TP9100 portables

Service Manual

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Contents

Preface

Scope of Manual

This manual contains information to service technicians for carrying out level-1 and level-2 repairs of TP9100 radios and accessories.

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.

Hardware and Software Versions

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

- Main board (B1 band) : 220-01734-**05**
- Main board (H5 band) : 220-01735-**06**
- Main board (H6 band) : 220-01736-**05**
- Main board (K5 band) : 220-02124-**07**
- Front-panel interface board : 220-02073-**04**
- Accessory flex board : 220-01728-**02**
- UI flex board : 220-01731-**01**
- Single charger main board : 220-01724-**04**
- Single charger contact board : 220-01725-**04**
- Multi charger main board : 220-02081-**03**

This manual describes all versions of programming and calibration software. However, make sure you have installed versions of software that support the database version and operating band of the radio under service. For more information, refer to the technical notes accompanying the relevant software releases.

Associated Documentation

The following associated documentation is available for this product:

- MPA-00004-**xx** TP9100 Safety and Compliance Information
- MPA-00001-**xx** TP9100 User's Guide
- MPA-00006-**xx** TP9100 Main Board (B1) PCB Information

- MPA-00007-**xx** TP9100 Main Board (H5) PCB Information
- MPA-00008-**xx** TP9100 Main Board (H6) PCB Information
- MPA-00019-**xx** TP9100 Main Board (K5) PCB Information
- MPA-00009-**xx** TP9100 Front-Panel Interface Board PCB Information
- MPA-00010-**xx** TP9100 Accessory and UI Flex Boards PCB Information
- MPA-00011-**xx** TP9100 PCB Information (printed, pre-punched and shrink wrapped; comprises MPA-00006-**xx** to MPA-00009-**xx** and MPA-00019-**xx**)

The characters **xx** represent the issue number of the documentation.

All available documentation is provided on the TM9100/TP9100 Service CD, product code TMAA24-01. Updates may also be published on the Tait support website.

Publication Record

Issue	Publication Date	Description
01	May 2005	first release
02	October 2006	information added on intrinsically safe radios and accessories, K5 band, and multi-charger

Alert Notices

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

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

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

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

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

Abbreviations

Abbreviation	Description
ACP	Adjacent Channel Power
ADC	Analog-to-Digital Converter
AGC	Automatic Gain Control
ALC	Automatic Level Control
APCO	Association of Public Safety Communications Officials
ASC	Accredited Service Center
BOM	Bill of Materials
C4FM	Compatible Four-level Frequency Modulation
CCTM	Computer-controlled Test Mode
CMOS	Complementary Metal–oxide Semiconductor
CODEC	Coder-Decoder
CSO	Customer Service Organization
CTCSS	Continuous-tone-controlled Subaudible Signaling
DAC	Digital-to-Analog Converter
DC	Direct Current
DSP	Digital Signal Processor
DTMF	Dual-Tone Multi-Frequency
EPTT	External PTT (Press-To-Talk)
ESD	Electrostatic Discharge
FCL	Frequency Control Loop
FE	Front-End
FEC	Forward Error Correction
FPGA	Field-Programmable Gate Array
FPI	Front Panel Interface
GPIO	General Purpose Input/Output
GPS	Global Positioning System
GUI	Graphical User Interface
IC	Integrated Circuit
IPN	Internal Part Number

Abbreviation	Description
IF	Intermediate Frequency
IQ	In-Phase and Quadrature
IS	Intrinsically Safe
ISC	International Service Center
LCD	Liquid-Crystal Display
LED	Light-Emitting Diode
LNA	Low-Noise Amplifier
LO	Local Oscillator
LPF	Low-Pass Filter
NPN	Negative-Positive-Negative
P25	Project 25
PA	Power Amplifier
PCB	Printed Circuit Board
PLL	Phase-Locked Loop
PNP	Positive-Negative-Positive
PSU	Power Supply Unit
PTT	Press-To-Talk
RISC	Reduced Instruction Set Computing
RSSI	Received Signal Strength Indication
SFE	Software Feature Enabler
SMA	Sub Miniature Version A
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
VCO	Voltage-Controlled Oscillator
VCXO	Voltage-Controlled Crystal Oscillator

Chapter 1
Description of the Radio

Chapter 1 – Contents

1 Introduction

Note The TP9100 series is a range of high-performance microprocessor-controlled portable radios for digital (APCO project 25-compatible), analog and mixed operation for voice and data communication.

This manual includes the information required for servicing the radio and its accessories.

Figure 1.1 TP9100 portable radios

This section describes the different options available for:

- keypads
- frequency bands
- accessories
- product codes

This section also gives an overview of the labels on the product and the specifications.

1.1 Keypads

The radios are available with the following keypads:

- TP9160 with 16-button keypad (two scroll and two selection keys and 10 alphanumeric keys)
- TP9155 with 4-button keypad (two scroll and two selection keys)

The keypads are implemented by different front panels and keypads. The rest of the radio hardware is identical.

1.2 Frequency Bands

The radios are available in the following frequency bands:

- 136 to 174MHz (B1)
- 400 to 470MHz (H5)
- 450 to 530MHz (H6)
- 762 to 870 MHz transmit, 762 to 776MHz and 850 to 870MHz receive (K5)

The frequency bands are implemented by different main boards.

1.3 Accessories

Tait offers a large variety of audio accessories, antennas, battery chargers, batteries, and other accessories such as carry cases.

For more information on the serviceable accessories refer to Chapter 3 Accessories on page 303 of this service manual.

Audio Accessories

The radios allow for the connection of a comprehensive range of audio accessories:

- “Evolution” speaker microphone
- light duty headset with boom microphone (behind the head)
- heavy duty headset with noise-canceling boom microphone (over the head)
- three wire headset with mini-lapel microphone
- accessory connector kit
- third-party audio accessories as approved on a per-CSO basis

Antennas

The radios allow for the connection of helical and whip antennas. For an overview of the antennas available, refer to “TPA-AN Antennas” on page 305.

Battery Chargers and Batteries

The desktop charger and multi-charger can be used to charge the following Tait batteries:

- 6-cell NiMH
- 6-cell NiCd

1.4 Product Codes

This section describes the product codes used to identify products of the TP9100 portable radio product line.

Radios

The product codes of the TP9100 portable radios have the format:

TPAB1**a–bbccd**

where:

- **a** identifies the keypad option:
  1=4-button keypad, 2=16-button keypad
- **bb** identifies the frequency band:
  B1, H5, H6, and K5 (refer to “Frequency Bands” on page 12)
- **cc** identifies any radio options:
  00=standard, 01=Intrinsically Safe
- **d** identifies product variants via software features
  A=P25 common air interface

Accessories

The product code of the accessories specific to the TP9100 portable radios have the format:

TPA–**bb**-ccc

where **bb** is the accessory type as follows:

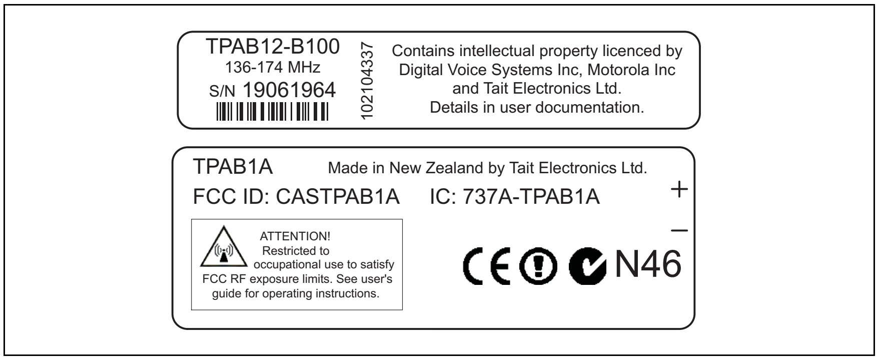
- AA=audio accessories
- AN=antennas
- BA=battery packs
- CA=carry accessories
- CH=charging accessories
- SP=spares items
- SV=service items

1.5 Labels

The following external labels are attached to the back of the radio (covered by the battery):

- compliance information and RF exposure safety warning
- serial number and product code

Figure 1.2 Labels of the TP9100 series



1.6 Intrinsically Safe Radios

Intrinsically Safe (IS) radios are certified by a third party to be safe to use in particular hazardous locations.

IS Identification

TP9100 IS portable radios can be identified by one or more of the following:

- an IS circle logo Ⓢ on the radio's front panel
- a label on the radio with IS information, including the FM diamond logo
- a label on the radio's battery with IS information, including the FM diamond logo

A radio with any of these features must only be serviced by an agency certified by both the approval authority and Tait Electronics Ltd. Any unauthorized repair or substitution of parts invalidates the intrinsic safety rating and the third party IS approval.

IS PCB servicing requirements

TP9100 IS portable radios must be returned to an authorized Tait branch or subsidiary for servicing. Any unauthorized repair or substitution of parts invalidates the intrinsic safety rating.

FM approval

TP9100 portable radios and accessories are approved by Factory Mutual Corporation (FM) to the following ratings:

- IS/I/1/CD/T3C Ta=40°C
- NI/I/2/ABCD/T3C Ta=40°C

See Table 1.1 for more detail on these ratings.

Table 1.1 FM ratings

Approval	Class	Division	Group	Temperature Rating
Intrinsically Safe: The unit is unable to cause ignition under normal or abnormal operating conditions.	Class I: Gas or petroleum type environment.	Division 1: Hazardous mixtures are normally present.	Groups C & D: Ethylene and propane gases.	T3C: 160°C
Incentive: The unit is unable to cause ignition under normal operating conditions.	Class I: Gas or petroleum type environment.	Division 2: Hazardous mixtures are present abnormally.	Groups A, B, C & D: Acetylene, hydrogen, ethylene and propane gases.	T3C: 160°C

FM approved products

Radios with the product code "TPAxxx–xx**01**x" have FM IS approval.

For more information about the TP9100 product code, refer to "Product Codes" on page 13.

FM approved accessories

The following accessories are approved for use with the TP9100 IS portable radios. This list is subject to change without notice. For an up-to-date list of FM-approved accessories, refer to the TaitWorld website or contact your nearest Tait office.

- TPA-BA-202: 6-cell NiCd IS high capacity battery
- TPA-BA-204: 6-cell NiMH IS high capacity battery
- TPA-AA-203: "Evolution" speaker microphone
- TPA-AA-204: "Evolution" RF speaker microphone
- TPA-AA-205: "Genesis" speaker microphone (meets IP68 specifications)
- TPA-AA-211: Light duty headset
- TPA-AA-212: Heavy duty headset
- TPA-AA-210: Hirose accessory adapter
- TPA-AA-213: 3-wire covert mic kit

Caution **The battery pack must not be charged in a hazardous location.**

1.7 Specifications

Introduction

Table 1.2 shows the specifications for the TP9100 radios. The parameter values quoted are minimum values. These specifications are valid for the date of publication only. For up-to-date specifications, refer to the area on the TaitWorld website reserved for TP9100 products.

Table 1.2 Specifications

Parameter	Values
Basic characteristics	
Frequency bands: • B1 band (VHF) • H5 band (UHF) • H6 band (UHF) • K5 band (800 MHz)	 136 to 174 MHz 400 to 470 MHz 450 to 530 MHz 762 to 870 MHz (transmit), 762 to 776 MHz and 850 to 870 MHz (receive)
Frequency stability	±1.5 ppm
Channel capacity (simplex or semi-duplex)	512
Channel spacing: • narrow • medium • wide	VHF: 15 kHz, 20 kHz, 30 kHz UHF/800 MHz: 12.5 kHz, 20 kHz, 25 kHz
Supply voltage:	7.5±1.5 V DC
Antenna connector	SMA
Accessory connector	Ports: 1 serial, 2I/O, 1 audio tap in, 1 audio tap out, PTT, speaker, microphone
Rated audio	>500 mW
Battery options	NiCD, NiMH
Battery shift life • with NiCd pack • with NiMH pack	 >8 hours 5/5/90 >12 hours 5/5/90
Physical characteristics	
Weight (with battery and antenna as stated, no belt clip): • with TPA-BA-201 (NiCd) and helical antenna • with TPA-BA-201 (NiCd) and whip antenna • with TPA-BA-203 (NiMH) and helical antenna • with TPA-BA-203 (NiMH) and whip antenna	 22.05 oz. (625 g) 21.55 oz. (611 g) 20.95 oz. (594 g) 20.46 oz. (580 g)
Dimensions (with battery, without antenna and belt clip): • height • width • depth	 7.28 in. (185 mm) 2.60 in. (65 mm) 1.77 in. (45 mm)

Table 1.2 Specifications (Continued)

Parameter	Values
Environmental conditions	
Operating temperatures	−22°F to +140°F (−30°C to +60°C)
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 • rain • humidity • salt fog • dust • vibration • shock
Receiver	
Analog Sensitivity (for 12dB SINAD)	<−117dBm (VHF/UHF), <−116dBm (800MHz)
Digital Sensitivity (at 5% BER)	<−120dBm (VHF/UHF), <−116dBm (800MHz)
Intermodulation	>70dB
Spurious responses	>75dB (VHF/UHF), >65dB (800MHz)
Selectivity (depends on programming): Digital RF Performance=ETSI/Australia • narrow channel spacing • medium channel spacing • wide channel spacing Digital RF Performance=FCC • narrow channel spacing • medium channel spacing • wide channel spacing	VHF / UHF / 800MHz >65dB / >65dB / N/A >72dB / >70dB / N/A >77dB / >72dB / N/A >45dB / >45dB / >45dB >65dB / >70dB / >60dB >70dB / >70dB / >70dB
Hum and noise: • narrow channel spacing • medium channel spacing • wide channel spacing	136 to 500MHz: / above 500MHz: >34dB / >31dB >38dB / >35dB >40dB / >37dB
Audio bandwidth	300Hz to3 kHz (flat or with de-emphasis)
Audio distortion	<3%
Audio response	+1/-3dB
Receive current (V_{cc}=7.5V) • stand-by (analog mode) • stand-by (P25 digital mode) • stand-by (dual mode) • receiver active, 0.5W audio into 16ohms	 89mA 90mA 91mA 270mA

Table 1.2 Specifications (Continued)

Parameter	Values
Transmitter	
Output power: • level 1 (very low) • level 2 (low) • level 3 (medium) • level 4 (high)	 1W 2W 3W (VHF), 2.5W (UHF), 2.3W (800MHz) 5W (VHF), 4W (UHF), 3W (800MHz)
Transmit current (V_{CC}=7.5V, radio transmitting at high power, mean value across each band) • B1 band • H5 band • H6 band • K5 band	 1.72A typ 1.76A typ 1.60A typ 1.32A typ
Modulation limiting: • narrow channel spacing • medium channel spacing • wide channel spacing	 <±2.5kHz <±4kHz <±5kHz
FM hum and noise: • narrow channel spacing • medium channel spacing • wide channel spacing	136 to 500MHz: above 500MHz: > 34dB >31dB > 38dB >35dB > 40dB >37dB
Conducted and radiated emissions: • up to 1GHz • between 1 and 4GHz (for radio operating frequencies below 500 MHz) • between 1 and 12.75GHz (for radio operating frequencies above 500MHz)	 <−36dBm <−30dBm <−30dBm
Audio bandwidth	300Hz to 3kHz (flat or with pre-emphasis)
Audio distortion	<3% at 1kHz 60% modulation
Audio response	+1/-3dB

2 Description

This section describes the mechanical design and architecture of the radio, explains the operation of the transceiver, and gives pinouts of the radio connectors and contacts.

2.1 Mechanical Design

Overview

The radio consists of the following main components:

- antenna
- battery
- radio

2.1.1 Antenna

The antenna screws into the antenna SMA connector at the top of the radio. For an overview of the available antennas refer to "TPA-AN Antennas" on page 305.

2.1.2 Battery

The battery is held in place by two lugs at the bottom of the battery which fit into two holes at the bottom of the radio, and a catch mechanism at the top of the radio, which is released by squeezing two symmetrical latches. The battery connects to the radio electrically by three contacts. For more information refer to "Connectors and Contacts" on page 27.

2.1.3 Radio

The circled numbers in this section refer to the items in Figure 2.1 on page 21.

Knobs and 3-way Actuator

The volume knob ⑩ is fitted to the D-profile shaft of the power/volume potentiometer, which is soldered to the main board. An internal D-profile spring holds the knob in place. The volume knob seal ⑨ around the shaft of the volume knob provides additional sealing.

The blue 3-way actuator ⑦ engages to the three-way switch of the combined 16-way/3-way selector switch, which is soldered to the main board. The channel knob ⑧ is fitted to the D-profile shaft of the 16-way switch of the combined 16-way/3-way selector switch. An internal D-profile spring holds the knob in place.

Front-Panel Assembly

The front-panel assembly ① contains the features and components of the user interface. For more information on the user interface refer to "User Interface" on page 26.

At the top of the front-panel assembly, three holes are provided for the antenna SMA connector, the 16-way/3-way selector switch, and the power/volume potentiometer of the main board ㉓.

An orange emergency key presses down on a metal lever on the inside of the front-panel assembly operating a tact switch on the main board ㉓.

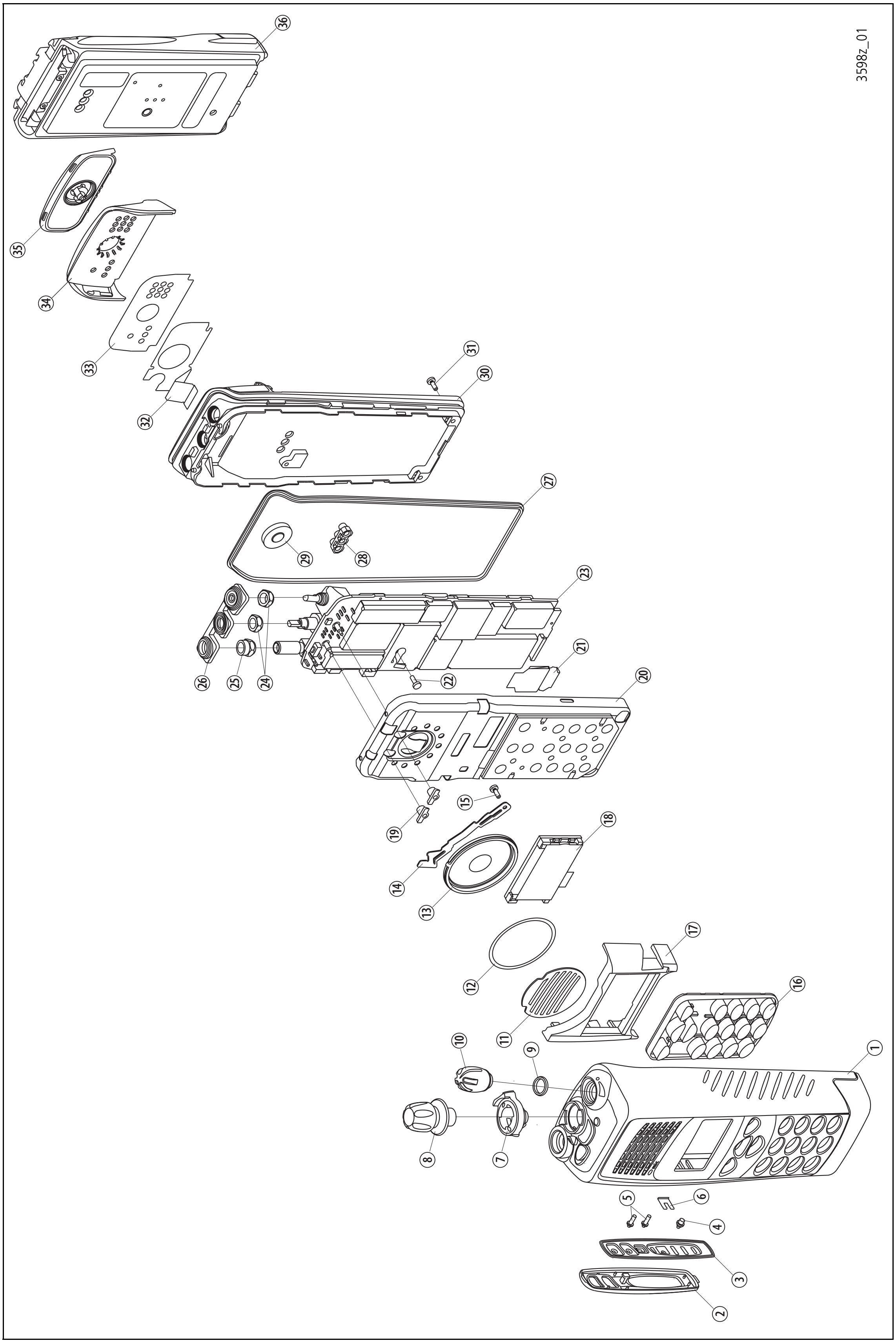
A light pipe fitted to the inside of the front-panel assembly transmits light from the status LED on the main board ㉓ to the top of the radio.

The front contains the speaker grille, the lens covering the LCD assembly ⑱, and 16 holes or 4 holes for the silicone keypad ⑯. A rectangular foam frame fitted around the aperture of the front panel protects the LCD assembly against mechanical shock.

Note The emergency key mechanism, the light pipe, the lens, and the rectangular foam seal are not serviceable items. In case of damage, the entire front-panel assembly must be replaced. For more information refer to "Spare Parts" on page 297.

Two screws inserts inside the bottom of the front-panel assembly are provided to screw the chassis ㉚ to the front-panel assembly.

Figure 2.1 Components of the radio



Speaker The speaker ⑬, which is also used as the microphone, sits inside a recess of the front-panel assembly, where an adhesive speaker cloth ⑪ is fixed to the speaker grille. An adhesive speaker ring ⑫ and a speaker clamp ⑭ hold the speaker in position. For correct orientation, alignment features are provided at the top of the speaker and the front-panel assembly ①. The top end of the speaker clamp is held in place by a recess inside the front-panel assembly, and the bottom end is fastened to a screw boss with a screw ⑮.

Two speaker contacts connect to two spring-loaded speaker pins on the main board ㉓. The speaker is earthed by a flexible tab on the main-shield assembly ⑳ which presses on the speaker chassis.

Keypad The 16-key or 4-key rubber keypad ⑯ protrudes through apertures in the front-panel assembly. To seal the radio, the keypad is fitted inside a groove.

PTT Keypad The PTT keypad located at the side of the front-panel assembly ① has one large key for activating the PTT, and two function keys (blue and black).

The PTT keypad consists of:

- the plastic PTT frame ②
- the silicone PTT keypad ③
- one bigger blue PTT pressel ④
- two smaller red function key pressels ⑤
- the metal PTT lock spring ⑥.

The PTT lock spring, which fits over a T-shaped protrusion of the PTT frame, secures the PTT keypad to the front-panel assembly. The pressels operate tact switches on the main board.

Chassis The magnesium chassis ㉚ serves as carrier for the main-shield assembly ⑳, the main board ㉓ and the rear panel ㉞.

At the top of the chassis, two positioning pins are provided to fit the main board to the chassis.

The main board is screwed to a screw boss of the chassis with one screw ㉒. Thermal paste is applied between the screw boss and the main board.

The chassis is screwed to the front-panel assembly with two screws ㉛.

Main Seal The rubber main seal ㉗ fitted around the perimeter of the chassis ㉚ seals the chassis against the front-panel assembly ①. The main seal is pre-shaped to follow the shape of the chassis.

Top Seal The top seal ㉗ seals the area at the top of the chassis ㉚ around the shafts of the power/volume potentiometer, the 16-way/3-way selector switch, and the antenna SMA connector against the front-panel assembly ①.

SMA and Knob Nuts One nut ㉕ for the antenna SMA connector and two identical nuts ㉔ for the 16-way/3-way selector switch and the power/volume potentiometer fasten these components to the chassis ㉚.

Speaker Pin Frames Two plastic speaker pin frames ⑲ are located around the speaker pins of the main board ㉓ to protect the speaker pins against mechanical shock.

LCD Frame The plastic LCD frame ⑰ holds the LCD assembly ⑱ in place on the main-shield assembly ⑳ and protects it against mechanical shock.

LCD Assembly The LCD assembly ⑱ sits between a foam seal inside a rectangular recess of the front-panel assembly ① and the main-shield assembly ⑳.

The loom of the LCD assembly runs through a slot in the main-shield assembly and connects to the LCD connector at the back of the main-shield assembly.

A rubber foam frame is fitted to the back of the LCD assembly to protect the LCD assembly against mechanical shock.

Main-Shield Assembly The main-shield assembly ⑳ consists of the metal main shield, the conductive mylar, the front-panel interface board, and the polydome.

Note The individual parts of the main-shield assembly are not serviceable items. In case of damage, the entire main-shield assembly must be replaced. For more information refer to "Spare Parts" on page 297.

At the top of the main-shield assembly, two positioning pins are provided to fit the main-shield assembly to the chassis ㉚.

At the rear of the main-shield assembly, the LCD connector connects to the LCD assembly, and the front-panel loom connector connects to the front-panel loom ㉑.

When a key is pressed on the keypad, the polydome closes the corresponding switch contact on the front-panel interface board and provides tactile feedback to the user.

The front-panel interface board also has LEDs for keypad illumination and an accelerometer for the man-down function.

Note The main-shield assembly is identical for the 16-key radio and the 4-key radio.

Front-Panel Loom

The flexible front-panel loom ㉑ connects the front-panel loom connector at the back of the main-shield assembly ⑳ and the front-panel interface connector of the main board ㉓.

The front-panel loom is folded twice and is long enough to fold the main-shield assembly away from the main board.

The front-panel loom is labeled with the words “RADIO”, KEYPAD”, and “OUTSIDE” to ensure correct orientation.

Main Board

The main board ㉓ is a printed circuit board in SMT design with components on the top and bottom sides. Most components are shielded by metal cans.

There are different main boards for each frequency band.

The antenna SMA connector, the 16-way/3-way selector switch, and the power/volume potentiometer are located at the top of the main board.

Important Special instructions must be followed when replacing the non-SMT components at the top of the main board. For more information refer to “Fitting the Non-SMT Components” on page 120.

An emergency key tact switch and a status LED are located at the top of the main board.

Tact switches for the PTT and function keys are located at the side of the main board.

The front-panel interface connector, which is located at the bottom of the main board, connects to the front-panel interface board of the main-shield assembly ⑳ via the front-panel loom ㉑.

The accessory connector, which is located at the top of the main board, connects to the flexible accessory board ㉜ at the back of the radio.

Two speaker contacts connect to two spring-loaded speaker pins on the main board ㉓. The speaker ⑬ is earthed by a flexible tab on the main-shield assembly ⑳ which presses on the speaker.

Two spring-loaded speaker pins on the main board connect to the speaker contacts.

Three spring-loaded battery pins on the main board protrude through the chassis and connect to the battery contacts.

For more information on connectors and contacts, refer to “Connectors and Contacts” on page 27.

For heat dissipation, the main board is screwed to the screw boss inside the chassis ㉚ with the screw ㉒.

Battery Pin Seal

The battery pin seal ㉘ is fitted around the three spring-loaded battery pins of the main board. It protrudes through and seals the three holes in the chassis ㉚ and also protects the battery pins against mechanical shock.

Chassis Plug Seal

The chassis plug seal ㉙ seals the hole in the rear-panel area of the chassis ㉚.

Rear Panel and Flexible Accessory Board

The rear panel provides the mechanical and electrical interface to the accessories. If no accessory is used, the rear panel is covered by a dummy cover ㉟.

The plastic rear panel ㉞ has a central catch for the lock of the dummy cover or accessory, and smaller holes for the 13 contacts of the flexible accessory board ㉜. For more information on the contacts refer to "Connectors and Contacts" on page 27.

Two lugs at the bottom of the rear panel engage with two lugs of the chassis, and the rear panel clips onto the chassis.

The loom of the flexible accessory board is fed though a slot in the chassis and connects to the accessory connector at the top of the main board.

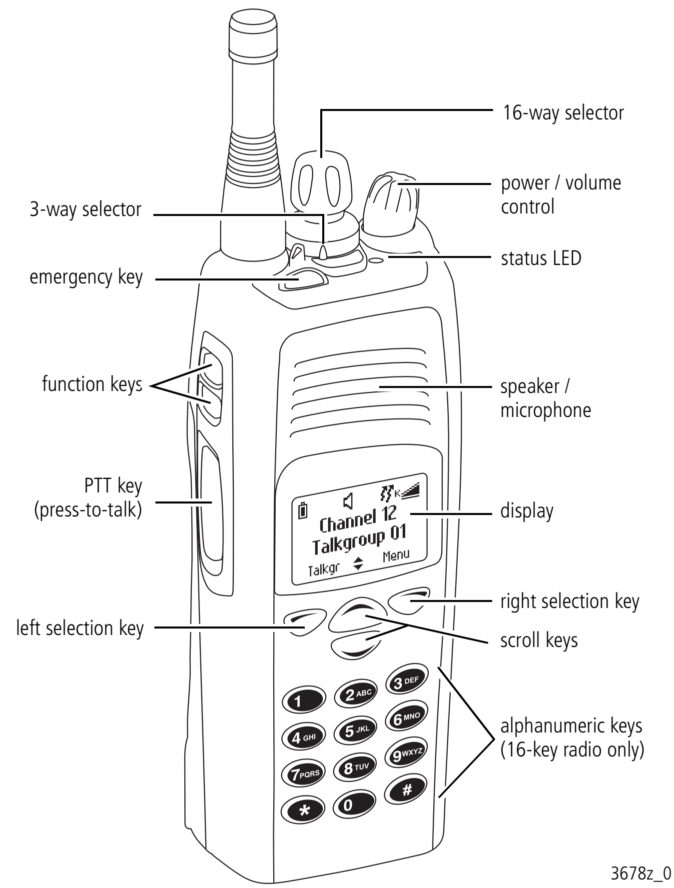
The flexible accessory board is held in place and sealed by the rear-panel seal ㉝.

2.2 User Interface

Figure 2.2 shows the controls and indicators of the user interface. For more information refer to the TP9100 User's Guide.

Some keys have functions assigned to both short and long key presses. A short key press is less than one second, and a long key press is more than one second.

Figure 2.2 User interface



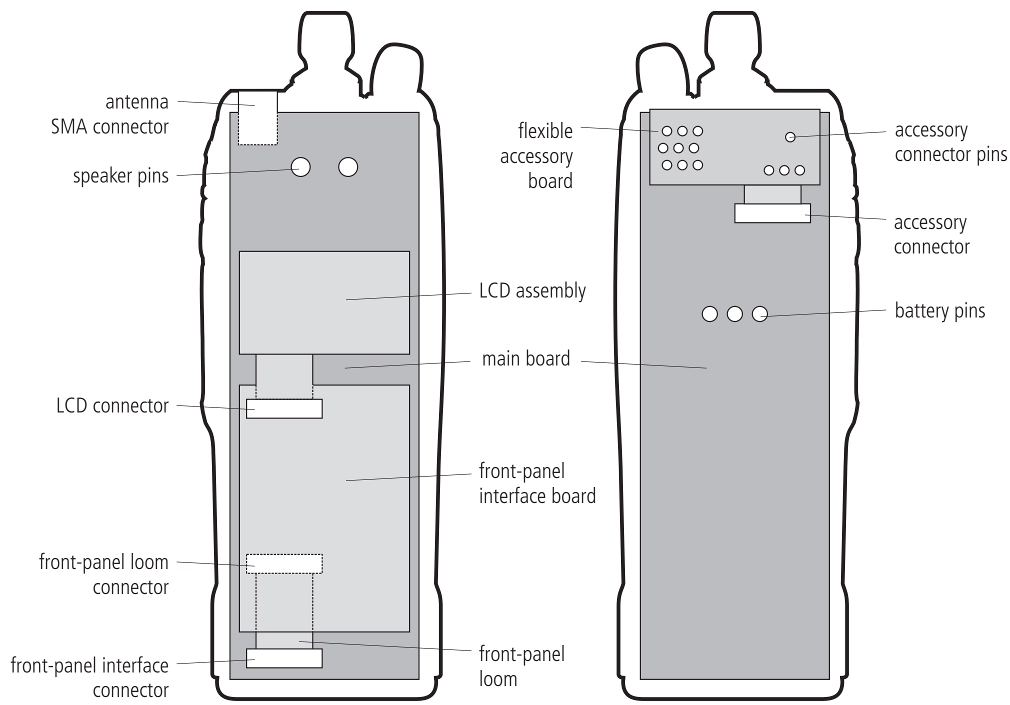
2.3 Connectors and Contacts

Overview

This section identifies the connectors and contacts of the radio, and describes the specifications and pinouts.

Figure 2.3 provides an overview of the connectors and contacts:

Figure 2.3 Connectors and contacts



2.3.1 Antenna SMA Connector

The antenna SMA connector is the RF interface to the antenna. The antenna SMA connector is a standard SMA connector with an impedance of 50Ω.

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

Table 2.1 Antenna SMA connector – pins and signals

Pinout	Pin	Signal Name	Signal Type
① ② top view of radio	1	RF	RF analog
	2	GND	RF ground

2.3.2 Battery Pins

The battery pins are the interface to the removable battery.

Table 2.2 Battery pins and signals

Pinout	Pin	Signal Name	Signal Type
① ② ③ rear view of radio	1	BATT DATA	Digital
	2	+7V5 BATT	+7.5V battery supply
	3	GND	Battery ground

2.3.3 Speaker Pins

Important The speaker load configuration is balanced; the speaker output lines must **not** be connected to ground. Connecting a speaker output line to ground will cause audio power amplifier shutdown.

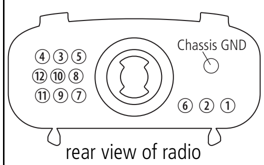
Table 2.3 Speaker pins and signals

Pinout	Pin	Signal Name	Signal Type
① ② view on main board	1	SPKR+	Analog audio
	2	SPKR–	Analog audio

2.3.4 Accessory Connector

The 12 pins of the accessory connector and the chassis ground provide the standard interface for external devices that are typically connected to a radio.

Table 2.4 Accessory connector – pins and signals

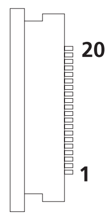
Pinout	Pin	Signal name	Description	Signal type
	1	AGND	Analog ground	Ground
	2	ACC PWR	Switched 3.3V supply. Supply is switched off when radio is switched off.	Power
	3	ACC RXD	Asynchronous serial port - Receive data	Digital, 3V3 CMOS
	4	AUD TAP OUT	Programmable tap point out of the Rx or Tx audio chain. DC-coupled.	Analog
	5	ACC TXD	Asynchronous serial port - Transmit data	Digital, 3V3 CMOS
	6	ACC MIC	Accessory microphone input. Electret microphone biasing provided. Dynamic microphones are not supported.	Analog
	7	ACC GPIO2	Programmable function and direction.	Digital, 3V3 CMOS input; open collector output with pullup
	8	AUD TAP IN	Programmable tap point into the Rx or Tx audio chain. DC-coupled.	Analog
	9	ACC–SPKR	Accessory speaker output. Balanced load configuration.	Analog
	10	ACC GPIO1	Programmable function and direction.	Digital, 3V3 CMOS input; open collector output with pullup
	11	ACC+SPKR	Accessory speaker output. Balanced load configuration.	Analog
	12	ACC PTT	PTT input from accessory, multiplexed with accessory function key.	Analog

The two I/O lines are reserved for use by certain accessories, and cannot be accessed in the programming application. Audio lines can be programmed to tap into, or out of, different points in the audio processing chain. For more information refer to the online help of the programming application.

2.3.5 Front-Panel Loom Connector

The front panel interface provides the interface between the front panel interface board and the radio main board.

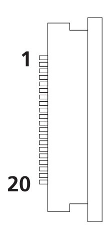
Table 2.5 Front-panel loom connector – pins and signals

Pinout	Pin	Signal name	Description	Signal type
 view on bottom-side of front-panel interface board	1 - 4	FPI_DIG_COL1 - 4	Keypad scanning column inputs	3V3 CMOS
	5 - 8	DIG_FPI_ROW1 - 4	Keypad scanning row output. The ROW5 signal exists on pin 9 but is not used.	3V3 CMOS
	10	DIG_FPI_LE	LCD driver SPI latch signal	3V3 CMOS
	11	DIG_FPI_SPI_CLK	LCD driver SPI clock signal	3V3 CMOS
	12	DIG_FPI_SPI_DO	LCD driver SPI data signal	3V3 CMOS
	13	DIG_FPI_CD	LCD driver SPI command/data signal	3V3 CMOS
	14	DIG_DSP_SYS_RST	System reset to LCD driver	3V3 CMOS
	15	FPI_CDC_TEMP	Analog signal from temperature measurement device on FPI	Analog
	16	FPI_CDC_MANDOWN	Analog signal from man down accelerometer (X and Y axis multiplexed)	Analog
	17	DIG_MUX_ADC	Multiplex control signal	Digital
	18	FPI_BL+	Backlight LED anode supply	Analog
	19	GND_FPI	Front panel interface ground	Power
	20	+3V3	Power	Ground

2.3.6 LCD Connector

The LCD interface is the connection point for communications with the LCD driver and backlight control.

Table 2.6 LCD connector – pins and signals

Pinout	Pin	Signal name	Description	Signal type
 view on bottom-side of front-panel interface board	4	FPI_BL+	Backlight LED anode supply	Analog
	7	DIG_FPI_LE	LCD driver SPI latch signal	3V3 CMOS
	9	DIG_DSP_SYS_RST	System reset to LCD driver	3V3 CMOS
	11	DIG_FPI_CD	LCD driver SPI command/data signal	3V3 CMOS
	13	DIG_FPI_SPI_CLK	LCD driver SPI clock signal	3V3 CMOS
	15	DIG_FPI_SPI_DO	LCD driver SPI data signal	3V3 CMOS
	17	+3V3	Power	Power
	All others	DGND	Ground	Ground

2.4 Hardware and Software Architecture

Overview

This section describes the hardware and software modules of the radio and their interaction in the functioning of the radio.

2.4.1 Hardware Architecture

The electrical hardware of the radio is implemented on the main board and the front-panel interface board.

For a detailed description and block diagrams of individual circuits, refer to "Circuit Descriptions" on page 51.

Main Board

The main board inside the radio body includes the following circuitry:

- transmitter
- receiver
- frequency synthesizer
- digital board with a RISC processor and custom logic (implemented on an FPGA), memory, and a DSP
- CODEC and audio
- interface
- power supply

For a basic block diagram of the hardware architecture, refer to Figure 2.4 on page 32.

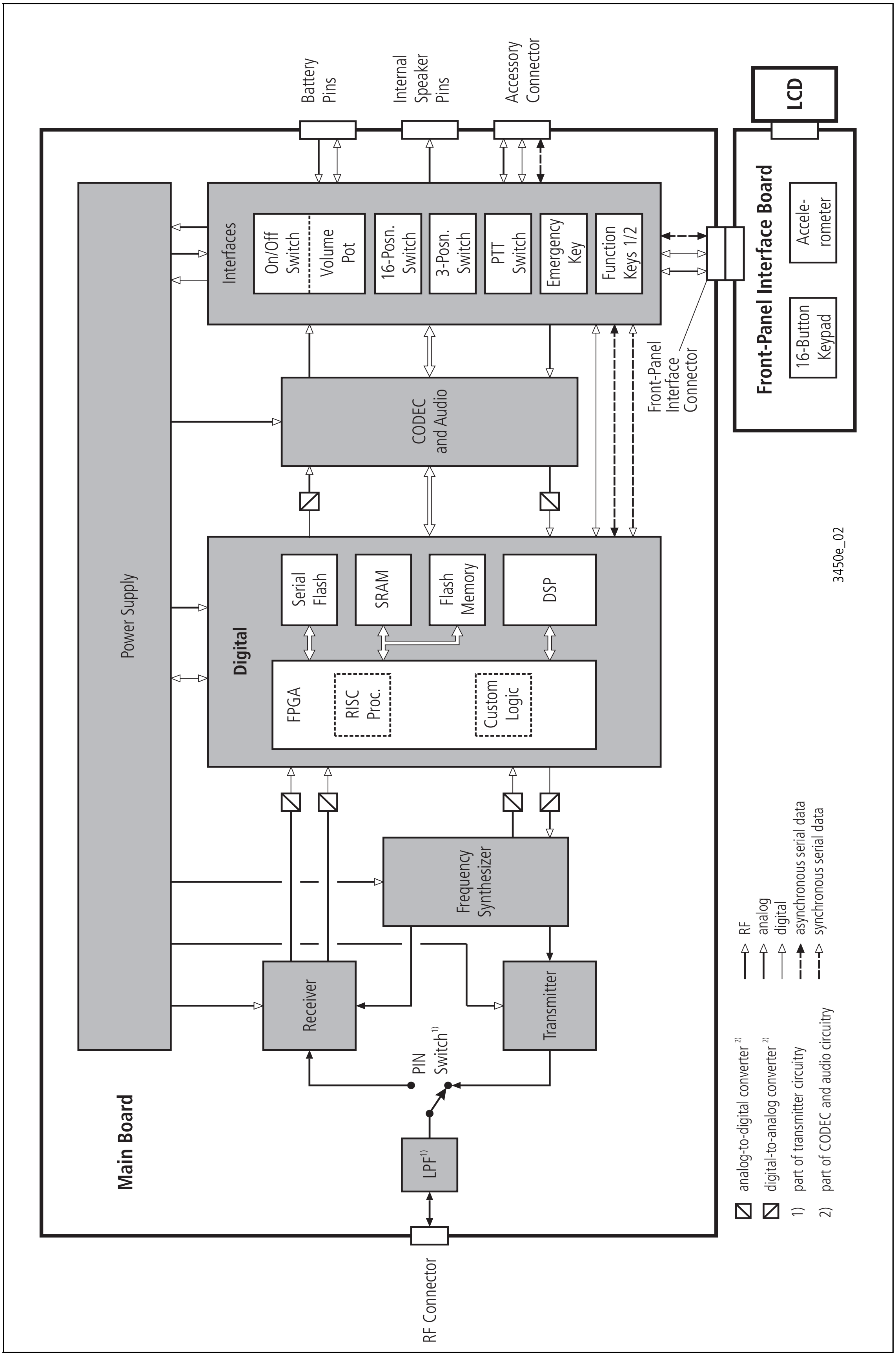
For a more detailed block diagram of the transceiver, refer to Figure 2.6 on page 36 (analog mode) and Figure 2.7 on page 37 (digital mode).

Front-Panel Interface Board

The front-panel interface board includes the circuitry needed for the controls and indicators on the front panel and the man-down function.

For a block diagram of the front-panel interface board, refer to Figure 3.10 on page 76.

Figure 2.4 Hardware architecture



2.4.2 Software Architecture

Overview

Software plays an important role in the functioning of the radio. Some radio functions such as the graphical user interface, processing of the analog and digital signals, and the implementation of analog and digital radio applications are completely implemented by software.

For a block diagram of the software architecture, refer to Figure 2.5 on page 33.

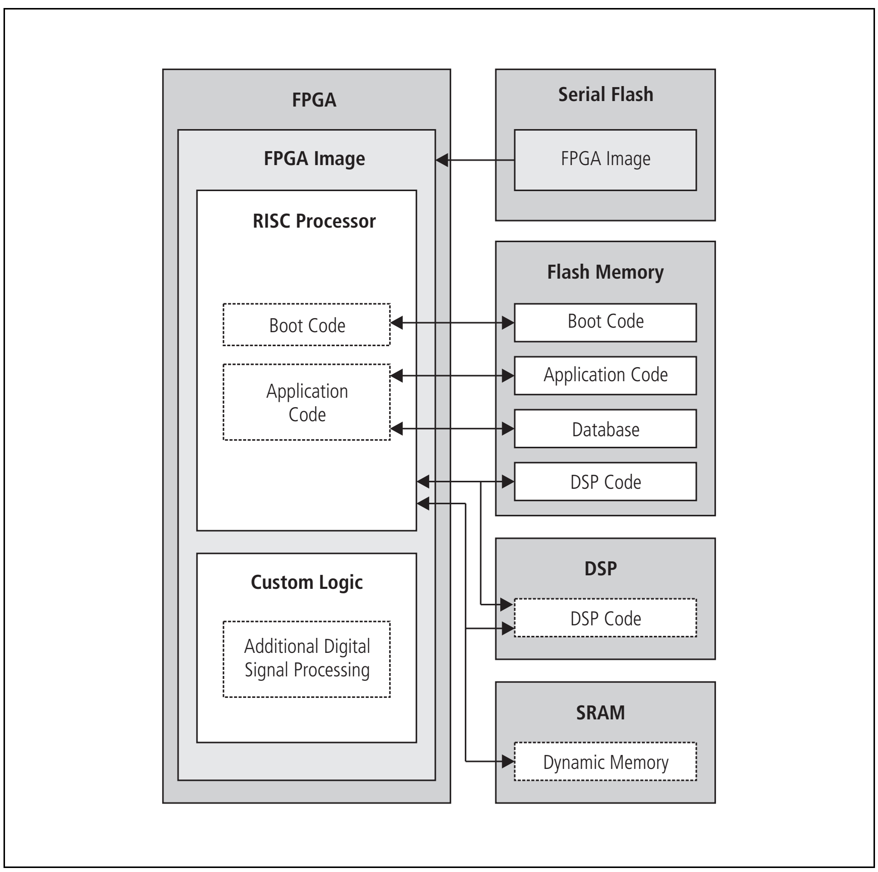
Software Modules

The following software modules are stored on the digital section of the main board:

- FPGA image, which includes the software-implemented RISC processor and the custom logic (the custom logic executes additional digital signal processing)
- boot code
- radio application code
- digital signal processing
- radio application database and radio calibration database

Hardware and interface drivers are part of the boot code, the RISC code, and the DSP code.

Figure 2.5 Software architecture



Software Start-Up

When the radio is turned on, the following processes are carried out on the main board:

Note This process describes the normal software start-up into normal radio operation mode.

1. The FPGA image, which includes the RISC processor and the custom logic, is loaded from the serial flash to the FPGA.

2. The RISC processor executes the boot code, which carries out an initialization and auto-calibration, and—in case of a fault—generates an error code for radio display.

3. Normal radio operation starts with:
   - the RISC processor executing the radio application code, including application software for the analog and/or digital modes
   - the DSP executing the DSP code for processing of digital signals in analog and digital mode
   - the custom logic executing additional digital signal processing

Software Shutdown

On shutdown, the programming and calibration data is stored in the database, and power is removed from the radio.

Important On power loss, any changes made to the programming or calibration data may be lost.

Programming and Calibration Files

One of the servicing tasks is the downloading and uploading of programming and calibration files to the database. For more information, refer to “Servicing Procedures” on page 129 and the online help of the programming and calibration applications.

Software Upgrades

During servicing it may become necessary to upload software to a replacement main board using the *Tools > Download* command of the programming application. For more information, refer to the online help of the programming application and to the technical notes accompanying the software files.

2.5 Operation in Receive Mode

This section describes the functioning of the transceiver in receive mode.

The operation of the transceiver is illustrated in simplified block diagrams in

- Figure 2.6 on page 36 (analog mode)
- Figure 2.7 on page 37 (digital mode)

These block diagrams show the hardware modules integrated with the software modules:

- hardware (transmitter, receiver, CODEC and audio)
- RISC processor (on the FPGA of the digital circuitry)
- custom logic (on the FPGA of the digital circuitry)
- DSP (on the digital circuitry)

Note The block diagrams for the analog and digital modes only differ in the operation of the DSP.

The receive path consists of three major functional parts:

- RF hardware
- digital baseband processing
- audio processing and signaling

Note The information flow on a digital radio can be categorized in two forms, signaling (including user data) and voice. Whilst setting up a call, signaling may be the only information transferred across the air interface. Once a call has been established however, both signaling and voice information are transported. The signaling information continues throughout the call for the purpose of maintaining the call and possibly sending data information.

Figure 2.6 Transceiver operation in analog mode

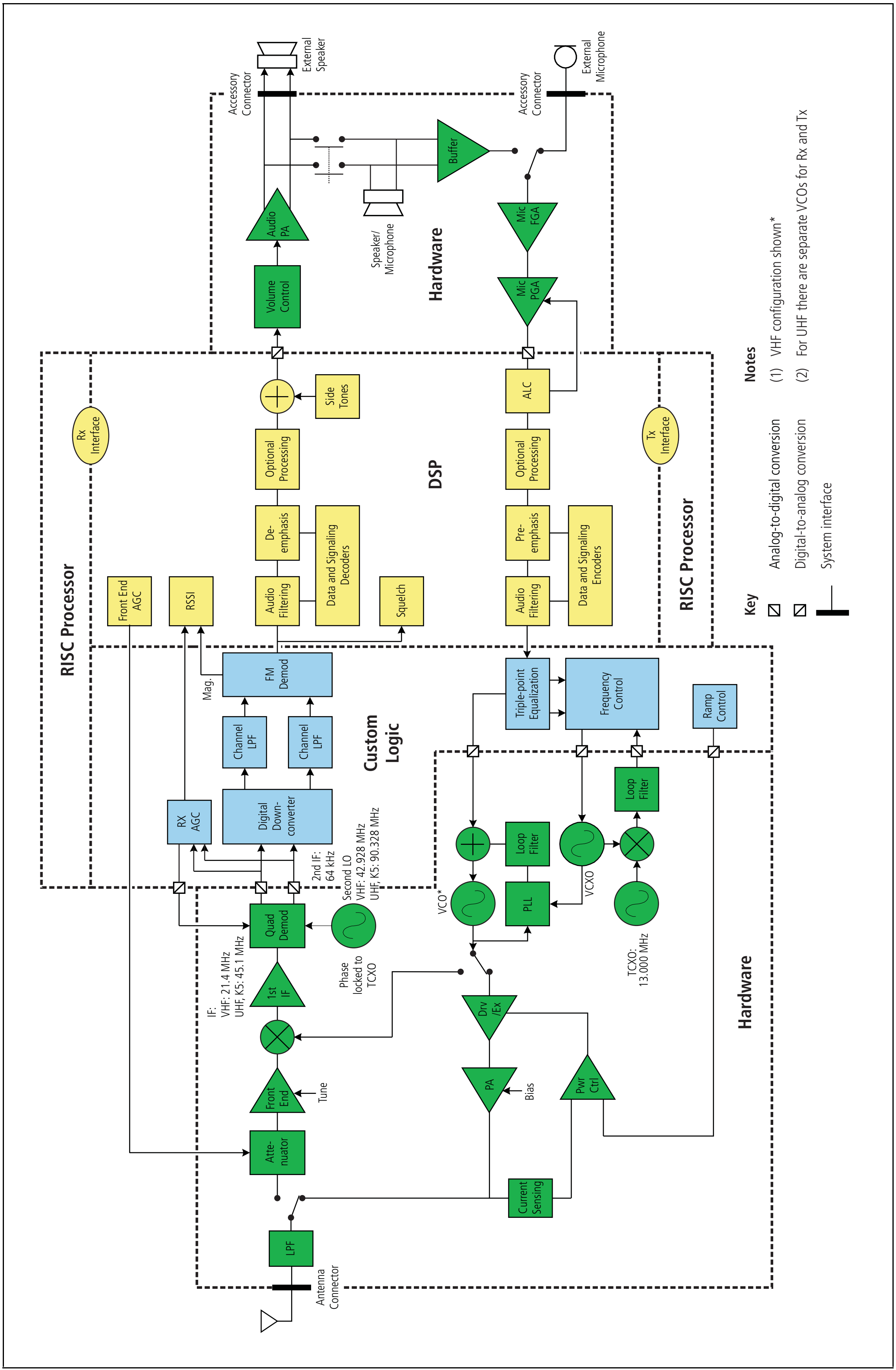
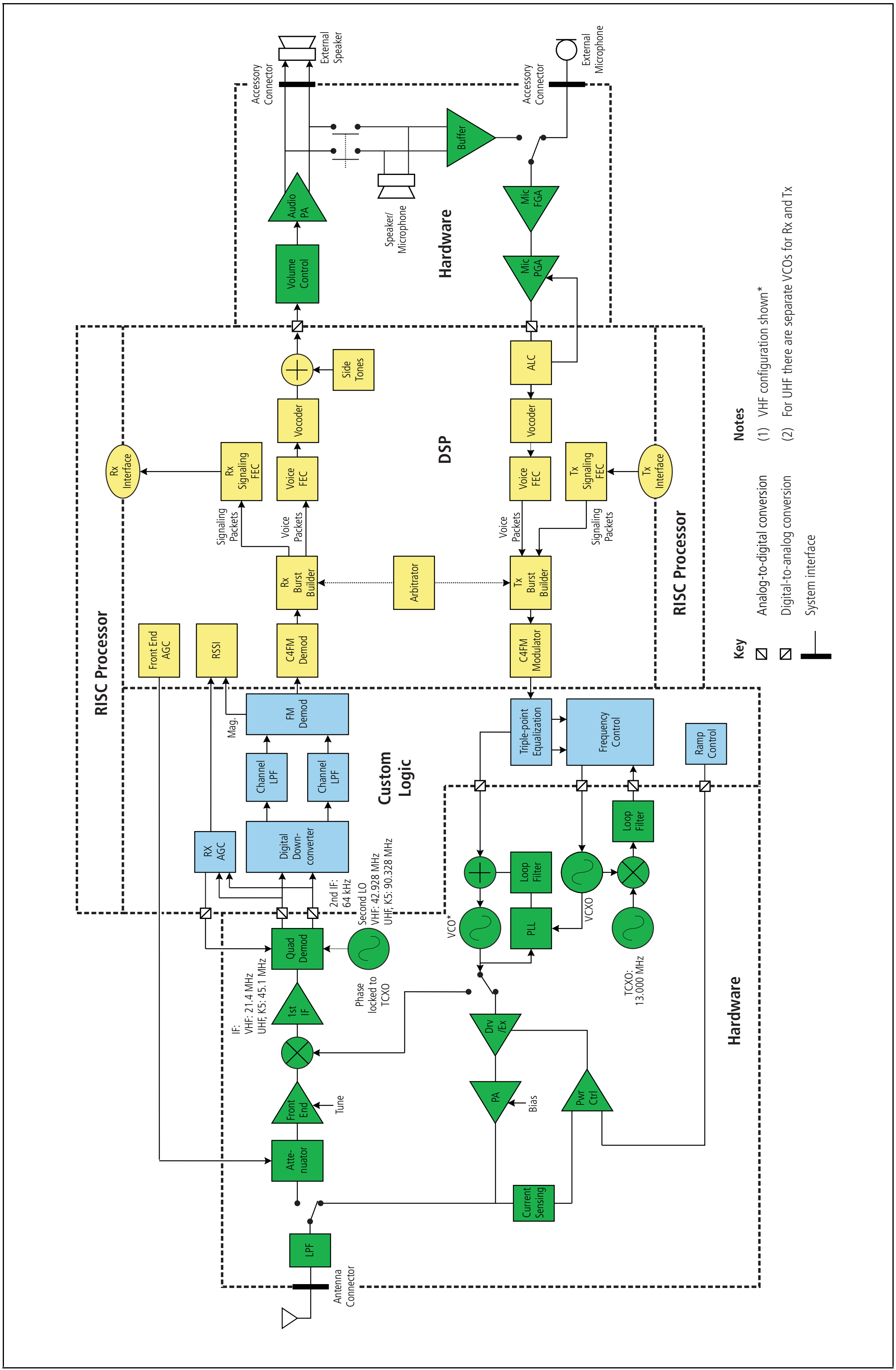


Figure 2.7 Transceiver operation in digital mode



2.5.1 RF Hardware

PIN Switch

The RF PIN switch circuitry selects the RF path to and from the antenna to either the Tx or Rx circuitry of the radio. In addition to the switching functionality, the PIN switch is used to provide attenuation to the Rx front end in high signal-strength locations.

Front End and First IF

The front-end hardware amplifies and filters the received RF spectrum, then down-converts the desired channel frequency to a first intermediate frequency IF1 of 45.1MHz (UHF and 800MHz) or 21.4MHz (VHF) where coarse channel filtering is performed. The first LO signal is obtained from the frequency synthesizer and is injected through an adjustable gain buffer on the low side of the desired channel frequency for all bands except K5. K5 band uses high-side inject for 762 to 776 MHz, and low-side inject for 850 to 870 MHz. In receive mode the modulation to the frequency synthesizer is muted. See “Frequency Synthesizer” on page 45 for a description of the frequency synthesizer. The output of the first IF is then down-converted using an image-reject mixer to a low IF of 64kHz. The K5 front-end has two paths (762 to 776 MHz and 850 to 870 MHz) which are selected depending on the Rx frequency.

Quadrature Demodulator

The LO for the image-reject mixer (quadrature demodulator) is synthesized and uses the TCXO 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 + 64kHz). The quadrature output from this mixer is fed to a pair of ADCs with high dynamic range where it is oversampled at 256kHz and fed to the custom logic device.

Automatic Gain Control

The AGC 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. Information about the signal level is obtained from the IQ data output stream from the ADCs. The control loop is completed within the 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 -70dBm.

2.5.2 Digital Baseband Processing

Custom Logic

The remainder of the receiver processing up to demodulation is performed by custom logic and DSP. The digitized quadrature signal from the RF hardware is digitally down-converted to a zero IF and channel filtering is performed at baseband. 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 48kHz. AGC and amplitude data are fed via a single synchronous serial port to the DSP which also performs demodulation. The stream is de-multiplexed 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.

RSSI

Receive signal strength is measured by a process resident in the DSP. This process obtains its input from the demodulator (RF signal magnitude value) and from the AGC (present gain value). 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 factory-calibrated:

- front-end tuning
- AGC
- noise squelch
- RSSI

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

2.5.3 Audio Processing and Signaling

Audio Processing (Analog Mode)

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 normalize the signal level for the remaining audio processing. The sample rate is decimated to 8 kHz and 0.3 to 3 kHz bandpass audio filtering is applied. De-emphasis is then applied to cancel out the receive signals pre-emphasized response and improve signal to noise performance. Optional processing such as decryption or companding is then applied if applicable.

Signaling Decoders (Analog Mode)

The signaling decoders obtain their signals from various points within the audio processing chain. The point used depends on the decoders' bandwidth 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 sidetone level is a fixed proportion (in the order of -10 dB) relative to full scale in the receive path.

C4FM Demodulator (Digital Mode)

Once the received signal is FM demodulated, it enters the C4FM demodulator. Once synchronization has been acquired, the received signals should exist as four possible frequencies. These frequencies are translated directly into received symbols ready to be passed to the burst builder.

Rx Burst Builder (Digital Mode)

The job of the burst builder is to dismantle the received burst. The burst builder can only receive an incoming burst once synchronization has been achieved by the C4FM modem. The synchronization sequence itself does not contain meaningful signaling payload and is discarded by the burst builder. The payload content of the burst is dismantled and routed to the appropriate signaling FEC or voice FEC task for decoding. The dismantling process is the reverse of the construction process performed by the burst builder.

Rx Signaling FEC (Digital Mode)

Prior to transmission, signaling information such as the network identifier was protected with forward error correction. Upon reception, the signaling may contain errors. If the number of errors is limited they can be corrected to recover the originally transmitted signaling.

Rx Vocoder FEC (Digital Mode)

The 144 bits received from the burst builder are de-interleaved on a frame by frame basis. An attempt is made to decode the 88 vocoder bits using the complementary process to that used in the encoder. An indication of the success of the decoder is produced. If the FEC algorithm is unable to decode correctly, a recommendation is made to the vocoder, depending on the severity of the errors, to either guess what the frame should be, to repeat the last frame, or to mute for this frame.

Rx Vocoder (Digital Mode)

The 88 bits from the FEC are decoded to generate the fundamental frequency of the frame, the voiced/unvoiced decisions for each frequency band, and the spectral amplitudes. 20ms of speech is synthesized from this information, and is interpolated between the previous frame and the next frame to minimize any artifacts due to the transition from one frame to the next.

Arbitrator (Digital Mode)

Transmission over the air-interface from a radio terminal is governed by channel access procedures. The radio must monitor the status symbols on the inbound channel, and wait for the status to indicate that the channel is free to use (idle) before transitioning to transmit mode. The channel access procedures are supervised by various timers. Normally, these procedures must be applied before transitioning from receive mode to transmit mode. However, they may be overridden under emergency conditions.

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 45 dB range in 1.5 dB steps, that performs volume control and muting. The DAC and the 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. 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 but the internal speaker can be switched under software control. The power delivered to each speaker is limited by its impedance. The internal speaker has 16 Ω impedance whereas the external speaker can be higher than this.

2.6 Operation in Transmit Mode

Overview

This section describes the functioning of the transceiver in transmit mode.

The operation of the transceiver is illustrated in simplified block diagrams in

- Figure 2.6 on page 36 (analog mode)
- Figure 2.7 on page 37 (digital mode)

These block diagrams show the hardware modules integrated with the software modules:

- hardware (transmitter, receiver, CODEC and audio)
- RISC processor (on the FPGA of the digital circuitry)
- custom logic (on the FPGA of the digital circuitry)
- DSP (on the digital circuitry)

Note The block diagrams for the analog and digital modes only differ in the operation of the DSP.

The transmit path consists of three major functional parts:

- audio processing and signaling
- frequency synthesizer
- RF transmitter

Note The information flow on a digital radio can be categorized in two forms, signaling (including user data) and voice. Whilst setting up a call, signaling may be the only information transferred across the air interface. Once a call has been established however, both signaling and voice information are transported. The signaling information continues throughout the call for the purpose of maintaining the call and possibly sending data information.

2.6.1 Audio Processing and Signaling

Microphone Input

The input to the transmitter path begins at the microphone input. There are two microphone sources: the internal speaker/microphone and an accessory microphone connected via the accessory connector. Only electret-type microphones are supported.

Analog Processing of the Microphone Input

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

Automatic Level Control

The ALC 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 10ms) and slow-decay (up to 2s) gain characteristic. This characteristic ensures that the peak signal level is regulated near full scale to maximize dynamic range.

DSP Audio Processing (Analog Mode)

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

Signaling Encoders (Analog Mode)

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

Tx Vocoder (Digital Mode)

The IMBE vocoder block takes audio samples in blocks of 20ms, analyses them and compresses them down to 88 bits. If there is no speech content in the segment, the vocoder produces silence. If speech is detected in the segment, the content of the segment is split into a variable number of frequency bands (max. 12) and a voiced/unvoiced decision is made for each band. It also estimates the pitch of the segment of speech and determines the spectral amplitudes of the voiced frequency bands.

Tx Vocoder FEC (Digital Mode)

The 88 bits from the vocoder have 56 bits of parity added to them. Different amounts of protection are afforded to the vocoder parameters, depending on their relative importance. Four blocks of 12 bits are given highest priority and are each encoded by (23,12) Golay codes. Three blocks of 11 bits are afforded less protection and are encoded by (15,11) Hamming codes.
The final 7 bits are unprotected. Finally all 144 bits are interleaved to spread the affect of bursts errors throughout the frame, and sent to the Burst Builder.

Tx Signaling FEC (Digital Mode)

In the same way as voice packets are protected using forward error correction, so too is the signaling information (control and data).
One example is the network identifier which is protected using a powerful BCH (Bose-Chandhuri-Hocquenghem) error code.

Tx Burst Builder (Digital Mode)

It is the nature of a digital radio transmission that the information is structured into bursts. An air interface burst can take several forms. Every burst consists of a frame synchronization sequence and Network identifier, followed by the main body of the burst, the content of which depends upon the type of burst. For a voice burst, it comprises a fixed number of voice packets with control signaling and low-speed data interspersed. For a data or control burst, it comprises a variable number of data blocks. Additionally, every air interface burst is expanded with a status symbol after every 70 bits of information. These status symbols are used for channel access procedures.

It is the job of the burst builder to construct the air interface burst using FEC-encoded code words delivered to it by the signaling FEC and voice FEC. The burst is then passed to the C4FM modulator.

C4FM Modulator (Digital Mode)

The burst builder creates a symbol stream that must be modulated onto the RF carrier. Four possible symbols can be transmitted. They are passed through a shaping filter defined by the APCO standard which limits the spectral occupancy on air. The four symbols are transmitted at pre-defined frequency deviations from the carrier.

2.6.2 Frequency Synthesizer

Introduction

As shown in Figure 2.6, the frequency synthesizer consists of two main parts:

- FCL
- RF PLL, comprising RF PLL device, loop filter, VCO, and VCO output switch

Frequency Control Loop

The FCL consists of the following:

- TCXO
- mixer
- loop filter
- VCXO
- frequency control block

The FCL provides the reference frequency for the RF PLL. The FCL 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
- VCO output switch

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

Note that patents are pending for several aspects of the synthesizer design.

Operation of Control Loop

The RF PLL is a conventional integer-N-type design with frequency resolution of 25kHz.

In transmit mode, the loop locks to the transmit frequency. In receive mode, it locks to the receive frequency minus the first IF frequency (low side inject), or the receive frequency plus the first IF frequency (high side inject).

Initially, the VCO generates an unregulated frequency in the required range. This is fed to the PLL device (ADF4111) and divided down by a programmed ratio to approximately 25kHz. The reference frequency input from the FCL is also divided down to approximately 25kHz. The phase of the two signals is compared and the error translated into a DC voltage by a programmable charge pump and dual-bandwidth loop filter. This DC signal is used to control the VCO frequency and reduce the initial error. The loop eventually settles to a point that minimizes 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 MHz±4 kHz. Initially a voltage controlled crystal oscillator (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 frequency of 12 kHz nominally. This is converted to digital form and transported to the frequency control block in the custom logic.

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

The FCL may be run in an open-loop configuration for short durations to increase the response time of the power-save modes.

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 analog form, to both the frequency reference and the VCO in the RF PLL, combining to produce a flat modulation response down to DC. Reference modulation is usually applied directly to the TCXO.

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

Frequency Generation

The RF PLL has a frequency resolution of 25 kHz. Higher resolution cannot be achieved owing to acquisition-time requirements and so for any given frequency the error could be as high as ±12.5 kHz. This error is corrected by altering the reference frequency to the RF PLL. The FCL supplies the reference frequency and is able to adjust it up to ±300 ppm with better than 0.1 ppm resolution (equivalent to better than 50 Hz resolution at the RF frequency). 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 to high by increasing the charge-pump current and reducing time constants in the loop filter. As a result, settling to within 1kHz of the final value occurs in under 4ms. 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 4.5ms.

Frequency Acquisition of FCL

The FCL utilizes 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 4ms.

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.

2.6.3 RF Transmitter

RF Power Amplifier and Switching

The RF power amplifier is a four-stage line-up with approximately 32dB of power gain. The output of the frequency generation sub-system is first buffered to reduce kick during power ramping. The buffer output goes to an exciter IC that produces approximately 100mW output. This is followed by an LDMOS driver producing up to 1.5W output that is power-controlled. The final stage consists of a single LDMOS device producing up to 4W for the B1 band, 5W for the H5 and H6 bands, and 3W for the K5 band.

Output of RF Power Amplifier

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 power control uses the power-sensing method. The steady-state power output of the transmitter is regulated using a hardware control loop. The DC current drawn by the PA is sensed via a 0.1 Ω resistor, and the minute voltage difference is amplified by a difference amplifier. The amplified difference voltage is compared by the integrator with the set reference voltage available from the CODEC. The PA output power is controlled by varying the driver gate bias voltage and—for H5, H6 and K5 bands—the base of the pre-driver stage. The driver gate voltage is hardware-limited to prevent overdrive. The reference voltage for the loop is supplied by a 13-bit DAC. The system driving the DAC supplies the steady-state voltage for a given power level as determined by factory calibration. The bandwidth of the loop is high to ensure that the loop does not limit the ramping slope and has approx. 25 dB power control range. Under load mismatch at the antenna (predetermined VSWR), the current drawn by the PA is maintained relatively constant and the output power is allowed to vary within predetermined limits.

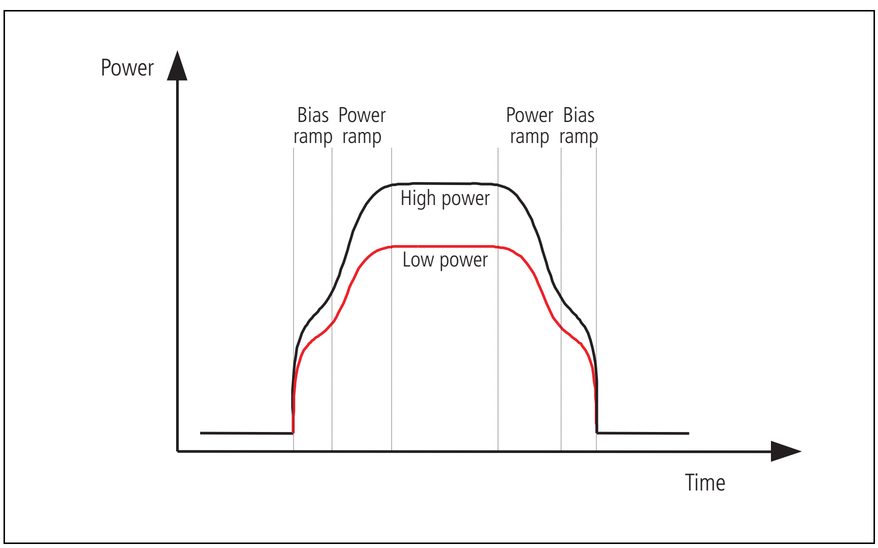
Ramping

Power ramp-up consists of two stages:

- bias
- power ramping

The timing between these two stages is critical to achieving the correct overall wave shape in order to meet the specification for transient ACP (adjacent channel power). A typical ramping waveform is shown in Figure 2.8.

Figure 2.8 Typical ramping waveforms



Bias Ramp-Up

The steady-state final-stage bias level is supplied by a 10-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. This signal is multiplexed with the Rx AGC 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.

PIN Switch

The RF PIN switch circuitry selects the RF path to and from the antenna to either the Tx or Rx circuitry of the radio. In addition to the switching functionality, the PIN switch is used to provide attenuation to the Rx front end in high signal-strength locations.

3 Circuit Descriptions

Introduction

This section describes and illustrates the circuitry of the main board and the front-panel interface board.

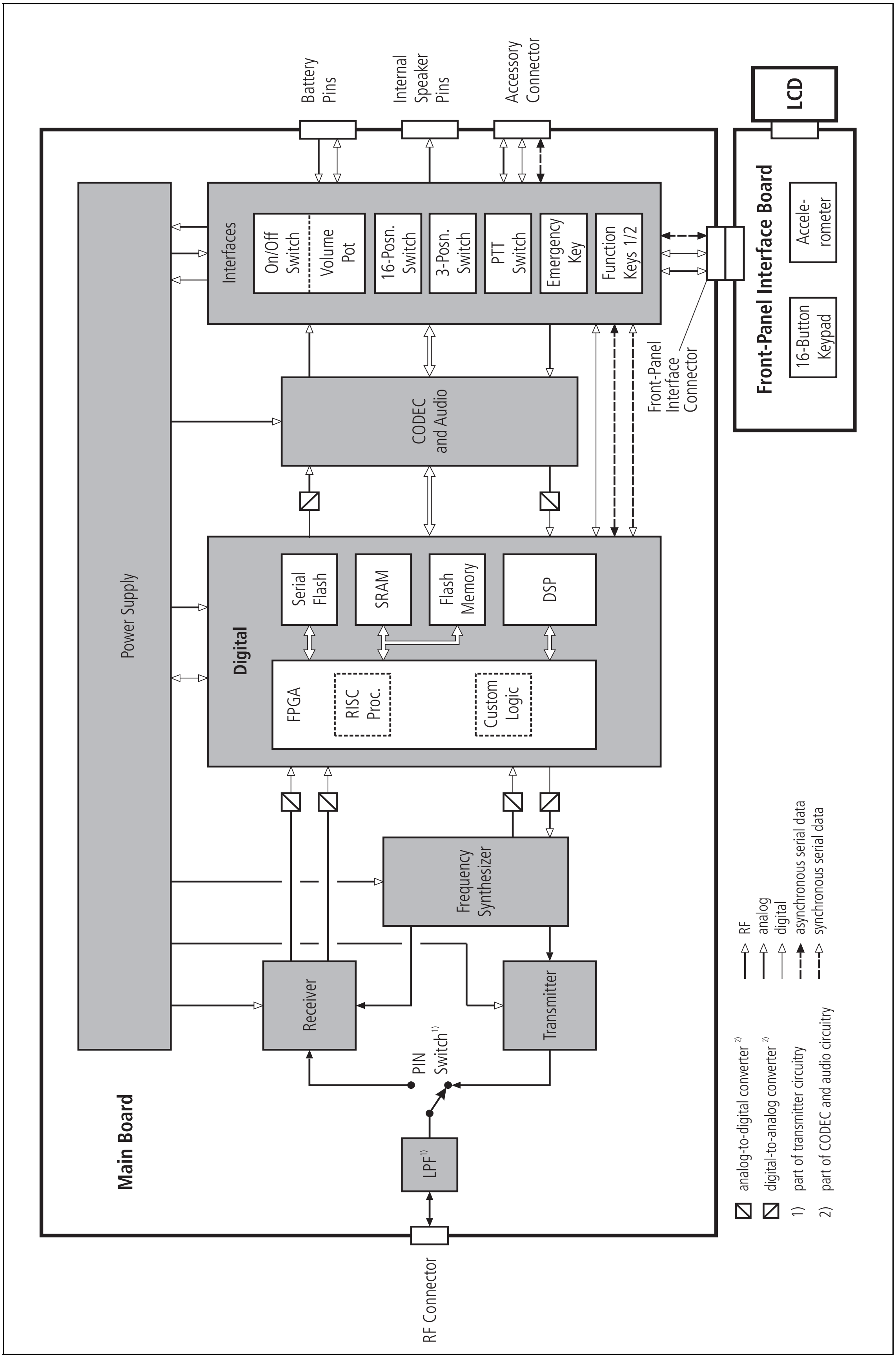
The main board is divided into the following circuitry modules:

- transmitter
- receiver
- frequency synthesizer (including FCL)
- CODEC and audio
- power supply
- interfaces
- digital
- front panel interface

Figure 3.1 gives an overview of the of the circuitry modules of the main board and the front-panel interface board, and shows how they are interconnected.

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

Figure 3.1 Hardware architecture



3.1 Transmitter Circuitry

Introduction

For a block diagram of the transmitter circuitry, refer to Figure 3.2.

Exciter

The exciter is different between the variants of the radio. The VCO buffer output is amplified through a combination of BJT discrete stage Q107 (B1 and H6), integrated amplifier IC100 (H5, H6 and K5), and BJT discrete stage Q100 (H5, H6 and K5). The exciter produces approximately +20 dBm output to the driver.

Driver

The LDMOS driver stage Q103 produces up to 1.5 W output (B1), 3 W output (H5 and H6) and 2 W output (K5), that is power-controlled via Q101 and IC101. Q101 provides current limiting. The gate voltage to the driver is reduced in excessive current conditions, determined by the voltage drop across the three resistors R122, R124, and R197. IC101 is part of the power control loop, comparing the current being drawn with the current expected to be drawn from calibration. It then adjusts the gate voltage to the driver to make drawn current and calibrated current the same for the given power setting.

Power Amplifier

The final-stage power amplifier consists of a single LDMOS device Q106 producing up to 5 W output (B1), 4 W output (H5 and H6) and 3 W output (K5). Final bias control comes from the IDAC channel of IC204 and one of the operational amplifiers making up IC202. Wave shaping of the bias signal is performed by one of the operational amplifiers of IC101. In addition, the bias signal can be inhibited by an out of lock signal from the synthesizer.

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 (Table 3.1). The control mechanism for this loop is via a DAC channel of IC204 and one of the operational amplifiers making up IC202. Wave shaping, filtering and feedback from current-sense resistor R150 is then performed by two of the operational amplifiers making up IC101. 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.

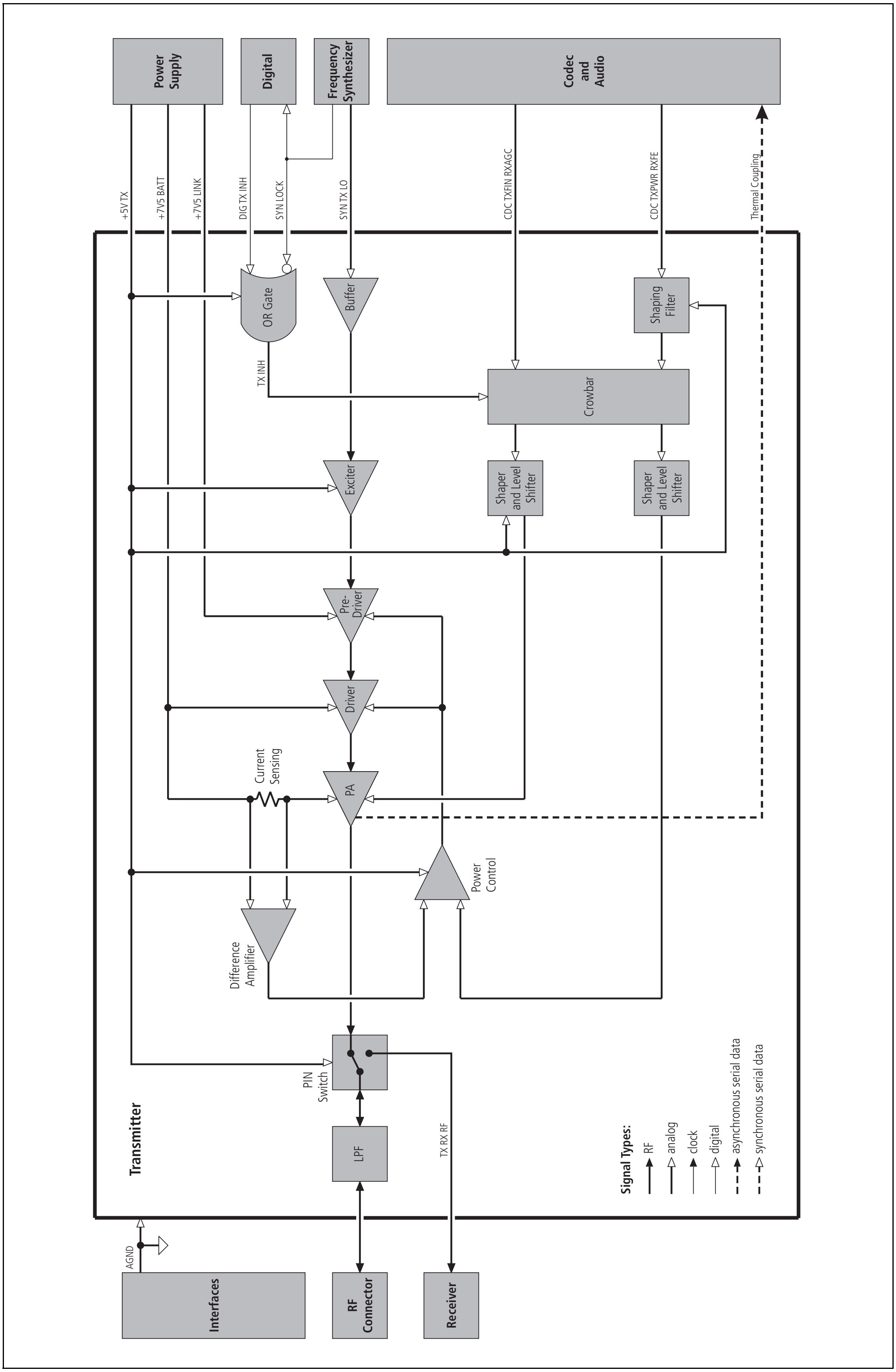
Table 3.1 Power levels

Frequency band	Level 1 (very low)	Level 2 (low)	Level 3 (medium)	Level 4 (high)
B1	1W	2W	3W	5W
H5/H6	1W	2W	2.5W	4W
K5	1W	2W	2.3W	3W

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.

Figure 3.2 Block diagram of the transmitter circuitry



3.2 Receiver Circuitry

Introduction

For a block diagram of the receiver circuitry, refer to Figure 3.3.

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 circuitry. The FPGA also carries out the demodulation of the received signals.

Front-End Circuitry

The front-end circuitry (B1, H5 and H6) 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.

The K5 receiver has a dual 700 MHz/800 MHz front-end. This consists of a switch followed by a SAW (surface acoustic wave) filter, then an LNA (low-noise amplifier), and then a second SAW filter and a second switch. The varicap tuning voltage CDC FE TUNE is used to control the switches that select which front-end is used.

First Mixer

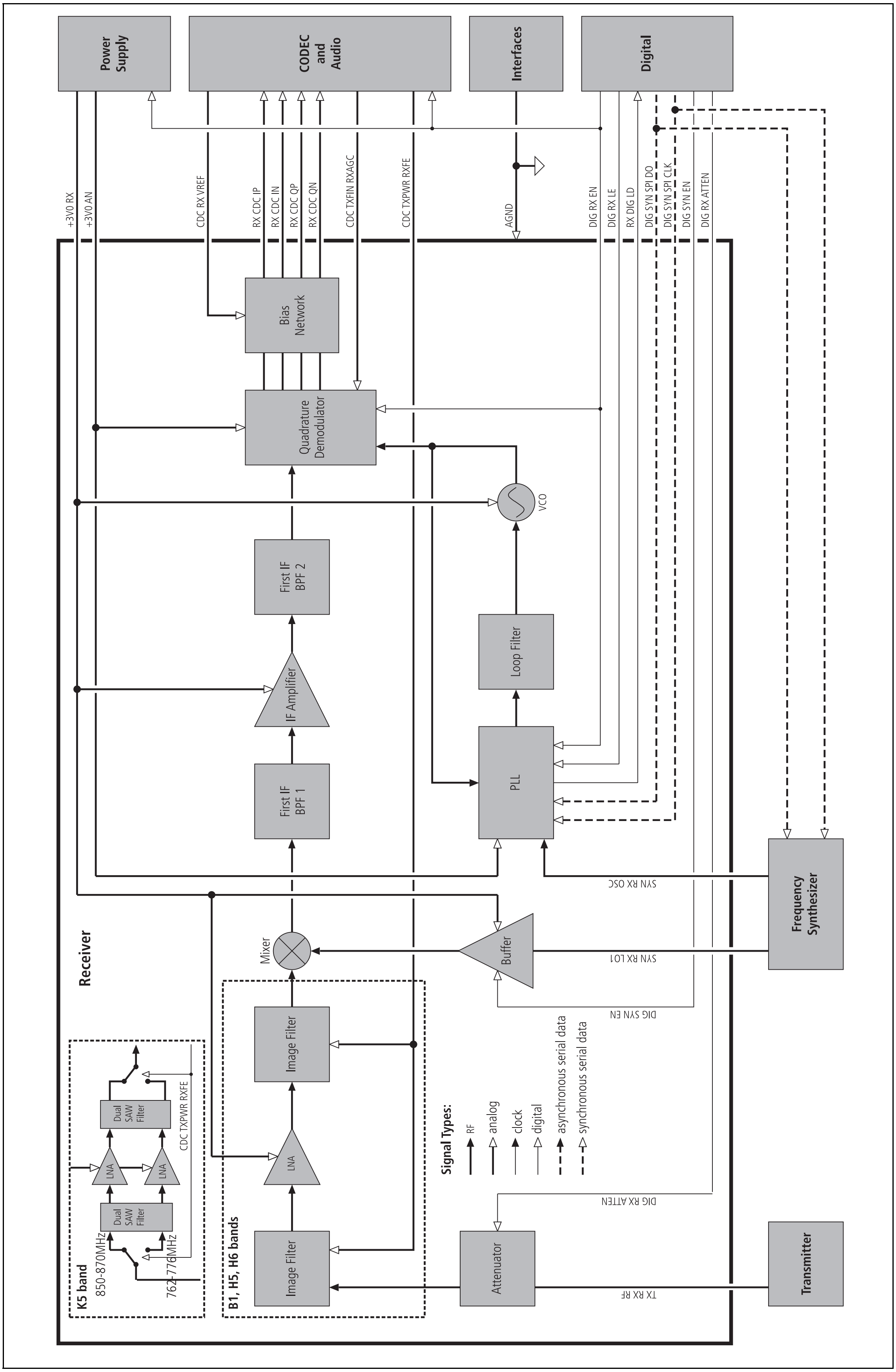
The first mixer (B1, H5 and H6) is a standard diode-ring mixer with SMD (surface-mount device) baluns and a quadruple SMD diode. The first LO signal from the VCO is buffered in IC404 at the mixer end to provide greater VCO isolation. The buffer stage has switchable attenuation to provide a low-power mode with reduced LO drive.

The first mixer (K5) is an integrated high performance mixer (IC409). The first LO signal from the VCO is tapped from the collector of Q504.

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.

Figure 3.3 Block diagram of the receiver circuitry



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
- H5, H6 and K5 bands: 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 DSP. Raw demodulated audio can be tapped out from the DSP for use with an external modem. The modem may be connected to the accessory connector.

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 TXFIN RXAGC 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 and the DSP. 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 total IF 3 dB bandwidths in Table 3.2.

Table 3.2 Total IF 3 dB bandwidths

Channel spacing	B1, H5, and H6 bands	K5 band
Wide	12.6kHz	9kHz
Medium	12.0kHz	11.0kHz
Narrow	7.8kHz	7.7kHz

(The FPGA runs from the FPGA 24M576 CLK signal, which has a frequency of 24.576 MHz.) The receiver requires the TCXO calibration to be completed to ensure that the channel filtering is centered, thereby minimizing distortion.

Received Signal Strength Indication

The RSSI is calculated in the FPGA and DSP. 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.

3.3 Frequency Synthesizer Circuitry

Introduction

For a block diagram of the frequency synthesizer circuitry, refer to Figure 3.4 (B1, H5 and H6 bands) and Figure 3.5 (K5 band).

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.

Power Supplies

Several power supplies are used by the frequency synthesizer owing to a combination of performance requirements and the availability of suitable components. The PLL IC includes analog and digital circuitry and uses separate power supplies for each section. The digital section is run on 3V, while the analog section is run on approximately 5V. The VCOs run off a supply of about 4.3V. The buffer amplifiers run off 3V (H5/H6 Rx, B1 Rx/Tx) or 5V (H5/H6 Tx). The active loop filter requires a supply of 14 to 15V, and a reference voltage of approximately 2.5V.

Performance Requirements

Low noise and good regulation of the power supply are essential to the performance of the synthesizer. A 5V regulator IC provides good line regulation of the 7.5V 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 a capacitance multiplier (Q508 and C585 for the VCO supply).

Effect of Tuning Range

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

Switch-mode Power Supply

The power supply VCL SUPPLY for the active loop filter is provided by a SMPS, which is in turn powered by 7.5V. 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. The SMPS is turned off by the removal of +3V0 AN.

Synthesizer Circuitry

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

Figure 3.4 Block diagram of the frequency synthesizer circuitry (B1, H5 and H6 bands)

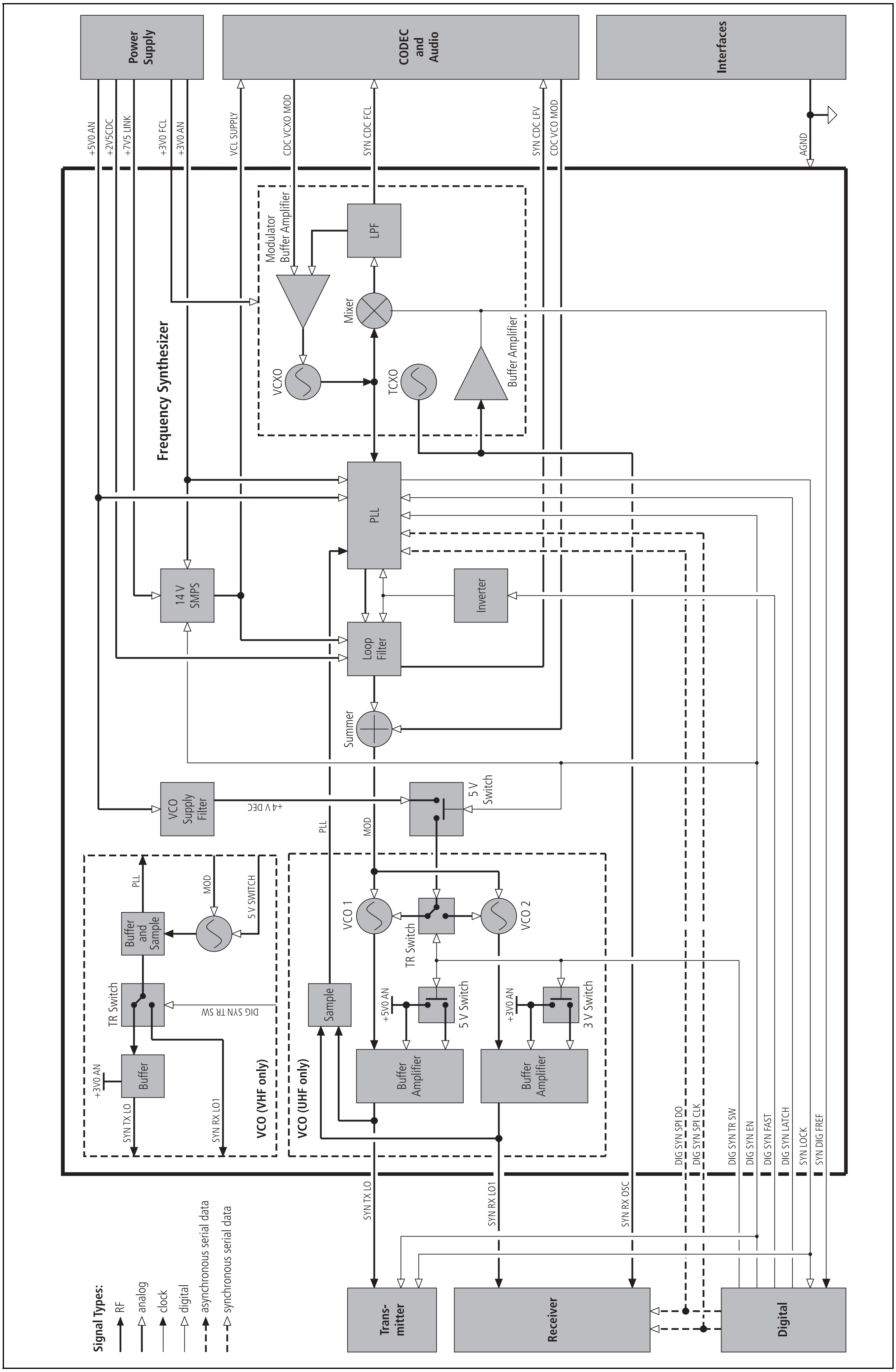
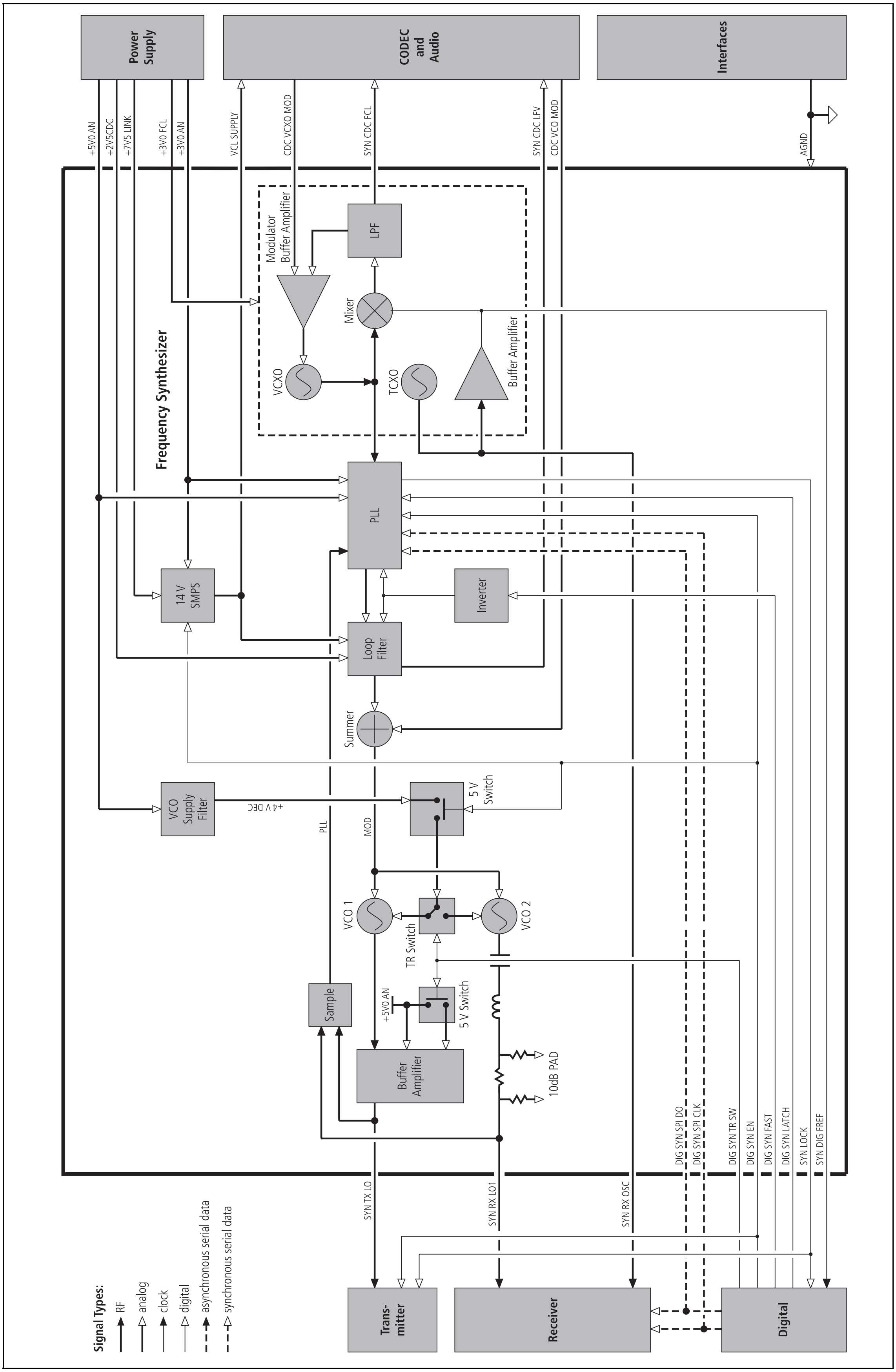


Figure 3.5 Block diagram of the frequency synthesizer circuitry (K5 band)



Reference Frequency

The 25kHz (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 2V and 12V. The VCO output power is amplified by a buffer amplifier. The power is low and varies from band to band. The buffer output power depends on which mode—receive or transmit—is used. In receive mode the output power should be about 6 to 7dBm (VHF/UHF) or -1 to -3dBm (800MHz), whereas in transmit mode it should be about 5 to 7dBm. The K5 receiver VCO is a ceramic resonator Colpits oscillator, and has no buffer amplifier.

