

# ASTRO<sup>®</sup> XTS<sup>™</sup> 5000

VHF

UHF Range 1

UHF Range 2

700 — 800 MHz

Digital Portable Radios

Detailed Service Manual



**MOTOROLA**

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**ASTRO® XTS™ 5000**  
**VHF/UHF Range 1/Range 2/700–800 MHz**  
**Digital Portable Radios**  
**Detailed Service Manual**

Motorola, Inc.  
8000 West Sunrise Boulevard  
Fort Lauderdale, Florida 33322

6881094C31-D

# Foreword

The information contained in this manual relates to all ASTRO® XTS™ 5000 digital portable radios, unless otherwise specified. This manual provides sufficient information to enable qualified service shop technicians to troubleshoot and repair an ASTRO XTS 5000 digital portable radio to the component level.

For details on the operation of the radio or level 1 or 2 maintenance procedures, refer to the applicable manuals, which are available separately. A list of related publications is provided in the section, "Related Publications," on page xii.

## Product Safety and RF Exposure Compliance



Before using this product, read the operating instructions for safe usage contained in the Product Safety and RF Exposure booklet enclosed with your radio.

### ATTENTION!

This radio is restricted to occupational use only to satisfy FCC RF energy exposure requirements. Before using this product, read the RF energy awareness information and operating instructions in the Product Safety and RF Exposure booklet enclosed with your radio (Motorola Publication part number 6881095C98) to ensure compliance with RF energy exposure limits.

For a list of Motorola-approved antennas, batteries, and other accessories, visit the following web site which lists approved accessories: <http://www.motorola.com/cqiss/index.shtml>

## Manual Revisions

Changes which occur after this manual is printed are described in FMRs (Florida Manual Revisions). These FMRs provide complete replacement pages for all added, changed, and deleted items, including pertinent parts list data, schematics, and component layout diagrams. To obtain FMRs, contact the Customer Care and Services Division (refer to "Appendix A Replacement Parts Ordering").

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## Notes

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# Commercial Warranty

## Limited Warranty

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Product Accessories	One (1) Year

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  - the damage or defect is caused by charging or using the battery in equipment or service other than the Product for which it is specified.
- H. Freight costs to the repair depot.
- I. A Product which, due to illegal or unauthorized alteration of the software/firmware in the Product, does not function in accordance with MOTOROLA's published specifications or the FCC type acceptance labeling in effect for the Product at the time the Product was initially distributed from MOTOROLA.
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- C. should the Product or parts become, or in MOTOROLA's opinion be likely to become, the subject of a claim of infringement of a United States patent, that such purchaser will permit MOTOROLA, at its option and expense, either to procure for such purchaser the right to continue using the Product or parts or to replace or modify the same so that it becomes noninfringing or to grant such purchaser a credit for the Product or parts as depreciated and accept its return. The depreciation will be an equal amount per year over the lifetime of the Product or parts as established by MOTOROLA.

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## VII. Governing Law

This Warranty is governed by the laws of the State of Illinois, USA.

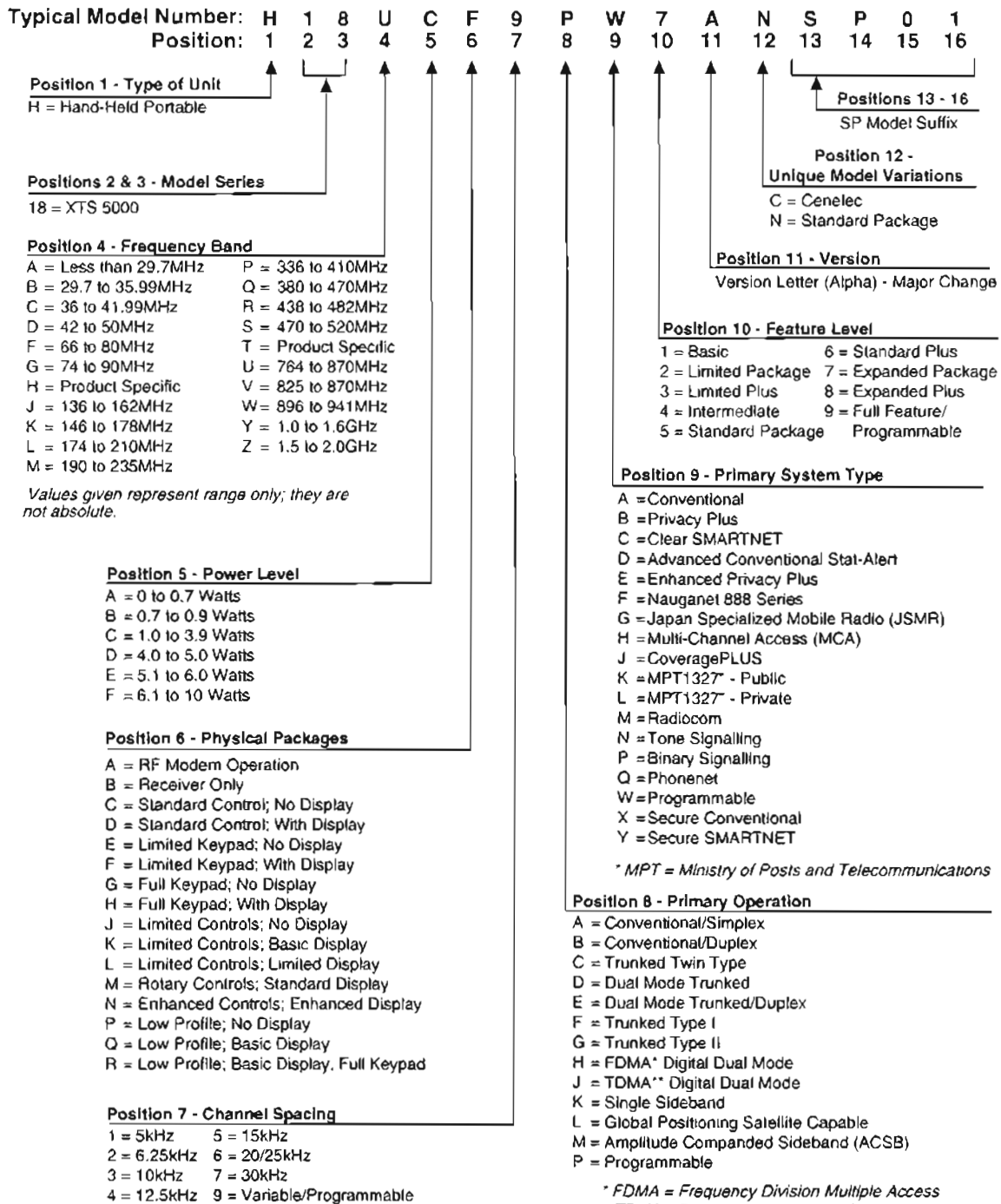


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## Notes

# Model Numbering, Charts, and Specifications

## Portable Radio Model Numbering System



## ASTRO XTS 5000 VHF Model Chart

MODEL NUMBER				DESCRIPTION
			H18KEC9PW5AN	VHF 1-6 Watts ASTRO XTS 5000 Model I
			H18KEF9PW6AN	VHF 1-6 Watts ASTRO XTS 5000 Model II
			H18KEH9PW7AN	VHF 1-6 Watts ASTRO XTS 5000 Model III
ITEM NUMBER				DESCRIPTION
X	X	X	NLD8910_	Board, Transceiver (VHF)
X	X	X	NNTN4563_ or, NNTN4717_	Board, VOCON* Board, VOCON*
X	X	X	—	Belt Clip Kit (Refer to the Basic Service Manual accessories appendix)
X	X	X	—	Battery (Refer to Table 2-1 and Table 2-2 on page 2-1)
X			NTN9682_	Kit, Front Cover, Model I
	X		NTN9681_	Kit, Front Cover, Model II
		X	NTN9680_	Kit, Front Cover, Model III
X	X	X	—	Antenna, VHF (Refer to the Basic Service Manual accessories appendix)
X	X	X	0985973B02	Assembly, B+ Connector
X	X	X	1505579Z01	Cover, Accessory Connector
X			2685567D01	Assembly, VOCON Shield, Model I
	X		2685567D02	Assembly, VOCON Shield-Keypad, Model II
		X	2685567D03	Assembly, VOCON Shield-Keypad, Model III
X	X	X	2685220D08	Shield, RF (Transceiver) Board
X	X	X	2785219D01	Assembly, Casting
X	X	X	2885866A01	Connector, Compression, 26-Pin
X	X	X	3285900E01	Gasket, Antenna O-Ring
X	X	X	3205349Z03	Seal, Main
X	X	X	3205351Z02	Seal, B+
X	X	X	3285877B02	Seal, Port
X	X	X	3385873B01	Label, Port
	X	X	7285726C02	Module, LCD Display
	X	X	7585189D01	Pad, Display Locator
X	X	X	7585936D02	Pad, RF
X	X	X	7585139E01	Pad, Battery holder
	X		7585104D02	Keypad, Model II
		X	7585104D01	Keypad, Model III

### Notes:

X = Item Included

- \* = The radio's model number, FLASHcode, Host code, and DSP code are required when placing an order for the VOCON Board.
  - The model number and (sometimes) the FLASHcode can be found on the FCC label on the back of the radio.
  - The model number, Host code, DSP code, and (sometimes) the FLASHcode can be found by putting a Model II or III radio into the Test Mode.
  - The model number, Host code, DSP code, and FLASHcode can be found by using the Programming Cable (RKN4105\_ or RKN4106\_) and the CPS to read a Model I, II, or III radio.

## ASTRO XTS 5000 R (Ruggedized) VHF Model Chart

MODEL NUMBER							DESCRIPTION	
H18KEC9PW5AN	w/Q155FE	Opt					Ruggedized VHF 1-6 Watts ASTRO XTS 5000 Model I	
H18KEF9PW6AN	w/Q155FF	Opt					Ruggedized VHF 1-6 Watts ASTRO XTS 5000 Model II	
H18KEH9PW7AN	w/Q155FG	Opt					Ruggedized VHF 1-6 Watts ASTRO XTS 5000 Model III	
H18KEC9PW5AN	w/Q155FS	Opt					Ruggedized Yellow VHF 1-6 Watts ASTRO XTS 5000 Model I	
H18KEF9PW6AN	w/Q155FT	Opt					Ruggedized Yellow VHF 1-6 Watts ASTRO XTS 5000 Model II	
H18KEH9PW7AN	w/Q155FU	Opt					Ruggedized Yellow VHF 1-6 Watts ASTRO XTS 5000 Model III	
ITEM NUMBER							DESCRIPTION	
X	X	X	X	X	X	X	NLD8910_	Board, Transceiver (VHF)
X	X	X	X	X	X	X	NNTN4563_ or, NNTN4717_	Board, VOCON* Board, VOCON*
X	X	X	X	X	X	X	—	Belt Clip Kit (Refer to the Basic Service Manual accessories appendix)
X	X	X	X	X	X	X	—	Battery (Refer to Table 2-1 and Table 2-2 on page 2-1)
X							NNTN4059_	Kit, Front Cover, Model I, Ruggedized
	X						NNTN4060_	Kit, Front Cover, Model II, Ruggedized
		X					NNTN4061_	Kit, Front Cover, Model III, Ruggedized
			X				NTN9685_	Kit, Yellow Front Cover, Model I, Ruggedized
				X			NTN9684_	Kit, Yellow Front Cover, Model II, Ruggedized
					X		NTN9683_	Kit, Yellow Front Cover, Model III, Ruggedized
X	X	X	X	X	X	X	—	Antenna, VHF (Refer to the Basic Service Manual accessories appendix)
X	X	X	X	X	X	X	0985973B02	Assembly, B+ Connector
X	X	X	X	X	X	X	1505579Z01	Cover, Accessory Connector
X			X				2685567D01	Assembly, VOCON Shield, Model I
	X			X			2685567D02	Assembly, VOCON Shield-Keypad, Model II
		X			X		2685567D03	Assembly, VOCON Shield-Keypad, Model III
X	X	X	X	X	X	X	2685220D08	Shield, RF (Transceiver) Board
X	X	X	X	X	X	X	2785219D04	Assembly, Ruggedized Casting
X	X	X	X	X	X	X	2885866A01	Connector, Compression, 26-Pin
X	X	X	X	X	X	X	3285900E01	Gasket, Antenna O-Ring
X	X	X	X	X	X	X	3205349Z03	Seal, Main
X	X	X	X	X	X	X	3205351Z02	Seal, B+
X	X	X	X	X	X	X	3285877B02	Seal, Port
X	X	X	X	X	X	X	3385873B01	Label, Port
	X	X		X	X		7285726C02	Module, LCD Display
	X	X		X	X		7585189D01	Pad, Display Locator
X	X	X	X	X	X	X	7585936D02	Pad, RF
X	X	X	X	X	X	X	7585139E01	Pad, Battery holder
X	X	X	X	X	X	X	3285688D01	Plug, Vacuum test port
	X			X			7585104D02	Keypad, Model II
		X			X		7585104D01	Keypad, Model III

### Notes:

X = Item Included

- \* The radio's model number, FLASHcode, Host code, and DSP code are required when placing an order for the VOCON Board.
- The model number and (sometimes) the FLASHcode can be found on the FCC label on the back of the radio.
- The model number, Host code, DSP code, and (sometimes) the FLASHcode can be found by putting a Model II or III radio into the Test Mode.
- The model number, Host code, DSP code, and FLASHcode can be found by using the Programming Cable (RKN4105\_ or RKN4106\_) and the CPS to read a Model I, II, or III radio.

