Multitone paging transmitter

Service Manual

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Contents

Preface

Scope of Manual

This manual contains information to service technicians for carrying out level-1 and level-2 repairs of the Multitone paging transmitter.

Level-1 repairs entail the replacement of faulty parts and circuit boards; level-2 repairs entail the repair of the transmitter module, with the exception of certain special items on the boards. The manual does not cover level-3 repairs, which entail the repair of the special items.

For more information on repair levels and serviceable parts, refer to "General Information" on page 73.

Hardware and Software Versions

This manual describes the following hardware and software versions. The IPN (internal part number) of the transmitter and paging boards are listed below; the last two digits in the IPN represent the issue of the board. The board information in this manual covers all production-issue boards up to the issue listed below.

- B1 band, 25W : 220-01700-**11**
- H5 band, 25W : 220-01697-**11**
- B1 band, 50W : 220-01723-**02**
- H5 band, 40W : 220-01722-**02**
- XA2731-01-PBA : 228-27311-01
- Programming application : version **1.18**
- Calibration application : version **1.15**

Associated Documentation

Updates may also be published on the Tait support website.

Publication Record

Issue	Publication Date	Description
01	July 2008	first release

Alert Notices

Within this manual, four types of alerts are given to the reader: warning, caution, important and note. The following paragraphs illustrate each type of alert and its associated symbol.

Warning!! **This alert is used when there is a potential risk of death or serious injury.**

Caution **This alert is used when there is the risk of minor or moderate injury to people.**

Important This alert is used to warn about the risk of equipment damage or malfunction.

Note This alert is used to highlight information that is required to ensure that procedures are performed correctly.

Abbreviations

Abbreviation	Description
ACP	Adjacent Channel Power
ADC	Analog-to-Digital Converter
AGC	Automatic Gain Control
ALC	Automatic Level Control
ASC	Accredited Service Centre
BOM	Bill of Materials
CCTM	Computer-Controlled Test Mode
CODEC	Coder-Decoder
CSO	Customer Service Organisation
DAC	Digital-to-Analog Converter
DC	Direct Current
DSP	Digital Signal Processor
ESD	Electrostatic Discharge
FCL	Frequency Control Loop
FE	Front-End
FPGA	Field-Programmable Gate Array
FSK	Frequency Shift Key

Abbreviation	Description
IC	Integrated Circuit
IPN	Internal Part Number
IF	Intermediate Frequency
IQ	In-Phase and Quadrature
ISC	International Service Centre
LCD	Liquid-Crystal Display
LED	Light-Emitting Diode
LNA	Low-Noise Amplifier
LO	Local Oscillator
LPF	Low-Pass Filter
PA	Power Amplifier
PCB	Printed Circuit Board
PLL	Phase-Locked Loop
PSU	Power Supply Unit
PTT	Press-To-Talk
RISC	Reduced Instruction Set Computing
SI	System Interface
SMD	Surface-Mount Device
SMT	Surface-Mount Technology
SMPS	Switch-Mode Power Supply
SPI	Serial Peripheral Interface
TCXO	Temperature-Compensated Crystal Oscillator
TEL	Tait Electronics Limited
UI	User interface
VCO	Voltage-Controlled Oscillator
VCXO	Voltage-Controlled Crystal Oscillator

Multitone paging transmitter

Chapter 1 Description

Chapter 1 – Description

1 Introduction

The Multitone paging transmitter is a software and hardware link-configured transmitter which is designed for operation in large variety of standard frequency ranges. It makes extensive use of digital and DSP technology. Many operating parameters such as channel spacing, audio bandwidth and signalling are controlled by software.

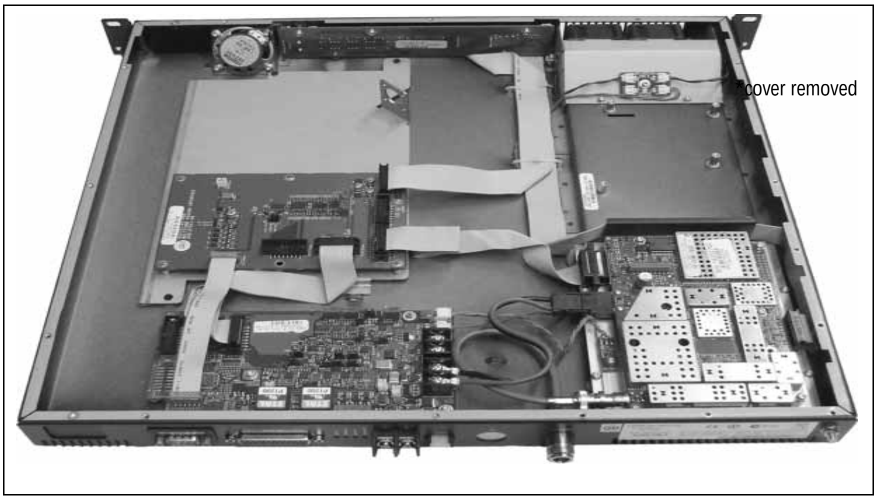
This manual includes the information required for servicing the Multitone paging transmitter.

This section describes the different options available for:

- frequency bands
- RF output power
- power supply
- product codes.

For specifications, refer to the specifications manual or the area on the TaitWorld website reserved for custom products.

Figure 1.1 Multitone paging transmitter



1.1 Frequency Bands

The Multitone paging transmitter is available in the following frequency bands:

- 136 to 174 MHz (B1)
- 400 to 470 MHz (H5)
  The RF band of the Multitone paging transmitter is implemented by the frequency band of the transmitter modules.

1.2 RF Output Power

The Multitone paging transmitter is available with 25 W and 50 W/40 W RF output power. The RF output power options are implemented by different transmitter modules.

The 25 W Multitone paging transmitter is available in the following frequency bands:

- B1
- H5

The 50 W/40 W Multitone paging transmitter is available in the following frequency bands:

- B1 (50 W)
- H5 (40 W)

1.3 Product Codes

This section describes the product codes used to identify products of the Multitone paging transmitter product line.

The product codes of the Multitone paging transmitter product line has the format:

TBB**00aa-cde-0M**

where:

- **aa** identifies the frequency band of the transmitter:
  B1 = 136 to 174 MHz, H5 = 400 to 470 MHz
- **c** identifies the RF output power and digital architecture:
  A = 25 W, level-1 digital architecture
  B = 35 W to 50 W, level-1 digital architecture
- **d** identifies the power supply option:
  0 = DC only
- **e** not used
- **0M** identifies Multitone paging transmitter

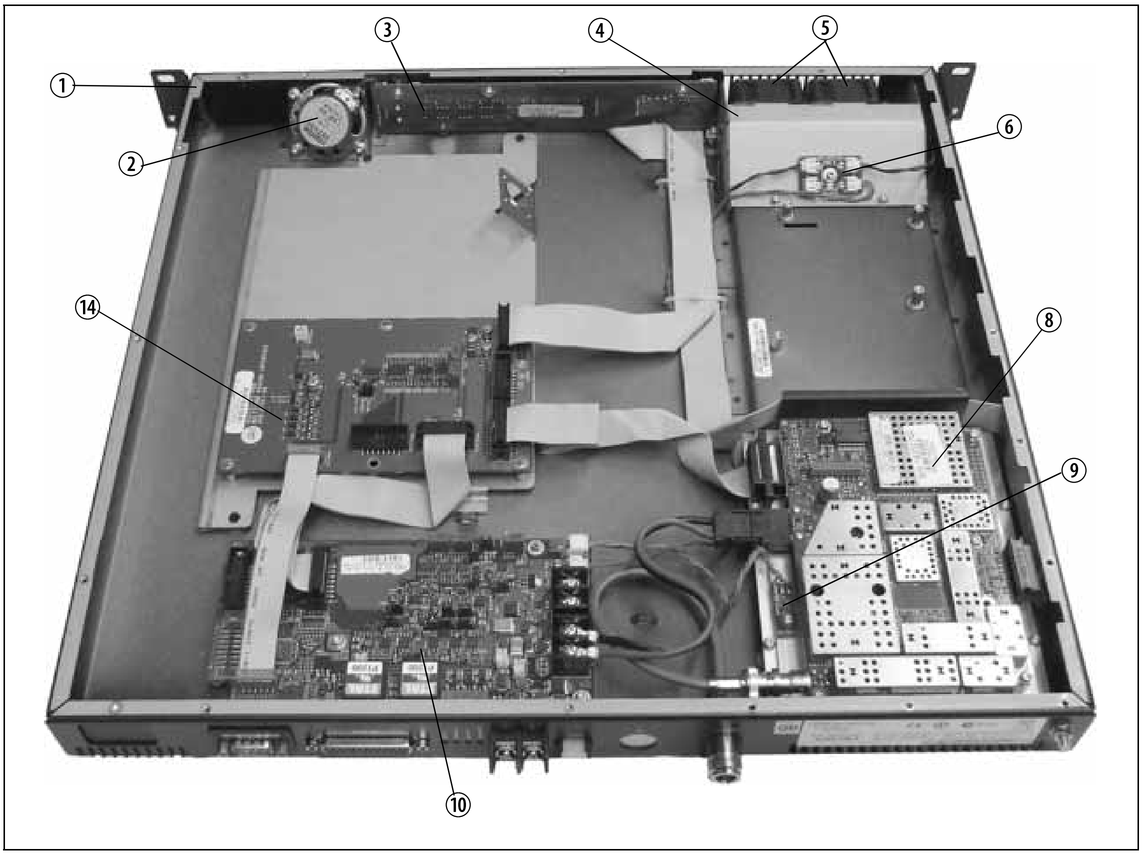
2 Mechanical Design

Overview

The Multitone paging transmitter consists of the following main modules:

- tray ①
- UI board (user interface) ③
- transmitter module ⑧
- SI board (system interface) ⑩
- Paging Interface board ⑭

Figure 2.1 Parts of the Multitone paging transmitter



All modules and boards are mounted from above into the 1U tray ①. The modules are secured by screws or clips into standoffs on the tray chassis, and are easily removed for replacement.

The Multitone paging transmitter includes the paging board ⑭, two cooling fans ⑤ and a fan duct ④ in front of the transmitter module, a speaker ② mounted behind the front panel, a fan power board ⑥ mounted on the fan duct, and a temperature sensor board ⑨ mounted on the heatsink of the transmitter module ⑧.

The modules and components are interconnected by looms and cables.

2.1 Tray

The 1U tray consists of a mild steel folded chassis and a flat cover (not shown) which is fastened to the chassis with 15 Torx T10 screws. The tray can be fitted into a standard 19 inch rack or cabinet using the two rack mounting brackets. It can also be wall mounted, and has holes for mounting transit brackets.

The front panel has holes to accommodate the controls and the microphone/programming connector of the UI board.
The rear panel has holes to accommodate the connectors and the fuse holder of the SI board, the antenna connectors, and a ground terminal.

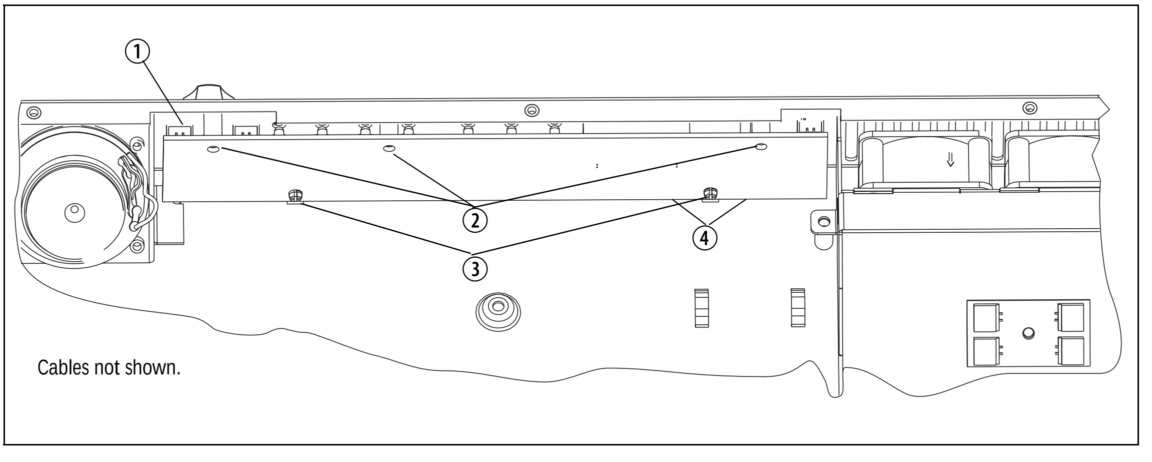
For more information on the connections, refer to “Connections” on page 57.

2.2 User Interface Board

The UI board is mounted behind the front panel with three Torx T10 screws ② and two spring clips ③. The UI board is connected to the transmitter module via the Micro-MaTch connectors ④ and the two UI cables (not shown). The UI board also has a speaker connector ①. The speaker is not used.

A volume knob is fitted to the shaft of the volume-control potentiometer. The volume-control potentiometer is not used.

Figure 2.2 UI board



2.3 Transmitter Module

The transmitter module consisting of a transmitter board ⑤ mounted on a purpose-designed heatsink ⑩ is mounted in the left rear of the tray with four Torx T10 screws (not shown).

The transmitter board is a printed circuit board in SMT design with components on the top and bottom sides. A digital board is reflow-soldered to the board. Most components are shielded by metal cans. There are different boards for each frequency band and each RF output power configuration.

The RF ①, DC power ②, auxiliary ③, and user interface ⑤ connectors are located on the bottom side of the board. The internal options connector ④ and a factory connector (not shown) for factory use are located on the top side of the board.

25W 50W 40W

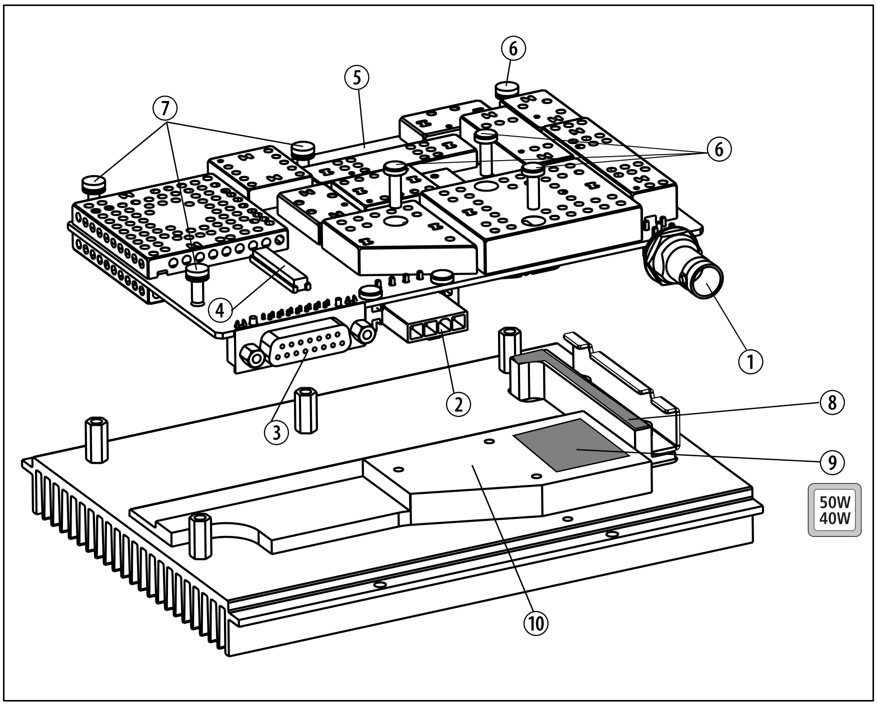
The 50 W/40 W version has a black DC power connector ② and the 25 W version has a white DC power connector. For more information on the connectors, refer to “Connections” on page 57.

The board ⑤ is mounted to the heatsink ⑩ with seven Torx T10 screws ⑥ and ⑦.

25W 50W 40W

An L-shaped gap pad ⑧ and (with the 50 W/40 W version) a rectangular gap pad ⑨ are fitted between the board ⑤ and the heatsink ⑩ to improve heat transfer.

Figure 2.3 Transmitter module



2.4 System Interface Board

The SI board is mounted in the rear right of the tray with two Torx T10 screws ⑩, one Pozidriv screw ⑨, and two spring clips ⑪.

The SI board has the following external connectors:

- 13.8V DC power connector (labelled 12V DC) ①
- system connector (labelled SYSTEM) ②

The SI board has the following internal connectors:

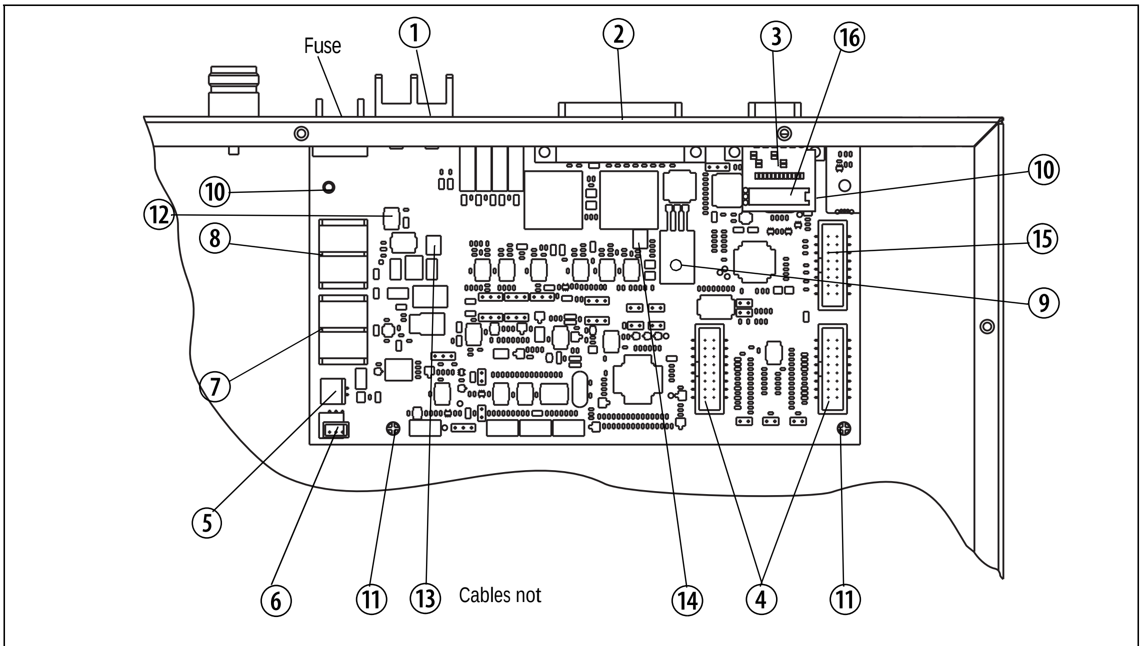
- two system interface connectors (J101 and J100) ④ (to transmitter)
- DC input connector (J102) ⑦
- DC output connector (J103) ⑧ (to transmitter)
- fan control connector (J201) ⑤ (to fan power board on fan duct)
- temperature control connector (J200) ⑥ (to temperature sensor on transmitter heatsink)
- mains fail signal connector (J110) ⑫
- DC output connector (J600) ⑬, relay driver connector (J109) ⑭, and a factory only connector (J202) ⑮ (not used).

Mounted above the SI board providing a connector on the rear is the XA2235-02-PCB. This is an EMC filter and has the following connectors:

- 9-way male D-range connector (FSK ENCODER) ③
- 12-way MicroMaTch connector (unlabelled) ⑯ to the paging interface.

For more information on the connectors, refer to “Connections” on page 57.

Figure 2.4 SI board



2.5 Paging Interface Board

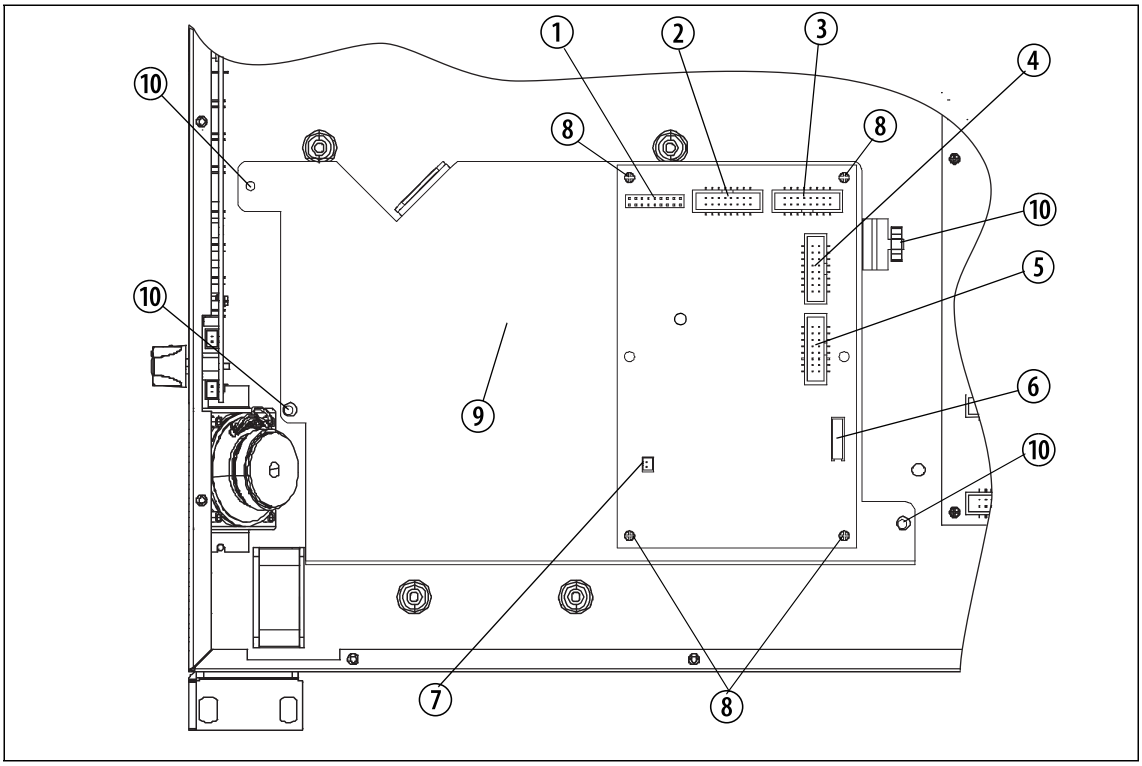
The paging board is mounted in the mid right of the tray with four pcb clips ⑧. The PCB clips are mounted on the supporting bracket ⑨ that is screwed and clipped to the chassis ⑩.

The paging board has the following internal connectors:

- user interface connector PL2 (labelled TO UI) ①
- receiver connector PL100 (labelled TO RX) ②
- transmitter connector PL100A (labelled TO TX) ③.
- system connector PL101A (labelled TO SIF PL101A) ④.
- system connector PL101 (labelled TO SIF PL101) ⑤.
- FSK encoder connector SK101 (labelled TO D-RANGE) ⑥.
- coax relay connector J1 (labelled COAX RELAY) ⑦.

For more information on the connectors, refer to “Connections” on page 57.

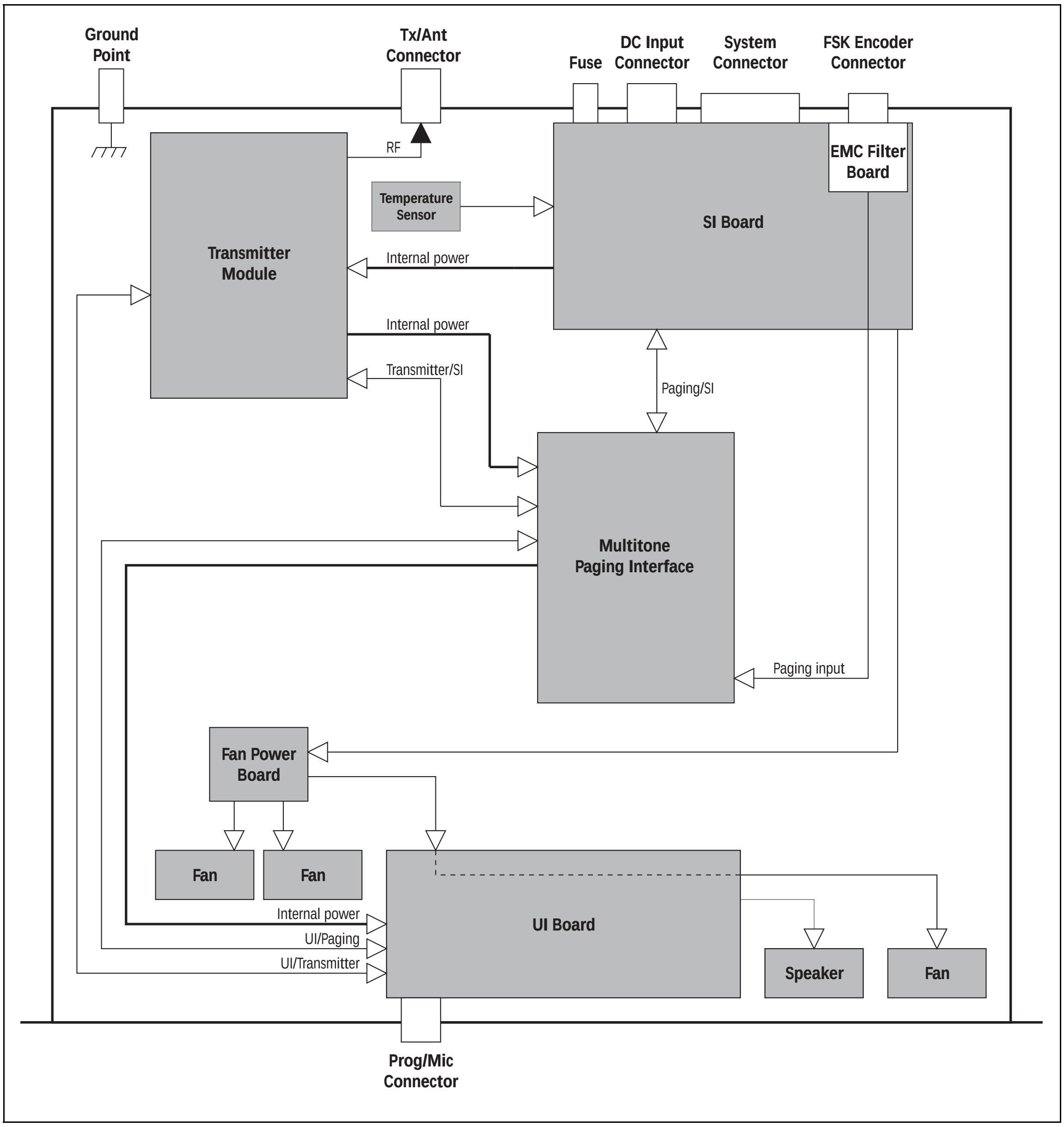
Figure 2.5 SI board



3 Functional Description

Figure 3.1 shows the high-level block diagram of the Multitone paging transmitter.

Figure 3.1 Multitone paging transmitter high-level block diagram



The block diagram illustrates the main inputs and outputs for power, RF and control signals, as well as the interconnection between modules:

- program data and audio from the PROG/MIC socket on the UI board to and from the transmitter module
- audio and signalling from the SYSTEM connector to and from the

transmitter module

- fan power and control from the SI board
- power distribution from the DC power input connector to the transmitter module, and to the UI board.

The circuitry of the individual modules that make up the Multitone paging transmitter is described in more detail in the following sections.

Frequency Bands and Sub-bands

The circuitry of the transmitter module is similar for all frequency bands and is therefore covered by a single description in this manual. Where the circuitry differs between bands, separate descriptions are provided for each frequency band. For more information on frequency bands, refer to the specifications manual.

Fan Signals

The power and ground signals for the fans are routed from the SI board to the fans behind the front panel. These signals are electrically isolated from all other system signals to ensure fan noise is not transferred to other sensitive system components.

If there is a fault in the fan circuitry, the transmitter module is protected from overheating by its internal foldback circuitry.

Power and Ground

The SI board provides power to the transmitter module. The paging interface board provides power to the UI board.

3.1 Transmitter Operation

Parts of Transmitter Board

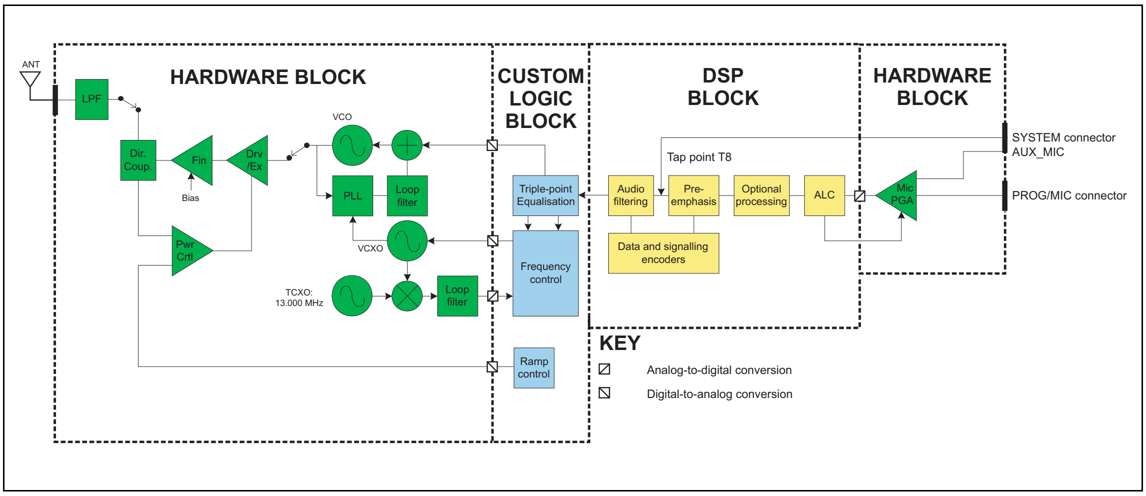
The main circuit parts of the transmitter board are:

- transmitter
- frequency synthesizer
- CODEC (coder-decoder)
- power supply
- interface circuitry

Software plays a prominent role in the functioning of the board. When describing the operation of the radio the software must be included with the above. This is considered further below.

These functional parts are described in detail below.

Figure 3.2 Transmitter high-level block diagram



3.1.1 Audio Processing and Signalling

Microphone Input

The input to the transmitter path begins at either the SI board or the PROG/MIC connector of the UI board. Only electret-type microphones are supported by the PROG/MIC connector. The SI board audio input is applied to tap point T12 on the transmitter board (the tap point is user-selectable), or to the AUX_MIC connector.

Analog Processing of Microphone Signal

The CODEC (AD6521) performs microphone selection and amplification. The microphone amplifier consists of an amplifier with a fixed gain of 16dB followed by a programmable-gain amplifier with 0dB to 22dB gain. The amplified microphone signal is converted to a digital stream by a 16-bit ADC with integral anti-alias filtering (0.1 to 3.2kHz). The digital stream is transported to the DSP for further audio processing.

Automatic Level Control

The ALC (automatic level control) follows, and is used to effectively increase dynamic range by boosting the gain of the microphone pre-amplifier under quiet conditions and reducing the gain under noisy acoustic conditions. The ALC function resides in the DSP and controls the microphone programmable-gain amplifier in the CODEC. The ALC has a fast-attack (about 10 ms) and slow-decay (up to 2 s) characteristic. This characteristic ensures that the peak signal level is regulated near full scale to maximise dynamic range.

DSP Audio Processing

The output of the automatic level control provides the input to the DSP audio-processing chain at a sample rate of 8 kHz. Optional processing such as encryption or companding is done first if applicable. Pre-emphasis, if required, is then applied. The pre-emphasised signal is hard limited to prevent over deviation, and filtered to remove high-frequency components. The sample rate is then interpolated up to 48 kHz and scaled to be suitable for the frequency synthesizer.

Data and Signalling Encoders

The data and signalling encoders inject their signals into various points within the audio-processing chain. The injection point depends on the bandwidth of the encoders and whether pre-emphasis is required.

3.1.2 Frequency Synthesizer

Main Parts of Synthesizer

The frequency synthesizer consists of two main parts:

- FCL (frequency control loop)
- RF PLL (phase-locked loop)

The FCL and RF PLL are described briefly below. Note that patents are pending for several aspects of the synthesizer design.

Frequency Control Loop

The FCL consists of the following:

- TCXO
- mixer
- loop filter
- VCXO (voltage-controlled crystal oscillator)
- frequency control block

The FCL provides the reference frequency for the RF PLL. It generates a high-stability reference frequency that can be both modulated and offset in fine resolution steps.

RF PLL

The RF PLL consists of the following:

- RF PLL device
- loop filter
- VCO (voltage-controlled oscillator)
- VCO output switch

The RF PLL has fast-locking capability but coarse frequency resolution. The above combination of control loops creates improved frequency generation and acquisition capabilities.

Operation of Control Loop

The RF PLL is a conventional integer-N design with frequency resolution of 25kHz. In transmit mode the loop locks to the transmit frequency.

Initially, the VCO generates an unregulated frequency in the required range. This is fed to the PLL device (ADF4111) and divided down by a programmed ratio to approximately 25kHz. The reference frequency input from the FCL is also divided down to approximately 25kHz. The phase of the two signals is compared and the error translated into a DC voltage by a programmable charge pump and dual-bandwidth loop filter. This DC signal is used to control the VCO frequency and reduce the initial error. The loop eventually settles to a point that minimises the phase error between divided-down reference and VCO frequencies. The net result is that the loop locks to a programmed multiple of the reference frequency.

The FCL generates an output of 13.012 ± 0.004MHz. Initially a VCXO produces a quasi-regulated frequency in the required range. The VCXO output is fed to a mixer where it is mixed with the 13.000MHz TCXO frequency. The mixer, after low-pass filtering to remove unwanted products, produces a nominal frequency of 12kHz. This is converted to digital form and transported to the frequency-control block in custom logic.

The frequency-control block compares the mixer output frequency with a reference generated by the digital clock and creates a DC error signal. A programmed offset is also added. This error signal is converted to analog form and used to control the VCXO frequency and reduce the initial error. Once settled, the loop locks to the TCXO frequency with a programmed offset frequency. The FCL output therefore acquires the TCXO's frequency stability.

Modulation

The full bandwidth modulation signal is obtained from the DSP in digital form at a sample rate of 48kHz. In traditional dual-point modulation systems the modulation is applied, in analog form, to both the frequency reference and the VCO in the RF PLL, combining to produce a flat modulation response down to DC. Reference modulation is usually applied directly to the TCXO.

In the system employed in the transmitter board, the frequency reference is generated by the FCL, which itself requires dual-point modulation injection to allow modulation down to DC. With another modulation point required in the RF PLL, this system therefore requires triple-point modulation.

The modulation signals applied to the FCL are in digital form, whereas for the RF PLL (VCO) the modulation signal is applied in analog form. The modulation cross-over points occur at approximately 30 and 300 Hz as determined by the closed loop bandwidths of the FCL and RF PLL respectively.

Frequency Generation

The RF PLL has a frequency resolution of 25 kHz. Higher resolution cannot be achieved owing to acquisition-time requirements and so for any given frequency the error could be as high as ± 12.5 kHz. This error is corrected by altering the reference frequency to the RF PLL. The FCL supplies the reference frequency and is able to adjust it up to ± 300 ppm with better than 0.1 ppm resolution (equivalent to better than 50 Hz resolution at the RF frequency).

Fast Frequency Settling

Both the FCL and RF PLL employ frequency-acquisition speed-up techniques to achieve fast frequency settling. The frequency-acquisition process of the FCL and RF PLL is able to occur concurrently with minimal loop interaction owing to the very large difference in frequency step size between the loops.

Frequency Acquisition of RF PLL

In the RF PLL the loop bandwidth is initially set high by increasing the charge pump current and reducing time constants in the loop filter. As a result settling to within 1 kHz of the final value occurs in under 4 ms. In order to meet noise performance requirements the loop parameters are then switched to reduce the loop bandwidth. There is a small frequency kick as the loop bandwidth is reduced. Total settling time is under 4.5 ms.

Frequency Acquisition of FCL

The FCL utilises self-calibration techniques that enable it to rapidly settle close to the final value while the loop is open. The loop is then closed and settling to the final value occurs with an associated reduction in noise. The total settling time is typically less than 4 ms.

Calibration

The following items are calibrated in the frequency synthesizer:

- nominal frequency
- KVCO
- KVCXO
- VCO deviation

Calibration of the nominal frequency is achieved by adding a fixed offset to the FCL nominal frequency; the TCXO frequency itself is not adjusted. The items KVCO and KVCXO are the control sensitivities of the RF VCO (in MHz/V) and VCXO (in kHz/V) respectively. The latter has temperature compensation.

3.1.3 RF Power Amplifier

RF Power Amplifier

50W 40W

The RF power amplifier and exciter of the 50W/40W radio is a five-stage line-up with approximately 40dB of power gain. The output of the frequency synthesizer is first buffered to reduce kick during power ramping. The buffer output goes to a discrete exciter that produces approximately 300 to 400mW output. This is followed by an LDMOS driver producing up to 8W output that is power-controlled. The final stage consists of two parallel LDMOS devices producing enough power to provide 40 to 50W at the RF connector.

25W

The RF power amplifier of the 25W version is a four-stage line-up with approximately 37dB of power gain. The output of the frequency synthesizer is first buffered to reduce kick during power ramping. The buffer output goes to a broad-band exciter IC that produces approximately 200mW output. This is followed by an LDMOS driver producing up to 2W output that is power-controlled. The final stage consists of two parallel LDMOS devices producing enough power to provide 25W at the RF connector.

Output of RF Power Amplifier

The output of the RF PA passes through a dual-directional coupler, used for power control and monitoring. Finally, the output is low-pass-filtered to bring harmonic levels within specification.

Power Control

The steady-state power output of the transmitter is regulated using a hardware control loop. The forward power output from the RF PA is sensed by the directional coupler and fed back to the power control loop. The PA output power is controlled by varying the driver gate bias voltage that has a calibrated maximum limit to prevent overdrive. The power control signal is supplied by a 13-bit DAC driven by custom logic.

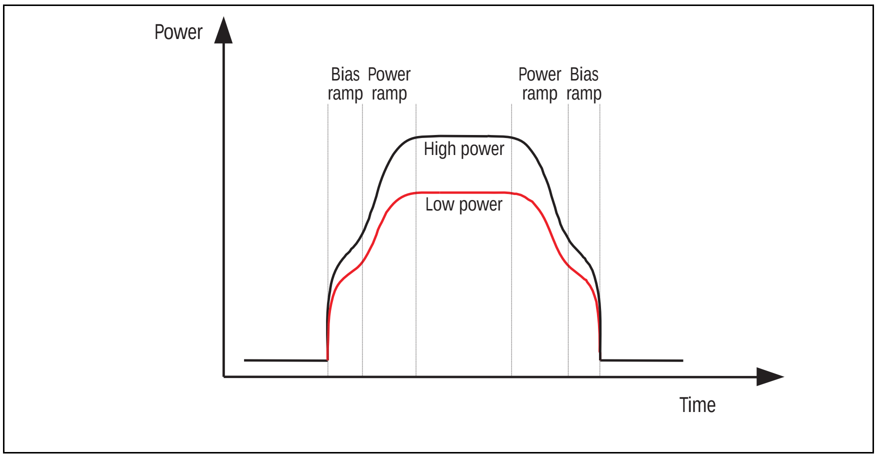
Ramping

Power ramp-up consists of two stages:

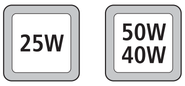
- bias
- power ramping

The timing between these two stages is critical to achieving the correct overall wave shape in order to meet the specification for transient ACP (adjacent channel power). A typical ramping waveform is shown in Figure 3.3.

Figure 3.3 Typical ramping waveforms



Bias Ramp-up



The steady-state final-stage bias level is supplied by an 8-bit DAC programmed prior to ramp-up but held to zero by a switch on the DAC output under the control of a TX INHIBIT signal. Bias ramp-up begins upon release by the TX INHIBIT signal with the ramping shape being determined by a low-pass filter. Owing to power leakage through the PA chain, ramping the bias takes the PA output power from less than –20 dBm for the 50 W/40 W version or –10 dBm for the 25 W version to approximately 25 dB below steady-state power.

Power Ramp-up

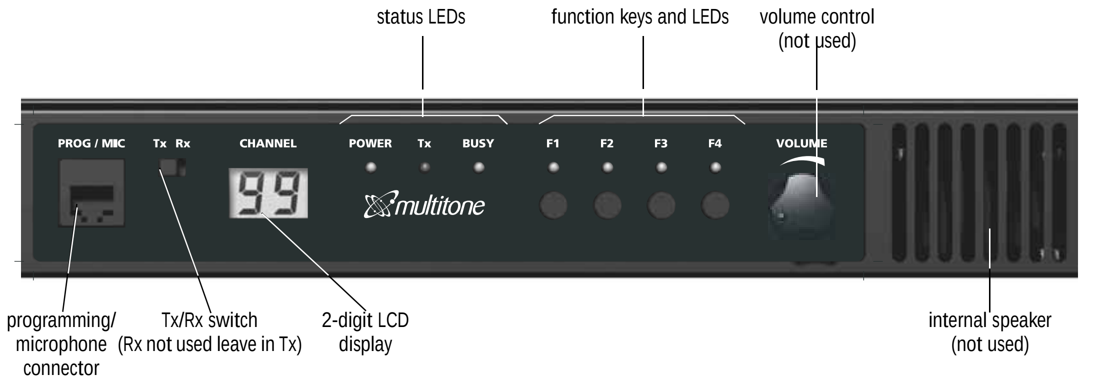
The power ramp signal is supplied by a 13-bit DAC that is controlled by custom logic. The ramp is generated using a look-up table in custom logic memory that is played back at the correct rate to the DAC to produce the desired waveform. The ramp-up and ramp-down waveforms are produced by playing back the look-up table in forward and reverse order respectively. For a given power level the look-up table values are scaled by a steady-state power constant so that the ramp waveform shape remains the same for all power levels.

3.2 User Interface Operation

This section describes the programming/microphone connector and the controls of the user interface, and the function of the UI board.

Figure 3.4 shows the controls and indicators of the user interface.

Figure 3.4 User interface



Programming/ Microphone Connector

The PROG/MIC connector can be used to connect a microphone or a programming cable.

TX/RX Switch

The TX/RX switch changes the LCD display to show either the transmitter channel or 00. The TX/RX switch also allows programming of the transmitter by the programming or calibration applications when in the TX position. The TX/RX switch does not work in the RX position always leave in the TX position.

The TB7100 programming application is a program on a PC that is connected to the Multitone paging transmitter via the PROG/MIC connector. The TB7100 programming application enables the user to program the Multitone paging transmitter with the required channels and subaudible signalling settings. The transmitter module is programmed individually according to the setting of the TX/RX switch. If the switch is in the RX position the transmitter module will not be programmed.

The calibration application is a program on a PC that is connected to the Multitone paging transmitter via the PROG/MIC connector. The transmitter module is designed to be totally electronically tuned. No physical tuning is required, as all tuning is done by electronic trimming. The calibration application can assist in the tuning of:

- AD6521 CODEC voltage reference
- TCXO frequency
- transmitter driver and final gate bias limit
- transmitter power control

- deviation and squelch.

Function Keys

Pressing the function keys will activate the functions assigned using the TB7100 programming application. Function keys may have functions assigned to both short and long key presses. A short key press is less than one second, and a long key press is more than one second.

Note The UI board can be configured to use the F1 and F2 keys to increment and decrement the channel. If the UI board is configured in this way, F1 and F2 can no longer be programmed using the TB7100 programming application. For more information refer Tait Application Note TN-1032-AN.

Volume Control and Internal Speaker

The volume-control and internal speaker are not used.

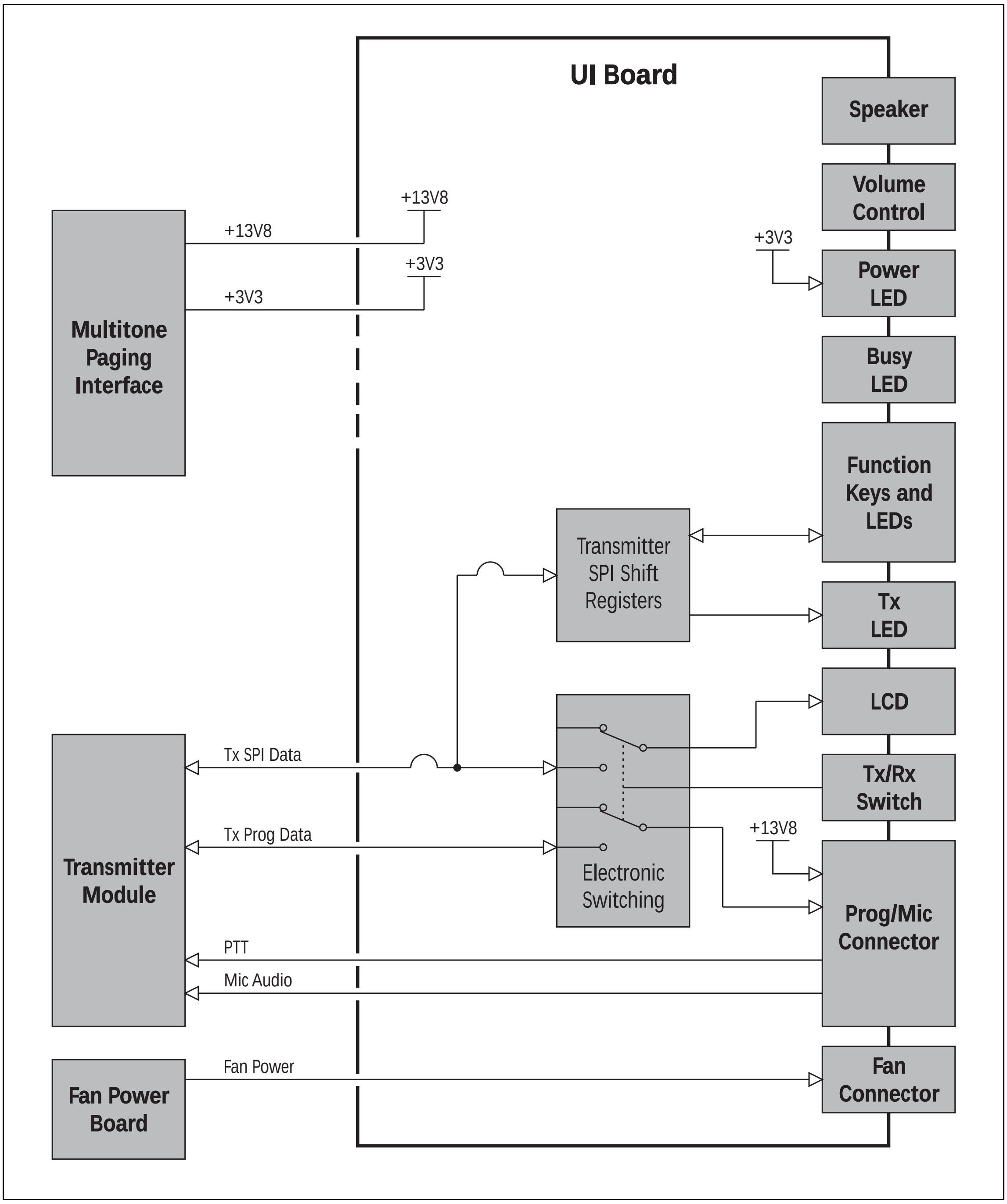
UI Board

The UI board is connected to the transmitter module via a 18-way ribbon cable. The internal speaker is connected to the UI board via a cable with a mating connector for easy disconnection. For more information on the connectors and their signals, refer to “Paging Interface to User Interface Connector” on page 67.

Figure 3.5 on page 31 shows a block diagram of the UI board.

The UI board does not include a microprocessor. A synchronous bi-directional serial interface provides communication of key status, LCD and LED-indicator data between the transmitter module and the UI board. The serial data is converted to or from a parallel form by a number of shift registers for the function keys and indicators. For the LCD, the serial data is fed to a driver IC that converts the serial data to a form suitable for the LCD. The keys are scanned and the LCD and LED indicators updated approximately every 50 ms.

Figure 3.5 UI board block diagram



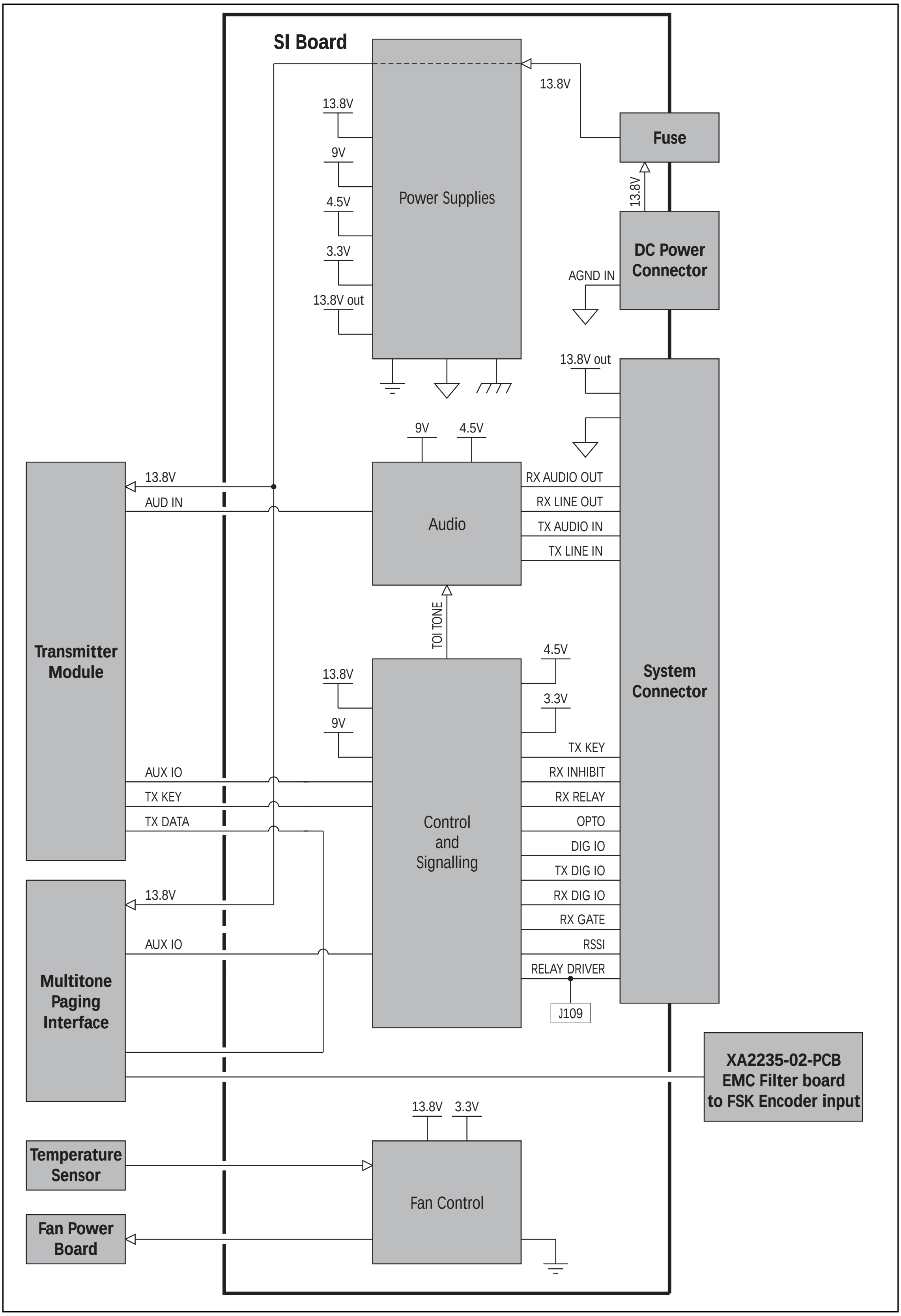
3.3 System Interface Operation

This section describes the functioning of the system interface. The system interface provides:

- internal power distribution
- external DC switching
- fan control
- general purpose IO
- transmitter audio processing
- opto-isolated keying
- relay output
- relay driver
- 13.8VDC (1.5A) output
- tone on idle (TOI).

These functional parts are described in detail below.

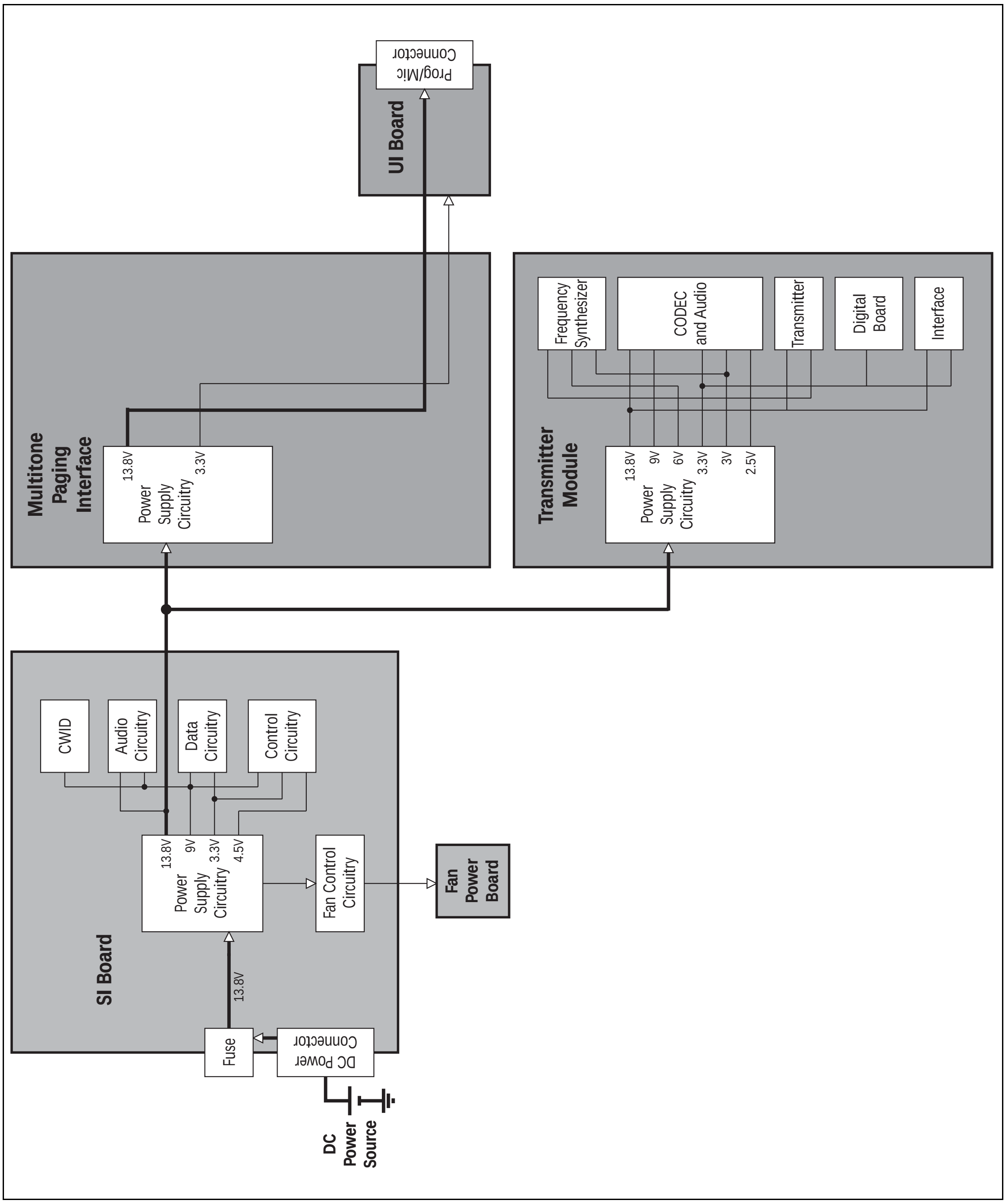
Figure 3.6 SI board block diagram



3.3.1 Internal Power Distribution

This section details how the input power feed is distributed throughout the Multitone paging transmitter to power its various sub-systems. Refer to Figure 3.7 for more information.

Figure 3.7 Power distribution



13.8V DC This is from the DC input on the rear of the Multitone paging transmitter. The DC power input of the Multitone paging transmitter is protected by a rear panel fuse. The 13.8V is distributed directly to the transmitter board and to the 13.8VDC output on the SYSTEM connector, rated at 1.5A. The 13.8VDC is also used to power the fans, via control circuitry.

Note The UI board obtains 13.8V and 3.3V from the paging interface board and outputs 13V8_SW to the PROG/MIC connector.

3.3V, 4.5V, 9V, 13.8V The other voltages derived on the SI board are used only on the SI board.

3.3.2 General Purpose IO

The transmitter board can be programmed to act upon signals from the SI board and also outputs signals for certain conditions. These settings are discussed in the installation and operation manual.

3.3.3 Transmitter Audio Processing

The SI board provides an unbalanced audio input and output for connecting to other devices.

3.3.4 Opto-Isolated Keying

External keying of the Multitone paging transmitter can be achieved using the current regulated optically isolated keying connections.

3.3.5 Fan Control

There are three modes of operation for the fans. The modes are:

- on continuous
- on when transmitting
- on at a pre-defined temperature.

The modes of operation are selected by links on the SI board. These settings are discussed in the installation and operation manual.

3.4 Fan Operation

The cooling fans are mounted behind the front panel. All fans in the chassis must be of the same type.

Dissipation of Heat

Heat needs to be dissipated from a number of components within the transmitter module, including the following:

- 9V regulator
- RF PA
- driver for RF PA

The mechanisms by which the heat is conducted away in each case are described below.

Dissipation of Heat from Transmitter

The transmitter board is mounted directly onto a heatsink through which the forced air from the fans is ducted.

Dissipation of Heat from RF PAs and Driver

Heat from the RF PAs and driver is conducted to the heatsink through a copper separator plate. The copper plate is fixed to the underside of the board and the components soldered directly to it. The copper plate is mounted directly to the main heatsink boss and a coating of thermal paste ensures good thermal transfer between these two surfaces.

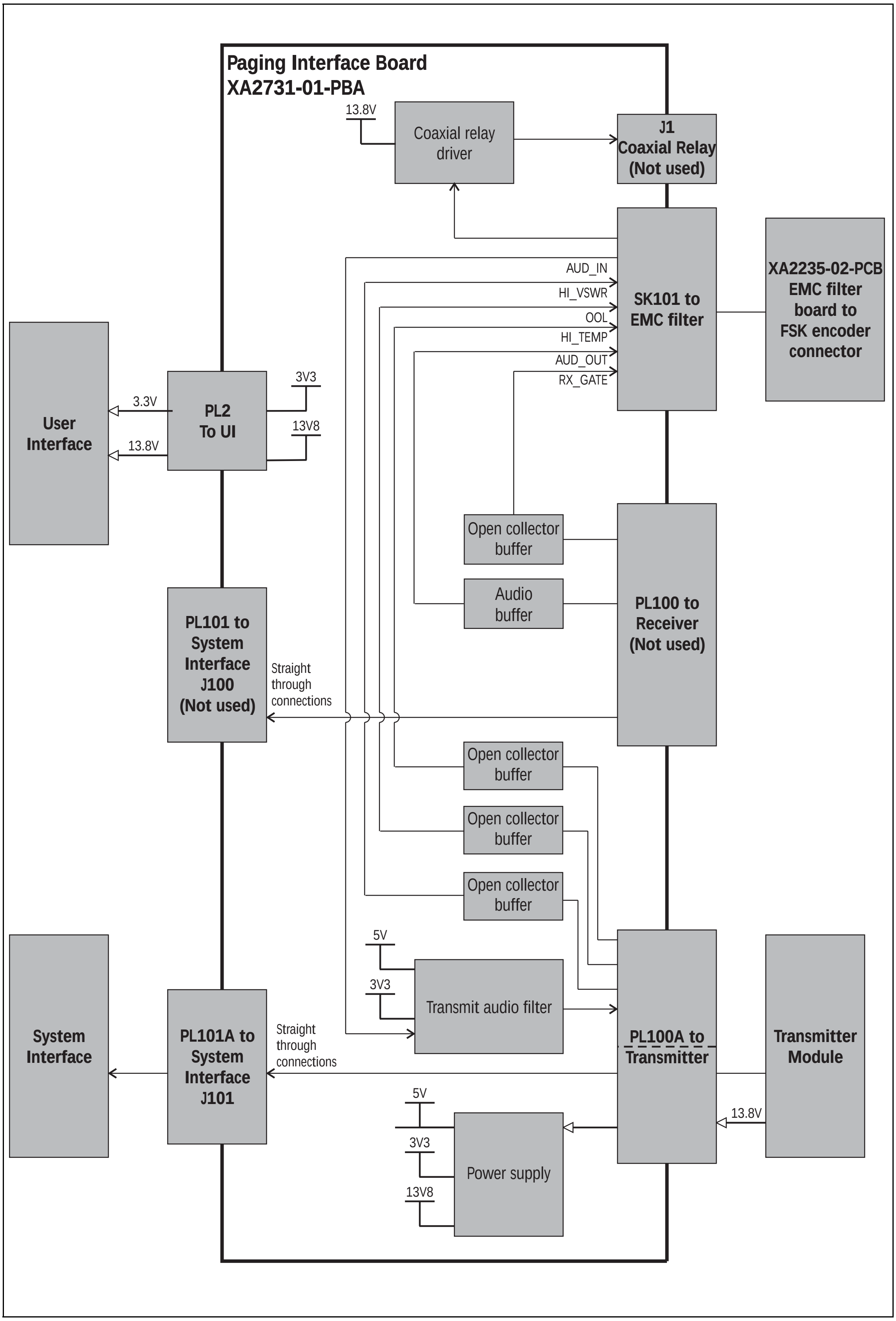
3.5 Paging Interface Operation

The XA2731-01-PBA takes audio from the FSK encoder connector and filters it for the transmitter. The board also provides three open collector alarm outputs to the FSK encoder connector.

These alarms are:

- High temperature
- High VSWR
- Out Of Lock

Figure 3.8 Paging board hardware architecture



4 Circuit Descriptions

Introduction

This section describes and illustrates the circuitry of the transmitter module.

The transmitter module is divided into the following circuitry:

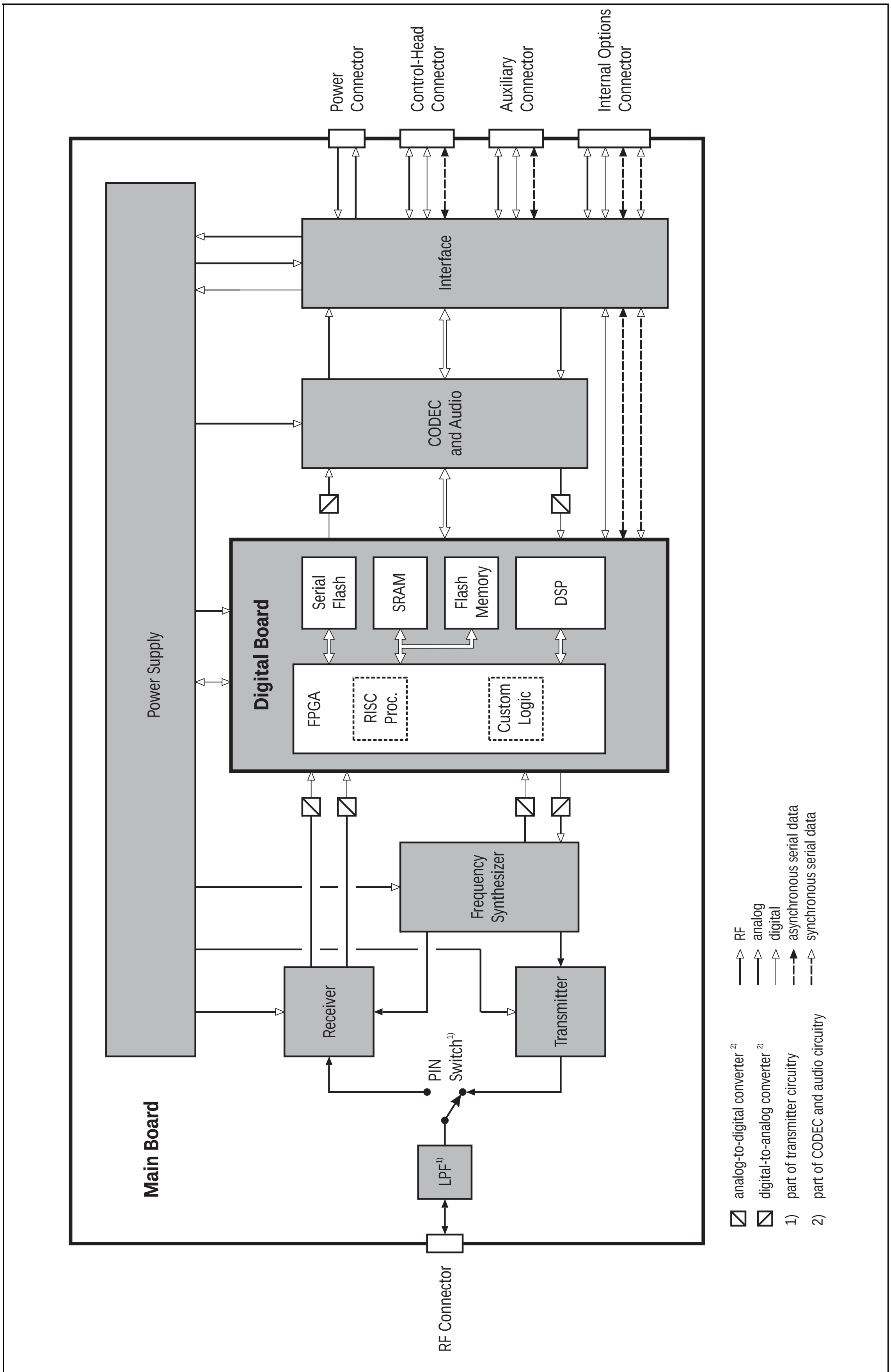
- transmitter
- frequency synthesizer (including FCL)
- CODEC
- power supply
- interface
- digital board

Figure 4.1 gives an overview of the of the circuitry of the transmitter board and shows how it is interconnected.

Sample Schematics

For up-to-date schematics refer to the relevant PCB information.

Figure 4.1 Transmitter board hardware architecture



4.1 Transmitter Circuitry

Introduction

For a block diagram of the transmitter circuitry, refer to Figure 4.2.

The transmitter circuitry is different for the 50 W/40 W boards and the 25 W boards, and the different bands.

Exciter

With the 50 W/40 W boards, the discrete-component exciter is designed for specific bands (UHF or VHF). It is made up of Q3501, Q3502, and Q3505, which amplify the signal provided by the frequency synthesizer from its level of 7 to 10 dBm up to 24 dBm for the frequency bands 136 to 174 MHz and 400 to 520 MHz.

With the 25 W boards, the broadband exciter is a common element in all the bands, as it operates across all frequencies from 66 to 530 MHz. It is made up of Q300 and Q303, which amplify the signal provided by the frequency synthesizer from its level of 7 to 10 dBm up to 24.5 dBm for the frequency band from 66 to 530 MHz.

The exciter operates in full saturation, thereby maintaining a constant output power independent of the varying input power level supplied by the synthesizer.

Power Amplifier

The power amplifier comprises the driver amplifier Q306 and two paralleled final devices Q309 and Q310.

With the 50 W/40 W boards, the signal from the exciter is amplified by Q306 to a power level of approximately 2 W (VHF) using a PD55003 and about 3 W (UHF) using a PD55008. The resulting signal is then amplified by Q309 and Q310 to produce a typical output power of 90 W at 155 MHz and 65 W across the UHF band, when measured after the series capacitors (C348, C349, C350) at the start of the directional coupler.

With the 25 W boards, the 24.5 dBm signal from the exciter is reduced by a band-dependent pi-attenuator and is amplified by Q306. The resulting signal is then amplified a second time by Q309 and Q310 to produce a typical output power of 40 W when measured after the series capacitors (C348, C349, C350) at the start of the directional coupler.

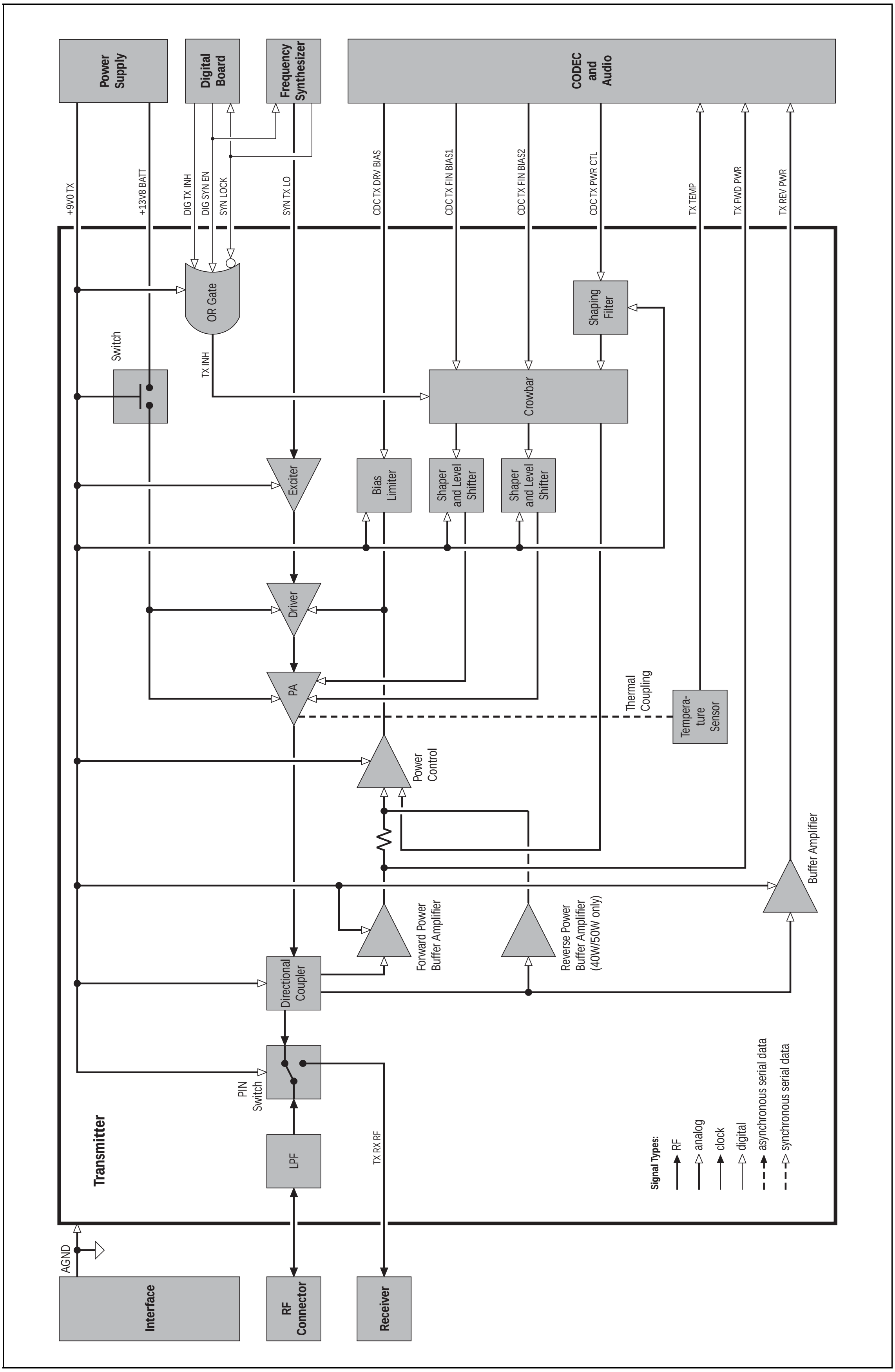
The high-level RF signal passes via the directional coupler, the transmit-receive PIN switch, and the LPF, through to the antenna. The LPF is used to attenuate unwanted harmonic frequencies.

Power Control Loop

Calibration is used to adjust the power control loop, thus setting the output of the transmitter to one of four preferred power levels:

- 10, 15, 25, and 50 watts (VHF), and
  10, 15, 20, and 40 watts (UHF) for 50 W/40 W boards
- 1, 5, 12 and 25 watts (all bands) for 25 W boards

Figure 4.2 Block diagram of the transmitter circuitry



The loop maintains these power settings under changing environmental conditions. The control mechanism for this loop is via the DAC IC204 and one of the operational amplifiers making up IC301. The power control loop will be inhibited if for any reason an out-of-lock signal is detected from the synthesizer. This ensures that no erroneous signals are transmitted at any time.

50W 40W

With the 50 W/40 W boards, the power control loop processes the voltages from the forward and reverse power sensors in the directional coupler. This signal is fed to the buffer and a band-limited operational amplifier back to the gate of Q306. In this way, the transmitter is protected against bad mismatches.

25W

With the 25 W boards, the power control loop senses the forward power by means of the diode D304. This signal is fed to the buffer and a band-limited operational amplifier back to the gate of Q306.

A voltage clamp (one of the operational amplifiers of IC301) for Q306 limits the maximum control-loop voltage applied to its gate.

Directional Coupler

50W 40W

With the 50 W/40 W boards, the directional coupler actively senses the forward power and the reverse power, and feeds them back to the power-control circuit.

25W

With the 25 W boards, the directional coupler actively senses the forward power and feeds it back to the power-control circuit. If the directional coupler detects too much reverse power, indicating a badly matched antenna, the transmitter will be reduced to a medium power setting (approximately 12W).

Temperature Sensor

For added protection, a temperature sensor ensures that the transmitter power is reduced to very low levels should a temperature threshold be exceeded. If the temperature does not decrease, the transmitter is switched off.

4.2 Frequency Synthesizer Circuitry

Introduction

For a block diagram of the frequency synthesizer circuitry, refer to Figure 4.3.

The frequency synthesizer includes an active loop filter, one or two VCOs and buffer amplifiers, and a PLL IC. The last-named uses conventional integer-N frequency division and includes a built-in charge pump. Speed-up techniques ensure a transmit-receive settling time of less than 4.5ms while retaining low noise characteristics in static operation.

Power Supplies

Several power supplies are used by the frequency synthesizer owing to a combination of performance requirements and the availability of suitable components. The PLL IC includes analog and digital circuitry and uses separate power supplies for each section. The digital section is run on 3V, while the analog section is run on approximately 5V. The VCOs and buffer amplifiers run off a supply of about 5.3V. The active loop filter requires a supply of 14 to 15V, and a reference voltage of approximately 2.5V.

Performance Requirements

Low noise and good regulation of the power supply are essential to the performance of the synthesizer. A 6V regulator IC provides good line regulation of the 9V supply and good load regulation. Good regulation of the power-supply line and load is essential for meeting the transient ACP requirements. The regulator output voltage is electrically noisy, however, and filtering is essential. Filtering of the power supply is achieved with two capacitance multipliers (Q508 and C585 for the VCO supply, and Q512 and C579 for the PLL and loop-filter supply). The VCO (or VCOs) use a separate capacitance multiplier because these multipliers have poor load regulation and the VCOs impart sufficient load transients to warrant a separate supply.

Effect of Tuning Range

For reasons of noise performance, the VCOs are designed to be tuned within a range of 2 to 12V. Active tuning circuitry is required. An active loop filter incorporating an IC operational amplifier achieves this range with a suitable power supply voltage. Normal synthesizer switching behaviour involves overshoot, which dictates that the tuning voltage range must extend above and below the range of 2 to 12V. The 14V limit is a result of limits on the working supply voltage of the IC operational amplifier.

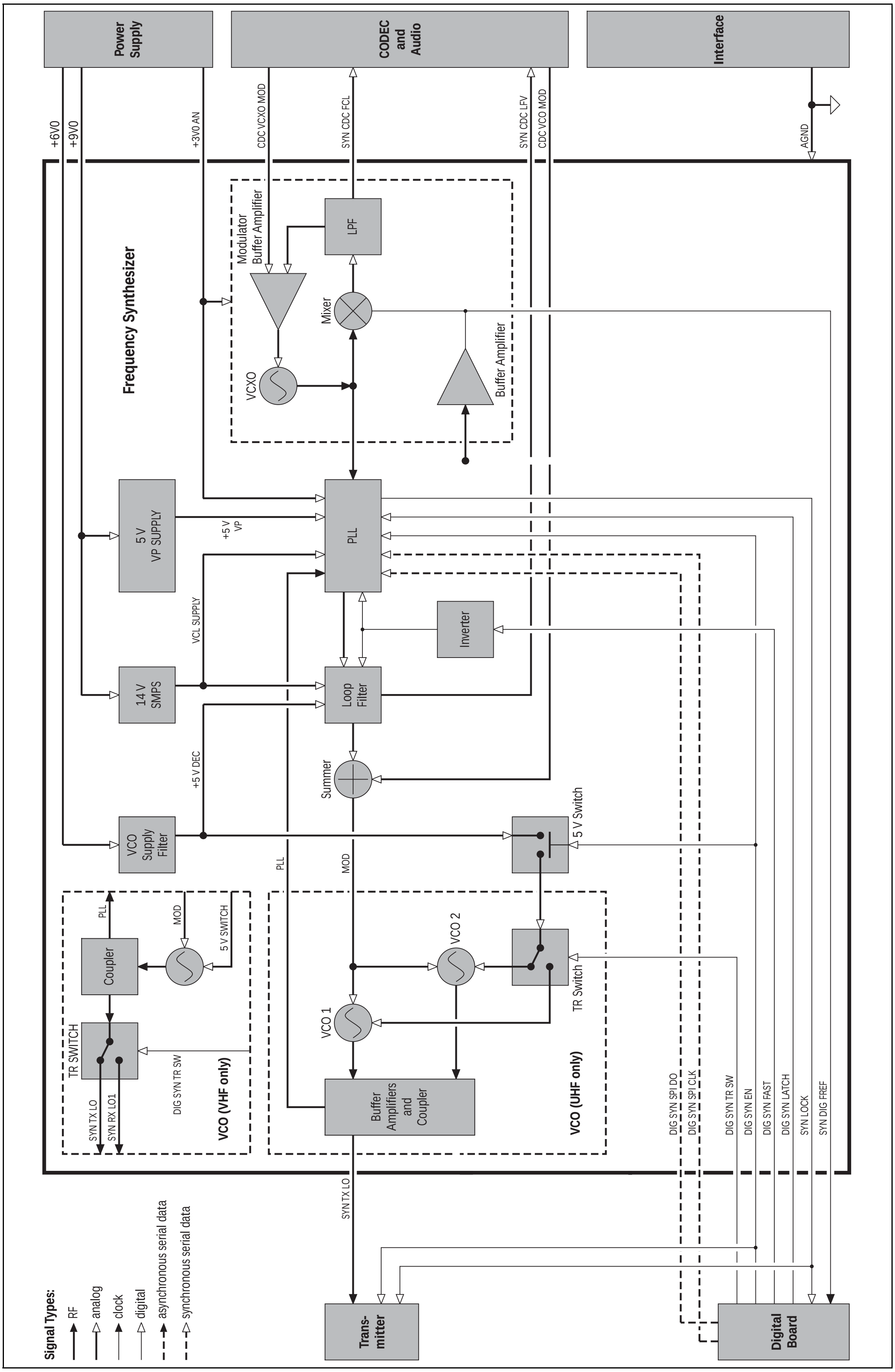
Switch-mode Power Supply

The power supply VCL SUPPLY for the active loop filter is provided by a SMPS, which is in turn powered by 9V. The SMPS consists of an oscillator (switching circuit) and a detector. The output voltage is monitored by a feedback circuit that controls the DC bias of the switching circuit to maintain a constant output voltage.

Synthesizer Circuitry

The essential function of the PLL frequency synthesizer is to multiply a 25kHz reference frequency to give any desired frequency that is an integer multiple of 25kHz. There are some constraints imposed by the capabilities of the synthesizer hardware, especially the tuning range of the VCOs.

Figure 4.3 Block diagram of the frequency synthesizer circuitry



Reference Frequency

The 25kHz (approximate) reference is obtained by dividing the 13MHz (approximate) output of the FCL. Any error in the FCL output frequency will be multiplied by the synthesizer. Therefore, if the synthesizer is locked but not the FCL, then the synthesizer output frequency will be wrong.

The FCL frequency division is performed by a digital counter inside the PLL IC. The divider setting is constant.

VCO Frequency and Output Power

The output frequency from the synthesizer is generated by a VCO.

The VCO frequency is tuned across the frequency range of the Multitone paging transmitter by means of a DC control voltage, typically between 2V and 12V. The VCO output power is amplified by a buffer amplifier.

The power is low and varies from band to band. The buffer output power depends on which mode—receive or transmit—is used. In transmit mode it should be about 9dBm.

Dual VCOs

Some variants of the synthesizer use two VCOs: one for receive and one for transmit. Synthesizers with two VCOs share the same tuning signal.

Only one VCO is switched on at a time, and so the PLL IC will see only one output frequency to tune. A portion of the RF output from the VCOs is fed to the RF input of the PLL IC. The RF signal is divided by an integer that would give 25kHz if the output frequency were correct.

Phase-locked Loop

The PLL IC compares the 25kHz reference and the divided VCO signal, and the error is used to control the internal charge pump. The charge pump is a current source that can sink or source current in proportion to the frequency or phase error. The output is a series of 25kHz pulses with a width that is dependent on the phase error. When the output frequency of the synthesizer is correct, there is no error and the charge pump output will become open circuit.

Active Loop Filter

The loop filter continuously integrates the current pulses from the charge pump and produces a steady DC output voltage that tunes the VCO (or VCOs). When the VCO frequency is correct, there is no frequency error and therefore no charge-pump output, and so the loop filter's output voltage remains constant. If the frequency is too high or too low, the error will result in the output of charge-pump current pulses (negative or positive depending on the sign of the error). The loop filter's output voltage will change accordingly, causing the VCO frequency to change in proportion. The synthesizer design is such that normally the VCO frequency will be automatically corrected.

Re-tuning of VCO Frequency

When the Multitone paging transmitter changes channels or switches between receive and transmit, the VCO frequency must be changed.

The rate at which the VCO is re-tuned is dependent on many factors, of which the loop filter is the main factor. The loop filter is an integrator built around an operational amplifier. The resistors and capacitors of the filter affect both the switching time and the stability of the synthesizer; the values of these components have been carefully selected to give optimum control characteristics.

Speed-up Techniques

To reduce the change-over time between transmit and receive, part-time speed-up techniques have been implemented. Speed-up involves changing some resistor values while simultaneously changing the PLL IC settings. This process is implemented in hardware under software control in conjunction with use of the synthesized reference input. The result is a transmit-receive settling time of less than 4.5ms. (The switching time is measured for a frequency change equal to the first IF plus 10MHz or 1MHz, depending on the repeater offsets used for the band. This implies a synthesizer transmit-receive change-over plus an offset of 1MHz or 10MHz in less than 4.5ms. The ramp-up and ramp-down of the transmitter, which totals 1ms, extends this change-over time to 5.5ms.)

4.3 Frequency Control Loop

Introduction

The FCL is included in the block diagram of the frequency synthesizer (see Figure 4.3).

The FCL forms part of the frequency-synthesizer module. The basis of the FCL is a VCXO, which generates the reference frequency required by the main PLL of the synthesizer.

Elements of FCL Circuitry

The FCL is a simple frequency-locked loop. The circuitry consists of the following elements:

- VCXO (XL501, Q501, Q503)
- TCXO (XL500)
- buffer amplifier (IC500)
- mixer (IC501)
- low-pass filter (IC502, pins 5 to 7)
- modulator buffer amplifier (IC502, pins 1 to 3)

The TCXO supplies a reference frequency of 13.0000MHz, which is extremely stable, regardless of the temperature. The VCXO runs at a nominal frequency of 13.0120MHz, and is frequency-locked to the TCXO reference frequency.

Circuit Operation

The VCXO output is mixed with the TCXO output to create a nominal difference (or offset) frequency SYN CDC FCL of 12.0kHz. The signal SYN CDC FCL is fed via the CODEC IC502 in the CODEC circuitry to the FPGA on the digital board. The FPGA detects the offset frequency, compares it with the programmed offset frequency, and outputs a corresponding feedback signal CDC VCXO MOD via IC205. The feedback signal is amplified and inverted by the modulator buffer amplifier and output as the loop voltage for the VCXO. With this design the VCXO frequency can be adjusted by very small precise amounts, and because the loop is locked, the VCXO inherits the temperature stability of the TCXO.

Modulation

The FCL modulation is implemented within the FPGA and appears at the output of IC205, and therefore on the VCXO loop voltage. Consequently, the VCXO is frequency modulated directly by the relevant modulation information. The latter may be the microphone audio, an audio tap-in signal, internal modem signals, or any combination of these.

4.4 CODEC

Introduction

For a block diagram of the CODEC and audio circuitry, refer to Figure 4.4.

A/D and D/A Conversion

The analog-to-digital conversion and digital-to-analog conversion is performed by the devices IC203, IC204 and IC205.

Device IC203

IC203 is an eight-channel DAC that provides control of transmitter biasing, front-end AGC, front-end tuning, and the output of analog RSSI signals. The digital input data are fed to IC203 in synchronous serial form. Three of the DAC channels are not used.

Device IC205

IC205 contains two CODECs. One is used by the FCL. The second is used for auxiliary audio (input) and VCO modulation (output). The digital section communicates with this device via a four-wire synchronous serial interface.

Device IC204

IC204 contains base-band, voice-band and auxiliary CODECs and some analog signal conditioning. The reference voltage (nominally 1.2V) for these CODECs is provided internally by IC204 but is decoupled externally by C228.

Voice-band CODEC

The voice-band CODEC handles the microphone and speaker signals. The digital section communicates with this CODEC via a three-wire synchronous serial interface (VSFS, VSDO and VSDI balls). IC204 also contains voice-band filtering and pre-amplification.

Auxiliary CODEC

The auxiliary CODEC handles transmitter power control and general analog monitoring functions. The digital section communicates with this CODEC via a three-wire synchronous serial interface (ASFS, ASDI and ASDO balls).

Audio Circuitry

The audio circuitry performs four functions:

- input of microphone audio signal
- input of auxiliary audio signal

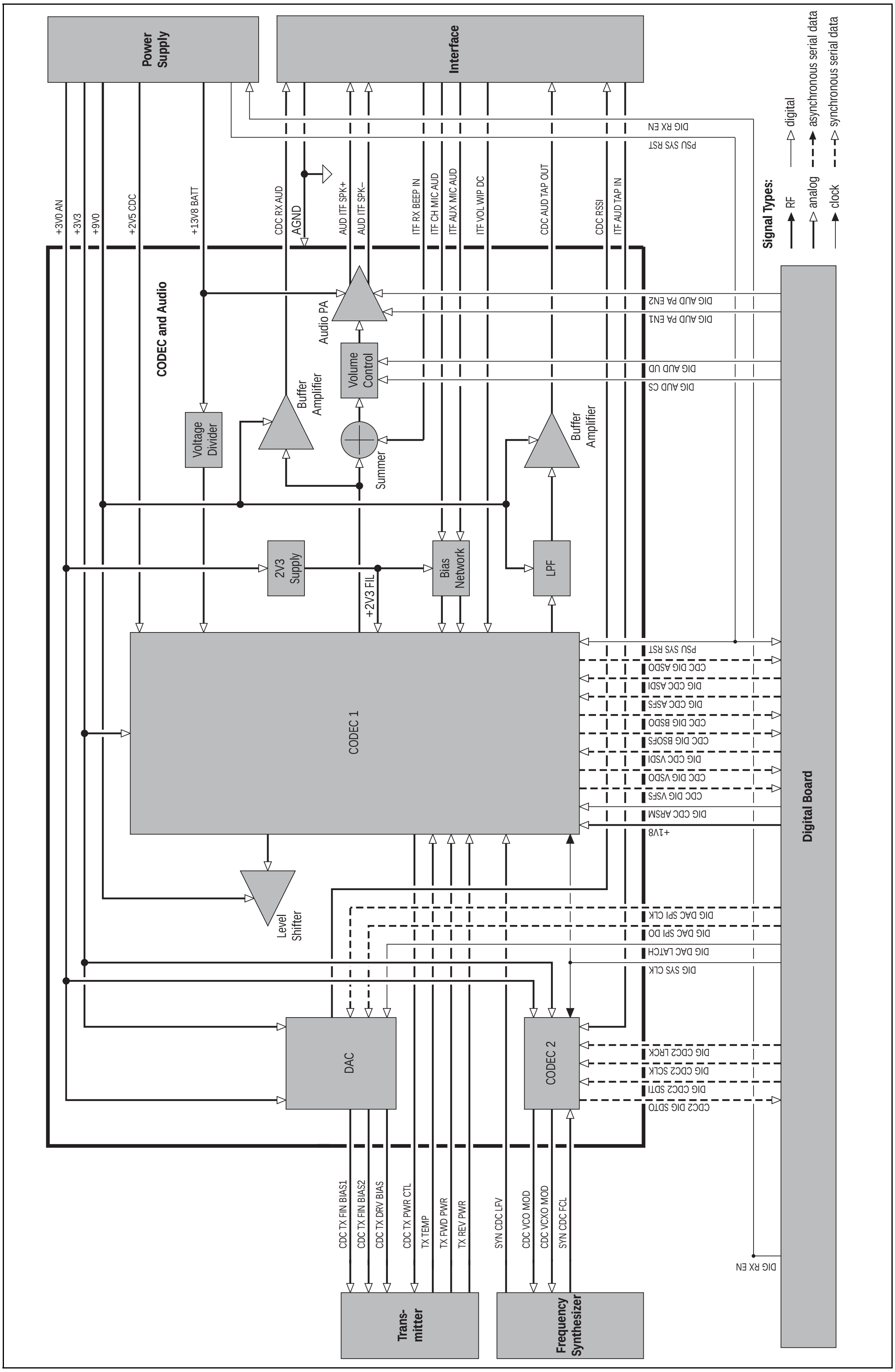
The sections of the circuitry concerned with these functions are described below.

Microphone Signals

There are two microphone source signals:

- ITF AUX MIC AUD from auxiliary or internal options connector

Figure 4.4 Block diagram of the CODEC and audio circuitry



- ITF CH MIC AUD from microphone connector

The biasing for electret microphones is provided by a filtered 3.0V supply via R226 and R227. The components R209 and C202 provide the supply filtering. The microphone inputs to IC204 (VINAUXP, VINAUXN, VINNORP, and VINNORN balls) are differential. The negative inputs are decoupled to the filtered 3.0V supply by C215 and C216. The positive inputs are biased to approximately 1.5 V by R229, R232, R230 and R233. AC coupling and DC input protection is provided by C213 and C214.

Auxiliary Audio Input

The auxiliary audio input signal ITF AUD TAP IN is DC-coupled to the ADC input of IC205. R241 combined with internal clamping diodes in IC205 provide DC protection for the ADC input. IC205 provides the input biasing of approximately 1.5V.

4.5 Power Supply Circuitry

Introduction

For a block diagram of the power supply circuitry, refer to Figure 4.5.

The power-supply circuitry consists of the following main sections:

- supply protection
- supervisory circuit
- internal power supplies
- control of internal power supplies
- control of external power supply

Supply Protection

50W 40W | 25W

Electrical protection to the Multitone paging transmitter is provided by the clamping diode D600 and by 20A fuses (for the 50W/40W boards) and 10A fuses (for the 25W boards) in the positive and negative leads of the power cable. This provides protection from reverse voltages, positive transients greater than 30V, and all negative transients. An ADC monitors the supply and is responsible for the protection of internal devices, which have an operating voltage of less than 30V. The ADC also ensures protection if the Multitone paging transmitter operates outside its specified voltage range of 10.8V to 16V.

