MOTOROLA

Portable Radiotelephones 136 - 174 & 403 - 470 MHz Technical Manual

- GP900
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LIST OF MODELS

CONVENTIONAL SYSTEMS RADIOS GP900 / HT1100 Model Family, Closed Architecture Controller					
Model Number	**Frequency Range**	**Power Level**	**Physical Package**	**Ch. Spacing**	**No. of Freq.**
H01KDC9AN1AN	136-174 MHz	1-5 Watts	No keypad	12.5/20/25 kHz	2
H01KDC9AN3AN	136-174 MHz	1-5 Watts	No keypad	12.5/20/25 kHz	16
H01KDG9AN1AN	136-174 MHz	1-5 Watts	3x5 keypad	12.5/20/25 kHz	2
H01KDG9AN3AN	136-174 MHz	1-5 Watts	3x5 keypad	12.5/20/25 kHz	16
H01RDC9AN1AN	403-470 MHz	1-4 Watts	No keypad	12.5/20/25 kHz	2
H01RDC9AN3AN	403-470 MHz	1-4 Watts	No keypad	12.5/20/25 kHz	16
H01RDG9AN1AN	403-470 MHz	1-4 Watts	3x5 keypad	12.5/20/25 kHz	2
H01RDG9AN3AN	403-470 MHz	1-4 Watts	3x5 keypad	12.5/20/25 kHz	16

MT2100 Model Family, Open Architecture Controller					
Model Number	**Frequency Range**	**Power Level**	**Physical Package**	**Ch. Spacing**	**No. of Freq.**
H01KDD4AN4AN	136-174 MHz (CEPT)	1-5 Watts	6 character top display	12.5 kHz	16/32
H01KDD4AN5AN	136-174 MHz (CEPT)	1-5 Watts	6 character top display, continuous rotary	12.5 kHz	16/250
H01KDH4AN7AN	136-174 MHz (CEPT)	1-5 Watts	14 character front display, 3x5 keypad	12.5 kHz	250
H01KDH4AN8AN	136-174 MHz (CEPT)	1-5 Watts	14 character front display, 3x5 keypad, continuous rotary	12.5 kHz	250
H01KDD9AN4AN	136-174 MHz (ETS300)	1-5 Watts	6 character top display	12.5/20/25 kHz	16/32
H01KDD9AN5AN	136-174 MHz (ETS300)	1-5 Watts	6 character top display, continuous rotary	12.5/20/25 kHz	16/250
H01KDH9AN7AN	136-174 MHz (ETS300)	1-5 Watts	14 character front display, 3x5 keypad	12.5/20/25 kHz	250
H01KDH9AN8AN	136-174 MHz (ETS300)	1-5 Watts	14 character front display, 3x5 keypad, continuous rotary	12.5/20/25 kHz	250
H01RDD4AN4AN	403-470 MHz (CEPT)	1-4 Watts	6 character top display	12.5 kHz	16/32
H01RDD4AN5AN	403-470 MHz (CEPT)	1-4 Watts	6 character top display, continuous rotary	12.5 kHz	16/250
H01RDH4AN7AN	403-470 MHz (CEPT)	1-4 Watts	14 character front display, 3x5 keypad	12.5 kHz	250
H01RDH4AN8AN	403-470 MHz (CEPT)	1-4 Watts	14 character front display, 3x5 keypad, continuous rotary	12.5 kHz	250
H01RDD9AN4AN	403-470 MHz (ETS300)	1-4 Watts	6 character top display	12.5/20/25 kHz	16/32
H01RDD9AN5AN	403-470 MHz (ETS300)	1-4 Watts	6 character top display, continuous rotary	12.5/20/25 kHz	16/250
H01RDH9AN7AN	403-470 MHz (ETS300)	1-4 Watts	14 character front display, 3x5 keypad	12.5/20/25 kHz	250
H01RDH9AN8AN	403-470 MHz (ETS300)	1-4 Watts	14 character front display, 3x5 keypad, continuous rotary	12.5/20/25 kHz	250

PRIVATE SYSTEMS RADIOS MTS2000 Model Family					
Model Number	**Frequency Range**	**Power Level**	**Physical Package**	**Ch. Spacing**	**No. of Freq.**
H01KDD9PW1BN	136-174 MHz	1-5 Watts	6 character top display	12.5/20/25 kHz	16/250
H01KDF9PW1BN	136-174 MHz	1-5 Watts	14 character front display, 3x2 keypad	12.5/20/25 kHz	16/250
H01KDH9PW1BN	136-174 MHz	1-5 Watts	14 character front display, 3x5 keypad	12.5/20/25 kHz	250
H01RDD9PW1BN	403-470 MHz	1-4 Watts	6 character top display	12.5/20/25 kHz	16/250
H01RDF9PW1BN	403-470 MHz	1-4 Watts	14 character front display, 3x2 keypad	12.5/20/25 kHz	16/250
H01RDH9PW1BN	403-470 MHz	1-4 Watts	14 character front display, 3x5 keypad	12.5/20/25 kHz	250

MPT SHARED SYSTEMS RADIOS PTX1200/GP1200 Model Family, Open Architecture Controller					
Model Number	**Frequency Range**	**Power Level**	**Physical Package**	**Ch. Spacing**	**No. of Freq.**
H01KDH9CK7BN	136-174 MHz (ETS300)	1-5 Watts	14 character front display, 3x5 keypad	12.5 kHz	N.A.
H01KDD9CK4AN	136-174 MHz (ETS300)	1-5 Watts	No keypad	12.5 kHz	N.A.
H01RDH9CK7BN	403-470 MHz (ETS300)	1-4 Watts	14 character front display, 3x5 keypad	12.5 kHz	N.A.
H01RDD9CK4AN	403-470 MHz (ETS300)	1-4 Watts	No keypad	12.5 kHz	N.A.

SERVICE POLICY

This family of portable radios uses manufacturing technologies that requires a different maintenance and service strategy than used today. The high complexity radio and controller circuitry is built on multi-layer boards with surface mounted components. This manufacturing technology is relatively cheap and gives high quality which drastically will reduce the repair cycle time for customers, and also reduce the spare part inventory which will consist of boards and accessory items only.

The high Mean Time Between Failure (MTBF) means that maintenance and service is based on a "Field Replaceable Unit" (FRU) strategy.

Defective FRUs will be returned to a central repair shop in the factory for evaluation. The defective FRUs will, during the warranty period (one year), be exchanged with factory produced boards at special exchange prices. The advantage is fast feedback of quality problems to the manufacturing plant, maintain a high level of repair quality, and fulfill the customer satisfaction program for quality repairs.

MOTOROLA SERVICE SHOPS/DEALERS AND NATIONAL SERVICE CENTERS

The Motorola Service Shop/Dealer will perform a failure diagnosis of the radio to find the defective board and then swap the board while the customer is waiting. The radio software personality will be copied and reprogrammed by means of the RSS. The repair policy is as detailed in the Maintenance and Repair Procedures.

The swap strategy implies that the service shop/dealer will hold a stock of spare boards. Field Replaceable Units which are software programmable, will be preprogrammed with the firmware when shipped from the factory repair shop, leaving only programming of the radio personality to be done by the shop or dealer. Spare accessories, ordered from Parts, will be held by the shop/dealer in the normal way.

The National Service Centre (NSC) will receive defective boards from local service shops/dealers, attach a tag with the fault description/symptom, and send them to the factory repair shop for exchange.

THE FACTORY REPAIR SHOP

The returned Field Replaceable Units will be replaced by new boards during the warranty period. Defective boards will be investigated by factory quality engineers for evaluation of repair possibilities. Normally, defective boards will be scrapped after technical investigation and registration. The factory will deliver new boards corresponding to received boards to the National Service Centers.

MAINTENANCE AND REPAIR PROCEDURES

THE USER

The user/customer performs normal preventive maintenance as described in the radio user guide. Defective radios are delivered to the dealer or Motorola Service Shop.

MOTOROLA SERVICE SHOP/DEALER SERVICE PROCEDURES

The Motorola Service Shop/Dealer is responsible for warranty repairs, initial trouble-shooting, minor mechanical repairs, board swapping, RSS programming and replacing of defective accessories.

SAFETY INFORMATION

During normal use, this radio will subject you to radio energy substantially below the level where any kind of harm is reported.

- **DO NOT** however hold the radio with the antenna very close to, or touching exposed parts of the body, especially the face or eyes, while transmitting. The radio will perform best if the microphone is 5 to 8 cm away from the mouth and the radio is vertical.
- **DO NOT** hold the transmit (PTT) key in when not actually desiring to transmit.
- **DO NOT** operate the radio near unshielded electrical blasting caps or in an explosive atmosphere.
- **DO NOT** dispose of the battery on a fire as it may explode.

Computer Software Copyrights

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RECOMMENDED AND REQUIRED TEST EQUIPMENT, SERVICE AIDS, AND TOOLS LIST

RECOMMENDED TEST EQUIPMENT

The list of equipment contained in the table below includes all of the standard test equipment required for servicing two-way portable 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.

MODEL NUMBER	DESCRIPTION	CHARACTERISTICS	APPLICATION
R2000 Series	System Analyzer	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	1 mV to 300 V, 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, 300 W	Transmitter power output measurements
R1065A	Load Resistor	10-watt Broadband	For use with Wattmeter
S1339A	RF Millivolt Meter 10 kHz to 1.2 GHz	100 µV to 3 V rf	RF level measurements
*R1013A	SINAD Meter		Receiver sensitivity measurements
S1347D or S1348D (programmable)	DC Power Supply	0-20 Vdc, 0-5 Amps	Bench supply for 7.5 Vdc current limited

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

Recommended Test Equipment

SERVICE AIDS AND RECOMMENDED TOOLS

Refer to the "SERVICE AIDS" and "RECOMMENDED TOOLS LIST" for a listing and description of the service aids and tools designed specifically for servicing the radio, as well as the more common tools required to disassemble and properly maintain the radio.

These kits and/or parts are available from Motorola.

FIELD PROGRAMMING

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

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

PART NUMBER	DESCRIPTION	APPLICATION
RKN4035A	RIB/Radio/Test Box Cable	Connects radio to RTX-4005B test box and RIB.
RLN1014A	Battery Eliminator	Interconnects radio to power supply.
RLN4335A	Battery Eliminator	With cigarette lighter adapter.
RLN1018A	Test Fixture	Provides for test, troubleshooting and programming of the radio when the housing is removed.
RTX4005B or	Test Box	Enables connection to the universal connector.
GTF285A		Allows switching for radio testing.
RLN4008B	Radio Interface Box	Enables communications between the radio and the computer's serial communications adapter.
EPN4040A	Power Supply	Used to supply power to the RIB (240 VAC).
EPN4041A	Power Supply	Used to supply power to the RIB (220 VAC).
3080369B72	Computer Interface Cable	Connects the computer's serial communications adapter to the RIB.
3080369B71	Computer Interface Cable	Connects the computer's asynchronous communications adapter to the RIB.
RKN4036A	Cloning Cable	Allows a radio to be duplicated from a master radio by transferring programmed data from one radio to anoter (GP900/HT1100 models only)
GVN6007 GVN6008 GVN6009	MPT1327 1200 Series MPT1327 1200 Series MPT1327 1200 Series	Radio Service Software, 3 1/2" floppy disc, English Radio Service Software, 3 1/2" floppy disc, German Radio Service Software, 3 1/2" floppy disc, French
GVN6011 GVN6012 GVN6013 GVN6015	2100 Series 2100 Series 2100 Series 2100 Series	Radio Service Software, 3 1/2" floppy disc, English Radio Service Software, 3 1/2" floppy disc, German Radio Service Software, 3 1/2" floppy disc, French Radio Service Software, 3 1/2" floppy disc, Spanish
EVN4140 EVN4143 EVN4144 EVN4145	900/1100/Visar Series 900/1100/Visar Series 900/1100/Visar Series 900/1100/Visar Series	Radio Service Software, 3 1/2" floppy disc, English Radio Service Software, 3 1/2" floppy disc, German Radio Service Software, 3 1/2" floppy disc, French Radio Service Software, 3 1/2" floppy disc, Spanish
5880348B33	SMA to BNC Adaptor	Adapts radio's antenna port to BNC cabling of test equipment to measure RF power. RF power from the side connector is measured with a speaker/mic accessory.
RLN4201B	Battery Tester	Tests battery charge.
RLN4048B	Battery Tester Adaptor	Adapts radio batteries to the RLN4201 Battery Tester.
RKN4037A	Cable/clip	7.5 V for use with RLN4201 and RLN4048.

Service Aids

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

PART NUMBER	DESCRIPTION	APPLICATION
6680387A59	Extractor, 2 contact	Removal of discrete surface-mounted devices
6680387A64	Heat controller with safety stand, or	
6680387A65	Safety stand only	
0180382A31	Portable desoldering unit	
6680375A74	0.025 replacement tip, 5/pk	For 0180382A31 portable desoldering unit
0180386A81	Miniature digital readout soldering station (incl. 1/64" micropoint tip)	
0180386A78	Illuminated magnifying glass with lens attachment	
0180386A82	Anti-static grounding kit	Used during all radio assembly and disassembly procedures
6684253C72	Straight prober	
6680384A98	Brush	
1010041A86	Solder (RMA type), 63/37, 0.020" diameter-1 lb. spool	
1080370B43	RMA liquid flux	
R-1070A	Shields and surface-mounted component - IC removal/rework station (order all heat focus heads separately)	Removal of surface-mounted integrated circuits
HEAT FOCUS HEADS	**INSIDE DIMENSIONS OF HEADS**	**USED ON**
6680334B49	0.410" x 0.410"	U601, U702
6680334B50	0.430" x 0.430"	U4, U5, U713
6680334B51	0.492" x 0.492"	U3
6680334B52	0.572" x 0.572"	U701, U705
6680334B53	0.670" x 0.790"	* metal shields B, C, E, and F
6680370B51	0.475" x 0.475"	U204
6680370B54	0.710" x 0.710"	U710
6680370B57	0.245" x 0.245"	U2, U201
6680370B58	0.340" x 0.340"	U101, U102
6680370B66	0.180" x 0.180"	U101, U102
6680371B15	0.460" x 0.560"	* metal shields A, D, G, H, and I
6680371B74	0.470" x 0.570"	U203

* Refer to the SHIELDS LOCATION DETAIL and Shields Parts List in the rear of this manual to match the shield with the proper heat focus head

Recommended Test Tools

MAINTENANCE

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

PREVENTIVE MAINTENANCE

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

Inspection

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

Cleaning

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

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

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

a. Cleaning External Plastic Surfaces

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

b. Cleaning Internal Circuit Boards and Components

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

Alcohol is a high-wetting liquid and can carry contamination into unwanted places if an excessive quantity is used. Make sure that controls or tunable components are not soaked with the liquid. Do not use high-pressure air to hasten the drying process, since this could cause the liquid to puddle and collect in unwanted places.

Upon completion of the cleaning process, use a soft, absorbent, lintless cloth to dry the area. Do not brush or apply any isopropyl alcohol to the frame, front cover, or back cover.

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

SAFE HANDLING OF CMOS DEVICES

Complementary metal-oxide semiconductor (CMOS) devices are used in this family of radios. While the attributes of CMOS are many, their characteristics make them susceptible to damage by electrostatic or high voltage charges. Damage can be latent, resulting in failures occurring weeks or months later. Therefore, special precautions must be taken to prevent device damage during disassembly, troubleshooting, and repair. Handling precautions are mandatory for CMOS circuits, and are especially important in low humidity conditions. DO NOT attempt to disassemble the radio without first referring to the CMOS CAUTION paragraph in the Disassembly and Reassembly section of the manual.

GENERAL REPAIR PROCEDURES AND TECHNIQUES

Refer to the Disassembly and Reassembly section prior to replacing and substituting parts.

PARTS REPLACEMENT AND SUBSTITUTION

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

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

RIGID CIRCUIT BOARDS

This family of radios uses bonded, multi-layer, printed circuit boards. Since the inner layers are not accessible, some special considerations are required when soldering and unsoldering components. The printed-through holes may interconnect multiple layers of the printed circuit. Therefore, care should be exercised to avoid pulling the plated circuit out of the hole.

When soldering near the module socket pins, use care to avoid accidentally getting solder in the socket. Also, be careful not to form solder bridges between the module socket pins. Closely examine your work for shorts due to solder bridges. When removing modules with metal enclosures, be sure to desolder the enclosure ground tabs as well as the module pins.

FLEXIBLE CIRCUITS

The flexible circuits are made from a different material than the rigid boards, and different techniques must be used when soldering. Excessive prolonged heat on the flexible circuit can damage the material. Avoid excessive heat and excessive bending. For parts replacement, use the ST-1087 Temperature-Controlled Solder Station with a 600 or 700 degree tip, and use small diameter solder such as ST-633. The smaller size solder will melt faster and require less heat being applied to the circuit.

To replace a component on a flexible circuit, grasp the edge of the flexible circuit with seizers (hemostats) near the part to be removed, and pull gently. Apply the tip of the soldering iron to the component connections while pulling with the seizers. Do not attempt to puddle out components. Prolonged application of heat may damage the flexible circuit.

SPECIFIC REPAIR PROCEDURES AND TECHNIQUES

Refer to the Disassembly and Reassembly section prior to replacing and substituting parts.

JUMPER FLEX

Because the jumper flex solders to the RF board and the controller board much like a surface mounted component, similar cautions and procedures should be followed for repair and replacement of this part. To remove the jumper flex, use a heat-focus head or similar heat-spreading device to uniformly heat 20 flex feed-thru holes (jumper flex side) on either the controller board or the transceiver board. Hot air temperature should not exceed 450 degrees F.

Once all of the solder on the heated side is molten, lift the flex up gently, taking care not to peel runners from the rigid board due to unmelted solder joints. Repeat this same process for the 20 feed-through holes on the remaining circuit board.

On both circuit boards, reflow any remaining solder on the 20 pads to ensure that each pad has roughly the same amount of solder. Add or remove solder from individual pads as required. A small dome of solder needs to reside on each pad. A pad that appears very flat, as if little or no solder is present, should have additional solder added. Once the solder is distributed evenly, apply a small amount of flux to all the pads.

Align the new flex to the controller board using the alignment holes in the board and corresponding holes in the jumper flex. Using the same heat-focus head or similar heat-spreading device as used in desoldering the jumper flex, solder the jumper flex to the controller board first and to the transceiver board second. Apply gentle pressure on the top surface of the flex during heating to ensure that all the 20 tabs solder. The solder, wicking up through the flex feed-thru holes, is a visual indication that a good joint is being made. Some solder joints may need to be "touched-up." Reflow these joints using a small-tipped soldering iron, taking care not to burn the flex.

Before soldering the jumper flex to the transceiver board, it may be helpful to first insert both boards (controller and transceiver) into the chassis. Visually confirm alignment between the jumper flex and the transceiver board by ensuring that the mating pad on the transceiver board is visible through the flex's corresponding feed-thru holes. Repeat heating process as described above.

RF SWITCH (S101)

Refer to the applicable exploded view and to your radio's RF board (antenna contact area) to locate the RF switch components.

> ***Note:***
> *The RF switch spring and the RF switch piston must be ordered separately.*

To remove the RF switch:

(1) Use a #2 slotted screwdriver to straighten the two tabs of the RF switch bracket that wrap around the RF board. Use your forefinger to hold the RF switch bracket to the rf board while straightening the tabs to avoid lifting the solder tabs on the opposite end of the RF switch bracket.

(2) Refer to figure 1 and use a small heat-focus head

to distribute heat over the area occupied by the three solder tabs until the solder softens.

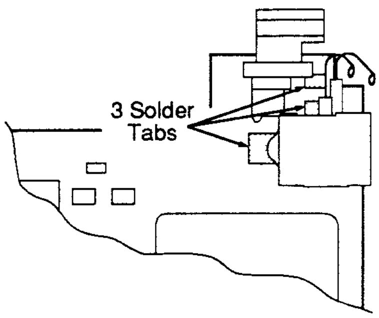


Figure 1.

(3) Carefully lift the RF switch assembly away from the RF board. Notice that the RF switch circuit board remains attached (soldered) to the RF board.

(4) Using the same heat-focus head as in step (3), unsolder the RF switch circuit board and remove it from the RF board using forceps.

(5) In the RF switch circuit board area, reflow all the solder pad areas on the main RF board such that similarly shaped pads have uniform solder heights. Add or remove solder as required. Clean the RF board thoroughly, then add a small dot of flux to each of the solder pads.

To replace the RF switch:

(1) Place the RF switch circuit board on the RF main board and gently heat. Visually inspect to make sure no flux migrated onto the gold plated areas of the RF switch board. The solder pad geometry between the two circuit boards should provide self alignment. But, a visual inspection should be made to make sure that the notches on the RF switch board do not cover the holes in the main rf board.

(2) Place the two plastic alignment pins of the new RF switch assembly into the respective holes on the RF board, making sure to fully bottom the plastic housing on the RF board. Use a soldering iron to solder down the bracket tab, then the two solder tabs of the plastic switch housing. Take care not to melt the plastic housing. A small amount of force may be applied to the bracket to aid in seating. Be careful in applying force, as excessive force during reflow will cause solder 'squeeze' and, as a result, shorting between adjacent solder pads.

(3) While holding the RF switch bracket firmly against the RF board, bend the two tabs around the side of the RF board as close to the board edge as possible to hold the bracket down tightly.

(4) Insert the new RF switch spring and RF switch piston into the RF switch assembly.The contacts of the piston should be facing the gold-plated pads of the RF switch board. Once the spring and piston are inserted into the RF switch, they will be retained by the switch.

CHIP CARRIERS

Using the appropriate heat-focus heads and settings as specified in table 20-3, remove and repair all prebumped chip carriers per the procedure outlined in the National Service Technician's Guide to Repairing Leadless Component Assemblies (TT907A). The duration of heating time at the maximum prescribed heat should not exceed sixty seconds.

Caution:
All prebumped carriers removed from a circuit board are not able to be reapplied because of the need for a very controlled amount of solder on each of the pads.

THIN SMALL OUTLINE PACKAGE (TSOP), U714, U715

To remove, apply a small amount of flux to the tops of all the leads. This allows for a smooth pad after part removal. Gently heat both ends of the TSOP using the appropriate heat-focus head until all the leads are lose in the solder; then remove by lifting straight up. Unsoldering and lifting one side at a time could cause a tearing of the solder pads on the opposite side and is therefore not recommended. To apply a new TSOP, reflow and level the solder pads to make them as uniform as possible. Add or remove solder as required. Clean the pads thoroughly, then apply small dots of flux to each of the pads. Use the tackiness of the flux to assist in holding of the part during placement. During heating, the part should self center, but a visual inspection should be done to ensure there are no solder shorts and all the leads are soldered.

SHIELDS

Using the appropriate heat-focus heads and settings as specified in table 20-3, remove and repair all soldered-down shields per the procedure outlined in the National Service Technician's Guide to Repairing Leadless Component Assemblies (TT907A). It is recommended that the R-1070A Repair Station be used when servicing soldered- down shields. The duration of heating time at the maximum prescribed heat should not exceed sixty seconds.

DISASSEMBLY AND REASSEMBLY

Caution:
THIS RADIO CONTAINS STATIC-SENSITIVE DEVICES. DO NOT OPEN THE RADIO UNLESS PROPERLY GROUNDED. TAKE THE FOLLOWING PRECAUTIONS WHEN WORKING ON THIS UNIT.

- *Store and transport all complementary metal-oxide semiconductor (CMOS) devices in conductive material so that all exposed leads are shorted together. Do not insert CMOS devices into conventional plastic "snow" trays used for storage and transportation of other semiconductor devices.*
- *Ground the working surface of the service bench to protect the CMOS device. We recommend using the Motorola Static Protection Assembly (part number 0180386A82), which includes a wrist strap, two ground cords, a table mat, and a floor mat.*
- *Wear a conductive wrist strap in series with a 100k resistor to ground. Replacement wrist straps that connect to the bench top covering are Motorola part number RSX-4015.*
- *Do not wear nylon clothing while handling CMOS devices.*
- *Neither insert nor remove CMOS devices with power applied. Check all power supplies that are to be used for testing CMOS devices to be certain that there are no voltage transients present.*
- *When straightening CMOS pins, provide ground straps for apparatus used.*
- *When soldering, use a grounded soldering iron.*
- *If at all possible, handle CMOS devices by the package and not by the leads. Prior to touching the unit, touch an electrical ground to remove any static charge that you may have accumulated. The package and substrate may be electrically common. If so, the reaction of a discharge to the case would cause the same damage as touching the leads.*

GENERAL

Since this product disassembles and reassembles without the use of any screws, it becomes important for the technician to pay particular attention to the snaps and tabs, and how parts align with each other.

DISASSEMBLY TO BOARD LEVEL

1. Turn off the radio.
2. Remove the battery (see figure 1).
   a. Hold the radio such that the battery is tilted down.
   b. Press down on the two battery-release levers.
   c. With the release levers pulled down, the top of the battery will fall away from the radio.
   d. Remove the battery completely away from the radio.

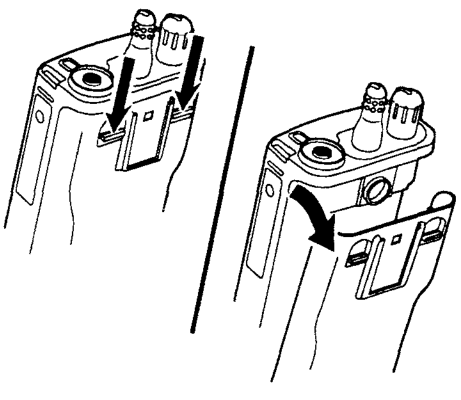


Figure 1

3. Loosen the antenna by turning it in a counterclockwise direction, and remove it from the radio.
4. Remove the volume on/off knob and the channel selector switch knob by puling them off their respective switch shafts.

Note:
Both knobs slide on and off but fit very snug on their respective switch shafts. A small flat blade screwdriver may be necessary to help pry the knobs loose. Take care not to mar the surrounding radio surface.

5. Separate the front cover assembly from the internal electronics (chassis) (see figure 2).

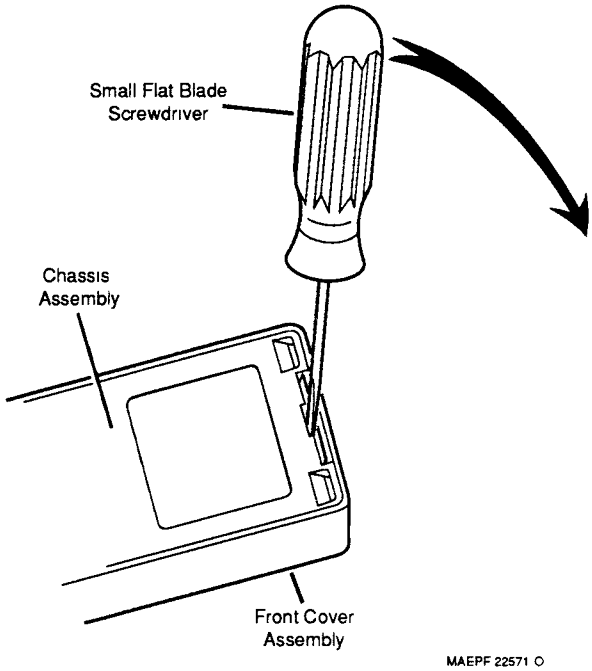


Figure 2

a. Insert small flat blade screwdriver or like instrument in the slotted area at the bottom center of the radio. Take care not to mar the O-ring sealing area on the housing.

b. Pry the bottom of the chassis free from the cover by pushing the screwdriver down and rotating the handle of the screwdriver over and behind the base of the radio. This prying action forces the thin inner plastic wall toward the base of the radio, which releases the two chassis base tabs.

Note:
A flexible ribbon cable (front cover/display flex), which connects to the front cover assembly and the chassis, keeps you from completely separating the two units.

c. Lay the chassis down, and rotate the front cover back and partially away from the chassis (see figure 3).

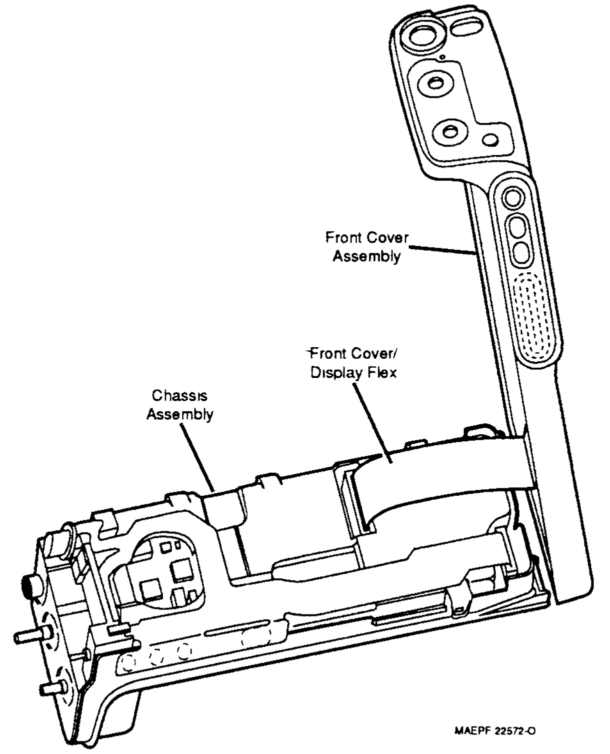


Figure 3

6. Disconnect the front cover display flex from the connector on the chassis.

Note:
A special locking connector secures the flex to the chassis (see figure 4).

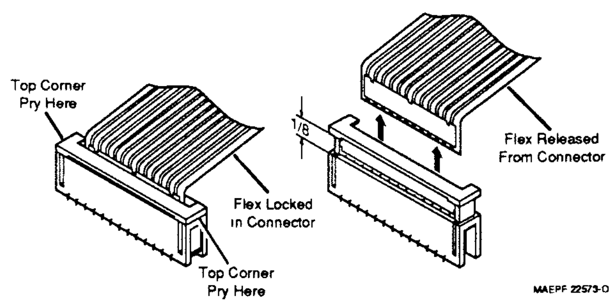


Figure 4

a. Use a small, thin, flat blade screwdriver (or like instrument) to help raise the sliding portion of the connector approximately 3 mm from its seated position. A slight prying action, alternating back and forth on the top corners of the connector, achieves the best results for unlocking the connector.

b. Remove the flex from the chassis connector.

7. Remove the contoured O-ring/antenna bushing seal from the chassis.

8. Disconnect the controls flex from the connector on the controller board by following the procedure in steps 6a and 6b.

Note:
A large portion of the controls flex is attached to the large metal shield (front shield) with adhesive. Do not remove the controls flex from the front shield unless it is absolutely necessary.

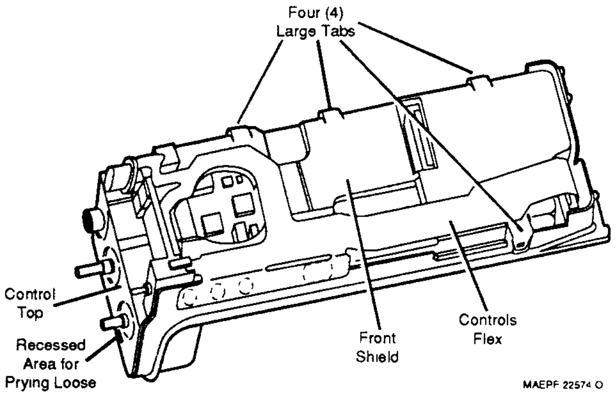


Figure 5

9. As a unit, separate the control top, the front shield, and the controls flex from the chassis and circuit boards (see figure 5).

Note:
Four large tabs secure the front shield to the chassis and hold the RF board and the controller board in the chassis.

a. Loosen the front shield by prying each of the four tabs away from the chassis. Be careful not to pry the tabs anymore than is necessary to free them from their respective retaining slots. To loosen the shield completely from the chassis, a slight lifting and clockwise twisting action may be required.

b. Insert a small flat blade screwdriver in the recessed area of the control top and pry the control top slightly away from the chassis.

c. Completely remove the control top/front shield/controls flex unit from the chassis.

10. Carefully remove the RF board and the controller board from the chassis.

Note:
The RF board and the controller board are connected together with a jumper flex. The connection is made more rigid using a hard plastic cover that snaps across the top of the jumper flex (see figure 6).

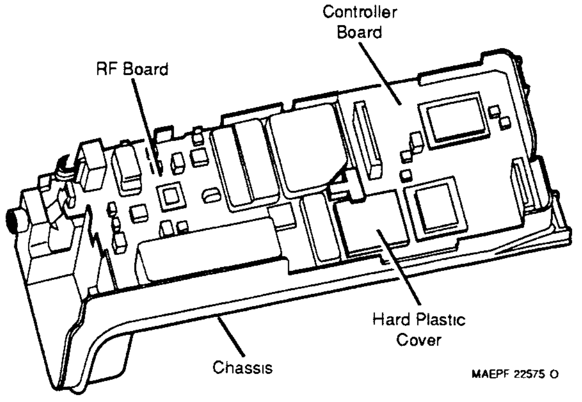


Figure 6

DISASSEMBLY OF CONTROL TOP

1. Remove the rubber controls seal from the control top.
2. Turn the control top such that the black switch housing cover is facing up.
   a. Five retaining clips hold the switch housing cover to the switch housing. Clips 1, 2, and 3 are important during disassembly (see figure 7).

Note: To perform step 2b, two tools will be required; your thumbnail or small flat blade screwdriver, and a pen, pencil, or another small flat blade screwdriver.

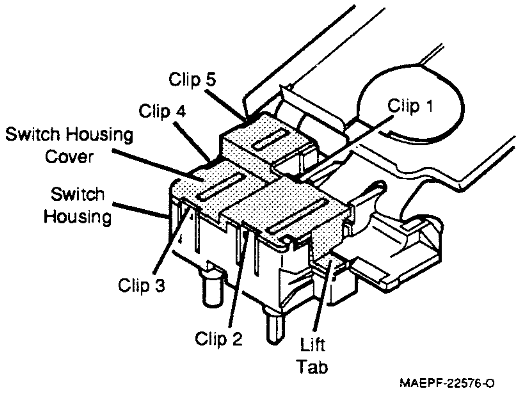


Figure 7

   b. Using your thumbnail or small flat blade screwdriver, lift the tab that covers the base of the LED approximately 2 mm from its seated position. While applying constant lifting pressure there, (in order) release clips 1, 2, and 3 with the other tool.
   c. The cover will pop loose from the switch housing.
3. Push the three switches and the LED out of the switch housing.
4. The remainder of the controls flex is attached to the switch housing with adhesive. Do not remove the flex from the switch housing unless it is absolutely necessary.

DISASSEMBLY OF FRONT COVER ASSEMBLY

1. On top display model radios only, release the display board by using a "press and pull" action on the top two corners of the display board. Press down on the two top corners of the display board and pull the top of the board away from the two corner retaining tabs. The display board will free itself from the retaining tabs and two retaining slots in the front cover housing.
2. Remove the edge connector (part of the front cover flex, located behind the universal connector), by sliding out of the plastic rails that hold it in place. A slight prying action, alternating back and forth on the bottom corners of the connector, achieves the best results.
3. Remove the speaker retainer bracket, speaker, microphone, and front cover flex from the front cover housing (see figure 8).

Note: The speaker and front cover flex are held in position with a three-leg retainer bracket. The legs of the bracket are secured by slots in the front cover. When removing the retainer bracket, use caution not to damage the speaker.

