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

Pin	Name	Description
9	F168	Reference clock input, 2.1 MHz
10, 13	QX, CQX	External capacitor for voltage multiplier
11, 12	Q, CQ	External capacitor for voltage multiplier
14	V10	Voltage multiplier output
15	VG	Internal band-gap reference voltage
16	V45	Regulated 4.5 Vdc output
17	V5EXT	Power supply input for internal voltage regulator
18	VAR2	Buffered D/A output
19	VLIM	Test point for internal D/A No.2 voltage
20	VAR1	Buffered D/A output
21	RS	Asynchronous reset input
22	NA	Spare pin
23	RX	RX/TX mode control-bit output
24	VAR3	Buffered D/A output
25	GND2	Ground
26	CLK	SPI clock input
27	BPOS	Power supply input
28	DATA	SPI data input/output
29	CEX	SPI chip select input
30	TEMP	Temperature sensor input
31	RSET	External resistor; used to set the temperature cutback rate
32	ANO	Switched BPOS output

3.1.3.9.1 Power and Control

Since U104 is powered from switched B+, it makes its own regulated 4.5 Vdc to power the internal logic. The supply input is V5EXT at pin 17, and the output is V45 at pin 16. RX at pin 23 is the control signal to the antenna switch control circuit.

3.1.3.9.2 Voltage Multiplier

The PCIC contains an internal voltage multiplier. This multiplier produces signal V10 (pin 14), a 10-V supply for the PCIC D/A converters (DACs). This enables the DACs outputs to reach 8 V. The FREF signal is a 2.1 MHz clock used to switch the multiplier. The voltage multiplier is not used in either the VHF, UHF Range 1, UHF Range 2, or 700–800 MHz radio.

3.1.3.9.3 Automatic Level Control (ALC)

In TX mode, the PCIC disables the receiver, turns on the transmitter, and controls the TX power level. The automatic level control (ALC) circuit operates as follows:

The power level is set by programming an internal DAC to a calibrated reference voltage. D/A settings for the power set points were determined during radio tuning and stored in EEPROM. An internal op-amp compares the D/A reference voltage to the detector voltage at pin 1(RFIN) (TP101) and produces an error signal output. This signal is buffered by another op-amp, configured as a low-pass filter, or integrator, to produce the INT output at pin 4 (TP104). This signal drives the base of voltage follower Q108.

Transistor Q108 supplies current to drive the gain control pins of amplifiers U102 and Q107. Resistors R105 and R106 determine the voltage ratio between U102 pin 2 (VCNTRL) and the Q107 gate. Transient response during key-up and key-down is controlled by the power amplifier rise and fall times. External capacitors at pins CI, CJ, and CL, along with internal programmable resistors, determine the ALC time constants.

3.1.3.9.4 Temperature Cut Back

The PCIC contains a temperature cut-back circuit to protect the power amplifier (PA) from thermal damage that might result from incorrect assembly of the radio. External sensor U103 is a linear temperature-to-voltage transducer, placed near the hottest spot in the radio: power module Q107. The output is a DC voltage at pin 2 (VOUT) proportional to the temperature at pin 3 (GND). VOUT is 750 mV at 25°C and increases by 10 mV/°C. The PCIC temperature cut-back threshold is programmed to correspond to 85 or 90°C. Above this threshold, the ALC gradually cuts back the transmitter until it is fully turned off at 125°C. The slope of cut-back versus temperature is set by external resistor R111. Diode D104 clamps TEMP to a voltage not much less than VG (pin 15), about 1.3 V, to improve the transient response of the cut-back circuit.

3.1.3.9.5 D/A Outputs

In RX mode, the PCIC shuts down the transmitter, turns on the receiver, and tunes the RX front-end pre-selector filters.

VHF: Signal VAR2 supplies the voltage used to tune both front-end preselector filters. The voltage range varies from 1.2 V to 2.4 V across the VHF band.

UHF Range 1: Signal VAR2 tunes both receiver preselector filters. Control voltage is in the 1 to 4 V range.

UHF Range 2: Signal VAR2 supplies the voltage used to tune both front-end preselector filters. The voltage

range varies from 1.2 V to 3.6 V.

700–800 MHz: Signals VAR1 and VAR2 are D/A outputs to the RX front-end preselector filters. Output voltage is in the range of about 1 to 4 V over the frequency band. In TX mode, VAR1 and VAR2 disconnect from the D/A and go to 0 Vdc, thus tuning the RX front-end filters out of band.

3.1.4 Frequency Generation Unit (FGU)

The frequency-generation function is performed by several ICs; multiple, discrete, voltage-controlled oscillators (VCOs); and associated circuitry. The reference oscillator provides a frequency standard to the fractional-N frequency synthesizer (FracN) IC, which controls the VCOs and VCO buffer IC (VCOBIC). The VCOBIC amplifies the VCO signal to the correct level for the next stage.

VHF: Two VCOs are employed—one to generate the first LO and the other to generate the transmit-injection signals.

UHF Range 1: Four VCOs are employed: two transmit and two receive.

UHF Range 2: Three VCOs are employed: one transmit and two receive.

700–800 MHz: Three VCOs generate the first LO and transmit-injection signals.

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

3.1.4.1 Reference Oscillator Y200

The radio's frequency stability and accuracy derive from the Voltage-Controlled Temperature-Compensated Crystal Oscillator (VCTCXO), Y200. This 16.8 MHz oscillator is controlled by the voltage from the WARP pin of the FracN (fractional-N frequency synthesizer) IC, U202, that can be programmed through a serial peripheral interface (SPI). The oscillator output at pin 3 is coupled through capacitor C234 to the FracN synthesizer reference oscillator input and through C236 (C237 for VHF and UHF Range 2) to the non-invertive input of the op-amp, U201.

Op-amp U201 buffers the 16.8 MHz output to the VOCON board. Components L205 and C214 (C213, L205, and C214 for VHF) form a low-pass filter to reduce harmonics of the 16.8 MHz.

The Digital-to-Analog Converter (DAC) IC, U203, and Switched Capacitors Filter (SCF) IC, FL200, form the interface between radio's DSP and the analog modulation input of the FracN IC.

3.1.4.2 Fractional-N Frequency Synthesizer (FracN) IC U202

The FracN IC, U202, is a mixed-mode, Motorola-proprietary, CMOS, fractional-N frequency synthesizer with built-in dual-port modulation. The XTS 5000 radio uses a low-voltage version of the device, sometimes called LVFracN, for compatibility with the 3 V logic used throughout the radio.

The FracN IC incorporates frequency division and comparison circuitry to keep the VCO signals stable. The FracN IC is controlled by the MCU through a serial bus. All of the synthesizer circuitry is enclosed in rigid metal cans on the transceiver board to reduce interference effects.

Separate power supply inputs are used for the various functional blocks on the IC. Inductors L203 and L204 provide isolation between supply pins 20 (AVDD) and 36 (DVDD) connected to Vdd3. Host control is through a three-wire, smart SPI interface (pins 7, 8, and 9) with a bi-directional data pin. FracN functions include frequency synthesis, reference clock generation, modulation control, voltage multiplication and filtering, and auxiliary logic outputs.

3.1.4.2.1 Synthesizer

Frequency synthesis functions include a dual-modulus prescaler, a phase detector, a programmable loop divider and its control logic, a charge pump, and a lock detector output. Fractional-N synthesizer IC principles of operation are covered in detail in the manufacturers' literature. No similar discussion will be attempted here.

3.1.4.2.2 Clocks

U202, pin 23 (XTAL1), is the 16.8 MHz reference oscillator input from the VCTCXO (Y200).

3.1.4.2.3 Modulation

To support many voice, data, and signaling protocols, XTS 5000 radios must modulate the transmitter carrier frequency over a wide audio frequency range, from less than 10 Hz up to more than 6 kHz. The FracN supports audio frequencies down to zero Hz by using dual-port modulation. The audio signal at pin 10 (MODIN) is internally divided into high- and low-frequency components, which modify both the synthesizer dividers and the external VCOs through signal MODOUT (pin 41). The IC is adjusted to achieve flat modulation frequency response during transmitter modulation balance calibration using a built-in modulation attenuator.

The power level is set by programming an internal DAC to a calibrated reference voltage. D/A settings for the power set points were determined during radio tuning and stored in EEPROM. An internal op-amp compares the D/A reference voltage to the detector voltage at pin 1(RFIN) (TP101) and produces an error signal output. This signal is buffered by another op-amp, configured as a low-pass filter, or integrator, to produce the INT output at pin 4 (TP104). This signal drives the base of voltage follower Q108.

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range varies from 1.2 V to 3.6 V.

700–800 MHz: Signals VAR1 and VAR2 are D/A outputs to the RX front-end preselector filters. Output voltage is in the range of about 1 to 4 V over the frequency band. In TX mode, VAR1 and VAR2 disconnect from the D/A and go to 0 Vdc, thus tuning the RX front-end filters out of band.

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The FracN IC incorporates frequency division and comparison circuitry to keep the VCO signals stable. The FracN IC is controlled by the MCU through a serial bus. All of the synthesizer circuitry is enclosed in rigid metal cans on the transceiver board to reduce interference effects.

Separate power supply inputs are used for the various functional blocks on the IC. Inductors L203 and L204 provide isolation between supply pins 20 (AVDD) and 36 (DVDD) connected to Vdd3. Host control is through a three-wire, smart SPI interface (pins 7, 8, and 9) with a bi-directional data pin. FracN functions include frequency synthesis, reference clock generation, modulation control, voltage multiplication and filtering, and auxiliary logic outputs.

3.1.4.2.1 Synthesizer

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3.1.4.2.2 Clocks

U202, pin 23 (XTAL1), is the 16.8 MHz reference oscillator input from the VCTCXO (Y200).

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To support many voice, data, and signaling protocols, XTS 5000 radios must modulate the transmitter carrier frequency over a wide audio frequency range, from less than 10 Hz up to more than 6 kHz. The FracN supports audio frequencies down to zero Hz by using dual-port modulation. The audio signal at pin 10 (MODIN) is internally divided into high- and low-frequency components, which modify both the synthesizer dividers and the external VCOs through signal MODOUT (pin 41). The IC is adjusted to achieve flat modulation frequency response during transmitter modulation balance calibration using a built-in modulation attenuator.

3.1.4.2.4 Voltage Multiplier and Superfilter

Pins 12 (VMULT3) and 11 (VMULT4) together with diode arrays D201 and D202 and their associated capacitors form the voltage multiplier. The voltage multiplier generates 11.5 Vdc to supply the phase detector and charge-pump output stage at pin 47 (VCP).

The superfilter is an active filter that provides a low-noise supply for the VCOs and VCOBIC. The input is regulated 5 Vdc from Vdd5 at pin 30 (SFIN). The output is superfiltered voltage FSF at pin 28 (SFOUT).

The output from pin 15 (VMULT1) is used as a clock for the SCF IC, FL200.

3.1.4.3 Loop Filter

The components connected to pins 43 (IOUT) and 45 (IADAPT) form a 3rd-order, RC low-pass filter. Current from the charge-pump output, IOUT, is transformed to voltage VCTRL, which modulates the VCOs. Extra current is supplied by IADAPT for rapid phase-lock acquisition during frequency changes. The lock detector output pin 4 (LOCK) goes to a logic "1" to indicate when the phased-lock loop is *in lock*.

3.1.4.4 VCO Buffer IC (VCOBIC)

The VCOBIC (U302 for VHF radios or U300 for UHF Range 1 and 700–800 MHz radios) is an analog IC containing two NPN transistors for use as oscillators, an active-bias circuit, transmitter and receiver buffer amplifiers, and switching circuitry. The VCOBIC has three RF outputs:

- TX_OUT (pin 10)—the modulated transmitter carrier
- RX_OUT (pin 8)—the receiver first LO
- PRESC_OUT (pin 12)—connected to FracN pin 32 (PREIN) through a matching circuit

Transmit/receive control is a single 5.0 Vdc logic input, TRB_IN (pin 19). When TRB_IN is low, the receiver buffer is active and the transmitter circuits are disabled. The converse is also true.

VHF: The VCOs in VHF radios use the VCOBIC internal transistors and implement the active bias via resistors R304 and R305. Bias to TX_OUT is supplied through resistor R313. Components L309 and C316 form a matching circuit for the TX_OUT impedance. C319 acts as a DC block, and resistors R314, R315, and R316 attenuate an output signal to an optimum level for the PA.

L312 and C320 form a low-pass bias supply filter for the RX_OUT. L310 and C317 are the RX_OUT impedance-matching circuit. C322 is a DC block, and resistors R317 and R318 attenuate an output signal to an optimum level for the mixer IC.

An NPN/PNP-packaged transistor, Q301, together with the supporting components R308, R309, and R310, form the 3.3 Vdc-to-5 Vdc logic-level shifter between the AUX3 pin of the FracN IC, U202, and VCOBIC, U302.

UHF Range 1: For these radios, four VCOs are used: two transmit and two receive. Control-logic translation is done by level shifter Q310 and Q311, and wired-OR D320.

UHF Range 2: Two VCOs are used for receive and one for Transmit. The fractional N synthesizer selects the appropriate VCO by toggling auxilary lines 2,3, or 4. The selection of the TX VCO with auxilary line 4 also sets TRB_IN high.

700–800 MHz: These radios use three external, discrete, varactor-tuned, Colpitts VCOs based on transistors Q301, Q303, and Q308. Bias current to the VCOs is switched on and off by the transistors Q302, Q306, and Q309, which are controlled by FracN outputs AUX1, AUX2, and AUX4. Transistor Q304 is an additional transmit buffer amplifier reducing frequency pulling on the transmit VCO. An additional buffer is switched on and off by the transistor Q305. Bias to TX_OUT is supplied through resistor R307. Components L307 and C208 form a low-pass bias supply filter. The RX_OUT impedance is matched by a one-component match, coil L310.

Transistors Q307 and Q310 form a 3.3 Vdc-to-5 Vdc logic-level shifter for the signal from the FracN AUX3 pin to the VCOBIC.

3.2 VOCON Board

This section provides a detailed circuit description of the ASTRO XTS 5000 VOCON board.

The VOCON board (Figure 3-7) is divided into the following sections:

- Controller and Memory
- Audio and Power
- Interface Support

3.2.1 Interconnections

The VOCON board interconnection diagram (see Figure 3-7) contains three functional blocks and five connector symbols.

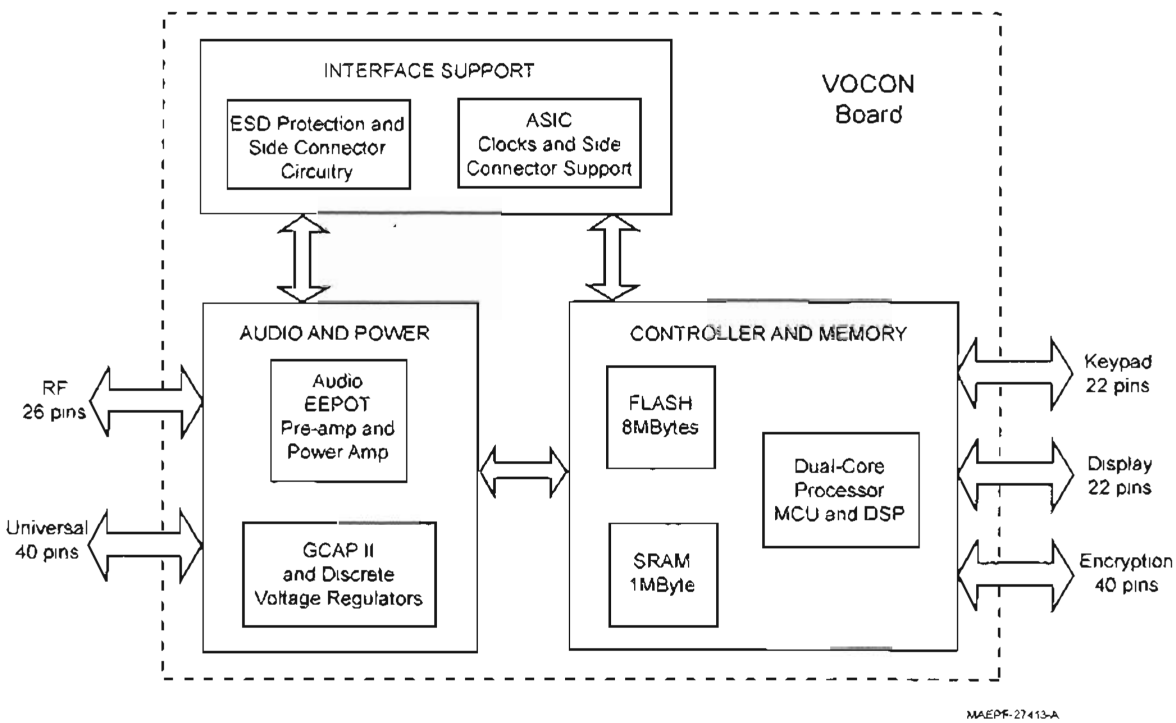


Figure 3-7. VOCON Board Interconnections

The functional blocks consist of the following:

- **Controller and Memory:** The Patriot (U401), the dual-core processor with the microcontroller unit (MCU) and a digital signal processor (DSP), the SRAM (U403) and Flash (U402) memory devices.
- **Audio and Power:** The GCAP II (U501), a 5 Vdc linear regulator (U505), a 1.55 Vdc linear regulator (NNTN4717 VOCON kit only), the audio pre-amplifier (U502), the audio power amplifier (U503), and the dual EEPOT (U509).
- **Interface Support:** The digital-support IC Flipper (U301), ESD protection circuitry, and side connector interface circuitry.

NOTE: Refer to Table 8-2, "List of VOCON Schematics and Board Overlays," on page 8-1 for a listing of VOCON schematics that will aid in the following discussion.

3.2.1.1 Universal Connector J101

This is a 40-pin connector that mates with the universal flex on the housing. A majority of the lines on the connector are for user interface: emergency and side buttons (pin 14), monitor button (pin 17), secure/clear switch (pin 23), frequency switch (pins 24, 25, 26, and 27), volume knob (pin 31), and the three-position switch (pin 34). The LEDs on the universal flex are controlled through pins 20, 21, and 22. Connections to the external accessory connector, which include serial communication data lines, external audio, and option select lines for controlling audio modes, are present at pins 1 through 13. Switched battery voltage (B+SENSE) is provided on pin 32. Most of the pins at this connector have ESD protection devices and components.

3.2.1.2 Encryption Connector J701

This 40-pin connector provides the interface between the VOCON board and the encryption module. Two voltages are provided to the encryption board: UNSWB+ and SWB+. The SAP SSI lines, serial communication data lines, and general-purpose I/O lines from the Patriot IC are included in the interface to the encryption board. A number of jumpers are present on some of the lines so that the VOCON board configuration to the encryption board can be changed depending on the encryption type present.

