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6880903Z45-A

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<td>41</td>
<td>Parts List for UHF Main Boards, 450-470 MHz, 12.5 &amp; 20-25 kHz, 40 W (Part of PMUE1039B, PMUE1040B, PMUE1056B, and PMUE1057B Radios)</td>
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<td>Schematic Diagram for UHF Main Boards, 470-490 MHz, 12.5 &amp; 20-25 kHz, 40 W (Part of HUE3761A, HUE3762A, HUE3611A, and HUE3612A Radios) (Sheet 1 of 2)</td>
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Scope of Manual

This manual is intended for use by experienced technicians familiar with similar types of equipment. It contains all service information required for the equipment described and is current as of the printing date. Changes which occur after the printing date are incorporated by instruction manual revision. These revisions are added to the manuals as the engineering changes are incorporated into the equipment.

How to Use This Manual

This manual contains introductory material such as model charts, accessories, and specifications, as well as four sections that deal with specific service aspects of the SM50 and SM120 Mobile Radios. Refer to the Table of Contents for a general overview of the manual, or to the "Overview" paragraph in each section for a specific overview of the information in that section.

Other Documentation

Table 1 lists other documentation for the SM Series Mobile Radios.

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<td>SM50 Accessory</td>
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</tr>
<tr>
<td>Feature Sheet</td>
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<tr>
<td>Basic Use of SM120</td>
<td>SM120 Operator Card (6880903Z89)</td>
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<tr>
<td>SM120 Accessory</td>
<td>6880903Z88</td>
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<tr>
<td>Feature Sheet</td>
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<tr>
<td>SM Series Installation</td>
<td>SM Series Installation/Licensing Guide (6880904Z10)</td>
</tr>
<tr>
<td>Programming</td>
<td>SM Series RSS Manual (6880903Z78)</td>
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Technical Support

To obtain technical support, you may call Motorola's Radius Product Services. When you call, we ask that you have ready the model and serial numbers of the respective radio or its parts.

Service Policy

If malfunctions occur within 30 days that cannot be resolved over the phone with Radius Product Services, a defective major component should be returned. You must obtain authorization from Radius Product Services before returning the component.

Ordering Replacement Parts

You can order additional components and some piece parts directly through your Radius price pages. When ordering replacement parts, include the complete identification number for all chassis, kits, and components. If you do not know a part number, include with your order the number of the chassis or kit which contains the part, and a detailed description of the desired component. If a Motorola part number is identified on a parts list, you should be able to order the part through Motorola Parts. If only a generic part is listed, the part is not normally available through Motorola. If no parts list is shown, generally, no user serviceable parts are available for the kit.

Technical Support
Radius Product Services
Hwy. 34 West
Mt. Pleasant, IA 52641 USA

Radius 30-Day Warranty
Radius Repair Depot
Attention: Warranty Return
3760 South Central Avenue
Rockford, IL 61102 USA
1-800-227-6772 (U.S. & Canada)
1-800-694-2161 (Latin America)

Radius Major Component Repair
Radius Repair Depot
3760 South Central Avenue
Rockford, IL 61102 USA

Motorola Parts
Worldwide System and
Aftermarket Products Division
Attention: Order Processing
1313 E. Algonquin Road
Schaumburg, IL 60196

Customer Service
1-800-422-4210
1-847-538-8198 (FAX)

Worldwide System and
Aftermarket Products Division
Attention: International Order Processing
1313 E. Algonquin Road
Schaumburg, IL 60196

Customer Service
1-800-422-4210
1-847-538-8198 (FAX)

Parts Identification
1-847-538-8023
1-847-576-3023 (FAX)
SM50
VHF Mobile Radio
136 - 156 MHz
10-25 Watts RF Power

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<td>PMUD1024_</td>
<td>Radio, 12.5 kHz, 10-25 W (Cancelled)</td>
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<td>PMLN4022_</td>
<td>X</td>
<td>Display Board (2-Freq.)</td>
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<td>PMUD1025_</td>
<td>Radio, 20/25/30 kHz, 10-25 W</td>
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<td>PMLN4006_</td>
<td>X</td>
<td>Hardware Kit</td>
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<td>HMN3174_</td>
<td>Microphone</td>
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<td>(See Note)</td>
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<td>Main Board, 12.5 kHz, 10-25 W</td>
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<td>Main Board, 20/25/30 kHz, 10-25 W</td>
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<td>Power Cable</td>
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<td>SM50 Operator's Kit</td>
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Note: Main board kits are not available separately for field replacement.
### SM50

**VHF Mobile Radio**
150 - 170 MHz
10 - 25 Watts RF Power &
40 Watts RF Power

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<th>Model</th>
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<tr>
<td>M4DGCC00A2AA</td>
<td>20/25/30 kHz, 10-25 W</td>
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<td>M4DGCC00A2AA</td>
<td>12.5 kHz, 40 W</td>
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<td>M4DGCC00A2AA</td>
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<td>PMUD1030_</td>
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<td>PMUD1031_</td>
<td>Radio, 20/25/30 kHz, 10-25 W</td>
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<tr>
<td>PMUD1067_</td>
<td>Radio, 12.5 kHz, 40 W</td>
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<tr>
<td>PMUD1068_</td>
<td>Radio, 20/25/30 kHz, 40 W</td>
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<tr>
<td>HMN3174_</td>
<td>Microphone</td>
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<tr>
<td>HLN9154_</td>
<td>Non-Locking Bracket</td>
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<td>HKN4137_</td>
<td>Power Cable</td>
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<td>HLN9335_</td>
<td>SM50 Operator's Kit</td>
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**Note:** Main board kits are not available separately for field replacement.
### SM50

**UHF Mobile Radio**

**450 - 470 MHz**

**10 - 25 Watts RF Power**

&

**40 Watts RF Power**

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<td>Display Board (2-Freq.)</td>
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<tr>
<td>M4DG200A2AA</td>
<td>20-25 kHz, 10-25 W</td>
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<td>Hardware Kit (See Note)</td>
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<td>M4DG200A2AA</td>
<td>12.5 kHz, 40 W</td>
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<td>Main Board, 12.5 kHz, 10-25 W</td>
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<td>M4DG200A2AA</td>
<td>20-25 kHz, 40 W</td>
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<td>Main Board, 20-25 kHz, 10-25 W</td>
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### Item Description:

- **PMUE1006**: Radio, 12.5 kHz, 10-25 W
- **PMUE1007**: Radio, 20-25 kHz, 10-25 W
- **PMUE1039**: Radio, 12.5 kHz, 40 W
- **PMUE1040**: Radio, 20-25 kHz, 40 W
- **HMN3174**: Microphone
- **HLN9154**: Non-Locking Bracket
- **HKN4137**: Power Cable
- **HLN9335**: SM50 Operator's Kit

### Note:

Main board kits are not available separately for field replacement.
### SM50

**UHF Mobile Radio**  
**470 - 490 MHz**  
*40 Watts RF Power*

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</tr>
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<td>20-25 kHz, 40 W</td>
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<tr>
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<tbody>
<tr>
<td>X</td>
<td>HUE3761_</td>
<td>Radio, 12.5 kHz, 40 W</td>
<td>X X X</td>
<td>X X X</td>
<td>X X X</td>
</tr>
<tr>
<td>X</td>
<td>HUE3762_</td>
<td>Radio, 20-25 kHz, 40 W</td>
<td>X X X</td>
<td>X X X</td>
<td>X X X</td>
</tr>
<tr>
<td>X</td>
<td>HLN9154_</td>
<td>Non-Locking Bracket</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>X</td>
<td>HLN154_</td>
<td>Power Cable</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>X</td>
<td>HLN9335_</td>
<td>SM50 Operator's Kit</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Note:** Main board kits are not available separately for field replacement.
**SM120**

**VHF Mobile Radio**

**136 - 156 MHz**

**10-25 Watts RF Power**

<table>
<thead>
<tr>
<th>MODEL</th>
<th>DESCRIPTION</th>
<th>FREQ.</th>
</tr>
</thead>
<tbody>
<tr>
<td>M350GC01C1AA</td>
<td>12.5 kHz, 10-25 W (Cancelled)</td>
<td>16</td>
</tr>
<tr>
<td>M350GC20C1AA</td>
<td>20/25/30 kHz, 10-25 W</td>
<td>16</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ITEM</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>PMUD1042_</td>
</tr>
<tr>
<td>X</td>
<td>PMUD1043_</td>
</tr>
<tr>
<td>X</td>
<td>HMN3174_</td>
</tr>
<tr>
<td>X</td>
<td>HLN9154_</td>
</tr>
<tr>
<td>X</td>
<td>HKN4137_</td>
</tr>
<tr>
<td>X</td>
<td>HLN9336_</td>
</tr>
</tbody>
</table>

**Note:** Main board kits are not available separately for field replacement
SM120
VHF Mobile Radio
150 - 170 MHz
10 - 25 Watts RF Power
&
40 Watts RF Power

