TM8000 mobiles

TM8000 3DK Hardware Developer's Kit
Application Manual

MMAA30-01-00-807 Version 1.01a (TEA)

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Contents

Preface

Scope of Manual

This manual contains a description of the radio interfaces and information on how to integrate third-party products and create internal and control-head options boards for TM8105 and TM8115 radios.

Enquiries and Comments

If you have any enquiries regarding this manual, or any comments, suggestions and notifications of errors, please contact Technical Support, Tait Electronics Ltd, Christchurch, New Zealand (refer to "Contact Information" on page 2).

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Associated Documentation

TM8100 Mobile Radio User's Guide (MM8100-00-03-804)

TM8100 Mobile Radio Service Manual (MM8100-02-00-812)

TM8100 Mobile Radio Accessories Manual (MMAA00-00-00-812)

TMAA30-02 TM8000 3DK Application Board Service Manual (MMAA30-02-00-812)

TMAA30-02 TM8000 3DK Application Board Software Manual (MMAA30-02-00-429)

TM8100 Computer-Controlled Data Interface (CCDI) Protocol Manual (MM8100-00-00-441)

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1	September 2003	1st release

Alert Notices

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

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

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

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

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

Abbreviations

Abbreviation	Description
3DK	Third-Party Developer's Kit
AGND	Analogue Ground
ALC	Automatic Level Control
ANI	Automatic Number Identification
AUD	Audio
AUX	Auxiliary
BCD	Binary-Coded Decimal
BIN	Binary
BNC	Bayonet Neill Concelman (RF connector)
CCDI	Computer-Controlled Data Interface
CH	Control Head
CMOS	Complementary Metal Oxide Semiconductor
COM	Communication (Port)
CTS	Clear to Send
DGND	Digital Ground
DSP	Digital Signal Processor
DTE	Data Terminal Equipment
EMC	Electromagnetic Compatibility
ESD	Electrostatic Discharge
ESR	Equivalent Series Resistance
FFSK	Fast Frequency Shift Keying
GND	Ground

Abbreviation	Description
GPIO	General Purpose Input/Output
GPS	Global Positioning System
I/O	Input/Output
IOP	Internal Options Port
IPN	Internal Part Number
LED	Light-Emitting Diode
LK1…LK4	Hardware Link 1…4
LSB	Least Significant Bit
MB	Medium Band
MIC	Microphone
N/A	Not Applicable
NB	Narrow Band
NMEA	National Marine Electronics Association
OTAR	Over-the-Air Rekeying
PA	Power Amplifier
PCB	Printed Circuit Board
PRG	Program
PSU	Power Supply Unit
PTT	Press To Talk
RF	Radio Frequency
RSD	Rated System Deviation
RSSI	Received Signal Strength Indicator
RTS	Request to Send
Rx	Receive
RXD	Receive Data
S/N	Signal/Noise
SCADA	Supervisory Control and Data Acquisition
SDM	Short Data Message
SMD	Surface-Mounted Device
SPK	Speaker
TTL	Transistor-Transistor Logic
Tx	Transmit
TXD	Transmit Data
UART	Universal Asynchronous Receiver/Transmitter
USB	Universal Serial Bus
WB	Wide Band

1 Introduction

This manual provides you with the information required to:

- interface to the radio and configure the programmable I/O lines:
  - "Description of the Radio Interfaces" on page 15
  - "Programmable I/O Lines" on page 39
- build your own options boards:
  - "Creating Your Own Options Board" on page 85
- interface application devices:
  - "Description of the Radio Interfaces" on page 15
  - "Programmable I/O Lines" on page 39
  - "Connecting Third-Party Products" on page 97
- connect an external alarm to the radio:
  - "Connecting an External Alert Device" on page 133
- configure the radio for different power configurations:
  - "Power Sense Options" on page 121
  - "Connector Power Supply Options" on page 131
  - "Description of the Radio Interfaces" on page 15
  - "Programmable I/O Lines" on page 39
- replace a T2000 radio and a T2000-A81 board with a TM8100 radio:
  - "Replacing the Tait T2000-A81 Board" on page 117
  - "Description of the Radio Interfaces" on page 15
  - "Programmable I/O Lines" on page 39

Refer to the technical support website for the latest information on the integration of application devices (refer to "Contact Information" on page 2).

2 Description of the Radio Interfaces

This chapter describes the characteristics of the mechanical and electrical interfaces of the radio body and the TM8115 control head or the TM8105 blank control head, which are suitable for the connection of TM8000 or application accessories and equipment.

Figure 2.1 provides an overview of the TM8000 interfaces:

Figure 2.1 TM8000 interfaces (with TM8115 control head)

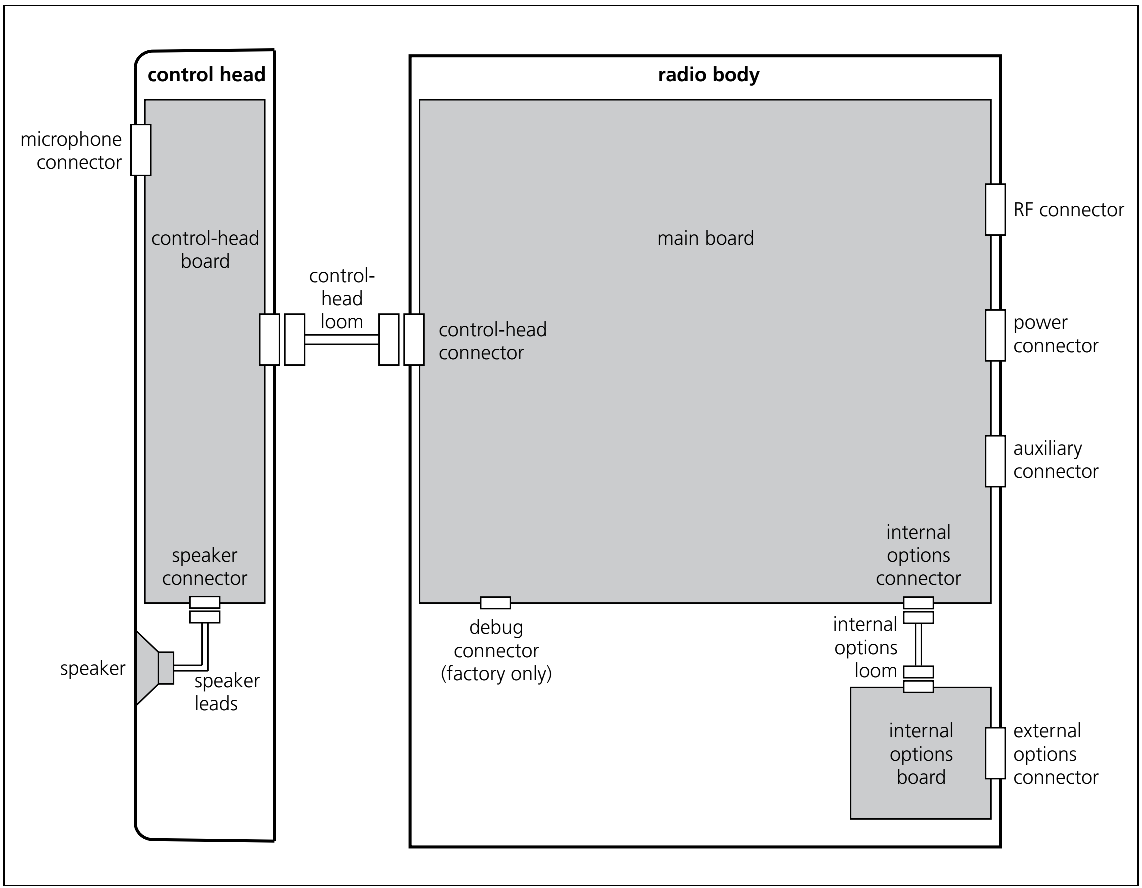


Figure 2.2 shows the connectors of the radio body.
Figure 2.3 shows the connectors of the TM8115 control head.
Figure 2.4 shows the connectors of the TM8105 blank control head.

For more block and circuit diagrams refer to the PCB Information chapter of the TM8100 Mobile Radio Service Manual.

Figure 2.2 Connectors of the radio body

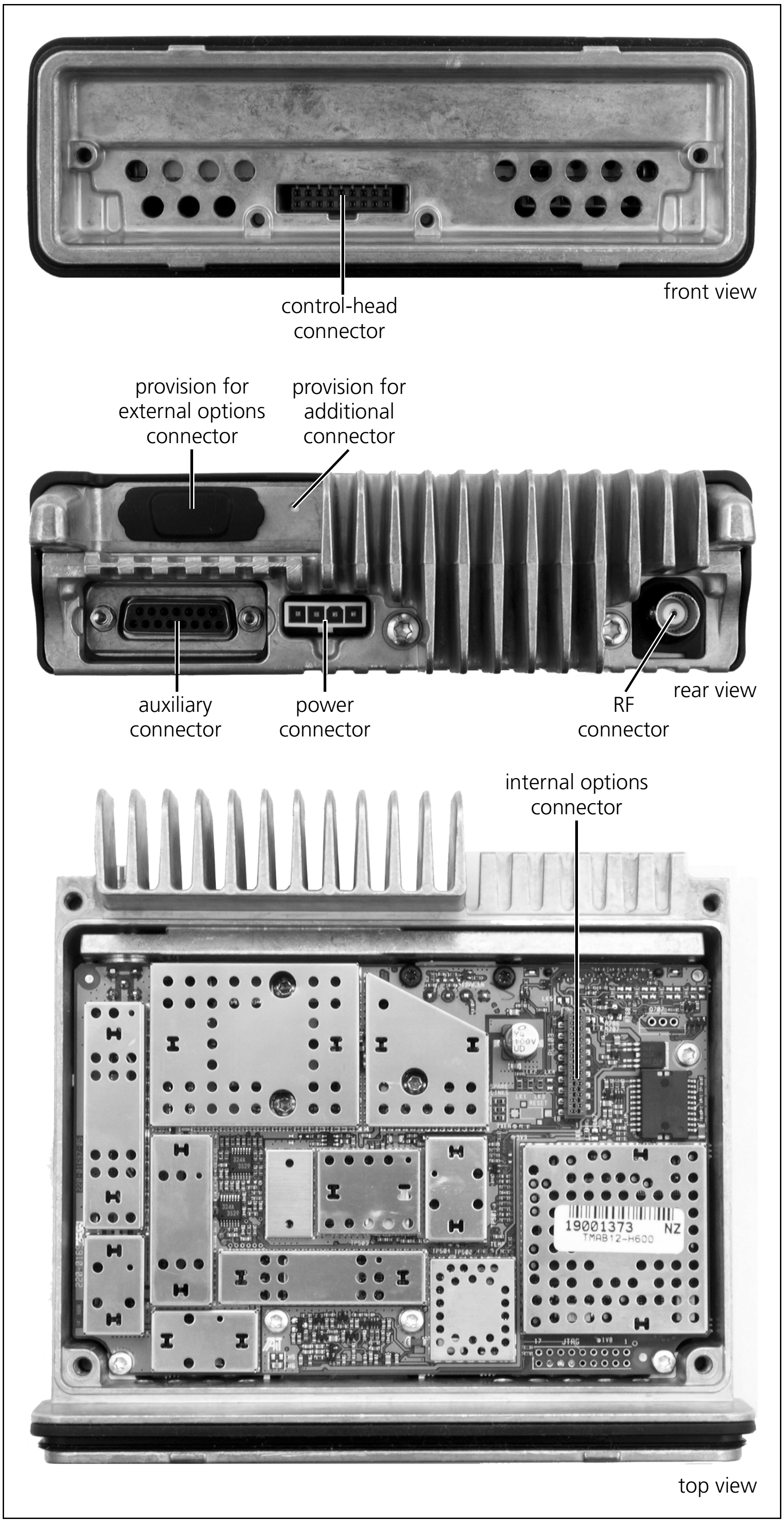


Figure 2.3 Connectors of the TM8115 control head

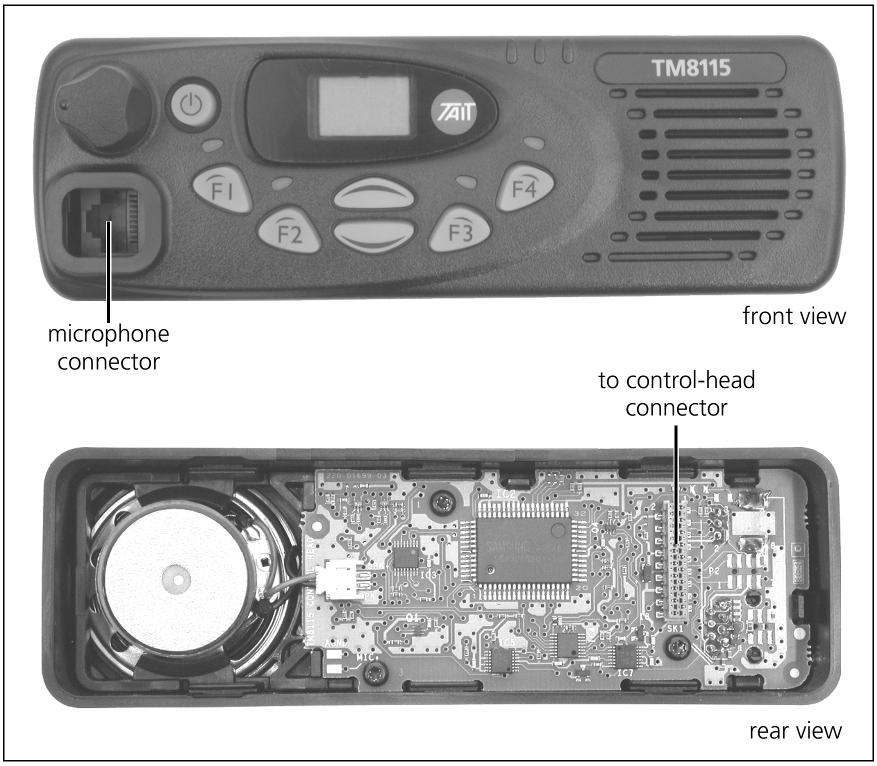
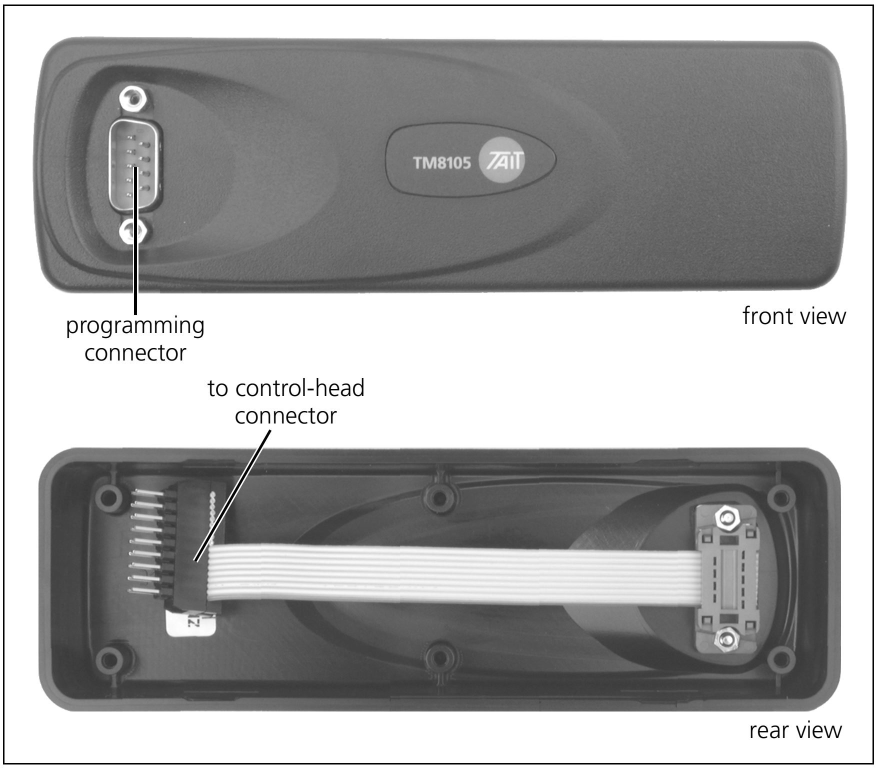


Figure 2.4 Connectors of the TM8105 blank control head

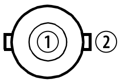


2.1 RF Connector

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

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

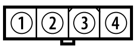
Table 2.1 RF connector - pins and signals

Pinout	Pin	Signal Name	Signal Type
 rear view	1	RF	RF analogue
	2	GND	RF ground

2.2 Power Connector

The power connector is the interface for the primary 13.8 V power source and the external speaker. The primary power source can be the vehicle battery or a mains-fed DC power supply. The power connector provides connection for an external speaker.

Table 2.2 Power connector - pins and signals

Pinout	Pin	Signal name	Description	Signal type
 rear view	1	AGND	Earth return for radio body power source.	Ground
	2	SPK–	External speaker output. Balanced load configuration.	Analogue
	3	SPK+	External speaker output. Balanced load configuration.	Analogue
	4	13V8_BATT	DC power input for radio body and control head.	Power

Warning!! **Danger of Fire! The protection mechanisms in Table 2.3 rely on the correct fuses in both the negative and positive power supply leads being present. Failure to fit the correct fuses may result in fire or damage to the radio.**

Table 2.3 Power connector - power supply input characteristics

Parameter	Standard				Test method and conditions	Comments
	min.	typ.	max.	units		
Radio operating range[a,b]	9.7		17.2	V		
Auto-recovery limits[b]	10.2		16.8	V	After supply voltage excursion outside the radio operating range	
Safe input range[b,c]	–0.5		30	V	No hardware damage.	
Reverse polarity protection	Crowbar diode with in-line fuse					Replacement fuse: Tait IPN 265-00010-80 or Littelfuse[d] part number 314010 or equivalent.
Cranking earth current protection	In-line fuse with negative lead					

a. While the transceiver will operate over this range RF performance to specification applies over 10.8 to 16.0V.

b. Outside the radio operating range the radio will shutdown. Auto recovery will occur if the supply voltage returns to within the auto recovery limits specified. Depending on the power sense option selected, auto recovery may not occur if supply voltage drops below 4V prior to returning to within the auto recovery limits.

c. Application of steady state voltage higher than 30V will cause the crowbar diode (D600) to fail short circuit and in-line fuse to blow. The radio will survive transients above 30V within the 95/54/EC standard.

d. Littelfuse is a registered trademark of Littelfuse Incorporated. Refer to www.littelfuse.com.

Important The speaker load configuration is balanced; no speaker output line must be connected to ground. Connecting a speaker output line to ground will cause audio power amplifier shutdown

Table 2.4 Power connector - speaker output characteristics

Parameter	Standard				Test method and conditions	Comments
	min.	typ.	max.	units		
Load configuration	Balanced					
Load	3.2			Ω		
Maximum power	10			W	Into 4Ω.	
Rated duty cycle			33	%	1 min at maximum power: 2 min Rx standby	
Rated audio power	3			W	Into 16Ω via external speaker port. Internal speaker is disconnected.	This is 'rated audio power' for the purposes of all external standards.

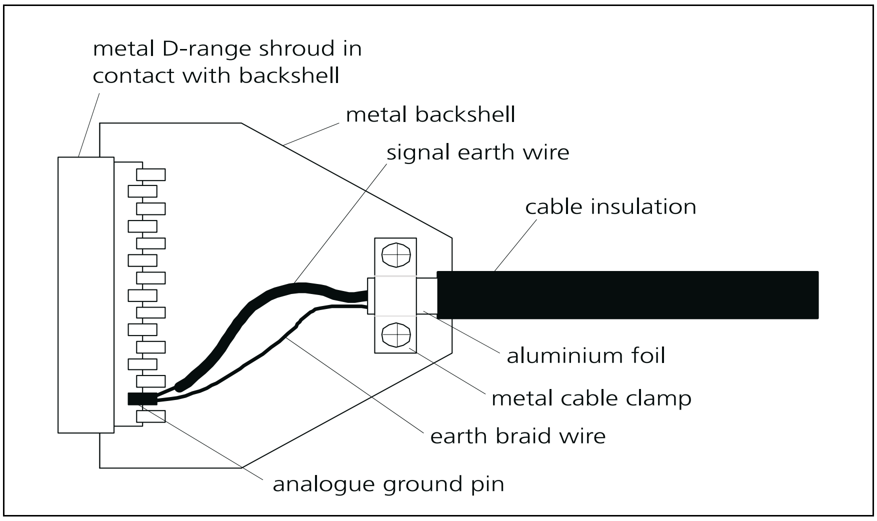
2.3 Auxiliary Connector

The auxiliary connector is the standard interface for external devices that are typically connected to a radio. The auxiliary connector is a 15-way standard-density D-range socket. The auxiliary connector provides a serial port, three programmable input lines, four programmable digital I/O lines and audio I/O.

Note The space for a mating plug is limited to 41mm in width and 18mm in height. Although most plugs will fit this space, it is recommended to test the plug to be used before manufacturing a cable. The internal options kit (described on page 89) includes a suitable plug (Tait IPN 240-00020-55).

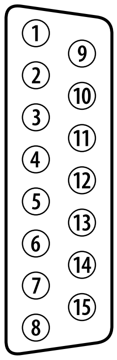
If the auxiliary cable is longer than 1 metre it is recommended to shield the cable and connector backshell. Figure 2.5 shows the recommended shielding arrangement. The earth braid wire (bare copper) and aluminium foil should only be earthed at the radio end of the cable.

Figure 2.5 Recommended auxiliary cable and connector shielding



The I/O lines can be programmed for a variety of functions, logic levels and in some cases direction (refer to "Programmable I/O Lines" on page 39). Audio lines can also be programmed to tap into or out of different points in the audio processing chain (refer to "Audio Tap In and Tap Out Lines" on page 80).

Table 2.5 Auxiliary connector - pins and signals

Pinout	Pin	Signal name	Description	Signal type
 rear view	12	AUX_GPI1	General purpose digital input. Programmable function.	Digital, 3V3 CMOS
	5	AUX_GPI2	General purpose digital input. Programmable function. With LK3 fitted, GPI2 is an emergency power sense input.[a]	Digital, 3V3 CMOS
	4	AUX_GPI3	General purpose digital input. Programmable function. With LK2 fitted, GPI3 is a power sense input.[a]	Digital, 3V3 CMOS
	10	AUX_GPIO4	Programmable function and direction. Pads available to fit a higher power driver transistor on GPIO4 line.[b]	Digital, 3V3 CMOS input; open collector output with pullup
	2	AUX_GPIO5		
	9	AUX_GPIO6		
	1	AUX_GPIO7		
	11	AUX_TXD	Asynchronous serial port - Transmit data	Digital, 3V3 CMOS
	3	AUX_RXD	Asynchronous serial port - Receive data	Digital, 3V3 CMOS
	7	AUD_TAP_IN	Programmable tap point into the Rx or Tx audio chain. DC-coupled.	Analogue
	13	AUD_TAP_OUT	Programmable tap point out of the Rx or Tx audio chain. DC-coupled.	Analogue
	14	AUX_MIC_AUD	Auxiliary microphone input. Electret microphone biasing provided. Dynamic microphones are not supported.	Analogue
	6	RSSI	Analogue RSSI output.	Analogue
	8	+13V8_SW[c]	Switched 13.8V supply. Supply is switched off when radio body is switched off.	Power
	15	AGND	Analogue ground	Ground

a. For more information on hardware links refer to "Power Sense Options" on page 121.

b. For more information on high power drive refer to "Special Purpose Outputs" on page 67.

c. Can be switched or unswitched. For more information refer to "Connector Power Supply Options" on page 131.

Table 2.6 Auxiliary connector - DC characteristics

Parameter	Standard				Test method and conditions	Comments
	min.	typ.	max.	units		
Digital signals						
Input low level:						
All inputs			0.7	V	No hardware links fitted[a].	Includes AUX_GPI3 with LK1/2 fitted.
AUX_GPI2			V_s–4	V	LK3 fitted.	Configured as emergency power sense input.
Input high level:						
All inputs	1.7			V	No hardware links fitted[a].	
AUX_GPI2	V_s–1.5			V	LK3 fitted.	Configured as emergency power sense input.
AUX_GPI3	2.6			V	LK1 and/or 2 fitted.	Configured as power sense input.
Input low current:						
All other inputs		–100	–120	µA	No links fitted[a]. Default pullups[c].	Default pullup resistance is 33kΩ.
AUX_GPI2			–13[b]	mA	LK3 fitted. V_s=13.8V	Configured as emerg. power sense input.
AUX_GPI3			–500	µA	LK1 and 2 fitted.	Configured as power sense input.
AUX_RXD			–1	mA	–8V input.	
Input high current:					No links fitted[a]. Default pullups[c].	Default pullup resistance is 33kΩ.
AUX_RXD			1	mA	+8V input.	
All other inputs			10	µA	3.3V input.	
			100	µA	5V input.	
Output low level:						
AUX_GPIO4-7			50	mV	100µA sink current.	Current limit occurs at 20mA typ.
			600	mV	10mA sink current.	
AUX_TXD			200	mV	100µA sink current.	
Output high level:						
AUX_GPIO4-7	3.1			V	No load. Default pullups[c].	
AUX_TXD	2.4			V	3kΩ load.	
Safe DC input limits:						Input current must not exceed ±50mA. This is the rating of the clamping diodes.
AUX_GPI1-3	–0.5		V_s+0.5	V		
AUX_GPIO4-7	–0.5		V_s+0.5	V		
AUX_RXD	–25V		V_s+0.5	V		
AUX_TXD[d]	–10		V_s+0.5	V		
Analogue signals						
DC output range:						
RSSI	0		3	V	See Table 2.9 on page 24.	
13V8_SW	9.7		17.2	V	Follows V_s.	Output switches off outside this range.
DC bias:						
AUD_TAP_IN	1.4	1.5	1.6	V		
AUD_TAP_OUT	2.1	2.3	2.5	V	No load. Zero Rx frequency error.	
AUX_MIC_AUD	2.9	3.0	3.1	V	Via 2.2kΩ.	Bias for electret microphone.
Input impedance:						
AUD_TAP_IN	50	100	150	kΩ	DC to 10kHz	
AUX_MIC_AUD	2.1	2.2	2.3	kΩ		
Output impedance:						
AUD_TAP_OUT	590	600	650	Ω	DC to 10kHz	
RSSI	950	1000	1050	Ω		
Safe DC input limits:						
AUD_TAP_IN	–17		+17	V		
AUD_TAP_OUT[d]	–0.5		+17	V		Short circuit-safe. Input current <±20mA
AUX_MIC_AUD	–17		+17	V		
RSSI[d]	–17		+17	V		

a. For more information on hardware links refer to "Power Sense Options" on page 121.

b. It is recommended that this input is driven by a mechanical switch or an open collector/drain output.

c. For more information on pullups refer to "Digital Input Lines" on page 39.

d. These outputs are protected against accidental input to the limits specified.

