MOTOROLA

ASTRO™ Digital XTS 3000™ and XTS 3000 R™

Portable Radios
Detailed Service Manual

Foreword

The information contained in this manual relates to all ASTRO Digital XTS 3000™ portable radios, unless otherwise specified. This manual provides sufficient information to enable service shop personnel to troubleshoot and repair an ASTRO Digital XTS 3000 portable radio to the component level.

Safety Information

Before operating an ASTRO Digital XTS 3000 radio, please read the “Safety” section in the front of this manual.

Manual Revisions

Changes which occur after this manual is printed are described in “FMRs.” These FMRs provide complete information on changes, including pertinent parts list data.

Computer Software Copyrights

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Safety

SAFETY AND GENERAL INFORMATION

IMPORTANT INFORMATION ON SAFE AND EFFICIENT OPERATION

READ THIS INFORMATION BEFORE USING YOUR MOTOROLA TWO-WAY RADIO

The information provided in this document supersedes the general safety information contained in user guides published prior to October 2000. For information regarding radio use in a hazardous atmosphere refer to the Factory Mutual (FM) manual supplement included with radio models that offer this capability and/or the intrinsic safety radio information section of this user manual.

Radio Frequency (RF) Operational Characteristics

To transmit (talk) you must push the Push-To-Talk button; to receive (listen) you must release the Push-To-Talk button. When the radio is transmitting, it generates radio frequency (RF) energy; when it is receiving, or when it is off, it does not generate RF energy.

Portable Radio Operation and EME Exposure

Your Motorola radio is designed to comply with the following national and international standards and guidelines regarding exposure of human beings to radio frequency electromagnetic energy (EME):

- United States Federal Communications Commission, Code of Federal Regulations; 47 CFR part 2 sub-part J
- American National Standards Institute (ANSI) / Institute of Electrical and Electronic Engineers (IEEE) C95. 1-1992
- Institute of Electrical and Electronic Engineers (IEEE) C95.1-1999 Edition
- National Council on Radiation Protection and Measurements (NCRP) of the United States, Report 86, 1986
- International Commission on Non-Ionizing Radiation Protection (ICNIRP) 1998
- Ministry of Health (Canada) Safety Code 6. Limits of Human Exposure to Radio Frequency Electromagnetic Fields in the Frequency Range from 3 kHz to 300 GHz, 1999
- Australian Communications Authority Radiocommunications (Electromagnetic Radiation - Human Exposure) Standard 1999 (applicable to wireless phones only)

To assure optimal radio performance and make sure human exposure to radio frequency electromagnetic energy is within the guidelines set forth in the above standards, always adhere to the following procedures:

Two-way Radio Operation

When using your radio, **hold the radio in a vertical position with the microphone one to two inches (2.5 to 5 centimeters) away from the lips.**

Body-worn Operation

To maintain compliance with FCC RF exposure guidelines, if you wear a radio on your body when transmitting, always place the radio in a Motorola approved clip, holder, holster, case, or body harness for this product. Use of non-Motorola-approved accessories may exceed FCC RF exposure guidelines. If you do not use a Motorola approved body-worn accessory and are not using the radio in the intended use positions along side of the head in the phone mode or in front of the face in the two-way radio mode, then ensure the antenna and radio is kept the following minimum distances from the body when transmitting:

- Phone or Two-way radio mode: one inch (2.5 centimeters)
- Data operation using any data feature with or without an accessory cable: one inch (2.5 centimeters)

Antenna Care

Use only the supplied or an approved replacement antenna. Unauthorized antennas, modifications, or attachments could damage the radio and may violate FCC regulations.

DO NOT hold the antenna when the radio is "IN USE". Holding the antenna affects call quality and may cause the radio to operate at a higher power level than needed.

Approved Accessories

For a list of approved Motorola accessories look in the appendix or accessory section of your radio's User Guide.

Electromagnetic Interference/Compatibility

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

Facilities

To avoid electromagnetic interference and/or compatibility conflicts, turn off your radio in any facility where posted notices instruct you to do so. Hospitals or health care facilities may be using equipment that is sensitive to external RF energy.

Aircraft

When instructed to do so, turn off your radio when on board an aircraft. Any use of a radio must be in accordance with applicable regulations per airline crew instructions.

Medical Devices

- Pacemakers

  The Health Industry Manufacturers Association recommends that a minimum separation of 6 inches (15 centimeters) be maintained between a handheld wireless radio and a pacemaker.These recommendations are consistent with those of the U.S. Food and Drug Administration.

  Persons with pacemakers should:

  - ALWAYS keep the radio more than 6 inches (15 centimeters) from their pacemaker when the radio is turned ON.
  - not carry the radio in the breast pocket.

- use the ear opposite the pacemaker to minimize the potential for interference.
- turn the radio OFF immediately if you have any reason to suspect that interference is taking place.

- Hearing Aids

  Some digital wireless radios may interfere with some hearing aids. In the event of such interference, you may want to consult your hearing aid manufacturer to discuss alternatives.

- Other Medical Devices

  If you use any other personal medical device, consult the manufacturer of your device to determine if it is adequately shielded from RF energy. Your physician may be able to assist you in obtaining this information.

SAFETY AND GENERAL

Use While Driving

Check the laws and regulations on the use of radios in the area where you drive. Always obey them.

When using your radio while driving, please:

- Give full attention to driving and to the road.
- Use hands-free operation, if available.
- Pull off the road and park before making or answering a call if driving conditions so require.

OPERATIONAL WARNINGS

FOR VEHICLES WITH AN AIR BAG

WARNING

Do not place a portable radio in the area over an air bag or in the air bag deployment area. Air bags inflate with great force. If a portable radio is placed in the air bag deployment area and the air bag inflates, the radio may be propelled with great force and cause serious injury to occupants of the vehicle.

POTENTIALLY EXPLOSIVE ATMOSPHERES

Turn off your radio prior to entering any area with a potentially explosive atmosphere, unless it is a radio type especially qualified for use in such areas as "Intrinsically Safe" (for example, Factory Mutual, CSA, UL, or CENELEC). Do not remove, install, or charge batteries in such areas. Sparks in a potentially explosive atmosphere can cause an explosion or fire resulting in bodily injury or even death.

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

BLASTING CAPS AND AREAS

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

OPERATIONAL CAUTIONS

ANTENNAS

Caution

Do not use any portable radio that has a damaged antenna. If a damaged antenna comes into contact with your skin, a minor burn can result.

BATTERIES

All batteries can cause property damage and/or bodily injury such as burns if a conductive material such as jewelry, keys, or beaded chains touch exposed terminals. The conductive material may complete an electrical circuit (short circuit) and become quite hot. Exercise care in handling any charged battery, particularly when placing it inside a pocket, purse, or other container with metal objects.

INTRINSICALLY SAFE RADIO INFORMATION

FMRC Approved Equipment

Anyone intending to use a radio in a location where hazardous concentrations of flammable material exist (hazardous atmosphere) is advised to become familiar with the subject of intrinsic safety and with the National Electric Code NFPA 70 (National Fire Protection Association) Article 500 (hazardous [classified] locations).

An Approval Guide, issued by Factory Mutual Research Corporation (FMRC), lists manufacturers and the products approved by FMRC for use in such locations. FMRC has also issued a voluntary approval standard for repair service (“Class Number 3605”).

FMRC Approval labels are attached to the radio to identify the unit as being FM Approved for specified hazardous atmospheres. This label specifies the hazardous Class/Division/Group along with the part number of the battery that must be used. Depending on the design of the portable unit, this FM label can be found on the back or the bottom of the radio housing. The FM Approval mark is shown below:

WARNINGS

WARNING

- Do not operate radio communications equipment in a hazardous atmosphere unless it is a type especially qualified for such use (e.g., FMRC Approved). An explosion or fire may result.
- Do not operate an FMRC Approved Product in a hazardous atmosphere if it has been physically damaged (e.g., cracked housing). An explosion or fire may result.
- Do not replace or charge batteries in a hazardous atmosphere. Contact sparking may occur while installing or removing batteries and cause an explosion or fire.

WARNINGS

- Do not replace or change accessories in a hazardous atmosphere. Contact sparking may occur while installing or removing accessories and cause an explosion or fire.
- Do not operate an FMRC Approved Product unit in a hazardous location with the accessory contacts exposed. Keep the connector cover in place when accessories are not used.
- Turn a radio off before removing or installing a battery or accessory.
- Do not disassemble an FMRC Approved Product unit in any way that exposes the internal electrical circuits of the unit.
- Radios must ship from the Motorola manufacturing facility with the hazardous atmosphere capability and FM Approval labeling. Radios will not be “upgraded” to this capability and labeled in the field.
- A modification changes the unit’s hardware from its original design configuration. Modifications can only be made by the original product manufacturer at one of its FMRC-audited manufacturing facilities.

WARNINGS

- Failure to use an FMRC Approved Product unit with an FMRC Approved battery or FMRC Approved accessories specifically approved for that product may result in the dangerously unsafe condition of an unapproved radio combination being used in a hazardous location.
- Unauthorized or incorrect modification of an FMRC Approved Product unit will negate the Approval rating of the product.

Repair of FMRC Approved Products

REPAIRS FOR MOTOROLA PRODUCTS WITH FMRC APPROVAL ARE THE RESPONSIBILITY OF THE USER.

You should not repair or relabel any Motorola- manufactured communication equipment bearing the FMRC Approval label (“FMRC Approved Product”) unless you are familiar with the current FMRC Approval standard for repairs and service (“Class Number 3605”).

You may want to consider using a repair facility that operates under 3605 repair service approval.

WARNINGS

- Incorrect repair or relabeling of any FMRC Approved Product unit could adversely affect the Approval rating of the unit.
- Use of a radio that is not intrinsically safe in a hazardous atmosphere could result in serious injury or death.

FMRC’s Approval Standard Class Number 3605 is subject to change at any time without notice to you, so you may want to obtain a current copy of 3605 from FMRC. Per the December 1994 publication of 3605, some key definitions and service requirements are as follows:

Repair

A repair constitutes something done internally to the unit that would bring it back to its original condition—Approved by FMRC. A repair should be done in an FMRC Approved facility.

Items not considered as repairs are those in which an action is performed on a unit which does not require the outer casing of the unit to be opened in a manner which exposes the internal electrical circuits of the unit. You do not have to be an FMRC Approved Repair Facility to perform these actions.

Relabeling

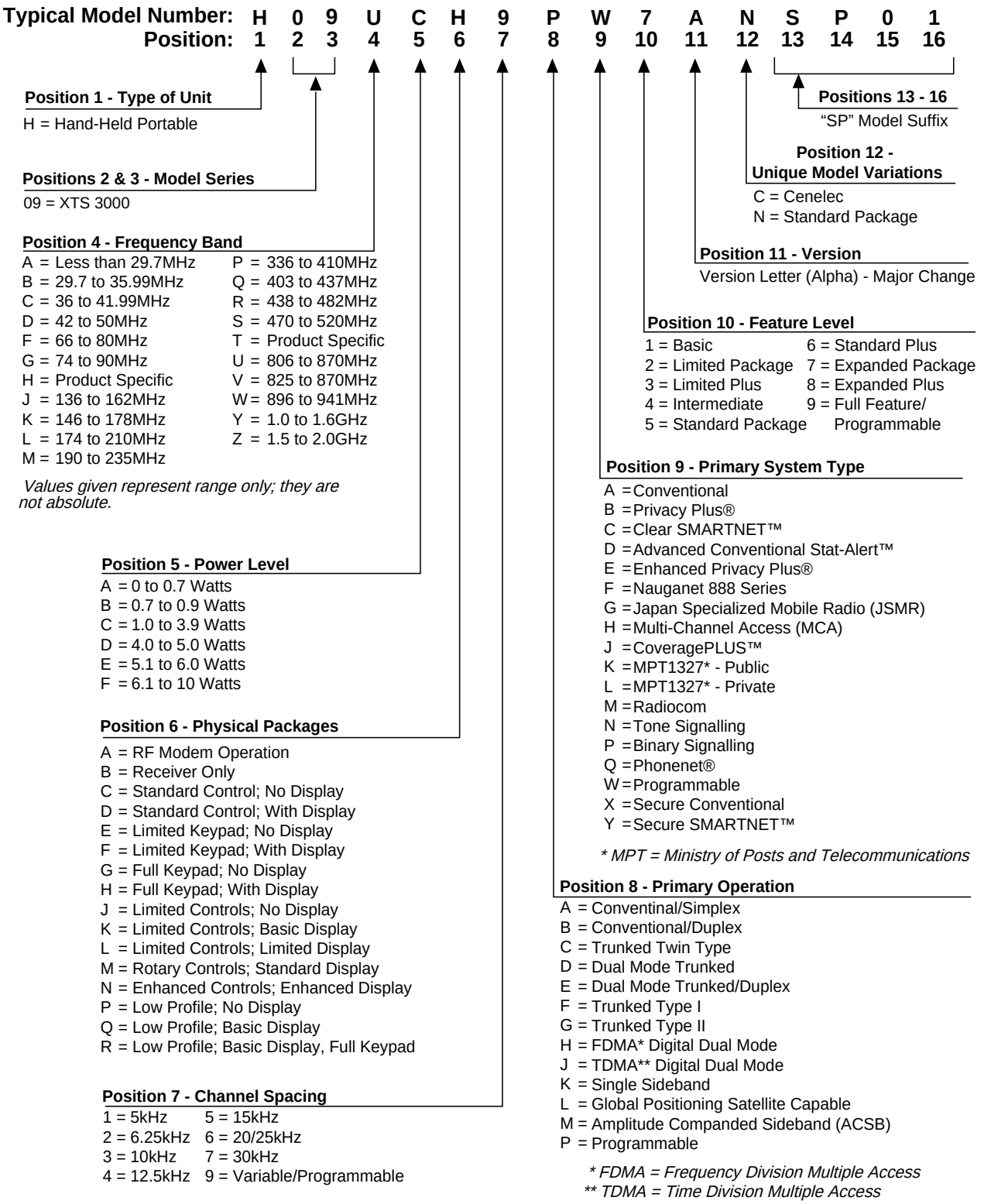
The repair facility shall have a method by which the replacement of FMRC Approval labels are controlled to ensure that any relabeling is limited to units that were originally shipped from the Manufacturer with an FM Approval label in place. FMRC Approval labels shall not be stocked by the repair facility. An FMRC Approval label shall be ordered from the original manufacturer, as needed, to repair a specific unit. Replacement labels may be obtained and applied by the repair facility, provided there is satisfactory evidence that the unit being relabeled was originally an FMRC Approved unit. Verification may include, but is not limited to: a unit with a damaged Approval label, a unit with a defective housing displaying an Approval label, or a customer invoice indicating the serial number of the unit and purchase of an FMRC Approved model.