## ASTRO XTS 5000 UHF Range 1 Model Chart

MODEL NUMBER							DESCRIPTION	
H18QDC9PW5AN							UHF Range 1, 1-5 Watts ASTRO XTS 5000 Model I	
H18QDF9PW6AN							UHF Range 1, 1-5 Watts ASTRO XTS 5000 Model II	
H18QDH9PW7AN							UHF Range 1, 1-5 Watts ASTRO XTS 5000 Model III	
H18QCC9PW5AN							UHF Range 1, Low Power, 20 mW - 2 Watts ASTRO XTS 5000 Model I	
H18QCF9PW6AN							UHF Range 1, Low Power, 20 mW - 2 Watts ASTRO XTS 5000 Model II	
H18QCH9PW7AN							UHF Range 1, Low Power, 20 mW - 2 Watts ASTRO XTS 5000 Model III	
							ITEM NUMBER	DESCRIPTION
X	X	X					NLE4272_	Board, Transceiver (UHF)
			X	X	X		NLE4278_	Board, Transceiver (UHF) Low Power
X	X	X	X	X	X		NNTN4819_ or, NNTN4717_	Board, VOCON* Board, VOCON*
X	X	X	X	X	X		—	Belt Clip Kit (Refer to the Basic Service Manual accessories appendix)
X	X	X	X	X	X		—	Battery (Refer to Table 2-1 and Table 2-2 on page 2-1)
X			X				NTN9682_	Kit, Front Cover, Model I
	X			X			NTN9681_	Kit, Front Cover, Model II
		X			X		NTN9680_	Kit, Front Cover, Model III
X	X	X	X	X	X		—	Antenna, UHF (Refer to the Basic Service Manual accessories appendix)
X	X	X	X	X	X		0985973B02	Assembly, B+ Connector
X	X	X	X	X	X		1505579Z01	Cover, Accessory Connector
X			X				2685567D01	Assembly, VOCON Shield, Model I
	X			X			2685567D02	Assembly, VOCON Shield-Keypad, Model II
		X			X		2685567D03	Assembly, VOCON Shield-Keypad, Model III
X	X	X	X	X	X		2685220D08	Shield, RF (Transceiver) Board
X	X	X	X	X	X		2785219D01	Assembly, Casting
X	X	X	X	X	X		2885866A01	Connector, Compression, 26-Pin
X	X	X	X	X	X		3285900E01	Gasket, Antenna O-Ring
X	X	X	X	X	X		3205349Z03	Seal, Main
X	X	X	X	X	X		3205351Z02	Seal, B+
X	X	X	X	X	X		3285877B02	Seal, Port
X	X	X	X	X	X		3385873B01	Label, Port
	X	X		X	X		7285726C03	Module, LCD Display
	X	X		X	X		7585189D01	Pad, Display Locator
X	X	X	X	X	X		7585936D04	Pad, RF
X	X	X	X	X	X		7585139E01	Pad, Battery holder
	X			X			7585104D02	Keypad, Model II
		X			X		7585104D01	Keypad, Model III

### Notes:

X = Item Included

- \* = The radio's model number, FLASHcode, Host code, and DSP code are required when placing an order for the VOCON Board.
- The model number and (sometimes) the FLASHcode can be found on the FCC label on the back of the radio.
- The model number, Host code, DSP code, and (sometimes) the FLASHcode can be found by putting a Model II or III radio into the Test Mode.
- The model number, Host code, DSP code, and FLASHcode can be found by using the Programming Cable (RKN4105\_ or RKN4106\_) and the CPS to read a Model I, II, or III radio.

## ASTRO XTS 5000 R (Ruggedized) UHF Range 1 Model Chart

MODEL NUMBER										DESCRIPTION	
H18QDC9PW5AN	w/Q155FE	Opt								Ruggedized UHF Range 1, 1-5 Watts ASTRO XTS 5000 Model I	
H18QDF9PW6AN	w/Q155FF	Opt								Ruggedized UHF Range 1, 1-5 Watts ASTRO XTS 5000 Model II	
H18QDH9PW7AN	w/Q155FG	Opt								Ruggedized UHF Range 1, 1-5 Watts ASTRO XTS 5000 Model III	
H18QDC9PW5AN	w/Q155FS	Opt								Ruggedized Yellow UHF Range 1, 1-5 Watts ASTRO XTS 5000 Model I	
H18QDF9PW6AN	w/Q155FU	Opt								Ruggedized Yellow UHF Range 1, 1-5 Watts ASTRO XTS 5000 Model II	
H18QDH9PW7AN	w/Q155FU	Opt								Ruggedized Yellow UHF Range 1, 1-5 Watts ASTRO XTS 5000 Model III	
H18QCC9PW5AN	w/Q155HW	Opt								Ruggedized UHF R1, Low Pwr, 20 mW-2 Watts ASTRO XTS 5000 Model I	
H18QCF9PW6AN	w/Q155HX	Opt								Ruggedized UHF R1, Low Pwr, 20 mW-2 Watts ASTRO XTS 5000 Model II	
H18QCH9PW7AN	w/Q155HY	Opt								Ruggedized UHF R1, Low Pwr, 20 mW-2 Watts ASTRO XTS 5000 Model III	
ITEM NUMBER										DESCRIPTION	
X	X	X	X	X	X	X	X	X	X	NLE4272_	Board, Transceiver (UHF)
X	X	X	X	X	X	X	X	X	X	NLE4278_	Board, Transceiver (UHF) Low Power
X	X	X	X	X	X	X	X	X	X	NNTN4819_ or, NNTN4717_	Board, VOCON* Board, VOCON*
X	X	X	X	X	X	X	X	X	X	—	Belt Clip Kit (Refer to the Basic Service Manual accessories appendix)
X	X	X	X	X	X	X	X	X	X	—	Battery (Refer to Table 2-1 and Table 2-2 on page 2-1)
X						X				NNTN4059_	Kit, Front Cover, Model I, Ruggedized
	X						X			NNTN4060_	Kit, Front Cover, Model II, Ruggedized
		X						X		NNTN4061_	Kit, Front Cover, Model III, Ruggedized
			X							NTN9685_	Kit, Yellow Front Cover, Model I, Ruggedized
				X						NTN9684_	Kit, Yellow Front Cover, Model II, Ruggedized
					X					NTN9683_	Kit, Yellow Front Cover, Model III, Ruggedized
X	X	X	X	X	X	X	X	X	X	—	Antenna, UHF (Refer to the Basic Service Manual accessories appendix)
X	X	X	X	X	X	X	X	X	X	0985973B02	Assembly, B+ Connector
X	X	X	X	X	X	X	X	X	X	1505579Z01	Cover, Accessory Connector
X			X			X				2685567D01	Assembly, VOCON Shield, Model I
	X			X			X			2685567D02	Assembly, VOCON Shield-Keypad, Model II
		X			X			X		2685567D03	Assembly, VOCON Shield-Keypad, Model III
X	X	X	X	X	X	X	X	X	X	2685220D08	Shield, RF (Transceiver) Board
X	X	X	X	X	X	X	X	X	X	2785219D04	Assembly, Ruggedized Casting
X	X	X	X	X	X	X	X	X	X	2885868A01	Connector, Compression, 26-Pin
X	X	X	X	X	X	X	X	X	X	3285900E01	Gasket, Antenna O-Ring
X	X	X	X	X	X	X	X	X	X	3205349Z03	Seal, Main
X	X	X	X	X	X	X	X	X	X	3205351Z02	Seal, B+
X	X	X	X	X	X	X	X	X	X	3285877B02	Seal, Port
X	X	X	X	X	X	X	X	X	X	3385873B01	Label, Port
	X	X		X	X		X	X		7285726C03	Module, LCD Display
	X	X		X	X		X	X		7585189D01	Pad, Display Locator
X	X	X	X	X	X	X	X	X	X	7585936D04	Pad, RF
X	X	X	X	X	X	X	X	X	X	7585139E01	Pad, Battery holder
X	X	X	X	X	X	X	X	X	X	3285688D01	Plug, Vacuum test port
	X			X			X			7585104D02	Keypad, Model II
		X			X			X		7585104D01	Keypad, Model III

### Notes:

X = Item Included

\* = The radio's model number, FLASHcode, Host code, and DSP code are required when placing an order for the VOCON Board.

• The model number and (sometimes) the FLASHcode can be found on the FCC label on the back of the radio.

• The model number, Host code, DSP code, and (sometimes) the FLASHcode can be found by putting a Model II or III radio into the Test Mode.

• The model number, Host code, DSP code, and FLASHcode can be found by using the Programming Cable (RKN4105\_ or RKN4106\_) and the CPS to read a Model I, II, or III radio.

## ASTRO XTS 5000 UHF Range 2 Model Chart

MODEL NUMBER				DESCRIPTION
H18SDC9PW6AN				UHF Range 2, 1-5 Watts ASTRO XTS 5000 Model I
H18SDF9PW6AN				UHF Range 2, 1-5 Watts ASTRO XTS 5000 Model II
H18SDH9PW7AN				UHF Range 2, 1-5 Watts ASTRO XTS 5000 Model III
ITEM NUMBER				DESCRIPTION
X	X	X	NLE4273_	Board, Transceiver (UHF R2)
X	X	X	NNTN4717_	Board, VOCON*
X	X	X	—	Belt Clip Kit (Refer to the Basic Service Manual accessories appendix)
X	X	X	—	Battery (Refer to Table 2-1 and Table 2-2 on page 2-1)
X			NTN9682_	Kit, Front Cover, Model I
	X		NTN9681_	Kit, Front Cover, Model II
		X	NTN9680_	Kit, Front Cover, Model III
X	X	X	—	Antenna, UHF (Refer to the Basic Service Manual accessories appendix)
X	X	X	0985973B01	Assembly, B+ Connector
X	X	X	1505579Z01	Cover, Accessory Connector
X			2685587D01	Assembly, VOCON Shield, Model I
	X		2685587D02	Assembly, VOCON Shield-Keypad, Model II
		X	2685587D03	Assembly, VOCON Shield-Keypad, Model III
X	X	X	2685220D02	Shield, RF (Transceiver) Board
X	X	X	2785219D01	Assembly, Casting
X	X	X	2885866A01	Connector, Compression, 26-Pin
X	X	X	3205082E96	Gasket, Antenna O-Ring
X	X	X	3205349Z03	Seal, Main
X	X	X	3205351Z02	Seal, B+
X	X	X	3285877B02	Seal, Port
X	X	X	3385873B01	Label, Port
	X	X	7285726C03	Module, LCD Display
	X	X	7585189D01	Pad, Display Locator
	X		7585104D02	Keypad, Model II
		X	7585104D01	Keypad, Model III

**Notes:**

X = Item Included

\* = The radio's model number, FLASHcode, Host code, and DSP code are required when placing an order for the VOCON Board.