Supervisory Circuit

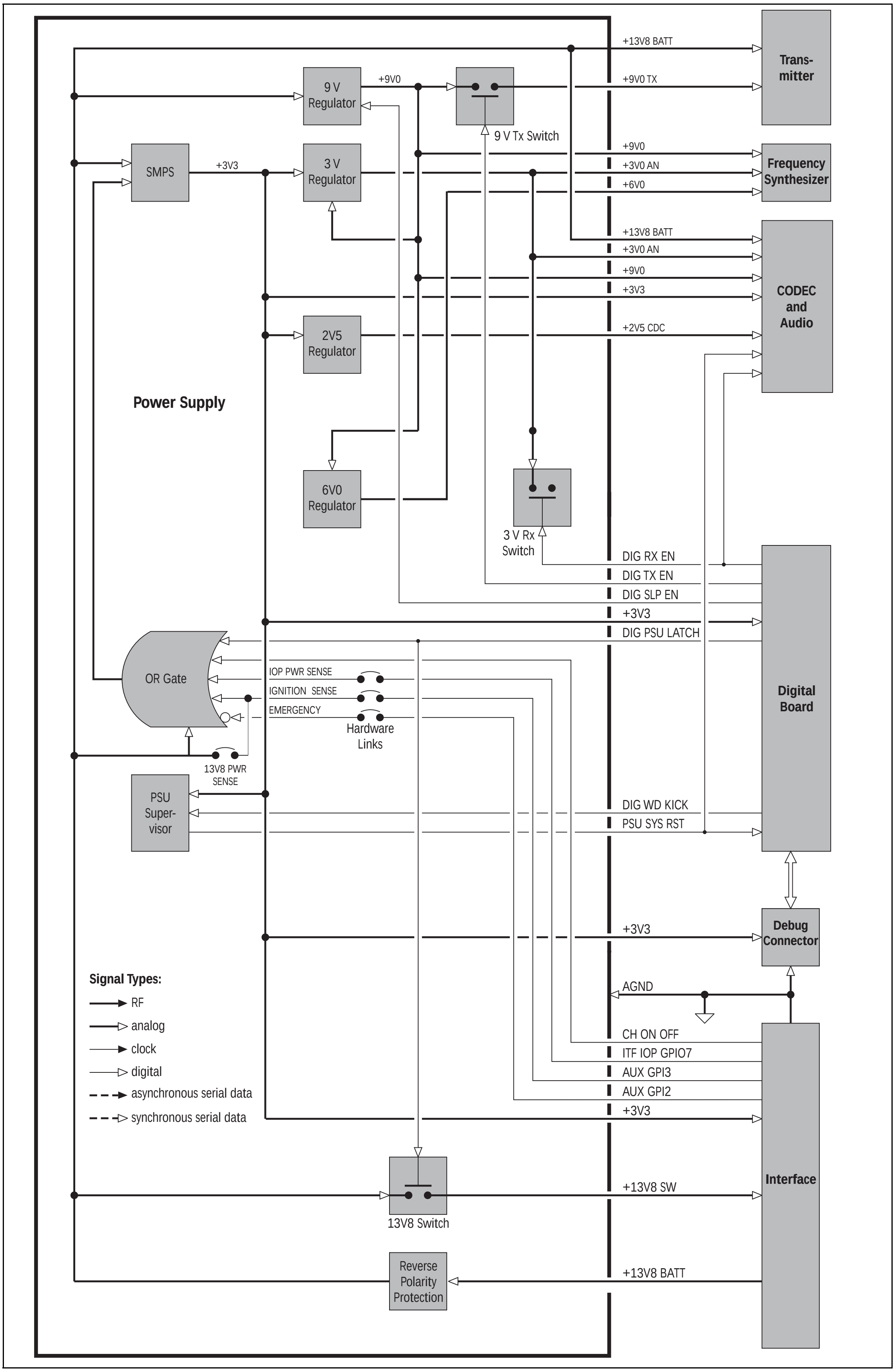
The supervisory circuit comprises a reset and watchdog timer. The circuit provides the reset signal PSU SYS RST to the digital section, which in turn provides the watchdog signal DIG WD KICK required by the supervisory circuit.

Internal Power Supplies

There are eight internal power supplies:

- one SMPS (+3V3)
- four linear regulators (+9V0, +6V0, +3V0 AN, +2V5 CDC)
- three switched supplies (+9V0 TX, +3V0 RX, +13V8 SW)

Figure 4.5 Block diagram of the power supply circuitry



The SMPS is used to regulate to 3.3V from the external supply +13V8 BATT. The four lower voltages required are then further stepped down with linear regulators. These all take advantage of the efficiency gain of the SMPS. The 9V regulator and the 13.8V switched supply are connected to +13V8 BATT. The two remaining switched supplies (9V and 3V) use P-channel MOSFETs.

4.6 Interface Circuitry

Introduction

For a block diagram of the interfaces circuitry, refer to Figure 4.6.

For more on the connector pinouts, refer to “Connections” on page 57.

Bi-directional Lines

Bi-directional lines are provided on four pins of the auxiliary connector, (AUX GPIO4 to AUX GPIO7) one on the control-head connector (CH GPIO1), and seven on the internal options connector (IOP GPIO1 to IOP GPIO7). Those on the auxiliary and control-head connectors are formed by combining two uni-directional lines. For example, the line AUX GPIO4 at pin 10 of the auxiliary connector is formed from ITF AUX GPI4 and DIG AUX GPO4.
The circuitry is the same in all five cases and is explained below for the case of AUX GPIO4.

Output Signals (e.g. AUX GPIO4)

An output on the line AUX GPIO4 originates as the 3.3V signal DIG AUX GPO4 from the digital section. The signal is first inverted by Q703 (pins 3 to 5) and the output divided down to 1.6V by R748 and R753 to drive the base of Q703 (pins 1, 2 and 6). When the latter’s collector current is low, the base current is a maximum and creates a small voltage drop across R761, causing the collector emitter to saturate. As the collector current increases, the base current decreases proportionally until the voltage across R761 reaches 1V. At this point the base-emitter begins to turn off and the base current diminishes rapidly. The net effect is a current-limiting action. The current limit value is approximately 18mA (the inverse of the value of R761).
The output configuration is open-collector with a pull-up to 3.3V by default. Pull-up options to 5V and 13.8V are also available. On AUX GPIO4 only, the optional MOSFET Q707, which has a high current drive, may be fitted. If Q707 is fitted, R768 must be removed.

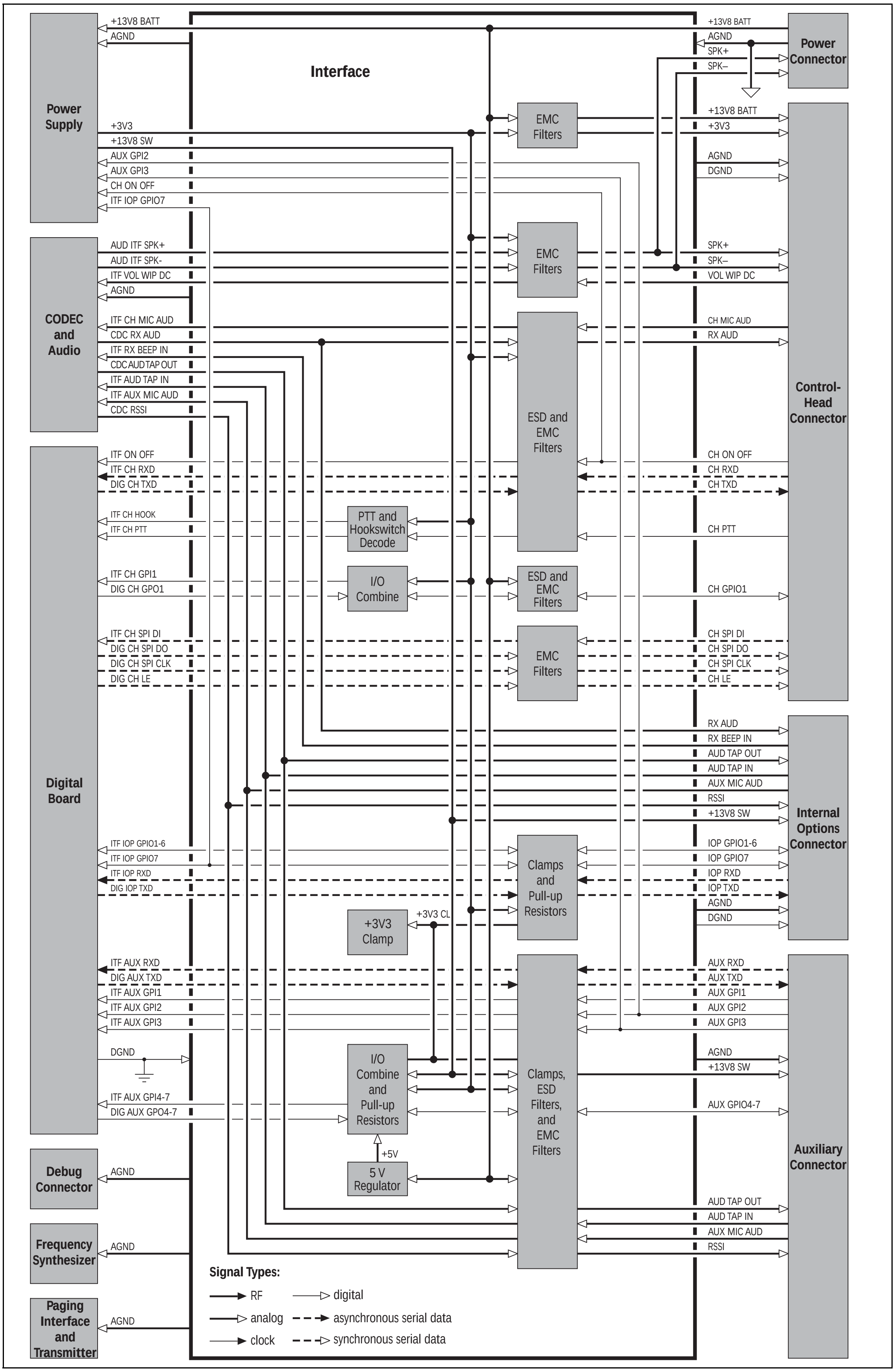
5-Volt Regulator

The 5V supply mentioned above is provided by a simple buffered zener regulator formed by Q702, D721, R721 and R722. The resistor R722 limits the current to about 25mA under short-circuit conditions.

Input Signals (e.g. AUX GPIO4)

An input signal applied to AUX GPIO4 is coupled via R757 to ITF AUX GPI4 and fed to the digital section. As the input signal may exceed the maximum allowed by the digital section, it is clamped by D711 and a shunt regulator. The shunt regulator consists of Q708, R719 and R720 and begins to turn on at approximately 2.7V. In combination with D711, the input to ITF AUX GPI4 is therefore clamped to 3.3V nominally. The value of R757 is made large to minimize the loading effect on the output pull-up resistors.

Figure 4.6 Block diagram of the interface circuitry



Input Signals (AUX GPI1 to AUX GPI3)

Dedicated inputs are provided on three pins of the auxiliary connector (AUX GPI1 to AUX GPI3). AUX GPI1 is a general-purpose input with strong protection of the same type used for AUX GPIO4. AUX GPI2 is normally a dedicated emergency input but can be made a general-purpose input like AUX GPI1 by removing the link LK3 in the power supply area. AUX GPI3 is normally a dedicated ignition-sense input but can be made a general-purpose input like AUX GPI1 by removing the link LK2 in the power supply area and fitting the 33kΩ resistor R775.

ESD Protection

On exposed inputs of the auxiliary and control-head connectors ESD (electrostatic discharge) protection is provided by a 470pF capacitor and by clamping diodes to ground and to 13.8V. For example, on AUX GPIO4 this would consist of D713 and C725. The lines IOP GPIO1 to IOP GPIO7 are intended for connection to internal digital devices and so these have relatively light protection.

Hookswitch Detection

Hookswitch detection is performed by Q700, R709, R706 and R712. When the resistance to ground on the PTT line is less than 13.2kΩ, Q700 will turn on and drive the ITF CH HOOK line high; this indicates either that the microphone is on hook or that the PTT (press-to-talk) switch is pressed.

4.7 Paging Interface Circuitry

Introduction

For more on the connector pinouts, refer to “Connections” on page 57.

There is no receive functionality currently in this product but it has been designed so further functionality may be added with minimal redesign at a later stage.

Buffers

All buffers are open collector output.

Output Signals

On SK101 pin 9 is AUD_OUT. The gain of this output can be adjusted by changing links on W1 (link 1 to 2 is default). The three alarm outputs HI_VSWR, HI_TEMP and OOL are all buffered on this board, also output is RX_GATE, no receive gate is available at this stage.

Regulators

The 13V8 supply is used to provide a 5V supply by a 78L05 U1. This is then regulated down to 3V3 with U L4931 U2.

Input Signals

The audio input on SK101 pin 5 is passed directly to U3 that shifts all levels to 3V3 to allow for differences in input. W2 is can be used to adjust for differences in polarity. From here the audio is passed to a digital tapped delay line comprised of U5 and U6. This low pass filter is required because the signal from the paging controller is square and the transmitter can not handle the some of the high frequency components. The bias of the filter is set by RV1. The output is amplified by U7 and level controlled by RV2 before passing to the transmitter.

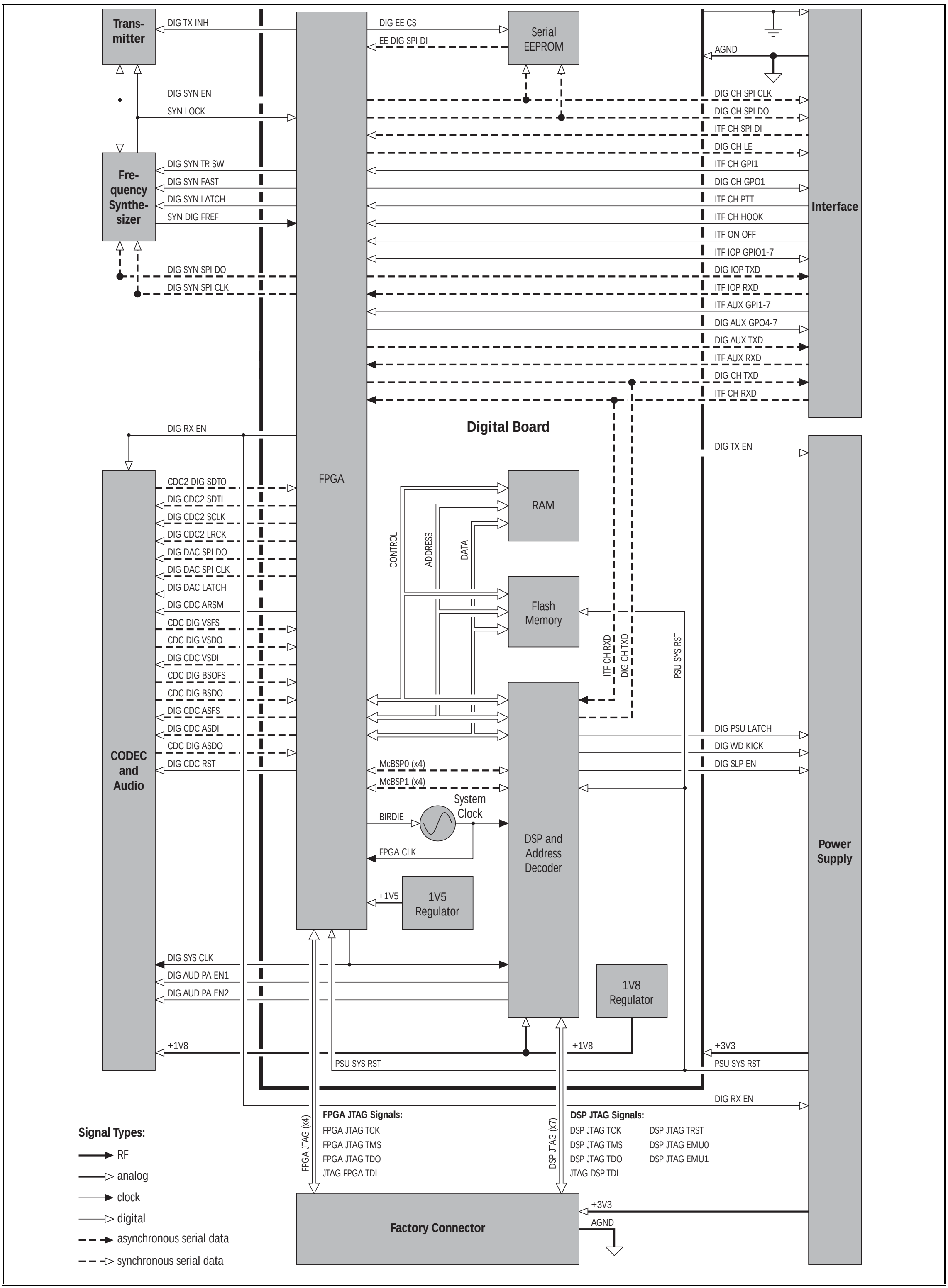
4.8 Digital Board

Introduction

For a block diagram of the digital board, refer to Figure 4.7.

The digital board is not serviceable at level-2 and is not described in this manual.

Figure 4.7 Block diagram of the digital board



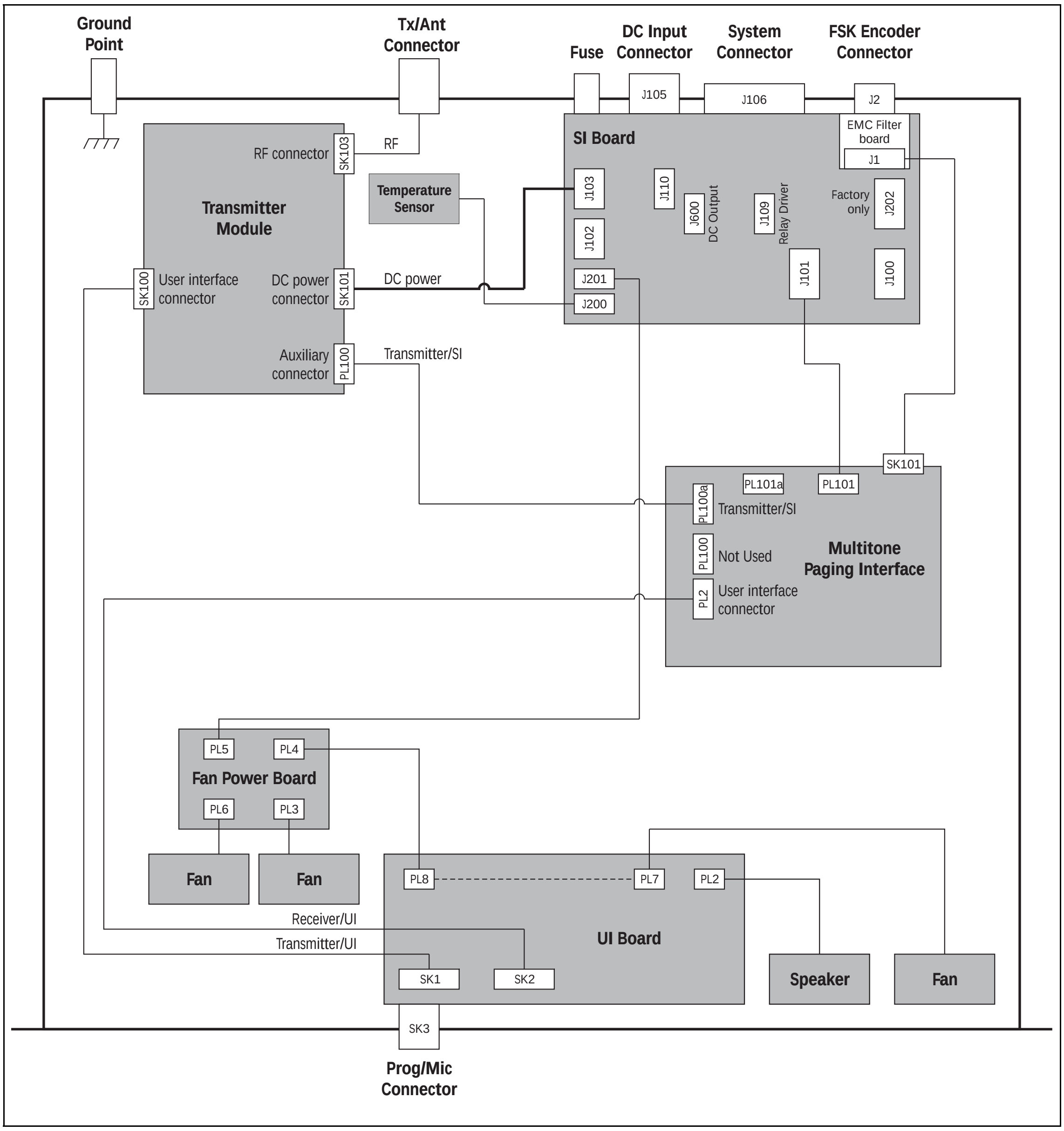
5 Connections

Overview

This section gives an overview of looms and cables, and describes the specifications and pinouts of the external and internal connectors.

Figure 5.1 provides an overview of the connections.

Figure 5.1 Connectors, looms and cables

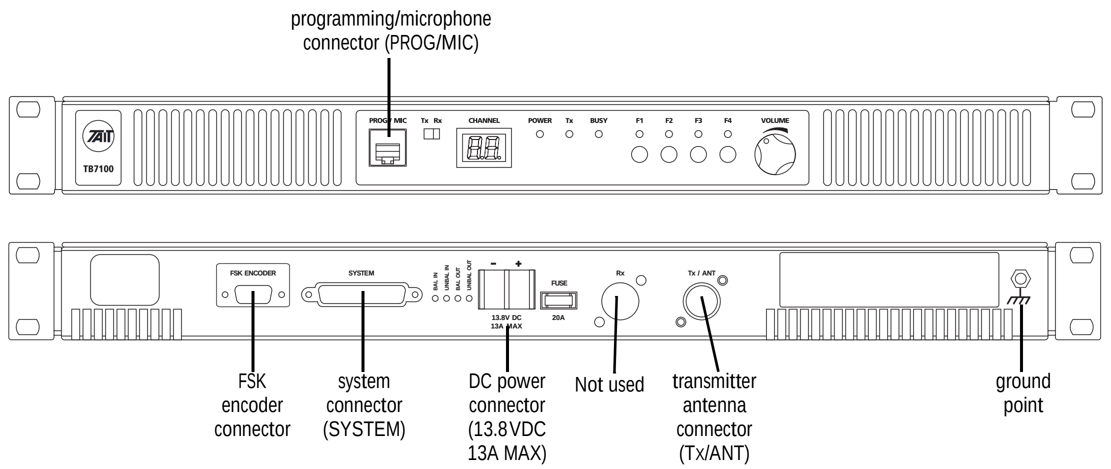


For information on the factory connector and the internal options connector of the transmitter, refer to the PCB information.

5.1 External Connectors

Figure 5.2 shows the external connectors:

Figure 5.2 External connectors

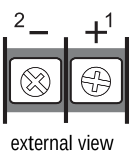


Ensure that DC power source is disconnected before opening the Multitone paging transmitter.

DC Power Connection

The Multitone paging transmitter is designed to accept a nominal 13.8V DC, with negative ground.

The DC power connector (J105) at the rear of the base station is a heavy-duty M4 screw terminal connector suitable for many forms of connection.

	Pin	Signal Name	Signal Type	Notes
	1	13.8VDC	input	
	2	ground	input	

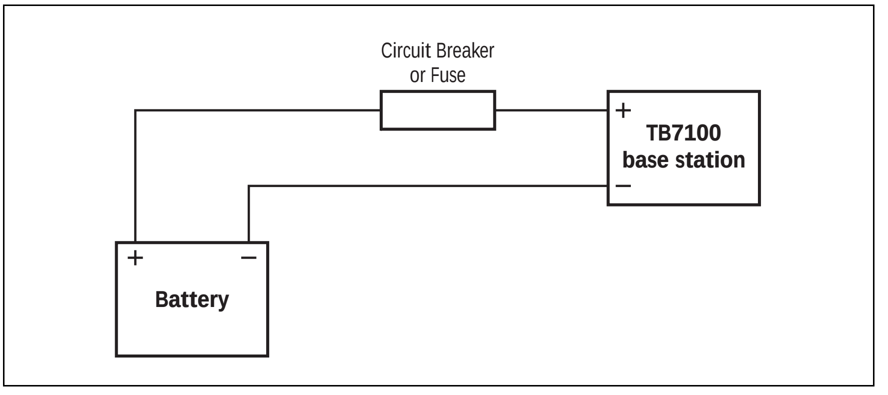
You must connect the DC supply from the battery to the Multitone paging transmitter via a readily accessible disconnect device such as a fuse or DC-rated circuit breaker with the appropriate rating, as shown in the table below. The DC input leads should be of a suitable gauge to ensure less than 0.2V drop at maximum load over the required length of lead.

Nominal Supply Voltage	Input Voltage Range	Circuit Breaker/Fuse Rating	Recommended Wire Gauge[a]
13.8VDC	10VDC to 16VDC	15A	8AWG / 8.35mm^2

a. For a length of 1.5m to 2m (5ft to 6.5ft) (typical).

Terminate the DC input leads with a suitable crimp connector for attaching to the J105 M4 screws.

Figure 5.3 Recommended DC power connection



Ground Point

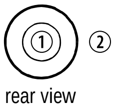
The ground point is a terminal for grounding the tray to the mounting rack.

RF Connections (Tx/ANT)

The RF output is via the Tx/ANT connector (N-type) on the rear panel of the Multitone paging transmitter.

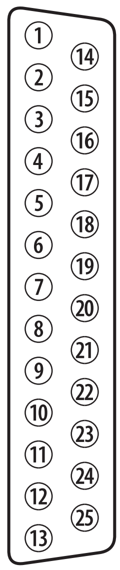
The RF connector is an N-type connector with an impedance of 50Ω.

Important The maximum RF input level is +27dBm. Higher levels may damage the radio.

	Pin	Signal Name	Signal Type	Notes
 rear view	1	RF	RF analog	
	2	GND	RF ground	

System Connector (SYSTEM)

The system connector (J106) at the rear of the base station is a 25-way standard-density D-range socket.

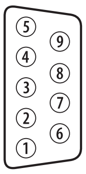


external view

Pin	Signal Name	Signal Type	Notes
1	Unused		
2	Tx digital input 1 (AUX_GPI1)	input	high ≥1.7 V, low ≤0.7 V BCD Pin 0
3	Tx digital input 2 (AUX_GPI2)	input	high ≥1.7 V, low ≤0.7 V BCD Pin 1
4	Unused		
5	Tx line input +	audio input	transformer isolated line
6	Tx digital input 3 (AUX_GPI3)	input	high ≥1.7 V, low ≤0.7 V BCD Pin 2
7	Tx digital output (AUX_GPIO4)	output	output: high ≥3.1 V (no load), low <0.6 V (10mA sink) input: high ≥1.7 V, low ≤0.7 V HI_VSWR alarm
8	Tx line input –	audio input	transformer isolated line
9	Unused		
10	Tx digital output (TX_AUX_GPIO5)	output	output: high ≥3.1 V (no load), low <0.6 V (10mA sink) input: high ≥1.7 V, low ≤0.7 V OUT_OF_LOCK alarm
11	Tx audio input	audio input	
12	Tx digital output (TX_AUX_GPIO6)	input/output	output: high ≥3.1 V (no load), low <0.6 V (10mA sink) input: high ≥1.7 V, low ≤0.7 V HI_TEMP alarm
13	ground	ground	
14	Unused		
15	Tx key	input	active low
16	Unused		
17	Unused		
18	Unused		
19	Unused		
20	Tx Opto input +	input	input voltage range 10VDC to 60VDC
21	Tx Opto input –	input	
22	Unused		
23	Digital output/Tx relay	output	active low, sinks up to 250mA
24	Unused		
25	13.8 volt output	power output	resetable SMD fuse 1.5A

FSK encoder Connector

The FSK encoder connector labelled FSK ENCODER is a 9-way male D-range connector, which provides a paging interface to the base station.



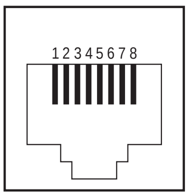
external view

Pin	Signal Name	Signal Type	Notes
1	PTT	input	PTT Input from FSK
2	RX_GATE	not used	RX gate from RX (if RX fitted)
3	AUD_IN	input	Audio in from FSK
4	GND	ground	Ground
5	AUD_OUT	not used	Audio out from TB7100 (if RX is fitted)
6	COAX_RLY	not used	Coax relay drive input. 5V tolerant
7	HI_VSWR	output	High VSWR Alarm
8	OOL	output	Out Of Lock Alarm
9	HI_TEMP	output	High Temp Alarm

Programming/ Microphone Connector (PROG/ MIC)

The PC running the programming and calibration application is connected to the base station via the programming/microphone connector (SK3) of the UI board. The programming/microphone connector is an 8-way RJ45 socket.

Use the TPA-SV-006 or the T2000-A19 programming lead and a TMAA20-04 adapter to connect the PC to the base station. It is possible to plug the RJ11 directly into the RJ45 socket without the use of the adapter, but this is not recommended. A microphone can also be connected to the base station via this connector.



external view

Pin	Signal Name	Signal Type	Notes
1	not connected		not connected
2	+13V8_SW	output	+13.8V, 250mA
3	TXD	input	transmit data
4	PTT	input	PTT
5	MIC_AUD_IN	input	voice band (microphone) input
6	GND	ground	
7	RXD	output	receive data
8	not connected		not connected

5.2 Internal Connectors

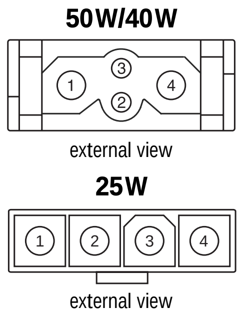
5.2.1 Transmitter Connectors

RF Connectors

The RF connectors of the transmitter are N-type connectors with an impedance of 50Ω.

DC Power Connectors

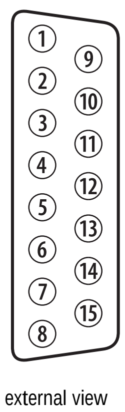
The DC power connectors of the transmitter are the interface for the primary 13.8V power source. There are different DC power connectors for the 50W/40W and 25W versions.



Pin	Signal name	Signal type	Notes
1	AGND	ground	
2	SPK–	analog output	not connected
3	SPK+	analog output	not connected
4	13.8VDC	DC power input	

Auxiliary Connectors

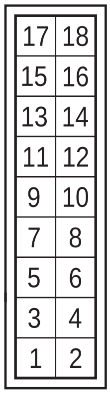
The auxiliary connector of the transmitter is a 15-way standard-density D-range socket. This is used to connect to the paging interface.



Pin	Signal Name	Signal Type	Notes
1	AUX GPIO7		
2	AUX GPIO5		
3	AUX RXD	input	
4	AUX GPI3		
5	AUX GPI2		
6	RSSI	output	
7	AUX TAP IN	input	
8	13.8VDC SW	output	
9	AUX GPIO6		
10	AUX GPIO4		
11	AUX TXD	output	
12	AUX GPI1		
13	AUD TAP OUT	output	
14	AUX MIC AUD	input	
15	AGND	ground	

User Interface Connector

The user interface connectors (SK100) of the transmitter is a 15-way moulded plastic connector.



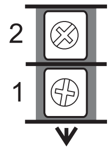
external view
pin 1 closest to PCB

Pin	Signal Name	Signal Type		Notes
		Transmitter	Receiver	
1	RX AUD	no connection	no connection	no connection
2	13.8VDC	no connection	output	+13V8DC for UI board
3	CH TXD	input	input	programming data
4	CH PTT	input	no connection	microphone PTT
5	CH MIC AUD	input	output	audio from microphone
6	AGND	ground	ground	analog ground
7	CH RXD	output	output	programming data
8	DGND	ground	ground	digital ground
9	CH ON OFF	output	output	digital ground
10	VOL WIP DC	input	input	
11	CH SPI D0	output	output	
12	CH LE	output	output	
13	CH GPIO1	output	output	digital ground
14	3.3VDC	no connection	output	+3V3DC for UI board
15	CH SPI D1	input	input	
16	CH SPI CLK	output	output	
17	SPK-	no connection	output	
18	SPK+	no connection	output	

5.2.2 SI Board Connectors

DC Power Connectors

The two DC power connectors (J102 and J103) on the SI board are heavy-duty M4 screw terminals. J102 (if fitted) accepts power from the internal AC power supply unit. J103 distributes the DC power to the transmitter and the receiver.

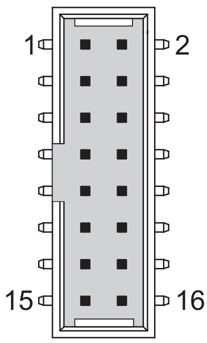


external view

Pin	Signal Name	Signal Type	Notes
1	Tx and Rx 13.8VDC	J102 :input J103: output	
2	Tx and Rx ground	J102 :input J103: output	

System Interface Connector to Paging Interface

The system interface connector (J101) to the paging interface is a 16-way surface-mounted connector.



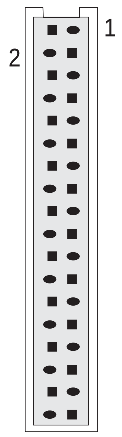
external view

Pin	Signal Name	Signal Type	Notes
1	TX_AUX_GPIO7	output	Tx key signal
2	TX_AUX_GPIO6	bidirectional	digital input/output
3	TX_AUX_GPIO5	bidirectional	digital input/output
4	TX_AUX_GPIO4	bidirectional	digital input/output
5	TX_AUX_RXD	input	data
6	TX_AUX_TXD	output	data
7	TX_AUX_GPI3	input	digital input
8	TX_AUX_GPI1	input	digital input
9	TX_AUX_GPI2	input	digital input
10	TX_AUD_TAP_OUT	no connection	
11	TX_RSSI	no connection	
12	TX_MIC_AUD	output	
13	TX_AUD_TAP_IN	output	Tx audio
14	TX_GND	ground	ground
15	TX_13V8	no connection	
16	N/C	no connection	

5.2.3 UI Board Connectors

User Interface Connector to Transmitter

The user interface connector (SK1) to the transmitter is a 18-way MicroMaTch connector.

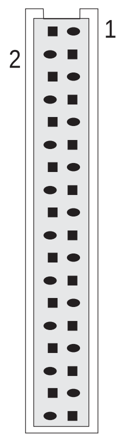


external view

Pin	Signal Name	Signal Type	Notes
1	TX_RX_AUD	no connection	no connection
2	TX_+13V8_SW	no connection	no connection
3	TX_CH_TXD	output	programming data
4	TX_CH_PTT	output	microphone PTT
5	TX_MIC_AUD_OUT	output	audio from microphone
6	TX_AGND	ground	analogue ground
7	TX_CH_RXD	input	programming data
8	TX_DGND	ground	digital ground
9	TX_CH_ON_OFF	input	digital ground
10	TX_VOL_WIP_DC	output	no connection
11	TX_CH_SPI_D0	input	
12	TX_CH_LE	input	
13	TX_CH_SPIO1	input	digital ground
14	TX_+3V3	no connection	no connection
15	TX_CH_SPI_DI	output	
16	TX_CH_SPI_CLK	input	
17	TX_CH_SPK-	no connection	no connection
18	TX_CH_SPK+	no connection	no connection

User Interface Connector to Paging Interface

The user interface connector (SK2) to the Paging Interface is a 18-way MicroMaTch connector.



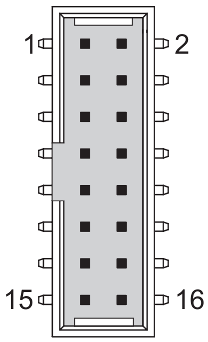
external view

Pin	Signal Name	Signal Type	Notes
1	RX_RX_AUD	no connection	no connection
2	RX_+13V8_SW	input	+13V8DC for PCB
3	RX_CH_TXD	output	programming data
4	RX_CH_PTT	no connection	no connection
5	RX_MIC_AUD_OUT	input	no connection
6	RX_AGND	ground	analogue ground
7	RX_CH_RXD	input	programming data
8	RX_DGND	ground	digital ground
9	RX_CH_ON_OFF	input	digital ground
10	RX_VOL_WIP_DC	output	
11	RX_CH_SPI_D0	input	
12	RX_CH_LE	input	
13	RX_CH_GPIO1	input	digital ground
14	RX_+3V3	input	+3V3DC for PCB
15	RX_CH_SPI_DI	output	
16	RX_CH_SPI_CLK	input	
17	RX_CH_SPK-	input	
18	RX_CH_SPK+	input	

5.2.4 Paging Interface Connectors

Paging Interface Connector to Transmitter

The system interface connector (PL100A) to the transmitter is a 16-way surface-mounted connector.

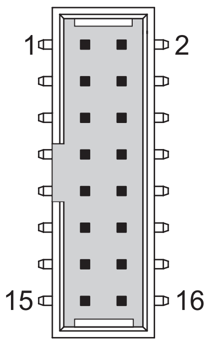


external view

Pin	Signal Name	Signal Type	Notes
1	TX_AUX_GPIO7	output	Tx key signal
2	TX_AUX_GPIO6	bidirectional	digital input/output
3	TX_AUX_GPIO5	bidirectional	digital input/output
4	TX_AUX_GPIO4	bidirectional	digital input/output
5	TX_AUX_RXD	input	data
6	TX_AUX_TXD	output	data
7	TX_AUX_GPI3	input	digital input
8	TX_AUX_GPI1	input	digital input
9	TX_AUX_GPI2	input	digital input
10	TX_AUD_TAP_OUT	no connection	
11	TX_RSSI	no connection	
12	TX_MIC_AUD	output	
13	TX_AUD_TAP_IN	output	Tx audio
14	TX_GND	ground	ground
15	TX_13V8	no connection	
16	N/C	no connection	

Paging Interface Connector to Receiver (not used)

The paging interface connector (PL100) to the receiver is a 16-way surface-mounted connector. Currently unused.

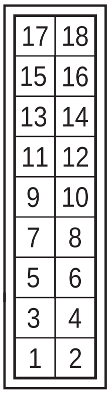


external view

Pin	Signal Name	Signal Type	Notes
1	RX_AUX_GPIO7	input	gate signal
2	RX_AUX_GPIO6	bidirectional	digital input/output
3	RX_AUX_GPIO5	bidirectional	digital input/output
4	RX_AUX_GPIO4	bidirectional	digital input/output
5	RX_AUX_RXD	input	data
6	RX_AUX_TXD	output	data
7	RX_AUX_GPI3	input	digital input
8	RX_AUX_GPI1	input	digital input
9	RX_AUX_GPI2	input	digital input
10	RX_AUD_TAP_OUT	input	receive audio
11	RX_RSSI	input	RSSI
12	RX_MIC_AUD	no connection	
13	RX_AUD_TAP_IN	no connection	
14	RX_GND	ground	ground
15	RX_13V8	no connection	
16	N/C	no connection	

Paging Interface to User Interface Connector

The paging interface to user interface connector (PL2) is a 18-way moulded plastic connector.

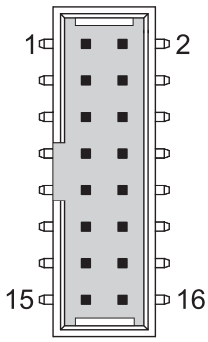


external view
pin 1 closest to PCB

Pin	Signal Name	Signal Type		Notes
		Transmitter	Receiver	
1	RX AUD	no connection	no connection	no connection
2	13.8VDC	no connection	output	+13V8DC for UI board
3	CH TXD	input	input	programming data
4	CH PTT	input	no connection	microphone PTT
5	CH MIC AUD	input	output	audio from microphone
6	AGND	ground	ground	analog ground
7	CH RXD	output	output	programming data
8	DGND	ground	ground	digital ground
9	CH ON OFF	output	output	digital ground
10	VOL WIP DC	input	input	
11	CH SPI D0	output	output	
12	CH LE	output	output	
13	CH GPIO1	output	output	digital ground
14	3.3VDC	no connection	output	+3V3DC for UI board
15	CH SPI D1	input	input	
16	CH SPI CLK	output	output	
17	SPK-	no connection	output	
18	SPK+	no connection	output	

Paging Interface Connector to System Interface (Tx J101)

The paging interface connector (PL101A) to the system interface for the transmitter is a 16-way surface-mounted connector.

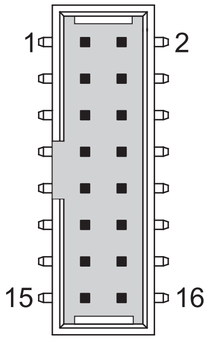


external view

Pin	Signal Name	Signal Type	Notes
1	TX_AUX_GPIO7	output	Tx key signal
2	TX_AUX_GPIO6	bidirectional	digital input/output
3	TX_AUX_GPIO5	bidirectional	digital input/output
4	TX_AUX_GPIO4	bidirectional	digital input/output
5	TX_AUX_RXD	input	data
6	TX_AUX_TXD	output	data
7	TX_AUX_GPI3	input	digital input
8	TX_AUX_GPI1	input	digital input
9	TX_AUX_GPI2	input	digital input
10	TX_AUD_TAP_OUT	no connection	
11	TX_RSSI	no connection	
12	TX_MIC_AUD	output	
13	TX_AUD_TAP_IN	output	Tx audio
14	TX_GND	ground	ground
15	TX_13V8	no connection	
16	N/C	no connection	

Paging Interface Connector to System Interface (Rx J100 not used)

The paging interface connector (PL101) to the system interface for the receiver is a 16-way surface-mounted connector. This connector is currently unused.

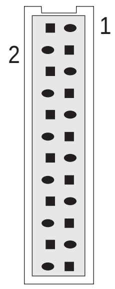


external view

Pin	Signal Name	Signal Type	Notes
1	RX_AUX_GPIO7	input	gate signal
2	RX_AUX_GPIO6	bidirectional	digital input/output
3	RX_AUX_GPIO5	bidirectional	digital input/output
4	RX_AUX_GPIO4	bidirectional	digital input/output
5	RX_AUX_RXD	input	data
6	RX_AUX_TXD	output	data
7	RX_AUX_GPI3	input	digital input
8	RX_AUX_GPI1	input	digital input
9	RX_AUX_GPI2	input	digital input
10	RX_AUD_TAP_OUT	input	receive audio
11	RX_RSSI	input	RSSI
12	RX_MIC_AUD	no connection	
13	RX_AUD_TAP_IN	no connection	
14	RX_GND	ground	ground
15	RX_13V8	no connection	
16	N/C	no connection	

Paging Interface Connector to XA2235-02-PCB

The FSK encoder connector (SK101) to the XA2235-02-PCB EMC filter is a 12-way MicroMaTch connector.



external view

Pin	Signal Name	Signal Type	Notes
1	PTT	input	
2	RELAY_DRV	not used	
3	RX_GATE	not used	
4	HI_VSWR	output	
5	AUD_IN	output	
6	OOL	output	
7	GND	ground	
8	HI_TEMP	output	
9	AUD_OUT	input	
10	N/C	Not used	
11	GND	ground	
12	GND	ground	

Multitone paging transmitter

Chapter 2 Servicing

Chapter 2 – Servicing

6 General Information

This section describes techniques and processes, and provides other information that will enable you to service the Multitone paging transmitter correctly. It includes the following sections:

- Repair Levels, Accreditation, and Website Access
- Tools, Equipment and Spares
- Servicing Precautions
- Setting up the Test Equipment
- Replacing Board Components
- Shielding Cans and Connectors
- SMT Repair Techniques
- Computer-Controlled Test Mode (CCTM)
- Defining Frequency Bands
- Visual Indicators

6.1 Repair Levels, Accreditation, and Website Access

6.1.1 Repair Levels

This manual covers level-1 and level-2 repairs of the Multitone paging transmitter.

Important The circuit boards in the Multitone paging transmitter are complex. They should be serviced only by an Accredited Service Centre (ASC). See “Accreditation of Service Centres” on page 74. If you attempt a repair without the necessary equipment, tools, or training, you could permanently damage the Multitone paging transmitter.

Level 1 Requirements

Level-1 repairs comprise the **replacement** of:

- transmitter module
- SI board
- UI board
- fans
- fan power board
- temperature sensor board
- EMC filter board XA2235-02-PCB
- Paging interface board XA2731-01-PBA

For level-1 repairs, basic electronic repair skills are sufficient.

You require:

- standard service centre tools and equipment
- special drivers and bits, see "Tools, Equipment and Spares" on page 99
- a TBA0STU Calibration & Test Unit

Level-2 Requirements

Level-2 repairs comprise the **repair** of:

- transmitter module

except for special items. The special items are:

- digital board
- RF PAs (Q309 and Q310)
- CODEC 1 (IC204)
- copper plate

Level-2 repairs also comprise the **replacement** of the connectors on the transmitter module, and the external connectors of the UI and SI boards.

For level-2 repairs, you require expertise in SMT repairs of circuit boards with a very high complexity and extreme component density.

You require the tools and equipment required for level-1 repairs, as well as standard SMT repair tools. A can-removal tool is strongly recommended but not mandatory.

6.1.2 Accreditation of Service Centres

Note All existing Accredited Service Centres must apply for an endorsement to work on Multitone paging transmitters. When the endorsement is granted, they will be permitted to carry out level 1 and level 2 repairs on the Multitone paging transmitters, whether the Multitone paging transmitter is under warranty or not.

If your service centre would like to apply for Accredited Service Centre (ASC) status, please contact Tait Technical Support at the address in the front of this manual. You will need to provide evidence that your centre meets the criteria for accreditation. Any centre applying for accreditation must also:

- make suitable staff available for training by Tait personnel
- allow the service facilities to be assessed
- provide adequate documentation of processes

Once staff are trained and facilities are confirmed as suitable, the centre is granted ASC status and endorsed for repairs. See also "Website Access" below.

6.1.3 Website Access

No password is required for the unsecured area of the website, which is accessible to the general public. To carry out level 1 or level 2 repairs, however, you need to log on to the secured area of the Tait Technical Support website, www.taitworld.com/technical. Technical Support supplies the necessary log-in information. The Single Sign-On feature automatically signs you on with your authorised level of access:

- level-1 repairs: “associate” access
- level-2 repairs: “ASC and Tait-only” access

Log-in passwords are needed for associate, ASC and Tait-only access; Technical Support supplies service centres with the necessary log-in information. (The unsecured portion of the Technical Support website is accessible to the general public. This type of access is called public access, and no log-in password is required.)

The website includes:

- Application Notes
- Calibration Software
- Firmware
- Fitting Instructions
- Installation Guides
- PCB Information
- Programming Software
- Programming User Manuals
- Service Manuals
- Technical Notes
- User’s Guides

Product Issue Tracking

Customers and service centres use the Tait Technical Support website to raise and track technical issues. The **Product Issue Tracking** link accesses to the Tait FOCUS call-logging database. Technical Support resolves any issue raised and informs the customer or service centre of the outcome. All issues and solutions can be seen by all service centres.

PCB Information

Except for the Paging Interface a PCB Information document provides the PCB layout, BOMs, and circuit diagrams for a specified issue of a board. For every issue of a board, there is a different **PCP Information document**. See “Check the issue number” on page 108. Always download the correct PCB Information document from the Tait Technical Support website. If you cannot find the required document, please contact your nearest CSO.

Tip It is good practice to print and store a copy of all relevant PCB Information.

6.2 Environmental Conditions

6.2.1 Operating Temperature Range

The operating temperature range is –30°C to +60°C (–22°F to +140°F) ambient temperature for the 25W Multitone paging transmitter and –30°C to +50°C (–22°F to +122°F) ambient temperature for the 50W and 40W Multitone paging transmitters. Ambient temperature is defined as the temperature of the air at the intake to the cooling fans.

6.2.2 Humidity

The humidity should not exceed 95% relative humidity through the specified operating temperature range.

6.2.3 Dust and Dirt

For uncontrolled environments, the level of airborne particulates must not exceed 100 $\mu g/m^3$.

6.3 Grounding and Lightning Protection

6.3.1 Electrical Ground

A threaded grounding connector is provided on the rear of the tray for connection to the site ground point (for more details refer to "Connections" on page 57).

6.3.2 Lightning Ground

It is extremely important for the security of the site and its equipment that you take adequate precautions against lightning strike. Because it is outside the scope of this manual to provide comprehensive information on this subject, we recommend that you conform to your country's standards organisation or regulatory body.

6.4 Ventilation

Always ensure there is adequate ventilation around the Multitone paging transmitter. **Do not** operate at high duty cycles in a sealed cabinet. You **must** keep the ambient temperature within the specified range, and we **strongly** recommend you ensure that the cooling airflow is not restricted.

Important The cooling fans are mounted behind the front panel. To ensure adequate airflow through the Multitone paging transmitter, do not operate it for more than a few minutes with the fans disconnected (e.g. for servicing purposes).

Cabinet and Rack Ventilation

Refer to Figure 6.1 on page 78.

Adequate cooling airflow is critical to the performance of the Multitone paging transmitter. The cooling airflow for the Multitone paging transmitter enters through the front panel and exits at the rear of the tray. For optimum thermal performance, the heated air that has passed through a Multitone paging transmitter must not be allowed to re-enter the air intakes on the front panel.

Each Multitone paging transmitter requires an unobstructed airflow of 18 m^3/h (11 cfm).

To allow enough cooling airflow through a cabinet mounted Multitone paging transmitter we recommend the following:

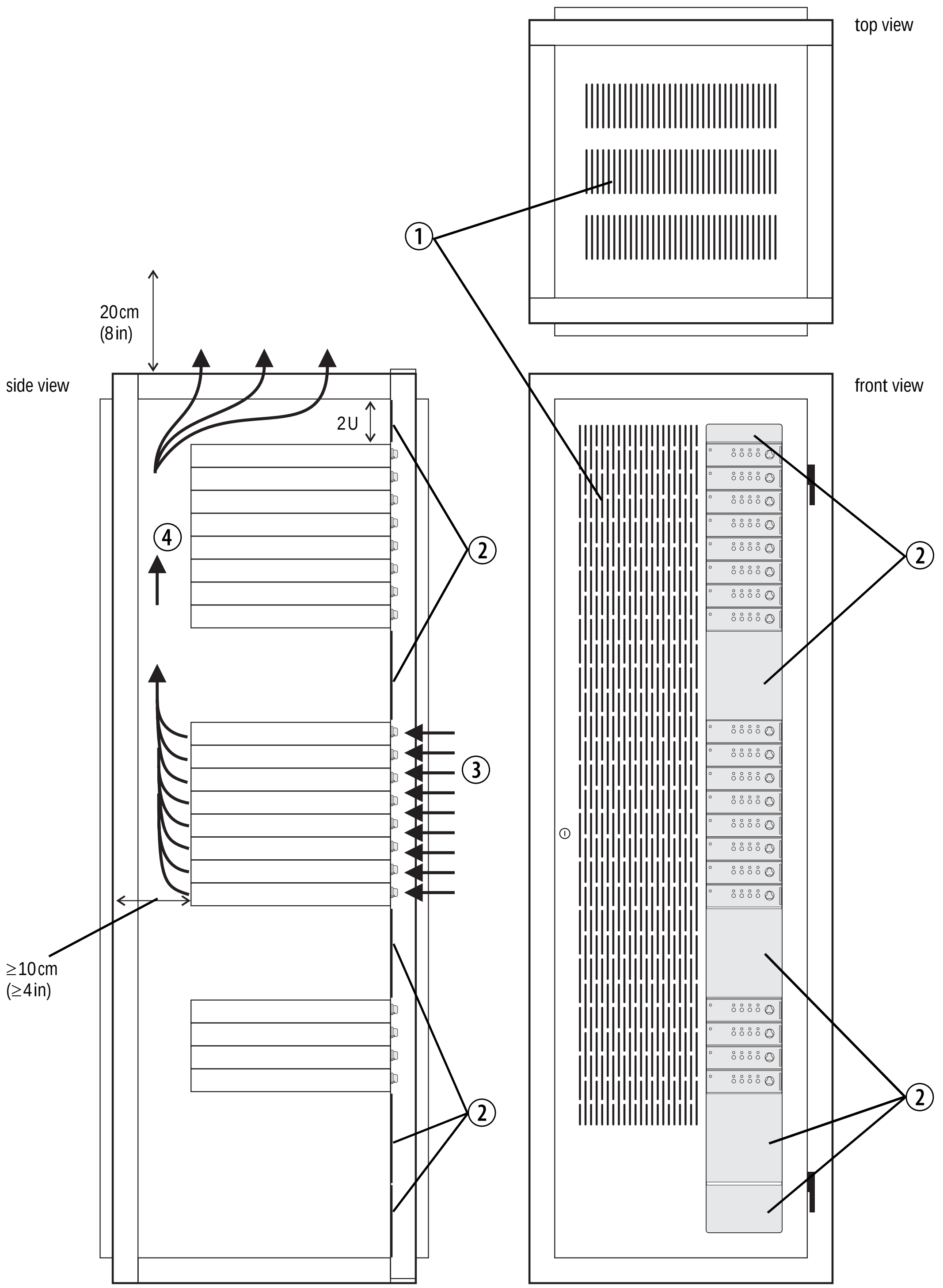
- a distance of 5 cm minimum clearance to any obstruction to the front of the tray.
- an open area of at least 50 cm^2 (8 sq. in.) per tray of ventilation slots or louvres in front of the air intakes for the fans for each tray; for example ten 6×85 mm (0.25×3.3 in.) slots will allow the recommended airflow.
- a distance of 10cm minimum clearance to any obstruction to the rear of the tray.
- an open area of at least 50 cm^2 (8 sq. in.) per tray of ventilation slots or louvres in the top of the cabinet, or to the rear of each tray.
- a 2U gap at the top of the cabinet.

Note The ventilation opening must be unrestricted. If the slots or holes are covered with a filter, mesh or grille, the open area must be increased to allow the same airflow as an unrestricted opening.

The maximum ambient temperature entering the cabinet must not exceed the maximum temperature specified for the Multitone paging transmitter.

If the Multitone paging transmitter is installed in a rack or cabinet with other equipment with different ventilation requirements, we recommend that the Multitone paging transmitter be positioned below this equipment.

Figure 6.1 Typical cabinet ventilation requirements



1 ventilation slots

2 blanking panels

3 airflow entry

4 airflow exit

Auxiliary Extractor Fans

If multiple Multitone paging transmitters are fitted in a cabinet, auxiliary extractor fans may be required to ensure adequate cooling. If fitted they should be capable of extracting 18 m^3/h (11 cfm) per Multitone paging transmitter in the cabinet.

If you have any other configuration, the performance of your system will depend on how closely you comply with the Multitone paging transmitter airflow requirements described above.

6.5 Installing the Multitone paging transmitter

6.5.1 Unpacking the Equipment

Unpacking the Base Station

The Multitone paging transmitter is packed in a strong corrugated cardboard carton with top and bottom foam cushions.

1. Cut the tape securing the flaps at the top of the carton and fold them flat against the sides.
2. Rotate the carton carefully onto its side and then onto its top, ensuring that none of the flaps is trapped underneath.
3. Slide the carton upwards over the foam cushions and lift it away. Remove the cushion from the bottom of the Multitone paging transmitter.
4. Lift the Multitone paging transmitter clear of the remaining cushion.

Disposal of Packaging

If you do not need to keep the packaging, we recommend that you recycle it according to your local recycling methods. The foam cushions are CFC- and HCFC-free and may be burnt in a suitable waste-to-energy combustion facility, or compacted in landfill.

6.5.2 Power Supply Options

All Multitone paging transmitters have an external DC input power connector which is used as main power supply.

An external Tait T809-10-87xx power supply can be used to supply the DC voltage required.

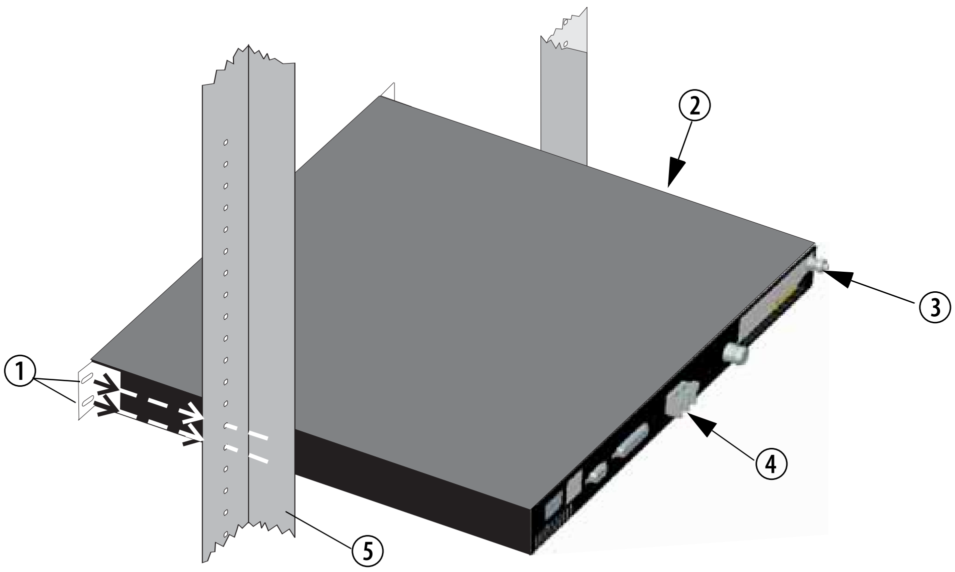
6.5.3 Mounting the Multitone paging transmitter

1. Fit the Multitone paging transmitter into the cabinet or rack and secure it firmly with an M6 (or 0.25 in if you are using imperial fittings) screw, flat and spring washer in each of the four main mounting holes ①, as shown in Figure 6.2 on page 80.

2. The Multitone paging transmitter can be wall-mounted by rotating the front mounting brackets and fitting the optional rear brackets (TBBA03-01). When the Multitone paging transmitter is wall-mounted ensure the airflow is from bottom to top (front panel mounted down) or side to side.

3. For transport or in installations subject to vibration, the Multitone paging transmitter should be supported at the rear using a transit bracket (Tait recommends to use the TB7100 transit bracket, Tait part number TBBA03-04).

Figure 6.2 Multitone paging transmitter mounting points



①	main mounting holes	④	DC power connector
②	Multitone paging transmitter	⑤	rack frame
③	ground point		

6.5.4 Cabling

We recommend that you route all cables to and from the Multitone paging transmitter along the side of the cabinet so the cooling airflow is not restricted.

Cables should be well supported so that the connectors or terminals on the Multitone paging transmitter and on the ends of the cables do not have to support the full weight of the cables.

Cables must be routed so that they do not restrict the air outlets at the rear of the Multitone paging transmitter.

6.5.5 Accessories

The Multitone paging transmitter can use the following accessories:

- T809-10-87xx power supply
- TBBA03-01 wall mounting kit
- TBBA03-04 TB7100 transit bracket kit
- TMAA02-01 fist microphone

6.6 Preparation for operation

The Multitone paging transmitter operation can be modified by the use of links (see Table 6.1) and programmable settings.

Table 6.1 System Interface links

Link[a]	Function	Setting
J206	Fan Control	1-2 J207 Controlled 2-3 Always On
J207	Fan Control	1-2 Tx Key Controlled 2-3 Temperature Controlled
J221	RS-232 Loop Back	1-2 RS-232 via serial port 2-3 Loop Back
J222	Fan activation temperature	Test point
J223	Heat sink temperature	Test point
RV200	Fan Activation Temperature	Adjustment
W300	Tx / Rx GPIO 5 Link	Not used
W301	Tx / Rx GPIO 6 Link	Not used

Table 6.1 System Interface links (Continued)

Link[a]	Function	Setting
W302	Tx Key to GPIO6 Link	When fitted Tx Key is connected to Tx Digital in/out 2. Used for applications where the Tx Key signal must also trigger an additional action.
J400	Tx Key Source	1-2 External 2-3 Rx Gate
J401	Rx Relay polarity control	1-2 Active High 2-3 Active Low
W401 W402	Tone on Idle Enable	Fit both links to enable TOI Remove both links to disable
RV400	Tone on Idle Frequency	Frequency Adjust
RV401	Tone on Idle Level	Level Adjust
J500	Line out frequency response	1-2 Flat 2-3 De-Emphasis
J501	Line in frequency response	1-2 Flat 2-3 Pre-Emphasis
J502	Tx Audio Source	1-2 Line / Unbalanced in 2-3 Rx Audio (repeater)
J503	Rx Audio Destination	1-2 Tx Audio (repeater) 2-3 Line / Unbalanced out
J507	Tx Line In Destination	1-2 Tx Mic Audio 2-3 Tx Audio Tap In
RV500	Balanced Line In	Sensitivity Adjust
RV501	Unbalanced Line In	Sensitivity Adjust
RV502	Unbalanced Line Out	Level Adjust
RV503	Balanced Line Out	Level Adjust

a. The positions of these links on the PCB are illustrated later in this section. They are also illustrated in TN-1264-AN.

6.7 Programmable Features

The programmable features are applied to the transmitter module by using the TB7100 programming application.

6.7.1 Connecting to the PC

1. Plug the TPA-SV-006 or T2000-A19 programming lead into the RS-232 serial port on a PC.

Note A USB-to-RS-232 adaptor can be used if the PC does not have a built in serial port.

2. Connect the TMAA20-04 adaptor cable (RJ12 socket to RJ45 plug) to the RJ12 plug on the TPA-SV-006 or T2000-A19 programming lead.

3. Plug the RJ45 plug on the TMAA20-04 adaptor cable into the PROG/MIC connector located on the front panel of the Multitone paging transmitter.

Select whether the TB7100 programming application communicates with the transmitter module by using the transmitter programming switch located on the user interface next to the PROG/MIC connector.

6.7.2 TB7100 Programming Application

The TB7100 programming application allows the configuration parameters of the transmitter to be read out of a module, edited and written back into the module. It is also possible the save the data files, so if a module ever needs to be replaced, the previously saved data file can be programmed into the new module. The model toolbar, indicates whether the data file is for a transmitter module.

Appearance

The TB7100 programming application has been optimised for mouse navigation. Most features can be easily enabled and configured using a check box or drop down list and the frequencies for each channel are simply typed into a table.

Feature	Function
Menus	Located along the top of the screen, these allow the user to perform functions such as opening or saving data files, and reading or programming the modules.
Toolbar	Located just below the menu bar, the toolbar allows easy access to the most commonly used menu items.
Radio Model Toolbar	Located just below the toolbar, this indicates whether a newly loaded file type is for a transmitter module. It also allows the required module type to be selected when a new data file is being created.
Forms Tree	Located on the left side of the screen, the Forms Tree lists all the forms that are available for editing.
Forms	Displayed beside the Forms Tree is the Active Form. The TB7100 programming application is made up of several Forms (a page of parameters). All the configuration parameters related to a particular feature are grouped together in one form. Each form is intuitively labelled and easily accessible from a Forms Tree

New Data Files

The reset to defaults feature in the TB7100 programming application makes it easy to create a new data file. The transmitter module type is selected by pressing the appropriate button on the radio model toolbar. The reset to defaults feature under the file menu is used to reset all the settings to their default states. This ensures all the mandatory and recommended settings are correct before starting to create a new data file. The customer-specific settings for the current application are entered. Reset to defaults only affects the currently active radio model, so the correct radio model must be selected first. If “reset to defaults” is greyed out, then the settings are already in their default states.

Existing Data Files

An existing data file can be read out of a transmitter module or loaded from file. The radio model toolbar in the TB7100 programming application will automatically update when a data file is loaded or read out of a module to indicate the file is for the transmitter module. The file can then be edited and saved or programmed back into the module.

6.7.3 Mandatory Settings

The mandatory settings must not be changed from their default states or the Multitone paging transmitter will not operate correctly. The reset to defaults feature in the TB7100 programming application will ensure all mandatory settings are correct for the selected module type. The mandatory settings are not locked out. It is possible to change a mandatory setting from its required state.

Transmitter Mandatory Settings

The mandatory settings for the transmitter are shown below, if these change the transmitter will no longer operate.

Form	Tab	Item Name	Setting
Data	General	Output SDMs Automatically	Disabled
Data	Serial Communications	Data_Port	AUX
Data	Serial Communications	XON_Character	11
Data	Serial Communications	XOFF_Character	13
Basic Settings	Sub Audible Signalling	Invert Rx DCS	Disabled
Channels	Detailed	RX_Frequency	000.000000
Channels	Detailed	RX Sig	none
Channels	Detailed	Squelch	hard
UI Preferences	Preferences	Confidence Tones	Disabled
UI Preferences	Audible Indicators	High Temperature Warning	Enabled
UI Preferences	Audible Indicators	Very High Temperature Warning	Enabled
UI Preferences	Audible Indicators	Out Of Lock	Enabled
UI Preferences	Audible Indicators	High Reverse Power Warning Tone	Enabled
Startup	Startup	Power On Mode	Power on
Startup	Startup	Reset On Error	Enabled
PTT	MIC PTT	PTT Priority	highest
PTT	MIC PTT	Audio Source	CH Mic
PTT	External PTT 1	PTT Priority	medium
PTT	External PTT 1	Audio Source	Audio Tap In

6.7.4 User-defined Settings

The user-defined settings are specific to the customers application. These are the only settings that need to be changed when configuring a Multitone paging transmitter for operation. To set up a basic voice repeater or Multitone paging transmitter only the channel information needs to be entered:

- frequency
- power level
- bandwidth
- squelch threshold

If the system is to be used for data then the data parameters also need to be set correctly:

- baud rate
- flow control
- error correction.

Transmitter User-defined Settings

The user-defined settings for the transmitter are shown below.

Form	Tab	Item Name	Value Range	Recommended
Data	General	Transparent Mode Enabled	Enabled / Disabled	Enabled
Data	General	THSD_Modem_ Enabled	Enabled / Disabled	Enabled
Data	Serial Communications	FFSK_Transparent_ Mode_Baudrate	1200, 2400, 4800, 9600, 14400, 19200, 28800	19200
Data	Serial Communications	THSD_Transparent_ Mode_Baudrate	1200, 2400, 4800, 9600, 14400, 19200, 28800	19200
Data	Serial Communications	Data Port	Mic, Aux, Internal Options	Aux
Basic Settings	Basic Network Settings	TX Timer Duration	0…250	0
Basic Settings	Basic Network Settings	TX Lockout Duration	0…250	0
Basic Settings	Sub Audible Signalling	CTCSS Lead-Out Delay	0…1000	0
Basic Settings	Sub Audible Signalling	Invert Tx DCS	Enabled, Disabled	Disabled
Basic Settings	Sub Audible Signalling	DCS Lead-Out Delay	0…1000	0
Channels	Detailed	TX_Frequency	000.000000… 999.999999	Required transmit channel frequency
Channels	Detailed	TX Sig	CTCSS tone OR DCS tone	none
Channels	Detailed	Power	off, very low, low, medium, high	high
Channels	Detailed	Network	1…4	1
Channels	Detailed	Bandwidth	12.5, 20, 25	25
Channels	Detailed	Use_Channel_For_ Data	Enabled, Disabled	Disabled
Key Settings	Key 1	Key Action	see Key Action type	Backlighting Toggle
Key Settings	Key 2	Key Action	see Key Action type	Keypress Tones Toggle
Key Settings	Key 3	Key Action	see Key Action type	Monitor
Key Settings	Key 4	Key Action	see Key Action type	Low Power Transmit
UI Preferences	User Interface	Backlight Mode	off, activity, continuous	off
UI Preferences	User Interface	Backlight Duration	0…15	5
PTT	MIC PTT	PTT Transmission Type	none, voice, data	Voice
PTT	External PTT 1	PTT Transmission Type	none, voice, data	Voice

Transmitter Digital IO

The user-defined settings for the transmitter digital IO are shown below. The cells in grey denote mandatory settings.

Pin	Direction	Label	Action	Active	Debounce	Signal State	Mirrored To
AUX_GPI1	Input	RT_DI_1	BCD Pin 0	Low	10	None	None
AUX_GPI2	Input	RT_DI_2	BCD Pin 1	Low	10	None	None
AUX_GPI3	Input	RT_DI_2	BCD Pin 2	Low	10	None	None
AUX_GPIO4	Output	HI_VSWR	Alarm Status	Low	None	None	None
AUX_GPIO5	Output	OOL	Alarm Status	Low	None	None	None
AUX_GPIO6	Output	HI_TEMP	Alarm Status	Low	None	None	None
AUX_GPIO7	Input	TXKEY	External PTT 1	High	2	None	None

Transmitter Audio

The user-defined settings for the transmitter audio IO are shown below. The cells in grey denote mandatory settings.

Rx/PTT Type	Tap In	Tap In Type	Tap In Unmute	Tap Out	Tap Out Type	Tap Out Unmute
Rx	None	A-Bypass In	On PTT	None	D-Split	On PTT
Mic PTT	None	A-Bypass In	On PTT	None	C-Bypass Out	On PTT
EPTT1	T12	A-Bypass In	On PTT	None	C-Bypass Out	On PTT
EPTT2	None	A-Bypass In	On PTT	None	C-Bypass Out	On PTT

6.7.5 Recommended Settings

Recommended settings provide system designers with an extra level of flexibility to meet a specific operational requirement. In general, recommended settings should not be changed from the recommended default value. However unlike mandatory settings, the user is permitted to make changes, providing they verify the correct operation of the enabled or modified feature.

No guarantee is given that a feature will work if the recommended settings disable the feature, or if a recommended value is changed.

Although the individual modules are capable of these features, they cannot be fully supported by the Multitone paging transmitter because of its two-module configuration. A few examples of features that are not fully supported by the Multitone paging transmitter are:

- selcall
- two tone
- emergency mode
- scanning
- encryption (voice inversion).

The reset to defaults feature in the TB7100 programming application will ensure all recommended settings are in their recommended default state.

6.7.6 Function Keys

The Multitone paging transmitter also has four user-defined function keys on the user interface, and programmable digital input and output lines on the system connector.

The tables below list the options that can be assigned to the function keys and the digital input and output lines. The grey cells can be programmed but are not recommended (see “Recommended Settings” on page 87).

Function Key Options	
None	Monitor / Squelch Override
Audible Indicators Volume	Network Preset Calls
Action Digital Output Line	Nuisance Delete
Backlighting Timer	Phone Patch Call Request / Release
Backlighting Toggle	Preset Channel
Backlighting Timer / Toggle	Public Address
Call Cleardown	Quiet Operation
Channel Preset Call	Repeater Access Tone Tx
Emergency Mode	Repeater Talkaround
Encryption	Reset Monitor
Group Scanning Activity	Reset Monitor / Call Cleardown
Ignore Two-Tone	Silent Operation
Keypress Tones Toggle	Single In-Band Tone
Keypress Tones Volume	Squelch Override
Low Power Transmit	Scanning / Nuisance Delete
Monitor	

Digital Input Line Actions	
No Action	Preset Channel
Toggle Stand-by Mode	Mute External Audio Input
Power Sense (Ignition)	Mute Audio Output Path
Enter Emergency Mode	Unmute Audio Output Path
Send Channel Preset Call	Send Mic Audio To Spkr
Send Network Preset Call 1	Force Audio PA On
External PTT 1 and 2	Force Audio PA Off
Inhibit PTT	Simulate F1 to F4 Key
Toggle Tx RF Inhibit	Toggle F1 to F4 Key LED
Decrement Channel	Toggle Alarm Mode
Increment Channel	Activate THSD Modem
Home Channel	RTS Control (DCE)
BCD Pin 0 to 4	

Digital Output Line Actions	
No Action	Signalling Audio Mute Status
Busy Status	SIBT Received
Radio Transmission Status	Monitor Status
Channel Lock Status	Hookswitch Status
Reflect PTT Status	Call Setup Status
External Alert 1 and 2	Control Status Rx (Line 1 to 3)
Public Address Status	Radio Stunned
Serial Data Tx In Progress	F1 to F4 Key Status
Reflect PTT Inhibit Status	FFSK Data Received Status
Reflect THSD Modem Status	CTS Control (DCE)

6.8 Additional Settings

The additional link settings control the following functions:

- subaudible signalling
  - CTCSS (continuous tone controlled squelch system)
  - DCS (digital coded squelch)
- soft off (Tx tail time)
- tone on idle
- fan operation
- channel ID
- relay polarity
- channel increment and decrement by function buttons
- CWID (carrier wave identification).

6.9 Soft Off (Tx Tail Time)

New Firmware (with or without subaudible signalling)

For systems with firmware version 2.10.00.07 (or later) and TB7100 programming application version 1.10.00.0001 (or later):

- Enter a delay time between 0 (default) and 5000ms in the PTT Deactivation Delay field of the PTT > Ext. PTT 1 tab.

Older Firmware (with subaudible signalling)

For systems with firmware versions before 2.10.00.07 and TB7100 programming application versions before 1.10.00.0001:

If subaudible signalling is used:

- Add a Tx tail time using the Networks > Basic Settings > Subaudible Signalling tab. A lead-out delay can be entered in the appropriate field.

Older Firmware (without subaudible signalling)

If subaudible signalling is not used, adding a lead-out delay will have no effect. If soft-off operation is still required, create a Tx tail time as follows:

1. Remove the cover as detailed in “Removing the Multitone paging transmitter” on page 122.
2. Link AUX_GPIO6 and AUX_GPIO7 of the transmitter with link W302 on the SI board, as per Table 6.2. Refer to Figure 6.3 on page 91 for link locations.

3. Fit the cover as detailed in “Final Reassembly” on page 131.

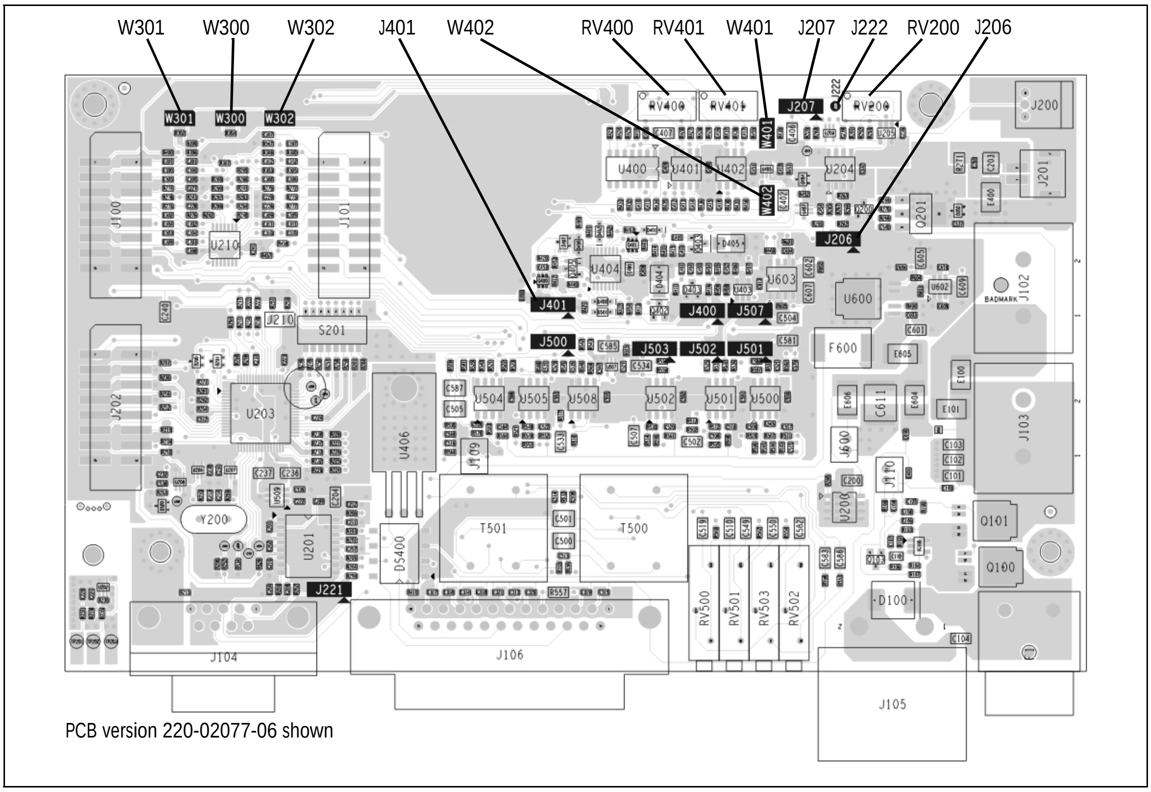
Table 6.2 Soft off - link settings

LINK	Name	Pins	Position	Function	Comments
W302	TX_Key to TX_GPIO6 link	2	Fitted Not fitted	When fitted this allows two external PTTs to control the transmitter; used for soft off mode	Default is: Not fitted

4. Add the following to the default Tx configuration:
   - AUX_GPIO6 > Direction = input
   - AUX_GPIO6 > Action = External PTT 2
   - AUX_GPIO6 > Active = High
   - AUX_GPIO6 > Debounce = 200 (or smaller if desired)
   - External PTT (2) > Transmission Type = Voice
   - External PTT (2) > Audio Source = Aux Mic or Ch Mic (whichever is not being used)

Note A maximum of 200ms tail time can be achieved using this method.

Figure 6.3 Link positions on the SI board



6.10 Tone On Idle (TOI)

The tone on idle provides a tone that can be used for indicating when the Multitone paging transmitter is not transmitting. The links to enable or disable the tone on idle are shown in the table below. Both links must be in for the TOI to work.

Link Settings

1. Remove the cover as detailed in “Removing the Multitone paging transmitter” on page 122.
2. Set the jumper positions on the SI board to match Table 6.3. Refer to Figure 6.3 on page 91 for link locations.
3. Fit the cover as detailed in “Final Reassembly” on page 131.

Table 6.3 Tone on idle (TOI)—link settings

LINK	Name	Pins	Position	Function	Comments
W401	TOI 9V Enable	2	Fitted Not fitted	Tone on Idle enable Tone on Idle disable	Default is: Not fitted
W402	TOI 4.5V Enable	2	Fitted Not fitted	Tone on Idle oscillator enable Tone on Idle oscillator disable	Default is: Not fitted

The potentiometers for the tone on idle adjustments shown in the table below can be found on the SI board. Refer to Figure 6.3 on page 91 for the potentiometer location.

Potentiometer	Function
RV400	Frequency adjust
RV401	level adjust

6.11 Fan Operation

The fans can be made to operate in three modes:

- continuous
- on when Multitone paging transmitter transmits
- on at a set temperature.

The fan operation can be set as shown in the table below.

Link Settings

1. Remove the cover as detailed in “Removing the Multitone paging transmitter” on page 122.
2. Set the jumper positions on the SI board to match Table 6.4. Refer to Figure 6.3 on page 91 for link locations.
3. Fit the cover as detailed in “Final Reassembly” on page 131.

Table 6.4 Fan operation—link settings

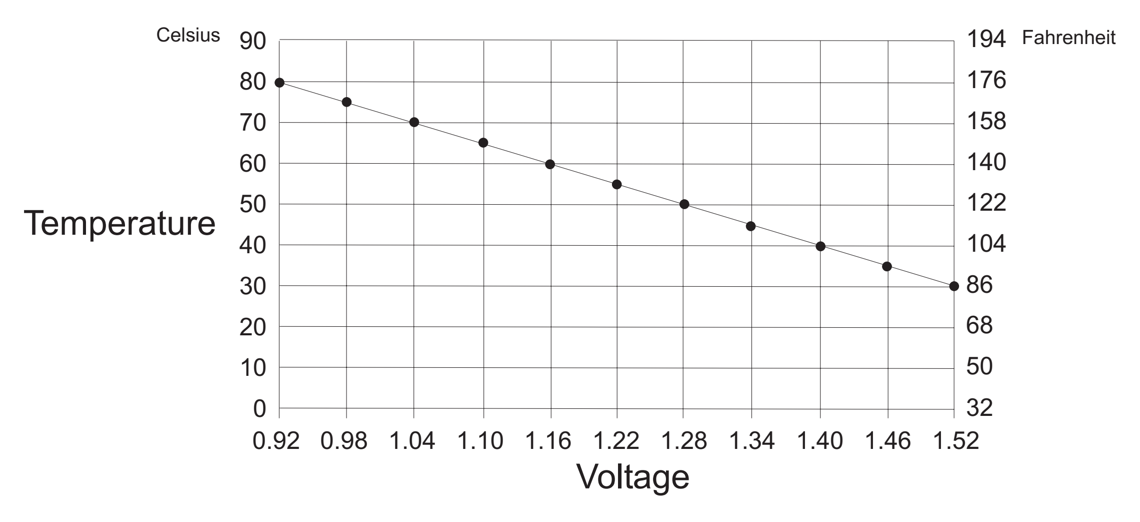
LINK	Name	Pins	Position	Function	Comments
J206	Fan Control 1	3	1-2 2-3	Fans controlled by J207 Fans always on	Default position is 1-2
J207	Fan Control 2	3	1-2 2-3	Fans Tx key-controlled Fans temperature-controlled	Default position is 2-3

The temperature threshold is set at the factory to 40°C. The potentiometer and test point to adjust the temperature threshold can be found on the SI board. Refer to Figure 6.3 on page 91 for the location.

Designator	Function
RV200	temperature threshold adjust
J222	test point for temperature threshold

When adjusting the temperature threshold the fans must be off.
The temperature threshold to voltage relationship is shown in Figure 6.4 on page 94.

Figure 6.4 temperature threshold-to-voltage relationship (RV200 and test point J222)



Important When using THSD and the user interface PTT, the fan setting should be temperature-controlled or always on. This is because the user interface PTT line does not toggle the Tx-key line on the system interface and the THSD is only on for short burst of time never allowing the fan time to spin up.

6.12 External Channel Selection

Channels can be selected externally using the digital I/O lines. This can be enabled using the TB7100 programming application and the links as below.

Link Settings

1. Remove the cover as detailed in "Removing the Multitone paging transmitter" on page 122.
2. Set the jumper positions on the SI board to match Table 6.5. Refer to Figure 6.3 on page 91 for link locations.
3. Fit the cover as detailed in "Final Reassembly" on page 131.

Table 6.5 External channel selection—link settings

LINK	Name	Pins	Position	Function	Comments
W300		2	Fitted Not fitted	When fitted this allows transmit module to be controlled by the same external digital IO lines, used for BCD; used with W301	Default: Not fitted
W301		2	Fitted Not fitted	When fitted this allows transmit module to be controlled by the same external digital IO lines; used with W300	Default: Not fitted

When Tx/Rx digital input 1-4 are used for channel selection only 16 binary or 10 BCD channels are available.

When Tx/Rx digital input 1-4 and another line, made from the shorting of Tx digital in/out 1 and Rx digital in/out 1 on the system interface connecter are used then a total of 32 binary or 20 BCD channels are selectable. Requires link W300 to be fitted.

6.13 Channel Increment and Decrement by Function Keys

Function button one and two can be configured to increment and decrement the channels. This requires two links fitted to the rear of the user interface board, this will hard wire the F1 and F2 buttons to the increment/decrement function. It is recommended F1 & F2 have no other programmed action.

This option will allow all 99 channels to be selected from the function buttons.

For more information, refer to the technical note TN-1032-AN “Implementing Channel Increment and Decrement on the TB7100” available from http://support.taitworld.com.

6.14 Configuring F1 and F2

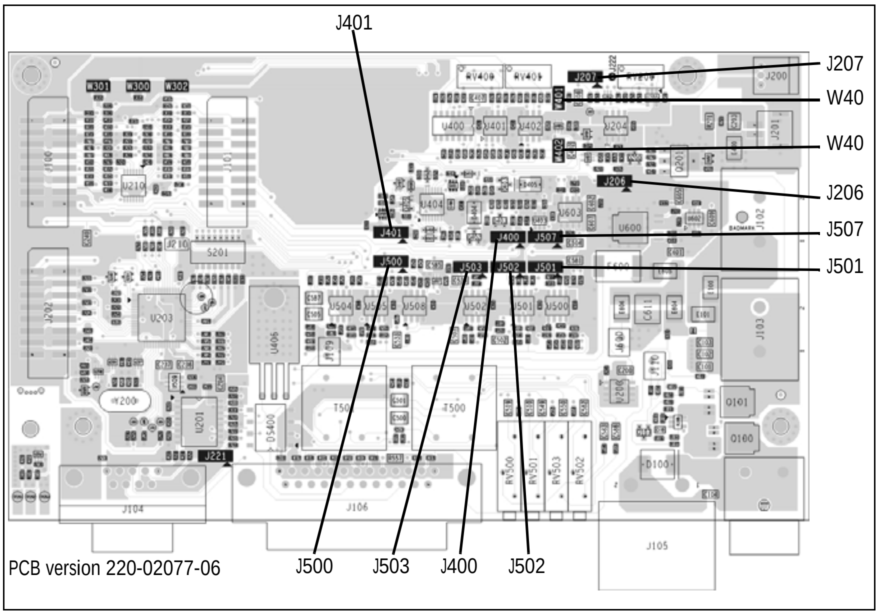
The UI board can be configured to use the F1 and F2 keys to increment and decrement the channel. If the UI board is configured in this way, F1 and F2 can no longer be programmed using the TB7100 programming application.

6.15 Paging Interface Board Levels

Note Ensure W401 and W402 jumpers on the SI board are parked before continuing.

Note A function generator will be required to generate the square waves the Multitone paging interface expects to receive.

Figure 6.5 Link positions on the SI board



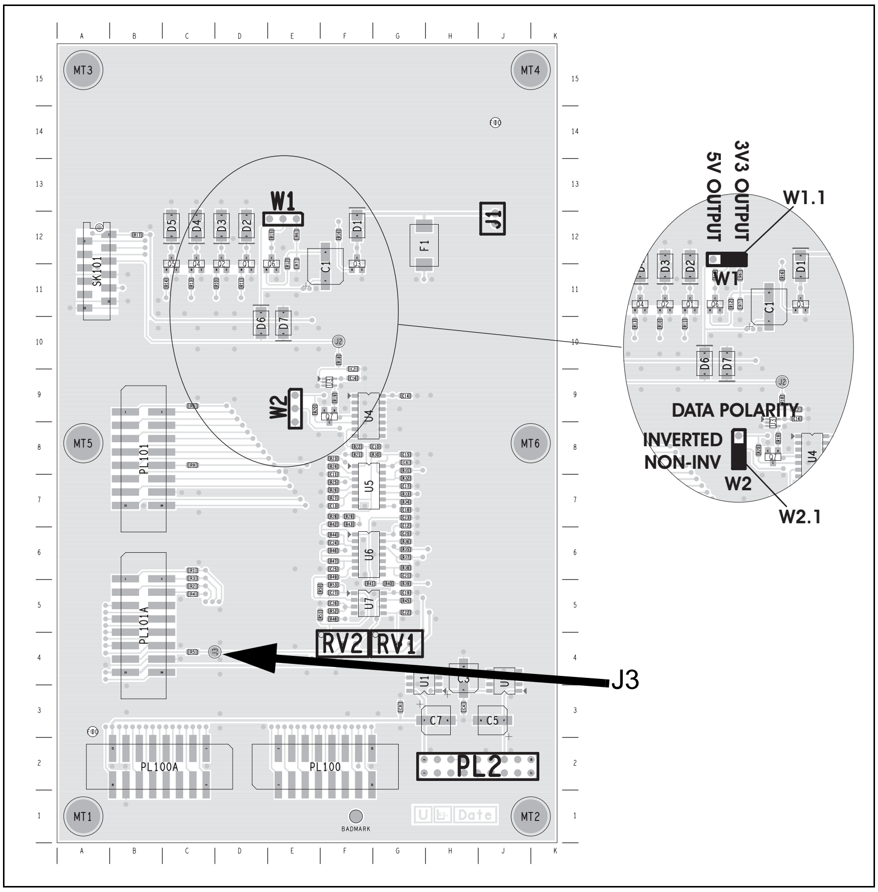
1. On a communications test set Monitor RF on the transmit channel.

2. Connect the Multitone paging transmitter system connector directly to the CTU using the standard cable, as shown in“Test setup with CTU (TBA0STU)” on page 105 .

3. Connect a multimeter between earth and J3 (“Multitone paging interface test points” on page 97) on the Multitone paging interface board. Adjust RV1 on the Multitone paging interface for 1.5VDC.

4. Connect the function generator to to pin 3 of the FSK ENCODER 9-way D-range. Inject 5V p-p square wave at 256Hz on pin 3 and key the transmitter using the TX key on the CTU. Adjust RV2 on the Multitone paging interface for 4.5kHz (WB) deviation.

Figure 6.6 Multitone paging interface test points



6.16 Maintenance Guide

The Multitone paging transmitter is designed to be very reliable and should require little maintenance. However, performing regular checks will prolong the life of the equipment and prevent problems from happening.

It is beyond the scope of this manual to list every check that you should perform on your Multitone paging transmitter. The type and frequency of maintenance checks will depend on the location and type of your system. The checks and procedures listed below can be used as a starting point for your maintenance schedule.

Performance Checks

We suggest you monitor the following operational parameters:

- VSWR
- DC input voltage, especially on transmit
- transmit deviation

These basic checks will provide an overview of how well your Multitone paging transmitter is operating.

Transmitter

There are no special maintenance requirements for the transmitter.

System Interface

There are no special maintenance requirements for the System interface.

Ventilation

The Multitone paging transmitter has been designed to have a front-to-back cooling airflow. We strongly recommend that you periodically check and maintain the ventilation requirements described in "Ventilation" on page 77 to ensure a long life and trouble-free operation for your Multitone paging transmitter.

Cooling Fans

The cooling fans have a long service life and have no special maintenance requirements.

Battery

If you are using battery, you should check the batteries regularly in accordance with the manufacturer's recommendations.

6.17 Tools, Equipment and Spares

Torque-drivers

For level-1 and level-2 repairs, excluding SMT repairs of the circuit boards, the following torque-drivers are required.

- Philips #2 bit
- PZ1, PZ2 and PZ3 Pozidriv bit
- Torx T10 bit
- 50W 40W With the 50 W/40 W board, a Torx T6 bit is required to replace the DC power connector.

Refer to the illustrations in “Disassembly and Reassembly” on page 121 for the corresponding torque values.

Card Remover Tool

To remove the UI board, it is recommended to use the card remover tool (220-02034-**xx**) included in the TBA0ST2 tool kit.

Tuning Tool

To tune the transmitter module, it is recommended to use the tuning tool (937-00013-**xx**) included in the TBA0ST2 tool kit.

Tools for SMT Repairs

In general only the standard tools for SMT work are required for level-2 repairs of the circuit boards. In addition, a can-removal tool is recommended but if none is available, a hot-air tool may be used instead. However, it should be noted that a hot-air tool affords little control. Even in skilled hands, use of a hot-air tool to remove cans will result in rapid uncontrolled rises in the temperature of components under the can being removed as well as under any adjacent cans. The circuit board might suffer damage as a result.

Test Equipment

The following test equipment is required:

- test PC
- calibration and test unit (TBA0STU)
- TB7100 CTU adapter (TBB0STU-TBB, included in TBA0STU)
- TMAA20-04 cable (RJ12 socket to RJ45 plug, included in TBB0P00)
- T2000-A19 cable (included in TBB0P00, or TPA-SV-006)
- RF communications test set (audio bandwidth of at least 10 kHz)
- oscilloscope
- digital current meter (capable of measuring up to 20 A)
- multimeter
- function generator
- 25W 50W 40W DC power supply (capable of 13.8 V and 10 A for 25 W Multitone paging transmitters, and 20 A for 50 W/40 W Multitone paging transmitters)

The standard test setup is illustrated in Figure 6.8. Separate instruments may be used in place of the RF communications test set. These are an RF signal generator, audio signal generator, audio analyser, RF power meter, and modulation meter.

An alternative test setup for testing the transmitter module, using the TOPA-SV-024 test unit and cables included in the TMAA21-00 kit and a TMAC20-0T control head is illustrated in Figure 6.9.

Programming applications

Install the TB7100 programming and calibration applications on the test PC. These applications are available fron the TaitWorld Support web site.

6.18 Servicing Precautions

Introduction

This section discusses the precautions that need to be taken when servicing the Multitone paging transmitter. These precautions fall into the following categories:

- mechanical issues
- compliance issues
- anti-static precautions
- transmitter issues

Service technicians should familiarize themselves with these precautions before attempting repairs of the Multitone paging transmitter.