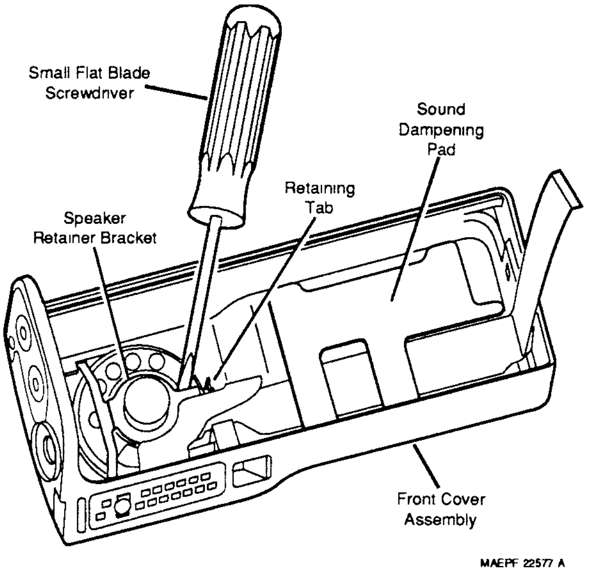


Figure 8

   a. Disengage the retainer bracket leg that points toward the bottom of the front cover from its retaining tab.
      (1) Insert a small flat blade screwdriver under the base of the bracket leg near the ring.
      (2) Lift the bracket leg until it pops loose from under its retaining tab.
   b. Lift the freed leg of the retainer bracket and use it to pull the remaining two legs of the bracket out and away from their respective slots in the front cover housing.
   c. Pull the rubber microphone boot, containing the microphone, from its seated position. Unless you are replacing the microphone, leave the microphone in the boot.
4. Remove, if necessary, and replace the sound dampening pad.
5. As necessary, replace the speaker and/or microphone while out of the front cover housing.

Note:
If the microphone is replaced, ensure that the microphone is reinstalled back into the rubber boot with the microphone port facing the round hole at the bottom of the boot.

6. On front display model radios only, notice that the keypad/display board is secured to the front cover housing using six tabs, three small tabs on one side and three larger tabs on the universal connector side. Remove the keypad/display board by inserting a small flat-blade screwdriver in the circuit board slot provided (slot nearest the top retaining tab on the universal connector side of the radio, see figure 9). A slight prying action will release the keypad/display board. If applicable, remove the rubber keypad.

Note:
Be careful not to mar the front cover housing o-ring sealing area so as to compromise the sealing integrity.

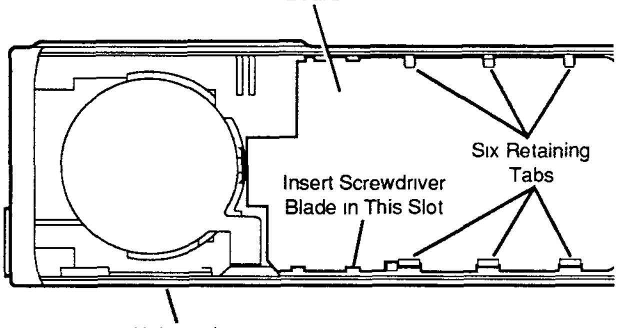


Figure 9

REASSEMBLY

Reassembly is the reverse of disassembly. Some suggestions and illustrations are provided to help you more easily reassemble the radio.

Keypad/Display Board
(front display model radios only)

1. If applicable, replace the rubber keypad.
2. Place the keypad/display board into the front cover housing at an angle such that the three small slots on the edge of the board slide under the three mating retaining tabs. Ensure that the board slid **under** the tabs.
3. Near the three larger slots on the other side of the board, use finger pressure to push and press that side of the board down until it snaps into place under the three large retaining tabs.

Front Cover Assembly

1. Place the speaker and microphone into their respective positions in the front cover. Make sure that the speaker is seated properly in the recessed area provided.
2. Press the rubber microphone boot into its respective recessed area in the front cover housing. The little rubber flap in the back of the rubber boot should fold up to cover the microphone insertion opening.
3. Reinstall the speaker retainer bracket (see figure 10).

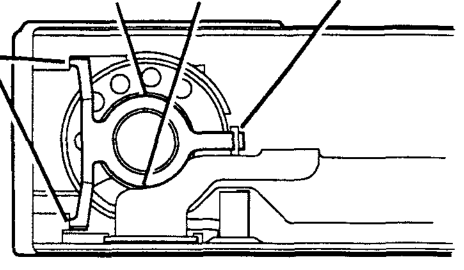


Figure 10

   a. Position the spring bracket over the speaker, and toward the top of the front cover housing, insert the appropriate two legs of the bracket into their respective slots
   b. Grasp the center portion of the spring bracket (ring area) with thumb and forefinger.
   c. While holding the ring area of the spring bracket at approximately the same height as the speaker's base, push the remaining leg down and into its respective slot.
4. Orient the edge connector so that its gold contacts face the gold contacts of the housing. Align the edge connector with the respective slots in the housing, and slide the connector down into place. Ensure that the edge connector is fully seated into position.
5. On top display model radios only, seat the display board by inserting the two display board tabs into their mating slots in the front cover housing. Push the top of the display board toward the top of the radio until the front cover housing retaining tabs engage the display board and secure it into position.

Chassis

Inside of the chassis where the RF board fits, is a protruding block that functions as the PA heatsink. To help provide maximum heat transfer, ensure that the PA heatsink block (top surface) is coated with a thin film of thermal compound (Motorola part number 1110022A55).

Place the RF board and controller board into the chassis. Ensure that the plastic cover that more rigidly holds the two boards together is snapped into place.

Control Top

1. Reinstall the switches and LED into the switch housing.
2. Reinstall the switch housing cover onto the switch housing by sliding tabs 4 and 5 of the cover into their respective clips on the housing. Then press down on the cover to engage tabs 1, 2, and 3.

Control Top/Front Shield/Controls Flex as a Unit to Chassis

1. Slide the control top into the appropriate position in the chassis, and place the front shield into position over the chassis and circuit boards.
2. Check to see that the four large tabs of the front shield are aligned with the respective slots on the sides of the chassis, then snap the front shield in place. Ensure that the shield is fully seated, especially in the PTT switch area.
3. Slide the connector end of the controls flex into the special locking connector mounted on the control board. Ensure that the flex is fully seated into the board connector and secure the connection.

Note: *View the flex connection at a slight angle from the **bottom** of the radio (see figure 11). If the flex is fully seated, the orange circuit plating will be parallel with the connector top surface and three reliefs in the plating will make the flex plating appear to be separated. If the orange plating of the flex is not parallel with the connector's top surface, or the three reliefs are raised enough to see plating under them, then the flex is not fully seated.*

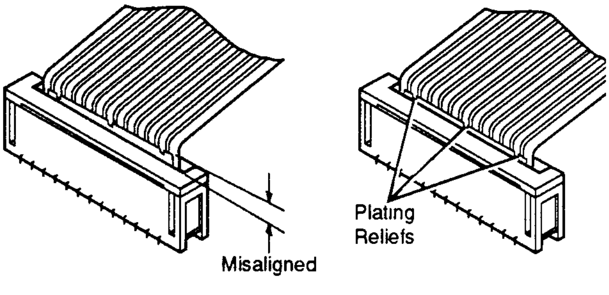


Figure 11

4. Reinstall the rubber controls top seal on the control top.

Note: *Two tabs are provided in the emergency button area to help hold the seal in place.*

Front Cover Assembly to Chassis

1. Install the contoured O-ring/antenna bushing seal around the antenna and in the groove provided (see figure 12).

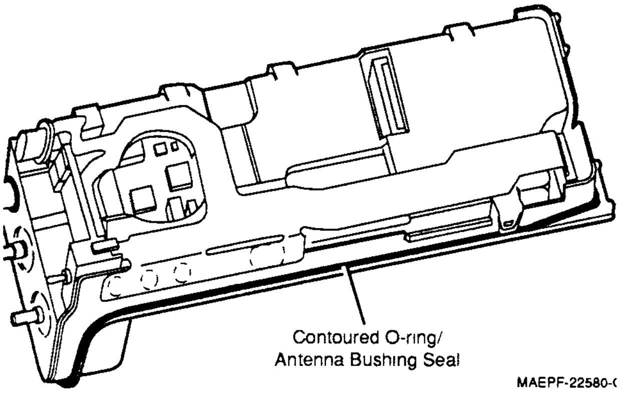


Figure 12

2. Orient the front cover assembly with the chassis, and insert the front cover/display flex connector into the locking connector of the controller board (refer back to figure 3). Secure the connection. View the flex connection at a slight angle from the top of the radio and ensure that the flex connector is fully seated into the locking connector as described in step 3 of "Control Top/Front Shields..." above.
3. Check to make sure that the O-ring is in place, and slide the chassis (switch end first) into the front cover assembly. Check to ensure that the orange emergency button seal slides into position freely.

Note: *When performing the next part of this step, pay particular attention to the O-ring near the bottom of the radio to ensure that it does not raise up and get pinched between the front cover clip and the chassis. With the top of the chassis fully seated, lower the bottom of the chassis and press it into the front cover assembly until it snaps into place.*

4. Check the emergency button again. If it is cocked to one side, repositioning it may be necessary.

Reinstall the switch knobs and antenna; the shorter knob with the volume on/off switch, the taller knob with the channel selector switch.

Reinstall the battery.

TRANSCEIVER PERFORMANCE TESTING
CLOSED ARCHITECTURE RADIOS

GENERAL

Performance testing can be carried out using the TEST MODE software contained in the radio. This allows the technician to select test frequencies, to configure the radio hardware in a number of predefined ways and monitor a set of radio parameters (Tables 3.3 and 3.4). The equipment set-up required for performance testing is connected as shown in Chapter 5 - Radio Alignment Procedure.

The TEST MODE or the "Air Test" consists of an RF Test Mode and a CH (Control Head) Test Mode. The RF Test Mode allows performance checking on the transmitter and receiver sections of the radio and the Control Head Test Mode allows the radio controls to be tested.

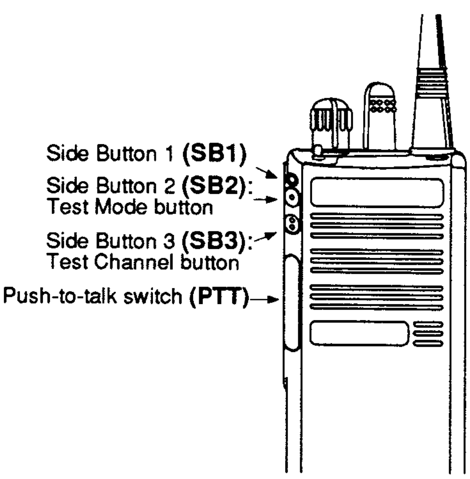
TEST MODE FEATURES

On entering Test Mode, the test mode application will examine the radio model number field of the radio codeplug in order to determine the type of radio and application it is operating within to decide how to support the specific test mode functions for that model.

The radio will be in an idle state, all indicators are extinguished and a keypad acknowledge alert will be sounded.

Keypad alerts will sound as feedback to indicate the channel number/test environment to the user.

Test mode control is provided by the two side buttons, SB2 and SB3.



Test mode button **SB2**, is used to scroll through the test mode environments (Table 3.1). Test channel function button **SB3** is used to enter the RF and CH Test Modes and also to scroll through the list of test channels (Table 3.2).

When the radio is in RF test mode the **PTT** button is used to key and de-key the transmitter. When the transmitter is keyed the red LED will be illuminated.

RF TEST MODE ENTRY

- Turn the radio on.
- Within ten seconds after the self test is complete, press SB3 five times in succession, ensuring that the first press is within 2 seconds after self test.
- After a keypad acknowledge alert, the radio is on Test Frequency Channel 1, Carrier Squelch Test Environment.
- Each additional press of SB3 will advance to the next test channel (refer to Table 3.2), and a corresponding number of alerts will indicate the channel number.
- Pressing SB2 will scroll through and access test environments as shown in table 3.1.

Note:
Transmit into a load when keying a radio under test.

No. OF BEEPS	ENVIRONMENT	FUNCTION
1	Carrier Squelch	RX: unsquelch if carrier detected TX: mic audio
3	Tone Private-Line	RX: unsquelch if carrier and tone detected TX: mic audio + tone
7	Dual-Tone Multiple Frequency	RX: not applicable TX: pre-defined DTMF tone pair
13	Select 5	RX: not applicable TX: mic audio + tone

Table 3.1 Test Environments

CONTROL HEAD TEST MODE ENTRY

- Enter the RF Test Mode.
- Press the Test Channel button (SB3) for 4 seconds, when a "beep" is heard.
- The green LED flashes continuously.
- All radio controls (switches, knob and keypad buttons) are tested by operating each one in turn and listening for a corresponding "beep".

TO EXIT either the RF Test Mode or the CH Test Mode, turn the radio off.

No. of Beeps	Test Channel	VHF	UHF Band
1	TX #1	136.025	403.100
	RX #1	136.075	403.150
2	TX #2	142.125	424.850
	RX #2	142.175	424.900
3	TX #3	154.225	438.050
	RX #3	154.275	438.100
4	TX #4	160.125	444.050
	RX #4	160.175	444.100
5	TX #5	168.075	456.350
	RX #5	168.125	456.400
6	TX #6	173.975	463.700
	RX #6	173.925	463.650

Table 3.2 Test Frequencies

TEST NAME	COMMUNICATIONS ANALYZER	RADIO	TEST SET	COMMENTS
Reference Frequency	Mode: PWR MON 4th channel test frequency❖ Monitor: Frequency error Input at RF In/Out	TEST MODE, Test Channel 4 carrier squelch output at antenna	PTT to continuous (during the performance check)	Frequency error to be ±150Hz
Rated Audio	Mode: GEN Output level: 1.0mV rf 4th channel test frequency❖ Mod: 1kHz tone at 3kHz deviation Monitor: DVM: AC Volts	TEST MODE, Test Channel 4 carrier squelch	PTT to OFF (center), meter selector to Audio PA	Set volume control to 3.74Vrms
Distortion	As above, except to distortion	As above	As above	Distortion < 3.0%
Sensitivity (SINAD)	As above, except SINAD, lower the rf level for 12dB SINAD.	As above	PTT to OFF (centre)	RF input to be < 0.35µV
Noise Squelch Threshold (only radios with conventional system need to be tested)	RF level set to 1mV RF	As above	PTT to OFF (centre), meter selection to Audio PA, spkr/load to speaker	Set volume control to 3.74Vrms
	As above, except change frequency to a conventional system. Raise rf level from zero until radio unsquelches.	out of TEST MODE; select a conventional system	As above	Unsquelch to occur at < 0.25µV. Preferred SINAD =8-10dB

❖ See Table 3.2

Table 3.3 Receiver Performance Checks

TEST NAME	COMMUNICATIONS ANALYZER	RADIO	TEST SET	COMMENTS
Reference Frequency	Mode: PWR MON 4th channel test frequency◆ Monitor: Frequency error Input at RF In/Out.	TEST MODE, Test Channel 4 carrier squelch	PTT to continuous (during the performance check)	Frequency error to be < 150Hz.
Power rf	As above	As above	As above	
Voice Modulation	Mode: PWR MON 4th channel test frequency◆ atten to –70, input to rf In/Out, Monitor: DVM, AC Volts Set 1kHz Mod Out level for 0.025Vrms at test set, 80mVrms at AC/DC test set jack	As above	As above, meter selector to mic	Deviation: VHF and UHF. ≥ 3 6kHz but ≤ 5.0kHz
Voice Modulation (internal)	Mode: PWR MON 4th channel test frequency◆ atten to –70, input to RF In/Out.	TEST MODE, Test Channel 4 carrier squelch output at antenna	Remove modulation input.	Press PTT switch on radio. Say "four" loudly into the radio mic. Measure deviation VHF and UHF: ≥ 3.8kHz but ≤ 5 0kHz
DTMF Modulation	As above, 4th channel test frequency◆	TEST MODE, Test Channel 4 DTMF output at antenna	As above.	Deviation: VHF and UHF: ≥ 3.8kHz but ≤ 5 0kHz
PL Modulation	As above, 4th channel test frequency◆ BW to narrow.	TEST MODE, Test Channel 4 TPL	As above	Deviation VHF and UHF ≥ 500Hz but ≤ 1000Hz.

◆ See Table 3.2

Table 3.4 Transmitter Performance Checks

TEST MODE FOR OPEN ARCHITECTURE RADIOS

GENERAL

The test mode allows the technician to monitor a set of radio parameters, to configure the radio hardware in a number of predefined ways, and have access to a number of test procedures.

Two basic areas of functionality are provided by the Test Mode:

- RF test mode - allows the RF functionality of the radio to be tested.
- CU (Control Unit) test mode - allows the radio display, buttons and switches to be tested.

The purpose of the test mode is to test the radio unit and its interfaces, but not to test the various accessories.

Test mode operation is fundamentally the same for radios with 6 character displays and radios with 14 characters displays. The only difference is the manner in which 6 character display radios handle large amounts of information.

Note:
Due to the reduced size of the 6 character display, it is necessary to spread some information over several displays. This information is then presented as a rotating display to the user.

TEST MODE FEATURES

On entering Test Mode the radio will be in an idle state, all indicators are extinguished and the "RF TST" Mode Select menu message will be displayed.

Test mode control is provided by two Side Buttons and a set of menus (left-hand flushed) which may be scrolled through and selected. The buttons are used to scroll through and select these menus.

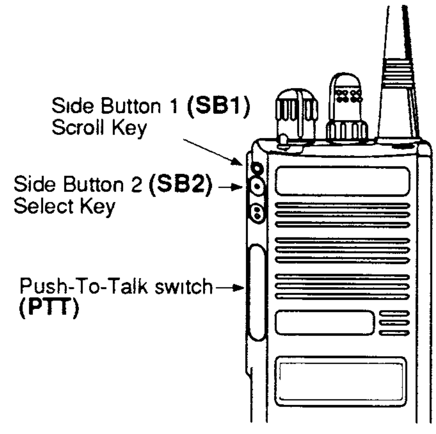
When the radio is in RF test mode the PTT button is used to key and de-key the transmitter. Whenever the transmitter keys up, the test mode application illuminates the red LED and whenever the transmitter keys down the application extinguishes the red LED.

ON ALL MENUS:

- CLEAR will clear the display.
- END will return the radio to the RF TST/CU TST Mode Select level.
- All selections are confirmed by a short "beep".

TEST MODE ENTRY

- Turn the radio on.
- Within ten seconds after power on press the **PTT** five (5) times, ensuring that the first press is within one second after power on.



- On entry, the "SERVICE" test mode message is displayed for 2 seconds. Following this, each of the following is displayed in sequence:
  - radio software part number
  - radio model number
  - radio serial number

  Each of these "temporary messages" lasts for 2 seconds. After the radio serial number has been displayed for 2 seconds, the display is blanked.
- Pressing **SB1** while one of the above "temporary messages" is displayed, cancels the display sequence and directly blanks the radio display.
- Within 6 seconds after the display is blanked the test mode entry password must be entered. The password is as follows:
  - 1 time SB1
  - 2 times SB2
  - 1 time SB1
  - PTT

Note: *In earlier radio software versions no password is required to enter service mode, i. e. after the "temporary messages" the radio enters service mode and the "RF TST" test mode message is displayed.*

The password must be entered correctly the first time, no re-tries are allowed. If an incorrect password is entered, turn off the radio and repeat the power up sequence.

- If the correct password is entered the radio enters test mode and the "RF TST" test mode message is displayed

TO EXIT either the RF Test Mode or the CU Test Mode turn the radio off.

RF/CU TEST MODE SELECT

Pressing the scroll key, **SB1,** alternates between the two Mode Select menus "RF TST" and "CU TST". To select either the RF or CU test menu press **SB2** while the desired menu is being displayed.

RF TEST MODE

On entry into the RF test mode the radio hardware will be configured for the default carrier squelch (CSQ) test mode environment, and the test mode application will examine the following parameters contained in the personality area of the radio codeplug:

- Frequency Range (Midband, VHF or UHF)
- Channel Step Size (5 or 6.25 kHz)
- Tx Channel Number.
- Rx Channel Number.
- Transmit Deviation (0, 2.5, 4 or 5 kHz).
- Channel Bandwidth (12.5, 20 or 25 kHz).
- Transmitter Power Level (1st, 2nd, 3rd or 4th).

TEST MODE ENVIRONMENTS

When the RF menu message **ENVIRO** is displayed, press the select key **SB1** to gain access to the RF test .node environments:

CSQ (Carrier Squelch) . . . (Default)
UNSQ (Unsquelch)
TPL (Tone Private Line)
DTMF (Dual Tone Modulation Frequency)
RC DPL (Radiocom 2000 Digital Public)
RC TR (Radiocom 2000 Trunking)
MPT TR (MPT 1327 Trunking)
SEL 5 (Select 5)

When the appropriate environment is selected the test mode application will configure the radio hardware for this environment.

CHANNEL NUMBERS

From the RF menu select CHAN to gain access to the Channel Number menu messages: 1, 2, ...n and CLEAR (n is the highest channel number specified by theTx/Rx pairs field). The test mode application will examine the number of Tx/Rx pairs field contained in the personality area of the radio codeplug in order to determine how many different channel number menu messages to display. Selecting one of the channel numbers will reconfigure the radio hardware with the specific transmit/receive frequency.

The resulting frequencies will be as follows:

- Transmit frequency: Offset frequency + (Tx channel number #n * Channel step size).
- Receive frequency: Offset frequency + (Rx channel number #n * Channel step size).

The Rx/Tx channel number #n and Channel step size values are extracted from the personality area of the radio codeplug and the offset frequency is derived from the offset frequency calculation performed on entry into RF test mode.

TRANSMIT POWER LEVELS

From the RF menu select **POWER** to gain access to the Transmit power levels: 1st, 2nd...nth (n is the highest power level specified by the highest power level field). The test mode application will examine the highest supported power level field contained in the personality area of the radio codeplug in order to determine how many different power level messages to display. Selecting one of the power levels will reconfigure the radio hardware with the specific power level.

CHANNEL BANDWIDTH

From the RF menu select **B/W** to gain access to the Channel Bandwidth menu messages: 12.5, 20, 25 and CLEAR. Selecting any one of the bandwidths will reconfigure the radio hardware with the specific channel bandwidth.

CU TEST MODE

On entry into the Control Unit test mode, all front panel indicators and display segments are displayed for a period of 5 seconds, and then extinguished. When the radio is in Control Unit test mode, all front panel momentary button presses/releases (apart from the dedicated scroll and select keys and the volume control), static switch activations and free revolving rotary activations are monitored. When any one of these is detected a short 'bip' will be heard and the associated button code (in decimal) and state will be displayed on the front panel.

TRUNKED MPT 1327 DIAGNOSTICS MODE

Note:
Calls which would normally make use of the numeric keypad may not be made whilst in diagnostics mode as the keypad has an alternative use whilst in this mode. Only trunked mode options that do NOT require use of the numeric keypad may be used (i.e. calls to units from the calls in absence list, last number redial calls, dedicated call button calls, emergency calls, and rotary switch calls can all be made), but the display will not provide the usual information associated with these calls when made in trunked mode.

The diagnostics mode allows the technician to monitor system and radio parameters. The diagnostics mode may be entered at any time during the radio's trunked mode operation. The trunked mode will continue to operate, e.g. if the radio was active on a traffic channel then it will be able to transmit and receive as normal.

The diagnostics mode may also be entered when the radio is powered up with no personality programmed. Only a subset of the features will be supported in this case.

Alert tones will continue to be sounded by the radio and the diagnostics display will be briefly overwritten by trunked mode messages.

DIAGNOSTICS MODE FOR 14 CHARACTER DISPLAY MODELS

DIAGNOSTICS MODE ENTRY

The diagnostics mode is entered by entering **120#** via the keypad, followed by the required **Feature** number 0 – 9 (see below). If the radio is not in the idle state when diagnostics mode entry is attempted the keys 120# must be pressed with less that one second between each key press, and the keys pressed will not be shown on the display but the key click will sound as each key is pressed.

Note:
Not all diagnostic displays can be supported from control and traffic channels. If the information to be displayed is inconsistent with the channel type or hunting state then the fields will be replaced with "".*

When in diagnostics mode, the user may move to another feature by pressing the required feature number 0 – 9. If an attempt is made to enter a mode which is not defined then the error tone will sound and the input will be ignored. No error message will be displayed.

FEATURES

The following features are available in the diagnostics mode by entering the corresponding feature number 0 – 9.

Feature No. 1 displays the current Channel Number (CCCC) and decimal representation of the RSSI level (XXX). Available on traffic and control channels.

```
CCCC        XXX
```

Feature No. 2 displays the last decoded System Identity in hexadecimal. Available on control channels only.

```
          XXXX
```

Feature No. 3 displays the number of Correct Codewords received (CCC) and number received with an Error (XXX). Samples for the correct and errored codeword counts will be taken over a 5 second period of time. Available on control channels while not hunting.

```
CCC         XXX
```

Feature No. 4 displays the radio's Software Version number. Available on traffic and control channels and when no personality is programmed.

```
CCCCCCCCCCCCC
```

Feature No. 5 display radio's Personality Format number. Available on traffic and control channels and when no personality is programmed.

```
CCCCCCCCCCCCC
```

Feature No. 6 displays the radio's own MPT1327 Prefix (PPP) and Identity (IIII) as stored in the radio's current personality. Available on traffic and control channels.

```
      PPP IIII
```

Feature No. 7 displays Channel number (CCCC), Hunting Status (S), Carrier Status (C), Hunt Level (H) and L2 Exceeded (L). Available on control channels only.

```
CCCC S  C  H L
```

The hunting status will be S when the radio is hunting or "–" when not hunting. The carrier status will be C when carrier is detected by the radio and '-' when no carrier is detected.

***N**ote:*
When the radio is hunting the scan rate is slowed down to check one control channel every 2 seconds. This display will be updated every time a channel is selected. When not hunting this display is updated every 5 seconds.

The hunt level will be a number 0, 2 or "–" defining the current level of the channel hunt, i.e. L0, L2 or no hunt currently active. The L2 exceeded flag will be L when L2 is exceeded and "–" otherwise.

Feature No. 8 displays the Electronic Serial Number consisting of Manufacturers Code (CCC), Model Number (MM) and Serial Number (SSSSSS). Available on control and traffic channels and when no personality is programmed.

```
CCC/MM/SSSSSS
```

Feature No. 9 displays the date and time that the internal codeplug was last programmed, last digit of the year (YY), month (MM), day of the month (DD), hour of programming in 24 hour clock format (HH) and minutes of programming time (MM).

```
YYMMDDHHMM
```

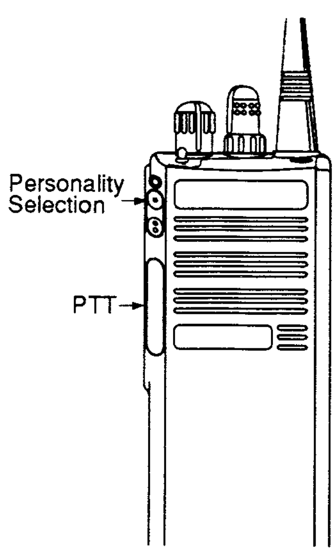
Feature No. 0. Return to trunked mode. This display will be overwritten by the next trunked mode display update.

```
--------------
```

DIAGNOSTICS MODE FOR 6 CHARACTER DISPLAY MODELS

DIAGNOSTICS MODE ENTRY

Diagnostics mode is entered by pressing the **PTT** key whilst holding down the **Personality Selection** key. Diagnostics mode can be selected when the radio is in the idle state and also when the radio does not have a personality. If diagnostics mode is selected when the radio does not have a personality, fewer features are available to the user. The features which are available in diagnostics mode are presented to the user in a predefined sequence. The sequence may be stepped through by pressing the **PTT** key.



***N**ote:*
Due to the reduced size of the 6 character display, the information associated with each feature is shown over several displays. This information is then presented as a rotating display to the user.

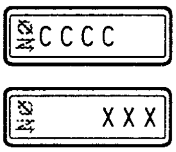
FEATURES

The following features are available in the diagnostics mode sequence:

1. Channel Number and RSSI Level

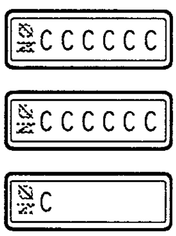
This is the only display which is available in trunked mode. The other displays can only be seen in diagnostics mode where trunked mode operation is not available.

The current Channel Number (CCCC) and decimal representation of the RSSI level (XXX) are available on traffic and control channels. This is the only display which changes operationally. The displays will be updated when diagnostics information is received. This information is not available when the radio does not have a personality.



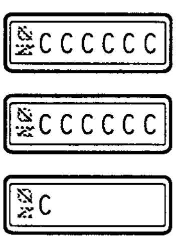
2. Software version number

The radio's software version number is available when the radio does not have a personality.



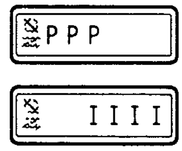
3. Personality Format Number

The radio's personality format number is available when the radio does not have a personality.



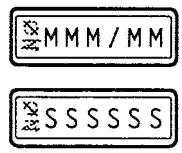
4. Prefix and Identity

The radio's own MPT1327 prefix (PPP) and identity (IIII) as stored in the radios current personality is only available when the radio has a personality.



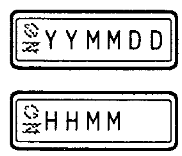
5. Serial / Manufacturer / Model Numbers

The Electronic Serial Number, manufacturers number (MMM), model number (MM) and the serial number (SSSSSS) is available when the radio does not have a personality.



6. Last programming Time and Date

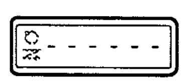
The date and time that the internal codeplug was last programmed, last digits of the year (YY), month (MM), day of the month (DD), hour of programming in 24 hour clock format (HH) and minutes of programming time (MM). This is available when the radio does not have a personality.



DIAGNOSTICS MODE EXIT

In order to exit from diagnostics mode, the user must press the **personality selection** key twice when the radio is displaying channel information and RSSI level information (feature 1) and once when any of the other features are being displayed.

Upon exiting from diagnostics mode the following display will be seen.



RADIO TUNING PROCEDURE

The recommended hardware platform is a 386 or 486 PC (personal computer) with 8 MByte RAM and RSS (Radio Service Software) are required to align the radio. Refer to your RSS Manual for installation and setup procedures for the software.

To perform the alignment procedures, the radio must be connected to the PC, RIB (Radio Interface Box), and Universal Test Set as shown in figure 1.

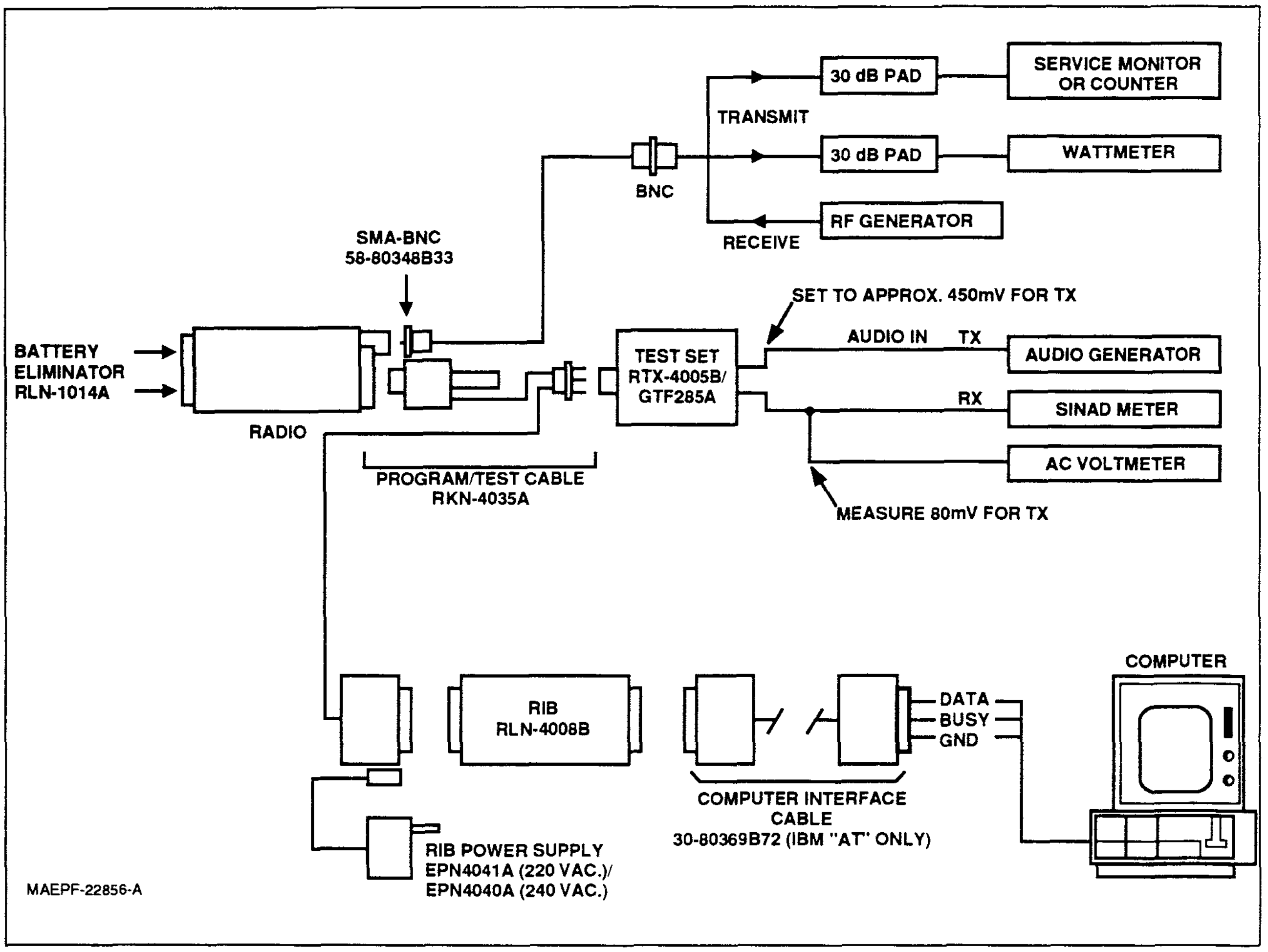


Figure 1. Radio Alignment Test Setup

All service and tuning procedures are performed from the SERVICE menu, which is selected by pressing F2 from the MAIN MENU. Figure 2 illustrates how the RSS SERVICE screens are organized.

Before going into the Service Aids menu, the radio must first be read using the GET/SAVE/PROGRAM Radio Data 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 RSS will have the radio's actual tuning values).

On 1200 Series and 2100 Series Two-way radios, to enter the tuning menu section: from the main menu, press F2 to select SERVICE AIDS. Then press F5 to select Tune Radio.

