TM8000 mobiles

TM8100 Mobile Radio **Service Manual**

radio communications

MM8100-02-00-812 Version 3.00

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Contents

Preface

Scope of Service Manual

This manual provides information to service technicians for carrying out level-1 and level-2 repairs of TM8100 mobile radios. Level-1 repairs entail the replacement of faulty parts and circuit boards; level-2 repairs entail the repair of circuit boards, 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. The servicing procedures are moreover limited to the control head and radio body of TM8100 mobile radios. Servicing of all accessories associated with the radio is covered in the accessories manual.

Summary of Service Manual

The service manual is divided into two chapters. A description of the radio is given in Chapter 1. After an introductory section, an illustrated parts breakdown is given for the radio. This is followed by a description of the principles of operation of the radio and the functioning of the circuitry.

The servicing procedures are given in Chapter 2. General information is given first, followed by the full sequence of tasks required to service a particular radio. The chapter concludes with additional details for certain tasks, namely, disassembly and re-assembly of the radio, servicing of the control head, general information on the servicing of the main circuit board, and the diagnosis of faults on the main circuit board.

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Any enquiries regarding this manual or the equipment that it describes, as well as any comments, suggestions and notifications of errors, should be addressed by e-mail to Technical Support (support@taitworld.com) or to the Technical Support Manager, Tait Electronics Limited, PO Box 1645, Christchurch, New Zealand. Orders for this manual can be placed with your Tait Dealer.

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Typographical Conventions

Conventions

In this manual a special font is used for the names of certain hardware-related and software-related elements. Details of these elements are given in the tables below. The font used is Helvetica Narrow, with small capitals for hardware-related and italics for software-related elements. In essence this typographical convention is used to distinguish long or cryptic names of elements from the ordinary text of the document.

Sequences of GUI elements

For indicating the selection of a sequence of GUI (graphical user interface) elements, the convention illustrated by the following example is applied: Select *“Start”* > *“Programs”* > *“Tait Programming Applications”* > *“TM8100 Programming Application”* means: Select the *“Start”* menu, then select the *“Programs”* option from the list that appears, then the *“Tait Programming Applications”* option from the second list, and finally the *“TM8100 Programming Application”* option from the third list that appears.

Hardware-related elements

Convention	Usage	Examples
“SMALL CAPS QUOTES”	Labelled hardware items and settings	Connect the cable to the “NODE” port. Set the switch to the “TX/PTT” position.
SMALL CAPS	Electrical signals	Check the signal DIG CDC2 LRCK at pin 10 of IC205.
	Unlabelled hardware items and settings	Remove the VCO TOP and SYN TOP cans. Press the ON/OFF key.

Software-related elements

Convention	Usage	Examples
“Italics Quotes”	Labelled GUI elements	Note the values listed in the *“AGC Delta Gain Values”* field.
Italics	Unlabelled GUI elements and displayed or typed text	Click the *Close* button. The message *node is not running* is displayed.
Bold italics	Variables in displayed or typed text or GUI items	Enter the CCTM command *304* ***ccc***, where ***ccc*** is the DAC value of the clamp current.

Alert notices

Alert notices that appear in the manual are selected from whichever of the following are appropriate. These alert notices are in accordance with the ANSI definitions.

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

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

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

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

Associated Documentation

Basic manuals

Together with this service manual, the following manuals are of concern to service technicians. The pair of digits in the third field of the document product code indicates the language of the document — 00 indicates an English and 03 a multi-lingual document.

MM8100-00-03-804
TM8100 mobile radio — User's guide

MMAA00-00-00-812
TM8100 mobile radio — Accessories manual

PCB information packages

Information on the circuit boards is supplied in the following separate documents. The information consists of the BOMs (bills of materials), grid reference indexes, PCB layouts, and circuit diagrams.

MMAB12-B1-00-814
Main board (B1) — PCB information package

MMAB12-D1-00-814
Main board (D1) — PCB information package

MMAB12-H5-00-814
Main board (H5/H6) — PCB information package

MMAC20-00-00-814
Control-head board (two-digit display) — PCB information package

MMAC50-00-00-814
Control-head board (one-digit display) — PCB information package

3DK manuals

The following manuals are mainly of concern to third-party developers. The manuals are supplied in soft-copy form on a 3DK (third-party developer's kit) resource CD.

MMAA30-01-00-807
TM8000 3DK hardware developer's kit — Application manual

MMAA30-02-00-429
TM8000 3DK application board — Software programmer's manual

MMAA30-02-00-812
TM8000 3DK application board — Service manual

MM8100-00-00-441
TM8100 Computer-controlled data interface — Protocol definition

Publication Record

Version	Publication date	Amended sections and pages
1.00	September 2003	First release — includes information for level-1 repairs only
2.00	March 2004	Second release — information for level-2 repairs added
3.00	May 2004	Third release — information for TM8110 radio and D1 band added

List of Acronyms

3DK	Third-party Developer's Kit
ACP	Adjacent Channel Power
ADC	Analogue-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
CTCSS	Continuous-tone-controlled Subaudible Signalling
DAC	Digital-to-analogue Converter
DSP	Digital Signal Processor
DTMF	Dual-tone Multi-frequency
ESD	Electrostatic Discharge
FCL	Frequency Control Loop
FE	Front-end
FPGA	Field-programmable Gate Array
GPS	Global Positioning System
GUI	Graphical User Interface
IPN	Internal Part Number
IF	Intermediate Frequency
IQ	In-phase and Quadrature
ISC	International Service Centre
LCD	Liguid-crystal Display
LED	Light-emitting Diode
LNA	Low-noise Amplifier
LO	Local Oscillator
LPF	Low-pass Filter
PA	Power Amplifier
PLL	Phase-locked Loop
PTT	Press-to-talk
RSSI	Received Signal Strength Indication
SFE	Software Feature Enabler
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

Chapter 1
Description of Radio

Chapter 1 Contents

1 Introduction

Scope of Section

This section introduces the TM8100 mobile radio system. There are six subsections covering the following aspects:

- introduction to items that make up system
- additional information on radio body
- additional information on control head
- repair levels that govern servicing of radio
- explanation of product codes for radio body and control head
- general specification for TM8100 radios

The radio body and control head are the principal items of the system and are the prime concern of this service manual.

1.1 TM8100 Mobile Radio System

Main Items of System

The TM8100 mobile radio system is a high-performance microprocessor-controlled transceiver with a comprehensive range of accessories. The system is designed primarily for installation in vehicles but can also be used in desktop, remote-monitoring and similar applications. The system consists of the following items:

- radio body
- control head
- audio accessories
- mounting for radio
- desktop power supply (optional)

Separate calibration and programming applications are used to calibrate and program the radio. The service manual covers the servicing of the radio body and control head only. The accessories manual covers servicing of all the remaining items.

Radio Body

The radio body contains the transmitter, receiver and microprocessor circuitry. The radio body also allows for the fitting of an internal options board to provide additional functions. There are three standard external connectors on the radio body: an RF connector, power connector, and auxiliary connector. If an internal options board is fitted, there might or might not be an associated external options connector. The auxiliary and external options connectors allow for the connection of various external devices.

Figure 1.1 Illustrations of the TM8115 radio showing both the front and rear

Control Head

The control head is attached to the radio body. There is a choice of three control heads:

- two-digit-display control head
- one-digit-display control head
- blank control head

The control heads with a display provide an interface with the radio user and include a socket for the connection of a microphone. (Aside from the number of characters displayed, there are no other differences between these two control heads.) The blank control head has no UI (user interface) but has a single external connector called the programming connector; this is typically used for monitoring purposes. For calibrating and programming the radio, the control head is connected (via the microphone or programming connector as appropriate) to the PC on which the calibration and programming applications are installed.

Designations

The designation of the radio depends on which control head is attached to the radio body:

- TM8115 : two-digit-display control head
- TM8110 : one-digit-display control head
- TM8105 : blank control head

Illustrations of the TM8115 radio are given in Figure 1.1 and illustrations of the TM8110 and TM8105 in Figure 1.2.

Audio Accessories

One or more audio accessories may be connected to the control head and radio body. A microphone is the accessory usually required; other accessories that are available are a handset, high-power remote speaker, and hands-free kit. Various external devices may also be connected. The user's guide and accessories manual describe the audio accessories.

Installation Kits and Desktop Power Supply

The mounting hardware for the radio is in the form of a U-cradle. It is supplied in an installation kit and provides for the installation of the radio in a vehicle. Alternatively, the radio might be needed for desktop use, in which case a desktop power supply is required. Tait desktop power supplies include the parts needed to mount the radio. The user's guide and accessories manual describe the installation kit.

Block Diagrams of System

The block diagrams of Figure 1.3 to Figure 1.5 illustrate possible configurations of the radio system. Figure 1.3 and Figure 1.4 show example installations of the TM8110 or TM8115 radio in a vehicle and on a desktop. Figure 1.5 shows an example of the TM8105 radio (with blank control head) installed in a vehicle. Different audio accessories are shown connected to the radio. The hands-free kit is connected to the auxiliary connector, and the remote speaker to the power connector. The accessories that may be connected to the microphone connector include the rugged microphone, as well as a DTMF (dual-tone multi-frequency) microphone, desktop microphone, and handset.

Figure 1.2 Illustration of the front of the TM8105 and TM8110 radios

Figure 1.3 Block diagram of an example installation in a vehicle of a radio with a user interface

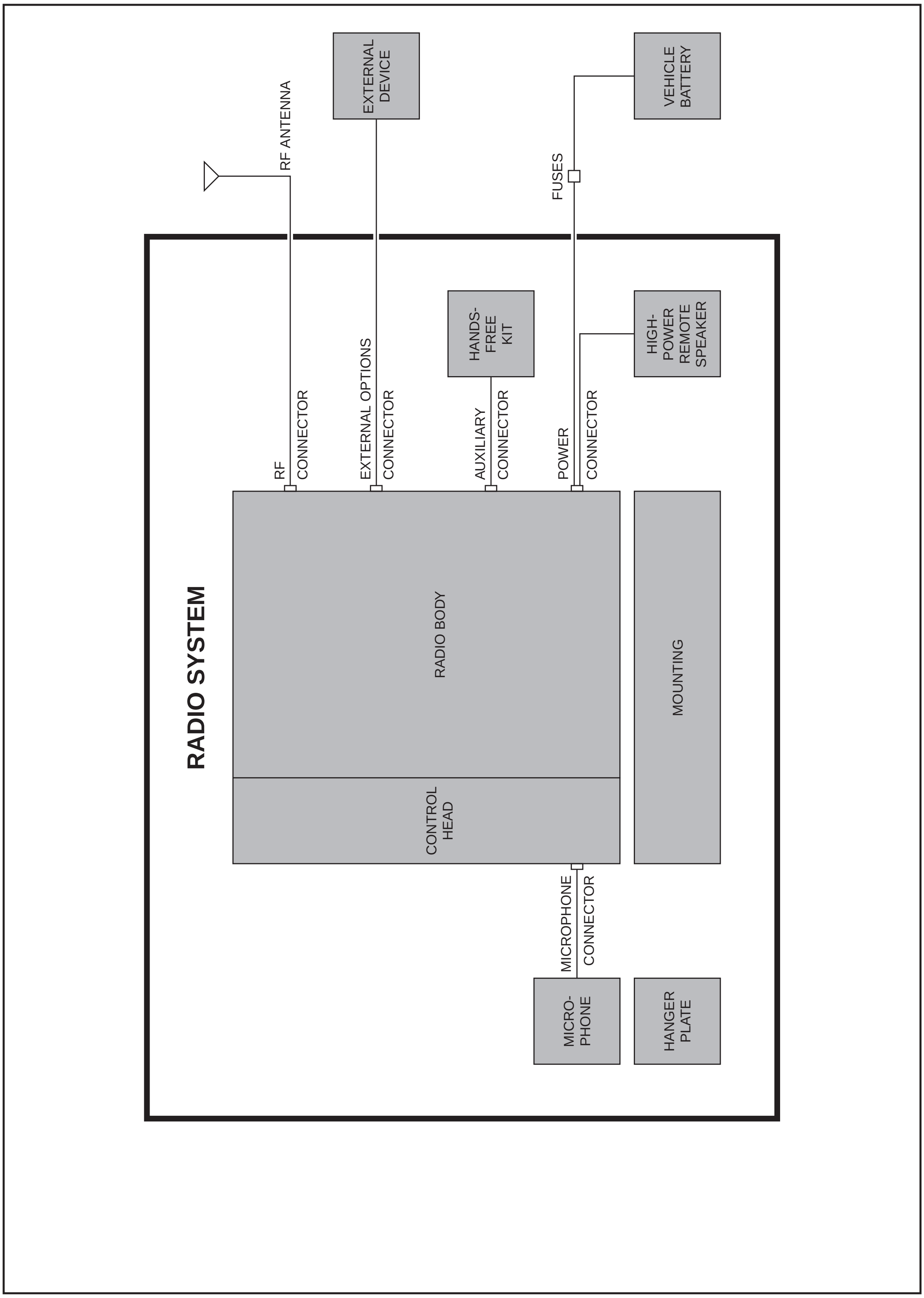
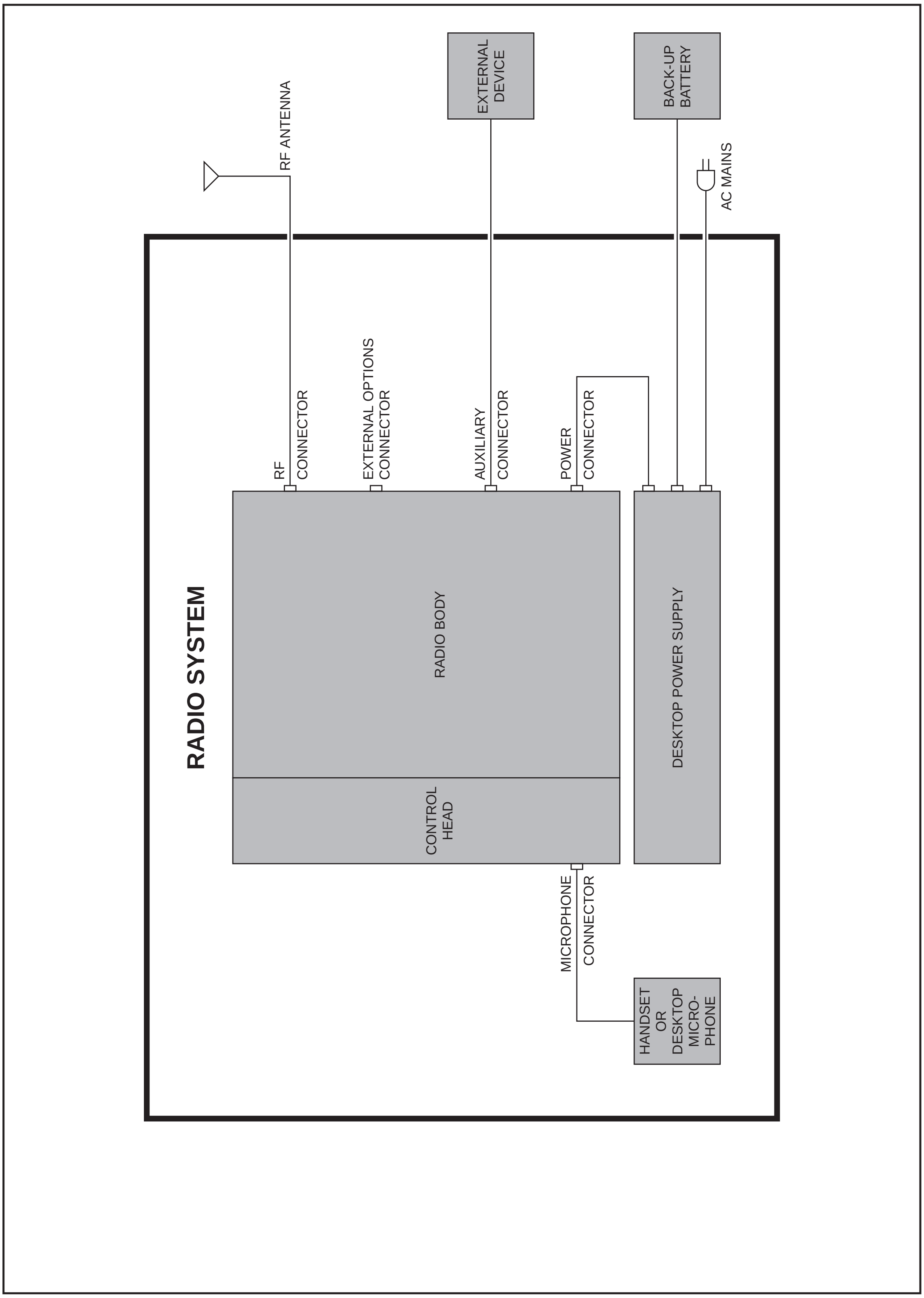


Figure 1.4 Block diagram of an example desktop installation of a radio with a user interface



1.2 Radio Body

Main, Digital and Internal Options Boards

The radio body consists of a rectangular case — or chassis — with a lid. The chassis houses a main board with the receiver and transmitter circuitry, and a digital board with the microprocessor that controls the radio. There are different main boards available covering different frequency bands and with different RF performances; refer to the product codes in Figure 1.8. The digital board is reflow-soldered to the main board. There is space in the lid for an optional internal options board. The essentials of the arrangement are illustrated in the block diagram of Figure 1.6.

Main-board Assembly

The rear edge of the main board is attached to a heat-transfer block. The block is in thermal contact with the rear of the case, where there are cooling fins for heat dissipation. Heat from the output stage of the transmitter is conducted via the heat-transfer block to the rear and radiated from the cooling fins. (The lower surface of the case is ridged to augment the dissipation of heat.) The RF, auxiliary and power connectors are fixed to the rear of the main board. They project through apertures in the heat-transfer block and the rear of the case. The main board, digital board, and heat-transfer block constitute a separate unit called the main-board assembly.

Internal Options Boards

Either Tait-designed or custom internal options boards may be fitted in the radio body. Full details of the boards are given in the accessories and 3DK manuals. Any internal options board that is fitted might or might not include an external options connector. If included, the connector will project through an aperture in the rear of the lid. If there is no connector, the aperture is sealed with a bung.

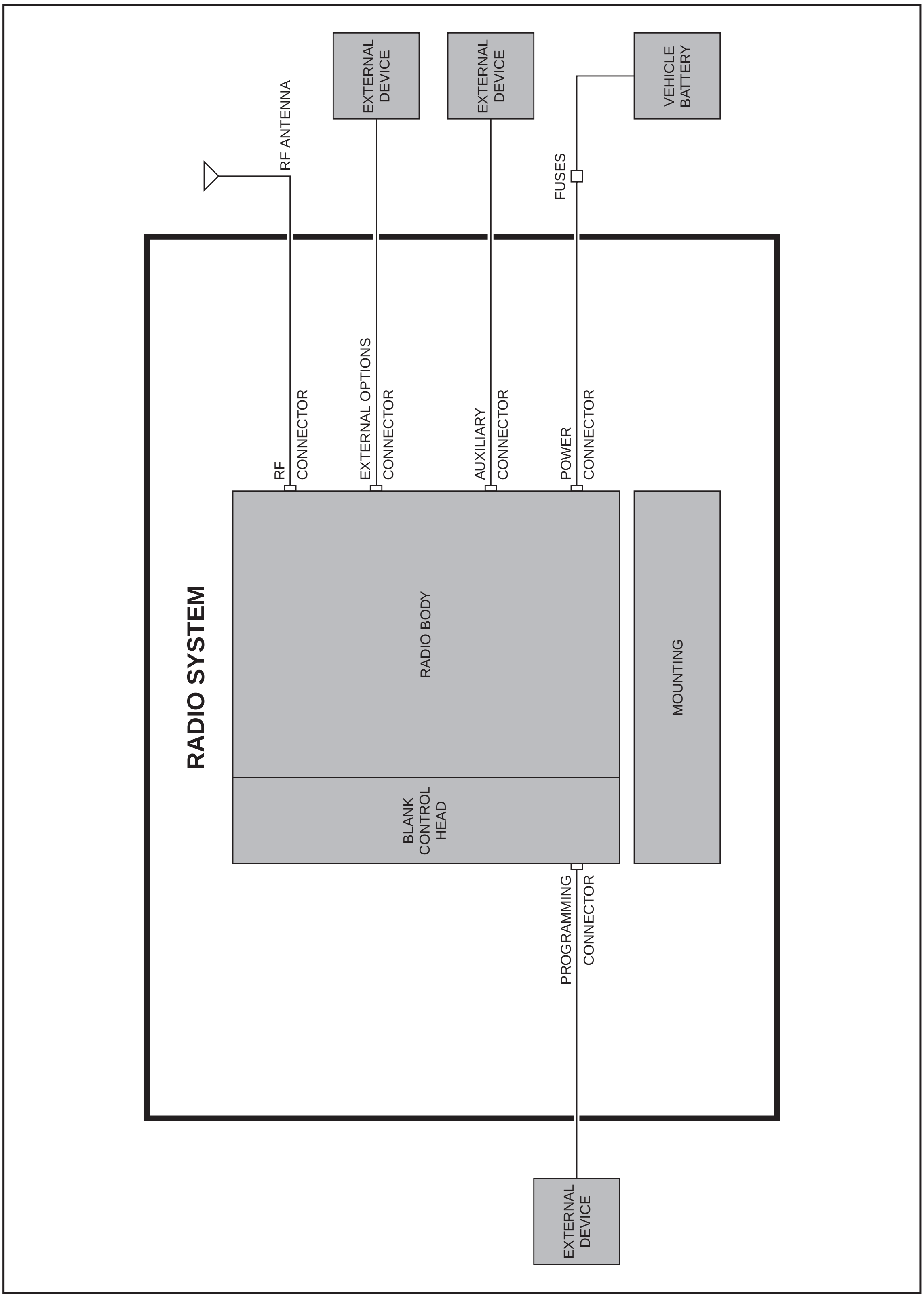
Internal Connections

There are three sets of internal connections to the main board; these use the following connectors:

- factory connector
- control-head connector
- internal options connector

The factory connector is for Factory use only. The control-head connector is on the front edge of the main board; it is used to connect a control-head loom from the control head to the main board. The internal options connector is required when an internal options board is fitted; it is used to connect an options loom between the two boards.

Figure 1.5 Block diagram of an example installation in a vehicle of a radio with a blank control head



1.3 Control Head

Introduction

The control head clips securely to the front of the radio body. The control-head loom between the two is enclosed in the space between them. For badging and branding purposes there are both a logo and a label for the product model code on the front panel. The control head may also be left unbadged. For the control heads with UI, the essential features are shown in the block diagram of Figure 1.6.

Control Heads with UI

The front panel of the control heads with UI is fitted with the controls and indicators needed by the radio user; these comprise:

- LCD (liquid-crystal display) screen
- indicator LEDs (light-emitting diodes)
- volume control
- ON/OFF key
- function keys
- channel-selection keys

In addition, there are the microphone connector and an internal speaker. The necessary circuitry for the above items is mounted on a control-head board fitted behind the front panel. The volume-control potentiometer is fixed to the board; so is a control-head connector, which is used for the control-head loom between the control head and radio body.

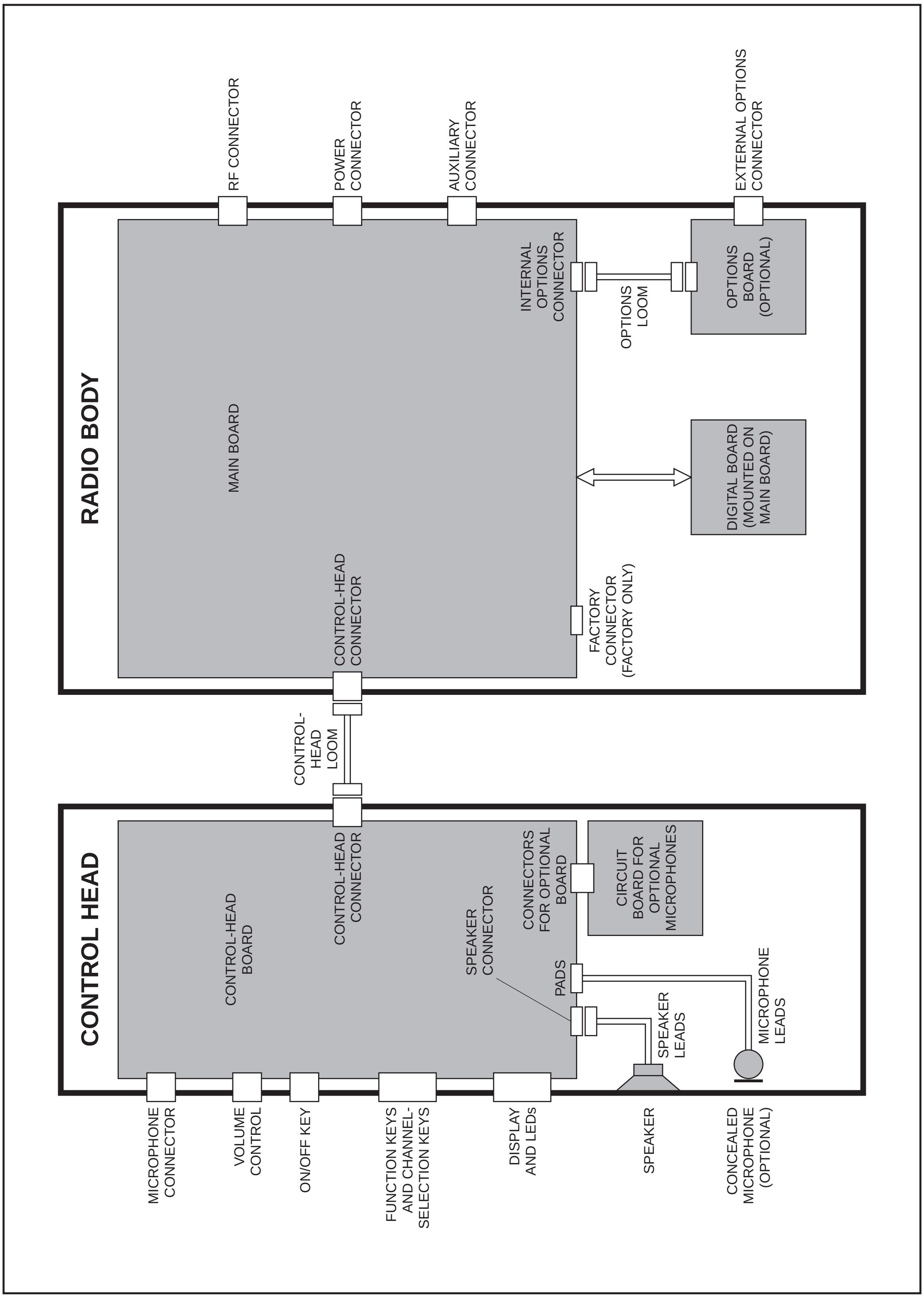
Options for Control Heads with UI

The control heads with UI allow for an optional concealed microphone or the use of a dynamic microphone. (A concealed microphone is fitted behind the front panel next to the speaker.) With either option a separate circuit board is required for the microphone. This board is connected to the control-head board by means of two connectors; the plugs of the connectors are mounted on the latter board and the sockets on the former. Full details of the optional microphones and circuit board are given in the accessories manual.

Blank Control Head

The blank control head has none of the features of the control heads with UI. The front panel of the blank control head is fitted only with the single programming connector. The control-head loom is permanently fixed to the rear of the programming connector. The space inside the control head can be used for the fitting of an optional third-party circuit board, but is otherwise empty.

Figure 1.6 Block diagram of the radio body and control head of a radio with a user interface



1.4 Repair Levels

Introduction

The repairs that can be carried out on the radio are grouped into categories — or levels — of increasing complexity. This manual covers two repair levels:

- level-1 repairs
- level-2 repairs

The repairs included at each level are defined below. The specific repair skills and resources needed for each repair level are discussed in Chapter 2. By resources is meant tools and equipment, spares kits, and the type of access to the TaitWorld website.

Level-1 Repairs

There are three types of level-1 repair:

- replacement of control-head board
- replacement of main-board assembly
- replacement of other parts

The last-named parts include the connectors and volume-control potentiometer on the control-head board, but not the connectors on the main board.

Level-2 Repairs

There are two types of level-2 repair:

- repair of control-head board
- repair of main-board assembly, excluding special items

These repairs entail the replacement of faulty SMT (surface-mount technology) components on the boards, as well as the connectors on the main board. The special items are the digital board and certain components on the main board; the details are given in Chapter 2. (Repairs of the special items are level-3 repairs.)

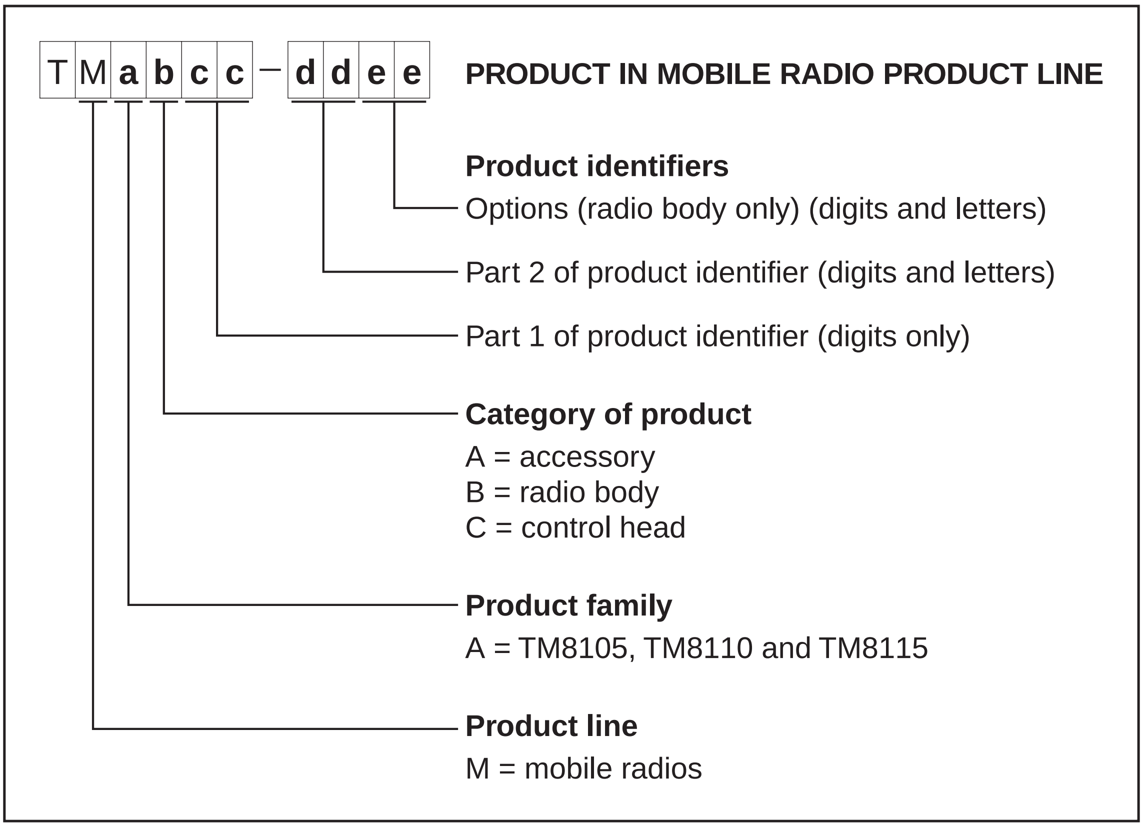
Service Centres

The service centres that carry out repairs of the radios can be divided into three categories:

- Dealers and Customers with appropriate facilities
- ASCs, including CSOs (Customer Service Organisations)
- TEL and ISC

ASCs (accredited service centres), the ISC (International Service Centre) and TEL (Tait Electronics Limited) may carry out both level-1 and level-2 repairs. These are moreover the only service centres that may repair a radio that is still under warranty — any repair by a non-accredited service centre will void the warranty. After the expiry of the warranty, Dealers and Customers with appropriate facilities may also carry out level-1 repairs, but are strongly advised not to attempt level-2 repairs. Details of the process by which service centres may achieve accreditation are given in Chapter 2.

Figure 1.7 Scheme for the product codes assigned to products of the mobile radio product line



Restrictions Regarding Level-3 Repairs

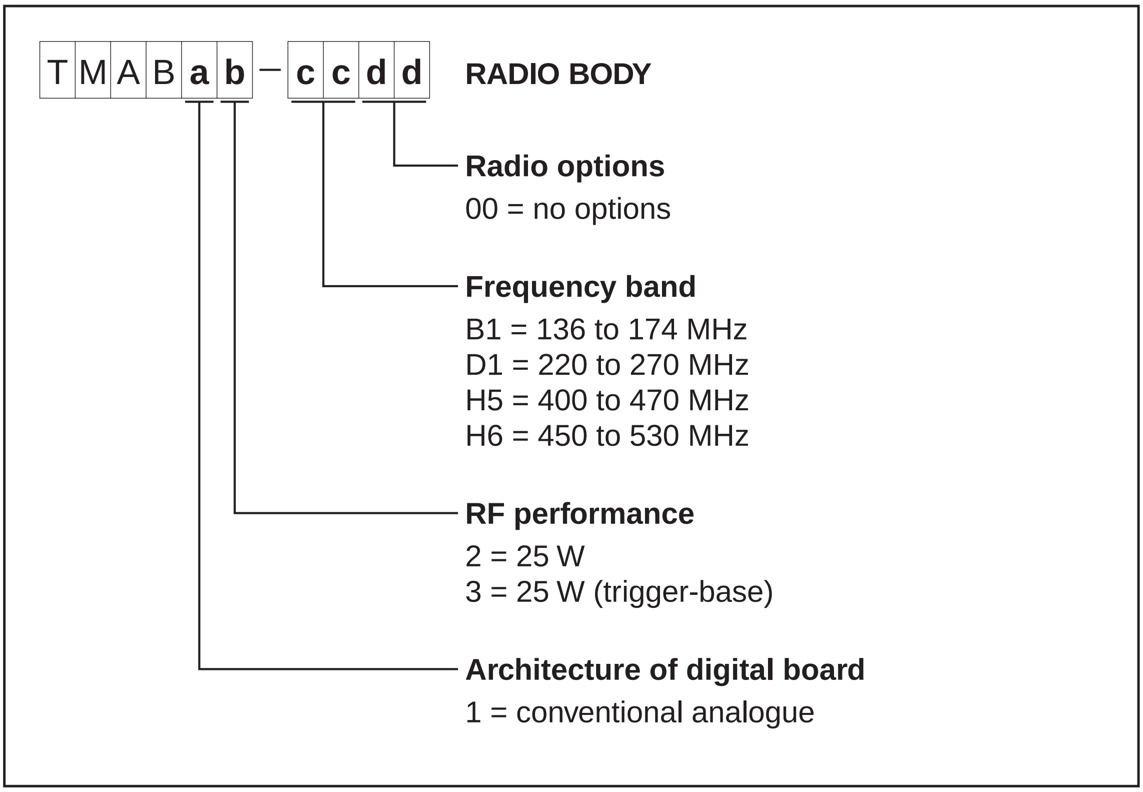
Only TEL and the ISC should carry out level-3 repairs. The level of technology employed in the TM8100 generation of radios is an order of magnitude greater than in earlier generations. This greater sophistication demands special equipment and techniques for level-3 repairs. Although other service centres are strongly advised not to attempt such repairs, those with sufficient resources and skilled technicians may wish to do so. These service centres should contact Technical Support for assistance and for the necessary documentation. TEL does not offer accreditation for level-3 repairs to any service centres other than the ISC.

1.5 Product Codes

Introduction

This subsection describes the product codes used to identify different products of the mobile radio product line. The product-code scheme in general is first explained, and then the product codes for the radio body and control head in particular. The purpose is solely to enable service technicians to identify the radio body and control head of a radio that has been delivered for repair.

Figure 1.8   Scheme for the product codes currently in use for the radio body



Limitations on Use of Product Codes

The product codes discussed in this subsection are those in use at the time of publication. For up-to-date information refer to the TaitWorld website. The explanations of the product codes are to aid identification only, and are not to be used as the basis for sales orders. There are two reasons for this: Firstly, an arbitrarily-constructed product code might apply to a product that, for compliance reasons, is restricted to certain markets. Secondly, a product with such a product code might not even exist.

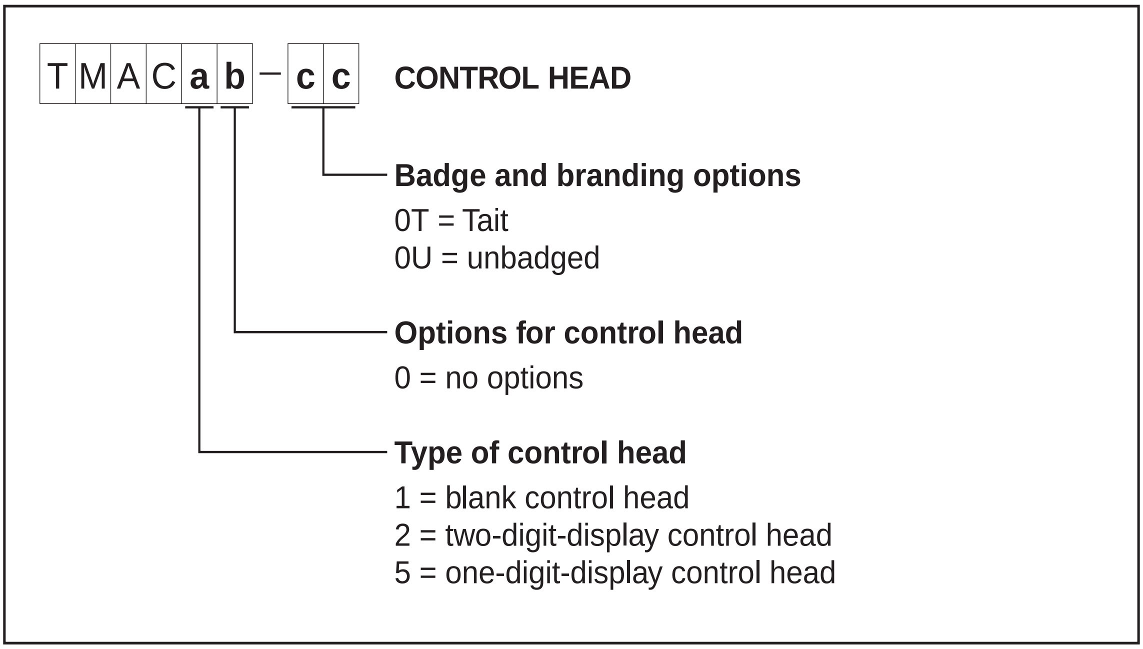
General Scheme for Product Codes

Individual products of the mobile radio product line are identified by product codes with the format:

TM**abcc–ddee**

where **a** and **b** are uppercase letters representing the product family and category of product respectively, and **cc**, **dd** and **ee** are characters that identify the specific product. The characters **ee** are applicable to the radio body only and identify different options. The product code scheme is summarised in Figure 1.7.

Figure 1.9 Scheme for the product codes currently in use for the control head



Product Families and Categories

Examples of different product families within the mobile radio product line are the T700, T2000 and TM8100 radios. The TM8100 family is however the first to which the above product-code scheme applies. Examples of different product categories are radio bodies, control heads, and accessories. These are the only categories identified to date. The product codes for the radio body and control head are discussed below; those for the accessory items are described in the accessories manual.

Product Codes for Radio Body

The product codes for the radio body have the format:

TMAB**ab–ccdd**

where **a** identifies the architecture of the digital board, **b** identifies the RF performance, **cc** is the letter-digit combination identifying the frequency band, and **dd** identifies any options selected. The characters **dd** are set to 00 for the default radio with no options added. For universal options available to all Customers, the digits 01 to 99 are used for **dd**. For custom options implemented for particular Customers, the letters AA to ZZ are used. The digits and letters identifying the universal and custom options are assigned sequentially. Figure 1.8 illustrates the product codes in use at the time of publication.

Product Codes for Control Head

The product codes for the control head have the format:

TMAC**ab**–**cc**

where **a** identifies the type of control head, **b** identifies any options selected, and **cc** identifies badging and branding options. By type is meant whether the control head is blank or has a user interface with a one- or two-digit display; allowance is made for additional types in the future. Only the digits 1 to 9 are allowed for **a** (0 is not used), and the digits 0 to 9 for **b**; the latter is set to 0 when no options are added. Both letters and digits may be used for **cc**. The default for **cc** is 0T; on one- and two-digit-display control heads the Tait logo is then displayed next to the LCD screen; the product model code TM8110 and TM8115 respectively is displayed above the speaker grille. Figure 1.9 illustrates the product codes in use at the time of publication.

1.6 Specifications

Introduction

General specifications for TM8100 radios are given in Table 1.1 and Table 1.2. The parameter values quoted in the tables are minimum values. These specifications are valid for the date of publication only. The specifications will also be found on the TaitWorld website in the area reserved for TM8000 products. The latter specifications are updated whenever changes occur.

Table 1.1 General specification for TM8100 radios — Basic, physical and environmental aspects

Parameter	Values
Basic characteristics	
Frequency bands: • B1 band • D1 band • H5 band • H6 band	 136 to 174 MHz 216 to 266 MHz 400 to 470 MHz 450 to 530 MHz
Frequency stability	±1.5 ppm
Channel capacity (simplex or semi-duplex): • TM8110 radio • TM8115 radio	 10 24
Channel spacing: • Narrow • Medium • Wide	 12.5 kHz 20 kHz 25 kHz
Power supply	Between 10.8 and 16 V DC
RF connector	50 Ω BNC or miniature UHF
Interface connectors: • Microphone connector • Auxiliary connector • Internal options connector	Ports: 1 serial, 1 I/O 1 serial, 3 input, 4 I/O, 1 audio tap in, 1 audio tap out 1 serial, 7 I/O, 1 audio tap in, 1 audio tap out
Physcial characteristics	
Weight	1.43 kg (50.44 ounces)
Dimensions: • Length • Width • Height	 175 mm (6.88 inches) 160 mm (6.29 inches) 50 mm (1.97 inches)
Environmental conditions	
Operating temperatures	−30°C to +60°C (−22°F to +140°F)
Standards • IP54 • MIL-STD 810C, D, E and F (for details contact Technical Support)	 Meets the requirements for sealing against: • Dust • Rain Meets the requirements regarding the following aspects: • Low pressure • High temperature • Low temperature • Temperature shock • Solar radiation • Vibration • Shock • Dust • Rain • Humidity • Salt fog

Table 1.2 General specification for TM8100 radios — Transmitter and receiver

Parameter	Values
Transmitter	
Output power: • Level 1 — very low • Level 2 — low • Level 3 — medium • Level 4 — high	 1 W 5 W 10 W 25 W
Modulation limiting: • Narrow channel spacing • Medium channel spacing • Wide channel spacing	 < ±2.5 kHz < ±4 kHz < ±5 kHz
FM hum and noise: • Narrow channel spacing • Medium channel spacing • Wide channel spacing	 > 33 dB > 41 dB > 43 dB
Conducted and radiated emissions: • Up to 1 GHz • Between 1 and 4 GHz (for radio operating frequencies below 500 MHz) • Between 1 and 12.75 GHz (for radio operating frequencies above 500 MHz)	 < −36 dBm < −30 dBm < −30 dBm
Audio response	300 Hz to 3 kHz (flat or with pre-emphasis)
Audio distortion	< 3% at 1 kHz 60% modulation
Transmit rise time (From the time the external PTT line is asserted to the time when the RF output power reaches 90% of its final value)	< 10 ms
Receiver	
Sensitivity	< −118 dBm for 12 dB SINAD
Intermodulation	> 66 dB
Spurious responses	> 72 dB
Selectivity: • Narrow channel spacing • Medium channel spacing • Wide channel spacing	 > 65 dB > 70 dB > 75 dB
Hum and noise: • Narrow channel spacing • Medium channel spacing • Wide channel spacing	 > 40 dBm > 41 dBm > 43 dBm
Audio response	300 Hz to 3 kHz (flat or with de-emphasis)
Audio distortion	< 3%
Receive detect time (From the time an RF signal is first present at the antenna to the time when the BUSY DETECT line changes state)	< 3 ms

2 General Description

Scope of Section

This section comprises a general description of the radio body and control head of TM8100 radios. Firstly, the mechanical parts, miscellaneous parts, and circuit boards that make up the radio are identified and discussed. Secondly, the basic modules of the circuitry are identified and their essential functions described. Thirdly, the operation of the control-head circuitry is summarised. Finally, the principles of operation of the radio are given in three separate subsections.

2.1 Illustrated Parts Breakdown

Introduction

This subsection identifies all the mechanical parts, miscellaneous parts, and circuit boards that make up the radio. The parts and circuit boards are illustrated in three sets of figures covering respectively the control heads with UI, the blank control head, and the radio body. The figures are exploded-view illustrations showing how the parts and circuit boards are assembled to build the complete radio. Accompanying the figures are tables in which the parts identified in the figures are listed and their details given.

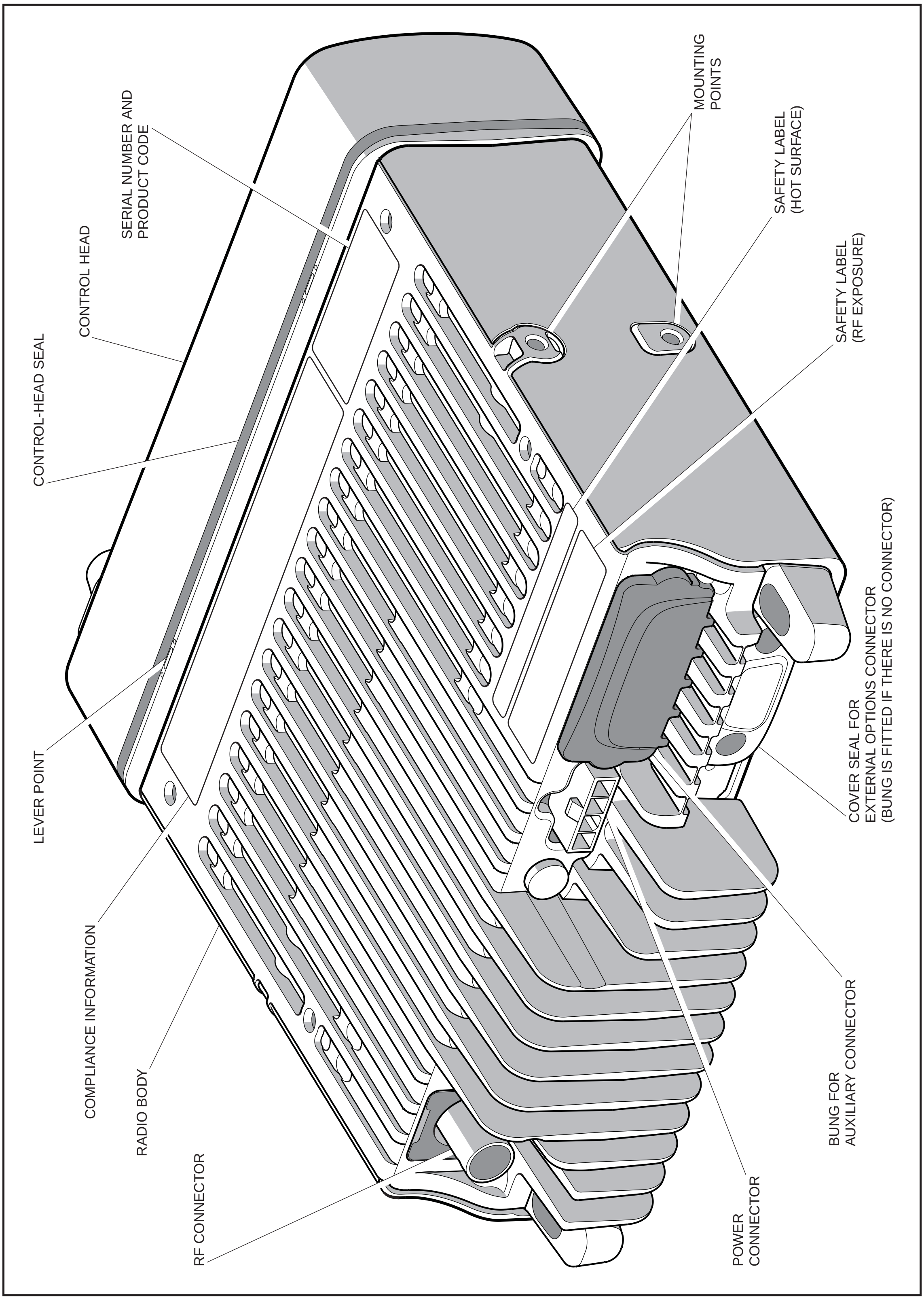
Labels on Radio

Before the different parts of the radio are considered, however, some important external features are described. These are illustrated in Figure 2.1, which shows the underside of the radio. The first feature is the set of four labels with the following information:

- compliance information
- serial number and product code
- safety label — hot surface
- safety label — RF exposure

The two safety labels concern the high temperatures that the body of the radio can attain in operation and exposure to RF radiation during transmissions. Regarding the former, the figure clearly shows the cooling fins at the rear and the ridges on the underside, which are provided for heat dissipation.

Figure 2.1 Underside of the radio showing the labels and connectors on the radio body



Mounting Points, Seals and Connectors

Other features illustrated in Figure 2.1 are the mounting points for the radio, the seal between the control head and radio body, and the connectors at the rear. The last-named are:

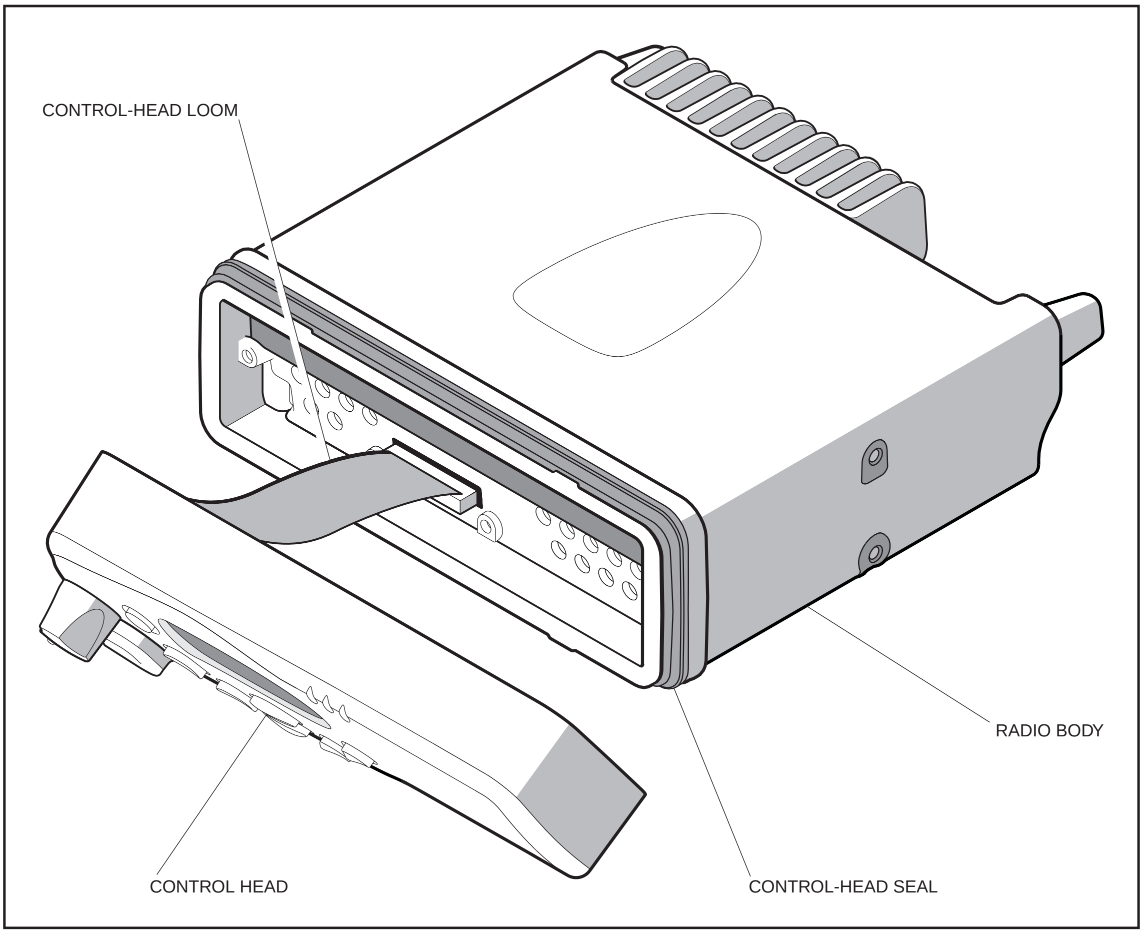
- RF connector
- power connector
- auxiliary connector
- external options connector (optional)

A bung seals the access to the auxiliary connector when this connector is not used. A second bung seals the aperture provided for the external options connector when there is no internal options board with such a connector. If an options board with a connector is installed, a cover seal is supplied instead. Whenever the connector is not in use, the cover seal is fitted over the connector as shown in the figure. The bungs and seals ensure that the radio is sealed to IP54 standards.

Separation of Control Head and Radio Body

Figure 2.2 shows the control head detached from the radio body, the control-head loom between them, and the control-head seal. The seal is fitted to the front face of the radio body. The loom is shown still connected to the control-head connector on the radio body. The two points where the control head is levered off the radio body are indicated by dot-dash-dot marks on the underside. These lever points are shown in Figure 2.1. The control head may be attached to the radio body with the underside of the radio body facing either up or down. Which orientation is appropriate depends on the installation.

Figure 2.2 Illustration showing the control head detached from the radio body



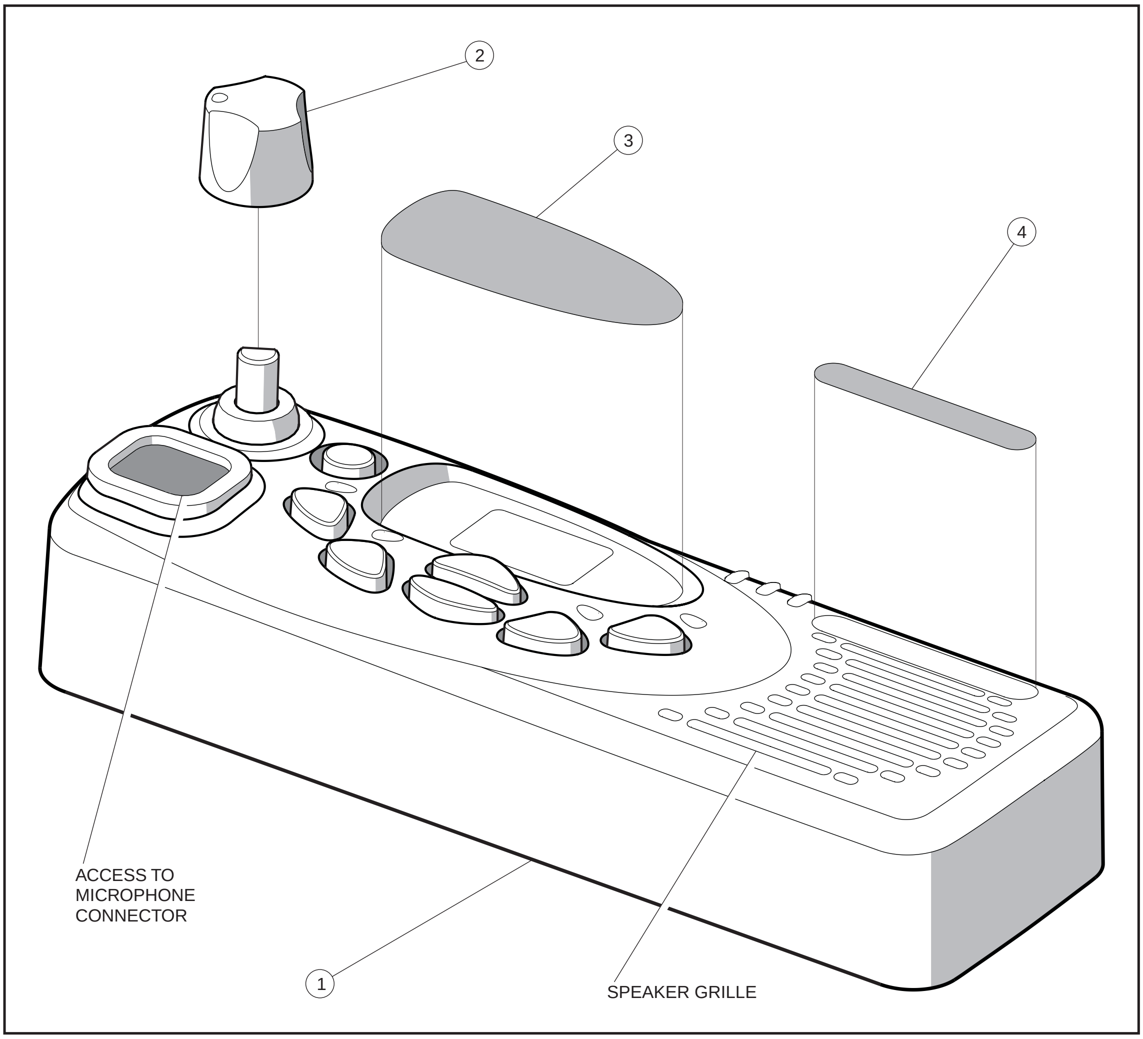
Parts of Control Head with UI

Figure 2.3 to Figure 2.5 illustrate the parts of a control head with UI. In the figures each relevant part is identified by an index number. In Table 2.1 all the index numbers are listed and the corresponding details of these parts are given. The parts of accessory items are also identified in the figures but are not assigned index numbers. Details of such parts are given in the accessories manual.

Exterior of Control Head

Figure 2.3 shows the exterior of the control head. Illustrated are the front panel with the various keys and indicator LEDs, and the lens covering the display. There is a rectangular aperture in the lens through which the display is viewed. Depending on the type of control head, the aperture is sized to fit either the one or the two characters displayed. An identifying label distinguishes the control heads. Externally the control heads differ only in this label and the lens. Also shown in Figure 2.3 are the knob for the volume-control potentiometer and the access to the microphone connector. The potentiometer and connector are mounted on the control-head board inside the front panel.

Figure 2.3 Exterior of a control head with UI



Control-head Board

Figure 2.4 and Figure 2.5 show the interior of the control head. The control-head board is screwed to a space-frame that is fitted inside the front panel. (Different boards are required for the one- and two-digit-display control heads.) The control-head loom connected to the board requires a female-to-female adaptor to allow connection to the radio body. Figure 2.4 also shows the separate circuit board mounted on the control-head board when a dynamic or concealed microphone is used.

Space-frame, Keypad and Display

The space-frame fits over the speaker, a keypad, and the LCD for the display. The keypad is designed so that pressing any key results in contact being made with the control-head board. There are four light pipes in the keypad for the LEDs associated with the function keys. Light pipes for the three STATUS LEDs, however, are moulded into the front panel. The LCD fits in a recess in the front panel. Electrical contact between the LCD and the control-head board is ensured by two elastomeric strips held in place by the space-frame.

Figure 2.4 Interior of a control head with UI showing the space-frame and associated parts

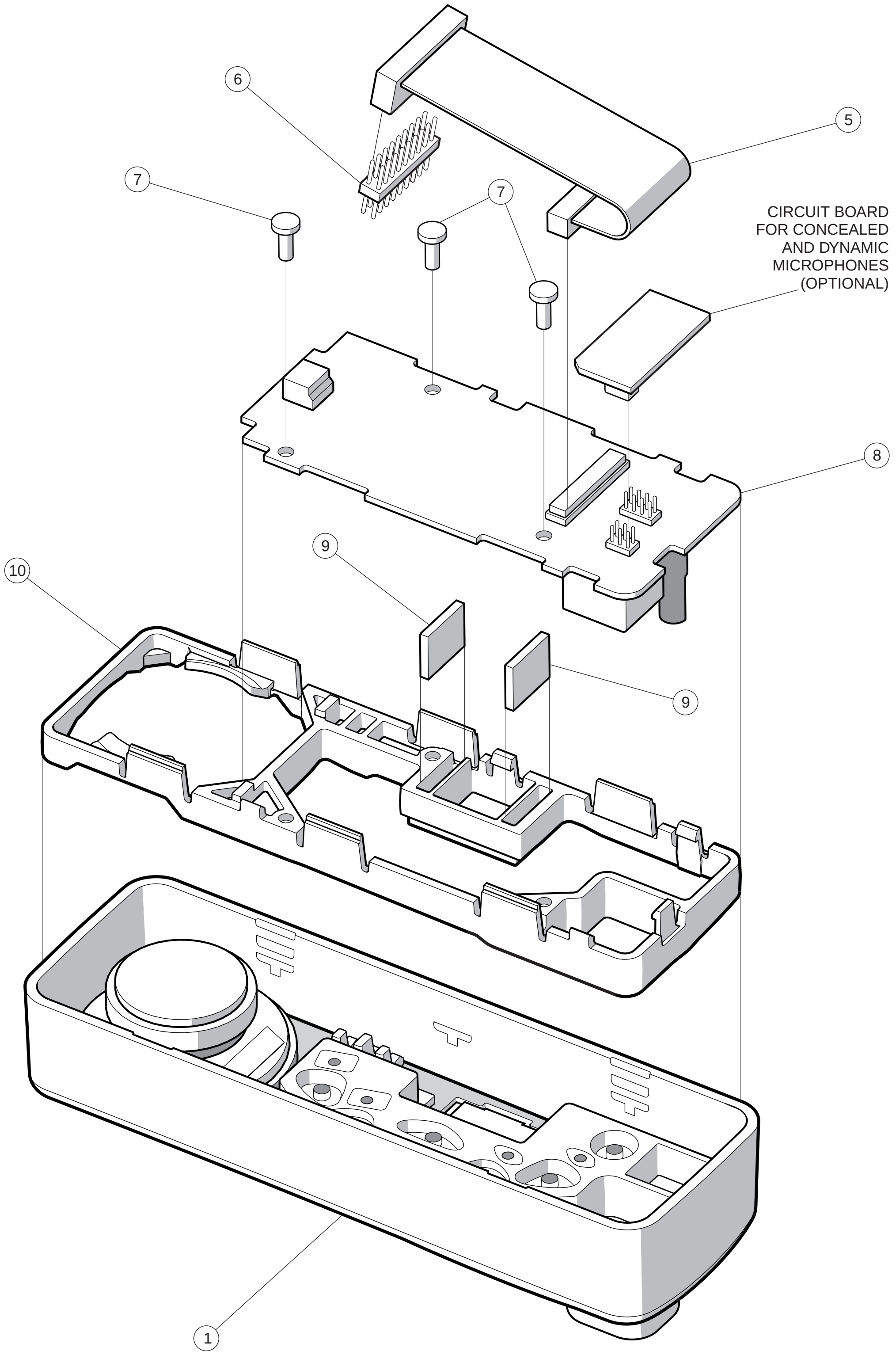


Table 2.1 Parts of the control heads with UI

Index	Reference	IPN	Description	Quantity
1	Figure 2.3	316-06786-**xx**	Front panel	1
2	Figure 2.3	311-01054-**xx**	Knob for volume-control potentiometer	1
3	Figure 2.3	312-01095-**xx**	Lens with Tait logo (two-digit display)	1
		312-01106-**xx**	Lens with Tait logo (one-digit display)	
4	Figure 2.3	365-01717-**xx**	Label for TM8115	1
		365-01745-**xx**	Label for TM8110	
5	Figure 2.4	219-02882-**xx**	Control-head loom	1
6	Figure 2.4	240-00021-41	Female-female adaptor for control-head connector	1
7	Figure 2.4	346-10030-08	3 x 8 PT screw for control-head board	3
8	Figure 2.4	XMAC20	Control-head board (two-digit display)	1
		XMAC50	Control-head board (one-digit display)	
9	Figure 2.4	209-00011-**xx**	Elastomeric strip	2
10	Figure 2.4	319-30073-**xx**	Space-frame	1
11	Figure 2.5	252-00011-**xx**	Speaker	1
12	Figure 2.5	307-01024-**xx**	Speaker membrane	1
13	Figure 2.5	311-03114-**xx**	Keypad	1
14	Figure 2.5	262-00003-**xx**	Short light pipe	2
15	Figure 2.5	262-00004-**xx**	Long light pipe	2
16	Figure 2.5	008-00031-**xx**	LCD	1

Note
The characters **xx** in an IPN (internal part number) stand for the issue number. Items in the control head will always be the latest issue at the time the control head is manufactured.