Dual VCOs

Some variants of the synthesizer use two VCOs: one for receive and one for transmit. Synthesizers with two VCOs share the same tuning signal. Only one VCO is switched on at a time, and so the PLL IC will see only one output frequency to tune. A portion of the RF output from the VCOs is fed to the RF input of the PLL IC. The RF signal is divided by an integer that would give 25kHz if the output frequency were correct.

Phase-locked Loop

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

Active Loop Filter

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

Re-tuning of VCO Frequency

When the 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 4.5ms. (The switching time is measured for a frequency change equal to the first IF plus 10MHz or 1MHz, depending on the repeater offsets used for the band. This implies a synthesizer transmit-receive change-over plus an offset of 1MHz or 10MHz in less than 4.5ms. The ramp-up and ramp-down of the transmitter further extends this change-over time from 5.7ms (high power) to 6.3ms (low power).

3.4 Frequency Control Loop

Introduction

The FCL is included in the block diagram of the frequency synthesizer (see Figure 3.4 and Figure 3.5).

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

Elements of FCL Circuitry

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

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

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

3.5 CODEC and Audio Circuitry

Introduction

For a block diagram of the CODEC and audio circuitry, refer to Figure 3.6.

A/D and D/A Conversion

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

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, transmitter biasing, and some analog signal conditioning. The reference voltage (nominally 1.2V) for these CODECs is provided internally by IC204 but is decoupled externally by C217.

Device IC204 (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 analog signals are differential and biased at 1.2V nominally. The digital section communicates with this CODEC via a two-wire synchronous serial interface (BSDO and BSOFS balls). The digital-to-analog conversion section of the base-band CODEC is not used.

Device IC204 (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.

Device IC204 (Auxiliary CODEC)

The auxiliary CODEC handles transmitter biasing and power control, receiver tuning and gain control, accessory audio output and general analog 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 transmitter bias and receiver gain control (IDACOUT ball) is a current output type. Current-to-voltage conversion is performed by R238. The full-scale output of 1.2V is amplified by IC201 to approximately 3V as required by the receiver and transmitter.

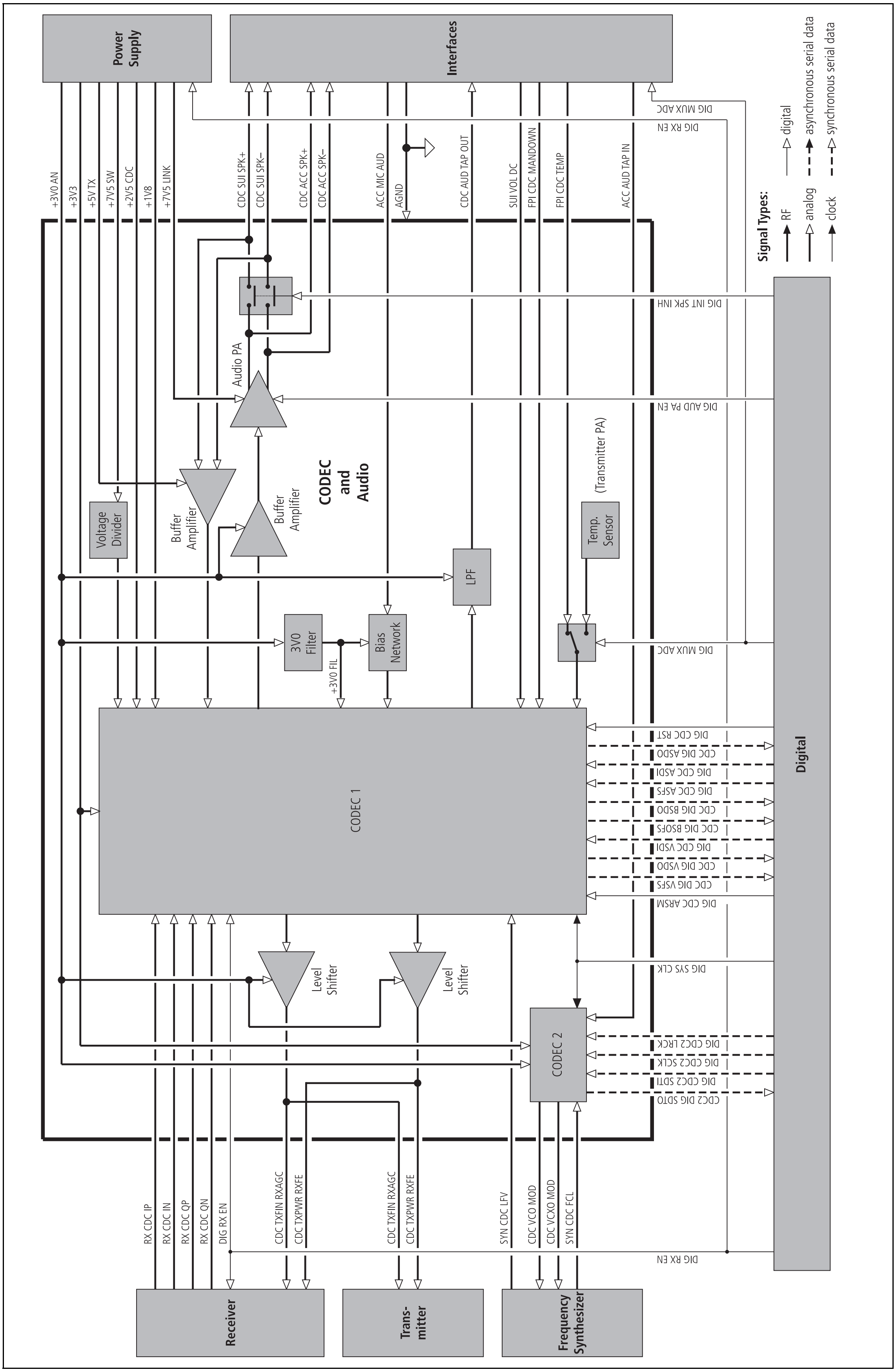
Audio Circuitry

The audio circuitry performs four functions:

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

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

Figure 3.6 Block diagram of the CODEC and audio circuitry (main boards issue 05 and higher)



Audio Signal for Speaker

The audio signal for the speaker is generated by IC204 (VOUTAUXP ball). This signal is post-volume-control filtered by R273 and C243, fed to a pre-amplifier IC201 and then to the audio power amplifier. IC201 has a gain of 20 dB.

Note For issue 03 main boards, the audio signal is post-volume-control decoupled by C238 and fed directly to the audio power amplifier.

Audio Power Amplifier

The signal from IC201 (or C238) is fed to the audio power amplifier IC200. IC200 has 27 dB of gain (22 dB for issue 03 main boards) and a differential output configuration. Gain is configured by the resistors R260 and R259. When operational, the output bias voltage for IC200 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 IC200 is controlled by one signal from the digital section, DIG AUD PA EN. The network consisting of Q200, R254 and R256 converts the digital signal to the single three-level analog signal required by IC200. A "pop-free" audio PA on/off control is activated by a fast transition on the MODE pin of IC 200.

Control of Internal Speaker Audio

The differential signal to the internal speaker can be disconnected by dual-MOSFET IC207, under control of the digital signal DIG INT SPK INH.
The external speaker audio signal is permanently connected to the output of IC200.

Microphone Signals

There are two microphone source signals:

- ACC MIC AUD from accessory connector
- internal speaker as a microphone

The biasing for electret microphones is provided by a filtered 3.0 V supply via R226. 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 input of ACC MIC AUD is biased to approximately 1.5 V by R229 and R232. AC coupling and DC input protection is provided by C213.

The microphone signal from the internal speaker is converted from differential to single/ended by IC202 and then fed to VINNORP ball of IC204 as the internal microphone signal.

Accessory Audio Input

The accessory audio input signal ACC 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.

Accessory Audio Output

The source for the accessory 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 artifacts. The low-pass filter, formed by IC201 (pins 1 to 3), R205, R221, R224, R276, C208, C209, and C210, is a third-order Butterworth type with a cut frequency of approximately 12 kHz. The output of the low-pass filter, via R207 and R208, drives the CDC AUD TAP OUT interface line. The DC bias for this signal path is provided by IC204 and is approximately 1.2V when operational. The offset at CDC AUD TAP OUT is approximately 1.2V owing to the gain of the buffer amplifier.

Note For issue 03 main boards, the low-pass filter is formed by IC201 (pins 1 to 3), R219, R221, R224, C206, C208 and C210.
The output of the low-pass filter is buffered by IC201 (pins 5 to 7).

3.6 Power Supply Circuitry

Introduction

For a block diagram of the power supply circuitry, refer to Figure 3.7.

Internal Power Supplies

The radio has the following internal power supplies:

- Two 5V regulators are connected to the +7V5 LINK supply and generate the voltages +5V0 TX and +5V0 AN.
- A 3V3 SMPS regulates the +7V5 BATT supply to +3V3.
- A 1V5 SMPS regulates the +3V3 of the 3V3 SMPS to +1V5.
- Three linear regulators (3V, 2V5, 1V8) regulate the +3V3 of the 3V3 SMPS to +3V0 AN, +2V5 , +1V8). These linear regulators take advantage of the efficiency gain of the 3V3 SMPS.
- The 3V RX switch switches the +3V0 AN of the 3V linear regulator to +3V0 RX. The 3V RX switch uses a P-channel MOSFET.
- The 3V FCL switch (main boards issue 05 and higher) switches the +3V0 AN of the 3V linear regulator to +3V0 FCL. The 3V FCL switch uses a P-channel MOSFET.

Power-Up Circuitry

When the ON/OFF switch (RV1) is turned on, a short pulse of approximately 35ms is generated via C634 on the base of the NPN transistor Q606, turning it on. This turns on the PNP transistor and charges C620. After the short pulse, C610 can hold the 3V3 SMPS (IC610) for a further approximately 2.5s (a voltage higher than approximately 1V on pin 1 turns this regulator on). This regulator supplies the digital circuitry, and the software asserts the DIG PSU LATCH signal. This signal holds the transistors and keeps C610 charged. The benefit of keeping the transistor charged is that in case of a reset (due to a watchdog timeout or power supply spike) the radio has 2.4s to recover (including rebooting and reasserting DIG PSU LATCH) and does not turn off.

It is also possible to power up the radio by the method described above (except via C634) when the battery is attached.

PSU Supervisor

The PSU supervisor monitors the +3V3 of the SMPS. It comprises a reset and watchdog timer, and provides the reset signal PSU SYS RST to the digital section, which in turn provides the watchdog signal DIG WD KICK required by the PSU supervisor.

Radio Modes and Internal Power Supplies

Table 3.3 lists the radio modes and shows which power supplies are on and off during these modes.

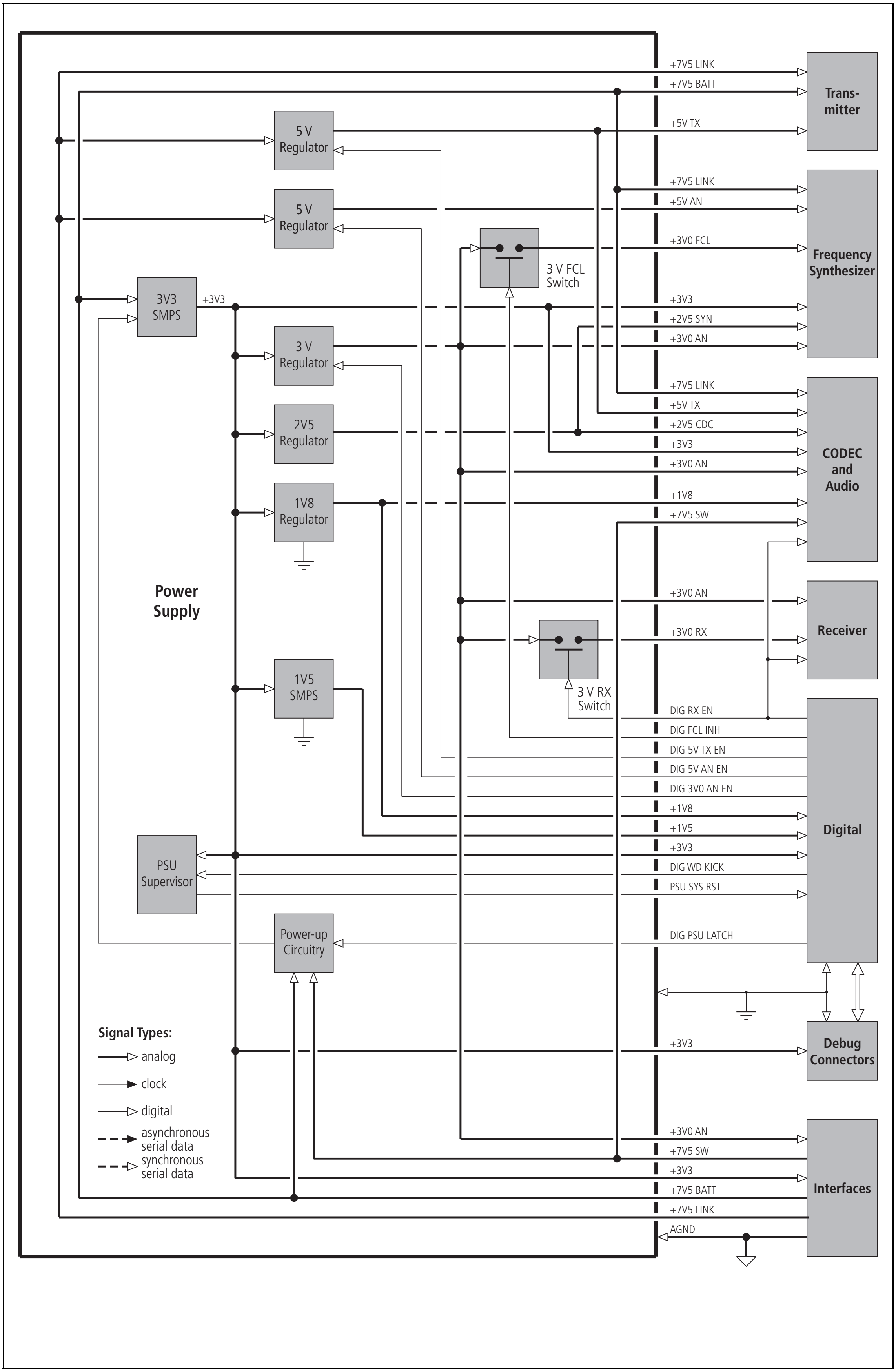
The 3V3 SMPS and the 2V5, 1V8 and 1V5 linear regulators are always on.

Table 3.3 Radio modes and internal power supplies

Internal Power Supply	Radio Mode			
	Tx	RX Audio[a]	RX Standby[b]	Economy Mode[c]
+5V TX	on	off	off	off
+5V AN	on	on	on	off/on cycling
+3V AN	on	on	on	off/on cycling
+3V RX	off	on	on	off/on cycling
+3V FCL	off	on	on	off/on cycling
Audio PA	off	on	off	off/on cycling

a. Receiving and audio PA on.
b. Receiving and audio PA off.
c. Only if programmed

Figure 3.7 Block diagram of the power supply circuitry (main boards issue 05 and higher)



3.7 Interfaces Circuitry

Introduction

For a block diagram of the interfaces circuitry, refer to Figure 3.8.

For more information on the connector pinouts, refer to "Connectors and Contacts" on page 27.

Bi-directional Lines

Bi-directional lines are provided on two pins of the accessory connector (ACC GPIO1 and ACC GPIO2). These are formed by combining two uni-directional lines. For example, the line ACC GPIO1 at pin 10 of the accessory connector is formed from ACC DIG GPI1 and DIG ACC GPO1. The circuitry is the same in both cases and is explained below for the case of ACC GPIO1.

Output Signals (ACC GPIO1)

An output on the line ACC GPIO1 originates as the 3.3V signal DIG ACC GPO1 from the digital section. The signal is first inverted by Q905 (PNP device) and the output divided down to 2.7V by internal resistors (10kΩ and 47kΩ) and R933 to drive the base of Q905 (NPN device). When the latter's collector current is low, the base current is a maximum and creates a small voltage drop across R933, causing the collector emitter to saturate. As the collector current increases, the base current decreases proportionally until the voltage across R933 reaches 2.1V. At this point the base-emitter begins to turn off and the base current diminishes rapidly. The net effect is a current-limiting action. The current limit value is approximately 18mA (the inverse of the value of R933). The output configuration is open-collector with a pull-up to 3.3V.

Input Signals (ACC GPIO1)

An input signal applied to ACC GPIO1 is coupled via R908 to ACC DIG GPI1 and fed to the digital section. As the input signal may exceed the maximum allowed by the digital section, it is clamped by D906 and a shunt regulator. The shunt regulator consists of Q900, R901 and R902 and begins to turn on at approximately 2.7V. In combination with D906, the input to ACC DIG GPI1 is therefore clamped to 3.3V nominally. The value of R908 is made large to minimize the loading effect on the output pull-up resistors.

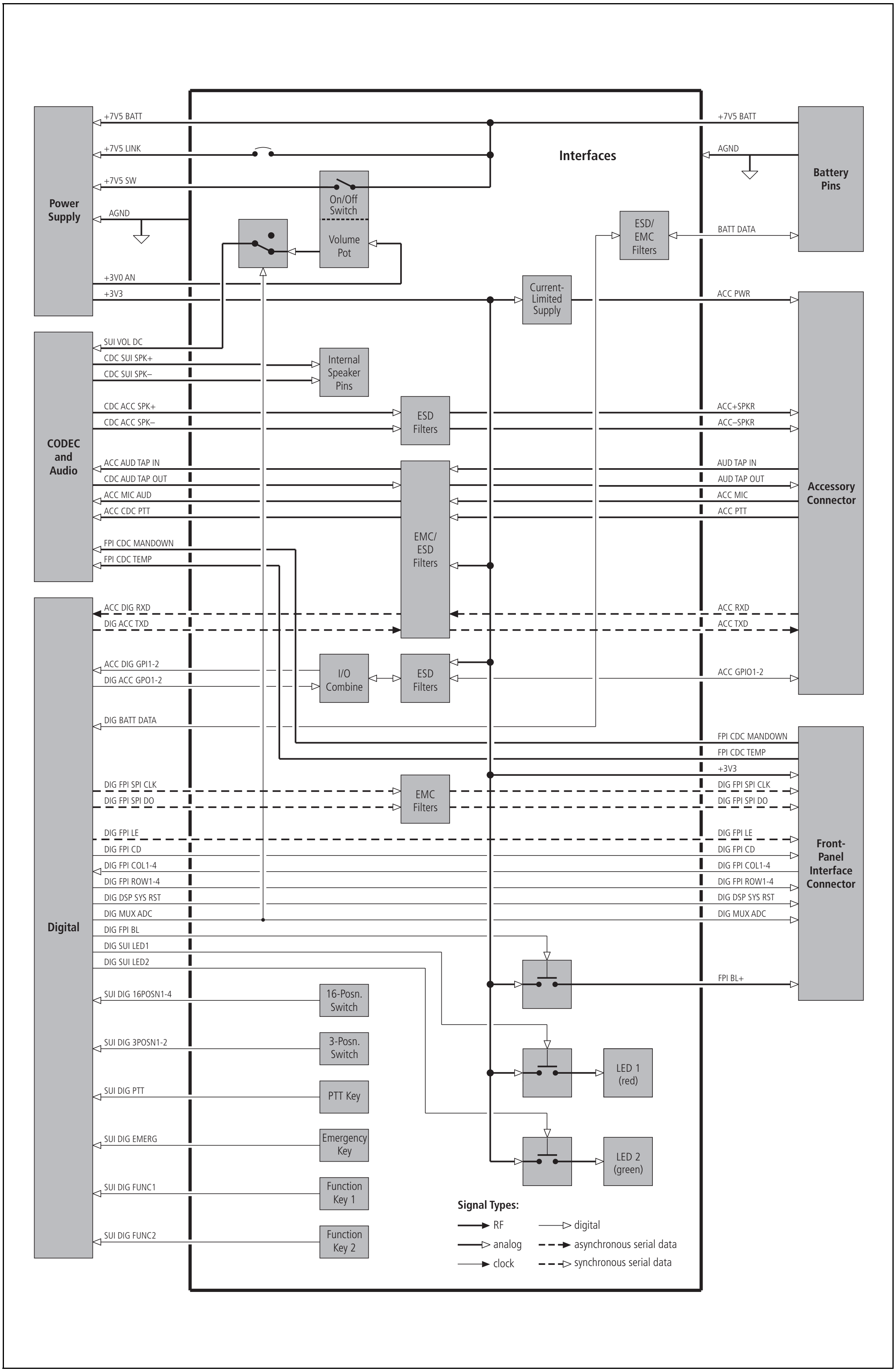
ESD Protection

On exposed inputs and outputs of the accessory and battery connectors, ESD (electrostatic discharge) protection is provided. The protection provided depends on the signal type and speed. GPIO and data signals are protected by a 470pF capacitor, series resistors and clamping diodes.
For example, on ACC_RXD this consists of C903, R903 and D900. Audio signals are protected by 10nF or 1nF capacitors (example: AUD TAP OUT consists of C909). ACC PTT is protected by a 100nF capacitor (C900) and series resistor (R906).

Accessory PTT Detection

Accessory PTT and function button signals are multiplexed in the accessory on to the ACC_PTT analog input. External button presses (EPTT, Function4, Function5 if fitted) create different DC voltages on the ACC_PTT input allowing the radio software to determine which button has been pressed. A voltage divider created by R904 and R931 ensure that the voltage on the ADC input pin of IC204 does not exceed 1.2V.

Figure 3.8 Block diagram of the interfaces circuitry



User Interface

The main board includes the circuitry for the following control elements:

- ON/OFF switch
- volume potentiometer
- status LEDs
- speaker/microphone
- PTT, function, and emergency keys

ON/OFF Switch

The radio is powered up as described in "Power-Up Circuitry" on page 68.

Volume Potentiometer

The voltage level of the volume potentiometer is converted to a digital signal by an analog/digital converter (IC204) and processed by the FPGA.

Status LEDs

The red and green status LEDs are controlled by an FPGA signal and a transistor (Q904 dual-device). Amber color is generated by turning on the red and green LEDs simultaneously.

Speaker/ Microphone

The two speaker/microphone lines (SPKR POS and SPKR NEG) are connected to the speaker through spring probe connectors. Speaker audio comes from IC200 and microphone audio is clamped and amplified through D200 and IC202.

PTT, Function, and Emergency Keys

The signals from the tact switches are connected directly to the input pins of the FPGA.

3.3V Accessory

A current limited 3.3V Accessory supply is provided on ACC_PWR output. Current is limited to approx 50mA by IC900. The current limit setpoint is determined by the value of R954. Above the current setpoint, the output voltage folds back to protect the radio and accessory from over-current.

Battery Data

A dedicated bidirectional data signal is provided on BATT DATA to allow the radio to communicate with a smart battery. After ESD and over-voltage protection though C912, D909, R930, D919 and R943 it connects to a bidirectional digital line in the digital section. In addition a 4.7kΩ pull up resistor (R721) can be switched in or out by the digital section to provide bias to the data line.

Front-Panel Keypad

The interface to the front-panel keypad is an array of four column inputs and four row inputs, giving a maximum of 16 keys. The column and row signals connect directly to the FPGA. During idle operation the ROW signals are driven low by the FPGA and the COL signals (pulled high by an external resistor) are monitored for activity by the FPGA. A key-press will generate a high-to-low transition on the associated COL signal. This, in turn, will initiate a sequence of high output levels on the ROW signals to identify which key was pressed.

LCD Module

The LCD module is physically connected to the front-panel interface board but is controlled by a serial link from the FPGA. The backlighting incorporated in the LCD module is controlled by a data line from the FPGA that switches transistor Q907. Power is supplied to the LCD module through a +3V3 signal on the front-panel interface.

Keypad Backlighting

The keypad backlighting is controlled by the same FPGA output to transistor Q907 as the LCD backlighting.

Man-Down and Temperature

Sensors on the front-panel interface board provide analog levels to indicate the status of X-axis tilt, Y-axis tilt and front-panel temperature. The tilt signals from the man-down sensor are multiplexed onto one output from the interface (FPI CDC MANDOWN). Whether this signal has X or Y sense selected is determined by DIG MUX ADC.

3.8 Digital Circuitry

Introduction

For a block diagram of the digital circuitry, refer to Figure 3.9.

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

3.9 Front-Panel Interface Circuitry

Introduction

For a block diagram of the front-panel interface circuitry, refer to Figure 3.10.

The front-panel interface circuitry is not serviceable at level-2 and is not described in this manual.

Figure 3.9 Block diagram of the digital circuitry

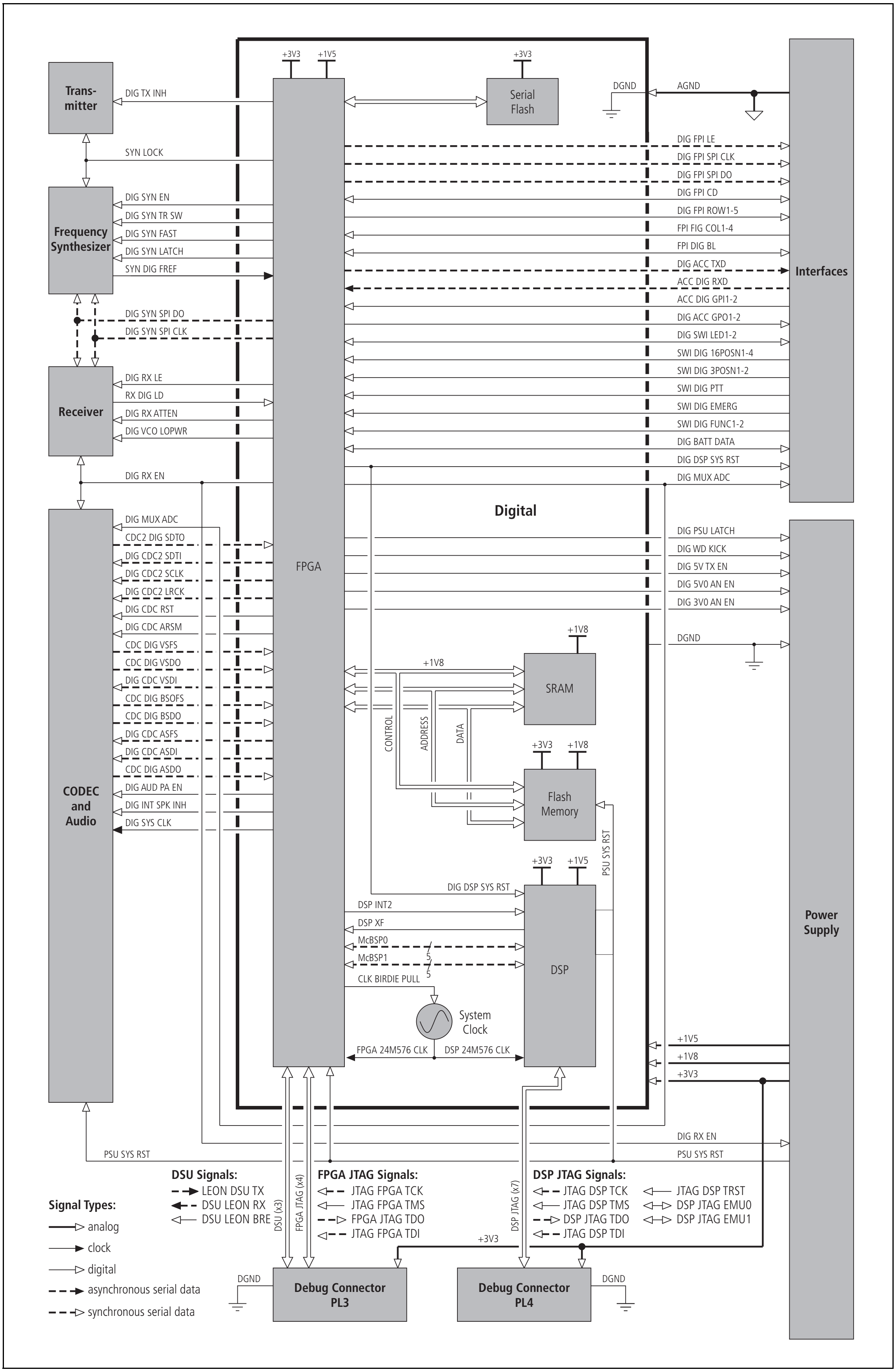
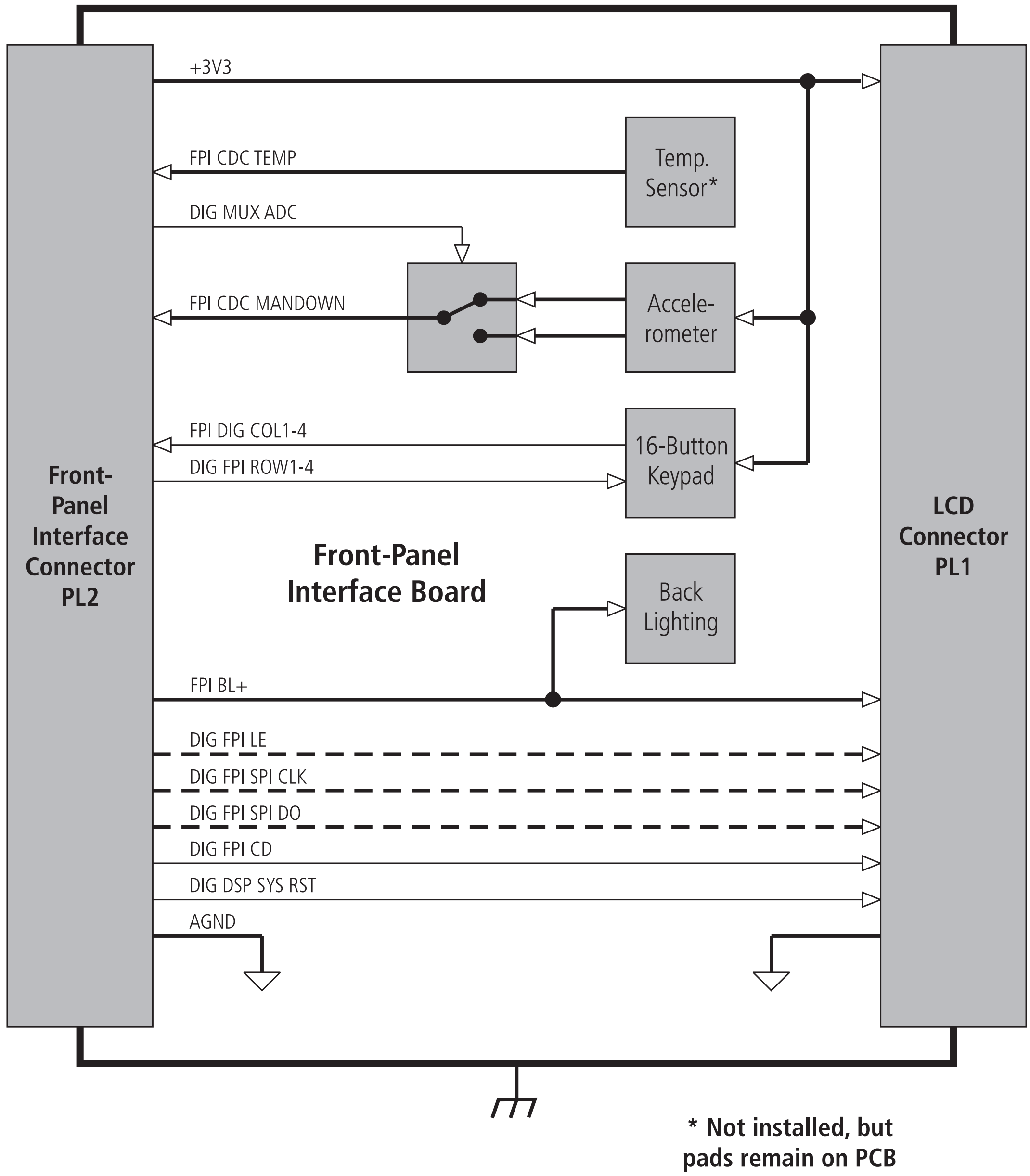


Figure 3.10 Block diagram of the front-panel interface board circuitry



Chapter 2
Servicing the Radio

Chapter 2 – Servicing the Radio

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

This manual covers level-1 and level-2 repairs of TP9100 radios.

Level-1 repairs comprise the **replacement** of main boards and other parts of the radio, including replacements of the non-SMT components:

- power/volume potentiometer
- 16-way/3-way selector switch
- antenna SMA connector.

Level-2 repairs comprise **repairs** of main boards, except for the following special items:

- digital circuitry (IC701, IC703, IC704, and IC705)
- CODEC 1 (IC204).

Important The main board is complex and should be serviced only by accredited service centers (ASC). Repairs attempted without the necessary equipment and tools or by untrained personnel might result in permanent damage to the radio.

Accreditation of Service Centers

Service centers that wish to achieve Accredited Service Center (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 centers 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 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. 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 center, certain torque drivers are required as well as a service kit.

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.

Website Access

To carry out level-1 and level-2 repairs, service centers need access to the secured portion of the Tait Technical Support website (http://support.taitworld.com). There are different access levels; those required for level-1 and level-2 repairs are:

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

Log-in passwords are needed for associate and Tait-only access; Technical Support supplies service centers 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 on the website is summarized in the following list. The PCB information is discussed in more detail below.

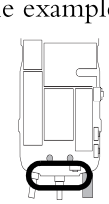
Note Access to some types of information will depend on your level of accreditation. Contact your nearest Customer Service Organization for more details.

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

PCB Information

All PCBs are identified by a unique 10 digit IPN (internal part number) which is printed onto the PCB, as shown in the example below.

220-01735-05



The last two digits of this number define the issue status, which starts at 01 and increments through 02, 03, 04 etc. as the PCB is updated.

PCB information for a particular circuit board consists of the relevant BOMs, PCB layouts, and circuit diagrams. Contact your nearest Customer Service Organization for more details on the availability of PCB information.

Tait FOCUS Database

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

4.2 Tools, Equipment and Spares

Torque-drivers

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

- Torx T6, and Torx T10 driver bits
- modified 3/16 inch (8mm) long-reach socket bit (IPN 355-00000-21).

Refer to the illustrations in "Disassembly and Reassembly" on page 103 for the corresponding torque values.

Tools for SMT Repairs

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

Test Equipment

The following test equipment is required for servicing the radio:

- test PC (with programming and calibration applications loaded)
- RF communications test set (audio bandwidth of at least 10kHz)
- oscilloscope
- digital current meter (capable of measuring up to 20A)
- multimeter
- DC power supply (capable of 7.5V and 3A)
- 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.

Service Kit

The service kit contains all the items needed for connecting the radio to the test equipment. The setting up of the equipment is described in "Test Equipment Setup" on page 88. The service kit also includes a service 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 4.1.

Note The characters **xx** below stand for the issue number of the manual. Only the latest issue of each manual will normally be available for ordering.

Table 4.1 Contents of service kit (TMAA24-00)

Product code	Item
TOPA-SV-006	RF cable
TPA-SV-005	Battery eliminator (power supply adaptor)
TPA-SV-007	Programming cable adapter(RJ12 socket to TP9100)
TPA-SV-011	Calibration cable (DB15 socket to TP9100)
TPA-SV-006	Programming cable (DB9 socket to RJ12 plug)
T950-001	USB to serial adapter (USB 1.1 to serial DB9 pin)
TOPA-SV-024	Test unit
TOPA-SV-011	Service tools (including the modified 3/16 inch (8 mm) long-reach socket bit)
MPA-00005-**xx**	Service manual
MPA-00011-**xx**	PCB information
TMAA24-01	Service CD
The following components are included in the service kit, but are used for TM9100 mobile radios only:	
TMAA21-01	Calibration cable (DB15 socket to RJ45 plug plus speaker connector)
TMAA23-02	Power cable (40W/50W power connector to banana plugs plus speaker connector)
TMAA20-03	Power cable (25W power connector to banana plugs plus speaker connector)
TMAA20-04	Programming cable (RJ12 socket to RJ45 plug)
MMA-00017-**xx**	Service manual
MMA-00026-**xx**	PCB information

4.3 Servicing Precautions

Introduction

This section 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 familiarize 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. The illustrations in "Reassembling the Radio" on page 114 show the correct torque values for the different screws and nuts.

Non-Scratch Bench Tops

Use workbenches with non-scratch bench tops so that the mechanical parts of the 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 seals are fitted correctly when reassembling the radio.

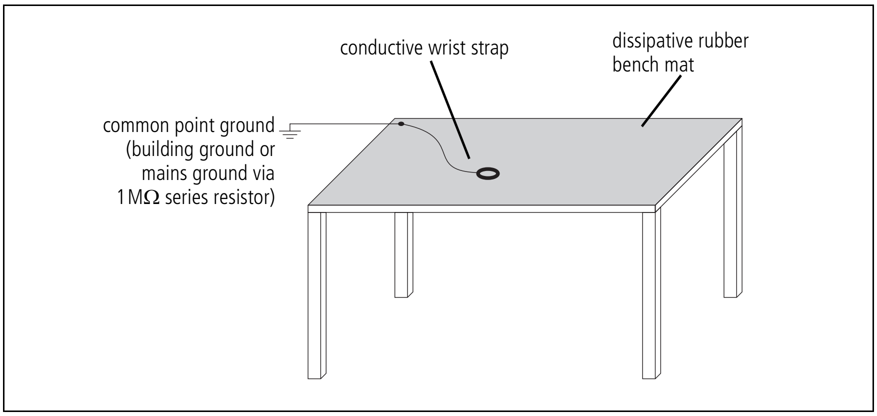
ESD Precautions

Important This equipment contains devices which are susceptible to damage from static discharges. You must handle these devices carefully and according to the procedures described in the manufacturers' data books.

We recommend you purchase an antistatic bench kit from a reputable manufacturer and install and test it according to the manufacturer's instructions. Figure 4.1 shows a typical antistatic bench set-up.

You can obtain further information on antistatic precautions and the dangers of electrostatic discharge (ESD) from standards such as ANSI/ESD S20.20-1999 or BS EN 100015-4 1994. The Electrostatic Discharge Association website is http://www.esda.org/.

Figure 4.1 Typical antistatic bench set-up



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 ground. 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 burns
- antenna loading
- test transmissions
- accidental transmissions
- distress beacons

The precautions required in each case are given below.

Caution **Avoid RF burns. Do not touch the antenna while the transmitter is operating.**

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

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

4.4 Test Equipment Setup

Introduction

This section 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
- basic programming and calibration tasks
- invoking CCTM (computer-controlled test mode)
- summary tables of CCTM commands and error codes
- visual and audible indications provided by radio

Connect Equipment

Connect the test equipment to the radio as shown in Figure 4.2. Use the test unit, cables and adaptor of the service kit. Refer to "Tools, Equipment and Spares" on page 83 for details of the test equipment and service kit. The test unit is described in "TOPA-SV-024 Test Unit" on page 345.

For testing receive and transmit functions respectively, the switches of the test unit 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".)

Settings for Receive Tests

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

- HOOK switch : "OFF HOOK"
- 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 16Ω 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:

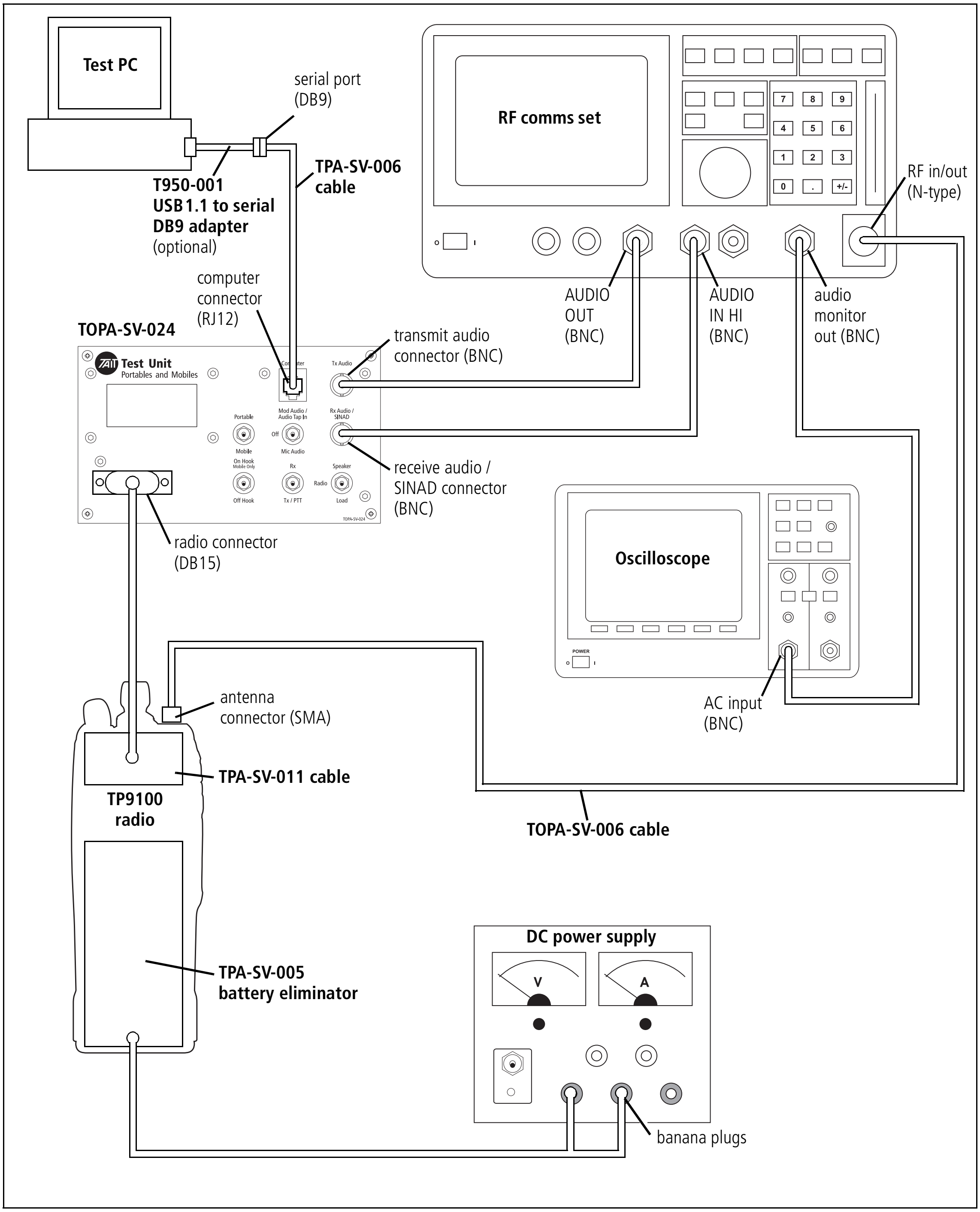
- HOOK switch : "OFF HOOK"
- MODE switch : "RX" initially
- AUDIO IN switch : "MIC AUDIO"
- AUDIO OUT switch: (immaterial)

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 radio.

Service CD

Install the programming and calibration applications on the test PC. These applications are included on the service CD supplied with the service kit.

Figure 4.2 Test setup



4.5 Replacing Main Board Components

This section describes the procedure for obtaining the correct replacement for any faulty component on the main board.

- identify version of PCB information applicable to board
- identify replacement component in BOM of PCB information
- 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

Identify the IPN of the PCB and compare the issue number with that in the PCB information supplied with the service documentation.

Note The IPN is the ten-digit number printed at one corner of the board. The last two digits in the IPN represent the issue number of the PCB.

If the issue numbers match, consult the BOM as described below. If the issue number indicates that the board is either an earlier or a later version, obtain the PCB information for the board under repair from the Technical Support website (support.taitworld.com).

Tip Print and store a copy of every PCB information published on the Technical Support website.

Identify Replacement Component

After locating the correct PCB information for the board, consult the BOM for the board. Identify the component in question in the BOM.
Note, however, that a new PCB information 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 as described below.

Consult Technical Notes

A technical note about each major change is published on the Technical Support website (support.taitworld.com). Technical notes giving details of any intervening minor but important changes are also published. It is advisable to print and store a copy of every technical note published.

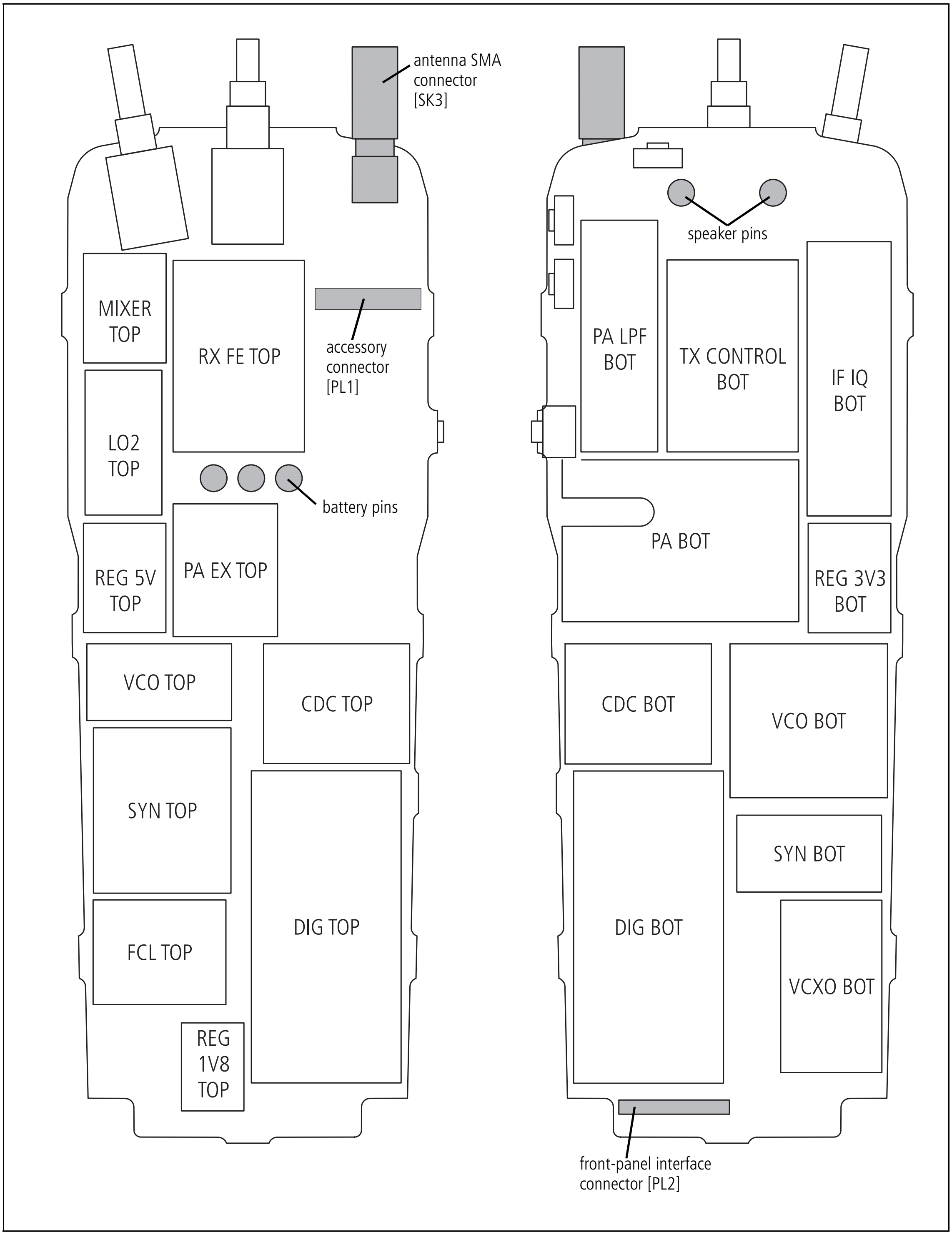
Obtain Replacement Component

Determine if the required replacement component is included in one of the spares kits. (Check with TEL regarding the availability of the kit.)
If the required component is not included in a 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.

4.6 Shielding Cans and Connectors

The shielding cans on the top- and bottom-side of the main board are identified in Figure 4.3. The figures also show the locations of the connectors on the board.

Figure 4.3 Shielding cans and connectors



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 centers.

Spare Cans

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

4.7 SMT Repair Techniques

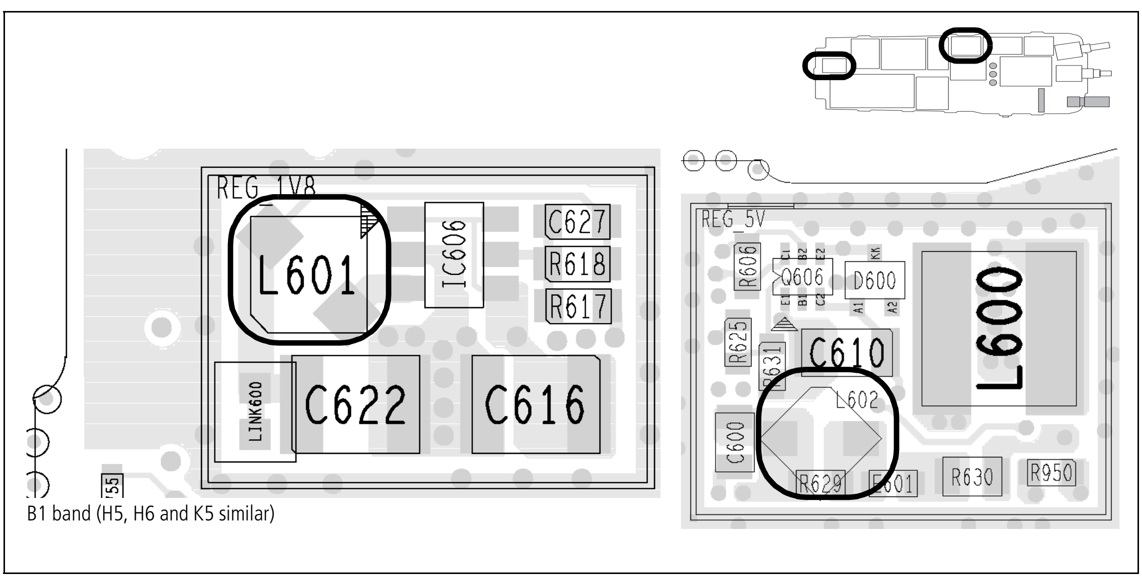
Standard Procedures

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

Non-standard Procedures

Do not use the standard SMT repair techniques when replacing the inductors L601 and L602. The standard techniques tend to produce excessive heat, which will damage these components. Do not use a hot-air tool or heat gun. Instead use solder paste and a standard soldering iron with an iron tip with a specified temperature of 600 °F (315 °C). These inductors are part of the SMPS of the power-supply circuitry on the bottom-side of the board. Figure 4.4 on page 92 shows the locations of the components.

Figure 4.4 Locations of the inductors L601 and L602 (top side)



4.8 Computer-Controlled Test Mode (CCTM)

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 4.2 to Table 4.7, grouped according to category.

Terminal Program for CCTM

Use the calibration application to place the radio in CCTM. To do this, run the calibration application, select *Tools > CCTM*, and click the *CCTM Mode* button. For more information, refer to the online help of the calibration application.

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

1. Open the terminal program. (In the case of HyperTerminal, click *Start* > *Programs* > *Accessories* > *Communications* > *HyperTerminal*.)
2. In the terminal program first select the COM port to which the 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.

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 after 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 *Test Mode* appears on the radio display. This implies that the radio has entered CCTM. If the attempt fails, repeat Steps 1 to 3.

Table 4.2 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 internal 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=internal speaker/microphone]; 1=accessory 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 (such as *r10*, *t3* or *t4*) and ***y*** the tap type (A=bypass in, B=combine, E=splice) (the default is A when ***y*** is omitted). **Note:** only the above tap in points are valid in P25 digital mode.	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 (such as *r1*) and ***y*** the tap type (C=bypass out, D=split, E=splice) (the default is D when ***y*** is omitted) **Note:** only the above tap out point is valid in P25 digital mode.	None

Table 4.3 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*	*QPA1F_**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*	*QPA1B_**x**_**y*** where ***x*** is a three-character identifier and ***y*** the version number
98 – FPGA version Reads the version number of the FPGA	*98*	*QPA1G_**x**_**y*** where ***x*** is a three-character identifier and ***y*** is the version number
133 – Hardware version Reads the product code of the radio body and the hardware version number	*133*	*TPAB1x-**y**_**z*** where ***y*** is the last four characters of the product code and ***z*** is the version 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 ID	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*	*System Error Dump* *System Error Number:* ***x*** ***y*** where ***x*** is the hexadecimal error number and ***y*** is associated data such as a firmware file and line reference.

Table 4.4 CCTM commands in the frequency-synthesizer and receiver categories

Command	Usage	
	Entry at keyboard	Response on screen
Frequency-synthesizer category		
72 – Lock status Reads the lock status of the RF PLL, FCL and LO2 respectively	*72*	***x y z*** where ***x*** is the RF PLL, ***y*** the FCL, and ***z*** the LO2 lock status (0=not in lock, 1=in lock)
101 – Radio frequencies Sets the transmit 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 in dB

Table 4.5 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
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
	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
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)	None
331 – Final bias 1 Sets or reads the bias voltage for the 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
803 – Temperature Reads the temperature in the vicinity of the front panel and PA	*803*	*FPI=**x** TX=**y*** where ***x*** is the temperature near the front panel and ***y*** is the temperate near the PA. To convert to °C, use this formula: temp=(**x** or **y**/-2.37)+160

Table 4.6 CCTM commands for the user interface

CCTM command	Entry at keyboard	Response on screen
50 - Key presses Switches on or off the facility for detecting the following user controls: on/off switch, 16-way selector, 3-way selector, function keys, emergency key, PTT key, left and right selection keys, scroll keys, and alphanumeric keys	50 1=key press detection on 50 0=key press detection off	***x*** where x is the serial output from the detection facility
325 - Toggle status LED Switches the status LED between various states	*325 0*=LED off *325 1*=LED red *325 2*=LED green	none
327 - LCD and keypad backlighting Activates the LCD and keypad backlighting	*327 1*=turn LCD and keypad backlighting on *327 0*=turn LCD and keypad backlighting off	none
513 - Generate audible indicator Sounds a programmed audible indicator on the radio	*513* ***x*** where ***x*** is an integer from 1 to 85	none
804 - Read volume potentiometer Returns the current volume pot level	*804*	***x*** where ***x*** is the raw volume pot ADC value. This reading is inversely proportional to the set volume level, and will be approximately 100 to 950.
820 - Battery monitoring Start or stops a log of battery information such as voltage and temperature	*820 1*=start log of battery information (returned every ten seconds) *820 0*=stop log	Charging, Temp, PackV, SubPackV, Current, PackT, Cap, DisT, EndOfChargeT, LastCapM, CapCorrection, LastChargeT, StatusMsg
855 - LCD Alters or resets the radio's LCD	*855* ***x*** where ***x*** is the command for the LCD (0 to 255, for example, 165 turns all pixels on, 164 reverts to normal pixel display, 167 inverts display, 166 turns invert off, 65 to 127 sets display start address)	none

Table 4.7 CCTM commands for digital P25 mode

CCTM command	Entry at keyboard	Response on screen
700 - Radio mode Sets the radio's mode of operation (analog FM or digital P25)	*700* ***x*** where ***x*** is the mode (0=analog FM mode, 1=digital P25 mode)	none
714 - Transmit P25 test pattern Transmits a 1011Hz audio tone test pattern	*714 4*	none

CCTM Error Codes

Once the radio is in CCTM, the CCTM commands may be entered as shown in Table 4.2 to Table 4.7. 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 4.8.

Table 4.8 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 ^.

4.9 Visual and Audible Indications

Visual and audible indicators give information about the state of the radio. Visual indications are provided by the status LED and LCD display.
The information conveyed by the status LED is listed in Table 4.9.
The LCD display normally displays channel and user information, or error messages. For more information on the LCD display during normal operation, refer to the user's guide. The error messages are listed in Table 6.1 on page 133. Audible indications are provided in the form of different tones emitted from the speaker. The information conveyed by the tones is given in Table 4.10 on page 101.

Table 4.9 Visual indications provided by the status LED

LED color	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 cannot transmit because the channel is busy (3) The battery is low (4) The radio is ready to use (on power-up)
Green	Receive and monitor	LED is on	There is activity on the current channel, although it might not be audible
		LED flashes	The monitor or squelch override has been activated
Amber	Scanning	LED flashes	The radio has detected activity on a certain channel and scanning has halted on this channel

Table 4.10 Audible indications

Type of tone	Meanings
One short beep	(1) On power-down — Radio is off (2) On pressing key — Key-press is valid (3) On pressing function key — Function has been initiated (4) While inserting radio in charger — Battery charging has commenced. (5) While removing radio from charger — Battery charging has stopped
One short low-pitched beep	On pressing function key again — Function has been terminated
One short high-pitched beep	Repeated beep every ten seconds while powered up — Battery level is low.
One long low-pitched beep	(1) On pressing key — Key-press is invalid (2) On pressing PTT switch — Transmission is inhibited (3) While powered up — Battery is flat
Two short beeps	On power-up — Radio is ready to use
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 display *Out of Lock.*
Continuous low-pitched tone	While powered up — System error has occurred and radio might be inoperable; LCD usually displays *E1* or *E2*.

5 Disassembly and Reassembly

Overview

This section describes how to:

- remove and fit the battery
- disassemble and reassemble the battery catch
- disassemble and reassemble the radio

General

Important Before disassembling the radio, disconnect the radio from any test equipment or power supply.

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

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

Observe the torque settings indicated in the relevant figures.

For information on spare parts, refer to "Spare Parts" on page 297.

5.1 Removing and Fitting the Battery

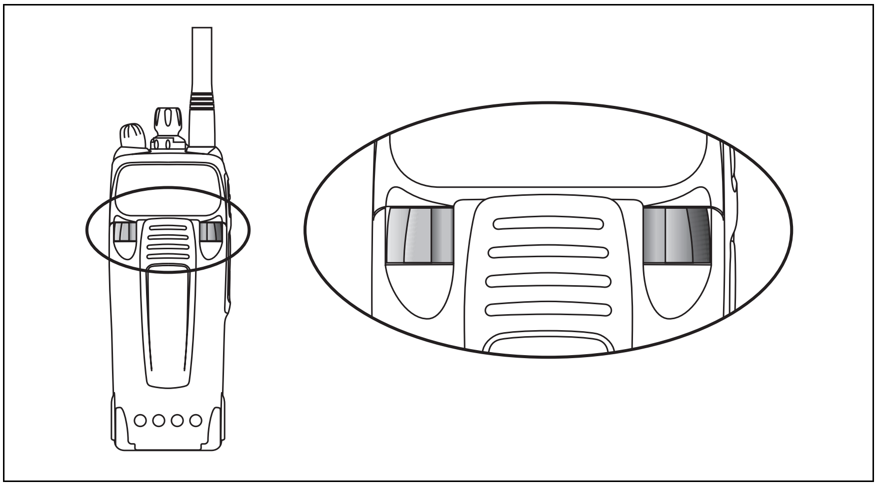
Removing the Battery

1. Simultaneously squeeze both battery catches inwards to release the catch mechanism.
2. Tilt the top of the battery outwards and lift the lugs at the bottom of the battery out of the holes at the bottom of the radio.

Fitting the Battery

1. Insert the lugs at the bottom of the battery into the holes at the bottom of the radio.
2. Push the top of the battery towards the radio until the catch mechanism snaps in.

Figure 5.1 Removing the battery from the radio



5.2 Disassembling the Battery Catch

Reassembly is carried out in reverse order of the disassembly.

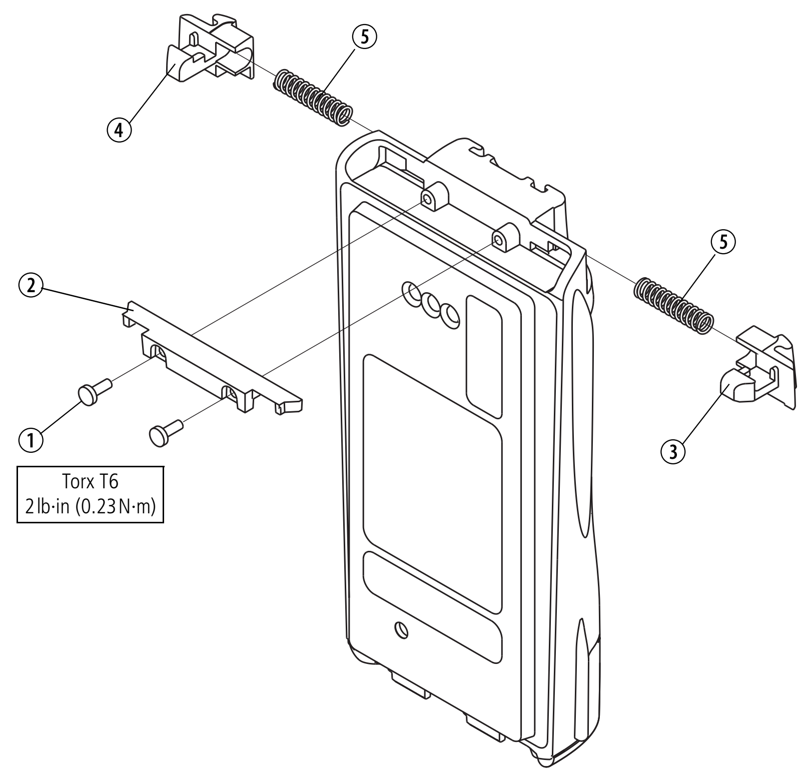
The circled numbers in this section refer to the items in Figure 5.2.

1. Undo the two screws ① and remove the battery catch support bracket ②.

Note The left battery catch ③ and the right battery catch ④ are symmetrical but different parts.

2. Remove the left battery catch ③, the right battery catch ④, and the two springs ⑤.

Figure 5.2 Components of the battery catch



① Torx T6 screw K1.8x5 PT (x2)

② battery catch support bracket

③ left battery catch

④ right battery catch

⑤ battery catch spring (x2)

5.3 Disassembling the Radio

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

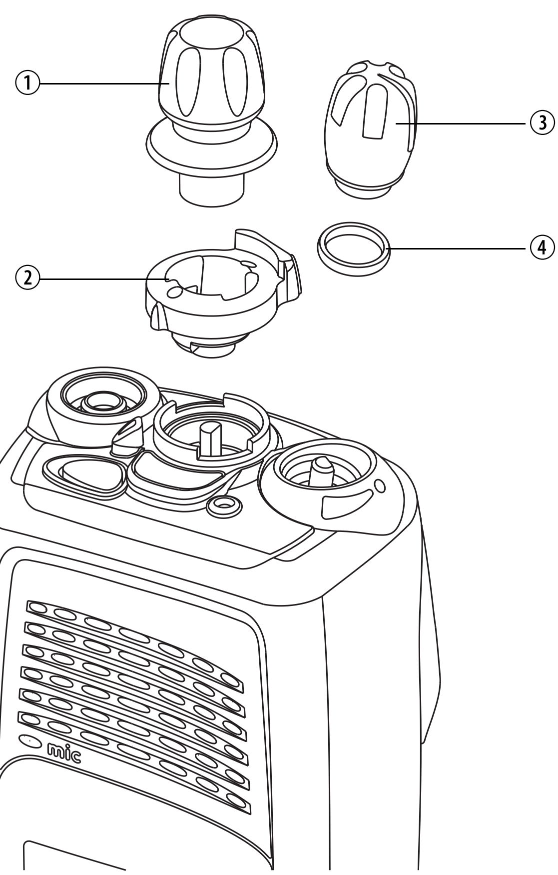
For reassembly instructions, refer to “Reassembling the Radio” on page 114.

Removing the Knobs and the 3-way Actuator

The circled numbers in this section refer to the items in Figure 5.3.

1. With your fingers, pull off the volume knob ③.
2. Inspect the volume knob seal ④ and replace it, if necessary.
3. With your fingers, pull off the channel knob ①.
4. With your fingers, pull off the 3-way actuator ②.

Figure 5.3 Removing the knobs and the 3-way actuator



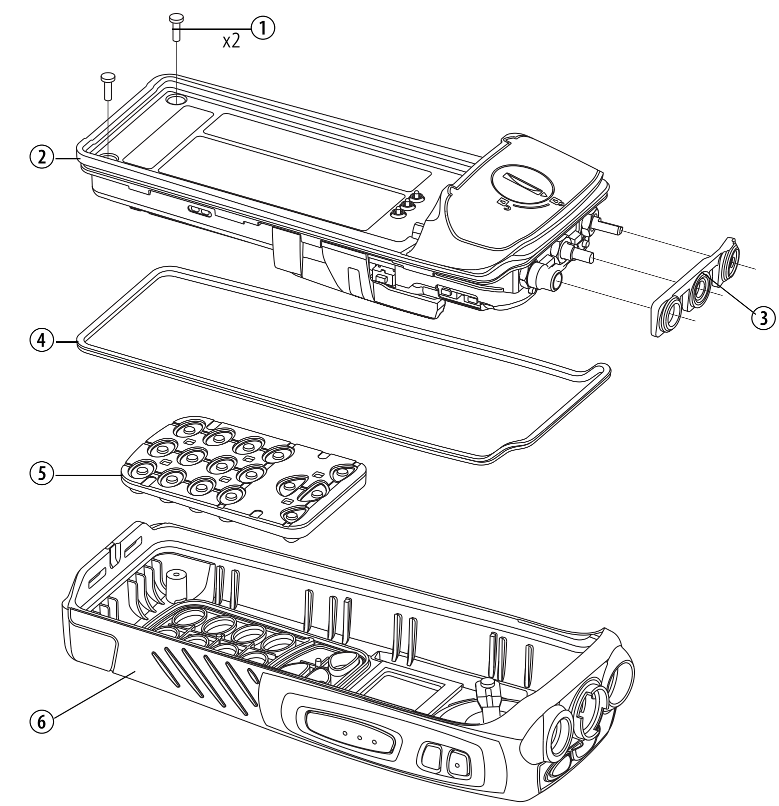
① channel knob
② 3-way actuator
③ volume knob
④ volume knob seal

Removing the Chassis from the Front Panel

The circled numbers in this section refer to the items in Figure 5.4.

1. If fitted, remove the battery and unscrew the antenna.
2. Use a Torx T6 screwdriver to remove the two screws ①.
3. While holding the radio with the chassis facing down, tap the bottom end of the radio on the workbench. Remove the chassis assembly ② from the front-panel assembly ⑥.
4. Remove the top seal ③.
5. Inspect the main seal ④ and replace it if necessary.
6. Remove the keypad ⑤.

Figure 5.4 Removing the chassis from the front panel



① Torx T6 screw M2x8 (x2)	④ main seal
② chassis assembly	⑤ keypad
③ top seal	⑥ front-panel assembly

Removing the Main-Shield Assembly

The circled numbers in this section refer to the items in Figure 5.5 on page 109.

1. Remove the LCD frame ① from the main-shield assembly ③.

Important Do not try to separate the LCD assembly from the main-shield assembly.

2. Remove the two speaker pin frames ②.

3. To separate the main shield assembly ③ from the chassis:

   a. Insert a small screwdriver into the recess point of the chassis adjacent to the catches engaging the main-shield assembly (see detail in Figure 5.5)

   b. Carefully separate the main-shield assembly from the chassis.

   Note the two locating holes at the top of the main-shield assembly which fit over two locating pins at the top of the chassis.

4. Release the lock of the front-panel interface connector at the bottom of the main board ⑤ and unplug the front-panel loom.

Removing the Main Board

The circled numbers in this section refer to the items in Figure 5.5 on page 109.

1. Use a Torx T6 screwdriver to remove the screw ④ fastening the main board ⑤ to the chassis ⑧.

2. Use a screwdriver with the modified 5/16 inch (8mm) long-reach socket to remove the SMA nut ⑨ and the two knob nuts ⑩.

3. Hold the main board at the bottom break-off points and pull it upwards to separate it from the chassis.

Important Do not move the main board past the maximum extension of the flexible accessory board before disconnecting it from the accessory connector.

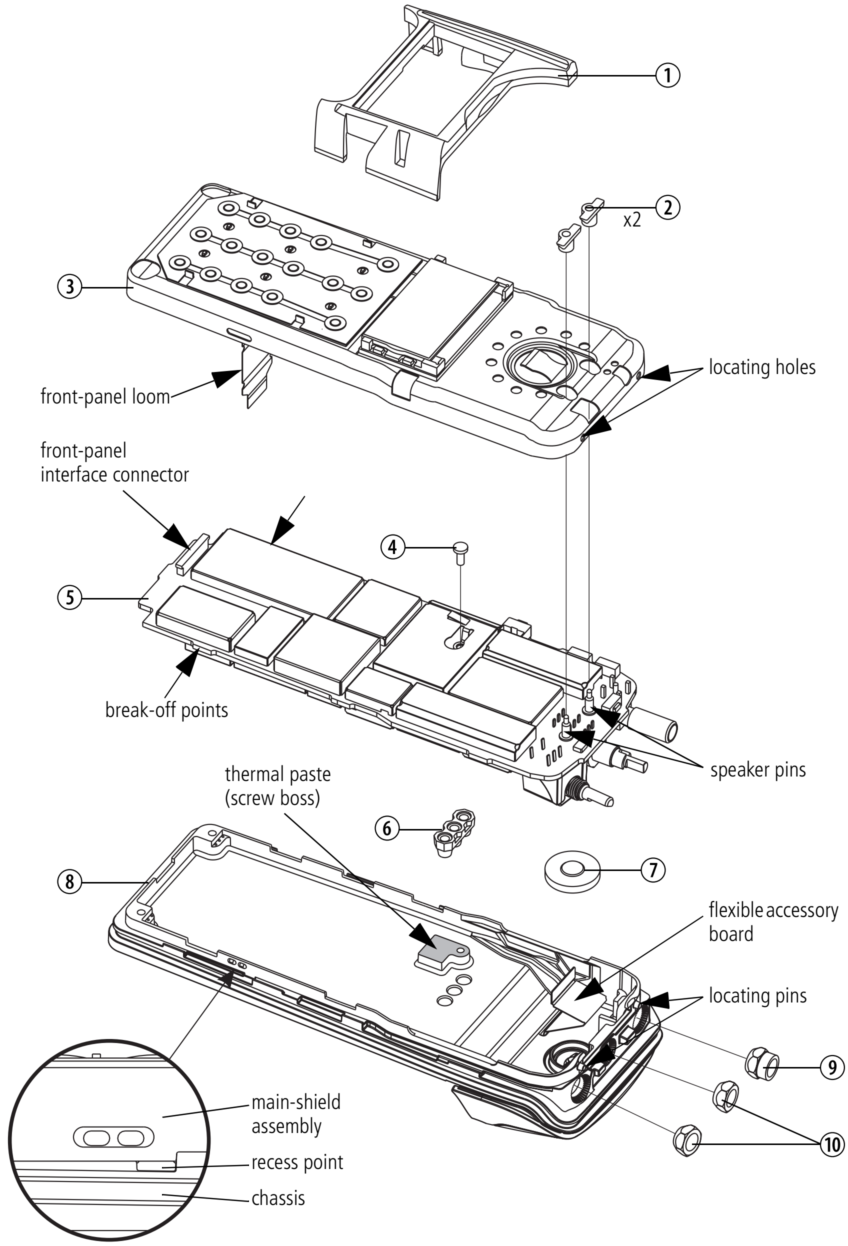
4. Use rubber-nose pliers to disconnect the flexible accessory board from the accessory connector [PL1] on the underside of the main board.

Note Make sure not to touch the thermal paste on the screw boss of the chassis and the underside of the main board. If the thermal paste is contaminated, you must re-apply thermal paste as described in "Reassembling the Radio" on page 114.

5. Remove the battery pin seal ⑥.

6. If necessary, remove the chassis plug seal ⑦.

Figure 5.5 Removing the main-shield assembly and the main board



1 LCD frame	6 battery pin seal
2 speaker pin frame (x2)	7 chassis plug seal
3 main-shield assembly	8 chassis
4 Torx T6 screw M2 x 5	9 SMA nut
5 main board	10 knob nut (x2)

Removing the LCD Assembly and the Front-Panel Loom

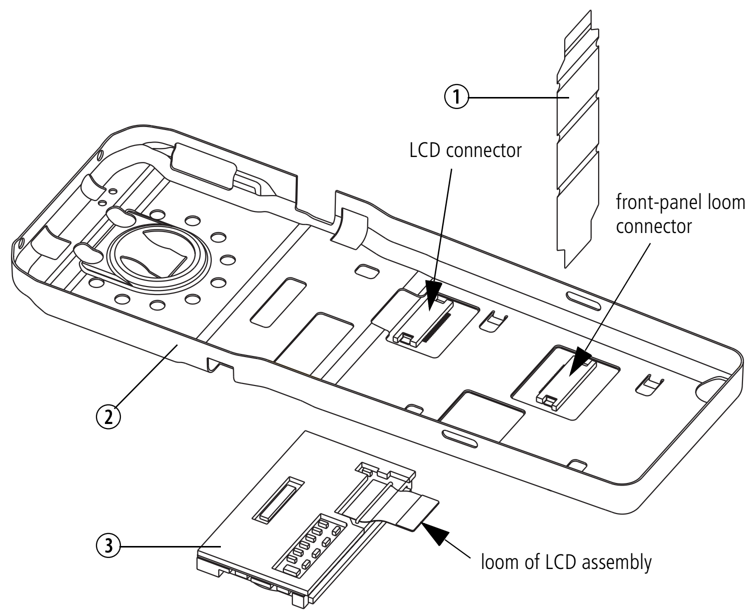
The circled numbers in this section refer to the items in Figure 5.6.

1. Release the lock of the LCD connector on the back of the main-shield assembly ② and unplug the loom of the LCD assembly ③.

2. Remove the LCD assembly ③.

3. Release the lock of the front-panel loom connector and disconnect the front-panel loom ①.

Figure 5.6 Removing the LCD assembly and the front-panel loom



① front-panel loom

② main-shield assembly

③ LCD assembly

Removing the Rear Panel and the Flexible Accessory Board

The circled numbers in this section refer to the items in Figure 5.7.

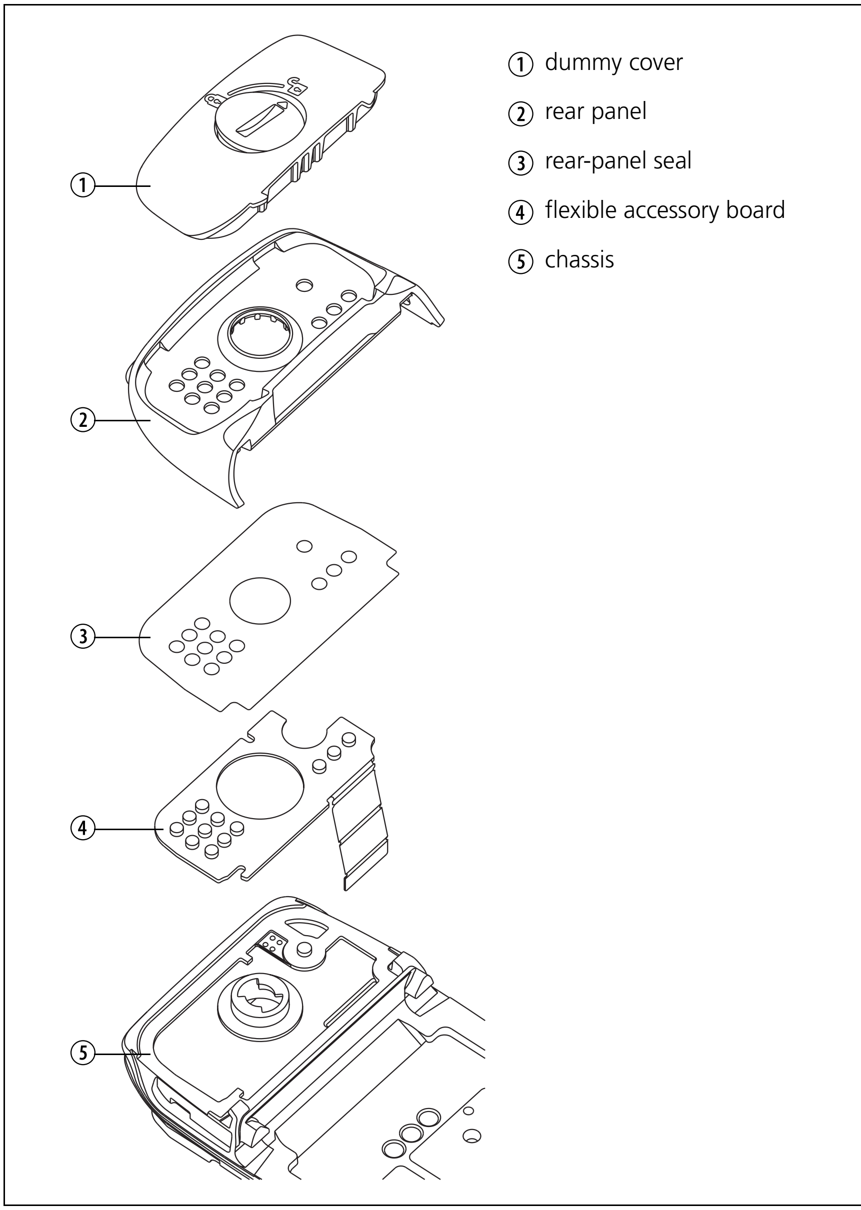
1. Turn the lock of the dummy cover ① clockwise by a quarter turn, and remove the dummy cover.

2. With two thumbs, push the top of the rear panel ② off the chassis ⑤, and unclip the rear panel. If necessary, carefully insert a flat-bladed screwdriver at the top between the rear panel and the chassis.

3. Remove the rear-panel seal ③. The rear-panel seal is self-adhesive and must be replaced each time it is removed.

4. Remove the flexible accessory board ④.

Figure 5.7 Removing the rear panel and the flexible accessory board



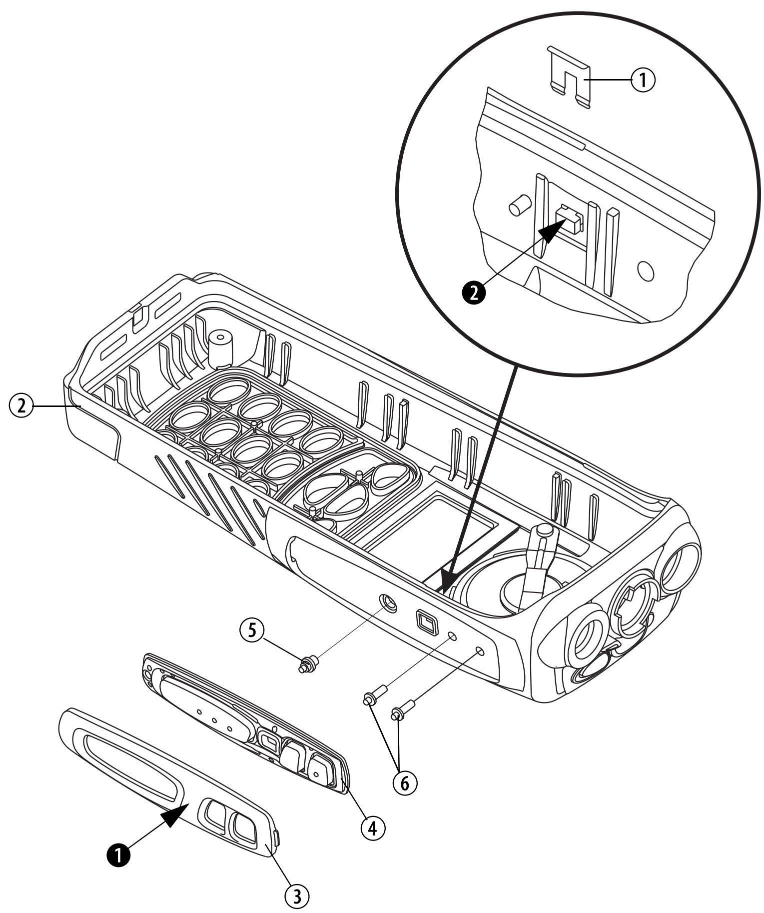
Removing the PTT Keypad

The circled numbers in this section refer to the items in Figure 5.8.

Important When removing the PTT lock spring ①, care must be taken to avoid damaging the mating surface for the main seal inside the front-panel assembly.

1. While pushing on the ridge (❶) between the PTT key and the lower function key, use pliers to remove the PTT lock spring ①.
2. Place a small screwdriver on the T-shaped protrusion (❷) on the inside of the PTT frame ④, and push the PTT frame off the front panel ②.
3. Remove the PTT keypad ③ from the PTT frame ④.
4. Remove the blue PTT pressel ⑤ and the two red function key pressels ⑥.

Figure 5.8 Removing the PTT keypad



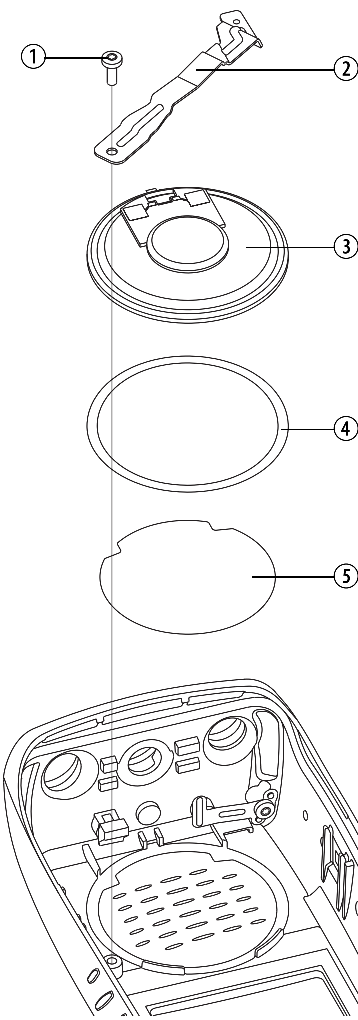
① PTT lock spring
② front-panel assembly
③ PTT frame
④ PTT keypad
⑤ PTT pressel
⑥ function key pressel (x2)

Removing the Speaker

The circled numbers in this section refer to the items in Figure 5.9.

1. Use a Torx T6 screwdriver to unscrew the screw ① and remove the speaker clamp ②.
2. Use a small flat-bladed screwdriver to remove the speaker ③.
   The speaker adhesive ring ④ must be replaced each time the speaker is removed.
3. If necessary, remove the speaker cloth ⑤.

Figure 5.9 Removing the speaker



① Torx T6 screw K1.8x5 PT

② speaker clamp

③ speaker

④ speaker adhesive ring

⑤ speaker cloth

5.4 Reassembling the Radio

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

Fitting the Speaker

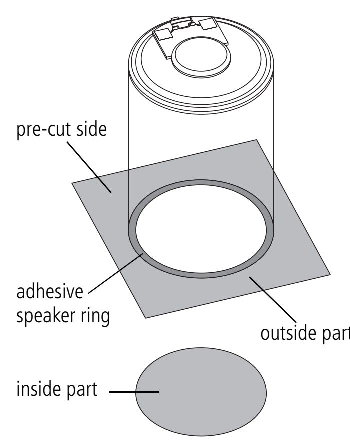
The circled numbers in this section refer to the items in Figure 5.10 on page 115.

1. Use alcohol to remove any adhesive residue left by the old adhesive speaker ring ④.

2. If the speaker cloth ⑤ has been removed, peel the new speaker cloth off the backing, and evenly press the speaker cloth on the contact surface inside the recess of the front panel.

3. Place the front of the new speaker ③ on sandpaper (grain 800 to 1000) and lightly sand the front rim in a figure-8 pattern.

4. The new adhesive speaker ring is provided on a sheet with backing on both sides and pre-cut on one side. To fit the adhesive speaker ring to the speaker:
   a. Remove and discard the inside part by pushing it through the adhesive speaker ring.
   b. Peel off the backing of the adhesive speaker ring on the pre-cut side.
   c. Press the speaker onto the adhesive speaker ring.
   d. Push the speaker and the adhesive speaker ring through the outside part.
   e. Peel off the second backing of the adhesive speaker ring.

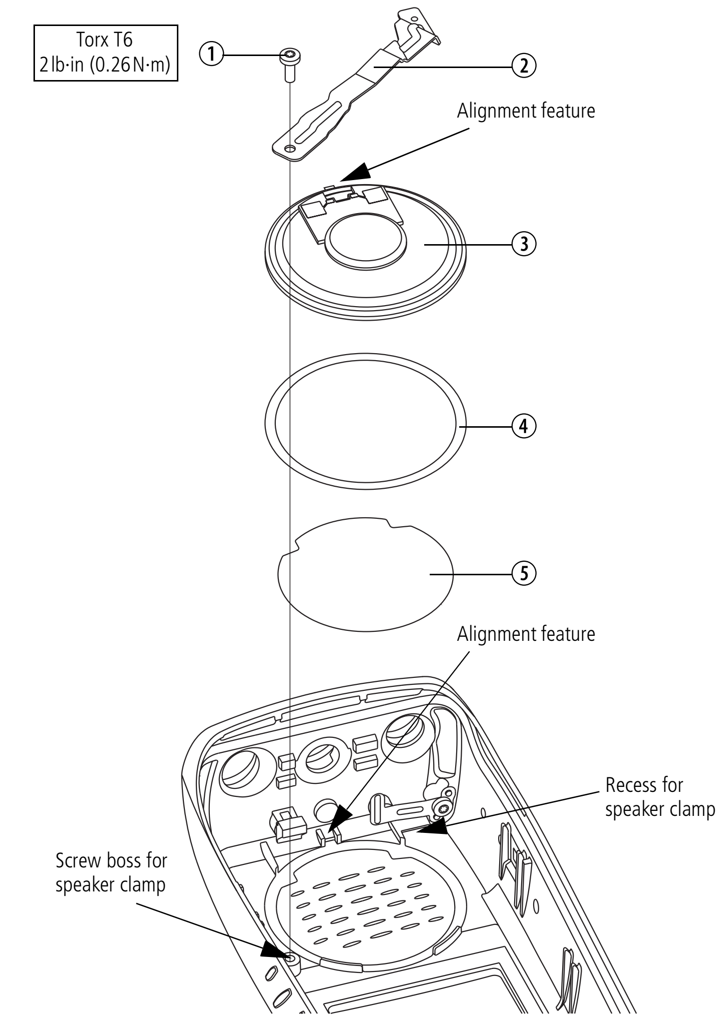


5. Place the speaker into the recess of the front panel. Ensure that the terminals face up to the alignment feature. Press down hard over the entire perimeter for ten seconds.

6. Inserting the top of the speaker clamp ④ into the recess inside the top of the front panel.

7. Use a Torx T6 torque-driver to tighten the screw ④ to 2lb·in (0.23N·m).

Figure 5.10 Fitting the speaker



① Torx T6 screw K1.8x5 PT	④ speaker adhesive ring
② speaker clamp	⑤ speaker cloth
③ speaker	

Fitting the PTT Keypad

The circled numbers in this section refer to the items in Figure 5.11 on page 117.