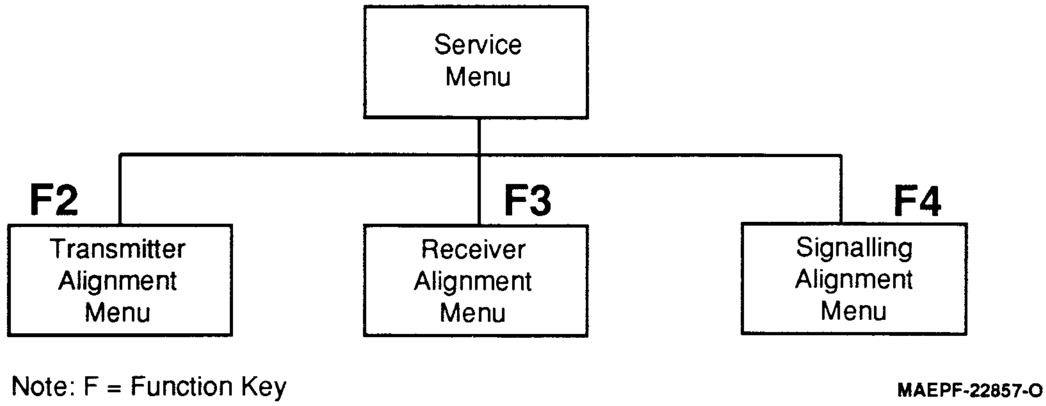


Figure 2. RSS Service Menu Layout

All SERVICE screens read and program the radio codeplug directly; you do NOT have to use the RSS GET/SAVE functions to use the SERVICE menus. You will be prompted at each screen to save changed values before exiting the screen.

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

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

Each SERVICE screen provides the capability to increase of decrease the 'softpot' value with the keyboard UP/DOWN arrow keys respectively. A graphical scale is displayed indicating the minimum, maximum, and proposed value of the softpot, as shown in figure 3.

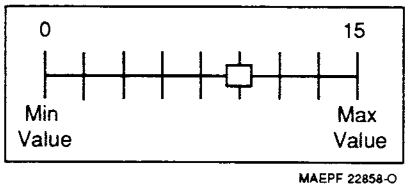


Figure 3. Softpot Concept

Adjusting the softpot value sends information to the radio to increase (or decrease) a DC voltage in the corresponding circuit. For example, pressing the UP arrow key at the Reference Oscillator screen instructs the radio microprocessor to increases the voltage across a varactor in the reference oscillator to increase the frequency.

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.

PERFORM THE FOLLOWING PROCEDURES IN THE SEQUENCE INDICATED

REFERENCE OSCILLATOR ALIGNMENT

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

1. From the SERVICE menu, press F2 to select TRANSMITTER alignment.
2. Press F2 again to select the REFERENCE OSCILLATOR softpot.
3. Choose the highest frequency and press F6 to key the radio. The screen will indicate that the radio is transmitting.
4. Measure the transmit frequency on your service monitor.

5. Use the UP / DOWN arrow keys to adjust the reference oscillator per the targets shown in table 1.

Band	Target
VHF	±150 Hz
UHF	±150 Hz

Table 1. Reference Oscillator Alignment

6. Press F6 again to dekey the radio.
7. Press F8 to program the softpot value; press F10 - F2 - F10 to return to SERVICE menu.

FRONT-END PRE-SELECTOR

1. Set the Test Box (RTX4005B) meter selection switch to the "VOL" position, and connect a DC voltmeter capable of 1 mV resolution to the Test Box AC/DC meter port to monitor the Received Signal Strength Indicator (RSSI).
2. From the SERVICE menu, press F3 to select RECEIVER alignment.
3. Press F2 to select the FRONT END FILTER softpot. The screen will indicate the receive frequencies at which the filter is to be tuned.
4. Set the RF test generator to the first receive frequency. Set the RF level at the radio standard antenna port to 4.0 uVolts with no modulation.
5. Adjust the UP/DOWN arrow keys to obtain a peak voltage on the DC voltmeter.
6. Press F8 to program the softpot value
7. Repeat steps 4-6 for the remaining test frequencies.
8. Press F10 and F2 to return to the RECEIVER menu.

RATED AUDIO

1. Set test box (RTX-4005B) meter selection switch to the "AUDIO PA" position and connect an AC voltmeter to the test box AC/DC meter port.
2. Press F3 to select the RATED AUDIO softpot. The screen will indicate the receive test frequency to be used.
3. Set the RF test generator to the receive test frequency, and set the RF level at the radio standard antenna port to 1mVolt modulated with standard test modulation. (See table 2 below.).
4. Adjust the UP/DOWN arrow keys to obtain rated audio (as close to 3.74 Vrms) into a speaker (28 ohms) or equivalent resistive load.
5. Press F8 to program the softpot value
6. Press F10 to return to the RECEIVER menu.

Channel Spacing	Deviation
25 kHz	3.0 kHz
20 kHz	2.4 kHz
12.5 kHz	1.5 kHz

Table 2 Standard Test Modulation (1 kHz Tone)

SQUELCH

1. Press F4 to select the SQUELCH softpot. The screen will indicate the receive test frequencies to be used.
2. Select the first test frequency shown, and adjust the UP/DOWN arrow key to the minimum squelch value.
3. Set the RF test generator to the test frequency and modulate the signal generator with standard test modulation. (See table 2.). Adjust the generator for a 8-10 dB SINAD level.
4. Adjust the UP/DOWN arrow key until the squelch just closes.
5. Monitor for squelch chatter; if chatter is present, repeat step 4.
6. When no chatter is detected, press F8 to program this value. Press "ENTER" to select next softpot adjustment.
7. Repeat steps 3-6 for all test frequencies shown on the screen.
8. Press F10, F2 then F10 to return to the SERVICE menu.

TRANSMITTER POWER

The radio requires two power level adjustments, a high power or rated power adjustment, and a low power adjustment. The low power adjustment is required since the radio may be used in a reduced power mode, or with a vehicular adapter.

Note:
All power measurements are to be made at the antenna port.

1. From the SERVICE menu, press F2 to select TRANSMITTER alignment.
2. Press F3 to select the TRANSMIT POWER softpot. The screen will indicate the transmit test frequencies to be used.
3. Begin with the highest test frequency shown.
4. Press F6 to key the radio, and use the UP/DOWN arrow keys to adjust the transmit power per the value shown in table 3.
5. Press F6 to dekey the radio, and then press F8 to program the value.

6. Repeat steps 4-5 for the remaining test frequencies.
7. Press F10, then F2 to return to the TRANSMIT menu.

VHF	Power Level	Test Frequencies 136-174 MHz
	5 W	5.2 - 5.4
	1 W	1.2 - 1.4
UHF	Power Level	Test Frequencies 403-470 MHz
	4 W	4.2 - 4.4
	1 W	1.2 - 1.4

Table 3. Transmit Power Setting

TRANSMIT DEVIATION BALANCE (COMPENSATION)

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

1. Press F4 to select the TRANSMIT DEVIATION BALANCE softpot. The screen will indicate the transmit test frequencies to be used.
2. Begin with the lowest test frequency shown on the screen.
3. Set the Test Box (RTX4005B) meter selector switch to the "MX DISC" position, and inject a 80 Hz tone at 100 mVrms into the AC/DC MTR port. Keep the AC voltmeter in parallel to insure the proper input signal level.
4. Press F6 to key the radio, and measure deviation.
5. Press F6 again to dekey the radio, and change the input tone to 3 kHz, 100 mVrms.
6. Press F6 to key the radio, and use the UP/DOWN arrow keys to adjust the deviation to within ±2% of the value recorded in step 4.
7. Press F6 to dekey the radio, and press F8 to program the softpot value. Press ENTER to move to next softpot value.
8. Repeat steps 3-7 for the remaining test frequencies.
9. Press F10 to return to the TRANSMIT menu.

Note: *The step size change for step 6 is approximately 2.5% softpot value.*

TRANSMIT DEVIATION LIMIT 25 kHz

1. Press F5 to select the TRANSMIT DEVIATION LIMIT softpot. The screen will indicate the transmit test frequencies to be used.
2. Begin with the lowest test frequency shown on the screen.
3. With the meter selector switch (RTX4005B) set to MIC, inject a 1 kHz tone on the AUDIO IN terminal on the test set, 80 mVrms as measured on the AC/DC MTR port.
4. Press F6 to key the radio, and use the UP/DOWN arrow keys to adjust the deviation to be within 4.30 - 4.60 kHz.
5. Press F6 to dekey the radio, and press F8 to program the softpot value. Press ENTER to move to the next softpot value.
6. Repeat steps 3-5 for the remaining frequencies shown on the screen.
7. Press F10 to return to the TRANSMIT menu.

TRANSMIT DEVIATION LIMIT 12.5/20 kHz

1. Press F6 to select the TRANSMIT DEVIATION LIMIT 12.5/20 kHz softpot.
2. With the meter selector switch (RTX4005B) set to MIC, inject a 1 kHz tone on the AUDIO IN terminal on the test set, 80 mVrms as measured on the AC/DC MTR port.
3. Press F6 to key the radio, and use the UP/DOWN arrow keys to adjust the deviation per table 4. below:

Channel Spacing	Deviation
20 kHz	3.40 - 3.60 kHz
12.5 kHz	2.20 - 2.30 kHz

Table 4: Transmit Deviation Limit Reference

4. Press F6 to dekey the radio, and press F8 to program the softpot value.
5. Press F10 to return to the TRANSMIT menu.

SIGNALLING ALIGNMENTS

MPT1327 Transmit Deviation

The MPT1327 Deviation Softpot is used to tune the FFSK signalling deviation. Tuning is performed at one frequency and for 25 kHz channel spacing. The radio generates an alternating bit pattern for tuning. Values for other frequencies and channel spacings are calculated by the radio software.

> **Note:**
> *Alignment of the Transmit Deviation Limit must be tuned before tuning MPT1327 Transmit Deviation.*

1. From the Radio Tuning menu, press F4 to select SIGNALLING alignment.
2. Press F2 again to select the MPT softpot.
3. Press F6 to key the radio on the test frequency. The screen will indicate that the radio is transmitting.
4. Measure the MPT deviation on your service monitor.
5. Use the UP/DOWN arrow keys to adjust the FFSK signalling deviation to be within 2.80 - 3.20 kHz.
6. Press F6 again to dekey the radio.
7. Press F8 to program the softpot value; press F10 to return to the SIGNALLING menu.

MPT RSSI Threshold Level Setting

1. From the SIGNALLING Menu press F3 to select RSSI Threshold Level Setting.
2. Apply a -80 dBm RF signal to the antenna connector and press the function key F3 to set the RSSI level.
3. Apply a -94 dBm RF signal to the antenna connector and press the function key F4 to set the RSSI level.

DTMF Transmit Deviation

The DTMF Deviation Softpot is used to tune the FFSK signalling deviation. Tuning is performed at one frequency and for 25 kHz channel spacing. The radio generates a DTMF signal for tuning. Values for other frequencies and channel spacings are calculated by the radio software.

1. From the SERVICE menu, press F4 to select SIGNALLING alignment.
2. Press F2 again to select the DTMF softpot.
3. Press F6 to key the radio on the test frequency. The screen will indicate that the radio is transmitting.
4. Measure the DTMF deviation on your service monitor.
5. Use the UP/DOWN arrow keys to adjust the DTMF deviation to be within 3.05 and 3.45 kHz.
6. Press F6 again to dekey the radio.
7. Press F8 to program the softpot value; press F10 to return to the SIGNALLING menu.

Select 5 Transmit Deviation

The Select 5 Deviation Softpot is used to tune the FFSK signalling deviation. Tuning is performed at one frequency and for 25 kHz channel spacing. The radio generates a Select 5 signal for tuning. Values for other frequencies and channel spacings are calculated by the radio software.

> **Note:**
> *Alignment of the Transmit Deviation Limit Reference MUST immediately PRECEDE the Select 5 Alignment Procedure.*

1. From the SERVICE menu, press F4 to select SIGNALLING alignment.
2. Press F3 again to select the Select 5 softpot.
3. Press F6 to key the radio on the test frequency. The screen will indicate that the radio is transmitting.
4. Measure the Select 5 deviation on your service monitor.
5. Use the UP/DOWN arrow keys to adjust the Select 5 deviation between 3.05 and 3.45 kHz.
6. Press F6 again to dekey the radio.
7. Press F8 to program the softpot value; press F10 to return to the SIGNALLING menu.

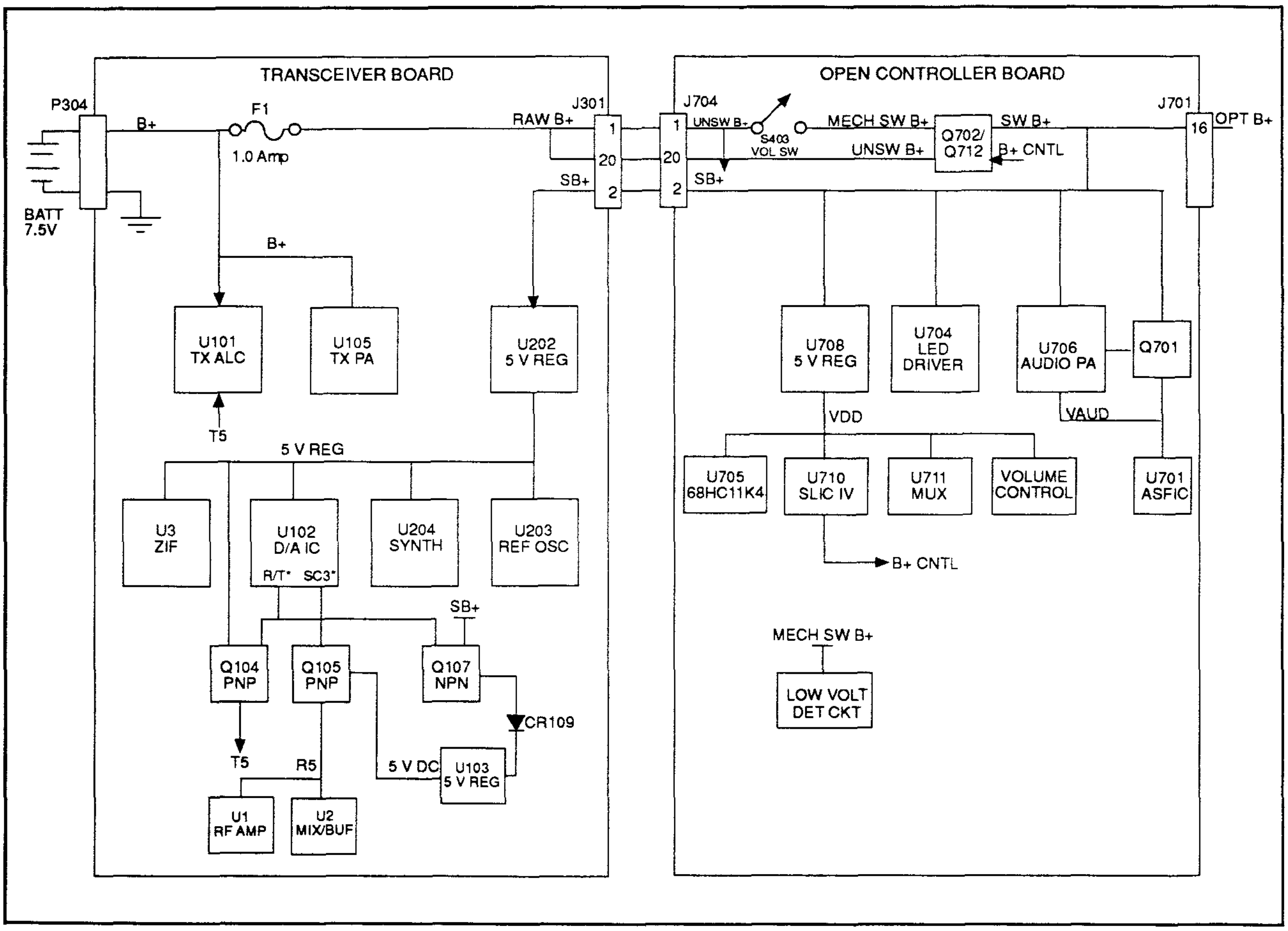
THEORY OF OPERATION

INTRODUCTION

This description covers a large family of portable radios, GP900/HT1100, PTX1200, GP1200, MTS2000, MT2100, PTX3600, GP3600 and MTX series units. They are software driven, and because of the wide range of operating systems and radio functionality provided by this family of radios, the theory description is divided into several major categories. The transceiver is frequency sensitive and falls into two frequency bands: VHF and UHF. The controller falls into two categories, a closed architecture controller and an open architecture controller; each will be discussed separately.

B+ ROUTING AND DC VOLTAGE DISTRIBUTION, OPEN ARCHITECTURE CONTROLLER

This radio differs from previous Motorola portable radios in that B+ from the battery is electrically switched to most of the radio, rather than routed through the ON/OFF/VOLUME switch S403/R401. The reason for this is to support a keep-alive mode in which the radio can, under software control, keep itself powered up even when the user has turned the ON/OFF switch to the OFF position.



DC Power Distribution Block Diagram

Raw B+ from the battery (herein referred to as UNSW B+) enters the radio on the RF board, where it is routed directly to the RF PA. It also splits off to a 1.0 A fuse, and is then routed to the controller board, where it enters on connecter pins J704-1 and J704-20. From the controller, it fans out to three different areas: (1) the Secure or Data option board via J703-1, (2) the electrical switch IC U712, pins 2 and 3, and (3) the control top flex via J703-8. UNSW B+ is routed to the Secure Board so that it can perform key management and other functions independently of SW B+. It is routed to the electrical switch IC U712 (a P-channel FET in an SOIC-8 package) which connects it to SW B+ when the control voltage U712-4 is low. SW B+ is then distributed to the rest of the radio, including the RF board, display/keypad board, Secure or Data option board, as well as other controller board circuitry. Finally, UNSW B+ is routed to the mechanical ON/OFF switch via J703-8, and returns to the controller as MECH SWB+ (J703-10). This signal is used to activate the electrical switch U712 and is also fed to a resistive divider so that the microcontroller U705 can monitor the battery voltage.

The electrical switch U712 is activated by Q702, which in turn is driven by either the MECH SWB+ or the B+ CNTL signals turning on one or both of the diodes in CR704. Let us consider what happens when the radio is initially off and all circuits are powered down. When the user switches the ON/OFF switch to the ON position, the MECH SWB+ signal will be connected to UNSW B+ and Q702 will then be turned on. Q702-3 will go low (< .3 V), and this will turn on U712, which in turn connects UNSW B+ to SW B+. SW B+ will then be fed to all the other radio circuitry, and the radio will begin its normal power-on sequence. In particular, the microcontroller U705 will initialize after regulated Vdd from U708 has reached 5.0 V. It can then program the gate array U710 so that the B+ CNTL signal can be an output high or low (initially this pin, U710-G8, is configured as an input so that it does not drive CR704).

Recalling that SW B+ to the radio is controlled by U712, which is activated by the B+ CNTL signal or MECH SWB+ via CR704 and Q702, if the user turns off the ON/OFF switch then MECH SWB+ drops to zero volts. If the µC has set B+ CNTL to logic zero, then inverter Q702's output (pin 3) will be high, and the power switch U712 will turn off, and SW B+ will drop to zero. If, however, the controller is programmed to support power-down de-affiliation (typically for a trunked system only), then it will have left B+ CNTL at a logic high. In this case, when the ON/OFF switch is turned off, SW B+ will continue to be supplied to the radio, but the µC will sense that the switch has turned off by reading that the voltage on pin U705-PE1 has fallen to zero. The µC can then key up the transmitter and send a de-affiliation ISW to the trunking system. After receiving and verifying an acknowledgement, the µC then shuts down SW B+ (and therefore, its own power, since Vdd comes from SW B+ via U708) by setting B+ CNTL=0. In summary, we see that turning the ON/OFF switch ON always supplies power to the radio circuitry, but the radio can only power down when the switch is OFF and the µC has set B+ CNTL=0.

LOW-BATTERY DETECT CIRCUIT (CONTROLLER BOARD)

The low battery detect circuit is used to warn the user that the radio's battery needs recharging. The implementation of this function on this radio takes advantage of the microcontroller's on-chip 8-bit, 8-channel A/D converter (pins PE0-PE7 of U705). The mechanically switched 7.5 V (MECH SWB+) is divided down to a nominal 3.92 V by resistors R725 and R726 and fed to Port PE1 of U705. This voltage is converted by the A/D to digital format. The microcontroller compares this voltage to a preset low-battery trip threshold which corresponds to a battery voltage of 7.024 V in standby mode, or 6.40 V in transmit mode. If the measured digitized voltage is lower than either low battery threshold, the low battery alert tone or flashing icon is generated to warn the user that only about 20 minutes of usable battery capacity remains.

POWER TO/FROM EXTERNAL ACCESSORIES

The switched 7.5 V also powers external accessories used with the radio. The voltage is picked up from the controller board and passed to the control flex via J701-16 (OPT B+/BOOT SEL). The control flex then applies the voltage to pin 4 of the side connector, where it is picked up by external accessories. R714, a 1 W resistor, provides current limiting to the external circuit to prevent internal damage should the external connector short.

The open architecture controller board uses Flash memory (U715) in place of conventional EPROMs. This allows the firmware to be reprogrammed through the side connector without opening the radio up.

When 12.7 V is applied to pin 10 of the side connector, current flows through diode CR705 and approximately 12.0 V is presented to the Vpp pin of Flash memory U715, which is required for reprogramming. Resistor R723 and zener diode VR715 prevent excess voltage from appearing at the input to U710 when the 12.7 volts is applied.

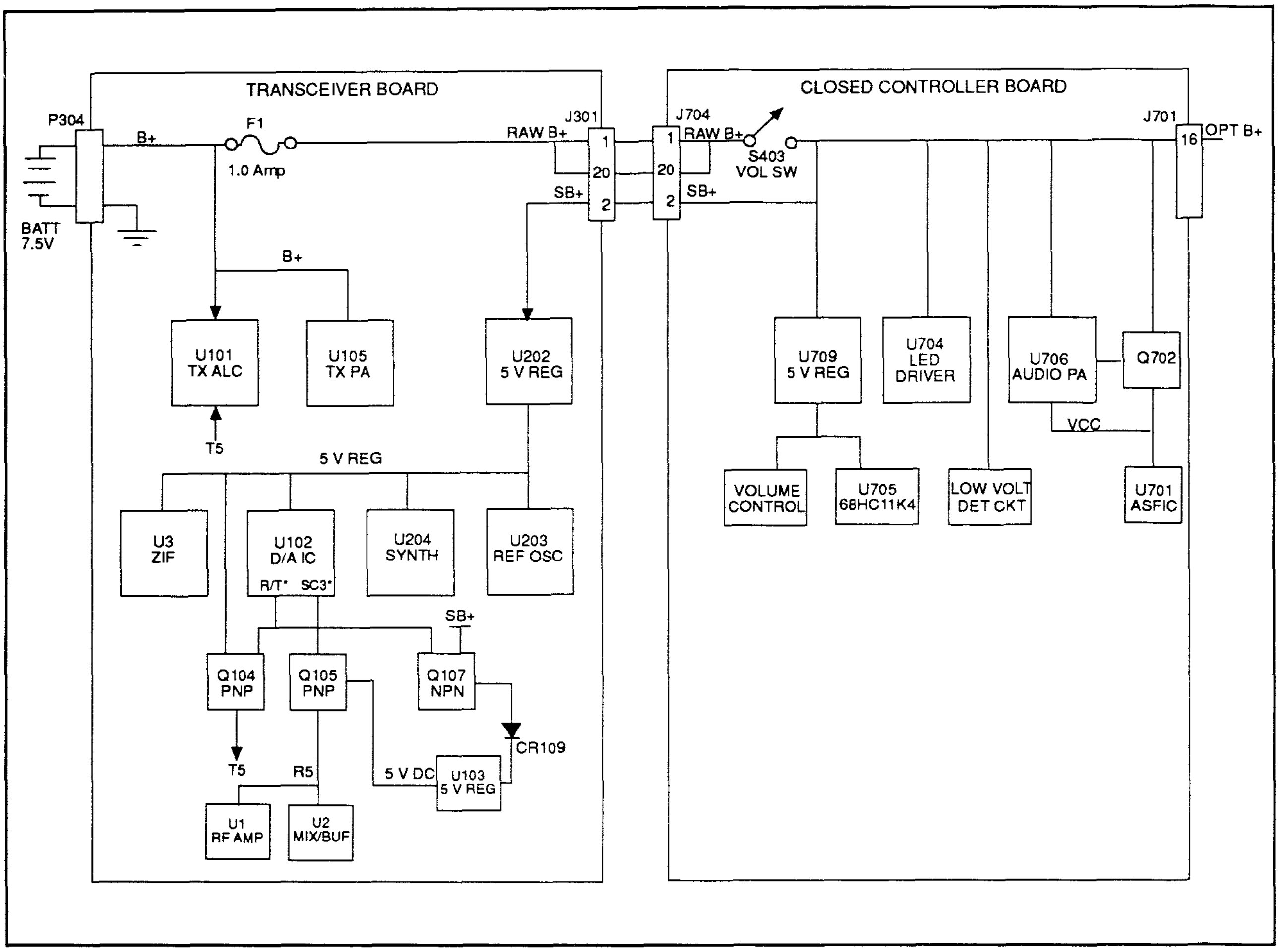
CONTROLLER BOARD 5V REGULATORS

To reduce the possibility of digital noise coupling into the audio circuitry, the controller board uses separate analog and digital 5 V supplies. The controller board regulated 5 V for the digital circuitry (Vdd) is derived from a dedicated linear regulator IC (U708) which also provides a low voltage reset function. This device uses SW B+ as input and produces an output that is regulated to 5 V ±0.1 V for all load currents up to 100 mA. The low voltage error output (U708-5) is used to hold the microcontroller (U705) RESET line low during power turn-on and turn-off conditions or when the battery is accidentally discharged to a very low voltage; this prevents the microcontroller from operating erratically during low voltage conditions.

The regulated analog 5 V supply (Vaud) from audio PA U702 provides the operating voltage for audio IC U701. It is generated in conjunction with the external PNP pass transistor Q701. The circuit uses a negative feedback loop with an internal differential amplifier and a reference voltage inside U702. As the load on the 5 V changes, the amplified error voltage is fed back to the base of Q701 to keep the 5 V regulated to a tolerance of ±0.25 V.

B+ ROUTING AND DC VOLTAGE DISTRIBUTION, CLOSED ARCHITECTURE CONTROLLER

Raw B+ from the battery nominally 7.5 V (herein referred to as B+) enters the radio on the RF board, where it is routed directly to the RF PA Module and ALC IC pin 13. It also splits off to a 1.0 A fuse and is then routed through the jumper flex (P704-1, P704-20) to the controller board, where it enters on connector pins J704-1 and J704-20. From the controller, it is routed to the control top flex via J703-8, then to the mechanical ON/OFF switch S403/R401 and returns to the controller as SB+ (J703-10). This signal is also fed to a resistive divider R708, R709 so that the microcontroller U705 can monitor the battery voltage.



DC Power Distribution Block Diagram

The SB+ supplies the audio PA U706 and its internal 5 V regulator booster transistor Q702 as well as a discrete 5 V regulator U709. The 5 V supply from the 5 V regulator only powers the micro-computer chip U705. The ASFIC IC U701 obtains its 5 V (Vcc) from the AUDIO PA internal 5 V regulator through a booster transistor Q702

The other sections of the RF boards are powered up through the SB+. There are two 5 V regulators U103 and U202 on the RF board. Supply to U103 in receive mode is via SB+, Q107, L131(UHF), L123(VHF), L121,CR109 and L122. U202 is used to supply the circuits that require to remain on at all times such as the reference oscillator (U203), fractional-N-synthesizer (U204), D/A IC (U102), Zero IF IC (U003). The D/A IC controls the DC switching of the transceiver board. Its outputs SC1, pins 12 control Q107, Q105 to give RX 5 V and SC3, pin 14 control Q104 to give TX 5 V.

The VCOB IC obtains its voltage from the VSF line of the Synthesizer. The other regulator U103 supplies the 5 V to the receiver front end as R5 via switching transistor Q105 during receive mode. R5 can be switched on and off by controlling pin 1 of Q105 in battery saver mode. U103 is not used during TX mode, and T5 for the ALC IC and other TX circuitry is obtained from U202 via switching transistor Q104 during transmit mode.

LOW-BATTERY DETECT CIRCUIT (CONTROLLER BOARD)

The low-battery detect circuit is used to warn the user that the radio's battery needs recharging. The implementation of this function takes advantage of the microcontroller's on-chip 8 bit, 8 channel A/D converter (pins PE0-PE7 of U105). The 7.5 V SB+ is divided down to a nominal 3.92 V by resistors R708 and R709 and fed to port PE4 of U105. This voltage is converted by the A/D to digital format. The microcontroller compares this voltage to a preset low-battery trip threshold which corresponds to a battery voltage of 7.04 V in standby mode or 6.2 V in transmit mode. If the measured voltage is lower than either low battery threshold, the bicolour LED on top of the radio will start flashing red indicating low battery to warn the user that approximately 20 minutes of usable battery capacity remains.

POWER TO/FROM EXTERNAL ACCESSORIES

The switched 7.5 V also powers external accessories used with the radio. The voltage is picked up from the controller board which is current limited by a 1W 120 ohms resistor R733 and passed to the display-control flex via J701-16 (OPT B+). The display-control flex then applies the voltage to pin 4 of the side connector, where it is picked up by external accessories.

TRANSCEIVER

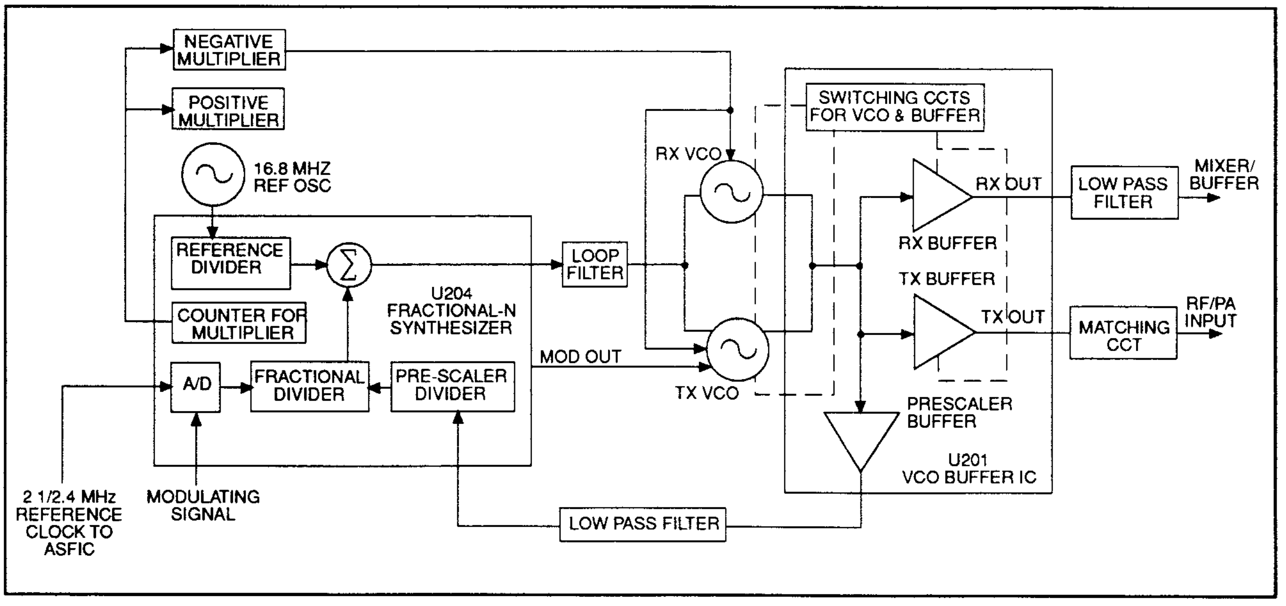
FREQUENCY GENERATION UNIT

The frequency generation unit (FGU) consists of three major sections; the high stability reference oscillator (U203), Fractional-N synthesizer (U204) and VCO Buffer IC (VCOBIC, U201). A 5 V regulator, U202, powers up the FGU, IF IC and the D/A IC, U102. The Mixer LO injection and transmit frequency are generated by the RX VCO and TX VCO respectively.

The RX VCO uses an external active device Q202, whereas the TX VCO active device is a transistor inside the VCOBIC. The base and emitter connections of this transistor are pins 11 and 12 of U201.

The VCOs and the VCOBIC are powered from a well filtered line coming from pin 19 of the synthesizer U204. Internal circuits within U204 and an external capacitor C253 provide this filtered supply. The RX VCO is a colpitts type oscillator with C236 and C235 providing feedback. The RX VCO transistor, Q202, is turned on when pin U201-7 switches from high to low. The RX VCO signal enters the VCOBIC IC on pin 9 where it is amplified by an internal buffer inside the IC. The amplified signal on pin 2 is filtered by a low-pass filter before being injected as the 1st LO signal into pin 8 of the 1st mixer, U2. In the VCOBIC IC, the RX VCO signal (or the TX VCO signal in the TX case) is also routed to an internal prescaler buffer inside U201. The buffered output on pin 16 of U201 is low-pass filtered by L205 and its associated capacitors before entering the prescaler circuits in the synthesizer, U204, on pin 21.

The divide ratios for the prescaler circuits are determined from information stored in the codeplug and bussed to the synthesizer via a micro-computer. The micro-computer extracts data for the division ratio as determined by the channel switch.



Frequency Generation Block Diagram

The reference frequency of the synthesizer is obtained from a 16.8 MHz temperature compensated reference oscillator. The 16.8 MHz reference oscillator is further divided into one of the three reference frequencies. A time based algorithm is used to generate a fractional-N ratio.

The output of the reference divider is compared with one of the reference frequencies. The phase detector error voltage (V-control) on pins 33 and 31 of U204, is applied to the loop filter consisting of R211 - R213, C247, C248, C246 and C244 . The filtered voltage alters the VCO frequency until the correct frequency is synthesized. The phase detector gain is set by components connected to pins 28 and 29 of the synthesizer.

In the TX mode, pin U204-7 goes high and pin U204-14 goes low causing Q202 to shut down and the internal TX VCO transistor in U204 to power up. The TX VCO feedback caps are C219 and C220. Varactor diode CR203 sets the TX frequency while varactor CR202 is the TX modulation varactor. The modulation of the carrier is achieved by using a 2-port modulation technique. The modulation of the low frequency tones such as DPL/TPL is achieved by injecting the tones into the A/D section of the fractional-N synthesizer. The digitized signal is then modulated by the fractional-N divider, generating the required deviation. The modulation of the high frequency audio signals is achieved by modulating the modulation varactor, CR203, through a frequency compensation network. R208 and R207 forms a potential divider for the higher frequency audio signals.

In order to cover the very wide bandwidths both positive and negative V-control voltages are used. To achieve high control voltages, positive and negative multipliers are used. The positive voltage multiplier consists of CR204, C256, C257 and reservoir capacitor C258, while the negative multiplier consists of CR205, CR206, C266, C267 and reservoir capacitor C284 in VHF and C259 in UHF. Out of phase clocks for the positive multiplier appears at pins 9 and 10 of U204 while out of phase clocks for the negative multiplier at pins 7 and 8 appears only when the negative V-control is required. (i.e. when the VCO frequency exceeds the cross-over frequency). Also when the negative V-control is not required Q201 is turned on and discharges C284 in VHF and C259 in UHF. The 13 V supply generated by the positive multiplier is used to power up the phase detector circuitry. The negative V-control is applied to the anodes of the VCO varactors.

The TX VCO signal, amplified by an internal buffer in the VCOBIC, is low-pass filtered by L224, C201 and C292 and routed to the TX PA module U105. The RX and TX VCOs and buffers are activated via a control signal from pin 38 of the synthesizer.

