MOTOROLA

SM Series

Mobile Radios

150-170 MHz
450-470 MHz

Service Manual

6880903Z45-A

THIS MANUAL HAS BEEN
DISCONTINUED

Radius®

6880903Z45-A

Radius®

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Foreword

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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.

Table 1. Other Documentations

Information	Location
Basic Use of SM50	SM50 Operator Card (6880903Z74)
SM50 Accessory Feature Sheet	6880903Z46
Basic Use of SM120	SM120 Operator Card (6880903Z89)
SM120 Accesory Feature Sheet	6880903Z88
SM Series Installation	SM Series Installation/Licensing Guide (6880904Z10)
Programming	SM Series RSS Manual (6880903Z78)

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)

Model Charts

SM50
VHF Mobile Radio
136 - 156 MHz
10-25 Watts RF Power

MODEL	FREQ.	DESCRIPTION
M33DGC00A1AA	2	12.5 kHz, 10-25 W (Cencelled)
M33DGC20A1AA	2	20/25/30 kHz, 10-25 W

ITEM	DESCRIPTION
PMLN4022_	Display Board (2-Freq.)
PMLN4006_	Hardware Kit
(See Note)	Main Board, 12.5 kHz, 10-25 W (Cancelled)
(See Note)	Main Board, 20/25/30 kHz, 10-25 W

M33DGC00A1AA	M33DGC20A1AA	Item	Description	PMLN4022_	PMLN4006_	(See Note)	(See Note)
X		PMUD1024_	Radio, 12.5 kHz, 10-25 W (Cancelled)	X	X	X	
	X	PMUD1025_	Radio, 20/25/30 kHz, 10-25 W	X	X		X
X	X	HMN3174_	Microphone				
X	X	HLN9154_	Non-Locking Bracket				
X	X	HKN4137_	Power Cable				
X	X	HLN9335	SM50 Operator's Kit				

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

MODEL	FREQ.	DESCRIPTION
M33DGC00A2AA	2	12.5 kHz, 10-25 W
M33DGC20A2AA	2	20/25/30 kHz, 10-25 W
M43DGC00A2AA	2	12.5 kHz, 40 W
M43DGC20A2AA	2	20/25/30 kHz, 40 W

ITEM	DESCRIPTION
PMLN4022_	Display Board (2-Freq.)
PMLN4006_	Hardware Kit
(See Note)	Main Board, 12.5 kHz, 10-25 W
(See Note)	Main Board, 20/25/30 kHz, 10-25 W
(See Note)	Main Board, 12.5 kHz, 40 W
(See Note)	Main Board, 20/25/30 kHz, 40 W

M33DGC00A2AA	M33DGC20A2AA	M43DGC00A2AA	M43DGC20A2AA	Item	Description	PMLN4022_	PMLN4006_	Main Board, 12.5 kHz, 10-25 W	Main Board, 20/25/30 kHz, 10-25 W	Main Board, 12.5 kHz, 40 W	Main Board, 20/25/30 kHz, 40 W
X				PMUD1030_	Radio, 12.5 kHz, 10-25 W	X	X	X			
	X			PMUD1031_	Radio, 20/25/30 kHz, 10-25 W	X	X		X		
		X		PMUD1067_	Radio, 12.5 kHz, 40 W	X	X			X	
			X	PMUD1068_	Radio, 20/25/30 kHz, 40 W	X	X				X
X	X	X	X	HMN3174_	Microphone						
X	X	X	X	HLN9154_	Non-Locking Bracket						
X	X	X	X	HKN4137_	Power Cable						
X	X	X	X	HLN9335	SM50 Operator's Kit						

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

MODEL	M34DGC00A2AA	M34DGC20A2AA	M44DGC00A2AA	M44DGC20A2AA			PMLN4022_	PMLN4006_	(See Note)	(See Note)	(See Note)	(See Note)
FREQ.	2	2	2	2		ITEM						
DESCRIPTION	12.5 kHz, 10-25 W	20-25 kHz, 10-25 W	12.5 kHz, 40 W	20-25 kHz, 40 W		DESCRIPTION	Display Board (2-Freq.)	Hardware Kit	Main Board, 12.5 kHz, 10-25 W	Main Board, 20-25 kHz, 10-25 W	Main Board, 12.5 kHz, 40 W	Main Board, 20-25 kHz, 40 W
					Item	**Description**						
	X				PMUE1006_	Radio, 12.5 kHz, 10-25 W	X	X	X			
		X			PMUE1007_	Radio, 20-25 kHz, 10-25 W	X	X		X		
			X		PMUE1039_	Radio, 12.5 kHz, 40 W	X	X			X	
				X	PMUE1040_	Radio, 20-25 kHz, 40 W	X	X				X
	X	X	X	X	HMN3174_	Microphone						
	X	X	X	X	HLN9154_	Non-Locking Bracket						
	X	X	X	X	HKN4137_	Power Cable						
	X	X	X	X	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

MODEL	M44DGC00A4AA	M44DGC20A4AA		ITEM	PMLN4022_	PMLN4006_	(See Note)	(See Note)
FREQ.	2	2						
DESCRIPTION	12.5 kHz, 40 W	20-25 kHz, 40 W		DESCRIPTION	Display Board (2-Freq.)	Hardware Kit	Main Board, 12.5 kHz, 40 W	Main Board, 20-25 kHz, 40 W
			Item	**Description**				
	X		HUE3761_	Radio, 12.5 kHz, 40 W	X	X	X	
		X	HUE3762_	Radio, 20-25 kHz, 40 W	X	X		X
	X	X	HMN3174_	Microphone				
	X	X	HLN9154_	Non-Locking Bracket				
	X	X	HKN4137_	Power Cable				
	X	X	HLN9335	SM50 Operator's Kit				

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

SM120
VHF Mobile Radio
136 - 156 MHz
10-25 Watts RF Power

MODEL	FREQ.	DESCRIPTION
M33DGC00C1AA	16	12.5 kHz, 10-25 W (Cancelled)
M33DGC20C1AA	16	20/25/30 kHz, 10-25 W

ITEM	DESCRIPTION
PMLN4023_	Display Board (16-Freq.)
PMLN4006_	Hardware Kit
(See Note)	Main Board, 12.5 kHz, 10-25 W (Cancelled)
(See Note)	Main Board, 20/25/30 kHz, 10-25 W

M33DGC00C1AA	M33DGC20C1AA	Item	Description	PMLN4023_	PMLN4006_	(See Note) Main Board, 12.5 kHz	(See Note) Main Board, 20/25/30 kHz
X		PMUD1042_	Radio, 12.5 kHz, 10-25 W (Cancelled)	X	X	X	
	X	PMUD1043_	Radio, 20/25/30 kHz, 10-25 W	X	X		X
X	X	HMN3174_	Microphone				
X	X	HLN9154_	Non-Locking Bracket				
X	X	HKN4137_	Power Cable (10-25 W)				
X	X	HLN9336	SM120 Operator's Kit				

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

MODEL	FREQ.	DESCRIPTION
M33DGC00C2AA	16	12.5 kHz, 10-25 W
M33DGC20C2AA	16	20/25/30 kHz, 10-25 W
M43DGC00C2AA	16	12.5 kHz, 40 W
M43DGC20C2AA	16	20/25/30 kHz, 40 W