- The model number and (sometimes) the FLASHcode can be found on the FCC label on the back of the radio.
- The model number, Host code, DSP code, and (sometimes) the FLASHcode can be found by putting a Model II or III radio into the Test Mode.
- The model number, Host code, DSP code, and FLASHcode can be found by using the Programming Cable (RKN4105 or RKN4106 ) and the CPS to read a Model I, II, or III radio

## ASTRO XTS 5000 R (Ruggedized) UHF Range 2 Model Chart

MODEL NUMBER							DESCRIPTION
X	X	X	X	X	X	X	Ruggedized UHF Range 2, 1-5 Watts ASTRO XTS 5000 Model I
X	X	X	X	X	X	X	Ruggedized UHF Range 2, 1-5 Watts ASTRO XTS 5000 Model II
X	X	X	X	X	X	X	Ruggedized UHF Range 2, 1-5 Watts ASTRO XTS 5000 Model III
X	X	X	X	X	X	X	Ruggedized Yellow UHF Range 2, 1-5 Watts ASTRO XTS 5000 Model I
X	X	X	X	X	X	X	Ruggedized Yellow UHF Range 2, 1-5 Watts ASTRO XTS 5000 Model II
X	X	X	X	X	X	X	Ruggedized Yellow UHF Range 2, 1-5 Watts ASTRO XTS 5000 Model III
ITEM NUMBER							DESCRIPTION
X	X	X	X	X	X	X	NLE4273_ Board, Transceiver (UHF R2)
X	X	X	X	X	X	X	NNTN4717_ Board, VOCON*
X	X	X	X	X	X	X	— Belt Clip Kit (Refer to the Basic Service Manual accessories appendix)
X	X	X	X	X	X	X	— Battery (Refer to Table 2-1 and Table 2-2 on page 2-1)
X							NNTN4059_ Kit, Front Cover, Model I, Ruggedized
	X						NNTN4060_ Kit, Front Cover, Model II, Ruggedized
		X					NNTN4061_ Kit, Front Cover, Model III, Ruggedized
			X				NTN9685_ Kit, Yellow Front Cover, Model I, Ruggedized
				X			NTN9684_ Kit, Yellow Front Cover, Model II, Ruggedized
					X		NTN9683_ Kit, Yellow Front Cover, Model III, Ruggedized
X	X	X	X	X	X	X	— Antenna, UHF (Refer to the Basic Service Manual accessories appendix)
X	X	X	X	X	X	X	0985973B02 Assembly, B+ Connector
X	X	X	X	X	X	X	1505579Z01 Cover, Accessory Connector
X			X				2685567D01 Assembly, VOCON Shield, Model I
	X			X			2685567D02 Assembly, VOCON Shield-Keypad, Model II
		X			X		2685567D03 Assembly, VOCON Shield-Keypad, Model III
X	X	X	X	X	X	X	2685220D02 Shield, RF (Transceiver) Board
X	X	X	X	X	X	X	2785219D04 Assembly, Ruggedized Casting
X	X	X	X	X	X	X	2885866A01 Connector, Compression, 26-Pin
X	X	X	X	X	X	X	3205082E96 Gasket, Antenna O-Ring
X	X	X	X	X	X	X	3205349Z03 Seal, Main
X	X	X	X	X	X	X	3205351Z02 Seal, B+ Ruggedized
X	X	X	X	X	X	X	3285877B02 Seal, Port
X	X	X	X	X	X	X	3385873B01 Label, Port
	X	X		X	X		7285726C03 Module, LCD Display
	X	X		X	X		7585189D01 Pad, Display Locator
	X			X			7585104D02 Keypad, Model II
		X			X		7585104D01 Keypad, Model III

## Notes:

X = Item Included

- \* = The radio's model number, FLASHcode, Host code, and DSP code are required when placing an order for the VOCON Board.
- The model number and (sometimes) the FLASHcode can be found on the FCC label on the back of the radio.
- The model number, Host code, DSP code, and (sometimes) the FLASHcode can be found by putting a Model II or III radio into the Test Mode.
- The model number, Host code, DSP code, and FLASHcode can be found by using the Programming Cable (RKN4105\_ or RKN4106\_) and the CPS to read a Model I, II, or III radio.



## ASTRO XTS 5000 700–800 MHz Model Chart

MODEL NUMBER				DESCRIPTION
H18UCC9PW5AN				700/800 MHz 1-3 Watts ASTRO XTS 5000 Model I
H18UCF9PW6AN				700/800 MHz 1-3 Watts ASTRO XTS 5000 Model II
H18UCH9PW7AN				700/800 MHz 1-3 Watts ASTRO XTS 5000 Model III
ITEM NUMBER				DESCRIPTION
X	X	X	NUF3577_	Board, Transceiver (700/800 MHz)
X	X	X	NTN9564_ or, NNTN4717_	Board, VOCON* Board, VOCON*
X	X	X	—	Belt Clip Kit (Refer to the Basic Service Manual accessories appendix)
X	X	X	—	Battery (Refer to Table 2-1 and Table 2-2 on page 2-1)
X			NTN9682_	Kit, Front Cover, Model I
	X		NTN9681_	Kit, Front Cover, Model II
		X	NTN9680_	Kit, Front Cover, Model III
X	X	X	—	Antenna, 700/800 MHz (Refer to the Basic Service Manual accessories appendix)
X	X	X	0985973B02	Assembly, B+ Connector
X	X	X	1505579Z01	Cover, Accessory Connector
X			2685567D01	Assembly, VOCON Shield, Model I
	X		2685567D02	Assembly, VOCON Shield-Keypad, Model II
		X	2685567D03	Assembly, VOCON Shield-Keypad, Model III
X	X	X	2685220D08	Shield, RF (Transceiver) Board
X	X	X	2785219D01	Assembly, Casting
X	X	X	2885866A01	Connector, Compression, 26-Pin
X	X	X	3285900E01	Gasket, Antenna O-Ring
X	X	X	3205349Z03	Seal, Main
X	X	X	3205351Z02	Seal, B+
X	X	X	3285877B02	Seal, Port
X	X	X	3385873B01	Label, Port
	X	X	7285726C01 or, 7285726C02	Module, LCD Display (for use only with the NTN9564_VOCON board) Module, LCD Display (for use only with the NNTN4717_VOCON board)
	X	X	7585189D01	Pad, Display Locator
X	X	X	7585936D04	Pad, RF
X	X	X	7585139E01	Pad, Battery holder
	X		7585104D02	Keypad, Model II
		X	7585104D01	Keypad, Model III

### Notes:

X = Item Included

- \* = The radio's model number, FLASHcode, Host code, and DSP code are required when placing an order for the VOCON Board.
- The model number and (sometimes) the FLASHcode can be found on the FCC label on the back of the radio.
- The model number, Host code, DSP code, and (sometimes) the FLASHcode can be found by putting a Model II or III radio into the Test Mode.
- The model number, Host code, DSP code, and FLASHcode can be found by using the Programming Cable (RKN4105\_ or RKN4106\_) and the CPS to read a Model I, II, or III radio.

## ASTRO XTS 5000 R (Ruggedized) 700–800 MHz Model Chart

MODEL NUMBER							DESCRIPTION
H18UCC9PW5AN w/Q155FP Opt							Ruggedized 700/800 MHz 1-3 Watts ASTRO XTS 5000 Model I
H18UCF9PW6AN w/Q155FQ Opt							Ruggedized 700/800 MHz 1-3 Watts ASTRO XTS 5000 Model II
H18UCH9PW7AN w/Q155FR Opt							Ruggedized 700/800 MHz 1-3 Watts ASTRO XTS 5000 Model III
H18UCC9PW5AN w/Q155GB Opt							Ruggedized Yellow 700/800 MHz 1-3 Watts ASTRO XTS 5000 Model I
H18UCF9PW6AN w/Q155GC Opt							Ruggedized Yellow 700/800 MHz 1-3 Watts ASTRO XTS 5000 Model II
H18UCH9PW7AN w/Q155GD Opt							Ruggedized Yellow 700/800 MHz 1-3 Watts ASTRO XTS 5000 Model III

### Notes:

X = Item Included

- \* = The radio's model number, FLASHcode, Host code, and DSP code are required when placing an order for the VOCON Board.
- The model number and (sometimes) the FLASHcode can be found on the FCC label on the back of the radio.
- The model number, Host code, DSP code, and (sometimes) the FLASHcode can be found by putting a Model II or III radio into the Test Mode.
- The model number, Host code, DSP code, and FLASHcode can be found by using the Programming Cable (RKN4105\_ or RKN4106\_) and the CPS to read a Model I, II, or III radio.

## Specifications for VHF Radios

All specifications are per Telecommunications Industries Association TIA-603 unless otherwise noted.

GENERAL		RECEIVER	TRANSMITTER
FCC Designation:	AZ489FT3804	Frequency Range:	136-174 MHz
Temperature Range:			
Operating:	-30°C to +80°C	Bandwidth:	38 MHz
Storage:	-40°C to +85°C		
Power Supply: Nickel-Cadmium Battery (NiCd) or Nickel-Metal-Hydride Battery (NiMH) or Lithium-Ion Battery (Li-Ion)		Usable Sensitivity (typical) (12 dB SINAD):	0.20 µV
		Intermodulation (typical):	-75 dB
Battery Voltage:		Selectivity (typical):	
Nominal:	7.5 Vdc	(25/30 kHz Channel):	-75 dB
Range:	6 to 9 Vdc	(12.5 kHz Channel):	-63 dB
Transmit Current Drain (Typical):	2100 mA	Spurious Rejection (typical):	-75 dB
Receive Current Drain (Rated Audio):	240 mA	Frequency Stability (-30 to +60°C; 25°C reference):	±0.0002%
Standby Current Drain:	80 mA		
Recommended Battery:		Rated Audio:	500 mW
Smart NiMH:	NNTN4435_	FM Hum and Noise (typical):	
or Ultra-High-Capacity NiCd:	NTN8294_	25 kHz	-55 dB
or Extended-Capacity NiMH:	NTN8293_	12.5 kHz	-49 dB
or Li-Ion:	NTN8610_		
or Ultra-High-Capacity NiCd FM:	NTN8295_	Distortion (typical):	1.5%
or Ultra-High-Capacity NiMH FM:	NTN8299_	Channel Spacing:	12.5/25 kHz
Optional FM (Factory Mutual) Battery:			
FM Intrinsically Safe: Class I, II, III, Division 1, Groups C, D, E, F, and G. FM Non-incendive. Class 1, Division 2, Groups A, B, C, and D.			
Dimensions (H x W x D):			
Note: 2.44" = width at PTT; 2.34" = width at bottom; 1.83" = depth at speaker; 0.97" = depth at keypad			
Without Battery (Radio Only):			
6.58" x 2.44" x 1.83"/6.58" x 2.34" x 0.97"			
(167.13 mm x 61.90 mm x 48.42 mm/ 167.13 mm x 59.49 mm x 24.56 mm)			
With Battery:			
6.58" x 2.44" x 1.83"/6.58" x 2.34" x 1.65"			
(167.13 mm x 61.90 mm x 48.42 mm/ 167.13 mm x 59.49 mm x 41.97 mm)			
Weight: (w/ Antenna):			
Less Battery:	14.10 oz (383 gm)		
With Ultra-High Cap. NiCd:	25.19 oz (693 gm)		
With Li-Ion:	20.41 oz (583 gm)		
With Ultra-High Cap. NiMH:	23.45 oz (644 gm)		
With Extended-Cap. NiMH:	24.04 oz (682 gm)		

Specifications subject to change without notice.

## Specifications for UHF Range 1 Radios

All specifications are per Telecommunications Industries Association TIA-603 unless otherwise noted.

GENERAL		RECEIVER	TRANSMITTER
FCC Designation:	AZ489FT4855	Frequency Range:	380-470 MHz
Temperature Range:			
Operating:	-30°C to +60°C	Bandwidth:	90 MHz
Storage:	-40°C to +85°C	Usable Sensitivity (typical) (12 dB SINAD):	0.25 µV
Power Supply: Nickel-Cadmium Battery (NiCd) or Nickel-Metal-Hydrate Battery (NiMH) or Lithium-Ion Battery (Li-Ion)		Intermodulation (typical):	-75 dB
Battery Voltage:		Selectivity (typical): (25/30 kHz Channel):	-78 dB
Nominal:	7.5 Vdc	(12.5 kHz Channel):	-80 dB
Range:	6 to 9 Vdc	Spurious Rejection (typical):	-80 dB
Transmit Current Drain (Typical):	2100 mA	Frequency Stability (-30 to +60°C; 25°C reference):	±0.0002%
Receive Current Drain (Rated Audio):	240 mA	Rated Audio:	500 mW
Standby Current Drain:	80 mA	FM Hum and Noise (typical):	25 kHz -54 dB 12.5 kHz -45 dB
Recommended Battery:		Distortion (typical):	1.0%
Smart NIMH:	NNTN4435	Channel Spacing:	12.5/25 kHz
or Ultra-High-Capacity NiCd:	NTN8294		
or Extended-Capacity NIMH:	NTN8293		
or Li-Ion:	NTN8610		
or Ultra-High-Capacity NiCd FM:	NTN8295*		
or Ultra-High-Capacity NIMH FM:	NTN8299*		
Optional FM (Factory Mutual) Battery:			
* FM Intrinsically Safe.			
Dimensions (H x W x D):			
Note 2.44" = width at PTT; 2.34" = width at bottom, 1.83" = depth at speaker; 0.97" = depth at keypad			
Without Battery (Radio Only):			
6.58" x 2.44" x 1.83"/6.58" x 2.34" x 0.97"			
(167.13 mm x 61.90 mm x 46.42 mm/ 167.13 mm x 59.49 mm x 24.56 mm)			
With Battery:			
6.58" x 2.44" x 1.83"/6.58" x 2.34" x 1.65"			
(167.13 mm x 61.90 mm x 46.42 mm/ 167.13 mm x 59.49 mm x 41.97 mm)			
Weight: (w/ Antenna):			
Less Battery:	14.10 oz (383 gm)		
With Ultra-High Cap. NiCd:	25.19 oz (693 gm)		
With Li-Ion:	20.41 oz (583 gm)		
With Ultra-High Cap. NIMH:	23.45 oz (644 gm)		
With Extended-Cap. NIMH:	24.04 oz (682 gm)		

Specifications subject to change without notice.