Use of Torque-drivers

Apply the correct torque when using a torque-driver to tighten a screw or nut in the Multitone paging transmitter. Under-torquing can cause problems with microphonics and heat transfer. Over-torquing can damage the Multitone paging transmitter. The illustrations in “Disassembly and Reassembly” on page 121 show the correct torque values for the different screws and nuts.

Non-scratch Bench Tops

Use workbenches with non-scratch bench tops so that the mechanical parts of the Multitone paging transmitter are not damaged during disassembly and re-assembly. (The workbench must also satisfy the anti-static requirements specified below.) In addition, use a clear area of the bench when disassembling and re-assembling the Multitone paging transmitter.

Compliance Issues

Note The Multitone paging transmitter is designed to satisfy the applicable compliance regulations. Do not make modifications or changes to the Multitone paging transmitter not expressly approved by TEL. Failure to do so could invalidate compliance requirements and void the Customer’s authority to operate the Multitone paging transmitter.

ESD Precautions

For information about anti-static precautions and the dangers of electrostatic discharge, refer to standards such as ANSI/ESD S20.20-1999 and BS EN 100015-4 1994, or go to the Electrostatic Discharge Association website www.esda.org/.

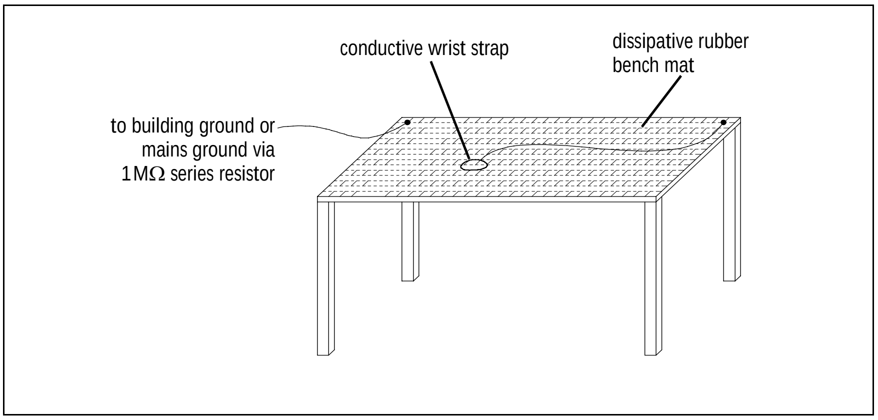
Important This equipment contains devices that are susceptible to damage from electrostatic discharge (ESD). Handle every device carefully and in strict according with the procedures defined in the data book provided by the manufacturer.

Tait recommends that you purchase an **anti-static bench kit** from a reputable manufacturer. The bench must have:

- a dissipative rubber bench top
- a conductive wrist strap
- a connection to ground

Install and test the bench kit in accordance with the manufacturer's instructions. See Figure 6.7.

Figure 6.7 Typical anti-static bench set-up



Also take strict anti-static precautions when **storing, shipping or carrying** a circuit board or its components:

- to carry, store or ship a circuit board use an anti-static bag
- to carry, store or chip a component use foil, an anti-static bag or an anti-static tube

You can also use an anti-static tray to carry a circuit board or component.

Transmitter Issues

The following issues relate to the operation of the transmitter:

- RF and thermal burns
- antenna loading
- test transmissions
- accidental transmissions
- distress beacons

The precautions required in each case are given below.

Caution **Avoid thermal burns. Do not touch the cooling fins or underside of the heatsink when the transmitter is**

or has been operating. Avoid RF burns. Do not touch the antenna while the transmitter is operating.

Important The Multitone paging transmitter has been designed to operate with a 50Ω termination impedance. Do not operate the transmitter without a suitable load. Failure to do so might result in damage to the power output stage of the transmitter.

Important While servicing the transmitter module, avoid overheating during test transmissions. The heatsink must be secured to the transmitter board. After completing any measurement or test requiring activation of the transmitter, immediately return the Multitone paging transmitter to the standby mode.

Important Under certain circumstances the microprocessor can key on the transmitter. Ensure that all instruments are protected at all times from such accidental transmissions.

Important When the transmitter module is not connected to the SI board, the transmitter will transmit continuously. To overcome this, connect pins 1 and 13 of a 15-way D-range plug and connect the plug to the auxiliary connector of the transmitter module.

Note The frequency ranges 156.8 MHz ± 375 kHz, 243 MHz ± 5 kHz, and 406.0 to 406.1 MHz are reserved worldwide for use by distress beacons. Do not program transmitters to operate in any of these frequency bands.

6.19 Setting up the Test Equipment

This section describes how to set up of the test equipment for servicing the Multitone paging transmitter. Refer to “Tools, Equipment and Spares” on page 99 for details of the test equipment.

Important For testing, the Multitone paging transmitter must be linked as a line-controlled Multitone paging transmitter and not as a repeater. Table 6.6 shows the link settings of the SI board. The optional duplexer must be removed before testing.

Table 6.6 Link settings of the SI board (PCB 220-02077-06 and later)

Link	Pins	Name	Default Position	Function
J400	3	Tx Key Source	1-2	External PTT signal to transmitter
J401	3	Rx Relay polarity control	1-2	
J500	3	Line Out Frequency Response	2-3	De-Emphasis
J501	3	Line In Frequency Response	1-2	Flat
J502	3	Tx Audio Source	2-3	Rx Audio (repeater)
J503	3	Rx Audio Destination	1-2	Tx Audio (repeater)
J507	3	Line In Destination	1-2	AUDIO_TAP_IN. The Tx Mic Audio
J221	3	RS-232 Loop Back	1-2	RS-232 via serial port

Table 6.7 Link settings of the UI board (PCB 220-02076-06 and later)

Link	Pins	Name	Default Position	Function
J1	3	Keypad	1-2	
J2	3	Keypad	1-2	

Test Setup with CTU The standard test setup using the CTU is shown in Figure 6.8.

Note The CTU is described in the TBA0STU Calibration & Test Unit Operation Manual (MBA-00013-**xx**).

1. Connect the test PC to the PROG/MIC connector on the front of the Multitone paging transmitter using the T2000-A19 and TMAA20-04 cables.

2. Connect the 25-pin SYSTEM INTERFACE connector of the CTU to the SYSTEM connector of the Multitone paging transmitter using the TB7100 CTU adapter and the 25-way D-range ribbon cable. Audio

connections between the CTU and test equipment are described in the relevant test steps.

3. Set all switches on the CTU to the off position, except the TX Key. The TX Key is not active when in the ON position because the Multitone paging transmitter is keyed by an active high.

4. On the System Interface board set links J400 to1-2 and J502 to 1-2.

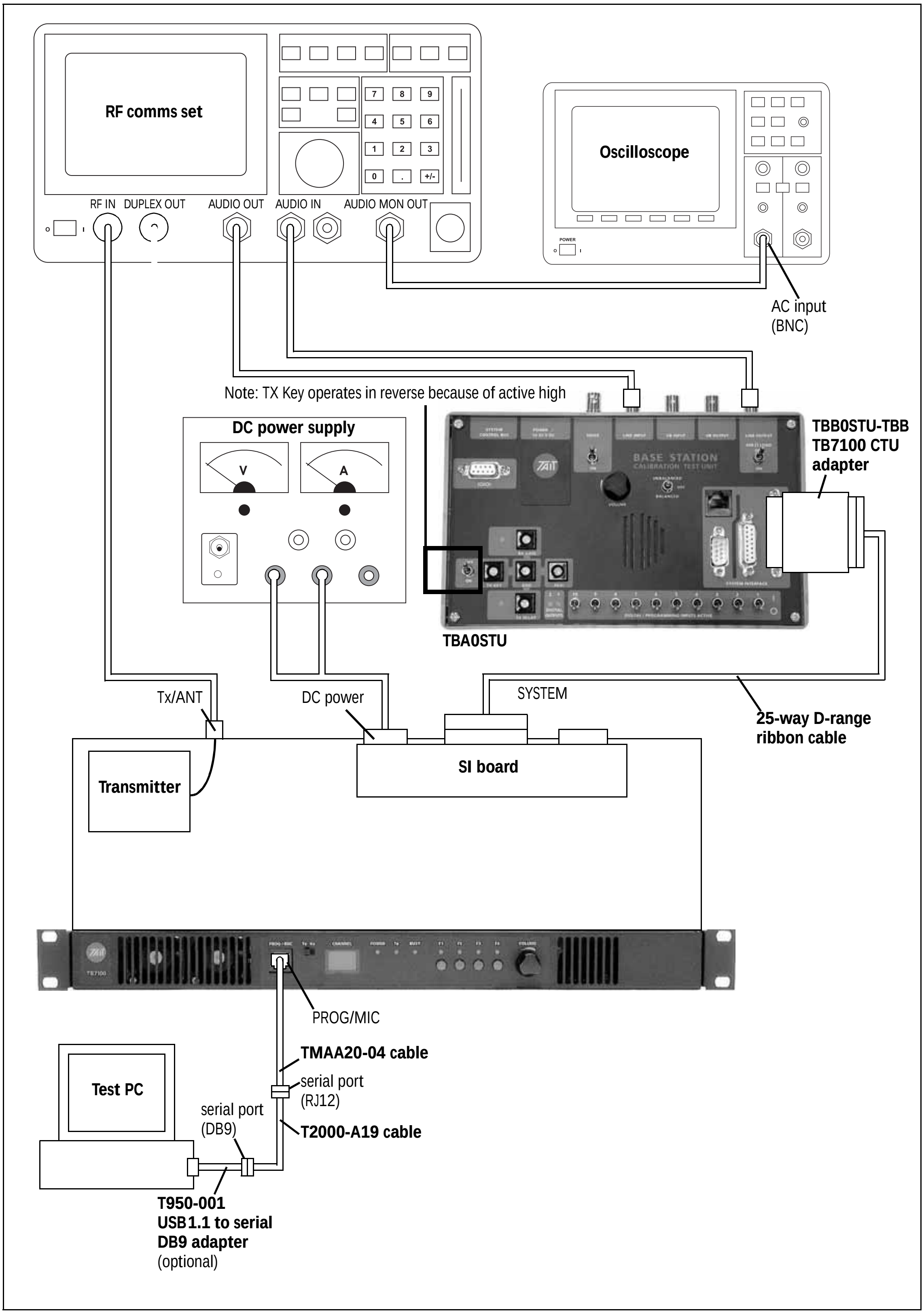
5. On the Paging Interface board fit 0 ohm resistors in the positions R1 to R5. This passes the signal direct from the SI board to the transmitter module bypassing the Multitone paging interface.

6. Connect the TX/ANT N-type connector of the Multitone paging transmitter to the input port of the RF test set (RF IN).

7. Connect the 13.8V DC power supply to the DC power connector (labelled 12VDC) of the Multitone paging transmitter.

8. When testing is completed remove the resistors R1 to R5 on the Paging Interface board and return the System Interface links J400 and J502 to default.

Figure 6.8 Test setup with CTU (TBA0STU)



Alternative Test Setup with TOPA-SV-024 Test Unit and TMAC20-0T Control Head

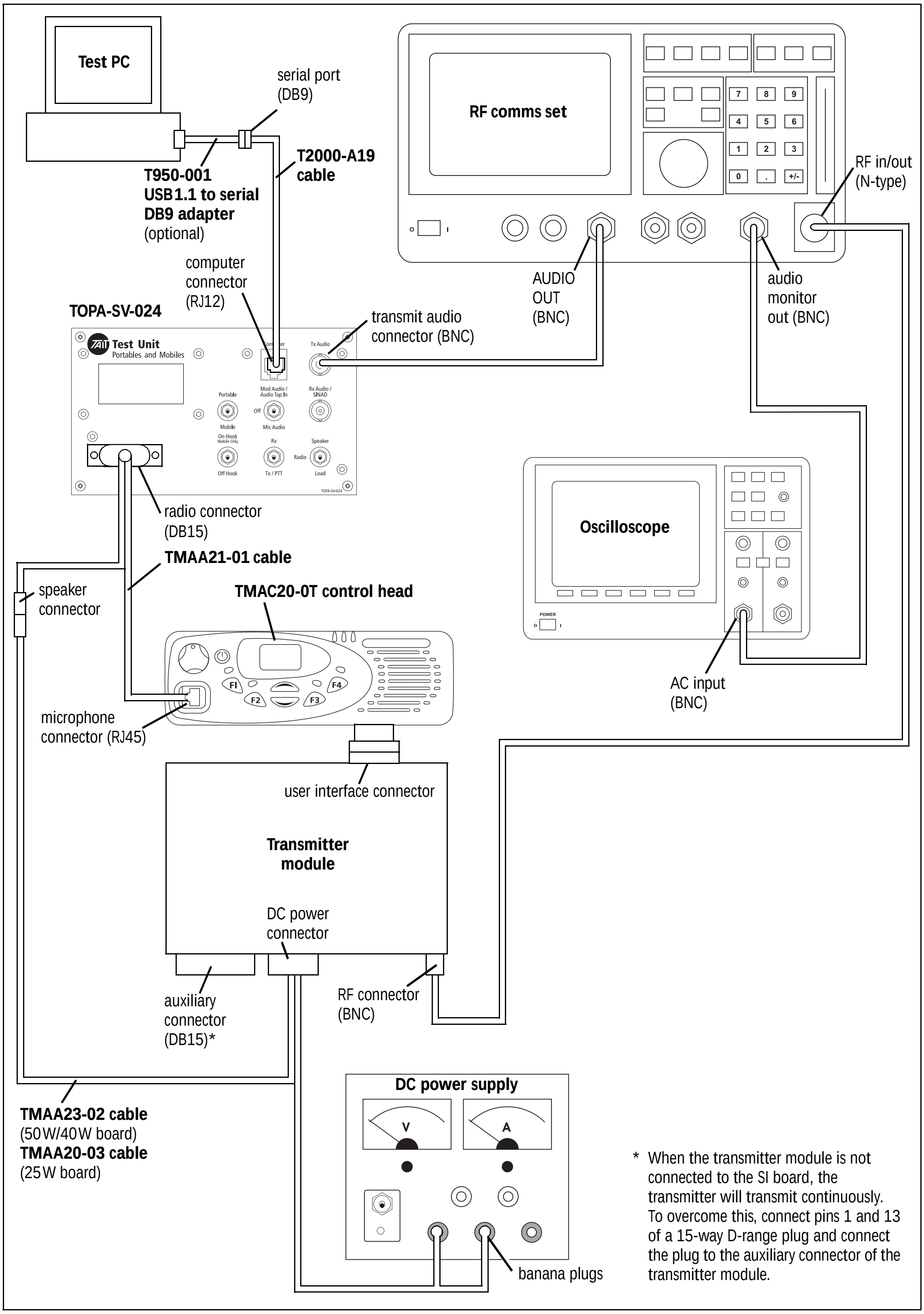
An alternative test setup using the TOPA-SV-024 test unit and cables of the TMAA21-00 kit and a TMAC20-0T control head used for testing the transmitter module is shown in Figure 6.9.

When using the alternative test setup, the switches of the test unit must be set as described below. (When programming or calibrating the Multitone paging transmitter, the switches have no effect, although it is good practice to set the MODE switch to “RX”.)

Transmit tests	
Switch	**Position**
HOOK	OFF HOOK
MODE	RX initially[a]
AUDIO IN	MIC AUDIO
AUDIO OUT	(immaterial)

a. When ready to transmit, set the mode switch to the TX/PTT position. This switch functions in the same way as the PTT switch on the microphone.

Figure 6.9 Test setup with TOPA-SV024 test unit and TMAC20-0T control head



6.20 Replacing Board Components

To obtain a replacement board component, complete the following steps in the order shown:

1. Check the issue number.
2. Identify the damaged component.
3. Consult the technical notes.
4. Verify the specifications.
5. Order the replacement component.

Check the issue number

1. Except for the paging interface PCB information that can be found in "Paging Interface PBA" on page 145. For all other PCBs follow the instructions below.
2. Locate the unique 10-digit Internal Part Number (IPN) that is printed on the PCB. For example, 220-01761-09.
3. Make sure that the IPN on the board is identical to the IPN on the PCB Information document that was supplied with the service documentation.

   The last two digits of each Internal Part Number (IPN) are the issue number of the board. Starting at 01, the issue number increments by one (02, 03, and so on) each time the PCB is re-issued. See also "Consult the Technical Notes", below.
4. If the IPNs do not match, download the correct version of the PCB Information from the Technical Support website.

Note To replace a printed board assembly, quote the relevant IPN: see "Spare Parts" on page 345. To replace a component on a PCB, however, use the IPN on the PCB to locate the correct PCB Information document: see "PCB Information" on page 75.

Identify the Damaged Component

1. Consult the BOM for the board under repair.
2. Use the BOM to identify the damaged component.

Consult the Technical Notes

Consult all technical notes that apply to the board before ordering the replacement component. Technical notes are published on the Technical Support website.

When there is a major change in the design of a board, such as a change in layout, the **issue number** of the board increments. When this happens, the IPN changes, new PCB Information is published, and a technical note is created. In between major changes, minor changes may be made to a board. For example, one component may be changed. There is no change to the issue number of the board, but if the minor change is important, a technical note is created. IPN and PCB Information will not alert you to a minor change: only the technical notes will. It is good practice to print and store a copy of every technical note.

Verify the Specifications

Before ordering the part, make sure the specifications of the damaged part are identical to the specifications given in the BOM. It is particularly important for tolerances to be the same. When the replacement component arrives, verify specifications again before installing the part.

Obtain Replacement Component

To determine whether the required replacement component can be ordered as a stand-alone part, see "Spare Parts" on page 345. If the item can be ordered as a stand-alone part, order it from your nearest Tait CSO. If the item is available only as part of a spares kit, check with Tait regarding the availability of the kit.

6.21 Shielding Cans and Connectors

The shielding cans on the top- and bottom-side of the transmitter board are identified in Figure 6.10 and Figure 6.11. The figures also show the locations of the connectors.

Figure 6.10 Shielding cans and connectors (top side)

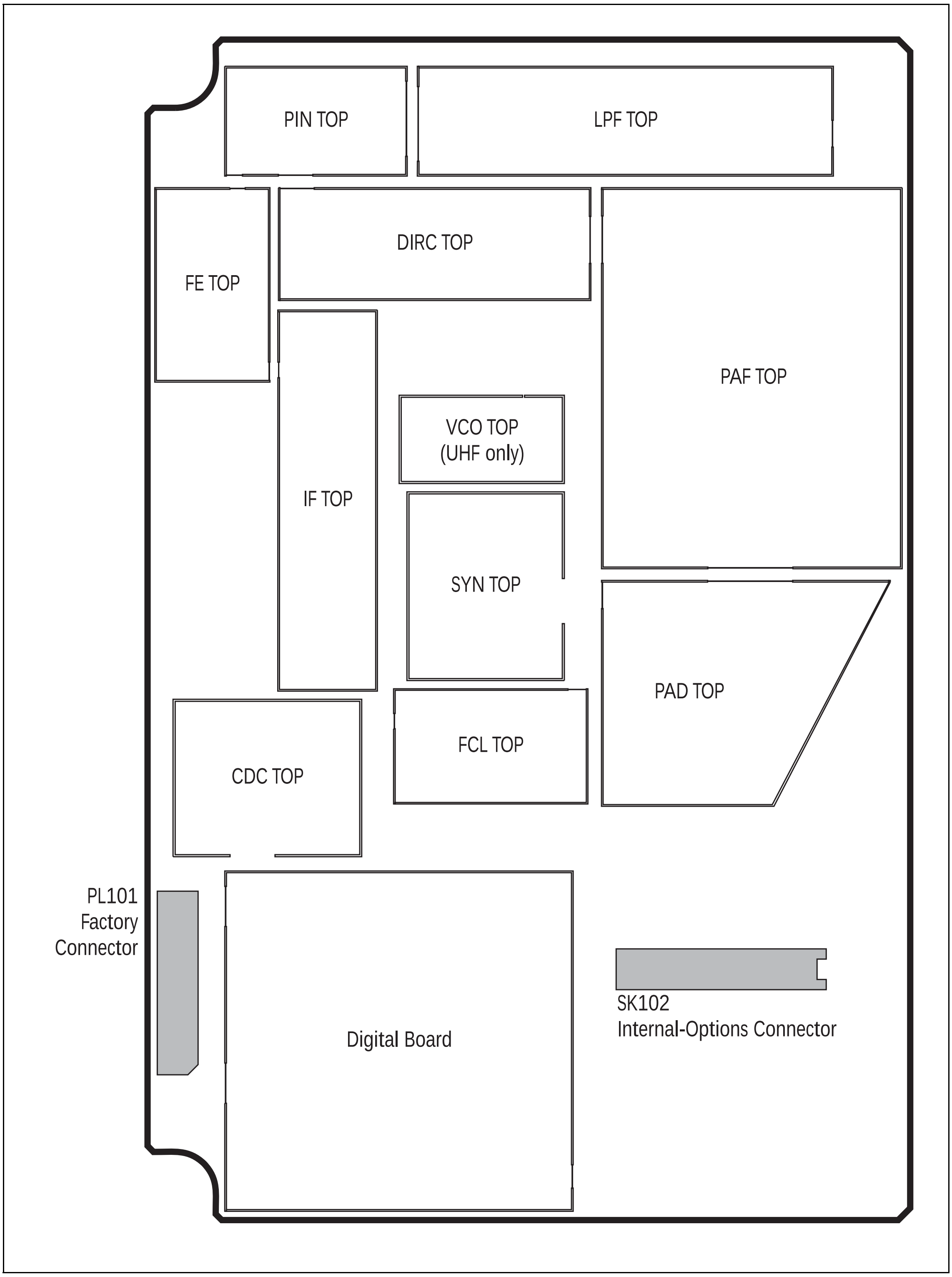
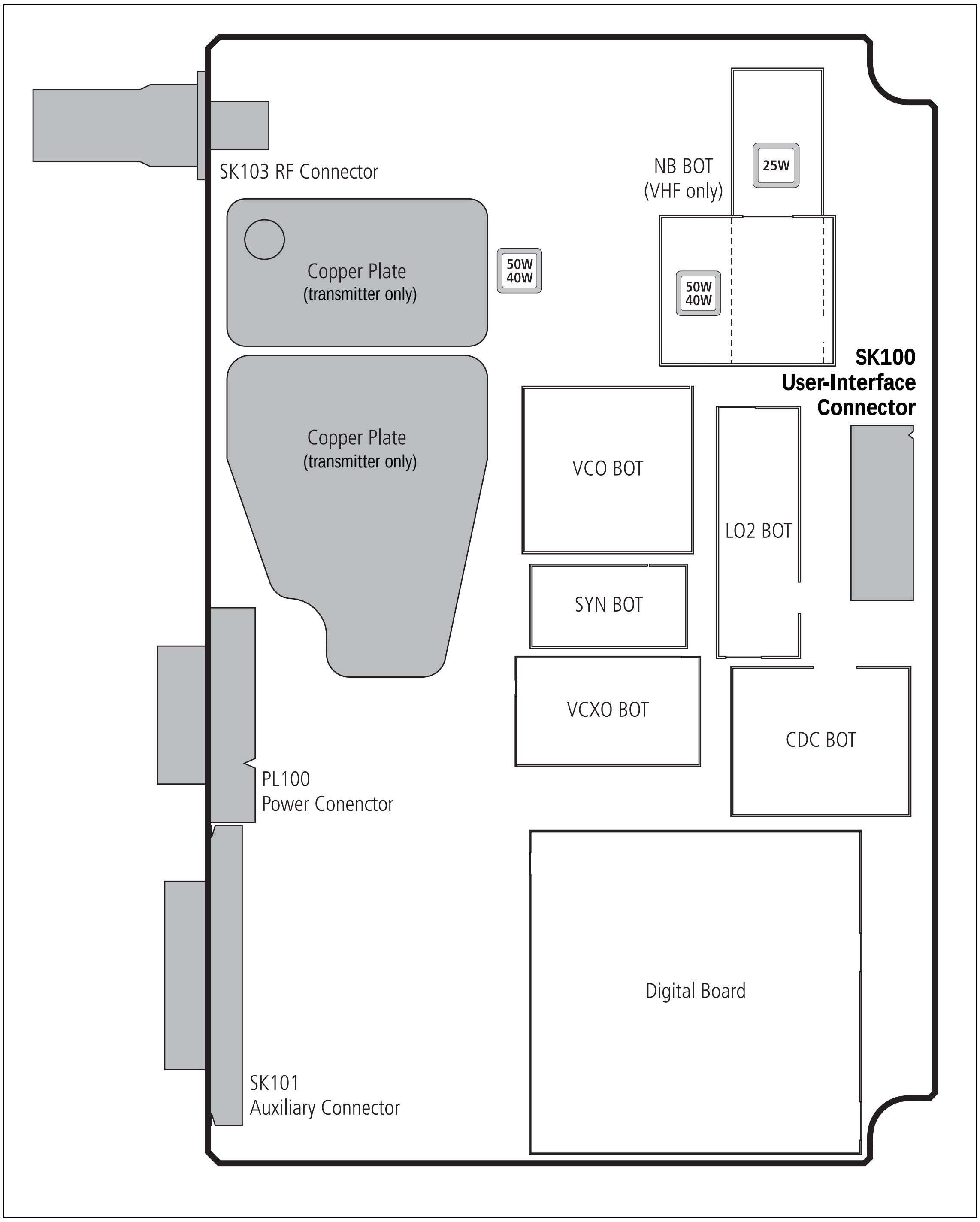


Figure 6.11 Shielding cans and connectors (bottom side)



Can Removal and Installation

Cans are best removed and installed using a can-removal tool. If this tool is available, technicians should refer to the documentation supplied with the tool for the correct procedures. If the tool is not available, a hot-air tool may be used instead. However, technicians require training in the best techniques to employ in the absence of a can-removal tool. Such training is part of the accreditation process for service centres.

Spare Cans

It is good practice to discard any can that has been removed and replace it with a spare can. If this is not done, special precautions are needed when re-installing the original can. These precautions are discussed as part of the training for accreditation.

6.22 SMT Repair Techniques

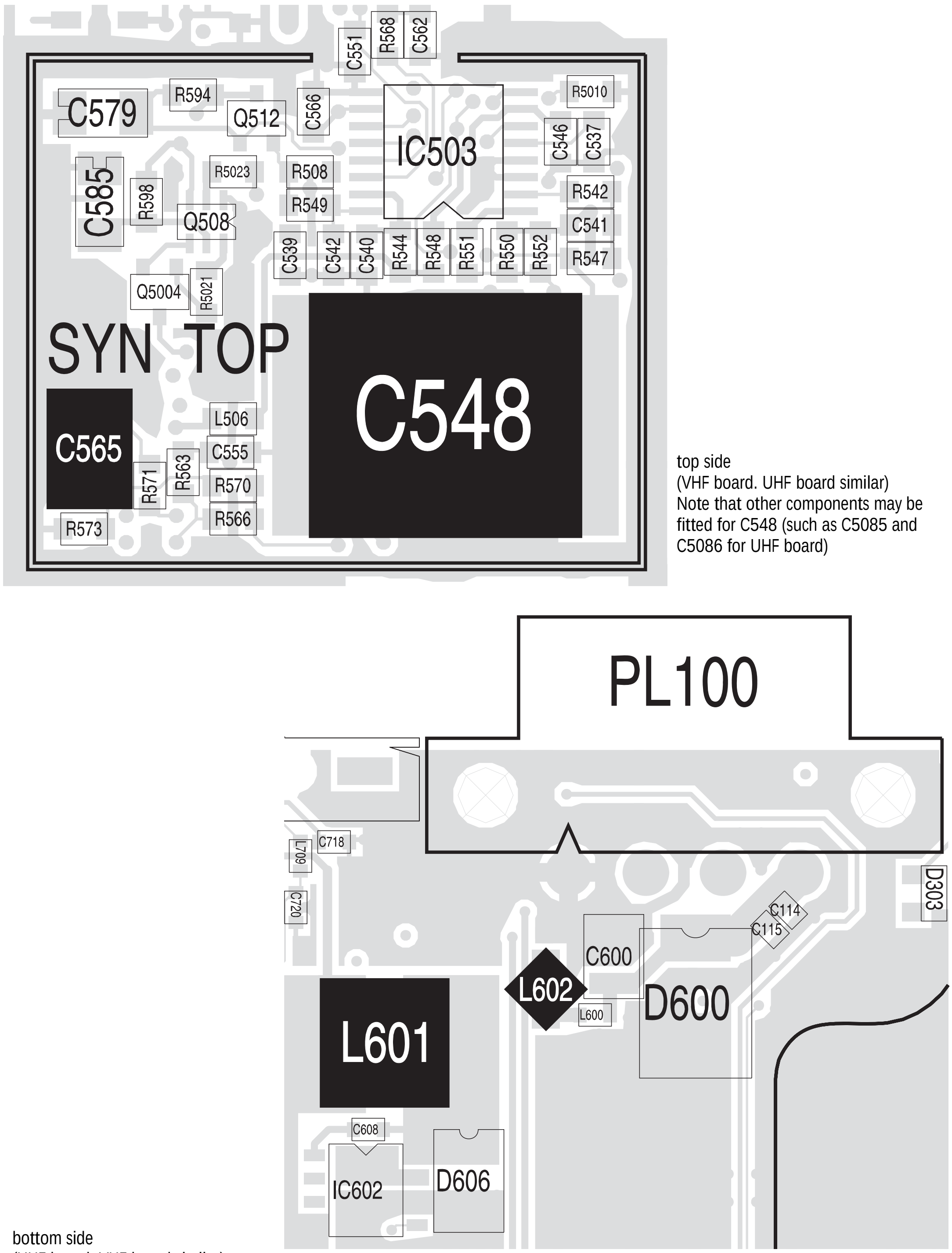
Standard Procedures

Service centres carrying out level-2 repairs are expected to be familiar with the standard techniques for the replacement of SMT components. However, certain components on the main board require non-standard techniques and these are discussed below. Another issue of concern is the procedure for removing and installing cans. A discussion of the issue concludes this section.

Non-standard Procedures

Do not use the standard SMT repair techniques when replacing the capacitors C548 and C565 and the inductors L601 and L602. The standard techniques tend to produce excessive heat, which will damage these components. Do not use a hot-air tool or heat gun. Instead use solder paste and a standard soldering iron with an iron tip with a specified temperature of 600°F (315°C). The capacitors are part of the frequency-synthesizer circuitry under the SYN TOP can. The inductors are part of the SMPS of the power-supply circuitry on the bottom-side of the board. Figure 6.12 on page 113 shows the locations of the components.

Figure 6.12 Locations of the capacitors C548 and C565 and the inductors L601 and L602



top side
(VHF board. UHF board similar)
Note that other components may be fitted for C548 (such as C5085 and C5086 for UHF board)

bottom side
(UHF board. VHF board similar)

6.23 Computer-Controlled Test Mode (CCTM)

The servicing procedures require the transmitter module to be placed in the computer-controlled test mode. In this mode CCTM commands can be entered at the test PC. These commands are then relayed via the test unit to the module. Certain CCTM commands cause the module to carry out particular functions; others read particular settings and parameter values in the module. The CCTM commands of use in servicing the modules are listed in Table 6.8 to Table 6.11, grouped according to category.

Terminal Program for CCTM

Use the HyperTerminal utility which is supplied with Microsoft Windows. As a preliminary, first select the settings for the communications port as follows:

1. Open the terminal program. (In the case of HyperTerminal, click *Start* > *Programs* > *Accessories* > *Communications* > *HyperTerminal*.)
2. In the terminal program first select the COM port to which the module is connected. Then select the following settings for the port:
   - bits per second : 19 200
   - data bits : 8
   - parity : none
   - stop bits : 1
   - flow control : none
3. Click the *OK* button (or equivalent).
4. Save the file with the port settings under a suitable name.
   For subsequent sessions requiring the terminal program, open this file.

Invoking CCTM

Using the terminal program, place the module in CCTM as follows:

1. Enter the character ^ to reset the module.
2. As soon as the module is reset, the letter *v* is displayed. (If an uppercase letter *V* appears, this implies a fault.)
3. Immediately the letter *v* is displayed, enter the character%.
   (The character% must be entered within half a second of the letter *v* appearing.)
4. If the character% is accepted, the character – is displayed in response, and the message *CL* appears on the Multitone paging transmitter display. This implies that the module has entered CCTM. If the attempt fails, repeat Step 1 to Step 3.

Table 6.8 CCTM commands in the audio category

Command	Usage	
	Entry at keyboard	**Response on screen**
Audio category		
22 – Mute microphone Mutes transmit modulation (effectively mutes microphone audio)	*22*	None
23 – Unmute microphone Unmutes transmit modulation (effectively unmutes microphone audio)	*23*	None
138 – Select microphone Selects the microphone required	*138* ***x*** where ***x*** is the required microphone (0=control-head microphone; 1=auxiliary microphone)	None
322 – Generate audio tone Generates an audio signal	*322* ***x y z*** where ***x*** specifies the tap point (*r1*, *r2*, *r3*, *r4*, *r5*, *t1*, *t2*, *t3* or *t7*), ***y*** specifies the frequency × 10 (e.g. 10000=1 kHz), and ***z*** specifies the amplitude (5000 is approx. 60% FSD or 1 V_{pp})	None
323 – Audio tap in Generates the audio tone AUD TAP IN at the specified tap point	*323* ***x y*** where ***x*** specifies the tap point (*r2*, *r5*, *t1* or *t5*) and ***y*** the tap type (A=bypass in, B=combine, E=splice) (the default is A when ***y*** is omitted)	None

Table 6.9 CCTM commands in the radio-information, radio-control and system categories

Command	Usage	
	Entry at keyboard	**Response on screen**
Radio-information category		
94 – Module serial number Reads the serial number of the module	*94*	***x*** where ***x*** is the serial number (an eight-digit number)
96 – Firmware version Reads the version number of the module firmware	*96*	*QMA1F_**x**_**y*** where ***x*** is a three-character identifier and ***y*** is an eight-digit version number
97 – Boot-code version Reads the version number of the boot code	*97*	*QMA1B_**x**_**y*** where ***x*** is a three-character identifier and ***y*** is an eight-digit version number
98 – FPGA version Reads the version number of the FPGA	*98*	*QMA1G_**x**_**y*** where ***x*** is a three-character identifier and ***y*** is an eight-digit version number
133 – Hardware version Reads the product code of the module and the hardware version number	*133*	***x*** **y** where ***x*** is the product code and ***y*** is the version number (a four-digit number)
134 – FLASH serial number Reads the serial number of the FLASH memory	*134*	***x*** where ***x*** is the serial number (a 16-digit hexadecimal number)
Radio-control category		
400 – Select channel Changes the current channel to that specified	*400* ***x*** (alternatively *****x***) where ***x*** is a valid channel number	None
System category		
46 – Supply voltage Reads the supply voltage	*46*	***x*** where ***x*** is the supply voltage in millivolts
203 – Clear system error Clears the last recorded system error	*203*	None
204 – Read system error Reads the last recorded system error and the associated data	*204*	*SysErr:* ***x*** **y** where ***x*** is the error number and ***y*** represents the associated data
205 – Erase persistent data Effectively resets the calibration parameters to their default values	*205*	None

Table 6.10 CCTM commands in the frequency-synthesizer categories

Command	Usage	
	Entry at keyboard	**Response on screen**
Frequency-synthesizer category		
72 – Lock status Reads the lock status of the RF PLL, FCL and LO2 respectively	*72*	***x y z*** where ***x*** is the RF PLL, ***y*** the FCL, and ***z*** the LO2 lock status (0=not in lock, 1=in lock)
101 – Radio frequencies Sets the transmit frequency to specified values	*101* ***x y*** *0* where ***x*** is the transmit and ***y*** the receive frequency in Hertz (any integer from 50 000 000 to 1000 000 000)	None
301 – Calibrate VCXO Calibrates the VCXO of the FCL	*301 0 10*	Four KVCXO control sensitivity values, followed by message with results of calibration attempt
302 – Calibrate VCO(s) Calibrates the VCO(s) of the frequency synthesizer	*302 0 10*	Eight KVCO control sensitivity values, followed by message with results of calibration attempt
334 – Synthesizer power Switches the frequency synthesizer on or off via the DIG SYN EN line	*334* ***x*** where ***x*** is the required state (0=off, 1=on)	None
335 – Synthesizer switch Switches the transmit-receive switch of the frequency synthesizer on or off via the DIG SYN TR SW line	*335* ***x*** where ***x*** is the required state (0=off, 1=on)	None
389 – Synthesizer mode Sets the mode of the frequency synthesizer to fast or slow	*389* ***x*** where ***x*** is the required mode (0=slow, 1=fast)	None

Table 6.11 CCTM commands in the transmitter category

Command	Usage	
	Entry at keyboard	**Response on screen**
Transmitter category		
33 – Transmit mode Sets the radio in the transmit mode	*33*	None
47 – Temperature Reads the temperature in the vicinity of the PAs	*47*	***x*** ***y*** where ***x*** is the temperature in degrees celsius, and ***y*** is the corresponding voltage in millivolts (a value from 0 to 1200 mV)

Table 6.11 CCTM commands in the transmitter category

Command	Usage	
	Entry at keyboard	**Response on screen**
114 – Transmitter power Sets or reads the transmitter power setting (compare command 326)	*114* (to read value)	***x*** where ***x*** is the current power setting (an integer from 0 to 1023)
	114 ***x*** (to set value) where ***x*** is the required power setting (an integer from 0 to 1023)	None
304 – Driver bias Sets or reads the clamp current at the gate of the PA driver	*304* (to read value)	***x*** where ***x*** is the DAC value of the clamp current (an integer from 0 to 255)
	304 ***x*** (to set value) where ***x*** is the required DAC value of the clamp current (an integer from 0 to 255)	None
318 – Forward power Reads the forward-power level	*318*	***x*** where ***x*** is the voltage in millivolts corresponding to the power level (a value from 0 to 1100 mV)
319 – Reverse power Reads the reverse-power level	*319*	***x*** where ***x*** is the voltage in millivolts corresponding to the power level (a value from 0 to 1100 mV)
326 – Transmitter power Sets the power level of the transmitter	*326* ***x*** where ***x*** specifies the level (0=off, 1=very low, 2=low, 3=medium, 4=high, 5=maximum)	None
331 – Final bias 1 Sets or reads the bias voltage for the first PA	*331* (to read value)	***x*** where ***x*** is the DAC value of the bias voltage (an integer from 0 to 255)
	331 ***x*** (to set value) where ***x*** is the DAC value of the required bias voltage (any integer from 0 to 255)	None
332 – Final bias 2 Sets or reads the bias voltage for the second PA	*332* (to read value)	***x*** where ***x*** is the DAC value of the bias voltage (an integer from 0 to 255)
	332 ***x*** (to set value) where ***x*** is the DAC value of the required bias voltage (any integer from 0 to 255)	None

CCTM Error Codes

Once the module is in CCTM, the CCTM commands may be entered as shown in Table 6.8 to Table 6.11. Depending on the command, a response might or might not be displayed. If an error occurs, an error code will be displayed. Possible error codes are listed in Table 6.12.

Table 6.12 CCTM error codes

Error code	Description
C01	An invalid CCTM command has been received. Enter a valid CCTM command.
C02	A valid CCTM command with invalid parameters has been received. Re-enter the CCTM command with valid parameters.
C03	A valid CCTM command has been received but cannot be processed at this time. Enter the CCTM command again. If the error persists, power the module down and up again, and re-enter the CCTM command.
C04	An error occurred on entry into CCTM. Power the module down and up again, and place the module in CCTM again.
C05	The module has not responded within the specified time. Re-enter the CCTM command.
X04	The DSP is not responding. Check the DSP pin connections. If the error persists, replace the DSP.
X05	The version of the DSP is incompatible with the version of the module firmware. Replace the DSP with a later version.
X06	The internal configuration of the MCU is incorrect. Adjust the configuration.
X31	There is an error in the checksum for the model configuration.
X32	There is an error in the checksum for the module's database.
X35	The module temperature is above the T1 threshold and a reduction in the transmit power is impending. To avoid damaging the module, stop transmitting until the module has cooled down sufficiently.
X36	The module temperature is above the T2 threshold and the inhibiting of transmissions is imminent.
X37	The supply voltage is less than the V1 threshold.
X38	The supply voltage is less than the V2 threshold and the module has powered itself down. The module will not respond to the reset command character ^.

6.24 Defining Frequency Bands

Where test procedures or figures differ according to the frequency band of the radio, the frequency band is given in brackets. The frequency band may be referred to as either ‘VHF’ (very high frequency) or ‘UHF’ (ultra-high frequency) or identified by the frequency sub-band, such as ‘B1’. For example:

RF output power: > 60W (**VHF**), > 52W (**UHF**) current: < 15A (**VHF**), < 12A (**UHF**)

The frequency bands for the Multitone paging transmitter are listed in Table 6.13. The relevant frequencies for the different bands are listed in this table.

Table 6.13 Defining frequency bands

	Frequency identification	Frequency sub-band
VHF	B band	B1 = 136MHz to 174MHz
UHF	H band	H5 = 400MHz to 470MHz

6.25 Visual Indicators

Visual indicators give information about the state of the Multitone paging transmitter. Visual indications are provided by the status LEDs, function key LEDs, and LCD display. The information conveyed by the LEDs is listed in Table 6.14. The behaviour of the function-key LEDs depends on the way the function keys are programmed. The LCD display normally displays channel and user information, or error messages. For more information on the LCD display during normal operation, refer to the installation and operation manual.

Table 6.14 Visual indications provided by the LEDs

LED color	LED name	Indications	Meanings
Red	Tx	LED is on	The Multitone paging transmitter is transmitting
		LED flashes	(1) The transmit timer is about to expire (2) The Multitone paging transmitter has been stunned
Green	Busy	LED is on	There is activity on the current channel, although it might not be audible
		LED flashes	Not applicable
Green	Power	LED is on	Power is supplied to the Multitone paging transmitter
		LED is off	No power is supplied to the Multitone paging transmitter

Note The Multitone paging transmitter does not generate audible signals.

7 Disassembly and Reassembly

This section describes how to:

- remove and open and close the Multitone paging transmitter
- remove and fit the modules and components
- disassemble and reassemble the transmitter module

General

Important Before disassembling the Multitone paging transmitter, disconnect the Multitone paging transmitter from any test equipment or power supply.

Disassemble only as much as necessary to replace the defective parts.

Inspect all disassembled parts for damage and replace them, if necessary.

Observe the torque settings indicated in the relevant figures.

For information on spare parts, refer to “Spare Parts” on page 345.

Important To ensure adequate airflow through the Multitone paging transmitter, do not cover the fan intake grill on the front panel. Do not operate for more than a few minutes with the fan intake covered.

Important The transmitter module can only be replaced with Multitone paging transmitter modules. The transmitter module can be identified by the heat transfer plate fitted to the underside.

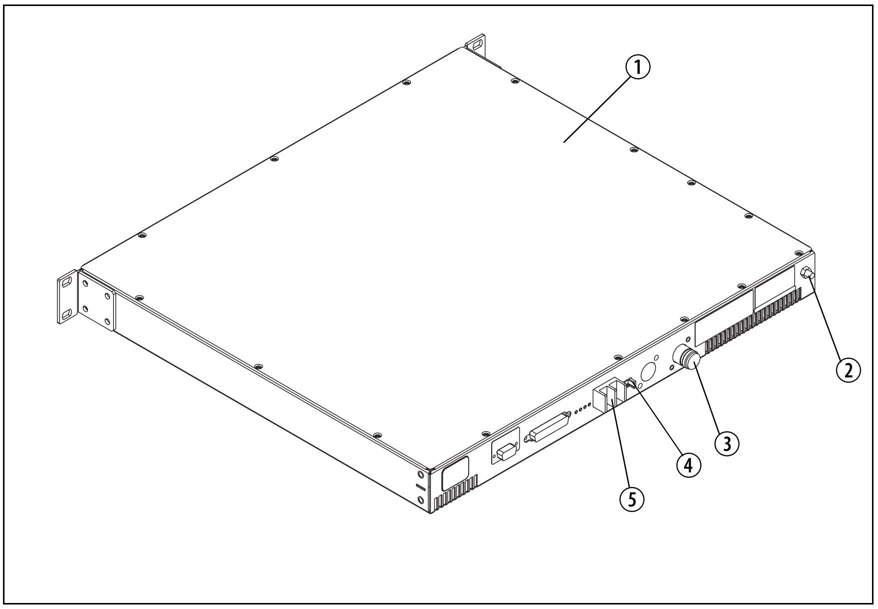
Saving the Multitone paging transmitter Configuration

Before replacing a module in the Multitone paging transmitter, you should decide whether you need to save its configuration data. If you are unsure whether you have a record of the configuration, use the Programming Application to read the Multitone paging transmitter and save the configuration files before removing any modules. Once you have replaced the module, you will be able to restore the original configuration by programming the saved configuration back into the Multitone paging transmitter. If one or more of the modules is faulty, you may be unable to read the Multitone paging transmitter. In this case, you will have to restore the configuration from a back-up file. Refer to the installation and operation manual for more information.

7.1 Removing the Multitone paging transmitter

Important The modules in the Multitone paging transmitter are **not** hot-pluggable. It is recommended the tray is removed from the rack before any modules are replaced.

Figure 7.1 Opening the tray



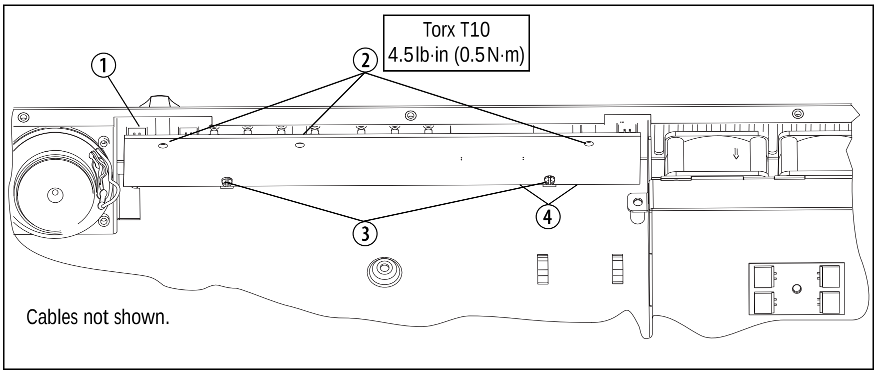
1. Remove the fuse ④ at the rear of the Multitone paging transmitter to disconnect the Multitone paging transmitter from DC power.
2. Use a Philips #2 screwdriver to disconnect the cables from the DC power connector ⑤.
3. Disconnect the antenna connectors ③.
4. Disconnect any other connectors.
5. Disconnect the ground cable from the ground point ②.
6. Use a PZ2 Pozidriv screwdriver to remove the four M6 screws, and remove the Multitone paging transmitter from the rack.
7. Use a Torx T10 screwdriver to remove the 15 countersunk screws. Remove the tray cover ①.

7.2 Replacing the UI Board

Removal

1. Remove the volume knob by pulling slowly but firmly. The knob is a friction fit and can leave the collet behind on the shaft. If this happens, remove the collet from the shaft and place inside the knob.
2. Disconnect the speaker connector ①.
3. Use a Torx T10 screwdriver to remove the three screws ② together with the spring washers and flat washers.
4. Insert the card remover tool (220-02034-xx) from the tool kit (TBA0ST2), or a small flat-bladed screwdriver into the two small holes at the bottom of the UI board. Lever the board completely off the spring clips ③.
5. Carefully slide the UI board towards the rear of the Multitone paging transmitter until the volume-control shaft clears the front panel. Lift the UI board clear of the chassis.
6. Disconnect the two Micro-MaTch connectors ④.

Figure 7.2 Removing the UI board



Fitting

1. Plug the two Micro-MaTch connectors ④ into the UI board. The Micro-MaTch connector for the transmitter is closest to the edge of the UI board.
2. Align the volume-control shaft with the hole in the front panel, also align the programming/microphone connector and function buttons as the board is slid into place.
3. Gently slide the UI board into position so that the spring clips ③ are engaged. Press firmly around the spring clips to ensure they are engaged fully.
4. Use a Torx T10 screwdriver to fasten the three screws ② to 4.5lb·in (0.5N·m).
5. Plug the speaker connector ① into the UI board.
6. Fit the volume knob onto the shaft and press firmly until fully seated.

7.3 Replacing the Transmitter Module

Removal

Note Release the latch underneath the DC power connector before attempting to disconnect it.

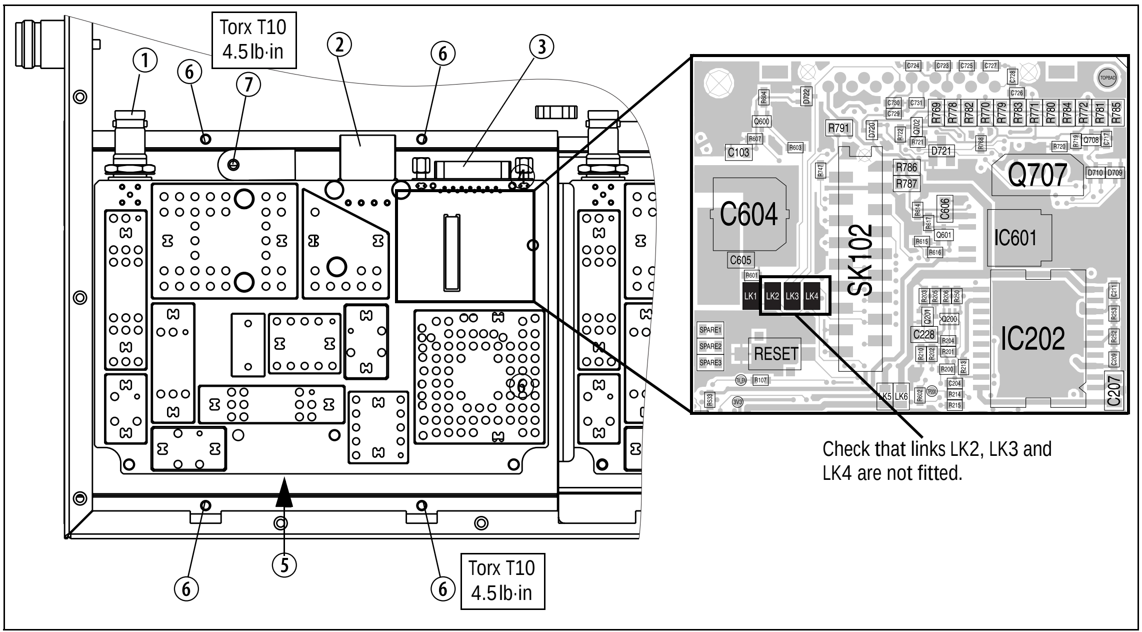
1. Disconnect the cables to the RF ①, DC power ②, system interface ③, and the user interface ⑤ connectors.

2. Use a Torx T10 screwdriver to remove the screw ⑦ fastening the temperature sensor to the heatsink.

3. Use a Torx T10 screwdriver to remove the four screws ⑥ fastening the heatsink to the tray chassis.

4. Lift the transmitter module clear of the tray chassis.

Figure 7.3 Replacing the transmitter module



Fitting

1. Check that the replacement module has links LK2, LK3 and LK4 not fitted as shown in Figure 7.3, and that R775 is fitted.

2. Position the transmitter module inside the tray chassis.

3. Use a Torx T10 torque-driver to fasten the four screws ⑥ to 4.5lbf·in (0.5N·m).

4. Use a Torx T10 torque-driver to fasten the temperature sensor with the screw ⑦ to 4.5lbf·in (0.5N·m).

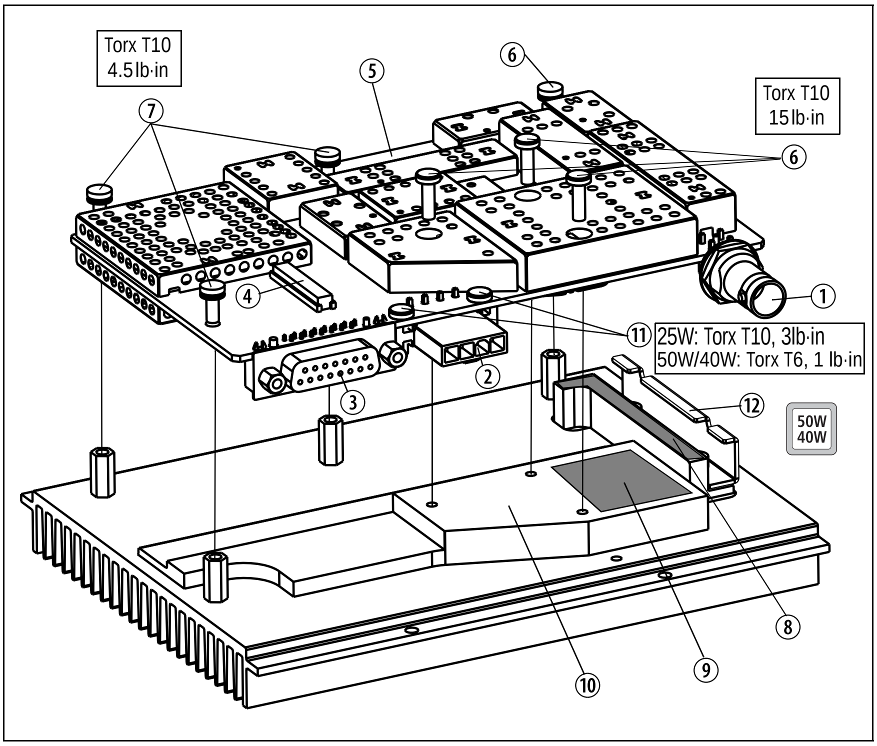
5. Connect the cables to the RF ①, DC power ②, system interface ③, and the user interface ⑤ connectors.

7.4 Disassembling the Transmitter Module

Important Disassembling the transmitter module is a level-2 repair and must only be performed by accredited service centres (ASC). For more information, refer to “Repair Levels, Accreditation, and Website Access” on page 73.

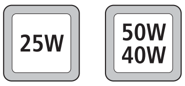
1. Remove the transmitter module as described in “Replacing the Transmitter Module” on page 124.
2. Use a Torx T10 screwdriver to unscrew the seven screws ⑥ and ⑦ together with the spring washers and flat washers.
3. Slide the transmitter module out of the bracket ⑫ and lift it clear of the heat sink ⑩.
4. 25W 50W 40W Remove and discard the gap pad ⑧ and (with the 50 W / 40 W boards) the gap pad ⑨.
5. To replace the power connector ②:
   - 25W 50W 40W With the 50 W / 40 W board, use a Torx T6 screwdriver to undo the two screws ⑪.
   - With the 25 W board, use a Torx T10 screwdriver to undo the two screws ⑪.

Figure 7.4 Removing and fitting the transmitter board

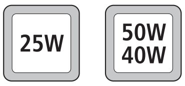


7.5 Reassembling the Transmitter Module

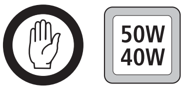
The circled numbers in this section refer to the items in Figure 7.4 on page 125.



1. If the power connector has been replaced:
   - With the 25W board, use a Torx T10 torque-driver to tighten the two screws ⑪ to 3lb·in (0.34N·m).
   - With the 50W/40W board, use a Torx T6 torque-driver to tighten the two screws ⑪ to 1lb·in (0.11N·m).



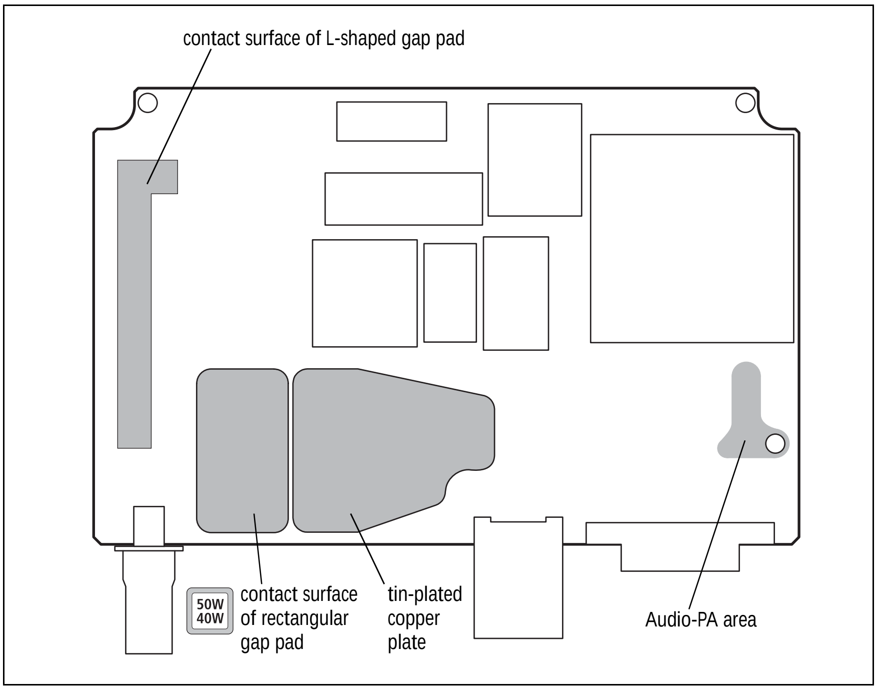
2. The L-shaped gap pad ⑧ and (with the 50W/40W board) the rectangular gap pad ⑨ must be replaced each time the board is separated from the heatsink ⑩:
   - Remove any residue of the gap pad(s) from the underside of the board and the heatsink.
   - Make sure that the heatsink and the heat plates are free of any dust.
   - Peel off the transparent film on one side of the L-shaped gap pad ⑧ and evenly press the gap pad on the contact surfaces of the heatsink.



Important With the 50W/40W board, the rectangular gap pad ⑨ must not overlap the edge of the tin-plated copper plate (refer to Figure 7.5).

   - Peel off the transparent film on one side of the rectangular gap pad and evenly press the gap pad on the contact surfaces of the board.
   - Peel off the transparent film on other of the gap pad(s).

Figure 7.5 Contact surfaces on the bottom side of the board



3. If the thermal paste on the heatsink ⑩ or the tin-plated cooper plate of the board has been contaminated, new thermal paste must be applied:
   - Remove any residue of the old thermal paste from both contact surfaces.
   - Use Dow Corning 340 silicone heat-sink compound (IPN 937-00000-55).

Important Ensure that no bristles from the brush come loose and remain embedded in the paste. The paste needs to be completely free of contaminants.

   - Use a stiff brush to apply 0.1 cm^3 of thermal paste over the complete contact surface on the tin-plated copper plate (refer to Figure 7.5 on page 126).

50W 40W

Important With the 50W/40W board, the rectangular gap pad ⑨ must not overlap the edge of the tin-plated copper plate (refer to Figure 7.5 on page 126).

4. Place the board in position under the bracket ⑫, then push the board and the heatsink ⑩ together to spread the thermal paste.
5. Place three screws ⑥ into the holes above the metal heatsink plate by:
   a. holding the module at a 60° angle
   b. fitting the screw on the Torx driver
   c. slipping it through the shield hole and into the PCB hole
6. Use a Torx T10 torque-driver to fasten the three screws ⑦ to 15lbf·in (1.7N·m).
7. Use a Torx T10 torque-driver to fasten the four screws ⑥ to 4.5lbf·in (0.5N·m).

7.6 Replacing the SI Board

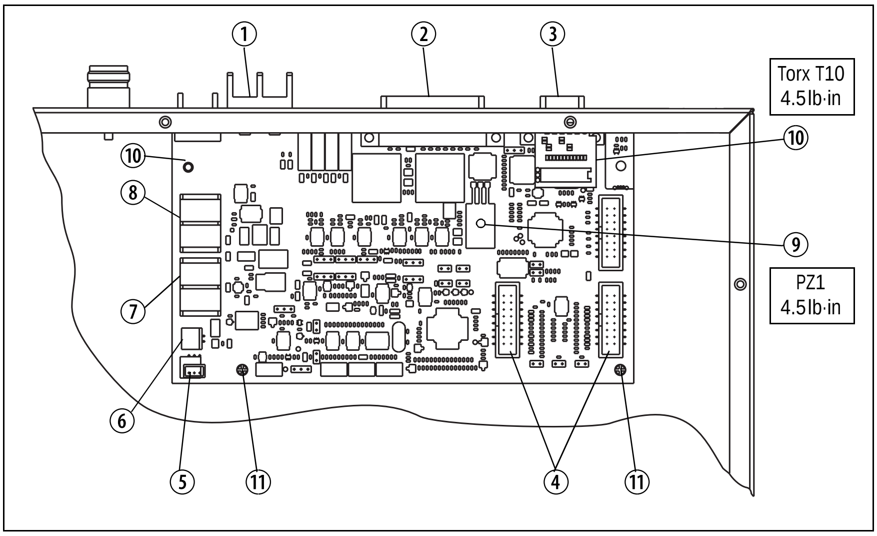
Removal

1. Disconnect the system interface cables ④ to the paging interface, the temperature sensor cable ⑥, and the mains fail signal cable, and move them to one side.
2. Remove the DC power cables ⑦ and ⑧ and move them to one side. Note the connection positions.
3. Use a Torx T10 screwdriver to remove the two screws ⑩.
   Use a PZ1 Pozidriv screwdriver to remove the screw ⑨ on the heatsink of U406.

4. Carefully lift the front of the SI board off the spring clips ⑪.

5. Carefully slide the SI board towards the front of the Multitone paging transmitter until the connectors ①, ② and ③ clear the rear panel. Lift the SI board clear of the chassis.

Figure 7.6 Replacing the SI board



Fitting

1. Slide the SI board into the tray chassis by fitting the connectors ①, ② and ③ into the rear panel.

2. Press down firmly on the front of the SI board to engage the two spring clips ⑪.

Important Make sure that the thermal pad is fitted under and the plastic insulating washer is fitted on U406.

3. Use a torque-driver to fasten the two screws ⑩ (Torx T10) the screw ⑨ (PZ1) on the heatsink of U406 to 4.5lb·in (0.5N·m).

4. Connect the system interface cables ④ to the paging interface, the fan control cable ⑤, the temperature sensor cable ⑥, the DC power cables ⑦ and ⑦, and the mains fail signal cable.

7.7 Replacing the Paging Interface Board

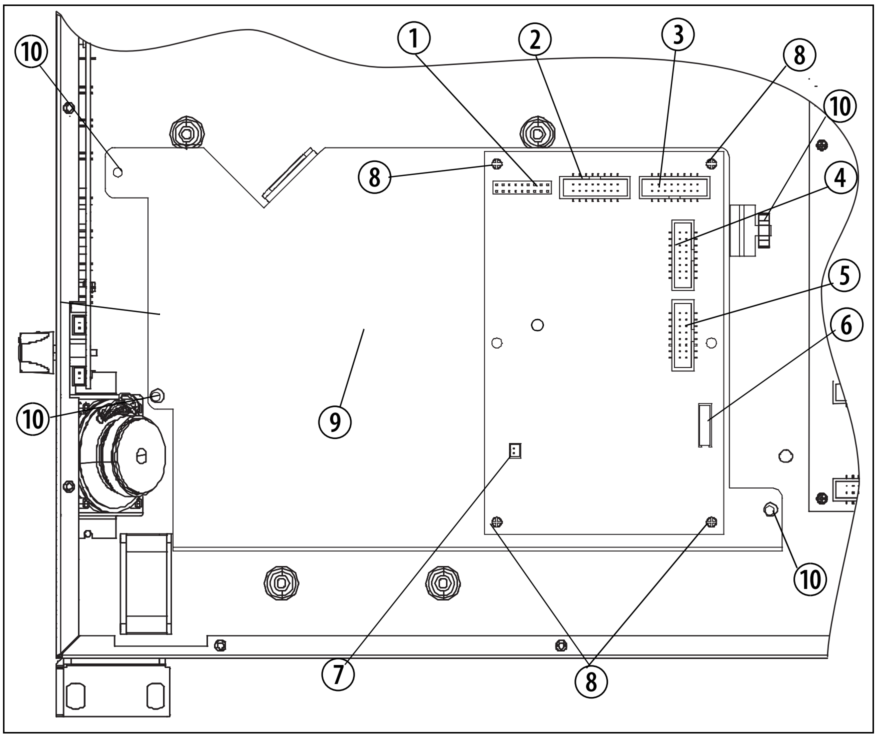
Removal

1. Disconnect the cables ③ to the transmitter and the ① User Interface, the System Interface cable ④, the FSK encoder connector cable ⑥, and move them to one side.

2. Carefully lift the front of the paging interface board off the four spring clips ⑧.

3. Lift the paging interface board clear of the chassis.

Figure 7.7 Replacing the Paging Interface board



Fitting

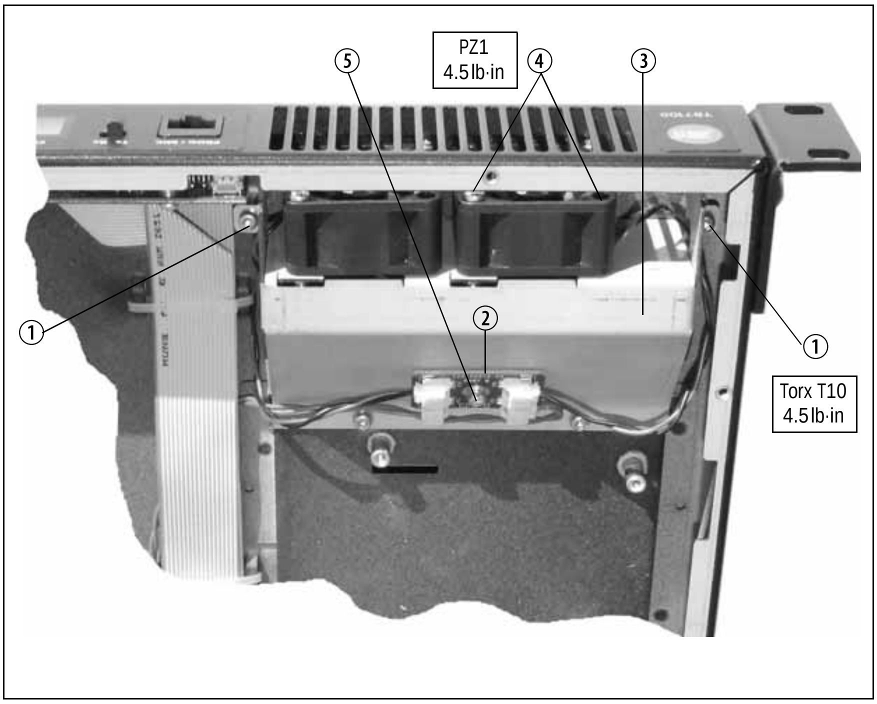
1. Place the board in position.
2. Press down firmly on the front of the Paging Interface board to engage the four spring clips ⑧.
3. Connect the cables from ③ the transmitter and the ① User Interface, the System Interface cable ④, the FSK encoder connector cable ⑥.

7.8 Replacing the Transmitter Fans

Removal

1. Use a Torx T10 screw driver to remove the four screws ① securing the fan duct ③ in the tray chassis.
2. Disconnect the fan control loom from the fan power board ②. Slide back the fan duct ③ and lift clear.
3. Unplug the fan to be replaced from the fan power board ② on the fan duct ③.
4. Use a PZ1 Pozidriv screwdriver to remove the two M3 × 25mm screws ④ and remove the fan.

Figure 7.8 Replacing the transmitter fans



Fitting

1. Place the fan into position on the fan duct ④ and use a PZ1 screwdriver to fasten the two M3 × 25 screws ④ to 4.5 lb·in (0.5 N·m).

2. Thread the fan cable through the hole in the side of the fan duct. Plug the fan into the fan power board ②.

3. Slide the fan duct ③ into the chassis. Plug the fan control loom into the fan power board ②.

4. Use a Torx T10 screwdriver to fasten the four screws ① to 4.5 lb·in (0.5 N·m).

7.9 Replacing the Fan Power Board

Note The fan power board is manufactured as part of the UI board and cannot be ordered separately. For more information, refer to "Spare Parts" in the service manual.

The circled numbers in this section refer to the items in Figure 7.8 on page 130.

1. Disconnect the fan control cable and the fan cables from the fan power board ②.

2. Use a Torx T10 screwdriver to remove the screw ⑤ attaching the fan power board ② to the fan duct ③.

3. Fitting is carried out in reverse order.

7.10 Replacing the Temperature Sensor Board

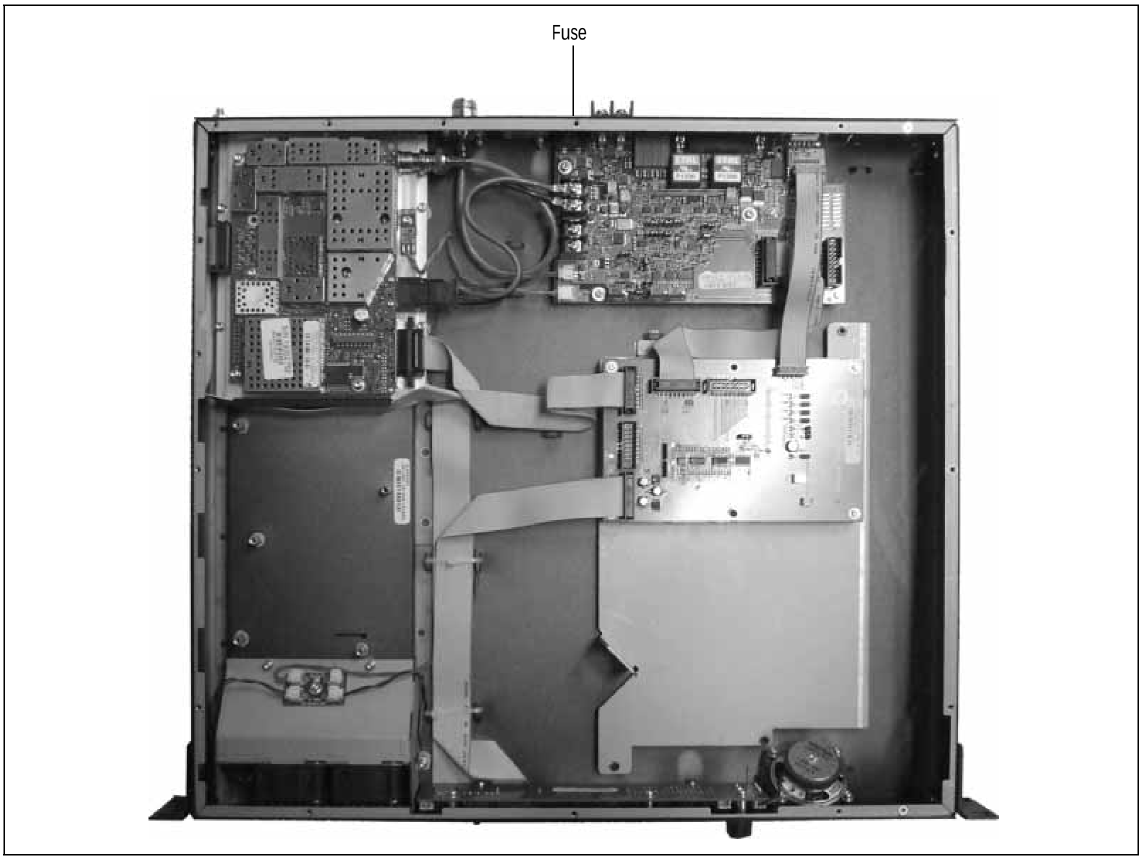
Note The temperature sensor board is manufactured as part of the SI board and cannot be ordered separately. For more information, refer to “Spare Parts” in the service manual.

1. Disconnect the temperature sensor cable from the SI board (Figure 7.6, ⑥).
2. Use a Torx T10 screwdriver to remove the screw (Figure 7.3, ⑦) attaching the temperature sensor board to the transmitter module.
3. Fitting is carried out in reverse order.

7.11 Final Reassembly

1. Ensure all internal cables are connected correctly as shown below.
2. Place the tray cover onto the chassis.
3. Use a Torx T10 torque-driver to fasten the tray cover with the 15 countersunk screws to 4.5 lb·in (0.5 N·m).
4. Fit the fuse ① at the rear of the Multitone paging transmitter.

Figure 7.9 Final reassembly



8 Servicing Procedures

This section gives the full sequence of tasks required when servicing this Multitone paging transmitter. These tasks fall into the following categories:

- Initial tasks: initial administration, visual inspection and fault diagnosis
- Final tasks: repair, final inspection, test and administration

For disassembly and reassembly instructions, refer to “Disassembly and Reassembly” on page 121.

Note The UI, SI, Paging Interface and EMC filter boards are not serviceable items.

8.1 Initial Tasks

List of Tasks

The following tasks need to be carried out:

- initial administration
- visual inspection
- power up the Multitone paging transmitter
- read the programming files
- read the calibration files
- check any error messages.
- check the transmit power and frequency
- check the transmit deviation and audio distortion
- check the transmitter module
- check the user interface
- check the fans

Important Observe the “General Information” on page 73.

Task 1 — Initial Administration

When a Multitone paging transmitter is received for repair, details of the Customer and the fault will be recorded in a fault database. The fault reported by the Customer might concern damage to or loss of a mechanical part, or the failure of a function, or both.

Task 2 — Visual Inspection

Check the Multitone paging transmitter for mechanical loss or damage, even if the fault concerns a function failure only. Inspect the Multitone paging transmitter as follows:

- fuse
- ventilation (refer to the installation and operation manual)
- tray and mounting brackets
- knob for volume-control potentiometer
- missing function buttons

If the Multitone paging transmitter is reported to have a functional fault, continue with Task 3. If the Multitone paging transmitter has no functional fault, repair any mechanical damage; conclude with the tasks of “Final Tasks” on page 141.

Task 3 — Power Up the Base Station

With the Multitone paging transmitter linked as a Line Controlled Multitone paging transmitter and connected to the test equipment as described in “Setting up the Test Equipment” on page 103, attempt to power up the Multitone paging transmitter following the steps below.

Note The TX switch position is tested first because the UI board is powered from the paging interface board. If the paging interface board is faulty and does not power up then there will be no indication that the transmitter module has powered up correctly.

If during these tests the LCD indicates that the module has powered up but fails to enter user-mode or displays an error code, the module is faulty. Refer to Table 8.1 on page 136.

If the LCD indicates that the transmitter module keeps resetting itself, check the voltage at the power connector on the module. If the voltage is correct, check the module’s power-sensing circuitry. If the voltage is not correct, replace the SI board and return to Step 2.

1. Before turning on the Multitone paging transmitter, check that:
   - all looms and cables at the front and rear of the Multitone paging transmitter and the links are fitted correctly
   - all connectors are secure
   - the 15A fuse is fitted.

Check Transmitter Function

2. Switch the TX/RX switch to the TX position and check that the Multitone paging transmitter powers up correctly.
   - The LCD indicates the current channel number.

   If the transmitter module powers up successfully, go to Task 4. If it does not, go to Step 3.

Check the Transmitter Power Supply

3. Check whether there is power at the DC power connector of the transmitter module. If there is, go to Step 5.

4. Check whether there is power at the DC power output connector to the transmitter on the SI board (J103). If there is, replace the

transmitter power cable and return to Step 2. If not, replace the SI board and return to Step 2.

5. Check whether the UI board and cable or the transmitter module is faulty by connecting a UI board and cable to the paging interface and transmitter.

Note **Both** UI cables (to the transmitter and the paging interface) need to be connected, and ensure the TX/RX switch is set to TX.

Tip Instead of the spare UI board, a TMAC20-0T control head can be connected to the transmitter module only.

6. If the transmitter module is faulty, go to “Power Supply Fault Finding” on page 155. Then return to Step 2.

Task 4 — Read the Programming File

Given that the Multitone paging transmitter powers up, the next task is to use the programming application to read the programming files of the transmitter modules and save the customer data. If the programming file can be read but is corrupted, upload a default file.

Note Many problems can be caused by the customer incorrectly programming the Multitone paging transmitter. Once the customer’s programming file has been read and saved load a default file that is known to work for the testing. If the Multitone paging transmitter works correctly with the default file then load the customer’s file and retest. If it no longer works Multitone paging transmitter has been programmed incorrectly.

1. Switch the TX/RX switch to the TX position and read the programming file.

2. If the programming file can be read, save a copy on the test PC before going to Step 3.

3. If the programming file could be read, load default test file to the transmitter module and go to Task 5.

4. If the programming file could not be read, go to Step 7

None of the Modules Could be Read

5. Check whether:
   - the Multitone paging transmitter is connected to the correct serial port of the test PC,
   - the programming application is set-up correctly. Refer to the troubleshooting section of the online help.

6. If the programming file can now be read, return to Step 1. If not, go to Step 7.

One of the Modules Could Not be Read

7. Switch the TX/RX switch to the correct position.

8. Cycle the power to the Multitone paging transmitter and immediately attempt to read the file. First cycling the power is

essential if the module is programmed to power up in transparent-data mode (both 1200 baud FFSK and Tait high-speed data) and if the selected data port is the microphone connector. Using the microphone as the transparent-mode data port is not a valid Multitone paging transmitter configuration.

9. If the module can now be read, reprogram the data port to Aux and return to Step 1 (transmitter). If not, go to Step 10.

Note Reprogramming the data port to Aux will make further programming easier. However, it is important to confirm with the customer whether this configuration is acceptable before returning the Multitone paging transmitter.

10. Check whether the UI board and cables or the transmitter module is faulty by connecting a spare UI board and cables to the transmitter.

Note When checking the transmitter module, both UI cables need to be connected.

Tip Instead of the spare UI board, a TMAC20-0T control head can be connected to the module.

11. If the module can now be read, return to Step 1 (transmitter). If not, go to Step 12.

12. Replace the transmitter module, load a default file, verify that the module can be read and return to Step 1 (transmitter).

Task 5 — Read the Calibration File

Use the calibration application to read the calibration files of the transmitter module and save it on the test PC. If the calibration file cannot be read, set up a suitable default calibration file and load it to the Multitone paging transmitter.

Note Loading a default calibration file into a module will allow fault basic tracing to take place. However once the faults are repaired the module must be correctly calibrated using the calibration application before being sent back to the customer.

Task 6 — Check Error Messages

The Multitone paging transmitter may display an error message. Carry out the corrective actions described in Table 8.1.

Table 8.1 Error messages

Error message	Corrective action
E1 (error 1)	Turn the Multitone paging transmitter off and then back on. If the error persists, read the last system error using CCTM command 204.
E2 (error 2)	
OL (out of lock)	Go to “Frequency Synthesizer Fault Finding” on page 169.

Task 7 — Check Tx Power and Frequency

This task only needs to be carried out if it relates to the fault reported or if the reported fault is not sufficiently specific to identify the faulty module.

Caution **Observe the servicing precautions for the transmitter listed in "Transmitter Issues" on page 101.**

1. Set up the test set to measure frequency and power level.
2. Activate the TX KEY switch on the CTU. (After completing the measurement, deactivate the TX KEY switch.)
3. If the transmitter keys up and the measured power level and frequency match the programmed settings (within the expected accuracy of the test set and taking into account cable losses), go to Step 6. If it does not, go to Step 4.
4. If the transmitter does not key up, check whether the SI board and cable or the transmitter module is faulty by connecting a spare transmitter module. If the transmitter keys up but the power level or frequency is incorrect, go to Task 9.

Tip It is not required to remove the original transmitter module from the tray chassis. Just unplug the connectors.

5. If the transmitter keys up now, the original transmitter module is faulty. Reconnect the original transmitter module and go to Task 9. Then continue with Step 6.
6. Connect a fist microphone to the PROG/MIC connector and press the PTT key.
7. If the transmitter keys up and the measured power level and frequency match the programmed settings (within the expected accuracy of the test set and taking into account cable losses), go to Step 10. If it does not, go to Step 8.
8. If the transmitter does not key up, check whether the UI board and cable or the transmitter module is faulty by connecting a spare UI board and cable to the transmitter. If the transmitter keys up but the power level or frequency is incorrect, go to Task 9.

Note When checking the transmitter module, both UI cables need to be connected.

Tip Instead of the spare UI board, a TMAC20-0T control head can be connected to the module.

9. If the transmitter does not key up, the original transmitter module is faulty. Reconnect the original UI board and cable and go to Task 9. Then continue with Step 10.
10. Activate the TX KEY switch on the CTU or the PTT key on the fist microphone. The TX LED should light up.
11. If the TX LED does not light up, replace the UI board.

Task 8 — Check Transmit Deviation and Audio Distortion

This task only needs to be carried out if it relates to the fault reported or if the reported fault is not sufficiently specific to identify the faulty module.

Caution **Observe the servicing precautions for the transmitter listed in “Transmitter Issues” on page 101.**

1. Connect the audio output from the test set to the Line Input on the CTU.
2. Set up the modulation analyser in the test set to measure the distortion and deviation of the modulated audio signal.
3. Set up the test set audio generator output to be 1kHz and at the level required by the customer’s system to produce 60% full system deviation (providing this is within the specified limits of the Multitone paging transmitter).
4. Activate the TX KEY switch and verify that the measured deviation is 60% of full system deviation and that the measured distortion level is within the transmitter specifications as detailed in the specifications manual.
5. If the measured value agrees with the programmed settings, go to Step 8, If it does not, attempt to complete the required transmitter audio level adjustment as described in the installation and operation manual.
6. If this rectifies the fault, go to Step 8. If it does not, check whether the SI board and cable or the transmitter module is faulty by connecting a spare transmitter module.

Tip It is not required to remove the original transmitter board from the tray chassis. Just unplug the connectors.

7. If this rectifies the fault, the original transmitter module is faulty. Reconnect the original transmitter module and go to Task 9. Then continue with Step 8.
8. Repeat from Step 1 using the Unbalanced Line Input.
9. Connect a fist microphone to the PROG/MIC connector, and whistle into the microphone while pressing the PTT key. Verify whether close to full system deviation is measured.

Note For a more accurate measurement, the TOPA-SV-024 test unit can be used to connect the microphone input of the Multitone paging transmitter to an audio source.

10. If the deviation is correct, go to Step 12. If there is no deviation or very low deviation, check whether the UI board and cable or the transmitter module is faulty by connecting a spare UI board and cables to the transmitter.

Note Ensure the Tx/Rx switch of the spare UI board is set to Tx. When checking the transmitter module, **both** UI cables need to be connected.

Tip Instead of the spare UI board, a TMAC20-0T control head can be connected to module.

11. If this rectifies the fault, go to Step 12. If it does not, go to Task 9. Return to Step 9.

12. If the reported fault was only with the transmitter and has now been repaired, go to “Final Tasks” on page 141.

Task 9 — Check the Transmitter Module

If the fault is with the transmitter module, this can be caused by:

- the synthesizer not being in lock
- no or wrong carrier power
- no modulation

If the cause is already known, go directly to the relevant fault-finding section.

Caution **Observe the servicing precautions for the transmitter listed in “Transmitter Issues” on page 101.**

Synthesizer Out of Lock

1. Use CCTM command *101 x y 0* to set the transmit frequency to the bottom of the band.

2. Use CCTM command *33* to set the Multitone paging transmitter to transmit mode.

3. Use CCTM command *72* to read the lock status.

4. If the synthesizer is in lock, go to Step 5. If the synthesizer is not in lock, repair the transmitter module as described in “Frequency Synthesizer Fault Finding” on page 169.

5. Repeat Step 1 to Step 3 with the transmit frequency set to the top of the band

No or Wrong Carrier Power

6. Use CCTM command *326 1* to set the power level to very low.

7. Connect a power meter and measure the transmit power.

8. If the carrier power is correct, go to Step 10. If the carrier power is not correct, try to re-calibrate the transmitter module.

9. If the re-calibration does not repair the fault, repair the transmitter module as described in “Transmitter Fault Finding (40 W / 50 W)” on page 271 and “Transmitter Fault Finding (25 W)” on page 217.

10. Repeat Step 7 to Step 9 with the power level set to high (*326 4*).

No Modulation

11. If the Multitone paging transmitter transmits, the synthesizer and transmitter circuitry are operating correctly. Repair the transmitter module as described in “CODEC and Audio Fault Finding” on page 335.

Task 10 — Check the User Interface

This task only needs to be carried out if it relates to the fault reported or if the reported fault is not sufficiently specific to identify the faulty module.

12. Use the programming application to view the functions assigned to the function keys and whether LCD backlighting is turned on or off.

Note Faults of the LCD, TX LED, BUSY LED, can also be caused by the transmitter module. Refer to the relevant tasks in this section.

13. Check the user interface for any of the following faults:
    - LCD (with the TX/RX switch in both positions)
    - function key LEDs
    - function keys
    - TX LED (go to Task 7)

14. Replace the UI board, if necessary.

Task 11 — Check the Fans

These tests assume that Tasks 1 to 5 were successful.

1. Set the jumpers on the SI board to match the settings below.
    - J206 = 2-3

2. Check that both fans turn on. If they do, go to Step 4. If one fan turns on, go to Step 3. If no fans turn on, check that there is 12V between pins 1 and 2 of J201. If not, replace the SI board.

3. Check for 12VDC between pins 1 and 2 on all connectors on the fan power board. If there is, replace the faulty fan(s). If not, replace the fan power board.

4. Set the jumpers on the SI board to match the settings below.
    - J206 = 1-2
    - J207 = 1-2

5. With the transmitter module connected to a suitable load, check that fans activate only when the TX Key line is activated.

6. If they do, go to Step 7. If not, replace the SI board.

7. Set the jumpers on the SI board to match the settings below.
    - J206 = 1-2
    - J207 = 2-3

8. Attempt to turn RV200 clockwise until the fans turn on and then anticlockwise until fans just turn off. If successful, go to Step 10.
If not, go to Step 9

9. Connect a spare temperature sensor and repeat Step 8. If the fault is still present, replace the SI board.

10. Use a hot air tool to gently heat the temperature sensor. If the fans turn on, the temperature sensor and fans are operating correctly. Reset RV200 to the correct turn-on temperature. If the fans do not turn on, replace the temperature sensor and repeat from Step 8.

8.2 Final Tasks

List of Tasks

The following tasks need to be carried out for **all** Multitone paging transmitters:

- repair
- final test
- final administration

Task 1 — Repair

The fault diagnosis will have resulted in the repair or replacement of a module. This section describes the steps after completion of the fault diagnosis:

1. If the transmitter module has been replaced, level-1 service centres should return the faulty module to the nearest ASC, and level-2 service centres should return the module to the ISC, if deemed necessary. Supply details of the fault and, if applicable, the attempted repair. (The replacement module will have been factory-calibrated.) Go to Step 5.

2. If the transmitter module has **not** been replaced, but was repaired then replace any cans removed and reinstall the module into the Multitone paging transmitter.

3. Reconnect the module to the test equipment and re-calibrate the module. Refer to the online help of the calibration application.

4. Use the programming and application to load the programming and files read or set-up in “Initial Tasks”.

5. Use the calibration application to load the calibration files read or set-up in “Initial Tasks”.

Note If the Multitone paging transmitter had to be reprogrammed with a **default** programming file, the following additional actions are required:

- If the Multitone paging transmitter is to be returned direct to a Customer who has **no** programming facilities, the appropriate programming file needs to be obtained and uploaded (or the data obtained to create the file).
- If the Multitone paging transmitter is to be returned to a Dealer

or direct to a Customer who does have programming facilities, the Dealer or Customer respectively need to be informed so that they can program the Multitone paging transmitter appropriately.

- If the fault was with the customer's data file, the customer needs to be informed of this and the changes that were made.

6. Test the Multitone paging transmitter as described in "Final Test" on page 142. It may be necessary to also carry out the audio level adjustments as described in the installation and operation manual.

Task 2 — Final Test

Test the Multitone paging transmitter to confirm that it is fully functional again. The recommended tests are listed in Figure 8.1. It is good practice to record the test results on a separate test sheet. A copy of the test sheet can be supplied to the Customer as confirmation of the repair.

Task 3 — Final Administration

The final administration tasks are the standard workshop procedures for updating the fault database and returning the repaired Multitone paging transmitter to the Customer with confirmation of the repair.

If the Multitone paging transmitter could not be repaired for one of the following reasons:

- fault not located
- repair of fault failed
- required repair is level-3 repair

Level-1 service centres should return the faulty Multitone paging transmitter to the nearest ASC, and level-2 service centres should return the Multitone paging transmitter to the ISC. Supply details of the Customer, the fault and, if applicable, the attempted repair.

Figure 8.1 Test sheet

TB7000 base stations

TB7100 Base Station - Single Channel Test Sheet

TAIT radio communications

Product Code: TBB_________-_________-________

Serial Number: ________________

Job Number: _________________

Test Set-up Details	
Test Equipment	HP8920
Test Equipment S/N	ID _ _ _ _
Programming App version	
Tx Configuration file	

Module details	Product code	DB Version	Serial number	F/W version	H/W version
TX Board					
SI Board					
UI Board					
Power Supply					

TX Frequency	Deviation @ TD (W/B Limit =3 ± 0.25 kHz) Pre-Emph, Balanced I/P	Tx Power * Refer to limits
MHz	KHz	W
Audio Distortion (<3%)	Balanced @ TD	________%
Limiter (4.0 kHz to 5.0 kHz)	Max. deviation	________kHz
(20dB step balanced input)	@ audio freq.	________kHz
Unbalanced deviation @ TD, 1Vpp I/P level_ (3 kHz ± 0.25 kHz)		________kHz
Microphone deviation (whistle) (4.4 kHz ± 0.4 kHz)		________kHz

Power Supply

Input power type: DC ☐

*Transmit power limits	
TBBxxxx – Axxx	=25W (21-32W)
TBBxxxx – Bxxx	=40W (33-50W)
TBBxxB1 – Bxx	=50W (42-65W)

Comments

Rack frame

Fan operation @40°C (J222=1.40V)	OK ☐
F1, F2, F3, F4 keys	OK ☐
LED functionality	OK ☐
Digital I/P & LCD RX	OK ☐
Digital I/P & LCD TX	OK ☐
Digital O/P RX	OK ☐
Digital O/P TX	OK ☐
TOI (Links w401, w402); Default =disabled	OK ☐
THSD testing	OK ☐
TTR (J400p2-3, J503p1-2, J502p2-3)	OK ☐

Final Configuration		
	Default SW configuration loaded	OK ☐
	Default HW links set (TTR defaults- ref KPI7001)	OK ☐

Test sheet completed by: ______________________ Date: ____________

Assembled by: ______________________ Date: ____________

Notes

1. All performance tests are at TF unless otherwise stated.
2. Software settings on next page used to generate test results.

Test tone settings

TL RF Test Level = -70dBm, 1kHz modulation @ 60% max deviation.

TD RF Test Deviation = 60% max, 1kHz test tone.

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9 Paging Interface PBA

9.1 The XA2731-01-PBA

The XA2731-01-PBA intercepts several signals that pass between the transmitter module and the SIF of a Multitone paging transmitter. These signals are passed to and from a rear connector via the XA2235-02-PCB EMC filter board.

