MOTOROLA

MCX600E

Mobile Radio

Service Manual

Issue: December 1999

Computer Software Copyrights

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SAFETY INFORMATION

Read this information before using your radio.

SAFE AND EFFICIENT OPERATION OF MOTOROLA TWO-WAY RADIOS

This document provides information and instructions for the safe and efficient operation of Motorola Portable and Mobile Two-Way Radios. The information provided in this document supersedes the general safety information contained in user guides published prior to 1 January 1998.

For information regarding radio use in hazardous areas, please refer to the Factory Mutual (FM) approval manual supplement.

EXPOSURE TO RADIO FREQUENCY ENERGY

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

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

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

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

MOBILE RADIO OPERATION AND EME EXPOSURE

- Transmit only when people inside and outside the vehicle are at least the minimum distance away from a properly installed, externally mounted antenna.

Table 1 below lists the minimum distance for several different ranges of rated radio power.

Table 1: Rated Power versus Distance

Rated Power of Vehicle-Installed Mobile Two-Way Radio	Minimum Distance From Transmitting Antenna
7-15 Watts	1 Foot (30.5 Centimeters)
16-50 Watts	2 Feet (61 Centimeters)
More Than 50 Watts	3 Feet (91.5 Centimeters)

MOBILE ANTENNA INSTALLATION

A vehicle antenna must be installed external to the vehicle and in accordance with:

- The requirements of the antenna manufacturer/supplier
- Instructions in the Radio Installation Manual

CONTROL STATION OPERATION

When radio equipment is used to operate as a control station, it is important that the antenna be installed outside the building and away from places where people may be in close proximity.

NOTE Refer to Table 1 for rated power and minimum distance values for transmitting antennas.

ELECTROMAGNETIC INTERFERENCE/COMPATIBILITY

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

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

OPERATIONAL WARNINGS

Potentially explosive atmospheres

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

Blasting caps and areas

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

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

OPERATIONAL CAUTIONS

Damaged antennas

CAUTION: Do not use any two-way radio that has a damaged antenna. If a damaged antenna comes into contact with your skin, a minor burn can result.

CAUTION

ELECTROSTATIC SENSITIVE DEVICES

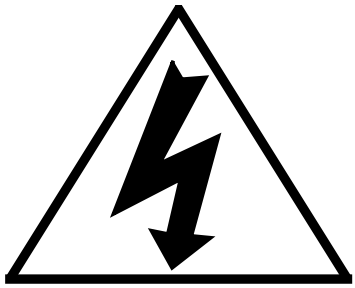
PRECAUTIONS SHOULD BE TAKEN TO MINIMIZE THE RISK OF DAMAGE BY ELECTROSTATIC DISCHARGE TO ELECTROSTATIC SENSITIVE DEVICES (ESDs).

ANY DEVICES EMPLOYING METAL OXIDE SILICON (MOS) TECHNOLOGY ARE PARTICULARLY SUSCEPTIBLE.

CIRCUIT DIAGRAMS MARKED WITH THE ABOVE SYMBOL INDICATE ELECTRONIC CIRCUITS (PECs) FOR WHICH ESD HANDLING PRECAUTIONS ARE NECESSARY.

THE USER SHOULD REFER TO BS5783, 1984: HANDLING OF ELECTROSTATIC SENSITIVE DEVICES. THIS BRITISH STANDARD SUPERSEDES DEF STAN 59-98, ISSUE 2.

WARNING



SAFETY WARNINGS

THE ELECTRICAL POWER USED IN THIS EQUIPMENT IS AT A VOLTAGE HIGH ENOUGH TO ENDANGER LIFE.

BEFORE CARRYING OUT MAINTENANCE OR REPAIR, PERSONS CONCERNED MUST ENSURE THAT THIS EQUIPMENT IS ISOLATED FROM THE ELECTRICAL SUPPLY AND TESTS ARE MADE TO ENSURE THAT ISOLATION IS COMPLETE.

WHEN THE SUPPLY CANNOT BE ISOLATED, MAINTENANCE AND REPAIR MUST BE UNDERTAKEN BY PERSONS WHO ARE FULLY AWARE OF THE DANGERS INVOLVED AND WHO HAVE TAKEN ADEQUATE PRECAUTIONS TO PROTECT THEMSELVES.

COMPONENTS CONTAINING BERYLLIUM OXIDE ARE USED IN THIS EQUIPMENT. DUST FROM THIS MATERIAL IS A HEALTH HAZARD IF INHALED OR ALLOWED TO COME INTO CONTACT WITH THE SKIN.

GREAT CARE MUST BE TAKEN WHEN HANDLING THESE COMPONENTS WHICH MUST NOT BE BROKEN OR SUBJECTED TO EXCESSIVE HEATING. DEFECTIVE COMPONENTS MUST BE DISPOSED OF IN ACCORDANCE WITH CURRENT INSTRUCTIONS.

LEAD ACID BATTERIES MAY BE FITTED AS THE STANDBY BATTERY. CARE MUST BE TAKEN WHEN REMOVING OR INSTALLING THESE BATTERIES TO:

1. ENSURE THAT THE TERMINALS ARE NOT SHORTED TOGETHER.

2. PREVENT SPILLAGE OF THE CORROSIVE ELECTROLYTE.

Service Manual

Contents

Chapter

Appendix

Chapter 1

Introduction

Table of Contents

1.0 Introduction

This chapter outlines the scope and use of the service manual and provides an overview of the warranty and service support. The radio specifications are also supplied in this chapter.

2.0 Scope of Manual

This manual is intended for use by experienced technicians familiar with similar types of equipment. It contains service information required for the equipment described and is current as of the printing date. Changes which occur after the printing date are incorporated by a complete Service Manual revision to your Product Manual.

3.0 How to Use This Manual

This manual contains introductory material such as overview, model charts, specifications and accessories and the remaining chapters deal with specific service aspects of the radio.
Refer to the Table of Contents for a general overview of the manual.

4.0 Warranty and Service Support

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

4.1 Warranty Period

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

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

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

4.2 After Warranty Period

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

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

4.3 Piece Parts

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

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

4.4 Technical Support

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

Toll-Free

Country	Number
Australia	1800-774457
China	800-810-0976
Hong Kong	25904800
Indonesia	0800-1-686868
Korea	080-300-7400
Malaysia	1800-801687
New Zealand	0800-442109
Philippines	1800-16510271
Singapore	1800-4855333
Taiwan	0080-651661
Thailand (outside Bangkok)	088-225412

Non-Toll-Free

Country	Number
India	80-6658922
Thailand (Bangkok area)	2548388
All Other Countries	IDD Code+(65)-4855333

5.0 Specifications

5.1 General

Frequency Range	336-390MHz
Channel Spacing	25kHz
Modulation	FM, Type 8K5G3,14G3,16G3
Antenna Impedance	50 Ohms
Mode of Operation	Trunked/Conventional
Power Supply VDC	10.8 - 15.6
Operating Temperature	- 25 to + 55°C
Storage Temperature	- 40 to + 85°C
Environmental	IP 54, MILSTD 810E
Frequency Stability	300MHz: 3 ppm
Dimensions	168x160x44 (HxWxD)
Weight	1030g

5.2 Receiver

	25kHz
Sensitivity 12dB SINAD µV	0.35
Audio Output Power <5% distortion @1kHz with rated audio output	4W (internal loudspeaker) 13W (external loudspeaker)
Spurious / Image Rejection	70dB
Selectivity	70dB
Intermodulation	65dB
Switching Bandwidth No degradation	300MHz: 336-390MHz

5.3 Transmitter

Power Output (no degradation)	5 - 25W
Maximum Deviation 25kHz	± 5kHz
Audio Distortion (@1kHz, 60% deviation)	5%
Spurious and Harmonics	- 36dBm
Switching Bandwidth No degradation	336-390MHz

Chapter 2

Model Chart and Accessories

Table of Contents

1.0 Overview

This chapter lists the models and accessories available for the MCX600E mobile radio.

2.0 Model Chart

Model	Description
AZM08PHN6DL5_N	MCX600E 336-390 MHz 25 kHz 25W MPS

MCX600E
336-390 MHz

X = Indicates one of each required

	Item	Description
X	GBN6147	Packaging Kit
X	GLN7331	Blank Control Head
X	GLN7317	MPT Trunnion Kit
X	PMMN4005	Hand Held Control Head
X	PMUD1663	MCX600E S/T 336-390MHz 25k MPS
X	GKN6270	Power Cable
X	6804111J88	MCX600E User Guide

3.0 Accessories

3.1 Mechanical Hardware Kits

GLN7317_	Standard Trunnion kit
GLN7324_	Low Profile Trunnion kit
GLN7331_	Blank Control Head

3.2 Speakers

All speaker connecting cables have 16-pin accessory connector plug.

GSN6059_	13W External Speaker, square

3.3 Cables

GKN6270_	Battery power cable 3m, 10A fuse (Standard)
GKN6271_	Ignition switch cable

3.4 Other

GKN6272_	Alarm, Relay and Cable Kit
GLN7323_	External PTT
GLN7318_	Base Tray
GPN6126_	24/12V DC Converter, 6A
GPN6127_	24/12V DC Converter, 15A
GPN6133_	EMC approved mains Power Supply
HPN4002_	Non-EMC approved mains Power Supply
HPN8393_	Non-EMC approved mains Power Supply

Chapter 3

Maintenance

Table of Contents

1.0 Overview

This chapter explains, step by step, how to disassemble and assemble the radio, to transceiver board level. The chapter also contains a list of test equipment required to service the radio and the procedure for radio alignment/test setup is also available in this chapter.

Note: Control head type may differ from the diagram shown in this section, depending on the models supported. However, the instructions pertaining to its removal and assembly are the same across models.

2.0 Disassemble the Radio

2.1 Remove the Control Head

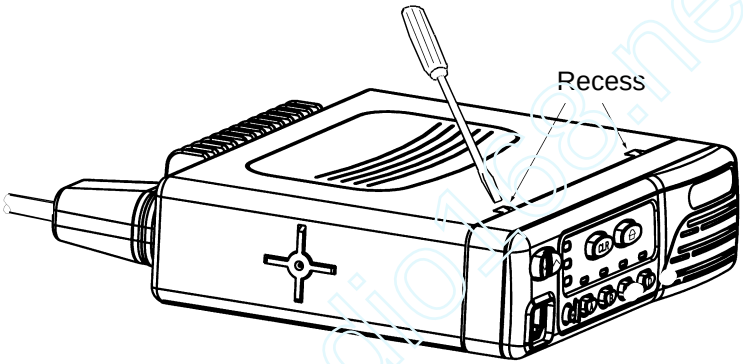


Figure 3-1 Control Head Removal.

1. Insert a small flat blade screw driver, or similar, in the recess between the control head and the transceiver (to minimise cosmetic damage to the radio cover start from the bottom side).
2. Press until the side of the control head releases and then repeat the operation on the opposite side of the radio.
3. Pull the control head away from the transceiver.
4. Remove the flex from the socket on the control head board.

2.2 Remove the Top Cover

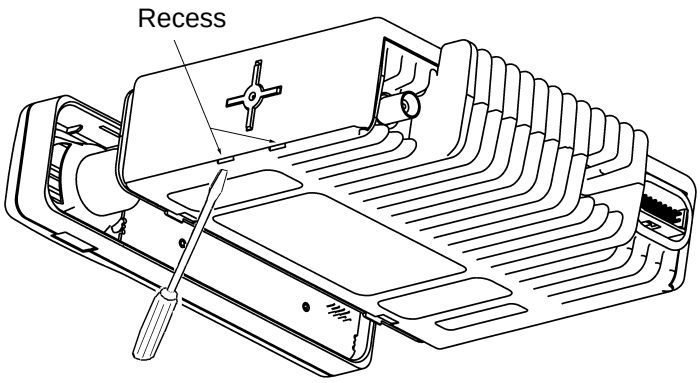


Figure 3-2 Top Cover Removal.

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

2.3 Remove the Transceiver Board

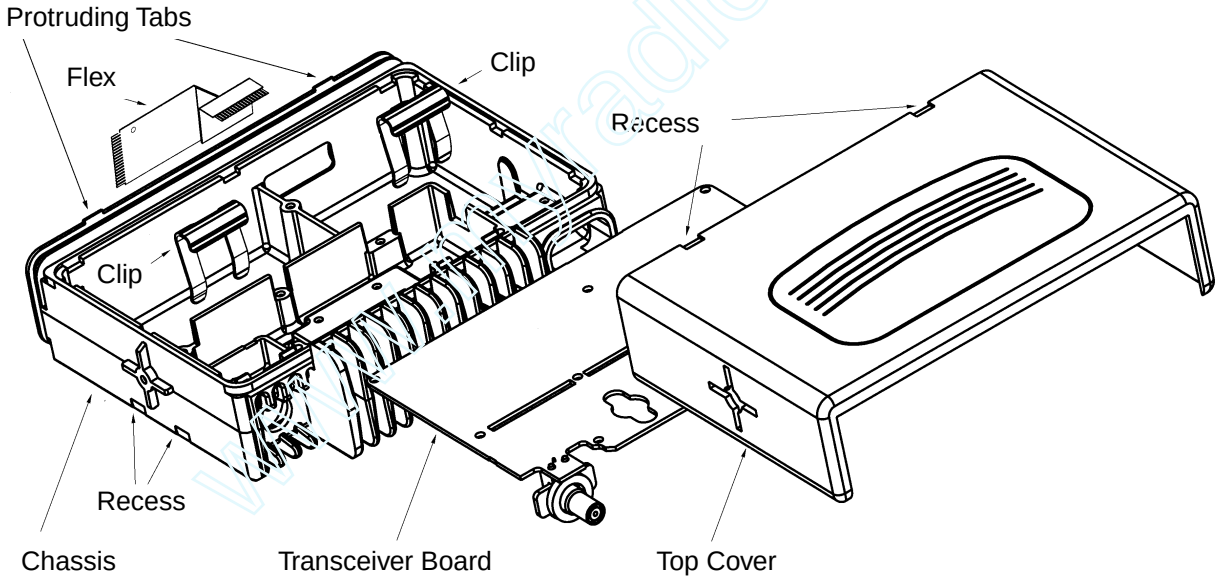


Figure 3-3 Transceiver Board Removal.

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 13 screws from the transceiver board using a T8 TORX driver.

3. Carefully remove the transceiver board by rotating it out of the chassis:

   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 devises to be over stressed if the board is lifted too quickly.

3.0 Assemble Radio

3.1 Replace the Transceiver Board

1. Inspect and if necessary, reapply thermal grease to the heatsinking pads in the chassis.
2. Before installing the connector retaining clips, ensure that the board is sitting flush on the chassis mounting surface.
3. Install the 13 screws with 0.4 -07 NM (4-6 in lbs) of torque using a T8 TORX driver.

3.2 Replace the Top Cover and Control Head

1. Position the top cover over the chassis and replace. Ensure that the cross snaps 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 tabs on the chassis snap into the recesses inside the control housing, see Figure 3-4.

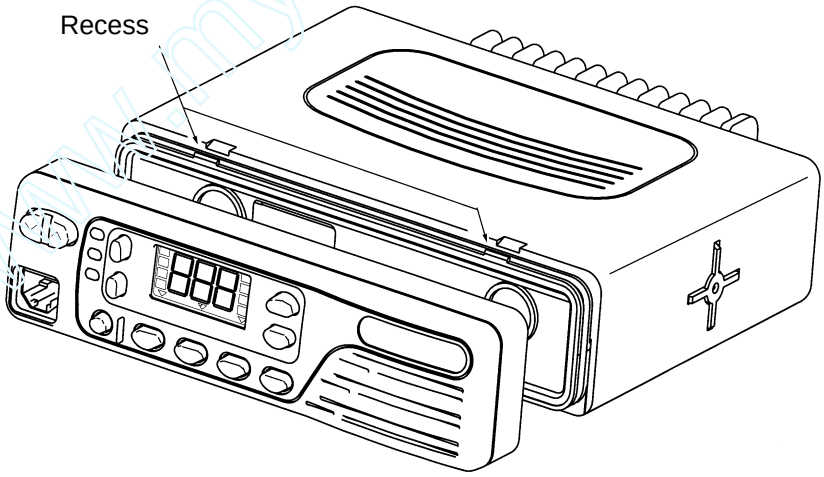


Figure 3-4 Control Head Replacement.

4.0 Exploded View Diagrams and Parts

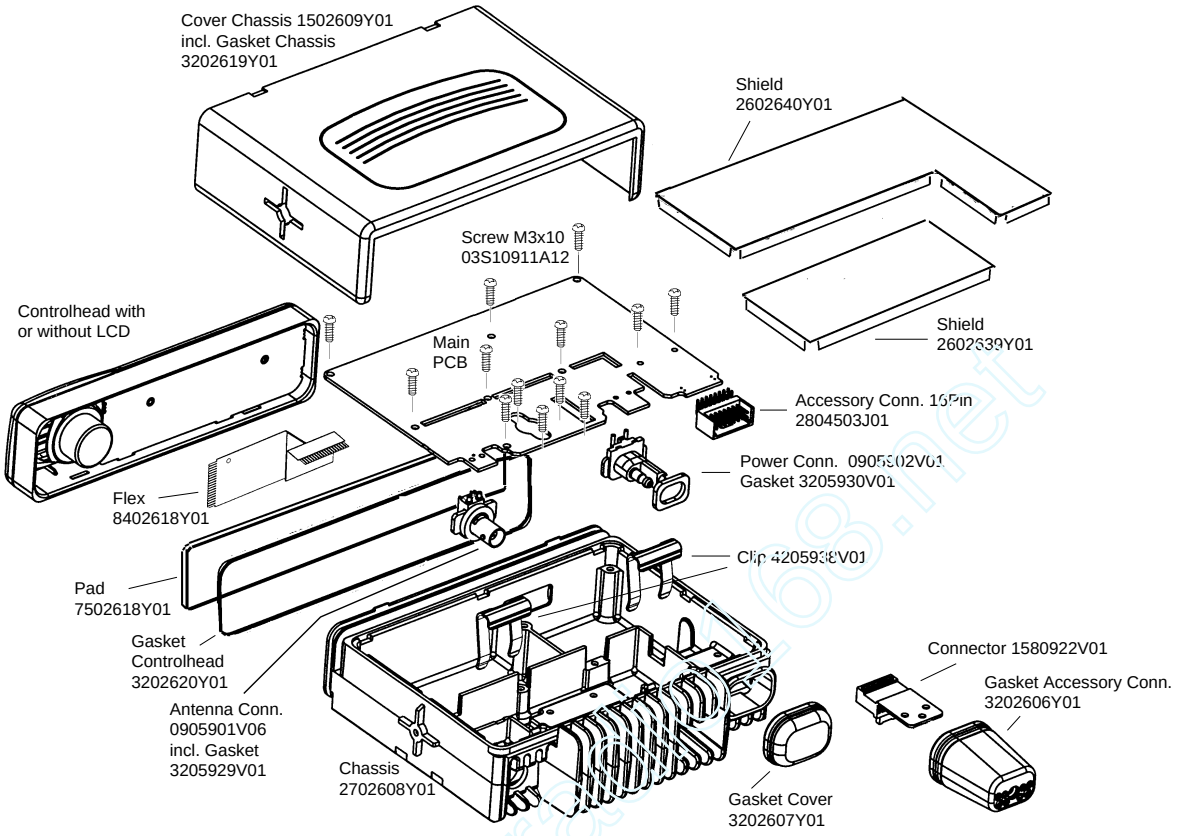


Figure 3-5 Radio Exploded View Diagram.

5.0 Service Aids

The list in table 3-1 includes service aids recommended for working on the radio.

Table 3-1 Service Aids.

PART No.	DESCRIPTION	APPLICATION
GTF376	Test Box Cable	Connects radio to GTF180 test box.
GTF374	Combined Interface Cable	Connects radio to RLN4008 RIB.
GTF377	Combined Interface Cable	Connects Databox radio to RLN4008 RIB.
GPN6133	Power Supply	Used to supply power to the radio.
GKN6266	DC Power Cable for radio	Interconnects radio to power supply.
GTF180	Test Box	Enables connection to the universal connector. Allows switching for radio testing.
RLN4008	Radio Interface Box	Enables communications between the radio and the computer's serial communications adapter.
EPN4040	Power Supply	Used to supply power to the RIB (240 VAC).
EPN4041	Power Supply	Used to supply power to the RIB (220 VAC).
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.
PMVN4022D	PTX600/MCX600E DPS_Dealer	DPS Dealer Software, 3.5" floppy disks
PMVN4023D	PTX600/MCX600E DPS_Network	DPS Network Software, 3.5" floppy disks

6.0 Test Equipment

The list in table 3-2 includes all standard test equipment required for servicing two-way mobile radios, as well as several unique items designed specifically for servicing the radio. 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 3-2 Recommended Test Equipment.

MODEL No.	DESCRIPTION	CHARACTERISTICS	APPLICATION
R2000 Series	System Analyser	This monitor will substitute for items with an asterisk (*)	Frequency/deviation meter and signal generator for wide-range troubleshooting and alignment.
*R1150C	Code Synthesizer		Injection of audio and digital signalling codes
*S1053D *HM-203-7 *SKN6008A *SKN6001A	220 VAC Voltmeter 110 VAC Voltmeter Power Cable for Meter Test Leads for Meter	1mV to 300V, 10-Mohm Input impedance	Audio voltage measurements
*S1350C *ST1213B (VHF) *ST1223B (UHF)	Watt Meter Plug-in Element RF Dummy Load	50 ohm, ±5% accuracy 10 Watts, maximum 0-1000 MHz, 300W	Transmitter power o/p measurements
R1065A	Load Resistor	10-watt Broadband	For use with Wattmeter
S1339A	RF Millivolt Meter 10kHz to 1.2 GHz	100µV to 3V rf	RF level measurements
*R1013A	SINAD Meter		Receiver sensitivity measurements
S1347D or S1348D (programmable)	DC Power Supply	0-20Vdc, 0-5 Amps	Bench supply for 13.2Vdc current limited

* Any of the R2000 Series system analysers will substitute for items with an asterisk (*)

7.0 Radio Tuning Procedure

7.1 General

The recommended hardware platform is a 386 or 486 DX 33 PC (personal computer) with 8 Mbytes RAM, MS DOS 5.0, Windows 3.1, and DPS (Dealer Programming Software). These are required to align the radio. Refer to your DPS Installation Manual for installation and setup procedures for the required software; the user manual is accessed (and can be printed if required) via the DPS.

To perform the alignment procedures, the radio must be connected to the PC, RIB (Radio Interface Box), and Universal Test Set as shown in Figure 3-6.

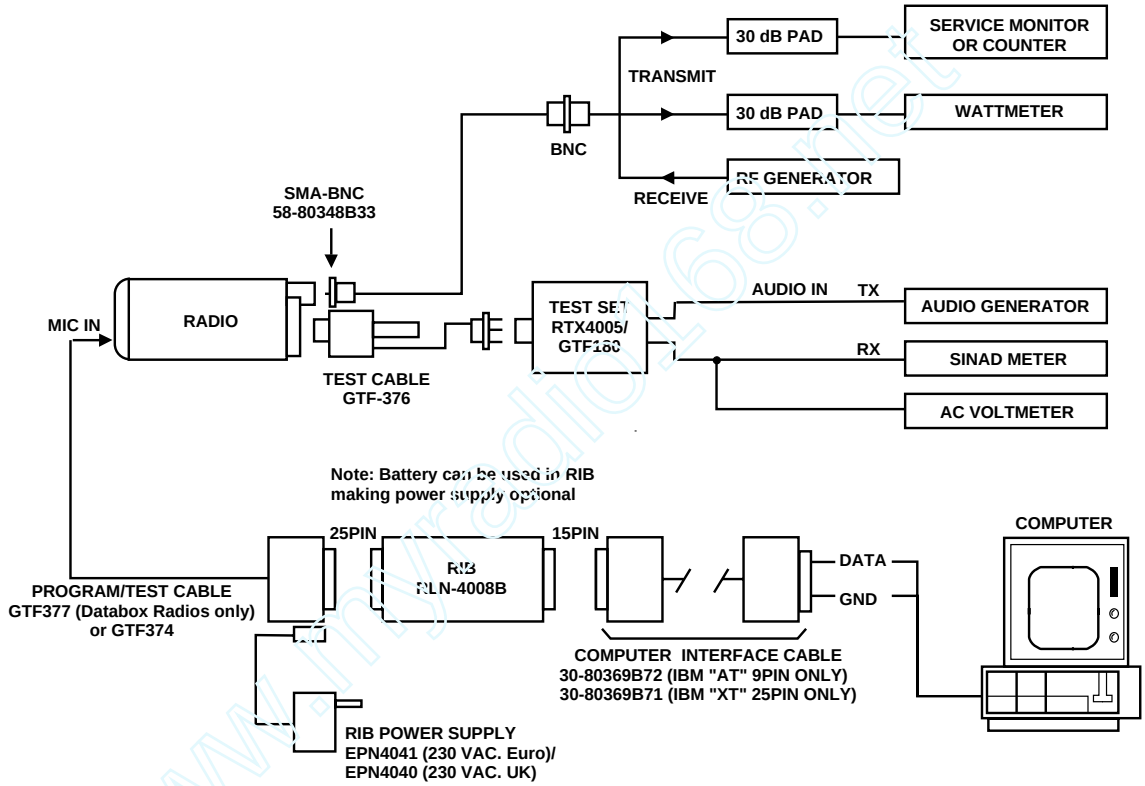


Figure 3-6 Radio Alignment Test Setup

All tuning procedures are performed from the Service menu.