Do Not Substitute Options or Accessories

The Motorola communications equipment certified by Factory Mutual is tested as a system and consists of the FM Approved portable, FM Approved battery, and FM Approved accessories or options, or both. This FM Approved portable and battery combination must be strictly observed. There must be no substitution of items, even if the substitute has been previously Approved with a different Motorola communications equipment unit. Approved configurations are listed in the FM Approval Guide published by FMRC, or in the product FM Supplement. This FM Supplement is shipped from the manufacturer with the FM Approved radio and battery combination. The Approval Guide, or the Approval Standard Class Number 3605 document for repairs and service, can be ordered directly from Factory Mutual Research Corporation located in Norwood, Massachusetts.

Notes:

Portable Radio Model Numbering System



ASTRO Digital XTS 3000 Model Chart (“A” Models)

MODEL NUMBER												DESCRIPTION
H09KDC9PW5AN												VHF 1-5 Watt ASTRO Digital XTS 3000 Model I
	H09KDF9PW7AN											VHF 1-5 Watt ASTRO Digital XTS 3000 Model II
		H09KDH9PW7AN										VHF 1-5 Watt ASTRO Digital XTS 3000 Model III
			H09RDC9PW5AN									UHF Range 1 1-4 Watt ASTRO Digital XTS 3000 Model I
				H09RDF9PW7AN								UHF Range 1 1-4 Watt ASTRO Digital XTS 3000 Model II
					H09RDH9PW7AN							UHF Range 1 1-4 Watt ASTRO Digital XTS 3000 Model III
						H09SDC9PW5AN						UHF Range 2 1-4 Watt ASTRO Digital XTS 3000 Model I
							H09SDF9PW7AN					UHF Range 2 1-4 Watt ASTRO Digital XTS 3000 Model II
								H09SDH9PW7AN				UHF Range 2 1-4 Watt ASTRO Digital XTS 3000 Model III
									H09UCC9PW5AN			800MHz 3 Watt ASTRO Digital XTS 3000 Model I
										H09UCF9PW7AN		800MHz 3 Watt ASTRO Digital XTS 3000 Model II
											H09UCH9PW7AN	800MHz 3 Watt ASTRO Digital XTS 3000 Model III
											ITEM NUMBER	DESCRIPTION
X	X	X	X	X	X	X	X	X	X	X	X	NCN6128_	Board, Controller *
X	X	X										NLD8898_	Board, VHF Transceiver (136-174MHz)
			X	X	X							NLE4249_	Board, UHF Range 1 Transceiver (403-470MHz)
						X	X	X				NLE4250_	Board, UHF Range 2 Transceiver (450-520MHz)
X	X	X	X	X	X	X	X	X	X	X	X	NTN8250_	Board, Vocoder **
X	X	X	X	X	X	X	X	X	X	X	X	NTN8266_	Belt Clip Kit
X	X	X	X	X	X	X	X	X	X	X	X	NTN8294_	Battery, Nickel-Cadmium (1525mAh)
		X			X			X			X	NTN8311_	Board, Keypad, Model III
	X			X			X			X		NTN8493_	Board, Keypad, Model II
X			X			X			X			NTN8272_	Kit, Front Cover, Model I
	X			X			X			X		NTN8495_	Kit, Front Cover Kit, Model II
		X			X			X			X	NTN8273_	Kit, Front Cover, Model III
									X	X	X	NUF6472_	Board, 800MHz Transceiver (806-870MHz)
X	X	X	X	X	X	X	X	X	X	X	X	0705330Z01	Bracket, Display Flex
X	X	X	X	X	X	X	X	X	X	X	X	0705368Z01	Bracket, Keypad Flex
X	X	X	X	X	X	X	X	X	X	X	X	0905585Z02	Assembly, B+ Connector
X			X			X			X			1405874Z01	Insulator, Controller
X	X	X	X	X	X	X	X	X	X	X	X	1505348Z01	Assembly, Casting
X	X	X	X	X	X	X	X	X	X	X	X	1505579Z01	Cover, Accessory Connector
X	X	X	X	X	X	X	X	X	X	X	X	2605342Z01	Shield, Controller Board
X	X	X	X	X	X	X	X	X	X	X	X	2605343Z01	Shield, RF Board
X	X	X	X	X	X	X	X	X	X	X	X	2605344Z01	Shield, Vocoder
X	X	X	X	X	X	X	X	X	X	X	X	2805214Z03	Connector, Compression, 50 Pin
X	X	X	X	X	X	X	X	X	X	X	X	2805216Z03	Connector, Compression, 20 Pin
X	X	X	X	X	X	X	X	X	X	X	X	3205082E96	Gasket, Antenna O-Ring
X	X	X	X	X	X	X	X	X	X	X	X	3205349Z02	Seal, Main
X	X	X	X	X	X	X	X	X	X	X	X	3205351Z02	Seal, B+
X	X	X	X	X	X	X	X	X	X	X	X	4205631Z01	Clip, Locking
	X	X		X	X		X	X		X	X	5105385Y19	Module, LCD Display
		X			X			X			X	7505293Z01	Keypad, Model III
	X	X		X	X		X	X		X	X	7505336Z01	Pad, Display Locator
	X			X			X			X		7585696A01	Keypad, Model II
									X	X	X	8505241U03	Antenna, 800MHz
			X	X	X	X	X	X				8505241U05	Antenna, UHF
X	X	X										8505518V01	Antenna, VHF

Notes:

X = Item Included

* = The radio’s model number, FLASHcode, Host code, and DSP code are required when placing an order for the Controller 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 Smart RIB (RLN1015_) and the RSS to read a Model I, II, or III radio

** = The Host code and the DSP code are required when placing an order for the Vocoder Board.

ASTRO Digital XTS 3000 Model Chart (”B” Models)

MODEL NUMBER												DESCRIPTION
H09KDC9PW5BN												VHF 1-5 Watt ASTRO Digital XTS 3000 Model I
	H09KDF9PW7BN											VHF 1-5 Watt ASTRO Digital XTS 3000 Model II
		H09KDH9PW7BN										VHF 1-5 Watt ASTRO Digital XTS 3000 Model III
			H09RDC9PW5BN									UHF Range 1 1-4 Watt ASTRO Digital XTS 3000 Model I
				H09RDF9PW7BN								UHF Range 1 1-4 Watt ASTRO Digital XTS 3000 Model II
					H09RDH9PW7BN							UHF Range 1 1-4 Watt ASTRO Digital XTS 3000 Model III
						H09SDC9PW5BN						UHF Range 2 1-4 Watt ASTRO Digital XTS 3000 Model I
							H09SDF9PW7BN					UHF Range 2 1-4 Watt ASTRO Digital XTS 3000 Model II
								H09SDH9PW7BN				UHF Range 2 1-4 Watt ASTRO Digital XTS 3000 Model III
									H09UCC9PW5BN			800MHz 3 Watt ASTRO Digital XTS 3000 Model I
										H09UCF9PW7BN		800MHz 3 Watt ASTRO Digital XTS 3000 Model II
											H09UCH9PW7BN	800MHz 3 Watt ASTRO Digital XTS 3000 Model III
											ITEM NUMBER	DESCRIPTION
X	X	X	X	X	X	X	X	X	X	X	X	NCN6167_	Board, Controller *
X	X	X										NLD8898_	Board, VHF Transceiver (136-174MHz)
			X	X	X							NLE4249_	Board, UHF Range 1 Transceiver (403-470MHz)
						X	X	X				NLE4250_	Board, UHF Range 2 Transceiver (450-520MHz)
X	X	X	X	X	X	X	X	X	X	X	X	NTN8250_	Board, Vocoder **
X	X	X	X	X	X	X	X	X	X	X	X	NTN8266_	Belt Clip Kit
X	X	X	X	X	X	X	X	X	X	X	X	NTN8294_	Battery, Nickel-Cadmium (1525mAh)
		X			X			X			X	NTN8311_	Board, Keypad, Model III
	X			X			X			X		NTN8493_	Board, Keypad, Model II
X			X			X			X			NTN8751_	Kit, Front Cover, Model I
	X			X			X			X		NTN8752_	Kit, Front Cover Kit, Model II
		X			X			X			X	NTN8753_	Kit, Front Cover, Model III
									X	X	X	NUF6472_	Board, 800MHz Transceiver (806-870MHz)
X	X	X	X	X	X	X	X	X	X	X	X	0705330Z01	Bracket, Display Flex
X	X	X	X	X	X	X	X	X	X	X	X	0705368Z01	Bracket, Keypad Flex
X	X	X	X	X	X	X	X	X	X	X	X	0905585Z02	Assembly, B+ Connector
X			X			X			X			1405874Z01	Insulator, Controller
X	X	X	X	X	X	X	X	X	X	X	X	1505348Z01	Assembly, Casting
X	X	X	X	X	X	X	X	X	X	X	X	1505579Z01	Cover, Accessory Connector
X	X	X	X	X	X	X	X	X	X	X	X	2605342Z01	Shield, Controller Board
X	X	X	X	X	X	X	X	X	X	X	X	2605343Z01	Shield, RF Board
X	X	X	X	X	X	X	X	X	X	X	X	2605344Z01	Shield, Vocoder
X	X	X	X	X	X	X	X	X	X	X	X	2805214Z03	Connector, Compression, 50 Pin
X	X	X	X	X	X	X	X	X	X	X	X	2805216Z03	Connector, Compression, 20 Pin
X	X	X	X	X	X	X	X	X	X	X	X	3205082E96	Gasket, Antenna O-Ring
X	X	X	X	X	X	X	X	X	X	X	X	3205349Z02	Seal, Main
X	X	X	X	X	X	X	X	X	X	X	X	3205351Z02	Seal, B+
X	X	X	X	X	X	X	X	X	X	X	X	4205631Z01	Clip, Locking
	X	X		X	X		X	X		X	X	5105385Y19	Module, LCD Display
		X			X			X			X	7505293Z01	Keypad, Model III
	X	X		X	X		X	X		X	X	7505336Z01	Pad, Display Locator
	X			X			X			X		7585696A01	Keypad, Model II
									X	X	X	8505241U03	Antenna, 800MHz
			X	X	X	X	X	X				8505241U05	Antenna, UHF
X	X	X										8505518V01	Antenna, VHF

Notes:

X = Item Included

* = The radio’s model number, FLASHcode, Host code, and DSP code are required when placing an order for the Controller 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 Smart RIB (RLN1015_) and the RSS to read a Model I, II, or III radio

** = The Host code and the DSP code are required when placing an order for the Vocoder Board.

ASTRO Digital XTS 3000 R (Ruggedized) Model Chart

MODEL NUMBER	DESCRIPTION
H09KDC9PW5BN	Ruggedized VHF 1-5 Watt ASTRO Digital XTS 3000 Model I
H09KDF9PW7BN	Ruggedized VHF 1-5 Watt ASTRO Digital XTS 3000 Model II
H09KDH9PW7BN	Ruggedized VHF 1-5 Watt ASTRO Digital XTS 3000 Model III
H09RDC9PW5BN	Ruggedized UHF Range 1 1-4 Watt ASTRO Digital XTS 3000 Model I
H09RDF9PW7BN	Ruggedized UHF Range 1 1-4 Watt ASTRO Digital XTS 3000 Model II
H09RDH9PW7BN	Ruggedized UHF Range 1 1-4 Watt ASTRO Digital XTS 3000 Model III
H09SDC9PW5BN	Ruggedized UHF Range 2 1-4 Watt ASTRO Digital XTS 3000 Model I
H09SDF9PW7BN	Ruggedized UHF Range 2 1-4 Watt ASTRO Digital XTS 3000 Model II
H09SDH9PW7BN	Ruggedized UHF Range 2 1-4 Watt ASTRO Digital XTS 3000 Model III
H09UCC9PW5BN	Ruggedized 800MHz 3 Watt ASTRO Digital XTS 3000 Model I
H09UCF9PW7BN	Ruggedized 800MHz 3 Watt ASTRO Digital XTS 3000 Model II
H09UCH9PW7BN	Ruggedized 800MHz 3 Watt ASTRO Digital XTS 3000 Model III