Speaker and Microphones

A speaker is always fitted, although in certain installations it is not used and therefore not connected to the control-head board. (The connecting wires are not shown in the figures.) A cloth membrane for the speaker is fixed to the speaker grille on the inside of the front panel. Figure 2.5 also shows the two parts of a concealed microphone — the microphone capsule and a rubber seal. These are fitted in a recess in the front panel next to the speaker. The leads from the capsule are soldered to pads on the control-head board. Before the microphone is fitted a small hole is drilled in the recess to provide an acoustic path to the microphone. The hole is covered by the rubber seal to ensure that the control head remains sealed to IP54 standards. The concealed microphone is an optional accessory like the dynamic microphone; both are described in the accessories manual.

Figure 2.5 Interior of a control head with UI showing the parts remaining after the removal of the space-frame

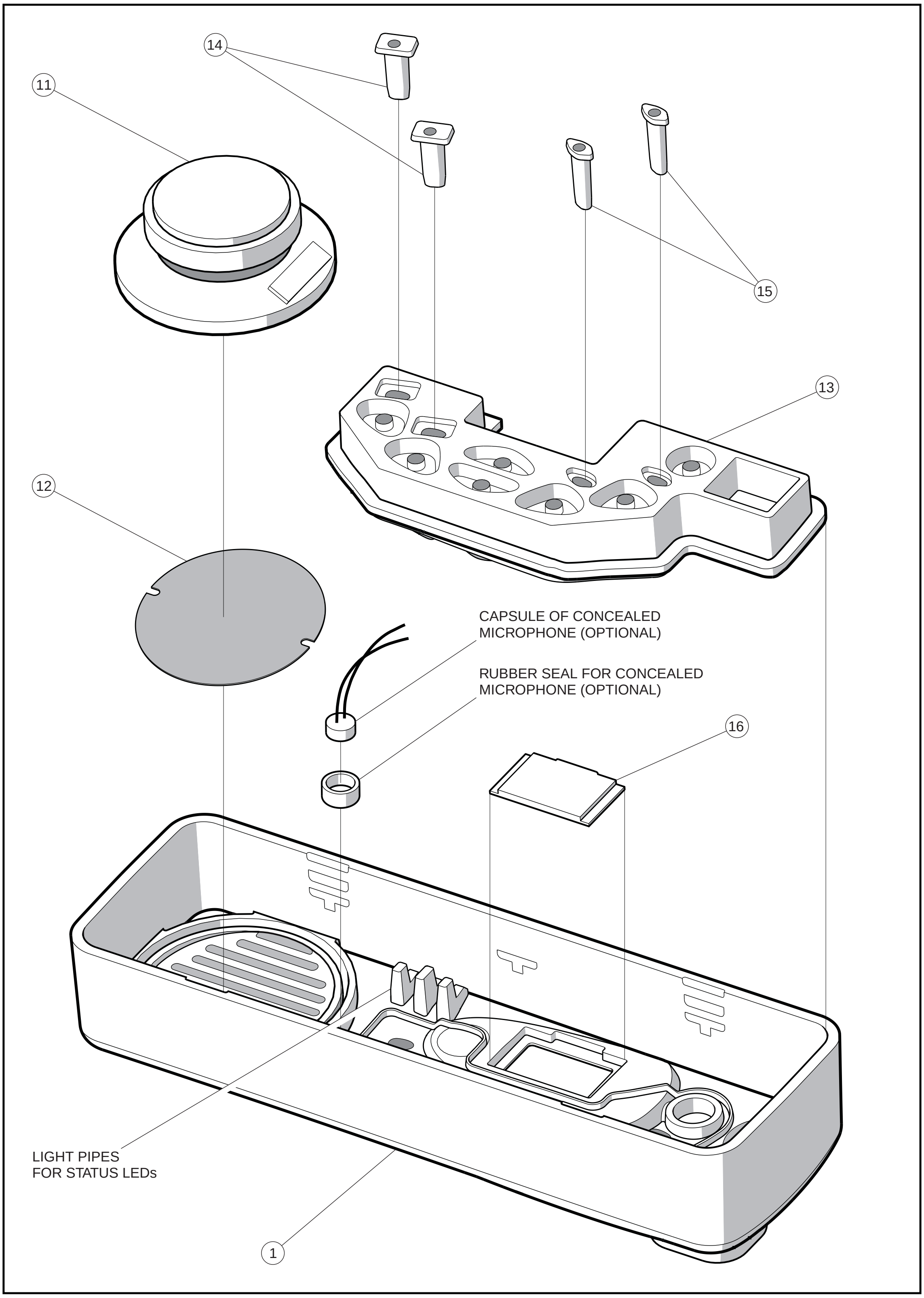
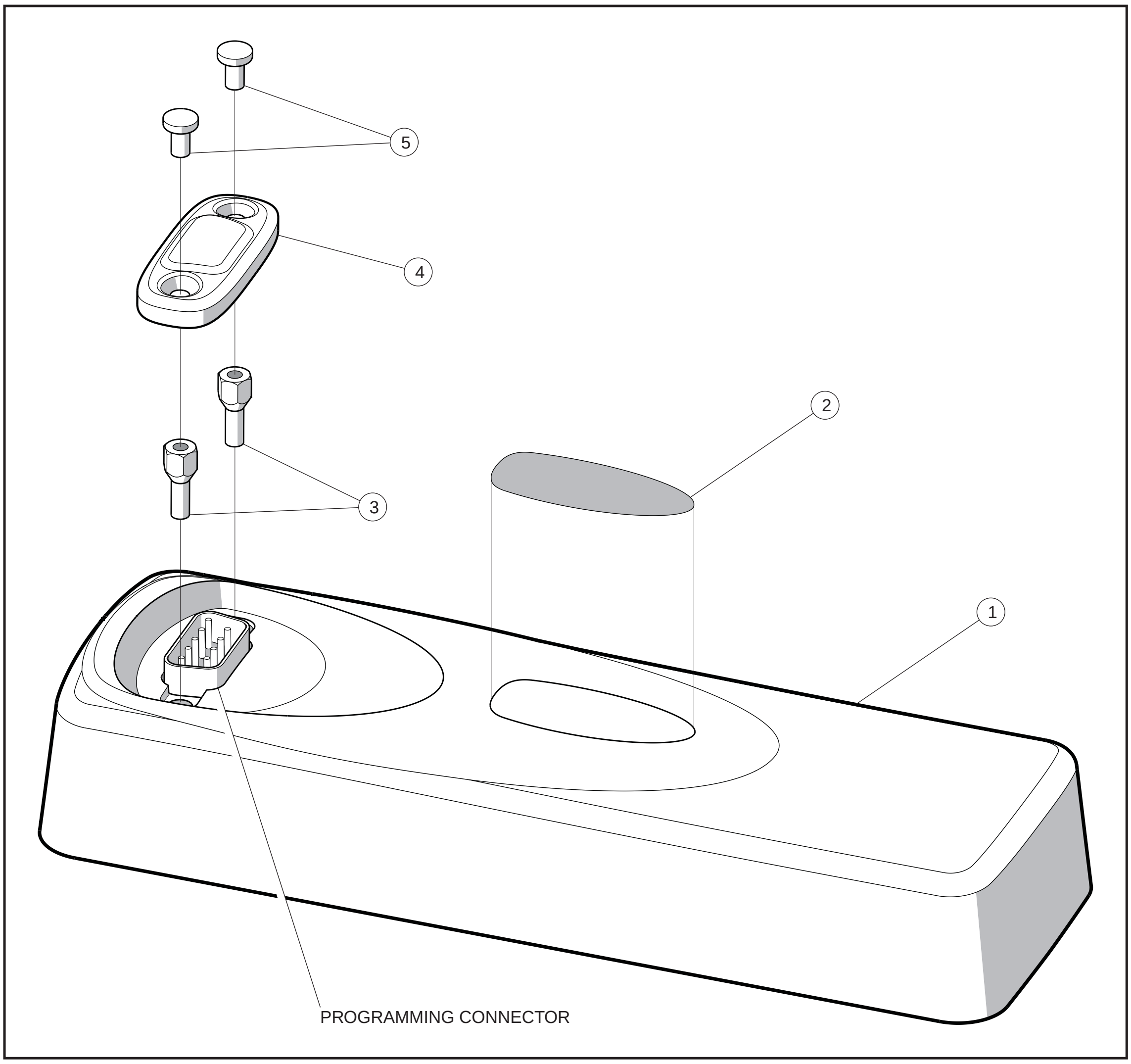


Figure 2.6 Exterior of the blank control head



Parts of Blank Control Head

Figure 2.6 and Figure 2.7 illustrate the parts of the blank control head. Details of the parts are summarised in Table 2.2. Figure 2.6 shows the exterior of the control head. Illustrated are the front panel and the cover seal for the programming connector. When the connector is not in use, the seal is fitted to ensure that the control head is sealed to IP54 standards. Figure 2.7 shows the interior of the control head. There is provision in the blank control head for the fitting of a custom circuit board. Otherwise, as shown in the figure, only the control-head loom is fitted. The programming connector at one end of the loom is screwed to the front panel. The female-to-female adaptor needed for connection of the other end to the radio body is supplied as part of the loom.

Figure 2.7 Interior of the blank control head

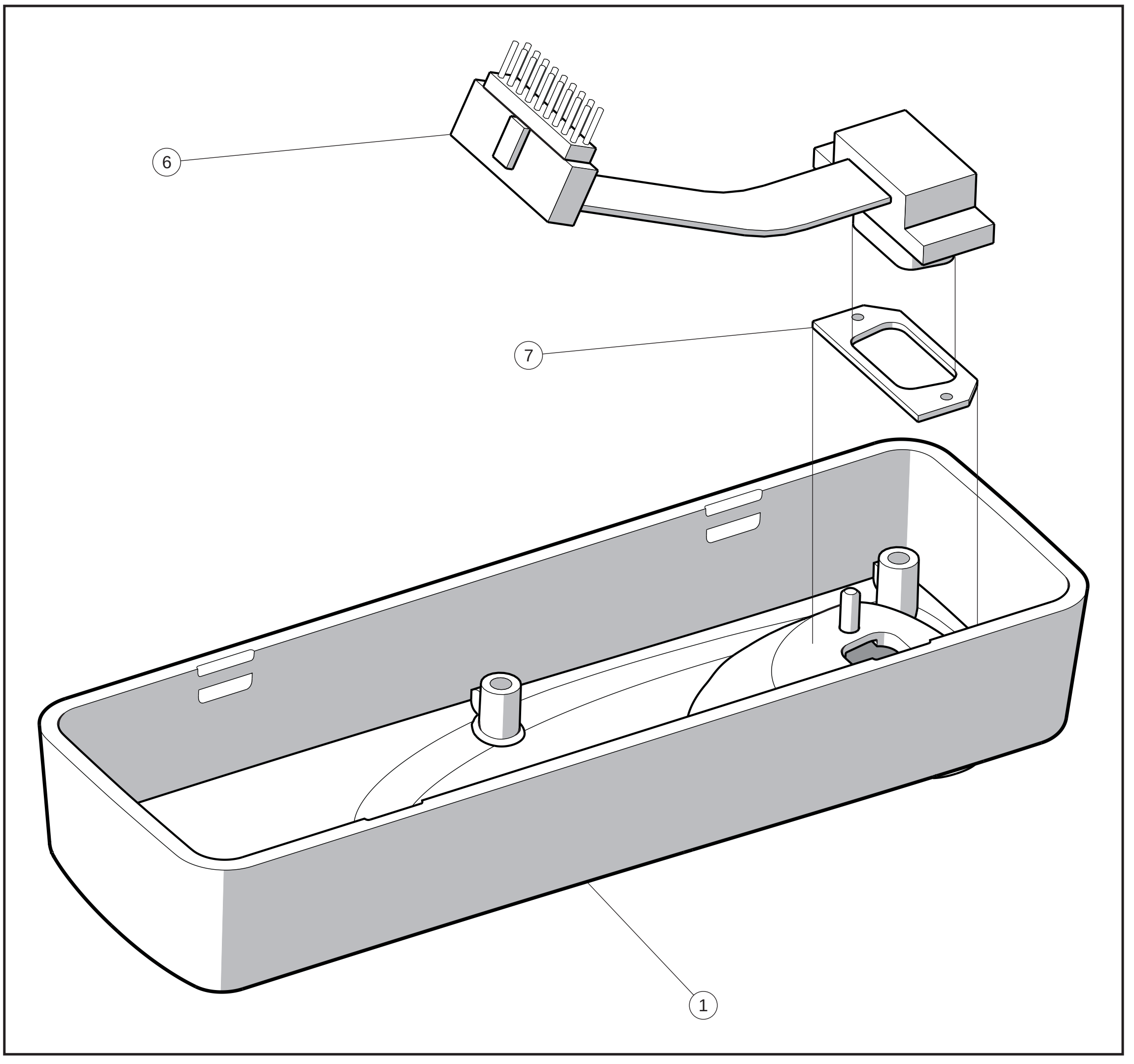


Table 2.2 Parts of the blank control head

Index	Reference	IPN	Description	Quantity
1	Figure 2.6	316-06786-**xx**	Front panel of blank control head	1
2	Figure 2.6	312-01095-**xx**	Label with Tait logo	1
3	Figure 2.6	354-01043-**xx**	Lock-nut for programming connector	1 pair
4	Figure 2.6	362-01108-**xx**	Cover seal for programming connector	1
5	Figure 2.6	347-00011-**xx**	UNC 4-40 x 3/16-inch pan Pozi screw for cover seal	2
6	Figure 2.7	219-02902-**xx**	Control-head loom for blank control head	1
7	Figure 2.7	362-01111-**xx**	Foam seal for programming connector	1

Note
The characters **xx** in an IPN stand for the issue number. Items in the control head will always be the latest issue at the time the control head is manufactured.

Parts of Radio Body

Figure 2.8 to Figure 2.12 illustrate the parts of the radio body. Details of the parts are summarised in Table 2.3. Figure 2.8 shows the two main assemblies that make up the radio body — the lid assembly and the chassis assembly. Also shown are the cover for the radio body and the control-head seal detached from the chassis. The cover label shown in the figure is permanently fixed to the cover. The screws secure the lid to the chassis. The parts of the lid assembly and chassis assembly are shown in the remaining figures.

Lid Assembly

Figure 2.9 and Figure 2.10 show the parts of the lid assembly. Any internal options board is mounted inside the lid, and this case is illustrated in Figure 2.10. The main seal shown in both figures is an O-ring that fits in a groove in the wall of the lid. This seal ensures that the lid is properly sealed to the chassis. Figure 2.9 also shows the bung that seals the aperture provided in the lid for an external options connector. Figure 2.10 shows a typical large options board. A cover seal is supplied for the board’s external options connector. The options loom connects the options board to the internal options connector on the main board. The latter connector is indicated in Figure 2.12.

Chassis Assembly

Figure 2.11 and Figure 2.12 show the parts of the chassis assembly. Illustrated in Figure 2.11 are the chassis and the main board, digital board, and heat-transfer block of the main-board assembly. Also shown are the bung for the auxiliary connector and the seal needed for the RF connector. The screws secure the main-board assembly in the chassis. Figure 2.12 shows the heat-transfer block detached from the main board. All the parts associated with the block are illustrated; the principal parts are inner and outer foam seals needed for the auxiliary connector, and a rubber seal for the power connector. The lock washer and hexagonal nut are supplied as integral parts of the RF connector. The screws secure the heat-transfer block to the main board.

Figure 2.8 Cover, control-head seal, lid assembly, and chassis assembly of the radio body

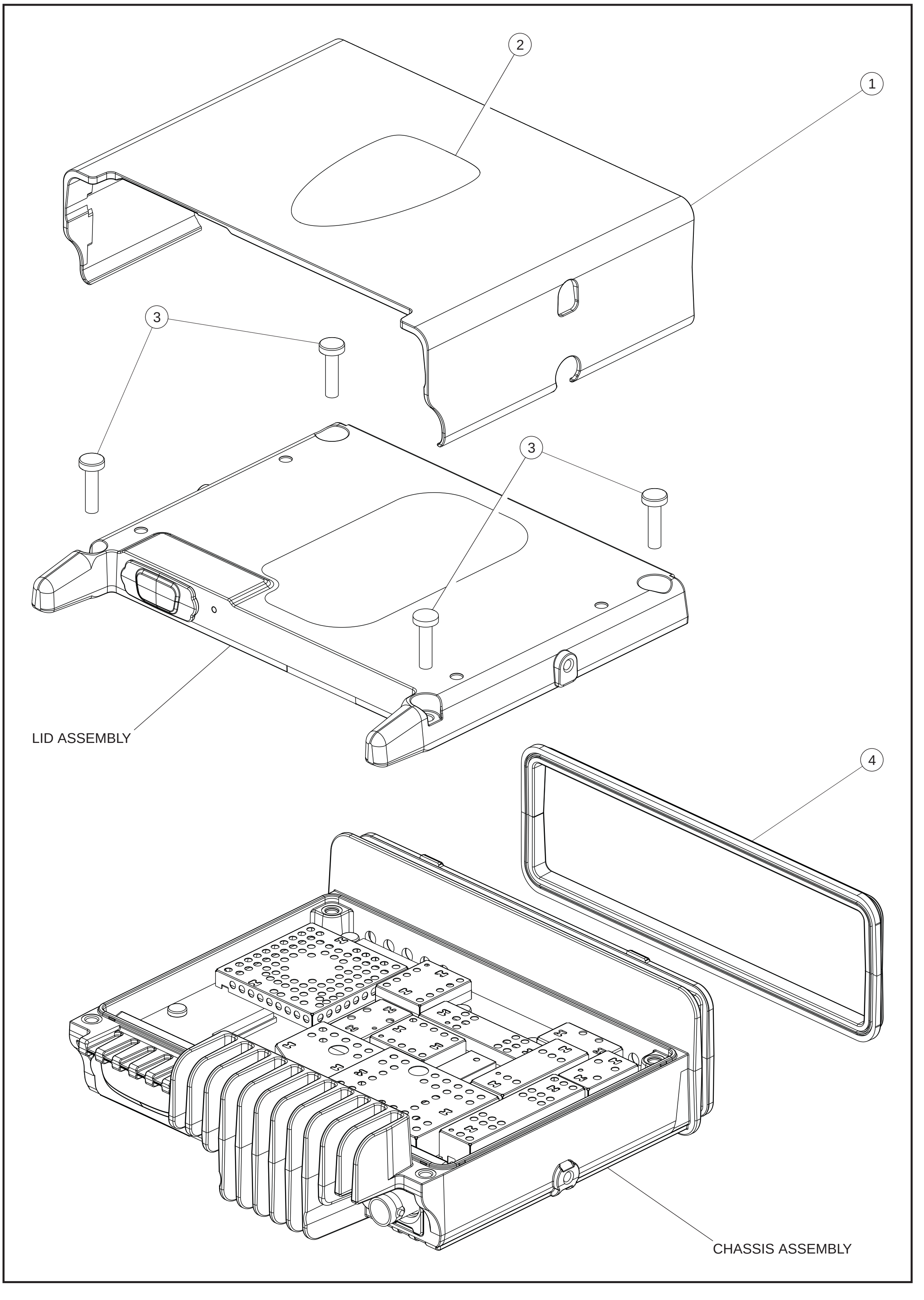
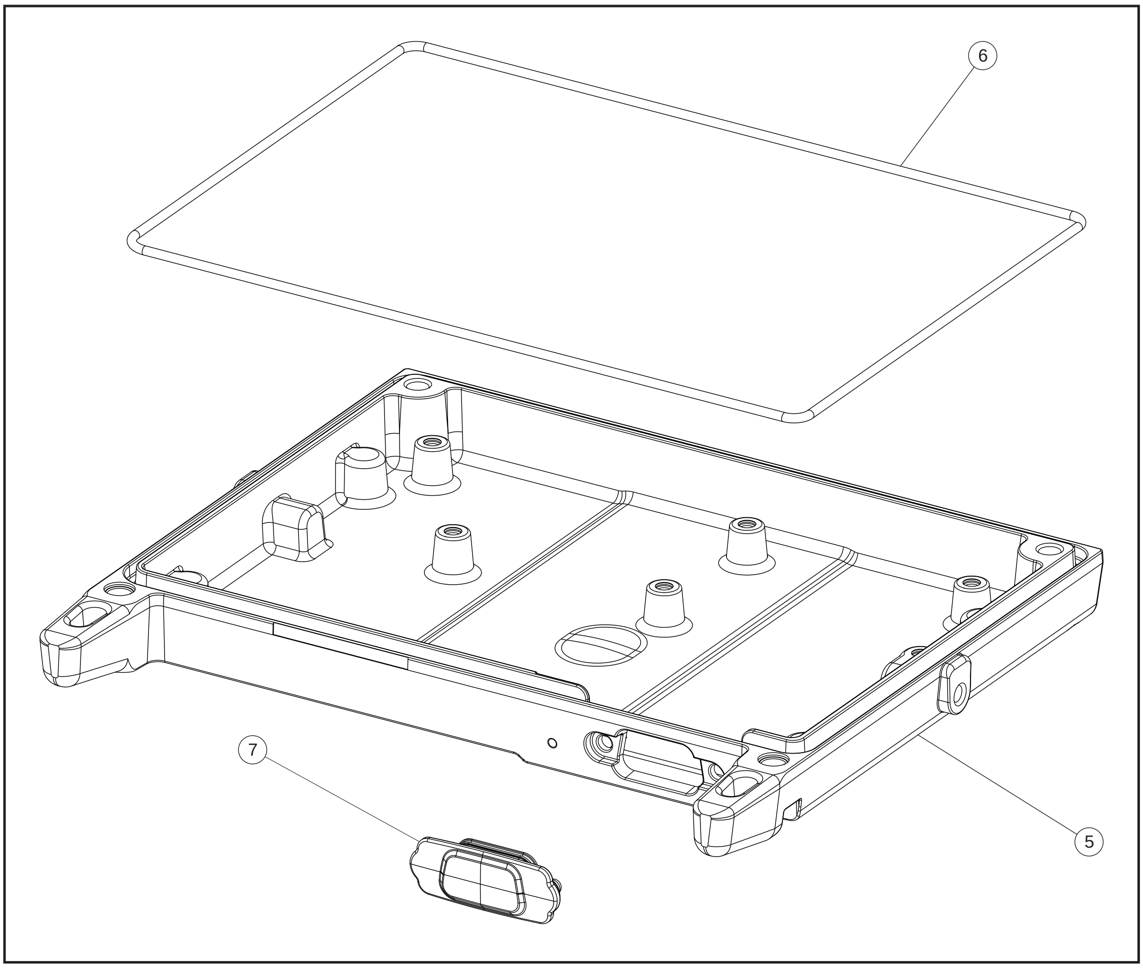


Figure 2.9 Parts of the lid assembly



Dissipation of Heat

Heat needs to be dissipated from the interior of the radio body and, in particular, from the following components on the main board:

- 9 V regulator
- audio PA (power amplifier)
- two RF PAs
- driver for RF PAs

These components are discussed in Section 3. The mechanisms by which the heat is conducted away in each case are described below.

Dissipation of Heat from Radio Interior

Heat from the radio interior is conducted via the heat-transfer block to the cooling fins at the rear, where it is radiated away. The ridged underside of the chassis augments the dissipation of heat. The rear face of the block is in contact with the chassis where the fins are situated. A coating of thermal paste on the rear face ensures the necessary thermal contact between the two surfaces. The coated area is shown in both Figure 2.11 and Figure 2.12.

Figure 2.10 Parts of the lid assembly with an internal options board

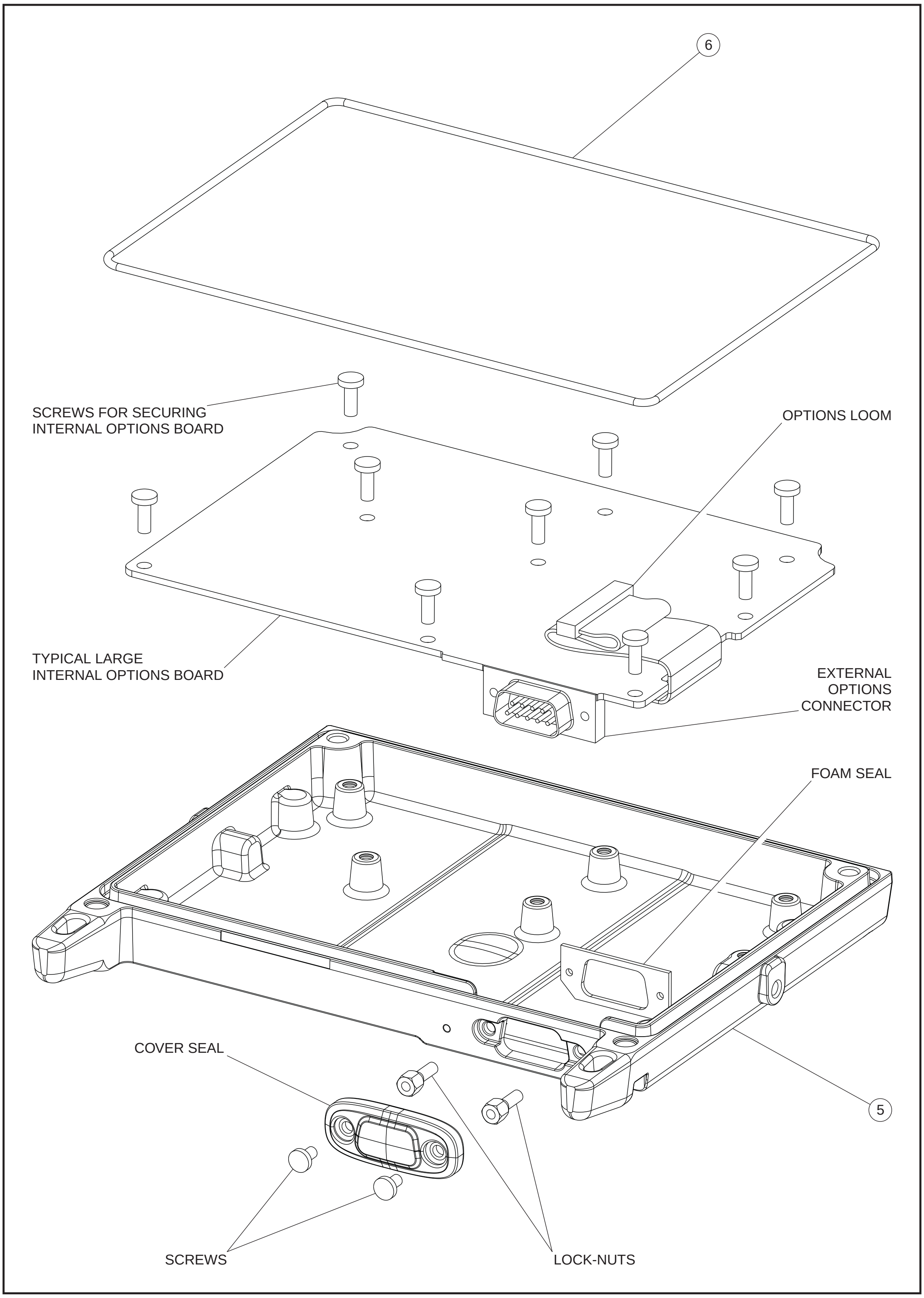


Table 2.3 Parts of the radio body

Index	Reference	IPN	Description	Quantity
1	Figure 2.8	303-23166-**xx**	Cover	1
2	Figure 2.8	365-01712-**xx**	Label for cover	1
3	Figure 2.8	349-02067-**xx**	M4 x 16 screw for lid of radio body	4
4	Figure 2.8	362-01115-**xx**	Control-head seal	1
5	Figure 2.9	312-01091-**xx**	Lid of radio body	1
6	Figure 2.9	362-01109-**xx**	Main seal in lid	1
7	Figure 2.9	302-50000-**xx**	Bung for aperture for external options connector	1
8	Figure 2.11	303-11225-**xx**	Chassis of radio body	1
9	Figure 2.11	349-02066-**xx**	Internal M3 x 10 screw for main-board assembly	5
10	Figure 2.11	362-01113-**xx**	Seal for RF connector	1
11	Figure 2.11	349-02067-**xx**	External M4 x 16 screw for main-board assembly	2
12	Figure 2.11	302-50001-**xx**	Bung for auxiliary connector	1
13	Figure 2.12	349-02066-**xx**	M3 x 10 screw for heat-transfer block	3
14	Figure 2.12	308-13147-**xx**	Heat-transfer block	1
15	Figure 2.12	362-01114-**xx**	Rubber seal for power connector	1
16	Figure 2.12	354-01043-**xx**	Lock-nut for auxiliary connector	1 pair
17	Figure 2.12	362-01112-**xx**	Outer foam seal for auxiliary connector	1
18	Figure 2.12	362-01110-**xx**	Inner foam seal for auxiliary connector	1

Note
The characters **xx** in an IPN stand for the issue number. Items in the radio body will always be the latest issue at the time the radio body is manufactured.

Dissipation of Heat from Regulator and Audio PA

Heat from the regulator and audio PA is conducted to the underside of the chassis via a screw boss on the floor of the chassis. The boss is in contact with the underside of the PCB where the components are mounted. A coating of thermal paste on the screw boss ensures the necessary thermal contact between the boss and the PCB. The coated area is shown in Figure 2.11.

Dissipation of Heat from RF PAs and Driver

Heat from the RF PAs and driver is conducted to the cooling fins via a copper plate and the heat-transfer block. The copper plate is fixed to the underside of the PCB beneath these components. It is in contact with a large metal block projecting from the front of the heat-transfer block. A coating of thermal paste on the plate ensures the necessary thermal contact between the surfaces. The contact area on the heat-transfer block is shown in Figure 2.12.

Figure 2.11 Parts of the chassis assembly

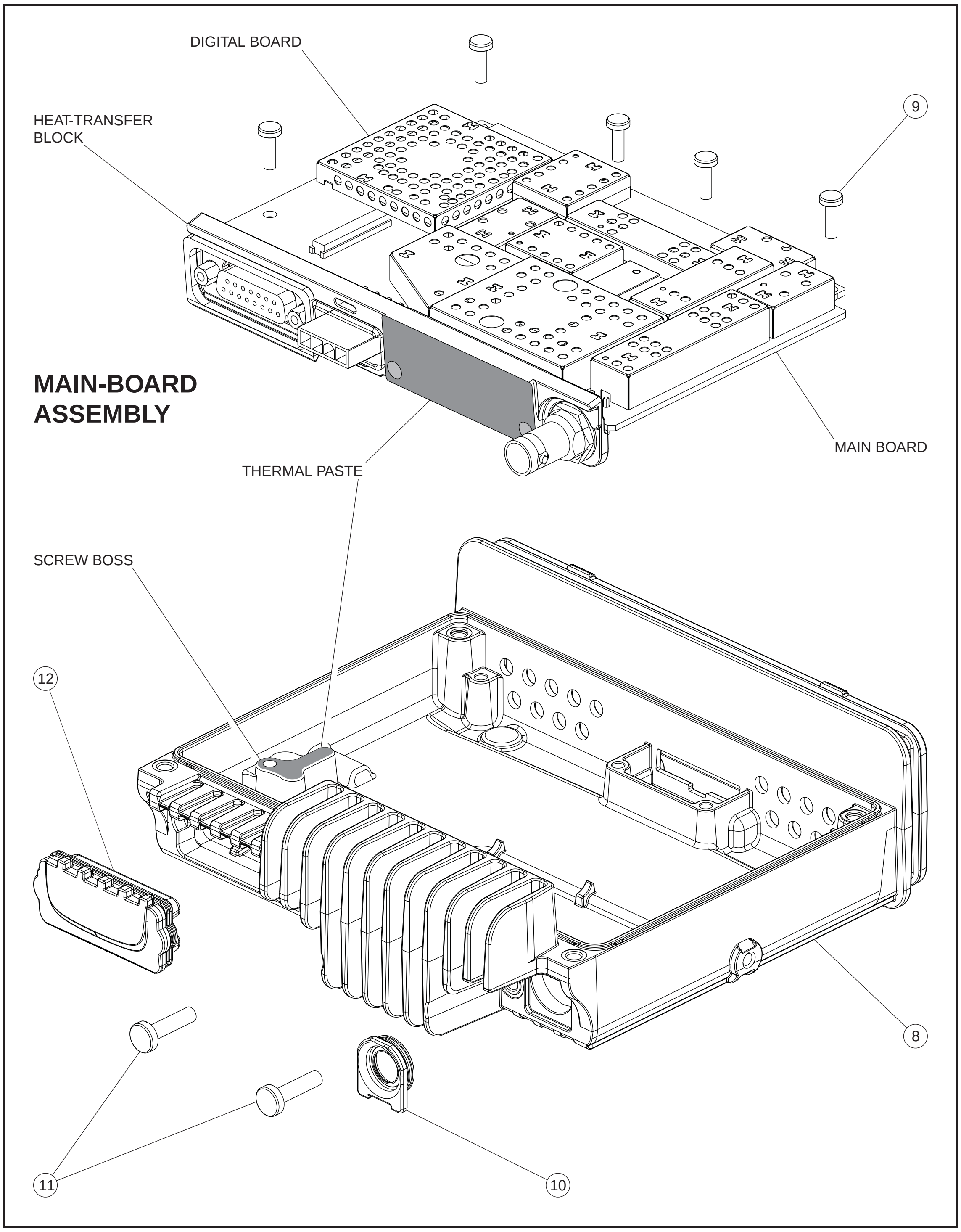


Figure 2.12 Parts of the main-board assembly

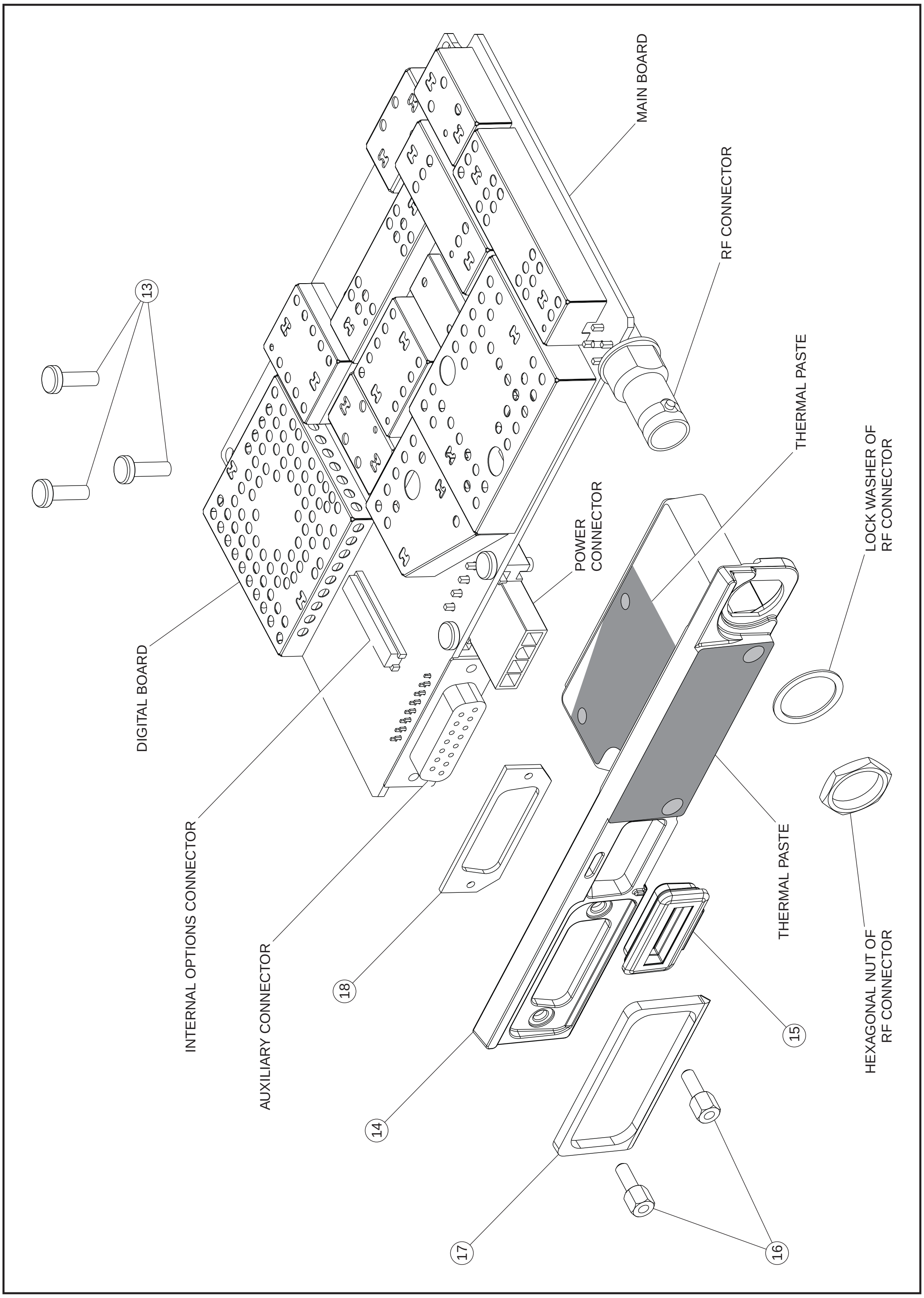
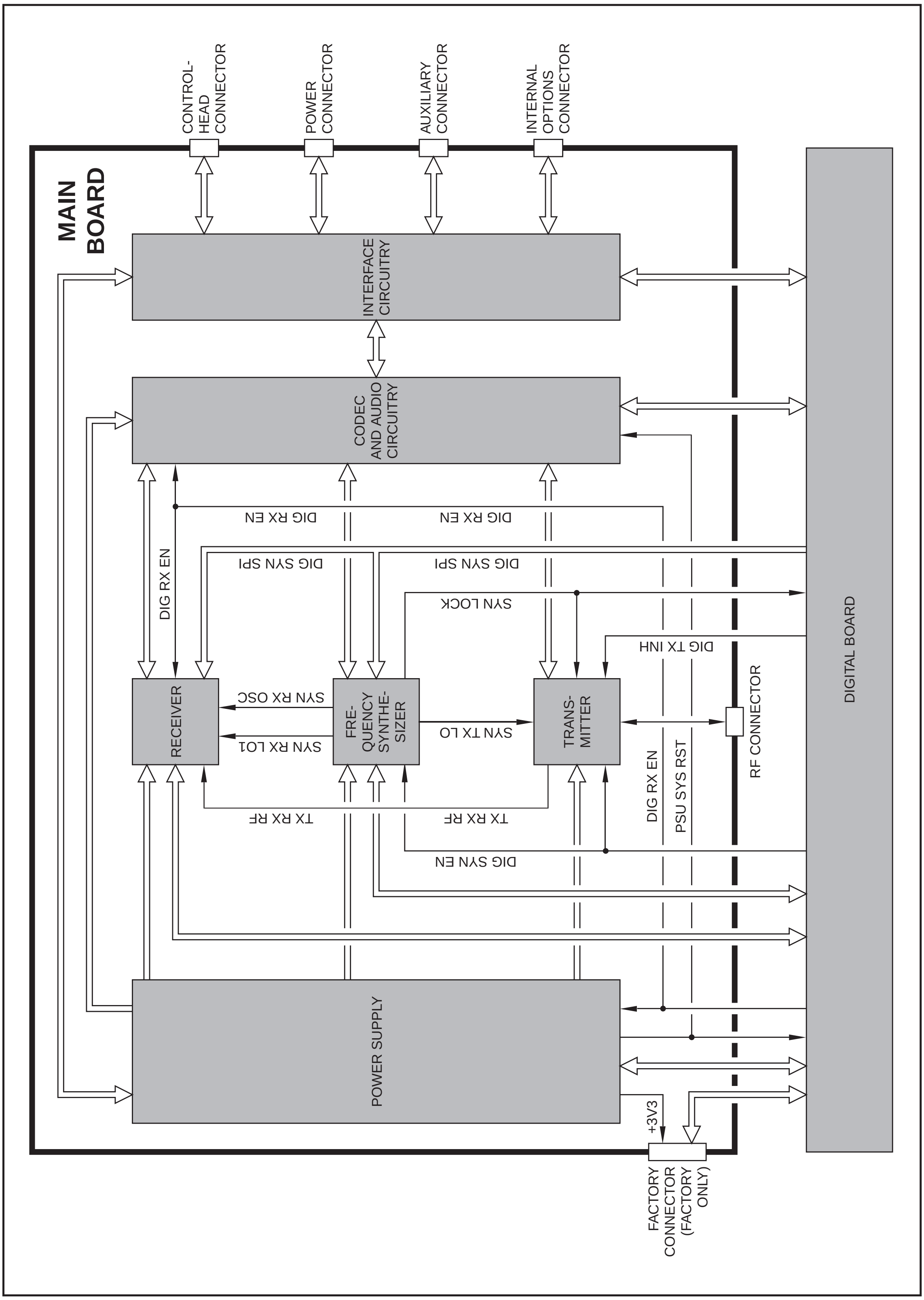


Figure 2.13 Block diagram of the main board of the radio body



2.2 Architecture of Radio

Introduction

In this subsection the architecture of the radio is described. The different circuit modules of the control-head, main and digital boards introduced in Subsection 2.1 (on page 33) are identified and their essential functions are summarised. The optional circuit boards mentioned in Subsection 2.1 are covered in other manuals.

Control Head

The control heads with UI house a control-head board with the circuitry needed for the controls and indicators on the front panel. There is provision for an optional circuit board for use with dynamic microphones or with a concealed microphone inside the control head. There is also provision for the fitting of an optional third-party circuit board in the blank control head.

Circuit Boards in Control Head

The operation of the control-head board is summarised in Subsection 2.3 (on page 53). The circuit board for concealed and dynamic microphones is described in the accessories manual. The fitting of third-party circuit boards in the blank control head is discussed in the application manual for 3DK hardware developers.

Radio Body

The radio body houses a main board with the transmitter, receiver and associated circuitry, and a digital board with the microprocessor and associated circuitry. The digital board is reflow-soldered to the main board. There is also provision for an internal options board to be connected to the main board.

Circuit Boards and Modules in Radio Body

The different circuit modules of the main board are discussed below and the operation of the circuitry is described in Subsection 2.4 (on page 54) and Subsection 2.5 (on page 57). The different internal options boards are discussed in the accessories manual and the 3DK manuals.

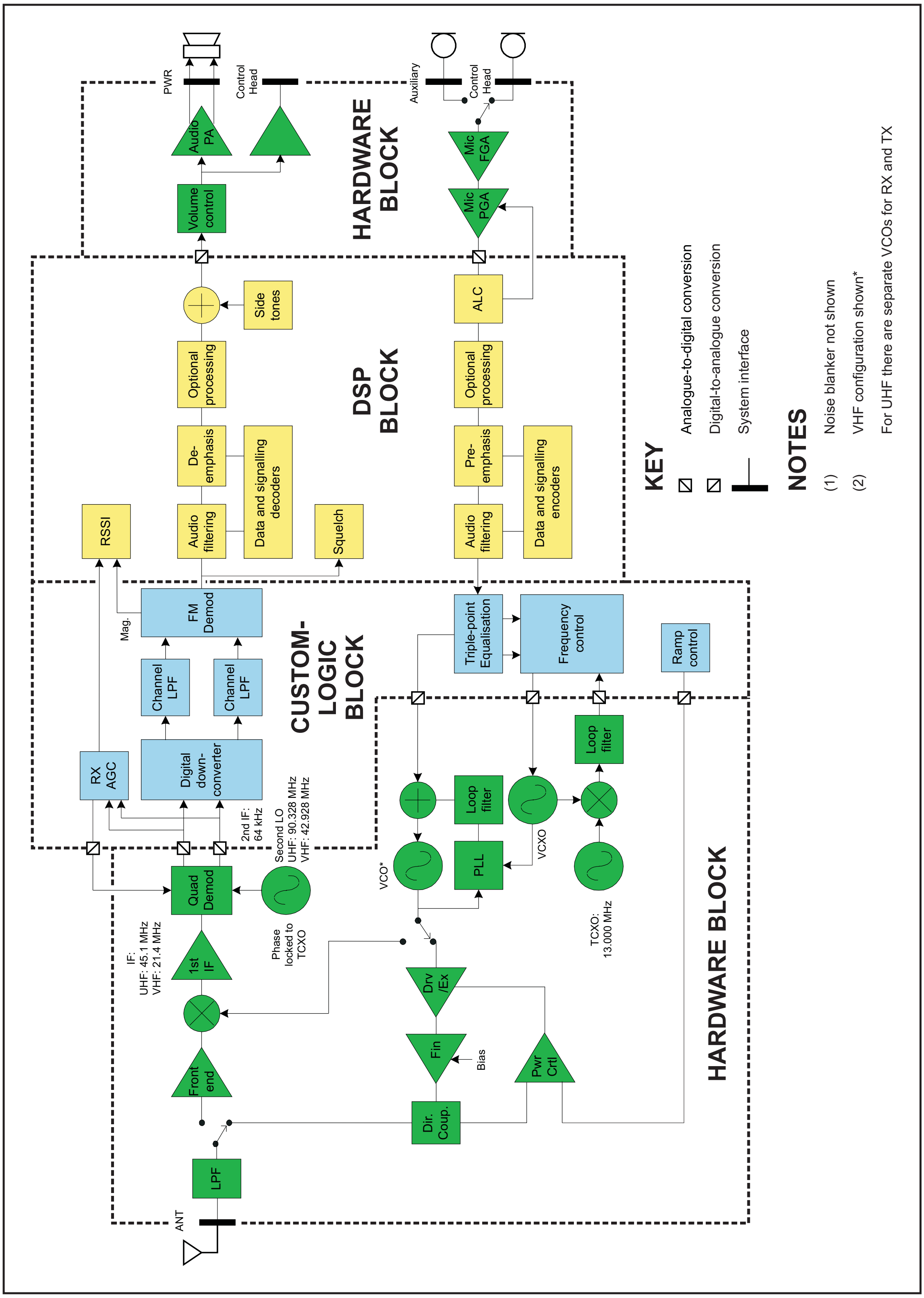
Modules of Main Board

The control-head, main and digital boards, and the connectors on the boards, are illustrated in Figure 1.6 of the previous section. Figure 2.13 is a block diagram showing the main and digital boards and the circuit modules of the main board. These modules are:

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

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

Figure 2.14 Architecture of the TM8100 transceiver



Operation of Radio

Figure 2.14 is a simplified block diagram of the transceiver architecture showing the hardware modules integrated with the software modules. The same DSP (digital signal processor) device includes the software that controls the transceiver and the software constituting the digital-signal-processing blocks in Figure 2.14. The operation of the radio is then best described with reference to Figure 2.14 and with a division into the following two parts:

- operation in receive mode
- operation in transmit mode

Operational descriptions of these two parts are given in Subsection 2.4 (on page 54) and Subsection 2.5 (on page 57) respectively.

2.3 Operation of Control-head Circuitry

User Interface

In this subsection the operation of the control-head circuitry is summarised. A detailed description of the circuitry is given in Section 3 (on page 63). Control heads with UI provide a user interface consisting of:

- seven-segment LCD
- up and down channel-selection keys
- four programmable function keys
- ON/OFF push-button key
- LED indicators
- volume control
- internal speaker
- microphone connector

The LCD displays one or two characters depending on the type of control head. The microphone connector may also be used for the connection of a handset or programming lead. If required, a concealed microphone may be fitted inside the control head.

Connectors and Circuit Boards

There is an 18-way electrical interface between the control head and radio body. The physical connection is via an 18-way loom. The control head normally contains a single PCB assembly called the control-head board. The differences between the boards for the one- and two-digit-display control heads are discussed in Section 3 (on page 63). If a dynamic microphone is used or a concealed microphone fitted, a small circuit board must be mounted on the control-head board. The added board has the necessary amplification, filtering and switching functions. The internal speaker is connected to the control-head board via a lead with a mating connector so that it can be easily disconnected.

Control-head Board

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

2.4 Operation in Receive Mode

Receive Path

This subsection describes the functioning of the radio in receive mode. Detailed descriptions of the circuitry involved are given in Section 3 (on page 63). As shown in Figure 2.14, the receive path exists in the hardware, custom-logic and DSP domains. From a functional point of view there are three major parts:

- RF hardware
- digital base-band processing
- audio processing and signalling

These functional parts are described in detail below.

RF Hardware

Front-end Circuitry and First IF

The front-end hardware amplifies and image-filters the received RF spectrum, then down-converts the desired channel frequency to a first intermediate frequency IF1 of 45.1 MHz (UHF) or 21.4 MHz (VHF) where coarse channel filtering is performed. The first LO (local oscillator) signal is obtained from the frequency synthesizer and is injected on the low side of the desired channel frequency for all bands. In receive mode the modulation to the frequency synthesizer is muted. See Subsection 2.5 (on page 57) for a description of the synthesizer. The output of the first IF (intermediate frequency) stage is then down-converted using an image-reject mixer to a low IF of 64 kHz.

Quadrature Demodulator

The LO for the image-reject mixer (quadrature demodulator) is synthesized and uses the TCXO (temperature-compensated crystal oscillator) as a reference. This ensures good centring of the IF filters and more consistent group-delay performance. The quadrature demodulator device has an internal frequency division of 2 so the second LO operates at 2 x (IF1 + 64 kHz). The quadrature output from this mixer is fed to a pair of ADCs (analogue-to-digital converters) with high dynamic range where it is oversampled at 256 kHz and fed to the custom logic device.

Automatic Gain Control

The AGC (automatic gain control) is used to limit the maximum signal level applied to the image-reject mixer and ADCs in order to meet the requirements for intermodulation and selectivity performance. Hardware gain control is performed by a variable-gain amplifier within the quadrature demodulator device driven by a 10-bit DAC (digital-to-analogue converter). Information about the signal level is obtained from the IQ (in-phase and quadrature) data output stream from the ADCs. The control loop is completed within custom logic. The AGC will begin to reduce gain when the combined signal power of the wanted signal and first adjacent channels is greater than about −70 dBm. In the presence of a strong adjacent-channel signal it is therefore possible that the AGC may start acting when the wanted signal is well below −70 dBm.

Noise Blanking (B1 band only)

For the B1 band only, noise-blanking circuitry is included. The noise blanker removes common sources of electrical interference such as vehicle ignition noise. The programming application allows for disabling the noise blanker if it is not required. The noise blanker functions by sampling the RF input to the receiver for impulse noise and momentarily disconnecting the first LO for the duration of the impulse. The response time of the noise blanker is very fast (tens of nanoseconds) and is shorter than the time taken for the RF signal to pass through the front-end hardware, so that the LO is disabled before the impulse reaches the IF stage where it could cause crystal filter ring.

Digital Base-band Processing

Custom Logic

The remainder of the receiver processing up to demodulation is performed by custom logic. The digitised quadrature signal from the RF hardware is digitally down-converted to a zero IF, and channel filtering is performed at base-band. Different filter shapes are possible to accommodate the various channel spacings and data requirements. These filters provide the bulk of adjacent channel selectivity for narrow-band operation. The filters have linear phase response so that good group-delay performance for data is achieved. The filters also decimate the sample rate down to 48 kHz. Custom logic also performs demodulation, which is multiplexed along with AGC and amplitude data, and fed via a single synchronous serial port to the DSP. The stream is demultiplexed and the demodulation data used as an input for further audio processing.

Noise Squelch

The noise squelch process resides in the DSP. The noise content above and adjacent to the voice band is measured and compared with a preset threshold. When a wanted signal is present, out-of-band noise content is reduced and, if below the preset threshold, is indicated as a valid wanted signal.

Received Signal Strength Indication

Received signal strength is measured by a process resident in the DSP. This process obtains its input from the demodulator (value of RF signal magnitude) and from the AGC (value of present gain). With these two inputs and a calibration factor, the RF signal strength at the antenna can be accurately calculated.

Calibration

The following items within the receiver path are calibrated in the Factory:

- front-end tuning
- AGC
- noise squelch
- RSSI (received signal strength indication)

Information on the calibration of these items is given in the on-line help facility of the calibration application.

Audio Processing and Signalling

Audio Processing

Raw demodulated data from the receiver is processed within the DSP. The sample rate at this point is 48 kHz with signal bandwidth limited only by the IF filtering. Scaling (dependent on the bandwidth of the RF channel) is then applied to normalise the signal level for the remaining audio processing. The sample rate is decimated to 8 kHz and bandpass audio filtering (0.3 to 3 kHz) is applied. De-emphasis is then applied to cancel out the receive signals pre-emphasised response and improve signal-to-noise performance. Optional processing such as decryption or companding is then applied if applicable.

Data and Signalling Decoders

The data and signalling decoders obtain their signals from various points within the audio processing chain. The point used depends on the bandwidth of the decoders and whether de-emphasis is required. Several decoders may be active simultaneously.

Side Tones

Side tones are summed in at the end of the audio-processing chain. These are tones that provide some form of alert or give the user confidence an action has been performed. The confidence tones may be generated in receive or transmit mode. The side-tone level is a fixed proportion (in the order of −10 dB) relative to full scale in the receive path.

CODEC

The combined audio and side-tone signal is converted to analogue form by a 16-bit DAC with integral anti-alias filtering. This is followed by a programmable-gain amplifier with a range of 45 dB in 1.5 dB steps. The amplifier performs volume control and muting. The DAC and volume control are part of the same CODEC device (AD6521).

Output to Speakers

The output of the CODEC is fed to an audio power amplifier and to the control head via a buffer amplifier. The output configuration of the audio power amplifier is balanced and drives an internal speaker and, optionally, an external speaker. The speaker loads are connected in parallel rather than being switched. The power delivered to each speaker is limited by its impedance. The internal speaker has 16 Ω impedance whereas the external speaker can be as low as 4 Ω.

2.5 Operation in Transmit Mode

Transmit Path

This subsection describes the functioning of the radio in transmit mode. Detailed descriptions of the circuitry involved are given in Section 3 (on page 63). As shown in Figure 2.14, the transmit path exists in the hardware, custom-logic and DSP domains. From a functional point of view there are three major parts:

- audio processing and signalling
- frequency synthesizer
- RF transmitter

These functional parts are described in detail below.

Audio Processing and Signalling

Microphone Input

The input to the transmitter path begins at the microphone input. There are two microphone sources: a fist microphone connected to the control head and an auxiliary microphone connected via the auxiliary or external options connector. Only electret-type microphones are supported. Support for optional dynamic fist microphones is facilitated by a hardware amplifier and filter; this circuitry is mounted on a separate board that needs to be installed in the control head.

Analogue Processing of Microphone Signal

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

Frequency Synthesizer

Main Parts of Synthesizer

As shown in Figure 2.14, 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. Detailed descriptions of the circuitry are given in Section 3 (on page 63). 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 25 Hz. In transmit mode the loop locks to the transmit frequency, whereas in receive mode it locks to the receive frequency minus the first IF 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 25 kHz. The reference frequency input from the FCL is also divided down to approximately 25 kHz. 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 ± 0.004 MHz. 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 13.000 MHz TCXO frequency. The mixer, after low-pass filtering to remove unwanted products, produces a nominal frequency of 12 kHz. 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 analogue 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 48 kHz. In traditional dual-point modulation systems the modulation is applied, in analogue 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 TM8100 radio, 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 analogue 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). The FCL offset will usually be different for receive and transmit modes.

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.

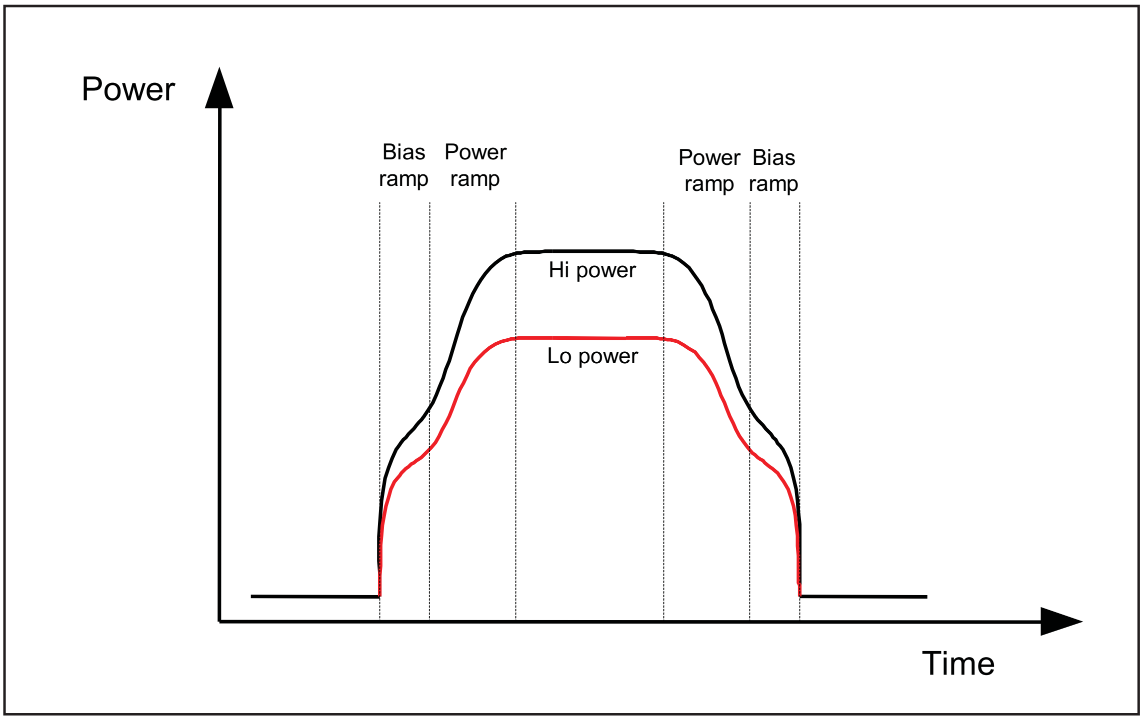
Calibration

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.

Figure 2.15 Typical ramping waveform



RF transmitter

RF Power Amplifier and Switching

The RF PA (power amplifier) is a four-stage line-up with approximately 42 dB 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 200 mW output. This is followed by an LDMOS driver producing up to 2 W output that is power-controlled. The final stage consists of two parallel LDMOS devices producing enough power to provide 25 W 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, to the PIN switch. The PIN switch toggles the antenna path between the receiver and transmitter in receive and transmit modes respectively. 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 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 carefully controlled in order to achieve the correct overall wave shape and meet the specification for transient ACP (adjacent channel power). A typical ramping waveform is shown in Figure 2.15.

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 −10 dBm 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 Circuit Descriptions

Scope of Section

This section contains descriptions of the circuitry of the control-head board and each of the modules of the main board. The latter are the transmitter, receiver, frequency synthesizer and FCL, CODEC and audio circuitry, power supply, and interface circuitry. Since the digital board is not serviceable at level-2, no description of the digital circuitry is given.

3.1 Control-head Board

Introduction

This subsection describes the circuitry of the control-head boards for the one- and two-digit-display control heads. The boards differ only in their layouts; the components are identical. The circuit description given below is sufficiently general to be applicable to both boards.

Connectors and UI Devices

The control-head board includes the circuitry for the seven keys, 18 LEDs, and the LCD device of the control head. Also mounted on the board are the volume-control potentiometer and the following five connectors:

- control-head connector
- microphone connector
- speaker connector
- two connectors for optional circuit board

Protection circuitry is provided for the microphone connector. The optional circuit board is installed when a dynamic microphone is used or a concealed microphone is fitted.