9.2 Parts List

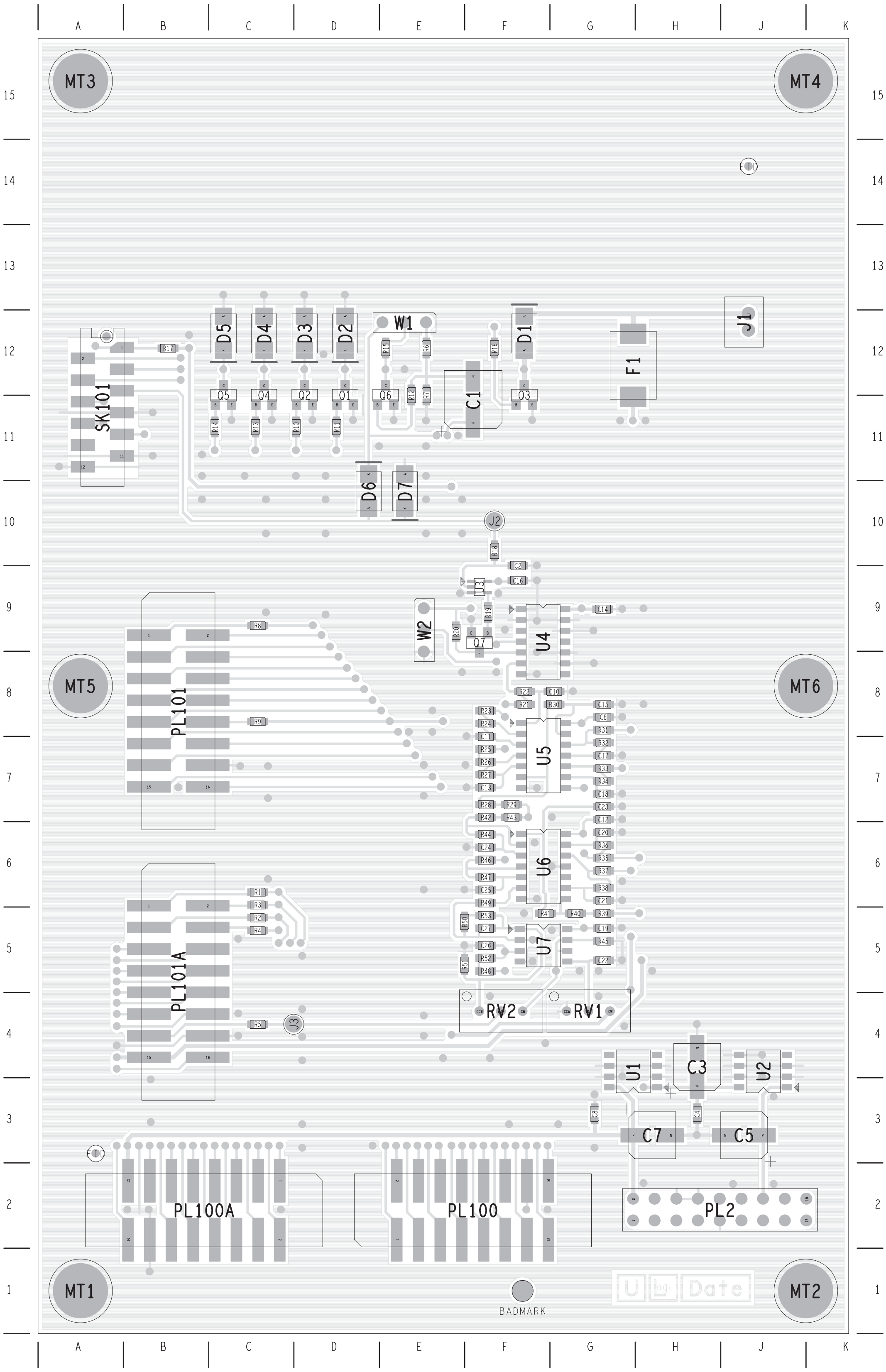
XA2731-01-PBA Rev 004 Board (PCB IPN 228-27311-01)

Part	IPN	Description	Layout	Circuit
	228-27311-01	PCB TA2731-01 Multi Tone Paging		
C1	016-09100-03	CAP eltro 100u 16V 20%	F11	1E9
C2	018-14101-00	CAP 1n 50V NPO ±5% 0603	F10	2F2
C3	016-08100-03	CAP eltro 10uF 35V 105× 2000h	H4	1F2
C4	018-16100-00	CAP 100n 16V ±10% 0603 X7R	H3	1F3
C5	016-08100-03	CAP eltro 10uF 35V 105× 2000h	J3	1F4
C6	018-16100-00	CAP 100n 16V ±10% 0603 X7R	G8	2B4
C7	016-08100-03	CAP eltro 10uF 35V 105× 2000h	H3	1F1
C8	018-16100-00	CAP 100n 16V ±10% 0603 X7R	G3	1F1
C10	018-14101-00	CAP 1n 50V NPO ±5% 0603	G8	2F4
C11	018-14101-00	CAP 1n 50V NPO ±5% 0603	F8	2F5
C12	018-16100-00	CAP 100n 16V ±10% 0603 X7R	G7	2B5
C13	018-14101-00	CAP 1n 50V NPO ±5% 0603	F7	2F6
C14	018-16100-00	CAP 100n 16V ±10% 0603 X7R	G9	2B3
C15	018-14101-00	CAP 1n 50V NPO ±5% 0603	G8	2F7
C16	018-16100-00	CAP 100n 16V ±10% 0603 X7R	F9	2B2
C17	018-14101-00	CAP 1n 50V NPO ±5% 0603	G7	2F7
C18	018-14101-00	CAP 1n 50V NPO ±5% 0603	G7	2F8
C19	018-16100-00	CAP 100n 16V ±10% 0603 X7R	G5	2B6
C20	018-14101-00	CAP 1n 50V NPO ±5% 0603	G6	2F9
C21	018-14101-00	CAP 1n 50V NPO ±5% 0603	G6	2F10
C22	018-14101-00	CAP 1n 50V NPO ±5% 0603	G5	2J10
C23	018-14101-00	CAP 1n 50V NPO ±5% 0603	G7	2F11
C24	018-14101-00	CAP 1n 50V NPO ±5% 0603	F6	2F11
C25	018-14101-00	CAP 1n 50V NPO ±5% 0603	F6	2F12
C26	018-14101-00	CAP 1n 50V NPO ±5% 0603	F5	2G12
C27	018-14101-00	CAP 1n 50V NPO ±5% 0603	F5	2F13
D1	001-10011-74	DIODE MRA4004T3 1A/400V	F12	1H10
D2	001-10010-40	DIODE BZG03C33V 3W Zen SOD106	D12	1G11
D3	001-10010-40	DIODE BZG03C33V 3W Zen SOD106	D12	1F11
D4	001-10010-40	DIODE BZG03C33V 3W Zen SOD106	C12	1E11
D5	001-10010-40	DIODE BZG03C33V 3W Zen SOD106	C12	1D11

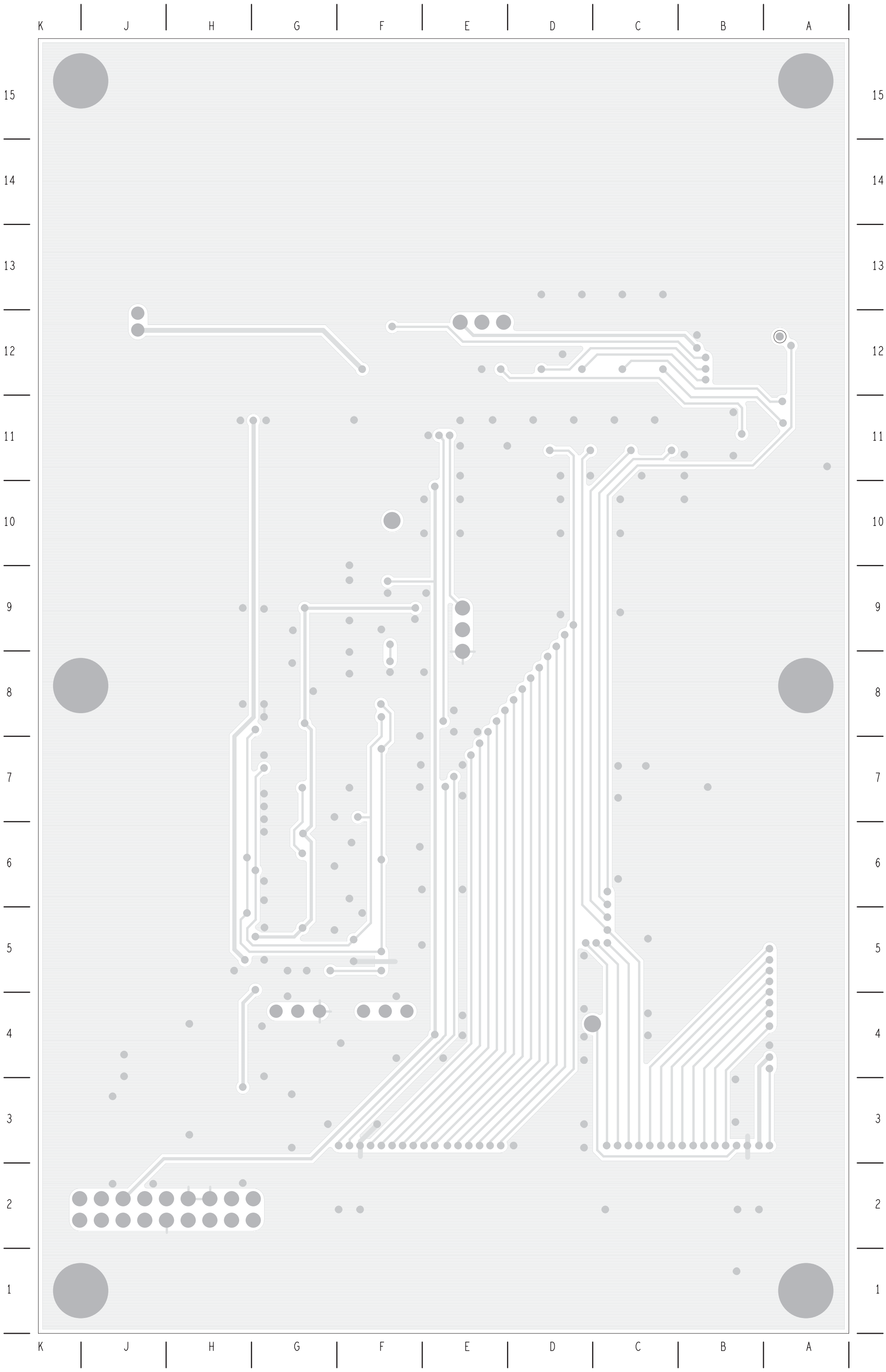
Part	IPN	Description	Layout	Circuit
D6	001-10011-74	DIODE MRA4004T3 1A/400V	D10	1F13
D7	001-10011-74	DIODE MRA4004T3 1A/400V	E10	1E13
F1	265-10055-00	FUSE 0.3A Reset SMD030-2	G12	1H10
J1	240-00011-50	CONN 2wy 2mm vert PCB mtg	J12	1H10
J2		Test point	F10	2G2
J3		Test point	D4	2F14
PL100	240-10000-19	CONN 16wy plg 0.1mm SMD	F2	1J1
PL100A	240-10000-19	CONN 16wy plg 0.1mm SMD	B2	1C1
PL101	240-10000-19	CONN 16wy plg 0.1mm SMD	B8	1J10
PL101A	240-10000-19	CONN 16wy plg 0.1mm SMD	B5	1C10
PL2	240-00021-41	HDR 18wy 2row pin 2.54mm str	G2	1F4
Q1	000-10008-17	XSTR SMD BC817-25 NPN SOT23	D12	1G11
Q2	000-10008-17	XSTR SMD BC817-25 NPN SOT23	D12	1F11
Q3	000-10008-17	XSTR SMD BC817-25 NPN SOT23	F12	1G11
Q4	000-10008-17	XSTR SMD BC817-25 NPN SOT23	C12	1E11
Q5	000-10008-17	XSTR SMD BC817-25 NPN SOT23	C12	1D11
Q6	000-10008-17	XSTR SMD BC817-25 NPN SOT23	E12	1E10
Q7	000-10008-17	XSTR SMD BC817-25 NPN SOT23	F9	2G3
R1	DNI		C6	1D9
R2	DNI		C5	1D9
R3	DNI		C6	1D9
R4	DNI		C5	1D9
R5	DNI		C4	1C9
R6	038-15180-10	RES 0603 18K 1% 1/10W	E12	1E10
R7	038-15100-10	RES 0603 10k 1% 1/10W	E12	1E10
R8	DNI		C9	1K9
R9	DNI		C8	1J9
R10	038-15100-10	RES 0603 10k 1% 1/10W	D11	1F10
R11	038-15100-10	RES 0603 10k 1% 1/10W	D11	1G10
R12	038-15100-10	RES 0603 10k 1% 1/10W	E12	1E10
R13	038-15100-10	RES 0603 10k 1% 1/10W	C11	1E10
R14	038-15100-10	RES 0603 10k 1% 1/10W	C11	1D10
R15	038-15100-10	RES 0603 10k 1% 1/10W	E12	1F10
R16	038-13390-10	RES 0603 390R 1% 1/10W	F12	1G11
R17	038-15100-10	RES 0603 10k 1% 1/10W	B12	1H12
R18	038-13100-10	RES 0603 100R 1% 1/10W	F10	2G2
R19	038-14100-10	RES 0603 1k0 1% 1/10W	F9	2G3
R20	038-16100-10	RES 0603 100k 1% 1/10W	E9	2G3
R21	038-16560-00	RES 0603 560k 5% 1/10W	F8	2G4
R22	038-15180-10	RES 0603 18k 1% 1/10W	F8	2G4
R23	038-16270-10	RES 0603 270k 1% 1/10W	F8	2F5
R24	038-15180-10	RES 0603 18k 1% 1/10W	F8	2G5
R25	038-16150-10	RES 0603 150k 1% 1/10W	F7	2G6
R26	038-15100-10	RES 0603 10k 1% 1/10W	F7	2G6
R27	038-15180-10	RES 0603 18k 1% 1/10W	F7	2G6
R28	038-16100-10	RES 0603 100k 1% 1/10W	F7	2F6
R29	038-15100-10	RES 0603 10k 1% 1/10W	F7	2F6
R30	038-15180-10	RES 0603 18k 1% 1/10W	G8	2G6
R31	038-15820-10	RES 0603 82k 1% 1/10W	G8	2G7
R32	038-15180-10	RES 0603 18k 1% 1/10W	G7	2G7
R33	038-15680-10	RES 0603 68k1 1% 1/10W	G7	2F8

Part	IPN	Description	Layout	Circuit
R34	038-15180-10	RES 0603 18k 1% 1/10W	G7	2G8
R35	038-15680-10	RES 0603 68k1 1% 1/10W	G6	2G9
R36	038-15180-10	RES 0603 18k 1% 1/10W	G6	2G9
R37	038-15820-10	RES 0603 82k 1% 1/10W	G6	2F10
R38	038-15180-10	RES 0603 18k 1% 1/10W	G6	2G10
R39	038-15100-10	RES 0603 10k 1% 1/10W	G5	2G10
R40	038-16100-10	RES 0603 100k 1% 1/10W	G5	2G10
R41	038-15180-10	RES 0603 18k 1% 1/10W	F5	2G10
R42	038-16150-10	RES 0603 150k 1% 1/10W	F7	2F11
R43	038-15100-10	RES 0603 10k 1% 1/10W	F7	2F11
R44	038-15180-10	RES 0603 18k 1% 1/10W	F6	2G11
R45	038-14100-10	RES 0603 1k0 1% 1/10W	G5	2J12
R46	038-16270-10	RES 0603 270k 1% 1/10W	F6	2G12
R47	038-15180-10	RES 0603 18k 1% 1/10W	F6	2G12
R48	038-14390-10	RES 0603 3k9 1% 1/10W	F5	2H12
R49	038-16560-00	RES 0603 560k 5% 1/10W	F6	2F12
R50	038-14390-10	RES 0603 3k9 1% 1/10W	F5	2F13
R51	038-15100-10	RES 0603 10k 1% 1/10W	F5	2F13
R52	038-13390-10	RES 0603 390R 1% 1/10W	F5	2H12
R53	038-13390-10	RES 0603 390R 1% 1/10W	F5	2F13
RV1	044-06100-08	RES pre 100k 25T Flat	G4	2J10
RV2	044-05100-08	RES pre 10k 25T Flat	F4	2G14
SK101	240-10000-06	CONN 12wy 2row skt M/M SMD	A11	1F13
U1	002-10078-05	IC 78L05 5V rgltr SO8	G4	1G2
U2	002-14931-00	IC L4931CD33 3.3V 250mA rgltr	J4	1F3
U3	002-74910-41	IC 74V1G04 inv SC70	F9	2G2 2B2
U4	002-74900-86	IC 74HC86 quad excl OR SO14	F9	2C10 2B3 2B10 2G4
U5	002-10074-14	IC 74HC14 hex inv SOT14	F7	2G8 2G7 2G6 2G5 2G9 2B4
U6	002-10074-14	IC 74HC14 hex inv SOT14	F6	2B5 2G11 2G10 2G9 2C10 2G12
U7	002-19120-00	IC TS912ID CMOS R2R OP-amp	F5	2G13 2B6 2J11
W1	240-00020-59	HDR 3wy 1row PCB mtg	E12	1F10
W2	240-00020-59	HDR 3wy 1row PCB mtg	E9	2G4
W1.1	240-04020-62	SKT 2wy 0.1" rcpt shorting lnk		
W2.1	240-04020-62	SKT 2wy 0.1" rcpt shorting lnk		

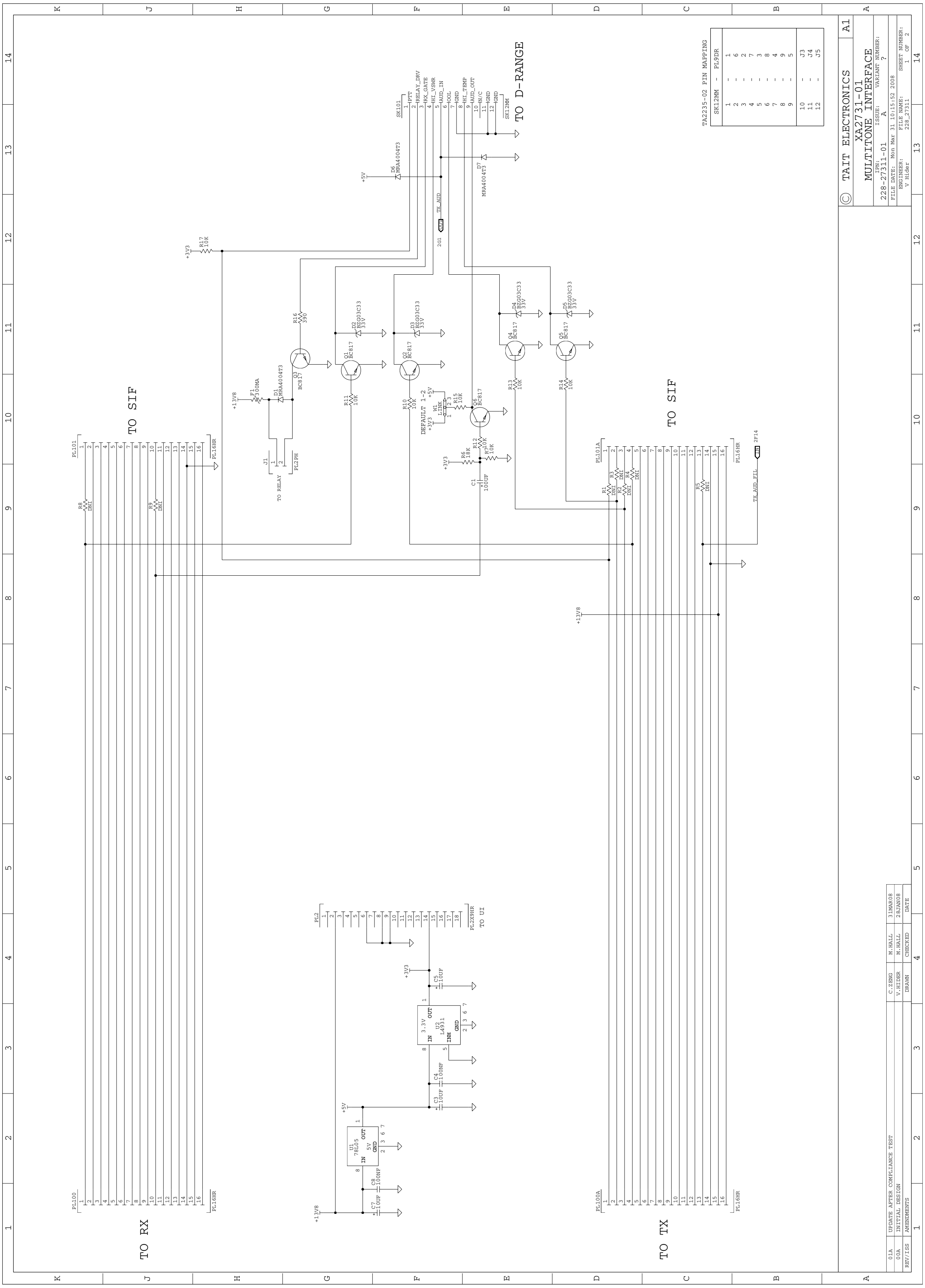
9.3 Paging Interface Board Layout (top side)



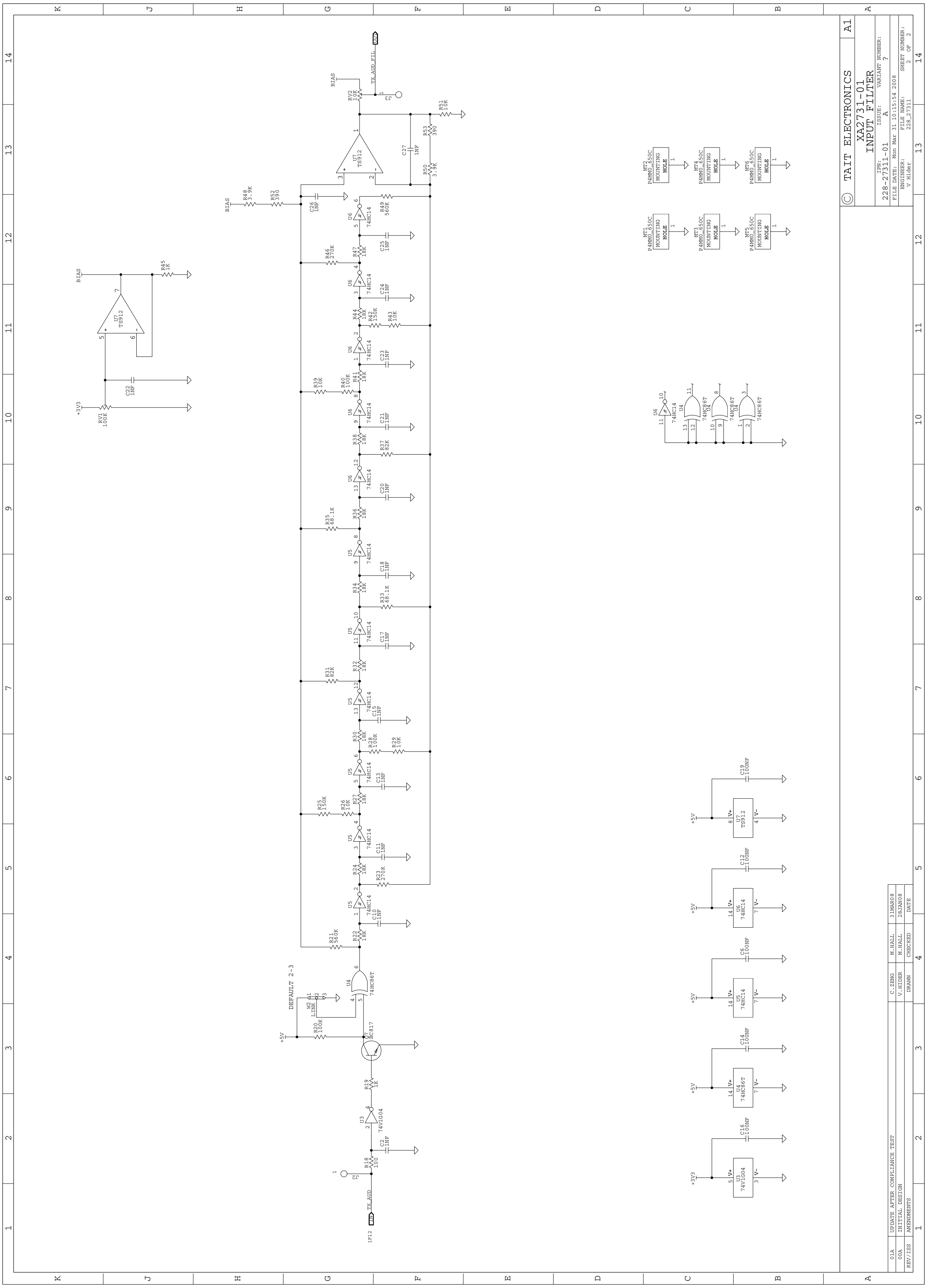
9.4 Paging Interface Board Layout (bottom side)



9.5 Paging Interface Board Circuit Diagram (1 of 2)



9.6 Paging Interface Board Circuit Diagram (2 of 2)



10 Power Supply Fault Finding

Fault-Diagnosis Tasks

Fault diagnosis of the power-supply circuitry is divided into the following tasks:

- Task 1: check inputs to SMPS
- Task 2: check 3.3V supply
- Task 3: check linear regulators (for 2.5V, 3V, 6V and 9V supplies)
- Task 4: check power-up configuration
- Task 5: check power-up options
- Task 6: check provision of external power.

Types of Fault

Which of the above tasks are applicable depends on the nature of the fault:

- Radio fails to power up: The radio fails to power up immediately when power is applied, or it fails to power up when power is applied and the ON/OFF key is pressed. Carry out Task 1 to Task 3
- Power-up option has failed: The radio powers up when the ON/OFF key is pressed, but not for a power-up option for which it is configured. Carry out Task 4 and Task 5.
- External power at connector has failed: The external power required at a particular connector is no longer present. Carry out Task 6.

Task 1 — Check Inputs to SMPS

The test equipment and radio should be set up as described in “Setting up the Test Equipment” on page 103. If not already done, remove the board. Connect the control head to the assembly. Then check the SMPS as follows:

1. Use a multimeter to check the supply voltage at pin 7 of **IC602** (see **Figure 10.1**) in the SMPS circuitry; the voltage should be:

pin 7 of IC602: 13.8 V DC

   If it is, go to Step 5. If it is not, go to Step 2.

2. Disconnect the 13.8V supply at the power connector PL100. Check for continuity and shorts to ground in the path between the power connector **PL100** and pin 7 of **IC602** (see **Figure 10.1**). Locate and repair the fault.

3. Reconnect the 13.8V supply. Confirm the removal of the fault by measuring the voltage at pin 7 of **IC602**. If the voltage is correct, continue with Step 4. If it is not, the repair failed; replace the board and go to “Final Tasks” on page 141.

4. Press the ON/OFF key. If the radio powers up, return to “Initial Tasks” on page 133. If it does not, go to Step 5.

5. Check the digital power-up signal at pin 5 of **IC602** (see **Figure 10.1**); the signal is active high, namely, when the voltage exceeds 2.0V DC. Measure the voltage at pin 5.

pin 5 of IC602: more than 2.0 V DC

   If it exceeds 2.0V, go to Task 2. If it does not, go to Step 6.

6. Keep the probe of the multimeter on pin 5 of **IC602** and press the ON/OFF key. The voltage should exceed 2.0V DC while the key is depressed. If it does, go to Task 2. If it does not, go to Step 7.

7. Disconnect the 13.8V supply at the power connector PL100. Check for continuity and shorts to ground in the path from pin 5 of **IC602**, via **R600** and via **Q709** in the interface circuitry (see Figure 11.4), to pin 9 of the control-head connector **SK100** (ITF PSU ON OFF line). Locate and repair the fault. Go to Step 8.

8. Reconnect the 13.8V supply. Press the ON/OFF key. If the radio powers up, return to “Initial Tasks” on page 133. If it does not, go to Step 9.

9. With the probe of the multimeter on pin 5 of **IC602** (see Figure 10.1), press the ON/OFF key again. The voltage should exceed 2.0V DC while the key is depressed. If it does, go to Task 2. If it does not, the repair failed; replace the board and go to “Final Tasks” on page 141.

Figure 10.1 Important components of the power-supply circuitry (bottom side), including 3.3V regulator IC602

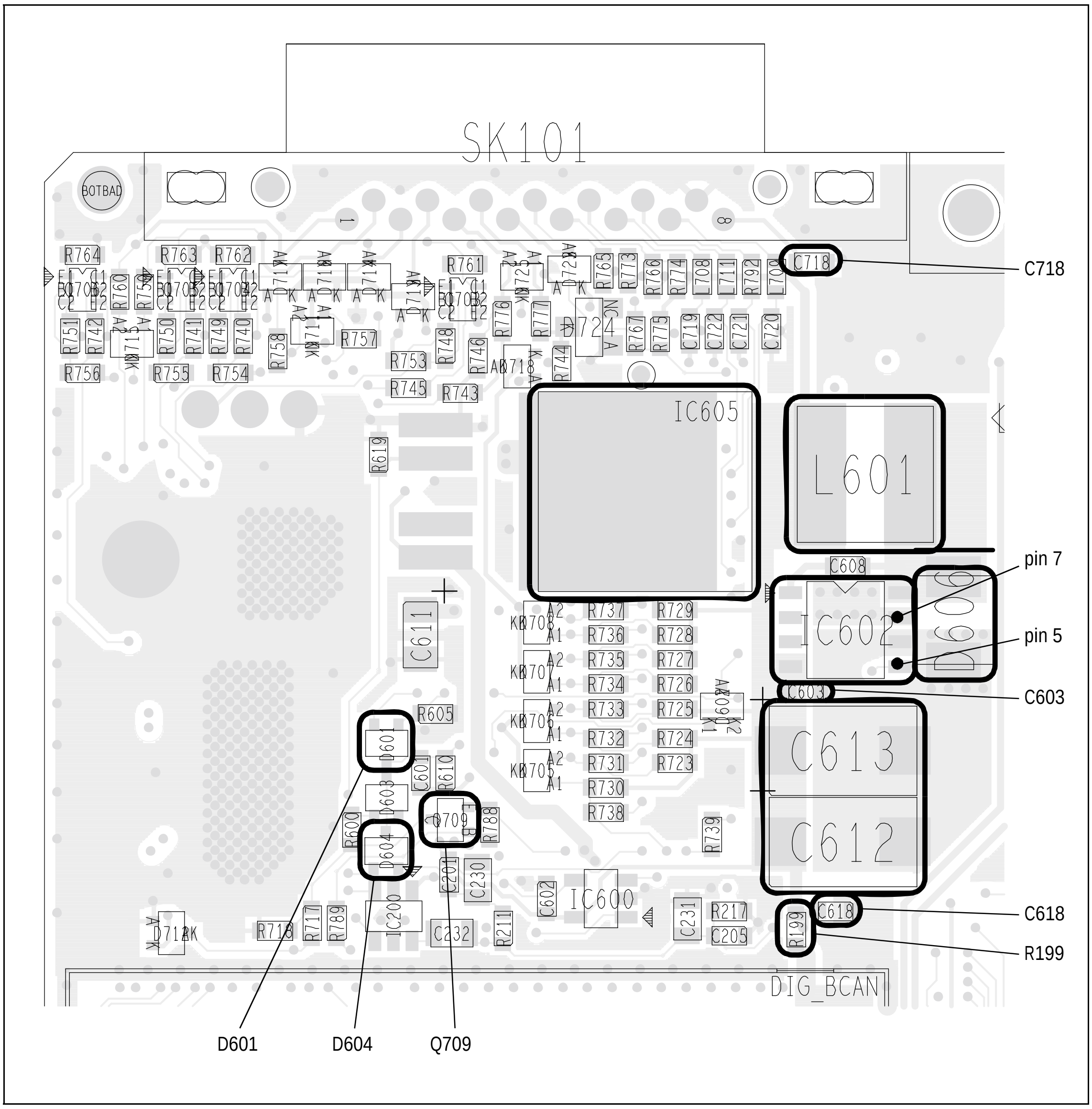
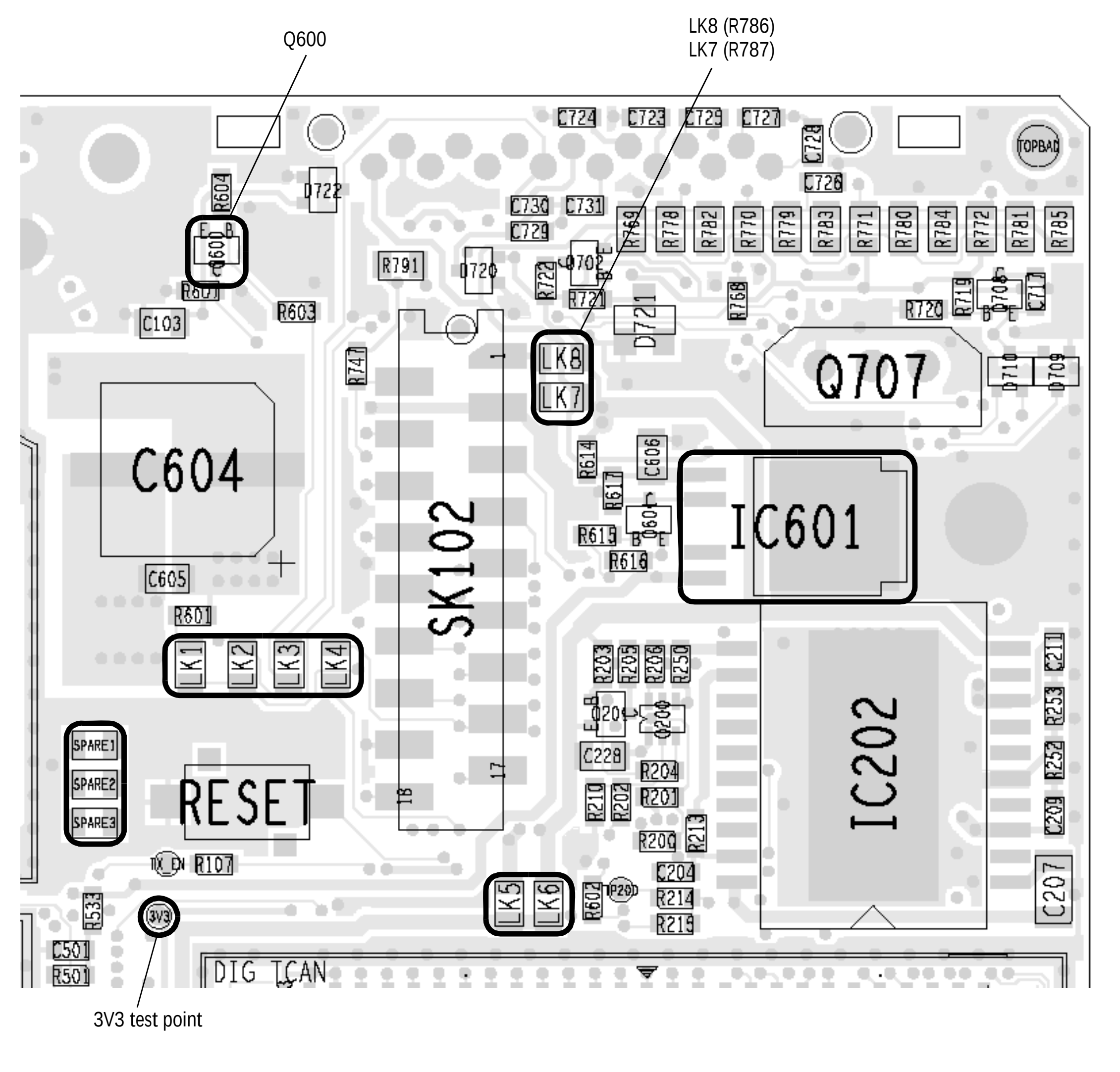


Figure 10.2 Important components of the power-supply circuitry (top side), including 9V regulator IC601



Task 2 — Check 3.3V Supply

If the inputs at pin 5 and pin 7 of IC602 in the SMPS circuitry are correct, but the radio fails to power up, then the 3.3V DC supply needs to be investigated.

1. First determine as follows if a fault on the digital board is affecting the supply or preventing the radio from powering up: While keeping the ON/OFF key depressed, measure the supply at the **3V3 test point** near the corner of the digital board (see **Figure 10.2**). The voltage is 3.3V when there is no fault.

3V3 test point: 3.3 ± 0.1 V DC

If the voltage is correct, the digital board is faulty; replace the board and go to “Final Tasks” on page 141. If the voltage is not correct, go to Step 2.

2. Disconnect the 13.8V supply at the power connector. Remove **R199** (see **Figure 10.1**). Reconnect the 13.8V supply.

3. With the probe of the multimeter on the **3V3 test point**, press the ON/OFF key. If the voltage is now 3.3 ± 0.1V, the digital board is faulty; replace the board and go to “Final Tasks” on page 141. If the voltage is still not correct, go to Step 4.

4. If the digital board is functional, the fault is on the main board. Replace **R199**. Disconnect the 13.8V supply. Use the multimeter to measure the resistance between the **3V3 test point** and ground.
If there is a short circuit, continue with Step 5. If there is no short circuit (but the voltage is wrong), go to Step 7.

5. Search for shorts to ground in the components **C603**, **C612**, **C613**, **C618**, **D606** of the SMPS circuitry (see **Figure 10.1**) as well as in the CODEC and interface circuitry. Repair any fault and repeat the resistance measurement of Step 4 to confirm the removal of the fault. If there is no fault, go to Step 6. If the fault remains, the repair failed; replace the board and go to “Final Tasks” on page 141.

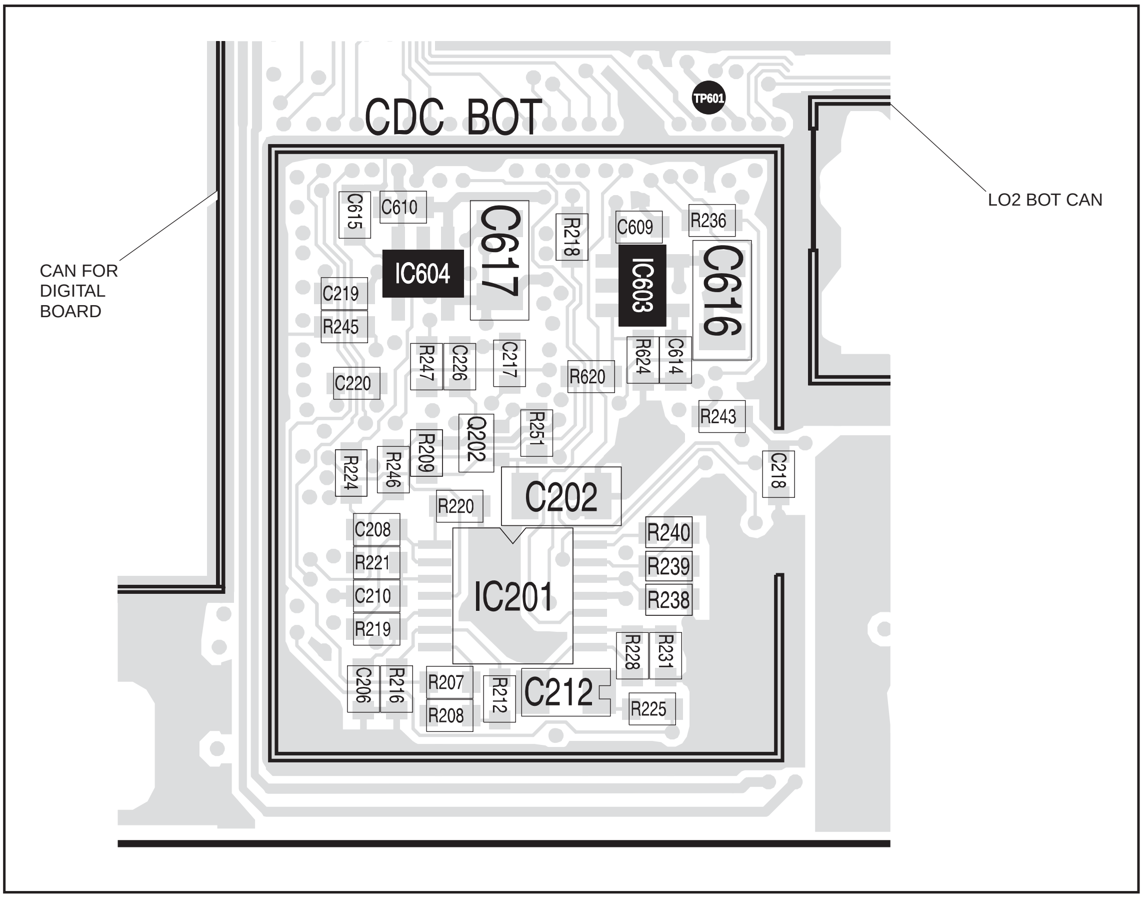
6. Reconnect the 13.8V supply. Press the ON/OFF key. If the radio powers up, return to “Initial Tasks” on page 133. If the radio fails to power up, disconnect the 13.8V supply and go to Step 7.

7. Measure the resistance of **L601** (see **Figure 10.1**). The resistance should be virtually zero. If it is, go to Step 8. If it is not, replace L601. Reconnect the 13.8V supply and press the ON/OFF key. If the radio powers up, return to “Initial Tasks” on page 133. If the radio fails to power up, disconnect the 13.8V supply and go to Step 8.

8. Remove the CDC BOT can. Remove **IC603** (3.0V regulator) and **IC604** (2.5V regulator) (see **Figure 10.3**). Reconnect the 13.8V supply and press the ON/OFF key. If the 3.3V supply is restored, go to Task 3 to check each regulator (3.0V and 2.5V) in turn. If the 3.3V supply is not restored, continue with Step 9.

9. Suspect **IC602**. Disconnect the 13.8V supply. Replace IC602 with a spare (see **Figure 10.1**). Resolder **IC603** and **IC604** in position (see **Figure 10.3**). Reconnect the 13.8V supply and press the ON/OFF key. If the radio powers up, return to “Initial Tasks” on page 133. If the radio fails to power up, the repair failed; replace the board and go to “Final Tasks” on page 141.

Figure 10.3 Power-supply circuitry under the CDC BOT can, including 3V regulator IC603 and 2.5V regulator IC604



Task 3 — Check Linear Regulators

This task describes the general procedure for checking any linear regulator. There are two possible faults: either the regulator has failed and prevents the radio from powering up, or the regulator voltage is incorrect. (The regulator IC might or might not have been removed during earlier checks.)

1. Disconnect the 13.8 V supply. Check for continuity and shorts to ground (if not already done) on the input, output and control line of the relevant regulator IC. Repair any fault.

2. If the regulator IC has been removed, resolder it in position.

3. Reconnect the 13.8 V supply and press the ON/OFF key. If the radio powers up or the correct regulator voltage is restored, return to "Initial Tasks" on page 133. If the repair failed, go to Step 4.

4. Disconnect the 13.8 V supply. Replace the regulator IC with a spare. Reconnect the 13.8 V supply and press the ON/OFF key. If the radio powers up or the correct regulator voltage is restored, go to "Final Tasks" on page 141. If the repair failed, replace the board and go to "Final Tasks" on page 141.

Task 4 — Check Power-up Configuration

The radio may be configured for one or more of the following power-up options:

- battery power sense
- auxiliary power sense
- emergency power sense
- internal-options power sense

A particular option is implemented by inserting the link mentioned in Table 10.1. If there is a fault with a power-up option for which the radio is configured, first confirm that the configuration is correct:

1. Confirm that the correct link or links have been inserted for the required power-up options (see **Figure 10.2** and **Table 10.1**). For all except the battery-power-sense option, also check the radio's programming as follows:

2. Open the *"Programmable I/O"* form.

3. Under the *"Digital"* tab, scroll to the relevant digital line listed in the *"Pin"* field:
   - internal-options power sense: IOP GPIO7
   - auxiliary power sense: AUX GPI3
   - emergency power sense: AUX GPI2

4. For the first two lines, confirm that the *"Power Sense (Ignition)"* option has been selected in the *"Action"* field, and *"High"* or *"Low"* in the *"Active"* field. For the third line, confirm that *"Enter Emergency Mode"* has been selected.

5. If the link and programming settings are correct, go to Task 5. If they are not, rectify the settings and check if the fault has been removed. If it has, return to "Initial Tasks" on page 133. If it has not, go to Task 5.

Table 10.1 Implementation of the power-up options

Power-up option	Link to insert	Factory default	Activation mechanism	Connector
Battery power sense	LK1	Link in	Connection of 13.8V supply	Power connector
Auxiliary power sense	LK2	Link out	AUX GPI3 line goes high (If LK1 is in, line floats high; if LK1 is out, line floats low)	Pin 4 of auxiliary connector
Emergency power sense	LK3	Link out	AUX GPI2 line goes low	Pin 5 of auxiliary connector
Internal-options power sense	LK4	Link out	IOP GPIO7 line goes high	Pin 15 of internal-options connector

Task 5 — Check Power-up Options

The functioning of the power-up options may be checked as described in Step 1 to Step 4 below. Carry out the procedure in the appropriate step or steps. In all four cases the procedure involves checking the digital power-up signal at pin 5 of IC602. For a particular option, the activation mechanism is the condition that results in the power-up signal becoming active (the signal is active high).

1. For the battery power-sense option the link **LK1** should be inserted (see **Figure 10.2**). Check the power-up signal at pin 5 of **IC602** (see **Figure 10.1**) while first disconnecting and then reconnecting the 13.8V DC supply at the power connector.

   The power-up signal should go high when the power is reconnected. If it does, conclude with Step 5. If it does not, check for continuity and shorts to ground between the link **LK1** and the +13V8 BATT input at the power connector **PL100**. Repair any fault and go to Step 5.

2. For the auxiliary power-sense option the link **LK2** should be inserted (see **Figure 10.2**). Connect +3.3V DC (more than 2.6V to be precise) from the power supply to the AUX GPI3 line (pin 4 of the auxiliary connector **SK101**). Check that the power-up signal at pin 5 of **IC602** (see **Figure 10.1**) is high.

   Remove the +3.3V supply and ground the AUX GPI3 line (to be precise the voltage on the line should be less than 0.6V). If the power-up signal is now low, conclude with Step 5. If it is not, check for continuity and shorts to ground between **D601** (see **Figure 10.1**) and pin 4 of the auxiliary connector **SK101**. Repair any fault and go to Step 5.

3. For the emergency power-sense option the link **LK3** should be inserted (see **Figure 10.2**). Connect the AUX GPI2 line (pin 5 of the auxiliary connector **SK101**) to ground. Check that the power-up signal at pin 5 of **IC602** (see **Figure 10.1**) is high.

   Remove the connection to ground. If the power-up signal is now low, conclude with Step 5. If it is not, check for continuity and shorts to ground in the path from **D601** (see **Figure 10.1**), via **Q600** (see **Figure 10.2**), to pin 5 of the auxiliary connector **SK101**. Repair any fault and go to Step 5.

4. For the internal-options power-sense option the link **LK4** should be inserted (see **Figure 10.2**). Connect +3.3V DC (more than 2.6V to be precise) from the power supply to the IOP GPIO7 line (pin 15 of the internal-options connector **SK102**). Check that the power-up signal at pin 5 of **IC602** (see **Figure 10.1**) is high.

   Remove the +3.3V supply and ground the IOP GPIO7 line (to be precise the voltage on the line should be less than 0.6V). If the power-up signal is now low, conclude with Step 5. If it is not, check for continuity and shorts to ground between **D604** (see **Figure 10.1**) and pin 15 of the internal-options connector **SK102**. Repair any fault and go to Step 5.

5. After checking all the relevant power-up options, and if necessary repairing any faults, go to “Final Tasks” on page 141. If the fault could not be found or repairs failed, replace the board and go to “Final Tasks” on page 141.

Task 6 — Check Provision of External Power

External power is supplied to pin 8 of the auxiliary connector SK101. The power is normally switched, but will be unswitched if all the links LK5 to LK8 are inserted. (With all the links inserted, the power at the other connectors is also unswitched.)

External power, either switched or unswitched, is supplied to pin 2 of the control-head connector SK100. The power is switched or not depending on the links LK5 and LK6:

- switched power: LK5 in, LK6 out
- unswitched power: LK5 out, LK6 in

External power is also supplied to pin 1 of the internal-options connector SK102. The power is switched or not depending on the links LK7 and LK8:

- switched power: LK7 in, LK8 out
- unswitched power: LK7 out, LK8 in

Note In some boards, LK7 is R786 and LK8 is R787.

If there is a fault with the supply of external power to any of these connectors, first confirm the link settings required and then carry out the following procedure:

1. With the radio powered up, confirm that 13.8V DC is present at pin 3 of **IC605** (see **Figure 10.1**) and more than 3V DC at pin 2.

2. Check that 13.8 V is present at pin 5 of **IC605**. If there is, go to Step 3. If there is not, go to Step 4.

3. Check for an open circuit between pin 5 of **IC605** and the relevant pin of the connector in question. Repair any fault, confirm the removal of the fault, and go to “Final Tasks” on page 141. If the repair failed or the fault could not be found, replace the board and go to “Final Tasks” on page 141.

4. Check for continuity between pin 5 of **IC605** and the relevant pin of the connector in question. Check for shorts to ground, check **C718** at the auxiliary connector (see **Figure 10.1**), and check **C715** at the internal-options connector (see **Figure 11.2**).

5. Repair any fault found in the above checks. If no fault could be found, replace **IC605**.

6. Confirm the removal of the fault and go to “Final Tasks” on page 141. If the repair failed, replace the board and go to “Final Tasks” on page 141.

11 Interface Fault Finding

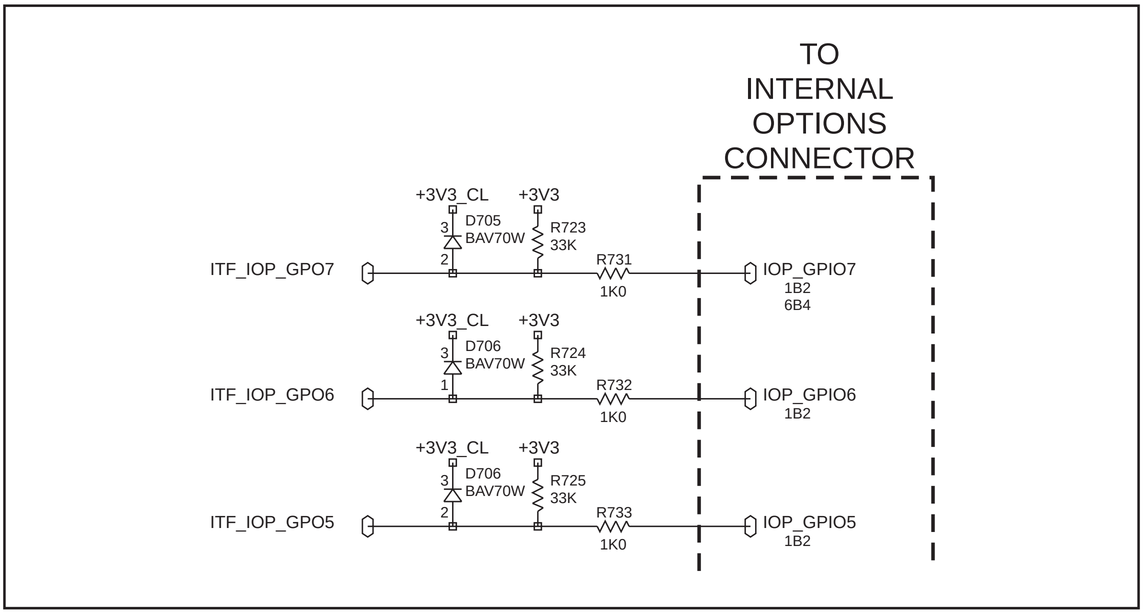
Introduction

This section covers the diagnosis of faults involving signals output from or input to the radio's internal circuitry via the control-head, internal options, power, or auxiliary connectors. For most inputs and outputs, filtering or basic processing is applied between the internal circuitry and the connectors.

Internal and Connector Signals

The signals at the internal circuitry and those at the connectors are distinguished as internal signals and connector signals respectively. On the circuit diagram for the internal circuitry, dashed lines enclose connector signals. Internal signals are all named signals outside these enclosures. In Figure 11.1, which shows part of the internal options connector as an example, IOP GPIO7 is a connector signal and ITF IOP GPIO7 is an internal signal.

Figure 11.1 Example illustrating the convention for internal and connector signals



Types of Signals

The connector and internal signals can be of two types:

- input lines
- bi-directional lines.

For diagnosing faults in these two cases, carry out, Task 1 or Task 2 respectively. Where components need to be replaced to rectify faults, refer to Figure 11.2 to Figure 11.4 for the locations of the components. These figures show the three areas of the main board where the components of the interface circuitry are situated.

Figure 11.2 Components of the interface circuitry (top side near the CDC TOP and IF TOP cans)

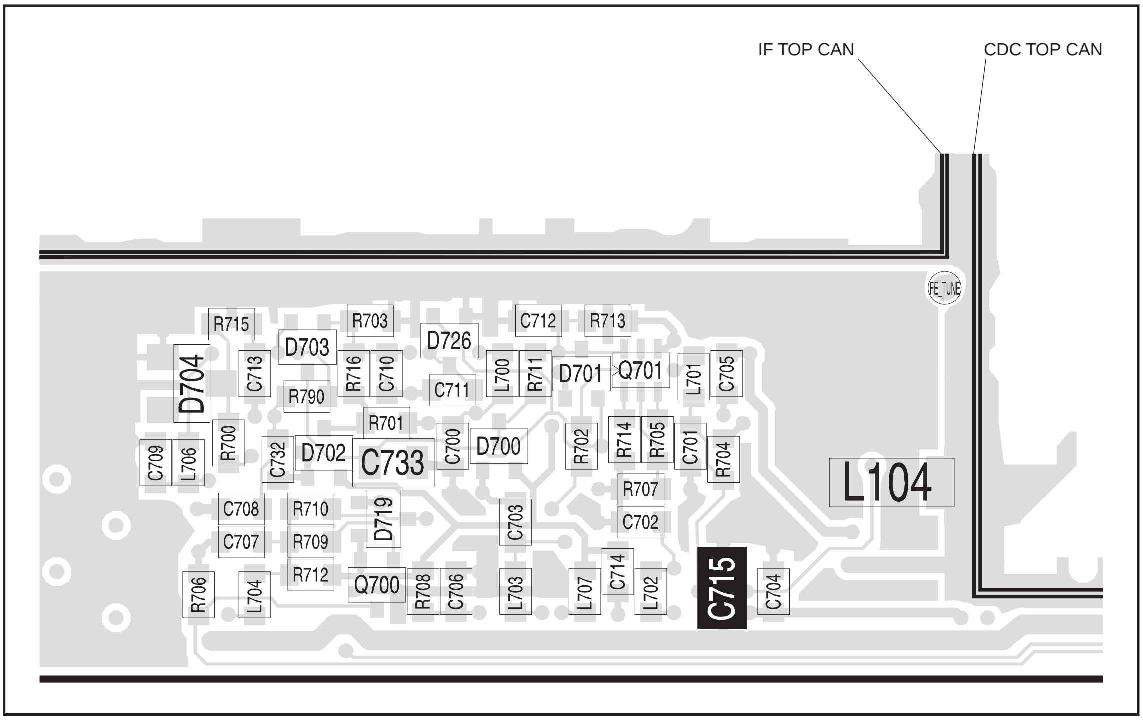


Figure 11.3 Components of the interface circuitry (top side at the corner)

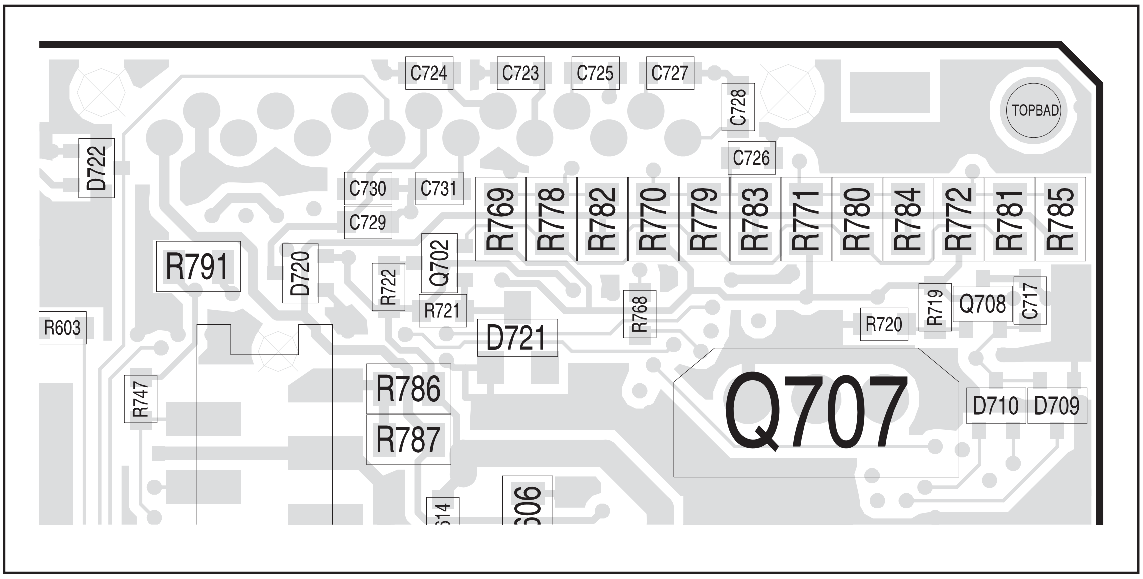
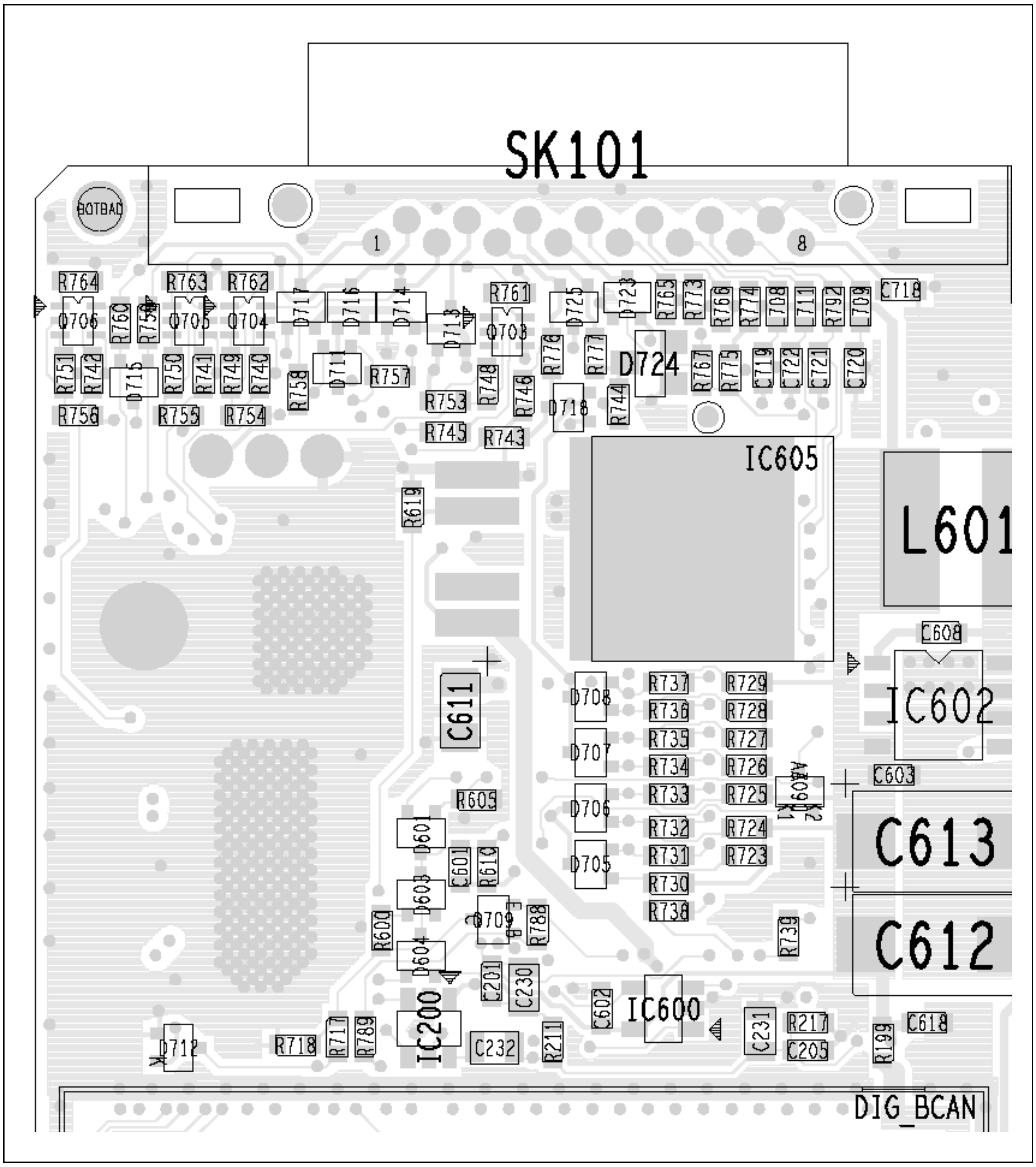


Figure 11.4 Components of the interface circuitry (bottom side)



Task 1 — Check Input Lines

For an input line suspected or reported to be faulty, proceed as follows:

1. For a suspect CH ON OFF line, go to Step 4. For all other input lines go to Step 2.

2. For the suspect line, apply a 3.3V DC test signal to a connector mated to the radio connector in question.

3. Check the internal signal for the line under test. If 3.3V DC is present, go to Step 7. If it is not, go to Step 8.

4. For the CH ON OFF line, apply a short to ground on pin 5 of a connector mated to the control-head connector. Check that there is 3.9V DC present on the ITF ON OFF line, and that PSU ON OFF is approximately equal to the radio's primary supply voltage, nominally 13.8V DC.

5. Remove the short on the connector. Check that, with CH ON OFF open-circuit, both ITF ON OFF and ITF PSU ON OFF are close to 0.0V.

6. If the voltages given in Step 4 and Step 5 are observed, go to Step 7. If they are not, go to Step 8.

7. The fault lies with the radio's internal circuitry. If the power-supply circuitry or the CODEC and audio circuitry is suspect, continue with the fault diagnosis as in "Power Supply Fault Finding" on page 155 and "CODEC and Audio Fault Finding" on page 335, respectively. If the digital board is suspect, replace the board and go to "Final Tasks" on page 141.

8. The fault lies in the filtering, basic processing, or connector for the line under test. Re-solder components or replace faulty components as necessary. Confirm the removal of the fault and go to "Final Tasks" on page 141. If the fault could not be found, replace the board and go to "Final Tasks" on page 141.

Task 2 — Bi-directional Lines

For a bi-directional line suspected or reported to be faulty, proceed as described below. In the procedure the direction of the line will need to be configured. For information on this topic consult the on-line help facility on the programming application's *"Programmable I/O"* page.

1. Configure the suspect line as an input, and then carry out the procedure given in Task 1.

12 Frequency Synthesizer Fault Finding

Introduction

This section covers the diagnosis of faults in the frequency synthesizer. The sections are divided into the following:

- Initial checks
- Fault diagnosis of RF PLL circuitry
- Fault diagnosis of FCL circuitry.

The initial checks will indicate whether it is the RF PLL or the FCL that is suspect. Note that the synthesizer is a closed-loop control system. A fault in one area can cause symptoms to appear elsewhere. Locating the fault can therefore be difficult.

Measurement Techniques

The radio must be in CCTM for all the fault-diagnosis procedures of this section. The CCTM commands required are listed in Table 12.1.
Full details of the commands are given in “Computer-Controlled Test Mode (CCTM)” on page 114. Use an oscilloscope with a x10 probe for all voltage measurements required. The signals should appear stable and clean. Consider any noise or unidentified oscillations as evidence of a fault requiring investigation. Use a frequency counter for all measurements of high frequencies. The RF power output from the frequency synthesizer will not exceed 10 mW. If a probe is used for frequency measurements, use the x1 setting.

Table 12.1 CCTM commands required for the diagnosis of faults in the frequency synthesizer

Command	Description
72	Read lock status of RF PLL, FCL and LO2 — displays **xyz** (0=not in lock, 1=in lock)
101 **x y** 0	Set transmit frequency (**x** in Hertz) and receive frequency (**y** in Hertz) to specified values
205	Reset calibration parameters to their default values
301 0 10	Calibrate VCXO of FCL
302 0 10	Calibrate VCO(s) of RF PLL
334 **x**	Set synthesizer on (**x**=1) or off (**x**=0) via DIG SYN EN line
335 **x**	Set transmit-receive switch on (**x**=1) or off (**x**=0) via DIG SYN TR SW line
389 **x**	Set synthesizer mode to slow (**x**=0) or fast (**x**=1)
393 1 **x**	Write data **x** to FPGA

12.1 Initial Checks

Types of checks

There are two different types of initial checks, which are covered in the following tasks:

- Task 1: calibration checks
- Task 2: lock status.

Which, if any, of these tasks needs to be carried out depends on the symptoms of the fault.

Symptoms of Fault

The symptoms of the fault may be divided into three categories:

- system error is displayed
- lock error is displayed
- paging transmitter is in lock but exhibits transmit fault

In the first two cases the checks of Task 1 and Task 2 respectively are required. In the last case there are several symptoms; these are listed below.

Frequency Bands

Where test procedures or figures differ according to the frequency band of the radio, the frequency band is given in brackets. The frequency band may be referred to as either ‘VHF’ (very high frequency) or ‘UHF’ (ultra high frequency) or identified by the frequency sub-band, such as ‘B1’.

The product-code label on the radio body will identify the frequency band as described in “Product Codes” on page 14. A definition of frequency bands is given in “Defining Frequency Bands” on page 120.

Transmit Faults

A transmit fault will be implied by one of the following consequences:

- radio fails to enter transmit mode
- radio exits transmit mode unexpectedly
- radio enters transmit mode but fails to transmit
- radio enters transmit mode but transmit performance is degraded.

With a fault of this kind, neither of the initial tasks is required.
Fault diagnosis should begin with “Power Supplies” on page 173.

Summary

To summarize, given the nature of the fault, proceed to the task or section indicated below:

- Task 1: system error
- Task 2: lock error
- “Power Supplies”: transmit fault.

The checks of Task 1 and Task 2 will indicate the section with which the fault diagnosis should continue.

Task 1 — System Error

A system error indicates a fault in the calibration of either the FCL or the frequency synthesizer. To determine which is faulty, calibrate the VCXO and the transmit VCO as described below. (Always calibrate the former first, because the latter depends on the former.)

1. Place the radio in CCTM.

2. Enter the CCTM command *301 0 10* to calibrate the VCXO. The response will be one of the following three messages:
   - *"passed sanity check. Cal'd values put into effect"*
   - *"failed sanity check. Cal'd values not in effect"*
   - *"Cal failed: lock error".*

   The first two messages will be preceded by <u>four</u> calibration values.

3. In the case of the first message (passed), go to Step 4. In the case of the second and third messages (failed), the FCL is suspect; go to "Power Supply for FCL" on page 206.

4. Enter the CCTM command *302 0 10* to calibrate the transmit VCO. The response will be one of the three messages listed in Step 2. The first two messages will be preceded by <u>eight</u> calibration values. Reset the radio and re-enter CCTM.

5. If the calibration succeeded but the system error persists, replace the board and go to "Final Tasks" on page 141. In the case of the second message (failed sanity check), go to Step 6. In the case of the third message (calibration failed), go to Step 8 (UHF radios) or "Power Supplies" on page 173 (VHF radios).

6. Enter the CCTM command *205* to reset the calibration values to the default values. Then enter the CCTM command *302 0 10* again to calibrate the transmit VCO.

7. If the calibration succeeded, confirm the removal of the fault, and go to "Final Tasks" on page 141. If the calibration failed, go to Step 8 (UHF radios) or "Power Supplies" on page 173 (VHF radios).

8. Program the radio with the <u>maximum</u> frequency in the radio's frequency band: Enter the CCTM command *101* ***x x*** *0*, where ***x*** is the frequency in Hertz.

9. Enter the CCTM command *72* to determine the lock status in receive mode. Note the response.

lock status=**xyz** (**x**=RF PLL; **y**=FCL; **z**=LO2) (0=not in lock; 1=in lock)

10. If the lock status is *111* or *110*, the synthesizer is functioning in the receive mode, and the power supplies and PLL are functioning correctly. Go to “Loop Filter” on page 188 to check the loop filter, VCOs, and buffer amplifiers. If the lock status is *011* or *010*, the synthesizer is faulty in the receive mode. Go to “Power Supplies” on page 173.

Task 2 — Lock Status

A lock error indicates that the frequency synthesizer, FCL or second LO is out of lock. To determine which is faulty, check the lock status as described below.

1. If not already done, place the radio in CCTM.

2. Program the radio with the receive frequency of a channel that is known to be out of lock: Enter the CCTM command *101* ***x*** ***x*** *0*, where ***x*** is the frequency in Hertz.

3. Enter the CCTM command *72* to determine the lock status in receive mode. Note the response. The action required depends on the lock status as described in the following steps.

lock status=**xyz** (**x**=RF PLL; **y**=FCL; **z**=LO2) (0=not in lock; 1=in lock)

4. If the lock status is ***x****0****x***, where ***x*** is *0* or *1*, the FCL is suspect; go to “Power Supply for FCL” on page 206.

5. If the lock status is *011*, the synthesizer is suspect, although the power supplies are functioning correctly; go to “Loop Filter” on page 188.

6. If the lock status is *010*, the synthesizer and second LO are both out of lock. First investigate the synthesizer, excluding the power supplies; go to “Loop Filter” on page 188. If necessary, investigate the receiver later.

7. If the lock status is *111*, this implies normal operation. But if the lock error persists, replace the board and go to “Final Tasks” on page 141.

12.2 Power Supplies

Introduction

First check that a power supply is not the cause of the fault. There are four power supplies for the frequency synthesizer — two are supplied from the PSU (power supply unit) module and two are produced in the synthesizer circuitry itself:

- Task 3: 14 V DC supply from SMPS (VCL SUPPLY)
- Task 4: 6 V DC supply from 6 V regulator in PSU module (+6V0)
- Task 5: 5 V DC supply following filtering of 6 V supply (+5V DEC)
- Task 6: 3 V DC supply from 3 V regulator in PSU module (+3V0 AN).

The measurement points for diagnosing faults in the power supplies are summarized in Figure 12.1.

Figure 12.1 Measurement points for the frequency synthesizer power supply circuitry

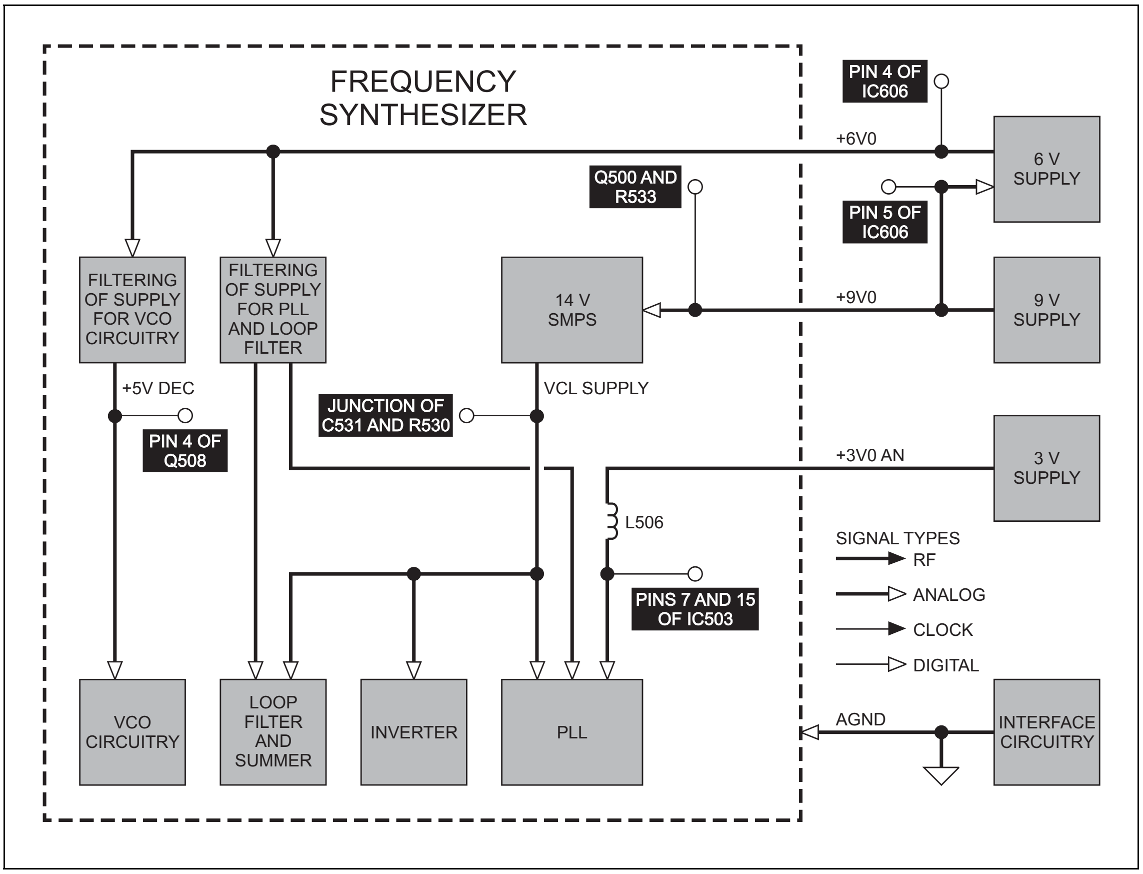
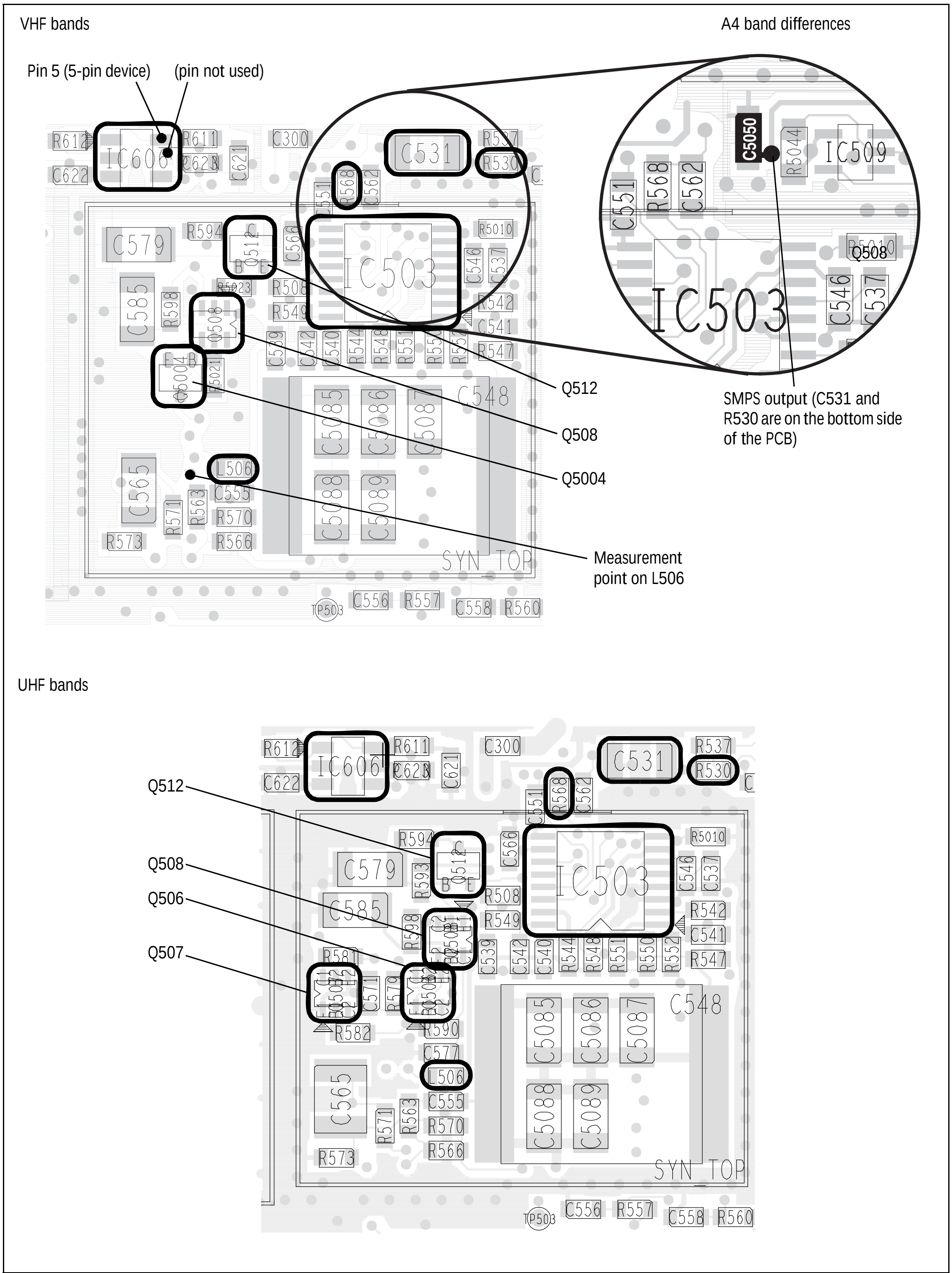


Figure 12.2 Synthesizer circuitry under the SYN TOP can and the 6 V regulator IC606 (top side)



Task 3 — 14V Power Supply

First check the output VCL SUPPLY from the SMPS, which is itself provided with a 9V DC supply from a 9V regulator in the PSU module.

1. Remove the board from the chassis.

2. Place the radio in CCTM.

3. Measure the SMPS output VCL SUPPLY at the via between **C531** and **R530** (see **Figure 12.2**).

C531: 14.2 V ± 0.3 DC

4. If the SMPS output is correct, go to Task 4. If it is not, go to Step 5.

5. Check the 9 V supply at **Q500** and **R533** (see **Figure 12.3**).

Q500 and R533: 9.0 V ± 0.3 DC

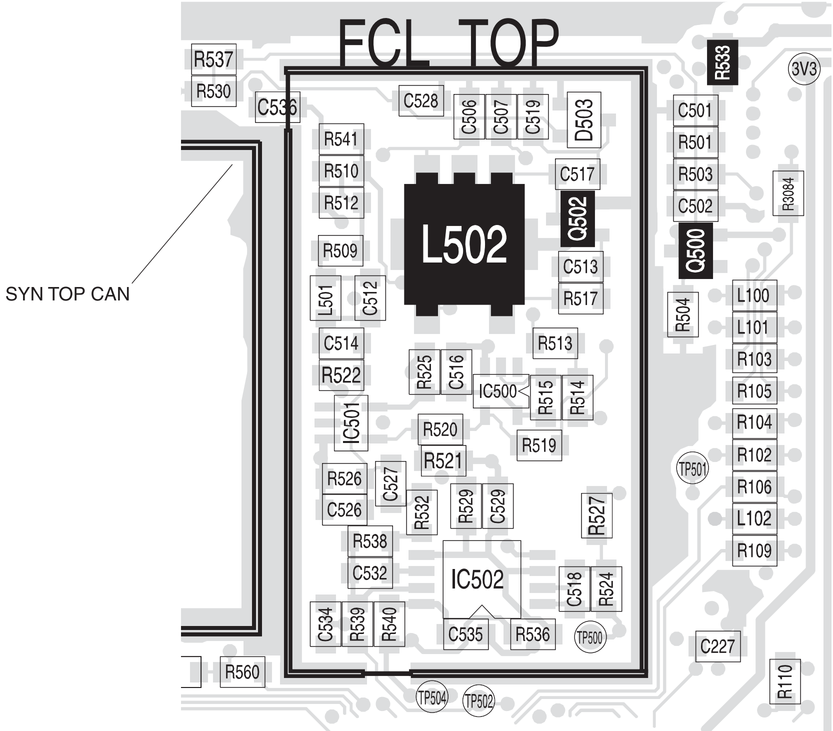
6. If the voltage is correct, go to Step 7. If it is not, the 9V regulator **IC601** is suspect; go to Task 3 of “Power Supply Fault Finding” on page 160.

7. Remove the FCL TOP can and check the SMPS circuit based on **Q500**, **Q502** and **L502** (see **Figure 12.3**).

   Remove the SYN BOT can and check **IC504** and **IC505** for shorts (see **Figure 12.4**); replace any suspect IC.

8. If a fault is found, repair the circuit, confirm the removal of the fault, and go to “Final Tasks” on page 141. If the repair failed or no fault could be found, replace the board and go to “Final Tasks” on page 141.

Figure 12.3 Synthesizer circuitry under the FCL TOP can (top side)



Task 4 — 6V Power Supply

If the output of the SMPS is correct, check the 6V DC supply next.

1. Measure the supply +6V0 at pin 4 of **IC606** (see **Figure 12.2**).

pin 4 of IC606: 6.0 ± 0.3V DC

2. If the voltage is correct, go to Task 5. If it is not, measure the 9V input at pin 5 of **IC606** (see **Figure 12.2**).

pin 5 of IC606: 9.0 ± 0.3V DC

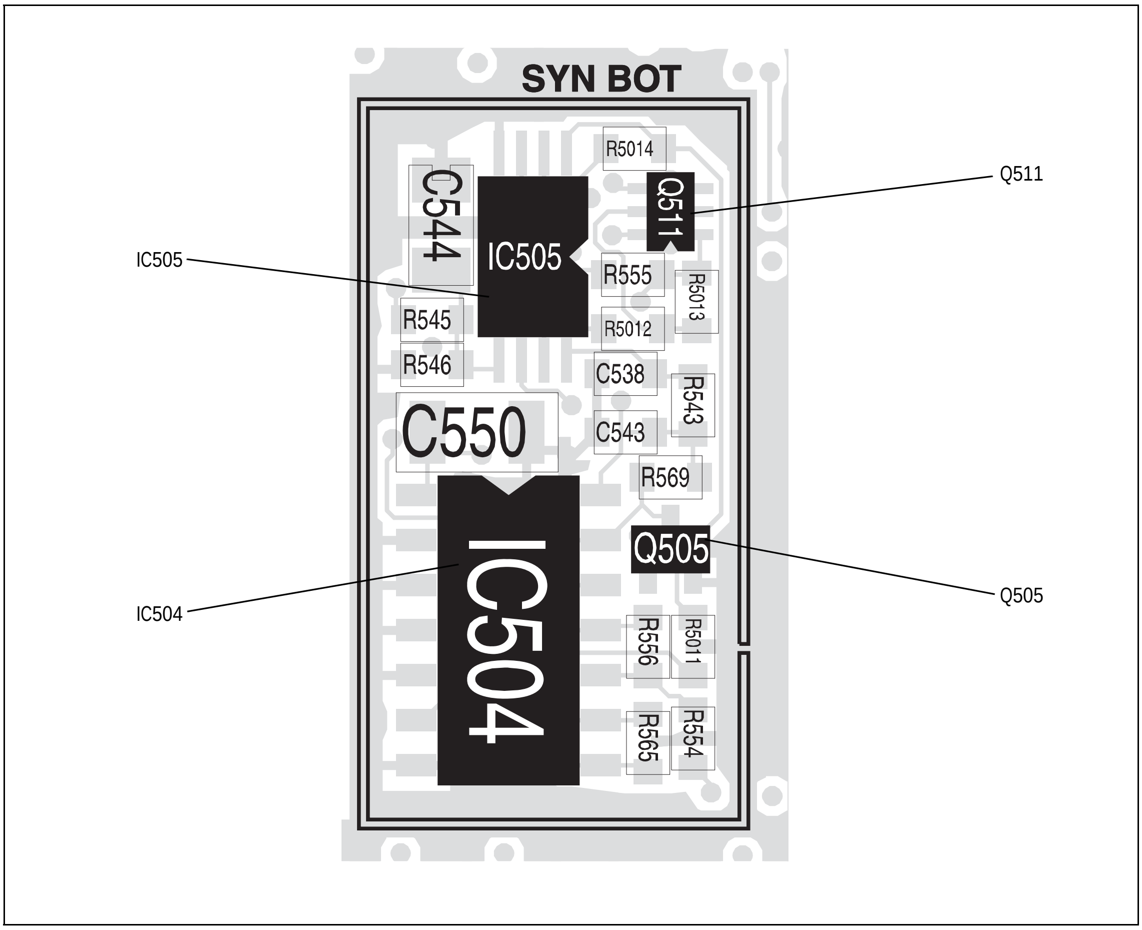
3. If the voltage is correct, go to Step 4. If it is not, the 9V regulator **IC601** is suspect; go to Task 3 of “Power Supply Fault Finding” on page 160.

4. If the input to the regulator **IC606** is correct but not the output, check **IC606** (see **Figure 12.2**) and the associated circuitry; if necessary, replace **IC606**.

   Remove the SYN TOP can and check the C-multipliers **Q508** (pins 3, 4, 5) and **Q512** for shorts (see **Figure 12.2**); replace any suspect transistor.

5. If a fault is found, repair the circuit, confirm the removal of the fault, and go to “Final Tasks” on page 141. If the repair failed or no fault could be found, replace the board and go to “Final Tasks” on page 141.

Figure 12.4 Synthesizer circuitry under the SYN BOT can (bottom side)



Task 5 — 5V Power Supply

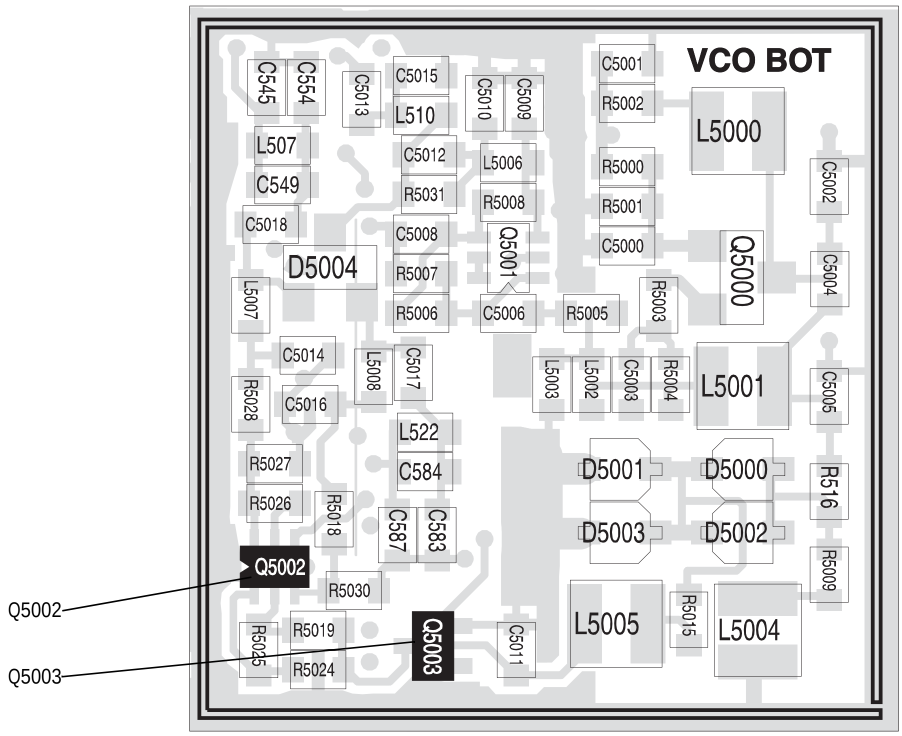
If the SMPS output and 6V DC supply are correct, check the +5V DEC supply next.

1. Remove the SYN TOP can.
2. Measure the supply +5V DEC at pin 4 of **Q508** (see **Figure 12.2**).

pin 4 of Q508: 5.3 ± 0.3V DC

3. If the voltage is correct, go to Task 6. If it is not, go to Step 4 (UHF radios) or Step 5 (VHF radios).
4. With a UHF radio check for faults in the C-multiplier **Q508** (pins 3, 4, 5) and the 5V and transmit-receive switches based on **Q506**, **Q507** and **Q508** (pins 1, 2, 6) (see **Figure 12.2**). Replace any suspect transistor. Conclude with Step 6.
5. With a VHF radio, check for faults in the C-multiplier and 5V switch based on **Q508** and **Q5004** (see **Figure 12.2**). Remove the VCO BOT can, and check the transmit-receive switch based on **Q5002** and **Q5003** (see **Figure 12.5**). Replace any suspect transistor. Conclude with Step 6.
6. If a fault is found, repair the circuit, confirm the removal of the fault, and go to “Final Tasks” on page 141. If the repair failed or no fault could be found, replace the board and go to “Final Tasks” on page 141.

Figure 12.5 Transmit-receive switch components — VHF bands



Task 6 — 3V Power Supply

If the SMPS output and the 6V and 5V supplies are correct, the remaining power supply to check is the 3V DC supply.

1. Measure the supply +3V0 AN at pins 7 and 15 of **IC503** (see **Figure 12.2**).

pins 7 and 15 of IC503: 2.9 ± 0.3V DC

2. If the voltage is correct, go to “Phase-locked Loop” on page 182. If it is not, go to Step 3.

3. Check the supply at **L506** (see **Figure 12.2**). The measurement point is the via shown in the figure.

L506: 2.9 ± 0.3V DC

4. If the voltage is correct, go to Step 5. If it is not, the 3 V regulator **IC603** is suspect; go to Task 3 of “Power Supply Fault Finding” on page 160.

5. Check the components in the path from **L506** to **IC503**. Also check IC503; if necessary, replace IC503 (see **Figure 12.2**).

6. If a fault is found, repair the circuit, confirm the removal of the fault, and go to “Final Tasks” on page 141. If the repair failed or no fault could be found, replace the board and go to “Final Tasks” on page 141.

12.3 Phase-locked Loop

Introduction

If there is no fault with the power supplies, check the critical output from, and inputs to, the PLL:

- Task 7: supply for charge pump
- Task 8: reference frequency input
- Task 9: DIG SYN EN line input
- Task 10: SYN LOCK line output.

The measurement points for diagnosing faults concerning the PLL inputs and output are summarized in Figure 12.6.

Task 7 — Supply for Charge Pump

First check the supply for the charge pump of the PLL.

1. Measure the supply for the charge pump at pin 16 of **IC503** (see **Figure 12.2**).

pin 16 of IC503: 5.0 ± 0.3 V DC

2. If the voltage is correct, go to Task 8. If it is not, go to Step 3.

3. Check the C-multiplier **Q512** (see **Figure 12.2**) and check **IC503** itself; if necessary, replace the transistor or IC.

4. If there is a fault, repair the circuit, confirm the removal of the fault, and go to “Final Tasks” on page 141. If the repair failed or no fault could be found, replace the board and go to “Final Tasks” on page 141.

