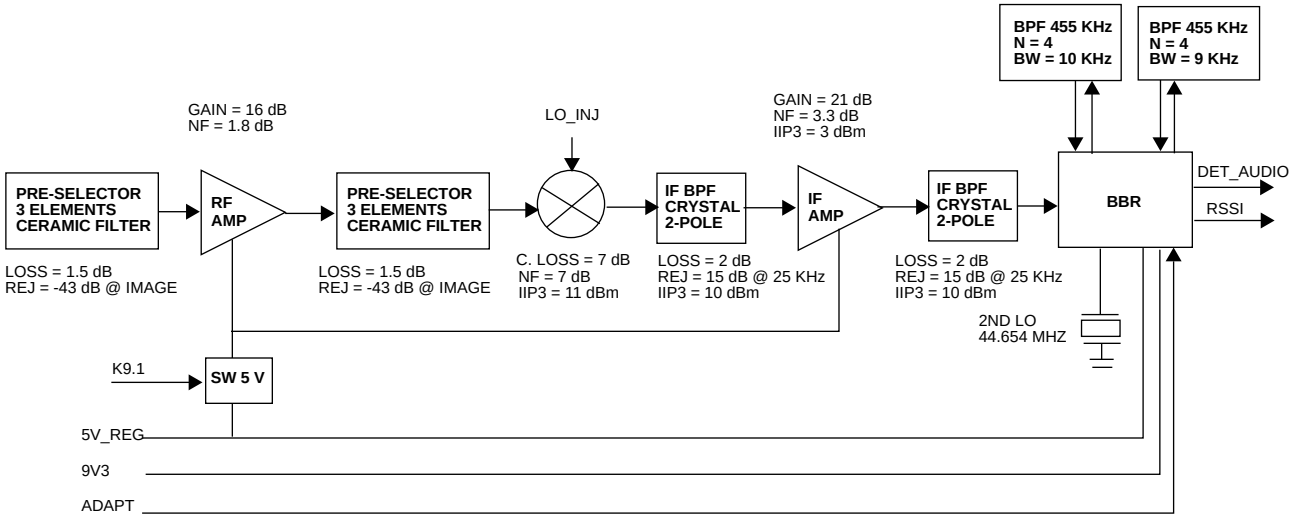


Figure 7-2 Receiver Functional Block Diagram

After the amplifier, the signal enters a second bandpass filter (FL5204), which is identical to FL5203. The bandpass filter is fixed tuned from 851 to 870 MHz.

After the second bandpass filter, mixer U5211 down-converts the signal to the IF frequency.

The mixer is a passive double-balance mixer that gets a local oscillator signal in the range of 805.9 to 824.9 MHz from the synthesizer and works on 4-dBm power. The IF frequency is 45.1 MHz. A diplexer matches the mixer IF port to 50 Ohm out of the IF frequency band.

The diplexer consists of R5401, C5404, L5402.

The IF signal is fed to first crystal filter Y5201 through matching network L5401, C5200.

Crystal filter Y5201 has two poles. The crystal filter is followed by matching elements, that match the filter output impedance to the input impedance of IF amplifier Q5201.

Following the IF amplifier is a matching network that matches the IF amplifier output impedance to the input impedance of a second 45.1-MHz crystal filter (Y5202). The second crystal filter is followed by matching elements that match the output of the second crystal filter to the input of the receiver back end circuits. After the matching circuit, the signal passes a pair of hot-carrier limiting diodes (D5201) placed in front of the back end circuit.

The receiver back end consists of BBR IC (U5201) that contains the following functions:

- Preamplifier & mixer to convert the signal to a second IF frequency of 455 kHz.
- Second LO circuit

- Second IF amplifiers
- FM Demodulator
- Audio amplifier

In addition to BBR IC, the back end contains the following components:

- Second LO resonator for 44.645 MHz (Y5211)
- Crystal filters for 455 kHz (FL5201, FL5202)
- Demodulator filter (C5224)

The IF signal routed to BBR IC is amplified, converted to 455 kHz, filtered, limited and demodulated.

Demodulated audio comes out of BBR IC at pin 28 and is fed to the ASFIC, which is part of the radio controller section.

In addition to the audio output signal, the receiver section provides an RSSI (Receiver Signal Strength Indicator) at pin 11. The RSSI signal is fed to the controller.

ADAPT signal in pin 22 controls the BBR IC. The normally low (0 V) ADAPT signal is high (5 V) during change of radio channels or at turn-on. The ADAPT signal is used to control precharge of capacitor C5231 at DEMOD_OUT. This is done in order to eliminate the transient during a change in the frequency or when the radio goes from transmit to receive mode.

Transmitter Detailed Functional Description

The 15-W PA is a three-stage amplifier used to amplify the output from the injection string to the radio transmit level. It consists of driver stage Q6501, followed by two-stage Class C Power Module U6501.

The two stages of the power module operate from the A+ supply voltage. The module is switched on/off by the K9.1 line through switch U6502 (which connects the A+ line to pin 2 of U6501 when transmit is enabled).The RF drive, which is routed into transistor Q6501, is controlled from Q6506 via the PA control line. The rising control voltage on the PA control line causes a rising collector voltage on Q6501. This causes more power out of the stage. Conversely, a decreasing control line voltage decreases the power delivered into the next stage. By controlling the drive power to U6501 and the following stages in the power amplifier lineup, ALC loop is able to regulate the output power of the transmitter.

The antenna switch is switched synchronously with the keyed 9.1 voltage. In the transmit mode, this 9.1 voltage is high—turning on diodes CR6502, CR6503 and CR6504. When CR6502 is turned on, it forms a low impedance to the RF transmit path and allows the signal to pass through. Diodes CR6503 and CR6504 short the ends of quarter wavelength lines to ground, presenting a high impedance towards the receiver. In this way no power is delivered into the receiver, the transmit path remains undisturbed, and the receiver is protected during transmission.

In the receive mode, all these diodes are off. The off capacitance of CR6502 is tuned by L6508 to form a high impedance looking into the transmitter. Therefore, energy coming in the receive mode is channeled to the RX port. Harmonics of the transmitter are attenuated by the harmonic filter. The harmonic filter is formed by inductors L6513 and L6518 as well as capacitors C6540-C6542, C6551-C6553.

This network forms a low-pass filter to attenuate harmonic energy of the transmitter to specifications level.

A forward-power detector follows the harmonic filter. This forward-power detector is a microstrip printed circuit, which couples a small amount of the forward energy and sends it to diode CR6506 where it is rectified. This rectified signal (VFORWARD) forms the forward voltage which the power control circuit holds constant. Holding this voltage constant (which is proportional to the RF rectified energy appearing across the diode) ensures the forward-power out of the radio is held to a constant value.

In the PA section, 50k thermistor R6519 senses temperature in the area of the power module. This signal is fed back into the power control circuit to protect the power amplifier against over-temperature conditions. Resistor R6520, in series with the A+ line supply, feeds voltage to the power module. The voltage across R6520 is monitored and these two inputs are channeled to the power control circuit. The power control circuit monitors the voltage drop across this resistor, which is determined by the magnitude of the drain current in U6501. It uses this as a limiting mechanism whereby the power control circuit limits the magnitude of current that can be drawn by U6501. This protects the device from over dissipation.

Bias voltage reverse polarity protection for the transmitter is provided by diode CR6508. Under reverse polarity conditions to the radio, this diode conducts and protects the radio from damage. This diode also provides transient over-voltage protection by breaking down when the supply voltage to the radio exceeds 24 V.

Power Control Circuitry

The power control circuitry consists of three mechanisms.

Power Set

The control loop compares the power output level to the pre-set value. The VFORWARD voltage from the forward power detector is amplified by U0701 (pins 5 and 7) and compared to D/A U0702, outputs 2 and 4. Should a difference be detected, an error current is generated into the loop integrator (U0702, pins 8 and 10) until equilibrium is obtained. The use of 2 D/A outputs for power set (pins 2 and 4) enables fine tuning where pin 2 is the coarse tune through resistor R0703 (10 kΩ) and pin 4 is fine tune through resistor R0706 (100 kΩ).

Current Limit

The current to the power module is monitored using R6520 and compared to a pre-set limit (D/A pin 11, and U0701 pins 1-3). When the limit is exceeded, an error current is generated through diode CR0721 (pins 1 and 3) to the loop integrator, which lessens the PA_CNTRL line and reduces the power amplifier output.

Thermal Protection

When the power module overheats, the resistance of thermistor R 6519 drops. Because of the voltage divider formed by R0725, R0721, and R6519, this resistance drop is sensed and amplified through U0701 pins 12-14. This causes a current error through diode CR0721 pins 2 and 3 to flow into the loop integrator and reduce transmitted output power.

The PA_ENABLE line is for emergency shut down of transmission. When the line is driven high, transistor Q0731 is driven into saturation, causing the power control line to be driven to ground voltage. The K9.1_ENABLE line generates the K9.1 voltage when high enabling transmission.

Synthesizer Detailed Functional Description

The complete synthesizer subsystem consists of a reference oscillator (U5700), a Fractional-N Synthesizer IC (U5702), two on-board voltage controlled oscillators, a buffer stage (U5701), and two line-up amplifiers (Q5707, Q5705).

Reference oscillator U5700 contains a temperature compensated crystal with an oscillation frequency of 16.8 MHz. The output of the oscillator (pin 10 of U5700) is then applied to pin 14 (XTAL1) of U5702 via C5733 and R5715.

There are two VCOs which are varactor tuned. The oscillator frequency is controlled by the voltage applied via L5702 and L5701. This control voltage ranges from about 2.5 to 10.5 V DC. A small control voltage produces a lower frequency and a large control voltage produces a high frequency respectively.

The RX/TX VCO (806 - 825 MHz frequency range) provides the first LO injection frequency which is 45.1 MHz below the carrier frequency and the TX injection in the conventional mode. The RX/TX VCO is selected by pulling pin 1 (AUX 3) low on U5702.

The TA (Talk-Around) VCO (851 - 870 MHz frequency range) provides the transmit frequency in talk-around mode. The TA VCO is selected by pulling pin 1 high on U5702.

The buffer stage (U5701) and the feedback amplifier (Q5703) provide the necessary gain and isolation for the synthesizer loop.

Fractional-N Synthesizer IC U5702 consists of:

- Prescaler
- Programmable loop divider
- Control divider logic
- Phase detector
- Charge pump
- A/D Converter for low frequency digital modulation
- Balance attenuator to balance the high and low frequency analog modulation
- 13-V positive voltage multiplier,
- Serial interface for control,
- Super filter for the regulated 9.3 V

C5712 is used as a super filter capacitor. The output voltage of the super filter (pin 18) drops from 9.3 V to about 8.5 V. This filtered 8.5 VDC supplies the voltage for the VCOs, the VCO switching units (U5704 & U5705), feedback amplifier (Q5703), and synthesizer charge pump resistor network (R5707- R5709).

The synthesizer supply voltage is provided by the 5 V regulator (U5703). The 2.1 MHz reference signal (pin 11 of U5702) is generated by dividing down the signal of reference oscillator U5700 after it is applied to pin 14 of U5702.

In order to generate a high voltage that supplies the charge pump output stage at pin VCP (pin 32 of U5702), 13 V is generated at pin 3 of CR5700 by the positive voltage multiplier circuitry (CR5700). This voltage multiplier is basically a diode capacitor network driven by two 1.05 MHz, 180-degree out-of-phase signals (pin 9 and 10 of U5702).

The serial interface (SPI_DATA) is connected to the microprocessor via the data line (pin 5 of U5702), clock line (pin 6 of U5702), and chip enable line (pin 5 of U5702). Proper enabling of these lines should allow the microprocessor to load the synthesizer IC.

The output of the VCO is fed into the buffer input port (pin 1) of U5701. The output of the buffer, pin 5 of U5701, is applied to the input of the feedback amplifier (Q5703) through an attenuator network (R5735, R5733, R5732). To close the synthesizer loop, the output of Q5703 is connected to the PREIN port (pin 20) of synthesizer U5702. The buffer output (pin 5 of U5701) also provides signal for the receiver LO injection and transmit injection string circuit. The charge pump current is present at pin 31 of U5702.

The loop filter (which consists of R5716, R5717, R5734, C5750, C5744, C5745, C5736, C5746, C5747, C5794, C5795, C5796, C5797, C5798, C5799) will then transform this current into a voltage that will, in turn, be applied to Vcontrol of the VCOs and alter the output frequency.

In order to modulate the PLL, the two-point modulation method is utilized. The audio signal is applied to both the A/D converter (low frequency path) as well as the balance attenuator (high frequency path) via pin 8 on U5702.

The A/D converter will convert the low-frequency, analog modulating signal into a digital code that will in turn be applied to the loop divider. This will cause the carrier to deviate. The balance attenuator is used to adjust the VCO deviation sensitivity to high frequency modulating signals. The output of the balance attenuator is present at the MODOUT port (pin 28 of U5702).

The transmit injection string consists of two amplifier stages (Q5707 & Q5705) whose main purpose is to maintain a constant output to drive the RFPA and provide isolation. The Q5705 stage is actively biased through Q5701, and Q5707 has passive bias. The TX injection string is on, only during the transmit mode (K 9.1V line is at 9.1 V).

There are two VCOs, one for the 806-825 band that is used as LO INJ. during receive and TX INJ. at conventional mode. The second VCO is used as TX INJ. in the talk-around mode.

The VCOs get their control voltage through L5702 and L5701. Q5704 and Q5706 are the oscillation transistors. C5793, C5792 and C5785, C5784 are the oscillator feedback capacitors. U5707 and U5706 are micro strip resonators. CR5702 and CR5701 are the varactors. C5790 and C5782 determine the KV. C5703 and C5704 determine the VCO operation frequency.

C5791 and C5783 are the coupling capacitors between the tank and the oscillation transistor.

The two VCOs are coupled to the buffer (Q5702) through C5789 and C5786. The stage output signal is fed to U5701 input (pin 1) through C5770 & R5736.

Controller Detailed Functional Description

General

The radio controller consists of four main subsections:

- Digital Control
- Audio Processing
- Power Control
- Voltage Regulation

The digital section consists of a microprocessor, memory ICs, glue logic circuitry, signal MUX ICs, On/Off circuit, and general purpose Input/Output circuitry.

The controller is based on the Motorola 68HC11K1 microprocessor (U0101), 8-Kbyte SRAM (U0103), 128 Kbyte-OTP memory (U0102), and 4 Kbyte EEPROM (U0104).

Note: From this point on, the 68HC11K1 microprocessor will be referred to as K1µP or µP.
References to a Control Head will be to type P+ (Display radio).

Voltage Regulators

Voltage regulation for the controller is provided by 3 separate devices; U0631 (LP2951CM) +5V, U0601 (LM2941T) +9.3V, and UNSW 5V (R0621 and VR0621). An additional regulator is located in the RF section.

5-V voltage regulation for the digital circuitry is provided by U0631. Input and output capacitors (C0631/0632 and C0633-0635) are used to reduce high-frequency noise and provide proper operation during short battery transients. This regulator provides a reset output (pin 5) that drops to 0 V while the regulator output goes out of regulation. This is used to reset the controller in order to prevent improper operation. Diode D0631 prevents discharge of C0632 by negative spikes on the 9V3 voltage.

Regulator U0601 is used to generate the 9.3 V required by some audio circuits, the RF circuitry and power control circuitry. Input and output capacitors (C0601-0603 and C0604/0605) are used to reduce high-frequency noise. R0602/R0603 set the regulator output voltage. If the voltage at pin 1 is greater than 1.3 volts the regulator output decreases and if the voltage is less than 1.3 V, the regulator output increases. This regulator output is electronically disabled by a 0 V signal on pin 2. Q0601 and associated circuitry (R0601/0604/0605) are used to disable the regulator when the radio is turned off.

UNSW 5V is only used by a few circuits which draw low current and require 5 V while the radio is off.

UNSW 5V CL is used to save the internal RAM data. C0622 allows the battery voltage to be disconnected for a couple of minutes without losing RAM parameters. Diode D0621 prevents radio circuitry from discharging this capacitor.

The SW +B voltage is monitored by the µP through voltage divider R0641/R0642. Diode VR0641 limits the divided voltage to 5.1 V in order to protect the µP.

Diode D5601 located on the PA section acts as protection against transients and wrong polarity of the supply voltage.

Electronic On/Off

The radio has circuitry which allows radio software and/or external triggers to turn the radio on or off without direct user action.

Some examples of where this is useful are: 1) automatic turn on when emergency switch is engaged; 2) automatic turn on when ignition is sensed and off when ignition is off.

Q0611 is used to provide SW B+ to the various radio circuits. Q0611 acts as an electronic on/off switch controlled by Q0612 (the switch is on while Q0612 is on). When the radio is turned on, the voltage at the base of Q0612 is high (about 0.6 V). Q0612 switches on (saturation) and pulls down the voltage at Q0611-base. This turns on Q0611 and supplies SWB+ to the radio. The on resistance of Q0611 is very low (less than 1 Ω), so the voltage level at SWB+ is quite the same as A+.

The electronic on/off circuitry can be enabled by the microprocessor (through ASFIC, line B+ CONTROL), the emergency switch (line EMERGENCY CONTROL), the mechanical On/Off button on the control head (line ON OFF CONTROL), or the ignition sense circuitry (line IGNITION CONTROL). If one of the 4 paths cause a low at the collector of Q0612, the electronic ON process is engaged.

Emergency

The emergency switch, when pressed, grounds the base of Q0441 and pulls the line EMERGENCY CONTROL to low. EMER IGN SENSE is pulled high by R0441. When the emergency switch is released, the base of Q0441 is pulled high by R0442. This causes the collector of transistor Q0441 to drop down (0.2 V), thereby setting the EMER IGN SENSE line to low.

While EMERGENCY CONTROL is low, Q0611 is turned on, SW B+ is enabled, the microprocessor starts execution, reads the voltage level of EMER IGN SENSE line, and sets the B+ CONTROL output of the ASFIC to a logic high. This high level keeps Q0611 switched on through Q0612. This operation allows powering on the radio by a momentary press of the emergency switch. When the microprocessor has finished processing the emergency press, it sets the B+ CONTROL line to a logic 0. This cuts off Q0611 and the radio turns off. Notice that the microprocessor is alerted to the emergency condition via line EMER IGN SENSE. If the radio was already on when emergency was triggered, then B+ CONTROL would have already been at a high level.