3.2.1.3 Keypad Module Connector P107

This 22-pin connector mates the VOCON board to the keypad module flex used on Model II and III radios. The keypad module is provided with 5 volts (pins 7 and 8) for the LEDs. The LEDs are activated by the signal at pin 6, BL_EN. The row signal lines (pins 13, 14, 15, 16, 17, 18, and 19) and column signal lines (pins 1, 2, and 3) are all at the dual-core processor's GPIO voltage.

3.2.1.4 RF Interface Connector P201

This is a 26-pin compression connector that interfaces between the VOCON board and the transceiver board. See Section 3.1.1.2 " VOCON Connector P1," on page 3-3 for a detailed description of the interface between the VOCON and transceiver boards through P201. Ground clip M202 is used on the bottom side of the VOCON board to contact the transceiver shield. This additional connection provides a consistent, common ground with the VOCON board and the radio chassis.

3.2.1.5 Display Module Connector P301

This 22-pin connector mates the VOCON board to the display module flex used on Model II and III radios. The NTN9564 VOCON kit has a parallel data interface to the display module. In this design, two voltages are provided to the display module: 1.8 V and 3 V. The display's parallel data lines (pins 9, 10, 11, 12, 13, 14, 15, and 16), chip select line (pin 5), read/write line (pin 8), register select line (pin 7), and parallel/serial configuration line (pin 4) are at 1.8-V logic levels.

The NNTN4563 and NNTN4819 VOCON kits have a serial data interface to the display module. In this design, only 3 V is provided to the display module on pins 17 and 18. The display's serial data line (pin 16), serial clock line (pin 15), chip select line (pin 5), and register select line (pin 7) are at 3 V logic levels. The NNTN4717 VOCON board has a serial data interface to the display module, and all the lines are at 2.9 V logic levels.

3.2.2 Controller and Memory

The controller and memory section contains the following components:

- Patriot IC (U401)

- Static RAM (SRAM) IC (U403)
- Flash memory IC (U402)

The Patriot IC acts as both the microcontroller unit (MCU) and the digital signal processor (DSP) for the radio The MCU controls receive/transmit frequencies, power levels, display programming, user interface (PTT, keypad, channel select, etc.), and programming of ICs, as well as other functions. The DSP performs voice encoding and decoding, audio filtering, volume control, PL/DPL encode and alert-tone generation, squelch control, and receiver/transmitter filtering, as well as other functions.

The Patriot IC executes a stored program located in the Flash memory device. The SRAM, a volatile device, is used as working memory and shares the address and data bus with the Flash memory device.

NOTE: Refer to Table 8-2, "List of VOCON Schematics and Board Overlays," on page 8-1 for a listing of VOCON schematics that will aid in the following discussion.

3.2.2.1 Patriot IC U401

The Patriot IC U401 is a dual-core processor that contains both a 32-bit microcontroller unit (MCU) and a 16-bit digital signal processor (DSP) in one IC package. It comes in a 256-pin, ball-grid array (BGA) package with 1mm pitch solder balls. On the NTN9564, NNTN4563, and NNTN4819 VOCON boards, the dual-core processor is supplied with two voltages: 1.8 V (E401) and 3 V (E402). The 1.8 V supply is used as the core voltage, as well as the interface voltage, to the memory devices and display (1.8 V display interface only for the NTN9564 VOCON board). Most of the pins on the Patriot IC operate from the 3 V supply.

The NNTN4717 kit uses a new dual-core processor which requires some different operating voltages. The 1.8 V supply is used as the interface to the memory devices, unchanged from the original processor. A 1.55 V supply is used for the core voltage and the clock amplifier module. The remaining pins of the processor use a 2.9 V supply.

NOTE: GPIO voltage for the NTN9564, NNTN4563, and NNTN4819 VOCON boards is 3.0 V.

NOTE: GPIO voltage for the NNTN4717 VOCON board is 2.9 V.

Two main clocks are provided to the Patriot IC. The CKIH pin (C452) is provided a 16.8 MHz sine wave. This is the most important clock since it is internally used to generate the clocks for both the MCU and DSP cores, as well as most of the peripherals. A 3 V peak-to-peak 32 kHz square wave (32 kHz test point) is generated by the Flipper IC U301 and supplied to the CKIL pin on the Patriot IC. While not as widely used as the 16.8 MHz clock, the 32 kHz clock is needed by some components in the Patriot including the reset circuitry.

3.2.2.1.1 Microcontroller Unit (MCU)

The MCU portion of the Patriot IC has 22.5k x 32 bits of internal RAM and 1k x 32 bits of internal ROM, which is used for the bootstrapping code. The MCU has several peripherals including an External Interface Module (EIM), the Multiple Queue Serial Peripheral Interface (MQSPI), two Universal Asynchronous Receiver/Transmitter (UART) modules, and the One-Wire Interface module. The MCU communicates internally to the DSP through the MCU/DSP Interface (MDI).

External Interface Module (EIM)

The External Interface Module (EIM) is the MCU interface to the SRAM U403 and Flash Memory U402, as well as the display (only for the NTN9564 VOCON kit). The EIM lines include 24 external address lines, 16 external bi-directional data lines, 6 chip selects lines, read/write line, and output enable line among others. All of the EIM lines operate at 1.8-V logic levels, and the EIM operates at the MCU clock speed.

Multiple Queue Serial Peripheral Interface (MQSPI)

The Multiple Queue Serial Peripheral Interface (MQSPI) is the MCUs programming interface to other ICs. The Patriot IC has two independent SPI busses, and each has its own clock line (test points SCKA and SCKB), data-out line (test points MOSIA and MOSIB), and data-in line (test points MISOA and MISOB). There are 10 SPI chip selects (SPICS) that are programmable to either SPI A, the transceiver board SPI bus, or to SPI B, the dedicated VOCON SPI bus.

The devices on the SPI A bus include the PCIC and FracN IC on the SPICS4 (R131), the Abacus III IC on SPICS5 (R126), an analog-to-digital converter (ADC) on SPICS6 (R133), and the serial EEPROM on SPICS7 (R132). The two SPI B chip selects are for the GCAP II IC U501 on SPICS2 (R539) and the Flipper IC U301 on SPICS3. On the NNTN4563, NNTN4819, and NNTN4717 VOCON boards, two additional SPI chip select lines are used for the display: SPICS0 (R442) and SPICS1 (U407 pin 14). All of the SPI module lines operate at GPIO voltage logic levels.

There are several devices on the transceiver board that only have one bi-directional SPI data line. Components U404, U405, and U406 are configurable by MCU GPIO pin TOUT13 (MISOA_SEL) to route the data line to the appropriate pin on the Patriot IC depending on which SPI device is being accessed.

Universal Asynchronous Receiver/Transmitter (UART)

The Patriot IC has two Universal Asynchronous Receiver/Transmitter (UART) modules. UART1 handles the RS232 lines while UART 2 is connected to the SB9600 lines. Each UART has a receive data line (URXD), a transmit data line (UTXD), and hardware flow control signals (RTS–request to send) and (CTS–clear to send). All UART lines operate at GPIO voltage logic levels. The translation to 5 V logic levels for the accessory side connector is discussed in the Flipper section.

One-Wire Interface

The MCU has a One-Wire Interface module that is used to communicate to a One-Wire device like a USB cable or a smart battery using the Dallas Semiconductor protocol. This module has one external pin, OWIRE_DAT (Q504 pin 2), and it uses a GPIO voltage logic level.

3.2.2.1.2 Digital Signal Processor (DSP)

The DSP portion of the Patriot IC has 84k x 24 bits of program RAM and 62k x 16 bits of data RAM. The DSP has its own set of peripherals including the Baseband Interface Port (BBP), the DSP Timer module, and the Serial Audio CODEC Port (SAP). Additionally, the DSP shares some penpherals with the MCU, including the USB interface and the General Purpose Input/Output module (GPIO).

Baseband Interface Port (BBP)

The Baseband Interface Port (BBP) module is the DSP's serial synchronous interface (SSI) to the transceiver board. The BBP has independent sections for the receiver and the transmitter. The receiver BBP pins include the receive data pin SRDB (R121), the receive clock signal pin SC0B (R124), and the receive frame synchronization (sync) signal pin SC1B (R123). The transmitter's BBP pins include the transmit data pin STDB (R127), the transmit clock signal pin SCKB (R125), and the transmit frame sync signal pin SC2B (R119). All BBP lines use GPIO voltage logic levels.

DSP Timer Module

While the BBP receive clock and frame sync signals are supplied by the Abacus III IC from the transceiver board, the BBP transmit clock and frame sync signals are generated by the DSP Timer. The BBP receive clock, connected to the DSP Timer input pin T10, is reference used to generate the BBP transmit clock and frame sync signals. These two signals, along with the BBP transmit data signal, are connected to the DAC on the transceiver board.

Serial Audio CODEC Port (SAP)

The Serial Audio CODEC Port (SAP) module is the DSP's serial synchronous interface (SSI) to the audio CODEC on the GCAP II IC. The SAP also interfaces with the encryption module.

The SAP interface consists of four signals including the SAP clock line pin SCKA (component R405), the SAP frame sync line pin SC2A (component R406), the SAP receive data line pin SRDA (component R402), and the transmit data line pin STDA (component R403). On the NTN9564, NNTN4563, and NNTN4819 VOCON boards, the SAP clock is generated by the Flipper IC U301, and is a 520 kHz, 3 V peak-to-peak square wave. The SAP frame sync signal is also generated by the Flipper IC, and is an 8 kHz, 3 V peak-to-peak square wave.

On the NNTN4717 VOCON board, the SAP clock is generated by the dual-core processor U401, and is a 256 kHz, 2.9 V peak-to-peak square wave. The SAP frame sync signal is generated by the dual-core processor U401, and is an 8 kHz, 2.9 V peak-to-peak square wave.

Universal Serial Bus (USB)

The Patriot IC USB peripheral, shared by the MCU and the DSP, provides the required buffering and protocol to communicate on the Universal Serial Bus. The Patriot IC supports USB slave functionality.

For receive data, the USB differentially decoded data comes from the Flipper IC URXD_RTS pin into the Patriot URTS1 pin, while the single-ended USB data positive signal goes to pin PA2_USB_VPIN, and the single-ended USB data minus signal goes to pin URXD1. The two data lines are used to detect the single-ended zero state.

For transmit data, the USB data comes out of the Patriot IC UTXD1 pin and goes to the Flipper IC TXD_USB_VPO pin. The USB transmit single-ended zero signal is generated from the Patriot IC PC0_USB_VMOUT pin.

General-Purpose Input/Output (GPIO) Module

The General-Purpose Input/Output (GPIO) module is shared by the MCU and the DSP. This module consists of four 16-pin bi-directional ports and a 15 pin bi-directional port. While some of the pins on these ports are being used for other functions (UART, SPI, SAP, BBP, and Interrupt pins), the remaining pins can be programmed to become GPIOs that can be used by either the DSP or the MCU. Each GPIO pin has up to 8 alternate output functions and up to 4 alternate input functions. This allows for the GPIO pins to be routed internally to pertinent Patriot IC modules. Additionally, the GPIO module adds selectable edge-triggered or level-sensitive interrupt functionality to the GPIO pins. Some examples of GPIO pins include the Audio PA control signals (EXT_SPKR_SEL, AUDIO_PA_EN, and AUDIO_MODE_SEL), the EEPOT control signals (EEPOT_INC*, EEPOT_U_D*, EEPOT_CS*, and EEPOT_CS_EXT*), and the LED control signals (RED_LED and GREEN_LED).

3.2.2.2 Static RAM (SRAM) U403

The static RAM (SRAM) IC U403 is an asynchronous, 1 MB, CMOS device that is capable of 70 ns access speed. It is supplied with 1.8 volts. The SRAM has its 19 address lines and 16 data lines connected to the EIM of the Patriot IC through the Address(23:0) and Data(15:0) busses.

The SRAM has an active-high chip select CS2 that is tied directly to the 1.8 V supply and an active-low chip select CS1 that is connected to the EIM CS2_N pin (test point CS2). When the SRAM CS1 pin is not asserted, the SRAM is in standby mode, which reduces current consumption.

Two other control signals from the EIM that change the mode of the SRAM are the read/write signal, R/W, and the output enable signal, OE. The R/W of the EIM is connected to the SRAM EN_WE pin (test point R_W), while the OE signal from the EIM is connected to the SRAM EN_OE pin. The SRAM is in read mode when the EN_WE pin is not asserted and the EN_OE pin is asserted. The SRAM is in write mode when the EN_WE pin is asserted, regardless of the state of the EN_OE pin.

The other SRAM pins are the lower-byte enable pin LB and the upper-byte enable pin UB. These pins are used to determine which byte (LB controls data lines 0-7 and UB controls data lines 8-15) is being used when there is a read or a write request from the Patriot IC. The LB pin is controlled by the EIM EB1_N signal, while the UP pin is controlled by the EB0_N signal.

3.2.2.3 FLASH Memory U402

The Flash memory IC is an 8 MB CMOS device with simultaneous read/write or simultaneous read/erase operation capabilities with 70 ns access speed. It is supplied with 1.8 volts. The Flash memory has its 22 address lines and 16 data lines connected to the EIM of the Patriot IC through the Address(23:0) and Data(15:0) busses. The Flash memory contains host firmware, DSP firmware, and codeplug data with the exception of the tuning values that reside on the transceiver board's serial EEPROM. The Flash memory IC is not field repairable.

The RESET_OUT of the Patriot IC is at a GPIO voltage logic level. Components D401 and R401 are used to convert the voltage down to a 1.8 V logic level, and this 1.8 V reset signal is fed to the Flash RESET pin. When this pin is asserted (active low logic), the Flash is in reset mode. In this mode, the internal circuitry powers down, and the outputs become high-impedance connections.

The Flash active-low chip select pin, EN_CE, is connected to the active-low CS0_N pin (CS0 test point) of the EIM. When the EN_CE is not asserted, the Flash is in standby mode, which reduces current consumption.

Several other active-low control pins determine what mode the Flash memory is in: the address valid pin ADV (ADV test point) that is connected to the EIM LBA_N signal, the output enable pin EN_OE that is connected to the EIM OE_N signal, and the write enable pin EN_WE that is connected to the EIM EB1_N signal. For read mode, the ADV and EN_OE pins are asserted while the EN_WE pin is not asserted. When the EN_WE is asserted and the EN_OE pin is unasserted, the Flash operates in the write mode.

Figure 3-8 illustrates the EIM and memory ICs block diagram.

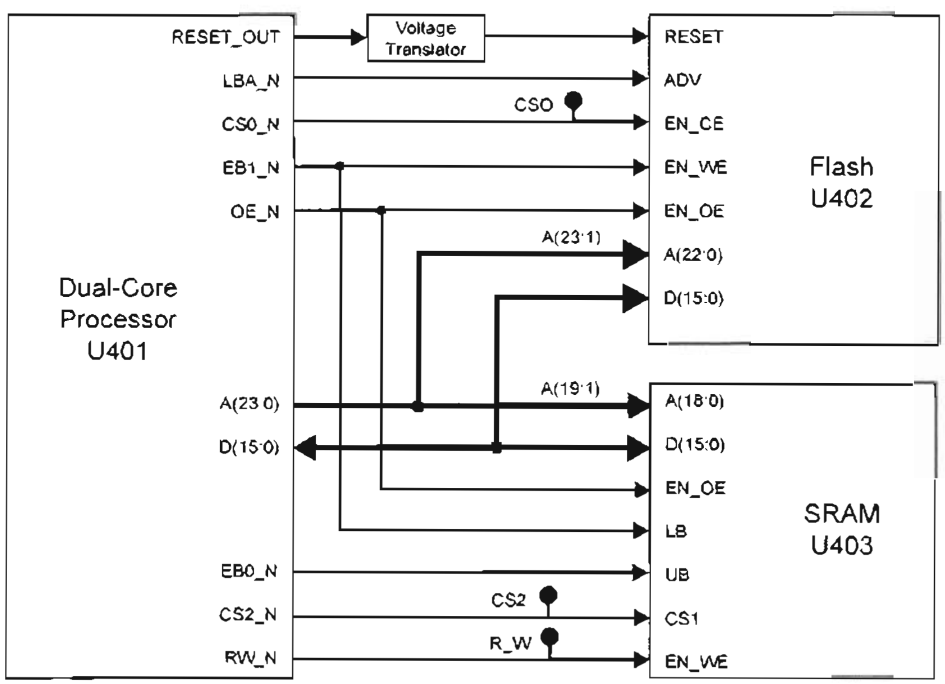


Figure 3-8. Patriot EIM and Memory Block Diagram

3.2.3 Audio and Power

The audio and power section contains the following components:

- GCAP II IC U501
- 5 V regulator U505
- Audio pre-amplifier U502
- Audio power amplifier U503
- EEPOT U509
- 1.55 V regulator (NNTN4717 VOCON board only)

The GCAP II IC contains a CODEC, amplification, filtering, and multiplexing capability for receive and transmit audio, voltage regulators, an analog-to-digital converter (ADC), and a real-time clock (RTC) The GCAP II IC is programmed by the Patriot IC.

The audio pre-amplifier and the audio power amplifier condition the received audio signal before being routed to the speaker. The dual EEPOT sets the gain of the microphone signal. These devices are programmed by the Patriot IC.

NOTE: Refer to Table 8-2, "List of VOCON Schematics and Board Overlays," on page 8-1 for a listing of audio and power-related schematics that will aid in the following discussion.

3.2.3.1 GCAP II IC U501

The GCAP II IC is a mixed-signal (analog and digital) IC that provides control, audio, and voltage regulation functionality. It comes in a 100-pin, ball-grid array (BGA) package with 0.8 mm pitch solder balls. The GCAP II IC is supplied with switched battery voltage GCAP_B+ (R581).

3.2.3.1.1 Voltage Regulation

The GCAP II IC contains several voltage regulators that are used in the design of the VOCON board: VSW1, VSW2, and V2. The VSW1 regulator is a programmable switching regulator that uses the switched battery voltage as its input on pin PSRC1. The output voltage of VSW1 (R502) is programmable by the Patriot IC U401 through the SPI bus. The initial output of VSW1 is 3.2 volts, which is then programmed to 3.8 volts. The VSW1 voltage is supplied to the RF Interface connector P201 pin 15 and to the input pins of the VSW2 and V2 regulators.

The VSW2 regulator is a SPI programmable switching regulator that uses VSW1 as its input on pin PSRC2. The initial output of VSW2 (R501) is 2.2 volts, which is then programmed to 1.875 volts (referred to as 1.8 volts throughout this document). The VSW2 voltage is supplied to the Patriot IC (core voltage and the EIM voltage), the SRAM U403, the Flash memory U402, and the display module connector J301 (1.8 V display interface only for the NTN9564 VOCON kit).

The V2 regulator is a SPI programmable linear regulator that uses VSW1 as its input on pin VIN2. The initial output of V2 (R560) is 2.775 volts, which is then programmed to 3 volts for the NTN9564, NNTN4563, and NNTN4819 VOCON boards, and 2.9 volts for the NNTN4717 VOCON board. The V2 voltage is supplied to the Patriot IC (I/O ring - SPI, BBP, SAP, UART, GPIO, etc.), the Flipper IC U301, the EEPOT U509, the display module connector J301, and the many discrete components that interface with the Patriot IC and the Flipper IC.