The reference oscillator supplies a 16.8 MHz clock to the synthesizer where it is divided down to either a 2.1 or a 2.4 MHz clock. This divided down clock is fed to U701 in the controller board where the clock is further processed for internal use in U701. U701 also use this signal to synthesize the microcontroller clock. The controller will program the synthesizer to provide 2.1 or 2.4 MHz as required. At power up the controller will warp the programmable reference oscillator to on frequency based on data stored in the code plug.

ANTENNA SWITCH AND RF JACK

The function of the antenna switch CR108 and CR109 is to route the transmitter power to the antenna during the transmit mode (CR108) or route the RF carrier received from the antenna to the receiver front end during the receiver mode (CR109). The TX antenna switch CR108 is turned on with a constant current of about 25 mA via pin 21 of U101, L105, CR108, L122 and pin 19 of U101. The RX antenna switch is turned on via SB+, Q107, L131(UHF), L123 (VHF), L121, CR109, L122 and U103.

A mechanical RF Switch, S101, connects the harmonic filter output to the standard antenna output. This switch allows the harmonic filter output to be connected to the remote antenna output P402 which is located at the universal side connector. The switching is done mechanically by a plunger located on the external side connector when it is mated to the radio universal side connector.

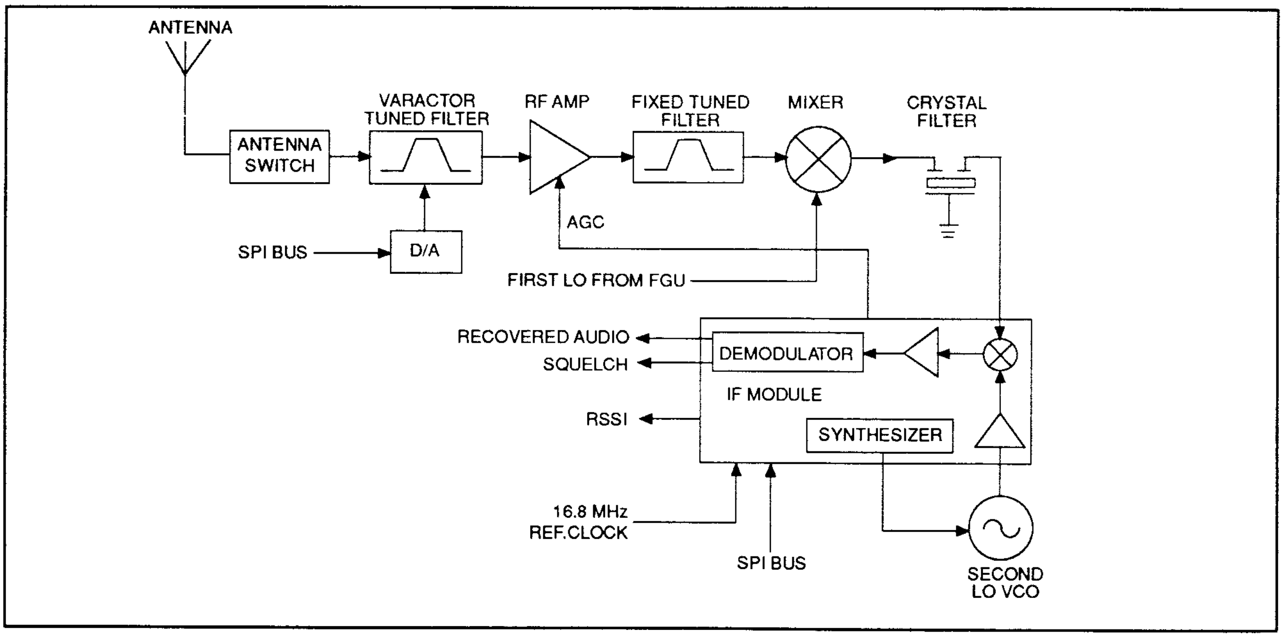
RECEIVER FRONT END

The RF signal received by the antenna is coupled to the first band-pass filter through a low-pass filter (VHF: L126 - L128, C151, C150, C130, C149; UHF: L126 - L128 C149 - C151) and an antenna switch (CR109). The band-pass filter (VHF: L11 UHF: L30 - L35, CR6 - CR9, C1 - C3; UHF: L30 - L32, L34, L35, C1 - C3, CR6 - CR9) is tuned by applying a control voltage to the varactor diodes in the filter. The band-pass filter is electronically tuned by the D/A IC (U102) controlled by the micro-computer. The D/A output range is extended through use of a current mirror Q108, R115 and R116. When Q108 is turned on via R115 the D/A output is reduced due to the voltage drop across R116. Depending on the carrier frequency the microcomputer will turn on or off Q108. Wideband operation of the filter is achieved by retuning the band-pass filter across the band. The output of the band-pass filter is then applied to a wideband GaAs RF Amplifier IC, U1 (RF AMP). Automatic gain control (AGC) is applied to the RF amplifier through an AGC network consisting of pin diode CR11, resistor (UHF: R52; VHF: R72) and choke (VHF: L32; UHF: L16). The AGC control voltage is derived from pin 4 of the IF IC, U3. Bypassing is provided by C16 and C17, while temperature compensation is provided by schottky diode CR12 and R51 in VHF and R70 in UHF. When a strong signal is received, the voltage on pin 4 of the IF IC drops causing current to flow from the receive 5 volts line, R5, through the pin diode. When this happens the RF signal is shunted to ground via C16 thus reducing the amplitude of the RF signal applied to the 1st mixer. When the received RF signal is very weak, the voltage on pin U3-4 raises and no current flows through the pin diode. The RF amplifier will then be at maximum gain. After being amplified by the RF AMP the RF signal is further filtered by a second broad band fixed tuned band-pass filter (VHF: UHF: C4 - C7, C88 - C94, C99, L11 - L15) to improve the spurious rejection.

The filtered RF signal is then routed to the input of a broadband GaAs Mixer IC, U2, via a broadband 50 ohm transformer, T1. An injection signal (FIRST LO) of about -10 dBm, supplied by the Frequency Generation Unit (FGU) is applied to pin 8 of the Mixer, resulting in an output signal which is the first IF frequency. The first IF frequency of UHF and VHF bands are 73.35 MHz and 44.85 MHz respectively. The 1st LO signal for VHF is 44.85 MHz higher than the carrier frequency while that for the UHF is 73.35 MHz lower than the carrier frequency. The IF frequency is then filtered by a 2-pole crystal filter FL1 to remove unwanted mixer products before being routed to the IF section. In the UHF radio, components, C35, C36, L20 are crystal filter matching elements on the mixer side. A 50 ohm 3 dB resistive Pi-pad appears between the output of the IF transformer T2 and the crystal filter matching network. The total front end gain up to the beginning of the Pi-pad is about 9-10 dB.

RECEIVER BACK END

The crystal filter is matched to the IF buffer amplifier, Q4 by components L22 and C38. Q4 is biased from pin 2 of the IF IC, U3. The IF frequency from Q4 is applied to pin 2 of the IF IC where it is down converted, amplified, filtered and demodulated to produce the recovered audio (at pin 28 of U3). This IF IC is electronically programmable and the amount of filtering which is dependent on the radio channel spacing is controlled by the micro-computer. Additional filtering which used to be provided externally by conventional ceramic filters is replaced by internal filters in the IF IC. The IF IC uses a type of direct conversion process where the second LO frequency is very close to the first IF frequency. The IF IC synthesizes the second LO and phase locks the VCO to track the first IF frequency.



Receiver Block Diagram

In the absence of an IF signal the VCO will "hunt" or its frequency will vary about a frequency close to the IF frequency. When an IF signal is received the VCO will lock onto the IF signal. The 2nd LO/VCO is a Colpitts oscillator built around Q1. The VCO has a varactor diode, CR5, to adjust the VCO frequency. The control signal for the varactor is derived from a loop filter consisting of C52, C53, and R16. The IF IC also provides an RSSI (Received Signal Strength Indicator) and a squelch output. The squelch output pin provides high frequency audio output which is routed to squelch shaping and squelch detection circuits within U701 in the controller board for use in other part of the radio. The RSSI is monitored by the microcomputer. The RSSI DC voltage is also used as a peak indicator during radio bench tuning of the receiver front-end varactor filter. The RSSI DC Voltage is routed through micro-computer control to a pin in the universal connector via the audio filter IC U701. When tuning the front-end filter, care should be exercised not to send in an RF signal greater than -95 dBm to prevent the AGC circuit from kicking in.

The IC also receives a 16.8 MHz clock signal (from the reference oscillator, U203) which it uses to generate internal reference signals. The IC also monitors the strength of the received signal and provides an AGC voltage at pin 4 which is then fed to the RF amplifier AGC circuit. L23 and C70 prevent any IF signal from leaking back to the front-end circuits. Pull up resistor /diode resistor networks connected to pin 4 of the IF IC set the cut in point for the AGC circuit.

TRANSMITTER

The transmitter consists of the following major sections:

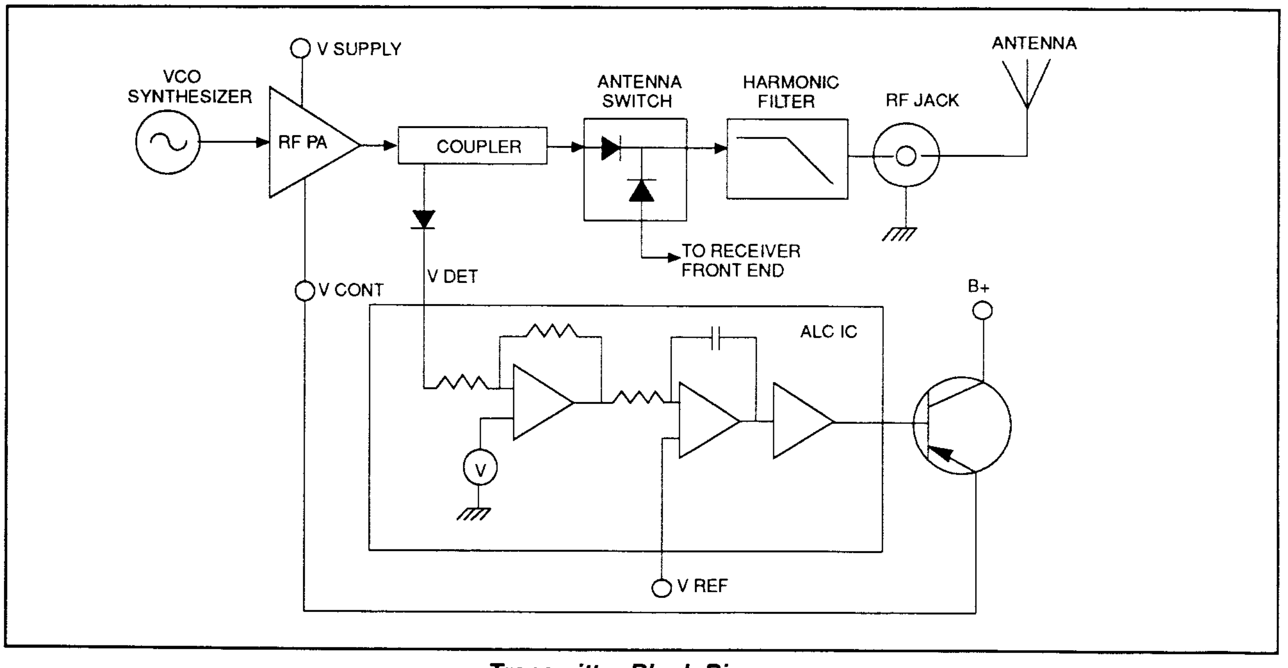
- Harmonic filter
- RF Power Amplifier module
- ALC circuits

Harmonic Filter

The Harmonic filter attenuates the harmonics of the carrier frequency which is generated by the Power Amplifier (PA) module U105 and TX antenna switch CR108.The harmonic filter circuit consists of the following components L126, L127, L128, C149, C150, C151 for the VHF models, plus C129, C130 for the UHF models. Resistor R117(UHF) or R128 (VHF) provides a current limited 5 V to P402 for Vehicular Adapter .application.

RF Power Amplifier Module

The RF power Amplifier module U105 is a wide band multi-stage amplifier (3 stages for the VHF models and 4 stages for the UHF models), which has the required gain to boost the input power typically +3 dBm from the TX buffers to produce an output level up to 7.2 watts for the VHF models and 5.8 watts for the UHF models. The modules also has some harmonic filtering internally but not sufficient to meet the system requirements. Both RF power amplifiers have nominal input and output impedances of 50 ohms. Pins 2 and 4 of the PA module will be biased up during TX mode. Biasing voltage closed to the B+ level is obtained via switching transistor Q101. Q101 is controlled by pin U101-13 which only turns on when a lock signal from the synthesizer is present on pin U101-16 and a ready signal (5 V) present on pin U101-14. The ready signal comes from pin 3 of the DAC U102 which is controlled by the microcomputer.



Transmitter Block Diagram

ALC Circuits

The purpose of U104 is to sample both the forward and the reverse power of the PA output voltage. Reverse power will be present when other than 50 ohms are present at the antenna port. The sampling will be achieved by coupling some of the forward and/or reverse power, then applied to CR102 (VHF), CR101 (UHF) and CR103 for rectification and summing. This resultant DC signal is then applied to pin U101-2, ALC IC as RFDET to be used as a RF strength indicator.

The transmit ALC circuit built around U101, is the heart of the power control loop. Pin 7, REF V, a DC signal supplied from the D/A IC U102, and the RF DET signal described earlier, are compared internally in the ALC IC to determine the amount of C BIAS, pin 4, to be applied to the base of Q110. Q110 will, in response to the base drive, vary the DC control voltages applied to pin 3 of the RF PA controlling the RF power of module, U105. The ALC IC also controls the base switching to Q101 via pin 13.

The other condition which reduces the PA power output is when an abnormal operating condition exists, which will cause the PA slab temperature to rise to an unacceptable level. The thermistor RT101, located close to the PA, senses these conditions and forces the ALC to cut back the set power.

OPEN ARCHITECTURE CONTROLLER

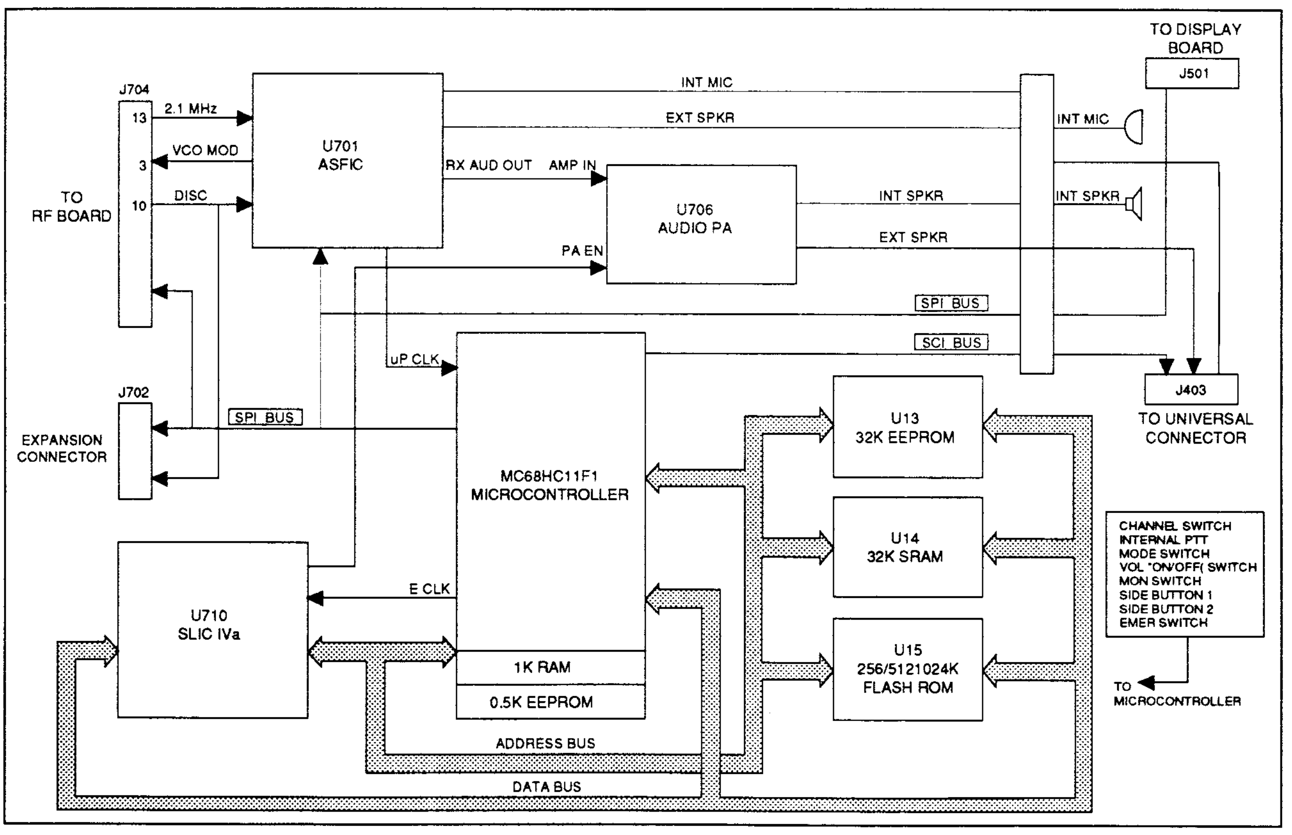
Since the controller is the central interface between the various subsystems of the radio, and because of the controllers complexity, this section will be divided into two areas of discussion, the microcomputer and its associated circuits, and the controller board's circuit operation.

MICROCOMPUTER (U705) AND ASSOCIATED CIRCUITS

The digital open controller architecture consists of (1) U705, a new generation Motorola microcontroller, (2) U710, a custom gate array, (3) U715, normally a 256K or 512K Flash memory, (4) U714, a 32K static RAM, and (5) U713, an EEPROM which could be 8K or 32K. All these devices are powered by the 5 V provided by U708. In addition to the external memory devices, U705 has 1K of RAM and 512 bytes of EEPROM on chip. Miscellaneous logic and switching functions are provided by U706, U703, U709, and U711.

Functions

The microcontroller, in conjunction with the SLIC IVa gate array U710 (which can actually be considered an extension of the microcontroller), has two basic functions: interfacing to the outside world and controlling the internal workings of the radio. It interfaces directly to the keypad, display, side buttons, PTT, rotary switch, battery voltage indicator, toggle switch, and 13-pin side connector. It is constantly monitoring these inputs and interpreting any changes into commands that control the rest of the radio. Some control functions it performs include loading the synthesizer with the desired RF frequency, turning the RF PA on or off, turning the microphone and speaker on or off, enabling and disabling audio and data paths, and generating tones. Operations and operating conditions within the radio are interpreted by the microcontroller and fed back to the operator as visible (the display) or audible (alert tone) indications of current status.



Controller Block Diagram

Normal Operation

The regulated 5 V output from U708 powers the microcontroller (U705) and the rest of the digital ICs. The µC's clock is generated by the ASFIC, U701, which has a built in programmable clock synthesizer

Microcontroller Clock Synthesizer

Upon power-up, and assuming that the ASFIC receives a proper 2.1 MHz input on U701-E1 (which comes from the RF board), the ASFIC outputs a 3.6864 MHz CMOS square wave (0-5Vpp logic) on pin U701-D1, which connects to the EXTAL input of the µC (U705-A6). The µC operates at 1/4 of this frequency, which in this case computes to 921.6 kHz. In particular, the E-clock output (pin U705-A5) will be a 50% duty cycle square wave at this frequency; this will control all bus timing accesses and is also routed to the SLIC IVa (U710).

An E-clock of 921.6 kHz is, however, too slow for the radio firmware to properly execute its functions. After the µC initializes its registers upon power-up, one of the first things it does is to reprogram the ASFIC to change the E-clock to either 1.8432 or 3.6864 MHz. Therefore, soon after the controller is powered up, one should be able to observe serial data being sent to the ASFIC on signal lines U701-E3 and U701-F1 while ASFIC select line U701-F2 is held low, and after that the UP CLK signal from U701-D1 should be 4x1.8432 MHz (=7.3728 MHz) or 4x3.6864 MHz (=14.7456 MHz), and the ECLK signal 1.8432 or 3.6864 MHz.

BUS Operation

The microcontroller operates in expanded memory mode and executes firmware contained in the 128 or 256K Flash memory U715. Unlike some HC11 µCs, this HC11F1 uses a non-multiplexed address data bus consisting of data lines D0-D7 and address lines A0-A15. In addition, the HC11F1 µC has integrated chip-select logic so that external memories can be accessed without the need for external address decoder gates. These chip select signals are provided by pins U705-PG5, PG6, and PG7.

The SLIC IVa (U710) provides an extra 32 I/O ports which can be accessed as byte-wide memory locations. These ports are used to generate additional control signals or to read more input signals. In addition, the SLIC also provides a memory-management function (MMU). Since the HC11F1 only provides 16 address lines, it can only directly address 64K (=2^16) of external memory. The SLIC contains logic to switch in 16K blocks of Flash memory, so that an address space as large as 1 MByte can be realized.

When the controller board is functioning normally, the microcontroller's 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 nsec. The low-order address lines (A0-A4) and the data lines (D0-D7) should be toggling at a high rate, e.g., you should set your oscilloscope sweep to 1 usec/div or faster to observe individual pulses. High speed CMOS transitions should also be observed on the µC control lines such as R/W* (U705-B6), and the chip select lines U705-PG7, PG6, and PG5. Another line of interest is the MODA line, pin U705-C5, which is also connected to U703-1 and R727. While the CPU is running, this signal is an open-drain CMOS output which goes low whenever the µC begins a new instruction (an instruction typically requires 2-4 external bus cycles, or memory fetches). Since it is an open-drain output, however, the waveform rise assumes an exponential shape similar to an RC circuit.

On the µC U705, the lines XIRQ (pin E8) and RESET (pin E5) 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 the RESET line goes low periodically, with the period being on the order of msec.

RAM

The on-chip 1K static RAM from U705 provides some scratchpad memory, with the bulk of it coming from the external 32K SRAM U714. Note that this chip is packaged in the new TSOP (Thin Small Outline Package) style. External SRAM accesses are indicated by the CSGEN signal U714-20 (which comes from U705-PG6) going low. Normally RAM is accessed less often than the Flash U715, i.e., the number of transitions per second on U715 chip select (pin 30) should be 5-15 times higher than those on U714-20.

EEPROM

The so-called radio codeplug storage is provided by U705's internal 512 byte EEPROM, with an additional 8K or 32K bytes of data provided by U713, an external EEPROM. From a software standpoint, both devices are treated as one large block of EEPROM. There are three basic types of codeplug information: information on the trunked system(s) on which the radio is authorized to operate, information on the conventional system(s), which is either of the repeater or talk-around type, on which the radio is authorized to operate, and information on the configuration and tuning of the radio itself.

SB9600 Serial Interface

The radio uses a proprietary multiprocessor serial protocol known as SB9600, which is based on the Longhorn protocol used on previous mobile radios. This protocol allows the µC in the system to interface to an external PC for programming using Radio Service Software, a remote hand-held mic, or a Vehicular Adapter.

From a hardware standpoint, this interface is comprised of the external side connector pins LH BUSY and LH DATA (pins 9 and 11, respectively). The LH DATA signal is a bidirectional 0-5 V RS-232 line that uses U705's integrated RS-232 asynchronous serial communications interface (SCI) peripheral, with the SCI TX line being U705-PD1 and the SCI RX line being U705-PD0. The SCI TX line is connected to the controller board signal LH DATA through Schottky diode CR702. This diode allows the SCI TX line to drive LH DATA active low only; when SCI TX is high, the diode does not conduct and LH DATA is pulled high by 10K resistor R743. This active-low, passive pull-up scheme is required so that if two processors on the SB9600 bus send data simultaneously, there will not be potentially destructive output contention, which could occur if one µC's output were active high and the other were active low. The LH DATA line is connected to U705's SCI RX line through analog switch U709, which is normally closed unless the radio is in the Flash programming mode, as discussed above. The LH DATA signal is routed to the controller connector pin J701-26 via analog mux U711, which is normally configured to select signals X0, Y0, and Z0 by virtue of the common control signal MUX CNTL being a logic low.

The LH BUSY signal, which is simply labelled BUSY on the controller schematic, is connected to two digital ports: U705 input PA1, and U710 output PL6. The BUSY signal is a bidirectional active-high signal that is normally pulled down by 10K resistor R739. It is routed to the controller connector pin J701-22 via U711, pins 2 and 15.

A typical usage of the SB9600 interface is using a PC running the Radio Service Software package and the Radio Interface Box (RIB) to program the radio's codeplug. When the PC sends a command or data to the radio, one should observe the SCI RX line (U705-PD0) toggling at a 9600 baud rate, and the BUSY line going high when data is actually being sent. After data transfers are completed, the BUSY line should idle low and the LH DATA line should idle high. The controller board also sends a power-up status message when it is first turned on, so one should be able to observe SB9600 data being sent from the radio within a few msec after power-up.

SPI Interface

The microcontroller communicates to several ICs and modules through a dedicated on-chip Serial Peripheral Interface (SPI) port which consists of transmit data line MOSI (U705-PD3), receive data line MISO (U705-PD2), and clock line SCK (U705-PD4). In addition, each IC that can be accessed by the µC using the SPI has a select line associated with it. The programmable ICs or circuits and their associated select lines are: (1) the ASFIC (U701), with select line U705-PG3, (2) the RF board reference oscillator, with select line U705-PG1, (3) the RF board synthesizer, with select line U705-PG0, (4) the RF board Zero IF chip, with select line U710-PL4, (5) the LCD display board, with select line U710-PK6, and (6) the Secure/Data board, which has two independent select lines, U710-PK5 and U710-PK0. For all these SPI devices, the select lines are active-low, i.e., the select line goes low only when the associated device is being programmed. The first four ICs are listen-only, i.e., they cannot output data on the MISO line.

The LCD keypad/display board uses the MOSI line to send data to the display driver IC, and the MISO line to send keypad data back to the controller µC. Note, however, that the keypad (or any other SPI device) can never initiate display data; the µC is at all times the SPI master device. Thus the MOSI line, which means Master Out/Slave In, and the MISO line (Master In/Slave Out) are always in the Master configuration. When a key is pressed, logic in the keypad board causes the KEY INT line (J701-9) to go low. The µC detects this transition using U710, and then sends a harmless command to the display in order to read the keypad data.

The Secure/Data option board (which connects to J702) supports two slave SPI devices which can each return data to the µC. The select lines for these devices are J702-21 and J702-23, and the interrupt lines (which perform the same function as the KEY INT line above) are J702-20 and J702-22. These connect to U710-PK5, U710-PK0, U710-PK5, and U710-PJ4, respectively.

Option Select Lines

The two option select lines OPT SEL 1 and OPT SEL 2, pins 1 and 5 of the radio side connector, are used to identify the presence of external accessories and also to key up the radio with an external microphone. The table below shows the modes indicated by the various combinations of the signal states. Note that both signals have pull-ups on the controller board (R702 and R717) so that if no external device is connected to these pins, they will be at a logic high level and the radio will be in the normal mode, i.e., internal speaker and microphone will be used. Note also that RF power will always be routed to the internal antenna port unless a side connector is installed that activates the electromechanical switch inside the RF board which redirects power to the external antenna port. The microcontroller has no knowledge or control of which port RF energy is being directed to an external PTT (OPT SEL 1=0, OPT SEL 2=0) will cause the external mic audio port to be activated, but the RF could conceivably be routed through either RF port.

Option Select Definition

OPT SEL 1	OPT SEL 2	FUNCTION
Low	Low	External PTT
Low	High	External Speaker
High	Low	Man Down
High	High	Normal Mode

LED Control

The bicolor LED on the top of the radio is activated by

U710 output ports U710-PK7 and U710-PL7, in conjunction with the dual NPN transistor IC U704. When either output is at logic high, the corresponding output pin of U704 (pin 6 for the green LED, pin 3 for the red) should be at approximately 4.3 volts. Note that it is possible to have both LED outputs on simultaneously, in which case the LED emits a reddish/yellow light.

Secure Board Interfacing

The full keypad radio can provide Secure Voice Encryption using an optional Secure board (with a number of possible encryption algorithms) connected to J702. A standard Motorola Key Variable Loader can be used to transfer keys to the Secure board. The keyloader connects the signals DVP WE, KID, and KEY/FAIL to the radio side connector pins 7, 9, and 11, which correspond to controller pins J701-21, 22, and 26. In addition, the Key Variable Loader identifies itself by grounding side connector pins 10 and 12, which correspond to controller pins J701-23 and 25. When the µC detects these pins at a logic low level, it sets the control line labelled MUX CNTL for mux U711 to a logic one, which causes it to select the lines X1, Y1, and Z1. These are the DVP WE, KEY INSERT DATA, and KEY/FAIL lines from the Secure board connector J702. The keyloader can then be used to transfer keys to the Secure board.

CONTROLLER BOARD CIRCUIT OPERATION

The circuits to be considered here are the transmit audio path between the microphone and the transmit RF block, the transmit data path between the microcontroller and the RF block, the receive audio path between the receive RF block and the speaker, the receive data path between the receive RF block and the microcontroller, and the alert tone path between the microcontroller and the speaker. The transmit and receive audio paths are disabled in the standby mode and selectively enabled by the microcontroller when the radio transmits or receives a signal. Also, there are minor differences in the functioning of both paths depending on whether an internal or external (accessory) microphone/speaker is being used. The radio constantly monitors the received data path for control channel data in trunking operation or sub-audible data in conventional operation.

Transmit Audio Circuits

There are three major circuits in the transmit audio path. Some require enable lines and some are active devices that are always operating. When the operator presses the PTT switch while in trunked mode, the radio will request a voice channel from the channel control. When it receives a message, it will move to the specified voice channel and the microcontroller will enable the path between the microphone and the RF section. When the operator presses the PTT switch while in conventional mode, the radio will first monitor the channel for traffic (smart PTT) and if it is not busy the microcontroller will enable the path between the microphone and the RF block.

The microphones used for the radio (internal mic) and remote microphone (external mic) are of the FET ELectret type and, thus, require a DC biasing voltage provided by R703 and R706, respectively. Note that there are two distinct microphone audio input paths (U701-A7 and U701-B8) for amplification; logic inside the ASFIC (U701) is used to select one of the signals.

(1) Internal Microphone Path

The internal microphone is located on the front cover of the radio and is connected to the controller board via J701-7. From here the signal is routed to R706 and R707. R706 is the DC biasing resistor and R707 provides input protection for the CMOS amplifier input. Filter capacitor C617 provides low-pass filtering to eliminate frequency components above 3 kHz, and C713 serves as a DC blocking capacitor.

The HPF formed by C793 and R700 attenuates objectionable low frequency audio components of speech.

(2) External Microphone Path

The external microphone signal enters the radio on side connector pin 3 and is connected to the controller board via J701-14. It is then routed to U701 through resistor R704 and capacitors C712 and C620, with DC bias provided by R703.

(3) PTT Sensing and TX Audio Processing

Depression of the Internal PTT switch is detected via U710 port PH6, which has an internal pull-up resistor. An external PTT is generated by grounding both the OPT SEL 1 and OPT SEL 2 pins on the side connector (pins 1 and 5). These lines are read by U710 ports PJ5 and PJ6. When the Internal PTT is sensed, the µC will always configure the ASFIC for the internal mic audio path, and External PTT will result in the external mic audio path being selected. Inside the ASFIC, the mic audio is amplified, filtered to eliminate components outside the 300-3000 Hz voice band, pre-emphasized, and then limited so as to prevent the transmitter from over deviating. The limited mic audio is then routed through a summer which is used to add in PL or DPL sub-audio band modulation and then to a splatter filter to eliminate high frequency spectral components that could be generated by the limiter. After the splatter filter, the audio is routed to the two modulation 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 U701-H8, at which point it is DC coupled to the VCO on the RF board through J704-3.

(4) TX Secure Audio

The Transmit Secure audio follows the normal transmit audio processing until it emerges from the ASFIC pre-emphasis out pin (U701-C8), which is fed to the secure board (J702-7). The Secure board contains circuitry to amplify, digitize, encrypt, and filter the audio. The encrypted signal is then fed back from J702-14 to the ASFIC AUX TX input (U701-D7). The signal level at this pin should be about 1 Vpp. The signal is then routed through the AUX TX path (which bypasses the ASFIC splatter filter) and summed into the main modulation path. After the summer it runs through the modulation attenuator and then to the VCO MOD port, the same as all other TX audio.

Transmit Data Circuits

There are four major types of transmit data: sub-audible data (PL/DPL/Connect Tone) that gets summed with voice, high speed (3600 baud) data for trunking control channel communication, DTMF data for telephone communication in trunked and conventional systems, and MDC data for use in Motorola proprietary MDC systems. The deviation levels of the latter three types are tuned by a 5-bit digital attenuator inside the ASFIC. For each data type and each bandsplit there is a distinct set of tuning values that are programmed into the ASFIC before the data is about to be generated and transmitted.

(1) Sub-audible Data (PL/DPL)

Sub-audible data is composed of low frequency PL and DPL waveforms for conventional operation and connect tones for trunked voice channel operation. (The trunking connect tone is simply a PL sine wave 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 300 Hz, so these tones are never heard in the actual system.

Only one type of sub-audible data can be generated by U701 at any one time. The process is as follows: using the SPI, the microcontroller programs the ASFIC (U701) to set up the proper low-speed data deviation and select the PL or DPL filters. The microcontroller then generates a square wave from U705-PA6 which strobes the ASFIC PL/DPL encode input U701-C3 at twelve times the desired data rate. (For example, for a PL frequency of 103 Hz, the frequency of the square wave at U701-32 would be 1236 Hz). This drives a tone generator inside U701 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 U701-H8 (VCO MOD), where it is sent to the RF board as previously described for transmit audio.

(2) High Speed Data

High speed data refers to the 3600 baud data waveforms Inbound Signalling Words (ISWs) and Outbound Signalling Words (OSWs) used in a trunking system for high speed communication between the radio and the central controller. To generate an ISW, the microcontroller first programs the ASFIC (U701) to the proper filter and gain settings. It then begins strobing U701-G1 (Trunking Clock In) with a pulse when the data is supposed to change states. U701's 5-3-2 State Encoder (wwhich 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 via the VCO MOD pin J704-3.

(3) Dual Tone Multiple Frequency (DTMF) Data

DTMF data is a dual tone waveform used during phone interconnect operation. There are seven frequencies, with four in the low group (697-941 Hz) and three in the high group (1209-1477 Hz). The high-group tone is generated by the microcontroller (µC) U705-PA5 strobing U701-G1 at six times the tone frequency for tones less than 1440 Hz or twice the frequency for tones greater than 1440 Hz. The low group tone is generated by (µC) U705-PA4 strobing U701-G2 (DTMF CLOCK) at six times the tone frequency. Inside U701 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.

(4) MDC Data

Note that the MDC signal follows exactly the same path as the DTMF high group tone. MDC data utilizes MSK modulation, in which a logic zero is represented by one cycle of a 1200 Hz sine wave, and a logic one by 1.5 cycles of an 1800 Hz sine wave. To generate the data, the microcontroller first programs the ASFIC (U701) to the proper filter and gain settings. It then begins strobing U701-G1 (Trunking Clock In) with a square wave (from U705-PA5) at the same baud rate as the data. The output waveform from U701's 5-3-2 State Encoder is then fed to the post-limiter summer block and then the splatter filter. From that point it is routed through the mod attenuators and then out of the ASFIC to the RF board via the VCO MOD pin J704-3.