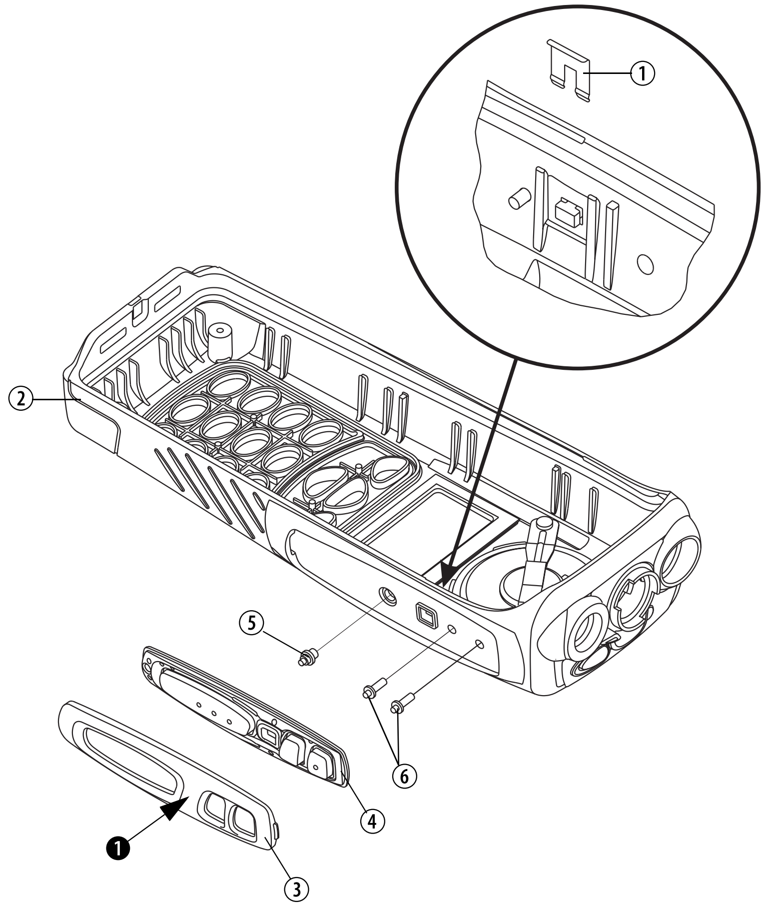
1. Insert the blue PTT pressel ⑤ and the two red function key pressels ⑥ in the side of the front panel ②.

2. Insert the PTT keypad ④ into the PTT frame ③.

3. Fit the PTT frame ③ and the PTT keypad ④ to the front panel ② by first inserting the bottom tab, then bending the PTT frame slightly to allow the top tab to slide in.

4. While pushing on the ridge between the PTT key and the lower function key (❶), use pliers to fit the PTT lock spring ① over the PTT keypad's T-shaped protrusion on the inside of the front panel (see detail in Figure 5.11). The PTT lock spring can only be inserted one way.

Figure 5.11 Fitting the PTT keypad



1. PTT lock spring
2. front-panel assembly
3. PTT frame
4. PTT keypad
5. PTT pressel
6. function key pressel (x2)

Fitting the Flexible Accessory Board and the Rear Panel

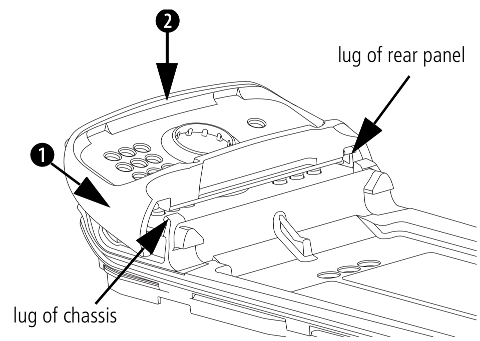
The circled numbers in this section refer to the items in Figure 5.12 on page 119.

1. Pre-bend the joint of the flexible accessory board ④ and its loom by 90° as illustrated in Figure 5.12.

2. Feed the loom through the slot in the chassis ⑤ and place the flexible accessory board into the cavity provided.

3. Peel off the backing of a new rear-panel seal ③ and place the rear-panel seal over the flexible accessory board and chassis. To achieve proper sealing, use a blunt instrument to press down the rear-panel seal inside the perimeter of the rear-panel seal and around **all** holes.

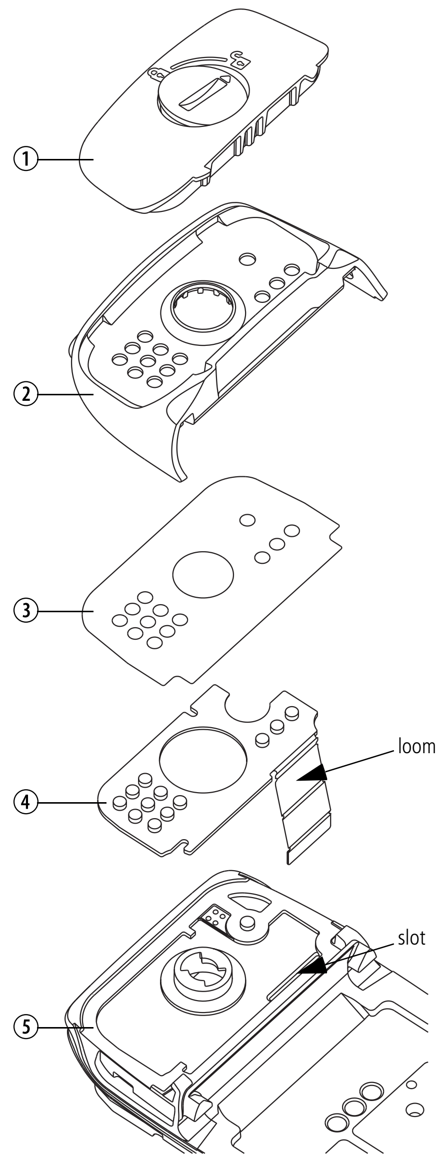
4. At an inclined angle (❶), slide the rear panel onto the chassis until the two lugs of the rear panel are positioned under the two lugs of the chassis.



5. Press against the top edge (❷) of the rear panel until the rear panel clicks into place.

6. If applicable, fit the dummy cover ① and turn the lock counter-clockwise by a quarter turn.

Figure 5.12 Fitting the flexible accessory board and the rear panel



① dummy cover

② rear panel

③ rear-panel seal

④ flexible accessory board

⑤ chassis

Fitting the Non-SMT Components

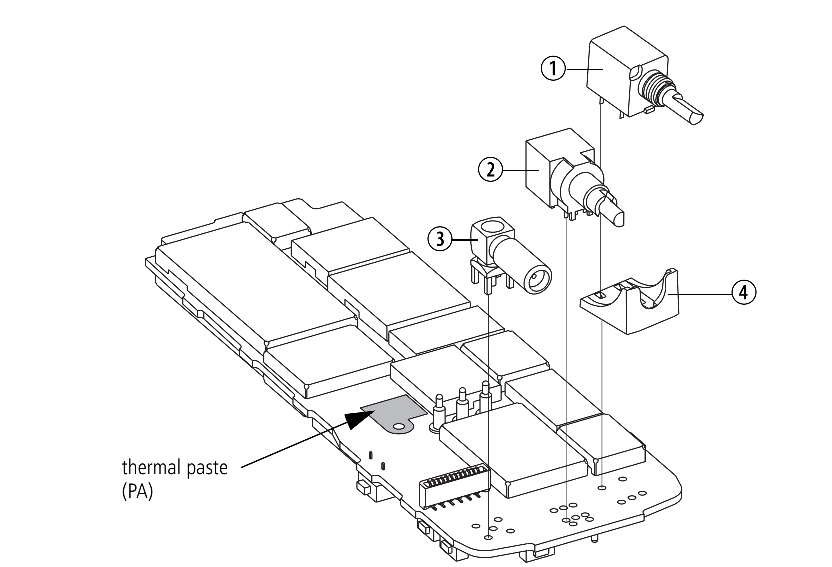
This section describes how to fit the following non-SMT components to the main board:

- power/volume potentiometer [RV1] ①
- 16-way/3-way selector switch [RSW1] ②
- antenna SMA connector [SK3] ③

The circled numbers in this section refer to the items in Figure 5.13.

1. In case of the power/volume potentiometer ①, insert the potentiometer into the vector plate ④.
2. Tack-solder the component(s) to the main board at two diagonally opposite legs.
3. Fit the main board to the chassis as described in "Fitting the Main Board" on page 122, but do not fit the two knob nuts and the SMA nut.
4. De-solder the legs tack-soldered in step 2.
5. Fit and tighten the two knob nuts and the SMA nut as described in "Fitting the Main Board" on page 122.
6. Solder all legs of the component(s).

Figure 5.13 Fitting the non-SMT components



① power/volume potentiometer
② 16-way/3-way selector switch
③ antenna SMA connector
④ vector plate

Fitting the LCD Assembly and the Front-Panel Loom

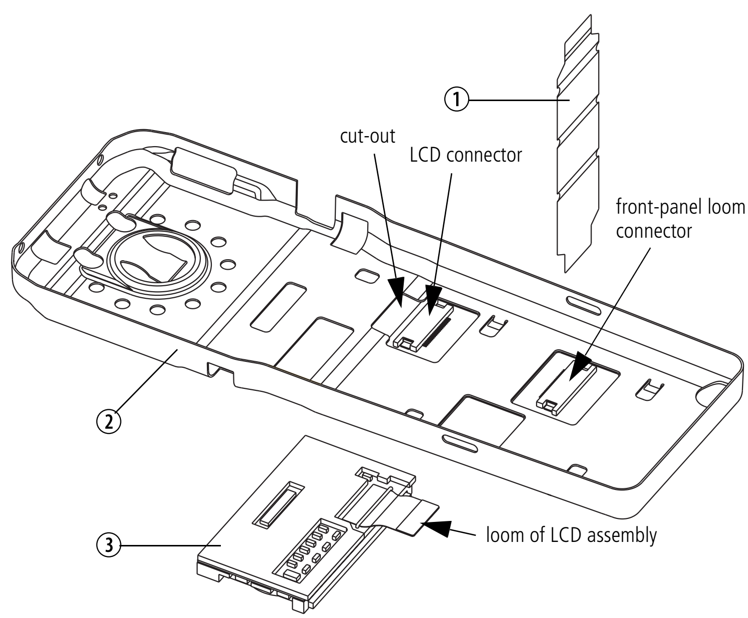
The circled numbers in this section refer to the items in Figure 5.14.

1. Open the lock of the LCD connector on the back of the main-shield assembly ②.
2. Feed the loom of the LCD assembly ③ through the cut-out in the main-shield assembly.
3. Use rubber-nose pliers to carefully insert the loom of the LCD assembly into the LCD connector.
4. Make sure that the loom is correctly seated, and lock the connector.
5. Open the lock of the front-panel loom connector on the back of the main-shield assembly.

Important Make sure that the side of the front-panel loom ① labeled “OUTSIDE” faces to the closest side of the chassis.

6. Use rubber-nose pliers to carefully insert the side of the front-panel loom ① labeled “KEYPAD” into the connector.
7. Make sure that the front-panel loom is correctly seated, and lock the connector.

Figure 5.14 Fitting the LCD assembly and the front-panel loom



① front-panel loom ③ LCD assembly

② main-shield assembly

Fitting the Main Board

The circled numbers in this section refer to the items in Figure 5.15.

1. Fit the chassis plug seal ⑦.

2. Place the battery pin seal ⑥ over the three battery pins of the main board ⑤.

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

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

   - Use a stiff brush to apply a thin and even coat of thermal paste over the complete contact surface of the screw boss of the chassis.

4. Use rubber-nose pliers to carefully insert the loom of the flexible accessory board into the accessory connector [PL1] on the underside of the main board.

5. Insert the main board ⑤ into the chassis ⑧.

6. Check that the battery pin seal ⑥ is positioned correctly.

Important If the power/volume potentiometer, the 16-way/3-way selector switch, and/or the antenna SMA connector were replaced, observe the instruction in “Fitting the Non-SMT Components” on page 120.

Important With all nuts, make sure that the tapered end faces towards the radio.

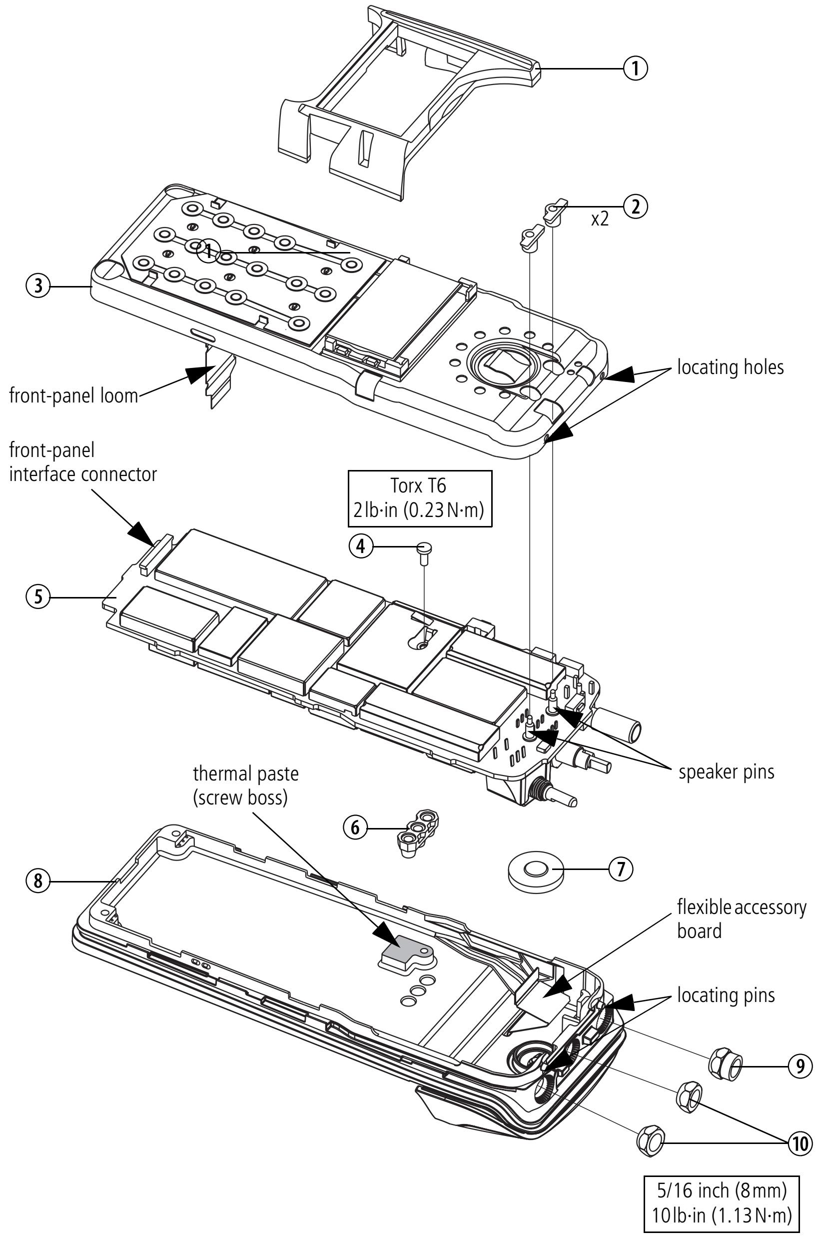
Important The nut of the power/volume potentiometer is located at an angle. Make sure not to tilt the nut.

7. Use a torque-driver with the modified 5/16 inch (8mm) long-reach socket to fit the nuts of the:
   - power/volume potentiometer ⑩
   - 16-way/3-way selector switch ⑩
   - antenna SMA connector ⑨

   and tighten them with 10lb·in (1.13N·m).

8. Use a Torx T6 torque-driver to fit the screw ④ attaching the main board to the chassis and fasten it with 2lb·in (0.23N·m).

Figure 5.15 Fitting the main-board and main-shield assemblies



① LCD frame	⑥ battery pin seal
② speaker pin frame (x2)	⑦ chassis plug seal
③ main-shield assembly	⑧ chassis
④ screw M2 x 5	⑨ SMA nut
⑤ main board	⑩ knob nut (x2)

Fitting the Main-Shield Assembly

The circled numbers in this section refer to the items in Figure 5.15 on page 123.

1. Open the lock of the front-panel interface connector [PL2] at the bottom of the main board ⑤.

2. Use rubber-nose pliers to carefully insert the end of the front-panel loom labeled “RADIO” into the connector.

3. Make sure that the loom is correctly seated, and lock the connector.

4. To fit the main-shield assembly ③ to the chassis ⑧:
   a. Start at the top by sliding the two locating holes of the main-shield assembly over the two locating pins of the chassis.
   b. Snap-fit the bottom of the main-shield assembly into place.

5. Fit the two speaker pin frames ② over the speaker pins, with the horizontal part of the speaker pin frames facing upwards.

6. Place the LCD frame ① in position over the LCD assembly and the main-shield assembly.

Fitting the Chassis Assembly to the Front Panel

The circled numbers in this section refer to the items in Figure 5.16.

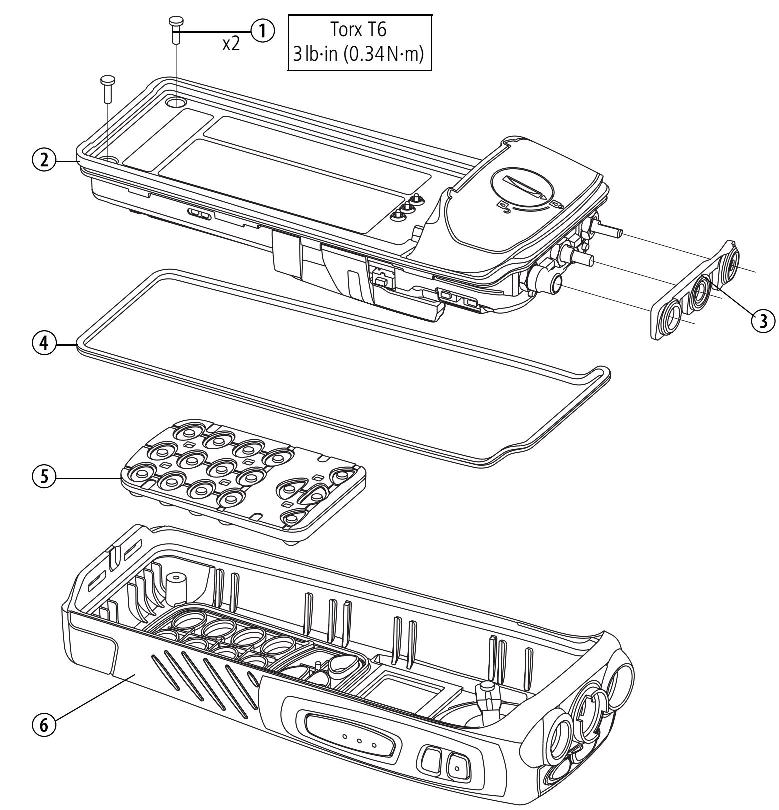
Important Do not stretch or twist the main seal.

1. To fit the main seal ④ to the chassis assembly ②:
   a. Place the pre-shaped main seal next to the chassis assembly and identify the correct orientation, in particular around the bends near the top corners.
   b. Insert the top two corners of the main seal and hold them in place.
   c. Insert the bottom two corners of the main seal.
   d. Lift the main seal into place around the bends near the top of the chassis.

Important Do not stretch the main seal by pulling it or rubbing into place with your fingers.

   e. With your fingers, tap the main seal into the groove of the chassis.

Figure 5.16 Fitting the chassis to the front panel



① Torx T6 screw M2x8 (x2)
② chassis assembly
③ top seal
④ main seal
⑤ keypad
⑥ front-panel assembly

2. Place the top seal ③ over the power/volume potentiometer, 16-way/3-way selector switch, and antenna SMA connector.

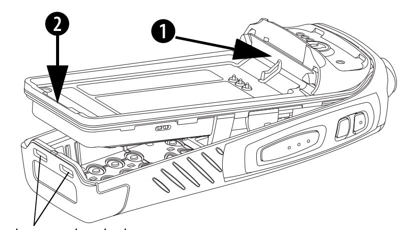
3. Fit the main keypad ⑤ to the inside of the front-panel assembly ⑥. Ensure that the outside edge of the keypad sits correctly inside the groove of the front-panel assembly.

4. To insert the chassis assembly into the front-panel assembly:

Important When pushing the chassis assembly into the front-panel assembly, check by looking through the battery lug holes, that the main seal ④ is not displaced at the base near the battery lugs.

a. Insert the top components of the chassis assembly through the holes of the front-panel assembly.

b. Push and hold the chassis assembly towards the top (❶) and carefully push the chassis into the bottom of the front-panel assembly (❷).



5. Look through the holes in the top of the front-panel assembly and check whether the top seal ③ is placed correctly around the power/volume potentiometer, 16-way/3-way selector switch, and antenna SMA connector

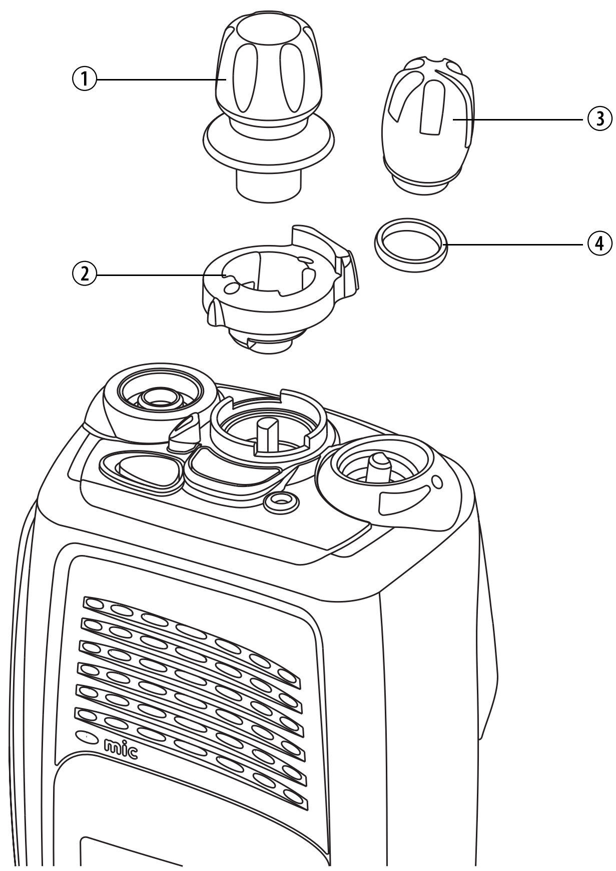
6. Use a Torx T6 torque-driver to tighten the two screws ③ to 3lb·in (0.34N·m).

Fitting the 3-way Actuator and the Knobs

The circled numbers in this section refer to the items in Figure 5.17.

1. Fit the blue 3-way actuator ②.
2. Fit the channel knob ①.
3. Fit the volume knob seal ④ over the shaft off the volume knob ③.
4. Fit the volume knob ③.

Figure 5.17 Fitting the 3-way actuator and the knobs



① channel knob
② 3-way actuator
③ volume knob
④ volume knob seal

6 Servicing Procedures

Scope of Section

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

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

For disassembly and reassembly instructions, refer to "Disassembly and Reassembly" on page 103.

6.1 Initial Tasks

List of Tasks

The following tasks need to be carried out for **all** radios:

- initial administration
- visual inspection
- powering up the radio
- reading the programming file
- obtaining the details of the Software Feature Enabler (SFE)
- reading the calibration file
- checking the user interface
- checking any error messages

The following tasks only need to be carried out if they relate to the fault reported:

- checking the transmit and transmit-audio functions
- checking the receive and receive-audio functions

Important Observe the "General Information" on page 81.

Task 1 — Initial Administration

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.

Task 2 — Visual Inspection

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

- knob for power/volume control
- knob for channel control, and 3-way actuator
- antenna SMA connector
- keys, lens and LCD
- front panel
- metal chassis
- accessory connector

Important Engraving the chassis can significantly reduce the mechanical strength and will void any warranty. If the chassis has been engraved, it must be replaced.

Task 3 — Power Up the Radio

With the radio connected to the test equipment as described in "Test Equipment Setup" on page 88, attempt to power up the radio.

1. Apply power to the radio and turn on the power/volume control.
2. If the radio powers up successfully, go to Task 4. If it does not, repair the radio as described in "On/Off Switch Faulty" on page 143.
3. If the repair succeeded without the need for replacing the main board go to Task 4. Otherwise continue with Step 4.
4. If the main board was replaced or if the repair failed, re-assemble the radio as described in "Reassembling the Radio" on page 114. Conclude with the tasks of "Final Tasks" on page 136.

Task 4 — Read the 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. Use the programming application to read the programming file.
2. If the programming file can be read, save a copy on the test PC, and go to Task 5.
3. If the programming file cannot be read, check whether:
   - the radio is connected to the correct serial port of the test PC,
   - the Mode switch of the test unit is set to Rx,
   - the programming application is set-up correctly. Refer to the troubleshooting section of the online help.
4. If the programming file can be read now, save a copy on the test PC, and go to Task 5. If not, repair the radio as described in "Accessories Interface Faulty" on page 149.
5. If the repair succeeded without the need for replacing the main board go to Step 6. Otherwise continue with Step 7.
6. If the programming file can be read now, save a copy on the test PC, and go to Task 5. If the file still cannot be read, go to step 7.
7. Set up a suitable default programming file and attempt to upload it to the radio
8. If the upload succeeds, go to Task 6. If the upload fails, continue with Step 9.
9. If the main board was replaced or if the repair failed, re-assemble the radio as described in "Reassembling the Radio" on page 114. Conclude with the tasks of "Final Tasks" on page 136.

Task 5 — Obtain the Details of the Software Feature Enabler (SFE)

Use the programming application to obtain and record the details of any software-enabled features (*Tools > Optional Features*).

For more information refer to the online help of the programming application.

Task 6 — Read the Calibration File

Use the calibration application to read the calibration file and save it on the test PC. If the calibration file cannot be read, set up a suitable default calibration file and load it to the radio

Task 7 — Check the User Interface

Check the user interface as follows:

Note Use the programming application to confirm specific radio start-up and user interface behavior, such as quiet/silent modes, and programmed function keys, channels and scan groups.

1. Turn on the radio, make sure that the volume control is not set to low, and check the start-up sequence:
   - the LED lights up amber briefly
   - the speaker gives two short beeps
   - LCD and keypad backlighting activates
   - the LCD displays a power-up message then a channel number, or an error message.

2. Check for the following elements of the user interface:
   - power/volume control: Use CCTM command *804* to read the volume potentiometer. The returned value should be between 340 and 800.
   - zone/channel control: Scroll through all settings and observe the radio display.
   - LCD: Check visually or use CCTM command *855 165* to switch on all LCD elements. CCTM command *855 164* resets the LCD to its original state.
   - LED: Check visually or use CCTM commands *325 1* (red) and *325 2* (green) to check the status LED. CCTM command *325 0* resets the LED to off.
   - LCD and keypad backlighting (if programmed): Check visually or use CCTM command *327 1* to activate backlighting.
   - PTT key: While pressing the PTT key, the transmit symbol or should appear on the radio display (unless transmit is inhibited on the selected channel).
   - function keys: Check whether the programmed function is activated.
   - emergency key: Check whether the programmed function is activated.
   - keypad: Use CCTM command *50 1* to turn on key press detection. Check that each key, when pressed, returns a value. CCTM command *50 0* turns key press logging off.

3. If there is a fault in the user interface, repair the radio as described in “Interface Fault Finding” on page 141.

4. If there is no fault, go to Task 8.

Task 8 — Check Error Messages

If the radio displays shows an error message, carry out the corrective actions described in Table 6.1.

Table 6.1 Error messages

Error message	Corrective action
Error E0001 Unknown	Turn the radio off and then back on
Error E0002 Unknown	Continue with servicing tasks to locate the problem
Error E0003 Corrupt FW	Re-download the radio's firmware
Error E0008 System error 0x*abcdefgh*	Turn the radio off and then back on. If the system error persists, consult the product's technical notes for further information on the system error. If there is no relevant information in the technical notes, continue with servicing tasks to locate the problem. To capture details of the system error, use CCTM command *204*
Error E0015 Battery error	Replace the battery
Error E0016 Battery error	Replace the battery
Temperature threshold exceeded	Wait until the radio has cooled down
Cannot tx	Go to Task 9 on page 134
Battery is flat	Recharge the battery
Unsafe battery	Replace the battery
Discharge battery	Discharge then recharge the battery
Programming mode, invalid radio ...	Re-program the radio with a new programming database. If the problem persists, update or reload the radio's firmware, and re-program the radio's calibration database.

Task 9 — Check the Transmit and Transmit-Audio Functions

If the radio does not transmit, this can be caused by:

- the synthesizer not being in lock
- no or wrong carrier power
- a faulty speaker (which also serves as the microphone)
- no modulation

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

Caution **Observe the servicing precautions for transmitter issues listed on page 87.**

1. Use CCTM command *101 x y 0* to set the transmit frequency to the bottom of the band.
2. Use CCTM command *33* to set the radio to transmit mode.
3. Use CCTM command *72* to read the lock status.

Note The last value returned (LO2) does not have to be in lock while transmitting.

4. If the synthesizer is in lock, go to Step 5. If the synthesizer is not in lock (one or both of the first two values returned are “0”), repair the radio as described in “Frequency Synthesizer Fault Finding” on page 161.
5. Repeat Step 1 to Step 4 with the transmit frequency set to the top of the band.
6. Use CCTM command *326 1* to set the power level to very low.
7. Connect a power meter and measure the transmit power.
8. If the carrier power is correct, go to Step 10. If the carrier power is not correct, try to re-calibrate the radio.
9. If the re-calibration repairs the fault, go to “Final Tasks” on page 136. If it does not, repair the radio as described in “Transmitter Fault Finding” on page 221.
10. Repeat Step 6 to Step 9 with the power level set to high (*326 4*).
11. Check whether the speaker/microphone is the source of the fault, as described in “Internal Speaker/ Microphone Faulty” on page 148.
12. If the radio transmits audio now, the original speaker was faulty. Reassemble the radio and go to “Final Tasks” on page 136. If the radio still fails to transmit, reconnect the original speaker and go to Step 13.

13. After having eliminated the synthesizer, the transmitter circuitry, and the speaker as cause for the fault, repair the radio as described in "CODEC and Audio Fault Finding" on page 277.

14. If the main board was replaced or if the repair failed, re-assemble the radio as described in "Reassembling the Radio" on page 114. Conclude with the tasks of "Final Tasks" on page 136.

Task 10 — Check the Receive and Receive-Audio Functions

If the radio does not receive, this can be caused by:

- the synthesizer not being in lock
- no carrier detected
- a faulty speaker or volume control
- no modulation

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

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

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

3. If the synthesizer is in lock, go to Step 5. If the synthesizer is not in lock, repair the radio as described in "Frequency Synthesizer Fault Finding" on page 161.

4. Repeat Step 1 to Step 3 with the receive frequency set to the top of the band

5. Feed a signal without modulation on the receive channel at −47 dBm. Check for maximum RSSI using:
   - the indicator on the radio display
   - the green status LED
   - CCTM command *63* should return the fed signal strength ±1 dBm.

6. Repeat the check in Step 5 with −117 dBm. The RSSI indicator should show as empty or close to empty.

7. If the carrier is detected correctly, go to Step 9. If the carrier is not detected correctly, try to re-calibrate the radio.

8. If the re-calibration repairs the fault, go to "Final Tasks" on page 136. If it does not, repair the radio as described in "Receiver Fault Finding" on page 257.

9. Check whether the speaker is the source of the fault, as described in "Internal Speaker/ Microphone Faulty" on page 148.

10. If the radio receives audio now, the original speaker was faulty. Reassemble the radio and go to "Final Tasks" on page 136. If the

radio still fails to receive, reconnect the original speaker and go to Step 11.

11. Use CCTM command *804* to read the status of the volume potentiometer. The value returned should vary as the volume control is rotated.

12. If the volume potentiometer is faulty, repair it as described in "Volume Control Faulty" on page 144. If it is not faulty, go to Step 13.

13. After having eliminated the synthesizer, the receiver circuitry, the speaker, and the volume potentiometer as cause for the fault, repair the radio as described in "CODEC and Audio Fault Finding" on page 277.

14. If the main board was replaced or if the repair failed, re-assemble the radio as described in "Reassembling the Radio" on page 114. Conclude with the tasks of "Final Tasks" on page 136.

6.2 Final Tasks

List of Tasks

The following tasks need to be carried out for **all** radios:

- repair
- enable software features (if applicable)
- final inspection
- final test
- final administration

Task 1 — Repair

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

1. Use the programming and calibration applications to load the programming and calibration files read or set-up in "Initial Tasks".

Note 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.

Note If the main board has been replaced, certain software features may need to be enabled before the programming file can be loaded. See Task 2 on page 137.

2. Test the radio as described in "Final Test" on page 138.
   It may be necessary to also re-calibrate to make the radio functional, in particular if the main board had to be replaced or if a default calibration file had to be loaded. Refer to the online help of the calibration application.

3. If the main board has been replaced, level-1 service centers should return the faulty board to the nearest ASC, and level-2 service centers should return the board or assembly to the ISC, if deemed necessary. Supply details of the fault and, if applicable, the attempted repair. Go to step Step 6.

   If the main board has **not** been replaced, go to Step 4.

4. Replace any cans removed. Refer to "Shielding Cans and Connectors" on page 91.

5. Re-test the radio as described in "Final Test" on page 138.

6. Reassemble the radio as described in "Reassembling the Radio" on page 106.

7. Reconnect the radio to the test equipment and carry out a final calibration of the radio. Refer to the online help of the calibration application.

Task 2 — Enable Software Features (SFE)

If the main board has been replaced, ensure that the correct software features, if any, are enabled for the customer. If software features need to be enabled, a special license file is required for the replacement main board. 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 read the software features in "Obtain the Details of the Software Feature Enabler (SFE)" on page 131, go to Step 2. If it was not possible, go to Step 3.

2. Reading the software features 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, go to Task 3.

3. Technicians **not** at a CSO should contact their CSO regarding the radio's software features. Technicians at CSOs should contact Technical Support at TEL.

4. Supply the serial number of the radio under repair, and the serial number of the replacement main board (located on a label on the main board).

5. If it is known that the radio had software features enabled, go to Step 6. Otherwise go to Step 7.

6. Ask the CSO (or TEL) for a license file for the replacement main board. 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 license file for the replacement main board. The CSO (or TEL) will either indicate that the radio had no software features enabled or supply the required file. If the radio had no software features enabled, go to Task 3. If the required file was supplied, go to Step 8.

8. On receiving the license file, run the programming application on the test PC. On the menu bar click *Tools* > *Optional Features*.
The *Software Feature Enabler* dialog appears.

9. Use the license file to enable the appropriate software features.
The procedure is given in the online help facility under the heading *Enabling a feature*. Go to Task 3.

Task 3 — Final Inspection

Make a final inspection of the exterior to check that no mechanical parts were damaged during the repair. Repeat the inspection given in "Visual Inspection" on page 130. Rectify any damage.

Task 4 — Final Test

Test the radio to confirm that it is fully functional again. The recommended tests are listed in Table 6.2 to Table 6.4. (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.

Task 5 — Final Administration

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.

If 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

Level-1 service centers should return the faulty radio to the nearest ASC, and level-2 service centers should return the radio to the ISC. Supply details of the customer, the fault and, if applicable, the attempted repair.

Table 6.2 Final tests of transmitter function (analog mode)

Test	Limits
Error in transmit frequency	+100 Hz to –100 Hz
Transmit power (B1 band): • High • Medium • Low • Very low Transmit power (H5/H6 bands): • High • Medium • Low • Very low Transmit power (K5 band): • High • Medium • Low • Very low	 5.1W to 5.2W 3.0W to 3.1W 2.0W to 2.1W 1.0W to 1.2W 4.1W to 4.2W 2.5W to 2.6W 2.0W to 2.1W 1.0W to 1.2W 3.0W to 3.1W 2.3W to 2.4W 2.0W to 2.1W 1.0W to 1.2W
Current at high power: • B1-band radios • H5-band radios • H6-band radios	 < 1.9A < 1.9A < 1.9A
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 signaling) deviation: • Narrow-band • Medium-band • Wide-band	 250 to 350 Hz 500 to 560 Hz 580 to 680 Hz

Table 6.3 Final tests of receiver functions (analog mode)

Test	Limits
Receive sensitivity	≤118dBm for 12dB SINAD
Mute opening: • Country • City • Hard	 >6dB and <10dB SINAD >10dB and <14dB SINAD >18dB and <22dB SINAD
Audio power (maximum volume at –47dBm): • at RX AUDIO/SINAD connector on test unit • at pins 9 (SPKR–) and 11 (SPKR+) of accessory connector	 >2.8mV$_{rms}$ >2.8V$_{rms}$
Distortion (at –47dBm, 60% rated system deviation at 1 kHz, with volume set to give 3W into 16Ω load)	<3.00%

Table 6.4 Final tests of general radio functions

Test	Description
PTT switch	Check that PTT switch functions
Microphone	Check operation of microphone
Speaker	Check operation of speaker
Function and keypad keys	Check operation of all function and keypad keys
LCD display	Check operation of LCD display (shows all pixels)
Status LED	Check operation of status LEDs (red, green and amber)
Backlighting	Check operation of keypad and LCD backlighting
Volume control	Check operation of volume control and ON/OFF switch
16-way and 3-way selectors	Check operation of 16-way selector, and 3-way selector (if used)

7 Interface Fault Finding

Overview

This section describes fault finding of the user interface and accessories interface connector. User interface fault finding includes the following:

- Front panel keypad. This includes the numeric keypad, scroll and selection keys, and keypad backlighting.
- LCD. This includes the LCD display and LCD backlighting.
- Top and side of radio. This includes the ON/OFF switch, volume control, 3-way and 16-way selectors, status LED indicators, function keys and PTT, and internal speaker/microphone.

The faults can be detected by visual inspection (refer to “Initial Tasks” on page 129) or using CCTM commands (refer to Table 4.6 on page 98).

General

The following notes apply to all interface fault finding procedures:

- For disassembly and reassembly instructions, see “Disassembly and Reassembly” on page 103.
- After completing the repair, carry out the tasks in “Final Tasks” on page 136.
- The main-shield assembly and LCD assembly are non-serviceable items, and must be replaced in their entirety if faulty. For more information refer to “Spare Parts” on page 297.

Task 1 — Front Panel Keypad Faulty

Use this procedure for faults with numeric keys, scroll keys, selection keys or keypad backlighting. Before proceeding, make sure the fault is not an issue with programming. For backlighting faults, make sure backlighting is enabled in the programming application. For keypad faults (16-key models only), make sure full keypad functionality is enabled via the *Software Feature Enabler* in the programming application.

If the keypad is faulty:

1. Remove the front panel.
2. Remove the main-shield assembly, and fold the assembly open leaving the loom connected between the front panel and the main board.
3. Check the integrity of the front-panel loom and confirm it is seated correctly at both ends (RADIO and KEYPAD).
4. Reassemble and power-up the radio. Check the functionality of the keypad.
5. If still faulty, remove the front panel and replace the front-panel loom with a known good one.
6. Reassemble and power-up the radio. Check the functionality of the keypad.

7. If the keypad operates as expected, the loom was faulty. Discard and use a new one. If still faulty, remove the front panel and replace the main-shield assembly with a known good assembly.
8. Reassemble and power-up the radio. Check the functionality of the keypad.
9. If the keypad operates as expected, the main-shield assembly was faulty. Discard and use a new one. If the keypad is still faulty, the problem is with the main board.
10. Check for obvious faults around the front-panel interface connector [PL2]. If no fault can be found, replace the main board.

Task 2 — LCD Faulty

Use this procedure for faults with the LCD, such as distorted or missing pixels on the display or backlighting problems. Before proceeding, make sure the fault is not an issue with programming. For backlighting faults, make sure backlighting is enabled in the programming application.

If the LCD is faulty:

1. Remove the front panel.
2. Remove the main-shield assembly, and fold the assembly open leaving the loom connected between the front panel and the main board.
3. Check the integrity of the front-panel loom and confirm it is seated correctly at both ends (RADIO and KEYPAD).
4. Check the integrity of the LCD assembly loom and its connection to the LCD connector on the main-shield assembly.
5. Reassemble and power-up the radio. Check the functionality of the LCD.
6. If still faulty, replace the LCD assembly with a known good assembly.
7. Reassemble and power-up the radio. Check the functionality of the LCD.
8. If the LCD operates as expected, the LCD assembly was faulty. Discard and use a new one. If still faulty, remove the front panel and replace the front-panel loom with a known good one.
9. If the LCD operates as expected, the loom was faulty. Discard and use a new one. If the LCD is still faulty, remove the front panel and replace the main-shield assembly with a known good assembly.
10. If the LCD operates as expected, the main-shield assembly was faulty. Discard and use a new one. If the keypad is still faulty, the problem is with the main board.
11. Check for obvious faults around the front-panel interface connector [PL2]. If no fault can be found, replace the main board.

Task 3 — On/Off Switch Faulty

Use this procedure if the radio fails to power up when the ON/OFF switch is turned on. Before proceeding, make sure the fault is not related to one or more of the following:

- The battery is flat.
- The LCD, LED or speaker is faulty. This can be misinterpreted as a faulty ON/OFF switch if the radio does not exhibit normal startup behavior.
- The radio is inhibited (stunned).
- The firmware is missing or corrupt.

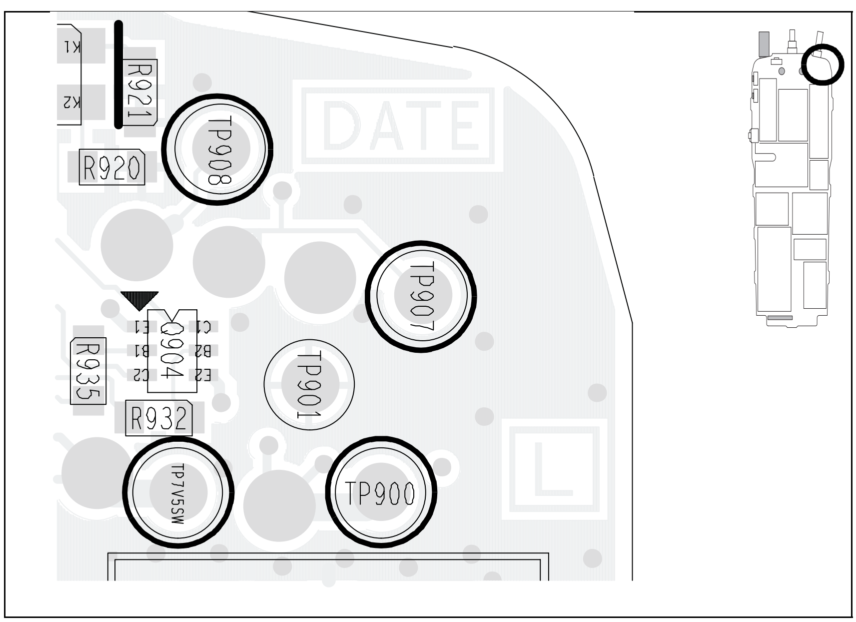
If the ON/OFF switch is faulty:

1. Remove the front panel and main-shield assembly.
2. Remove power from the radio.
3. Connect a resistance meter (such as a multimeter) across the test points **TP900** and **TP7V5SW**. See Figure 7.1.
4. Measure the resistance with the switch in the on and off positions. The correct ranges are below:

resistance when switch position ON: $< 10\Omega$ resistance when switch position OFF: $> 100\text{k}\Omega$

5. If the switch resistances are outside these limits, replace **RV1**. If the resistances are within the limits then the on/off switch is not faulty; go to "Power Supply Fault Finding" on page 151.

Figure 7.1 PCB layout of test points next to the switch pins of RV1 (bottom side)



Task 4 — Volume Control Faulty

Use this procedure if the volume control works intermittently, works only at full volume, or doesn't work at all. These symptoms can indicate a fault with the volume pot, or the CODEC and audio circuitry. Before proceeding, make sure the *Minimum Volume Level* is not set to 255 in the programming application. This will result in a maximum volume level, regardless of the position of the volume control.

If the volume control is faulty:

1. Remove the front panel and main-shield assembly.
2. Remove power from the radio.
3. Connect a resistance meter (such as a multimeter) across the test points **TP908** and **TP907**. See Figure 7.1.
4. Vary the volume control position between extremes, and measure the resistance. The correct ranges are below:

   resistance at extreme limit (low): $< 50\Omega$
   resistance at extreme limit (high): $> 9k\Omega$

5. If the control resistances are outside these limits, replace **RV1**. If the resistances are within the limits then the volume control is not faulty; go to "CODEC and Audio Fault Finding" on page 277.

Task 5 — 16-Way or 3-Way Selectors Faulty

Use this procedure if the radio fails to change the channel when the 16-way selector is turned, or the zone when the 3-way selector is turned. Before proceeding, make sure there is more than one channel and zone programmed for the radio, and those channels and zones have been assigned to different positions on the 16-way and 3-way selectors.

If the 16-way selector or 3-way selector is faulty:

1. Remove the front panel and main-shield assembly.
2. Power up and turn on the radio.
3. Connect a multimeter or oscilloscope to pins 1, 2, 4, and 8 (16-way selector) or pins A and B (3-way selector) of **RSW1**. See Figure 7.2.

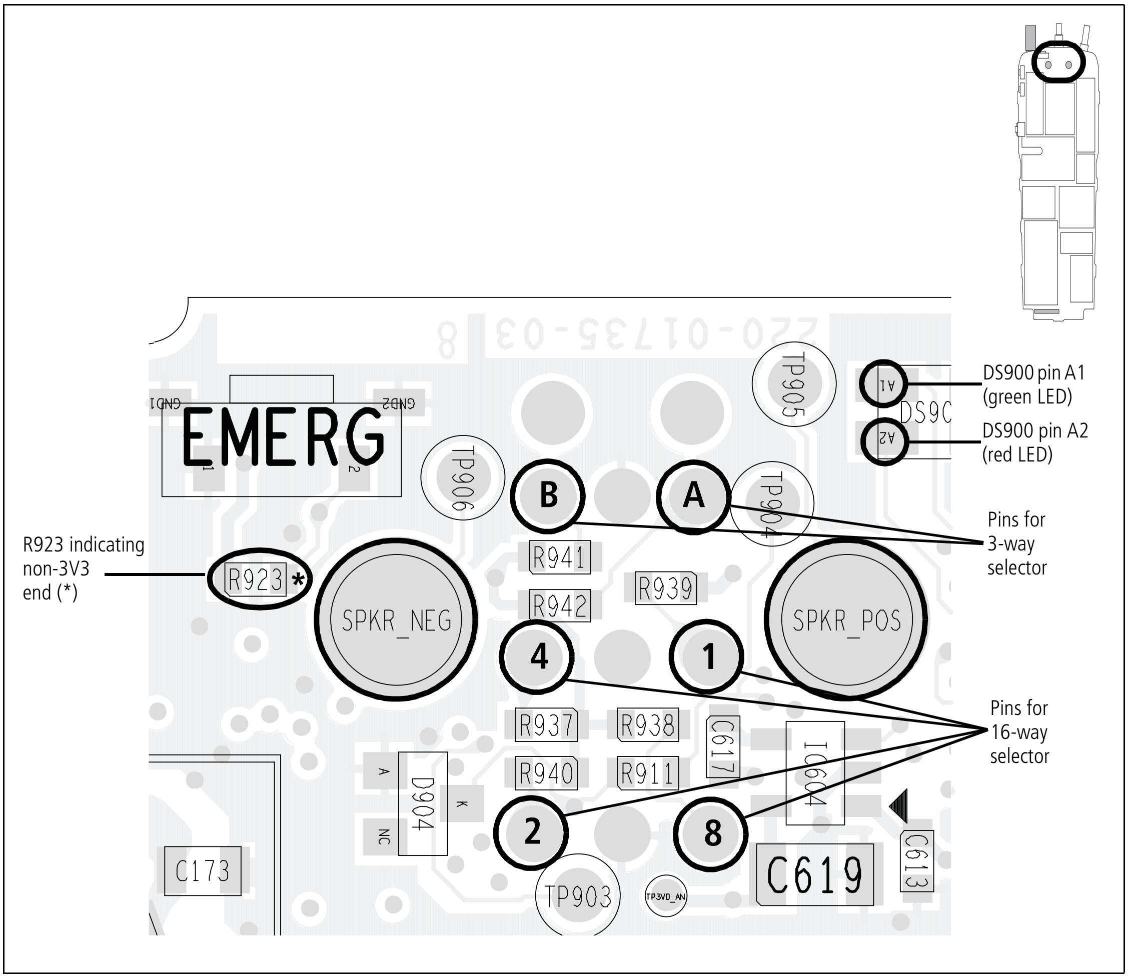
   16-way selector: pins 1, 2, 4, and 8
   3-way selector: pins A and B

4. Check the voltage on the pins as the 16-way selector or 3-way selector is rotated. Depending on the selector position, each pin should switch between the following logic levels:

   logic level low: <0.5V
   logic level high: >3.0V

5. If the logic levels are not correct then replace **RSW1** and retest. If the logic levels are correct, or replacing **RSW1** does not repair the fault, replace the main board.

Figure 7.2 PCB layout of pins for RSW1 and DS900 (bottom side)



Task 6 — Status LED Faulty

Use this procedure if the status LED is not operating according to Table 4.9 on page 100. For example, the red LED does not operate when the radio is transmitting, or the green LED does not operate when the radio is receiving. Before proceeding make sure the fault is not transmitter or receiver related. See "Check the Transmit and Transmit-Audio Functions" on page 134 and "Check the Receive and Receive-Audio Functions" on page 135.

If the status LED is faulty:

1. Remove the front panel and the main shield assembly.

2. Connect a multimeter or oscilloscope to pin A1 (green LED) or pin A2 (red LED) of **DS900**. See Figure 7.2.

green LED: pin A1 red LED: pin A2

3. Activate the relevant LED. Use CCTM command *325 1* to activate the red LED. Use CCTM command *325 2* to activate the green LED.

4. As the LED is activated, monitor the voltage on the appropriate pin. The voltage should be as follows:

LED inactive: <1 V LED active: >3 V

5. If the voltage levels are not correct proceed to Step 6. If they are correct, proceed to Step 7.

6. Replace **Q904**, and **R932** (red LED faulty) and/or **R935** (green LED faulty). Retest the LED. If the LED is still faulty, proceed to Step 7.

7. Replace **DS900**, and **R921** (red LED faulty) and/or **R920** (green LED faulty). Retest the LED.

8. If the LED is still faulty, replace the main board.

Task 7 — Function Keys or PTT Faulty

Use this procedure if a function key fails to activate the programmed function, or the PTT fails to key the transmitter. Before proceeding:

- For function keys, make sure there are functions programmed that have obvious effects on the radio (such as backlighting and monitor), and recheck the faulty keys.
- For the PTT, use CCTM commands to check that the fault is not transmitter-related. See "Check the Transmit and Transmit-Audio Functions" on page 134.

If a function key or the PTT is faulty:

1. Remove the front panel and main-shield assembly.

2. Remove the main board and apply power using an open radio test lead.

3. Connect a multimeter or oscilloscope to the non-3V3 end of **R922** (PTT – see Figure 7.3), **R923** (function key 1 – see Figure 7.2), or **R924** or **R295** (function key 2 or 3 – see Figure 7.4).

   PTT: R922 (non-3V3 end)
   function key 1 (top of radio): R923 (non-3V3 end)
   function key 2 (side of radio): R924 (non-3V3 end)
   function key 3 (side of radio): R925 (non-3V3 end)

4. As each key is pressed, monitor the voltage on the appropriate resistor. The signal voltages should be as follows:

   Not pressed: > 3.0V
   Pressed: < 0.5V

5. If the logic levels are not correct then replace the relevant key switch and retest. If the logic levels are correct, or replacing the key switch does not repair the fault, replace the main board.

Figure 7.3 PCB layout showing R922 (top side)

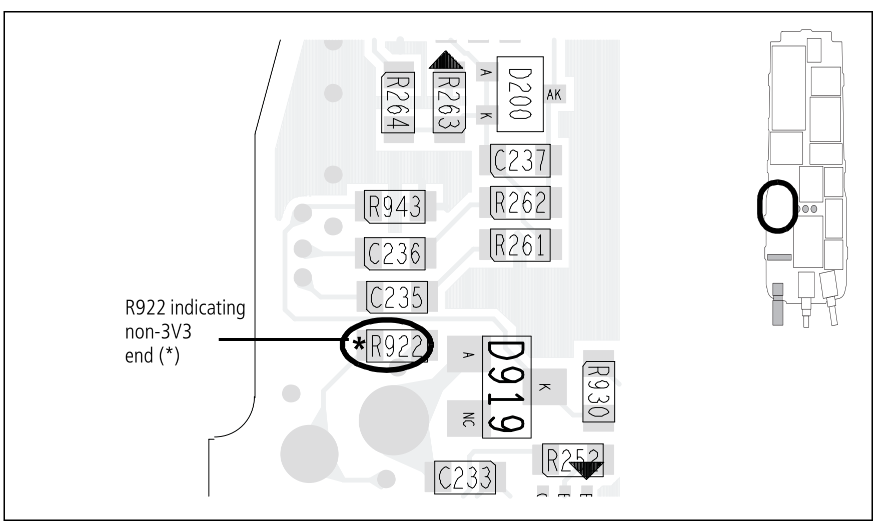
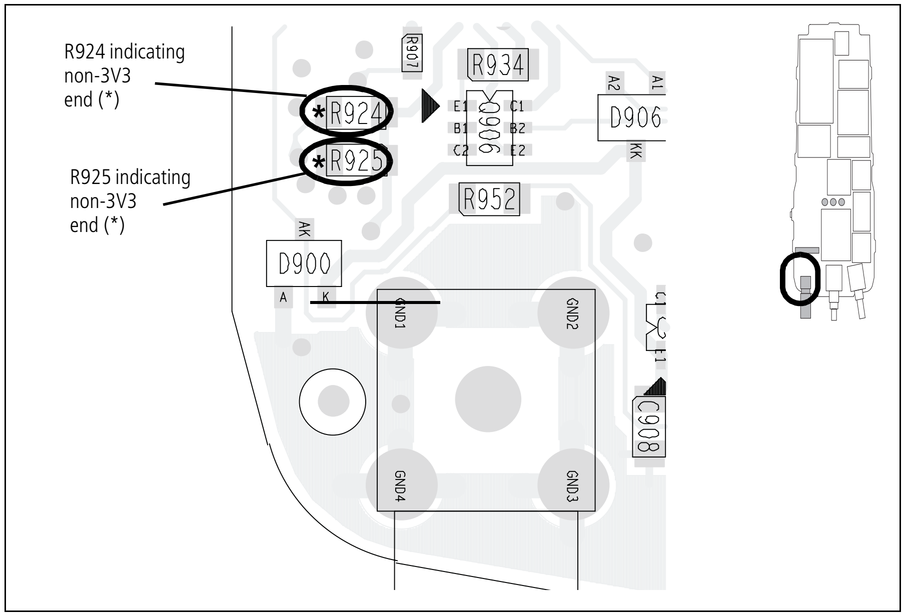


Figure 7.4 PCB layout showing R924 and R925 (top side)



Task 8 — Internal Speaker/ Microphone Faulty

Use this procedure for the following faults:

- no internal speaker audio
- internal speaker audio distorted
- no transmit modulation from internal speaker
- modulation distorted from internal speaker

These symptoms can indicate a fault with the speaker, the speaker pins, or the CODEC & audio circuitry.

If the speaker/microphone is faulty:

1. Remove the front panel of the radio, and replace with a front panel that has a known good speaker.
2. Reassemble and power-up the radio. Check the functionality of the speaker/microphone.
3. If the speaker/microphone operates as expected, the speaker was faulty. Discard and replace with a new one (see “Spare Parts” on page 297). If the speaker/microphone is still faulty, proceed to Step 4.
4. Check the integrity and soldering of speaker pins **SPKR_POS** and **SPKR_NEG**. See Figure 7.2. Re-solder or replace as required.
5. Recheck the functionality of the speaker/microphone. If still faulty, reconnect the original speaker and go to “CODEC and Audio Fault Finding” on page 277.

Task 9 — Accessories Interface Faulty

Use this procedure for the following faults with the accessories interface:

- Faulty accessory
- Dirt, moisture or dust on the connector
- Serial communications fault
- External audio fault
- Digital I/O fault

Note If the fault is with external audio (speaker or microphone), audio tap in or tap out, the external PTT, or an external function key, first complete tasks related to the symptom in "CODEC and Audio Fault Finding" on page 277.

If the accessories interface is faulty:

1. Remove the front panel, main-shield assembly, and rear panel.
2. Replace the flexible accessory board with a known good one.
3. Reassemble and check the functionality of the accessories interface.
4. If the accessory interface operates as expected, the flexible accessory board was faulty. Discard and use a new one (see "Spare Parts" on page 297). If still faulty, check for faults with the accessory connector **PL1** on the main board, and components around **PL1**.
5. If a fault is found, repair and recheck the functionality of the accessories interface. If still faulty or a fault cannot be found with **PL1**, replace the main board.

8 Power Supply Fault Finding

Fault-Diagnosis Tasks

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

- Task 1: initial checks
- Task 2: check +3V3 SMPS
- Task 3: check +1V5 SMPS
- Task 4: check linear regulators

The regulators of concern in Task 4 are those for the 5 V (2x), 3.0 V, 2.5 V, and 1.8 V supplies.

Task 1 — Initial Checks

In order to power up the radio (processor running and display active) the following supplies are required: +3V3, +1V8, and +1V5.

Set up the radio and the test equipment as described in "Test Equipment Setup" on page 88. If not already done, remove the main board from the chassis.

1. Use a multimeter to measure the 7.5 V voltage across the battery pin:

voltage across BATT NEG and BATT POS: 7.5V DC

2. While turning the power/volume control on, measure the voltage at **TP3V3 test point** (see **Figure 8.1**):

voltage at TP3V3: 3.3V DC ±5%

   If it is continuously 3.3V or turns on for a short time (approximately 2s), go to Step 3. If it never reaches 3.3 V, go to Task 2.

3. While turning the power/volume control on, use a multimeter to measure the voltage at **C721** (see **Figure 8.1**). To do this, probe the positive side of the C721 through the DIG BOT can:

voltage at C721: 1.8V DC ±5%

   If it is continuously 1.8 V or turns on for a short time (approximately 2s) go to Step 4. If it never reaches 1.8 V go to Task 4.

4. While turning the power/volume control on, use a multimeter to measure the voltage at **TP1V5 test point** (see **Figure 8.1**).

voltage at TP1V5: 1.5V DC ±5%

   If it never reaches 1.5V go to Task 3.

   If it is continuously at 1.5V go to Step 5.

   If it turns on for a short time (approximately 2s), go to Step 7. (TP3V3 and C721 should exhibit similar behavior.)

5. Ensure the programming cable is correctly connected, and use the programming application to reload the radio's programming file

(recreated from default data if necessary). Confirm the removal of the fault, and go to “Final Tasks” on page 136. If reloading the programming file failed or failed to repair the fault, replace the main board, and go to “Final Tasks” on page 136.

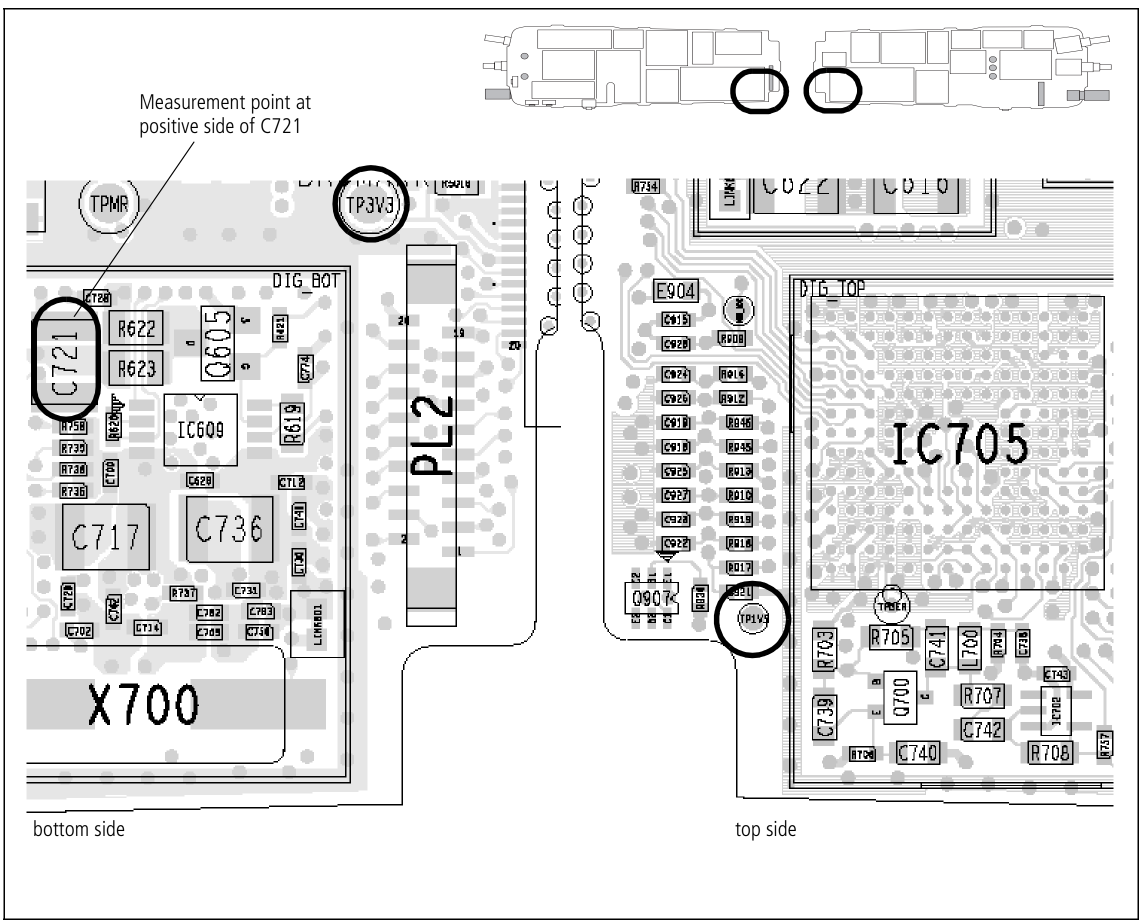
6. Check whether the serial cable is correctly connected and try to reload the software/debug using the CCTM.

   If a fault is found, repair it, confirm the removal of the fault, and go to “Final Tasks” on page 136. If the repair failed or no fault could be found, replace the main board, and go to “Final Tasks” on page 136.

7. Check for shorts to ground and continuity of the DIG PSU LATCH signal from **D602** (see **Figure 8.2**) to the FPGA.

   If a fault is found, repair it, confirm the removal of the fault, and go to “Final Tasks” on page 136. If the repair failed or no fault could be found, replace the main board, and go to “Final Tasks” on page 136. The FPGA image needs to be upgraded by the factory.

Figure 8.1 Test and measurement points for the initial checks



Task 2 — Check +3V3 SMPS

If the voltage at the TP3V3 test point does not reach 3.3V, then the +3V3 SMPS needs to be investigated.

1. Use a multimeter to check the supply voltage to the SMPS at pin 8 of **IC610** (see **Figure 8.2**). The voltage should be:

pin 8 of IC610: approximately 7.5V DC

   If it is, go to Step 4. If it is not, go to Step 2.

2. Disconnect the 7.5V external supply. Check for continuity and shorts to ground in the path between the BATT POS battery pin and pin 8 of **IC610** (see **Figure 8.2**). Locate and repair the fault.

3. Reconnect the 7.5V external supply. Confirm the removal of the fault by measuring the voltage in Step 1.

   If the voltage is correct, confirm the removal of the fault, and go to "Final Tasks" on page 136. If it is not, the repair failed; replace the main board and go to "Final Tasks" on page 136.

4. While turning the power/volume control on, check the enable signal at pin 1 of **IC610** (see **Figure 8.2**). For the radio to power up, this voltage must exceed 2.0V DC.

pin 1 of IC610: more than 2.0V DC

   If it exceeds 2.0V for at least one second, go to Step 7.

   If it does not, go to Step 5.

5. When the power/volume control is turned on, 7V5_SW should go from 0V to 7.5V. This generates a pulse through **C634** which turns both **Q606** transistors on for approximately 30ms, and charges **C610** to approximately 7.5V (see **Figure 8.2**). Check for continuity and shorts to ground or power in this path. Locate and repair the fault.

6. Re-measure the voltage in Step 4.

   If the voltage is correct, confirm the removal of the fault, and go to "Final Tasks" on page 136. If it is not, the repair failed; replace the main board and go to "Final Tasks" on page 136.

7. Disconnect the external 7.5V power supply. Cut the track joining **LINK603** (see **Figure 8.2**). The resistance can be measured between the pads to ensure that the link is cut. Reconnect the 7.5V external supply and turn the power/volume control on. Measure the voltage across **C631**.

voltage across C631: 3.3V DC

   If it is correct, go to Step 8. If it is not, go to Step 10.

8. There is a fault on the +3V3 rail. Disconnect the 7.5V external supply. To isolate further, short **LINK603** with solder and cut the track joining **LINK602**. Again, measure the resistance to ensure that the link is cut.

Reconnect the 7.5V external supply and turn the power/volume control on. Measure the voltage across **C631** (see **Figure 8.2**).

voltage across C631: 3.3V DC

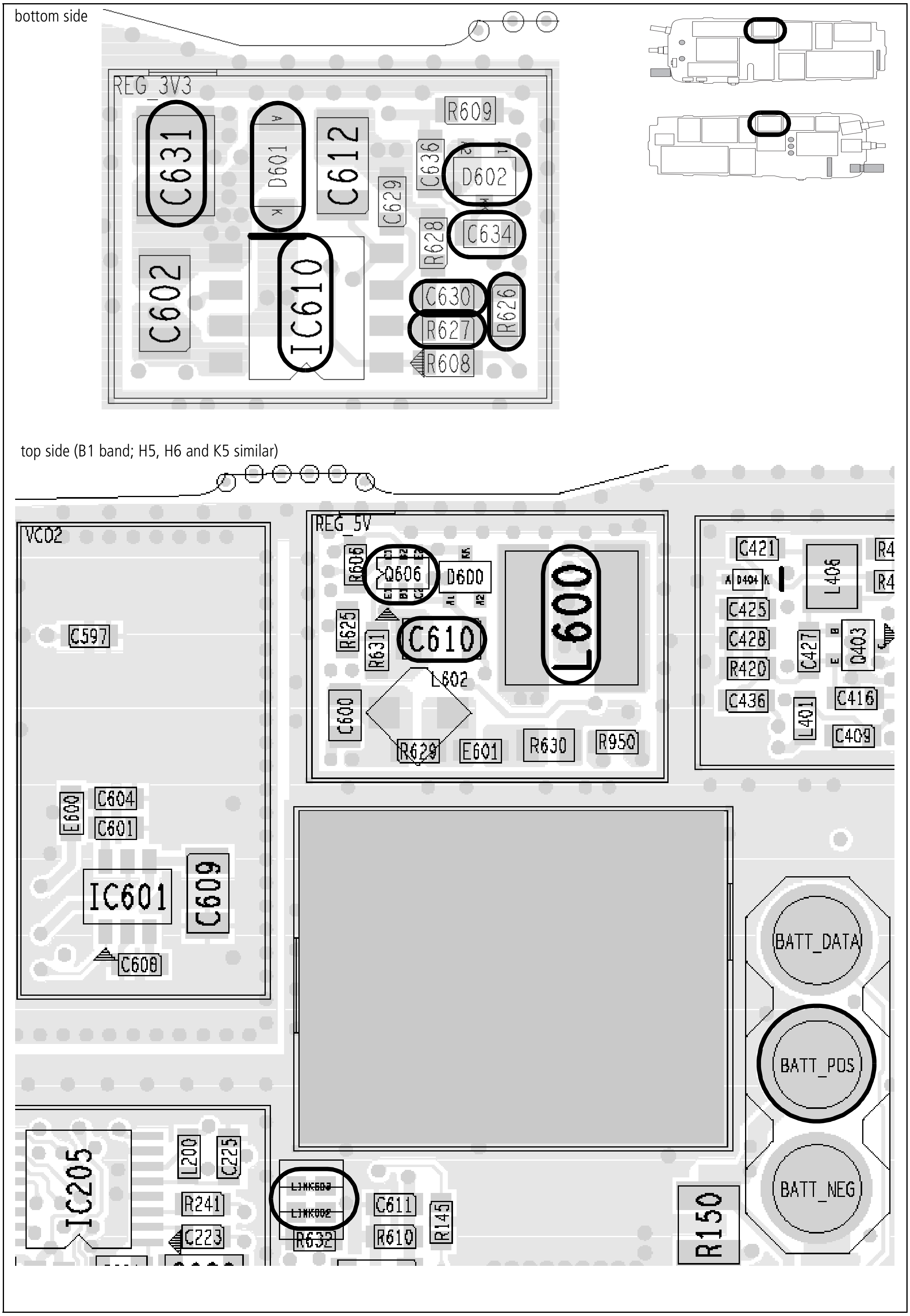
If it is correct, the fault is in the digital area. If not, the fault is on the +3V3 rail excluding the digital area. If no fault can be found visually, try to remove the ICs on the relevant rail. Locate and repair the fault.

9. Repair **LINK602** (see **Figure 8.2**), reconnect the external 7.5V power supply and turn on the radio. If the radio powers up, go to "Final Tasks" on page 136. If the radio fails to power up, the repair failed; replace the main board and go to "Final Tasks" on page 136.

10. Disconnect the 7.5V external supply. Check for continuity and faults around **IC610**, **D601**, **L600**, **R626**, **R627**, **R628**, and **C630** (see **Figure 8.2**), and repair any faults

11. Repair **LINK603**, reconnect the external 7.5V power supply and turn on the radio. If the radio powers up, go to "Final Tasks" on page 136. If the radio fails to power up, the repair failed; replace the main board and go to "Final Tasks" on page 136.

Figure 8.2 Measurement points for the checking the +3V3 SMPS



Task 3 — Check +1V5 SMPS

If the voltage at the TP3V3 test point is 3.3 V but the voltage at the TP1V5 does not reach 1.5 V then the +1V5 SMPS needs to be investigated.

1. Use a multimeter to check the supply to the SMPS at pin 4 and the enable signal at pin 1 of **IC606** (see **Figure 8.3**):

pin 4 of IC606: 3.3V DC (supply) pin 1 of IC606: 3.3V DC (enable)

   If both voltages are correct, go to Step 4. If either or both are not go to Step 2.

2. Disconnect the 7.5 V external supply. Check for continuity on the 3V3 rail to pins 1 and 4 of IC606. Locate and repair the fault.

3. Reconnect the 7.5 V external supply and turn the power/volume control on. Confirm the removal of the fault by re-measuring the voltage in Step 1, and go to "Final Tasks" on page 136. If the voltage is not correct, the repair failed; replace the main board and go to "Final Tasks" on page 136.

4. Disconnect the 7.5 V external supply. Cut the track joining LINK600 (see **Figure 8.3**). The resistance can be measured between the pads to ensure that the link is cut. Check the voltage across **C622** (see **Figure 8.3**):

voltage across C622: 1.5V DC

   If it is correct, go to Step 5. If it is not, go to Step 7.

5. There is a fault on the +1V5 rail. Disconnect the 7.5 V external supply. To isolate further, short LINK600 out with solder and cut the track joining LINK601. Again measure the resistance to ensure that the link is cut. Measure the voltage across **C622** (see **Figure 8.3**):

voltage across C622: 1.5V DC

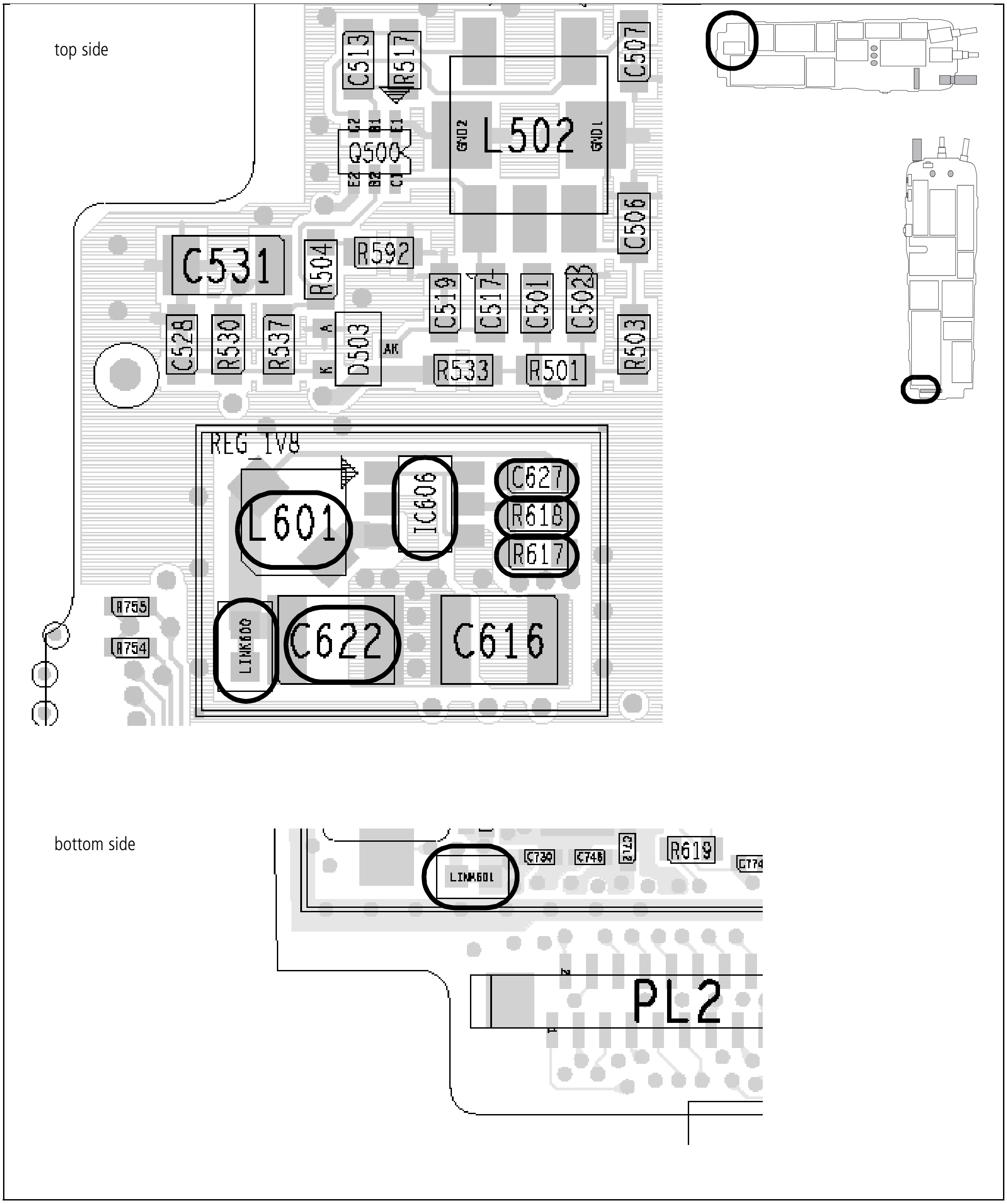
   If it is correct, the fault is somewhere on the rail after LINK601. If it is not, the fault is on the rail between the links. Locate and repair the fault.

6. Repair LINK600 and LINK601 (see **Figure 8.3**), reconnect the external 7.5 V power supply and turn on the radio. If the radio powers up, go to "Final Tasks" on page 136. If the radio fails to power up, the repair failed; replace the main board and go to "Final Tasks" on page 136.

7. Disconnect the 7.5 V external supply. Check continuity and for faults around **IC606**, **L601**, **C627**, **C622**, **R618**, and **R617** (see **Figure 8.3**).

8. Repair LINK600 (see **Figure 8.3**), reconnect the external 7.5 V power supply and turn on the radio. If the radio powers up, go to "Final Tasks" on page 136. If the radio fails to power up, the repair failed; replace the main board and go to "Final Tasks" on page 136.

Figure 8.3 Measurement points for the checking the +1V5 SMPS



Task 4 — Check Linear Regulators

This section gives the general procedure for checking any linear regulator. There are two possible faults: either the 1.8V regulator has failed and prevents the radio from powering up, or, with the other linear regulators, the radio will power up but will not function correctly. (The regulator IC might or might not have been removed during earlier checks.)

Table 8.1 gives an overview of the ICs and the relevant voltages. See also Figure 8.4 on page 159, and for IC601, Figure 9.3 on page 169.

Table 8.1 Input, output and control/enable voltages of the linear regulators

Regulator		Input		Control/Enable		Output	
Voltage	**IC**	**Pin**	**Voltage**	**Pin**	**Voltage**	**Pin**	**Voltage**
5V (TX)	IC600	pin 6	7.5V	pin 1	>2V	pin 4	5V
5V (AN)	IC601	pin 6	7.5V	pin 1	>2V	pin 4	5V
3.0V	IC604	pin 1	3.3V	pin 3	>2V	pin 5	3.0V
2.5V	IC605	pin 1	3.3V	pin 3	>2V	pin 5	2.5V
1.8V	IC608	pin 1	3.3V	pin 3	>2V	pin 5	1.8V

Note If the +3V0 RX voltage is missing, check the 3.0V linear regulator, the DIG RX EN signal, and the 3V RX switch (Q604).

1. Measure the input voltage to the relevant regulator is correct. Repair any fault.

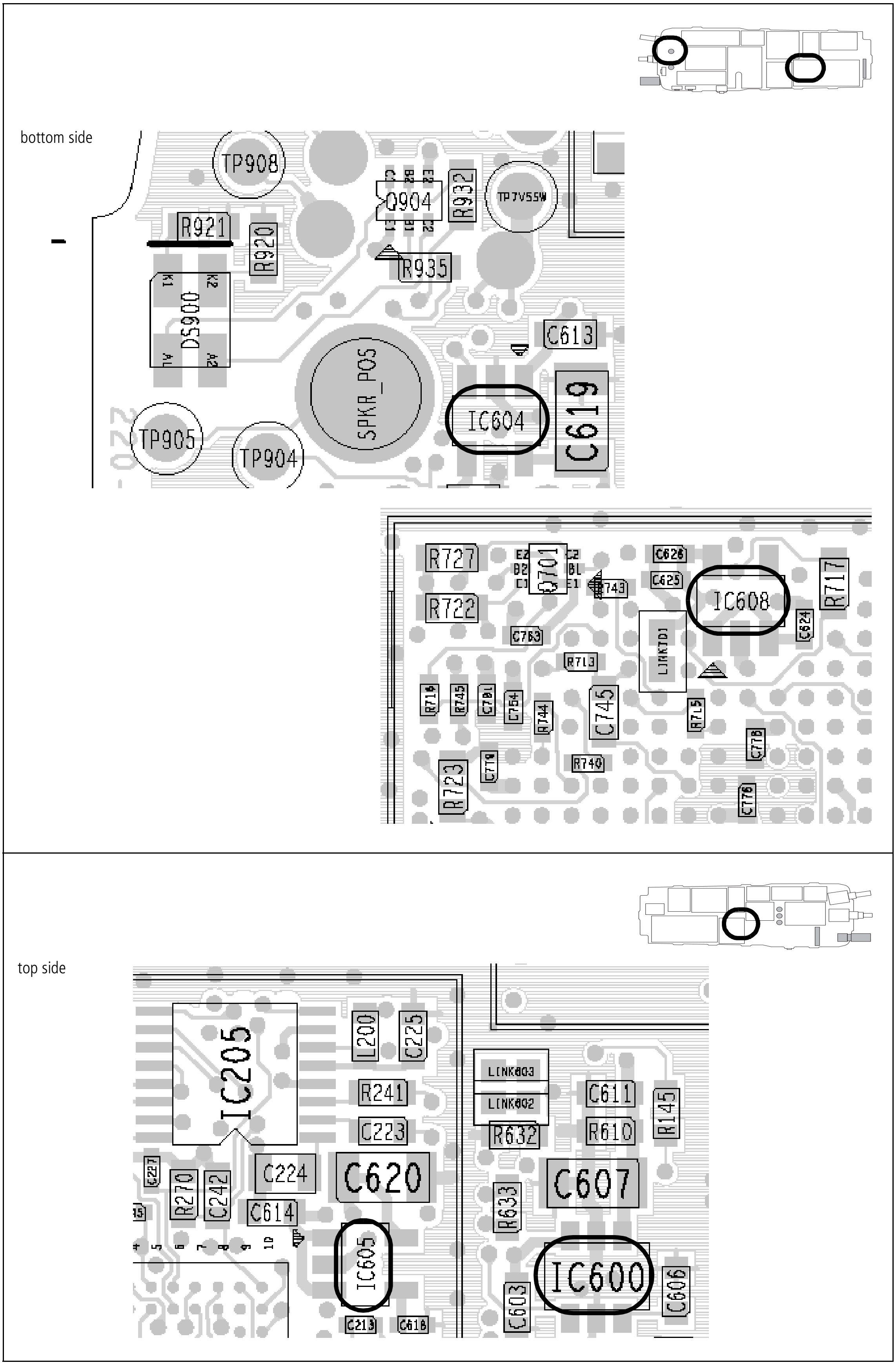
2. Check the control/enable signal to the relevant regulator is active. Repair any fault.

3. Check the output for shorts to ground. Repair any fault.

4. Reconnect the 7.5V external supply and turn the power/volume control on. If the radio powers up or the correct regulator voltage is restored, go to “Final Tasks” on page 136. If the repair failed, go to Step 5.

5. Disconnect the 7.5V external supply. Replace the regulator IC with a spare. Reconnect the 7.5V external supply and turn the power/volume control on. If the radio powers up or the correct regulator voltage is restored, go to “Final Tasks” on page 136. If the repair failed, replace the main board and go to “Final Tasks” on page 136.

Figure 8.4 Measurement points for the checking the linear regulators



9 Frequency Synthesizer Fault Finding

Introduction

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

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

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

Measurement Techniques

The radio must be in CCTM for all the fault-diagnosis procedures of this section. The CCTM commands required are listed in Table 9.1. Full details of the commands are given in “Computer-Controlled Test Mode (CCTM)” on page 93. Use an oscilloscope with a x10 probe for all voltage measurements required. The signals should appear stable and clean. Consider any noise or unidentified oscillations as evidence of a fault requiring investigation. Use a frequency counter for all measurements of high frequencies. The RF power output from the frequency synthesizer will not exceed 10mW. If a probe is used for frequency measurements, use the x1 setting.

Table 9.1 CCTM commands required for the diagnosis of faults in the frequency synthesizer

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

9.1 Initial Checks

Types of Checks

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

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

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

Symptoms of Fault

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

- radio fails to power up and *System error* is displayed
- *Out of lock* is displayed (lock error)
- radio is in lock but exhibits transmit or receive fault

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

Transmit and Receive Faults

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

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

With a fault of this kind, neither of the initial tasks is required.
Fault diagnosis should begin with "Power Supplies" on page 165.

Summary

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

- Task 1: system error
- Task 2: lock error
- "Power Supplies": transmit or receive fault

The checks of Tasks 1 and 2 will indicate the section with which the fault diagnosis should continue. Note that there are some differences in the fault-diagnosis procedures, depending on whether the radio is a UHF or 800MHz radio (H5, H6 and K5 bands), or VHF radio (B1 band).
The product-code label on the radio body will identify the frequency band as described in "Product Codes" on page 13.

Task 1 — System Error

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

1. Place the radio in CCTM.

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

   The first two messages will be preceded by four calibration values.

3. In the case of the first message (passed), go to Step 4. In the case of the second and third messages (failed), the FCL is suspect; go to "Power Supply for FCL" on page 209.

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

5. If the calibration succeeded but the system error persists, replace the main board, and go to "Final Tasks" on page 136. In the case of the second message (failed sanity check), go to Step 6. In the case of the third message (calibration failed), go to Step 8 (UHF and 800MHz radios) or "Power Supplies" on page 165 (VHF radios).

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

7. If the calibration succeeded, confirm the removal of the fault, and go to "Final Tasks" on page 136. If the calibration failed, go to Step 8 (UHF and 800MHz radios) or "Power Supplies" on page 165 (VHF radios).

8. Program the radio with the maximum frequency in the radio's frequency band: Enter the CCTM command *101 **x** **x** 0*, where ***x*** is the frequency in hertz.

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

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

10. If the lock status is *111* or *110*, the synthesizer is functioning in the receive mode, and the power supplies and PLL are functioning correctly. Go to "Loop Filter" on page 178 to check the loop filter, VCOs, and buffer amplifiers. If the lock status is *011* or *010*, the synthesizer is faulty in the receive mode. Go to "Power Supplies" on page 165.

Task 2 — Lock Status

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

1. If not already done, place the radio in CCTM.
2. Program the radio with the receive frequency of a channel that is known to be out of lock: Enter the CCTM command ***101 x x 0***, where ***x*** is the frequency in hertz.
3. Enter the CCTM command ***72*** to determine the lock status in receive mode. Note the response. The action required depends on the lock status as described in the following steps.

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

4. If the lock status is ***x0x***, where ***x*** is *0* or *1*, the FCL is suspect; go to "Power Supply for FCL" on page 209.
5. If the lock status is *011*, the synthesizer is suspect, although the power supplies are functioning correctly; go to "Loop Filter" on page 178.
6. If the lock status is *010*, the synthesizer and second LO are both out of lock. First investigate the synthesizer, excluding the power supplies; go to "Loop Filter" on page 178. If necessary, investigate the receiver later.
7. If the lock status is *110*, the second LO is out of lock. Investigate the receiver; go to "Receiver Fault Finding" on page 257.
8. If the lock status is *111*, this implies normal operation. But if the lock error persists, replace the main board and go to "Final Tasks" on page 136.

9.2 Power Supplies

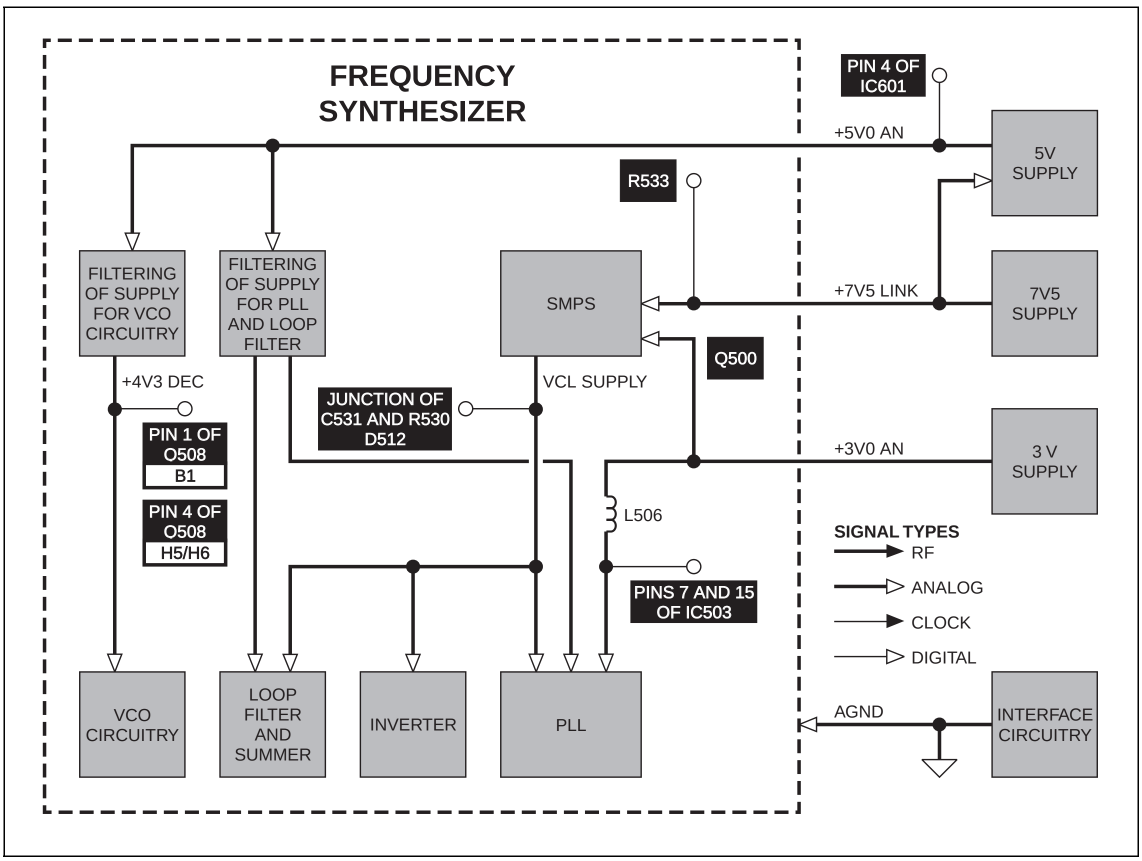
Introduction

First check that a power supply is not the cause of the fault. There are four power supplies for the frequency synthesizer:

- Task 3: 14V DC supply from SMPS (VCL SUPPLY)
- Task 4: 5V DC supply from 7V5 LINK in power supply circuitry (+5V0 AN)
- Task 5: 4.3V DC supply following filtering of 5V AN (+4V3 DEC)
- Task 6: 3V DC supply from 3V regulator in power supply circuitry (+3V0 AN)

The measurement points for diagnosing faults in the power supplies are summarized in Figure 9.1.

Figure 9.1 Measurement points for the synthesizer power supply circuitry



Task 3 — 14V Power Supply

First check the output VCL SUPPLY from the SMPS, which is itself provided with a 7V5 LINK DC supply.

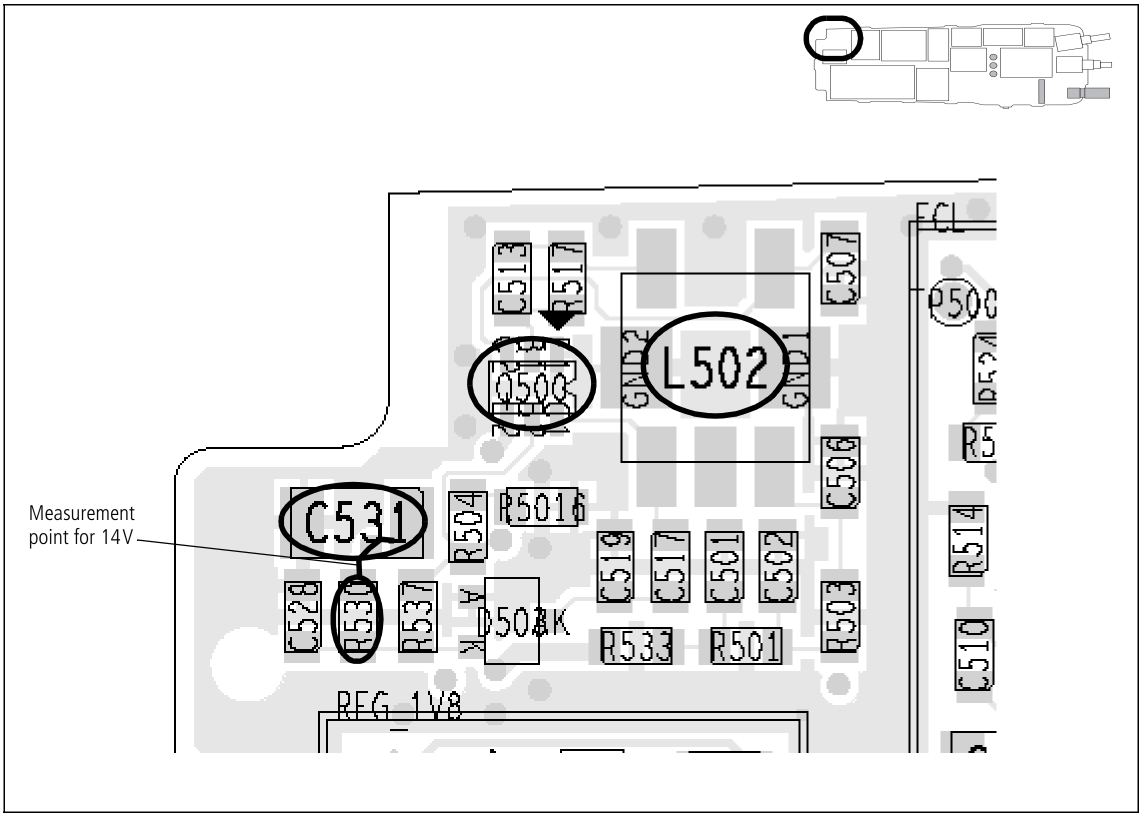
1. Remove the main board from the chassis.
2. Place the radio in CCTM.
3. Measure the SMPS output VCL SUPPLY at the junction between **C531** and **R530** (see **Figure 9.2**).