3.2.3.1.2 MCU Interface

The GCAP II IC has a four-wire, SPI connection to the Patriot IC (SPI B). The SPI B clock is connected to the SPI_CLK pin (test point SCKB). The SPI B MOSI line is connected to the SPI_DW pin (test point MOSIB). The SPI B MISO line is connected to the SPI_DR pin (test point MISOB). The GCAP SPI B chip-select signal is connected to the CE pin (R539). Through this interface, the Patriot IC can program the voltage regulators, the CODEC, the transmit and receive audio filters and amplifiers, as well as read information from the ADC and the real-time clock.

The GCAP II IC has an 8-bit ADC with general-purpose six channels and four voltage-monitoring channels. The six general-purpose analog-to-digital (A/D) channels are assigned to monitor volume (AD5); the three-position toggle switch from the universal connector J101 (AD1); the emergency, monitor, and side buttons (AD0); the battery status line (AD2); the board type indicator (AD3); and the board identification voltage (AD4). Battery voltage is also monitored by the ADC. The Patriot IC activates and reads the A/D values through the SPI bus.

The real-time clock (RTC) module of the GCAP II IC consists of several counters to determine elapsed time. The Patriot IC reads the RTC registers through the SPI bus. The RTC is supplied with voltage from a backup lithium rechargeable battery (LI_CELL) and a 32.768 kHz clock signal from the Flipper IC to the GCAP II IC XTAL1 pin.

3.2.3.1.3 Audio Circuitry

A 13-bit CODEC, internal to the GCAP II IC and programmable by the Patriot IC through the SPI bus, converts microphone audio into a digital bit stream for processing by the DSP. The CODEC also converts receive audio data that was processed by the DSP into an analog audio signal for amplification to a speaker. The CODEC interfaces to the DSP through the 4-wire SAP bus. The CODEC clock, which is 520 kHz (for the NTN9564, NNTN4563, and NNTN4819 VOCON boards) or 256 kHz (for the NNTN4717 VOCON board) is supplied to the DCLK pin. The CODEC 8 kHz CODEC frame synchronization signal is supplied to the FSYNC pin. The CODEC transmit data signal is on the TX pin, while the CODEC receive data signal is on the RX pin. For the CODEC to operate with those clock and frame sync signals, a 13 MHz clock (R302), generated by the Flipper IC, is supplied to the GCAP CLK_IN pin.

The GCAP II IC contains internal amplification, filtering, and multiplexing functionality for both receive and transmit audio. These functions are Patriot IC-programmable through the SPI bus. The input for the internal microphone audio (R540) is the MICIN_NEG pin, while the input for the external microphone audio (R566) is the AUX_MIC_NEG pin. The output for the speaker audio is the EXTOUT pin (C533).

3.2.3.2 5 V Regulator U505

The 5 V regulator uses UNSW_B+ as its input voltage. The Flipper IC WDI line controls the regulator's SHUTDOWN pin. The 5 V supply (R503) is used by the Flipper IC U301, audio pre-amplifier U502, microphone bias circuitry (R531 and R563), Flipper IC protection diodes, bi-directional voltage translators, battery data-line isolation circuitry, and ESD protection circuitry.

3.2.3.3 1.55 V Regulator

The 1.55 V regulator is made up of the following components: U508, Q503, R598, R507, R508, R509, R512, R599, C576, C565, C512, C580, and C567 (check the NNTN4717 VOCON board BOM for part values and placement). This circuit uses VSW1 to bias the regulator while VSW2 sources the current. This voltage is used by the dual-core processor U401 for its core voltage and clock amplifier. The 1.55 V regulator is only instantiated on the NNTN4717 VOCON board.

3.2.3.4 Audio Pre-Amplifier U502

The audio pre-amplifier U502 is a single-package, 5-pin, op-amp supplied with 5 volts. This pre-amp stage provides a fixed gain, which is selected by the components R551 and R537. The input (U502 pin 4) of stage is the EXTOUT pin from the GCAP II IC, while the output (U502 pin 1) of this stage goes to the audio PA.

3.2.3.5 Audio Power Amplifier U503

The audio power amplifier (PA) U503 consists of two BTL amplifiers, complementary outputs, and control logic. Each of the amplifiers has a fixed gain—the external audio PA gain is set by components R553 and R554, while the internal audio PA gain is set by components R549 and R550. The MODE pin (U503 pin 4) voltage determines the operation of the amplifier. That voltage is controlled by the Patriot IC GPIO lines AUDIO_PA_EN (to Q505) and AUDIO_MODE_SEL (to Q506). Table 3-4 describes how the Patriot IC GPIO lines configure the audio PA.

Table 3-4. Audio PA Status

AUDIO_PA_EN	AUDIO_MODE_SEL	Audio PA Status	MODE Voltage
0	0	Standby	V_Mode > 7 V
0	1	Mute	1.5 V < V_Mode < 6 V
1	0	On	V_Mode < 0.5 V
1	1	On	V_Mode < 0.5 V

The SELECT pin (U503 pin 6) is used to switch the audio path between internal and external speaker. The voltage on that pin is determined by the EXT_SPKR_SEL line from the Patriot IC and the Q505 transistor. When the voltage at the SELECT pin is high (B+), the audio is routed to the internal speaker lines. When the voltage at the SELECT pin is low (V_select < 0.5V), the audio is routed to the external speaker lines.

3.2.3.6 EEPOT U509

The EEPOT is a digitally programmable potentiometer with 256 taps and a total resistance of 50 kohms. This 10-pin package contains two independent potentiometers, one for each microphone line. The EEPOT resistance values are programmed by the Patriot IC GPIOs EEPOT_INC* (U509 pin 9) and EEPOT_U_D* (U509 pin 2). The EEPOT_INC* signal increments the resistance value up or down, which depends on the EEPOT_U_D* signal. The EEPOT_CS* line (U509 pin 10) is asserted when the internal microphone gain is being changed. Similarly, the EEPOT_CS_XST* (U509 pin 1) is asserted for external microphone gain changes. The EEPOT is supplied with voltage from the GCAP II V2 regulator.

3.2.4 Interface Support

The interface support section consists of the following:

- Flipper IC U301
- ESD protection circuitry
- Universal connector interface circuitry

The Flipper IC contains a USB transceiver, switching logic between RS232 and boot data path, One-Wire side connector support, and several clock generators. The Flipper IC is programmed by the Patriot IC.

ESD protection devices include zener diodes and low-capacitance ESD suppressors.

Side connector interface circuitry includes current-limiting resistors and noise-suppressing shunt capacitors.

3.2.4.1 Flipper IC U301

See Figure 8-64, "NTN9564B VOCON Flipper Circuit," on page 8-99 for schematic details of the following discussion.

The Flipper IC U301 is an application-specific, integrated circuit (ASIC) device designed for the XTS-radio product line. The Flipper IC is contained in a 64-pin µBGA package with 0.8 mm pitch solder balls. The Flipper IC is supplied with 5 volts and the processor's GPIO voltage, and it uses the 16.8 MHz clock (C307) as its master clock. The Flipper IC is programmable by the Patriot IC through the SPI bus.

The Flipper IC supports many functions including the radio side connector interface, bi-directional logic level translation, boot data path control, USB transceiver, One-Wire option detect support, watchdog timer, 32 kHz oscillator with CMOS output, 13 MHz reference generation for the GCAP II IC, and SSI clock and frame sync generator.

3.2.4.1.1 Side Connector Interface, Logic Level Translation, and Boot Data Path Control

The Flipper IC facilitates the interface to the radio's side connector. Some of the side connector lines are at 5 V logic levels, so the Flipper IC converts those lines to GPIO voltage logic levels to interface to the Patriot IC, as well as the encryption module. These lines include the SB9600 bus busy line LH_BUSY (TP207), the RS 232 CTS (TP208) and RTS (TP209) lines, the RS232 data-out line (TP210), and the RS232 data-in line (TP211). The SB9600 data line uses an external, bi-directional, voltage translation circuit that includes Q303, D301, R325, R326, and R327.

Another function that the Flipper IC provides with these lines is boot data path control. The boot data path is as follows: boot data-in is multiplexed onto the RS232 data-out line while the boot data-out is multiplexed with the SB9600 data line. This alternate data path is used only to Flash code into a radio for the first time. The Patriot IC, through the SPI bus, controls this feature.

3.2.4.1.2 USB Transceiver

The USB transceiver, internal to the Flipper IC, is capable of transmitting and receiving serial data at a rate of 12 megabits per second. The differential USB data comes from the side connector, through the 22-ohm resistors R252 and R253 and the isolation switch Q301, and then to the USB_DPLUS and USB_DMINUS pins on the Flipper IC. The USB receive interface from the Flipper IC to the Patriot IC is as follows: USB_DPLUS routed to USB_VPI, USB_DMINUS routed to USB_VMI_RXD, and the differential decoded data is output at the URXD_RTS pin and goes to the Patriot IC URTS1 pin.

The USB transmitter is enabled when the USB_SUSP and USB_TXENAB signals are both driven low by the Patriot IC. The single-ended data is output from the Patriot IC on the UTXD1 pin and goes to the Flipper TXD_USB_VPO pin. The data is driven out differentially on the USB_DPLUS and USB_DMINUS pins, which go to the side connector. The Patriot IC sends the single-ended zero signal from pin PCO_USB_VMOUT to the Flipper IC USB_FSEZ pin.

When a USB cable is detected, the USB_DIS pin (Q302 pin 2) goes high. This controls the isolation switch Q301 so that the data that is on those lines are routed to the USB transceiver. If a USB cable is not detected, the USB_DIS pin is low and the USB transceiver on the Flipper IC is isolated from the side connector. This isolation is done primarily because the RS232 data lines are 5 V lines, so the switch protects the transceiver since it operates at a lower voltage, and the USB data lines to the side connector also act as the RS232 lines.

On the NNTN4717 VOCON board, the USB transceiver on the Flipper IC is not used. Instead, a discrete USB transceiver U310 is used. This transceiver is provided with 5 V and 2.9 V. The 5 V powers an internal 3.3 V voltage regulator on the transceiver, which is used as the voltage for the USB data pins D+ an D- as well as the VPU pin. The 2.9 V is used by the remaining pins as they interface to the dual-core processor U401.

3.2.4.1.3 One-Wire Support

New options and accessories that attach to the side connector are identified by the Patriot IC using the One-Wire protocol The Option Select 2 pin on the side connector also serves as the One-Wire data pin (R218). This signal is connected to the ONE_WIRE_OPT pin. This pin is connected to the Patriot IC One-Wire bus ONE_WIRE_UP through an internal isolation switch controlled by a Patriot IC GPIO line to the Flipper IC ONE_WIRE_EN_X pin. This isolation is needed to prevent possible contention on the One-Wire bus when a smart battery is attached to the radio.

These new accessories are to ground pin 10, CTS (TP208), of the side connector. When this occurs, the Flipper IC pin KVL_USB_DET_X is asserted and the Patriot IC detects the change. The Patriot IC then asserts the ONE_WIRE_EN_X pin on the Flipper IC to connect the side connector One-Wire line to the Patriot IC One-Wire bus. In the case of the USB cable, the Patriot IC reads the One-Wire data from the cable and, upon determining that a USB cable is attached, programs the Flipper IC for USB mode.

3.2.4.1.4 Watchdog Timer

The Flipper IC monitors the position of the radio's On/Off switch on the BP_SEN_X pin, and that signal is located on Q508 pin 3. If the voltage on pin 3 is ground, then the radio is turned on. If the voltage on pin 3 is 3 volts, then the radio is off. When the radio is turned off, a counter inside the Flipper IC begins incrementing. That counter can be refreshed by the Patriot IC through the SPI bus. This is done so that the software has enough time to complete its tasks before the power is taken away from the Patriot IC. If the counter is not refreshed by the time the count is complete, the Flipper IC pin WD_OUT goes low, which shuts down the GCAP II voltage regulators. During normal radio operation, WD_OUT should be high (V2 regulated voltage).

3.2.4.1.5 32 kHz Oscillator and CMOS output

The 32 kHz oscillator circuitry uses a separate voltage supply pin (VDD3_XTL) than the other 3-V portions of the Flipper IC. This 32 kHz clock is used by the GCAP II RTC module to keep track of time. The VDD3_XTS pin is supplied with the backup lithium (Li) rechargeable battery voltage LI_CELL. The oscillator circuitry is internal to the Flipper IC, and the 32.768 kHz crystal Y301 and additional load capacitors C308 and C309 are located next to the IC.

The output of the 32 kHz oscillator is an LI_CELL voltage (approximately 3 volts peak-to-peak), 32.768 kHz square wave on pin REF32_OUT. This clock goes to two destinations: the Patriot IC CKIL pin (32 kHz test point) as a square wave and the GCAP II IC XTAL1 pin (C306) as a sine wave. Components C306 and C313 are used to filter the square wave into a sine wave before the signal goes to the GCAP II IC.

3.2.4.1.6 13 MHz Reference Generation for GCAP II

The 13 MHz reference is required by the GCAP II IC for the CODEC time base and the SSI clock generator module internal to the Flipper IC. A phase locked loop (PLL) is used to generate the 13 MHz using the 16.8 MHz clock, which is provided to the Flipper IC REF_16_IN pin (C307). An external RC loop filter network, consisting of R301, C301, and C302, is connected to the PLL_LFT pin.

The 13 MHz reference output pin, REF_13_OUT, is conditioned by the RC network of R302 and C303. The signal at REF_13_OUT is a 3-V peak-to-peak square wave, and the RC filter produces a lower-level triangle wave that is suitable for the GCAP II IC.

The 13 MHz reference is disabled as the Flipper IC powers up. The 13 MHz reference is enabled by the Patriot IC through the SPI bus, and, during normal radio operation, this signal should be present.

3.2.4.1.7 SSI Clock and Frame Sync Generator

The Flipper IC generates the SSI clock and frame sync signals for the SAP bus used by the Patriot IC, GCAP II IC, and encryption module. These signals are generated from the 13 MHz reference. The SSI clock output pin is labeled SSI_CLK, and the frequency is 520 kHz. The SSI frame sync output pin is FRSYNC, and the frequency is 8 kHz. These signals are not active when the Flipper IC comes out of reset, so they are programmed by the Patriot IC through the SPI bus.

The Flipper IC provides four 16-bit TDM slots per frame on the SAP bus. The first slot (slot 0) begins immediately after the frame sync pulse, and this slot is used by the GCAP II IC. The SEC_SS_X pin is active for the first 8 bits of the second slot (slot 1). This signal is used by the encryption module to synchronize its input and output to the SSI frame. The other two slots are reserved for possible design additions in the future.

On the NNTN4717 VOCON board, the Flipper IC is not programmed to generate the SSI clock, SSI frame sync signal, or the secure slave select signal (SEC_SS_X); the dual-core processor U401 generates these signals.

3.2.4.2 ESD Protection Circuitry

See Figure 8-63, "NTN9564B VOCON Universal Connector Circuit," on page 8-98 for schematic details of the following discussion.

Several components on the VOCON board protect the circuitry from ESD. The side connector signal lines have ESD protection components on them since they are exposed. These protection components include:

- 5.6-V zeners VR205, VR206, VR220, and VR221 on the SB9600 lines, RS232 lines, microphone lines, and option-select lines
- 12-V zeners VR201, VR203, and VR209 on the internal and external speaker audio lines
- 13-V zener VR204 on the OPTB+ line
- Low-capacitance ESD suppressors D203, D204, D205, and D206 on audio lines, USB data lines, and option-select lines

There were also several protection diodes on lines connected to the Flipper IC. These include D302, D303, D304, D305, D306, D307, and D308. ESD protection for the battery status line is provided by a 5.6-V zener VR501.

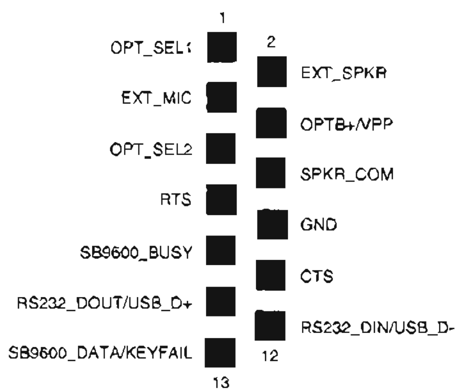
3.2.4.3 Universal Connector Interface Circuitry

See Figure 8-63, "NTN9564B VOCON Universal Connector Circuit" on page 8-98 for schematic details of the following discussion.

Some important components on the universal connector interface are two op-amps. The first op-amp, U201, is used as a comparator for the option-select 1 line. The comparator threshold is determined by the voltage-divider network of R257 and R258. Similarly, the other op-amp, U202, is used as a comparator for the option-select 2 line. The comparator threshold is determined by the voltage-divider network of R240 and R243. The remaining components consist of current-limiting serial resistors and noise-suppressing shunt capacitors.

3.2.4.3.1 Universal Connector and Option Selects

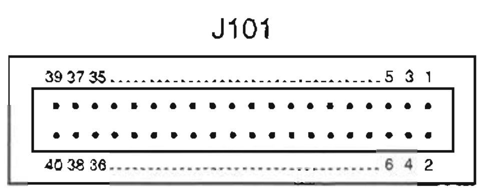
The universal connector is located on the side of the radio. It is the external port or interface to the outside and is used for programming and interfacing to external accessories. The universal connector connects to the VOCON board at connector J101 via a flex circuit that is routed inside the external housing. Connections to the universal connector and J101 on the VOCON board are shown in Figure 3-9 on page 3-28 and Figure 3-10 on page 3-28.



MAEPF-27415-O

Figure 3-9. Universal (Side) Connector

Signal Name	J101-Pin #
OPT_SEL1	11
EXT_SPKR	9
EXT_MIC	13
OPTB+/VPP	12
OPT_SEL2	7
SPKR_COM	5
RTS	10
GND	3
SB9600_BUSY	8
CTS	1
RS232_DOUT/USB_D+	6
SB9600_DATA/KEYFAIL	2
RS232_DIN/USB_D-	4



MAEPF-27452-O

Figure 3-10. VOCON Board Connector—J101

Most of the signals are extensions of circuits described in other areas of this manual. However, there are two option select pins (see Table 3-5) used to configure special modes: Option Select 1 and Option Select 2. These pins are controlled by accessories connected to the universal connector. Table 3-5 outlines their functions as defined at the universal connector. In the case of the XTS Vehicular Adapter (XTVA), Option Select 1 pin is connected to Option Select 2 pin by a diode internal to the XTVA.

Table 3-5. Option-Select Functions

Function	Option Select 1	Option Select 2
External PTT	0	0
No Function (Normal)	1	1
Man Down	1	0
External Speaker	0	1
XTVA	Diode cathode	Diode anode

3.2.4.4 Display Module

An optional, integral, 96 pixels by 64 pixels, bit-mapped, liquid-crystal display (LCD) module is available with either a 3 x 2 keypad with a navigational button (Model II radios) or 3 x 6 keypad with a navigational button (Model III radios). The display module is connected to the VOCON board through flex connector J301. The display module uses chip-on-film technology and is not field repairable.