Before going into the Service menu, the radio must first be read using the File / Read Radio menu (if the radio has just been programmed with data loaded from disk or from a newly created codeplug, then it must still be read so that the DPS will have the radio's actual tuning values).

All Service windows read and program the radio codeplug directly; you do NOT have to use the DPS Read Radio / Write Radio functions to program new tuning values.

CAUTION: **DO NOT** switch radios in the middle of any Service procedure. Always use the Program or Cancel key to close the tuning window before disconnecting the radio. Improper exits from the Service window may leave the radio in an improperly configured state and result in seriously degraded radio or system performance.

The Service windows introduce the concept of the “Softpot”, an analog SOFTware controlled POTentiometer used for adjusting all transceiver alignment controls. A softpot can be selected by clicking with the mouse at the value or the slider or by hitting the TAB key until the value or the slider is highlighted.

Each Service window provides the capability to increase or decrease the ‘softpot’ value with the mouse, the arrow keys or by entering a value with the keyboard. The window displays the minimum, maximum, and step value of the softpot. In addition transmitter tuning windows indicate whether the radio is keyed and the transmitter frequency.

Adjusting the softpot value sends information to the radio to increase (or decrease) a DC voltage in the corresponding circuit. For example, increasing the value in the Reference Oscillator tune window instructs the radio microprocessor to increases the voltage across a varactor in the reference oscillator to increase the frequency. Pressing the Program button stores all the softpot values of the current window permanently in the radio.

In ALL cases, the softpot value is just a relative number corresponding to a D/A (Digital-to-Analog) generated voltage in the radio. All standard measurement procedures and test equipment are similar to previous radios.

Refer to the DPS on-line help for information on the tuning software.

Perform the following procedures in the sequence indicated.

Note: All tuning procedures must be performed at a supply voltage of 13.2V unless otherwise stated.

7.2 PA Bias Voltage

Adjustment of the PA Bias is critical for proper radio operation. Improper adjustment will result in poor operation and may damage the PA FET device. For this reason, the PA bias must be set before the transmitter is keyed the first time.

Note: For certain radio models there are two bias voltage settings. For these radios both ‘ Bias 1 Voltage ’ and ‘ Bias 2 Voltage ‘ need to be adjusted when aligning the PA Bias. For models that only have one bias voltage setting, the ‘ Bias 2 Voltage ‘ will be shown in grey on the service menu.

1. From the Service menu, select Transmitter Alignment.
2. Select Bias Voltage Tuning to open the bias voltage tuning window. If the control voltage is out of range, an error message will be displayed. In this case the radio hardware has a problem and tuning must be stopped immediately.
3. Click the button labelled “0” to set the quiescent current temporarily to 0 mA
4. Measure the DC current of the radio. Note the measured value and add the specified quiescent current shown in table 3-3. The result is the tuning target.
5. Adjust the current per the target calculated in step 3.
6. Click the Program button to store the softpot value.

Table 3-3 Quiescent Current Alignment

RF-Band	Target
UHF VHF / 336-390MHz	440mA±10% 150mA±15%

7.3 Transmitter Power

The radio has two power level settings, a high power level setting, and a low power level setting. **IMPORTANT**: To set the transmitter power for customer applications use the Common Radio Parameters window under the Edit menu and set the “Low Power Level” and “High Power Level” powers to the desired values. Only if the transmitter components have been changed or the transmitter does not transmit with the power set in the Common Radio Parameters window the following procedure should be performed.

The advanced power setting technology employed in the radio makes use of two reference power level settings along with parameters describing the circuit behaviour. To determine these parameters the DPS requires the power values measured for two different settings.

1. From the Service menu, select Transmitter Alignment.
2. Select RF Power Tuning to open the RF power tuning window. The window will indicate the transmit test frequencies to be used.
3. Select Point 1 value of the first frequency.
4. Click Toggle PTT to key the radio. The status bar will indicate that the radio is transmitting.
5. Measure the transmitter power on your power meter.
6. Enter the measured value in the box Point 1.
7. Select Point 2 value of the first frequency.
8. Measure the transmitter power on your power meter.
9. Enter the measured value in the box Point 2.
10. Click Toggle PTT to dekey the radio.
11. Repeat steps 4 - 7 for all test frequencies shown in the window.
12. Click Program to store the softpot values.

7.4 Battery Threshold

The radio uses 2 battery threshold levels Tx High and Tx Low to determine the battery condition.

The Program buttons must only be activated when the power supply is set to the indicated voltage. If the DPS detects that the voltage is not within the expected range for the threshold in question then a message will be displayed to warn that the radio may not be set up correctly for the alignment operation.

CAUTION: Inadvertant use of the program buttons may result in radio failure.

1. From the Service menu, select Transmitter Alignment.
2. Select Battery Threshold to open the battery threshold tuning window. The current softpot values are displayed for information only and can´t be edited.
3. Set the supply voltage to the value indicated for TX High.
4. Click the TX High Program button to store the softpot value for TX High.
5. Set the supply voltage to the value indicated for TX Low.
6. Click the TX Low Program button to store the softpot value for TX Low.
7. Close the window by clicking Cancel.

7.5 Reference Oscillator

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. From the Service menu, select Transmitter Alignment.
2. Select Reference Oscillator to open the reference oscillator tuning window. The tuning window will indicate the target transmit frequency.
3. Click Toggle PTT to key the radio. The status bar will indicate that the radio is transmitting.
4. Measure the transmit frequency on your frequency counter.
5. Adjust the reference oscillator softpot in the tuning window to achieve a transmit frequency within the limits shown in table 3-4.
6. Click Toggle PTT again to dekey the radio and then press Program to store the softpot value.

Table 3-4 Reference Oscillator Alignment

RF-Band	Target
All bands	±150 Hz

7.6 Front-End Pre-Selector

Alignment of the front-end pre-selector is normally not required on these radios. Only if the radio has poor receiver sensitivity or the pre-selector parts has been replaced the following procedure should be performed. The softpot value sets the control voltage of the pre-selector. Its value needs to be set at 7 frequencies across the frequency range.

1. Set the test box (GTF180) meter selection switch to the "Audio PA" position and connect a SINAD meter to the "METER" port.
2. From the Service menu, select Receiver Alignment.
3. Select Front End Filter to open the pre-selector tuning window. The window will indicate the receive test frequencies to be used.
4. Select the first test frequency shown, and set the corresponding value to maximum.
5. Set the RF test generator to the receive test frequency, and set the RF level to 10µV modulated with a 1 kHz tone at the normal test deviation shown in table 3-5.
6. Measure the RSSI voltage at accessory connector pin 15 with a dc voltmeter capable of 1 mV resolution.
7. Change the softpot value by the stepsize shown in table 3-6 and note the RSSI voltage.The target softpot value is achieved when the measured RSSI voltage change between step 6 and step 7 is lower than the tuning target for the first time. The tuning target, shown in table 3-6, is expressed as the percentage of the measured RSSI voltage and must be recalculated for every tuning step. If the measured RSSI voltage decreases before the target value has been achieved, approximation should be stopped and the current softpot value should be used as target value. Set test box (GTF180B) audio switch to the “SPKR” position. The 1 kHz tone must be audible at the target value to make sure the radio is receiving.
8. Repeat steps 4 - 7 for all test frequencies shown in the window.
9. Click the Program button to store the softpot values.

Table 3-5 Normal Test Deviation.

Channel Spacing	Deviation
12.5 kHz 20 kHz 25 kHz	1.5 kHz 2.4 kHz 3 kHz

Table 3-6 Start Value for Front-End Pre-selector Tuning.

RF-Band	Target	Stepsize	Start Value
UHF VHF 336-390MHz	0.5% 0.42% 0.84	-2 +2 -2	Maximum Minimum Maximum

7.7 Rated Volume

The rated volume softpot sets the volume at normal test modulation.

1. Set test box (GTF180) meter selection switch to the “AUDIO PA” position and the speaker load switch to the "MAXAR" position. Connect an AC voltmeter to the test box meter port.
2. From the Service menu, select Receiver Alignment.
3. Select Rated Volume to open the rated volume tuning window. The screen will indicate the receive test frequency to be used.
4. Set the RF test generator to the receive test frequency, and set the RF level to 1mVolt modulated with a 1 kHz tone at the normal test deviation shown in table 3-5. Set test box (GTF180) audio switch to the “SPKR” position. The 1 kHz tone must be audible to make sure the radio is receiving.
5. Adjust the value of the softpot to obtain rated audio volume (as close to 3.87 Vrms).
6. Click the Program button to store the softpot value.

7.8 Squelch

The squelch softpots set the signal to noise ratio at which the squelch opens. The squelch value needs to be set at 7 frequencies across the frequency range.

1. Set the test box (GTF180) meter selection switch to the "Audio PA" position and connect a SINAD meter to the "METER" port.
2. From the Service menu, select Receiver Alignment.
3. Select Squelch Attenuation to open the squelch attenuation tuning window. The window will indicate the receive test frequencies to be used.
4. Select the first test frequency shown, and set the corresponding value to 0.
5. Set the RF test generator to the test frequency and modulate the signal generator at the normal test deviation shown in table 3-5, with 1 kHz tone. Adjust the generator for a 8-10 dB SINAD level (weighted with psophometric filter).
6. Adjust the softpot value until the squelch just closes.
7. Monitor for squelch chatter; if chatter is present, repeat step 6.

8. When no chatter is detected, select the next softpot and repeat steps 4 - 7 for all test frequencies shown in the window.
9. Click the Program button to store the softpot values.

7.9 Transmit Voltage Limit

The transmit control voltage limit softpot sets the maximum power control voltage. All 7 voltage limit softpots are tuned and programmed automatically when the Program button is clicked.

1. From the Service menu, select Transmitter Alignment.
2. Select Voltage Limit to open the voltage limit tuning window.
3. Set the Power Factor to 1.3.
4. Click the Program button to store the softpot values.

7.10 Transmit Deviation Balance (Compensation)

Compensation alignment balances the modulation sensitivity of the VCO and reference modulation (synthesiser low frequency port) lines. Compensation algorithm is critical to the operation of signalling schemes that have very low frequency components (e.g. DPL) and could result in distorted waveforms if improperly adjusted. The compensation value needs to be set at 7 frequencies across the frequency range.

1. From the Service menu, select Transmitter Alignment.
2. Select Modulation Attenuation to open the deviation balance tuning window. The window will indicate the transmit test frequencies to be used.
3. Set the Test Box (GTF180) meter selector switch to the “GEN” position, and inject a 80 Hz tone at 200 mVrms into the "Audio In" port. (The deviation measured at step 6 should be about 1-4kHz.) Connect an AC meter to the meter port to insure the proper input signal level.
4. Select the first test frequency shown in the window.
5. Click Toggle PTT to key the radio. The status bar will indicate that the radio is transmitting.
6. Measure the transmitter deviation.
7. Change the input tone to 3 kHz, 200 mVrms.
8. Adjust the deviation to within ±2% of the value recorded in step 6.
9. Check the deviation at 80 Hz again and repeat step 7-8, if it has changed since step 6.
10. Click the Toggle PTT to dekey the radio.
11. Repeat steps 3 - 10 for the remaining test frequencies.
12. Click the Program button to store the softpot values.

Note: The step size change for step 8 is approximately 2.5% softpot value.

7.11 Transmit Deviation Limit

The transmit deviation limit softpot sets the maximum deviation of the carrier. The deviation value needs to be set at 7 frequencies across the frequency range.

1. From the Service menu, select Transmitter Alignment.
2. Select Reference Attenuation to open the reference attenuation tuning window.
3. Set the maximum value and press Program to store the softpot value.
4. From the Service menu, select Transmitter Alignment.
5. Select VCO Attenuation to open the deviation limit tuning window. The window will indicate the transmit test frequencies to be used.
6. Set the Test Box (GTF180) meter selector switch to the “GEN” position, and inject a 1 kHz tone at 800 mVrms into the "Audio In" port. Connect an AC meter to the meter port to ensure the proper input signal level.
7. Select the first test frequency shown in the window.
8. Click the Toggle PTT to key the radio. The status bar will indicate that the radio is transmitting.
9. Adjust the transmitter deviation to the value shown in table 3-6.
10. Click the Toggle PTT to dekey the radio.
11. Repeat steps 8 - 10 for the remaining test frequencies.
12. Click the Program button to store the softpot values.

Table 3-7 Transmitter Deviation

Channel Spacing	Deviation
12.5 kHz	2.2-2.3 kHz
20 kHz	3.4-3.6 kHz
25 kHz	4.3-4.6 kHz

7.12 Signalling Alignments

7.12.1 MPT RSSI Threshold Level

The Program buttons must only be activated when the required signal is input to the radio and the radio is receiving. If the DPS detects that the input signal is not within the expected range for the RSSI level in question then a message will be displayed to warn that the radio may not be set up correctly for the alignment operation.

INADVERTANT USE OF THE PROGRAM BUTTONS MAY RESULT IN RADIO FAILURE.

1. Set test box (GTF180) meter selection switch to the “AUDIO PA” position and the speaker load switch to the "MAXAR" position.
2. From the Service menu, select Receiver Alignment.
3. Select RSSI to open the RSSI tuning window. The screen will indicate the receive test frequency to be used.

4. Set the RF test generator to the receive test frequency, and set the RF level to the value indicated for RSSI Level 0, modulated with a 1 kHz tone at the normal test deviation shown in table 3-5. Set test box (GTF180) audio switch to the “SPKR” position. The 1 kHz tone must be audible to make sure the radio is receiving.
5. Click the Program button to store the softpot value for RSSI Level 0.
6. Repeat steps 4 - 5 for the remaining RSSI levels.
7. Click the Cancel button to close the window.

7.12.2 MPT1327 Transmit Deviation / DTMF Transmit Deviation

The MPT1327 Deviation Softpot is used to tune the FFSK signalling deviation. Tuning is performed at one frequency. The radio generates an alternating bit pattern for tuning. Values for other frequencies are calculated by the radio software.

The DTMF Deviation Softpot is used to tune the DTMF signalling deviation. Tuning is performed at one frequency. The radio generates a DTMF signal for tuning. Values for other frequencies are calculated by the radio software.

1. From the Service menu, select Transmitter Alignment.
2. Select Signalling Deviation to open the signalling deviation tuning window.
3. Select the MPT value and press Toggle PTT to key the radio. The status bar will indicate that the radio is transmitting.
4. Adjust the transmitter deviation to the value shown in table 3-8.
5. Click the Toggle PTT to dekey the radio.
6. Repeat steps 3 - 5 for DTMF deviation.
7. Click the Program button to store the softpot value.

Table 3-8 Signalling Deviation

Channel Spacing	MPT 1327	Deviation
12.5 kHz	1.4-1.6 kHz	1.5-1.8 kHz
20 kHz	2.2-2.6 kHz	2.4-2.8 kHz
25 kHz	2.8-3.2 kHz	3.0-3.4 kHz

Chapter 4

Theory of Operation

Table of Contents

300MHz SPECIFIC CIRCUIT DESCRIPTION

1.0 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 either mounted directly on the front of the radio or connected via an extension cable in remote mount operation. The control head contains a speaker, LED indicators, a microphone connector, buttons and dependent of radio type, a display. These provide the user with interface control over the various features of the radio.

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.

2.0 Open Controller

2.1 General

The radio controller consists of 4 main subsections:

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

The digital control section of the radio board is based upon an open architecture controller configuration. It consists of a microprocessor, support memory, support logic, signal MUX ICs, the On/Off circuit, and general purpose Input/Output circuitry.

The controller uses the Motorola 68HC11K1 microprocessor (U0101). In addition to the microprocessor, the controller has 3 external memory devices. The 3 memory devices consist of a 32 kByte SRAM (U0103), a 256kByte FLASH EEPROM (U0102), and an optional EEPROM (U0104 or U0107) upto 16kByte.

Note: From this point on the 68HC11K1 microprocessor will be referred to as µP or K1µP.

2.2 Voltage Regulators

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

Voltage regulation providing 5V for the digital circuitry is done by U0631. Input and output capacitors (C0631/C0632 and C0633-C0635) are used to reduce high frequency noise and provide proper operation during battery transients. This regulator provides a reset output (pin 5) that goes to 0 volts if the regulator output goes out of regulation. This is used to reset the controller 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 volts required by some audio circuits, the RF circuitry and power control circuitry. Input and output capacitors (C0601-C0603 and C0604/C0605) are used to reduce high frequency noise. R0602/R0603 set the output voltage of the regulator. If the voltage at pin 1 is greater than 1.3 volts the regulator output decreases and if the voltage is less than 1.3 volts the regulator output increases. This regulator output is electronically enabled by a 0 volt signal on pin 2. Q0601 and associated circuitry (R0601/R0604/R0605) are used to disable the regulator when the radio is turned off.

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

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

The voltage 9V3 SUPP is only used in the VHF radio (T1) to supply the drain current for the RF MOS FET in the PA.

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

Diode D5601 (UHF) / D3601 (VHF) / D8601 (336-390MHz) located on the PA section acts as protection against transients and wrong polarity of the supply voltage.

2.3 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. For example, 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 when the collector of Q0612 is low. When the radio is off Q0612 is cutoff and the voltage at Q0611-base is at A+. This effectively prevents current flow through Q0611 from emitter to collector. When the radio is turned on the voltage at the base of Q0612 is high (about 0.6V) and Q0612 switches on (saturation) and pulls down the voltage at Q0611-base. With Transistor Q0611 now enabled current flows through the device. This path has a very low impedance (less than 1Ω) from emitter to collector. This effectively provides the same voltage level at SWB+ as at A+.

The electronic on/off circuitry can be enabled by the microprocessor (through ASFIC port GCB2, 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 any of the 4 paths cause a low at the collector of Q0612, the electronic ON is engaged.

2.4 Emergency

The emergency switch (J0400-9), when engaged, grounds the base of Q0441 and pulls the line EMERGENCY CONTROL to low via D0441. 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 go low (0.2V), thereby setting the EMER IGN SENSE line to low.

While EMERGENCY CONTROL is low, SW B+ is on, the microprocessor starts execution, reads that the emergency input is active through the voltage level of EMER IGN SENSE, and sets the B+ CONTROL output of the ASFIC pin B4 to a logic high. This high will keep Q0611 switched on through Q0612. This operation allows a momentary press of the emergency switch to power up the radio. When the microprocessor has finished processing the emergency press, it sets the B+ CONTROL line to a logic 0. This turns 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 already be high.

2.5 Mechanical On/Off

This refers to the typical on/off button, located on the control head or mic, and which turns the radio on and off. If the radio is turned off and the on/off button is pressed, line ON OFF CONTROL goes high and switches the radio on as long as the button is pressed. The microprocessor is alerted through line ANALOG 3 which is pulled to low by Q0925 (Control Head with display) while the on/off button is pressed. If the software detects a low state it asserts B+ CONTROL via ASFIC pin B4 high which keeps Q0612 and Q0611, and in turn the radio switched on.

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

2.6 Ignition

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

When the IGNITION input (J0400-10) goes above 6 volts Q0612 is turned on via line IGNITION CONTROL. Q0612 turns on SW B+ by turning on Q0611 and the microprocessor starts execution. A high IGNITION input reduces the voltage of line EMER IGN SENSE by turning on Q0450. 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 output of the ASFIC pin B4 to high to latch on SW B+.

When the IGNITION input goes below 6 volts, Q0450 switches off and R0449, R0450 pull line EMER IGN SENSE high. The software is alerted by line EMER IGN SENSE to switch off the radio by setting B+ CONTROL to low. The next time the IGNITION input goes above 6 volts the above process will be repeated.

2.7 Hook RSS

The HOOK RSS input is used to inform the µP when the Microphone's hang-up switch is engaged. Dependent on the radio model the µP may take actions like turning the audio PA on or off.
The signal is routed from J0101-3 and J0400-14 through transistor Q0101 to the µP U0101-23. The voltage range of HOOK RSS in normal operating mode is 0-5V.

To start SBEP communication with the radio this voltage must be above 6V. This condition generates a µP interrupt via VR0102, Q0105, Q0104, Q0106 and enables the BUS+ line for communication via Q0122, Q0121.

2.8 Microprocessor Clock Synthesizer

The clock source for the microprocessor system is generated by the ASFIC (U0201). Upon power-up the synthesizer U5701 (UHF) / U3701 (VHF) / U8701 (300MHz-R1) generates a 2.1 MHz waveform that is routed from the RF section (via C0202) to the ASFIC (on U0201-E1) For the main board controller the ASFIC uses 2.1MHz 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 1200Hz to 32.769MHz in 1200 Hz steps.

When power is first applied, the ASFIC will generate its default 3.6864 MHz CMOS square wave µP CLK (on U0201-D1) and this is routed to the microprocessor (U0101-73). After the microprocessor starts operation, it reprograms the ASFIC clock synthesizer to a higher µP CLK frequency (usually 7.9488 MHz) and continues operation.

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

The ASFIC synthesizer loop uses C0228, C0229 and R0222 to set the switching time and jitter of the clock output. If the synthesizer cannot generate the required clock frequency it will switch back to its default 3.6864MHz output.

Because the ASFIC synthesizer and the µP system will not operate without the 2.1MHz reference clock, it (and the voltage regulators) should be checked first when debugging the system.

2.9 Serial Peripheral Interface (SPI)

The µP communicates to many of the ICs through its SPI port. This port consists of SPI TRANSMIT DATA (MOSI) (U0101-1), SPI RECEIVE DATA (MISO) (U0101-80), SPI CLK (U0101-2) and chip select lines going to the various ICs connected on the SPI PORT (BUS). This BUS is a synchronous bus, in that the timing clock signal CLK is sent while SPI data (SPI TRANSMIT DATA or SPI RECEIVE DATA) is sent. Therefore, whenever there is activity on either SPI TRANSMIT DATA or SPI RECEIVE DATA there should be a uniform signal on CLK. The SPI TRANSMIT DATA is used to send serial from a µP to a device, and SPI RECEIVE DATA is used to send data from a device to a µP. The only device from which data can be received via SPI RECEIVE DATA is the EEPROM (U0104 or U0107).

On the controller there are three ICs on the SPI BUS, ASFIC (U0201-F2), EEPROM (U0104-1 or U0107-1) and D/A (U0731-6). In the RF sections there is one IC on the SPI BUS which is the FRAC-N Synthesizer. The SPI TRANSMIT DATA and CLK lines going to the RF section are filtered by L0131/L0132 to minimize noise. The chip select lines for the IC´s are decoded by the address decoder U0105.

The SPI BUS is also used for the control head. U0106-2,3 buffer the SPI TRANSMIT DATA and CLK lines to the control head. U0106-1 switch off the CLK signal for the LCD display if it is not selected via LCD CE and Q0141.

When the µP needs to program any of these IC's it brings the chip select line for that IC to a logic 0 and then sends the proper data and clock signals. The amount of data sent to the various IC's are different, for example the FRAC-N can receive up to 13 bytes (97 bits) while the DAC can receive up to 3 bytes (24 bits). After the data has been sent the chip select line is returned to a logic 1.

2.10 SPEB Serial Interface

The SBEP serial interface allows the radio to communicate with the Dealer Programming Software (DPS) via the Radio Interface Box (RIB). This interface connects to the accessory connector J0400-6 and comprises BUS+ (J0101-15). The line is bi-directional, meaning that either the radio or the DPS can drive the line.