Mechanical On/Off

This refers to the typical on/off button which is located on the control head and turns the radio on and off. While the on/off button is turned on, line ON OFF CONTROL goes high during the short pulse generated by the ON_OFF “one-shot” circuitry in the control head. This switches the radio on. The microprocessor is alerted through line ANALOG 3 which is pulled to low by Q0925 (Control Head P+) while the on/off button is turned on. If the software detects a low state, it asserts B+ CONTROL via ASFIC-GCB2, which keeps Q0612 and Q0611on, and in turn the radio is switched on.

While the on/off button is turned off, the software detects the line ANALOG 3 changing to low and switches the radio off by setting B+ CONTROL to low.

Ignition

Ignition sense is used to prevent the radio from draining the vehicle’s battery while the engine is not running.

When the IGNITION input goes above 6 V, Q0450, Q0612 and Q0611 turn on, supplying SW B+ to the radio and enabling U0601 and U0631 to supply the regulated voltage (+5 V and 9.3 V) to all the circuitry. The µP starts to run the software, reads the line EMER IGN SENSE, determines from the level (Emergency has a different level) that the IGNITION input is active and sets the B+ CONTROL (via the ASFIC-GCB2) to high and latches SW B+ to on.

While the IGNITION line drops below 6 V, Q0450 switches off and R0441 pulls line EMER IGN SENSE high. The software is alerted by line EMER IGN SENSE to switch off the radio by setting B+ CONTROL line to low. Whenever the IGNITION line goes above 6 V, the above process will be repeated—depending if the radio was previously on or off**.**

Hook

The HOOK line is used to inform the µP when the Microphone´s hang-up switch is engaged. Depending on the radio model, the µP turns the audio PA on or off. The signal is routed from J0101-3 and J0400-14 through transistor Q0101 to the K1µP U0101-PH1 (pin 23). The voltage range of HOOK in normal operating mode is 0-5 V.

Microprocessor Clock Synthesizer

The clock source for the controller's microprocessor system is generated by the ASFIC (U0201). Upon power-up the synthesizer (U5701) generates a 2.1 MHz waveform that is routed from the RF section (via C0202) to the ASFIC (on U0201 XTAL_IN). For the main board controller, the ASFIC uses 2.1 MHz as a reference input clock signal for its internal synthesizer. The ASFIC, in addition to audio circuitry, has a programmable synthesizer which can generate a synthesized signal ranging from 1200 Hz to 32.769 MHz with steps of 1200 Hz.

While the radio is turned on, the ASFIC generates a default 3.6864 MHz CMOS square wave µP CLK (on U0201-UPCLK) which is routed to the µP (U0101-EXTAL). After the µP starts operation, it reprograms the ASFIC synthesizer clock to a higher µP CLK frequency (usually 7.3728 or 14.7456 MHz) and continues operation.

The ASFIC synthesizer clock is controlled by the software, and may slightly be changed while harmonics of this clock source interfere with the specific radio receive frequency.

The ASFIC synthesizer loop components (C0228, C0229 and R0222) 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 3.6864 MHz frequency.

Serial Peripheral Interface (SPI)

The µP communicates with the other programmable ICs through its SPI port. This port consists of SPI TRANSMIT DATA (MOSI) (K1µP: U0101-1), SPI RECEIVE DATA (MISO) (K1µP: U0101-80), SPI CLK (K1µP: U0101-2) and chip select lines going to the various programmable ICs. This BUS is a synchronous bus (the timing clock signal CLK is sent with SPI TRANSMIT DATA or SPI RECEIVE DATA).

In the controller section, there are three ICs on the SPI BUS: ASFIC (U0201-E3), EEPROM (U0104) and D/A (U0731-6). In the RF sections, there are 2 ICs on the SPI BUS: Pendulum (Reference Oscillator U5702-24) and Synthesizer (U5701-7). The SPI TRANSMIT DATA and CLK lines going to the RF section are filtered with L0131/L0132 to minimize noise. The chip select lines for the ICs are decoded by the address decoder U0105.

SPI BUS is also used for the control head. U0106 buffers the SPI TRANSMIT DATA and CLK lines to the control head. U0106 serves also to switch off the CLK signal for the LCD display while it is not selected via LCD CE signal.

When the µP needs to program any of these ICs, it drops down the chip select line of the specific IC to a logic 0 and then sends the proper data and clock signals. The data sent to the various ICs are different. For example the ASFIC receives 21 bytes (168 bits) while the DAC needs 3 bytes (24 bits). After the data has been sent the chip select line is returned to a logic 1.

SBEP Serial Interface

The SBEP serial interface line allows the radio to communicate with the Dealer Programming Software (DPS). This interface connects to the Microphone connector (J0902) via Control Head connector (J0101) and comprises BUS+ (J0101-15). The line is bi-directional, meaning that either the radio or the DPS can drive the line.

The connection from the Control Head is made through the BUS+ line, via L421 (SCI_RSS line) and diode CR151 to the K1µP-TxD and K1µP-RxD ports.

Microprocessor (Open Controller)

For this radio, the K1µP is configured to operate in the expanded or bootstrap modes. In expanded mode the K1µP uses external memory ICs, whereas in bootstrap mode it uses only its internal memory. In normal radio operation, the K1µP is operating in the expanded mode.

In the radio expanded mode, the K1µP (U0101) has access to three external memory ICs: U0102 (OTP memory), U0103 (SRAM), U0104 (EEPROM). Also, within the K1µP there are 768 bytes of internal RAM and 640 bytes of internal EEPROM, as well as glue logic circuitry to select external memory ICs.

The external EEPROM (U0104) as well as the K1µP's own internal EEPROM contain the radio information which is customer specific, referred to as the codeplug. This information consists of items such as: 1) frequency operating band, 2) channel frequencies, and 3) general tuning information. General tuning information and other more frequently accessed items are stored in the internal EEPROM (within the 68HC11K1), while the remaining data is stored in the external EEPROM. (See the particular IC subsection for more details.)

The external SRAM (U0103) as well as the K1µP's own internal RAM are used for temporary calculations required by the software during normal radio operation. All of the data stored in both of these locations is lost when the radio is powered off. (See the particular IC subsection for more details.)

The OTP memroy contains the actual Radio Operating Software. This software is common to all radios for the same model type. For example Securenet radios may have a different version of software in the OTP memory than a non-secure radio. (See the particular IC subsection for more details.)

The K1µP has an address bus of 16 address lines (A0-A15), a data bus of 8 data lines (D0-D7). and three control lines; CSPROG (U0101-29) to select U0102-30 (OTP memory), CSGP2 (U0101-28) to select U0103-20 (SRAM) and PG7_R_W for read and write. All other chips (ASFIC/PENDULLUM/DAC/FRACN/LCD/LED/EEPROM) are selected by 3 lines of the K1µP using chip select decoder U0105. While the K1µP is functioning normally, the address and data lines should be within CMOS logic levels.

The low-order address lines (A0-A7) and the data lines (D0-D7) should change.

On the K1µP the lines XIRQ (U0101-30), MODA LIR (U0101-77), MODB VSTPY (U0101-76) and RESET (U0101-75) should be logic high during all normal K1µP operation. Whenever a data or an address line becomes unloaded or shorted to an adjacent line, a common symptom is that short negative pulses occur on the RESET line, with a period of 20 msec. When two lines are short-circuited, mid logic level (around 2.5 V) may be observed, while these lines are opposite driven by two different ICs.

The MODA LIR (U0101-77) and MODB VSTPY (U0101-76) inputs to the K1µP must be at a logic 1 level for proper operation. After the K1µP starts execution, it will periodically pulse these lines to determine the desired operating mode. While the Central Processing Unit (CPU) is running a new instruction, MODA LIR (as an open-drain CMOS output) drops low.

However, since it is an open-drain output, the signal waveform rise has an exponential shape, like an RC circuit.

The µP has eight analog-to-digital converter ports (A/D): PE0 to PE7. These lines may measure voltage levels in the range of 0 to 5 V and convert that level to a number ranging from 0 to 255 which can be read by the software to take appropriate action.

For example, U0101-46 is the battery voltage detect line. R0641 and R0642 form a resistor divider on SWB+. With 30K and 10K and a voltage range of 11 V to 17 V, that A/D port would see 2.74 V to 4.24 V which would then be converted to digital values of ~140 to 217 respectively.

U0101-51 is the high reference voltage for the A/D ports on the K1µP. Resistor R0106 and capacitor C0106 filter the +5 V reference. If this voltage is lower than +5 V the A/D readings will be incorrect. Likewise U0101-50 is the low reference for the A/D ports. This line is normally tied to ground. If this line is not connected to ground, the A/D readings will be incorrect.

Capacitors C0104, C0105 serve to filter out any AC noise which may ride on +5V at U0101.

Input IRQ (U101-61) generates an interrupt, if either HOOK (J0101-3) is higher than 6V (SBEP communication) or a low at the option interrupt pin (J0103-8) turns Q0124 off and Q0125 on. The K1µP determines the interrupt source by reading the collector of Q0104 via U0101-6 and the collector Q0124 via U0101-7.

One-Time Programmable (OTP) Memory

The 128-KByte OTP memory (U0102) contains the radio's operating software.

This memory is read-only. The memory access signals (CE, OE and WE) are generated by the µP.

The OTP memory is factory-programmed once only.

Capacitor C0131 serves to filter out any AC noise which may ride on +5V at U0101, and C0132 filters out any AC noise on Vpp.

Electrically Erasable Programmable Memory (EEPROM)

EEPROM (U0104) contains the radio's operating parameters such as operating frequency and signalling features, commonly known as the codeplug. It is also used to store radio operating state parameters such as current mode and volume. U0104 is a 4 Kbyte device. This memory can be written to in excess of 100,000 times and will retain the data when power is removed from the radio. The memory

access signals (SI, SO and SCK) are generated by the K1µP and chip select (CS) is generated by address decoder U0105.

Additional EEPROM is contained in the K1µP (U0101). This EEPROM is used to store radio tuning and alignment data. Like the external EEPROM this memory can be programmed multiple times and will retain the data when power is removed from the radio.

Note: The external EEPROM plus the 640 bytes of internal EEPROM in the 68HC11K1 comprise the complete codeplug.

Static Random Access Memory (SRAM)

The SRAM (U0103) 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 U103-20 (which comes from U101-CSGP2) going low. U0103 is commonly referred to as the external RAM as opposed to the internal RAM which is the 768 bytes of RAM which is part of the 68HC11K1. Both RAM spaces serve the purpose. However, the internal RAM is used for the calculated values which are accessed most often. Capacitor C0133 serves to filter out any AC noise which may ride on +5V at U0103.

Control Head Model P+

Control Head Model P+ is available for user interface. The Control Head contains the internal speaker, the microphone connector, several buttons to operate the radio and several indicator LEDs to inform the user about the radio status. Additionally Control Head P+ uses a 3 digit LCD display for the channel number.

When turned on, the On/Off switch switches the voltage regulators on by pulling ON OFF CONTROL to high and connects the base of Q0925(P), Q0825(K) to FLT A+. This transistor pulls the line ANALOG 3 to low to inform the µP that the On/Off button is pressed. If the radio is switched off, the µP will switch it on and vice versa. All other buttons work the same way. If a button is pressed, it will connect one of the 3 lines ANALOG 1,2,3 to a resistive voltage divider connected to +5V. The voltages of the lines are A/D converted inside the µP and specify the pressed button.

All the back light and indicator LEDs are driven by current sources and controlled by the µP via SERIAL PERIPHERAL INTERFACE (SPI) interface. The LED status is stored in shift register U0941(P). Line LED CE enables the serial write process via Q0941(P), while line LED CLCK BUF shifts the data of line SPI DATA BUF into the shift register.

In addition Control Head P contains the LCD display H0931, the display driver U0932 and a transistor (U0931) to switch the display driver on and off in emergency condition. Q0931 is controlled by the µP via shift register U0941, The display data of line SPI DATA BUF is shifted into the display driver by clock signal LCD CLCK BUF.

Controller Audio & Signaling Circuits

General

Audio Signalling Filter IC (ASFIC)

The ASFIC (U0201) used in the controller has four functions;

- RX/TX audio shaping, i.e. filtering, amplification, attenuation
- RX/TX signalling, PL/DPL/HST/MDC/MPT
- Squelch detection
- Microprocessor clock signal generation (see Microprocessor Clock Synthesizer Description Block).

The ASFIC is programmable through the SPI BUS (U0201-E3/F1/F2), normally receiving 21 bytes. This programming sets up various paths within the ASFIC to route audio and/or signalling signals through the appropriate filtering, gain and attenuator blocks. The ASFIC also has 6 General Control Bits GCB0-5 which are CMOS level outputs and used for AUDIO PA ENABLE (GCB0) to switch the audio PA on and off, EXTERNAL ALARM (GCB1) and B+ CONTROL (GCB2) to switch the voltage regulators (and the radio) on and off. GCB3 controls output GPI/O (accessory connector J0400-12), HIGH LOW BAND (GCB4) can be used to switch between band splits and GCB5 is available on the option board connector J0102-5.

Audio Ground

VAG is the dc bias used as an audio ground for the op-amps that are external to the Audio Signalling Filter IC (ASFIC). U0251 forms this bias by dividing 9.3V with resistors R0251, R0252, and buffering the 4.65V result with a voltage follower. VAG emerges at pin 1 of U0251. C0235 is a bypass capacitor for VAG. The ASFIC generates its own 2.5V bias for its internal circuitry. C0221 is the bypass for the ASFIC's audio ground dc bias.

Note: While there are ASFIC VAG, and BOARD VAG (U0201-1), each of these are separated. They are not connected together.

Transmit Audio Circuits

Refer to the following sections.

Mic Input Path

The radio supports two distinct microphone paths known as internal and external mic and an auxiliary path (FLAT TX AUDIO). The microphones used for the radio require a DC biasing voltage provided by a resistive network.

These two microphone audio input paths enter the ASFIC at U0201-A7 (external mic) and U0201-B8 (internal mic). Following the internal mic path; the microphone is plugged into the radio control head and is connected to the controller board via J101-16.

From here the signal is routed to R0206. R0204 and R0205 provide the 9.3VDC bias and R0206 provides input protection for the CMOS amplifier input. R0205 and C0209 provide a 1kohm 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.

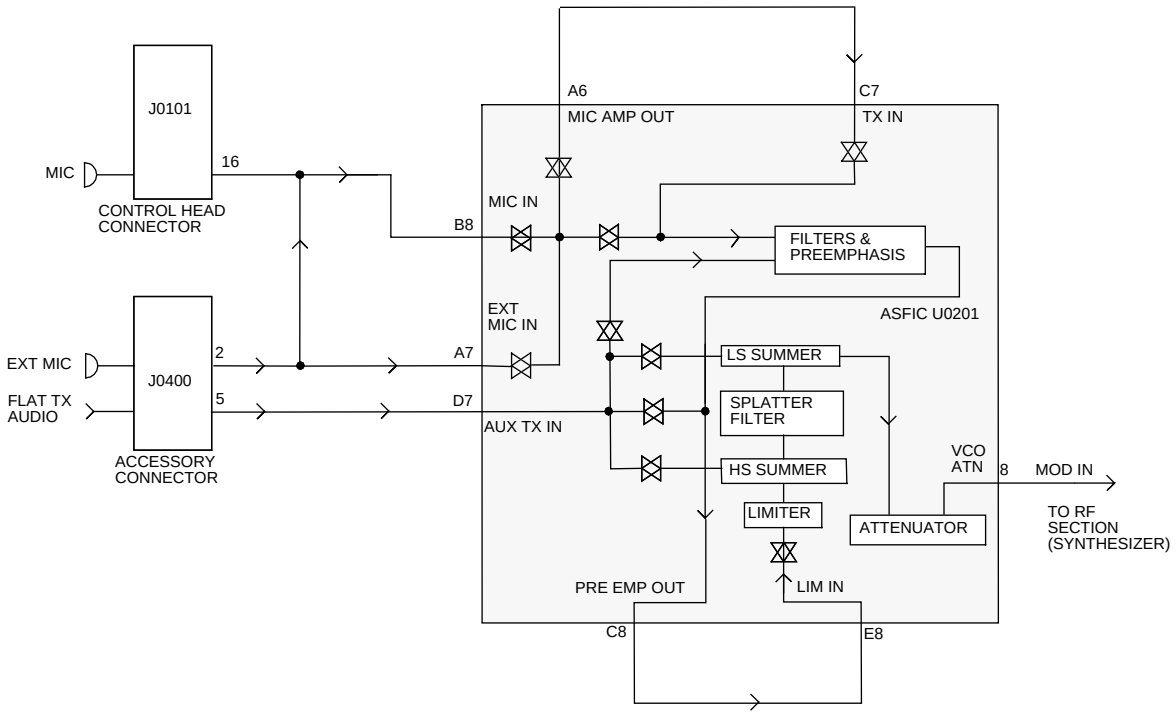


Figure 7-3 Transmit Audio Paths

Filter capacitor C0210 provides low-pass filtering to eliminate frequency components above 3 kHz, and C0211 serves as a DC blocking capacitor. The audio signal at U0201-B8 should be approximately 80mV for 3kHz of deviation with 25 kHz channel spacing.

The FLAT TX AUDIO signal from accessory connector J0400-5 is buffered by op-amp U0202-1 and fed to the ASFIC U0201-D7 through C0205.

External Mic Path

The external microphone signal enters the radio on accessory connector J0400 pin 2 and connects to the standard microphone input through R0413. The signal is routed to the ASFIC (U0201-A7) through resistor R0414 and capacitors C0413 and C0414, with DC bias provided by R0415 / R0416.

PTT Sensing and TX Audio Processing

Mic PTT is sensed by the µP. An external PTT can be generated by grounding pin 3 on the radio accessory connector. When microphone PTT is sensed, the µP will always configure the ASFIC for the “internal” mic audio path, and external PTT will result in the external mic audio path being selected for models with separated MIC and EXT MIC signals.

Inside the ASFIC, the mic audio is filtered to eliminate components outside the 300-3000Hz voice band, pre-emphasized if pre-emphasis is enabled. The capacitor between ASFIC pre-emphasis out U0201-C8 and ASFIC limiter in U0201-E8 AC couples the signal between ASFIC blocks and prevents the DC bias at the ASFIC output U0201-H8 from shifting when the ASFIC transmit circuits are powered up. 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 signalling data, and then to a splatter filter to eliminate high frequency spectral components that could be generated by the limiter. The audio is then

routed to two attenuators, which are tuned in the factory or the field to set the proper amount of FM deviation. The TX audio emerges from the ASFIC at U0201-H8 MOD IN, and is routed to the RF section.