												ITEM NUMBER	DESCRIPTION
X	X	X	X	X	X	X	X	X	X	X	X	NCN6167_	Board, Controller *
X	X	X										NLD8898_	Board, VHF Transceiver (136-174MHz)
			X	X	X							NLE4249_	Board, UHF Range 1 Transceiver (403-470MHz)
						X	X	X				NLE4250_	Board, UHF Range 2 Transceiver (450-520MHz)
X	X	X	X	X	X	X	X	X	X	X	X	NTN8250_	Board, Vocoder **
X	X	X	X	X	X	X	X	X	X	X	X	NTN8266_	Belt Clip Kit
X	X	X	X	X	X	X	X	X	X	X	X	NTN8297_	Battery, Nickel-Cadmium (1525mAh)
		X			X			X			X	NTN8311_	Board, Keypad, Model III
	X			X			X			X		NTN8493_	Board, Keypad, Model II
X			X			X			X			NTN8650_	Kit, Ruggedized Front Cover, Model I
	X			X			X			X		NTN8651_	Kit, Ruggedized Front Cover, Model II
		X			X			X			X	NTN8652_	Kit, Ruggedized Front Cover, Model III
									X	X	X	NUF6472_	Board, 800MHz Transceiver (806-870MHz)
X	X	X	X	X	X	X	X	X	X	X	X	0705330Z01	Bracket, Display Flex
X	X	X	X	X	X	X	X	X	X	X	X	0705368Z01	Bracket, Keypad Flex
X	X	X	X	X	X	X	X	X	X	X	X	0905585Z03	Assembly, B+ Connector
X			X			X			X			1405874Z01	Insulator, Controller
X	X	X	X	X	X	X	X	X	X	X	X	1505348Z04	Assembly, Casting
X	X	X	X	X	X	X	X	X	X	X	X	1505579Z01	Cover, Accessory Connector
X	X	X	X	X	X	X	X	X	X	X	X	2605342Z01	Shield, Controller Board
X	X	X	X	X	X	X	X	X	X	X	X	2605343Z01	Shield, RF Board
X	X	X	X	X	X	X	X	X	X	X	X	2605344Z01	Shield, Vocoder
X	X	X	X	X	X	X	X	X	X	X	X	2805214Z03	Connector, Compression, 50 Pin
X	X	X	X	X	X	X	X	X	X	X	X	2805216Z03	Connector, Compression, 20 Pin
X	X	X	X	X	X	X	X	X	X	X	X	3205082E96	Gasket, Antenna O-Ring
X	X	X	X	X	X	X	X	X	X	X	X	3205349Z02	Seal, Main
X	X	X	X	X	X	X	X	X	X	X	X	3205351Z02	Seal, B+
X	X	X	X	X	X	X	X	X	X	X	X	4205631Z01	Clip, Locking
	X	X		X	X		X	X		X	X	5105385Y19	Module, LCD Display
		X			X			X			X	7505293Z02	Keypad, Model III
	X	X		X	X		X	X		X	X	7505336Z01	Pad, Display Locator
	X			X			X			X		7585696A02	Keypad, Model II
									X	X	X	8505241U03	Antenna, 800MHz
			X	X	X	X	X	X				8505241U05	Antenna, UHF
X	X	X										8505518V01	Antenna, VHF

Notes:

X = Item Included

* = The radio's model number, FLASHcode, Host code, and DSP code are required when placing an order for the Controller 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 Smart RIB (RLN1015_) and the RSS to read a Model I, II, or III radio

** = The Host code and the DSP code are required when placing an order for the Vocoder Board.

ASTRO Digital XTS 3000 R (Ruggedized) Yellow Model Chart

MODEL NUMBER												DESCRIPTION
H09KDC9PW5BN												Ruggedized Yellow VHF 1-5 Watt ASTRO Digital XTS 3000 Model I
	H09KDF9PW7BN											Ruggedized Yellow VHF 1-5 Watt ASTRO Digital XTS 3000 Model II
		H09KDH9PW7BN										Ruggedized Yellow VHF 1-5 Watt ASTRO Digital XTS 3000 Model III
			H09RDC9PW5BN									Ruggedized Yellow UHF Range 1 1-4 Watt ASTRO Digital XTS 3000 Model I
				H09RDF9PW7BN								Ruggedized Yellow UHF Range 1 1-4 Watt ASTRO Digital XTS 3000 Model II
					H09RDH9PW7BN							Ruggedized Yellow UHF Range 1 1-4 Watt ASTRO Digital XTS 3000 Model III
						H09SDC9PW5BN						Ruggedized Yellow UHF Range 2 1-4 Watt ASTRO Digital XTS 3000 Model I
							H09SDF9PW7BN					Ruggedized Yellow UHF Range 2 1-4 Watt ASTRO Digital XTS 3000 Model II
								H09SDH9PW7AN				Ruggedized Yellow UHF Range 2 1-4 Watt ASTRO Digital XTS 3000 Model III
									H09UCC9PW5BN			Ruggedized Yellow 800MHz 3 Watt ASTRO Digital XTS 3000 Model I
										H09UCF9PW7BN		Ruggedized Yellow 800MHz 3 Watt ASTRO Digital XTS 3000 Model II
											H09UCH9PW7BN	Ruggedized Yellow 800MHz 3 Watt ASTRO Digital XTS 3000 Model III
											ITEM NUMBER	DESCRIPTION
X	X	X	X	X	X	X	X	X	X	X	X	NCN6167_	Board, Controller *
X	X	X										NLD8898_	Board, VHF Transceiver (136-174MHz)
			X	X	X							NLE4249_	Board, UHF Range 1 Transceiver (403-470MHz)
						X	X	X				NLE4250_	Board, UHF Range 2 Transceiver (450-520MHz)
X	X	X	X	X	X	X	X	X	X	X	X	NTN8250_	Board, Vocoder **
X	X	X	X	X	X	X	X	X	X	X	X	NTN8266_	Belt Clip Kit
X	X	X	X	X	X	X	X	X	X	X	X	NTN8294_	Battery, Nickel-Cadmium (1525mAh)
		X			X			X			X	NTN8311_	Board, Keypad, Model III
	X			X			X			X		NTN8493_	Board, Keypad, Model II
X			X			X			X			NTN8669_	Kit, Ruggedized Yellow Front Cover, Model I
	X			X			X			X		NTN8670_	Kit, Ruggedized Yellow Front Cover, Model II
		X			X			X			X	NTN8671_	Kit, Ruggedized Yellow Front Cover, Model III
									X	X	X	NUF6472_	Board, 800MHz Transceiver (806-870MHz)
X	X	X	X	X	X	X	X	X	X	X	X	0705330Z01	Bracket, Display Flex
X	X	X	X	X	X	X	X	X	X	X	X	0705368Z01	Bracket, Keypad Flex
X	X	X	X	X	X	X	X	X	X	X	X	0905585Z03	Assembly, B+ Connector
X			X			X			X			1405874Z01	Insulator, Controller
X	X	X	X	X	X	X	X	X	X	X	X	1505348Z04	Assembly, Casting
X	X	X	X	X	X	X	X	X	X	X	X	1505579Z01	Cover, Accessory Connector
X	X	X	X	X	X	X	X	X	X	X	X	2605342Z01	Shield, Controller Board
X	X	X	X	X	X	X	X	X	X	X	X	2605343Z01	Shield, RF Board
X	X	X	X	X	X	X	X	X	X	X	X	2605344Z01	Shield, Vocoder
X	X	X	X	X	X	X	X	X	X	X	X	2805214Z03	Connector, Compression, 50 Pin
X	X	X	X	X	X	X	X	X	X	X	X	2805216Z03	Connector, Compression, 20 Pin
X	X	X	X	X	X	X	X	X	X	X	X	3205082E96	Gasket, Antenna O-Ring
X	X	X	X	X	X	X	X	X	X	X	X	3205349Z02	Seal, Main
X	X	X	X	X	X	X	X	X	X	X	X	3205351Z02	Seal, B+
X	X	X	X	X	X	X	X	X	X	X	X	4205631Z01	Clip, Locking
	X	X		X	X		X	X		X	X	5105385Y19	Module, LCD Display
		X			X			X			X	7505293Z02	Keypad, Model III
	X	X		X	X		X	X		X	X	7505336Z01	Pad, Display Locator
	X			X			X			X		7585696A02	Keypad, Model II
									X	X	X	8505241U03	Antenna, 800MHz
			X	X	X	X	X	X				8505241U05	Antenna, UHF
X	X	X										8505518V01	Antenna, VHF

Notes:

X = Item Included

* = The radio's model number, FLASHcode, Host code, and DSP code are required when placing an order for the Controller 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 Smart RIB (RLN1015_) and the RSS to read a Model I, II, or III radio

** = The Host code and the DSP code are required when placing an order for the Vocoder Board.

Model History Tables

The following tables include all of the ASTRO XTS 3000 Digital Portable Radio models from the beginning of this product line to date. Each table includes model number, model number description, and the part numbers of the front cover kit, transceiver board (Xcvr Bd), controller board, and vocoder board that shipped with that particular model.

Standard Models

Model Number	Description	Front Cover Kit	Xcvr Board	Controller Board	Vocoder Board
H09KDC9PW5AN	VHF 1-5 Watt Model I	NTN8272C	NLD8898C	NCN6128B	NTN8250C
			NLD8898E		NTN8250D
H09KDC9PW5BN	VHF 1-5 Watt Model I	NTN8751A	NLD8898E	NCN6167A	NTN8250D
H09KDF9PW7AN	VHF 1-5 Watt Model II	NTN8495A	NLD8898C	NCN6128B	NTN8250C
			NLD8898E		NTN8250D
H09KDF9PW7BN	VHF 1-5 Watt Model II	NTN8752A	NLD8898E	NCN6167A	NTN8250D
H09KDH9PW7AN	VHF 1-5 Watt Model III	NTN8273B	NLD8898C	NCN6128B	NTN8250C
			NLD8898E		NTN8250D
H09KDH9PW7BN	VHF 1-5 Watt Model III	NTN8753A	NLD8898E	NCN6167A	NTN8250D
H09RDC9PW5AN	UHF Range 1 1-4 Watt Model I	NTN8272C	NLE4249A	NCN6128B	NTN8250C
			NLE4249B		NTN8250D
H09RDC9PW5BN	UHF Range 1 1-4 Watt Model I	NTN8751A	NLE4249B	NCN6167A	NTN8250D
H09RDF9PW7AN	UHF Range 1 1-4 Watt Model II	NTN8495A	NLE4249A	NCN6128B	NTN8250C
			NLE4249B		NTN8250D
H09RDF9PW7BN	UHF Range 1 1-4 Watt Model II	NTN8752A	NLE4249B	NCN6167A	NTN8250D
H09RDH9PW7AN	UHF Range 1 1-4 Watt Model III	NTN8273B	NLE4249A	NCN6128B	NTN8250C
			NLE4249B		NTN8250D
H09RDH9PW7BN	UHF Range 1 1-4 Watt Model III	NTN8753A	NLE4249B	NCN6167A	NTN8250D
H09SDC9PW5AN	UHF Range 2 1-4 Watt Model I	NTN8272C	NLE4250A	NCN6128B	NTN8250C
			NLE4250B		NTN8250D
H09SDC9PW5BN	UHF Range 2 1-4 Watt Model I	NTN8751A	NLE4250B	NCN6167A	NTN8250D
H09SDF9PW7AN	UHF Range 2 1-4 Watt Model II	NTN8495A	NLE4250A	NCN6128B	NTN8250C
			NLE4250B		NTN8250D
H09SDF9PW7BN	UHF Range 2 1-4 Watt Model II	NTN8752A	NLE4250B	NCN6167A	NTN8250D
H09SDH9PW7AN	UHF Range 2 1-4 Watt Model III	NTN8273B	NLE4250A	NCN6128B	NTN8250C
			NLE4250B		NTN8250D
H09SDH9PW7BN	UHF Range 2 1-4 Watt Model III	NTN8753A	NLE4250B	NCN6167A	NTN8250D

Standard Models

Model Number	Description	Front Cover Kit	Xcvr Board	Controller Board	Vocoder Board
H09UCC9PW5AN	800MHz 3 Watt Model I	NTN8272C	NUF6472B	NCN6128B	NTN8250C
			NUF6472B		NTN8250D
H09UCC9PW5BN	800MHz 3 Watt Model I	NTN8751A	NUF6472B	NCN6167A	NTN8250D
H09UCF9PW7AN	800MHz 3 Watt Model II	NTN8495A	NUF6472B	NCN6128B	NTN8250C
			NUF6472B		NTN8250D
H09UCF9PW7BN	800MHz 3 Watt Model II	NTN8752A	NUF6472B	NCN6167A	NTN8250D
H09UCH9PW7AN	800MHz 3 Watt Model III	NTN8273B	NUF6472B	NCN6128B	NTN8250C
			NUF6472B		NTN8250D
H09UCH9PW7BN	800MHz 3 Watt Model III	NTN8753A	NUF6472B	NCN6167A	NTN8250D

Note 1: When replacing an NTN8272C, NTN8495A, or NTN8273B Front Housing Kit with a new NTN8751A, NTN8752A, or NTN8753A Front Housing Kit, respectively, an NCN6167A Controller Board must also be ordered to replace the NCN6128D Controller Board. For example, for H09KDC9PW5AN, to replace NTN8272C with NTN8751A, you must also order NCN6167A to replace NCN6128D, because NTN8151A is NOT compatible with NCN6128D.

Note 2: When replacing an NCN6128D Controller Board with an NCN6167A Controller Board, the NTN8272C, NTN8495A, or NTN8273B Front Housing Kit must also be replaced by a new NTN8751A, NTN8752A, or NTN8753A Front Housing Kit, respectively. For example, for model H09KDC9PW5AN, to replace NCN6128D, you must also order NTN8751A to replace NTN8272C, because NCN6167A is NOT compatible with NTN8272C.