Figure 12.6 Test and measurement points for the synthesizer PLL and loop filter

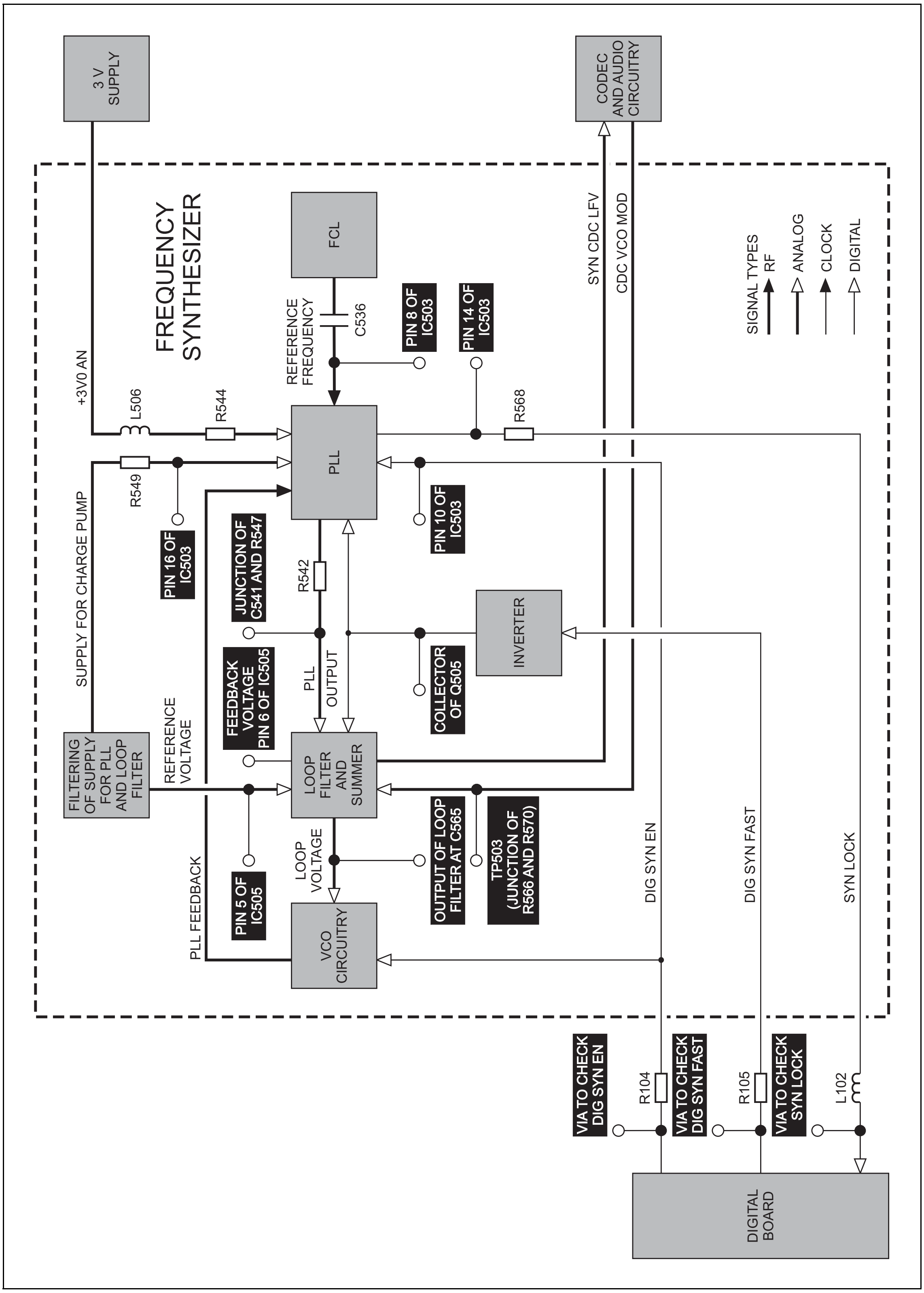
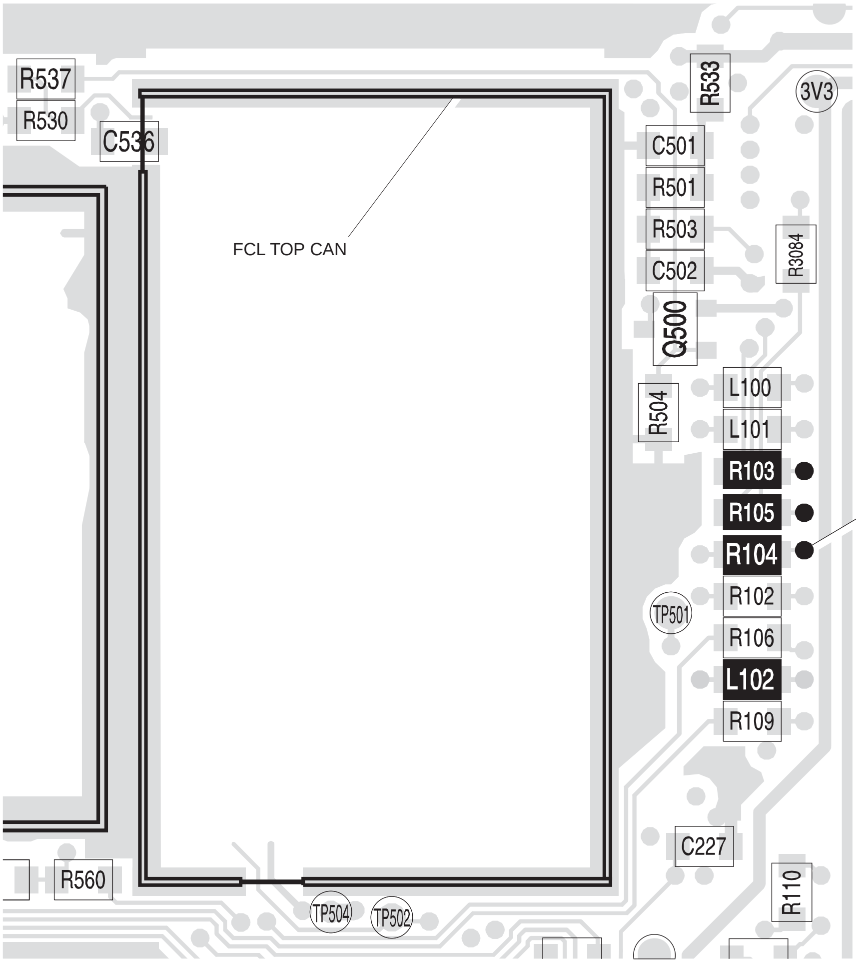


Figure 12.7 Components between the digital board and the frequency synthesizer



Task 8 — Reference Frequency

If the supply for the charge pump is correct, check the reference frequency input from the FCL to the PLL.

1. Measure the reference frequency at pin 8 of **IC503** (see **Figure 12.2**).

pin 8 of IC503: 13.012 ± 0.002 MHz and 1.1 ± 0.2 V_{pp}

2. If the signal is correct, go to Task 9. If it is not, go to Step 3.

3. Check **IC503** (see **Figure 12.2**). Replace IC503 if it is suspect.

4. Determine if the fault has been removed. If it has, go to “Final Tasks” on page 141. If it has not, the FCL is suspect; go to “Power Supply for FCL” on page 206.

Task 9 — DIG SYN EN Line

If the supply for the charge pump and the reference frequency are correct, check the DIG SYN EN line input.

1. Check the DIG SYN EN line at pin 10 of **IC503** (see **Figure 12.2**). Enter the CCTM command *334 0* to switch off the synthesizer, and measure the voltage at pin 10.

pin 10 of IC503: 0 V DC (after entry of CCTM 334 0)

2. Enter the command *334 1* to switch on the synthesizer, and measure the voltage again.

pin 10 of IC503: 2.5 ± 0.3 V DC (after entry of CCTM 334 1)

3. If the voltages measured in Step 1 and Step 2 are correct, go to Task 10. If they are not, go to Step 4.

4. Remove **R104** (see **Figure 12.7**) and repeat the above measurements as follows:

5. Enter the CCTM command *334 0* to switch off the synthesizer, and measure the voltage at the via between **R104** (see **Figure 12.7**) and the digital board.

via at R104: 0 V DC (after entry of CCTM 334 0)

6. Enter the CCTM command *334 1* to switch on the synthesizer, and measure the voltage at the via between **R104** (see **Figure 12.7**) and the digital board.

via at R104: 3.3 ± 0.3 V DC (after entry of CCTM 334 1)

7. If the voltages measured in Step 5 and Step 6 are still not correct, the digital board is faulty; replace the board and go to "Final Tasks" on page 141. If the voltages are correct, go to Step 8.

8. There is a fault between the digital board and **IC503**. Locate the fault. Check and resolder **R104** in position (see **Figure 12.7**), and check for continuity between pin 10 of IC503 (see **Figure 12.2**) and the digital board via R104.

9. If there is a fault, repair the circuit, confirm the removal of the fault, and go to "Final Tasks" on page 141. If the repair failed or no fault could be found, replace the board and go to "Final Tasks" on page 141.

Task 10 — SYN LOCK Line

If all the critical inputs to the PLL are correct, check the SYN LOCK line output.

1. Enter the CCTM command *72* to determine the lock status in receive mode. Note the status.

lock status=**xyz** (**x**=RF PLL; **y**=FCL; **z**=LO2) (0=not in lock; 1=in lock)

2. Check the SYN LOCK line by measuring the voltage at pin 14 of **IC503** (see **Figure 12.2**). The voltage should depend on the lock status as follows:

lock status 111 or 110: 3.0 ± 0.3 V DC at pin 14 of IC503 lock status 011 or 010: 0 V DC at pin 14 of IC503

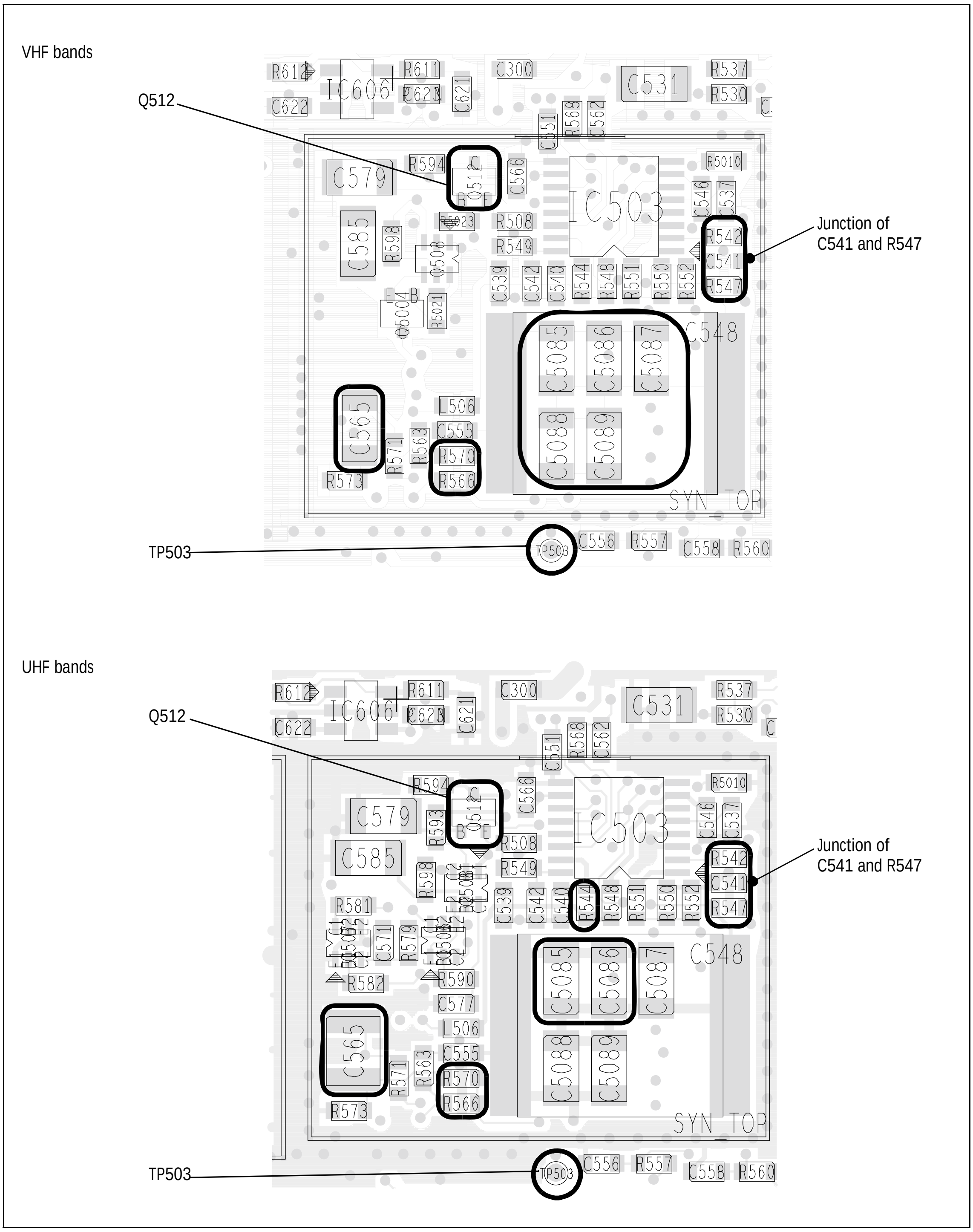
3. If the voltage measured in Step 2 is correct, go to “Loop Filter” on page 188. If it is not, go to Step 4.

4. Check for continuity between pin 14 of **IC503** and the digital board via **R568** (see **Figure 12.2**) and **L102** (see **Figure 12.7**).

5. If there is a fault, go to Step 6. If there is no fault, the digital board is faulty; replace the board and go to “Final Tasks” on page 141.

6. Repair the fault. Confirm the removal of the fault and go to “Final Tasks” on page 141. If the repair failed or no fault could be found, replace the board and go to “Final Tasks” on page 141.

Figure 12.8 Synthesizer circuitry under the SYN TOP can (top side)



12.4 Loop Filter

Introduction

If the power supplies for the frequency synthesizer are correct, and the PLL is functioning properly, check the loop filter next:

- Task 11: check loop voltage
- Task 12: VCO fault
- Task 13: check reference voltage
- Task 14: check feedback voltage
- Task 15: check DIG SYN FAST line
- Task 16: check TP503 test point.

The test and measurement points for diagnosing faults concerning the loop filter are summarized in Figure 12.6.

Task 11 — Check Loop Voltage

Check whether the loop filter is functioning correctly by measuring the loop voltage at the output of the filter at C565.

1. If not already done, remove the board from the chassis, remove the SYN TOP can, and place the radio in CCTM.

2. Remove **R542** (see **Figure 12.8**).

3. Using an oscilloscope, proceed as follows to observe the voltage at **C565** before and after grounding the junction between **C541** and **R547** (see **Figure 12.8**):

   While holding the oscilloscope probe at C565, use a pair of tweezers to momentarily ground the junction. The voltage should change to the following value (if it is not already at this value):

C565: 13.3 ± 0.3 V DC

4. If the loop voltage is correct, go to Step 5. If it is not, the loop-filter circuitry is suspect; go to Task 13.

5. Proceed as follows to observe the voltage at **C565** before and after applying 3 V DC to the junction of **C541** and **R547**; there is a convenient 3 V level at **R544** (see **Figure 12.8**):

   While holding the probe at C565, use the tweezers to momentarily apply 3 V DC to the junction; do not touch the board with your hand, and do not allow the tweezers to touch any cans when you remove them. The voltage should change to:

C565: < 0.5 V DC

6. If the loop voltage is correct, go to Task 12. If it is not, the loop-filter circuitry is suspect; go to Task 13.

Task 12 — VCO Faulty

If the loop voltage is correct, the loop filter is functioning properly. The VCO and related circuitry is therefore suspect. The section to proceed to depends on the type of the radio and the nature of the fault.

1. With a UHF radio go to Step 2. With a VHF radio go to “VCO and Related Circuitry (VHF Radios)” on page 198.

2. If it exhibits a system error or a transmit fault, the transmit VCO is suspect; go to “Transmit VCO and Related Circuitry (UHF Radios)” on page 193.

Task 13 — Check Reference Voltage

If the loop-filter circuitry is suspect, first check the reference voltage for the filter.

1. Remove the SYN BOT can.

2. Measure the reference voltage at pin 5 of **IC505** (see **Figure 12.4**). The result should be:

IC505 pin 5:	2.8 ± 0.1 V DC

3. If the voltage is correct, go to Task 14. If it is not, the reference-voltage circuitry is suspect; go to Step 4.

4. Resolder **R542** in position and check the C-multiplier **Q512** (see **Figure 12.8**).

5. If a fault is found, repair the circuit, and confirm that the reference voltage is now correct. If it is, go to “Final Tasks” on page 141. If it is not, or if no fault could be found, replace the board and go to “Final Tasks” on page 141.

Task 14 — Check Feedback Voltage

If the loop filter is suspect but the reference voltage is correct, check the feedback voltage.

1. Measure the feedback voltage at pin 6 of **IC505** (see **Figure 12.4**). The result should be:

IC505 pin 6:	2.8 ± 0.1 V DC

2. If the voltage is not correct, the loop filter is faulty; go to Step 3. If the voltage is correct, resolder **R542** in position (see **Figure 12.8**) and go to Task 15.

3. Check **IC504**, **IC505**, **Q511** (see **Figure 12.4**) and associated components.

4. Check the following components (see **Figure 12.8**):

   B1 band: **C5085** to **C5089**

   H5 band: **C5085** and **C5086**

Note On early issue boards, **C548** is fitted instead of these components.

5. If a fault is found, repair the circuit, repeat the measurement of the feedback voltage in Step 1, and resolder **R542** in position (see **Figure 12.8**).

6. If the feedback voltage is now correct, go to "Final Tasks" on page 141. If it is not, or if no fault could be found, replace the board and go to "Final Tasks" on page 141.

Task 15 — Check DIG SYN FAST Line

If the loop filter is suspect but the reference and feedback voltages are correct, check the DIG SYN FAST line, which is input to the inverter.

1. Enter the CCTM command *389 1* to set the synthesizer mode to fast.
2. Measure the voltage at the collector of **Q505** (see **Figure 12.4**). The result should be:

Q505 collector: 14.2 ± 0.3 V DC (after entry of CCTM 389 1)

3. Enter the CCTM command *389 0* to set the mode to slow.
4. Measure the voltage at the collector of **Q505** (see **Figure 12.4**). The result should be:

Q505 collector: 0 V DC (after entry of CCTM 389 0)

5. If the voltages measured in Step 2 and Step 4 are correct, go to Task 16. If they are not, go to Step 6.
6. Remove **R105** (see **Figure 12.7**).
7. Enter the CCTM command *389 1* to set the mode to fast.
8. Measure the voltage at the via between **R105** and the digital board (see **Figure 12.7**). The result should be:

via at R105: 0 V DC (after entry of CCTM 389 1)

9. Enter the CCTM command *389 0* to set the mode to slow.
10. Measure the voltage at the via between **R105** and the digital board (see **Figure 12.7**). The result should be:

via at R105: 3.3 ± 0.3 V DC (after entry of CCTM 389 0)

11. If the voltages measured in Step 8 and Step 10 are correct, go to Step 12. If they are not, the digital board is faulty; replace the board and go to “Final Tasks” on page 141.
12. Check and resolder **R105** in position (see **Figure 12.7**), and check for continuity between the collector of **Q505** (see **Figure 12.4**) and the digital board via R105.
13. If a fault is found, repair the circuit, and confirm that the voltages are now correct. If they are, go to “Final Tasks” on page 141. If they are not, or if no fault could be found, replace the board and go to “Final Tasks” on page 141.

Task 16 — Check TP503 Test Point

If the reference voltage, feedback voltage, and DIG SYN FAST line are all correct, check the voltage at the TP503 test point.

1. Measure the voltage at the **TP503 test point** (see **Figure 12.8**). The oscilloscope should show a DC level less than 3.0 V with no sign of noise or modulation.

TP503 test point: < 3.0 V DC

2. If the correct result is obtained, go to Step 3. If it is not, go to Step 5.

3. The loop filter is faulty but the above measurements do not provide more specific information. Check **IC504**, **IC505**, **Q511** (see **Figure 12.4**) and associated components.

4. Check the following components (see **Figure 12.8**), then conclude with Step 9:

   B1 band: **C5085** to **C5089**

   H5 band: **C5085** and **C5086**

Note On early issue boards, **C548** may be fitted instead of these components.

5. Remove **R566** and **R570** (see **Figure 12.8**), which provide a modulation path to the VCO(s).

6. Repeat the measurement of Step 1.

7. If the correct result is now obtained, go to Step 8. If the correct result is still not obtained, the CODEC and audio circuitry is suspect; resolder **R566** and **R570** in position (see **Figure 12.8**), and go to “CODEC and Audio Fault Finding” on page 335.

8. Resolder **R566** and **R570** in position (see **Figure 12.8**).

9. Check **IC504** (pins 6, 8, 9) (see **Figure 12.4**) and the associated components in the loop filter.

10. If a fault is found, repair the circuit, and confirm that the voltages are now correct. If they are, go to “Final Tasks” on page 141. If they are not, or if no fault could be found, replace the board and go to “Final Tasks” on page 141.

12.5 Transmit VCO and Related Circuitry (UHF Radios)

Introduction

If there is no fault with the power supplies, the PLL inputs and output, and the loop filter, check the VCO and related circuitry. The procedures in this section apply only to UHF radios with a system error or transmit fault, and therefore with suspect transmit VCO and related circuitry. (The minimum and maximum transmit frequencies for the different UHF frequency bands are defined in Table 12.2.) There are five aspects:

- Task 17: check transmit VCO
- Task 18: repair PLL feedback
- Task 19: repair transmit VCO
- Task 20: check switching to transmit mode
- Task 21: check transmit buffer amplifier.

The measurement points for diagnosing faults in the VCO and related circuitry are summarized in Figure 12.9.

Table 12.2 Minimum and maximum transmit frequencies for the different UHF frequency bands

Frequency band	Transmit frequency in MHz	
	Minimum	Maximum
H5	371 ± 5	492 ± 5

Task 17 — Check Transmit VCO

Check that the correct transmit frequency is synthesized. This is the frequency of the transmit VCO output SYN TX LO at the TX port shown in Figure 12.10.

1. Enter the CCTM command *335 1* to set the transmit-receive switch on (transmit mode).

2. Using a frequency counter, proceed as follows to observe the transmit frequency at the TX port before and after grounding the junction between **C541** and **R547** (see **Figure 12.10**):

   While holding the probe from the counter on the TX port, use a pair of tweezers to momentarily ground the junction. The frequency should change to:

TX port: maximum transmit frequency (see Table 12.2)

   The loop filter will hold its output steady at 13.3 V. This should result in a frequency equal to the maximum given in **Table 12.2**.

3. If the transmit frequency measured in Step 2 is correct, go to Step 4. If it is incorrect, go to Task 19. If no frequency is detected, go to Task 20.

4. Proceed as follows to observe the transmit frequency at the TX port before and after applying 3 V DC to the junction of **C541** and **R547**; there is a convenient 3 V level at **R544** (see **Figure 12.10**):

   While holding the probe on the TX port, use the tweezers to momentarily apply 3 V DC to the junction; do not touch the board with your hand, and do not allow the tweezers to touch any cans when you remove them. The frequency should change to:

TX port: minimum transmit frequency (see Table 12.2)

   The loop filter will hold its output steady at about 0V. This should result in a frequency equal to the minimum given in **Table 12.2**.

5. If the transmit frequency measured in Step 4 is correct, go to Task 18. If it is incorrect, go to Task 19. If no frequency is detected, go to Task 20.

Task 18 — Repair PLL feedback

If both the minimum and maximum transmit frequencies are correct, the PLL feedback is suspect.

1. Resolder **R542** in position (see **Figure 12.10**).
2. Remove the VCO BOT can.
3. Replace the components **C570**, **R578** (see **Figure 12.11**) and **IC503** (see **Figure 12.10**).
4. Confirm that the fault in the radio has been removed. If it has, go to “Final Tasks” on page 141. If it has not, replace the board and go to “Final Tasks” on page 141.

Task 19 — Repair Transmit VCO

If either or both the minimum and maximum transmit frequencies are incorrect, the transmit VCO circuitry is faulty.

1. Remove the VCO TOP can.
2. Check the transmit VCO. The circuitry is based on **Q510** (see **Figure 12.10**).
3. If a fault is found, repair it and go to Step 4. If no fault is found, go to Step 6.
4. Repeat the frequency measurements in Step 2 and Step 4 of Task 17.
5. If the frequencies are now correct, resolder **R542** in position (see **Figure 12.10**), and go to “Final Tasks” on page 141. If they are still not correct, go to Step 6.
6. Resolder **R542** in position (see **Figure 12.10**). Replace the board and go to “Final Tasks” on page 141.

Task 20 — Check Switching to Transmit Mode

If no transmit frequency is detected in the check of the transmit VCO, first check that the transmit-receive switch is functioning correctly.

1. Resolder **R542** in position (see **Figure 12.10**).

2. Enter the CCTM command *335 1* to switch on the supply to the transmit VCO.

3. Measure the voltage at the second collector (pin 6) of **Q506** (see **Figure 12.10**). The voltage should be:

pin 6 of Q506: 5.0 ± 0.3 V DC (after entry of CCTM 335 1)

4. Enter the CCTM command *335 0* to switch off the supply.

5. Again measure the voltage at the second collector of **Q506**.

pin 6 of Q506: 0 V DC (after entry of CCTM 335 0)

6. If the voltages measured in Step 2 and Step 4 are correct, go to Task 21.

Task 21 — Check Transmit Buffer Amplifier

If no transmit frequency is detected but the switching network is not faulty, check the transmit buffer amplifier. If the amplifier is not faulty, there might be a fault in the transmit VCO that was not detected earlier.

1. Remove the VCO BOT can.

2. Check the transmit buffer amplifier in receive mode: Enter the CCTM command *335 0* to set the transmit-receive switch off.

3. Measure the voltage at pin 6 of **Q5001** (see **Figure 12.11**).

pin 6 of Q5001: 0 V DC (receive mode)

4. Then check the transmit buffer amplifier in transmit mode: Enter the CCTM command *335 1* to set the transmit-receive switch on.

5. Again measure the voltage at **Q5001**.

pin 6 of Q5001: 0.7 ± 0.1 V DC (transmit mode)

6. If the voltages are correct, the transmit VCO is suspect; go to Step 7. If they are not, the transmit buffer amplifier is suspect; go to Step 9.

7. Remove the VCO TOP can.

8. Check the transmit VCO circuitry based on **Q510** (see **Figure 12.10**). Conclude with Step 10.

9. Check the buffer circuitry based on **Q5001** (see **Figure 12.11**).

10. If a fault is found, repair the circuit, and confirm that the voltages are now correct. If they are, go to “Final Tasks” on page 141. If they are not, or if no fault could be found, replace the board and go to “Final Tasks” on page 141.

12.6 VCO and Related Circuitry (VHF Radios)

Introduction

If there is no fault with the power supplies, the PLL inputs and output, and the loop filter, check the VCO and related circuitry. The procedures in this section apply only to VHF radios; the VHF frequency bands are defined in Table 12.3. There are six aspects:

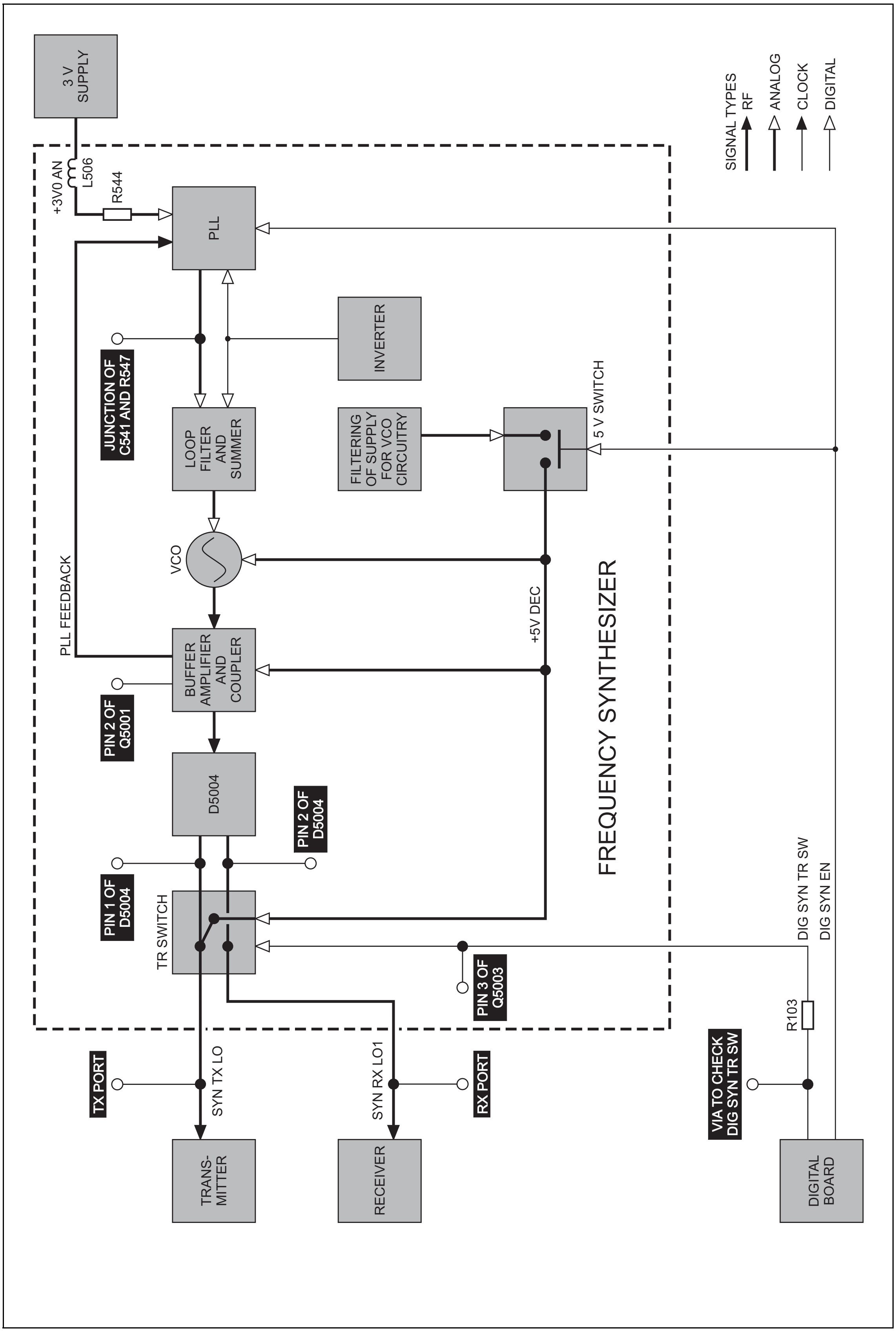
- Task 22: check VCO
- Task 23: repair PLL feedback
- Task 24: repair VCO
- Task 25: check transmit-receive switch
- Task 26: repair switching network
- Task 27: check buffer amplifier.

The measurement points for diagnosing faults in the VCO and related circuitry are summarized in Figure 12.9.

Table 12.3 Minimum and maximum frequencies for the different VHF frequency bands

Frequency band	Frequency in MHz	
	Minimum	**Maximum**
B1 25W	84 ± 5	200 ± 5
B1 50W	95 ± 5	190 ± 5

Figure 12.9 Measurement points for the VCO and related circuitry in VHF radios



Task 22 — Check VCO

Check that the correct transmit frequencies are synthesized. The transmit frequency is that of the output SYN TX LO at the TX port.

1. Enter the CCTM command *335 1* to set the transmit-receive switch on (transmit mode).

2. Using a frequency counter, proceed as follows to observe the transmit frequency at the TX port before and after grounding the junction between **C541** and **R547** (see **Figure 12.10**):

   While holding the probe from the counter on the TX port, use a pair of tweezers to momentarily ground the junction. The frequency should change to:

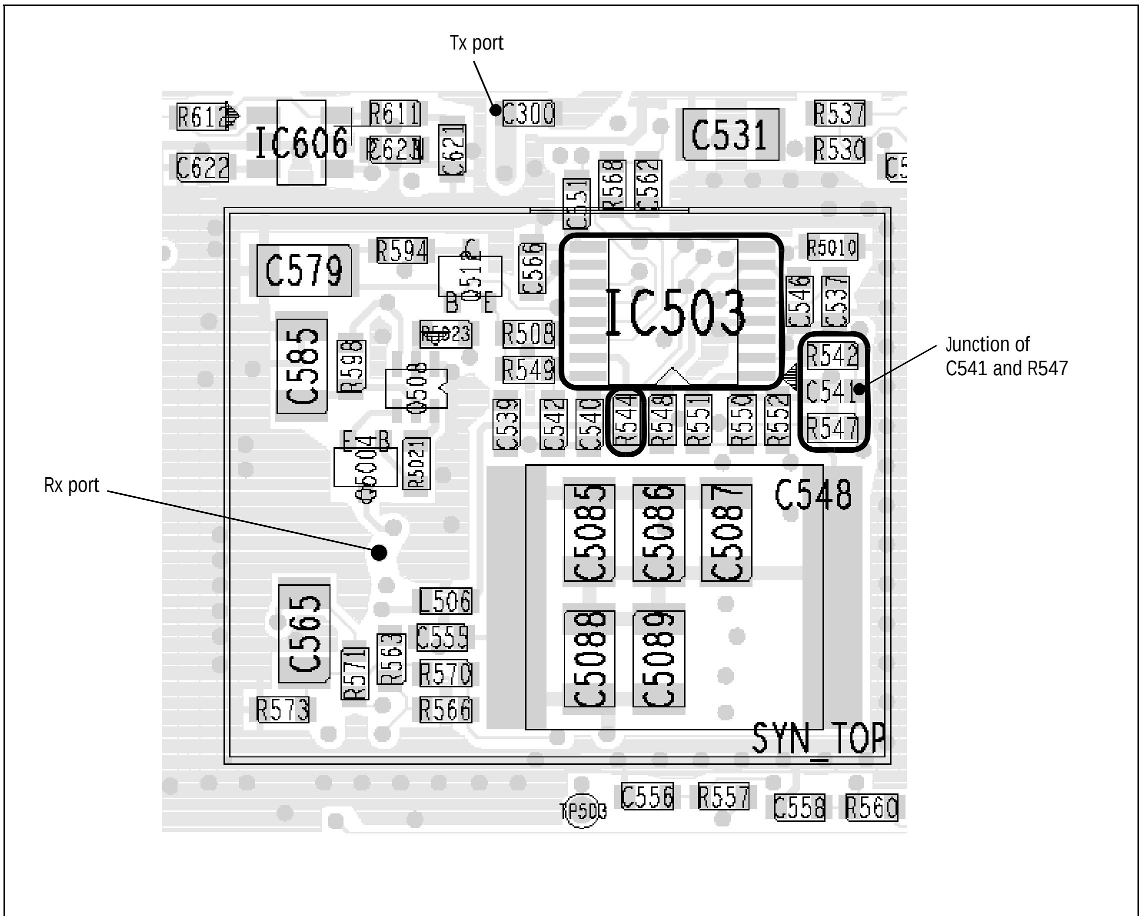
TX port: maximum VCO frequency (see Table 12.3)

   The loop filter will hold its output steady at 13.3 V. This should result in a frequency equal to the maximum given in **Table 12.3**.

3. If the maximum frequency measured in Step 2 is correct, go to Step 4. If it is incorrect, go to Task 24, but if no frequency at all is detected, go to Task 25.

4. Enter the CCTM command *335 0* to set the transmit-receive switch off (receive mode).

Figure 12.10 Synthesizer circuitry under the SYN TOP can (VHF radios, top side)



Task 23 —
Repair PLL feedback

If both the maximum and minimum VCO frequencies are correct, then the PLL feedback is suspect.

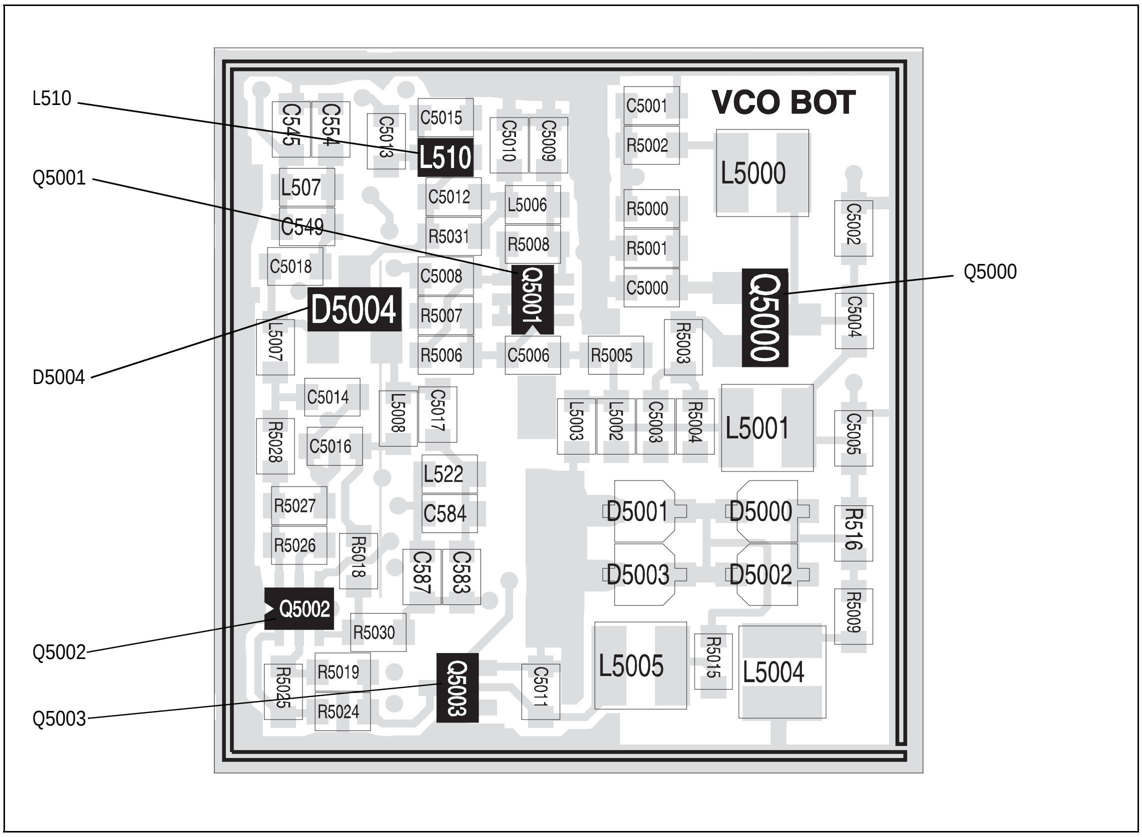
1. Resolder **R542** in position (see **Figure 12.10**).

2. Remove the VCO BOT can.

3. Replace the components **L510** (see **Figure 12.11**) and **IC503** (see **Figure 12.10**).

4. Confirm that the fault in the radio has been removed. If it has, go to “Final Tasks” on page 141. If it has not, replace the board and go to “Final Tasks” on page 141.

Figure 12.11 Synthesizer circuitry under the VCO BOT can (VHF radios)



Task 24 — Repair VCO

If either or both the maximum and minimum frequencies are incorrect, the VCO circuitry is faulty.

1. Remove the VCO BOT can.
2. Check the VCO. The circuitry is based on **Q5000** (see **Figure 12.11**).
3. If a fault is found, repair it and go to Step 4. If no fault is found, go to Step 7.
4. Repeat Step 1 and Step 2 of Task 22 to measure the maximum VCO frequency.
5. Repeat Step 4 of Task 22 to measure the minimum VCO frequency.
6. If the frequencies are now correct, resolder **R542** in position (see **Figure 12.10**), and go to “Final Tasks” on page 141. If they are still not correct, go to Step 7.
7. Resolder **R542** in position (see **Figure 12.10**). Replace the board and go to “Final Tasks” on page 141.

Task 25 — Check Transmit-receive Switch

If no frequency is detected in the check of the VCO, first check that the transmit-receive switch is functioning correctly.

1. Resolder **R542** in position (see **Figure 12.10**).

2. Remove the VCO BOT can.

3. Enter the CCTM command *335 0* to switch on the supply to the RX port.

4. Measure the voltage at pin 2 of **D5004** (see **Figure 12.11**). (Some RF noise might be observed.) The voltage should be:

pin 2 of D5004: 5.0 ± 0.3 V DC (after entry of CCTM 335 0)

5. Enter the CCTM command *335 1* to switch off the supply.

6. Again measure the voltage at pin 2 of **D5004**.

pin 2 of D5004: 0 V DC (after entry of CCTM 335 1)

7. If the voltages measured in Step 4 and Step 6 are correct, go to Step 8. If they are not, the switching network is suspect; go to Task 26.

8. Enter the CCTM command *335 1* to switch on the supply to the TX port.

9. Measure the voltage at pin 1 of **D5004** (see **Figure 12.11**). (Some RF noise might be observed.) The voltage should be:

pin 1 of D5004: 5.0 ± 0.3 V DC (after entry of CCTM 335 1)

10. Enter the CCTM command *335 0* to switch off the supply.

11. Again measure the voltage at pin 1 of **D5004**.

pin 1 of D5004: 2.1 ± 0.4 V DC (after entry of CCTM 335 0)

12. If the voltages measured in Step 9 and Step 11 are correct, go to Task 27. If they are not, the switching network is suspect; go to Task 26.

Task 26 — Repair Switching Network

If the transmit-receive switch is not functioning correctly, first check the DIG SYN TR SW line to confirm that the digital board is not the cause. If the digital board is not faulty, the switching network is suspect.

1. Enter the CCTM command *335 0* to set the transmit-receive switch off (receive mode). Measure the voltage on the DIG SYN TR SW line at pin 3 of **Q5003** (see **Figure 12.11**).

pin 3 of Q5003: 5.0 ± 0.3 V DC (after entry of CCTM 335 0)

2. Enter the CCTM command *335 1* to set the transmit-receive switch on (transmit mode). Again measure the voltage at **Q5003**.

pin 3 of Q5003: 0 V DC (after entry of CCTM 335 1)

3. If the voltages measured in Step 1 and Step 2 are correct, go to Step 9. If they are not, remove **R103** (see **Figure 12.7**) and go to Step 4.

4. Enter the CCTM command *335 0* and measure the voltage at the via between **R103** and the digital board (see **Figure 12.7**).

via at R103: 3.3 ± 0.3 V DC (after entry of CCTM 335 0)

5. Enter the CCTM command *335 1* and again measure the voltage at the via between **R103** and the digital board.

via at R103: 0 V DC (after entry of CCTM 335 1)

6. If the voltages measured in Step 4 and Step 5 are correct, go to Step 7. If they are not, the digital board is faulty; resolder **R103** in position (see **Figure 12.7**), replace the board and go to “Final Tasks” on page 141.

7. Check and resolder **R103** in position (see **Figure 12.7**), and check for continuity between **Q5003** (see **Figure 12.11**) and the digital board via R103.

8. If no fault is found, go to Step 9. If a fault is found, repair the circuit, confirm that the voltages are now correct, and go to “Final Tasks” on page 141. If the repair failed, replace the board and go to “Final Tasks” on page 141.

9. Check the circuitry for the transmit-receive and 5V switches (based on **Q5002** and **Q5003**) (see **Figure 12.11**).

10. If a fault is found, repair the circuit, confirm that the voltages are now correct, and go to “Final Tasks” on page 141. If the repair failed or the fault could not be found, replace the board and go to “Final Tasks” on page 141.

Task 27 — Check Buffer Amplifier

If no VCO frequency is detected but the switching network is not faulty, check the buffer amplifier. If the amplifier is not faulty, there might be a fault in the VCO that was not detected earlier.

1. Enter the CCTM command *335 0* to set the transmit-receive switch off.

2. Measure the voltage at pin 3 of **D5004** (see **Figure 12.11**). (Some RF noise might be observed.)

pin 3 of D5004: 4.2 ± 0.2 V DC

3. Measure the voltage at pin 1 of **Q5001** (see **Figure 12.11**).

pin 1 of Q5001: 0.7 ± 0.2 V DC

4. If the voltages measured in Step 2 and Step 3 are not correct, go to Step 5. If they are, check the VCO circuitry based on **Q5000** (see **Figure 12.11**). Conclude with Step 6.

5. The buffer amplifier is suspect. Check the buffer circuitry (based on **Q5001**) (see **Figure 12.11**).

6. If a fault is found, repair the circuit, and confirm that the voltages are now correct. If they are, go to “Final Tasks” on page 141. If they are not, or if no fault could be found, replace the board and go to “Final Tasks” on page 141.

12.7 Power Supply for FCL

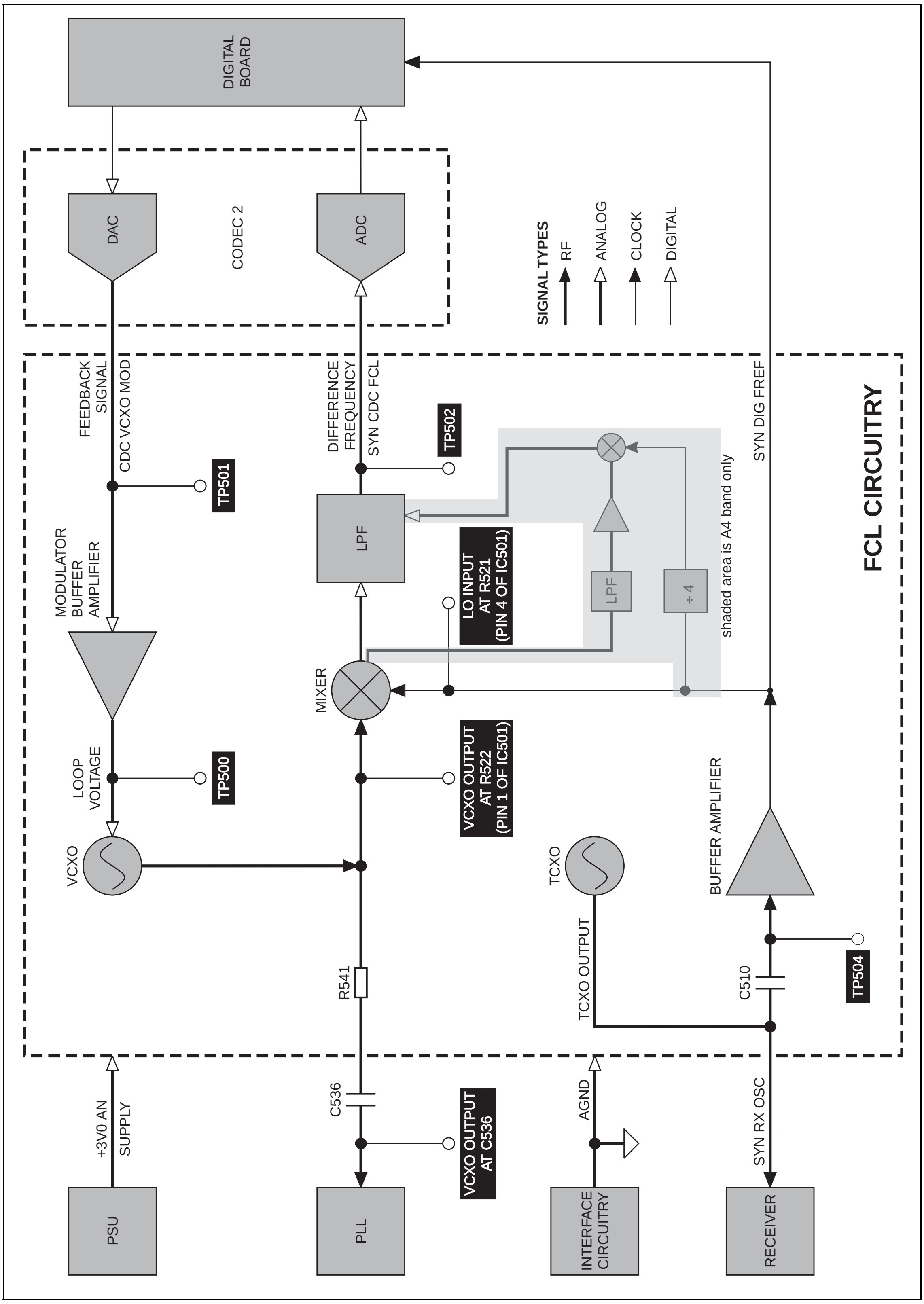
Fault-Diagnosis Stages

Indications of a fault in the FCL will have been revealed by the initial checks in “Initial Checks” on page 170 and the PLL checks in “Phase-locked Loop” on page 182. In the latter case a fault with the reference frequency input from the FCL to the PLL will imply that the FCL is suspect. Fault diagnosis of the FCL is divided into four stages:

- check power supply
- check VCXO and TCXO outputs
- check signals at TP501 and TP502
- check VCXO and CODEC circuitry.

The checking of the power supply is given in this section in Task 28 below. The remaining three stages are covered in “VCXO and TCXO Outputs” to “VCXO and CODEC Circuitry” respectively. The test and measurement points for diagnosing faults in the FCL are summarized in Figure 12.12.

Figure 12.12 Test and measurement points the FCL circuitry



Task 28 — Power Supply

If the FCL is suspect, first check that the 3V power supply is not the cause of the fault.

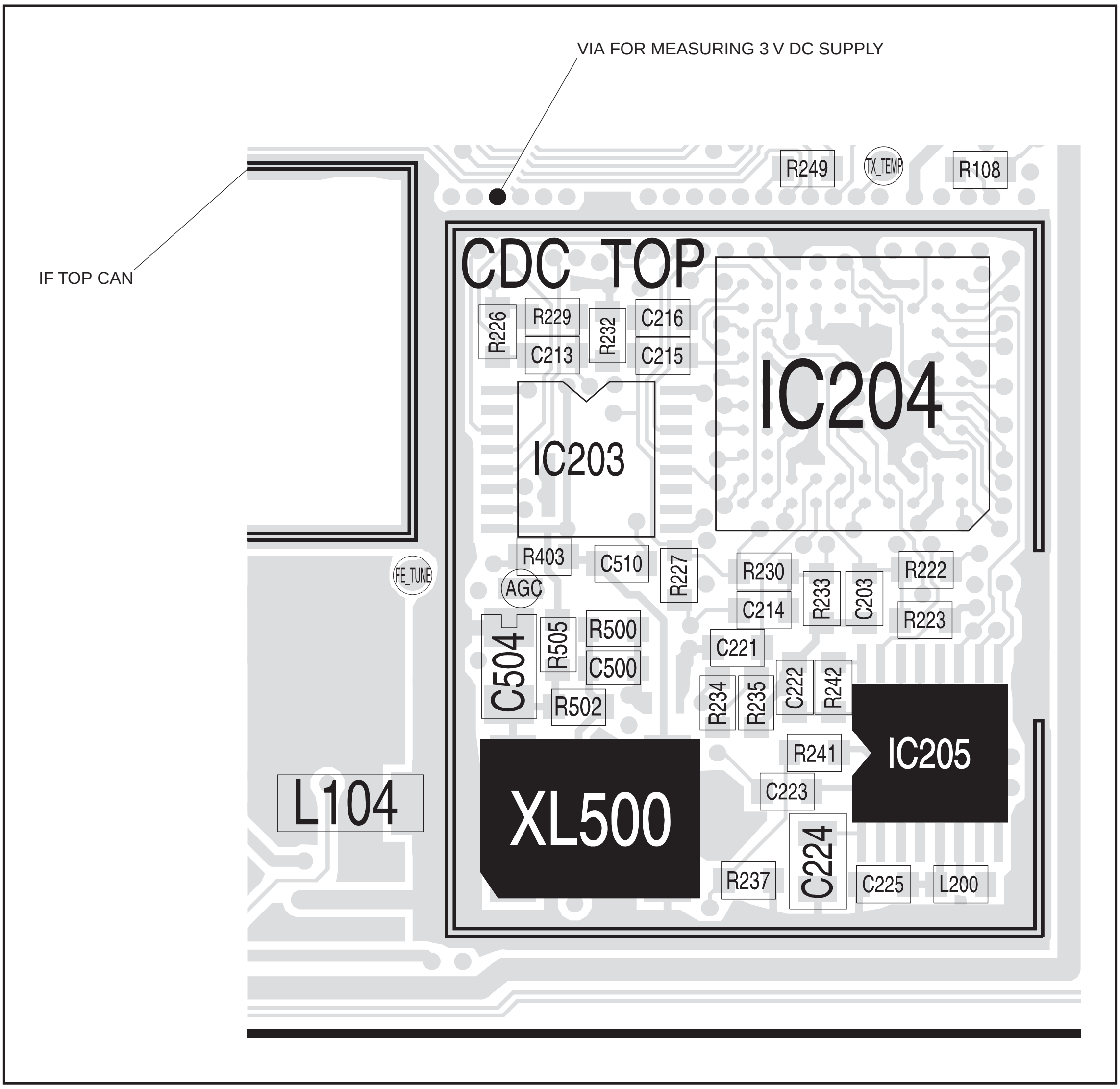
1. If not already done, remove the board from the chassis and place the radio in CCTM.

2. Measure the supply +3V0 AN at the via shown in **Figure 12.13**. The via is adjacent to the CDC TOP can.

via adjacent to CDC TOP can: 3.0 ± 0.3 V DC

3. If the voltage is correct, go to “VCXO and TCXO Outputs” on page 209. If it is not, the 3V regulator **IC603** is suspect; go to Task 3 of “Power Supply Fault Finding” on page 160.

Figure 12.13 TCXO circuitry under the CDC TOP can



12.8 VCXO and TCXO Outputs

Task 29 — VCXO Output

If the 3V power supply is not faulty, check the VCXO output as follows:

1. Use an oscilloscope probe to check the VCXO output at the following position:

   C536 — probe the via next to C536 (see **Figure 12.14**). The signal should be:

VCXO output at C536: sine wave of 1.1 ± 0.2 V_{pp} on 1.4 ± 0.2 V DC

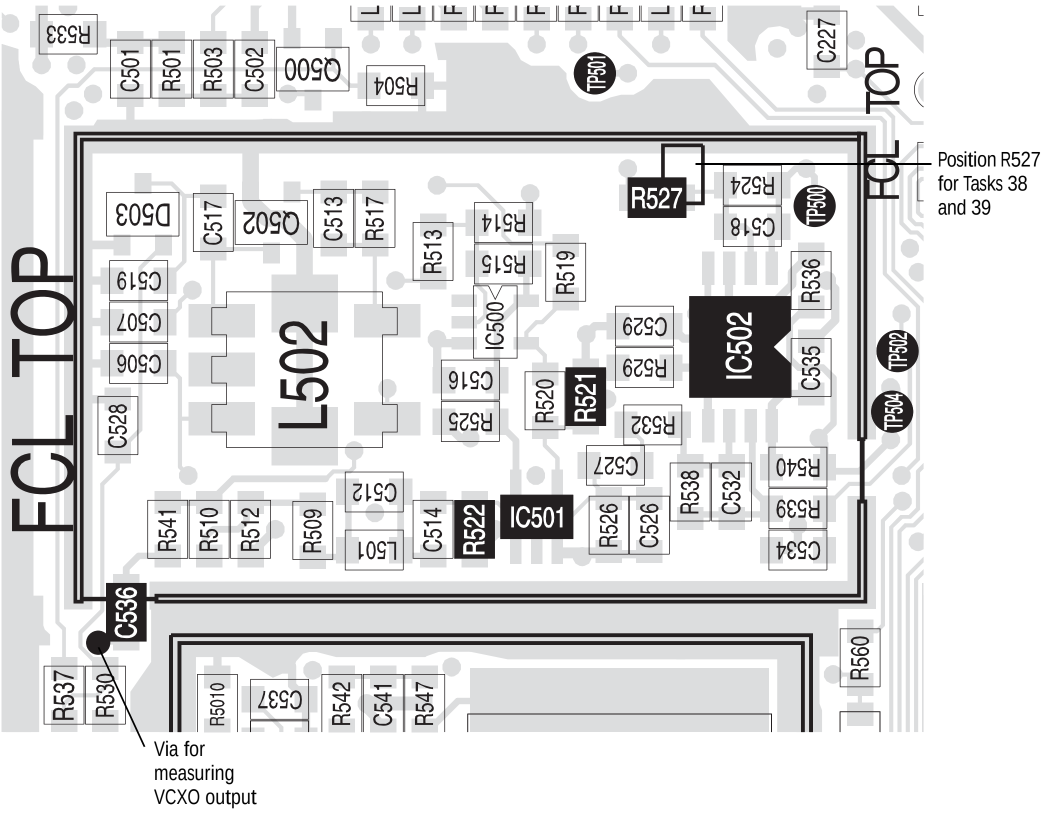
2. If the signal is correct, go to Task 30. If it is not, go to Step 3.

3. The VCXO circuitry under the VCXO BOT can is faulty. Remove the VCXO BOT can.

4. Locate and repair the fault in the VCXO (**Q501**, **Q503**, **XL501** and associated components) (see **Figure 12.15**).

5. Confirm the removal of the fault and go to Task 30. If the repair failed, replace the board and go to “Final Tasks” on page 141.

Figure 12.14 FCL circuitry under and adjacent the FCL TOP can



Task 30 — TCXO Output

If the VCXO output is correct, check the TCXO output as follows:

1. Use the oscilloscope probe to check the TCXO output at the **TP504 test point** (see **Figure 12.14**). The signal is SYN RX OSC and should be:

TCXO output at TP504 test point: clipped sine wave of 1.0 ± 0.2 V_{pp}

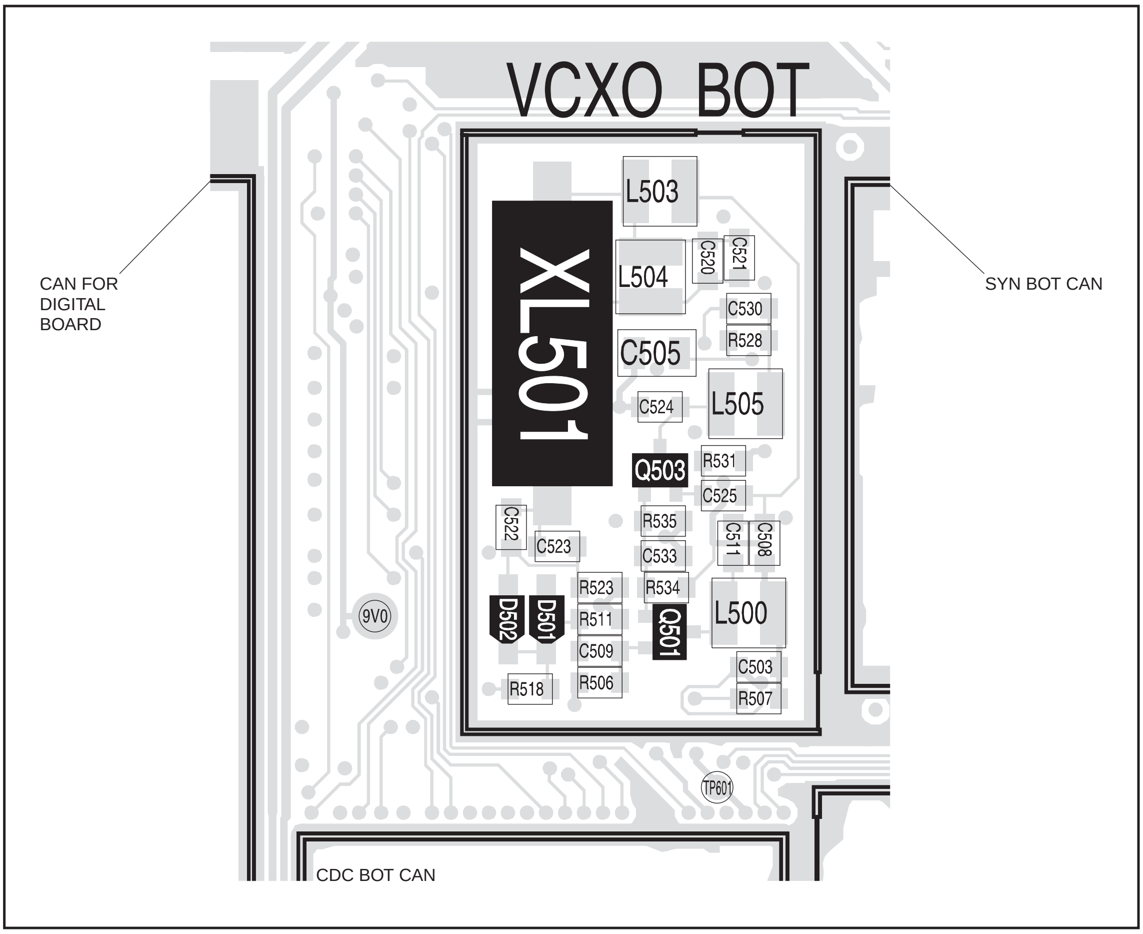
2. If the signal is correct, go to “Signals at TP501 and TP502” on page 211. If it is not, go to Step 3.

3. The TCXO circuitry under the CDC TOP can is faulty. Remove the CDC TOP can.

4. Locate and repair the fault in the TCXO (**XL500** and associated components) (see **Figure 12.13**).

5. Confirm the removal of the fault and go to “Signals at TP501 and TP502” on page 211. If the repair failed, replace the board and go to “Final Tasks” on page 141.

Figure 12.15 FCL circuitry under the VCXO BOT can



12.9 Signals at TP501 and TP502

Introduction

If the VCXO and TCXO outputs are correct, the next stage is to check the signals at the TP501 and TP502 test points. The procedure is divided into three tasks:

- Task 31: check signal at TP502
- Task 32: check signal at TP501 and ground TP501 if loop is oscillating
- Task 33: check signal at TP502 with TP501 grounded.

These checks will reveal any faults in the mixer and LPF circuitry, and any additional fault in the VCXO circuitry.

Task 31 — TP502 Test Point

Check the signal at the TP502 test point to determine if there is a fault in the mixer or LPF (low-pass filter) circuitry:

1. Use the oscilloscope probe to check the difference frequency at the **TP502 test point** (see **Figure 12.14**). The signal is SYN CDC FCL and should be:

TP502 test point: sine wave of 1.1 ± 0.2 V_{pp} on 1.5 ± 0.1 V DC

2. If the signal is correct, go to Task 32. If it is not, go to Step 3.

3. The mixer or LPF circuitry under the FCL TOP can is faulty. Remove the FCL TOP can.

4. Locate the fault in the mixer (**IC501** and associated components) or LPF circuitry (**IC502** pins 5 to 7, and associated components) (see **Figure 12.14**).

5. Repair the circuitry. Note that the TCXO input to the mixer (see **Figure 12.14**) should be:

   TCXO input at **R521** (pin 4 of **IC501**):

TCXO input: square wave with frequency of 13 MHz and amplitude of 3.0 ± 0.2 V_{pp}

   Also, the VCXO input to the mixer (see **Figure 12.14**), although noisy and difficult to measure, should be:

   VCXO input at **R522** (pin 1 of **IC501**):

VCXO input: sine wave of 20 ± 10 mV_{pp}

6. Confirm the removal of the fault and go to Task 32. If the repair failed, replace the board and go to “Final Tasks” on page 141.

Task 32 — TP501 Test Point

If the signal at the TP502 test point is correct, check the signal at the TP501 test point:

1. With the oscilloscope probe at the **TP501 test point** (see **Figure 12.14**), check the DAC output CDC VCXO MOD. If a triangular wave is present, go to Step 2. Otherwise go to “VCXO and CODEC Circuitry” on page 214.

2. A fault is causing the loop to oscillate. If not already done, remove the FCL TOP can.

3. Check the waveform at the **TP500 test point** (see **Figure 12.14**). The waveform should be an amplified and inverted version of the waveform at the **TP501 test point**.

4. If the waveform is correct, go to Step 5. If it is not, there is a fault in the modulator buffer amplifier (**IC502** pins 1 to 3, and associated components) (see **Figure 12.14**). Rectify the fault and return to Step 1.

5. Connect the **TP501 test point** to ground by resoldering **R527** in the position shown in **Figure 12.14**. The VCXO loop voltage is forced high.

6. Use the oscilloscope probe to check the VCXO output at **C536** — probe the via next to C536 (see **Figure 12.14**). The signal should be:

VCXO output at C536:	sine wave with frequency of 13.017 MHz and amplitude of 1.1 ± 0.2 V_{pp} on 1.4 ± 0.2 V DC

7. If the signal is correct, go to Task 33. If it is not, go to Step 8.

8. The VCXO circuitry is faulty. If not already done, remove the VCXO BOT can.

9. Locate and repair the fault in the VCXO circuitry (**Q501**, **Q503**, **XL501** and associated components) (see **Figure 12.15**).

10. Confirm the removal of the fault, and go to Task 33. If the repair failed, replace the board and go to “Final Tasks” on page 141.

Task 33 — TP502 Test Point (TP501 Grounded)

If the loop was oscillating, Task 32 will have revealed any fault in the VCXO circuitry. If there was no fault, or if the circuit was repaired, a check at the TP502 test point is now required. This will show if there are any additional faults in the mixer or LPF circuitry.

1. Use the oscilloscope probe to check the difference frequency at the **TP502 test point** (see **Figure 12.14**). The signal is SYN CDC FCL and should be:

TP502 test point:	sine wave with frequency of at least 15kHz and amplitude of 1.1 ± 0.2 V_{pp} on 1.5 ± 0.1 V DC

2. If the signal is correct, go to Step 6. If it is not, go to Step 3.

3. The mixer circuitry (**IC501** and associated components) or the LPF circuitry (**IC502** pins 5 to 7, and associated components) under the FCL TOP can is faulty (see **Figure 12.14**). Locate the fault.

4. Repair the circuitry. Note that the TCXO input to the mixer (see **Figure 12.14**) should be:

   TCXO input at **R521** (pin 4 of **IC501**):

TCXO input: square wave with frequency of 13 MHz and amplitude of 3.0 ± 0.2 V_{pp}

   Also, the VCXO input to the mixer (see **Figure 12.14**), although noisy and difficult to measure, should be:

   VCXO input at **R522** (pin 1 of **IC501**):

VCXO input: sine wave of 20 ± 10 mV_{pp}

5. Confirm the removal of the fault, and go to Step 6. If the repair failed, resolder **R527** in its original position as shown in **Figure 12.14**, replace the board and go to "Final Tasks" on page 141.

6. Resolder **R527** in its original position as shown in **Figure 12.14**.

7. Replace all cans.

8. Use the oscilloscope probe to check the difference frequency at the **TP502 test point** (see **Figure 12.14**). The signal is SYN CDC FCL and should be:

TP502 test point: sine wave of 1.1 ± 0.2 V_{pp} on 1.5 ± 0.1 V DC

9. If the signal is correct, the fault has been removed; go to "Final Tasks" on page 141. If the signal is not correct, the repair failed; replace the board and go to "Final Tasks" on page 141.

12.10 VCXO and CODEC Circuitry

Introduction

If the signals at the TP501 and TP502 test points are correct, two CCTM checks will reveal any remaining faults. These possible faults concern the VCXO tank circuit and the CODEC 2 circuitry. There are therefore three aspects, which are covered in Task 34 to Task 36:

- Task 34: CCTM checks
- Task 35: VCXO tank circuit
- Task 36: CODEC 2 circuitry.

Following any repairs of the VCXO or CODEC 2 circuitry, Task 34 will need to be repeated to confirm the removal of the fault.

Task 34 — CCTM Checks

If the signals at the TP501 and TP502 test points are correct, or any related faults were rectified, perform the following CCTM checks:

1. Enter the CCTM command *393 1 1900*. Measure the voltage level at the **TP501 test point** (see **Figure 12.14**):

TP501 test point: 1.3 ± 0.2 V DC (after CCTM 393 1 1900)

2. Enter the CCTM command *72* and note the lock status.

lock status=**xyz** (**x**=RF PLL; **y**=FCL; **z**=LO2) (0=not in lock; 1=in lock)

3. Enter the CCTM command *393 1 –1900*. Again measure the voltage level at the **TP501 test point**:

TP501 test point: 2.1 ± 0.2 V DC (after CCTM 393 1 –1900)

4. Enter the CCTM command *72* and note the lock status.

5. If the above voltage levels are not correct or if the FCL is out of lock in either or both of the above cases, investigate the VCXO tank circuit; go to Task 35.

   If the voltage level remains fixed at about 1.5V DC, investigate the CODEC 2 circuitry; go to Task 36.

   If the voltage levels are all correct (following earlier repairs), the fault has been removed; go to “Final Tasks” on page 141.

Task 35 — VCXO Tank Circuit

If the CCTM checks indicate that the VCXO tank circuit is faulty, repair the circuit as follows:

1. If not already done, remove the VCXO BOT can.

2. Locate and repair the fault in the VCXO tank circuit (**Q501**, **D501**, **D502**, **XL501** and associated components) (see **Figure 12.15**).

3. Confirm the removal of the fault and go to Step 4. If the repair failed, replace the board and go to “Final Tasks” on page 141.

4. Replace all cans.

5. Repeat Task 34 to confirm the removal of the fault. If the repair failed, replace the board and go to “Final Tasks” on page 141.

Task 36 — CODEC 2 Circuitry

If the CCTM checks indicate a fault in the CODEC 2 circuitry or with the digital signals to and from the circuitry, rectify the fault as follows:

1. Most of the CODEC 2 circuitry is situated under the CDC TOP can. If not already done, remove the CDC TOP can.

2. Check the following digital signals at **IC205** (see **Figure 12.13**):
   - pin 10 : DIG CDC2 LRCK
   - pin 12 : DIG CDC2 SCLK
   - pin 8 : CDC2 DIG SDTO
   - pin 9 : DIG CDC2 SDTI.

   These signals to and from the digital board should all be active:

digital signals: 3.3 ± 0.3 V

3. If the digital signals are correct, the CODEC 2 circuitry is suspect; go to Step 6. If they are not, go to Step 4.

4. If any or all digital signals are missing, check the connections between **IC205** and the digital board (see **Figure 12.13**).

5. If there are faults such as open circuits in the connections, repair the circuitry and repeat Task 34.

   If the connections are not faulty, then the digital board is faulty. Replace the board and go to “Final Tasks” on page 141.

6. The CODEC 2 circuitry comprises **IC205** and associated components under the CDC TOP can (see **Figure 12.13**) as well as **R246** under the CDC BOT can (see **Figure 10.3 on page 160**). Locate the fault.

7. Repair the circuitry. Note that, if the circuitry is functioning properly, probing the **TP501 test point** (see **Figure 12.14**) during power-up will show a five-step staircase signal followed by a random nine-step staircase signal — this is the expected power-up auto-calibration sequence.

8. Confirm the removal of the fault, and go to Step 9. If the repair failed, replace the board and go to “Final Tasks” on page 141.

9. Replace all cans.

10. Repeat Task 34 to confirm the removal of the fault. If the repair failed, replace the board and go to “Final Tasks” on page 141.

13 Transmitter Fault Finding (25 W)

Introduction

This section covers the diagnosis of faults in the 25 W transmitter circuitry. The main indication of a fault in the transmitter is a reduction in range. This implies that the power output is wrong or too low. Another type of fault is manifested when the radio always transmits at full power, even if set otherwise. Regardless of the fault, the lock status should be normal.

Fault-Diagnosis Tasks

The procedure for diagnosing transmitter faults is divided into tasks, which are grouped into the following sections:

- “Power Supplies”
- “Transmitter RF Power”
- “Biasing of PA Driver and PAs”
- “RF Signal Path”.

Before beginning the fault diagnosis with “Power Supplies”, note the following information regarding CCTM commands, frequency bands, can removal and replacement, and transmit tests.

CCTM Commands

The CCTM commands required in this section are listed in Table 13.1. Full details of the commands are given in “Computer-Controlled Test Mode (CCTM)” on page 114.

Table 13.1 CCTM commands required for the diagnosis of faults in the transmitter

Command	Description
33	Set radio in transmit mode
47	Read temperature near PAs — displays temperature **x** in degrees celsius and voltage **y**
101 **x** **y** 0	Set transmit frequency (**x** in Hertz) and receive frequency (**y** in Hertz) to specified values
114 **x**	Set DAC value **x** (in range 0 to 1023) of transmit power
304	Read clamp current at gate of PA driver — displays DAC value **x** (in range 0 to 255)
304 **x**	Set DAC value **x** (in range 0 to 255) of clamp current at gate of PA driver
318	Read forward-power level — displays corresponding voltage **x** in millivolts
319	Read reverse-power level — displays corresponding voltage **x** in millivolts
326 **x**	Set transmitter power level **x** (0=off, 1=very low, 2=low, 3=medium, 4=high, 5=maximum)
331	Read bias voltage for first PA — displays DAC value **x** (in range 0 to 255)
331 **x**	Set DAC value **x** (in range 0 to 255) of bias voltage for first PA
332	Read bias voltage for second PA — displays DAC value **x** (in range 0 to 255)
332 **x**	Set DAC value **x** (in range 0 to 255) of bias voltage for second PA
334 **x**	Set synthesizer on (**x**=1) or off (**x**=0) via DIG SYN EN line
335 **x**	Set transmit-receive switch on (**x**=1) or off (**x**=0) via DIG SYN TR SW line

Frequency Bands

Where test procedures or figures differ according to the frequency band of the radio, the frequency band is given in brackets. The frequency band may be referred to as either ‘VHF’ (very high frequency) or ‘UHF’ (ultra high frequency) or identified by the frequency sub-band, such as ‘B1’. For example:

RF output power: > 35W current: < 8A (**VHF**), < 9A (**UHF**)

A definition of frequency bands is given in “Defining Frequency Bands” on page 120.

Table 13.2 Lowest, centre and highest frequencies in MHz

Band	Lowest frequency	Centre frequency	Highest frequency
B1	136	155	174
H5	400	435	470

Emergency Frequencies

The following frequency ranges are reserved worldwide for use as maritime emergency frequencies or by distress beacons:

- B1 band: 156.8MHz ± 375kHz
- D1 band: 243MHz ± 5kHz
- H5 band: 406.0 to 406.1MHz.

Do <u>not</u> program the radio with any frequency in the above ranges.

Can Removal

There are five cans shielding the bulk of the transmitter circuitry:

- PAD TOP
- PAF TOP
- DIRC TOP
- PIN TOP
- LPF TOP.

To remove any can, first remove the board. In the case of the PAD TOP and PAF TOP cans, first detach the heat-transfer block from the board. Secure the block again after removing the cans. Follow the procedures given in “Disassembly and Reassembly” on page 121.

Can Replacement

Replace all cans that have been removed only after repairing the board. This applies to the B1 and H5 and bands. For certain other bands the transmitter will not operate correctly unless all the cans are fitted.

Transmit Tests

The following points need to be borne in mind when carrying out transmit tests:

- secure board
- ensure proper antenna load
- limit duration of transmit tests
- protect against accidental transmissions
- avoid thermal and RF burns.

These points are discussed in more detail below.

Secure Board

Before conducting any transmit tests, ensure that the board is adequately secured in the chassis. This is essential if overheating of the radio is to be avoided. (As mentioned earlier, the heat-transfer block must already be secured to the board of the assembly.)

Ensure Proper Antenna Load

The radio has been designed to operate with a 50Ω termination impedance, but will tolerate a wide range of antenna loading conditions. Nevertheless, care should be exercised. Normally the RF connector on the board will be connected to the RF communications test set as shown in Figure 6.8 on page 105. But for those tests where this connection is not necessary, a 50Ω load may be used instead. Do not operate the transmitter without such a load or without a connection to the test set. Failure to do so might result in damage to the power output stage of the transmitter.

Limit Duration of Transmit Tests

After setting the frequency and power level (if necessary), enter the CCTM command *33* to perform a transmit test. This command places the radio in transmit mode. After completing the measurement or check required, immediately enter the CCTM command *32*. This command returns the radio to the receive mode. Restricting the duration of transmit tests in this way will further limit the danger of overheating. The reason for this precaution is that the transmit timers do not function in the CCTM mode.

Protect Against Accidental Transmissions

Under certain circumstances the microprocessor can key on the transmitter. Ensure that all instruments are protected at all times from such accidental transmissions.

Avoid Thermal and RF Burns

Avoid thermal burns. Do not touch the cooling fins or underside of the radio body when the transmitter is or has been operating. Avoid RF burns. Do not touch the antenna or the RF signal path on the circuit board while the transmitter is operating.

13.1 Power Supplies

Introduction

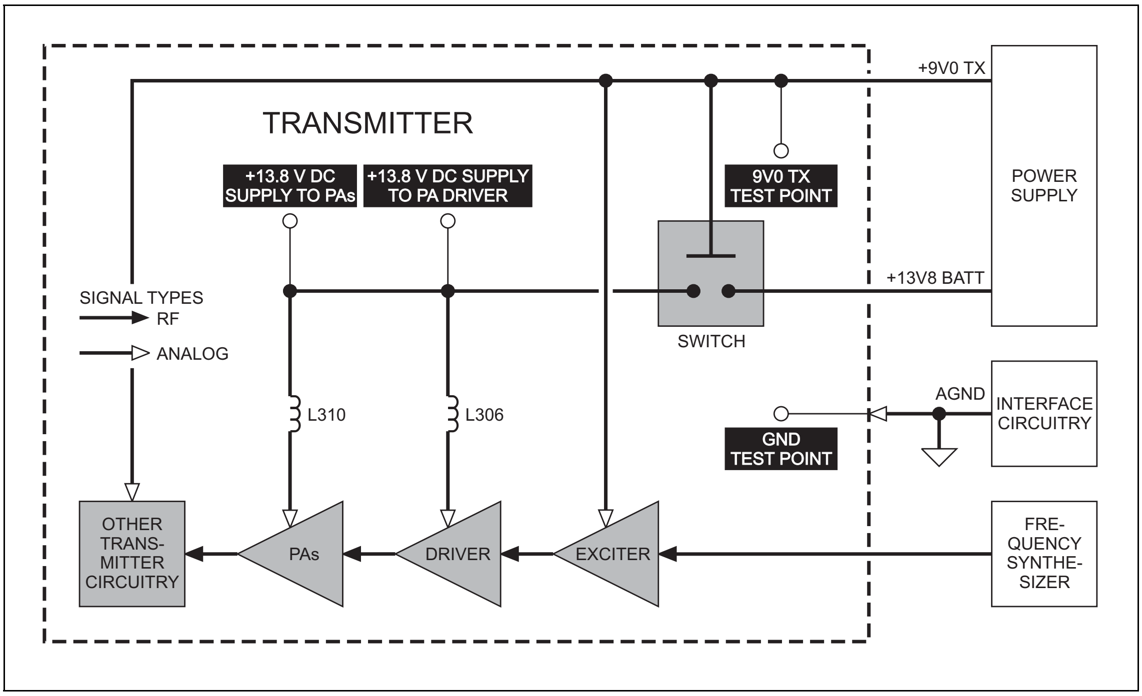
First check that a power supply is not the cause of the fault. There are two power supplies and a switch circuit for the transmitter:

- Task 1: 13.8V DC supply from power connector (+13V8 BATT)
- Task 2: switch circuit for 13.8V DC supply

- Task 3: 9V DC supply from 9V regulator in PSU module (+9V0 TX).

The measurement and test points for diagnosing faults in the power supplies are summarized in Figure 13.1.

Figure 13.1 Measurement and test points for diagnosing faults involving the power supplies for the transmitter



Task 1 — 13.8V Power Supply

First check the power supply from the power connector.

1. Obtain a needle probe to use for measurements of the power supply at the PA driver and PAs. If none is available, remove the PAF TOP and PAD TOP cans.

2. Set the DC power supply to 13.8V, with a current limit of 9A.

3. Program the radio with the highest frequency in the radio's frequency band: Enter the CCTM command *101* ***x x*** *0*, where ***x*** is the frequency in Hertz. The required values for the different frequency bands are given in **Table 13.2**.

4. Enter the CCTM command *326 5* to set the radio to maximum power.

5. Attempt to place the radio in transmit mode. Enter the CCTM command *33*.

6. If the radio enters the transmit mode, continue with Step 7. If instead a *C03* error is displayed in response to the command *33*, go to Task 7 in "Transmitter RF Power" on page 230.

7. Measure the voltage at the point on **L310** shown in **Figure 13.2**. This is the supply at the common drain of **Q309** and **Q310**, and should be:

common drain of Q309 and Q310: more than 13V DC

8. Also measure the voltage at the point on **L306** shown in **Figure 13.3**. This is the supply at the drain of **Q306**, and should be:

drain of Q306: more than 13V DC

9. Enter the CCTM command *32* to place the radio in receive mode.

10. If the power supply measured in Step 7 and Step 8 is not correct, go to Task 2. If it is, go to Task 3.

Figure 13.2 Point for measuring the power supply to the PAs (UHF shown)

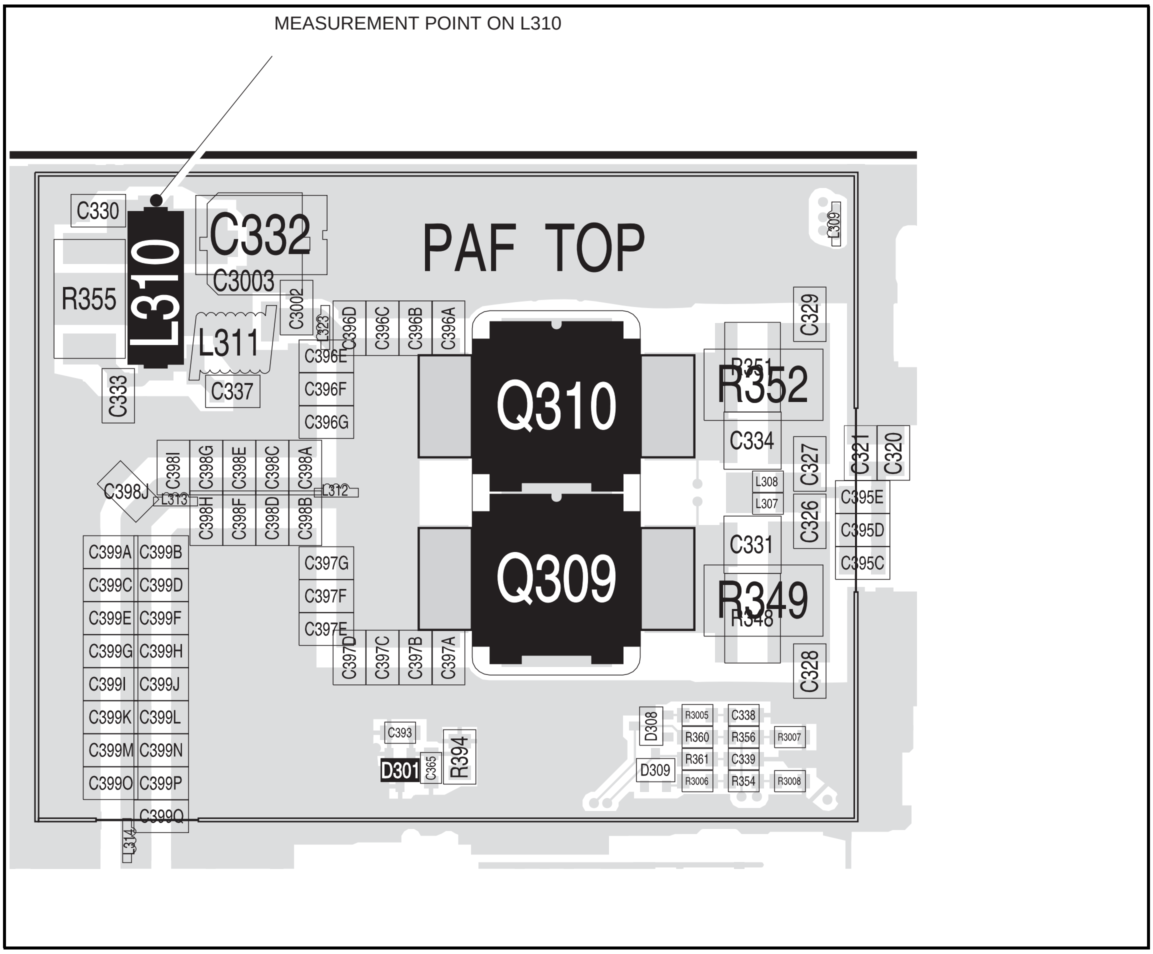
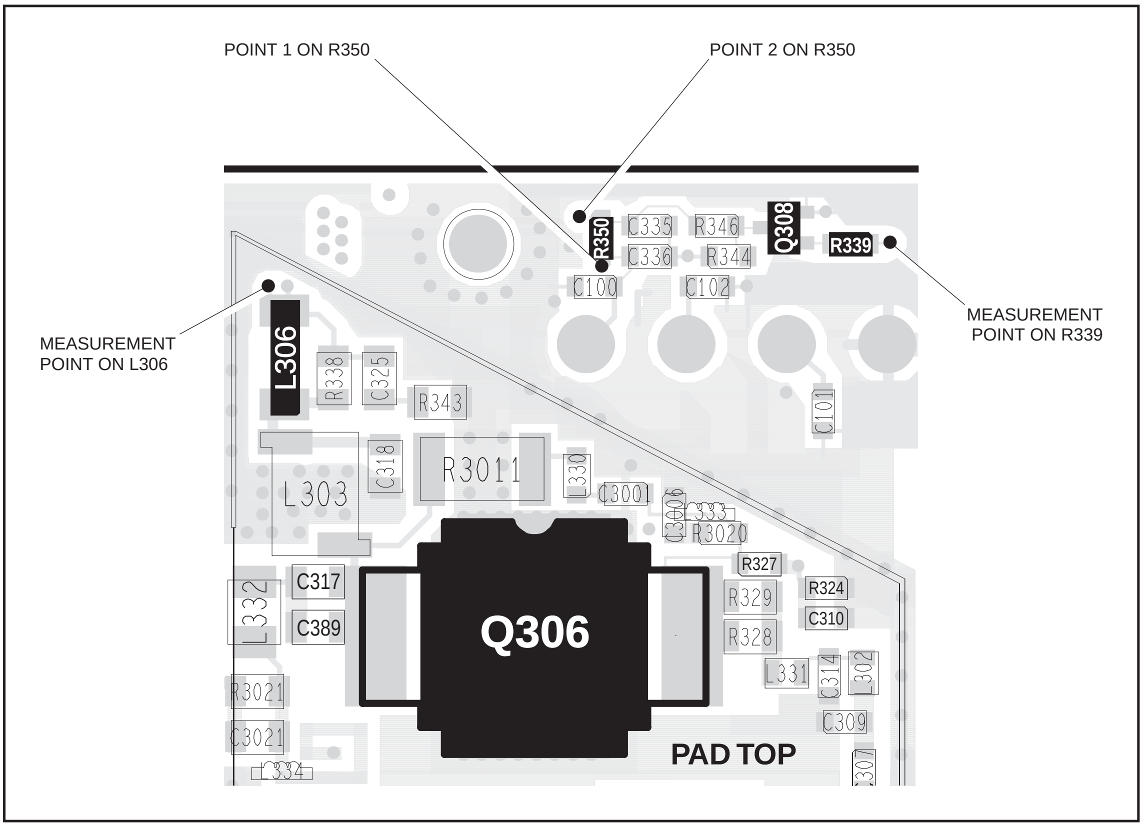


Figure 13.3 Point for measuring the power supply to the PA driver (VHF shown)



Task 2 — Check Switch Circuit

If the power supply to the drains of the PAs and PA driver is not correct, the switch circuit is suspect. Check the circuit as follows:

1. Measure the voltage at the point 1 on **R350** shown in **Figure 13.3**. The voltage should be:

point 1 on R350: 13.8V DC

2. If the voltage measured in Step 1 is correct, go to Step 3. If it is not, check for continuity between **R350** and the power connector. Repair any fault and conclude with Step 8.

3. Measure the voltage at **R339** as shown in **Figure 13.3**. The voltage should be:

R339: 9V DC

4. If the voltage measured in Step 3 is correct, go to Step 5. If it is not, go to Task 3 and check the 9V power supply.

5. Measure the voltage at the point 2 on **R350** shown in **Figure 13.3**. The voltage should be:

point 2 on R350: < 5V DC

6. If the voltage measured in Step 5 is correct, go to Step 7. If it is not, replace **Q308** — see **Figure 13.3** — and conclude with Step 8.

7. Remove the heat-transfer block from the board. Replace **Q311** (situated on the bottom-side of the board next to the power connector). Replace the heat-transfer block, and conclude with Step 8.

8. Repeat Task 1 to confirm the removal of the fault, and go to “Final Tasks” on page 141. If the repair failed or the fault could not be found, replace the board and go to “Final Tasks” on page 141.

Task 3 — 9V Power Supply

If the supply from the power connector is correct, check the 9V DC supply.

1. Enter the CCTM command *326 1* to set the transmitter power level very low.

2. Enter the CCTM command *33* to place the radio in transmit mode.

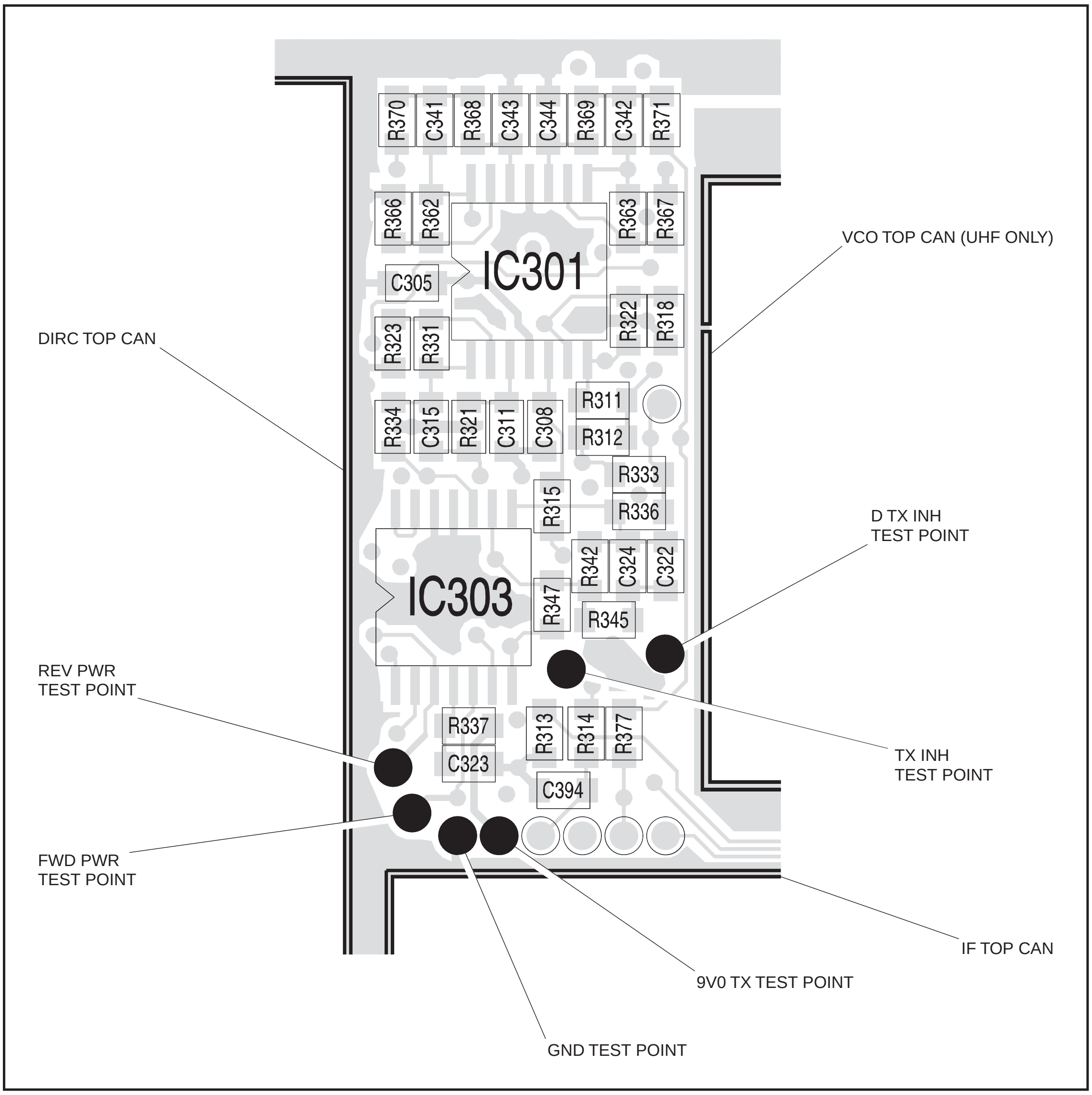
3. Measure the supply voltage between the **9V0 TX test point** and the **GND test point** (see **Figure 13.4**).

supply 9V0 TX: 9.0 ± 0.5V DC

4. Enter the CCTM command *32* to place the radio in receive mode.

5. If the supply measured in Step 3 is correct, go to Task 4 in “Transmitter RF Power” on page 228. If it is not, the 9V regulator **IC601** and the associated switching circuitry **Q603** are suspect; go to Task 3 of “Power Supply Fault Finding” on page 160.