Table 2.7 Auxiliary connector - AC characteristics

Parameter	Standard min.	Standard typ.	Standard max.	Standard units	Test method and conditions	Comments
AUD_TAP_IN (refer to note 4)						
Nominal input level: Tap T3, T4, T5, T8, T12 Tap T13 Tap R7, R10	 0.62 0.78 0.62	 0.69 0.87 0.69	 0.76 0.96 0.76	 V_{p-p} V_{p-p} V_{p-p}	 Level for 60% RSD@1kHz. Level for 3kHz dev.@1kHz. Refer to note 3.	 Equivalent to –10dBm into 600Ω.
Full scale input level		2.0		V_{p-p}		
Frequency response: All tap-points	Refer to the plots in Table 2.10 and Table 2.11.					
Group delay - absolute: Tap T13 Tap T12 Tap T8 Tap T5 Tap T4 Tap T3		 1.8 1.8 9.6 11.6 11.7 11.7		 ms ms ms ms ms ms	At 1kHz. Refer to note 2. Refer to note 1. Refer to note 1.	
Group delay - distortion: Tap T12 and Tap T13	Refer to the plots in Table 2.12.					
AUD_TAP_OUT						
Nominal output level: All Rx tap-points except R1 Tap R1 Tap T3	 0.62 0.54 0.62	 0.69 0.60 0.69	 0.76 0.66 0.76	 V_{p-p} V_{p-p} V_{p-p}	Rload=600Ω. Level at 60% RSD@1kHz. Level at 3kHz dev.@1kHz Refer to "Microphone sensitivity" of AUX_MIC_AUD.	 Equivalent to –10dBm into 600Ω.
Full scale output level		2.0		V_{p-p}	Rload=600Ω.	
Frequency response: All tap-points	Refer to the plots in Table 2.10 and Table 2.11.					
Group delay - absolute: Tap R1 Tap R2 Tap R4 Tap R5 Tap R7 Tap R10		 1.8 1.8 6.6 6.7 8.5 8.7		 ms ms ms ms ms ms	At 1kHz. Refer to note 2. Refer to note 1.	
Group delay - distortion: Tap R1 and Tap R2	Refer to the plots in Table 2.12.					
AUX_MIC_AUD						
Rated System Deviation NB MB WB	 –2.5 –4.0 –5.0		 +2.5 +4.0 +5.0	 kHz kHz kHz	EIA-603B	 Units are peak frequency deviation from nominal carrier frequency in kHz.
Modulation frequency response	Refer to the plot in Table 2.13.				EIA-603B	
Microphone sensitivity	6.0	7.5	9.0	mV rms	EIA-603B	

Notes:

1. Optional processing blocks are bypassed in the above specification.
2. For AUD_TAP_IN and AUD_TAP_OUT specifications the following signal paths apply:

Case	Input	Output
Tap into Rx chain	AUD_TAP_IN	RX_AUD
Tap out of Rx chain	Modulation at antenna	AUD_TAP_OUT
Tap into Tx chain	AUD_TAP_IN	Modulation at antenna
Tap out of Tx chain	AUX_MIC_AUD	AUD_TAP_OUT

3. For tap into the Rx path, nominal level refers to the level required to give output at RX_AUD that is same as the 60% dev level from the receiver. The level specified applies at 1 kHz only.
4. AUD_TAP_IN uses a DC-coupled analog-to-digital converter and the bias voltage specified in Table 2.6 should be used to maximise dynamic range. The DC bias is removed internally by a digital high-pass filter so the Tx carrier frequency will not be affected by any bias error. it is recommended to use external AC-coupling for applications which do not require modulation to very low frequencies.

Table 2.8 Auxiliary connector - data characteristics

Parameter	Standard				Test method and conditions	Comments
	min.	typ.	max.	units		
Serial port						
Baud rate:	1200, 2400, 4800, 9600, 14400, 19200			bit/s		All UART parameters are fixed and common to all UARTs except for the baud rate which is configurable and different for different modes/ applications
Data bits:	8					
Start bit:	1					
Stop bit:	1					
Parity:	None					
Protocol:	CCDI2					
Flow control: Software	XON/XOFF					
GPIO						
Delays: I/O mirror to IOP UI key delay			500 50	µs ms		

Table 2.9 RSSI voltage vs. signal strength

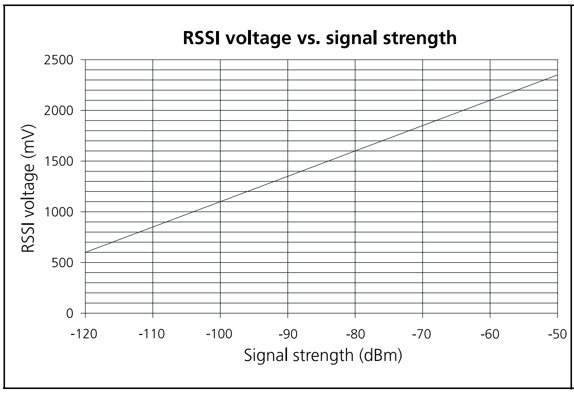
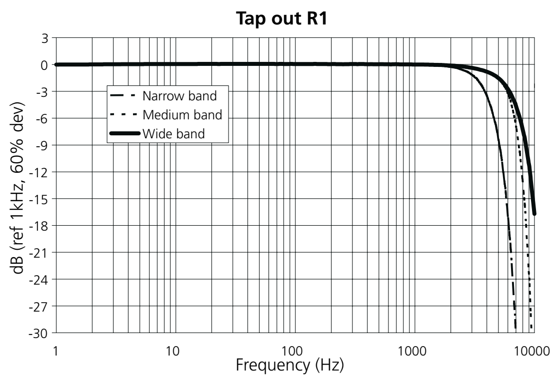
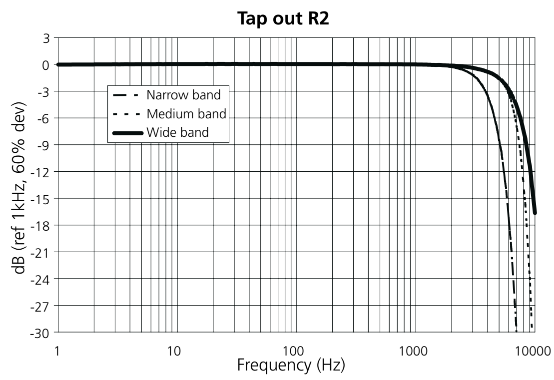
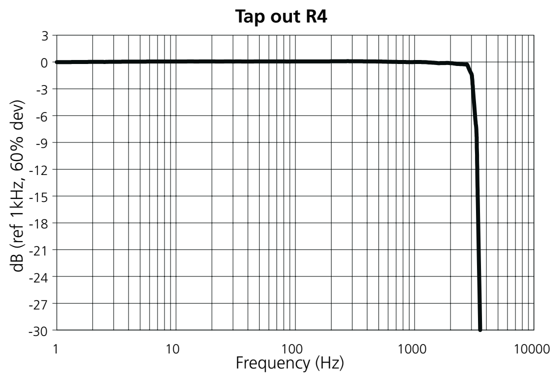
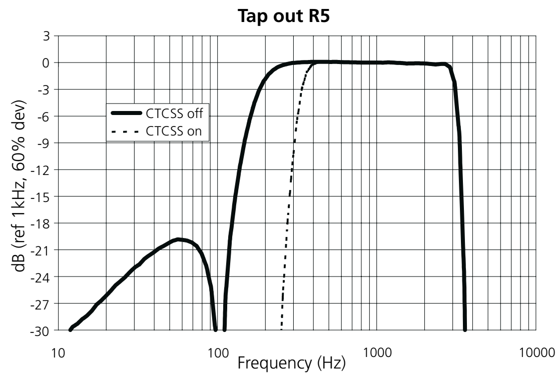


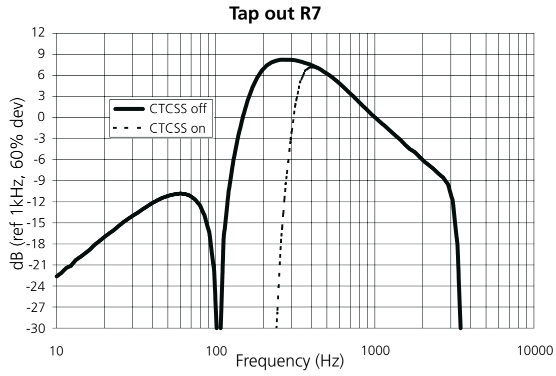
Table 2.10 Rx path tap frequency response plots

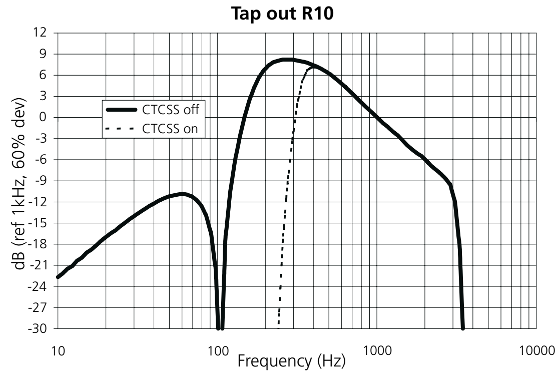


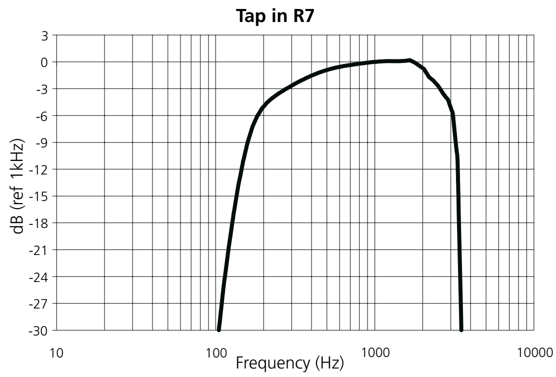












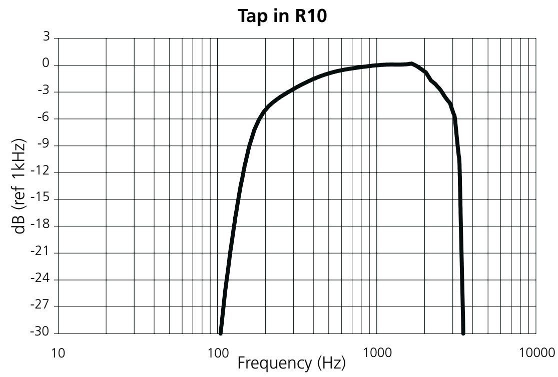
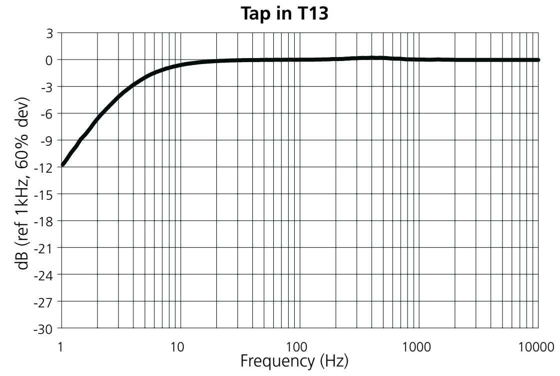
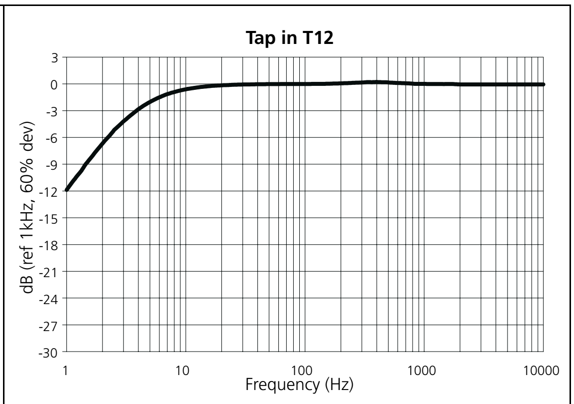
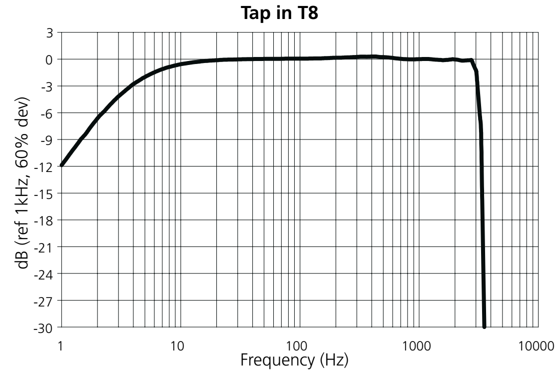
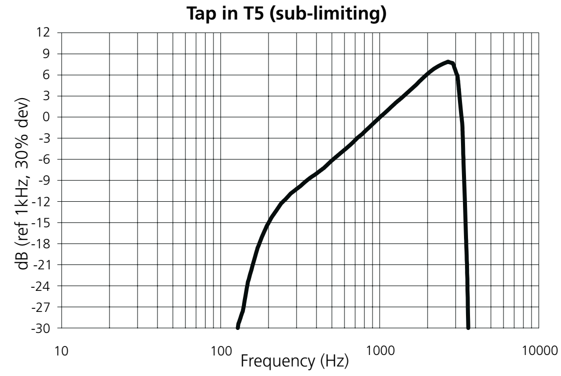


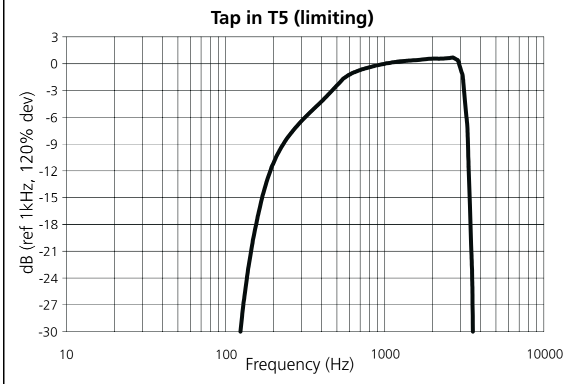
Table 2.11 Tx path tap frequency response plots

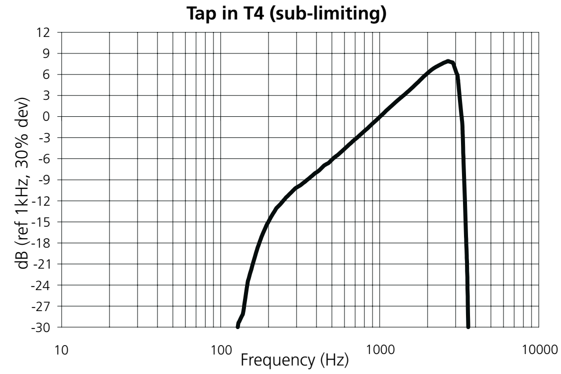












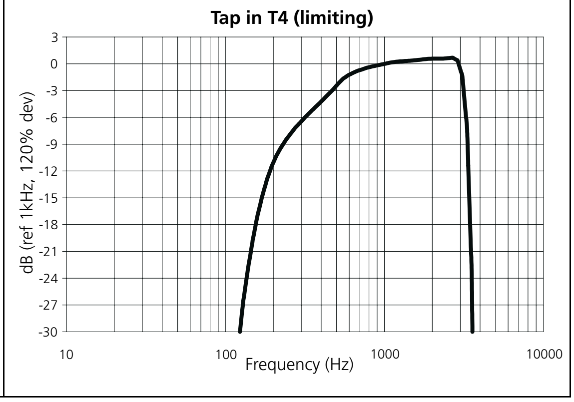
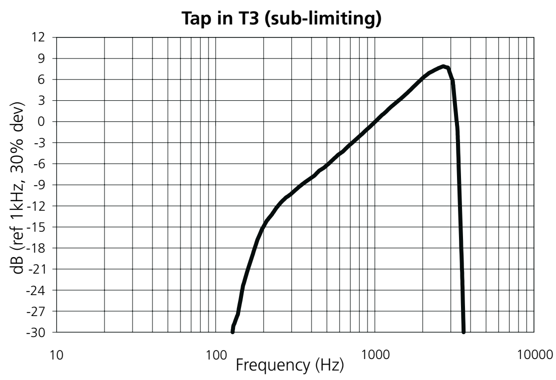
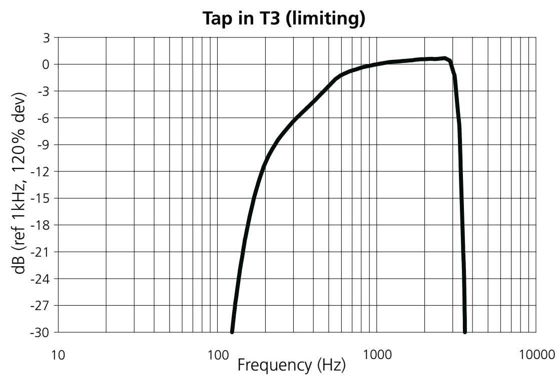
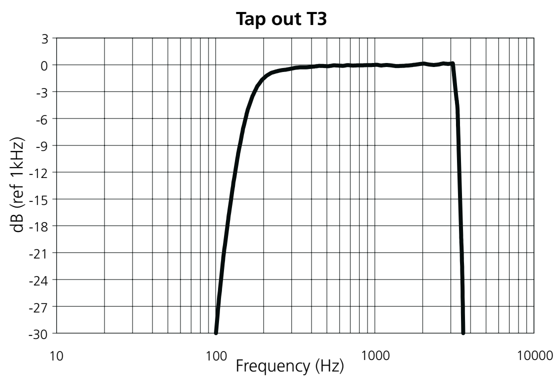


Table 2.11 Tx path tap frequency response plots (continued)







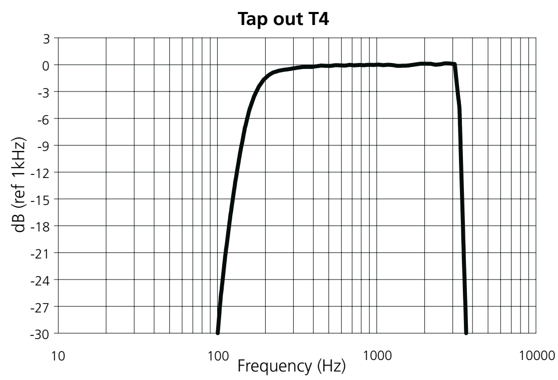
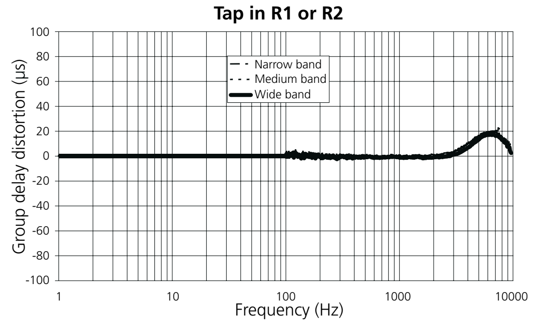


Table 2.12 Group delay distortion frequency response plots



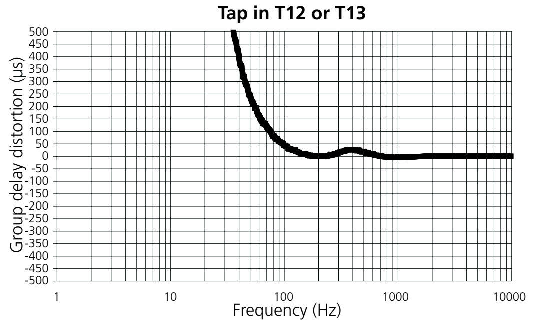
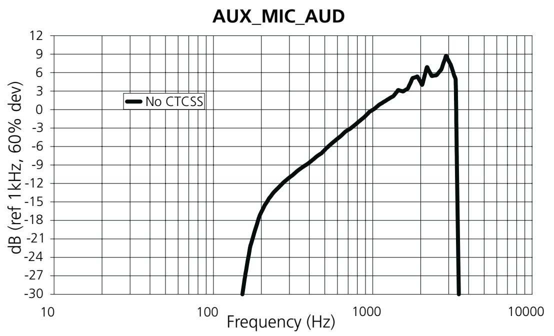


Table 2.13 AUX_MIC_AUD frequency response plot



2.4 Internal Options Connector

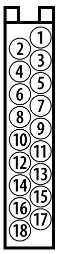
When installing an internal options board, the internal options connector is the electrical interface to the main board of the radio body.
The internal options connector provides similar I/O to the auxiliary connector. The digital signals and the serial port are independent of the auxiliary connector signals, but the AUD_TAP_IN, AUD_TAP_OUT, AUX_MIC_AUD, RSSI signals are shared with the auxiliary connector.
The internal options connector is an 18-pin 0.1in pitch Micro-MaTch connector.

Examples of internal options boards:

- TMAA30-02 3DK Application Board.
  Refer to the TM8000 3DK Application Board Service Manual.
- TMAA01-01 Line-Interface Board.
  Refer to the TM8100 Mobile Radio Accessories Manual.
- TMAA01-05 Options Extender Board.
  Refer to the TM8100 Mobile Radio Accessories Manual.

For information on how to create your own internal options board, refer to "Internal Options Board" on page 85.

Table 2.14 Internal options connector - pins and signals

Pinout	Pin	Signal	Description	Signal type
 top view	1	13V8_SW[a]	Switched 13V8 supply. Supply is switched off when the Radio Body is switched off.	Power
	2	AUD_TAP_OUT	Programmable tap point out of the Rx or Tx audio chain. DC-coupled.	Analogue
	3	AGND	Analogue ground.	Ground
	4	AUX_MIC_AUD	Auxiliary microphone input. Electret microphone biasing provided. Dynamic microphones are not supported.	Analogue
	5	RX_BEEP_IN	Receive sidetone input. AC-coupled.	Analogue
	6	AUD_TAP_IN	Programmable tap point into the Rx or Tx audio chain. DC-coupled.	Analogue
	7	RX_AUD	Receive audio output. Post volume control. AC-coupled.	Analogue
	8	RSSI	Analogue RSSI output.	Analogue
	9…15	IOP_GPIO1…7	Programmable function and direction. With LK4 fitted, GPIO7 is a power sense input[b].	Digital. 3V3 CMOS
	16	DGND	Digital ground.	Ground
	17	IOP_RXD	Asynchronous serial port - Receive data.	Digital. 3V3 CMOS
	18	IOP_TXD	Asynchronous serial port - Transmit data.	Digital. 3V3 CMOS

a. Can be switched or unswitched. For more information refer to "Connector Power Supply Options" on page 131.
b. For more information on hardware links refer to "Power Sense Options" on page 121.

Important The digital I/O signals are intended to interface directly with compatible logic signals only. Do not connect these signals to external devices without appropriate signal conditioning and ESD protection.

Table 2.15 Internal options connector - DC characteristics

Parameter	Standard				Test method and conditions	Comments
	min.	typ.	max.	units		
Digital signals						
Input low level: All inputs			0.7	V	No hardware links fitted[a].	Also applies to IOP_GPIO7 with LK4 fitted.
Input high level: All inputs IOP_GPIO7	1.7 2.8			V V	No hardware links fitted. LK4 fitted[a].	Configured as power sense input.
Input low current: All inputs		–100	–120	µA	No hardware links fitted[a].	Also applies to IOP_GPIO7 with LK4 fitted.
Input high current: All inputs IOP_GPIO7			10 1500 250	µA µA µA	3.3V input. 5V input. 3.3V input. LK4 fitted[a].	Configured as power sense input.
Output low level: All outputs			120	mV	100µA sink current.	1kΩ series R on all outputs.
Output high level: All outputs	3.1			V	100µA source current.	1kΩ series R on all outputs.
Safe DC input limits: All inputs/outputs	–0.5		+5.5	V		Input current must not exceed ±10mA.
Analogue signals (for signals not listed here refer to the auxiliary connector specification)						
Safe DC input limits: RX_AUD RX_BEEP_IN	–17 –17		+7 +17	V V		

a. For more information on hardware links refer to “Power Sense Options” on page 121.

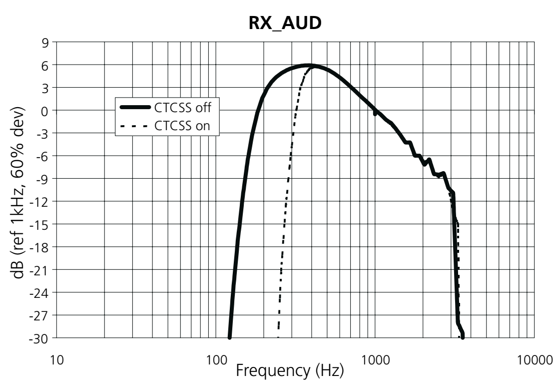
Table 2.16 Internal options connector - AC characteristics

Parameter	Standard				Test method and conditions	Comments
	min.	typ.	max.	units		
RX_BEEP_IN						
Nominal input level		0.76		V_{p-p}	For 6.2V_{p-p} at speaker @1kHz.	Level for 10dB below rated power.
Full scale input level			2.5	V_{p-p}	For onset of clipping at 13.8V.	
Frequency response	0.3 to 3kHz				–3dB with respect to level at 1kHz.	
Input impedance	10			kΩ	DC–10kHz	
RX_AUD						
Nominal output level		1.0		V_{p-p}	At 1kHz, 60% dev. Full volume	
Full scale output level:		2.0		V_{p-p}	At 1kHz, 120% dev. Full volume	
Output impedance:		100		Ω	At 1kHz.	
Frequency response:	Refer to plot in Table 2.18.					

Table 2.17 Internal options connector - data characteristics

Parameter	Standard				Test method and conditions	Comments
	min.	typ.	max.	units		
Serial port						
Baud rate:	1200, 2400, 4800, 9600, 14400, 19200			bit/s		All UART parameters are fixed and common to all UARTs except for the baud rate which is configurable and different for different modes/applications
Data bits:	8					
Start bit:	1					
Stop bit:	1					
Parity:	None					
Protocol:	CCDI2					
Flow control: Software	XON/XOFF					
GPIO						
Delays: I/O mirror to AUX UI key delay			 500 50	 µs ms		

Table 2.18 RX_AUD frequency response plot



2.5 Provision for External Options Connector

The radio has a mechanical interface for the external connector of an internal options board. This external options connector can be a 9-way standard-density or 15-way high-density D-range connector. If no internal options board is installed (standard configuration), the hole for the external options connector is sealed by a bung.