## Specifications for UHF Range 2 Radios

All specifications are per Telecommunications Industries Association TIA-603 unless otherwise noted.

GENERAL		RECEIVER	TRANSMITTER
FCC Designation:	AZ489FT4864	Frequency Range:	450-520 MHz
Temperature Range:			
Operating:	-30°C to +60°C	Bandwidth:	70 MHz
Storage:	-40°C to +85°C		
Power Supply: Nickel-Cadmium Battery (NiCd) or Nickel-Metal-Hydrate Battery (NiMH) or Lithium-Ion Battery (Li-Ion)		Usable Sensitivity (typical) (12 dB SINAD):	0.19 µV
		Intermodulation (typical):	-77 dB
Battery Voltage:		Selectivity (typical): (25/30 kHz Channel):	-79 dB
Nominal:	7.5 Vdc	(12.5 kHz Channel):	-65 dB
Range:	6 to 9 Vdc	Spurious Rejection (typical):	-85 dB
Transmit Current Drain (Typical):	2100 mA	Frequency Stability (-30 to +60°C; 25°C reference):	±0.0002%
Receive Current Drain (Rated Audio):	240 mA		
Standby Current Drain:	80 mA	Rated Audio:	500 mW
Recommended Battery:		FM Hum and Noise (typical):	25 kHz -53 dB 12.5 kHz -45 dB
Smart NiMH:	NNTN4435		
or Ultra-High-Capacity NiCd:	NTN8294	Distortion (typical):	1.0%
or Extended-Capacity NiMH:	NTN8293	Channel Spacing:	12.5/25 kHz
or Li-Ion:	NTN8810		
or Ultra-High-Capacity NiCd FM:	NTN8295*		
or Ultra-High-Capacity NiMH FM:	NTN8299*		
Optional FM (Factory Mutual) Battery:			
* FM Intrinsically Safe.			
Dimensions (H x W x D):			
Note 2.44" = width at PTT, 2.34" = width at bottom, 1.83" = depth at speaker, 0.97" = depth at keypad			
Without Battery (Radio Only):			
6.58" x 2.44" x 1.83"/6.58" x 2.34" x 0.97"			
(167.13 mm x 61.90 mm x 46.42 mm/ 167.13 mm x 59.49 mm x 24.56 mm)			
With Battery:			
8.58" x 2.44" x 1.83"/8.58" x 2.34" x 1.65"			
(167.13 mm x 61.90 mm x 46.42 mm/ 167.13 mm x 59.49 mm x 41.97 mm)			
Weight: (w/ Antenna):			
Less Battery:	13.0 oz (368 gm)		
With Ultra-High Cap. NiCd:	25.19 oz (693 gm)		
With Li-Ion:	20.41 oz (583 gm)		
With Ultra-High Cap. NiMH:	23.45 oz (644 gm)		
With Extended-Cap. NiMH:	24.04 oz (682 gm)		

Specifications subject to change without notice.

## Specifications for 700–800 MHz Radios

All specifications are per Telecommunications Industries Association TIA-603 unless otherwise noted.

GENERAL	RECEIVER	TRANSMITTER
<b>FCC Designation:</b> AZ489FT5806 <b>Temperature Range:</b> <b>Operating:</b> –30°C to +60°C <b>Storage:</b> –40°C to +85°C  <b>Power Supply:</b> Nickel-Cadmium Battery (NiCd) or Nickel-Metal-Hydrate Battery (NiMH) or Lithium-Ion Battery (Li-Ion)  <b>Battery Voltage:</b> <b>Nominal:</b> 7.5 Vdc <b>Range:</b> 6 to 9 Vdc  <b>Transmit Current Drain (Typical)</b> 1400 mA <b>Receive Current Drain (Rated Audio):</b> 240 mA <b>Standby Current Drain:</b> 80 mA  <b>Recommended Battery:</b> Ultra-High-Capacity Smart NiCd: HNN9031_ or Ultra-High-Capacity NiCd: NTN8294_ or Extended-Capacity NiMH: NTN8293_ or Li-Ion: NTN8610_ or Ultra-High-Capacity NiCd FM: NTN8295_ or Ultra-High-Capacity NiMH FM: NTN8299_ Optional FM (Factory Mutual) Battery: • FM Intrinsically Safe Class I, II, III, Division 1, Groups C, D, E, F, and G. FM Non-incendive. Class 1, Division 2, Groups A, B, C, and D.  <b>Dimensions (H x W x D):</b> Note 2.44" = width at PTT, 2.34" = width at bottom; 1.83" = depth at speaker; 0.97" = depth at keypad <b>Without Battery (Radio Only):</b> 6.58" x 2.44" x 1.83"/6.58" x 2.34" x 0.97" (167.13 mm x 61.90 mm x 46.42 mm/ 167.13 mm x 59.49 mm x 24.56 mm) <b>With Battery:</b> 6.58" x 2.44" x 1.83"/6.58" x 2.34" x 1.65" (167.13 mm x 61.90 mm x 46.42 mm/ 167.13 mm x 59.49 mm x 41.97 mm)  <b>Weight: (w/ Antenna):</b> <b>Less Battery:</b> 14.10 oz (383 gm) <b>With Ultra-High Cap. NiCd:</b> 25.19 oz (693 gm) <b>With Li-Ion:</b> 20.41 oz (583 gm) <b>With Ultra-High Cap. NiMH:</b> 23.45 oz (644 gm) <b>With Extended-Cap. NiMH:</b> 24.04 oz (682 gm)	<b>Frequency Range:</b> <b>700 MHz:</b> 764 to 767, 773 to 776 MHz <b>800 MHz:</b> 851 to 870 MHz  <b>Bandwidth:</b> 106 MHz  <b>Usable Sensitivity (typical)</b> <b>(12 dB SINAD):</b> 0.20 µV  <b>Intermodulation (typical):</b> –75 dB  <b>Selectivity (typical):</b> <b>(25/30 kHz Channel):</b> –72 dB <b>(12.5 kHz Channel):</b> –63 dB  <b>Spurious Rejection (typical):</b> –75 dB  <b>Frequency Stability</b> <b>(–30/+60°C; 25°C reference):</b> ±0.00015%  <b>Rated Audio:</b> 500 mW  <b>FM Hum and Noise (typical):</b> 25 kHz –48 dB 12.5 kHz –40 dB  <b>Distortion (typical):</b> 1.5%  <b>Channel Spacing:</b> 12.5/25 kHz	<b>Frequency Range:</b> <b>700 MHz:</b> 764 to 767, 773 to 776, 794 to 797, 803 to 806 MHz <b>800 MHz:</b> 808 to 824, 851 to 870 MHz  <b>RF Power:</b> <b>764–806 MHz:</b> 2.5 Watts <b>806–870 MHz:</b> 3 Watts  <b>Frequency Stability (typical)</b> <b>(–30 to +60°C; 25°C ref.):</b> ±0.00015%  <b>Emission (typical conducted):</b> –75 dBc  <b>FM Hum and Noise (typical)</b> <b>(Companion Receiver):</b> 25 kHz –45 dB 12.5 kHz –40 dB  <b>Distortion (typical):</b> 1.5% (typical)  <b>Modulation Limiting:</b> 25 kHz chnls ±5.0 kHz 12.5 kHz chnls ±2.5 kHz  <b>Emissions Designators:</b> 20K0F1E, 16K0F3E, 11K0F3E, 8K10F1D, and 8K10F1E

Specifications subject to change without notice.

## Notes

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# Chapter 1 Introduction

## 1.1 General

This manual includes all the information needed to maintain peak product performance and maximum working time for the ASTRO XTS 5000 radio. This detailed level of service (component level) is typical of the service performed by some service centers, self-maintained customers, and distributors.

Use this manual in conjunction with the *ASTRO XTS 5000 VHF/UHF Range 1/700–800 MHz Digital Portable Radios Basic Service Manual* (Motorola part number 6881094C28), which can help in troubleshooting a problem to a particular printed circuit (PC) board.

Conduct the basic performance checks outlined in the basic service manual first to verify the need to analyze the radio and to help pinpoint the functional problem area. In addition, you will become familiar with the radio test mode of operation, which is a helpful tool. If any basic receive or transmit parameters fail to be met, the radio should be aligned according to the radio alignment procedure.

Included in other areas of this manual are functional block diagrams, detailed theory of operation, troubleshooting charts and waveforms, schematics, and parts lists. You should become familiar with these sections to aid in determining circuit problems. Also included are component location diagrams to aid in locating individual circuit components and some IC diagrams, which identify some convenient probe points.

"Chapter 3, Theory of Operation," on page 3-1, contains detailed descriptions of the operations of many circuits. Once you locate the problem area, review the troubleshooting flowchart for that circuit to fix the problem.

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## 1.2 Notations Used in This Manual

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

**NOTE:** An operational procedure, practice, or condition that is essential to emphasize.



**Caution**

**CAUTION** indicates a potentially hazardous situation which, if not avoided, might result in equipment damage.



**WARNING**

**WARNING** indicates a potentially hazardous situation which, if not avoided, could result in death or injury.



**DANGER**

**DANGER** indicates an imminently hazardous situation which, if not avoided, will result in death or injury.

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## Chapter 2 Radio Power

This chapter provides a detailed circuit description of the power distribution of an ASTRO XTS 5000 radio.

### 2.1 General

In the ASTRO XTS 5000 radio, power (B+) is distributed to two boards: the transceiver (RF) board and the VOCON board (see Figure 2-1 on page 2-2 for UHF Range 1 (R1) and 700–800 MHz, and Figure 2-2 on page 2-2 for VHF). In the case of a secure model radio, B+ is also supplied to the encryption module.