Basic Circuitry

The LCD driver is based on IC2, IC5 and IC7. Electrical contact between the control head and the LCD itself is via two elastomeric strips as described in Subsection 2.1 (on page 33). There are pads on the board for the seven keys — four function keys, two channel-selection keys, and an ON/OFF key. The device IC4 reads the status of the function and channel-selection keys. Of the 18 LEDs, there are red, orange and green STATUS LEDs, and four green LEDs for the function keys, as well as 11 green LEDs for back-lighting — one for each key and four for the LCD. The four dual switching transistors Q1 to Q4 control the switching of the LEDs; the transistors are driven by IC3.

Serial Peripheral Interface

The control-head board uses an SPI (serial peripheral interface) to control the display on the LCD, turn back-lighting on and off, control the STATUS LEDs, and read the status of the keys. The interface consists of the following four lines at the control-head connector:

- pin 11: data out CH SPI DO
- pin 12: latch line CH LE
- pin 15: data in CH SPI DI
- pin 16: clock CH SPI CLK

The handling of the data is described below.

Data Input and Output

Data that are input to the control head are clocked through the LCD driver and daisy-chained to a shift register. Once all the data have been clocked in, the latch line is driven low. On this falling edge all the outputs (LEDs and LCD segments) are driven to their new state. When the latch line is driven high, the state of each key is latched into another shift register. The data are then clocked out back to the radio body so that the radio can respond accordingly.

LCD Driver

An oscillator is used to run the LCD. It oscillates at about 60 Hz and employs a Schmitt trigger and D flip-flop to ensure a 50% duty cycle to the LCD. A reset circuit is required because the reset from the main board is not routed to the control head. The reset circuit also employs a Schmitt trigger.

Volume Control

The volume-control potentiometer is linear and passes the DC voltage signal VOL WIP DC to the radio body. The signal is read by an ADC on the main board, and the volume is adjusted accordingly.

3.2 Transmitter

Broadband Exciter

The transmitter circuitry is given on sheet 3 of the circuit diagram for the main board. The broadband exciter is a common element in all the variants of the TM8100 mobile radio, as it operates across all frequencies from 66 MHz to 940 MHz. It is made up of Q300 and Q303, which amplify the signal provided by the frequency synthesizer from its level of 7 to 9 dBm up to 24.5 dBm for the frequency band from 66 to 530 MHz and slightly less than this for the bands covering 530 MHz to 940 MHz. The exciter operates in full saturation, thereby maintaining a constant output power independent of the varying input power level supplied by the synthesizer (7 to 9 dBm).

Power Amplifier

The power amplifier comprises the driver amplifier Q306 and two paralleled final devices Q309 and Q310. The 24.5 dBm signal from the broadband 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 42 W when measured after the series capacitors at the start of the directional coupler (C348, C349, C350). The high-level RF signal passes via the directional coupler, the transmit-receive PIN switch, and the low pass filter, through to the antenna. The low-pass filter 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 (1, 5, 12 and 25 watts). 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. 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 current that this device can draw.

Directional Coupler

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 the lowest power setting.

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.

3.3 Receiver

Introduction

The receiver circuitry is given on sheet 4 of the circuit diagram for the main board. The receiver is of the triple-conversion superheterodyne type. The first two IF stages are implemented in hardware; the third stage is implemented in the FPGA (field-programmable gate array) of the digital board. The FPGA also carries out the demodulation of the received signals.

Front-end Circuitry

The front-end circuitry is a standard varicap-tuned singlet (band-pass filter), followed by an LNA (low-noise amplifier), and then a varicap-tuned doublet (image filter). The varicap tuning voltage CDC RX FE TUNE is provided by a DAC, with voltages calculated from a calibration table stored in non-volatile memory. The two varicap-tuned filters need to be calibrated to ensure that maximum sensitivity is achieved.

First Mixer

The first mixer is a standard diode-ring mixer with SMD (surface-mount device) baluns and a quadruple SMD diode. For the VHF band the receiver includes a circuit for suppressing ignition noise. This circuit momentarily removes the LO signal from the mixer when an ignition noise pulse is detected. The ignition-noise suppressor is selectable on a per-channel basis when the radio is programmed.

First IF Stage and Second Mixer

The first IF stage consists of a crystal channel filter (BPF1), followed by an IF amplifier, and then another crystal filter (BPF2). The second mixer is an IC quadrature mixer with an internal AGC amplifier. This IC has a divide-by-two function on the LO input in order to provide the quadrature LO frequencies required internally. The second LO frequency is synthesized by an integer PLL (IC403), which uses the TCXO frequency SYN RX OSC (13.0000 MHz) as its reference.

Frequencies of IF Stages

The frequency of the first IF stage depends as follows on the frequency band of the radio:

- B1 band: 21.400 029 MHz
- D1 band: 21.400 029 MHz
- H5 band: 45.100 134 MHz
- H6 band: 45.100 134 MHz

The above are nominal values; the actual frequency will differ by a small amount depending on the exact initial frequency of the TCXO. The frequency of the second IF stage will always be precisely 64.000 kHz once the TCXO calibration has been completed. (The TCXO calibration does not adjust the TCXO frequency, but instead adjusts the VCXO frequency, which in turn adjusts the VCO or first LO frequency as well as the frequency of the first IF stage. The second LO frequency remains fixed.) The third IF stage is completely within the FPGA and is not accessible.

Demodulation

Demodulation takes place within the FPGA. Demodulated audio is passed to the DSP of the digital board for processing of the receiver audio signal. Raw demodulated audio can be tapped out from the DSP for use with an external modem. The modem may be connected to the auxiliary connector or to the external options connector when an internal options board is fitted.

Automatic Gain Control

The receiver has an AGC circuit to enable it to cover a large signal range. Most of the circuit functions are implemented in the FPGA. The FPGA passes the AGC signal to the CODEC IC204 for output from pin 14 (IDACOUT) and thence via IC201 as the signal CDC RX AGC to pin 23 of the quadrature mixer IC400. As the antenna signal increases, the AGC voltage decreases.

Channel Filtering

The channel filtering is split between the first and third IF stages. The channel filtering circuit in the first IF stage comprises a pair of two-pole crystal filters. The first filter has a 3 dB bandwidth of 12 kHz, and the second a 3 dB bandwidth of 15 kHz. Most of the channel filtering, however, is implemented in the FPGA. When the radio is programmed, the different filters are selected as assigned by the channel programming. The selectable filters plus the fixed crystal filters result in the following total IF 3 dB bandwidths:

- wide channel spacing : 12.6 kHz
- medium channel spacing: 12.0 kHz
- narrow channel spacing : 7.8 kHz

(The FPGA runs from the DIG SYS CLK signal, which has a frequency of 12.288 MHz.) The receiver requires the TCXO calibration to be completed to ensure that the channel filtering is centred, thereby minimising distortion.

Received Signal Strength Indication

The RSSI is calculated in the FPGA and DSP, and can be passed as an analogue voltage to the internal options interface and the external auxiliary interface. To obtain an accurate estimate of the RSSI (over the signal level and frequency), it is necessary to calibrate the AGC characteristic of the receiver and the front-end gain versus the receive frequency.

3.4 Frequency Synthesizer

Introduction

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 4.5 ms while retaining low noise characteristics in static operation. In the following description of the circuitry, first the necessary power supplies and then the synthesizer itself are discussed. The circuitry is given on sheet 5 of the circuit diagram for the main board.

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 analogue and digital circuitry and uses separate power supplies for each section. The digital section is run on 3 V, while the analogue section is run on approximately 5 V. The VCOs and buffer amplifiers run off a supply of about 5.3 V. The active loop filter requires a supply of 14 to 15 V, and a reference voltage of approximately 2.5 V.

Performance Requirements

Low noise and good regulation of the power supply are essential to the performance of the synthesizer. A 6 V regulator IC provides good line regulation of the 9 V 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 12 V. 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 12 V. The 14 V 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 (switch-mode power supply), which is in turn powered by 9 V. 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 25 kHz reference frequency to give any desired frequency that is an integer multiple of 25 kHz. There are some constraints imposed by the capabilities of the synthesizer hardware, especially the tuning range of the VCOs.

Reference Frequency

The 25 kHz (approximate) reference is obtained by dividing the 13 MHz (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 radio by means of a DC control voltage, typically between 2 V and 12 V. 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 receive mode the output power should be about 7 dBm, whereas in transmit mode it should be about 9 dBm.

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 25 kHz if the output frequency were correct.

Phase-locked Loop

The PLL IC compares the 25 kHz 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 25 kHz 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 radio 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 4.5 ms. (The switching time is measured for a frequency change equal to the first IF plus 10 MHz or 1 MHz, depending on the repeater offsets used for the band. This implies a synthesizer transmit-receive change-over plus an offset of 1 MHz or 10 MHz in less than 4.5 ms. The ramp-up and ramp-down of the transmitter, which totals 1 ms, extends this change-over time to 5.5 ms.)

3.5 Frequency Control Loop

Introduction

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. The FCL circuitry is given on sheet 5 of the circuit diagram for the main board, and is described below.

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 13.0000 MHz, which is extremely stable, regardless of the temperature. The VCXO runs at a nominal frequency of 13.0000 MHz, 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 12.0 kHz. 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.

3.6 CODEC and Audio Circuitry

CODEC Circuitry The CODEC circuitry and audio circuitry are given on sheet 2 of the circuit diagram for the main board. Regarding the former, analogue-to-digital conversion and digital-to-analogue 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 tuning, and the output of analogue 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 analogue signal conditioning. The reference voltage (nominally 1.2 V) for these CODECs is provided internally by IC204 but is decoupled externally by C228.

Base-band CODEC The base-band CODEC handles the I and Q outputs (IRXP, IRXN, QRXP and QRXN balls) of the receiver's second IF stage. The analogue signals are differential and biased at 1.2 V nominally. The digital section communicates with this CODEC via a two-wire synchronous serial interface (BSDO and BSOFS balls). The digital-to-analogue conversion section of the base-band CODEC is not used.

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, pre-amplification and volume control.

Auxiliary CODEC

The auxiliary CODEC handles transmitter power control, receiver gain control, auxiliary audio output and general analogue monitoring functions. The digital section communicates with this CODEC via a three-wire synchronous serial interface (ASFS, ASDI and ASDO balls). The DAC used for receiver gain control (IDACOUT ball) is a current output type. Current-to-voltage conversion is performed by R238. The full-scale output of 1.2 V is amplified by IC201 to approximately 3 V as required by the receiver.

Audio Circuitry

The audio circuitry performs four functions:

- output of audio signal for speaker
- input of microphone audio signal
- input of auxiliary audio signal
- output of auxiliary audio signal

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

Audio Signal for Speaker

The audio signal for the speaker is generated by IC204 (VOUTAUXP ball). This signal is post-volume-control and has a pre-emphasised frequency response. The signal is then processed by R218, R217 and C205 to restore a flat frequency response and reduce the signal level to that required by the audio power amplifier.

Summing Circuit

The top of C205 is where side tones are summed in and the CDC RX AUD signal is obtained. C201 and R211 pre-emphasize and attenuate the side-tone signal to give a flat side-tone frequency response and reduce the input to an appropriate level.

Buffer Amplifier

IC201 (pins 8 to 10) amplifies the signal at the top of C205 by 19 dB and drives the CDC RX AUD system interface line via C212 and R225. The capacitor C212 provides AC output coupling and R225 ensures stability. The DC bias for this amplifier is derived from IC204.

Audio Power Amplifier

The signal at the top of C205 is fed via C204 to the audio power amplifier IC202. IC202 has 46 dB of gain and a differential output configuration. C209, C211, R252 and R253 ensure stability of the amplifier at high frequencies. When operational, the output bias voltage for IC202 is approximately half the radio supply voltage. When not operational, the output becomes high impedance.

Control of Audio Power Amplifier

Power up, power down, and muting of IC202 is controlled by two signals from the digital section, DIG AUD PA EN1 and DIG AUD PA EN2. The network consisting of Q200, Q201, R200 to R206, R210 and R250 converts the two digital signals to the single three-level analogue signal required by IC202.

Microphone Signals

There are two microphone source signals:

- ITF AUX MIC AUD from auxiliary or internal options connector
- ITF CH MIC AUD from control head

The biasing for electret microphones is provided by a filtered 3.0 V 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 3.0 V 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 1.5 V.

Auxiliary Audio Output

The source for the auxiliary audio output signal CDC AUD TAP OUT is provided by IC204 (RAMPDAC ball). The DAC output of IC204 is low-pass filtered to remove high-frequency artefacts. The low-pass filter, formed by IC201 (pins 1 to 3), R219, R220, R221, R224, C206, C208 and C210, is a third-order Butterworth type with a cut frequency of approximately 12 kHz. The output of the low-pass filter is amplified by 6 dB by a buffer amplifier, IC201 (pins 5 to 7), and fed via R207 and R208 to drive the CDC AUD TAP OUT interface line. The DC bias for this signal path is provided by IC204 and is approximately 1.2 V when operational. The offset at CDC AUD TAP OUT is approximately 2.4 V owing to the gain of the buffer amplifier.

3.7 Power Supply

Introduction

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

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

The power-supply circuitry is given on sheet 6 of the circuit diagram for the main board, and is described below.

Supply Protection

Electrical protection to the radio is provided by the clamping diode D600 and 10 A fuses in the positive and negative leads of the power cable. This provides protection from reverse voltages, positive transients greater than 30 V, 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 30 V. The ADC also ensures protection if the radio operates outside its specified voltage range of 10.6 V to 16 V.

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 nine internal power supplies:

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

The SMPS is used to regulate to 3.3 V 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 9 V regulator and the 13.8 V switched supply are connected to +13V8 BATT. The two remaining switched supplies (9 V and 3 V) use P-channel MOSFETs.

Control of Internal Power Supplies

The radio can be turned on using the ON/OFF key on the control head or by means of external signals. For the latter case hardware links are required and there are several power-sense options; these are discussed below. Some internal power supplies can be controlled by means of digital lines depending on the mode in which the radio is operating.

Power-sense Options

There are five power-sense options for powering up and powering down the radio:

- battery power sense
- auxiliary power sense
- internal-options power sense
- no power sense
- emergency power sense

The emergency power-sense option can be used in conjunction with any of the other four options. The ON/OFF key can be used with any of the options, although the behaviour of the radio will depend on the option selected. The links LK1 to LK4 on the main board are used to implement the desired option. The power-sense options and the link settings are described below.

Battery Power Sense

For the battery-power-sense option the link LK1 is required to connect +13V8 BATT of the power connector to the power-up circuitry. With this option, when a 13.8 V supply is connected to the radio, the radio enters the programmed power-on mode. The ON/OFF key can then be used to turn the radio on and off. This option has the disadvantage that the radio still draws about 28 mA after being switched off using the ON/OFF key. The reason is that the radio enters the stand-by mode and does not shut down completely.

Auxiliary Power Sense

With the auxiliary power-sense option the digital input line AUX GPI3 of the auxiliary connector is used to power up and power down the radio. The link LK2 is required to connect the line to the power-up circuitry. The line is active high; it is on when the level exceeds 2.6 V and off when the level falls below 0.7 V; the line tolerates maximum inputs equal to the radio supply voltage. When the line becomes active, the radio enters the programmed power-on mode. The ON/OFF key can then be used to switch the radio on and off. With the radio off and the line active, the radio draws about 28 mA. When the line becomes inactive, the radio is shut down completely regardless of whether it was on or in stand-by mode. With the line inactive the radio draws less than 1 mA. In a vehicle installation this avoids flattening the battery when the ignition key is off.

Internal-options Power Sense

The internal-options power-sense option is similar to the auxiliary power-sense option, except that the IOP GPIO7 line of the internal options connector is used. The link LK4 is required to connect the line to the power-up circuitry. This line is also active high; it is on when the level exceeds 2.6 V and off when the level falls below 0.7 V; the line tolerates maximum inputs of 5 V. The behaviour of the ON/OFF key is the same as with the auxiliary power-sense option.

No Power Sense

If no power-sense option is selected, the radio can only be powered up and powered down by means of the ON/OFF key. For this option the links LK1, LK2 and LK4 must be removed. The advantage of this option over the battery power-sense option is that the radio draws less than 1 mA when it is switched off.

Emergency Power Sense

For the emergency power-sense option the AUX GPI2 line of the auxiliary connector is used. Externally, this line is typically connected to a hidden switch. Internally, the link LK3 is required to connect the line to the power-up circuitry. The line is active low and has an internal pull-up resistor to the external supply voltage. The line is on when the level falls below 0.7 V. When the line becomes active, as when the hidden switch is pressed for two seconds, the radio enters the emergency mode. This mode can also be activated by making an emergency call or by pressing a key that has been programmed appropriately. The concealed microphone is typically fitted when the emergency power-sense option is selected.

Operation in Emergency Mode

If the radio is off when the emergency mode is activated, the radio is powered up but the display on the control head is not switched on. If the radio is on when the mode is activated, the display is frozen. In the latter case, if the ON/OFF key is pressed, the display is switched off but the radio remains in the emergency mode. While in this mode the radio cycles between transmit and receive. To exit the emergency mode the ON/OFF key needs to be pressed again.

3.8 Interface Circuitry

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

An output on the line AUX GPIO4 originates as the 3.3 V 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 1.6 V by R746 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 1 V. 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 18 mA (the inverse of the value of R761). The output configuration is open-collector with a pull-up to 3.3 V by default. Pull-up options to 5 V and 13.8 V are also available.

Five-volt Regulator

The 5 V 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 25 mA under short-circuit conditions.

Input Signals (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 2.7 V. In combination with D711, the input to ITF AUX GPI4 is therefore clamped to 3.3 V nominally. The value of R757 is made large to minimise the loading effect on the output pull-up resistors. On AUX GPIO4 only, the optional MOSFET Q707, which has a high current drive, may be fitted.

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 33 kΩ resistor R775.

ESD Protection

On exposed inputs of the auxiliary and control-head connectors ESD (electrostatic discharge) protection is provided by a 470 pF capacitor and by clamping diodes to ground and to 13.8 V. 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 13.2 kΩ, 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.

Chapter 2
Servicing of Radio

Chapter 2 Contents

4 General Information

Scope of Section

This section discusses the two repair levels covered by the service manual, details concerning website access, the tools, equipment and spares required, and the setting up of the necessary test equipment. General servicing precautions are also given, as well as details of certain non-standard SMT techniques required for level-2 repairs.

4.1 Repair Levels and Website Access

Repair Levels

As described in Section 1, this manual covers level-1 and level-2 repairs of TM8100 radios. To summarise, level-1 repairs comprise the replacement of control-head boards, main-board assemblies, and other parts of the radio; level-2 repairs comprise repairs of control-head boards and, except for special items, main-board assemblies. The special items are:

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

Replacements of the connectors and volume-control potentiometer on the control-head board are level-1 repairs. Replacements of the connectors on the main-board assembly, however, are level-2 repairs because these repairs entail the disassembly of the main-board assembly.

Important The circuit boards in the TM8100 radio are complex. They should be serviced only by accredited service centres. Repairs attempted without the necessary equipment and tools or by untrained personnel might result in permanent damage to the radio.

Accreditation of Service Centres

Service centres that wish to achieve ASC status should contact Technical Support. They will need to provide evidence that they meet the criteria required for accreditation; Technical Support will supply details of these criteria. These centres must then make available suitable staff for training by TEL personnel, allow their service facilities to be assessed, and provide adequate documentation of their processes. They will be accorded ASC status and endorsed for repairs of TM8100 radios after their staff have been trained and their facilities confirmed as suitable. Existing ASCs need to apply for and be granted an endorsement for repairs of TM8100 radios. All ASCs with the necessary endorsements may carry out level-1 and level-2 repairs of these radios, whether under warranty or not.

Skills and Resources for Level-1 Repairs

For level-1 repairs basic electronic repair skills are sufficient. Apart from the standard tools and equipment of any service centre, certain torque drivers are required as well as a service kit and, for diagnostic purposes, a spare control head. Replacement control-head boards and main-board assemblies are supplied by TEL in separate spares kits. The other replacement parts are supplied in four spares kits: parts for the one-digit-display control head, parts for the two-digit-display control head, parts for the radio body, and spare control-head seals. Further details are given in Subsection 4.2 (on page 84).

Skills and Resources for Level-2 Repairs

For level-2 repairs expertise is required in SMT repairs of circuit boards with a very high complexity and extreme component density. Apart from the tools and equipment needed for level-1 repairs, the standard SMT repair tools are required. A can-removal tool is strongly recommended but not mandatory. Replacement SMT components are supplied by TEL in two separate spares kits, one for the control-head boards and one for the main board. Spare special items are not supplied. Further details are given in Subsection 4.2.

Website Access

To carry out level-1 and level-2 repairs, service centres need access to the secured portion of the Technical Support website. There are different access levels; those required for level-1 and level-2 repairs are:

- level-1 repairs: associate access
- level-2 repairs: Tait-only access

Log-in passwords are needed for associate 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.)

Items Available on Website

The information available at the different access levels is summarised in Table 4.1. The technical notes mentioned are of different types. Associate technical notes relate to the repair of the radio but not the downloading of firmware; Tait-only technical notes relate to the firmware. The PCB information packs are discussed in more detail below.

Table 4.1 Items relating to TM8100 radios that are available on the Technical Support website

Item	Public access	Associate access	Tait-only access
Operator's manuals	•	•	•
User's guides	•	•	•
Installation guides	•	•	•
Public technical notes	•	•	•
Product release notes		•	•
Specifications		•	•
Calibration software		•	•
Programming software		•	•
Programming user manuals		•	•
Fitting instructions		•	•
Service manuals		•	•
Associate technical notes		•	•
Software release information			•
Firmware			•
Tait-only technical notes			•
PCB information packs			•

PCB Information Packs

A PCB information pack for a particular circuit board consists of the relevant BOMs, grid reference indexes, PCB layouts, and circuit diagrams. (The grid reference indexes give the locations of components on the PCB layouts and circuit diagrams.) A PCB information pack is compiled whenever there is a major change in the layout of the board. All PCB information packs are published on the Technical Support website. In the service documentation, however, the PCB information pack for only the current release of the board is included.

Tait FOCUS Database

An additional source of information to service centres is the Tait FOCUS call-logging database. (This is accessible on the Technical Support website also.) All Customer-related technical issues regarding the radios are recorded on this database. These issues may be raised by both Customers and service centres. Technical Support resolves the issues and informs the Customer or service centre concerned of the outcome. All issues and their solutions are available for review by all service centres.

4.2 Tools, Equipment and Spares

Torque-drivers

For level-1 and level-2 repairs, excluding SMT repairs of the circuit boards, the torque-drivers listed in Table 4.2 are required. These are the only special tools required over and above the standard workshop tools. For level-1 repairs only the Torx T10 and Torx T20 driver bits are necessary. The sockets are needed for disassembling and re-assembling the main-board assembly, which is a level-2 task.

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 borne in mind 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.

Table 4.2 Torque-drivers

Drive type	Torque (N.m)	Torque (lbf.in)	Repair level
Torx T20	2.5	22	1
Torx T10	1.9	17	1
	1.7	15	2
	0.56	5	1
	0.34	3	1
3/16-inch socket	0.90	8	2
14 mm long-reach socket	1.7	15	2

Test Equipment

The following test equipment is required for servicing the radio:

- test PC (with programming and calibration applications loaded)
- RF communications test set (audio bandwidth of at least 10 kHz)
- oscilloscope
- digital current meter (capable of measuring up to 3 A)
- multimeter
- DC power supply (capable of 13.8 V and 10 A)
- spare TM8115 control head
- spare TM8110 control head
- TMAA21-00 service kit

Separate instruments may be used in place of the RF communications test set. These are an RF signal generator, audio signal generator, audio analyzer, RF power meter, and modulation meter. Details of the service kit are given below.

Service Kit

The TMAA21-00 service kit contains all the items needed for connecting the radio to the test equipment. The setting up of the equipment is described in Subsection 4.5 (on page 93). The service kit also includes a product support CD and a folder with the necessary service documentation, including this manual. The CD contains the programming application, calibration application, and soft-copies of the service and related documentation. The contents of the service kit are listed in Table 4.3. Note that the TMAA20-04 cable listed is required only if the test PC is to be connected directly to the radio for programming purposes.

Table 4.3 Contents of TMAA21-00 service kit

Product code	Item
TMAA21-01	Cable (DB14 socket to RJ45 plug plus in-line connector)
TMAA20-01	Product support CD
TMAA20-02	Adaptor (RJ45 socket to DB9 socket)
TMAA20-03	Cable (power connector to banana plugs plus in-line connector)
TMAA20-04	Cable (RJ12 socket to RJ45 plug)
T2000-A19	Cable (DB9 socket to RJ12 plug)
TOPA-SV-024	Test unit
MM8100-01-00-812	Service and accessories manuals

Spares Kits

The spares kits required for the servicing of the radio are listed in Table 4.4. The corresponding repair levels are also indicated. A spares kit (Spares kit 6) for the repair of the rugged microphone is also supplied but is not discussed in this manual; refer to the accessories manual for the details. The contents of Spares kits 1, 2 and 10 are given in Section 6 (on page 125). Contents lists for Spares kits 4 and 5 are supplied with the kits.

Table 4.4 Spares kits

Kit number	Product code	Description	Repair level
1	TMAA22-01	Parts of two-digit-display control head — excluding control-head board	1
2	TMAA22-02	Mechanical parts of radio body	1
3	TMAA22-03	Control-head boards (two-digit display)	1
4	TMAA22-04	Selected components of control-head boards	2
5	TMAA22-05	Selected components of main board	2
7	TMAA22-07	Control-head seals	1
10	TMAA22-90	Parts of one-digit-display control head — excluding control-head board	1
11	TMAA22-91	Control-head boards (one-digit display)	1
	TMAA22-12B1	Main-board assembly (B1 band)	1
	TMAA22-12H5	Main-board assembly (H5 band)	1
	TMAA22-12H6	Main-board assembly (H6 band)	1

4.3 Servicing Precautions

Introduction

This subsection discusses the precautions that need to be taken when servicing the radios. These precautions fall into the following categories:

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

Service technicians should familiarise themselves with these precautions before attempting repairs of the radios.

Use of Torque-drivers

Apply the correct torque when using a torque-driver to tighten a screw or nut in the radio. Under-torquing can cause problems with microphonics and heat transfer. Over-torquing can damage the radio. Table 6.3 in Section 6 (on page 125) lists 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 radio 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 radio.

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

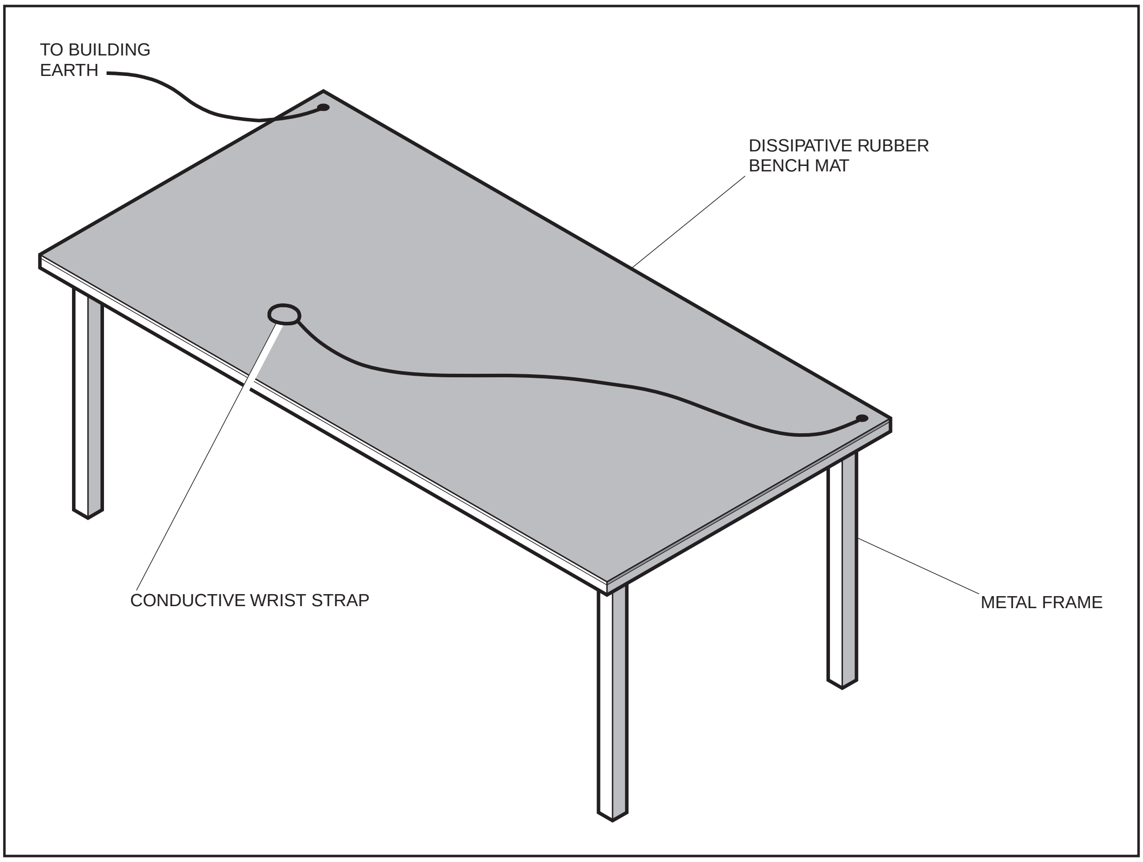
Sealing of Radio

To maintain the sealing of the radio to IP54 standards, ensure that all bungs and seals are fitted after servicing the radio. These are for the auxiliary, RF, external options, and programming connectors:

- bung for auxiliary connector
- rubber seal for RF connector
- bung for aperture for options connector (connector not fitted)
- cover seal for options connector (connector fitted)
- cover seal for programming connector (blank control head only)

In addition, ensure that the grommet sealing the aperture to the microphone connector of two-digit-display control heads is properly fitted.

Figure 4.1 Typical installation of an anti-static workbench



Important The components of the circuit boards in the radios are susceptible to damage from electrostatic discharges. Observe anti-static precautions when handling the boards or their components. Follow the procedures given in the manufacturers' data books.

Storage and Transport of Items

Always observe anti-static precautions when storing, shipping or carrying the circuit boards and their components. Use anti-static bags for circuit boards and anti-static bags or tubes for components that are to be stored or shipped. Use anti-static bags or trays for carrying circuit boards, and foil or anti-static bags, trays, or tubes for carrying components.

Anti-static Workbenches

Use an anti-static workbench installed and tested according to the manufacturer's instructions. A typical installation is shown in Figure 4.1. These benches have a dissipative rubber bench top, a conductive wrist strap, and a connection to the building earth. The material of the bench top must satisfy not only anti-static requirements but also the non-scratch requirements mentioned above.

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

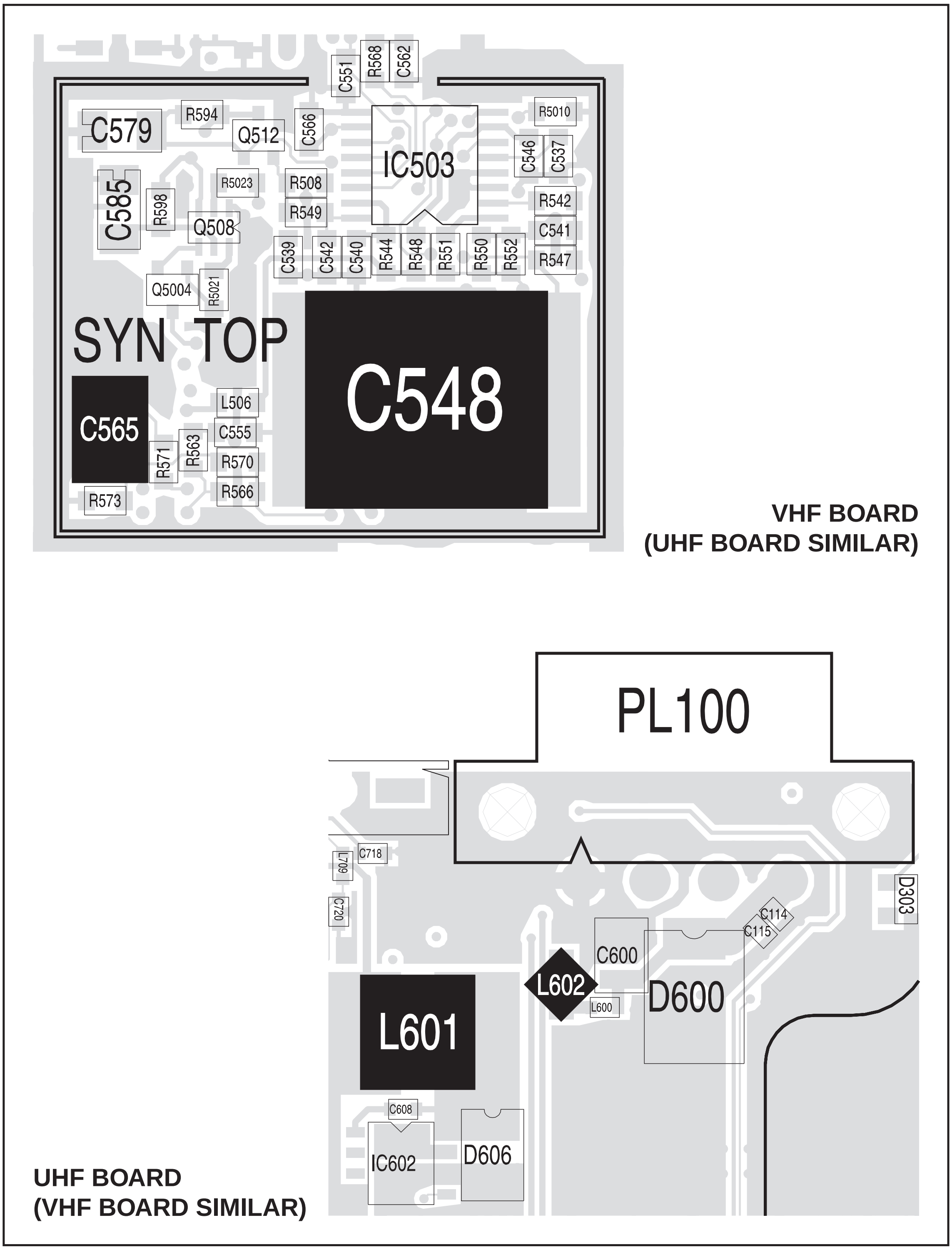
Important The radio has been designed to operate with a 50 Ω termination impedance, but will tolerate a wide range of antenna loading conditions. Nevertheless, do not operate the transmitter without a suitable load. Failure to do so might result in damage to the power output stage of the transmitter.

Important While servicing the main board, avoid overheating the radio during test transmissions. The following is good practice: Secure the main-board assembly in the chassis with the two external screws and one of the internal screws. The screws are labelled 9 and 11 in Figure 2.11. The heat-transfer block must be secured to the main board. The lid of the radio body may be left off. After completing any measurement or test requiring activation of the transmitter, immediately return the radio to the receive 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.

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.

Figure 4.2 Locations of the capacitors C548 and C565 and the inductors L601 and L602 on the main board



4.4 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 subsection.

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 a number-6 iron tip. 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 4.2 shows the locations of the components.

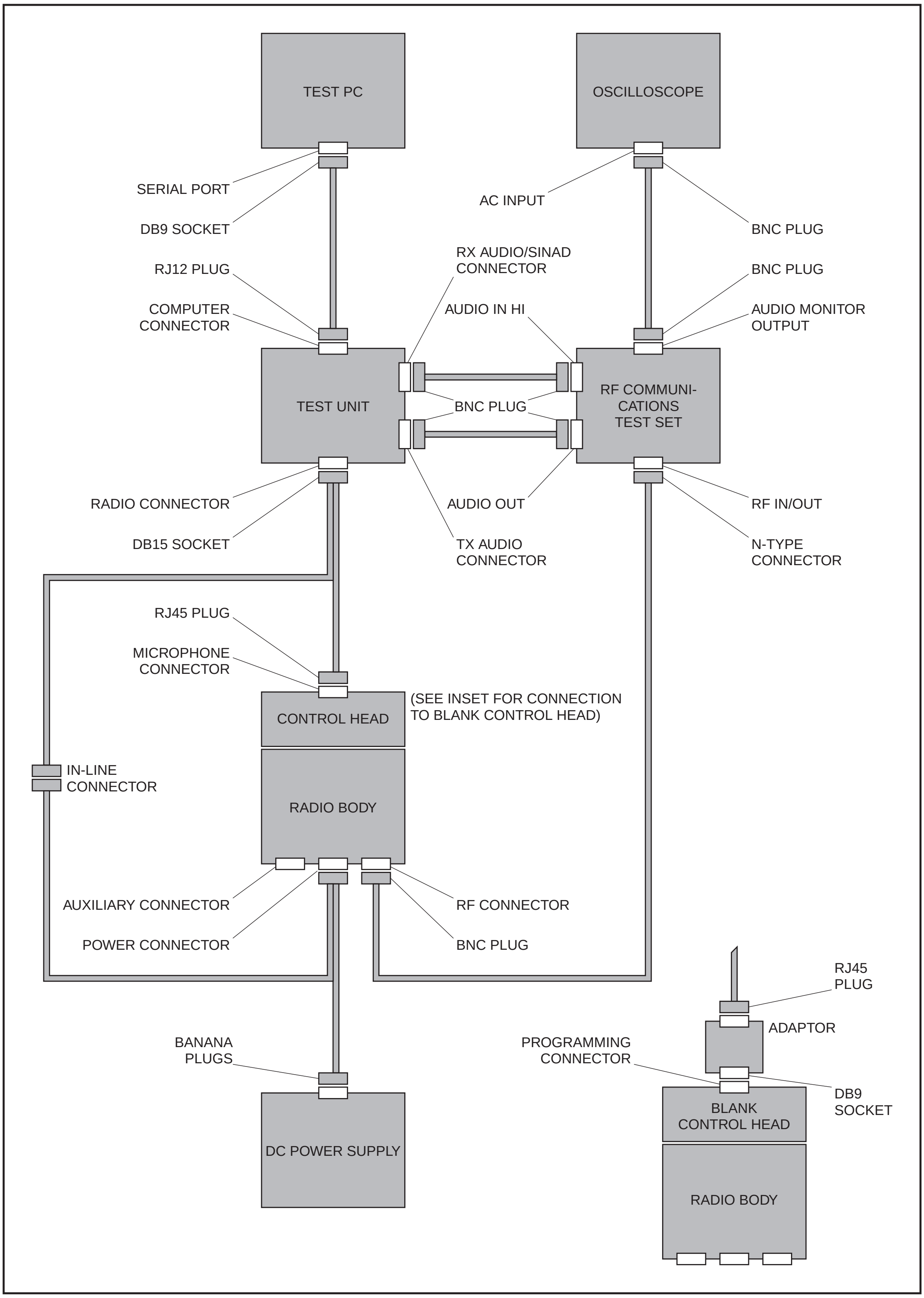
Can Removal and Installation

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 from Spares kit 5. 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.

Figure 4.3 Test equipment for servicing radios



4.5 Equipment Set-up

Introduction

This subsection covers the setting up of the test equipment for servicing the radios, as well as related aspects:

- setting up of test equipment, including test unit
- use of test unit
- installing programming and calibration applications
- basic programming and calibration tasks
- invoking CCTM (computer-controlled test mode)
- summary tables of CCTM commands and error codes
- visual and aural indications provided by radio

The last-named aspect applies to control heads with UI, and concerns the STATUS LEDs and LCD screen, and the various alerts and confidence tones emitted from the speaker.

Connect Equipment

Connect the test equipment to the radio as shown in Figure 4.3. Use the test unit, cables and adaptor of the service kit. Refer to Subsection 4.2 (on page 84) for details of the test equipment and service kit. The face of the test unit is fitted with a speaker, five switches, and the following connectors:

- "RADIO" connector (DB15 plug)
- "COMPUTER" connector (RJ12 socket)
- "TX AUDIO" connector (BNC socket)
- "RX AUDIO/SINAD" connector (BNC socket)

These connectors are all required for connecting the test equipment and radio. Figure 4.4 illustrates the face of the test unit.

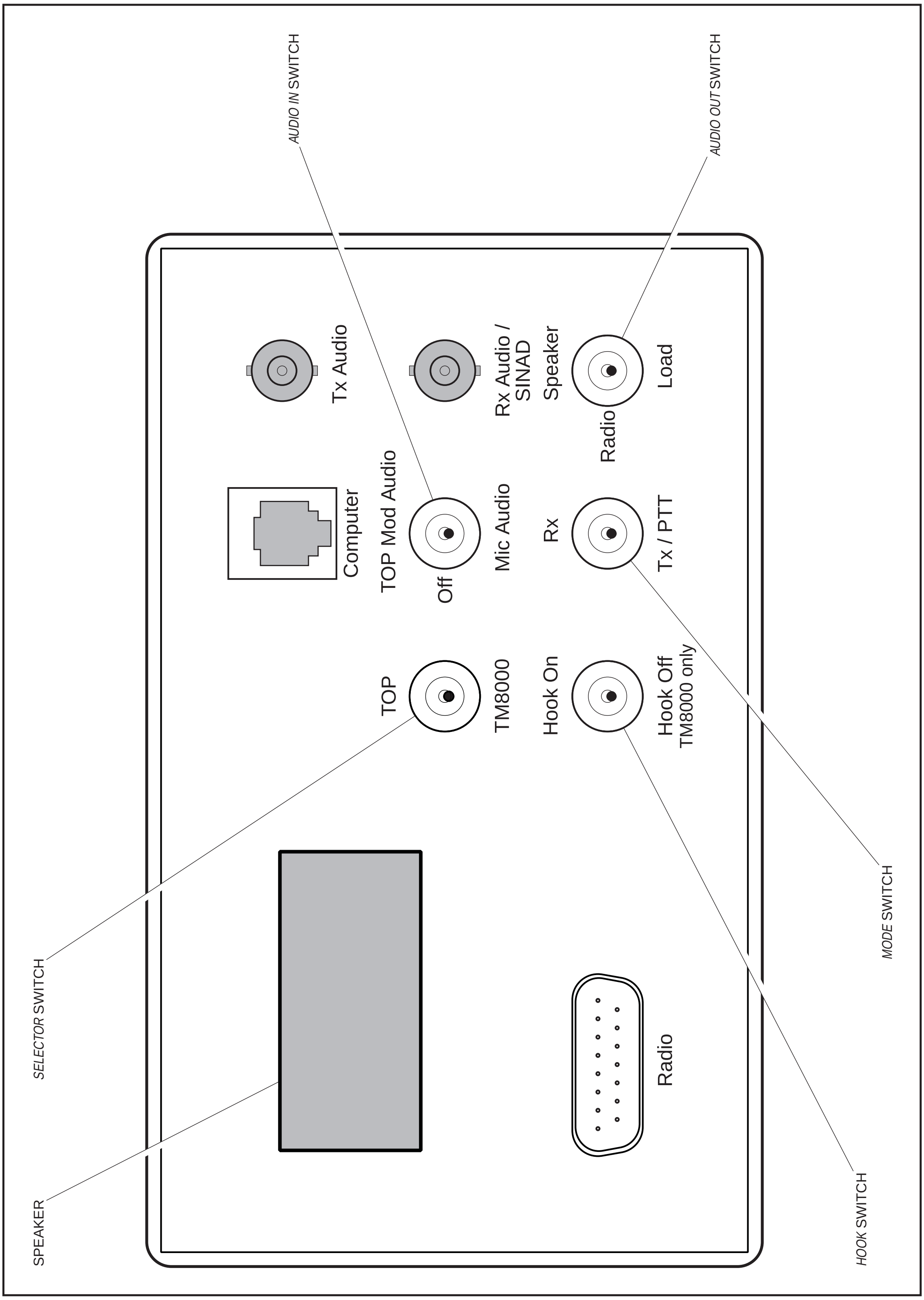
Use of Test Unit

The test unit facilitates the testing of the receive and transmit functions of radios. When the switches are set for the required mode, the test unit automatically routes all signals to the appropriate destinations. The unit may be used with both mobile and portable radios. A full description is given in the accessories manual. As shown in Figure 4.4, the switches are:

- SELECTOR switch
- HOOK switch
- MODE switch
- AUDIO IN switch
- AUDIO OUT switch

For servicing TM8100 radios set the SELECTOR switch to "TM8100". For testing receive and transmit functions respectively, the remaining switches must be set as described below. (When programming or calibrating radios the switches have no effect, although it is good practice to set the MODE switch to "RX".)

Figure 4.4 Illustration of the face of the test unit



Settings for Receive Tests

For receive tests set the switches on the test unit as follows:

- HOOK switch : "HOOK OFF"
- MODE switch : "RX"
- AUDIO IN switch : "OFF"
- AUDIO OUT switch: "SPEAKER" or "LOAD"

In the last-named case, with the switch in the "SPEAKER" position, the received audio is output from the test unit's speaker. In the "LOAD" position a 16 Ω load is switched into the circuit in place of the test unit's speaker. Note, however, that the AUDIO OUT switch has no effect on the radio's speaker.

Settings for Transmit Tests

For transmit tests set the switches on the test unit as follows:

- HOOK switch : "HOOK OFF"
- MODE switch : "RX" initially
- AUDIO IN switch : "MIC AUDIO"
- AUDIO OUT switch: (immaterial)

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.

Product Support CD

After setting up the test equipment for the first time, install the programming and calibration applications on the test PC. These applications are included on the product support CD supplied with the service kit. Access the contents of the CD as follows:

1. Insert the product support CD in the CD-ROM drive of the test PC.
2. The *Contents* window of the CD should appear; the window is illustrated in Figure 4.5. If the *Contents* window fails to appear, proceed as follows:
3. Click *"Start"* > *"Run"*. The *"Run"* dialogue box appears.
4. Type ***d***:*\menu.exe*, where ***d*** is the letter designating the CD-ROM drive.
5. Click the *"OK"* button. The *"Run"* dialogue box is closed and the *Contents* window appears.

Figure 4.5 The *Contents* window of the product support CD

Install Applications

The upper two buttons in the *Contents* window of the product support CD allow for the installation of the programming and calibration applications:

1. Click the *"Programming"* button. Installation of the programming application begins automatically. Follow the instructions on the screen to complete the installation.

2. Click the *"Calibration"* button. Installation of the calibration application begins automatically. Follow the instructions on the screen to complete the installation.

3. The *Contents* window remains open following installation of the above applications. Investigate the remaining features of the product support CD as described below, or click the *Close* button to remove the window.

4. Remove and store the product support CD.

View Documents

The middle six buttons in the *Contents* window of the product support CD give access to the documents stored on the CD:

- user's guide
- service manual
- operator's manual
- PCB information packs
- accessories manual
- licence agreement

To view any document click the corresponding button. The Adobe Acrobat Reader application needs to be installed on the test PC.

Access TaitWorld Website

Of the two lower and remaining buttons in the *Contents* window of the product support CD, the *"Miscellaneous"* button is currently unused. Clicking the *"TaitWorld"* button opens the default browser installed on the test PC and accesses the TaitWorld website.

Programming Application

The programming application is typically used to read the programming file of a radio, change settings in the various forms constituting the file, and reprogram the radio. Alternatively, the application can be used to open a new file, select the required settings, and program one or more radios. To run the application and become familiar with its features, proceed as follows:

1. Click *"Start"* > *"Programs"* > *"Tait Programming Applications"* > *"TM8100 Programming Application"*. The programming application is opened.
2. On the menu bar, click *"Help"* > *"Contents and Index"*. The on-line help facility is opened.
3. Read the information provided by the on-line help facility.
4. Close the on-line help facility and close the programming application.

Calibration Application

The calibration application is used to read radio calibration files, perform diagnostic functions, change certain settings, perform calibration tests, view and check calculated calibration data, and program radios with calibration files. To run the application and become familiar with its features, proceed as follows:

1. Click *"Start"* > *"Programs"* > *"Tait Programming Applications"* > *"TM8100 Calibration Application"*. The calibration application is opened.
2. On the menu bar, click *"Help"* > *"Contents and Index"*. The on-line help facility is opened.
3. Read the information provided by the on-line help facility.
4. Close the on-line help facility and close the calibration application.

Computer-controlled Test Mode

The servicing procedures require a radio 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 radio. Certain CCTM commands cause the radio to carry out particular functions; others read particular settings and parameter values in the radio. The CCTM commands of use in servicing radios are listed in Table 4.5 to Table 4.9, grouped according to category.

Terminal Program for CCTM

To place a radio in CCTM requires the use of a terminal program on the test PC. An example is HyperTerminal, 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 radio 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.

Table 4.5 CCTM commands in the audio category

Command	Usage	
	Entry at keyboard	**Response on screen**
Audio category		
20 – Mute received audio Forces muting of the received audio signal	*20*	None
21 – Unmute received audio Forces unmuting of the received audio signal	*21*	None
22 – Mute microphone Mutes transmit modulation (effectively mutes microphone audio)	*22*	None
23 – Unmute microphone Unmutes transmit modulation (effectively unmutes microphone audio)	*23*	None
74 – Audio PA Controls the state of the audio PA (and hence enables or disables the speaker)	*74* ***x*** where ***x*** is the required state (0=stand-by, 1=on, 2=mute)	None
110 – Audio volume Sets the level of the audio volume	*110* ***x*** where ***x*** defines the required level (any integer from 0 to 255)	None
138 – Select microphone Selects the microphone required	*138* ***x*** where ***x*** is the required microphone (0=control-head microphone; 1=auxiliary microphone)	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
324 – Audio tap out Outputs the audio signal at the specified tap point to AUD TAP OUT	*324* ***x y*** where ***x*** specifies the tap point (*r1*, *r2*, *r3*, *r4*, *r5*, *t1*, *t2*, *t3* or *t7*) and ***y*** the tap type (C=bypass out, D=split, E=splice) (the default is D when ***y*** is omitted)	None

Table 4.6 CCTM commands in the radio-information, radio-control and system categories

Command	Usage	
	Entry at keyboard	**Response on screen**
Radio-information category		
94 – Radio serial number Reads the serial number of the radio	*94*	***x*** where ***x*** is the serial number (an eight-digit number)
96 – Firmware version Reads the version number of the radio 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 radio body 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

Table 4.7 CCTM commands in the frequency-synthesizer and receiver categories

Command	Usage: Entry at keyboard	Usage: 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 and receive frequencies 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
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
Receiver category		
32 – Receive mode Sets the radio in the receive mode	*32*	None
63 – RSSI level Reads the averaged RSSI level	*63*	***x*** where ***x*** is the averaged level in multiples of 0.1 dBm
376 – Front-end tuning Sets or reads the tuning voltage for the front-end circuitry of the receiver	*376* (to read voltage)	***x*** where ***x*** is the front-end tuning voltage in millivolts
	376 ***x*** (to set voltage) where ***x*** is the front-end tuning voltage in millivolts (any integer from 0 to 3000)	None
378 – Receiver output level Reads the signal power at the output of the channel filter (the square of the amplitude)	*378*	***x*** where ***x*** is the signal power

Table 4.8 CCTM commands in the transmitter category (part 1)

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 ADC value of the tem-perature (an integer from 0 to 1023) and ***y*** is the corresponding voltage in millivolts (a value from 0 to 1200 mV)
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

Table 4.9 CCTM commands in the transmitter category (part 2)

Command	Usage	
	Entry at keyboard	**Response on screen**
Transmitter category		
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

Invoking CCTM

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

1. Enter the character *^* to reset the radio.
2. As soon as the radio 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* (two-digit display) or *C* (one-digit display) appears on the radio's LCD screen. This implies that the radio has entered CCTM. If the attempt fails, repeat Steps 1 to 3.

CCTM Error Codes

Once the radio is in CCTM, the CCTM commands may be entered as shown in Table 4.5 to Table 4.9. 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 4.10.

Table 4.10 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 radio down and up again, and re-enter the CCTM command.
C04	An error occurred on entry into CCTM. Power the radio down and up again, and place the radio in CCTM again.
C05	The radio 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 radio 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 radio's database.
X35	The radio temperature is above the T1 threshold and a reduction in the transmit power is impending. To avoid damaging the radio, stop transmitting until the radio has cooled down sufficiently.
X36	The radio 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 radio has powered itself down. The radio will not respond to the reset command character ^.

Visual and Aural Indications

In radios that have a control head with UI, visual and aural indicators give information about the state of the radio. Visual indications are provided by the STATUS LEDs, function-key LEDs, and LCD screen on the front panel. The information conveyed by the STATUS LEDs is listed in Table 4.11. The behaviour of the function-key LEDs depends on the way the function keys are programmed; further information is not appropriate in this manual. The LCD screen normally displays only the number of the channel to which the radio is tuned. Other displays will be mentioned where necessary but are not summarised here. Aural indications are provided in the form of different tones emitted from the speaker. The information conveyed by the tones is given in Table 4.12. Not all of the tones listed are relevant to the servicing of radios but they are included for the sake of completeness.

Table 4.11 Visual indications provided by the STATUS LEDs of control heads with UI

LED colour	LED name	Indications	Meanings
Red	Transmit	LED is on	The radio is transmitting
		LED flashes	(1) The transmit timer is about to expire (2) The radio has been stunned
Green	Receive and monitor	LED is on	There is activity on the current channel, although it might not be audible
		LED flashes	(1) The radio has received a call with valid special signalling (2) The monitor has been activated (3) The squelch override has been activated
Amber	Scanning	LED is on	The radio is scanning a group of channels for activity
		LED flashes	The radio has detected activity on a certain channel and scanning has halted on this channel

Table 4.12 Aural indications emitted from the speaker of control heads with UI

Type of tone	Meanings
One short beep	(1) After power-up — Radio is locked; PIN is required (2) On power-down — Radio is off (3) On pressing key — Key-press is valid (4) On pressing function key — Function has been initiated
One short low-pitched beep	On pressing function key again — Function has been terminated
One short high-pitched beep	While powered up — Radio has been stunned
One long low-pitched beep	(1) On pressing key — Key-press is invalid (2) On entry of PIN — PIN is invalid (3) On pressing PTT switch — Transmission is inhibited
Two short beeps	(1) On power-up — Radio is ready to use (2) On entry of PIN — PIN has been accepted and radio is ready to use (3) After radio has been stunned — Radio has been revived and is ready to use
Two low-pitched beeps	While powered up — Temperature of radio is high
Two high-pitched beeps	While powered up — Temperature of radio is very high and all transmissions will be at low power; if temperature rises further, transmissions will be inhibited
Three short beeps	While powered up — Previously busy channel is now free
Three beeps	During transmission — Transmit time-out is imminent; transmission will be terminated in 10 seconds
Warble	While powered up — Frequency synthesizer is out of lock on current channel; LCD will usually be flashing *OL* (two-digit display) or *L* (one-digit display)
Continuous low-pitched tone	While powered up — System error has occurred and radio might be inoperable; LCD usually displays *E1* or *E2* (two-digit display) or *E* (one-digit display)

5 Servicing Procedure

Scope of Section

This section gives the full sequence of tasks required when servicing a particular radio. These tasks are:

- initial inspection
- fault diagnosis and repair
- final inspection, test and administration

The tasks are described in Subsection 5.1 to Subsection 5.3 respectively. Where more details are required regarding disassembly and re-assembly procedures, references are given to Section 6 (on page 125). For the servicing of the control head and main board, references are given to Section 7 (on page 151) and Section 8 (on page 165) respectively.

5.1 Initial Inspection

Introduction

When a radio 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 of the radio, or both. Whatever the case, first check the radio for mechanical loss or damage. This is advisable even if the fault concerns a function failure only. Inspect the radio as follows:

Check for Minor Damage or Loss

Check for damage or loss of parts that can be replaced without disassembling the radio. These parts are:

- knob for volume-control potentiometer
- microphone grommet
- rubber seal for RF connector
- bung for auxiliary connector
- bung for aperture for external options connector

The last-named part should be replaced by a cover seal if an external options connector is present. All the parts are illustrated in Subsection 2.1 (on page 33). Except for the microphone grommet, if any of these parts is missing or damaged, replace it as described below. In the case of the microphone grommet, refer to the accessories manual for the repair procedure.

Replace Damaged or Missing Knob

Remove the volume-control knob if it is damaged. Obtain a replacement knob from Spares kit 1 or 10. The contents of the kit are listed in Table 6.1 of Section 6 (on page 125). Push the replacement knob onto the shaft of the volume-control potentiometer. Ensure that the knob turns freely.

Replace Damaged or Missing Seals and Bungs

Remove any damaged seal or bung. Obtain a replacement seal for the RF connector or a replacement bung from Spares kit 2. The contents of the kit are listed in Table 6.2 of Section 6 (on page 125). Order a replacement cover seal (and screws) from TEL; the IPNs of the parts are listed in Table 2.2. In fitting a replacement bung, ensure that it is not upside down and that it is properly seated. To fit the seal for the RF connector, first fit the upper part of the seal and then press down around the sides of the seal to the bottom. Ensure that the seal is properly seated around its entire periphery.

Check for Additional Damage

Also check for damage to exterior parts that can be replaced only by partly disassembling the radio. These parts are:

- cover assembly for radio body
- keys, lens and LCD of control head
- front panel of control head

In the case of the front panel, inspect particularly the light pipes for the STATUS LEDs and the membrane behind the speaker grille. If the radio is reported to have a functional fault, continue with the tasks given in Subsection 5.2 (on page 109) — any additional mechanical damage will be repaired during the course of rectifying the functional fault. If the radio has no functional fault, repair any additional damage as described below; conclude with the tasks of Subsection 5.3 (on page 121).

Replace Damaged Cover Assembly

Remove a damaged cover assembly as described in Subsection 6.3 (on page 137). Obtain a replacement assembly from Spares kit 2. The cover assembly comprises a cover and a label, as shown in Figure 2.8; the label is permanently fixed to the cover. The IPNs of both items are given in Table 6.2. If a spares kit is not available, order both items from TEL. Fit the replacement cover assembly to the radio body.

Repair Damaged Control Head

If the control head is damaged, detach it from the radio body as described in Subsection 6.1 (on page 127). The procedure includes inspecting the interior of the control head for evidence of other damage. Disassemble the control head and repair all damage as described in Subsection 6.2 (on page 131). Obtain replacement parts from Spares kit 1 (two-digit-display control head) or Spares kit 10 (one-digit-display control head). Then re-assemble the control head and re-attach it to the radio body as described in Subsection 6.5 (on page 148).

5.2 Fault Diagnosis and Repair

List of Tasks

When the radio is reported to have a functional fault, carry out the tasks described in this section. There are seven possible tasks in all:

- Task 1 — power up radio
- Task 2 — read programming file
- Task 3 — obtain SFE (software feature enabler) details
- Task 4 — read calibration file
- Task 5 — check user interface
- Task 6 — check receive and receive-audio functions
- Task 7 — check transmit and transmit-audio functions

Only the task relevant to the reported fault needs to be carried out, except that the first four tasks must always be done. If the report of the fault is not sufficiently specific, all the tasks must be done. If the fault is not confirmed when the relevant task is done, obtain more information from the Customer; in particular, determine whether the radio is properly configured for the Customer's system.

Task 1 — Power up Radio

With the radio connected to the test equipment as described in Subsection 4.5 (on page 93), attempt to power up the radio:

1. Apply power to the radio. If the radio doesn't power up automatically, press the ON/OFF switch.

2. If the radio powers up successfully, proceed to Task 2. If it does not, attempt to rectify the fault as described in the chart of Figure 5.1.

3. If the repair succeeded — without the need for replacing the main-board assembly — proceed to Task 2. Otherwise continue with Step 4.

4. If the main-board assembly was replaced or if the repair failed, re-assemble the radio as described in Subsection 6.4 (on page 144) and Subsection 6.5 (on page 148). Conclude with the tasks of Subsection 5.3 (on page 121).

POWER-UP FAULTS

1. Initial checks

(1) If the radio fails to power up properly, check the fuses, cables, connectors, mains plug, and DC power supply. Rectify any fault. (If a fuse has blown, replace it with exactly the same type of fast-blow fuse.)

(2) Check if the radio powers up.

(3) If the radio powers up, return to Step 3 of Task 1. If it does not, go to (4) below.

(4) Detach the control head as in Subsection 6.1 (on page 127), and exchange it for a serviceable spare control head.

(5) Check if the radio powers up.

(6) If the radio powers up, the original control head is faulty; disconnect the spare control head, and go to Part 2 below. If the radio still fails to power up, the radio body is faulty; reconnect the original control head, and go to Part 3.

2. Control head faulty

(1) Exchange the control-head loom for a serviceable spare loom.

(2) Check if the radio powers up.

(3) If the radio powers up, the original loom is faulty; go to (4). If the radio still fails to power up, reconnect the original loom, and go to (5).

(4) Replace the faulty control-head loom, and return to Step 3 of Task 1.

(5) Check the control-head connector on the control-head board.

(6) If the connector is faulty, remove the control-head board as in Subsection 6.2 (on page 131), and replace the connector. If the connector is not faulty, replace the control-head board as in Subsection 7.4 (on page 163).

(7) Check if the radio powers up.

(8) If the radio powers up, return to Step 3 of Task 1. If the radio does not power up, the repair has failed; re-assemble the control head with the original control-head board as in Subsection 6.5 (on page 148), and return to Step 3 of Task 1.

3. Radio body faulty

(1) Remove the lid of the radio body as in Subsection 6.3 (on page 137), and check the power connector.

(2) If the connector is not faulty, go to (5). If it is, go to (3).

(3) At level-1 service centres, go to (5) and replace the main-board assembly. At level-2 service centres, remove and disassemble the main-board assembly as in Subsection 6.3, replace the connector, and re-assemble the main-board assembly as in Subsection 6.4 (on page 144).

(4) Check if the radio powers up. If it does, return to Step 3 of Task 1. If it does not, go to (5).

(5) Repair or replace the main-board assembly as in Section 8 (on page 165).

(6) The final test in Section 8 will indicate whether the repair succeeded or failed. Return to Step 3 of Task 1.

Figure 5.1 Chart for locating and rectifying faults that affect power up

Task 2 — Read Programming File

Given that the radio powers up, the next task is to read the radio's programming file or upload a default file.

1. Run the programming application on the test PC as described in Subsection 4.5 (on page 93).

2. Attempt to read the radio's programming file. If it seems that the file cannot be read, cycle the power to the radio and again attempt to read the file. First cycling the power is essential if the radio 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 (control head with UI) or programming connector (blank control head).