3.2.4.4.1 7285726C01 Display Module

NOTE: The NTN9564 VOCON kit is only compatible with the 7285726C01 display module.

The 7285726C01 display module is controlled by the Patriot IC MCU core, which programs the display through the EIM data lines D0 - D7 (pins 9 through 16, respectively), the display chip select line (pin 5), the EIM read/write line (pin 8), and the EIM address 0 line (pin 7) that is used to select the register to be programmed. The Patriot IC can reset the display module through pin 6. The display is supplied with 1.8 V (B102) to pin 17 and 3.0 V (B101) to pin 18. Display backlighting is controlled by the Patriot IC GPIO line BL_EN signal through components R140 and Q101. The LEDs on the display module are powered by 5 V going through resistors R101, R102, R103, and R104.

3.2.4.4.2 7285726C02 and 7285726C03 Display Modules

NOTE: The NNTN4563 VOCON kit is compatible only with the 7285726C02 display module, while the NNTN4819 VOCON kit is compatible only with the 7285726C03 display module. Check the model charts for display part number compatibility with the NNTN4717 VOCON board.

The 7285726C02 and 7285726C03 display modules are controlled by the Patriot IC SPI bus, which programs the display through the serial data line (pin 16), the serial clock line (pin 15), chip select line (pin 5), and register select line (pin 7) that is used to select the register to be programmed. The Patriot IC can reset the display module through pin 6. The display is supplied with GCAP II V2 regulated voltage (B101) to pins 17 and 18. Display backlighting is controlled by the Patriot IC GPIO line BL_EN signal through components R140 and Q101. The LEDs on the display module are powered by 5 V going through resistors R103 and R104.

3.2.4.5 Keypad Module

The keypad module is either a 6- x 3-button (Model III) or a 2- x 3-button (Model II) module with backlighting.

The keypad module is connected to the VOCON board through flex connector J107. The keypad is read though a row-and-column matrix made up of ROW1, ROW2, ROW3, ROW4, ROW5, ROW6, and COL1, COL2, and COL3. When a key is pressed, a row and a column are connected to each another. The Patriot IC determines a key press by a scanning algorithm. Each column line is configured as an open drain output and pulled low. The Patriot IC then scans the row pins (each row pin has an internal pull-up resistor). If a row signal is read low, then the Patriot IC determines that a key was pressed. If none of the row signal lines are low, then another column line is pulled low and the row scanning routine occurs.

The keypad backlighting is controlled by the Patriot IC GPIO BL_EN, and that signal goes to pin 6 of the J107 connector. Pins 7 and 8 are supplied with 5 volts, which is used to power the LEDs on the keypad module.

3.2.4.6 Controls and Control Top Flex

The universal flex assembly contains an On/Off switch/volume control knob, frequency selector switch, push-to-talk (PTT) switch, monitor button, several function-selectable switches, universal connector, speaker, and microphone.

The housing assembly top controls include the On/Off switch/volume control (S1), a 16-position mode-select switch with programmable two-position concentric switch (U1), a programmable three-position (A,B,C) toggle switch (S2), and a programmable top (orange) button (SW3). The side controls include three programmable, momentary, pushbutton switches (side button 1 [SB2], side button 2 [SB3], top side button [SB1]) and a PTT switch (SW2). These components are connected through a flex circuit to the controller at J101 (see Table 3-11, "Control Top Flex," on page 3-31). The assembly also contains the radio's internal speaker and internal microphone.

UNSW_B+ is routed through switch S1 to provide the B+SENSE signal, which is used to activate the SW_B+ and GCAP_B+ voltages that, in turn, power up the radio. Volume control is also provided by S1, which contains a potentiometer biased between V2 regulated voltage and ground. The VOL signal is a voltage level between V2 regulated voltage and ground, depending on the position of the rotary knob. The VOL signal is fed to buffer U507 pin 3, and then the output of the buffer is voltage-divided down to 2.5 volts before the signal goes to the GCAP II IC AD5 pin. The Patriot IC reads the GCAP II IC A/D value through the SPI bus, and from this reading, the Patriot IC DSP adjusts the speaker volume.

Switch S2 is the three-position, programmable, toggle switch typically used for expanded zone/channel selection. The switch can output the following voltages: 0 volts, half of the V2 regulated voltage, or V2 regulated voltage (measurable at R231). The switch is connected to the GCAP II IC AD1 input pin through the voltage divider network of R519 and R523. The Patriot IC reads the A/D value through the SPI bus, and it uses that reading to determine the position of the toggle switch.

The programmable top (orange) button SW3 is typically used for emergency. This button, along with programmable side buttons SB1 through SB3, is connected to a resistor divider network, biased between V2 regulated voltage and ground. This network, made up of R1, R2, and R3, provides a voltage level, controlled by whichever button is pressed, to pin 3 of buffer U504. The output of the buffer is voltage- divided down to 2.5 volts before the signal goes to the GCAP II IC AD0 pin. The Patriot IC reads the GCAP II IC A/D value through the SPI bus, and it uses that data to determine which button was pressed.

LED D1 is the TX/RX indicator. LEDs D2 through D6 are used for backlighting the frequency knob.

U1 is a binary-coded switch. The output pins from U1, which are connected to GPIO pins on the Patriot IC, provide a four-bit binary word (signals RTA0, RTA1, RTA2, and RTA3) to the MCU, indicating to which of the 16 positions the rotary is set. This switch provides an additional output, TG2, which is typically used for coded or clear mode selection. It is an input to the Patriot IC TOUT8_PD4 GPIO pin. Selecting clear mode pulls this signal to a logic low, and it can be monitored from R234.

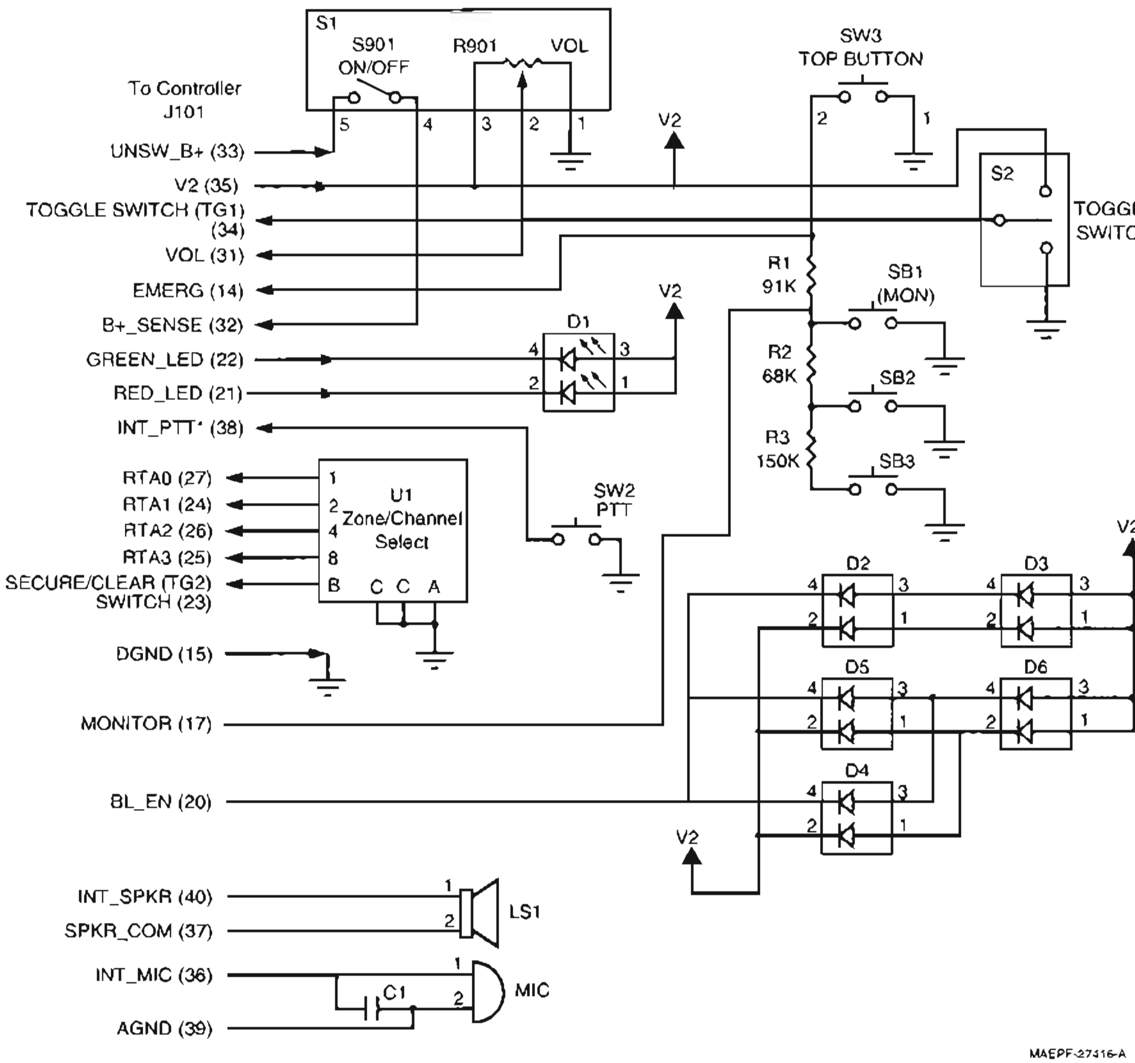


Figure 3-11. Control Top Flex

3.2.4.7 System Clocks

The Patriot IC is supplied with two clocks. The first clock, a 16.8 MHz sine wave, comes from the RF interface connector P201 pin 7. It is conditioned by the clock buffer circuit, which includes Q450, Q451, L450, C450, C452, C452, R450, R451, R452, R453, R454, and R455. The output of this buffer (C452) goes to the Patriot IC CKIH pin as well as the Flipper IC REF_16_IN (C307).

The other clock supplied to the Patriot IC is a 32.768 kHz square wave. This clock is generated by the Flipper IC internal oscillator and an external 32.768 kHz crystal Y301 and is connected to the Patriot IC CKIL pin.

3.2.5 VOCON Audio Paths

This section describes the VOCON transmit and receive audio paths. See Figure 8-67, "NTN9564B VOCON Audio and DC Circuits," on page 8-102 for schematic details of the following discussion.

3.2.5.1 Transmit Audio Path

Refer to Figure 3-12. The internal microphone audio enters the VOCON board through the universal connector J101 pin 36, and the internal microphone bias is set by circuitry that includes R531, R533, C519 and C521. The internal microphone signal is connected to the MICIN_NEG pin, which is the input terminal on the GCAP II IC internal op-amp A3. The gain of the A3 op-amp is set by the values of R540, R555, and the resistance of EEPOT U509 (digital potentiometer), which is programmed by Patriot IC GPIO lines.

The external microphone audio enters the VOCON board through the universal connector J101 pin 13, and the external microphone bias is set by circuitry that includes R563, R565, C547, and C548. The external microphone signal is connected to the AUX_MIC_NEG pin, which is an input terminal on the GCAP II IC internal op-amp A5. The gain of the A5 op-amp is set by the values of R566, R561, and the resistance of the EEPOT U509.

The Patriot IC, through the SPI bus, programs a multiplexer to select one of the microphone signals. Then, the selected amplified microphone signal goes through a programmable gain amplifier before it goes to the CODEC for A/D conversion. The resulting digital data is filtered and sent to the DSP on the SAP CODEC_TX line from the GCAP II IC TX pin. After additional filtering and processing, the DSP sends the data-out from the STDB pin to the RF interface connector P201 pin 4 (TX_DATA), which is connected to the DAC U203 on the transceiver board.

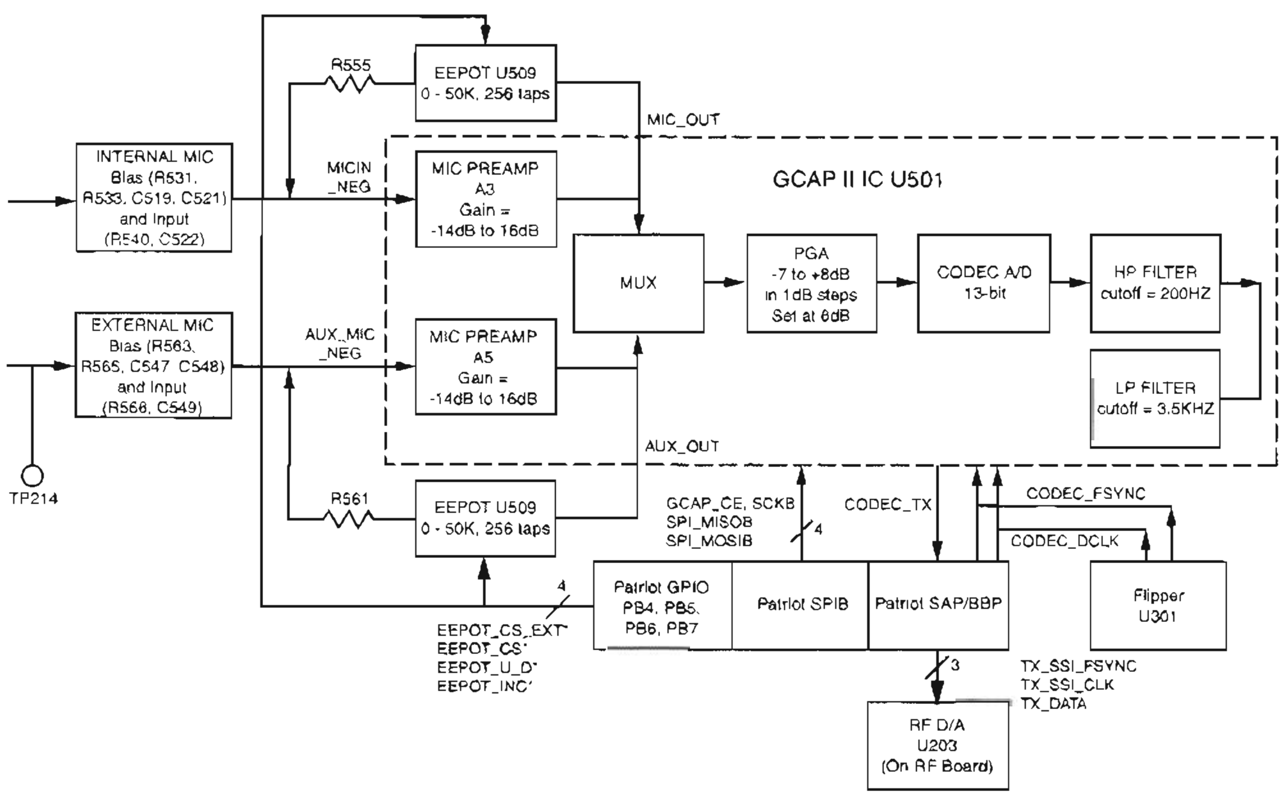
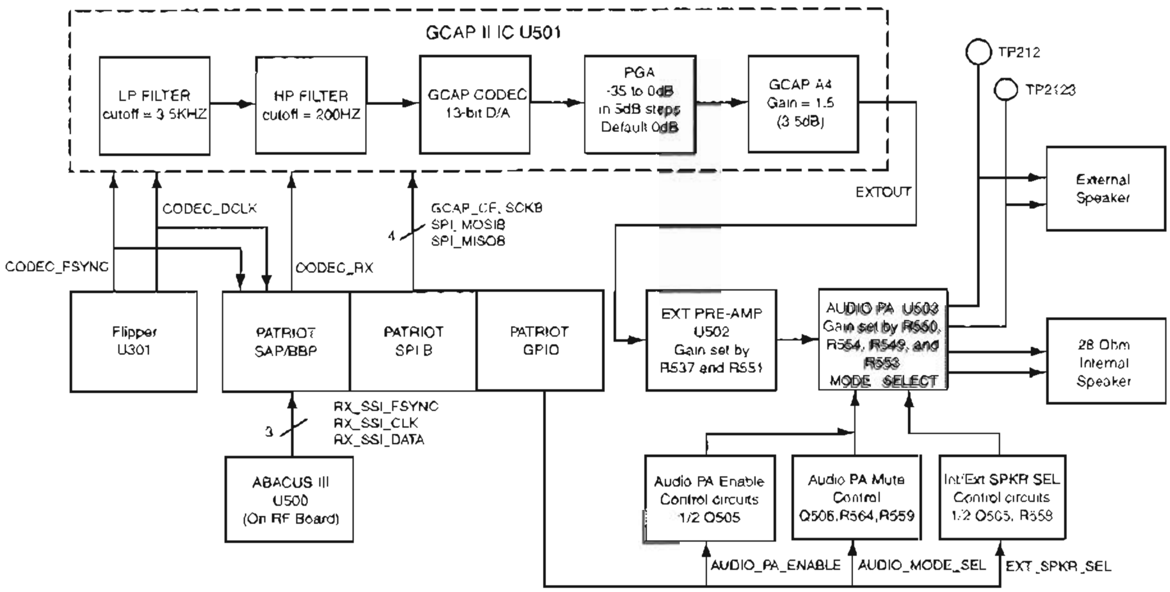


Figure 3-12. VOCON Transmit Audio Path

3.2.5.2 Receive Audio Path

Refer to Figure 3-13. The receive audio data comes from the Abacus III IC U500 through the RF interface connector P201 pin 12 (RX_DATA) to the Patriot IC SRDB pin. The DSP decodes the data and sends it out through the CODEC_RX line to the GCAP II IC RX pin. The CODEC filters and converts the digital data into an analog audio signal, which, in turn, is sent to a programmable gain amplifier. The Patriot IC programs a multiplexer to route the audio signal to the A4 amplifier, which has a fixed gain of 3.5 dB. The output of the A4 amplifier is pin EXTOUT.

From the EXTOUT pin, the audio signal goes through the pre-amplifier U502 and then to the audio power amplifier U503, which together provide approximately 30 dB of gain. The Patriot IC selects whether the amplified audio is routed to the internal speaker or the external speaker.



Audio_PA_Enable	Audio_Mode_Sel	Audio PA Status
0	0	Audio Off
0	1	Mute
1	0	Audio On
1	1	Audio On

Mode (V)	PA Status
1.5V <V_mode<6V	Mute
<0.5V	Audio On
>7V	Audio Off

Select (V)	Internal Speaker
B+ (7.5V)	Internal Speaker
<0.5V	External Speaker

MAEPF-27117-A

Figure 3-13. VOCON Receive Audio Path

3.2.6 Radio Power-Up/Power-Down Sequence

The radio power-up sequence begins when the user closes the radio On/Off switch on the control top, placing 7.5 Vdc on the B+SENSE line. This voltage enables the pass element Q501 and Q502, enabling SW_B+ and GCAP_B+.