Examples of internal options boards:

- TMAA30-02 3DK Application Board.
  Refer to the TM8000 3DK Application Board Service Manual.
- TMAA01-01 Line-Interface Board.
  Refer to the TM8100 Mobile Radio Accessories Manual.
- TMAA01-05 Options Extender Board.
  Refer to the TM8100 Mobile Radio Accessories Manual.

For information on how to create your own internal options board, refer to "Internal Options Board" on page 85.

2.6 Provision for Additional Connector

The radio has a provision to fit an additional round connector or cable exit next to the external options connector on the rear of the radio. The position is indicated in Figure 2.2 on page 16. The maximum hole diameter is 7.5 mm, suitable for an SMA connector or a cable grommet.

Important When fitting an additional connector, it is the integrator's sole responsibility to provide adequate sealing.

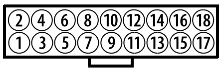
2.7 Control-Head Connector

The control-head connector is the standard interface between the radio body and the TM8115 control head or TM8105 blank control head.

You can integrate your own blank control head options board into the cavity between the radio body and the TM8105 blank control head.
For information on how to create your own blank control head options board, refer to "Blank Control Head Options Board" on page 95.

The TM8115 control head uses all 18 signals of the control-head connector. The programming connector of the TM8105 blank control head uses the signals 1 to 9.

Table 2.19 Control-head connector - pins and signals

Pinout	Pin	Signal	Description	Signal type
 front view	1	RX_AUD	Receive audio output. Post volume control. AC-coupled.	Analogue
	2	+13V8[a]	Power supply output from radio body power source.	Power
	3	CH_TXD	Asynchronous serial port - Transmit data.	Digital. 3V3 CMOS.
	4	CH_PTT	PTT input from microphone. Also carries the hookswitch signal.	Digital
	5	CH_MIC_AUD	Fist microphone audio input.	Analogue
	6	AGND	Analogue ground.	Ground
	7	CH_RXD	Asynchronous serial port - Receive data.	Digital. 3V3 CMOS.
	8	DGND	Digital ground.	Ground
	9	CH_ON_OFF	Hardware power on/software-controlled power off input. Active low.	Digital
	10	VOL_WIP_DC	DC signal from TM8115 volume pot wiper.	Analogue
	11	CH_SPI_DO	Data output signal to TM8115 control head.	Digital. 3V3 CMOS.
	12	CH_LE	Latch enable output to TM8115 control head.	Digital. 3V3 CMOS.
	13	CH_GPIO1	General purpose digital input/output.	Digital. 3V3 CMOS input. Open collector output with pullup.
	14	+3V3	Power supply to control head digital circuits.	Power
	15	CH_SPI_DI	Data input from TM8115 control head.	Digital. 3V3 CMOS.
	16	CH_SPI_CLK	Clock output to TM8115 control head.	Digital. 3V3 CMOS.
	17	SPK–	Speaker audio output for non-remote control head. Balanced load configuration.	Analogue
	18	SPK+	Speaker audio output for non-remote control head. Balanced load configuration.	Analogue

a. Can be switched or unswitched. For more information refer to "Connector Power Supply Options" on page 131.

Table 2.20 Control-head connector - DC characteristics

Parameter	Standard min.	typ.	max.	units	Test method and conditions	Comments
Digital signals						
Input low level:						
CH_SPI_DI			0.7	V		
CH_RXD			0.7	V		
CH_GPIO1			0.7	V		
CH_PTT			0.7	V		
CH_ON_OFF			V_s–4	V		
Input high level:						
CH_SPI_DI	1.7			V		
CH_RXD	1.7			V		
CH_GPIO1	1.7			V		
CH_PTT	1.7			V		
CH_ON_OFF	V_s–1.5			V		
Input low current:						
CH_SPI_DI			10	µA		
CH_RXD			–1	mA	V_{in}=–8V	
CH_GPIO1			–120	µA		
CH_PTT			–800	µA		
CH_ON_OFF			–13	mA	V_s=13.8V	
Input high current:						
CH_SPI_DI			10	µA	V_{in}=3.3V	
CH_RXD			1	mA	V_{in}=8V	
CH_GPIO1			10	µA	V_{in}=3.3V	
CH_PTT			10	µA	V_{in}=3.3V	
CH_ON_OFF			10	µA	V_{in}=V_s	
Output low level:						
All outputs except			200	mV	100µA sink current	
CH_GPIO1			50	mV	100µA sink current	
CH_GPIO1			600	mV	10mA sink current	Current limit occurs at 20mA typ.
Output high level:						
All outputs except	3.1				100µA source current	
CH_TXD	2.4				3kΩ load	
CH_GPIO1	3.1				No load	33kΩ pullup to 3.3V.
Hookswitch resistance:						
CH_PTT	5.6		13.2	kΩ		Microphone on hook resistance.
Safe DC input limits:						
CH_SPI_X	–0.5		+4.1	V		I_{in} must not exceed ±10mA.
CH_LE	–0.5		+4.1	V		I_{in} must not exceed ±10mA.
CH_TXD	–10		V_s+0.5	V		I_{in} must not exceed +50/–10mA.
CH_RXD	–25		V_s+0.5	V		I_{in} must not exceed +50mA.
CH_GPIO1	–0.5		V_s+0.5	V		I_{in} must not exceed ±50mA.
CH_PTT	–17		+17	V		
CH_ON_OFF	–0.5		V_s+0.5	V		I_{in} must not exceed ±50mA.

Table 2.20 Control-head connector - DC characteristics (continued)

Parameter	Standard min.	Standard typ.	Standard max.	Standard units	Test method and conditions	Comments
Analogue signals (for signals not listed here refer to the Auxiliary interface specification)						
DC input range: VOL_WIP_DC	0 0		0.6 10	V kΩ	Voltage/resistance for min/ max volume respectively.	This line is used for control-head detection. An open-circuit input is considered as no head fitted.
DC bias: SPK+/– CH_MIC_AUD	 2.9	0.5Vs	 3.1	V V	Audio PA on. Via 2.2kΩ	Bias for electret microphone.
Input resistance: CH_MIC_AUD	2.1	2.2	2.3	kΩ		
Output resistance: SPK+/–		0.5		Ω	Audio PA on.	
Output load: +3V3 +13V8			100 1	mA A		Specification must be derated by load amount from internal options and auxiliary interfaces.
Safe DC input limits: VOL_WIP_DC RX_AUD SPK+/– CH_MIC_AUD	–7 –17 0 –17		+17 +7 +17 +17	V V V V		Short circuit-safe.

Table 2.21 Control-head connector - AC characteristics

Parameter	Standard min.	Standard typ.	Standard max.	Standard units	Test method and conditions	Comments
RX_AUD	refer to Table 2.16					
CH_MIC_AUD	refer to AUX_MIC_AUD in Table 2.7					
SPK+/–	refer to Table 2.22					

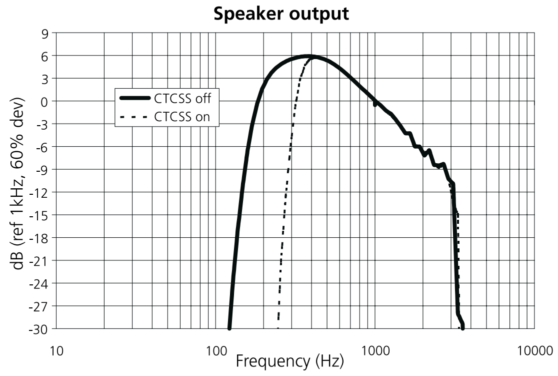
Table 2.22 Control-head connector - speaker output characteristics

Parameter	Standard min.	Standard typ.	Standard max.	Standard units	Test method and conditions	Comments
Mute ratio	70	75		dB	With respect to maximum output power. Noise measured in 0.3-3kHz bandwidth.	Signal path muted. Audio PA on.
Receive audio frequency response	Refer to plot in Table 2.24.				EIA-603B	
Internal speaker output:						
Load configuration	Balanced					
Load	12.8	16	19.2	Ω	At 1kHz.	
Maximum power	3			W	Into 16Ω.	
Rated duty cycle			100	%	At maximum power.	
Concurrent speaker output:						
Rated duty cycle			33	%	1min at maximum power 2min Rx standby	The internal and external speaker loads are connected in parallel (not switched).

Table 2.23 Control-head connector - data characteristics

Parameter	Standard				Test method and conditions	Comments
	min.	typ.	max.	units		
Serial port						
Baud rate:	1200, 2400, 4800, 9600, 14400, 19200			bit/s		All UART parameters are fixed and common to all UARTs except for the baud rate which is configurable and different for different modes/ applications
Data bits:	8					
Start bit:	1					
Stop bit:	1					
Parity:	None					
Protocol:	RPI CCDI2					
Flow control: Software	XON/XOFF					
GPIO						
Delays: I/O mirror to IOP UI key delay			500 50	µs ms		

Table 2.24 Speaker frequency response plot



Detection of Control Head

When the TM8115 control head is not installed, the radio body will receive no volume control level or power on/off signal from the control head. In order for the volume control default to work properly, the absence of a control head is detected by detecting the absence of the volume potentiometer.

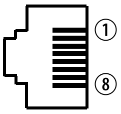
For operation with the TM8105 blank control head, the radio must be programmed always to power up when power is applied and the ignition-sense hardware link LK1 must be fitted. For more information on hardware links refer to "Power Sense Options" on page 121.

2.8 Microphone Connector

The microphone connector of the TM8115 control head is an RJ-45 socket.

When the TM8115 control head is connected to the control-head connector of the radio body using the loom provided, the microphone connector uses the following eight control-head connector signals:

Table 2.25 Microphone connector - pins and signals

Pinout	Pin	Signal name	Description	Signal type
 front view	1	MIC_RX_AUD	Receive audio output.	Analogue
	2	+13V8[a]	Power supply output. Switched off when radio body is switched off.	Power
	3	MIC_TXD	Asynchronous serial port - Transmit data.	3.3V CMOS
	4	MIC_PTT	PTT input from microphone. Also carries hookswitch signal.	Digital
	5	MIC_AUD	Fist microphone audio input.	Analogue
	6	AGND	Analog ground.	Analogue ground
	7	MIC_RXD	Asynchronous serial port - Receive data.	3.3V CMOS
	8	MIC_GPIO1	General purpose digital input/ output.	Open collector out 3.3V CMOS in

a. Can be switched or unswitched. For more information refer to "Connector Power Supply Options" on page 131.

For characteristics refer to the corresponding signals of the control-head connector.

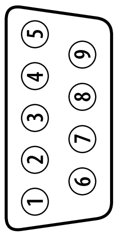
2.9 Programming Connector

The programming connector of the TM8105 blank control head is a 9-way standard-density D-range plug.

The programming connector can also be used to connect application products.

When the TM8105 blank control head is connected to the radio body, the programming connector uses the signals shown in Table 2.26:

Table 2.26 Programming connector - pins and signals

Pinout	Pin	Signal name	Description	Signal type
 front view	1	PRG_RX_AUD	Receive audio output.	Analogue
	2	PRG_TXD	Asynchronous serial port - Transmit data.	3.3V CMOS
	3	PRG_MIC_AUD	Fist microphone audio input.	Analogue
	4	PRG_RXD	Asynchronous serial port - Receive data.	3.3V CMOS
	5	PRG_ON_OFF	Hardware power on/software-power off input. Active low.	Digital
	6	+13V8[a]	Power supply output. Switched off when radio body is switched off.	Power
	7	PRG_PTT	PTT input from microphone. Also carries hookswitch signal.	Digital
	8	AGND	Analogue ground	Ground
	9	DGND	Digital ground	Ground

a. Can be switched or unswitched. For more information refer to "Connector Power Supply Options" on page 131.

For characteristics refer to the corresponding signals of the control-head connector.

3 Programmable I/O Lines

This chapter describes the programmable

- digital input lines
- digital output lines
- audio tap out lines
- audio tap in lines

These input and output lines can be configured using the Programmable I/O form of the programming application. For more information refer to the online help of the programming application.

The connectors and electrical characteristics of the programmable I/O lines are described in "Description of the Radio Interfaces" on page 15.

3.1 Digital Input Lines

This section describes the general design principles for use of the programmable I/O lines configured as inputs, and the input signals which can be set for them.

Available Input Lines

The following lines are available to be used as inputs:

Table 3.1 Digital input lines

Signals	Connector	Direction
AUX_GPI1…3	auxiliary connector	input only
AUX_GPIO4…7	auxiliary connector	input or output
IOP_GPIO1…7	internal options connector	input or output
CH_GPIO1 MIC_GPIO1[a] (TM8115) PGR_GPIO1[a] (TM8105)	control-head connector microphone connector programming connector	input or output

a. CH_GPIO1 of the control-head connector is the same signal as MIC_GPIO1 of the microphone connector (TM8115) and PRG_GPIO1 of the programming connector (TM8105).

For details on the connector pin-outs and electrical characteristics of these lines refer to "Description of the Radio Interfaces" on page 15.

Compatibility and Tolerance

Table 3.2 describes the compatibility of the input lines with common industry logic standards:

Table 3.2 Digital input lines - compatibility and tolerance

Input line	Logic standard input compatibility and tolerance			
	3.3V CMOS	5V CMOS	5V TTL	RS-232
AUX_GPI1	Yes	Yes	Yes	No[a]
AUX_GPI2[b]	Yes	Yes	Yes	No[a]
AUX_GPI3[c]	Yes	Yes	Yes	No[a]
AUX_GPIO4…7	Yes	Yes	Yes	No[a]
AUX_RXD	Yes	Yes	Yes	Yes
IOP_GPIO1…7	Yes	Yes	Yes	No[a]
IOP_RXD	Yes	Yes	Yes	No[a]
CH_RXD MIC_RXD PRG_RXD	Yes	Yes	Yes	Yes
CH_GPIO1 MIC_GPIO1	Yes	Yes	Yes	No[a]

a. Level compatible but not tolerant. Inputs can be made RS-232-tolerant by using 3.3kΩ series resistance inserted at the radio end.

b. Hardware link LK3 not fitted.

c. Hardware link LK2 not fitted.

Input Philosophy

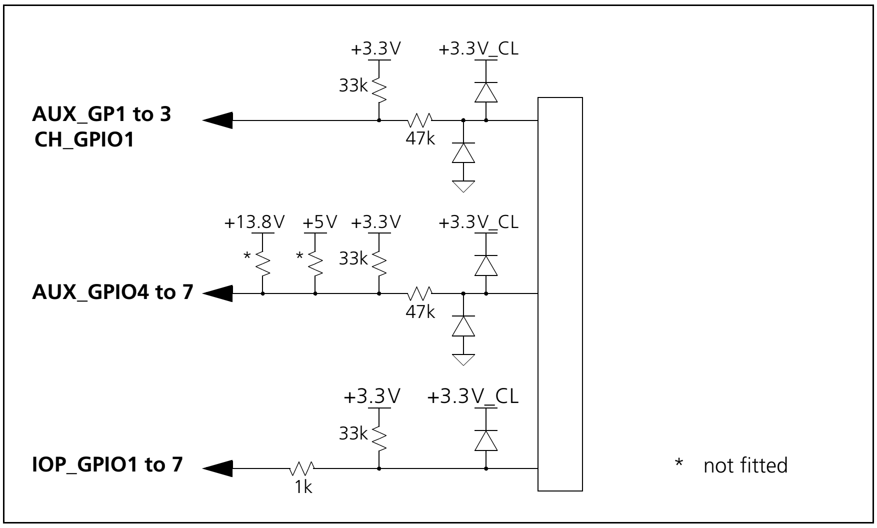
The digital inputs are designed to simplify the interfacing to a wide range of signal sources, broadly encompassing directly wired switches, open-collector transistors, opto-isolators, digital logic and direct microprocessor drive. In many cases, the amount of interfacing circuitry can be kept to a minimum, thus reducing design effort and keeping down both cost and circuit board area.

Input Circuitry

Figure 3.1 shows a simplified circuit diagram of the digital input lines (ESD protection not shown). For full circuit diagrams, refer to the PCB Information chapter of the TM8100 Mobile Radio Service Manual or the technical support website.

The input lines of the auxiliary connector and the control-head connector are protected against both over-voltage and under-voltage drive via the clipping diodes and 47kΩ current-limiting resistor. The input lines of the internal options connector are only protected against minor over-voltage conditions (refer to “Internal Options Connector” on page 28).

Figure 3.1 Digital input lines - simplified circuit diagrams



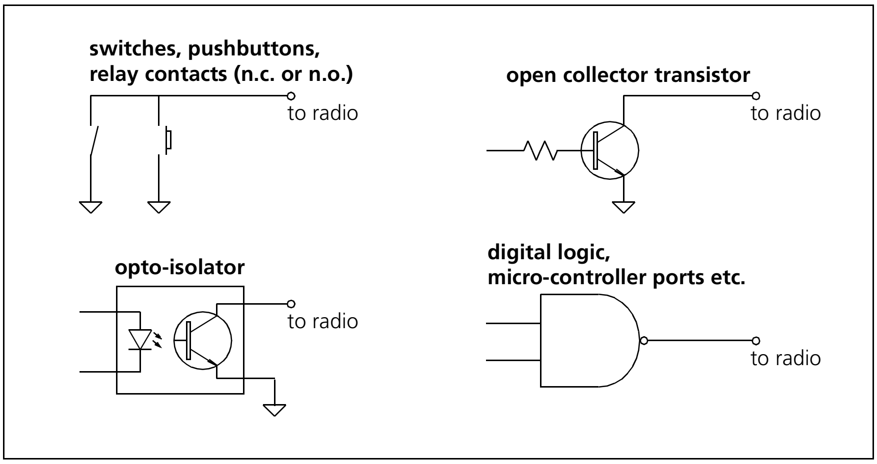
Pullup Resistors

Pullup resistors are provided on all digital input lines. For the input lines of the internal options connector and the auxiliary connector this is 33kΩ to 3.3V. For the auxiliary input/output lines, several pullup options are available for the hardware (refer to “Pullup Resistors” on page 66).

Driving the Inputs

Figure 3.2 shows some possible input drive circuits and illustrates the relative simplicity of connection to the radio.

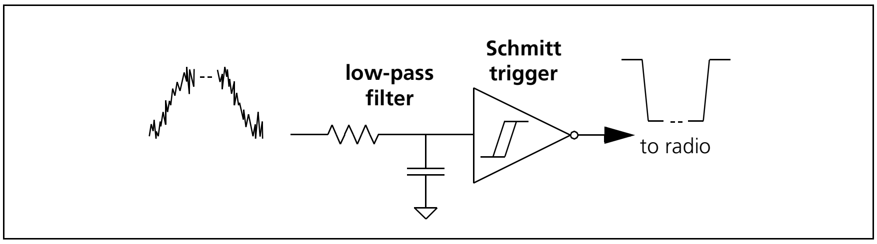
Figure 3.2 Digital input lines - input drive circuits



Signal Conditioning

Although the radio can apply some debouncing to inputs, excessively noisy signals may require pre-conditioning to eliminate the worst of the noise. A simple low-pass filter and hysteresis switch (Schmitt trigger) as shown in Figure 3.3 will usually be adequate.

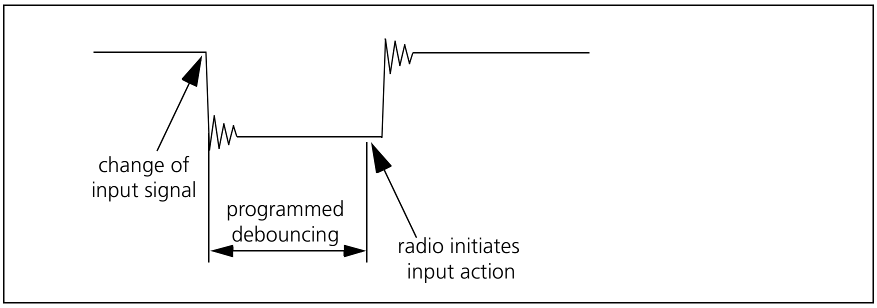
Figure 3.3 Digital input lines - signal conditioning



Debouncing

Physical switches with bounce or jitter make it necessary to introduce a delay before the input is recognised, in order to prevent multiple activation. We recommend that you measure this jitter and program the input line accordingly. If the jitter can not be measured, we recommend that you set the debounce time to between 50 and 100ms. If the radio exhibits erratic behaviour upon closing or opening a switch, try increasing the debounce time further. Signals from logic circuits or microprocessors generally do not require debouncing. The input signal must be applied for at least the duration of the debouncing programmed. Figure 3.4 shows the debouncing characteristics.

Figure 3.4 Digital input lines - debouncing



Active Logic Level

The active and inactive logic levels can be programmed to high or low in the Programmable I/O form of the programming application

Important Because of the pullups, setting the active state to High will cause the action to commence if the connector is removed or dislodged while the radio is on. To prevent this happening set the active state to Low.

Special Purpose Inputs

AUX_GPI2, AUX_GPI3, and IOP_GPIO7 can be used as general purpose inputs but can also be configured for the following dedicated purposes:

- AUX_GPI2 can be set to power the radio up into emergency mode (refer to "Enter Emergency Mode" on page 45).
- AUX_GPI3 can be set to control radio power-up/power-down via an ignition sense signal or similar (refer to "Power Sense (Ignition)" on page 44).
- IOP_GPIO7 can be set to control radio power-up/power-down via a logic signal (refer to "Power Sense (Ignition)" on page 44).

The use of these inputs for power sensing requires that certain hardware links be placed on the main board assembly. For more information refer to "Power Sense Options" on page 121.

Note Conversely, if these inputs are used for other purposes it is important to check that the hardware links are removed. If the hardware links are not removed the radio may power up or down unexpectedly. Note that some of these links may have been fitted in the factory.

Input Signals

The following sections describe the input signals available for programming of the digital input lines:

- Toggle Stand-by Mode
- Power Sense (Ignition)
- Enter Emergency Mode
- Send Channel Preset Call
- Send Free Format Preset 1
- External PTT 1 and 2
- Inhibit PTT
- Toggle Tx RF Inhibit
- Decrement Channel
- Increment Channel
- Home Channel
- BCD Pin 0 to 4
- Preset Channel
- Mute External Audio Input
- Mute Audio Output Path
- Unmute Audio Output Path
- Force Audio PA On
- Force Audio PA Off
- Simulate F1 to F4 Key
- Toggle F1 to F4 Key LED

3.1.1 Toggle Stand-by Mode

Application

This input signal is used to toggle between a powered-on state, and a stand-by state where the radio appears off. The radio will draw approximately 28 mA when in stand-by mode.

Configuration

Configure an input line and associate it with this action. Set the active state to high and the debounce time (0 to 100 ms).

Timing

The input line must be activated for at least 5 s.

Description

When the input line is activated, the radio exits stand-by mode.

When the input line is deactivated, the radio enters stand-by mode.

Related Actions

The 'Power Sense (Ignition)' input signal can be used to power the radio down to a consumption of < 1 mA.

3.1.2 Power Sense (Ignition)

Application

If AUX_GPI3 is configured for 'auxiliary power sense' or IOP_GPIO7 is programmed for 'internal options power sense', these input lines can no longer be used as general inputs. In order to prevent any other action to be accidentally programmed for one of these input lines, these input lines should be set to 'Power Sense (Ignition)'. This setting itself has no function.

For more information refer to "Power Sense Options" on page 121.

3.1.3 Enter Emergency Mode

Application

This input signal is used to enter the emergency mode. For more information on emergency mode refer to the online help of the programming application.

Use this action with the AUX_GPI2 line to configure the 'emergency power sense' option to power up the radio into emergency mode. The 'emergency power sense' is completely independent of any other power sense option configured in the radio. For more information refer to "Power Sense Options" on page 121.

Note The 'Enter Emergency Mode' action can be programmed on AUX_GPI2 or IOP_GPIO1…7, but only AUX_GPI2 provides the ability to also power up the radio.

Configuration

1. If required, configure the 'emergency power sense' option as described in "Configuring the Hardware Links LK1 to LK4" on page 126.
2. Configure the additional parameters required for the emergency mode (stealth, emergency call settings etc.).
3. Configure an input line (AUX_GPI2 with emergency power sense) and associate it with this action. Set the active state to low.
   As the emergency input driver is usually a mechanical switch, to prevent accidental activation, set the debounce time to 100ms.

Timing

The input line must be activated for at least 2s.

Description

If 'emergency power sense' is configured and the radio is off, activation of AUX_GPI2 for >2s will power up the radio and enter it into emergency mode immediately. If 'emergency power sense' is not configured and the radio is off, activation of the programmed input line will have no effect.

If 'emergency power sense' is **not** configured and the radio is on, activation of the programmed input line will enter it into emergency mode immediately.

The radio will ignore further assertions of this input line until emergency mode has been exited at which point another assertion of this line would cause emergency mode to be initiated again.

If this input is active when the radio is powered on, the radio will enter emergency mode immediately.

Related Actions

None.

3.1.4 Send Channel Preset Call

Application

When activated, this action sends a fixed-format call for the current channel.

For Selcalls, one indexed call is specified for each channel. Each channel has indexes to a number of elements that make up a signalling sequence for the in band signalling scheme associated with the network selected for that channel. One for Repeater burst, one for a RX Decode burst, one for a Caller ID burst and one for a status burst.

For DTMF calls, one preset sequence is specified per DTMF network.

Configuration

1. Configure channel preset call sequences associated with each network/channel.
2. Configure the additional parameters required to make an indexed preset call.
3. Configure an input line and associate it with this action. Set the active state (high or low) and the debounce time (0 to 100ms).

Timing

Call duration depends on the programmed signalling scheme timing.

Description

When the input line is activated, the leading edge triggers the attempt to transmit an outgoing call using the signalling scheme associated on this channel.

The radio will ignore state changes on this I/O line until the transmission has competed. Once the transmission has completed, assertion of this I/O line will be acted upon as normal.

This input line is of a momentary type and therefore no action is performed on its deactivation.

Related Actions

The PTT can be programmed to initiate a call on PTT press.

3.1.5 Send Free Format Preset 1

Application

For Selcalls, four free format preset sequences can be specified per network. This input signal is used to send the free format preset 1 sequence over the air. For more information on free format preset sequences refer to the online help of the programming application.

Note Only free-format preset 1 can be sent with this input signal.

Configuration

1. Configure the parameters required to send the free format preset 1 sequence.
2. Configure an input line and associate it with this action. Set the active state (high or low) and the debounce time (0 to 100ms).