When the RIB (Radio Interface Box) is connected to the radio, a voltage on the HOOK RSS line above 6 volts switches on Q0105. The low state at collector of Q0105 switches Q0104 off and in turn, Q0106 on. A high to low transition at the collector of Q0106 generates an interrupt via µP pin 61. The µP determines the interrupt source by reading a high at the collector of Q0104 via µP pin 6 and R0125. The switched on Q0105 also switches off Q0122 enabling the µP to read BUS+ via pin 78 and to write BUS+ via pin 79 and transistors Q0123,Q0121. While the radio is sending serial data at pin 79 via Q0123 and Q0121 it receives an “echo” of the same data at pin 78.

When the voltage on the HOOK RSS line is below 6 volts (RIB is not connected), the high collector of Q0105 turns on Q0122. The low collector of Q0122 prevents the µP from writing data to BUS+ via Q0123. In this mode line BUS+ is used for signal SCI RX of the Serial Communication Interface (SCI). The µP reads the SCI via signal SCI RX (pin 78) and writes via signal SCI TX (pin 79). Both signals are available on the accessory connector J0400 (SCI DATA OUT, SCI DATA IN).

2.11 General Purpose Input/Output

The Controller provides one general purpose line (GP I/O) available on the accessory connector J0400-12 to interface to external options. The software and the hardware configuration of the radio model defines the function of the port. The port uses an output transistor (Q0432) controlled by µP via ASFIC port GCB3 (pin B3).

An external alarm output, available on J0400 pin 4 is generated by the µP via ASFIC port GCB1 (pin K3) and transistor Q0411. Input EXTERNAL PTT on J0400 pin 3 is read by the µP via line REAR PTT and µP pin 8.

2.12 Normal Microprocessor Operation

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

In expanded mode on this radio, the µP (U0101) has access to three external memory devices; U0102 (FLASH EEPROM), U0103 (SRAM), U0104 or U0107 (optional EEPROM). Also, within the µP there are 768 bytes of internal RAM and 640 bytes of internal EEPROM, as well as logic to select external memory devices.

The (optional) external EEPROM (U0104 or U0107) as well as the µP’s own internal EEPROM space contain the information in the radio which is customer specific, referred to as the codeplug. This information consists of items such as: 1) what band the radio operates in, 2) what frequencies are assigned to what channel, and 3) tuning information. In general tuning information and other more frequently accessed items are stored in the internal EEPROM (space within the 68HC11K1), while the remaining data is stored in the external EEPROM. (See the particular device subsection for more details.)

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

The FLASH EEPROM contains the actual Radio Operating Software. This software is common to all open architecture radios within a given model type. For example Securenet radios may have a different version of software in the FLASH EEPROM than a non-secure radio (See the particular device subsection for more details).

The K1µP provides an address bus of 16 address lines (A0-A15), and a data bus of 8 data lines (D0-D7). There are also three control lines; CSPROG (U0101-29) to chip select U0102-30 (FLASH EEPROM), CSGP2 (U0101-28) to chip select U0103-20 (SRAM) and PG7_R_W to select whether to read or to write. All other chips (ASFIC/PENDULLUM/DAC/FRACN/LCD/LED/optional EEPROM/OPTION BOARD) are selected by 3 lines of the µP using address decoder U0105. When the µP is functioning normally, the address and data lines should be toggling at CMOS logic levels. Specifically, the logic high levels should be between 4.8 and 5.0 V, and the logic low levels should be between 0 and 0.2 V. No other intermediate levels should be observed, and the rise and fall times should be <30 ns.

The low-order address lines (A0-A7) and the data lines (D0-D7) should be toggling at a high rate, i.e., you should set your oscilloscope sweep to 1 us/div. or faster to observe individual pulses. High speed CMOS transitions should also be observed on the µP control lines.

On the µP the lines XIRQ (U0101-30), MODA LIR (U0101-77), MODB VSTPY (U0101-76) and RESET (U0101-75) should be high at all times during normal operation. Whenever a data or address line becomes open or shorted to an adjacent line, a common symptom is that the RESET line goes low periodically, with the period being in the order of 20 msecs. In the case of shorted lines you may also detect the line periodically at an intermediate level, i.e. around 2.5 V when 2 shorted lines attempt to drive to opposite rails.

The MODA LIR (U0101-77) and MODB VSTPY (U0101-76) inputs to the µP must be at a logic 1 for it to start executing correctly. After the µP starts execution it will periodically pulse these lines to determine the desired operating mode. While the Central Processing Unit (CPU) is running, MODA LIR is an open-drain CMOS output which goes low whenever the µP begins a new instruction (an instruction typically requires 2-4 external bus cycles, or memory fetches).

However, since it is an open-drain output, the waveform rise assumes an exponential shape similar to an RC circuit.

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

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 ~140 to 217 respectively.

U0101-51 is the high reference voltage for the A/D ports on the µP. 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, C0113, C0114 serve to filter out any AC noise which may ride on +5V at U0101.

Input IRQ (U101-61) generates an interrupt, if either HOOK RSS (J0101-3) is higher than 6V (SBEP communication) and turns Q0106 on via Q0105, Q0104, or a low at the option interrupt pin (J0103-8) turns Q0124 off and Q0125 on. The µP determines the interrupt source by reading the collector of Q0104 via U0101-6 and the collector Q0124 via U0101-7.

2.13 FLASH Electronically Erasable Programmable Memory (FLASH EEPROM)

The 256 KByte FLASH EEPROM (U0102) contains the radio operating software. This software is common to all open architecture radios within a given model type. This is, as opposed to the codeplug information stored in EEPROM (U0104) which could be different from one user to another in the same company.

In normal operating mode, this memory is only read, not written to. The memory access signals (CE, OE and WE) are generated by the µP.

To upgrade/reprogram the FLASH software, the µP must be set in bootstrap operating mode, and the FLASH device pin (U0102-9) V_{pp} must be between 11.4 and 12.6 V. Taking diode D0102 into account, the voltage at J400-12 to enable FLASH programming may range between 12.1 and 13.1V. This voltage also switches Q0102 on and in turn Q0103 off. The low state at collector of Q0102 pulls MODA LIR (U0101-77) and MODB VSTBY (U0101-76) via diode D0101 to low which enables the bootstrap operating mode after power up. The high state at collector of Q0103 enables the µP to control the FLASH EN OE (U0102-32) input via U0106-4. Chip select (U103-30) and read or write operation (U103-7) are controlled by µP pins 29 and 33. In normal operating mode V_{PP} is below 5V which switches Q0102 off and Q0103 on.

Resistor divider pair R0132 and R0133 set up 4.1 V on U0102-9 which reduces the chance of logic transitions. The FLASH device may be reprogrammed 1,000 times without issue. It is not recommended to reprogram the FLASH device at a temperature below 0°C.

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

2.14 Electrically Erasable Programmable Memory (EEPROM)

The optional EEPROM (U0104 or U0107) contains additional radio 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 can have up to 8Kbyte and U0107 up to 16 Kbyte. 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 µP and chip select (CS) is generated by address decoder U0105-4.

Additional EEPROM is contained in the µP (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.

2.15 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.

2.16 Blank Control Head

The blank control head provides the connector to the hand held control mic or head.

2.16.1 Power Supplies

The power supply to the Control Head is taken from the host radio's FLT A+ voltage via connector J0801(K2) / J0901(K3) pin 2 and the regulated +5V via connector J0801(K2) / J0901(K3) pin 10. The voltage FLT A+ is at battery level and is used for the LEDs, the back light and to power up the radio via the On / Off button. The stabilized +5 volt is used for the (display, the display driver,-K3 only) the shiftregister and the keypad buttons.

2.16.2 Power On / Off

The On/Off button when pressed switches the radio's voltage regulators on by pulling ON OFF CONTROL to high via D0825(K2) / D0925(K3) and connects the base of D0825(K2) / D0925(K3) 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. If the On/Off button is pressed and held while the radio is on, the software detects a low state on line ANALOG 3 and switches the radio off.

2.16.3 Electrostatic Transient Protection

Electrostatic transient protection is provided for the sensitive components in the Control Head by diodes VR0801 - VR0809(K2) / VR0901 - VR0909(K3). The diodes limit any transient voltages to tolerable levels. The associated capacitors provide Radio Frequency Interference (RFI) protection.

2.16.4 Reversible Control Head

The control head is connected to the RF transceiver by means of a short flexible ribbon cable. This allows the control head to be mounted either way up in relation to the body of the transceiver. This means that the transceiver can be mounted in the most cosmetically pleasing and most efficient cooling orientation and still have the user interface the "right way" up.

CONTROLLER BOARD AUDIO AND SIGNALLING CIRCUITS

3.0 General

3.1 Audio Signalling Filter IC (ASFIC)

The ASFIC (U0201) used in the controller has 4 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 J0102-3. The supply voltage for the ASFIC has additional filtering provided by Q0200, D0200, R0200, L0200 and C0200. Diode D0200 increases the voltage at the base of Q0200 about 0.6 volts above the 5 volt supply voltage to compensate the base - emitter voltage drop of Q0200.

3.2 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). U0251-1 form 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 U0251-1. C0253 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 that while there are ASFIC VAG, and BOARD VAG (U0201-1) each of these are separate. They do not connect together.

4.0 Transmit Audio Circuits

Refer to Figure 4.1 for reference for the following sections.

4.1 Mic Input Path

The radio supports two distinct microphone paths known as internal (from Control Head) and external mic (from accessory connector J0400-2) 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 inputs are connected together through R0413; resistors R0414 and R0415 are not placed. 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.

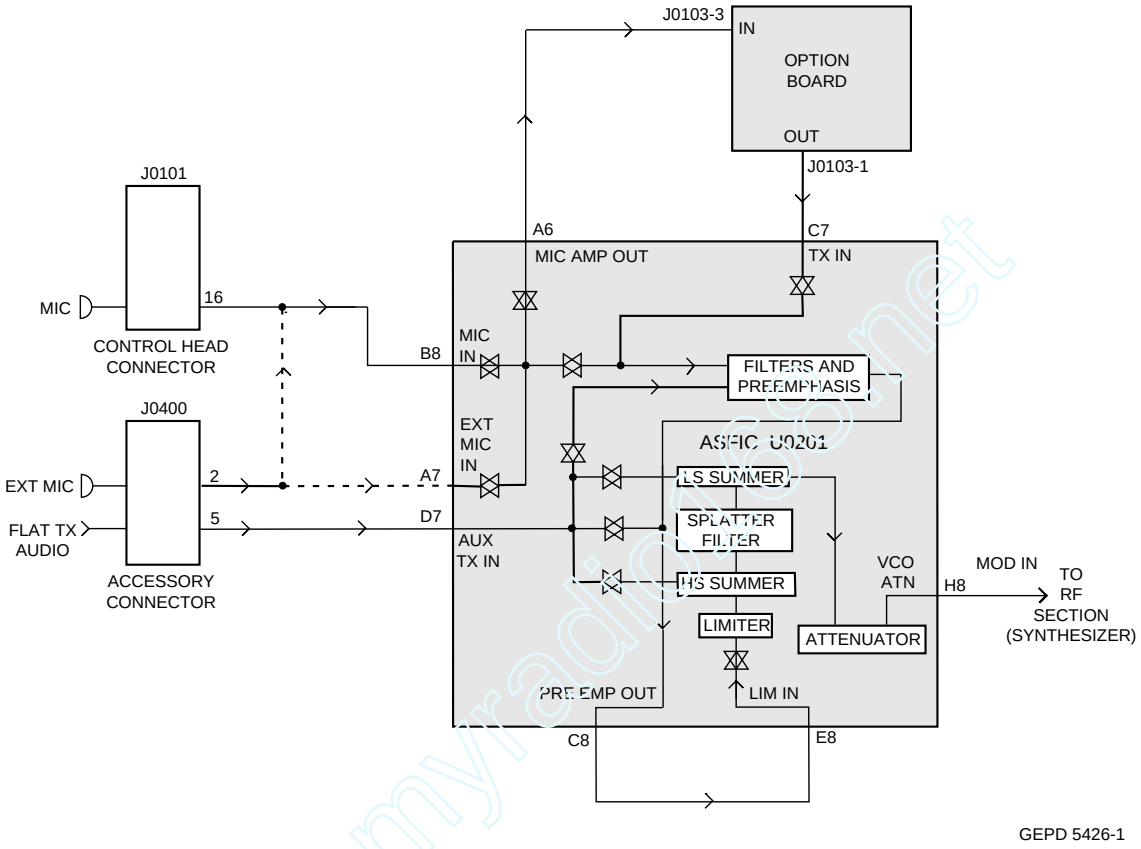


Figure 4.1 Transmit Audio Paths

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 1.5kHz or 3kHz of deviation with 12.5kHz or 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.

4.2 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. Components R0414 - R0416, C0413, C0414, C0417 are not used.

4.3 PTT Sensing and TX Audio Processing

Mic PTT coming from the Control Head via connector J101-4 is sensed by the µP U0101 pin 22. An external PTT can be generated by grounding pin 3 on the accessory connector. When microphone PTT or external PTT is sensed, the µP will always configure the ASFIC for the internal mic audio path.

Inside the ASFIC, the MIC audio is filtered to eliminate frequency 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, at which point it is routed to the RF section.

5.0 Transmit Signalling Circuits

Refer to Figure 4.2 for reference for the following sections. From a hardware point of view, there are three types of signalling:

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

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

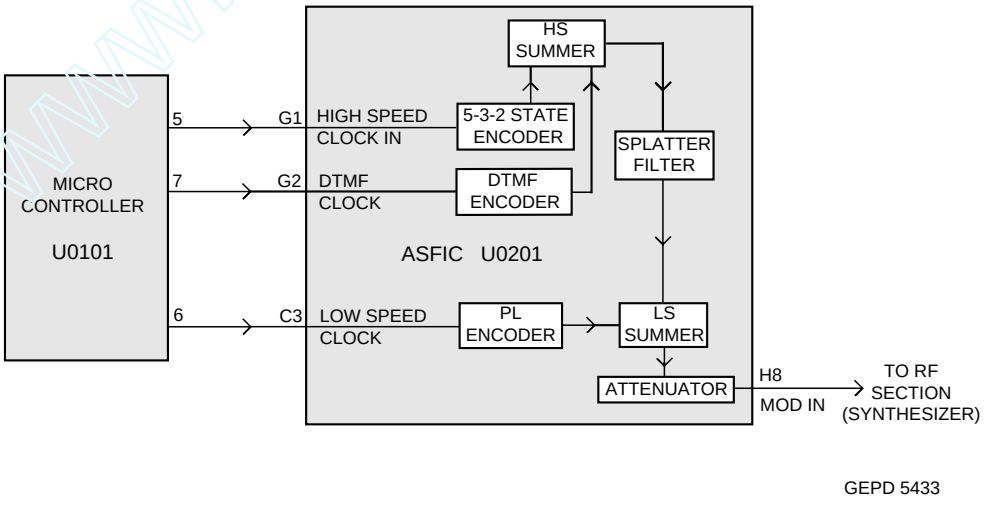


Figure 4.2 Transmit Signalling Paths

5.1 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 103Hz, the frequency of the square wave would be 1236Hz.

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.

5.2 High Speed Data

High speed data refers to the 3600 baud data waveforms, known as Inbound Signalling Words (ISWs) used in a trunking system for high speed communication between the central controller and the radio. To generate an ISW, the µP first programs the ASFIC (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.

5.3 Dual Tone Multiple Frequency (DTMF) Data

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

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

The high-group tone is generated by the µP (U0101-5) 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.

6.0 Receive Audio Circuits

Refer to Figure 4.3 for reference for the following sections.

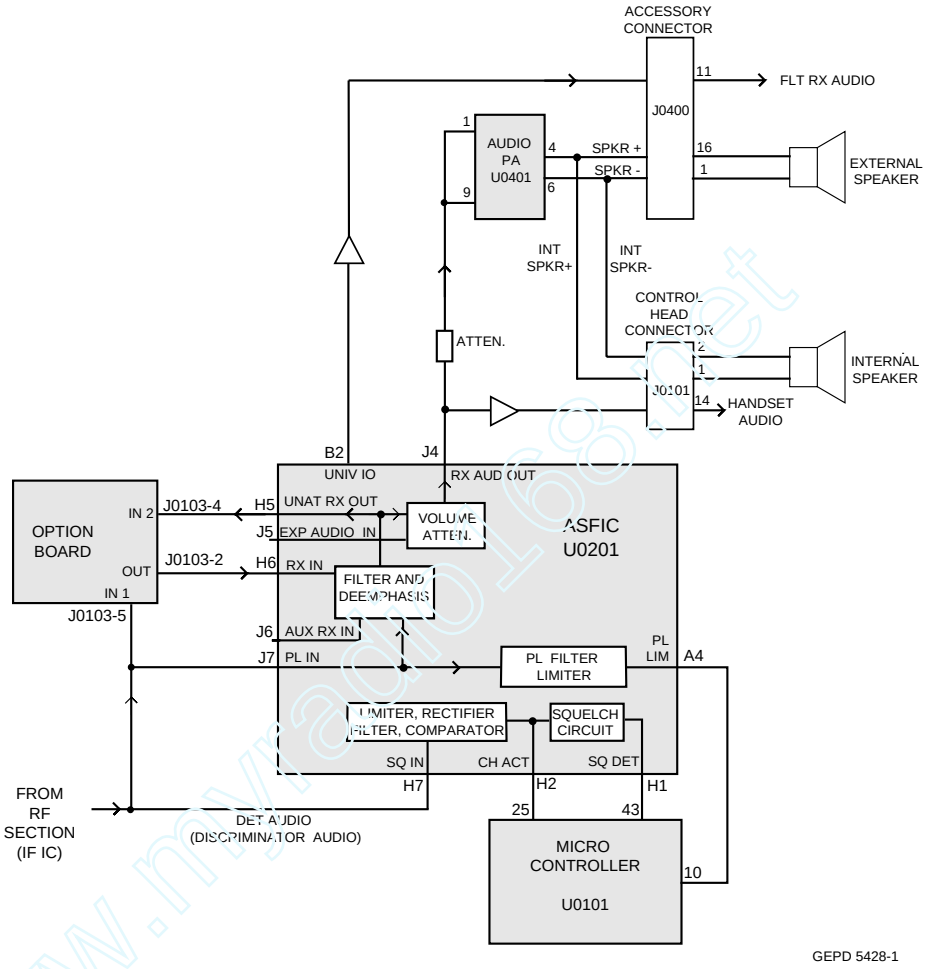


Figure 4.3 Receive Audio Paths.

6.1 Squelch Detect

The radio's RF circuits are constantly producing an output at the discriminator U5201-28 (UHF) / U5201-28 (VHF) / U8201-28 (300MHz-R1). 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 inputs 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.

6.2 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 2 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.

6.3 Audio Amplification Speaker (+) Speaker (-)

The output of the ASFIC's digital volume pot, 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 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 voltage at 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 a DC offset of 5V, and FLT A+ of 17V yields a DC offset of 8.5V. If either of these lines is shorted to ground, it is possible that the audio PA 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).

6.4 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 determine the gain of op-amp U0202-2. The output of U0202-2 is the routed to J0400-11.Note that any volume adjustment of the signal on this path must be done by the accessory.

7.0 Receive Signalling Circuits

Refer to Figure 4.4 for reference for the following sections.

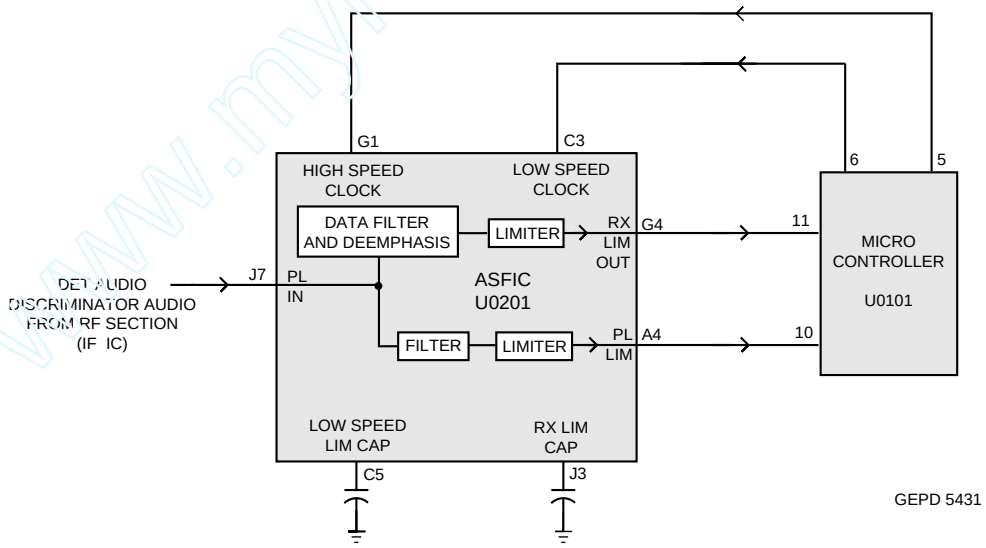


Figure 4.4 Receive Signalling Path.

7.1 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 that during HS data the µP may generate a sampling waveform seen at U0201-G1.

7.2 Alert Tone Circuits

When the software determines that it needs to give the operator an audible feedback (for a good key press, or for a bad key press), or radio status (trunked system busy, phone call, circuit failures), it sends an alert tone to the speaker.

It does so by sending SPI BUS data to 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.

300MHz SPECIFIC CIRCUIT DESCRIPTION

8.0 Receiver Front-End

The receiver is able to cover the range from 336 to 390 MHz. It consists of four major blocks: front-end, mixer, first IF section and IF IC. Antenna signal pre-selection is performed by two varactor tuned bandpass filters. A double balanced schottky diode mixer converts the signal to the first IF at 45.1 MHz.

Two crystal filters in the first IF section and two ceramic filters in the second IF section provide the required selectivity. The second IF at 455 kHz is mixed, amplified and demodulated in the IF IC. The processing of the demodulated audio signal is performed by an audio processing IC located in the controller section.

8.1 Front-End Band-Pass Filter & Pre-Amplifier

A two pole pre-selector filter tuned by the varactor diodes D8301 and D8302 pre-selects the incoming signal (PA RX) from the antenna switch to reduce spurious effects to following stages. The tuning voltage (FE CNTL VLTG) ranging from 2 volts to 8 volts is controlled by a Digital to Analog (D/A) converter (U0731-11) in the controller section. A dual hot carrier diode (D8303) limits any inband signal to 0 dBm to prevent damage to the pre-amplifier.

The RF pre-amplifier is an SMD device (Q8301) with collector base feedback to stabilize gain, impedance, and intermodulation. The collector current of approximately 11-16 mA is drawn from the voltage 9V3 via L8302 and R8302.

A second two pole varactor tuned bandpass filter provides additional filtering to the amplified signal. The varactor diodes D8304 and D8305 are controlled by the same signal which controls the pre-selector filter. A following 1 dB pad (R8310, R8314, R8316) stabilizes the output impedance and intermodulation performance. If the radio is configured for a base station application, R8319 is not placed, and TP8301 and TP8302 are shorted.

8.2 Mixer and Intermediate Frequency (IF) Section

The signal coming from the front-end is converted to the first IF (45.1 MHz) using a double balanced schottky diode mixer (D8401). Its ports are matched for incoming RF signal conversion to the 45.1 MHz IF using low side injection. The injection signal (VCO MIXER) coming from the mixer buffer (Q8881) is filtered by the lowpass consisting of (L8403, L8404, C8401 - C8403) and has a level of approximately 10 dBm.

The mixer IF output signal (RX IF) from transformer T8401 pin 2 is fed to the first two pole crystal filter Y5201. The filter output in turn is matched to the following IF amplifier.

The IF amplifier Q5201 is actively biased by a collector base feedback (R5201, R5202) to a current drain of approximately 5 mA drawn from the voltage 5V STAB. Its output impedance is matched to the second two pole crystal filter Y5202. A dual hot carrier diode (D5201) limits the filter output voltage swing to reduce overdrive effects at RF input levels above -27 dBm.

8.3 IF IC (U5201)

The first IF signal from the crystal filters feeds the IF IC (U5201) at pin 6. Within the IF IC the 45.1MHz first IF signal mixes with the second local oscillator (LO) at 44.645MHz to the second IF at 455 kHz. The second LO uses the external crystal Y5211. The second IF signal is amplified and then filtered by two external ceramic filters (FL5201, FL5202). Back in the IF IC the signal is demodulated in a phase-lock detector and fed from IF IC pin 28 to the audio processing circuit ASFIC U0201 located in the controller section (line DET AUDIO).