3. If the file can be read, store a copy on the test PC and proceed to Task 3. If the file cannot be read, attempt to rectify the fault as described in the chart of Figure 5.2.

4. If the repair succeeded — without the need for replacing the main-board assembly — continue with Step 5. Otherwise continue with Step 8.

5. If the programming file can be read now, store a copy on the test PC and proceed to Task 3. If the file still cannot be read, set up a default programming file.

6. Attempt to upload the default programming file to the radio.

7. If the upload succeeds, proceed to Task 4. If the upload fails, continue with Step 8.

8. If the main-board assembly was replaced or if the repair failed, re-assemble the radio as described in Subsection 6.4 (on page 144) and Subsection 6.5 (on page 148). Conclude with the tasks of Subsection 5.3 (on page 121).

Task 3 — Obtain SFE Details

Determine if any software features have been enabled for the radio under repair.

1. Use the programming application to obtain details of software features. On the menu bar click *"Tools"* > *"Optional Features"*. The *"Software Feature Enabler"* dialogue box appears.

2. In the dialogue box all available features are listed in the *"Feature Set"* field. The corresponding product codes are given in the *"Feature Code"* field.

3. Click the *"Read Radio"* button.

4. The status of each feature listed — whether enabled or disabled — is shown in the *"Status"* field. Note if any features are enabled.

PROGRAMMING FAULTS

1. Initial checks

(1) If the radio's programming file cannot be read, check the connections between the test PC and the radio, the cables, the test unit, and that the serial port of the test PC is correct. (It is good practice to set the MODE switch on the test unit to "RX".) Rectify any fault.

(2) Check if the programming file can be read.

(3) If the file can be read, return to Step 4 of Task 2. If it cannot be read, go to (4) below.

(4) Detach the control head as in Subsection 6.1 (on page 127), and exchange it for a serviceable spare control head.

(5) Check if the programming file can be read.

(6) If the file can be read, the original control head is faulty; disconnect the spare control head, and go to Part 2 below. If the file still cannot be read, the radio body is faulty; reconnect the original control head, and go to Part 3.

2. Control head faulty

(1) If the control-head loom has already been checked, go to (5). If it has not, exchange the loom for a serviceable spare loom.

(2) Check if the programming file can be read.

(3) If the file can be read, the original loom is faulty; go to (4). If the file still cannot be read, reconnect the original loom, and go to (5).

(4) Replace the faulty control-head loom, and return to Step 4 of Task 2.

(5) Check the control-head connector and microphone connector on the control-head board and the path between them.

(6) If either connector is faulty, remove the control-head board as in Subsection 6.2 (on page 131), and replace the connector. If there is an obvious fault causing a break in the path between the connectors, repair it. If no fault can be found, replace the control-head board as in Subsection 7.4 (on page 163).

(7) Check if the programming file can be read.

(8) If the file can be read, return to Step 4 of Task 2. If the file cannot be read, re-assemble the control head with the original control-head board, and return to Step 4 of Task 2.

3. Radio body faulty

(1) Remove the lid of the radio body as in Subsection 6.3 (on page 137).

(2) Repair or replace the main-board assembly as in Section 8 (on page 165).

(3) The final test in Section 8 will indicate whether the repair succeeded or failed. Return to Step 4 of Task 2.

Figure 5.2 Chart for locating and rectifying faults that affect the reading of the programming file

Task 4 — Read Calibration File

Given that the programming file can be read, or a default programming file uploaded, the next task is to read the calibration file.

1. Run the calibration application on the test PC as described in Subsection 4.5 (on page 93).

2. Attempt to read the radio's calibration file. (If the radio is programmed to power up in transparent-data mode as discussed in Task 2, first cycle the power to the radio.)

3. If the file can be read, store a copy on the test PC and proceed to the next paragraph. If the file cannot be read, set up a suitable default calibration file.

4. Upload the default calibration file. This should be successful because any faults affecting this task should have been rectified in Task 2.

Remaining Tasks

Further action depends on the nature of the reported fault. There are five possibilities:

1. If the reported fault concerns powering up the radio — and this has now been addressed — servicing of the radio is complete. Re-assemble the radio, if necessary, and conclude with the tasks of Subsection 5.3 (on page 121).

2. If the reported fault concerns reading the programming file — and this has now been addressed — servicing of the radio is complete. Re-assemble the radio, if necessary, and conclude with the tasks of Subsection 5.3.

3. If the reported fault concerns the user interface or a receive or transmit function, carry out only the relevant task below.

4. If the reported fault is unspecific, carry out each of the remaining tasks in sequence.

5. If the reported fault concerns powering up the radio or reading the programming file, and this has <u>not</u> been confirmed, obtain more information from the Customer.

Task 5 — Check User Interface

This task does not apply to the blank control head. Check the user interface of one- and two-digit-display control heads as follows:

1. Check for any of the following faults:
   - LCD faulty
   - some or all LEDs faulty
   - some or all keys faulty
   - speaker faulty
   - volume control faulty

   In the case of the function-key LEDs, note from the programming file whether the back-lighting option is on or off.

2. If there is no fault, continue with Step 6. If there is a fault, continue with Step 3.

3. Attempt to rectify the fault as described in Section 7 (on page 151). The final test in Section 7 will indicate whether the repair succeeded or failed.

4. If the repair succeeded, continue with Step 5. If the repair failed, conclude with the tasks of Subsection 5.3 (on page 121).

5. If the reported fault is unspecific, proceed to Task 6. If the reported fault concerns the user interface — and this has now been rectified — re-assemble the radio, if necessary, and conclude with the tasks of Subsection 5.3.

6. If the reported fault concerns the user interface — and this has not been confirmed — obtain more information from the Customer. If the reported fault is unspecific, proceed to Task 6.

Task 6 — Check Receive and Receive-audio Functions

Check the receive and receive-audio functions of the radio as follows:

1. Check whether the radio receives.
2. If the radio receives, continue with Step 7. If it does not, continue with Step 3.
3. Attempt to rectify the fault as described in the charts of Figure 5.3 and Figure 5.4.
4. If the repair succeeded — without the need for replacing the main-board assembly — continue with Step 6. Otherwise continue with Step 5.
5. If the main-board assembly was replaced or if the repair failed, re-assemble the radio as described in Subsection 6.4 (on page 144) and Subsection 6.5 (on page 148). Conclude with the tasks of Subsection 5.3 (on page 121).
6. If the reported fault concerns the receive function — and this has now been rectified — re-assemble the radio, if necessary, and conclude with the tasks of Subsection 5.3. If the reported fault is unspecific, proceed to Task 7.
7. If the reported fault concerns the receive function — and this has not been confirmed — obtain more information from the Customer. If the reported fault is unspecific, proceed to Task 7.

RECEIVE AND RECEIVE-AUDIO FAULTS — PARTS 1 AND 2

1. Initial checks

(1) If the radio fails to receive, detach the control head as in Subsection 6.1 (on page 127), and exchange it for a serviceable spare control head.

(2) Check if the radio receives.

(3) If the radio receives, the original control head is faulty; disconnect the spare control head, and go to Part 2 below. If the radio still fails to receive, the radio body is faulty; reconnect the original control head, and go to Part 3 in Figure 5.4.

2. Control head faulty

(1) If the control-head loom has already been checked, go to (5). If it has not, exchange the loom for a serviceable spare loom.

(2) Check if the radio receives.

(3) If the radio receives, the original loom is faulty; go to (4). If the radio still fails to receive, reconnect the original loom, and go to (5).

(4) Replace the faulty control-head loom, and return to Step 4 of Task 6.

(5) If the speaker and volume control have already been checked, go to (8). If they have not, check if either is faulty. If there is no fault, go to (8). If there is a fault, repair it as in Subsection 7.1 (on page 151).

(6) If the repair succeeded, go to (7). If the repair failed, return to Step 4 of Task 6.

(7) Check if the radio receives. If it does, return to Step 4 of Task 6. If it does not, go to (8).

(8) Check the control-head connector and microphone connector on the control-head board and the path between them.

(9) If either connector is faulty, remove the control-head board as in Subsection 6.2 (on page 131), and replace the connector. If there is an obvious fault causing a break in the path between the connectors, repair it. If no fault can be found, replace the control-head board as in Subsection 7.4 (on page 163).

(10) Check if the radio receives.

(11) If the radio receives, return to Step 4 of Task 6. If the radio still fails to receive, re-assemble the control head with the original control-head board, and return to Step 4 of Task 6.

Figure 5.3 Chart for locating and rectifying faults that affect the receive function — control head is faulty

RECEIVE AND RECEIVE-AUDIO FAULTS — PART 3

3. Radio body faulty

(1) Enter the CCTM command 72 to check if the radio is in lock.

(2) If the radio is in lock, go to (6). If it is not, check the programming file, and in particular the frequency band and channel frequencies.

(3) If the programming file is OK, go to (13). If it is not, reprogram the radio.

(4) Check if the radio is in lock. If it is, go to (5). If it is not, go to (13).

(5) Check if the radio receives. If it does, return to Step 4 of Task 6. If it does not, go to (6).

(6) Check the receiver sensitivity. If the sensitivity is OK, go to (7). If it is not, go to (9).

(7) Check the squelch function. If it is OK, go to (9). If it is not, recalibrate the radio.

(8) Check if the radio receives. If it does, return to Step 4 of Task 6. If it does not, go to (9).

(9) Remove the lid of the radio body as in Subsection 6.3 (on page 137), and check the RF connector.

(10) If the connector is OK, go to (13). If it is faulty, go to (11).

(11) At level-1 service centres, go to (13) and replace the main-board assembly. At level-2 service centres, remove and disassemble the main-board assembly as in Subsection 6.3, replace the connector, and re-assemble the main-board assembly as in Subsection 6.4 (on page 144).

(12) Check if the radio receives. If it does, return to Step 4 of Task 6. If it does not, go to (13).

(13) Repair or replace the main-board assembly as in Section 8 (on page 165).

(14) The final test in Section 8 will indicate whether the repair succeeded or failed. Return to Step 4 of Task 6.

Figure 5.4 Chart for locating and rectifying faults that affect the receive function — radio body is faulty

Task 7 — Check Transmit and Transmit-audio Functions

Check the transmit and transmit-audio functions of the radio as follows:

1. Check whether the radio transmits.

2. If the radio transmits, continue with Step 5. If it does not, continue with Step 3.

3. Attempt to rectify the fault as described in the charts of Figure 5.5 and Figure 5.6.

4. Re-assemble the radio, if necessary. Conclude with the tasks of Subsection 5.3 (on page 121).

5. If the reported fault concerns the transmit function — and this has not been confirmed — obtain more information from the Customer. If the reported fault is unspecific, and no fault could be found with the radio, also obtain more information. Otherwise re-assemble the radio, if necessary, and conclude with the tasks of Subsection 5.3.

TRANSMIT AND TRANSMIT-AUDIO FAULTS — PARTS 1 AND 2

1. Initial checks

(1) If the radio fails to transmit, exchange the microphone for a serviceable spare microphone.

(2) Check if the radio transmits.

(3) If the radio transmits, the original microphone is faulty; go to (4). If the radio still fails to transmit, reconnect the original microphone, and go to (5).

(4) Repair the faulty microphone as described in the accessories manual, and return to Step 4 of Task 7.

(5) Detach the control head as in Subsection 6.1 (on page 127), and exchange it for a serviceable spare control head.

(6) Check if the radio transmits.

(7) If the radio transmits, the original control head is faulty; disconnect the spare control head, and go to Part 2 below. If the radio still fails to transmit, the radio body is faulty; reconnect the original control head, and go to Part 3 in Figure 5.6.

2. Control head faulty

(1) If the control-head loom has already been checked, go to (5). If it has not, exchange the loom for a serviceable spare loom.

(2) Check if the radio transmits.

(3) If the radio transmits, the original loom is faulty; go to (4). If the radio still fails to transmit, reconnect the original loom, and go to (5).

(4) Replace the faulty control-head loom, and return to Step 4 of Task 7.

(5) Check the control-head connector and microphone connector on the control-head board and the path between them.

(6) If either connector is faulty, remove the control-head board as in Subsection 6.2 (on page 131), and replace the connector. If there is an obvious fault causing a break in the path between the connectors, repair it. If no fault can be found, replace the control-head board as in Subsection 7.4 (on page 163).

(7) Check if the radio transmits.

(8) If the radio transmits, return to Step 4 of Task 7. If the radio still fails to transmit, re-assemble the control head with the original control-head board, and return to Step 4 of Task 7.

Figure 5.5 Chart for locating and rectifying faults that affect the transmit function — control head is faulty

TRANSMIT AND TRANSMIT-AUDIO FAULTS — PART 3

3. Radio body faulty

(1) If the radio transmits a carrier but not audio, go to (7).

(2) Enter the CCTM command 72 to check if the radio is in lock.

(3) If the radio is in lock, go to (7). If it is not, check the programming file, and in particular the frequency band and channel frequencies.

(4) If the programming file is OK, go to (7). If it is not, reprogram the radio.

(5) Check if the radio is in lock. If it is, go to (6). If it is not, go to (7).

(6) Check if the radio transmits. If it does, return to Step 4 of Task 7. If it does not, go to (7).

(7) Remove the lid of the radio body as in Subsection 6.3 (on page 137), and check the RF connector.

(8) If the connector is OK, go to (11). If it is faulty, go to (9).

(9) At level-1 service centres, go to (11) and replace the main-board assembly. At level-2 service centres, remove and disassemble the main-board assembly as in Subsection 6.3, replace the connector, and re-assemble the main-board assembly as in Subsection 6.4 (on page 144).

(10) Check if the radio transmits. If it does, return to Step 4 of Task 7. If it does not, go to (11).

(11) Repair or replace the main-board assembly as in Section 8 (on page 165).

(12) The final test in Section 8 will indicate whether the repair succeeded or failed. Return to Step 4 of Task 7.

Figure 5.6 Chart for locating and rectifying faults that affect the transmit function — radio body is faulty

5.3 Final Inspection, Test and Administration

Remaining Tasks

This subsection discusses the servicing tasks remaining after the repair, or attempted repair, of the radio:

- final inspection
- final test
- final administration

If the radio could not be repaired, omit the first two tasks.

Final Inspection

After repairing and re-assembling the radio, make a final inspection of the exterior to check that no mechanical parts were damaged during the repair. Repeat the inspection given in Subsection 5.1 (on page 107). Rectify any damage.

Final Test

Reconnect the radio to the test equipment. Test the radio to confirm that it is fully functional again. The recommended tests are listed in Table 5.1 to Table 5.3. (The calibration application can be used for many of these tests.) 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.

Final Administration

The administration tasks following a successful repair of the radio are discussed in the next paragraph. There will be cases, on the other hand, where the radio could not be repaired for one of the following reasons:

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

In these cases level-1 service centres should return the faulty radio to the nearest ASC, and level-2 service centres should return the radio to the ISC. Supply details of the Customer, the fault and, if applicable, the attempted repair.

Administration Tasks

The final administration tasks are the standard workshop procedures for updating the fault database and returning the repaired radio to the Customer with confirmation of the repair. With TM8100 radios, however, additional tasks are necessary if:

- faulty control-head board or main-board assembly is replaced
- default programming file is used

These additional tasks are discussed further below.

Table 5.1 Final tests of transmitter function

Test	Limits
Error in transmit frequency	+100 Hz to –100 Hz
Transmit power: • High • Medium • Low • Very low	 23.2 W to 29.2 W 11.1 W to 14.0 W 4.6 W to 5.8 W 0.9 W to 1.2 W
Current at high power: • B1-band radios • D1-band radios • H5-band radios • H6-band radios	 < 5.5 A < 5.5 A < 6.5 A < 6.5 A
Peak deviation (sweep tone of 300 Hz to 3 kHz): • Narrow-band • Medium-band • Wide-band	 ≤ 2.5 kHz ≤ 4.0 kHz ≤ 5.0 kHz
Distortion: • 1 kHz at 1.5 kHz deviation (narrow-band) • 1 kHz at 3.0 kHz deviation (wide-band)	 < 3% < 3%
CTCSS (continuous-tone-controlled subaudible signalling) deviation: • Narrow-band • Medium-band • Wide-band	 250 to 350 Hz 500 to 560 Hz 580 to 680 Hz

Replacement of Board or Assembly

In some cases the repair of the radio will require the replacement of a complete control-head board or a complete main-board assembly. In these cases level-1 service centres should return the faulty board or assembly to the nearest ASC, and level-2 service centres should return the board or assembly to the ISC. Supply details of the fault and, if applicable, the attempted repair.

New Programming File

If the radio had to be reprogrammed with a default programming file, the following additional actions are required: If the radio 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 radio 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 radio appropriately.

Table 5.2 Final tests of receiver functions

Test	Limits
Receive sensitivity	≤118 dBm for 12 dB SINAD
Mute opening: • Country • City • Hard	 >6 dB and <10 dB SINAD >8 dB and <14 dB SINAD >18 dB and <22 dB SINAD
Audio power (maximum volume at –47 dBm): • At "Rx Audio/SINAD" connector on test unit • At pins 3 (spk–) and 4 (spk+) of power connector on radio	 >500 mV_{rms} >5.00 V_{rms}
Distortion (at –47 dBm, 60% rated system deviation at 1 kHz, with volume set to give 3 W into 16 Ω load)	<3.00%

Table 5.3 Final tests of general radio functions

Test	Description
PTT switch	Check that PTT switch functions
Microphone	Check operation of microphone Check operation of hook-switch
Data communications	Test 1200 baud data transmission (standard) Test Tait high-speed data transmission (if feature is enabled)
Direct-connect GPS (global positioning system)	Check that GPS poll returns correct position (if feature is enabled)
Selcall	Check that radio encodes selcall Check that radio decodes selcall
Audio tap points and digital I/O	Check configuration of programmed options and test operation of these lines to confirm that Customer requirements are satisfied

6 Disassembly and Re-assembly of Radio

Introduction

This section covers the procedures for disassembling and re-assembling the radio:

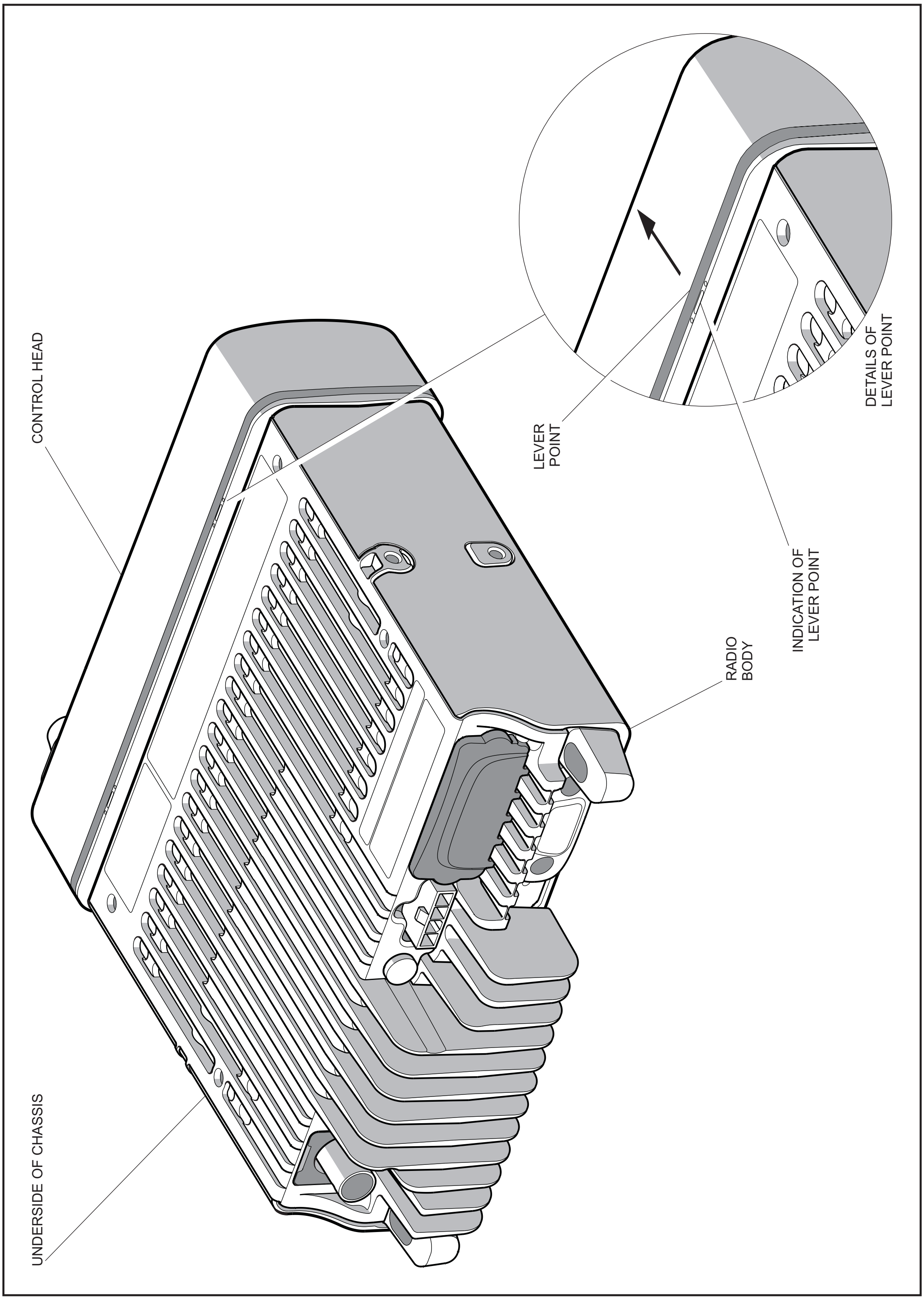
- detachment of control head
- disassembly of control head
- disassembly of radio body
- re-assembly of radio body
- re-assembly and attachment of control head

The procedures are detailed in Subsection 6.1 to Subsection 6.5 respectively.

References to Disassembly and Re-assembly Procedures

The full sequence of tasks entailed in servicing the radio is given in Subsection 5.2 (on page 109). During the course of servicing a particular radio, some or all of the above disassembly and re-assembly procedures will be required. In Subsection 5.2 there are instructions at the appropriate points regarding which disassembly or re-assembly procedure needs to be carried out. However, these procedures can also be followed independently to disassemble and re-assemble the radio.

Figure 6.1 Lever points for detaching the control head from the radio body



6.1 Detachment of Control Head

Detach Control Head

Whether the control head or the radio body is faulty, the control head needs to be detached from the radio body. Do so as follows:

1. Note which way up the control head is attached to the radio body. The control head may be oriented with the underside of the radio body either facing up or facing down. The configuration depends on the Customer's installation, and the radio will need to be returned to the Customer with the same configuration.

2. Disconnect the radio from any test equipment or power supply.

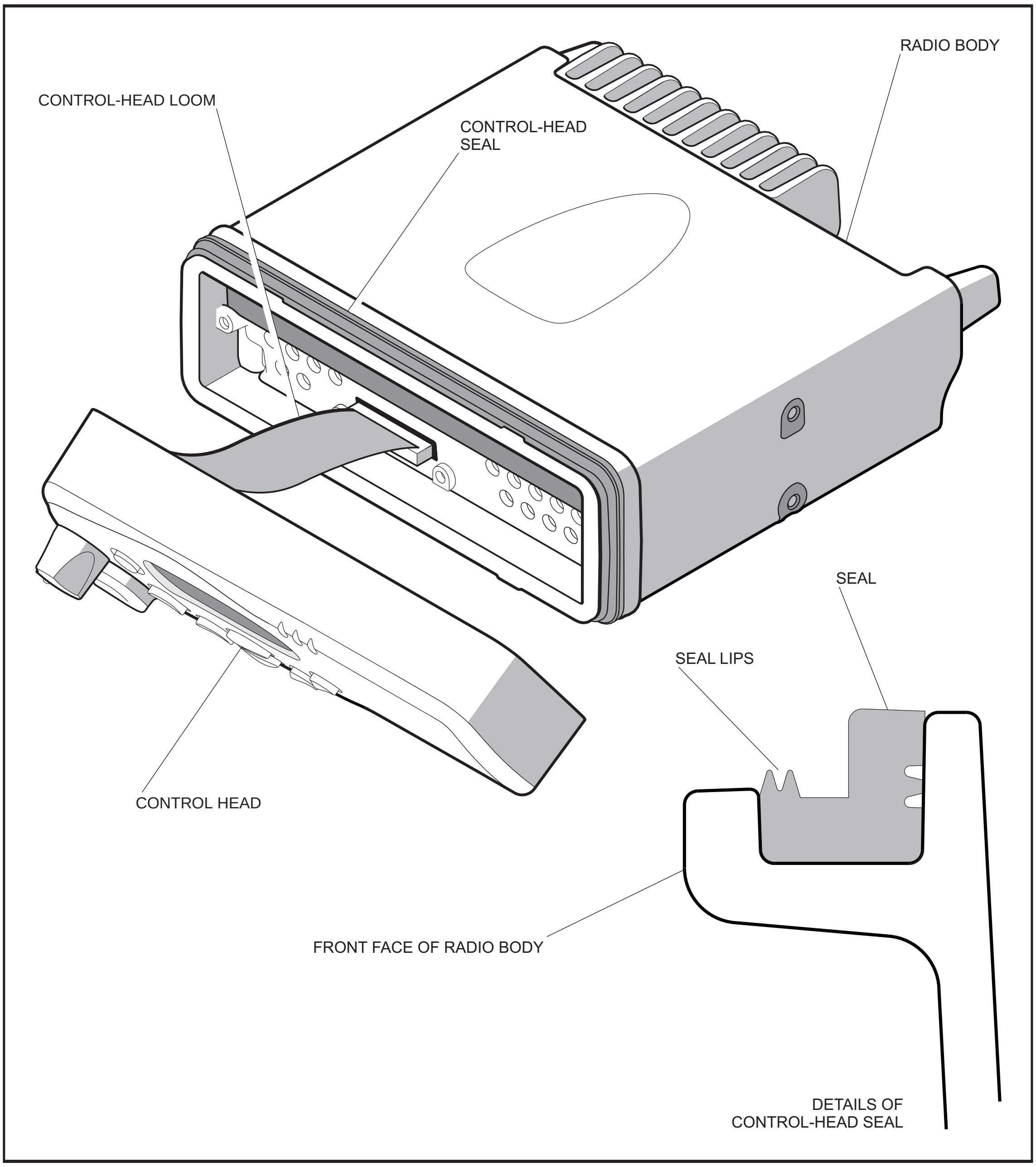
3. Note the two points where the control head should be levered off the radio body. As shown in Figure 6.1, these points are indicated by dot-dash-dot marks on the underside of the radio body. The lever point is between the rubber control-head seal and the front panel of the control head.

4. At each of the above lever points, insert the blade of a medium-sized (about 5 mm) flat-bladed screwdriver and lever off the control head.

5. After detaching the control head, disconnect the control-head loom at the connector on the radio body. Refer to Figure 6.2.

6. Inspect the control head and loom as described below.

Figure 6.2 Details of the control-head seal between the radio body and control head



Inspect Mechanical Parts

Regardless of the reason for detaching the control head, it is advisable to inspect the mechanical parts for damage. Any exterior damage will have been identified already in Subsection 5.1 (on page 107). Check for and rectify any interior damage as follows:

1. Inspect the control-head loom. If the loom has obvious physical damage, replace it with a spare loom from Spares kit 1 (two-digit display) or Spares kit 10 (one-digit display). The product code and contents of the kit are listed in Subsection 6.2 (on page 131).

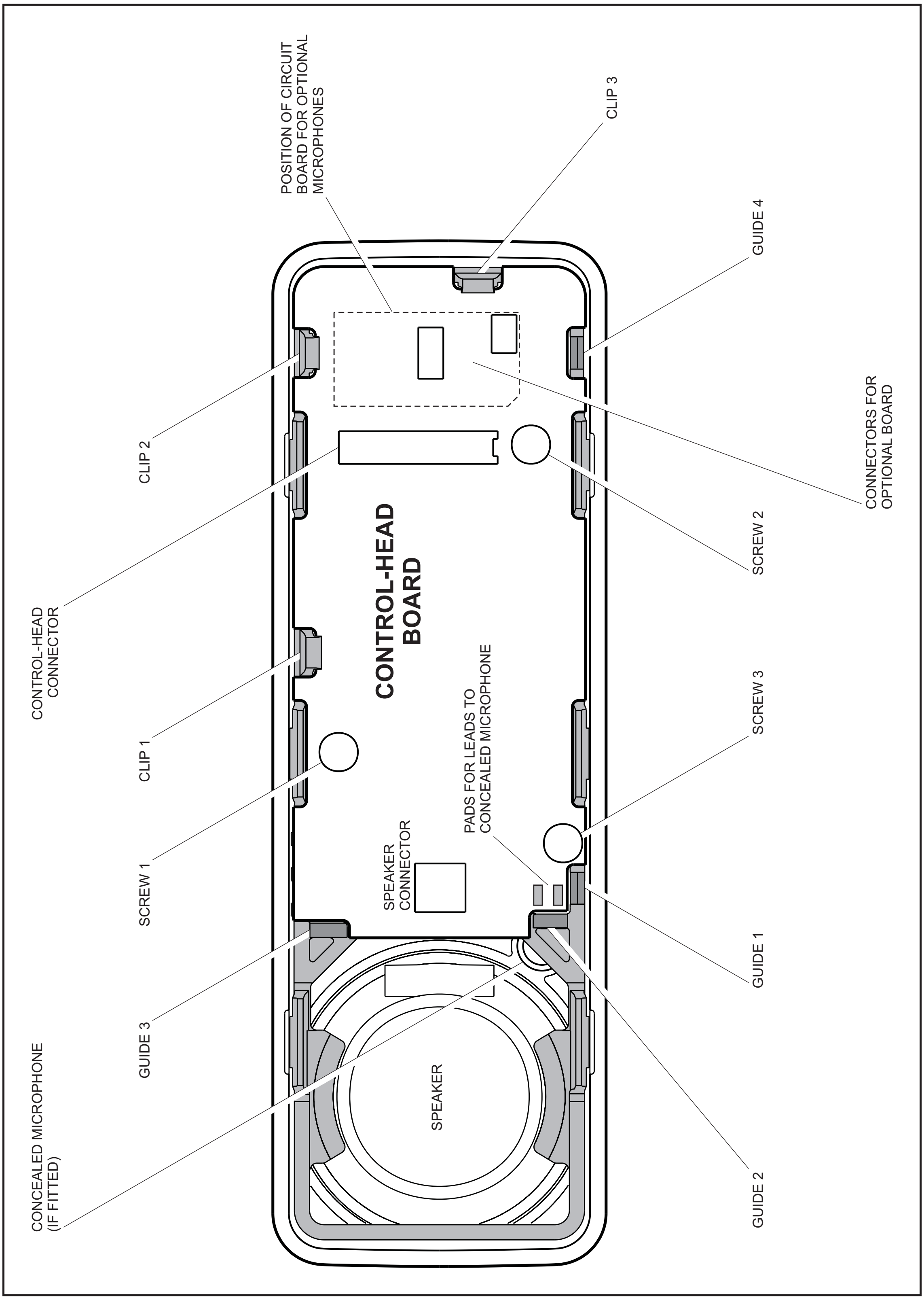
2. Inspect the control-head seal. Refer to Figure 6.2, which shows a cross-section of the seal. Check for any sign of deformation, cuts or tears. Pay particular attention to the two lips of the seal.

3. If the seal is damaged, replace it with a spare seal from Spares kit 7. This kit contains a set of these seals.

4. Inspect the interior of the control head for signs of damage. Check for cracked, broken or burnt parts. In a control head with UI the parts to inspect are the space-frame, speaker and, if fitted, concealed microphone. In a blank control head inspect the programming connector and attached loom.

5. If the inspection in Step 4 reveals no damage, continue with the repair of the radio as described in Subsection 5.2 (on page 109). If there is damage in a control head with UI, disassemble the control head and replace the damaged part or assembly as described in the next subsection. If there is damage in a blank control head, replace the complete control head; for the relevant product code refer to Subsection 1.5 (on page 26).

Figure 6.3 Plan view of the control head showing the control-head board



6.2 Disassembly of Control Head

Introduction

This subsection covers the disassembly of control heads with UI and the replacement of a damaged part or assembly. There are two stages in the disassembly procedure:

- remove control-head board
- replace damaged part or assembly

For the latter task the control-head board must be removed. To repair the board, removal is unnecessary unless there is a need to gain access to components on the underside or to replace the complete board. A separate circuit board for a concealed or dynamic microphone might or might not be mounted on the control-head board.

Remove Control-head Board

The procedure for removing the control-head board is as follows. Refer to Figure 6.3.

1. Pull off the knob from the volume-control potentiometer. Do not use any tools to do so as this might cause damage.

2. If a circuit board for a concealed or dynamic microphone is fitted, unplug it from the control-head board.

3. If a concealed microphone is fitted, unsolder the microphone leads from the control-head board. The leads are soldered to pads on the board as shown in Figure 6.3.

4. Note whether the speaker leads are connected to the control-head board. If so, disconnect the leads. The radio will need to be returned to the Customer in its original state.

5. Use a Torx T10 screwdriver to remove the screws securing the control-head board. The order of removal is immaterial. The screws are labelled screw 1 to screw 3 in Figure 6.3; these numbers are also inscribed on the PCB. The control-head board is now held down only by the clips labelled clip 1 to clip 3 in Figure 6.3.

6. Pull upwards on the edge of the control-head board adjacent to the speaker. At the same time push clip 1 and clip 2 by hand away from the board. The board will lift up slightly.

7. Push clip 3 away from the control-head board while simultaneously pressing on the shaft of the volume-control potentiometer. The board will be freed from the space-frame. Remove the board.

8. If the earlier inspections have not revealed any damaged parts, continue with the repair of the radio as described in Subsection 5.2 (on page 109). If there is damage, continue with the disassembly of the control head and rectify the damage as described below.

Table 6.1 Contents of TMAA22-01 Spares kit 1 and TMAA22-10 Spares kit 10 — parts of the two- and one-digit-display control heads less the control-head board

IPN	Description	Quantity	Reference
—	Front-panel assembly (see below for constituent parts)	1	Figure 2.3
311-01054-**xx**	Knob for volume-control potentiometer	1	Figure 2.3
—	Control-head-loom assembly (see below for constituent parts)	1	Figure 2.4
346-10030-08	3 x 8 PT screw for control-head board	3	Figure 2.4
Parts of front-panel assembly			
316-06786-**xx**	Front panel	1	Figure 2.3
312-01095-**xx**	Lens with Tait logo (two-digit display)	1	Figure 2.3
312-01106-**xx**	Lens with Tait logo (one-digit display)		
365-01717-**xx**	Label for TM8115	1	Figure 2.3
365-01745-**xx**	Label for TM8110		
209-00011-**xx**	Elastomeric strip	2	Figure 2.4
319-30073-**xx**	Space-frame	1	Figure 2.4
008-00031-**xx**	LCD	1	Figure 2.5
252-00011-**xx**	Speaker	1	Figure 2.5
307-01024-**xx**	Speaker membrane	1	Figure 2.5
311-03114-**xx**	Keypad	1	Figure 2.5
262-00003-**xx**	Short light pipe	2	Figure 2.5
262-00004-**xx**	Long light pipe	2	Figure 2.5
Parts of control-head-loom assembly			
219-02882-**xx**	Control-head loom	1	Figure 2.4
240-00021-41	Female-female adaptor for control-head connector	1	Figure 2.4
Note The characters **xx** in an IPN stand for the issue number. Items in the spares kit will always be the latest issue at the time the spares kit is produced.			

Front-panel Assembly and Spares kits 1 and 10

The assembly remaining after the removal of the control-head board is called the front-panel assembly. A complete front-panel assembly is included in Spares kit 1 (two-digit display) and Spares kit 10 (one-digit display). The other parts in these kits are a control-head loom, screws for the control-head board, and a volume-control knob. The contents of the kits, including the parts of the front-panel assembly, are listed in Table 6.1. The IPN of each spare part is given but, if applicable, not the issue number within the IPN. The latest issue of a particular part is always supplied.

Repair of Front-panel Assembly

There are two methods of repairing a damaged front-panel assembly:

- replace complete front-panel assembly
- replace damaged parts of front-panel assembly

Generally either method may be used. However, the latter method must be used if a concealed microphone is fitted or custom labels have been added to the front panel. The two methods are described separately below:

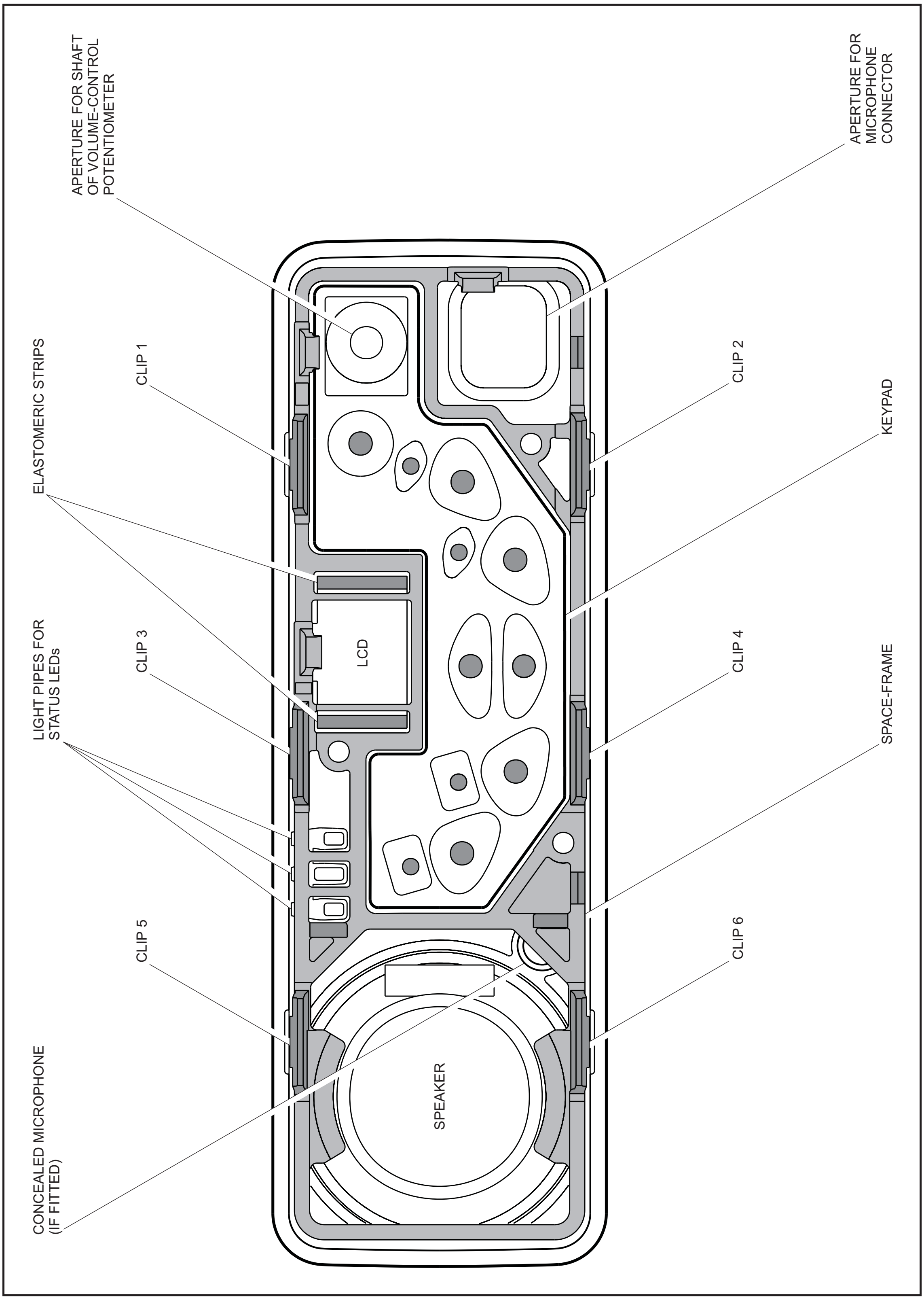
Replace Front-panel Assembly

To replace the complete front-panel assembly, discard the damaged assembly and obtain a replacement assembly from the appropriate spares kit:

- Spares kit 1 : two-digit-display control head
- Spares kit 10 : one-digit-display control head

Leave the spare control-head loom, the screws, and the volume-control knob in the kit. Continue with the repair of the radio as described in Subsection 5.2 (on page 109). Later in the repair procedure the control head board will be fitted to the new front-panel assembly and the complete control head will be assembled.

Figure 6.4 Plan view of the control head with the control-head board removed



Replace Damaged Parts — Disassembly Task

To replace a damaged part, first disassemble the damaged front-panel assembly as well as a spare assembly from the appropriate spares kit. Proceed as follows. Refer to Figure 6.4.

1. Note the clips on the space-frame labelled clip 1 to clip 6 in Figure 6.4. These clips need to be released to remove the space-frame.

2. While pulling upwards on the space-frame at the corner where the microphone connector is situated, release the clips in the order: clips 1 and 2, 3 and 4, and then 5 and 6. To release each clip use a medium-sized (about 5 mm) flat-bladed screwdriver to lever the clip out of its recess. Pulling on the space-frame helps release the clips.

3. Pull the space-frame out when all six clips have been released.

4. Remove the elastomeric strips, speaker, LCD, keypad and, if fitted, concealed microphone.

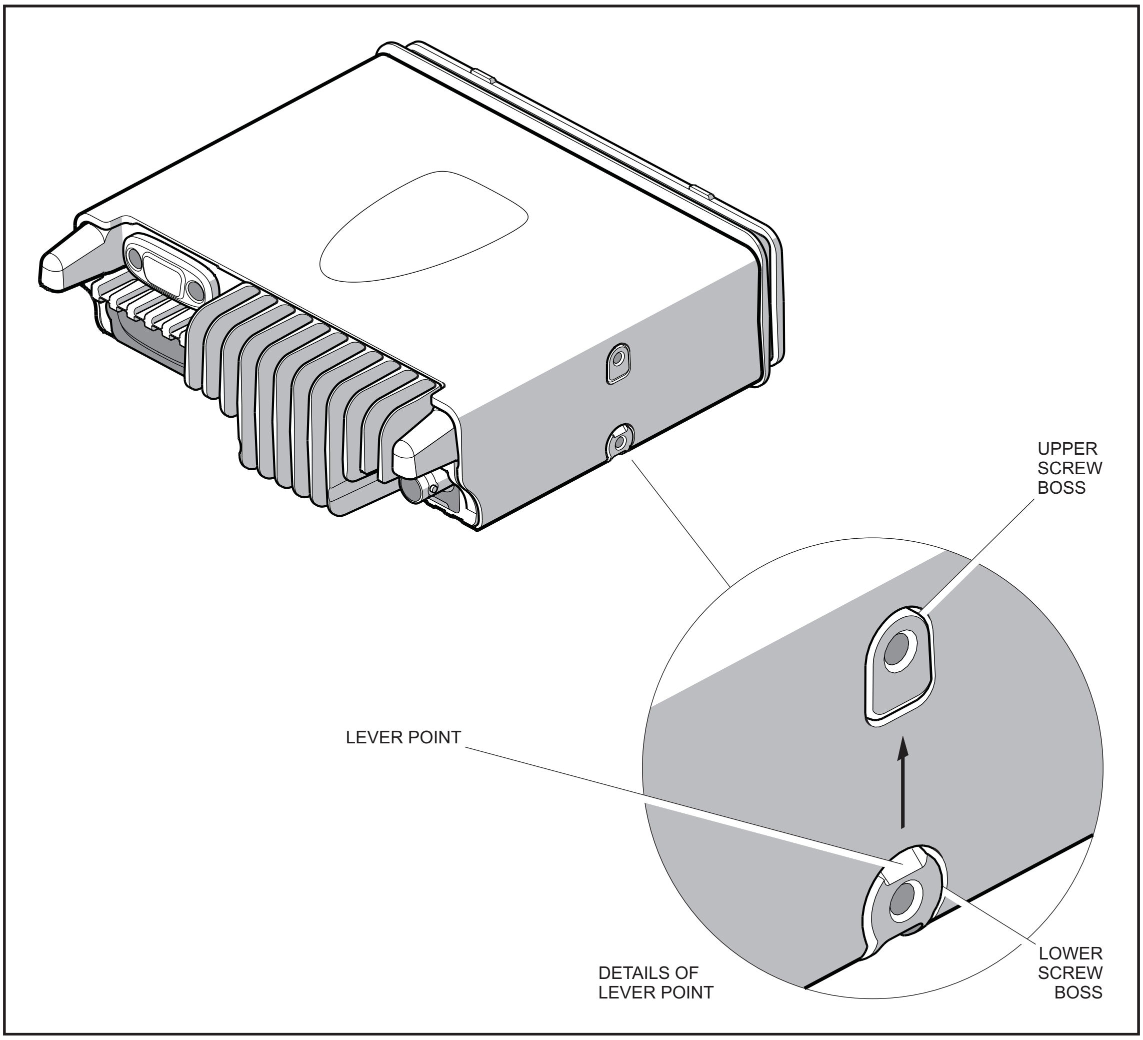
Replace Damaged Parts — Replacement Task

Replace any of the following parts that external and internal inspection have shown to be damaged. Refer to the accessories manual regarding the replacement of a concealed microphone that has been damaged.

- elastomeric strips
- space-frame
- speaker
- keypad
- LCD
- front panel

Obtain replacement parts from the disassembled spare front-panel assembly. Discard the damaged parts and return unused spare parts to the spares kit. Note that spare front panels include the speaker membrane, lens and branding label; the LED light pipes are moulded into the panel. If any part of the front panel is damaged, including the membrane, lens and light pipes, replace the complete panel.

Figure 6.5 Lever points for removing the cover of the radio body



6.3 Disassembly of Radio Body

Introduction

This subsection covers the disassembly of the radio body. There are three stages in the disassembly procedure:

- open radio body
- remove main-board assembly
- disassemble main-board assembly

The control head need not be detached before the radio body is opened, but it must be detached before the main-board assembly can be removed. Remove the main-board assembly only if it requires repair or replacement. Disassemble the main-board assembly only if a connector on the board requires replacement.

Open Radio Body

The first stage in disassembling the radio body is to remove the cover and lid. In the process it is advisable to inspect and, if necessary, replace the main seal in the lid. The procedure is included in the disassembly instructions:

1. Note the two screw bosses on each side of the chassis. The cover clips to the underside of each upper boss. Also note the two points where the cover should be levered off the radio body. As shown in Figure 6.5, each lever point is a slot above the lower screw boss.

2. Insert the blade of a small (about 3 mm) flat-bladed screwdriver in each of the above slots in turn. In each case push the screwdriver under the cover towards the upper screw boss. This will release the cover from the upper boss. Remove the cover.

3. Use a Torx T20 screwdriver to remove the four screws securing the lid of the radio body. The screws are shown in Figure 6.6.

4. Carefully remove the lid. If an options board is fitted, there will be an options loom connecting the main board in the chassis and the options board in the lid. If this is the case, place the lid next to the chassis as shown in Figure 6.7 and disconnect the loom.

5. Inspect the main seal in the lid for any sign of deformation, cuts or tears. Refer to Figure 6.7. If the seal is damaged, replace it with a spare seal from Spares kit 2. The contents of the kit are listed in Table 6.2. The IPN of each spare part is given but, if applicable, <u>not</u> the issue number within the IPN. The latest issue of a particular part is always supplied.

6. Continue with the servicing procedure detailed in Subsection 5.2 (on page 109).

Figure 6.6 The four screws that secure the lid to the chassis of the radio body

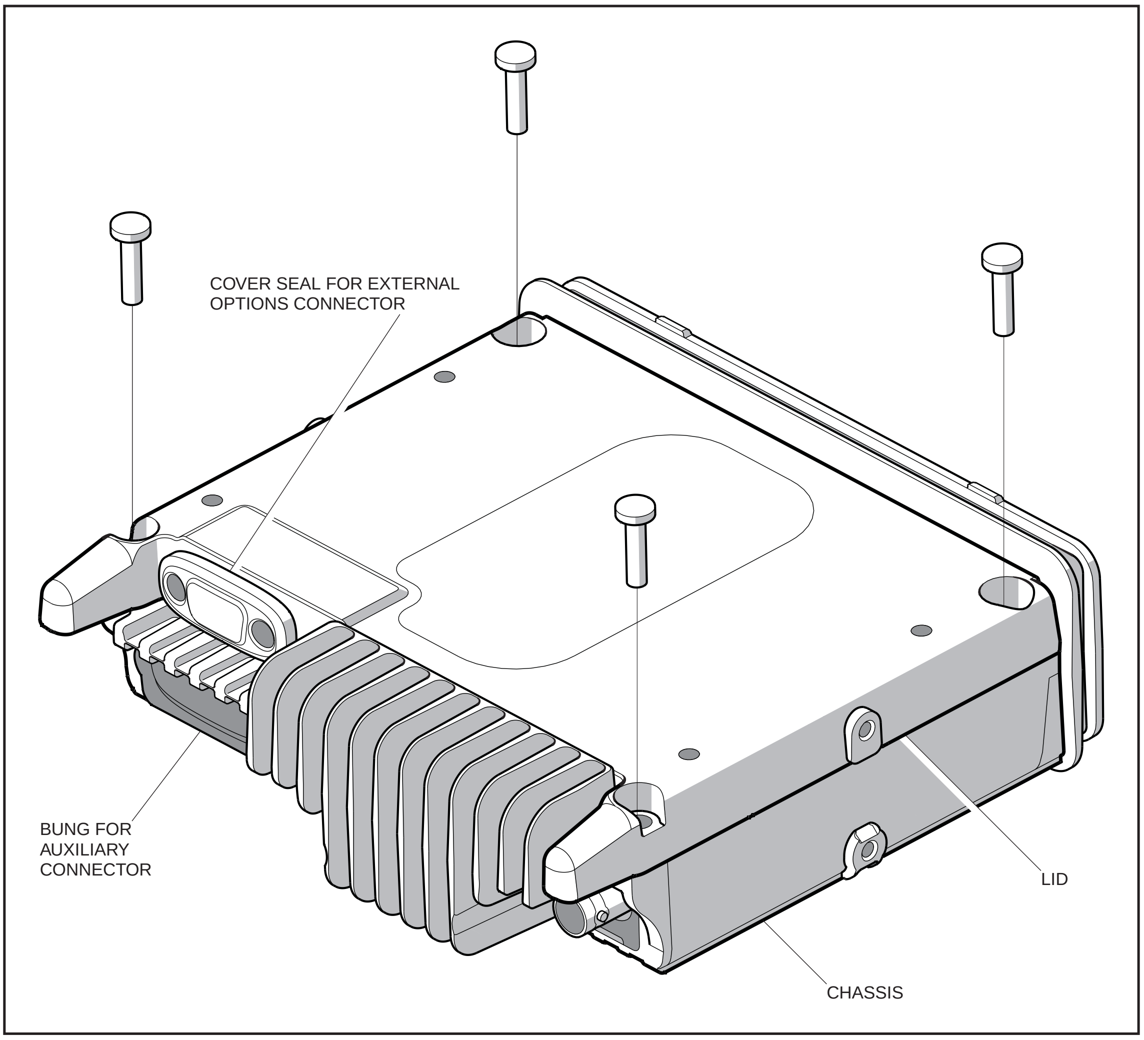


Figure 6.7 Illustration of the lid removed from the chassis of the radio body, with an options board installed in the lid

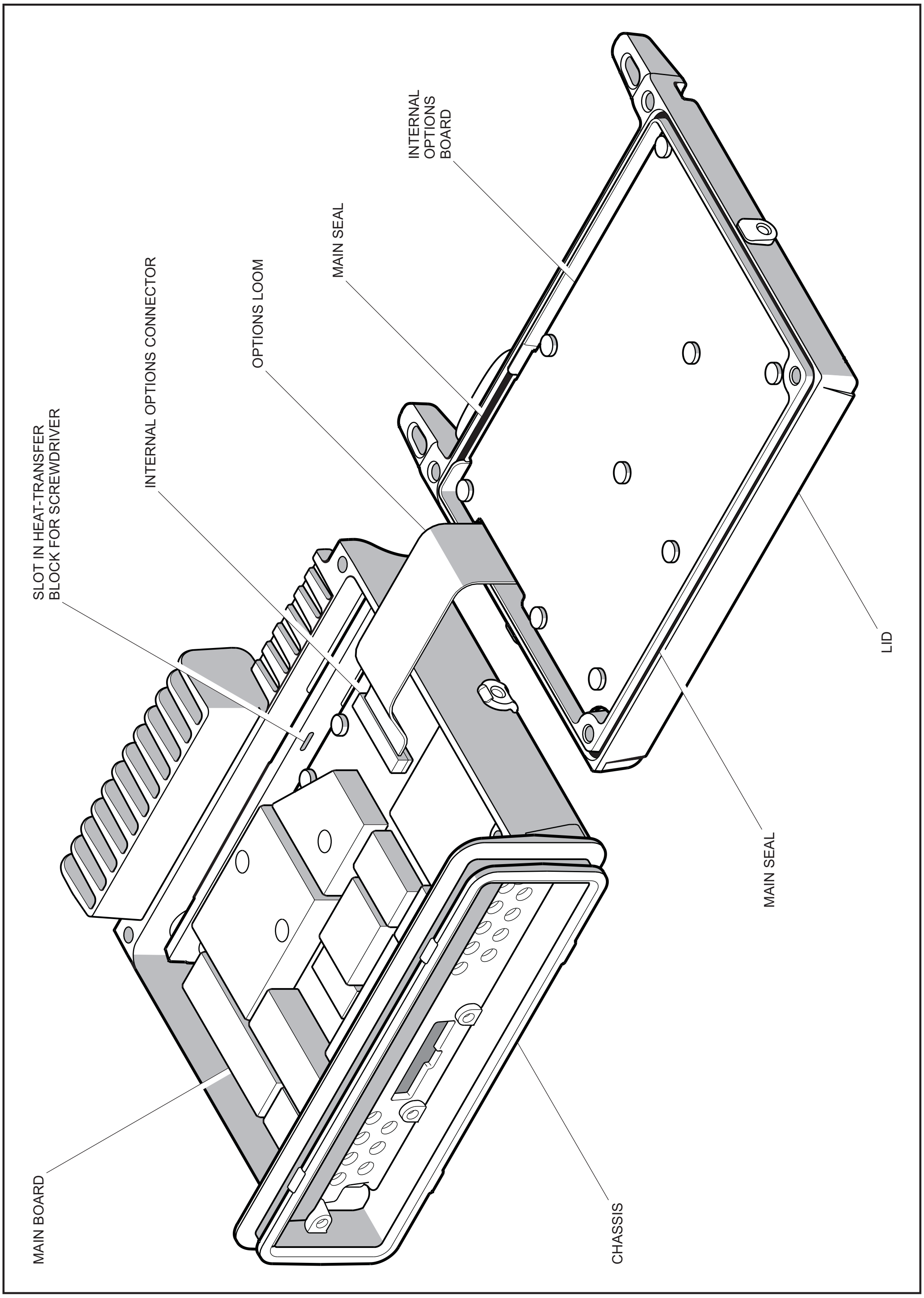
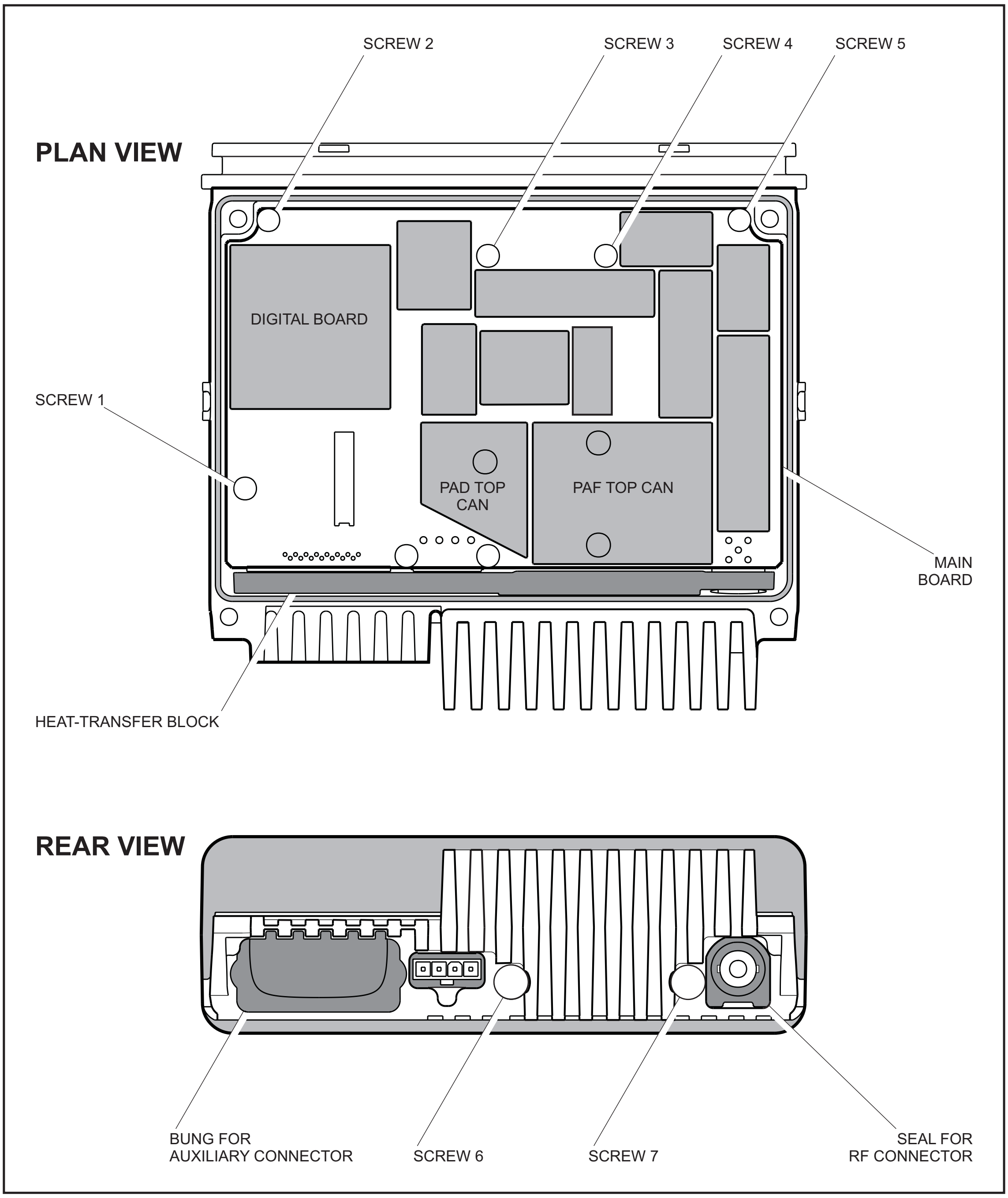


Figure 6.8 Illustration of the chassis showing the screws that secure the main-board assembly

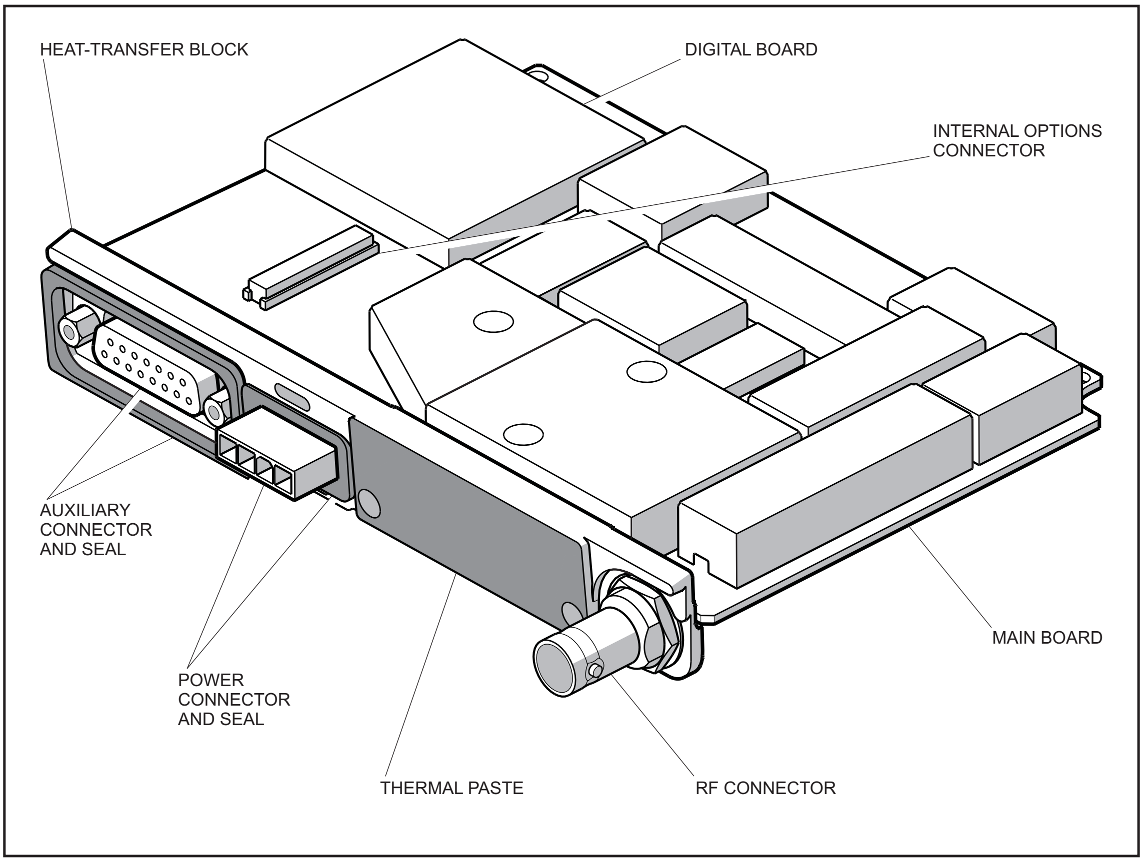


Remove Main-board Assembly

The second stage, if necessary, in disassembling the radio body is to remove the main-board assembly.