C531: 14.9V ± 0.2 DC at room temperature

Note The fault could also be caused by the load shorted to ground. With power off, measure the resistance to ground at the junction of **C531** and **R530**. It should be approx. 117kΩ.

4. If the SMPS output is correct, go to Task 4. If it is not, go to Step 5.
5. Check the 7V5 LINK supply at **R533** and 3VO AN at E2 of **Q500** (see **Figure 9.2**).
6. If the voltages are correct, go to Step 7. If it is not, the 7.5V supply is faulty. Go to “Power Supply Fault Finding” on page 151.
7. Check the SMPS circuit based on **Q500** and **L502** (see **Figure 9.2**).
8. If a fault is found, repair the circuit, confirm the removal of the fault, and go to “Final Tasks” on page 136. If the repair failed or no fault could be found, replace the main board, and go to “Final Tasks” on page 136.

Figure 9.2 Synthesizer 14V power supply circuitry (top side)



Task 4 — 5V Power Supply

If the output of the SMPS is correct, check the 5V DC supply next.

1. Measure the supply +5V0 at pin 4 of **IC601** (see **Figure 9.3**).

pin 4 of IC606: 5.0 ± 0.02V DC

2. If the voltage is correct, go to Task 5. If it is not, measure the 7V5 LINK input at pin 6 of **IC601** (see **Figure 9.3**).

pin 6 of IC601: 7.5V (battery voltage)

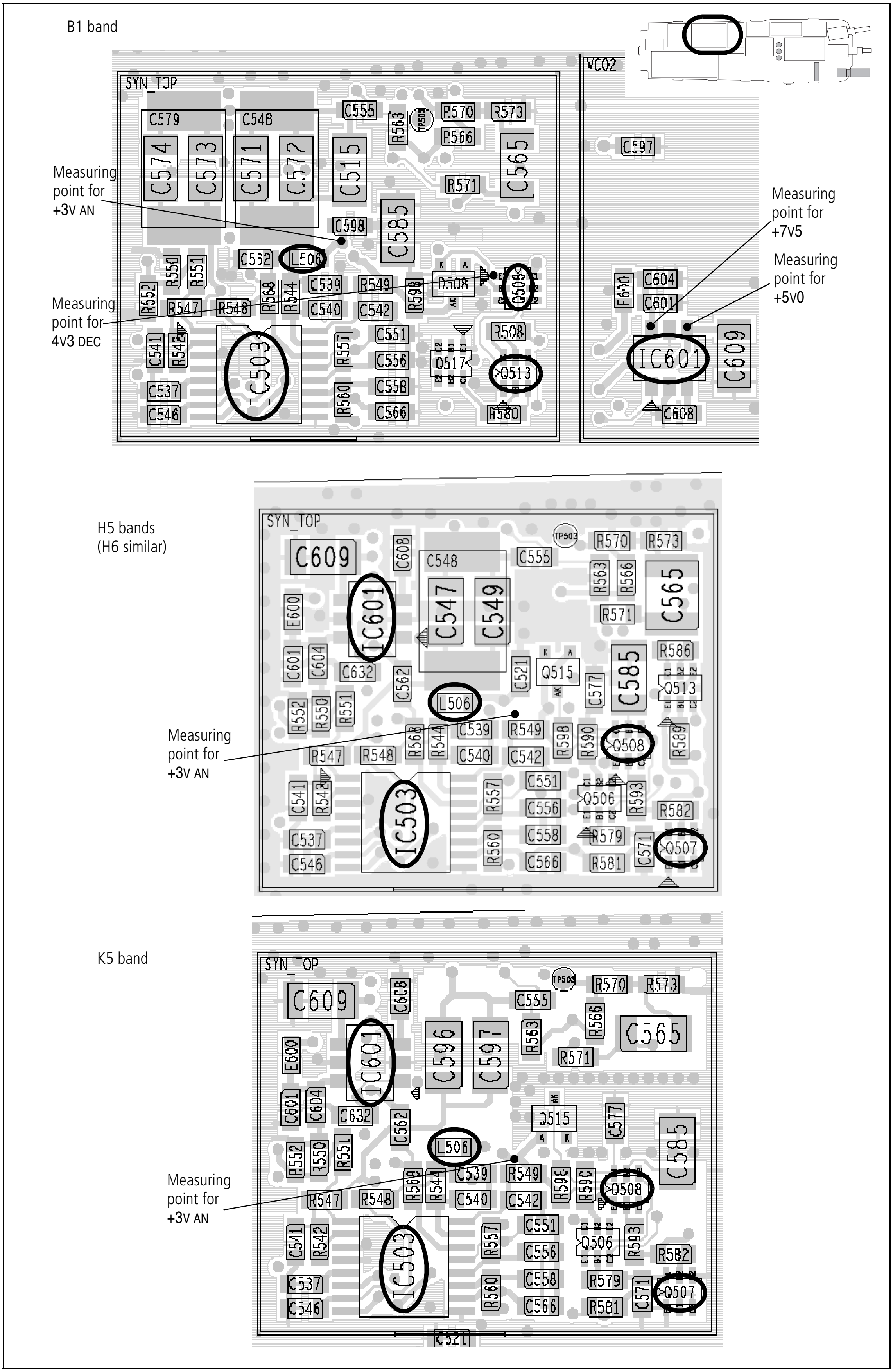
3. If the voltage is correct, go to Step 4. If it is not, the 7.5V supply is faulty. Go to "Power Supply Fault Finding" on page 151.

4. If the input to the regulator **IC601** is correct but not the output, check IC601 (see **Figure 9.3**) and the associated circuitry; if necessary, replace IC601.

   Remove the SYN TOP can and check the C-multipliers **Q508** (pins 3, 4, 5) (see **Figure 9.3**).

5. If a fault is found, repair the circuit, confirm the removal of the fault, and go to "Final Tasks" on page 136. If the repair failed or no fault could be found, replace the main board, and go to "Final Tasks" on page 136.

Figure 9.3 Synthesizer components under the SYN TOP and VCO TOP cans (top side)



Task 5 — 4.3 V Power Supply

If the SMPS output and 5 V DC supply are correct, check the +4V3 DEC supply next.

1. Remove the SYN TOP can.
2. Measure the supply +4V3 DEC at pin 4 of **Q508** (see **Figure 9.3**).

pin 4 of Q508: 4.3 ± 0.15V DC

3. If the voltage is correct, go to Task 6. If it is not, go to Step 4 (UHF and 800 MHz radios) or Step 5 (VHF radios).
4. With a UHF or 800 MHz radio check for faults in the C-multiplier **Q508** (pins 3, 4, 5) and the 5 V and transmit-receive switches based on **Q513**, **Q507** and **Q508** (pins 1, 2, 6) (see **Figure 9.3**). Replace any suspect transistor. Conclude with Step 6.
5. With a VHF radio check for faults in the C-multiplier and 5 V switch based on **Q508** and **Q513** (see **Figure 9.3**). Check the operation of Q517 and Q513. Conclude with Step 6.
6. If a fault is found, repair the circuit, confirm the removal of the fault, and go to "Final Tasks" on page 136. If the repair failed or no fault could be found, replace the main board, and go to "Final Tasks" on page 136.

Task 6 — 3V Power Supply

If the SMPS output and the 5V and 4.3V supplies are correct, the remaining power supply to check is the 3V DC supply.

1. Measure the supply +3V0 AN at pins 7 and 15 of **IC503** (see **Figure 9.3**).

pins 7 and 15 of IC503: 2.9 ± 0.3V DC

2. If the voltage is correct, go to “Phase-Locked Loop” on page 172. If it is not, go to Step 3.

3. Check the supply at **L506** (see **Figure 9.3**). The measurement point is the via shown in the figure.

L506: 2.9 ± 0.3V DC

4. If the voltage is correct, go to Step 7. If it is not, the 3V regulator **IC604** is suspect (see **Figure 9.4**).

5. Measure the voltage DIG 3V AN EN at pin 3 of **IC604** (see **Figure 9.4**).

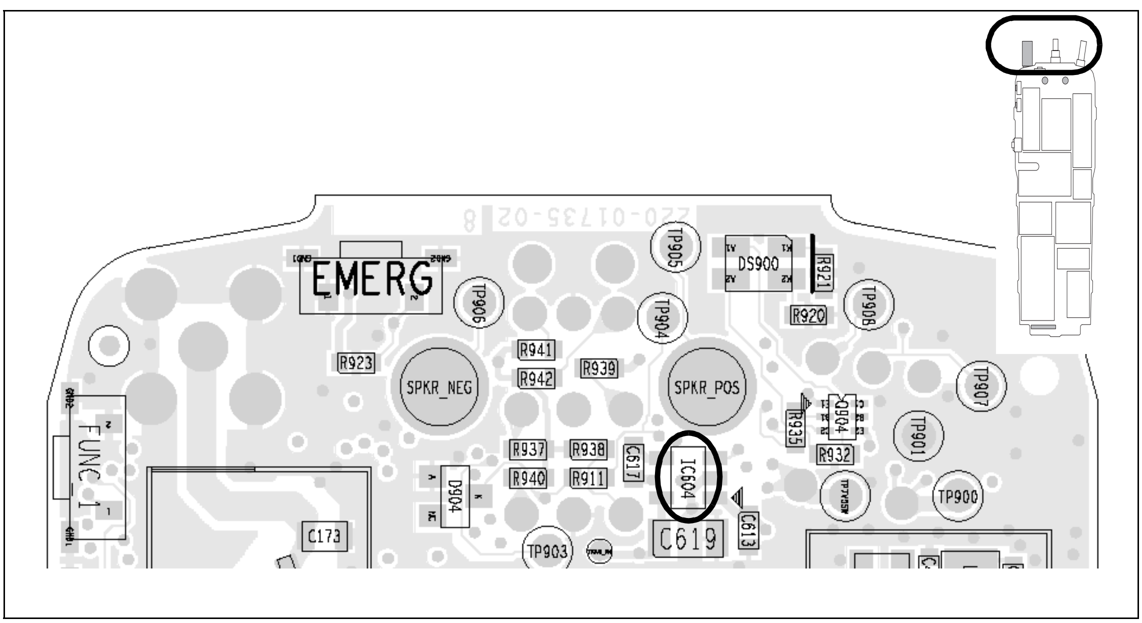
L506: 2.9 ± 0.3V DC

6. If it is correct, go to Step 7. If it is not correct, go to “Power Supply Fault Finding” on page 151.

7. Check the components in the path from **L506** to **IC503**. Also check IC503; if necessary, replace IC503 (see **Figure 9.3**).

8. If a fault is found, repair the circuit, confirm the removal of the fault, and go to “Final Tasks” on page 136. If the repair failed or no fault could be found, replace the main board, and go to “Final Tasks” on page 136.

Figure 9.4 Location of the 3V regulator IC604 (bottom side)



9.3 Phase-Locked Loop

Introduction

If there is no fault with the power supplies, check the critical output from, and inputs to, the PLL:

- Task 7: supply for charge pump
- Task 8: reference frequency input
- Task 9: DIG SYN EN line input
- Task 10: SYN LOCK line output

The measurement points for diagnosing faults concerning the PLL inputs and output are summarized in **Figure 9.5**.

Task 7 — Supply for Charge Pump

First check the supply for the charge pump of the PLL.

1. Measure the supply for the charge pump at pin 16 of **IC503** (see **Figure 9.2**).

pin 16 of IC503: 5.0 ± 0.3V DC

2. If the voltage is correct, go to Task 8. If it is not, go to Step 3.
3. Check **IC503**; if necessary, replace the IC.
4. If there is a fault, repair the circuit, confirm the removal of the fault, and go to "Final Tasks" on page 136. If the repair failed or no fault could be found, replace the main board, and go to "Final Tasks" on page 136.

Task 8 — Reference Frequency

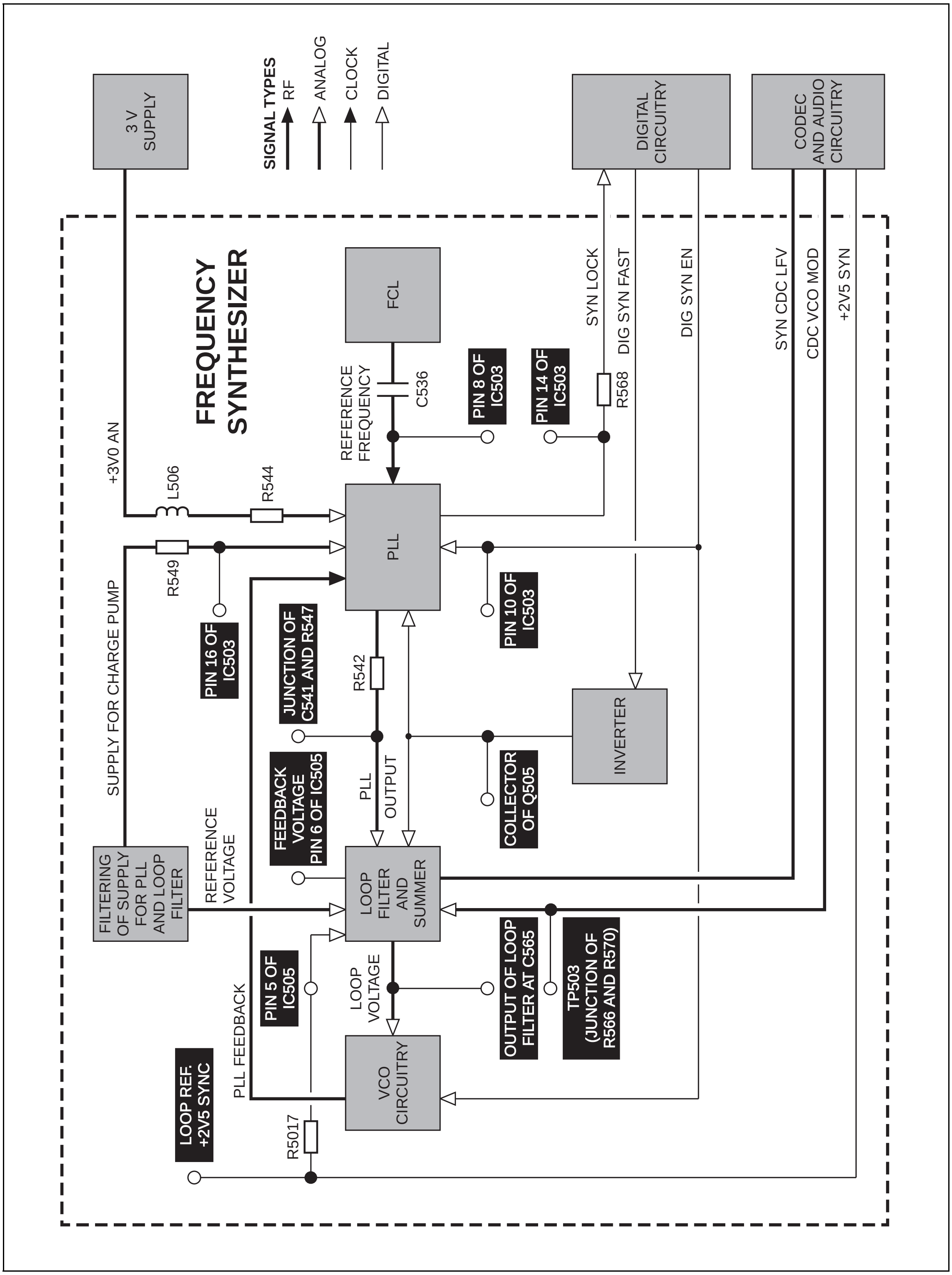
If the supply for the charge pump is correct, check the reference frequency input from the FCL to the PLL.

1. Measure the reference frequency at pin 8 of **IC503** (see **Figure 9.3**).

pin 8 of IC503: 13.012 ± 0.002 MHz and 1.1 ± 0.2V_{pp} sine wave

2. If the signal is correct, go to Task 9. If it is not, go to Step 3.
3. Check **IC503** (see **Figure 9.3**). Replace IC503 if it is suspect.
4. Determine if the fault has been removed. If it has, go to "Final Tasks" on page 136. If it has not, the FCL is suspect; go to "Power Supply for FCL" on page 209.

Figure 9.5 Measurement points for the synthesizer PLL and loop filter



Task 9 — DIG SYN EN Line

If the supply for the charge pump and the reference frequency are correct, check the DIG SYN EN line input.

1. Check the DIG SYN EN line at pin 10 of **IC503** (see **Figure 9.2**). Enter the CCTM command *334 0* to switch off the synthesizer, and measure the voltage at pin 10.

pin 10 of IC503: 0V DC (after entry of CCTM 334 0)

2. Enter the command *334 1* to switch on the synthesizer, and measure the voltage again.

pin 10 of IC503: 2.5 ± 0.3V DC (after entry of CCTM 334 1)

3. If the voltages measured in Step 1 and Step 2 are correct, go to Task 10. If they are not, go to Step 4.

4. Remove DIG BOT can.

5. Enter the CCTM command *334 0* to switch off the synthesizer, and measure the voltage on both sides of **R716** (see **Figure 9.6**).

R716: 0V DC (after entry of CCTM 334 0)

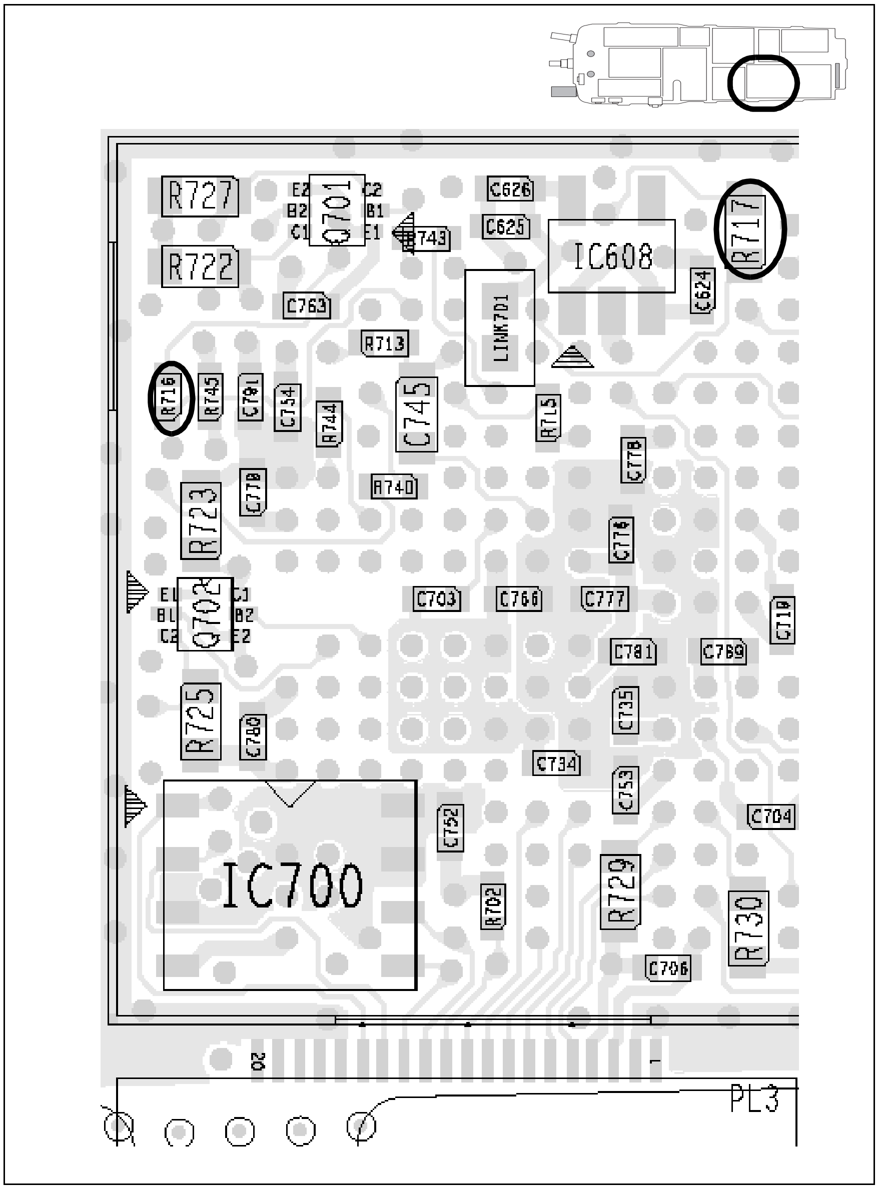
6. Enter the CCTM command *334 1* to switch on the synthesizer, and measure the voltage on both sides of **R716** (see **Figure 9.6**).

R716: 3.3 ± 0.3V DC (after entry of CCTM 334 1)

7. If the voltages measured in Step 5 and Step 6 are still not correct, check whether the IO port (D2) of IC701 is faulty or shorted by solder. If the voltages are correct, go to Step 8.

8. If there is a fault, repair the circuit, confirm the removal of the fault, and go to “Final Tasks” on page 136. If the repair failed or no fault could be found, replace the main board, and go to “Final Tasks” on page 136.

Figure 9.6 Synthesizer components under the DIG BOT can (bottom side)



Task 10 — SYN LOCK Line

If all the critical inputs to the PLL are correct, check the SYN LOCK line output.

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

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

2. Check the SYN LOCK line by measuring the voltage at pin 14 of **IC503** (see **Figure 9.3**). The voltage should depend on the lock status as follows:

lock status 111 or 110: 3.0 ± 0.3V DC at pin 14 of IC503 lock status 011 or 010: 0V DC at pin 14 of IC503

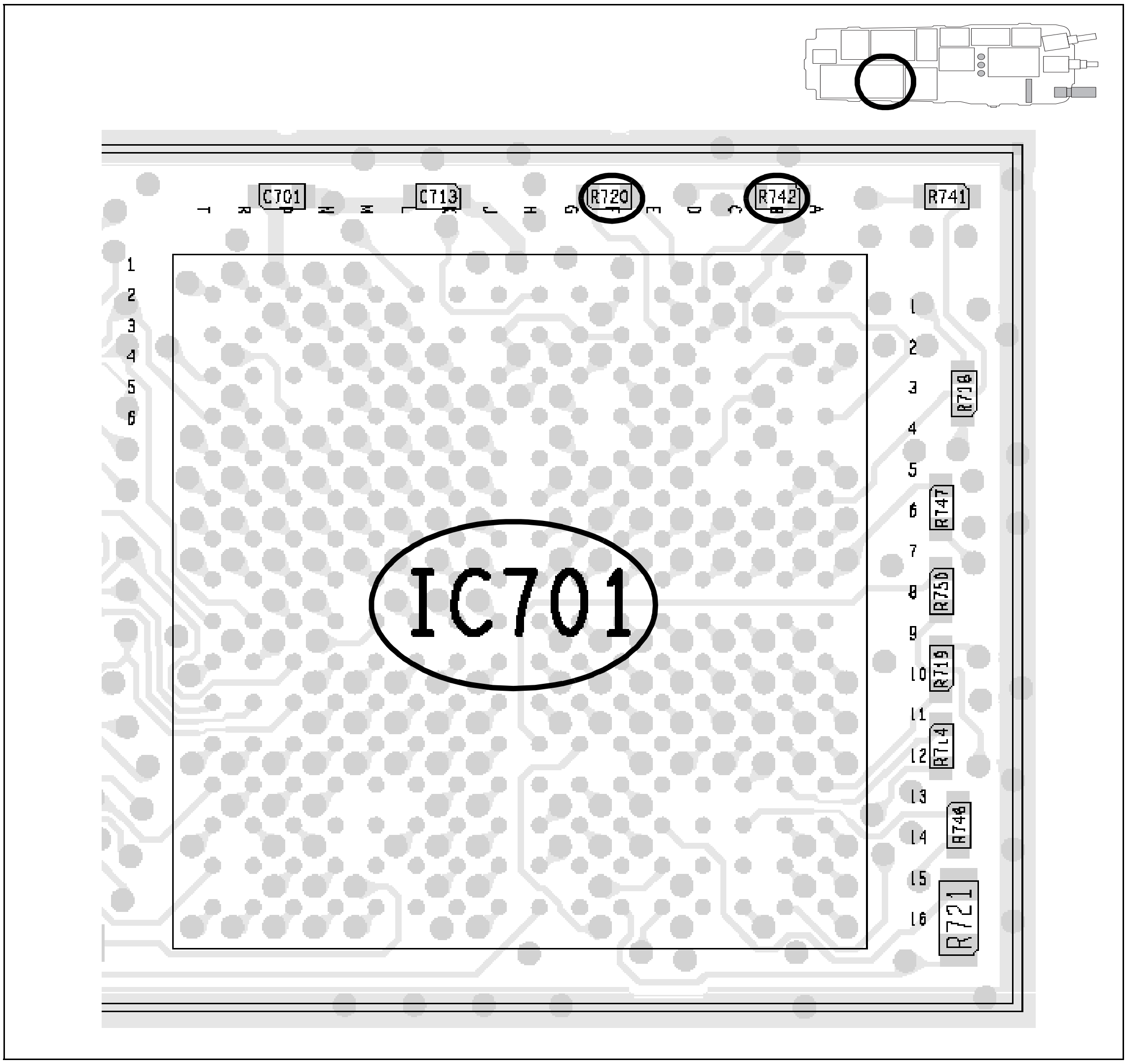
3. If the voltage measured in Step 2 is correct, go to "Loop Filter" on page 178. If it is not, go to Step 4.

4. Check for continuity between pin 14 of **IC503** and the digital input **R742** to D1 of **IC701** (DIG TOP can) (**Figure 9.7**).

5. If there is a fault, go to Step 6. If there is no fault, the digital circuitry is faulty; replace the main board, and go to "Final Tasks" on page 136.

6. Repair the fault. Confirm the removal of the fault and go to "Final Tasks" on page 136. If the repair failed or no fault could be found, replace the main board, and go to "Final Tasks" on page 136.

Figure 9.7 Synthesizer components under the DIG TOP can (top side)



9.4 Loop Filter

Introduction

If the power supplies for the frequency synthesizer are correct, and the PLL is functioning properly, check the loop filter next:

- Task 11: check loop voltage
- Task 12: VCO fault
- Task 13: check reference voltage
- Task 14: check feedback voltage
- Task 15: check DIG SYN FAST line
- Task 16: check TP503 test point

The test and measurement points for diagnosing faults concerning the loop filter are summarized in **Figure 9.5**.

Task 11 — Check Loop Voltage

Check whether the loop filter is functioning correctly by measuring the loop voltage at the via next to SYN BOT can, or remove SYN BOT can and measure at pin 1 of **Q511** (see **Figure 9.9**).

1. If not already done, remove the main board from the chassis, remove the SYN TOP can, and place the radio in CCTM.

2. Remove **R542** (see **Figure 9.8**).

3. Using an oscilloscope, proceed as follows to observe the voltage at **C565** before and after grounding the junction between **C541** and **R547** (see **Figure 9.8**):

   While holding the oscilloscope probe at C565, use a pair of tweezers to momentarily ground the junction. The voltage should change to the following value (if it is not already at this value):

C565: 13.3 ± 0.3V DC

4. If the loop voltage is correct, go to Step 5. If it is not, the loop-filter circuitry is suspect; go to Task 13.

5. Proceed as follows to observe the voltage at **C565** before and after applying 3V DC to the junction of **C541** and **R547**; there is a convenient 3V level at **R544** (see **Figure 9.8**):

   While holding the probe at C565, use the tweezers to momentarily apply 3V DC to the junction; do not touch the board with your hand, and do not allow the tweezers to touch any cans when you remove them. The voltage should change to:

C565: < 0.5V DC

6. If the loop voltage is correct, go to Task 12. If it is not, the loop-filter circuitry is suspect; go to Task 13.

Figure 9.8 Synthesizer components under the SYN TOP can (top side)

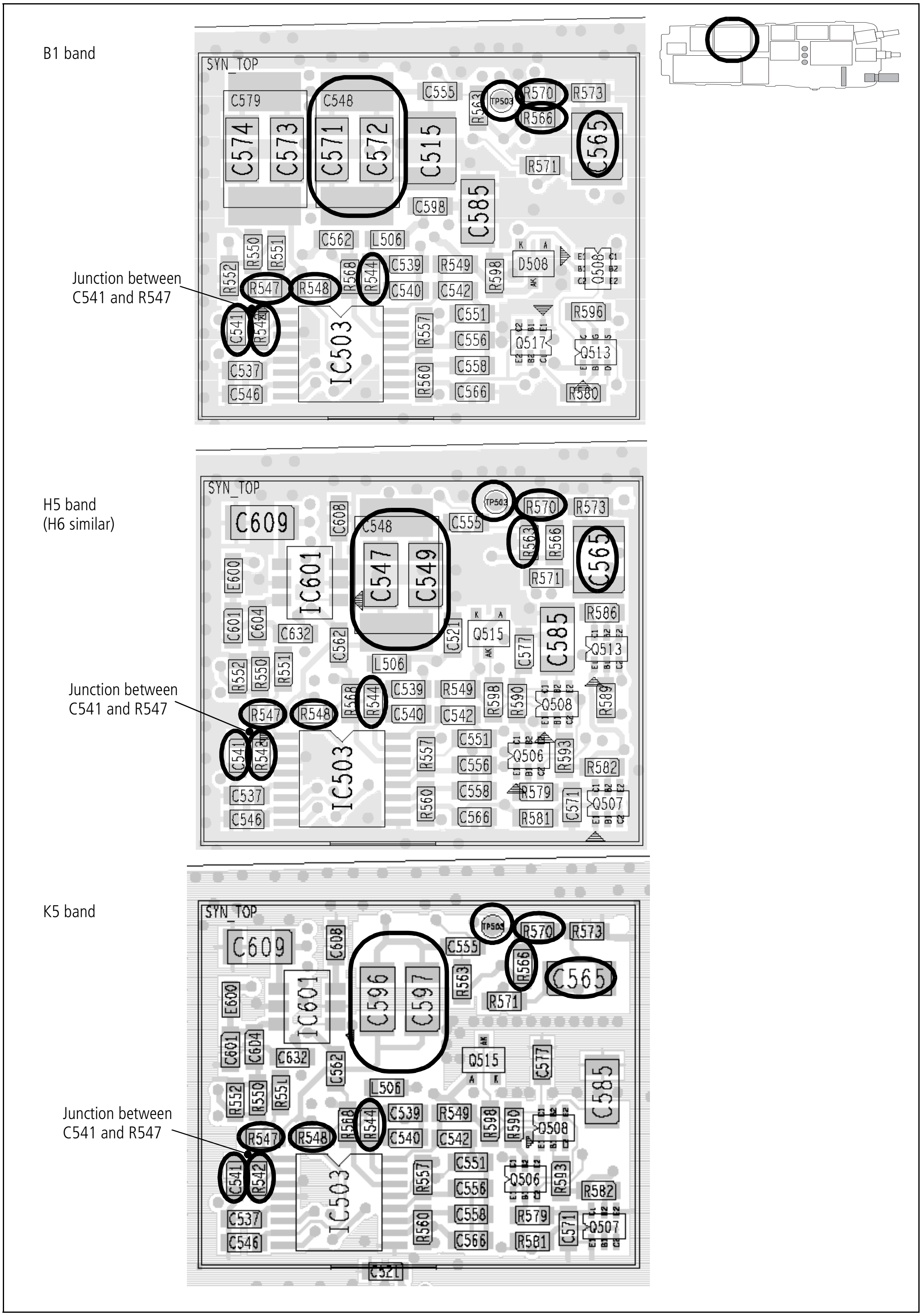
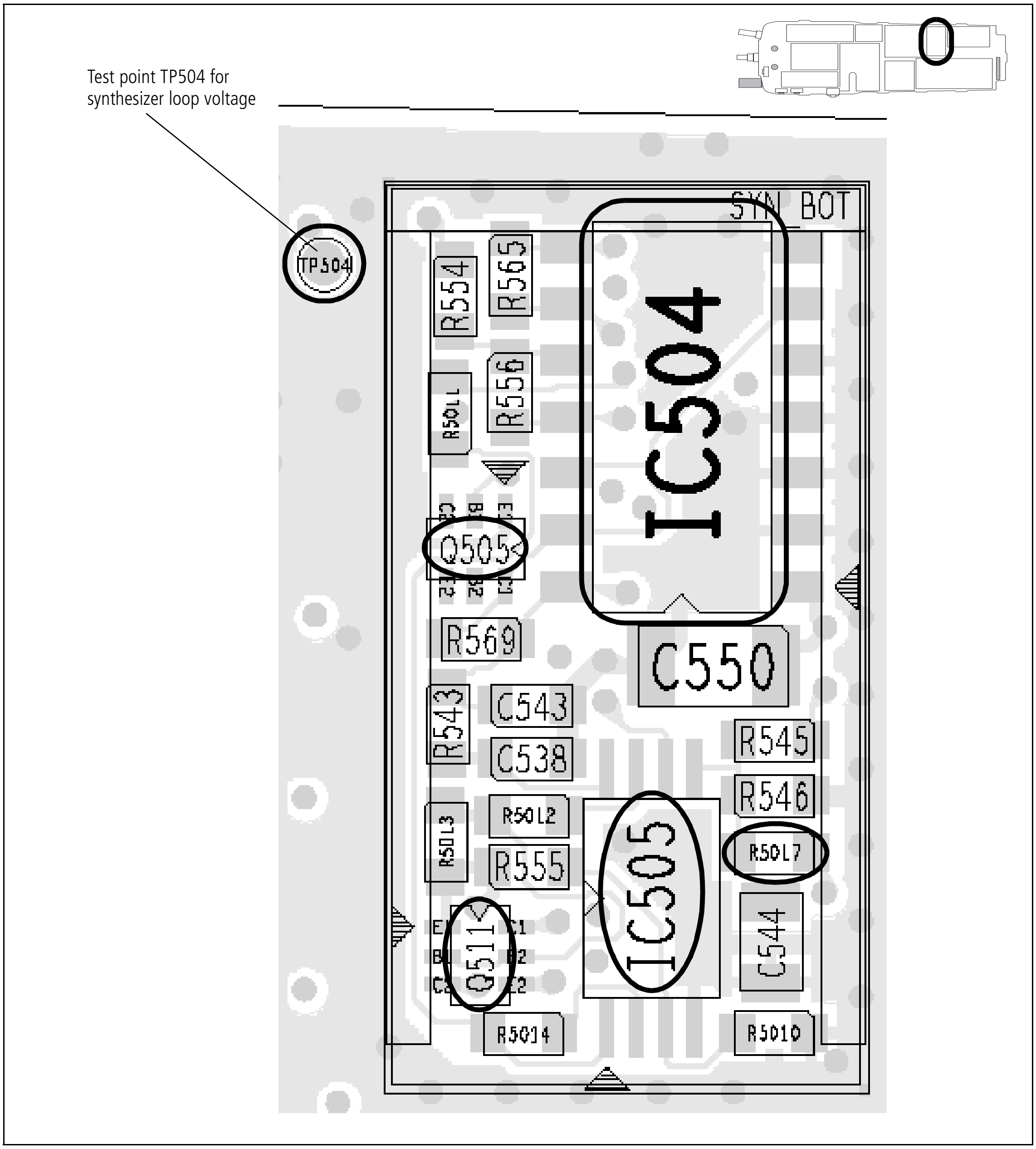


Figure 9.9 Synthesizer components under the SYN BOT can (bottom side)



Task 12 — VCO Faulty

If the loop voltage is correct, the loop filter is functioning properly. The VCO and related circuitry is therefore suspect. The section to proceed to depends on the type of the radio and the nature of the fault.

1. With a UHF or 800MHz radio go to Step 2. With a VHF radio go to "VCO and Related Circuitry (VHF Radios)" on page 200.

2. If a UHF or 800MHz radio exhibits a lock error or a receive fault. the receive VCO is suspect; go to "Receive VCO and Related Circuitry (UHF and 800MHz Radios)" on page 185.

   If it exhibits a system error or a transmit fault, the transmit VCO is suspect; go to "Transmit VCO and Related Circuitry (UHF and 800MHz Radios)" on page 195.

Task 13 — Check Reference Voltage

If the loop-filter circuitry is suspect, first check the reference voltage for the filter.

1. Remove the SYN BOT can.

2. Measure the reference voltage at pin 5 of **IC505** (see **Figure 9.9**). The result should be:

IC505 pin 5:	2.5 ± 0.05V DC

3. If the voltage is correct, go to Task 14. If it is not, the reference-voltage circuitry is suspect; go to Step 4.

4. Check **R5017** (see **Figure 9.9**).

5. If a fault is found, repair the circuit, and confirm that the reference voltage is now correct. If it is, go to "Final Tasks" on page 136. If it is not, or if no fault could be found, replace the main board, and go to "Final Tasks" on page 136.

Task 14 — Check Feedback Voltage

If the loop filter is suspect but the reference voltage is correct, check the feedback voltage.

1. Measure the feedback voltage at pin 6 of **IC505** (see **Figure 9.9**). The result should be:

IC505 pin 6:	2.5 ± 0.1 V DC

2. If the voltage is not correct, the loop filter is faulty; go to Step 3. If the voltage is correct, resolder **R542** in position (see **Figure 9.8**) and go to Task 15.

3. Check **IC504**, **IC505**, **Q511** (see **Figure 9.9**), **C548** (see **Figure 9.8**), and associated components.

4. If a fault is found, repair the circuit, repeat the measurement of the feedback voltage in Step 1, and resolder **R542** in position (see **Figure 9.8**).

5. If the feedback voltage is now correct, go to "Final Tasks" on page 136. If it is not, or if no fault could be found, replace the main board, and go to "Final Tasks" on page 136.

Task 15 — Check DIG SYN FAST Line

If the loop filter is suspect but the reference and feedback voltages are correct, check the DIG SYN FAST line, which is the input to the inverter **Q505**.

1. Enter the CCTM command *389 1* to set the synthesizer mode to fast.

2. Measure the voltage at the collector of **Q505** (see **Figure 9.9**). The result should be:

Q505 collector: 14.2 ± 0.3V DC (after entry of CCTM 389 1)

3. Enter the CCTM command *389 0* to set the mode to slow.

4. Measure the voltage at the collector of **Q505** (see **Figure 9.9**). The result should be:

Q505 collector: 0V DC (after entry of CCTM 389 0)

5. If the voltages measured in Step 2 and Step 4 are correct, go to Task 16. If they are not, go to Step 6.

6. Remove **R717** (see **Figure 9.6**).

7. Enter the CCTM command *389 1* to set the mode to fast.

8. Measure the voltage at the via between **R717** (see **Figure 9.6**) and the digital circuitry. The result should be:

via at R105: 0V DC (after entry of CCTM 389 1)

9. Enter the CCTM command *389 0* to set the mode to slow.

10. Measure the voltage at the via between **R717** (see **Figure 9.6**) and the digital circuitry. The result should be:

via at R105: 3.3 ± 0.3V DC (after entry of CCTM 389 0)

11. If the voltages measured in Step 8 and Step 10 are correct, go to Step 12. If they are not, the digital circuitry is faulty; replace the main board and go to "Final Tasks" on page 136.

12. Check and resolder **R717** in position (see **Figure 9.6**), and check for continuity between the collector of **Q505** (see **Figure 9.9**) and the digital circuitry via R717.

13. If a fault is found, repair the circuit, and confirm that the voltages are now correct. If they are, go to "Final Tasks" on page 136. If they are not, or if no fault could be found, replace the main board, and go to "Final Tasks" on page 136.

Task 16 — Check TP503 Test Point

If the reference voltage, feedback voltage, and DIG SYN FAST line are all correct, check the voltage at the TP503 test point.

1. Measure the voltage at the **TP503 test point** (see **Figure 9.8**). The oscilloscope should show a DC level less than 3.0V with no sign of noise or modulation (Rx mode).

TP503 test point: < 3.0V DC

2. If the correct result is obtained, go to Step 3. If it is not, go to Step 4.

3. The loop filter is faulty but the above measurements do not provide more specific information. Check **IC504**, **IC505**, **Q511** (see **Figure 9.9**), **C548** (see **Figure 9.8**) and associated components. Conclude with Step 9.

4. Remove **R566** and **R570** (see **Figure 9.8**), which provide a modulation path to the VCO(s).

5. Repeat the measurement of Step 1.

6. If the correct result is now obtained, go to Step 7. If the correct result is still not obtained, the CODEC and audio circuitry is suspect; resolder **R566** and **R570** in position (see **Figure 9.8**), and go to "CODEC and Audio Fault Finding" on page 277.

7. Resolder **R566** and **R570** in position (see **Figure 9.8**).

8. Check **IC504** (pins 6, 8, 9) (see **Figure 9.9**) and the associated components in the loop filter.

9. If a fault is found, repair the circuit, and confirm that the voltages are now correct. If they are, go to "Final Tasks" on page 136. If they are not, or if no fault could be found, replace the main board, and go to "Final Tasks" on page 136.

9.5 Receive VCO and Related Circuitry (UHF and 800 MHz Radios)

Introduction

If there is no fault with the power supplies, the PLL inputs and output, and the loop filter, check the VCO and related circuitry. The procedures in this section apply only to UHF and 800 MHz radios with a lock error or receive fault, and therefore with suspect receive VCO and related circuitry. (The minimum and maximum receive frequencies for the different frequency bands are defined in Table 9.2.) There are six aspects:

- Task 17: check receive VCO
- Task 18: repair PLL feedback
- Task 19 repair receive VCO
- Task 20: check switching to receive mode
- Task 21: repair switching network
- Task 22: check receive buffer amplifier

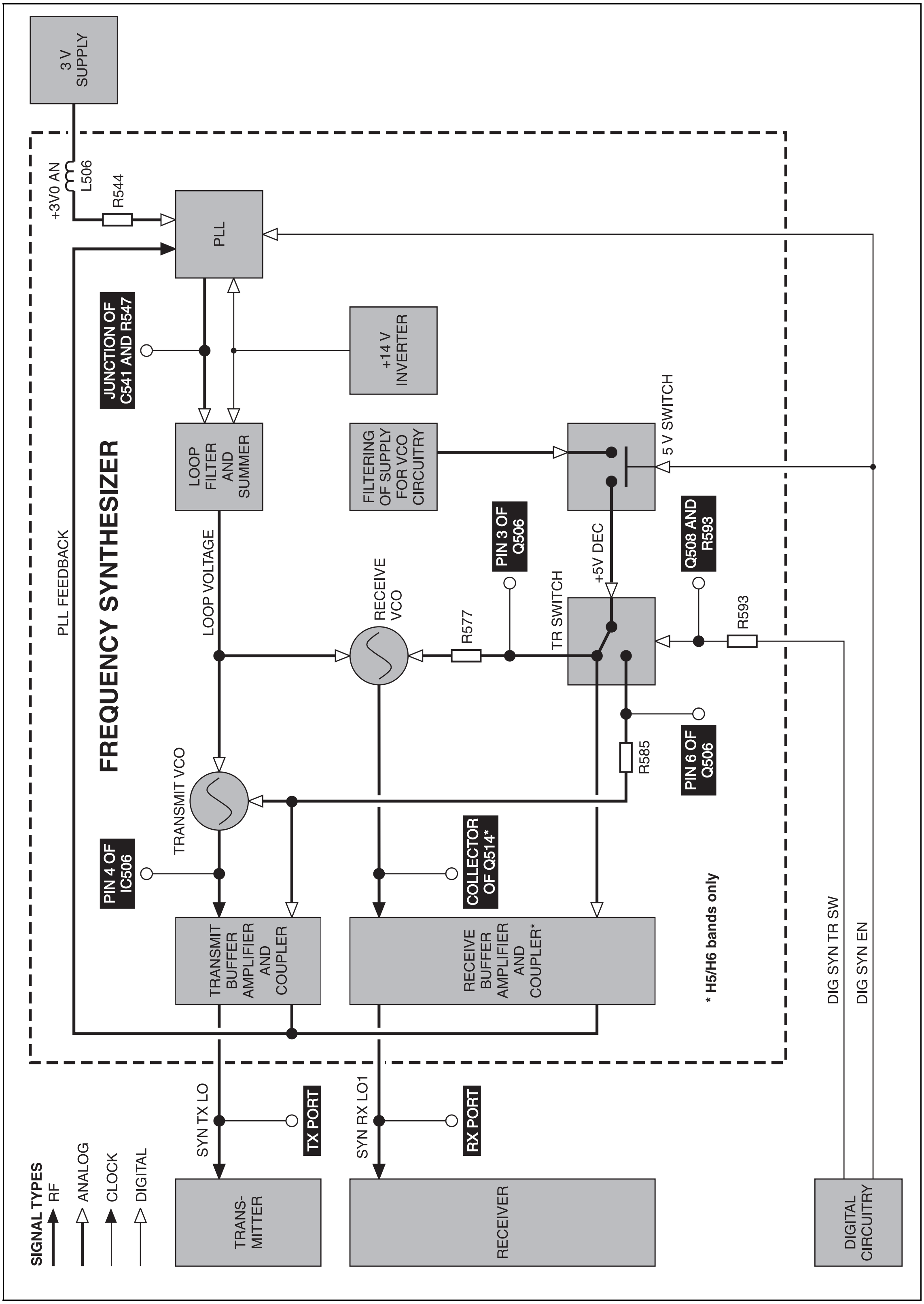
The measurement points for diagnosing faults in the VCO and related circuitry are summarized in **Figure 9.10**.

Table 9.2 Minimum and maximum receive frequencies for the different UHF and 800 MHz frequency bands

Frequency band	Receive frequency in MHz	
	Minimum	Maximum
H5	337 ± 5	441 ± 5
H6	378 ± 5	498 ± 5
K5	805[a]	825[a]

a. The radio firmware only allows these frequencies.

Figure 9.10 Measurement points for the VCO and related circuitry in UHF and 800 MHz radios



Task 17 — Check Receive VCO

Check that the correct receive frequency is synthesized. This is the frequency of the receive VCO output SYN RX LO1 at the RX port shown in **Figure 9.11**.

1. Enter the CCTM command *335 0* to set the transmit-receive switch off (receive mode).

2. Using a frequency counter, proceed as follows to observe the receive frequency at the RX port of **T401** (see **Figure 9.12**) before and after grounding the junction between **C541** and **R547** (see **Figure 9.11**):

   While holding the probe from the counter on the RX port, use a pair of tweezers to momentarily ground the junction. The frequency should change to:

RX port: maximum receive frequency (see Table 9.2)

   The loop filter will hold its output steady at 13.3 V. This should result in a frequency equal to the maximum given in **Table 9.2**.

3. If the receive frequency measured in Step 2 is correct, go to Step 4. If it is incorrect, go to Task 19. If no frequency is detected, go to Task 20.

4. Proceed as follows to observe the receive frequency at the RX port before and after applying 3V DC to the junction of **C541** and **R547** (see **Figure 9.11**); there is a convenient 3V level at **R544** (see **Figure 9.11**):

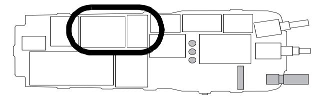
   While holding the probe on the RX port, use the tweezers to momentarily apply 3V DC to the junction; do not touch the board with your hand, and do not allow the tweezers to touch any cans when you remove them. The frequency should change to:

RX port: minimum receive frequency (see Table 9.2)

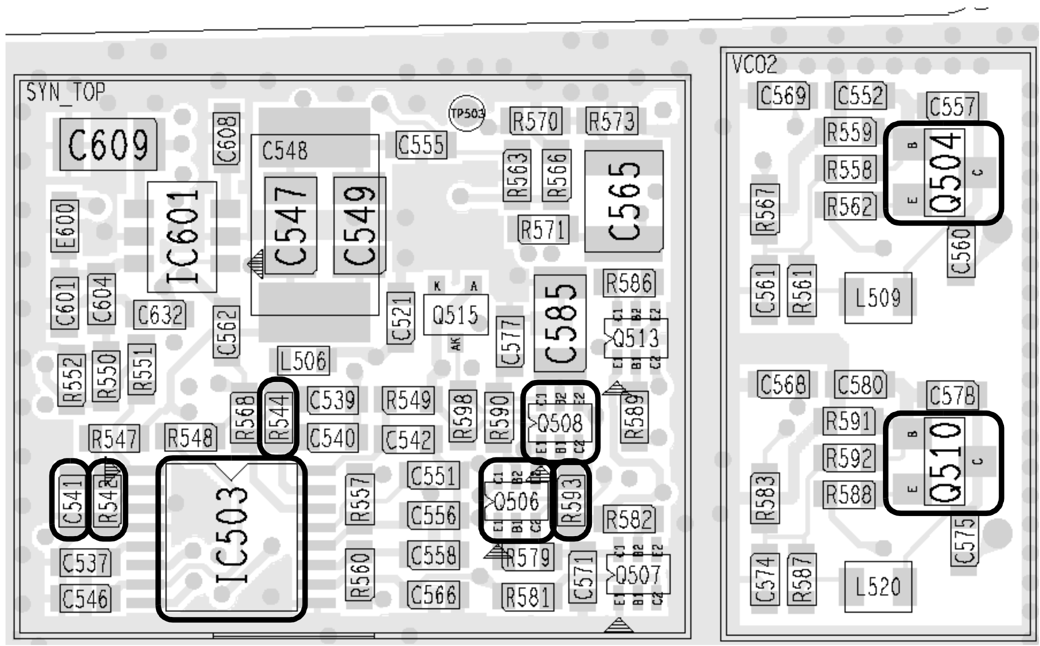
   The loop filter will hold its output steady at about 0V. This should result in a frequency equal to the minimum given in **Table 9.2**.

5. If the receive frequency measured in Step 4 is correct, go to Task 18. If it is incorrect, go to Task 19. If no frequency is detected, go to Task 20.

Figure 9.11 Synthesizer components under the SYN TOP and VCO TOP cans (UHF and 800 MHz radios, top side)



H5 band (H6 similar)



K5 band

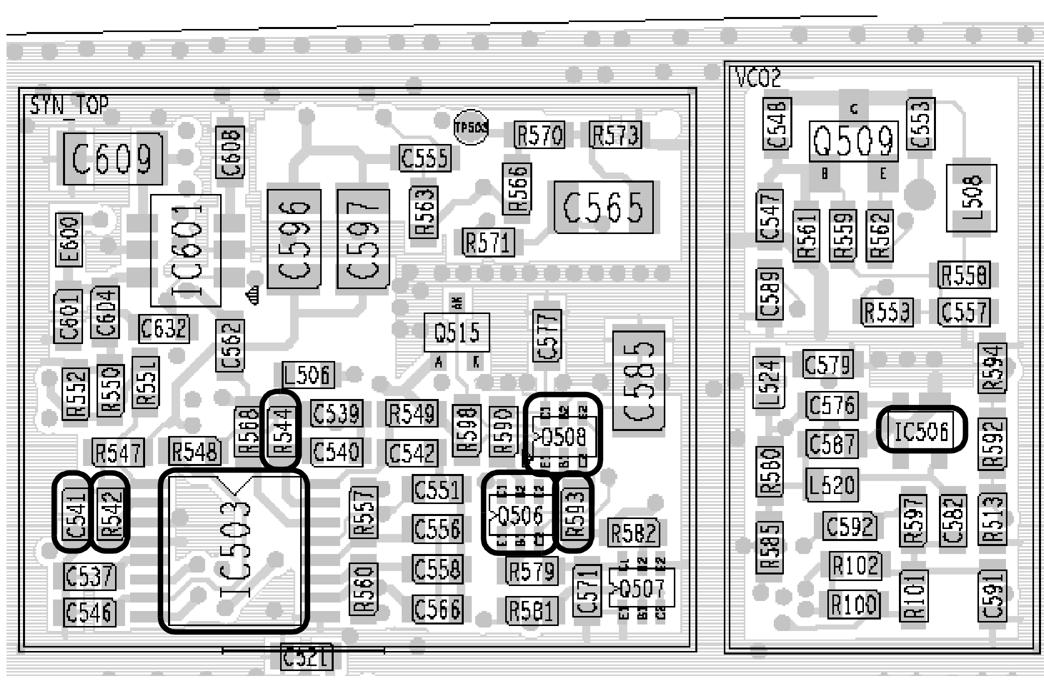
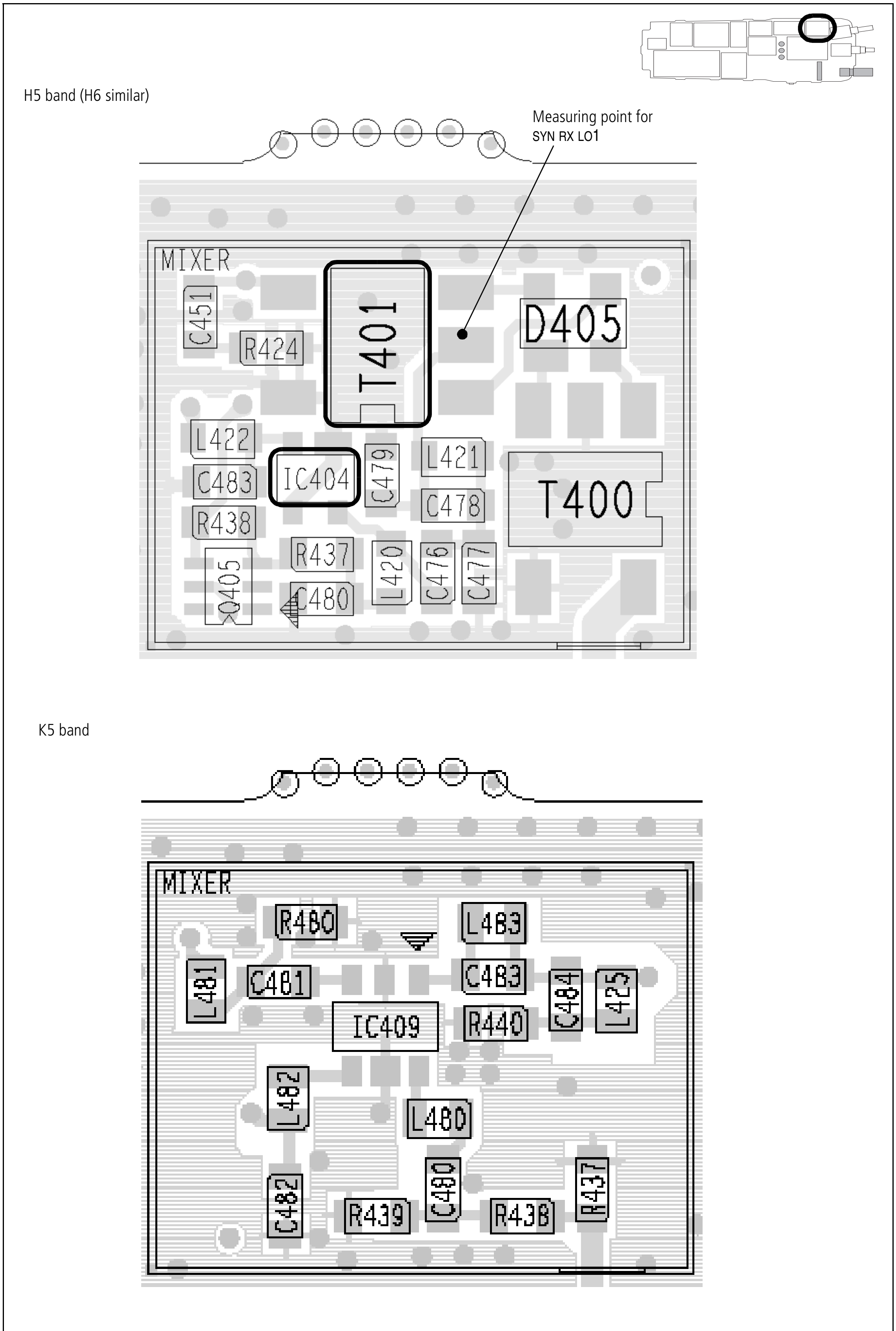


Figure 9.12 Synthesizer components under the MIXER TOP can (UHF and 800 MHz radios, top side)

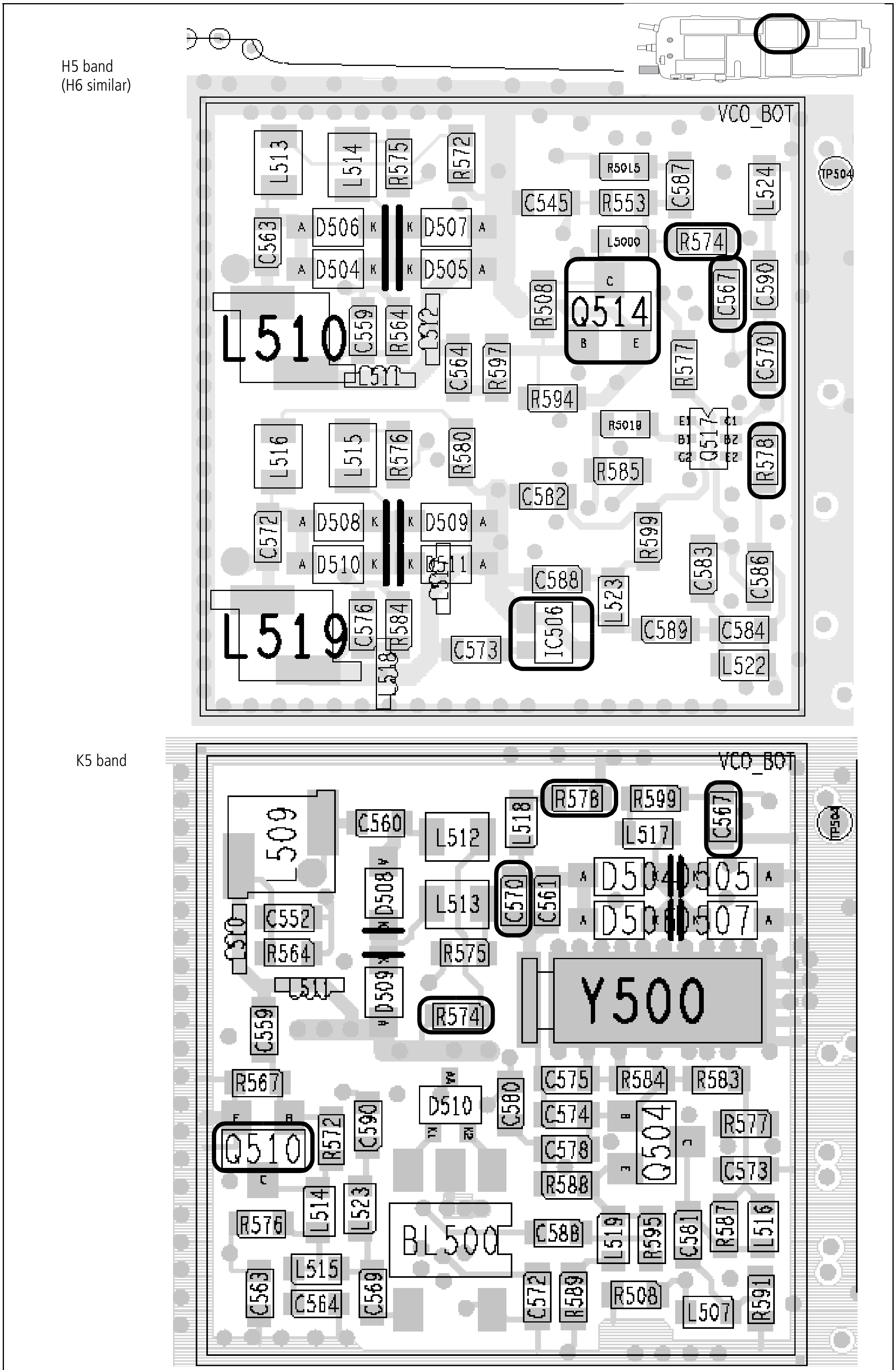


Task 18 — Repair PLL feedback

If both the minimum and maximum receive frequencies are correct, the PLL feedback is suspect.

1. Resolder **R542** in position (see **Figure 9.11**).
2. Remove the VCO BOT can.
3. Replace the components **C567**, **R574** (see **Figure 9.13**) and **IC503** (see **Figure 9.11**).
4. For the H5 and H6 bands, also check the second stage of the receive buffer amplifier based on **IC404** (see **Figure 9.12**). Repair any fault.
5. Confirm that the fault in the radio has been removed. If it has, go to "Final Tasks" on page 136. If it has not, replace the main board, and go to "Final Tasks" on page 136.

Figure 9.13 Synthesizer components under the VCO BOT can (UHF and 800 MHz radios, bottom side)



Task 19 — Repair Receive VCO

If either or both the minimum and maximum receive frequencies are incorrect, the receive VCO circuitry is faulty.

1. Remove the VCO TOP can.
2. Check the receive VCO. The circuitry is based on **Q504** (see **Figure 9.11**).
3. If a fault is found, repair it and go to Step 4. If no fault is found, go to Step 6.
4. Repeat the frequency measurements in Step 2 and Step 4 of Task 17.
5. If the frequencies are now correct, resolder **R542** in position (see **Figure 9.11**), and go to "Final Tasks" on page 136. If they are still not correct, go to Step 6.
6. Resolder **R542** in position (see **Figure 9.11**). Replace the main board and go to "Final Tasks" on page 136.

Task 20 — Check Switching to Receive Mode

If no receive frequency is detected in the check of the receive VCO, first check that the transmit-receive switch is functioning correctly.

1. Resolder **R542** in position (see **Figure 9.11**).
2. Enter the CCTM command *335 0* to switch on the supply to the receive VCO.
3. Measure the voltage at the first collector (pin 3) of **Q506** (see **Figure 9.11**). The voltage should be:

pin 3 of Q506: 5.0 ± 0.3V DC (after entry of CCTM 335 0)

4. Enter the CCTM command *335 1* to switch off the supply.
5. Again measure the voltage at the first collector of **Q506**.

pin 3 of Q506: 0V DC (after entry of CCTM 335 1)

6. If the voltages measured in Step 3 and Step 5 are correct,
   - H5 and H6 bands: go to Task 22.
   - K5 band: replace the main board, and go to "Final Tasks" on page 136.

   If the voltages are not correct, the switching network is suspect; go to Task 21.

Task 21 — Repair Switching Network

If the transmit-receive switch is not functioning correctly, first check the DIG SYN TR SW line to confirm that the digital circuitry is not the cause. If the digital circuitry is not faulty, the switching network is suspect.

1. Enter the CCTM command *335 0* to set the transmit-receive switch off (receive mode). Measure the voltage on the DIG SYN TR SW line between **Q508** and **R593** (see **Figure 9.11**).

R593: 0V DC (after entry of CCTM 335 0)

2. Enter the CCTM command *335 1* to set the transmit-receive switch on (transmit mode). Again measure the voltage at **R593**.

R593: 2.0 ± 0.5V DC (after entry of CCTM 335 1)

3. If the voltages measured in Step 1 and Step 2 are correct, go to Step 9. If they are not, remove **R720** (see **Figure 9.7**) and go to Step 4.

4. Enter the CCTM command *335 0* and measure the voltage at the via between **R720** (see **Figure 9.7**) and the digital circuitry.

via at R720: 0V DC (after entry of CCTM 335 0)

5. Enter the CCTM command *335 1* and again measure the voltage at the via between **R720** and the digital circuitry.

via at R720: 3.3 ± 0.3V DC (after entry of CCTM 335 1)

6. If the voltages measured in Step 4 and Step 5 are correct, go to Step 7. If they are not, the digital circuitry is faulty; resolder **R720** in position (see **Figure 9.7**), replace the main board and go to "Final Tasks" on page 136.

7. Check and resolder **R720** in position (see **Figure 9.7**), and check for continuity between **Q508** and the digital circuitry via **R593** (see **Figure 9.11**) and R720.

8. If no fault is found, go to Step 9. If a fault is found, repair the circuit, confirm that the voltages are now correct, and go to "Final Tasks" on page 136. If the repair failed, replace the main board and go to "Final Tasks" on page 136.

9. Check the circuitry for the transmit-receive and 4V3 DEC switches (based on **Q506**, **Q507** and **Q508**) (see **Figure 9.3**).

10. If a fault is found, repair the circuit, confirm that the voltages are now correct, and go to "Final Tasks" on page 136. If the repair failed or the fault could not be found, replace the main board, and go to "Final Tasks" on page 136.

Task 22 — Check Receive Buffer Amplifier (H5 and H6 bands only)

For the H5 and H6 bands, if no receive frequency is detected but the switching network is not faulty, check the receive buffer amplifier. If the amplifier is not faulty, there might be a fault in the receive VCO that was not detected earlier.

1. Remove the VCO BOT can.

2. Check the receive buffer amplifier in receive mode: Enter the CCTM command *335 0* to set the transmit-receive switch off.

3. Measure the voltages at the collector of **Q514** (see **Figure 9.13**) and pin 4 of **IC404** (see **Figure 9.12**).

collector of Q514:	0.7 ± 0.1 V DC (receive mode)
pin 4 of IC404:	2.0 ± 0.1 V DC (receive mode)

4. Then check the receive buffer amplifier in transmit mode: Enter the CCTM command *335 1* to set the transmit-receive switch on.

5. Again measure the voltage at **Q514** and **IC404**.

collector of Q514:	0 V DC (transmit mode)
pin 4 of IC404:	0 V DC (transmit mode

6. If the voltages are correct, the receive VCO is suspect; go to Step 7. If they are not, the receive buffer amplifier is suspect; go to Step 9.

7. Remove the VCO TOP can.

8. Check the receive VCO circuitry based on **Q504** (see **Figure 9.11**). Conclude with Step 10.

9. Check the first buffer stage (based on **Q514**) (see **Figure 9.13**) and the second stage (based on **IC404**) (see **Figure 9.12**).

10. If a fault is found, repair the circuit, and confirm that the voltages are now correct. If they are, go to "Final Tasks" on page 136. If they are not, or if no fault could be found, replace the main board, and go to "Final Tasks" on page 136.

9.6 Transmit VCO and Related Circuitry (UHF and 800 MHz Radios)

Introduction

If there is no fault with the power supplies, the PLL inputs and output, and the loop filter, check the VCO and related circuitry. The procedures in this section apply only to UHF and 800 MHz radios with a system error or transmit fault, and therefore with suspect transmit VCO and related circuitry. (The minimum and maximum transmit frequencies for the different frequency bands are defined in Table 9.3.) There are five aspects:

- Task 23: check transmit VCO
- Task 24: repair PLL feedback
- Task 25: repair transmit VCO
- Task 26: check switching to transmit mode
- Task 27: check transmit buffer amplifier

The measurement points for diagnosing faults in the VCO and related circuitry are summarized in Figure 9.10.

Table 9.3 Minimum and maximum transmit frequencies for the different UHF and 800 MHz frequency bands

Frequency band	Transmit frequency in MHz	
	Minimum	Maximum
H5	371 ± 5	492 ± 5
H6	419 ± 5	545 ± 5
K5	762 794 806 851	776 824 870

Task 23 — Check Transmit VCO

Check that the correct transmit frequency is synthesized. This is the frequency of the transmit VCO output SYN TX LO at the TX port shown in Figure 9.13.

1. Enter the CCTM command *335 1* to set the transmit-receive switch on (transmit mode).

2. Using a frequency counter, proceed as follows to observe the transmit frequency at the TX port before and after grounding the junction between **C541** and **R547** (see **Figure 9.11**).

   While holding the probe from the counter on the TX port, use a pair of tweezers to momentarily ground the junction. The frequency should change to:

TX port: maximum transmit frequency (see Table 9.3)

   The loop filter will hold its output steady at 13.3 V. This should result in a frequency equal to the maximum given in **Table 9.3**.

3. If the transmit frequency measured in Step 2 is correct, go to Step 4. If it is incorrect, go to Task 25. If no frequency is detected, go to Task 26.

4. Proceed as follows to observe the transmit frequency at the TX port before and after applying 3 V DC to the junction of **C541** and **R547**; there is a convenient 3 V level at **R544** (see **Figure 9.11**):

   While holding the probe on the TX port, use the tweezers to momentarily apply 3 V DC to the junction; do not touch the board with your hand, and do not allow the tweezers to touch any cans when you remove them. The frequency should change to:

TX port: minimum transmit frequency (see Table 9.3)

   The loop filter will hold its output steady at about 0 V. This should result in a frequency equal to the minimum given in **Table 9.3**.

5. If the transmit frequency measured in Step 4 is correct, go to Task 24. If it is incorrect, go to Task 25. If no frequency is detected, go to Task 26.

Task 24 — Repair PLL feedback

If both the minimum and maximum transmit frequencies are correct, the PLL feedback is suspect.

1. Resolder **R542** in position (see **Figure 9.11**).
2. Remove the VCO BOT can.
3. Replace the components **C570**, **R578** (see **Figure 9.13**) and **IC503** (see **Figure 9.11**).
4. Confirm that the fault in the radio has been removed. If it has, go to "Final Tasks" on page 136. If it has not, replace the main board, and go to "Final Tasks" on page 136.

Task 25 — Repair Transmit VCO

If either or both the minimum and maximum transmit frequencies are incorrect, the transmit VCO circuitry is faulty.

1. Remove the VCO TOP can.
2. Check the transmit VCO. The circuitry is based on **Q510** (for the H5 and H6 bands see **Figure 9.11**, for the K5 band see **Figure 9.13**).
3. If a fault is found, repair it and go to Step 4. If no fault is found, go to Step 6.
4. Repeat the frequency measurements in Step 2 and Step 4 of Task 23.
5. If the frequencies are now correct, resolder **R542** in position (see **Figure 9.11**), and go to "Final Tasks" on page 136. If they are still not correct, go to Step 6.
6. Resolder **R542** in position (see **Figure 9.11**). Replace the main board and go to "Final Tasks" on page 136.

Task 26 — Check Switching to Transmit Mode

If no transmit frequency is detected in the check of the transmit VCO, first check that the transmit-receive switch is functioning correctly.

1. Resolder **R542** in position (see **Figure 9.11**).
2. Enter the CCTM command *335 1* to switch on the supply to the transmit VCO.
3. Measure the voltage at the second collector (pin 3) of **Q506** (see **Figure 9.11**). The voltage should be:

pin 3 of Q506: 4.3 ± 0.1V DC (after entry of CCTM 335 1)

4. Enter the CCTM command *335 0* to switch off the supply.
5. Again measure the voltage at the second collector of **Q506**.

pin 3 of Q506: 0V DC (after entry of CCTM 335 0)

6. If the voltages measured in Step 2 and Step 4 are correct, go to Task 27. If they are not, the switching network is suspect; go to Task 21.

Task 27 — Check Transmit Buffer Amplifier

If no transmit frequency is detected but the switching network is not faulty, check the transmit buffer amplifier. If the amplifier is not faulty, there might be a fault in the transmit VCO that was not detected earlier.

1. Remove the VCO BOT can.

2. Check the transmit buffer amplifier in receive mode: Enter the CCTM command *335 0* to set the transmit-receive switch off.

3. Measure the voltage at pin 4 of **IC506** (for the H5 and H6 bands see **Figure 9.13**, for the K5 band see **Figure 9.11**).

pin 4 of IC506: 0V DC (receive mode)

4. Then check the transmit buffer amplifier in transmit mode: Enter the CCTM command *335 1* to set the transmit-receive switch on.

5. Again measure the voltage at **IC506**.

pin 4 of IC506: +3 ± 0.2V DC (transmit mode)

6. If the voltages are correct, the transmit VCO is suspect; go to Step 7. If they are not, the transmit buffer amplifier is suspect; go to Step 9.

7. Remove the VCO TOP can.

8. Check the transmit VCO circuitry based on **Q510** (for the H5 and H6 bands see **Figure 9.11**, for the K5 band see **Figure 9.13**). Conclude with Step 10.

9. Check the buffer circuitry based on **IC506** (for the H5 and H6 bands see **Figure 9.13**, for the K5 band see **Figure 9.11**).

10. If a fault is found, repair the circuit, and confirm that the voltages are now correct. If they are, go to "Final Tasks" on page 136. If they are not, or if no fault could be found, replace the main board and go to "Final Tasks" on page 136.

9.7 VCO and Related Circuitry (VHF Radios)

Introduction

If there is no fault with the power supplies, the PLL inputs and output, and the loop filter, check the VCO and related circuitry. The procedures in this section apply only to VHF radios; the VHF frequency bands are defined in Table 9.4. There are six aspects:

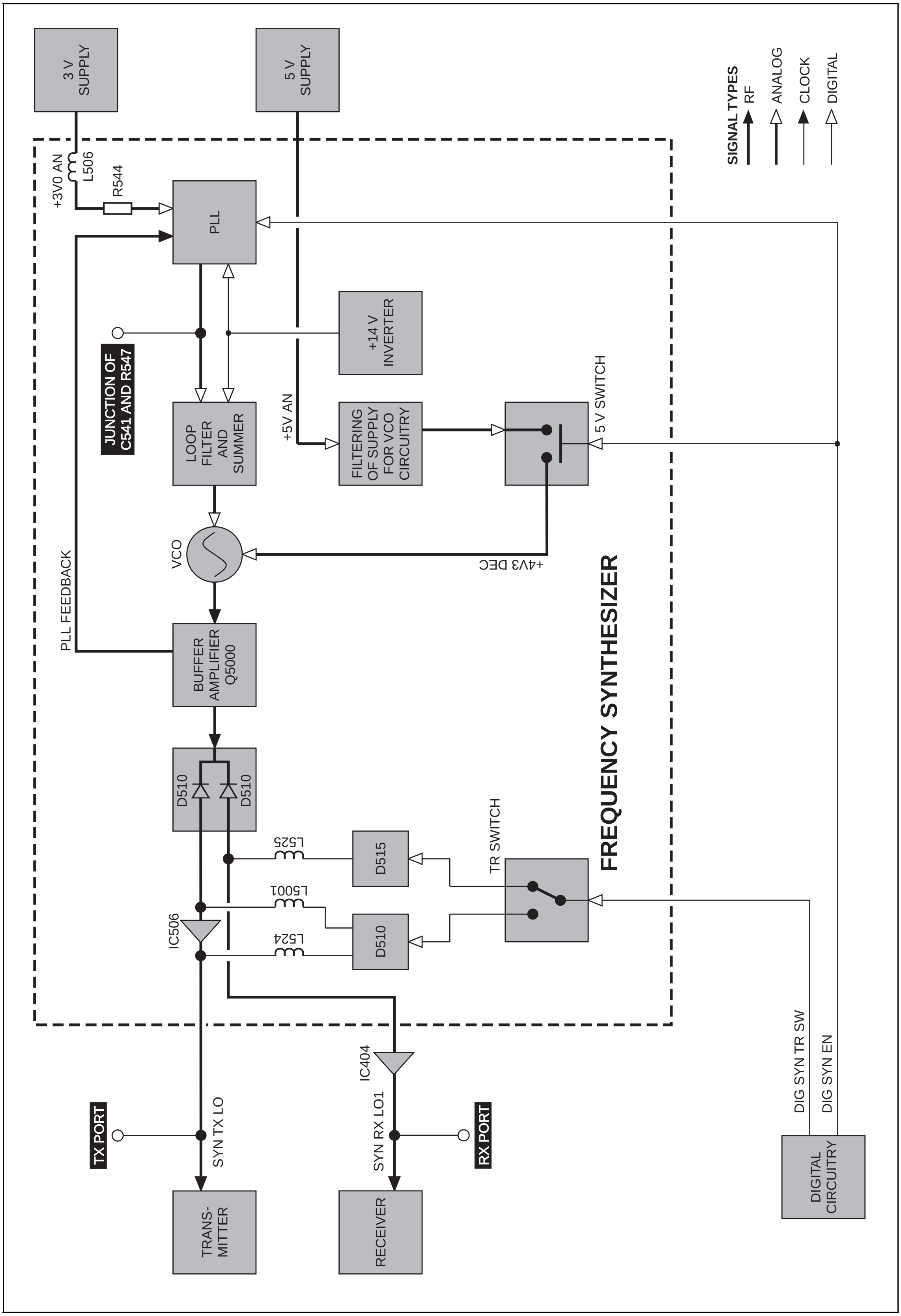
- Task 28: check VCO
- Task 29: repair PLL feedback
- Task 30: repair VCO
- Task 31: check transmit-receive switch
- Task 32: repair switching network
- Task 33: check buffer amplifier

The measurement points for diagnosing faults in the VCO and related circuitry are summarized in Figure 9.14.

Table 9.4 Minimum and maximum frequencies for the VHF frequency band

Frequency band	Frequency in MHz	
	Minimum	Maximum
B1	84 ± 5	200 ± 5

Figure 9.14 Measurement points for the VCO and related circuitry in VHF radios



Task 28 — Check VCO

Check that the correct receive and transmit frequencies are synthesized. The receive frequency is that of the VCO output SYN RX LO1 at the RX port shown in **Figure 9.3**. The transmit frequency is that of the output SYN TX LO at the TX port.

1. Enter the CCTM command *335 1* to set the transmit-receive switch on (transmit mode).

2. Using a frequency counter, proceed as follows to observe the transmit frequency at the TX port (see **Figure 9.16**) before and after grounding the junction between **C541** and **R547** (see **Figure 9.15**):

   While holding the probe from the counter on the TX port, use a pair of tweezers to momentarily ground the junction. The frequency should change to:

TX port: maximum VCO frequency (see Table 9.4)

   The loop filter will hold its output steady at 13.3 V. This should result in a frequency equal to the maximum given in **Table 9.4**.

3. If the maximum frequency measured in Step 2 is correct, go to Step 4. If it is incorrect, go to Task 30, but if no frequency at all is detected, go to Task 31.

4. Enter the CCTM command *335 0* to set the transmit-receive switch off (receive mode).

5. Proceed as follows to observe the receive frequency at the RX port before and after applying 3V DC to the junction of **C541** and **R547**; there is a convenient 3V level at **R544** (see **Figure 9.15**):

   While holding the probe on the RX port, use the tweezers to momentarily apply 3V DC to the junction; do not touch the board with your hand, and do not allow the tweezers to touch any cans when you remove them. The frequency should change to:

RX port: minimum VCO frequency (see Table 9.4)

   The loop filter will hold its output steady at about 0V. This should result in a frequency equal to the minimum given in **Table 9.4**.

6. If the minimum frequency measured in Step 5 is correct, go to Task 29. If it is incorrect, go to Task 30. If no frequency is detected, go to Task 31.

Figure 9.15 Synthesizer components under the SYN TOP can (VHF radio, top side)

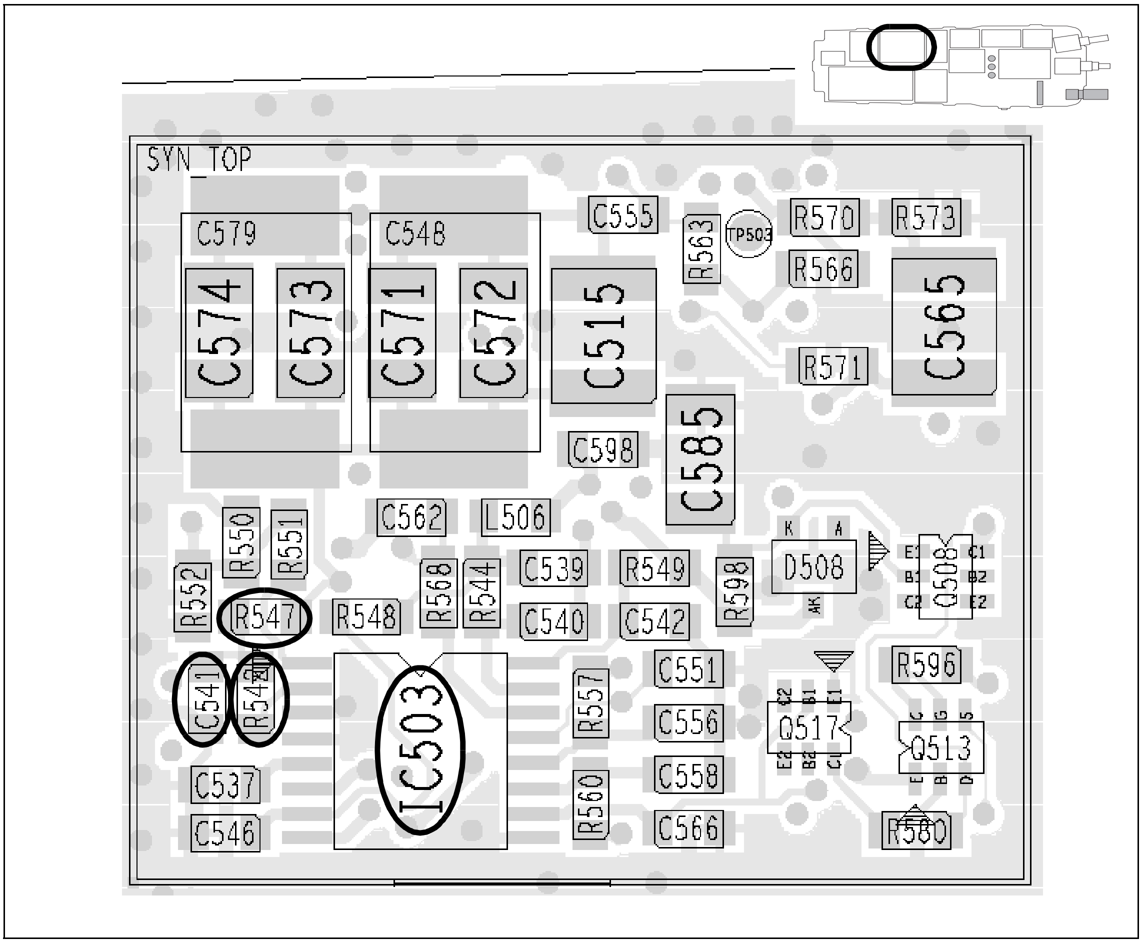
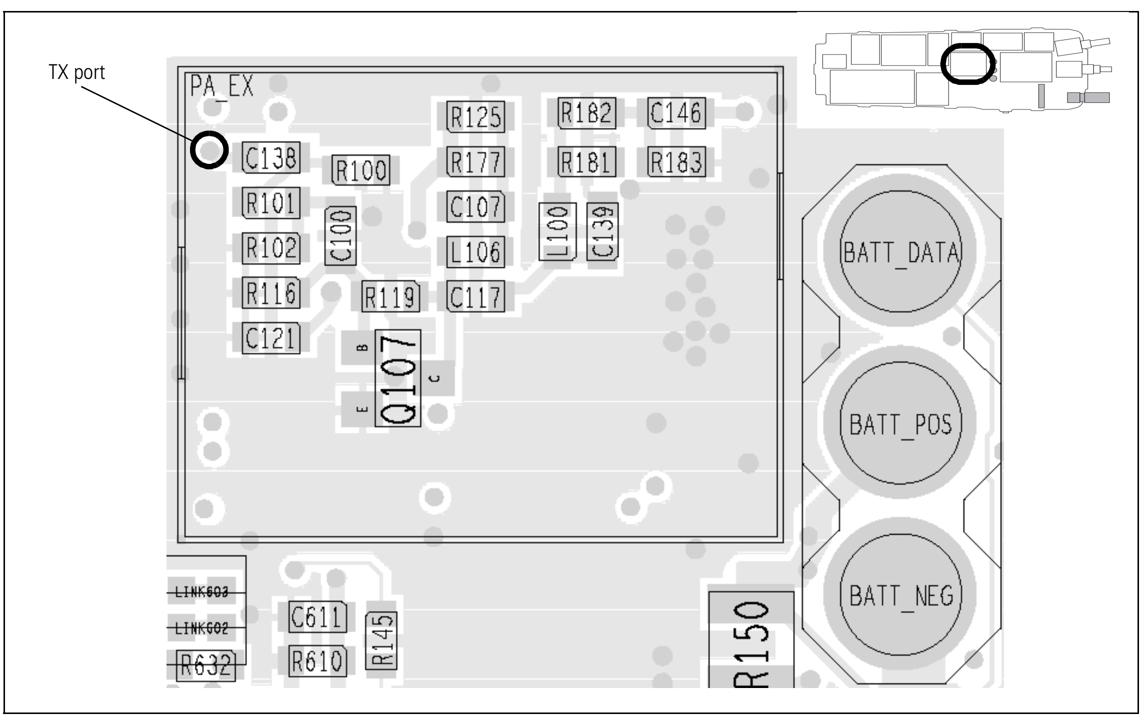


Figure 9.16 Synthesizer components under the PA EX TOP can (VHF radio, top side)

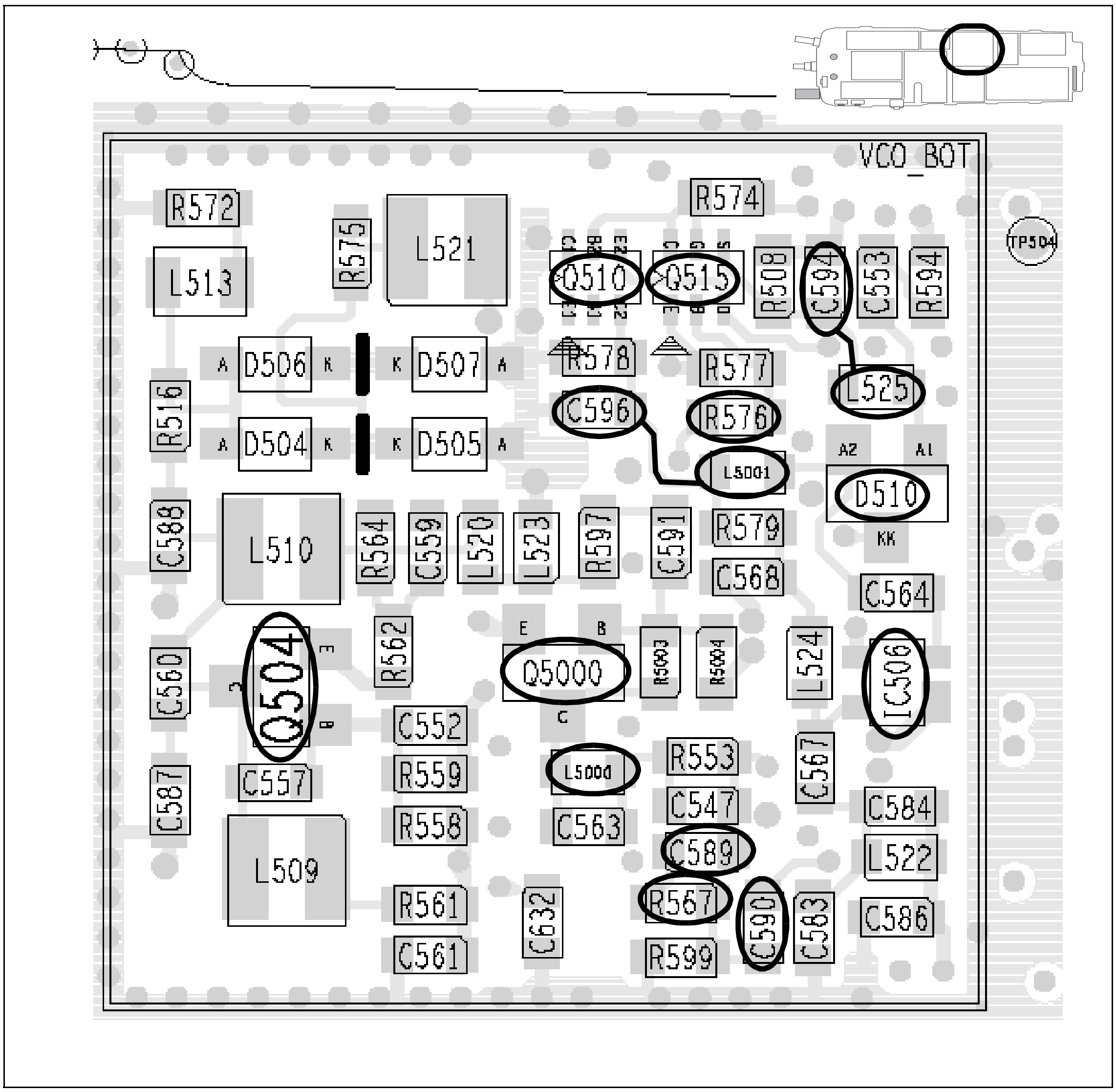


Task 29 — Repair PLL feedback

If both the maximum and minimum VCO frequencies are correct, then the PLL feedback is suspect.

1. Resolder **R542** in position (see **Figure 9.15**).
2. Remove the VCO BOT can.
3. Check the components **R567**, **C589**, **C590**, and **L5000** (see **Figure 9.17**) and **IC503** (see **Figure 9.15**).
4. Confirm that the fault in the radio has been removed. If it has, go to "Final Tasks" on page 136. If it has not, replace the main board and go to "Final Tasks" on page 136.

Figure 9.17 Synthesizer circuitry under the VCO BOT can (VHF radio, bottom side)



Task 30 — Repair VCO

If either or both the maximum and minimum frequencies are incorrect, the VCO circuitry is faulty.

1. Remove the VCO BOT can.
2. Check the VCO. The circuitry is based on **Q504** (see **Figure 9.17**).
3. If a fault is found, repair it and go to Step 4. If no fault is found, go to Step 7.
4. Repeat Step 1 and Step 2 of Task 28 to measure the maximum VCO frequency.
5. Repeat Step 4 and Step 5 of Task 28 to measure the minimum VCO frequency.
6. If the frequencies are now correct, resolder **R542** in position (see **Figure 9.15**), and go to "Final Tasks" on page 136. If they are still not correct, go to Step 7.
7. Resolder **R542** in position (see **Figure 9.15**). Replace the main board and go to "Final Tasks" on page 136.

Task 31 — Check Transmit-Receive Switch

If no frequency is detected in the check of the VCO, first check that the transmit-receive switch is functioning correctly.

1. Resolder **R542** in position (see **Figure 9.15**).
2. Remove the VCO BOT can.
3. Enter the CCTM command *335 0* to switch on the supply to the RX port.
4. Measure the voltage at the junction of **L525** and **C594** (see **Figure 9.17**). (Some RF noise might be observed.) The voltage should be:

junction of L525/C594: 3.0 ± 0.1V DC (after entry of CCTM 335 0)

5. Enter the CCTM command *335 1* to switch off the supply.
6. Again measure the voltage at the junction of **L525** and **C594**.

junction of L525/C594: 0V DC (after entry of CCTM 335 1)

7. If the voltages measured in Step 4 and Step 6 are correct, go to Step 8. If they are not, the switching network is suspect; go to Task 32.
8. Enter the CCTM command *335 1* to switch on the supply to the TX port.
9. Measure the voltage at the junction of **L5001** and **C596** (see **Figure 9.17**). (Some RF noise might be observed.) The voltage should be:

junction of L5001/C596: 3.0 ± 0.1V DC (after entry of CCTM 335 1)

10. Enter the CCTM command *335 0* to switch off the supply.
11. Again measure the voltage at the junction of **L5001** and **C596**.

junction of L5001/C596: 2.1 ± 0.4V DC (after entry of CCTM 335 0)

12. If the voltages measured in Step 9 and Step 11 are correct, go to Task 33. If they are not, the switching network is suspect; go to Task 32.