Transmit Signalling Circuits

See Figure 7-4 for reference for the following sections. From a hardware point of view, there are three types of signalling:

- Sub-audible data (PL / DPL / Connect Tone) that gets summed with transmit voice or signalling,
- DTMF data for telephone communication in trunked and conventional systems, and
- Audible signalling including Select 5, MPT-1327, MDC, High speed Trunking.

Note: The hardware supports all three types while the radio software determines which signalling type is available.

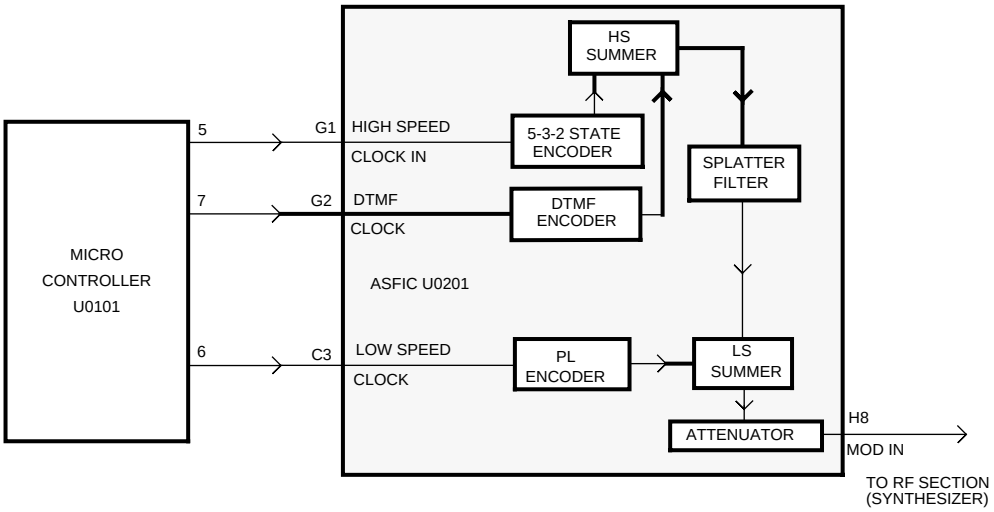


Figure 7-4 Transmit Signalling Paths

Sub-audible Data (PL/DPL)

Sub-audible data implies signalling 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 U0201 (ASFIC) at any one time. The process is as follows, using the SPI BUS, the µP programs the ASFIC 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 PL CLK U0201-C3 at twelve times the desired data rate. For example, for a PL frequency of 103 Hz, the frequency of the square wave would be 1236 Hz.

This drives a tone generator inside U0201 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 U0201-H8 (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.

High Speed Data

High speed data refers to the 3600 baud data waveforms, known as Inbound Signalling Words (ISWs) used in a trunking system for high speed communication between the central controller and the radio. To generate an ISW, the µP first programs the ASFIC (U0201) to the proper filter and gain settings. It then begins strobing U0201-G1 (TRK CLK IN) with a pulse when the data is supposed to change states. U0201's 5-3-2 State Encoder (which is in a 2-state mode) is then fed to the post-limiter summer block and then the splatter filter.

From that point it is routed through the modulation attenuators and then out of the ASFIC to the RF board. MPT 1327 and MDC are generated in much the same way as Trunking ISW. However, in some cases these signals may also pass through a data pre-emphasis block in the ASFIC. Also these signalling schemes are based on sending a combination of 1200 Hz and 1800 Hz tones only. Microphone audio is muted during High Speed Data signalling.

Dual Tone Multiple Frequency (DTMF) Data

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

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

The high-group tone is generated by the µP (U0101-5) strobing U0201-G1 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 µP (U0101-7) strobing U0201-G2 (DTMF CLCK) at six times the tone frequency. Inside U0201 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.

Receive Audio Circuits

Refer to the following sections.

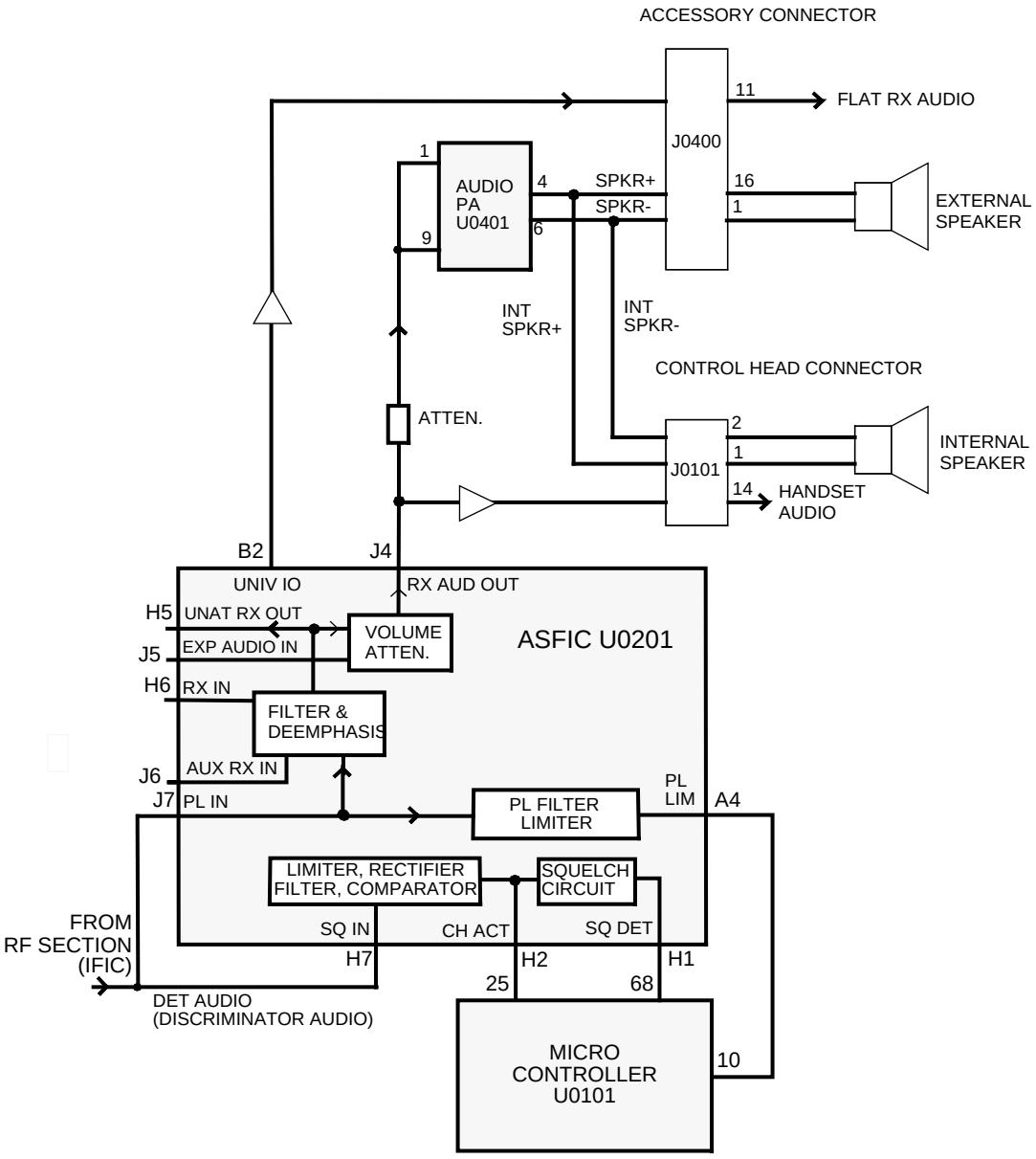


Figure 7-5 Receive Audio Paths

Squelch Detect

The radio's RF circuits are constantly producing an output at the discriminator (U5201-28). This signal (DET AUDIO) is routed to the ASFIC's squelch detect circuitry input SQ IN (U0201-H7). All of the squelch detect circuitry is contained within the ASFIC. Therefore from a user's point of view, DET AUDIO enters the ASFIC, and the ASFIC produces two CMOS logic outputs based on the result. They are CH ACT (U0201-H2) and SQ DET (U0201-H1).

The squelch signal entering the ASFIC 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 (U0201-H1) 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 µP pin 25 while SQ DET adds up with LOCK DET, weighted by resistors R0113, R0114, and is routed to one of the µP´s ADC input U0101-43. From the voltage weighted by the resistors the µP determines whether SQ DET, LOCK DET or both are active.

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.

Audio Processing and Digital Volume Control

The receiver audio signal enters the controller section from the IF IC (U5201-28) on DET AUDIO and passes through RC filter R0203 and C0208 which filters out IF noise. The signal is AC coupled by C0207 and enters the ASFIC via the PL IN pin U0201-J7.

Inside the ASFIC, the signal goes through two paths in parallel, the audio path and the PL/DPL path.

The audio path has a programmable amplifier, whose setting is based on the channel bandwidth being received, then a LPF filter to remove any frequency components above 3000Hz and then an 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. The audio signal exits the ASFIC at RX AUDIO (U0201-J4).

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

Since sub-audible signalling is summed with voice information on transmit, it must be separated from the voice information before processing. Any sub-audible signalling enters the ASFIC from the IF IC at PL IN U0201-J7. Once inside it goes through the PL/DPL path.

The signal first passes through one of 2 low pass filters, either PL low pass filter or DPL/LST low pass filter. Either signal is then filtered and goes through a limiter and exits the ASFIC at PL LIM (U0201-A4). At this point the signal will appear as a square wave version of the sub-audible signal which the radio received. The microprocessor (U0101-10) will decode the signal directly to determine if it is the tone / code which is currently active on that mode.

Audio Amplification Speaker (+) Speaker (-)

The ASFIC's received audio signal output, U0201-J4, is routed through a voltage divider formed by R0401 and R0402 to set the correct input level to the audio PA (U0401). This is necessary because the gain of the audio PA is 46 dB, and the ASFIC output is capable of overdriving the PA unless the maximum volume is limited.

The audio then passes through C0401 which provides AC coupling and low frequency roll-off. C0402 provides high frequency roll-off as the audio signal is routed to pins 1 and 9 of the audio power amplifier U0401.

The outputs of the Audio PA (EXT-SPKR+, INT/EXT SPKR-) are routed to the external speaker through the accessory connector. The INT/EXT SPKR- is directly connected to the INT-SPKR(-).

The EXT-SPKR+ can be connected to the internal speaker(+) in two ways: 1) internal connection via R456 (0 Ohm); 2) Externally, via a jumper between pin 16 and pin 13 of the accessory connector.

The audio power amplifier has one inverted and one non-inverted output that produces the differential audio output SPK+ / SPK- (U0401-4/6). The inputs for each of these amplifiers are pins 1 and 9 respectively; these inputs are both tied to the received audio. The audio PA's DC biases are not activated until the audio PA is enabled at pin 8.

The audio PA is enabled via AUDIO PA ENABLE signal from the ASFIC (U0201-B5). When the base of Q0401 is low, the transistor is off and U0401-8 is high, using pull up resistor R0406, and the Audio PA is ON. The U0401-8 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 (U0401-1/9) off. This is a mute condition which is not employed in this radio design. R0404 ensures that the base of Q0401 is high on power up. Otherwise there may be an audio pop due to R0406 pulling U0401-8 high before the software can switch on Q0401.

The SPK+ and SPK- outputs of the audio PA have a DC bias which varies proportionately with FLT A+ (U0401-7). FLT A+ of 11V yields DC offset of 5V, and FLT A+ of 17V yields a DC offset of 8.5V. If either of these lines is shorted to ground, it is possible that the audio PA will be damaged. SPK+ and SPK- are routed to the accessory connector (J400-16 and 1) and to the control head (connector J0101-1 and 2).

Handset Audio

Certain hand-held accessories have a speaker within them which require a different voltage level than that provided by U0401. For those devices HANDSET AUDIO is available at J0101-14.

The received audio from the output of the ASFIC's digital volume attenuator is also routed to U0202-4 pin 9 where it is amplified 15 dB; this is set by the 10k/68k combination of R0233 and R0232. This signal is routed from the output of the op amp U202-4 pin 8 to J0101-14. The control head sends this signal directly out to the microphone jack. The maximum value of this output is 6.6Vp-p.

Filtered Audio

The ASFIC has an audio whose output at U0201-B2 has been filtered and de-emphasized, but has not gone through the digital volume attenuator. From ASFIC U0201-B2 the signal is AC coupled to U0202-2 by capacitor C0230. R0224 and R0225 being equal value set up the op-amp as a unity gain device, i.e. a buffer.

Note: Any volume adjustment of the signal on this path must be done by the accessory.

Discriminator Audio (Unfiltered)

Note: Discriminator audio DET AUDIO from the IF IC U5201, in addition to being routed to the ASFIC, is also routed to the option connector J0103-5. (See Secure Rx description blocks for further information.)

Receive Signalling Circuits

Refer to the following sections.

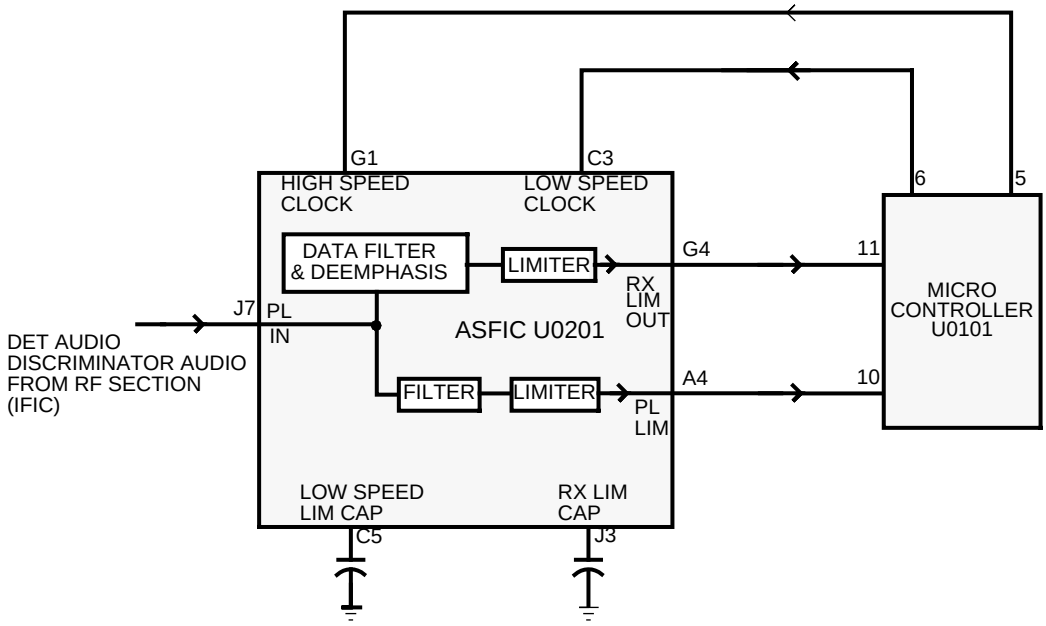


Figure 7-6 Receive Signalling Path.

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

The ASFIC (U0201) is used to filter and limit all received data. The data enters the ASFIC at U0201-J7. Inside U0201 the data is filtered according to data type (HS or LS), then it is limited to a 0-5V digital level. The MDC and trunking high speed data appear at U0201-G4, where it connects to the µP U0101-11.

The low speed limited data output (PL, DPL, and trunking LS) appears at U0201-A4, where it connects to the µP U0101-10. While receiving low speed data, the µP may output a sampling waveform depending on the sampling technique to U0201-C3 between 1 and 2 kHz.

The low speed data is read by the µP at twice the frequency of the sampling waveform; a latch configuration in the ASFIC stores one bit every clock cycle. The external capacitors C0226, C0225, and C0223 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.

Note: During HS data, the µP may generate a sampling waveform seen at U0201-G1.

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 U0201 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, or externally using the µP and the ASFIC.

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 sets up the path and determines the tone frequency, and at what volume level to generate the tone. (It does not have to be related to the voice volume setting).

For external alert tones, the μP can generate any tone within the 100-3000Hz audio band. This is accomplished by the μP generating a square wave which enters the ASFIC at U0201-C3.

Inside the ASFIC, 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 U0201 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 U0201-J4 and is routed to the audio PA like receive audio.