1. Remove the bung (if fitted) covering the auxiliary connector.
2. Remove the rubber seal around the RF connector — preferably by hand. If necessary, however, lever up the seal by inserting the blade of a small (about 3 mm) flat-bladed screwdriver in the gap beneath the seal. See Figure 6.8. Do not damage the seal with the screwdriver.
3. Note the five interior screws securing the main-board assembly; these are labelled screw 1 to screw 5 in Figure 6.8. Use a Torx T10 screwdriver to remove the screws. The order of removal is immaterial, but good practice would be to follow the order from screw 1 to screw 5.
4. Note the two exterior screws securing the main-board assembly; these are labelled screw 6 and screw 7 in Figure 6.8. Use a Torx T20 screwdriver to remove the screws.
5. The main-board assembly is now free of the chassis. Note the slot in the heat-transfer block shown in Figure 6.7. Insert the blade of a small (about 3 to 5 mm) flat-bladed screwdriver in the slot. Tilt the screwdriver to lever up the front edge of the circuit board. Grip the edge of the board and pull out the assembly, but avoid the thermal paste on the heat-transfer block and PCB underside. The areas coated with thermal paste are shown in Figure 2.11 and Figure 6.9.

Figure 6.9 Features of the main-board assembly



Disassemble Main-board Assembly

The third stage, if necessary, in disassembling the radio body is to disassemble the main-board assembly.

1. Remove the rubber seal for the power connector.
2. Use a torque-driver with a 3/16-inch socket to remove the lock-nuts for the auxiliary connector.
3. Use a torque-driver with a 14 mm long-reach socket to remove the hexagonal nut of the RF connector. Also remove the lock washer.
4. Use a Torx T10 screwdriver to remove the three screws securing the copper plate on the main board to the heat-transfer block. Access to the screws is via the holes in the PAD TOP and PAF TOP cans shown in Figure 6.8.

Table 6.2 Contents of TMAA22-02 Spares kit 2 — mechanical parts of radio body

IPN	Description	Quantity	Reference
—	Cover assembly (see below for constituent parts)	1	Figure 2.8
349-02067-**xx**	M4 x 16 screw for lid of radio body	4	Figure 2.8
362-01115-**xx**	Control-head seal	1	Figure 2.8
362-01109-**xx**	Main seal in lid	1	Figure 2.9
302-50000-**xx**	Bung for external options connector	1	Figure 2.9
302-50001-**xx**	Bung for auxiliary connector	1	Figure 2.11
362-01113-**xx**	Seal for RF connector	1	Figure 2.11
349-02067-**xx**	External M4 x 16 screw for main-board assembly	2	Figure 2.11
349-02066-**xx**	Internal M3 x 10 screw for main-board assembly	5	Figure 2.11
362-01114-**xx**	Rubber seal for power connector	1	Figure 2.12
354-01043-**xx**	Lock-nut for auxiliary connector	1 pair	Figure 2.12
362-01112-**xx**	Outer foam seal for auxiliary connector	1	Figure 2.12
362-01110-**xx**	Inner foam seal for auxiliary connector	1	Figure 2.12
Parts of cover assembly			
303-23166-**xx**	Cover	1	Figure 2.8
365-01712-**xx**	Label for cover	1	Figure 2.8

Note
The characters **xx** in an IPN stand for the issue number. Items in the spares kit will always be the latest issue at the time the spares kit is produced.

5. Separate the main board from the heat-transfer block. Avoid touching or fouling the thermal paste on the copper plate and heat-transfer block.

6. Replace any faulty connector. In the case of the power connector note that, as well as the pins being soldered to the PCB, there are two screws securing the connector. Use a Torx T10 screwdriver to remove the screws. After replacing the connector, use a torque-driver to tighten the screws to 0.34 N·m (3 lbf·in).

6.4 Re-assembly of Radio Body

Introduction

There are three stages in the re-assembly of the radio body:

- re-assemble main-board assembly
- install main-board assembly
- close radio body

The first stage is necessary only if the main-board assembly has been disassembled, and the second only if it has been removed from the chassis. The procedures for the three stages are given separately below. The torque values for the fasteners involved are summarised in Table 6.3.

Re-assemble Main-board Assembly — Apply Thermal Paste

If the main-board assembly needs to be re-assembled, first replenish the thermal paste on the copper plate:

1. Thermal paste is required over the complete surface of the copper plate. The corresponding area of the heat-transfer block is shown in Figure 2.12. This area constitutes the contact area between the copper plate and the heat-transfer block.

2. Inspect the area on the copper plate requiring thermal paste, as well as the corresponding area on the heat-transfer block. If the residual paste has been contaminated with dirt, clean off the paste.

3. Obtain 0.1 cm^3 of thermal paste. Use Dow Corning 340 silicone heat-sink compound (IPN 937-00000-55) or the equivalent.

4. Use a stiff brush to apply the paste in a thin film to the required area on the copper plate. Ensure that no bristles from the brush come loose and remain embedded in the paste. The paste needs to be completely free of contaminants.

Re-assemble Main-board Assembly — Fasten Parts of Assembly

Complete the assembly of the main-board assembly by securing the main board to the heat-transfer block.

1. Fit the main board to the heat-transfer block, and screw in the three screws that secure the copper plate to the heat-transfer block. Use a Torx T10 torque-driver to tighten the screws to 1.7 N·m (15 lbf·in).

2. Clean off any excess thermal paste on the heat-transfer block.

3. Secure the two lock-nuts for the auxiliary connector. Use a torque-driver with a 3/16-inch socket to tighten each lock-nut to 0.90 N·m (8 lbf·in).

4. Fit the lock washer and hexagonal nut of the RF connector. Use a torque-driver with a 14 mm long-reach socket to tighten the nut to 1.7 N·m (15 lbf·in).

5. Fit the rubber seal for the power connector. There is only one correct orientation. Ensure that the seal is properly seated.

Table 6.3 Summary of the torque values for the fasteners used in TM8100 mobile radios

Description of screws	Drive type	Quantity	Torque (N·m)	Torque (lbf·in)
Screws for control-head board	Torx T10	3	0.56	5
Screws for lid of radio body	Torx T20	4	2.5	22
External screws for main-board assembly	Torx T20	2	2.5	22
Internal screws for main-board assembly	Torx T10	5	1.9	17
Screws for copper plate	Torx T10	3	1.7	15
Screws for power connector	Torx T10	2	0.34	3
Lock-nuts for auxiliary connector	3/16-inch socket	2	0.90	8
Hexagonal nut of RF connector	Long-reach socket	1	1.7	15

Install Main-board Assembly — Apply Thermal Paste

If the main-board assembly needs to be installed, first replenish the thermal paste on the heat-transfer block and on the screw boss on the floor of the chassis:

1. Thermal paste is required on the area of the heat-transfer block shown in Figure 6.9. This area constitutes the contact area between the main-board assembly and the chassis.

2. Inspect the area on the heat-transfer block requiring thermal paste, as well as the corresponding area on the chassis. If the residual paste has been contaminated with dirt, clean off the paste.

3. Obtain 0.1 cm^3 of thermal paste. Use Dow Corning 340 silicone heat-sink compound (IPN 937-00000-55) or the equivalent.

4. Use a stiff brush to apply the paste in a thin film to the required area on the heat-transfer block. Ensure that no bristles from the brush come loose and remain embedded in the paste. The paste needs to be completely free of contaminants.

5. Thermal paste is also required on the screw boss in contact with the PCB. The area is shown in Figure 2.11. Inspect the area, as well as the corresponding area on the PCB. If the residual paste has been contaminated with dirt, clean off the paste.

6. Replenish the paste on the screw boss as described in Steps 3 and 4. The amount of paste required is about one-tenth of that used for the heat-transfer block.

Important Ensure that the two external screws securing the main-board assembly are properly tightened; otherwise the radio will overheat and might be damaged.

Install Main-board Assembly — Secure Assembly in Chassis

Complete the installation of the main-board assembly by securing the assembly in the chassis:

1. Place the main-board assembly in position in the chassis.
2. Screw in the two external screws by hand as far as possible. The screws are labelled screw 6 and screw 7 in Figure 6.8. Ensure that the screws start easily and are not cross-threaded.
3. Identify the diagonal edge of the PAD TOP can. The can is shown in Figure 6.8.
4. While pressing down firmly on the diagonal edge of the PAD TOP can, use a Torx T20 torque-driver to tighten the screws to 2.5 N·m (22 lbf·in). (If the screws are not tightened properly, the radio will overheat.) The reason for pressing down on the can is to ensure that the circuit board is seated correctly on the bosses for the five internal screws.
5. Clean off any excess thermal paste on the heat-transfer block.
6. Screw in the five internal screws by hand as far as possible. The screws are labelled screw 1 to screw 5 in Figure 6.8. Ensure that the screws start easily and are not cross-threaded. Then use a Torx T10 torque-driver to tighten the screws to 1.9 N·m (17 lbf·in).
7. Fit the rubber seal for the RF connector; first fit the upper part of the seal and then press down around the sides of the seal to the bottom. Ensure that the seal is properly seated around its entire periphery.
8. In most radios a bung will have been supplied for the auxiliary connector. In such cases the bung must be fitted again on re-assembly to ensure that the radio is sealed. In fitting the bung, ensure that it is not upside down and that it is properly seated.

Close Radio Body

Secure the lid and cover of the radio body as follows:

1. If an options board is installed in the lid of the radio body, reconnect the options loom to the internal options connector on the main board. This is best done with the lid placed next to the chassis as shown in Figure 6.7.
2. Place the lid in position on the chassis. Ensure that the main seal in the lid is properly seated.
3. Screw in by hand the four screws that secure the lid. Ensure that the screws start easily and are not cross-threaded. Then use a Torx T20 torque-driver to tighten the screws to 2.5 N·m (22 lbf·in).
4. Fit the cover of the radio body.
5. Continue with the servicing procedure detailed in Subsection 5.2 (on page 109).

6.5 Re-assembly and Attachment of Control Head

Introduction

There are at most three stages in the re-assembly and attachment of the control head. The first two stages concern only control heads with UI, not the blank control head. The three stages are:

- re-assemble front-panel assembly
- re-install control-head board
- re-attach control head

The procedures for the three stages are given separately below. The first stage is required only if the control head has been completely disassembled. The second stage is required if the control-head board has been removed; this stage includes the fitting, if applicable, of the circuit board for optional concealed and dynamic microphones. The torque values for the screws involved are included in Table 6.3.

Re-assemble Front-panel Assembly

If the control head has been completely disassembled, re-assemble the mechanical parts as follows:

1. If the LCD is a spare delivered by TEL and not obtained from Spares kit 1 or 10, it will have a protective film covering the screen. Peel off the film before continuing.
2. Ensure that the LCD is free of dirt and fingerprints. Use isopropyl alcohol and a soft lens-cleaning cloth to clean the LCD, including the electrical contact points. Take care not to scratch the soft polariser material on both sides of the LCD.
3. Place the LCD in its recess in the cover as shown in Figure 6.4. There is only one correct orientation: the small protrusion on the edge of the LCD must be adjacent to the wall of the front panel.
4. Place the keypad in position on the floor of the front panel.
5. Place the speaker in position and, if included, the concealed microphone.
6. Place the space-frame in position. Ensure that the leads from the speaker and, if fitted, the concealed microphone do not foul the frame. The leads will need to be connected to the top of the control-head board when the board is installed.
7. Press down on the space-frame until all six clips on the frame snap into place in their recesses.
8. Ensure that the conductors along the edges of the two elastomeric strips are clean. Wipe the strips with a soft lens-cleaning cloth. If necessary, clean the strips using isopropyl alcohol.
9. Insert the two elastomeric strips in their slots in the space-frame.

Re-install Control-head Board

Re-install the control-head board and, if included, the optional microphone board as follows. The torque values for the screws securing the control-head board are included in Table 6.3.

1. Place the control-head board in position on the space-frame. Ensure that the board fits inside the four guides on the frame. The guides are labelled guide 1 to guide 4 in Figure 6.3.

2. Press straight down on the control-head board until the three clips on the space-frame snap into position against the board. The clips are labelled clip 1 to clip 3 in Figure 6.3. It is important <u>not</u> to press down on the circuit board at an angle. To do so might distort the elastomeric strips, causing failure in the operation of the LCD.

3. Screw in by hand the three screws that secure the control-head board. The screws are labelled screw 1 to screw 3 in Figure 6.3. Ensure that the screws start easily and are not cross-threaded. Then, beginning with screw 1, use a Torx T10 torque-driver to tighten the screws to 0.6 N·m (5 lbf·in).

4. If an optional microphone board is included, attach the board to the control-head board. Two sockets on the former connect to corresponding plugs on the latter.

5. If a concealed microphone is fitted, solder the leads from the microphone to the relevant pads on the control-head board. The pads are shown in Figure 6.3.

6. If the speaker leads were originally connected to the control-head board, as noted in Subsection 6.2 (on page 131), then reconnect the leads. Orient the plug on the leads so that the ridge on one side of the plug is uppermost.

7. Push the knob onto the shaft of the volume-control potentiometer. Ensure that the knob turns freely.

Re-attach Control Head

Re-attach the control head to the radio body as follows. The procedure applies both to the blank control head and to control heads with UI.

1. Orient the control head with respect to the radio body as noted in Subsection 6.1 (on page 127).
2. Reconnect the control-head loom to the connector on the radio body. Refer to Figure 6.2.
3. Align the control head with the inner face of the radio body. Ensure that the control-head loom folds properly into the space between the control head and the radio body.
4. Press the control head against the radio body until it clips into position. Ensure that the seal is not damaged in the process.
5. Continue with the servicing procedure detailed in Subsection 5.2 (on page 109).

7 Servicing of Control Head

Scope of Section

This section covers servicing of the control head following the initial investigation described in Subsection 5.2 (on page 109). The investigation will have revealed either of the following:

- user interface is faulty
- control-head board needs to be replaced

The former includes faults with the two-digit display, LEDs, keys, speaker, and volume control. Subsection 7.1 to Subsection 7.3 describe repairs of the user interface. Subsection 7.4 describes the replacement of the control-head board. Throughout this section data in square brackets are grid references giving the locations of the components concerned on the circuit diagram.

Repair of User Interface

Faults in the user interface can be divided into two categories:

- faults not involving control-head board
- faults involving control-head board

Subsection 7.1 below and Subsection 7.2 (on page 157) cover the repair procedures for these two cases respectively. Repair of the control-head board, however, is a level-2 repair. Level-1 service centres should instead replace the board as described in Subsection 7.4 (on page 163). For level-2 service centres, Subsection 7.3 (on page 160) describes how to find the correct replacement for a faulty component on the board. For a discussion of SMT repair techniques, refer to Subsection 4.4 (on page 91).

7.1 Faults not Involving Control-head Board

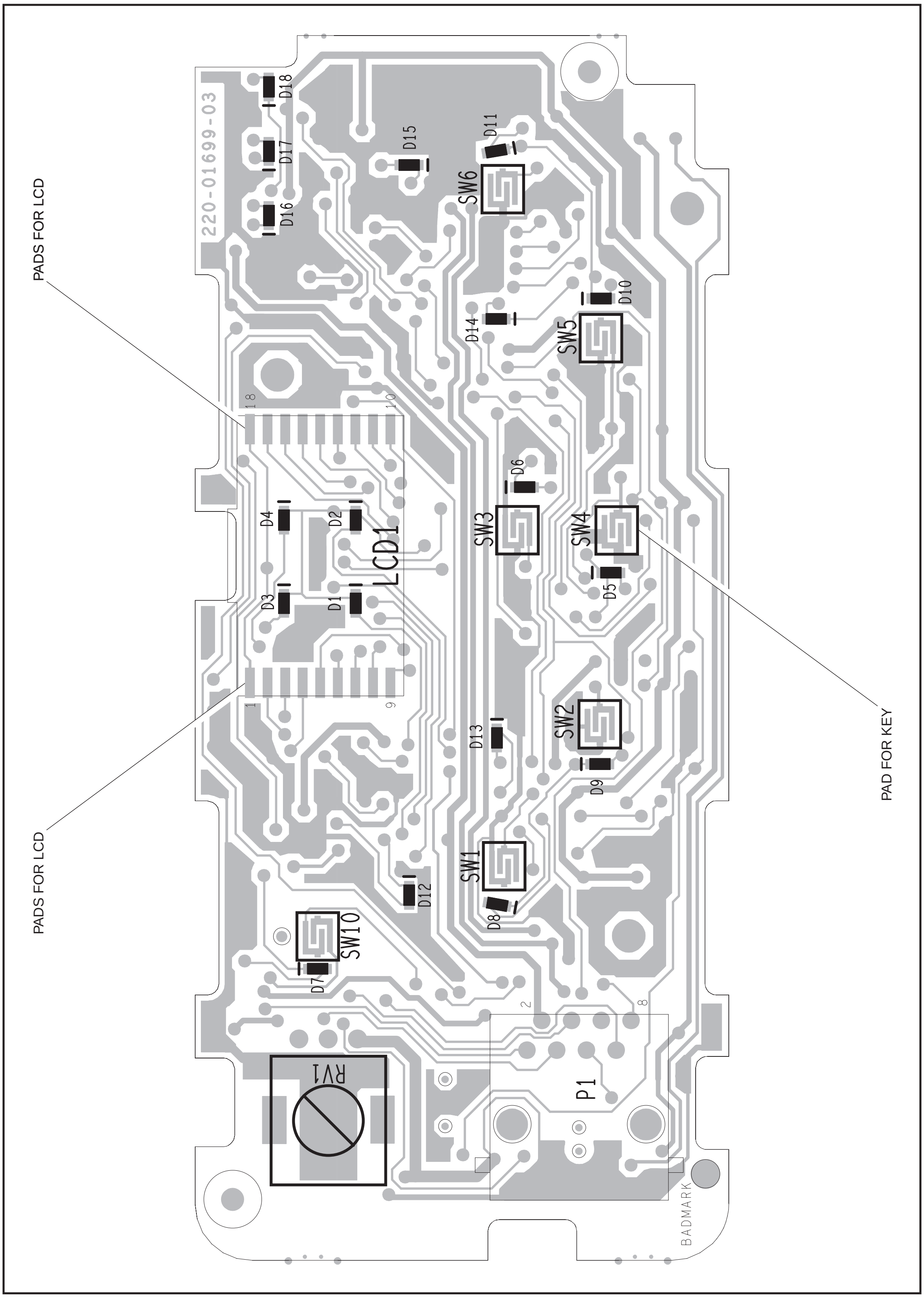
Types of Faults

This subsection gives the procedures for rectifying the following faults in the user interface:

- display is faulty but not LEDs
- some but not all keys are faulty
- speaker is faulty
- volume control is faulty

The repair procedures are given in Tasks 1 to 5 below. A faulty display might or might not be caused by a faulty control-head board — Tasks 1 and 2 deal with the case where the board is not the cause. The remaining three faults also do not involve the board, and these are dealt with in Tasks 3 to 5 respectively.

Figure 7.1 Primary side of the control-head board



Task 1 — Display Faulty but not LEDs — Check Elastomeric Strips

If all the LEDs function correctly but the display functions only partially or not at all, first check the elastomeric strips as follows:

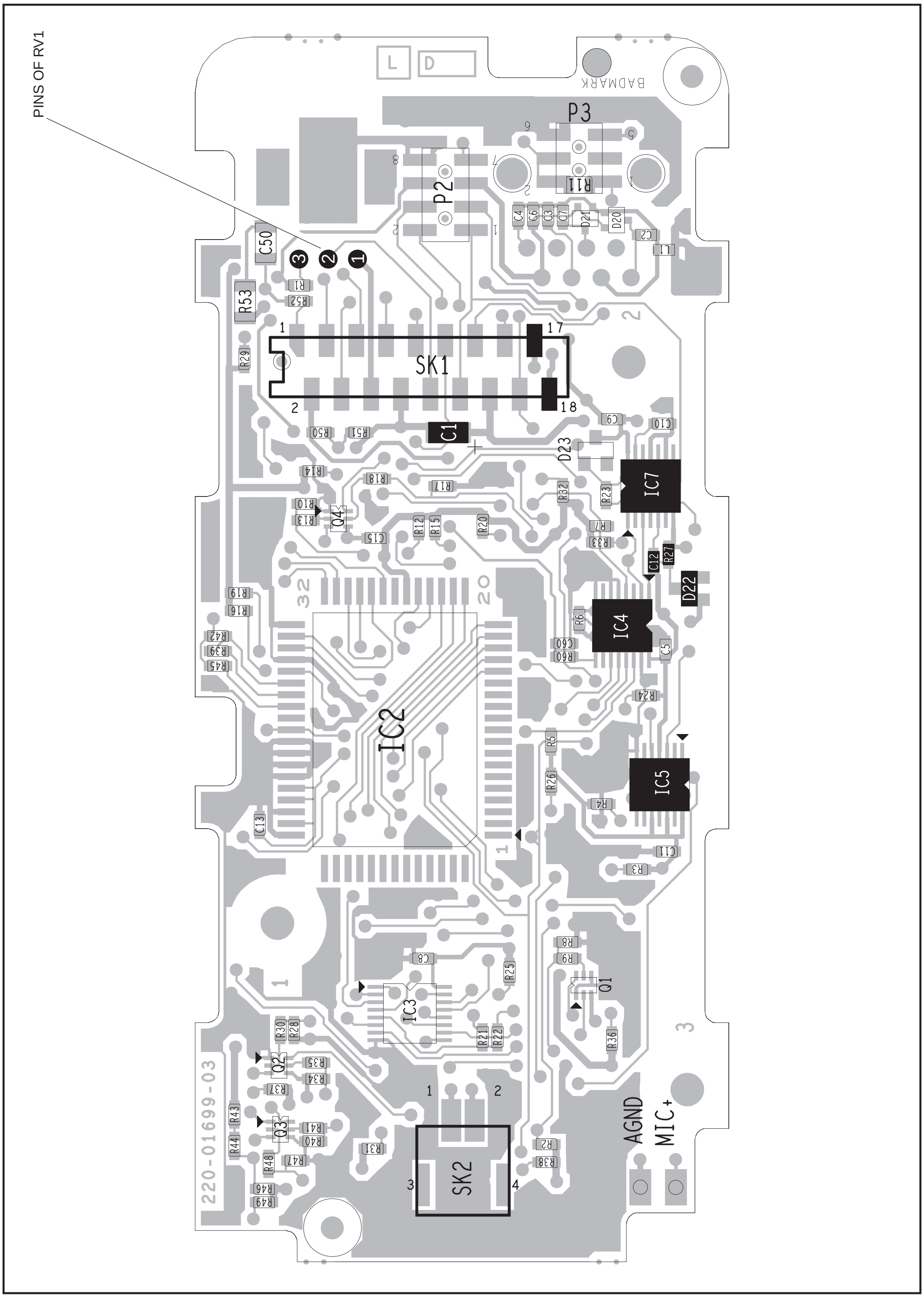
1. Disconnect the control-head loom from the control head. Remove the control-head board as described in Subsection 6.2 (on page 131).
2. Remove the elastomeric strips and check the conductors in the strips for continuity. Replace the strips if they are faulty. (Obtain spare strips by disassembling the spare control head of Spares kit 1 or 10 as described in Subsection 6.2.)
3. Ensure that the conductors along the edges of the strips are clean. Use isopropyl alcohol and a soft lens-cleaning cloth to clean the edges.
4. Use isopropyl alcohol and a soft lens-cleaning cloth to clean the pads for the LCD on the control-head board. See Figure 7.1.
5. Insert the elastomeric strips in their slots in the space-frame.
6. Install the control-head board as described in Subsection 6.5 (on page 148).
7. Reconnect the control-head loom to the control head and test the user interface. If the fault has been removed, return to Subsection 5.2 (on page 109). If it has not, go to Task 2.

Task 2 — Display Faulty but not LEDs — Replace LCD

If the elastomeric strips are not the cause of the fault, replace the LCD as follows:

1. Disconnect the control-head loom. Remove the control-head board and disassemble the control head as described in Subsection 6.2.
2. Remove the LCD. Obtain a spare LCD by disassembling the spare control head of Spares kit 1 or 10 as described in Subsection 6.2.
3. Use isopropyl alcohol and a soft lens-cleaning cloth to clean the electrical contact points on the spare LCD. Take care not to scratch the soft polariser material on both sides of the LCD.
4. Re-assemble the control head as described in Subsection 6.5.
5. Reconnect the control-head loom and test the user interface. If the fault has been removed, return to Subsection 5.2. If it has not, go to Step 6.
6. The control-head board is suspect. Level-1 service centres should replace the board as described in Subsection 7.4 (on page 163). Level-2 service centres should attempt to repair the board as described in Subsection 7.2 (on page 157).

Figure 7.2 Secondary side of the control-head board with the LCD driver circuitry and other components indicated



Task 3 — Some but not All Keys Faulty

If one or more (but not all) of the keys are faulty, repair the control head as follows:

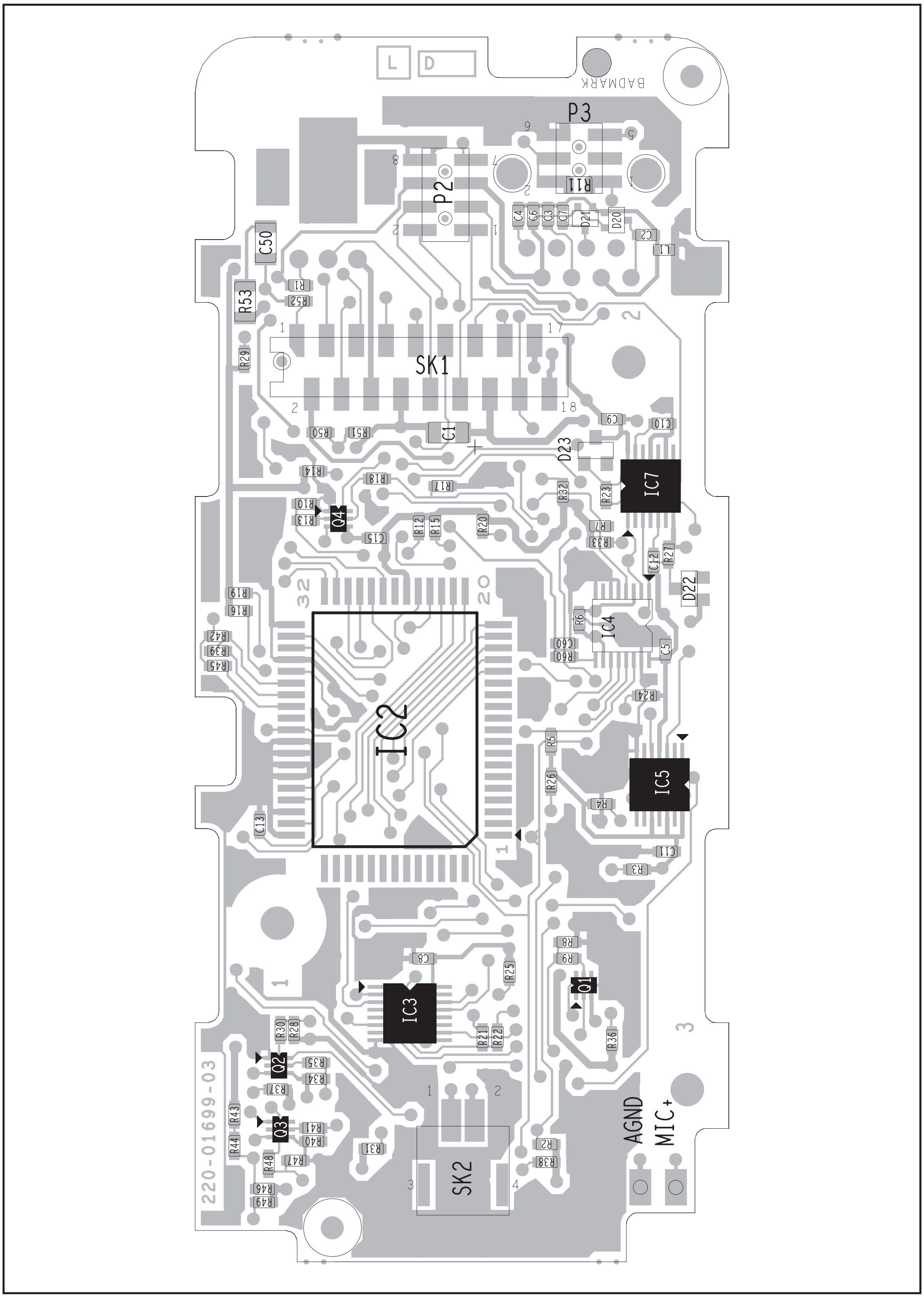
1. Disconnect the control-head loom and remove the control-head board as described in Subsection 6.2 (on page 131).
2. Use isopropyl alcohol and a soft lens-cleaning cloth to clean the pads on the control-head board for those keys that are faulty. Figure 7.1.
3. Re-install the control-head board as described in Subsection 6.5 (on page 148).
4. Reconnect the control-head loom and test the keys. If the fault has been removed, return to Subsection 5.2 (on page 109). If it has not, go to Step 5.
5. Disassemble the control head completely as described in Subsection 6.2. Replace the keypad with a spare. Obtain the spare keypad by disassembling the spare control head of Spares kit 1 or 10 as described in Subsection 6.2.
6. Re-assemble the control head as described in Subsection 6.5. Reconnect the control-head loom, test the keys to confirm the removal of the fault, and return to Subsection 5.2.

Task 4 — Speaker Faulty

If the speaker functions only intermittently or the audio level is low, repair the control head as follows:

1. Disconnect the control-head loom and disassemble the control head completely as described in Subsection 6.2.
2. Replace the speaker with a spare. Obtain a spare speaker by disassembling the spare control head of Spares kit 1 or 10 as described in Subsection 6.2.
3. Re-assemble the control head as described in Subsection 6.5.
4. Check the continuity from the speaker connector SK2 to pin 17 (SPK−) and pin 18 (SPK+) [at 1E1] of the control-head connector SK1 (see Figure 7.2). If there is no fault, go to Step 5. If there is still a fault, go to Task 5.
5. Reconnect the control-head loom, test the speaker to confirm the removal of the fault, and return to Subsection 5.2.

Figure 7.3 Secondary side of the control-head board with IC3, IC5, IC7 and the switching transistors for the LEDs indicated



Task 5 — Volume Control Faulty

If the volume control works only intermittently, works only at full volume, or does not work at all, repair the control head as follows:

1. Disconnect the control-head loom.
2. Check that the resistance between pins 1 and 2 of the volume-control potentiometer RV1 [at 1D3] varies linearly between about 0 Ω and 10 kΩ (see Figure 7.2). If it does, go to Step 3. If it does not, go to Step 6.
3. Disassemble the control head completely as described in Subsection 6.2 (on page 131).
4. Replace the speaker with a spare. Obtain a spare speaker by disassembling the spare control head of Spares kit 1 or 10 as described in Subsection 6.2.
5. Re-assemble the control head as described in Subsection 6.5 (on page 148). Reconnect the control-head loom. Confirm the removal of the fault, and return to Subsection 5.2 (on page 109).
6. Remove the control-head board as described in Subsection 6.2.
7. Replace the potentiometer RV1. See Figure 7.1.
8. Re-install the control-head board as described in Subsection 6.5. Reconnect the control-head loom. Confirm the removal of the fault, and return to Subsection 5.2.

7.2 Faults Involving Control-head Board

Types of Faults

This subsection gives the procedure for repairing a faulty control-head board. (Level-1 service centres should replace the board as described in Subsection 7.4 (on page 163), rather than attempt to repair it.) A faulty board can have the following effects:

- display faulty but not LEDs
- some LEDs faulty
- all LEDs faulty
- display and all LEDs faulty
- all keys faulty

In the case of a faulty display, the cause will have been narrowed to the board following the checks in Subsection 7.1 (on page 151). The repair procedures are given below in Tasks 1 to 5 respectively. For obtaining replacement components, refer to Subsection 7.3 (on page 160).

Task 1 — Display Faulty but not LEDs

If the checks in Subsection 7.1 (on page 151) show that neither the LCD nor the elastomeric strips are faulty, check the relevant components on the control-head board as follows:

1. Use an oscilloscope to display the signal at pin 5 [at 1H10] of IC5 (see Figure 7.3). The signal should be a square wave with a frequency of about 60 Hz and an amplitude that alternates between 0.0 and 3.3 V. If the signal is correct, go to Step 3. If it is not, go to Step 2.
2. Replace IC2 [at 1G12] (see Figure 7.3). Test the user interface. If the fault has been removed, return to Subsection 5.2 (on page 109). If it has not, go to Step 3.
3. Use the oscilloscope to display the signal at pin 12 [at 1H9] of IC7 (see Figure 7.3). The signal should be a square wave with a frequency of about 120 Hz and an amplitude that alternates between 0.0 and 3.3 V. If the signal is correct, replace IC5 and go to Step 4. If it is not, replace IC7 and go to Step 4.
4. Test the user interface. If the fault has been removed, return to Subsection 5.2. If it has not, the repair failed; replace the control-head board as described in Subsection 7.4 (on page 163).

Task 2 — Some LEDs Faulty

If the display functions correctly but one or more (but not all) of the LEDs D1 to D18 are faulty, check the control-head board as follows:

1. Disconnect the control-head loom. Remove the control-head board as described in Subsection 6.2 (on page 131). Reconnect the loom to the board.
2. Use a multimeter to measure the forward voltage across each faulty LED. See Figure 7.1. The voltage should be 2.0 ± 0.4 V DC. If it is, go to Step 3. If it is not, replace the LED and go to Step 4.
3. If the forward voltage is correct, the LED is functional but the associated switching transistor is suspect. Replace the transistor corresponding to the LED in question. The switching transistors associated with the LEDs D1 to D18 are Q1 to Q4. See Figure 7.3. Continue with Step 4.
4. Test the user interface. If the fault has been removed, re-install the control-head board as described in Subsection 6.5 (on page 148), and return to Subsection 5.2. If it has not, the repair failed; replace the control-head board as described in Subsection 7.4.

Task 3 — All LEDs Faulty

If the display functions correctly but all the LEDs are faulty, repair the control head as follows:

1. Disconnect the control-head loom.
2. Replace IC3 [at 1D5] which drives the switching transistors for the LEDs. See Figure 7.3.
3. Reconnect the loom and test the user interface. If the fault has been removed, return to Subsection 5.2 (on page 109). If it has not, the repair failed; replace the control-head board as described in Subsection 7.4 (on page 163).

Task 4 — Display and All LEDs Faulty

If the display is faulty as well as all the LEDs, repair the control head as follows:

1. Use a multimeter to measure the 3.3 V DC supply voltage across C1 [at 1D2] (see Figure 7.2). If it is correct, go to Step 3. If it is not, go to Step 2.
2. Check for shorts to ground of the 3.3 V supply. Repair any fault and go to Step 8.
3. Use the multimeter to check that the RST line at pin 6 [at 1E10] of IC7 is high. The level should be 3.3 V. If it is, go to Step 5. If it is not, go to Step 4.
4. Check for continuity in the LCD driver circuitry (D22, C12, R27) [at 1E9 and 1E10] (see Figure 7.2). Repair any fault and go to Step 8. If there is no continuity fault, replace IC7 and go to Step 8.
5. Use the multimeter to check that the OE line at pin 8 [at 1F10] of IC5 is low. The level should be less than 0.6 V. If it is, replace IC7 and go to Step 8. If it is not, go to Step 6.
6. Check that the voltage at pins 4, 10 and 14 of IC5 is 3.3 V DC. Also check that pin 7 [at 1J8] of IC5 is at ground. If the voltages are correct, replace IC7 and go to Step 8. If they are not, go to Step 7.
7. Check for continuity between IC5 and the control-head connector SK1. Also check for shorts to ground between IC5 and SK1. Repair any fault and go to Step 8.
8. Confirm the removal of the fault, and return to Subsection 5.2. If the repair failed or no fault could be found, replace the control-head board as described in Subsection 7.4.

Task 5 — All Keys Faulty

If all the keys, with the exception of the ON/OFF key, are faulty, repair the control head as follows:

1. Disconnect the control-head loom. Replace IC4 [at 1C2], which reads the status of the keys. See Figure 7.2.

2. Reconnect the control-head loom and test the keys to confirm the removal of the fault. If the fault has been removed, return to Subsection 5.2 (on page 109). If it has not, replace the control-head board as described in Subsection 7.4 (on page 163).

7.3 Replacement of Faulty Component

Introduction

This subsection gives the procedure for obtaining the correct replacement for any faulty component on the control-head board. There are four steps:

- identify version of PCB information pack applicable to board
- identify replacement component in BOM of PCB information pack
- consult technical notes
- obtain replacement component

The technical notes will indicate whether there have been any changes affecting the component in question.

Identify PCB Information Pack

First identify which version of PCB information pack applies to the control-head board under repair:

1. Note the IPN of the PCB. The IPN is printed at one corner of the board as shown in Figure 7.1 to Figure 7.3. The last two digits in the IPN comprise the issue number of the PCB.

2. Compare the issue number in the IPN with that in the PCB information pack supplied with the service documentation.

3. If the issue numbers match, consult the BOM as described in the paragraph following the next. If the issue number indicates that the board is either an earlier or a later version, continue with Step 4.

4. Obtain the PCB information pack for the board under repair. If a copy is not available, refer to the Technical Support website as described in the next paragraph.

Access Website

To locate the correct version of PCB information pack, follow the procedure given below. It is advisable to print and store a copy of every PCB information pack published on the Technical Support website.

1. Access the Technical Support website at *support.taitworld.com*.
2. Click the *"Login"* button. The *Log-in* dialogue box appears.
3. Enter the required log-in information in the *"Username"* and *"Password"* fields. (Tait-only access is required.) Click the *"Login"* button.
4. Click the *"Mobile Radios — TM8000"* option. A list of facilities for this product family appears.
5. Click the *"PCB Information"* facility. A list of all PCB information packs for TM8100 radios appears.
6. Navigate to the required PCB information pack and click the adjacent *"view/download"* command. The document is displayed. View the document, print a copy, or save a copy in the test PC. Alternatively, right-click the *"view/download"* command and select the save or print option from the menu that appears.

Identify Replacement Component

After locating the correct PCB information pack for the board, consult the BOM for the board. Identify the component in question in the BOM. Note, however, that a new PCB information pack is published only whenever there is a major change in the design of the board. A major change normally involves a change in the layout of the PCB, which requires that the issue number in the IPN be incremented. Any minor changes following a major change (and preceding the next major change) normally involve only changes in the components on the board. Such minor changes might affect the component in question. To determine if this is the case, consult any technical notes that might apply to the board; the procedure is given in the next paragraph.

Consult Technical Notes

A technical note about each major change is published on the Technical Support website. Technical notes giving details of any intervening minor but important changes are also published. To access these technical notes, follow the procedure below. It is advisable to print and store a copy of every technical note published.

1. If not already logged on to the Technical Support website, do so as described above. (Associate access is sufficient.)
2. Click the *"Mobile Radios — TM8000"* option. A list of facilities for this product family appears.
3. Click the *"Technical Notes"* facility. A list of all technical notes appears.
4. From the publication dates of the technical notes identify those that follow publication of the PCB information pack in question.
5. Identify any of the above technical notes that apply to the control-head board.
6. For each technical note identified in Step 5, click the adjacent *"view/download"* command. The technical note is displayed. View the document, print a copy, or save a copy in the test PC. Alternatively, right-click the *"view/download"* command and select the save or print option from the menu that appears.
7. Determine from the technical notes if any changes apply to the required replacement component.

Obtain Replacement Component

Determine if the required replacement component is included in Spares kit 4; a contents list is supplied with the kit. (Check with TEL regarding the availability of the kit.) If the required component is not included in the kit, order the component from a CSO or, in the case of a CSO, from TEL. Always ensure that the replacement component has the identical specification to that given in the BOM. It is particularly important for the tolerances to be the same.

7.4 Replacement of Faulty Control-head Board

Replace Board

A faulty control-head board requires replacement in any of these situations:

- only level-1 repairs permitted
- fault on board not located
- repair of fault failed

If not already done, remove the faulty board as described in Subsection 6.2 (on page 131). Obtain a spare board from Spares kit 3 or Spares kit 11. These kits contain replacement control-head boards for two- and one-digit-display control heads respectively. (Check with TEL regarding the availability of the kits.)

Re-assemble and Test Control Head

Re-assemble the control head with the replacement control-head board as described in Subsection 6.5 (on page 148). Reconnect the control-head loom to the radio body, and test the user interface as described in Task 5 of Subsection 5.2 (on page 109). If there is no fault, return to Subsection 5.2 and continue with the servicing of the radio. If there is still a fault, the repair failed; remove the spare board, re-assemble the control head with the original board, and return to Subsection 5.2.

8 Servicing of Main Board

Scope of Section

This section covers servicing of the main board following the initial investigation described in Subsection 5.2 (on page 109). There are three aspects:

- fault diagnosis and repair of main board
- replacement of faulty component
- replacement of faulty main-board assembly

These aspects are described in Subsection 8.1 to Subsection 8.3 respectively. The initial investigation will have determined that the main board is faulty. Subsection 8.1 below gives the subsequent repair procedure. Repair of the main board, however, is a level-2 repair. Level-1 service centres should instead replace the complete main-board assembly as described in Subsection 8.3 (on page 169). For level-2 service centres, Subsection 8.2 (on page 166) describes how to find the correct replacement for a faulty component on the board.

8.1 Fault Diagnosis and Repair

Identify Suspect Circuit Module

With the information gained from the initial investigation, identify which module of the circuitry on the main board is faulty:

- power-supply circuitry
- interface circuitry
- frequency synthesizer
- frequency control loop
- receiver
- transmitter
- CODEC and audio circuitry

Depending on which module is suspect, refer to Subsection 9.1 to Subsection 9.7 respectively for the further fault diagnosis and repair of the circuit.

Recalibration and Reprogramming

During the above fault-diagnosis procedure, if the calibration is found to be faulty at any time, recalibrate the radio before continuing. (Certain restrictions might apply.) Similarly, if there is a problem with the radio firmware, reprogram the radio before continuing. (Use a default programming file if necessary.)

Action Following Fault Diagnosis

There are several outcomes following the fault-diagnosis and repair procedures given in Section 9 (on page 171). If the main board was successfully repaired, conclude the servicing task as described below. If the repair failed, if the fault could not be found, or if the repair required is a level-3 repair, replace the complete main-board assembly as described in Subsection 8.3 (on page 169).

Test Main-board Assembly

After repairing the main board, confirm the removal of the fault by carrying out the basic tests given in Subsection 5.2 (on page 109). Recalibration or reprogramming of the radio, as mentioned above, might also be necessary. If the tests confirm the removal of the fault, continue as described in the next paragraph. If they do not, replace the complete main-board assembly as described in Subsection 8.3.

Re-install Cans and Retest

Finally, re-install all cans on the main board that have been removed; refer to Subsection 4.4 (on page 91) for information on can replacement. Repeat the above basic tests following the re-installation of the cans. The tests should again confirm the removal of the fault. Re-assemble the radio body as described in Subsection 6.4 (on page 144). Return to Subsection 5.2 to continue with the servicing of the radio. If the tests do not confirm the repair, replace the complete main-board assembly as described in Subsection 8.3.

8.2 Replacement of Faulty Component

Introduction

This subsection gives the procedure for obtaining the correct replacement for any faulty component on the main board. There are four steps:

- identify version of PCB information pack applicable to board
- identify replacement component in BOM of PCB information pack
- consult technical notes
- obtain replacement component

The technical notes will indicate whether there have been any changes affecting the component in question.

Identify PCB Information Pack

First identify which version of PCB information pack applies to the main board under repair:

1. Note the IPN of the PCB. The IPN is the ten-digit number printed at one corner of the board. The last two digits in the IPN comprise the issue number of the PCB.
2. Compare the issue number in the IPN with that in the PCB information pack supplied with the service documentation.
3. If the issue numbers match, consult the BOM as described in the paragraph following the next. If the issue number indicates that the board is either an earlier or a later version, continue with Step 4.
4. Obtain the PCB information pack for the board under repair. If a copy is not available, refer to the Technical Support website as described in the next paragraph.

Access Website

To locate the correct version of PCB information pack, follow the procedure given below. It is advisable to print and store a copy of every PCB information pack published on the Technical Support website.

1. Access the Technical Support website at *support.taitworld.com*.
2. Click the *"Login"* button. The *Log-in* dialogue box appears.
3. Enter the required log-in information in the *"Username"* and *"Password"* fields. (Tait-only access is required.) Click the *"Login"* button.
4. Click the *"Mobile Radios — TM8000"* option. A list of facilities for this product family appears.
5. Click the *"PCB Information"* facility. A list of all PCB information packs for TM8100 radios appears.
6. Navigate to the required PCB information pack and click the adjacent *"view/download"* command. The document is displayed. View the document, print a copy, or save a copy in the test PC. Alternatively, right-click the *"view/download"* command and select the save or print option from the menu that appears.

Identify Replacement Component

After locating the correct PCB information pack for the board, consult the BOM for the board. Identify the component in question in the BOM. Note, however, that a new PCB information pack is published only whenever there is a major change in the design of the board. A major change normally involves a change in the layout of the PCB, which requires that the issue number in the IPN be incremented. Any minor changes following a major change (and preceding the next major change) normally involve only changes in the components on the board. Such minor changes might affect the component in question. To determine if this is the case, consult any technical notes that might apply to the board; the procedure is given in the next paragraph.

Consult Technical Notes

A technical note about each major change is published on the Technical Support website. Technical notes giving details of any intervening minor but important changes are also published. To access these technical notes, follow the procedure below. It is advisable to print and store a copy of every technical note published.

1. If not already logged on to the Technical Support website, do so as described above. (Associate access is sufficient.)
2. Click the *"Mobile Radios — TM8000"* option. A list of facilities for this product family appears.
3. Click the *"Technical Notes"* facility. A list of all technical notes appears.
4. From the publication dates of the technical notes identify those that follow publication of the PCB information pack in question.
5. Identify any of the above technical notes that apply to the main board.
6. For each technical note identified in Step 5, click the adjacent *"view/download"* command. The technical note is displayed. View the document, print a copy, or save a copy in the test PC. Alternatively, right-click the *"view/download"* command and select the save or print option from the menu that appears.
7. Determine from the technical notes if any changes apply to the required replacement component.

Obtain Replacement Component

Determine if the required replacement component is included in Spares kit 5; a contents list is supplied with the kit. (Check with TEL regarding the availability of the kit.) If the required component is not included in the kit, order the component from a CSO or, in the case of a CSO, from TEL. Always ensure that the replacement component has the identical specification to that given in the BOM. It is particularly important for the tolerances to be the same.

8.3 Replacement of Faulty Main-board Assembly

Replace Assembly

A faulty main-board assembly requires replacement in any of these situations:

- only level-1 repairs permitted
- fault on board not located
- repair of fault failed
- required repair is level-3 repair

If not already done, remove the faulty main-board assembly from the chassis as described in Subsection 6.3 (on page 137). Obtain a replacement assembly. The product codes for spare main-board assemblies are listed in Table 4.4 of Subsection 4.2 (on page 84). Install the replacement assembly in the chassis as described in Subsection 6.4 (on page 144).

Calibrate and Program Radio

Connect the radio to the test equipment. Calibrate and program the replacement main-board assembly in the same way as the faulty assembly. Use the files downloaded as described in Tasks 2 and 4 of Subsection 5.2 (on page 109). If a file could not be downloaded, use the default file.

Test Main-board Assembly

Carry out the basic tests given in Subsection 5.2 to confirm that the replacement main-board assembly functions as required. If there is no fault, re-assemble the radio as described in Subsection 6.4 and Subsection 6.5 (on page 148), and conclude with the task discussed below. If the tests do not confirm the proper functioning of the radio, the repair failed; remove the spare assembly, re-assemble the radio with the original assembly, and return to Subsection 5.2.

Enable Software Features

If the main-board assembly is successfully replaced, ensure that the correct software features, if any, are enabled for the Customer. If software features need to be enabled, a special licence file is required for the replacement main-board assembly. The file must allow for the enabling of the same software features as in the original assembly. Proceed as follows:

1. If it was possible to carry out Task 3 of Subsection 5.2 (on page 109), go to Step 2. If it was not possible, go to Step 3.
2. Task 3 will have revealed if any software features were enabled for the radio under repair. If there were, go to Step 3. If there were none, return to Subsection 5.2 to continue with the servicing of the radio.
3. Technicians not at a CSO should contact their CSO regarding the radio's software features. Technicians at CSOs should contact Logistics at TEL.
4. Supply the serial number of the radio under repair, and the serial number of the replacement main-board assembly.
5. If it is known from Task 3 above that the radio had software features enabled, go to Step 6. Otherwise go to Step 7.
6. Ask the CSO (or TEL) for a licence file for the replacement main-board assembly. The CSO will supply the required file. Go to Step 8.
7. Ask the CSO (or TEL) if the radio under repair had any software features enabled, and if so, to send a licence file for the replacement main-board assembly. The CSO (or TEL) will either indicate that the radio had no software features enabled or supply the required file. In the former case return to Subsection 5.2 to continue with the servicing of the radio. In the latter case go to Step 8.
8. On receiving the licence file, run the programming application on the test PC. On the menu bar click *"Tools"* > *"Optional Features"*. The *"Software Feature Enabler"* dialogue box appears.
9. Use the licence file to enable the appropriate software features. The procedure is given in the on-line help facility under the heading *"Enabling a feature"*. Then return to Subsection 5.2 to continue with the servicing of the radio.

9 Diagnosis of Faults on Main Board

Introduction

The previous section describes how to determine which module of circuitry on the main board is faulty. This section provides guidelines for locating and rectifying faults within a suspect module. The section is divided into seven subsections which cover the seven modules concerned:

- power-supply circuitry
- interface circuitry
- frequency synthesizer
- frequency control loop
- receiver
- transmitter
- CODEC and audio circuitry

For obtaining replacements for faulty components, refer to Subsection 8.2 (on page 166). For a discussion of SMT repair techniques, refer to Subsection 4.4 (on page 91); refer to this subsection also regarding the replacement of the capacitors C548 and C565 and the inductors L601 and L602.

Grid References

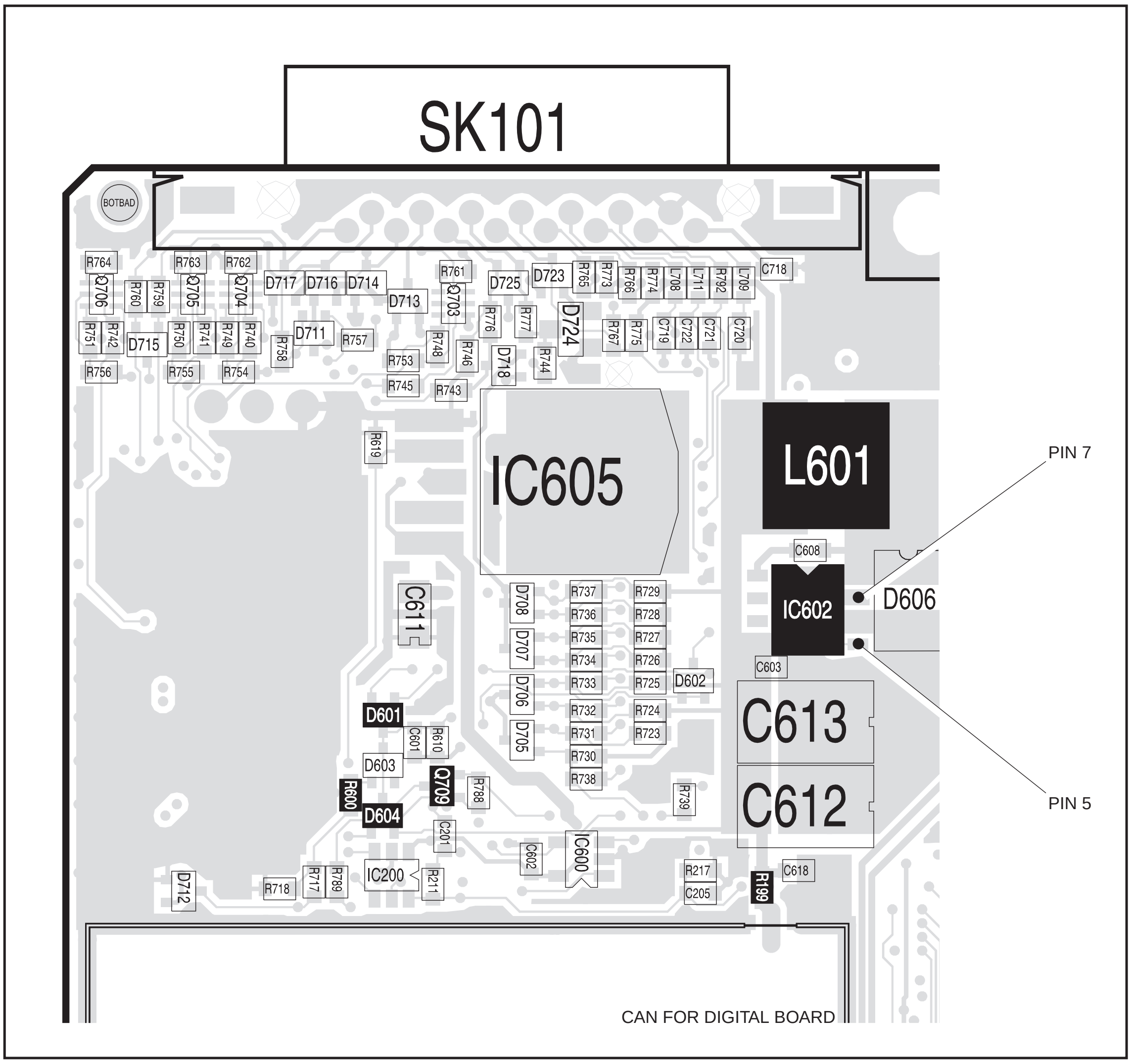
Throughout this section data in square brackets are grid references giving the locations of the components concerned on the circuit diagram. The first reference in square brackets is for the B1, H5 and H6 bands, and the second is for the D1 band. Using the first reference in the next subsection as an example, the format is thus: [at 6F7/6E6].

9.1 Power-supply Circuitry

Two Types of Fault

Fault diagnosis of the power-supply circuitry is divided into four tasks. Which tasks are applicable depends on the nature of the power-up fault. There are two cases: Firstly, either 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. Secondly, the radio powers up when the ON/OFF key is pressed, but not for a power-up option for which it is configured. With the first type of fault, carry out Tasks 1 to 3. With the second type of fault, carry out Task 4.

Figure 9.1 Important components of the power-supply circuitry on the bottom-side of the main board



Task 1 — Check Inputs to SMPS

The test equipment and radio should be set up as described in Subsection 4.5 (on page 93). If not already done, remove the main-board assembly from the chassis. 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 [at 6F7/6E6] of IC602 (see Figure 9.1) in the SMPS circuitry; the voltage should be 13.8 V DC. If it is, go to Step 5. If it is not, go to Step 2.

2. Disconnect the 13.8 V supply at the power connector PL100. Check for continuity and shorts to ground in the path between the power connector and pin 7 of IC602 (see Figure 9.1). Locate and repair the fault.

3. Reconnect the 13.8 V 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; return to Subsection 8.1 and replace the complete main-board assembly.

4. Press the ON/OFF key. If the radio powers up, return to Subsection 8.1. If it does not, go to Step 5.

5. Check the digital power-up signal at pin 5 [at 6G6/6E6] of IC602 (see Figure 9.1); the signal is active high, namely, when the voltage exceeds 2.0 V DC. Measure the voltage at pin 5. If it exceeds 2.0 V, go to Task 2. If it does not, go to Step 6.

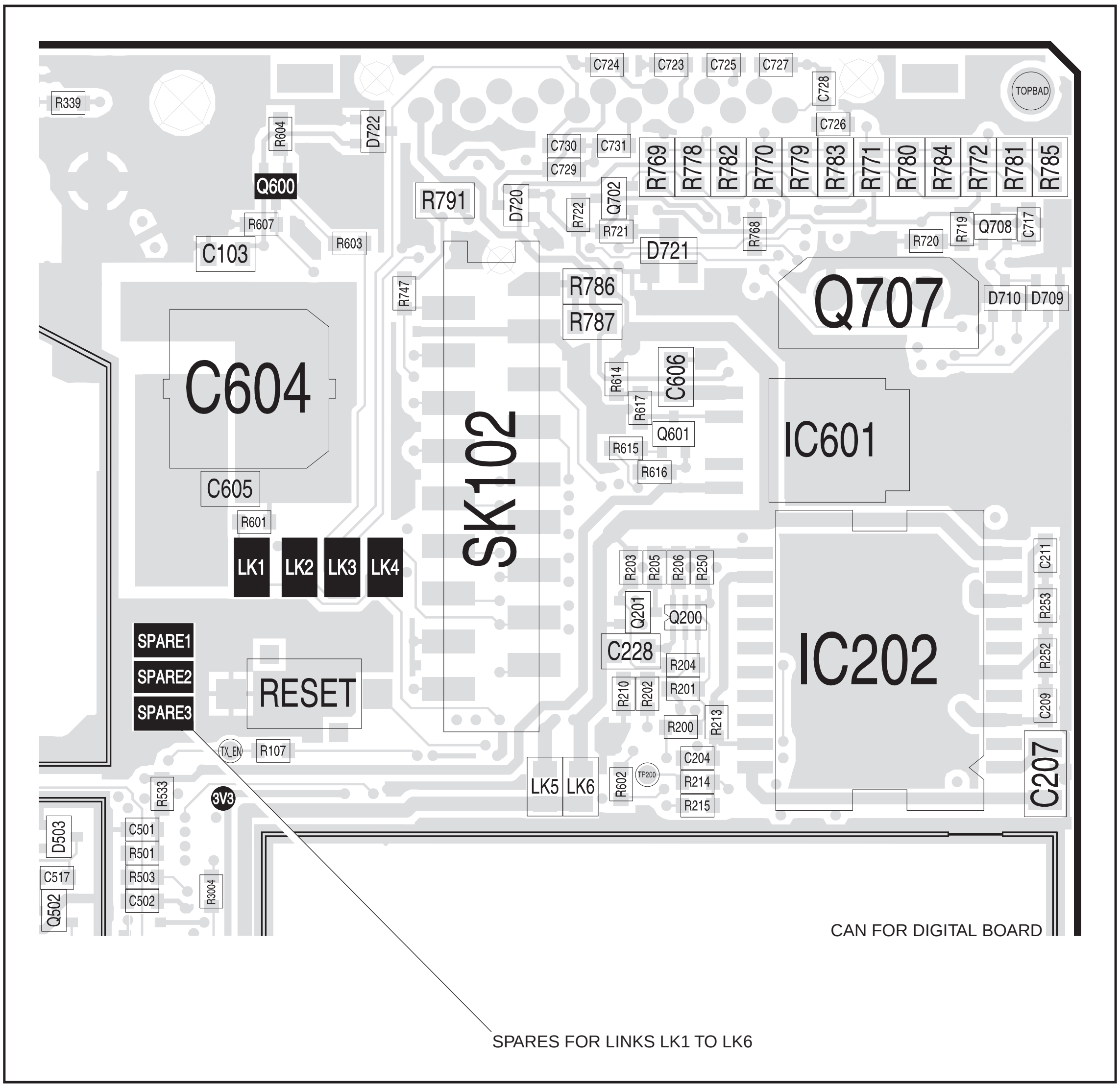
6. Keep the probe of the multimeter on pin 5 of IC602 and press the ON/OFF key. The voltage should exceed 2.0 V DC while the key is depressed. If it does, go to Task 2. If it does not, go to Step 7.

7. Disconnect the 13.8 V supply at the power connector PL100. Check for continuity and shorts to ground in the path from pin 5 of IC602, via R600 [at 6B4/6D2] and via Q709 [at 7C2/7D2] in the interface circuitry (see Figure 2.6.1), 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 13.8 V supply. Press the ON/OFF key. If the radio powers up, return to Subsection 2.5.1. If it does not, go to Step 9.

9. With the probe of the multimeter on pin 5 of IC602 (see Figure 9.1), press the ON/OFF key again. The voltage should exceed 2.0 V DC while the key is depressed. If it does, go to Task 2. If it does not, the repair failed; return to Subsection 8.1 and replace the complete main-board assembly.

Figure 9.2 Important components of the power-supply circuitry on the top side of the main board



Task 2 — Check 3.3 V 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 3.3 V 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 [at 1N0/1B11] near the corner of the digital board (see Figure 9.2). The voltage is 3.3 ± 0.1 V when there is no fault. If the voltage is correct, the digital board is faulty; return to Subsection 8.1 and replace the complete main-board assembly. If the voltage is not correct, go to Step 2.

2. Disconnect the 13.8 V supply at the power connector. Remove R199 [at 1J6/1H8] (see Figure 9.1). Reconnect the 13.8 V 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 ± 0.1 V, the digital board is faulty; return to Subsection 2.5.1 and replace the complete main-board assembly. 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 13.8 V 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 [at 6G6 to 6J6/6E6 to 6E8] of the SMPS circuitry (see Figure 9.1) 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; return to Subsection 8.1 and replace the complete main-board assembly.