Task 32 — Repair Switching Network

If the transmit-receive switch is not functioning correctly, first check the DIG SYN TR SW line to confirm that the digital circuitry is not the cause. If the digital circuitry is not faulty, the switching network is suspect.

1. Enter the CCTM command *335 0* to set the transmit-receive switch off (receive mode). Measure the voltage at the end of the DIG SYN TR SW line at **R576** (see **Figure 9.17**).

R576: 0V DC (after entry of CCTM 335 0)

2. Enter the CCTM command *335 1* to set the transmit-receive switch on (transmit mode). Again measure the voltage at **R576**.

R576: 3.0V DC (after entry of CCTM 335 1)

3. If the voltages measured in Step 1 and Step 2 are correct, go to Step 9. If they are not, go to Step 4.

4. Enter the CCTM command *335 0* and measure the voltage at the left side of **R720** (see **Figure 9.7**).

left side of R720: 3.3 ± 0.3V DC (after entry of CCTM 335 0)

5. Enter the CCTM command *335 1* and again measure the voltage at the left side of **R720**.

left side of R720: 0V DC (after entry of CCTM 335 1)

6. If the voltages measured in Step 4 and Step 5 are correct, go to Step 7. If they are not, the digital circuitry is faulty; replace the main board and go to “Final Tasks” on page 136.

7. Check for continuity between **R576** (see **Figure 9.17**) and **R720**.

8. If no fault is found, go to Step 9. If a fault is found, repair the circuit, confirm that the voltages are now correct, and go to “Final Tasks” on page 136. If the repair failed, replace the main board and go to “Final Tasks” on page 136.

9. Check the circuitry for the transmit-receive and 3V switches (based on **Q515** and **Q510**) (see **Figure 9.17**).

10. If a fault is found, repair the circuit, confirm that the voltages are now correct, and go to “Final Tasks” on page 136. If the repair failed or the fault could not be found, replace the main board and go to “Final Tasks” on page 136.

Task 33 — Check Buffer Amplifier

If no VCO frequency is detected but the switching network is not faulty, check the buffer amplifier. If the amplifier is not faulty, there might be a fault in the VCO that was not detected earlier.

1. Enter the CCTM command *335 0* to set the transmit-receive switch to receive.

2. Measure the voltage at pin A1 of **D510** (see **Figure 9.17**). (Some RF noise might be observed.)

pin A1 of D510: 1.6V DC

3. Measure the voltage at the collector of **Q5000** (see **Figure 9.17**).

collector of Q5000: 0.7 ± 0.2V DC

4. If the voltages measured in Step 2 and Step 3 are not correct, go to Step 5. If they are, check the VCO circuitry based on **Q504** (see **Figure 9.17**). Conclude with Step 6.

5. The buffer amplifier is suspect. Check the buffer circuitry (based on **Q5000, IC506**) (see **Figure 9.17**).

6. If a fault is found, repair the circuit, and confirm that the voltages are now correct. If they are, go to “Final Tasks” on page 136. If they are not, or if no fault could be found, replace the main board and go to “Final Tasks” on page 136.

9.8 Power Supply for FCL

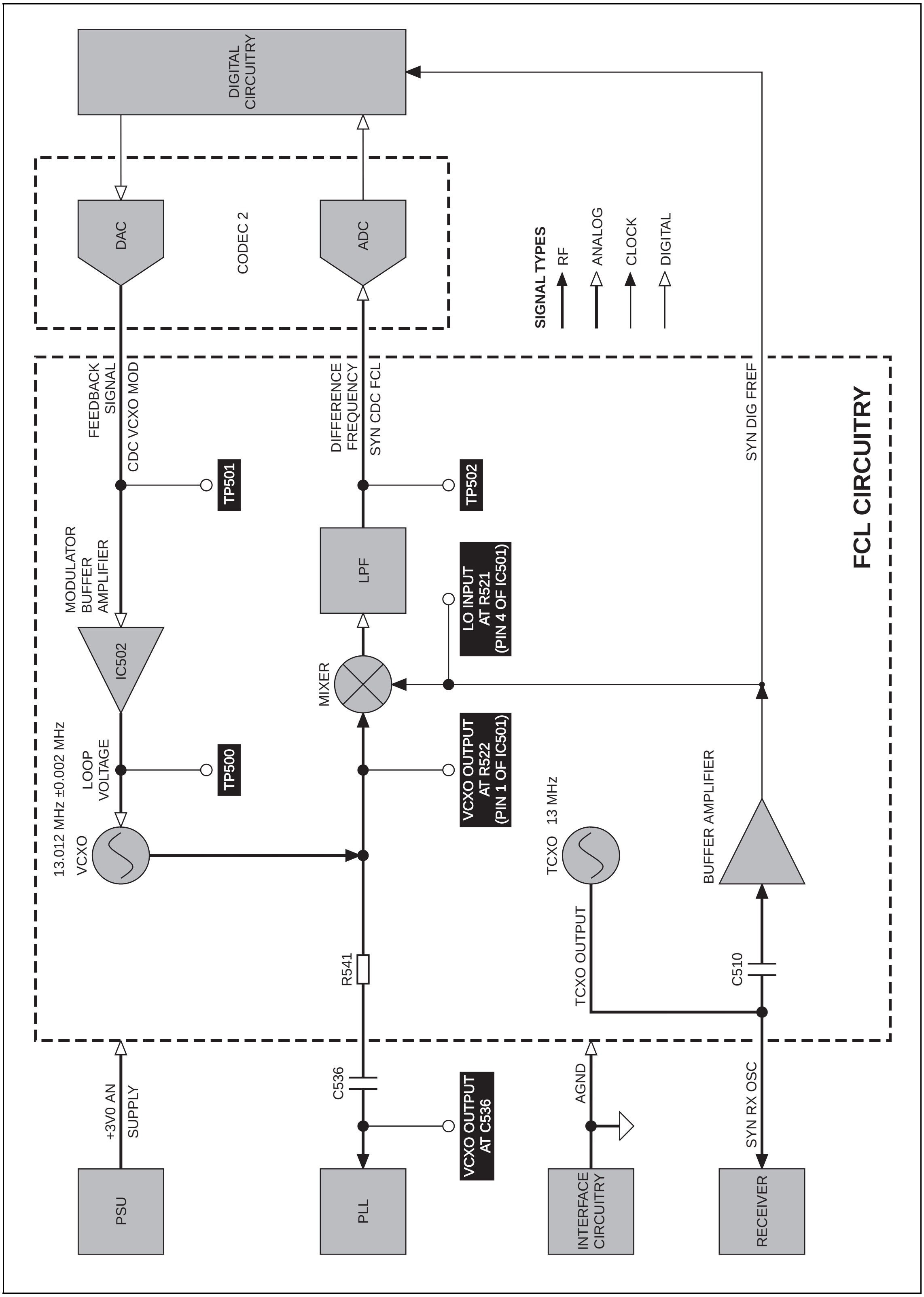
Fault-Diagnosis Stages

Indications of a fault in the FCL will have been revealed by the initial checks in “Initial Checks” on page 162 and the PLL checks in “Phase-Locked Loop” on page 172. In the latter case a fault with the reference frequency input from the FCL to the PLL will imply that the FCL is suspect. Fault diagnosis of the FCL is divided into four stages:

- check power supply
- check VCXO and VCTCXO outputs
- check signals at TP501 and TP502
- check VCXO and CODEC circuitry

The checking of the power supply is given in this section in Task 34 below. The remaining three stages are covered in “VCXO and VCTCXO Outputs” to “VCXO and CODEC Circuitry” on page 218 respectively. The test and measurement points for diagnosing faults in the FCL are summarized in Figure 9.18.

Figure 9.18 Test and measurement points for the FCL circuitry



Task 34 — Power Supply

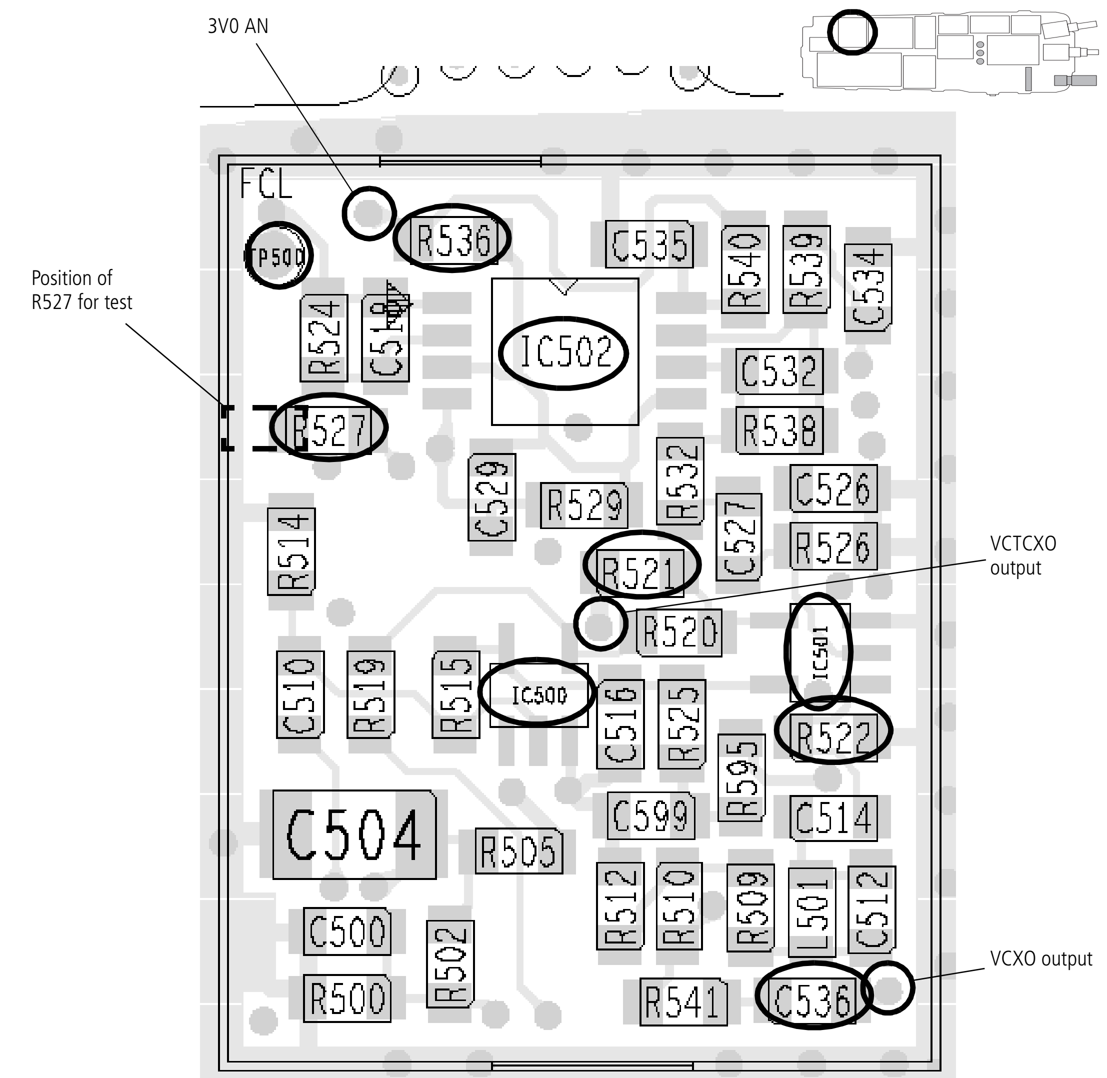
If the FCL is suspect, first check that the 3V power supply is not the cause of the fault.

1. If not already done, remove the FCL TOP can and place the radio in CCTM.
2. Measure the supply +3V0 AN at the via shown in **Figure 9.19**.

via adjacent R536: 3.0 ± 0.06V DC

3. If the voltage is correct, go to "VCXO and VCTCXO Outputs" on page 212. If it is not, the 3V regulator **IC604** is suspect; go to Task 4 of "Power Supply Fault Finding" on page 158.

Figure 9.19 FCL circuitry under the FCL TOP can (top side)



9.9 VCXO and VCTCXO Outputs

Task 35 — VCXO Output

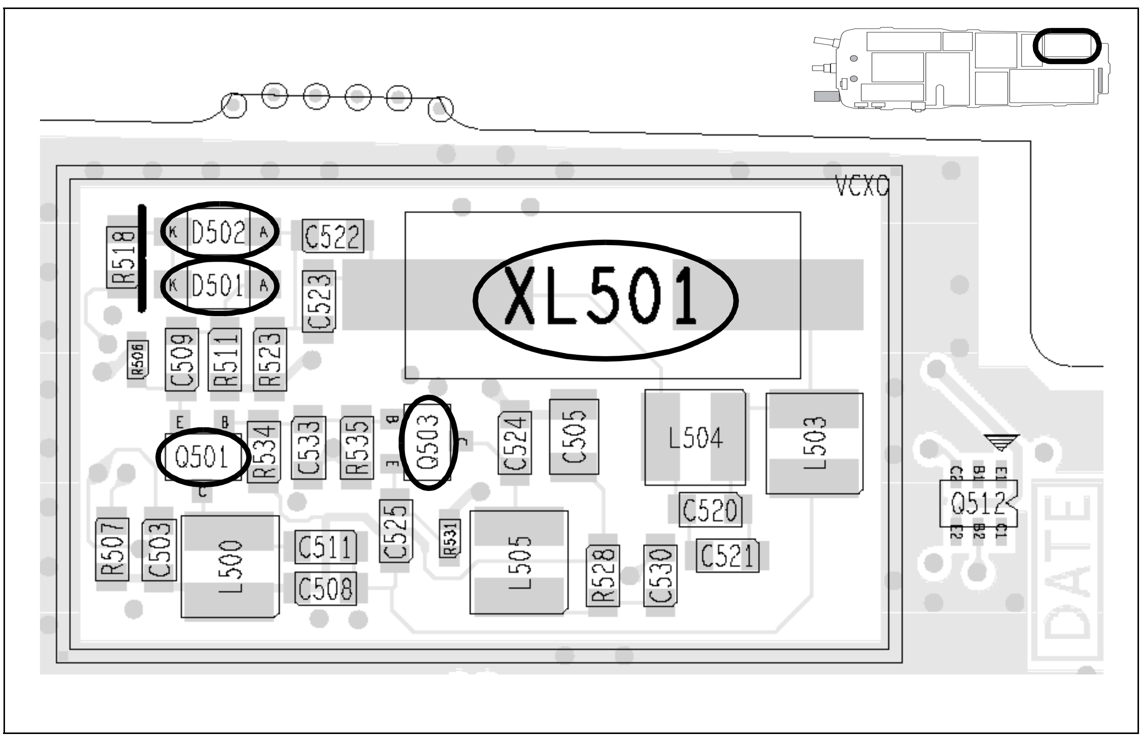
If the 3V power supply is not faulty, check the VCXO output as follows:

1. Use an oscilloscope probe to check the VCXO output at **C536** — probe the via next to C536 (see **Figure 9.19**). The signal should be:

VCXO output at C536: sine wave of 1.1 ± 0.2V_{pp} on 1.4 ± 0.2V DC

2. If the signal is correct, go to Task 36. If it is not, go to Step 3.
3. The VCXO circuitry under the VCXO BOT can is faulty. Remove the VCXO BOT can.
4. Locate and repair the fault in the VCXO (**Q501**, **Q503**, **XL501** and associated components) (see **Figure 9.20**).
5. Confirm the removal of the fault and go to Task 36. If the repair failed, replace the main board and go to “Final Tasks” on page 136.

Figure 9.20 FCL circuitry under the VCXO BOT can (bottom side)



Task 36 — VCTCXO Output

If the VCXO output is correct, check the VCTCXO output as follows:

1. Use the oscilloscope probe to check the VCTCXO output at pin 4 of **IC500** (see **Figure 9.19**). The signal should be:

VCTCXO output at pin 4 of IC500: 13 MHz ± 1.5 ppm, 3 V_{pp} square

2. If the signal is correct, go to "Signals at TP501 and TP502" on page 214. If it is not, go to Step 3.

3. The VCTCXO module XL500 or its supply voltage is faulty.

4. Locate and repair the fault of **XL500** and associated components (see **Figure 9.21**).

5. Confirm the removal of the fault and go to "Signals at TP501 and TP502" on page 214. If the repair failed, replace the main board and go to "Final Tasks" on page 136.

9.10 Signals at TP501 and TP502

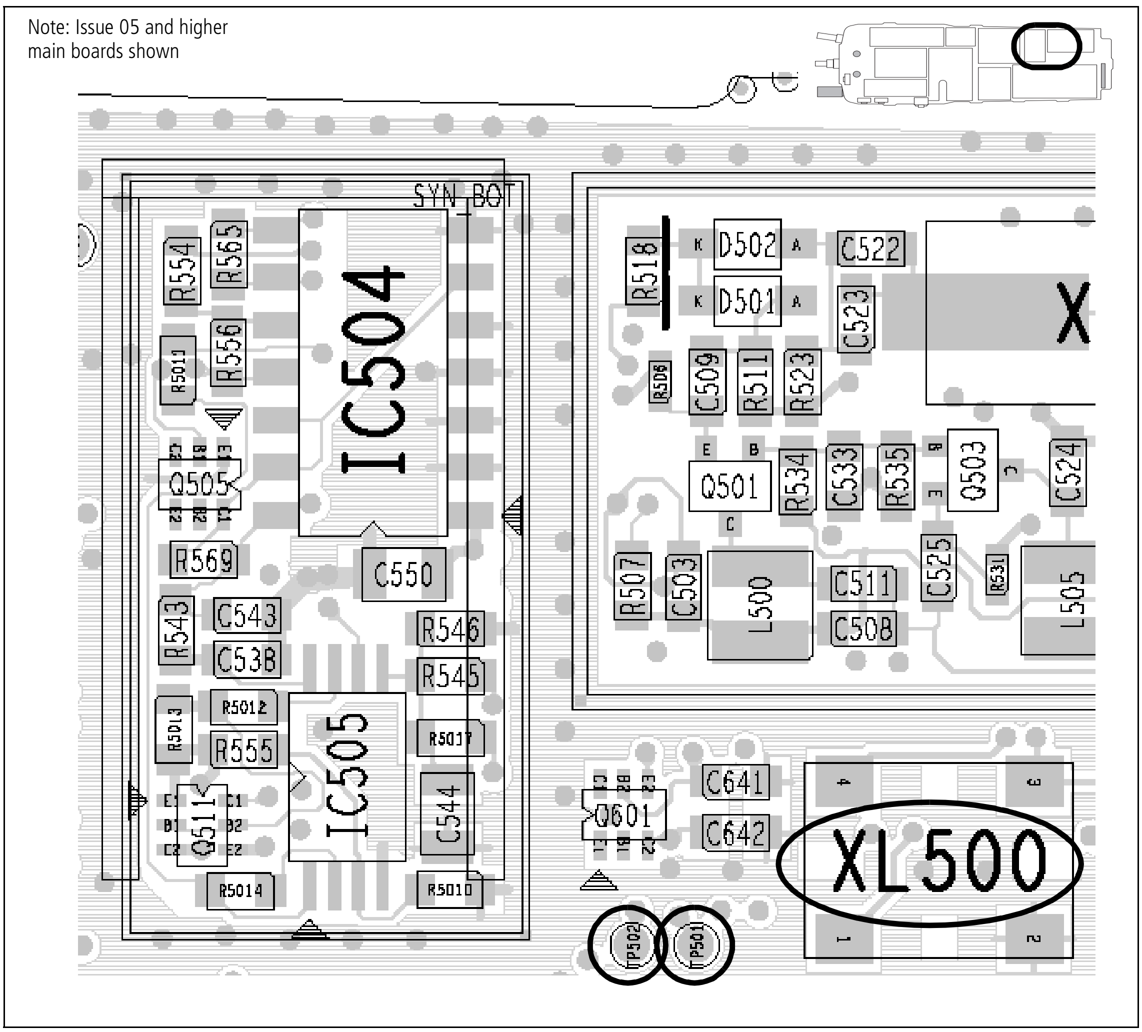
Introduction

If the VCXO and VCTCXO outputs are correct, the next stage is to check the signals at the TP501 and TP502 test points. The procedure is divided into three tasks:

- Task 37: check signal at TP502
- Task 38: check signal at TP501 and ground TP501 if loop is oscillating
- Task 39: check signal at TP502 with TP501 grounded

These checks will reveal any faults in the mixer and LPF (low-pass filter) circuitry, and any additional fault in the VCXO circuitry.

Figure 9.21 Test points TP501 and TP502 (bottom side)



Task 37 — TP502 Test Point

Check the signal at the TP502 test point to determine if there is a fault in the mixer or LPF (low-pass filter) circuitry:

1. Use the oscilloscope probe to check the difference frequency at the **TP502 test point** (see **Figure 9.21**). The signal is SYN CDC FCL and should be:

TP502 test point: sine wave of 1.1 ± 0.2 V_{pp} on 1.5 ± 0.1 V DC +12 kHz

2. If the signal is correct, go to Task 38. If it is not, go to Step 3.

3. The mixer or LPF circuitry under the FCL TOP can is faulty.

4. Locate the fault in the mixer (**IC501** and associated components) or LPF circuitry (**IC502** pins 5 to 7, and associated components) (see **Figure 9.19**).

5. Repair the circuitry. Note that the TCXO input to the mixer at **R521** (pin 4 of IC501) (see **Figure 9.19**) should be:

TCXO input at R521:	square wave with frequency of 13000000 Hz and amplitude of 3.0 ± 0.2 V_{pp}

   Also, the VCXO input to the mixer at **R522** (pin 1 of IC501) (see **Figure 9.19**), although noisy and difficult to measure, should be:

VCXO input at R522:	sine wave with frequency of 13.012±0.002 MHz and amplitude of 20 ± 10 mV_{pp}

6. Confirm the removal of the fault and go to Task 38. If the repair failed, replace the main board and go to "Final Tasks" on page 136.

Task 38 — TP501 Test Point

If the signal at the TP502 test point is correct, check the signal at the TP501 test point:

1. With the oscilloscope probe at the **TP501 test point** (see **Figure 9.21**), check the DAC output CDC VCXO MOD.
   If a sawtooth wave (1.8 V_{pp}) is present, go to Step 2. Otherwise go to "VCXO and CODEC Circuitry" on page 218.

2. A fault is causing the loop to oscillate. If not already done, remove the FCL TOP can.

3. Check the waveform at the **TP500 test point** (see **Figure 9.19**). The waveform should be an amplified and inverted version of the waveform at the **TP501 test point**.

4. If the waveform is correct, go to Step 5. If it is not, there is a fault in the modulator buffer amplifier (**IC502** pins 1 to 3, and associated components) (see **Figure 9.19**). Rectify the fault and return to Step 1.

5. Connect the **TP501 test point** to ground by resoldering **R527** in the position shown in **Figure 9.19**. This forces the VCXO loop voltage high.

6. Use the oscilloscope probe to check the VCXO output at **C536** — probe the via next to C536 (see **Figure 9.19**). The signal should be:

VCXO output at C536:	sine wave with frequency of 13.017 MHz and amplitude of 1.1 ± 0.2 V_{pp} on 1.4 ± 0.2 V DC

7. If the signal is correct, go to Task 39. If it is not, go to Step 8.

8. The VCXO circuitry is faulty. If not already done, remove the VCXO BOT can.

9. Locate and repair the fault in the VCXO circuitry (**Q501**, **Q503**, **XL501** and associated components) (see **Figure 9.20**).

10. Confirm the removal of the fault, and go to Task 39. If the repair failed, replace the main board and go to "Final Tasks" on page 136.

Task 39 — TP502 Test Point (TP501 Grounded)

If the loop was oscillating, Task 38 will have revealed any fault in the VCXO circuitry. If there was no fault, or if the circuit was repaired, a check at the TP502 test point is now required. This will show if there are any additional faults in the mixer or LPF circuitry.

1. Use the oscilloscope probe to check the difference frequency at the **TP502 test point** (see **Figure 9.21**). The signal is SYN CDC FCL and should be:

TP502 test point:	sine wave with frequency of at least 15kHz and amplitude of 1.1 ± 0.2V_{pp} on 1.5 ± 0.1V DC

2. If the signal is correct, go to Step 6. If it is not, go to Step 3.

3. The mixer circuitry (**IC501** and associated components) or the LPF circuitry (**IC502** pins 5 to 7, and associated components) under the FCL TOP can is faulty (see **Figure 9.19**). Locate the fault.

4. Repair the circuitry. Note that the TCXO input to the mixer at **R521** (pin 4 of IC501) (see **Figure 9.19**) should be:

TCXO input at R521:	square wave with frequency of 13000000Hz and amplitude of 3.0 ± 0.2V_{pp}

   Also, the VCXO input to the mixer at **R522** (pin 1 of IC501) (see **Figure 9.19**), although noisy and difficult to measure, should be:

VCXO input at R522:	sine wave of 20 ± 10mV_{pp}

5. Confirm the removal of the fault, and go to Step 6. If the repair failed, resolder **R527** in its original position as shown in **Figure 9.19**, replace the main board and go to "Final Tasks" on page 136.

6. Resolder **R527** in its original position as shown in **Figure 9.19**.

7. Replace all cans.

8. Use the oscilloscope probe to check the difference frequency at the **TP502 test point** (see **Figure 9.21**). The signal is SYN CDC FCL and should be:

TP502 test point: sine wave of 1.1 ± 0.2V_{pp} on 1.5 ± 0.1V DC (approx. 12kHz)

9. If the signal is correct, the fault has been removed; go to "Final Tasks" on page 136. If the signal is not correct, the repair failed; replace the main board and go to "Final Tasks" on page 136.

9.11 VCXO and CODEC Circuitry

Introduction

If the signals at the TP501 and TP502 test points are correct, two CCTM checks will reveal any remaining faults. These possible faults concern the VCXO tank circuit and the CODEC 2 circuitry. There are therefore three aspects, which are covered in Tasks 40 to 42:

- Task 40: CCTM checks
- Task 41: VCXO tank circuit
- Task 42: CODEC 2 circuitry

Following any repairs of the VCXO or CODEC 2 circuitry, Task 40 will need to be repeated to confirm the removal of the fault.

Task 40 — CCTM Checks

If the signals at the TP501 and TP502 test points are correct, or any related faults were rectified, perform the following CCTM checks:

1. Enter the CCTM command *393 1 1900*. Measure the voltage level at the **TP501 test point** (see **Figure 9.21**):

TP501 test point: 1.3 ± 0.2V DC (after CCTM 393 1 1900)

2. Enter the CCTM command *72* and note the lock status.

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

3. Enter the CCTM command *393 1 –1900*. Again measure the voltage level at the **TP501 test point**:

TP501 test point: 2.1 ± 0.2V DC (after CCTM 393 1 –1900)

4. Enter the CCTM command *72* and note the lock status.

5. If the above voltage levels are not correct or if the FCL is out of lock in either or both of the above cases, investigate the VCXO tank circuit; go to Task 41.

   If the voltage level remains fixed at about 1.5V DC, investigate the CODEC 2 circuitry; go to Task 42.

   If the voltage levels are all correct (following earlier repairs), the fault has been removed; go to "Final Tasks" on page 136.

Task 41 — VCXO Tank Circuit

If the CCTM checks indicate that the VCXO tank circuit is faulty, repair the circuit as follows:

1. If not already done, remove the VCXO BOT can.
2. Locate and repair the fault in the VCXO tank circuit (**Q501**, **D501**, **D502**, **XL501** and associated components) (see **Figure 9.20**).
3. Confirm the removal of the fault and go to Step 4. If the repair failed, replace the main board and go to “Final Tasks” on page 136.
4. Replace all cans.
5. Repeat Task 40 to confirm the removal of the fault. If the repair failed, replace the main board and go to “Final Tasks” on page 136.

Task 42 — CODEC 2 Circuitry

If the CCTM checks indicate a fault in the CODEC 2 circuitry or with the digital signals to and from the circuitry, rectify the fault as follows:

1. Most of the CODEC 2 circuitry is situated under the CDC TOP can. If not already done, remove the CDC TOP can.
2. Check the following digital signals at **IC205** (see **Figure 9.22**):
   - pin 10 : DIG CDC2 LRCK
   - pin 12 : DIG CDC2 SCLK
   - pin 8 : CDC2 DIG SDTO
   - pin 9 : DIG CDC2 SDTI

   These signals to and from the digital circuitry should all be active:

digital signals: 3.3 ± 0.3V

3. If the digital signals are correct, the CODEC 2 circuitry is suspect; go to Step 6. If they are not, go to Step 4.
4. If any or all digital signals are missing, check the connections between **IC205** and the digital circuitry (see **Figure 9.22**).
5. If there are faults such as open circuits in the connections, repair the circuitry and repeat Task 40.

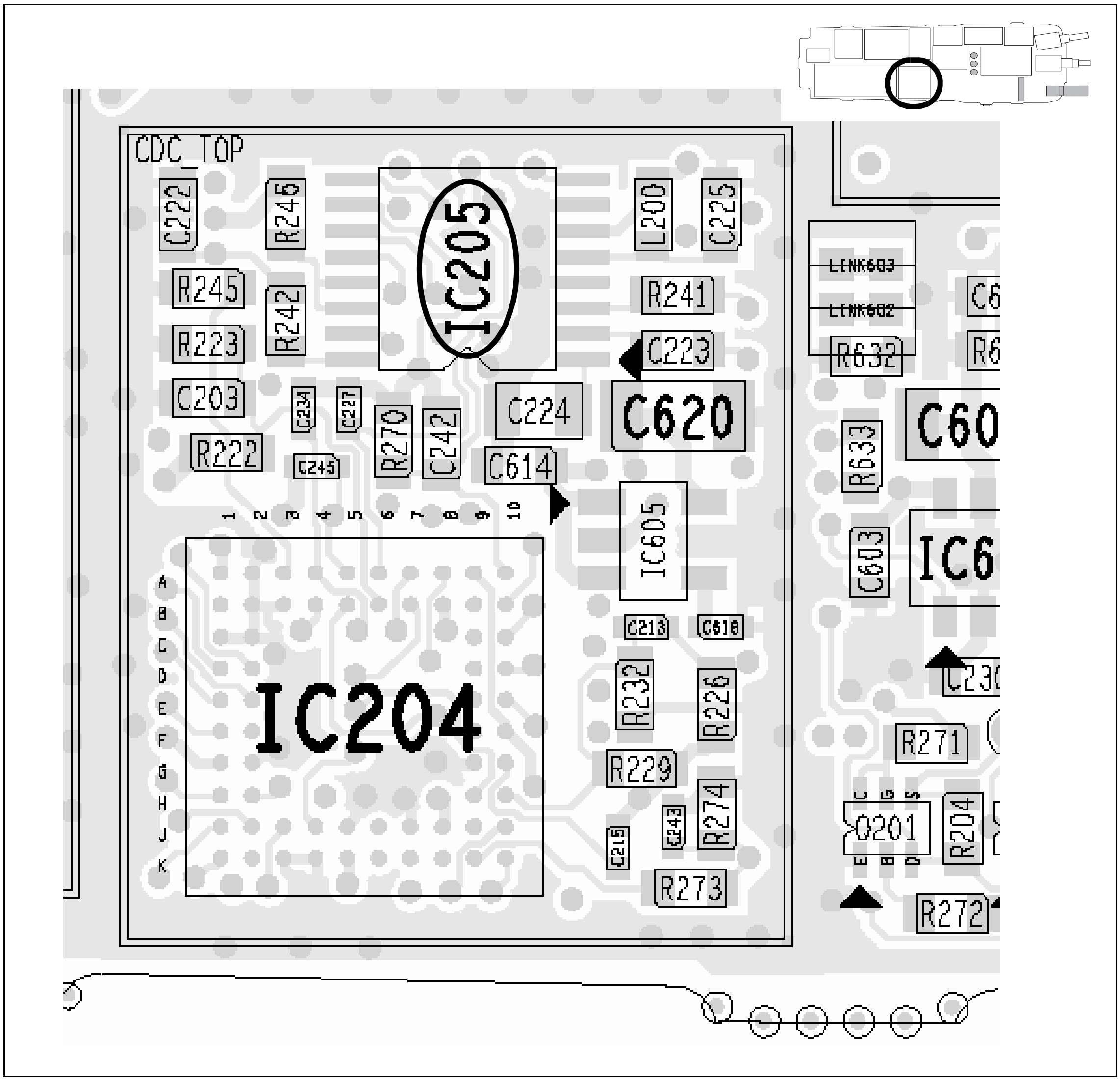
   If the connections are not faulty, then the digital circuitry is faulty. Replace the main board and go to “Final Tasks” on page 136.
6. The CODEC 2 circuitry comprises **IC205** and associated components under the CDC TOP can. Locate the fault.
7. Repair the circuitry. Note that, if the circuitry is functioning properly, probing the **TP501 test point** (see **Figure 9.21**) during power-up will show a five-step staircase signal followed by a random nine-step staircase signal — this is the expected power-up auto-calibration sequence.

8. Confirm the removal of the fault, and go to Step 9. If the repair failed, replace the main board and go to “Final Tasks” on page 136.

9. Replace all cans.

10. Repeat Task 40 to confirm the removal of the fault. If the repair failed, replace the main board and go to “Final Tasks” on page 136.

Figure 9.22 Synthesizer components under the CDC TOP can (top side)



10 Transmitter Fault Finding

Introduction

This section 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.

Fault-Diagnosis Tasks

The procedure for diagnosing transmitter faults is divided into tasks, which are grouped into the following sections:

- "Power Supplies"
- "Transmitter RF Power"
- "Biasing of PA Driver and PA"
- "RF Signal Path"

Before beginning the fault diagnosis with "Power Supplies", note the following information regarding CCTM commands, frequency bands, can removal and replacement, and transmit tests.

CCTM Commands

The CCTM commands required in this section are listed in Table 10.1. Full details of the commands are given in "Computer-Controlled Test Mode (CCTM)" on page 93.

Table 10.1 CCTM commands required for the diagnosis of faults in the transmitter

Command	Description
32	Set radio in receive mode
33	Set radio in transmit mode
803	Read temperature near front panel (FPI=**x**) and PA (TX=**y**). To convert to °C: temp=(**x** or **y**/-2.37)+160
101 **x** **y** 0	Set transmit frequency (**x** in hertz) and receive frequency (**y** in hertz) to specified values
114 **x**	Set DAC value **x** (in range 0 to 1023) of transmit power
326 **x**	Set transmitter power level **x** (0=off, 1=very low, 2=low, 3=medium, 4=high, 5=maximum)
331	Read bias voltage for first PA — displays DAC value **x** (in range 0 to 255)
331 **x**	Set DAC value **x** (in range 0 to 255) of bias voltage for first PA
334 **x**	Set synthesizer on (**x**=1) or off (**x**=0) via DIG SYN EN line
335 **x**	Set transmit-receive switch on (**x**=1) or off (**x**=0) via DIG SYN TR SW line

Frequency Bands

Some fault-diagnosis tasks require programming the radio with the lowest, center or highest frequency in the radio's frequency band. The relevant frequencies for the different bands are listed in Table 10.2. Note that the following frequency ranges are reserved worldwide for use by distress beacons:

- B1 band: 156.8MHz ± 375kHz
- H5 band: 406.0 to 406.1MHz

Do not program the radio with any frequency in the above ranges.

Table 10.2 Lowest, center and highest frequencies in MHz

Band	Lowest frequency	Center frequency	Highest frequency
B1	136	155	174
H5	400	435	470
H6	450	490	530
K5	762	816	870

Can Removal

There are four cans shielding the bulk of the transmitter circuitry:

- PA BOT can
- PA LPF BOT can
- TX CONTROL BOT can
- PA EX TOP can

To remove any can, first remove the main board from the chassis. Follow the procedures given in "Disassembly and Reassembly" on page 103.

Can Replacement

Replace all cans that have been removed after repairing the board.

Transmit Tests

The following points need to be borne in mind when carrying out transmit tests:

- secure main board
- ensure proper antenna load
- limit duration of transmit tests
- protect against accidental transmissions
- avoid thermal and RF burns

These points are discussed in more detail below.

Secure Main Board

Before conducting any transmit tests, ensure that the main board is adequately secured in the chassis. This is essential if overheating of the radio is to be avoided.

Ensure Proper Antenna Load

The radio has been designed to operate with a 50Ω termination impedance, but will tolerate a wide range of antenna loading conditions. Nevertheless, care should be exercised. Normally the RF connector on the main board will be connected to the RF communications test set as shown in Figure 4.2 on page 89. But for those tests where this connection is not necessary, a 50Ω load may be used instead. Do not operate the transmitter without such a load or without a connection to the test set. Failure to do so might result in damage to the power output stage of the transmitter.

Limit Duration of Transmit Tests

After setting the frequency and power level (if necessary), enter the CCTM command *33* to perform a transmit test. This command places the radio in transmit mode. After completing the measurement or check required, immediately enter the CCTM command *32*. This command returns the radio to the receive mode. Restricting the duration of transmit tests in this way will further limit the danger of overheating. The reason for this precaution is that the transmit timers do not function in the CCTM mode.

Protect Against Accidental Transmissions

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

Avoid Thermal and RF Burns

Avoid thermal burns. Do <u>not</u> touch the PA body when the transmitter is or has been operating. Avoid RF burns. Do <u>not</u> touch the antenna connector while the transmitter is operating.

10.1 Power Supplies

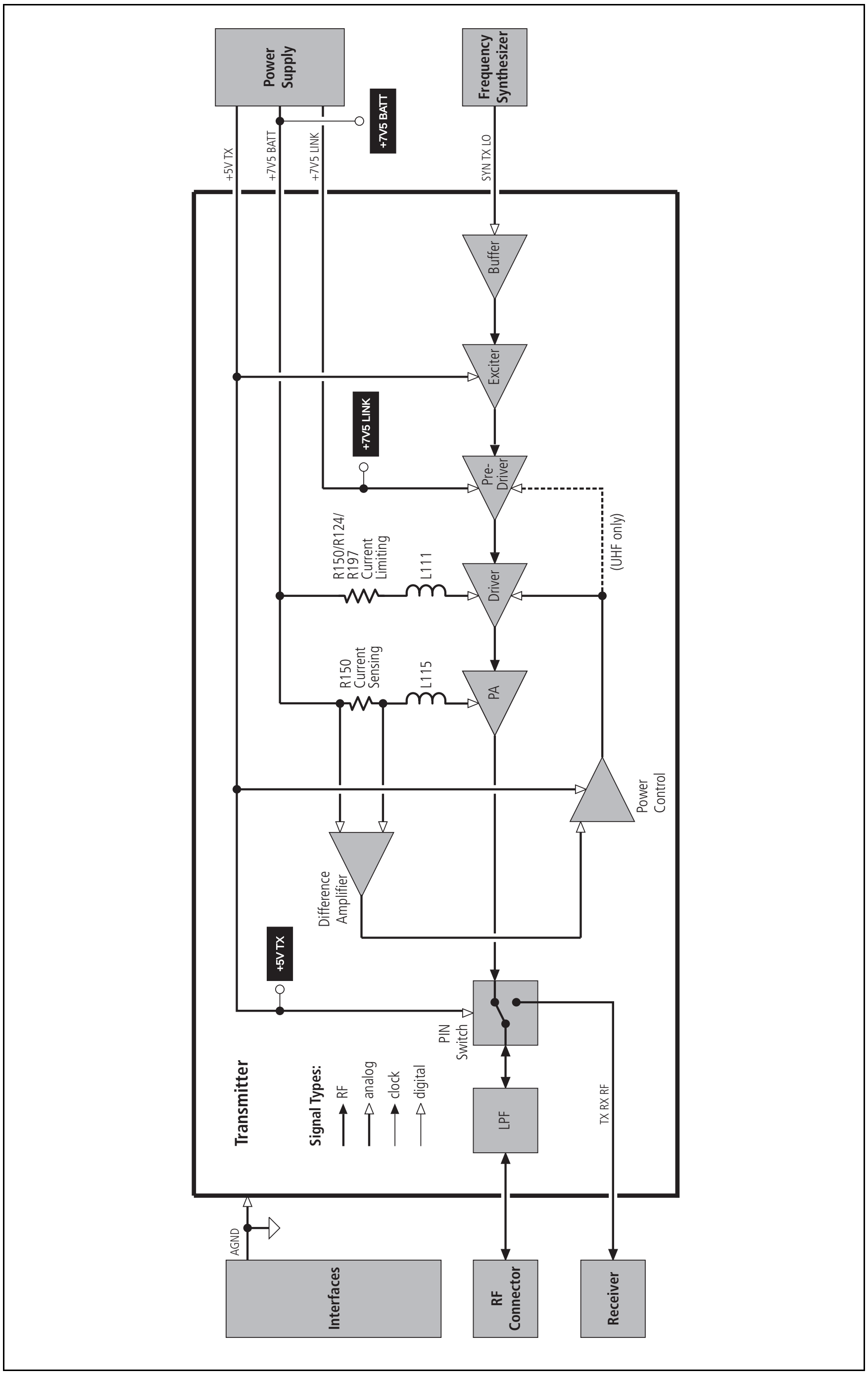
Introduction

First check that a power supply is not the cause of the fault. There are two power supplies for the transmitter:

- Task 1: 7.5VDC supply from power connector (+7V5 BATT)
- Task 2: 5VDC supply from 9V regulator in PSU module (+5V0 TX)

The power supplies distribution is summarized in Figure 10.1.

Figure 10.1 Measurement and test points for diagnosing faults involving the power supplies for the transmitter



Task 1 — 7.5V Power Supply

First check the 7.5V power supply.

1. Remove PA BOT can, PA LPF BOT can, and TX CONTROL BOT can, and carry out a thorough visual inspection
2. Obtain a needle probe to use for measurements of the power supply at the PA driver and PAs.
3. Set the DC power supply to 7.5V, with a current limit of 3A.
4. Program the radio with the highest frequency in the radio's frequency band: Enter the CCTM command *101* ***x*** ***x*** *0*, where ***x*** is the frequency in hertz. The required values for the different frequency bands are given in **Table 10.2 on page 222**.
5. Enter the CCTM command *326 4* to set the radio to high power.

Note Using the CCTM command *326 5* will set the radio to maximum power and the driver stage will be under current limiting.

6. Attempt to place the radio in transmit mode. Enter the CCTM command *33*.
7. If the radio enters the transmit mode, continue with Step 8. If instead a *C03* error is displayed in response to the command *33*, go to Task 5 on page 232.
8. Measure the voltage at the point on **L115** shown in **Figure 10.2**. This is the supply at the drain of **Q106**, and should be:

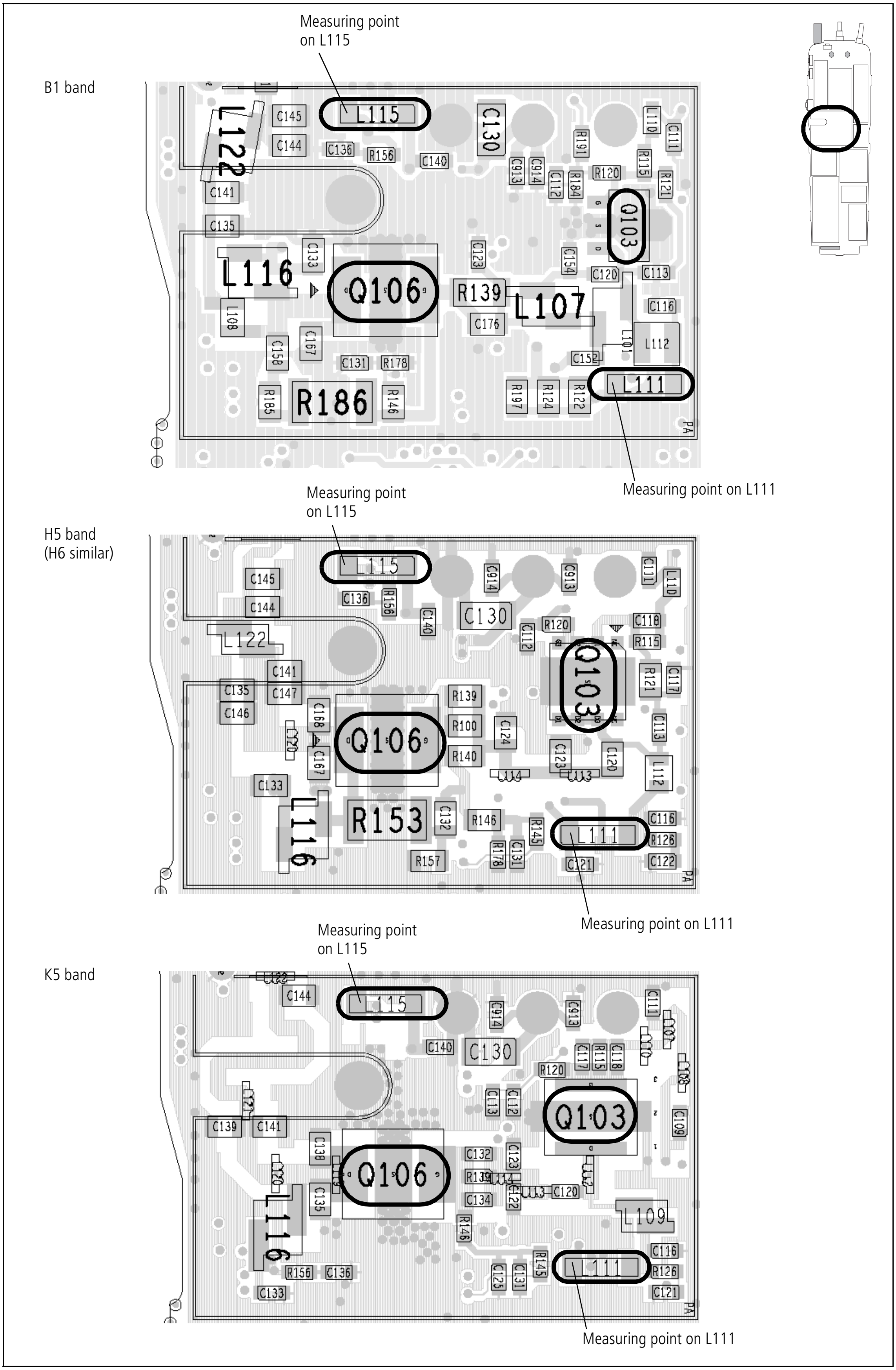
drain of Q106: approximately 7.0V DC

9. Also measure the voltage at the point on **L111** shown in **Figure 10.2**. This is the supply at the drain of **Q103**, and should be:

drain of Q103: approximately 7.0V DC

10. Enter the CCTM command *32* to place the radio in receive mode.
11. If the power supply measured in Step 8 and Step 9 is correct, go to Task 2. If it is not, go to "Power Supply Fault Finding" on page 151.

Figure 10.2 Measuring points under the PA BOT can (bottom side) for measuring the power supply



Task 2 — 5V Power Supply

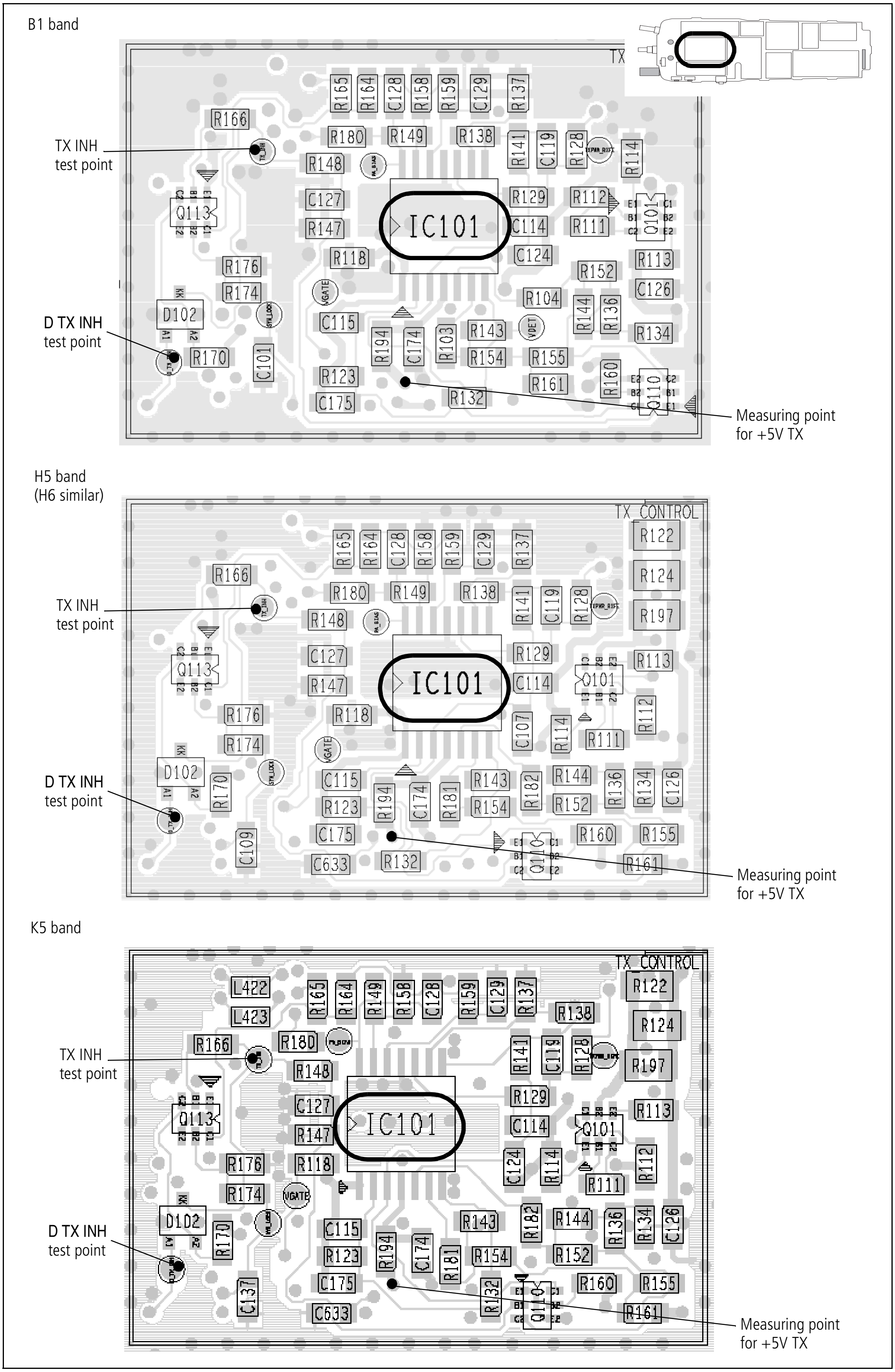
If the 7.5V power supply is correct, check the 5V DC supply.

1. Enter the CCTM command *326 1* to set the transmitter power level very low.
2. Enter the CCTM command *33* to place the radio in transmit mode.
3. Measure the +5V TX supply voltage under the TX CONTROL BOT can (see **Figure 10.3**).

supply +5V TX: 5.0V DC

4. Enter the CCTM command *32* to place the radio in receive mode.
5. If the supply measured in Step 3 is correct, go to Task 3. If it is not, the 5V regulator **IC600** and the associated switching circuitry are suspect; go to Task 4 of "Power Supply Fault Finding" on page 158.

Figure 10.3 Measuring points under TX CONTROL BOT can (bottom side) for checking the +5V TX supply



10.2 Transmitter RF Power

Introduction

If there is no fault with the power supplies, check the transmitter RF power and correct any fault. The procedure is covered in the following eight tasks:

- Task 3: check RF output power
- Task 4: power unchanged regardless of setting
- Task 5: check for inhibiting of transmitter
- Task 6: check temperature sensor
- Task 7: power and current are skewed
- Task 8: power and current are low

The measurement points for diagnosing faults concerning the transmitter RF power are summarized in Figure 10.4.

Task 3 — Check RF Output Power

If the power supplies are correct, check the RF output power of the transmitter.

1. Enter the CCTM command *326 4* to set the transmitter power level to high power.

2. If not already done, program the radio with the highest frequency in the radio's frequency band: Enter the CCTM command *101* ***x x*** *0*, where ***x*** is the frequency in hertz. The required values for the different frequency bands are given in **Table 10.2 on page 222**.

3. Enter the CCTM command *33* to place the radio in transmit mode.

4. Note the RF output power measured by the test set, and note the current reading on the DC power supply.

RF output power: >5W (B1 band); >4W (H5/H6 bands); >3W (K5 band) current: <1.9A (B1, H5 and H6 bands); 1.84A (K5 band)

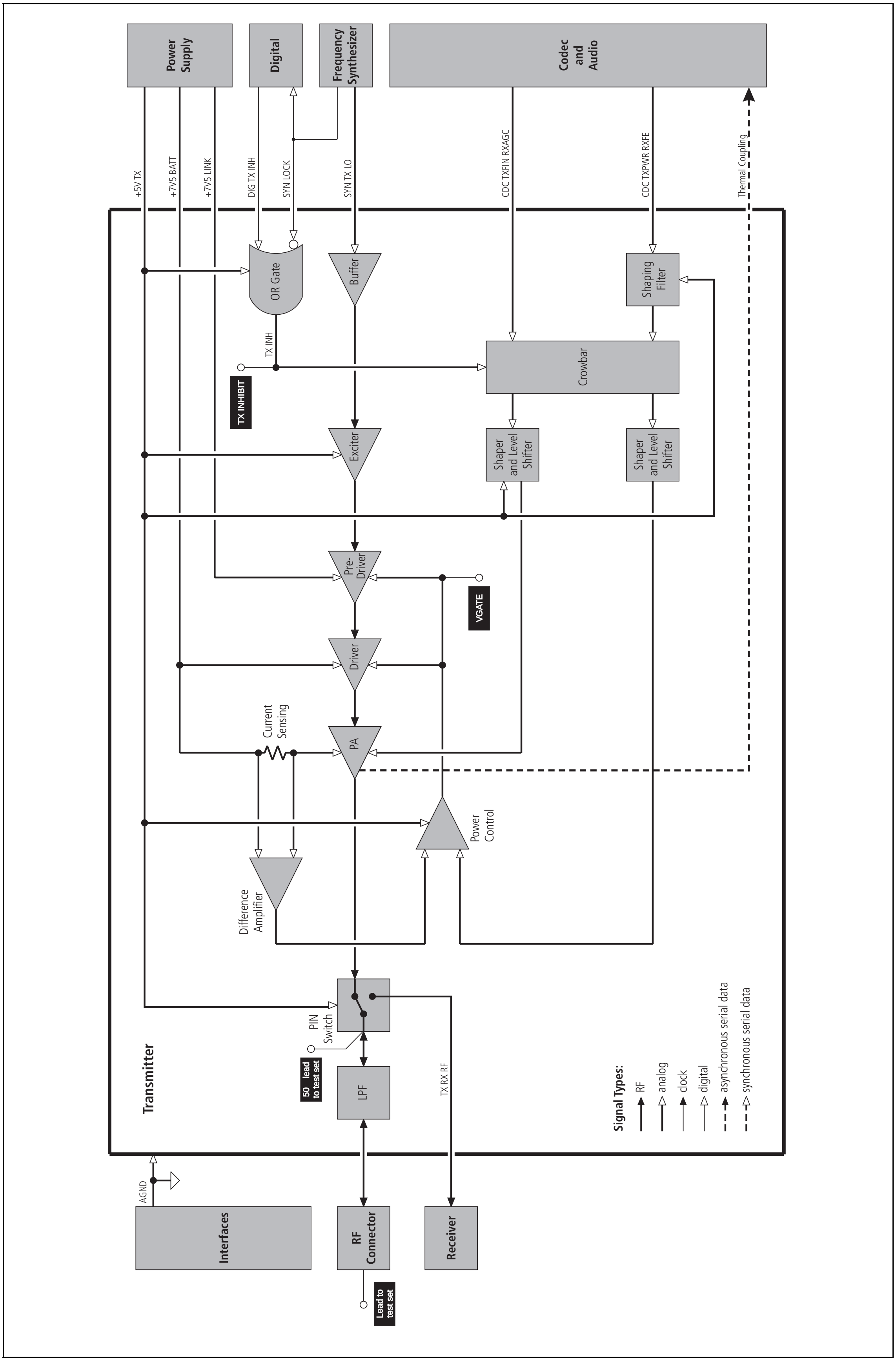
5. Enter the CCTM command *32* to place the radio in receive mode.

6. Program the radio with the center frequency in the radio's frequency band: Enter the CCTM command *101* ***x x*** *0*, where ***x*** is the frequency in hertz. The required values for the different frequency bands are given in **Table 10.2 on page 222**.

7. Repeat Step 3 to Step 5.

8. Program the radio with the lowest frequency in the radio's frequency band: Enter the CCTM command *101* ***x x*** *0*, where ***x*** is the frequency in hertz. The required values for the different frequency bands are given in **Table 10.2 on page 222**.

Figure 10.4 Measurement and test points for diagnosing faults concerning the transmitter RF power



9. Repeat Step 3 to Step 5.

10. Depending on the results of the above measurements, proceed to the task indicated in **Table 10.3**. Note that the power and current are considered to be skewed if they are low at one part of the frequency band and high elsewhere.

Table 10.3 Tasks to be performed according to the results of the power and current measurements of Task 3

Power	Current	Task
Correct	Correct	Task 4 — Power unchanged regardless of setting
Correct	Wrong	Task 13 — Biasing of PA driver
Skewed	Skewed	Task 7 — Power and current are skewed
Low (> 0.1 W)	Low (> 0.5 A)	Task 8 — Power and current are low
None at RF connector (< 0.1 W)	Low (> 0.5 A)	Task 13 — Biasing of PA driver
None at RF connector (< 0.1 W)	None (< 0.5 A)	Task 5 — Check for inhibiting of transmitter

Task 4 — Power Unchanged Regardless of Setting

If all the power and current values measured in Task 3 are correct, it is likely that the power remains unchanged regardless of the power setting.

1. Enter the following CCTM commands in turn and measure the RF output power in each case:
   - *326 3* – mid power
   - *326 2* – low power
   - *326 1* – very low power

2. The above measurements should confirm that the power remains unchanged at all settings. Carry out Task 9 and then Task 12.

Task 5 — Check for Inhibiting of Transmitter

If the transmitter is drawing no current or the wrong current, check whether it is being inhibited. This check is also required if a *CO3* error occurs in Task 1.

1. If not already done, enter the CCTM command *33* to place the radio in transmit mode.
2. Check the logic signal at the **TX INH test point** (see **Figure 10.3**). The signal should be:

TX INH test point: about 0V (inactive)

3. If the signal is inactive as required, go to Step 4. If it is active — about 2.3V — the transmitter is being inhibited; go to Step 5.
4. Enter the CCTM command *32* to place the radio in receive mode, and go to Task 9.
5. Check the logic signal at the **D TX INH test point** (see **Figure 10.3**). The signal should be:

D TX INH test point: about 0V (inactive)

6. If the signal is inactive as required, go to Step 8. If it is active — about 2.8V — the temperature sensor is suspect; go to Step 7.
7. Enter the CCTM command *32* to place the radio in receive mode, and go to Task 6.
8. The lock status is possibly no longer normal. Enter the CCTM command *72* and check the lock status.
9. Enter the CCTM command *32* to place the radio in receive mode.
10. The normal lock status is *110*. If it is not, proceed to the relevant section. If it is, go to Step 11.
11. Check for short circuits on the DIG TX INH line from the **D TX INH test point**.
12. Repair any fault, confirm the removal of the fault, and go to "Final Tasks" on page 136. If the repair failed or no fault could be found, replace the main board and go to "Final Tasks" on page 136.

Task 6 — Check Temperature Sensor

If the transmitter is being inhibited and the logic signal at the D TX INH test point is active, a fault in the temperature sensor might be the cause.

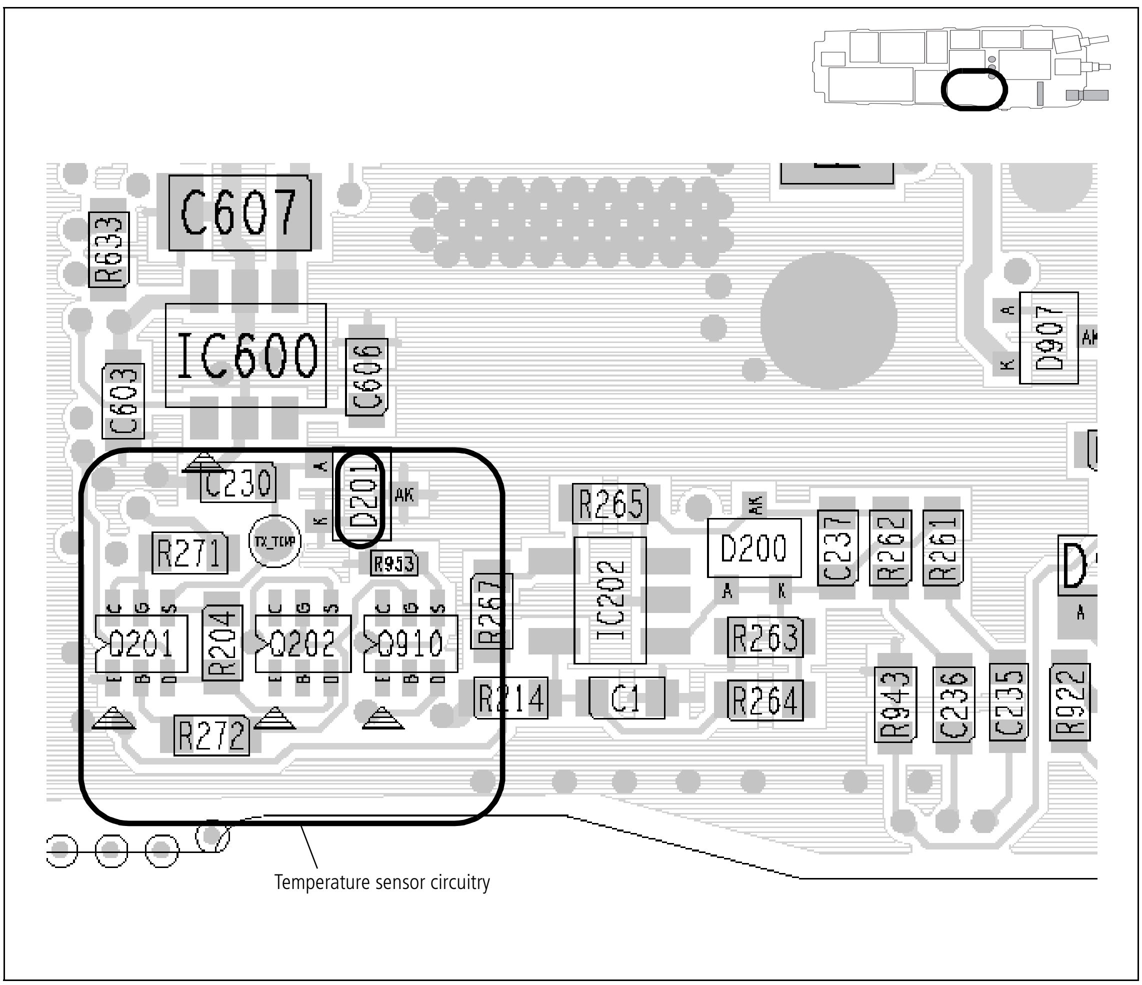
1. Enter the CCTM command *803* to check the temperature reading.

2. Of the two numbers returned, the first is the temperature near the front panel, and after converting to degrees celsius (use the formula on page 221) should be about 23 to 25°C. If it is, go to "Biasing of PA Driver and PA" on page 235. If it is not, go to Step 3.

3. Check **D201** and the surrounding components (see **Figure 10.5**). The temperature sensor is located on the top side of the main board.

4. If there is no fault, go to "CODEC and Audio Fault Finding" on page 277. If a fault is found, repair it, confirm the removal of the fault and go to "Final Tasks" on page 136. If the repair failed, replace the main board and go to "Final Tasks" on page 136.

Figure 10.5 Temperature sensor circuitry (top side)



Task 7 — Power and Current are Skewed

If the RF output power and the supply current are skewed, the output matching is suspect.

1. Remove the PA BOT can and PA LPF BOT can.
2. Check that the PA output matching capacitor are in the correct position as depicted in the latest BOM revision.
3. Go to Task 21 – the PIN switch and LPF require checking.

Task 8 — Power and Current are Low

If the RF output power and the supply current are uniformly low at all frequencies, the PA is suspect or the input to the PA is reduced. Check the circuitry of the PA (Q106) and the PA driver (Q103):

1. Enter the CCTM command *331* to check the DAC value of final bias 1 (CDC TX FIN RXAGC). Record the value ***x*** returned.
2. Enter CCTM command *114 0* to turn off power control. Note the current reading on the DC power supply. This is the bias current. Table 10.4 shows the bias currents for each power setting.
3. Enter the CCTM command *32* to place the radio in receive mode.
4. If the current measured in Step 2 is correct, go to "Biasing of PA Driver and PA" on page 235. If not, go to Task 11.

Table 10.4 PA bias currents in mA at different power levels

Frequency band	Very low power	Low power	Mid power	High power
B1	200	200	200	200
H5	150	800	800	800
H6	200	800	800	900
K5	200	650	650	750

10.3 Biasing of PA Driver and PA

Introduction

The measurements of the transmitter RF output power in “Transmitter RF Power” might indicate a need to check the biasing of the PA and the PA driver. The procedure is covered in this section. The tasks are grouped as follows:

- Task 9: prepare to check biasing
- Task 10 to Task 12: check biasing of PA
- Task 13 to Task 14: check biasing of PA driver
- Task 15 to Task 17: repair circuitry

The test and measurement points for diagnosing faults in the biasing of the PA and PA driver are summarized in Figure 10.6 on page 236.

Important The PA BOT can must not be removed while the radio is in transmit mode.

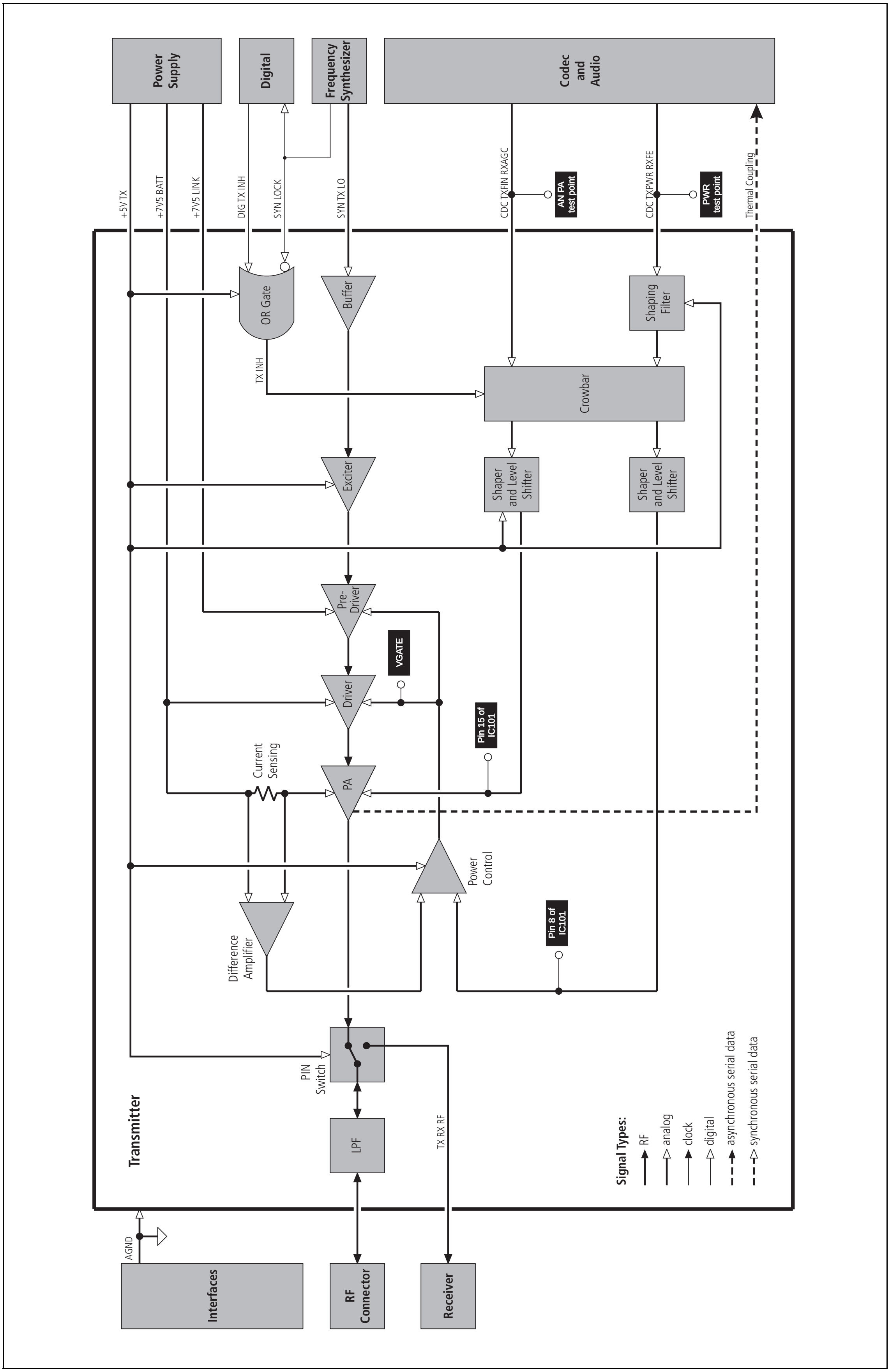
To access the measurement and test points, remove the TX CONTROL BOT and PA BOT cans.

Task 9 — Prepare to Check Biasing

If the transmitter is not being inhibited, check the biasing of the PA. First make the following preparations:

1. Set the current limit on the DC power supply to 2 A.
2. Enter the CCTM command *331* to check the DAC value of final bias 1 (CDC TX FIN BIAS) at high power (CCTM command *326 4*). Record the value ***x*** returned.
3. Enter the CCTM command *33* to place the radio in transmit mode.
4. Switch off all biases by entering the following CCTM commands in sequence:
   - *331 1*
   - *326 4* (set to high power)
5. Note the current reading on the DC power supply. This will be less than 550 mA.
6. With the radio still in transmit mode, check the biasing of the PA, beginning with Task 10.

Figure 10.6 Test points and components of the shaping filter



Task 10 — Check Biasing of PA

Check the biasing of the PA (Q106).

Important Ensure that the current limit on the DC supply is 2A. And, when entering the CCTM command ***331 x***, do not specify a value ***x*** higher than that recorded in Task 9. Failure to do so might result in the destruction of the PAs.

1. Use a multimeter to measure the voltage at pin 14 of **IC101** (see **Figure 10.7**). The voltage should be:

pin 14 of IC301: < 100mV (initially)

2. Note the current reading on the DC power supply. As mentioned in Step 5 of Task 9, this will be less than 550mA.

3. Enter the CCTM command ***331 x*** (where ***x*** was recorded in Task 9).

4. Check that the voltage changes to:

pin 14 of IC301: 2 to 5V (after entry of CCTM 331 **x**)

5. Also note the current reading. This should increase by an amount approximately equal to the offset given in **Table 10.5**.

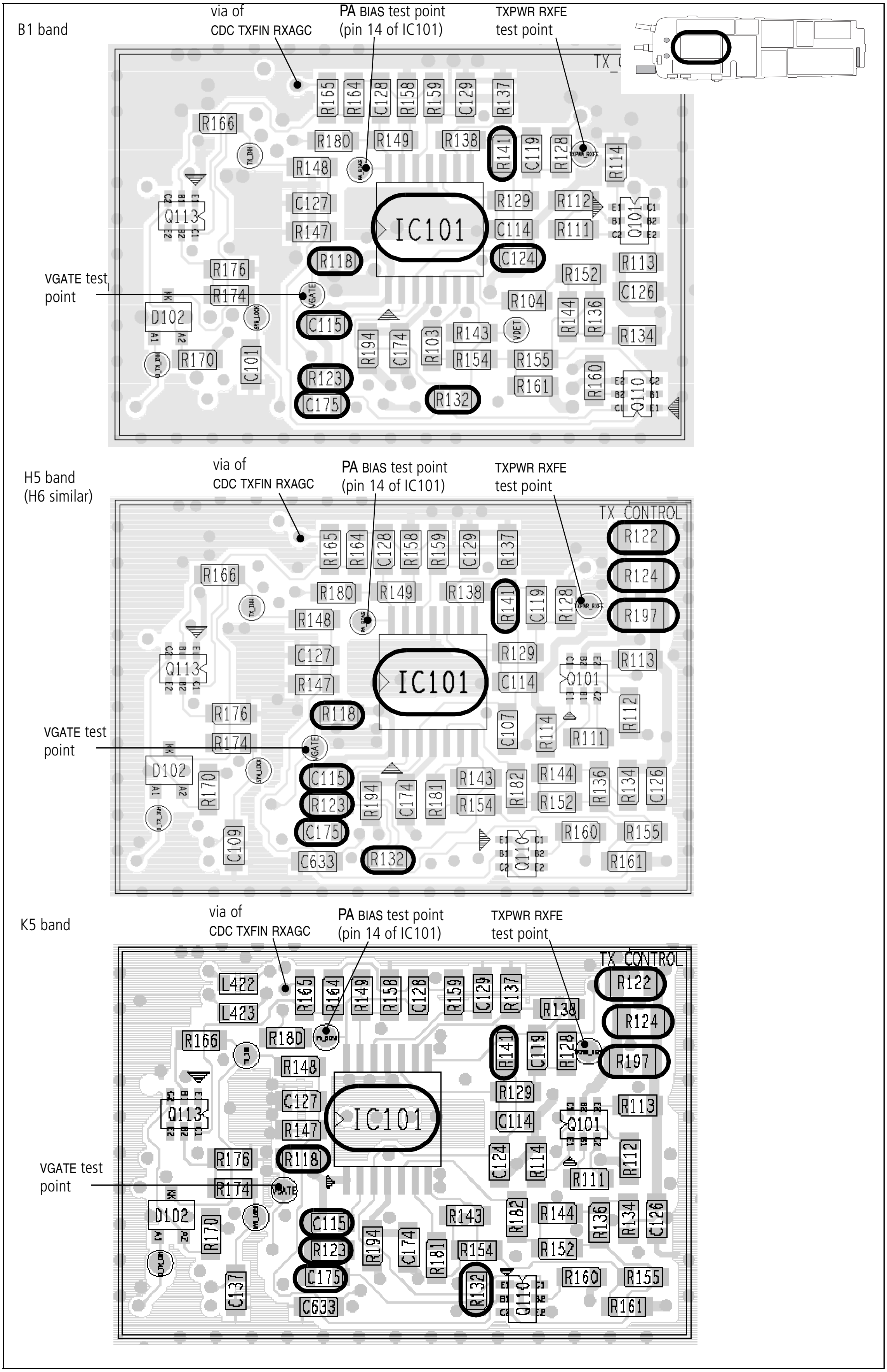
6. If the voltage and current are both correct, go to Step 7. If the voltage is correct but not the current, go to Task 11. If neither the current nor the voltage is correct, go to Task 12.

7. Enter the CCTM command *331 1* to switch off final bias 1, and go to Task 14.

Table 10.5 Gate biases for the PA at high power

Frequency band	PA offset current in mA
B1	600
H5	800
H6	900
K5	750

Figure 10.7 PA circuitry under the TX CONTROL BOT can (bottom side)



Task 11 — Shaper and Level Shifter

If the voltage measured in Task 10 is correct but not the current, either the PA or the shaper and level shifter for the PA is suspect.

Important Ensure that the current limit on the DC supply is 2A. And, when entering the CCTM command *331* ***x***, do not specify a value ***x*** higher than that recorded in Task 9. Failure to do so might result in the destruction of the PAs.

1. Enter the CCTM command *33* to place the radio in transmit mode.

2. Enter the CCTM command *331* ***x*** (where ***x*** was recorded in Task 9).

3. Check that the voltage at the gate of **Q106** (see **Figure 10.8**) is:

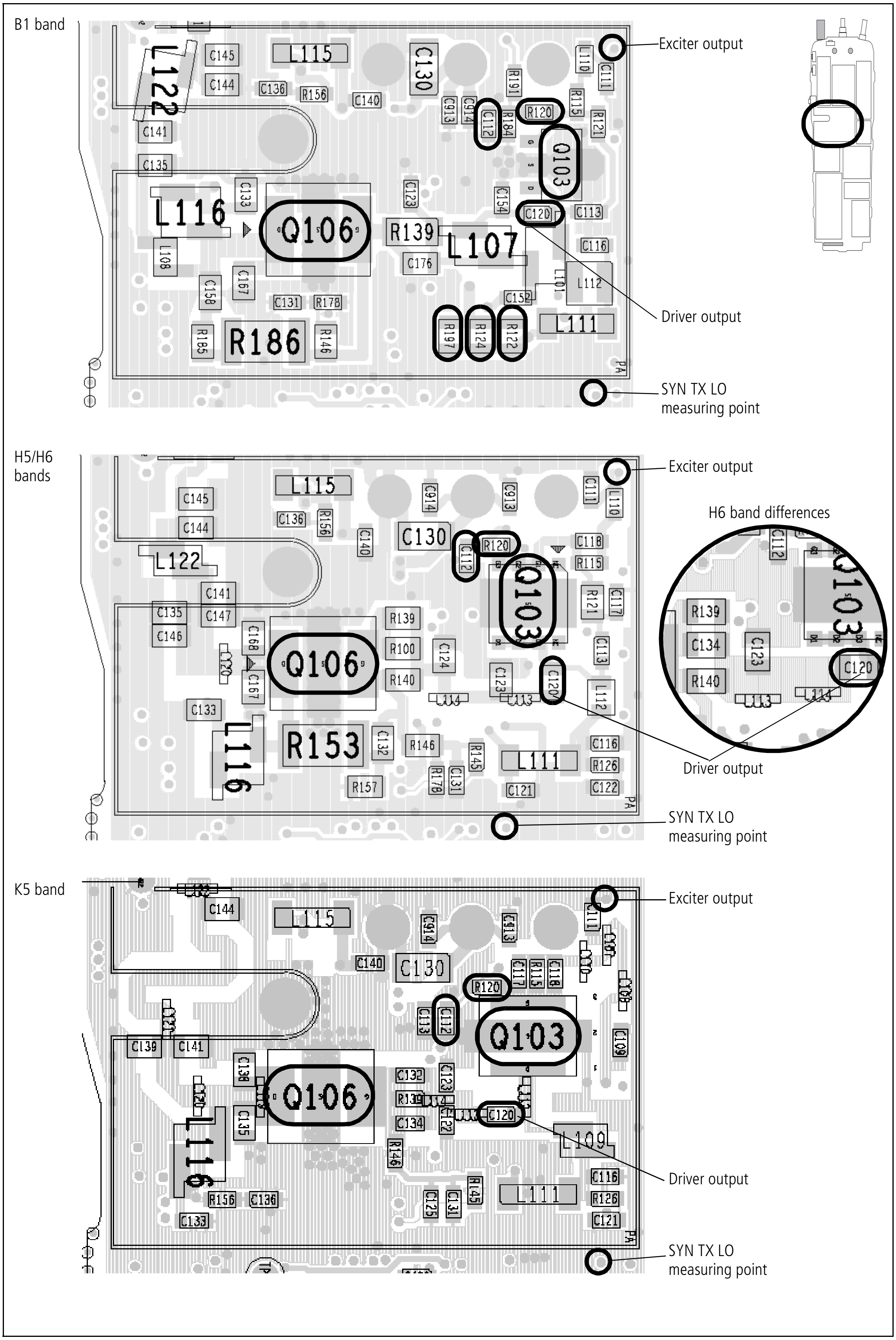
gate of Q106: 2 to 5V

4. Enter the CCTM command *32* to place the radio in receive mode.

5. If the voltage measured above is correct, **Q106** is faulty; replace the main board and go to "Final Tasks" on page 136. If it is not correct, go to Step 6.

6. Check the circuitry between pin 14 of **IC101** (see **Figure 10.7**) and the gate of **Q106** (see **Figure 10.8**). If a fault is found, repair it, confirm the removal of the fault, and go to "Final Tasks" on page 136. If the repair failed or Q106 itself is faulty, replace the main board and go to "Final Tasks" on page 136.

Figure 10.8 PA driver circuitry under the PA BOT can (bottom side)



Task 12 — Shaping Filter for Power Control

If neither the voltage nor the current measured in Task 10 is correct, then the shaping filter for the power-control circuitry or the CODEC and audio circuitry is suspect.

Important Ensure that the current limit on the DC supply is 2A. And, when entering the CCTM command *331 **x***, do not specify a value ***x*** higher than that recorded in Task 9. Failure to do so might result in the destruction of the PAs.

1. Use the multimeter to measure the voltage at the via of CDC TXFIN RXAGC (see **Figure 10.7**). The voltage should be:

via of CDC TXFIN RXAGC: 64 ± 2mV (initially)

2. Enter the CCTM command *331 **x*** (where ***x*** was recorded in Task 9).

3. Check that the voltage changes to:

via of CDC TXFIN RXAGC: 1.1 to 2.7V (after entry of CCTM 331 **x**)

4. Enter the CCTM command *32* to place the radio in receive mode.

5. If the voltage measured above is correct, go to Step 6. If it is not, go to "CODEC and Audio Fault Finding" on page 277.

6. Check **IC101** and the surrounding shaping-filter circuitry (see **Figure 10.7**). If a fault is found, repair it, confirm the removal of the fault, and go to "Final Tasks" on page 136. If the repair failed, replace the main board and go to "Final Tasks" on page 136.

Task 13 — Biasing of PA Driver — voltage clamp

If the PA biasing and power control are correct, then proceed to check the voltage clamp current of the driver.

1. Enter the CCTM command *324 4* to set the radio to high power.

2. Measure the voltage across the resistors **R122**, **R124**, and **R197** (see **Figure 10.8** for the B1 band and **Figure 10.7** for the H5, H6 and K5 bands). The voltage should be:

voltages across R122, R124, R197: < 0.3V (after entry of CCTM 324 4)

3. If the voltage is correct, go to Task 14. If it is not correct, replace Q106 and Q103. Confirm the removal of the fault and go to "Final Tasks" on page 136. If the repair failed, replace the main board and go to "Final Tasks" on page 136.

Task 14 — Biasing of PA Driver — SET PWR test point

If there is no fault in the biasing of the PA, investigate the biasing of the PA driver (Q103).

1. Check the voltage at the **VGATE test point** (see **Figure 10.7**):

VGATE test point: 2 to 5V (B1, H5 and H6 bands); 1V to 5V (K5 band)

2. If the voltage is correct, go to Step 3. If it is not, go to Task 15.

3. Enter the CCTM command 33 to place the radio in transmit mode.

4. Check the voltage on the gate of **Q103** (see **Figure 10.8**):

gate of Q103: 2 to 3V (B1, H5 and H6 bands); 1V to 5V (K5 band)

5. Enter the CCTM command 32 to place the radio in receive mode.

6. If the voltage is correct, replace **Q103**; confirm the removal of the fault and go to "Final Tasks" on page 136. If it is not, go to Task 15.

Task 15 — Check Power Control

Check the power-control circuitry if the voltage at the VGATE test point is incorrect.

Important Ensure that the current limit on the DC supply is 2A.

1. Enter the CCTM command *114 0* to switch off the power.

2. Note the current reading on the DC power supply.

3. Check that the voltage from the DAC is changing: Measure the voltage at the **TXPWR RXFE test point** (CDC TXPWR RXFE) (see **Figure 10.7**).

4. Enter the CCTM command *114 1023*. The voltage should increase to:

PWR test point: 3.4 ± 0.1V

5. Enter the CCTM command 32 to place the radio in receive mode.

6. If the voltage at the **TXPWR RXFE test point** increases as required, go to Task 16. If it does not, go to "CODEC and Audio Fault Finding" on page 277.

Task 16 — Power Control for PA Driver

In this task any faults in the path between the power-control circuit and the PA driver will be located, as well as any fault with the PA driver.

1. Check for short circuits at the gate of the PA driver **Q103** (see **Figure 10.8**). Check **R118** (see **Figure 10.7**), **C112**, and **R120** (see **Figure 10.8**) between the power-control circuit and Q103.

2. Repair any fault revealed by the checks in Step 1. If none of the above-mentioned components are faulty, replace **Q103** (see **Figure 10.8**).

3. Confirm the removal of the fault and go to “Final Tasks” on page 136. If the repair failed, replace the main board and go to “Final Tasks” on page 136.

Task 17 — Power Control and Shaping Filter

In this task any faults in the power-control and shaping-filter circuitry will be located:

1. Enter the CCTM command *32* and then check **C115**, **C175**, **R123**, and **R132** (see **Figure 10.7**) in the power-control circuit.

2. Repair any fault revealed by the checks in Step 1. Confirm the removal of the fault and go to “Final Tasks” on page 136. If the repair failed, or a fault cannot be found, go to Step 3.

3. Measure the voltage at pin 1 of **IC101** (see **Figure 10.7**) in the shaping-filter circuit. The voltage should be:

pin 1 of IC101: 1.0 ± 0.5V

4. Enter the CCTM command *32* to place the radio in receive mode.

5. If the voltage measured in Step 3 is correct, go to Step 6. If it is not, go to Step 7.

6. Check the components **R141** and **C124** (see **Figure 10.7**) and go to Step 8.

7. Check the components between the **TXPWR RXFE test point** and pin 1 of **IC101** (see **Figure 10.7**) and go to Step 8.

8. Repair any fault revealed by the checks in Step 6 and Step 7. Replace **IC101** (see **Figure 10.7**) if none of the components are faulty. Confirm the removal of the fault and go to “Final Tasks” on page 136. If the repair failed, replace the main board and go to “Final Tasks” on page 136.

10.4 RF Signal Path

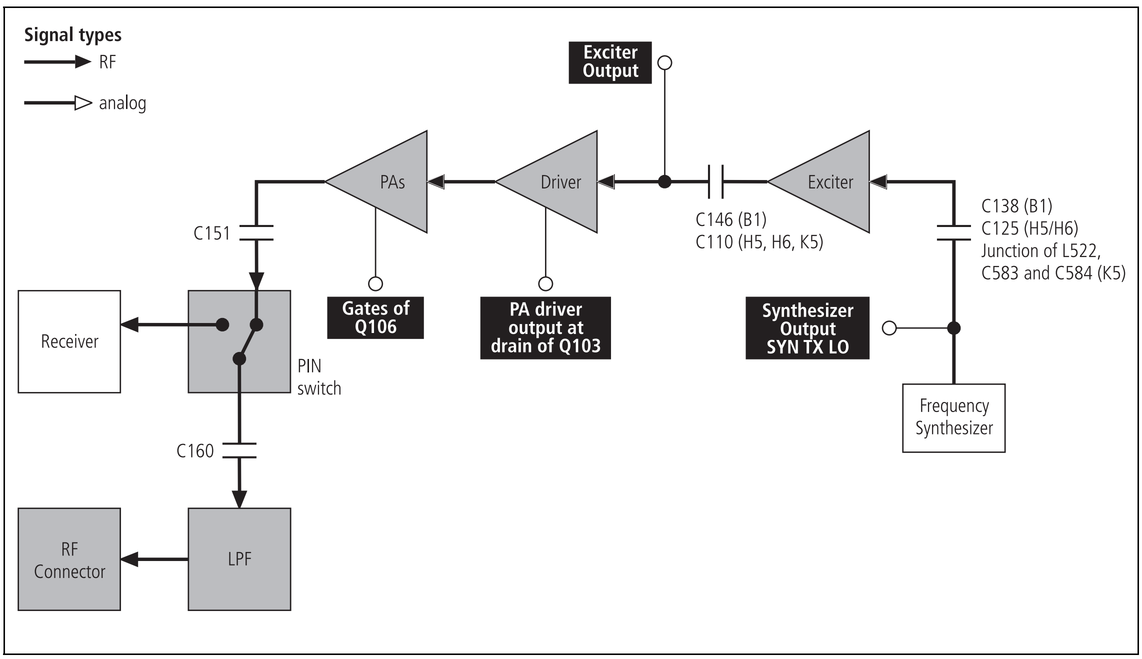
Introduction

The RF signal path extends from the output of the frequency synthesizer to the LPF. This section of circuitry will require investigation either following certain checks in "Transmitter RF Power" or if the biasing checks of "Biasing of PA Driver and PA" reveal no fault. The procedure is divided into nine tasks grouped as follows:

- Task 18 to Task 20: initial RF signal path
- Task 21 and Task 22: PIN switch
- Task 23: LPF

The initial signal path includes the exciter and PA driver. The PIN switch, and LPF make up the final signal path. The measurement points for diagnosing faults in the signal path are summarized in Figure 10.9.

Figure 10.9 Measurement points for diagnosing faults in the RF signal path



Task 18 — Output of Frequency Synthesizer

The first point to check in the initial RF signal path is the output SYN TX LO from the frequency synthesizer. This signal is input to the exciter at C138 (B1 band), C125 (H5 and H6 bands), or the junction of L522, C583 and C584 (K5 band).

1. For test purposes select a representative power level and frequency from **Table 10.6** (B1), **Table 10.7** (H5), **Table 10.8** (H6), or **Table 10.9** (K5). Note that the data for these tables was obtained using an RFP5401A RF probe

2. To set the power level, enter the CCTM command *326* ***x***, where ***x*** defines the level.

3. To set the frequency, enter the CCTM command *101* ***x x*** *0*, where ***x*** is the frequency in hertz.

4. Enter the CCTM command *33* to place the radio in transmit mode.

5. Use an RFP5401A RF probe or the equivalent to measure the RF voltage at the SYN TX LO measuring via. For the B1 band measure the RF voltage before **C138** (B1 band), for H5 and H6 measure before **C125**, and for K5 measure at the junction of **L522**, **C583** and **C584** (see **Figure 10.10**). The required voltage should be as given in **Table 10.6** (B1 band), **Table 10.7** (H5 band), **Table 10.8** (H6 band), or **Table 10.9** (K5 band).

6. Enter the CCTM command *32* to place the radio in receive mode.

7. If the voltage measured above is correct, go to Task 19. If it is not, go to Step 8.

8. Check **C138** (B1 band), **C125** (H5 and H6 bands), or **C583** and **C584** (K5 band) (see **Figure 10.10**). If the capacitor or capacitors are not faulty, go to “Frequency Synthesizer Fault Finding” on page 161. If a capacitor is faulty, replace it and return to Step 2.