Figure 13.4 Test points for checking the 9V supply, the forward and reverse RF power, and the inhibiting of the transmitter



13.2 Transmitter RF Power

Introduction

If there is no fault with the power supplies, check the transmitter RF power and correct any fault. The procedure is covered in the following eight tasks:

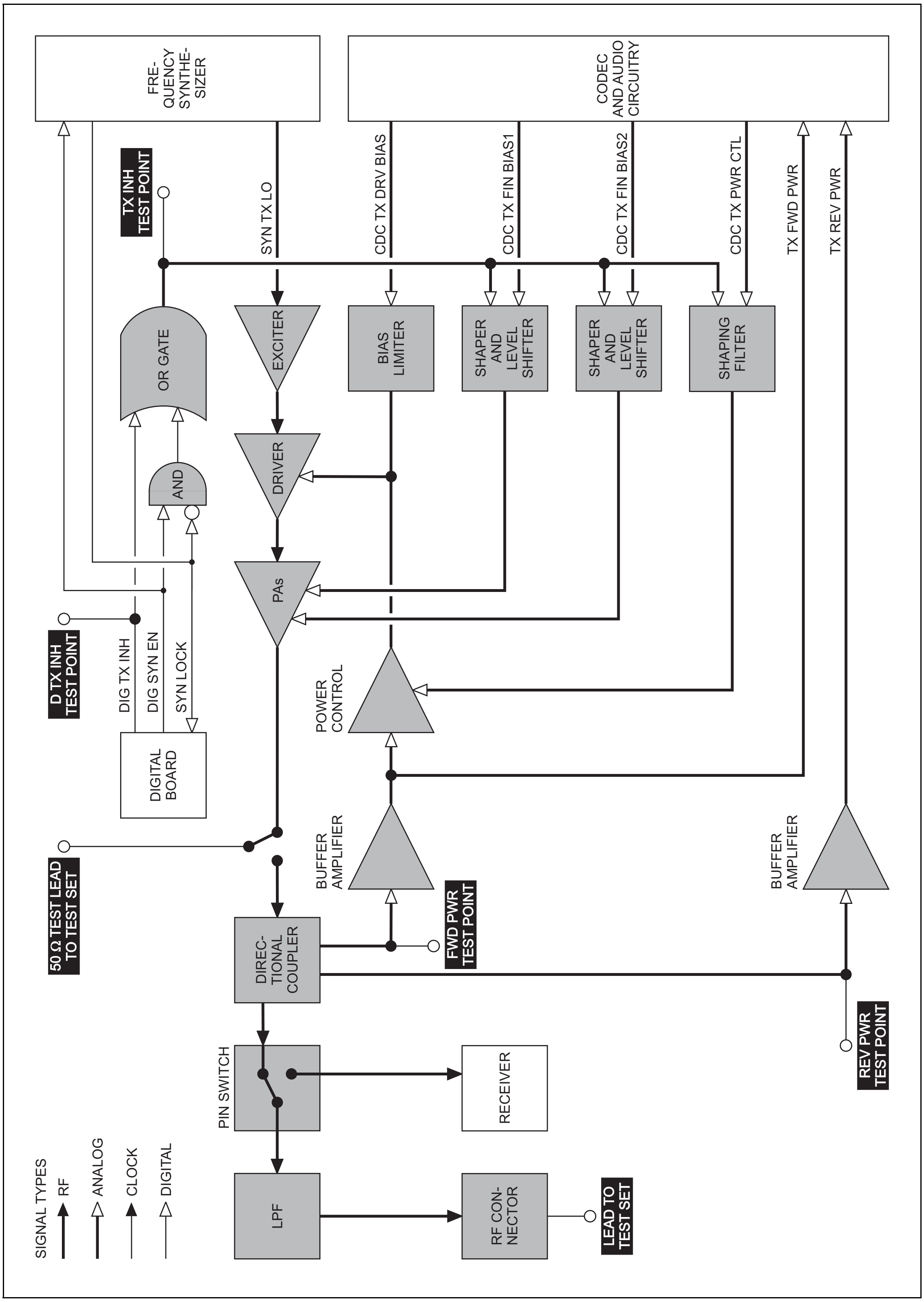
- Task 4: check forward and reverse powers
- Task 5: check RF output power
- Task 6: power unchanged regardless of setting
- Task 7: check for inhibiting of transmitter
- Task 8: check temperature sensor
- Task 9: power and current are skewed
- Task 10: repair output matching circuitry
- Task 11: power and current are low

The measurement points for diagnosing faults concerning the transmitter RF power are summarized in Figure 13.5. Data required for the first task (checking the forward and reverse powers) are supplied in Table 13.3.

Table 13.3 Voltages in millivolts corresponding to nominal forward and reverse powers

Frequency band	Forward power (318 command)	Reverse power (319 command)
B1	1100 to 2000	<500
H5	2500 to 3500	<1000

Figure 13.5 Measurement and test points for diagnosing faults concerning the transmitter RF power



Task 4 — Check Forward and Reverse Powers

First check the forward and reverse powers for an indication of which part of the circuitry is suspect.

1. Enter the CCTM command *326 4* to set the transmitter power level high.
2. Enter the CCTM command *33* to place the radio in transmit mode.
3. Enter the CCTM command *318* to check the forward power.
   The value returned is the voltage in millivolts corresponding to the power level, and should be as shown in **Table 13.3**.
4. Confirm the above result by checking the level at the **FWD PWR test point** (see **Figure 13.4**) using an oscilloscope.
5. Enter the CCTM command *319* to check the reverse power.
   The value returned is the voltage in millivolts corresponding to the power level, and should be as shown in **Table 13.3**.
6. Confirm the above result by checking the level at the **REV PWR test point** (see **Figure 13.4**) using an oscilloscope.

   If the oscilloscope momentarily indicates a very high reverse power, then the most likely scenario is that the antenna VSWR threshold has been exceeded and the PA has shut down to very low power.
7. Enter the CCTM command *32* to place the radio in receive mode.
8. If the values obtained in Step 3 and Step 5 are both correct, and there is no indication of a momentary high reverse power, go to Task 5.
   If one or both are incorrect, go to Step 9.
9. Check the connection from the RF connector on the radio to the test set.
10. If there is no fault, go to Step 11. If there is, rectify the fault and repeat the above measurements.
11. If the reverse power is momentarily too high, the directional coupler, PIN switch or LPF is suspect; go to Task 29. Otherwise go to Task 5.

Task 5 — Check RF Output Power

If the power supplies are correct, check the RF output power of the transmitter.

1. Enter the CCTM command *326 5* to set the transmitter power level to the maximum value.
2. If not already done, program the radio with the highest frequency in the radio's frequency band: Enter the CCTM command *101* ***x x*** *0*, where ***x*** is the frequency in Hertz. The required values for the different frequency bands are given in **Table 13.2**.
3. Enter the CCTM command *33* to place the radio in transmit mode.
4. Note the RF output power measured by the test set, and note the current reading on the DC power supply.

RF output power: > 30W current: < 8A (VHF), < 9A (UHF)

5. Enter the CCTM command *32* to place the radio in receive mode.
6. Program the radio with the centre frequency in the radio's frequency band: Enter the CCTM command *101* ***x x*** *0*, where ***x*** is the frequency in Hertz. The required values for the different frequency bands are given in **Table 13.2**.
7. Repeat Step 3 to Step 5.
8. Program the radio with the lowest frequency in the radio's frequency band: Enter the CCTM command *101* ***x x*** *0*, where ***x*** is the frequency in Hertz. The required values for the different frequency bands are given in **Table 13.2**.
9. Repeat Step 3 to Step 5.
10. Depending on the results of the above measurements, proceed to the task indicated in **Table 13.4**. Note that the power and current are considered to be skewed if they are low at one part of the frequency band and high elsewhere.

Table 13.4 Tasks to be performed according to the results of the power and current measurements of Task 5

Power	Current	Task
Correct	Correct	Task 6 — Power unchanged regardless of setting
Correct	Wrong	Task 29 — Check power at directional coupler
Skewed	Skewed	Task 9 — Power and current are skewed
Low (> 0.1W)	Low (> 0.5A)	Task 11 — Power and current are low
None at RF connector (< 0.1W)	Low (> 0.5A)	Task 29 — Check power at directional coupler
None at RF connector (< 0.1W)	None (< 0.5A)	Task 7 — Check for inhibiting of transmitter

Task 6 — Power Unchanged Regardless of Setting

If all the power and current values measured in Task 5 are correct, it is likely that the power remains unchanged regardless of the power setting.

1. Enter the following CCTM commands in turn and measure the RF output power in each case:
   - *326 4*
   - *326 3*
   - *326 2*
   - *326 1*
2. The above measurements should confirm that the power remains unchanged at all settings. Carry out Task 12 and then Task 19.

Task 7 — Check for Inhibiting of Transmitter

If the transmitter is drawing no current or the wrong current, check whether it is being inhibited. This check is also required if a *CO3* error occurs in Task 1.

1. If not already done, enter the CCTM command *33* to place the radio in transmit mode.
2. Check the logic signal at the **TX INH test point** (see **Figure 13.4**). The signal should be:

TX INH test point: about 0V (inactive)

3. If the signal is inactive as required, go to Step 4. If it is active — about 1.1V — the transmitter is being inhibited; go to Step 5.
4. Enter the CCTM command *32* to place the radio in receive mode, and go to Task 12 in “Biasing of PA Driver and PAs” on page 236.
5. Check the logic signal at the **D TX INH test point** (see **Figure 13.4**). The signal should be:

D TX INH test point: about 0V (inactive)

6. If the signal is inactive as required, go to Step 8. If it is active — about 3.2V — the temperature sensor is suspect; go to Step 7.
7. Enter the CCTM command *32* to place the radio in receive mode, and go to Task 8.
8. The lock status is possibly no longer normal. Enter the CCTM command *72* and check the lock status.
9. Enter the CCTM command *32* to place the radio in receive mode.
10. The normal lock status is *110*. If it is not, proceed to the relevant section. If it is, go to Step 11.
11. Check for short circuits on the DIG TX INH line from the **D TX INH test point**.

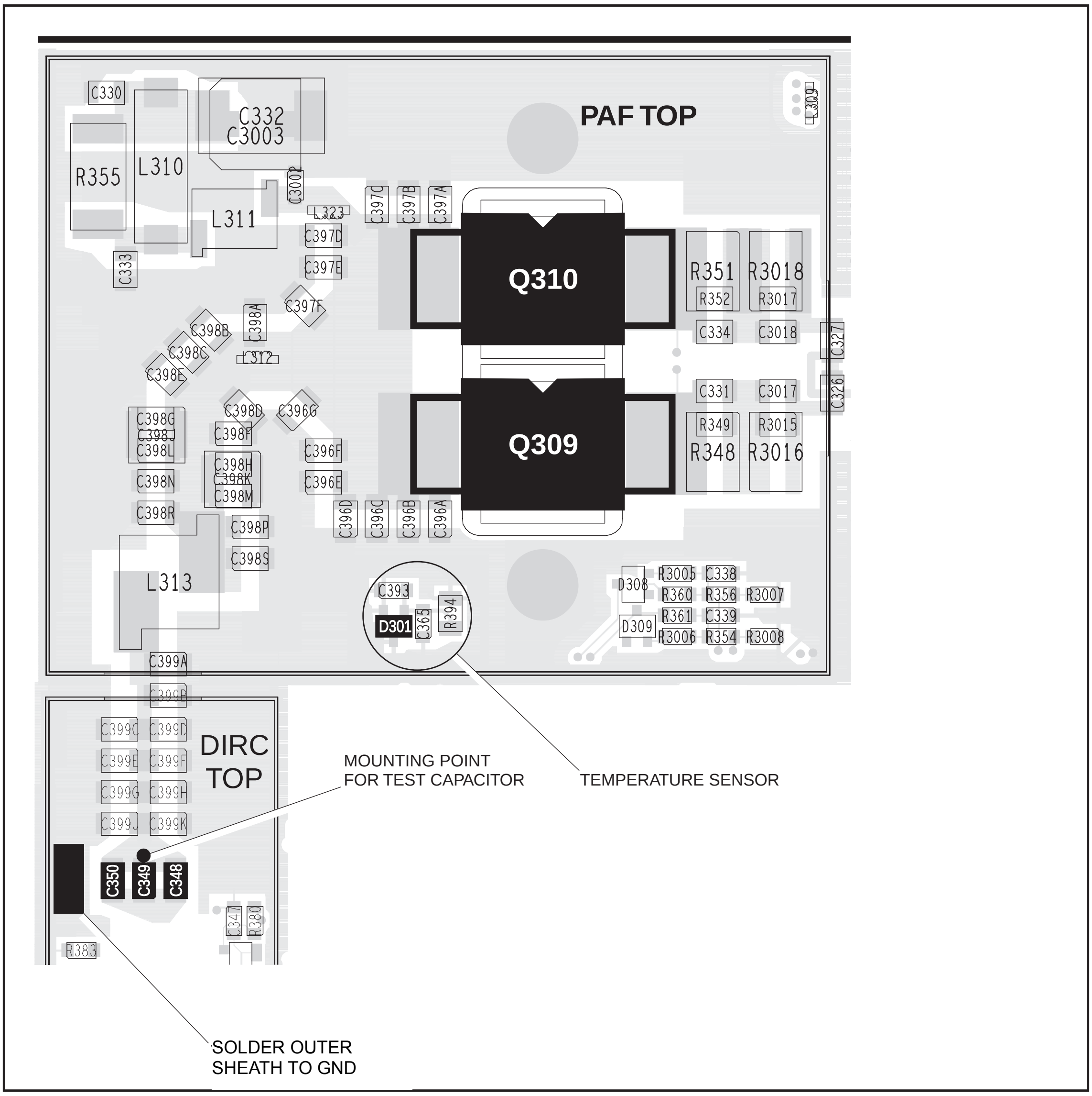
12. Repair any fault, confirm the removal of the fault, and go to “Final Tasks” on page 141. If the repair failed or no fault could be found, replace the board and go to “Final Tasks” on page 141.

Task 8 — Check Temperature Sensor

If the transmitter is being inhibited and the logic signal at the D TX INH test point is active, a fault in the temperature sensor might be the cause.

1. Enter the CCTM command *47* to check the temperature reading.
2. Of the two numbers returned, the first is the temperature in degrees celsius and should be about 25°C. If it is, go to Task 12 in “Biasing of PA Driver and PAs” on page 236. If it is not, go to Step 3.
3. If not already done, remove the PAF TOP can.
4. Check **D301** and the surrounding components — see **Figure 13.6**.
5. If there is no fault, go to “CODEC and Audio Fault Finding” on page 335. If a fault is found, repair it, confirm the removal of the fault, and go to “Final Tasks” on page 141. If the repair failed, replace the board and go to “Final Tasks” on page 141.

Figure 13.6 PA circuitry under the PAF TOP can and part of the directional coupler under the DIRC TOP can (VHF shown)



Task 9 — Power and Current Are Skewed

If the RF output power and the supply current are skewed, the output matching is suspect.

1. Remove the DIRC TOP can.
2. Remove the coupling capacitors **C348**, **C349** and **C350** — see **Figure 13.6**.
3. Solder one terminal of a test capacitor to the PCB at the point shown in **Figure 13.6**. Mount the capacitor vertically. Use a test capacitor of the type GRM111, DLI C17, ATC100B, or the equivalent.

   The value of the capacitor depends on the frequency band of the radio:
   - B1 — 680pF
   - H5 — 82pF.
4. Solder a 50Ω test lead to the PCB. Solder the outer sheath in the position shown in **Figure 13.6**, and solder the central wire to the other terminal of the test capacitor.
5. Connect the test lead to the test set.
6. Program the radio with the highest frequency in the radio's frequency band: Enter the CCTM command *101* ***x x*** *0*, where ***x*** is the frequency in Hertz.
7. Enter the CCTM command *33* to place the radio in transmit mode.
8. Note the RF output power measured by the test set, and note the current reading on the DC power supply.

RF output power: > 35W current: < 8A (VHF), < 9A (UHF)
9. Enter the CCTM command *32* to place the radio in receive mode.
10. Program the radio with the centre frequency in the band: Enter the CCTM command *101* ***x x*** *0*, where ***x*** is the frequency in Hertz.
11. Repeat Step 7 to Step 9.
12. Program the radio with the lowest frequency in the band: Enter the CCTM command *101* ***x x*** *0*, where ***x*** is the frequency in Hertz.
13. Repeat Step 7 to Step 9.
14. If the power and current are still skewed, go to Task 10. If the power and current are correct, remove the test lead and test capacitor, resolder the coupling capacitors in position, and go to Task 31 — the PIN switch and LPF require checking.

Task 10 — Repair Output Matching Circuitry

If the checks in Task 9 show that the power and current are still skewed, there is a fault in the output matching circuitry.

1. If not already done, remove the PAF TOP can.
2. Check for faulty, shorted or misplaced components in the circuit between the test capacitor and the common drain of **Q309** and **Q310** (see **Figure 13.6**). Repair any fault.
3. Program the radio with the highest frequency in the radio's frequency band: Enter the CCTM command *101* ***x x*** *0*, where ***x*** is the frequency in Hertz.
4. Enter the CCTM command *33* to place the radio in transmit mode.
5. Note the RF output power measured by the test set, and note the current reading on the DC power supply.

   RF output power: > 35W
   current: < 8A (VHF), < 9A (UHF)

6. Enter the CCTM command *32* to place the radio in receive mode.
7. Program the radio with the centre frequency in the band: Enter the CCTM command *101* ***x x*** *0*, where ***x*** is the frequency in Hertz.
8. Repeat Step 4 to Step 6.
9. Program the radio with the lowest frequency in the band: Enter the CCTM command *101* ***x x*** *0*, where ***x*** is the frequency in Hertz.
10. Repeat Step 4 to Step 6.
11. Remove the test lead and test capacitor, and resolder the coupling capacitors **C348**, **C349** and **C350** in position (see **Figure 13.6**).
12. If the power and current are now correct at all three frequencies, the fault has been rectified; go to “Final Tasks” on page 141. If they are not, go to Task 25 in “RF Signal Path” on page 255.

Task 11 — Power and Current Are Low

If the RF output power and the supply current are uniformly low at all frequencies, one of the PAs is suspect or the input to the PAs is reduced. Check each PA in turn:

1. For the first PA (Q310), enter the CCTM command *331* to check the DAC value of final bias 1 (CDC TX FIN BIAS 1). Record the value ***x*** returned.
2. Note the current reading on the DC power supply.
3. Enter the CCTM command *331 1* to turn off final bias 1.
4. Enter the CCTM command *33* to place the radio in transmit mode.
5. Note the RF output power measured at the test set. This should be as shown in **Table 13.5**.
6. If the RF power is correct, go to Step 7 to repeat the check with the second PA. If it is not, enter the CCTM command *32* to place the radio in receive mode, and carry out Task 12 and then Task 13.
7. For the second PA (Q309), enter the CCTM command *332* to check the DAC value of final bias 2 (CDC TX FIN BIAS 2). Record the value ***y*** returned.
8. Note the current reading on the DC power supply.
9. Enter the CCTM command *332 1* to turn off final bias 2.
10. With the radio still in transmit mode, note the RF output power measured at the test set. This should be as shown in **Table 13.5**.
11. Enter the CCTM command *32* to place the radio in receive mode.
12. If the RF power measured in Step 10 is correct, go to “RF Signal Path” on page 254. If it is not, carry out Task 12 and then Task 16.

Table 13.5 RF output power of individual RF power amplifiers at different frequencies

Frequency band	Frequency within band		
	Lowest frequency	Centre frequency	Highest frequency
B1	29 ± 5W	34 ± 5W	29 ± 5W
H5	5 ± 5W	12 ± 5W	27 ± 5W

13.3 Biasing of PA Driver and PAs

Introduction

The measurements of the transmitter RF output power in “Transmitter RF Power” might indicate a need to check the biasing of the two PAs and the PA driver. The procedure is covered in this section. There are thirteen tasks grouped as follows:

- Task 12: prepare to check biasing
- Task 13 to Task 15: check biasing of first PA
- Task 16 to Task 18: check biasing of second PA
- Task 19 and Task 20: check biasing of PA driver
- Task 21 to Task 24: repair circuitry

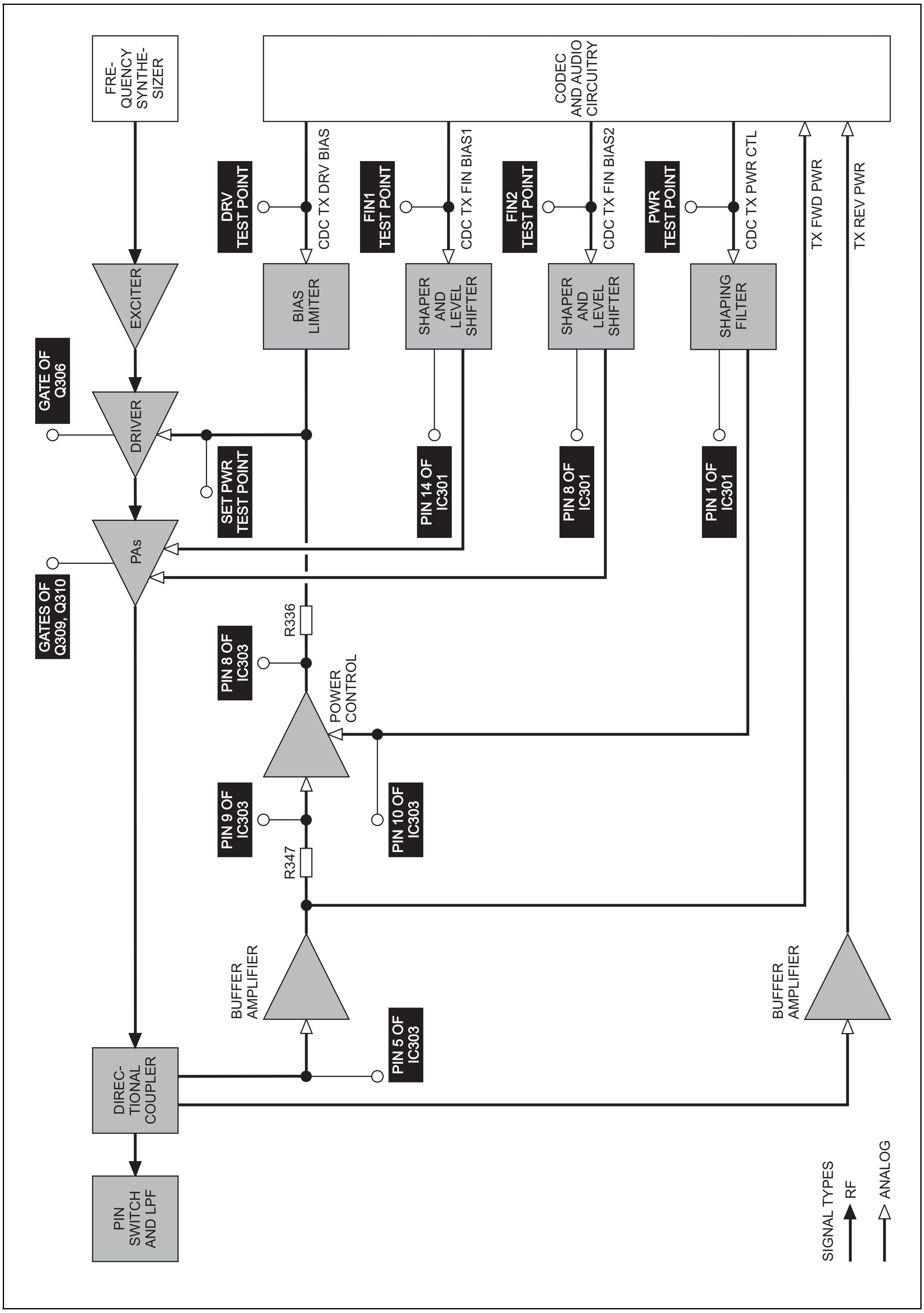
The test and measurement points for diagnosing faults in the biasing of the PAs and PA driver are summarized in Figure 13.7.

Task 12 — Prepare to Check Biasing

If the transmitter is not being inhibited, check the biasing of the two PAs and the PA driver. First make the following preparations:

1. Set the current limit on the DC power supply to 2A.
2. Enter the CCTM command *331* to check the DAC value of final bias 1 (CDC TX FIN BIAS 1) at maximum power. Record the value ***x*** returned.
3. Enter the CCTM command *332* to check the DAC value of final bias 2 (CDC TX FIN BIAS 2) at maximum power. Record the value ***y*** returned.
4. Enter the CCTM command *304* to check the DAC value of the clamp current at the driver gate. Record the value ***z*** returned.
5. Enter the CCTM command *33* to place the radio in transmit mode.
6. Switch off all biases by entering the following CCTM commands in sequence:
   - *331 1*
   - *332 1*
   - *304 1*
   - *114 1023*
   - *334 0*
   - *335 0*
7. Note the current reading on the DC power supply. This will be less than 500mA.
8. With the radio still in transmit mode, check the biasing of the PAs and PA driver, beginning with Task 13.

Figure 13.7 Measurement and test points for diagnosing faults in the biasing of the PAs and PA driver



Task 13 — Check Biasing of First PA

Check the biasing of the first PA (Q310).

Important Ensure that the current limit on the DC supply is 2A. And, when entering the CCTM command *331* ***x***, do not specify a value ***x*** higher than that recorded in Task 12. Failure to do so might result in the destruction of the PAs.

1. Use a multimeter to measure the voltage at pin 14 of **IC301** (see **Figure 13.8**). The voltage should be:

pin 14 of IC301: < 100mV (initially)

2. Note the current reading on the DC power supply. As mentioned in Step 7 of Task 12, this will be less than 500mA.
3. Enter the CCTM command *331* ***x*** (where ***x*** was recorded in Task 12).
4. Check that the voltage changes to:

pin 14 of IC301: 2 to 5V (after entry of CCTM 331 **x**)

5. Also note the current reading. This should increase by an amount approximately equal to the offset given in **Table 13.6**.
6. If the voltage and current are both correct, go to Step 7. If the voltage is correct but not the current, go to Task 14. If neither the current nor the voltage is correct, go to Task 15.
7. Enter the CCTM command *331 1* to switch off final bias 1, and go to Task 16.

Table 13.6 Gate biases for the PAs and PA driver at high power

Frequency band	Offset currents in mA		
	First PA	**Second PA**	**PA driver**
B1	750	750	300
H5	1000	1000	450

Figure 13.8 Test points and components of the shaping filter

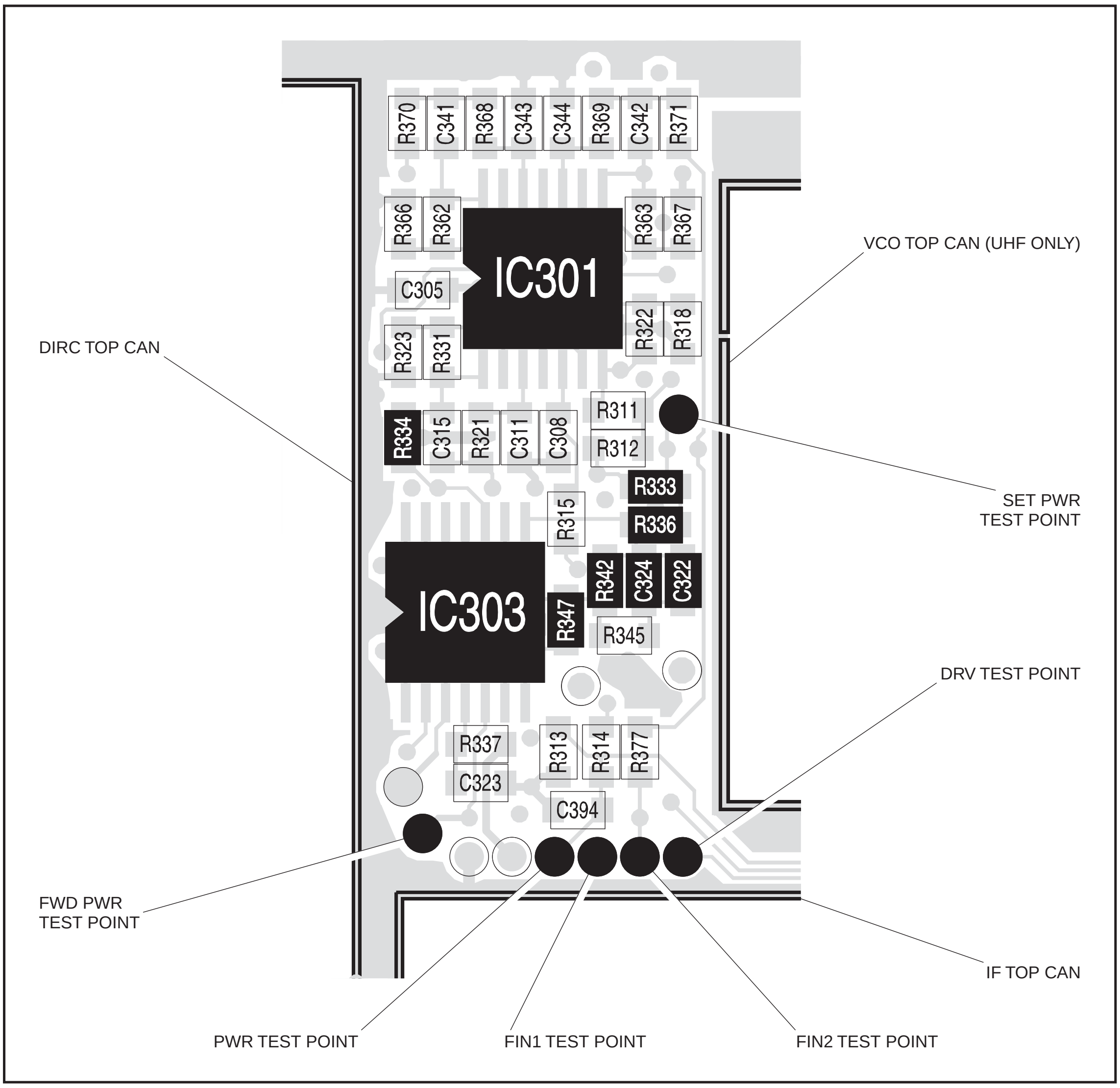
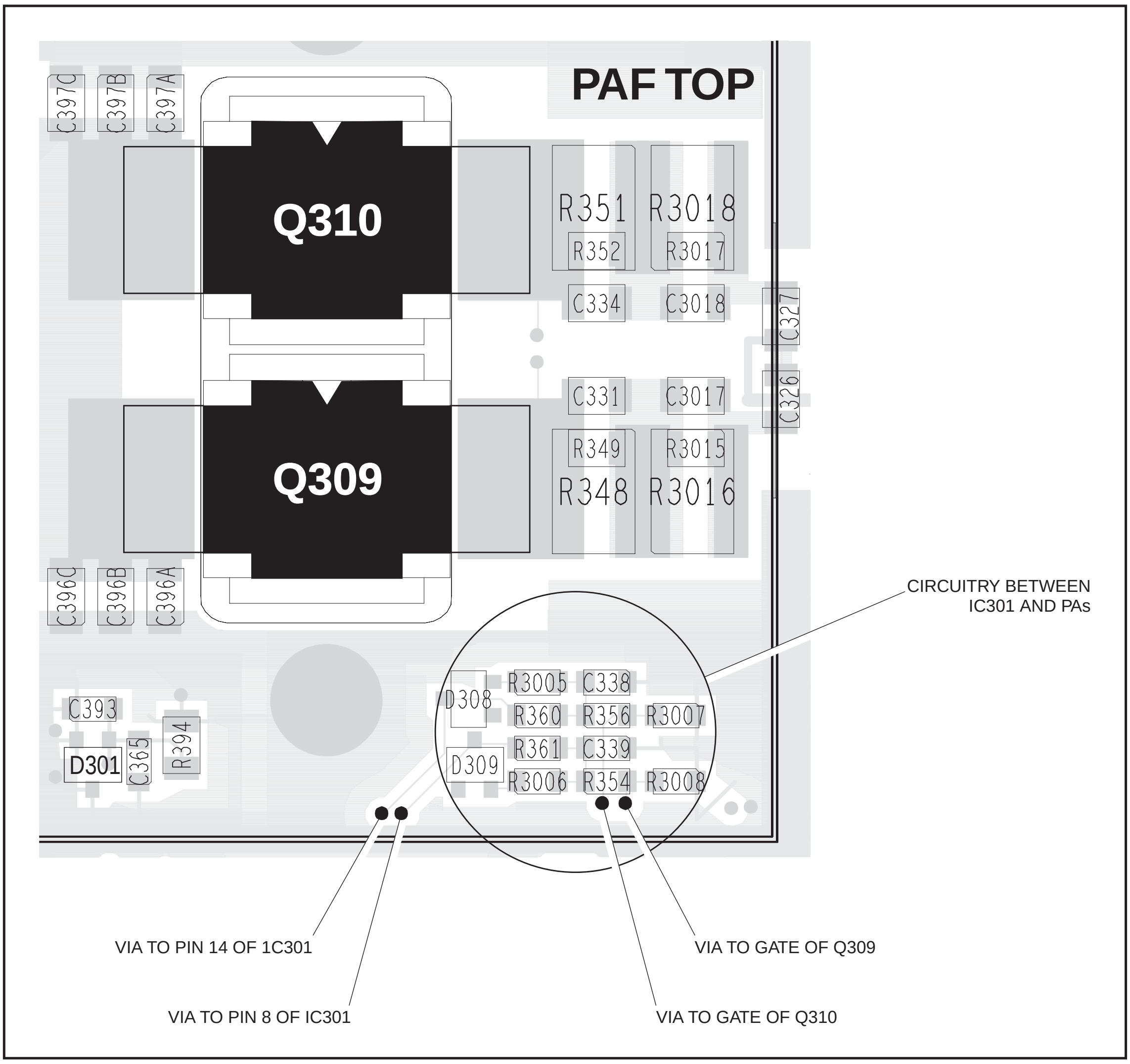


Figure 13.9 PA circuitry under the PAF TOP can (VHF shown)



Task 14 — Shaper and Level Shifter

If the voltage measured in Task 13 is correct but not the current, either the first PA or the shaper and level shifter for the PA is suspect.

Important Ensure that the current limit on the DC supply is 2A. And, when entering the CCTM command *331* ***x***, do not specify a value ***x*** higher than that recorded in Task 12. Failure to do so might result in the destruction of the PAs.

1. If the PAF TOP can has already been removed, go to Step 5. If it has not, go to Step 2.
2. Enter the CCTM command *32* to place the radio in receive mode.
3. Remove the PAF TOP can.
4. Enter the CCTM command *33* to place the radio in transmit mode.
5. Enter the CCTM command *331* ***x*** (where ***x*** was recorded in Task 12).
6. Check that the voltage at the gate of **Q310** is (see **Figure 13.9**):

gate of Q310: 2 to 5V

7. Enter the CCTM command *32* to place the radio in receive mode.
8. If the voltage measured above is correct, **Q310** is faulty; replace the board and go to “Final Tasks” on page 141. If it is not correct, go to Step 9.
9. Check the circuitry between pin 14 of **IC301** and the gate of **Q310** (see **Figure 13.9**). If a fault is found, repair it, confirm the removal of the fault, and go to “Final Tasks” on page 141. If the repair failed or Q310 itself is faulty, replace the board and go to “Final Tasks” on page 141.

Task 15 — Shaping Filter for Power Control

If neither the voltage nor the current measured in Task 13 is correct, then the shaping filter for the power-control circuitry or the CODEC and audio circuitry is suspect.

Important Ensure that the current limit on the DC supply is 2A. And, when entering the CCTM command *331* ***x***, do not specify a value ***x*** higher than that recorded in Task 12. Failure to do so might result in the destruction of the PAs.

1. Use the multimeter to measure the voltage at the **FIN1 test point** (see **Figure 13.8**). The voltage should be:

FIN1 test point: 18 ± 2mV (initially)

2. Enter the CCTM command *331* ***x*** (where ***x*** was recorded in Task 12).
3. Check that the voltage changes to:

FIN1 test point: 1.1 to 2.7V (after entry of CCTM 331 **x**)

4. Enter the CCTM command *32* to place the radio in receive mode.
5. If the voltage measured above is correct, go to Step 6. If it is not, go to “CODEC and Audio Fault Finding” on page 335.
6. Check **IC301** and the surrounding shaping-filter circuitry (see **Figure 13.8**). If a fault is found, repair it, confirm the removal of the fault, and go to “Final Tasks” on page 141. If the repair failed, replace the board and go to “Final Tasks” on page 141.

Task 16 — Check Biasing of Second PA

If the biasing of the first PA is correct, check that of the second PA (Q309).

Important Ensure that the current limit on the DC supply is 2A. And, when entering the CCTM command *332* ***y***, do not specify a value ***y*** higher than that recorded in Task 12. Failure to do so might result in the destruction of the PAs.

1. Use the multimeter to measure the voltage at pin 8 of **IC301** (see **Figure 13.8**). The voltage should be:

pin 8 of IC301: < 100mV (initially)

2. Note the current reading on the DC power supply. As mentioned in Step 7 of Task 12, the current will be less than 500mA.

3. Enter the CCTM command *332* ***y*** (where ***y*** was recorded in Task 12).

4. Check that the voltage changes to:

pin 8 of IC301: 2 to 5V (after entry of CCTM 332 **y**)

5. Also note the current reading. This should increase by an amount approximately equal to the offset given in **Table 13.6**.

6. If the voltage and current are both correct, go to Step 7. If the voltage is correct but not the current, go to Task 17. If neither the current nor the voltage is correct, go to Task 18.

7. Enter the CCTM command *332 1* to switch off final bias 2, and go to Task 19.

Task 17 — Shaper and Level Shifter

If the voltage measured in Task 16 is correct but not the current, either the second PA or the shaper and level shifter for the PA is suspect.

Important Ensure that the current limit on the DC supply is 2A. And, when entering the CCTM command *332* ***y***, do not specify a value ***y*** higher than that recorded in Task 12. Failure to do so might result in the destruction of the PAs.

1. If the PAF TOP can has already been removed, go to Step 5. If it has not, go to Step 2.
2. Enter the CCTM command *32* to place the radio in receive mode.
3. Remove the PAF TOP can.
4. Enter the CCTM command *33* to place the radio in transmit mode.
5. Enter the CCTM command *332* ***y*** (where ***y*** was recorded in Task 12).
6. Check that the voltage at the gate of **Q309** is (see **Figure 13.9**):

gate of Q309: 2 to 5V

7. Enter the CCTM command *32* to place the radio in receive mode.
8. If the voltage is correct, **Q309** is faulty; replace the board and go to “Final Tasks” on page 141. If it is not, go to Step 9.
9. Check the circuitry between pin 8 of **IC301** and the gate of **Q309** (see **Figure 13.9**). If a fault is found, repair it, confirm the removal of the fault, and go to “Final Tasks” on page 141. If the repair failed or Q309 itself is faulty, replace the board and go to “Final Tasks” on page 141.

Task 18 — Shaping Filter for Power Control

If neither the voltage nor the current measured in Task 16 is correct, then the shaping filter for the power-control circuitry or the CODEC and audio circuitry is suspect.

Important Ensure that the current limit on the DC supply is 2A. And, when entering the CCTM command *332* ***y***, do not specify a value ***y*** higher than that recorded in Task 12. Failure to do so might result in the destruction of the PAs.

1. Use the multimeter to measure the voltage at the **FIN2 test point** (see **Figure 13.8**). The voltage should be:

FIN2 test point: 18 ± 2V (initially)

2. Enter the CCTM command *332* ***y*** (where ***y*** was recorded in Task 12).
3. Check that the voltage changes to:

FIN2 test point: 1.1 to 2.7V (after entry of CCTM 332 **y**)

4. Enter the CCTM command *32* to place the radio in receive mode.
5. If the voltage measured above is correct, go to Step 6. If it is not, go to “CODEC and Audio Fault Finding” on page 335.
6. Check **IC301** and the surrounding shaping-filter circuitry (see **Figure 13.8**). If a fault is found, repair it, confirm the removal of the fault, and go to “Final Tasks” on page 141. If the repair failed, replace the board and go to “Final Tasks” on page 141.

Task 19 — Biasing of PA Driver— DRV test point

If there is no fault in the biasing of the PAs, investigate the biasing of the PA driver (Q306). First check the DRV test point.

Important Ensure that the current limit on the DC supply is 2A. And, when entering the CCTM command *304* ***z***, do not specify a value ***z*** higher than that recorded in Task 12. Failure to do so might result in the destruction of the PA driver.

1. Note the current reading on the DC power supply. As mentioned in Step 7 of Task 12, the current will be less than 500mA.
2. Enter the CCTM command *304* ***z*** (where ***z*** was recorded in Task 12) to switch on the clamp current.
3. Note the current reading on the DC power supply.
4. Compare the above current readings. The current should increase by an amount approximately equal to the offset given in **Table 13.6**. If it does, go to Task 21. If it does not, go to Step 5.
5. Check as follows that the voltage from the DAC is changing: First enter the CCTM command *304 1* to switch off the bias.
6. Measure the voltage at the **DRV test point** (CDC TX DRV BIAS) (see **Figure 13.8**). The voltage should be:

DRV test point: < 0.1V (after entry of CCTM 304 1)

7. Enter the CCTM command *304* ***z*** (where ***z*** was recorded in Task 12) to change the DAC value of the clamp current.
8. The voltage should increase to:

DRV test point: 0.8 to 2.5V (after entry of CCTM 304 **z**)

9. If the voltage does change, go to Task 20. If it does not, go to Step 10.
10. Enter the CCTM command *32* to place the radio in receive mode, and go to “CODEC and Audio Fault Finding” on page 335.

Task 20 — Biasing of PA Driver— SET PWR test point

If the voltage at the DRV test point is correct, check that at the SET PWR test point.

1. Check the voltage at the **SET PWR test point** (see **Figure 13.8**):

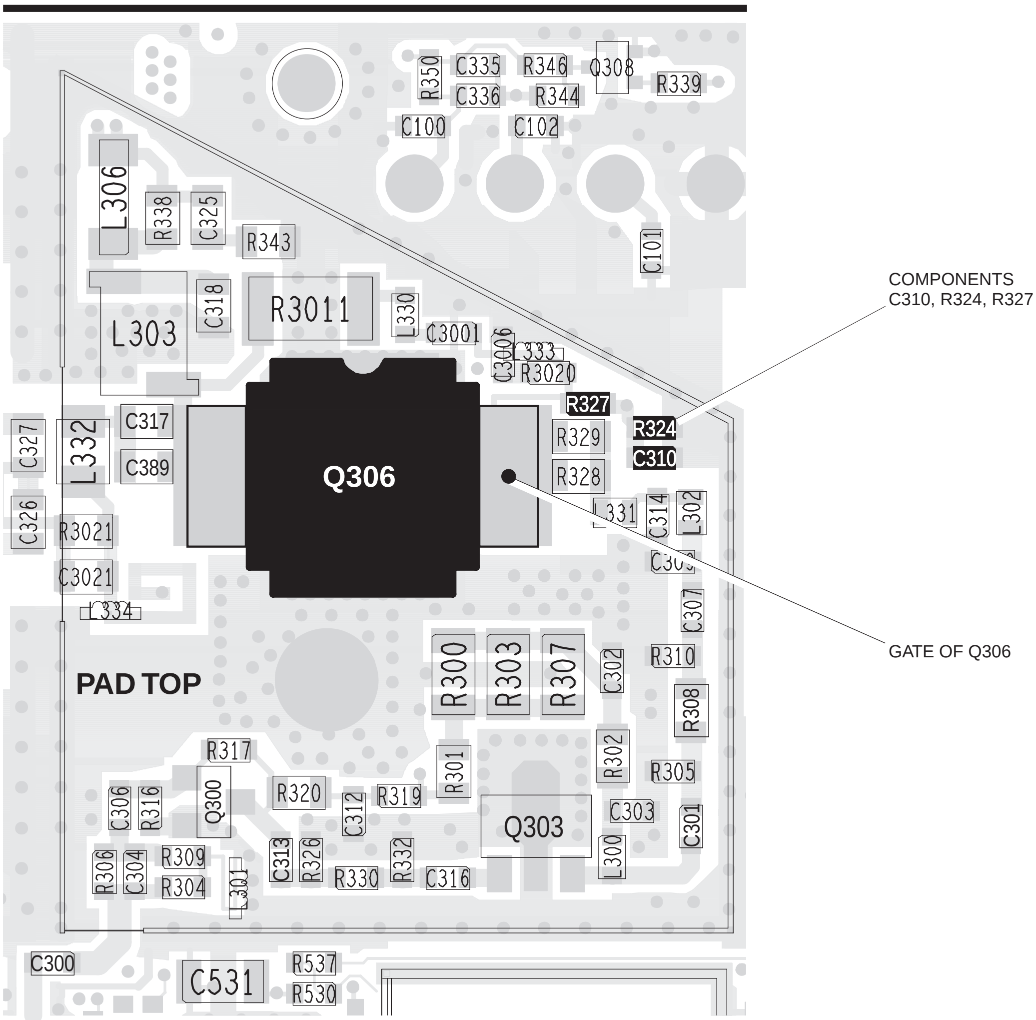
SET PWR test point: 2 to 5V

2. If the voltage is correct, go to Step 3. If it is not, go to Task 21.
3. If the PAD TOP can has already been removed, go to Step 7. If it has not, go to Step 4.
4. Enter the CCTM command 32 to place the radio in receive mode.
5. Remove the PAD TOP can.
6. Enter the CCTM command 33 to place the radio in transmit mode.
7. Check the voltage on the gate of **Q306** (see **Figure 13.10**):

gate of Q306: 2 to 5V

8. Enter the CCTM command 32 to place the radio in receive mode.
9. If the voltage is correct, replace **Q306**; confirm the removal of the fault and go to “Final Tasks” on page 141. If it is not, go to Task 23.

Figure 13.10 PA driver circuitry under the PAD TOP can (VHF shown)



Task 21 — Check Power Control

Check the power-control circuitry if the clamp current for the PA driver is correct or if the voltage at the SET PWR test point is incorrect.

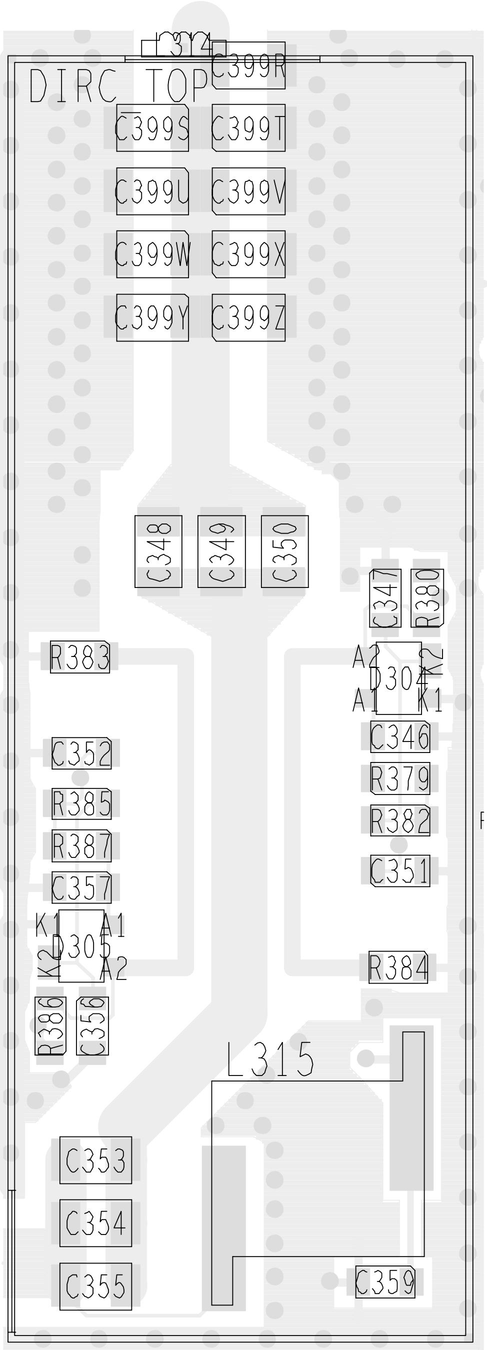
Important Ensure that the current limit on the DC supply is 2A. And, when entering the CCTM command *304* ***z***, do not specify a value ***z*** higher than that recorded in Task 12. Failure to do so might result in the destruction of the PA driver.

1. Enter the CCTM command *304* ***z*** (where ***z*** was recorded in Task 12).
2. Note the current reading on the DC power supply.
3. Enter the CCTM command *114 0* to switch off the power.
4. Note the current reading on the DC power supply.
5. Compare the above current readings. The current should decrease by an amount approximately equal to the offset given in **Table 13.6**. If it does, go to Task 25 in "RF Signal Path" on page 255. If it does not, go to Step 6.
6. Check that the voltage from the DAC is changing. Measure the voltage at the **PWR test point** (CDC TX PWR CTL) (see **Figure 13.8**).
7. Enter the CCTM command *114 1023*. The voltage should increase to:

PWR test point: 2.4 ± 0.1V

8. Enter the CCTM command 32 to place the radio in receive mode.
9. If the voltage at the **PWR test point** increases as required, go to Task 22. If it does not, go to "CODEC and Audio Fault Finding" on page 335.

Figure 13.11 Circuitry under the DIRC TOP can (UHF shown)



Task 22 — Directional Coupler and Buffer Amplifier

Following the checks in Task 19 to Task 21, locate the fault and repair the circuitry as described in the remaining tasks of the section. In this task any faults in the directional coupler or buffer amplifier will be located.

1. Cycle the power.
2. Enter the CCTM command *326 5* to set the transmitter to maximum power.
3. Enter the CCTM command *33* to place the radio in transmit mode.
4. Measure the voltage at pin 9 of **IC303** in the power-control circuit (see **Figure 13.8**).
5. The above voltage should be as given in **Table 13.7**. If it is, go to Task 24. If it is not, go to Step 6.
6. Check the voltage at pin 5 of **IC303** (or use the **FWD PWR test point**) (see **Figure 13.8**). Note that the probe impedance might affect the measurement.
7. Enter the CCTM command 32 to place the radio in receive mode.
8. The voltage measured in Step 6 should be as given in **Table 13.7**. If it is not, go to Step 9. If it is, go to Step 11.

Table 13.7 Voltages at IC303 at maximum power (40 W)

Frequency band	Frequency (MHz)	Voltage (V)	
		Pin 9	Pin 5 (FWD PWR)
B1	136 155 174	2.2 ± 0.5 2.3 ± 0.5 2.5 ± 0.5	1.9 ± 0.5 2.1 ± 0.5 2.3 ± 0.5
H5	400 435 470	3.4 ± 0.5 3.8 ± 0.5 4.0 ± 0.5	3.3 ± 0.5 3.7 ± 0.5 3.9 ± 0.5

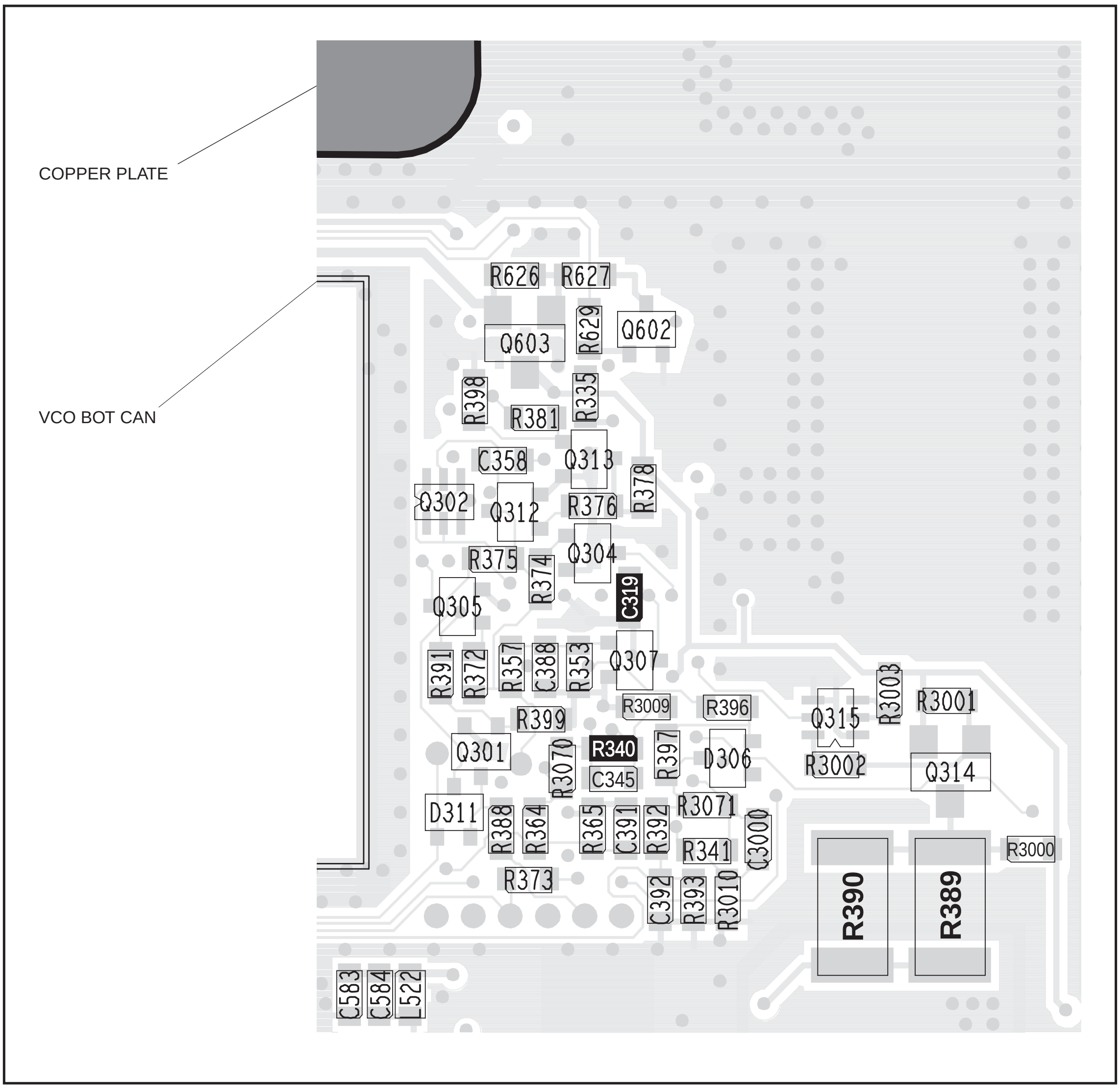
9. Remove the DIRC TOP can.
10. Check the components of the directional coupler (see **Figure 13.11**) and go to Step 12.
11. Check **R340** between pins 6 and 7 of **IC303** in the buffer amplifier (see **Figure 13.12**), and then go to Step 12.
12. Repair any fault revealed by the above checks. Replace **IC303** if none of the other components is faulty (see **Figure 13.8**).
13. Confirm the removal of the fault and go to “Final Tasks” on page 141. If the repair failed, replace the board and go to “Final Tasks” on page 141.

Task 23 — Power Control for PA Driver

In this task any faults in the path between the power-control circuit and the PA driver will be located, as well as any fault with the PA driver.

1. Check for short circuits at the gate of the PA driver **Q306**. Check **R333**, **R336** (see **Figure 13.8**), **C310**, **R324** and **R327** (see **Figure 13.10**) between the power-control circuit and Q306.
2. Repair any fault revealed by the checks in Step 1. If none of the above-mentioned components is faulty, replace **Q306** (see **Figure 13.10**).
3. Confirm the removal of the fault and go to “Final Tasks” on page 141. If the repair failed, replace the board and go to “Final Tasks” on page 141.

Figure 13.12 Components of concern on the bottom-side of the board (VHF shown)



Task 24 — Power Control and Shaping Filter

In this task any faults in the power-control and shaping-filter circuitry will be located:

1. Measure the voltage at pin 8 of **IC303** (see **Figure 13.8**) in the power-control circuit. The voltage should be:

pin 8 of IC303: 7.4 ± 0.5V

2. If the voltage is correct, go to Step 3. If it is not, enter the CCTM command *32* and return to Task 23.

3. Measure the voltage at pin 10 of **IC303** (see **Figure 13.8**) in the power-control circuit. The voltage should be:

pin 10 of IC303: 4.8 ± 0.5V

4. If the voltage is correct, go to Step 5. If it is not, go to Step 8.

5. Enter the CCTM command *32* to place the radio in receive mode.

6. Check **C322**, **C324**, **R342**, **R347** (see **Figure 13.8**) in the power-control circuit.

7. Repair any fault revealed by the checks in Step 5. Replace **IC303** (see **Figure 13.8**) if none of the other components is faulty. Confirm the removal of the fault and go to "Final Tasks" on page 141. If the repair failed, replace the board and go to "Final Tasks" on page 141.

8. Measure the voltage at pin 1 of **IC301** (see **Figure 13.8**) in the shaping-filter circuit. The voltage should be:

pin 1 of IC301: 4.8 ± 0.5V

9. Enter the CCTM command *32* to place the radio in receive mode.

10. If the voltage measured in Step 8 is correct, go to Step 11. If it is not, go to Step 12.

11. Check the components **R334** (see **Figure 13.8**) and **C319** (see **Figure 13.12**) and go to Step 13.

12. Check the components between the **PWR test point** and pin 1 of **IC301** (see **Figure 13.8**) and go to Step 13.

13. Repair any fault revealed by the checks in Step 11 and Step 12. Replace **IC301** (see **Figure 13.8**) if none of the other components is faulty. Confirm the removal of the fault and go to "Final Tasks" on page 141. If the repair failed, replace the board and go to "Final Tasks" on page 141.

13.4 RF Signal Path

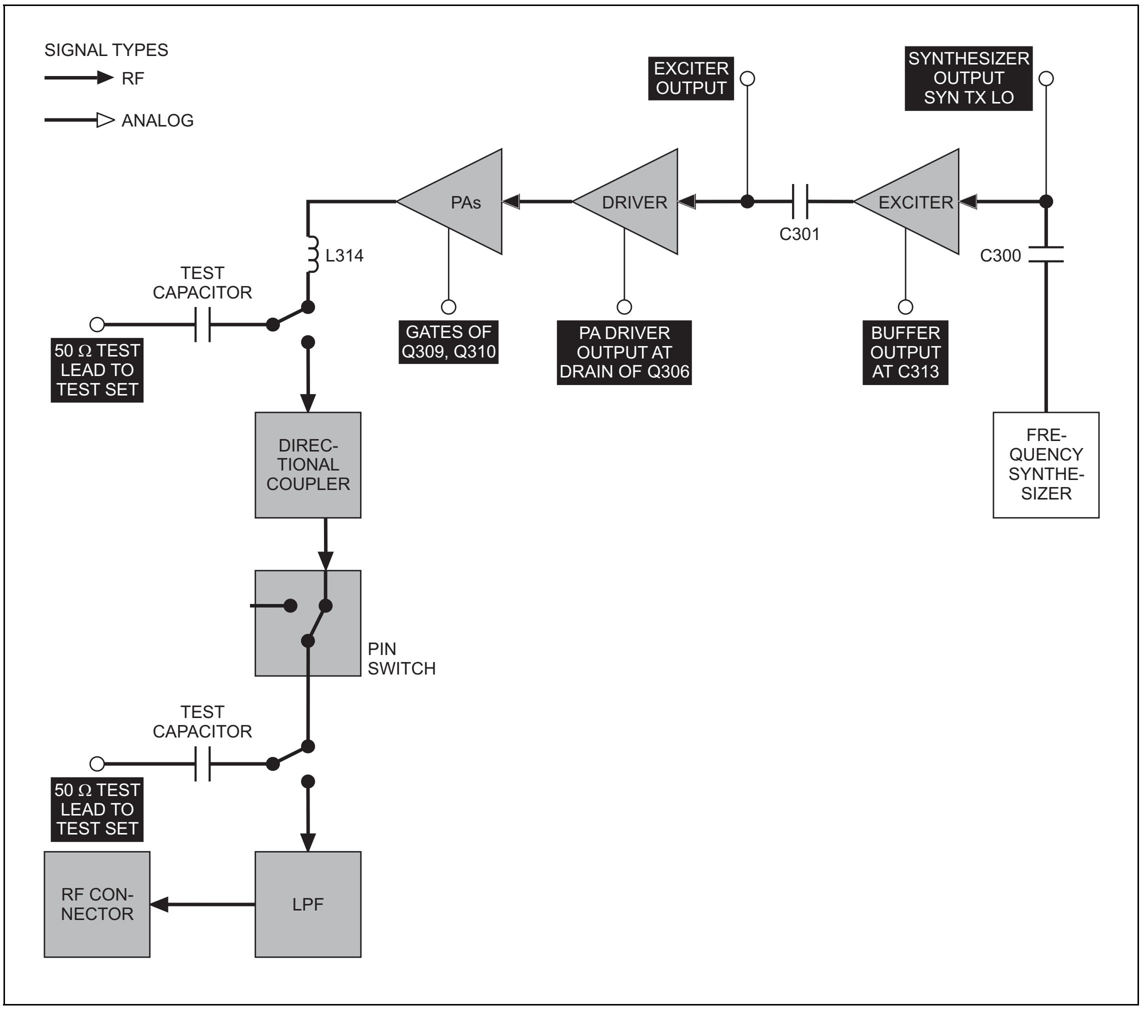
Introduction

The RF signal path extends from the output of the frequency synthesizer to the LPF. This section of circuitry will require investigation either following certain checks in “Transmitter RF Power” or if the biasing checks of “Biasing of PA Driver and PAs” reveal no fault. The procedure is divided into nine tasks grouped as follows:

- Task 25 to Task 28: initial RF signal path
- Task 29 and Task 30: directional coupler
- Task 31 and Task 32: PIN switch
- Task 33: LPF

The initial signal path includes the exciter and PA driver. The directional coupler, PIN switch, and LPF make up the final signal path.
The measurement points for diagnosing faults in the signal path are summarized in Figure 13.13.

Figure 13.13 Measurement points for diagnosing faults in the RF signal path



Task 25 — Output of Frequency Synthesizer

The first point to check in the initial RF signal path is the output SYN TX LO from the frequency synthesizer. This signal is input to the exciter at C300.

1. For test purposes select a representative power level and frequency from **Table 13.8** (B1 band), or **Table 13.9** (H5 bands). (Note that the data for these tables were obtained using an RFP5401A RF probe.)

2. To set the power level, enter the CCTM command *326* ***x***, where ***x*** defines the level. To set the frequency, enter the CCTM command *101* ***x x*** *0*, where ***x*** is the frequency in Hertz.

3. Enter the CCTM command *33* to place the radio in transmit mode.

4. Use an RFP5401A RF probe or the equivalent to measure the RF voltage after **C300** (see **Figure 13.14**). Earth the probe to the FCL TOP can adjacent to the PA driver circuitry. The required voltage should be as given in **Table 13.8** (B1 band), or **Table 13.9** (H5 bands).

5. Enter the CCTM command *32* to place the radio in receive mode.

6. If the voltage measured above is correct, go to Task 26. If it is not, go to Step 7.

7. Check **C300** (see **Figure 13.14**). If C300 is not faulty, go to “Frequency Synthesizer Fault Finding” on page 169. If C300 is faulty, replace it and return to Step 2.

Figure 13.14 PA driver circuitry under the PAD TOP can (UHF shown)

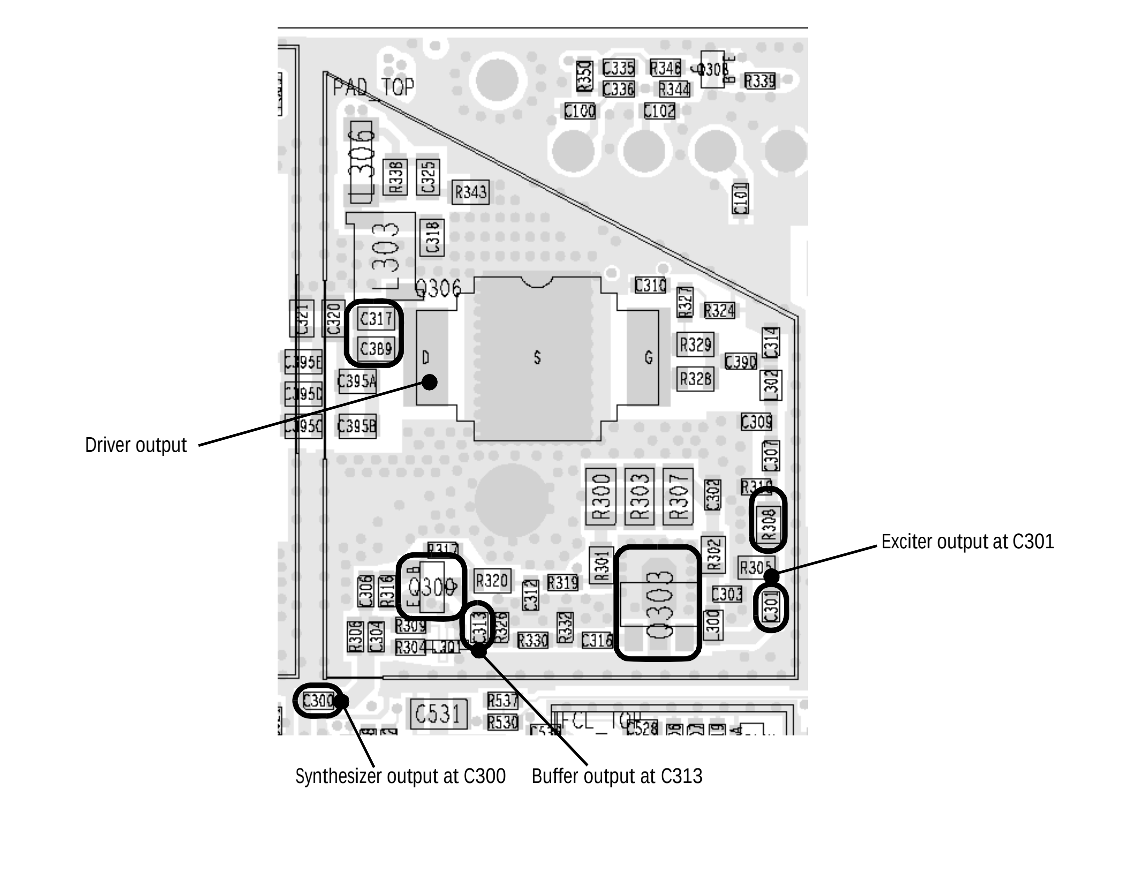


Table 13.8 RF voltages along the initial RF signal path of the VHF radio (B1 band)

Power level (W)	Frequency (MHz)	RF voltages (V)			
		Synthesizer output	Buffer output	Exciter output	Driver output
1	136 155 174	0.3 ± 0.1 0.3 ± 0.1 0.2 ± 0.1	0.2 ± 0.1 0.3 ± 0.1 0.2 ± 0.1	2.4 ± 0.5 2.5 ± 0.5 2.6 ± 0.5	1.8 ± 0.5 1.0 ± 0.5 1.5 ± 0.5
5	136 155 174	0.3 ± 0.1 0.2 ± 0.1 0.2 ± 0.1	0.2 ± 0.1 0.3 ± 0.1 0.2 ± 0.1	2.5 ± 0.5 2.6 ± 0.5 2.6 ± 0.5	3.0 ± 0.5 1.5 ± 0.5 2.6 ± 0.5
12	136 155 174	0.3 ± 0.1 0.2 ± 0.1 0.2 ± 0.1	0.2 ± 0.1 0.3 ± 0.1 0.3 ± 0.1	2.5 ± 0.5 2.6 ± 0.5 2.7 ± 0.5	4.2 ± 0.5 2.0 ± 0.5 3.8 ± 0.5
26	136 155 174	0.3 ± 0.1 0.2 ± 0.1 0.2 ± 0.1	0.2 ± 0.1 0.3 ± 0.1 0.3 ± 0.1	2.4 ± 0.5 2.4 ± 0.5 2.5 ± 0.5	3.3 ± 0.5 1.7 ± 0.5 4.5 ± 0.5
40	136 155 174	0.3 ± 0.1 0.2 ± 0.1 0.3 ± 0.1	0.4 ± 0.1 0.4 ± 0.1 0.3 ± 0.1	2.5 ± 0.5 2.5 ± 0.5 2.5 ± 0.5	8.2 ± 0.5 5.5 ± 0.5 7.7 ± 0.5

Table 13.9 RF voltages along the initial RF signal path of the UHF radio (H5 band)

Power level (W)	Frequency (MHz)	RF voltages (V)			
	H5 band	Synthesizer output	Buffer output	Exciter output	Driver output
1	400 435 470	0.2 ± 0.1 0.2 ± 0.1 0.2 ± 0.1	0.3 ± 0.1 0.3 ± 0.1 0.4 ± 0.1	4.5 ± 0.5 4.6 ± 0.5 3.9 ± 0.5	2.3 ± 0.5 1.5 ± 0.5 0.8 ± 0.5
5	400 435 470	0.2 ± 0.1 0.2 ± 0.1 0.2 ± 0.1	0.3 ± 0.1 0.4 ± 0.1 0.4 ± 0.1	4.6 ± 0.5 4.6 ± 0.5 3.6 ± 0.5	3.6 ± 0.5 2.6 ± 0.5 1.2 ± 0.5
12	400 435 470	0.2 ± 0.1 0.2 ± 0.1 0.2 ± 0.1	0.2 ± 0.1 0.3 ± 0.1 0.3 ± 0.1	3.9 ± 0.5 4.0 ± 0.5 3.4 ± 0.5	4.5 ± 0.5 3.9 ± 0.5 1.7 ± 0.5
26	400 435 470	0.2 ± 0.1 0.1 ± 0.1 0.1 ± 0.1	0.2 ± 0.1 0.2 ± 0.1 0.2 ± 0.1	3.8 ± 0.5 3.6 ± 0.5 3.0 ± 0.5	4.6 ± 0.5 4.5 ± 0.5 1.8 ± 0.5
40	400 435 470	0.2 ± 0.1 0.2 ± 0.1 0.2 ± 0.1	0.3 ± 0.1 0.3 ± 0.1 0.3 ± 0.1	4.2 ± 0.5 3.6 ± 0.5 3.2 ± 0.5	8.6 ± 0.5 8.2 ± 0.5 2.5 ± 0.5

Task 26 — Output of Buffer in Exciter Circuit

If the synthesizer output is correct, check the output at C313 of the buffer amplifier in the exciter circuit.

1. If not already done, remove the PAD TOP can.
2. Enter the CCTM command *326* ***x***, where ***x*** defines the power level selected in Task 25.
3. Enter the CCTM command *101* ***x x*** *0*, where ***x*** is the frequency selected in Task 25.
4. Enter the CCTM command *33* to place the radio in transmit mode.
5. Measure the RF voltage after **C313** (see **Figure 13.14**). (Use an RFP5401A RF probe or the equivalent.) The required voltage should be as given in **Table 13.8** (B1 band) or **Table 13.9** (H5 bands).
6. Enter the CCTM command *32* to place the radio in receive mode.
7. If the voltage measured above is correct, go to Task 27. If it is not, go to Step 8.
8. Check the components around **Q300** (see **Figure 13.14**).
9. Repair any fault revealed by the above checks. Replace **Q300** (see **Figure 13.14**) if none of the other components is faulty.
10. Confirm the removal of the fault and go to "Final Tasks" on page 141. If the repair failed, replace the board and go to "Final Tasks" on page 141.

Task 27 — Output of Exciter

If the output of the buffer amplifier is correct, check that of the exciter at C301.

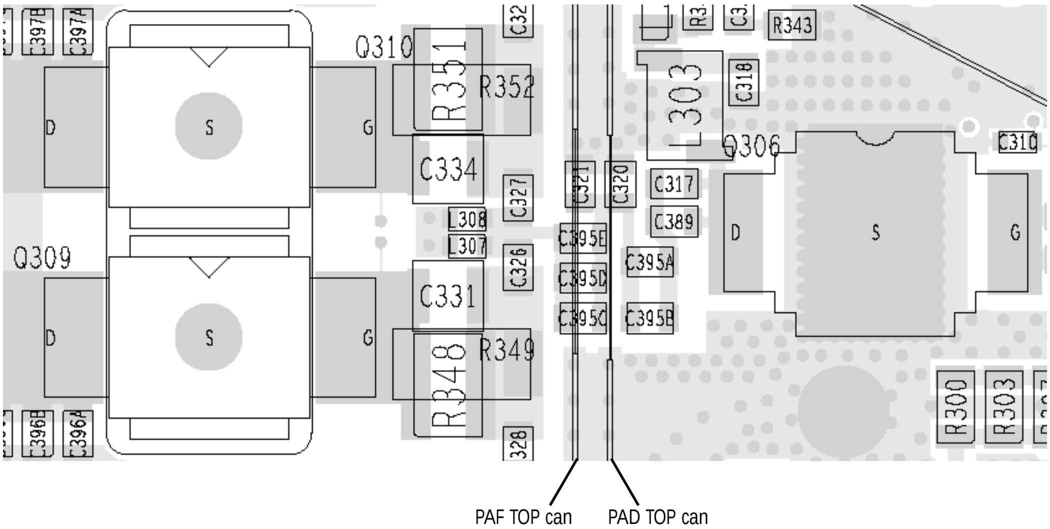
1. With the radio still in transmit mode, measure the RF voltage after **C301** (see **Figure 13.14**). (Use an RFP5401A RF probe or the equivalent.) The required voltage should be as given in **Table 13.8** (B1 band), or **Table 13.9** (H5 bands).
2. If the voltage is correct, go to Task 28. If it is not, go to Step 3.
3. Enter the CCTM command *32* to place the radio in receive mode.
4. Check the components between **C313** and **Q303**, and between Q303 and **R308** (see **Figure 13.14**).
5. Repair any fault revealed by the above checks. Replace **Q303** (see **Figure 13.14**) if none of the other components is faulty.
6. Confirm the removal of the fault and go to "Final Tasks" on page 141. If the repair failed, replace the board and go to "Final Tasks" on page 141.

Task 28 — Output of PA Driver

If the exciter output is correct, check the output of the PA driver at the drain of Q306. If necessary, also check the signal at the gates of the PAs Q309 and Q310. This is the last point in the initial RF signal path.

1. With the radio still in transmit mode, measure the RF voltage at the drain of **Q306** (B1) or after **C317** and **C389** (H5) (see **Figure 13.14**). (Use an RFP5401A RF probe or the equivalent.) The required voltage should be as given in **Table 13.8** (B1), or **Table 13.9** (H5).
2. Enter the CCTM command *32* to place the radio in receive mode.
3. If the voltage measured above is correct, go to Step 7. If it is not, go to Step 4.
4. Check the components between **C301** and **Q306** (see **Figure 13.14**).
5. If the above checks reveal a fault, go to Step 6. If they do not, go to Task 12 in "Biasing of PA Driver and PAs" on page 236.
6. Repair the fault. Confirm the removal of the fault and go to "Final Tasks" on page 141. If the repair failed, replace the board and go to "Final Tasks" on page 141.
7. If not already done, remove the PAF TOP can.
8. Enter the CCTM command *326 5* to set the power level to the maximum, and then the command *33* to place the radio in transmit mode.
9. Measure the RF voltage at the gates of the PAs **Q309** and **Q310** (see **Figure 13.15**).
10. Enter the CCTM command *32* to place the radio in receive mode.
11. If an RF voltage is present, there is no fault in the initial RF signal path; go to Task 29. If there is no RF voltage, go to Step 12.
12. Check the components of the interstage matching circuitry between the PA driver **Q306** and the gates of the PAs **Q309** and **Q310** (see **Figure 13.15**).
13. If a fault is found, repair it, confirm the removal of the fault, and go to "Final Tasks" on page 141. If the repair failed or the fault could not be found, replace the board and go to "Final Tasks" on page 141.

Figure 13.15 Components of the interstage matching circuitry between the PA driver Q306 and the PAs Q309 and Q310 (UHF shown)



Task 29 — Check Power at Directional Coupler

If, as determined in Task 25 to Task 28, there is no fault in the initial RF signal path, investigate the final signal path. This part of the circuitry may also require investigation following certain checks in “Transmitter RF Power”. Begin by checking the directional coupler as follows:

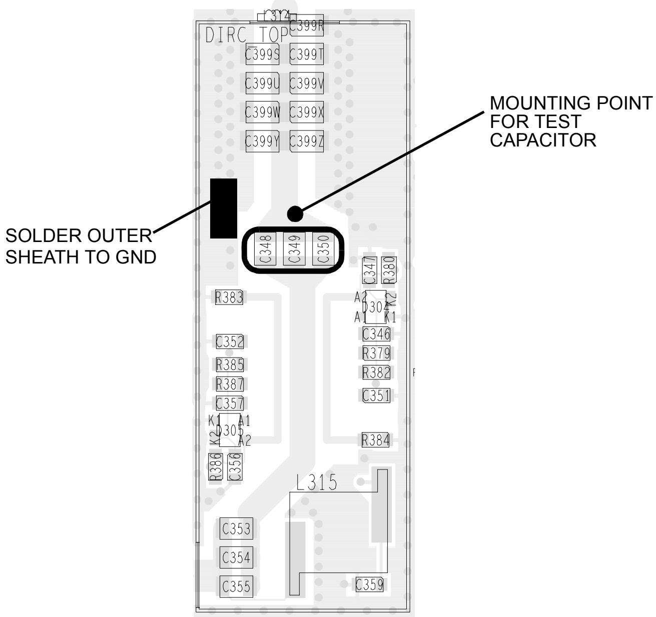
1. If not already done, remove the DIRC TOP can.
2. Remove the coupling capacitors **C348**, **C349**, **C350** (see **Figure 13.16**).
3. Solder one terminal of a test capacitor to the PCB at the point shown in Figure 13.16. Mount the capacitor vertically. Use a test capacitor of the type GRM111, DLI C17, ATC100B, or the equivalent.

   The value of the capacitor depends on the frequency band of the radio:

   - B1 — 680pF
   - H5 — 82pF.
4. Solder a 50Ω test lead to the PCB. Solder the outer sheath in the position shown in **Figure 13.16**, and solder the central wire to the other terminal of the test capacitor.
5. Connect the test lead to the test set.
6. Enter the CCTM command *326 5* to set the transmitter power level to the maximum.
7. Enter the CCTM command *101* ***x x*** *0*, where ***x*** is the lowest frequency (in Hertz) for maximum power, as given in **Table 13.8** (B1), or **Table 13.9** (H5).
8. Enter the CCTM command *33* to place the radio in transmit mode.
9. Measure the RF output power. This should exceed 35W.

RF output power: more than 35W
10. Enter the CCTM command *32* to place the radio in receive mode.
11. Enter the CCTM command *101* ***x x*** *0*, where ***x*** is the highest frequency (in Hertz) for maximum power, as given in **Table 13.8** (B1) or **Table 13.9** (H5).
12. Repeat Step 8 to Step 10.
13. If the power measured in both the above cases exceeds 35W, go to Step 14. If it does not, go to Task 30.
14. Remove the test lead and test capacitor, resolder the coupling capacitors in position, and go to Task 31.

Figure 13.16 Circuitry under the DIRC TOP can, and the points for attaching the test lead and test capacitor (UHF shown)



Task 30 — Repair Circuitry

If the RF output power measured in Task 29 is low, there is a fault in the circuit between the common drain of the PAs and the test capacitor.

1. If not already done, remove the PAF TOP can.
2. Check for faulty, shorted or misplaced components in the circuit between the test capacitor and the common drain of **Q309** and **Q310** (see **Figure 13.6**).
3. Repair any fault revealed by the above checks and go to Step 5. If no fault could be found, go to Step 4.
4. Remove the test lead and test capacitor, resolder the coupling capacitors **C348**, **C349** and **C350** in position (see **Figure 13.16**), and go to Task 25.
5. With the test lead still connected to the test set, enter the CCTM command *326 5* to set the transmitter power level to the maximum.
6. Enter the CCTM command *101* ***x x*** *0*, where ***x*** is the lowest frequency (in Hertz) for maximum power, as given in **Table 13.8** (B1 band) or **Table 13.9** (H5 bands).
7. Enter the CCTM command *33* to place the radio in transmit mode.
8. Measure the RF output power. This should exceed 35 W.

RF output power: more than 35W

9. Enter the CCTM command *32* to place the radio in receive mode.
10. Enter the CCTM command *101* ***x x*** *0*, where ***x*** is the highest frequency (in Hertz) for maximum power, as given in **Table 13.8** (B1 band) or **Table 13.9** (H5 bands).
11. Repeat Steps Step 7 to Step 9.
12. Remove the test lead and test capacitor, and resolder the coupling capacitors **C348**, **C349** and **C350** in position (see **Figure 13.16**).
13. If the power in both the above cases is now correct, the fault has been rectified; go to “Final Tasks” on page 141. If it is not, the repair failed; replace the board and go to “Final Tasks” on page 141.

Task 31 — Check PIN Switch

In checking the final RF signal path, if no fault is found in the directional coupler, then check the PIN switch next. The PIN switch may also require investigation following certain checks in “Transmitter RF Power” on page 226.

1. Remove the PIN TOP can.

2. Remove the three blocking capacitors **C361**, **C362** and **C363** (see **Figure 13.17**).

3. Solder one terminal of a test capacitor to the PCB at the point shown in Figure 13.17. Mount the capacitor vertically. Use a test capacitor of the type GRM111, DLI C17, ATC100B, or the equivalent.

   The value of the capacitor depends on the frequency band of the radio:

   - B1 — 33pF
   - H5 — 22pF.

4. Solder a 50W test lead to the PCB. Solder the outer sheath in the position shown in Figure 13.17, and solder the central wire to the other terminal of the test capacitor.

5. Connect the test lead to the test set.

6. Enter the CCTM command *326 5* to set the transmitter power level to the maximum.

7. Enter the CCTM command *101* ***x x*** *0*, where ***x*** is the lowest frequency (in Hertz) for maximum power, as given in **Table 13.8** (B1 band) or **Table 13.9** (H5 bands).

8. Enter the CCTM command *33* to place the radio in transmit mode.

9. Measure the RF output power. This should exceed 35W.

RF output power: more than 35W

10. Enter the CCTM command *32* to place the radio in receive mode.

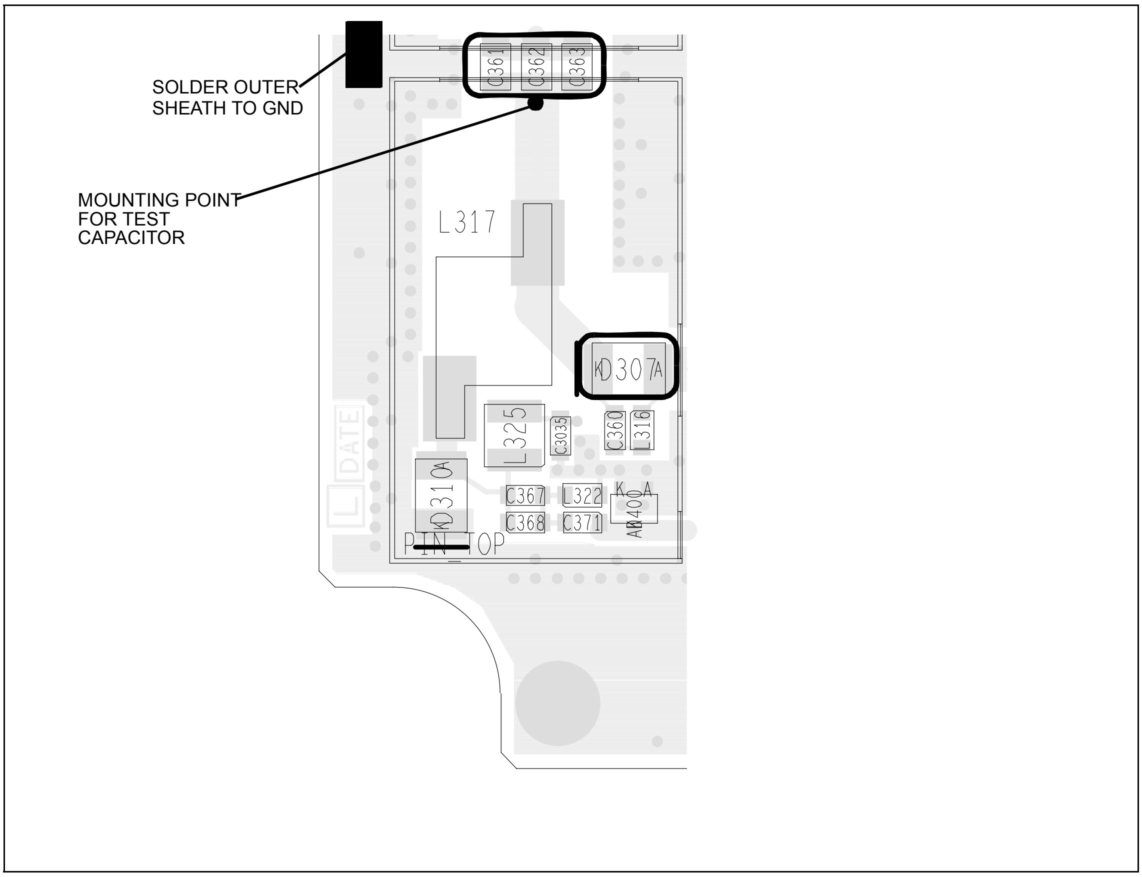
11. Enter the CCTM command *101* ***x x*** *0*, where ***x*** is the highest frequency (in Hertz) for maximum power, as given in **Table 13.8** (B1 band) or **Table 13.9** (H5 bands).

12. Repeat Step 8 to Step 10.

13. If the power in both the above cases exceeds 35 W, go to Step 14. If it does not, the circuitry of the PIN switch is suspect; go to Task 32.

14. Remove the test lead and test capacitor, resolder the blocking capacitors in position, and go to Task 33.

Figure 13.17 Circuitry under the PIN TOP can, and points for attaching the test lead and test capacitor (UHF shown)



Task 32 — Repair PIN switch

If the RF power at the PIN switch is low, the switch is not drawing the expected current or the diode is faulty. Check the circuit as follows:

1. Perform a diode check of **D307** (see **Figure 13.17**). If it is not faulty, go to Step 2. If it is, replace D307 and go to Step 3.

2. Check the +9V0_TX supply to the PIN switch via the following resistors on the bottom-side of the PCB (see **Figure 13.18** and **Figure 13.19**):
   - B1 — **R3000, R389** and **R390**
   - H5 — **R3000** and **R389**.

   If any resistor is faulty, replace the resistor as well as **D307**. (A faulty resistor is likely to have resulted in damage to D307.)

3. With the test lead still connected to the test set, enter the CCTM command *326 5* to set the transmitter power level to the maximum.

4. Enter the CCTM command *101* ***x x*** *0*, where ***x*** is the <u>lowest</u> frequency (in Hertz) for maximum power, as given in **Table 13.8** (B1 band) or **Table 13.9** (H5 bands).

5. Enter the CCTM command *33* to place the radio in transmit mode.

6. Again measure the RF output power. This should exceed 35W.

RF output power: more than 35W

7. Enter the CCTM command *32* to place the radio in receive mode.

8. Enter the CCTM command *101* ***x x*** *0*, where ***x*** is the <u>highest</u> frequency (in Hertz) for maximum power, as given in **Table 13.8** (B1 band) or **Table 13.9** (H5 bands).

9. Repeat Step 5 to Step 7.

10. Remove the test lead and test capacitor, and resolder the blocking capacitors **C361**, **C362** and **C363** (see **Figure 13.17**) in position.

11. If the power in both the above cases is now correct, the fault has been rectified; go to “Final Tasks” on page 141. If it is not, the repair failed: replace the board and go to “Final Tasks” on page 141.