When the GCAP II IC U501 detects a low-to-high voltage transition on GCAP_B+, it turns on and enables voltage supplies VSW1, VSW2, V2 and Vref. As soon as these voltages come up, the 1.55 V regulator ramps up (only on the NNTN4717 VOCON board), and the Flipper IC U301 drives the WDI line high to enable VCC5 from regulator U505 and to maintain the GCAP II IC in the ON state. If WDI remains low, the GCAP II IC turns off 50 ms after turning on.

The radio power-down sequence begins by opening the radio On/Off switch, which removes the B+SENSE signal from the VOCON board. This does not immediately remove power because the GCAP II IC has control of Q502 through Vref, and U301 through WDI maintains the GCAP II IC in an active state. Both the MCU and Flipper IC monitor B+SENSE. After B+SENSE is removed, the Flipper IC waits 125 ms. before releasing WDI to allow for software cleanup; however, the software has the ability to prolong this time if it was necessary to complete its operations. When WDI is released, the GCAP II IC shuts down its supplies and the rest of the radio through Q501.

3.3 Encryption Module

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

The encryption modules are designed to digitally encrypt and decrypt voice and ASTRO data in ASTRO XTS 5000 radios. This section covers the encryption modules, hardware kits **NTN9738** and **NNTN5032**.

NOTE: The encryption modules are NOT serviceable. The information contained in this section is only intended to help determine whether a problem is due to a encryption module or the radio itself.

The encryption module uses a custom encryption IC and an encryption key variable to perform its encode/decode function. The encryption key variable is loaded into the encryption module, via the radio's universal (side) connector, from a hand-held, key variable loader (KVL). The encryption IC corresponds to the particular encryption algorithm purchased. Table 3-6 lists the encryption algorithms and their corresponding kit numbers.

Table 3-6. Encryption Module Software Kits and Algorithms

Software Kit Number	Algorithm
NNTN4006	DES, DES-XL, DES-OFB
NTN9837	DES, DES-XL, DES-OFB WITH DVP-XL
NTN9838	DVI-XL
NTN9839	DVP-XL
NNTN4197	AES
NNTN4198	AES with DES, DES-XL, DES-OFB

The encryption module operates from two power supplies (UNSW_B+ and SW_B+). The SW_B+ is turned on and off by the radio's On/Off switch. The UNSW_B+ provides power to the encryption module as long as the radio battery is in place.

Key variables are loaded into the encryption module through connector J701, pin 1. Depending on the type of encryption module, up to 16 keys can be stored in the module at a time. The key can be infinite key retention or 30-seconds key retention, depending on how the codeplug is set up.

The radio' s host processor communicates with the encryption module on the Synchronous Serial Interface (SSI) bus. The SSI bus consists of five signal lines. A communications failure between the host processor and the secure module will be indicated as an *ERROR 09/10* message on the display.

To troubleshoot the encryption module, refer to the flowcharts in Chapter 5 "Troubleshooting Charts."

Chapter 4 Troubleshooting Procedures

The purpose of this chapter is to aid in troubleshooting problems with the ASTRO XTS 5000 radio. It is intended to be detailed enough to localize the malfunctioning circuit and isolate the defective component. It also contains a listing of service tools recommended for PC board repair at the component level.

Caution	Most of the ICs are static sensitive devices. Do not attempt to disassemble the radio or troubleshoot a board without first referring to the following Handling Precautions section.

4.1 Handling Precautions

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

1. Eliminate static generators (plastics, Styrofoam, etc.) in the work area.
2. Remove nylon or double-knit polyester jackets, roll up long sleeves, and remove or tie back loose-hanging neckties.
3. Store and transport all static-sensitive devices in ESD-protective containers.
4. Disconnect all power from the unit before ESD-sensitive components are removed or inserted unless otherwise noted.
5. Use a static-safeguarded workstation, which can be accomplished through the use of an anti-static kit (Motorola part number 01-80386A82). This kit includes a wrist strap, two ground cords, a static-control table mat and a static-control floor mat.

4.2 Recommended Service Tools

Table 4-1 lists recommended service tools that can be used for PC board repairs at the component level. For listings of additonal service tools, service aids, and test equipment that are recommended for all levels of service, refer to the XTS 5000 basic service manual (see " Related Publications" on page xii).

Table 4-1. Recommended Service Tools

Motorola Part Number	Description	Application
R1453	Digital-readout solder station	Digitally controlled soldering iron
RLN4062	Hot-air workstation, 120V	Tool for hot-air soldering/desoldering of surface-mounted integrated circuits
0180386A78	Illuminated magnifying glass with lens attachment	Illumination and magnification of components
0180302E51	Master lens system	
0180386A82	Anti-static grounding kit	Used during all radio assembly and disassembly procedures
6684253C72	Straight prober	
6680384A98	Brush	
1010041A86	Solder (RMA type), 63/67, 0.5 mm diameter, 1 lb. spool	
0180303E45	SMD tool kit (included with R1319A)	
R1319	ChipMaster (110V)	Surface-mount removal and assembly of surface-mounted integrated circuits and/or rework station shields. Includes 5 nozzles.
R1321	ChipMaster (220V)	
R1364	Digital heated tweezer system	Chip component removal
R1427	Board preheater	Reduces heatsink on multi-level boards
6680309B53	Rework equipment catalog	Contains application notes, procedures, and technical references used to rework equipment
ChipMaster Options:		
6680370B54	0.710" x 0.710"	Heat-focus heads for R1319 workstation
6680370B57	0.245" x 0.245"	
6680370B58	0.340" x 0.340"	
6680371B15	0.460" x 0.560"	

Table 4-1. Recommended Service Tools (Continued)

Motorola Part Number	Description	Application
ChipMaster Nozzles:		
6680333E28	PA nozzle	Soldering and unsoldering ICs
6680332E83	PLCC-28* nozzle	
6680332E93	PLCC-32 nozzle	
6680332E82	PLCC-44* nozzle	
6680332E94	PLCC-52 nozzle	
6680332E95	PLCC-68* nozzle	
6680332E96	PLCC-84 nozzle	
6680332E89	QFP-80 nozzle	
6680332E90	QFP-100* nozzle	
6680332E91	QFP-132* nozzle	
6680334E67	QFP-160 nozzle	
6680332E86	SOIC-14/SOL-16J nozzle	
6680333E46	SOL-18 nozzle	
6680332E84	SOIC-20 nozzle	
6680332E87	SOL-20J nozzle	
6680333E45	SOL-24 nozzle	
6680332E88	SOL-28J nozzle	
6680333E54	TSOP-32 nozzle	
6680333E55	TSOP-64 nozzle	

* Included with ChipMaster packages

4.3 Voltage Measurement and Signal Tracing

It is always a good idea to check the battery voltage under load. This can be done by checking the OPT_B+_VPP pin at the side connector (pin 4). The battery voltage should remain at or above 7.0 Vdc. If the battery voltage is less than 7.0 Vdc, then it should be recharged or replaced as necessary prior to analyzing the radio.

In most instances, the problem circuit may be identified using a multimeter, an RF millivoltmeter, oscilloscope (preferably with 100 MHz bandwidth or more), and a spectrum analyzer.

> **Caution**: When checking a transistor or module, either in or out of circuit, do not use an ohmmeter having more than 1.5 Vdc appearing across test leads or use an ohms scale of less than x100.

4.4 Standard Bias Table

Table 4-2 outlines some standard supply voltages and system clocks which should be present under normal operation. These should be checked as a first step to any troubleshooting procedure.

Table 4-2. Standard Operating Bias

Signal Name	Nominal Value	Tolerance	VOCON Board Source
13 MHz	13 MHz	±1000 ppm	C303 (NTN9564) C339 (NNTN4563, NNTN4819 & NNTN4717)
FLIP_32K	32.768 kHz	±400 ppm	U302, pin2 (under shield SH102 on NNTN4563, NNTN4819 & NNTN4717)
SINE32K	32.768 kHz	±400 ppm	C313 (NTN9564) C306 (NNTN4563, NNTN4819 & NNTN4717)
CKIH	16.8 MHz		R452 (under shield SH101 on NNTN4563, NNTN4819 & NNTN4717 or test fixture pin 7 on the board-to-board connector)
16_8MHz	16.8 MHz		C452 (under shield SH101 on NNTN4563, NNTN4819 & NNTN4717)
POR	3.0 Vdc	±5%	POR test point
RESET_OUT	3.0 Vdc	±5%	RESET_OUT test point (NTN9564) D401, pin 3 (NNTN4563, NNTN4819 & NNTN4717)
VSW1	3.85 Vdc	±5%	R502
VSW2	1.85 Vdc	±5%	R501
FILT_B+	7.5 Vdc	6.0-9.0 Vdc	C523
V2	3.0 Vdc* 2.9 Vdc**	±5%	R560
GCAP_B+	7.5 Vdc	6.0-9.0 Vdc	R581
UNSW_B+	7.5 Vdc	6.0-9.0 Vdc	B104
SW_B+	7.5 Vdc	6.0-9.0 Vdc	R587
VCC5	5.0 Vdc	±5%	R503
VSW_1_55 V	1.55 Vdc	±5%	R407 (NNTN4717 VOCON kit only)

* = NTN9564, NNTN4563, & NNTN4819 VOCON kits
** = NNTN4717 VOCON kit

4.5 Power-Up Self-Check Errors

Each time the radio is turned on, the MCU and DSP perform a series of internal diagnostics. These diagnostics consist of checking such programmable devices as the FLASH ROMs, the EEPROM, and SRAM devices.

Problems detected during the power-up self-check routines are presented as error codes on the radio's display. For non-display radios, the problem is presented at power up by a single, low-frequency tone. Table 4-3 lists possible error codes, a description of each error code, and a recommended corrective action.

Table 4-3. Power-Up Self-Check Error Codes

Error Code	Description	Corrective Action
01/02	FLASH ROM codeplug Checksum Non-Fatal Error	Reprogram the codeplug
01/12	Security Partition Checksum Non-Fatal Error	Send radio to depot
01/20	ABACUS Tune Failure Non-Fatal Error	Turn radio off, then on
01/22	Tuning Codeplug Checksum Non-Fatal Error	Send radio to depot
01/81	Host ROM Checksum Fatal Error	Send radio to depot
01/82	FLASH ROM Codeplug Checksum Fatal Error	Reprogram the codeplug
01/88	External RAM Fatal Error — Note: Not a checksum error	Send radio to depot
01/90	General Hardware Failure Fatal Error	Turn radio off, then on
01/92	Security Partition Checksum Fatal Error	Send radio to depot
01/93	FLASHport Authentication Code Failure	Send radio to depot
01/98	Internal RAM Fail Fatal Error	Send radio to depot
01/A2	Tuning Codeplug Checksum Fatal Error	Send radio to depot
02/81	DSP ROM Checksum Fatal Error	Send radio to depot
02/88	DSP RAM Fatal Error — Note: Not a checksum error	Turn radio off, then on
02/90	General DSP Hardware Failure (DSP startup message not received correctly)	Turn radio off, then on
09/10	Secure Hardware Failure	Turn radio off, then on
09/90	Secure Hardware Fatal Error	Turn radio off, then on

4.6 Power-Up Self-Check Diagnostics and Repair (Not for Field Use)

Table 4-4 lists additional action items that can be used for the diagnosis and resolution of the error codes listed in Table 4-3 on page 4-5.

Table 4-4. Power-Up Self-Check Diagnostic Actions

Error Code	Diagnostic Actions
01/02	This non-fatal error will likely recover if the radio's power is cycled In the event that this does not resolve the issue, the radio should be reflashed. As a last resort, the FLASH ROM U402 should be replaced.
01/12	The radio should be sent to the depot for reflashing of the security codeplug.
01/20	Cycling radio power should resolve this issue.
01/22	The radio should be sent to the depot for reflash of the tuning codeplug followed by retuning of the radio.
01/81	The radio should be sent to the depot for reflashing of the host code
01/82	The radio should be sent to the depot for reflashing of the radio codeplug.
01/88	Reflashing of the radio should first be performed. If this fails to resolve the issue, then replacement of the SRAM U403 is necessary.
01/90	Cycle power to radio. Continued failure indicates a likely IC failure (GCAP, PCIC, FLIPPER, ABACUS). In this event, radio should be sent to the depot for isolation and repair of the problem IC.
01/92	The radio should be sent to the depot for reprogramming of the security codeplug.
01/93	The radio should be sent to the depot for reflashing of the host code.
01/98	Send radio to the depot for replacement of the SRAM U403.
01/A2	The radio should be sent to the depot for reflashing of the tuning codeplug followed by re-tuning of the radio.
02/81	The radio should be sent to the depot for examination and/or replacement of either the FLASH U402, or the PATRIOT MCU/DSP U401.
02/88	Cycle power to the radio. If this does not fix the problem, then the radio should be sent to the depot for reflashing of the DSP code. Continued failure requires examination and/or replacement of the SRAM U403.
02/90	Cycle power to the radio. If this fails to fix the problem, then the radio should be sent to the depot for reflashing of the DSP code. Continued failure may require replacement of U401, the PATRIOT MCU/DSP.
09/10	Cycle power to the radio. If this fails then follow instructions in the secure hardware failure troubleshooting flowchart.
09/90	Cycle power to the radio. If this fails then follow instructions in the secure hardware failure troubleshooting flowchart.

Chapter 5 Troubleshooting Charts

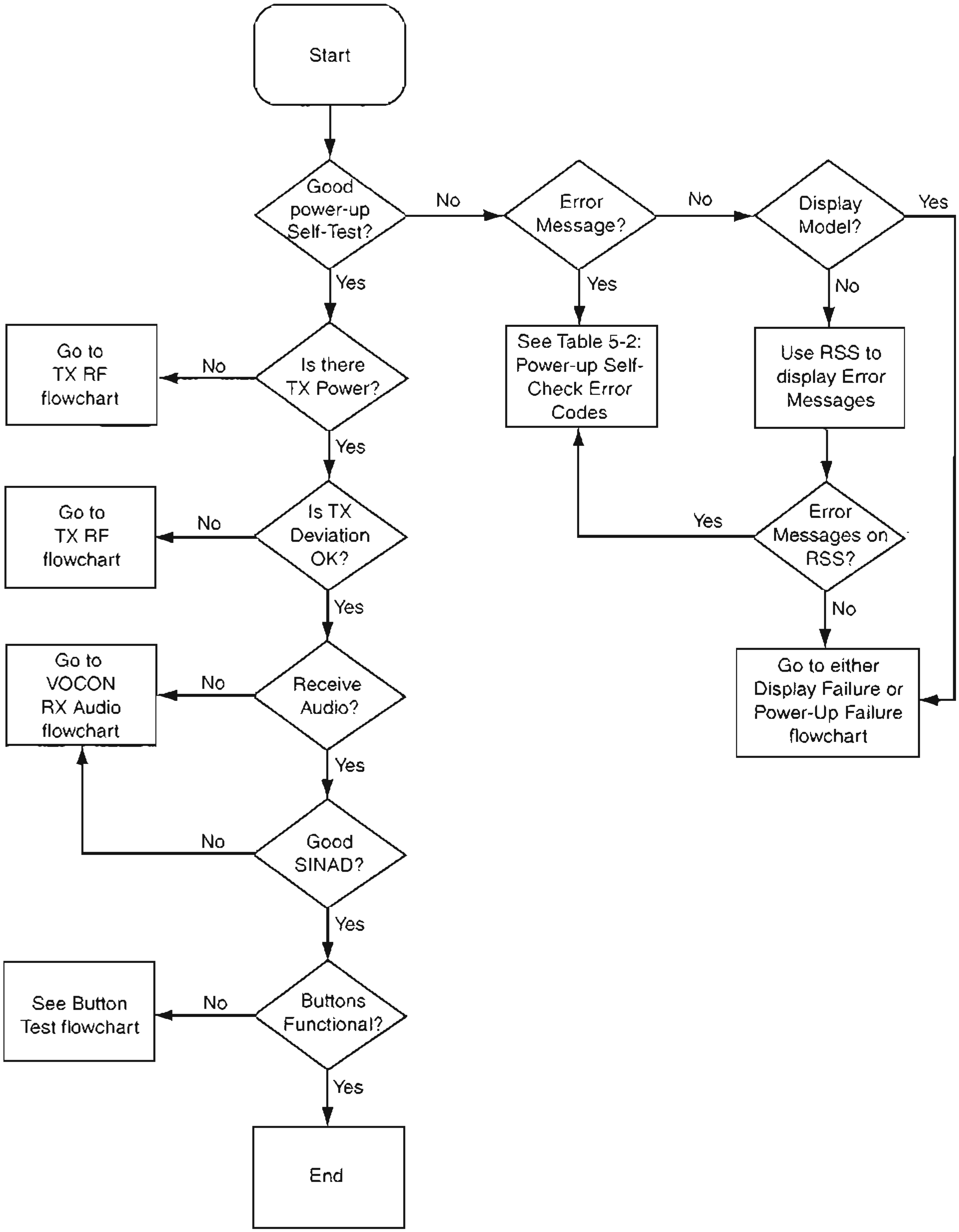
This section contains detailed troubleshooting flowcharts. These charts should be used as a guide in determining the problem areas. They are not a substitute for knowledge of circuit operation and astute troubleshooting techniques. It is advisable to refer to the related detailed circuit descriptions in the theory of operation sections prior to troubleshooting a radio.