ITEM	DESCRIPTION
PMLN4023_	Display Board (16-Freq.)
PMLN4006_	Hardware Kit
(See Note)	Main Board, 12.5 kHz, 10-25 W
(See Note)	Main Board, 20/25/30 kHz, 10-25 W
(See Note)	Main Board, 12.5 kHz, 40 W
(See Note)	Main Board, 20/25/30 kHz, 40 W

M33DGC00C2AA	M33DGC20C2AA	M43DGC00C2AA	M43DGC20C2AA	Item	Description	PMLN4023_	PMLN4006_	Main Board, 12.5 kHz, 10-25 W	Main Board, 20/25/30 kHz, 10-25 W	Main Board, 12.5 kHz, 40 W	Main Board, 20/25/30 kHz, 40 W
X				PMUD1086_	Radio, 12.5 kHz, 10-25 W	X	X	X			
	X			PMUD1087_	Radio, 20/25/30 kHz, 10-25 W	X	X		X		
		X		PMUD1088_	Radio, 12.5 kHz, 40 W	X	X			X	
			X	PMUD1089_	Radio, 20/25/30 kHz, 40 W	X	X				X
X	X	X	X	HMN3174_	Microphone						
X	X	X	X	HLN9154_	Non-Locking Bracket						
X	X	X	X	HKN4137_	Power Cable						
X	X	X	X	HLN9336	SM120 Operator's Kit						

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

MODEL	FREQ.	DESCRIPTION
M34DGC00C2AA	16	12.5 kHz, 10-25 W
M34DGC20C2AA	16	20-25 kHz, 10-25 W
M44DGC00C2AA	16	12.5 kHz, 40 W
M44DGC20C2AA	16	20-25 kHz, 40 W

ITEM	DESCRIPTION
PMLN4023_	Display Board (16-Freq.)
PMLN4006_	Hardware Kit
(See Note)	Main Board, 12.5 kHz, 10-25 W
(See Note)	Main Board, 20-25 kHz, 10-25 W
(See Note)	Main Board, 12.5 kHz, 40 W
(See Note)	Main Board, 20-25 kHz, 40 W

M34DGC00C2AA	M34DGC20C2AA	M44DGC00C2AA	M44DGC20C2AA	Item	Description	PMLN4023_	PMLN4006_	(See Note) Main Board, 12.5 kHz, 10-25 W	(See Note) Main Board, 20-25 kHz, 10-25 W	(See Note) Main Board, 12.5 kHz, 40 W	(See Note) Main Board, 20-25 kHz, 40 W
X				PMUE1054_	Radio, 12.5 kHz, 10-25 W	X	X	X			
	X			PMUE1055_	Radio, 20-25 kHz, 10-25 W	X	X		X		
		X		PMUE1056_	Radio, 12.5 kHz, 40 W	X	X			X	
			X	PMUE1057_	Radio, 20-25 kHz, 40 W	X	X				X
X	X	X	X	HMN3174_	Microphone						
X	X	X	X	HLN9154_	Non-Locking Bracket						
X	X	X	X	HKN4137_	Power Cable (10-25 W)						
X	X	X	X	HLN9336	SM120 Operator's Kit						

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

SM120
UHF Mobile Radio
470 - 490 MHz
40 Watts RF Power

MODEL	FREQ.	DESCRIPTION
M44DGC00C4AA	16	12.5 kHz, 40 W
M44DGC20C4AA	16	20-25 kHz, 40 W

ITEM	DESCRIPTION
PMLN4023_	Display Board (16-Freq.)
PMLN4006_	Hardware Kit
(See Note)	Main Board, 12.5 kHz, 40 W
(See Note)	Main Board, 20-25 kHz, 40 W

M44DGC00C4AA	M44DGC20C4AA	Item	Description	PMLN4023_	PMLN4006_	Main Board, 12.5 kHz, 40 W	Main Board, 20-25 kHz, 40 W
X		HUE3611_	Radio, 12.5 kHz, 40 W	X	X	X	
	X	HUE3612_	Radio, 20-25 kHz, 40 W	X	X		X
X	X	HMN3174_	Microphone				
X	X	HLN9154_	Non-Locking Bracket				
X	X	HKN4137_	Power Cable (10-25 W)				
X	X	HLN9336	SM120 Operator's Kit				

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
HMN3175_	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_	Control Station Cable
HKN9019_	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_	16-pin 7.5 W External Speaker for Received Audio
HKN9327_R	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
6880904Z05	DTMF Microphone Service Manual
HLN9335	SM50 Manual Kit
HLN9336	SM120 Manual Kit
HLN3096	Quik-Call™ Advantage™ Option Board
HLN9247	SmarTrunk™ Advantage™ Option Board

Specifications

GENERAL

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

TRANSMITTER

	VHF		UHF	
Freq. Stability:	±0.00025%			
Spurs/Harmonics:	-16 dBm (25 µW)			
Audio Response:*	+1/-3 dB*			
Audio Distortion:	<3% TIA (@1000 Hz, 60% of Rated Max. Deviation)			
FCC Designation:	ABZ99FT3034 (10-25 W) ABZ99FT3035 (10-25 W) ABZ99FT3036 (40 W)		ABZ99FT4038 (10-25 W) ABZ99FT4039 (40 W) ABZ99FT4040 (40 W)	
FCC Modulation:				
20/25/30 kHz	16K0F2D & 16K0Ff3E			
12.5 kHz	11K0F2D & 11K0F3D			
Output Impedance:	50 ohms			
Modulation Sensitivity:	80 mV rms for 60% deviation @ 1000 Hz			
FM Noise:	40 dB	45 dB	35 dB	40 dB

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

RECEIVER

	VHF		UHF	
Sensitivity EIA @ 12 dB SINAD:	0.35 µV	0.30 µV	0.35 µV	0.30 µV
Selectivity TIA:	65 dB	75 dB	60 dB	70 dB
Intermodulation TIA*:	65 dB	75 dB	60 dB	70 dB
Spur & Image Rejection:	75 dB		70 dB	
Audio Output:				
8 ohms (external)	7.5 W @ 5% distortion			
22 ohms (internal)	3.0 W Nominal			
Input impedance:	50 ohms			
Squelch (internally pre-set):	10 dB SINAD			
TIA Usable Bandwidth:	1.2 kHz	2.0 kHz	1.2 kHz	2.0 kHz

* Local mode adds 10 dB protection against wideband interference.

SPECIFICATIONS SUBJECT TO CHANGE WITHOUT NOTICE

Service Aids

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

Motorola Part No.	Description	Application
HLN9214	Radio Interface Box	Enables communication between the radio and the computer's serial communications adapter.
HSN9412	RIB Power supply	Used to supply power to the RIB.
HKN9216 HKN9215	Computer Interface cable	Connects the computer's serial communications adapter to the RIB.
HLN9390	AT to XT Computer adapter	Allows HKN9216 to plug into a XT style communications port.
HKN9217	Program Test Cable	RIB to Radio Cable
HKN9402	Power Supply Cable	Connects the power supply to the radio.
HVN9007	Radio Service Software	Software on 3-1/2 in. and 5-1/4 in. floppy disc.
HKN9755	Cloning Cable	Allows the radio to be duplicated from a master radio by transferring programmed data from one radio to another.