8

Troubleshooting

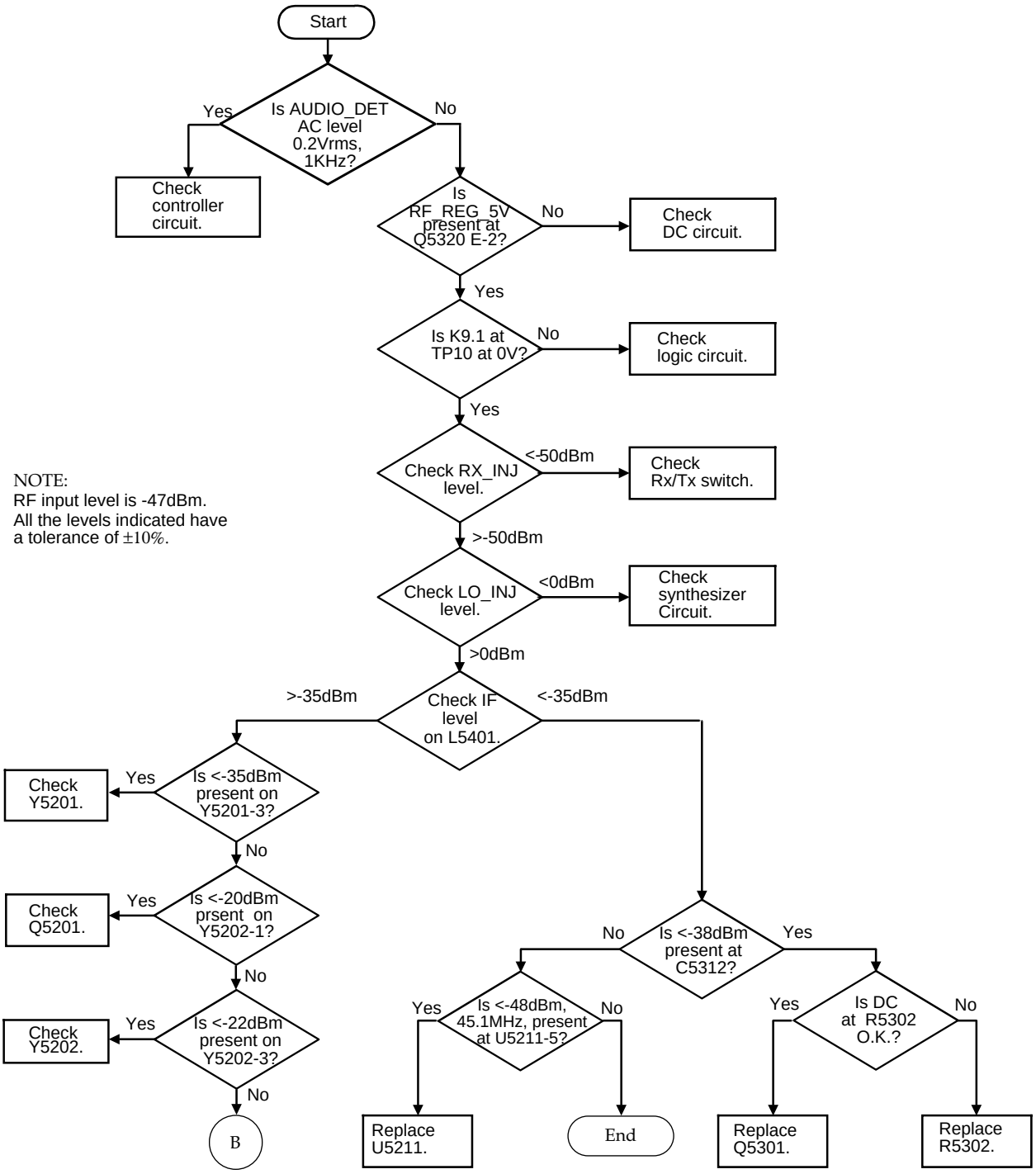
Overview

This section contains three troubleshooting tables for the following GTX/ LCS 2000 components:

- Receiver
- Synthesizer
- Power Amplifier
- Controller
- Control Head

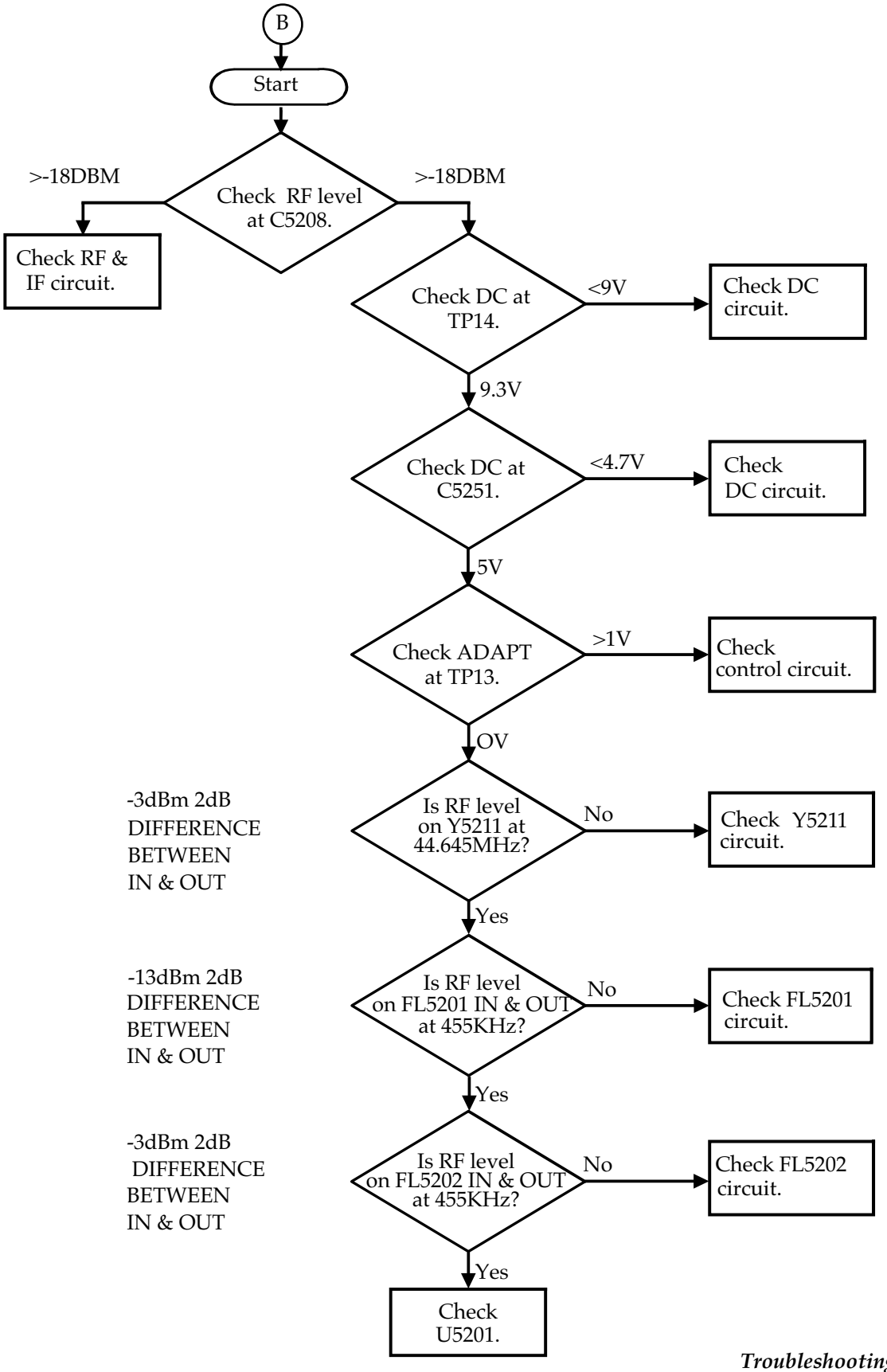
Troubleshooting Charts

Refer to following pages.



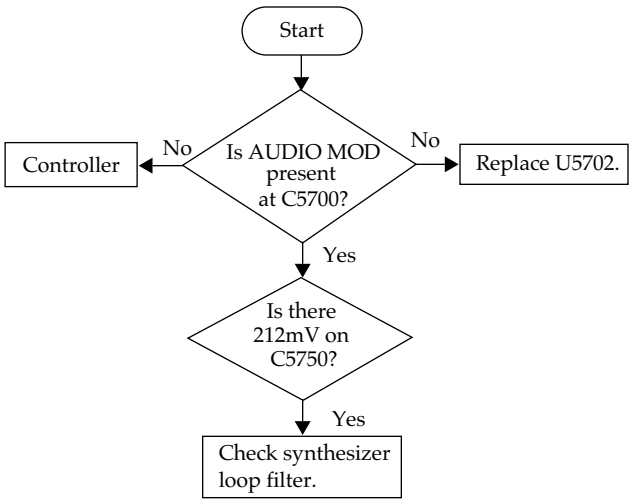
NOTE:
RF input level is -47dBm.
All the levels indicated have a tolerance of ±10%.

Troubleshooting Flow Chart for Receiver

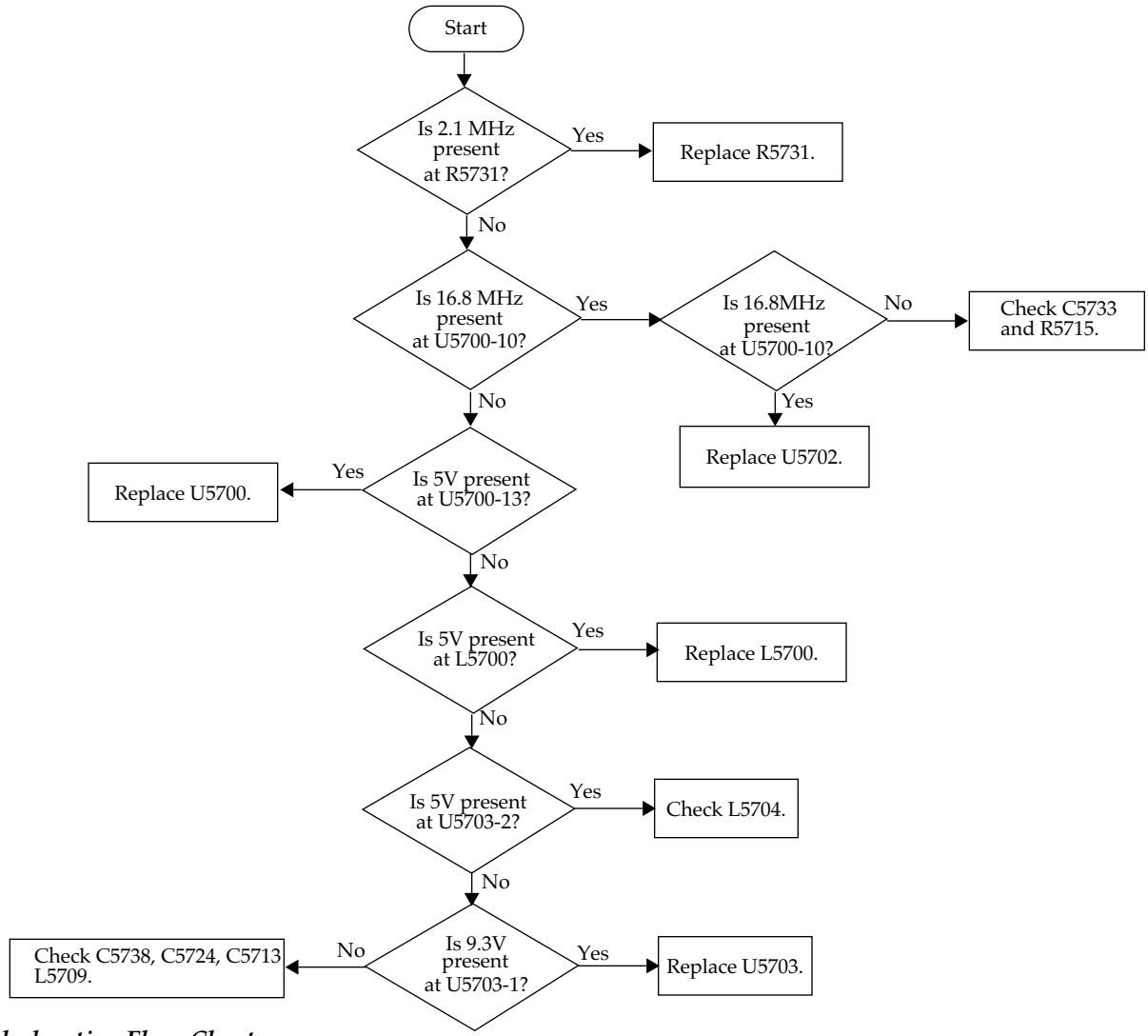


Troubleshooting Flow Chart for Receiver (cont.)

SYNTHESIZER DEVIATION

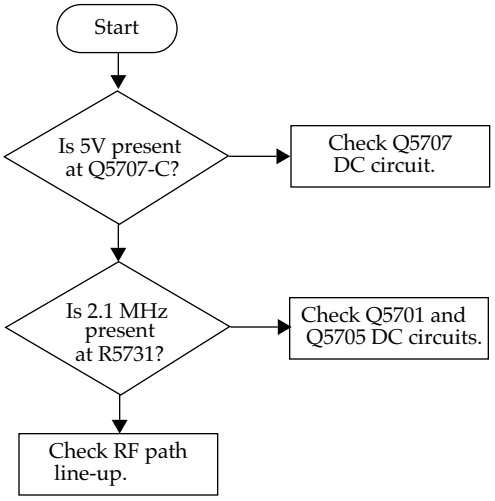


SYNTHESIZER PENDULUM

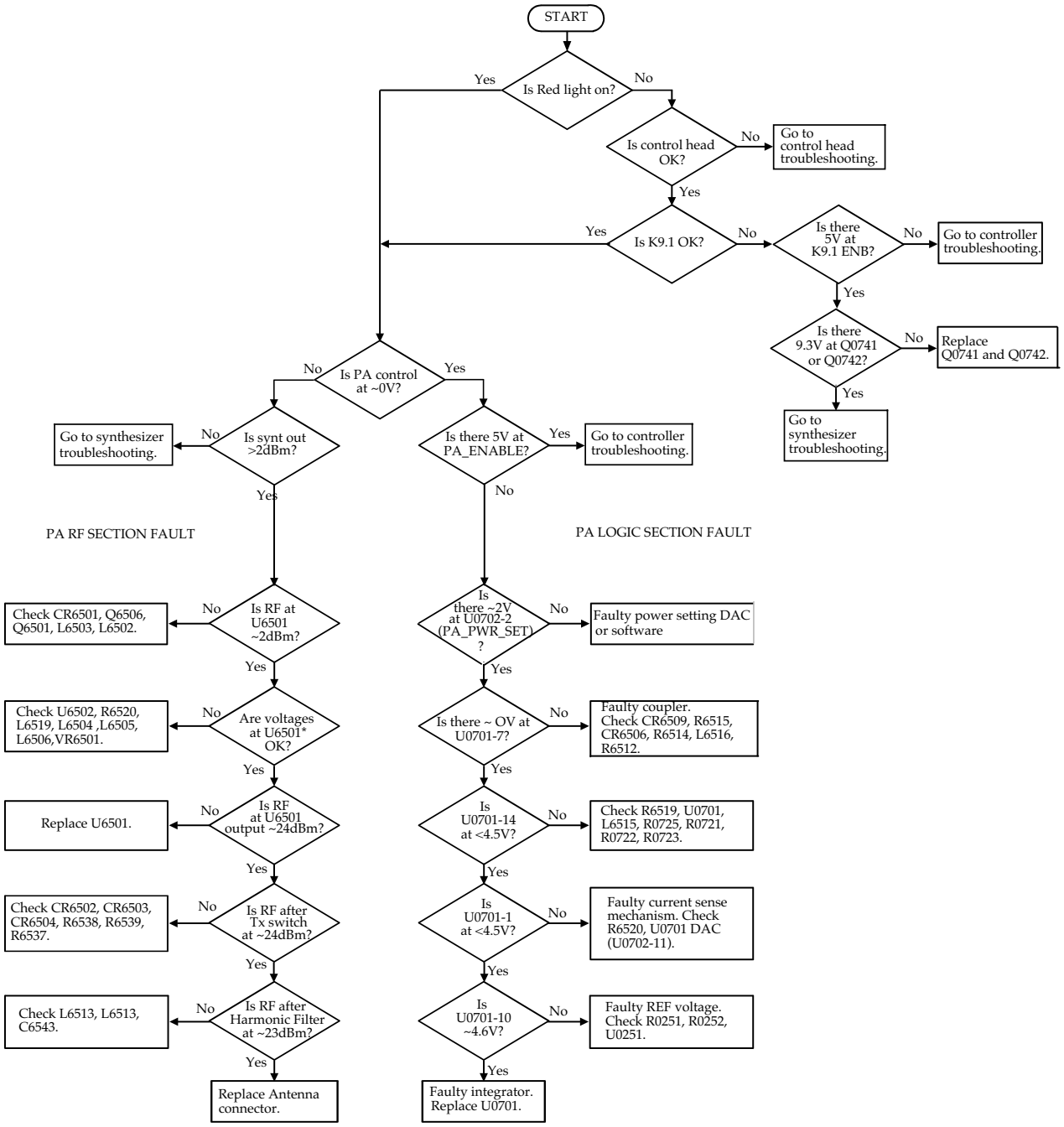


Troubleshooting Flow Chart for Synthesizer

NO Tx INJECTION



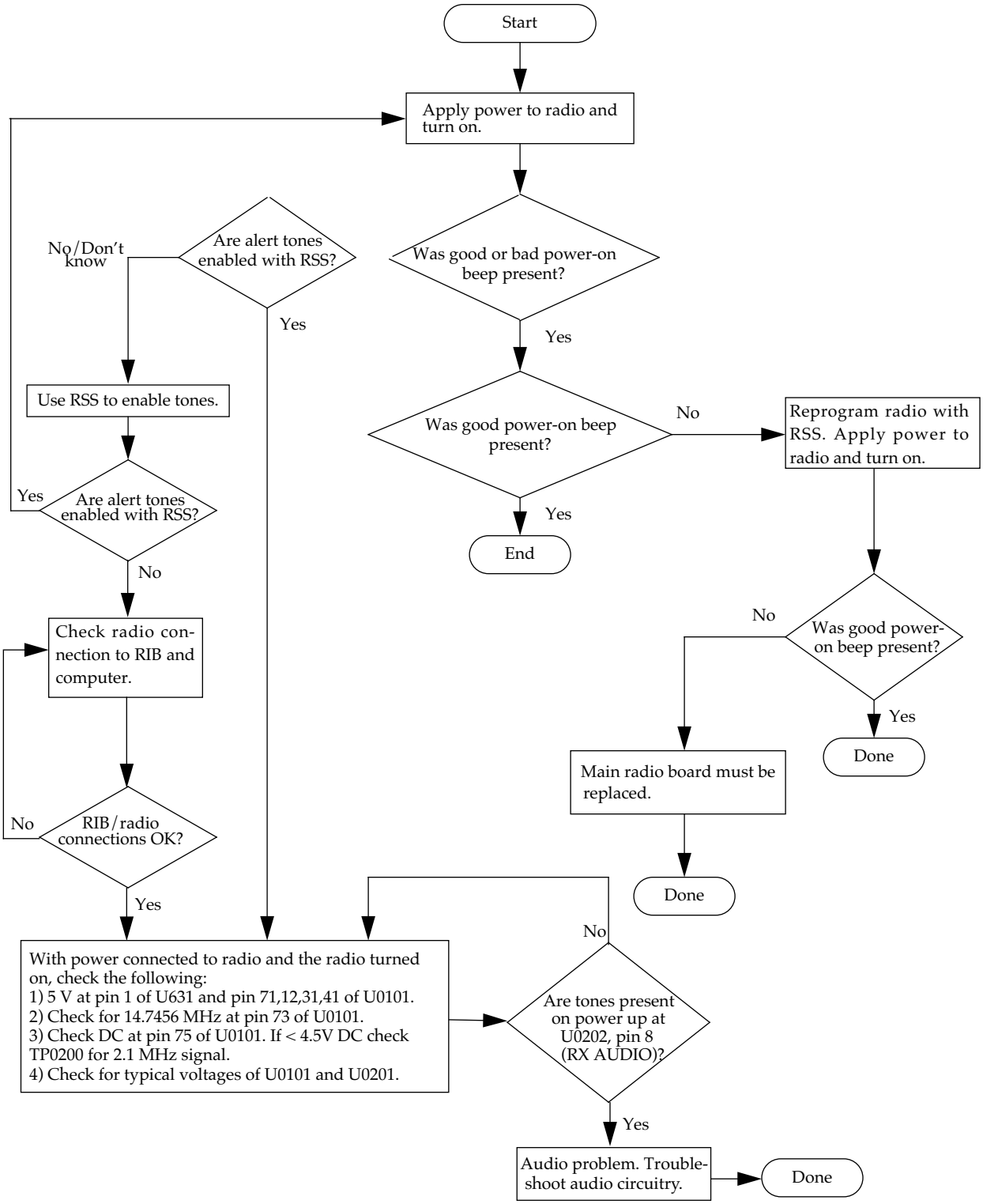
Troubleshooting Flow Chart for Synthesizer (cont.)