<table>
<thead>
<tr>
<th>MODEL</th>
<th>DESCRIPTION</th>
<th>FREQUENCY</th>
<th>WATTAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>M33DG00C2AA</td>
<td>12.5 kHz, 10-25 W</td>
<td>20/25 kHz, 10-25 W</td>
<td>16</td>
</tr>
<tr>
<td>M33DG20C2AA</td>
<td>12.5 kHz, 40 W</td>
<td>20/25 kHz, 40 W</td>
<td>16</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>PMUD1086_ Radio, 12.5 kHz, 10-25 W</td>
<td>X X X X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>X</td>
<td>PMUD1087_ Radio, 20/25/30 kHz, 10-25 W</td>
<td>X X</td>
<td>X X X X</td>
<td></td>
</tr>
<tr>
<td>X</td>
<td>PMUD1088_ Radio, 12.5 kHz, 40 W</td>
<td>X X X X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>X</td>
<td>PMUD1089_ Radio, 20/25/30 kHz, 40 W</td>
<td>X X X X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>X X X X</td>
<td>HLN3174_ Microphone</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>X X X X</td>
<td>HLN9154_ Non-Locking Bracket</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>X X X X</td>
<td>HKN4137_ Power Cable</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>X X X X</td>
<td>HLN9336 SM120 Operator's Kit</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Main board kits are not available separately for field replacement.
### SM120
**UHF Mobile Radio**
*450 - 470 MHz*
**10 - 25 Watts RF Power**
&
**40 Watts RF Power**

<table>
<thead>
<tr>
<th>MODEL</th>
<th>DESCRIPTION</th>
<th>FREQ.</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>M34GDG00C2AA</td>
<td>Radio, 12.5 kHz, 10-25 W</td>
<td>16</td>
<td>Display Board (16-Freq.)</td>
</tr>
<tr>
<td>M34GDG00C2AA</td>
<td>Radio, 12.5 kHz, 10-25 W</td>
<td>16</td>
<td>Main Board, 20-25 kHz, 10-25 W</td>
</tr>
<tr>
<td>M44GDG20C2AA</td>
<td>Radio, 12.5 kHz, 40 W</td>
<td>16</td>
<td>Main Board, 20-25 kHz, 40 W</td>
</tr>
<tr>
<td>M44GDG20C2AA</td>
<td>Radio, 20-25 kHz, 40 W</td>
<td>16</td>
<td>Main Board, 20-25 kHz, 40 W</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>X X X</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>PMUE1054_</td>
<td></td>
</tr>
<tr>
<td>X</td>
<td>PMUE1055_</td>
<td></td>
</tr>
<tr>
<td>X</td>
<td>PMUE1056_</td>
<td></td>
</tr>
<tr>
<td>X</td>
<td>PMUE1057_</td>
<td></td>
</tr>
<tr>
<td>X X X X</td>
<td>HMN3174_</td>
<td>X X</td>
</tr>
<tr>
<td>X X X X</td>
<td>HLN9154_</td>
<td></td>
</tr>
<tr>
<td>X X X X</td>
<td>HKN4137_</td>
<td></td>
</tr>
<tr>
<td>X X X X</td>
<td>HLN9336_</td>
<td></td>
</tr>
</tbody>
</table>

- **Note:** Main board kits are not available separately for field replacement
## SM120
UHF Mobile Radio
470 - 490 MHz
40 Watts RF Power

<table>
<thead>
<tr>
<th>MODEL</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>M44DGDC20C4AA</td>
<td>20-25 kHz, 40 W</td>
</tr>
<tr>
<td>M44DGDC0C4AA</td>
<td>12.5 kHz, 40 W</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>FREQ.</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>16</td>
<td>16</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ITEM</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>HUE3611_ Radio, 12.5 kHz, 40 W</td>
</tr>
<tr>
<td>X</td>
<td>HUE3612_ Radio, 20-25 kHz, 40 W</td>
</tr>
<tr>
<td>X</td>
<td>HMN3174_ Microphone</td>
</tr>
<tr>
<td>X</td>
<td>HLN9154_ Non-Locking Bracket</td>
</tr>
<tr>
<td>X</td>
<td>HKN4137_ Power Cable (10-25 W)</td>
</tr>
<tr>
<td>X</td>
<td>HLN9336_ SM120 Operator’s Kit</td>
</tr>
</tbody>
</table>

Note: Main board kits are not available separately for field replacement.
Accessories

Radius offers several accessories to increase communications efficiency. Many of the accessories available are listed below, but for a complete list, consult your Radius dealer.

Antennas:
- HAD4007_R: VHF 146-150.8 MHz, 1/4 Wave Roof Mount
- HAD4008_R: VHF 150.8-162 MHz, 1/4 Wave Roof Mount
- HAD4009_R: VHF 162-174 MHz, Antenna Roof Mount
- HAD4014_R: VHF 146-172 MHz, 3 dB Gain Roof Mount
- HAE4003_R: UHF 450-470 MHz, 1/4 Wave Roof Mount
- HAE4011_R: UHF 450-470 MHz, 3.5 dB Gain Roof Mount
- RAE4004AR: UHF 450-470 MHz, 5 dB Gain Roof Mount
- HKN9557_R: PL259/Mini-U Antenna Adapter with 8 in. Cable
- HLN5282_R: Mini-U Connector
- HLN8027: Mini - UHF to BNC Adapter

Microphones:
- HMN1035_R: Heavy Duty Palm Microphone with 10.5 ft. cord
- HMN3174: Compact Microphone with Tx LED, 7 ft. cord
- HMN3001: Compact Microphone with Tx LED, 10 ft. cord
- HMN3175C: Compact Touch-Code™ Microphone with 7 ft. cord
- HMN3141_R: Handset w/Hang-up Cup
- HLN9073_R: Microphone Hang-up Clip
- HLN9414: Universal Hang-up Clip
- HLN9560_R: 10.5 ft. Extended Coil Cord
- HLN9559_R: 7 ft. Coil Cord

Installation Accessories:
- HLN9162: 5 in. Goose Neck Mounting Bracket
- HLN9227: 8 in. Goose Neck Mounting Bracket
- HLN9408: Gooseneck Decor Sleeve
- HLN9228: Clam Shell Swivel Mounting Bracket
- HLN9179: Quick Release Mounting Bracket
- HLN9617: Key Lock Mounting Bracket
- HLN9573_R: Shorting Plug
- HLN9534: Right Angle Mini - UHF Connector

Control Station Accessories:
- HLN9226: Mobile Holder
- HLN9415: Mobile Holder with Power Supply
- HMN3000: Black Desk Microphone
- HMN1038_R: Beige Desk Microphone
- HLN3053: Control Station Package (10-25 W)
- HKN9018_A: Control Station Cable
- HKN9019_A: 16-pin Conductor Cable
- HPN8393: GR300/GR400 Power Supply (45 W)

Accessories / Kits Interfacing with the 16-Pin Connector:
- HKN9242: 16-pin Accessory Kit with Expanded Connector
- HSN9008_A: 16-pin 7.5 W External Speaker for Received Audio
- HKN9327: 16-pin Ignition Switch Cable
- HLN9328_R: External Alarm Relay and Cable for Horn & Lights
- HKN9407: Cigarette Lighter Adapter (25 W models only)

Manuals/Kits:
- L1547A: DC Remote Adapter Manual
- L1475A: Tone Remote Adapter Manual
- 6880904205: DTMF Microphone Service Manual
- HLN9335: SM50 Manual Kit
- HLN9336: SM120 Manual Kit
- HLN3096_A: Quick-Call™ Advantage™ Option Board
- HLN9247: SmarTrunk™ Advantage™ Option Board

xv
### Specifications

#### GENERAL

<table>
<thead>
<tr>
<th></th>
<th>VHF</th>
<th>UHF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model Series:</td>
<td>M33DGC, M43DGC</td>
<td>M34DGC, M44DGC</td>
</tr>
<tr>
<td>Frequency Range:</td>
<td>136-156 MHz &amp; 150-170 MHz</td>
<td>450-470 MHz &amp; 470-490 MHz</td>
</tr>
<tr>
<td>RF Output:</td>
<td>10-25 W or 40 W</td>
<td></td>
</tr>
<tr>
<td>Channel Spacing:</td>
<td>12.5 kHz</td>
<td>12.5 kHz</td>
</tr>
<tr>
<td>Dimensions:</td>
<td>H 1.73” X W 6.61” X D 4.25” (H 44mm X W 168mm X D 108mm)</td>
<td>20/25/30 kHz</td>
</tr>
<tr>
<td>Weight:</td>
<td>36 oz. (1.02kg)</td>
<td></td>
</tr>
<tr>
<td>Channel Capacity:</td>
<td>2 or 16 Channels</td>
<td></td>
</tr>
<tr>
<td>Freq. Separation:</td>
<td>20 MHz</td>
<td></td>
</tr>
<tr>
<td>Input Voltage:</td>
<td></td>
<td>13.6 ±10%</td>
</tr>
<tr>
<td>Current Drain: Standby</td>
<td>300 mA</td>
<td>8 A @ 10-25 W</td>
</tr>
<tr>
<td>Rx @ Rated Audio:</td>
<td>1.5 A</td>
<td>12.5 A @ 40 W</td>
</tr>
<tr>
<td>Transmit:</td>
<td>7 A @ 10-25 W</td>
<td>8 A @ 10-25 W</td>
</tr>
<tr>
<td></td>
<td>12.5 A @ 40 W</td>
<td>12.5 A @ 40 W</td>
</tr>
<tr>
<td>Squelch Capabilities:</td>
<td>Tone Coded, Digital Coded and/or Carrier Squelch</td>
<td></td>
</tr>
</tbody>
</table>