Timing

Call duration depends on the programmed signalling scheme timing.

Description

When the input line is activated, the radio determines the current channel and network and sends free format preset 1 sequence.

Tip Use the input signals for channel selection (e.g. ‘Home Channel’) to select the channel with the desired network before activating this signal.

The radio will ignore state changes on this I/O line until the transmission has competed. Once the transmission has completed, assertion of this I/O line will be acted upon as normal.

This input line is of a momentary type and therefore no action is performed on its deactivation.

Related Actions

To send other configured free format preset calls, program them to any of the function keys and use the ‘Simulate F1 to F4 Key’ action to simulate the key press (refer to “Simulate F1 to F4 Key” on page 62).

The PTT can be programmed to initiate a call on PTT press.

3.1.6 External PTT 1 and 2

Application

This input signal is used to configure an input line as an external PTT. Up to two external PTT input lines can be assigned using the auxiliary and the internal options connectors. All PTT lines may be active at any time, and the PTT line with the highest priority controls the audio path. For more information on PTT refer to the online help of the programming application.

Configuration

Configure an input line and associate it with this action. Set the active state (high or low) and the debounce time (0 to 100ms).

Timing

The response time is less than 8ms to 90% of full power plus debounce time.

Description

When the input line is activated, the radio executes the PTT operation.

If the 'Toggle Tx RF Inhibit' or 'Inhibit PTT' actions are active, no action will result. If 'Toggle Tx RF Inhibit' or 'Inhibit PTT' action is activated within 300µs following an activation of Activate External PTT action, the external PTT action will not be initiated.

If the input line is active while the radio is powered up, it must be re-applied for the action to be carried out.

Related Actions

The 'Reflected PTT Status' reports the PTT status by generating a logic OR of all PTT sources programmed to reflect their status.

3.1.7 Inhibit PTT

Application

This input signal is used to stop any current PTT transmissions, return to receive state and inhibit any further PTT transmission requests. This allows external applications to interrupt user-initiated transmissions, and prevents users from interrupting e.g. a data transmission.

Configuration

1. In the PTT form, configure the 'Inhibit PTT When External PTT Inhibit Active' check box for each PTT type.
2. In the Programmable I/O form, configure an input line and associate it with this action. Set the active state (high or low) and the debounce time (0 to 100ms).

Timing

If this line is activated within 300µs following an activation of any one of the PTT sources, the PTT action will not be initiated.

Description

When this input line is activated, the radio stops any current PTT transmissions and inhibits any further PTT requests.

If the input line is active while the radio is powered up, it must be re-applied for the action to be carried out.

Note Non-PTT transmission such as calls programmed on a function key will be carried out, even when this signal is active.

Emergency Mode Transmission

If an emergency mode transmission is requested, the 'Inhibit PTT' action will be ignored. Once the emergency mode transmission is complete, the 'Inhibit PTT' action will be restored if the input line is still active.

Related Actions

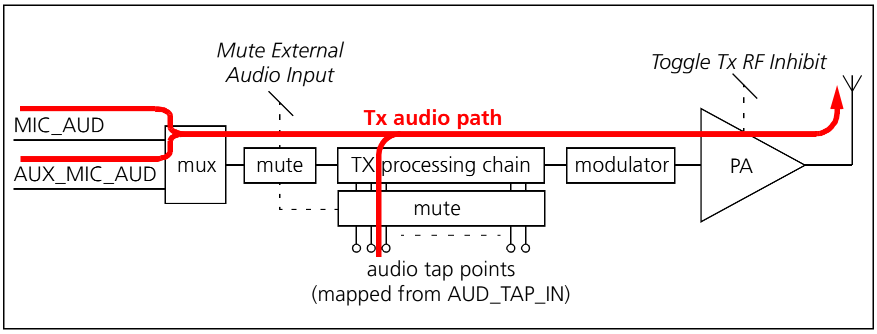
The 'Toggle Tx RF Inhibit' input signal allows the radio to be in transmit mode but inhibits transmitting.

3.1.8 Toggle Tx RF Inhibit

Application

This input signal is used to prevent the RF carrier from being radiated while in transmit mode. This can be used e.g. for precise timing of data transmissions such as GPS.

Figure 3.5 Toggle Tx RF Inhibit



Activation of one or more 'Toggle Tx RF Inhibit' input lines will inhibit the radios transmitter PA from generating RF power. The radio is otherwise unaffected by this input (i.e. the radio will still enter and exit transmit state, indicate transmit to the user, time transmit duration, send signalling through the transmit audio path and in all other respects act as per normal).

Configuration

Configure an input line and associate it with this action. Set the active state (high or low) and the debounce time (0 to 100ms). This action can be programmed to both the auxiliary and the internal options connector at the same time (logical OR).

Timing

The input line has a response time of less than 2.5ms.

If this line is activated within 300µs following an activation of any one of the PTT sources, the PTT action will not be initiated.

Description

When any 'Toggle Tx RF Inhibit' input line is activated and the radio is in transmit mode (on any channel and independent of the type of transmission), the radio will ramp down the RF power to <–10dBm (100µW), but it will remain in the transmit state.

If the input line is active while the radio is powered up, it must be re-applied for the action to be carried out.

When all 'Toggle Tx RF Inhibit' input lines are deactivated and the radio is in transmit mode, the radio will ramp up the RF power to its previous setting.

If the radio starts transmission while one or more 'Toggle Tx RF Inhibit' input lines are active, the radio will enter transmit state as normal, but will not ramp up the RF power.

The radio is able to leave the transmit state (e.g. to return to receive state) irrespective of the state of the 'Toggle Tx RF Inhibit' input lines.

Emergency Mode Transmission

If an emergency mode transmission is requested, the 'Toggle Tx RF Inhibit' input line will be ignored. Once the emergency mode transmission is complete, the 'Toggle Tx RF Inhibit' action will be restored if the input line is still active.

Related Actions

The 'Inhibit PTT' input signal stops any current PTT transmissions, returns to receive state and inhibits any further PTT transmission requests.

3.1.9 Decrement Channel

Application

This input signal is used to select the next lowest channel. This action uses the same restrictions for channel wrap around as programmed.

Configuration

1. Configure a list of channels.
2. Enable or disable the TM8115 front panel lockout as desired (BCD tab).
3. Configure an input line and associate it with this action. Set the active state (high or low) and the debounce time (0 to 100ms).
4. Select a defined channel, if desired, using the 'Home Channel' actions.

Timing

The time between pulses should be at least 20ms. The minimum pulse width is the debounce time plus 2ms.

Description

When this input line is activated, the radio decrements the current channel. If the radio is at the start of the channel list and wrap around is disabled, the radio ignores the channel change request.

This input line is of a momentary type and therefore no action is performed on its deactivation.

Related Actions

The 'Increment Channel' input signal performs the corresponding action of incrementing the channel.

The 'BCD Pin 0 to 4' input signal is used to change to a specified channel number.

The 'Home Channel' input signal is used to change to a specified reference channel, which can be used to increment or decrement from.

3.1.10 Increment Channel

Application

This input signal is used to select the next highest channel. This action uses the same restrictions for channel wrap around as programmed.

Configuration

1. Configure a list of channels.
2. Enable or disable the TM8115 front panel lockout as desired (BCD tab).
3. Configure an input line and associate it with this action. Set the active state (high or low) and the debounce time (0 to 100ms).
4. Select a defined reference channel, if desired, using the 'Home Channel' action.

Timing

The time between pulses should be at least 20ms. The minimum pulse width is the debounce time plus 2ms.

Description

When this input line is activated, the radio increments the current channel. If the radio is at the end of the channel list and wrap around is disabled, the radio ignores the channel change request.

This input line is of a momentary type and therefore no action is performed on its deactivation.

Related Actions

The 'Decrement Channel' input signal performs the corresponding action of decrementing the channel.

The 'BCD Pin 0 to 4' input signal is used to change to a specified channel number.

The 'Home Channel' input signal is used to change to a specified reference channel, which can be used to increment or decrement from.

3.1.11 Home Channel

Application

This input signal is used to change to a specified reference channel, which can then be used to increment or decrement from.

Configuration

1. Configure a list of channels.
2. Configure an input line and associate it with this action. Set the active state (high or low) and the debounce time (0 to 100ms).
3. On the same form, select the home channel.

Timing

Allow 10ms before applying another channel change action.

Description

When this input line is activated, the radio changes to the home channel.

This input line is of a momentary type and therefore no action is performed on its deactivation.

If the input line is active while the radio is powered up, it must be re-applied for the action to be carried out.

Related Actions

The 'Preset Channel' input signal is used to temporarily select a pre-programmed channel

The 'BCD Pin 0 to 4' input signal is used to change to a specified channel number.

The 'Increment Channel' and 'Decrement Channel' input signals are used to increment or decrement the current channel by one.

3.1.12 BCD Pin 0 to 4

Application

These signals are used to select a discrete channel using a bit pattern on up to five input lines.

BCD/BIN Operation

The bit pattern can be decoded in BCD or binary (BIN) operation.

In BCD operation, the bit pattern is divided into a block of four signals (pin 0 to 3) to provide the decimal numbers 0 to 9 (0000 to 1001), and a most significant bit (pin 4) to indicate 0 or 1. This allows five lines to represent the decimal channel numbers 1 to 19. Invalid BCD bit patterns are ignored.

In BIN operation, the bit pattern represents the decimal channel numbers 1 to 31.

When channel 0 is selected in either BCD or BIN mode, no channel change occurs.

Table 3.3 shows a list of BCD pin signals and their equivalent BCD and BIN channel numbers.

When any of these input lines changes, the corresponding channel will be selected.

Table 3.3 BCD pin signals and BCD/binary channels

BCD Pin					Channel	
4	**3**	**2**	**1**	**0**	**BCD**	**BIN**
0	0	0	0	0	No change	
0	0	0	0	1	1	1
0	0	0	1	0	2	2
...	...	...	...	...	...	...
0	1	0	0	1	9	9
0	1	0	1	0	Prev[a]	10
0	1	0	1	1	Prev[a]	11
...	...	...	...	...	...	...
0	1	1	1	1	Prev[a]	15
1	0	0	0	0	10	16
1	0	0	0	1	11	17
...	...	...	...	...	...	...
1	1	0	0	1	19	25
1	1	0	1	0	Prev[a]	26
...	...	...	...	...	...	...
1	1	1	1	1	Prev[a]	31

a. 'Prev' means that the input is ignored (invalid BCD) and that the previously selected channel remains selected.

Configuration

1. Configure up to 5 input lines and associate them with this action. Set the active state (high or low) and the debounce time (preset to 10ms). Lines must be assigned in order, starting with pin 0 (LSB). Unassigned signals are assumed to be logic 0.

2. Select BCD or BIN operation (BCD tab).

3. Enable or disable the front panel lockout as desired (BCD tab).

4. Configure a list of channels corresponding to the BCD or binary values.

Timing

A fixed debounce time of 4ms is applied to all BCD inputs to ensure that all lines have settled to their new state before being read. This is adequate for logic-driven inputs but additional debounce time needs to be programmed if a BCD switch or similar is used.

Description

When the current state of the BCD input lines is changed, the radio determines the new channel according to Table 3.3 and selects it for use.

When the radio is turned on, the BCD input lines are read. If the BCD input lines are not set to zero, the radio will select the corresponding channel. If they are set to zero, the radio will select the last saved channel.

If the bit pattern in BCD operation does not represent a valid BCD number (from 01010 to 01111 and from 11010 to 11111), the radio will remain on the current channel.

When the current state of the BCD input lines is changed while the radio is in transmit mode, the channel change will be carried out as soon as the radio returns to receive mode.

Related Actions

The 'Increment Channel' and 'Decrement Channel' input signals are used to increment or decrement the current channel by one.

The 'Home Channel' input signal is used to change to a specified reference channel, which can be used to increment or decrement from.

3.1.13 Preset Channel

Application

This input signal is used to temporarily select a pre-programmed channel. When this input line is deactivated, the radio returns to the channel it was on at the time the input line was activated. This allows temporary channel change for purposes such as transmitting GPS data on a data channel instead of the voice channel.

Configuration

1. Configure a list of channels.
2. Configure an input line and associate it with this action. Set the active state (high or low) and the debounce time (0 to 100ms).
3. On the same form, select the preset channel. Hidden channels are also available for selection. Scan group IDs are not available.

Timing

Allow debounce time plus 2ms plus time for channel change (typically 10ms) for the preset channel to be selected or to return to the previous channel. If timing is critical in your application, then this will need to be measured with the frequency step you intend to use.

Description

When the input line is activated, the currently selected channel ID is stored for future use and the radio changes to the preset channel.

When the input line is deactivated, the radio returns to last selected channel.

While the input line is activated, the channel selection keys on the control head are not functional.

If the input line is active while the radio is powered up, it must be re-applied for the action to be carried out.

If a preset channel is selected and the radio powers down and up again then the last selected channel will be selected and not the preset channel.

Related Actions

The 'BCD Pin 0 to 4' input signal is used to change to a specified channel number.

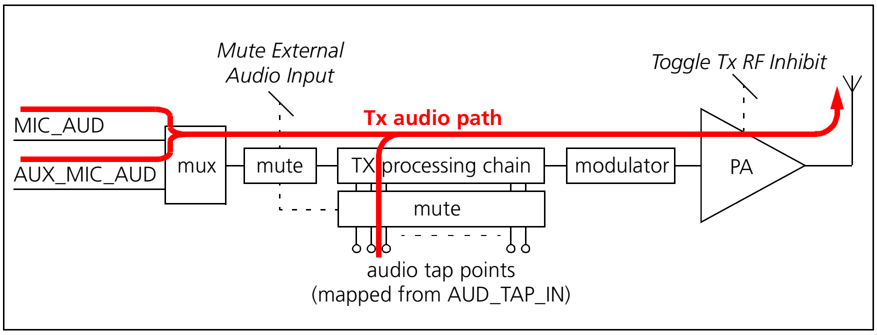
The 'Home Channel' input signal is used to permanently change to a specified reference channel, which can be used to increment or decrement from.

3.1.14 Mute External Audio Input

Application

This input signal is used to open or close the mute of selected audio inputs to allow or prevent transmission of unwanted audio. This can be useful in cases where a controller wants to send information and does not want to be interrupted by incoming audio.

Figure 3.6 Mute External Audio Input



Configuration

1. Configure an input line and associate it with this action. Set the active state (high or low) and the debounce time (0 to 100ms).
2. On the same form, configure an option to mute the audio from the microphone inputs, the audio tap inputs, or all audio inputs.

Timing

The response time for both activation and deactivation is approx. 2ms plus debounce time.

Description

When the input line is activated, the radio mutes the audio input(s) selected. If a higher priority unmute condition exists, activation of this line will have no effect.

When the input line is deactivated, the audio input path reverts to its previous state. If a higher priority mute condition exists, deactivation of this line will have no effect.

If the input line is active while the radio is powered up, it must be re-applied for the action to be carried out.

Related Actions

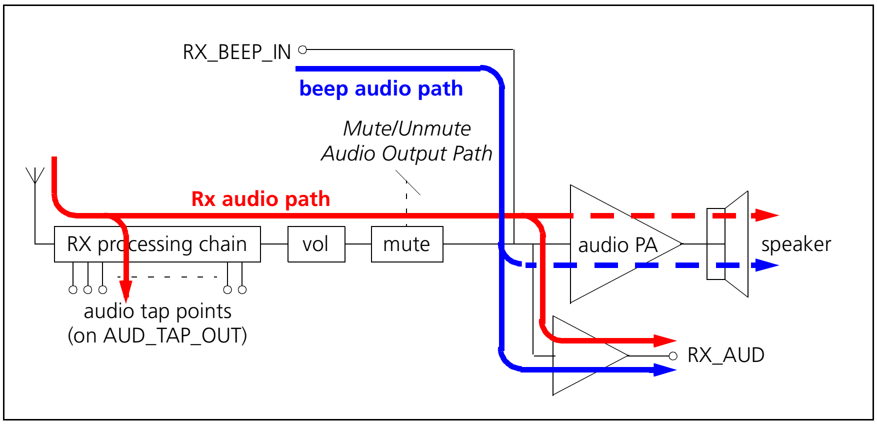
None.

3.1.15 Mute Audio Output Path

Application

This input signal is used to close the mute of selected audio paths to prevent audio from being output. This allows an external device to turn off audio to the speaker (e.g. for a data channel) or other audio equipment.

Figure 3.7 Mute/Unmute Audio Path



Configuration

1. Configure an input line and associate it with this action. Set the active state (high or low) and the debounce time (0 to 100ms).

2. On the same form, configure an option to mute the audio output of the speaker output path, the auxiliary output path, or all output paths.

Timing

The response time for both activation and deactivation is approx. 2ms plus debounce time.

Description

When this input line is activated, the radio mutes the configured audio output path(s). If a higher priority unmute condition exists, activation of this line will have no effect.

When this input line is deactivated, the audio output path(s) reverts to its (their) previous state. If higher priority mute condition exists, deactivation of this line will have no effect.

If the input line is active when the radio is powered up, it must be re-applied for the action to be carried out.

Related Actions

The 'Unmute Audio Output Path' input signal deactivates the Rx audio path only.

The 'Force Audio PA Off' input signal deactivates the audio PA.

The 'Force Audio PA On' input signal activates the audio PA.

3.1.16 Unmute Audio Output Path

Application

This input signal is used to open the mute of selected audio paths to allow audio to be received. This allows the signal to go through to the speaker (e.g. for beeps of an external device, a public address system, or an external voice recorder). Please refer also to Figure 3.7 on page 58.

Configuration

1. Configure an input line and associate it with this action. Set the active state (high or low) and the debounce time (0 to 100 ms).

2. On the same form, configure an option to unmute the audio output of the speaker output path, the auxiliary output path, or all output paths.

Timing

The response time for both activation and deactivation is approx. 2 ms plus debounce time.

Description

When this input line is activated, the radio unmutes the configured audio output path(s). If a higher priority mute condition exists, activation of this line will have no effect.

When this input line is deactivated, the audio output paths reverts to their previous state. If higher priority unmute condition exists, deactivation of this line will have no effect.

Related Actions

The 'Mute Audio Output Path' input signal activates the Rx audio path only.

The 'Force Audio PA Off' input signal deactivates the audio PA.

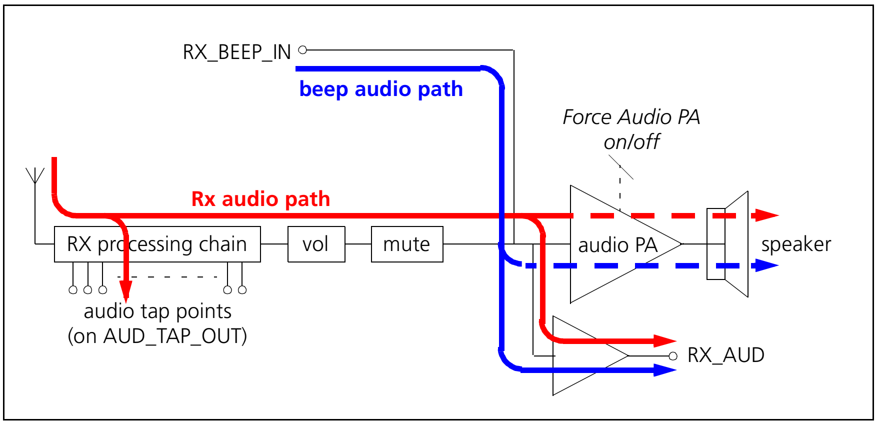
The 'Force Audio PA On' input signal activates the audio PA.

3.1.17 Force Audio PA On

Application

This input signal is used to activate the audio PA. This action is required to allow any audio on the RX_BEEP_IN line of the internal options connector to be heard from the speaker when no other audio unmute conditions exist.

Figure 3.8 Force Audio PA on/off



Configuration

Configure an input line and associate it with this action. Set the active state (high or low) and the debounce time (0 to 100ms).

Timing

When this input line is activated and the audio PA is off, there will be a delay of 50ms before audio PA output is unmuted. This delay prevents undesired transient noise (audible 'pop') caused by the audio PA powering up. If the audio PA is already on or there has been speaker audio within 100ms prior to activation there is no significant unmute delay.

Description

When this input line is activated, the radio unmutes the audio PA. If the audio PA is already unmuted, no action occurs. If a higher priority mute condition exists, activation of this line will have no effect.

When this input line is deactivated, the audio PA reverts to its previous state. If a higher priority unmute condition exists, deactivation of this line will have no effect.

If the input line is active while the radio is powered up, it must be re-applied for the action to be carried out.

Related Actions

A related 'Force Audio PA Off' input signal exists, for which another input line can be assigned. Separate input lines are needed because deactivation of each line should release the corresponding action rather than forcing the audio PA into the opposite state.

The 'Mute Audio Output Path' input signal activates the Rx audio path only.

The 'Unmute Audio Output Path' input signal deactivates the Rx audio path only.

3.1.18 Force Audio PA Off

Application

This input signal is used to deactivate the audio PA. This action is required, for example, to allow the use of a telephone handset for which—when it is taken off hook—the audio PA should be deactivated to prevent the audio from coming out of the internal or remote speaker. Please refer also to Figure 3.8 on page 60.

Configuration

Configure an input line and associate it with this action. Set the active state (high or low) and the debounce time (0 to 100ms).

Timing

When this input line is activated and the audio PA is on, there will be no significant delay before the speaker audio is muted. After 100ms the audio PA will be fully powered down and current consumption will reduce by 50mA.

Description

When this input line is activated, the radio mutes the audio PA. If the audio PA is already muted, no action occurs.

When this input line is deactivated, the audio PA reverts to its previous state.

If the input line is active while the radio is powered up, it must be re-applied for the action to be carried out.

Activation of 'Force Audio PA Off' input line takes precedence over the 'Force Audio PA On' input line. When both inputs are active at the same time, the speaker is disabled but any audio signal present is still output through RX_AUD.

Related Actions

A related 'Force Audio PA On' input signal exists, for which another input line can be assigned. Separate input lines are needed because deactivation of each line should release the corresponding action rather than forcing the audio PA into the opposite state.

The 'Mute Audio Output Path' input signal activates the Rx audio path only. The 'Unmute Audio Output Path' input signal deactivates the Rx audio path only.

3.1.19 Simulate F1 to F4 Key

Application

These input signals are used to simulate the press of function keys on the control head. Both short and long key presses can be simulated.

These input lines do not perform any pre-defined actions, but only simulate the press of specific function keys. This means that when the associated function key is re-programmed to carry out a different function, activation of this line will also carry out the new function.

Configuration

Configure an input line and associate it with this action. Set the active state (high or low) and the debounce time (0 to 100ms).

Timing

When a function key has only one function assigned, the key press will be actioned as soon as it is sensed.

When a function key is assigned different functions for short and long key press:

- The short key press function will be actioned as soon as the signal is released, if the signal has been active for between 100 and 750ms.
- The long key press function will be actioned as soon as the signal has been active for 750 ms.

Description

When any of these input lines is activated, the function associated with the corresponding function key is carried out. Short/long activations of this input line will have the same effect as short/long function key presses.

Related Actions

The 'Toggle F1 to F4 Key LED' input signals are used to turn the LEDs of the control head on and off for display purposes, e.g. for keys functions that have no LED assigned.

The 'F1 to F4 Key Status' output signals are used to reflect the press of function keys on the control head.

3.1.20 Toggle F1 to F4 Key LED

Application

These input signals are used to turn the LEDs of the control head on and off for display purposes, e.g. for keys functions that have no LED assigned. When any of these lines is active, no other source will be able to control the associated LED.

Configuration

Configure an input line and associate it with this action. Set the active state (high or low) and the debounce time (0 to 100ms).

Timing

The display is updated every 50ms. The response time of the LED can therefore be between 2 and 52ms plus debounce time.

Description

When this input line is activated, the associated LED lights up.

When this input line is deactivated, the associated LED goes out.

If the input line is active while the radio is powered up, it must be re-applied for the action to be carried out.

Related Actions

These 'Simulate F1 to F4 Key' input signals are used to simulate the press of function keys on the control head. Both short and long key presses can be simulated.

The 'F1 to F4 Key Status' output signals are used to reflect the press of function keys on the control head.

3.2 Digital Output Lines

This section describes the general design principles for use of the programmable I/O lines configured as outputs, and the output signals which can be set for them.

Available Output Lines

The following lines are available to be used as outputs:

Table 3.4 Digital output lines

Signals	Connector	Direction
AUX_GPIO4…7	auxiliary connector	input or output
IOP_GPIO1…7	internal options connector	input or output
CH_GPIO1 MIC_GPIO1[a] (TM8115) PRG_GPIO1[a] (TM8105)	control-head connector microphone connector programming connector	input or output

a. CH_GPIO1 of the control-head connector is the same signal as MIC_GPIO1 of the microphone connector (TM8115) and PRG_GPIO1 of the programming connector (TM8105).

For details on the connector pin-outs and electrical characteristics of these lines refer to "Description of the Radio Interfaces" on page 15.

Compatibility

Table 3.2 describes the compatibility of the output lines with common industry logic standards:

Table 3.5 Digital output lines - compatibility

Output line	Logic standard output compatibility			
	3.3V CMOS	5V CMOS	5V TTL	RS-232[a]
AUX_GPIO4…7	Yes	Yes[b]	Yes	No
AUX_TXD	Yes	No	Yes	No
IOP_GPIO1…7	Yes	No[c]	Yes	No
IOP_TXD	Yes	No[c]	Yes	No
CH_TXD MIC_TXD PRG_TXD	Yes	No	Yes	No
CH_GPIO1 MIC_GPIO1	Yes	No[c]	Yes	No

a. While the output levels do not comply with the RS-232 standard, almost all modern RS-232 level conversion devices are 3.3V/5V CMOS or TTL level-compatible. Therefore, it usually possible to drive modern external RS-232 devices directly without level conversion if the length of the connection cable is <3m.