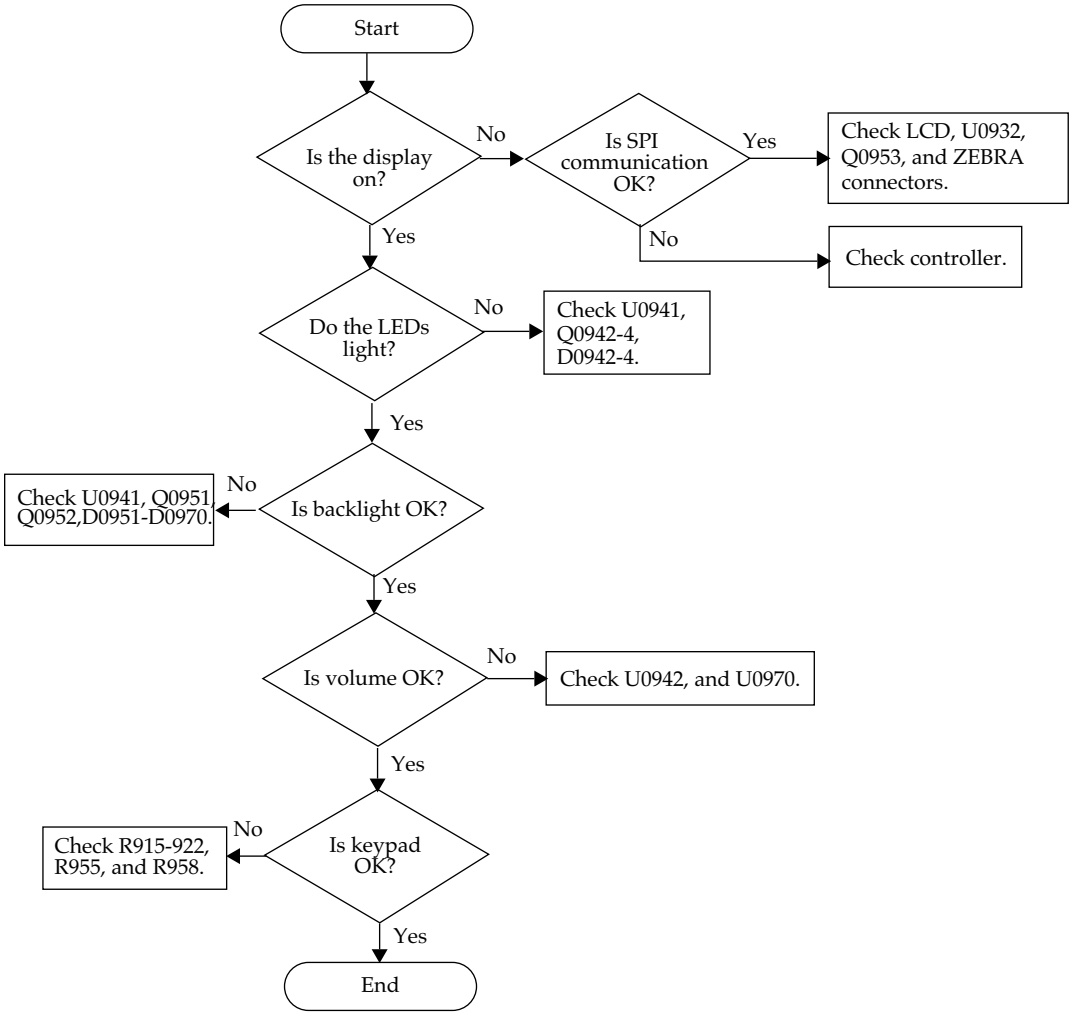
Levels were measured with an RF probe in series with 0.5pF capacitor.

*U6501 DC voltages:
Pins 3 and 4: A+-0.1V
Pin 2: 9.1V (during Tx only)

Troubleshooting Flow Chart for Power Amplifier

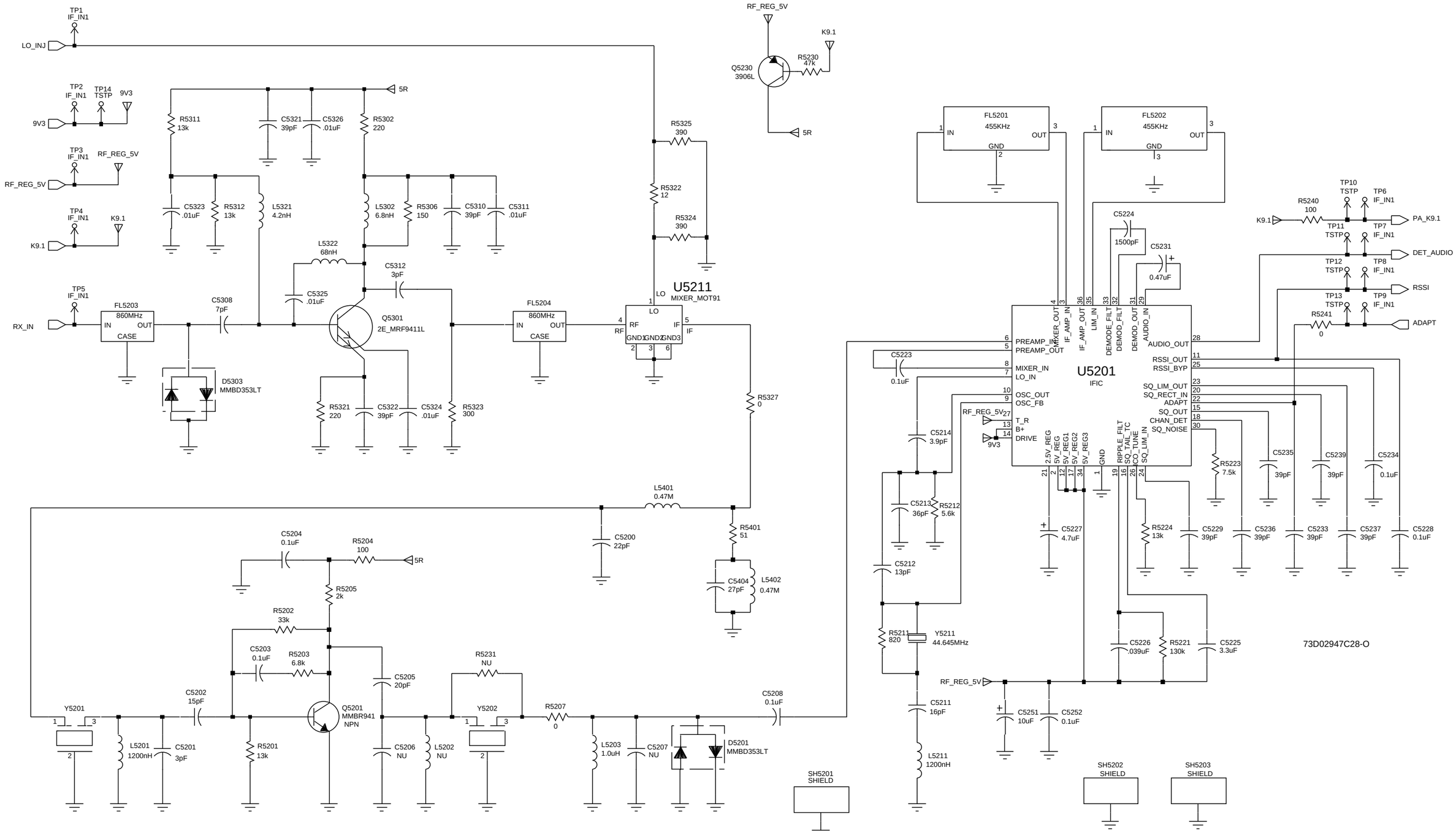


Troubleshooting Flow Chart for Controller

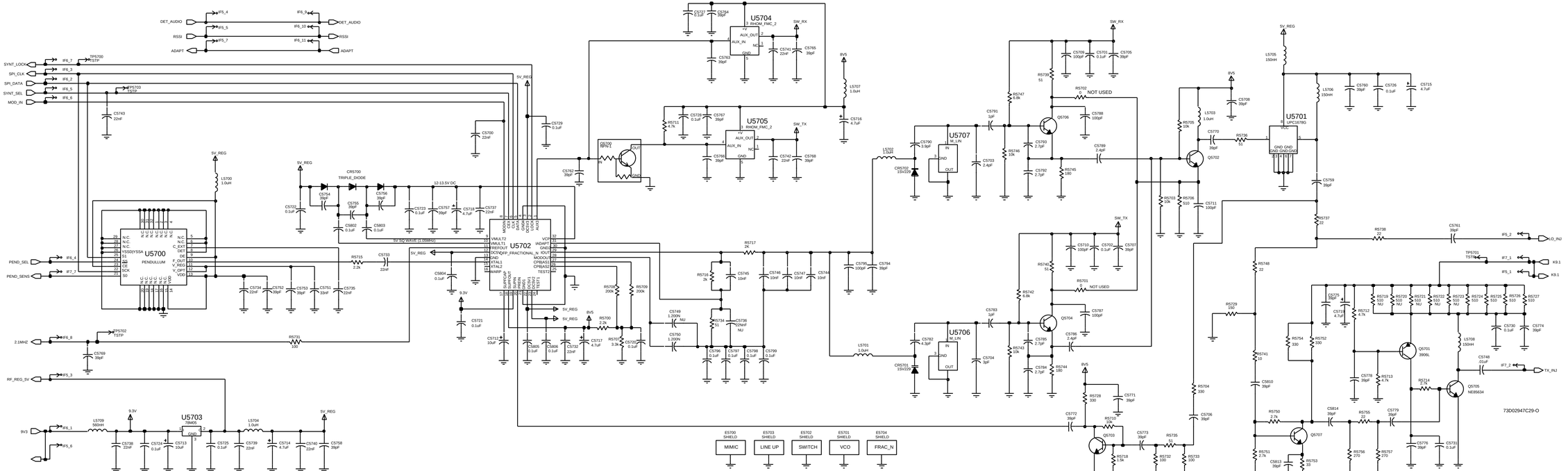


Troubleshooting Flow Chart for Control Head

SCHEMATIC DIAGRAMS, CIRCUIT BOARD DETAILS, & PARTS LISTS



Schematic Diagram for FLF5582A Main Board, Receiver Section



Schematic Diagram for FLF5582A Main Board, Synthesizer Section

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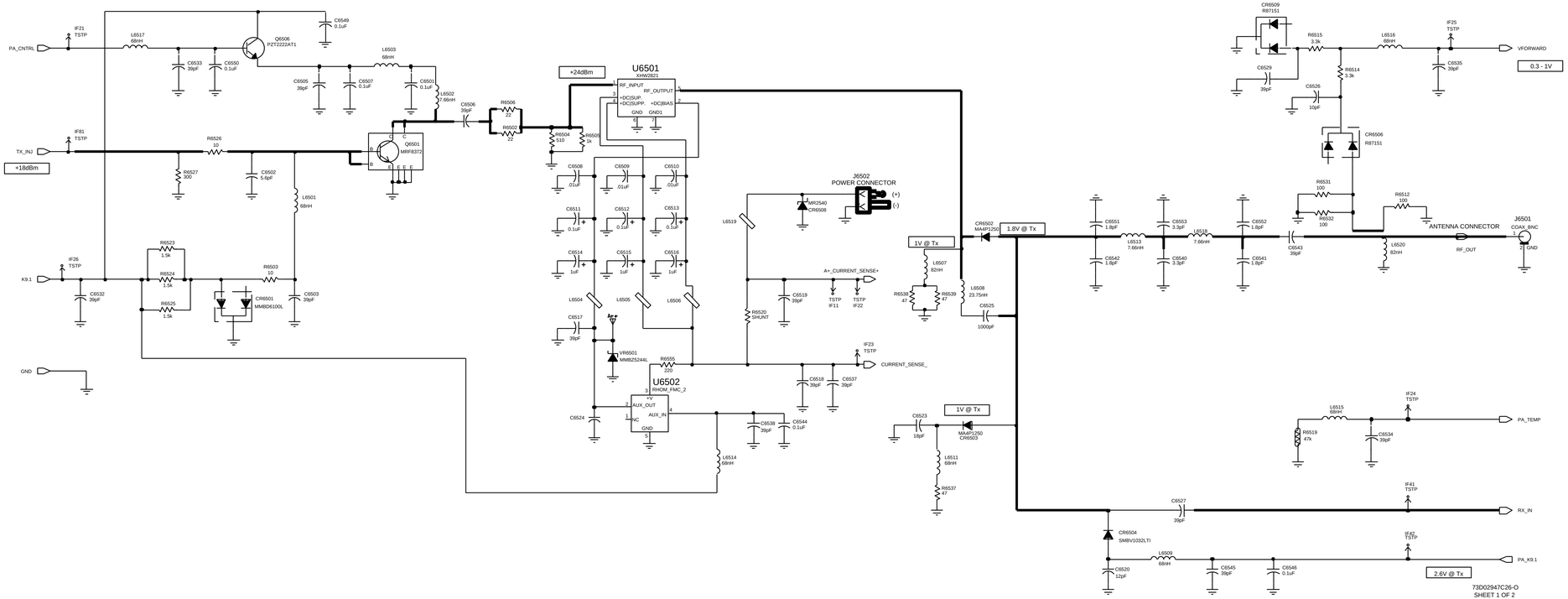
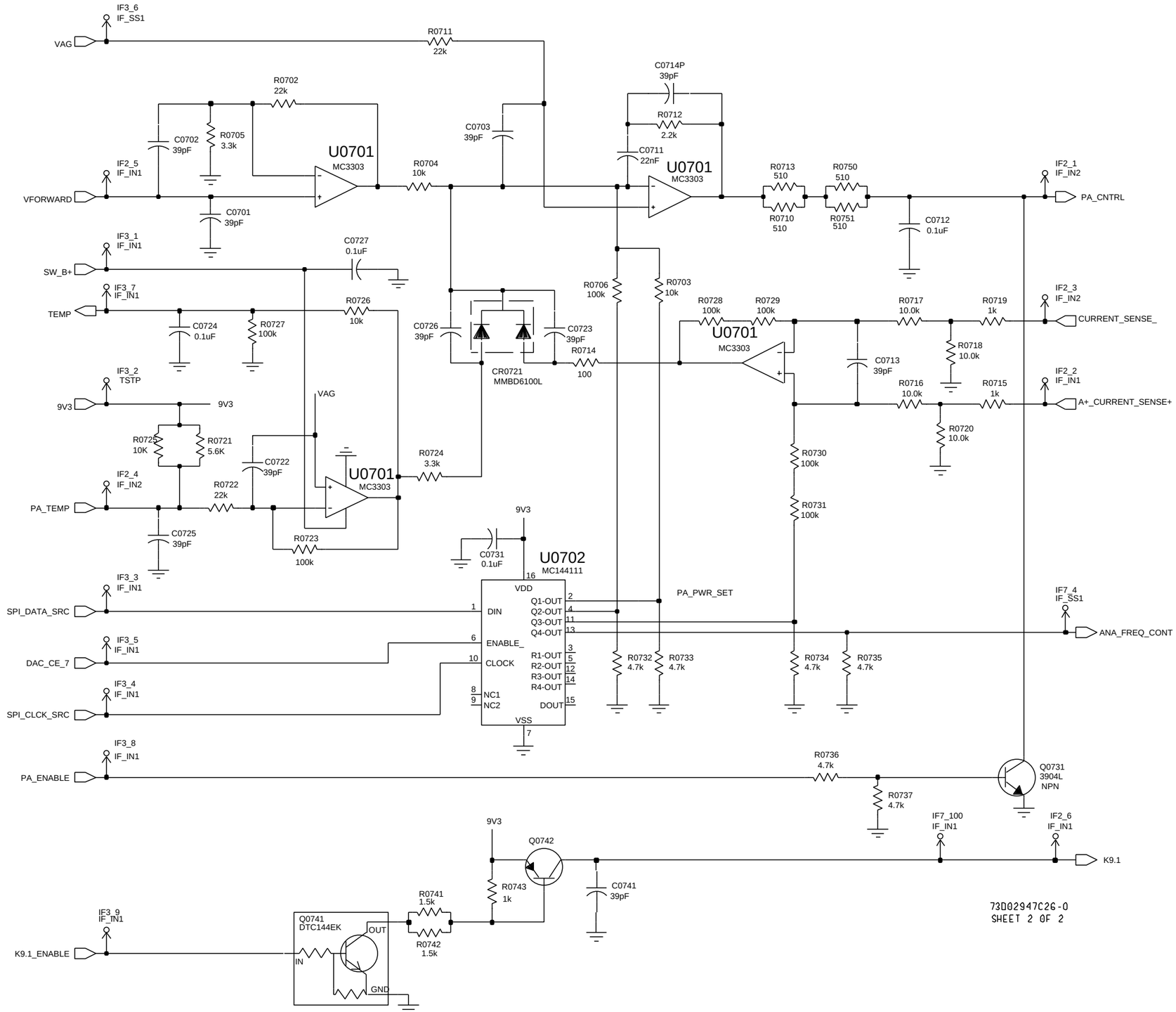