The squelch circuit of the IF IC is not used. Instead the squelch circuit inside the audio processing IC ASFIC (U0201) determines the squelch performance and sets the squelch threshold. The detector output signal from IF IC (U5201) pin 28 (DET AUDIO) is fed to the ASFIC pin H7.

At IF IC pin 11 an RSSI signal is available with a dynamic range of 70 dB. The RSSI signal is used by the ASFIC (U0201 pin G8) and after buffering by op-amp U0202-3 available at accessory connector J0400-15.

9.0 Transmitter Power Amplifier (PA) 5-25W

The radio's 5-25 W PA is a four stage amplifier used to amplify the output from the exciter to the radio transmit level. It consists of four stages in the line-up. The first (Q8510) is a bipolar stage that is controlled via the PA control line. It is followed by another bipolar stage (Q8520), a MOS FET stage (Q8530, Q8531) and a final bipolar stage (Q8540).

Devices Q8510, Q8520,Q8530 and Q8531 are surface mounted. Bipolar Transistor Q8540 is directly attached to the heat sink.

9.1 Power Controlled Stage

The first stage (Q8510) amplifies the RF signal from the VCO (line EXCITER PA) and controls the output power of the PA. The output power of the transistor Q8510 is proportional to its collector current which is adjusted by a voltage controlled current source consisting of Q8612 and Q8621. The whole stage operates off the K9V1 source which is 9.1V in transmit mode and nearly 0V in receive mode.

The collector current of Q8510 causes a voltage drop across the resistors R8623 and R8624. Transistor Q8612 adjusts the voltage drop across R8621 through PA control line (PWR CNTL). The current source Q8621 adjusts the collector current of Q8510 by modifying its base voltage until the voltage drop across R8623 and R8624 plus VBE (0.6V) equals the voltage drop across R8621 plus VBE (0.6V) of Q8611. If the voltage of PWR CNTL is raised, the base voltage of Q8612 will also rise causing more current to flow to the collector of Q8612 and a higher voltage drop across R8621. This in turn results in more current driven into the base of Q8510 by Q8621 so that the current of Q8510 is increased. The collector current settles when the voltage over the series configuration of R8623 and R8624 plus VBE of Q8621 equals the voltage over R8621 plus VBE (0.6V) of Q8611. By controlling the output power of Q8510 and in turn the input power of the following stages the ALC loop is able to regulate the output power of the transmitter. Q8611 is used for temperature compensation of the PA output power.

9.2 PA Stages

The bipolar transistor Q8520 is driven by Q8510. To reduce the collector-emitter voltage and in turn the power dissipation of Q8510 its collector current is drawn from the antenna switch circuit.

In transmit mode the base of Q8520 is slightly positive biased by a divided K9V1 signal. This bias along with the rf signal from Q8510 allows a collector current to be drawn from the antenna switch circuit and in turn switches the antenna switch to transmit, while in receive mode the low K9V1 signal with no rf signal present cuts off the collector current and in turn switches the antenna switch to receive.

The following stage uses two enhancement mode N-Channel MOS FET devices (Q8530, Q8531) and requires for each device a positive gate bias and a quiescent current flow for proper operation. The voltages of the lines BIAS VLTG and BIAS VLTG 2 are set in transmit mode by two Digital to Analog (D/A) converters (U0731-4, U0731-11) and fed to the gates of Q8531 and Q8530 via two resistive dividers. The bias voltages are tuned in the factory. If one or both transistor are replaced, the bias voltages must be tuned with the Dealer Programming Software (DPS). Care must be taken, not to damage any device by exceeding the maximum allowed bias voltage. The collector currents are drawn from the supply voltage A+ via L8531 and L8532.

The final stage uses the bipolar device Q8540 and operates off the A+ supply voltage. For class C operation the base is DC grounded by two series inductors (L8533, L8534). A matching network consisting of C8541-C8544 and two striplines transform the impedance to 50 Ohms and feed the directional coupler.

9.3 Directional Coupler

The directional coupler is a microstrip printed circuit which couples a small amount of the forward power off the rf power from Q8541. The coupled signal is rectified to an output power proportional negative DC voltage by the diode D8553 and sent to the power control circuit in the controller section via the line PWR DETECT for output power control. The power control circuit holds this voltage constant, thus ensuring the forward power out of the radio to be held to a constant value.

9.4 Antenna Switch

The antenna switch is switched synchronously with the K9V1 voltage and feeds either the antenna signal coming through the harmonic filter to the receiver or the transmitter signal coming from the PA to the antenna via the harmonic filter.

In transmit mode, this K9V1 voltage is high and biases Q8520 and, along with the rf signal from Q8510, allows a collector current to be drawn. The collector current of Q8520 drawn from A+ flows via L8542, L8541, directional coupler, D8551, L8551, D8631, L8631, R8616, R8617 and L8611 and switches the PIN diodes D8551 and D8631 to the low impedance state. D8551 leads the rf signal from the directional coupler to the harmonic filter. The low impedance of D8631 is transformed to a high impedance at the input of the harmonic filter by the resonant circuit formed by L8551, C8633 and the input capacitance of the harmonic filter.

In receive mode the low K9V1 and no rf signal present from Q8510 turn off the collector current of Q8520. With no current drawn by Q8520 and resistor R8615 pulling the voltage at PIN diode D8631 to A+ both PIN diodes are switched to the high impedance state. The antenna signal, coming through the harmonic filter, is channelled to the receiver via L8551, C8634 and line PA RX.

A high impedance resonant circuit formed by D8551 in off state and L8554, C8559 prevents an influence of the receive signal by the PA stages. The high impedance of D8631 in off state doesn´t influence the receiver signal.

9.5 Harmonic Filter

The transmitter signal from the antenna switch is channelled through the harmonic filter to the antenna connector J8501.The harmonic filter is formed by inductors L8552, L8553, and capacitors C8551 through C8554. This network forms a low-pass filter to attenuate harmonic energy of the transmitter to specifications level. R8550 is used for electro-static protection.

9.6 Power Control

The power control loop regulates transmitter power with an automatic level control (ALC) loop and provides protection features against excessive control voltage and high operating temperatures.

MOS FET device bias, power and control voltage limit are adjusted under microprocessor control using a Digital to Analog (D/A) converter (U0731). The microprocessor writes the data into the D/A converter via serial interface (SRL) composed of the lines SPI CLCK SRC (clock), SPI DATA SRC (data) and DAC CE (chip enable). The D/A adjustable control voltage limit increases transmitter rise time and reduces adjacent channel splatter as it is adjusted closer to the actual operating control voltage.

The microprocessor controls K9V1 ENABLE (U0101-3) to switch on the first and the second PA stage via transistors Q0741, Q0742 and signal K9V1. The antenna switch is turned on by the collector current of the second PA stage. In TX mode the front-end control D/A (U0731-11) is used for BIAS VOLTAGE 2 (via R0736) and K9V1 ENABLE pulls signal FE CNTL VLTG to ground via Q0743. PA DISABLE, also microprocessor controlled (U0101-26), sets BIAS VLTG (U0731-4) and VLTG LIMIT SET (U0731-13) via D0731 and BIAS VLTG 2 via D0733 in receive mode to low to switch off the biases of the MOS FET devices Q8530, Q8531 and to switch off the power control voltage (PWR CNTL).

Through an Analog to Digital (A/D) input (VLTG LIMIT) the microprocessor can read the PA control voltage (PWR CNTL) during the tuning process.The ALC loop regulates power by adjusting the PA control line PWR CNTL to keep the forward power voltage PWR DETECT at a constant level.

Opamp U0701-2 and resistors R0701 to R0703 and R0731 subtract the negative PWR DETECT voltage from the PA PWR SET D/A output U0731 pin 2. The result is connected to opamp inverting input U0701-4 pin 9 which is compared with a 4.6 volt reference VAG present at noninverting input U0701-4 pin 10 and controls the output power of the PA via pin 8 and control line PWR CNTL. The 4.6 volt reference VAG is set by a resistive divider circuit (R0251, R0252) which is connected to ground and 9.3 volts, and buffered by opamp U0251-1.

During normal transmitter operation the voltages at the opamp inputs U0701-4 pins 9 and 10 should be equal to 4.6 volts and the PA control voltage output at pin 8 should be between 4 and 7 volts. If power falls below the desired setting, PWR DETECT becomes less negative, causing the output at U0701-2 pin 7 to decrease and the opamp output U0701-4 pin 8 to increase.

A comparator formed by U0701-4 increases the PA control voltage PA CNTL until PWR DETECT is at the desired level. The power set D/A output voltage PA PWR SET (U0731-2) at U0701-2 pin 5 adjusts power in steps by adjusting the required value of PWR DETECT. As PA PWR SET (U0731-2) decreases, transmitter power must increase to make PWR DETECT more negative and keep the inverting input U0701-4 pin 9 at 4.6 volts.

Loop frequency response is controlled by opamp feedback components R0712 and C0711. Opamp U0701-3 compares the power control voltage PWR CNTL divided by resistors R0717 to R0719 with the voltage limit setting VLTG LIMIT SET from the D/A converter (U0731-13) and keeps the control voltage constant via Q0711 if the control voltage, reduced by the resistive divider (R0717 to R0719), approaches the voltage of VLTG LIMIT SET (U0731-13).

Rise and fall time of the output power during transmitter keying and dekeying is controlled by the comparator formed by opamp U0701-3.

During normal transmitter operation the voltage at U701-3 pin 13 is higher than the voltage at pin 12 causing the output at pin 14 being low and switching off transistor Q0711. Diode D0732 reduces the bias voltages BIAS VLTG, BIAS VLTG 2 for low control voltage levels.

The temperature of the PA area is monitored by opamp U0701-1 using thermistor R8641 (located in the PA section). If the temperature increases, the resistance of the thermistor decreases, decreasing the voltage PA TEMP. The inverting amplifier formed by U0701-1 amplifies the PA TEMP voltage and if the voltage at opamp pin 1 approaches 4.6 V plus the voltage (ON) across D0721, U701-1 simulates an increased power which in turn decreases the power control voltage until the voltage at U0701-4 pin 9 is 4.6V again. During normal transmitter operation the output voltage of opamp U701-1 pin 1 is below 4.6V. Diode D8601 located in the PA section acts as protection against transients and wrong polarity of the supply voltage.

10.0 Frequency Synthesis

The complete synthesizer subsystem consists of the Reference Oscillator (U8702), the Fractional-N synthesizer (U8701), the Voltage Controlled Oscillator (Q8802), the RX and TX buffer stages (Q8831, Q8851, Q8852, Q8881) and the feedback amplifier (Q8841).

10.1 Reference Oscillator

The Reference Oscillator (Y8702) contains a temperature compensated crystal oscillator with a frequency of 16.8 MHz. An analog to digital (A/D) converter internal to U8701 (FRAC-N) and controlled by the microprocessor via serial interface (SRL) sets the voltage at the warp output of U8701 pin 16 to set the frequency of the oscillator. The output of the oscillator (pin 2 of Y8702) is applied to pin 14 (XTAL1) of U8701 via a RC series combination.

10.2 Fractional-N Synthesizer (U8701)

The FRAC-N synthesizer IC (U8701) consists of a pre-scaler, a programmable loop divider, control divider logic, a phase detector, a charge pump, an A/D converter for low frequency digital modulation, a balance attenuator to balance the high frequency analog modulation and low frequency digital modulation, a 13V positive voltage multiplier, a serial interface for control, and finally a super filter for the regulated 9.3 volts.

A voltage of 9.3V applied to the super filter input (U8701 pin 22) supplies an output voltage of 8.6 VDC at pin 18. It supplies the VCO (Q8802), VCO modulation bias circuit (via R8714) and the synthesizer charge pump resistor network (R8723, R8724, R8726). The synthesizer supply voltage is provided by the 5V regulator U8891.

In order to generate a high voltage to supply the phase detector (charge pump) output stage at pin VCP (U8701-32), a voltage of 13 VDC is being generated by the positive voltage multiplier circuitry (D8701-1-3, C8716, C8717). This voltage multiplier is basically a diode capacitor network driven by two (1.05MHz) 180 degrees out of phase signals (U8701-9 and -10).

Output LOCK (U8701-2) provides information about the lock status of the synthesizer loop. A high level at this output indicates a stable loop. IC U8701 divides the 16.8 MHz reference frequency down to 2.1 MHz and provides it at pin 11. This signal is used as clock signal by the controller.

The serial interface (SRL) is connected to the microprocessor via the data line SPI DATA (U8701-5), clock line SPI CLK (U8701-6), and chip enable line FRACN CE (U8701-7).

10.3 Voltage Controlled Oscillator (VCO)

The Voltage Controlled Oscillator (VCO) is formed by the colpitts oscillator FET Q8802. Q8802 draws a drain current of 10 mA from the FRAC-N IC super filter output. The oscillator frequency is half of the desired frequency and mainly determined by L8804, C8809, C8810, C8812 - C8815 and varactor diodes D8802 / D8803. Diode D8804 controls the amplitude of the oscillator.

A balanced frequency doubler T8821, D8821 converts the oscillator fundamental to the desired frequency. With a steering voltage from 2.5V to 10.5V at the varactor diodes the full RX and TX frequency range from 254.9 MHz to 350 MHz is covered.

The doubler output is buffered by Common VCO Buffer Q8831 which draws a collector current of 15 mA from the stabilized 5V (U8891). A bandpass filter composed of L8831, C8832 - C8836, 15 nH micro-stripline rejects unwanted harmonics at the first and third oscillator fundamental frequency and matches the output to the following buffer stages. Buffer Q8831 drives the Pre-scaler Buffer Q8841, the PA Buffers Q8851, Q8852 (Pout = 13dBm) and Mixer Buffer Q8881 (Pout = 10dBm). Q8841 draws a collector current of 14 mA from the stabilized 5V, Q8851 draws 15mA, Q8852 draws 20 mA and Q8881 draws 18 mA form the FLT 9V3 source. The buffer stages Q8851, Q8881 and the feedback amplifier Q8841 provide the necessary gain and isolation for the synthesizer loop.

Q8801 is controlled by output AUX3 of U8701 (pin 1) and enables the RX or TX buffer. In RX mode AUX3 is nearly at ground level, in TX mode about 5V DC. In TX mode, with R8802 pulled to ground level by Q8801, the modulation signal coming from the FRAC-N synthesizer IC (U8701 pin28) modulates the VCO via varactor diode D8801 while in RX mode the modulation circuit is disabled by pulling R8802 to a higher level through R8882.

10.4 Synthesizer Operation

The complete synthesizer subsystem works as follows. The output signal of the VCO (Q8802) is frequency doubled by doubler D8821 and, buffered by Common VCO Buffer Q8831. To close the synthesizer loop, the collector of Q8841 is connected to the PREIN port of synthesizer U8701 (pin 20). The buffer output (Q8831) also provides signals for the Mixer Buffer Q8881 and the PA Buffers (Q8851, Q8852).

The pre-scaler in the synthesizer (U8701) is basically a dual modulus pre-scaler with selectable divider ratios. This divider ratio of the pre-scaler is controlled by the loop divider, which in turn receives its inputs via the SRL. The output of the pre-scaler is applied to the loop divider. The output of the loop divider is connected to the phase detector, which compares the loop divider´s output signal with the reference signal.The reference signal is generated by dividing down the signal of the reference oscillator (Y8702).

The output signal of the phase detector is a pulsed DC signal which is routed to the charge pump. The charge pump outputs a current at pin 29 (I OUT of U8701). The loop filter (which consists of R8715-R8717, C8723-C8725, C8727) transforms this current into a voltage that is applied to the varactor diodes D8802, D8803 and alters the output frequency of the VCO. The current can be set to a value fixed in the FRAC-N IC or to a value determined by the currents flowing into CPBIAS 1 (U8701-27) or CPBIAS 2 (U8701-26). The currents are set by the value of R8724 or R8726 respectively. The selection of the three different bias sources is done by software programming.

To reduce synthesizer lock time when new frequency data has been loaded into the synthesizer the magnitude of the loop current is increased by enabling the IADAPT line (U8701-31) for a certain software programmable time (Adapt Mode). The adapt mode timer is started by a low to high transient of the FRACN CE line. When the synthesizer is within the lock range the current is determined only by the resistors connected to CPBIAS 1, CPBIAS 2, or the internal current source.

A settled synthesizer loop is indicated by a high level of signal LOCK DET (U8701-2). Open architecture only: LOCK DET adds up with signal SQ DET, weighted by resistors R0113, R0114, and is routed to one of the uP´s ADCs input U0101-43. From the voltage weighted by the resistors the uP determines whether SQ DET, LOCK DET or both are active.

In order to modulate the PLL the two spot modulation method is utilized. Via pin 8 (MODIN) on U8701 the audio signal is applied to both the A/D converter (low freq path) as well as the balance attenuator (high freq path). The A/D converter converts the low frequency analog modulating signal into a digital code that is applied to the loop divider, thereby causing the carrier to deviate. The balance attenuator is used to adjust the VCO's deviation sensitivity to high frequency modulating signals. The output of the balance attenuator is present at the MODOUT port (U8701-28) and connected to the VCO modulation diode D8801.

Chapter 5

PCB/Schematic Diagrams and Parts Lists

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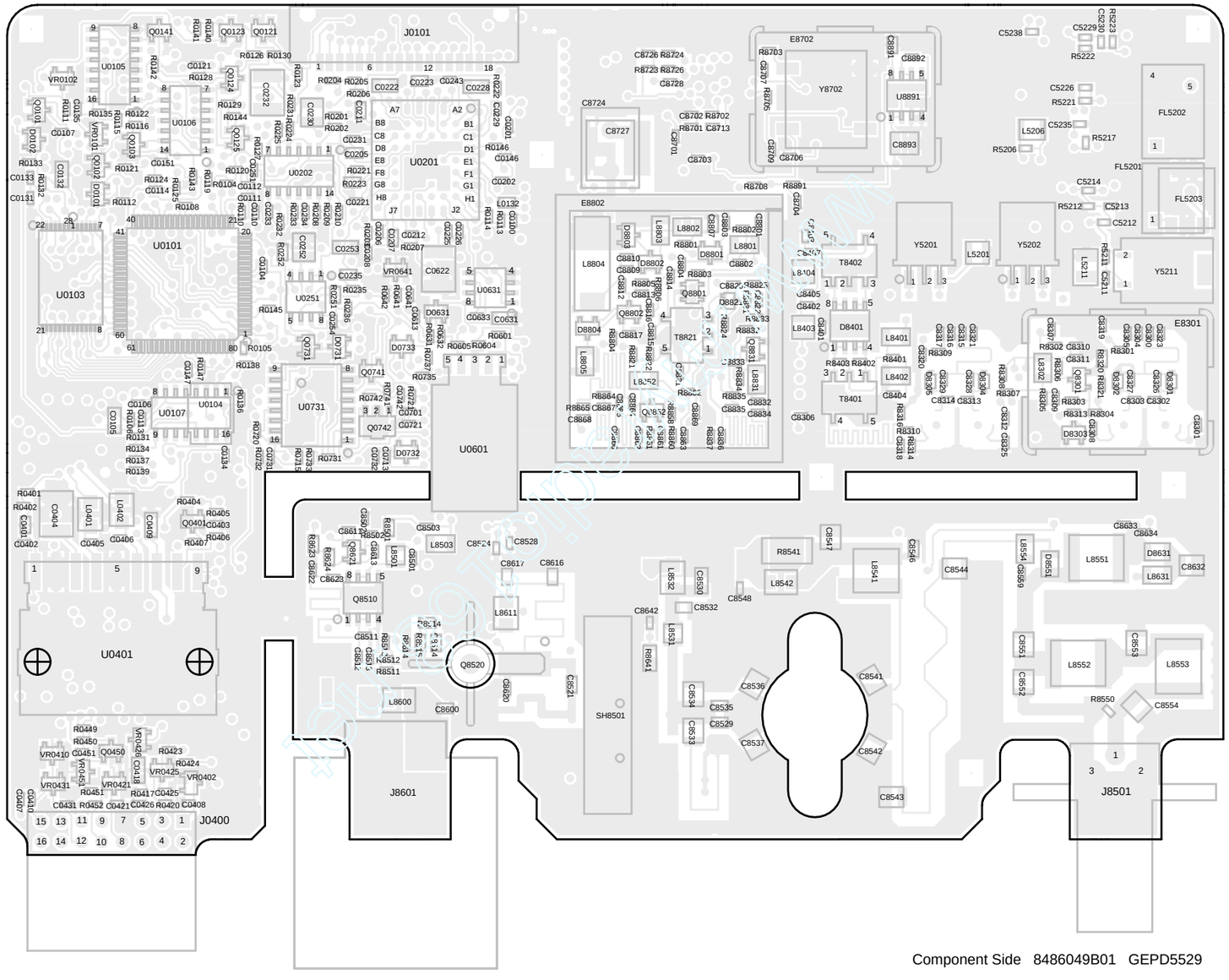
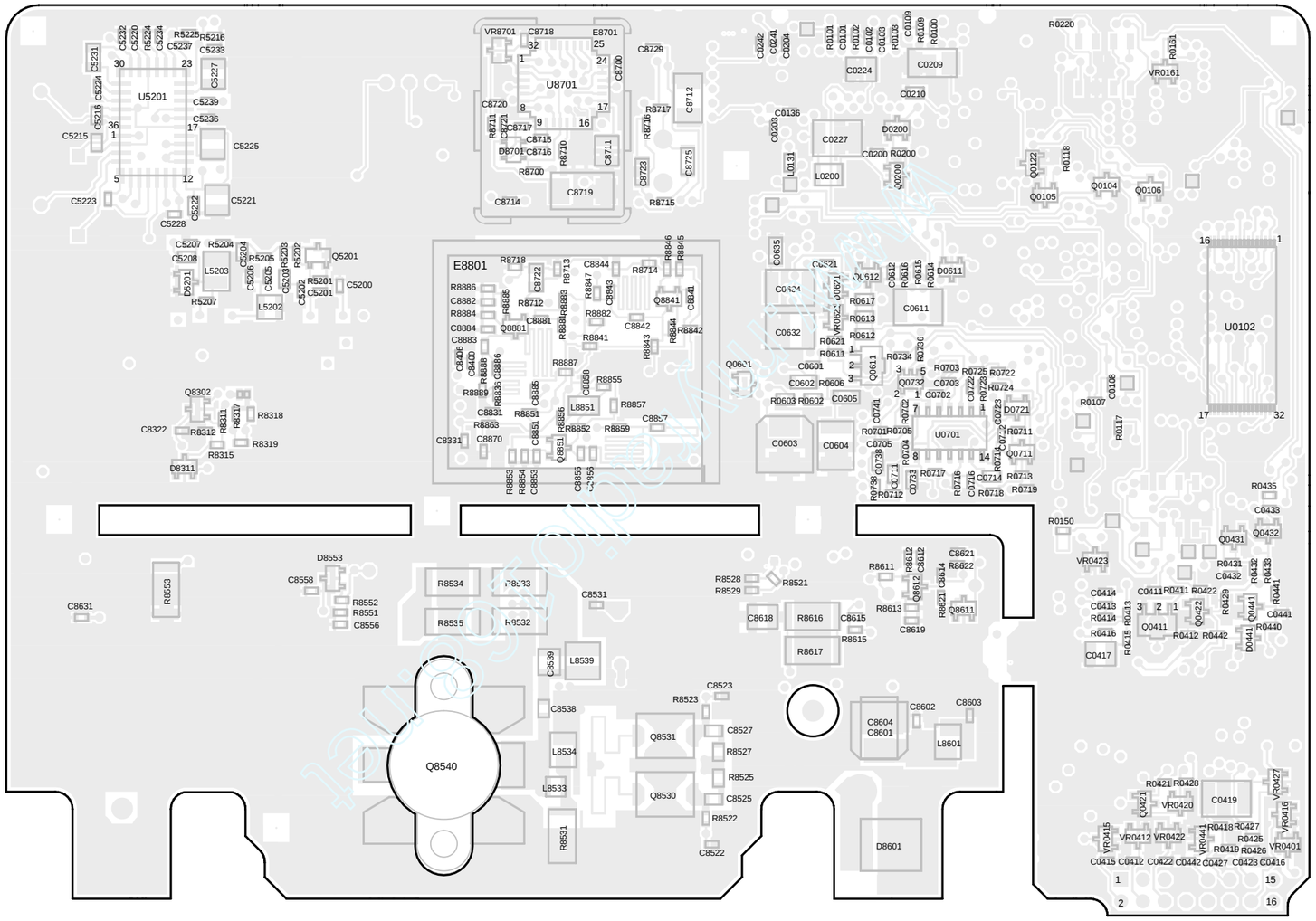