5.1 List of Troubleshooting Charts

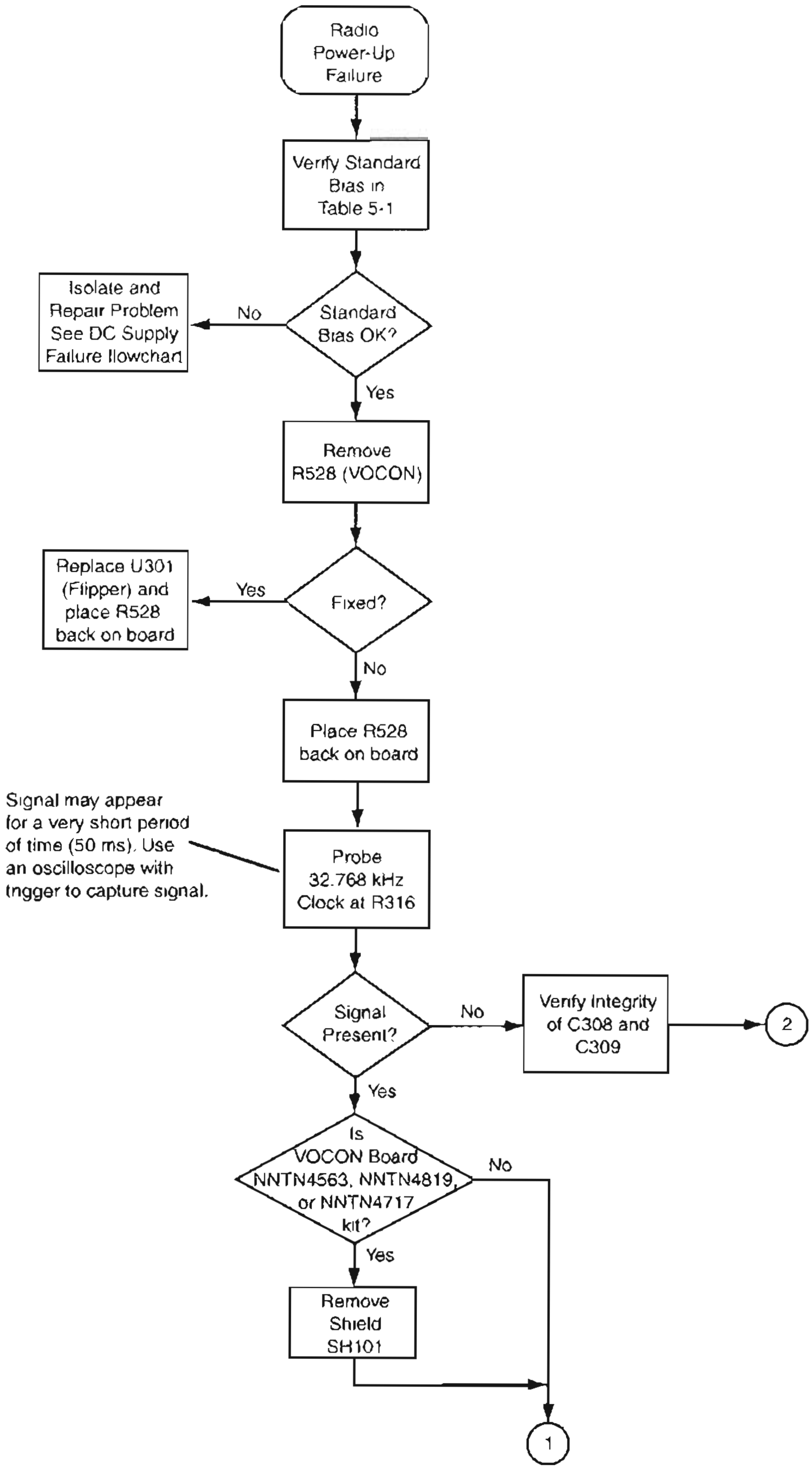
Most troubleshooting charts (see Table 5-1) end up by pointing to an IC to replace. **It is not always noted, but it is good practice to verify supplies and grounds to the affected IC and to trace continuity to the malfunctioning signal and related circuitry before replacing any IC.** For instance, if a clock signal is not available at a destination, continuity from the source IC should be checked before replacing the source IC.

Table 5-1. Troubleshooting Charts List

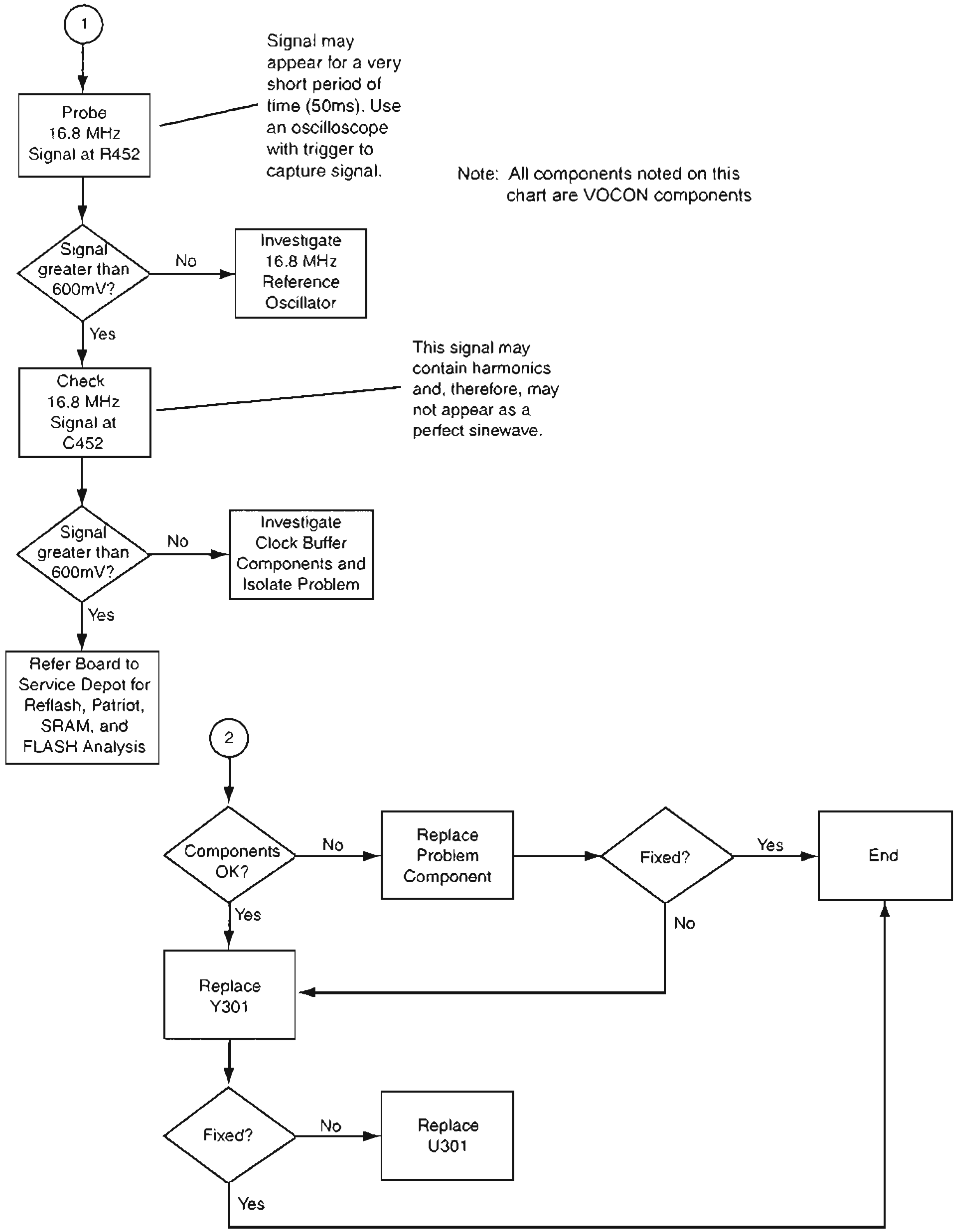
5.2 Main Troubleshooting Flowchart



5.3 Power-Up Failure—Page 1



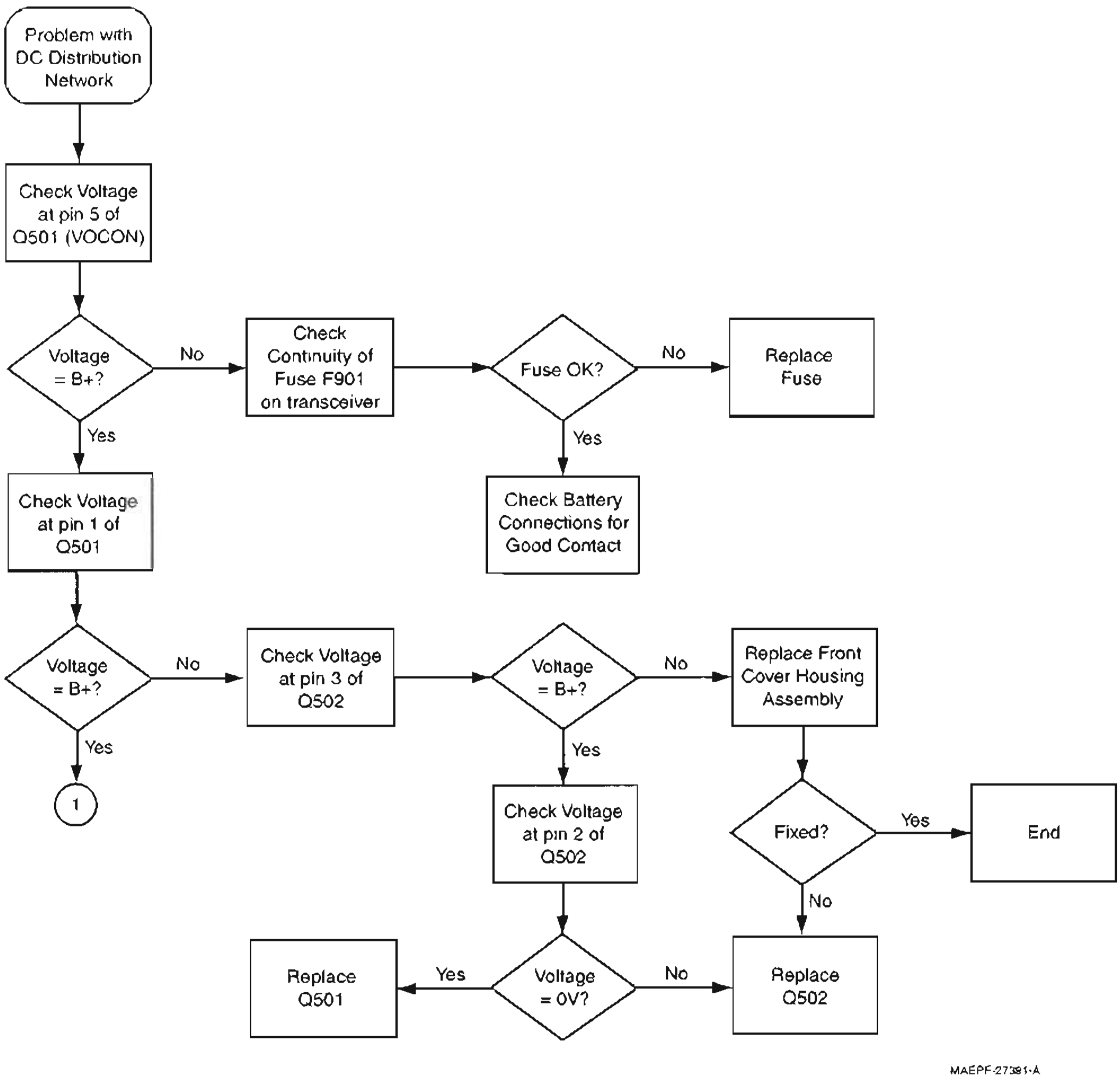
Power-Up Failure—Page 2



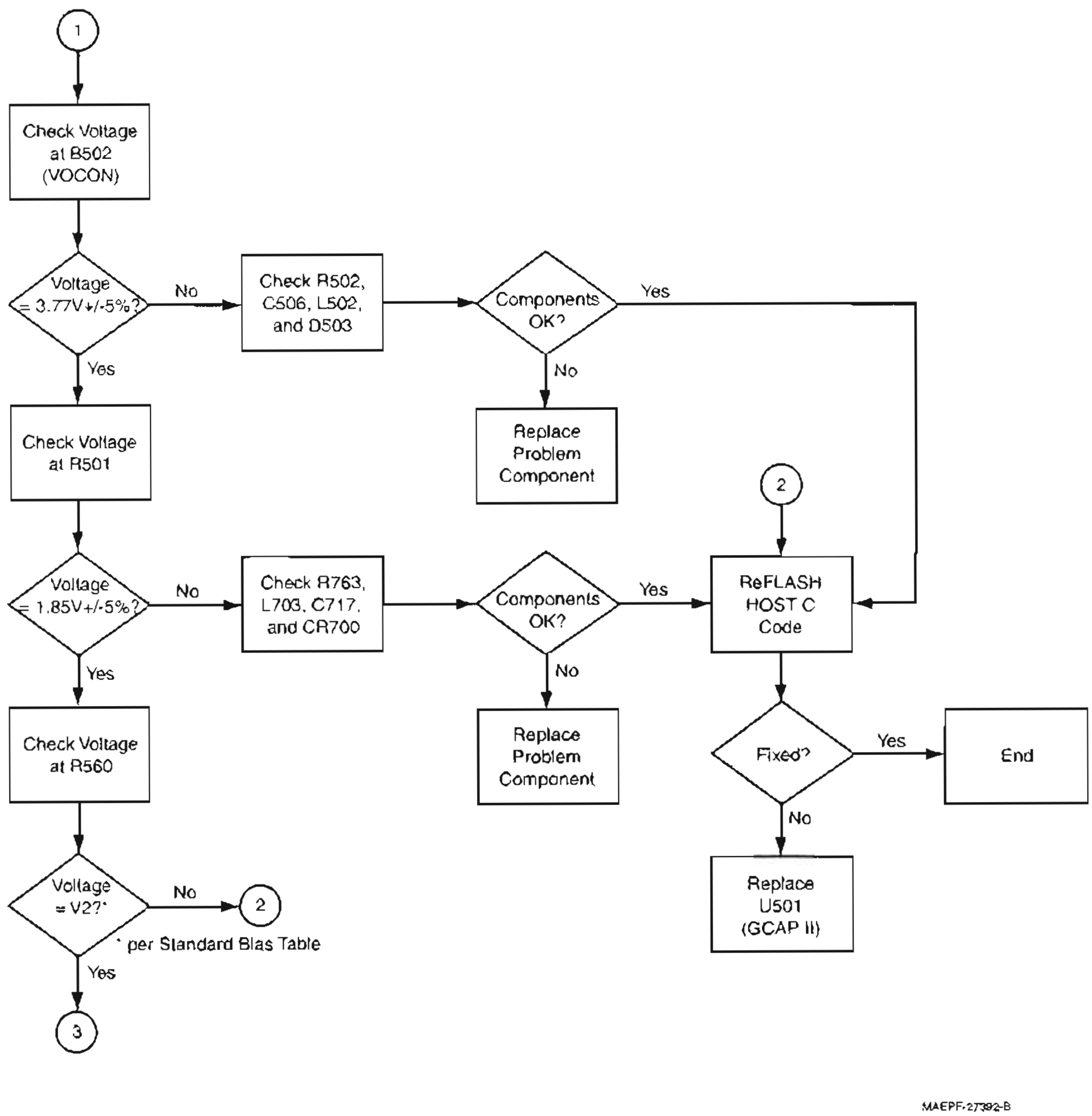
MAEPF-27390-A

5.4 DC Supply Failure—Page 1

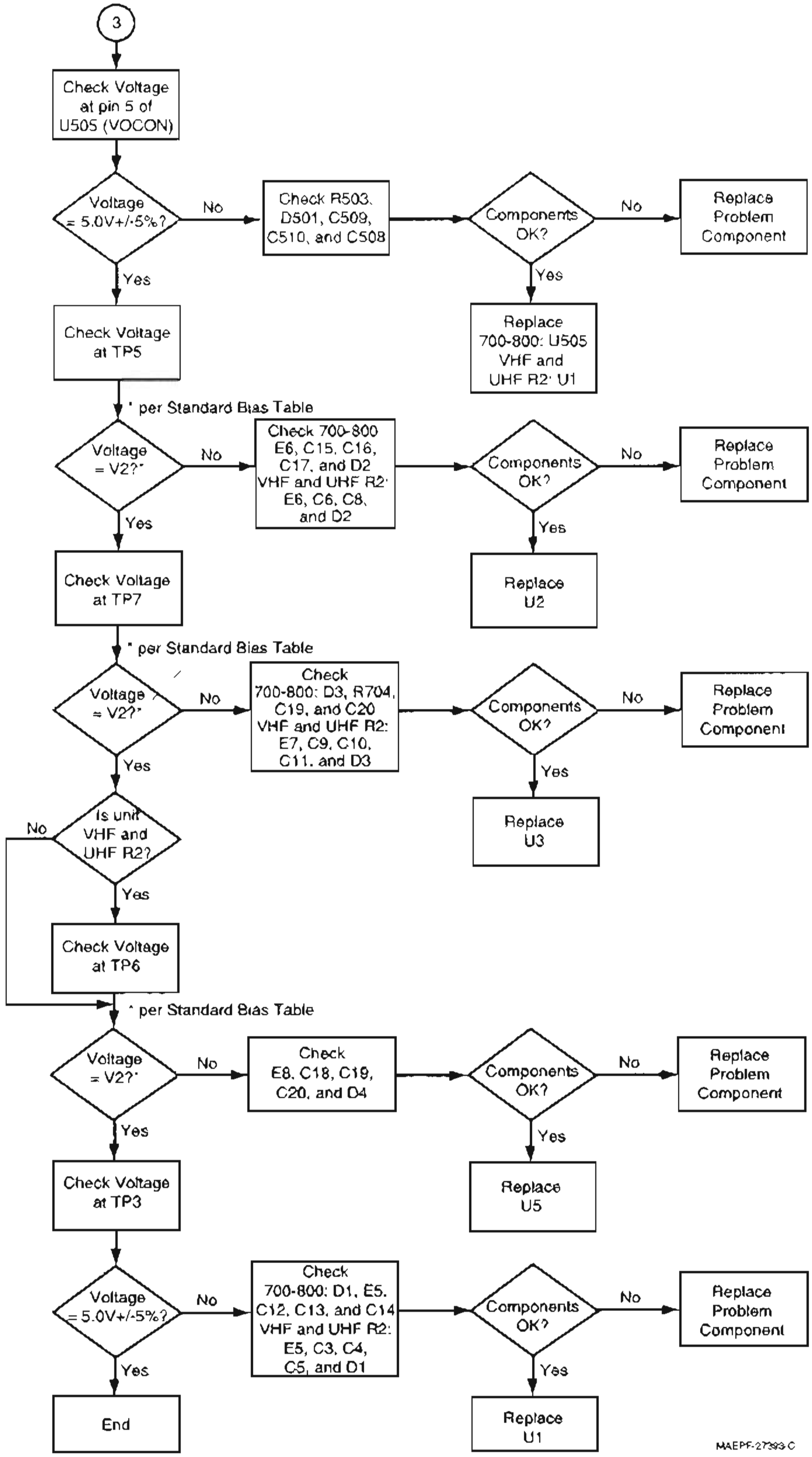
NOTE: Since the failure of a critical voltage supply might cause the radio to automatically power down, supply voltages should first be probed with a multimeter. If all the board voltages are absent, then the voltage test point should be retested using a rising-edge-triggered oscilloscope. If the voltage is still absent, then another voltage should be tested using the oscilloscope. If that voltage is present, then the original voltage supply in question is defective and requires investigation of associated circuitry.