Receive Audio Circuits

There are two major circuits in the receive audio path. These are the ASFIC (U701) and the Audio PA (U702). The ASFIC is an SPI-programmable device, while the other IC has direct control lines. The ASFIC is a new custom IC that were designed for the open architecture radio; the Audio PA is a repackaged version of the PA that was used on previous radios.

The radio's RF circuits are constantly producing an output at the discriminator. Whenever the radio is in trunked standby mode, it is processing data from the control channel. While in conventional standby mode, it is always monitoring the squelch line and/or or sub-audible data. The raw discriminator from the RF board enters the controller board on J704-10. In addition to the raw discriminator signal DISC, the RF board's Zero IF IC also provides a pre-filtered version of the discriminator signal that is dedicated to the ASFIC's squelch detect circuitry. This signal, labelled SQUELCH, enters the controller board on J704-12 and is routed to the ASFIC on U701-H7. The squelch signal is filtered, rectified, and low-pass filtered. It is then to a comparator to produce an active high signal on CH ACT. A squelch tail circuit is used to produce SQ DET from CH ACT. The microcontroller makes a detect decision based on SQ DET, and sets up the receive audio path on U701 and enables the audio PA.

(1) <u>U701 Audio Processing and Digital Volume Control</u>

The signal enters the controller via the PL IN pin U701-J7. Inside the IC, the signal first passes through an LPF filter to remove any frequency components above 3000 Hz and then a HPF to strip off any sub-audible data below 300 Hz. Next the recovered audio passes through a de-emphasis filter to reduce the effects of FM noise. Finally, the IC amplifies the audio and passes it through the 8-bit programmable attenuator whose level is set depending on the value of the volume control. The µC U705 programs the value of the 8-bit attenuator in accordance with the voltage sensed on the volume potentiometer, which is connected to U705-PE2. This pin is one of the eight channels of U705's 8-bit A/D converter. Sensing the volume pot digitally avoids having to run the audio all the way up to the control top (where it can pick up noise) and also provides flexibility, e.g., when the radio is in CVC audio mode the µC will maintain the ASFIC's 8-bit attenuator at a constant setting regardless of the voltage sensed on U705-PE2. After passing through the 8-bit digital attenuator, the audio goes to a buffer amp and then exits at U701-J4, where it is routed to the Audio PA U702.

(2) <u>Differential Speaker Audio Amplification</u>

The final stage in the receive path is the audio amplifiers that drive either the internal or external speakers. Each speaker is driven using a two amplifier arrangement. Since one amplifier can be shared as common between the two speakers, only three total amplifiers are needed inside the audio PA IC U702. Benefits of using the two amplifier configuration include: reduced distortion due to larger possible signals before the amplifiers begin to clip, 6 dB more gain than a single amplifier arrangement, and elimination of the need for ac coupling devices. The audio is coupled into the amplifiers on U702-C6.

There are two enable lines controlling the three audio amplifiers of U702. The External Speaker Select line, which is used to control the phase of the internal or external amplifier, comes from U701-B4 and the Audio PA Enable line (which is used to enable all three amplifiers) comes from U710-PK4 . The Audio PA Enable line is active-high, while the External Speaker Select is active-low, i.e., the external speaker is selected if this control line is at a logic low, and the internal speaker otherwise. The microcontroller determines that audio should be routed to the external or internal speaker by reading the option select lines 1 and 2, which are pins 1 and 5 of the radio side connector. If the µC reads these OPT SEL 1 to be 0 and OPT SEL 2 to be 1, and the radio is in receive audio mode, the audio will be directed to the external speaker lines (pins 2 and 6 of radio side connector) with the audio level being controlled by the radio volume pot. If the µC senses that there is a Vehicular Adapter connected to the radio (which is identified by having a diode from OPT SEL 2 to OPT SEL 1, with the anode at OPT SEL 2), and the radio is in receive audio mode, the audio will be directed to the external speaker lines (pins 2 and 6 of radio side connector) with the audio set to a fixed level, independent of the radio volume pot. When the receive path is to be enabled, the microcontroller sends data to U710 to put a high on U710-PK4 which turns on all three amplifiers. If the internal speaker amplifier is selected, then its output is 180 degrees out of phase with the output of the common amplifier. The result at the internal speaker is a signal twice as large as either amplifier's output, while the external amplifier is in phase with the common amplifier; the result at the external speaker is no signal. The reverse is true if the external speaker is selected. The overall gain using the two amplifier arrangement is approximately 32.5 dB. Since the radio uses a 28 ohm internal speaker, the nominal voltage for rated audio is 3.74 Vrms, and the nominal audio input to U702 is 88.7 mVrms when rated audio output is obtained.

Secure Receive Audio

Discriminator audio is routed to the secure board via J702-5. On the secure board it is decrypted and converted back to analog format, and then fed back to the ASFIC from the AUX RX line (J702-9). It is then routed to the ASFIC pin U701-J6; from then on it traverses a path identical to conventional receive audio.

Receive Data Circuits

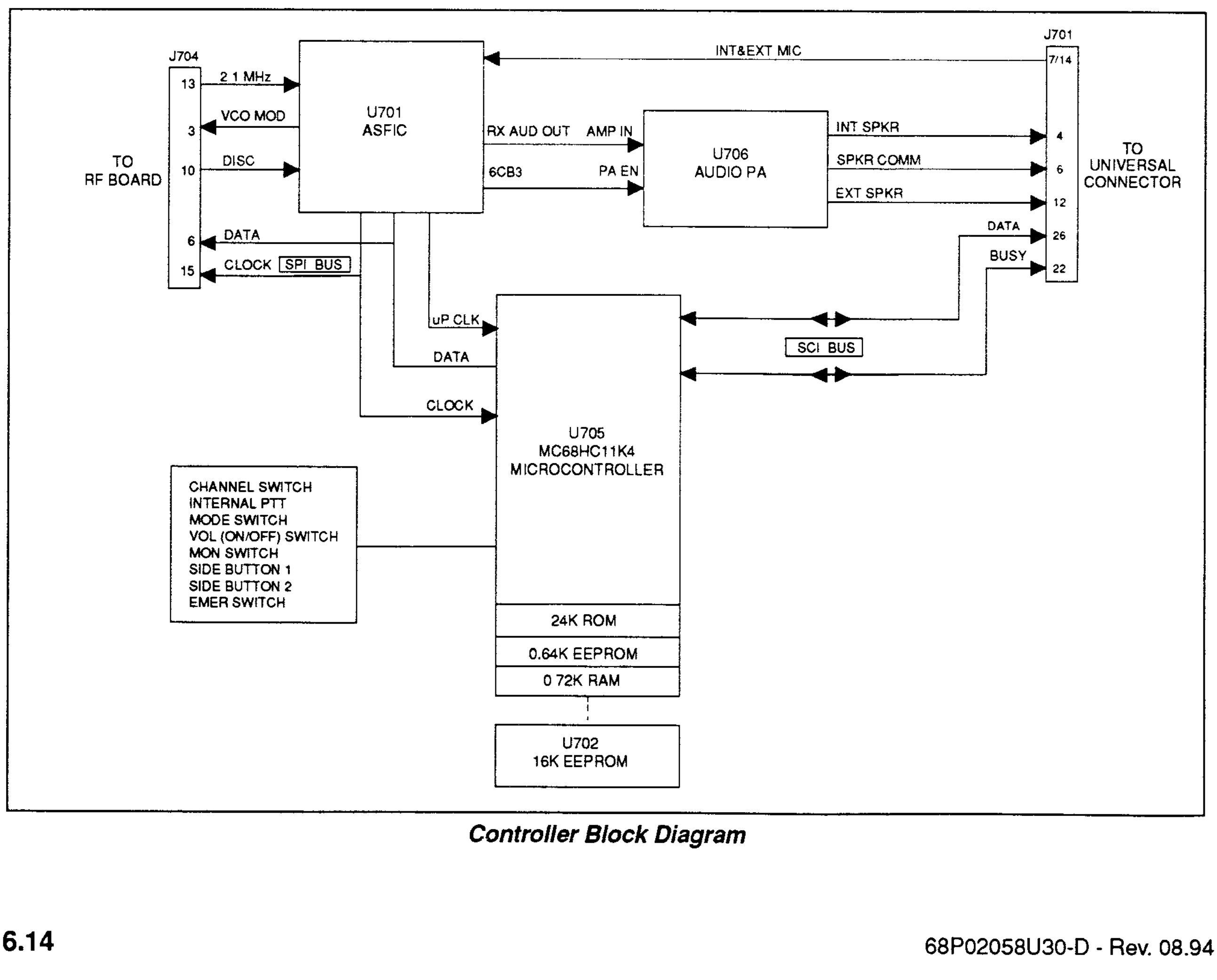
The ASFIC (U701) is used to decode all receive data, which includes PL, DPL, Low-speed trunking, MDC, and High-speed trunking data. The "decode" process for each data type typically involves low-pass or band-pass filtering, signal amplification, and then routing the signal to a comparator which outputs a logic zero or one signal. The discriminator output from the RF board is routed to U701-J7 through coupling capacitor C709. Inside U701 the data is filtered according to the data type (HS data or LS data), then hard-limited to a 0–5 V digital level. The high speed limited data output (MDC and trunking high-speed) appears at U701-G4, where it connects to U705-PA0. The low speed limited data output (PL, DPL and trunking low-speed) appears at U701-A4, where it connects to U710-PK7. If, for example, the radio is receiving 192.8 Hz PL, the discriminator should contain a 192.8 Hz sine wave at about 53 mVrms, and the limited PL output should be a 192.8 Hz square wave. While the radio is decoding PL, DPL, or low-speed trunking data, the µC also outputs a sampling waveform on U705-PA6, which is routed to U701-C3. (This is the same line used to generate TX PL or DPL data). This sampling waveform is a square wave between 1000 and 2000 Hz.

Alert Tone Circuits

When the microcontroller needs to give the operator feedback (for a good key press or for a bad key press) or radio status (trunked system busy, low battery condition, phone call, circuit failures), it sends an alert tone to the speaker. It does so by sending data to U701 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 µC and the ASFIC. The allowable internal alert tones are 300, 900, and 1800 Hz. For external alert tones, the µC can generate any tone within the 100-3000 Hz audio band. This is accomplished by the µC toggling the output line U705-PA4, which is also the same line used to generate low-group DTMF data. Inside the ASFIC, this signal is routed to the external input of the alert tone generator; the output of the generator is summed into the audio chain just after the RX audio de-emphasis block. Inside U701 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. (Note that the expander is bypassed even if U601 is present). The tone exits at U701-J4, then is routed to the audio PA the same as receive audio.

CLOSED ARCHITECTURE CONTROLLER

Since the controller is the central interface between the various subsystems of the radio, and because of the controllers complexity, this section will be divided into two areas of discussion, the microcomputer and its associated circuits, and the controller board's circuit operation.



Controller Block Diagram

MICROCOMPUTER (U705) AND ASSOCIATED CIRCUITS

The heart of the closed architecture controller consists of a new generation Motorola HC11k4 microcontroller, U705. The HC11K4 micro-computer consists of 640 bytes of EEPROM, 760 bytes of RAM and 24K ROM and operates in single chip mode.

Functions

The microcontroller, has two basic functions: interfacing to the outside world and controlling the internal workings of the radio. It interfaces directly to the keypad, display, side buttons, PTT, rotary switch, toggle switch and 13 pin side connector. It is constantly monitoring these inputs and interpreting any changes into commands that control the rest of the radio. Some of its functions include loading the synthesizer with the desired RF frequency, turning the RF PA on or off, turning the microphone and speaker on or off, enabling and disabling audio and data paths and generating tones. Operations and operating conditions within the radio are interpreted by the microcontroller and fed back to the operator as visible (the display) or audible (alert tone) indications of current status.

Microcontroller Clock Synthesizer

Upon power-up, and assuming that the ASFIC receives a proper 2.1 MHz input at pin 33 of U701 (which comes from the RF board), the ASFIC outputs a 3.6864 MHz CMOS square wave on pin 35 of U701, which connects to the EXTAL input of the microcontroller, U705-77. The microcontroller operates at 1/4 of this frequency which, in this case, computes to 921.6 kHz.

An E-clock of 921.6 kHz, however, is too slow for the radio firmware to properly execute its functions. After the microcomputer initializes its registers upon power-up, one of the first thing it does is to program the ASFIC to change the E-clock to 1.9872 MHz. Therefore, soon after the controller is powered up, one should be able to observe serial data being sent to the ASFIC on signal lines U701-32 while select line U701-30 is held low, and after that the microcontroller clock signal from U701-35 should be 4x1.9872 MHz (=7.9844 MHz).

SB9600 Serial Interface

The radio uses a proprietary multiprocessor serial protocol known as SB9600, which is based on the Longhorn protocol used on previous mobile radios. This protocol allows the microcontroller in the system to interface to an external PC (for programming using Radio Service Software), a remote hand-held microphone or a Vehicular Adaptor.

From a hardware standpoint, this is comprised of the external side connector pins LH BUSY and LH DATA (pins 9 and 11, respectively). The LH DATA signal is a bidirectional 0-5 V RS-232 line that uses U705's integrated RS-232 asynchronous serial communication interface (SCI) peripheral, with the SCI TX line being U705-PD1 and the SCI RX line being U705-PD0. The SCI TX line and the SCI RX line are connected together thus providing the signal LH DATA. The LH DATA signal line is routed to the controller connector pin J701-26.

The LH BUSY signal, which is simply labelled BUSY on the controller schematic, is connected to U705 input PA3. The BUSY signal is a bidirectional signal that is normally pulled down by 10K resistor R737. It is routed to the controller pin J701-22 .

A typical usage of the SB9600 interface is using a PC running the RSS software package and the Radio Interface Box (RIB) to program the radio's codeplug. When the PC sends a command or data to the radio, one should observe the SCI RX line (U705-PD0) toggling at a 9600 baud rate, and the BUSY line going high when data is actually being sent. After data transfer is complete, the busy line should idle low and the LH DATA line should idle high. The controller board also sends power-up status message when it is first turned on, so one should be able to observe SB9600 data being sent from the radio within a few msec after power-up.

SPI Interface

The microcontroller communicates to several ICs and modules through a dedicated on-chip Serial Peripheral Interface (SPI) port which consists of transmit data line MOSI (U705 PD3), receive data line MISO (U705-PD2), and clock line SCK (U705-PD4). In addition, each IC that can be accessed by the microcontroller using the SPI has a select line associated with it. The programmable ICs or circuits and their associated select lines are: (1) the ASFIC (U701), with select line at pin 30, (2) the RF board reference oscillator U203, with select line at pin 24, (3) the RF board synthesizer (U204), with select line at pin 4, (4) the RF board Zero IF chip (U3), with select line at pin 21, (5) the RF board D/A (U102), with select line at pin 16. For all these SPI devices, the select lines are active low, i.e, the select line goes low only when the associated device is being programmed.

Option Select Lines

The two option select lines OPT SEL 1 and OPT SEL 2, pins 1 and 5 of the radio side connector, are used to identify the presence of external accessories and also to key up the radio with an external microphone. The table below shows the modes indicated by the various combinations of the signal states. Note that both signals have pull-ups internally inside the microcontroller so that if no external device is connected to these pins, they will be at a logic high level and the radio will be in the normal mode, i.e, internal speaker and microphone will be used. Note that RF power will always be routed to the internal antenna port unless a side connector is installed that activates the electro-mechanical switch inside the RF board which redirects power to the external antenna port. The micro-controller has no knowledge or control of which port RF energy is being directed to. An external PTT (OPT SEL 1=0, OPT SEL 2=0) will cause the external microphone audio port to be activated, but the RF could be routed through either RF port.

Option Select Definition

OPT SEL 1	OPT SEL 2	FUNCTION
Low	Low	External PTT
Low	High	External Speaker
High	Low	Man Down
High	High	Normal Mode

LED Control

The bicolour LED on the top of the radio is activated by U705 PC0 and PC1 in conjunction with the dual NPN transistor IC U704. When either output is at logic high, the corresponding output pin of U704 (pin 3 for the green LED, pin 6 for the red) should be at approximately 4.3 Volts. Note that it is possible to have both LED outputs on simultaneously, in which case the LED emits an orange / yellow light.

CONTROLLER BOARD CIRCUIT OPERATION

The circuits to be considered here are the transmit audio path between the microphone and the transmit RF block, the transmit data path between the micro-controller and the RF block, the receive audio path between the receive RF block and the speaker, the receive data path between the the receive RF block and the microcontroller, and the alert tone path between the microcontroller and the speaker. The transmit and receive audio paths are disabled in the standby mode and selectively enabled by the micro-controller when the radio transmits or receives a signal. Also there are minor differences in the functioning of both paths depending on whether an internal or external (accessory) microphone/speaker is being used.

Transmit Audio Circuits

There are three major circuits in the transmit audio path. Some require enable lines and some are active devices that are always operating. When the operator presses the PTT switch while in conventional mode, the radio will first monitor the channel for traffic (smart PTT) and if it is not busy the microcontroller will enable the path between the microphone and the RF block.

The microphone for the radio (internal mic) and remote microphone (external mic) are of the FET Electret type and, thus, require a DC biasing voltage provided by R701 and R756 respectively. Note that there are two distinct microphone audio paths (U701 pin 2 and pin 54) for amplification; logic inside the ASFIC is used to select one of the signals.

(1) Internal Microphone Path

The internal microphone is located on the front cover of the radio and is connected to the controller board via J701-7. From here the signal is routed to R701 and R703. R701 is the DC biasing resistor and R703 provides input protection for the CMOS amplifier input. Filter capacitor C703 provides low-pass filtering to eliminate frequency components above 3 kHz, and C706 and C779 serves as DC blocking capacitor

The HPF formed by C779 and R704 attenuates objectionable low frequency audio components of speech.

(2) External Microphone Path

The external microphone signal enters the radio on side connector pin 3 and is connected to the controller board via J701-14. It is then routed to U701 through resistor R756 and R702 and C705 with DC bias provided by R703.

(3) PTT Sensing and TX Audio Processing

Depression of the internal PTT switch is detected via U705 port PF2, which has an internal pull-up resistor. An external PTT is generated by grounding both the OPT SEL 1 and OPT SEL 2 pins on the side connector (pin 1 and 5). These lines are read by U705 ports PG5 and PG6. When the Internal PTT is sensed, the microcontroller will always configure the ASFIC for the internal microphone audio path, and External PTT will result in the external microphone audio path being selected. Inside the ASFIC, the microphone audio is amplified, filtered to eliminate components outside the 300-3000 Hz voice band, pre-emphasized, and then limited so as to prevent the transmitter from overdeviating. The limited microphone audio is then routed through a summer which is used to add PL or DPL sub-audio band modulation and then to a splatter filter to eliminate high frequency spectral components that could be generated by the limiter. After the splatter filter, the audio is routed to the two modulation 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 U701 pin 13, at which point it is DC coupled to the synthesizer (U204 pin 5) on the RF board through J704-3.

Transmit Data Circuits

There are three major types of transmit data: sub-audible data (PL/DPL), DTMF data for telephone communication, and MDC data for use in Motorola proprietary MDC systems. The deviation levels of later two types are tuned by a 5-bit digital attenuator inside the ASFIC. For each data type and each bandsplit there is a distinct set of tuning values that are programmed into the ASFIC before the data is about to be generated and transmitted.

(1) Sub-audible Data (PL/DPL)

Sub-audible data is composed of low frequency PL and DPL waveforms for conventional operation. 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 300 Hz, so these tones are never heard in the actual system.

Only one type of sub-audible data can be generated by U705 at any one time. The process is as follows: using the SPI, the microcontroller programs the ASFIC to set up the proper low-speed data deviation and select the PL or DPL filters. The microcontroller then generates a square wave from U705 port PA5 which strobes the ASFIC PL/DPL encode input U701 pin 40. This drives a tone generator inside U701 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 U701 pin 13 (VCO MOD), where it is sent to the RF board as previously described for transmit audio.

(2) Dual Tone Multiple Frequency (DTMF) Data

DTMF data is a dual tone waveform used during phone interconnect operation. There are seven frequencies, with four in the low group (697-941 Hz) and three in the high group (1209-1477 Hz). The high group tone is generated by U705 port PH0 strobing U701 pin 29 at six times the tone frequency for tones less than 1440 Hz or twice the frequency for tones greater than 1440 Hz. The low group tone is generated by U705 port PH1 strobing U701 pin 28 at six times the tone frequency. Inside U701 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. From that point it is routed through the mod attenuators and then out of the ASFIC to the RF board via the VCO MOD pin J704-3.

(3) MDC Data

The MDC signal follows exactly the same path as the DTMF high group tone. MDC data utilizes MSK modulation, in which a logic zero is represented by one cycle of a 1200 Hz sine wave, and a logic one by 1.5 cycles of an 1800 Hz sine wave. To generate the data, the microcontroller first programs the ASFIC (U701) to the proper filter and gain settings. It then begins strobing U701 pin 29 (Trunking Clock In) with a square wave (from U705 port PH0) at the same baud rate as the data. The output waveform from U701's 5-3-2 State Encoder is then fed to the post-limiter summer block and then the splatter filter. From that point it is routed through the mod attenuators and then out of the ASFIC to the RF board via the VCO MOD pin J704-3.

Receive Audio Circuits

There are two major circuits in the receive audio path. These are the ASFIC (U701) and the Audio PA (U706). The ASFIC is an SPI programmable device, while the audio PA have direct control lines.

The radio's RF circuits are constantly producing an output at the discriminator. In conventional standby mode, it is always monitoring the squelch line and/or sub-audible data.The raw discriminator from the RF board enters the controller board on J704-10. In addition to the raw discriminator signal DISC, the RF board's Zero IF IC also provides a pre-filtered version of the discriminator signal that is dedicated to the ASFIC's squelch detect circuitry. This signal, labelled SQUELCH , enters the controller board on J704-12 and is routed to the ASFIC on U701 pin 14. The squelch signal is filtered, rectified, and low-pass filtered. It is then to a comparator to produce an active high signal on CH ACT. A squelch tail circuit is used to produce SQ DET from CH ACT. The microcontroller makes a detect dicision based on SQ DET, and sets up the receive audio path on U701 and enables the audio PA

(1) U701 Audio Processing & Digital Volume Control

The signal next enters the ASFIC U701 pin16 for further processing. Inside the IC, the signal first passes through a LPF to remove any frequency components above 3000 Hz and then a HPF to strip off any sub-audible data below 300 Hz. Next the recovered audio passes through a de-emphasis filter to reduce the effects of FM noise. Finally, the IC amplifies the audio and passes it through the 8-bit programmable attenuator whose level is set depending on the value of the volume control. The microcontroller U705 programs the value of the 8-bit attenuator in accordance with the voltage sensed on the volume potentiometer, which is connected to U705 port PE1. Sensing the volume pot digitally avoids having to run the audio all the way up to the control top and also provides flexibility, eg, when the radio is in CVC audio mode the microcontroller will maintain the ASFIC's 8-bit attenuator at a constant setting regardless of the voltage sensed on U705 port

PE1. After passing through the 8-bit digital attenuator, the audio goes to a buffer amp and then exits at U701 pin 21, where it is routed to the audio PA U706.

(2) Differential Speaker Audio Amplification

The final stage in the receive path is the audio amplifiers that drive either the internal or external speakers. Each speaker is driven using a two amplifier arrangement. Since one amplifier can be shared as common between the two speakers, only three total amplifiers are needed inside the audio PA IC U706. Benefits of using the two amplifier configuration include: reduced distortion due to larger possible signals before the amplifiers begin to clip, 6 dB more gain than a single amplifier arrangement, and elimination of the need for AC coupling devices. The audio is coupled into the amplifiers on U706 pin 8.

There are two enable lines controlling the three audio amplifies of U706. The External Speaker Select line, which is used to control the phase of the internal or external amplifier, comes from U701 pin 43 and the Audio PA Enable line (which is used to enable all three amplifies) comes from U701 pin 44. The Audio PA Enable line is active-high, while the External Speaker Select is active-low. The microcontroller determines that audio should be routed to the external or internal speaker by reading option select lines 1 and 2, which are pins 1 and 5 of the radio side connector. If the microcontroller senses that there is a Vehicular Adapter connected to the radio (which is identified by having a diode from OPT SEL 2 to OPT SEL 1, with the anode at OPT SEL 2), and the radio is in receive mode, the audio will be directed to the external speaker lines (pins 2 and 6 of the radio side connector) with the audio set to a fixed level, independent of the radio volume pot. When the receive path is enabled, all three amplifiers in U706 is turned on. If the internal speaker amplifier is selected, then its output is 180 degrees out of phase with that of the common amplifier. The result at the internal speaker is a signal twice as large as either amplifier's output, while the external amplifier is in phase with the common amplifier; the result at the external speaker is no signal. The reverse is true if the external speaker is selected. The overall gain of the two amplifier arrangement is approximately 32.5 dB. Since the radio uses a 28 ohms internal speaker, the nominal voltage for rated audio is 3.74 Vrms, and the nominal audio input to U706 is 88.7 m Vrms when rated audio output is obtained.

Receive Data Circuits

The ASFIC (U701) is used to decode all receive data, which includes PL, DPL and MDC. The decode process for each data type typically involves low-pass or band-pass filtering, signal amplification, and then routing the signal to a comparator which outputs a logic zero or one signal. The discriminator output from the RF board is routed to U701 pin 15 through coupling capacitor C710. Inside U701 the data is filtered according to the data type (HS data or LS data), then hard-limited to a 0-5 V digital level. The high speed data output (MDC) appears at U701 pin 23, where it connects to U705-PA0. The low speed limited data output (PL, DPL) appears at U701 pin 48, where it connects to U705-PA1. If, for example, the radio is receiving 192.8 Hz PL, the discriminator should contain a 192.8 Hz sine wave at about 53 m Vrms, and the limited PL output should be a 192.8 Hz square wave. While the radio is decoding PL, DPL, the microcontroller also outputs a sampling waveform on U705-PA5, which is routed to U701 pin 40. (This is the same line used to generate TX PL or DPL data). This sampling waveform is a square wave between 1000 and 2000 Hz

Alert Tone Circuits

When the microcontroller needs to give the operator feedback (for a good key press or for a bad keypress) or radio status (low battery condition, phone call, circuit failures), it send an alert tone to the speaker. It does so by sending data to U701 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 microcontroller and the ASFIC. The allowable internal alert tones are 300, 900, and 1800 Hz. For external alert tones, the microcontroller can generate any tone within the 100-3000 Hz audio band. This is accomplished by the microcontroller toggling the output line U705-PA6, which is also the same line used to generate low-group DTMF data. Inside the ASFIC, this signal is routed to the external input of the alert tone generator; the output of the generator is summed into the audio chain after the RX audio de-emphasis block. Inside U701 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 U701 pin 21, then is routed to the audio PA, the same as the receive audio.

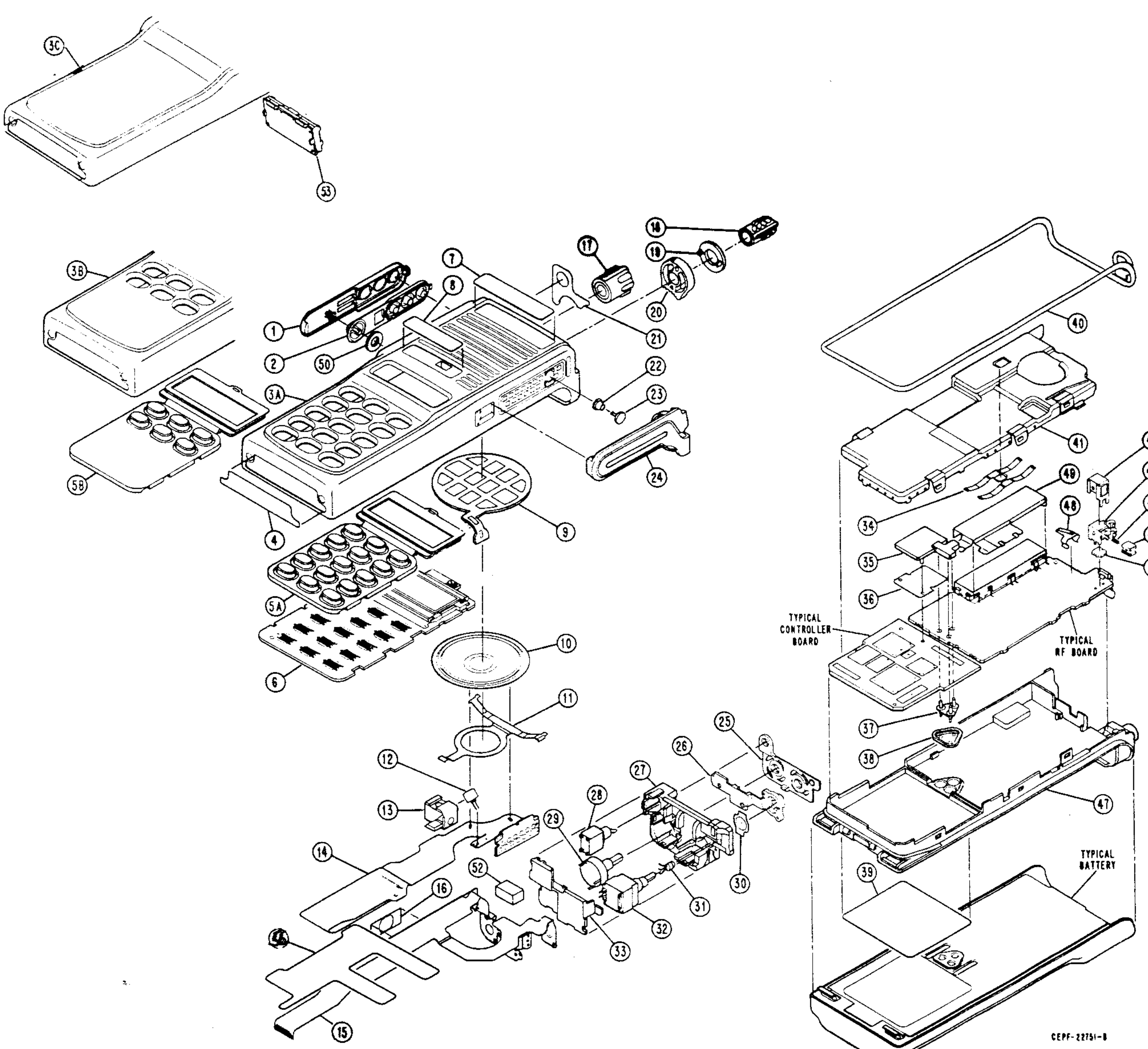
DIAGRAMS AND PARTS LISTS OVERVIEW

PARTS LIST FOR OPEN ARCHITECTURE, KEYPAD & TOP DISPLAY RADIOS

Ref.	Part/Kit No.	Description
		Front/Top Cover:
	NTN7154A	Keypad, 3x5 keys, 1 Line Dot Matrix Display
	NTN7153A	Keypad, 3x2 keys, 1 Line Dot Matrix Display
	NTN7152A	Top Mounted, 6 Char, 1 Line Display containing:
1	4505896U01	LEVER, PTT
2	3205902U01	SEAL, PTT, and ACTUATOR for S404, S405, S406, and S408
3A	1505637V01	COVER, Front Keypad, 3x5 keys (NTN7154A only)
3B	1505637V02	COVER, Front Keypad 3x2 keys (NTN7153A only)
3C	1505627V02	COVER, Top Mounted Display (NTN7152A only)
4	----------	LABEL, Agency Approval; not field replaceable
5A	7505870U01	KEYPAD, 3x5 keys (NTN7154A only)
5B	7505870U02	KEYPAD, 3x2 keys (NTN7153A only)
6	5105238U83	MODULE, Display (NTN7153/54A only)
7	----------	LABEL
8	----------	LABEL
9	3505264V03	FELT, Speaker
10	See Note	SPEAKER (LS401)
11	0705470V01	BRACKET, Speaker Retainer
12	See Note	MICROPHONE (MK401)
13	1405330W01	BOOT, Microphone
14	8405310W01	FLEX, Front Cover/Display
14	8405641V01	FLEX, Front Cover/Display (NTN7152A only)
21	1305698V01	ESCUTCHEON, Control Top
22	3205160W01	SEAL, Actuator; for S101
23	2205159W01	PIN, Actuator; for S101
24	3205514W01	SEAL, Accessory Connector
50	0405717W01	WASHER, PTT Seal
53	5105238U82	LCD, Top Display (NTN7152A only)
56	7505334W01	PAD, Sound Dampening (NTN7152A only)
		Controls Flex:
	NTN7087A	16 ps. Cont. Top , Freq. Sw., w/Flex
	NTN7088A	Cont. Rotary Sw. Cont. Top w/Flex containing:
15	8405333W01	FLEX, Controls
16	3905517V01	POPPLE, PTT (p/o S406)
25	3205292W01	SEAL, Control Top
26	3205293W01	SEAL, Emergency Button
27	2705877U01	HOUSING, Switch
28	See Note	SWITCH, Toggle (S402)
29	See Note	POTENTIOMETER/SWITCH, On/Off/Volume Control (R401/S403)
30	3905329W01	POPPLE, Emergency Button
31	See Note	LED (CR702A/CR702B)
32	See Note	SWITCH, Frequency (S401)
33	1505632V01	COVER, Switch Housing
52	7505393N33	PAD, Shock
		Miscellaneous
17	3605253V01	KNOB, On/Off/Volume
18	3605636V01	KNOB, Frequency
19	1305633V01	RING, Concentric; Escutcheon
20	3605635V01	KNOB, Concentric Ring
40	3205126W01	O-RING, Contoured/SEAL, Antenna

Ref.	Part/Kit No.	Description
		Transceiver and Controller Boards:
	NUD7080A	VHF, Transceiver Board (ETS300)
	NUD7071A	VHF, Transceiver Board (CEPT)
	NUE7230A	UHF, Transceiver Board (ETS300)
	NUE7215A	UHF, Transceiver Board (CEPT)
	NTN7678A	Controller Board
34	----------	SPRING, PA; not field replaceable, order front shield (item 41)
35	4205946W01	STRAIN RELIEF
36	8405247V01	FLEX, Jumper
37	See Note	PLUG, Connector (P404)
38	3205820V01	SEAL, Connector Plug
41	2605891U01	SHIELD, Front
42	0705856V01	BRACKET, RF Switch
43	1505520V01	HOUSING, RF Switch
44	4105266V01	SPRING, RF Switch
45	4405524V01	PISTON, RF Switch
46	8405523V01	CIRCUIT BOARD, RF Switch
48	----------	Not used
49	----------	Not used
	NHN6527A	COVER, Rear
39	----------	LABEL, Rear; Information; not field replaceable
47	1505892U01	CHASSIS, Rear Cover
		Batteries:
	NTN7143C	1300 mAh, NiCD High Capacity
	NTN7144A	1500 mAh, NiCD Ultra High Capacity
	NTN7145A	600 mAh, Fatory Mutual Intrin. Safe Medium Capacity
	NTN7146A	1300 mAh, Fatory Mutual Intrin. Safe High Capacity
	NTN7147A	1500 mAh, Fatory Mutual Intrin. Safe High Capacity
	NTN7148A	CENELEC to level IIcT5
		Antennas:
	8505644V01	Helical, 136-151 MHz
	8505644V02	Helical, 151-162 MHz
	8505644V03	Helical, 162-174 MHz
	8505644V04	Helical, 403-435 MHz
	8505644V05	Helical, 435.470 MHz
	8505644V06	Helical, 470-520 MHz
	8505241U05	Whip, 403-520 MHz
	8505518V01	Helical, Wideband, 136-151 MHz
		Belt Clips:
	4205638V01	Plastic, 6.35 mm (2.5 inch) Belt Width
	4205638V02	Black Alu., 8.9 mm (3.5 inch) Belt Width

Note: Refer to electrical parts list for part number and complete description. See page 7.22.