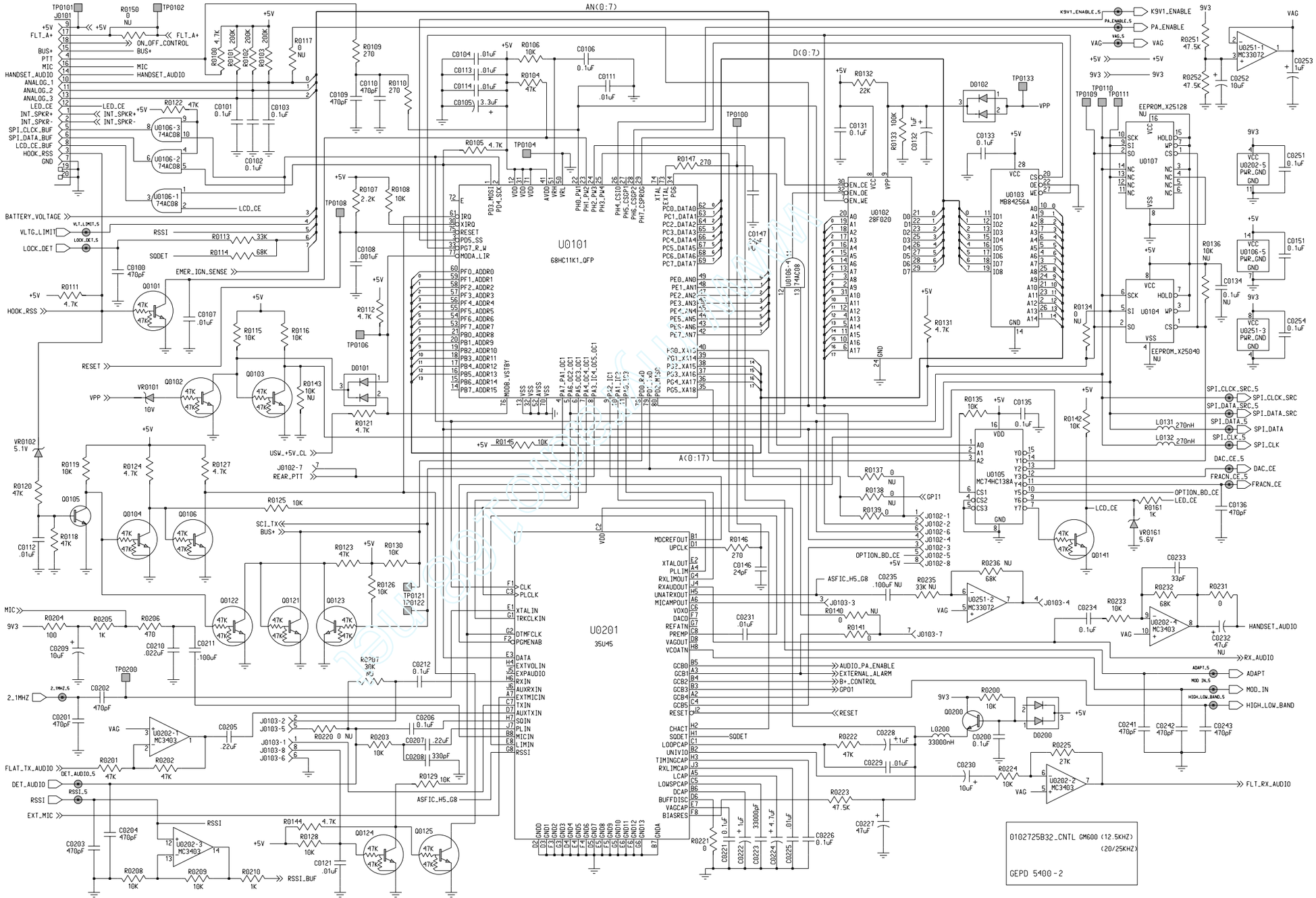
Component Side 8486049B01 GEPD5529

336-390MHz Main Board Component Side
PCB No. 8486049B01



Solder Side 8486049B01 GEPD5530

336-390MHz Main Board Solder Side
PCB No. 8486049B01



336-390MHz Open Controller Schematic Diagram
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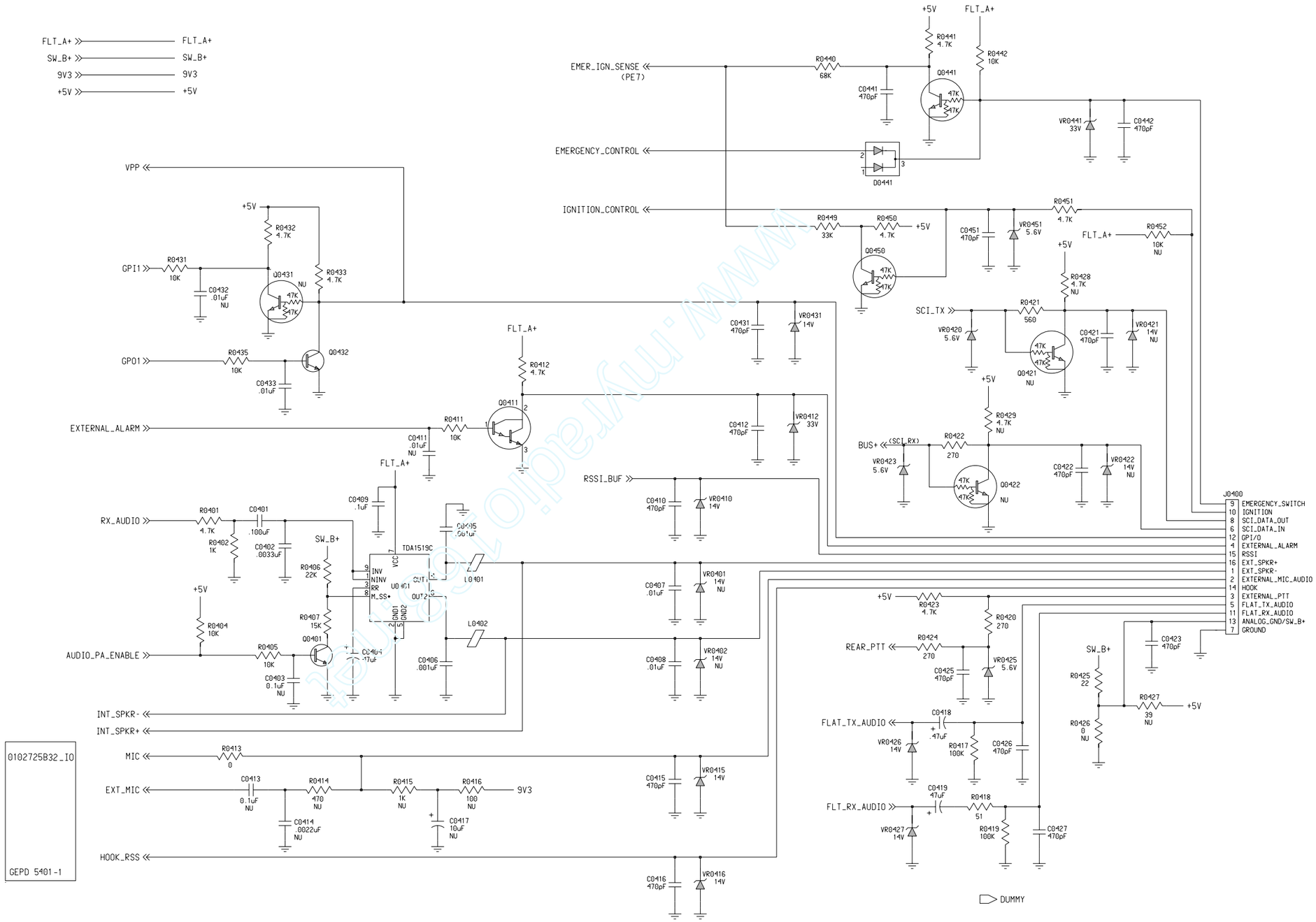
Controller Parts List

Circuit Ref	Motorola Part No.	Description
C0100	2113741F17	470pF 50V
C0101	2113743K15	100nF 16V
C0102	2113743K15	100nF 16V
C0103	2113743K15	100nF 16V
C0104	2113741F49	10nF 50V
C0105	2311049A42	TANT CP 3.3uF 10% 6V
C0106	2113743K15	100nF 16V
C0107	2113741F49	10nF 50V
C0108	2113741F25	1nF 50V
C0109	2113741F17	470pF 50V
C0110	2113741F17	470pF 50V
C0111	2113741F49	10nF 50V
C0112	2113741F49	10nF 50V
C0113	2113741F49	10nF 50V
C0114	2113741F49	10nF 50V
C0121	2113741F49	10nF 50V
C0131	2113743K15	100nF 16V
C0132	2311049A07	TANT CP 1uF 10% 16V
C0133	2113743K15	100nF 16V
C0135	2113743K15	100nF 16V
C0136	2113741F17	470pF 50V
C0146	2113740F36	24pF 5% 50V
C0151	2113743K15	100nF 16V
C0200	2113743K15	100nF 16V
C0201	2113741F17	470pF 50V
C0202	2113741F17	470pF 50V
C0203	2113741F17	470pF 50V
C0204	2113741F17	470pF 50V
C0205	2113743F08	220nF 5% 50V
C0206	2113743K15	100nF 16V
C0207	2113743F08	220nF 5% 50V
C0208	2113741F13	330pF 50V
C0209	2311049J26	TANT CP 10uF 20% 16V
C0210	2113741M53	22nF 50V
C0211	2113743A19	100nF 16V
C0212	2113743K15	100nF 16V Y5V
C0221	2113743K15	100nF 16V Y5V
C0222	2311049A07	TANT CP 1uF 10% 16V
C0223	2113741A57	33nF 50V
C0224	2311049J11	TANT CP 4.7uF 10% 16V
C0225	2113741F49	10nF 50V
C0226	2113743K15	100nF 16V
C0227	2311049A99	TANT CP 47uF 20% 10V
C0228	2311049A01	TANT CP 100nF 10% 35V
C0229	2113741F49	10nF 50V
C0230	2311049J23	TANT CP 10uF 10% 6V
C0231	2113741F49	10nF 50V
C0233	2113740F39	33pF 5% 50V
C0234	2113743K15	100nF 16V
C0235	2113743A19	100nF 16V
C0241	2113741F17	470pF 50V
C0242	2113741F17	470pF 50V
C0243	2113741F17	470pF 50V
C0251	2113743K15	100nF 16V Y5V
C0252	2311049J23	TANT CP 10uF 10% 6V
C0253	2311049A07	TANT CP 1uF 10% 16V
C0254	2113743K15	100nF 16V Y5V
C0401	2113743A19	100nF 16V
C0402	2113741F37	3.3nF 50V
C0404	2311049A99	TANT CP 47uF 20% 10V
C0405	2113741F25	1nF 50V
C0406	2113741F25	1nF 50V
C0407	2113741F49	10nF 50V
C0408	2113741F49	10nF 50V
C0409	2109720D14	CER LOW DIST 100nF
C0410	2113741F17	470pF 50V
C0412	2113741F17	470pF 50V
C0415	2113741F17	470pF 50V
C0416	2113741F17	470pF 50V
C0418	2311049A05	TANT CP 470nF 10% 25V
C0419	2311049A99	TANT CP 47uF 20% 10V
C0421	2113741F17	470pF 50V
C0422	2113741F17	470pF 50V
C0423	2113741F17	470pF 50V
C0425	2113741F17	470pF 50V
C0426	2113741F17	470pF 50V
C0427	2113741F17	470pF 50V
C0431	2113741F17	470pF 50V
C0433	2113741F49	10nF 50V
C0441	2113741F17	470pF 50V
C0442	2113741F17	470pF 50V
C0451	2113741F17	470pF 50V
D0101	4813833C02	DUAL SOT MMBD6100
D0102	4813833C02	DUAL SOT MMBD6100
D0200	4813833C02	DUAL SOT MMBD6100
D0441	4813833C02	DUAL SOT MMBD6100
J0101	0902636Y01	Connector Flex Side Entry
J0102	0904424J06	Connector Double Row
J0103	0904424J06	Connector Double Row
J0400	2804503J01	CONNECTOR ACCY 16 PIN
L0131	2462587Q40	COIL CHIP 270nH
L0132	2462587Q40	COIL CHIP 270nH
L0200	2462587K26	CHIP IND 33000 NH
L0401	2484657R01	Ferrite Bead
L0402	2484657R01	Ferrite Bead
Q0101	4880048M01	NPN DIG 47k/47k
Q0102	4880048M01	NPN DIG 47k/47k
Q0103	4880048M01	NPN DIG 47k/47k
Q0104	4880048M01	NPN DIG 47k/47k
Q0105	4813824A10	NPN 40V .2A B=50-150
Q0106	4880048M01	NPN DIG 47k/47k
Q0121	4880048M01	NPN DIG 47k/47k
Q0122	4880048M01	NPN DIG 47k/47k
Q0123	4880048M01	NPN DIG 47k/47k
Q0124	4880048M01	NPN DIG 47k/47k
Q0125	4880048M01	NPN DIG 47k/47k
Q0141	4880048M01	NPN DIG 47k/47k
Q0200	4813824A10	NPN 40V .2A B=50-150
Q0401	4813824A10	NPN 40V .2A B=50-150
Q0411	4880052M01	NPN DRLNGTN MXTA
Q0432	4813824A10	NPN 40V .2A B=50-150
Q0441	4880048M01	NPN DIG 47k/47k
Q0450	4880048M01	NPN DIG 47k/47k
R0100	0662057A65	4k7 1/16W 5%
R0101	0662057B05	200k 1/16W
R0102	0662057B05	200k 1/16W
R0103	0662057B05	200k 1/16W
R0104	0662057A89	47k 1/16W 5%
R0105	0662057A65	4k7 1/16W 5%
R0106	0662057A73	10k 1/16W 5%
R0107	0662057A57	2k2 1/16W 5%
R0108	0662057A73	10k 1/16W 5%
R0109	0662057A35	270 1/16W 5%
R0110	0662057A35	270 1/16W 5%
R0111	0662057A65	4k7 1/16W 5%
R0112	0662057A65	4k7 1/16W 5%
R0113	0662057A85	33k 1/16W 5%
R0114	0662057A93	68k 1/16W 5%
R0115	0662057A89	47k 1/16W 5%
R0116	0662057A73	10k 1/16W 5%
R0118	0662057A89	47k 1/16W 5%



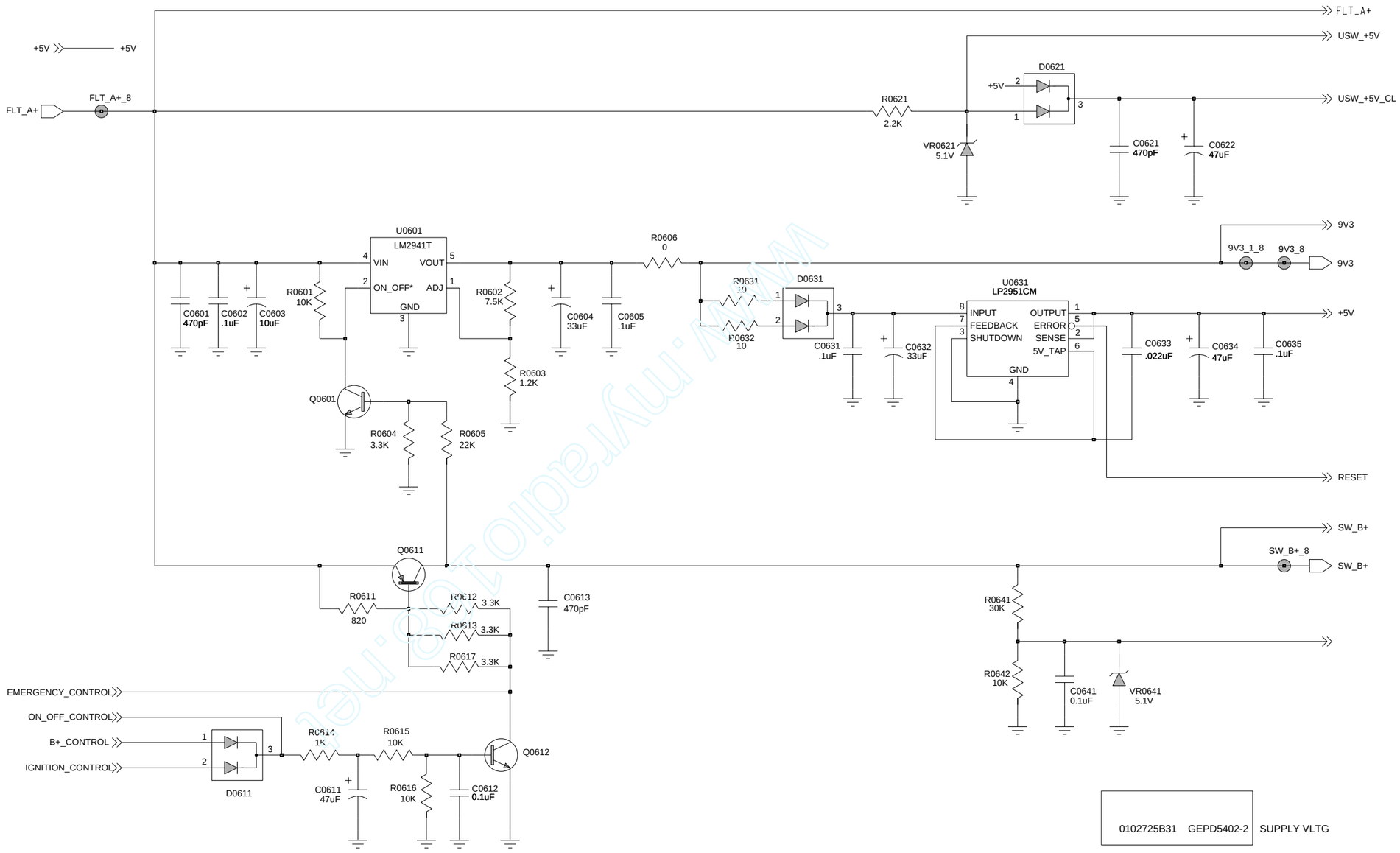
336-390MHz Open Controller_IO Schematic Diagram 2 of 2

Circuit Ref	Motorola Part No.	Description
R0119	0662057A73	10k 1/16W 5%
R0120	0662057A89	47k 1/16W 5%
R0121	0662057A65	4k7 1/16W 5%
R0122	0662057A89	47k 1/16W 5%
R0123	0662057A89	47k 1/16W 5%
R0124	0662057A65	4k7 1/16W 5%
R0125	0662057A73	10k 1/16W 5%
R0126	0662057A73	10k 1/16W 5%
R0127	0662057A65	4k7 1/16W 5%
R0128	0662057A73	10k 1/16W 5%
R0129	0662057A73	10k 1/16W 5%
R0130	0662057A73	10k 1/16W 5%
R0131	0662057A65	4k7 1/16W 5%
R0132	0662057A81	22k 1/16W 5%
R0133	0662057A97	100k 1/16W
R0135	0662057A73	10k 1/16W 5%
R0139	0662057B47	0 1/16W
R0141	0662057B47	0 1/16W
R0142	0662057A73	10k 1/16W 5%
R0144	0662057A65	4k7 1/16W 5%
R0145	0662057A73	10k 1/16W 5%
R0146	0662057A35	270 1/16W 5%
R0147	0662057A35	270 1/16W 5%
R0161	0662057A49	1k 1/16W 5%
R0200	0662057A73	10k 1/16W 5%
R0201	0662057A89	47k 1/16W 5%
R0202	0662057A89	47k 1/16W 5%
R0203	0662057A73	10k 1/16W 5%
R0204	0662057A25	100 1/16W 5%
R0205	0662057A49	1k 1/16W 5%
R0206	0662057A41	470 1/16W 5%
R0208	0662057A73	10k 1/16W 5%
R0209	0662057A73	10k 1/16W 5%

Circuit Ref	Motorola Part No.	Description
R0210	0662057A49	1k 1/16W 5%
R0221	0662057B47	0 1/16W
R0222	0662057A89	47k 1/16W 5%
R0223	0662057R92	47.5k .1W 1%
R0224	0662057A73	10k 1/16W 5%
R0225	0662057A73	10k 1/16W 5%
R0231	0662057B47	0 1/16W
R0232	0662057A93	68k 1/16W 5%
R0233	0662057A73	10k 1/16W 5%
R0235	0662057A85	33k 1/16W 5%
R0236	0662057A93	68k 1/16W 5%
R0251	0662057R92	47.5k .1W 1%
R0252	0662057R92	47.5k .1W 1%
R0401	0662057A65	4k7 1/16W 5%
R0402	0662057A49	1k 1/16W 5%
R0404	0662057A73	10k 1/16W 5%
R0405	0662057A73	10k 1/16W 5%
R0406	0662057A81	22k 1/16W 5%
R0407	0662057A77	15k 1/16W 5%
R0411	0662057A73	10k 1/16W 5%
R0412	0662057A65	4k7 1/16W 5%
R0413	0662057B47	0 1/16W
R0417	0662057A97	100k 1/16W
R0418	0662057A18	51 1/16W 5%
R0419	0662057A97	100k 1/16W
R0420	0662057A35	270 1/16W 5%
R0421	0662057A43	560 1/16W 5%
R0422	0662057A35	270 1/16W 5%
R0423	0662057A65	4k7 1/16W 5%
R0424	0662057A35	270 1/16W 5%
R0425	0662057A09	22 1/16W 5%
R0431	0662057A73	10k 1/16W 5%
R0432	0662057A65	4k7 1/16W 5%

Circuit Ref	Motorola Part No.	Description
R0433	0662057A65	4k7 1/16W 5%
R0435	0662057A73	10k 1/16W 5%
R0440	0662057A93	68k 1/16W 5%
R0441	0662057A65	4k7 1/16W 5%
R0442	0662057A73	10k 1/16W 5%
R0449	0662057A85	33k 1/16W 5%
R0450	0662057A65	4k7 1/16W 5%
R0451	0662057A65	4k7 1/16W 5%
U0101	5113802A48	PROC350 PLAT S/W R010000 A3
U0102	5105625U73	IC 256K x 8 FLS ROM NIN TSOP
U0103	5185748L01	32KX8 SRAM 28 PIN TSOP
U0104	5105462G76	L IC EEPROM 4K SPICMOS
U0105	5113805A30	IC 10F8 DCDR/REMUX 74HC138
U0106	5105492X36	74AC08 4 AND GATES
U0201	5105835U45	ASFIC
U0202	5183222M49	IC QUAD OPAMP __3403_
U0251	5113818A03	IC HIGh Performance SI
U0401	5109699X01	AUDIO PA TDA1915C
VR0101	4813830A23	10V 5% 20mA 350mW
VR0102	4813830A14	5.1V 5% 225mW
VR0161	4813830A15	5.6V 5% 225mW
VR0410	4813830A27	DIODE 14V 5% 225mW
VR0412	4813830A40	SOC23 AUTO SDN
VR0415	4813830A27	DIODE 14V 5% 225mW
VR0416	4813830A27	DIODE 14V 5% 225mW
VR0420	4813830A15	DIODE 5.6V 5% 225mW
VR0423	4813830A15	DIODE 5.6V 5% 225mW
VR0425	4813830A15	DIODE 5.6V 5% 225mW
VR0426	4813830A27	DIODE 14V 5% 225mW
VR0427	4813830A27	DIODE 14V 5% 225mW
VR0431	4813830A27	DIODE 14V 5% 225mW