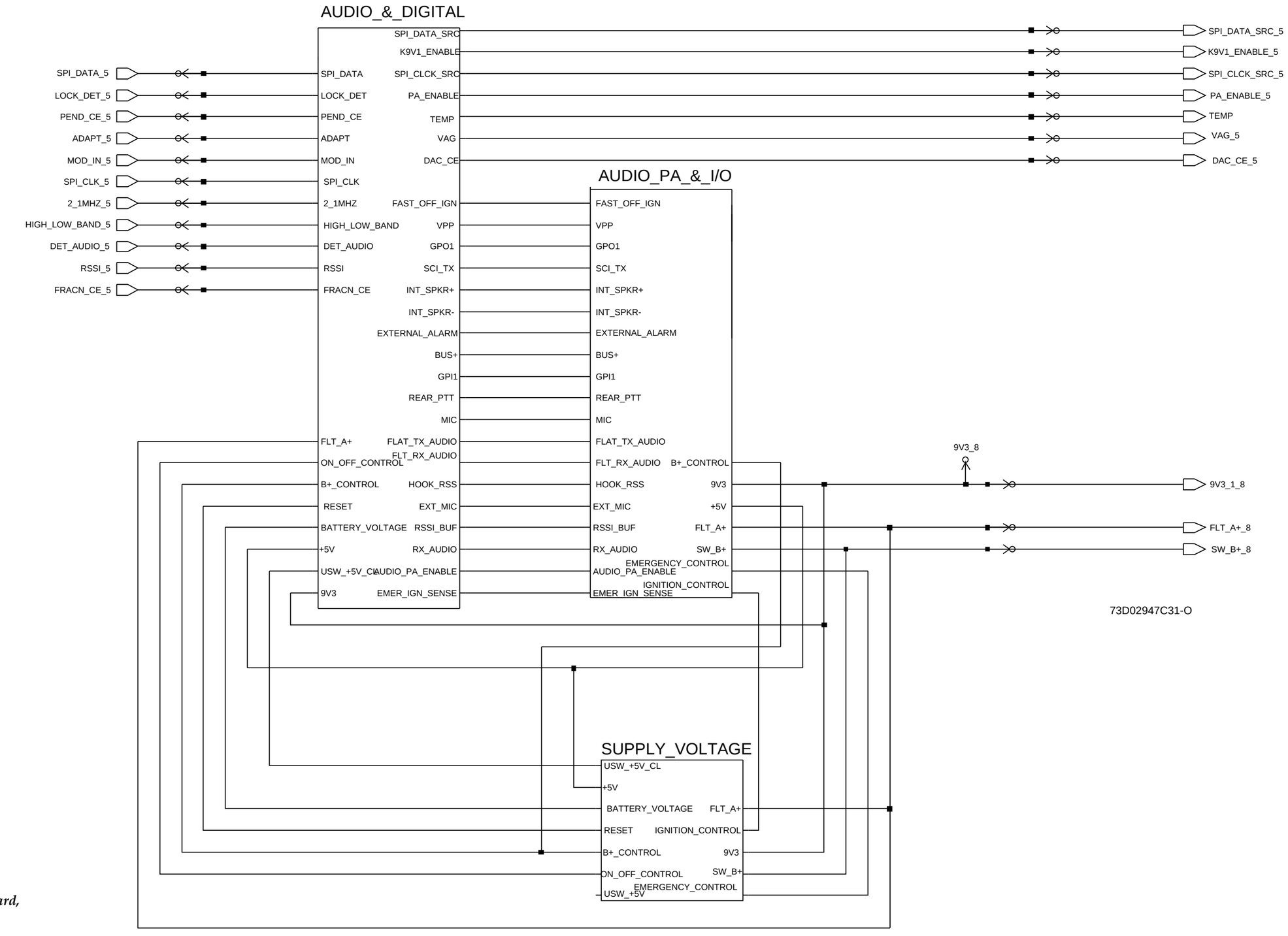
Schematic Diagram for FLF5582A Main Board,
Power Amplifier Section, Power Amplifier Sub-section

This document was created with FrameMaker 4.0.3

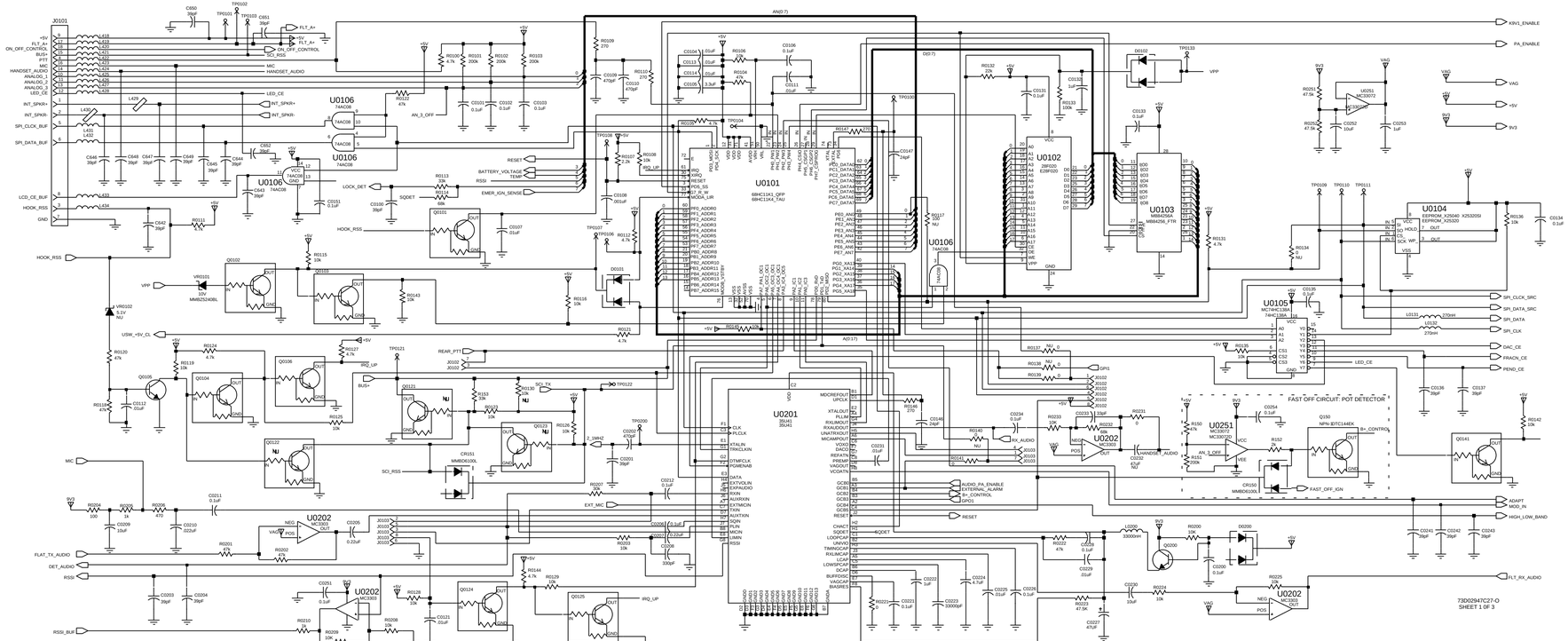


Schematic Diagram for FLF5582A Main Board,
Power Amplifier Section, Power Control Sub-section

This document was created with FrameMaker 4.0.3

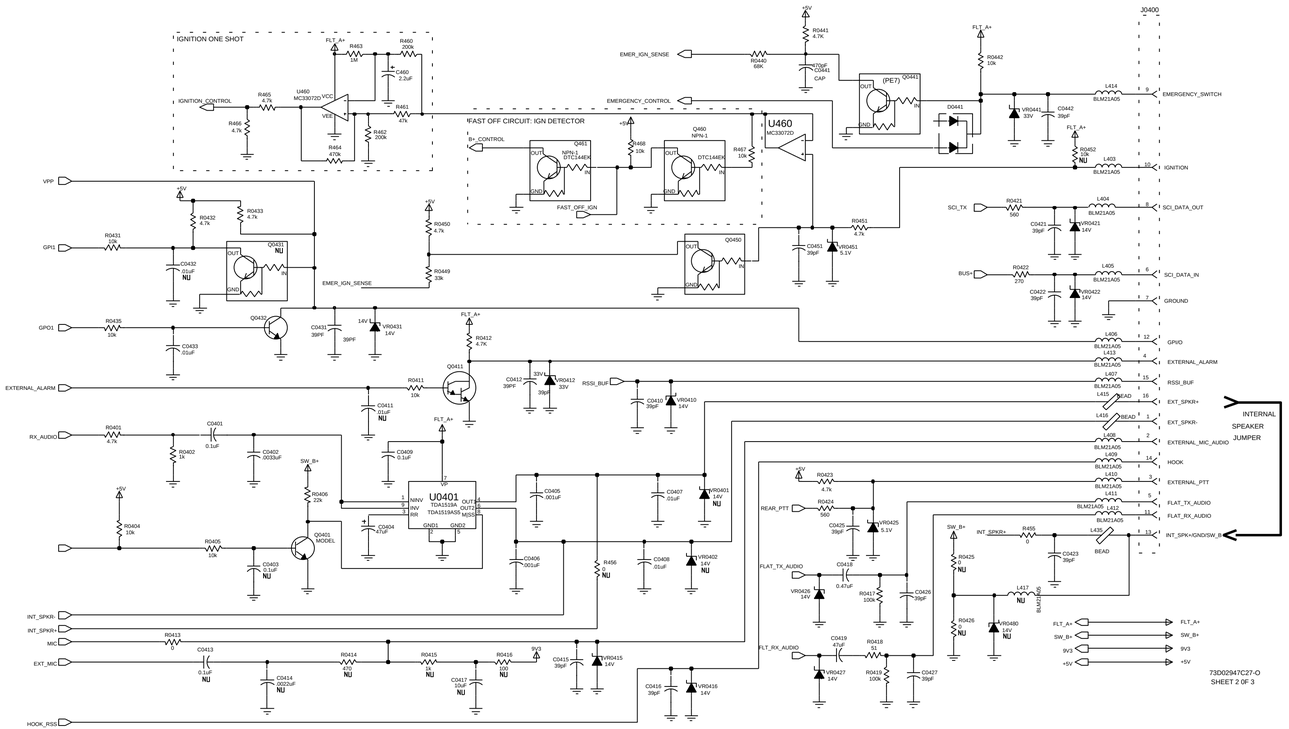


Schematic Diagram for FLF5582A Main Board, Controller Section Wiring



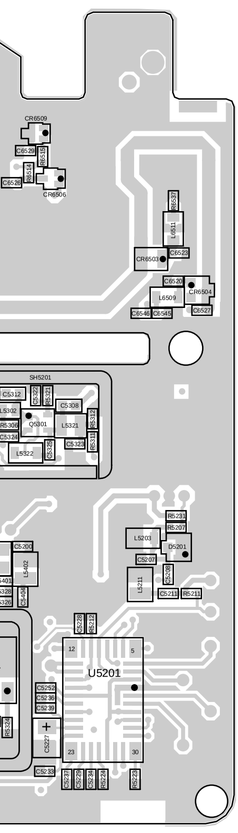
Schematic Diagram for FLF5582A Main Board, Controller Section, Logic Sub-section

This document was created with FrameMaker 4.0.3



Schematic Diagram for FLF5582A Main Board, Controller Section, Audio I/O & Regulator Sub-sections

This document was created with FrameMaker 4.0.3


CR6609
C6-29
C6-30
C6-28
CR6606
L6511
C6-23
CR6501
C6-20
CR6504
L6509
C6-46
C6-545
C6-27
SH5201
C5-18
C5-17
C5-16
C5-308
C5-309
C5-310
C5-128
C5-129
C5-130
C5-131
C5-132
C5-133
C5-134
C5-135
C5-136
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C5-149
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C5-151
C5-152
C5-153
C5-154
C5-155
C5-156
C5-157
C5-158
C5-159
C5-160
C5-161
C5-162
C5-163
C5-164
C5-165
C5-166
C5-167