Power for the radio is provided through a battery supplying a nominal 7.5 Vdc directly to the transceiver. The following battery types and capacities are available:

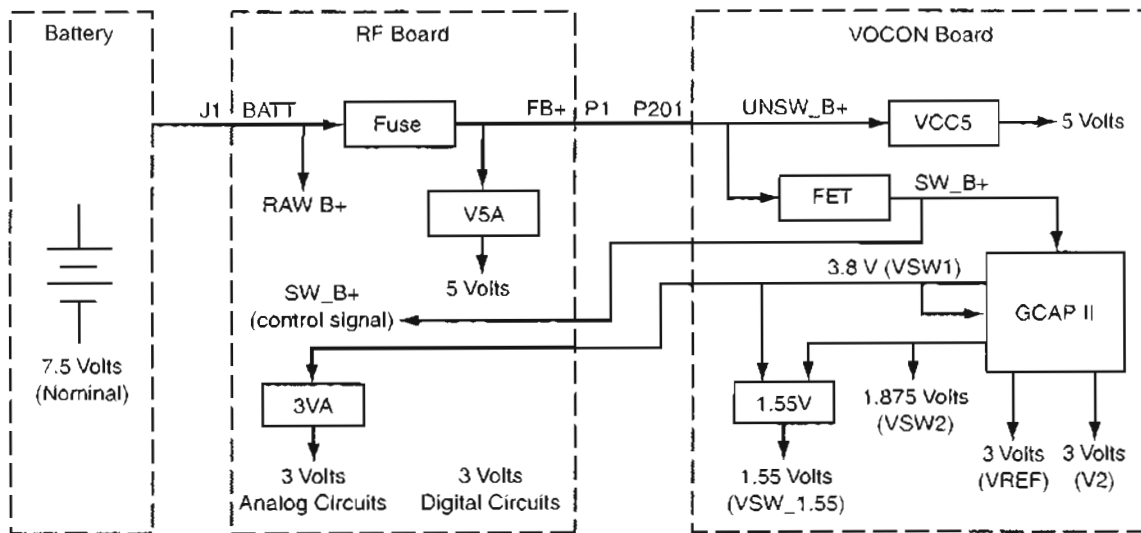
*Table 2-1. Conventional Batteries*

Part Number	Description
NTN8294	1525 NiCd, Ultra-High Capacity
NTN8295	1525 NiCd High-Capacity Factory Mutual (FM) Intrinsically Safe
NTN8297	1525 NiCd High-Capacity Factory Mutual (FM) Intrinsically Safe, Rugged
NTN8299	1750 NiMH Ultra-Capacity FM
NTN8610	1650 Lithium Ion
NTN8923	1800 NiMH Ultra-Capacity
NTN9177	Battery Holder, Clamshell, Black
NTN9183	Battery Holder, Clamshell, Orange
RNN4006	3000 NiMH
RNN4007	3000 NiMH FM

*Table 2-2. Smart Batteries*

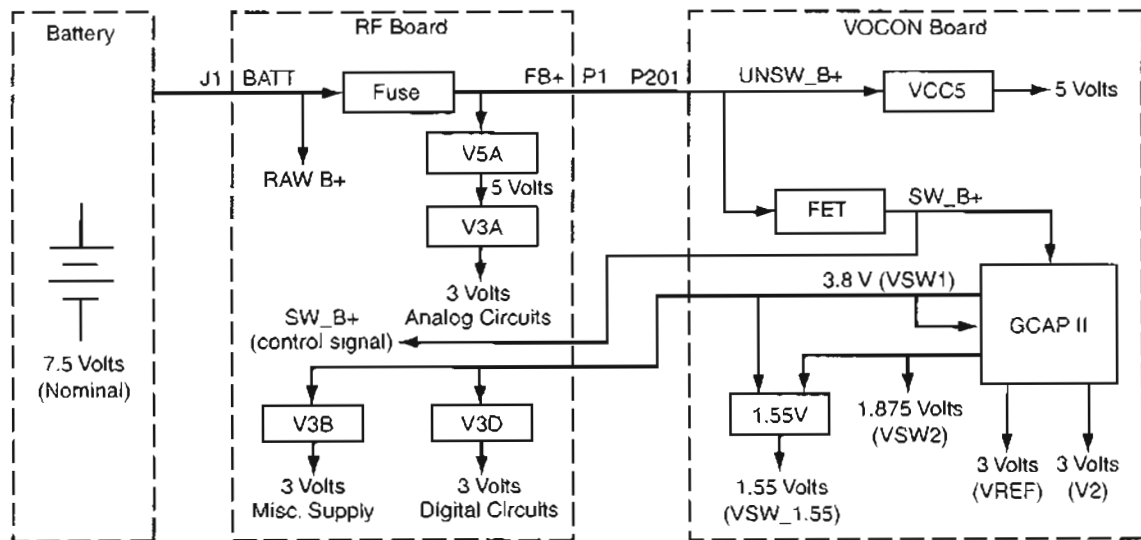
Part Number	Description
HNN9031	1525 NiCd Smart
HNN9032	1525 NiCd Smart FM
NNTN4435_R	1800 mAh, NiMH Smart
NNTN4436	1750 NiMH Smart FM (VHF use only)

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MAEPF-27419-A

Figure 2-1. DC Power Distribution—UHF Range 1 and 700–800 MHz Radios



MAEPF-27520-A

Figure 2-2. DC Power Distribution—VHF and Range 2 Radios

B+ from the battery is electrically switched to most of the radio, rather than routed through the On/Off/volume control knob, S1. The electrical switching of B+ supports a *keep-alive* mode. Under software control, even when the On/Off/volume control knob has been turned to the Off position, power remains on until the MCU completes its power-down, at which time the radio is physically powered down.

## 2.2 DC Power Routing—Transceiver Board

**NOTE:** Refer to Table 8-1, "List of Transceiver Schematics and Board Overlays," on page 8-1 for a listing of schematics showing the transceiver board DC power routing components.

Connector J1, the B-plus assembly, connects the battery to the transceiver board. Capacitors C1, C2, and C3 provide protection against momentary breaks at the B-plus connector due to contact bounce when the radio is dropped.

**UHF R1 and 700–800 MHz:** Components C5, E4, C7, and E1 form a power-line filter for signal RAWB+, which supplies battery voltage to the transmitter PA.

**UHF R2 and VHF:** Component E1 forms a power-line filter for signal RAWB+, which supplies battery voltage to the transmitter PA.

Transistor Q1, controlled by signal SWB+ (SB+ for VHF) from the VOCON board, turns on XB+, which supplies to the 5-V linear regulator and TX\_ALC block.

Fuse F901 and filter C11, L1, C10 (C14, L1, C13 for VHF) supply fused B-plus to the VOCON board. In turn, the VOCON board supplies VSW1, regulated 3.8 Vdc, from the Global Control Audio and Power (GCAP) switching regulator to the XCVR. Switch Q99 (Q503 for VHF), controlled by SWB+, turns on V38 to the XCVR 3-V linear regulators. The XCVR regulated power supplies are summarized in Table 2-3.

Table 2-3. Transceiver Voltage Regulators

Ref. Desig.	IC Name	Output Signal Name	Description
U1	LP2989	V5A	Regulated 5.0 Vdc
U2	LP3985	V3D	Regulated 3.0 Vdc digital
U3	LP3985	V3A	UHF R1 and 700–800 MHz: Regulated 3.0 Vdc analog for the RX FE UHF R2 and VHF: Regulated 3.0 Vdc analog for synthesizer
U5	LP3985	V3B	UHF R2 and VHF only: Regulated 3.0 Vdc miscellaneous supply

## 2.3 DC Power Routing—VOCON Board

**NOTE:** Refer to Table 8-2, "List of VOCON Schematics and Board Overlays," on page 8-1 for a listing of schematics showing the VOCON board DC power routing components.

Raw B+, or unswitched B+, (UNSW\_B+) is routed to connector P1 on the transceiver board, and then on to P201 on the VOCON board. Here the UNSW B+ is forwarded to the radio's control top On/Off/volume knob through connector J101 and a flex circuit, as well as to regulator U505 (VCC5).

The On/Off/volume knob controls B+SENSE to Q502, which in turn controls Q501. Transistor Q501 is a solid-state power switch that provides SW B+ to the VOCON board, the audio PA, the GCAP II IC (via GCAP\_B+), and back to the transceiver board.

In the case of a secure radio model, SW B+ and UNSW B+ are also supplied to the encryption module through connector J701.

Transistor Q501 is also under the control of the microcontroller unit (MCU) via Vref from U501. This allows the MCU to follow an orderly power-down sequence when it senses that B+SENSE is off. This sense is provided through MECH\_SW\_BAR (inverted B+SENSE, see Q508).

The digital circuits in the VOCON board are powered from regulators located in the GCAP II IC (U501), an external 5 Vdc regulator (VCC5, U505), and an external 1.55 Vdc regulator (VSW\_1.55V, on NNTN4717 VOCON kit only). The GCAP II IC provides three supplies: VSW1, VSW2, and V2. These regulators are software programmable. Table 2-4 lists the supply voltages and the circuits that use these voltages.

Table 2-4. VOCON Board DC Power Distribution

Supply Name	Output Voltage	Supply Type	Unprogrammed Output Voltage	Circuits Supplied
UNSW_B+	9 to 6 Vdc 7.5 Vdc nominal	Battery	N/A	VCC5 input Mechanical switch Power switch (FET) Secure module Real-time clock battery
SW_B+	9 to 6 Vdc 7.5 Vdc nominal	Battery	N/A	VSW1 input (GCAP) Audio power amplifier Side connector SW_B+ to transceiver board GCAP IC Secure module USB circuitry
VCC5	5Vdc	Linear Regulator	N/A	Smart battery circuitry Int. / ext. microphone bias Audio preamplifier Flipper IC Keypad / Display LEDs
VSW1	3.8 Vdc	Switching regulator software programmable	3.2 Vdc	3-V regulators (RF) VSW2 input V2 input
VSW2	1.8 Vdc	Switching regulator software programmable	2.2 Vdc	Patriot core FLASH IC SRAM Display (only on NTN9564 VOCON board)
V2	3 Vdc* 2.9 Vdc**	Linear regulator software programmable	2.775 Vdc	Patriot I/O ring Flipper IC EEPOT Display 16.8 MHz buffer
VSW_1_55V	1.55 Vdc	Linear regulator	N/A	Patriot core (only on NNTN4717 VOCON board)

\* = NTN9564, NNTN4563 & NNTN4819 VOCON kits

\*\* = NNTN4717 VOCON kit

## 2.2 DC Power Routing—Transceiver Board

**NOTE:** Refer to Table 8-1, "List of Transceiver Schematics and Board Overlays," on page 8-1 for a listing of schematics showing the transceiver board DC power routing components.

Connector J1, the B-plus assembly, connects the battery to the transceiver board. Capacitors C1, C2, and C3 provide protection against momentary breaks at the B-plus connector due to contact bounce when the radio is dropped.

**UHF R1 and 700–800 MHz:** Components C5, E4, C7, and E1 form a power-line filter for signal RAWB+, which supplies battery voltage to the transmitter PA.

**UHF R2 and VHF:** Component E1 forms a power-line filter for signal RAWB+, which supplies battery voltage to the transmitter PA.

Transistor Q1, controlled by signal SWB+ (SB+ for VHF) from the VOCON board, turns on XB+, which supplies to the 5-V linear regulator and TX\_ALC block.

Fuse F901 and filter C11, L1, C10 (C14, L1, C13 for VHF) supply fused B-plus to the VOCON board. In turn, the VOCON board supplies VSW1, regulated 3.8 Vdc, from the Global Control Audio and Power (GCAP) switching regulator to the XCVR. Switch Q99 (Q503 for VHF), controlled by SWB+, turns on V38 to the XCVR 3-V linear regulators. The XCVR regulated power supplies are summarized in Table 2-3.

Table 2-3. Transceiver Voltage Regulators

Ref. Desig.	IC Name	Output Signal Name	Description
U1	LP2989	V5A	Regulated 5.0 Vdc
U2	LP3985	V3D	Regulated 3.0 Vdc digital
U3	LP3985	V3A	UHF R1 and 700–800 MHz: Regulated 3.0 Vdc analog for the RX FE UHF R2 and VHF: Regulated 3.0 Vdc analog for synthesizer
U5	LP3985	V3B	UHF R2 and VHF only: Regulated 3.0 Vdc miscellaneous supply

## 2.3 DC Power Routing—VOCON Board

**NOTE:** Refer to Table 8-2, "List of VOCON Schematics and Board Overlays," on page 8-1 for a listing of schematics showing the VOCON board DC power routing components.

Raw B+, or unswitched B+, (UNSW\_B+) is routed to connector P1 on the transceiver board, and then on to P201 on the VOCON board. Here the UNSW B+ is forwarded to the radio's control top On/Off/volume knob through connector J101 and a flex circuit, as well as to regulator U505 (VCC5).

The On/Off/volume knob controls B+SENSE to Q502, which in turn controls Q501. Transistor Q501 is a solid-state power switch that provides SW B+ to the VOCON board, the audio PA, the GCAP II IC (via GCAP\_B+), and back to the transceiver board.

In the case of a secure radio model, SW B+ and UNSW B+ are also supplied to the encryption module through connector J701.

Transistor Q501 is also under the control of the microcontroller unit (MCU) via Vref from U501. This allows the MCU to follow an orderly power-down sequence when it senses that B+SENSE is off. This sense is provided through MECH\_SW\_BAR (inverted B+SENSE, see Q508).

The digital circuits in the VOCON board are powered from regulators located in the GCAP II IC (U501), an external 5 Vdc regulator (VCC5, U505), and an external 1.55 Vdc regulator (VSW\_1.55V, on NNTN4717 VOCON kit only). The GCAP II IC provides three supplies: VSW1, VSW2, and V2. These regulators are software programmable. Table 2-4 lists the supply voltages and the circuits that use these voltages.