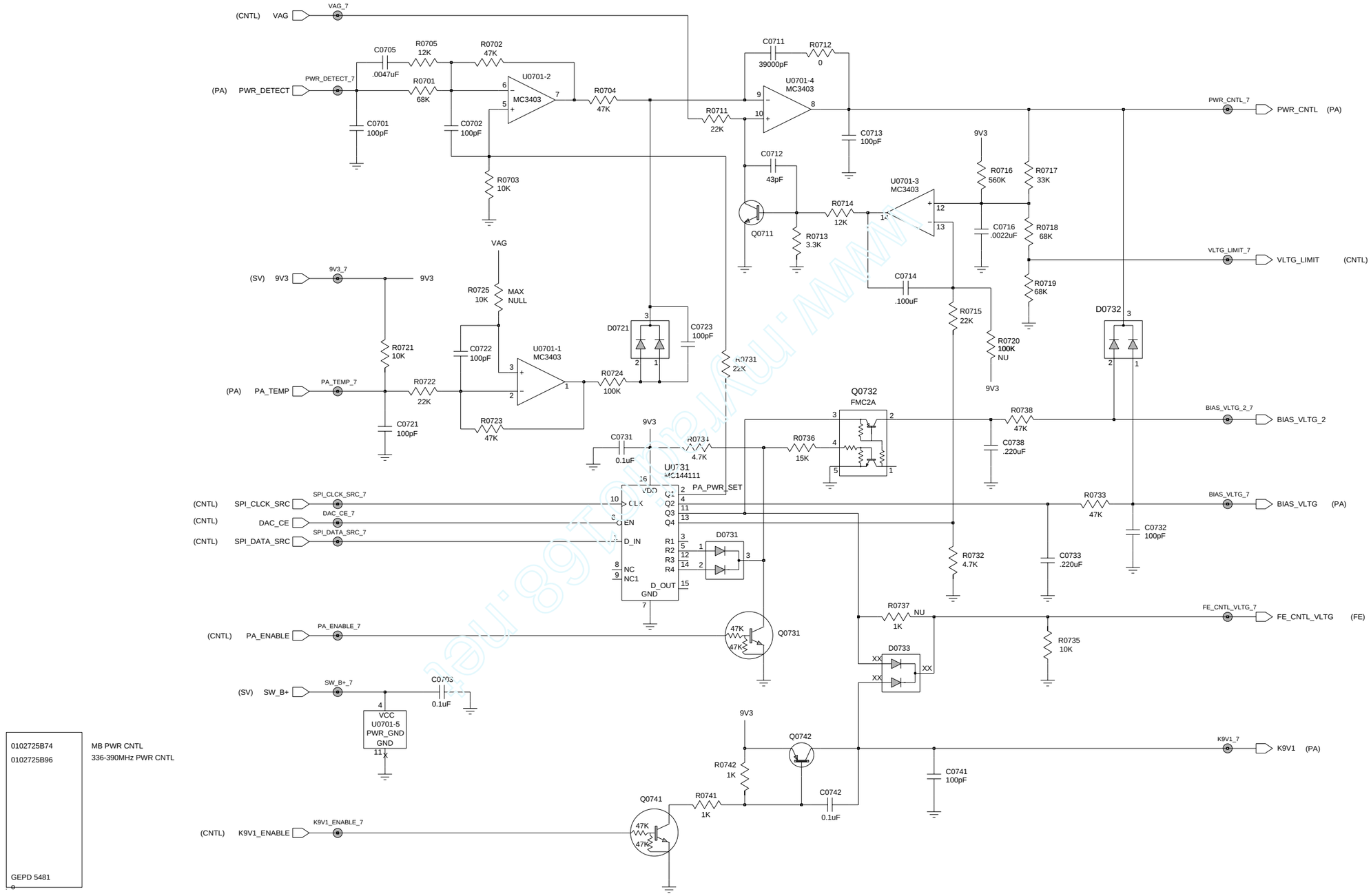
Circuit Ref	Motorola Part No.	Description
VR0441	4813830A40	SOC23 AUTO SDN
VR0451	4813830A15	DIODE 5.6V 5% 225mW



336-390MHz Supply Voltage Schematic Diagram

Supply Voltage Parts List

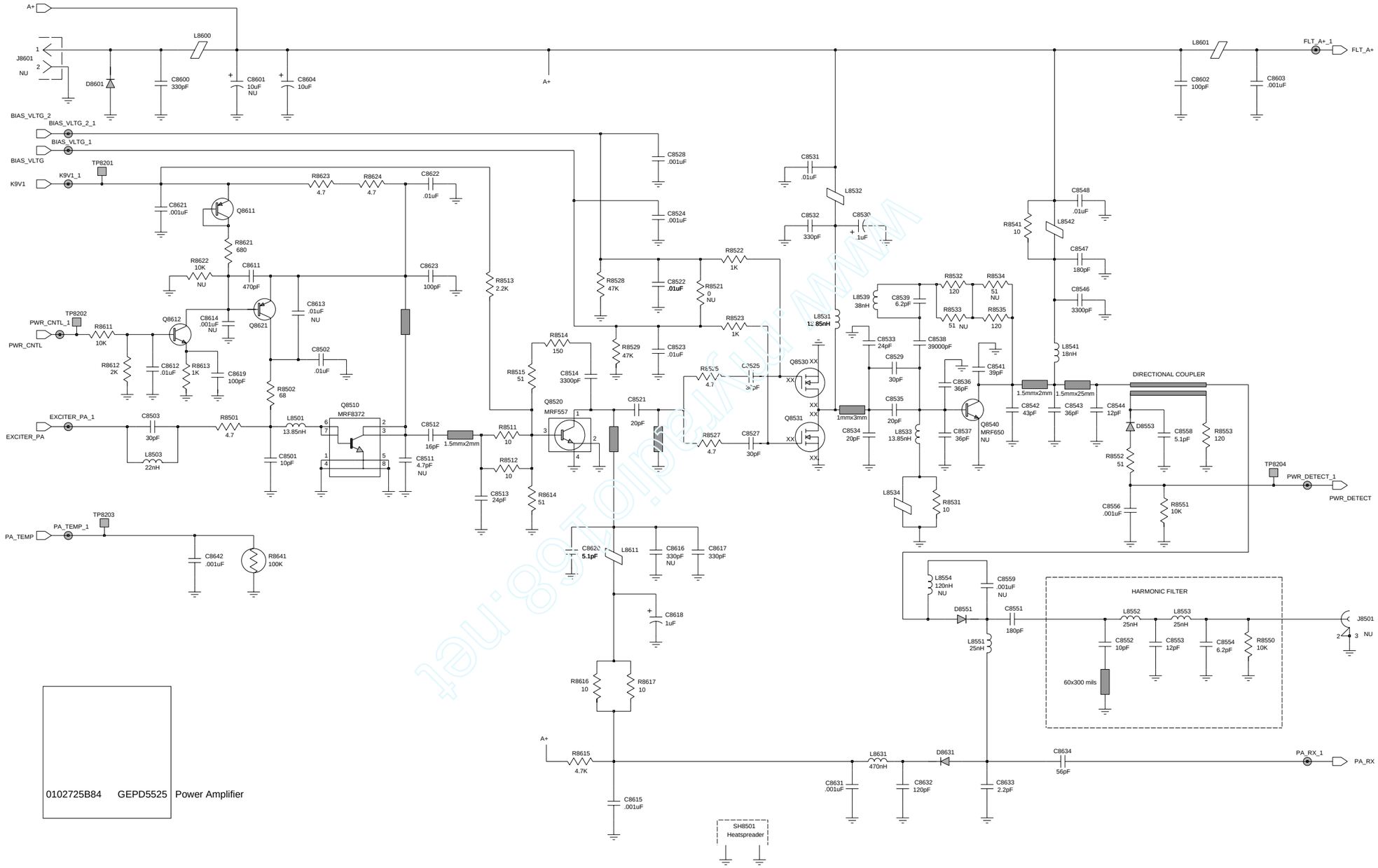
Circuit Ref	Motorola Part No.	Description
C0601	2113741F17	470pF 50V
C0602	2109720D14	CER LOW DIST 100nF
C0603	2380090M24	CHIP LYT 10uF 50V 20%
C0604	2311049A97	TANT CP 33uF 20% 16V
C0605	2109720D14	CER LOW DIST 100nF
C0611	2311049A99	TANT CP 47uF 20% 10V
C0612	2113743K15	100nF 16V Y5V 0603
C0613	2113741F17	470pF 50V X7R 0603
C0621	2113741F17	470pF 50V X7R 0603
C0622	2311049A99	TANT CP 47uF 20% 10V
C0631	2109720D14	CER LOW DIST 100nF
C0632	2311049A97	TANT CP 33uF 20% 16V
C0633	2113743E07	22nF 16V X7R
C0634	2311049A99	TANT CP 47uF 20% 10V
C0635	2109720D14	CER LOW DIST 100nF
C0641	2113743K15	CHIP 100nF 16V
D0611	4813833C02	DIODE DUAL SOT MMBD6100
D0621	4813833C02	DIODE DUAL SOT MMBD6100
D0631	4813833C02	DIODE DUAL SOT MMBD6100
Q0601	4813824A10	NPN 40V .2A B=50-150
Q0611	4805128M27	PNP SOT89 BSR33 LH
Q0612	4813824A10	NPN 40V .2A B=50-150
R0601	0662057A73	RES CHP 10k 1/16W 5%
R0602	0660076E70	RES CHIP FILM 7500 1 1
R0603	0660076E51	RES CHIP FILM 1200 1 1
R0604	0662057A61	RES CHP 3k3 1/16W 5%
R0605	0662057A81	RES CHP 22k 1/16W 5%
R0606	0662057B47	RES CHIP 0 1/16W
R0611	0662057A47	RES CHP 820 1/16W 5%
R0612	0662057C87	RES CHIP 3300 5 1/8
R0613	0662057C87	RES CHIP 3300 5 1/8
R0614	0662057A49	RES CHP 1k 1/16W 5%
R0615	0662057A73	RES CHP 10k 1/16W 5%
R0616	0662057A73	RES CHP 10k 1/16W 5%
R0617	0662057C87	RES CHIP 3300 5 1/8
R0621	0662057A57	RES CHP 2k2 1/16W 5%
R0631	0662057A01	RES CHP 10 1/16W 5%
R0632	0662057A01	RES CHP 10 1/16W 5%
R0641	0662057A84	RES CHP 30k 1/16W 5%
R0642	0662057A73	RES CHP 10k 1/16W 5%
U0601	5105625U25	IC 9.3V REG 2941
U0631	5105469E65	IC VLTG REGLTR LP2951C
VR0621	4813830A14	DIODE 5.1V 5% 225mW
VR0641	4813830A14	DIODE 5.1V 5% 225mW



336-390MHz Power Control Schematic Diagram

Power Control Parts List

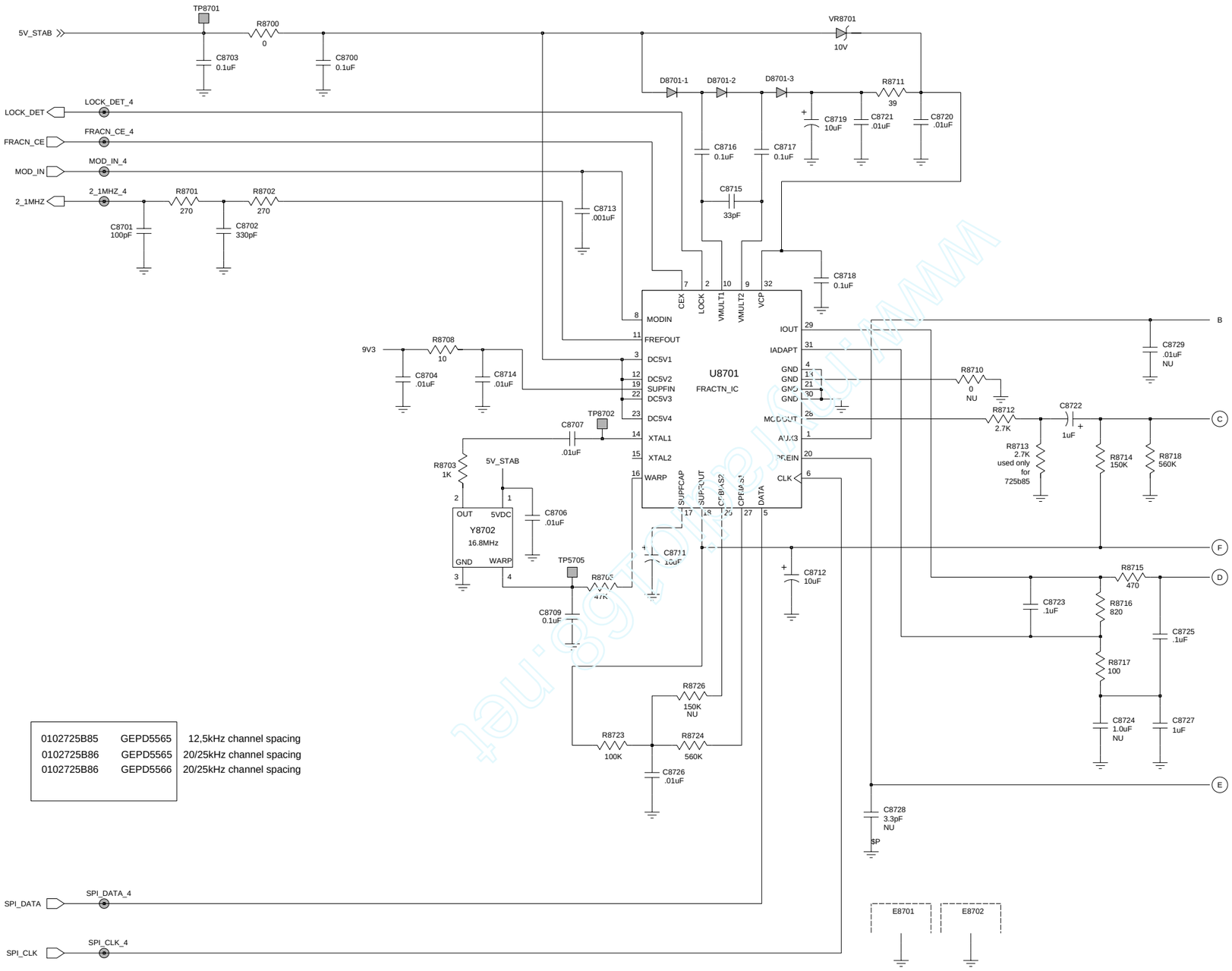
Circuit Ref	Motorola Part No.	Description
C0701	2113740F51	100pF 5% 50V
C0702	2113740F51	100pF 5% 50V
C0703	2113743K15	100nF 16V
C0705	2113741F41	47nF 50V
C0711	2113741A59	CL2
C0712	2113740F42	43pF 5% 50V
C0713	2113740F51	100pF 5% 50V
C0714	2113743A19	100nF 16V
C0716	2113741F33	2.2nF 50V
C0721	2113740F51	100pF 5% 50V
C0722	2113740F51	100pF 5% 50V
C0723	2113740F51	100pF 5% 50V
C0731	2113743K15	100nF 16V Y5V
C0732	2113740F51	100pF 5% 50V
C0733	2113743A23	220nF 16V
C0738	2113743A23	220nF 16V
C0741	2113740F51	100pF 5% 50V
C0742	2113743K15	100nF 16V
D0721	4813833C02	DIODE DUAL SOT MMBD6100
D0731-D0733	4813833C02	DIODE DUAL SOT MMBD6100
Q0711	4813824A10	TSTR NPN 40V .2A
Q0731	4880048M01	TSTR NPN DIG 47k/47k
Q0732	4805921T02	TSTR DUAL ROHM FMC
Q0741	4880048M01	TSTR NPN DIG 47k/47k
Q0742	4805128M27	TSTR PNP SOT89 BSR33
R0701	0662057A93	68k 1/16W 5%
R0702	0662057A89	47k 1/16W 5%
R0703	0662057A73	10k 1/16W 5%
R0704	0662057A93	68k 1/16W 5%
R0705	0662057A75	12k 1/16W 5%
R0711	0662057A81	22k 1/16W 5%
R0712	0662057B47	0
R0713	0662057A61	3k3 1/16W 5%
R0714	0662057A75	12k 1/16W 5%
R0715	0662057A81	22k 1/16W 5%
R0716	0662057B16	560k 1/16W 5%
R0717	0662057A85	33k 1/16W 5%
R0718	0662057A93	68k 1/16W 5%
R0719	0662057A93	68k 1/16W 5%
R0721	0662057A73	10k 1/16W 5%
R0722	0662057A81	22k 1/16W 5%
R0723	0662057A89	47k 1/16W 5%
R0724	0662057A97	100k 1/16W
R0725	0662057A73	10k 1/16W 5%
R0731	0662057A81	22k 1/16W 5%
R0732	0662057A65	4k7 1/16W 5%
R0733	0662057A89	47k 1/16W 5%
R0734	0662057A65	4k7 1/16W 5%
R0735	0662057A73	10k 1/16W 5%
R0736	0662057A77	15k 1/16W 5%
R0738	0662057A89	47k 1/16W 5%
R0741	0662057A49	1k 1/16W 5%
R0742	0662057A49	1k 1/16W 5%
U0701	5183222M49	IC QUAD OPAMP __3403_
U0731	5113811G02	IC D/A CONV & BIT 4 CHAN W/SPI



336-390MHz Power Amplifier 5-25W Schematic Diagram

Power Amplifier 5-25W Parts List

Circuit Ref	Motorola Part No.	Description
C8501	2113740F27	10pF 5% 50V
C8502	2113741F49	10nF 50V
C8503	2113740F38	30pF 5% 50V
C8512	2113740F32	16pF 5% 50V
C8513	2113740F36	24pF 5% 50V
C8514	2113741A33	3.3nF 50V
C8521	2113740A36	20pF 5% 50V
C8522	2113741F49	10nF 50V
C8523	2113741F49	10nF 50V
C8524	2113741F25	1nF 50V
C8525	2113740A40	30pF 5% 50V
C8527	2113740A40	30pF 5% 50V
C8528	2113741F25	1nF 50V
C8529	2113740A40	30pF 5% 50V
C8530	2311049A01	TANT CP 100nF 10% 35V
C8531	2113741F49	10nF 50V
C8532	2113740A67	330pF 5% 50V
C8533	2111078B23	HQ 24pF 5%
C8534	2111078B31	HQ 36pF 5%
C8535	2113740A36	20pF 5% 50V
C8536	2111078B31	HQ 36pF 5%
C8537	2111078B31	HQ 36pF 5%
C8538	2113741A59	CL2
C8539	2111078B08	HQ 6.2pF 5%
C8541	2111078B32	HQ 39pF 5%
C8542	2111078B33	HQ 43pF 5%
C8543	2111078B31	HQ 36pF 5%
C8544	2111078B15	HQ 12pF 5%
C8546	2113741A33	3.3nF 50V
C8547	2111078B49	HQ 180pF 5%
C8548	2113741F49	10nF 50V
C8551	2111078B49	HQ 180pF 5%
C8552	2111078B16	HQ 13pF 5%
C8553	2111078B15	HQ 12pF 5%
C8554	2111078B080	HQ 6.2pF 5%
C8556	2113741F25	1nF 50V
C8558	2113740F20	5.1pF 5% 50V
C8600	2113740A67	330pF 5% 50V
C8602	2113740F51	100pF 5% 50V
C8603	2113741F25	1nF 50V
C8604	2311049A45	TANT CP 10uF 10% 35V
C8611	2113741F17	470pF 50V
C8612	2113741F49	10nF 50V
C8615	2113741F25	1nF 50V
C8617	2113740A67	330pF 5% 50V USD
C8618	2311049A08	TANT CP 1uF 10% 35V
C8619	2113740F51	100pF 5% 50V NP0
C8620	2113740F20	5.1pF 5% 50V
C8621	2113741F25	1nF 50V
C8622	2113741F49	10nF 50V
C8623	2113740F63	330pF 5% 50V
C8631	2113741F25	1nF 50V
C8632	2111078B42	CAP ALT E21
C8633	2113740F11	2.2pF 5% 50V
C8634	2113740F45	56pF 5% 50V
C8642	2113741F25	1nF 50V
D8551	4802482J02	DIODE PIN MA/COM
D8553	4880236E05	DIODE CHIP SCHOTTKY
D8601	4813832B35	DIODE TRANSORB
D8631	4802482J02	DIODE PIN MA/COM
J8501	0905901V02	CONNECTOR ANTENNA BNC
J8601	0905902V04	CONNECTOR POWER W/GASKET
L8501	2460591C23	SQUARE COIL 16nH 3T
L8503	2462587T38	COIL CHIP 22nH 5%
L8531	2460591C23	SQUARE COIL 16nH 3T
L8532	2484657R01	Ferrite Bead
L8533	2460591C23	SQUARE COIL 16nH 3T
L8534	2484657R01	Ferrite Bead
L8539	2460591M77	SQUARE COIL 38nH 4T
L8541	2460591X01	COIL SQUARE
L8542	2484657R01	Ferrite Bead
L8551	2460591X02	COIL SQUARE 25nH
L8552	2460591X02	COIL SQUARE 25nH
L8553	2460591X02	COIL SQUARE 25nH
L8600	2484657R01	Ferrite Bead
L8601	2484657R01	Ferrite Bead
L8611	2484657R01	Ferrite Bead
L3631	2462587T23	COIL CHIP 470nH
Q8510	4813827A26	TSTR RF NPN MRF8372
Q8520	4813827D13	TSTR 870MHZ PWR MACRO-X
Q8530	4813827A36	TSTR MRF 5003
Q8531	4813827A36	TSTR MRF 5003
Q8611	4813824A17	TSTR PNP 40V .2A
Q8612	4813824A10	TSTR NPN 40V .2A
Q8621	4813824A17	TSTR PNP 40V .2A
R8501	0662057C19	4R7 1/10W 5%
R8502	0662057A21	68 1/16W 5%
R8511	0662057A01	10 1/16W 5%
R8512	0662057A01	10 1/16W 5%
R8513	0662057A57	2k2 1/16W 5%
R8514	0662057C55	CHIP RES 150 0HMS 5%
R8515	0662057C44	51 1/10W 5%
R8522	0662057A49	1k 1/16W 5%
R8523	0662057A49	1k 1/16W 5%
R8525	0662057C19	4R7 1/10W 5%
R8527	0662057C19	4R7 1/10W 5%
R8528	0662057A89	47k 1/16W 5%
R8529	0662057A89	47k 1/16W 5%
R8531	0680194M01	10 1W 5%
R8532	0683962T51	120 1W 5%
R8535	0683962T51	120 1W 5%
R8541	0680194M01	10 1W 5%
R8550	0662057A73	10k 1/16W 5%
R8551	0662057A73	10k 1/16W 5%
R8552	0662057A18	51 1/16W 5%
R8553	0683962T51	120 1W 5%
R8611	0662057A73	10k 1/16W 5%
R8612	0662057A56	2k 1/16W 5%
R8613	0662057A49	1k 1/16W 5%
R8614	0662057A18	51 1/16W 5%
R8615	0662057A65	4k7 1/16W 5%
R8616	0680194M01	10 1W 5%
R8617	0680194M01	10 1W 5%
R8621	0662057A45	CHIP RES 680 OHMS 5%
R8623	0662057C19	4R7 1/10W 5%
R8624	0662057C19	4R7 1/10W 5%
R8641	0680149M02	THERMISTOR 100K @25
SH8501	2602642Y01	HEAT SPREADER