Ruggedized Models

Model Number	Description	Front Cover Kit	Transceiver Board	Controller Board	Vocoder Board
H09KDC9PW5BN	VHF 1-5 Watt Model I	NTN8650A	NLD8898E	NCN6167A	NTN8250D
H09KDF9PW7BN	VHF 1-5 Watt Model II	NTN8651A	NLD8898E	NCN6167A	NTN8250D
H09KDH9PW7BN	VHF 1-5 Watt Model III	NTN8652A	NLD8898E	NCN6167A	NTN8250D
H09RDC9PW5BN	UHF Range 1 1-4 Watt Model I	NTN8650A	NLE4249B	NCN6167A	NTN8250D
H09RDF9PW7BN	UHF Range 1 1-4 Watt Model II	NTN8651A	NLE4249B	NCN6167A	NTN8250D
H09RDH9PW7BN	UHF Range 1 1-4 Watt Model III	NTN8652A	NLE4249B	NCN6167A	NTN8250D
H09SDC9PW5BN	UHF Range 2 1-4 Watt Model I	NTN8650A	NLE4250B	NCN6167A	NTN8250D
H09SDF9PW7BN	UHF Range 2 1-4 Watt Model II	NTN8651A	NLE4250B	NCN6167A	NTN8250D
H09SDH9PW7BN	UHF Range 2 1-4 Watt Model III	NTN8652A	NLE4250B	NCN6167A	NTN8250D
H09UCC9PW5BN	800MHz 3 Watt Model I	NTN8650A	NUF6472B	NCN6167A	NTN8250D
H09UCF9PW7BN	800MHz 3 Watt Model II	NTN8651A	NUF6472B	NCN6167A	NTN8250D
H09UCH9PW7BN	800MHz 3 Watt Model III	NTN8652A	NUF6472B	NCN6167A	NTN8250D

Ruggedized Yellow Models

Model Number	Description	Front Cover Kit	Transceiver Board	Controller Board	Vocoder Board
H09KDC9PW5BN	VHF 1-5 Watt Model I	NTN8699A	NLD8898E	NCN6167A	NTN8250D
H09KDF9PW7BN	VHF 1-5 Watt Model II	NTN8670A	NLD8898E	NCN6167A	NTN8250D
H09KDH9PW7BN	VHF 1-5 Watt Model III	NTN8671A	NLD8898E	NCN6167A	NTN8250D
H09RDC9PW5BN	UHF Range 1 1-4 Watt Model I	NTN8699A	NLE4249B	NCN6167A	NTN8250D
H09RDF9PW7BN	UHF Range 1 1-4 Watt Model II	NTN8670A	NLE4249B	NCN6167A	NTN8250D
H09RDH9PW7BN	UHF Range 1 1-4 Watt Model III	NTN8671A	NLE4249B	NCN6167A	NTN8250D
H09SDC9PW5BN	UHF Range 2 1-4 Watt Model I	NTN8699A	NLE4250B	NCN6167A	NTN8250D
H09SDF9PW7BN	UHF Range 2 1-4 Watt Model II	NTN8670A	NLE4250B	NCN6167A	NTN8250D
H09SDH9PW7BN	UHF Range 2 1-4 Watt Model III	NTN8671A	NLE4250B	NCN6167A	NTN8250D
H09UCC9PW5BN	800MHz 3 Watt Model I	NTN8699A	NUF6472B	NCN6167A	NTN8250D
H09UCF9PW7BN	800MHz 3 Watt Model II	NTN8670A	NUF6472B	NCN6167A	NTN8250D
H09UCH9PW7BN	800MHz 3 Watt Model III	NTN8671A	NUF6472B	NCN6167A	NTN8250D

Glossary

A/D	Analog to Digital converter; converts an instantaneous dc voltage level to a corresponding digital value.
ABACUS IC	Custom integrated circuit providing a digital receiver IF backend.
ADSIC	ABACUS/DSP Support IC; custom integrated circuit providing peripheral functions for the DSP.
ALC	Automatic Level Control; a circuit in the transmit RF path that controls RF power amplifier output, provides leveling over frequency and voltage, and protects against high VSWR.
CBI	Controller Board Initialization; a process by which a replacement Controller Board can be initialized with the serial number of the radio into which it will be installed. This initialization is a one-shot process, and must therefore be approached with care.
D/A	Digital to Analog converter; converts a digital value to a corresponding dc voltage value.
DTMF	Dual Tone Multi-Frequency
DPL	Digital Private-Line™
DSP	Digital Signal Processor; microcontroller specifically tailored for signal processing computations. In this case refers specifically to Motorola DSP56001.
DSP Code	Digital Signal Processor Code; object code executed by the Digital Signal Processor in an ASTRO or XTS3000 subscriber radio. The DSP is responsible for computation-intensive tasks, such as decoding ASTRO signalling
Firmware	Code executed by an embedded processor such as the Host or DSP in a subscriber radio. This type of code is typically resident in non-volatile memory and as such is more difficult to change than code executed from RAM.
FGU	Frequency Generation Unit
FLASHcode	A 13-digit code which uniquely identifies the System Software Package and Software Revenue Options that are enabled in a particular subscriber radio. FLASHcodes are only applicable for radios which are upgradeable through the FLASHport process.
FLASHport™	A Motorola term that describes the ability of a radio to change memory. Every FLASHport radio contains a FLASHport EEPROM memory chip that can be software written and rewritten to, again and again.
Host	Motorola HC11F1 microcontrol unit U204 (see MCU).
Host Code	Object code executed by the Host Processor in an ASTRO or XTS3000 subscriber radio. The Host is responsible for control-oriented tasks such as decoding and responding to user inputs.

Host Port	Parallel memory mapped interface consisting of eight registers in the DSP56001.
IC	Integrated Circuit
IMBE	A sub-band, voice encoding algorithm used in ASTRO digital voice.
ISW	Inbound Signalling Word; data transmitted on the control channel from a subscriber unit to the central control unit.
LSH	Low Speed Handshake; 150 baud digital data sent to the radio during trunked operation while receiving audio.
MCU	MicroControl Unit
MDC	Motorola Digital Communications
OMPAC	Over-Molded Pad-Array Carrier; a Motorola custom IC package, distinguished by the presence of solder balls on the bottom pads.
Open **Architecture**	A controller configuration that utilizes a microprocessor with extended ROM, RAM, and EEPROM.
OSW	Outbound Signalling Word; data transmitted on the control channel from the central controller to the subscriber unit.
PC Board	Printed Circuit board
PL	Private-Line® tone squelch; a continuous sub-audible tone that is transmitted along with the carrier.
PLL	Phase-Locked Loop; a circuit in which an oscillator is kept in phase with a reference, usually after passing through a frequency divider.
PTT	Push-To-Talk; the switch located on the left side of the radio which, when pressed, causes the radio to transmit.
Registers	Short-term data-storage circuits within the microcontrol unit or programmable logic IC.
Repeater	Remote transmit/receive facility that re-transmits received signals in order to improve communications coverage.
RESET	Reset line; an input to the microcontroller that restarts execution.
RF PA	Radio Frequency Power Amplifier
RSS	Radio Service Software
RPT/TA	RePeaTer/Talk-Around
RX DATA	Recovered digital data line.
Signal Qualifier Mode	An operating mode whereby the radio is muted but still continues to analyze receive data to determine RX signal type.

SCI IN	Serial Communication Interface INput line
SLIC	Support-Logic IC; a custom gate array used to provide I/O and memory expansion for the microcontroller.
Smart RIB	Smart Radio Interface Box; a service aid that enables communications between the radio and the computer's serial communications adapter. Used in conjunction with the RSS to read the DSP Code, FLASHcode, Host Code, and model number.
Softpot	Software potentiometer; a computer-adjustable electronic attenuator.
Software	Computer programs, procedures, rules, documentation, and data pertaining to the operation of a system.
SPI	Serial Peripheral Interface; how the microcontroller communicates to modules and ICs through the CLOCK and DATA lines.
Squelch	Muting of audio circuits when received signal levels fall below a pre-determined value.
SRAM	Static-RAM chip used for volatile, program/data memory.
SSI	Synchronous Serial Interface on the DSP56001 consisting of six signals and used for an RX and TX modulated data interface to the ADSIC.
Standby Mode	An operating mode whereby the radio is muted but still continues to monitor data.
System Central Controllers	Main control unit of the trunked dispatch system; handles ISW and OSW messages to and from subscriber units (see ISW and OSW).
System Select	The act of selecting the desired operating system with the system-select switch (also, the name given to this switch).
TOT	Time-Out Timer; a timer that limits the length of a transmission.
TSOP	Thin Small-Outline Package
UART	Universal Asynchronous Receiver Transmitter.
µC	Microcontrol unit (see MCU).
VCO	Voltage-Controlled Oscillator; an oscillator whereby the frequency of oscillation can be varied by changing a control voltage.
VCOB IC	Voltage-Controlled Oscillator Buffer IC
Vocoder	VOice enCODER; the DSP-based system for digitally processing the analog signals, includes the capabilities of performing voice compression algorithms or voice encoding.
VSELP	Vector Sum Excited Linear Predictive coding; a voice encoding technique used in ASTRO digital voice.
VSWR	Voltage Standing Wave Ratio

Notes

Introduction

1

General

This manual includes all the information needed to maintain peak product performance and maximum working-time. This detailed level of service (component level) is typical of some service centers, self-maintained customers, and distributors. This manual is to be used in conjunction with the ASTRO Digital XTS 3000 Portable Radios Basic Service Manual (Motorola part number 68P81083C85), which uses the pass/fail service approach to radio problems.

Conduct the basic performance checks first. This will verify the actual need for analyzing the radio and help pinpoint the functional problem area. In addition, the technician will become familiar with the radio test mode of operation, which is a helpful tool. If any basic receive or transmitter parameters fail, then the radio should be aligned per the radio alignment procedure.

Included in other areas of this manual are disassembly/reassembly procedures, functional block diagrams, detailed theory of operation, troubleshooting charts and waveforms, schematics and parts lists, a nd exploded view and parts list. The technician should be very familiar with these sections to aid in determining the problem circuit. Also included are component location diagrams to aid in locating individual circuit components and some IC diagrams, which point out some convenient probe points.

The theory of operation sections of this manual contain detailed descriptions of the operations of many circuits. Once the area of the problem is located, it would be strongly advisable to review the operation of the circuit pertaining to the troubleshooting flow chart.

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, etc., which is essential to emphasize.

Caution

CAUTION indicates a potentially hazardous situation which, if not avoided, may result in equipment damage. To properly word a caution, first identify the gravity of the risk, then describe the nature of the risk, then tell the user how to avoid the risk, and finally communicate this risk clearly to the person exposed to the risk.

WARNING

WARNING indicates a potentially hazardous situation which, if not avoided, could result in death or injury. To properly word a caution, first identify the gravity of the risk, then describe the nature of the risk, then tell the user how to avoid the risk, and finally communicate this risk clearly to the person exposed to the risk.

DANGER

DANGER indicates an imminently hazardous situation which, if not avoided, will result in death or injury. To properly word a caution, first identify the gravity of the risk, then describe the nature of the risk, then tell the user how to avoid the risk, and finally communicate this risk clearly to the person exposed to the risk.

In this publication you will also find the use of the asterisk symbol (*) to indicate a negative or NOT logic true signal.

General Overview of an ASTRO Digital XTS 3000 Radio

2

The ASTRO Digital XTS 3000 radio is a dual-mode (trunked/conventional), 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, it provides for digital modulation techniques, utilizing voice encoding techniques with error correction schemes, to provide 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 add the capability of supporting a multitude of system features.

The three ASTRO Digital XTS 3000 radio models (I, II, and III) are available in the VHF (136-174MHz) band, two UHF bands (403-470MHz and 450-512MHz), and the 800MHz (806-870MHz) band.

The ASTRO Digital XTS 3000 radio consists of:

- a vocoder (DSP) board,
- a controller board,
- a band-dependent transceiver (RF) board,
- display and keypad assemblies (models II and III only), and
- an encryption board (in secure models only).

The vocoder board consists of a Digital Signal Processor (DSP), Static-RAM (SRAM), FLASH program memory, and a custom ABACUS/DSP support integrated circuit (ADSIC). This section handles all the analog and signaling functions previously accomplished with analog integrated circuits (ICs) by processing the signals digitally. In addition, it provides advanced digital signal processing functions which include digital modulation and voice encoding techniques while still maintaining compatibility with today's analog radio systems.

The controller board consists of a microcontroller with FLASH program memory, EEPROM, SRAM, audio power amplifier (audio PA), and a custom IC—the SLIC. This section handles general radio control and ergonomics through the various user buttons, and rotary knobs.

The transceiver is frequency dependent, and one transceiver exists for each of the bands: VHF, UHF (range 1 and 2), and 800MHz. The distinction with these transceivers is the incorporation of the ABACUS IC. The ABACUS is a digital IF/Discriminator which provides a true digital interface to the digital circuitry of the vocoder.

The display module is a four-line x 12-character, liquid-crystal display (LCD) with associated circuitry. This module utilizes chip-on-board technology and is not considered field repairable.

The keypad module is either a 6 x 3- or a 2 x 3-button module with backlighting.

The encryption board (secure models only) connects directly to the controller board and interfaces directly with the vocoder digital circuitry. It contains an independent microcontroller and two custom ICs to perform digital, numerical, encryption algorithms.