#### TRANSMITTER

<table>
<thead>
<tr>
<th></th>
<th>VHF</th>
<th>UHF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freq. Stability:</td>
<td>±0.00025%</td>
<td></td>
</tr>
<tr>
<td>Spurs/Harmonics:</td>
<td>-16 dBm (25 µW)</td>
<td></td>
</tr>
<tr>
<td>Audio Response:*</td>
<td>+1/-3 dB*</td>
<td></td>
</tr>
<tr>
<td>Audio Distortion:</td>
<td>&lt;3% TIA (@1000 Hz, 60% of Rated Max. Deviation)</td>
<td></td>
</tr>
<tr>
<td>FCC Designation:</td>
<td>ABZ99FT3034 (10-25 W)</td>
<td>ABZ99FT4038 (10-25 W)</td>
</tr>
<tr>
<td></td>
<td>ABZ99FT3035 (10-25 W)</td>
<td>ABZ99FT4039 (40 W)</td>
</tr>
<tr>
<td></td>
<td>ABZ99FT3036 (40 W)</td>
<td>ABZ99FT4040 (40 W)</td>
</tr>
<tr>
<td>FCC Modulation:</td>
<td>20/25/30 kHz</td>
<td>16K0F2D &amp; 16K0F3E</td>
</tr>
<tr>
<td></td>
<td>12.5 kHz</td>
<td>11K0F2D &amp; 11K0F3D</td>
</tr>
<tr>
<td>Output Impedance:</td>
<td>50 ohms</td>
<td></td>
</tr>
<tr>
<td>Modulation Sensitivity:</td>
<td>80 mV rms for 60% deviation @ 1000 Hz</td>
<td></td>
</tr>
<tr>
<td>FM Noise:</td>
<td>40 dB</td>
<td>45 dB</td>
</tr>
<tr>
<td></td>
<td>35 dB</td>
<td>40 dB</td>
</tr>
</tbody>
</table>

*Relative to 6 dB/octave pre-emphasis, 300-3000 Hz (2550 Hz @ 12.5 kHz)*

#### RECEIVER

<table>
<thead>
<tr>
<th></th>
<th>VHF</th>
<th>UHF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensitivity EIA @ 12 dB SINAD:</td>
<td>0.35 µV</td>
<td>0.35 µV</td>
</tr>
<tr>
<td>Selectivity TIA:</td>
<td>65 dB</td>
<td>75 dB</td>
</tr>
<tr>
<td>Intermodulation TIA*:</td>
<td>65 dB</td>
<td>75 dB</td>
</tr>
<tr>
<td>Spur &amp; Image Rejection:</td>
<td>75 dB</td>
<td>70 dB</td>
</tr>
<tr>
<td>Audio Output:</td>
<td>7.5 W @ 5% distortion</td>
<td>3.0 W Nominal</td>
</tr>
<tr>
<td></td>
<td>22 ohms (internal)</td>
<td></td>
</tr>
<tr>
<td>Input impedance:</td>
<td>50 ohms</td>
<td></td>
</tr>
<tr>
<td>Squelch (internally pre-set):</td>
<td>10 dB SINAD</td>
<td></td>
</tr>
<tr>
<td>TIA Usable Bandwidth:</td>
<td>1.2 kHz</td>
<td>2.0 kHz</td>
</tr>
<tr>
<td></td>
<td>1.2 kHz</td>
<td>2.0 kHz</td>
</tr>
</tbody>
</table>

* Local mode adds 10 dB protection against wideband interference.

**SPECIFICATIONS SUBJECT TO CHANGE WITHOUT NOTICE**

March, 1998
Service Aids

The following table lists service aids recommended for working on the SM Series Mobile Radio.

<table>
<thead>
<tr>
<th>Motorola Part No.</th>
<th>Description</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>HLN9214</td>
<td>Radio Interface Box</td>
<td>Enables communication between the radio and the computer’s serial communications adapter.</td>
</tr>
<tr>
<td>HSN9412</td>
<td>RIB Power supply</td>
<td>Used to supply power to the RIB.</td>
</tr>
<tr>
<td>HKN9216</td>
<td>Computer Interface cable</td>
<td>Connects the computer’s serial communications adapter to the RIB.</td>
</tr>
<tr>
<td>HKN9215</td>
<td>AT to XT Computer adapter</td>
<td>Allows HKN9216 to plug into a XT style communications port.</td>
</tr>
<tr>
<td>HLN9390</td>
<td>Program Test Cable</td>
<td>RIB to Radio Cable</td>
</tr>
<tr>
<td>HKN9217</td>
<td>Power Supply Cable</td>
<td>Connects the power supply to the radio.</td>
</tr>
<tr>
<td>HVN9007</td>
<td>Radio Service Software</td>
<td>Software on 3-1/2 in. and 5-1/4 in. floppy disc.</td>
</tr>
<tr>
<td>HKN9755</td>
<td>Cloning Cable</td>
<td>Allows the radio to be duplicated from a master radio by transferring programmed data from one radio to another.</td>
</tr>
</tbody>
</table>

Test Equipment

The following table lists test equipment required to service the SM Series Mobile Radio and other two-way radios.

<table>
<thead>
<tr>
<th>Motorola Model No.</th>
<th>Description</th>
<th>Characteristics</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>R2200, R2400, or R2001 with trunking option</td>
<td>Service Monitor</td>
<td>This monitor will substitute for items with an asterisk *</td>
<td>Frequency/deviation meter and signal generator for wide-range troubleshooting and alignment</td>
</tr>
<tr>
<td>*R1049</td>
<td>Digital Multimeter</td>
<td></td>
<td>Two meters recommended for ac/dc voltage and current measurements</td>
</tr>
<tr>
<td>*SI100</td>
<td>Audio Oscillator</td>
<td>67 to 200 Hz tones</td>
<td>Used with service monitor for injection of PL tones</td>
</tr>
<tr>
<td>*S1053, *SKN6009, *SKN6001</td>
<td>AC Voltmeter, Power Cable for meter, Test leads for meter</td>
<td>1mV to 300V; 10-Megohm input impedance</td>
<td>Audio voltage measurements</td>
</tr>
<tr>
<td>R1053</td>
<td>Dual-trace Oscilloscope</td>
<td>20 MHz bandwidth, 5mV/cm - 20V/cm</td>
<td>Waveform measurements</td>
</tr>
<tr>
<td>*S1350, *ST1215 (VHF) *ST1223 (UHF) *T1013</td>
<td>Wattmeter, Plug-in Elements (VHF &amp; UHF), RF Dummy Load</td>
<td>50-ohm, ± 5% accuracy 10 Watts, maximum 0-1000 Mhz, 300W</td>
<td>Transmitter power output measurements</td>
</tr>
<tr>
<td>S1339</td>
<td>RF Millivolt Meter</td>
<td>100uV to 3V RF, 10 kHz to 1.2 GHz</td>
<td>RF level measurements</td>
</tr>
<tr>
<td>*R1013</td>
<td>SINAD Meter</td>
<td></td>
<td>Receiver sensitivity</td>
</tr>
<tr>
<td>S1347 or S1348 (prog)</td>
<td>DC Power Supply</td>
<td>0-20 Vdc, 0-5 Amps</td>
<td>Bench supply for 12.5Vdc</td>
</tr>
</tbody>
</table>
Section 1
Radio Disassembly/Assembly

Overview
This section explains, step-by-step, how to disassemble and reassemble the SM Series radio.

Disassembling the Radio

Removing the Housing

1. Pull the volume control knob straight off.
2. Remove the housing cover by pushing down on the release latch with one finger while sliding the cover off with the other hand (Figure 1-1).

![Figure 1-1. Removing the Housing](image)

Removing the Front Panel Display Board

1. Disconnect the flex cable from the black header on the main board by gently lifting upwards.
2. Remove the display board by tilting it forward slightly and gently lifting upwards.

Removing the Mechanical Components from the Main Board

Refer to Figure 1-2 for steps 1 through 7 for the removal of the mechanical components from the main board. Refer to the exploded mechanical view diagram for more details.

![Figure 1-2. Mechanical Components](image)

1. Pull the 2-pin speaker cable connector upwards to disconnect it from the main board.

**CAUTION**
In order to avoid damage to the speaker, Do Not grasp the speaker cone when removing the rubber gasket/speaker from the heatsink.