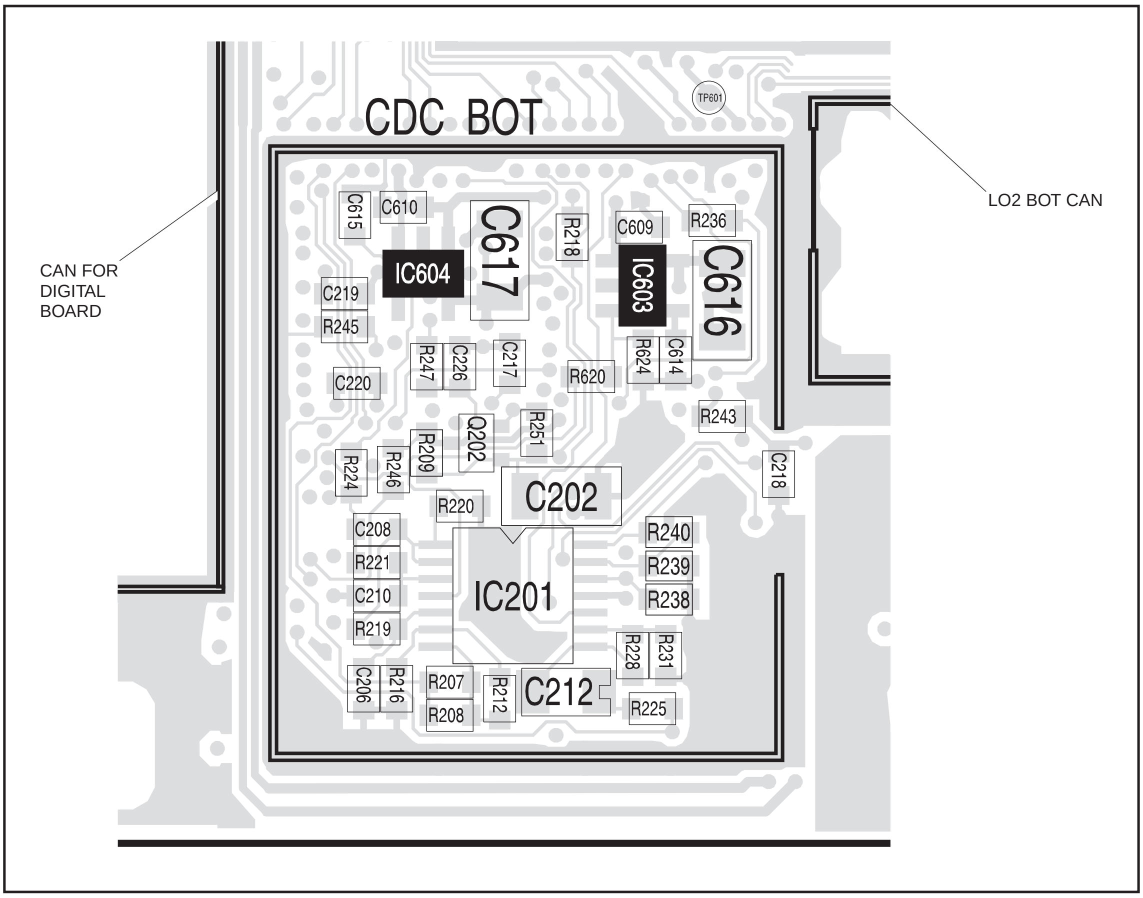
6. Reconnect the 13.8 V supply. Press the ON/OFF key. If the radio powers up, return to Subsection 8.1. If the radio fails to power up, disconnect the 13.8 V supply and go to Step 7.

7. Measure the resistance of L601 [at 6H6/6E7] (see Figure 9.1). The resistance should be virtually zero. If it is, go to Step 8. If it is not, replace L601. Reconnect the 13.8 V supply and press the ON/OFF key. If the radio powers up, return to Subsection 8.1. If the radio fails to power up, disconnect the 13.8 V supply and go to Step 8.

8. Remove the CDC BOT can. Remove IC603 (3.0 V regulator) [at 6H5/6D7] and IC604 (2.5 V regulator) [at 6H3/6C7] (see Figure 9.3). Reconnect the 13.8 V supply and press the ON/OFF key. If the 3.3 V supply is restored, go to Task 3 to check each regulator (3.0 V and 2.5 V) in turn. If the 3.3 V supply is not restored, continue with Step 9.

9. Suspect IC602 [at 6G7/6E6]. Disconnect the 13.8 V supply. Replace IC602 with a spare (see Figure 9.1). Resolder IC603 and IC604 in position (see Figure 9.3). Reconnect the 13.8 V supply and press the ON/OFF key. If the radio powers up, return to Subsection 8.1. If the radio fails to power up, the repair failed; return to Subsection 8.1 and replace the complete main-board assembly.

Figure 9.3 Regulator ICs under the CDC BOT can



Task 3 — Check Linear Regulators

This section gives 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 Subsection 8.1. 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, return to Subsection 8.1. If the repair failed, return to Subsection 8.1 and replace the complete main-board assembly.

Task 4 — Check Digital Power-up Signals

The radio may be configured for one or more of the power-up options listed in Table 9.1. A particular option is implemented by inserting the link mentioned in the table. The activation mechanism is the condition that results in the digital power-up signal at pin 5 [at 6F6/6E6] of IC602 (see Figure 9.1) becoming active.

The functioning of the power-up options may be checked as described in Steps 1 to 4 below; information on rectifying faults is also given. If there is a fault with a particular power-up option for which the radio is configured, carry out the procedure described in the relevant step.

1. For the 13V8-power-sense option the link LK1 [at 6C6/6E3] should be inserted (see Figure 9.2). Check the power-up signal while first disconnecting and then reconnecting the 13.8 V DC supply at the power connector. The signal should go high when the power is reconnected. If it does, return to Subsection 8.1. 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 return to Subsection 8.1.

2. For the auxiliary-power-sense option the link LK2 [at 6B6/6E2] should be inserted (see Figure 9.2). Connect +3.3 V DC (more than 2.6 V 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 is high. Remove the +3.3 V supply and ground the AUX GPI3 line (to be precise the voltage on the line should be less than 0.6 V). If the signal is correct, return to Subsection 8.1. If it is not, check for continuity and shorts to ground between D601 [at 6C6/6E3] (see Figure 9.1) and pin 4 of the auxiliary connector. Repair any fault and return to Subsection 8.1.

3. For the emergency option the link LK3 [at 6B5/6D2] should be inserted (see Figure 9.2). Connect the AUX GPI2 line (pin 5 of the auxiliary connector SK101) to ground. Check that the power-up signal is high. Remove the connection to ground. If the signal is correct, return to Subsection 8.1. If it is not, check for continuity and shorts to ground in the path from D601 [at 6C5/6D3] (see Figure 9.1), via Q600 [at 6C5/6D2] (see Figure 9.2), to pin 5 of the auxiliary connector. Repair any fault and return to Subsection 8.1.

4. For the internal-options-power-sense option the link LK4 [at 6B4/6C2] should be inserted (see Figure 9.2). Connect +3.3 V DC (more than 2.6 V 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 is high. Remove the +3.3 V supply and ground the IOP GPIO7 line (to be precise the voltage on the line should be less than 0.6 V). If the signal is correct, return to Subsection 8.1. If it is not, check for continuity and shorts to ground between D604 [at 6C4/6C3] (see Figure 9.1) and pin 15 of the internal options connector. Repair any fault and return to Subsection 8.1.

Table 9.1 Implementation of the power-up options

Power-up option	Link to insert	Factory default	Activation mechanism	Connector
13V8 power sense	LK1	Link in	Connection of 13.8 V supply	Power connector
Auxiliary power sense	LK2	Link in	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	LK3	Link in	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

9.2 Interface Circuitry

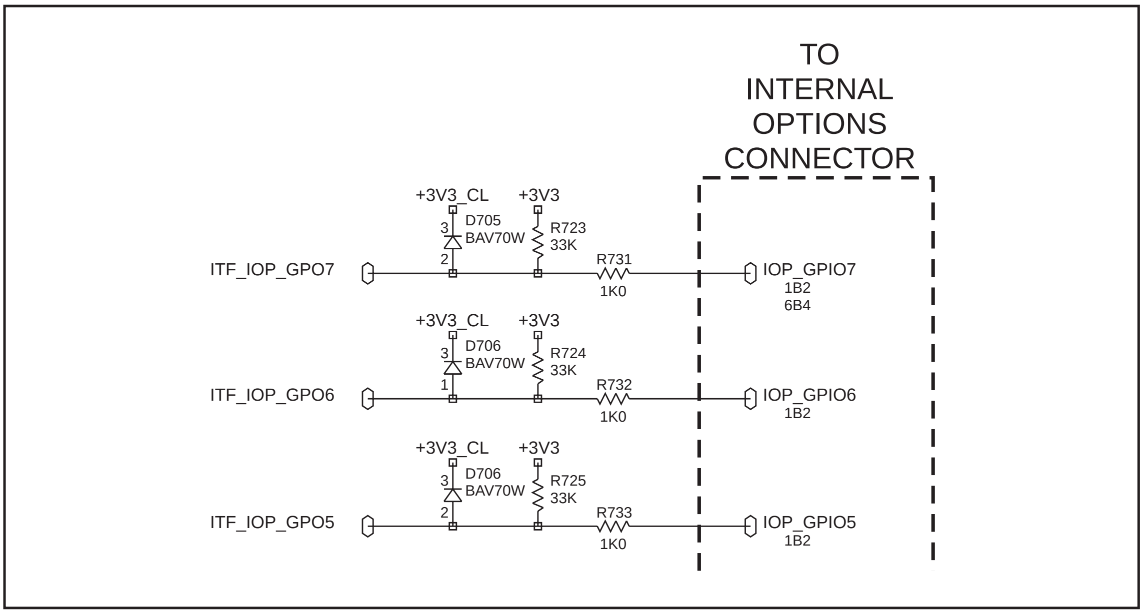
Introduction

This subsection 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 9.4, 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 9.4 Example illustrating the convention for internal and connector signals



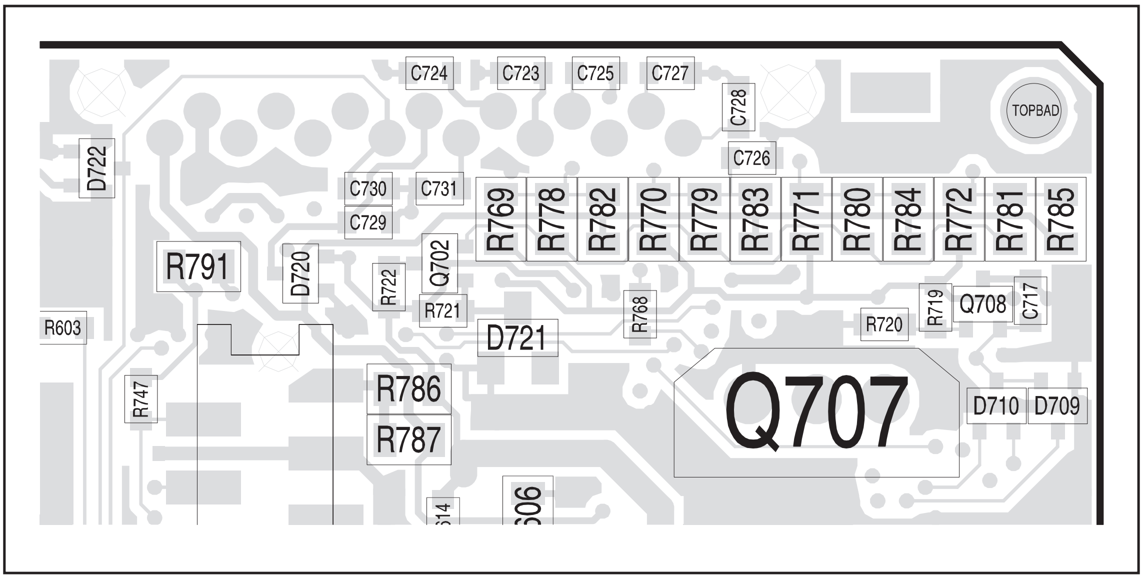
Types of Signals

The connector and internal signals can be of three types:

- output lines
- input lines
- bi-directional lines

For diagnosing faults in these three cases, carry out Task 1, Task 2 or Task 3 respectively. Where components need to be replaced to rectify faults, refer to Figure 9.5 to Figure 9.7 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 9.5 Components of the interface circuitry on the top-side of the main board at the corner



Task 1 — Check Output Lines

For an output line suspected or reported to be faulty, compare actual and expected signals as described below. If necessary, determine what an expected signal should be by copying the faulty radio's programming file into a serviceable radio and measuring the relevant points on the latter.

1. Check the electrical signal at the appropriate pin of a connector mated to the radio connector in question. If the expected connector signal is not present, go to Step 3. If it is, go to Step 2.

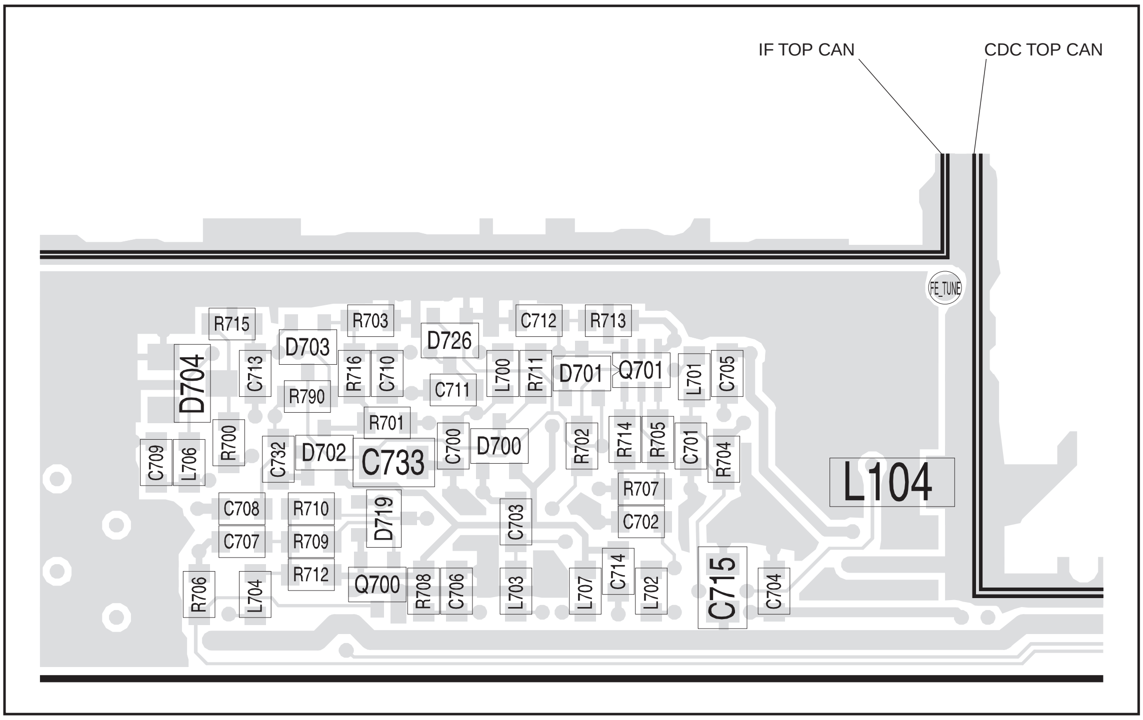
2. If the expected signal is present, there might be no fault on that line or there could be an intermittent fault. Subject the radio to mild mechanical shock or vibration, or to a temperature change. This might expose any intermittent contact, in which case go to Step 3.

3. If the expected signal is not present, check whether the expected internal signal is present. If it is, go to Step 5. If it is not, go to Step 4.

4. 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 Subsection 9.1 and Subsection 9.7 respectively. If the digital board is suspect, return to Subsection 8.1 and replace the complete main-board assembly.

5. The fault lies in the filtering, basic processing, or connector for the line under test. Re-solder components or replace damaged or faulty components as necessary. Confirm the removal of the fault and return to Subsection 8.1. If the fault could not be found, return to Subsection 8.1 and replace the complete main-board assembly.

Figure 9.6 Components of the interface circuitry on the top-side of the main board near the CDC TOP and IF TOP cans



Task 2 — 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 3.3 V DC test signal to a connector mated to the radio connector in question.

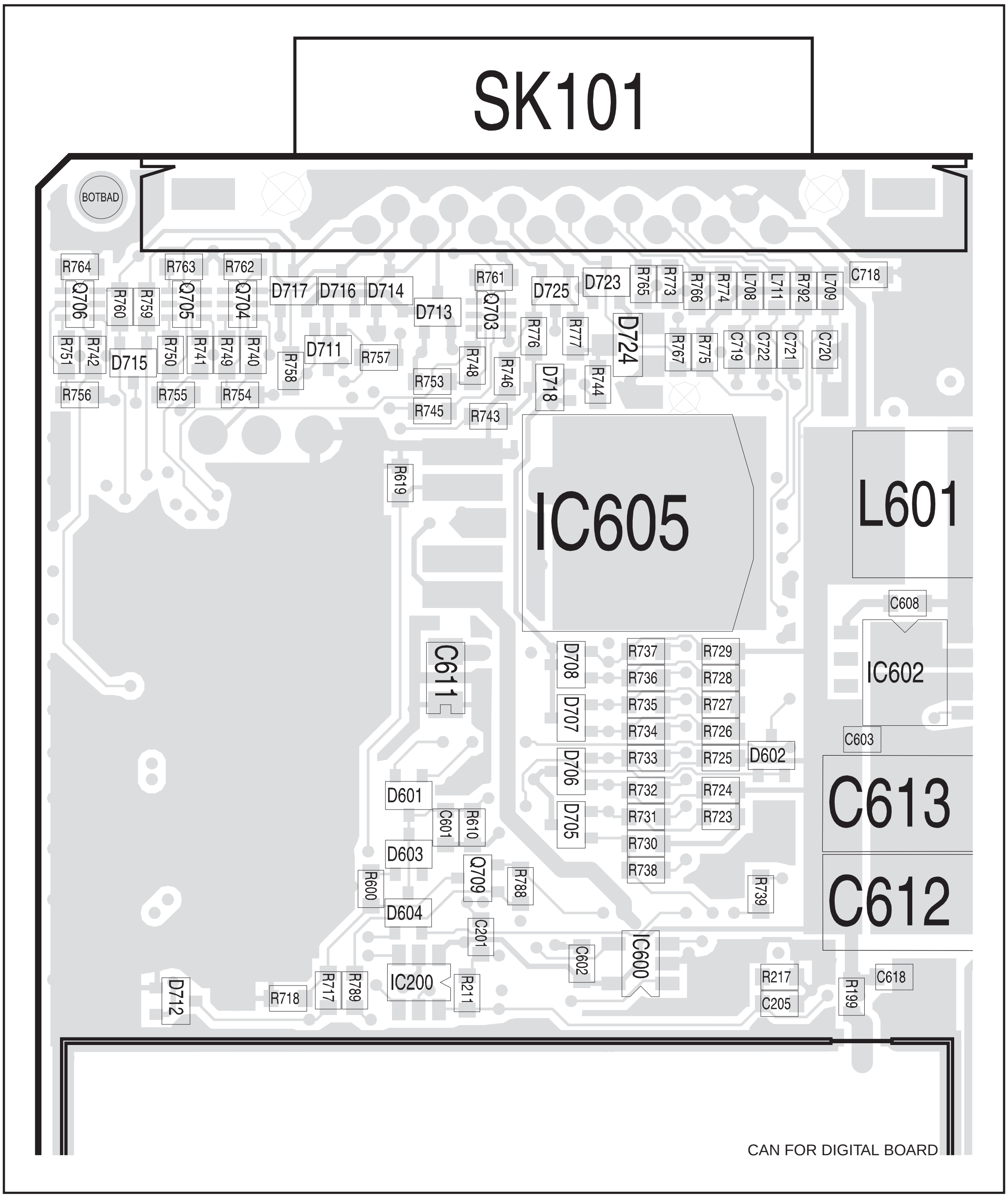
3. Check the internal signal for the line under test. If 3.3 V DC is present, go to Step 7. If it is not, go to Step 8.

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 3.9 V DC present on the ITF ON OFF line, and that PSU ON OFF is approximately equal to the radio's primary supply voltage, nominally 13.8 V 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 0.0 V.

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

Figure 9.7 Components of the interface circuitry on the bottom-side of the main board



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 Subsection 9.1 and Subsection 9.7 respectively. If the digital board is suspect, return to Subsection 8.1 and replace the complete main-board assembly.

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 return to Subsection 8.1. If the fault could not be found, return to Subsection 8.1 and replace the complete main-board assembly.

Task 3 — 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 output, and then carry out the procedure given in Task 1.

2. Configure the suspect line as an input, and then carry out the procedure given in Task 2.

9.3 Frequency Synthesizer

Introduction

This subsection covers the diagnosis of faults in the frequency synthesizer. 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. The fault-diagnosis procedure is divided into four tasks. First discussed, however, is the lock status of the radio, which will indicate whether or not the synthesizer is suspect.

Lock Status

The lock status of the radio might already have been determined as part of the preliminary fault diagnosis. The following is a summary:

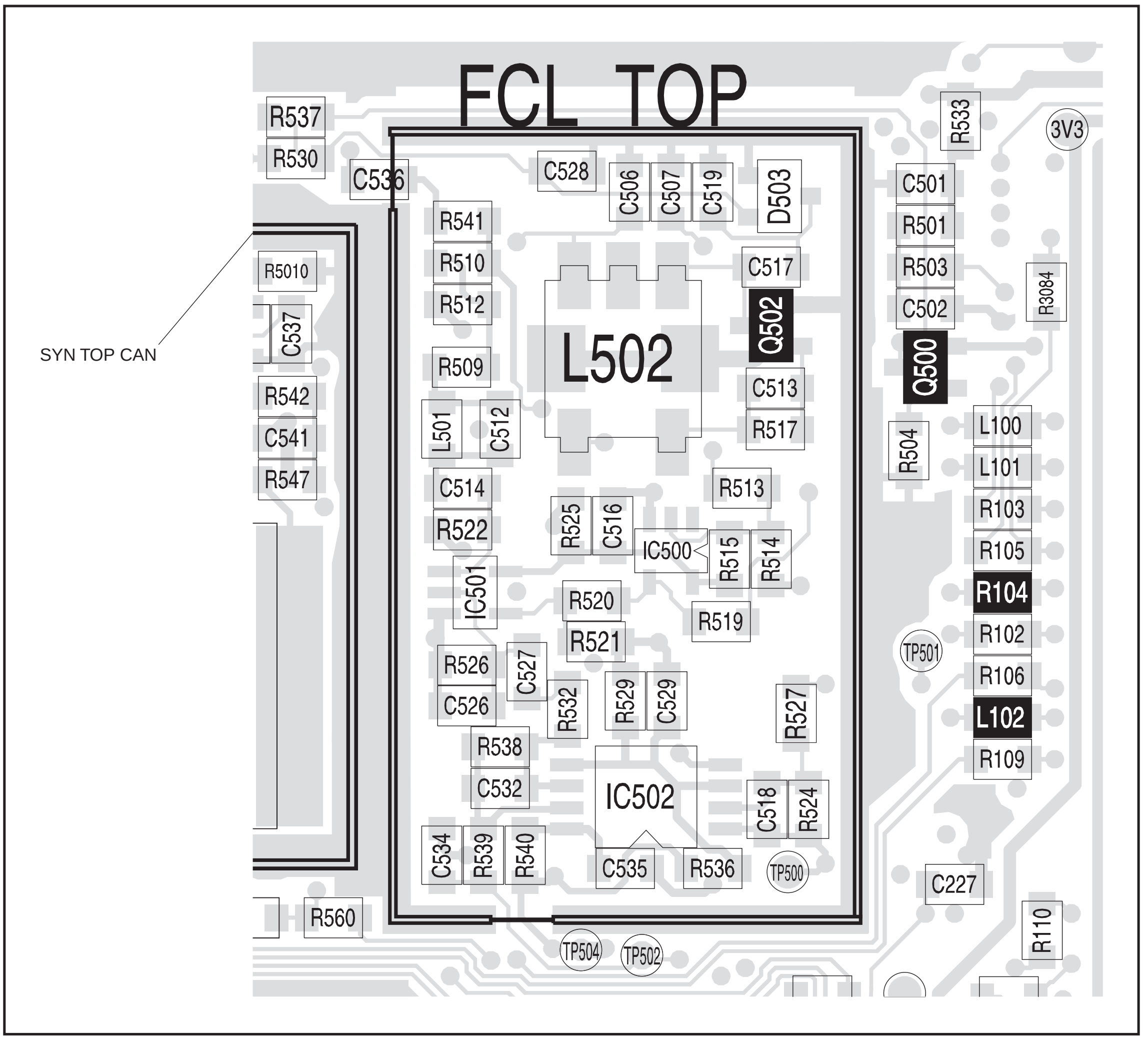
1. Enter the CCTM command *33* to place the radio in transmit mode. Enter the command *72* to determine the lock status in this mode. Note the response. The normal status is *110*.

2. Enter the CCTM command *32* to place the radio in receive mode. Enter the command *72* to determine the lock status in this mode. Note the response. The normal status is *111*.

3. If the lock status in either or both receive and transmit mode is ***a0a***, where ***a*** is *0* or *1*, the FCL is suspect; go to Subsection 9.4.

4. If the lock status is *011* or *010* in receive mode or *010* in transmit mode, the synthesizer is suspect; proceed to Task 1. (If the status is *010* in receive mode, investigate the receiver later also.)

Figure 9.8 Synthesizer circuitry under the FCL TOP can on the top-side of the main board



Task 1 — Initial Checks

First check that the digital board or a power supply is not the cause of the fault:

1. Check the lock-detect signal on each side of L102 [at 1J2/1D7]. (See Figure 9.8.) When the circuit is functioning properly, the lock-detect signal is active (about 3 V) to match the lock status *111* or *110*. When there is a fault and the lock status is *011* or *010*, the lock-detect signal should be inactive (about 0 V). If it is, go to Step 3. If it is not, go to Step 2.

2. Check L102, check for shorts and other faults near L102, and check the signal SYN LOCK at pin 14 of IC503 [at 5H7] (see Figure 9.8 and Figure 9.9). If no fault is found, the digital board is faulty; return to Subsection 8.1 and replace the complete main-board assembly. If there is a fault, repair it, confirm the removal of the fault, and return to Subsection 8.1. If the repair failed, return to Subsection 8.1 and replace the complete main-board assembly.

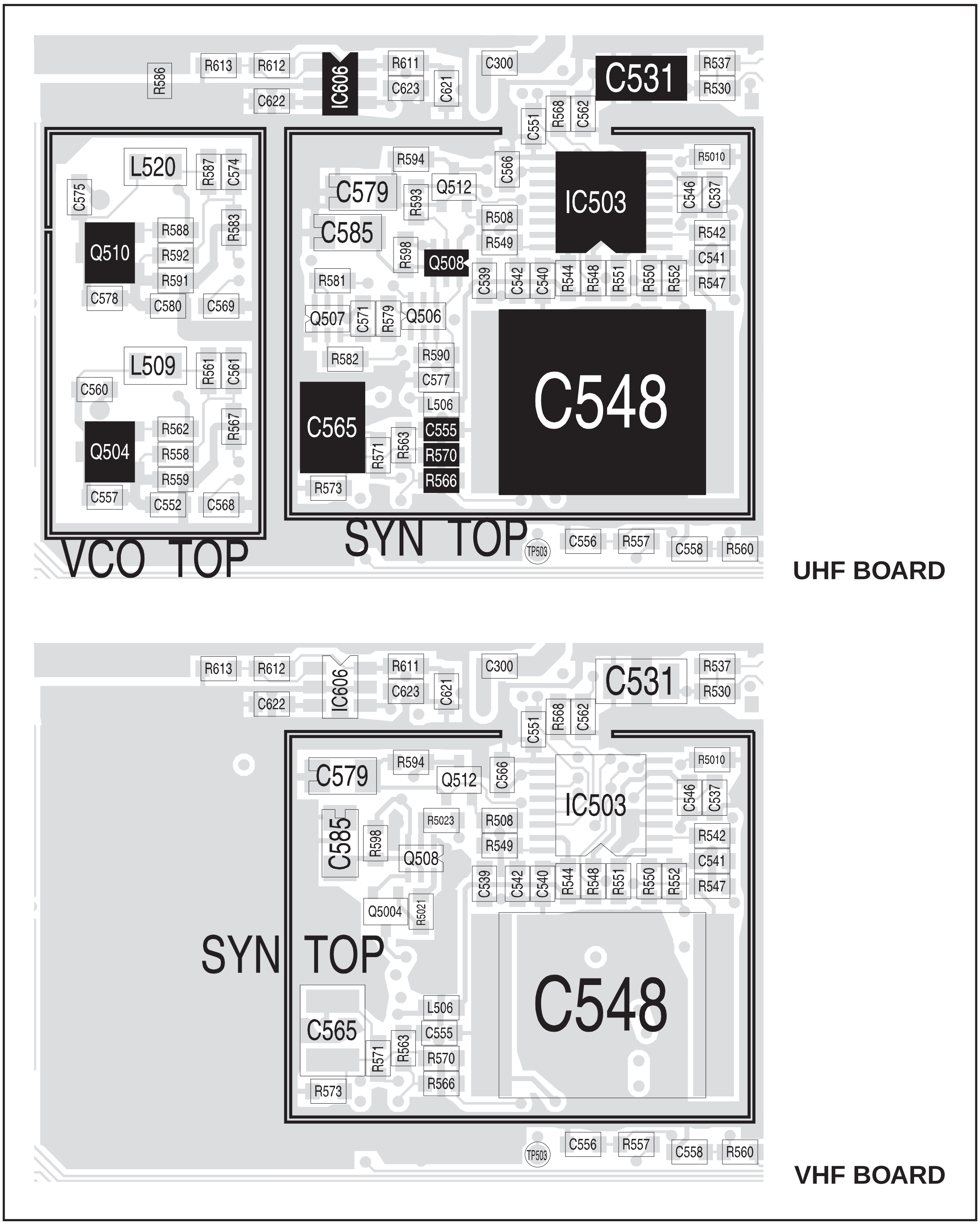
3. Check the 6 V output from IC606 [at 6E3/6C4] (see Figure 9.9). If the voltages are correct, go to Step 4. If they are not, check that the logic setting at pin 1 of IC606 is 9 V, check the 9 V output from the regulator, and check IC606 itself. If a fault is found, repair it and confirm the removal of the fault; then enter the CCTM command *72* again and take the action indicated. If the repair failed or no fault could be found, return to Subsection 8.1 and replace the complete main-board assembly.

4. Check for 3 V DC on pins 7, 15 and 16 of IC503 [at 5H7] (see Figure 9.9). If there is, go to Step 5. If there is not, check for faults in the +3V0 AN supply to IC503 from IC603 [at 6H5/6D7]. If a fault is found, repair it and confirm the removal of the fault; then enter the CCTM command *72* again and take the action indicated. If the repair failed or no fault could be found, return to Subsection 8.1 and replace the complete main-board assembly.

5. Check the VCL supply at C531 [at 5F0/5B5] (see Figure 9.9). It should be about 14 V DC. If it is, go to Step 6. If it is not, check the SMPS circuit based on Q500 [at 5A1/5C1] and Q502 [at 5D1/5B3] (see Figure 9.8). If a fault is found, repair it and confirm the removal of the fault; then enter the CCTM command *72* again and take the action indicated. If the repair failed or the fault could not be found, return to Subsection 8.1 and replace the complete main-board assembly.

6. Check that the DIG SYN EN line at R104 [at 1J2/1D7] is active (see Figure 9.8). If it is, go to Task 2. If it is not, check R104, and check for shorts and other faults near R104. If no fault is found, the digital board is faulty; return to Subsection 8.1 and replace the complete main-board assembly. If there is a fault, repair it, confirm the removal of the fault, and return to Subsection 8.1. If the repair failed, return to Subsection 8.1 and replace the complete main-board assembly.

Figure 9.9 Synthesizer circuitry under the SYN TOP and VCO TOP cans on the top-side of the main board



Task 2 — VCO Checks

If there is no fault with the digital board or power supplies, check the VCO. The following procedure applies to the UHF board (bands H5 and H6); the procedure for the VHF board (bands B1 and D1) is similar.

1. Remove the VCO TOP and SYN TOP cans.

2. Enter the CCTM command *32* to place the radio in receive mode. Measure the voltage on the collector of Q504 [at 5K3] (see Figure 9.9). It should be about 5 V. If it is, go to Step 3. If it is not, check the circuit between Q504 and pin 3 of Q508 [at 5Q6]. If a fault is found, repair it and confirm that the voltage is now correct; then enter the CCTM command *72* again and take the action indicated; if the lock status is still *011* or *010*, go to Step 3. If the repair failed or the fault could not be found, return to Subsection 8.1 and replace the complete main-board assembly.

3. Use the CCTM command *101* to program the radio with the centre frequency of the frequency band. The format of the command is *101* ***a a*** *0*, where ***a*** is the transmit frequency in hertz. Enter the CCTM command *335 1* to switch on the transmit-receive switch in the synthesizer. Carry out the checks in Step 4. After these checks enter the CCTM command *335 0* to switch off the transmit-receive switch.

4. Measure the voltage on the collector of Q510 [at 5Q3] (see Figure 9.9). It should be about 5 V. If it is, go to Step 5. If it is not, check the circuit between Q510 and pin 3 of Q508 [at 5Q6]. If a fault is found, repair it and confirm that the voltage is now correct; then enter the CCTM command *72* again and take the action indicated; if the lock status is still *010*, go to Step 5. If the repair failed or the fault could not be found, return to Subsection 8.1 and replace the complete main-board assembly.

5. Use the CCTM command *101* to program the radio with the lowest frequency of the frequency band. Enter the CCTM command *33* (transmit mode) and then the command *32* (receive mode), and in each case carry out the checks in Step 7. (If the radio fails to enter transmit mode, go to Task 4.)

6. Repeat Step 5 with the radio programmed with the highest frequency of the frequency band.

7. Measure the VCO tuning voltage at C565 [at 5M5] (see Figure 9.9). The tuning voltage should be steady DC with no modulation or noise. The DC values listed in Table 9.2 should be obtained. (The corresponding values for VHF radios are also given in the table.) If the voltages are correct, return to Subsection 8.1 and replace the complete main-board assembly. If there is unexpected modulation or noise, go to Task 3. If the voltages are not correct, go to Task 4.

Figure 9.10 Synthesizer circuitry under the SYN BOT and VCO BOT cans on the bottom-side of the main board

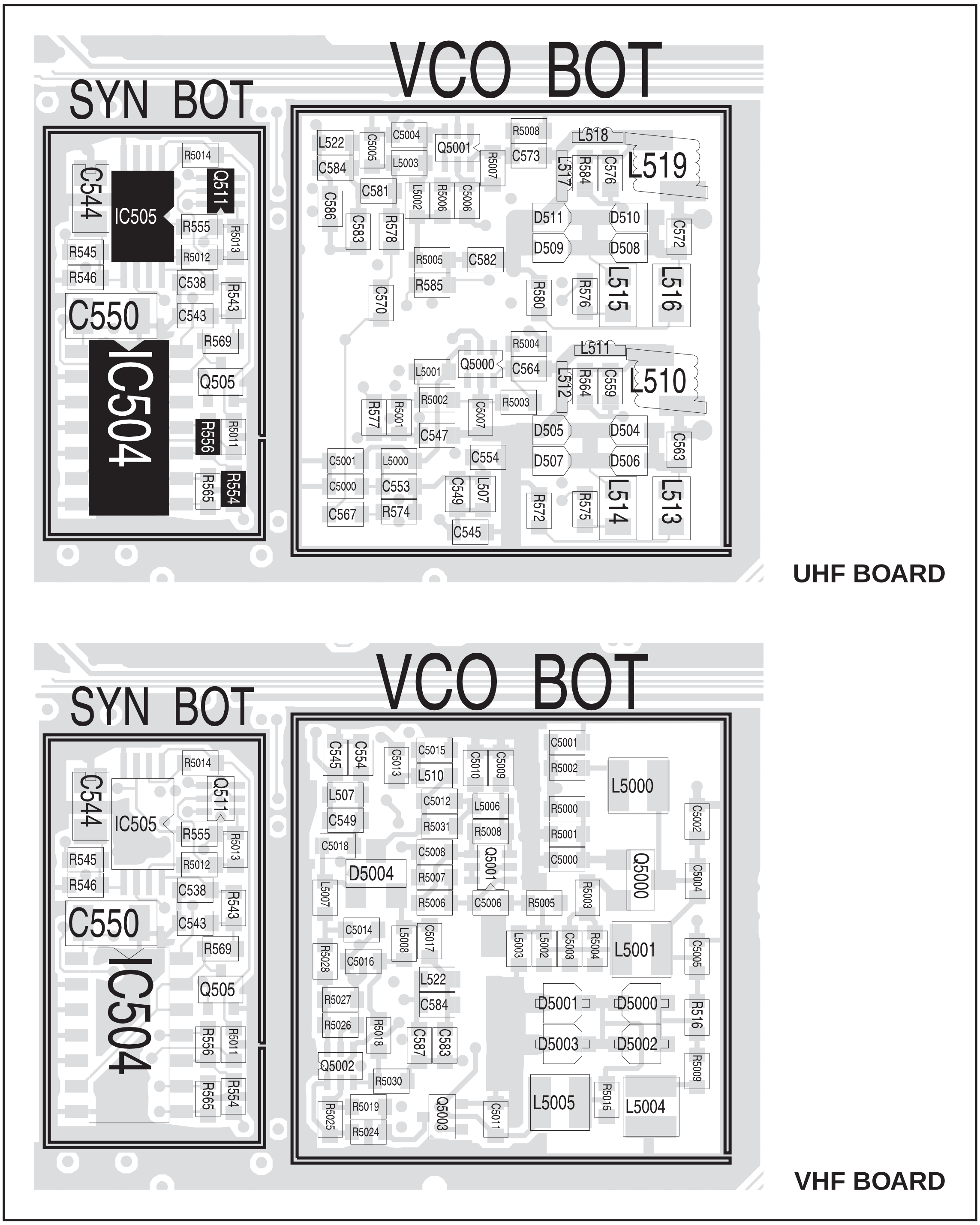


Table 9.2 Nominal VCO tuning voltages

Frequency band	Mode	Frequency	Nominal VCO tuning voltage
B1	Receive	Lowest	3 to 4 V
		Highest	7 to 8 V
	Transmit	Lowest	5.5 to 6.5 V
		Highest	9.5 to 10.5 V
D1	Receive	Lowest	2.5 to 3.5
		Highest	7.5 to 8.5
	Transmit	Lowest	5 to 6
		Highest	10 to 11
H5	Receive	Lowest	3 to 4 V
		Highest	11 to 12 V
	Transmit	Lowest	3 to 4 V
		Highest	10.5 to 11.5 V
H6	Receive	Lowest	2.5 to 3.5 V
		Highest	11 to 12.5 V
	Transmit	Lowest	2 to 3 V
		Highest	10 to 11 V

Task 3 — Modulation or Noise on VCO Tuning Voltages

Noise or modulation can result in the frequency synthesizer providing a tuning voltage that is approximately correct on average, but without locking. Rectify the fault as follows:

1. Remove R570 [at 5M4/5F11] and R566 [at 5L4/5F10], which provide a modulation path to the VCO(s) (see Figure 9.9).

2. Use the CCTM command *72* again to determine if the fault has been removed. If it has, the CODEC and audio circuitry requires investigation; go to Subsection 9.7. If the fault has not been removed, replace R570 and R566, and go to Step 3.

3. The PLL is probably receiving insufficient RF power from the VCO(s). Check for faults in the circuitry of the VCO(s) and related buffer amplifier(s). If a fault is found, repair it, confirm the removal of the fault, and return to Subsection 8.1. If the repair failed or the fault could not be found, return to Subsection 8.1 and replace the complete main-board assembly.

Task 4 — Incorrect VCO Tuning Voltages

If the VCO tuning voltages are incorrect, rectify the fault as follows:

1. Remove the SYN TOP and SYN BOT cans.

2. There are two basic faults: Firstly, the VCO tuning voltage at C565 is low, whereas the voltage at pin 7 of IC505 is much higher; in this case go to Step 3. Secondly, the tuning voltage is either near 0 V or near the VCL supply voltage measured in Step 3 of Task 1; in this case go to Step 4.

3. Check for damage, shorts, open circuits, and dry solder joints in the circuitry along the path between pin 7 of IC505 [at 5J5/5F8] and C565 [at 5M5/5F11] (see Figure 9.9 and Figure 9.10). If a fault is found, repair it, confirm the removal of the fault, and return to Subsection 8.1. If the repair failed or the fault could not be found, return to Subsection 8.1 and replace the complete main-board assembly.

4. Check for open circuits, short circuits, and faulty components in the circuitry in the feedback path for the operational amplifier IC505 [at 5J5/5F8] (Q511, IC504, R554, R556, C548, C555) (see Figure 9.9 and Figure 9.10). If no fault is found, go to Step 5. If a fault is found, repair it, confirm the removal of the fault, and return to Subsection 8.1. If the repair failed, return to Subsection 8.1 and replace the complete main-board assembly.

5. Check the reference input signal at pin 8 of IC503 [at 5H7] of the PLL (see Figure 9.9). The signal should be about 13 MHz and 1 V_{pp}. If it is, return to Subsection 8.1 and replace the complete main-board assembly. If it is not, go to Step 6.

6. Remove IC503. Repeat the above check of the reference input signal. It should now be about 1.5 to 2.0 V_{pp}. If it is not, the FCL requires investigation; go to Subsection 9.4. If it is, replace IC503, confirm the removal of the fault, and return to Subsection 8.1. If the repair failed, return to Subsection 8.1 and replace the complete main-board assembly.

9.4 Frequency Control Loop

Lock Status

Fault diagnosis of the FCL is divided into four tasks. First discussed, however, is the lock status of the radio, which will indicate whether or not the FCL is suspect. The lock status might already have been determined as part of the preliminary fault diagnosis. The following is a summary:

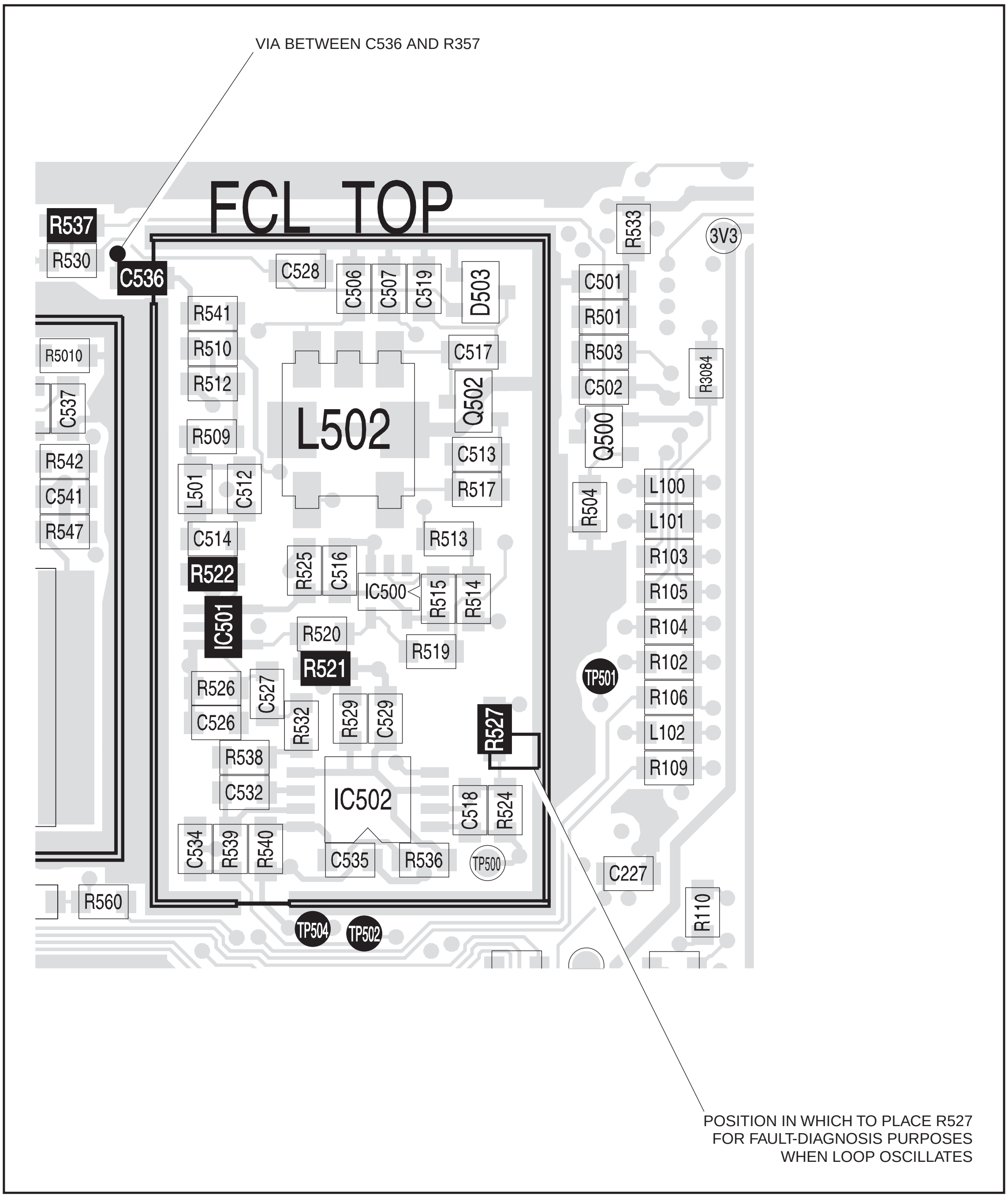
1. Enter the CCTM command *33* to place the radio in transmit mode.
2. Enter the CCTM command *72* to determine the lock status in transmit mode. Note the response. The normal status is *110*.
3. Enter the CCTM command *32* to place the radio in receive mode.
4. Enter the CCTM command *72* to determine the lock status in receive mode. Note the response. The normal status is *111*.
5. If the lock status in either or both receive and transmit mode is ***a0a***, where ***a*** is *0* or *1*, the FCL is suspect; proceed to Task 1.

Task 1 — Check VCXO and TCXO Outputs

First check the VCXO output and the TCXO output as follows:

1. Use an oscilloscope probe to check the VCXO output at C536 [at 5G8/5H6] — probe the via situated between C536 and R537 (see Figure 9.11). The signal should be a sine wave of about 1.1 V_{pp} on 1.45 V DC. If it is, go to Step 3. If it is not, go to Step 2.
2. The VCXO circuitry (Q501, Q503, XL501 and associated components) under the VCXO BOT can is faulty. If not already done, remove the main-board assembly from the chassis, and remove the VCXO BOT can. Locate and repair the fault in the VCXO (see Figure 9.12). Confirm the removal of the fault and go to Step 3. If the repair failed, return to Subsection 8.1 and replace the complete main-board assembly.
3. Use the oscilloscope probe to check the TCXO output at the TP504 test point [at 5B8/5J2] (see Figure 9.11). (The test point is at the junction of C510 and R513.) The signal is SYN RX OSC and should be a clipped sine wave of about 1.0 V_{pp}. If it is, go to Task 2. If it is not, go to Step 4.
4. The TCXO circuitry (XL500 [at 5B8/5J2] and associated components) under the CDC TOP can is faulty. Remove the CDC TOP can. Locate and repair the fault in the TCXO (see Figure 9.16 in Subsection 9.5). Confirm the removal of the fault and go to Task 2. If the repair failed, return to Subsection 8.1 and replace the complete main-board assembly.

Figure 9.11 FCL circuitry under and adjacent the FCL TOP can



Task 2 — Check Signals at TP501 and TP502

If the VCXO and TCXO outputs are correct, or any related faults were rectified, check the signals at the TP501 and TP502 test points:

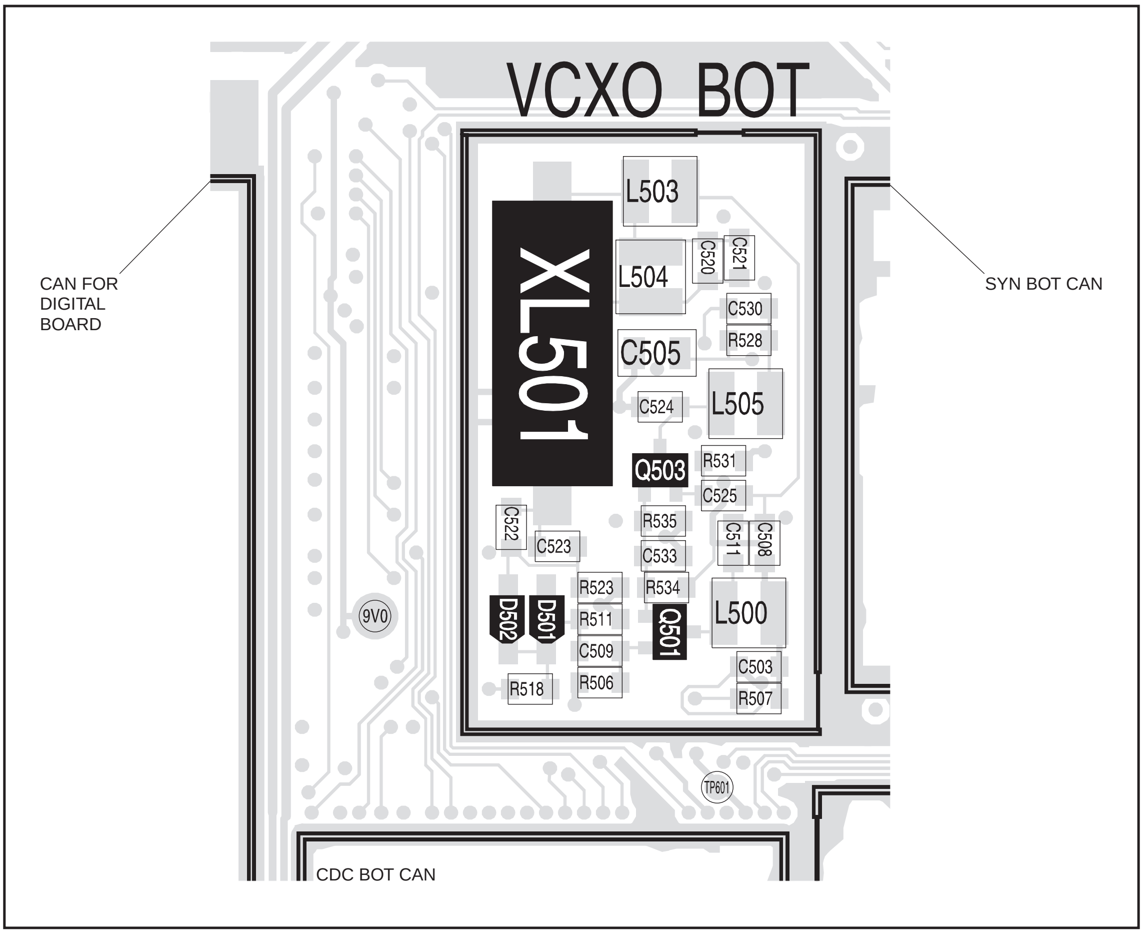
1. Use the oscilloscope probe to check the difference frequency at the TP502 test point [at 5F8/5J6] (see Figure 9.11). The signal is SYN CDC FCL and should be a sine wave of about 1.3 V_{pp} on 1.5 V DC. If it is, go to Step 4. If it is not, go to Step 2.

2. The mixer circuitry (IC501 [at 5D7/5H4] and associated components) or the LPF (low-pass filter) circuitry (IC502 pins 5 to 7 [at 5F7/5H5] and associated components) under the FCL TOP can is faulty. Remove the FCL TOP can.

3. Locate the fault in the mixer or LPF circuitry (see Figure 9.11). Note that the TCXO input to the mixer at R521 [at 5D7/5H3] (pin 4 of IC501) should be a square wave with a frequency of 13 000 000 Hz and an amplitude of 3 V_{pp}. Also, the VCXO input to the mixer at R522 [at 5D6/5G3] (pin 1 of IC501) should be a sine wave of 20 mV_{pp} (but the signal is noisy and difficult to measure). Repair the circuitry, confirm the removal of the fault, and go to Step 4. If the repair failed, return to Subsection 8.1 and replace the complete main-board assembly.

4. With the oscilloscope probe at the TP501 test point [at 5F5/5G5] (see Figure 9.11), check the DAC output CDC VCXO MOD. If a triangular wave is present, the loop is oscillating; go to Task 4. Otherwise go to Task 3.

Figure 9.12 FCL circuitry under the VCXO BOT can



Task 3 — 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*. Note the voltage level; this should be about 1.3 V DC. Then enter the CCTM command *72* and note the lock status.
2. Enter the CCTM command *393 1 –1900*. Note the voltage level; this should be about 2.1 V DC. Then enter the CCTM command *72* and note the lock status.
3. If the above voltage levels are not correct or if the FCL is out of lock in either or both of the above cases, go to Step 4. If the voltage level remains fixed at about 1.5 V DC, go to Step 5. If the voltage levels are all correct (following earlier repairs), the fault has been removed; return to Subsection 8.1.

4. The VCXO tank circuit (Q501, D501, D502, XL501 and associated components) or the crystal XL501 [at 5D3/5E4] is faulty (see Figure 9.12). If not already done, remove the main-board assembly from the chassis, and remove the VCXO BOT can. Locate and repair the fault, confirm the removal of the fault, and go to Step 9. If the repair failed, return to Subsection 8.1 and replace the complete main-board assembly.

5. There is a fault in the CODEC 2 circuitry or with the digital signals to and from IC205 [at 2P2/2D12]. The CODEC 2 circuitry comprises IC205 and associated components under the CDC TOP can (see Figure 9.16 in Subsection 9.5) as well as R246 [at 2Q1/2C13] under the CDC BOT can (see Figure 9.3 of Subsection 9.1). If not already done, remove the CDC TOP can.

6. Check the signals DIG CDC2 LRCK at pin 10 of IC205, DIG CDC2 SCLK at pin 12, CDC2 DIG SDTO at pin 8, and DIG CDC2 SDTI at pin 9 [at 2Q2]. The signals should be active 3.3 V digital signals to and from the digital board. If the signals are correct, go to Step 8. If they are not, go to Step 7.

7. If any or all digital signals are missing, check the connections between IC205 and the digital board. Repair any faults such as open circuits, and return to Step 1. If the connections are not faulty, then the digital board is faulty. Return to Subsection 8.1 and replace the complete main-board assembly.

8. The CODEC 2 circuitry identified in Step 5 is faulty. Locate and repair the fault, confirm the removal of the fault, and go to Step 9. Note that, if the circuitry is functioning properly, probing the TP501 test point [at 5F5/5G5] (see Figure 9.11) 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. If the repair failed, return to Subsection 8.1 and replace the complete main-board assembly.

9. Replace all cans. Repeat Steps 1 to 3 to confirm the removal of the fault. If the repair failed, return to Subsection 8.1 and replace the complete main-board assembly.

Task 4 — Loop is Oscillating

If a check of the signal at the TP501 test point shows that the loop is oscillating, proceed as follows:

1. If not already done, remove the FCL TOP can. Connect the TP501 test point [at 5F5/5G5] to ground by resoldering R527 [at 5E5/5F4] in the position shown in Figure 9.11. This forces the VCXO loop voltage high.

2. Use the oscilloscope probe to check the VCXO output at C536 [at 5G8/5H6] — probe the via situated between C536 and R537 (see Figure 9.11). The signal should be a sine wave with a frequency of 13.017 MHz and an amplitude of about 1.1 V_{pp} on 1.45 V DC. If the signal is correct, go to Step 4. If it is not, go to Step 3.

3. The VCXO (Q501, Q503, XL501 and associated components) is faulty. If not already done, remove the main-board assembly from the chassis, and remove the VCXO BOT can. Locate and repair the fault in the VCXO (see Figure 9.12), confirm the removal of the fault, and go to Step 4. If the repair failed, return to Subsection 8.1 and replace the complete main-board assembly.

4. Use the oscilloscope probe to check the difference frequency at the TP502 test point [at 5F8/5J6] (see Figure 9.11). The signal is SYN CDC FCL and should be a sine wave with a frequency of about 17 kHz and an amplitude of about 1.3 V_{pp} on 1.5 V DC. If the signal is correct, go to Step 6. If it is not, go to Step 5.

5. The mixer circuitry (IC501 [at 5D7/5H4] and associated components) or the LPF circuitry (IC502 pins 5 to 7 [at 5F7/5H5] and associated components) under the FCL TOP can is faulty. Locate the fault in the mixer or LPF (see Figure 9.11). Note that the TCXO input to the mixer at R521 [at 5D7/5H3] (pin 4 of IC501) should be a square wave with a frequency of 13000000 Hz and an amplitude of 3 V_{pp}. Also, the VCXO input to the mixer at R522 [at 5D6/5G3] (pin 1 of IC501) should be a sine wave of 20 mV_{pp} (but the signal is noisy and difficult to measure). Repair the circuitry, confirm the removal of the fault, and go to Step 6. If the repair failed, return to Subsection 8.1 and replace the complete main-board assembly.

6. Resolder R527 [at 5E5/5F4] in its original position as shown in Figure 9.11. Replace all cans. Repeat Steps 1 to 3 of Task 3 to confirm the removal of the fault. If the repair failed, return to Subsection 8.1 and replace the complete main-board assembly.

9.5 Receiver

Fault Conditions

Fault diagnosis of the receiver is divided into seven tasks. The symptoms of the fault in the receiver circuitry determine which tasks need to be carried out. There are four cases:

- receiver sensitivity is too low
- RSSI readings are incorrect
- radio mute is faulty
- receiver distortion is too high

For the case of low sensitivity proceed to Task 1. Depending on the extent of the sensitivity loss, Task 2, Task 3 or Task 4 will also need to be carried out. For the remaining three cases proceed to Task 5, Task 6 and Task 7 respectively.

Task 1 — Low Receiver Sensitivity

Depending on the nature of the fault, a reduction in receiver sensitivity of 1 dB is often due to a reduction in receiver gain of many decibels. It is therefore easier to measure gain loss rather than sensitivity loss. Consequently, if the receiver sensitivity is too low, first check the receiver gain as follows:

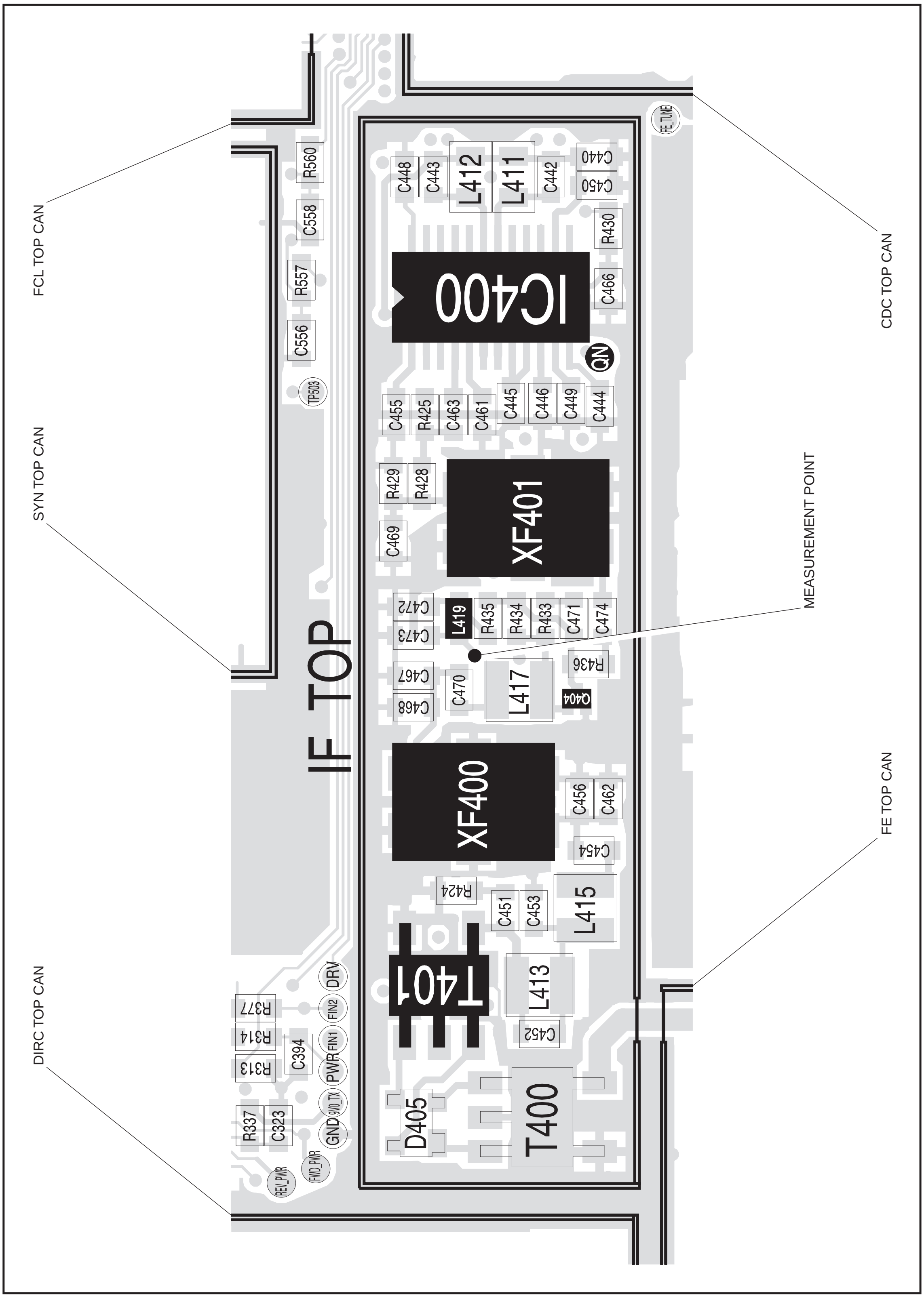
1. Input an RF signal (not necessarily modulated) of –90 dBm (or –84 dBm with a trigger-base radio) at the RF connector.

2. Enter the CCTM command *378* to measure the receiver output level. Note the value ***x*** returned. (A change in the input level of 10 dB should result in a tenfold change in ***x***.)

3. Normally ***x*** should be between 500 000 and 6000 000, depending on the frequency band in which the radio operates. The corresponding RF voltages at the QN test point [at 4P1/4C12] (see Figure 9.13) are 12 mV_{pp} and 120 mV_{pp} respectively. (These can be measured through a hole in the IF TOP can.) With an unmodulated RF signal the frequency should be 64.000 kHz, provided that the LO1, FCL and LO2 are locked and on the correct frequency.

4. Given the value of ***x***, go to the relevant task as follows:
   - ***x*** < 500, go to Task 2 (sensitivity is more than 40 dB too low)
   - ***x*** < 40 000, go to Task 3 (sensitivity is about 15 dB too low)
   - ***x*** < 500 000, go to Task 4 (sensitivity is a few decibels too low)

Figure 9.13 Receiver circuitry under the IF TOP can



Task 2 — Receiver Sensitivity Is More Than 40 dB Too Low

If the receiver sensitivity is more than 40 dB too low, the fault is probably in the power-supply, control, LO, IF1 or IF2 circuitry.