parts list

FLF5582A Main Board

REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
		capacitors: pF, ±5% 50V, unless otherwise specified
C100	2113740F41	39
C101-103	2113743K15	ceramic 0.100µF
C104	2113741F49	10000
C105	2311049A42	tantalum 3.3 10% 6V
C106	2113743K15	ceramic 0.100µF
C107	2113741F49	10000
C108	2113741F25	1000
C109-110	2113740F41	39
C111-114,121	2113741F49	10000
C131	2113743K15	ceramic 0.100µF
C132	2311049A07	tantalum 1 10% 16 V
C133-135	2113743K15	ceramic 0.100µF
C136-137	2113740F41	39
C147	2113740F36	24
C151,200	2113743K15	ceramic 0.100µF
C201	2113740F41	39
C202	2113741F17	470
C203-204	2113740F41	39
C205	2113743F08	ceramic 0.220µF
C206	2113743K15	ceramic 0.100µF
C207	2113743F08	ceramic 0.220µF
C208	2113741F13	330
C209	2311049J26	tantalum 10 20% 16V
C210	2113741M53	22000 10%
C211	2113743A19	0.100µF 10%
C212,221	2113743K15	ceramic 0.100µF
C222	2311049A07	tantalum 1 10%16V
C223	2113741A57	33000
C224	2311049J11	tantalum 4.7 10%16V
C226	2113743K15	ceramic 0.100µF
C228	2311049A01	tantalum 0.1 10% 35V
C229	2113741F49	10000
C230	2311049J23	tantalum 10 10% 7V
C231	2113741F49	10000
C232	2311049J44	tantalum 47 20% 10V
C233	2113740F39	33
C234	2113743K15	ceramic 0.100µF
C241-243	2113740F41	39
C251	2113743K15	ceramic 0.100µF
C252	2311049J23	tantalum 10 10% 7V
C253	2311049A07	tantalum 1 10% 16V
C254,401	2113743K15	ceramic 0.100µF
C402	2113741F37	3300
C403	2113743K15	ceramic 0.100µF
C404	2311049J44	tantalum 47 20% 10V
C405-406	2113741F25	1000
C407-408	2113741F49	10000
C409	2109720D14	ceramic low DIST 0.1 µF
C410	2113740F41	39
C411	2113741F49	10000
C412	2113740F41	39
C413	2113743K15	ceramic 0.100µF
C415-416	2113740F41	39
C417	2311049A57	tantalum 10µF 10% 1V
C418	2311049A05	tantalum 0.47 10% 25V
C419	2311049J44	tantalum 47 20% 10V
C421-423, C425-427,431	2113740F41	39
C432-433	2113741F49	10000
C441	2113741F17	470
C442,451	2113740F41	39
C460	2311049A09	tantalum 2.2 10% 20V
C601	2113740F41	39
C602	2109720D14	ceramic low DIST 0.1µF
C603	2380090M24	10 20% 50V SMT
C604	2311049J40	tantalum 33 20% 16V
C605	2109720D14	ceramic low DIST 0.1 µF
C611	2311049C05	tantalum 47µF 10% 16V
C612	2113743K15	ceramic 0.100µF
C613,621	2113740F41	39
C622	2311049J44	tantalum 47 20% 10V
C631	2109720D14	ceramic low DIST 0.1 µF
C632	2311049J40	tantalum 33 20% 16V
C634	2311049J44	tantalum 47 20% 10V
C635	2109720D14	ceramic low DIST 0.1 µF
C642-652, C701-703	2113740F41	39
C711	2113743E07	ceramic .022µF
C712	2113743K15	ceramic 0.100µF
C713-714, C722-723,725-726	2113740F41	39
C727,731	2113743K15	ceramic 0.100µF
C741	2113740F41	39
C5200	2113740F35	22
C5201	2113740F14	3.0
C5202	2113740F31	15
C5203-5204	2113743K15	ceramic 0.100µF
C5207	2113740F34	20
C5208	2113743K15	ceramic 0.100µF
C5211	2113740F32	16
C5212	2113740F30	13
C5213	2113740F40	36
C5214	2113740F17	3.9
C5223	2113743K15	ceramic 0.100µF
C5224	2113741F29	1500
C5225	2311049A11	tantalum 3.3 10% 16V
C5226	2113743K05	ceramic .039µF
C5227	2311049J11	tantalum 4.7 10% 16V
C5228	2113743K15	ceramic 0.100µF
C5229	2113740F41	39
C5231	2311049A05	tantalum 0.47 10% 25V
C5233	2113740F41	39
C5234	2113743K15	ceramic 0.100µF
C5235-5237, C5239	2113740F41	39
C5252	2113743K15	ceramic 0.100µF
C5308	2103689A10	7.0 ±0.5 pF
C5310	2113740F41	39
C5311	2113741F49	10000
C5312	2103689A09	3.0 ±0.25 pF
C5321-5322	2113740F41	39
C5323-5326	2113741F49	10000
C5404	2113740F37	27
C5700	2113743E07	ceramic .022µF
C5701-5702	2113743K15	ceramic 0.100µF
C5703	2113740F12	2.4
C5704	2113740F14	3.0
C5705-5708	2113740F41	39
C5709-5711	2113740F51	100
C5712-5713	2311049J26	tantalum 10 20% 16V
C5714-5717	2311049J12	tantalum 4.7 20% 16V
C5718	2311049A14	tantalum 4.7 10% 20V
C5719	2311049J12	tantalum 4.7 20% 16V
C5720-5731	2113743K15	ceramic 0.100µF
C5732-5743	2113743E07	ceramic .022µF
C5744-5747	2109720D01	ceramic low DIST .01 µF
C5748	2113741F49	10000
C5750	2105248W02	low DIST
C5751	2113741A57	33000
C5752-5776, C5778-5779	2113740F41	39
C5782	2113740F14	3.0
C5783	2113740F03	1.0
C5784-5785	2113740F13	2.7
C5786	2113740F12	2.4
C5787-5788	2113740F51	100,side entry
C5789	2113740F12	2.4
C5790	2113740F16	3.9
C5791	2113740F03	1.0
C5792-5793	2113740F13	2.7
C5794	2113740F41	39
C5795	2113740F51	100
C5796-5799, C5802-5803	2109720D14	ceramic low DIST 0.1 µF
C5804-5806	2113743K15	ceramic 0.100µF
C5810, C5813-5814	2113740F41	39
C6501	2113743K15	ceramic 0.100µF
C6502	2113740F21	5.6
C6503, C6505-6506	2113740F41	39
C6507	2113743K15	ceramic 0.100µF
C6508-6510	2113741F49	10000
C6511-6513	2311049A01	tantalum 0.1 10% 35V
C6514-6516	2311049A08	tantalum 1 10% 35V
C6517-6519	2113740F41	39
C6520	2113740F29	12
C6523	2113740F33	18
C6524	2113743E07	ceramic .022µF
C6525	2113741F25	1000
C6526	2113740F27	10
C6527,6529, C6532-6535,6537-6538	2113740F41	39
C6540	2111078A17	RF 3.3 0.25 NPO 100V
C6541-6542	2111078A09	RF 1.8 0.25 NPO 100V
C6543	2113742B29	ceramic 39.0 5%
C6544	2113743K15	ceramic 0.100µF
C6545	2113740F41	39
C6546, C6549-6550	2113743K15	ceramic 0.100µF
C6551-6552	2111078A09	RF 1.8 0.25 NPO 100V
C6553	2111078A17	RF 3.3 0.25 NPO 100V
		diodes: (See Note 1)
CR150-151,600, CR721	4813833C02	dual 70V common cathode
CR5700	4802233J09	triple SOT143-RH
CR5701-5702	4862824C01	varactor
CR6501	4813833C02	dual 70V common cathode
CR6502-6503	4802482J02	pin diode SMD
CR6504	4805129M96	dual
CR6506	4805218N57	dual
CR6508	4880222R01	reverse polarity
CR6509	4805218N57	dual
		spark gaps:
E5700	2602660J01	shield, harmonic filter, UHF
E5701	2604668E02	VCO fence
E5702-5703	2602660J01	shield, harmonic filter, UHF
E5704	2604043K01	shield
		filters:
FL5201	9180098D06	filter ceramic 3 WR
FL5202	9180098D05	filter ceramic 3 WR
FL5203-5204	9102603S24	860MHz filter
		connectors, receptacle:
J400	2804503J01	accessory, 16-pin
J101	0902636Y01	connector, flexible cable, side entry
J6501	0980322L01	antenna
J6502	0905902V01	connector power
		coils:
L131-132	2462587Q40	270nH 10%
L200	2462587K26	33000nH 10%
L404-414	2402601S05	ferrite BLM21A121SP
L415-416	2484657R01	bead
L417-428	2402601S05	ferrite BLM21A121SP
L429-430	2484657R01	bead
L431-434	2402601S05	ferrite BLM21A121SP
L435	2484657R01	bead chip
L5202	2462587M19	1200nH 5%
L5203	2462587T30	1000nH 5% low PRO
L5211	2483411T74	shielded
L5302	2413926E09	6.8nH 5%
L5321	2460591A01	air wound 4.22
L5322	2462587T13	68nH 5% low PRO
L5401-5402	2483411T69	shield
L5700-5704	2462587T30	1000nH 5% low PRO
L5705-5706	2462587T17	150nH 5% low PRO
L5707	2462587T30	1000nH 5% low PRO
L5708	2462587T17	150nH 5% low PRO
L5709	2462587Q44	560nH 10%
L6501	2462587T13	68nH 5% low PRO
L6502	2460591A11	air wound 7.66
L6503	2462587T13	68nH 5% low PRO
L6504-6506	2484657R01	bead
L6507	2460591R53	air wound 81.86
L6508	2460591E24	air wound 23.75
L6509,6511	2462587T13	68nH 5% low PRO
L6513	2460591A11	air wound 7.66
L6514-6517	2462587T13	68nH 5% low PRO
L6518	2460591A11	air wound 7.66
L6519	2484657R01	bead
L6520	2460591R53	air wound 81.86
		transistors: (See Note 1)
Q101-104	4880048M01	NPN DIG 47K/47K
Q105	4813824A10	NPN 40V 0.2A general purpose
Q106,121-125, Q141	4880048M01	NPN DIG 47K/47K
Q200,401	4813824A10	NPN 40V 0.2A general purpose
Q411	4880052M01	NPN Darlington MXTA27
Q431	4880048M01	NPN DIG 47K/47K
Q432	4813824A10	NPN 40V 0.2A general purpose
Q441,450	4880048M01	NPN DIG 47K/47K
Q601	4813824A10	NPN 40V 0.2A general purpose
Q611	4805128M27	SOT89 BSR33 LH
Q612,731	4813824A10	NPN 40V 0.2A general purpose
Q741	4880048M01	NPN DIG 47K/47K
Q742	4805128M27	SOT89 BSR33 LH
Q5201	4813827A07	NPN SML SIG MMBR941LT1
Q5230	4813824A17	PNP40V 0.2A general purpose
Q5301	4813827A18	NPN SML SIG MRF9411LT1
Q5700	4880048M01	NPN DIG 47K/47K
Q5701	4813824A17	PNP 40V 0.2A general purpose
Q5702-5704,	4809527E01	NPN RF
Q5705	4804188K01	NPN RF NE85634
Q5706-5707	4809527E01	NPN RF
Q6501	4813827A26	NPN SML SIG MRF8372 83
Q6506	4813824B01	NPN 40V gen. purpose 2222AT
		resistors: Ω, 5%, 1/8 W unless otherwise stated
R100	0662057A65	4700
R101-103	0662057B05	200K
R104	0662057A89	47K
R105	0662057A65	4700
R106	0662057A73	10K
R107	0662057A57	2200
R108	0662057A73	10K
R109-110	0662057A35	270
R111-112	0662057A65	4700
R113	0662057A85	33K
R114	0662057A93	68K
R115-116	0662057A73	10K
R118	0662057A89	47K
R119	0662057A73	10K
R120	0662057A89	47K
R121	0662057A65	4700
R122	0662057A89	47K
R123	0662057A73	10K
R124	0662057A65	4700
R125-126	0662057A73	10K
R127	0662057A65	4700
R128-130	0662057A73	10K
R131	0662057A65	4700
R132	0662057A81	22K
R134	0662057B47	0 +-.050
R135-136, R142-143	0662057A73	10K
R144	0662057A65	4700
R145	0662057A73	10K
R146-147	0662057A35	270
R150	0662057A89	47K
R151	0662057B05	200K
R153	0662057A85	33K
R200	0662057A73	10K
R201-202	0662057A69	6800
R203	0662057A73	10K
R205	0662057A49	1000
R207	0662057A84	30K
R208-209	0662057A73	10K
R210	0662057A49	1000
R221	0662057B47	0 +-.050
R222	0662057A89	47K
R223	0662057R92	47.5K 0.1W 1%
R224-225	0662057A73	10K
R231	0662057B47	0 +-.050
R232	0662057A93	68K
R233	0662057A73	10K
R251-252	0662057R92	47.5K 0.1W 1%
R401	0662057A65	4700
R402	0662057A49	1000
R404-405	0662057A73	10K
R406	0662057A81	22K
R411	0662057A73	10K
R412	0662057A65	4700
R414	0662057A41	470
R415	0662057A49	1000
R416	0662057A25	100
R417	0662057A97	100K
R418	0662057A18	51
R419	0662057A97	100K
R421	0662057A43	560
R422-423	0662057A65	4700
R424	0662057A43	560
R431	0662057A73	10K
R432-433	0662057A65	4700
R435	0662057A73	10K
R440	0662057A93	68K
R441	0662057A65	4700
R442	0662057A73	10K
R449	0662057A85	33K
R450-451	0662057A65	4700
R452	0662057A73	10K
R456	0662057C01	0 +.050
R460	0662057B05	200K
R461	0662057A89	47K
R462	0662057B05	200K
R463	0662057B22	1.0M
R464	0662057B14	470K
R465-466	0662057A65	4700
R601	0662057A73	10K
R602	0662057R55	7500 0.1W 1%
R603	0662057R31	1210 0.1W 1%
R604	0662057A69	6800
R605	0662057A81	22K
R611	0662057A51	1200
R612-613	0662057C87	3300
R614	0662057A49	1000
R615-616	0662057A73	10K
R617	0662057C87	3300
R621	0662057A57	2200
R631-632	0662057A01	10
R641	0662057A84	30K
R642	0662057A73	10K
R702	0662057A81	22K
R703-704	0662057A73	10K
R705	0662057A61	3300
R706	0662057A97	100K
R711	0662057A81	22K
R712	0662057A57	2200
R714	0662057A25	100
R715	0662057R30	1000 0.1W 1%
R716-718	0662057R60	10K 0.1W 1%
R719	0662057R30	1000 0.1W 1%

Parts List for FLF5582A Main Board

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REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
R720	0662057R60	10K 0.1W 1%
R721	0662057A67	5600
R722	0662057A81	22K
R723	0662057A97	100K
R724	0662057A61	3300
R725-726	0662057A73	10K
R727	0662057A97	100K
R728-731	0662057G13	100 K 1%
R732-737	0662057A65	4700
R741-742	0662057A53	1500
R743	0662057A49	1000
R5201	0662057A76	13K
R5202	0662057A85	33K
R5203	0662057A69	6800
R5204	0662057A25	100
R5205	0662057A56	2000
R5207	0662057B47	0 +-.050
R5211	0662057A47	820
R5212	0662057A67	5600
R5221	0662057B01	130K
R5223	0662057A70	7500
R5224	0662057A76	13K
R5230	0662057A89	47K
R5240	0683962T49	100 5-1
R5241	0662057B47	0 +-.050
R5302	0662057A33	220
R5306	0662057A29	150
R5311-5312	0662057A76	13K
R5321	0662057A33	220
R5323	0662057A36	300
R5324	0662057A39	390
R5327	0662057A03	12
R5328	0662057A39	390
R5401	0662057A18	51
R5700	0662057A57	2200
R5701-5702	0662057B47	0 +-.050
R5703	0662057A73	10K
R5704	0662057A37	330
R5705	0662057A73	10K
R5707	0662057A61	3300
R5708-5709	0662057B05	200K
R5710	0662057A73	10K
R5711-5713	0662057A65	4700
R5714	0662057A59	2700
R5715	0662057A57	2200
R5716-5717	0662057A56	2000
R5718	0662057A53	1500
R5719-5727	0662057A42	510
R5728	0662057A37	330
R5729	0662057A29	150
R5731-5733	0662057A25	100
R5734-5736	0662057A18	51
R5737-5738	0662057A09	22
R5739-5740	0662057A18	51
R5741	0662057A01	10
R5742	0662057A69	6800
R5743	0662057A73	10K
R5744-5745	0662057A31	180
R5746	0662057A73	10K
R5747	0662057A69	6800
R5748	0662057A09	22
R5750-5751	0662057A59	2700
R5752	0662057A37	330
R5753	0662057A13	33
R5754	0662057A37	330
R5755	0662057A09	22
R5756-5757	0662057A35	270
R6502	0662057A09	22
R6503	0662057A01	10
R6504	0662057A42	510
R6506	0662057A09	22
R6512	0662057A25	100
R6514-6515	0662057A61	3300
R6519	0680361L01	thermistor 47K
R6520	1705603W01	SMT shunt
R6523-6525	0662057A53	1500
R6526	0662057A01	10
R6527	0662057A36	300
R6531-6532	0662057A25	100
R6537-6539	0662057A17	47
R6555	0662057A33	220
		shields:
SH5201	2605261V01	shield Z1F
SH5202-5203	2605417V01	crystal shield
		integrated circuits: (See Note 1)
U1	5105835U41	CC contact 91W58 DIE
U2	5105191W42	CC flat PK contact 5625U29
U101	5102463J20	68HC11K1
U103	5105662U54	hybrid 32K X 8 SRAM tested
U104	5108444S49	4KX8 EEPROM
U105	5113805A30	1 of 8 DCDR/demux 74HC138
U106	5113808A07	AND quad 2 INP MC74AC08D
U202	5113819A04	QD op amp gen. purpose MC3303
U251	5113818A03	high performance single supply
U401	5105457W10	CC audio PA
U460	5113818A03	high performance single supply
U601	5105625U25	9.3V regulator 2941
U631	5105469E65	voltage regulator LP2951C
U701	5113819A04	QD op amp gen. purpose MC3303
U702	5113811G02	D/A converter 6-bit 4-channel with SPI
U5201	5180207R01	IF IC
U5211	0108106L10	mixer DBL balanced
U5700	5105279V31	16.8MHz ref. oscillator mode
U5701	5105625U27	MIMIC
U5702	5105191W42	CC flat PK contact 5625U29
U5703	5113816A07	regulator 5V 500mA MC78M05BDT
U5704-5705	4805921T02	transistor FMC2 RH
U5706-5707	4804122K04	microstrip line resonator
U6501	5113829D22	806-870MHz, 20W,12.5V
U6502	4805921T02	transistor FMC2 RH
		Zener diodes: (See Note 1)
VR101	4813830A23	10V 5% 225mW MMBZ5240B
VR401	4813830A27	14V 5% 225mW MMBZ5244B
VR412	4813830A40	33V 5% 225mW MMBZ5257B
VR416,421-422	4813830A27	14V 5% 225mW MMBZ5244B
VR425	4813830A14	5.1V 5% 225mW MMBZ5231
VR426-427,431	4813830A27	14V 5% 225mW MMBZ5244B
VR441	4813830A40	33V 5% 225mW MMBZ5257B

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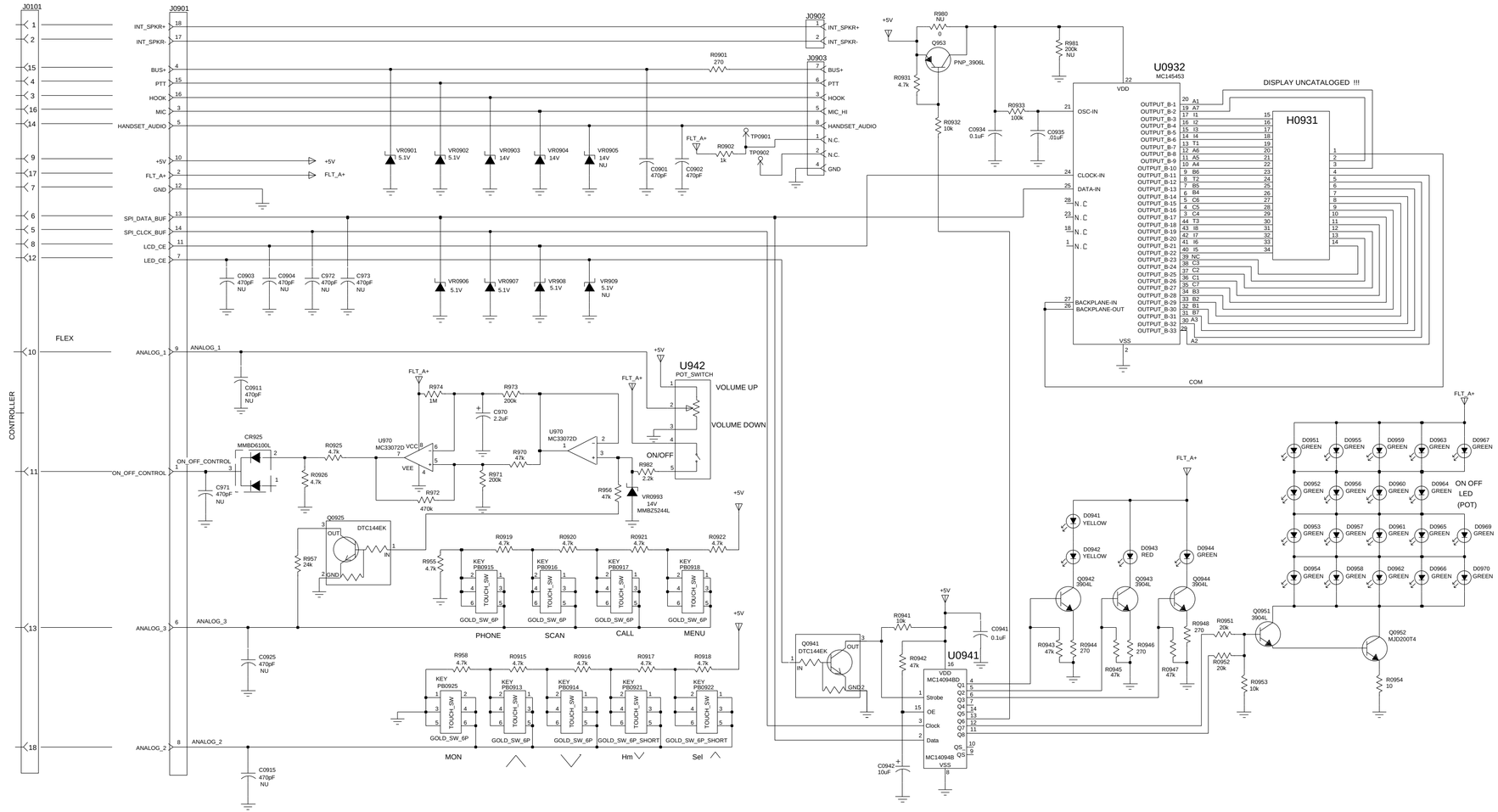
REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
VR451	4813830A14	5.1V 5% 225mW MMBZ5231
VR480	4813830A27	14V 5% 225mW MMBZ5244B
VR621,641	4813830A14	5.1V 5% 225mW MMBZ5231
VR6501	4813830A27	14V 5% 225mW MMBZ5244B
		crystals: (See Note 2)
Y5201	9180112R05	45.1MHz crystal filter
Y5211	4880008K02	resonator 44.645MHz
Qty		**non-referenced items:**
D101-102,200, D441,611,621, D631	4813833C02	dual 70V common cathode
D5201,5303	4880154K03	dual Schottky mixer
1	8408029Y34	PCB
1	8408029Y01	PCB

Notes

1 For optimum performance, diodes, transistors and integrated circuits must be ordered by MOTOROLA part numbers.

2. When ordering quartz crystal units or ceramic resonators, specify carrier frequency, crystal (or resonator) frequency, and crystal (or resonator) type number.