2. Grasp the speaker at its edges and slide the rubber gasket/speaker upwards to remove it from the heatsink.
3. Pry the plug of the rear gasket out of the square pocket of the heatsink.
4. Lift and peel off the rear gasket from the heatsink.
5. Disengage the power cable from double-D slot of the heatsink by rotating the strain relief towards the PA shield (clockwise) and sliding it upwards.
6. Remove the shroud by unsnapping the catch-tabs, located on the inside wall of the heatsink, using a thin bladed screwdriver and pulling the shroud away from the heatsink.
7. Pry off the PA shield cover using a thin bladed screwdriver.
Removing the Main Board

1. Remove the hex nut from the underside of the heatsink using a 5/16" nut driver.
2. Remove all 12 mounting screws from the main board using a T10 Torx® driver.
3. Loosen the antenna connection using a 1/2" nut driver.
4. Remove the main board. Using thumb and forefingers of both hands, grasp the edges of the main board, the antenna connector, the microphone connector, and the 16-pin connector and lift upwards and away from the heatsink.

**CAUTION**
Avoid damaging the PA stud on the underside of the main board when lifting away from the heatsink.

Reassembling the Radio

Replacing the Main Board

1. Carefully place the main board into the heatsink, making sure that the PA stud clears the hole on the underside of the main board.

**NOTE**
Make sure that the internal tooth washer and nut of the mini-U connector are on the outside of the heatsink wall.

2. Tighten the antenna connection using a 1/2" nut driver and torque at 20-24 in-lbs.
3. Replace the 12 mounting screws into the main board using a T10 Torx® driver and torque the 3 screws attaching to the plastic devices at 6-8 in-lbs. and the remaining 9 screws at 8-10 in-lbs.

Replacing the Mechanical Components to the Main Board

1. Rotate the strain relief towards the PA shield (clockwise) and insert it into the double-D slot located on the heatsink
2. Slide the strain relief downward, and rotate it away from the PA shield until it's fully seated.
3. Insert the shroud into the heatsink and press the catch-tabs onto the snaps.
4. Place the rear gasket onto the heatsink, making sure it fits between the wall of the heatsink and the PA frame, while firmly pressing the five ribs into the five teardrop indentations on the heatsink.
5. Insert the plug on the rear gasket into the square pocket of the heatsink.
6. Attach the hex nut to the underside of the heatsink, using a 5/16" nut driver and torque to 5 in-lbs.
7. Snap the PA shield cover into place on the PA shield frame, making sure not to pinch the rear gasket.
8. Slide the rubber gasket/speaker downwards onto the posts on the heatsink with the word TOP facing up.

**CAUTION**
The speaker cable should be routed around the 10-position black header and the 8-position black header on the main board to prevent the housing's rear hook from dislodging and damaging the speaker connector when replacing the housing (Figure 1-3).

![Figure 1-3. Position of Speaker Cable](image)

9. Attach the 2-pin speaker cable connector to the connector on the main board.

Replacing the Front Panel Display Board

1. Insert the display board into the slide rails and gently push downward until it's fully seated.

**NOTE**
Make sure that the tab on the main board is locked into the slot on the display board.

2. Connect the flex cable to the black header on the main board.
Replacing the Housing

NOTE
Before replacing the housing, make sure that all four buttons on the keypad are protruding properly through the housing.

1. With the radio on a flat surface, place the housing approximately halfway onto the heatsink (Figure 1-4).

2. Using both hands, press downward on both sides of the housing to assure that the heatsink and the housing rails are properly aligned (Figure 1-4).

3. Slide the housing forward on the heatsink rails, making sure that the power cord and the rear gasket clear the housing.

4. Continue to slide the housing forward on the heatsink rails until the housing is flush with the rear of the heatsink.

NOTE
Verify that the outside corners of the gasket are properly inserted and aligned with the corners of the housing.

5. Insert the volume control knob by aligning it to the “D” shaft and pushing it inward while twisting it onto the volume control shaft.

Figure 1-4. Aligning the Heatsink to the Housing Rails
Overview

This section provides detailed theory of operation for the components of the SM Series radio.

Receiver Circuitry

VHF Receiver Front End

The received signal applied to the radio's antenna input connector is routed through the harmonic filter and PIN diode antenna switch. In the receive mode, PIN diodes CR2650 and CR2651 are both off, allowing the signal to pass unattenuated to the receiver front end filter. The insertion loss of the harmonic filter/antenna switch is less than 1 dB. The harmonic filter provides 19 dB attenuation for image protection at 240 MHz, with increased attenuation at higher frequencies.

The signal is routed to a fixed-tuned 4 pole capacitive-coupled resonator filter having a 3 dB bandwidth of 55 MHz and a 1 dB bandwidth of 50 MHz centered at 160 MHz. Insertion loss is 1.5 dB. Attenuation for image protection is 41 dB at 240 MHz, with increasing attenuation at higher frequencies.

The output of the filter is matched to the base of RF amplifier Q1, which provides 15 dB of gain and has a noise figure of 3.5 dB. Current source Q2 is used to maintain the collector current of Q1 constant at 30 mA. Transistors Q1 and Q2 are supplied from the 5R source. This source is switched by transistor Q412 which is controlled by an auxiliary output from DAC U403. 5R is only present in the receive mode. This reduces dissipation in Q1 during transmit. Diode CR1 clamps excessive input signals, protecting Q1.

The output of Q1 is applied to a fixed-tuned 3 pole series-coupled resonator filter having a 3 dB bandwidth of 68 MHz and a 1 dB bandwidth of 55 MHz centered at 160 MHz. Insertion loss is 1.3 dB. Attenuation for image protection is 34 dB at 240 MHz, with increasing attenuation at higher frequencies.

A pin diode attenuator is located between the 4 pole filter and the first mixer. The bias current through this diode is switched by dual-composite transistor switch Q3. In the Distance mode, Q3 is turned on by a logic high at Q3-4 from U403-19. CR2 is forward-biased which bypasses R10, and no loss is introduced. In the Local mode, Q3 and CR2 are off (U403-19 is low), inserting 10 dB of attenuation due to R10. Because the attenuator is located after the RF amplifier, receiver sensitivity is reduced only by 5 dB, while the overall third order input intercept is raised by 15 dB. Thus, the Local mode significantly reduces the susceptibility to IM-related interference.

The first mixer, U1, is a passive, double-balanced type. This mixer provides all of the necessary rejection of the half-IF spurious response, since the improvement due to filter selectivity is negligible at 150 MHz. High-side injection at +6 dBm is delivered to the first mixer from the injection buffer in the VCO/Buffer IC (U251).

The mixer output is connected to a diplexer network which matches its output to the first two pole crystal filter, Y51A, at the IF frequency of 45.1 MHz, and terminates it in a 51 ohm resistor, R51, at all other frequencies.

UHF Receiver Front End

The received signal applied to the radio's antenna input connector is routed through the harmonic filter and PIN diode antenna switch. In the receive mode, PIN diodes CR2650 and CR2651 are both off, allowing the signal to pass unattenuated to the receiver front end filter. The insertion loss of the harmonic filter/antenna switch is less than 1 dB.

The signal is routed to a fixed-tuned 3 pole shunt resonator filter having a 3 dB bandwidth of 70 MHz and a 1 dB bandwidth of 50 MHz centered at 460 MHz. Insertion loss is 1.8 dB. Attenuation for image protection is 33 dB at 380 MHz, with increasing attenuation at lower frequencies.

The output of the filter is matched to the base of RF amplifier Q1, which provides 17 dB of gain and has a noise figure of 3 dB. Current source Q2 is used to maintain the collector current of Q1 constant at 30 mA. Transistors Q1 and Q2 are supplied from the 5R source. This source is switched by transistor Q412 which is controlled by an auxiliary output from DAC U403. 5R is only present in the receive mode. This reduces dissipation in Q1 during transmit. Diode CR1 clamps excessive input signals, protecting Q1.

The output of Q1 is applied to a fixed-tuned 4 pole shunt resonator filter having a 3 dB bandwidth of 45 MHz and a 1 dB bandwidth of 27.5 MHz centered at 460 MHz. Insertion loss is 2.6 dB. Attenuation for
image protection is 57 dB at 380 MHz, with increasing attenuation at lower frequencies.

A pin diode attenuator is located between the 4 pole filter and the first mixer. The bias current through this diode is switched by dual-composite transistor switch U2. In the Distance mode, U2 is turned on by a logic high at U2-4 from U403-19. CR2 is forward-biased which bypasses R11, and no loss is introduced. In the Local mode, U2 and CR2 are off (U403-19 is low), inserting 10 dB of attenuation due to R11. Because the attenuator is located after the RF amplifier, receiver sensitivity is reduced only by 5 dB, while the overall third order input intercept is raised by 15 dB. Thus, the Local mode significantly reduces the susceptibility to IM-related interference.