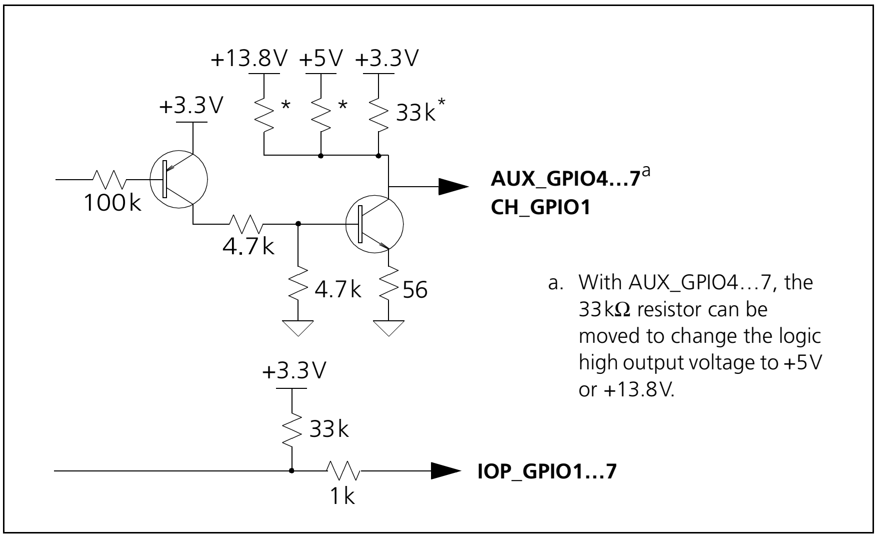
b. Yes, provided internal pullups to 5V are selected.

c. These outputs can be made 5V CMOS-compatible using a 3.3kΩ pullup resistor to 5V that is provided by the device being driven.

Output Circuitry

The digital outputs are designed to interface to application circuitry in a straightforward manner. Figure 3.9 shows a simplified diagram of the digital output lines (ESD protection not shown). For full details of the interface, refer to the PCB information chapter of the TM8100 Mobile Radio Service Manual or the technical support website.

Figure 3.9 Digital output lines - simplified circuit diagrams



The internal logic circuitry of the radio operates at 3.3V. Unless application circuitry is able to operate at this voltage level, some form of level conversion will normally be required. With the AUX and CH output lines, conversion to 5V or 13.8V can be selected by moving the pullup resistor as indicated in Figure 3.9.

Note These resistors only provide a weak pullup and hence the output is only able to source a very small current. In the logic low state, the outputs can sink a higher current. For more information refer to "Description of the Radio Interfaces" on page 15.

The IOP output lines always operate at 3.3V logic levels and any level conversion is the responsibility of the application circuit designer.

Pullup Resistors

For the output lines AUX_GPIO4 to AUX_GPIO7 the output configuration is open collector with pullup. The hardware provides several pullup options.

Placeholder pullup resistors to 3.3V, 5V or 13.8V are provided. Table 3.6 gives an overview of the output lines and their placeholder pullup resistors.

Table 3.6 Placeholder pullup resistors

Output line	3.3V pullup	5V pullup	13.8V pullup
AUX_GPIO4	R769[a]	R778	R782
AUX_GPIO5	R770[a]	R779	R783
AUX_GPIO6	R771[a]	R780	R784
AUX_GPIO7	R772[a]	R781	R785

a. Factory default.

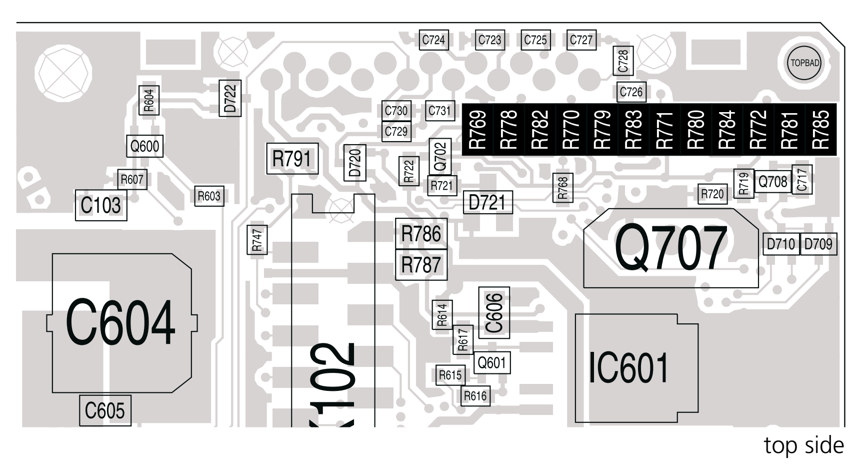
Figure 3.10 shows the positions of these placeholders on the main board assembly.

Follow the instructions of the TM8100 Service Manual on removing and fitting the radio lid, the main board assembly, and SMD components.

For any I/O line, exactly one pullup resistor must be fitted. To change the pullup option it is recommended to move the factory-fitted pullup resistor to the desired location.

If you require a different pullup resistance value, remove the factory-fitted resistor and fit your own in the desired location. The current through the pullup resistor must not exceed 5 mA when the output is low. For example, the value of a pullup resistor to 5 V must be >1 kΩ.

Figure 3.10 Positions of placeholder pullup resistors on main board assembly



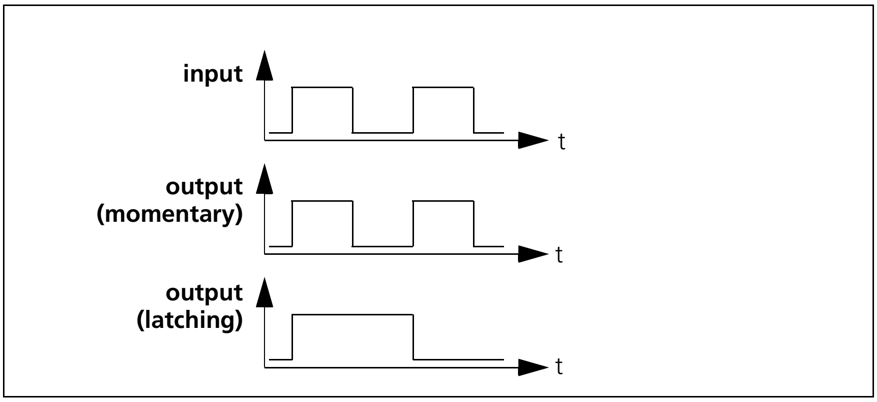
Special Purpose Outputs

AUX_GPIO4 can be used as a general purpose output with normal drive levels, or it can be configured as a high current sink output capable of directly driving external devices. To configure high current sink, a high power transistor must be soldered to the main board assembly. For more information refer to "Connecting an External Alert Device" on page 133.

Momentary or Latching

Output signals are latching or momentary, depending on their function. Examples: 'Control Status Rx (Line 1 to 3)' is always latching. Most of the other output signals are momentary. 'F1 to F4 Key Status' can be either latching or momentary.

Figure 3.11 Momentary and latching output signals



Power-Up Considerations

During power-up of the radio, any I/O lines configured as outputs are in an uncontrolled and high-impedance state. The pullup resistors have a dominant effect and thus all outputs will appear as if they are indicating logic high during this period.

The radio will not actively control these lines for up to 1 to 2 seconds after power is first applied or the radio has been switched on. It is therefore important to consider how this will affect application circuitry interfaced to the radio and take measures to manage what happens during this transition.

Defining the active state of the outputs as logic low may provide suitable protection, as outputs will appear inactive during radio power-up. In other cases it may be necessary to buffer the outputs with suitable circuitry to isolate application circuits from the radio signals during this transition.

Output Signals

The following sections describe the output signals available for programming of the digital output lines:

- Busy Status
- Radio Transmission Status
- Channel Locked Status
- Reflected PTT Status
- External Alert 1 and 2
- Reflected PTT Inhibit Status
- Signalling Audio Mute Status
- Monitor Status
- Hookswitch Status
- Call Setup Status
- Control Status Rx (Line 1 to 3)
- Inband Tone Received
- Radio Stunned
- F1 to F4 Key Status
- FFSK Data Received Status

3.2.1 Busy Status

Application

This output signal is used to reflect the busy status, i.e. whether or not the receiver detects an RF carrier (busy detect LED is on). The detection of the RF carrier can be based on either signal strength (RSSI) or noise level. This allows the radio to wake up a receiving modem or start voice recording (for example).

Note The detection method can be set in the Squelch Detect Type field of the Networks / Basic Settings form (Basic Networks Settings tab) of the programming application. For more information refer to the online help of the programming application

Configuration

Configure an output line and associate it with this action. Set the active state to be high or low (as required).

Timing

The response time of this output line is <3ms for signal strength and <20ms for noise level.

Description

When the radio detects a change in the state of the busy-detect circuitry, the radio sets the state of this output line to reflect the busy detect state. When 'busy', the output line is active. When 'not busy', the output line is inactive.

Related Actions

An indication of received signal strength is available from the RSSI output.

The 'Signalling Audio Mute Status' output signal indicates that a signal is being received which also has valid signalling.

3.2.2 Radio Transmission Status

Application

This output signal indicates, whether the radio is in transmission mode.

This can be used

- with external modems as a gate for the start of data transmission
- with external applications, instead of looking at the PTT status, in order to not interrupt a transmission by the user
- to switch scramblers from receive to transmit

Configuration

Configure an output line and associate it with this action. Set the active state to be high or low (as required).

Timing

Specification not finalised at time of publication. For further information, please contact Customer Support, Tait Electronics Ltd, Christchurch, New Zealand (refer to "Contact Information" on page 2).

Description

When the radio starts a RF transmission, this output line is activated. When the radio stops the RF transmission, this output is deactivated.

While the 'Toggle TX RF Inhibit' input line is active, the RF output will be inhibited, but the radio stays in transmit mode (refer to "Toggle Tx RF Inhibit" on page 50). The 'Radio Transmission Status' input line is not affected by the 'Toggle TX RF Inhibit' input line.

Related Actions

The 'Reflected PTT Inhibit Status' output signal reports transmission requests via any of the PTT input signals.

3.2.3 Channel Locked Status

Application

This output signal is used to indicate the frequency lock status of the synthesizer and is constantly activated during normal operation. The output is deactivated, if the radio synthesizer is unable to "lock" to the current channel frequency, which can be caused by a hardware fault.
The deactivation of this output always coincides with the "OL" (out of lock) control head display.

> ***Note*** During channel change, although the synthesizer has to re-synchronise with the new channel frequency, this output will not be temporarily deactivated.

Configuration

Configure an output line and associate it with this action. Set the active state to be high or low (as required).

Timing

The maximum time out of lock before this action is activated (e.g. during channel change) is 50ms.

Description

When the radio detects a change of the synthesizer lock detect state, the radio sets the state of this output line to reflect the lock detect state. When the synthesizer is locked, the output line is active. When the synthesizer is not locked, the output line is inactive.

Related Actions

None.

3.2.4 Reflected PTT Status

Application

This action is used to report the PTT status by generating a logic OR of all PTT sources programmed to reflect their status. The priority does not affect the logic OR.

Configuration

1. In the PTT form, configure the 'PTT State is Reflected' check box for each PTT type.
2. In the Programmable I/O form, configure an output line and associate it with this action. Set the active state to be high or low (as required).

Timing

The response time of this output line is less than 2ms.

Description

When the radio detects a change in PTT state, it sets the state of this output line to reflect the PTT state. When any PTT state changes to active, the output line is active. When all PTT states change to inactive, the output line is inactive.

Related Actions

The external PTTs can be monitored directly by the external application.

3.2.5 External Alert 1 and 2

Application

These two output signals are used to indicate the reception of a call to an externally connected device. The alert can be programmed to occur for specific call types.

The AUX_GPIO4 line of the auxiliary connector can be fitted with a power MOSFET in order to directly connect signal indicators to the radio (e.g. flashing light, buzzer, horn relay). With the other GPIO lines, if no power MOSFET is fitted to the AUX_GPIO4 line, the signal characteristics specified in "Description of the Radio Interfaces" apply.

Two different external alert types (external alert 1 and 2) can be specified, and either none, external alert 1, external alert 2 or both can be activated.

For more information on external alerts refer to the online help of the programming software.

Configuration

1. If you want to connect to an external alert device such as horn or lights relay, follow the instructions in "Connecting an External Alert Device" on page 133.
2. Configure AUX_GPIO4 (when connection to an external alert device) or any other output line and associate it with this action. Set the active state to be high or low (as required).
3. On the Alerts form, configure external alert 1 and/or 2 (delay, duration, mode).

Timing

The timing of the external alert signal activation and deactivation is determined by the settings in the programming application.

Description

When the radio receives a call (individual call 1 or 2, priority call, group call or emergency call), which goes unanswered for the specified amount of time, the radio indicates the incoming call to the external device via the output line according to the currently programmed settings for the call alert function.

When the call is answered (i.e. external PTT activated or PTT pressed), the radio will stop indicating the incoming call to the external device.

Related Actions

None.

3.2.6 Reflected PTT Inhibit Status

This output signal is used to report the current PTT inhibit status by generating a logic OR of all PTT sources programmed to reflect their status. The priority does not affect the logic OR.

Configuration

1. In the PTT form, configure the 'PTT Inhibit State is Reflected' check box for each PTT type.
2. In the Programmable I/O form, configure an output line and associate it with this action. Set the active state to be high or low (as required).

Timing

The response time of this output line is less than 2ms.

Description

When the PTT inhibit status changes from on to off or off to on, this status is reflected on the output line.

Related Actions

The 'Inhibit PTT' input signal is used to stop any current PTT transmissions, return to receive state and inhibit any further PTT transmission requests.

3.2.7 Signalling Audio Mute Status

Application

This output signal is used to indicate valid traffic on a channel (e.g. to quieten a car stereo).

Configuration

Configure an output line and associate it with this action. Set the active state to be high or low (as required).

Timing

The response time of this output line is less than 2ms.

Description

If the radio receives a carrier and either signalling is valid or the monitor is active, this output line becomes active.

If the radio receives a carrier, and the channel is not programmed to have signalling, this output line becomes active.

Any condition that would cause audio mute to close will cause deactivation of this signal.

Related Actions

The 'Busy Status' output signal also detects the carrier but ignores signalling.

3.2.8 Monitor Status

Application

This output signal is used to indicated the state of the monitor function. This allows an external application to determine whether the user has activated the monitor.

Note This output line only indicates the monitor function and not the hookswitch monitor function.

For more information on the monitor function refer to the user guide and the online help of the programming application.

Configuration

Configure an output line and associate it with this action. Set the active state to be high or low (as required).

Timing

The response time of this output line is less than 2ms.

Description

When the radio detects a change in state of the monitor function, the radio sets the state of this output line to reflect the state of the monitor function. When monitor is active, the output line is active. When monitor is inactive the output line is inactive.

Related Actions

The 'Hookswitch Status' output signal indicates the state of the hookswitch.

3.2.9 Hookswitch Status

Application

This output signal is used to indicate the state of the hookswitch.

Configuration

Configure an output line and associate it with this action. Set the active state to be high or low (as required).

Timing

The response time of this output line is less than 2ms.

Description

When the radio detects a change in state of the hookswitch, the radio sets the state of this output line to reflect the state of the hookswitch. When the hookswitch is off the hook, the output line is active. When the hookswitch is on the hook, the output line is inactive.

Related Actions

None.

3.2.10 Call Setup Status

This output signal is activated when the radio is busy in a voice call. It remains active as long as the call is in progress, and may be used to trigger an application such as a voice recorder, or to quieten external audio equipment during the call.

Configuration

1. Configure an output line and associate it with this action. Set the active state to be high or low (as required).
2. Configure the Monitor function to activate on both call reception and call initiation. Set the Monitor Auto-Quiet timer to minimise the chance of turning the Monitor off in the middle of a call.

Timing

The call setup status signal will respond within 2ms of monitor activation during call setup or reception.

Description

This output signal is activated when the monitor function is activated by either a call setup or call reception.

The signal will be deactivated when the call is finished i.e. when the monitor is deactivated again due to auto-quiet timeout or reset signalling.

Note The monitor function does not get activated if the call is determined to be non-voice e.g. contains a control status.

Related Actions

None.

3.2.11 Control Status Rx (Line 1 to 3)

These three output signals indicate that a call has been received which contains a pre-defined status code, causing the signal to either activate or deactivate. Up to three separate signals may be defined, each having unique activation and deactivation status control codes.

These outputs may be used in SCADA type systems to remotely control application devices by radio command. Example applications might include remote activation or deactivation of outstation equipment (beacons, pumps, generators etc.) from a central control point.

Configuration

1. Set up the radio to operate with Selcall on the intended operating channel.
2. Set an alert and/or a delay (in Detailed tab of the Selcall / Selcall Identity form).
3. Define the required control status values to activate and deactivate the desired control status signal (in the Selcall / Control Status form).
4. Configure an output line and associate it with this action. Set the active state to be high or low (as required).

Note This signal state of this signal can be set to latching only.

Timing

The control status signal will respond within 2ms of receiving the last digit of the call sequence. If an alert and/or delay is configured, 500 ms for the alert and/or the programmed delay will be added to the response time.

Description

The output signal is activated upon reception of a valid Selcall sequence containing the pre-defined control activation status value.

The signal remains active until another valid Selcall sequence is received which contains the pre-defined control deactivation status value.

Related Actions

None.

3.2.12 Inband Tone Received

This output signal indicates reception of a defined audio band (inband) tone.

This signal might be used to alert an application device to the presence of a pilot tone prior to other traffic being received.

Configuration

1. Set up the radio to operate with inband tone signalling on the intended operating channel.
2. Configure the inband tone parameters: tone frequency, minimum duration, and tone hold time
3. Configure an output line and associate it with this action. Set the active state to be high or low (as required).

Timing

The output signal response time is dominated by the settings of minimum tone duration and tone hold time.

Note The detection response time may lengthen if the S/N of the incoming signal is poor.

Description

This output signal is activated once the presence of the pre-defined in-band tone has been detected for the configured minimum duration.

The signal will remain active until the tone has not been detected for the duration of the configured tone hold time.

Related Actions

None.

3.2.13 Radio Stunned

Application

This output signal is used to indicate whether the radio has been stunned by receiving a Selcall that contained a control status set to full stun or Tx stun. This can be used to indicate to external applications, that the radio is unusable, or to control an external device to disable other equipment.

Configuration

Configure an output line and associate it with this action. Set the active state to be high or low (as required).

Timing

The response time of all output lines is less than 2ms after the last tone in the sequence was received.

Description

When the radio becomes stunned, this output line becomes active.

When the radio is revived, this output line becomes inactive.

Related Actions

None.

3.2.14 F1 to F4 Key Status

These output signals are used to reflect the press of function keys on the control head. The actions can be programmed to be either:

- momentary – reflects the state of the function key (active when the function key is pressed, inactive when the function key is released)
- latching – one short press of the function key activates the output line, which then stays active until next short press of function key

These signals allow user interaction with an application device.

Configuration

1. Program any function to the function key (including 'None'). The function key LED will reflect the function key state.

Note If the function key is programmed to 'None' and an output line has been configured to reflect the function key state, the LED associated with this function key will not be affected.

2. It is recommended to configure the key to Action Digital Output Line (Key Settings form) in order for the corresponding LED to reflect the key status.

3. Configure an output line and associate it with this action. Set the active state to be high or low (as required).

4. Configure the signal state to be either momentary or latching.

Timing

The response time of this output lines is less than 50ms.

Description

When the relevant function key is pressed, the output line becomes active.

Depending on the programmed mode, the output line remains active until the function key is released (momentary) or until the next key press (latching).

Related Actions

The 'Simulate F1 to F4 Key' input signals are used to simulate the press of function keys on the control head. Both short and long key presses can be simulated.

The 'Toggle F1 to F4 Key LED' input signals are used to turn the LEDs of the control head on and off for display purposes, e.g. for keys functions that have no LED assigned.

3.2.15 FFSK Data Received Status

This output signal indicates that the internal 1200 baud modem is detecting valid FFSK signalling i.e. indicating data reception.

This signal might be used to alert application devices to the presence of data.

Configuration

1. Configure the radio to expect FFSK data.On the Data form, check either the CCDI Options/Transparent Mode Enabled checkbox or the SDM Options/SDM Enabled check box.
2. Configure an output line and associate it with this action. Set the active state to be high or low (as required).

Timing

The output will indicate the presence of FFSK data within 2ms of the preamble/sync sequence being successfully decoded. Note that the preamble/sync sequence is 32 bit periods long (approximately 27ms duration).

The output will indicate the absence of FFSK once the channel is no longer busy.

Description

The output is activated when the radio successfully decodes an FFSK preamble/sync sequence.

Important The output will remain active as long as the channel remains busy (even if FFSK signalling disappears) and will become inactive once the incoming transmission ceases.

Related Actions

None.

3.3 Audio Tap In and Tap Out Lines

This section describes the general design principles for use of the programmable audio tap in and tap out lines.

Audio Tap Point Philosophy

The radio provides the ability to input and output audio at various tap points in the transmit and receive audio paths. This removes the need of tapping wires into the circuitry of the radio. The tap points and the type of tap are programmed into the radio and cannot be modified by the radio user.

Available Audio Tap In and Tap Out Lines

The following lines are available to tap into and tap out of the audio paths:

Table 3.7 Audio tap in and tap out lines

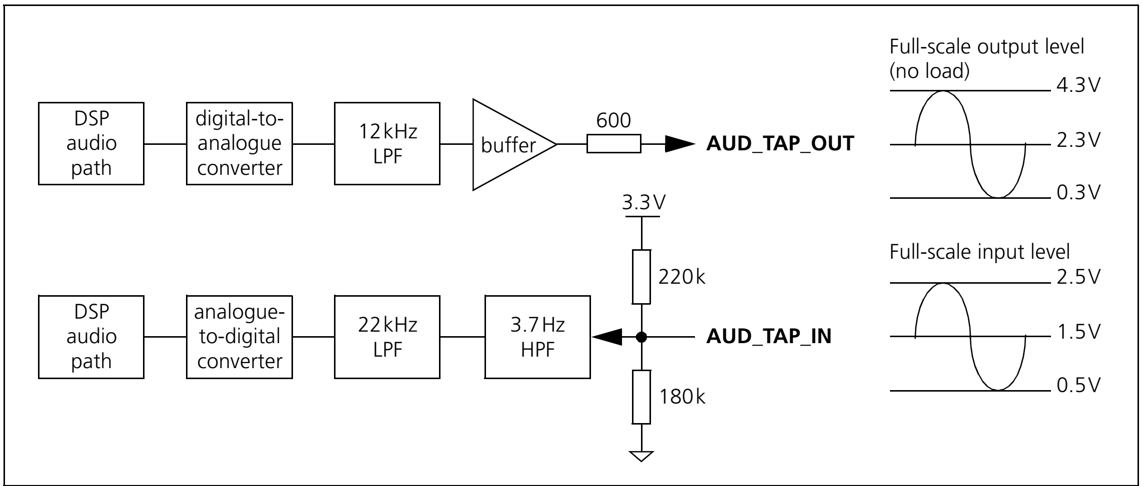
Signals	Connector	Direction
AUD_TAP_IN	auxiliary connector internal options connector	input only
AUD_TAP_OUT	auxiliary connector internal options connector	output only

For details on the connector pin-outs and electrical characteristics of these lines refer to “Description of the Radio Interfaces” on page 15.

Input/Output Circuitry

Figure 3.12 shows a simplified circuit diagram of the audio tap in and tap out lines. Protection circuits are not shown.

Figure 3.12 Audio tap input and output - simplified circuit diagram



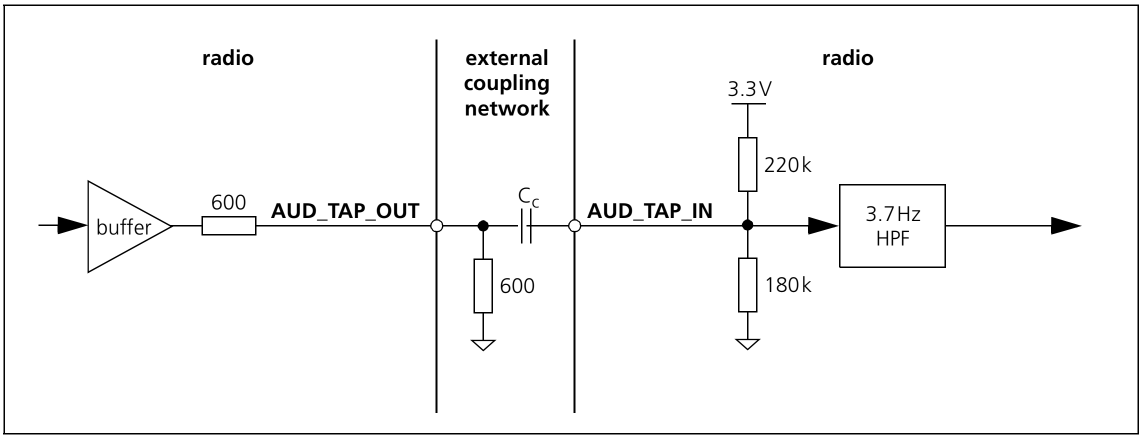
The signal source for the audio tap out line comes from the DSP audio path (refer to Figure 3.14 for details) and is fed to a digital to analogue converter at 48000 samples per second. The converter output is low pass filtered at 12kHz to remove alias components and fed to a buffer amplifier. The buffer amplifier output is DC coupled to the AUD_TAP_OUT line and has a DC offset of nominally 2.3V. The DC offset is affected by Rx carrier frequency error for taps R1, R2 and R4. Full scale output level is nominally $4V_{p-p}$ with no load (for more information refer to “Auxiliary Connector” on

page 20). The buffer amplifier has an output impedance of nominally 600 Ω that is constant across frequency.

The audio tap in line is also DC-coupled. A DC bias network provides a bias of nominally 1.5 V. The valid DC input signal range is 0.5 to 2.5 V nominally regardless of bias voltage. Therefore, to avoid asymmetrical clipping and reduced dynamic range, it is important that the input bias voltage is preserved when driving the input. This can be achieved by simply AC-coupling the drive signal. For data applications, DC-coupling may be desirable so, in this case, the driver must provide a DC bias signal as close as possible to 1.5 V. After input biasing, the AUD_TAP_IN signal is fed to a switched capacitor high-pass filter with a cut frequency of 3.7 Hz. This prevents the DC bias affecting the transmitter carrier frequency. The high-pass-filtered signal is then low-pass-filtered to prevent aliasing, and sampled by an analogue-to-digital converter at 48 kHz. The analogue-to-digital converter output is then fed to the DSP audio path (refer to Figure 3.14 for details)

For some applications, such as a crossband link or fitting an encryption module, it is necessary to connect the audio tap out line to the audio tap in line. The two are not directly compatible but can be made so using a simple external coupling network as shown in Figure 3.13.