Test Equipment

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

Motorola Model No.	Description	Characteristics	Application
R2200, R2400, or R2001 with trunking option	Service Monitor	This monitor will substitute for items with an asterisk *	Frequency/deviation meter and signal generator for wide-range troubleshooting and alignment
*R1049	Digital Multimeter		Two meters recommended for ac/dc voltage and current measurements
*S1100	Audio Oscillator	67 to 200 Hz tones	Used with service monitor for injection of PL tones
*S1053, *SKN6009, *SKN6001	AC Voltmeter, Power Cable for meter, Test leads for meter	1mV to 300V, 10-Megohm input impedance	Audio voltage measurements
R1053	Dual-trace Oscilloscope	20 MHz bandwidth, 5mV/cm - 20V/cm	Waveform measurements
*S1350, *ST1215 (VHF) *ST1223 (UHF) *T1013	Wattmeter, Plug-in Elements (VHF & UHF), RF Dummy Load	50-ohm, ± 5% accuracy 10 Watts, maximum 0-1000 Mhz, 300W	Transmitter power output measurements
S1339	RF Millivolt Meter	100uV to 3V RF, 10 kHz to 1.2 GHz	RF level measurements
*R1013	SINAD Meter		Receiver sensitivity
S1347 or S1348 (prog)	DC Power Supply	0-20 Vdc, 0-5 Amps	Bench supply for 12.5Vdc

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).

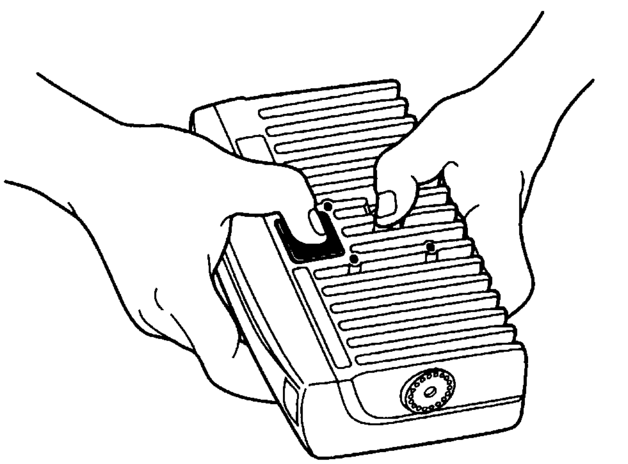


Figure 1-1. Removing the Housing

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.

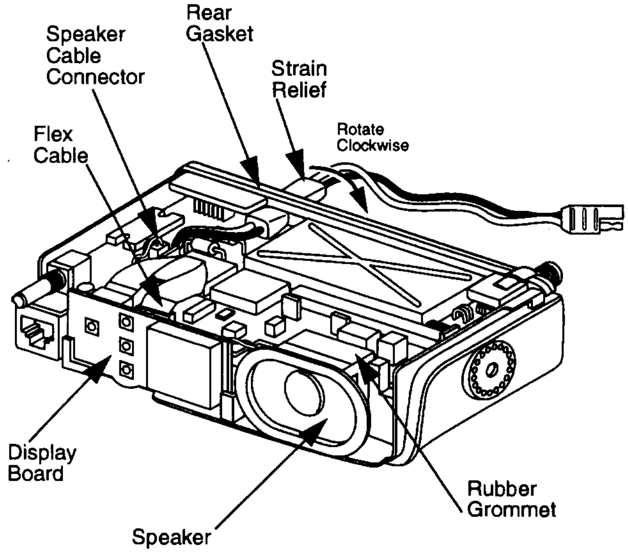


Figure 1-2. Mechanical Components

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).

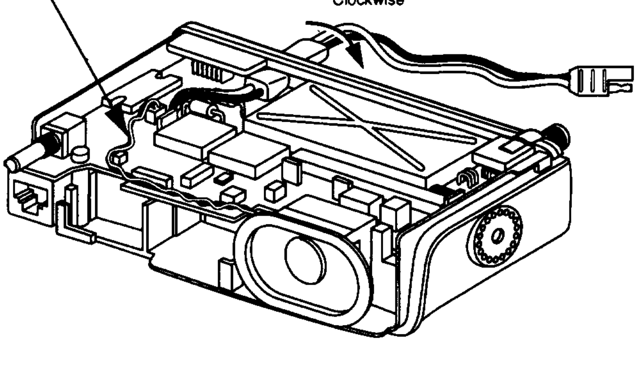


Figure 1-3. Position of Speaker Cable

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.

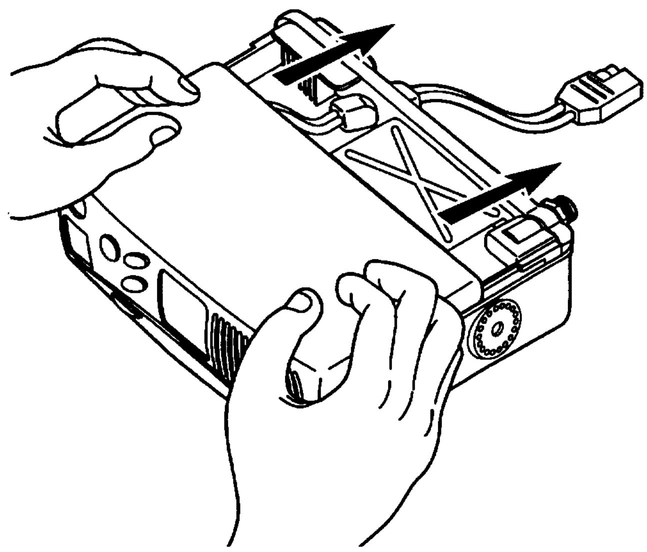


Figure 1-4. Aligning the Heatsink to the Housing Rails

Section 2
Theory of Operation

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 adapt 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 is 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 U501. 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 this 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 U501-8 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 U501-7 is negligible when U501-8 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 U402-22 is 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 falsing immunity. The detected output from the center-slicer is coupled from to 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

(3kHz)

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 adjustment 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 Chebychev low- pass filter with a 3 dB frequency of approximately 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 protects 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 amplifier, 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 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 L2451 and C2453 to the receiver input. In the transmit mode, 8T is present and both diodes are forward-biased into conduction. The transmitter RF from Q2440 via the directional 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 Chebychev low pass filter with a 3 dB frequency of approximately 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 amplifier, 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 rectifier by 5 V to allow separating the power adjustment range into two overlapping segments, if required for greater power set resolution. This capability is presently 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 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.

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 to Q2610 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 pin 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 PA 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 reduces Q2620's output until equal voltages at U451A-2 and 3 are again achieved.