The first mixer, U1, is a passive, double-balanced type. This mixer provides all of the necessary rejection of the half-IF spurious response, since the improvement due to filter selectivity is negligible at 470 MHz. Low-side injection at +6 dBm is delivered to the first mixer from the injection buffer, Q271, in the VCO/buffer circuit.

The mixer output is connected to a diplexer network which matches its output to the first two pole crystal filter, Y51A, at the IF frequency of 45.1 MHz, and terminates it in a 51 ohm resistor, R51, at all other frequencies.

**Receiver Back End**

Q51 amplifies the IF signal from Y51A by approximately 17 dB. The output of Q51 is matched to a second two pole crystal filter, Y51B. The overall 3 dB bandwidth of the crystal filters is 18 kHz for 20/25/30 kHz channel spacing models, and 10 kHz for 12.5 kHz channel spacing models. The signal from Y51B is applied to the input of the receiver system IC U51-6. Diode CR51 prevents overload of the amplifier and second mixer in the receiver system IC.

The 45.1 MHz first IF signal is applied to the second mixer section of U51. A 44.645 MHz crystal oscillator in U51 provides the low side injection signal, which is applied to U51-7. The output of the second mixer is a 455 kHz second IF signal which is filtered by ceramic filter FL51, amplified, filtered by ceramic filter FL52, and applied to the audio detector. As with the crystal filter, the bandwidth of the ceramic filters are narrower for 12.5 kHz channel spacing models than for 20/25/30 kHz.

The audio detector is a phase-locked loop type. The free-running oscillator frequency is determined by capacitor C61. Detected audio from U51-28 is routed to the RX IN and PL IN ports on the Audio Filter IC (AFIC) U402 (pins 7 and 8 respectively), and also via CMOS switch U553B to op-amp U551A, whose output is routed to the accessory connector J3-11.

U51 also contains the carrier-squelch circuitry. When an on-channel signal is present, the amount of high-frequency audio noise at the detector output is reduced. This change in noise level is sensed to indicate the presence of an on-channel signal. The bandwidth of the sampled noise is determined by R59, R60, C64 and C65. Squelch sensitivity is adjusted electronically by an attenuator in U402. Squelch noise is routed from U51-23 to U402-16, and the adjusted noise level is returned from U402-18 back to U51-20. This noise level is detected in U51 and compared to a preset threshold. Noise levels greater than a preset threshold, indicating weak or no signal present, cause U51-15 to go low. This is routed to microcomputer port PE6 (U401-18). When the noise level decreases below the threshold, due to on-channel quieting, U51-15 and therefore U401-18 go high. This indicates an on-channel signal is present, and the microcomputer unmutes the audio path.

Components R57, C68 and C69 determine squelch time constants as a function of the charging currents supplied by U51. These charging currents vary from weak to strong signal conditions, providing a variable squelch closing time-constant. For weak signals the time constant is long to minimize "chattering" or rapid muting and unmuting of the audio. For strong signals, where the carrier-absent to carrier-present conditions are substantial, the closing time-constant is shortened to minimize the length of the "squelch-tail".

**Frequency Generation System**

The frequency generation system utilizes two IC's, the Fractional-N Synthesizer (U201) and the VCO/Buffer (U251). Designed to maximize compatibility, the two IC's provide many functions which would normally require additional circuitry.

The frequency generation circuitry is supplied from the analog 5 V supply regulated by U405. The synthesizer IC further filters this voltage (SUPFOUT, U201-18, 4.65 Vdc) and supplies it to the VCO/Buffer IC.

The synthesizer also interfaces with the logic and AFIC circuitry. Synthesizer programming is accomplished through the SR DATA (U201-5), SR CLOCK (U201-6), and SYN LE (U201-7) lines by microcomputer U401. A serial stream of 98 bits is sent whenever the synthesizer is programmed. Synthesizer lock is indicated by a logic high at LOCK DET pin U201-2, and a logic low indicates out-of-lock.

In the transmit mode, modulation from the attenuators in the AFIC (U402-19 and 20) is resistively summed and applied to U201-8. The audio is digitized within U201 and applied to the loop divider to provide the low-port modulation. The audio is also routed through an internal attenuator for balancing of the high and low port modulation, before being applied to the VCO from U201-28.
The AFIC employs switched-capacitor filters which require an external 2.1 MHz clock signal. This clock is generated in U201 by dividing the 16.8 MHz reference oscillator. The signal, at U201-11, is filtered, attenuated, and applied to U402-35 at a level of approximately 2 Vp-p.

Synthesizer

The Fractional-N synthesizer uses a 16.8 MHz crystal (Y201) to provide the reference frequency for the system. External components C201-3, R201-2, and CR201 are also part of the temperature-compensated oscillator circuit. The dc voltage applied to varactor CR201 is determined by a temperature-compensation algorithm within U201, and is specific to each crystal Y201 based on a unique code assigned to the crystal.

The divided frequencies of the reference oscillator and the VCO signal (as applied to U201-20) are compared to generate the necessary correction voltage, or steering line voltage, which maintains the proper VCO frequency. The steering line voltage from U201-29 is filtered and applied to varactors CR241 and CR251 to control the frequencies of the receive and transmit VCOs respectively. To achieve fast lock time, an internal adaptive charge pump provides higher momentary current capability at U201-31 than in the normal steady-state mode. The normal and adaptive charge pumps receive their dc supply from a voltage-multiplier circuit which includes CR211, CR212 and associated capacitors C210-C216. By combining two 5 V square waves which are 180 degrees out-of-phase and adding this to the regulated 5 V supply, a source of approximately 12.6 Vdc is available at U201-32. The current for the normal mode charge pumps is set by R242. The pre-scaler for the loop is internal to U201 with the value determined by the frequency band of operation.

VCO

The VCO (U251) used in conjunction with the Fractional-N synthesizer (U201) generates an RF signal for both receive and transmit modes. The TRB line (U251-5) determines which oscillator and buffer is enabled, as described below. A sample of the RF signal from the enabled oscillator is routed from U251-23 to the prescaler input U201-20 via a matching network. After frequency comparison with the reference in the synthesizer, a resultant control voltage is applied to the varactors CR241 and CR251. This voltage, when locked, is between 3 and 10 V depending on VCO frequency.

In the receive mode, U251-5 is low, enabling the receive VCO and buffer in U251. The RF output signal at U251-2 is further amplified by Q271 (in UHF models only), low-pass filtered, and matched to the 50 ohm injection port of first mixer U1 at a level of +6 dBm.

During transmit, U251-5 is high, activating the transmit VCO and buffer. The RF output signal at U251-4 is low-pass filtered and matched into Q281 for further amplification before being applied to the RF power amplifier. A resistive attenuator (R284 through R286) isolates the VCO and buffer from impedance variations presented by the power amplifier for improved stability. The power output presented to the first stage (Q2610) of the RF power amplifier is +13 dBm.

Transmit and Receive Audio Circuitry

The majority of Rx and Tx audio processing is performed by U402, the Audio Filter IC (AFIC), which provides the following functions:

- Tone/Digital PL encoding and decoding
- PL rejection filter in Rx audio path
- Tx pre-emphasis amplifier
- Tx audio limiter
- Post-limiter (splatter) filter
- Tx deviation adjust digitally-controlled attenuators
- Programmable microphone gain attenuator
- Carrier squelch digitally-controlled attenuator
- Microcomputer output port expansion
- 2.5 Vdc reference source

The parameters of U402 which are programmable are selected by the microcomputer via the SR CLOCK (U402-31), SR DATA (U402-30) and chip enable (U402-33) lines.

Rx Audio Path

Low-Level Rx Audio

Detected audio from the IFIC U51-28 is routed via C551 to the AFIC Rx input (U402-7) and PL input (U402-8) and also, via CMOS switch U553B, to op-amp U551A.

The audio applied to U402-7 is sharply high-pass filtered to remove all PL and DPL tones below 300 Hz. Audio is then routed through a digitally controlled attenuator which is set to approximately 6 dB attenuation. This attenuation is intended to be non-adjustable, since it is desirable for the output at U402-23 to be at a fixed and known level, since this level is applied to the internal option board via connector J6-4. Level adjustment is accomplished at a later point via the volume control R554. The internal de-emphasis characteristic is normally enabled within U402, with the result that audio at U402-23 is de-emphasized but otherwise unmuted.

This audio signal is routed via R551 to op-amp gain stage U551B, through mute gate U554A, and applied to the top of the volume control R554. The signal at the top of the volume control is also routed to two other paths, the Handset Audio path and the Accessory Connector Rx Audio path.
Handset Audio Path

Rx audio from U551B via mute gate U554A is amplified by op-amp U551D and applied to the microphone connector J5-8 for use with a telephone-type handset. This audio is de-emphasized and muted (by U554A). When the radio has been programmed for handset operation, the audio power amplifier is muted whenever the handset is off-hook by a logic high from U402-3. Therefore, speaker audio is muted whenever the handset is in use.