Analog Mode of Operation

When the radio is *receiving*, the signal comes from the antenna/ antenna-switch connector to the transceiver board, passes through the RX/TX switch and the receiver front end. The signal is then filtered, amplified, and mixed with the first local-oscillator signal generated by the voltage-controlled oscillator (VCO). The resulting intermediate frequency (IF) signal is fed to the IF circuitry, where it is again filtered and amplified. This amplified signal is passed to the digital back-end IC, where it is mixed with the second local oscillator to create the second IF at 450kHz. It is then converted to a digital bit stream and mixed a third time to produce a baseband signal. This signal is passed to the vocoder board through a current-driven differential output. On the vocoder board, the ADSIC (ABACUS DSP Support IC) digitally filters and discriminates the signal, and passes it to the digital-signal processor (DSP). The DSP decodes the information in the signal and identifies the appropriate destination for it. For a voice signal, the DSP will route the digital voice data to the ADSIC for conversion to an analog signal. The ADSIC will then present the signal to the controller board's audio power amplifier, which drives the speaker. For signalling information, the DSP will decode the message and pass it to the microcontrol unit.

When the radio is *transmitting*, microphone audio is passed from the audio power amplifier (PA) to the ADSIC, where the signal is digitized. The ADSIC passes digital data to the DSP, where pre-emphasis and low-pass (splatter) filtering are done. The DSP returns this signal to the ADSIC, where it is reconverted into an analog signal and scaled for application to the voltage-controlled oscillator as a modulation signal. Transmitted signalling information is accepted by the DSP from the microcontrol unit, coded appropriately, and passed to the ADSIC, which handles it the same as a voice signal. Analog modulation information is passed to the synthesizer along the modulation line. A modulated carrier is provided to the RF PA, which transmits the signal under dynamic power control.

ASTRO Mode (Digital Mode) of Operation

In the ASTRO mode (digital mode) of operation, the transmitted or received signal is limited to a discrete set of four deviation levels. The receiver handles an ASTRO-mode signal identically to an analog-mode signal up to the point where the DSP decodes the received data. In the ASTRO receive mode, the DSP uses a specifically defined algorithm to recover information. In the ASTRO transmit mode, microphone audio is processed identically to an analog mode with the exception of the algorithm the DSP uses to encode the information. This algorithm will result in deviation levels that are limited to four discrete levels.

Transceiver Board Overview

The receiver front end consists of a preselector, an RF amplifier, a second preselector, and a mixer. In the VHF and UHF radios, both preselectors are varactor-tuned, two-pole filters controlled by the microcontrol unit (MCU) through the digital/analog (D/A) IC. On the 800MHz receiver front end, these filters are fixed-tuned. The RF amplifier is a dual-gate, gallium- arsenide based IC. The mixer is a double-balanced, active mixer coupled by transformers. Injection is provided by the VCO through an injection filter. See Table 14 for local oscillator (LO) and first IF information.

The frequency generation function is performed by three ICs and associated circuitry. The reference oscillator provides a frequency standard to the synthesizer/prescaler IC, which controls the VCO IC. The VCO IC actually generates the first LO and transmit-injection signals and buffers them to the required power level. The synthesizer/ prescaler circuit module incorporates frequency-division and comparison circuitry to keep the VCO signals stable. The synthesizer/ prescaler IC is controlled by the microcontrol unit through a serial bus. Most of the synthesizer circuitry is enclosed in rigid metal cans on the transceiver board to reduce microphonic effects.

The receiver back end consists of a two-pole crystal filter, an IF amplifier, a second two-pole crystal filter, and the digital back-end IC (ABACUS). The two-pole filters are wide enough to accommodate 5kHz modulation. Final IF filtering is done digitally in the ADSIC.

The digital back-end IC (ABACUS) consists of an amplifier, the second mixer, an IF analog-to-digital converter, a baseband down-converter, and a 2.4MHz synthesis circuit to provide a clock to the ADSIC on the vocoder board. The second LO is generated by discrete components external to the IC. The output of the ABACUS IC is a digital bit stream that is current driven on a differential pair for a reduction in noise generation.

The transmitter consists of an RF PA IC that gets an injection signal from the VCO. Transmit power is controlled by two custom ICs that monitor the output of a directional coupler and adjust PA control voltages correspondingly. The signal passes through a RX/TX switch that uses PIN diodes to automatically provide an appropriate interface to transmit or receive signals. Antenna selection is done mechanically in the control top.

Controller Board Overview

The controller board (see Figure 1) contains the radio's microcontrol unit with its memory and support circuits, voltage regulators, audio, and power control circuits. Connected to the controller board are the display module, keypad module, transceiver board, vocoder board, secure module, and front cover housing assembly.

The microcontrol unit (MCU) controls receive/transmit frequencies, power levels, display, and other radio functions, using either direct logic control or serial communications paths to the devices.The microcontrol unit executes a stored program located in its FLASH ROM. Data is transferred to and from memory by the microcontrol unit data bus. The memory location from which data is read, or to which data is written, is selected by the address lines.

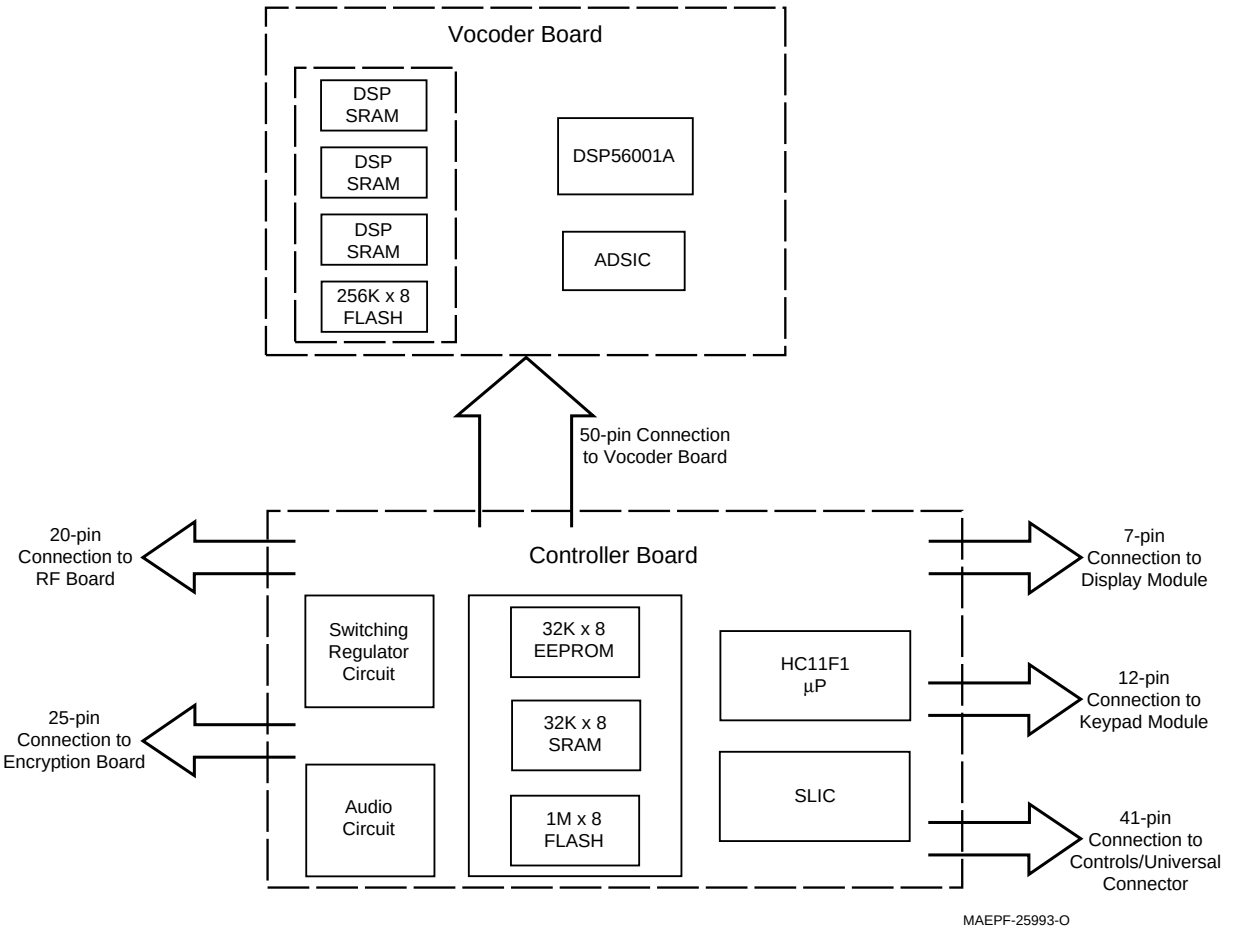


Figure 1 Controller Board/Vocoder Board Interconnection

The SLIC acts as an extension of the microcontrol unit by providing logic functions such as lower address latch, reset, memory address decoding, and additional control lines for the radio. The microcontrol unit controls the crystal-pull circuit to adjust the crystal oscillator's frequency on the microcontrol unit, so that the E-clock' s harmonics do not cause interference with the radio's receive channel.

Switched +5V is used for all circuits on the vocoder and controller boards, except the audio PA, which is sourced from 7.5V. The regulator automatically provides 5V when the radio is turned on. The regulator's power-down mode is controlled by the microcontrol unit, which senses the position of the on/off/volume control knob.

Vocoder Board Overview

The vocoder board (see Figure 1) contains the radio's DSP and ADSIC circuitry. It is responsible for all voice and data processing and signalling.

The DSP performs all signalling and voice encoding and decoding as well as audio filtering and volume control. This includes Private-Line®/Digital Private Line™ (PL/DPL) encode and alert-tone generation. The IC transmits pre-emphasis on analog signals and applies a low-pass (splatter) filter to all transmitted signals. It is programmed using parallel programming from the microcontrol unit and the ADSIC.

The DSP executes a stored program located in its FLASH ROM. The code is actually moved out of the FLASH ROM to the DSP's high-speed SRAM, and executed from there.

The DSP also controls a crystal pull circuit to adjust its oscillator frequency, preventing harmonics from interfering with the radio's receive channel.

The ADSIC performs analog-to-digital and digital-to-analog conversions on audio signals. It contains attenuators for volume, squelch, deviation, and compensation, and it executes receiver filtering and discrimination. The IC requires a 2.4MHz clock to function (generated by the ABACUS IC) and is programmed by the microcontrol unit SPI bus.

Notes

Radio Power

3

Introduction to This Section

This section of the manual provides a detailed circuit description of the power distribution for an ASTRO Digital XTS 3000 radio.

General

In the ASTRO XTS 3000 radio, power (B+) is distributed to two boards: the transceiver board and the controller board. 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 7.5Vdc directly to the transceiver. The battery is available in the following forms:

- Nickel-Cadmium, 1525 mAh
- Nickel-Cadmium, 1525 mAh, FM Approved
- Nickel-Metal-Hydride, 1650 mAh
- Nickel-Metal-Hydride, 1650 mAh, FM Approved

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.

B+ Routing for VHF/UHF Transceiver Boards

Refer to Figure 2 and the appropriate schematic diagram.

Raw B+ (7.5V) from the battery (Batt B+) enters the radio on the transceiver board through a 3-contact connector (J3). From J3 it is routed through two ferrite beads (E1, E101) on the VHF board, or three ferrite beads (E1, E101, E106) on the UHF board, to the RF power amplifier module (U105) and ALC IC (U101). Battery B+ is fused, and then routed through connector J1, pins 15 and 20, to the controller board (P201, pins 15 and 20). The B+ supply is routed through the controller board to the on/off/volume control knob (S1) on the control top/PTT flex at plug P101. With the mechanical on/off switch (S1) placed in the “on” position, switched B+ (B+ SENSE) is routed from the control top flex at connector plug P101, pin 32, and applied to the controller board at connector jack J101, pin 32. This signal is also fed to resistive divider R170, R172 on the controller board, so that the microcontrol unit (U701) can monitor the battery voltage.