Table 10.6 RF voltages along the initial RF signal path (B1 band)

Power level (W)	Frequency (MHz)	RF voltages (V)		
		Synthesizer output	Exciter output	Driver output
1	136 155 174	0.47 ± 0.1 0.45 ± 0.1 0.36 ± 0.1	1.8 ±0.3 1.8 ±0.3 1.6 ±0.3	0.43 ±0.3 0.43 ±0.3 0.46 ±0.3
2	136 155 174	0.47 ± 0.1 0.45 ± 0.1 0.36 ± 0.1	1.8 ±0.3 1.8 ±0.3 1.6 ±0.3	0.70 ±0.3 0.66 ±0.3 0.71 ±0.3
3	136 155 174	0.47 ± 0.1 0.45 ± 0.1 0.36 ± 0.1	1.8 ±0.3 1.8 ±0.3 1.6 ±0.3	0.92 ±0.3 1.0 ±0.3 0.96 ±0.3
5	136 155 174	0.47 ± 0.1 0.45 ± 0.1 0.36 ± 0.1	1.8 ±0.3 1.8 ±0.3 1.6 ±0.3	1.4 ±0.3 1.3 ±0.3 1.6 ±0.3

Table 10.7 RF voltages along the initial RF signal path (H5 band)

Power level (W)	Frequency (MHz)	RF voltages (V)		
		Synthesizer output	Exciter output	Driver output
1	400 435 470	0.50 ± 0.1 0.51 ± 0.1 0.55 ± 0.1	1.3 ±0.3 1.5 ±0.3 1.4 ±0.3	0.85 ±0.3 0.83 ±0.3 0.73 ±0.3
2	400 435 470	0.45 ± 0.1 0.51 ± 0.1 0.55 ± 0.1	1.3 ±0.3 1.5 ±0.3 1.4 ±0.3	0.81 ±0.3 0.75 ±0.3 0.68 ±0.3
2.5	400 435 470	0.45 ± 0.1 0.46 ± 0.1 0.55 ± 0.1	1.3 ±0.3 1.5 ±0.3 1.4 ±0.3	0.95 ±0.3 0.91 ±0.3 0.82 ±0.3
4	400 435 470	0.45 ± 0.1 0.53 ± 0.1 0.65 ± 0.1	1.4 ±0.3 1.8 ±0.3 1.6 ±0.3	1.4 ±0.3 1.6 ±0.3 1.4 ±0.3

Table 10.8 RF voltages along the initial RF signal path (H6 band)

Power level (W)	Frequency (MHz)	RF voltages (V)		
		Synthesizer output	Exciter output	Driver output
1	450 490 530	0.35 ± 0.1 0.51 ± 0.1 0.46 ± 0.1	0.85 ±0.3 1.4 ±0.3 1.8 ±0.3	0.46 ±0.3 0.44 ±0.3 0.57 ±0.3
2	450 490 530	0.35 ± 0.1 0.54 ± 0.1 0.49 ± 0.1	0.85 ±0.3 1.4 ±0.3 1.9 ±0.3	0.53 ±0.3 0.61 ±0.3 0.73 ±0.3
2.5	450 490 530	0.55 ± 0.1 0.61 ± 0.1 0.51 ± 0.1	1.9 ±0.3 1.6 ±0.3 2.0 ±0.3	0.77 ±0.3 0.71 ±0.3 0.78 ±0.3
4	450 490 530	0.61 ± 0.1 0.68 ± 0.1 0.56 ± 0.1	2.2 ±0.3 2.0 ±0.3 2.2 ±0.3	1.2 ±0.3 1.2 ±0.3 1.3 ±0.3

Note For the B1, H5 and H6 bands, the ground of the measuring probe must be connected as close to the measuring point as possible.

Table 10.9 RF voltages along the initial RF signal path (K5 band)

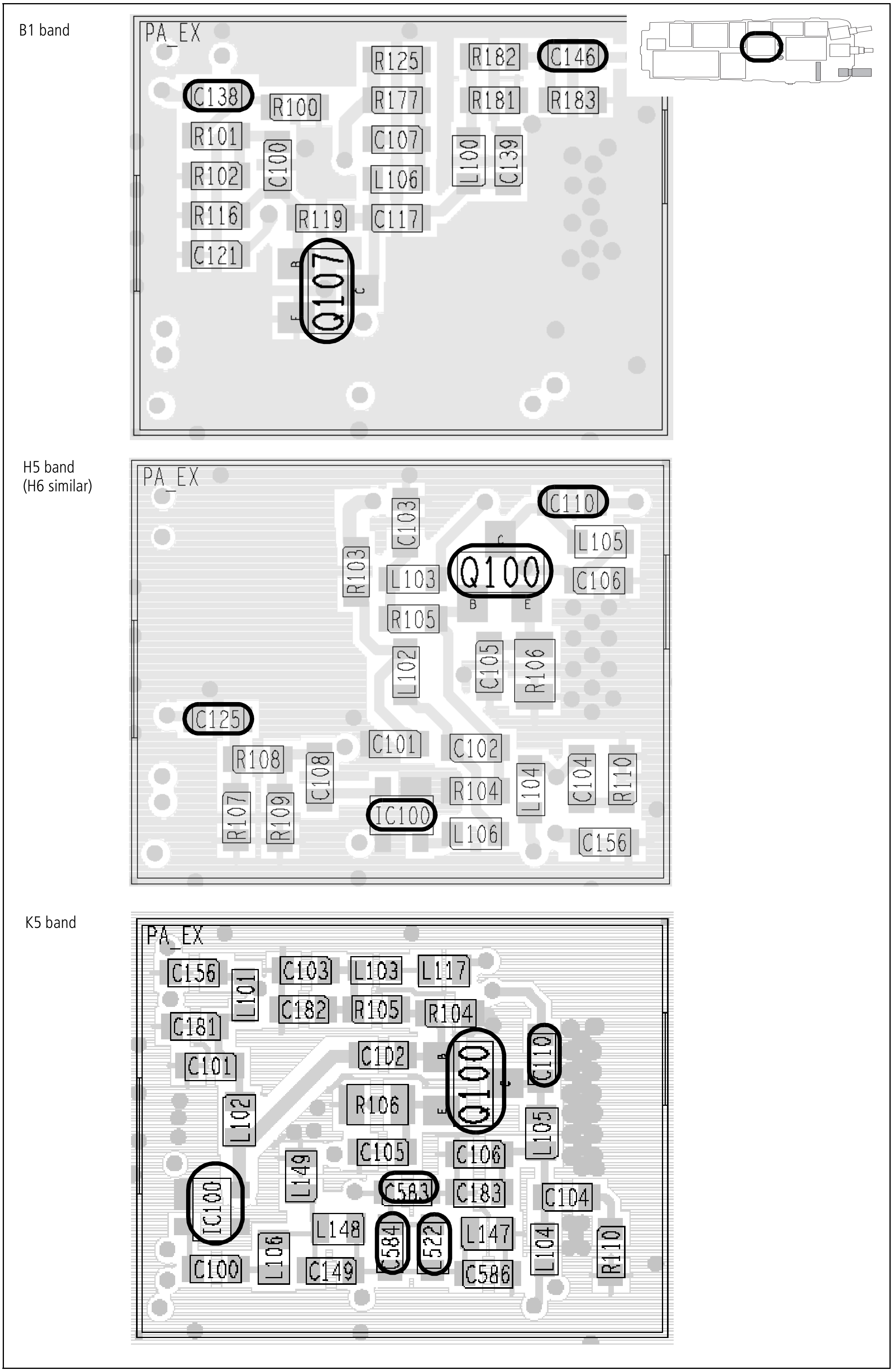
Power level (W)	Frequency (MHz)	RF voltages (V)		
		Synthesizer output	Exciter output	Driver output
1	762 816 870	0.32 ± 0.1 0.5 ± 0.1 0.45 ± 0.1	2.95 ±0.3 3.12 ±0.3 1.41 ±0.3	0.54 ±0.3 0.55 ±0.3 0.45 ±0.3
2	762 816 870	0.3 ± 0.1 0.48 ± 0.1 0.43 ± 0.1	3.09 ±0.3 3.14 ±0.3 1.13 ±0.3	0.66 ±0.3 0.7 ±0.3 0.9 ±0.3
2.5	762 816 870	0.29 ± 0.1 0.47 ± 0.1 0.4 ± 0.1	2.96 ±0.3 2.92 ±0.3 1.08 ±0.3	0.6 ±0.3 0.8 ±0.3 0.84 ±0.3
3	762 816 870	0.3 ± 0.1 0.52 ± 0.1 0.46 ± 0.1	2.95 ±0.3 2.76 ±0.3 0.92 ±0.3	0.8 ±0.3 0.91±0.3 1.07 ±0.3

Task 19 — Output of Exciter Circuit

If the synthesizer output is correct, check the output at Q107 (B1 band) or Q100 (H5, H6 and K5 bands) of the exciter circuit.

1. If not already done, remove the PA BOT can.
2. Enter the CCTM command *326* ***x***, where ***x*** defines the power level selected in Task 18.
3. Enter the CCTM command *101* ***x x*** *0*, where ***x*** is the frequency selected in Task 18.
4. Enter the CCTM command *33* to place the radio in transmit mode.
5. Use an RFP5401A RF probe or the equivalent to measure the RF voltage after **C146** (B1 band) or **C110** (H5, H6 and K5 bands) at the exciter output measuring point in **Figure 10.8**. The required voltage should be as given in **Table 10.6** (B1 band), **Table 10.7** (H5 band), **Table 10.8** (H6 band), or **Table 10.9** (K5 band).
6. Enter the CCTM command *32* to place the radio in receive mode.
7. If the voltage measured above is correct, go to Task 19. If it is not, go to Step 8.
8. Check the components around **Q107** (B1 band) or **Q100** and **IC100** (H5, H6 and K5 bands) (see **Figure 10.10**).
9. Repair any fault revealed by the above checks.
10. Confirm the removal of the fault and go to "Final Tasks" on page 136. If the repair failed, replace the main board and go to "Final Tasks" on page 136.

Figure 10.10 Components under the PA EX TOP can (top side)



Task 20 — Output of PA Driver

If the exciter output is correct, check the output of the PA driver at the drain of Q103. If necessary, also check the signal at the gates of the PA Q106. This is the last point in the initial RF signal path.

1. With the radio still in transmit mode, use an RFP5401A RF probe or the equivalent to measure the RF voltage after **C120** (see **Figure 10.8**). The required voltage should be as given in **Table 10.6** (B1 band), **Table 10.7** (H5 band), **Table 10.8** (H6 band), or **Table 10.9** (K5 band).
2. Enter the CCTM command *32* to place the radio in receive mode.
3. If the voltage measured above is correct, go to Step 7. If it is not, go to Step 4.
4. Check the components between **C120** and **Q103** (see **Figure 10.8**).
5. If the above checks reveal a fault, go to Step 6. If they do not, go to Task 9.
6. Repair the fault. Confirm the removal of the fault and go to “Final Tasks” on page 136. If the repair failed, replace the main board and go to “Final Tasks” on page 136.
7. Enter the CCTM command *326 5* to set the power level to the maximum, and then the command *33* to place the radio in transmit mode.
8. Measure the RF voltage at the gates of the PA **Q106** (see **Figure 10.8**).
9. Enter the CCTM command *32* to place the radio in receive mode.
10. If an RF voltage is present, there is no fault in the initial RF signal path; go to Task 21. If there is no RF voltage, go to Step 11.
11. Check the components of the interstage matching circuitry between the PA driver **Q103** and the gates of the PA **Q106** (see **Figure 10.8**).
12. If a fault is found, repair it, confirm the removal of the fault, and go to “Final Tasks” on page 136. If the repair failed or the fault could not be found, replace the main board and go to “Final Tasks” on page 136.

Task 21 — Check PIN Switch

In checking the final RF signal path, if no fault is found in the PA and driver, then check the PIN switch next. The PIN switch may also require investigation following certain checks in "Transmitter RF Power".

1. Remove the PA LPF BOT can.

2. For the B1, H5 and H6 bands, remove the blocking capacitor **C160** (see **Figure 10.11**).

3. For the B1, H5 and H6 bands, solder one terminal of a 22pF test capacitor to the PCB at the point shown in **Figure 10.11**. Mount the capacitor vertically. Use a test capacitor of the type 0805 or the equivalent. For the K5 band, mount **C160** vertically on the first pad nearest D101 (see **Figure 10.11).**

4. Solder a 50Ω test lead to the PCB. Solder the outer sheath to ground and solder the central wire to the other terminal of the test capacitor.

5. Connect the test lead to the test set.

6. Enter the CCTM command *326 5* to set the transmitter power level to the maximum.

7. Enter the CCTM command *101 **x x** 0*, where ***x*** is the lowest frequency (in hertz) for maximum power, as given in **Table 10.6** (B1 band), **Table 10.7** (H5 band), **Table 10.8** (H6 band), or **Table 10.9** (K5 band).

8. Enter the CCTM command *33* to place the radio in transmit mode.

9. Measure the RF output power. This should exceed 6W (B1 band), 5W (H5 and H6 bands), or 4W (K5 band).

RF output power: >6W (B1 band); >5W (H5 and H6 bands); >4W (K5 band)

10. Enter the CCTM command *32* to place the radio in receive mode.

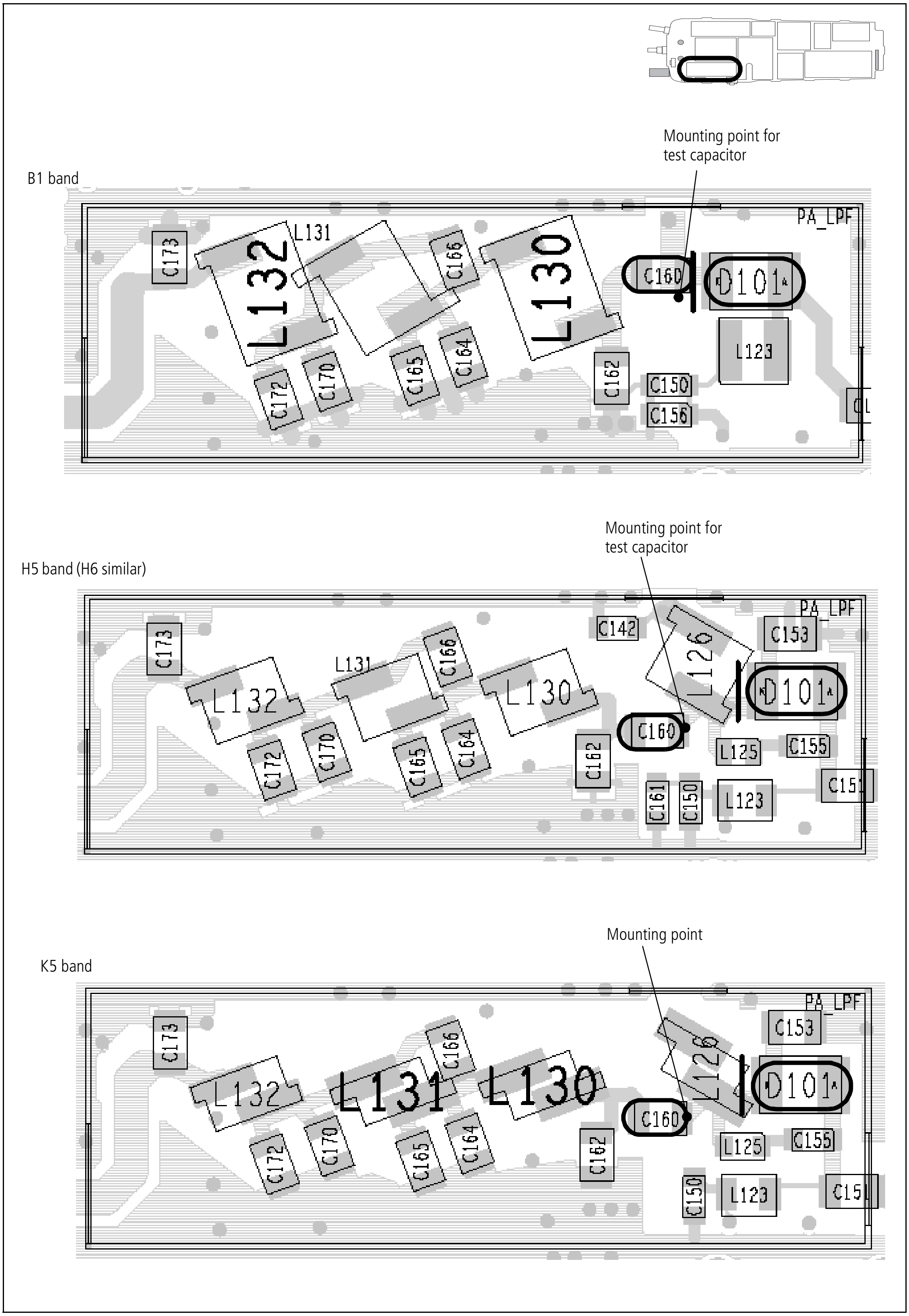
11. Enter the CCTM command *101 **x x** 0*, where ***x*** is the highest frequency (in hertz) for maximum power, as given in **Table 10.6** (B1 band), **Table 10.7** (H5 band), **Table 10.8** (H6 band), or **Table 10.9** (K5 band).

12. Repeat Step 8 to Step 10.

13. If the power in both the above cases exceeds 6W (B1 band), 5W (H5 and H6 bands), or 4W (K5 band), go to Step 14. If it does not, the circuitry of the PIN switch is suspect; go to Task 22.

14. Remove the test lead, and for the B1, H5 and H6 bands, the test capacitor. Refit C160, and go to Task 23.

Figure 10.11 Circuitry under the PA LPF BOT can (bottom side)



Task 22 — Repair PIN switch

If the RF power at the PIN switch is low, the switch is not drawing the expected current. Check the circuit as follows:

1. Check **D101** (see **Figure 10.11**). If it is not faulty, go to Step 2. If it is, replace D307 and go to Step 3.

2. Check the +5V0 TX supply to the PIN switch via the following components:
   - B1 band: **L123** (see **Figure 10.11**), **D103**, **L109**, **R189**, **R190**, **R192** (see **Figure 10.12**)
   - H5, H6 and K5 bands: **L123**, **L126** (see **Figure 10.11**), **D105**, **D106**, **D107**, **R171**, **R172**, **R173** (see **Figure 10.12**)

   Replace any faulty component.

3. With the test lead still connected to the test set, enter the CCTM command *326 5* to set the transmitter power level to the maximum.

4. Enter the CCTM command *101* ***x x*** *0*, where ***x*** is the lowest frequency (in hertz) for maximum power, as given in **Table 10.6** (B1 band), **Table 10.7** (H5 band), **Table 10.8** (H6 band), or **Table 10.9** (K5 band).

5. Enter the CCTM command *33* to place the radio in transmit mode.

6. Again measure the RF output power. This should exceed 6W (B1 band), 5W (H5 and H6 bands), or 4W (K5 band).

RF output power: >6W (B1 band); >5W (H5 and H6 bands); >4W (K5 band)

7. Enter the CCTM command *32* to place the radio in receive mode.

8. Enter the CCTM command *101* ***x x*** *0*, where ***x*** is the highest frequency (in hertz) for maximum power, as given in **Table 10.6** (B1 band), **Table 10.7** (H5 band), **Table 10.8** (H6 band), or **Table 10.9** (K5 band).

9. Repeat Step 5 to Step 7.

10. Remove the test lead and test capacitor, and resolder the blocking capacitors **C160** (see **Figure 10.11**) in position.

11. If the power in both the above cases is now correct, the fault has been rectified; go to “Final Tasks” on page 136. If the repair failed, replace the main board and go to “Final Tasks” on page 136.

Task 23 — Check Components of LPF

If there are no faults in the final RF signal path up to and including the PIN switch, then the fault should lie in the LPF. Check the LPF as follows:

1. Remove the PA LPF BOT can.

2. Connect the RF connector to the test set.

3. Check the capacitors and inductors of the LPF between the PIN switch and the RF connector. See **Figure 10.12**. Check for shorts, open circuits, and faulty components. Repair any fault.

4. Enter the CCTM command *326 5* to set the transmitter power level to the maximum.

5. Enter the CCTM command *101* ***x x*** *0*, where ***x*** is the lowest frequency (in hertz) for maximum power, as given in **Table 10.6** (B1 band), **Table 10.7** (H5 band), **Table 10.8** (H6 band), or **Table 10.9** (K5 band).

6. Enter the CCTM command *33* to place the radio in transmit mode.

7. Measure the RF output power. This should exceed 6 W (B1 band), 5 W (H5 and H6 bands), or 4 W (K5 band).

RF output power: >6W (B1 band); >5W (H5 and H6 bands); >4W (K5 band)

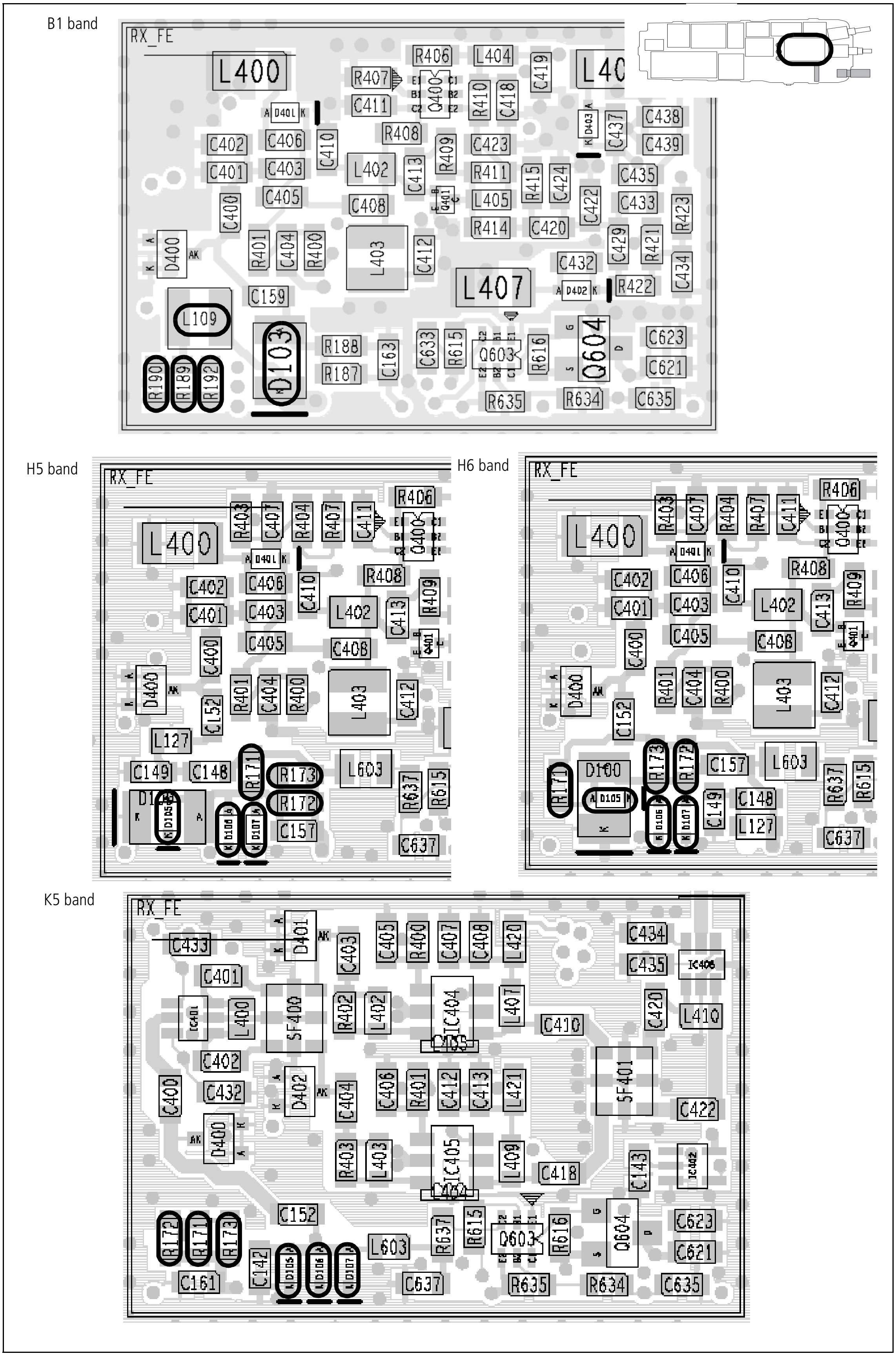
8. Enter the CCTM command *32* to place the radio in receive mode.

9. Enter the CCTM command *101* ***x x*** *0*, where ***x*** is the highest frequency (in hertz) for maximum power, as given in **Table 10.6** (B1 band), **Table 10.7** (H5 band), **Table 10.8** (H6 band), or **Table 10.9** (K5 band).

10. Repeat Step 6 to Step 8.

11. If the power in both the above cases is now correct, the fault has been rectified; go to “Final Tasks” on page 136. If the repair failed, replace the main board and go to “Final Tasks” on page 136.

Figure 10.12 Circuitry under the RX FE TOP can (top side)



11 Receiver Fault Finding

Fault Conditions

This section covers the diagnosis of faults in the receiver. The fault-diagnosis procedures consist of a number of tasks grouped into the following sections. The symptoms of the fault in the receiver circuitry determine which sections are relevant:

- "Faulty Receiver Sensitivity"
- "Excessive Loss of Sensitivity"
- "Moderate or Slight Loss of Sensitivity"
- "Incorrect RSSI Readings"
- "Faulty Radio Mute"
- "High Receiver Distortion"

If the receiver sensitivity is low, begin with "Faulty Receiver Sensitivity" on page 258 to determine the extent of the loss in sensitivity.

CCTM Commands

The CCTM commands required are listed in Table 11.1. Full details of the commands are given in "Computer-Controlled Test Mode (CCTM)" on page 93.

Table 11.1 CCTM commands required for the diagnosis of faults in the receiver

Command	Description
72	Read lock status of RF PLL, FCL and LO2 — displays **xyz** (0=not in lock, 1=in lock)
101 **x y** 0	Set transmit frequency (**x** in hertz) and receive frequency (**y** in hertz) to specified values
376	Read tuning voltage for front-end circuitry — displays voltage **x** in millivolts
378	Read signal power at output of channel filter — displays power **x** (square of amplitude)

11.1 Faulty Receiver Sensitivity

Introduction

This section covers the determination of the extent of the receiver's loss of 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. The procedure is given in Task 1 below.

Task 1 — Determine Extent of Sensitivity Loss

Determine the receiver gain as follows. The corresponding loss of sensitivity can then be deduced. Depending on the extent of the loss, continue with "Excessive Loss of Sensitivity" on page 259 or "Moderate or Slight Loss of Sensitivity" on page 265 to rectify the fault.

1. Input an RF signal (not necessarily modulated) of –90 dBm at the RF connector.

2. Enter the CCTM command *378* to measure the receiver output level.

3. Note the value ***x*** returned for the receiver output level. Depending on the frequency band in which the radio operates, the value should be:

receiver output level ***x***: normally between 500 000 and 6 000 000

   Note that a change in the input level of 10 dB should result in a ten-fold change in ***x***.

4. If necessary, measure the RF voltage at the `QN` test point **TP444** (see Figure 12.5). For comparison, the voltages corresponding to the above values of ***x*** are:

x=500 000: 12 mV_{pp} ***x***=6000 000: 120 mV_{pp}

   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.

5. Given the value of ***x***, go to the relevant section as follows:

   - ***x*** < 1500, go to "Excessive Loss of Sensitivity" on page 259 (sensitivity is very low)
   - ***x*** < 500 000, go to "Moderate or Slight Loss of Sensitivity" on page 265 (sensitivity is low)

11.2 Excessive Loss of Sensitivity

Introduction

This section covers the case where the receiver has suffered an excessive loss of sensitivity. As measured in Task 1, the receiver gain will be less than 1500, which implies a sensitivity that is more than 40dB too low. The fault-diagnosis procedure for this case consists of five tasks:

- Task 2: check power supplies
- Task 3: check logic signal
- Task 4: check lock status
- Task 5: check biasing of IF amplifier
- Task 6: check matching circuitry

If the fault does not lie with the power supplies, it is probably in the control, LO, IF1 or IF2 circuitry.

Task 2 — Check Power Supplies

First check the two power supplies 3V0 AN and 3V0 RX for the receiver circuitry.

1. Remove the main board from the chassis.

2. Check for 3.0V DC (3V0 AN) at the **TP3V0 AN test point** near the speaker pin (see **Figure 12.3 on page 281**).

TP3V0 AN test point: 3.0V DC

3. If the voltage is correct, go to Step 4. If it is not, the 3V regulator **IC604** is suspect; go to Task 4 of "Power Supply Fault Finding" on page 158.

4. Remove the LO2 TOP can.

5. Check for 3.0V DC (3V0 RX) around the collector feed to **Q402** or **Q403** of LO2 (see **Figure 11.2**).

Q402 or Q403 collector: 3.0V DC

   Alternative measurement points are:

   - B1, H5 and H6 bands: the collector feed to **Q401** of the RF LNA under the RX FE TOP can (see **Figure 11.3**).
   - K5 band: the collector feed to **IC404** or **IC405** of the RF LNA under the RX FE TOP can (see **Figure 11.3**).
   - All bands: **Q404** of the IF amplifier under the IF IQ BOT can (see **Figure 11.1**).

6. If the voltage is correct, go to Task 3. If it is not, the 3V RX switch (based on **Q603** and **Q604**) in the PSU module is suspect; go to Task 4 of "Power Supply Fault Finding" on page 158.

Figure 11.1 Receiver circuitry under the IF IQ BOT can (bottom side)

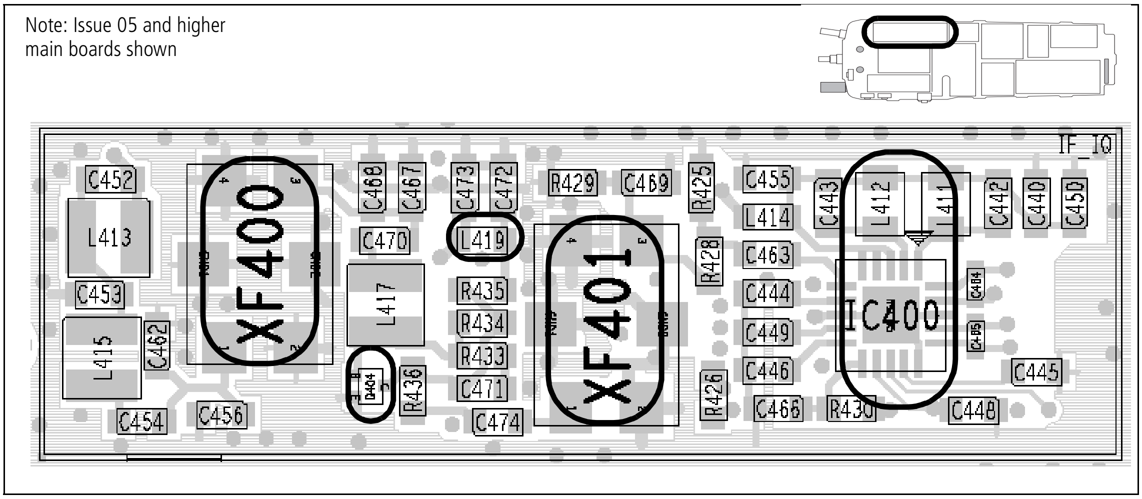


Figure 11.2 Receiver circuitry under the LO2 TOP can (top side)

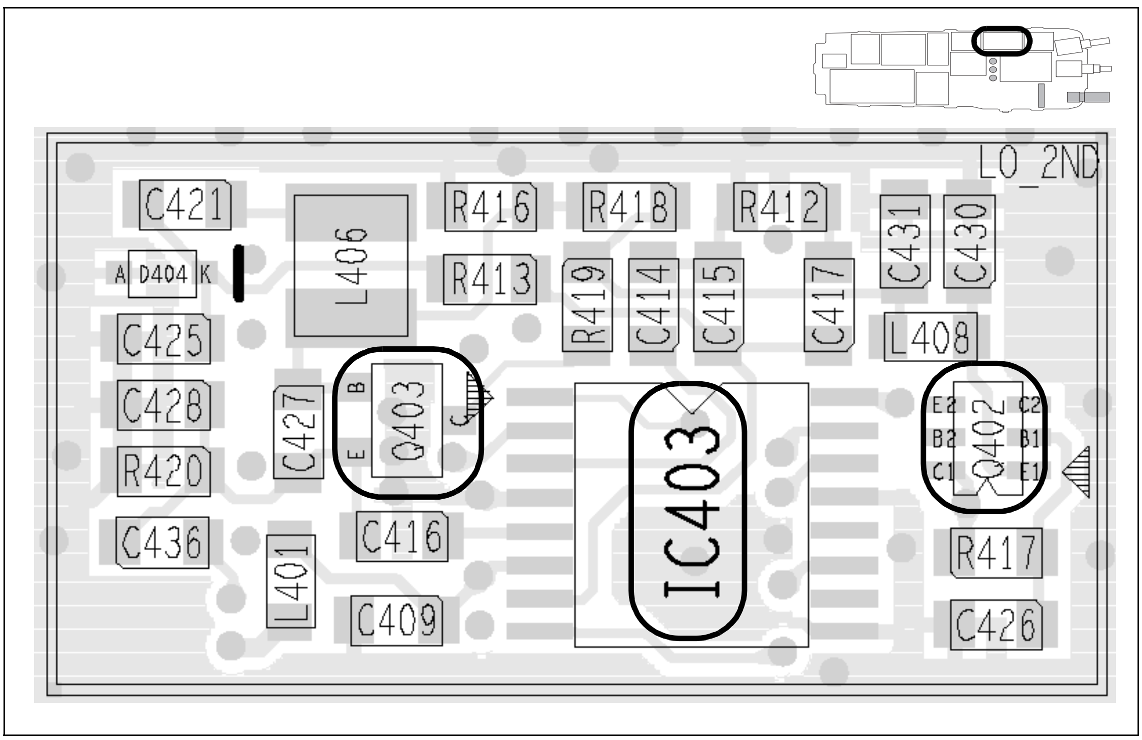
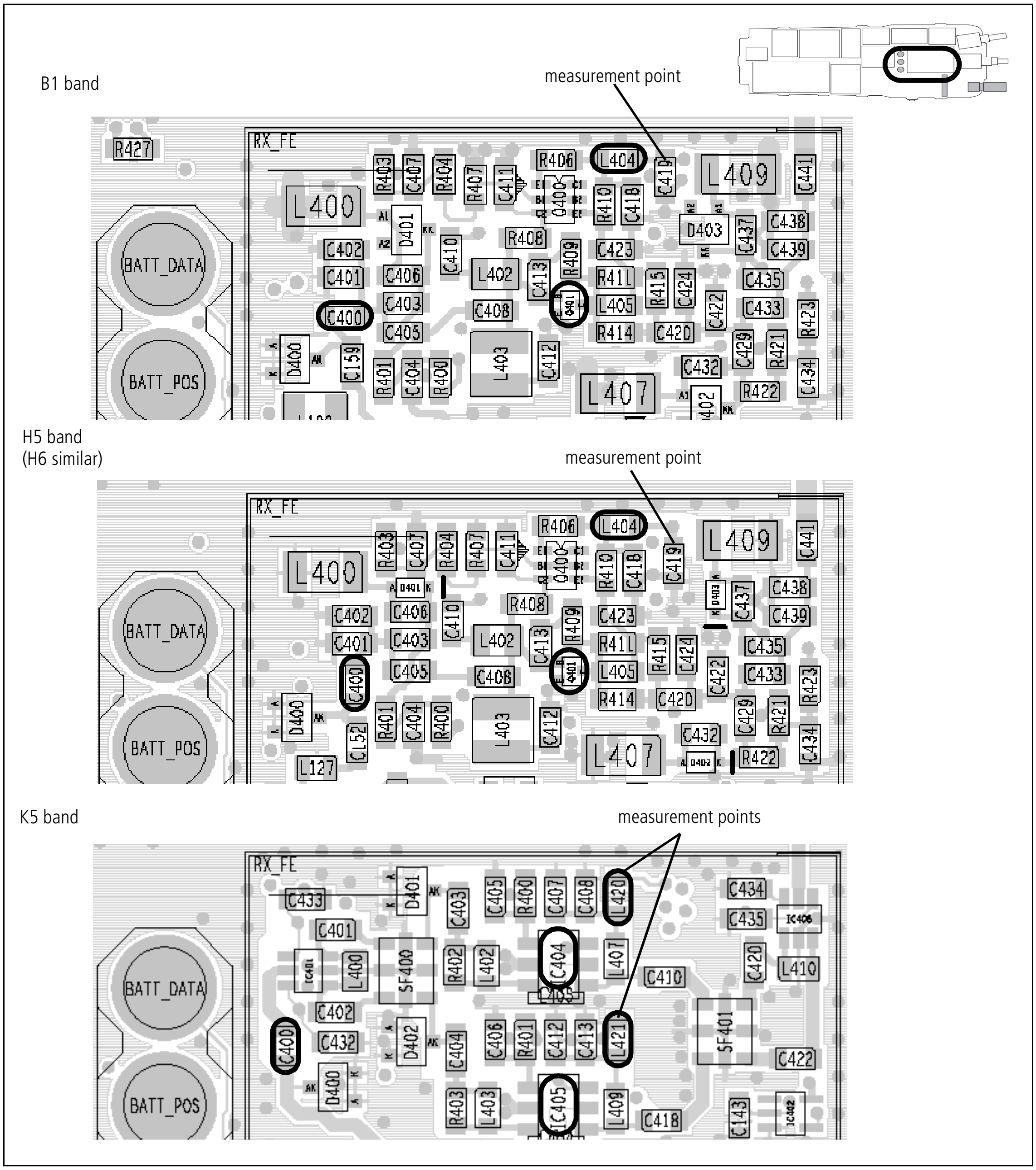


Figure 11.3 Receiver circuitry under the RX FE TOP can (top side)



Task 3 — Check Logic Signal

If there is no fault with the power supplies, check the logic signal DIG RX EN that is input from the digital circuitry.

1. Check the logic signal DIG RX EN at pin 8 of **IC403** (see **Figure 11.2**). The signal is active high. The required status is active.

pin 8 of IC403: about 3.0V (active)

   An alternative measurement point to the above is pin 24 of **IC400** under the IF IQ BOT can (see **Figure 11.1**).

2. If DIG RX EN is active, go to Task 4. If it is not, go to Step 3.

3. Check the signal continuity from the digital board to the receiver. Repair any fault and go to Step 4. If the digital board itself appears to be faulty, replace the main board and go to "Final Tasks" on page 136.

4. Recalibrate the receiver using the calibration application.

5. Confirm the removal of the fault and go to "Final Tasks" on page 136. If the repair failed, go to Task 7.

Task 4 — Check Lock Status

If the logic signal from the digital board is active, as required, check the lock status of the radio.

1. Enter the CCTM command *72* to determine the lock status. The status should be normal:

lock status: 111 (LO1, FCL, LO2 all in lock)

2. If the lock status is normal, go to Task 5. If the LO1 is not in lock, go to "Frequency Synthesizer Fault Finding" on page 161. If the FCL is not in lock, go to "Power Supply for FCL" on page 209. If the LO2 is not in lock, go to Step 3.

3. Check the components around **IC403**, **Q402** and **Q403** (see **Figure 11.2**). Repair any fault.

4. Recalibrate the receiver using the calibration application.

5. Confirm the removal of the fault and go to "Final Tasks" on page 136. If the repair failed, go to Task 7.

Task 5 — Check Biasing of IF Amplifier

If the lock status is normal, check the biasing of the IF amplifier.

1. Remove the IF IQ BOT can.
2. Check all components around **Q404** of the IF amplifier (see **Figure 11.1**).
3. Check the 3V supply voltage at **L419**; use the measurement point shown in **Figure 11.1**.
4. Also check the amplifier bias conditions. First measure V_c between the collector of **Q404** and ground (see **Figure 11.1**).

V_c: 2.0±0.2V

5. Secondly, check I_c. To do so, mount **L419** vertically by unsoldering and raising one terminal (see **Figure 11.1**). Connect a multimeter between this terminal and the pad for the terminal, and measure the current.

I_c: 1.8±0.5mA

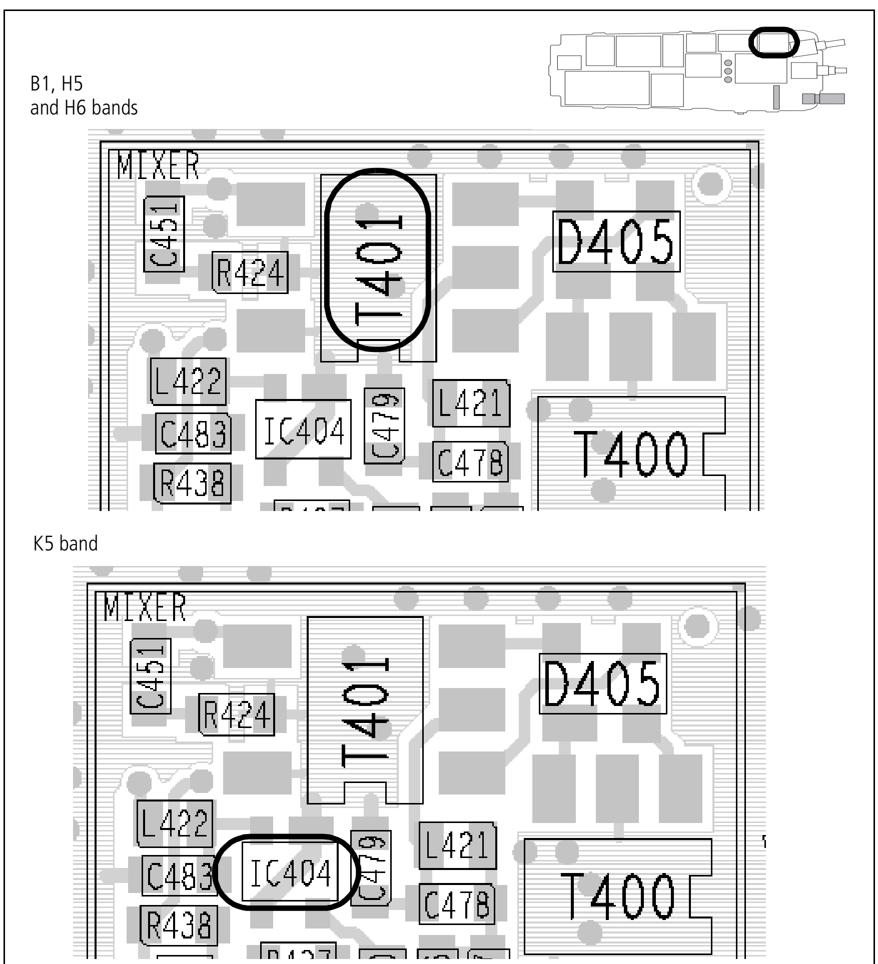
6. If the checks in Step 2 to Step 5 reveal no fault, go to Task 6. If there is a fault, repair it and go to Step 7.
7. Recalibrate the receiver using the calibration application.
8. Confirm the removal of the fault and go to "Final Tasks" on page 136. If the repair failed, go to Task 7.

Task 6 — Check Matching Circuitry

Having excluded the IF amplifier, check the matching circuitry for the crystal filters.

1. Check all remaining components between **T401** and **IC400** (B1, H5 and H6 bands), or **IC409** and **IC400** (K5 band). See **Figure 11.4** and **Figure 11.1**. These form the matching circuitry for the crystal filters **XF400** and **XF401** (see **Figure 11.1**).
2. If the above check reveals no fault, go to Step 3. If there is a fault, repair it and go to Step 6.
3. Remove the RX FE TOP and PA LPF BOT cans.
4. Make a visual check of the components in the receive path of the PIN switch and LPF circuits.
5. If the visual check reveals an obvious fault, repair it and go to Step 6. If there is no obvious fault, go to Task 7.
6. Recalibrate the receiver using the calibration application.
7. Confirm the removal of the fault and go to “Final Tasks” on page 136. If the repair failed, go to Task 7.

Figure 11.4 Receiver circuitry under the MIXER TOP can (top side)



11.3 Moderate or Slight Loss of Sensitivity

Introduction

This section covers the case where the receiver has suffered a moderate or slight loss of sensitivity. As measured in Task 1, the receiver gain will be less than 500 000, but not as low as 1500. With a gain less than 40 000, the loss of sensitivity will be moderate — about 15 dB too low; otherwise it will be slight — just a few decibels too low. There are three tasks:

- Task 7: front-end calibration and tuning voltages (B1, H5 and H6 bands only)
- Task 8: moderately low receiver sensitivity
- Task 9: slightly low receiver sensitivity

The fault-diagnosis procedures of Task 8 and Task 9 are similar; although the differences are minor they are important.

Task 7 — Front-end Calibration and Tuning Voltages

If the loss of sensitivity is moderate or slight, the fault is probably in the front-end tuning circuitry. This task is for the B1, H5 and H6 bands only. For the K5 band, go to Task 8 on page 267.

1. Using the calibration application, check the calibration of the front-end tuning circuitry: Open the *"Raw Data"* page and click the *"Receiver"* tab.

2. 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; the values are given in **Table 11.2**.)

3. 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.

4. Compare the values measured in Step 2 and Step 3 with the nominal DAC and voltage values listed in **Table 11.2**.

5. If the DAC and voltage values are correct, go to Step 8. If they are not, go to Step 6.

6. Recalibrate the receiver using the calibration application, and check the DAC and voltage values again.

7. If the DAC and voltage values are now correct, the fault has been rectified; go to "Final Tasks" on page 136. If they are not, go to Step 8.

8. Go to Task 8 if the receiver output level ***x*** measured in Task 1 was less than 40 000; otherwise go to Task 9.

Task 8 — Moderately Low Sensitivity

For the B1, H5 and H5 bands, following the initial investigation in Task 7, check the circuitry as follows when the sensitivity loss is moderate. For the K5 band, the steps for this task start on page 267.

B1, H5 and H6 bands only

1. Remove the RX FE TOP can and, if not already done, the IF IQ BOT can.

2. Check the soldering of all the components of the front-end tuning circuitry from **C400** to **T401** (see **Figure 11.3** and **Figure 11.4**).

3. Check the 3V supply voltage at **L404**; use the measurement point shown in **Figure 11.3**.

4. Also check the LNA bias conditions. First measure V_c between the collector of **Q401** and ground (see **Figure 11.3**).

V_c: 2.7±0.1V

5. Secondly, check I_c. To do so, unsolder and raise one terminal of **L404** (tombstone position) (see **Figure 11.3**), connect a multimeter between this terminal and the pad for the terminal, and measure the current.

I_c: 10±1mA

6. If the checks in Step 2 to Step 5 reveal no fault, go to Step 7. If there is a fault, repair it and go to Step 8.

7. Check the signal level at the output of LO1 and continue the fault diagnosis as in "Power Supply for FCL" on page 209.

8. Recalibrate the receiver using the calibration application.

9. Confirm the removal of the fault and go to "Final Tasks" on page 136. If the repair failed, go to Task 9.

Table 11.2 Front-end tuning voltages and corresponding DAC values (B1, H5 and H6 bands)

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 15 ± 15 0.20 ± 0.20	145.1 88 ± 15 1.04 ± 0.18	155.1 138 ± 15 1.65 ± 0.18	164.1 174 ± 15 2.04 ± 0.18	174.1 210 ± 15 2.52 ± 0.18
H5 band Frequency (MHz) DAC value Voltage (V)	399.9 15 ± 15 0.2 ± 0.2	417.1 44 ± 15 0.52 ± 0.18	435.1 102 ± 15 1.20 ± 0.18	452.1 153 ± 15 1.84 ± 0.18	470.1 191 ± 15 2.28 ± 0.18
H6 band Frequency (MHz) DAC value Voltage (V)	449.9 64 ± 20 0.75 ± 0.24	470.1 115 ± 15 1.35 ± 0.18	490.1 156 ± 15 1.85 ± 0.18	510.1 191 ± 15 2.35 ± 0.18	530.1 217 ± 15 2.60 ± 0.18

For the K5 band, check the circuitry as follows when the sensitivity loss is moderate. For the B1, H5 and H6 bands, the steps for this task start on page 266.

K5 band only

1. Remove the RX FE TOP can and, if not already done, the IF IQ BOT can.
2. Check the soldering of all the components of the front-end circuitry from **C400** to **IC409** (see **Figure 11.3** and **Figure 11.4**).
3. Check the 3V supply voltage at **L420** and **L421**; use the measurement points shown in **Figure 11.3**.
4. Also check the LNA enable conditions. First measure V_c on pin 1 of the collector of **IC404** or **IC405** and ground (see **Figure 11.3**).

   IC404 is enabled for channels between 850 to 970MHz, and **IC405** is enabled for channels between 762 and 776MHz.

V_c: 2.9±0.1V

5. If the checks in Step 2 to Step 4 reveal no fault, go to Step 6.
   If there is a fault, repair it and go to Step 7.
6. Check the signal level at the output of LO1 and continue the fault diagnosis as in "Power Supply for FCL" on page 209.
7. Confirm the removal of the fault and go to "Final Tasks" on page 136. If the repair failed, go to Task 9.

Table 11.3 Front-end tuning voltages and corresponding DAC values (K5 band)

Frequency band	Tuning voltages at five different frequencies				
	FE TUNE0	*FE TUNE1*	*FE TUNE2*	*FE TUNE3*	*FE TUNE4*
K6 band					
Frequency (MHz)	761.9	776.1	849.9	860.1	870.1
DAC value	0	0	255	255	255
Voltage (V)	0	0	3.0	3.0	3.0

Task 9 —Slightly Low Sensitivity

Following the initial investigation in Task 7, check the circuitry as follows when the sensitivity loss is slight.

1. Remove the RX FE TOP can and, if not already done, the IF IQ BOT can.
2. Check the soldering of all the components of the front-end tuning circuitry from **C400** to **T401** (B1, H5 and H6 bands), or from **C400** to **IC409** (K5 band). See **Figure 11.3** and **Figure 11.4**.
3. Check the IF-amplifier bias conditions as in Step 4 and Step 5 of Task 5.
4. Check the LNA bias conditions as in Step 4 and Step 5 of Task 8.
5. If the checks of Step 2 to Step 4 reveal no fault, go to Step 6.
   If there is a fault, repair it and go to Step 7.
6. Check the PIN switch and LPF as in Task 21 to Task 23 of "Transmitter Fault Finding".
7. Recalibrate the receiver using the calibration application.
8. Confirm the removal of the fault and go to "Final Tasks" on page 136. If the repair failed, replace the main board and go to "Final Tasks" on page 136.

11.4 Incorrect RSSI Readings

Introduction

If the RSSI readings are incorrect, the receiver calibration is suspect. There are four tasks, which cover the four types of settings concerned:

- Task 10: AGC voltage calibration
- Task 11: FE tune BPF settings (B1, H5 and H6 only)
- Task 12: RSSI delta gain
- Task 13: AGC delta gain

If the receiver is properly calibrated but the fault persists, then the receiver sensitivity is suspect.

Task 10 — AGC Voltage Calibration

The first settings to check concern the AGC voltage calibration.

1. In the calibration application open the *"Raw Data"* page and click the *"Receiver"* tab.

2. Note the settings listed in the *"AGC Voltage Cal Pts"* field. The nominal settings should be as listed in **Table 11.4**.

3. If the settings are correct, go to Task 11. If they are not, go to Step 4.

4. Recalibrate the receiver and check the settings again.

5. If the settings 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, go to "Final Tasks" on page 136. If it has not, go to Task 11 (B1, H5 and H6 bands) or Task 12 (K5 band).

Table 11.4 Nominal AGC data

Parameter	AGC Voltage (mV)				Receiver Input Power (dBm)
	B1 Band	H5 Band	H6 Band	K5 Band	
AGC0	2100 ± 100	2100 ± 100	2200 ± 100	2100 ± 100	-68
AGC1	1900 ± 100	1900 ± 100	2000 ± 100	1900 ± 100	-60
AGC2	1750 ± 100	1750 ± 100	1850 ± 100	1750 ± 100	-50

Task 11 — FE Tune BPF Settings

If the AGC voltage calibration is correct, check the FE tune BPF settings (B1, H5 and H6 bands only).

1. Note the settings listed in the *"FE Tune BPF Settings"* field. The nominal settings should be as listed in **Table 11.2**.
2. If the settings are correct, go to Task 12. If they are not, go to Step 3.
3. Recalibrate the receiver and check the settings again.
4. If the settings are now correct, go to Step 5. If they are not, go to Task 1 and check the receiver sensitivity.
5. Check if the RSSI fault has been removed. If it has, go to "Final Tasks" on page 136. If it has not, go to Task 12.

Task 12 — RSSI Delta Gain

Check the RSSI delta gain values.

1. Note the values listed in the *"Rx Delta Gain Values"* field. The values should be between 0 dB and about –3 dB (B1, H5 and H6 bands) or between 3 dB and about –3 dB (K5 band).
2. If the values are as expected, go to Task 13. If they are not, go to Step 3.
3. Recalibrate the receiver and check the values again.
4. If the values are now correct, go to Step 5. If they are not, go to Task 1 and check the receiver sensitivity.
5. Check if the RSSI fault has been removed. If it has, go to "Final Tasks" on page 136. If it has not, go to Task 13.

Task 13 — AGC Delta Gain

If the RSSI delta gain values are also correct, check the AGC delta gain values.

1. Note the values listed in the *"AGC Delta Gain Values"* field. The values should run gradually from 0 dB to about 35 dB.
2. If the values are as expected, go to Step 6. If they are not, go to Step 3.
3. Recalibrate the receiver and check the values again.
4. If the values are now correct, go to Step 5. If they are not, go to Task 1 and check the receiver sensitivity.
5. Check if the RSSI fault has been removed. If it has, go to "Final Tasks" on page 136. If it has not, go to Step 6.
6. 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.

11.5 Faulty Radio Mute

Introduction

If the radio mute is faulty, the calibration settings are suspect. There are three tasks:

- Task 14: determine type of muting selected
- Task 15: noise muting selected
- Task 16: RSSI muting selected

The programming application is required for Task 14, and the calibration application for Task 15 and Task 16.

Task 14 — Determine Type of Muting Selected

First use the programming application to determine the type of muting selected.

1. In the programming application click the *"Basic Settings"* page under the *"Channel Profiles"* heading.
2. Click the *"General Settings"* tab.
3. Check the setting in the *"Squelch Detect Type"* field. Ensure that the setting is what the customer expects.
4. If the setting is *"Noise Level"*, implying that noise muting is selected, go to Task 15. If the setting is *"Signal Strength"*, implying that RSSI muting is selected, go to Task 16.

Task 15 — Noise Muting Selected

With noise muting selected, check the noise mute settings:

1. In the calibration application open the *"Dev/Squelch"* page and click the *"Squelch and Signalling Thresholds"* tab.
2. Ensure that, under the *"Squelch Threshold"* label, the settings in the *"Country"*, *"City"* and *"Hard"* fields are what the customer expects.
3. Open the *"Raw Data"* page and click the *"Mute"* tab.
4. Compare the values in the *"Mute Noise Readings"* field with the required minimum and maximum values listed in **Table 11.5**.
5. If the mute noise readings 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.
7. If the fault has been removed, go to "Final Tasks" on page 136. If it has not, go to Task 1 and check the receiver sensitivity.

Table 11.5 Mute data

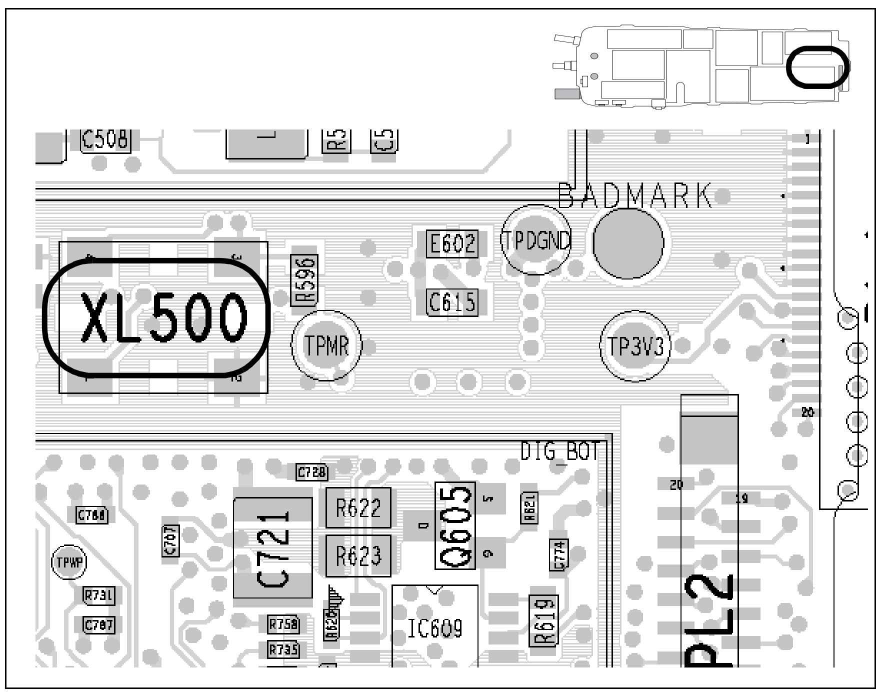
Channel spacing	SINAD (dB)	Mute noise readings (B1, H5 and H6 bands)		Mute noise readings (K5 band)	
		Minimum	Maximum	Minimum	Maximum
Narrow (12.5 kHz)	8	1900	2300	1200	4500
	20	250	500	250	440
Medium (20 kHz)	8	3700	4200	2000	6500
	20	1000	1500	700	2400
Wide (25 kHz)	8	5500	7300	3500	9500
	20	2200	3700	1300	3200

Task 16 — RSSI Muting Selected

With RSSI muting selected, check the RSSI mute settings.

1. In the calibration application open the *“Dev/Squelch”* page and click the *“Squelch and Signalling Thresholds”* tab.
2. Check that the values in the *“Opening Pt”* fields and the *“Hysteresis”* fields under the *“Squelch Thresholds”* label are what the customer expects.
3. If the calibration values are as expected, go to Task 10 and check the RSSI calibration. If they are not, go to Step 4.
4. Adjust the values in the *“Opening Pt”* and *“Hysteresis”* fields. Program the radio with the new values.
5. Check if the mute fault has been removed. If it has, go to “Final Tasks” on page 136. If it has not, go to Task 10 and check the RSSI calibration.

Figure 11.5 Position of XL500 (bottom side)



11.6 High Receiver Distortion

Introduction

If there is high receiver distortion, the TCXO is suspect, or alternatively, the matching circuitry for the crystal filters XF400 and XF401 is suspect. There are two tasks:

- Task 17: TCXO calibration and repair of TCXO
- Task 18: second IF and repair of matching circuitry

Recalibrating the TCXO might often be sufficient to rectify the fault.

Task 17 — TCXO Calibration and Repair of TCXO

First check the TCXO calibration and, if necessary, repair the TCXO.

1. Use the calibration application to check the TCXO calibration: Open the *"Raw Data"* page and click the *"Volt Ref/TCXO/VCO/VCXO"* tab.

2. Note the values listed in the *"Tx TCXO"* and *"Rx TCXO"* fields of the *"TCXO"* group box. The values should be:

Tx TCXO and Rx TCXO values: between +20 Hz and −20 Hz

3. If the calibration values are correct, go to Step 4. If they are not, recalibrate the TCXO and go to Step 8.

4. Remove the FCL TOP can.

5. Check the components of the TCXO, which is based on **XL500** (see **Figure 11.5**). Repair any fault.

6. Recalibrate the TCXO and check the TCXO calibration values again as in Step 1 and Step 2.

7. If the calibration values are now correct, go to Step 8. If they are not, go to Task 18.

8. Check if the distortion fault has been removed. If it has, go to "Final Tasks" on page 136. If it has not, go to Task 18.

Task 18 — Second IF and Repair of Matching Circuitry

If the TCXO is not faulty, check the second IF and, if necessary, repair the matching circuitry.

1. Input a large unmodulated RF input signal exceeding –90 dBm at the RF connector.

2. Use a needle probe to measure the frequency of the signal at the QN test point **TP444** (see Figure 12.5). The frequency is the second IF and should be:

frequency at QN test point: 64.000 kHz

3. If the second IF is correct, go to Step 6. If it is not, go to Step 4.

4. Recalibrate the TCXO.

5. Check if the distortion fault has been removed. If it has, go to "Final Tasks" on page 136. If it has not, go to Step 6.

6. Remove the IF IQ BOT can.

7. Check the components between **T401** and **IC400** (B1, H5 and H6 bands), or **IC409** and **IC400** (K5 band). See **Figure 11.4** and **Figure 11.1**. These form the matching circuitry for the crystal filters **XF400** and **XF401** (see **Figure 11.1**). Repair any fault.

8. Confirm the removal of the fault, and go to "Final Tasks" on page 136. If the repair failed or the fault could not be found, replace the main board and go to "Final Tasks" on page 136.

12 CODEC and Audio Fault Finding

Fault Conditions

This section covers the diagnosis of faults in the CODEC and audio circuitry. There are five conditions that indicate a possible fault in the circuitry:

- no speaker audio or speaker audio is distorted
- no audio tap out at accessory connector
- receiver does not operate
- no transmit modulation or modulation is distorted from the internal speaker/microphone
- no transmit modulation or modulation is distorted from the accessory connector

In the first and second cases regarding the speaker audio, the green status LED will be operating correctly and all unmute criteria will be satisfied. In the third case the assumption is that the receiver and power-supply circuitry were checked and no faults were found. In the fourth and fifth cases regarding the transmit modulation, the radio will be transmitting the correct amount of RF power.

Fault-Diagnosis Procedures

The procedures for diagnosing the above faults are given below in the following sections. In each case, however, first carry out the tasks of "Power Supplies" on page 278. Also note that the conditions concerning the accessory connector can both occur at the same time. In this case carry out both "No Audio Tap Out at Accessory Connector" on page 286 and "Faulty Modulation Using Accessory Audio Tap In" on page 295.

Important The fault diagnosis must only be carried out on an analog channel.

CCTM commands

The CCTM commands required in this section are listed in Table 12.1. Full details of the commands are given in "Computer-Controlled Test Mode (CCTM)" on page 93.

Table 12.1 CCTM commands required for the diagnosis of faults in the CODEC and audio circuitry

Command	Description
21	Unmute received audio
32	Set radio in receive mode
33	Set radio in transmit mode
110 **x**	Set level **x** (in range 0 to 255) of audio volume
323 **x y**	Generate audio tone AUD TAP IN at tap point **x** of tap type **y**
324 **x y**	Output audio signal at tap point **x** of tap type **y** to AUD TAP OUT
400 **x**	Select channel with channel number **x**

12.1 Power Supplies

Introduction

First check that a power supply is not the cause of the fault. Of these supplies, the 3.3V DC supply (+3V3) will already have been checked in "Power Supply Fault Finding" on page 151. The remaining supplies that need to be checked are:

- Task 1: 7.5V DC supply from battery via 0Ω link R950 (7V5 LINK)
- Task 2: 3V DC supply from 3V regulator (+3V0 AN)
- Task 3: 2.5V DC supply from 2.5V regulator (+2V5 CDC)

One other supply used in the CODEC and audio circuitry is a 1.8 V DC supply (+1V8) from the digital circuitry. Faults in this supply are dealt with elsewhere.

Task 1 — 7.5V Power Supply

First check the 7.5V DC supply (7V5 LINK), which is required by IC200.

1. Remove the main board from the chassis.
2. Measure the voltage 7V5 SW at pin 6 of **IC200** (see **Figure 12.1**).

pin 6 of IC200: 7.5V DC

3. If the voltage is correct, go to Task 2. If it is not, go to Step 4.
4. The fault will be at **IC200** (see **Figure 12.1**), since any fault with 7V5 LINK in the interfaces circuitry will already have been rectified. Therefore, check the soldering of IC200. Repair any fault.
5. Confirm the removal of the fault and go to "Final Tasks" on page 136. If the repair failed or the fault could not be found, replace the main board and go to "Final Tasks" on page 136.

Task 2 — 3V Power Supply

If the 7.5V supply (7V5 LINK) is correct, check the 3V DC supply (+3V0 AN) next.

1. Measure the voltage +3V0 AN at the **TP3V0 AN test point** (see **Figure 12.2**).

TP 3V0 AN: 3.0 ± 0.3V DC

2. If the voltage is correct, go to Task 3. If it is not, go to Step 3.
3. The 3V regulator **IC604** is suspect (see **Figure 12.2**). Check the regulator as described in Task 4 of "Power Supply Fault Finding" on page 158.

Figure 12.1 Circuitry in the vicinity of PL1 and IC200 (top side)

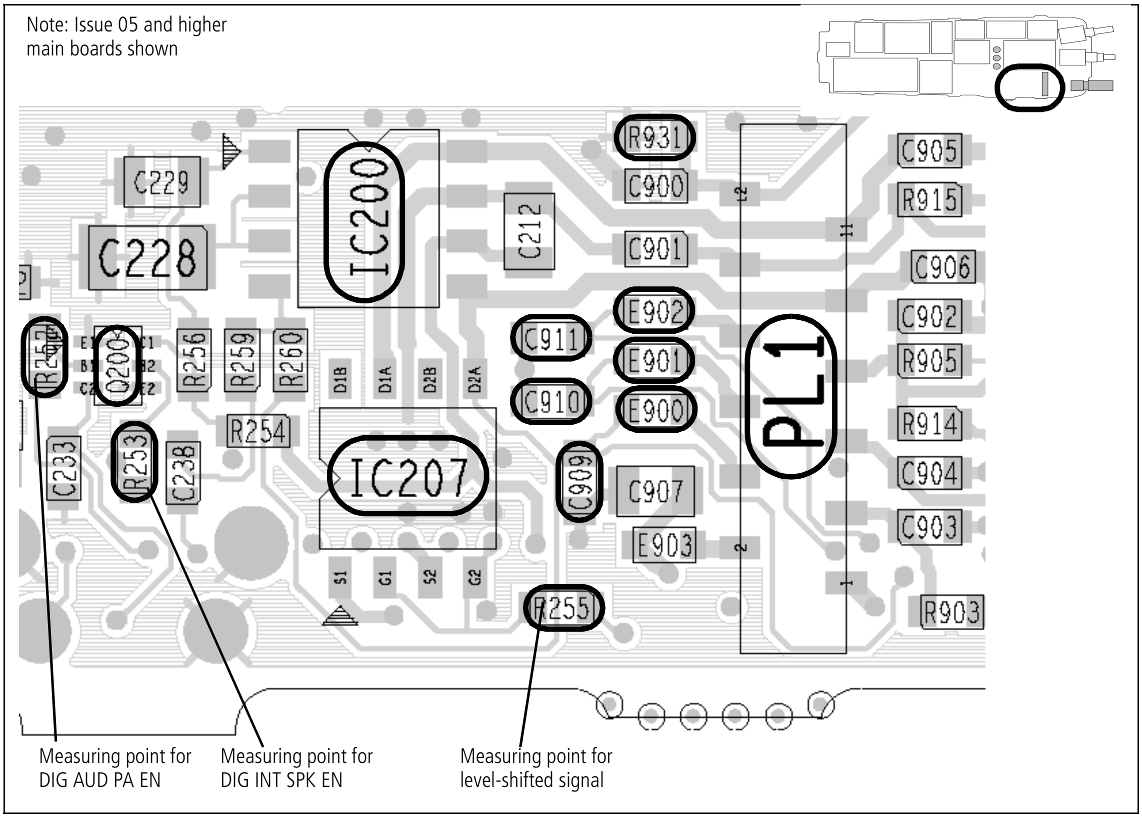
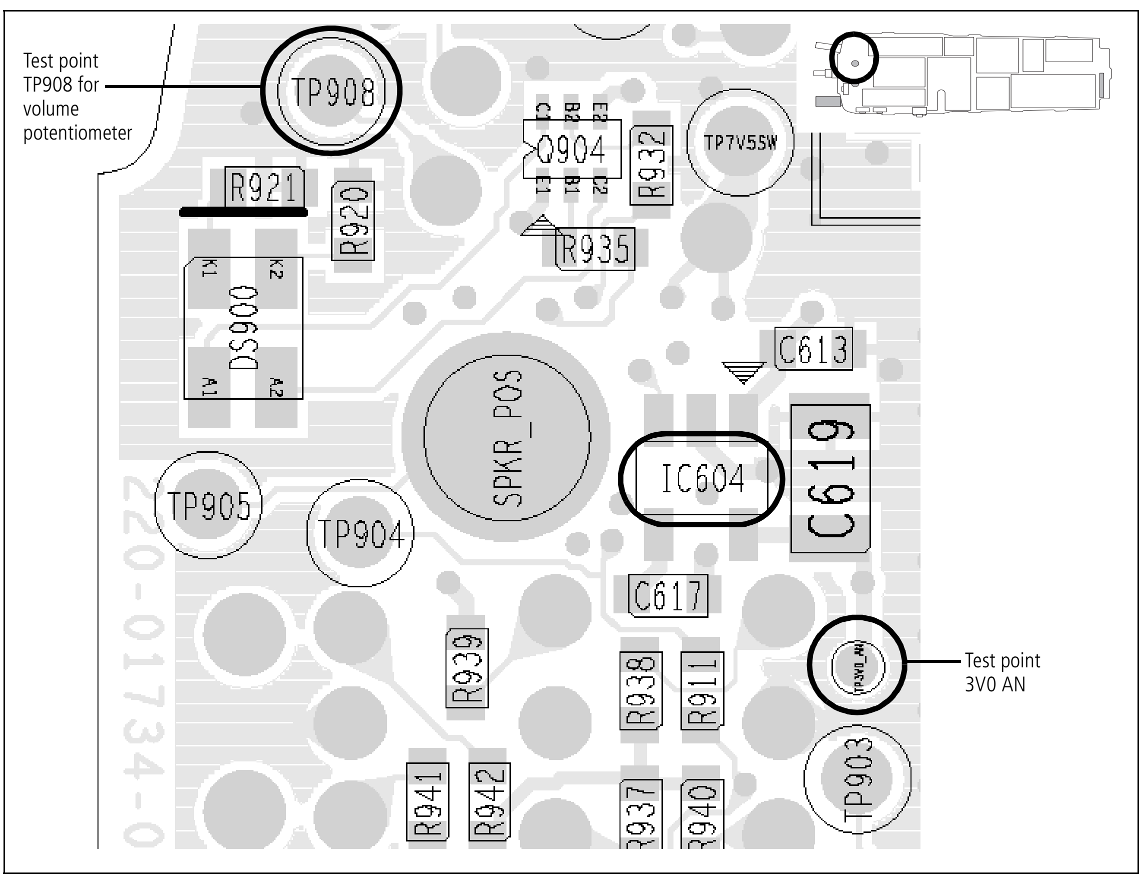


Figure 12.2 Test points for the 3V power supply and the volume potentiometer (bottom side)



Task 3 — 2.5V Power Supply

If the 7.5V (7V5 LINK) and 3V supplies are correct, the remaining power supply to check is the 2.5V DC supply (+2V5 CDC).

1. Measure the voltage +2V5 CDC at pin 5 of **IC605** (see **Figure 12.3**).

pin 5 of IC605: 2.5 ± 0.3V DC

2. If the voltage is correct, go to Step 4. If it is not, go to Step 3.

3. The 2.5V regulator **IC605** is suspect (see **Figure 12.3**). Check the regulator as described in Task 4 of "Power Supply Fault Finding" on page 158.

4. Proceed to the section relevant to the fault exhibited:
   - "Faulty Speaker Audio" (distorted or no speaker audio)
   - "No Audio Tap Out at Accessory Connector"
   - "Faulty Receiver" (receiver does not operate)
   - "Faulty Modulation" (distorted or no transmit modulation)
   - "Faulty Modulation Using Accessory Audio Tap In" (modulation at accessory connector only)

   Further details are given in the introduction to the section.

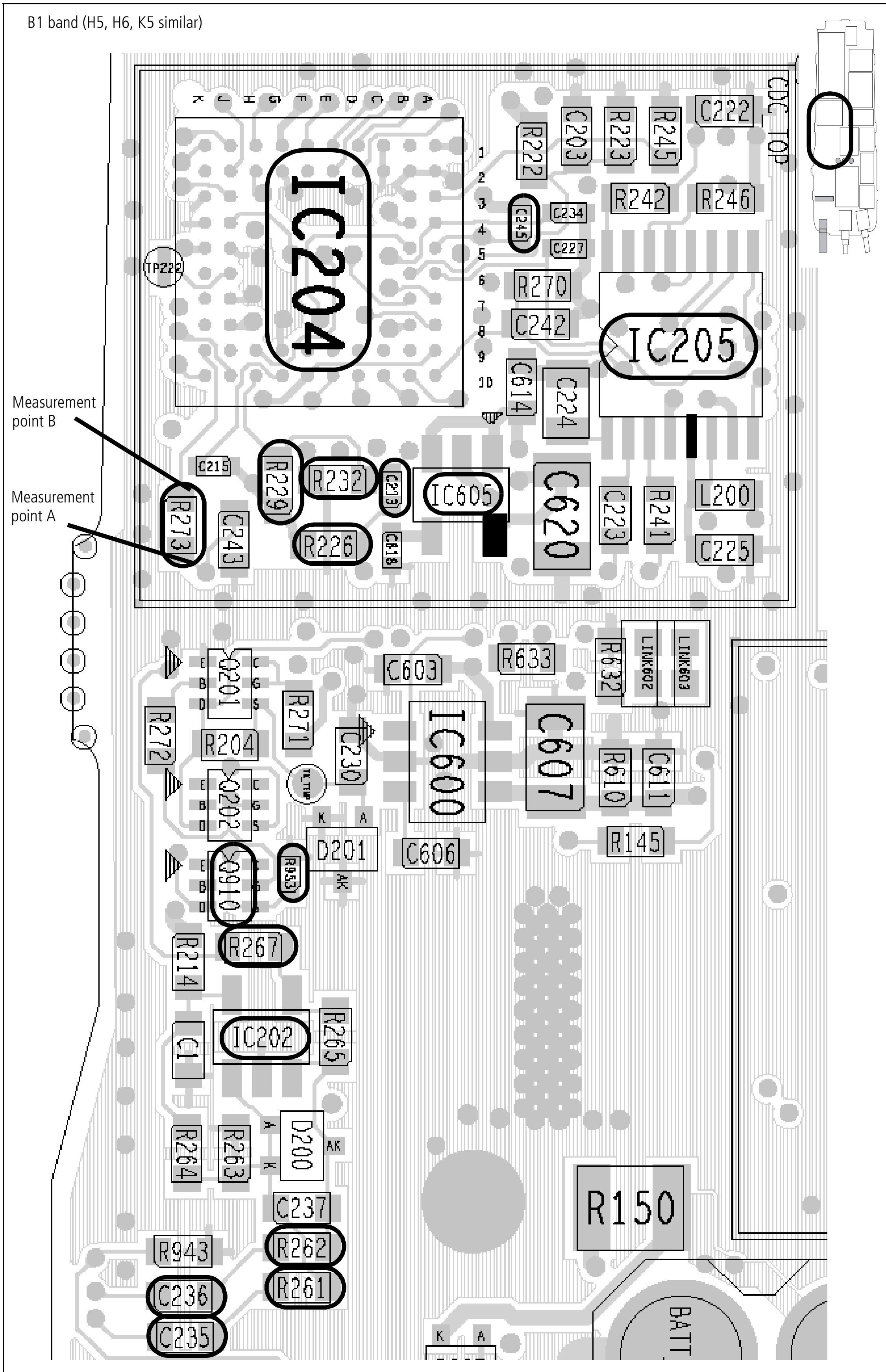
12.2 Faulty Speaker Audio

Introduction

This section covers the case where 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. There are three tasks:

- Task 4: check audio power amplifier
- Task 5: check speaker outputs
- Task 6: check SUI VOL DC input signal

Figure 12.3 Circuitry under and next to the CDC TOP can (top side)



Task 4 — Check Audio Power Amplifier

If there is no fault with the power supplies, check the inputs to the audio PA as follows. This check is only applicable, however, if the output of the voice-band CODEC is correct and the signal level varies as the volume is varied.

1. Use the programming application to find the frequency selected for channel 1. Ensure that the channel is programmed as an analog channel.

2. In user mode apply an on-channel RF FM signal of −47 dBm with 60% deviation, 1 kHz tone. The channel must not have signaling enabled. Set the volume to maximum.

3. For issue 05 boards or higher, use an oscilloscope probe to check the output of the voice-band CODEC at **R273** (see measurement point A in **Figure 12.3**). The signal should be:

R273: sine wave of approx 15 mV_{pp} with 1.2 V DC offset

   For issue 03 boards, check the output of the voice-band CODEC at **C238**. The signal should be:

C238: sine wave of 100 mV_{pp} with 1.2 V DC offset

4. If the above signal is correct, go to Step 7. If it is not, go to Step 5.

5. Check the signal in Step 3 at the other side of **R273** (see measurement point B in **Figure 12.3**).

6. If the above signal is correct, repair **R273** and go to Step 12. Otherwise the main board is faulty; replace the main board and go to “Final Tasks” on page 136.

7. Vary the volume control. This should cause the signal level at **R273** (or **C238** for issue 03 boards) to vary. If it does, go to Step 8 (or for issue 03 boards, Step 10). If it does not, go to Task 6.

8. For issue 05 boards or higher, check the output of **IC201** at pin 7. The signal should be:

IC201: sine wave of approx 130 mV_{pp} at maximum volume

9. If correct, go to Step 10. If not, repair faults in the components **IC201**, **R215**, **C206**, **R212**, and **C238**, and go to Step 12.

10. Check the voltage at pin 1 of **IC200** (see **Figure 12.1**):

pin 1 of IC200: less than 0.5V DC

11. If the voltage is correct, go to Step 13. If it is not, check for and repair any faults in the circuits incorporating **Q200** (see **Figure 12.1**).

12. Confirm the removal of the fault and go to “Final Tasks” on page 136. If the repair failed, replace the main board and go to “Final Tasks” on page 136.

13. Check the digital signals DIG AUD PA EN at **R252** and DIG INT SPK INH at **R253** and the level-shifted signal at **R255** (see **Figure 12.1**):

R252 (DIG AUD PA EN):	3.3V DC
R253 (DIG INT SKP EN):	0V DC (if internal speaker is enabled) 3.3V DC (if internal speaker is disabled)
R255:	0V DC (if internal speaker is disabled) >10V DC (if internal speaker is enabled)

14. If the signals are correct, go to Task 5. If they are not, check the programming and test set-up; otherwise the main board is faulty; replace the main board and go to “Final Tasks” on page 136.

Task 5 — Check Speaker Outputs

If the inputs to the audio PA are not faulty, check the speaker outputs from the PA.

Speaker output checks depend on whether the internal speaker or external accessory speaker is used. The accessory speaker signals are permanently enabled, whereas the internal speaker signals are disabled when the accessory interface signal ACC GPIO1 is connected to 0V.

To check internal speaker operation:

1. Check that ACC GPIO1 is not connected to 0V.

2. In user mode apply an on-channel RF FM signal of −47dBm with 60% deviation, 1kHz tone. The channel must not have signaling enabled. Set the volume to maximum.

3. Check the positive and negative audio PA outputs at pins 5 and 8 of **IC200** (see **Figure 12.1**):

pin 5 of IC200: approximately half of +7V5 BATT pin 8 of IC200: approximately half of +7V5 BATT

4. If the audio PA outputs are correct go to step 6. If they are not go to Step 5.

5. Check for and repair any soldering faults around **IC200** (see **Figure 12.1**), or else replace IC200.

6. Confirm the removal of the fault and go to “Final Tasks” on page 136. If the repair failed, replace the main board and go to “Final Tasks” on page 136.

7. Check the positive and negative speaker pins:

SPKR POS: approximately half of +7V5 BATT SPKR NEG: approximately half of +7V5 BATT

8. If the speaker outputs are correct go to Step 11. If not, go to Step 9.

9. Check for and repair any soldering faults around **IC207** (see **Figure 12.1**), or else replace IC207. Also check speaker

connection pins as described in "Internal Speaker/ Microphone Faulty" on page 148.

10. Confirm the removal of the fault and go to "Final Tasks" on page 136. If the repair failed, replace the main board and go to "Final Tasks" on page 136.

11. With the volume at maximum, check the positive and negative audio PA outputs at pins 5 and 8 of **IC200** (see **Figure 12.1**):

    pin 5 of IC200: approximately 5.5Vpp AC
    pin 8 of IC200: approximately 5.5Vpp AC

12. If the audio PA outputs are correct, the fault is unknown (and could be intermittent); go to "Final Tasks" on page 136. If the repair failed, replace the main board and go to "Final Tasks" on page 136.

To check external speaker operation:

1. Disconnect the internal speaker.

2. In user mode apply an on-channel RF FM signal of −47 dBm with 60% deviation, 1kHz tone. The channel must not have signaling enabled. Set the volume to maximum.

3. Check the positive and negative audio PA outputs at pins 5 and 8 of **IC200** (see **Figure 12.1**):

    pin 5 of IC200: approximately half of +7V5 BATT
    pin 8 of IC200: approximately half of +7V5 BATT

4. If the audio PA outputs are correct go to Step 7. If they are not go to Step 5.

5. Check for and repair any soldering faults around **IC200** (see **Figure 12.1**), or else replace IC200

6. Confirm the removal of the fault and go to "Final Tasks" on page 136. If the repair failed, replace the main board and go to "Final Tasks" on page 136.

7. Check accessory speaker connection pins for ACC+SPKR and ACC−SPKR and accessory flex as described in "Accessories Interface Faulty" on page 149.

8. Confirm the removal of the fault and go to "Final Tasks" on page 136. If the repair failed, replace the main board and go to "Final Tasks" on page 136.

9. With the volume at maximum, check the positive and negative audio PA outputs at pins 5 and 8 of **IC200** (see **Figure 12.1**):

    pin 5 of IC200: approximately 5.5Vpp AC
    pin 8 of IC200: approximately 5.5Vpp AC

10. If the audio PA outputs are correct, the fault is unknown (and could be intermittent); go to "Final Tasks" on page 136. If the repair failed, replace the main board and go to "Final Tasks" on page 136.

Task 6 — Check SUI VOL DC Input Signal

If the output of the voice-band CODEC is correct, but the signal level does not vary as the volume control is varied, check the SUI VOL DC signal.

1. Check the operation of the volume pot **RV1** (see **Figure 12.4**) as described in "Volume Control Faulty" on page 144.

2. Check the voltage on **TP908** (see **Figure 12.2**). As the volume varies, the voltage should vary as follows:

TP908: 0.4 to 1.1V as volume varies

3. If the volume varies as expected, go to Step 6. If it does not, go to Step 4.

4. Check and repair any soldering faults around **R900** (see **Figure 12.4**), **Q910**, and **R953** (see **Figure 12.3**).

5. Confirm the removal of the fault and go to "Final Tasks" on page 136. If the repair failed, replace the main board and go to "Final Tasks" on page 136.

6. Remove the CDC TOP can.

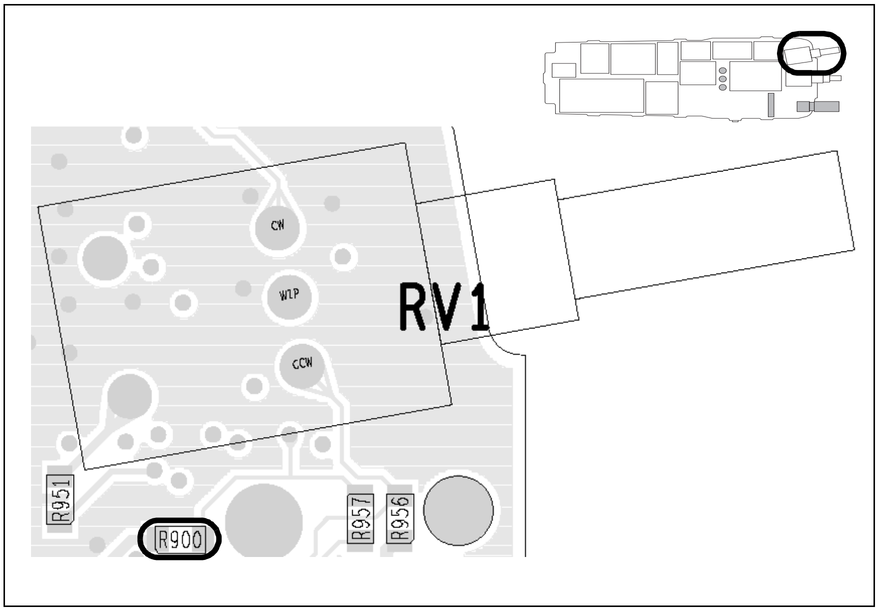
7. Check the voltage at the junction of **C245** (non grounded end, see **Figure 12.3**). As the volume varies, the voltage should vary as follows.

C245: 0.4 to 1.1V as volume varies

   If the voltage varies as expected, CODEC 1 (**IC204**, see **Figure 12.3**) is suspect.

8. Replace the main board and go to "Final Tasks" on page 136.

Figure 12.4 Volume potentiometer RV1 and resistor R900 (top side)



12.3 No Audio Tap Out at Accessory Connector

Introduction

This section covers the case where the receiver operates normally but there is no tap out audio at the accessory connector. In other words, there is no signal at pin 4 (AUD TAP OUT) of the connector. The fault-diagnosis procedure comprises two tasks:

- Task 7: check signal from PL1
- Task 8: check CODEC, LPF and buffer

These tasks need to be followed by those of "Faulty Modulation Using Accessory Audio Tap In" on page 295 if there is also a fault with the transmit modulation using the accessory connector.

Task 7 — Check Signal from PL1

First generate an appropriate audio test signal and check whether the signal is present at the output of the audio tap-out circuitry.

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%, 1kHz modulation to the RF signal. Reduce the volume to a minimum.

5. Enter the CCTM command *324 r5*.

6. Check the received signal is present at pin 4 of connector **PL1** (see **Figure 12.1**). The signal should be:

pin 4 of PL1: received signal with 1.2V DC offset

7. If the signal is correct, the fault is with PL1 or the accessory flex connector. Refer to "Accessories Interface Faulty" on page 149 for accessory connector service instructions. If the signal is not correct go to Step 8.

8. Check the received signal is present at the junction of **E900** and **C909** (see **Figure 12.1**). The signal should be:

junction of E900 and C909: received signal with 1.2V DC offset

9. If the signal is correct go to Step 10. If it is not, go to Task 8.

10. Check the soldering and components around **PL1**, **E900**, and **C909** (see **Figure 12.1**). Repair any fault.

11. Confirm the removal of the fault and go to Step 12. If the repair failed or the fault could not be found, replace the main board and go to "Final Tasks" on page 136.

12. If there is also a fault with the transmit modulation, notwithstanding modulation at the accessory connector, go to Task 15. If there is no other fault, go to "Final Tasks" on page 136

Task 8 — Check CODEC, LPF and Buffer

If there is no test signal at the connector PL1, then either CODEC 1 is faulty, or there is a fault in the LPF and buffer amplifier.

1. Remove the `CDC BOT` can.

2. At the test set apply 60%, 1kHz modulation to the RF signal. Reduce the volume to a minimum.

3. For issue 05 boards and higher, check the signal at **R205** (see **Figure 12.5**). For issue 03 boards, check **R224**. This should be:

R205 or R224: 0.7 V_{pp} with 1.2V DC offset

4. If the above signal is correct, go to Step 5. If it is not, CODEC 1 (**IC204**) is faulty; replace the main board and go to "Final Tasks" on page 136.

5. Check the voltage at pin 1 of **IC201** (see **Figure 12.5**).

pin 1 of IC201: 0.7V_{pp} with 1.2V DC offset

6. If the voltage is correct, go to Step 9 (issue 05 boards and higher), or Step 7 (issue 03 boards). If it is not, check the LPF circuit based on **IC201** (pins 1 to 3) (see **Figure 12.5**). Repair any fault and conclude with Step 10.

7. For issue 03 boards, check the voltage at pin 7 of **IC201**.

pin 7 of IC201: 0.7V_{pp} with 1.2V DC offset

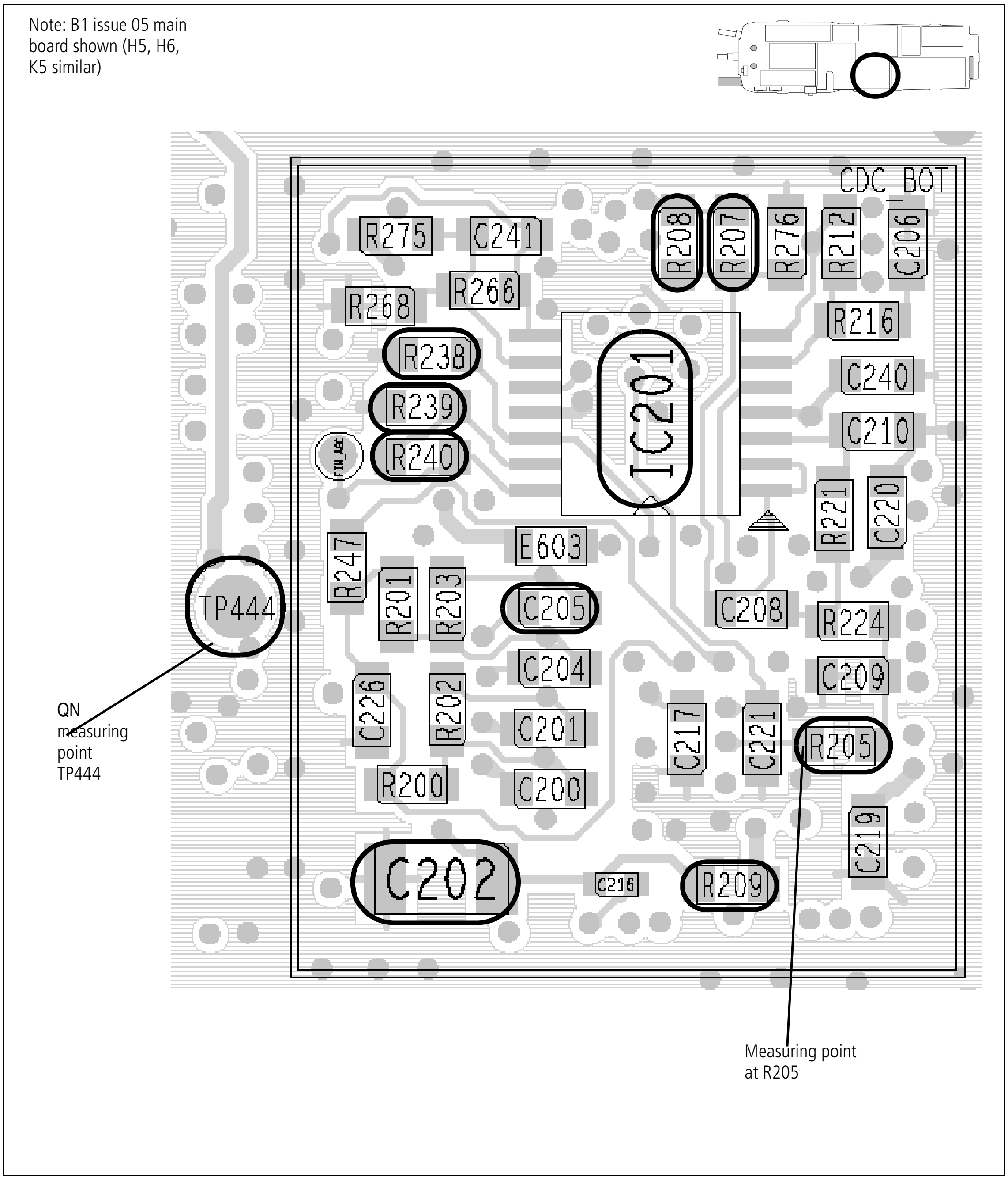
8. If the voltage is correct, go to Step 9. If it is not, check the buffer amplifier based on **IC201** (pins 5 to 7). Repair any fault and conclude with Step 10.