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 U551 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

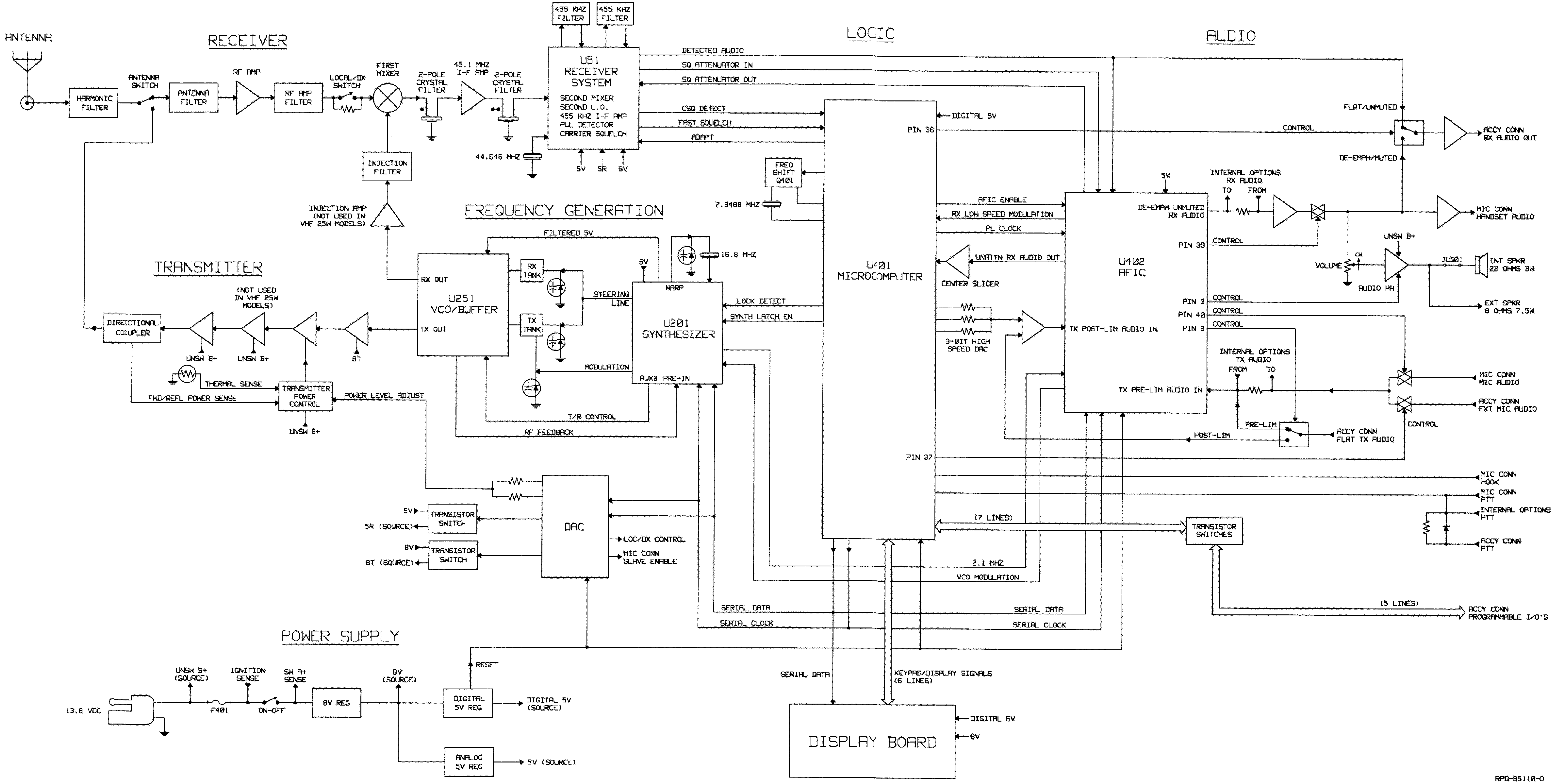
The 2-frequency display board contains backlighting LEDs, Option and Monitor LEDs controlled by transistor switches Q1006 and Q1007 respectively, and Red (Tx) and Green (Rx) LED indicators for each channel, controlled by transistors Q1001-Q1004. To function as a "channel busy" indicator, the appropriate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



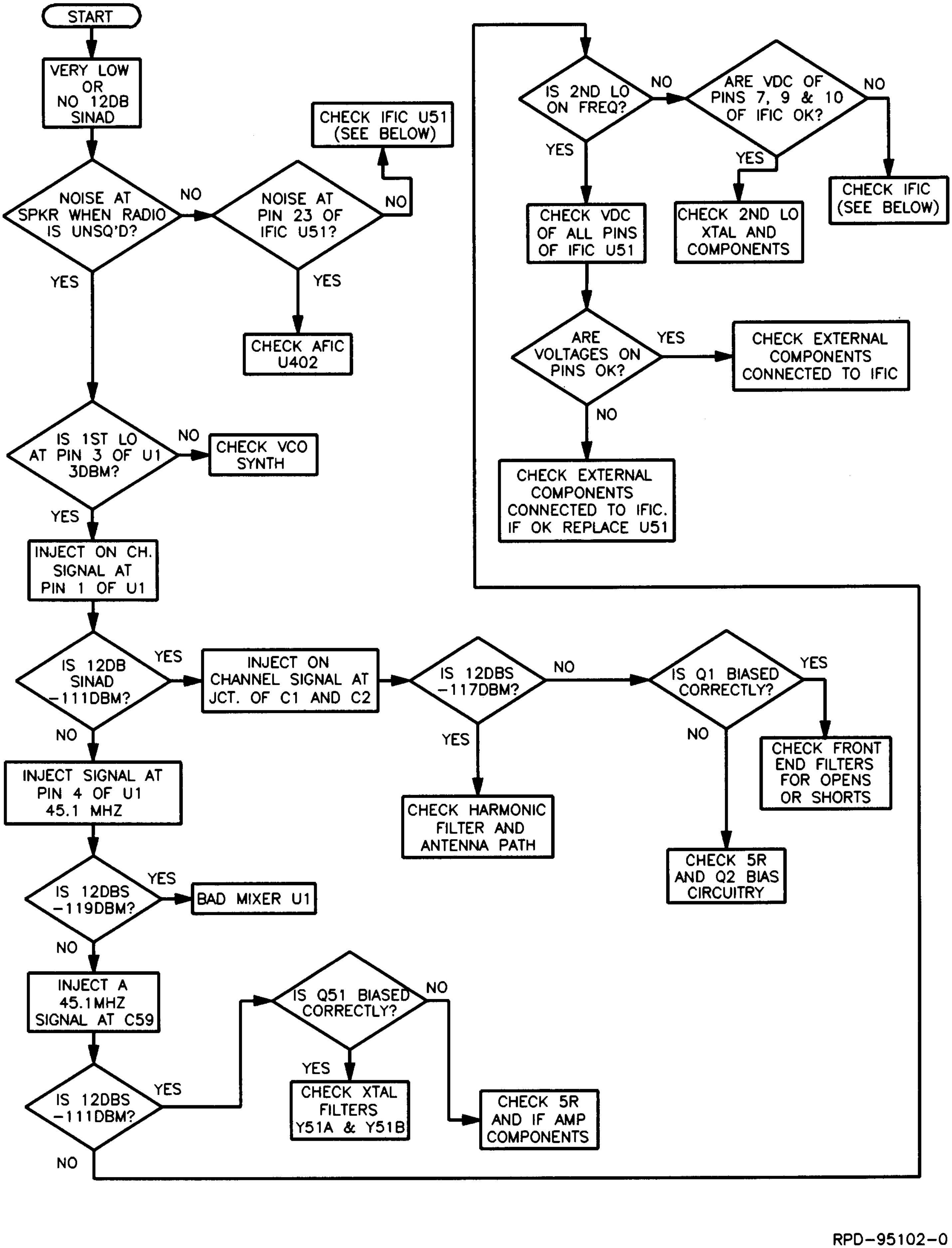
SM Series Radio Functional Block Diagram