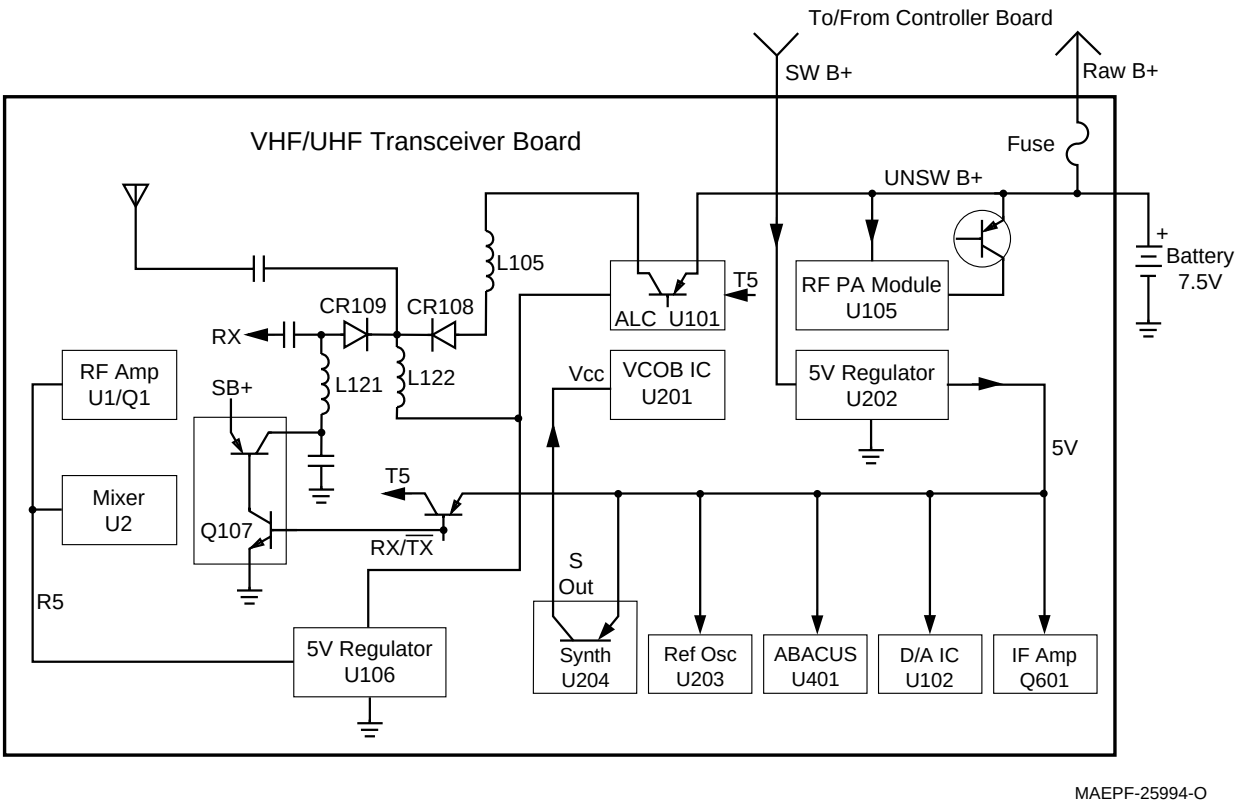


Figure 2 B+ Routing for VHF/UHF Transceiver Boards

The switched B+ voltage supplies power to circuits on the transceiver board. This voltage is applied to the 5-volt regulator (U202) via decoupling component C302 to produce a stable 5.0-volt output. Raw B+ (7.5V), which is connected to the ALC IC (U101), is switched through the output (CATH1) to another 5-volt regulator (U106).

Regulator U202 supplies those circuits which need to remain on at all times, such as the reference oscillator (U203), fractional-N synthesizer (U204), D/A IC (U102), and the ABACUS IC (U401). The D/A IC controls dc switching of the transceiver board. The SC1 signal at U102, pin 12 controls transistors Q107, Q111, and the transmit 5 volts (T5). The SC3 signal at U102, pin C4 controls the Rx 5V switch U106, and the receive 5 volts (R5). A voltage on the synthesizer SOUT line at U204, pin 19 supplies power (Vcc) to the VCO buffer at U201, pin 3.

During the receive mode, regulator U106 supplies regulated 5V (R5) to the receiver front end. In the battery-saver mode, R5 can be switched on and off by controlling pin 3 of U106. Module U106 is not used during the transmit mode. During the transmit mode, transmit 5 volts (T5) for the ALC IC and other TX circuitry is obtained from U202 via switching transistor Q111.

B+ Routing for 800MHz Transceiver Boards

Refer to Figure 3 and the appropriate schematic diagram.

Raw B+ (7.5V) from the battery (Batt B+) enters the radio on the transceiver board through a 3-contact connector (J3). From J3 it is routed through four ferrite beads (E1, E2, E3, E4) and applied to the RF power amplifier (U502) and the ALC IC (U504). Battery B+ is fused and then routed to the controller board, where it enters on connector J1, pins 15 and 20. On secure radios, Raw B+ is also routed to the encryption board so that it can perform key management and other functions independent of SW B+.

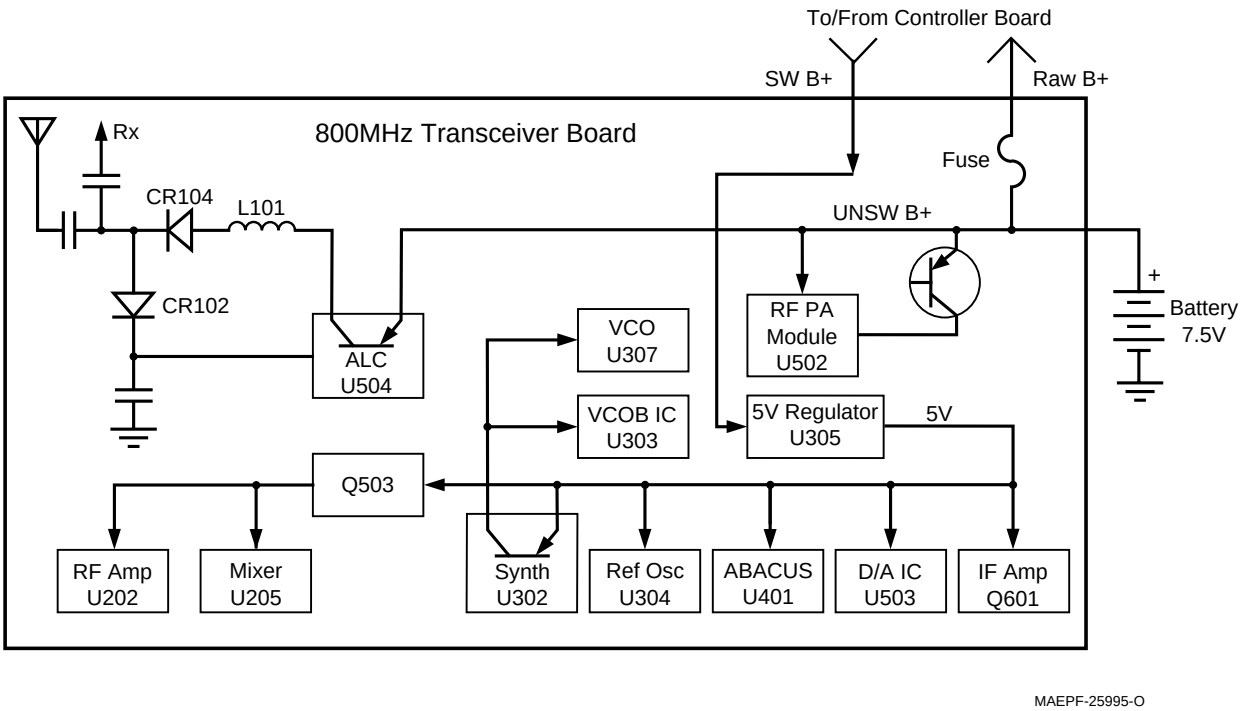


Figure 3 B+ Routing for 800MHz Transceiver Boards

The SW B+ is applied to the 5V regulator (U305) to produce a stable 5.0 volt output. Regulator U305 supplies those circuits which need to remain on at all times, such as the reference oscillator (U304), fractional-N synthesizer (U302), D/A IC (U503), and the ABACUS IC (U401). The D/A IC controls dc switching of the transceiver board. The SCI signal at U503, pin B4 controls Q503 and transmit 5 volts (T5). The SC3 signal at U503, pin C4 controls the RX 5V switch in Q503 and the receive 5 volts (R5). During the receive mode, switch Q503 supplies regulated 5volts (R5) to the receiver front end.

B+ and +5V Routing for Controller and Vocoder Boards

Refer to Figures 4 and 5 and the appropriate schematic diagrams.

Power for the radio is derived from a 7.5 volt battery, which is applied to the transceiver board through J3. This Raw B+, or unswitched B+ (UNSW B+), is routed to J1 on the transceiver board and then on to P201 on the controller board. Here the UNSW B+ is forwarded to the radio's control top on/off/volume knob through J101 and a flex circuit. The on/off/volume knob controls B+_SENSE to Q105, which in turn controls Q106. Transistor Q106 is a solid-state power switch that provides SW B+ to the controller and transceiver board's analog 5V regulators, the audio PA, and back to the transceiver board. In addition, UNSW B+ is routed to the main digital 5V regulator (U709); B+ SENSE provides for enabling or disabling this regulator.

In the case of a secure radio model, SW B+ and UNSW B+ are also supplied to the encryption module through J601.

Q106 is also under the control of the microcontrol unit (MC—-U701) through a port on the SLIC IC (U702). This allows the MCU to follow an orderly power-down sequence when it senses the SW B+ is off. This sense is provided through the resistor network of R170 and R172, which provides an input to the A/D port on the MCU.

The controller board contains two 5V regulators partitioned between the digital logic circuitry and the analog circuitry. The 5V regulator for the digital circuitry consists of U709, D104, L119, C180, and associated components. This circuit is a switched mode regulator. Switched mode regulators use a switched storage device (L119) to supply just enough energy to the output to maintain regulation. This allows for much greater efficiency and lower power dissipation. This +5V digital supply powers all digital ICs on both the controller and vocoder boards, as well as the display and keypad modules.

The analog circuitry of the ADSIC (U406) and the audio PA (U718) is powered through a separate 5V linear regulator (U710).

It should also be noted that a system reset is provided by U726. This device brings the system out of reset on power-up. It provides a system reset to the microcomputer on power-down or if the digital 5V regulator falls out of regulation.

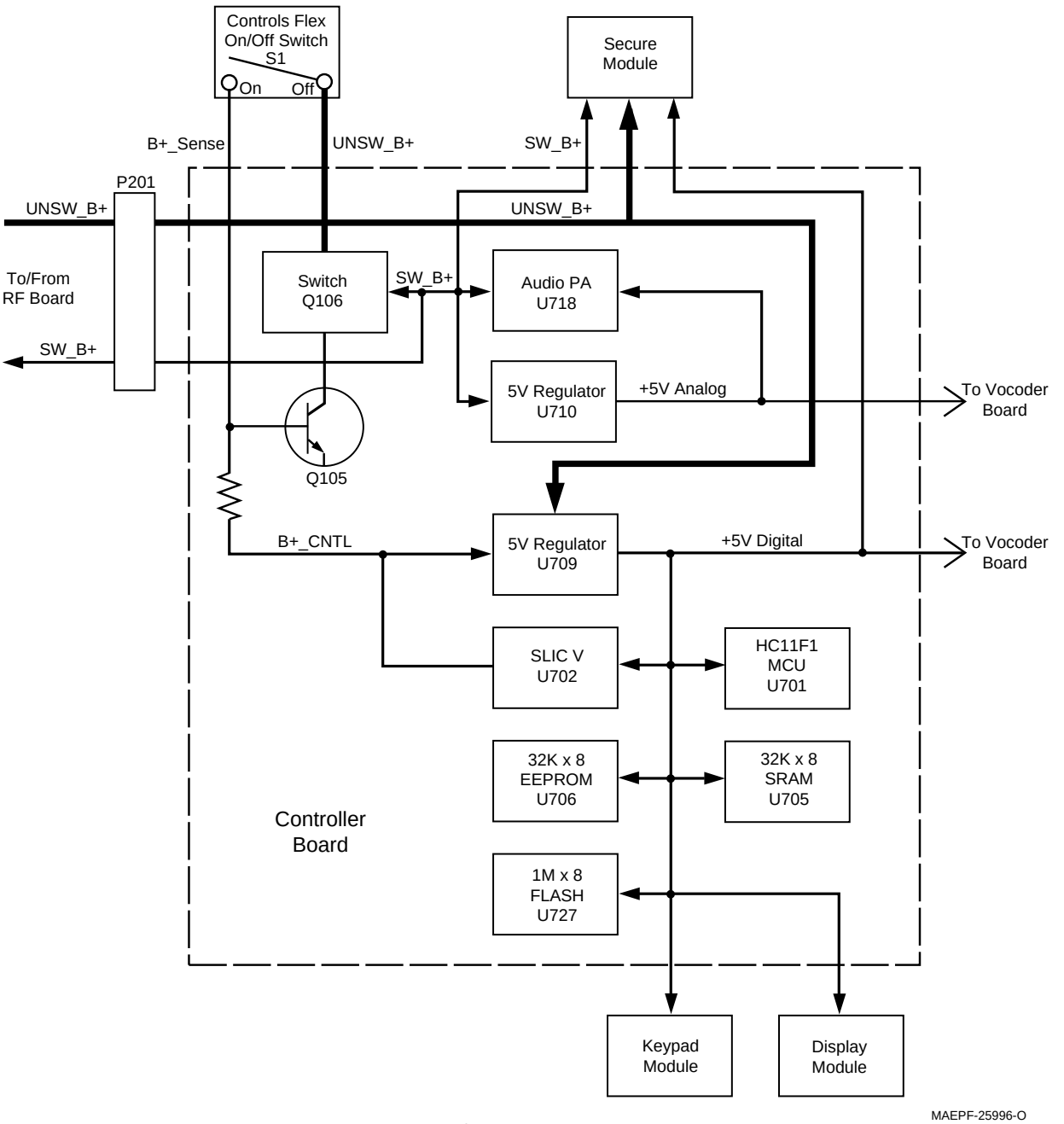


Figure 4 B+ Routing for Controller Board

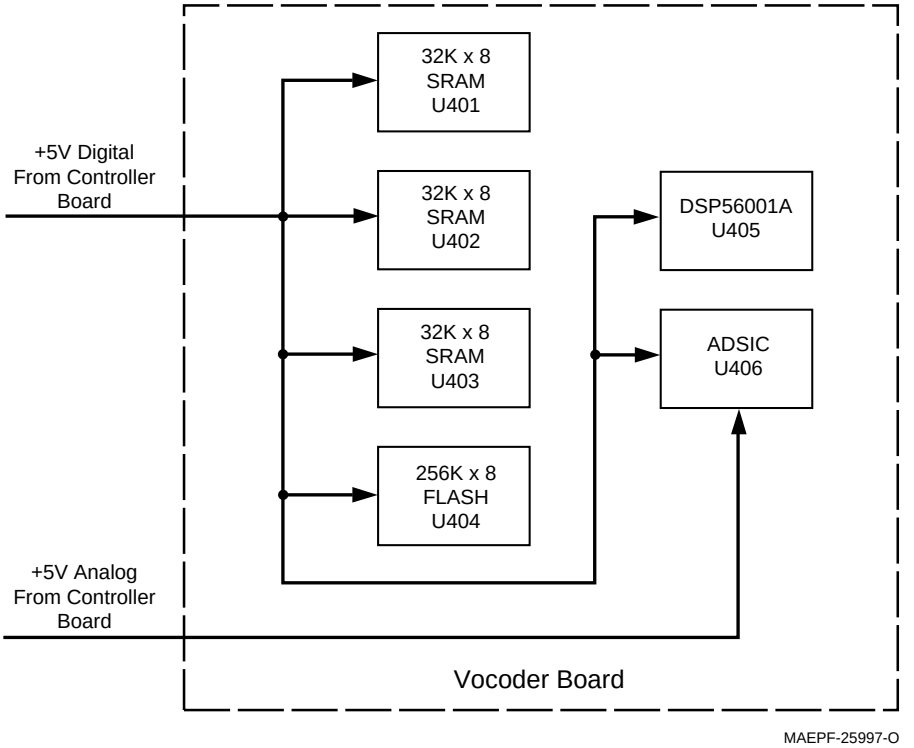


Figure 5 +5V Routing for Vocoder Board

VHF/UHF Transceiver Board Detailed Theory of Operation

4

Introduction to This Section

This section of the manual provides a detailed circuit description of the ASTRO Digital XTS 3000 VHF and UHF transceiver boards. When reading the theory of operation, refer to the appropriate schematic and component location diagrams located in the back section of this manual. This detailed theory of operation will help isolate the problem to a particular component.