Table 2-4. VOCON Board DC Power Distribution

Supply Name	Output Voltage	Supply Type	Unprogrammed Output Voltage	Circuits Supplied
UNSW_B+	9 to 6 Vdc 7.5 Vdc nominal	Battery	N/A	VCC5 input Mechanical switch Power switch (FET) Secure module Real-time clock battery
SW_B+	9 to 6 Vdc 7.5 Vdc nominal	Battery	N/A	VSW1 input (GCAP) Audio power amplifier Side connector SW_B+ to transceiver board GCAP IC Secure module USB circuitry
VCC5	5Vdc	Linear Regulator	N/A	Smart battery circuitry Int. / ext. microphone bias Audio preamplifier Flipper IC Keypad / Display LEDs
VSW1	3.8 Vdc	Switching regulator software programmable	3.2 Vdc	3-V regulators (RF) VSW2 input V2 input
VSW2	1.8 Vdc	Switching regulator software programmable	2.2 Vdc	Patriot core FLASH IC SRAM Display (only on NTN9564 VOCON board)
V2	3 Vdc* 2.9 Vdc**	Linear regulator software programmable	2.775 Vdc	Patriot I/O ring Flipper IC EEPOT Display 16.8 MHz buffer
VSW_1_55V	1.55 Vdc	Linear regulator	N/A	Patriot core (only on NNTN4717 VOCON board)

\* = NTN9564, NNTN4563 & NNTN4819 VOCON kits

\*\* = NNTN4717 VOCON kit

## Chapter 3 Theory of Operation

This chapter provides a detailed circuit description of the ASTRO XTS 5000 transceiver and VOCON boards. When reading the theory of operation, refer to the appropriate schematic and component location diagrams located in the back of this manual. This detailed theory of operation can help isolate the problem to a particular component.

The ASTRO XTS 5000 radio is a dual-mode (digital/analog), microcontroller-based transceiver incorporating a digital signal processor (DSP). The microcontroller handles the general radio control, monitors status, and processes commands input from the keypad or other user controls. The DSP processes the typical analog signals, and generates the standard signaling digitally to provide compatibility with existing analog systems. In addition, the DSP provides digital modulation techniques, utilizing voice encoding techniques with error correction schemes. This provides the user with enhanced range and audio quality, all in a reduced bandwidth channel requirement. It allows embedded signaling, which can mix system information and data with digital voice to support a multitude of system features.

The three ASTRO XTS 5000 radio models (I, II, and III) are available in the VHF (136 to 174 MHz), UHF Range 1 (380 to 470 MHz), UHF Range 2 (450 to 520 MHz), and 700–800 MHz (764 to 870 MHz) frequency bands.

The ASTRO XTS 5000 radio (Figure 3-1) consists of the following:

- Band-dependent transceiver (RF) board
- Vocoder/controller (VOCON) board
- Universal flex assembly
- Display and keypad assemblies (Models II and III only)
- Encryption board (secure models only)

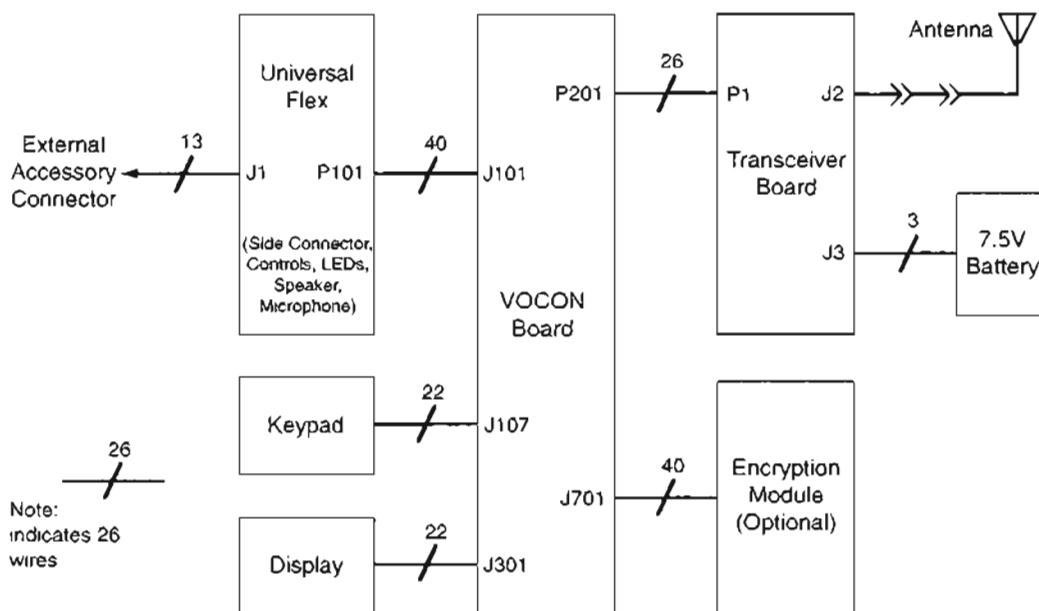




Figure 3-1. XTS 5000 Overall Block Diagram

### 3.1 Transceiver Board

The transceiver (XCVR) board performs the transmitter and receiver functions necessary to translate between voice and data from the VOCON board and the modulated radio-frequency (RF) carrier at the antenna. The transceiver board contains all the radio's RF circuits for the following major components:

- Receiver
- Transmitter
- Frequency Generation Unit (FGU)

Figure 3-2 illustrates the VHF transceiver board block diagram while Figure 3-3 on page 3-3 illustrates the transceiver UHF Range 1 and 700–800 MHz transceiver block diagrams.

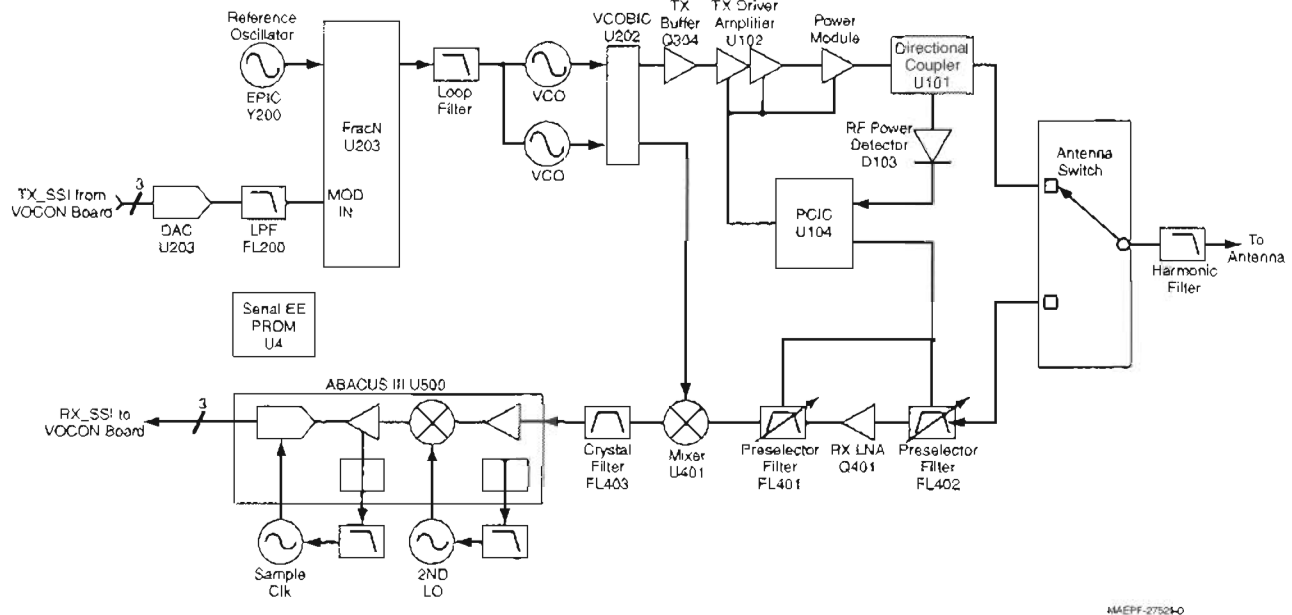


Figure 3-2. Transceiver (VHF) Block Diagram (Power and Control Omitted)

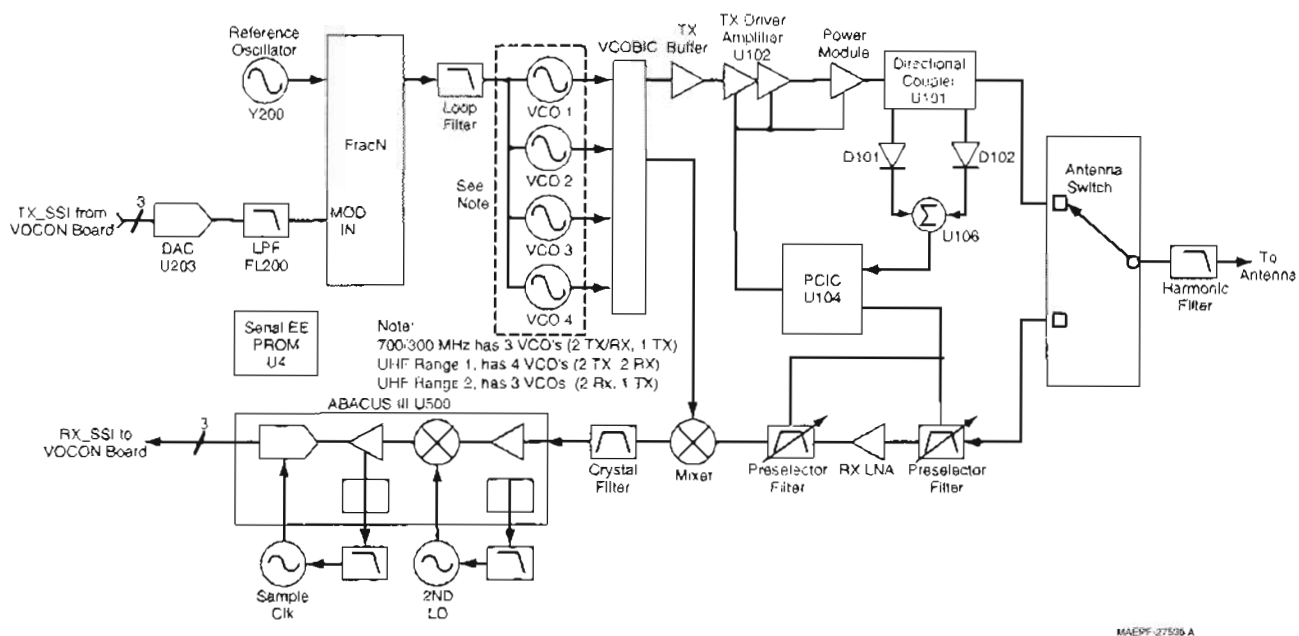


Figure 3-3. Transceiver (UHF Range 1, UHF Range 2 and 700-800 MHz) Block Diagram (Power and Control Omitted)

### 3.1.1 Interconnections

This section describes the various interconnections for the transceiver board.

#### 3.1.1.1 Battery Connector J3

Battery connector J3 consists of three gold-plated contacts on the printed circuit board that mate with a B-plus connector assembly. Signal descriptions are in Table 3-1.

Table 3-1. Battery Connector J3

Pin No.	Signal	Description
1	BATT	Battery positive terminal, nominally 7.5 Vdc
2	BSTAT	Battery status, from battery to VOCON
3	BAT_RTN	Battery negative terminal, tied to PCB ground

#### 3.1.1.2 VOCON Connector P1

VOCON connector P1 (located on the XCVR board) consists of 26 gold-plated pads for the 26-pin compression connector, and one plated tool hole (pin 27) used for connector alignment. This is a digital interface carrying DC power, control, and data between the XCVR and VOCON boards. P1 connects through the compression connector to P201 on the VOCON board.

Table 3-2 lists the connector pins, their signals, and functions. SPI refers to serial peripheral interface, which is the control bus from the microprocessor. SSI is the serial synchronous interface bus for data to and from the DSP. There is a RX SSI bus for demodulated data from the receiver and a TX SSI bus for modulation data to the transmitter.