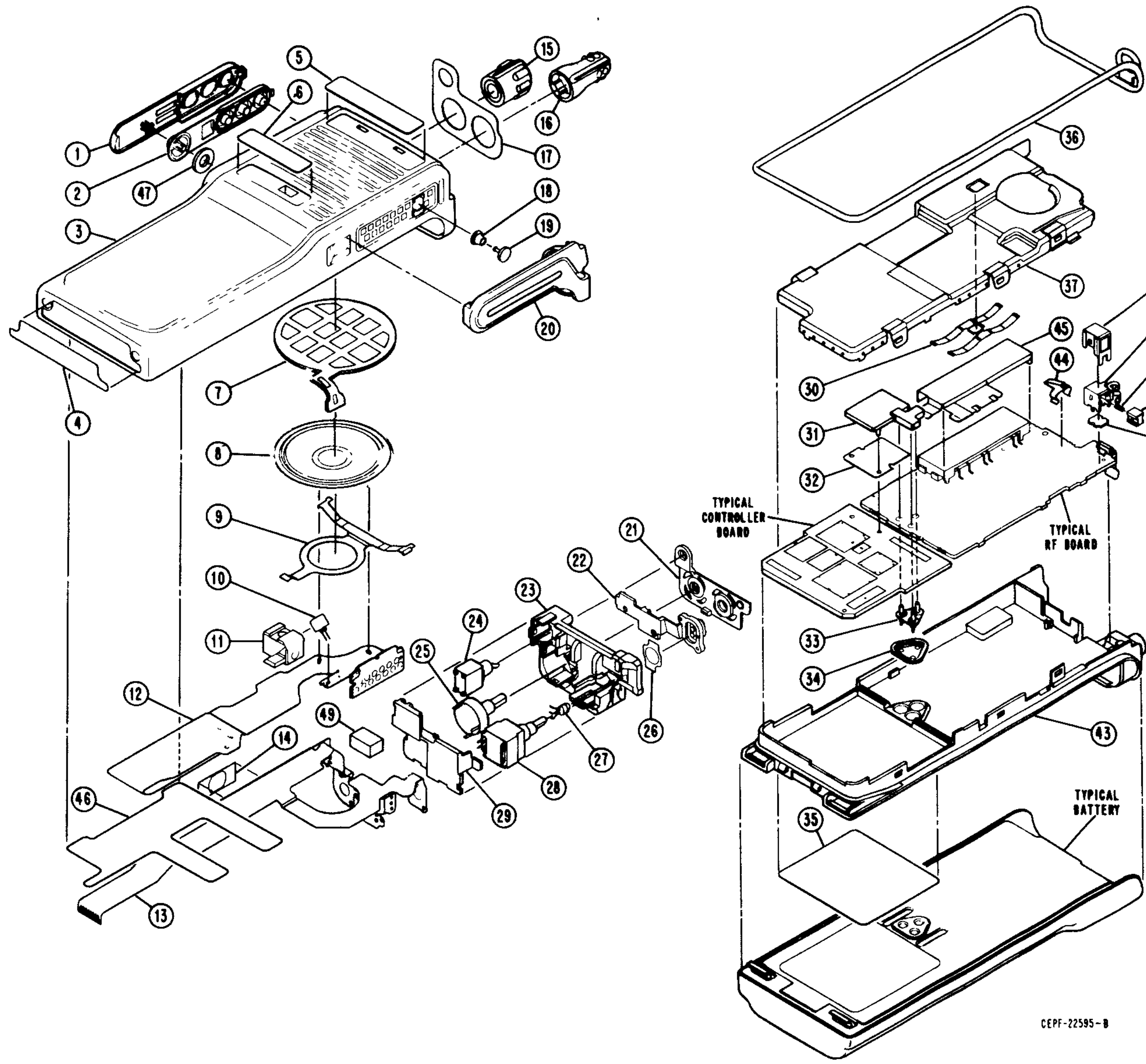


OPEN ARCHITECTURE CONTROLLER RADIOS
KEYPAD & TOP DISPLAY RADIOS, EXPLODED VIEW DIAGRAM

PARTS LIST FOR CLOSED ARCHITECTURE CONTROLLER RADIOS (GP900/HT1100)

Ref.	Part/Kit No.	Description
		Front/Top Cover
	NTN7151A	BASIC RADIO (no keypad, no display)
	NTN7795A	Keypad, 3x5 keys, DTMF containing
1	4505896U01	LEVER, PTT
2	3205902U01	SEAL, PTT, and ACTUATOR for S404, S405, S406, and S408
3	1505627V01	COVER, Front
4	----------	LABEL, Agency Approval, not field replaceable
5	----------	LABEL
6	----------	LABEL
7	3505264V03	FELT, Speaker
8	See Note	SPEAKER (LS401)
9	0705470V01	BRACKET, Speaker Retainer
10	See Note	MICROPHONE (MK401)
11	1405330W01	BOOT, Microphone
12	8405310W01	FLEX, Front Cover/Display
18	3205160W01	SEAL, Actuator; for S101
19	2205159W01	PIN, Actuator, for S101
20	3205514W01	SEAL, Accessory Connector
46	7505334W01	PAD, Sound Dampening
47	0405717W01	WASHER, PTT Seal
		Controls Flex
	NTN7087A	16 ps. Cont Top , Freq. Sw., w/Flex
	NTN7088A	Cont Rotary Sw Cont Top w/Flex containing
13	8405333W01	FLEX, Controls
14	3905517V01	POPPLE, PTT (p/o S406)
21	3205292W01	SEAL, Control Top
22	3205293W01	SEAL, Emergency Button
23	2705877U01	HOUSING, Switch
24	See Note	SWITCH, Toggle (S402)
25	See Note	POTENTIOMETER/SWITCH, On/Off/Volume Control (R401/S403)
26	3905329W01	POPPLE, Emergency Button
27	See Note	LED (CR702A/CR702B)
28	See Note	SWITCH, Frequency (S401)
29	1505632V01	COVER, Switch Housing
49	7505393N33	PAD, Shock
		Miscellaneous:
15	3605253V01	KNOB, On/Off/Volume
16		KNOB, Frequency
	3605254V02	2-Frequency Radios
or	3605254V03	8-Frequency Radios
or	3605254V01	16-Frequency Radios
17		ESCUTCHEON, Control Top
	1505872U02	2-Frequency Radios
	1505872U03	8-Frequency Radios
	1505872U01	16-Frequency Radios
36	3205126W01	O-RING, Contoured/SEAL, Antenna
		Transceiver and Controller Boards:
	NUD7080A	VHF, Transceiver Board (ETS300)
	NUD7071A	VHF, Transceiver Board (CEPT)
	NUE7230A	UHF, Transceiver Board (ETS300)
	NUE7215A	UHF, Transceiver Board (CEPT)
	NTN7809A	Controller Board
30	----------	SPRING, PA; not field replaceable, order front shield (item 37)
31	4205946W01	STRAIN RELIEF
32	8405247V01	FLEX, Jumper

Ref.	Part/Kit No.	Description
33	See Note	PLUG, Connector (P404)
34	3205820V01	SEAL, Connector Plug
35	3305873U01	LABEL
37	2605891U01	SHIELD, Front
	2605891U02	SHIELD, Front (NTN1372 ONLY)
38	0705856V01	BRACKET, RF Switch
39	1505520V01	HOUSING, RF Switch
40	4105266V01	SPRING, RF Switch
41	4405524V01	PISTON, RF Switch
42	8405523V01	CIRCUIT BOARD, RF Switch
44	----------	Not used
45	----------	Not used
	NHN6527A	COVER, Rear
39	----------	LABEL, Rear, Information, not field replaceable
43	1505892U01	CHASSIS, Rear Cover
		Batteries:
	NTN7143C	1300 mAh, NiCD High Capacity
	NTN7144A	1500 mAh, NiCD Ultra High Capacity
	NTN7145A	600 mAh, Fatory Mutual Intrin Safe Medium Capacity
	NTN7146A	1300 mAh, Fatory Mutual Intrin. Safe High Capacity
	NTN7147A	1500 mAh, Fatory Mutual Intrin. Safe High Capacity
	NTN7748A	CENELEC to level IIcT5
		Antennas:
	8505644V01	Helical, 136-151 MHz
	8505644V02	Helical, 151-162 MHz
	8505644V03	Helical, 162-174 MHz
	8505644V04	Helical, 403-435 MHz
	8505644V05	Helical, 435 470 MHz
	8505644V06	Helical, 470-520 MHz
	8505241U05	Whip, 403-520 MHz
	8505518V01	Helical, Wideband, 136-151 MHz
		Belt Clips:
	4205638V01	Plastic, 6 35 mm (2.5 inch) Belt Width
	4205638V02	Black Alu., 8.9 mm (3 5 inch) Belt Width
		Note: Refer to electrical parts list for part number and complete description. See page 7.22.



CLOSED ARCHITECTURE CONTROLLER RADIOS (GP900/HT1100)
EXPLODED VIEW DIAGRAM

SCHEMATIC AND CIRCUIT BOARD NOTES

* COMPONENT IS FREQUENCY SENSITIVE. REFER TO THE ELECTRICAL PARTS LIST FOR VALUE AND USAGE.

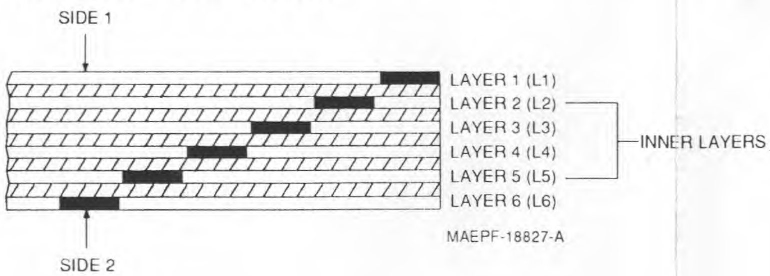
1. UNLESS OTHERWISE STATED, RESISTANCES ARE IN OHMS (k = 1000), AND CAPACITANCES ARE IN PICOFARADS (pF) OR MICROFARADS (uF).
2. DC VOLTAGES ARE MEASURED FROM POINT INDICATED TO CHASSIS GROUND USING A MOTOROLA DC MULTIMETER OR EQUIVALENT. TRANSMITTER MEASUREMENTS SHOULD BE MADE WITH A 1.2 uF CHOKE IN SERIES WITH THE VOLTAGE PROBE TO PREVENT CIRCUIT LOADING.
3. REFERENCE DESIGNATORS ARE ASSIGNED IN THE FOLLOWING MANNER:

UNITS SERIES	=	RECEIVER
100 SERIES	=	TRANSMITTER
200 SERIES	=	FREQUENCY GENERATION
300 SERIES	=	MISCELLANEOUS
400 SERIES	=	HOUSING/ESCUTCHEON
500 SERIES	=	DISPLAY
600 SERIES	=	HEAR CLEAR OPTION
700 SERIES	=	CONTROLLER

4. INTERCONNECT TIE POINT LEGEND:

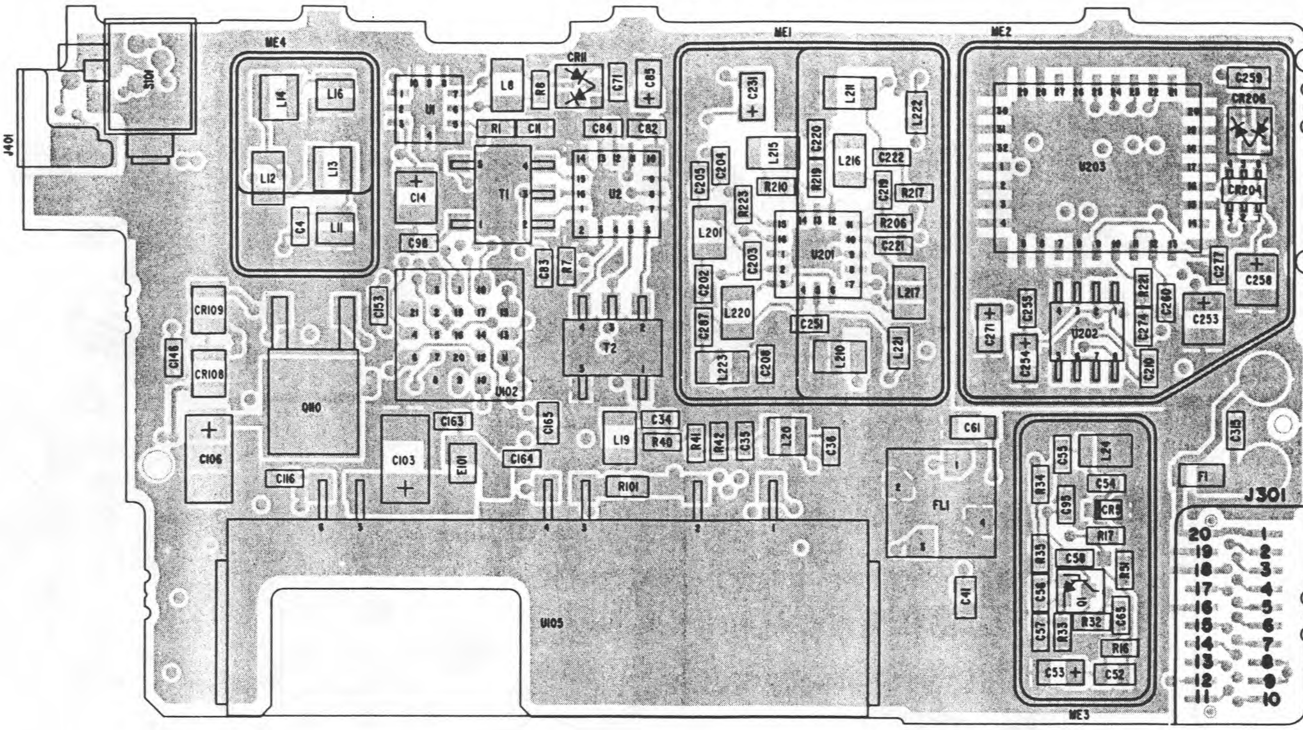
5V REG	=	REGULATED FIVE VOLTS
B+	=	BATTERY VOLTAGE (7.5V)
R5	=	RECEIVER FIVE VOLTS
T5	=	TRANSMITTER FIVE VOLTS
CLK	=	CLOCK
D	=	DATA
DAC	=	DIGITAL TO ANALOG CONVERTER
DAC RST	=	DAC RESET
LCK	=	LOCK
NC	=	NO CONNECTION
SYN	=	SYNTHESIZER
VR	=	VOLTAGE REGULATOR

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



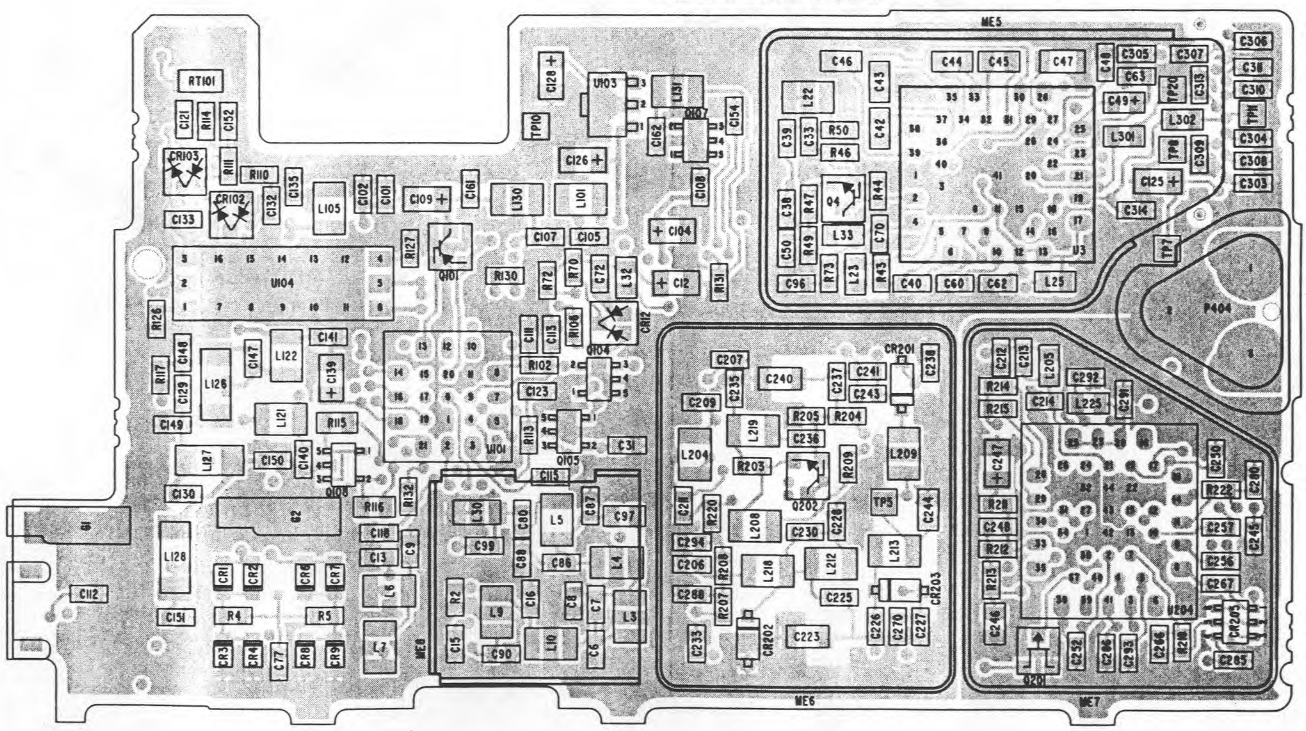
NUD7080A (ETS) NUD7071A (CEPT), VHF TRANSCEIVER BOARD COMPONENT LOCATION DIAGRAM

VIEWED FROM SIDE 1

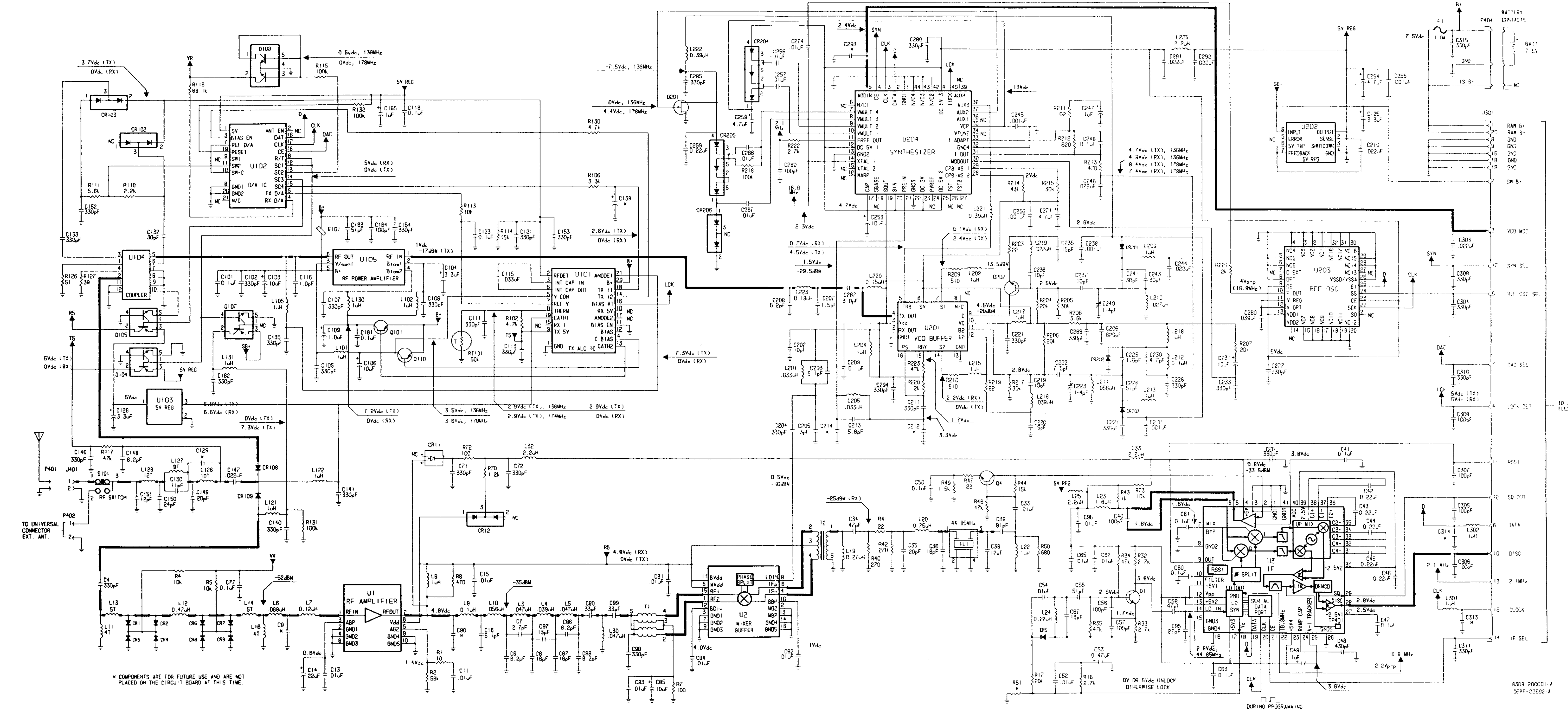


LI-BEPF-23459-0
OL-BEPF-23460-0

VIEWED FROM SIDE 2



L8-BEPF-23461-0
OL-BEPF-23462-0



NUD7080A (ETS) NUD7071A (CEPT),
VHF TRANSCEIVER BOARD
SCHEMATIC DIAGRAM

PARTS LIST FOR VHF (136-174 MHz) TRANSCEIVER BOARDS NUD7080A/NUD7071A

Ref.	Part/Kit No.	Description
	NUD7071A	**12.5 kHz (CEPT)**
	NUD7080A	**12.5/20/25 kHz (ETS)**
		CAPACITOR Fixed pF ±5%
		50V unless stated
C4	2113741F13	330
C6	2113740F22	6 2 ± 0 25pF
C7	2113740F13	2 7 ± 0 25pF
C8	2113740F32	16
C9	- -	Not Placed
C11	2113741F49	01μF
C13	2113741F49	01μF
C14	2311049A66	22μF, 4V
C15	2113741F49	01μF
C16	2113740F20	5 1 ± 0 25pF
C31	2113741F49	01μF
C33	2113741F26	9 1 ±0 25pF
C34	2113740F43	47
C35	2113740F40	36
C36	2113740F19	4 7 ±0 25pF
C38	2113740F17	3 9 ±0 25pF
C39	0662057B47	0
C40	2113740F51	100
C41	2113743A19	0 1μF
C42		
thru		
C46	2113743A23	0 22μF
C47	2109720D14	0 1μF
C48	2113741F33	0022μF
C49	2311049A86	1μF 10V
C50	2113743K15	0 1μF
C52	2113743A23	220μF
C53	2311049A40	2 2μF 10V
C54	2113741F13	330
C55	2113740F37	27
C56	2113740F42	43
C57	2113740F42	43
C58	2113740F11	2 2 ±0 25pF
C60	2113743K15	0 1μF
C61	2109720D14	0 1uF
C62	2113741F49	01μF
C63	2113743K15	0 1μF
C65	2113741F49	01μF
C70	2113741F49	01μF
C71	2113741F13	330
C72	2113741F13	330
C77	2113743K15	0 1μF
C80	2113740F39	33
C82		
thru		
C84	2113741F49	01μF
C85	2311049A60	10μF, 4V
C86	2113740F22	6 2 ± 0 25pF
C87	2113740F32	16
C88	2113740F25	8 2 ± 0 25pF
C90	2113740F18	4 3 ±0 25pF
C95	2113740F33	18
C96	2113741F49	01μF
C97	2113740A32	13
C98	2113741F13	330
C99	2113740F39	33
C101	2113743K15	0 1μF
C102	2113741F13	330
C103	2311049J26	10μF 16V

Ref.	Part/Kit No.	Description
C104	2311049A54	3 3μF 16V
C105	2113741F13	330
C106	2311049J26	10μF 16V
C107	2113741F13	330
C108	2113741F13	330
C109	2311049A07	1μF, 16V
C111	2113741F13	330
C112	---------	Not Placed
C113	2113741F13	330
C115	2113743K03	033μF
C116	2113740F03	1 0±0 1pF
C118	2113743K15	0 1μF
C121	2113741F13	330
C123	2113743K15	0 1μF
C125	2311049A54	3 3μF 16V
C126	2311049A54	3 3μF, 16V
C128	2311049A07	1μF, 16V
C129	-----	Not Placed
C130	2113740F28	11
C132	2113740F38	30
C133	2113741F13	330
C135	2113741F13	330
C139	-- -------	Not Placed
C140	2113741F13	330
C141	2113741F13	330
C146	2113741F13	330
C147	2113743E07	022μF
C148	2113740F22	6 2 ± 0 25pF
C149	2113740F34	20
C150	2113740F35	22
C151	2113740F28	11
C152	2113741F13	330
C153	2113741F13	330
C154	2113741F13	330
C161	2113743K15	0 1μF
C162	2113741F13	330
C163	2113740F44	51
C164	2113740F51	100
C165	2311049A86	1 0μF, 10V
C202	2113740F27	10
C203	2113740F20	5 1 ± 0 25pF
C204	2113741F13	330
C205	2113740F14	3 0 ± 0 25pF
C206	2113741F20	620
C207	2113740F03	1 0
C208	2113740F22	6 2 ± 0 25pF
C209	2113743K15	0 1μF
C210	2113743E07	022μF
C211	2113741F13	330
C212	- --------	Not Placed
C213	2113740F21	5 6 ± 0 25pF
C214	--------	Not Placed
C219	2113740F27	10
C220	2113740F31	15
C221	2113741F13	330
C222	2113740F24	7 5 ± 0 25pF
C223	2113906C02	LZR 4/5
C225	2113740F08	1 6 ± 0 1pF
C226	2113740F46	62
C227	2113741F13	330
C228	2113741F13	330
C230	2113740F19	4 7 ± 0 25pF
C231	2311049A60	10μF 4V
C233	2113741F13	330

PARTS LIST FOR VHF (136-174 MHz) TRANSCEIVER BOARDS NUD7080A/NUD7071A

Ref.	Part/Kit No.	Description
C235	2113740F31	15
C236	2113740F27	10
C238	2113741F25	001μF
C240	2113906C02	LZR 4/5
C241	2113740F38	30
C243	2113740F38	30
C244	2109720D09	022μF
C245	2113741F25	001μF
C246	2109720D09	022μF
C247	2311049A07	1μF, 16V
C248	2113743K15	0 1μF
C250	2113741F25	001μF
C251	2113741F13	330
C252	2113741F13	330
C253	2311049J23	10μF, 6V
C254	2311049A56	4 7μF, 10V
C255	2113741F25	001μF
C256	2113741F49	01μF
C257	2113741F49	01μF
C258	2311049J11	4 7μF, 16V
C259	2113743A23	0 22μF
C260	2113743K05	039μF
C266	2113741F49	01μF
C267	2113741F49	01μF
C270	2113741F25	001μF
C271	2311049A56	4 7μF, 10V
C274	2113741F49	01μF
C277	2113741F13	330
C280	2113740F51	100
C285	2113741F13	330
C286	2113741F13	330
C287	2113740F14	3 0 ± 0 25pF
C288	2113741F13	330
C291	2113743E07	022μF
C292	2113743E07	022μF
C293	- --------	Not Placed
C294	2113741F13	330
C303	2113743E07	022μF
C304	2113741F13	330
C305		
thru		
C308	2113740F51	100
C309	2113741F37	0033μF
C310	2113741F13	330
C311	2113741F37	0033μF
C313	----------	Not Placed
C314	----------	Not Placed
C315	2113741F13	330
		DIODE
CR1		
thru		
CR9	4862824C01	Varactor
CR11	4805129M96	PIN
CR12	4805218N57	Dual
CR102	4805129M67	Dual
CR103	4805129M67	Dual
CR108	4802482J02	PIN
CR109	4802482J02	PIN
CR201	4805649Q10	Varactor
CR202	4805649Q04	Varacto
CR203	4805649Q04	Varacto
CR204	4802233J09	Triple
CR205	4802233J09	Triple

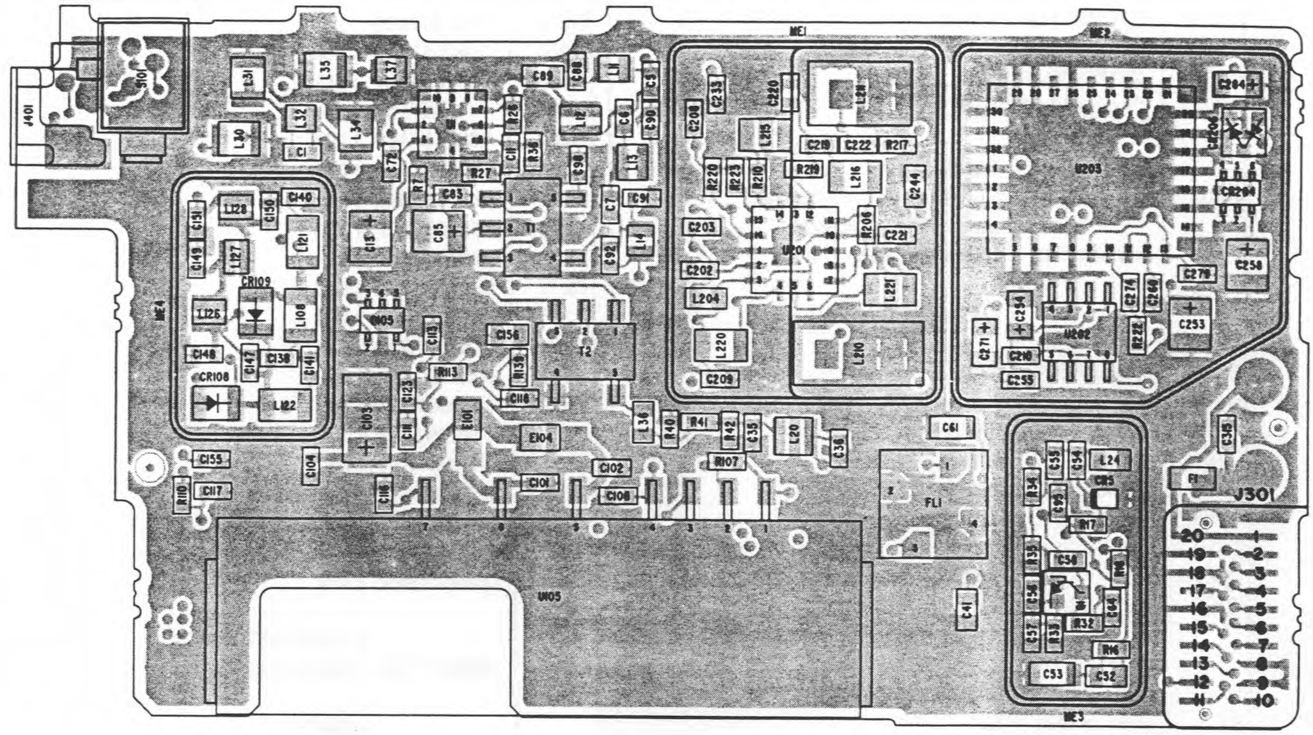
Ref.	Part/Kit No.	Description
CR206	4805129M06	Dual
		CORE
E101	2484657R01	Bead, Ferrite
F1	6505757V01	FUSE 1-Amp
		FILTER
FL1	4802655J06	Crystal 44 85 MHz (9 kHz)
		JACK
J301	-- -------	Circuit plating 20 contacts, to P301 on Jumper Flex
J401	3905264W01	Contact, Antenna
and	3905643V01	Contact, Antenna Ground
		COIL, RF
L3	2462587T42	047μH
L4	2462587T41	039μH
L5	2462587T42	047μH
L6	2462587T13	068μH
L7	2462587T16	0 12μH
L8	2462587T17	0 15μH
L9	2462587T15	0 1μH
L10	2462587T12	056μH
L11	2460591M12	4 turns, airwound
L12	2462587T23	0 47μH
L13	2460591N36	5 turns, airwound
L14	2460591N36	5 turns, airwound
L16	2460591M12	4 turns, airwound
L19	2462587T20	0 27μH
L20	2462587N69	1 2μH
L22	2462587T30	1μH
L23	2462587Q50	1 8μH
L24	2462587T23	0 47μH
L25	2462587Q20	2 2μH
L30	2462575A21	047μH
L32	2462587Q20	2 2μH
L33	2462587Q20	2 2μH
L101	2462587T30	1μH
L102	---------	Not Placed
L105	2462587T30	1μH
L121	2462587T30	1μH
L122	2462587T30	1μH
L126	2460591K40	12 turns, airwound
L127	2460591G24	9 turns, airwound
L128	2460591K40	12 turns airwound
L130	2462587T30	1μH
L131	2462587T30	1μH
L201	2462587T40	033μH
L204	2462587T30	1μH
L205	2462587S28	033μH
L208	2462587T30	1μH
L209	2462587T30	1μH
L210	2462587T39	027μH
L211	2462587T12	056μH
L212	2462587T15	0 1μH
L213	2462587T30	1μH
L215	2462587T30	1μH
L216	2462587T41	039μH
L217	2462587T30	1μH
L218	2462587T30	1μH
L219	2462587T38	022μH
L220	2462587T17	0 15μH
L221	2462587Q42	0 39μH
L222	2462587Q42	0 39μH

PARTS LIST FOR VHF (136-174 MHz) TRANSCEIVER BOARDS NUD7080A/NUD7071A

Ref.	Part/Kit No.	Description
L223	2462587T18	0 18µH
L225	2462587Q20	2.2µH
L301	2462587Q47	1µH
L302	2462587Q47	1µH
		PLUG
P402	----------	Contact, External Antenna part of RF switch S101
P404	3905819V01	Connector, Battery, 3-pin
		TRANSISTOR
Q1	4805218N63	NPN
C4	4805218N63	NPN
Q101	4805128M16	PNP
Q104	4805921T02	PNP NPN
C105	4805921T02	PNP NPN
C107	4805921T02	PNP NPN
Q108	4802245J10	NPN Dual
Q110	4813822A10	PNP
Q201	4802245J15	JFET
Q202	4805218N55	NPN
		RESISTOR Fixed Ω ± 5% 0625W unless stated
R1	0662057A01	10
R2	0662057A91	56k
R4	0662057A73	10k
R5	0662057A73	10k
R7	0662057A25	100
R8	0662057A41	470
R16	0662057A35	270
R17	0662057A80	20k
R32	0662057A59	2 7k
R33	0662057A59	2 7k
R34	0662057A89	47k
R35	0662057A89	47k
R40	0662057A35	270
R41	0662057A09	22
R42	0662057A35	270
R43	0662057A40	430
R44	0662057A77	15k
R46	0662057A89	47k
R47	0662057A09	22
R49	0662057A53	1.5k
R50	0662057A63	3.9k
R51	0662057B05	200k
R70	0662057A53	1.5k
R72	0662057A25	100
R73	0662057A73	10k
R101	0662057C01	o
R102	0662057A65	4 7k
R106	0662057A61	3.3k
R110	0662057A57	2.2k
R111	0662057A67	5 6k
R113	0662057A73	10k
R114	0662057A77	15k
R115	0662057G27	182k, 1%
R116	0662057G19	130k, 1%
R117	0662057A89	47k
R126	0662057A18	51
R127	0662057A15	39
R130	0662057A65	4 7k
R131	0662057A97	100k
R132	0662057A97	100k