Figure 3.13 Connecting audio tap out and audio tap in

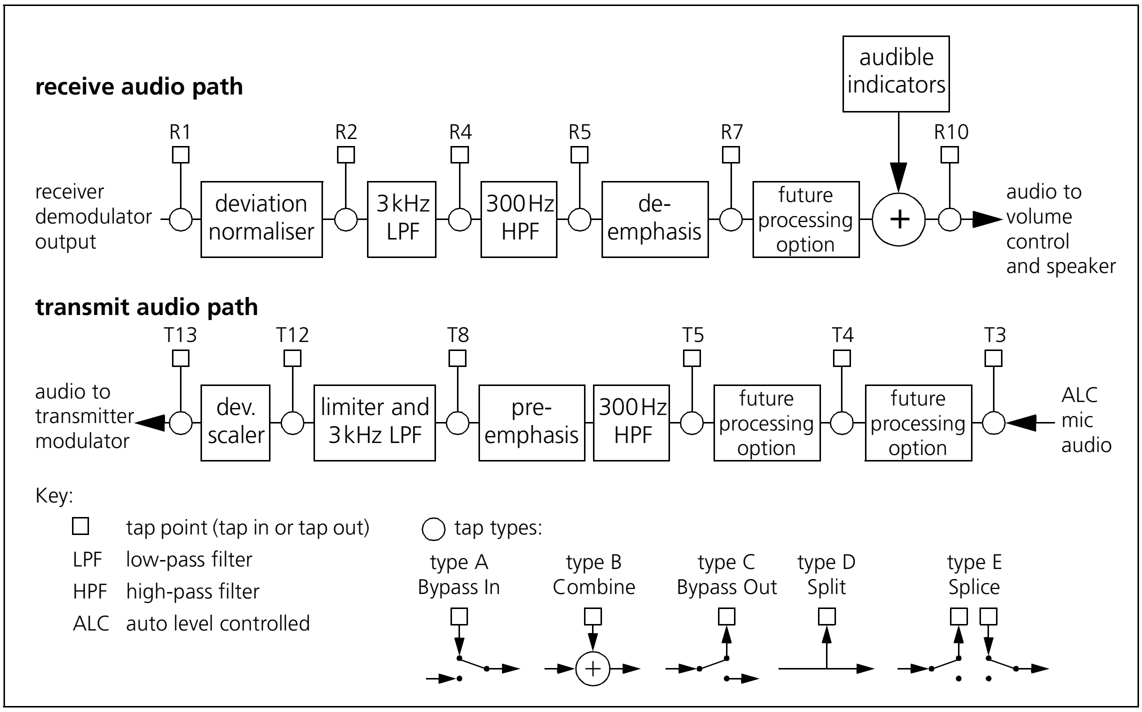


The 600 Ω shunt resistor reduces the maximum level of audio tap out to nominally 2 $V_{p\text{-}p}$ to match the maximum input level of audio tap in. The coupling capacitor removes the DC offset. For voice applications, C_C should be at least 100 nF. If high-speed baseband data modulation throughput is required, C_C of at least 4.7 µF is recommended. The C_C capacitor should be a non-polarised type.

Audio Paths

Figure 3.14 shows a simplified block diagram of the receive and transmit audio paths, the locations of the tap points available, and the tap types.

Figure 3.14 Receive and transmit audio paths - simplified block diagram



Audio Configuration

The audio configuration consists of the following elements:

- audio source associated with each PTT (CH_MIC_AUD, AUX_MIC_AUD, AUD_TAP_IN)
- Rx/PTT type (Rx, Mic PTT, EPTT1, EPTT2)
- tap out point (R1, R2, R4, R5, R7, R10, T3, T4)
- tap out type (C-Bypass Out, D-Split, E-Splice)
- tap out unmute condition
- tap in point (T3, T4, T5, T8, T12, T13, R7, R10)
- tap in type (A-Bypass In, B-Combine, E-Splice)
- tap in unmute condition

Audio Source

For each PTT (Mic PTT, EPTT1 and EPTT2) a different audio source can be selected. These audio sources are CH_MIC_AUD, AUX_MIC_AUD and AUD_TAP_IN.

Note You can allocate an audio tap input at the same time as a microphone input by setting the audio source for a PTT to CH_MIC_AUD or AUX_MIC_AUD, and defining a tap in and out point for the same PTT. However, audio samples from the audio tap input will overwrite those from the microphone input, unless the tap in type and tap out type are set to ‘Splice’.

Rx/PTT Type

The radio can be programmed to tap into and out of the respective audio path, when the radio is receiving or transmitting (initiated by one of the PTTs).

Tap Out and Tap In Points and Types

Table 3.8 lists the available tap points and the tap types available for them. The tap points and tap types are illustrated in Figure 3.14.

Select a tap out point to feed audio to an application device, and a tap in point to feed audio from an application device.

Important Do not use 'Bypass Out' on R1, R2 and R4 with subaudible or inband signalling schemes, as this may prevent correct operation of the signalling decoder.

The same tap point can be selected for both tap in and tap out. This is referred to as a 'Splice' tap type as it allows an audio processing device to be inserted into the radio's audio path. This tap type is primarily used for encryption applications (refer to "Encryption Module (Scrambler)" on page 107).

The 'Combine' tap type is intended for the injection of sidetone beeps into the Rx path.

Table 3.8 Tap out points and tap out types

Rx/PTT type	Tap out points	Tap out types	Tap in points	Tap in types
Rx	R1	C - Bypass Out D - Split	R7	E - Splice
	R2	C - Bypass Out D - Split	R10	A - Bypass In B - Combine
	R4	C - Bypass Out D - Split		
	R5	C - Bypass Out D - Split		
	R7	C - Bypass Out D - Split E - Splice		
	R10	C - Bypass Out D - Split		
PTT, EPTT1, EPTT2	T3	C - Bypass Out D - Split	T3	A - Bypass In
	T4	E - Splice	T4	E - Splice
	R10	C - Bypass Out D - Split	T5	A - Bypass In
			T8	A - Bypass In
			T12	A - Bypass In
			T13	A - Bypass In

Note If a tap type is set to 'Splice', then the corresponding tap in or tap out type must also be set to 'Splice'. Both tap points and both unmute conditions must also be identical.

Tap In and Tap Out Unmute

For the Rx path, the settings for unmuting the tap in and the tap out points are:

- Busy Detect
- Busy Detect and Subaudible
- Rx Mute Open
- Except on PTT (not available for tap type E - Splice)

For all PTT types, the only setting for unmuting the tap in and the tap out points is On PTT

Applications

For application examples refer to:

- "External Modem" on page 98
- "Encryption Module (Scrambler)" on page 107
- "ANI Module" on page 113

4 Creating Your Own Options Board

TM8000 radios provide space for the following options boards:

- an internal options board inside the radio body using the internal options connector and (optional) the hole provided for the external options connector
- a blank control head options board (TM8105 only) between the radio body and the blank control head using the control-head connector

This chapter describes the mechanical envelopes of these options boards, common design practices and EMC guidelines and the Internal Options Kit available from Tait.

Important Modifications to radio-frequency transmitting equipment can void the user's authority to operate the equipment. By distributing the TM8000 3DK Hardware Developer's Kit, Tait Electronics Ltd. does not accept liability for any non-compliance or infringement of intellectual property rights resulting from the application or use of this kit or information. Any person modifying Tait radio-frequency transmitting equipment is responsible for ensuring that the modified equipment meets all legal and regulatory requirements in the country of use or supply.

4.1 Internal Options Board

TM8000 radios provide space inside the radio body to accommodate an internal options board.

The internal options board is connected to the internal options connector and can also use the hole provided for the external options connector.
The internal options connector is described on page 28.
The provision for the external options connector is described on page 31.

Examples of internal options boards available from Tait:

- TMAA30-02 3DK Application Board.
  Refer to the TM8000 3DK Application Board Service Manual.
- TMAA01-01 Line-Interface Board.
  Refer to the TM8100 Mobile Radio Accessories Manual.
- TMAA01-05 Options Extender Board.
  Refer to the TM8100 Mobile Radio Accessories Manual.

4.1.1 Mechanical Envelope

Figure 4.1 and Figure 4.2 show the mechanical envelope available for internal options boards. Nine screw points are provided on the inside of the lid of the radio body.

Internal options boards can be sized and shaped as required and can use any combination of fixing parts to suit. Figure 4.3 shows an installation example.

Note Unless stated otherwise, all dimensions are given in millimetres.

Figure 4.1 Internal options board - maximum dimensions

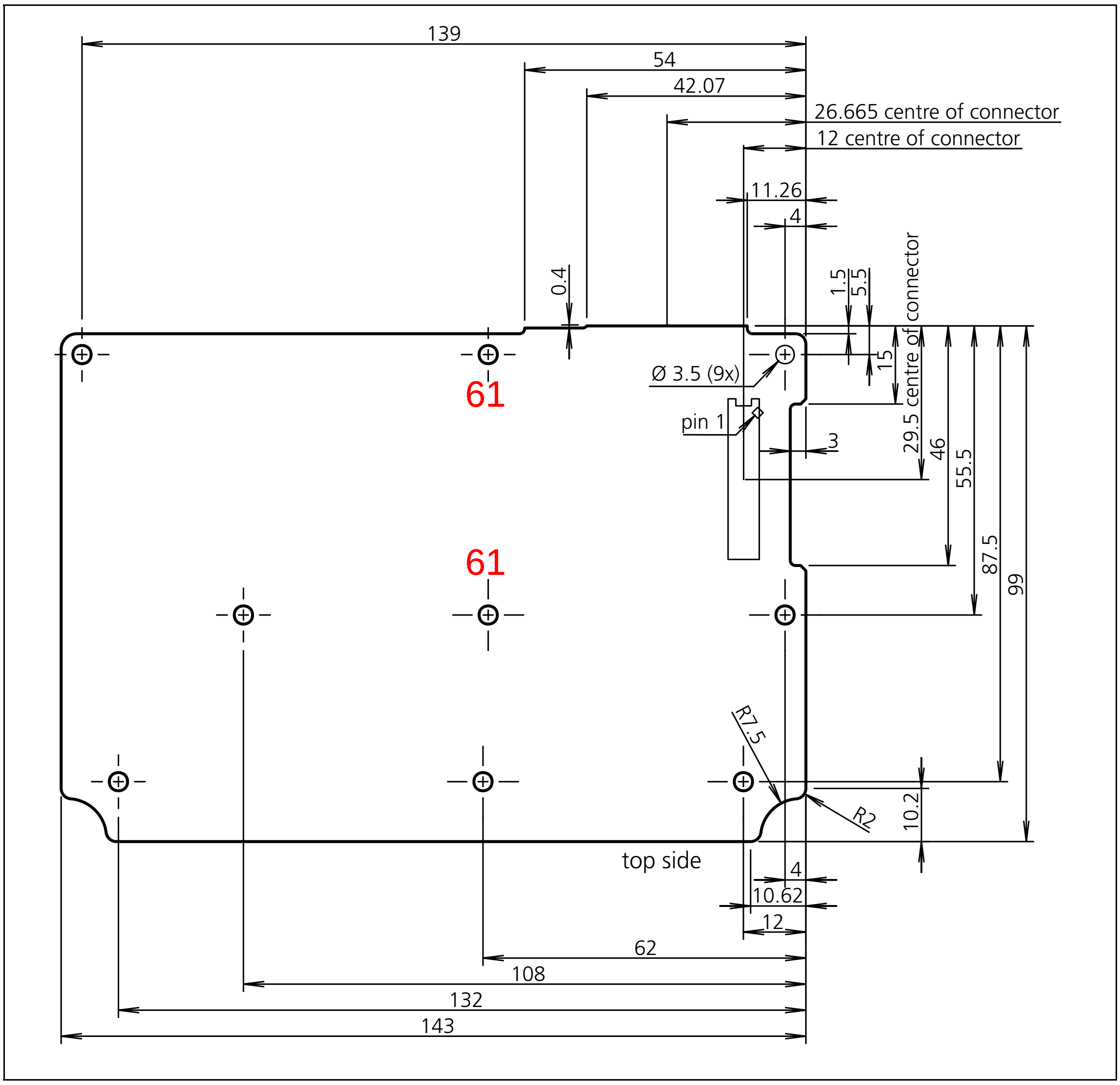


Figure 4.2 Internal options board - component height restrictions

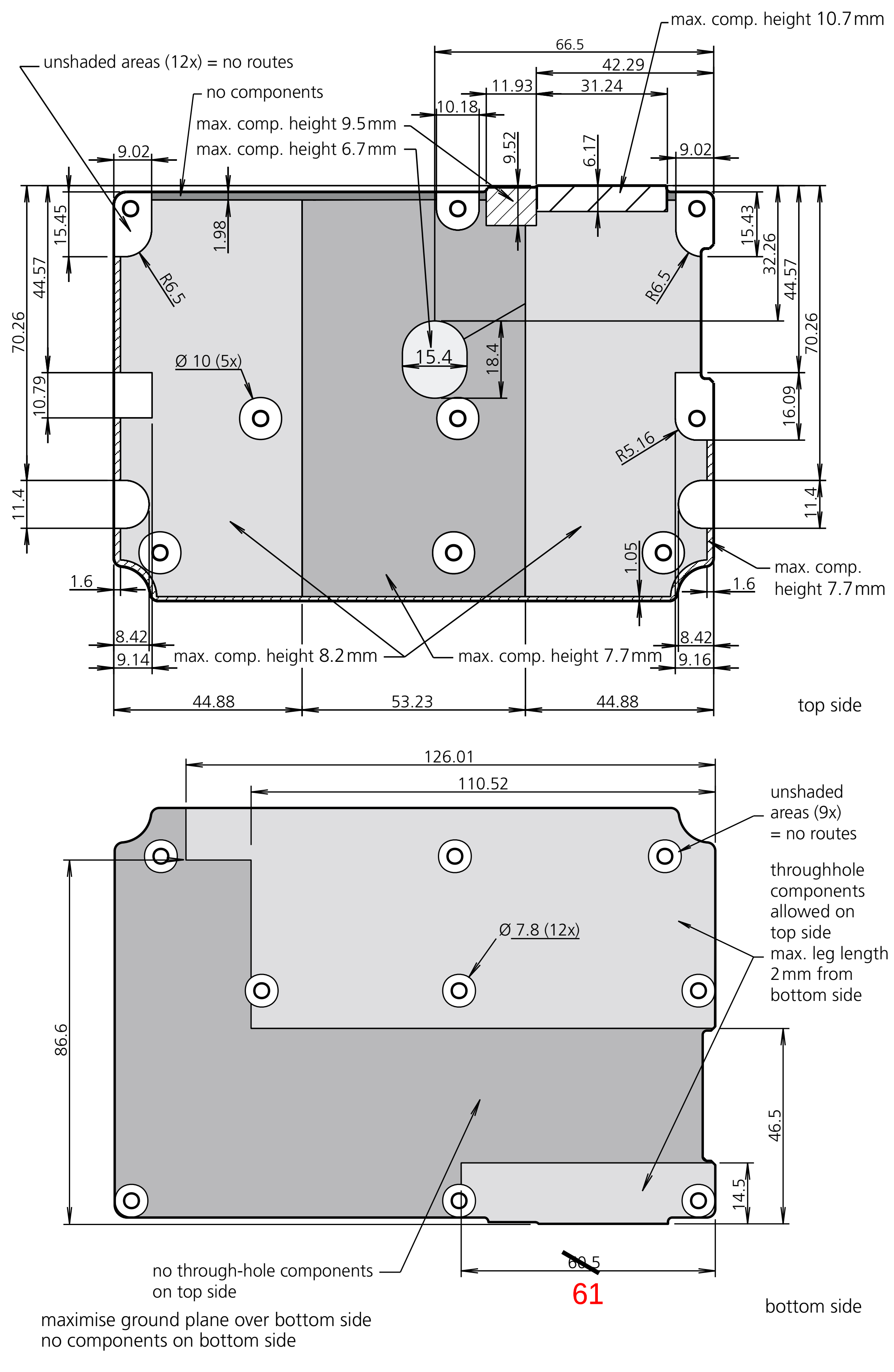
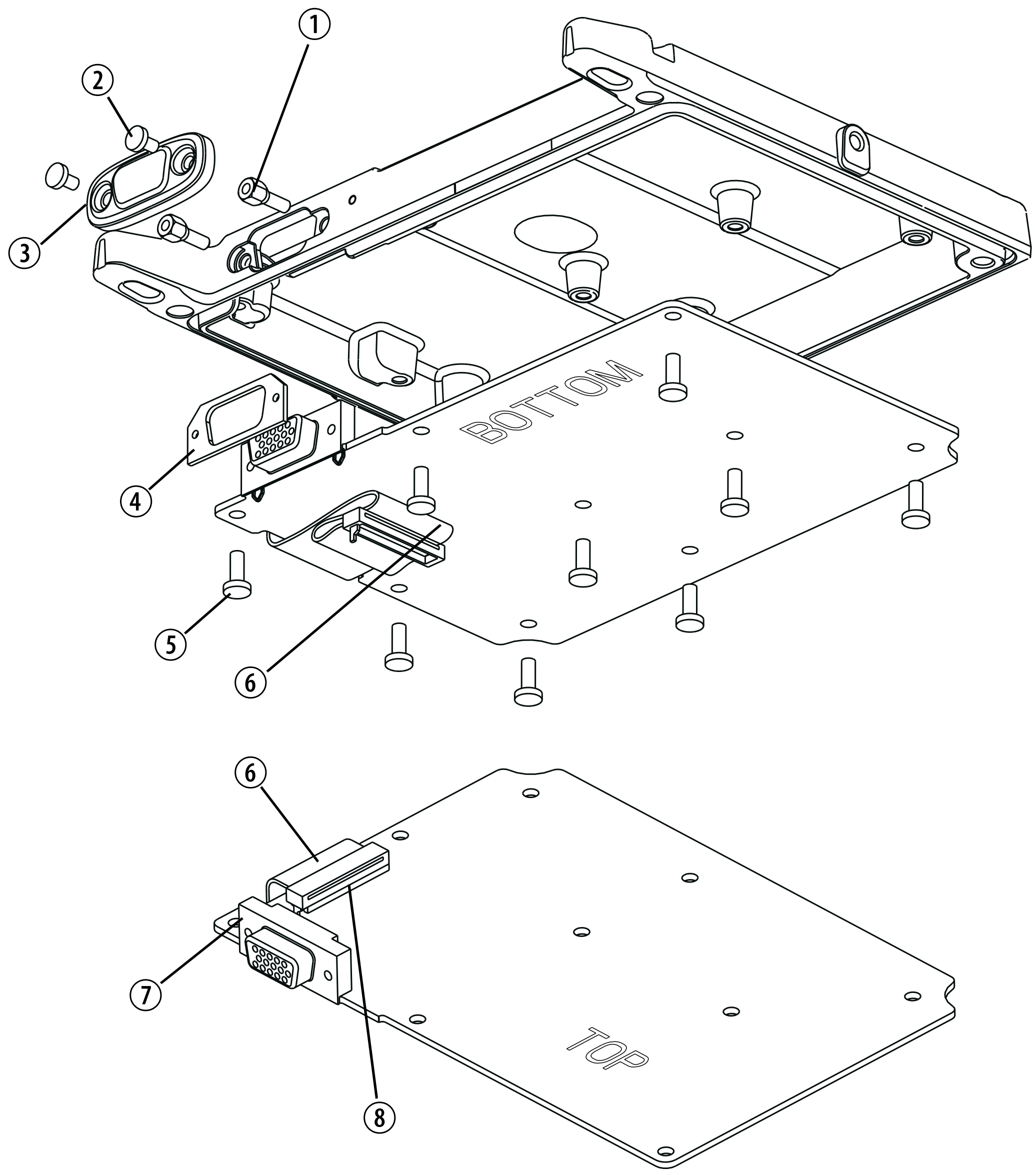


Figure 4.3 Internal options board - installation example

Important Assemble and tighten the two hexlocks (tightening torque 0.9N·m=8lbf·in) before screwing the internal options board to the lid.



Note The labelled parts are available with the TM8000 internal options kit described on page 89.

① D-range hexlok-style fastener 4–40 (2x) (tightening torque 0.9N·m=8lbf·in)
② screw 4-40x3/16 (2x)
③ protective rubber cap
④ foam seal for D-range connector
⑤ screw M3x10, self-tapping (9x)
⑥ loom with 18-way Micro-MaTch plugs
⑦ 15-way high-density D-range socket, PCB-mount
⑧ 18-way Micro-MaTch socket, SMD, PCB-mount

4.1.2 TM8000 Internal Options Kit

The TM8000 internal options kit (product code TMAA30-06) includes all special connectors, a loom, seals and screws required to connect to the internal options connector, the external options connector and the screw points inside the radio body.

The components of the TM8000 internal options kit, that are fitted to the radio, are illustrated in Figure 4.3.

Table 4.1 TM8000 internal options kit - bill of material

Tait IPN	Qty.	Description	Pos. in Figure 4.3
354-01043-00	2	Fsnr Scrw Lok 1pr 4-40	①
347-00011-00	2	Scrw 4-40*3/16 Unc P/P Blk	②
362-01108-00	1	Seal Drng Cvr 9way TMA	③
362-01111-00	1	Seal Drng 9way TMA	④
349-02062-00	9	Scrw M3*8 T/T P/T Conti Rmnc	⑤
219-00329-00	1	Loom TMA Int Opt	⑥
240-00011-67	1	Skt 15w Drng Ra Slim Dsub 7912 (footprint see Figure 4.4)	⑦
240-10000-11	1	Conn SMD 18w Skt M/Match (footprint see Figure 4.5)	⑧
240-00010-80	1	Plg 15w Drng Hi-D	not illustrated
240-06010-29	1	Conn 9w Hood/Cvr Lets	not illustrated

Figure 4.4 Footprint of 15-way D-range socket, PCB-mount

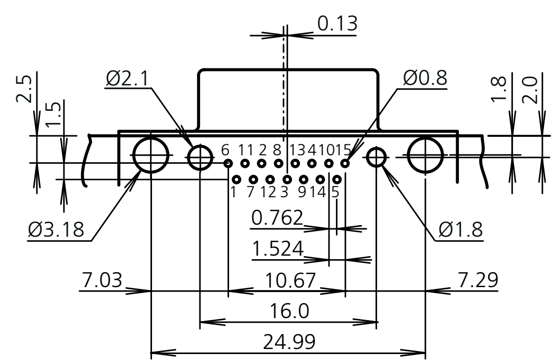
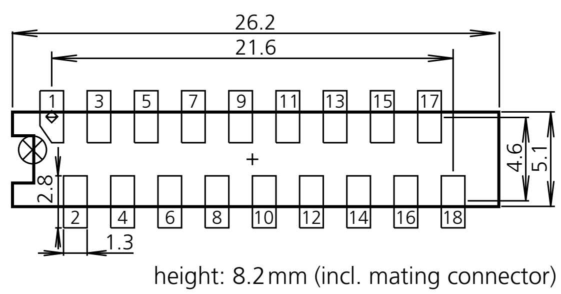


Figure 4.5 Footprint of 18-way Micro-MaTch socket, SMD, PCB-mount



4.1.3 Common Practices for Internal Options Board Design

Thermal Considerations

Select components which withstand the temperatures inside the radio body, in particular during high duty cycles and high ambient temperatures. Tait recommends the use of industrial-grade components (<85 °C).

Heat dissipation added by an internal options board can reduce the radio's operating temperature range or duty cycle. Keep heat dissipation to a minimum.

Sealing

The IP54 protection class no longer applies when the external options connector or an additional connector are used. When fitting one of these connectors, it is the integrator's sole responsibility to provide adequate sealing.

Electromagnetic Compatibility

It is important that the internal options board is electro-magnetically compatible (EMC) with the radio itself and the external environment. This means that the internal options board is not affected by and does not interfere with the radio or the external environment. An EMC problem has three components: a source, a coupling mechanism and a receiver. The coupling mechanism can be conducted and/or radiated.

Key things to consider are as follows:

Susceptibility to Interference

If the internal options board has connections via the external options connector and the radio's antenna is located close to the options cable, significant RF pick up on to the cable may occur.

If the internal options board contains sensitive analogue circuits (particularly microphone circuits), digital ground noise may be a problem if the internal options board is not earthed correctly.

Electrostatic discharge (ESD) onto the options cable may cause damage to the internal options board or malfunction if proper protection is not provided.

Emissions from the Internal Options Board

The radio's receiver is extremely sensitive and radiation from the internal options board on the desired channel frequency may cause interference.

If the internal options board has connections via the external options connector and the radio's antenna is located close to the cable, radiation from the cable may be picked by the antenna as interference.

Radiation from the options cable, if strong enough, may interfere with other devices near the radio or cause failure to comply with EMC regulations in your country or region. The cable creates a good antenna at high frequencies.

Follow the guidelines in "Guidelines for EMC Design" on page 91.

4.1.4 Guidelines for EMC Design

Earthing

Figure 4.6 and Figure 4.7 show the recommended earthing of the internal options board. The earthing used depends on the type of circuitry on the internal options board.