9. Check **R207** and **R208** (see **Figure 12.5**). Repair any fault and conclude with Step 10.

10. Confirm the removal of the fault and go to Step 11. If the repair failed or the fault could not be found, replace the main board and go to "Final Tasks" on page 136.

11. If there is also a fault with the transmit modulation, notwithstanding modulation at the accessory connector, go to "Faulty Modulation Using Accessory Audio Tap In" on page 295. If there is no other fault, go to "Final Tasks" on page 136.

Figure 12.5 Circuitry under the CDC BOT can (bottom side)



12.4 Faulty Receiver

Introduction

This section covers the case where the receiver does not operate, although there is no apparent fault in the receiver circuit itself. There are two tasks:

- Task 9: check level shifter
- Task 10: check QN signal

The latter check will isolate the module at fault if the level shifter is not the cause of the problem.

Task 9 — Check Level Shifter

Check the operation of the base-band CODEC and receiver AGC as described below. This concerns the level-shifter circuit. It is assumed that the receiver and power-supply circuitry were checked and no faults were found.

1. If not already done, remove the CDC BOT can.
2. With no RF signal applied and in receive mode, check the voltage at pin 14 of **IC201** (see **Figure 12.5**):

pin 14 of IC201: more than 2.5V DC

3. If the above voltage is correct, go to Task 10. If it is not, go to Step 4.
4. Check the voltage at pin 12 of **IC201** (see **Figure 12.5**):

pin 12 of IC201: more than 1V DC

5. If the above voltage is correct, go to Step 8. If it is not, go to Step 6.
6. Check for and repair any shorts to ground at the junction of **R238** and pin 12 of **IC201** (see **Figure 12.5**).
7. Confirm the removal of the fault and go to "Final Tasks" on page 136. If the repair failed or the fault could not be found, replace the main board go to "Final Tasks" on page 136.
8. Check the circuitry (**R238**, **R239**, **R240**) around pins 12, 13 and 14 of **IC201** (see **Figure 12.5**). Repair any fault.
9. Confirm the removal of the fault and go to "Final Tasks" on page 136. If the repair failed or the fault could not be found, replace the main board and go to "Final Tasks" on page 136.

Task 10 — Check QN Signal

If the level shifter is not faulty, check the QN signal. This will ascertain whether the digital circuitry, CODEC 1, or the receiver is at fault.

1. Use the programming application to find the frequency selected for channel 1.

2. Apply a strong on-channel signal.

3. Check that a sine wave is present using **TP444** (see **Figure 12.5**).

TP444: sine wave

4. If there is a sine wave present, go to Step 5. If there is not, go to "Receiver Fault Finding" on page 257.

5. Either the digital circuitry or CODEC 1 (**IC204**) is faulty. Replace the main board and go to "Final Tasks" on page 136.

12.5 Faulty Modulation

Introduction

This section covers the case where the radio transmits the correct amount of RF power, but there is either no modulation or the modulation is distorted. There are four tasks:

- Task 11: check internal microphone
- Task 12: initial checks of external microphone
- Task 13: check external microphone audio
- Task 14: check external microphone bias

Task 11 — Check Internal Microphone

To check the modulation from the internal microphone:

1. Remove any external microphone or accessory and apply an audio acoustic signal from an external speaker or noise source near the internal speaker.
2. Enter the CCTM command *33* to place the radio in transmit mode (the frequency is that of channel 1). The radio **must** be in transmit mode for the +5V TX and microphone pre-amp circuit to operate.
3. Create an audio signal by whistling into the speaker and check that the audio signal appears at the junction of **C235** and **R261**, and also the junction of **C236** and **R262** (see **Figure 12.3**).
4. If the audio signal is not present check and repair the speaker, speaker pins, components and soldering of **C235** and **C236** (see **Figure 12.3**). If the signal is present, go to Step 6.
5. Confirm the removal of the fault and go to "Final Tasks" on page 136. If the repair failed or the fault could not be found, replace the main board and go to "Final Tasks" on page 136.
6. Create an audio signal by whistling into the speaker and check that the audio signal appears at the junction of **R267** and **IC202** (see **Figure 12.3**).
7. Enter the CCTM command *32* to place the radio in receive mode.
8. If the audio signal is present, go to "Frequency Synthesizer Fault Finding" on page 161 on the frequency synthesizer fault finding. If it is not, go to Step 9.
9. Check the components and soldering around IC202 and repair or replace as required.
10. Confirm the removal of the fault and go to "Final Tasks" on page 136. If the repair failed or the fault could not be found, replace the main board and go to "Final Tasks" on page 136.

Task 12 — Initial Checks of the External (Accessory) Microphone

Carry out the following checks to isolate the part of the circuitry that is faulty.

1. Check the connector **PL1** (see **Figure 12.1**) and the flexible accessory board connection to the main board as defined in "Accessories Interface Faulty" on page 149. Assuming this is correct, proceed to Step 2.

2. Check the DC level on the ACC MIC signal on pin 6 of **PL1**.

pin 6 of PL1: 3.0 ±0.3V (typical)

3. If the DC level is not present check and repair components and soldering around **PL1**, **E901**, and **C910** (see **Figure 12.1**). If the signal is present, the audio path is suspect; go to Task 13.

4. Confirm the removal of the fault and go to "Final Tasks" on page 136. If the repair failed, the DC bias is suspect; go to Task 14.

Task 13 — Check External (Accessory) Microphone Audio

To check the modulation from the external microphone:

1. Apply an AC-coupled 1kHz audio signal with level $9.5\,mV_{rms}$ to the ACC MIC signal on pin 6 of the connector PL1.

2. Check that the audio signal appears at the junction of **R229**, **R232**, and **C213** (see **Figure 12.3**):

junction of R229, R232, and C213: $9.5\,mV_{rms}$ with 1.5V DC offset

3. If the signal is not present, check and repair components and soldering around **R229**, **R232**, and **C213** (see **Figure 12.3**). If the signal is present go to "Frequency Synthesizer Fault Finding" on page 161.

4. Confirm the removal of the fault and go to "Final Tasks" on page 136. If the repair failed or the fault could not be found, replace the main board and go to "Final Tasks" on page 136.

Task 14 — Check External (Accessory) Microphone DC Bias

To check the DC bias on the external microphone:

1. Check the DC level on the +3V0 FIL signal at the junction of **R209** and **C202** (see **Figure 12.5**):

junction of R209 and C202: 3.0V ±0.2V (typical)

2. If the DC level is not present, check the components and soldering of **R209** and **C202** (see **Figure 12.5**). If the signal is present, go to Step 4.

3. Confirm the removal of the fault and go to "Final Tasks" on page 136. If the repair failed or the fault could not be found, replace the main board and go to "Final Tasks" on page 136.

4. Check the DC levels at the junction of **R226** and **C213**, also the junction of **R229** and **C213** (see **Figure 12.3**):

junction of R226 and C213: 3.0V ±0.2V junction of R229 and C213: 1.5V ±0.2V

5. If either DC level is not present, check and repair the components and soldering around **R226**, **R229**, **R232**, and **C213** (see **Figure 12.3**). If both DC levels are correct then the fault is between **E901** (see **Figure 12.1**) and **R226**/**C213**. Replace the main board and go to "Final Tasks" on page 136.

6. Confirm the removal of the fault and go to "Final Tasks" on page 136. If the repair failed or the fault could not be found, replace the main board and go to "Final Tasks" on page 136.

12.6 Faulty Modulation Using Accessory Audio Tap In

Introduction

This section covers the case where the transmitter operates normally but there is no modulation from AUD TAP IN (although there is modulation at the accessory connector). There are two tasks:

- Task 15: check AUD TAP IN path
- Task 16: check audio and modulation

If there was also a fault with the speaker audio at the accessory connector, it is assumed that this has now been rectified.

Task 15 — Check AUD_TAP_IN Path

To check the AUD TAP IN path:

1. Check the connector **PL1** (see **Figure 12.1**) and the flexible accessory board connection to the main board as defined in "Accessories Interface Faulty" on page 149. Assuming this is correct, proceed to Step 2.

2. Check the DC offset voltage at pin 8:

pin 8 of PL1: approximately 1.5V DC offset

3. If the offset is correct, go to Task 16. If the offset is not correct go to Step 4

4. Check and repair the components and soldering around **PL1**, **E902**, and **C911** (see **Figure 12.1**).

5. Confirm the removal of the fault and go to "Final Tasks" on page 136. If the repair failed, go to Step 6.

6. Check for and repair any soldering faults around **IC205** and **R241** (see **Figure 12.3**).

7. Confirm the removal of the fault and go to "Final Tasks" on page 136. If the repair failed, go to Step 8.

8. Check the DC offset voltage at pin 3 of IC205:

pin 3 of IC205: approximately 1.5V DC offset

9. If the offset is correct, **IC205** is okay but there is a fault between IC205 and PL1. Recheck soldering and components **R241** (see **Figure 12.3**), **E902**, **C911** (see **Figure 12.1**). If the offset is not correct, replace IC205.

10. Confirm the removal of the fault and go to "Final Tasks" on page 136. If the repair failed or the fault could not be found, replace the main board and go to "Final Tasks" on page 136.

Task 16 — Check AUD TAP IN Audio and Modulation

This task assumes that Task 15 has already been performed and passed, which confirms the connection between AUD TAP IN and IC205.

1. Apply a 1kHz AC-coupled signal of 0.7 V_{pp} at pin 8 (AUD TAP IN) of the connector **PL1** (see **Figure 12.1**).

2. Enter CCTM command *33* to place radio in transmit mode.

3. Enter CCTM command *323 t5* to select AUD TAP IN as modulation source.

4. Check the modulation of the radio. If there is no modulation, go to "Frequency Synthesizer Fault Finding" on page 161. If there is modulation, the hardware is not faulty. Check the setup of the audio tap points in the programming application.

5. Enter CCTM command *32* to place the radio in receive mode.

13 Spare Parts

Introduction

This section illustrates and lists all serviceable parts (except SMT components of the main board), and lists the spares kits available.

For SMT components of the main board, refer to the corresponding PCB information.

13.1 Illustrated Spare Parts Catalogue

Table 13.1 lists all the serviceable parts (except PCB components) and shows whether a part can be ordered individually and/or as part of a spares kit. If a part can be ordered individually, the "internal part number" (IPN) is listed. If a part can be ordered as part of a spares kit, the name and number of the spares kit(s) is listed. If a part can only be ordered as part of a spares kit, the IPN is listed as "not available".

The positions are illustrated in Figure 13.1 on page 300.

Table 13.1 Serviceable parts

Pos.	Description	IPN	Kit
①	front-panel assembly (4 keys) [a] front-panel assembly (16 keys)	not available not available	TPA-SP-001 TP9155 re-skinning kit TPA-SP-002 TP9155 general spares kit TPA-SP-003 TP9160 re-skinning kit TPA-SP-004 TP9160 general spares kit
②	PTT keypad	not available	TPA-SP-101 PTT spares kit TPA-SP-001/003 reskinning kits TPA-SP-002/004 general spares kits
③	PTT frame	not available	TPA-SP-101 PTT spares kit TPA-SP-001/003 reskinning kits TPA-SP-002/004 general spares kits
④	PTT pressel	not available	TPA-SP-101 PTT spares kit TPA-SP-001/003 reskinning kits TPA-SP-002/004 general spares kits
⑤	function key pressel (2x)	not available	TPA-SP-101 PTT spares kit TPA-SP-001/003 reskinning kits TPA-SP-002/004 general spares kits
⑥	PTT lock spring	not available	TPA-SP-101 PTT spares kit TPA-SP-001/003 reskinning kits TPA-SP-002/004 general spares kits
⑦	3-way actuator	not available	TPA-SP-100 knob spares kit TPA-SP-001/003 reskinning kits TPA-SP-002/004 general spares kits
⑧	channel knob	not available	TPA-SP-100 knob spares kit TPA-SP-001/003 reskinning kits TPA-SP-002/004 general spares kits

Table 13.1 Serviceable parts (Continued)

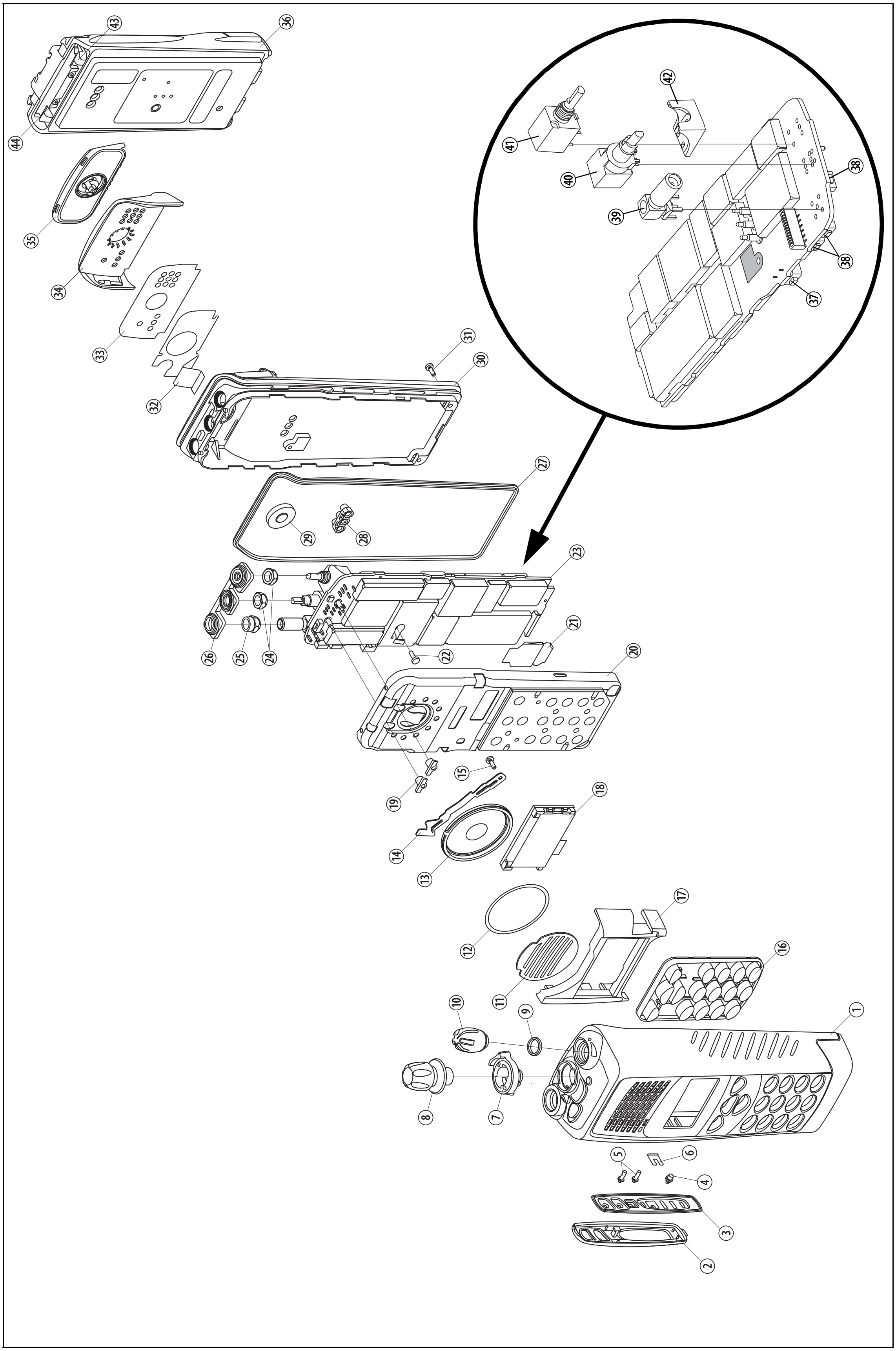
Pos.	Description	IPN	Kit
⑨	volume knob seal	not available	TPA-SP-100 knob spares kit TPA-SP-001/003 reskinning kits TPA-SP-002/004 general spares kits
⑩	volume knob	not available	TPA-SP-100 knob spares kit TPA-SP-001/003 reskinning kits TPA-SP-002/004 general spares kits
⑪	speaker cloth	362-01128-00	
⑫	adhesive speaker ring	369-01039-00	TPA-SP-102 speaker spares kit
⑬	speaker	252-00010-77	TPA-SP-102 speaker spares kit TPA-SP-002/004 general spares kits
⑭	speaker clamp	302-00013-00	TPA-SP-102 speaker spares kit
⑮ ㊹	screw 1.8x5mm PT	349-00030-02	TPA-SP-001/003 reskinning kits TPA-SP-002/004 general spares kits TPA-SP-102 speaker spares kit TPA-SP-108 battery latch spares kit
⑯	keypad (4-button) [a] keypad (16-button)	311-03017-00 311-03018-00	TPA-SP-001 TP9155 re-skinning kit TPA-SP-002 TP9155 general spares kit TPA-SP-003 TP9160 re-skinning kit TPA-SP-004 TP9160 general spares kit
⑰	LCD frame	306-01047-00	
⑱	LCD assembly	not available	TPA-SP-104 LCD spares kit
⑲	speaker pin frame (2x)	304-07044-00	TPA-SP-002/004 general spares kits
⑳	main-shield assembly	not available	TPA-SP-103 main-shield assembly spares kit
㉑	front-panel loom	not available	TPA-SP-103 main-shield assembly spares kit
㉒	screw M2x5	345-00020-09	TPA-SP-002/004 general spares kits
㉓	main board – B1 band – H5 band – H6 band	 TPAA10-B100 TPAA10-H500 TPAA10-H600	 TPAA10-B100 TPAA10-H500 TPAA10-H600
㉔	knob nut (2x)	352-00013-00	TPA-SP-002/004 general spares kits
㉕	SMA nut	352-00012-00	TPA-SP-002/004 general spares kits
㉖	top seal	362-01132-00	TPA-SP-002/004 general spares kits
㉗	main seal	362-01131-00	TPA-SP-001/003 reskinning kits TPA-SP-002/004 general spares kits TPA-SP-107 main seal spares kit
㉘	battery pin seal	362-01038-00	TPA-SP-002/004 general spares kits
㉙	chassis plug seal	362-01035-01	TPA-SP-002/004 general spares kits
㉚	chassis	303-10003-00	TPA-SP-105 chassis assembly spares kit
㉛	screw M2x8 (2x)	345-00020-11	TPA-SP-001/003 reskinning kits TPA-SP-002/004 general spares kits
㉜	flexible accessory board	not available	TPA-SP-105 chassis assembly spares kit TPA-SP-106 accessory flex spares kit
㉝	rear panel seal	not available	TPA-SP-105 chassis assembly spares kit TPA-SP-106 accessory flex spares kit
㉞	rear panel	316-02025-00	TPA-SP-001/003 reskinning kits TPA-SP-105 chassis assembly spares kit
㉟	dummy cover	303-23171-00	TPA-SP-002/004 general spares kits

Table 13.1 Serviceable parts (Continued)

Pos.	Description	IPN	Kit
㊱	NiCd battery NiMH battery	TPA-BA-201 TPA-BA-203	
㊲	PTT tact switch [PTT]	232-00010-44	TPA-SP-002/004 general spares kits
㊳	function key tact switch	232-00010-32	
㊴	antenna SMA connector [SK3]	240-02156-01	TPA-SP-002/004 general spares kits
㊵	16-way/3-way selector switch [RSW1]	231-00000-01	TPA-SP-002/004 general spares kits
㊶	volume potentiometer [RV1]	040-05500-10	TPA-SP-002/004 general spares kits
㊷	volume potentiometer alignment plate	302-05274-00	TPA-SP-002/004 general spares kits TPA-SP-103 main-shield assembly spares kit
㊸	battery catch (left)	303-03077-00	TPA-SP-108 battery latch spares kit
	battery catch (right)[a]	303-03075-00	TPA-SP-108 battery latch spares kit
	battery latch beam[a]	302-30045-00	TPA-SP-108 battery latch spares kit
	battery latch coil[a]	319-01043-00	TPA-SP-108 battery latch spares kit
	speaker / battery contact probes[a]	356-01070-00	TPA-SP-002/004 general spares kits
	emergency key actuator[a]	319-00101-00	TPA-SP-002/004 general spares kits
	light pipe[a]	262-00009-00	TPA-SP-002/004 general spares kits

a. not illustrated

Figure 13.1 Serviceable parts



13.2 Spares Kits

The following spares kits are available:

- TPA-SP-001 TP9155 re-skinning kit (4-button radio)
- TPA-SP-002 TP9155 spares kit (4-button radio)
- TPA-SP-003 TP9160 re-skinning kit (16-button radio)
- TPA-SP-004 TP9160 spares kit (16-button radio)
- TPA-SP-100 volume/channel knob spares kit
- TPA-SP-101 PTT spares kit
- TPA-SP-102 Speaker spares kit
- TPA-SP-103 main-shield assembly spares kit
- TPA-SP-104 LCD spares kit
- TPA-SP-105 chassis assembly spares kit
- TPA-SP-106 accessory flex spares kit
- TPA-SP-107 main seal spares kit
- TPA-SP-108 battery latch spares kit

Chapter 3
Accessories

Chapter 3 – Contents

14 TPA-AN Antennas

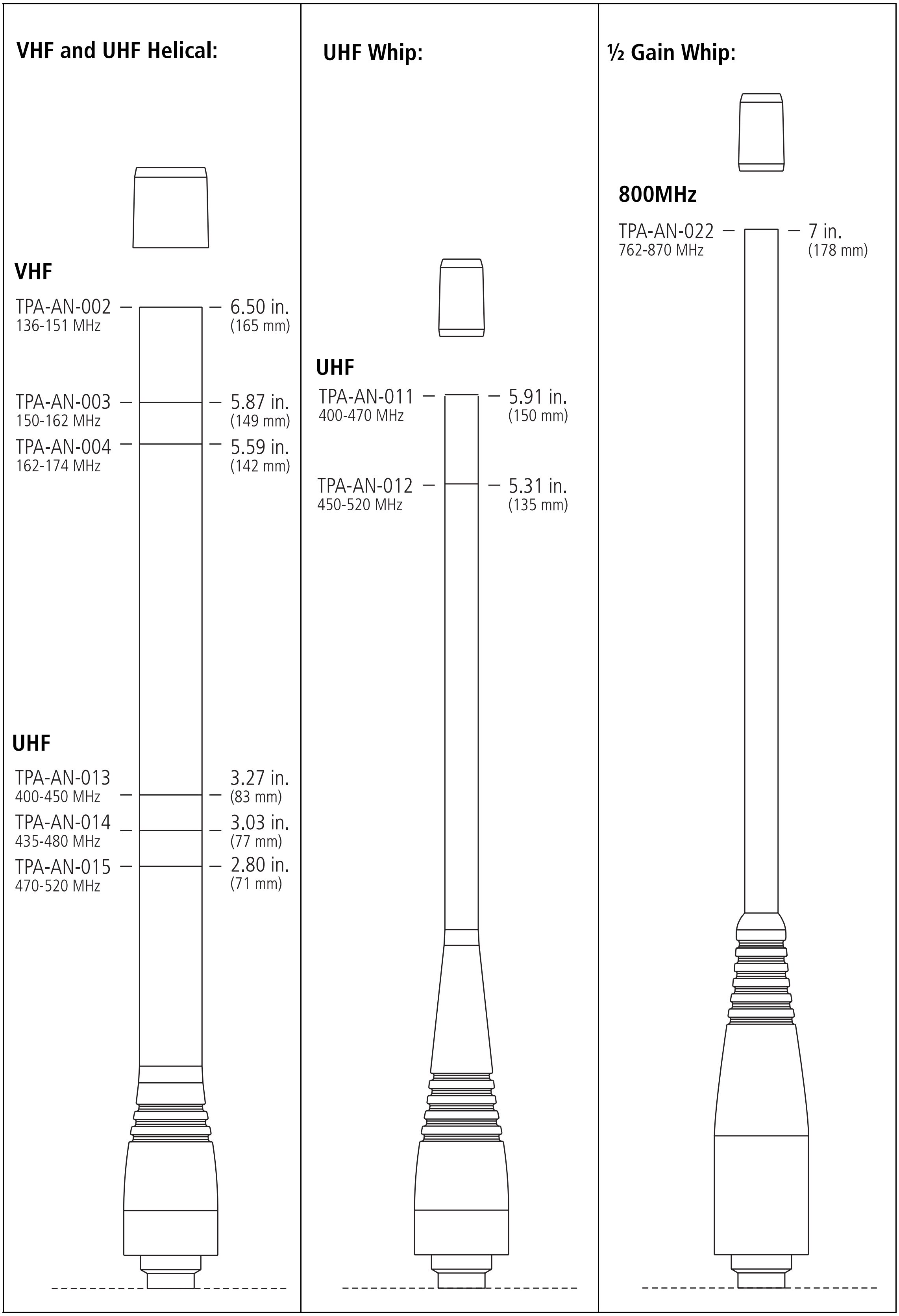
It is important that the correct antenna is matched to the frequency band and channels used for each individual radio. Table 14.1 lists the range of pre-tuned antennas that are available for TP9100 radios.

Table 14.1 Tait-approved radio antennas

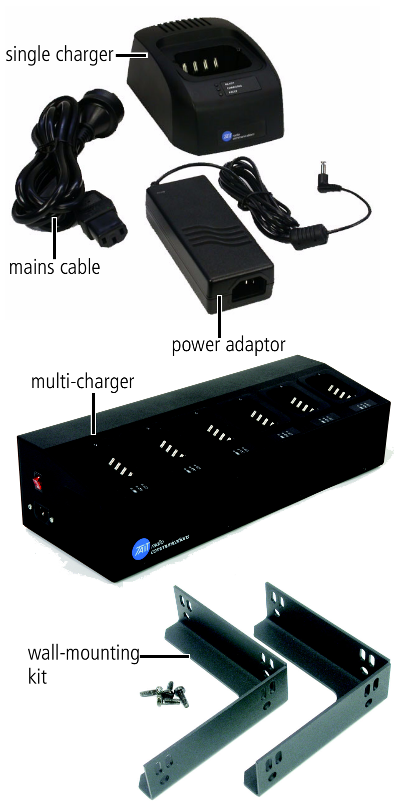
IPN	Frequency range/band	Antenna type
TPA-AN-002	136-151 MHz (low B1 band)	VHF helical
TPA-AN-003	150-162 MHz (mid B1 band)	VHF helical
TPA-AN-004	162-174 MHz (high B1 band)	VHF helical
TPA-AN-011	400-470 MHz (H5 band)	UHF whip
TPA-AN-012	450-520 MHz (H6 band)	UHF whip
TPA-AN-013	400-450 MHz (low H5 band)	UHF helical
TPA-AN-014	435-480 MHz (high H5 band, low H6 band)	UHF helical
TPA-AN-015	470-520 MHz (high H6 band)	UHF helical
TPA-AN-022	762-870 MHz (K5 band)	800 MHz ½ gain whip

Figure 14.1 contains more information on antenna types and lengths, and can also be used to identify a radio's antenna and the antenna part number.

Figure 14.1 Antenna identification chart



15 TPA-CH-001 and TPA-CH-011 Battery Chargers



There are two battery chargers available for the TP9100: the TPA-CH-001 desktop charger for charging single batteries, and the TPA-CH-011 multi-charger for charging any combination of up to six batteries. The following Tait batteries can be charged:

- TPA-BA-201 (NiCd)
- TPA-BA-203 (NiMH)
- TPA-BA-202 (NiCd, intrinsically safe)
- TPA-BA-204 (NiMH, intrinsically safe)

A charger kit consists of the following items:

- desktop charger or multi-charger
- 12V 3A power adaptor T952-40x (desktop charger only)
- battery care and charging guide,
- safety and compliance information.
- region-specific mains cable (if the product code is TPA-CH-0x1-**0a**, where a is the region as follows: 1=Australia/New Zealand, 2=United Kingdom, 3=Europe, 4=United States)
- wall-mounting kit TPA-CH-012 (multi-charger only; if the product code is TPA-CH-011-**0a**)

15.1 Installation

Warning!! **High voltage! Use the correct mains cable for your mains voltage. For the desktop charger, use the correct 12V 3A power adaptor (T952-40x).**

Note For information on installing the multi-charger wall mounting bracket, refer to the installation instructions provided with the kit.

1. Desktop charger: plug the mains cable into the 12V 3A power adaptor (T952-40x), and plug the power adaptor cable into the charger.

   Multi charger: plug the mains cable directly into the charger.

2. Plug the mains cable into the mains socket.

3. For the multi-charger only, switch the charger on.

When power is first applied to the charger, the LEDs should light up for two seconds and then go out. For the multi-charger only, the fan should activate for five seconds.

15.2 Charging the Battery

For information on how to charge batteries, as well as important information on maintaining battery life and performance, refer to the "Battery Care and Charging Guide" supplied with the charger.

If the amber "Fault" LED flashes or glows after inserting a battery, or there is no LED activity, check the possible causes listed in Table 15.1.

Table 15.1 Troubleshooting the charger

Fault LED	Possible causes and solutions
Flashing (fault)	■ The battery is not compatible with the charger—use only Tait chargers and batteries. ■ There is insufficient voltage to the charger—check you are using the correct power adaptor. ■ The battery may be deeply discharged (less than 3V)—disconnect the battery from the radio and charge the battery. ■ The battery may be faulty—consult your radio provider for advice.
Glowing (charging is suspended)	The battery pack is either too hot or too cold. Charging will begin when the temperature of the battery is between 41°F (5°C) and 95°F (35°C).
No LED activity	See "Desktop Charger Fault Finding" on page 309 or "Multi-Charger Fault Finding" on page 311.

15.3 Spare Parts

There are two spares kits available for level-1 servicing of the desktop and multi-chargers: TPA-SP-200 and TPA-SP-201. Parts are illustrated in Figure 15.2 on page 310 (desktop charger), and Figure 15.4 on page 314 and Figure 15.5 on page 315 (multi-charger).

Note The cradle XPA-CH-M03 can be used in both the desktop and multi-chargers.

TPA-SP-200 Cradle Spares Kit

Description	IPN
charger cradle (x1)	XPA-CH-M03

TPA-SP-201 multi-charger spares kit

Description	IPN
charger cradle (x3)	XPA-CH-M03
multi-charger main board	XPA-CH-M11
power switch	230-00010-23
fan	258-00017-00
5A fuse (x2)	265-00010-51

15.4 Desktop Charger Servicing

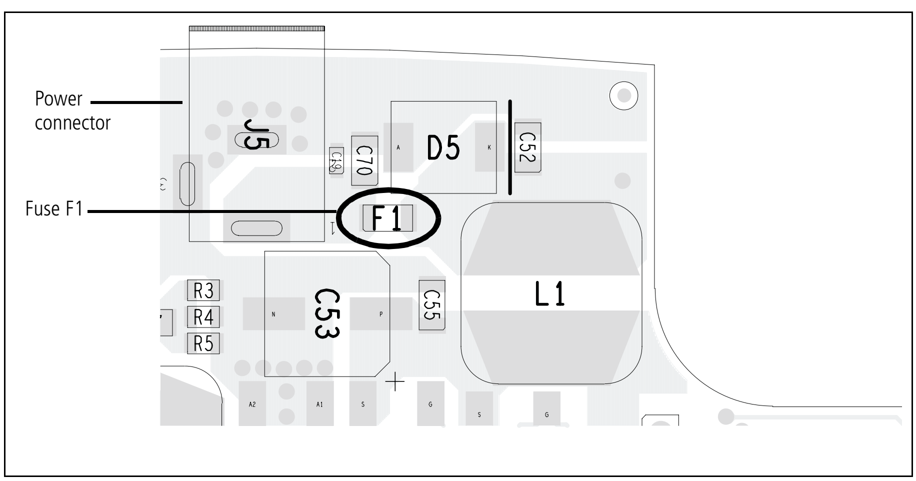
This section covers level-1 repairs of the desktop charger. For information on repair levels, as well as tools required, see Section 4 on page 81.

15.4.1 Desktop Charger Fault Finding

Complete the following steps if the charger fails to power on, or you insert a known good battery into the charger and no LED activity occurs. Parts mentioned in this section and IPNs are listed in Figure 15.2 on page 310.

1. Check the output voltage of the power adaptor. It should be between 11.5 V and 12.5 V. If faulty, replace the adaptor.
2. Confirm the removal of the fault. If the charger is still faulty, proceed with the following steps.
3. Disassemble the charger as described in "Desktop Charger Disassembly/Reassembly" on page 310.
4. Check the charger contacts and contact board. Replace the cradle assembly if faulty (from spares kit TPA-SP-200).
5. Check the looms and connection between the main board and contact board. Reconnect or replace if faulty.
6. Check fuse F1 (see Figure 15.1). Replace if faulty.
7. Confirm the removal of the fault. If the repair failed, replace the main board.

Figure 15.1 Desktop charger main board showing fuse F1 (top side)

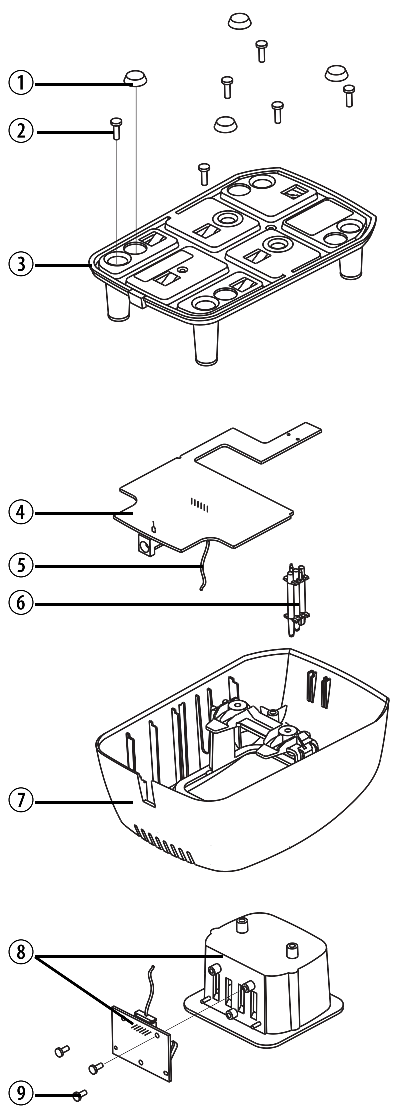


15.4.2 Desktop Charger Disassembly/Reassembly

Disassemble only as much as necessary to replace the defective parts. Reassembly is carried out in reverse order of the disassembly.

1. Unscrew the four corner screws ② and remove the bottom cover ③.
2. Unplug the cable ⑤ from the contact PCB ⑨ and remove the main PCB ④ and the light pipe ⑥.
3. Unscrew the two screws ② holding the cradle ⑧ in place.
4. Remove the ⑧ cradle and contact PCB ⑨.
5. Unscrew the three screws ⑩ and remove the contact PCB ⑨.

Figure 15.2 Parts of the desktop charger



	Description	IPN
①	rubber bumper (x4)	369-00010-11
②	screw P/T 30x10 (x6)	346-10030-10
③	bottom cover	346-10025-06
④	main PCB	XPA-CH-M01
⑤	cable	219-02944-00
⑥	light pipe	262-00007-**xx**
⑦	top cover	303-23168-**xx**
⑧	cradle assembly (cradle and contact PCB)	XPA-CH-M03
⑨	screw P/T 25x6 (x3)	346-10025-06

Note:
The characters **xx** in an IPN (Tait Internal Part Number) stand for the issue number of the part. Only the latest issue of each part will normally be available for ordering as spare or replacement parts.

Power adaptor	T952-400, or T952-401
Fuse F1	265-10300-10
Mains cable	
North America	T952-340
Europe	T952-330
United Kingdom	T952-320
Australia/New Zealand	T952-310

15.5 Multi-Charger Servicing

This section covers level-1 repairs of the multi-charger. For information on repair levels, as well as tools required, see Section 4 on page 81.

15.5.1 Multi-Charger General Description

The multi-charger uses two identical main boards, with three charger slots per-board. An individual charger slot uses the same circuitry and a similar cradle assembly to the desktop charger. A 110V–240V switch-mode internal power supply provides the necessary power to charge the maximum six batteries. A fan is mounted at the end of the multi-charger for cooling, and is activated shortly after a battery begins charging.

15.5.2 Multi-Charger Fault Finding

Parts mentioned in this section and IPNs are listed in Figure 15.4 on page 314 and Figure 15.5 on page 315.

Fan Faulty

Complete these steps if the charger powers on, but you cannot hear fan noise while a battery is charging and the red LED is glowing. Note there is a three minute delay between inserting a battery and the fan starting.

1. Disassemble the charger as described in "Multi-Charger Disassembly/Reassembly" on page 313.
2. Check the connection between J2 on one main board and J3 on the other board. Reconnect or replace the loom if faulty.
3. Check the connection between the fan and the J1 on the right-most main board. Reconnect or replace the loom if faulty.
4. Confirm the removal of the fault. If no fault could be found or the repair failed, replace the fan.

Power Switch or Power Supply Faulty

Complete the following steps if the charger fails to power on and there is no LED or fan activity.

1. Check the switch. Replace or repair if faulty.
2. Check the power supply output (12V).
3. Check that the screw terminals are tight.
4. Disassemble the charger as described in "Multi-Charger Disassembly/Reassembly" on page 313.
5. Check the power supply fuse. Replace if faulty (IPN: 265-00010-51).
6. Confirm the removal of the fault. If no fault could be found or the repair failed, replace the power supply.

Individual Charger Slot Faulty

Complete the following steps if an individual charger slot is faulty (you insert a known good battery into the charger slot and no LED activity occurs), and the other five charger slots continue to charge batteries.

1. Disassemble the charger as described in "Multi-Charger Disassembly/Reassembly" on page 313.

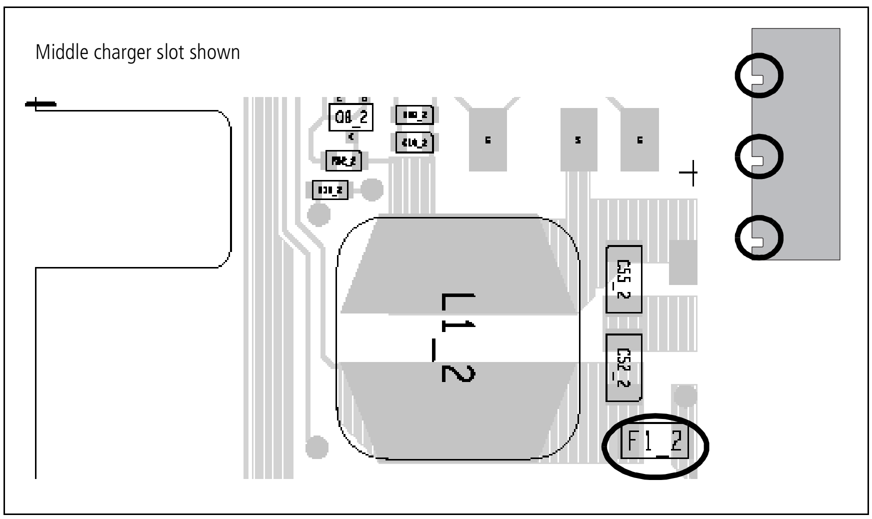
2. Check the charger contacts and contact board. Replace the cradle assembly if faulty.

3. Check the looms and connection between the main board and contact board. Reconnect or replace if faulty.

4. Check fuse F1 (see Figure 15.3). Replace if faulty (IPN: 265-10300-10).

5. Confirm the removal of the fault. If no fault could be found or the repair failed, replace the appropriate main board.

Figure 15.3 Multi-charger main board showing fuse F1 (top side)



Set of 3 Charger Slots Faulty

Complete the following steps if three charger slots are faulty (you insert a known good battery into each of the charger slots and no LED activity occurs), and the remaining three charger slots continue to charge batteries. This fault can indicate a problem with one of the charger's main boards.

1. Disassemble the charger as described in "Multi-Charger Disassembly/Reassembly" on page 313.

2. Check the loom and connection from the faulty main board to the power supply. Reconnect or replace if faulty.

3. Check that the screw terminals are tight.

4. Confirm the removal of the fault. If no fault could be found or the repair failed, replace the faulty main board.

15.5.3 Multi-Charger Disassembly/Reassembly

Disassemble only as much as necessary to replace the defective parts. Reassembly is carried out in reverse order of the disassembly.

The circled numbers in this section refer to the items in Figure 15.4 and Figure 15.5 on page 314.

1. Undo the four front and four back screws ⑤ holding the cover (Figure 15.4) to the base assembly (Figure 15.5).

2. Slightly pull the front and back sides of the cover outwards, and carefully lift the cover from the base assembly.

Important Take care not to pinch or over-extend the cables.

3. For each cradle ⑥ (as necessary):
   a. Unplug the cradle loom.
   b. Unscrew the two screws ② holding the cradle assembly in place.
   c. Remove the cradle assembly.

4. Unplug the fan loom from the right-most main board ①.

5. Unscrew the screws ⑩ and nuts ⑮ holding the fan assembly in place.

6. Remove the fan guard ⑬ and fan ⑭.

7. For each main board ① (as necessary):
   a. Unplug the loom from J2 or J3 (depending on which board is being removed).
   b. Unsolder the power cables from +V and -GND, and gently remove the cables.

Symbol on PCB	Cable Color
+V	red
-GND	black

   c. Unscrew the two nuts ③ holding the board in place.
   d. Gently remove the board from the standoffs ④.

Note The edge of the board fits into the guides inside the top of the cover.

Important Take care not to bend the board.

8. Remove the cover from the power supply terminal block ⑫.

9. Unscrew and remove the seven cables.

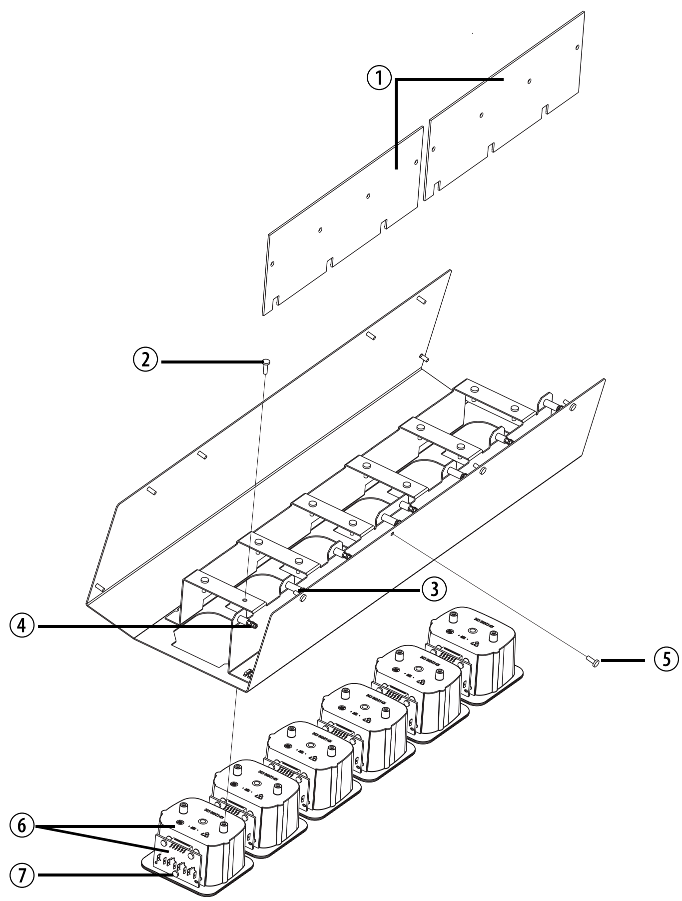
Symbol on PSU	Color
+V (x2)	red
-V (x2)	black
⏚	green

Symbol	Color
N	blue (x2)
L	brown

10. Unscrew the three screws ⑱ holding the power supply ⑪ to the base assembly, and remove the washers ⑲.

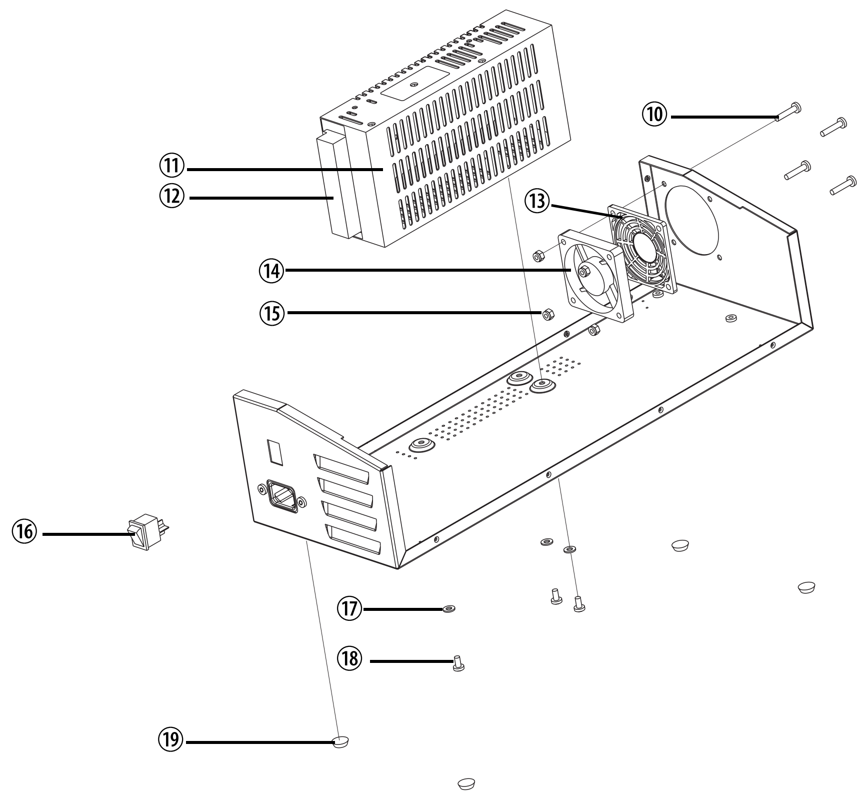
11. Remove the power supply.

Figure 15.4 Parts of the multi-charger cover



	Description	IPN
①	main PCB (x2)	XPA-CH-M11
②	screw 30X10 PT (x12)	346-10030-10
③	nut M3 hex (x4)	352-00010-08
④	standoff (x8)	
⑤	screw M3x8 PT (x8)	349-00020-36
⑥	cradle assembly (x6) (cradle and contact PCB)	XPA-CH-M03
⑦	screw P/T 25x6 (x3)	346-10025-06

Figure 15.5 Parts of the multi-charger base assembly



	Description	IPN		Description	IPN
⑩	screw M4x20 PT (x4)	349-02057-00	⑮	nut M4 hex (x4)	352-00010-29
⑪	power supply	009-00009-00	⑯	power switch	230-00010-23
⑫	terminal block		⑰	washer M4 (x3)	353-00010-23
⑬	fan guard	258-00018-00	⑱	screw M4x8 PT (x3)	349-02059-00
⑭	fan	258-00017-00	⑲	rubber bumper (x4)	369-00010-11

Not illustrated

fuse F1	265-10300-10	Mains cable: Europe	T952-330
power supply fuse	265-00010-51	Mains cable: United Kingdom	T952-320
Mains cable: North America	T952-340	Mains cable: Australia/New Zealand	T952-310

15.6 Desktop Charger Main Board (XPA-CH-M01) PCB Information

The following information applies to the desktop charger main board with the PCB IPN 220-01724-04. The component values in the circuit diagram are indicative only. Refer to the parts lists for actual values used.

15.6.1 Parts List (Rev. 12)

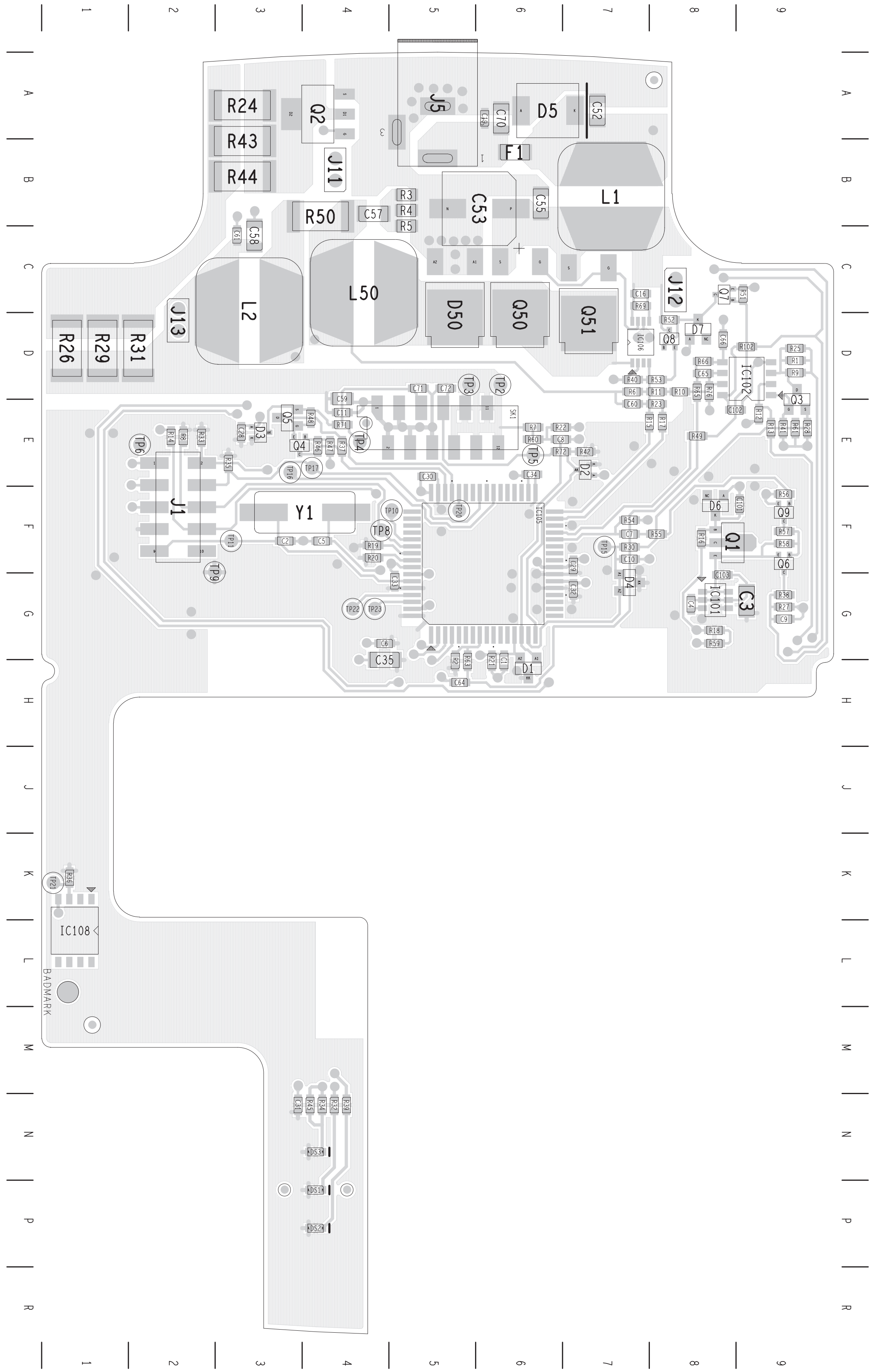
Ref.	IPN	Description
C1	018-16100-00	CAP 100n 16V ±10% 0603 X7R
C2	018-12330-10	CAP 33p 50V NPO ±1% 0603
C3	015-07470-20	CAP cer 4u7 25V 10% 1206 X7R
C4	018-16100-00	CAP 100n 16V ±10% 0603 X7R
C5	018-12330-10	CAP 33p 50V NPO ±1% 0603
C6	018-16100-00	CAP 100n 16V ±10% 0603 X7R
C7	018-16100-00	CAP 100n 16V ±10% 0603 X7R
C8	018-16100-00	CAP 100n 16V ±10% 0603 X7R
C10	018-16100-00	CAP 100n 16V ±10% 0603 X7R
C16	018-13470-00	CAP 470p 50V ±10% 0603 X7R
C19	018-14101-00	CAP 1n 50V NPO ±5% 0603
C28	018-16100-00	CAP 100n 16V ±10% 0603 X7R
C29	018-16100-00	CAP 100n 16V ±10% 0603 X7R
C30	018-16100-00	CAP 100n 16V ±10% 0603 X7R
C31	018-16100-00	CAP 100n 16V ±10% 0603 X7R
C32	018-16100-00	CAP 100n 16V ±10% 0603 X7R
C33	018-16100-00	CAP 100n 16V ±10% 0603 X7R
C34	018-16100-00	CAP 100n 16V ±10% 0603 X7R
C35	015-07470-20	CAP cer 4u7 25V 10% 1206 X7R
C52	015-07470-20	CAP cer 4u7 25V 10% 1206 X7R
C53	016-09100-07	CAP eltro 100u 35V low ESR
C55	015-07470-20	CAP cer 4u7 25V 10% 1206 X7R
C57	015-07470-20	CAP cer 4u7 25V 10% 1206 X7R
C58	015-07470-20	CAP cer 4u7 25V 10% 1206 X7R
C61	018-14101-00	CAP 1n 50V NPO ±5% 0603
C64	018-16100-00	CAP 100n 16V ±10% 0603 X7R
C65	018-14101-00	CAP 1n 50V NPO ±5% 0603
C66	018-13470-00	CAP 470p 50V ±10% 0603 X7R
C70	015-07470-20	CAP cer 4u7 25V 10% 1206 X7R
C71	018-13470-00	CAP 470p 50V ±10% 0603 X7R
C72	018-13470-00	CAP 470p 50V ±10% 0603 X7R
C101	018-16100-00	CAP 100n 16V ±10% 0603 X7R
C102	018-16100-00	CAP 100n 16V ±10% 0603 X7R
C103	018-16100-00	CAP 100n 16V ±10% 0603 X7R
D1	001-10000-70	DIODE BAV70 dual sw SOT23
D2	001-10099-01	DIODE BAV99W dual SIG
D3	001-10099-01	DIODE BAV99W dual SIG
D4	001-10000-70	DIODE BAV70 dual sw SOT23
D5	001-10015-50	DIODE 1.5SMC22AT3 TVS/Zen
D6	001-10084-82	DIODE BZX84C8V2 Zen SOT23
D7	001-10084-33	DIODE BZX84C3V3 Zen SOT23
D50	001-10008-35	DIODE MBRD835 sch Dpak
DS1	008-10002-00	LED 0603 red KRKT Ultrabright
DS2	008-10001-00	LED 0603 org KFKT ultrabright
DS3	008-10004-00	LED 0603 grn KGKT Ultrabright
F1	265-10300-10	FUSE 1206 3A 63V
IC101	002-11125-00	IC TK11250 5V rgltr 380mA
IC102	002-10003-58	IC LM358 dual OP-Amp
IC105	002-17232-10	IC ST72F321 MCU 8bit 48K TQFP
IC106	002-10384-50	IC LM3485 Hi-M PWM ctrl MSOP8
J1	240-10005-10	HDR 10wy 5x2 2.54mm vert SMD
J5	240-02021-01	SKT DC jack 2.5mm RA 5A@16VDC
L1	057-10047-00	IND pwr 4.7uH CDRH124 5.7A
L2	057-10047-00	IND pwr 4.7uH CDRH124 5.7A
L50	057-10022-10	IND pwr 22uH CDRH127LD 4A7
Q1	000-10561-60	XSTR BCX56-16 AF NPN SOT89
Q2	000-10000-14	XSTR IRFL014 Fet 3A/60V SOT223
Q3	000-10001-23	XSTR SMD BSS123 N DMOS SOT23
Q4	000-10084-71	XSTR BC847BW NPN SOT323
Q5	000-10001-23	XSTR SMD BSS123 N DMOS SOT23
Q6	000-10085-71	XSTR SMD BC857BW PNP SOT323
Q7	000-10084-71	XSTR BC847BW NPN SOT323
Q8	000-10084-71	XSTR BC847BW NPN SOT323
Q9	000-10084-71	XSTR BC847BW NPN SOT323
Q50	000-11006-00	XSTR PCh Mfet 60V 10A Dpak
Q51	000-11006-00	XSTR PCh Mfet 60V 10A Dpak
R2	038-16100-10	RES 0603 100k 1% 1/10W
R3	036-11100-10	RES 0805 1R0 1% 1/8W
R4	036-11100-10	RES 0805 1R0 1% 1/8W
R5	036-11100-10	RES 0805 1R0 1% 1/8W
R6	038-14680-10	RES 0603 6k8 1% 1/10W
R7	038-14390-10	RES 0603 3k9 1% 1/10W
R8	038-15100-10	RES 0603 10k 1% 1/10W
R9	038-13100-10	RES 0603 100R 1% 1/10W
R10	038-15100-10	RES 0603 10k 1% 1/10W
R11	038-14680-10	RES 0603 6k8 1% 1/10W
R12	038-16100-10	RES 0603 100k 1% 1/10W
R13	038-13100-10	RES 0603 100R 1% 1/10W
R14	038-16100-10	RES 0603 100k 1% 1/10W
R15	038-15100-10	RES 0603 10k 1% 1/10W
R16	038-14390-10	RES 0603 3k9 1% 1/10W
R17	038-15100-10	RES 0603 10k 1% 1/10W
R18	038-14680-10	RES 0603 6k8 1% 1/10W
R19	038-15100-10	RES 0603 10k 1% 1/10W
R20	038-15100-10	RES 0603 10k 1% 1/10W
R21	038-14390-10	RES 0603 3k9 1% 1/10W
R22	038-14390-10	RES 0603 3k9 1% 1/10W
R23	038-15100-10	RES 0603 10k 1% 1/10W
R24	036-00619-10	RES 2512 6R19 1% 1W
R25	038-13100-10	RES 0603 100R 1% 1/10W
R26	036-00619-10	RES 2512 6R19 1% 1W
R27	038-15470-10	RES 0603 47k 1% 1/10W
R28	038-14680-10	RES 0603 6k8 1% 1/10W
R29	036-00619-10	RES 2512 6R19 1% 1W

Ref.	IPN	Description
R30	038-14100-10	RES 0603 1k0 1% 1/10W
R31	036-00619-10	RES 2512 6R19 1% 1W
R32	038-14100-10	RES 0603 1k0 1% 1/10W
R33	038-15100-10	RES 0603 10k 1% 1/10W
R34	038-14100-10	RES 0603 1k0 1% 1/10W
R35	038-15100-10	RES 0603 10k 1% 1/10W
R37	038-14390-10	RES 0603 3k9 1% 1/10W
R38	038-10000-00	RES 0603 0R 5% 1/10W
R39	038-14100-10	RES 0603 1k0 1% 1/10W
R40	038-14100-10	RES 0603 1k0 1% 1/10W
R41	038-15100-10	RES 0603 10k 1% 1/10W
R42	038-16100-10	RES 0603 100k 1% 1/10W
R43	036-00619-10	RES 2512 6R19 1% 1W
R44	036-00619-10	RES 2512 6R19 1% 1W
R45	038-14100-10	RES 0603 1k0 1% 1/10W
R46	038-14100-10	RES 0603 1k0 1% 1/10W
R47	038-14390-10	RES 0603 3k9 1% 1/10W
R48	038-14270-00	RES 0603 2k7 5% 1/10W
R49	038-15470-10	RES 0603 47k 1% 1/10W
R50	036-00033-10	RES 2512 0R033 1% 1W
R51	038-15470-10	RES 0603 47k 1% 1/10W
R52	038-15100-10	RES 0603 10k 1% 1/10W
R53	038-13100-10	RES 0603 100R 1% 1/10W
R54	038-16100-10	RES 0603 100k 1% 1/10W
R55	038-16100-10	RES 0603 100k 1% 1/10W
R56	038-15470-10	RES 0603 47k 1% 1/10W
R57	038-15470-10	RES 0603 47k 1% 1/10W
R58	038-15470-10	RES 0603 47k 1% 1/10W
R59	038-14680-10	RES 0603 6k8 1% 1/10W
R60	038-14100-10	RES 0603 1k0 1% 1/10W
R61	038-14390-10	RES 0603 3k9 1% 1/10W
R63	038-14100-10	RES 0603 1k0 1% 1/10W
R65	038-16100-10	RES 0603 100k 1% 1/10W
R66	038-16100-10	RES 0603 100k 1% 1/10W
R69	038-16100-10	RES 0603 100k 1% 1/10W
R71	038-13100-10	RES 0603 100R 1% 1/10W
R72	038-13100-10	RES 0603 100R 1% 1/10W
R76	038-15100-10	RES 0603 10k 1% 1/10W
R102	038-13100-10	RES 0603 100R 1% 1/10W
SA	938-10001-01	SMT Alloy Lead Free (sac)
SK1	240-10000-06	CONN 12wy 2row skt M/M SMD
Y1	274-10011-00	XTAL 16.128MHz ±20ppm TQY-1002

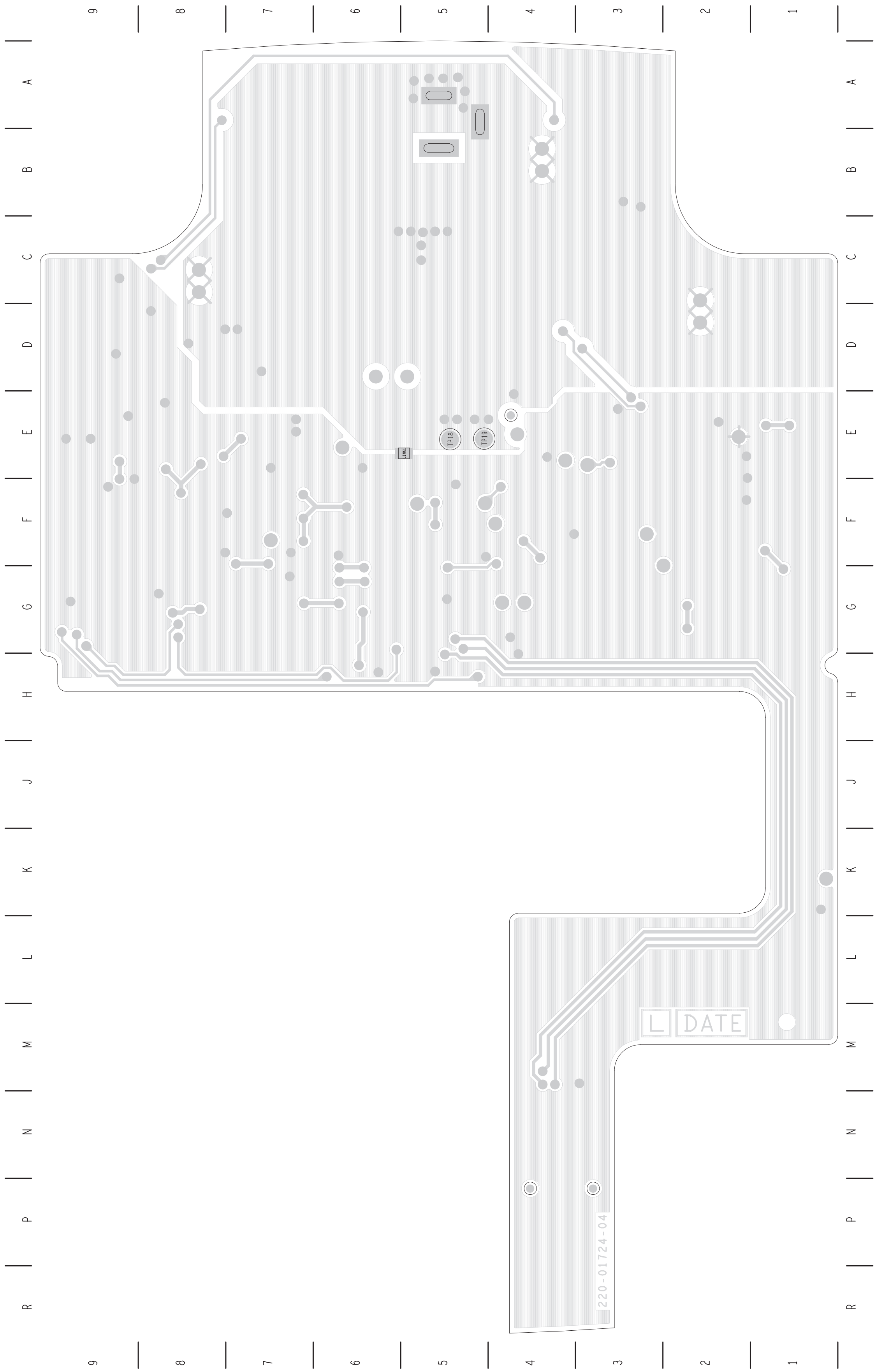
15.6.2 Grid Reference Index

Ref.	PCB	Circuit
C1	1:H6	1-C1
C2	1:F3	1-D2
C3	1:G9	1-G3
C4	1:G8	1-G3
C5	1:F4	1-D2
C6	1:G4	1-C6
C7	1:F7	1-B8
C8	1:E6	1-C9
C9	1:G9	1-B9
C10	1:F7	1-F10
C11	1:E4	1-D9
C16	1:C7	1-E6
C19	1:A6	1-F4
C28	1:E3	1-E1
C29	1:F7	1-E1
C30	1:E5	1-D1
C31	1:N3	1-F1
C32	1:G7	1-E1
C33	1:G5	1-E1
C34	1:E6	1-D1
C35	1:H4	1-F1
C52	1:A7	1-F5
C53	1:B6	1-F5
C55	1:B6	1-F5
C57	1:B4	1-F7
C58	1:C3	1-F9
C59	1:D4	1-D9
C60	1:E7	1-E8
C61	1:C3	1-F9
C64	1:H5	1-A5
C65	1:D8	1-B6
C66	1:D8	1-A7
C70	1:A6	1-F4
C71	1:D5	1-D9
C72	1:D5	1-D9
C101	1:F9	1-F1
C102	1:E8	1-B1
C103	1:G8	1-F2
D1	1:H6	1-D2 1-C2
D2	1:E7	1-C7 1-B7
D3	1:E3	1-B8 1-C8
D4	1:G7	1-C2
D5	1:A6	1-F5
D6	1:F8	1-F1
D7	1:D8	1-D5
D50	1:C5	1-F7
DS1	1:P4	1-D5
DS2	1:P4	1-D5
DS3	1:N4	1-D5
F1	1:B6	1-G4
IC101	1:G8	1-G2
IC102	1:D9	1-B7 1-B1 1-G8
IC105	1:F6	1-C3
IC106	1:D7	1-E6
IC108	1:L1	1-A8
J1	1:F2	1-E2
J5	1:B5	1-F3
J11	1:B4	1-B1
J12	1:C8	1-B1
J13	1:C2	1-B2
L1	1:B7	1-F5
L2	1:C3	1-F8
L50	1:C4	1-F7
LINK1	2:E5	1-G4
Q1	1:F8	1-G1
Q2	1:A4	1-B10
Q3	1:E9	1-G9
Q4	1:E3	1-C5
Q5	1:E3	1-C6
Q6	1:F9	1-B9
Q7	1:C8	1-E5
Q8	1:D8	1-E5
Q9	1:F9	1-B8
Q50	1:C6	1-F6
Q51	1:C7	1-F6
R1	1:D9	1-F8
R2	1:H5	1-C2
R3	1:B5	1-E7
R4	1:B5	1-E7
R5	1:C5	1-E7
R6	1:D7	1-E8
R7	1:E6	1-C9
R8	1:E2	1-F2
R9	1:D9	1-F7
R10	1:D8	1-B7
R11	1:D8	1-B7
R12	1:E9	1-F8
R13	1:E9	1-F8
R14	1:E2	1-E2
R15	1:E8	1-B6
R16	1:F8	1-G1
R17	1:E8	1-B6
R18	1:G8	1-D1
R19	1:F4	1-E4
R20	1:F4	1-E4
R21	1:H6	1-C1
R22	1:E6	1-C9
R23	1:E8	1-B6
R24	1:A3	1-C10
R25	1:D9	1-F7
R26	1:D1	1-C9
R27	1:G9	1-B10
R28	1:E9	1-F9
R29	1:D1	1-C10
R30	1:F7	1-G9
R31	1:D2	1-C10
R32	1:N4	1-D5
R33	1:E2	1-F3
R34	1:N4	1-D5
R35	1:E3	1-F3
R36	1:K1	1-A7
R37	1:E4	1-B4
R38	1:G9	1-B9
R39	1:N4	1-D5
R40	1:D7	1-E8
R41	1:E9	1-G9
R42	1:E7	1-C7
R43	1:B3	1-C10
R44	1:B3	1-C9
R45	1:N4	1-C5
R46	1:E4	1-C5
R47	1:E4	1-B5
R48	1:E4	1-C6
R49	1:E8	1-E4
R50	1:B4	1-F8
R51	1:C9	1-D5
R52	1:D8	1-E5
R53	1:D8	1-D6
R54	1:F7	1-B7
R55	1:F8	1-B8
R56	1:F9	1-B8
R57	1:F9	1-B9
R58	1:F9	1-B9
R59	1:G8	1-C1
R60	1:E6	1-C9
R61	1:E9	1-F9
R63	1:H5	1-A5
R65	1:D8	1-A6
R66	1:D8	1-A6
R69	1:C7	1-E6
R71	1:E4	1-D8
R72	1:E6	1-D8
R76	1:D8	1-A7
R102	1:D9	1-B1
SK1	1:E5	1-D10
TP10	1:F5	1-E3
TP11	1:F3	1-E2
TP15	1:F7	1-G10
TP16	1:E3	1-F4
TP17	1:E4	1-F4
TP18	2:E5	1-E10
TP19	2:E5	1-E10
TP20	1:F5	1-B4
TP21	1:K1	1-A7
TP22	1:G4	1-C4
TP23	1:G4	1-C4
TP2	1:D6	1-E9
TP3	1:D5	1-E9
TP4	1:E4	1-D9
TP5	1:E6	1-D10
TP6	1:E2	1-F2
TP8	1:F4	1-E2
TP9	1:F2	1-E3
Y1	1:F4	1-D2

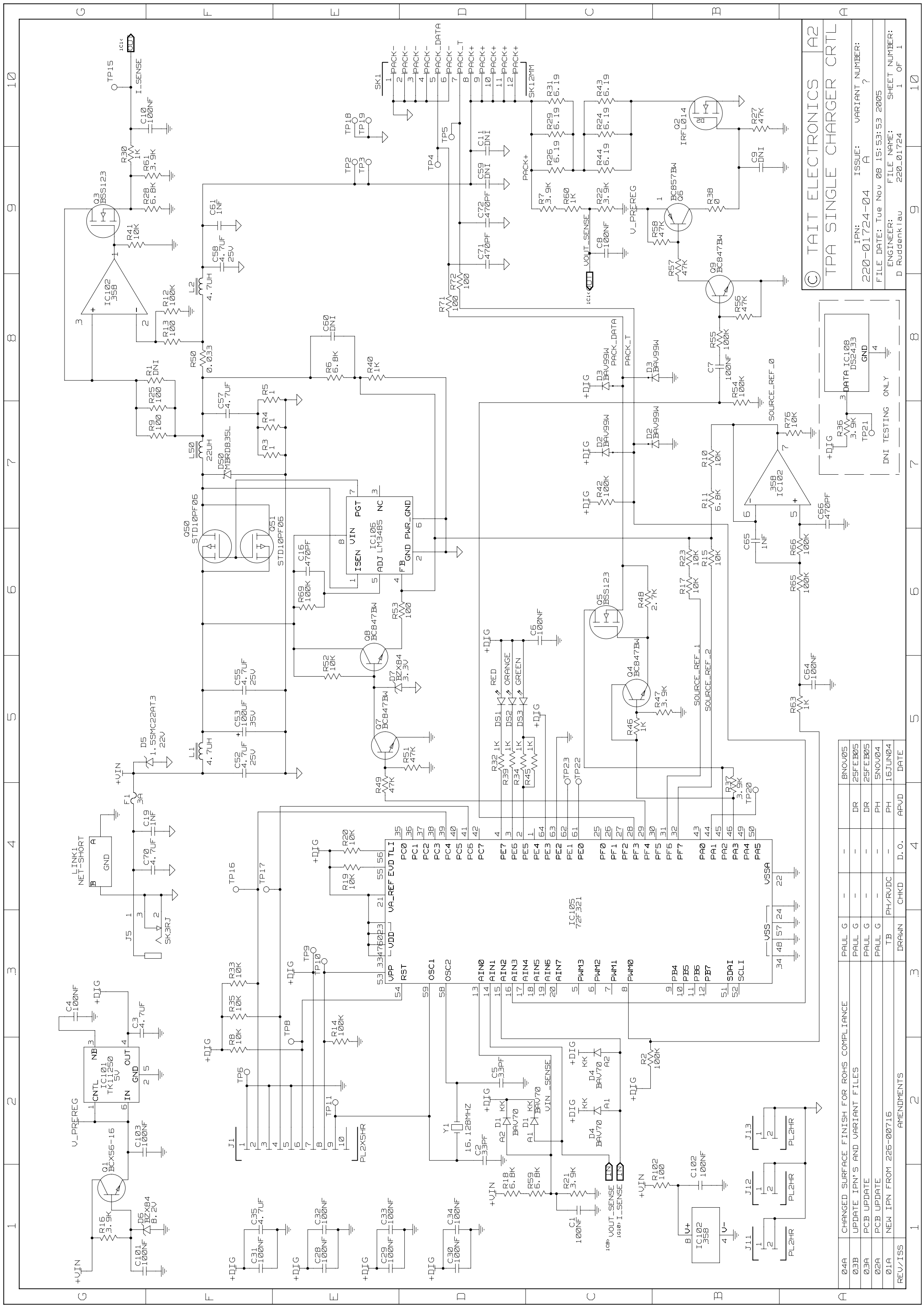
15.6.3 PCB Layout (top side)



15.6.4 PCB Layout (bottom side)



15.6.5 Circuit Diagram



15.7 Multi-Charger Main Board (XPA-CH-M11) PCB Information

The following information applies to the multi-charger main board with the PCB IPN 220-02081-02. The component values in the circuit diagram are indicative only. Refer to the parts lists for actual values used.

15.7.1 Parts List (Rev. 7)

Ref.	IPN	Description
C1	018-16100-00	CAP 100n 16V ±10% 0603 X7R
C1_(1-3)	018-16100-00	CAP 100n 16V ±10% 0603 X7R
C2	018-14101-00	CAP 1n 50V NPO ±5% 0603
C2_(1-3)	018-12330-10	CAP 33p 50V NPO ±1% 0603
C3	018-16100-00	CAP 100n 16V ±10% 0603 X7R
C3_(1-3)	015-07470-20	CAP cer 4u7 25V 10% 1206 X7R
C4	018-14101-00	CAP 1n 50V NPO ±5% 0603
C4_(1-3)	018-16100-00	CAP 100n 16V ±10% 0603 X7R
C5	018-14101-00	CAP 1n 50V NPO ±5% 0603
C5_(1-3)	018-12330-10	CAP 33p 50V NPO ±1% 0603
C6	018-14101-00	CAP 1n 50V NPO ±5% 0603
C6_(1-3)	018-16100-00	CAP 100n 16V ±10% 0603 X7R
C7_(1-3)	018-16100-00	CAP 100n 16V ±10% 0603 X7R
C8_(1-3)	018-16100-00	CAP 100n 16V ±10% 0603 X7R
C10_(1-3)	018-16100-00	CAP 100n 16V ±10% 0603 X7R
C16_(1-3)	018-13470-00	CAP 470p 50V ±10% 0603 X7R
C19_(1-3)	018-14101-00	CAP 1n 50V NPO ±5% 0603
C28_(1-3)	018-16100-00	CAP 100n 16V ±10% 0603 X7R
C29_(1-3)	018-16100-00	CAP 100n 16V ±10% 0603 X7R
C30_(1-3)	018-16100-00	CAP 100n 16V ±10% 0603 X7R
C31_(1-3)	018-16100-00	CAP 100n 16V ±10% 0603 X7R
C32_(1-3)	018-16100-00	CAP 100n 16V ±10% 0603 X7R
C33_(1-3)	018-16100-00	CAP 100n 16V ±10% 0603 X7R
C34_(1-3)	018-16100-00	CAP 100n 16V ±10% 0603 X7R
C35_(1-3)	015-07470-20	CAP cer 4u7 25V 10% 1206 X7R
C52_(1-3)	015-07470-20	CAP cer 4u7 25V 10% 1206 X7R
C53_(1-3)	016-09100-07	CAP eltro 100u 35V low ESR
C55_(1-3)	015-07470-20	CAP cer 4u7 25V 10% 1206 X7R
C57_(1-3)	015-07470-20	CAP cer 4u7 25V 10% 1206 X7R
C58_(1-3)	015-07470-20	CAP cer 4u7 25V 10% 1206 X7R
C61_(1-3)	018-14101-00	CAP 1n 50V NPO ±5% 0603
C64_(1-3)	018-16100-00	CAP 100n 16V ±10% 0603 X7R
C65_(1-3)	018-14101-00	CAP 1n 50V NPO ±5% 0603
C66_(1-3)	018-13470-00	CAP 470p 50V ±10% 0603 X7R
C70_(1-3)	015-07470-20	CAP cer 4u7 25V 10% 1206 X7R
C71_(1-3)	018-13470-00	CAP 470p 50V ±10% 0603 X7R
C72_(1-3)	018-13470-00	CAP 470p 50V ±10% 0603 X7R
C101_(1-3)	018-16100-00	CAP 100n 16V ±10% 0603 X7R
C102_(1-3)	018-16100-00	CAP 100n 16V ±10% 0603 X7R
C103_(1-3)	018-16100-00	CAP 100n 16V ±10% 0603 X7R
D1	001-10070-01	DIODE BAV70W dual smsig SOT323
D1_(1-3)	001-10070-01	DIODE BAV70W dual smsig SOT323
D2	001-10070-01	DIODE BAV70W dual smsig SOT323
D2_(1-3)	001-10099-01	DIODE BAV99W dual SIG
D3_(1-3)	001-10099-01	DIODE BAV99W dual SIG
D4_(1-3)	001-10070-01	DIODE BAV70W dual smsig SOT323
D6_(1-3)	001-10084-82	DIODE BZX84C8V2 Zen SOT23
D7_(1-3)	001-10084-33	DIODE BZX84C3V3 Zen SOT23
D50_(1-3)	001-10008-35	DIODE MBRD835 sch Dpak
DS1_(1-3)	008-10006-00	LED 1206 red RA 2V2 18MCD
DS2_(1-3)	008-10008-00	LED 1206 org RA 2V2 28MCD
DS3_(1-3)	008-10007-00	LED 1206 grn RA 2V2 18MCD
F1_(1-3)	265-10300-10	FUSE 1206 3A 63V
IC101_(1-3)	002-11125-00	IC TK11250 5V rgltr 380mA
IC102_(1-3)	002-10003-58	IC LM358 dual OP-Amp
IC105_(1-3)	002-17232-10	IC ST72F321 MCU 8bit 48K TQFP
IC106_(1-3)	002-10384-50	IC LM3485 Hi-M PWM ctrl MSOP8
J1	240-00011-55	HDR 3wy 2mm PCB RA mtg
J1_(1-3)	240-10005-10	HDR 10wy 5x2 2.54mm vert SMD
J2	240-02026-22	SKT 4wy M/M FTE SMD
J3	240-02026-22	SKT 4wy M/M FTE SMD
L1_(1-3)	057-10047-00	IND pwr 4.7uH CDRH124 5.7A
L2_(1-3)	057-10047-00	IND pwr 4.7uH CDRH124 5.7A
L50_(1-3)	057-10022-10	IND pwr 22uH CDRH127LD 4A7
Q1	000-10000-14	XSTR IRFL014 Fet 3A/60V SOT223
Q1_(1-3)	000-10561-60	XSTR BCX56-16 AF NPN SOT89
Q2	000-10085-71	XSTR SMD BC857BW PNP SOT323
Q2_(1-3)	000-10000-14	XSTR IRFL014 Fet 3A/60V SOT223
Q3	000-10084-71	XSTR BC847BW NPN SOT323
Q3_(1-3)	000-10001-23	XSTR SMD BSS123 N DMOS SOT23
Q4_(1-3)	000-10084-71	XSTR BC847BW NPN SOT323
Q5_(1-3)	000-10001-23	XSTR SMD BSS123 N DMOS SOT23
Q6_(1-3)	000-10085-71	XSTR SMD BC857BW PNP SOT323
Q7_(1-3)	000-10084-71	XSTR BC847BW NPN SOT323
Q8_(1-3)	000-10084-71	XSTR BC847BW NPN SOT323
Q9_(1-3)	000-10084-71	XSTR BC847BW NPN SOT323
Q50_(1-3)	000-11006-00	XSTR PCh Mfet 60V 10A Dpak
Q51_(1-3)	000-11006-00	XSTR PCh Mfet 60V 10A Dpak
R1	038-14100-10	RES 0603 1k0 1% 1/10W
R2	038-15100-10	RES 0603 10k 1% 1/10W
R2_(1-3)	038-16100-10	RES 0603 100k 1% 1/10W
R3	038-15100-10	RES 0603 10k 1% 1/10W
R3_(1-3)	036-11100-10	RES 0805 1R0 1% 1/8W
R4	038-15470-10	RES 0603 47k 1% 1/10W
R4_(1-3)	036-11100-10	RES 0805 1R0 1% 1/8W
R5_(1-3)	036-11100-10	RES 0805 1R0 1% 1/8W
R6	038-15470-10	RES 0603 47k 1% 1/10W
R6_(1-3)	038-14680-10	RES 0603 6k8 1% 1/10W
R7	038-16100-10	RES 0603 100k 1% 1/10W
R7_(1-3)	038-14390-10	RES 0603 3k9 1% 1/10W
R8	038-15100-10	RES 0603 10k 1% 1/10W
R8_(1-3)	038-15100-10	RES 0603 10k 1% 1/10W

Ref.	IPN	Description
R9	038-16100-10	RES 0603 100k 1% 1/10W
R9_(1-3)	038-13100-10	RES 0603 100R 1% 1/10W
R10	038-13100-10	RES 0603 100R 1% 1/10W
R10_(1-3)	038-15100-10	RES 0603 10k 1% 1/10W
R11	038-10000-00	RES 0603 0R 5% 1/10W
R11_(1-3)	038-14680-10	RES 0603 6k8 1% 1/10W
R12	038-10000-00	RES 0603 0R 5% 1/10W
R12_(1-3)	038-16100-10	RES 0603 100k 1% 1/10W
R13	038-10000-00	RES 0603 0R 5% 1/10W
R13_(1-3)	038-13100-10	RES 0603 100R 1% 1/10W
R14	038-10000-00	RES 0603 0R 5% 1/10W
R14_(1-3)	038-16100-10	RES 0603 100k 1% 1/10W
R15	038-10000-00	RES 0603 0R 5% 1/10W
R15_(1-3)	038-15100-10	RES 0603 10k 1% 1/10W
R16	038-10000-00	RES 0603 0R 5% 1/10W
R16_(1-3)	038-14390-10	RES 0603 3k9 1% 1/10W
R17	038-10000-00	RES 0603 0R 5% 1/10W
R17_(1-3)	038-15100-10	RES 0603 10k 1% 1/10W
R18	038-10000-00	RES 0603 0R 5% 1/10W
R18_(1-3)	038-14680-10	RES 0603 6k8 1% 1/10W
R19_(1-3)	038-15100-10	RES 0603 10k 1% 1/10W
R20_(1-3)	038-15100-10	RES 0603 10k 1% 1/10W
R21_(1-3)	038-14390-10	RES 0603 3k9 1% 1/10W
R22_(1-3)	038-14390-10	RES 0603 3k9 1% 1/10W
R23_(1-3)	038-15100-10	RES 0603 10k 1% 1/10W
R24_(1-3)	036-00619-10	RES 2512 6R19 1% 1W
R25_(1-3)	038-13100-10	RES 0603 100R 1% 1/10W
R26_(1-3)	036-00619-10	RES 2512 6R19 1% 1W
R27_(1-3)	038-15470-10	RES 0603 47k 1% 1/10W
R28_(1-3)	038-14680-10	RES 0603 6k8 1% 1/10W
R29_(1-3)	036-00619-10	RES 2512 6R19 1% 1W
R30_(1-3)	038-14100-10	RES 0603 1k0 1% 1/10W
R31_(1-3)	036-00619-10	RES 2512 6R19 1% 1W
R32_(1-3)	038-14100-10	RES 0603 1k0 1% 1/10W
R33_(1-3)	038-15100-10	RES 0603 10k 1% 1/10W
R34_(1-3)	038-13220-10	RES 0603 220R 1% 1/10W
R35_(1-3)	038-15100-10	RES 0603 10k 1% 1/10W
R37_(1-3)	038-14390-10	RES 0603 3k9 1% 1/10W
R38_(1-3)	038-10000-00	RES 0603 0R 5% 1/10W
R39_(1-3)	038-14100-10	RES 0603 1k0 1% 1/10W
R40_(1-3)	038-14100-10	RES 0603 1k0 1% 1/10W
R41_(1-3)	038-15100-10	RES 0603 10k 1% 1/10W
R42_(1-3)	038-16100-10	RES 0603 100k 1% 1/10W
R43_(1-3)	036-00619-10	RES 2512 6R19 1% 1W
R44_(1-3)	036-00619-10	RES 2512 6R19 1% 1W
R45_(1-3)	038-14100-10	RES 0603 1k0 1% 1/10W
R46_(1-3)	038-14100-10	RES 0603 1k0 1% 1/10W
R47_(1-3)	038-14390-10	RES 0603 3k9 1% 1/10W
R48_(1-3)	038-14270-00	RES 0603 2k7 5% 1/10W
R49_(1-3)	038-15470-10	RES 0603 47k 1% 1/10W
R50_(1-3)	036-00033-10	RES 2512 0R033 1% 1W
R51_(1-3)	038-15470-10	RES 0603 47k 1% 1/10W
R52_(1-3)	038-15100-10	RES 0603 10k 1% 1/10W
R53_(1-3)	038-13100-10	RES 0603 100R 1% 1/10W
R54_(1-3)	038-16100-10	RES 0603 100k 1% 1/10W
R55_(1-3)	038-16100-10	RES 0603 100k 1% 1/10W
R56_(1-3)	038-15470-10	RES 0603 47k 1% 1/10W
R57_(1-3)	038-15470-10	RES 0603 47k 1% 1/10W
R58_(1-3)	038-15470-10	RES 0603 47k 1% 1/10W
R59_(1-3)	038-14680-10	RES 0603 6k8 1% 1/10W
R60_(1-3)	038-14100-10	RES 0603 1k0 1% 1/10W
R61_(1-3)	038-14390-10	RES 0603 3k9 1% 1/10W
R63_(1-3)	038-14100-10	RES 0603 1k0 1% 1/10W
R65_(1-3)	038-16100-10	RES 0603 100k 1% 1/10W
R66_(1-3)	038-16100-10	RES 0603 100k 1% 1/10W
R67_(1-3)	038-14100-10	RES 0603 1k0 1% 1/10W
R69_(1-3)	038-16100-10	RES 0603 100k 1% 1/10W
R71_(1-3)	038-13100-10	RES 0603 100R 1% 1/10W
R72_(1-3)	038-13100-10	RES 0603 100R 1% 1/10W
R76_(1-3)	038-15100-10	RES 0603 10k 1% 1/10W
R102_(1-3)	038-13100-10	RES 0603 100R 1% 1/10W
SA	938-10001-01	SMT Alloy Lead Free (sac)
SK1_(1-3)	240-10000-06	CONN 12wy 2row skt M/M SMD
Y1_(1-3)	274-10011-00	XTAL 16.128MHz ±20ppm TQY-1002

15.7.2 Grid Reference Index

Ref.	PCB	Circuit
+V	1:A8	1-C4
C1_1	1:C3	2-C1
C1_2	1:K3	3-C1
C1_3	1:S3	4-C1
C1	1:X4	1-D2
C2_1	1:B3	2-D2
C2_2	1:J3	3-D2
C2_3	1:R3	4-D2
C2	1:X4	1-D2
C3_1	1:B1	2-G3
C3_2	1:H1	3-G3
C3_3	1:R1	4-G3
C3	1:W4	1-D3
C4_1	1:B2	2-G3
C4_2	1:H2	3-G3
C4_3	1:P2	4-G3
C4	1:W5	1-D3
C5_1	1:B4	2-D2
C5_2	1:J4	3-D2
C5_3	1:R4	4-D2
C5	1:W2	1-E4
C6_1	1:B3	2-C6
C6_2	1:J3	3-C6
C6_3	1:R3	4-C6
C6	1:X3	1-B6
C7_1	1:D3	2-B8
C7_2	1:K3	3-B8
C7_3	1:T3	4-B8
C8_1	1:C6	2-C9
C8_2	1:J6	3-C9
C8_3	1:R6	4-C9
C9_1	1:C1	2-B9
C9_2	1:K1	3-B9
C9_3	1:S1	4-B9
C10_1	1:C2	2-F10
C10_2	1:K2	3-F10
C10_3	1:S2	4-F10
C11_1	1:C7	2-D9
C11_2	1:J7	3-D9
C11_3	1:S7	4-D9
C16_1	1:F2	2-E6
C16_2	1:M2	3-E6
C16_3	1:U2	4-E6
C19_1	1:G4	2-F4
C19_2	1:P4	3-F4
C19_3	1:W4	4-F4
C28_1	1:B5	2-E1
C28_2	1:J5	3-E1
C28_3	1:R5	4-E1
C29_1	1:D4	2-E1
C29_2	1:L4	3-E1
C29_3	1:T4	4-E1
C30_1	1:C5	2-D1
C30_2	1:J5	3-D1
C30_3	1:R5	4-D1
C31_1	1:B2	2-F1
C31_2	1:H2	3-F1
C31_3	1:R2	4-F1
C32_1	1:D3	2-E1
C32_2	1:L3	3-E1
C32_3	1:T3	4-E1
C33_1	1:B3	2-E1
C33_2	1:J3	3-E1
C33_3	1:R3	4-E1
C34_1	1:D5	2-D1
C34_2	1:K5	3-D1
C34_3	1:S5	4-D1
C35_1	1:B3	2-F1
C35_2	1:H3	3-F1
C35_3	1:R3	4-F1
C52_1	1:G3	2-F5
C52_2	1:N3	3-F5
C52_3	1:W3	4-F5
C53_1	1:F4	2-F5
C53_2	1:N4	3-F5
C53_3	1:V4	4-F5
C55_1	1:F3	2-F5
C55_2	1:N3	3-F5
C55_3	1:V3	4-F5
C57_1	1:F6	2-F7
C57_2	1:N6	3-F7
C57_3	1:V6	4-F7
C58_1	1:D8	2-F9
C58_2	1:L8	3-F9
C58_3	1:T8	4-F9
C59_1	1:C7	2-D9
C59_2	1:K7	3-D9
C59_3	1:S7	4-D9
C60_1	1:D5	2-E8
C60_2	1:L5	3-E8
C60_3	1:T5	4-E8
C61_1	1:F7	2-F9
C61_2	1:N7	3-F9
C61_3	1:V7	4-F9
C64_1	1:C5	2-A5
C64_2	1:J5	3-A5
C64_3	1:S5	4-A5
C65_1	1:C5	2-B6
C65_2	1:K5	3-B6
C65_3	1:S5	4-B6