Table 3-2. VOCON Connector P1

Pin No.	VOCON Signal	XCVR Signal	XCVR I/O	Type	Description
1	UNSW_B+	FUB+	O	dc	Fused B+ to VOCON
2	UNSW_B+	FUB+	O	dc	Fused B+ to VOCON
3	LOCK_DET*	LOCK	O	status	FGU lock detect
4	TX_SSI_DATA	TXTD	O	ssi	TX SSI data
5	SSI_CLK	RXCK	O	ssi	RX SSI clock
6	SSI_FSYNC	SSFS	O	ssi	RX SSI frame sync
7	16.8MHz	F168	O	RF	16.8 MHz reference clock
8	SW_B+	SWB+	I	dc	Switch control
9	TX_SSI_FSYNC	TXFS	I	ssi	TX SSI frame sync
10	TX_SSI_CLK	TXCK	I	ssi	TX SSI clock
11	GND	GND			
12	RX_SSI_DATA	RXDO	O	ssi	RX SSI data
13	ABACUS3_CS	ABCS	I	ssi	SPI Abacus chip select
14	GND	GND			
15	VSW1	VSW1	I	dc	Regulated 3.8 V
16	SPI_CLK_A	SPCK	I	spi	SPI clock
17	SPI_MISO_A	MISO	O	spi	SPI data out
18	EEPROM_SEL*	EECS	I	spi	SPI EEPROM chip select
19	TX_INHIBIT	TXINH	I	control	TX inhibit control for secure
20	GND	GND			
21	BAT_STATUS	BSTAT	O	dc	Battery status
22	GND	GND			
23	SPI_MOSI_A	MOSI	I/O	spi	SPI data I/O
24	UNI_CS	USEL	I	spi	SPI universal chip select
25	AD_CS	ADCS	I	spi	SPI ADC chip select
26	POR*	RSTL	I/O	control	asynchronous reset, active low

### 3.1.1.3 Antenna Port J2

Antenna port J2 is a surface-mount, miniature coaxial connector for the antenna cable.

### 3.1.1.4 Serial EEPROM

The serial, electrostatically erasable, programmable, read-only memory (EEPROM), U907 in VHF and 700–800 MHz or U4 in UHF Range 1, holds all of the transceiver tuning data. This allows transceivers to be tuned in the factory and installed in the field without retuning.

### 3.1.1.5 Power Conditioning Components

DC power-conditioning components include zener diodes, capacitors, ferrite beads, a power inductor, and the fuse. Diodes VR1 and VR2 provide over-voltage protection. Ferrite beads (designated E1, etc.) and capacitors suppress electromagnetic interference from the transceiver. The power-line filter consisting of L1, C13, and C14 for VHF radios or L1, C10, and C11 for UHF Range 1 and 700–800 MHz radios, suppresses digital noise from the VOCON board switching power supplies that could degrade the transmitter spectral purity.

Pass transistor Q1 switches the battery voltage to the transceiver when control signal SWB+ or SB+ from the VOCON board is asserted high. This increases the transceiver's immunity to conducted interference that might be present on SWB+ or SB+, such as from switching voltage regulators on the VOCON board.

Ground clips G1 through G12 make contact between the transceiver board ground and the radio chassis. The chassis connection is a necessary electrical reference point to complete the antenna circuit path. Shields SH101 through SH700 and the tool hole appear on the schematic to show their connection to ground.

## 3.1.2 Receiver

The XTS 5000 transceiver has a dual-conversion superheterodyne receiver. Figure 3-4 illustrates the major receiver components:

- Receiver Front End
- Receiver Back End

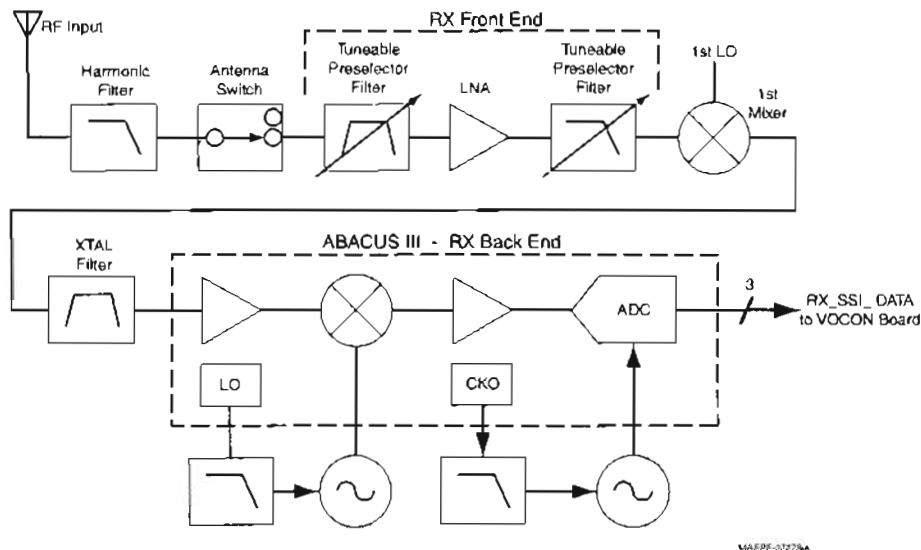


Figure 3-4. Receiver Block Diagram

### 3.1.2.1 Receiver Front End

**NOTE:** Refer to Table 8-1, "List of Transceiver Schematics and Board Overlays," on page 8-1 for a listing of receiver front end schematics.

The receiver front end tunes to the desired channel and down converts the RF signal to the first intermediate frequency (IF). Channel selection is by way of a tunable local oscillator, RXLO, from the FGU.

The receiver front end consists of a preselector filter, an RF amplifier, a second preselector, mixer, and an IF crystal filter. VHF, UHF Range 1 and UHF Range 2 radios also contain a switchable attenuator between the antenna switch and the first preselector filter. The RF amplifier is a discrete RF transistor with associated circuitry. The mixer is a double-balanced, active mixer IC, coupled by transformers. The receiver (RX) local oscillator (LO) is provided by the FGU.

#### 3.1.2.1.1 Preselector Filters

**VHF, UHF Range 1, and UHF Range 2:** The receiver front end uses two discrete, tunable, bandpass filters to achieve its required out-of-band rejection. The first preselector filter precedes the RF amplifier, while the second preselector filter follows the RF amplifier. DAC2, from the PCIC, is used to simultaneously tune both preselector filters by applying voltage to the varactors.

**700–800 MHz:** The receiver front end uses two, multi-layer, ceramic, tunable, bandpass filters to achieve its required out-of-band rejection. The first preselector filter, FL401, precedes the discrete RF amplifier. To tune the center frequency of the first filter, voltage from port DAC1 is applied to pin 3 of FL401. Pin 3 connects to the surface-mounted varactor diodes placed on each filter. A second identical filter, FL402, follows the discrete RF amplifier. The second filter is tuned by applying voltage from port DAC2 to pin 3 of FL402. Capacitors C409 and C410 are RF bypasses. Capacitors C400 and C411 are used to filter out noise from the DAC1 and DAC2 control lines.

#### 3.1.2.1.2 LNA (Low-Noise Amplifier)

The XTS 5000 radio uses a discrete transistor for the low-noise amplifier (Q428 in VHF, Q430 in UHF Range 1, Q428 in UHF Range 2, and Q401 in 700–800 MHz). A feedback network between the collector and base improves stability and gain balance across the frequency band. Input and output LC networks match the LNA impedance to 50 ohms.

A diode limiter (D722 in VHF, D400 in UHF Range 1, D722 in UHF Range 2, and D401 in 700–800 MHz) protects the amplifier damage by strong input signals.

#### 3.1.2.1.3 Mixer

The mixer (U45 in VHF, U470 in UHF Range 1, U451 in UHF Range 2 and U401 in 700–800 MHz) down-converts the received RF to the first intermediate frequency (IF). The IF is 44.85 MHz for VHF, 73.35 MHz for UHF Range 1 and UHF Range 2, and 109.65 MHz for 700–800 MHz. High-side LO injection is used for VHF and 700 MHz, low-side for the UHF bands and 800 MHz. Transformers are used as baluns to convert signals from single-ended to balanced at pins MI, MIX, LO, and LOX. An output transformer converts the balanced signal at pins MO and MOX to a single-ended output.

#### 3.1.2.1.4 IF Filter

The IF filter (FL451 in VHF, FL490 in UHF Range 1, FL451 in UHF Range 2, and FL403 in 700–800 MHz) is a leadless, surface-mount, 3-pole, quartz crystal filter. This narrow bandpass filter gives the radio its adjacent-channel and alternate-channel rejection performance.

Input and output LC networks match the filter impedance to 50 ohms. Exceptions are the VHF and UHF Range 2, where the output is matched to 50 ohms, but the input is not.

### 3.1.2.2 Receiver Back End

The receiver back end, which consists of the Abacus III (AD9874 IF digitizing subsystem) IC and its associated circuitry, processes the down-converted IF signal to produce digital data for final processing by the VOCON DSP.

**NOTE:** Refer to Table 8-1, "List of Transceiver Schematics and Board Overlays," on page 8-1 for a listing of receiver back end schematics.

#### 3.1.2.2.1 Abacus III IC U500

The AD9874 (Figure 3-5) is a general-purpose, IF subsystem that digitizes a low-level 10–300 MHz IF input with a bandwidth up to 270 kHz. The output of the Abacus III IC is SSI data to the VOCON.

The signal chain of the AD9874 consists of a low-noise amplifier, a mixer, a bandpass sigma-delta A/D converter, and a decimation filter with programmable decimation factor. An automatic gain control (AGC) circuit provides the AD9874 with 12 dB of continuous gain adjustment. The high dynamic range and inherent anti-aliasing provided by the bandpass sigma-delta converter allow the AD9874 to cope with blocking signals 80 dB stronger than the desired signal.

Auxiliary blocks include frequency synthesizers for the second LO and sampling clock LO, as well as an SPI port. The second LO uses a discrete external loop filter and VCO. The clock oscillator has an external loop filter and resonator.

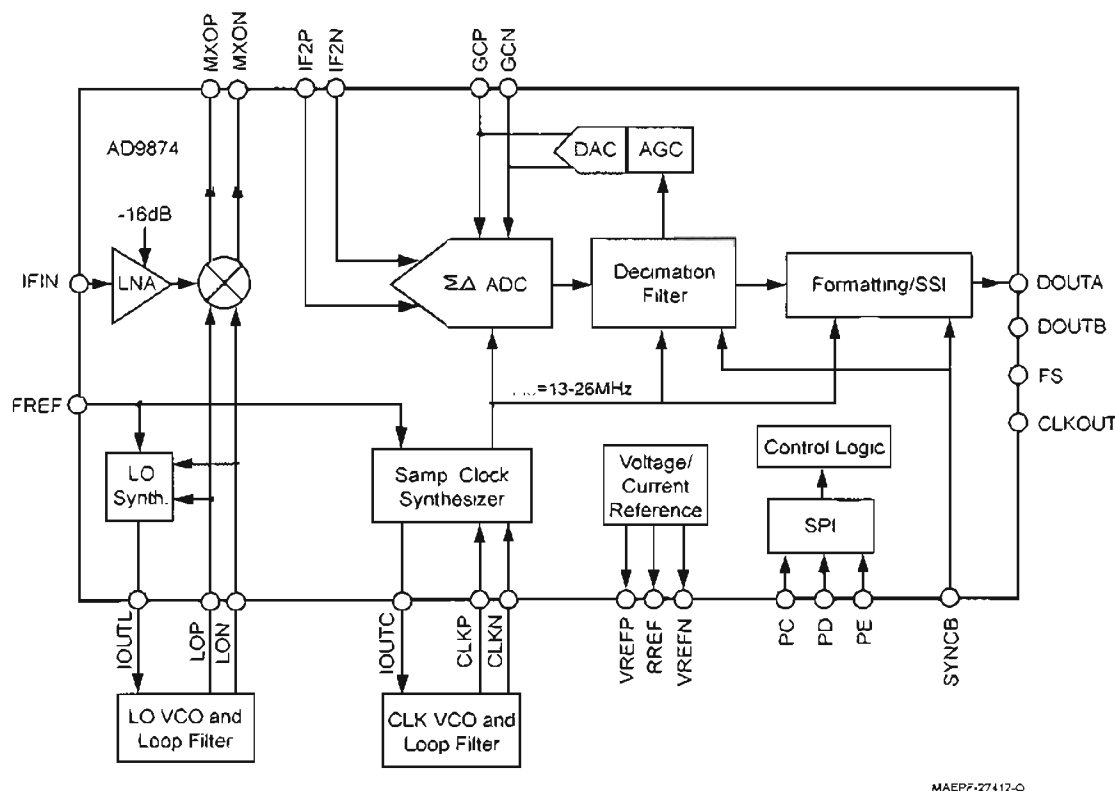


Figure 3-5. Abacus III (AD9874) Functional Block Diagram (from data sheet)

**VHF:** Input signal RXIF is the 44.8 MHz IF from crystal filter FL451 in the receiver front end. Components C547 and L542 match the input impedance from 50 ohms at the RXIF to the Abacus input IFIN.