Figure 4.6 Internal options board - earthing for low-speed circuits

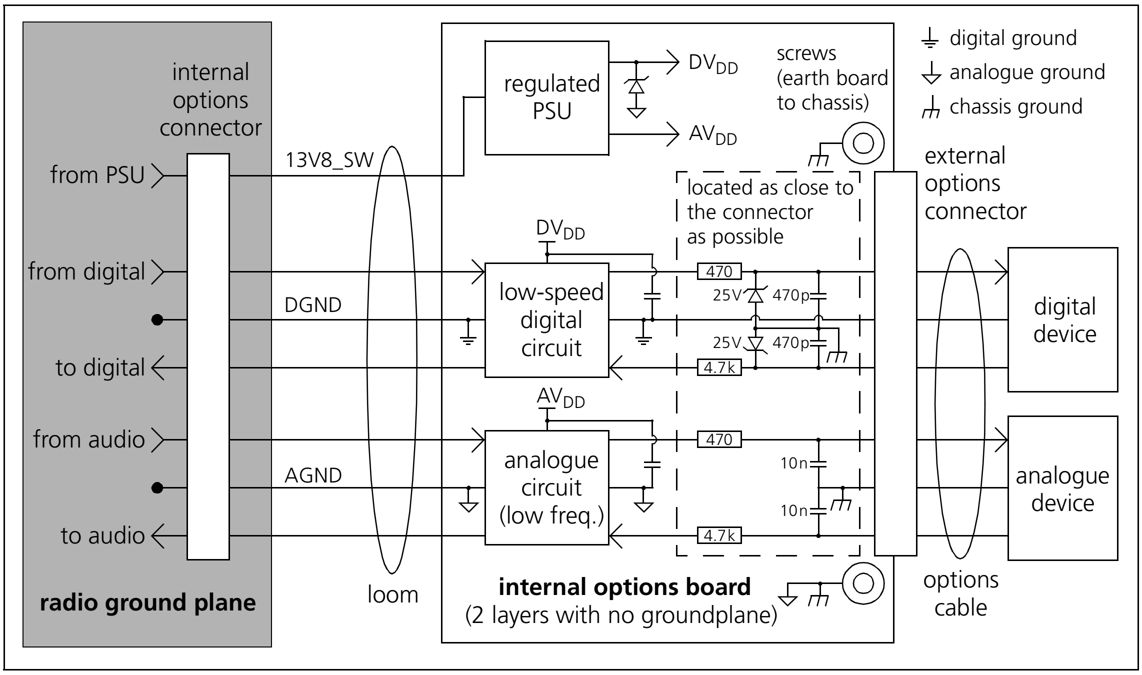
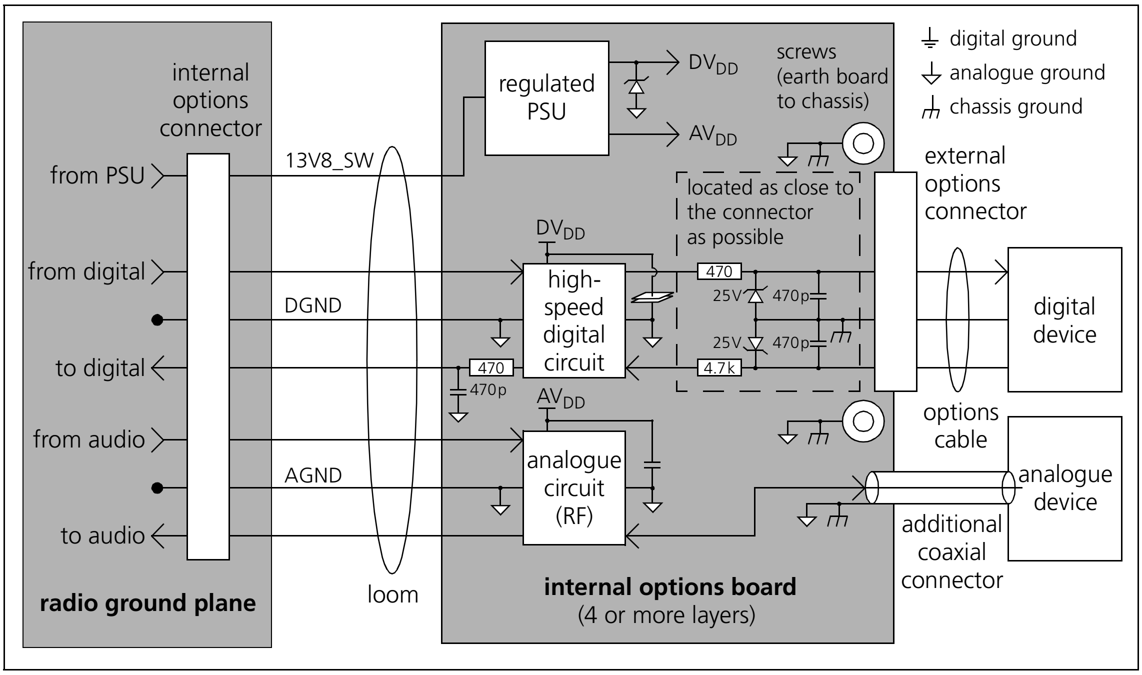


Figure 4.7 Internal options board - earthing for high-speed circuits



For low-speed digital designs or audio designs, a two layer board with plated through holes is usually sufficient. Low-speed digital devices have relatively long rise and fall times, this includes standard CMOS logic gates and low power 5V 8-bit micro-controllers. Tracked earthing is usually sufficient but ground fill should be used where possible.

For high-speed digital designs or RF designs it is strongly recommended that a PCB with four or more layers is used. High-speed digital devices have short rise and fall times, this includes most Digital Signal Processors and 16/32-bit micro-controllers. The board should have one layer reserved as a ground plane. No signal tracks should be placed on this layer.

The internal options connector has separate analog and digital earth pins. These are connected together on the radio PCB through a low impedance ground plane. Separate ground signals allow digital I/O and analog ground current to flow in different wires on the loom. This is important because the loom wire has relatively high impedance and so significant earth noise voltage due to digital I/O activity can be developed across the length of the wire. Having two earth wires also halves the impedance of the earth connection where the earths are common at the internal options board end.

On the internal options board, the earth signals can either be connected together or kept separate and fed to the appropriate digital and analog circuitry. For low-speed designs it is practical to keep them separate but for high-speed design it is not usually the case due to ground plane requirements.

It is recommended that the internal options board is earthed to the chassis lid as close as possible to the external options connector. This can be achieved via the mounting screws closest to the external options connector. For the screw hole, use a plated through hole diameter 3.5mm with pad diameter 7mm on both sides. The resist should be cleared from the pad and the pad connected to analog earth or the ground plane. Other mounting screws may also be connected to the chassis lid but this is not essential.

Shielding

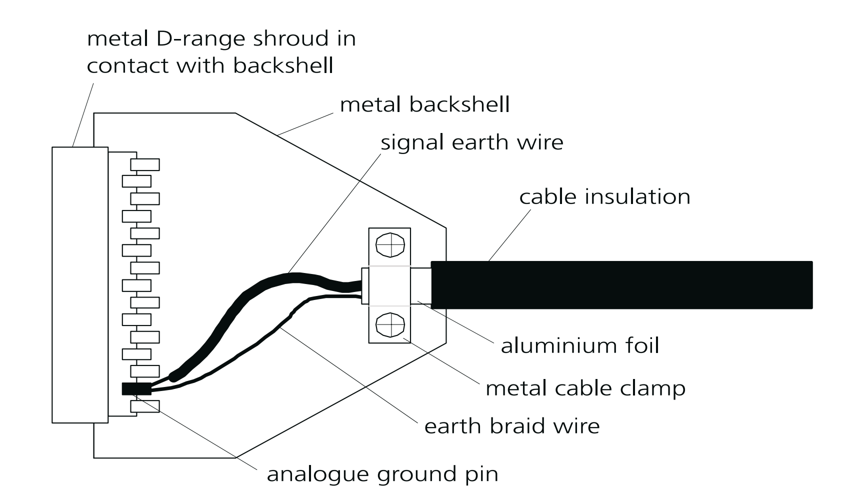
For low-speed designs shielding is usually not necessary. For high-speed designs shielding may be necessary. For RF designs it is usually essential.

Cable Shielding

If the external options cable is longer than 1 metre it is recommended to shield the cable and connector backshell. Figure 4.8 shows the recommended shielding arrangement. The earth braid wire (bare copper) and aluminium foil should only be earthed at the radio end of the cable.

For RF signals, coaxial cable must be used and the shield must be earthed at both ends of the cable.

Figure 4.8 Recommended auxiliary cable and connector shielding



Input/Output Filtering

The recommended filtering for input and output (I/O) lines from the internal options board is shown in Figure 4.6 and Figure 4.7 on page 91. The component values shown are for guidance but should be suitable for most applications.

For the I/O lines to or from the radio, filtering is usually not necessary. The exception is when the internal options board contains high-speed digital circuits. In this case, the outputs to the radio should be RC-filtered on the internal options board as close as possible to the connector to minimise noise on the loom.

It is recommended that filtering is applied on all I/O signals of the external options connector. They also need ESD protection. The filtering shown in Figure 4.6 and Figure 4.7 on page 91 provides both ESD protection and high frequency filtering. For the audio, 10nF capacitors are recommended because they are large enough to keep the voltage developed by an electrostatic discharge to a safe level while not significantly affecting audio frequency response. The capacitors are earthed to the chassis to provide a low impedance return path for large ESD currents. High frequency filtering is provided by the series resistance and 10nF capacitor.

Large decoupling capacitors cannot be used for digital signals because they round the wave form edges to an unacceptable extent. Therefore for ESD protection, a small 470pF decoupling capacitor in parallel with a zener diode clamp is recommended. The capacitor reduces the slew rate of the ESD pulse so that the zener diode clamps without overshoot. Again, the capacitor and zener diode are earthed to the chassis to provide a low impedance return path for large ESD currents. It is also recommended that a zener diode is placed on the digital supply as some current will flow back into the supply via the series resistance and digital IC clamping diodes during an ESD event. The zener voltage should be approximately 0.5V higher than the supply voltage. High frequency filtering is provided by the series resistance and 470pF capacitor.

It is essential that all I/O filter components are located as close as possible to the connector. This minimises the possibility of noise bypassing the filters.

Power Supply Decoupling

Power supply decoupling is most effective when the decoupling is placed close to the load. For high-impedance loads, some resistance in series with the load can be beneficial. For most applications a single 100 nF capacitor is sufficient to remove high-frequency noise.

For high-speed digital designs, the use of a power plane for each digital supply rail is strongly recommended. The power plane enables many decoupling capacitors and device power pins to be connected together with very low impedance. The inter-plane capacitance is usually not sufficient by itself for decoupling. Low ESR tantalums for low-frequency decoupling are recommended. Multiple ceramic 100 nF capacitors are recommended for high-frequency decoupling. Design analysis should be undertaken to ensure that decoupling is effective up to at least 500 MHz.

Separate power supply rails for digital and analog circuitry are recommended.

Note High-speed digital design requires a high level of design experience, appropriate design tools and high bandwidth test equipment to be successful. This should not be undertaken without all of the above.

4.2 Blank Control Head Options Board

The TM8105 radio with blank control head provides space between the blank control head and the radio body for accommodating an options board. Six screw points are located on the inside of the blank control head.

Figure 4.9 and Figure 4.10 show the mechanical envelope available. Six screw points are located on the inside of the blank control head. Figure 4.11 shows an installation example.

Figure 4.9 Blank control head options board - maximum dimensions

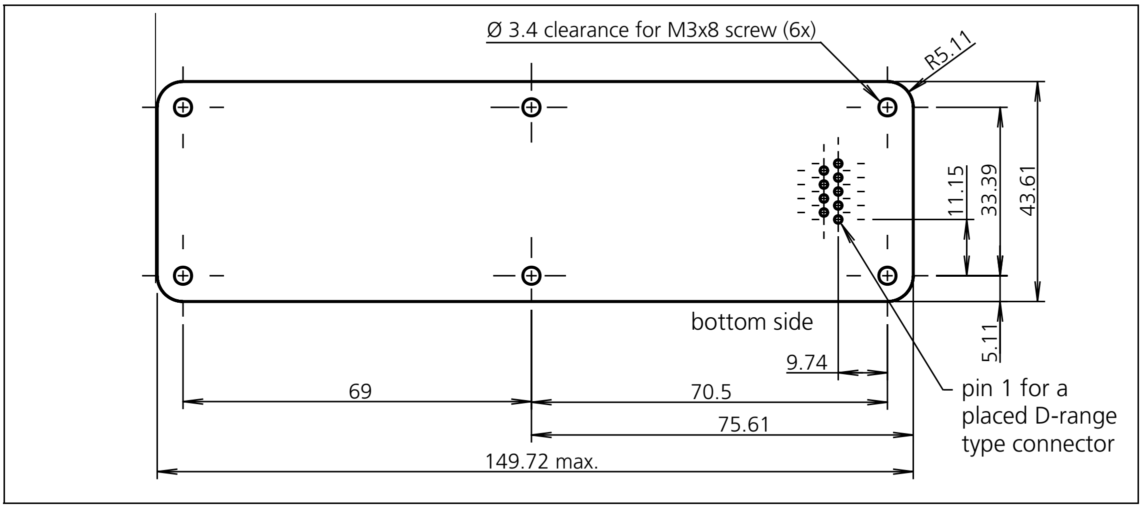


Figure 4.10 Blank control head options board - component height restrictions

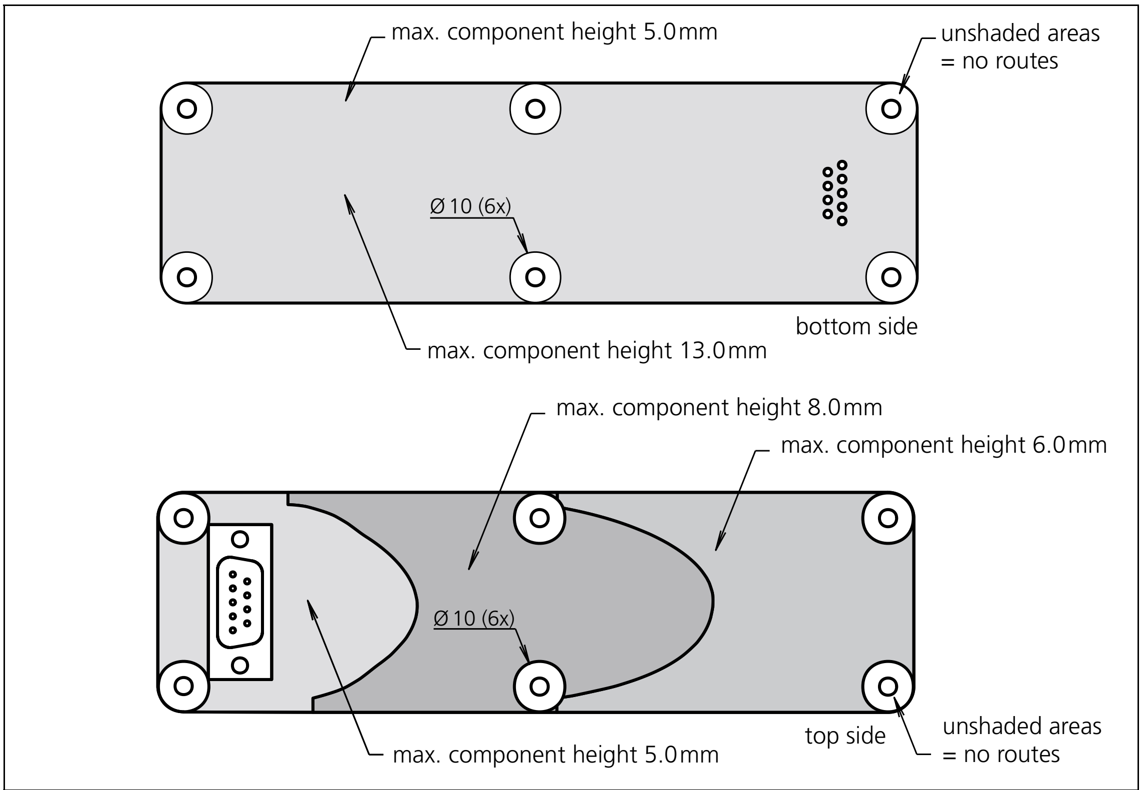
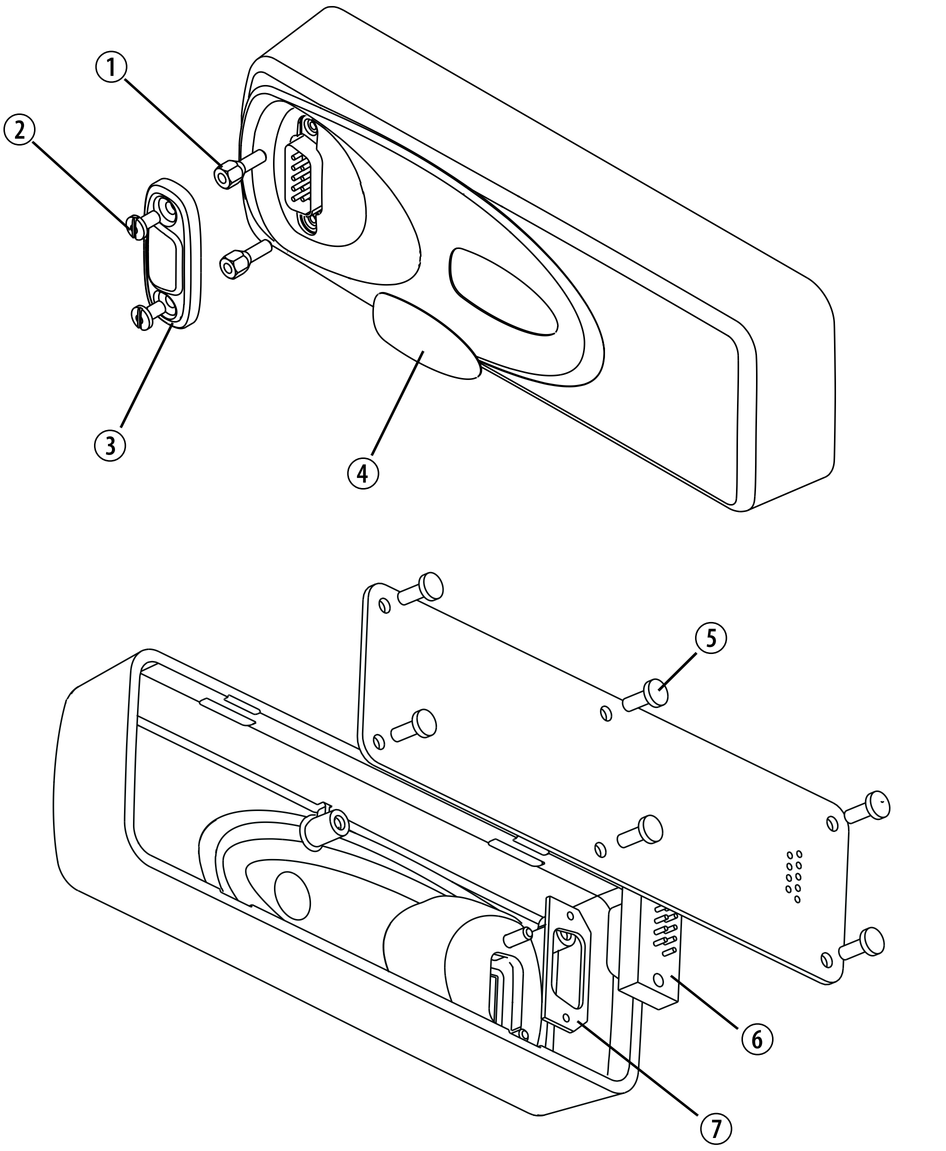


Figure 4.11 Blank control head options board - installation example



① D-range hexlok-style fastener 4–40 (2x) (tightening torque 0.45N·m=4lbf·in)
② screw 4-40x3/16 (2x)
③ D-range cover seal
④ branding label
⑤ screw M3x8 plastic type (6x)
⑥ 9-way D-range socket, vertical PCB mounting with threaded inserts on connector
⑦ foam seal for D-range connector

5 Connecting Third-Party Products

This chapter describes in examples the connection of external and internal products of third-party manufacturers to the TM8000 radio.

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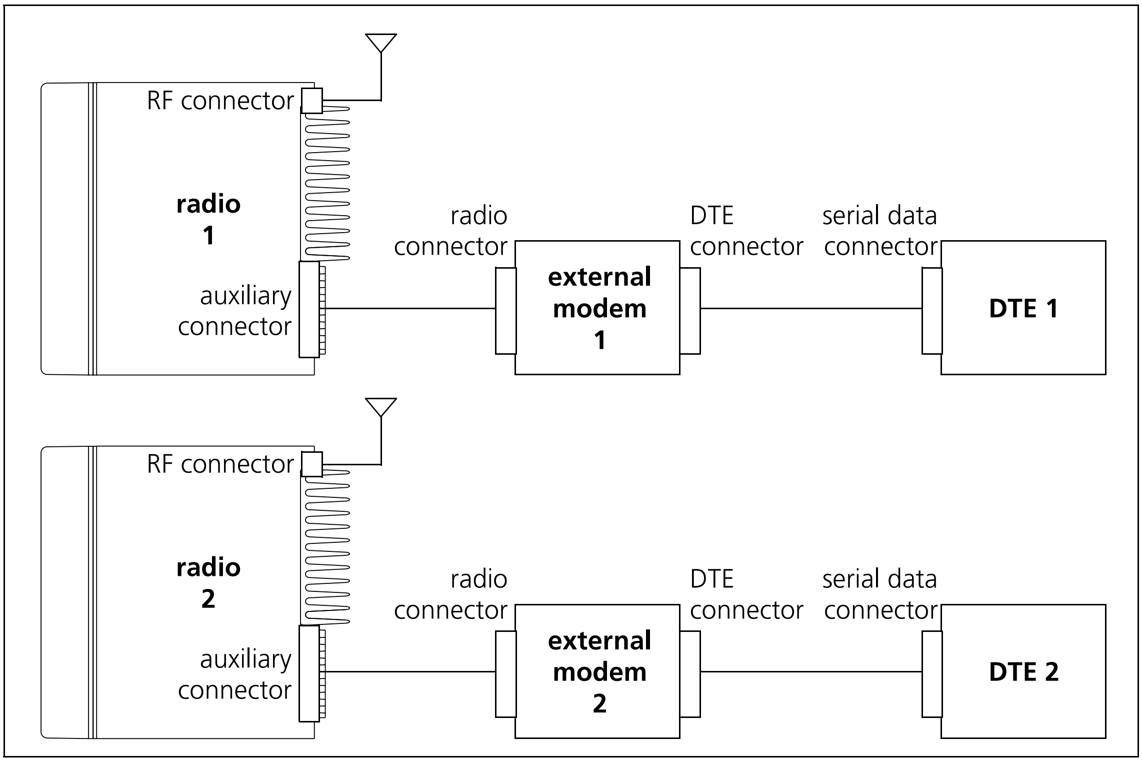
5.1 External Products

5.1.1 External Modem

Data Flow

Figure 5.1 shows a simple point-to-point data link system using two radios and external modems.

Figure 5.1 Basic system configuration using two external modems and radios



1. DTE 1 transmits the source data in serial form to the external modem 1. The DTE can be a PC or a data head.
2. The modem encodes the data into a baseband modulation signal which is suitable for over-the-air transmission, and feeds it to radio 1.
3. Radio 1 uses the baseband modulation signal for frequency modulation of the RF carrier signal, and then sends the modulated signal over the air (via a repeater, if necessary).
4. Radio 2 receives the modulated signal, recovers the baseband modulation signal from the RF carrier, and then feeds the baseband modulation signal to external modem 2.
5. External modem 2 decodes the baseband modulation signal into serial digital form and feeds it to DTE 2.

DTE 2 can also be the source and DTE 1 the destination, however because the TM81xx is a simplex radio, simultaneous data flow in opposite directions is not possible.

Interface Specification

The external modem is connected to the auxiliary connector, which is described on page 20. For the interface specification of the external modem to the DTE please refer to the manufacturer's documentation.

Table 5.1 shows how to connect the lines of the external modem to the auxiliary connector.

Table 5.1 External analogue modem interface specification

External modem	Auxiliary connector		Description/parameter	Specification
Signal	**Pin**	**Signal**		
Power	8	13V8_SW	Power supply to modem. Max. current draw: Operating voltage range:	 must be <1A 9.7V to 17.2V
Ground	15	AGND	Analogue ground.	
Baseband modulation output	7	AUD_TAP_IN	Baseband modulation to radio. Format[a]: Audio tap input point: Audio tap input muting: Signal level: DC bias required: AUD_TAP_IN input impedance:	 GMSK, FFSK, 4-level FSK 1200-9600 baud Use T13-A or T12-A for GMSK/4FSK Use T8-A for low-baud modems. Use 'on PTT' associated with EPTT1 T13-A: 870mVp-p (3kHz dev.) T12-A: 690mVp-p (60% RSD[b]) T8-A: 690mVp-p (60% RSD[b]) 1.5±0.2V[c] 100kΩ typical
Baseband modulation input	13	AUD_TAP_OUT	Baseband modulation from radio. Format: Audio tap input point Audio tap input muting: Signal level into 600Ω: AUD_TAP_OUT output impedance:	 Constant envelope. GMSK, FFSK, 4-level FSK 1200-9600 baud Use R1-D or R2-D for GMSK/4FSK Use R4-D for low-baud modems. Use 'except on PTT' R1-D: 600mVp-p (3kHz dev.) R2-D: 690mVp-p (60% RSD[b]) R4-D: 690mVp-p (60% RSD[b]) 600Ω typical
Push-to-talk	12	AUX_GPI1	PTT signal to radio. Function: Active state: Logic output levels required:	 EPTT1 or EPTT2 Low 3.3V CMOS-compatible
Carrier detect	10	AUX_GPIO4	Carrier detect. Some modems may not need this signal. Function: Active state: Modem input logic threshold required:	 Busy status based on RSSI High 3.3V CMOS-compatible[d]

a. The modulation formats listed may not comply with transmit spectral emission mask regulations in some countries. It is the integrator's responsibility to ensure that the system complies with the relevant regulations.

b. RSD = Rated System Deviation

c. While AUD_TAP_IN is DC-coupled, it has a digital HPF in the modulation path to prevent DC bias error affecting the transmit carrier frequency. The HPF has a –3dB point of 3.7Hz which is low enough for GMSK. If the modem cannot provide the bias voltage required then a large coupling capacitor, typically 10μF, should be used.

d. If the modem input is 5V CMOS, the pullup output on AUX_GPIO4 should be linked to 5V. For more information refer to "Digital Output Lines" on page 64.

Radio Programming

Use the programming application to configure the radio.

1. In the Digital tab of the Programmable I/O form, carry out the following settings:

Pin	Direction	Action	Active	Debounce	Signal state
AUX_GPI1	Input	External PTT1	Low	0	None
AUX_GPIO4	Output	Busy Status	High	None	Momentary

2. In the PTT / External PTT (1) form, set the Advanced EPTT1 group to:
   - PTT Transmission Type: Data
   - PTT State Is Reflected: cleared
   - PTT Priority: Highest
   - Audio Source: Audio Tap In

3. In the Networks / Basic Settings / Basic Network Settings form, set the Squelch Detect type to Signal Strength.

4. In the Audio tab of the Programmable I/O form, carry out the following settings:

Rx / PTT Type	Tap In	Tap In Type	Tap In Unmute	Tap Out	Tap Out Type	Tap Out Unmute
Rx	None			R1	D - Split	Except on PTT
EPTT1	T13	A - Bypass In	On PTT	None		

   Tap out R1 is the tap point closest to the demodulator. Tap in T13 is the tap point closest to the modulator. For more information on the tap points refer to "Auxiliary Connector" on page 20 and "Audio Tap In and Tap Out Lines" on page 80.

   If not all the channels that the modem will be communicating on have the same channel spacing or bandwidth, tap in T12 and tap out R2 should be used. The signal levels on these taps are automatically scaled to match the channel spacing, i.e. 3kHz deviation on a 25kHz channel and 1.5kHz deviation on a 12.5kHz channel will result in the same tap in and tap out signal levels.

   For modems operating at 2400baud or less, tap in T8 and tap out R4 should be used. These tap points have linear-phase 3kHz low-pass filtering applied.