Accessory Connector RX Audio Path

Rx audio from U551B via mute gate U554A is also routed via CMOS switch U553B-2 to op-amp gain stage U551A, whose output is routed to accessory connector J3-11. The audio at J3-11 may be either de-emphasized and muted (U401-36 low, U553B-2 connected to 15) or flat and unmuted (U401-36 high, U553B-1 connected to 15). The flat, unmuted signal applied to U553B-1 comes directly from the IFIC detected audio output. In this path, the gain adjustment for 12.5 kHz vs. 20/25/30 kHz is accomplished by resistor R563. In a similar manner, IFIC detected audio output is supplied via R555 to the internal option connector J6-5.

Audio Power Amplifier

Audio from the wiper of the volume control is amplified by the audio power amplifier IC US01. This is a bridge amplifier delivering without distortion 7.8 Vrms between pins 4 and 6. This is sufficient to develop 7.5 watts of audio power into an external 8 ohm load, or approximately 3 watts of audio power into an internal 22 ohm speaker (under a condition, undistorted audio output voltage swing exceeds 8.2 Vrms). The audio power amplifier is muted whenever speaker audio is not required, to reduce current drain and eliminate all noise in the speaker. The audio amp is muted when US01-8 is low, which is accomplished when Q416 is saturated (U402-3 high) or when the radio is turned off. The current drain into supply pin US01-7 is negligible when US01-8 is low.

Because the power amplifier is a bridge-type, neither speaker terminal is grounded. Care should be taken that any test equipment used to measure the speaker audio voltage does not ground either speaker output terminal, otherwise damage to the audio power amplifier IC may result. If the test equipment input is not isolated from ground, voltage measurements may be made from either one of the speaker output terminals (J3-1 or J3-16) to ground, in which case the voltage indicated will be one half of the voltage applied to the speaker or load resistor. In any case when a load resistor is used, it should be connected from J3-1 to J3-16. Neither side of the load resistor should be grounded.

PL Decoder

Detected Rx Audio at U402-8, the PL Decoder input, first passes through the Tone PL filter or Digital PL filter, depending on the PL option selected for the current operating mode. Filtered PL is then coupled to the PL detector circuit, with detected output at U402-27. The detected PL signal is coupled from U402-27 to microcomputer U401-64 where algorithms perform the final PL decoding. Data for the tone PL frequency or Digital PL code for each mode is programmed through the Radio Service Software.

Center-Slicer

The center-slicer circuit U601A is used for detection of high-speed signalling on radio models equipped with this capability. Unattenuated Rx audio from U402-22is dc-coupled to the two inputs of U601A. The non-inverting input U601A-3 is fed through resistor R603, with C602 providing a 3.3 kHz low-pass corner. The inverting input U601A-2 is fed through resistor R602, with C601 setting a low-pass corner frequency of 16 Hz. During operation, R602 and C601 establish an averaged dc offset level at U601A-2 dependent on the average dc level of the undetected signal to set the "trigger" threshold of U601A. R603 and C602 provide high-frequency roll-off to improve false immunity. The detected output from the center-slicer is coupled from microcomputer U401-1 where algorithms perform the final data decoding.

RadiusPort™ Internal Option Board Rx Audio Path

De-emphasized, unmuted audio is available at J6-4 for use by an internally installed option board. If this audio is processed and returned to the receive audio path, for an option such as a scrambler, the processed audio is returned from a low-impedance source to J6-2. The unprocessed audio through R551 is shunted due to the low source impedance of the option board at J6-2.

Non-de-emphasized, unmuted audio is also available at J6-5. Options requiring non-de-emphasized audio may use this, or may re-pre-emphasize the audio at J6-4, depending on the design of the option.

Noise Squelch Attenuator

The AFIC contains a 16 step programmable digital squelch attenuator whose input is U402-16 and output is U402-18. Noise squelch sensitivity is set using RSS, with open squelch at step 0 and maximum (tight) squelch at step 15.

Tx Audio Path

Voice Path via Front Panel

Microphone audio from the front panel mic jack J5-5 is attenuated from 80 mV rms (for 60% deviation at ($\frac{3}{4}$) kHz).
1 kHz) to 65 mV by R658 and R659. When mic PTT is sensed from J5-6, CMOS gate U554B is enabled by a logic high at U402-40. Audio passes R654 through pre-emphasis network R653 and C651 to the summing junction of an inverting op-amp gain stage within U402 (pin 10). Audio processing, including limiting, splatter filtering, and level adjustment are performed within U402. The outputs of the two programmable deviation-adjustment attenuators (U402-19 and 20) are resistively summed and applied to the VCO modulation input of the frequency generation system.

Voice Path via Accessory Connector

Microphone audio from an accessory such as a desk set applied to External Mic Audio input J3-2 is attenuated from 80 mV rms (for 60% deviation at 1 kHz) to 65 mV by R666 and R665. When External Mic PTT is sensed at J3-3 (or from any programmable input to which Ext Mic PTT has been assigned), CMOS gate U554C is enabled by a logic high at U401-37. Audio passes R654 through pre-emphasis network R653 and C651 to the summing junction of an inverting op-amp gain stage within U402 (pin 10). Audio processing, including limiting, splatter filtering, and level adjustment are performed within U402. The outputs of the two programmable deviation-adjustment attenuators (U402-19 and 20) are resistively summed and applied to the VCO modulation input of the frequency generation system.

Flat (Non-Pre-Emphasized) Tx Audio Path via Accessory Connector

Audio applied at J3-5 may be routed to the transmitter either before (PRE-LIM) or after (POST-LIM) the limiter. This is chosen by RSS one time and not changed subsequently. The path is controlled by CMOS gate U553C, as determined by the dc level of U402-2. Logic low provides PRE-LIM, logic high provides POST-LIM. When the POST-LIM path is chosen, audio is routed via R671 and op-amp U551C to the AUX TX INPUT (U402-13), therefore this input of the AFIC must be enabled whenever an accessory connector PTT is sensed at J3-3 (or from any programmable input to which Accessory PTT has been assigned).

If the PRE-LIM path is chosen, audio is coupled by C655 and R670 to the summing input of an op-amp within U402 (pin 10). Because R670 is significantly larger than R671, R669 provides a faster charging path for C655 when the PRE-LIM route is selected.

RadiusPort™ Internal Option Board Tx Audio Path

Microphone audio which is attenuated to a level of 65 mV rms for 60% deviation at 1 kHz is applied to the option board via J6-3. After processing by the option board, audio is returned via J6-1 from a low-impedance source on the option board. This effectively shorts out the direct audio path through resistor R654.

Transmitter Circuitry

VHF 10-25 Watt Transmitter RF Power Amplifier

The 10-25 watt VHF power amplifier is designed to cover the range of 150-170 MHz. It consists of three stages. The first stage, Q2610, operates in Class A with base bias supplied by the 8T source. The collector voltage is supplied from controlled B+. The output level of this stage (i.e. the gain of this device) is varied by changes in the controlled B+ voltage. The magnitude of the control voltage depends on the PA output power, temperature and also antenna load mismatch.

The second stage of the PA, Q2630, is the driver which amplifies the output of low level amplifier to a level sufficient to drive the final stage device. This device operated in Class C delivers up to 3 watts output power. Collector voltage is supplied by UNSWB+.

The third stage, Q2640, is the final RF power amplifier, which operates in Class C directly from UNSWB+. It provides up to 30 watts output power.

A directional coupler, located between the final power amplifier and the harmonic filter, monitors the forward and reflected power. The sampled RF is rectified by diodes CR2601 (forward power) and CR2602 (reflected power), and the resulting dc voltage is routed to the power control circuit. The HI/LO power line (U451-3) offsets the voltage reference for the forward power rectifier by 5 V to allow separating the power adjust range into two overlapping segments, if required for greater power set resolution. This capability is presently not used.

Antenna switch consists of a pair of PIN diodes, CR2650 and CR2651, a pi-network and current limiting resistors. A voltage at the bias terminal 8T forward biases both diodes, so that there is a low impedance path from transmitter to antenna while shorting out the receiver input. When this voltage is absent, both diodes look like high impedances and transmitter is effectively disconnected from the antenna, while antenna signal appears across the receiver front-end input terminals.

During transmit mode, 8T is present and both diodes are forward biased into conduction. The transmitter RF from Q2640 via the directional coupler is routed through CR2650, and via the harmonic filter to the antenna jack J1. The PIN diode CR2651 in the shunt-leg conducts, shunting RF power and preventing it from reaching the sensitive receiver front-end. The impedance inverter network contributes approximately 30 dB to transmit/receive isolation. Whereas, during receive mode, both the PIN diodes are non-conducting. Thus, the signal applied at the antenna jack J1 are routed via the harmonic filter, through C2658, L2652 and C2659 to the receiver input.
The harmonic filter is a seven pole 0.1 dB ripple Cheby-
chev low pass filter with a 3 dB frequency of approxi-
mately 200 MHz and less than 1 dB insertion loss in the
passband. The filter’s primary function is to attenuate
harmonic spurs generated by the transmitter. It also
adds low-pass selectivity for the receiver. L2663 pro-
tects the power amplifier from static discharge.