Ref.	PCB	Circuit
C66_1	1:C6	2-A7
C66_2	1:J6	3-A7
C66_3	1:S6	4-A7
C70_1	1:G4	2-F4
C70_2	1:N4	3-F4
C70_3	1:W4	4-F4
C71_1	1:C7	2-D9
C71_2	1:K7	3-D9
C71_3	1:S7	4-D9
C72_1	1:D7	2-D9
C72_2	1:K7	3-D9
C72_3	1:S7	4-D9
C101_1	1:B1	2-F1
C101_2	1:J1	3-F1
C101_3	1:R1	4-F1
C102_1	1:C6	2-B1
C102_2	1:J6	3-B1
C102_3	1:S6	4-B1
C103_1	1:B1	2-G2
C103_2	1:J1	3-G2
C103_3	1:R1	4-G2
D1_1	1:D2	2-C2
		2-D2
D1_2	1:K2	3-C2
		3-D2
D1_3	1:S2	4-D2
		4-C2
D1	1:X7	1-C5
		1-C6
D2_1	1:D5	2-C7
D2_2	1:K5	3-C7
D2_3	1:T5	4-C7
D2	1:W4	1-D2
D3_1	1:B5	2-C8
D3_2	1:J5	3-C8
D3_3	1:R5	4-C8
D4_1	1:C2	2-C2
D4_2	1:K2	3-C2
D4_3	1:S2	4-C2
D6_1	1:C1	2-F1
D6_2	1:J1	3-F1
D6_3	1:R1	4-F1
D7_1	1:E2	2-E5
D7_2	1:L2	3-E5
D7_3	1:T2	4-E5
D50_1	1:E5	2-F7
D50_2	1:M5	3-F7
D50_3	1:U5	4-F7
DS1_1	1:D1	2-D6
DS1_2	1:L1	3-D6
DS1_3	1:U1	4-D6
DS2_1	1:D1	2-D6
DS2_2	1:M1	3-D6
DS2_3	1:V1	4-D6
DS3_1	1:C1	2-D6
DS3_2	1:K1	3-D6
DS3_3	1:T1	4-D6
F1_1	1:G4	2-G4
F1_2	1:P4	3-G4
F1_3	1:W4	4-G4
GND	1:A7	1-C3
IC101_1	1:B2	2-G2
IC101_2	1:H2	3-G2
IC101_3	1:R2	4-G2
IC102_1	1:C6	2-G8 2-B7
		2-B1
IC102_2	1:K6	3-B7 3-G8
		3-B1
IC102_3	1:S6	4-B1 4-B7
		4-G8
IC105_3	1:S4	4-C3
IC105_2	1:K4	3-C3
IC105_1	1:C4	2-C3
IC106_2	1:L2	3-E6
IC106_3	1:U2	4-E6
IC106_1	1:E2	2-E6
J1_1	1:B7	2-E2
J1_2	1:H7	3-E2
J1_3	1:R7	4-E2
J1	1:X7	1-C7
J2	1:X6	1-D7
J3	1:A6	1-E7
L1_1	1:G3	2-F5
L1_2	1:N3	3-F5
L1_3	1:V3	4-F5
L2_1	1:E7	2-F8
L2_2	1:M7	3-F8
L2_3	1:U7	4-F8
L50_1	1:E6	2-F7
L50_2	1:M6	3-F7
L50_3	1:U6	4-F7
LINK1_1	2:C6	2-G4
LINK1_2	2:K6	3-G4
LINK1_3	2:S6	4-G4
MT1	1:A5	1-B1
MT2	1:H5	1-B1
MT3	1:P5	1-A1
MT4	1:W5	1-A1
Q1_1	1:B2	2-G1
Q1_2	1:J2	3-G1
Q1_3	1:R2	4-G1
Q1	1:X3	1-B6
Q2_1	1:G5	2-B10
Q2_2	1:N5	3-B10
Q2_3	1:W5	4-B10
Q2	1:W2	1-E4
Q3_1	1:D6	2-G9
Q3_2	1:K6	3-G9
Q3_3	1:T6	4-G9
Q3	1:X5	1-D4
Q4_1	1:C5	2-C5
Q4_2	1:J5	3-C5
Q4_3	1:S5	4-C5
Q5_1	1:C5	2-C6
Q5_2	1:K5	3-C6
Q5_3	1:S5	4-C6
Q6_1	1:D1	2-B9
Q6_2	1:K1	3-B9
Q6_3	1:S1	4-B9
Q7_1	1:D2	2-E5
Q7_2	1:L2	3-E5
Q7_3	1:T2	4-E5
Q8_1	1:E2	2-E5
Q8_2	1:M2	3-E5
Q8_3	1:U2	4-E5
Q9_1	1:D2	2-B8
Q9_2	1:K2	3-B8
Q9_3	1:S2	4-B8
Q50_1	1:E4	2-F6
Q50_2	1:M4	3-F6
Q50_3	1:U4	4-F6
Q51_1	1:E3	2-F6
Q51_2	1:M3	3-F6
Q51_3	1:U3	4-F6
R1_1	1:D6	2-F8
R1_2	1:L6	3-F8
R1_3	1:T6	4-F8
R1	1:X5	1-D1
R2_1	1:C3	2-C3
R2_2	1:K3	3-C3
R2_3	1:S3	4-C3
R2	1:X4	1-D1
R3_1	1:F5	2-F7
R3_2	1:N5	3-F7
R3_3	1:V5	4-F7
R3	1:X4	1-D2
R4_1	1:F5	2-F7
R4_2	1:N5	3-F7
R4_3	1:V5	4-F7
R4	1:W5	1-D3
R5_1	1:F5	2-F7
R5_2	1:M5	3-F7
R5_3	1:V5	4-F7
R5	1:W5	1-D3
R6_1	1:D5	2-E8
R6_2	1:L5	3-E8
R6_3	1:T5	4-E8
R6	1:X2	1-E3
R7_1	1:C8	2-C9
R7_2	1:J8	3-C9
R7_3	1:S8	4-C9
R7	1:X5	1-D4
R8_1	1:B5	2-F2
R8_2	1:H5	3-F2
R8_3	1:R5	4-F2
R8	1:W2	1-E4
R9_1	1:D6	2-F7
R9_2	1:L6	3-F7
R9_3	1:T6	4-F7
R9	1:X3	1-E4
R10	1:W3	1-B6
R10_1	1:D5	2-B7
R10_2	1:K5	3-B7
R10_3	1:T5	4-B7
R11_1	1:D5	2-B7
R11_2	1:L5	3-B7
R11_3	1:T5	4-B7
R12_1	1:D6	2-F8
R12_2	1:L6	3-F8
R12_3	1:T6	4-F8
R13_1	1:D6	2-F8
R13_2	1:L6	3-F8
R13_3	1:T6	4-F8
R14_1	1:B5	2-E2
R14_2	1:H5	3-E2
R14_3	1:R5	4-E2
R15_1	1:D5	2-B6
R15_2	1:L5	3-B6
R15_3	1:T5	4-B6
R16_1	1:C2	2-G1
R16_2	1:J2	3-G1
R16_3	1:S2	4-G1
R17_1	1:D5	2-B6
R17_2	1:L5	3-B6
R17_3	1:T5	4-B6
R18_1	1:C2	2-D1
R18_2	1:J2	3-D1
R18_3	1:S2	4-D1
R19_1	1:B5	2-E4
R19_2	1:H5	3-E4
R19_3	1:R5	4-E4
R20_1	1:B4	2-E4
R20_2	1:H4	3-E4
R20_3	1:R4	4-E4
R21_1	1:C3	2-C1
R21_2	1:K3	3-C1
R21_3	1:S3	4-C1
R22_1	1:C6	2-C9
R22_2	1:J6	3-C9
R22_3	1:R6	4-C9
R23_1	1:D5	2-B6
R23_2	1:L5	3-B6
R23_3	1:T5	4-B6
R24_1	1:G6	2-C10
R24_2	1:N6	3-C10
R24_3	1:W6	4-C10
R25_1	1:D6	2-F7
R25_2	1:L6	3-F7
R25_3	1:T6	4-F7
R26_1	1:G7	2-C9
R26_2	1:N7	3-C9
R26_3	1:W7	4-C9
R27_1	1:C1	2-B10
R27_2	1:K1	3-B10
R27_3	1:S1	4-B10
R28_1	1:D6	2-F9
R28_2	1:L6	3-F9
R28_3	1:T6	4-F9
R29_1	1:G7	2-C10
R29_2	1:N7	3-C10
R29_3	1:V7	4-C10
R30_1	1:D5	2-G9
R30_2	1:K5	3-G9
R30_3	1:T5	4-G9
R31_1	1:F7	2-C10
R31_2	1:N7	3-C10
R31_3	1:V7	4-C10
R32_1	1:C3	2-D5
R32_2	1:J3	3-D5
R32_3	1:R3	4-D5
R33_1	1:B5	2-F3
R33_2	1:J5	3-F3
R33_3	1:R5	4-F3
R34_1	1:C3	2-D5
R34_2	1:J3	3-D5
R34_3	1:R3	4-D5
R35_1	1:B5	2-F3
R35_2	1:J5	3-F3
R35_3	1:R5	4-F3
R36_1	1:F2	2-G5
R36_2	1:M2	3-G5
R36_3	1:V2	4-G5
R37_1	1:C5	2-B5
R37_2	1:J5	3-B5
R37_3	1:S5	4-B5
R38_1	1:C1	2-B9
R38_2	1:K1	3-B9
R38_3	1:S1	4-B9
R39_1	1:C3	2-D5
R39_2	1:J3	3-D5
R39_3	1:S3	4-D5
R40_1	1:E2	2-E8
R40_2	1:L2	3-E8
R40_3	1:T2	4-E8
R41_1	1:D6	2-F9
R41_2	1:K6	3-F9
R41_3	1:T6	4-F9
R42_1	1:D5	2-C7
R42_2	1:K5	3-C7
R42_3	1:T5	4-C7
R43_1	1:G6	2-C10
R43_2	1:N6	3-C10
R43_3	1:W6	4-C10
R44_1	1:G7	2-C9
R44_2	1:N7	3-C9
R44_3	1:W7	4-C9
R45_1	1:B3	2-B3
R45_2	1:J3	3-B3
R45_3	1:R3	4-B3
R46_1	1:C5	2-C5
R46_2	1:J5	3-C5
R46_3	1:S5	4-C5
R47_1	1:C5	2-B5
R47_2	1:J5	3-B5
R47_3	1:R5	4-B5
R48_1	1:C5	2-C6
R48_2	1:J5	3-C6
R48_3	1:R5	4-C6
R49_1	1:D3	2-E4
R49_2	1:L3	3-E4
R49_3	1:T3	4-E4
R50_1	1:F6	2-F8
R50_2	1:N6	3-F8
R50_3	1:V6	4-F8
R51_1	1:D2	2-D5
R51_2	1:K2	3-D5
R51_3	1:T2	4-D5
R52_1	1:F2	2-E5
R52_2	1:M2	3-E5
R52_3	1:V2	4-E5
R53_1	1:E2	2-D6
R53_2	1:L2	3-D6
R53_3	1:U2	4-D6
R54_1	1:D3	2-B7
R54_2	1:L3	3-B7
R54_3	1:T3	4-B7
R55_1	1:D2	2-B8

Ref.	PCB	Circuit
R55_2	1:K2	3-B8
R55_3	1:T2	4-B8
R56_1	1:C2	2-B8
R56_2	1:K2	3-B8
R56_3	1:S2	4-B8
R57_1	1:D2	2-B9
R57_2	1:K2	3-B9
R57_3	1:S2	4-B9
R58_1	1:D2	2-B9
R58_2	1:K2	3-B9
R58_3	1:S2	4-B9
R59_1	1:C3	2-C1
R59_2	1:J3	3-C1
R59_3	1:S3	4-C1
R60_1	1:C8	2-C9
R60_2	1:J8	3-C9
R60_3	1:R8	4-C9
R61_1	1:D6	2-F9
R61_2	1:L6	3-F9
R61_3	1:T6	4-F9
R62_1	1:D4	2-G5
R62_2	1:L4	3-G5
R62_3	1:T4	4-G5

Ref.	PCB	Circuit
R63_1	1:C5	2-A5
R63_2	1:K5	3-A5
R63_3	1:S5	4-A5
R64_1	1:D2	2-G5
R64_2	1:L2	3-G5
R64_3	1:T2	4-G5
R65_1	1:C5	2-A6
R65_2	1:K5	3-A6
R65_3	1:S5	4-A6
R66_1	1:C6	2-A6
R66_2	1:J6	3-A6
R66_3	1:S6	4-A6
R67_1	1:B3	2-C5
R67_2	1:J3	3-C5
R67_3	1:R3	4-C5
R69_1	1:E2	2-E6
R69_2	1:M2	3-E6
R69_3	1:U2	4-E6
R71_1	1:C7	2-D8
R71_2	1:J7	3-D8
R71_3	1:R7	4-D8
R72_1	1:C6	2-D8
R72_2	1:J6	3-D8
R72_3	1:S6	4-D8

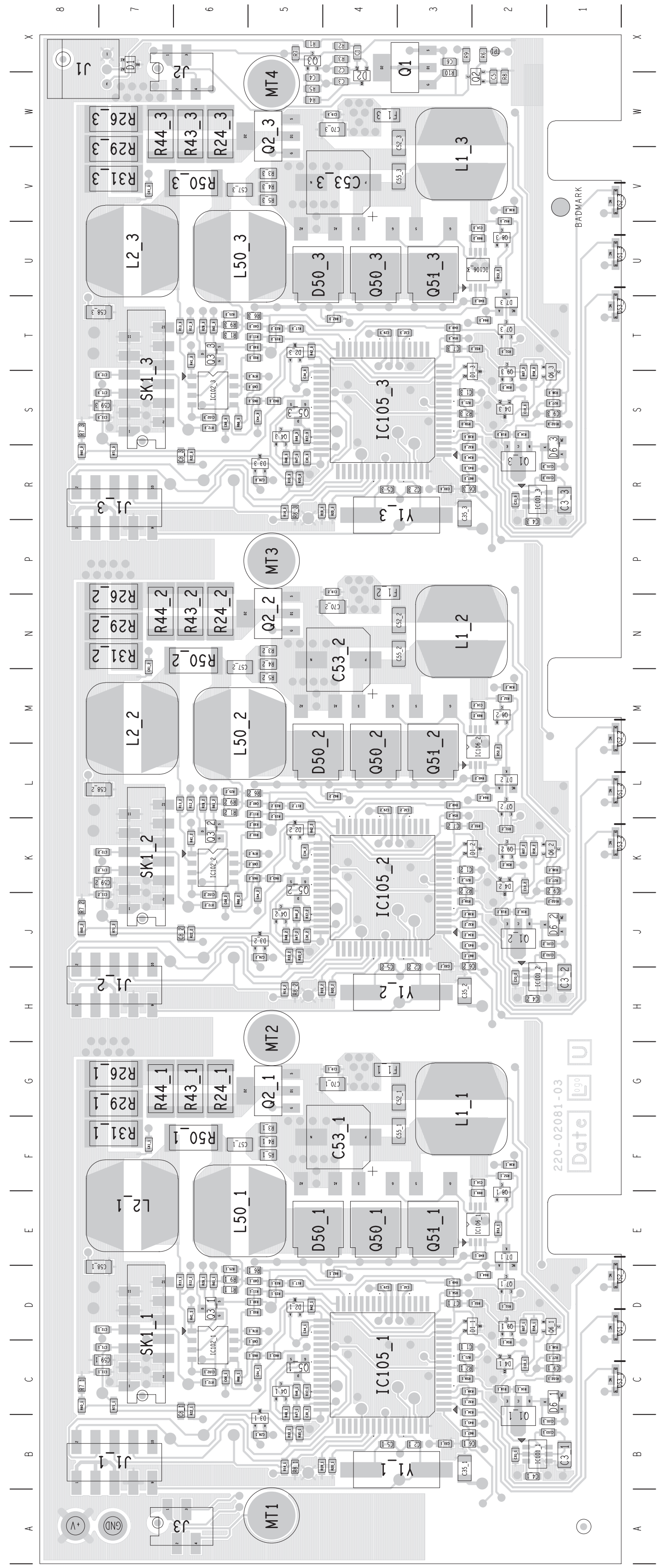
Ref.	PCB	Circuit
R76_1	1:D5	2-A7
R76_2	1:K5	3-A7
R76_3	1:S5	4-A7
R102_1	1:C1	2-B1
R102_2	1:J1	3-B1
R102_3	1:S1	4-B1
SK1_1	1:D7	2-D10
SK1_2	1:K7	3-D10
SK1_3	1:S7	4-D10
TP10_1	2:C4	2-E3
TP10_2	2:J4	3-E3
TP10_3	2:R4	4-E3
TP11_1	2:B3	2-E2
TP11_2	2:H3	3-E2
TP11_3	2:P3	4-E2
TP15_1	2:D5	2-G10
TP15_2	2:K5	3-G10
TP15_3	2:T5	4-G10
TP16_1	2:B7	2-F4
TP16_2	2:J7	3-F4
TP16_3	2:R7	4-F4
TP17_1	2:B6	2-F4
TP17_2	2:J6	3-F4
TP17_3	2:R6	4-F4

Ref.	PCB	Circuit
TP18_1	2:C7	2-E10
TP18_2	2:K7	3-E10
TP18_3	2:S7	4-E10
TP19_1	2:C7	2-E10
TP19_2	2:J7	3-E10
TP19_3	2:S7	4-E10
TP1	1:X2	1-E3
TP20_1	2:C4	2-B4
TP20_2	2:J4	3-B4
TP20_3	2:S4	4-B4
TP22_1	2:C3	2-C4
TP22_2	2:J3	3-C4
TP22_3	2:S3	4-C4
TP23_1	2:C3	2-C4
TP23_2	2:J3	3-C4
TP23_3	2:S3	4-C4
TP2_1	2:D8	2-E9
TP2_2	2:K8	3-E9
TP2_3	2:T8	4-E9
TP3_1	2:D8	2-E9
TP3_2	2:L8	3-E9
TP3_3	2:T8	4-E9

Ref.	PCB	Circuit
TP4_1	2:C7	2-D9
TP4_2	2:J7	3-D9
TP4_3	2:S7	4-D9
TP5_1	2:C6	2-D10
TP5_2	2:J6	3-D10
TP5_3	2:S6	4-D10
TP6_1	2:B2	2-F2
TP6_2	2:H2	3-F2
TP6_3	2:P2	4-F2
TP8_1	2:B6	2-E2
TP8_2	2:J6	3-E2
TP8_3	2:R6	4-E2
TP9_1	2:B5	2-E3
TP9_2	2:H5	3-E3
TP9_3	2:R5	4-E3
Y1_1	1:B4	2-D2
Y1_2	1:H4	3-D2
Y1_3	1:R4	4-D2

15.7.3 PCB Layout - Top Side

Figure 15.6 Overview



See Figure 15.7 on page 326

See Figure 15.8 on page 326

Figure 15.7 Components at the J2-end of the board

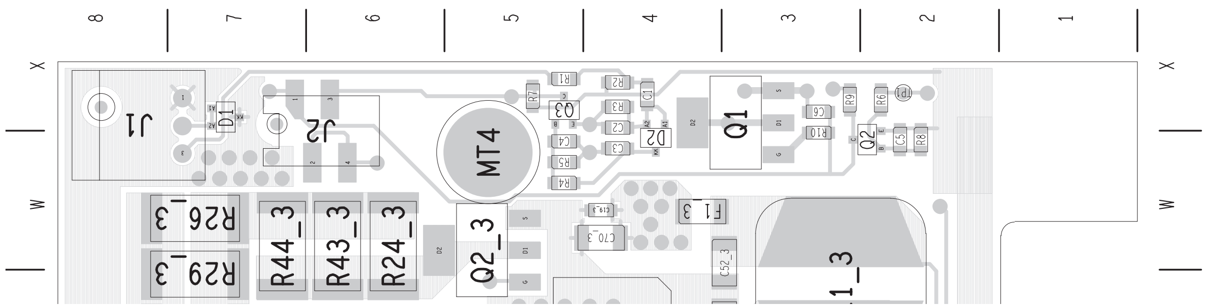
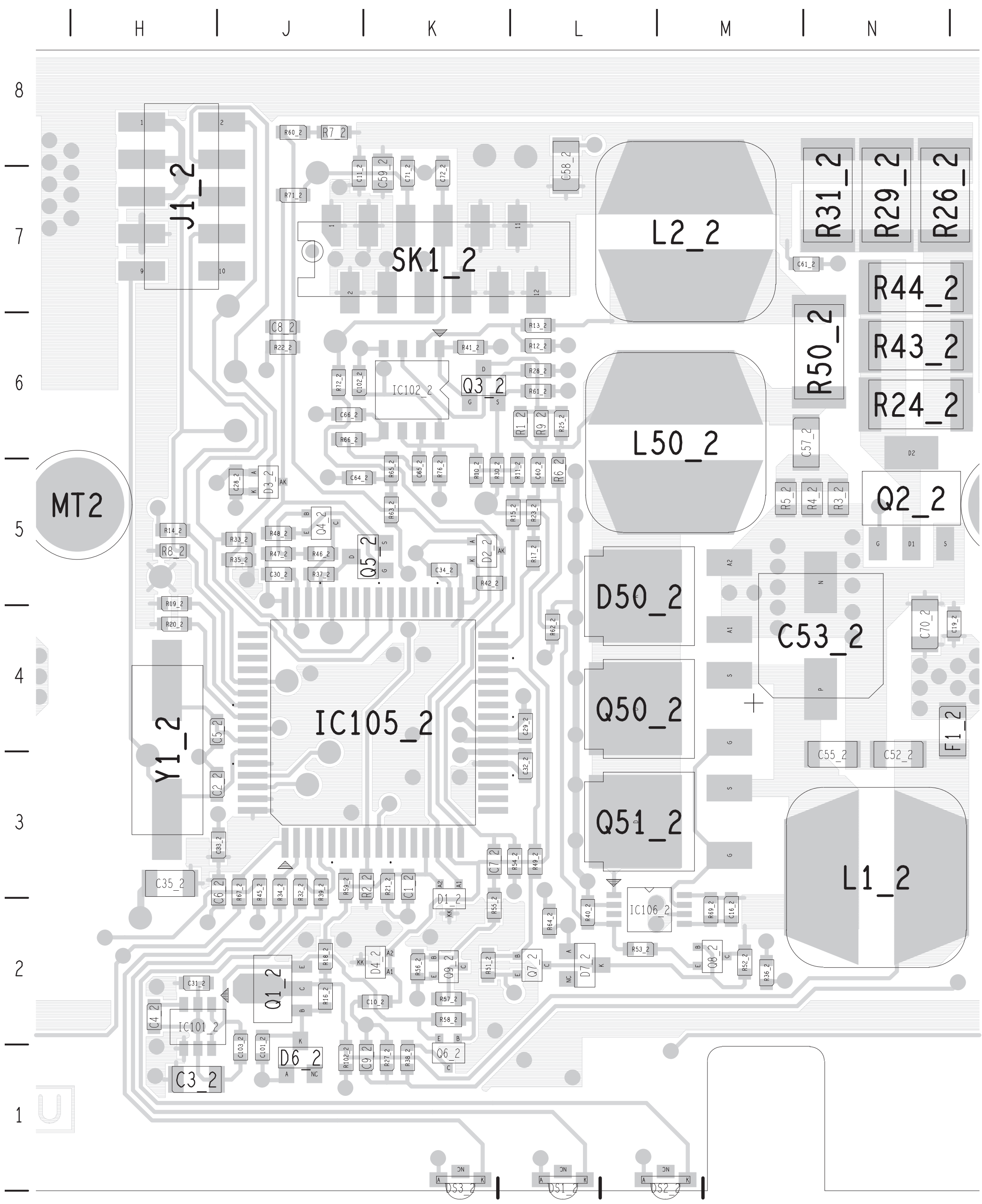
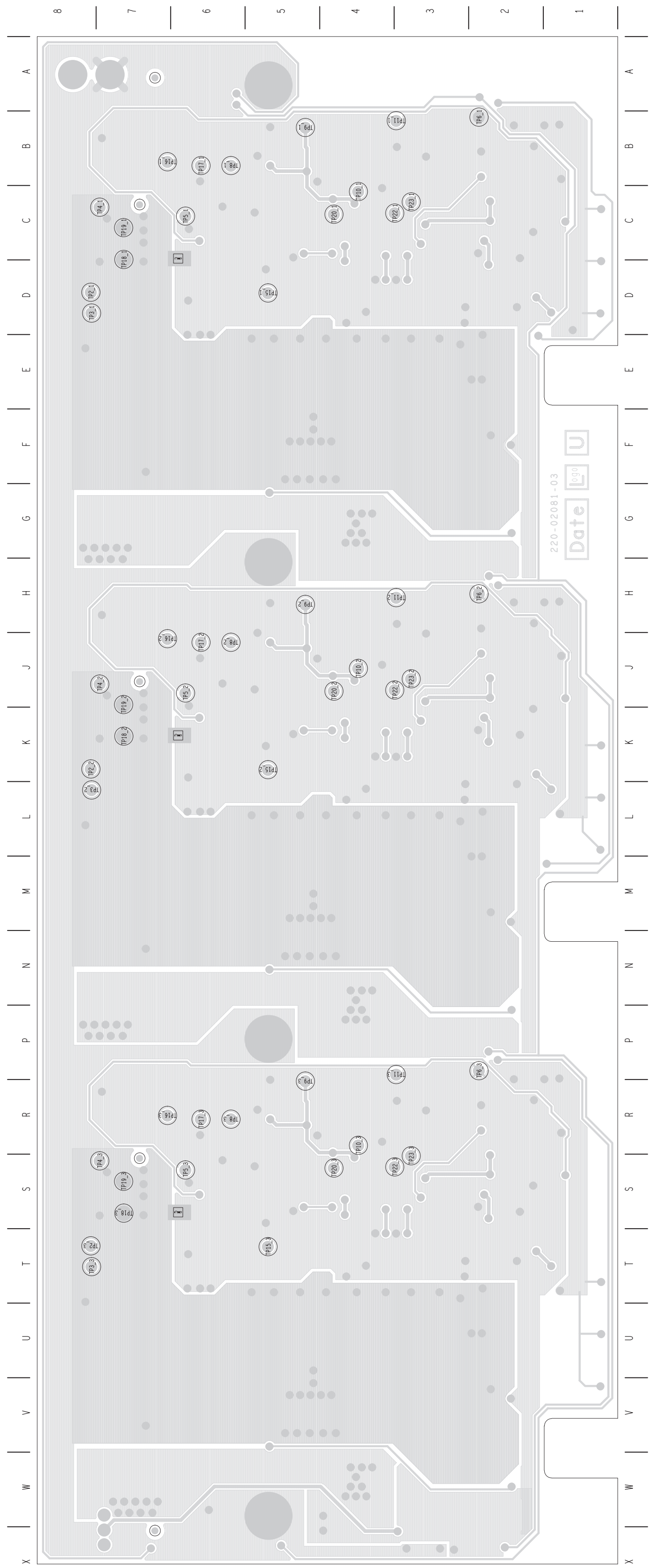


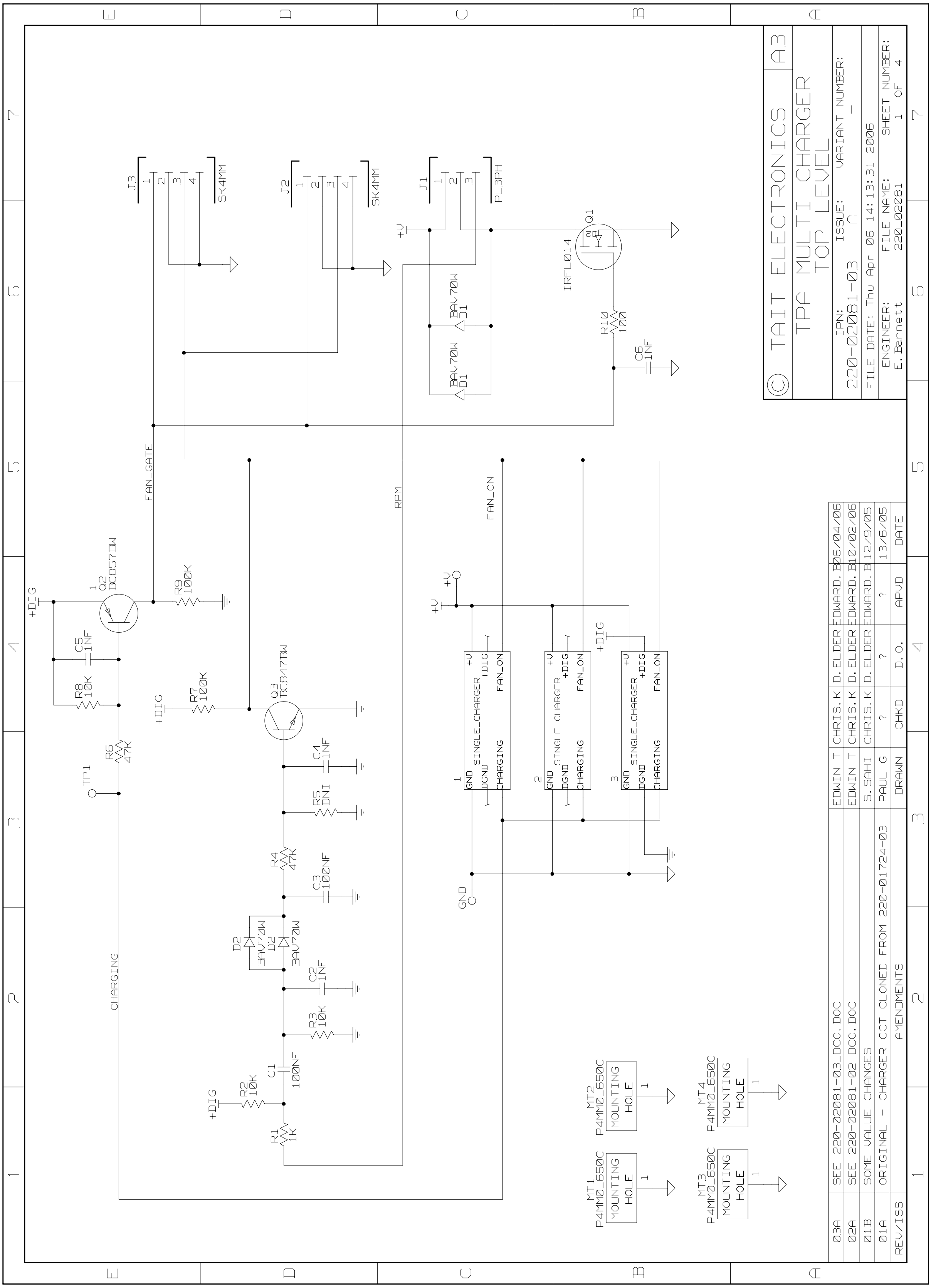
Figure 15.8 Components of the middle charger slot

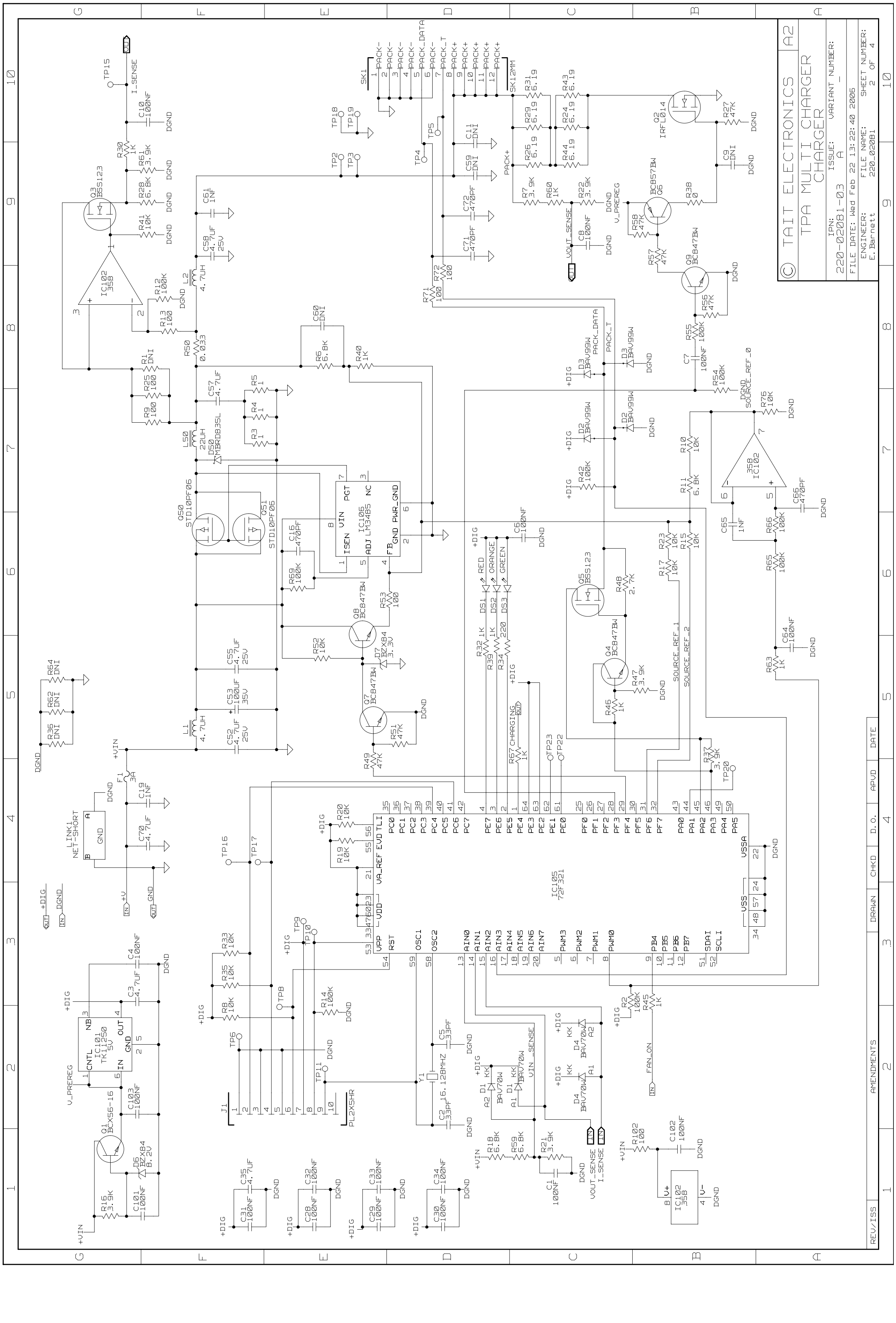


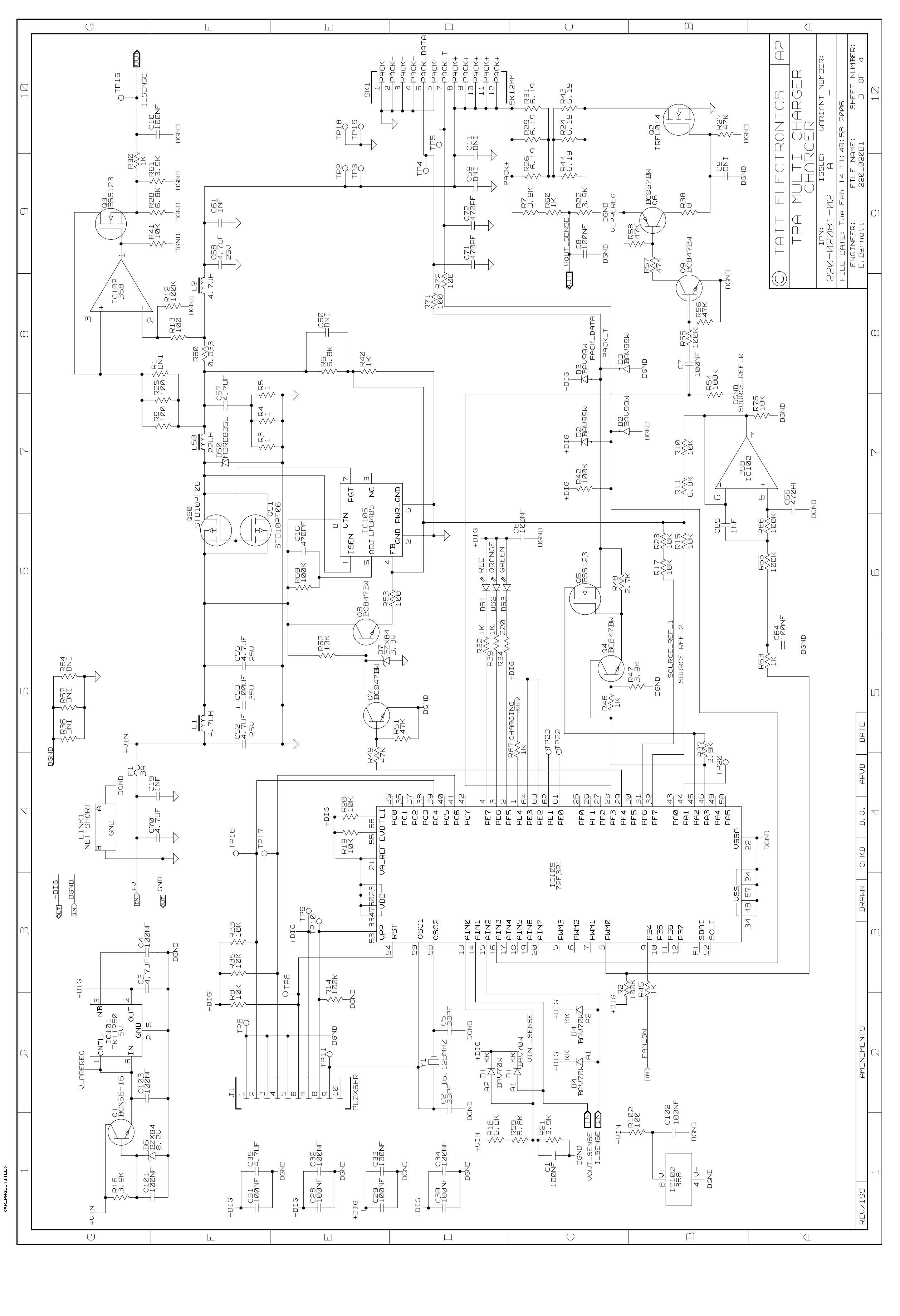
15.7.4 PCB Layout - Bottom Side

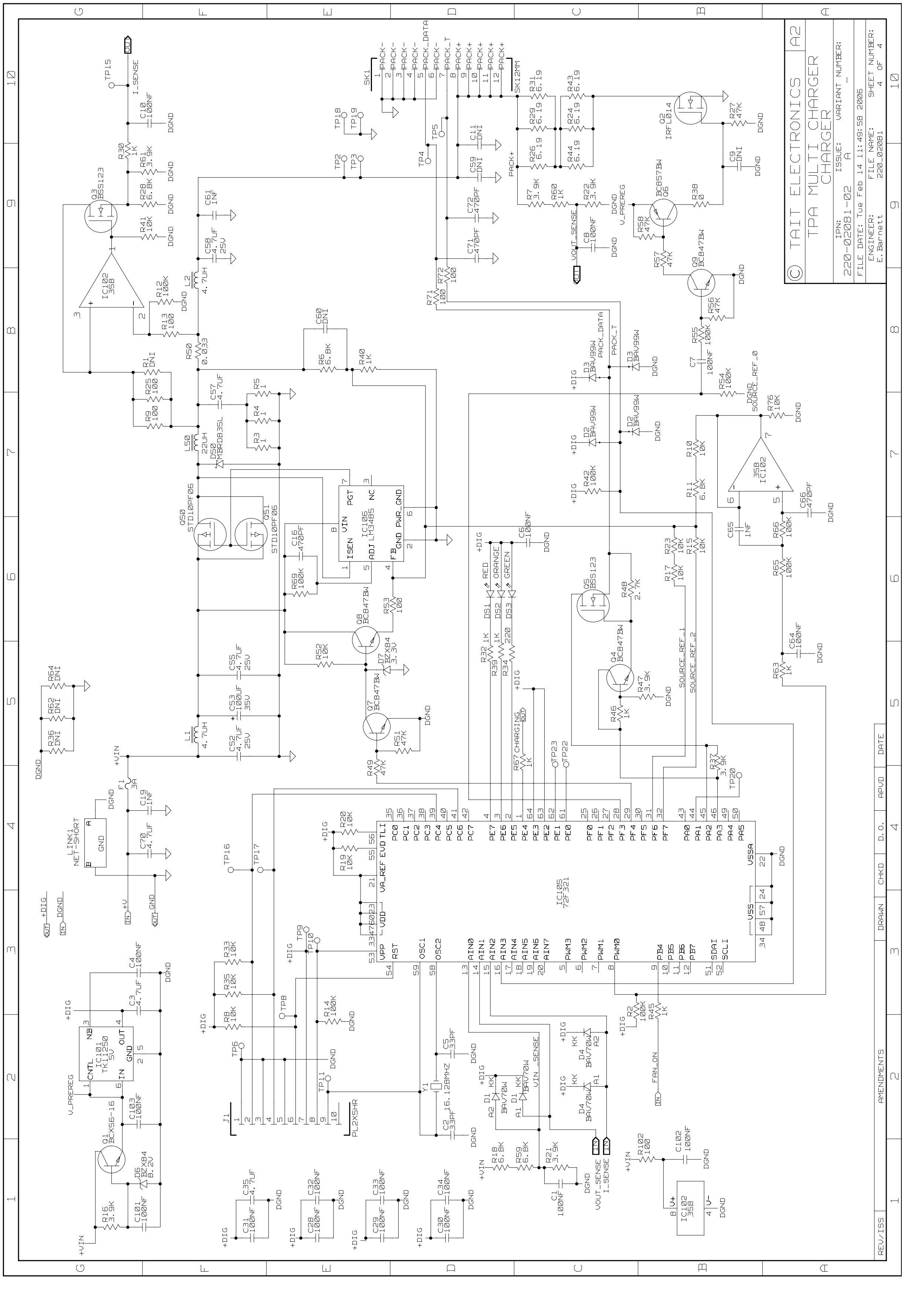


15.7.5 Circuit Diagrams




TAIT ELECTRONICS
A2
TPA MULTI CHARGER
CHARGER
IPN: 220-02081-03
ISSUE: A
VARIANT NUMBER: -
FILE DATE: Wed Feb 22 13:22:40 2006
FILE NAME: 220_02081
ENGINEER: E.Barnett
SHEET NUMBER: 2 OF 4


TAIT ELECTRONICS
TPA MULTI CHARGER
CHARGER
IPN:
220-02081-02
ISSUE:
A
FILE DATE: Tue Feb 14 11:49:58 2006
ENGINEER:
E.Barnett
FILE NAME:
220_02081
SHEET NUMBER:
3 OF 4


TAIT ELECTRONICS
TPA MULTI CHARGER
A2
IPN: 220-02081-02
ISSUE: A
FILE DATE: Tue Feb 14 11:49:58 2006
ENGINEER: E.Barnett
FILE NAME: 220_02081
SHEET NUMBER: 4 OF 4

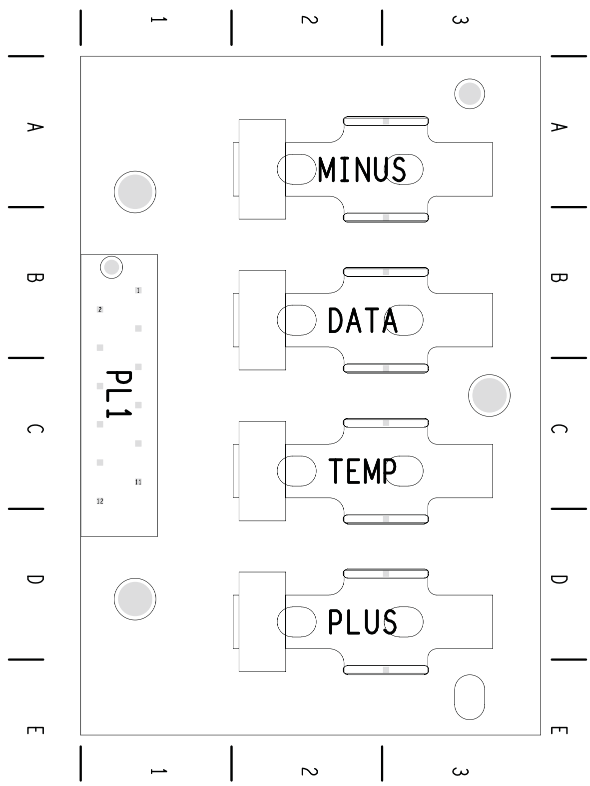
15.8 Contact Board (XPA-CH-M02 and XPA-CH-M03) PCB Information

The following information applies to the contact board with the PCB IPN 220-01725-04.

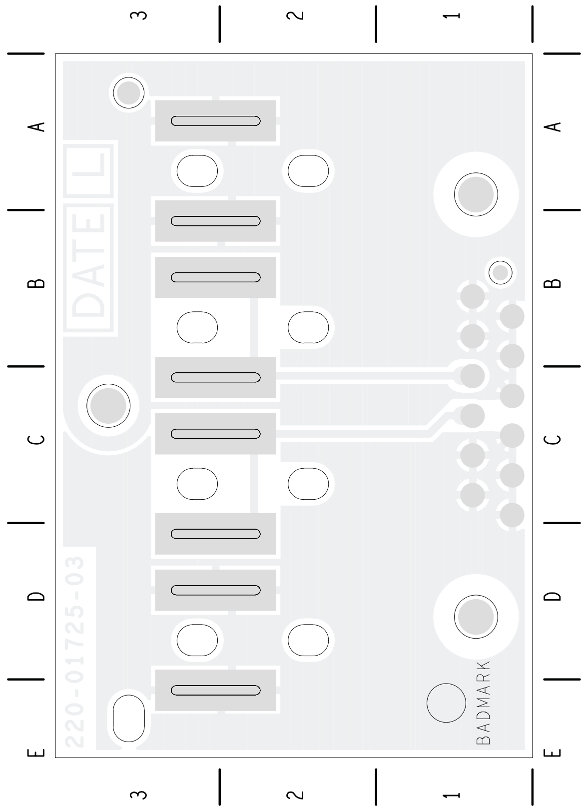
15.8.1 Parts List

Ref.	IPN	Description
DATA	303-50030-00	Cntct Apco DP1 Chgr
MINUS	303-50030-00	Cntct Apco DP1 Chgr
PLUS	303-50030-00	Cntct Apco DP1 Chgr
TEMP	303-50030-00	Cntct Apco DP1 Chgr
	219-02622-01	T700 Interface Cbl 12way

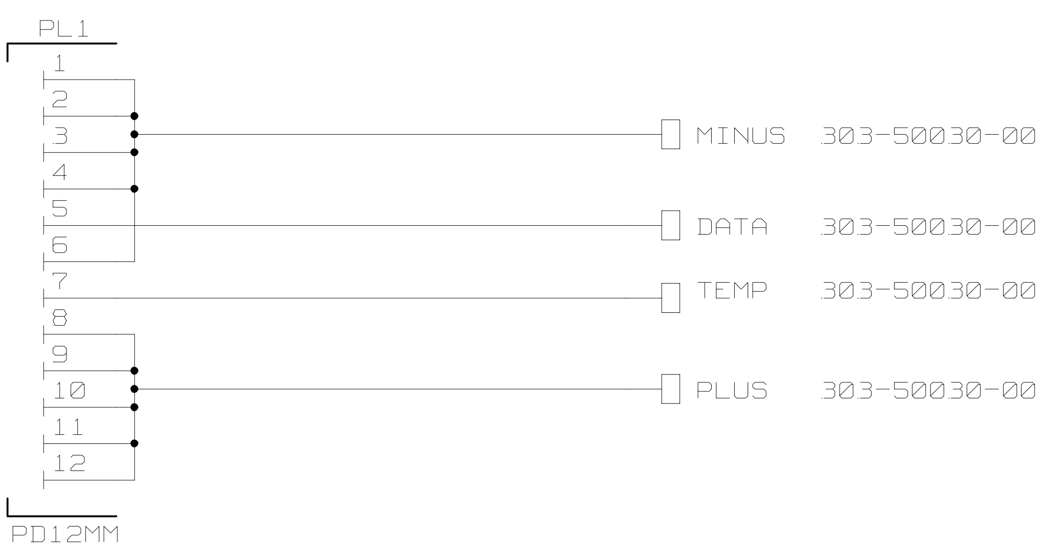
15.8.2 PCB Layout (top side)



15.8.3 PCB Layout (bottom side)



15.8.4 Circuit Diagram



16 TPA-AA-201 Accessory Connector Kit

Caution **The radio produces a specific audio level at the maximum rated power. It is the sole responsibility of the end-user to ensure applicability and compliance with the relevant legal regulations defining the noise level an individual can be subjected to.**

The TPA-AA-201 accessory connector kit is used to connect external third-party accessories, such as speaker microphones and headsets, to the accessory connector at the rear of the radio.

16.1 Connecting an Accessory

1. Verify that your accessory is compatible with the accessory connector, refer to Table 16.1.

2. When connecting an accessory, make sure it meets the following specifications:
   - speaker impedance: 32Ω (16Ω min.)
   - speaker power: 0.25 W_{rms} (min.)
   - microphone: electret, approximately 1kΩ
   - PTT switch: not in series with microphone.

Note If your accessory has a PTT switch in series with the microphone, the accessory cannot be used. The PTT needs to be a separate signal and must be made available at the connector separately; it must not be multiplexed on any other signal.

3. Disassemble the kit as described in "Disassembly and Reassembly" on page 338.

4. Solder the accessory lines to the pads provided on the bottom side of the accessory connector PCB (refer to Figure 16.1).

Important The recommended cable diameter is 0.205 inch (5.2mm), to fit into the insert and strain relief (see Figure 16.2). Any other cable diameter cannot be properly retained and is not recommended. Sealing against water and dust ingress cannot be guaranteed using this connector kit.

5. Modify the components on the accessory connector PCB as follows (refer to Figure 16.1). Note that some components may already be fitted by default.
   - For all accessories with differential speaker (not referenced to ground), fit a 0Ω link (1206) at position C1 instead of the fitted 0Ω link (1206).
   - For all accessories with a single-ended speaker (referenced to ground), fit a 4.7µF capacitor (ceramic, 1206, X7R, 16V) at position C1.
   - To disable the radio's internal speaker, fit a 0Ω link (0603) at position R3.
   - When using an external switch to control the ACC PTT line, for example in a hands-free vehicle kit, fit a 0Ω (0603) link at position R4.
   - To enable an external function button, fit a 12kΩ resistor (0603, 1/10W ±5%) at position R1.

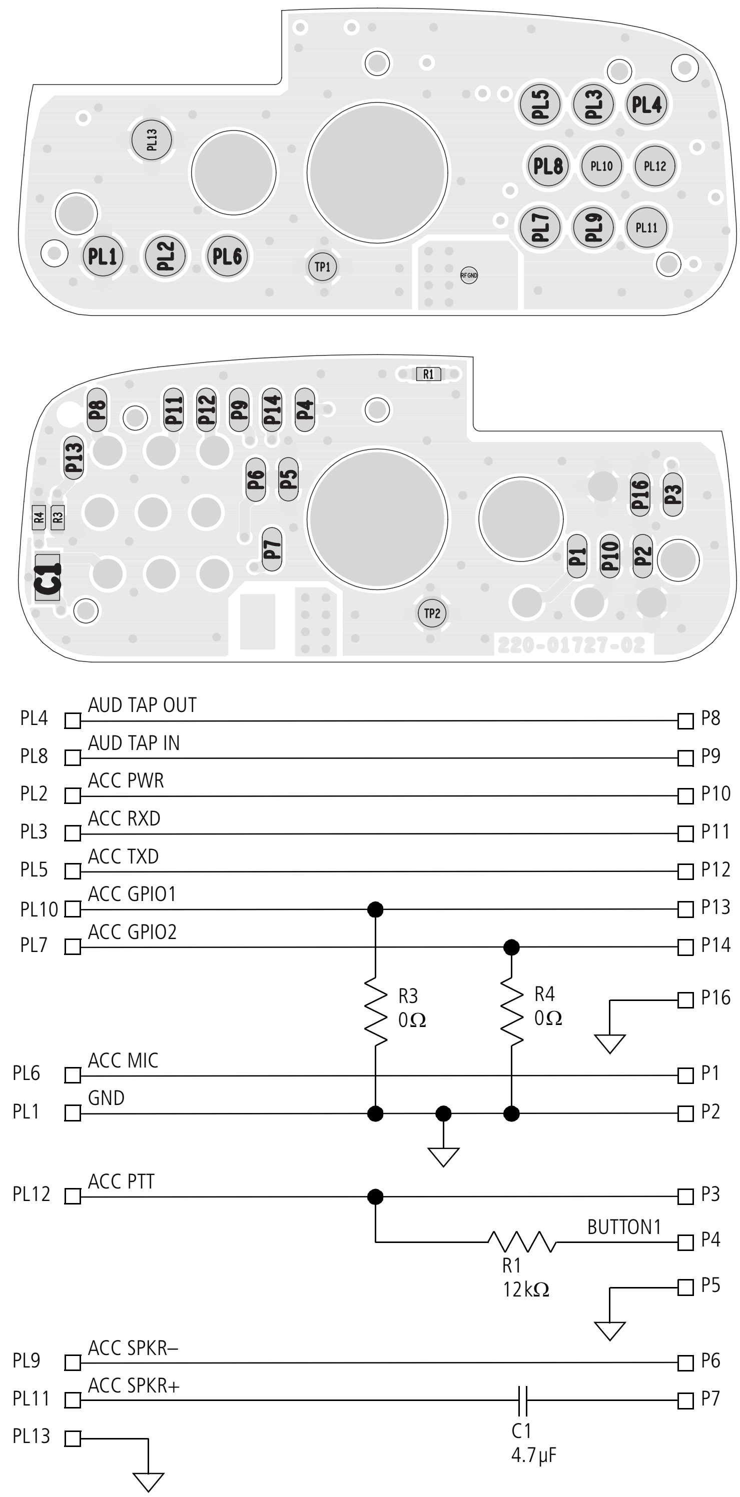
6. Reassemble the kit as described in "Disassembly and Reassembly" on page 338.

Table 16.1 Accessory connector – pads and signals

Signal name	Pad	Description	Signal type	Signal level	Output impedance/ current	Input impedance
AUD TAP OUT	P8	Programmable tap point out of the Rx or Tx audio chain, DC-coupled	Analog audio	$0.69V_{pp}$ for 60% deviation at 1kHz (–10dBm into 600Ω)	600Ω	–
AUD TAP IN	P9	Programmable tap point into the Rx or Tx audio chain, DC-coupled	Analog audio	$0.69V_{pp}$ for 60% deviation at 1kHz (–10dBm into 600Ω)	–	100kΩ DC to 100kHz
ACC PWR	P10	Accessory power	DC supply	3.3V nominal	100mA (max)	–
ACC RXD	P11	Serial receive data	3V3 CMOS	high=0 low=1	–	–
ACC TXD	P12	Serial transmit data	3V3 CMOS	high=0 low =1	1mA (max)	–
ACC GPIO1	P13	Accessory sense (internal speaker disable)	3V3 CMOS	high=1 low=0	1mA (max)	–
ACC GPIO2	P14	Accessory sense	3V3 CMOS	high=1 low=0	1mA (max)	–
ACC MIC	P1	External microphone input (electret) Dynamic microphones are not supported.	Analog audio	$9.5V_{rms}$ for 60% modulation at 1kHz, DC-coupled	–	2.2kΩ
GND	P2	Analog ground	Ground	–	–	–
ACC PTT	P3	External press-to-talk input	Analog DC	0 to 2.5V, PTT=0	–	27kΩ
ACC SPKR–	P6	External speaker differential output	Analog audio	$+6.5V_{pp}$[a] differential	To drive 16Ω differentially	–
ACC SPKR+	P7	External speaker differential output	Analog audio	$+6.5V_{pp}$[a] differential	To drive 16Ω differentially	–

a. Dependent on battery charge level.

Figure 16.1 Accessory connector PCB and circuit diagram



16.2 Disassembly and Reassembly

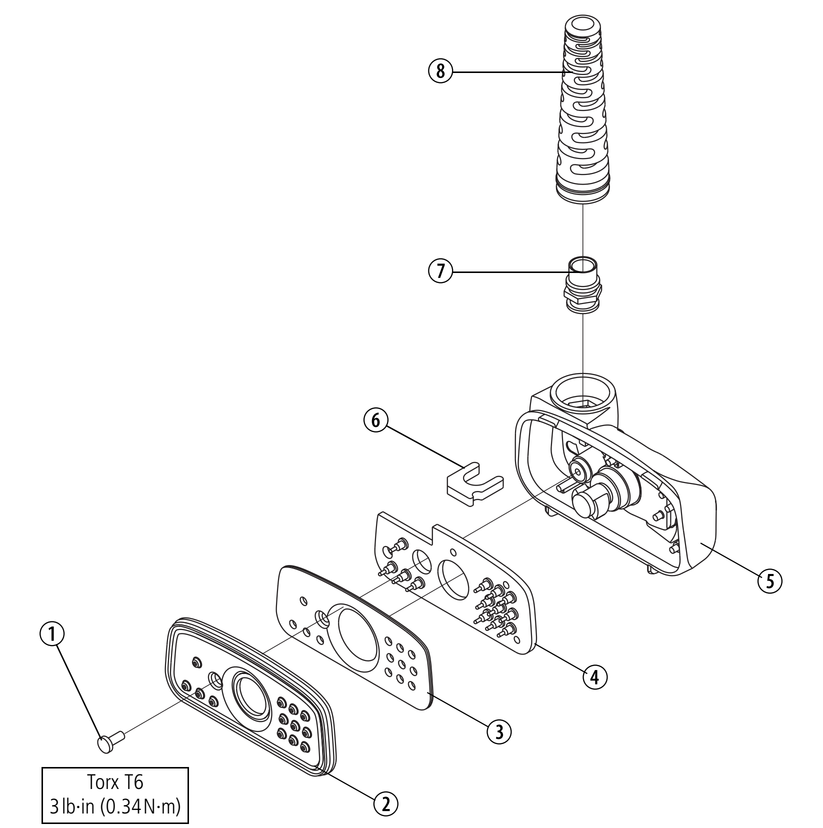
1. Use a Torx T6 screwdriver to remove the screw ①, and remove the accessory housing seal ②, the accessory seal plate ③, and the accessory connector PCB ④.

2. Use pliers to pull out the clamp ⑥, and remove the strain relief ⑧, and the insert ⑦.

Important During reassembly, make sure that the accessory housing seal ② is inserted correctly inside the accessory connector housing ⑤.

Reassembly is carried out in reverse order of the disassembly.

Figure 16.2 Components of the accessory connector kit



① Torx T6 screw
② accessory housing seal
③ accessory seal plate
④ accessory connector PCB
⑤ accessory connector housing
⑥ clamp
⑦ insert
⑧ strain relief

17 TPA-AA-202 Accessory Cable Kit

Caution **The radio produces a specific audio level at the maximum rated power. It is the sole responsibility of the end-user to ensure applicability and compliance with the relevant legal regulations defining the noise level an individual can be subjected to.**

The TPA-AA-202 accessory cable kit is used to connect external third-party accessories, such as speaker microphones and headsets, to the accessory connector at the rear of the radio.

17.1 Connecting an Accessory

1. Verify that your accessory is compatible with the accessory connector, refer to Table 17.1.

2. When connecting an accessory, make sure it meets the following specifications:

   - speaker impedance: 32Ω (16Ω min.)
   - speaker power: 0.25 W_{rms} (min.)
   - microphone: electret, approximately 1kΩ
   - PTT switch: not in series with microphone.

Note If your accessory has a PTT switch in series with the microphone, the accessory cannot be used. The PTT needs to be a separate signal and must be made available at the connector separately; it must not be multiplexed on any other signal.

3. Disassemble the kit as described in "Disassembly and Reassembly" on page 342.

4. Solder the wires of the accessory cable kit to the interface of your accessory (refer to Table 17.1 on page 340).

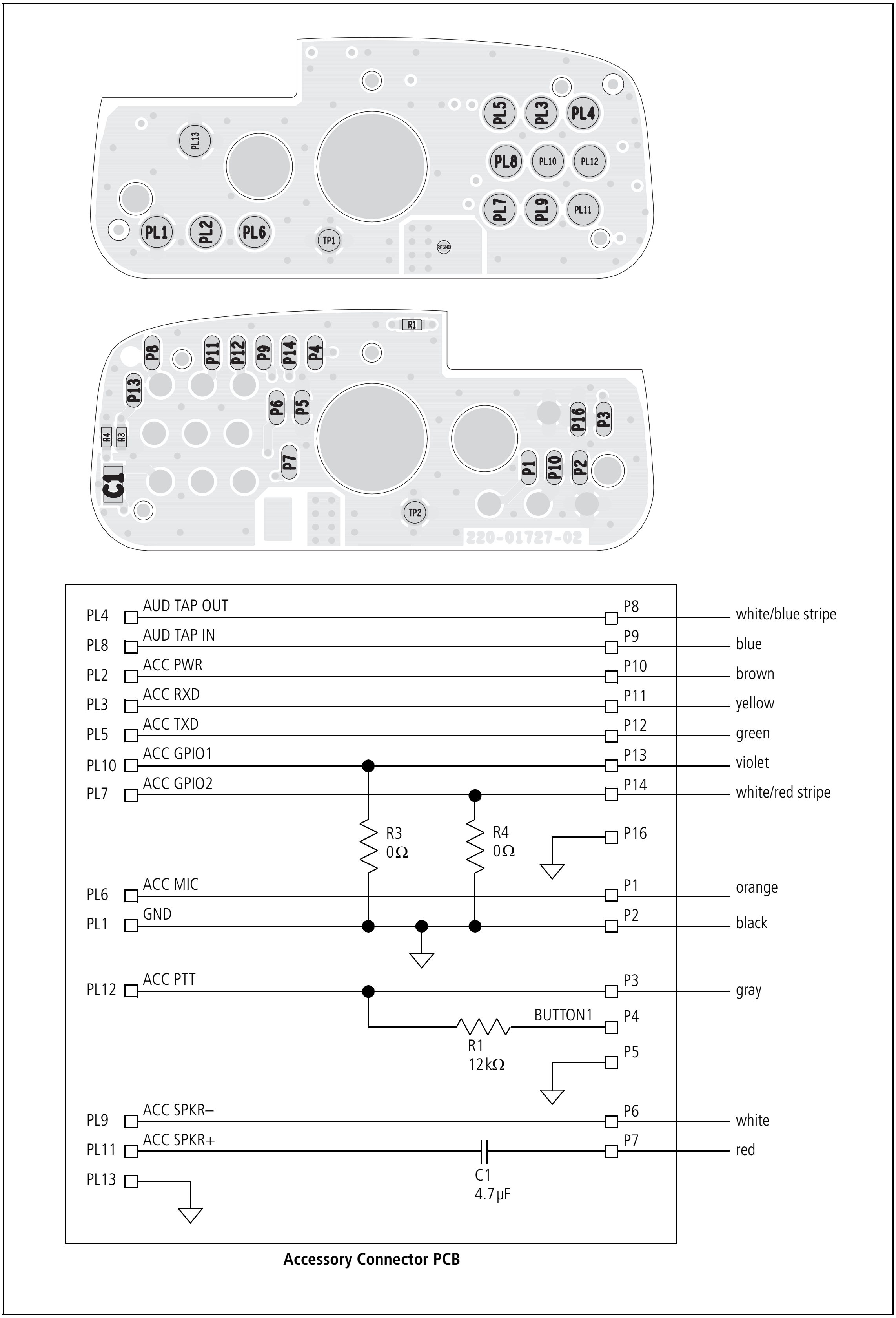
5. Modify the components on the accessory connector PCB as follows (refer to Figure 17.1). Note that some components may already be fitted by default.
   - For all accessories with differential speaker (not referenced to ground), fit a 0Ω link (1206) at position C1.
   - For all accessories with a single-ended speaker (referenced to ground), fit a 4.7µF capacitor (ceramic, 1206, X7R, 16V) at position C1 instead of the fitted 0Ω link (1206).
   - To disable the radio's internal speaker, fit a 0Ω link (0603) at position R3.
   - When using an external switch to control the ACC PTT line, for example in a hands-free vehicle kit, fit a 0Ω (0603) link at position R4.
   - To enable an external function button, fit a 12kΩ resistor (0603, 1/10W ±5%) at position R1.
6. Reassemble the kit as described in "Disassembly and Reassembly" on page 342.

Table 17.1 Accessory cable – wires and signals

Signal name	Wire	Description	Signal type	Signal level	Output impedance/ current	Input impedance
AUD TAP OUT	white/ blue stripe	Programmable tap point out of the Rx or Tx audio chain, DC-coupled	Analog audio	$0.69V_{pp}$ for 60% deviation at 1kHz (–10dBm into 600Ω)	600Ω	–
AUD TAP IN	blue	Programmable tap point into the Rx or Tx audio chain, DC-coupled	Analog audio	$0.69V_{pp}$ for 60% deviation at 1kHz (–10dBm into 600Ω)	–	100kΩ DC to 100kHz
ACC PWR	brown	Accessory power	DC supply	3.3V nominal	100mA (max)	–
ACC RXD	yellow	Serial receive data	3V3 CMOS	high=0 low=1	–	–
ACC TXD	green	Serial transmit data	3V3 CMOS	high=0 low=1	1mA (max)	–
ACC GPIO1	violet	Accessory sense (internal speaker disable)	3V3 CMOS	high=1 low=0	1mA (max)	–
ACC GPIO2	white/ red stripe	Accessory sense	3V3 CMOS	high=1 low=0	1mA (max)	–
ACC MIC	orange	External microphone input (electret) Dynamic microphones are not supported.	Analog audio	$9.5V_{rms}$ for 60% modulation at 1kHz, DC-coupled	–	2.2kΩ
GND	black	Analog ground	Ground	–	–	–
ACC PTT	gray	External press-to-talk input	Analog DC	0 to 2.5V, PTT=0	–	27kΩ
ACC SPKR–	white	External speaker differential output	Analog audio	$+6.5V_{pp}$ [a] differential	To drive 16Ω differentially	–
ACC SPKR+	red	External speaker differential output	Analog audio	$+6.5V_{pp}$ [a] differential	To drive 16Ω differentially	–

a. Dependent on battery charge level.

Figure 17.1 Accessory connector PCB and circuit diagram



17.2 Disassembly and Reassembly

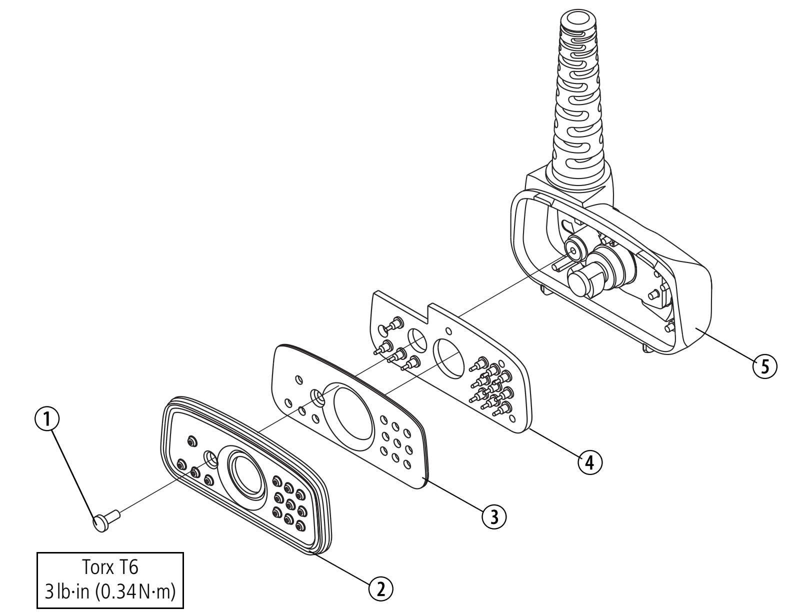
1. Use a Torx T6 screwdriver to remove the screw ①, and remove the accessory housing seal ②, and the accessory seal plate ③.

2. Fold out the accessory connector PCB ④.

Important During reassembly, make sure that the accessory housing seal ② is inserted correctly inside the accessory connector housing ⑤.

Reassembly is carried out in reverse order of the disassembly.

Figure 17.2 Components of the accessory cable kit



① Torx T6 screw

② accessory housing seal

③ accessory seal plate

④ accessory connector PCB

⑤ accessory connector housing

18 TPA-AA-210 Hirose Accessory Adapter

Caution **The radio produces a specific audio level at the maximum rated power. It is the sole responsibility of the end-user to ensure applicability and compliance with the relevant legal regulations defining the noise level an individual can be subjected to.**

The TPA-AA-210 Hirose accessory adapter is used to connect the following recommended Hirose accessories, available from Tait and OTTO Communications (www.ottoeng.com):

Table 18.1 Compatible Hirose accessories from Tait and Otto

Tait Part No.	Otto Part No.	Description
TPA-AA-211	V4BA1TP1	Light-duty breeze headset
TPA-AA-212	V4-10482	Heavy-duty BTH headset
TPA-AA-213	V1-10163	3-wire mini-lapel microphone kit (beige)
–	V4-10190	Single-speaker headset
–	V4-HC2MD3B	Hurricane headset
–	V1-T12MD137	Tactical throat microphone
–	V1-10167	Earphone (beige)
–	V1-10168	Earphone (black)
–	V1-10165	2-wire palm microphone (beige)
–	V1-10166	2-wire palm microphone (black)
–	V1-10164	2-wire mini-lapel microphone kit (black)
–	V1-10777	2-wire earbud kit
–	V4-10279	Skull microphone

18.1 Connecting an Accessory

1. Verify that your accessory is compatible with the Hirose accessory adapter, refer to Table 18.2.

2. When connecting an accessory, make sure it meets the following specifications:
   - speaker impedance: 32Ω (16Ω min.)
   - speaker power: 0.25 W_{rms} (min.)
   - speaker configuration: single-ended
   - microphone: electret, approximately 1kΩ
   - PTT switch: not in series with microphone.

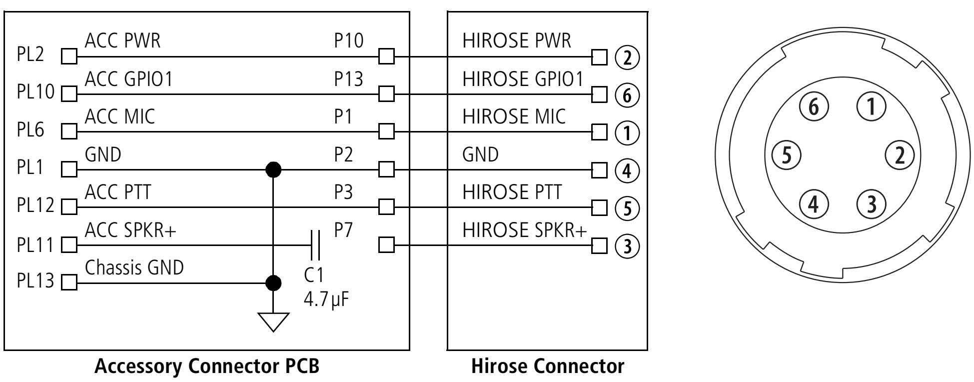
Note If your accessory has a PTT switch in series with the microphone, the accessory cannot be used. The PTT needs to be a separate signal and must be made available at the connector separately; it must not be multiplexed on any other signal

Table 18.2 Hirose accessory adapter – pins and signals

Signal name	Pin	Description	Signal type	Signal level	Output impedance/ current	Input impedance
HIROSE MIC	1	External microphone input (electret) Dynamic microphones are not supported.	Analog audio	9.5V_{rms} for 60% modulation at 1kHz, DC-coupled	–	2.2kΩ
HIROSE PWR	2	Accessory power	DC supply	3.3V nominal	100mA (max)	–
HIROSE SPKR+	3	External speaker output	Analog audio	+6.5V_{pp}[a]	To drive 16Ω	–
GND	4	Analog ground	Ground	–	–	–
HIROSE PTT	5	External press-to-talk input	Analog DC	0 to 2.5V, PTT=0	–	27kΩ
HIROSE GPIO1	6	Accessory sense (internal speaker disable)	3V3 CMOS	high=1 low=0	1mA (max)	–

a. Dependent on battery charge level.

Figure 18.1 Hirose accessory adapter – pinout and circuit diagram



Note Connecting the Hirose adapter to the radio alone does not mute the internal speaker of the radio. The internal speaker is muted when the accessory is connected to the Hirose adapter.

18.2 Disassembly and Reassembly

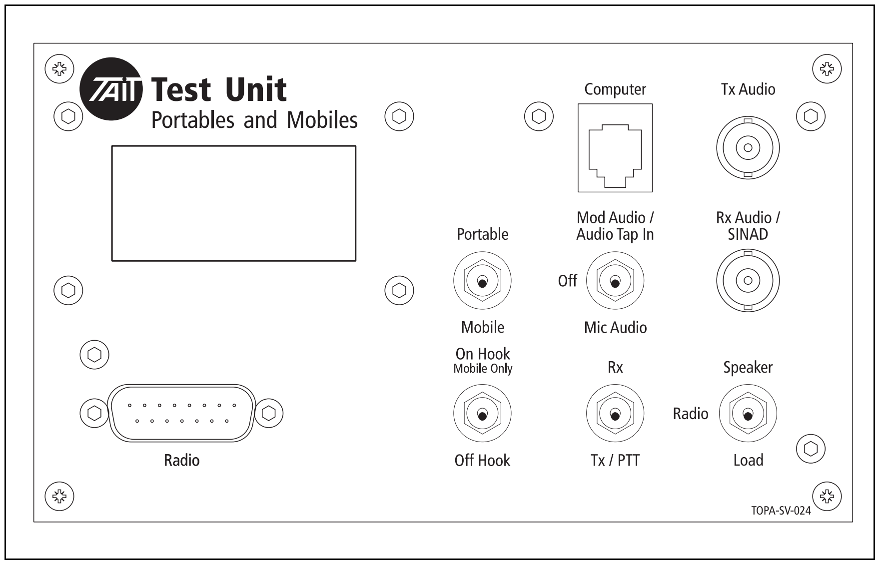
Disassembly and reassembly is the same as the TPA-AA-201 accessory connector kit, refer to "Disassembly and Reassembly" on page 338.

19 TOPA-SV-024 Test Unit

The TOPA-SV-024 test unit is used to test and maintain Tait portable and mobile radios by providing an interface between the radio, a test PC, and an RF communications test set.

The diagram below shows the front panel of the test unit.

Figure 19.1 TOPA-SV-024 test unit

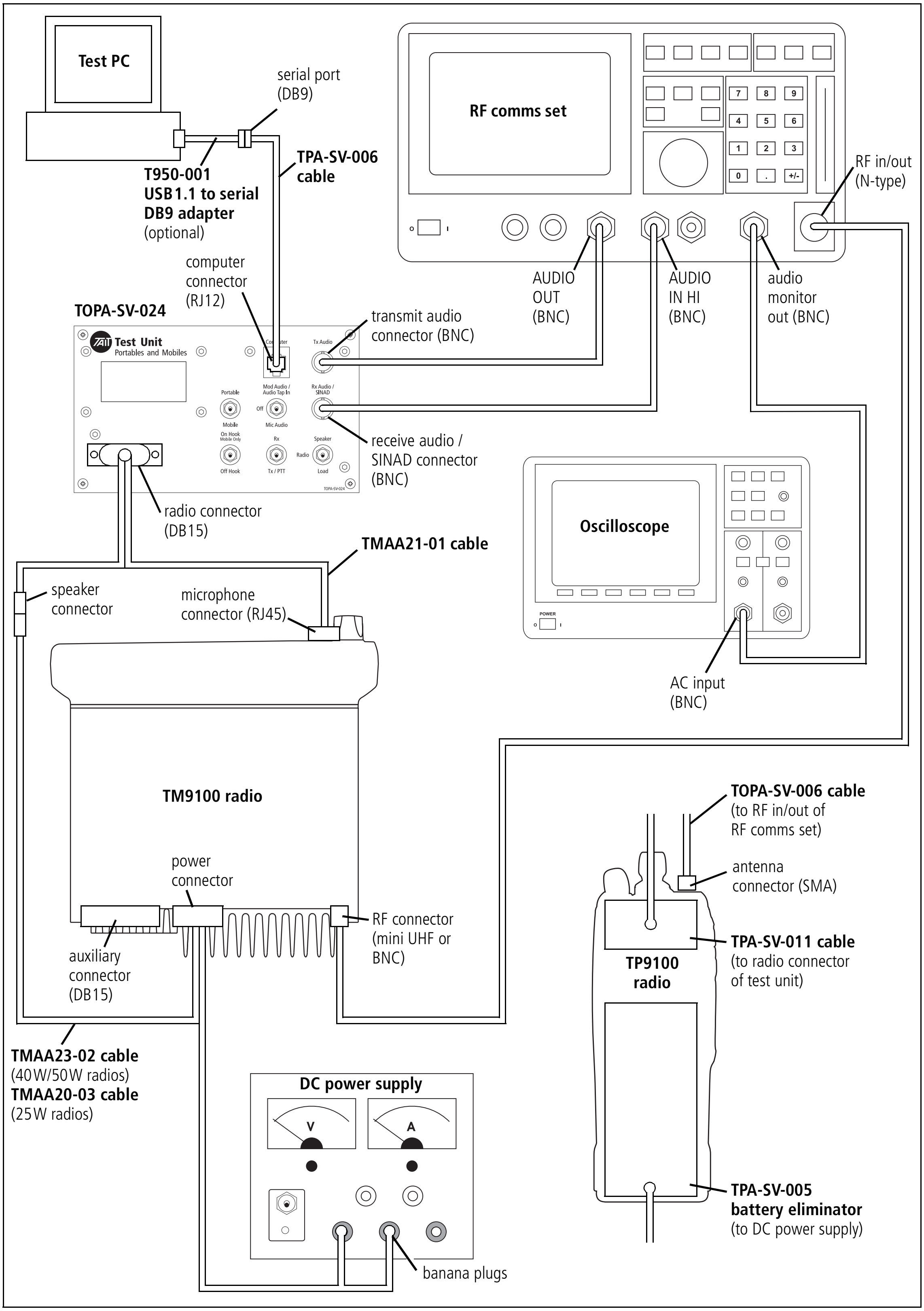


19.1 Test Setup

The diagram on the following page shows how the test unit is connected to the radio, the test PC, and the RF communications test set.

Note The test unit can also be connected to a Tait Orca portable radio (TOP) using the TOPA-SV-007 cable, or to a T2000 radio using the T2000-11 cable. Use with Tait Orca and T2000 radios is not described in this section.

Figure 19.2 Test setup



19.2 Operation

This section explains the function of the TOPA-SV-024 test unit controls. The procedure for using the test unit is described in "Test Equipment Setup" on page 88.

19.2.1 Portable / Mobile Switch

This 2-way toggle switch is used to switch attenuation resistors (R4, R5, R6) in and out of the line from the radio's positive speaker output to the positive receive audio/SINAD output of the test unit (before the isolating transformer).

- When set to **Portable**, the attenuation resistors are switched out.
- When set to **Mobile**, the attenuation resistors are switched in (attenuation 10:1).

Important Selecting the wrong switch position may result in incorrect SINAD readings and damage to the test unit.

19.2.2 Mod Audio/Audio Tap In / Off / Mic Audio Switch

This 3-way toggle switch is used to switch between **Mod Audio/Audio Tap In**, **Mic Audio**, and **Off** (no audio signal).

- With the Tait Orca portables, this switch can be used for setting up dual point modulation by applying modulation to different parts of the radio.
- For normal transmit deviation tests (other portables and mobiles), this switch is set to **Mic Audio**.

19.2.3 On Hook / Off Hook Switch

Important When using the test unit with portables, the **On Hook / Off Hook** toggle switch **must** be set to **Off Hook**. Portables do not have a hookswitch, and if the switch is set to **On Hook**, the accessory function key of the portable is activated.

This 2-way toggle switch is used to simulate the microphone hookswitch opening ("hook off") and closing ("hook on"). This is done by switching a 12kΩ resistor (R3) in or out of the MIC_PTT line.

- When set to **Off Hook**, the 12kΩ resistor (R3) is switched out of the MIC_PTT line. This simulates the microphone being removed from the microphone clip.
- When set to **On Hook**, a 12kΩ resistor (R3) is switched into the MIC_PTT line. This simulates the microphone being placed on the microphone clip.

19.2.4 Rx / Tx/PTT Switch

This 2-way toggle switch is used to switch between receive and transmit mode.

- When set to **Rx**, the PTT line is switched to high impedance.
- When set to **Tx/PTT**, the PTT line is pulled to ground.

19.2.5 Speaker / Radio / Load Switch

This 3-way toggle switch is used during receive audio tests to switch the audio to the test unit speaker (**Speaker**), to the radio's internal speaker (**Radio**) or to a dummy load consisting of R1 and R2 (**Load**).

Note This switch does not disconnect the radio's internal speaker on mobiles. If the switch is set to **Speaker** or **Load**, this simulates an external speaker being connected in parallel to the radio's internal speaker.

With all settings, a low level audio signal is available for testing through the SINAD port.

Portable

- When set to **Speaker**, only the speaker of the test unit is active.
- When set to **Radio**, only the speaker of the portable is active.
- When set to **Load**, no speaker is active. The audio signal is terminated in the test unit dummy load.

Mobile

- When set to **Speaker**, the speakers of the test unit and the mobile are both active. The speaker of the mobile cannot be disconnected.
- When set to **Radio**, only the speaker of the mobile is active.
- When set to **Load**, the speaker of the mobile remains active.

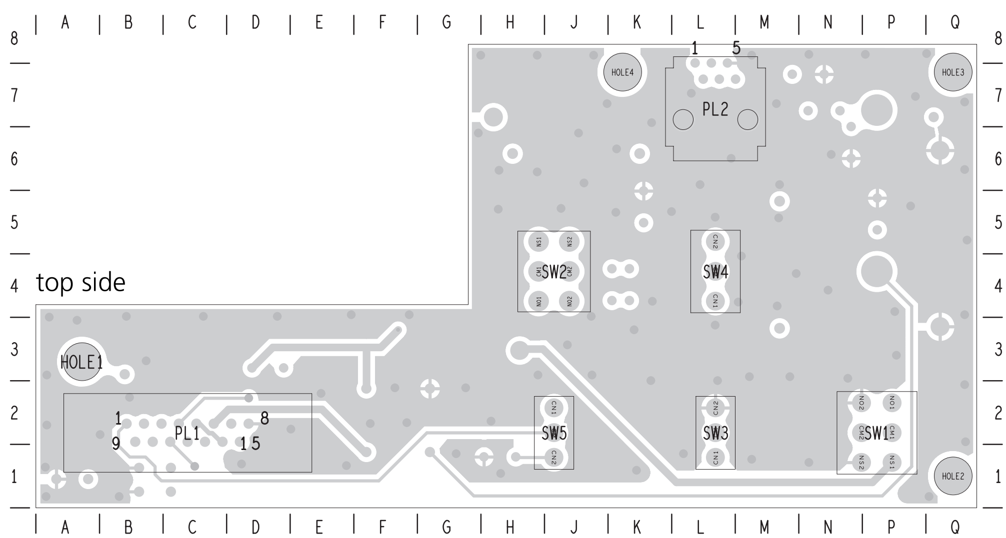
19.3 PCB Information (PCB IPN 220-01418-02A)

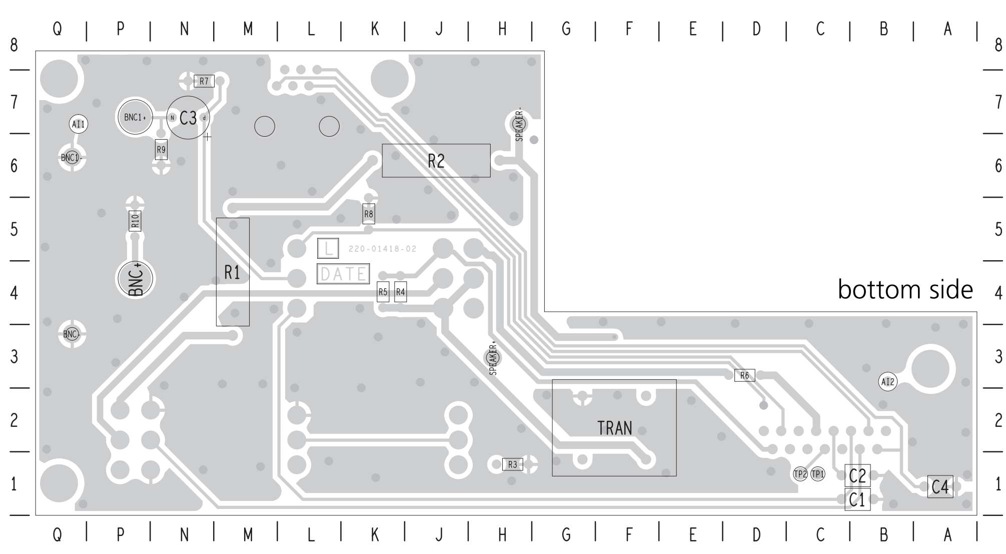
19.3.1 Parts List (Rev. 4)

Ret.	IPN	Description
BNC1	240-02100-11	Skt Coax BNC 3.5mm Pnl N/Tag
BNC2	240-02100-11	Skt Coax BNC 3.5mm Pnl N/Tag
C1	011-54100-01	Cap Cer Al 1n 10% T/C B 50v
C2	011-54100-01	Cap Cer Al 1n 10% T/C B 50v
C3	020-59100-06	Cap Elec Rdl 100m 16v 6.3x11
C4	011-54100-01	Cap Cer Al 1n 10% T/C B 50v
PL1	240-00010-55	Plg 15w Drng W-Wrap Pnl Mtg
PL2	240-04021-60	Skt 6w Modr Ph Vrt T-Ent
R1	032-31820-01	Res M/F Pwr 17x5 8e2 5% 2.5w
R2	032-31820-01	Res M/F Pwr 17x5 8e2 5% 2.5w
R3	030-55120-20	Res Flm 4x1.6 12k 5% 0.4w
R4	030-53560-20	Res Flm 4x1.6 560e 5% 0.4w
R5	030-54270-20	Res Flm 4x1.6 2k7 5% 0.4w
R6	030-52560-20	Res Flm 4x1.6 56e 5% 0.4w
R7	030-55100-20	Res Flm 4x1.6 10k 5% 0.4w

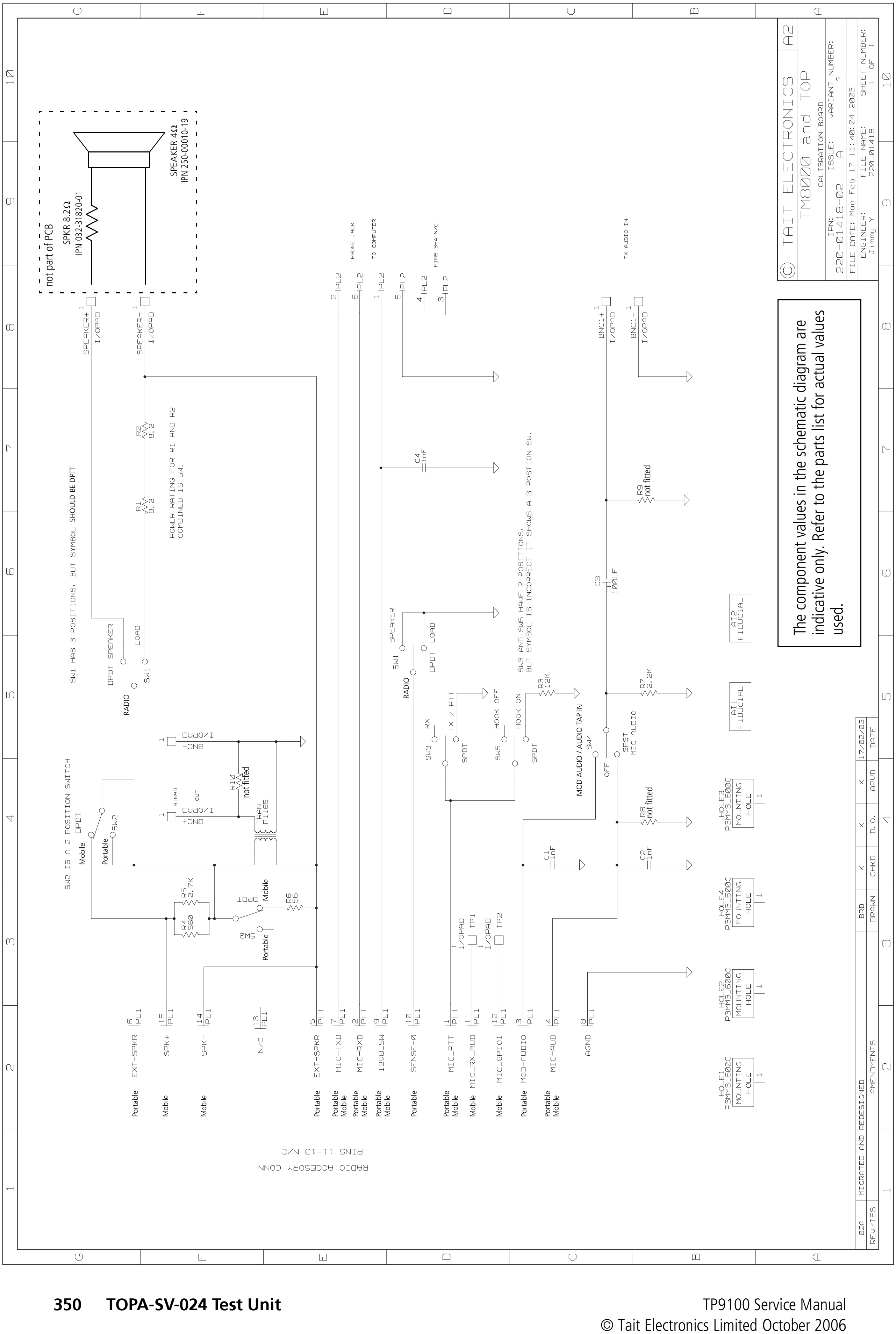
Ret.	IPN	Description
SW1	230-00010-42	Sw Tgl On Off On Dpdt Ms500hb
SW2	230-00010-57	Sw Tgl Dpdt On-On Pnl Mtg
SW3	230-00010-03	Sw Tgl Spst Mini Pnl Mtg
SW4	230-00010-16	Sw Tgr Spst 3-Pos Pnl Mtg
SW5	230-00010-03	Sw Tgl Spst Mini Pnl Mtg
TRAN	054-00010-17	Xfmr Line 600 Ohm 1:1
Not part of the PCB:		
SPKR	032-31820-01	Res M/F Pwr 17x5 8e2 5% 2.5w
	250-00010-19	Spkr C/W Rubber Sealing Ring

19.3.2 PCB Layout





19.3.3 Circuit Diagram



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