1. Remove the main-board assembly from the chassis. Check for 3.0 V DC (3V0 AN) at the TP601 test point [at 6K5/6D8] near the LO2 BOT can (see Figure 9.14). If the voltage is correct, go to Step 2. If it is not, go to Task 3 of Subsection 9.1 on the power-supply circuitry.

2. Remove the LO2 BOT can. Check for 3.0 V DC (3V0 RX) around the collector feed to Q402 [at 4G3/4E6] or Q403 [at 4G2/4D6] of LO2 (see Figure 9.14). If the voltage is correct, go to Step 3. If it is not, go to Task 3 of Subsection 9.1 on the power-supply circuitry.

   Alternative measurement points are the collector feed to Q401 [at 4F6/4G5] of the RF LNA under the FE TOP can (see Figure 9.15) or Q404 [at 4R6/4G14] of the IF amplifier under the IF TOP can (see Figure 9.13).

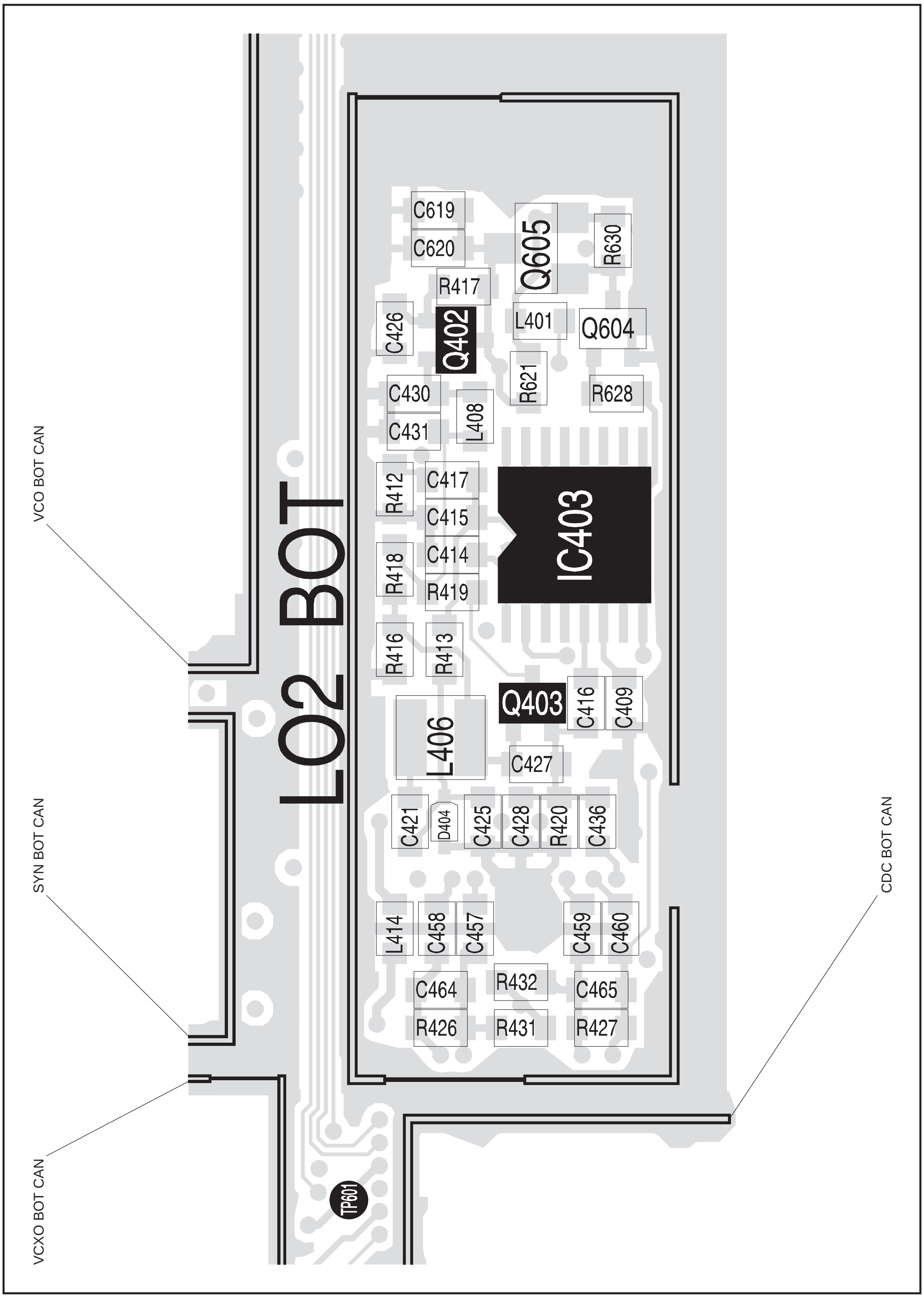
3. Check the logic signal DIG SYN EN at pin 8 [at 4D1/4C3] of IC403 (see Figure 9.14). The signal is active high. The required status is active — about 3.0 V. If it is, go to Step 4. If it is not, check the signal continuity from the digital board to the receiver. Repair any fault and go to Step 7. If the digital board itself appears faulty, return to Subsection 8.1 and replace the complete main-board assembly.

   An alternative measurement point to the above is pin 24 [at 4L2/4D10] of IC400 under the IF TOP can (see Figure 9.13).

4. Enter the CCTM command *72* to determine the lock status. The result should be *111* (LO1, FCL, LO2). If it is, go to Step 5. If the LO1 is not in lock, go to Subsection 9.3 on the frequency synthesizer. If the FCL is not in lock, go to Subsection 9.4 on the FCL. If the LO2 is not in lock, check the components around IC403, Q402 and Q403 (see Figure 9.14). Repair any fault and go to Step 7.

5. Remove the IF TOP can. Check all components around Q404 [at 4R6/4G14] of the IF amplifier (see Figure 9.13). Check the supply voltage at L419 [at 4R8/4H14]. Also check the amplifier bias conditions: V_c should be 1.5 ± 0.2 V and I_c should be 1.8 ± 0.5 mA. Measure V_c between the collector of Q404 and the point shown in Figure 9.13. To check I_c, unsolder and raise one terminal of L419 (tombstone position), connect a multimeter between this terminal and the pad for the terminal, and measure the current. If there is no fault, go to Step 6. If there is, repair the fault and go to Step 7.

Figure 9.14 Receiver circuitry under the LO2 BOT can



6. Having excluded the IF amplifier, check all remaining components between T401 [at 4L6/4G10] and IC400 [at 4M1/4C10] — these form the matching circuitry for the crystal filters XF400 [at 4N6/4G12] and XF401 [at 4Q2/4D13] (see Figure 9.13). If there is no fault, go to Task 3. If there is, repair the fault and go to Step 7.

7. Recalibrate the receiver using the calibration application. Confirm the removal of the fault and return to Subsection 8.1. If the repair failed, go to Task 3.

Task 3 — Receiver Sensitivity Is About 15 dB Too Low

If the receiver sensitivity is about 15 dB too low, the fault is probably in the front-end tuning circuitry.

1. Using the calibration application, check the calibration of the front-end tuning circuitry: Open the *"Raw Data"* page and click the *"Receiver"* tab. Record the values listed in the *"Rx FE Tune BPF Settings"* field — these are the DAC values of the FE (front-end) tuning voltages for the five frequencies *FE TUNE0* to *FE TUNE4*. (*FE TUNE0* is the lowest frequency and *FE TUNE4* the highest frequency in the radio's frequency band.)

2. For each of the frequencies *FE TUNE0* to *FE TUNE4* in turn, carry out the following procedure: Enter the CCTM command *101 **a a** 0*, where ***a*** is the frequency in hertz. Enter the CCTM command *376* and record the value returned — this is the front-end tuning voltage in millivolts.

3. Compare the values measured in Steps 1 and 2 with the nominal DAC and voltage values listed in Table 9.3. If the values are correct, go to Step 4. If they are not, recalibrate the receiver using the calibration application, and check the DAC and voltage values again. If the values are now correct, the fault has been rectified; return to Subsection 8.1. If they are not, go to Step 4.

4. Remove the FE TOP and IF TOP cans. Check the soldering of all the components of the front-end tuning circuitry from C400 [at 4B6/4G1] to T401 [at 4L6/4G10] (see Figure 9.13 and Figure 9.15). Check the supply voltage at L404 [at 4E7/4H5]. Also check the LNA bias conditions: V_c should be 2.7 ± 0.1 V and I_c should be 10 ± 1 mA. Measure V_c between the collector of Q401 [at 4F6/4G5] and the point shown in Figure 9.15. To check I_c, unsolder and raise one terminal of L404 (tombstone position), connect a multimeter between this terminal and the pad for the terminal, and measure the current. If there is no fault, go to Step 5. If there is, repair the fault and go to Step 6.

5. Check the signal level at the output of LO1 and continue the fault diagnosis as in Subsection 9.3 on the frequency synthesizer.

6. Recalibrate the receiver using the calibration application. Confirm the removal of the fault and return to Subsection 8.1. If the repair failed, go to Task 4.

Figure 9.15 Receiver circuitry under the FE TOP can

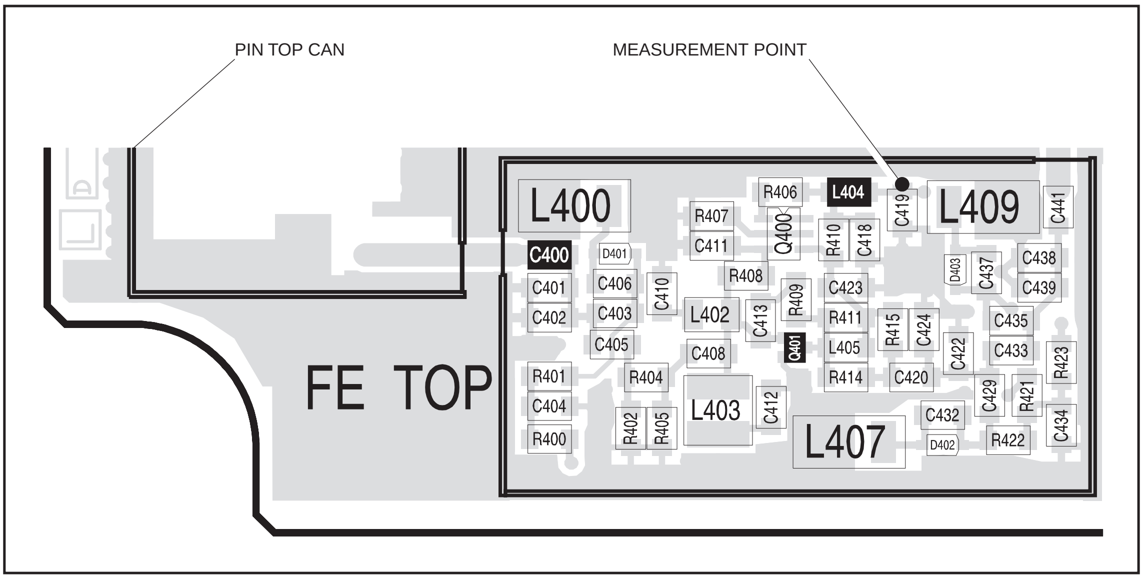


Table 9.3 Front-end tuning voltages and corresponding DAC values

Frequency band	Tuning voltages at five different frequencies				
	FE TUNE0	*FE TUNE1*	*FE TUNE2*	*FE TUNE3*	*FE TUNE4*
B1 band Frequency (MHz) DAC value Voltage (V)	135.9 37 ± 20 0.44 ± 0.24	145.1 88 ± 15 1.04 ± 0.18	155.1 136 ± 15 1.60 ± 0.18	164.1 174 ± 15 2.04 ± 0.18	174.1 210 ± 15 2.57 ± 0.18
D1 band Frequency (MHz) DAC value Voltage (V)	215.9 42 ± 20 0.5 ± 0.2	228.1 103 ± 15 1.2 ± 0.18	241.1 151 ± 15 1.7 ± 0.18	253.1 187 ± 15 2.2 ± 0.18	266.1 224 ± 10 2.6 ± 0.12
H5 band Frequency (MHz) DAC value Voltage (V)	399.9 0 to 36 0 to 0.43	417.1 94 ± 15 1.11 ± 0.18	435.1 106 ± 15 1.25 ± 0.18	452.1 156 ± 15 1.84 ± 0.18	470.1 191 ± 15 2.25 ± 0.18
H6 band Frequency (MHz) DAC value Voltage (V)	449.9 41 ± 20 0.48 ± 0.24	470.1 91 ± 15 1.07 ± 0.18	490.1 134 ± 15 1.58 ± 0.18	510.1 176 ± 15 2.07 ± 0.18	530.1 210 ± 15 2.47 ± 0.18

Task 4 — Receiver Sensitivity Is Few Decibels Too Low

If the receiver sensitivity is just a few decibels too low, the fault-diagnosis procedure is similar to that of Task 3.

1. Using the calibration application, check the calibration of the front-end tuning circuitry: Open the *"Raw Data"* page and click the *"Receiver"* tab. Record the values listed in the *"Rx FE Tune BPF Settings"* field — these are the DAC values of the FE tuning voltages for the five frequencies *FE TUNE0* to *FE TUNE4*. (*FE TUNE0* is the lowest frequency and *FE TUNE4* the highest frequency in the radio's frequency band.)

2. For each of the frequencies *FE TUNE0* to *FE TUNE4* in turn, carry out the following procedure: Enter the CCTM command *101 **a a** 0*, where ***a*** is the frequency in hertz. Enter the CCTM command *376* and record the value returned — this is the front-end tuning voltage in millivolts.

3. Compare the values measured in Steps 1 and 2 with the nominal DAC and voltage values listed in Table 9.3. If the values are correct, go to Step 4. If they are not, recalibrate the receiver using the calibration application, and check the DAC and voltage values again. If the values are now correct, the fault has been rectified; return to Subsection 8.1. If they are not, go to Step 4.

4. Remove the FE TOP and IF TOP cans. Check the soldering of all the components of the front-end tuning circuitry from C400 [at 4B6/4G1] to T401 [at 4L6/4G10] (see Figure 9.13 and Figure 9.15). Also check the LNA and IF-amplifier bias conditions as in Step 4 of Task 3 and Step 5 of Task 2 respectively. If there is no fault, go to Step 5. If there is, repair the fault and go to Step 6.

5. Check the PIN switch and LPF as in Task 9 and Task 10 of Subsection 9.6 on the transmitter.

6. Recalibrate the receiver using the calibration application. Confirm the removal of the fault and return to Subsection 8.1. If the repair failed, return to Subsection 8.1 and replace the complete main-board assembly.

Table 9.4 Nominal AGC data

Parameter	AGC voltages and receiver input powers		
	AGC0	*AGC1*	*AGC2*
AGC voltage (mV)			
B1 frequency band	2110 ± 50	1960 ± 40	1790 ± 40
D1 frequency band	2050 ± 50	1900 ± 40	1750 ± 40
H5 frequency band	2200 ± 50	2040 ± 40	1860 ± 40
H6 frequency band	2220 ± 50	2050 ± 40	1870 ± 40
Receiver input power (dBm)			
Standard radio	−68	−60	−50
Trigger-base radio	−62	−54	−44

Task 5 — Incorrect RSSI Readings

If the RSSI readings are incorrect, use the calibration application to check the receiver calibration as follows:

1. Open the *"Raw Data"* page and click the *"Receiver"* tab. Note the settings listed in the *"AGC Voltage Cal Pts"* field. The nominal settings should be as listed in Table 9.4. If the settings are correct, go to Step 3. If they are not, recalibrate the receiver and check the settings again. If they are now correct, go to Step 2. If they are not, go to Task 1 and check the receiver sensitivity.

2. Check if the RSSI fault has been removed. If it has, return to Subsection 8.1. If it has not, go to Step 3.

3. Note the settings listed in the *"FE Tune BPF Settings"* field. The nominal settings should be as listed in Table 9.3. If the settings are correct, go to Step 5. If they are not, recalibrate the receiver and check the settings again. If they are now correct, go to Step 4. If they are not, go to Task 1 and check the receiver sensitivity.

4. Check if the RSSI fault has been removed. If it has, return to Subsection 8.1. If it has not, go to Step 5.

5. Note the values listed in the *"RSSI Delta Gain Values"* field. The values should run gradually from 0 dB to about –3 dB. If they do, go to Step 7. If they do not, recalibrate the receiver and check the values again. If they are now correct, go to Step 6. If they are not, go to Task 1 and check the receiver sensitivity.

6. Check if the RSSI fault has been removed. If it has, return to Subsection 8.1. If it has not, go to Step 7.

7. Note the values listed in the *"AGC Delta Gain Values"* field. The values should be between 0 dB and about 35 dB. If they are, go to Step 9. If they are not, recalibrate the receiver and check the values again. If they are now correct, go to Step 8. If they are not, go to Task 1 and check the receiver sensitivity.

8. Check if the RSSI fault has been removed. If it has, return to Subsection 8.1. If it has not, go to Step 9.

9. In this case all the RSSI calibration settings are correct, but there is still an RSSI fault; go to Task 1 and check the receiver sensitivity.

Task 6 — Radio Mute Faulty

If the radio mute is faulty, use the programming and calibration applications to check the relevant settings.

1. Check the programming of the mute. In the programming application click the *"Basic Settings"* page under the *"Networks"* heading. Click the *"Basic Network Settings"* tab.

2. Check the setting in the *"Squelch Detect Type"* field. Ensure that the setting is what the Customer expects. If the setting is *"Noise Level"*, implying that noise muting is selected, go to Step 3. If the setting is *"Signal Strength"*, implying that RSSI muting is selected, go to Step 7.

3. With noise muting selected, check the noise mute settings: In the calibration application open the *"Variable Parameters"* page and click the *"Squelch and Signal Strength"* tab.

4. Ensure that, under the *"Squelch Threshold"* label, the settings in the *"Country"*, *"City"* and *"Hard"* fields are what the Customer expects.

5. Open the *"Raw Data"* page and click the *"Mute"* tab. Compare the values in the *"Mute Noise Readings"* field with the required minimum and maximum values listed in Table 9.5. If the values are correct, go to Task 1 and check the receiver sensitivity. If they are not, go to Step 6.

6. Recalibrate the mute and then check if the mute fault has been removed. If it has, return to Subsection 8.1. If it has not, go to Task 1 and check the receiver sensitivity.

7. With RSSI muting selected, check the RSSI mute settings: In the calibration application open the *"Variable Parameters"* page and click the *"Squelch and Signal Strength"* tab.

8. Check that the values in the *"Busy Opening Pt"* fields and the *"Busy Hysteresis"* fields are what the Customer expects. If they are, go to Task 5 and check the RSSI calibration. If they are not, go to Step 9.

9. Adjust the values in the *"Busy Opening Pt"* and *"Busy Hysteresis"* fields. Program the radio with the new values. Check if the mute fault has been removed. If it has, return to Subsection 8.1. If it has not, go to Task 5 and check the RSSI calibration.

Figure 9.16 TCXO circuitry under the CDC TOP can

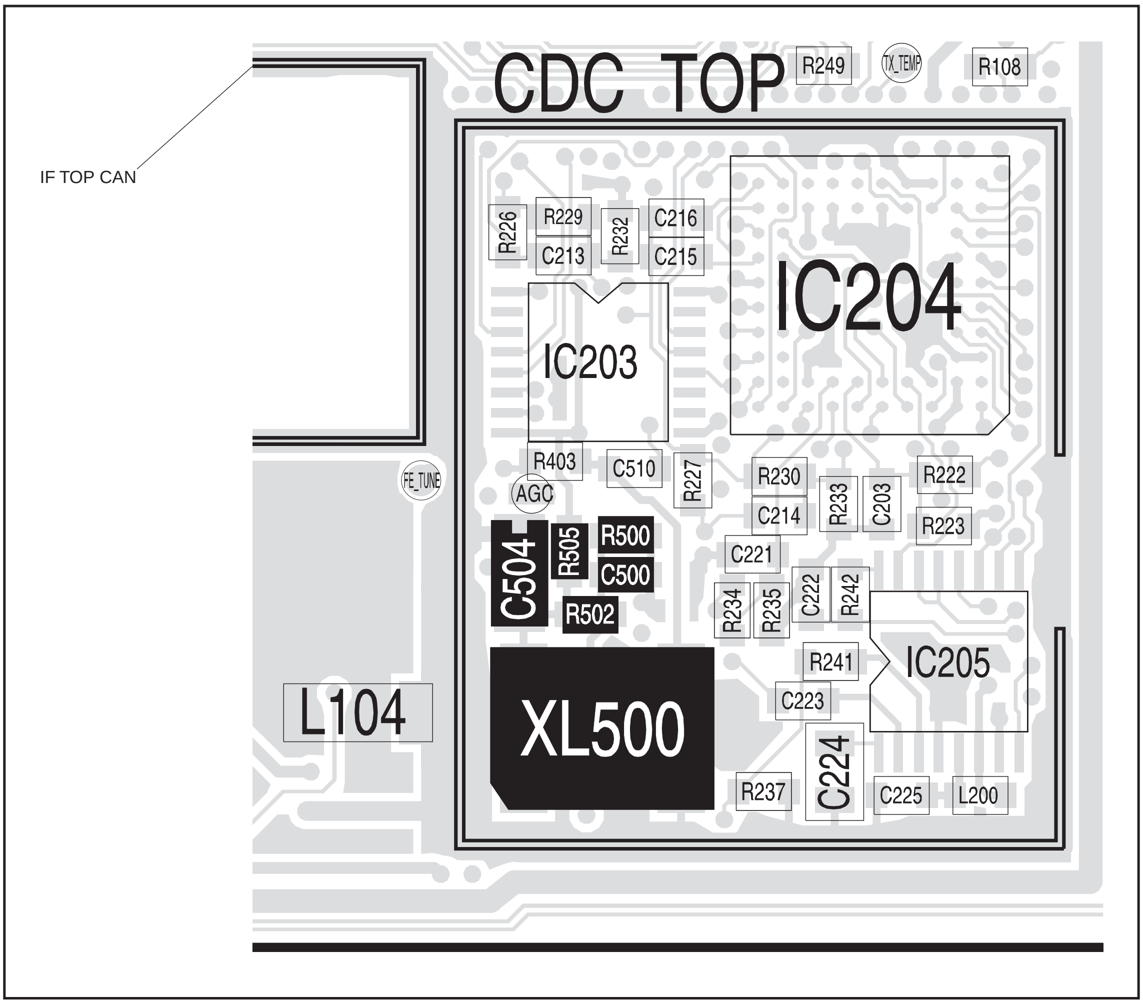


Table 9.5 Mute data

Channel spacing	SINAD (dB)	Minimum noise value	Maximum noise value
Narrow (12.5 kHz)	8	1900	2300
	20	250	500
Medium (20 kHz)	8	3700	4200
	20	1000	1500
Wide (25 kHz)	8	5500	7300
	20	2200	3700

Task 7 — High Receiver Distortion

If there is high receiver distortion, the TCXO is suspect.

1. Use the calibration application to check the TCXO calibration: Open the *"Raw Data"* page and click the *"Voltage Ref, TCXO and VCXO"* tab. Note the values listed in the *"Tx TCXO"* and *"Rx TCXO"* fields of the *"TCXO"* group box. The values should be between +20 Hz and –20 Hz. If they are, go to Step 3. If they are not, go to Step 2.

2. Remove the CDC TOP can. Check the TCXO components and repair any fault (see Figure 9.16). Recalibrate the TCXO and check the TCXO calibration values again as in Step 1. If the values are now correct, go to Step 3. If they are not, go to Step 4.

3. Check if the distortion fault has been removed. If it has, return to Subsection 8.1. If it has not, go to Step 4.

4. Input a large unmodulated RF input signal exceeding –90 dBm at the RF connector. Use a needle probe to measure the frequency of the signal at the QN test point [at 4P1/4C12] — access is through the hole in the IF TOP can (see Figure 9.13). The frequency is the second IF and should be 64.000 kHz. If it is, go to Step 6. If it is not, go to Step 5.

5. Recalibrate the TCXO and check if the distortion fault has been removed. If it has, return to Subsection 8.1. If it has not, go to Step 6.

6. Remove the IF TOP can. Check the components between T401 [at 4L6/4G10] and IC400 [at 4M1/4C10] — these form the matching circuitry for the crystal filters XF400 [at 4N6/4G12] and XF401 [at 4Q2/4D13] (see Figure 9.13). Repair any fault, confirm the removal of the fault, and return to Subsection 8.1. If the repair failed or the fault could not be found, return to Subsection 8.1 and replace the complete main-board assembly.

9.6 Transmitter

Introduction

This subsection covers the diagnosis of faults in the 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. The procedure for diagnosing transmitter faults is divided into 16 tasks. Before beginning the fault diagnosis with Task 1, note the following concerning can removal and transmit tests.

Can Removal and Replacement

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 main-board assembly from the chassis. In the case of the PAD TOP and PAF TOP cans, also remove the screws securing the heat-transfer block to the PCB; then separate the block slightly from the PCB (the RF connector limits the amount of movement). Secure the block again before any transmit tests. Replace all cans that have been removed only after repairing the board. (This applies to the B1, D1, H5 and H6 bands. For certain other bands the transmitter will not operate correctly unless all the cans are fitted.)

Transmit Tests

Observe the precautions listed in Subsection 8.1 regarding transmit tests. In particular, always place the main-board assembly in the chassis before a transmit test. Also ensure that the assembly is secured by at least the two external screws and one of the internal screws. There is no need, however, to secure the lid of the radio body. To prevent overheating, place the radio in receive mode as soon as possible after a transmit test. The reason for this is that the transmit timers do not function in CCTM mode.

Task 1 — Check Power Supply

First check the power supplies for the transmitter circuitry.

1. Set the DC power supply to 13.8 V, with a current limit of 9 A.
2. Enter the CCTM command *326 5* to set the radio to maximum power.
3. Enter the CCTM command *33* to place the radio in transmit mode.
4. Check for more than 13 V DC at the drain of Q306 [at 3C3/3E3] by measuring the voltage at the point on L306 [at 3D5/3F3] shown in Figure 9.20 and Figure 9.21. Also check for more than 13 V at the common drain of Q309 [at 3F3/3E5] and Q310 [at 3F2/3D5] by measuring the voltage at the point on L310 [at 3F5/3F5] shown in Figure 9.18 and Figure 9.19. Use a needle probe or else remove the PAF TOP and PAD TOP cans. If the supply is correct, go to Step 5. If it is not, go to Subsection 9.1 on the power-supply circuitry.
5. Check for 9.0 ± 0.5 V DC between the 9V0_TX and GND test points [at 3A9/3J1] (see Figure 9.17). If the supply is correct, go to Task 2. If it is not, go to Subsection 9.1.

Task 2 — Check Forward and Reverse Powers

Next check the forward and reverse power for an indication of which part of the circuitry is suspect.

1. 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 9.6.
2. Confirm the above result by checking the level at the FWD PWR test point (see Figure 9.17) using an oscilloscope.
3. Enter the CCTM command 319 to check the reverse power. The values returned is the voltage in millivolts corresponding to the power level, and should be as shown in Table 9.6.
4. Confirm the above result by checking the level at the REV PWR test point (see Figure 9.17) 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. Check the 50 W antenna load.
5. If the reverse power is momentarily too high, the directional coupler, PIN switch or LPF is suspect; go to Task 11. Otherwise go to Task 3.

Figure 9.17 Test points and components of the shaping filter

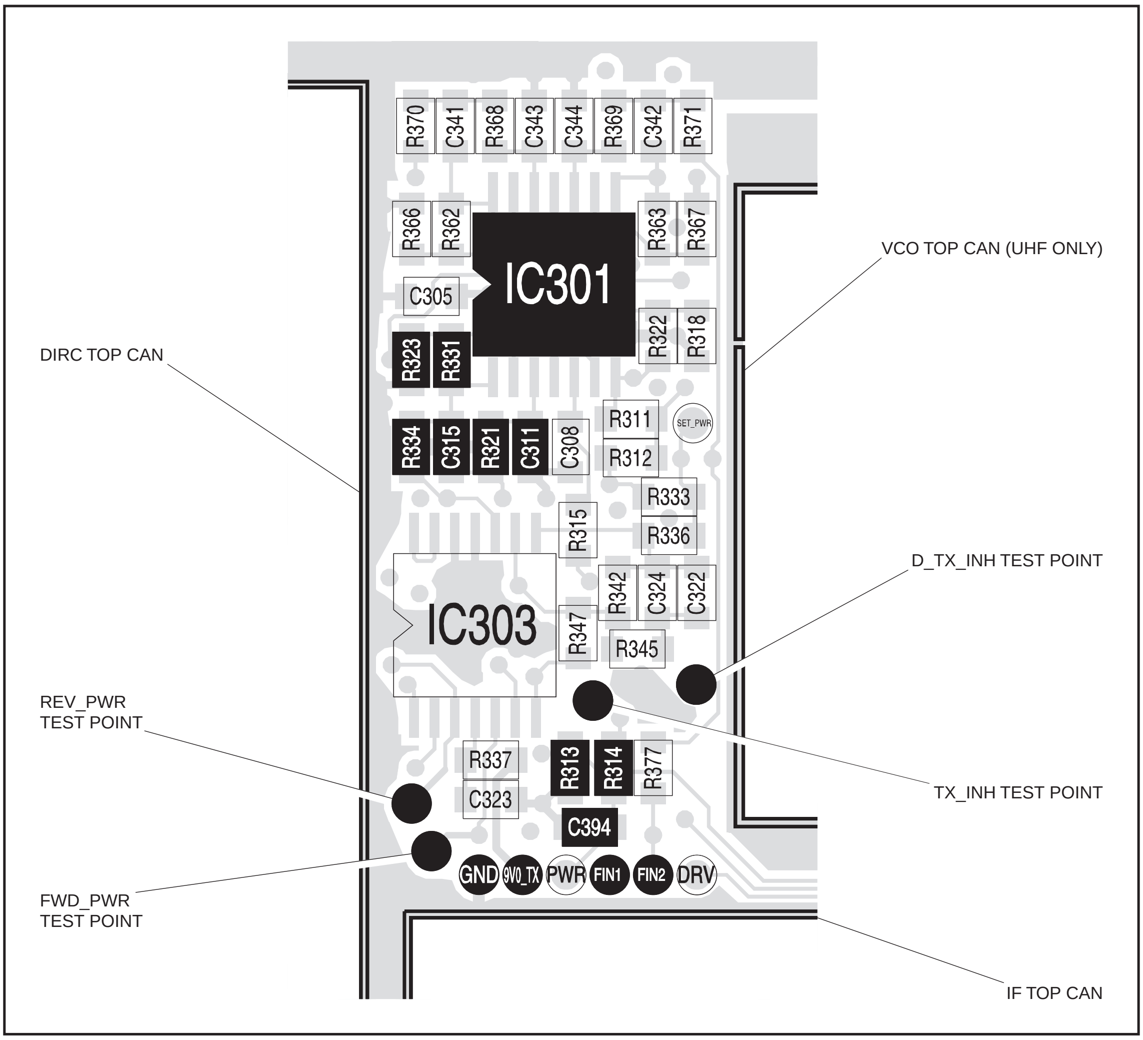


Table 9.6 Voltages in millivolts corresponding to nominal forward and reverse powers

Frequency band	Forward power (318 command)	Reverse power (319 command)
B1	1200 to 1900	< 500
D1	1700 to 2400	< 700
H5	2600 to 3400	< 1000
H6	2900 to 3800	< 1000

**Task 3 —
Check RF Output Power**

If the power supplies are correct, check the RF output power of the transmitter. This check assumes that the test probe from the test set is connected to the RF connector.

1. With the radio in transmit mode, note the RF output power measured by the test set, and note the current reading on the DC power supply. The power should exceed 32 W. The current should exceed 5 A (UHF) or 4 A (VHF).

2. If the RF output power measured in Step 1 is correct, go to Step 3. If there is no power at all, go to Step 5. If the power is wrong or too low, go to Task 14.

3. If the current measured in Step 1 is correct, go to Step 4. If it is not, go to Task 11.

4. Enter the following CCTM commands in turn and measure the RF output power in each case:
   - 326 4
   - 326 3
   - 326 2
   - 326 1

   If the power remains unchanged at all settings, go to Task 5 and then Task 8.

5. If the radio draws some current but there is no power output at the antenna, go to Task 11. If no current is drawn, go to Task 4.

Task 4 — Check for Inhibiting of Transmitter

If the transmitter is drawing no current or the wrong current, check whether it is being inhibited.

1. With the radio in transmit mode, check the logic signal at the TX INH test point [at 3J0/3A8] (see Figure 9.17). The signal is active high. The required status is inactive — about 0 V. If it is, go to Task 5. If the signal is active — about 1.1 V — go to Step 2.

2. Check the logic signal at the D TX INH test point [at 3L0/3B9] (see Figure 9.17). The signal is active low. The required status is inactive — about 3.2 V. If it is, go to Step 3. If the signal is active — about 0 V — go to Step 5.

3. The lock status is possibly no longer normal. With the transmitter in transmit mode, enter the CCTM command *72* to check the lock status. The normal status is *110*. If it is not, proceed to the relevant subsection. If it is, go to Step 4.

4. Check for short circuits on the DIG TX INH line from the D TX INH test point. Repair any fault, confirm the removal of the fault, and return to Subsection 8.1. If the repair failed or no fault could be found, return to Subsection 8.1 and replace the complete main-board assembly.

5. Suspect the temperature sensor. Enter the CCTM command *47* to check the temperature reading. Of the two numbers returned, the first should be in the range *380* to *420*, corresponding to a temperature of around 25°C. If it is, go to Task 5. If it is not (the value will be typically less than 200), go to Step 6.

6. If not already done, remove the PAF TOP can.

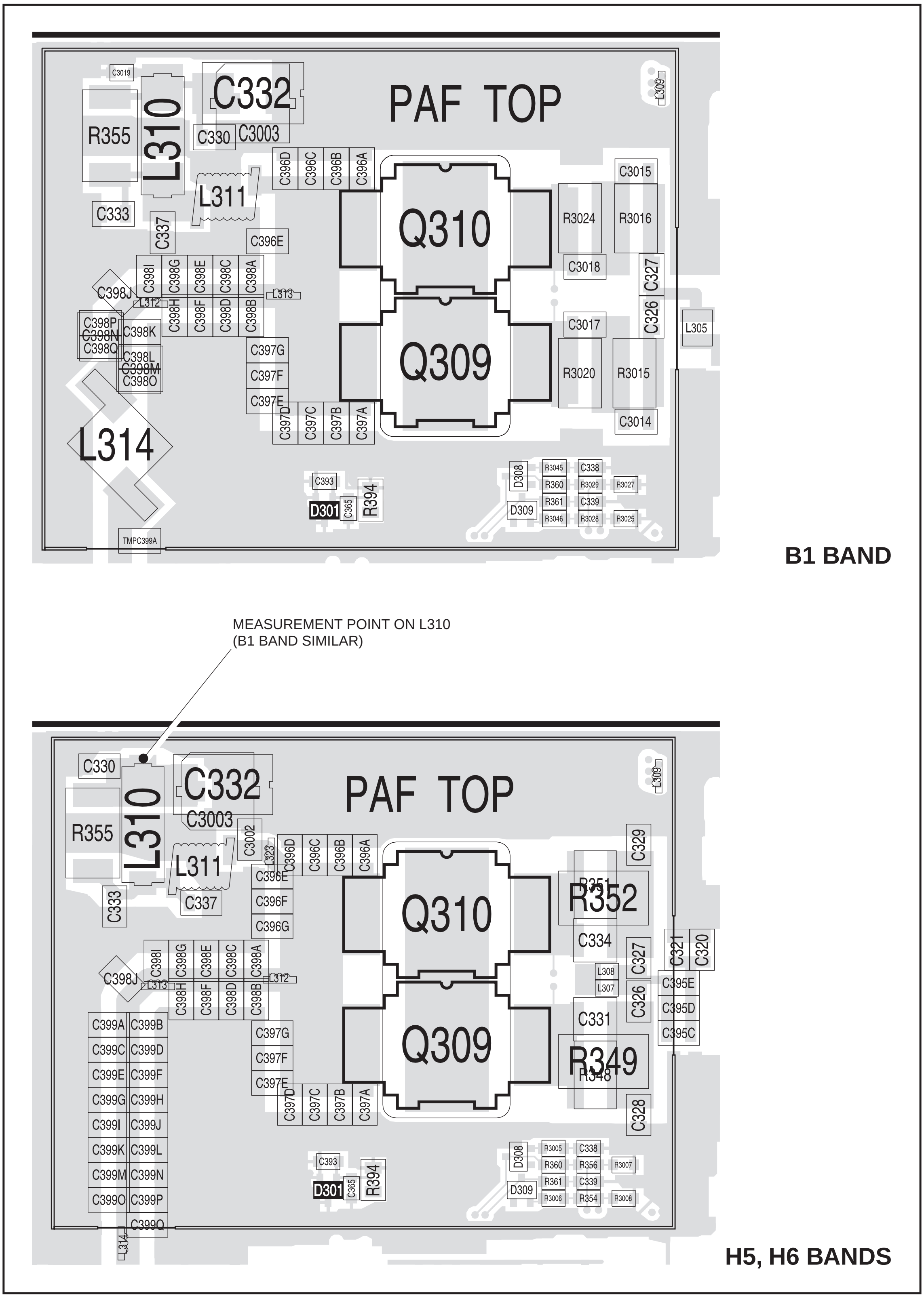
7. Check D301 and the surrounding components (see Figure 9.18 and Figure 9.19). If there is no fault, go to Subsection 9.7 on the CODEC and audio circuitry. If a fault is found, repair it, confirm the removal of the fault, and return to Subsection 8.1. If the repair failed, return to Subsection 8.1 and replace the complete main-board assembly.

Task 5 — 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 2 A.
2. Use the calibration application to determine the bias offset current for the first PA: Open the *"Final Gate Bias 1"* page, click the *"Set"* button and, under the *"Target Current"* label, note the offset current (in mA) in the *"High Power"* field.
3. Repeat Step 2 to find the offset current for the second PA on the *"Final Gate Bias 2"* page.
4. Also find the offset current for the PA driver: Open the *"Tx Driver Bias Limit"* page, click the *"Set"* button, and note the offset current (in mA) in the *"Target Current"* field.
5. 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 ***a*** returned.
6. 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 ***b*** returned.
7. Enter the CCTM command *304* to check the DAC value of the clamp current at the driver gate. Record the value ***c*** returned.
8. Enter the CCTM command *33* to place the radio in transmit mode.
9. Turn off all biases by entering the following CCTM commands in sequence:
   - 331 1
   - 332 1
   - 304 1
   - 114 1023
   - 334 0
   - 335 0
10. Note the current reading on the DC power supply. This will be about 300 mA.

Figure 9.18 PA circuitry under the PAF TOP can (B1, H5 and H6 bands)



Task 6 — Check Biasing of First PA

Check the biasing of the first PA (Q310).

1. Use a multimeter to measure the voltage at pin 14 of IC301 [at 3G1/3C6] (see Figure 9.17). The voltage will be 40 ± 5 mV. Enter the CCTM command ***331 a*** (where ***a*** was recorded in Task 5) and check that the voltage is between 2 and 5 V. Also note the current reading; this should increase by an amount equal to the offset noted in Step 2 of Task 5.

2. If the voltage and current are both correct, enter the CCTM command ***331 1*** to turn off final bias 1, and go to Task 7. If the voltage is correct but not the current, go to Step 3. If neither the current nor the voltage is correct, go to Step 5.

3. If not already done, remove the PAF TOP can. Enter the CCTM command ***331 a*** (where ***a*** was recorded in Task 5) and check that the voltage at the gate of Q310 [at 3F2/3D5] is between 2 and 5 V. If it is, Q310 is faulty; return to Subsection 8.1 and replace the complete main-board assembly. If it is not, go to Step 4.

4. Check the circuitry between pin 14 of IC301 and the gate of Q310 (see Figure 9.17 to Figure 9.21). If a fault is found, repair it, confirm the removal of the fault, and return to Subsection 8.1. If the repair failed or Q310 itself is faulty, return to Subsection 8.1 and replace the complete main-board assembly.

5. Use the multimeter to measure the voltage at the FIN1 test point [at 3J1/3C8] (see Figure 9.17). The voltage will be 18 ± 2 mV. Enter the CCTM command ***331 a*** (where ***a*** was recorded in Task 5) and check that the voltage is between 1.1 and 2.7 V. If it is, go to Step 6. If it is not, go to Subsection 9.7 on the CODEC and audio circuitry.

6. Check IC301 and the surrounding shaping-filter circuitry (see Figure 9.17). If a fault is found, repair it, confirm the removal of the fault, and return to Subsection 8.1. If the repair failed, return to Subsection 8.1 and replace the complete main-board assembly.

Figure 9.19 PA circuitry under the PAF TOP can (D1 band)

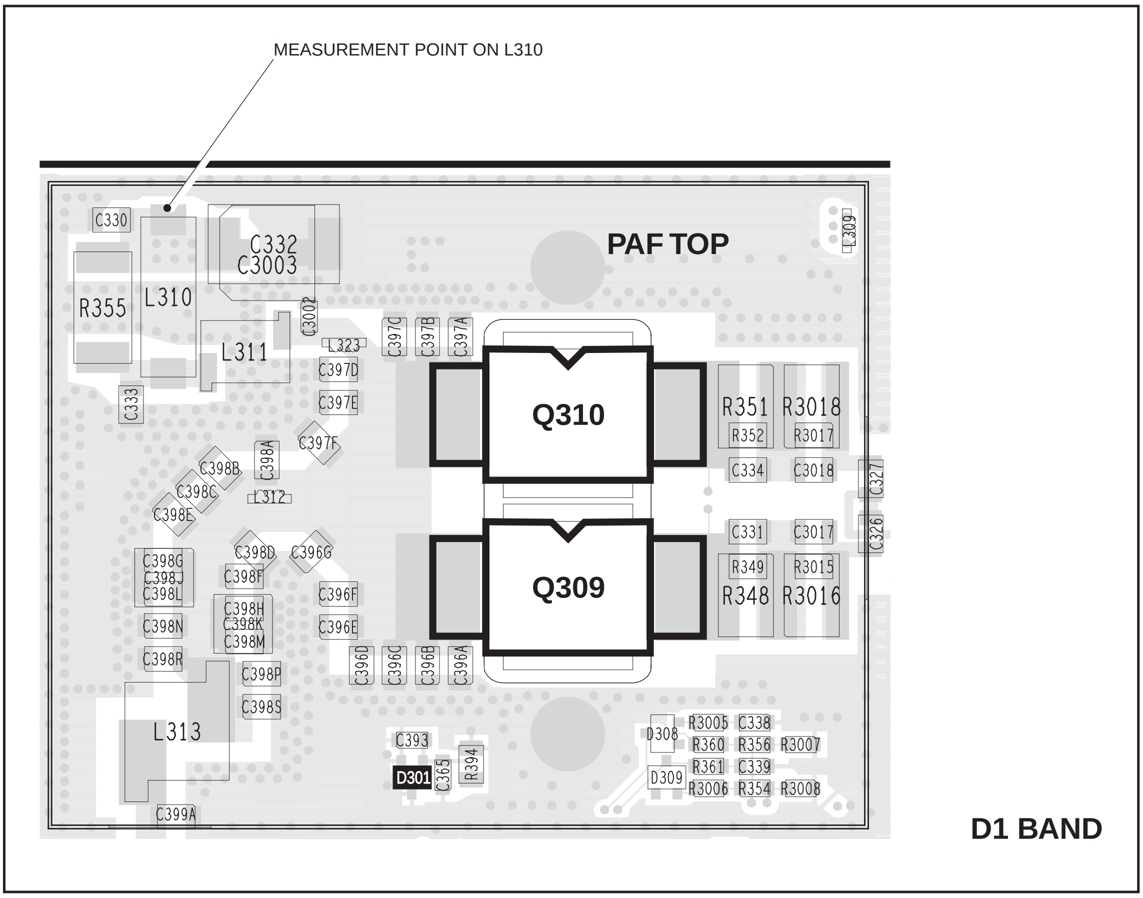


Figure 9.20 PA driver circuitry under the PAD TOP can (B1, H5 and H6 bands)

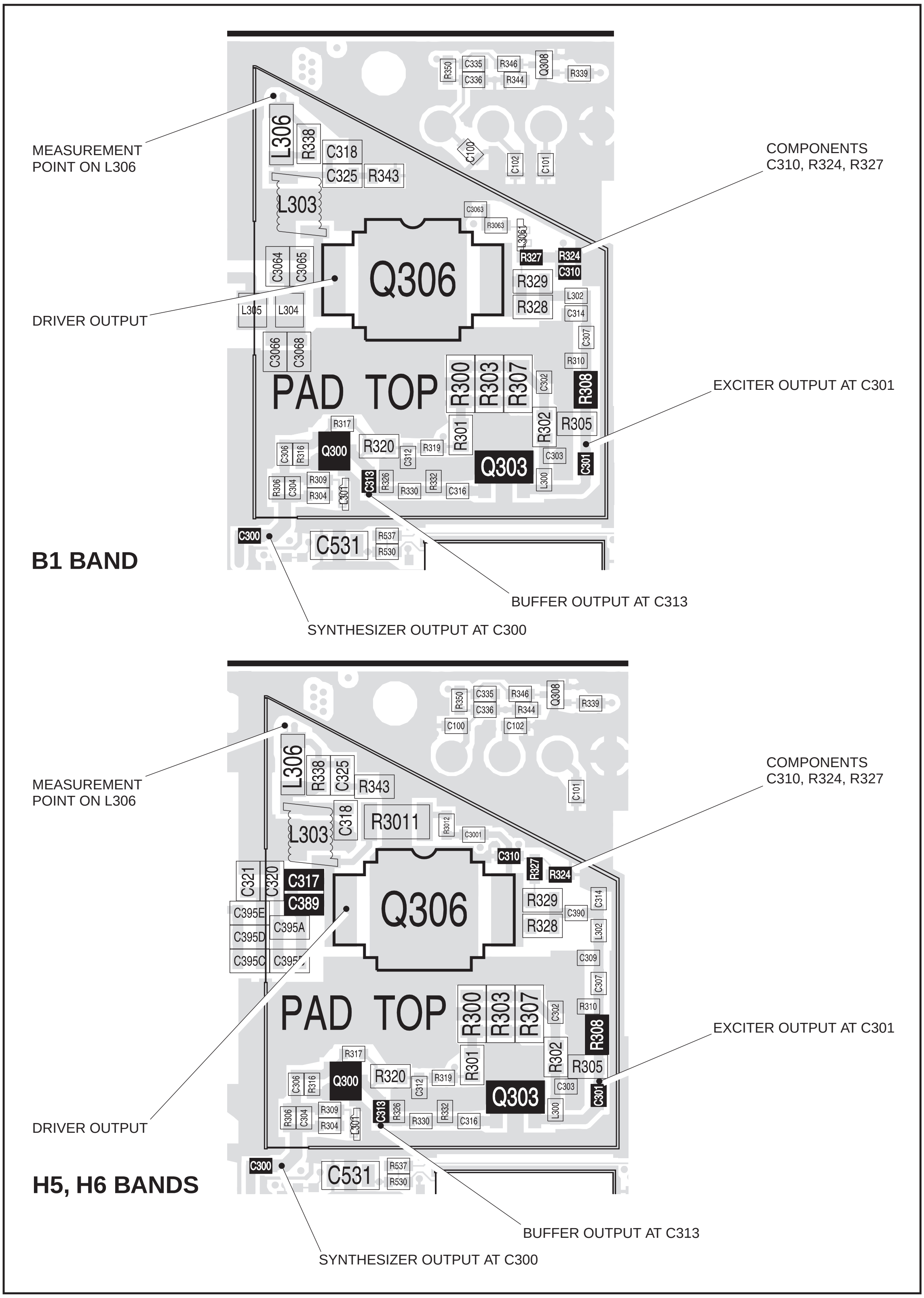
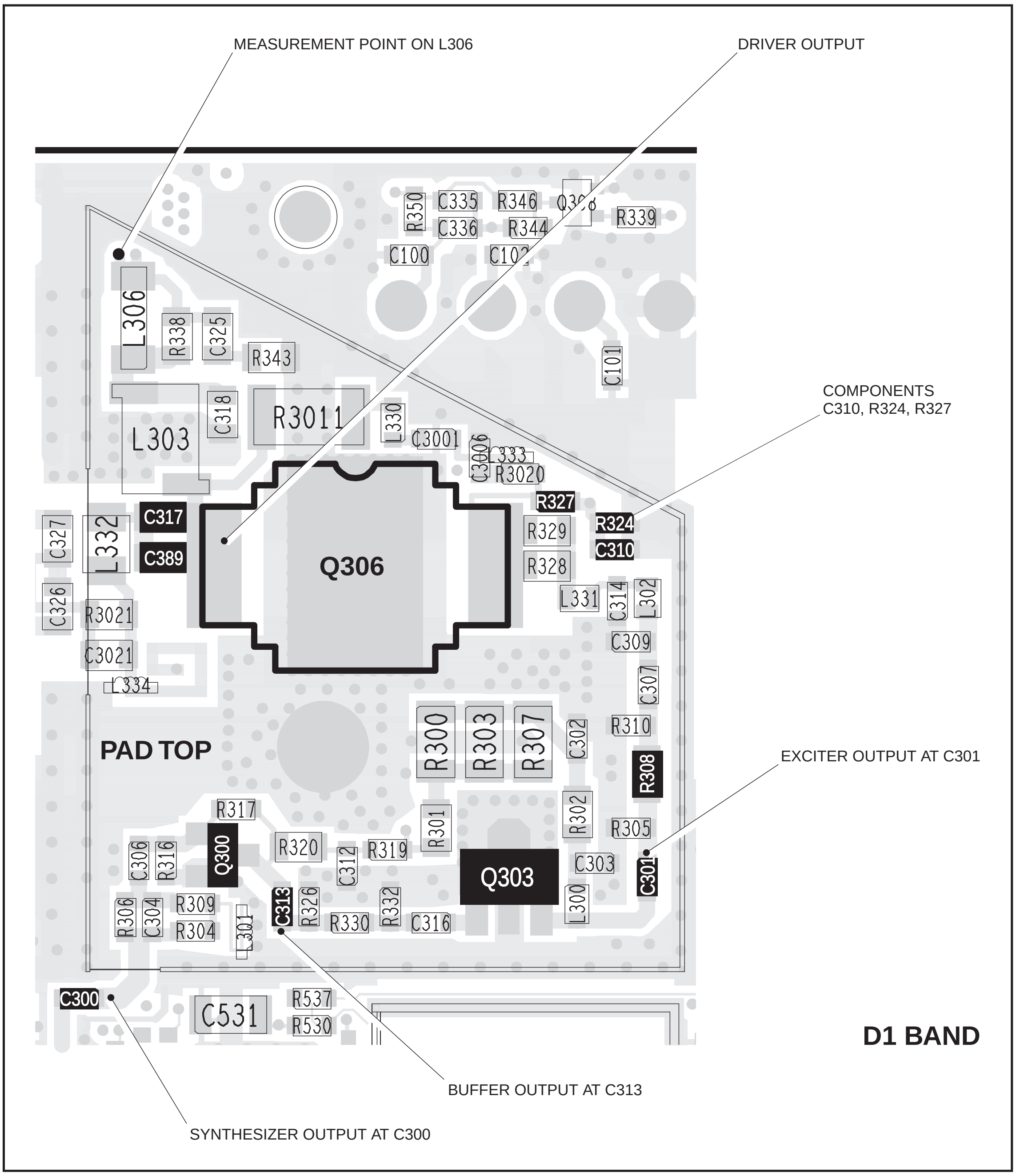


Figure 9.21 PA driver circuitry under the PAD TOP can (D1 band)



Task 7 — Check Biasing of Second PA

If there is no fault in the biasing of the first PA, check that of the second PA (Q309).

1. Use the multimeter to measure the voltage at pin 8 of IC301 [at 3G0/3B6] (see Figure 9.17). The voltage should be 40 ± 5 mV. Enter the CCTM command ***332 b*** (where ***b*** was recorded in Task 5) and check that the voltage is between 2 and 5 V. Also note the current reading; this should increase by an amount equal to the offset noted in Step 3 of Task 5.

2. If the voltage and current are both correct, enter the CCTM command *332 1* to turn off final bias 2, and go to Task 8. If the voltage is correct but not the current, go to Step 3. If neither the current nor the voltage is correct, go to Step 5.

3. If not already done, remove the PAF TOP can. Enter the CCTM command ***332 b*** (where ***b*** was recorded in Task 5) and check that the voltage at the gate of Q309 [at 3F3/3E5] is between 2 and 5 V. If it is, Q309 is faulty; return to Subsection 8.1 and replace the complete main-board assembly. If it is not, go to Step 4.

4. Check the circuitry between pin 8 of IC301 and the gate of Q309 (see Figure 9.17 to Figure 9.21). If a fault is found, repair it, confirm the removal of the fault, and return to Subsection 8.1. If the repair failed or Q309 itself is faulty, return to Subsection 8.1 and replace the complete main-board assembly.

5. Use the multimeter to measure the voltage at the FIN2 test point [at 3K0/3B9] (see Figure 9.17). The voltage will be 18 ± 2 mV. Enter the CCTM command ***332 b*** (where ***b*** was recorded in Task 5) and check that the voltage is between 1.1 and 2.7 V. If it is, go to Step 6. If it is not, go to Subsection 9.7 on the CODEC and audio circuitry.

6. Check IC301 and the surrounding shaping-filter circuitry (see Figure 9.17). If a fault is found, repair it, confirm the removal of the fault, and return to Subsection 8.1. If the repair failed, return to Subsection 8.1 and replace the complete main-board assembly.

Figure 9.22 Test points and components of the power-control circuitry

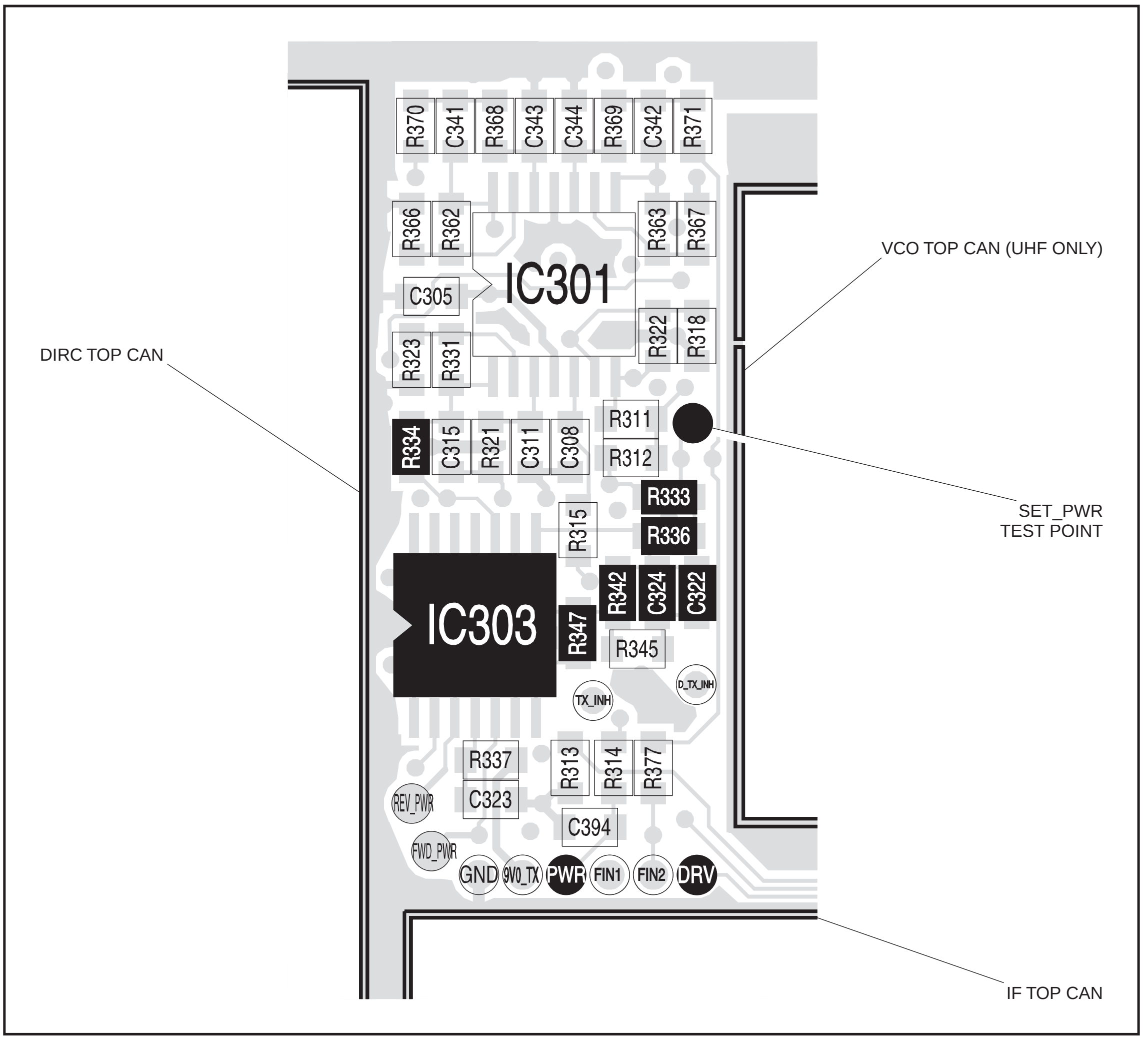


Table 9.7 Voltages at IC303 at maximum power (40 W)

Frequency band	Frequency (MHz)	Voltage (V)	
		Pin 9	Pin 5 (FWD PWR)
B1	136 155 174	2.2 ± 0.1 2.3 ± 0.1 2.5 ± 0.1	1.9 ± 0.1 2.1 ± 0.1 2.3 ± 0.1
D1	216 241 266	2.2 ± 0.1 2.2 ± 0.1 2.3 ± 0.1	4.3 ± 0.1 4.3 ± 0.1 4.7 ± 0.1
H5	400 435 470	3.4 ± 0.1 3.8 ± 0.1 4.0 ± 0.1	3.3 ± 0.1 3.7 ± 0.1 3.9 ± 0.1
H6	450 490 530	3.9 ± 0.1 4.2 ± 0.1 4.7 ± 0.1	3.8 ± 0.1 4.1 ± 0.1 4.6 ± 0.1

Task 8 — Check Biasing of PA Driver

If there is no fault in the biasing of the PAs, check that of the PA driver (Q306).

1. Note the current reading on the DC power supply. Enter the CCTM command *304* ***c*** (where ***c*** was recorded in Task 5) to turn on the clamp current; do not specify a value higher than ***c***. Compare the current reading with that noted in Task 5. If the current is correct, go to Step 5. If it is not, go to Step 2.

2. Check that the voltage from the DAC is changing by measuring the voltage at the DRV test point [at 3A7/3H1] (CDC TX DRV BIAS) (see Figure 9.22). Enter the CCTM command *304 1* to turn off the bias. The voltage should be 0.0 V. Enter the CCTM command *304* ***c*** (where ***c*** was recorded in Task 5) to change the DAC value of the clamp current; do not specify a value higher than ***c***. The voltage should increase to between 0.8 and 2.5 V. If it does, go to Step 3. If it does not, go to Subsection 9.7 on the CODEC and audio circuitry.

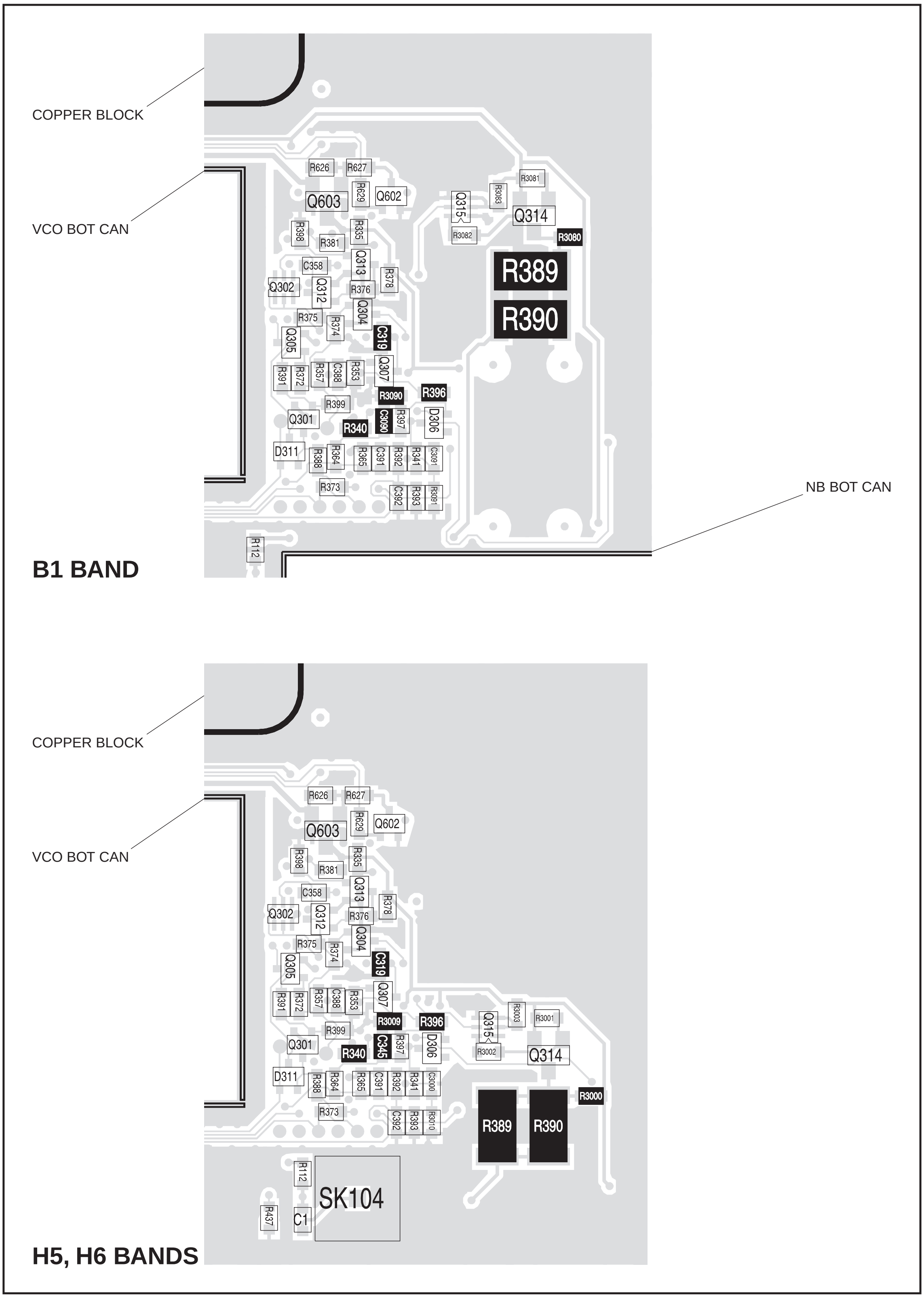
3. Check that the voltage at the SET PWR test point [at 3B5/3G2] (see Figure 9.22) is between 2 and 5 V. If it is, go to Step 4. If it is not, go to Step 5.