DC Supply Failure—Page 2

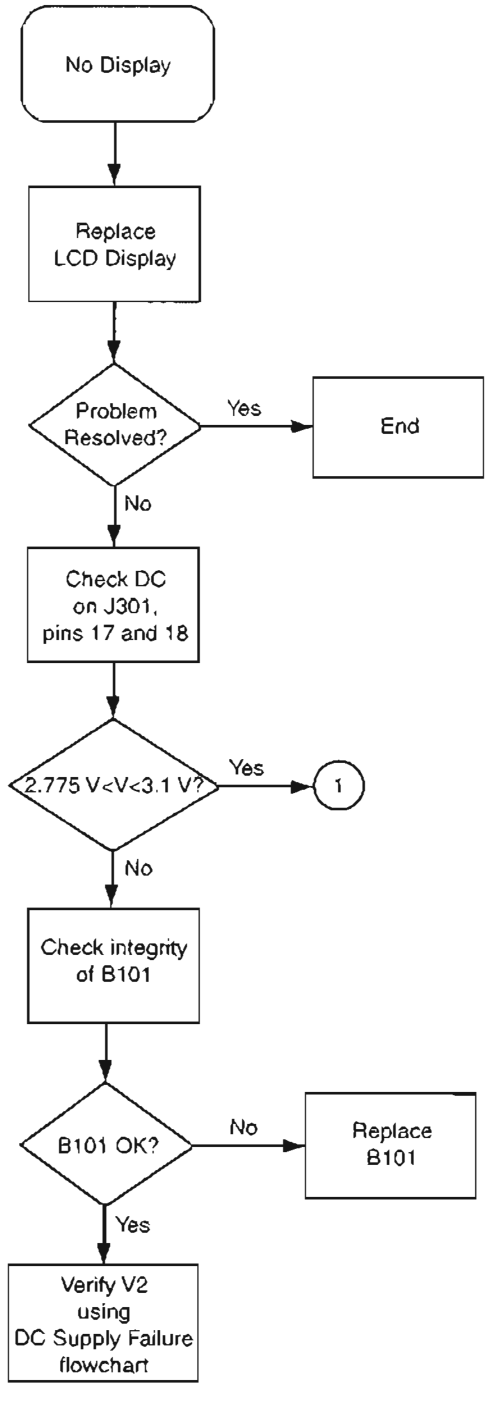


DC Supply Failure—Page 3

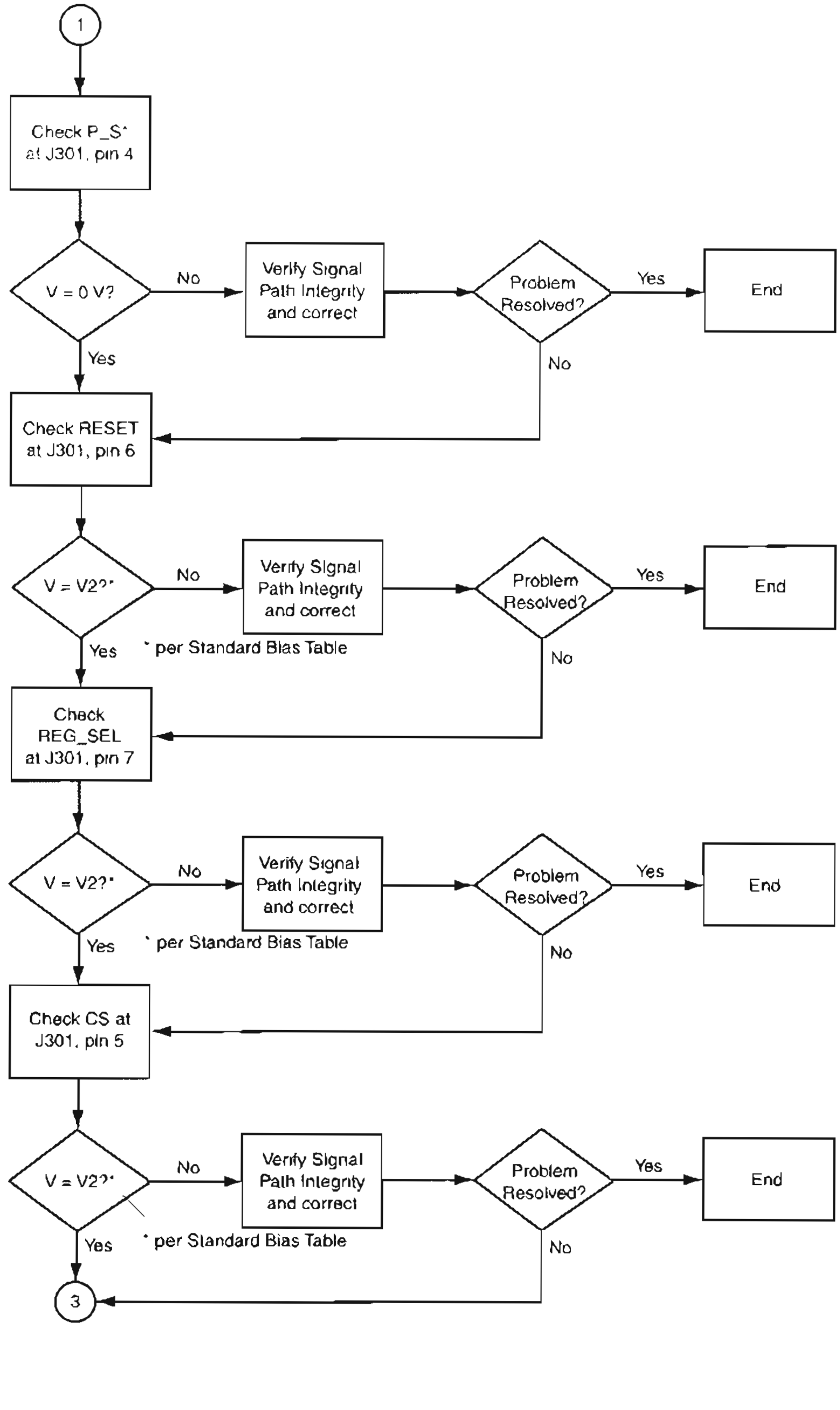


5.5 Display Failure (NNTN4563, NNTN4819, & NNTN4717 VOCON Kits) Page 1

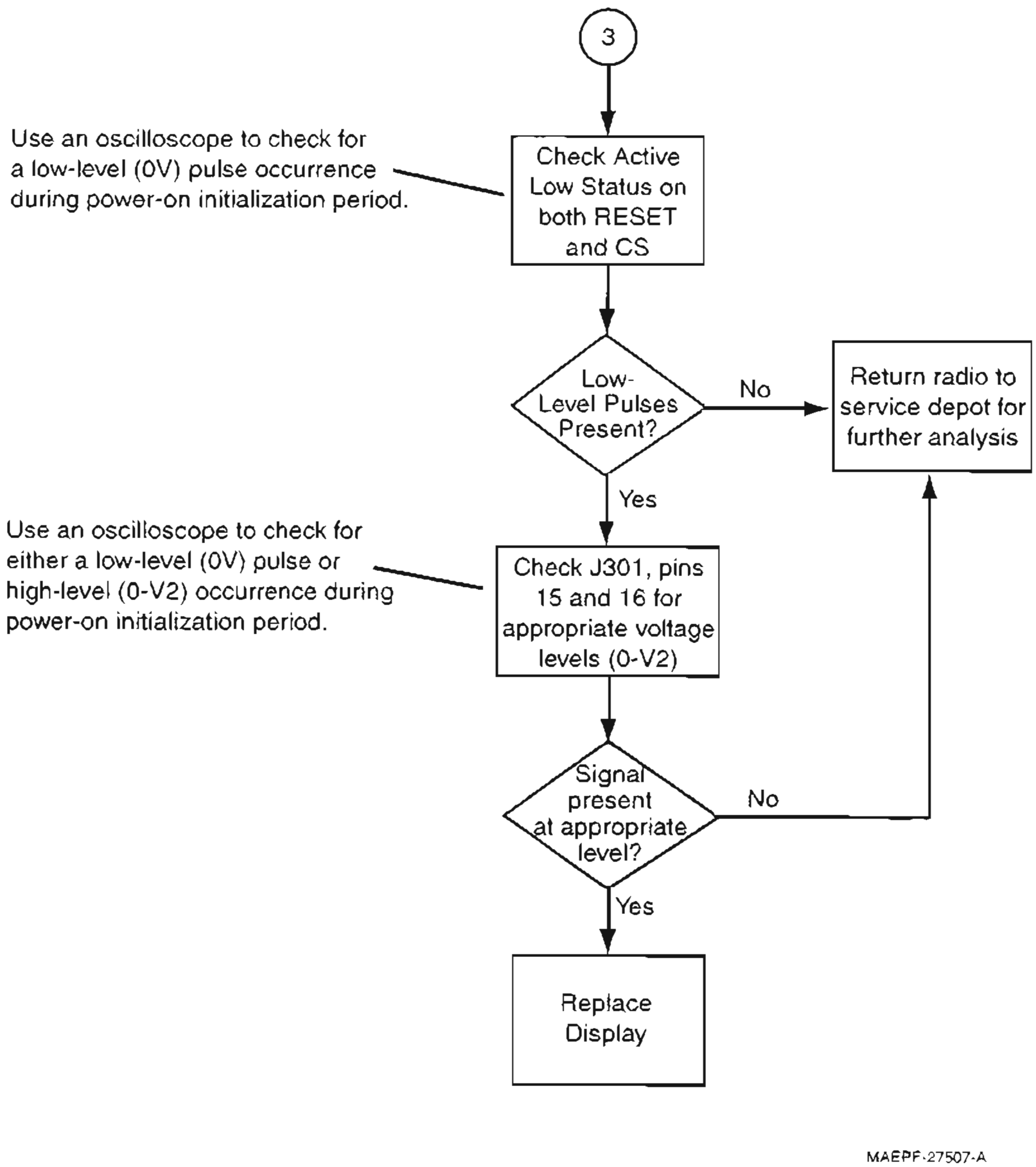
NOTE: The NNTN4563 VOCON board is compatible only with the 7285726C02 display module, and the NNTN4819 VOCON board is compatible only with the 7285726C03 display module.



Display Failure (NNTN4563, NNTN4819, & NNTN4717 VOCON Kits) Page 2

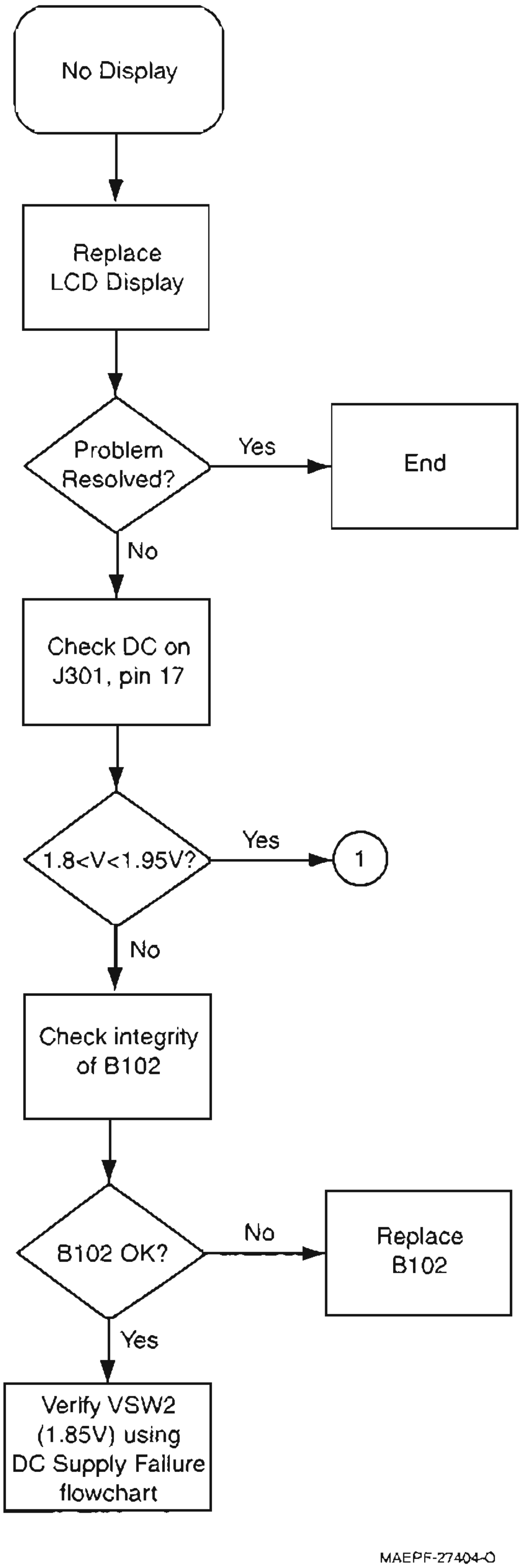


Display Failure (NNTN4563, NNTN4819, & NNTN4717 VOCON Kits) Page 3

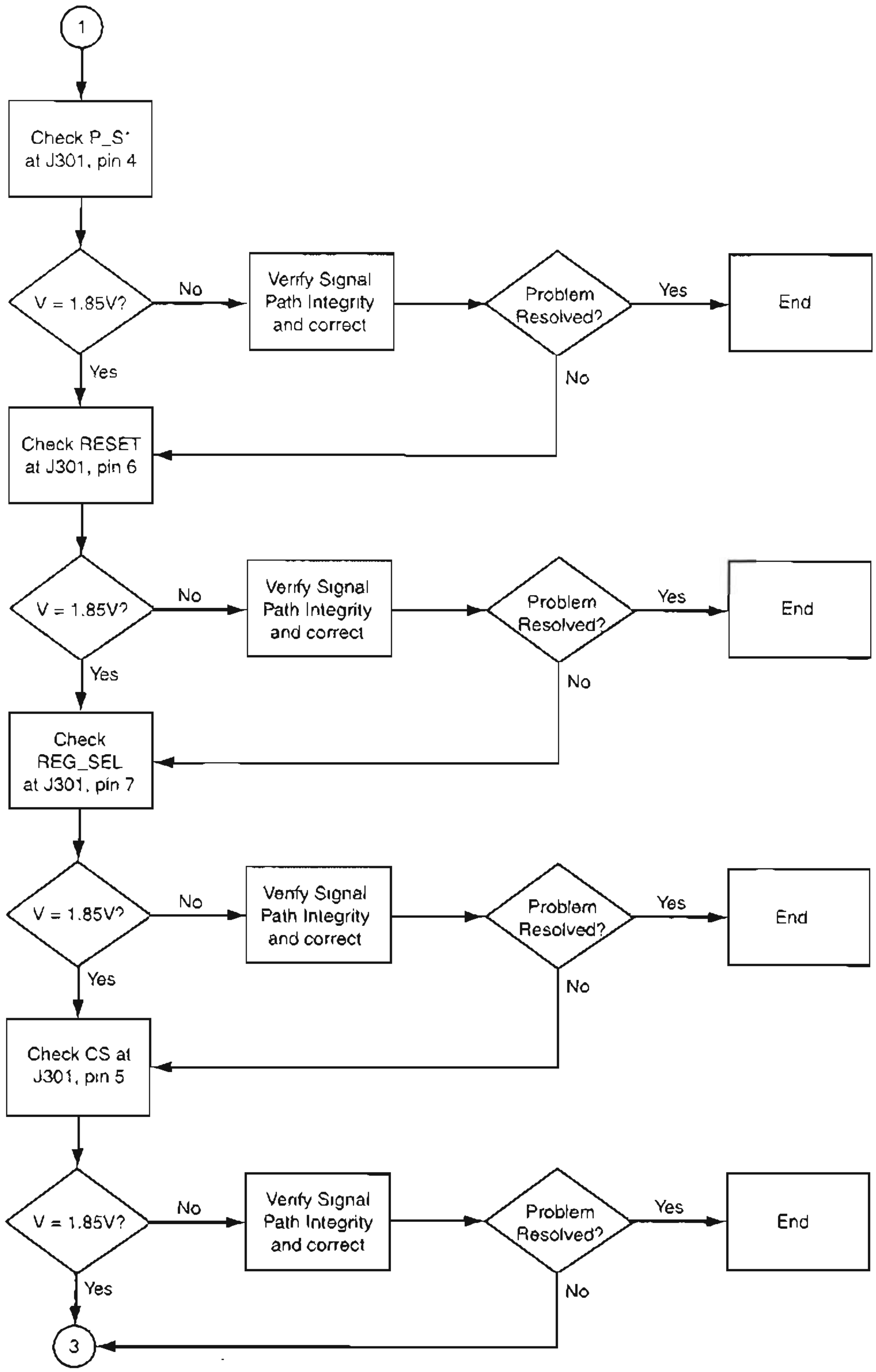


5.6 Display Failure (NTN9564)—Page 1

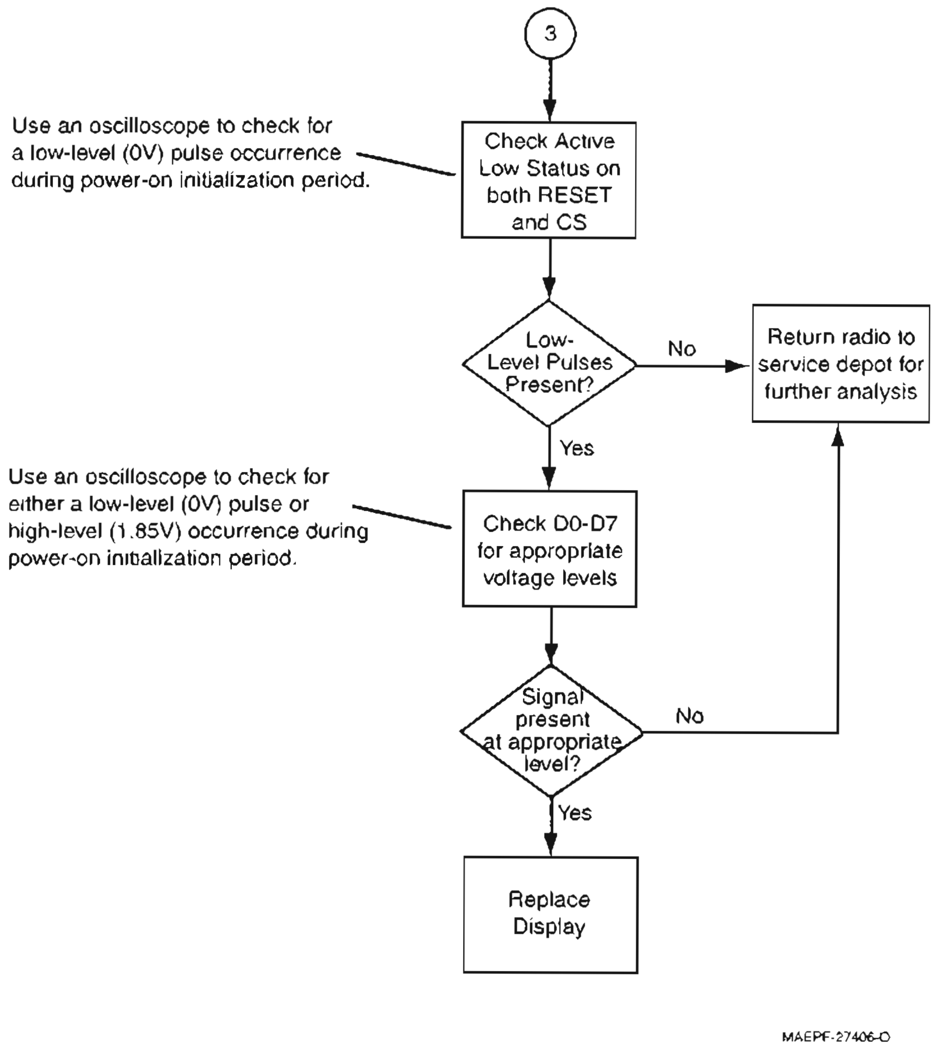
NOTE: The NTN9564 VOCON board is compatible only with the 7285726C01 display module.