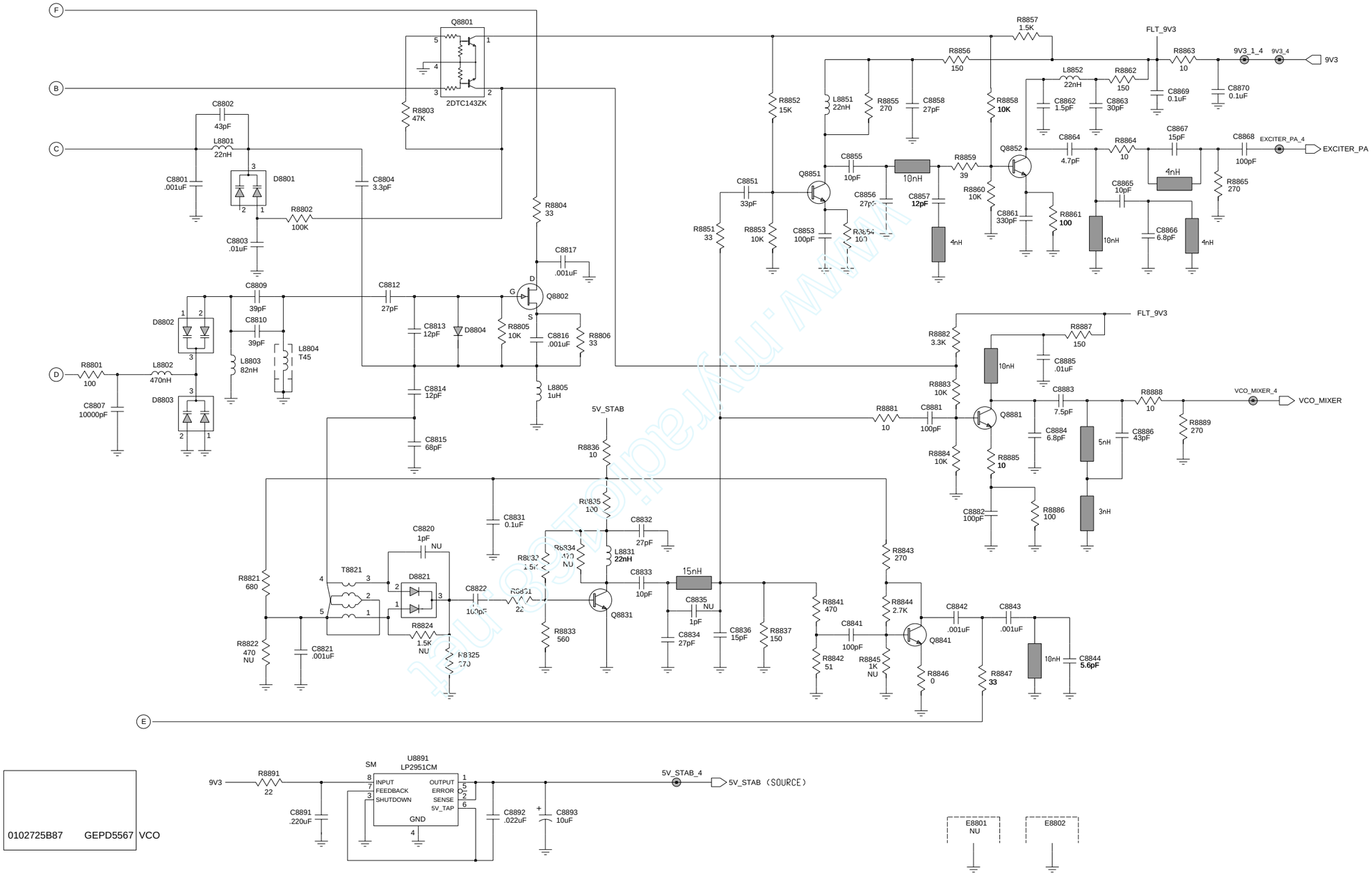
0102725B85	GEPD5565	12,5kHz channel spacing
0102725B86	GEPD5565	20/25kHz channel spacing
0102725B86	GEPD5566	20/25kHz channel spacing

REV:

336-390MHz Synthesizer Schematic Diagram

Synthesizer Parts List

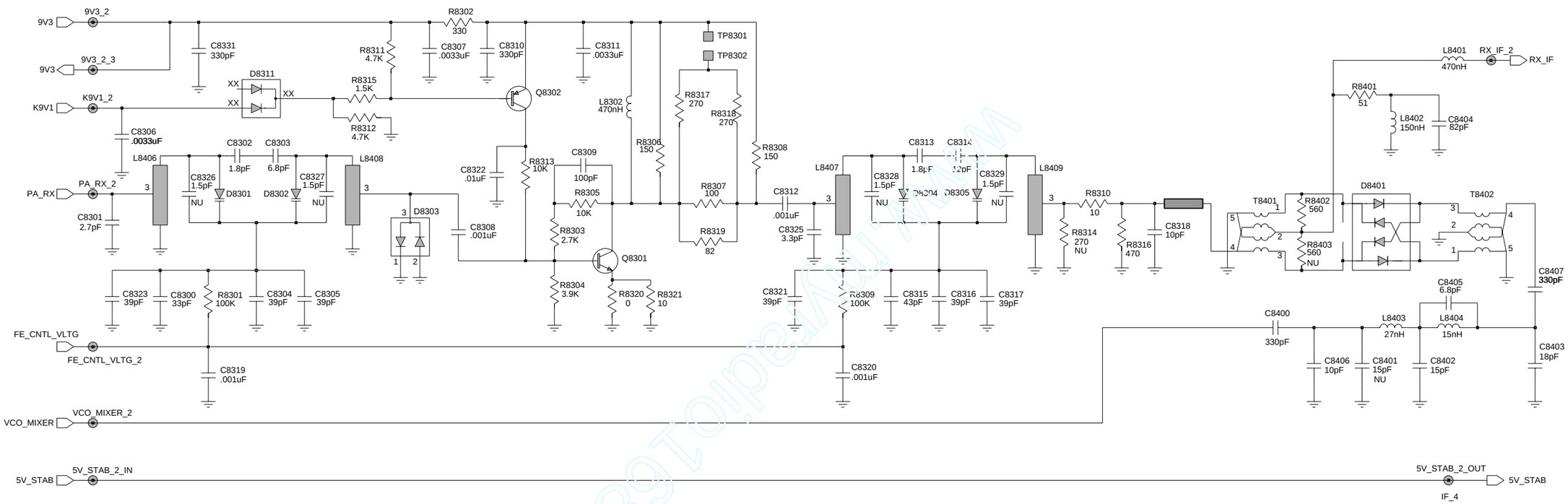
Circuit Ref	Motorola Part No.	Description
C8700	2113743K15	100nF 16V
C8701	2113740F51	100pF 5% 50V
C8702	2113741F13	330pF 50V
C8703	2113743K15	100nF 16V
C8704	2113741F49	10nF 50V
C8706	2113741F49	10nF 50V
C8707	2113741F49	10nF 50V
C8709	2113743K15	100nF 16V
C8711	2311049A63	TANT CP 10uF 10% 10V
C8712	2311049J26	TANT CP 10uF 20% 16V
C8713	2113741F25	1nF 50V
C8714	2113741F49	10nF 50V
C8715	2113740F39	33pF 5% 50V
C8716	2113743K15	100nF 16V
C8717	2113743K15	100nF 16V
C8718	2113743K15	100nF 16V
C8719	2311049A19	TANT CP 10uF 10% 25V
C8720	2113741F49	10nF 50V
C8721	2113741F49	10nF 50V
C8722	2311049A07	TANT CP 1uF 10% 16V
C8723	2109720D14	CER LOW DIST 100nF
C8725	2109720D14	CER LOW DIST 100nF
C8726	2113741F49	10nF 50V
C8727	0811051A19	MTLZ POLY 1uF 5%
D8701	4802233J09	DIODE TRIPLE SOT143-RH
E8701	2605915V01	SHLD PCB MOUNT 1
R8700	0662057B47	0 1/16W
R8701	0662057A35	270 1/16W 5%
R8702	0662057A35	270 1/16W 5%
R8703	0662057A49	1k 1/16W 5%
R8705	0662057A89	47k 1/16W 5%
R8708	0662057A01	10 1/16W 5%
R8711	0662057A15	39 1/16W 5%
R8712	0662057A59	2k7 1/16W 5%
R8713	0662057A59	2k7 1/16W 5% (12.5kHz)
R8714	0662057B02	150k 1/16W
R8715	0662057A41	470 1/16W 5%
R8716	0662057A47	820 1/16W 5%
R8717	0662057A25	100 1/16W 5%
R8718	0662057B16	560k 1/16W 5%
R8723	0662057A97	100k 1/16W
R8724	0662057B16	560k 1/16W 5%
U8701	5105457W72	CC QFP CONT FRAC-N 91W59
VR8701	4813830A23	10V 5% 20mA 350mW
Y8702	4809863M01	REF OSC 16.8 MHZ



336-390MHz Voltage Controlled Oscillator Schematic Diagram

Voltage Controlled Oscillator Parts List

Circuit Ref	Motorola Part No.	Description
C8801	2113741F25	1nF 50V
C8802	2113740F42	43pF 5% 50V
C8803	2113741F49	10nF 50V
C8804	2113740F17	3.9pF 5% 50V
C8807	2113741A45	CAP CHP 10nF 50V
C8809	2113740F41	39pF 5% 50V
C8810	2113740F41	39pF 5% 50V
C8812	2113740F37	27pF 5% 50V
C8813	2113740F31	15pF 5% 50V
C8814	2113740F29	12pF 5% 50V
C8815	2113740F47	68pF 5% 50V
C8816	2113741F25	1nF 50V
C8817	2113741F25	1nF 50V
C8821	2113741F25	1nF 50V
C8822	2113740F51	100pF 5% 50V
C8831	2113743K15	100nF 16V
C8832	2113740F37	27pF 5% 50V
C8833	2113740F27	10pF 5% 50V
C8834	2113740F37	27pF 5% 50V
C8836	2113740F31	15pF 5% 50V
C8841	2113740F51	100pF 5% 50V
C8842	2113741F25	1nF 50V
C8843	2113741F25	1nF 50V
C8844	2113740F21	5.6pF 5% 50V
C8851	2113740F39	33pF 5% 50V
C8853	2113740F51	100pF 5% 50V
C8855	2113740F27	10pF 5% 50V
C8856	2113740F37	27pF 5% 50V
C8857	2113740F29	12pF 5% 50V
C8858	2113740F37	27pF 5% 50V
C8861	2113741F13	330pF 50V
C8862	2113740F07	1.5pF 5% 50V
C8863	2113740F38	30pF 5% 50V
C8864	2113740F19	4.7pF 5% 50V
C8865	2113740F27	10pF 5% 50V
C8866	2113740F23	6.8pF 5% 50V
C8867	2113740F21	15pF 5% 50V
C8868	2113740F51	100pF 5% 50V
C8869	2113743K15	0.1uF
C8870	2113743K15	0.1uF
C8881	2113740F51	100pF 5% 50V
C8882	2113740F51	100pF 5% 50V
C8883	2113740F24	7.5pF 5% 50V
C8884	2113740F23	6.8pF 5% 50V
C8885	2113741F49	10nF 50V
C8886	2113740F42	43pF 5% 50V
C8891	2113743A23	220nF 16V
C8892	2113743E07	22nF 16V
C8893	2311049A63	10uF
D8801-D8803	4805649Q13	DIODE VCTR 1SV228 SOT23
D8804	4880236E05	DIODE CHIP SCHOTTKY
D8821	4805218N57	DIODE DUAL SCHOTTKY SOT23
E8802	2602641Y02	SHIELD VCO
L8801	2462587T38	COIL CHIP 22nH
L8802	2462587T23	COIL CHIP 470nH
L8803	2462587T14	COIL CHIP 82nH
L8804	0105950T45	COIL HELICAL MOLDED FIN .175
L8805	2462587T30	COIL CHIP 1uH
L8831	2462587T38	COIL CHIP 22nH 5%
L8851	2462587T38	COIL CHIP 22nH 5%
L8852	2462587T38	COIL CHIP 22nH 5%
Q8801	4805921T09	XSTR DUAL ROHM FMG8
Q8802	4813823A05	TSTR N-CH RF JFET MMBU310LT1
Q8831	4813827A07	TSTR NPN SML SIG MMBR9
Q8841	4813827A07	TSTR NPN SML SIG MMBR9
Q8851	4813827A07	TSTR NPN SML SIG MMBR9
Q8852	4813827A07	TSTR NPN SML SIG MMBR9
Q8881	4813827A07	TSTR NPN SML SIG MMBR9
R8801	0662057A25	100 1/16W 5%
R8802	0662057A97	100k 1/16W
R8803	0662057A89	47k 1/16W 5%
R8804	0662057A13	33 1/16W 5%
R8805	0662057A73	10k 1/16W 5%
R8806	0662057A13	33 1/16W 5%
R8821	0662057A45	680 OHMS 5%
R8825	0662057A35	270 1/16W 5%
R8831	0662057A09	22 1/16W 5%
R8832	0662057A53	1k5 1/16W 5%
R8833	0662057A43	560 1/16W 5%
R8835	0662057A25	100 1/16W 5%
R8836	0662057A01	10 1/16W 5%
R8837	0662057A29	150 1/16W 5%
R8841	0662057A41	470 1/16W 5%
R8842	0662057A18	51 1/16W 5%
R8843	0662057A35	270 1/16W 5%
R8844	0662057A59	2k7 1/16W 5%
R8846	0662057B47	0 1/16W
R8847	0662057A13	33 1/16W 5%
R8851	0662057A13	33 1/16W 5%
R8852	0662057A77	15k 1/16W 5%
R8853	0662057A73	10k 1/16W 5%
R8854	0662057A25	100 1/16W 5%
R8855	0662057A35	270 1/16W 5%
R8856	0662057A29	150 1/16W 5%
R8857	0662057A53	1k5 1/16W 5%
R8858	0662057A73	10k 1/16W 5%
R8859	0662057A15	39 1/16W 5%
R8860	0662057A73	10k 1/16W 5%
R8861	0662057A25	100 1/16W 5%
R8862	0662057A29	150 1/16W 5%
R8863	0662057A01	10 1/16W 5%
R8864	0662057A01	10 1/16W 5%
R8865	0662057A35	270 1/16W 5%
R8881	0662057A01	10 1/16W 5%
R8882	0662057A61	3k3 1/16W 5%
R8883	0662057A73	10k 1/16W 5%
R8884	0662057A73	10k 1/16W 5%
R8885	0662057A01	10 1/16W 5%
R8886	0662057A25	100 1/16W 5%
R8887	0662057A29	150 1/16W 5%
R8888	0662057A01	10 1/16W 5%
R8889	0662057A35	270 1/16W 5%
R8891	0662057A09	22 1/16W 5%
T8821	2505515V03	XFMR MIXER SMD 4:1
U8891	5105469E65	VLTG REGLTR LP2951C



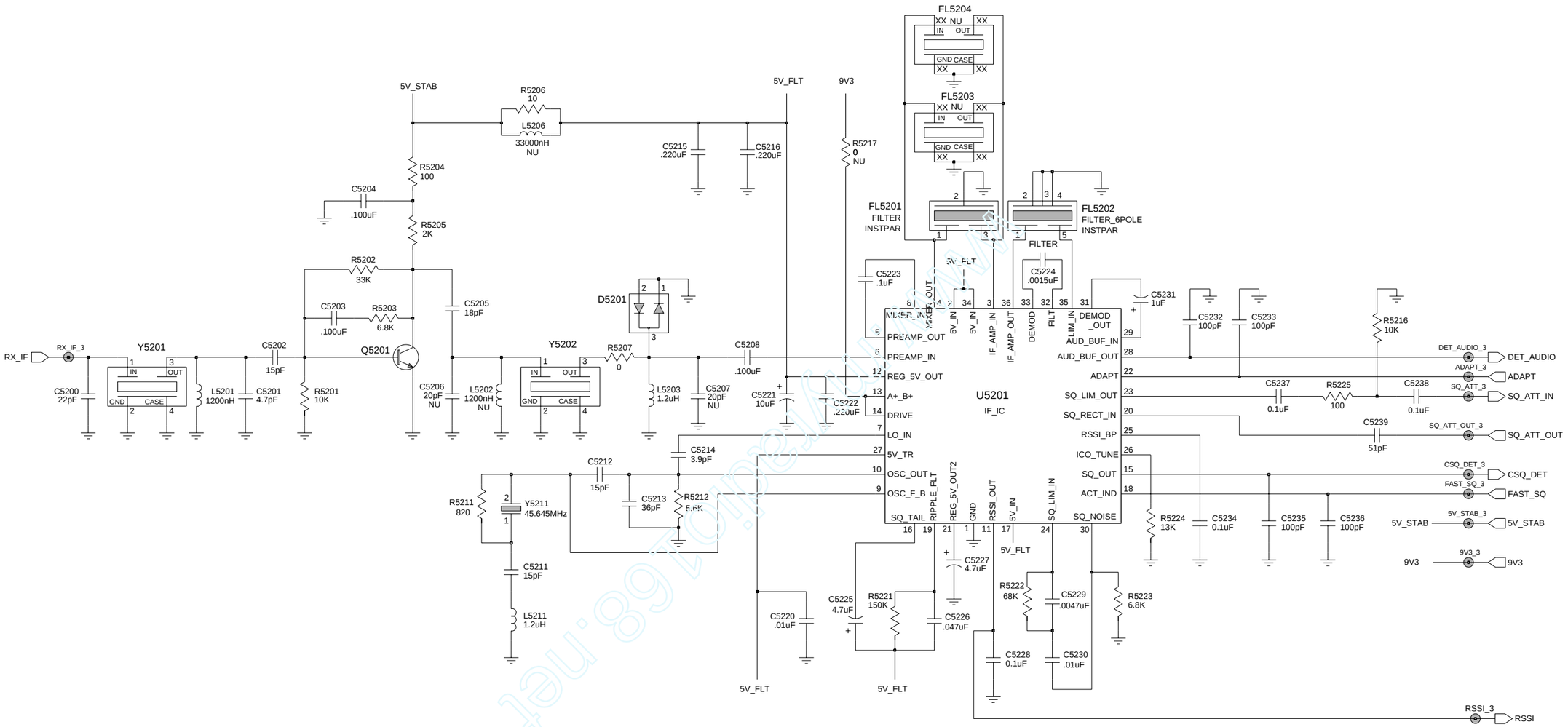
0102725B88 GEPD5526 Front End 336 - 390 MHz

E8301
NU

336-390MHz RX-FE Schematic Diagram

RX-FE Parts List

Circuit Ref	Motorola Part No.	Description
C8300	2113740F39	33pF 5% 50V
C8301	2113740F13	2.7pF 5% 50V
C8302	2113740F09	1.8pF 5% 50V
C8303	2113740F23	6.8pF 5% 50V
C8304	2113740F41	39pF 5% 50V
C8305	2113740F41	39pF 5% 50V
C8306	2113741F37	3.3nF 50V
C8307	2113741F37	3.3nF 50V
C8308	2113741F25	1nF 50V
C8309	2113740F51	100pF 5% 50V
C8310	2113741F13	330pF 50V
C8311	2113741F37	3.3nF 50V
C8312	2113741F25	1nF 50V
C8313	2113740F09	1.8pF 5% 50V
C8314	2113740F29	12pF 5% 50V
C8315	2113740F42	43pF 5% 50V
C8316	2113740F41	39pF 5% 50V
C8317	2113740F41	39pF 5% 50V
C8318	2113740F27	10pF 5% 50V
C8319	2113741F25	1nF 50V
C8320	2113741F25	1nF 50V
C8321	2113740F41	39pF 5% 50V
C8322	2113741F49	10uF 5% 50V
C8323	2113740F41	39pF 5% 50V
C8325	2113740F15	3.3pF 5% 50V
C8331	2113741F13	330pF 50V
C8400	2113740F63	330pF 5%
C8402	2113740F31	15pF 5% 50V
C8403	2113740F33	18pF 5% 50V
C8404	2113740F49	82pF 5% 50V
C8405	2113740F23	6.8pF 5% 50V
C8406	2113740F27	10pF 5% 50V
C8407	2113740F63	330pF 5%
D8301	4862824C01	DIODE VARACTOR
D8302	4862824C01	DIODE VARACTOR
D8303	4880154K03	DUAL SCHOTTKY SOT23
D8304	4862824C01	DIODE VARACTOR
D8305	4862824C01	DIODE VARACTOR
D8311	4813833C02	DIODE DUAL SOT MMBD6100
D8401	4880174R01	DIODE QUAD SOIC 8 PIN
L8302	2462587T23	COIL CHIP 470nH
L8401	2462587T23	COIL CHIP 470nH
L8402	2462587T17	COIL CHIP 150nH
L8403	2462587N46	IND Chip 27.0 N 5%
L8404	2462587N43	IND Chip 15.0 N 5%
Q8301	4813827A07	TSTR NPN SML SIG MMBR9
Q8302	4813824A17	TSTR PNP 40V .2A GENP B =100-300
R8301	0662057A97	100k 1/16W
R8302	0662057A37	330 1/16W 5%
R8303	0662057A59	2k7 1/16W 5%
R8304	0662057A63	3k9 1/16W 5%
R8305	0662057A73	10k 1/16W 5%
R8306	0662057A29	150 1/16W 5%
R8307	0662057A25	100 1/16W 5%
R8308	0662057A29	150 1/16W 5%
R8309	0662057A97	100k 1/16W
R8310	0662057A01	10 1/16W 5%
R8311	0662057A65	4700 1/16W 5%
R8312	0662057A65	4700 1/16W 5%
R8313	0662057A73	10k 1/16W 5%
R8315	0662057A53	1500 1/16W 5%
R8316	0662057A41	470 1/16W 5%
R8317	0662057A35	270 1/16W 5%
R8318	0662057A35	270 1/16W 5%
R8319	0662057A23	82 1/16W 5%
R8320	0662057C01	0 1/10W 5%
R8401	0662057A18	51 1/16W 5%
R8402	0662057A43	560 1/16W 5%
T8401	2505515V03	XFMR JEDI MIXER SMD 4:1
T8402	2505515V04	XMFR MIXER 5:1



0102725B89	GEPD5527	12,5kHz channel spacing
0102725B90	GEPD5528	20/25kHz channel spacing

336-390MHz RX-IF Schematic Diagram

RX-IF Parts List

Circuit Ref	Motorola Part No.	Description
C5200	2113740F35	22pF 5% 50V
C5201	2113740F19	4.7pF 5% 50V
C5202	2113740F31	15pF 5% 50V
C5203	2113743A19	100nF 16V X7R
C5204	2113743A19	100nF 16V X7R
C5205	2113740F33	18pF 5% 50V
C5208	2113743A19	100nF 16V
C5211	2113740F31	15pF 5% 50V
C5212	2113740F31	15pF 5% 50V
C5213	2113740F40	36pF 5% 50V
C5214	2113740F17	3.9pF 5% 50V
C5215	2113743A23	220nF 16V
C5216	2113743A23	220nF 16V
C5220	2113741F49	10nF 50V
C5221	2311049A63	TANT CP 10uF 10% 10V
C5222	2113743A23	220nF 16V
C5223	2113743E20	100nF 16V
C5224	2113741F29	1.5nF 50V
C5225	2311049J11	TANT CP 4.7uF 10% 16V
C5226	2113743K15	100nF 16V
C5227	2311049J11	TANT CP 4.7uF 10% 16V
C5228	2113743K15	100nF 16V
C5229	2113741F25	1nF 50V
C5230	2113741F49	10nF 50V
C5231	2311049A07	TANT CP 1uF 10% 16V
C5232	2113740F51	100pF 5% 50V
C5233	2113740F51	100pF 5% 50V
C5234	2113743K15	100nF 16V
C5235	2113740F51	100pF 5% 50V
C5236	2113740F51	100pF 5% 50V
C5237	2113743K15	100nF 16V
C5238	2113743K15	100nF 16V Y5V
C5239	2113740F44	51pF 5% 50V
D5201	4880154K03	Dual Schottky SOT23
FL5201	9180098D06	Filter CER 4-EL 455kHz
FL5202	9180097D06	Filter CER 6-EL 455kHz
L5201	2462587N69	CHIP IND 1200 NH
L5203	2483411T74	Inductor Chip Shielded
L5211	2483411T74	Inductor Chip Shielded
Q5201	4813827A07	NPN SML SIG MMBR9
R5201	0662057A73	10k 1/16W 5%
R5202	0662057A85	33k 1/16W 5%
R5203	0662057A69	6k8 1/16W 5%
R5204	0662057A25	100 1/16W 5%
R5205	0662057A56	2k 1/16W 5%
R5206	0662057A01	10 1/16W 5%
R5207	0662057B47	0 1/16W
R5211	0662057A47	820 1/16W 5%
R5212	0662057A67	5k6 1/16W 5%
R5216	0662057A69	6k8 1/16W 5%
R5221	0662057B05	200k 1/16W
R5222	0662057A93	68k 1/16W 5%
R5223	0662057A63	3k9 1/16W 5%
R5224	0662057A76	13k 1/16W 5%
R5225	0662057A61	3k3 1/16W 5%
U5201	5180207R01	IF IC
Y5201	9102652Y01	XTAL FLTR 45.1MHZ 20/25KHz 80dB
Y5202	9102652Y02	XTAL FLTR 45.1MHZ 20/25KHz 80dB
Y5211	4802653Y01	XTAL OSC 44.645MHZ

Appendix A

PL Codes

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1.0 PL Codes

The following PL Codes have been tested and are acceptable for programming into any transmit or receive frequency.