**UHF Range 1:** Input signal RXIF is 73.35 MHz. Components L547 and C547 match the input impedance to 50 ohms.

**UHF Range 2:** Input signal RXIF is 73.35 MHz. L542, C515, and C547 match the Abacus input to 50 Ohms.

**700–800 MHz:** Input signal RXIF is the 109.65 MHz IF from crystal filter FL403 in the receiver front end. Components L547 and C542 match the input impedance from 50 ohms at RXIF to approximately 420 ohms in parallel with a 1 pF capacitance at the Abacus input IFIN. Formatted SSI data is output to the VOCON board on ports FS, DOUTA, and CLKOUT.

#### 3.1.2.2.2 Second Local Oscillator

The second LO is controlled by the Abacus LO synthesizer, which mixes with IFIN to produce a 2.25 MHz final IF. The external VCO consists of Q502 and its bias network and frequency-determining elements. Signal FREF is the 16.8 MHz reference from the FGU. Darlington transistor Q501 with C550 and R501 form an active power-line filter.

**VHF:** The second LO frequency is 42.6 MHz by default, or 47.1 MHz in special cases as needed to avoid radio self-quieters. The loop filter is composed of R507, C558, C559, and C503.

**UHF Range 1:** The second LO frequency is 71.1 MHz by default or 75.6 MHz in special cases as needed to avoid radio self-quieters. The loop filter is composed of R551, C558, C559, R552, and C512.

**UHF Range 2:** The 2nd LO frequency is 71.1 Mhz. C558, R507, and C559 form the loop filter.

**700–800 MHz:** The second LO frequency is 107.4 MHz by default or 111.9 MHz in special cases as needed to avoid radio self-quieters. The loop filter is composed of R507, C558, C559, R505, and C512.

#### 3.1.2.2.3 Sampling Clock Oscillator

The Abacus sampling clock synthesizer operates at 18 MHz = 8 x 2.25 MHz. The VCO uses an internal transistor and external resonator. The resonator is composed of L503, C535, and D501.

**VHF:** The loop filter is composed of R514, C536, C570, and C571.

**UHF Range 1 and 700–800 MHz:** The loop filter is composed of R514, C570, and C571.

**UHF Range 2:** C503, C536, R415, C570, and C571 form the loop filter.

### 3.1.3 Transmitter

The transmitter takes modulated RF from the FGU and amplifies it to the radio's rated output power to produce the modulated transmitter carrier at the antenna.

**NOTE:** Refer to Table 8-1, "List of Transceiver Schematics and Board Overlays," on page 8-1 for a listing of transmitter-related schematics that will aid in the following discussion.

The transmitter (Figure 3-6 on page 3-9) consists of an RF driver IC that receives its input signal from the voltage-controlled oscillator (VCO) and a high-power output transistor. Transmitter power is controlled by a power-control IC (PCIC) that senses the output of a directional coupler and adjusts PA control voltages to maintain a constant power level. The signal passes through an antenna switch and harmonic filter to the antenna.

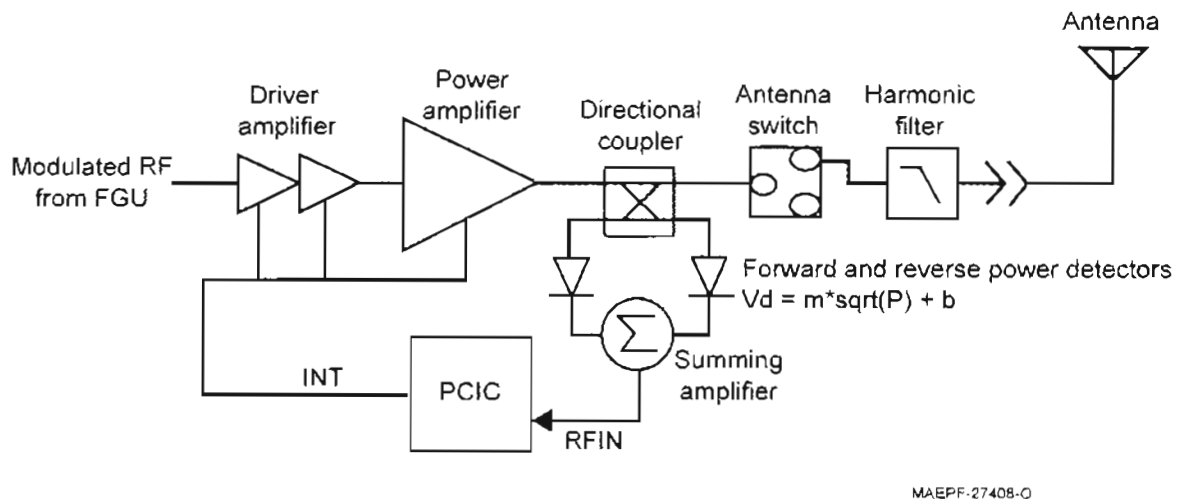


Figure 3-6. Transmitter Block Diagram

### 3.1.3.1 Power Distribution

To minimize voltage drop to the power amplifiers, net RAWB+ connects to power module Q107 and the second stage of driver amplifier U102 through components having minimal series resistance—ferrite beads and chokes only. During receive, no RF or DC bias is applied, and leakage current through U102 and Q107 is less than 100 microamps. The first stage of U102 uses less than 50 mA and is supplied by TX7V, which is switched on during TX, and switched off during RX or whenever TXINH, the transmitter inhibit control line, is high.

**VHF:** At a transmitter power of 6 Watts, the radio consumes approximately 2000 mA. Bias TX7V is controlled by transistors Q101, Q102, Q103, and Q106.

**UHF Range 1 and Range 2:** At the rated transmitter power of 5 Watts, the radio consumes approximately 2000 mA. Bias TX7V is controlled by transistors Q101, Q102, Q103, and Q106.

**700–800 MHz:** At a transmitter power of 3 Watts, the radio consumes approximately 1200 mA. Bias TX7V is controlled by transistors Q101, Q102, Q103, and Q107.

### 3.1.3.2 Driver Amplifier

The driver amplifier IC (U102) contains two LDMOS FET amplifier stages and two internal resistor bias networks. Pin 16 is the RF input. Modulated RF from the FGU, at a level of +3 dBm ±2 dB, is coupled through a blocking capacitor to the gate of FET-1. An LC interstage matching network connects the first stage output VD1 to the second stage input G2. The RF output from the drain of FET-2 is pin 6 (RFOUT1). Gain control is provided by a voltage applied to pin 1 (VCNTRL). Typical output power is about +27 dBm (500 mW) with VCNTRL at 5.0 V.

**VHF:** L109 and C113 are the interstage matching network. Components C108–C111 and L106–L107 match the output impedance to maximize power transfer to Q107; capacitor C107 is a DC block.

**UHF Range 2:** L109 and C113 are the interstage matching network. Components C108–C111 and L105, L107, and L108 match the output impedance to maximize power transfer to Q107.

**UHF Range 1 and 700–800 MHz:** L109 and C116 are the interstage matching network. Components L105 and C110 match the output impedance to 50 ohms; capacitor C107 is a DC block.



### 3.1.3.3 Power Amplifier Transistor Q107

The power amplifier transistor, Q107, is an LDMOS FET housed in a high-power, surface-mount, ring package. To prevent thermal damage, it is essential that the heat sink of the power module be held in place against the radio chassis. The input impedance-matching network uses discrete inductors and capacitors. The low-pass output matching network uses both transmission lines and lumped LCs. Drain bias is applied through E101 and L101. Gain is dynamically controlled by adjusting the gate bias. The gate is insulated from the drain and source so that gate bias current is essentially zero.

**VHF:** The input and output impedance-matching networks consist of L112–L114 and C137–C140. Gate bias is applied through R105, R106, and L108.

**UHF Range 2:** The input and output impedance-matching networks consist of L113, L114 and C137, C139, C140, C149, and C151.

Gate bias is applied through R105, R106, and L720.

**UHF Range 1 and 700–800 MHz:** The input impedance-matching network is L106, L107, C108, and C109. A transmission-line structure and C137, C111, and C112 form the output-matching network. Gate bias applied through R106 and L110.

### 3.1.3.4 Directional Coupler

A directional coupler senses the transmitter forward and reverse power as control signals in the transmitter's automatic level control (ALC) loop. Isolated ports are terminated with external resistors.

**VHF and UHF Range 1:** The directional coupler consists of three embedded transmission lines.

**UHF Range 1 and 700–800 MHz:** The directional coupler is U101, a low-loss, bidirectional coupler.

### 3.1.3.5 Antenna Switch

**NOTE:** Refer to Table 8-1, "List of Transceiver Schematics and Board Overlays," on page 8-1 for a listing of schematics that will aid in the following discussion.

The antenna switch is a single-pole, double-throw, positive-intrinsic-negative (PIN) diode, transmit/receive (T/R) antenna switch. Forward DC bias turn the diodes ON, reverse or zero bias turns them OFF.

**VHF and UHF Range 2:** PIN diodes D707 and D717 form a narrow-band, quarter-wave, T/R switch. In transmit mode, both diodes are forward-biased, and the signal goes from the transmitter to the antenna through the low resistance of the series PIN diode, while the low resistance of the shunt diode shorts the receiver. In receive mode, neither diode is biased and both behave as small-value capacitors, creating a high blocking impedance, in effect disconnecting the transmitter circuitry from the antenna.

**UHF Range 1:** Diodes D701 and D702 form a broadband switch. Inductors L706 and L707 resonate with the OFF diode parasitic capacitance to improve isolation.

**700–800 MHz:** PIN diodes D701 and D702 form a narrow-band, quarter-wave, T/R switch. When the PIN diodes are OFF, parallel inductors L706 and L707 resonate with the diode parasitic capacitance to increase isolation at the signal frequency.

The switch control circuit consists of transistors Q101, Q103, Q106, and associated resistors. The input signals are TXINH from the VOCON board and RXH (RX for VHF) from the PCIC. When TXINH is low and RXH (RX for VHF) is high, the switch is in the receive state. When TXINH and RXH (RX for VHF) are low, the switch is in its transmitter state. When TXINH is held high, the radio is inhibited from transmitting. This is a secure-module control feature.

### 3.1.3.6 Harmonic Filter

The harmonic filter is a high-power, low-loss, low-pass filter. Its purpose is to suppress transmitter harmonics. The filter also improves receiver out-of-band rejection. Shield SH700 must be in place to achieve the required stop band rejection.

**VHF:** The harmonic filter uses discrete components. The pass band is up to 190 MHz, and the stop band is above 260 MHz.

**UHF Range 1:** The harmonic filter is discrete, the pass band is up to 470 MHz, and the stop band is above 760 MHz.

**UHF Range 2:** The harmonic filter uses discrete components. The pass band is up to 595 MHz, and the stop band is above 900 MHz.

**700–800 MHz:** The harmonic filter uses both discrete components and transmission lines. The pass band is up to 870 MHz, and the stop band is above 1500 MHz.

### 3.1.3.7 RF Detectors D101 and D102

Two Schottky diodes, D101 and D102, are used as forward- and reverse-power detectors. Forward-coupled RF from the power amplifier, and reverse-coupled RF from the antenna are converted to DC voltages FWD and RVS. Detector output is a positive DC voltage, proportional to the amplitude of the RF signal at the input.

### 3.1.3.8 Summing Amplifier U106

This op-amp circuit is a non-inverting buffer. Signals FWD and RVS are summed and sent to the ALC input of the PCIC. When the antenna port is loaded with a low VSWR (voltage standing wave ratio), as in normal operation, RVS is far less than FWD, the amplifier output is a function of FWD, and the radio maintains a constant output power. Under high VSWR conditions, such as when the antenna is damaged or held near a large metal surface, the amplitude of RVS becomes a large fraction of FWD, the amplifier output increases proportionally, and the radio cuts back the transmitter power by up to 50%. This reduces high battery current into a large VSWR transmitter to extend battery life.

### 3.1.3.9 Power-Control IC (PCIC) U104

The PCIC, U104, contains all of the digital, and most of the analog, circuits needed to control the transmitter power amplifier. Host control is through a 3-wire, smart SPI interface. Pin descriptions are shown in Table 3-3.

*Table 3-3. Power Control IC (U104) Pin Descriptions*

Pin	Name	Description
1	RFIN	Detector voltage input to ALC
2	T1	Test point
3	CI	External capacitor for integrator time constant
4	INT	Integrator output; control voltage to amplifiers
5	CJ	External capacitor for PA rise and fall times
6, 7	VL, CL	External capacitor for PA rise and fall times
8	GND1	Ground