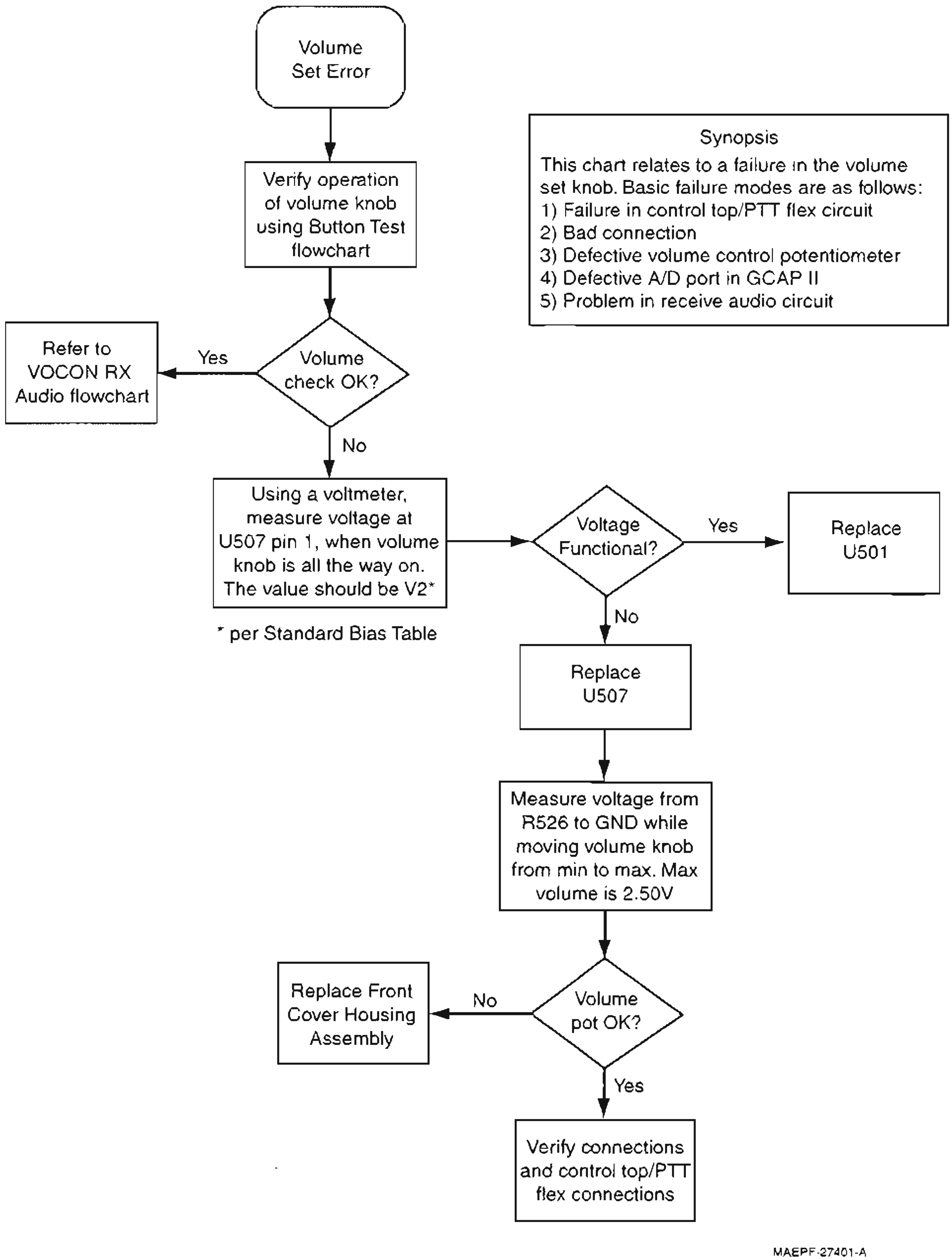
Display Failure (NTN9564)—Page 2



Display Failure (NTN9564)—Page 3



5.7 Volume Set Error

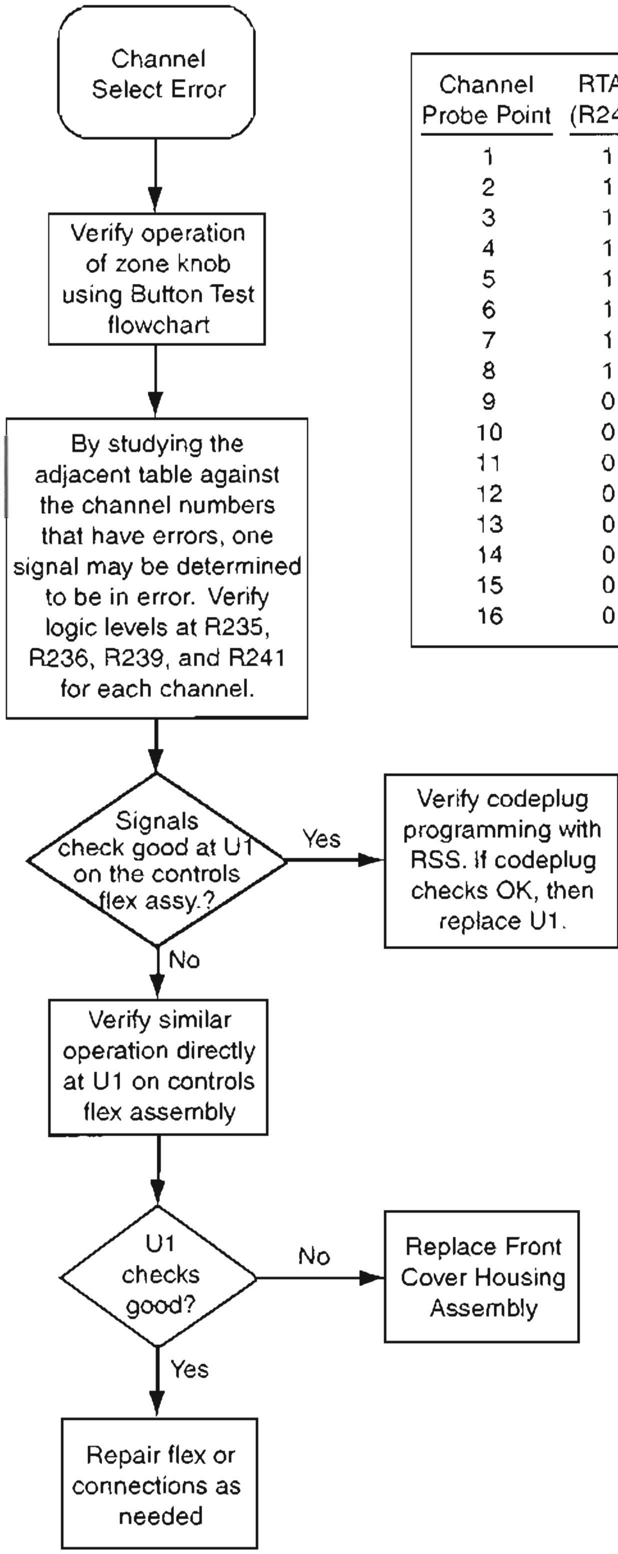


Synopsis

This chart relates to a failure in the volume set knob. Basic failure modes are as follows:

1) Failure in control top/PTT flex circuit
2) Bad connection
3) Defective volume control potentiometer
4) Defective A/D port in GCAP II
5) Problem in receive audio circuit

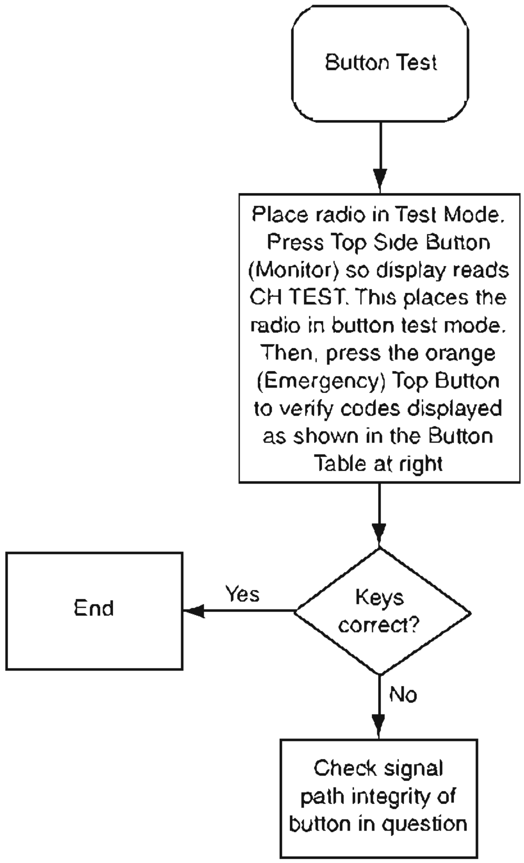
5.8 Channel/Zone Select Error



Channel Probe Point	RTA3 (R241)	RTA2 (R239)	RTA1 (R236)	RTA0 (R235)
1	1	1	1	1
2	1	1	1	0
3	1	1	0	1
4	1	1	0	0
5	1	0	1	1
6	1	0	1	0
7	1	0	0	1
8	1	0	0	0
9	0	1	1	1
10	0	1	1	0
11	0	1	0	1
12	0	1	0	0
13	0	0	1	1
14	0	0	1	0
15	0	0	0	1
16	0	0	0	0

MAEPF-27402-O

5.9 Button Test



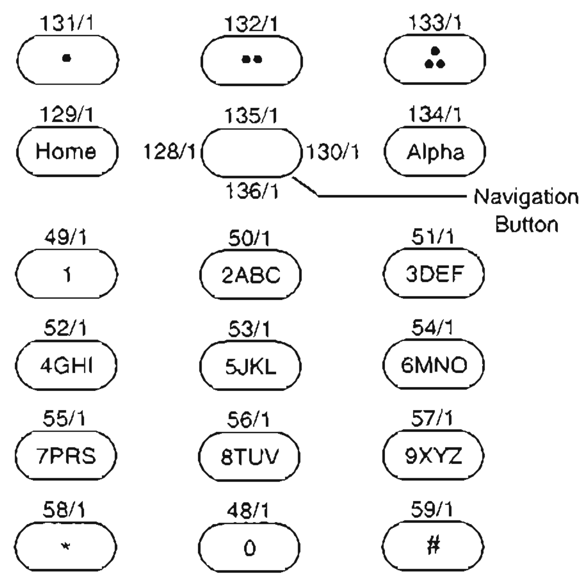
Synopsis

This chart relates to a failure in the button functions Basic Failure modes are as follows:

1) Failure in control top/PTT or keypad flex assembly
2) Bad Connection
3) Defective Switches or pads
4) Defective A/D port in GCAP II

Button Table

Button	Code
PTT	1/ 0-1
Top Button (Emergency)	3/ 0-1
Side Button 1 (Monitor)	96/ 0-1
Side Button 2	97/ 0-1
Side Button 3	98/ 0-1
Channel Select (Frequency)	4/ 0-15
Volume Control Knob	0/ 0-244
Zone Select	65/ 0-2



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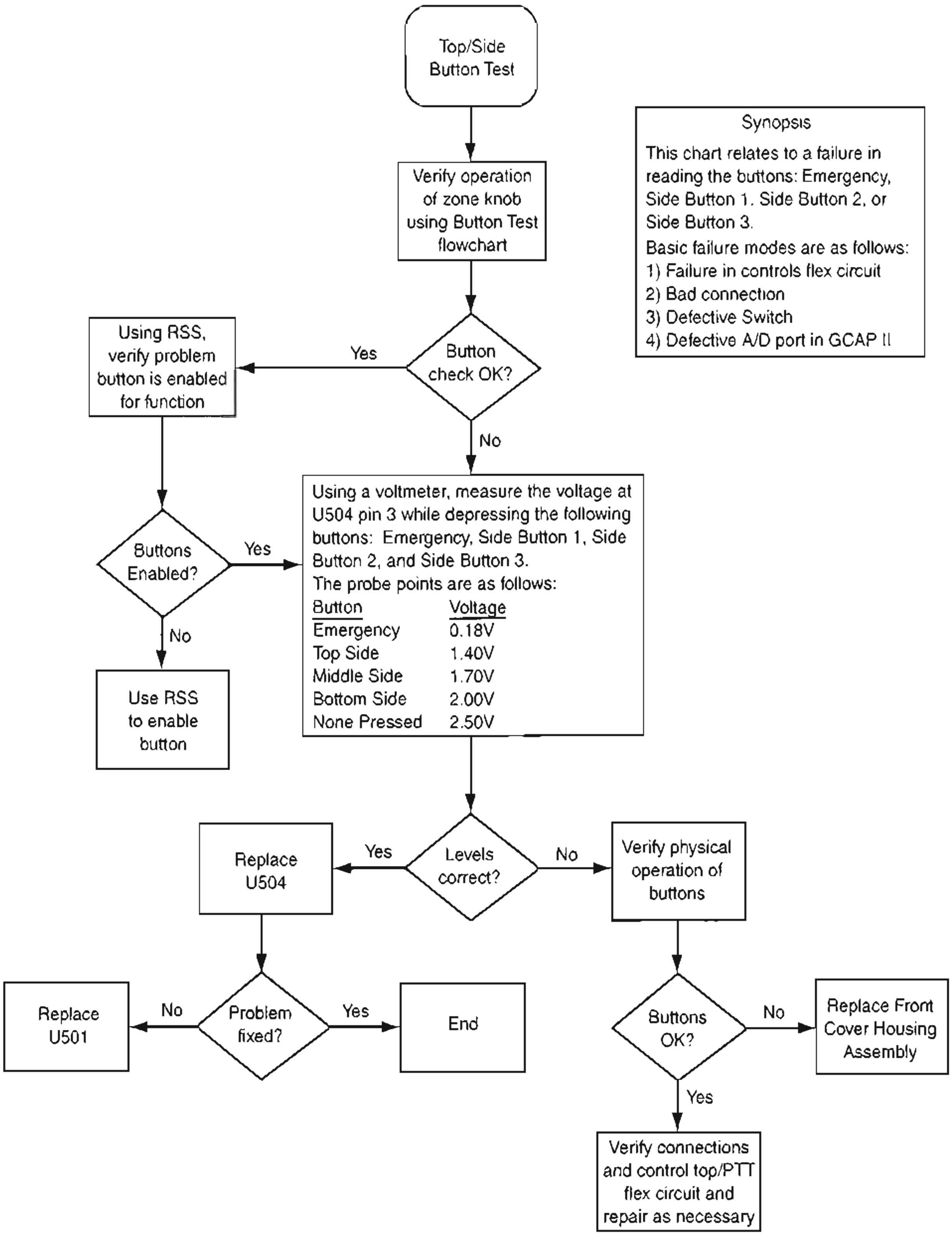
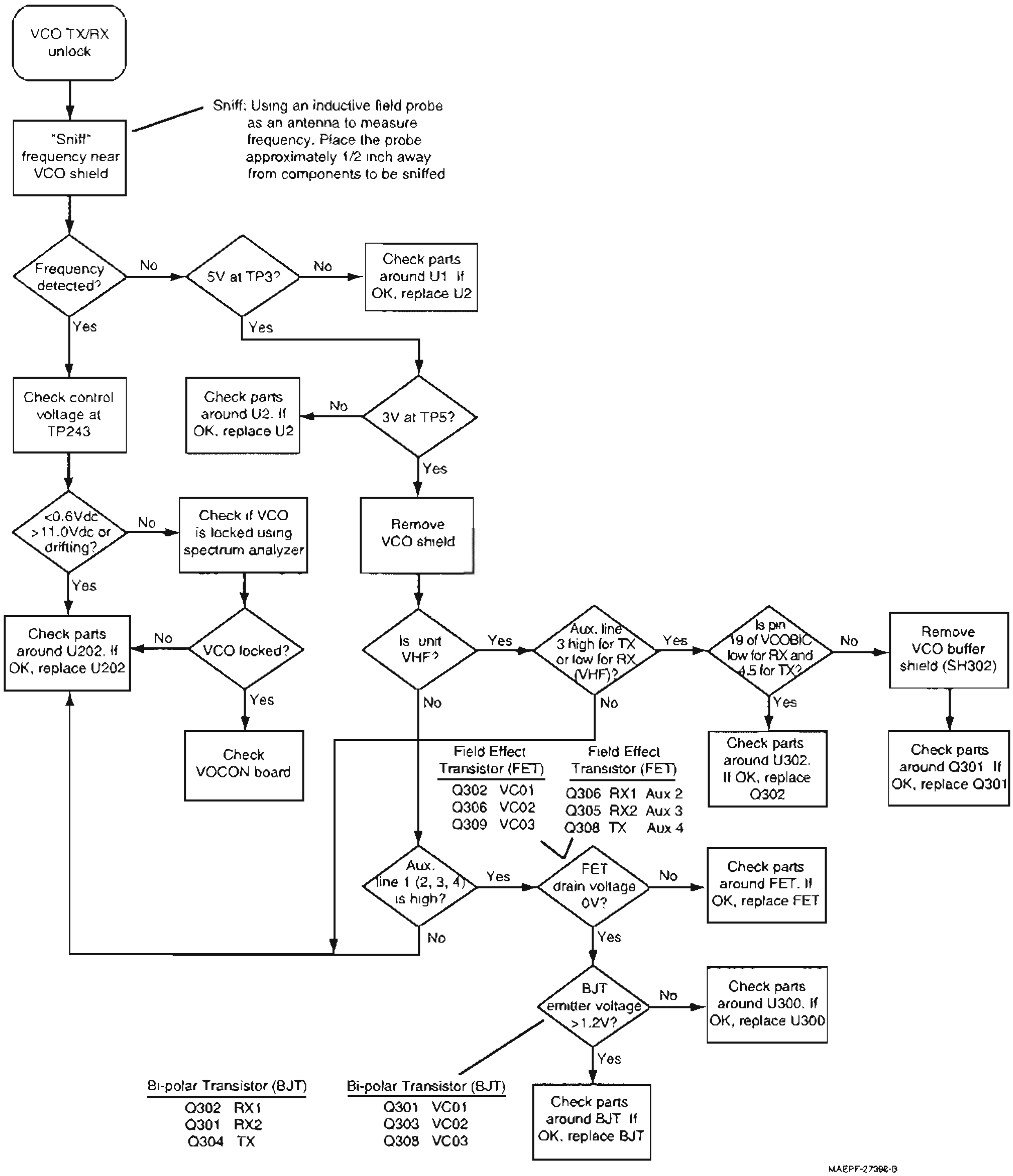
5.10 Top/Side Button Test



5.11 VCO TX/RX Unlock



5.12 VOCON TX Audio—Page 1