Section 3
Troubleshooting

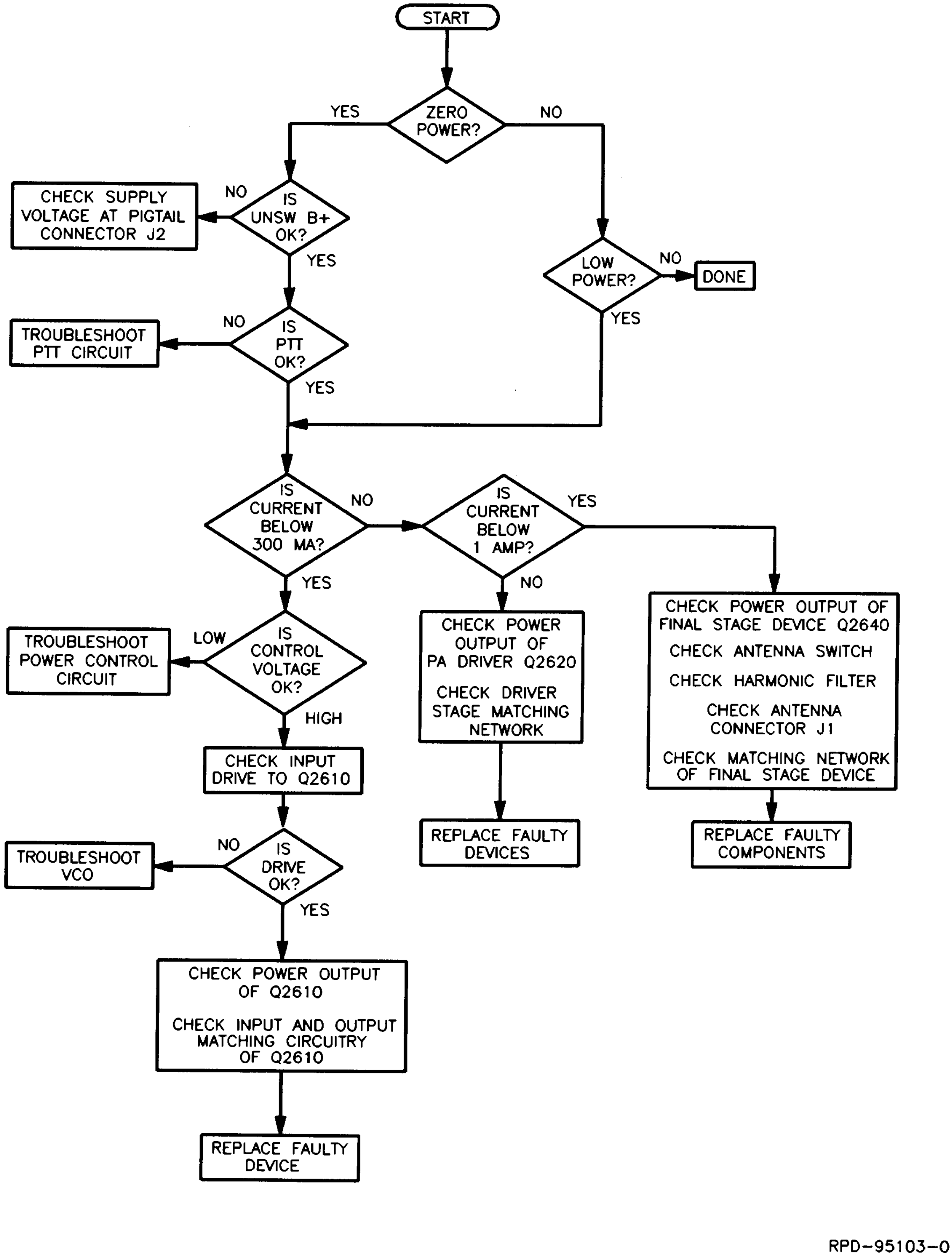
Overview

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

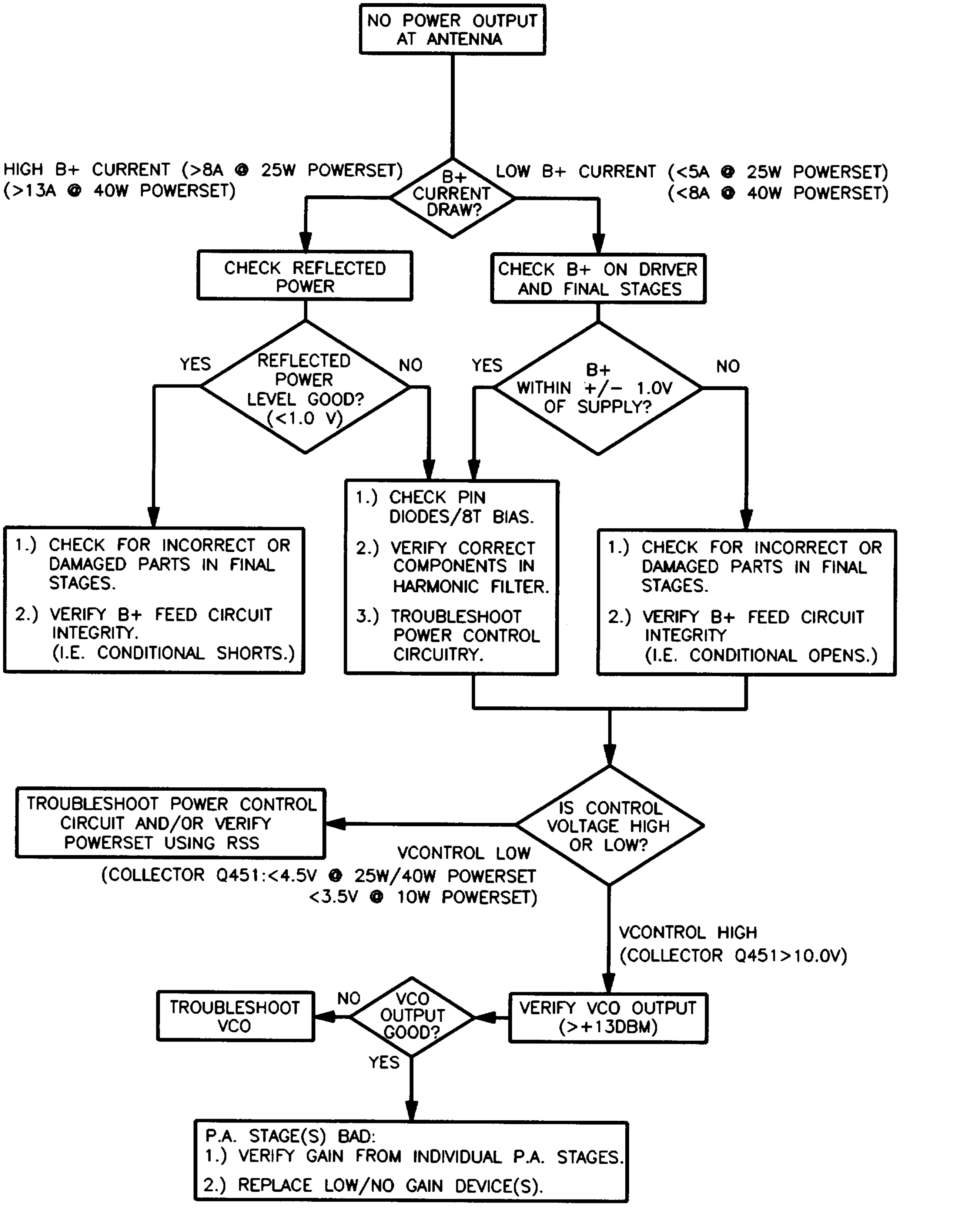
- Receiver (all models)
- Transmitter (VHF 25 W models)
- Transmitter (VHF 40 W, UHF 25 W, and UHF 40 W models)
- Synthesizer (VHF 25 W models)
- Synthesizer (VHF 40 W, UHF 25 W, and UHF 40 W models)
- Voltage Controlled Oscillator (VCO) (VHF 25 W models)
- Voltage Controlled Oscillator (VCO) (VHF 40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