**VHF 40 Watt Transmitter RF Power Amplifier**

The 40 watt VHF power amplifier is designed to cover
the range of 150-170 MHz and has four stages. The first
stage, Q2410, operates in Class A from the 8T source. It
provides 13 dB of gain and an output of 400 mW.

The second stage, Q2420, has a nominal gain of 9.4 dB
and power output of up to 3.5 watts. The output of this
stage is adjusted by the controlled B+ voltage which
supplies its collector. (VB+ max = 6.55 V).

The third stage, Q2430, operates in Class C with 8.1 dB
gain and a power output of up to 22 watts. Collector
voltage is directly from UNSW B+.

The fourth stage, Q2440, is the final RF power ampli-
 fier, which operates Class C directly from UNSW B+. It
provides up to 65 watts output.

A directional coupler, located between the final power
amplifier and the harmonic filter, monitors the forward
and reflected power. The sampled RF is rectified by
diodes CR2480 (forward power) and CR2481 (reflected
power) and the resulting dc voltage is routed to the
power control circuit.

The antenna switch consists of two pin diodes, CR2450
and CR2451. L2452 and C2450, combined with the
"on" inductance of CR2451, form a series resonant cir-
cuit to lower the shunt impedance presented by
CR2451 when it is turned on. In the receive mode, both
diodes are off. Signals applied at the antenna jack J1 are
routed, via the harmonic filter, through L2451 and
C2453 to the receiver input. In the transmit mode, 8T is
present and both diodes are forward-biased into con-
duction. The transmitter RF from Q2440 via the direc-
tional coupler is routed through CR2450, and via the
harmonic filter to the antenna jack. CR2451 conducts,
shunting RF power and preventing it from reaching
the receiver. L2451 is selected to appear as a 1/4 wave
at VHF, so that the low impedance of CR2451 appears
as a high impedance at the junction of CR2450 and the
harmonic filter input. This provides a high series
impedance and low shunt impedance divider between
the power amplifier output and receiver input.

The harmonic filter is a seven pole 0.1 dB ripple Cheby-
chev low pass filter with a 3 dB frequency of approxi-
mately 200 MHz and less than 1 dB insertion loss in the
passband.

**UHF 10-25 Watt Transmitter RF Power Amplifier**

The 10-25 watt UHF power amplifier is designed to
cover the range of 450-470 MHz and has four stages.
The first stage, Q2610, operates in Class A from the 8T
source. It provides 11.8 dB of gain and an output of
300 mW.

The second stage, Q2620, has a nominal gain of 8.2 dB
and power output of up to 2 watts. The output of this
stage is adjusted by the controlled B+ voltage which
supplies its collector.

The third stage, Q2630, operates in Class C with 8.1 dB
gain and a power output of up to 13 watts. Collector
voltage is directly from UNSW B+.

The fourth stage, Q2640, is the final RF power ampli-
 fier, which operates Class C directly from UNSW B+. It
provides up to 30 watts output.

A directional coupler, located between the final power
amplifier and the harmonic filter, monitors the forward
and reflected power. The sampled RF is rectified by
diodes CR2680 (forward power) and CR2681 (reflected
power) and the resulting dc voltage is routed to the
power control circuit. The HI/LO power line (U403-20)
offsets the voltage reference for the forward power rec-
tifier by 5 V to allow separating the power adjustment
range into two overlapping segments, if required for
greater power set resolution. This capability is pres-
ently not used.

The antenna switch consists of two pin diodes, CR2650
and CR2651. L2652 and C2650, combined with the
"on" inductance of CR2651, form a series resonant cir-
cuit to lower the shunt impedance presented by
CR2651 when it is turned on. In the receive mode, both
diodes are off. Signals applied at the antenna jack J1 are
routed, via the harmonic filter, through L2651 and
C2653 to the receiver input. In the transmit mode, 8T is
present and both diodes are forward-biased into con-
duction. The transmitter RF from Q2640 via the direc-
tional coupler is routed through CR2650, and via the
harmonic filter to the antenna jack. CR2651 conducts,
shunting RF power and preventing it from reaching
the receiver. L2651 is selected to appear as a 1/4 wave
at UHF, so that the low impedance of CR2651 appears
as a high impedance at the junction of CR2650 and the
harmonic filter input. This provides a high series
impedance and low shunt impedance divider between
the power amplifier output and receiver input.

The harmonic filter is a seven pole 0.1 dB ripple Cheby-
chev low pass filter with a 3 dB frequency of approxi-
mately 600 MHz and less than 1 dB insertion loss in the
passband.
**UHF 40 Watt Transmitter RF Power Amplifier**

The 40 watt UHF power amplifier is designed to cover the range of 450-470 MHz and has four stages. The first stage, Q2610, operates in Class A from the 8T source. It provides 11.8 dB of gain and an output of 300 mW.

The second stage, Q2620, has a nominal gain of 8.2 dB and power output of up to 2 watts. The output of this stage is adjusted by the controlled B+ voltage which supplies its collector.

The third stage, Q2630, operates in Class C with 8.1 dB gain and a power output of up to 13 watts. Collector voltage is directly from UNSW B+.

The fourth stage, Q2640, is the final RF power amplifier, which operates Class C directly from UNSW B+. It provides up to 50 watts output.

A directional coupler, located between the final power amplifier and the harmonic filter, monitors the forward and reflected power. The sampled RF is rectified by diodes CR2680 (forward power) and CR2681 (reflected power) and the resulting dc voltage is routed to the power control circuit.

The antenna switch consists of two pin diodes, CR2650 and CR2651. L2652 and C2650, combined with the “on” inductance of CR2651, form a series resonant circuit to lower the shunt impedance presented by CR2651 when it is turned on. In the receive mode, both diodes are off. Signals applied at the antenna jack J1 are routed, via the harmonic filter, through L2651 and C2653 to the receiver input. In the transmit mode, 8T is present and both diodes are forward-biased into conduction. The transmitter RF from Q2640 via the directional coupler is routed through CR2650, and via the harmonic filter to the antenna jack. CR2651 conducts, shunting RF power and preventing it from reaching the receiver. L2651 is selected to appear as a 1/4 wave at UHF, so that the low impedance of CR2651 appears as a high impedance at the junction of CR2650 and the harmonic filter input. This provides a high series impedance and low shunt impedance divider between the power amplifier output and receiver input.

The harmonic filter is a seven pole 0.1 dB ripple Chebychev low pass filter with a 3 dB frequency of approximately 600 MHz and less than 1 dB insertion loss in the passband.

**VHF Power Control Circuit**

The VHF power control circuit is a dc-coupled amplifier whose output is the controlled voltage applied to Q2620 collector circuit. Comparator U451A is configured as a current source and maintains the reference current setting at the collector of Q451. Under steady-state conditions, the reference current is the sum of detected current by the rectified forward power and reflected power at the bi-directional coupler. The reference current level varies proportionally with the desired output power level.

By changing the DAC settings, and thus varying dc current from DAC U403 pins 9 and 11, the desired output power between 10-25 watts can be obtained. The power control loop varies the collector voltage of Q2610 as necessary to maintain equal current at the collector of Q451.

Under conditions of poor antenna match resulting in high reflected power, the control voltage at the collector of Q455 is reduced due to lowering of the detected current by the forward power detector. The output power is reduced to maintain the reference current at the collector of Q451 (due to increase in detected current by reflected power detector).

The temperature-sensing circuit protects the PA devices from excessively high temperature. As the temperature increases, the resistance of thermistor RT460 decreases. When the temperature-sensing circuit triggers into operation, the voltage at pin 3 of comparator U451 increases. Since the DAC values remain unchanged, the reference current level at pin 1 of current source amplifier, U451, is lowered. This is interpreted by the power control circuit as a lowering of desired output power. When the power output is reduced, the generated heat is reduced to a safe level. If temperature falls below the cutback temperature, the output power of the PA is increased to its nominal value.

Under severe environmental conditions, more than one circuit may be attempting to reduce power output at the same time (i.e., during high VSWR conditions, the high reflected power may initially reduce power, but eventually heat build-up will cause further power reduction by the thermal cut-back circuitry).