GROUP A		GROUP B		GROUP C	
Code	**Freq**	**Code**	**Freq**	**Code**	**Freq**
XZ	67.0	XA	71.9	WZ	69.3
XB	77.0	YZ	82.5	WA	74.4
YB	88.5	ZA	94.8	WB	79.7
1Z	100.0	1A	103.5	YA	85.4
1B	107.2	2Z	110.0	ZZ	91.5
2A	114.8	2B	118.8	ZB	97.4
3Z	123.0	3A	127.3	5B	162.2
3B	131.8	4Z	136.5	8Z	206.5
4A	141.3	4B	146.2		
5Z	151.4	5A	156.7		
6A	173.8	6Z	167.9		
7Z	186.2	6B	179.9		
M1	203.5	7A	192.8		
M3	218.1	M2	210.7		

Appendix B

Hand Held Control Head PMMN4005

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Appendix

Appendix B.1

Introduction/Theory of Operation

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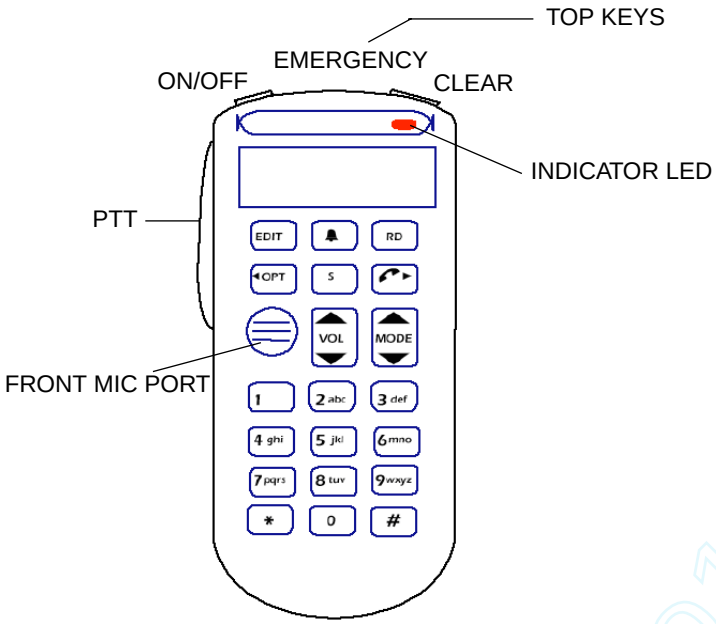
1.0 Overview

Hand Held Control Head PMMN4005



2.0 Theory of Operation

2.1 General

The Hand Held Control Head contains the microphone, 3 top buttons and 1 side button (PTT button) and 22 keypad buttons to operate the radio, several indicator Light Emitting Diodes (LED) and 7 icons of LCD Display to inform the user about the radio status and 10 character (5x7dot matrix) Liquid Crystal Display (LCD) for radio information e.g. channel number, unit or group address.

2.2 Power Supplies

The power supply to the HHCH is taken from the host radio's FLT A+ voltage via connector J0901 pin 8. This voltage is at battery level and is used for the voltage regulator (U0971), the indicator LEDs, the back light and to power up the radio via the On/Off button. The voltage regulator (U0971) provides the stabilized 5 volt source for the LCD driver, the shift register, inverter and the keypad buttons. The regulated output of U0971 is enabled by a low state and disabled by a high state at pin 3 (SHUTDOWN) to switch the HHCH circuits on and off. Input and output capacitors (C0972, C0975 and C0976) are used to reduce high frequency noise and provide proper operation during battery transients.

2.3 Power On / Off

The On/Off button when pressed switches the radio's voltage regulators on by pulling ON OFF CONTROL to high via D0971 and connects the base of Q0971 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. If the On/Off button is pressed and held while the radio is on, the software detects a low state on line ANALOG 3 and switches the radio off.

While the radio is switched on, the radio's controller enables the regulated output pin 1 of U0971 by setting line LED CE to high and in turn pulling input U0971-3 to ground by transistor Q0972. Line LED CE is also used to write data into the shiftregister U0983. After the serial write process line LED CE is set to low for a few microseconds to update the output of the shiftregister with the new data. The low - pass filtering provided by C0973 and R0974 filters out these small low periods and prevents disabling of the voltage regulator output.

2.4 PTT Button

The PTT function is achieved by pressing button S0901 which places a low on the PTT line to the radio, causing the radio to transmit.

2.5 ON/OFF Hook Control

When the HHCH is off-hook the monitor input (line HOOK; J0901_7) to the radio is open circuit. When the HHCH is placed on-hook the hang up clip shorts the TP0901 and TP0902 terminals which takes the monitor input to ground, indicating to the radio that the microphone is on-hook. Diode VR0922 and C0922, C0923 provide Electro Static Discharge (ESD) and Radio Frequency Interference (RFI) protection.

2.6 Keypad and Top Keys

The HHCH keypad has 22 keys, plus 3 additional top keys, the on/off key being one of them, which are located on the top of the HHCH.

All keys of the keypad are configured as 2 analogue lines (ANALOG_1 & ANALOG_2) to the radio. The microprocessor in the mobile radio will compare the voltage when any one of the keypad row or keypad column keys is being pressed. The microprocessor will then sample the Analog to Digital voltages at the keypad row and keypad column and map it with the table (shown as below) so that the key being pressed can be identified. Once the key has been identified, the message that corresponds to the key will show up at the display.

ANALOG_2 /V ANALOG_1 /V	(C1) 0	(C2) 1.21	(C3) 2.31	(C4) 3.29	(C5) 4.18
(R1) 0			S13 (EDIT)	S14 (Alarm)	S15 (RD)
(R2) 1.21	S21 (<OPT)	S22 (S)	S23 (Phone)	S24 (Vol ^)	S25 (Mode ^)
(R3) 2.31	S31 (1)	S32 (2)	S33 (3)	S34 (Vol ∨)	S35 (Mode ∨)
(R4) 3.29	S41 (4)	S42 (5)	S43 (6)	S44 (8)	S45 (9)
(R5) 4.18	S51 (7)	S52 (*)	S53 (0)	S54 (#)	

Normally, the ANALOG_1 and ANALOG_2 is 5V (without pressing any key)

The three top keys are configured to ANALOG_3 to the radio. The voltage on the analogue lines depends on which key is pressed. (0V for ON/OFF Button, 1.31V for EMG Button and 2.55V for CLR Button).

The voltages of these lines (ANALOG _1, 2 & 3) are A/D converted inside the microprocessor on the mobile radio and are used to specify the pressed button.

2.7 Status LED and Back Light Circuit

All the indicator LEDs (2) and the back light LEDs (18) are driven by current sources Q0982 – Q0985 and controlled by the microprocessor in mobile radio via SERIAL PERIPHERAL INTERFACE (SPI). Shift Register U0983 stores the LED status. To update the LED status line LED CLCK BUF shifts the data of line SPI DATA BUF into the Shift Register. When all the data has been written, line LED CD is set to low for a few microseconds to update the output of the Shift Register with the new data.

2.8 Liquid Crystal Display (LCD)

The LCD display is a 10 character 5 X 7 dot matrix display which incorporates 7 icons. Data is loaded serially into the display driver U0951 via the SPI interface. The display data of line SPI DATA BUF is shifted by clock signal LCD CLCK BUF. When the last bit has been received, the LCD display is updated.

2.9 Microphone Amplifier

The microphone cartridge contains a capacitive transducer coupled to a FET amplifier. The microphone's audio signal is fed from the microphone inputs, MIC+ and MIC-, at J0903 to the microphone amplifier. The microphone amplifier sets the frequency response and amplifies the audio signal to the required radio input level (about 80mV at nominal sound pressure level). The first stage (Q0902 connected to the microphone is an active high-pass filter which suppresses frequency components below 300 Hz to prevent PL falsing in a receiving radio. The collector current of Q0902, drawn from the collector of the following stage Q0901, is approximately 0.27 mA. A low pass filter composed of R0904 and C0907, C0908 filters out any audio frequency components riding on this voltage. The output of the first stage is fed via R0906 to the second stage (Q0901) which amplifies the audio signal to the radio's input level. The supply voltage of the stage is provided by the radio's 9V3 voltage regulator via the load resistor (1k ohm) located on the radio's controller section, line MIC and connector J0901 pin 12. Q0901 draws a collector current of 2 mA. The collector AC current of Q0901 causes a voltage drop across the load resistor representing the audio signal from the microphone.

2.10 Connections to the Radio

Interconnections between the HHCH and the host radio are via an expanding cable which is permanently connected to the HHCH. The cable has an 18 pin Molex connector which connects to connector P0951 in the blank head of the host radio. P0951 is mounted on an adapter PCB. After additional filtering the signals are fed to the host radio's main PCB via connector J0950, also located on the adapter PCB, a flexible ribbon cable and connector J0101. The connections between the PCB in the HHCM and the main PCB in the radio are shown in the following table:

Radio	Adapter	PCB	Cable	HHCH	Description
J0101	J0950	P0951	Connector	J0901	
1	18	18	1	-	INT SPKR+ (NU)
2	17	17	2	-	INT SPKR- (NU)
13	6	16	3	14	ANALOG 3
4	15	15	4	13	PTT
10	9	9	10	3	ANALOG 1
11	8	8	11	5	ANALOG 2
17	2	4	15	8	FLT A+
18	1	1	18	2	ON OFF CONTROL
8	11	14	5	11	LCD CLCK BUF
6	13	13	6	10	SPI DATA BUF
5	14	3	16	1	LED CLCK BUF
7	12	12	7	15	GND
16	3	10	9	12	MIC
3	16	6	13	7	HOOK
12	7	7	12	9	LED CE

2.11 Electrostatic Transient Protection

Electrostatic transient protection is provided for the sensitive components in the HHCM by diodes VR0901, VR0921, VR0922, VR0924 - VR0929. The diodes limit any transient voltages to tolerable levels. The associated capacitors provide Radio Frequency Interference (RFI) protection.

Appendix B.2

PCB/Schematic Diagram and Parts List

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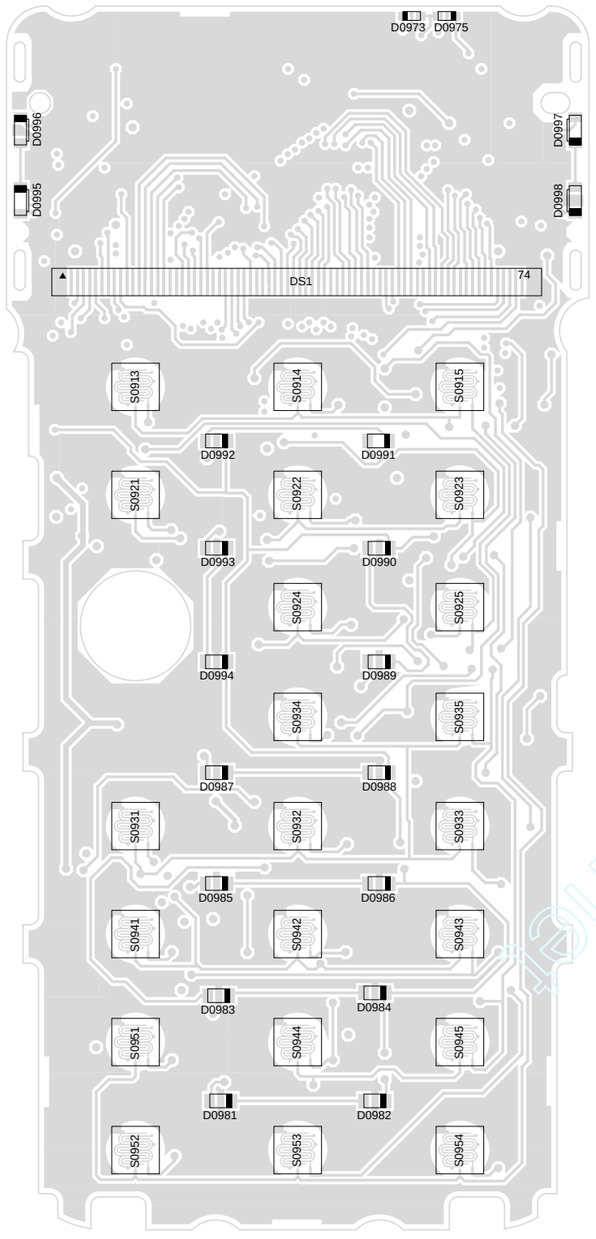
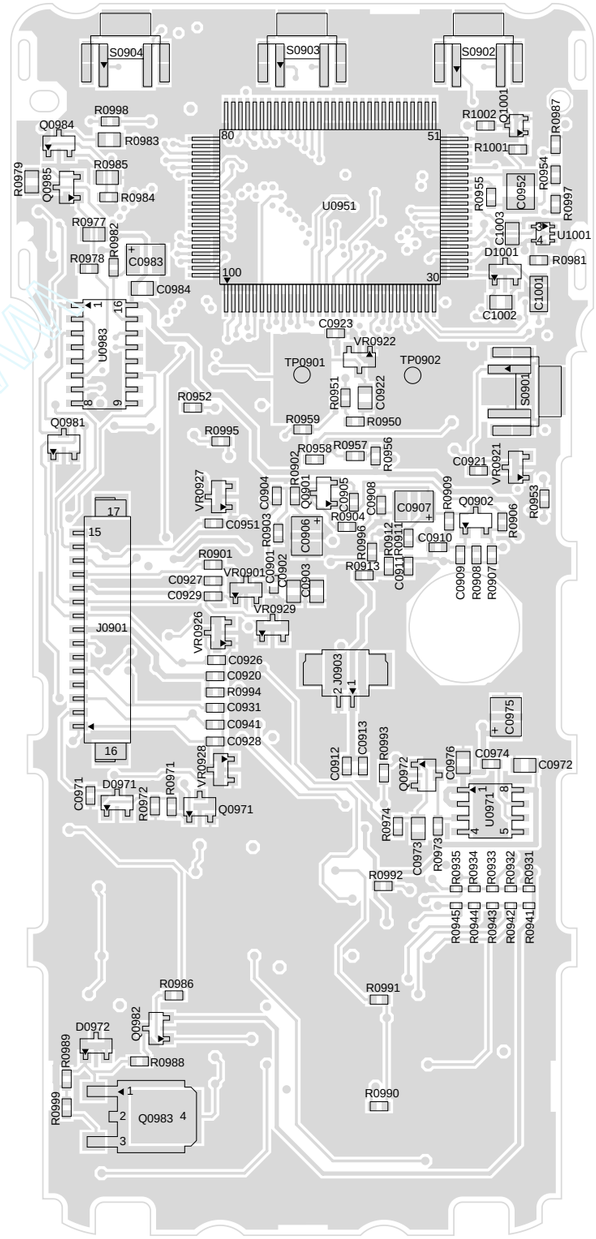


Component Side

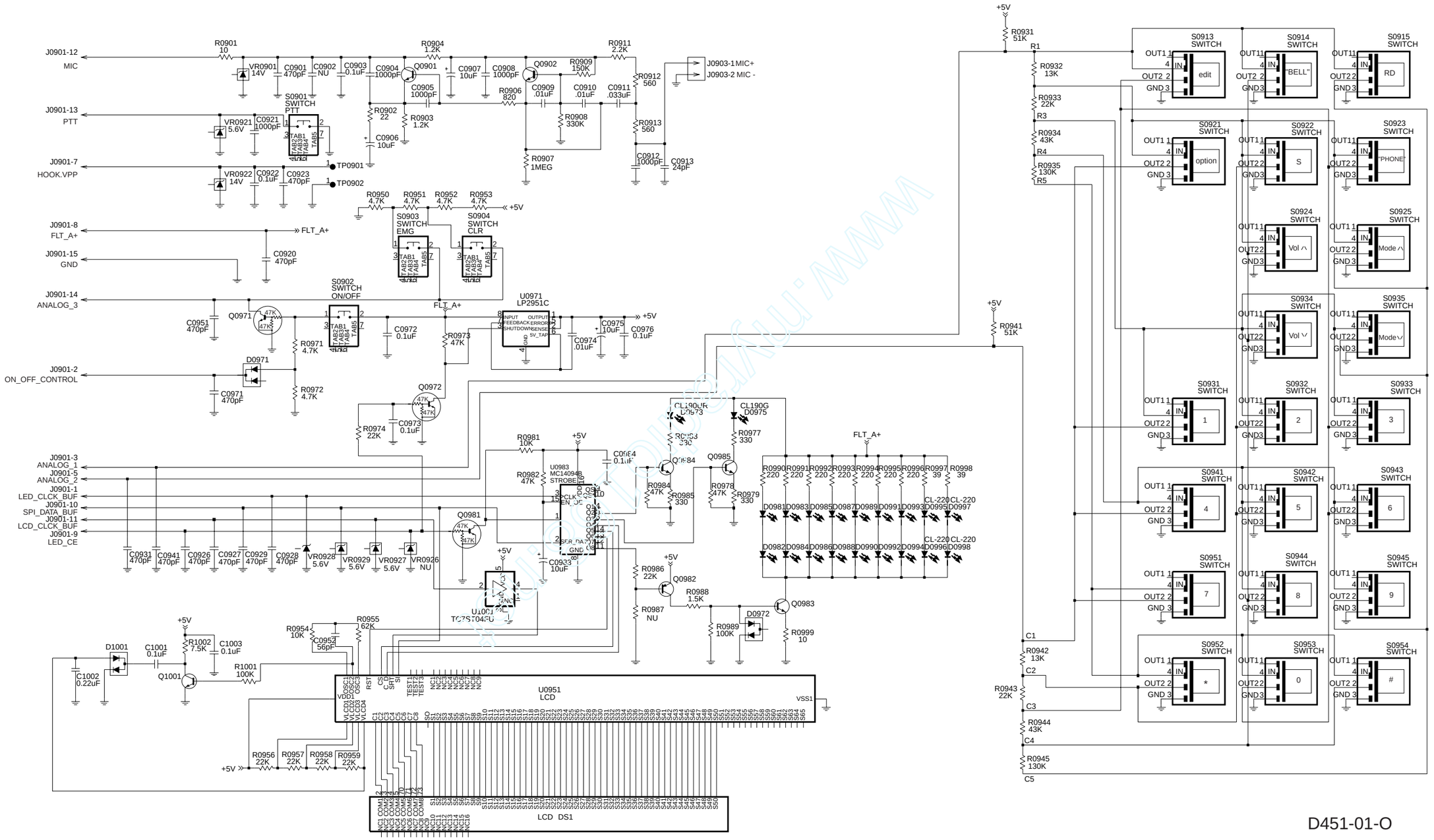
D451-02-O



Solder Side

D451-03-O

Hand Held Control Head PMMN4005
PCB No. 8485770Z01



D451-01-O

Hand Held Control Head Schematic Diagram

Hand Held Control Head Parts List

Circuit Ref	Motorola Part No.	Descritpion
C0901	2113741F17	470pF 50V
C0903	2113743A19	100nF 16V
C0904	2113741F25	1nF 50V
C0905	2113741F25	1nF 50V
C0906	2311049A63	TANT CP 10µF 10% 10V
C0907	2311049A63	TANT CP 10µF 10% 10V
C0908	2113741F25	1nF 50V
C0909	2113741F49	10nF 50V
C0910	2113741F49	10nF 50V
C0911	2113743E10	33nF 10%
C0912	2113741F25	1nF 50V
C0913	2113740F36	24pF 5% 50V
C0920	2113741F17	470pF 50V
C0921	2113741F25	1nF 50V
C0922	2113743A19	100nF 16V
C0923	2113741F17	470pF 50V
C0926	2113741F17	470pF 50V
C0927	2113741F17	470pF 50V
C0928	2113741F17	470pF 50V
C0929	2113741F17	470pF 50V
C0931	2113741F17	470pF 50V
C0941	2113741F17	470pF 50V
C0951	2113741F17	470pF 50V
C0952	2111078B36	56pF 100V
C0971	2113741F17	470pF 50V
C0972	2113743A19	100nF 16V
C0973	2113743A19	100nF 16V
C0974	2113741F49	10nF 50V
C0975	2311049A63	TANT CP 10µF 10% 10V
C0976	2113743A19	100nF 16V
C0983	2311049J23	TANT CP 10uF 10% 6V
C0984	2113743A19	100nF 16V
C1001	2109720D14	0.1uF 16V
C1002	2113743F08	0.22uF 16V
C1003	2113743A19	100nF 16V
D0971	4813833C02	DUAL SOT MMBD6100
D0981-D0994	4805729G75	LED SMT GREEN HP
D0972	4813833C05	BAV 99
D0973	4805729G81	RED LED 29G81
D0975	4805729G83	GREEN LED 29G83
D0995-D0998	4805729G85	LED SMT GREEN CL 220
D1001	4813833C05	BAV 99
DSI	7285773Z01	LCD DISPLAY
J0901	2809926G05	CONN 1.25MM 15PIN
J0903	2809926G01	CONN 1.25MM 2PIN
Q0901	4813824A10	NPN 40V .2A B=50-150
Q0902	4813824A10	NPN 40V .2A B=50-150
Q0971	4880048M01	NPN DIG 47k/47k
Q0972	4880048M01	NPN DIG 47k/47k
Q0981	4880048M01	NPN DIG 47k/47k
Q0982	4805128M16	PNP MMBT 3906
Q0983	4805780V01	NPN MJD 200
Q0984	4813824A10	NPN 40V .2A B=50-150
Q0985	4813824A10	NPN 40V .2A B=50-150
Q1001	4805218N63	NPN BFQ 67W
R0901	0662057A01	10 1/16W 5%
R0902	0662057A09	22 1/16W 5%
R0903	0662057A51	1k2 1/16W 5%
R0904	0662057A51	1k2 1/16W 5%
R0906	0662057A47	820 1/16W 5%
R0907	0662057B22	1MEG 1/16W 5%
R0908	0662057B10	330k 1/16W 5%
R0909	0662057B02	150k 1/16W
R0911	0662057A57	2k2 1/16W 5%
R0912	0662057A43	560 1/16W 5%
R0913	0662057A43	560 1/16W 5%
R0931	0662057V20	51k 1/16W 1%
R0932	0662057V05	13k 1/16W 1%
R0933	0662057V11	22k 1/16W 1%
R0934	0662057V18	43k 1/16W 1%
R0935	0662057V30	130k 1/16W 1%
R0941	0662057V20	51k 1/16W 1%
R0942	0662057V05	13k 1/16W 1%
R0943	0662057V11	22k 1/16W 1%
R0944	0662057V18	43k 1/16W 1%
R0945	0662057V30	130k 1/16W 1%
R0950-R0953	0662057A65	4.7k 1/16W 5%
R0954	0662057A73	10k 1/16W 5%
R0955	0662057A92	62k 1/16W 5%
R0956-R0959	0662057A81	22k 1/16W 5%
R0971	0662057A65	4k7 1/16W 5%
R0972	0662057A65	4k7 1/16W 5%
R0973	0662057A89	47k 1/16W 5%
R0974	0662057A81	22k 1/16W 5%
R0977	0662057C63	330 1/10W 5%
R0978	0662057A89	47k 1/10W 5%
R0979	0662057C63	330 1/10W 5%
R0981	0662057A73	10k 1/16W
R0982	0662057A89	47k 1/16W 5%
R0983	0662057C63	330 1/10W 5%
R0984	0662057A89	47k 1/16W 5%
R0985	0662057C63	330 1/10W 5%
R0986	0662057A81	22k 1/16W 5%
R0988	0662057A53	1.5k 1/16W 5%
R0989	0662057A97	100k 1/16W 5%
R0990-R0996	0662057A33	220 1/16W 5%
R0997	0662057A15	39k 1/16W 5%
R0998	0662057A15	39k 1/16W 5%
R0999	0662057A01	10 1/16W 5%
R1001	0662057A97	100K 1/16W 5%
R1002	0662057A70	7.5K 1/16W 5%
S0901-S0904	4005840X02	SWITCH
U0951	5102463J71	LCD DRIVER MSM9005
U0971	5105469E65	IC VLTG REGLTR LP2951C
U0983	5113806A35	MC14094, REG, 8-STAGE,SHIFT/STORE
U1001	5102463J61	INVERTER TC7ST04FU
VR0901	4813830A27	DIODE 14V 5% 225mW
VR0921	4813830A15	DIODE 5.6V 5% 225mW
VR0922	4813830A27	DIODE 14V 5% 225mW
VR0927	4813830A15	DIODE 5.6V 5% 225mW
VR0928	4813830A15	DIODE 5.6V 5% 225mW
VR0929	4813830A15	DIODE 5.6V 5% 225mW

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