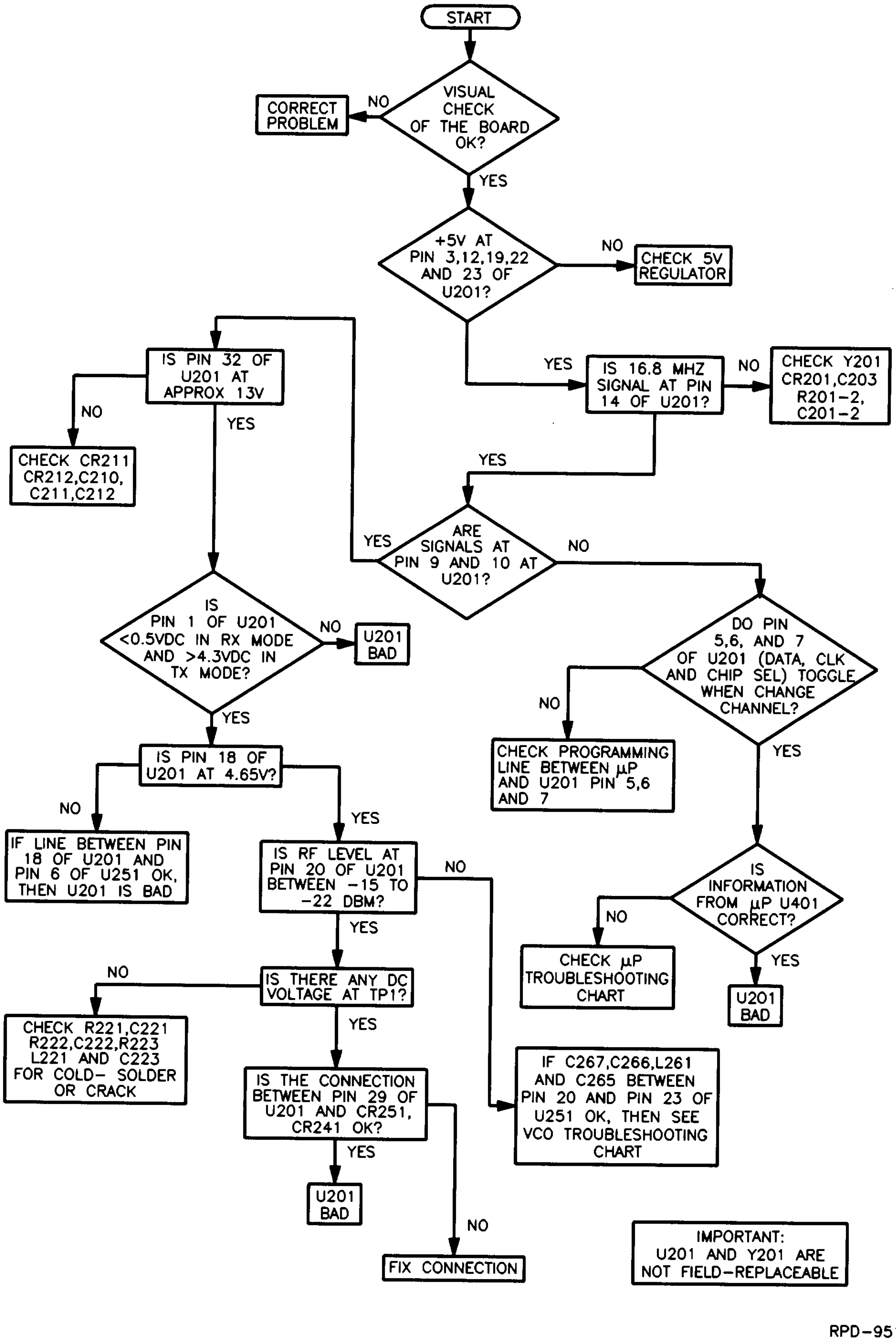
Troubleshooting Flow Chart for Receiver (all models)