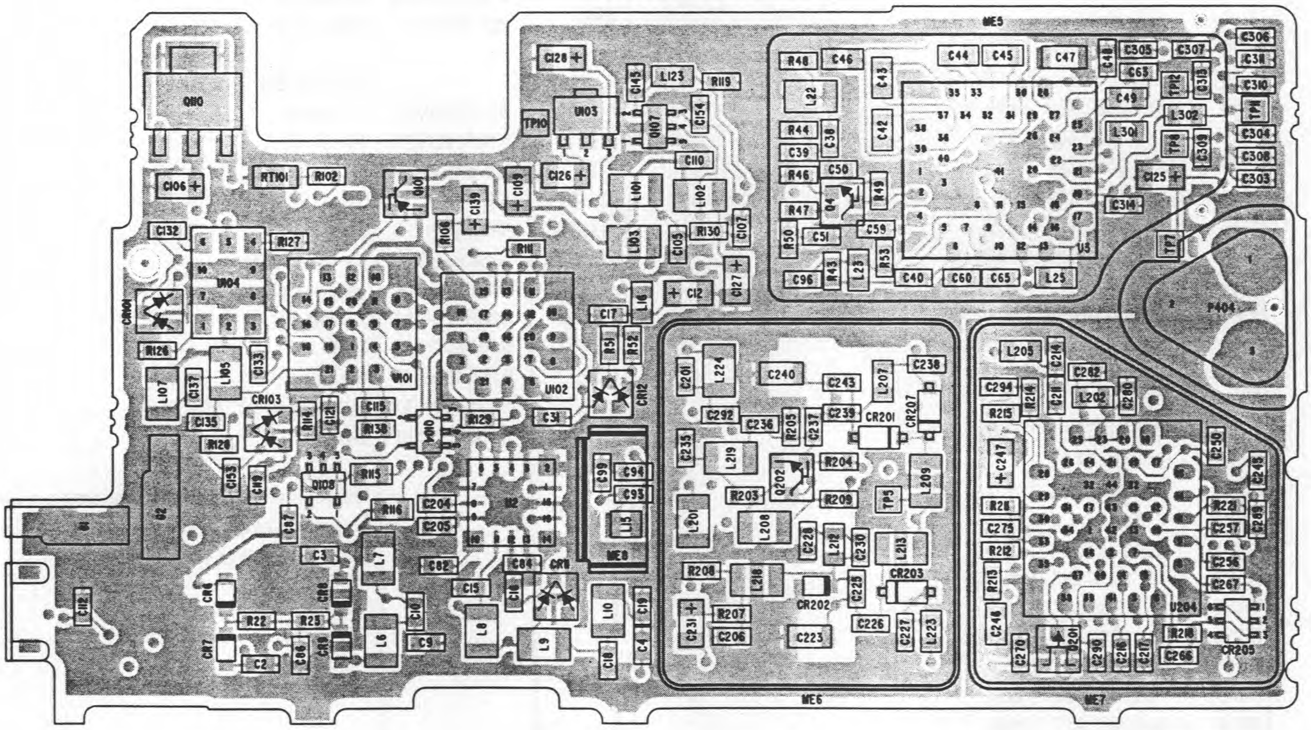
Ref.	Part/Kit No.	Description
R203	0662057A09	22
R204	0662057A80	20k
R205	0662057A84	30k
R206	0662057A80	20k
R207	0662057A80	20k
R208	0662057A62	3 6k
R209	0662057A42	510
C210	0662057A42	510
R211	0662057A20	62
R212	0662057A44	620
R213	0662057A41	470
R214	0662057A88	43k
R215	0662057A84	30k
R217	0662057A84	30k
R218	0662057A97	100k
R219	0662057A09	22
R220	0662057A56	2k
R221	0662057A56	2k
R222	0662057A51	1 2k
R223	0662057A89	47k
		THERMISTOR
RT101	0605621T02	Thermistor, 50k
		SWITCH
S101	----------	Refer to exploded view and exploded view parts list for part numbers and description
		TRANSFORMER
T1	2505515V08	Balun 4 1
T2	2505515V11	Balun, 16 1
		MODULES
U1	5105329V20	RF Amp
U2	5105329V26	Mixer
U3	5105457W05	IF
U101	5105662U72	TX ALC
U102	5105662U70	D/A
U103	5160880B02	5V Regulator
U104	5102001J69	Stripline Coupler
U105	5105625U03	5-Watt PA
U201	5105662U78	VCO
U202	5105469E65	5V Regulator
U203	5105279V39	Ref Oscillator, 16 8 MHz
U204	5105625U31	Synthesizer
		Note: " Not Placed" components are for future use and are not placed on the cir cuit board at this time

VIEWED FROM SIDE 1



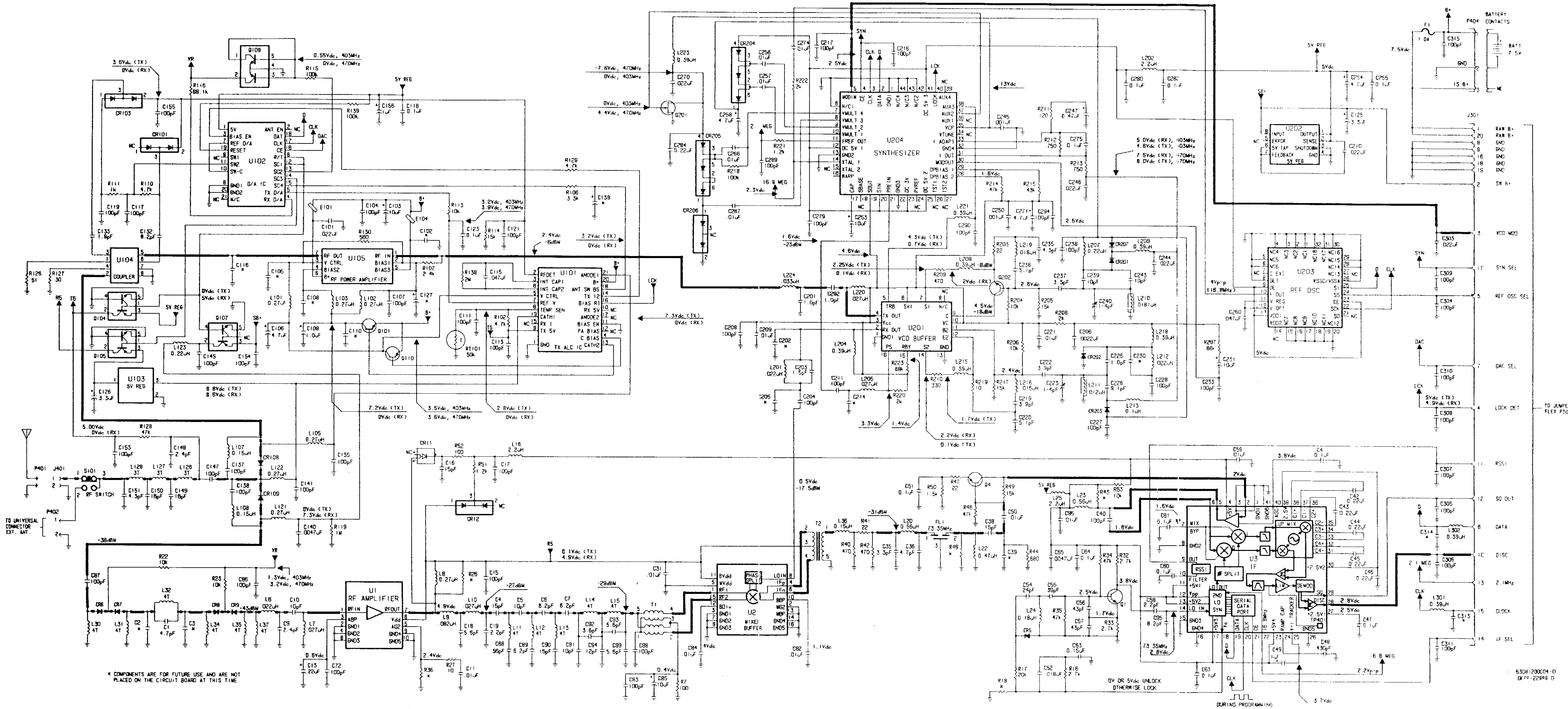
L1-BEPF-23463-0
OL-BEPF-23464-0

VIEWED FROM SIDE 2



L6-BEPF-23465-0
OL-BEPF-23466-0

NUE7230A (ETS) / NUE7215A (CEPT), UHF TRANSCEIVER BOARD COMPONENT LOCATION DIAGRAM



NUE7230A (ETS) / NUE7215A (CEPT), UHF TRANSCEIVER BOARD SCHEMATIC DIAGRAM

PARTS LIST FOR UHF (403-470 MHz) TRANSCEIVER BOARDS NUE7230A/NUE7215A

Ref.	Part/Kit No.	Description
	NUE7230A	12.5/20/25 kHz (ETS)
	NUE7215A	12:5 kHz (CEPT)
		CAPACITOR Fixed pF ±5% 50V unless stated
C1	2113740F19	4 7 ± 0 25pF
C2	------	Not Placed
C3	---- -	Not Placed
C4	2113740F31	15
C5	2113740F27	10
C6	2113740F22	6 2 ± 0 25pF
C7	2113740F39	7 5 ± 0 25pF
C9	2113740F12	2 4 ± 0 25pF
C10	2113740F27	10
C11	2113741F49	01µF
C12	---	Not Placed
C13	2311049A66	22µF 4V
C15	2113740F51	100
C16	2113740F31	15
C17	2113743K15	0 1µF
C18	2113740F16	3 6 ± 0 25pF
C19	2113740F09	1 8 ± 0 25pF
C31	2113741F49	01µF
C35	2113740F15	3 3 ± 0 25pF
C36	2113740F19	4 7 ± 0 25pF
C38	2113740F31	15
C39	-------	Not Placed
C40	2113740F51	100
C41	2113743A19	0 1µF
C42 thru C46	2113743A23	0 22µF
C47	2109720D14	0 1µF
C48	2113741F33	0022µF
C49	2311049A86	1 0µF 10V
C50	2113741F49	01µF
C51	2113743K15	0 1µF
C52	2113743A23	22µF
C53	2311049A40	2 2µF 10V
C54	2113740F36	24
C55	2113740F41	39
C56	2113740F42	43
C57	2113740F42	43
C58	2113740F11	2 2 ± 0 25pF
C59	2113743L41	01µF
C60	2113743K15	0 1µF
C61	2109720D14	0 1µF
C63	2113743K15	0 1µF
C64	2113743K15	0 1µF
C65	2113741F41	0047µF
C72	2113740F51	100
C82	2113741F49	01µF
C83	2113740F51	100
C84	2113741F49	001µF
C85	2311049J23	10µF 6V
C86	2113740F51	100
C87	2113740F51	100
C88	2113740F45	56
C89	2113740A23	6 2 ± 0 25pF
C90	2113740F31	15
C91	2113740F27	10
C92	2113740F18	4 3 ± 0 25pF
C93	2113740F17	3 9 ± 0 25pF
C94	2113740F28	11
C95	2113740F25	8 2 ± 0 25pF
C96	2113741F49	01µF
C98	2113740F51	100
C99	2113740F24	7 5 ± 0 25pF
C101	2113743E07	022µF
C102	----------	Not Placed
C103	2311049J26	10µF 16V
C104	2113740F51	100
C105	----------	Not Placed
C106	2311049A56	4 7µF, 10V
C107	2113740F51	100
C108	------- -	Not Placed
C109	2311049A07	1µF, 16V
C110	----------	Not Placed
C111	2113740F51	100
C112	---------	Not Placed
C113	2113740F51	100
C115	2113743K07	047µF
C116	---- -- -	Not Placed
C117	2113740F51	100
C118	2113743K15	0 1µF
C119	2113740F51	100
C121	2113740F51	100
C123	2113743K15	0 1uF
C125	2311049A54	3 3µF, 16V
C126	2311049A54	3 3µF, 16V
C127	----------	Not Placed
C132	2113740F25	8 2 ± 0 25pF
C133	2113740F09	1 8 ± 0 25pF
C135	2113740F51	100
C137	2113740F51	100
C138	2113740F51	100
C139	----------	Not Placed
C140	2113741F41	0047µF
C141	2113740F51	100
C145	2113740F51	100
C147	2113740F51	100
C148	2113740F12	2 4 ± 0 25pF
C149	2113740F32	16
C150	2113740F32	16
C151	2113740F17	3 9 ± 0 25pF
C153	2113740F51	100
C154	2113740F51	100
C155	2113740F51	100
C156	2311049A86	1 0µF 10V
C201	2113740F03	1 0 ± 0 1pF
C202	-----	Not Placed
C203	2113740F07	1 5 ± 0 1pF
C204	2113740F51	100
C205	--- -	Not Placed
C206	2113741F33	0022µF
C208	2113740F51	100
C209	2113741F49	01µF
C210	2113743E07	022µF
C211	2113740F51	100
C214	------	Not Placed
C216	2113741F37	0033µF
C217	2113740F51	100
C219	2113740F17	3 9 ± 0 25pF
C220	2113740F20	5 1 ± 0 25pF
C221	2113741F49	01µF
C222	2113740F17	3 9 ± 0 25pF
C223	2113906C02	LZR 4/5

PARTS LIST FOR UHF (403-470 MHz) TRANSCEIVER BOARDS NUE7230A/NUE7215A

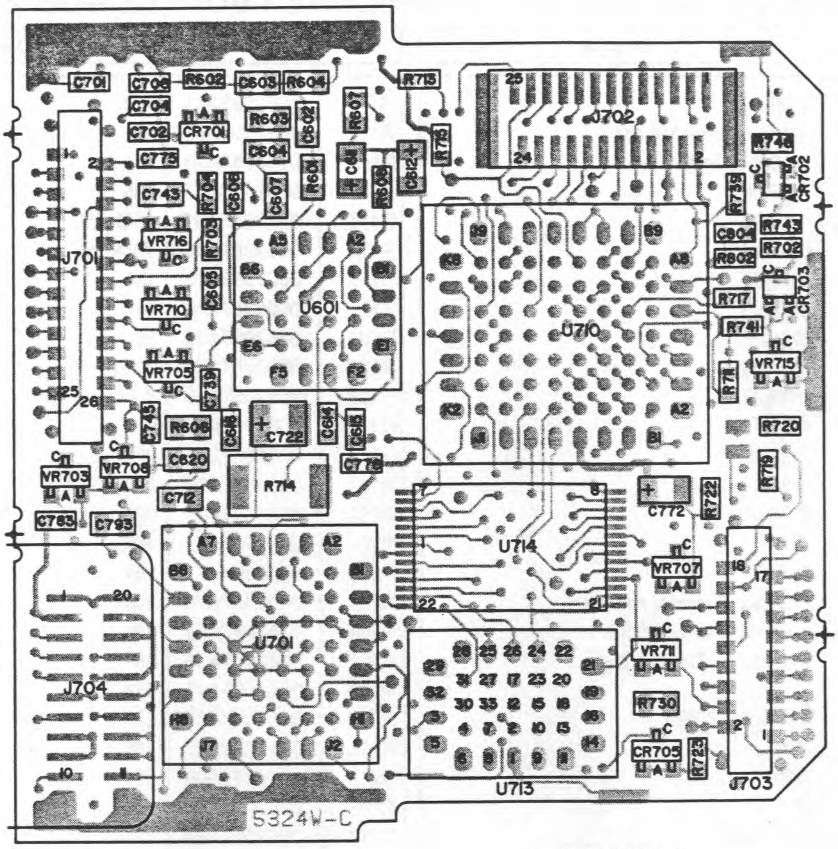
Ref.	Part/Kit No.	Description
C225	2113740F03	1 0 ± 0 1pF
C226	2113740F26	9 1 ± 0 25pF
C227	2113740F51	100
C228	2113740F51	100
C230	-- -------	Not Placed
C231	2311049A60	10μF, 4V
C233	2113740F51	100
C235	2113740F18	4 3 ± 0 25pF
C236	2113740F20	5 1 ± 0 25pF
C237	2113740F15	3 3 ± 0 25pF
C238	2113740F51	100
C239	2113740F27	10
C240	2113906B04	ATC, 4 0pF
C243	2113740F27	10
C244	2109720D09	022μF
C245	2113741F25	001μF
C246	2109720D09	022μF
C247	2311049A05	0 47μF, 16V
C250	2113741F25	001μF
C253	2311049J23	10μF, 6V
C254	2311049A56	4 7μF, 10V
C255	2113743K15	0 1μF
C256	2113741F49	01μF
C257	2113741F49	01μF
C258	2311049J11	4 7μF, 16V
C260	2113743K07	047μF
C266	2113741F49	01μF
C267	2113741F49	01μF
C270	2113741F25	001μF
C271	2311049A56	4 7μF, 10V
C274	2113741F49	01μF
C275	2113743K15	0 1μF
C279	2113740F51	100
C280	2113743K15	0 1μF
C282	2113743K15	0 1μF
C284	2311049A33	0 22μF, 35V
C289	2113740F51	100
C290	2113740F51	100
C292	2113740F03	1 0 ± 0 1pF
C294	2113740F51	100
C303	2113743E07	022μF
C304	2113740F51	100
C305	2113740F51	100
C306	2113740F51	100
C307	2113740F51	100
C308	2113740F51	100
C309	2113741F37	0033μF
C310	2113740F51	100
C311	2113741F37	0033μF
C313	----------	Not Placed
C314	--- -- - -	Not Placed
C315	2113740F51	100
		DIODE
CR5 thru CR9	4862824C01	Varactor
CR11	4805129M96	PIN
CR12	4805218N57	Dual
CR101	4805129M67	Dual
CR103	4805129M67	Dual
CR108	4802482J02	PIN
CR109	4802482J02	PIN
CR201	4805649Q10	Varactor
CR202	4862824C01	Varactor
CR203	4805649Q04	Varactor
CR204	4802233J09	Triple
CR205	4802233J09	Triple
CR206	4805129M06	Dual
CR207	4805649Q10	Varactor
		CORE
E101	2484657R01	Bead, Ferrite
E104	2484657R01	Bead, Ferrite
F1	6505757V01	FUSE 1-Amp
		FILTER
FL1	4802655J04	Crystal 73 35 MHz (9 kHz)
		JACK
J301	----------	Circuit plating, 20 contacts to P301 on Jumper Flex
J401	3905264W01	Contact, Antenna
and	3905643V01	Contact, Antenna Ground
		COIL, RF
L6	2462587T38	022μH
L7	2462587T39	027μH
L8	2462587T39	027μH
L9	2462587T13	068μH
L10	2462587T39	027μH
L11	2460591B04	4 turns airwound
L12	2460591M32	4 turns, airwound
L13	2460591B80	4 turns, airwound
L14	2460591B04	4 turns, airwound
L15	2460591B04	4 turns, airwound
L16	2462587Q20	2 2μH
L20	2462587N62	0 56μH
L22	2462587T23	0 47μH
L23	2462587Q44	0 56μH
L24	2462587S37	0 18μH
L25	2462587Q20	2 2μH
L30	2460591B22	4 turns, airwound
L31	2460591B22	4 turns, airwound
L32	2460591B04	4 turns, airwound
L34	2460591B22	4 turns, airwound
L35	2460591B22	4 turns, airwound
L36	2462587S36	0 15μH
L37	2460591B04	4 turns, airwound
L101	2462587T20	0 27μH
L102	---------	Not Placed
L103	2462587T20	0 27μH
L105	2462587T20	0 27μH
L107	2462587T17	0 15μH
L108	2462587T17	0 15μH
L121	2462587T20	0 27μH
L122	2462587T20	0 27μH
L123	2462587S38	0 22μH
L126 thru L128	2460591A56	3 turns airwound
L201	2462587T38	022μH
L202	2462587Q20	2 2μH
L204	2462587Q42	0 39μH
L205	2462587S27	027μH
L207	2462587S38	0 22μH
L208	2462587T22	0 39μH

PARTS LIST FOR UHF (403-470 MHz) TRANSCEIVER BOARDS NUE7230A/NUE7215A

Ref.	Part/Kit No.	Description
L209	2462587T22	0 39μH
L210	2405619V01	0181μH, molded coil
L211	2405619V05	012μH, molded coil
L212	2462587S26	022μH
L213	2462587T15	0 1μH
L215	2462587T22	0.39μH
L216	2462587T05	015μH
L218	2462587T22	0 39μH
L219	2462587T37	018μH
L220	2462587T39	027μH
L221	2462587T22	0 39μH
L223	2462587Q42	0 39μH
L224	2462587T40	033μH
L301	2462587Q42	0 39μH
L302	2462587Q42	0 39μH
		PLUG
P402	----------	Contact, External Antenna, part of RF switch S101
P404	3905819V01	Connector, Battery, 3-pin
		TRANSISTOR
Q1	4805218N63	NPN
Q4	4805218N63	NPN
Q101	4805128M16	PNP
Q104	4805921T02	PNP NPN
Q105	4805921T02	PNP NPN
Q107	4805921T02	PNP NPN
Q108	4802245J10	NPN Dual
Q110	4802245J12	PNP
Q201	4802245J15	JFET
Q202	4805218N55	NPN
		RESISTOR, Fixed Ω ± 5% 0625W unless stated
R7	0662057A25	100
R16	0662057A35	270
R17	0662057A80	20k
R18	0662057B05	200k
R22	0662057A73	10k
R23	0662057A73	10k
R26	----------	Not Placed
R27	0662057A01	10
R32	0662057A59	2 7k
R33	0662057A59	2 7k
R34	0662057A89	47k
R35	0662057A89	47k
R36	----------	Not Placed
R40	0662057A41	470
R41	0662057A09	22
R42	0662057A41	470
R43	----------	Not Placed
R44	0662057A45	680
R46	0662057A89	47k
R47	0662057A09	22
R48	----------	Not Placed
R49	0662057A77	15k
R50	0662057A53	1 5k
R51	0662057A51	1 2k
R52	0662057A25	100
R53	0662057A73	10k
R102	0662057A65	4 7k
R106	0662057A61	3 3k
R107	---------	Not Placed
R110	0662057A65	4 7k
R111	0662057A49	1k
R113	0662057A73	10k
R114	0662057A77	15k
R115	0662057G27	182k 1%
R116	0662057G19	130k 1%
R119	0662057B22	1M
R126	0662057A18	51
R127	0662057A12	30
R128	0662057A89	47k
R129	0662057A65	4 7k
R130	0662057B47	0
R138	0662057B29	2M
R139	0662057A97	100k
R203	0662057A09	22
R204	0662057A73	10k
R205	0662057A77	15k
R206	0662057A73	10k
R207	0662057A93	68k
R208	0662057A56	2k
R209	0662057A41	470
R210	0662057A37	330
R211	0662057A27	120
R212	0662057A46	750
R213	0662057A46	750
R214	0662057A89	47k
R215	0662057A88	43k
R217	0662057A77	15k
R218	0662057A97	100k
R219	0662057A01	10
R220	0662057A56	2k
R221	0662057A51	1 2k
R222	0662057A56	2k
R223	0662057A93	68k
		THERMISTOR
RT101	0605621T02	Thermistor 50k
		SWITCH
S101	----------	Refer to exploded view and exploded view parts list for part numbers and description
		TRANSFORMER
T1	2505515V08	Balun 4 1
T2	2505515V11	Balun, 16 1
		MODULE
U1	5105329V20	RF Amp
U2	5105329V26	Mixer
U3	5105457W05	IF
U101	5105662U72	TX ALC
U102	5105662U70	D/A
U103	5160880B02	5V regulator
U104	5102001J68	Stripline Coupler
U105	5105625U04	4-Watt PA
U201	5105662U78	VCO
U202	5105469E65	5V regulator
U203	5105279V39	Ref Oscillator, 16 8 MHz
U204	5105625U31	Synthesizer

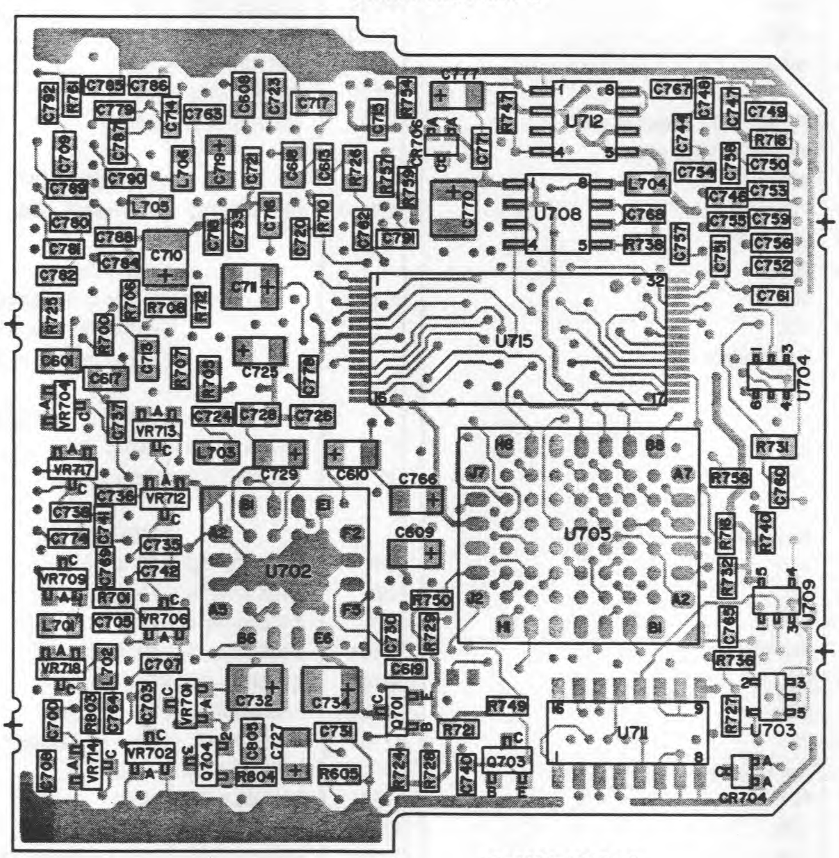
Note: " Not Placed" components are for future use and are not placed on the circuit board at this time

VIEWED FROM SIDE 1



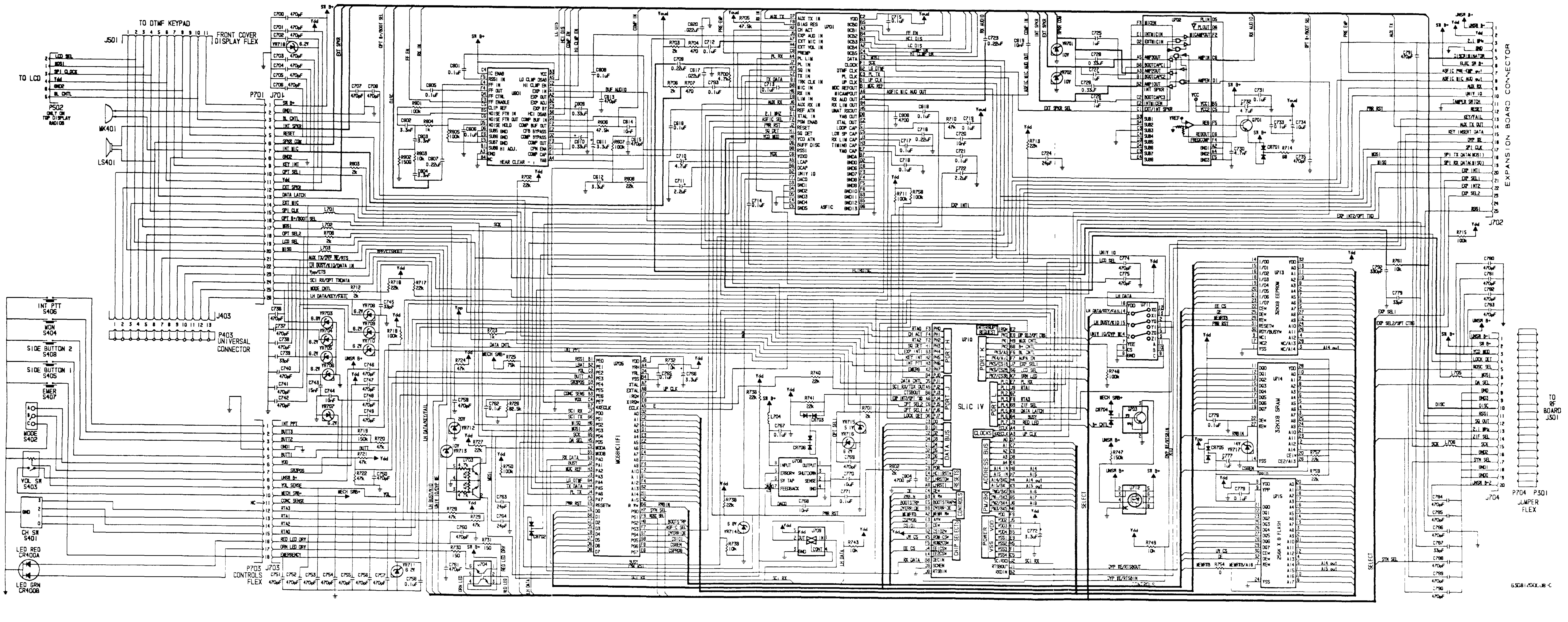
LI-BEPF-22692-B
OL-BEPF-22694-C

VIEWED FROM SIDE 2



L8-BEPF-22695-B
OL-BEPF-22697-C

OPEN ARCHITECTURE CONTROLLER BOARD NTN7678A
COMPONENT LOCATION DIAGRAM



OPEN ARCHITECTURE CONTROLLER BOARD NTN7678A
SCHEMATIC DIAGRAM

PARTS LIST FOR OPEN ARCHITECTURE CONTROLLER BOARD NTN7678A

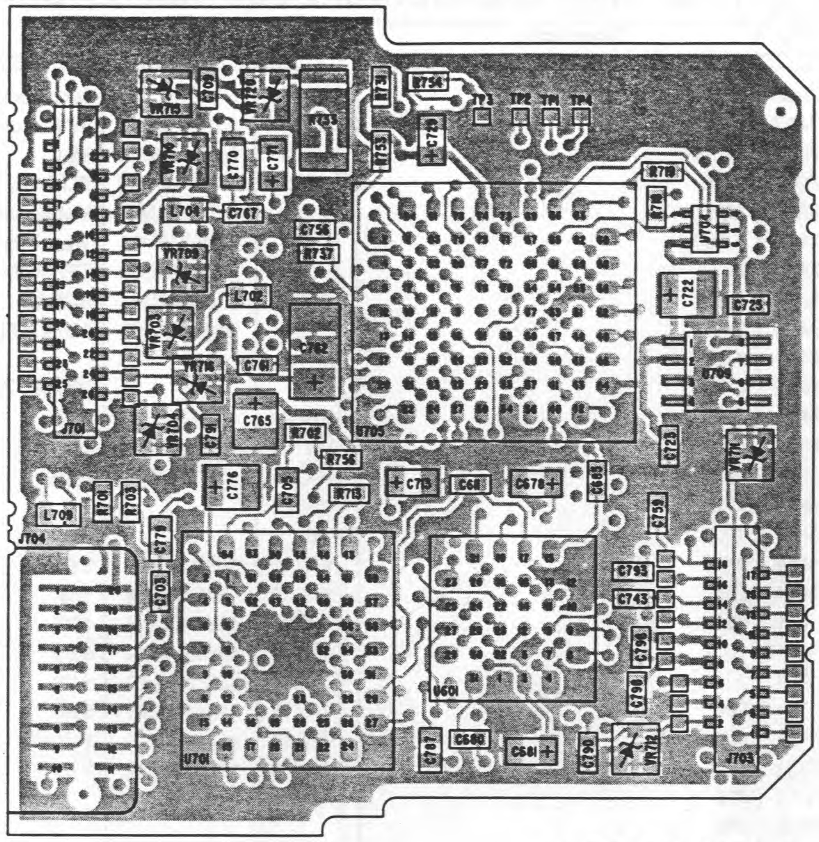
Ref.	Part/Kit No.	Description
		CAPACITOR, Fixed: pF ±5%; 50V unless stated
C601	2113743A19	0.1µF
C602	2113741A33	3.3nF
C603	2113741A33	3.3nF
C604	2113741A33	3.3nF
C605	2113743K15	0.1µF
C606	2113743K15	0.1µF
C607	2113743A23	0.22µF
C608	2113743A19	0.1µF
C609	2311049A04	0.33µF
C610	2311049A04	0.33µF
C611	2311049A42	3.3µF
C612	2311049A42	3.3µF
C613	2113741F17	470
C614	2113741F49	10nF
C615	2113741F17	470
C616	2113743K15	0.1µF
C617	2113741M53	.022µF
C618	2113743A19	0.1µF
C619	2113741F49	10nF
C620	2113741M53	.022µF
C700 thru C708	2113741F17	470
C709	2113743A23	0.22µF
C710	2311049A09	2.2µF
C711	2311049J11	4.7µF
C712	2113743A19	0.1µF
C713	2113743A19	0 1µF
C714	2113743k15	0.1µF
C715	2113743k15	0.1µF
C716	2113743A23	0.22µF
C717	2113743A19	0.1µF
C718	2113743K15	0.1µF
C719	2311049A01	0.1µF
C720	2113741F49	10nF
C721	2113743K15	0.1µF
C722	2311049A09	2.2µF
C723	2113743A23	0.22µF
C724	2113740F36	24
C725	2311049A07	1µF
C726	2113743F12	0.33µF
C727	2311049A07	1µF
C728	2113743F12	0.33µF
C729	2311049A07	1µF
C730	2113741F41	4.7nF
C731	2113743K15	0.1µF
C732	2311049J11	4.7µF
C733	2113743K15	0.1µF
C734	2311049J23	10µF
C735 thru C738	2113741F17	470
C739	2113740F39	33
C740	2113741F17	470
C741	2113741F17	470
C742	2113741F17	470
C743	2113741A49	15nF
C744	2113741A49	15nF
C745	2113740F39	33
C746 thru C757	2113741F17	470