Figure 13.18 Components of concern on the bottom-side of the board (C0, D1 bands)

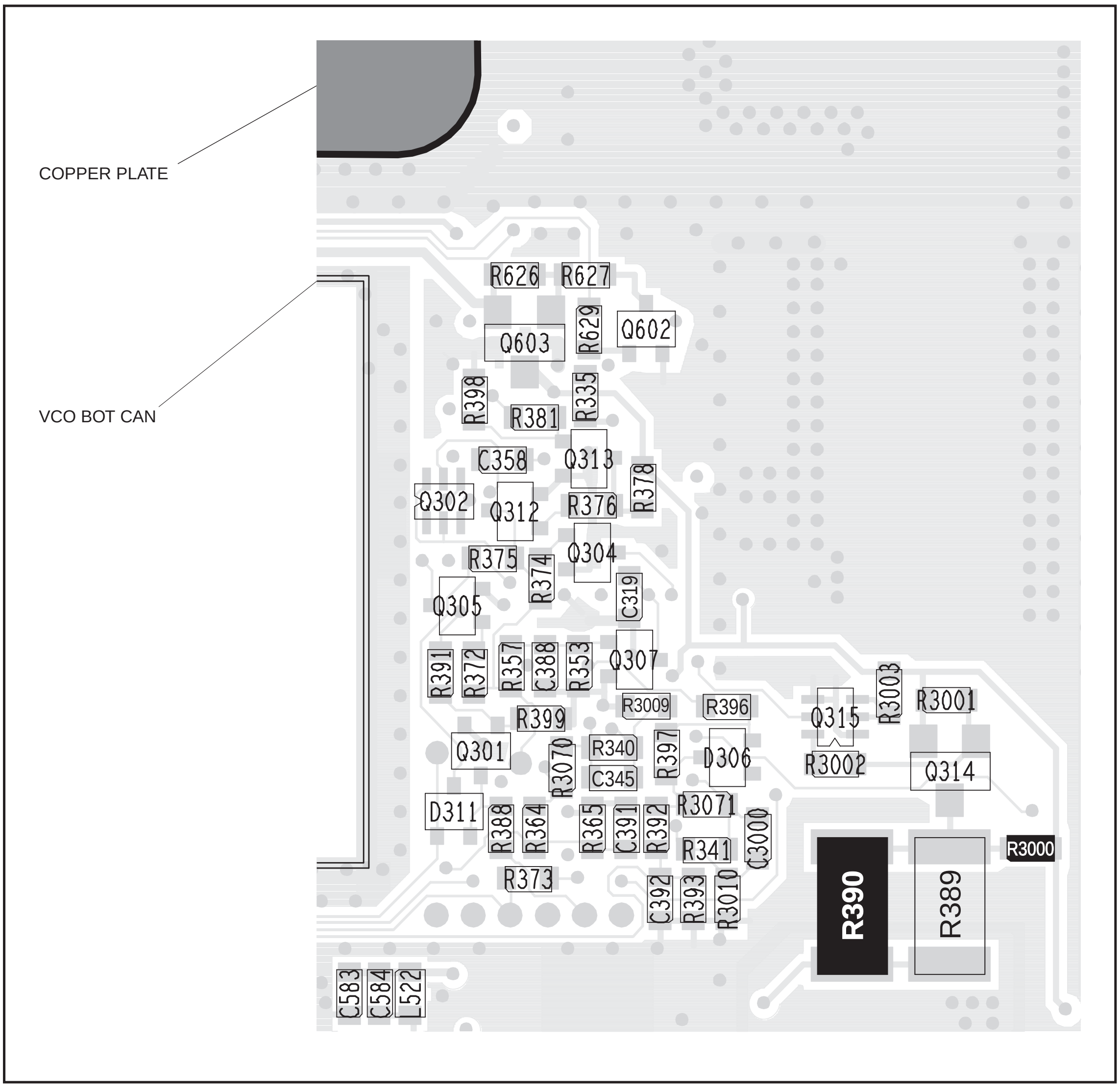


Figure 13.19 Components of concern on the bottom-side of the board (B1, H5 bands)

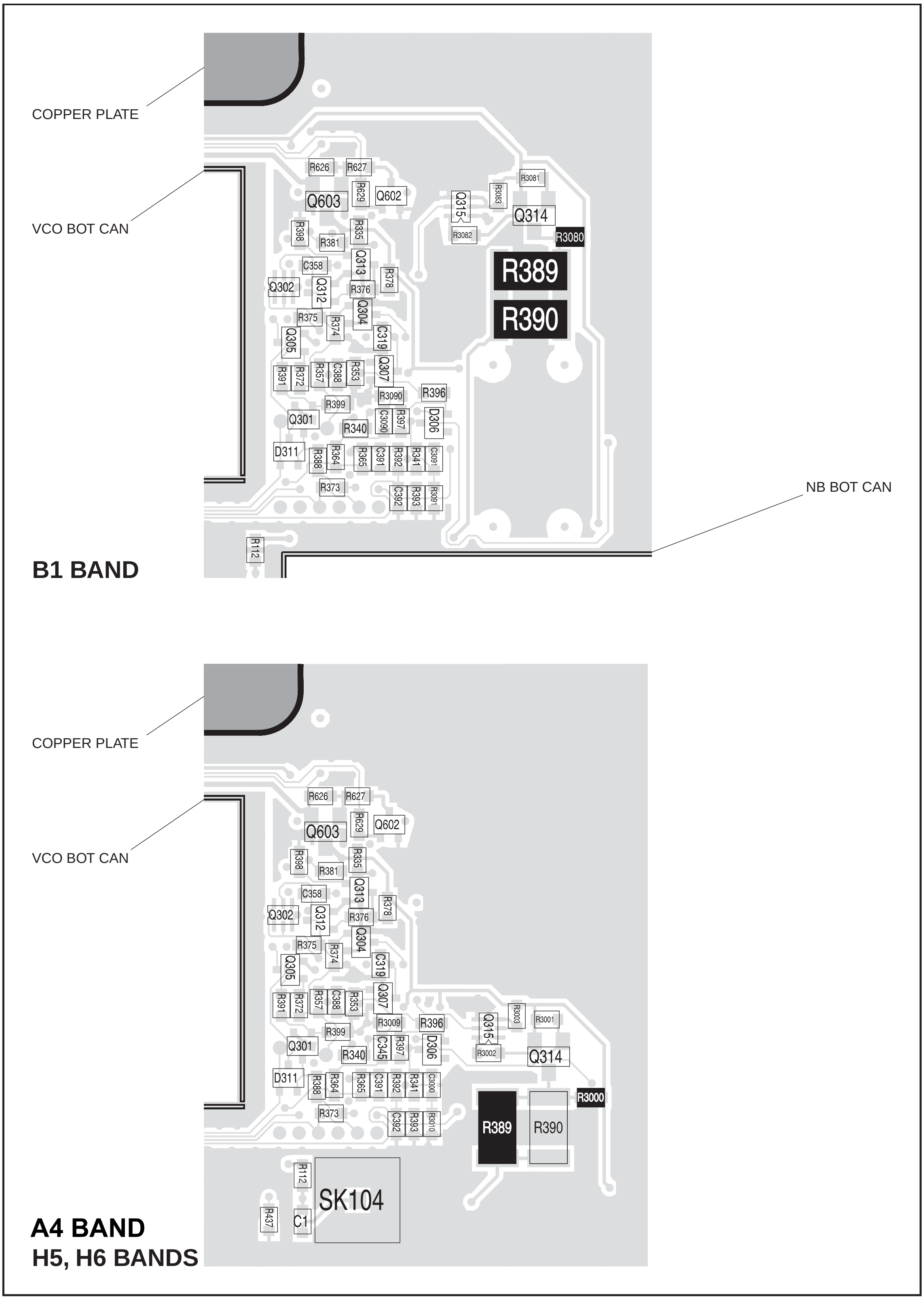
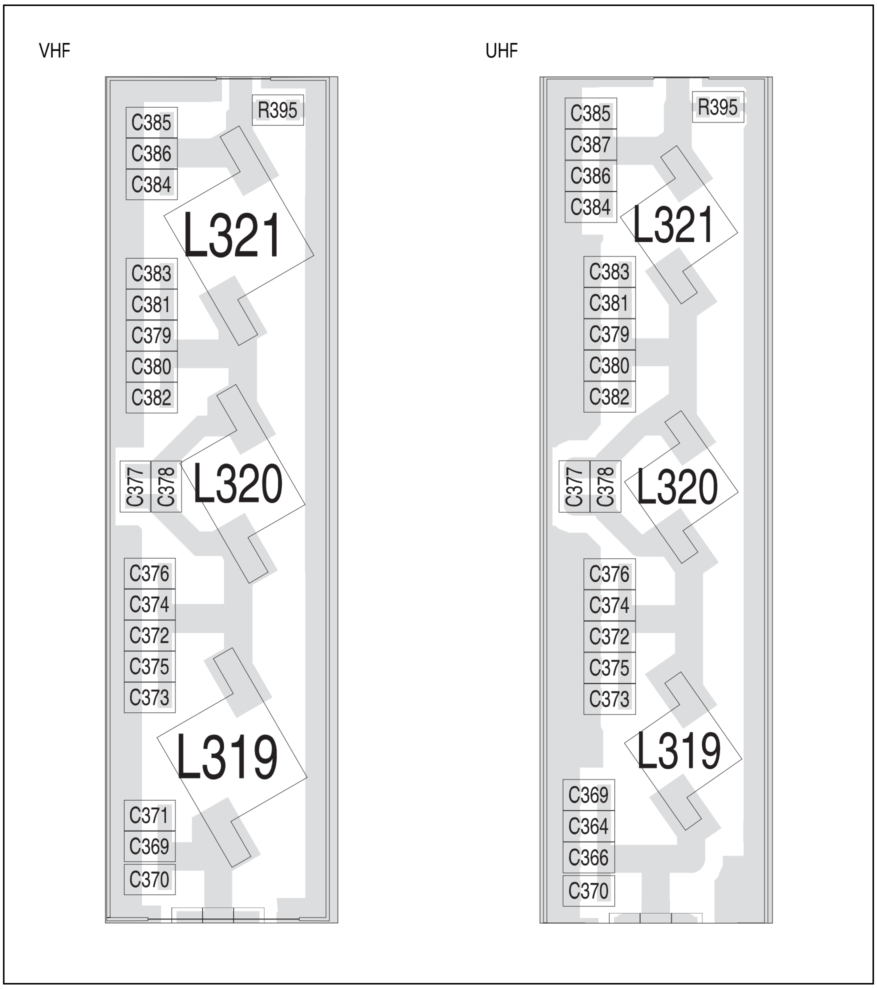


Figure 13.20 Circuitry under the LPF TOP can (top side)



Task 33 — Check Components of LPF

If there are no faults in the final RF signal path up to and including the PIN switch, then the fault should lie in the LPF. Check the LPF as follows:

1. Remove the LPF TOP can.
2. Connect the RF connector to the test set.
3. Check the capacitors and inductors of the LPF between the PIN switch and the RF connector. See **Figure 13.20**. Check for shorts, open circuits, and faulty components. Repair any fault.
4. Enter the CCTM command *326 5* to set the transmitter power level to the maximum.
5. Enter the CCTM command *101* ***x x*** *0*, where ***x*** is the lowest frequency (in Hertz) for maximum power, as given in **Table 13.8** (B1 band) or **Table 13.9** (H5 bands).
6. Enter the CCTM command *33* to place the radio in transmit mode.
7. Measure the RF output power. This should exceed 35W.

RF output power: more than 35W

8. Enter the CCTM command *32* to place the radio in receive mode.
9. Enter the CCTM command *101* ***x x*** *0*, where ***x*** is the highest frequency (in Hertz) for maximum power, as given in **Table 13.8** (B1 band) or **Table 13.9** (H5 bands).
10. Repeat Step 6 to Step 8.
11. If the power in both the above cases exceeds 35 W, the fault has been rectified; go to "Final Tasks" on page 141. If it does not, the repair failed; replace the board and go to "Final Tasks" on page 141.

14 Transmitter Fault Finding (40 W/50 W)

Introduction

50W
40W

This section covers the diagnosis of faults in the 40 W/50 W transmitter circuitry. The main indication of a fault in the transmitter is a reduction in range. This implies that the power output is wrong or too low. Another type of fault is manifested when the radio always transmits at full power, even if set otherwise. Regardless of the fault, the lock status should be normal.

Fault-Diagnosis Tasks

The procedure for diagnosing transmitter faults is divided into tasks, which are grouped into the following sections:

- “Power Supplies”
- “Transmitter RF Power”
- “Biasing of PA Driver and PAs”
- “RF Signal Path”.

Before beginning the fault diagnosis with “Power Supplies”, note the following information regarding CCTM commands, frequency bands, can removal and replacement, and transmit tests.

CCTM Commands

The CCTM commands required in this section are listed in Table 14.1. Full details of the commands are given in “Computer-Controlled Test Mode (CCTM)” on page 114.

Table 14.1 CCTM commands required for the diagnosis of faults in the transmitter

Command	Description
33	Set radio in transmit mode
47	Read temperature near PAs — displays temperature **x** in degrees celsius and voltage **y**
101 **x** **y** 0	Set transmit frequency (**x** in Hertz) and receive frequency (**y** in Hertz) to specified values
114 **x**	Set DAC value **x** (in range 0 to 1023) of transmit power
304	Read clamp current at gate of PA driver — displays DAC value **x** (in range 0 to 255)
304 **x**	Set DAC value **x** (in range 0 to 255) of clamp current at gate of PA driver
318	Read forward-power level — displays corresponding voltage **x** in millivolts
319	Read reverse-power level — displays corresponding voltage **x** in millivolts
326 **x**	Set transmitter power level **x** (0=off, 1=very low, 2=low, 3=medium, 4=high, 5=maximum)
331	Read bias voltage for first PA — displays DAC value **x** (in range 0 to 255)
331 **x**	Set DAC value **x** (in range 0 to 255) of bias voltage for first PA
332	Read bias voltage for second PA — displays DAC value **x** (in range 0 to 255)
332 **x**	Set DAC value **x** (in range 0 to 255) of bias voltage for second PA
334 **x**	Set synthesizer on (**x**=1) or off (**x**=0) via DIG SYN EN line
335 **x**	Set transmit-receive switch on (**x**=1) or off (**x**=0) via DIG SYN TR SW line

Frequency Bands

Where test procedures or figures differ according to the frequency band of the radio, the frequency band is given in brackets. The frequency band may be referred to as either 'VHF' (very high frequency) or 'UHF' (ultra high frequency) or identified by the frequency sub-band, such as 'B1'. For example:

> RF output power: > 60W (**VHF**), > 52W (**UHF**)
> current: < 15A (**VHF**), < 12A (**UHF**)

A definition of frequency bands is given in "Defining Frequency Bands" on page 120.

Some fault-diagnosis tasks require programming the radio with the lowest, centre or highest frequency in the radio's frequency band. The relevant frequencies for the different bands are listed in Table 14.2.

Table 14.2 Lowest, centre and highest frequencies in MHz

Band	Lowest frequency	Centre frequency	Highest frequency
B1	136	155	174
H5	400	435	470

Emergency Frequencies

The following frequency ranges are reserved worldwide for use as maritime emergency frequencies or by distress beacons:

- B1 band: 156.8MHz ± 375kHz
- H5 band: 406.0 to 406.1MHz.

Do not program the radio with any frequency in the above ranges.

Can Removal

There are five cans shielding the bulk of the transmitter circuitry:

- PAD TOP
- PAF TOP
- DIRC TOP
- PIN TOP
- LPF TOP.

To remove any can, first remove the board from the chassis. In the case of the PAD TOP and PAF TOP cans, first detach the heat-transfer block from the main board. Secure the block again after removing the cans. Follow the procedures given in "Disassembly and Reassembly" on page 121.

Can Replacement

Replace all cans that have been removed only after repairing the board. An exception is the B1 band, however, where the LPF TOP can must be in place if the transmitter is to operate correctly.

Transmit Tests

The following actions need to be taken when carrying out transmit tests:

- secure the board
- ensure the proper antenna load

- limit the duration of transmit tests
- protect against accidental transmissions
- avoid thermal and RF burns.

These points are discussed in more detail in the following sections.

Secure the Board

Before conducting any transmit tests, ensure that the board is adequately secured in the chassis. This is essential if overheating of the radio is to be avoided. (As mentioned earlier, the heat-transfer block must already be secured to the main board of the assembly.)

Ensure Proper Antenna Load

The radio has been designed to operate with a 50Ω termination impedance, but will tolerate a wide range of antenna loading conditions. Nevertheless, care should be exercised. Normally the RF connector on the board will be connected to the RF communications test set as shown in Figure 6.8 on page 105. But for those tests where this connection is not necessary, a 50Ω load may be used instead. Do not operate the transmitter without such a load or without a connection to the test set. Failure to do so may result in damage to the power output stage of the transmitter.

Limit Duration of Transmit Tests

After setting the frequency and power level (if necessary), enter the CCTM command *33* to perform a transmit test. This command places the radio in transmit mode. After completing the measurement or check required, immediately enter the CCTM command *32*. This command returns the radio to the receive mode. Restricting the duration of transmit tests in this way will further limit the danger of overheating. The reason for this precaution is that the transmit timers do not function in the CCTM mode.

Protect Against Accidental Transmissions

Under certain circumstances the microprocessor can key on the transmitter. Ensure that all instruments are protected at all times from such accidental transmissions.

Avoid Thermal and RF Burns

Avoid thermal burns. Do <u>not</u> touch the cooling fins or underside of the radio body when the transmitter is or has been operating. Avoid RF burns. Do <u>not</u> touch the antenna or the RF signal path on the circuit board while the transmitter is operating.

14.1 Power Supplies

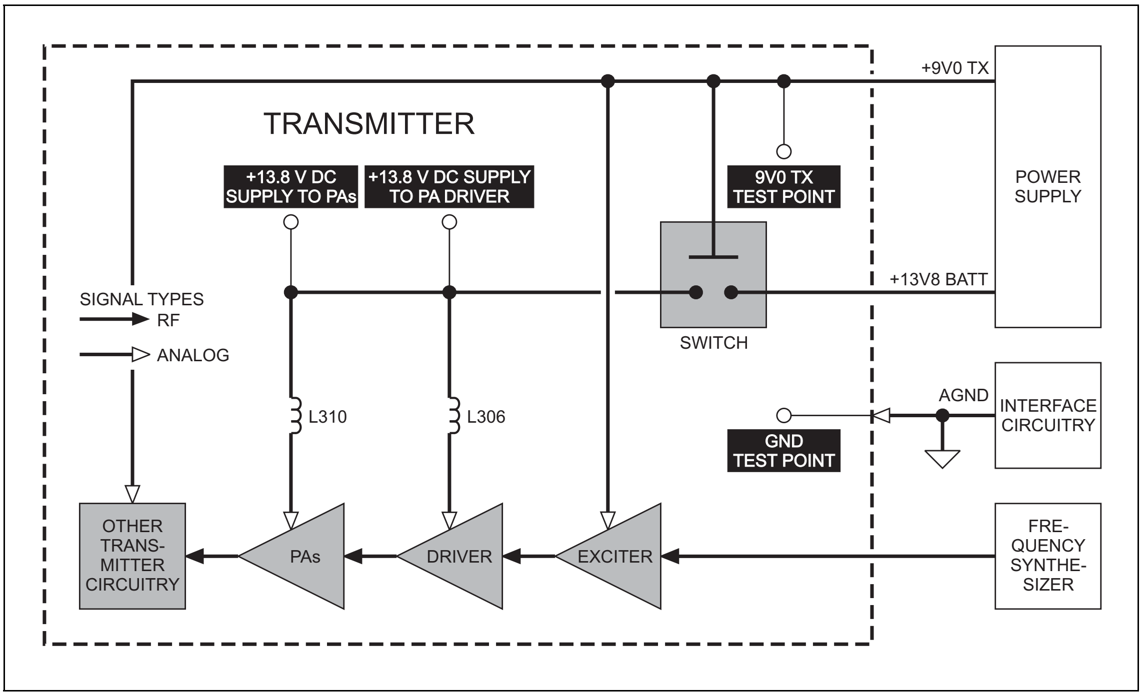
Introduction

First check that a power supply is not the cause of the fault. There are two power supplies and a switch circuit for the transmitter:

- Task 1: 13.8V DC supply from power connector (+13V8 BATT)
- Task 2: switch circuit for 13.8V DC supply
- Task 3: 9V DC supply from 9V regulator in PSU module (+9V0 TX).

The measurement and test points for diagnosing faults in the power supplies are summarized in Figure 14.1.

Figure 14.1 Measurement and test points for diagnosing faults involving the power supplies for the transmitter



Task 1 — 13.8V Power Supply

First check the power supply from the power connector.

1. Obtain a needle probe to use for measurements of the power supply at the PA driver and PAs. If none is available, remove the PAF TOP and PAD TOP cans.

2. Set the DC power supply to 13.8V, with a current limit of 10A.

3. Program the radio with the highest frequency in the radio's frequency band: Enter the CCTM command *101* ***x*** ***x*** *0*, where ***x*** is the frequency in Hertz. The required values for the different frequency bands are given in **Table 14.2**.

4. Enter the CCTM command *326 5* to set the radio to maximum power.

5. Attempt to place the radio in transmit mode. Enter the CCTM command *33*.

6. If the radio enters the transmit mode, continue with Step 7. If instead a *C03* error is displayed in response to the command *33*, go to Task 7 in "Transmitter RF Power" on page 281.

7. Measure the voltage at the point on **L310** shown in **Figure 14.2** (VHF) or **Figure 14.3** (UHF). This is the supply at the common drain of **Q309** and **Q310**, and should be:

common drain of Q309 and Q310: more than 13V DC

8. Also measure the voltage at the point on **L306** shown in **Figure 14.3**. This is the supply at the drain of **Q306**, and should be:

drain of Q306: more than 13V DC

9. Enter the CCTM command *32* to place the radio in receive mode.

10. If the power supply measured in Step 7 and Step 8 is not correct, go to Task 2. If it is, go to Task 3.

Figure 14.2 Point for measuring the power supply to the PAs and PA driver (VHF)

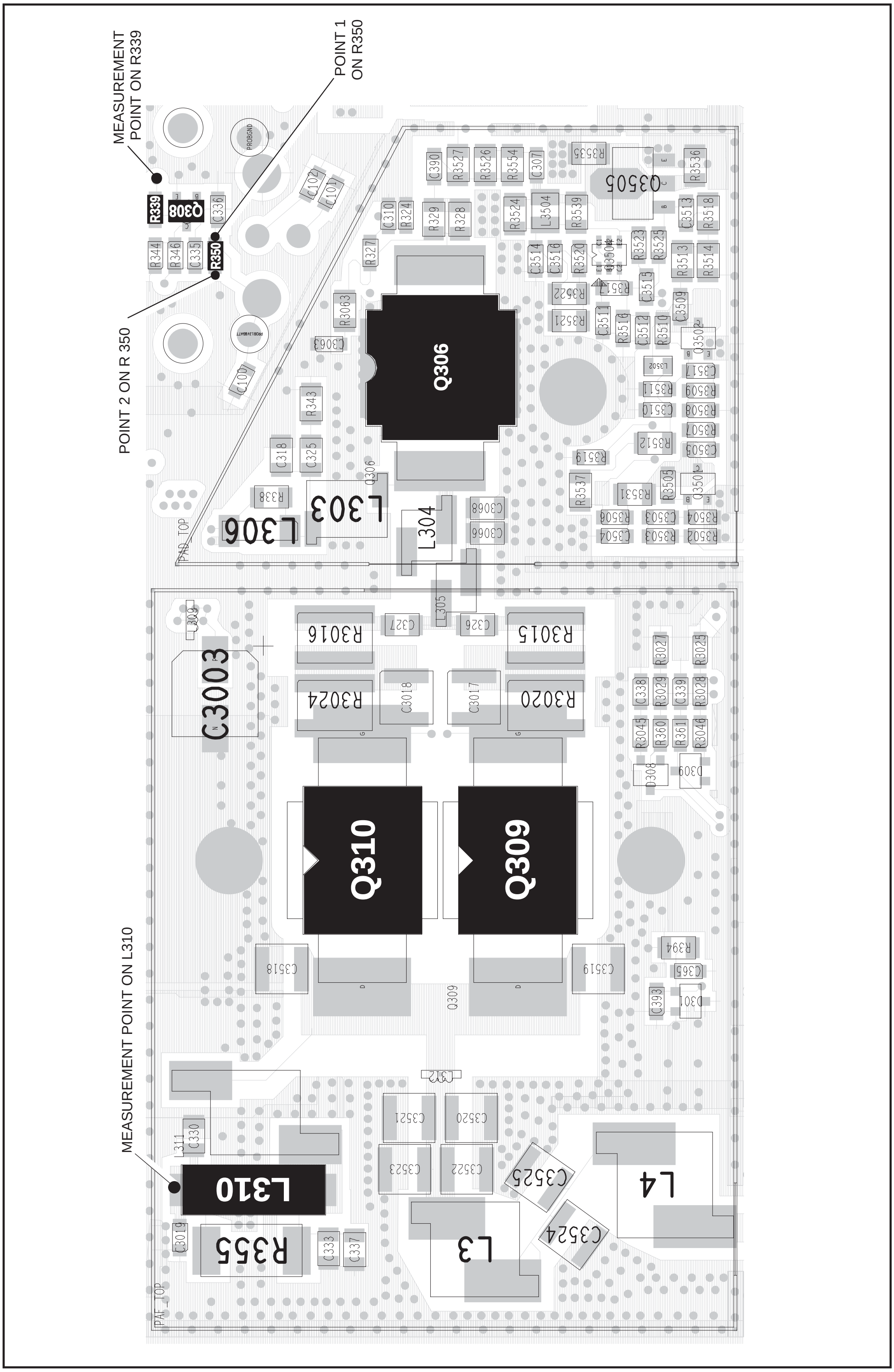
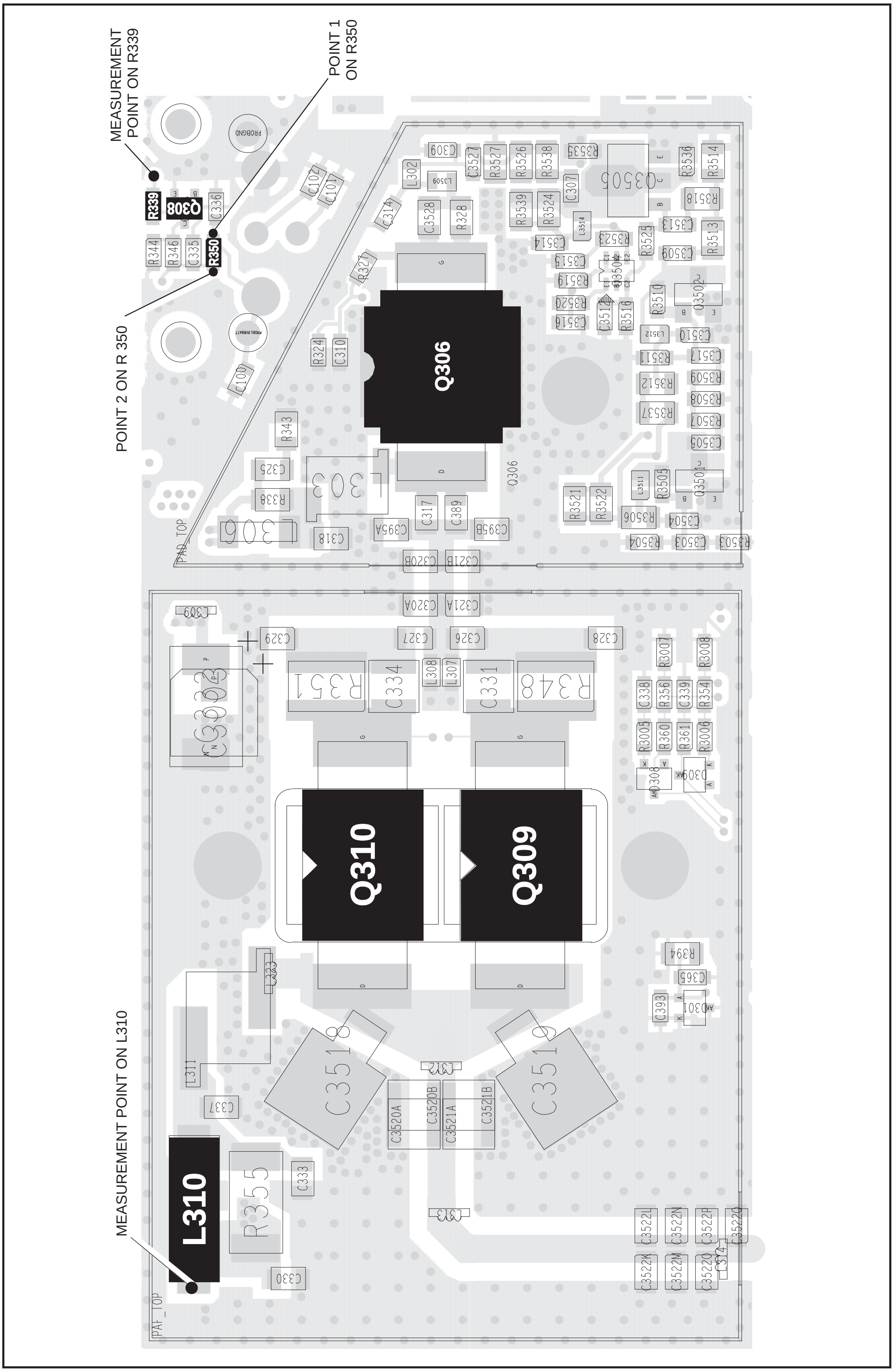


Figure 14.3   Point for measuring the power supply to the PAs and PA driver (UHF)



Task 2 — Check Switch Circuit

If the power supply to the drains of the PAs and PA driver is not correct, the switch circuit is suspect. Check the circuit as follows:

1. Measure the voltage at the point 1 on **R350** shown in **Figure 14.2** (VHF) or **Figure 14.3** (UHF). The voltage should be:

point 1 on R350: 13.8V DC

2. If the voltage measured in Step 1 is correct, go to Step 3. If it is not, check for continuity between **R350** and the power connector. Repair any fault and conclude with Step 8.

3. Measure the voltage at **R339** as shown in **Figure 14.2** (VHF) or **Figure 14.3** (UHF). The voltage should be:

R339: 9V DC

4. If the voltage measured in Step 3 is correct, go to Step 5. If it is not, go to Task 3 and check the 9V power supply.

5. Measure the voltage at the point 2 on **R350** shown in **Figure 14.2** (VHF) or **Figure 14.3** (UHF). The voltage should be:

point 2 on R350: < 5V DC

6. If the voltage measured in Step 5 is correct, go to Step 7. If it is not, replace **Q308** — see **Figure 14.2** (VHF) or **Figure 14.3** (UHF) — and conclude with Step 8.

7. Remove the heat-transfer block from the main board. Replace **Q311** (situated on the bottom-side of the main board next to the power connector). Replace the heat-transfer block, and conclude with Step 8.

8. Repeat Task 1 to confirm the removal of the fault, and go to “Final Tasks” on page 141. If the repair failed or the fault could not be found, replace the board and go to “Final Tasks” on page 141.

Task 3 — 9V Power Supply

If the supply from the power connector is correct, check the 9V DC supply.

1. Enter the CCTM command *326 1* to set the transmitter power level very low.

2. Enter the CCTM command *33* to place the radio in transmit mode.

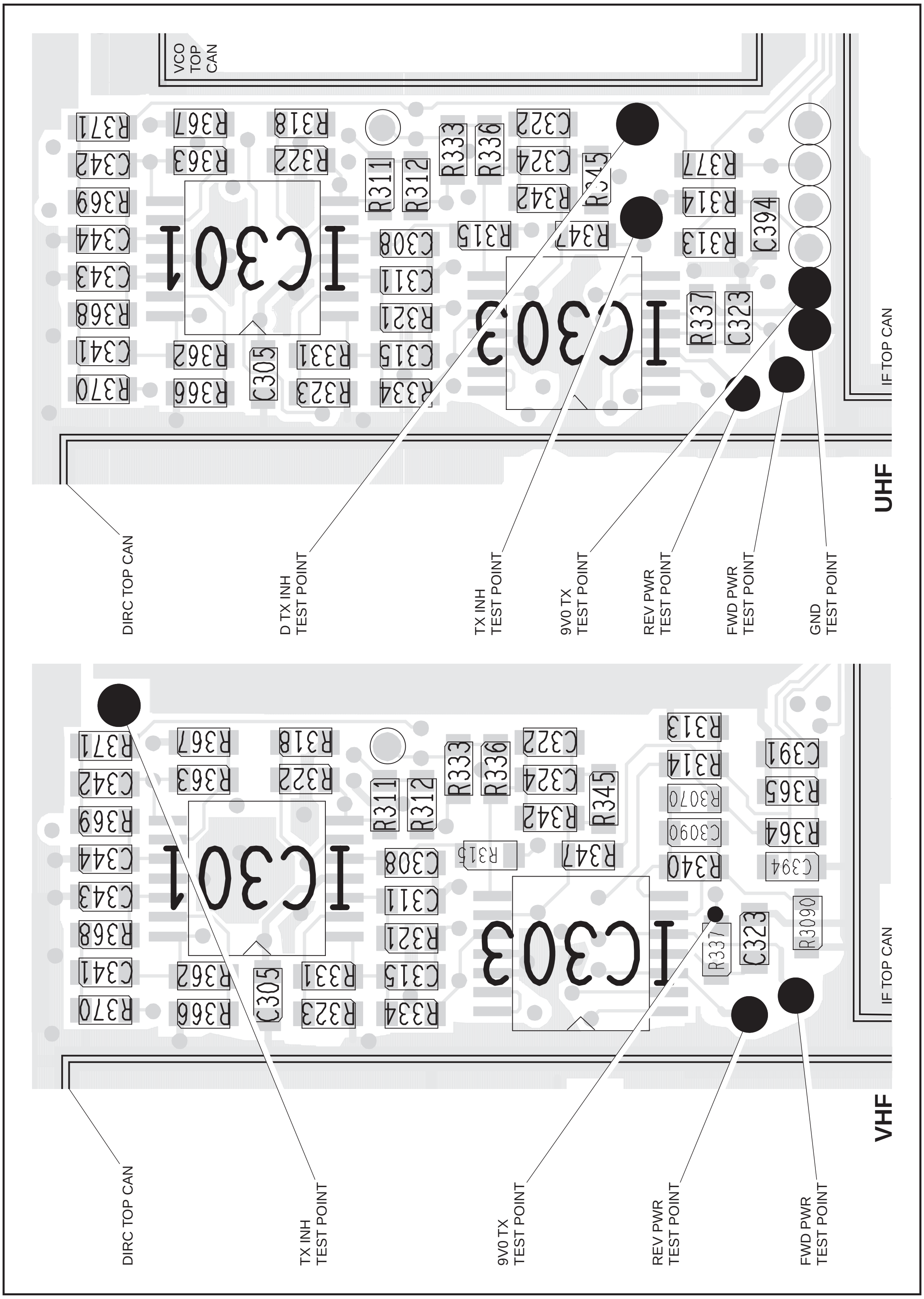
3. Measure the supply voltage between the **9V0 TX test point** and the **GND test point** (see **Figure 14.4**).

supply 9V0 TX: 9.0 ± 0.5V DC

4. Enter the CCTM command *32* to place the radio in receive mode.

5. If the supply measured in Step 3 is correct, go to Task 4 in “Transmitter RF Power” on page 281. If it is not, the 9V regulator **IC601** and the associated switching circuitry **Q603** are suspect; go to Task 3 of “Power Supply Fault Finding” on page 160.

Figure 14.4 **Test points for checking the 9V supply, the forward and reverse RF power, and the inhibiting of the transmitter**



14.2 Transmitter RF Power

Introduction

If there is no fault with the power supplies, check the transmitter RF power and correct any fault. The procedure is covered in the following eight tasks:

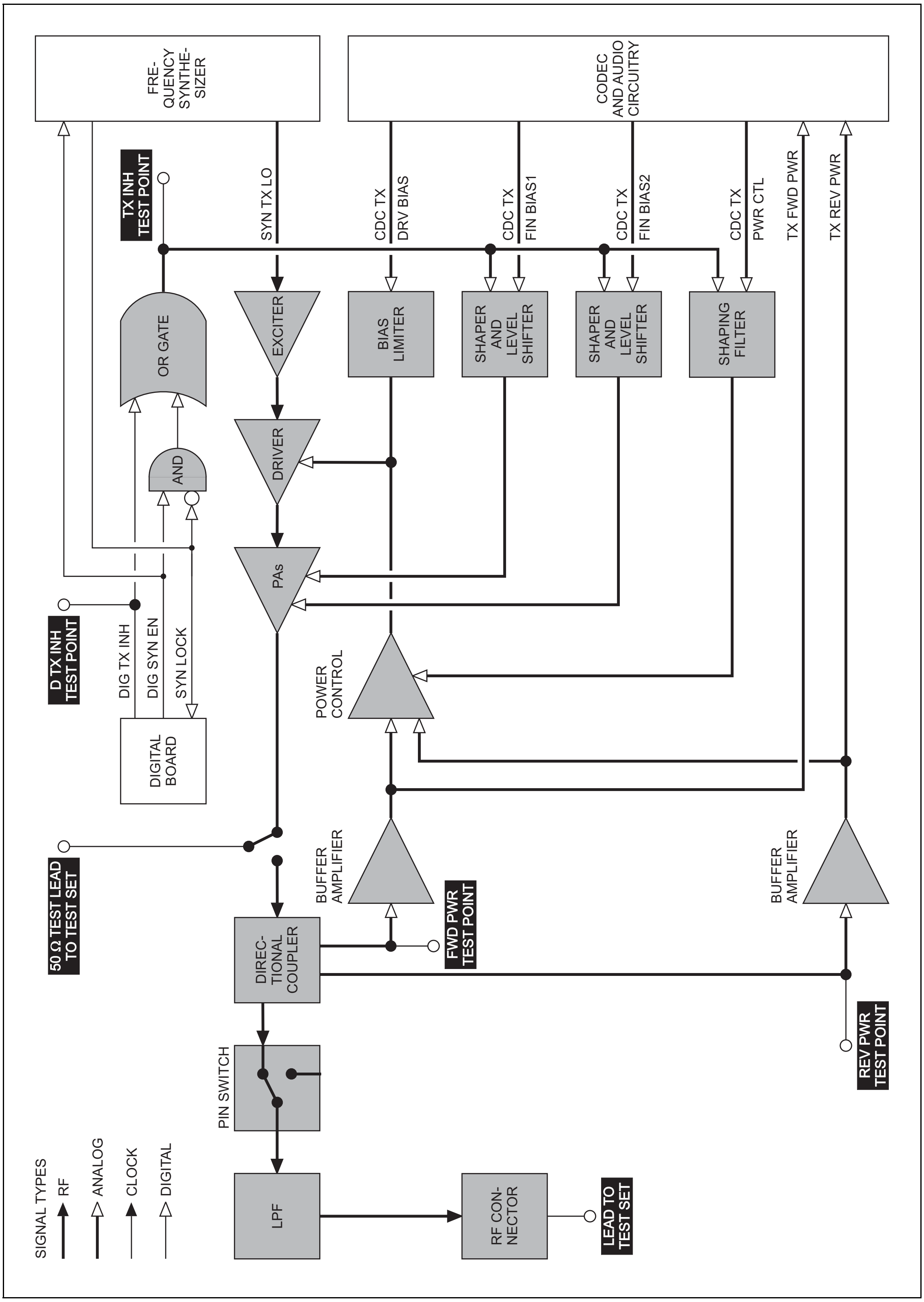
- Task 4: check forward and reverse powers
- Task 5: check RF output power
- Task 6: power unchanged regardless of setting
- Task 7: check for inhibiting of transmitter
- Task 8: check temperature sensor
- Task 9: power and current are skewed
- Task 10: repair output matching circuitry
- Task 11: power and current are low

The measurement points for diagnosing faults concerning the transmitter RF power are summarized in Figure 14.5. Data required for the first task (checking the forward and reverse powers) is supplied in Table 14.3.

Table 14.3 Voltages in millivolts corresponding to nominal forward and reverse powers

Frequency band	Forward power (318 command)	Reverse power (319 command)
B1	2600 to 3400	< 500
H5	3200 to 3900	< 700

Figure 14.5 Measurement and test points for diagnosing faults concerning the transmitter RF power



Task 4 — Check Forward and Reverse Powers

First check the forward and reverse powers for an indication of which part of the circuitry is suspect.

1. Enter the CCTM command *326 4* to set the transmitter power level high.
2. Enter the CCTM command *33* to place the radio in transmit mode.
3. Enter the CCTM command *318* to check the forward power.
   The value returned is the voltage in millivolts corresponding to the power level, and should be as shown in **Table 14.3**.
4. Confirm the above result by checking the level at the **FWD PWR test point** (see **Figure 14.4**) using an oscilloscope.
5. Enter the CCTM command *319* to check the reverse power.
   The value returned is the voltage in millivolts corresponding to the power level, and should be as shown in **Table 14.3**.
6. Confirm the above result by checking the level at the **REV PWR test point** (see **Figure 14.4**) using an oscilloscope.

   If the oscilloscope momentarily indicates a very high reverse power, then the most likely scenario is that the antenna VSWR threshold has been exceeded and the PA has shut down to very low power.
7. Enter the CCTM command *32* to place the radio in receive mode.
8. If the values obtained in Step 3 and Step 5 are both correct, and there is no indication of a momentary high reverse power, go to Task 5.
   If one or both are incorrect, go to Step 9.
9. Check the connection from the RF connector on the radio to the test set.
10. If there is no fault, go to Step 11. If there is, rectify the fault and repeat the above measurements.
11. If the reverse power is momentarily too high, the directional coupler, PIN switch or LPF is suspect; go to Task 31. Otherwise go to Task 5.

Task 5 — Check RF Output Power

If the power supplies are correct, check the RF output power of the transmitter.

1. Enter the CCTM command *326 5* to set the transmitter power level to the maximum value.
2. If not already done, program the radio with the highest frequency in the radio's frequency band: Enter the CCTM command *101* ***x x*** *0*, where ***x*** is the frequency in Hertz. The required values for the different frequency bands are given in **Table 14.2**.
3. Enter the CCTM command *33* to place the radio in transmit mode.
4. Note the RF output power measured by the test set, and note the current reading on the DC power supply.

RF output power: > 60W (VHF), > 52W (UHF) current: < 15A (VHF), < 12A (UHF)

5. Enter the CCTM command *32* to place the radio in receive mode.
6. Program the radio with the centre frequency in the radio's frequency band: Enter the CCTM command *101* ***x x*** *0*, where ***x*** is the frequency in Hertz. The required values for the different frequency bands are given in **Table 14.2**.
7. Repeat Step 3 to Step 5.
8. Program the radio with the lowest frequency in the radio's frequency band: Enter the CCTM command *101* ***x x*** *0*, where ***x*** is the frequency in Hertz. The required values for the different frequency bands are given in **Table 14.2**.
9. Repeat Step 3 to Step 5.
10. Depending on the results of the above measurements, proceed to the task indicated in **Table 14.4**. Note that the power and current are considered to be skewed if they are low at one part of the frequency band and high elsewhere.

Table 14.4 Tasks to be performed according to the results of the power and current measurements of Task 5

Power	Current	Task
Correct	Correct	Task 6 — Power unchanged regardless of setting
Correct	Wrong	Task 31 — Check power at directional coupler
Skewed	Skewed	Task 9 — Power and current are skewed
Low (> 0.1W)	Low (> 0.5A)	Task 11 — Power and current are low
None at RF connector (< 0.1W)	Low (> 0.5A)	Task 31 — Check power at directional coupler
None at RF connector (< 0.1W)	None (< 0.5A)	Task 7 — Check for inhibiting of transmitter

Task 6 — Power Unchanged Regardless of Setting

If all the power and current values measured in Task 5 are correct, it is likely that the power remains unchanged regardless of the power setting.

1. Enter the following CCTM commands in turn and measure the RF output power in each case:
   - *326 4*
   - *326 3*
   - *326 2*
   - *326 1*
2. The above measurements should confirm that the power remains unchanged at all settings. Carry out Task 12 and then Task 19.

Task 7 — Check for Inhibiting of Transmitter

If the transmitter is drawing no current or the wrong current, check whether it is being inhibited. This check is also required if a *CO3* error occurs in Task 1.

1. If not already done, enter the CCTM command *33* to place the radio in transmit mode.
2. Check the logic signal at the **TX INH test point** (see **Figure 14.4**). The signal should be:

TX INH test point: about 0V (inactive)

3. If the signal is inactive as required, go to Step 4. If it is active — about 1.1V — the transmitter is being inhibited; go to Step 5.
4. Enter the CCTM command *32* to place the radio in receive mode, and go to Task 12 in “Biasing of PA Driver and PAs” on page 292.
5. Check the logic signal at the **D TX INH test point**; see **Figure 14.14 on page 310** (VHF) or **Figure 14.4** (UHF). The signal should be:

D TX INH test point: about 0V (inactive)

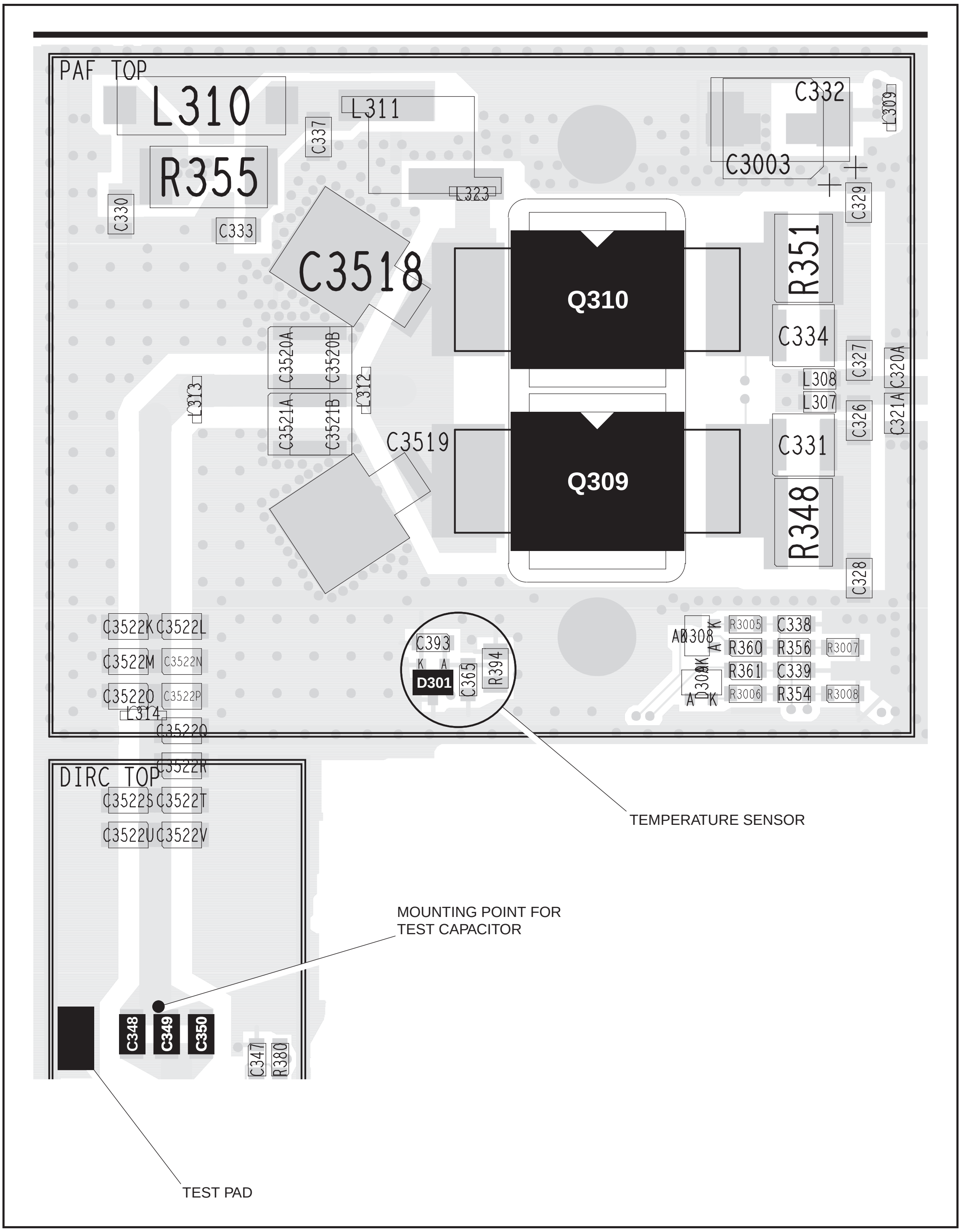
6. If the signal is inactive as required, go to Step 8. If it is active — about 3.2V — the temperature sensor is suspect; go to Step 7.
7. Enter the CCTM command *32* to place the radio in receive mode, and go to Task 8.
8. The lock status is possibly no longer normal. Enter the CCTM command *72* and check the lock status.
9. Enter the CCTM command *32* to place the radio in receive mode.
10. The normal lock status is *110*. If it is not, proceed to the relevant section. If it is, go to Step 11.
11. Check for short circuits on the DIG TX INH line from the **D TX INH test point**.
12. Repair any fault, confirm the removal of the fault, and go to “Final Tasks” on page 141. If the repair failed or no fault could be found, replace the board and go to “Final Tasks” on page 141.

Task 8 — Check Temperature Sensor

If the transmitter is being inhibited and the logic signal at the D TX INH test point is active, a fault in the temperature sensor may be the cause.

1. Enter the CCTM command *47* to check the temperature reading.
2. Of the two numbers returned, the first is the temperature in degrees celsius and should be about 25°C. If it is, go to Task 12 in “Biasing of PA Driver and PAs” on page 292. If it is not, go to Step 3.
3. If not already done, remove the PAF TOP can.
4. Check **D301** and the surrounding components — see **Figure 14.6** (UHF shown).
5. If there is no fault, go to “CODEC and Audio Fault Finding” on page 335. If a fault is found, repair it, confirm the removal of the fault, and go to “Final Tasks” on page 141. If the repair failed, replace the board, and go to “Final Tasks” on page 141.

Figure 14.6 PA circuitry under the PAF TOP can and part of the directional coupler under the DIRC TOP can (UHF shown)



Task 9 — Power and Current Are Skewed

If the RF output power and the supply current are skewed, the output matching is suspect.

1. Remove the DIRC TOP can.
2. Remove the coupling capacitors **C348**, **C349** and **C350** — see **Figure 14.6** (UHF shown).
3. Solder one terminal of a 680 pF (VHF) or 82 pF (UHF) test capacitor to the PCB at the point shown in **Figure 14.6**. Mount the capacitor vertically. Use a test capacitor of the type GRM111, DLI C17, ATC100B, or the equivalent.
4. Solder a 50 Ω test lead to the PCB. Solder the outer sheath to the test pad shown in **Figure 14.6**, and solder the central wire to the other terminal of the test capacitor.
5. Connect the test lead to the test set.
6. Program the radio with the highest frequency in the radio's frequency band: Enter the CCTM command *101* ***x x*** *0*, where ***x*** is the frequency in Hertz. The required values for the different frequency bands are given in **Table 14.2**.
7. Enter the CCTM command *33* to place the radio in transmit mode.
8. Note the RF output power measured by the test set, and note the current reading on the DC power supply.

RF output power: > 70W (VHF), > 60W (UHF) current: < 15A (VHF), < 12A (UHF)

9. Enter the CCTM command *32* to place the radio in receive mode.
10. Program the radio with the centre frequency in the band: Enter the CCTM command *101* ***x x*** *0*, where ***x*** is the frequency in Hertz.
11. Repeat Step 7 to Step 9.
12. Program the radio with the lowest frequency in the band: Enter the CCTM command *101* ***x x*** *0*, where ***x*** is the frequency in Hertz.
13. Repeat Step 7 to Step 9.
14. If the power and current are still skewed, go to Task 10. If the power and current are correct, remove the test lead and test capacitor, resolder the coupling capacitors in position, and go to Task 33 — the PIN switch and LPF require checking.

Task 10 — Repair Output Matching Circuitry

If the checks in Task 9 show that the power and current are still skewed, there is a fault in the output matching circuitry.

1. If not already done, remove the PAF TOP can.
2. Check for faulty, shorted or misplaced components in the circuit between the test capacitor and the common drain of **Q309** and **Q310** (see **Figure 14.6**). Repair any fault.
3. Program the radio with the highest frequency in the radio's frequency band: Enter the CCTM command *101* ***x*** ***x*** *0*, where ***x*** is the frequency in Hertz. The required values for the different frequency bands are given in **Table 14.2**.
4. Enter the CCTM command *33* to place the radio in transmit mode.
5. Note the RF output power measured by the test set, and note the current reading on the DC power supply.

RF output power: > 70W (VHF), > 60W (UHF) current: < 15A (VHF), < 12A (UHF)

6. Enter the CCTM command *32* to place the radio in receive mode.
7. Program the radio with the centre frequency in the band: Enter the CCTM command *101* ***x*** ***x*** *0*, where ***x*** is the frequency in Hertz.
8. Repeat Step 4 to Step 6.
9. Program the radio with the lowest frequency in the band: Enter the CCTM command *101* ***x*** ***x*** *0*, where ***x*** is the frequency in Hertz.
10. Repeat Step 4 to Step 6.
11. Remove the test lead and test capacitor, and resolder the coupling capacitors **C348**, **C349** and **C350** in position (see **Figure 14.6**).
12. If the power and current are now correct at all three frequencies, the fault has been rectified; go to “Final Tasks” on page 141. If they are not, go to Task 26 in “RF Signal Path” on page 315.

Task 11 — Power and Current Are Low

If the RF output power and the supply current are uniformly low at all frequencies, one of the PAs is suspect or the input to the PAs is reduced. Check each PA in turn:

1. For the first PA (Q310), enter the CCTM command *331* to check the DAC value of final bias 1 (CDC TX FIN BIAS 1). Record the value ***x*** returned.
2. Note the current reading on the DC power supply.
3. Enter the CCTM command *331 1* to turn off final bias 1.
4. Enter the CCTM command *33* to place the radio in transmit mode.
5. Note the RF output power measured at the test set. This should be as shown in **Table 14.5**.
6. If the RF power is correct, go to Step 7 to repeat the check with the second PA. If it is not, enter the CCTM command *32* to place the radio in receive mode, and carry out Task 12 and then Task 13.
7. For the second PA (Q309), enter the CCTM command *332* to check the DAC value of final bias 2 (CDC TX FIN BIAS 2). Record the value ***y*** returned.
8. Note the current reading on the DC power supply.
9. Enter the CCTM command *332 1* to turn off final bias 2.
10. With the radio still in transmit mode, note the RF output power measured at the test set. This should be as shown in **Table 14.5**.
11. Enter the CCTM command *32* to place the radio in receive mode.
12. If the RF power measured in Step 10 is correct, go to "RF Signal Path" on page 314. If it is not, carry out Task 12 and then Task 16.

Table 14.5 RF output power of individual RF power amplifiers at different frequencies

Frequency band	Frequency within band		
	Lowest frequency	Centre frequency	Highest frequency
B1	38 ± 5W	48 ± 5W	33 ± 5W
H5	16 ± 5W	17 ± 5W	21 ± 5W

14.3 Biasing of PA Driver and PAs

Introduction

The measurements of the transmitter RF output power in "Transmitter RF Power" may indicate a need to check the biasing of the two PAs and the PA driver. The procedure is covered in this section. There are thirteen tasks grouped as follows:

- Task 12: prepare to check biasing
- Task 13 to Task 15: check biasing of first PA
- Task 16 to Task 18: check biasing of second PA
- Task 19 and Task 20: check biasing of PA driver
- Task 21 to Task 24: repair circuitry

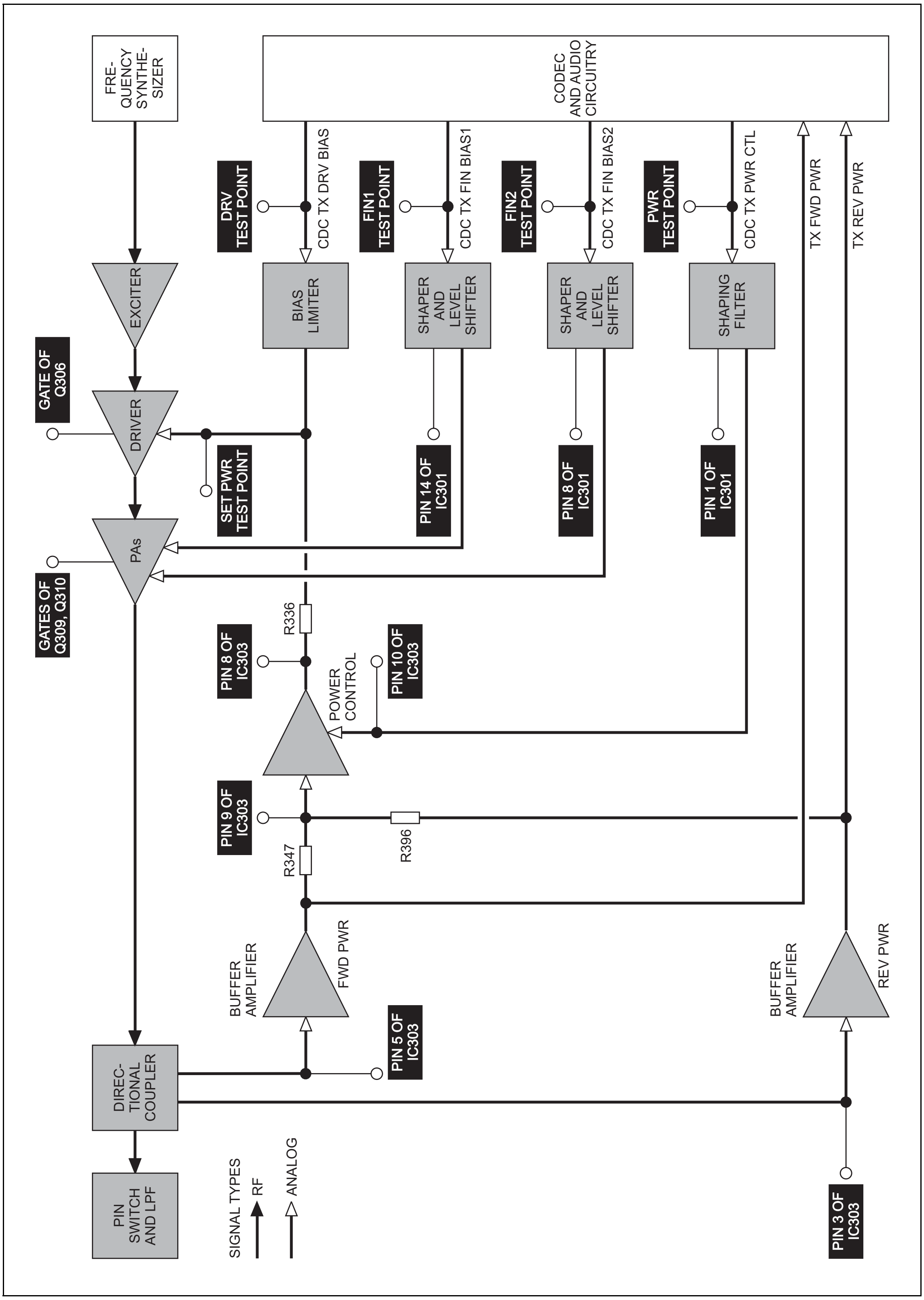
The test and measurement points for diagnosing faults in the biasing of the PAs and PA driver are summarized in Figure 14.7.

Task 12 — Prepare to Check Biasing

If the transmitter is not being inhibited, check the biasing of the two PAs and the PA driver. First make the following preparations:

1. Set the current limit on the DC power supply to 3A.
2. Enter the CCTM command *331* to check the DAC value of final bias 1 (CDC TX FIN BIAS 1) at maximum power. Record the value ***x*** returned.
3. Enter the CCTM command *332* to check the DAC value of final bias 2 (CDC TX FIN BIAS 2) at maximum power. Record the value ***y*** returned.
4. Enter the CCTM command *304* to check the DAC value of the clamp current at the driver gate. Record the value ***z*** returned.
5. Enter the CCTM command *33* to place the radio in transmit mode.
6. Switch off all biases by entering the following CCTM commands in sequence:
   - *331 1*
   - *332 1*
   - *304 1*
   - *114 1023*
   - *334 0*
   - *335 0*
7. Note the current reading on the DC power supply. This will be less than 500mA.
8. With the radio still in transmit mode, check the biasing of the PAs and PA driver, beginning with Task 13.

Figure 14.7 Measurement and test points for diagnosing faults in the biasing of the PAs and PA driver



Task 13 — Check Biasing of First PA

Check the biasing of the first PA (Q310).

Important Ensure that the current limit on the DC supply is 3A. And, when entering the CCTM command *331* ***x***, do not specify a value ***x*** higher than that recorded in Task 12. Failure to do so may result in the destruction of the PAs.

1. Use a multimeter to measure the voltage at pin 14 of **IC301** (see **Figure 14.8** and **Figure 14.9**). The voltage should be:

pin 14 of IC301: < 100mV (initially)

2. Note the current reading on the DC power supply. As mentioned in Step 7 of Task 12, this will be less than 500mA.

3. Enter the CCTM command *331* ***x*** (where ***x*** was recorded in Task 12).

4. Check that the voltage changes to:

pin 14 of IC301: 2 to 5V (after entry of CCTM 331 **x**)

5. Also note the current reading. This should increase by an amount approximately equal to the offset given in **Table 14.6**.

6. If the voltage and current are both correct, go to Step 7. If the voltage is correct but not the current, go to Task 14. If neither the current nor the voltage is correct, go to Task 15.

7. Enter the CCTM command *331 1* to switch off final bias 1, and go to Task 16.

Table 14.6 Gate biases for the PAs and PA driver at high power

Frequency band	Offset currents in mA		
	First PA	Second PA	PA driver
B1	1690	1690	150
H5	1800	1800	400

Figure 14.8 Test points and components of the shaping filter (VHF)

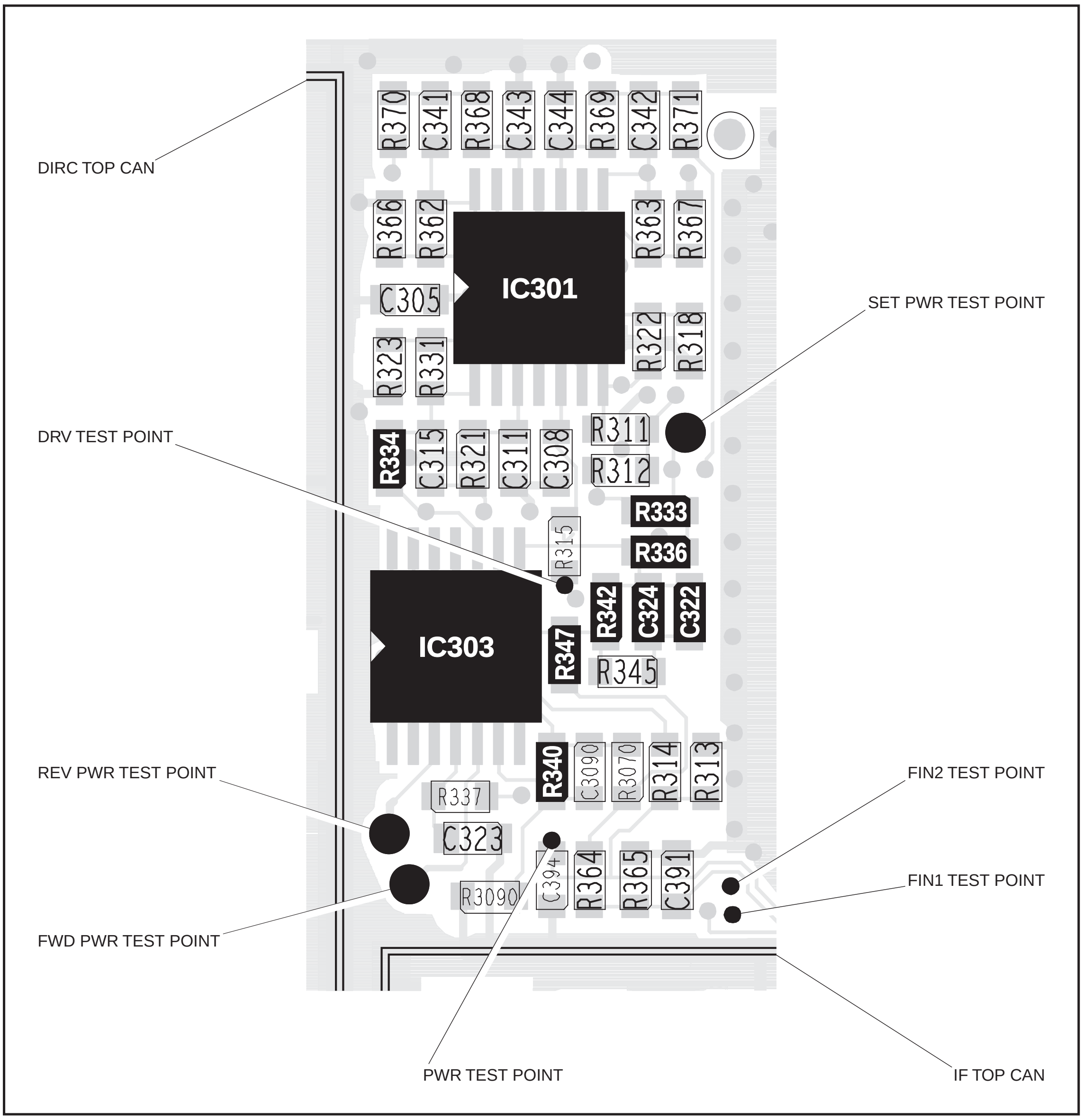
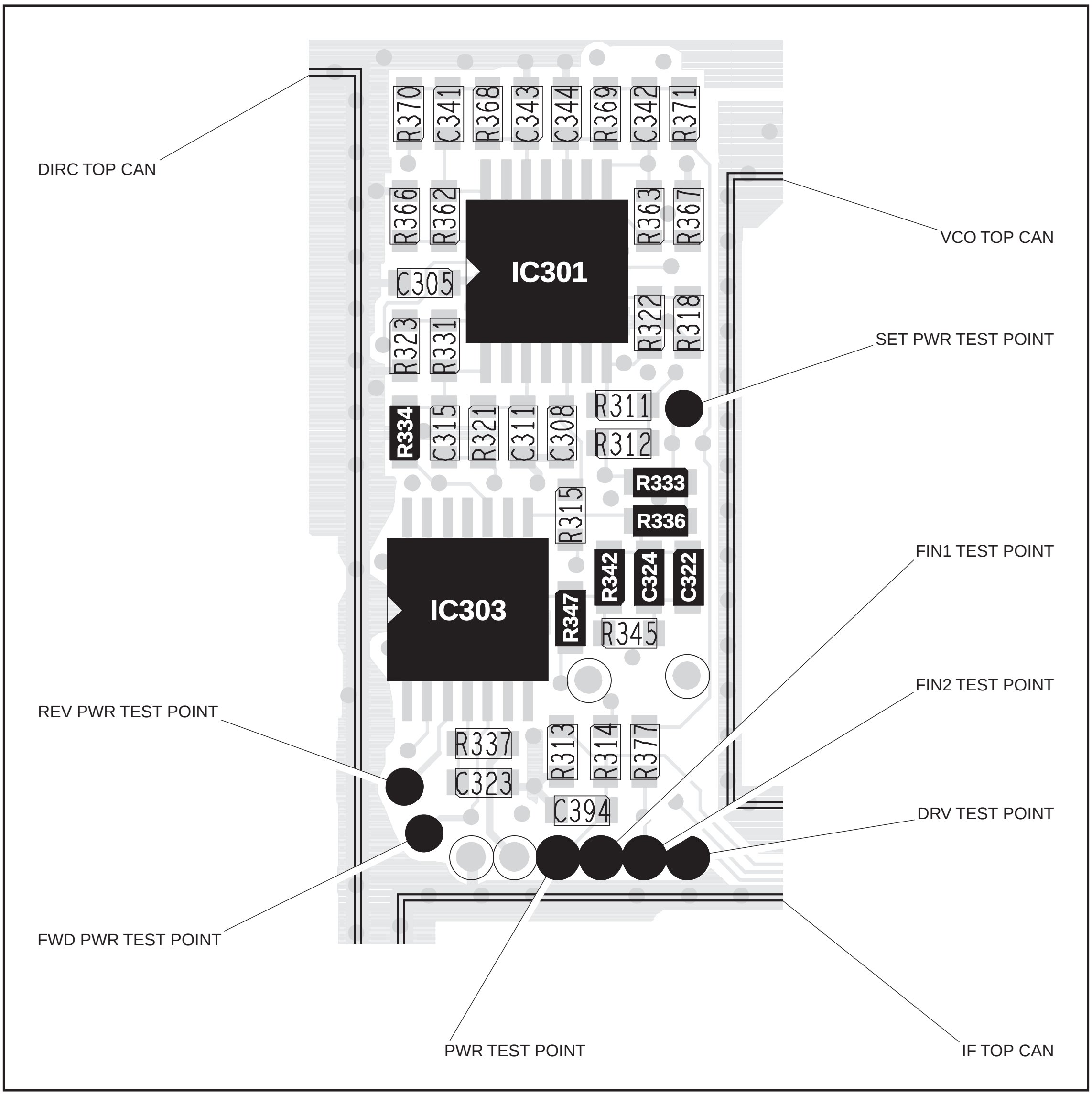


Figure 14.9 Test points and components of the shaping filter (UHF)



Task 14 — Shaper and Level Shifter

If the voltage measured in Task 13 is correct but not the current, either the first PA or the shaper and level shifter for the PA is suspect.

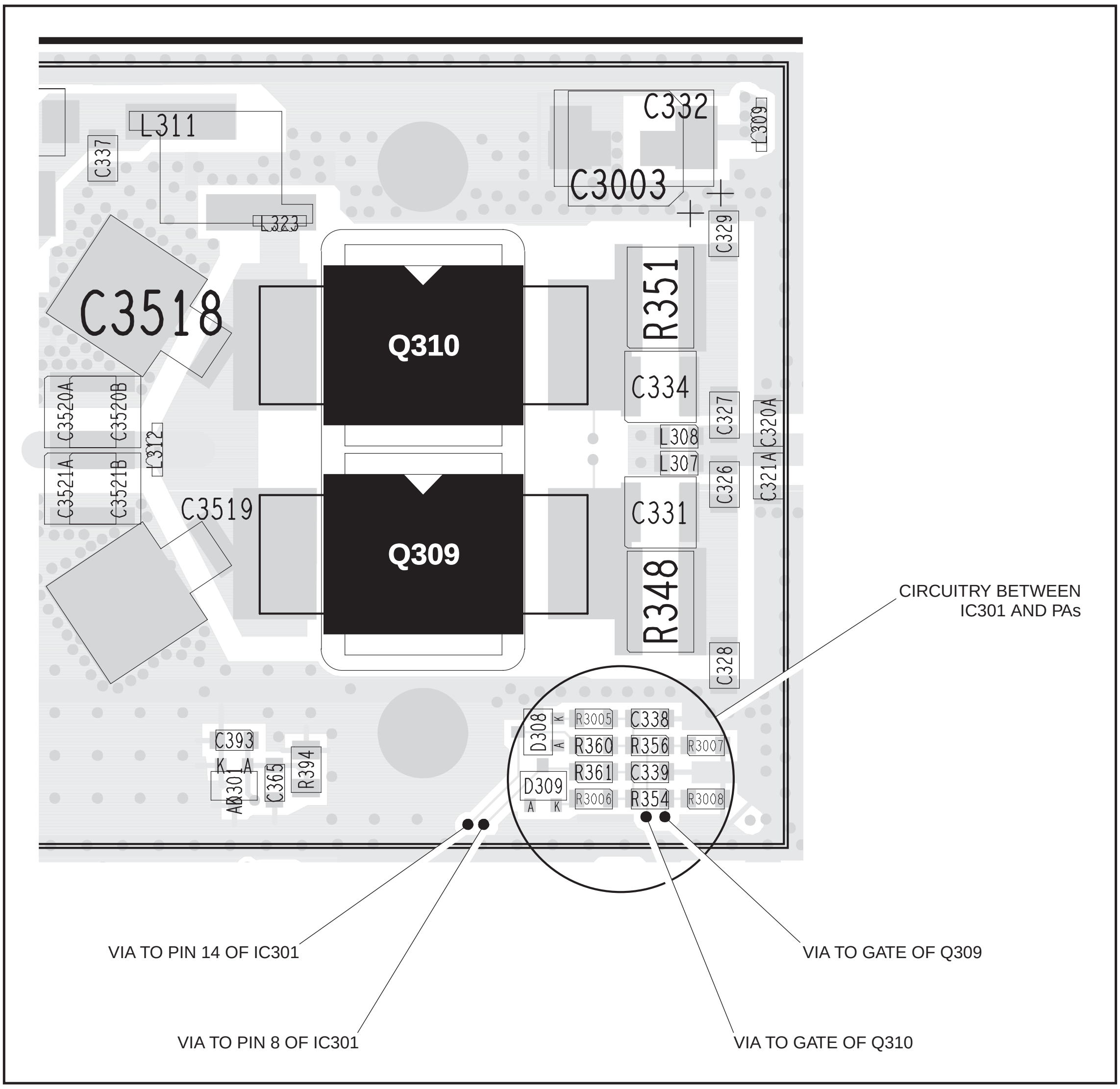
Important Ensure that the current limit on the DC supply is 3A. And, when entering the CCTM command *331* ***x***, do not specify a value ***x*** higher than that recorded in Task 12. Failure to do so may result in the destruction of the PAs.

1. If the PAF TOP can has already been removed, go to Step 5 If it has not, go to Step 2.
2. Enter the CCTM command *32* to place the radio in receive mode.
3. Remove the PAF TOP can.
4. Enter the CCTM command *33* to place the radio in transmit mode.
5. Enter the CCTM command *331* ***x*** (where ***x*** was recorded in Task 12).
6. Check that the voltage at the gate of **Q310** is (see **Figure 14.10**):

gate of Q310: 2 to 5V

7. Enter the CCTM command *32* to place the radio in receive mode.
8. If the voltage measured above is correct, **Q310** is faulty; replace the board and go to “Final Tasks” on page 141. If it is not correct, go to Step 9.
9. Check the circuitry between pin 14 of **IC301** and the gate of **Q310** (see **Figure 14.10**). If a fault is found, repair it, confirm the removal of the fault, and go to “Final Tasks” on page 141. If the repair failed or Q310 itself is faulty, replace the board and go to “Final Tasks” on page 141.

Figure 14.10 PA circuitry under the PAF TOP can (UHF shown)



Task 15 — Shaping Filter for Power Control

If neither the voltage nor the current measured in Task 13 is correct, then the shaping filter for the power-control circuitry or the CODEC and audio circuitry is suspect.

Important Ensure that the current limit on the DC supply is 3A. And, when entering the CCTM command *331* ***x***, do not specify a value ***x*** higher than that recorded in Task 12. Failure to do so may result in the destruction of the PAs.

1. Use the multimeter to measure the voltage at the **FIN1 test point** (see **Figure 14.8** and **Figure 14.9**). The voltage should be:

FIN1 test point: 18 ± 2mV (initially)

2. Enter the CCTM command *331* ***x*** (where ***x*** was recorded in Task 12).
3. Check that the voltage changes to:

FIN1 test point: 1.1 to 2.7V (after entry of CCTM 331 **x**)

4. Enter the CCTM command *32* to place the radio in receive mode.
5. If the voltage measured above is correct, go to Step 6. If it is not, go to "CODEC and Audio Fault Finding" on page 335.
6. Check **IC301** and the surrounding shaping-filter circuitry (see **Figure 14.8** and **Figure 14.9**). If a fault is found, repair it, confirm the removal of the fault, and go to "Final Tasks" on page 141. If the repair failed, replace the board and go to "Final Tasks" on page 141.

Task 16 — Check Biasing of Second PA

If the biasing of the first PA is correct, check that of the second PA (Q309).

Important Ensure that the current limit on the DC supply is 3A. And, when entering the CCTM command *332* ***y***, do not specify a value ***y*** higher than that recorded in Task 12. Failure to do so may result in the destruction of the PAs.

1. Use the multimeter to measure the voltage at pin 8 of **IC301** (see **Figure 14.8** and **Figure 14.9**). The voltage should be:

pin 8 of IC301: < 100mV (initially)

2. Note the current reading on the DC power supply. As mentioned in Step 7 of Task 12, the current will be less than 500mA.

3. Enter the CCTM command *332* ***y*** (where ***y*** was recorded in Task 12).

4. Check that the voltage changes to:

pin 8 of IC301: 2 to 5V (after entry of CCTM 332 **y**)

5. Also note the current reading. This should increase by an amount approximately equal to the offset given in **Table 14.6**.

6. If the voltage and current are both correct, go to Step 7. If the voltage is correct but not the current, go to Task 17. If neither the current nor the voltage is correct, go to Task 18.

7. Enter the CCTM command *332 1* to switch off final bias 2, and go to Task 19.

Task 17 — Shaper and Level Shifter

If the voltage measured in Task 16 is correct but not the current, either the second PA or the shaper and level shifter for the PA is suspect.

Important Ensure that the current limit on the DC supply is 3A. And, when entering the CCTM command *332* ***y***, do not specify a value ***y*** higher than that recorded in Task 12. Failure to do so may result in the destruction of the PAs.

1. If the PAF TOP can has already been removed, go to Step 5. If it has not, go to Step 2.
2. Enter the CCTM command *32* to place the radio in receive mode.
3. Remove the PAF TOP can.
4. Enter the CCTM command *33* to place the radio in transmit mode.
5. Enter the CCTM command *332* ***y*** (where ***y*** was recorded in Task 12).
6. Check that the voltage at the gate of **Q309** is (see **Figure 14.10**):

gate of Q309: 2 to 5V

7. Enter the CCTM command *32* to place the radio in receive mode.
8. If the voltage is correct, **Q309** is faulty; replace the board and go to "Final Tasks" on page 141. If it is not, go to Step 9.
9. Check the circuitry between pin 8 of **IC301** and the gate of **Q309** (see **Figure 14.6**). If a fault is found, repair it, confirm the removal of the fault, and go to "Final Tasks" on page 141. If the repair failed or Q309 itself is faulty, replace the board and go to "Final Tasks" on page 141.

Task 18 — Shaping Filter for Power Control

If neither the voltage nor the current measured in Task 16 is correct, then the shaping filter for the power-control circuitry or the CODEC and audio circuitry is suspect.

Important Ensure that the current limit on the DC supply is 3A. And, when entering the CCTM command *332* ***y***, do not specify a value ***y*** higher than that recorded in Task 12. Failure to do so may result in the destruction of the PAs.

1. Use the multimeter to measure the voltage at the **FIN2 test point** (see **Figure 14.8** and **Figure 14.9**). The voltage should be:

FIN2 test point: 18 ± 2V (initially)

2. Enter the CCTM command *332* ***y*** (where ***y*** was recorded in Task 12).

3. Check that the voltage changes to:

FIN2 test point: 1.1 to 2.7V (after entry of CCTM 332 **y**)

4. Enter the CCTM command *32* to place the radio in receive mode.

5. If the voltage measured above is correct, go to Step 6. If it is not, go to “CODEC and Audio Fault Finding” on page 335.

6. Check **IC301** and the surrounding shaping-filter circuitry (see **Figure 14.8** and **Figure 14.9**). If a fault is found, repair it, confirm the removal of the fault, and go to “Final Tasks” on page 141. If the repair failed, replace the board and go to “Final Tasks” on page 141.

Task 19 — Biasing of PA Driver — DRV test point

If there is no fault in the biasing of the PAs, investigate the biasing of the PA driver (Q306). First check the DRV test point.

Important Ensure that the current limit on the DC supply is 3A. And, when entering the CCTM command *304* ***z***, do not specify a value ***z*** higher than that recorded in Task 12. Failure to do so may result in the destruction of the PA driver.

1. Note the current reading on the DC power supply. As mentioned in Step 7 of Task 12, the current will be less than 500mA.
2. Enter the CCTM command *304* ***z*** (where ***z*** was recorded in Task 12) to switch on the clamp current.
3. Note the current reading on the DC power supply.
4. Compare the above current readings. The current should increase by an amount approximately equal to the offset given in **Table 14.6**. If it does, go to Task 21. If it does not, go to Step 5.
5. Check as follows that the voltage from the DAC is changing: First enter the CCTM command *304 1* to switch off the bias.
6. Measure the voltage at the **DRV test point** (CDC TX DRV BIAS) (see **Figure 14.8** and **Figure 14.9**). The voltage should be:

DRV test point: < 0.1V (after entry of CCTM 304 1)

7. Enter the CCTM command *304* ***z*** (where ***z*** was recorded in Task 12) to change the DAC value of the clamp current.
8. The voltage should increase to:

DRV test point: 0.8 to 2.5V (after entry of CCTM 304 **z**)

9. If the voltage does change, go to Task 20. If it does not, go to Step 10.
10. Enter the CCTM command *32* to place the radio in receive mode, and go to “CODEC and Audio Fault Finding” on page 335.

Task 20 — Biasing of PA Driver— SET PWR test point

If the voltage at the DRV test point is correct, check that at the SET PWR test point.

1. Check the voltage at the **SET PWR test point** (see **Figure 14.8** and **Figure 14.9**):

SET PWR test point: 2 to 5V

2. If the voltage is correct, go to Step 3. If it is not, go to Task 21.

3. If the PAD TOP can has already been removed, go to Step 7. If it has not, go to Step 4.

4. Enter the CCTM command 32 to place the radio in receive mode.

5. Remove the PAD TOP can.

6. Enter the CCTM command 33 to place the radio in transmit mode.

7. Check the voltage on the gate of **Q306** (see **Figure 14.11** and **Figure 14.12**):

gate of Q306: 2 to 5V

8. Enter the CCTM command 32 to place the radio in receive mode.

9. If the voltage is correct, replace **Q306**; confirm the removal of the fault and go to “Final Tasks” on page 141. If it is not, go to Task 23.

Figure 14.11 PA driver circuitry under the PAD TOP can (VHF)

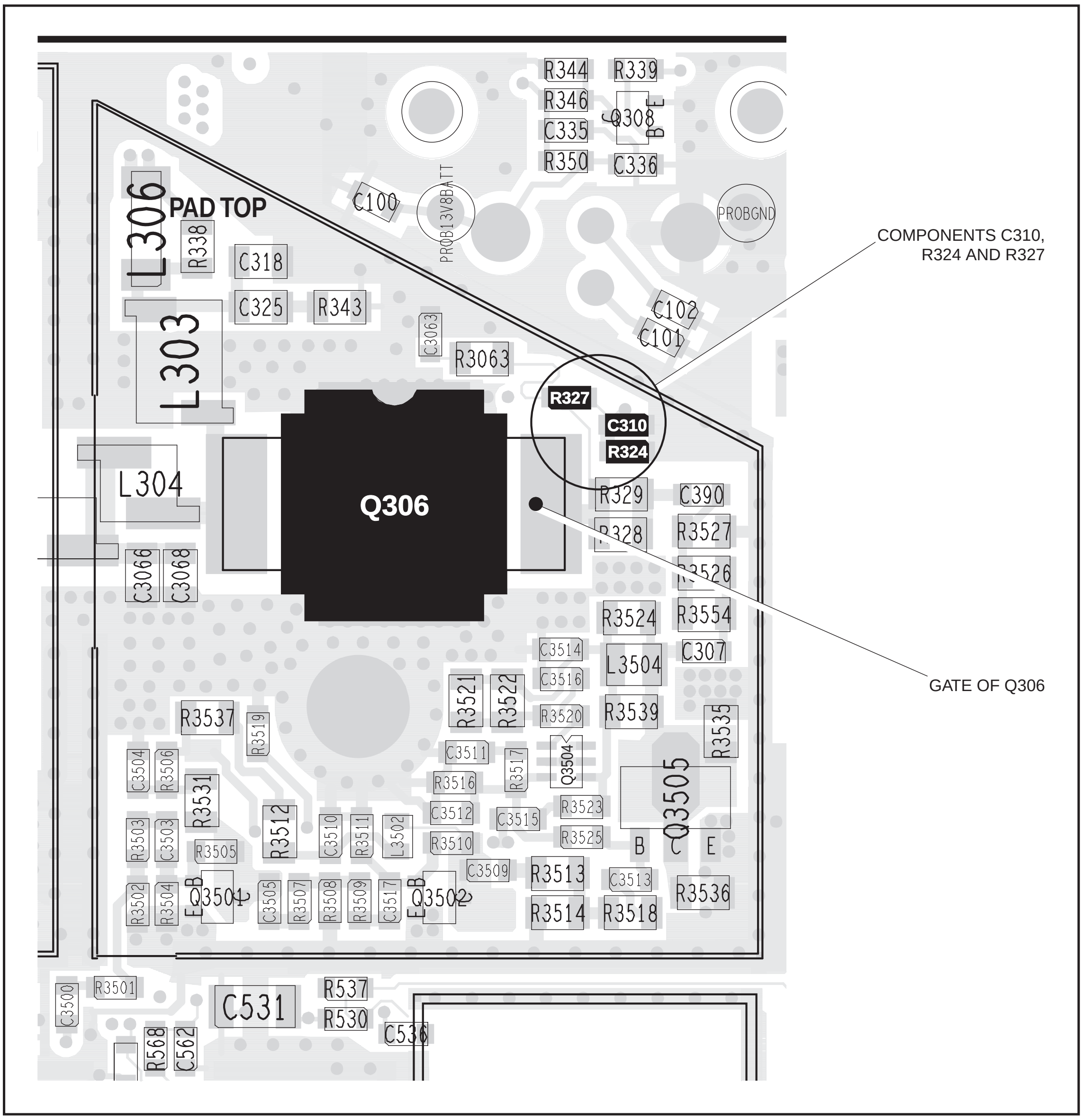
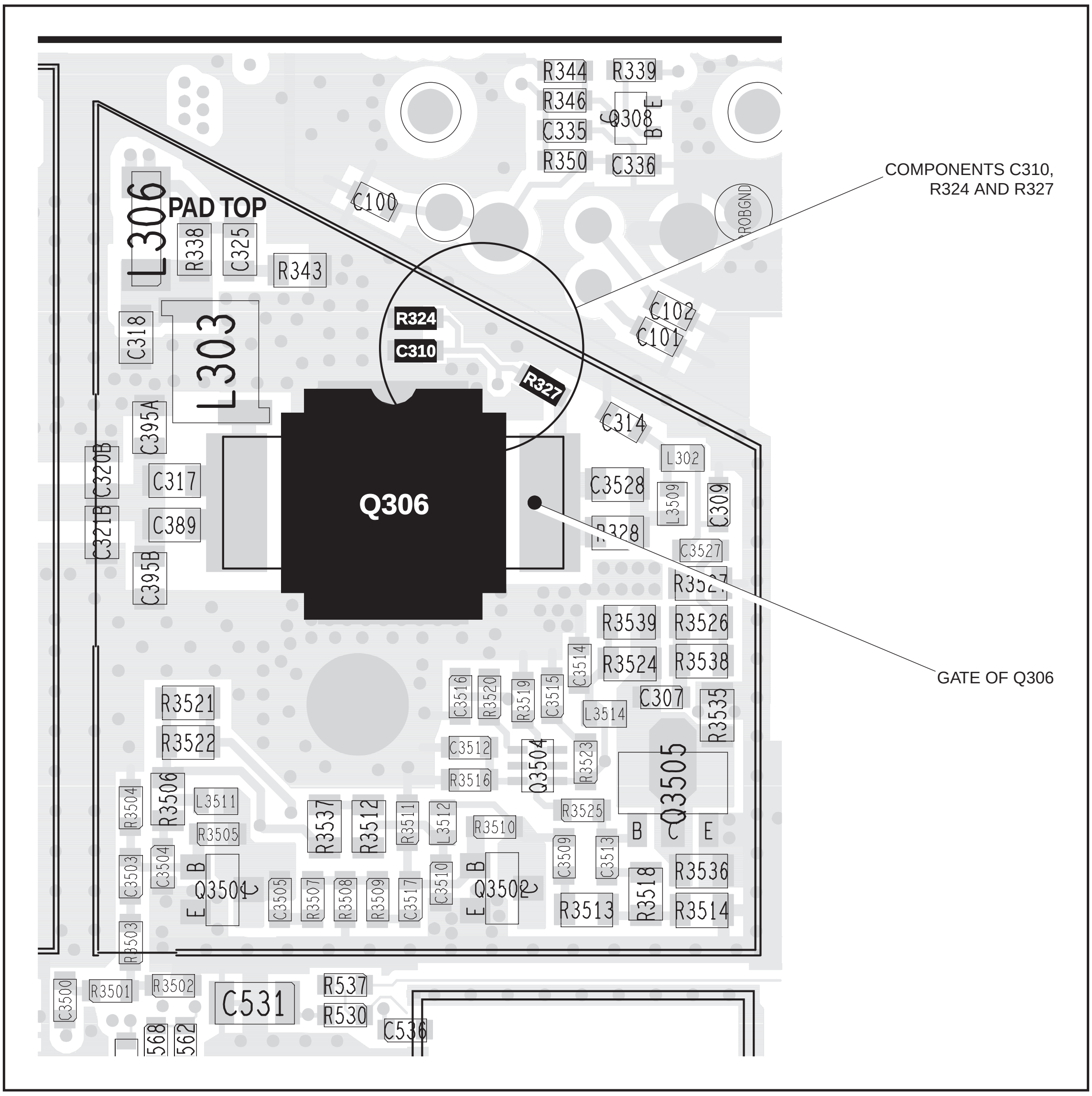


Figure 14.12 PA driver circuitry under the PAD TOP can (UHF)



Task 21 — Check Power Control

Check the power-control circuitry if the clamp current for the PA driver is correct or if the voltage at the SET PWR test point is incorrect.

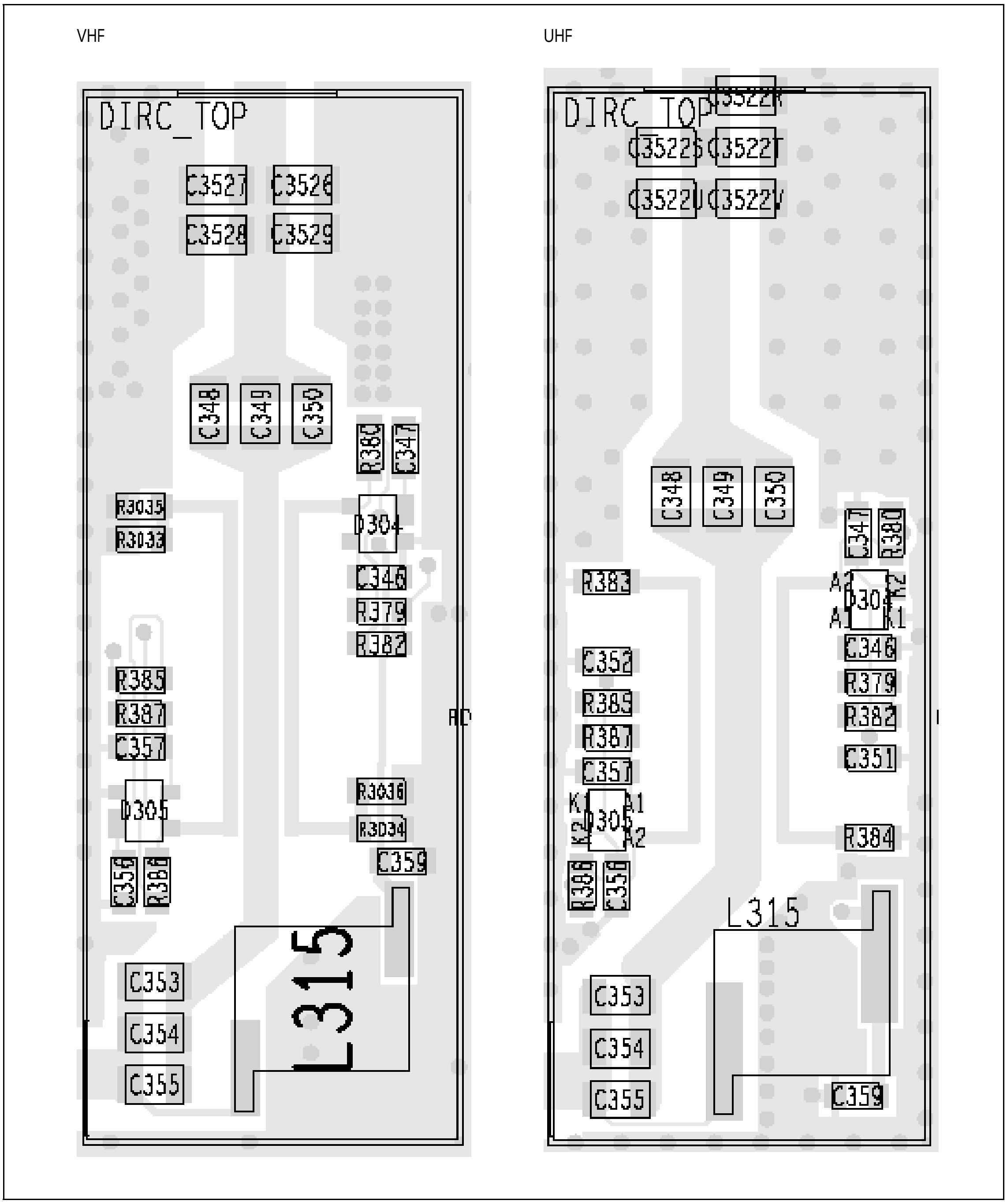
Important Ensure that the current limit on the DC supply is 3A. And, when entering the CCTM command *304* ***z***, do not specify a value ***z*** higher than that recorded in Task 12. Failure to do so may result in the destruction of the PA driver.

1. Enter the CCTM command *304* ***z*** (where ***z*** was recorded in Task 12).
2. Note the current reading on the DC power supply.
3. Enter the CCTM command *114 0* to switch off the power.
4. Note the current reading on the DC power supply.
5. Compare the above current readings. The current should decrease by an amount approximately equal to the offset given in **Table 14.6**. If it does, go to Task 26 in “RF Signal Path” on page 315. If it does not, go to Step 6.
6. Check that the voltage from the DAC is changing. Measure the voltage at the **PWR test point** (CDC TX PWR CTL) (see **Figure 14.8** and **Figure 14.9**).
7. Enter the CCTM command *114 1023*. The voltage should increase to:

PWR test point: 2.4 ± 0.1V

8. Enter the CCTM command 32 to place the radio in receive mode.
9. If the voltage at the **PWR test point** increases as required, go to Task 22. If it does not, go to “CODEC and Audio Fault Finding” on page 335.

Figure 14.13 Circuitry under the DIRC TOP can



Task 22 — Directional Coupler and Buffer Amplifiers

Following the checks in Task 19 to Task 21, locate the fault and repair the circuitry as described in the remaining tasks of the section. In this task any faults in the directional coupler or the buffer amplifiers will be located.

1. Cycle the power.

2. Enter the CCTM command *326 5* to set the transmitter to maximum power. Enter the CCTM command *33* to place the radio in transmit mode.

3. Measure the voltage at pin 9 of **IC303** in the power-control circuit (see **Figure 14.8** and **Figure 14.9**).

4. The above voltage should be as given in **Table 14.7**. If it is, go to Task 24. If it is not, go to Step 5.

5. Check the voltage at the **FWD PWR test point** (pin 5 of **IC303**) and at the **REV PWR test point** (pin 3 of IC303) (see **Figure 14.8** and **Figure 14.9**). Note that the probe impedance may affect these measurements.

6. Enter the CCTM command 32 to place the radio in receive mode.

7. The voltages measured in Step 5 should be as given in **Table 14.7**. If they are, go to Step 10. If the FWD PWR voltage is incorrect, go to Step 8. If the REV PWR voltage is incorrect, go to Step 9.

Table 14.7 Voltages at IC303 at maximum power (70 W for VHF, and 60W for UHF)

Frequency band	Frequency (MHz)	Voltage (V)		
		Pin 9	Pin 3 (REV PWR)	Pin 5 (FWD PWR)
B1	136 155 174	2.6 ± 0.5 2.9 ± 0.5 3.2 ± 0.5	0.4 ± 0.3 0.4 ± 0.3 0.5 ± 0.3	3.1 ± 0.5 3.4 ± 0.5 3.9 ± 0.5
H5	400 435 470	2.8 ± 0.5 3.0 ± 0.5 3.3 ± 0.5	0.6 ± 0.4 0.6 ± 0.4 0.5 ± 0.4	3.3 ± 0.5 3.7 ± 0.5 3.9 ± 0.5

8. Remove the DIRC TOP can. Check the components of the directional coupler (see **Figure 14.13**) and go to Step 11.

9. Remove the DIRC TOP can. Check **D305** and **R3035** (VHF) or **R383** (UHF) (see **Figure 14.13**). If there is no fault, the PIN switch or LPF or both are suspect; go to Task 33. If there is a fault, go to Step 11.