Frequency Generation Unit (FGU)

The frequency generation unit (FGU) consists of three major sections: the high stability reference oscillator (U203), the fractional-N synthesizer (U204,) and the VCO buffer (U201). A 5V regulator (U202), supplies power to the FGU. The synthesizer receives the 5V REG at U204, and applies it to a filtering circuit within the module and capacitor C253. The well-filtered 5-volt output at U204, pin 19 is distributed to the TX and RX VCOs and the VCO buffer IC. The mixer's LO injection signal and transmit frequency are generated by the RX VCO and TX VCO respectively. The RX VCO uses an external active device (Q202), whereas the VHF TX VCO's active device is a transistor inside the VCO buffer. The UHF TX VCO uses two active devices, one external (Q203) and the other internal to the VCO buffer. The base and emitter connections of this internal transistor are pins 11 and 12 of U201.

The RX VCO is a Colpitts-type oscillator, with capacitors C235 and C236 providing feedback. The RX VCO transistor (Q202) is turned on when pin 38 of U204 switches from high to low. The RX VCO signal is received by the VCO buffer at U201, pin 9, where it is amplified by a buffer inside the IC. The amplified signal at pin 2 is routed through a low-pass filter (L201 and associated capacitors) and injected as the first LO signal into the mixer (U2, pin 8). In the VCO buffer, the RX VCO signal (or the TX VCO signal during transmit) is also routed to an internal prescaler buffer. The buffered output at U201, pin 16 is applied to a low-pass filter (L205 and associated capacitors). After filtering, the signal is routed to a prescaler divider in the synthesizer at U204, pin 21.

The divide ratios for the prescaler circuits are determined from information stored in a codeplug, which is part of the microcontrol unit (U701 on the controller board). The microprocessor extracts data for the division ratio as determined by the position of the channel-select switch (U1), and busses the signal to a comparator in the synthesizer. A 16.8MHz reference oscillator, U203, applies the 16.8MHz signal to the synthesizer at U204 pin 14. The oscillator signal is divided into one of three pre-determined frequencies. A time-based algorithm is used to generate the fractional-N ratio.

If the two frequencies in the synthesizer's comparator differ, a control (error) voltage is produced. The phase detector error voltage (V control) at pins 31 and 33 of U204 is applied to the loop filter consisting of resistors R211, R212, and R213, and capacitors C244, C246, C247, and C248. The filtered voltage alters the VCO frequency until the correct frequency is synthesized. The phase detector gain is set by components connected to U204, pins 28 and 29.

In the TX mode, U204, pin 38 goes high and U201, pin 14 goes low, which turns off transistor Q202 and turns on the internal TX VCO transistor in U204 and the external TX VCO buffer Q203 on the UHF circuit. The TX VCO feedback capacitors are C219 and C220. Varactor diode CR203/CR207 sets the TX frequency while varactor CR202 is the TX modulation varactor. The modulation of the carrier is achieved by using a two-port modulation technique. The modulation of low-frequency tones such as DPL/TPL is achieved by injecting the tones into the A/D section of the fractional-N synthesizer. The digitized signal is modulated by the fractional-N divider, generating the required deviation. Modulation of the high-frequency audio signals is achieved by modulating the varactor (CR203) through a frequency compensation network. Resistors R207 and R208 form a potential divider for the higher-frequency audio signals.

In order to cover the very wide bandwidths, positive and negative V-control voltages are used. High control voltages are achieved using positive and negative multipliers. The positive voltage multiplier circuit consists of components CR204, C256, C257, and reservoir capacitor C258.The negative multiplier circuit consists of components CR205, CR206, C266, C267, and reservoir capacitor C254 in VHF and UHF radios. Out-of-phase clocks for the positive multiplier appear at U204, pins 9 and 10. Out-of-phase clocks for the negative multiplier appear at U204, pins 7 and 8, and only when the negative V-control is required (that is, when the VCO frequency exceeds the crossover frequency). When the negative V-control is not required, transistor Q201 is turned on, and capacitor C259 discharges. The 13V supply generated by the positive multiplier is used to power-up the phase detector circuitry. The negative V-control is applied to the anodes of the VCO varactors.

The TX VCO signal is amplified by an internal buffer in U201, routed through a low pass filter and routed to the TX PA module, U105, pin 1. The TX and RX VCOs and buffers are activated via a control signal from U204, pin 38.

The reference oscillator supplies a 16.8MHz clock to the synthesizer where it is divided down to a 2.1MHz clock. This divided-down clock is fed to the ABACUS IC (U401), where it is further processed for internal use.

Antenna Switch

Two antenna switches are part of the radio circuitry. One of the switches is a mechanical connector that attaches to the external antenna bushing. It switches between the radio antenna and a remote antenna. Switching is accomplished by a plunger located on the accessory connector. With a remote antenna installed, continuity between the radio antenna and the RF input line is broken; continuity is made from the remote antenna to the radio RF line.

The second switch is a current device. It is a pair of diodes (CR108/ CR109) that electronically steer RF between the receiver and the transmitter. In the transmit mode, RF is routed through transmit switching diode CR108, and sent to the antenna. In the receive mode, RF is received from the antenna, routed through receive switching diode CR109, and applied to the RF amplifier, U1 (UHF), Q1 (VHF). In transmit, bias current, sourced from U101, pin 21, is routed through L105, U104, CR108, and L122 in VHF, and L105, CR108, and L122 in UHF. Sinking of the bias current is through the transmit ALC module, U101, pin 19. In the receive mode, bias current, sourced from switched B+, is routed through Q107 (pin 3 to pin 2), L123 (UHF), L121, CR109, and L122. Sinking of the bias current is through the 5-volt regulator, U106, pin 8.

Receiver Front End

The RF signal is received by the antenna and coupled through the external RF switch. The UHF board applies the RF signal to a low-pass filter comprising L126, L127, L128, C149, C150, and C151. The VHF board bypasses the lowpass filter. The filtered RF signal is passed through the antenna switch (CR109) and applied to a bandpass filter comprising: VHF— L11 through L14, CR1 through CR9, C4, C2, and C3, or UHF—L30, L31, L32, L34, L35, CR6 through CR9, C1, C2, and C3. The bandpass filter is tuned by applying a control voltage to the varactor diodes in the filter (CR1 through CR9 in VHF and CR6 through CR9 in UHF).

The bandpass filter is electronically tuned by the D/A IC (U102), which is controlled by the microcomputer.The D/A output range is extended through the use of a current mirror: transistor Q108 and associated resistors R115 and R116. When Q108 is turned on via R115, the D/A output is reduced due to the voltage drop across R116. Depending on the carrier frequency, the microcomputer will turn Q108 on or off. Wideband operation of the filter is achieved by retuning the bandpass filter across the band.

The output of the bandpass filter is applied to a wideband GaAs RF amplifier IC, U1 (RF AMP), on the UHF transceiver board. The VHF board uses an active device for RF amplification (Q1). After being amplified by the RF AMP, the RF signal is further filtered by a second broadband, fixed-tuned, bandpass filter consisting of C6, C7, C8, C80, C86, C87, C88, C97, C99, L3, L4, L5, and L30 (VHF); or C4 through C7, C88 through C94, C99, and L11 through L15 (UHF) to improve the spurious rejection.

The filtered RF signal is routed through a broadband 50-ohm transformer (T1) to the input of a broadband mixer/buffer (U2). Mixer U2 uses GaAs FETs in a double-balanced, Gilbert Cell configuration.

The RF signal is applied to the mixer at U2 pins 1 and 15. An injection signal (1st LO) of about -10dBm, supplied by the FGU, is applied to U2, pin 8. Mixing of the RF and the 1st LO results in an output signal that is the first IF frequency. The first IF frequencies of the VHF and UHF bands are 45.15MHz and 73.35MHz respectively. The 1st LO signal for VHF is 45.15MHz higher than the carrier frequency, while that for the UHF is 73.35MHz lower than the carrier frequency. The 1st IF signal output at U2, pins 4 and 6 is routed through transformer T2 and impedance matching components, and applied to a two-pole crystal filter (FL1), which is the final stage of the receiver front end. The two-pole crystal filter removes unwanted mixer products. Impedance matching between the output of the transformer (T2) and the input of the filter (FL1) is accomplished by C605 and L605 (VHF); or C611, C614, and L605 (UHF).

Receiver Back End

The output of crystal filter FL1 is matched to the input of IF buffer amplifier transistor Q601 by components C610 and L604 (VHF), and C609, C610, and L600 (UHF). Transistor Q601 is biased by the 5V regulator (U202). The IF frequency on the collector of Q601 is applied to a second crystal filter through a matching circuit. The second crystal filter (FL2) input is matched by C604, C603, and L601 (VHF); or C604, L601, and L602 (UHF). The filter supplies further attenuation at the IF sidebands to increase the radios selectivity. The output of FL2 routed to pin 32 of U401 through a matching circuit which consists of L603, L606, and C608 (VHF); or L603, C606, and C605 (UHF).

In the ABACUS IC (U401), the first IF frequency is amplified and then down-converted to 450kHz, the second IF frequency. At this point, the analog signal is converted into two digital bit streams by a sigma-delta A/D converter. The bit streams are then digitally filtered, mixed down to baseband, and filtered again. The differential output data stream is then sent to the ADSIC (U406) on the vocoder board, where it is decoded to produce the recovered audio.

The ABACUS IC (U401) is electronically programmable, and the amount of filtering, which is dependent on the radio channel spacing and signal type, is controlled by the microcomputer. Additional filtering, which used to be provided externally by a conventional ceramic filter, is replaced by internal digital filters in the ABACUS IC. The ABACUS IC contains a feedback AGC circuit to expand the dynamic range of the sigma-delta converter. The differential output data contains the quadrature (I and Q) information in 16-bit words, the AGC information in a 9-bit word, imbedded word sync information, and fill bits dependent on sampling speed. A fractional-N synthesizer is also incorporated on the ABACUS IC for 2nd LO generation.

The 2nd LO/VCO is a Colpitts oscillator built around transistor Q401 (VHF) or Q1 (UHF). The VCO has a varactor diode, VR401 (VHF) or CR5 (UHF), to adjust the VCO frequency. The control signal for the varactor is derived from a loop filter consisting of C426, C428, and R413.

Transmitter

The transmitter consists of three major sections:

- Harmonic Filter
- RF Power Amplifier Module
- ALC Circuits

Harmonic Filter

RF from the power amplifier (PA) module (U105) is routed through the coupler (U104), passed through the transmit antenna switch (CR108), and applied to a harmonic filtering network in UHF. In the case of a VHF transceiver board, RF from the PA module (U105) is routed through the coupler (U104), then through the harmonic filtering network, and on to the antenna switch (CR108). The harmonic filtering circuit is composed of the following components: L126, L127, L128, C149, C150, and C151 (for VHF models); or L126, L127, L128, C149, C150, and C151 (for UHF models). Resistor R128 (UHF) or R117 (VHF) provides a current-limited 5V to J2 for mobile ASTRO XTS 3000 vehicular adapter (VA) applications.

RF Power Amplifier Module

The RF power amplifier module (U105) is a wide-band, multi-stage amplifier (three stages for the VHF models and four stages for the UHF models). Nominal input and output impedance of U105 is 50 ohms. The dc bias for U105 is on pins 2, 4, 5. In the transmit mode, the voltage on U105, pins 2 and 4 (close to the B+ level) is obtained via switching transistor Q101. Transistor Q101 receives its control base signal as follows:

- the microcomputer keys the D/A IC to produce a ready signal at U102 pin 3,
- the ready signal at U102 pin 3 is applied to the TX ALC IC at U101 pin 14 (5V), and
- the synthesizer sends a LOC signal to the TX ALC IC (U204 pin 40 to U101 pin 16).

When the LOC signal and the ready signal are both received, the TX ALC IC (pin 13) sends a control signal to turn on transistor Q101.