Ref.	Part/Kit No.	Description
C758	2113743K15	0 1µF
C759	2113741F17	470
C760	2113741F17	470
C761	2113741F17	470
C762	2113743K15	0 1µF
C763	2113740F36	24
C764	2113740F36	24
C765	2113743K15	0.1µF
C766	2311049A42	3 3µF
C767	2113743K15	0.1µF
C768	2113741F49	10nF
C769	2113741F17	470
C770	2311049J23	10µF
C771	2113743K15	0.1µF
C772	2311049A42	3.3µF
C774	2113741F17	470
C775	2113741F17	470
C776	2113743K15	0.1µF
C777	2311049A07	1µF
C778	2113743K15	0.1µF
C779	2113740F39	33
C780 thru C786	2113741F17	470
C787	2113740F39	33
C788 thru C791	2113741F17	470
C792	2113741F13	330
C793	2113743A19	0.1µF
C804	2113741F41	4700
C805	2113743A23	0.22µF
		DIODE.
CR701	4880236E05	Schottky
CR702	4805218N57	Dual
CR703	4805218N57	Dual
CR704	4805218N57	Dual
CR705	4805129M12	Dual
CR706	4805218N57	Dual
		JACK:
J701	0905257V04	Connector, 26-pin; to P701 on Front Cover Display Flex
J702	0913915A11	Connector, 25-pin
J703	0905257V03	Connector, 18-pin; to P703 on Controls Flex
J704	----------	Circuit Plating, 20 contacts, to P704 on Jumper Flex
L701 thru L706	2462587Q40	COIL, RF: 270 nH
		TRANISITOR:
Q701	4805128M40	PNP
Q703	4880048M01	NPN
Q704	4805128M42	NPN
		RESISTOR, Fixed: Ω ±5%; .0625W unless stated
R601	0662057G13	100k
R602	0662057A53	1.5k
R603	0662057R60	10k

PARTS LIST FOR OPEN ARCHITECTURE CONTROLLER BOARD NTN7678A

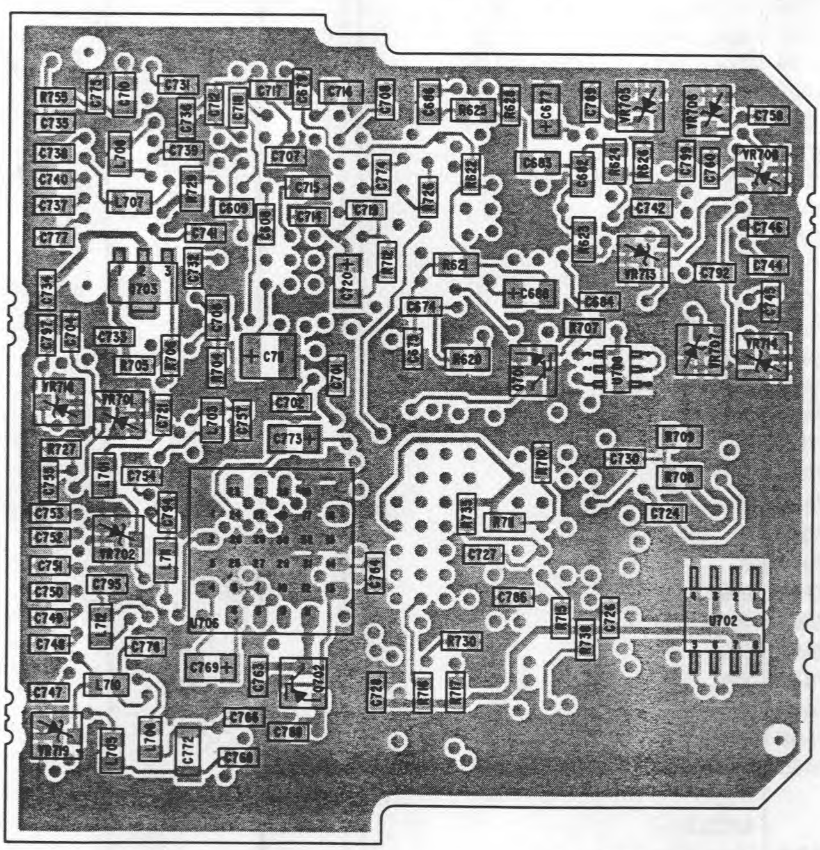
Ref.	Part/Kit No.	Description
R604	0662057R30	1k
R605	0662057A97	100k
R606	0662057R92	47.5k
R607	0662057G13	100k
R608	0662057A81	22k
R700	0662057A65	4.7k
R701	0662057A56	2k
R702	0662057A81	22k
R703	0662057A56	2k
R704	0662057A41	470
R705	0662057R92	47.5k
R706	0662057A56	2k
R707	0662057A41	470
R708	0662057A56	2k
R710	0662057A89	47k
R711	0662057A97	100k
R712	0662057A56	2k
R713	0662057A81	22k
R714	0683962T45	68
R715	0662057A97	100k
R716	0662057A81	22k
R717	0662057A81	22k
R718	0662057A97	100k
R719	0662057B02	150k
R720	0662057A89	47k
R721	0662057A89	47k
R722	0662057A89	47k
R723	0662057A49	1k
R724	0662057A89	47k
R725	0662057G07	75k
R726	0662057G08	82.5k
R727	0662057A81	22k
R728	0662057A89	47k
R729	0662057A89	47k
R730	0662057C55	150
R731	0662057C55	150
R732	0662057A73	10k
R736	0662057A81	22k
R737	0662057R92	47.5k
R738	0662057A81	22k
R739	0662057A73	10k
R740	0662057A81	22k
R741	0662057A81	22k
R743	0662057A73	10k
R746	0662057A97	100k
R747	0662057B02	150k
R749	0662057A89	47k
R750	0662057A97	100k
R754	0662057B47	0
R755	0662057B47	0
R757	0662057A81	22k
R758	0662057A97	100k
R759	0662057A81	22k
R761	0662057A73	10k
R802	0662057A56	2k
R803	0662057A56	2k
R804	0662057A65	4.7k
		MODULE:
U601	5105662U60	Hear Clear
U701	5105662U50	Audio Signalling Filter
U702	5105662U62	Audio PA
U703	4805921T09	Dual Transistor
U704	4805921T07	Transistor, NPN
U705	5105662U52	Microcomputer
U708	5105469E65	5V Regulator
U709	5105750U28	Mux
U710	5102103U02	SLIC IVa
U711	5184704M60	Multiplexer
U712	4805718V01	Transistor Package
U713	5105662U58	EEPROM
U714	5105662U54	SCRAM
U715	5105329V30	256 x 8 FLASH
		DIODE, Zener.
VR701	4880140L15	10V
VR702	4880140L15	10V
VR703	4880140L10	6.8V
VR704		
thru		
VR711	4880140L07	5.6V
VR712	4880140L25	20V
VR713	4880140L15	10V
VR714	4880140L10	6.8V
VR715	4880140L06	5.1V
VR716	4880140L07	5.6V
VR717	4880140L19	14V
VR718	4880140L07	5.6V

VIEWED FROM SIDE 1



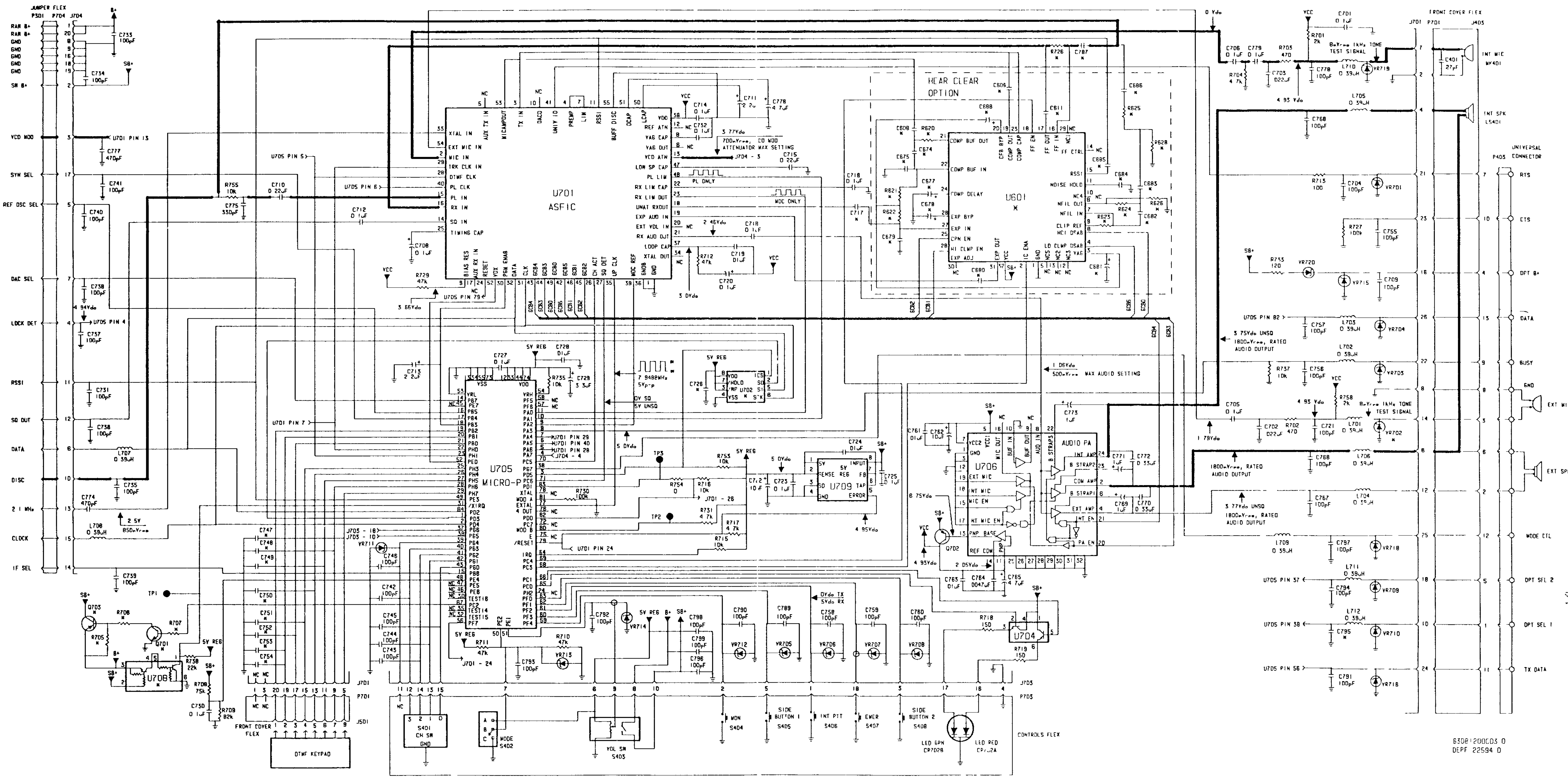
L1-BEPF-23471-0
OL-BEPF-23472-0

VIEWED FROM SIDE 2



L6-BEPF-23473-0
OL-BEPF-23474-0

CLOSED ARCHITECTURE CONTROLLER BOARD NTN7809A (GP900/HT1100) COMPONENT LOCATION DIAGRAM



CLOSED ARCHITECTURE CONTROLLER BOARD NTN7809A
(GP900/HT1100)
SCHEMATIC DIAGRAM

PARTS LIST FOR CLOSED ARCH. CONTROLLER BOARD NTN7809A (GP900/HT1100)

Ref.	Part/Kit No.	Description
		CAPACITOR, Fixed pF ±5%, 50V unless stated
C608	----------	Not Used
C609	----------	Not Used
C611	----------	Not Used
C674	----------	Not Used
C675	----------	Not Used
C677 thru C686	----------	Not Used
C688	----------	Not Used
C701	2113743K15	0 1µF
C702	2113743E07	022µF
C703	2113743E07	022µF
C704	2113740F51	100
C705	2113743A19	0 1µF
C706	2113743A19	0 1µF
C708	2113743K15	0 1µF
C709	2113740F51	100
C710	2113743A23	0 22µF
C711	2311049A09	2 2µF, 20V
C712	2113743K15	0 1µF
C713	2311049A09	2 2µF, 20V
C714	2113743K15	0 1µF
C715	2113743A23	0 22µF
C716	2113743A19	0 1µF
C717	----------	Not Used
C718	2113743K15	0 1µF
C719	2113741F49	01µF
C720	2311049A01	0 1µF, 35V
C721	2113740F51	100
C722	2311049J23	10µF, 6V
C723	2113743K15	0 1µF
C724	2113741F49	01µF
C725	2113743K15	0 1µF
C726	----------	Not Used
C727	2113743K15	0 1µF
C728	2113741F49	01µF
C729	2311049A42	3 3µF 6V
C730	2113743K15	0 1µF
C731	2113740F51	100
C732	2113743K15	0 1µF
C733 thru C746	2113740F51	100
C747 thru C754	----------	Not Used
C755 thru C760	2113740F51	100
C761	2113741F49	01µF
C762	2311049J25	10µF, 16V
C763	2113741F49	01µF
C764	2113741F41	0047µF
C765	2311049J11	4 7µF 16V
C766 thru C768	2113740F51	100
C769	2311049A07	1µF, 16V
C770	2113743B23	0 33µF
C771	2311049A07	1µF, 16V
C772	2113743B23	0 33µF
C773	2311049A07	1µF, 16V
C774	2113741F17	470
C775	2113741F13	330
C776	2311049J11	4 7µF, 16V
C777	2113741F17	470
C778	2113740F51	100
C779	2113743A19	0 1µF
C786	2113740F51	100
C787	----------	Not Used
C788 thru C794	2113740F51	100
C795	----------	Not Used
C796 thru C799	2113740F51	100
		JACK
J701	0905257V04	Connector, 26 pins, to P701 on Front Cover/Display Flex
J703	0905257V03	Connector, 18 pins, to P703 on Control Flex
J704	----------	Circuit plating, 20 contacts, to P704 on Jumper Flex
		COIL, RF
L701 thru L712	2462587Q42	0 39µH
		TRANSISTOR
Q701	----------	Not Used
Q702	4802245J04	PNP
Q703	----------	Not Used
		RESISTOR, Fixed Ω ± 5% 0625W unless stated
R620 thru R626	----------	Not Used
R628	----------	Not Used
R701	0662057A56	2k
R702	0662057A41	470
R703	0662057A41	470
R704	0662057A65	4 7k
R705 thru R707	----------	Not Used
R708	0662057G07	75k ± 1%, 0,1W
R709	0662057G08	82 5k ± 1%, 0 1W
R710 thru R712	0662057A89	47k
R713	0662057A25	100
R715	0662057A73	10k
R716	0662057A73	10k
R717	0662057A65	4 7k
R718	0662057A29	150
R719	0662057A29	150
R726	----------	Not Used
R727	0662057A97	100k
R729	0662057R92	47 5k ± 1%, 0 1W
R730	0662057A97	100k
R731	0662057A65	4 7k
R733	0683962T51	120

TPLF4074 A

PARTS LIST FOR CLOSED ARCH. CONTROLLER BOARD NTN7809A (HT1100 MODELS)

Ref.	Part/Kit No.	Description
R735	0662057A73	10k
R737	0662057A73	10k
R738	0662057A81	22k
R753	----------	Not Used
R754	0660076S01	0
R755	0662057A73	10k
R756	0662057A56	2k
		MODULE
U601	----------	Not Used
U701	5105662U50	Audio Signalling Filter
U702	----------	Not Used
U704	4805921T07	NPN NPN
U705	5102226J06	Microcomputer
U706	5105662U62	Audio PA
U708	----------	Not Used
U709	5105469E65	5V Regulator
		DIODE
VR701	4880140L09	Zener, 6 2V
VR702	----------	Not Used
VR703 thru VR714	4880140L09	Zener 6 2V
VR715	4880140L20	Zener, 15V
VR716	4880140L09	Zener, 6 2V
VR718	4880140L09	Zener, 6 2V
VR719	4880140L09	Zener, 6 2V
VR720	4880140L20	Zener, 15V

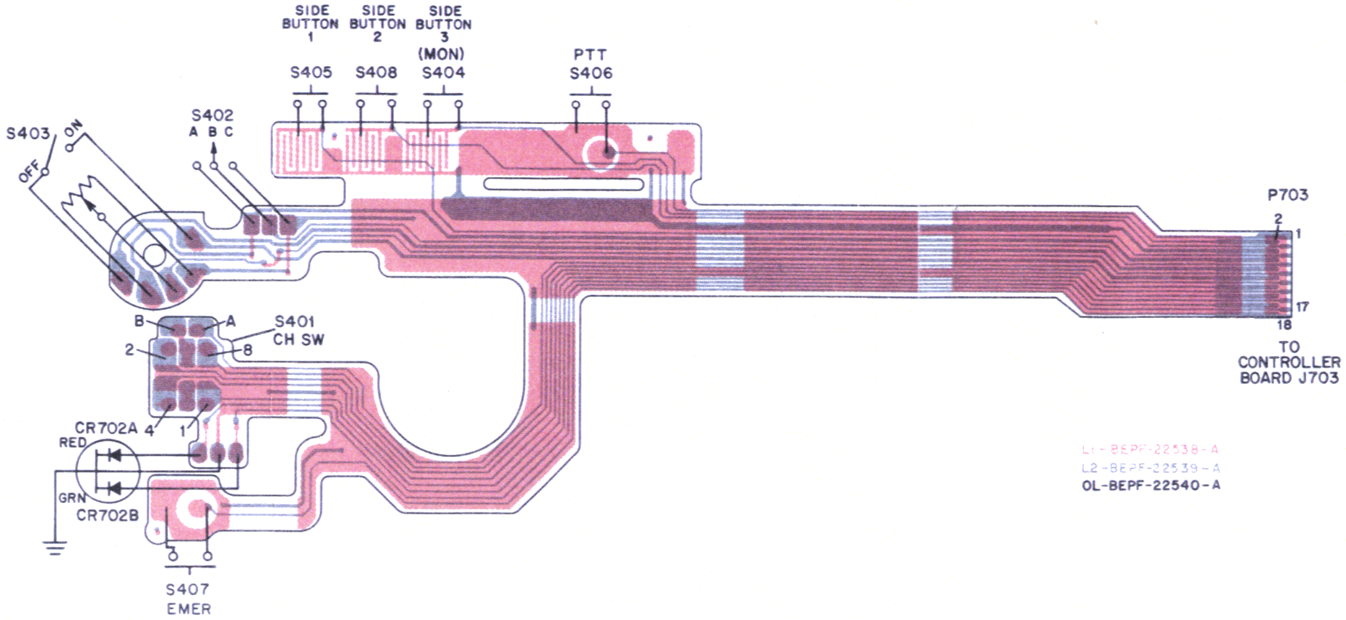
TPLF4074-A

MISCELLANEOUS PARTS LIST

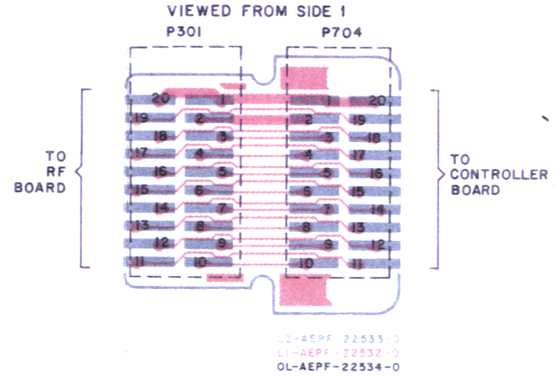
Ref.	Part/Kit No.	Description
	TPLF-4078-A	
		CAPACITOR, Fixed
C401	2113740F45	56pF ±5%, 50V
		JACK
J403	----------	Circuit Plating, 13 contacts on Front Cover/Display Flex (to Universal Connector P403)
J501	----------	Circuit Plating, 11 contacts on Front Cover/Display Flex (to Expansion Board)
		SPEAKER
LS401	5005213W05	28-Ohm
		MICROPHONE
MK401	5005227J07	Miniature Electret, Noise Cancelling
		PLUG
P301	----------	Circuit Plating, 20 contacts on Jumper Flex (to J301 on RF Board)
P403	----------	Universal Connector, 13 pins, not field repairable order Front Cover
P701	----------	Circuit Plating, 26 contacts on Front Cover/Display Flex (to P701 on Controller Board)
P703	----------	Circuit Plating, 18 contacts on Controls Flex (to J703 on Controller Board)
P704	----------	Circuit Plating, 20 contacts on Jumper Flex (to J704 on Controller Board)
		RESISTOR
R401	1805629V01	Potentiometer 50k Volume includes S403
		SWITCH
S401	4002622J01	Rotary, Frequency
S402	4005628V01	Toggle, 3-position Mode
S403	---------	On/Off, part of R401
S404	*	Monitor
S405	*	Side Button 1
S406	*	PTT
S407	*	Emergency
S408	*	Side Button 2

TPLF4078-A

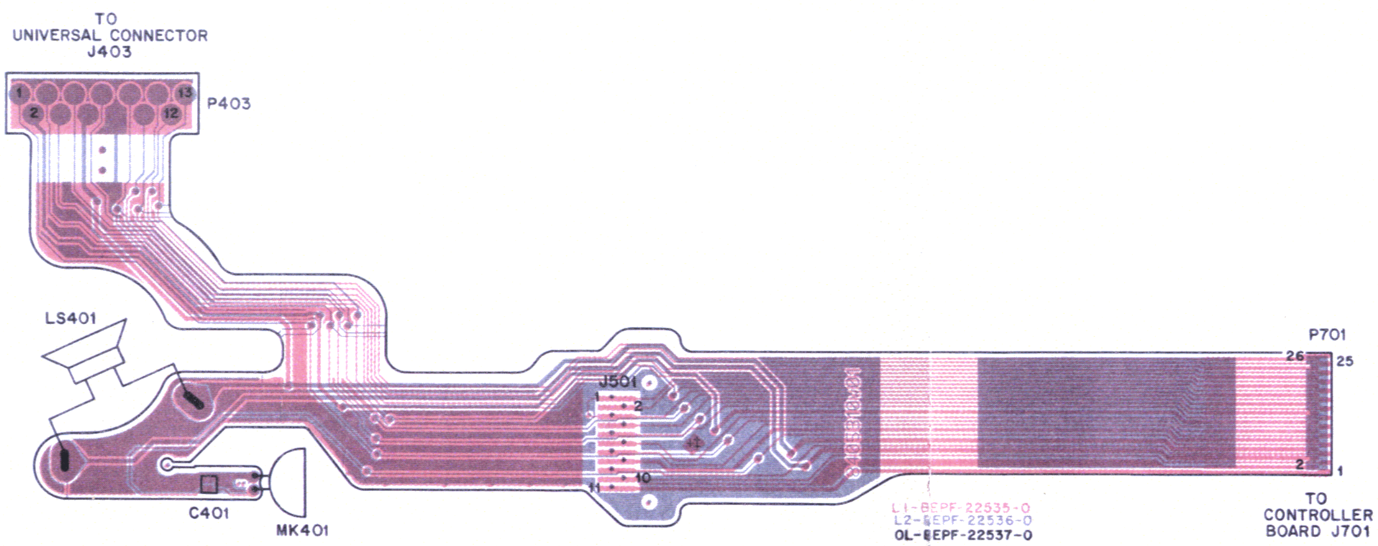
CONTROLS FLEX



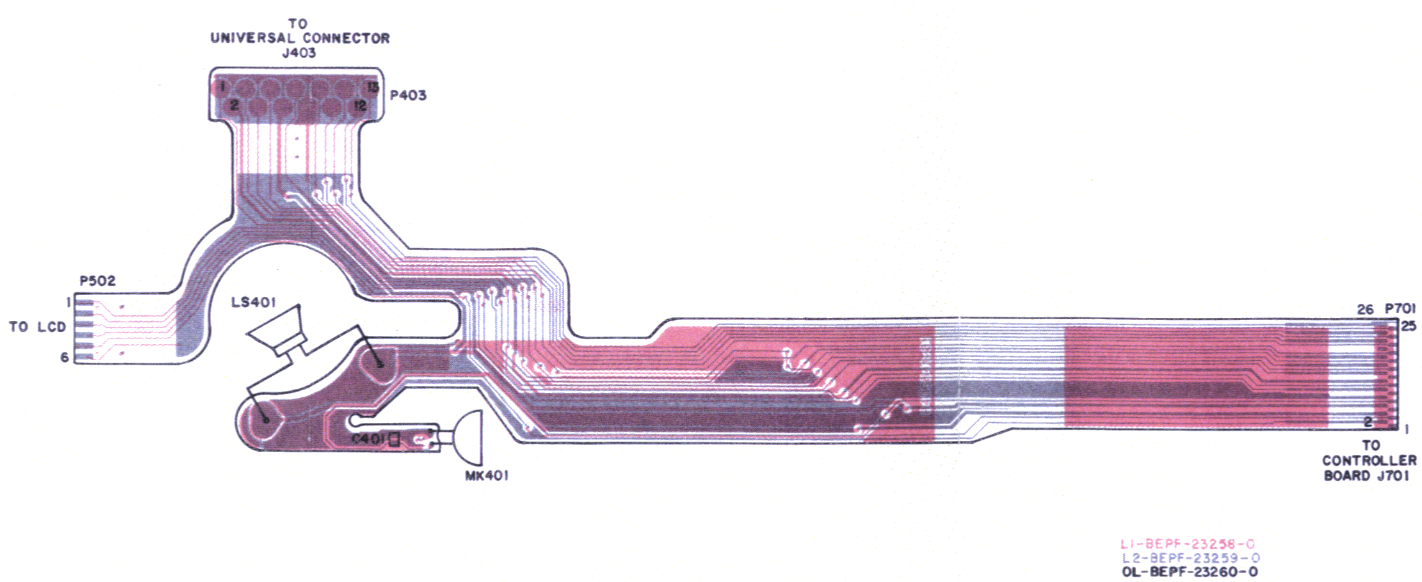
JUMPER FLEX



FRONT COVER/DISPLAY FLEX



FRONT COVER/DISPLAY FLEX

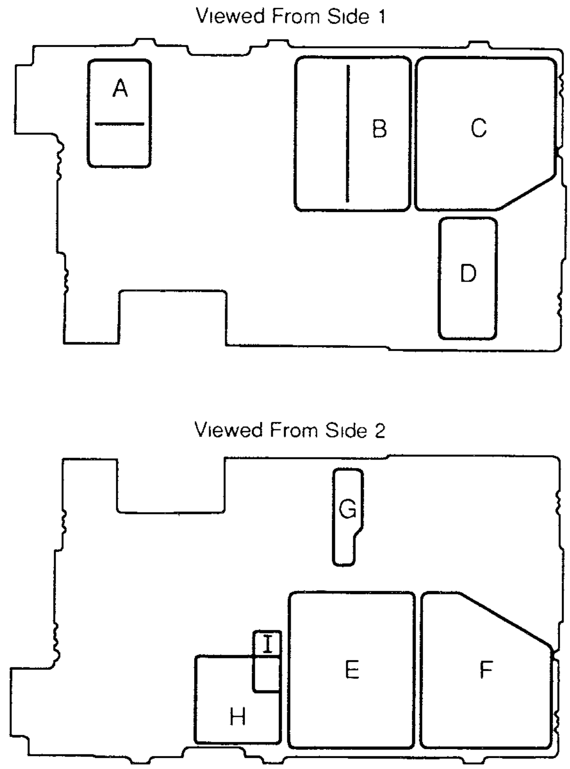


CONTROLS FLEX
FRONT COVER/DISPLAY FLEXES
JUMPER FLEX
COMPONENT LOCATION DIAGRAMS

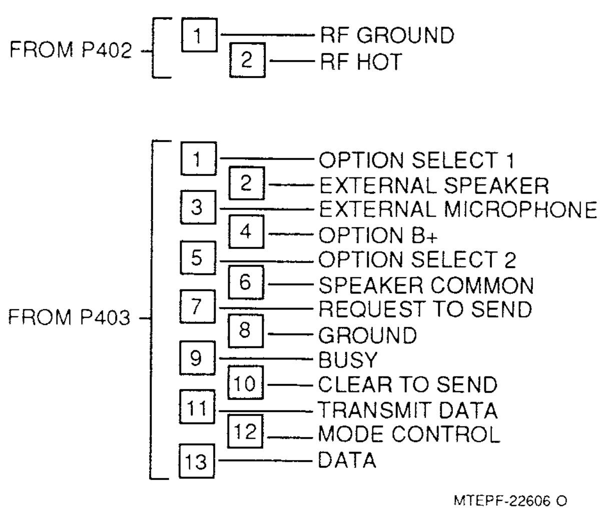
SHIELDS LOCATION DETAIL

PARTS LIST FOR SHIELDS LOCATION DETAILS

Ref.	Part/Kit No.	Description
A	2602661J01	SHIELD, Varactor Filter (VHF)
or	2602660J01	SHIELD, Varactor Filter (UHF)
B	2602657J01	SHIELD, VCO Front
C	2602658J01	SHIELD, Ref Oscillator
D	2602659J01	SHIELD, IF
E	2602674J01	SHIELD, VCO Back
F	2602675J01	SHIELD Synthesizer
G	2602680J01	SHIELD, AGC
H	2602815X01	SHIELD, Fixed Tuned Filter (VHF)
I	2602686J01	SHIELD, Coil (UHF)



UNIVERSAL (ACCESSORY) CONNECTOR PIN NUMBERS AND SIGNAL ASSIGMENT



RADIO FAULTS FOR TRUNKED MPT 1327 RADIOS

When the radio enters the fail mode the display will show:

"RADIO FAULT NN"

where the NN represents a 2 digit number indicating the failure type as shown below:

Displayed Error Number or Message	Failure Type
01	Invalid channel spacing: The channel spacing value programmed into the radio from the network file (via the RSS) is not within the range of valid values.
02	EEPROM checksum invalid (personality fields): Memory corruption has occured in either the internal EEPROM (factory initialised memory) or the external EEPROM (RSS programmed memory)
03	Synthesizer out of lock: The radio's synthesiser has failed.
04	Invalid RF configuration: The radio model number is inconsistent with the RX/TX base frequencies programmed into the radio, or the model number is invalid.
05	RAM test failed: The radio's internal RAM check has failed.
06	Invalid personality data: Invalid parameters in the current personality. Either the dialling plan or radio configuration bytes specified via the network file are incompatible with the radio.
10	Flash EEPROM checksum invalid: The Flash EEPROM area of memory containing the radio application has been corrupted.
12	Hardware test failure: An invalid SLIC IVa chip has been detected in the radio hardware or one of the attached radio accessories has failed.
NO PERSONALITY	The radio does not have any personality data loaded via the RSS, or the last stored personality number has been corrupted.

PL(CTCSS) CODES

SELF-QUIETING FREQUENCIES

Self-quieting frequencies are frequencies that are also generated by the radio and cause internal interference. On these frequencies, the interference caused by the self-quieter spurs is great enough that a radio will not meet its receiver sensitivity specification.

These are, respectively:

VHF: 151.2 and 168.0 MHz
UHF: 403.2, 420.0, 436.8, 440.1 and 453.6.MHz

ALLOWABLE 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	110.9	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		

GLOSSARY OF TERMS

ALC: Automatic level control; a circuit in the transmit RF path that controls RF power amplifier output, provides levelling over frequency and voltage, and protects against high vswr.

ASF IC: Audio signalling filter integrated circuit.

closed architecture: refers to the controller; the firmware operating system is a masked program, configured one time only in the manufacturing process (the microcomputer of the controller includes its own preprogrammed memory, which cannot be reprogrammed) See "open architecture" description.

DPL: Digital Private-Line™ .

firmware: software or a software/hardware combination of computer programs and data, with a fixed logic configuration stored in a read-only memory; information can not be altered or reprogrammed.

FLASHport™ : is a Motorola term that describes the ability of a radio to change memory. Every FLASHport radio contains a FLASHport EEPROM memory chip that have software written and rewritten to, again and again.

hardware: physical equipment used in data processing.

IF SEL: I-F select line; it activates the I-F module when low.

IM: Inter-modulation; unwanted frequencies produced in the mixer.

LSH: Low speed handshake; digital data sent to the radio during trunked operation at 150 baud while receiving modulation.

message time-out timer: A timer in the system central controller that maintains a channel allocation for calling parties (The timer may be programmed to time out the channel allocation within 0 to 6 seconds after de-key).

MRTI: Microprocessor Radio-Telephone Interconnect; a Motorola system that provides a repeater connection to the telephone network (The MRTI allows the radio to access the telephone network when the proper access code is received).

NF: Noise Figure; is a ratio of total noise power at the output to the input noise power.

OMPAC: Acronym for Over-Molded Pad Array Carrier, a Motorola custom package, distinguished by the presence of solder balls on the bottom pads.

open architecture: refers to the controller (The operating system can be completely changed; for example, a conventional radio could be reconfigured into a trunked radio.) Although the microprocessor of the controller contains on-board memory, the controller includes a separate FLASHport EEPROM memory chip.

OSW: Outbound signalling word; central controller transmissions to radios in the field.

PC Board: Printed circuit board. Radios contain an transceiver board, a controller board, and a front cover board (front cover board, telephone interconnect models only). The latter is a simple fibreglass two-sided board, while the others are multi-layered boards.

PL: Private-Line® tone squelch; a continuous sub-audible tone that is transmitted along with the carrier (A radio that has PL on the receive frequency will require both the presence of carrier and the correct PL tone before it will unmute). Also, if there is PL on the transmit frequency, all transmissions by the radio will be modulated with the PL tone. Modulation will be continuous.

PLL: Phase locked loop; a circuit in which an oscillator is kept in phase with a reference, usually after passing through a frequency divider.

PTT: Push-to-talk; the switch located on the left side of the radio which, when pressed, causes the radio to transmit.

registers: Short term data storage circuits within the microcontroller.

repeater: Remote transmit/receive facility that re-transmits received signals in order to improve communications range and coverage.

RESET: Reset line; an input to the microcontroller that restarts execution following a negative pulse.

RF PA: Power amplifier module, located on the transceiver board.

RSSI: Received signal strength indicator; a dc voltage proportional to the received rf signal strength.

RPT/TA: Repeater/Talk-around.

RX DATA: Recovered digital data line; inputs to the microcontroller.

SCI IN: Serial communication interface input line.

SLIC IV: Acronym for Support Logic IC, a custom gate array used to provide I/O and memory expansion for the microcontroller module

softpot: Software potentiometer; a computer-adjustable electronic attenuator

software: computer programs, procedures, rules, documentation, and data pertaining to the operation of a system.

SPI (clock and data lines): Serial Peripheral Interface; how the microcontroller communicates to modules and ICs through the CLOCK and DATA lines.

squelch: Automatic receiver quieting accomplished by muting audio circuits when received signal levels fall below a pre-determined value.

SRAM: Static RAM, memory chip used for scratchpad memory.

standby mode: An operating mode whereby the radio is muted but still continues to receive data.

SYN SEL: Synthesizer select line; activates the synthesizer when low.

system central controller: Main control unit of the trunked dispatch system; handles ISW and OSW messages to and from radios in the field (See ISW and OSW).

system select: The act of selecting the desired operating system with the system select switch (also, the name given to this switch).

Talk group: A collection of radios using the same communication path.

TSOP: Acronym for Thin Small-Outline Package, a new package being used for memory modules, typically less than .060" thick.

transmission time-out-timer: A timer that limits the length of a transmission made over a channel.

μC: microcontroller.

VCO: Voltage-controlled oscillator: an oscillator whereby the frequency of oscillation can be varied by changing a control voltage.

VCOB IC: Voltage-controlled oscillator buffer integrated circuit.

GM/GP1200

Please find listed below the error message and what it means:-

Displayed Error Number	Failure Type
01	Invalid channel spacing
02	EEPROM checksum invalid (personality fields)
03	Synthesizer out of lock
04	Invalid R.F. configuration
05	RAM test failed
06	Invalid personality data
07	Dynamic codeplug block failure
08	****NOT USED****
09	****NOT USED****
10	Flash EEPROM checksum invalid
11	****NOT USED****
12	Hardware test failure

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