10. In the buffer amplifiers, check **R340** (see **Figure 14.8** for VHF and **Figure 14.14** for UHF) and **R341** (see **Figure 14.14** and **Figure 14.15**).

11. Repair any fault revealed by the above checks. Replace **IC303** if none of the other components is faulty (see **Figure 14.8** and **Figure 14.9**).

12. Confirm the removal of the fault and go to “Final Tasks” on page 141. If the repair failed, replace the board and go to “Final Tasks” on page 141.

Task 23 — Power Control for PA Driver

In this task any faults in the path between the power-control circuit and the PA driver will be located, as well as any fault with the PA driver.

1. Check for short circuits at the gate of the PA driver **Q306**. Check **R333**, **R336** (see **Figure 14.8** and **Figure 14.9**), **C310**, **R324** and **R327** (see **Figure 14.11** and **Figure 14.12**) between the power-control circuit and Q306.

2. Repair any fault revealed by the checks in Step 1. If none of the above-mentioned components is faulty, replace **Q306** (see **Figure 14.11** and **Figure 14.12**).

3. Confirm the removal of the fault and go to “Final Tasks” on page 141. If the repair failed, replace the board and go to “Final Tasks” on page 141.

Figure 14.14 Components of concern on the bottom-side of the main board (VHF)

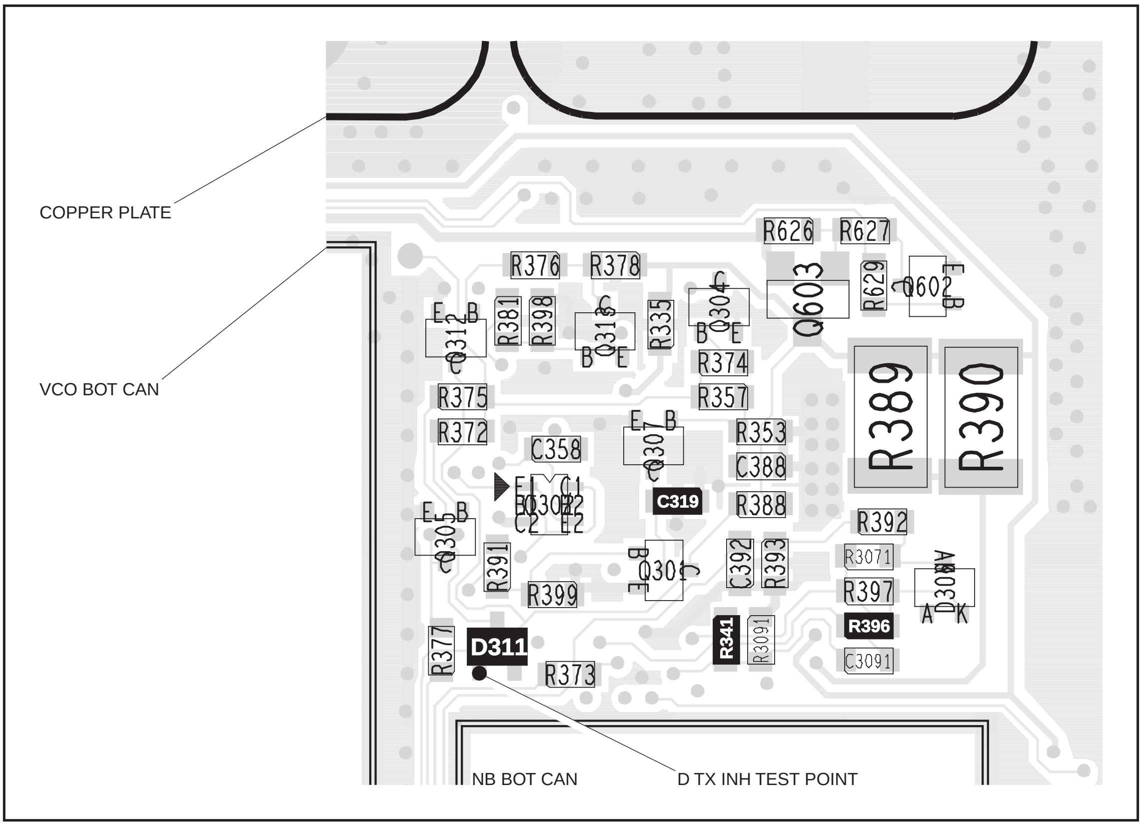
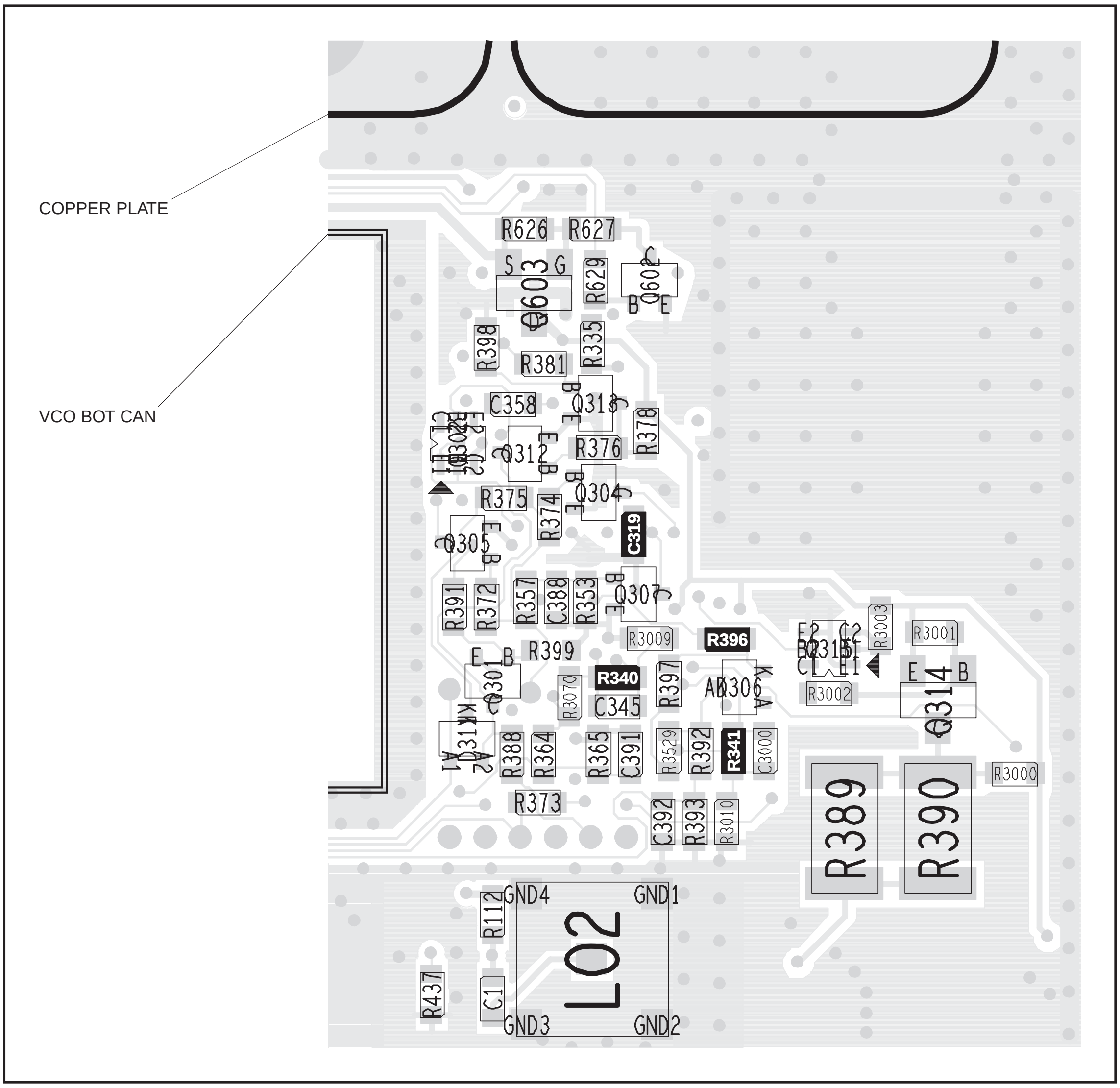


Figure 14.15 Components of concern on the bottom-side of the main board (UHF)



Task 24 — Power Control

In this task any faults in the power-control circuitry will be located:

1. Measure the voltage at pin 8 of **IC303** (see **Figure 14.8** and **Figure 14.9**) in the power-control circuit. The voltage should be:

pin 8 of IC303: 7.4 ± 0.5V

2. If the voltage is correct, go to Step 3. If it is not, enter the CCTM command *32* and return to Task 23.

3. Measure the voltage at pin 10 of **IC303** in the power-control circuit. The voltage should be:

pin 10 of IC303: 4.8 ± 0.5V

4. If the voltage is correct, go to Step 5. If it is not, go to Task 25.

5. Enter the CCTM command *32* to place the radio in receive mode.

6. Check **C322**, **C324**, **R342**, **R347** (see **Figure 14.8** and **Figure 14.9**) and **R396** (see **Figure 14.14** and **Figure 14.15**) in the power-control circuit. Repair any fault. Replace **IC303** if none of the other components is faulty.

7. Confirm the removal of the fault and go to "Final Tasks" on page 141. If the repair failed, replace the board and go to "Final Tasks" on page 141.

Task 25 — Shaping Filter

In this task any faults in the shaping-filter circuitry will be located.

1. With the radio still in transmit mode, measure the voltage at pin 1 of **IC301** (see **Figure 14.8** and **Figure 14.9**) in the shaping-filter circuit. The voltage should be:

pin 1 of IC301: 4.8 ± 0.5V

2. Enter the CCTM command *32* to place the radio in receive mode.
3. If the voltage measured in Step 1 is correct, go to Step 4. If it is not, go to Step 5.
4. Check the components **R334** (see **Figure 14.8** and **Figure 14.9**) and **C319** (see **Figure 14.14** and **Figure 14.15**) and go to Step 6.
5. Check the components between the **PWR test point** and pin 1 of **IC301** (see **Figure 14.8** and **Figure 14.9**) and go to Step 6.
6. Repair any fault revealed by the checks in Step 4 and Step 5. Replace **IC301** if none of the other components is faulty.
7. Confirm the removal of the fault and go to “Final Tasks” on page 141. If the repair failed, replace the board and go to “Final Tasks” on page 141.

14.4 RF Signal Path

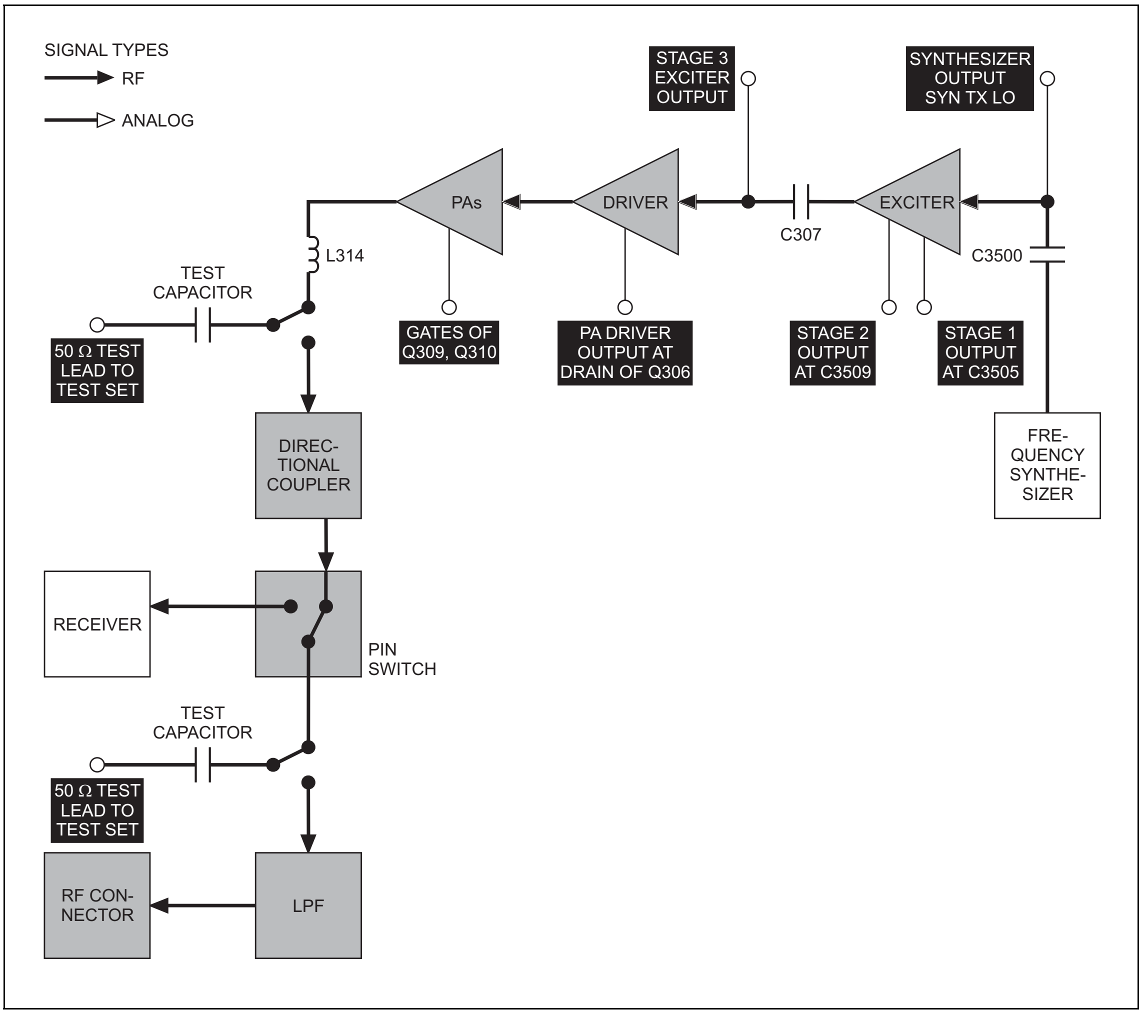
Introduction

The RF signal path extends from the output of the frequency synthesizer to the LPF. This section of circuitry will require investigation either following certain checks in “Transmitter RF Power” or if the biasing checks of “Biasing of PA Driver and PAs” reveal no fault. The procedure is divided into ten tasks grouped as follows:

- Task 26 to Task 30: initial RF signal path
- Task 31 and Task 32: directional coupler
- Task 33 and Task 34: PIN switch
- Task 35: LPF

The initial signal path includes the exciter and PA driver. The directional coupler, PIN switch, and LPF make up the final signal path.
The measurement points for diagnosing faults in the signal path are summarized in Figure 14.16.

Figure 14.16 Measurement points for diagnosing faults in the RF signal path



Task 26 — Output of Frequency Synthesizer

The first point to check in the initial RF signal path is the output SYN TX LO from the frequency synthesizer. This signal is input to the exciter at C300.

1. For test purposes select a representative power level and frequency from **Table 14.8** (B1) or **Table 14.9** (H5). (Note that the data for these tables were obtained using an RFP5401A RF probe.)

2. To set the power level, enter the CCTM command *326* ***x***, where ***x*** defines the level. To set the frequency, enter the CCTM command *101* ***x x*** *0*, where ***x*** is the frequency in Hertz.

3. Enter the CCTM command *33* to place the radio in transmit mode.

4. Use an RFP5401A RF probe or the equivalent to measure the RF voltage after **C3500** (see **Figure 14.17**). Earth the probe to the FCL TOP can adjacent to the PA driver circuitry. The required voltage should be as given in **Table 14.8** (B1) or **Table 14.9** (H5).

5. Enter the CCTM command *32* to place the radio in receive mode.

6. If the voltage measured above is correct, go to Task 27. If it is not, go to Step 7.

7. Check **C3500** (see **Figure 14.17)**. If C3500 is not faulty, go to “Frequency Synthesizer Fault Finding” on page 169. If C3500 is faulty, replace it and return to Step 2.

Figure 14.17 PA driver circuitry under the PAD TOP can (UHF shown)

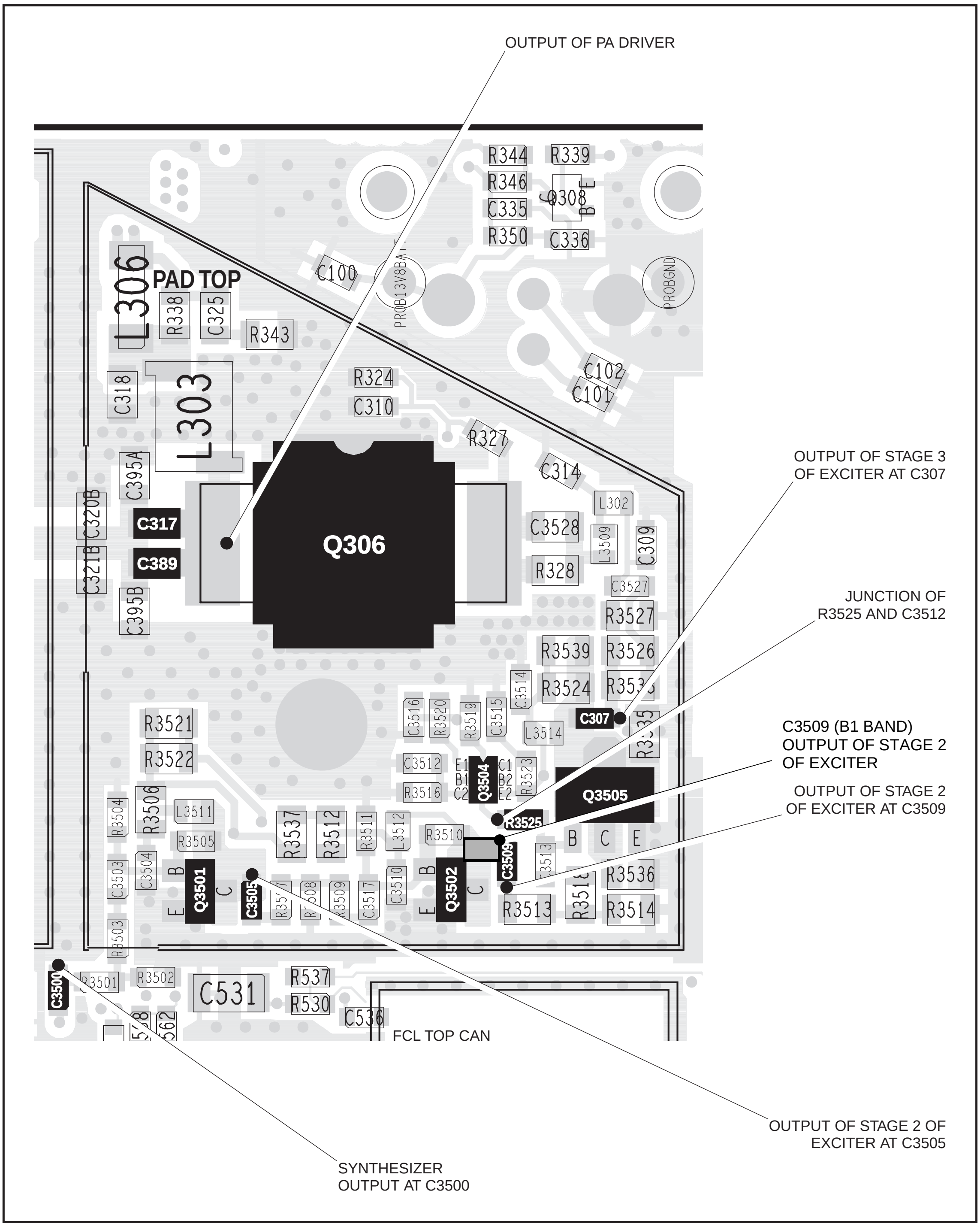


Table 14.8 RF voltages along the initial RF signal path of the VHF radio (B1 band)

Power level (W)	Frequency (MHz)	RF voltages (V)				
		Synthesizer output	Exciter stage 1	Exciter stage 2	Exciter stage 3	Driver output
10	136 155 174	0.3 ± 0.1 0.3 ± 0.1 0.2 ± 0.1	0.6 ± 0.2 0.6 ± 0.2 0.7 ± 0.2	2.7 ± 0.5 2.2 ± 0.5 1.7 ± 0.5	4.0 ± 0.5 3.7 ± 0.5 4.0 ± 0.5	9.9 ± 0.5 8.4 ± 0.5 8.4 ± 0.5
15	136 155 174	0.3 ± 0.1 0.2 ± 0.1 0.2 ± 0.1	0.6 ± 0.2 0.6 ± 0.2 0.7 ± 0.2	2.7 ± 0.5 2.2 ± 0.5 1.7 ± 0.5	4.0 ± 0.5 3.7 ± 0.5 4.0 ± 0.5	11.8 ± 0.5 10.0 ± 0.5 10.0 ± 0.5
25	136 155 174	0.3 ± 0.1 0.2 ± 0.1 0.2 ± 0.1	0.6 ± 0.2 0.6 ± 0.2 0.7 ± 0.2	2.7 ± 0.5 2.2 ± 0.5 1.7 ± 0.5	4.0 ± 0.5 3.7 ± 0.5 4.0 ± 0.5	14.3 ± 0.5 13.5 ± 0.5 14.7 ± 0.5
50	136 155 174	0.3 ± 0.1 0.2 ± 0.1 0.2 ± 0.1	0.6 ± 0.2 0.6 ± 0.2 0.7 ± 0.2	2.7 ± 0.5 2.2 ± 0.5 1.7 ± 0.5	4.0 ± 0.5 3.7 ± 0.5 4.0 ± 0.5	15.6 ± 0.5 15.0 ± 0.5 15.6 ± 0.5
70	136 155 174	0.3 ± 0.1 0.2 ± 0.1 0.3 ± 0.1	0.6 ± 0.2 0.6 ± 0.2 0.7 ± 0.2	2.7 ± 0.5 2.2 ± 0.5 1.7 ± 0.5	4.0 ± 0.5 3.7 ± 0.5 4.0 ± 0.5	24.5 ± 0.5 29.0 ± 0.5 22.0 ± 0.5

Table 14.9 RF voltages along the initial RF signal path of the UHF radio (H5 band)

Power level (W)	Frequency (MHz)	RF voltages (V)				
		Synthesizer output	Exciter stage 1	Exciter stage 2	Exciter stage 3	Driver output
10	400 435 470	0.3 ± 0.1 0.4 ± 0.1 0.3 ± 0.1	1.2 ± 0.2 2.4 ± 0.2 1.1 ± 0.2	4.2 ± 0.5 2.7 ± 0.5 2.1 ± 0.5	9.2 ± 0.5 6.8 ± 0.5 4.8 ± 0.5	3.0 ± 0.5 2.9 ± 0.5 2.0 ± 0.5
15	400 435 470	0.3 ± 0.1 0.3 ± 0.1 0.3 ± 0.1	1.2 ± 0.2 2.4 ± 0.2 1.1 ± 0.2	4.2 ± 0.5 2.7 ± 0.5 2.1 ± 0.5	9.2 ± 0.5 6.8 ± 0.5 4.8 ± 0.5	4.1 ± 0.5 3.8 ± 0.5 2.5 ± 0.5
20	400 435 470	0.4 ± 0.1 0.3 ± 0.1 0.3 ± 0.1	1.2 ± 0.2 2.4 ± 0.2 1.1 ± 0.2	4.2 ± 0.5 2.7 ± 0.5 2.1 ± 0.5	9.2 ± 0.5 6.8 ± 0.5 4.8 ± 0.5	4.8 ± 0.5 4.2 ± 0.5 3.0 ± 0.5
40	400 435 470	0.3 ± 0.1 0.3 ± 0.1 0.3 ± 0.1	1.2 ± 0.2 2.4 ± 0.2 1.1 ± 0.2	4.2 ± 0.5 2.7 ± 0.5 2.1 ± 0.5	9.2 ± 0.5 6.8 ± 0.5 4.8 ± 0.5	4.6 ± 0.5 4.0 ± 0.5 2.9 ± 0.5
60	400 435 470	0.3 ± 0.1 0.3 ± 0.1 0.3 ± 0.1	1.2 ± 0.2 2.4 ± 0.2 1.1 ± 0.2	4.2 ± 0.5 2.7 ± 0.5 2.1 ± 0.5	9.2 ± 0.5 6.8 ± 0.5 4.8 ± 0.5	8.1 ± 0.5 7.3 ± 0.5 5.3 ± 0.5

Task 27 — Output of First Stage of Exciter

If the synthesizer output is correct, check the output at C3505 of the first stage of the exciter circuit.

1. If not already done, remove the PAD TOP can.
2. Enter the CCTM command *326* ***x***, where ***x*** defines the power level selected in Task 26.
3. Enter the CCTM command *101* ***x*** ***x*** *0*, where ***x*** is the frequency selected in Task 26.
4. Enter the CCTM command *33* to place the radio in transmit mode.
5. Measure the RF voltage after **C3505** (see **Figure 14.17**). (Use an RFP5401A RF probe or the equivalent.) The required voltage should be as given in **Table 14.8** (B1) or **Table 14.9** (H5).
6. Enter the CCTM command *32* to place the radio in receive mode.
7. If the voltage measured above is correct, go to Task 29. If it is not, go to Step 8.
8. Check the components around **Q3501** (see **Figure 14.17**).
9. Repair any fault revealed by the above checks. Replace **Q3501** (see **Figure 14.17**) if none of the other components is faulty.
10. Confirm the removal of the fault and go to "Final Tasks" on page 141. If the repair failed, replace the board and go to "Final Tasks" on page 141.

Task 28 — Output of Second Stage of Exciter

If the output of the first stage of the exciter circuit is correct, check that of the second stage at C3509:

1. With the radio still in transmit mode, measure the RF voltage after **C3509** (see **Figure 14.17**). (Use an RFP5401A RF probe or the equivalent.) The required voltage should be as given in **Table 14.8** (B1) or **Table 14.9** (H5).
2. If the voltage is correct, go to Task 30. If it is not, go to Step 3.
3. Enter the CCTM command *32* to place the radio in receive mode.
4. Check the components around **Q3502** (see **Figure 14.17**).
5. Repair any fault revealed by the above checks. Replace **Q3502** (see **Figure 14.17**) if none of the other components is faulty.
6. Confirm the removal of the fault and go to "Final Tasks" on page 141. If the repair failed, replace the board and go to "Final Tasks" on page 141.

Task 29 — Output of Third Stage of Exciter

If the output of the second stage of the exciter circuit is correct, check that of the third and final stage at C307.

1. With the radio still in transmit mode, measure the RF voltage after **C307** (see **Figure 14.17**). (Use an RFP5401A RF probe or the equivalent.) The required voltage should be as given in **Table 14.8** (B1) or **Table 14.9** (H5).

2. If the voltage is correct, go to Task 30. If it is not, go toStep 3.

3. With the radio still in transmit mode, measure the RF voltage at the junction of **R3525** and **C3512** (see **Figure 14.17**). The voltage should be:

junction of R3525 and C3512:	1.3 ± 0.2V (VHF)
	1.8 ± 0.2V (UHF)

4. Enter the CCTM command *32* to place the radio in receive mode.

5. If the voltage measured in Step 3 is correct, go to Step 7. If it is not, go to Step 6.

6. Check the components around **Q3504** (see **Figure 14.17**). Repair any fault. Replace Q3504 if none of the other components is faulty. Conclude with Step 8.

7. Check the components around **Q3505** (see **Figure 14.17**). Repair any fault. Replace Q3505 if none of the other components is faulty.

8. Confirm the removal of the fault and go to “Final Tasks” on page 141. If the repair failed, replace the board and go to “Final Tasks” on page 141.

Task 30 — Output of PA Driver

If the exciter output is correct, check the output of the PA driver at the drain of Q306. If necessary, also check the signal at the gates of the PAs Q309 and Q310. This is the last point in the initial RF signal path.

1. With the radio still in transmit mode, measure the RF voltage at the drain of **Q306** (B1) or after **C317** and **C389** (other bands). See **Figure 14.17** and use an RFP5401A RF probe or the equivalent.) The required voltage should be as given in **Table 14.8** (B1) or **Table 14.9** (H5).
2. Enter the CCTM command *32* to place the radio in receive mode.
3. If the voltage measured above is correct, go to Step 7. If it is not, go to Step 4.
4. Check the components between **C307** and **Q306** (see **Figure 14.17**).
5. If the above checks reveal a fault, go to Step 6. If they do not, go to Task 12 in "Biasing of PA Driver and PAs" on page 292.
6. Repair the fault. Confirm the removal of the fault and go to "Final Tasks" on page 141. If the repair failed, replace the board and go to "Final Tasks" on page 141.
7. If not already done, remove the PAF TOP can.
8. Enter the CCTM command *326 5* to set the power level to the maximum, and then the command *33* to place the radio in transmit mode.
9. Measure the RF voltage at the gates of the PAs **Q309** and **Q310** (see **Figure 14.18** and **Figure 14.19**).
10. Enter the CCTM command *32* to place the radio in receive mode.
11. If an RF voltage is present, there is no fault in the initial RF signal path; go to Task 31. If there is no RF voltage, go to Step 12.
12. Check the components of the interstage matching circuitry between the PA driver **Q306** and the gates of the PAs **Q309** and **Q310** (see **Figure 14.18** and **Figure 14.19**).
13. If a fault is found, repair it, confirm the removal of the fault, and go to "Final Tasks" on page 141. If the repair failed or the fault could not be found, replace the board and go to "Final Tasks" on page 141.

Figure 14.18 Components of the interstage matching circuitry between the PA driver Q306 and the PAs Q309 and Q310 (VHF)

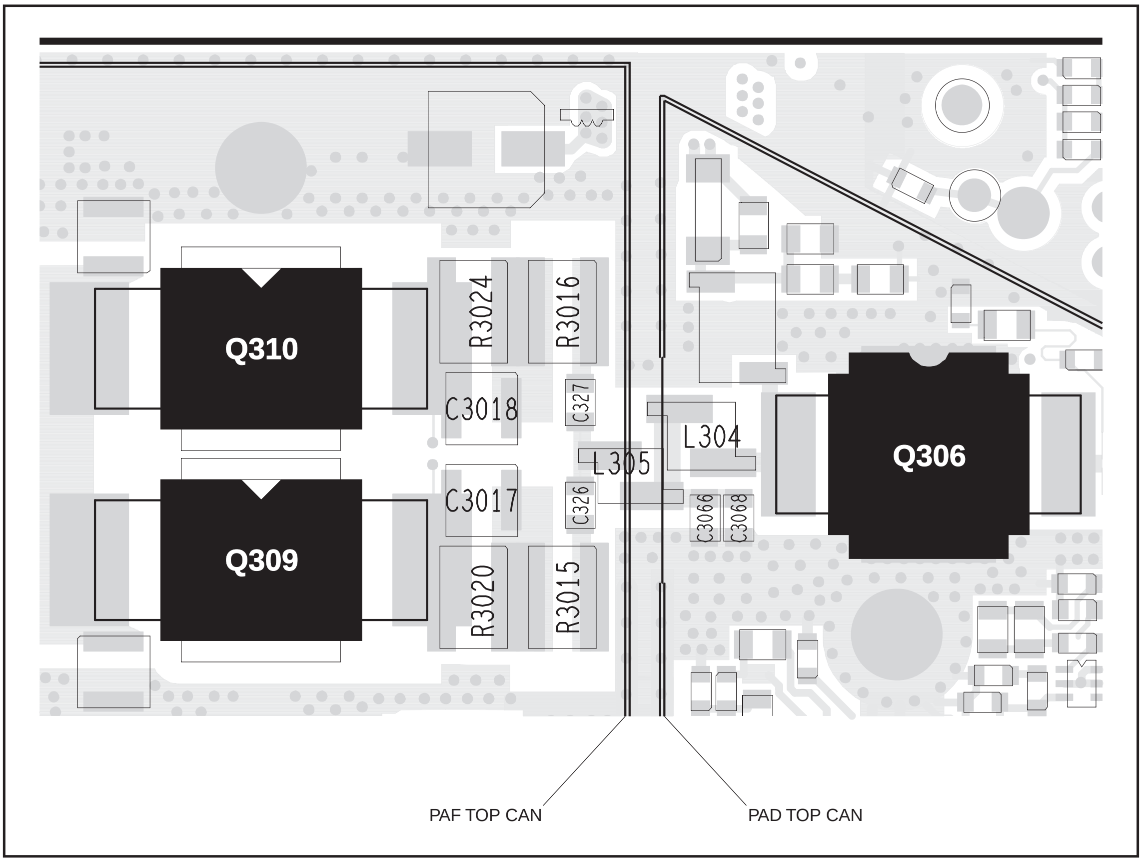
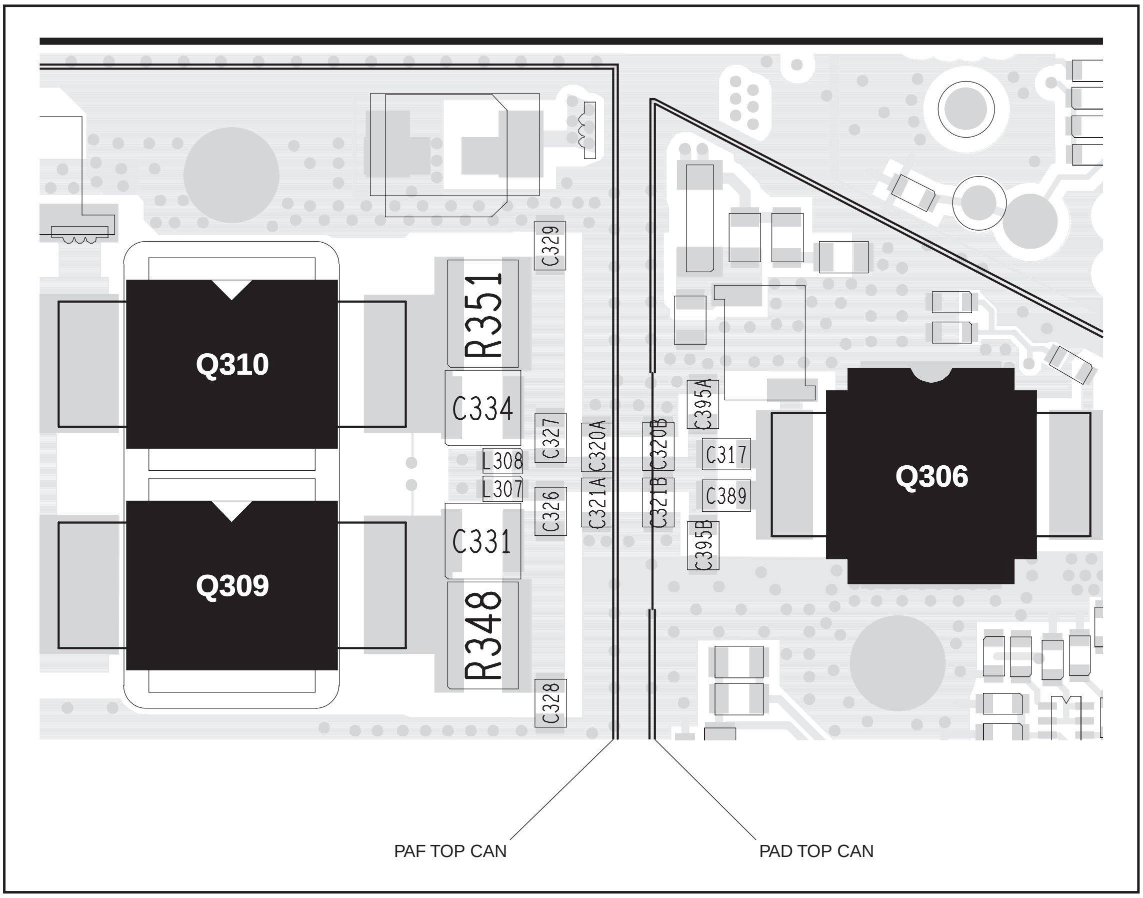


Figure 14.19 Components of the interstage matching circuitry between the PA driver Q306 and the PAs Q309 and Q310 (UHF)



Task 31 — Check Power at Directional Coupler

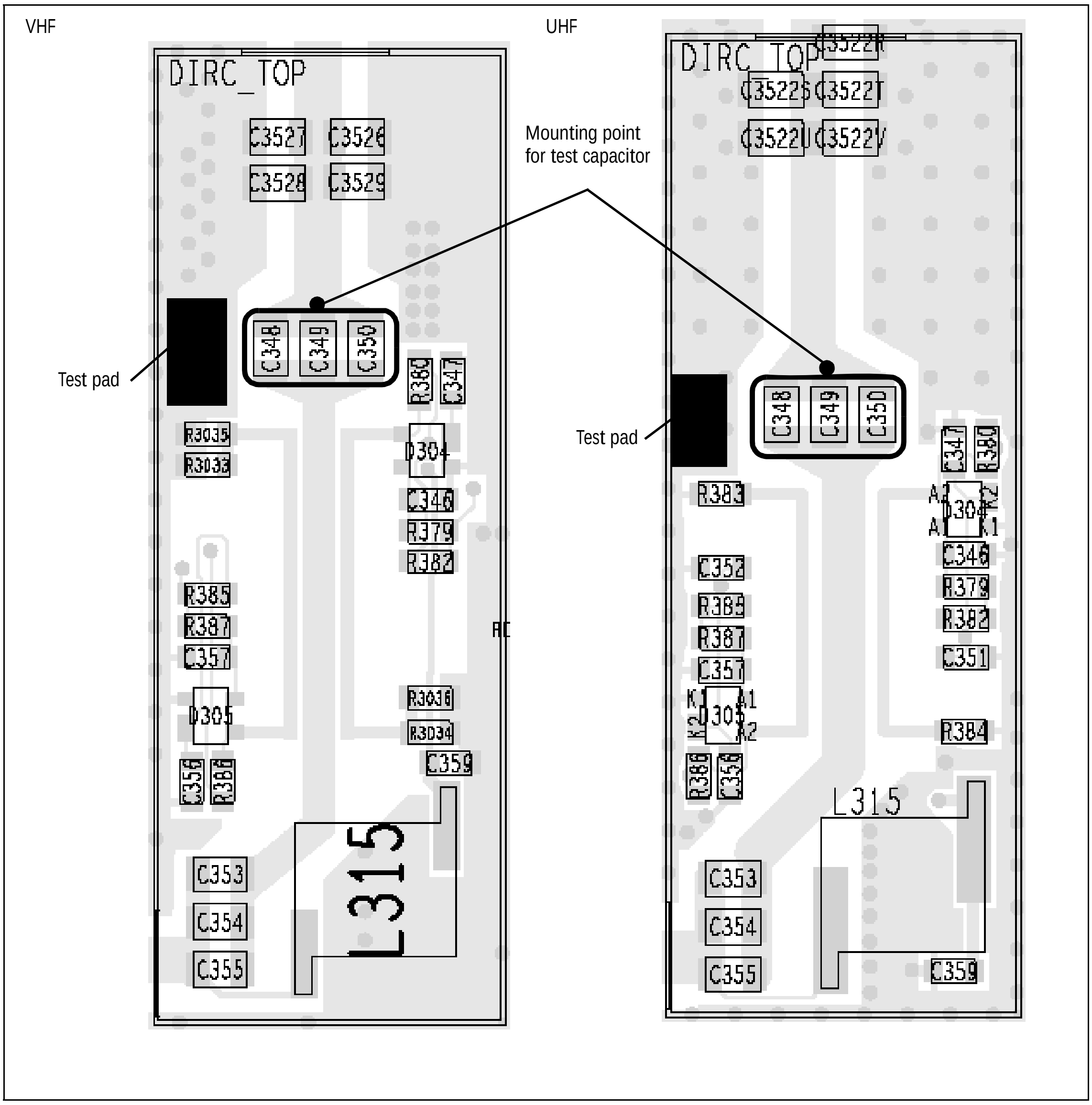
If, as determined in Task 26 to Task 30, there is no fault in the initial RF signal path, investigate the final signal path. This part of the circuitry may also require investigation following certain checks in "Transmitter RF Power". Begin by checking the directional coupler as follows:

1. If not already done, remove the DIRC TOP can.
2. Remove the coupling capacitors **C348**, **C349**, **C350** (see **Figure 14.20**).
3. Solder one terminal of a 80pF (VHF) or 82pF (UHF) test capacitor to the PCB at the point shown in **Figure 14.20**. Mount the capacitor vertically. Use a test capacitor of the type GRM111, DLI C17, ATC100B, or the equivalent.
4. Solder a 50Ω test lead to the PCB: Solder the outer sheath to the test pad shown in **Figure 14.20**, and solder the central wire to the other terminal of the test capacitor.
5. Connect the test lead to the test set.
6. Enter the CCTM command *326 5* to set the transmitter power level to the maximum.
7. Enter the CCTM command *101* ***x x*** *0*, where ***x*** is the lowest frequency (in Hertz) for maximum power, as given in **Table 14.8** (B1) or **Table 14.9** (H5).
8. Enter the CCTM command *33* to place the radio in transmit mode.
9. Measure the RF output power. This should be:

RF output power:	more than 70W (VHF) more than 60W (UHF)

10. Enter the CCTM command *32* to place the radio in receive mode.
11. Enter the CCTM command *101* ***x x*** *0*, where ***x*** is the highest frequency (in Hertz) for maximum power, as given in **Table 14.8** (B1) or **Table 14.9** (H5).
12. Repeat Step 8 to Step 10.
13. If the power measured in both the above cases exceeds 70W (VHF) or 60W (UHF), go to Step 14. If it does not, go to Task 32.
14. Remove the test lead and test capacitor, resolder the coupling capacitors in position, and go to Task 33.

Figure 14.20 Circuitry under the DIRC TOP can, and the points for attaching the test lead and test capacitor



Task 32 — Repair Circuitry

If the RF output power measured in Task 31 is low, there is a fault in the circuit between the common drain of the PAs and the test capacitor.

1. If not already done, remove the PAF TOP can.

2. Check for faulty, shorted or misplaced components in the circuit between the test capacitor and the common drain of **Q309** and **Q310** (see **Figure 14.6**).

3. Repair any fault revealed by the above checks and go to Step 5. If no fault could be found, go to Step 4.

4. Remove the test lead and test capacitor, resolder the coupling capacitors **C348**, **C349** and **C350** in position (see **Figure 14.20**), and go to Task 26.

5. With the test lead still connected to the test set, enter the CCTM command *326 5* to set the transmitter power level to the maximum.

6. Enter the CCTM command *101* ***x x*** *0*, where ***x*** is the lowest frequency (in Hertz) for maximum power, as given in **Table 14.8** (B1) or **Table 14.9** (H5).

7. Enter the CCTM command *33* to place the radio in transmit mode.

8. Measure the RF output power. This should be:

RF output power:	more than 70W (VHF) more than 60W (UHF)

9. Enter the CCTM command *32* to place the radio in receive mode.

10. Enter the CCTM command *101* ***x x*** *0*, where ***x*** is the highest frequency (in Hertz) for maximum power, as given in **Table 14.8** (B1) or **Table 14.9** (H5).

11. Repeat Step 7 to Step 9.

12. Remove the test lead and test capacitor, and resolder the coupling capacitors **C348**, **C349** and **C350** in position (see **Figure 14.20**).

13. If the power in both the above cases is now correct, the fault has been rectified; go to “Final Tasks” on page 141. If it is not, the repair failed; replace the board and go to “Final Tasks” on page 141.

Task 33 — Check PIN Switch

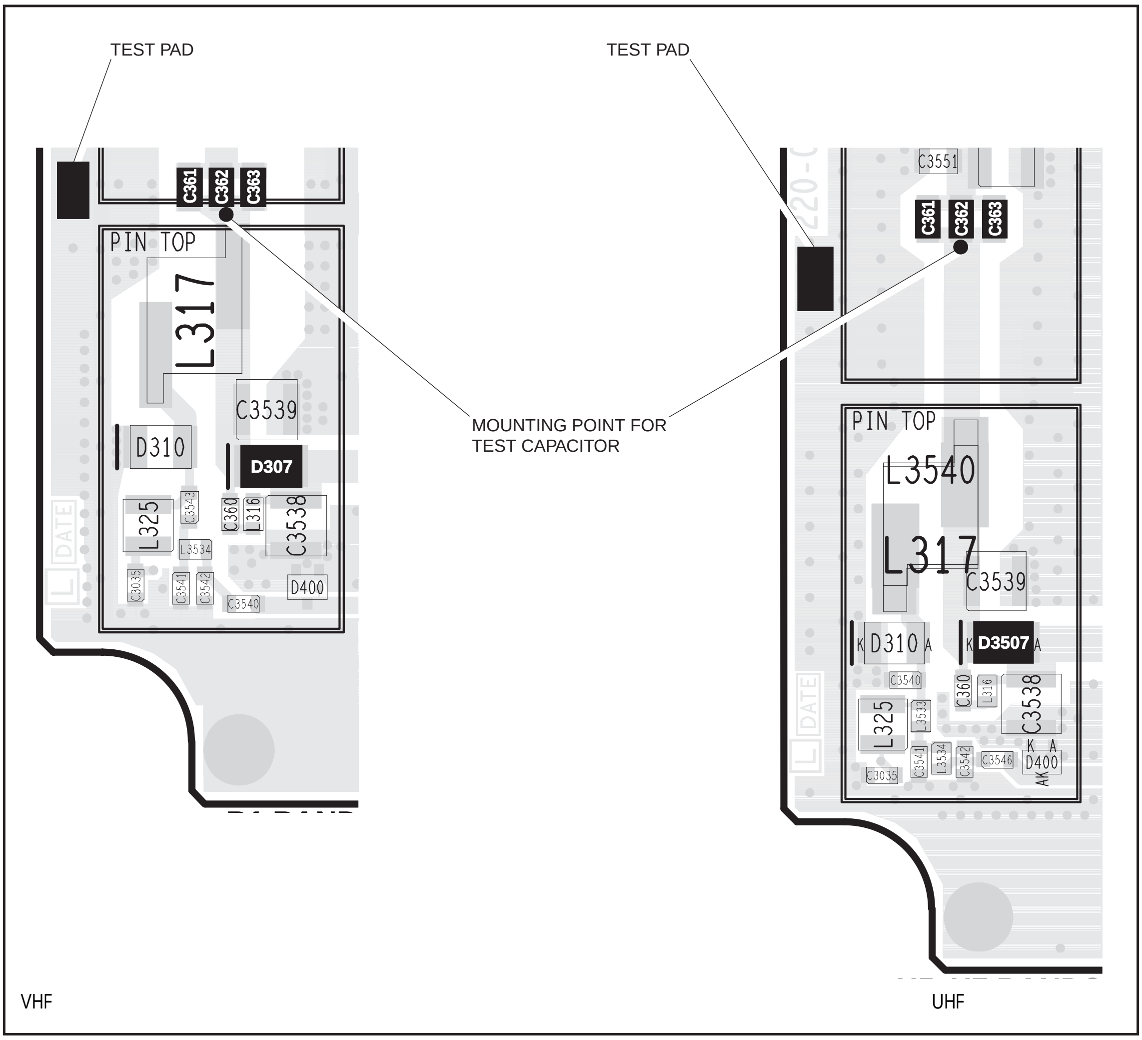
In checking the final RF signal path, if no fault is found in the directional coupler, then check the PIN switch next. The PIN switch may also require investigation following certain checks in "Transmitter RF Power".

1. Remove the LPF TOP can.
2. Remove the three blocking capacitors **C361**, **C362** and **C363** (see **Figure 14.21**).
3. Solder one terminal of a 56 pF (VHF) or 18 pF (UHF) test capacitor to the PCB at the point shown in **Figure 14.21**. Mount the capacitor vertically. Use a test capacitor of the type GRM111, DLI C17, ATC100B, or the equivalent.
4. Solder a 50 Ω test lead to the PCB. Solder the outer sheath to the test pad shown in **Figure 14.21**, and solder the central wire to the other terminal of the test capacitor.
5. Connect the test lead to the test set.
6. Enter the CCTM command *326 5* to set the transmitter power level to the maximum.
7. Enter the CCTM command *101* ***x x*** *0*, where ***x*** is the lowest frequency (in Hertz) for maximum power, as given in **Table 14.8** (B1) or **Table 14.9** (H5).
8. Enter the CCTM command *33* to place the radio in transmit mode.
9. Measure the RF output power. This should be:

RF output power:	more than 70W (VHF)
	more than 60W (UHF)

10. Enter the CCTM command *32* to place the radio in receive mode.
11. Enter the CCTM command *101* ***x x*** *0*, where ***x*** is the highest frequency (in Hertz) for maximum power, as given in **Table 14.8** (B1) or **Table 14.9** (H5).
12. Repeat Step 8 to Step 10.
13. If the power in both the above cases exceeds 70W (VHF) or 60W (UHF), go to Step 14. If it does not, the circuitry of the PIN switch is suspect; go to Task 34.
14. Remove the test lead and test capacitor, resolder the blocking capacitors in position, and go to Task 35.

Figure 14.21 Circuitry under the PIN TOP can, and points for attaching the test lead and test capacitor



Task 34 — Repair PIN switch

If the RF power at the PIN switch is low, the switch is not drawing the expected current or the diode is faulty. Check the circuit as follows:

1. Remove the PIN TOP can.

2. Perform a diode check of **D307** (VHF) or **D3507** (UHF) (see **Figure 14.21**). If it is not faulty, go to Step 3. If it is, replace D307 or D3507, and go to Step 4.

3. Check the +9V0_TX supply to the PIN switch via the following resistors on the bottom-side of the PCB (see **Figure 14.22** and **Figure 14.23**):
   - VHF: **R389** and **R390**
   - UHF: **R3000**, **R389** and **R390**

   If any resistor is faulty, replace the resistor as well as **D307** (VHF) or **D3507** (UHF). (A faulty resistor is likely to have resulted in damage to D307 or D3507.)

4. With the test lead still connected to the test set, enter the CCTM command *326 5* to set the transmitter power level to the maximum.

5. Enter the CCTM command *101* ***x x*** *0*, where ***x*** is the lowest frequency (in Hertz) for maximum power, as given in **Table 14.8** (B1) or **Table 14.9** (H5).

6. Enter the CCTM command *33* to place the radio in transmit mode. Again measure the RF output power. This should be:

RF output power:	more than 70W VHF)
	more than 60W (UHF)

7. Enter the CCTM command *32* to place the radio in receive mode.

8. Enter the CCTM command *101* ***x x*** *0*, where ***x*** is the highest frequency (in Hertz) for maximum power, as given in **Table 14.8** (B1) or **Table 14.9** (H5).

9. Repeat Step 5 to Step 7.

10. Remove the test lead and test capacitor, and resolder the blocking capacitors **C361**, **C362** and **C363** (see **Figure 14.21**) in position.

11. If the power in both the above cases is now correct, the fault has been rectified; go to “Final Tasks” on page 141. If it is not, the repair failed; replace the board and go to “Final Tasks” on page 141.

Figure 14.22 Components of concern on the bottom-side of the main board (VHF)

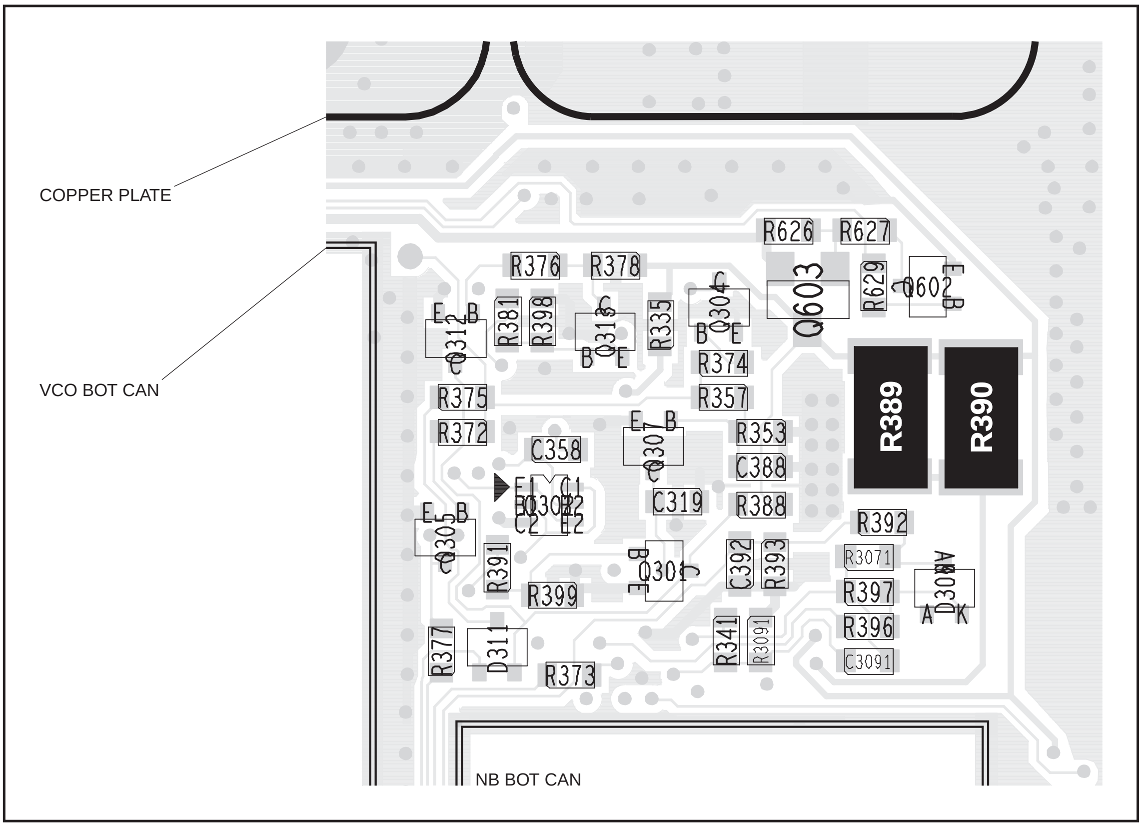


Figure 14.23 Components of concern on the bottom-side of the main board (UHF)

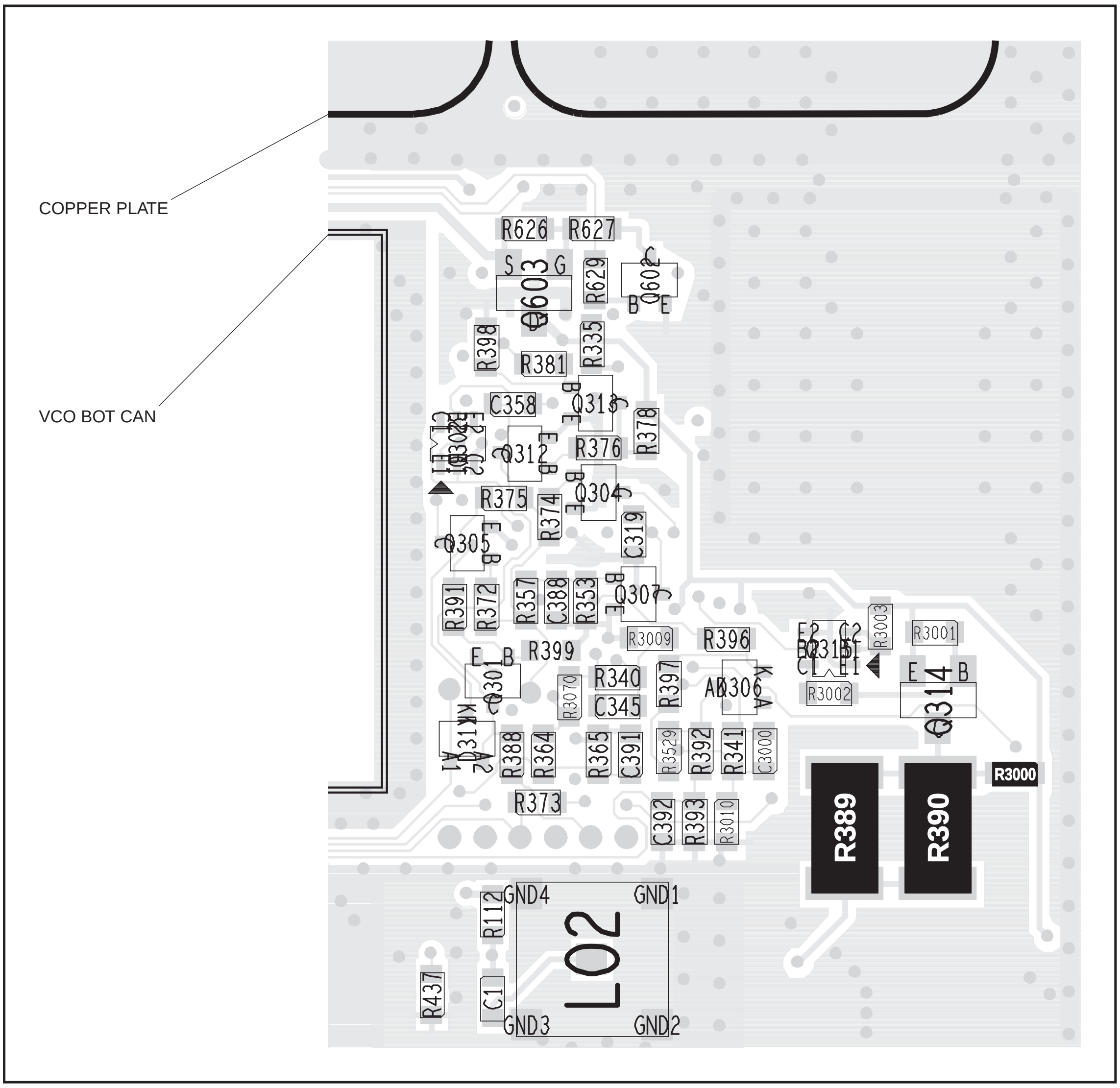
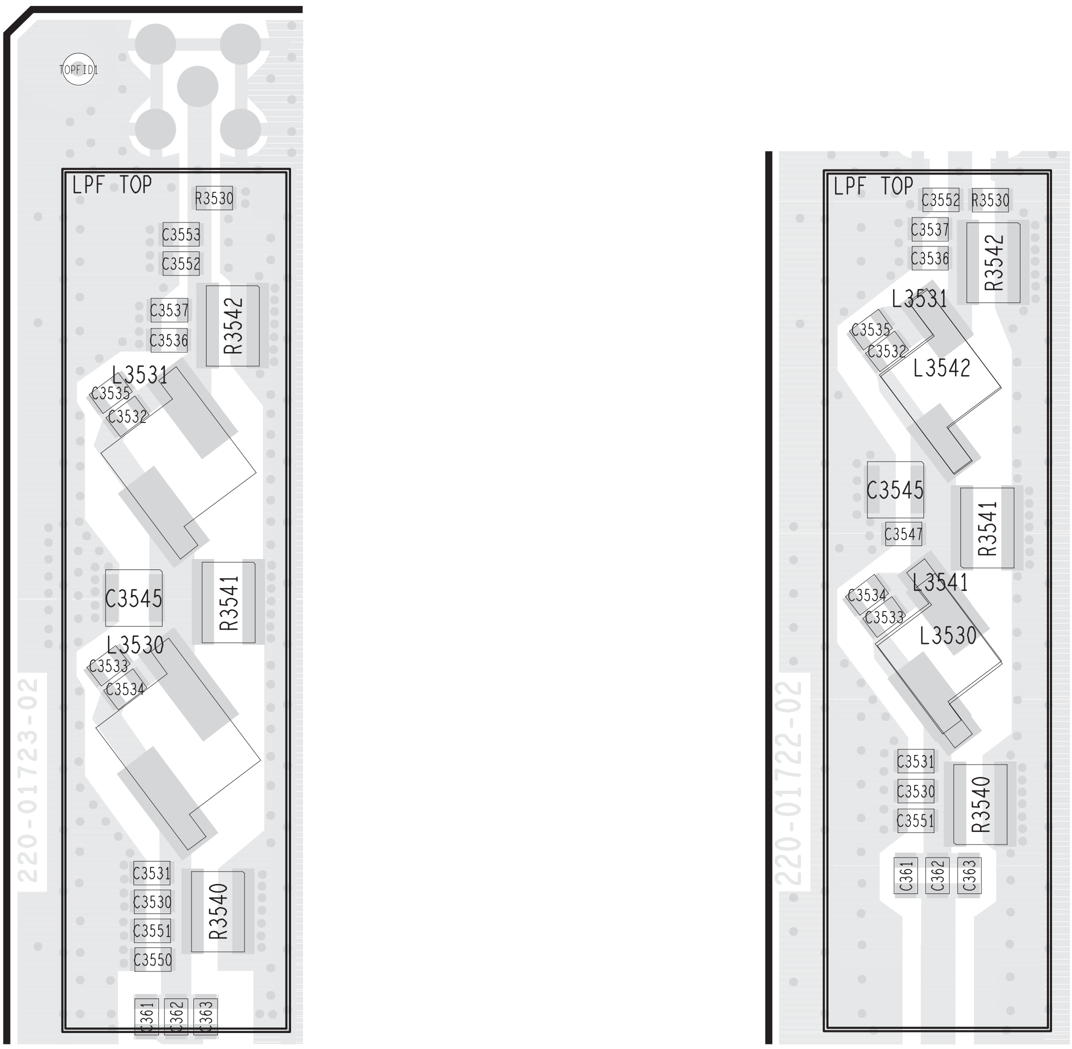


Figure 14.24 Circuitry under the LPF TOP can



VHF UHF

Task 35 — Check Components of LPF

If there are no faults in the final RF signal path up to and including the PIN switch, then the fault should lie in the LPF. Check the LPF as follows:

1. If not already done, remove the LPF TOP can.
2. Connect the RF connector to the test set.
3. Check the capacitors and inductors of the LPF between the PIN switch and the RF connector. See **Figure 14.24**. Check for shorts, open circuits, and faulty components. Repair any fault.
4. In the case of the B1 band, replace the LPF TOP can before continuing.
5. Enter the CCTM command *326 5* to set the transmitter power level to the maximum.
6. Enter the CCTM command *101* ***x x*** *0*, where ***x*** is the <u>lowest</u> frequency (in Hertz) for maximum power, as given in **Table 14.8** (B1) or **Table 14.9** (H5).
7. Enter the CCTM command *33* to place the radio in transmit mode.
8. Measure the RF output power. This should be:

RF output power:	more than 70W (VHF) more than 60W (UHF)

9. Enter the CCTM command *32* to place the radio in receive mode.
10. Enter the CCTM command *101* ***x x*** *0*, where ***x*** is the <u>highest</u> frequency (in Hertz) for maximum power, as given in **Table 14.8** (B1) or **Table 14.9** (H5).
11. Repeat Step 7 to Step 9.
12. If the power in both the above cases exceeds 70W (VHF) or 60W (UHF), the fault has been rectified; go to “Final Tasks” on page 141. If it does not, the repair failed; replace the board and go to “Final Tasks” on page 141.

15 CODEC and Audio Fault Finding

Fault Conditions

This section covers the diagnosis of faults in the CODEC and audio circuitry. There are five conditions that indicate a possible fault in the circuitry:

- no transmit modulation or modulation is distorted
- no transmit modulation despite modulation at auxiliary connector

In the first case regarding the transmit modulation, the radio will be transmitting the correct amount of RF power. In the second case the transmitter will be operating normally.

Fault-Diagnosis Procedures

The procedures for diagnosing the above faults are given below in the following sections. In each case, however, first carry out the tasks of "Power Supplies" on page 335. Also note that the conditions concerning the auxiliary connector can both occur at the same time. In this case carry out "Faulty Modulation Using Auxiliary Connector" on page 342.

CCTM Commands

The CCTM commands required in this section are listed in Table 15.1. Full details of the commands are given in "Computer-Controlled Test Mode (CCTM)" on page 114.

Table 15.1 CCTM commands required for the diagnosis of faults in the CODEC and audio circuitry

Command	Description
33	Set radio in transmit mode
110 **x**	Set level **x** (in range 0 to 255) of audio volume
323 **x y**	Generate audio tone AUD TAP IN at tap point **x** of tap type **y**
400 **x**	Select channel with channel number **x**

15.1 Power Supplies

Introduction

First check that a power supply is not the cause of the fault. Of these supplies, the 3.3V DC supply (+3V3) will already have been checked in "Power Supply Fault Finding" on page 155. The remaining supplies that need to be checked are:

- Task 1: 9V DC supply from 9V regulator (+9V0)
- Task 2: 3V DC supply from 3V regulator (+3V0 AN)
- Task 3: 2.5V DC supply from 2.5V regulator (+2V5 CDC)

Two other supplies used in the CODEC and audio circuitry are a 1.8V DC supply (+1V8) from the digital board and the 13.8V DC supply (+13V8 BATT) from the power connector. Faults in these supplies are dealt with elsewhere.

Task 1 — 9V Power Supply

First check the 9V DC supply (+9V0), which is required by IC201.

1. Remove the board from the chassis.

2. Remove the CDC BOT can.

3. Measure the voltage +9V0 at pin 4 of **IC201** (see **Figure 15.1**).

pin 4 of IC201: 9.0 ± 0.3V DC

4. If the voltage is correct, go to Task 2. If it is not, go to Step 5.

5. The fault will be at **IC201** (see **Figure 15.1**), since any fault with the 9V regulator in the PSU module will already have been rectified. Therefore, check the soldering of IC201. Repair any fault.

6. Confirm the removal of the fault and go to “Final Tasks” on page 141. If the repair failed or the fault could not be found, replace the board and go to “Final Tasks” on page 141.

Task 2 — 3V Power Supply

If the 9V supply is correct, check the 3V DC supply (+3V0 AN) next.

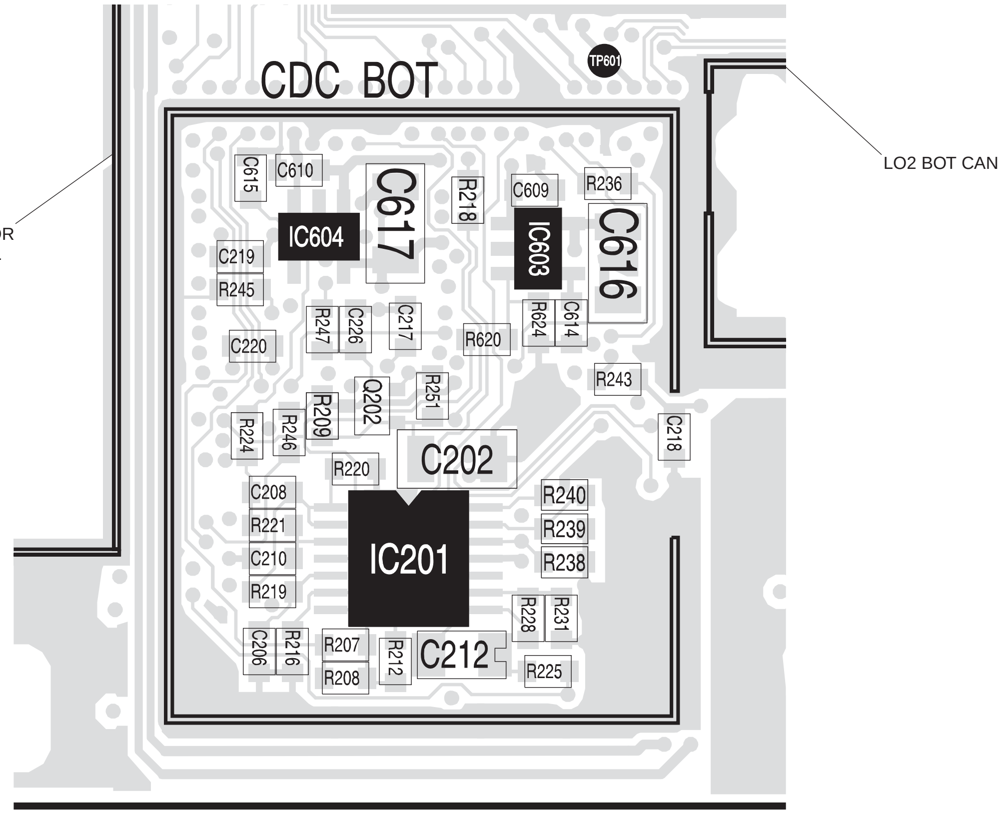
1. Measure the voltage +3V0 AN at the **TP601 test point** (see **Figure 15.1**).

TP601 test point: 2.9 ± 0.3V DC

2. If the voltage is correct, go to Task 3. If it is not, go to Step 3.

3. The 3V regulator **IC603** is suspect (see **Figure 15.1**). Check the regulator as described in Task 3 of “Power Supply Fault Finding” on page 160.

Figure 15.1 Power-supply circuitry for the CODEC and audio circuitry under the CDC BOT can



Task 3 — 2.5V Power Supply

If the 9V and 3V supplies are correct, the remaining power supply to check is the 2.5V DC supply (+2V5 CDC).

1. Measure the voltage +2V5 CDC at pin 5 of **IC604** (see **Figure 15.1**).

pin 5 of IC604: 2.5 ± 0.3V DC

2. If the voltage is correct, go to Step 4. If it is not, go to Step 3.

3. The 2.5V regulator **IC604** is suspect (see **Figure 15.1**). Check the regulator as described in Task 3 of "Power Supply Fault Finding" on page 160.

4. Proceed to the section relevant to the fault exhibited:
   - "Faulty Modulation" (distorted or no transmit modulation)
   - "Faulty Modulation Using Auxiliary Connector" (modulation at auxiliary connector only)

   Further details are given in the introduction to the section.

15.2 Faulty Modulation

Introduction

This section covers the case where the radio transmits the correct amount of RF power, but there is either no modulation or the modulation is distorted. There are three tasks:

- Task 4: initial checks
- Task 5: check 2.3V DC supply
- Task 6: check bias network

The initial checks will determine whether the frequency synthesizer, the 2.3V supply, or the bias network is at fault.

Task 4 — Initial Checks

Carry out the following checks to isolate the part of the circuitry that is faulty.

1. Apply a 1kHz audio signal of 20 mV_{pp} at the microphone input on the control head.

2. Enter the CCTM command *33* to place the radio in transmit mode. (The frequency is that of channel 1.)

3. Check that the 1kHz signal appears at the **TP503 test point**.

TP503 test point: 1kHz signal

4. Enter the CCTM command *32* to place the radio in receive mode.

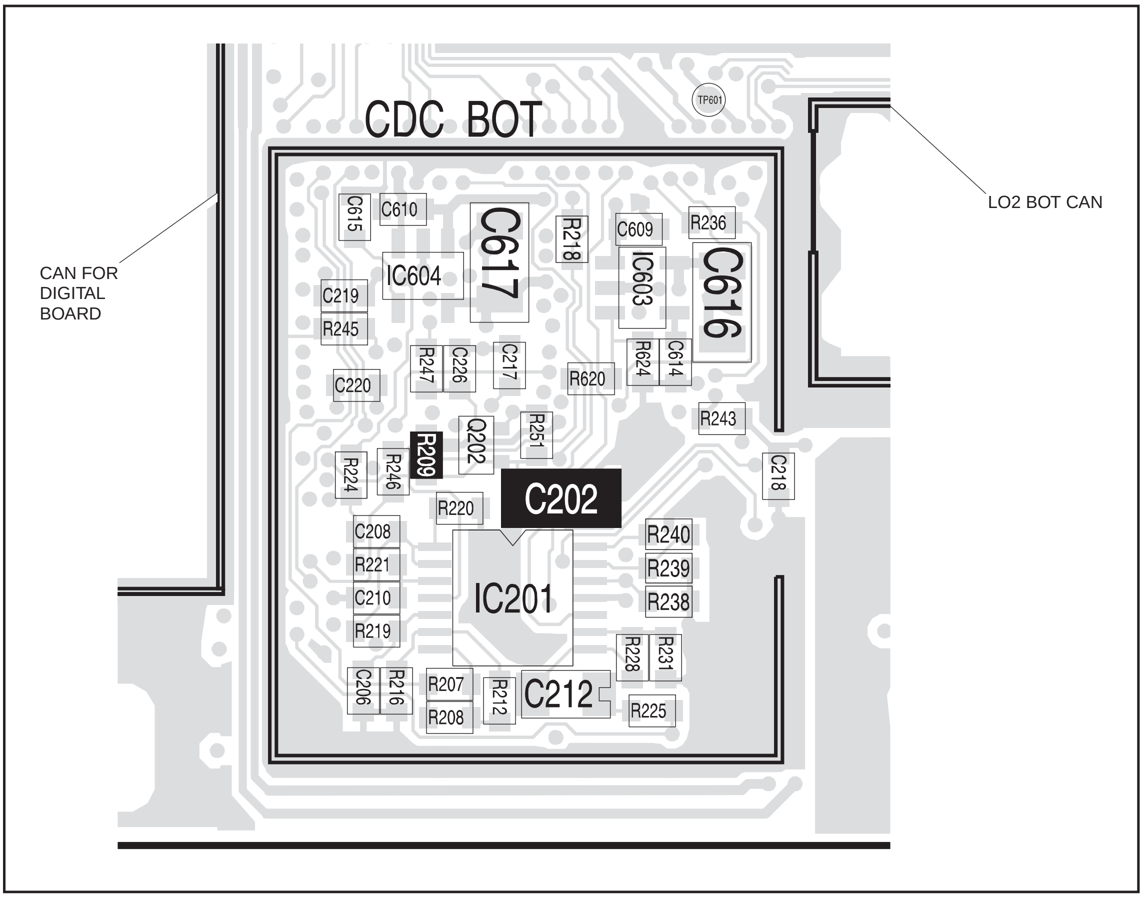
5. If the 1kHz signal is present, go to “Frequency Synthesizer Fault Finding” on page 169. If it is not, go to Step 6.

6. With no microphone connected, check the voltage at the junction of **C708** and **C732** (CH MIC AUD):

junction of C708 and C732: approximately 3V

7. If the above voltage is correct, go to Task 6; the bias network is suspect. If it is not, go to Task 5; the 2.3V supply is suspect.

Figure 15.2 Circuitry in under the CDC BOT can



Task 5 — Check 2.3V Supply

If the CH MIC AUD signal is not as expected, the 2.3V supply needs to be checked.

1. If not already done, remove the CDC BOT can.
2. Check the voltage across **C202** (see **Figure 15.2**):

voltage across C202: 3V

3. If the above voltage is correct, go to Task 6. If it is not, go to Step 4.
4. Check the soldering of **R209**, and check for shorts to ground at **C202** (see **Figure 15.2**). Repair any fault.
5. Confirm the removal of the fault and go to “Final Tasks” on page 141. If the repair failed or the fault could not be found, replace the board and go to “Final Tasks” on page 141.

Task 6 — Check Bias Network

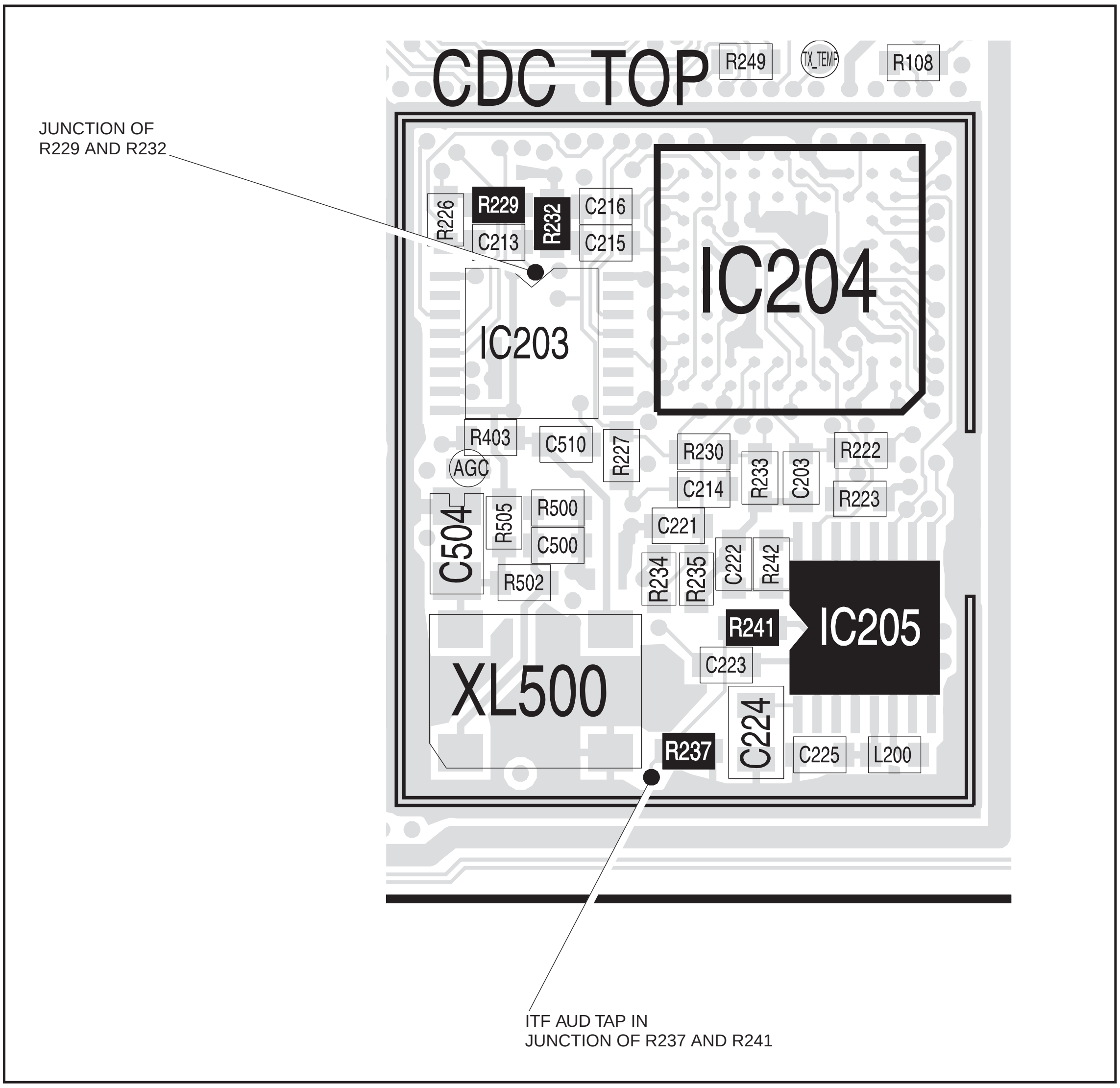
If the signal at the TP503 test point is incorrect, but the other checks in the above tasks reveal no fault, check the bias network.

1. Remove the CDC TOP can.
2. Check the voltage at the junction of **R229** and **R232** (see **Figure 15.3**):

junction of R229 and R232: 1.5V DC

3. If the voltage is correct, go to Step 4. If it is not, go to Step 5.
4. CODEC 1 (**IC204**) is faulty; replace the board and go to “Final Tasks” on page 141.
5. Check the soldering of **R229** and **R232**, and check for shorts across R232 (see **Figure 15.3**). Repair any fault.
6. Confirm the removal of the fault and go to “Final Tasks” on page 141. If the repair failed or the fault could not be found, replace the board and go to “Final Tasks” on page 141.

Figure 15.3 Circuitry under the CDC TOP can



15.3 Faulty Modulation Using Auxiliary Connector

Introduction

This section covers the case where the transmitter operates normally but there is no modulation (although there is modulation at the auxiliary connector). There are two tasks:

- Task 7: apply AUD TAP IN signal
- Task 8: check CODEC 2 device

Task 7 — Apply AUD TAP IN Signal

First check the modulation and, if necessary, the DC offset.

1. Enter the CCTM command *33* to place the radio in transmit mode. (The frequency is that of channel 1.)

2. Check the modulation via the microphone input.

3. Enter the CCTM command *32* to place the radio in receive mode.

4. If the modulation is correct, go to Step 5. If it is not, go to Task 4 of “Faulty Modulation” on page 338.

5. Apply a 1kHz AC-coupled signal of $0.7V_{pp}$ at pin 7 (AUD TAP IN) of the auxiliary connector (alternatively, as ITF AUD TAP IN at the junction of **R237** and **R241** — see **Figure 15.3**).

6. Enter the CCTM command *323 t5*.

7. Check the DC offset voltage at pin 7:

pin 7 of auxiliary connector: approximately 1.5V DC offset

8. If the above DC offset is correct, go to Step 9. If it is not, go to Step 11.

9. Remove the CDC TOP can.

10. Check for and repair any soldering faults around **IC205**, or else replace IC205 (see **Figure 15.3**). Conclude with Step 12.

11. Check for shorts at pin 7 of the auxiliary connector. If there are none, go to Task 8. If there are, repair the fault and conclude with Step 12.

12. Confirm the removal of the fault and go to “Final Tasks” on page 141. If the repair failed, replace the board and go to “Final Tasks” on page 141.

Task 8 — Check CODEC 2 Device

If the DC offset measured in Task 7 is incorrect but there is no fault with the auxiliary connector, check the CODEC 2 device.

1. Remove the CDC TOP can.

2. Check the voltage at both ends of **R241** (see **Figure 15.3**):

R241: 1.5V DC at both ends

3. If the voltages are correct, go to Step 4. If they are not, go to Step 6.

4. Check for and repair any soldering faults around **IC205**, or else replace IC205 (see **Figure 15.3**).

5. Confirm the removal of the fault and go to “Final Tasks” on page 141. If the repair failed, replace the board and go to “Final Tasks” on page 141.

6. Remove **R241**.

7. Check the voltage at pin 3 of **IC205** (see **Figure 15.3**):

pin 3 of IC205: 1.5V DC

8. If the above voltage is correct, go to Step 9. If it is not, replace the board and go to “Final Tasks” on page 141.

9. Check for and repair any soldering faults around **R241** and **IC205** (see **Figure 15.3**).

10. Confirm the removal of the fault and go to “Final Tasks” on page 141. If the repair failed, replace the board and go to “Final Tasks” on page 141.

16 Spare Parts

This section lists all serviceable parts (except PCB components).

16.1 DC Only Chassis

Table 16.1 DC only chassis

Description	Qty.	IPN	Figure
Tray chassis	1	303-11302-04	Figure 7.1
Tray cover	1	303-23169-03	Figure 7.1
Screw M3 x 6 (cover)	15	345-40460-00	Figure 7.1

16.2 All Chassis

Table 16.2 All chassis

Description	Qty.	IPN	Figure
Rack mounting bracket	2	302-05279-00	Figure 7.1
Screw M5 x 8 (rack mounting bracket)	4	346-00005-08	Figure 7.1
Fuse, 15 A, 32 V, mini-blade	1	265-00016-00	Figure 7.1
Volume control knob	1	311-01054-00	Figure 7.2
UI board (includes fan power board)	1	TBB-SP-U100	Figure 7.2
Transmitter module (50 W/40 W version) Transmitter module (25 W version except D1 band) Transmitter module (25 W D1)	1	TBB-SP-15yy02 TBB-SP-13yy02 TBB-SP-12D102	Figure 7.3
SI board (includes temperature sensor board)	1	TBB-SP-S104	Figure 7.6
Transmitter power cable (4-way to M3.5 spade) (50 W/40 W version) Transmitter power cable (4-way to M3.5 spade) (25 W version)	1	219-02975-00 219-02976-00	Figure 7.9
SI cable (16-way IDC to 15-way D-range)	2	219-02972-00	Figure 7.9
UI cable (18-way IDC to Micro-MaTch)	2	219-02977-00	Figure 7.9
Angled adapter for UI connector	2	240-00021-43	Figure 7.9
Coaxial cable (N-type to BNC)	2	219-02978-00	Figure 7.9
Fan power cable (DC TB7100)	1	219-02982-00	Figure 7.9
Label for front panel	1	365-01764-00	Figure 3.4
Label Tait TB7100	1	365-01765-00	Figure 3.4
Speaker	1	252-00011-00	Figure 2.1
Screw M3 x 8 (All module fittings and speaker DC TB7100)	24	345-40470-00	Figure 2.1
Washer M3 (speaker)	2	353-00010-10	Figure 2.1
Hexagonal screwlock fastener (D-range connectors)	4	354-01043-00	Figure 7.1

Table 16.2 All chassis (Continued)

Description	Qty.	IPN	Figure
Nut M3 Nyloc (N-type connectors)	4	352-00010-28	Figure 7.1
Earthing terminal (Only for DC TB7100)	1	356-00010-61	Figure 7.1
Insulating rubber (under regulator on SI board)	1	362-00010-21	Figure 7.6
Insulating washer M3 (for screw through regulator on SI board)	1	353-00010-18	Figure 7.6
Screw M3 x 10 (through regulator on SI board)	1	345-00040-11	Figure 7.6
Fan DC TB7100	2	258-00020-00	Figure 7.8
Fan duct	1	319-01269-00	Figure 7.8
Screw M3 x 25 (fans DC TB7100)	4	345-00040-19	Figure 7.8
Cable tie (DC TB7100)	5	369-00010-14	
Blanking Plates (DC TB1700 only)	2	316-06861-00	
Washer M4x8 for fitting blanking plates (DC TB100 only)	2	353-00010-24	
The characters yy in an IPN or spares kit number stand for the abbreviated frequency band. For more information, refer to "Frequency Bands" on page 13.			

Multitone paging transmitter

Chapter 3 Accessories

Chapter 3 – Accessories

17 TBBA03-01 Wall Mounting Kit

Contents of Kit

Pos.	Qty.	Part Number	Description
①	2	302-05279-00	TB7100 Rack Mounting Bracket
②	4	346-00005-08	Screw M5×8mm, Button Head Socket

Installation

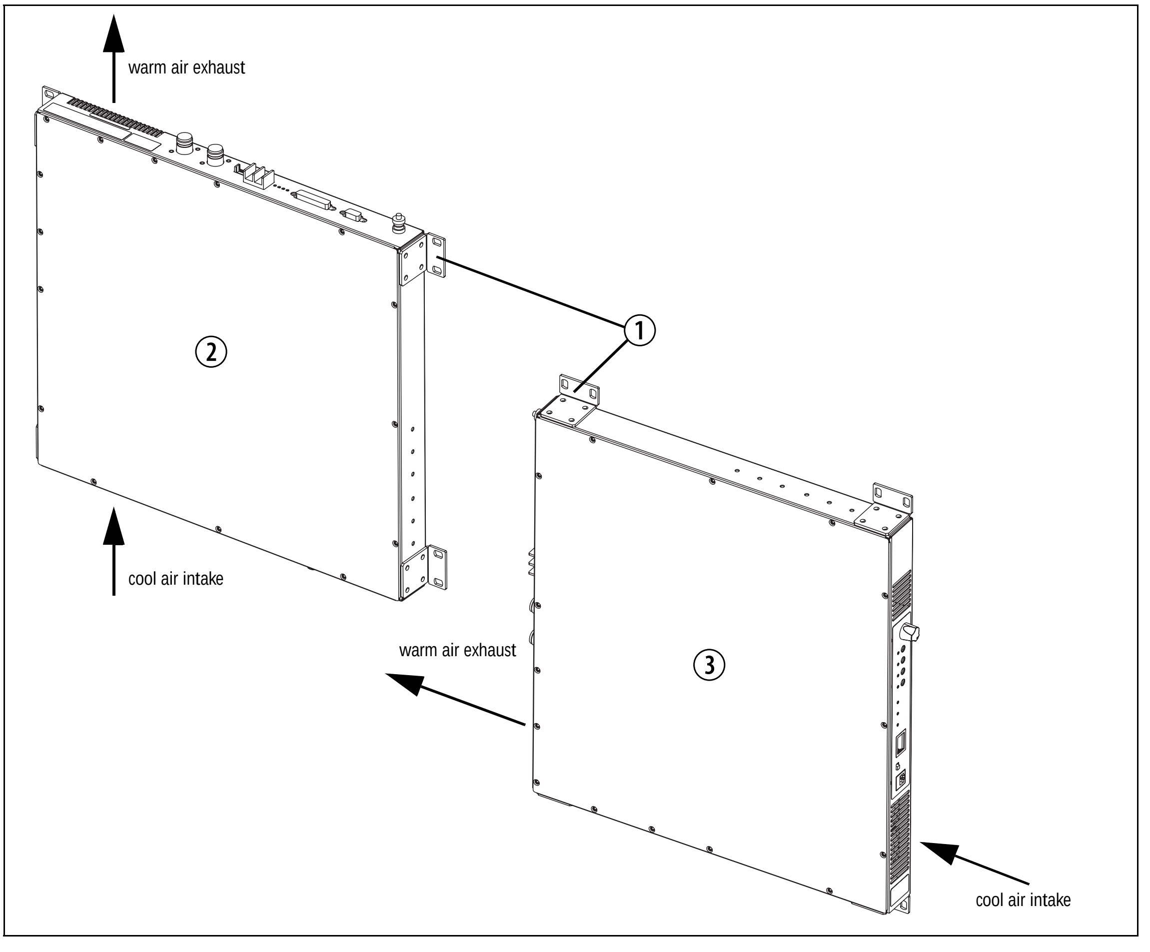
The Multitone paging transmitter can be wall-mounted by rotating the front mounting brackets and fitting the brackets supplied in the kit ① to the rear of the chassis.

When the Multitone paging transmitter is wall mounted, ensure the airflow is from bottom to top ② (front panel facing down), or side to side ③. The Multitone paging transmitter will perform best in these orientations.

We do not recommend mounting the Multitone paging transmitter with the airflow from top to bottom (front panel facing up), as testing has shown that recirculation of air may lead to overheating.

When mounting the Multitone paging transmitter, ensure that the areas in front of the air intake and air exhaust are free of obstruction to allow unrestricted airflow.

Figure 17.1 Recommended wall mounting options for a Multitone paging transmitter



18 TBBA03-04 Rear Support Brackets

Introduction

TBBA03-04 rear support brackets can be fitted to the rear of the Multitone paging transmitter to provide additional support when the Multitone paging transmitter is mounted in a rack.

Note These brackets are only suited for use in a rack which has a rear mounting rail at 380 mm depth.

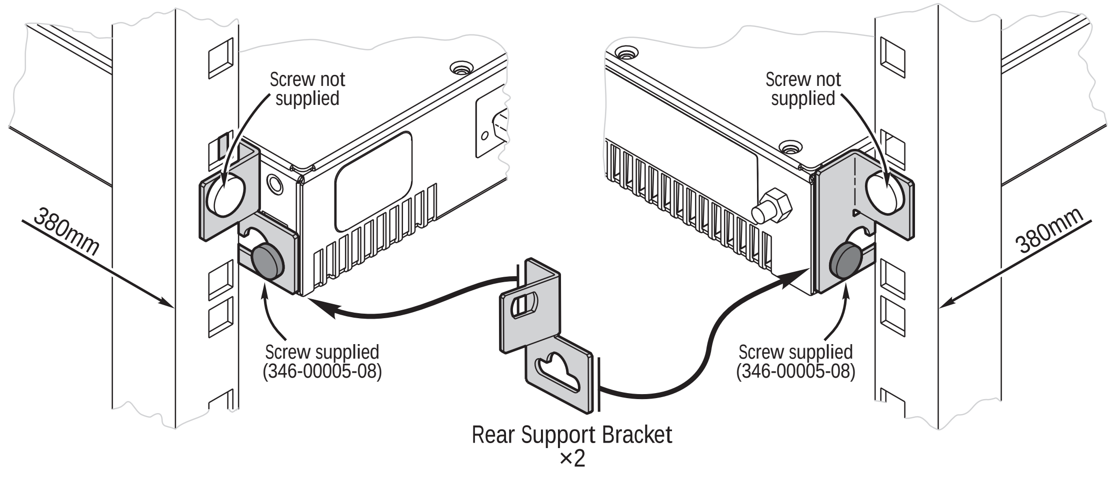
Contents of Kit

Qty.	Part Number	Description
2	302-05282-00	TB7100 rear support bracket
2	346-00005-08	Button head socket scrw M5×8

Installation

The two rear support brackets supplied in the kit are identical, and can be used on either side of the Multitone paging transmitter.

Figure 18.1 Recommended rear support mounting options for a Multitone paging transmitter



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