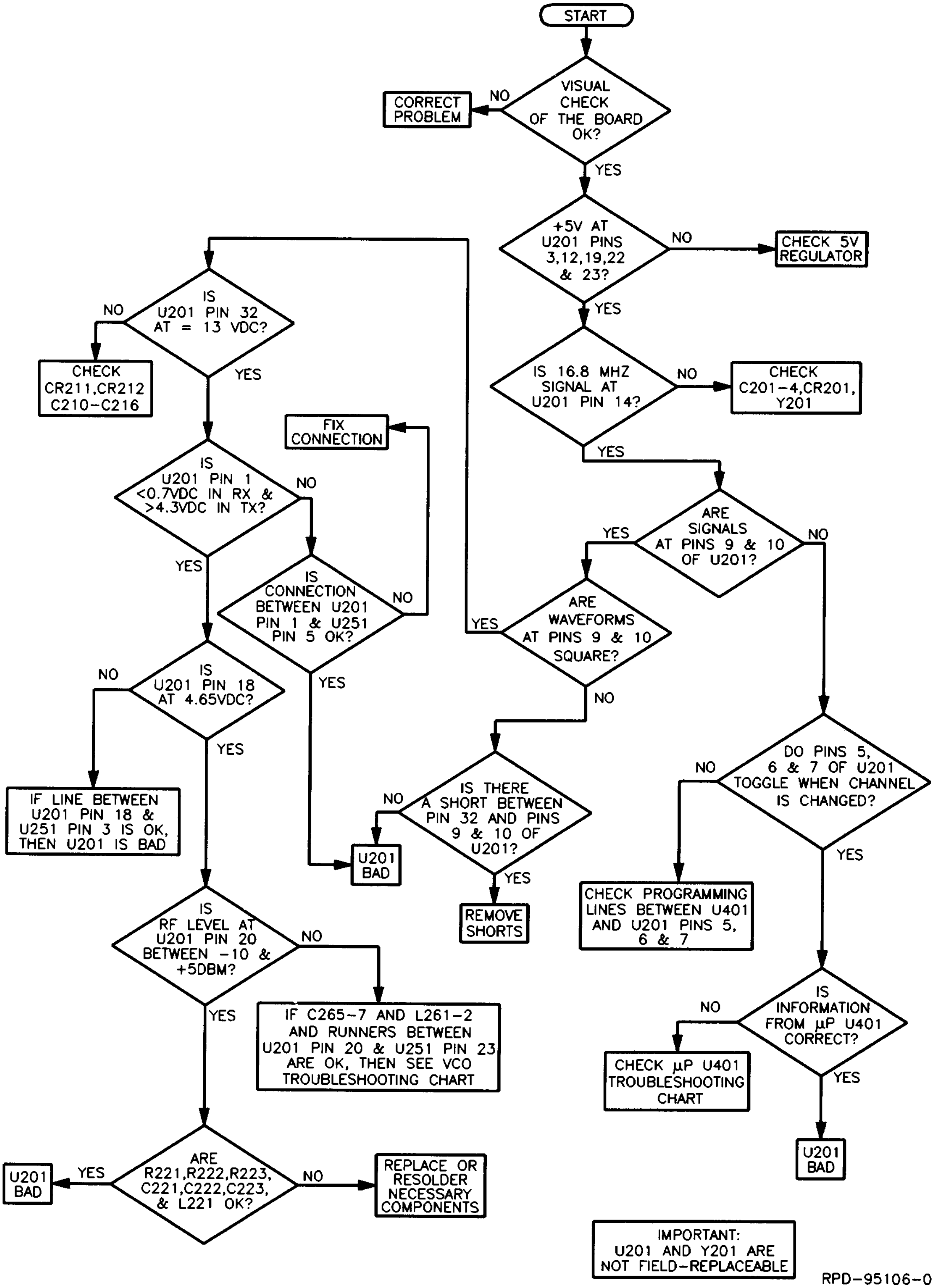
Troubleshooting Flow Chart for Transmitter (VHF 25 W Models)



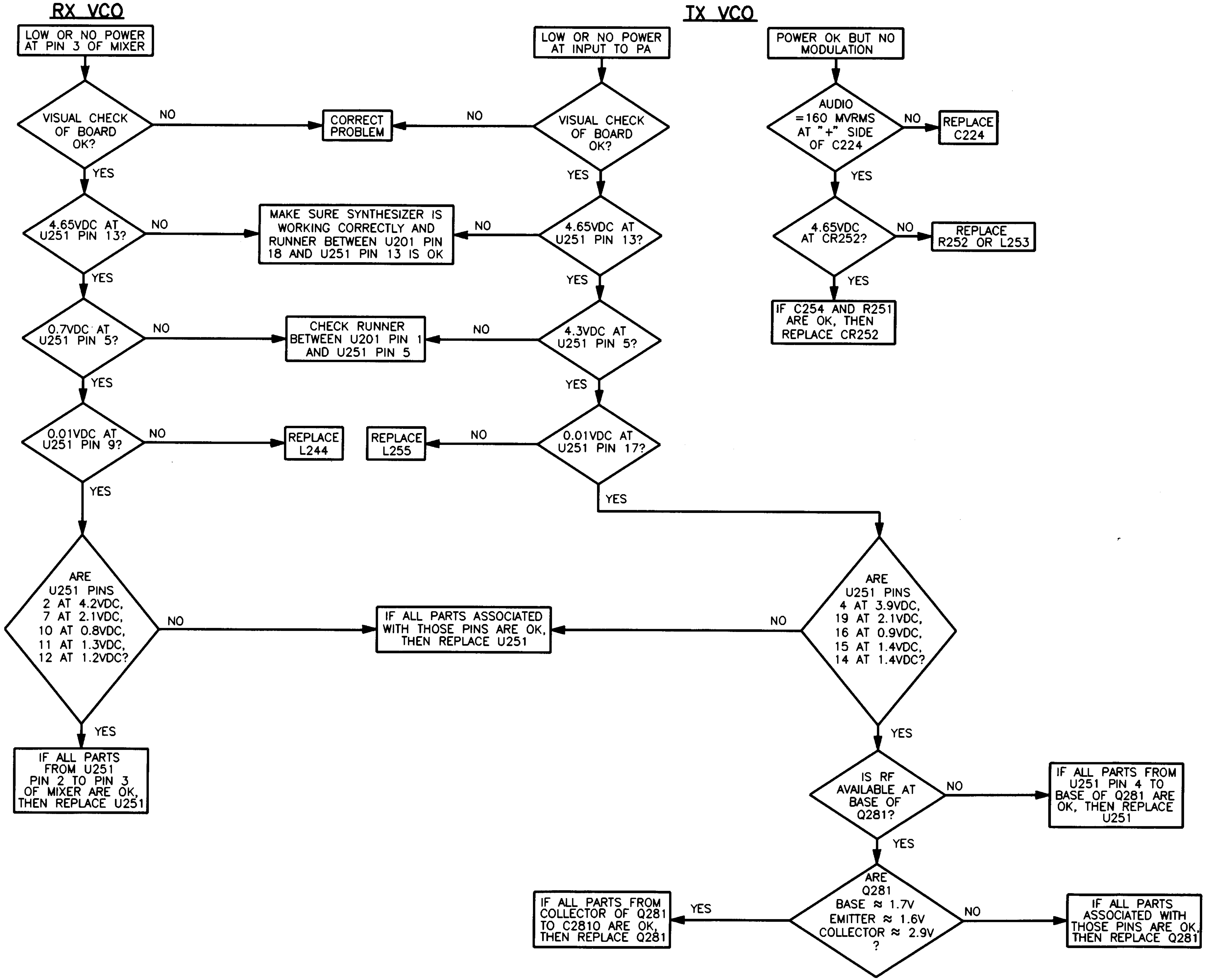
Troubleshooting Flow Chart
for Transmitter (VHF 40 W, UHF 25 W, and UHF 40 W Models)