**UHF Power Control Circuit**

The UHF power control circuit is a dc-coupled amplifier whose output is the controlled voltage applied to Q2620 collector circuit. The input voltage to U451A-2 is a dc voltage from the direction coupler forward power detector, and is proportional to RF power output. This is compared to a dc voltage from DAC U403 pins 9 and 11, which is proportional to the desired output power setting. The power control loop varies the output of stage Q2620 as necessary to keep equal voltages at U451A pins 2 and 3. Under conditions of poor antenna match resulting in high reflected power, or under excessively high temperatures near the RF final amplifier, the dc voltage at U451A-3 is reduced due to a lowering of the voltage at U451B-7 (mismatch) or decreasing resistance of thermistor R462 at high temperatures. These two voltages are summed via diode CR451, and are interpreted by the power control circuit as a lowering of the desired output power. The loop
PTT Circuit

The logic system uses a single microcomputer A/D input port PE1 (U401-15) to distinguish between three different types of PTT information. This is done by assigning different voltage levels to the different PTT functions as follows:

- 0 to 2.1 Vdc, Microphone PTT
- 2.2 to 3.6 Vdc, Accessory PTT
- 3.9 to 4.5 Vdc, Reserved for Special Applications

A microphone connected via the front panel jack J5 must present a low of less than 2.1 Vdc to be correctly interpreted as MIC PTT and causing the appropriate audio paths to be enabled. Similarly, an accessory whose PTT output is connected to J3-3 must present a low of less than approximately 2.1 V to be interpreted as an accessory PTT. This voltage is shifted to the range between 2.2 and 3.6 V by series resistor R432.

Special applications may require a microphone with an additional button for some specialized function. A series resistor within the microphone is chosen to present between 3.9 and 4.5 Vdc at port PE1 when the button is activated.

DC Regulation and Distribution

Unswitched B+ supplies operating voltage directly to the RF power amplifier third and fourth stages, the power control series pass device Q451-E, the RAM keep-alive constant supply to U401-25, the audio power amplifier supply pin U501-7 and, via fuse F401, to the external alarm switch transistor Q409-E. All of these circuits draw negligible current when the radio is turned off (less than 15 mA total).

When the on-off switch is "on," battery voltage is applied to 8 V regulator U406, whose regulated output is routed to the display board for backlighting, to 8T transistor switch Q414, to U51 pins 13 and 14, to op-amp US51 supply pin 4, and to the inputs of the 5 V regulators U404 (digital) and U405 (analog). Separate analog and digital regulators are used to minimize microcomputer noise from being introduced into sensitive VCO and receiver circuits. The digital 5 V regulator includes a reset timer which hold the reset line U404-3 low for a predetermined time after the radio is turned on. Zener diodes on the 8 V and digital 5 V lines minimize susceptibility to ESD damage.

Front Panel Circuits

2-Frequency Display Board

The 2-frequency display board contains backlighting LEDs, Option and Monitor LEDs controlled by transistor switches Q1006 and Q1007 respectively, and Red (Tx) and Green (Rx) LED indicators for each channel, controlled by transistors Q1001-Q1004. To function as a "channel busy" indicator, the appropriate channel Red LED is illuminated and the base drive to Q1005 is toggled on and off, causing the LED to blink.

The four pushbuttons apply voltage to the bases of four digital transistors Q1008-Q1011. The appropriate transistor, in turn, grounds a tap on the series resistor ladded R1015-R1017, producing a different dc level depending on which button is pressed. These dc levels are interpreted by an A/D input of the microcomputer (U401-17) and the corresponding function is enabled. The transistors ensure than the dc ladder voltage is consistent although the series resistance of the keypad contact may vary.

16-Frequency Display Board

The 16-frequency display board contains backlighting LEDs, and an LCD driven by LCD driver IC U1101. The desired display information is loaded serially into U1101 from the microcomputer via the SR Data and Display Clock lines. Because a dedicated clock line is used, no chip-select line is needed.

The four pushbuttons apply voltage to the bases of four digital transistors Q110-Q1104. The appropriate transistor, in turn, grounds a tap on the series resistor ladded R1106-R1108, producing a different dc level depending on which button is pressed. These dc levels are interpreted by an A/D input of the microcomputer (U401-17) and the corresponding function is enabled. The transistors ensure than the dc ladder voltage is consistent although the series resistance of the keypad contact may vary.
Section 3
Troubleshooting

Overview

This section contains 9 troubleshooting tables for the following SM Series components:

- Receiver (all models)
- Transmitter (VHF 25 W models)
- Transmitter (VHF 40 W, UHF 25 W, and UHF 40 W models)
- Synthesizer (VHF 25 W models)
- Synthesizer (VHF 40 W, UHF 25 W, and UHF 40 W models)
- Voltage Controlled Oscillator (VCO) (VHF 25 W models)
- Voltage Controlled Oscillator (VCO) (VHF 40 W, UHF 25 W, and UHF 40 W models)
- Microprocessor (all models)
Troubleshooting Flow Chart
for Receiver (all models)
Troubleshooting Flow Chart for Transmitter (VHF 25 W Models)

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Troubleshooting Flow Chart
for Transmitter (VHF 40 W, UHF 25 W, and UHF 40 W Models)

No Power Output at Antenna

High B+ Current (>8A @ 25W PowerSet)
(>13A @ 40W PowerSet)

B+ Current Draw?

Low B+ Current (<5A @ 25W PowerSet)
(<8A @ 40W PowerSet)

Check B+ on Driver and Final Stages

Yes

B+ Within +/- 1.0V of Supply?

No

Check Reflected Power

Reflected Power Level Good? (<1.0 V)

Yes

1.) Check for Incorrect or Damaged Parts in Final Stages.
2.) Verify B+ Feed Circuit Integrity. (i.e. Conditional Shorts.)

No

1.) Check Pin Diodes/8T Bias.
2.) Verify Correct Components in Harmonic Filter.
3.) Troubleshoot Power Control Circuitry.

Troubleshoot Power Control Circuit and/or Verify PowerSet Using RSS

(collector Q451:<4.5V @ 25W/40W PowerSet
<3.5V @ 10W PowerSet)

Is Control Voltage High or Low?

VControl Low

Troubleshoot VCO

No

VCO Output Good?

No

Verify VCO Output (> +13dBm)

Yes

P.A. Stage(s) Bad:
1.) Verify Gain from Individual P.A. Stages.
2.) Replace Low/No Gain Device(s).

VControl High
(collector Q451>10.0V)
Troubleshooting Flow Chart
for Synthesizer (VHF 40 W, UHF 25 W, and UHF 40 W Models)
Troubleshooting Flow Chart for VCO (VHF 25 W Models)

RX VCO

LOW OR NO POWER AT PIN 3 OF MIXER?

VISUAL CHECK OF BOARD OK?

NO

CORRECT PROBLEM

YES

MAKE SURE SYNTHESIZER IS WORKING CORRECTLY AND RUNNER BETWEEN U201 PIN 18 AND U251 PIN 13 IS OK

NO

4.65VDC AT U251 PIN 13?

YES

NO

CHECK RUNNER BETWEEN U201 PIN 1 AND U251 PIN 5

4.3VDC AT U251 PIN 9?

YES

0.01VDC AT U251 PIN 9?

NO

REPLACE L244

YES

ARE U251 PINS 2 AT 4.2VDC, 7 AT 2.0VDC, 10 AT 0.8VDC, 11 AT 1.3VDC, 12 AT 1.2VDC?

NO

IF ALL PARTS ASSOCIATED WITH THOSE PINS ARE OK, THEN REPLACE U251

YES

ARE U251 PINS 4 AT 3.9VDC, 19 AT 2.1VDC, 16 AT 0.9VDC, 15 AT 1.4VDC, 14 AT 1.4VDC?

NO

IS RF AVAILABLE AT BASE OF Q281?

NO

ARE Q281 BASE 1.7V AND COLLECTOR 1.6V?

NO

IF ALL PARTS FROM COLLECTOR OF Q281 TO Q2810 ARE OK, THEN REPLACE Q281

YES

IF ALL PARTS ASSOCIATED WITH THOSE PINS ARE OK, THEN REPLACE Q281

TX VCO

LOW OR NO POWER AT INPUT TO PA MODULATION

POWER OK BUT NO MODULATION

NO

4.65VDC AT CR252?

YES

REPLACE R252 OR L253

NO

IF C254 AND R251 ARE OK, THEN REPLACE CR252

NO

REPLACE C224

If all parts from collector of Q281 to Q2810 are OK, then replace Q281

YES

If all parts associated with those pins are OK, then replace Q281

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Troubleshooting Flow Chart
for Microprocessor (all models)

March, 1998

RPD-95109-0
### Parts List

<table>
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<th>REFERENCE</th>
<th>MOTOROLA SYMBOL</th>
<th>PART NO.</th>
<th>DESCRIPTION</th>
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<tbody>
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<td>152440L01</td>
<td>152440L02</td>
<td>HOUSING, cover assembly, SM120</td>
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<td>KNOB, antenna, SIRIUS</td>
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<td>750440L03</td>
<td>750440L02</td>
<td>KEYPAD, SM50</td>
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<td>HEATSink</td>
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<td>GASKET, release latch</td>
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<td>13</td>
<td>250440L01</td>
<td>250440L02</td>
<td>Main Board</td>
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<td>250440L02</td>
<td>Shield, PA trimmer cover</td>
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<td>350450L02</td>
<td>CONNECTOR, Mini-U antenna</td>
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*non-referenced items*

| 4289544L01 | CLIP, PA |

**END OF DOCUMENT**