ALC Circuits

Coupler module U104 samples the forward and reverse power of the PA output voltage. Reverse power is present when there is other than 50 ohms impedance at the antenna port. Sampling is achieved by coupling some of the forward and/or reverse power, and applying it to CR102 (VHF) or CR101 (UHF) and CR103 for rectification and summing. The resultant dc signal is then applied to the TX ALC IC (U101, pin 2) as RFDET to be used as an RF strength indicator.

The transmit ALC circuit, built around U101, is the heart of the power control loop. Circuits in the TX ALC module compare the signals at U101, pins 2 and 7. The resultant signal, C BIAS, at U101, pin 4 is applied to the base of transistor Q110. In response to the base drive, transistor Q110 varies the dc control voltages applied to the RF PA at U105, pin 3, thus controlling the RF power of module (U105).

Thermistor RT101 senses the temperature of the TX ALC IC. If an abnormal operating condition exists that causes the PA slab temperature to rise to an unacceptable level, the thermistor forces the ALC to reduce the set power.

Notes

800MHz Transceiver Board Detailed Theory of Operation

5

Introduction to This Section

This section of the manual provides a detailed circuit description of an ASTRO Digital XTS 3000 800MHz Transceiver Board. When reading the theory of operation, refer to your appropriate schematic and component location diagrams located in the back section of this manual. This detailed theory of operation will help isolate the problem to a particular component.

Frequency Synthesis

The complete synthesizer subsystem consists of the reference oscillator (U304), the voltage-controlled oscillator (VCO)(U307), a buffer IC (U303), and the synthesizer (U302).

The reference oscillator contains a temperature-compensated 16.8MHz crystal. This oscillator is digitally tuned and contains a temperature-referenced, five-bit, analog-to-digital (A/D) converter. The output of the oscillator (pin 10 on U304) is applied to pin 14 (XTAL1) on U302 through capacitor C309 and resistor R306.

Module U307, the voltage-controlled oscillator, is varactor tuned. That is, as the voltage (2-11V) being applied to pins 1 and 7 of the VCO varies, so does the varactor's capacitance, thereby changing the VCO's output frequency. The 800MHz VCO is a dual-range oscillator that covers the 806-825MHz and the 851-870MHz frequency bands. The low-band VCO (777-825MHz) provides the first LO injection frequencies (777-797MHz) that will be 73.35MHz below the carrier frequency. In addition, when the radio is operated through a repeater, the low-band VCO will generate the transmit frequencies (806-825MHz) that will be 45MHz below the receiver frequencies. The low-band VCO is selected by pulling pin 3 high and pin 8 low on U307. When radio-to-radio or talk-around operation is necessary, the high band VCO (851-870MHz) is selected. This is accomplished by pulling pin 3 low and pin 8 high on U307.

The buffer IC (U303) includes a TX, RX, and prescaler buffer whose main purpose is to individually maintain a constant output and provide isolation.The TX buffer is chosen by setting pin 7 of U303 high; the RX buffer is chosen by setting pin 7 of U303 low. The prescaler buffer will always be on. In order to select the proper combination of VCO and buffer, the following conditions must be true at pin 6 of U303 (or pin 38 of U302) and pin 7 of U303 (or pin 39 of U302):

- for the first LO injection frequencies 777-797MHz, pins 6 and 7 must both be low;
- for the TX repeater frequencies 806-825MHz, pins 6 and 7 must

both be high;

- for talkaround TX frequencies 851-870MHz, pin 6 must be low while pin 7 must be high.

The synthesizer IC (U302) consists of a prescaler, a programmable loop divider, a divider control logic, a phase detector, a charge pump, an A/D converter for low-frequency digital modulation, a balance attenuator to balance the high-frequency analog modulation to the low-frequency digital modulation, a 13V positive-voltage multiplier, a serial interface for control, and finally, a filter for the regulated 5 volts. This filtered five volts is present at pin 19 of U302, pin 9 of U307, and pins 2, 3, 4, and 15 of U303. It is also applied directly to resistors R309, R315, and R311. Additionally, the 13V, being generated by the positive voltage multiplier circuitry, should be present at pin 35 of U302. The serial interface (SRL) is connected to the microprocessor via the data line (pin 2 of U302), clock line (pin 3 of U302), and chip-enable line (pin 4 of U302).

The complete synthesizer subsystem works as follows:

- The output of the VCO, pin 4 on U307, is fed into the RF input port (pin 9) of U303. In the TX mode, the RF signal will be present at pin 4 of U303; in the RX mode, the RF signal will be present at pin 3 of U303.
- The output of the prescaler buffer, pin 15 of U303, is applied to the PREIN port (pin 21) of U302. The prescaler in U302 is a dual-modulus type with selectable divider ratios. This divider ratio is controlled by the loop divider, which in turn receives its inputs from the SRL. The loop divider adds or subtracts phase to the prescaler divider by changing the divide ratio via the modulus control line.
- The output of the prescaler is then applied to the loop divider.
- The output of the loop divider is then applied to the phase detector. The phase detector will then compare the loop divider's output signal with the signal from U304 (that is divided down after it is applied to pin 14 of U302). The result of the signal comparison is a pulsed dc signal which is applied to the charge pump.
- The charge pump outputs a current that will be present at pin 32 of U302. The loop filter (which consists of capacitors C322, C317, C318, C329, C324, and C315, and resistors R307, R305, and R314) will transform this current into a voltage that will be applied to pins 1 and 7 of U307, and alter the VCO's output frequency.

In order to modulate the PLL, the two-port modulation method is utilized. The analog modulating signal is applied to the A/D converter as well as the balance attenuator, via U302, pin 5. The A/D converter converts the low-frequency analog modulating signal into a digital code that is applied to the loop divider, thereby causing the carrier to deviate. The balance attenuator is used to adjust the VCO's deviation sensitivity to high-frequency modulating signals.

Antenna Switch

Switching between the standard and external antenna ports is accomplished with the external mechanical switch that is actuated by a plunger, located on the accessory connector.

An electronic PIN diode switch steers RF between the receiver and transmitter. The common node of the switch is at capacitor C101. In the transmit mode, RF is routed to the anode of diode CR104. In receive mode, RF is routed to pin 1 of U201. In transmit, bias current, sourced from U504, pin 21 is routed through PIN diodes CR104 and CR102, biasing them to a low-impedance state. Bias current returns to ground through U504, pin 20. In receive, U504, pin 21 is pulled down to ground and pin 20 is pulled up to B+, reverse-biasing diodes CR104 and CR102 to a high impedance.

Receiver Front End

For the purposes of this discussion, the receiver front end is defined as being the circuitry from the antenna switch to the output of the IF crystal filter. The 800MHz front end converts the received RF signal to the 1st IF frequency of 73.35MHz, while at the same time providing for spurious immunity and adjacent channel selectivity. A review of the interstage components of the front end will now be presented, with emphasis on troubleshooting considerations.

The received RF signal is passed through antenna switch input matching components C101, L105, and C114, tank components C106 and L103 (which are anti-resonant at the radios transmitter frequencies), and output matching components C103 and L104. Both pin diodes CR102 and CR104 must be back-biased to properly route the received signal.

The stage following the antenna switch is a 50-ohm, inter-digitated, three-pole, stripline preselector (U201). The preselector is positioned after the antenna switch to provide the receiver preamp with some protection to strong signal, out-of-band signals.

After the preselector (U201), the received signal is processed through the receiver preamp, U202. The preamp is a dual-gate, GaAs MESFET transistor which has been internally biased for optimum IM, NF, and gain performance. Components L201 and L202 match the input (gate 1) of the amp to the first preselector, while at the same time connecting gate 1 to ground potential. The output (drain) of the amp is pin 7, and is matched to the subsequent receiver stage through components L204 and C222. A supply voltage of 5Vdc is provided to pin 3 through RF choke L203 and bypass capacitor C204. The 5-volt supply is also present at pin 4, which connects to a voltage divider network that biases gate 2 (pin 5) to a predefined quiescent voltage of 1.2Vdc. Resistor R202 and capacitor C203 are connected to pin 5 to provide amp stability. The FET source (pin 3) is internally biased at 0.55 to 0.7Vdc for proper operation with bypass capacitors C201 and C202, connected to the same node.

The output of the amp is matched to a second three-pole preselector (U203) of the type previously discussed. The subsequent stage in the receiver chain is the 1st mixer, U205, which uses low-side injection to convert the RF carrier to an intermediate frequency (IF) of 73.35MHz.

Since low-side injection is used, the LO frequency is offset below the RF carrier by 73.35MHz, or Flo = Frf - 73.35MHz. The mixer utilizes GaAs FETs in a double-balanced, Gilbert Cell configuration. The LO port (pin 8) incorporates an internal buffer and a phase shift network to eliminate the need for a LO transformer. The LO buffer bypass capacitors (C208, C221, and C216) are connected to pin 10 of U205, and should exhibit a nominal dc voltage of 1.2 to 1.4Vdc. Pin 11 of U205 is LO buffer Vdd (5Vdc), with associated bypass capacitors C226 and C209 connected to the same node. An internal voltage divider network within the LO buffer is bypassed to virtual ground at pin 12 of U205 through bypass capacitor C213. The mixer's LO port is matched to the radio's PLL by a capacitive tap, C207 and C206.

A balun transformer (T202) is used to couple the RF signal into the mixer. The primary winding of T202 is matched to the preceding stage by capacitor C223, with C227 providing a dc block to ground. The secondary winding of T202 provides a differential output, with a 180° phase differential being achieved by setting the secondary center tap to virtual ground using bypass capacitors C210, C211 and C212. The secondary of transformer T202 is connected to pins 1 and 15 of the mixer IC, which drives the source leg of dual FETs used to toggle the paralleled differential amplifier configuration within the Gilbert Cell.

The final stage in the receiver front end is a two-pole crystal filter (FL1). The crystal filter provides some of the receiver's adjacent channel selectivity. The input to the crystal filter is matched to the 1st mixer using components L605, C600, and C614. The output of the crystal filter is matched to the input of IF buffer amplifier transistor Q601 by components L600, C609, and C610.

Receiver Back End

The IF frequency on the collector of Q601 is applied to a second crystal filter (FL2) through a matching circuit consisting of L601, L602, C604, and C612. The filter supplies further attenuation at the IF sidebands to increase the radio's selectivity. The output of FL2 is routed to pin 32 of U401 through a matching circuit consisting of L603, C603, and C606, and dc block capacitor C613.

In the ABACUS IC (U401), the first IF frequency is amplified and then down-converted to 450kHz, the second IF frequency. At this point, the analog signal is converted into two digital bit streams by a sigma-delta A/D converter. The bit streams are then digitally filtered, mixed down to baseband, and filtered again. The differential output data stream is then sent to the ADSIC (U406) on the vocoder board, where it is decoded to produce the recovered audio.

The ABACUS IC (U401) is electronically programmable, and the amount of filtering, which is dependent on the radio channel spacing and signal type, is controlled by the microcomputer. Additional filtering, which used to be provided externally by a conventional ceramic filter, is replaced by internal digital filters in the ABACUS IC. The ABACUS IC contains a feedback AGC circuit to expand the dynamic range of the sigma-delta converter. The differential output data contains the quadrature (I and Q) information in 16-bit words, the AGC information in a 9-bit word, imbedded word sync information, and fill bits, dependent on sampling speed. A fractional-N synthesizer is also incorporated on the ABACUS IC for 2nd LO generation.

The second LO/VCO is a Colpitts oscillator built around transistor Q1. The VCO has a varactor diode (VR401), which is used to adjust the VCO frequency. The control signal for the varactor is derived from a loop filter consisting of C426, C428, and R413.

Transmitter

The 800MHz RF power amplifier (PA) is a five-stage amplifier (U502). The RF power amplifier has a nominal input and output impedance of 50 ohms.

An RF input drive level of approximately +3dBm, supplied from the VCO buffer IC (U303), is applied to pin 1 of U502. The dc bias for the internal stages of U502 is applied to pins 3 and 4 of the module; pin 3 is switched through Q502 and pin 4 is unswitched B+ to the final amplifier stage. Power control is achieved through the varying of the dc bias to pin 2, the third and fourth amplifier stages of the module. The amplified RF signal leaves the PA module at pin 5 and is applied to the directional coupler (U501).

The purpose of U501 is to sample both the forward power and the reverse power. The reverse power will be present when there is other than a 50-ohm load at the antenna port. The sampling will be achieved by coupling some of the reflected power, forward and/or reverse, to a coupled leg on the coupler. The sampled RF signals are applied to diode CR501 for rectification and summing. The resultant dc signal is applied to the ALC IC (U504, pin 2) as RFDET, to be used as an indicator of the strength of the RF signal being passed through the directional coupler (U501).

The transmit ALC IC (U504) is the heart of the power control loop. The REF V line (U504 pin 7), a dc signal supplied from the D/A IC (U503), and the RF DET signal described earlier, are compared internally in the ALC IC to determine the amount of C BIAS, pin 4, to be applied to the base of transistor Q501. Transistor Q501 responds to the base drive level by varying the dc control voltages applied to pin 2 of the RF PA, controlling the RF power level of module, U502. The ALC IC also controls the base switching to transistor Q502 via pin 12, BIAS.

The D/A IC (U503) controls the dc switching of the transceiver board. Its outputs, SC1 and SC3, pins 12 and 14 respectively, control transistor Q503, which then supplies TX 5V and RX 5V to the transceiver board. The D/A also supplies the dc bias to the detector diode (CR501) via pin 7, and the REF V signal to the ALC IC (U504).

Notes