4. Remove the PAD TOP can. Check that the voltage on the gate of Q306 [at 3C3/3E3] is between 2 and 5 V. If it is, replace Q306; confirm the removal of the fault and return to Subsection 8.1. If it is not, go to Step 6 of Task 9.

5. Check that the power control is functional: Enter the CCTM command *304* ***c*** (where ***c*** was recorded in Task 5). Note the current reading on the DC power supply. Enter the CCTM command *114 0* to switch off the power. Compare the current reading with that noted in Step 1. If the currents in both cases are correct, go to Task 10. If they are not, go to Step 6.

6. Check that the voltage from the DAC is changing: Measure the voltage at the PWR test point [at 3A9/3K1] (CDC TX PWR CTL) (see Figure 9.22). Enter the CCTM command *114 1023*. The voltage should increase to 2.4 ± 0.1 V. If it does, go to Task 9. If it does not, go to Subsection 9.7 on the CODEC and audio circuitry.

Figure 9.23 Components of concern on the bottom-side of the main board (B1, H5 and H6 bands)



Task 9 — Repair Circuitry

Following the checks in Task 8, locate and repair the fault in the circuitry as follows:

1. Cycle the power. 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. Measure the voltage at pin 9 of IC303 [at 3E7/3H4] in the power-control circuit (see Figure 9.22). The voltage should be as given in Table 9.7. If it is, go to Step 3. If it is not, go to Step 2.

2. Check the voltage at pin 5 of IC303 [at 3J7/3H8] (or use the FWD PWR test point). The voltage should be as given in Table 9.7. If it is, check the components between pins 6 and 7 of IC303 (see Figure 9.23 and Figure 9.24) [R340, C3090, R3090 (B1 band) or R340, C345, R3009 (D1, H5, H6)]. If it is not, check the components of the directional coupler (see Figure 9.27). In either case repair any fault. Replace IC303 if necessary. Confirm the removal of the fault and return to Subsection 8.1. If the repair failed, return to Subsection 8.1 and replace the complete main-board assembly.

3. Measure the voltage at pin 8 of IC303 [at 3D7/3H4] in the power-control circuit. The voltage should be 7.4 ± 0.5 V. If it is not, go to Step 5. If it is, measure the voltage at pin 10 of IC303. The voltage should be 4.8 ± 0.5 V. If it is, go to Step 4. If it is not, go to Step 5.

4. Check C322, C324, R342, R347 (see Figure 9.22) and R396 (see Figure 9.23 and Figure 9.24) in the power-control circuit. Repair any fault. If these components are not faulty, replace IC303. Confirm the removal of the fault and return to Subsection 8.1. If the repair failed, return to Subsection 8.1 and replace the complete main-board assembly.

5. Measure the voltage at pin 1 of IC301 [at 3C8/3J3] in the power-control circuit. The voltage should be 4.8 ± 0.5 V. If it is, check the components R334 (see Figure 9.22) and C319 (see Figure 9.23 and Figure 9.24) [at 3D8/3J4]. If it is not, check the components between the PWR test point [at 3A9/3K1] and pin 1 of IC301 (see Figure 9.22). Repair any fault. Replace IC301 if necessary. Confirm the removal of the fault and return to Subsection 8.1. If the repair failed, return to Subsection 8.1 and replace the complete main-board assembly.

6. Check for short circuits at the gate of the PA driver Q306 [at 3C3/3E3]. Check R333, R336 [at 3D7/3H3] (see Figure 9.22), C310, R324 and R327 [at 3C4/3F2] (see Figure 9.20 and Figure 9.21) between the power-control circuit and Q306. Repair any fault. If these components are not faulty, replace Q306. Confirm the removal of the fault and return to Subsection 8.1. If the repair failed, return to Subsection 8.1 and replace the complete main-board assembly.

Figure 9.24 Components of concern on the bottom-side of the main board (D1 band)

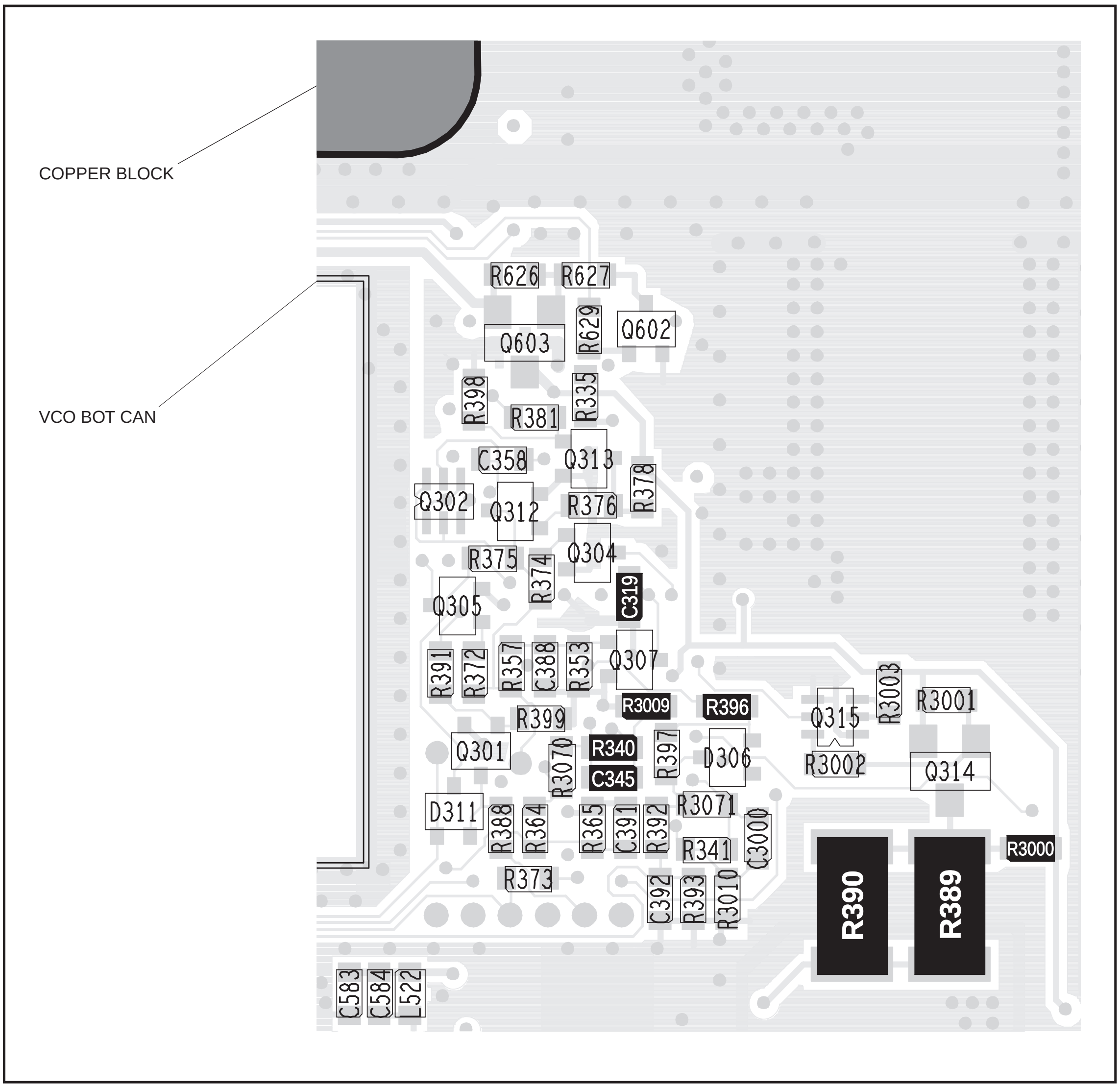


Figure 9.25 Components of the interstage matching circuitry between the PA driver Q306 and the PAs Q309 and Q310 (B1, H5 and H6 bands)

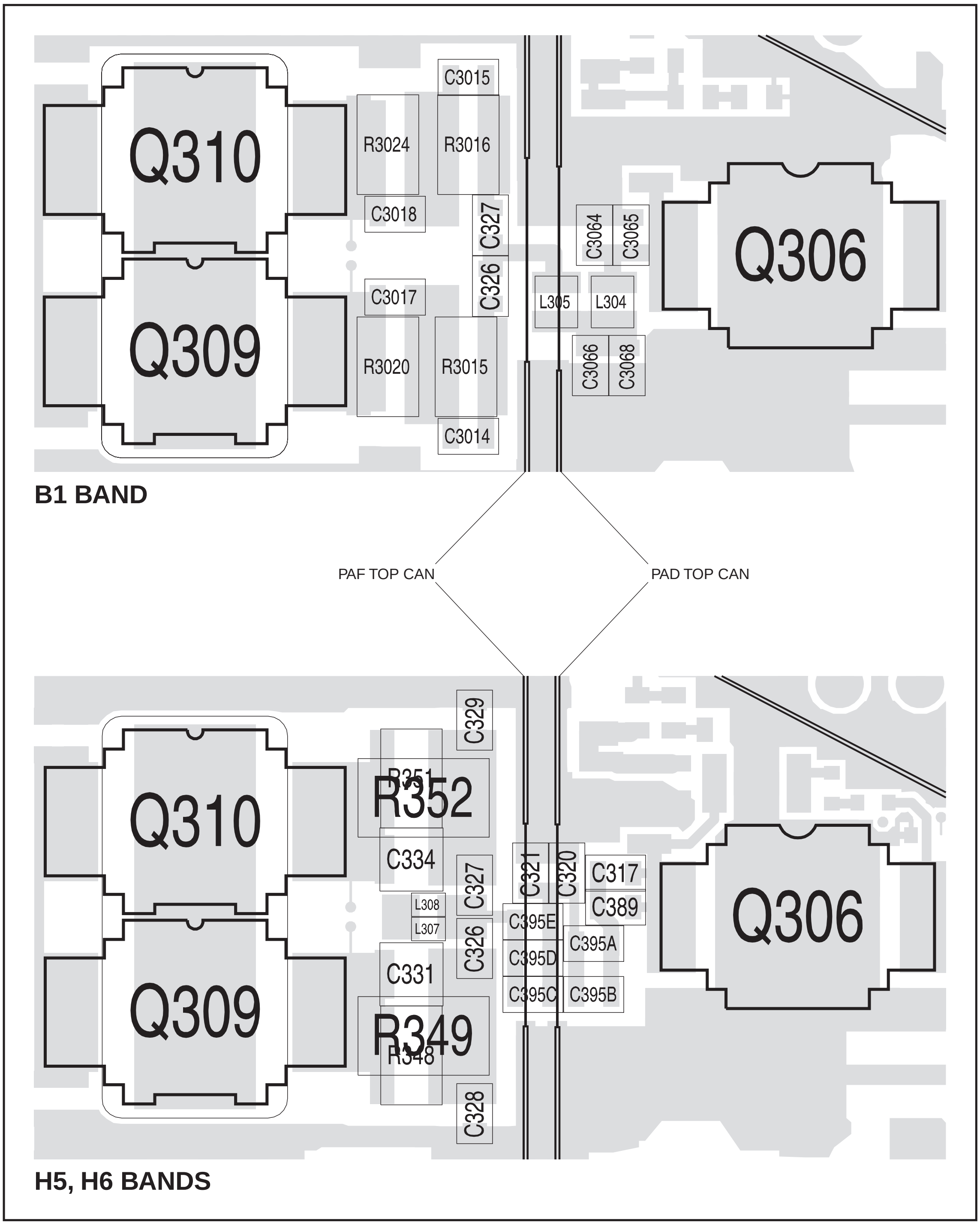


Figure 9.26 Components of the interstage matching circuitry between the PA driver Q306 and the PAs Q309 and Q310 (D1 band)

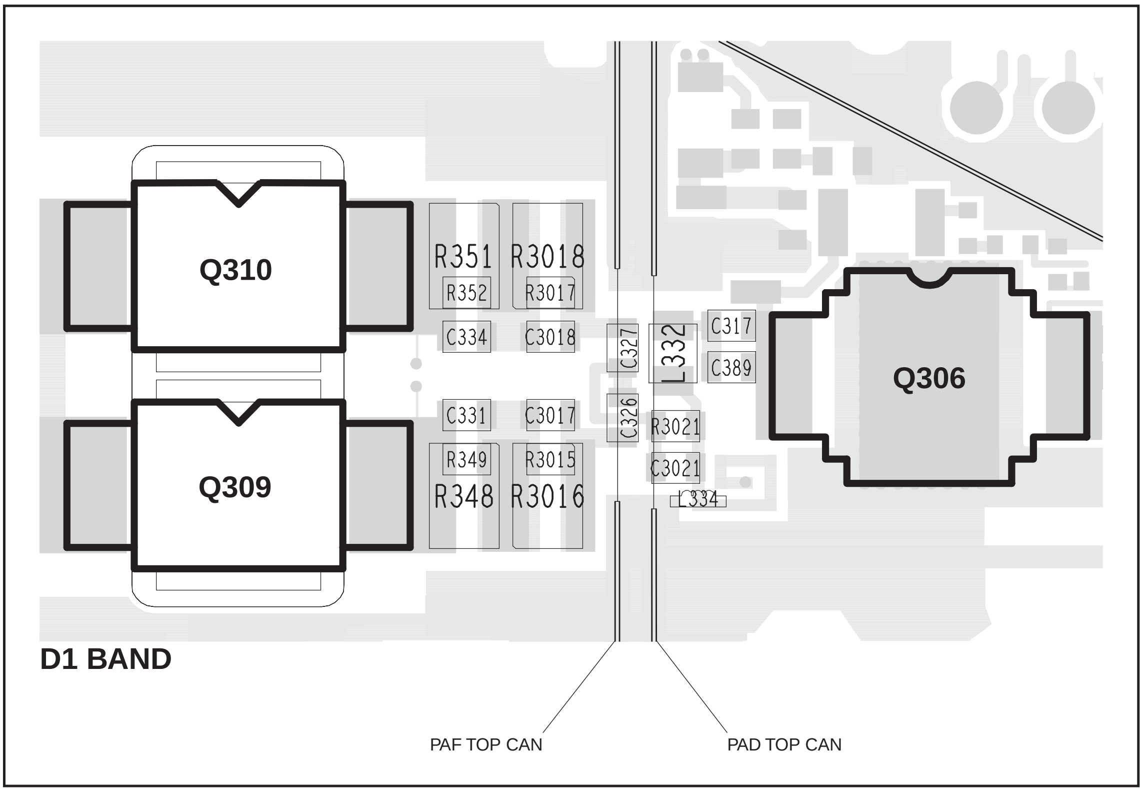


Table 9.8 RF voltages along the initial RF signal path of the VHF radio (B1 band)

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 9.9 RF voltages along the initial RF signal path of the VHF radio (D1 band)

Power level (W)	Frequency (MHz)	RF voltages (V)			
		Synthesizer output	Buffer output	Exciter output	Driver output
1	216 241 266	0.3 ± 0.1 0.4 ± 0.1 0.3 ± 0.1	0.3 ± 0.1 0.3 ± 0.1 0.3 ± 0.1	3.8 ± 0.5 3.7 ± 0.5 3.5 ± 0.5	1.3 ± 0.5 1.0 ± 0.4 2.3 ± 0.9
5	216 241 266	0.3 ± 0.1 0.3 ± 0.1 0.3 ± 0.1	0.3 ± 0.1 0.3 ± 0.1 0.3 ± 0.1	3.3 ± 0.5 3.2 ± 0.5 3.6 ± 0.5	3 ± 1 3 ± 1 6 ± 2
12	216 241 266	0.4 ± 0.1 0.3 ± 0.1 0.3 ± 0.1	0.2 ± 0.1 0.3 ± 0.1 0.3 ± 0.1	3.3 ± 0.5 3.6 ± 0.5 3.2 ± 0.5	4 ± 2 4 ± 2 9 ± 4
26	216 241 266	0.3 ± 0.1 0.3 ± 0.1 0.3 ± 0.1	0.3 ± 0.1 0.3 ± 0.1 0.3 ± 0.1	3.8 ± 0.5 3.5 ± 0.5 3.4 ± 0.5	4 ± 2 5 ± 2 12 ± 5
40	216 241 266	0.3 ± 0.1 0.3 ± 0.1 0.3 ± 0.1	0.3 ± 0.1 0.3 ± 0.1 0.2 ± 0.1	3.3 ± 0.5 3.3 ± 0.5 3.6 ± 0.5	12 ± 5 9 ± 4 20 ± 8

Table 9.10 RF voltages along the initial RF signal path of the UHF radio (H5 and H6 bands)

Power level (W)	Frequency (MHz)	RF voltages (V)			
		Synthesizer output	Buffer output	Exciter output	Driver output
1	450 490 530	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	450 490 530	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	450 490 530	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	450 490 530	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	450 490 530	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 10 — Trace Initial RF Signal Path

If the biasing of the PA driver and the PAs is correct, investigate the initial RF signal path in the transmitter circuitry.

1. Use an RF probe to measure the RF voltage after C300 [at 3A1/3C1] (see Figure 9.20 and Figure 9.21). This is the output SYN TX LO from the frequency synthesizer. The required voltage should be as given in Table 9.8 (B1 band), Table 9.9 (D1) or Table 9.10 (H5, H6). If it is, go to Step 3. If it is not, go to Step 2.

2. Check C300. If C300 is not faulty, go to Subsection 9.3 on the frequency synthesizer. If C300 is faulty, replace it and return to Step 1.

3. If not already done, remove the PAD TOP can. Measure the RF voltage after C313 [at 3B0/3B2] (see Figure 9.20 and Figure 9.21). This is the output of the buffer amplifier in the exciter circuit. The required voltage should be as given Table 9.8 (B1 band), Table 9.9 (D1) or Table 9.10 (H5, H6). If it is, go to Step 5. If it is not, go to Step 4.

4. Check the components around Q300 [at 3B0/3B2] (see Figure 9.20 and Figure 9.21). Repair any fault. If these components are not faulty, replace Q300. Confirm the removal of the fault and return to Subsection 8.1. If the repair failed, return to Subsection 8.1 and replace the complete main-board assembly.

5. Measure the RF voltage after C301 [at 3A3/3E1] (see Figure 9.20 and Figure 9.21). This is the output of the exciter. The required voltage should be as given in Table 9.8 (B1 band), Table 9.9 (D1) or Table 9.10 (H5, H6). If it is, go to Step 7. If it is not, go to Step 6.

6. Check the components between C313 and Q303 [at 3D0/3B3], and between Q303 and R308 [3A3/3E1] (see Figure 9.20 and Figure 9.21). Repair any fault. If these components are not faulty, replace Q303. Confirm the removal of the fault and return to Subsection 8.1. If the repair failed, return to Subsection 8.1 and replace the complete main-board assembly.

7. Measure the RF voltage at the drain of Q306 (B1 band) [at 3E3] or after C317 and C389 (D1, H5, H6) [at 3D3/3E3] (see Figure 9.20 and Figure 9.21). This is the output of the PA driver. The required voltage should be as given in Table 9.8 (B1 band), Table 9.9 (D1) or Table 9.10 (H5, H6). If it is, go to Step 9. If it is not, go to Step 8.

8. Check the components between C301 [at 3A3/3E1] and Q306 (see Figure 9.20 and Figure 9.21). Repair any fault. If these components are not faulty, replace Q306. Confirm the removal of the fault and return to Subsection 8.1. If the repair failed, return to Subsection 8.1 and replace the complete main-board assembly.

9. Measure the RF voltage at the gates of the PAs Q309 [at 3F3/3E5] and Q310 [at 3F2/3D5] (see Figure 9.18 and Figure 9.19). If an RF voltage is present, go to Task 11. If there is no RF voltage, check the components of the interstage matching circuitry between the PA driver Q306 and the gates of the PAs (see Figure 9.25 and Figure 9.26). If a fault is found, repair it, confirm the removal of the fault, and return to Subsection 8.1. If the repair failed or the fault could not be found, return to Subsection 8.1 and replace the complete main-board assembly.

Task 11 — Check Power at Directional Coupler

If, as determined in Task 10, there is no fault in the initial RF signal path, investigate the remainder of the circuitry: the directional coupler, PIN switch, and LPF. Check the directional coupler as follows:

1. Remove the DIRC TOP can.
2. Remove the coupling capacitors C348, C349, C350 [at 3K3/3E9] (see Figure 9.27 and Figure 9.28).
3. Solder one terminal of an 82 pF (B1 band) or 680 pF (D1, H5, H6) test capacitor to the PCB at the point shown in Figure 9.27 and Figure 9.28. Mount the capacitor vertically. Use a test capacitor of the type GRM111, DLI C17, Murata 1210, or the equivalent.
4. Solder a 50 Ω test lead to the PCB. Solder the outer sheath to the test pad shown in Figure 9.27 and Figure 9.28, and solder the central wire to the other terminal of the test capacitor.
5. Connect the test lead to the test set and measure the RF output power. This should exceed 35 W. If it does, remove the test lead and test capacitor, resolder the coupling capacitors in position, and go to Task 12. If it does not, go to Step 7.
6. Check for an open circuit between the test capacitor and the common drain of Q309 [at 3F3/3E5] and Q310 [at 3F2/3D5] (see Figure 9.18 and Figure 9.19 as well as Figure 9.27 and Figure 9.28). Also check for faulty, shorted or misplaced components in this part of the circuit. Repair any fault.
7. Again measure the RF output power. If it is correct, the fault has been rectified; if it is not, the repair failed. Remove the test lead and test capacitor, resolder the coupling capacitors in position, and return to Subsection 8.1. If the repair had failed, replace the complete main-board assembly.

Figure 9.27 Circuitry under the DIRC TOP can, the measurement point on L315, and the points for attaching the test lead and test capacitor (B1, H5 and H6 bands)

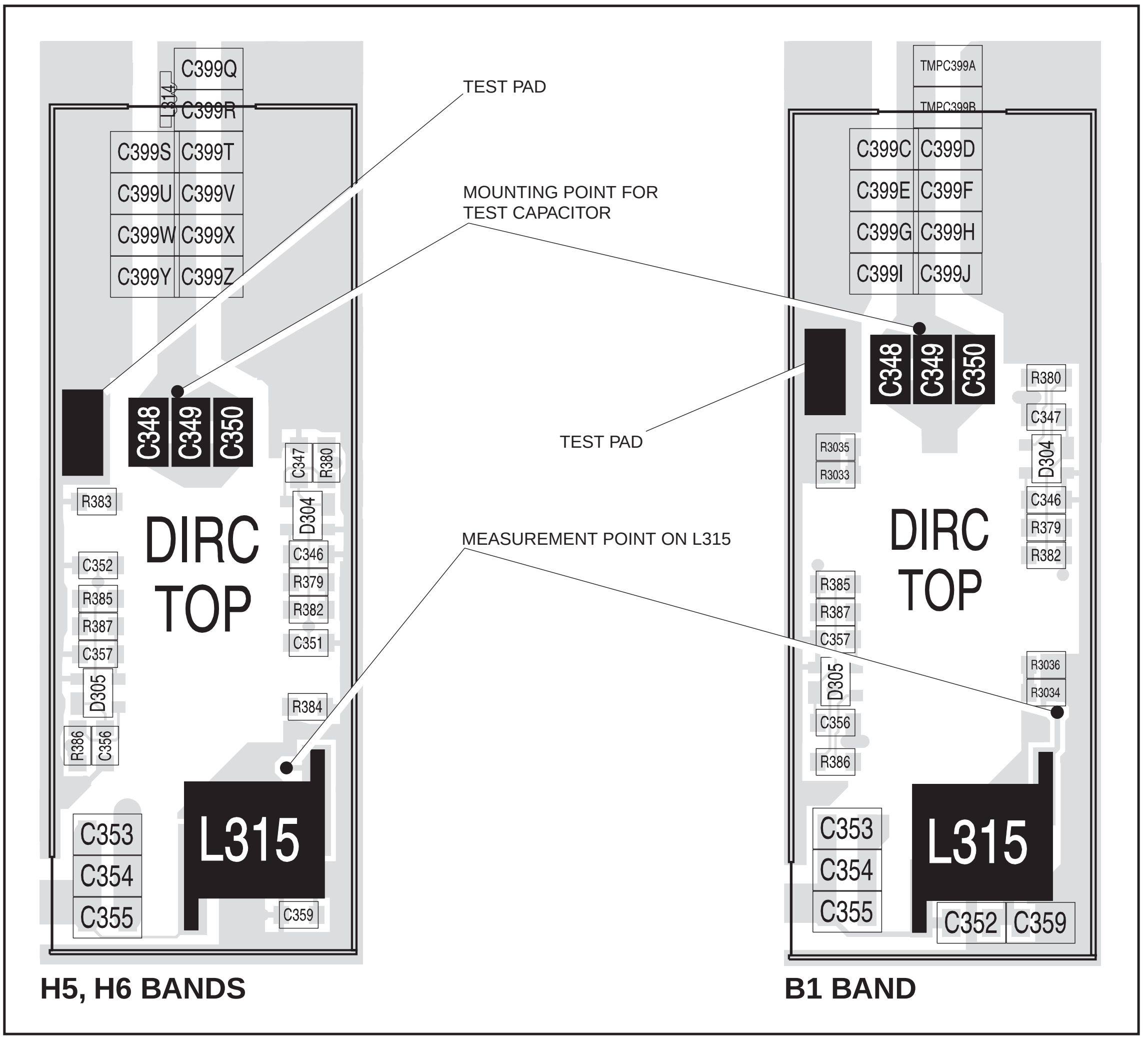


Figure 9.28 Circuitry under the DIRC TOP can, the measurement point on L315, and the points for attaching the test lead and test capacitor (D1 band)

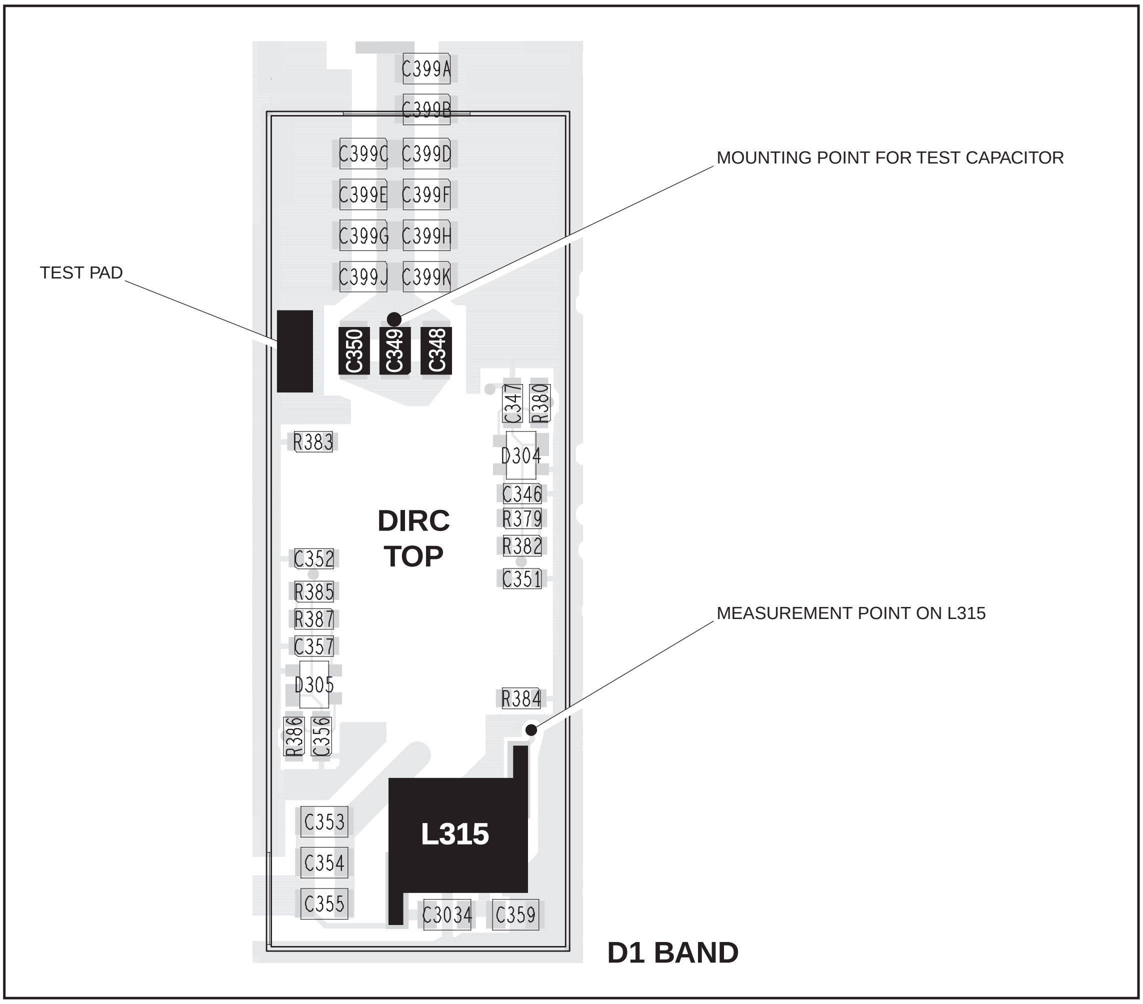
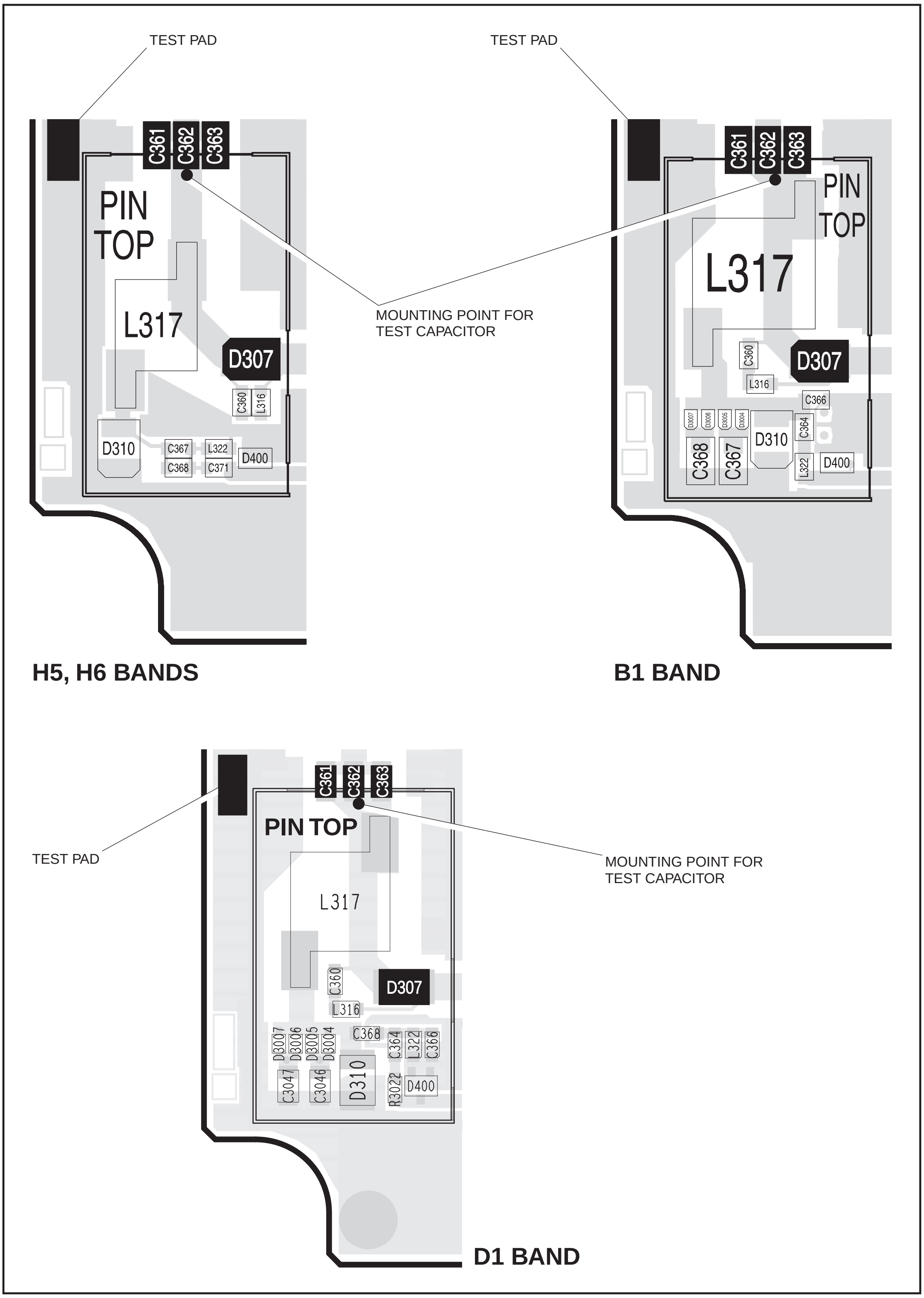


Figure 9.29 Circuitry under the PIN TOP can, and points for attaching the test lead and test capacitor



Task 12 — Check PIN Switch

If there is no fault in the directional coupler, check the PIN switch as follows:

1. Remove the PIN TOP can.

2. Remove the three blocking capacitors C361, C362 and C363 [at 3N3/3E11] (see Figure 9.29).

3. Solder one terminal of a 33 pF (D1 band) or 22 pF (B1, H5, H6) test capacitor to the PCB at the point shown in Figure 9.29. Mount the capacitor vertically. Use a test capacitor of the type GRM111, DLI C17, Murata 1210, or the equivalent.

4. Solder a 50 Ω test lead to the PCB. Solder the outer sheath to the test pad shown in Figure 9.29, and solder the central wire to the other terminal of the test capacitor.

5. Connect the test lead to the test set and measure the RF output power. This should exceed 35 W. If it does, remove the test lead and test capacitor, resolder the blocking capacitors in position, and go to Task 13. If it does not, go to Step 6.

6. The PIN switch is not drawing the expected current. Check D307 [at 3M3/3E10] (see Figure 9.29). If it is not faulty, go to Step 7. If D307 is faulty, replace it, confirm the removal of the fault, and return to Subsection 8.1. If the repair failed, return to Subsection 8.1 and replace the complete main-board assembly.

7. Check the +9V0_TX supply to the PIN switch via R3000 [at 3M5/3J10], and R389 and R390 [at 3M5/3F10] on the bottom-side of the PCB (see Figure 9.23 and Figure 9.24). Replace any faulty component and again measure the RF output power. If it is correct, the fault has been rectified; if it is not, the repair failed. Remove the test lead and test capacitor, resolder the blocking capacitors in position, and return to Subsection 8.1. If the repair had failed, replace the complete main-board assembly.

Task 13 — Check Components of LPF

If there is no fault in the directional coupler or PIN switch, 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. Check for shorts, open circuits, and faulty components.

4. Repair any fault and measure the RF output power. This should exceed 35 W. If it does, the fault has been rectified; return to Subsection 8.1. If it does not, the repair failed; return to Subsection 8.1 and replace the complete main-board assembly.

Task 14 — Transmitter Power Is Incorrect

If the check of the transmitter power in Task 3 shows that the power is wrong or too low, proceed as follows:

1. If not already done, enter the CCTM command *326 5*.
2. Use the CCTM command *101* to program the radio with the highest frequency of the frequency band. The format is *101* ***a a*** *0*, where ***a*** is the frequency in hertz. Enter the command *33*. Record the RF output power measured by the test set and the supply current measured by the DC power supply. Enter the command *32*.
3. Use the command *101* to program the radio with the middle frequency of the frequency band. Enter the command *33*. Measure and record the RF output power and the supply current. Enter the command *32*.
4. Use the command *101* to program the radio with the lowest frequency of the frequency band. Enter the command *33*. Measure and record the RF output power and the supply current. Enter the command *32*.
5. The RF output power should exceed 32 W and the supply current should be less than 5.2 A (VHF) or 6.0 A (UHF). If the power and current are skewed (low at one part of the frequency band and high elsewhere), go to Task 15. If the power and current are low at all three frequencies, go to Task 16.

Task 15 — 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, C350 [at 3K3/3E9] (see Figure 9.27 and Figure 9.28).
3. Solder one terminal of an 82 pF (B1 band) or 680 pF (D1, H5, H6) test capacitor to the PCB at the point shown in Figure 9.27 and Figure 9.28. Mount the capacitor vertically. Use a test capacitor of the type GRM111, DLI C17, Murata 1210, or the equivalent.
4. Solder a 50 Ω test lead to the PCB. Solder the outer sheath to the test pad shown in Figure 9.27 and Figure 9.28, and solder the central wire to the other terminal of the test capacitor.
5. Connect the test lead to the test set and repeat Steps 1 to 4 of Task 13.
6. If the power and current are still skewed, go to Step 7. If the power and current are correct, remove the test lead and test capacitor, resolder the coupling capacitors in position, and go to Task 12.

7. If not already done, remove the PAF TOP can. Check for an open circuit between the test capacitor and the common drain of Q309 [at 3F3/3E5] and Q310 [at 3F2/3D5] (see Figure 9.18 and Figure 9.19 as well as Figure 9.27 and Figure 9.28). Also check for faulty, shorted or misplaced components in this part of the circuit. Repair any fault.

8. Repeat Steps 1 to 4 of Task 14. Remove the test lead and test capacitor, and resolder the coupling capacitors in position. If the power and current are now correct at all three frequencies, the fault has been rectified; return to Subsection 8.1. If they are not, go to Task 10.

Task 16 — 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 ***a*** returned.

2. Note the current reading on the DC power supply. Enter the CCTM command *331 1* to turn off final bias 1.

3. Enter the CCTM command *33* to place the radio in transmit mode. Note the RF output power measured at the test set. This should be as shown in Table 9.10. If it is, go to Step 4 to repeat the check with the second PA. If it is not, carry out Task 5 and then Task 6.

4. 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 ***b*** returned.

5. Note the current reading on the DC power supply. Enter the CCTM command *332 1* to turn off final bias 2.

6. With the radio still in transmit mode, note the RF output power measured at the test set. This should be as shown in Table 9.10. If it is, go to Task 10. If it is not, carry out Task 5 and then Task 7.

Table 9.11 RF output power of individual RF power amplifiers at different frequencies

Frequency band	Frequency within band		
	Lowest frequency	Centre frequency	Highest frequency
B1	29 ± 5 W	34 ± 5 W	29 ± 5 W
D1	33 ± 5 W	28 ± 5 W	29 ± 5 W
H5	5 ± 5 W	12 ± 5 W	27 ± 5 W
H6	13 ± 5 W	19 ± 5 W	28 ± 5 W

9.7 CODEC and Audio Circuitry

Fault Conditions

This subsection covers the diagnosis of faults in the CODEC and audio circuitry. There are four conditions that indicate a possible fault in the circuitry:

- no speaker audio or speaker audio is distorted
- receiver does not operate
- no transmit modulation or modulation is distorted
- no receive audio at auxiliary connector
- no transmit modulation despite modulation at auxiliary connector

In the first case regarding the speaker audio, the green STATUS LED will be operating correctly and all unmute criteria will be satisfied. In the third case regarding the transmit modulation, the radio will be transmitting the correct amount of RF power. In the fourth case the receiver will be operating normally and in the fifth case the transmitter will be.

Fault-diagnosis Procedures

The procedures for diagnosing the above faults are given below in Tasks 2 to 6 respectively. In each case, however, first carry out Task 1. Also note that the fourth and fifth conditions mentioned above can both occur at the same time. In this case carry out both Task 5 and Task 6.

Task 1 — Check Power Supply

Before searching for faults in the CODEC and audio circuitry, first check the 2.5 V DC supply. The procedure is given in Task 3 of Subsection 9.1 on the power-supply circuitry.

Task 2 — Faulty Speaker Audio

If the green STATUS LED is operating correctly and all unmute criteria are satisfied, but there is either no speaker audio or the speaker audio is distorted, proceed as follows:

1. In user mode apply an on-channel RF signal of −47 dBm with 60%, 1 kHz deviation. (Use the programming application to find the frequency selected for channel 1.) The channel must not have signalling enabled. Set the volume to maximum. Use an oscilloscope probe to check the output of the voice-band CODEC at the TP200 test point [at 2D2/2D4] (see Figure 9.30). The signal should be a sine wave of 100 mV_{pp} with an offset of 0.6 V DC. If it is, go to Step 2. If it is not, go to Step 9.

2. Vary the volume control. This should cause the signal level at the TP200 test point to vary. If it does, go to Step 3. If it does not, go to Step 7.

3. Check that the voltage at pin 11 of IC202 [at 2D2/2D4] (see Figure 9.30) is at least 8 V DC. If it is, go to Step 4. If it is not, check for and repair any faults in the level-translation circuits incorporating Q200 [at 2D1/2D2] and Q201 [at 2D2/2D3] (see Figure 9.30). Confirm the removal of the fault and return to Subsection 8.1. If the repair failed, return to Subsection 8.1 and replace the complete main-board assembly.

4. Check that the digital signal DIG AUD PA EN1 at R200 [at 2B2/2D2] is 3.3 V DC, and that the digital signal DIG AUD PA EN2 at R202 [at 2C1/2C2] is 0.0 V DC (see Figure 9.30). If they are, go to Step 5. If they are not, check the programming and test set-up; otherwise the digital board is faulty; return to Subsection 8.1 and replace the complete main-board assembly.

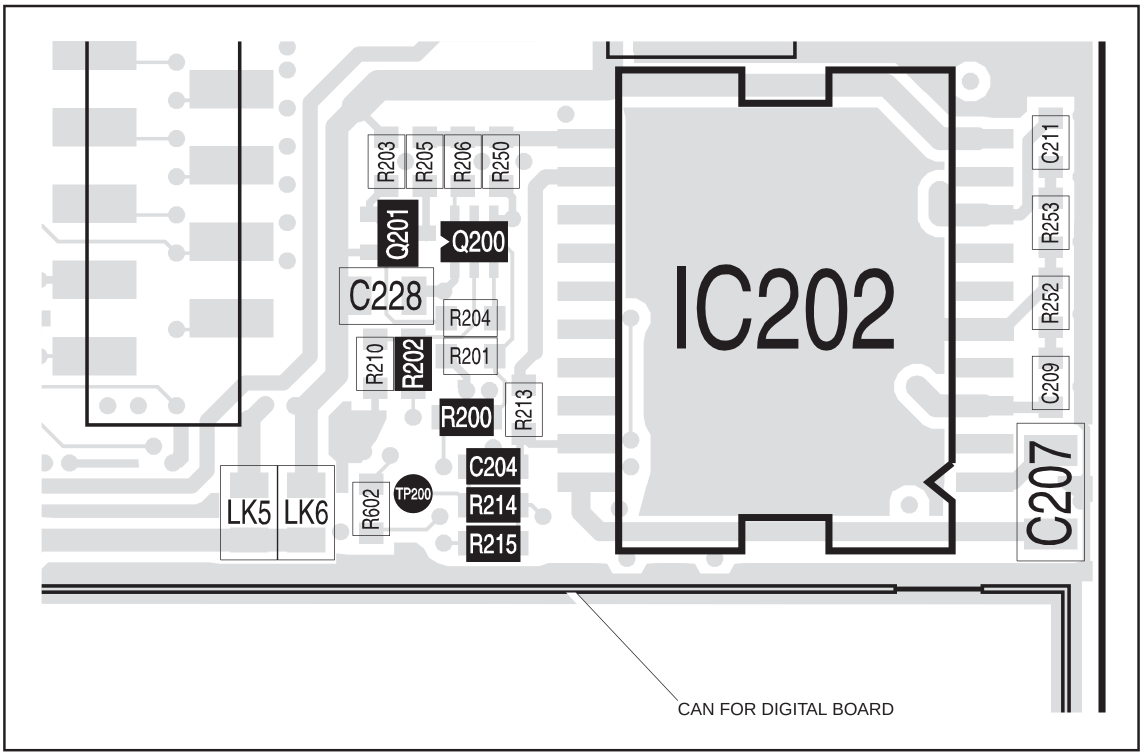
5. Check the positive and negative speaker outputs AUD ITF SPK+ [at 2F2/2D5] and AUD ITF SPK– [at 2F1/2C5] at pins 3 and 8 respectively of IC202 (see Figure 9.30). The outputs should have approximately half-rail bias. If they do, go to Step 6. If they do not, check for and repair any soldering faults around IC202, or else replace IC202. Confirm the removal of the fault and return to Subsection 8.1. If the repair failed, return to Subsection 8.1 and replace the complete main-board assembly.

6. Check that there is approximately 9.5 V_{pp} AC on each speaker output at maximum volume. If there is, the fault is unknown (it could be intermittent); return to Subsection 8.1 and replace the complete main-board assembly. If there is no AC, check that C204 [at 2D2/2D4] and R214 [at 2D3/2E4] (see Figure 9.30) are not faulty and are correctly soldered. Repair any fault. Confirm the removal of the fault and return to Subsection 8.1. If the repair failed or the fault could not be found, return to Subsection 8.1 and replace the complete main-board assembly.

7. Check the voltage on the VOL WIP DC line at the junction of R708 and C706 [at 7C4/7E3] (see Figure 9.31). As the volume varies, the voltage should vary between 0.0 and 1.2 V. If it does, go to Step 8. If it does not, check the control-head connector SK100. Repair or replace the connector if necessary. Confirm the removal of the fault and return to Subsection 8.1. If the repair failed or the fault could not be found, return to Subsection 8.1 and replace the complete main-board assembly.

8. Remove the CDC TOP can. Check that the voltage at the junction of R234 and R235 [at 2J5/2G8] (see Figure 9.31) varies between 0.0 and 0.6 V. If it does, IC204 is suspect; return to Subsection 8.1 and replace the complete main-board assembly. If it does not, check for continuity across R234, and check that R235 is properly soldered. Repair any fault. Confirm the removal of the fault and return to Subsection 8.1. If the repair failed or the fault could not be found, return to Subsection 8.1 and replace the complete main-board assembly.

Figure 9.30 Circuitry in the vicinity of IC202



9. Remove the CDC BOT can. Check the signal at the junction of R218 and IC204 [at 2E4/2G10] (see Figure 9.32). The signal should be a sine wave of approximately 1 V_{pp} with an offset of 1.2 V DC. If it is, go to Step 10. If it is not, IC204 or the digital board is faulty; return to Subsection 8.1 and replace the complete main-board assembly.

10. Check for continuity between the TP200 test point [at 2D2/2D4] (see Figure 9.30) and the junction between R218 and IC204 [at 2E4/2G10] (see Figure 9.32). Repair any fault; if necessary, replace R214, R215 [at 2D3/2E4] (see Figure 9.29) or R218. Confirm the removal of the fault and return to Subsection 8.1. If the repair failed or the fault could not be found, return to Subsection 8.1 and replace the complete main-board assembly.

Task 3 — Faulty Receiver

If the receiver does not operate, check the operation of the base-band CODEC and receiver AGC as described below. It is assumed that the receiver and power-supply circuitry were checked and no faults were found.

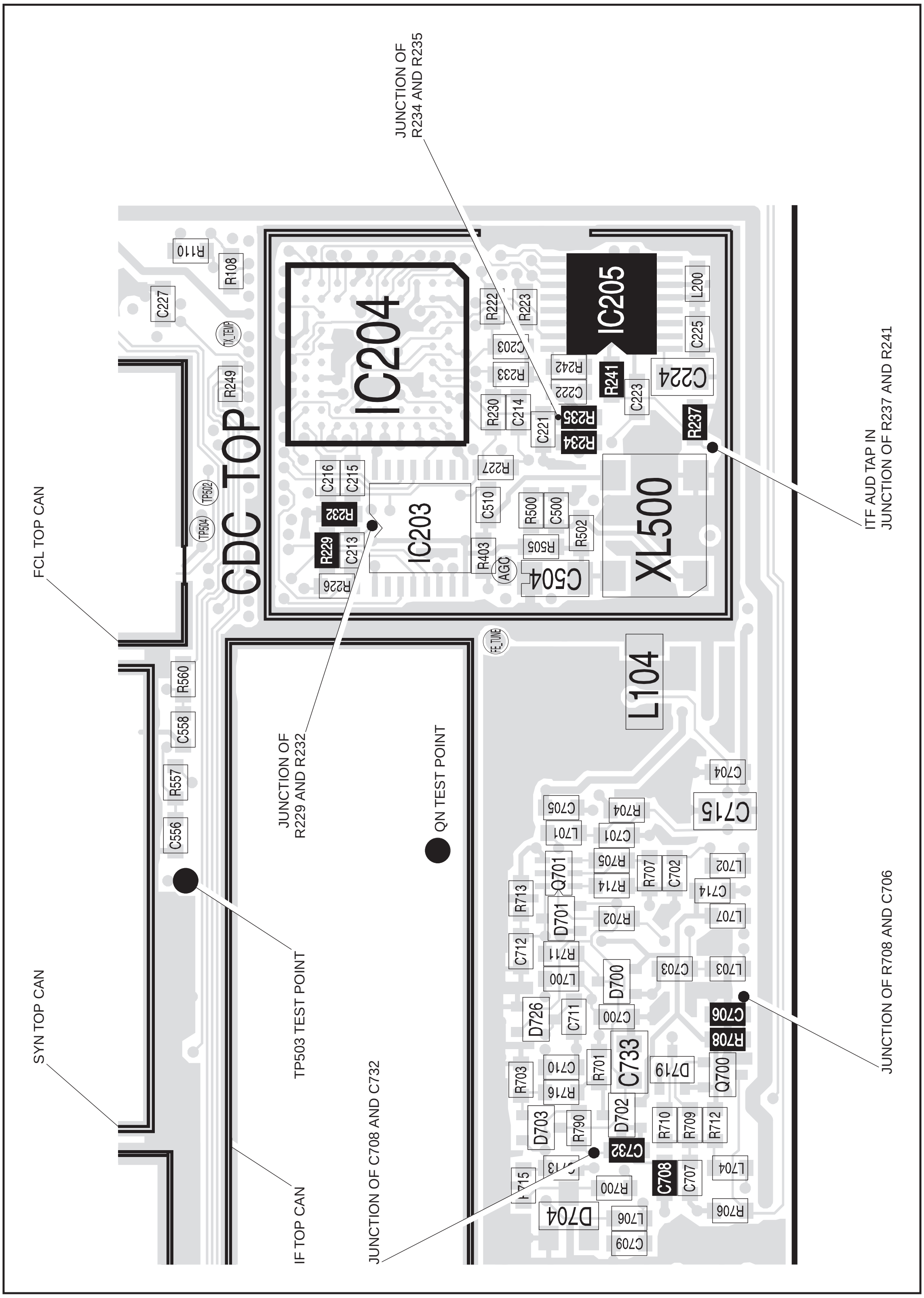
1. Remove the CDC BOT can. With no RF signal applied, check that the voltage at pin 14 [at 2N4/2F12] of IC201 exceeds 2.5 V DC (see Figure 9.32). If it does, go to Step 4. If it does not, go to Step 2.

2. Check that the voltage at pin 12 [at 2N5/2F11] of IC201 exceeds 1 V DC. If it does, go to Step 3. If it does not, check for and repair any shorts to ground at the junction of R238 [at 2N5/2F11] and pin 12 (see Figure 9.32). Confirm the removal of the fault and return to Subsection 8.1. If the repair failed or the fault could not be found, return to Subsection 8.1 and replace the complete main-board assembly.

3. Check the circuitry (R238, R239, R240) [at 2N4/2F11] around pins 12, 13 and 14 of IC201 (see Figure 9.32). Repair any fault. Confirm the removal of the fault and return to Subsection 8.1. If the repair failed or the fault could not be found, return to Subsection 8.1 and replace the complete main-board assembly.

4. Apply a strong on-channel signal. (Use the programming application to find the frequency selected for channel 1.) Check that a sine wave is present at the QN test point [at 4P1/4C12] (there is access through a hole in the IF TOP can — see Figure 9.31). If there is, the digital board or IC204 is faulty; return to Subsection 8.1 and replace the complete main-board assembly. If a sine wave is not present, go to Subsection 9.5 on the receiver.

Figure 9.31 Circuitry under the CDC TOP can, adjacent interface circuitry, and the QN and TP503 test points



Task 4 — Faulty Modulation

If the radio transmits the correct amount of RF power, but there is either no modulation or the modulation is distorted, proceed as follows:

1. Apply a 1 kHz audio signal of 20 mV_{pp} at the microphone input on the control head. Enter the CCTM command *33* to place the radio in transmit mode. (The frequency is that of channel 1.) Check that the 1 kHz signal appears at the TP503 test point [at 5N9/5J12] (see Figure 9.31). If it does, go to Subsection 9.3 on the frequency synthesizer. If it does not, go to Step 2.

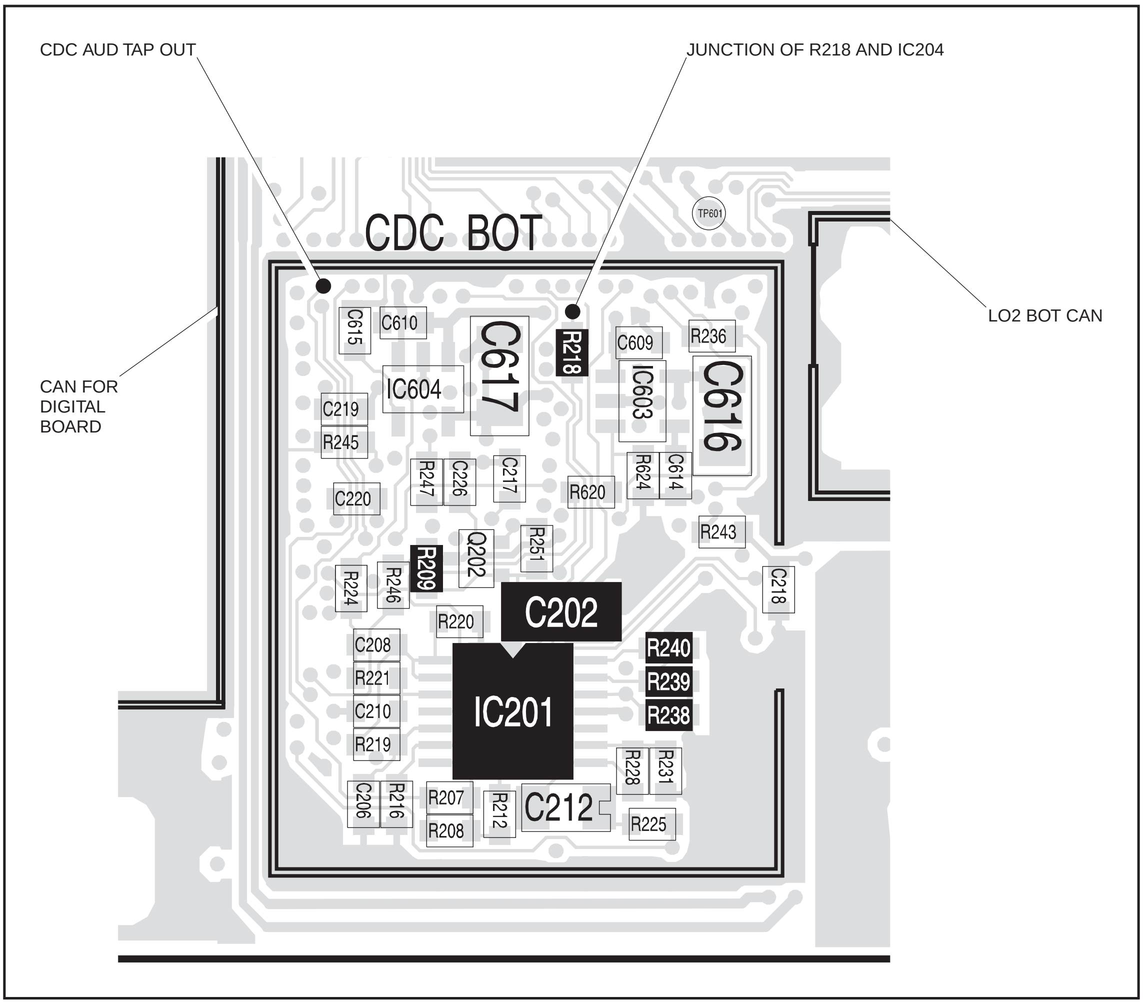
2. With no microphone connected, check that the voltage at the junction of C708 and C732 [at 7C0/7B3] (CH MIC AUD) is approximately 3 V (see Figure 9.31). If it is, go to Step 4. If it is not, go to Step 3.

3. Remove the CDC BOT can. Check that the voltage across C202 [at 2D7/2H3] is 3 V (see Figure 9.32). If it is, go to Step 4. If it is not, check the soldering of R209 [at 2D8/2J3] (see Figure 9.32), and check for shorts to ground at C202. Repair any fault. Confirm the removal of the fault and return to Subsection 8.1. If the repair failed or the fault could not be found, return to Subsection 8.1 and replace the complete main-board assembly.

4. Remove the CDC TOP can. Check that the voltage at the junction of R229 and R232 [at 2J5/2G8] is 1.5 V DC (see Figure 9.31). If it is, then IC204 is suspect; return to Subsection 8.1 and replace the complete main-board assembly. If it is not, go to Step 5.

5. Check the soldering of R229 and R232 [at 2J5/2G8], and check for shorts across R232 (see Figure 9.31). Repair any fault. Confirm the removal of the fault and return to Subsection 8.1. If the repair failed or the fault could not be found, return to Subsection 8.1 and replace the complete main-board assembly.

Figure 9.32 Circuitry under the CDC BOT can



Task 5 — Faulty Speaker Audio at Auxiliary Connector

If the receiver operates normally but there is no speaker audio at the auxiliary connector, proceed as follows:

1. Enter the CCTM command *400 **x***, where ***x*** is a valid channel number. (A suitable channel will depend on the programming of the radio.)

2. Enter the CCTM command *21* to force unmuting of the received audio signal.

3. Enter the CCTM command *110 128* to set the audio level at its midpoint.

4. At the test set apply 60%, 1 kHz modulation to the RF signal. Reduce the volume to a minimum.

5. Enter the CCTM command *324 r5*. Check that the received signal is present with an offset of 2.4 V DC at pin 13 (AUD TAP OUT) of the auxiliary connector (alternatively, as CDC AUD TAP OUT [at 2B6/2G3] at the junction of R207 and R208 — see Figure 9.32). If it is, go to Step 6. If it is not, return to Subsection 8.1 and replace the complete main-board assembly.

6. Remove the CDC BOT can. Check that the voltage at pin 1 [at 2E6/2H4] of IC201 is 1.2 V, and that the voltage at pin 7 [at 2D6/2G3] is 2.4 V (see Figure 9.32). If they are, return to Subsection 8.1 and replace the complete main-board assembly. If they are not, go to Step 7.

7. Check the circuits involving IC201 (pins 1 to 3 and 5 to 7). Repair any fault. Confirm the removal of the fault and return to Subsection 8.1. If the repair failed or the fault could not be found, return to Subsection 8.1 and replace the complete main-board assembly.

Task 6 — Faulty Modulation Using Auxiliary Connector

If the transmitter operates normally but there is no modulation (although there is modulation at the auxiliary connector), proceed as follows:

1. Enter the CCTM command *33* to place the radio in transmit mode. (The frequency is that of channel 1.) Check the modulation via the microphone input. If it is correct, go to Step 2. If it is not, go to Task 4.

2. Apply a 1 kHz AC-coupled signal of 0.7 V_{pp} at pin 7 (AUD TAP IN) of the auxiliary connector (alternatively, as ITF AUD TAP IN [at 2M2/2D11] at the junction of R237 and R241 — see Figure 9.31). Enter the CCTM command *323 t5*. Check that the DC offset voltage at pin 7 is approximately 1.5 V DC. If it is, go to Step 3. If it is not, go to Step 4.

3. Remove the CDC TOP can. Check for and repair any soldering faults around IC205 [at 2P2/2D12], or else replace IC205 (see Figure 9.31). Confirm the removal of the fault and return to Subsection 8.1. If the repair failed, return to Subsection 8.1 and replace the complete main-board assembly.

4. Check that there are no shorts at pin 7 of the auxiliary connector. If there are none, go to Step 5. If there are, repair the fault. Confirm the removal of the fault and return to Subsection 8.1. If the repair failed, return to Subsection 8.1 and replace the complete main-board assembly.

5. Remove the CDC TOP can. Check that the voltage at both ends of R241 [at 2P2/2D12] is 1.5 V DC (see Figure 9.31). If it is, go to Step 6. If it is not OK, go to Step 7.

6. Check for and repair any soldering faults around IC205 [at 2P2/2D12], or else replace IC205 (see Figure 9.31). Confirm the removal of the fault and return to Subsection 8.1. If the repair failed, return to Subsection 8.1 and replace the complete main-board assembly.

7. Remove R241 and check that the voltage at pin 3 of IC205 is 1.5 V DC (see Figure 9.31). If it is, go to Step 8. If it is not, return to Subsection 8.1 and replace the complete main-board assembly.

8. Check for and repair any soldering faults around R241 and IC205 [at 2P2/2D12] (see Figure 9.31). Confirm the removal of the fault and return to Subsection 8.1. If the repair failed, return to Subsection 8.1 and replace the complete main-board assembly.