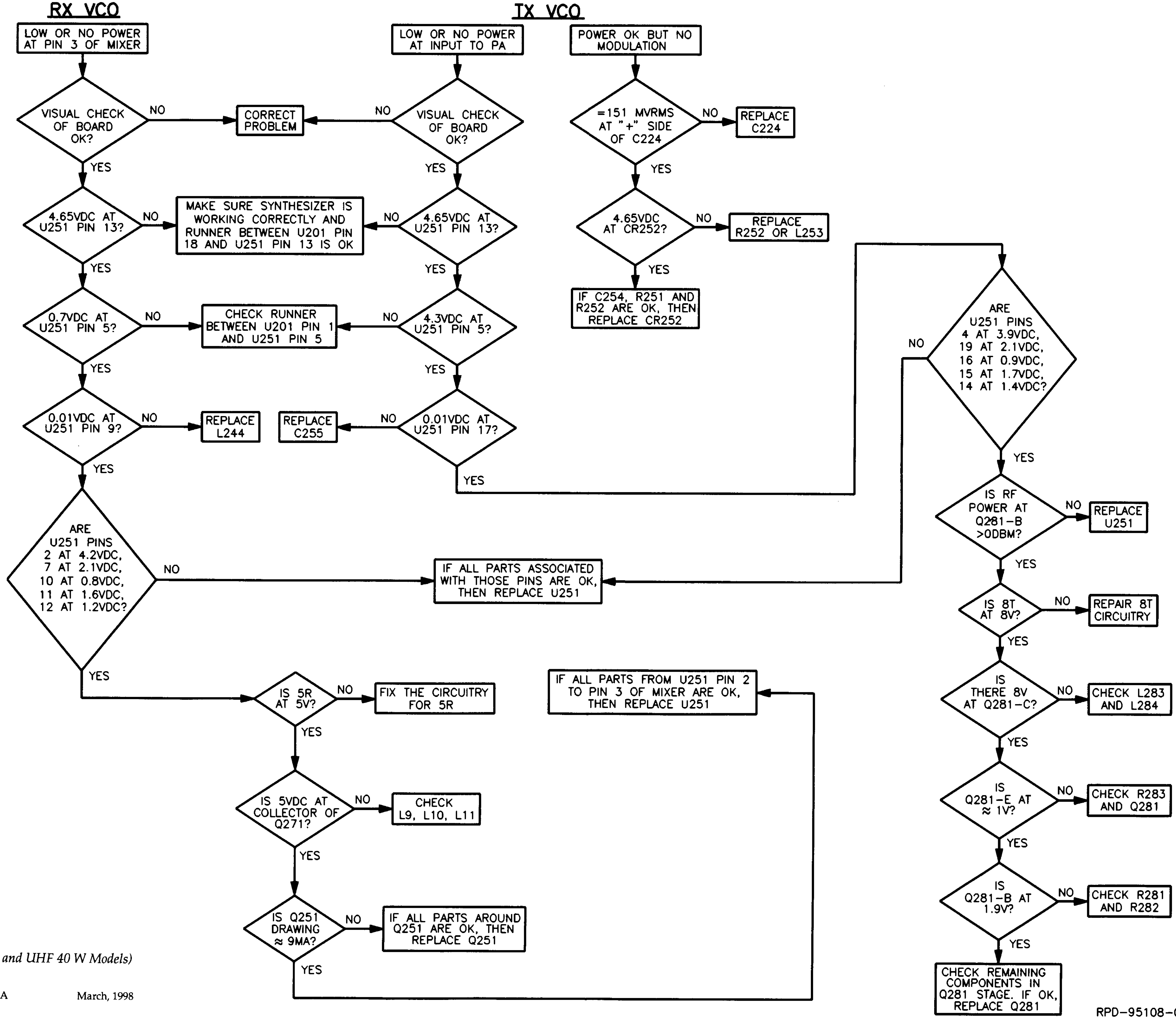
Troubleshooting Flow Chart for Synthesizer (VHF 25 W Models)



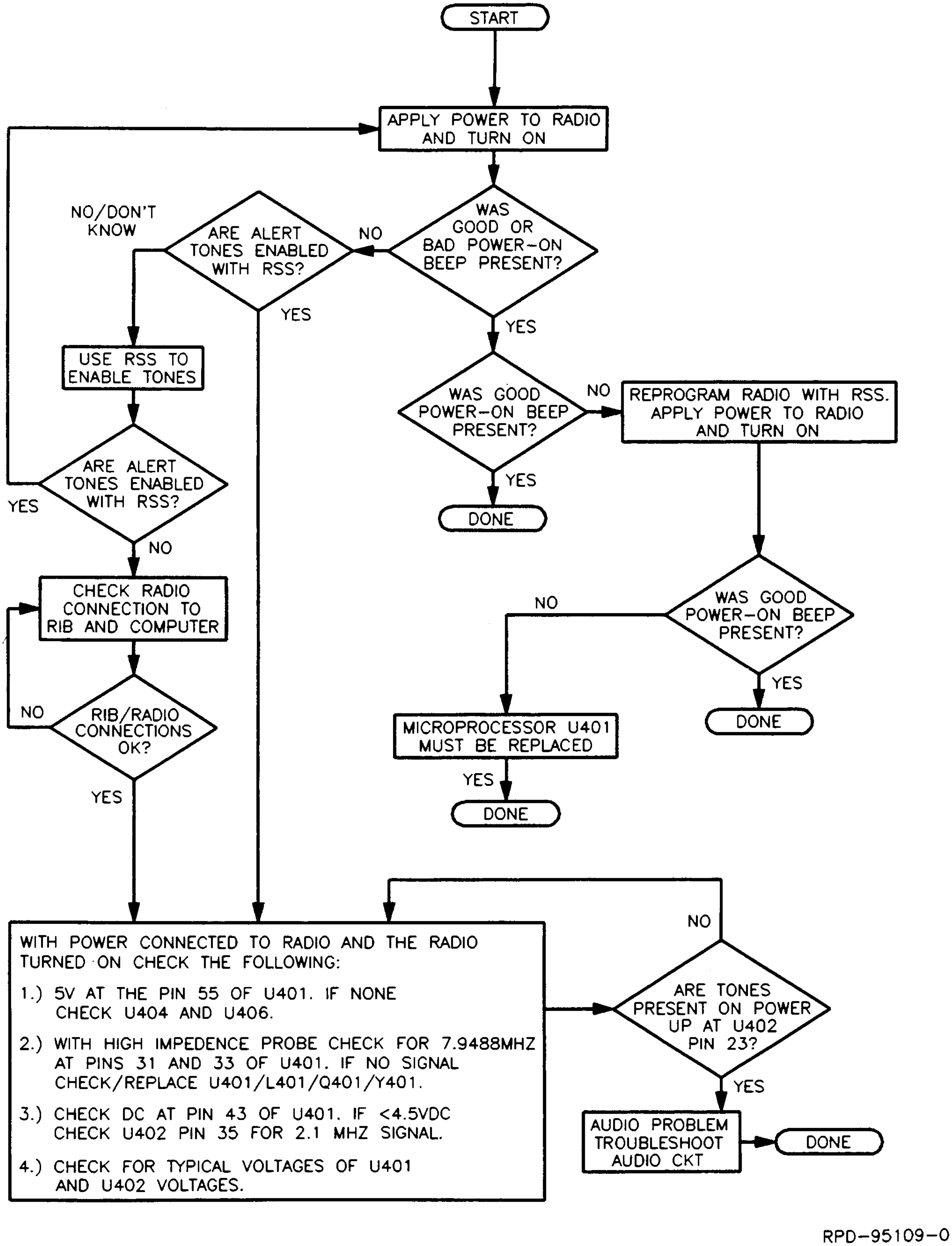
Troubleshooting Flow Chart
for Synthesizer (VHF 40 W, UHF 25 W, and UHF 40 W Models)



Troubleshooting Flow Chart for VCO (VHF 25 W Models)



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



Troubleshooting Flow Chart for Microprocessor (all models)