Schematic Diagram for FLN8530A Control Head

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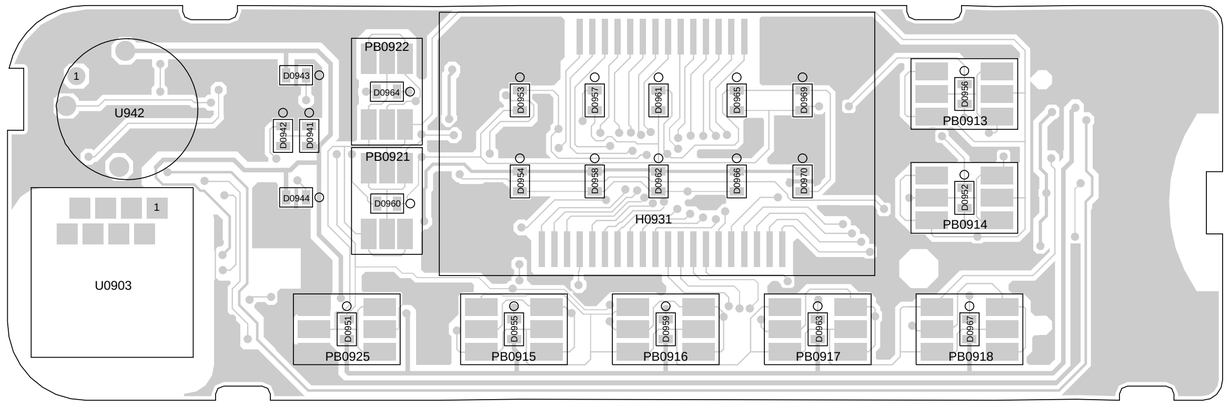

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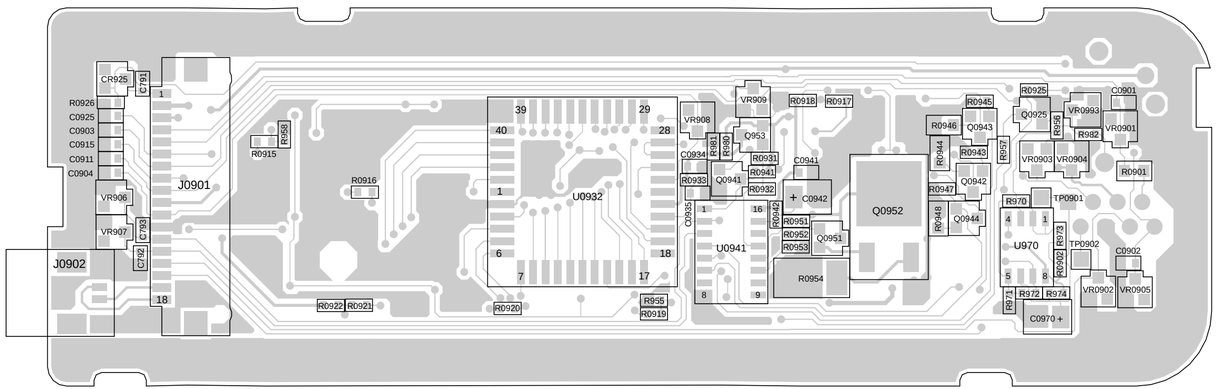

Circuit Board Details & Parts List for FLN8530A Control Head

parts lists

FLN8530A Control Head Board

REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
		capacitors: µF, ±5% 50V, unless otherwise specified
C901-902	2113741F17	470
C934	2113743K15	ceramic 0.100
C935	2113741F49	10000pF
C941	2113743K15	ceramic 0 .100
C942	2311049J23	tantalum 10 10% 7V
C970	2311049A09	tantalum 2.2 10% 20V
		diodes: (See Note 1)
CR925	4813833C02	dual 70V common cathode
		connectors, receptacle:
J901	0902636Y01	connector, flex. cable,side entry
J902	2809926G01	SMT header
J903	2805924V01	MIC connector
		transistors: (See Note)
Q925, 941	4880048M01	NPN DIG 47K/47K
Q942-944, 951	4813824A10	NPN 40V 0.2A general purpose
Q952	4813822A20	NPN 25V 5A
Q953	4813824A17	PNP 40V 0.2A general purpose
		resistors: Ω, 5%, 1/8 W unless otherwise stated
R901	0662057C61	270
R902	0662057A49	1000
R915-922, R925-926, 931	0662057A65	4700
R932	0662057A73	10K
R933	0662057A97	100K
R941	0662057A73	10K
R942-943	0662057A89	47K
R944	0662057C61	270
R945	0662057A89	47K
R946	0662057C61	270
R947	0662057A89	47K
R948	0662057C61	270
R951-952	0662057A80	20K
R953	0662057A73	10K
R954	0680194M01	10 1W
R955	0662057A65	4700
R956	0662057A89	47K
R957	0662057A82	24K
R958	0662057A65	4700
R970	0662057A89	47K
R971	0662057B05	200K
R972	0662057B14	470K
R973	0662057B05	200K
R974	0662057B22	1.0M
R981	0662057B05	200K
R982	0662057A57	2200
		integrated circuits: (See Note)
U932	5105625U61	LCD driver
U941	5113806A35	regulator, 8-stage shift/store
U942	1805642V01	volume potentiometer ON/OFF

REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
U970	5113818A03	high performance single supply
		Zener diodes: (See Note)
VR901-904, VR906-907	4813830A27	14V 5% 225mW MMBZ5244B
VR908	4813830A14	5.1V 5% 225mW MMBZ5231
VR993	4813830A27	14V 5% 225mW MMBZ5244B
Qty		**non-referenced items:**
D941-942	4805729G73	LED SMT YEL
D943	4805729G74	LED SMT RED
D944, 951-967, D969-970	4805729G75	LED SMT GREEN
1	8408057Y33	PCB
1	8408057Y01	PCB

Notes

1 For optimum performance, diodes, transistors and integrated circuits must be ordered by MOTOROLA part numbers.

2. When ordering quartz crystal units or ceramic resonators, specify carrier frequency, crystal (or resonator) frequency, and crystal (or resonator) type number.

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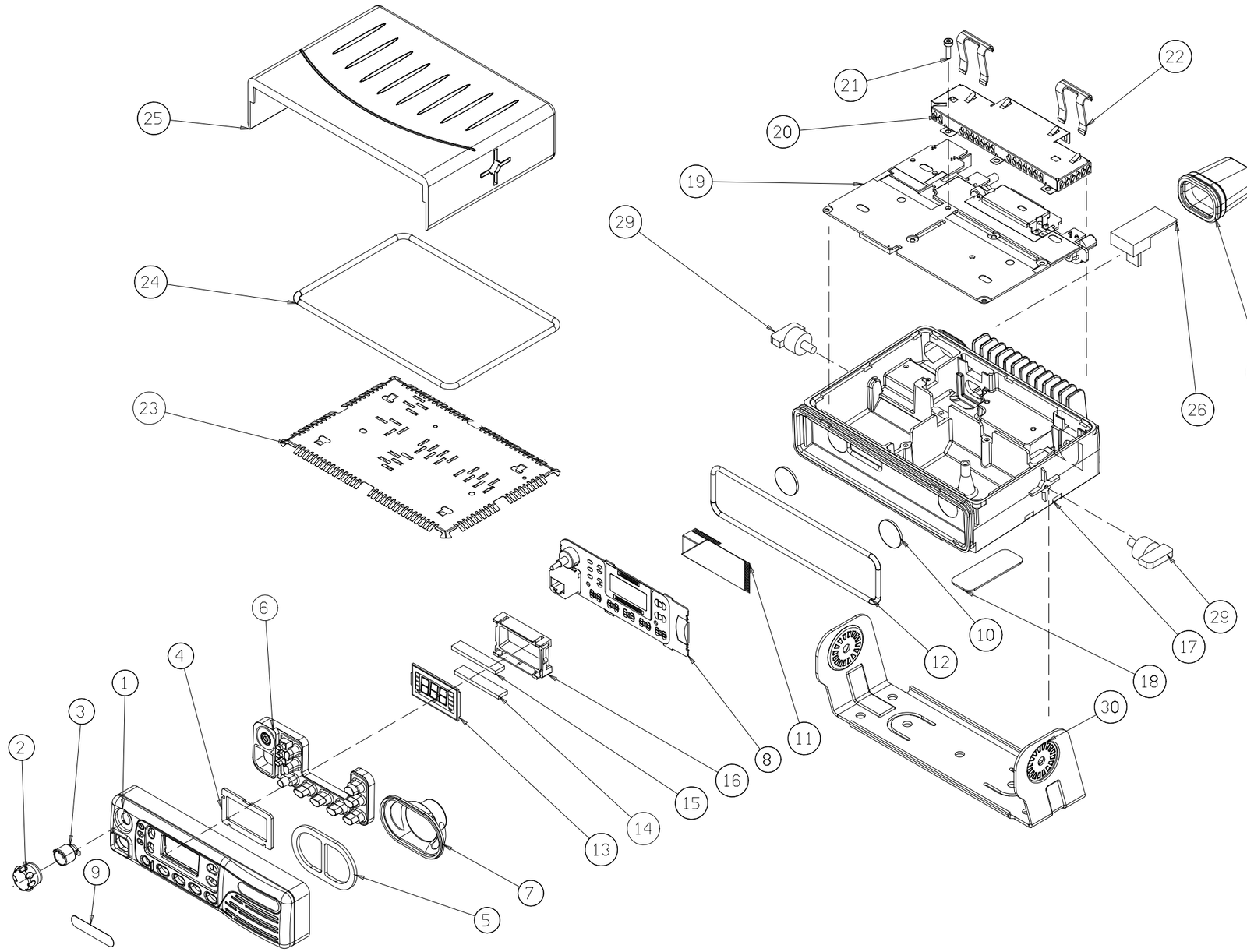

parts list

GTX Mechanical Parts List

REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
1	1580356K01	housing
2	3605422W02	exterior volume knob
3	3608147K01	inferior volume knob
4	3280511 L01	LCD frame gasket
5	3205932V01	speaker gasket
6	7580358K01	keypad
7	5002236P05	speaker
B	FLN8530	control head board
9	5480643K01	logo label
10	3280494K01	speaker pad
11	8402618Y01	flexible circuit
12	3202620Y01	control head gasket
13	7202631Y01	LCD display
14	2802638Y01	connector
15	2802638Y02	connector
16	0780360K01	LCD frame
17	2780354K01	chassis
18*	----------	FCC label
19	FLF5582	main board
20	2680519K01	PA shield
21	0310907A20	mechanical screw, M3x0.5x10
22	4205938V01	clip spring
23	2680439K01	cover shield
24	3202619Y01	pad
25	1580355K01	cover assembly
26	FHN5875	accessory kit
27	3202606Y01	accessory connector gasket
29, 30	GLN7317	trunnion kit

* Not field replaceable

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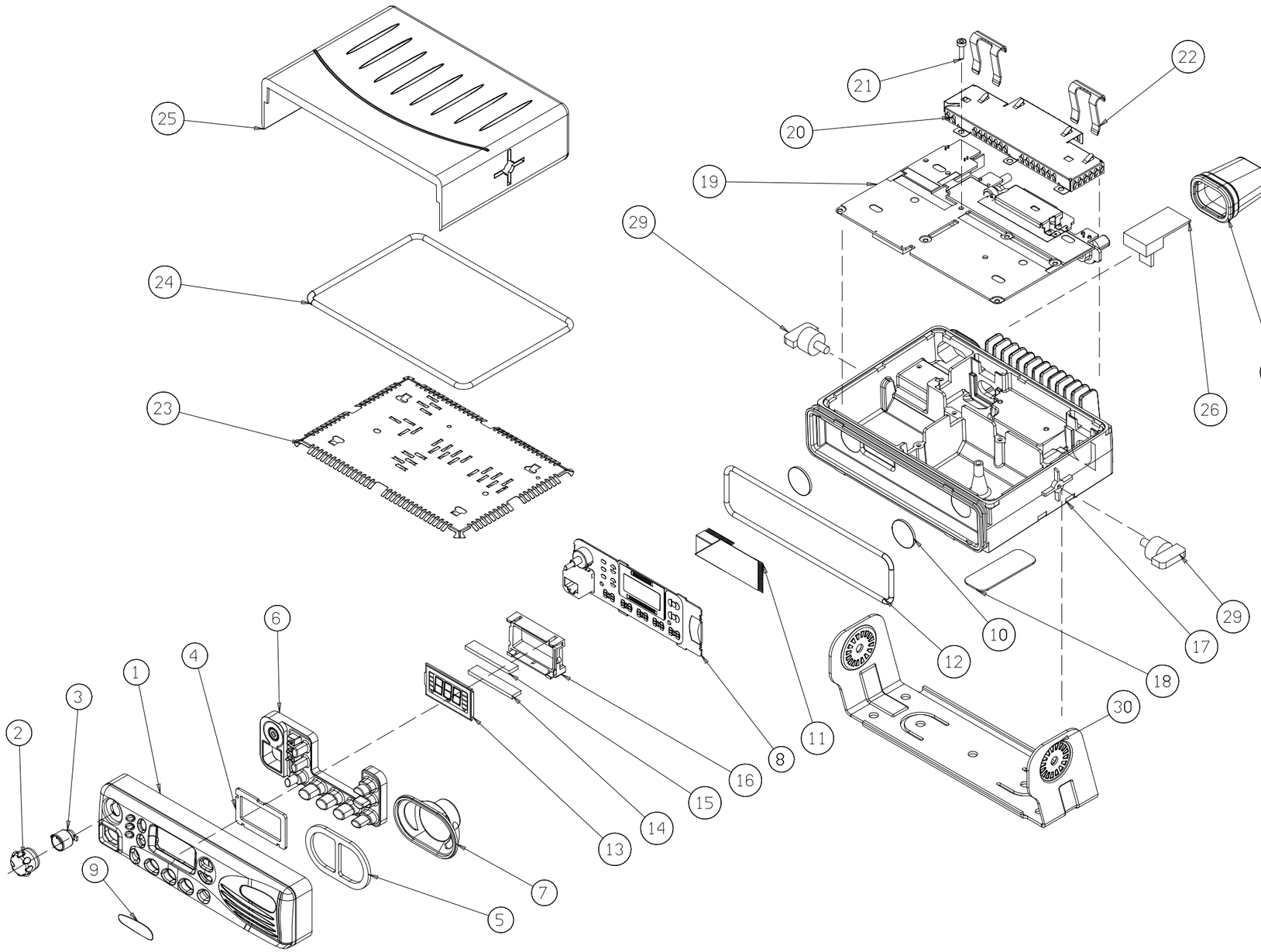
parts list

LCS 2000 Mechanical Parts List

REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
1	1580357K01	housing
2	3605422W02	exterior volume knob
3	5480493K01	interior volume knob
4	3280511 L01	LCD frame gasket
5	3205932V01	speaker gasket
6	7580359K01	keypad
7	5002236P05	speaker
8	FLN8530	control head board
9	5480643K01	logo label
10	3280494K01	speaker pad
11	8402618Y01	flexible circuit
12	3202620Y01	control head gasket
13	7202631Y01	LCD display
14	2802638Y01	connector
15	2802638Y02	connector
16	0780360K01	LCD frame
17	2780354K01	chassis
18*	--------	FCC label
19	FLF5582	main board
20	2680519K01	PA shield
21	0310907A20	mechanical screw, M3x0.5x10
22	4205938V01	clip spring
23	2680439K01	cover shield
24	3202619Y01	pad
25	1580355K01	cover assembly
26	FHN5875	accessory kit
27	3202606Y01	accessory connector gasket
29, 30	GLN7317	trunnion kit

* Not field replaceable



LCS 2000 Exploded View & Mechanical Parts List

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miscellaneous parts lists

FLN8544A Control Head (LCS 2000)

REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
Qty		**non-referenced items:**
1	0780360K01	LCD frame
1	1580357K01	housing
1	2802638Y01	elastomeric plug
1	2802638Y02	elastomeric plug
1	3202630Y01	LCD frame gasket
1	3205932V01	spekaer gasket
1	3680515K01	knob assembly
1	5002236P05	speaker
1	5480493K01	logo label
1	7202631Y01	LCD display
1	7580359K01	keypad
1	8402618Y01	flexible circuit

FLN8529A Main Board Hardware

REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
Qty		**non-referenced items:**
11	0310907A20	mechanical screw M3X0.5X10"
1	1580650K01	assembly cover
1	2680439K01	cover shield
1	2680519K01	PA section shield
1	2780354K01	chassis
1	3202606Y01	accessory connector gasket
1	3202620Y01	control head gasket
2	3280494K01	speaker pad
2	4205938V01	spring clip

FLN8531A Control Head Hardware

REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
Qty		**non-referenced items:**
1	8402618Y01	flexible cable
1	0780360K01	LCD frame
1	1580356K01	housing
1	2802638Y01	elastomeric
1	2802638Y02	elastomeric
1	3202630Y01	LCD frame gasket
1	3205932V01	speaker gasket
1	3680515K01	knob assembly
1	5002236P05	speaker
1	5480643K01	logo label
1	7202631Y01	LCD display
1	7580358K01	keypad

FLN8752A Manuals (GTX)

REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
Qty		**non-referenced items:**
1	6802946C75	User's Manual
1	6802946C85	Quick Start

FLN8753A Manuals (LCS 2000)

REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
Qty		**non-referenced items:**
1	6802945C90	User's manual
1	6802945C95	Quick Start

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SERVICE MANUAL QUESTIONNAIRE

We believe that reports from users provide valuable information for producing quality manuals. By taking a few moments to answer the following questions as they relate to this specific manual, you can take an active role in the continuing effort to ensure that our manuals contain the most accurate and complete information of benefit to you. Thank you for your cooperation.

In reference to Manual Number: 68P02945C70-O

GTX/LCS 2000™ Mobile Radio

1. Please check all the appropriate boxes:

	Complete	Incomplete	Correct	Incorrect	Clear	Confusing	Size Adequate	Size Too Small	Not Covered in This Manual
Disassembly Procedures									
Alignment Procedures									
Exploded Views									
Schematic Diagrams									
Circuit Board Details									
Electrical Parts Lists									
Exploded View Parts List									

2. How would you rate the overall organization of this manual?

☐ excellent ☐ very good ☐ good ☐ fair ☐ poor

3. Did this Service manual provide you with the information necessary to service and maintain the specific equipment?

☐ very much so ☐ generally yes ☐ to some extent ☐ no

4. How do you rate this particular Service Manual?

☐ excellent ☐ very good ☐ good ☐ fair ☐ poor

5. We would appreciate any corrections or recommendations for improving this manual. Please include the specific page number(s) of the diagram or procedure in question.

   a. Disassembly Procedures:(Page No. _____)

   b. Alignment Procedures:(Page No. _____)

   c. Exploded Views:(Page No. _____)

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Please specify the page number along with any corrections or recommendations for improvement.

d. Schematic Diagrams: (Page No. _____)
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g. Exploded View Parts List: (Page No. _____)

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