5. All channels that the modem uses for communication should be assigned to one network and all voice channels should be assigned to a second network. This ensures that the data and voice channel settings are independent of each other.

Modem Configuration

Refer to the manufacturer's documentation.

Setup and Testing

1. Configure the modem and DTE.

2. Test the modem and DTE configuration. The simplest means is usually a loop-back test. For this test a loop-back plug is required. This consists of a 15-way female plug with modem baseband modulation in and out connected together. Disconnect the modem from the radio and connect the loop-back plug onto the end of the cable between modem and radio. Send a large amount of data and check that the data received on the DTE is error-free. This test requires the DTE to be full duplex capable and the baseband modulation levels in and out of the modem to be equal.

3. Configure the radio as per described above.

4. Connect the modem and set up deviation levels as per the modem manufacturer's documentation.

5. Check that the transmit spectrum meets regulatory requirements in the country of sale. Not necessary if tap in point T8 is used.

6. Use a second system to confirm end-to-end communication over-the-air. Initially it is recommended to do this with strong signal conditions.

System Delays through the Radio

It is important for data applications to know the system delays through the radio. Table 5.2 shows the system delays through the radio.

Table 5.2 System delays through the radio

System delay through the radio		Specification
EPTT assertion (zero debounce) to full carrier power with valid modulation:		
	via tap T12 and T13	9.5±1ms
	via tap T8	17.3±1ms
EPTT de-assertion (zero debounce) to valid baseband modulation at AUD_TAP_OUT:		
	via tap R1 and R2	9.5±1ms
	via R4	14.3±1ms
Modulation delay - antenna to AUD_TAP_OUT:		
	via tap R1 and R2	1.8ms typical
	via tap R4	6.6ms typical
Modulation delay - AUD_TAP_IN to antenna:		
	via tap T12 and T13	1.8ms typical
	via tap R4	9.6ms typical
Valid RF signal arriving at the antenna to carrier detect active:		3ms typical

5.1.2 Audio Headset

Headsets provide a private and hands-free means of using a two-way radio and are typically used by dispatchers or users in high-noise environments. PTT is normally provided with a foot switch.

Interface Specification

The audio headset is connected to the microphone connector of the control head. The microphone connector is described on page 36. It can also be connected to the corresponding lines of the programming connector of the blank control head.

Figure 5.2 shows the diagram of an audio headset interfaced with the microphone connector of the TM8115 control head.

Figure 5.2 Diagram of an audio headset connected to the radio

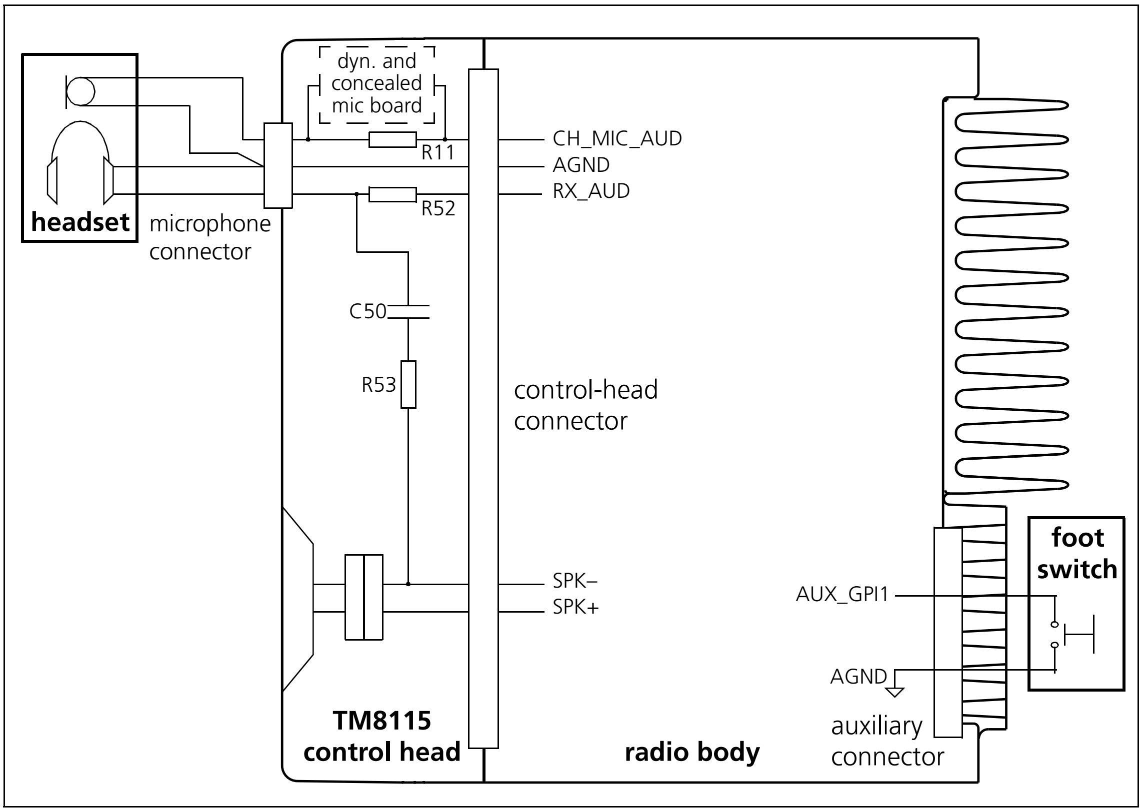


Table 5.3 shows how to connect the audio headset to the radio:

Table 5.3 Audio headset interface specification

Lines of audio headset	Microphone connector		Description/parameter
Signal	**Pin**	**Signal**	
Earphone Audio (+)	1	MIC_RX_AUD	Audio to earpiece.
Microphone Audio (+)	5	MIC_AUD	Microphone audio from headset.
Earphone Audio (–)	6	AGND	Analogue ground for earpiece.
Microphone Audio (–)	6	AGND	Analogue ground for microphone.

Table 5.4 shows how to connect the footswitch to the radio:

Table 5.4 Footswitch interface specification

Lines of footswitch	Auxiliary connector		Description/parameter
Signal	**Pin**	**Signal**	
Switch output	12	AUX_GPI1	External PTT input
Switch ground	15	AGND	Analog ground

Earphone Interface

If the headset is stereo, ensure both earphones are connected in parallel. The earphones are connected to pin 1 of the microphone connector.

As headset earphones vary widely in their impedance and power ratings, two different driver options are available in the TM8115. If you are unsure of the headsets drive requirements, try the factory default hardware configuration first.

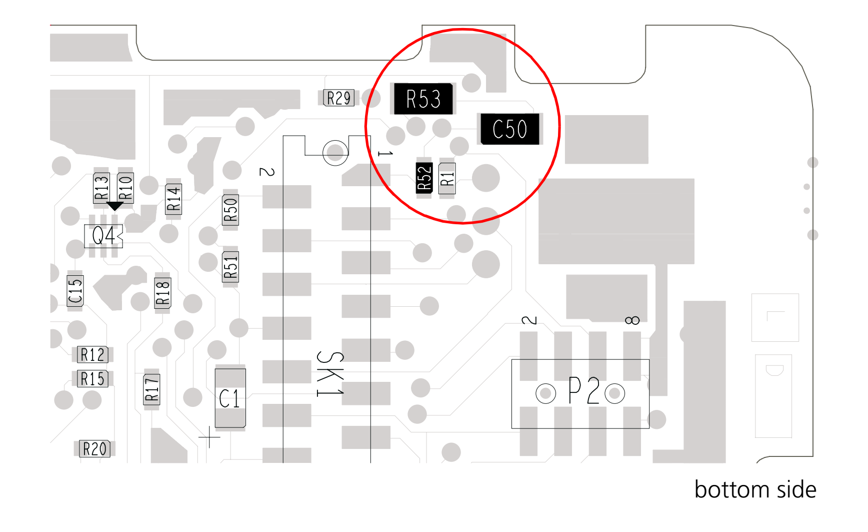
For headsets with low drive or volume requirements, the factory default hardware configuration can be used (R52 fitted, C50 and R53 not fitted). The earphone DC resistance in this case should greater than 100 Ω.

For headsets with high drive or volume requirements, one of the radios internal speaker outputs should be used to drive the earphones. To connect an internal speaker output to pin 1 on the microphone connector, remove R52 and fit C50 and R53 on the TM8115 control-head board.

Figure 5.3 on page 104 shows the positions of C50, R52 and R53 on the control-head board.

Follow the instructions of the TM8100 Service Manual on removing and fitting the control head, the control-head board, and standard and SMD components.

Figure 5.3 Positions of C50, R52 and R53 on the control-head board



Choose values for C50 and R53 as follows:

1. Measure the earphone DC resistance R_E using a multimeter.
2. Choose C50 to be at least 10µF and R53 to be approximately equal to R_E.
3. Select an on-air channel with frequent voice activity and disconnect the internal speaker.
4. Turn the volume to **minimum** and plug the headset into the microphone socket.
5. Select and test the value of R53 until the desired headset volume is achieved when the radios volume control is turned up to maximum. Ensure the radio is powered down when making changes to the value of R53.
6. Select the value of C50 to be $1/(1900 \cdot (R53+R_E))$
7. Round this result to the nearest preferred value.

The radios internal speaker should be left disconnected.

Microphone Interface

If the headset microphone is an electret type, the factory default hardware configuration (R11 fitted) can be used. DC bias for the headset microphone is provided by the radio. Noise-cancelling electret microphones do not require a different configuration.

If the headset microphone is a dynamic type, the TMAA02/06 Support Kit for Concealed and Dynamic Microphones must be fitted in the TM8115 control head. For information on how to fit this kit refer to the TM8100 Mobile Radio Accessories Manual.

PTT Interface

Connect a footswitch or gear-lever PTT between AUX_GPI1 (pin 12) and AGND (pin 15) on the radio's auxiliary connector.

Radio Programming

Use the programming application to configure the radio.

1. In the PTT /External PTT (1) form, set the /Advanced EPTT1 group to:
   - PTT Transmission Type: Voice
   - Audio Source: CH_MIC
2. In the Digital tab of the Programmable I/O form, carry out the following settings:

Pin	Direction	Action	Active	Debounce	Signal state
AUX_GPI1	Input	External PTT1	Low	10	None
AUX_GPIO4	Output	Busy Status	High	None	Momentary

3. To eliminate mute and unmute 'pop'' when the earphone is driven by an internal speaker output, the audio PA needs to be forced on. Configure the CH_GPIO1 line as follows.

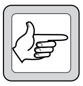
Pin	Direction	Action	Active	Debounce	Signal state
CH_GPIO1	Input	Force Audio PA On	High	10	None

Ensure that nothing is connected to pin 8 of the microphone connector.

Note This setting will cause the receive standby current to increase by approximately 50mA.

5.1.3 USB Adaptor

An increasing number of computers (in particular laptop computers) no longer provide serial COM ports and instead provide USB connections. To connect the radio to a USB port, a USB adaptor is required.



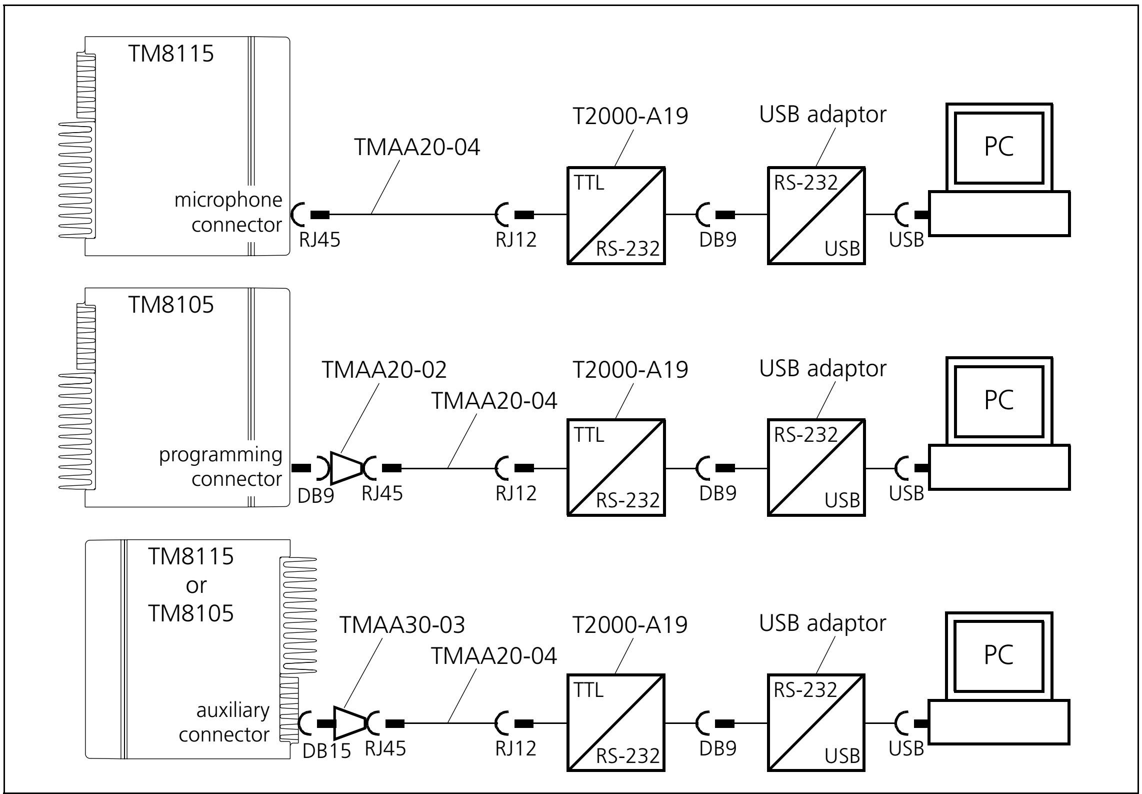
Note If the PC has a COM port, the T2000-A19 cable can be connected directly to the PC without using a USB adaptor.

The PC is typically connected to the microphone connector of the control head (TM8115) or to the programming connector of the blank control head (TM8105). The PC can also be connected to the auxiliary connector or, if an options extender board is installed, to the external options connector.

The Rx and Tx signals of these connectors have TLL levels and are described in "Description of the Radio Interfaces". The TLL level must be converted to RS-232 level using the Tait T2000-A19 cable. The T2000-A19 cable does not support CTS/RTS hardware handshaking.

Figure 5.4 shows typical connections between the radio and the USB port of the PC, and the cables and adaptors required (including Tait product codes):

Figure 5.4 Diagram of radio connected to the USB port of a PC



When installing the USB adaptor, follow the manufacturer's instructions on how to install the necessary device driver. The PC will typically see the USB adaptor as a COM port.

5.2 Internal Products

Important The maximum operating temperature specified for third-party internal modules can be lower than the temperature generated inside the radio in the ambient temperature range specified for the radio. This may require a reduction in the radio's operating temperature range or duty cycle. Suitable provisions for heat dissipation must be implemented.

5.2.1 Encryption Module (Scrambler)

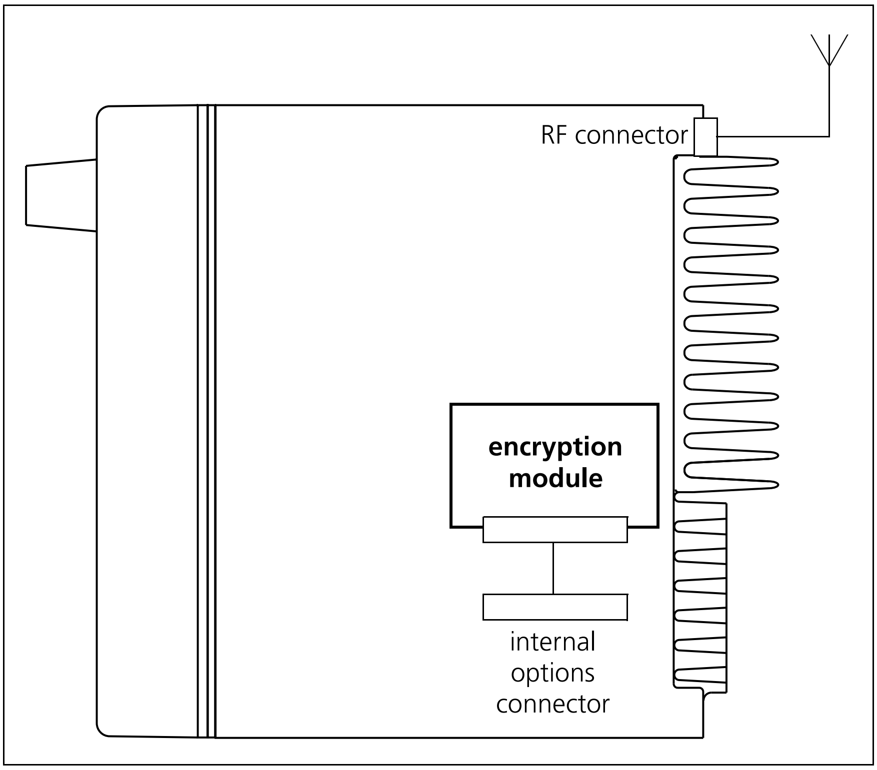
Important The installation and configuration of encryption modules is a complex task and should only be attempted by persons with in-depth knowledge of the installation and commissioning of encryption systems.

Interface Specification

The encryption module can be mounted inside the radio body where it connects to the internal options connector via a standard 1.27 mm pitch ribbon cable. The internal options connector is described on page 28. The audio lines are described in "Audio Tap In and Tap Out Lines" on page 80.

Figure 5.5 shows the diagram of an encryption module interfaced with the internal options connector inside the radio body.

Figure 5.5 Diagram of encryption module connected to radio



Configure the interface between the encryption module and the internal options connector as described in Table 5.5.

Table 5.5 Encryption module interface specification

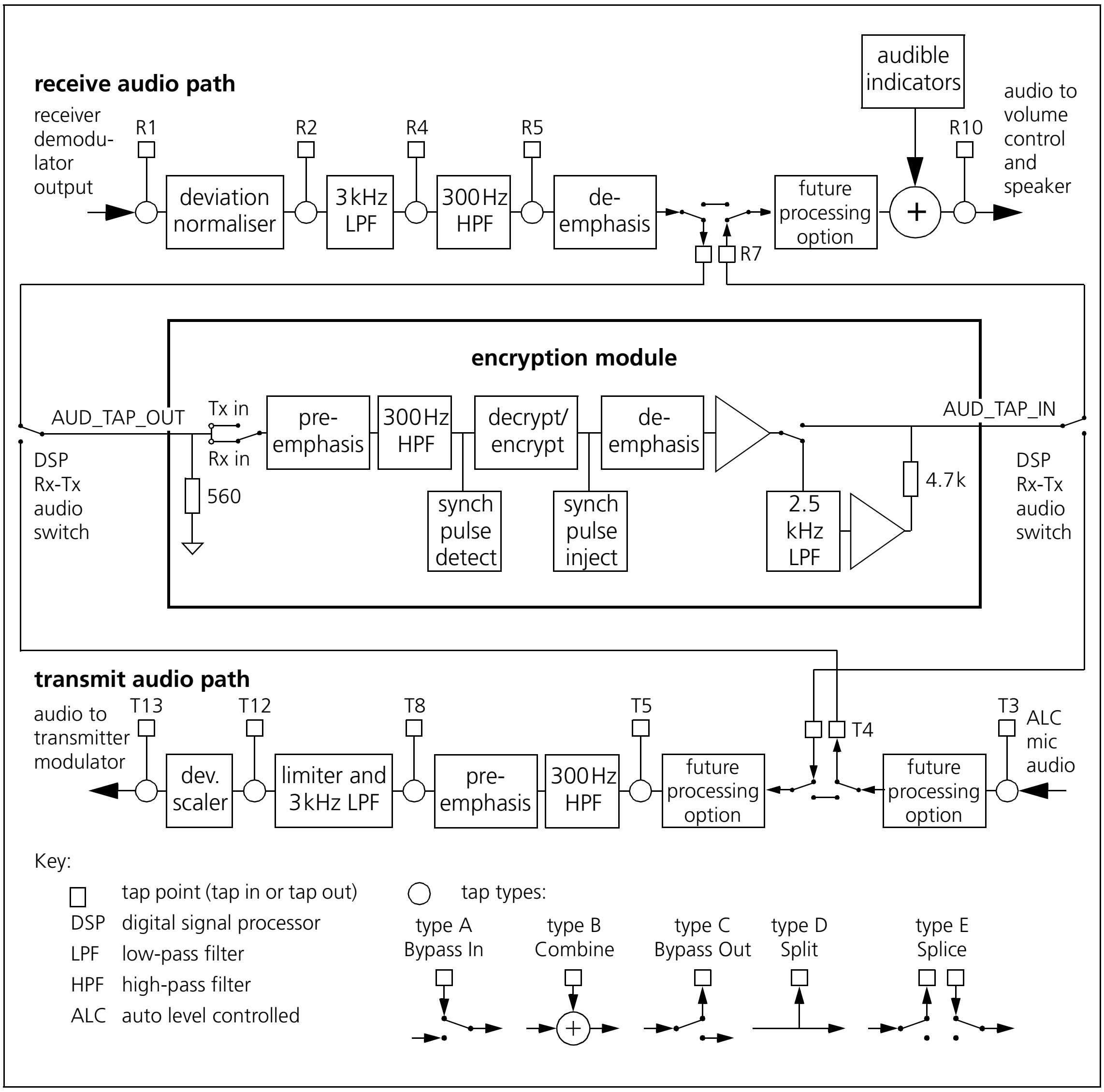
Encryption module	Internal options connector		Description/parameter	Specification
Signal	**Pin**	**Signal**		
Power	1	13V8_SW	Switched and unregulated power from radio.	
GND	3	AGND	Analog ground.	
PTT to options	9	IOP_GPIO1	Control head PTT signal from radio. Action: Active State: Module logic threshold required:	 Reflect PTT Status Low 3V3 CMOS-compatible[a]
Clear/code mode	10	IOP_GPIO2	Mode select from radio. Toggled by radio function key. Action: Active State: Module logic threshold required:	 F1…F4 Key Status Low 3V3 CMOS-compatible[a]
Secure mode	11	IOP_GPIO3	Mode indicator to radio. Action: Active State:	 Toggle F1…F4 Key LED High
Radio Tx audio to module	2	AUD_TAP_OUT	Tx audio from radio. Audio tap input point: Audio tap input unmuting: Signal level into 600Ω: AUD_TAP_OUT output impedance:	 Use T4-E Use 'on PTT' 690mVp-p (60% RSD[b]) 600Ω typical
Module Tx audio to radio	6	AUD_TAP_IN	Tx audio to radio. Audio tap input point: Audio tap input unmuting: Signal level into 600Ω: AUD_TAP_IN input impedance:	 Use T4-E Use 'except on PTT' 690mV$_{p-p}$ (60% RSD[b]) 100kΩ typical
Radio Rx audio to module	2	AUD_TAP_OUT	Rx audio from radio. Audio tap input point: Audio tap input unmuting: Signal level into 600Ω: AUD_TAP_OUT output impedance:	 Use T4-E Use 'on PTT' 690mV$_{p-p}$ (60% RSD[b]) 600Ω typical
Module Rx audio to radio	6	AUD_TAP_IN	Rx audio to radio. Audio tap input point: Audio tap input unmuting: Signal level into 600Ω: AUD_TAP_IN input impedance:	 Use T4-E Use 'except on PTT' 690mV$_{p-p}$ (60% RSD[b]) 100kΩ typical

a. If the module input is 5V CMOS then a 3.3kΩ pullup to 5V on the module will be required for compatibility. For more information refer to "Digital Output Lines" on page 64.

b. RSD = Rated System Deviation

Figure 5.6 shows the audio interfacing between the radio and the encryption module specified in Table 5.5.

Figure 5.6 Encryption module - audio interfacing



The audio interfaces in Figure 5.6 are recommended and best suit Transcrypt SC20-4xx series encryption modules. This configuration maximises system flexibility by not excluding other hardware options and system configurations from being used with encryption. For example, the encryption module could be used in a radio that is cross-band linked with a second radio.

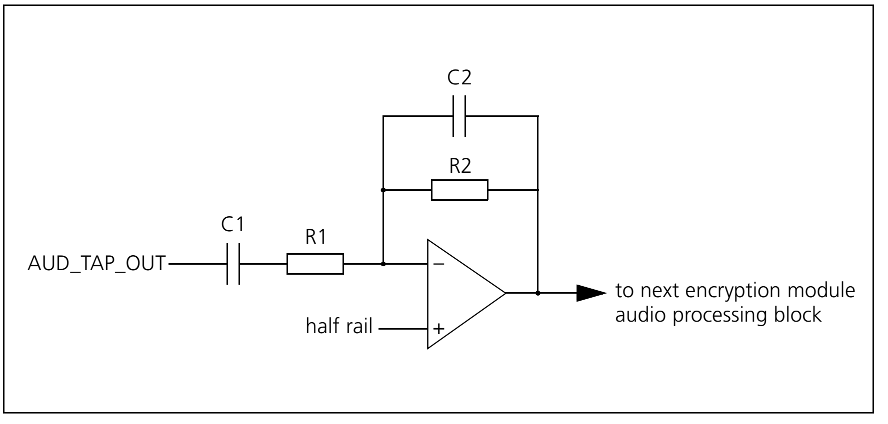
Encryption Module Hardware Configuration

1. Configure the encryption module hardware as shown in Figure 5.6.

2. Adjust encryption module for unity through-gain. At least 11dB headroom above the 1kHz 60% rated system deviation level will be required throughout the audio processing chain on the module to avoid clipping with speech signals.

3. Input pre-emphasis is required. A typical pre-emphasis circuit is shown in Figure 5.7. If this not available on the module it will need to be added as a separate circuit at the module input. Alternatively the input buffer on the module can be modified if its topology matches that of Figure 5.7.

Figure 5.7 Encryption module - typical pre-emphasis circuit



Use the following procedure to choose the component values in Figure 5.7:

a. Choose C1. 1nF is a typical value.

b. Determine R1: R1 = 1 / (35300 * C1)

c. Determine R2: R2 = 5.9 * R1 for unity gain. Scale R2 proportionally to change gain.

d. Ensure that C2 is zero.

e. Use the nearest preferred component values.

4. Ensure that de-emphasis is applied on both transmit and receive. If this cannot be done via software then the de-emphasis control line will need to be overridden by a hardware modification.

Encryption Module Software Configuration

To make configuration changes via over-the-air rekeying (OTAR), the module needs to be installed in the radio and be operational.

Key Management

For key management refer to the relevant sections of the encryption module manufacturer’s documentation.

Radio Programming

Use the programming application to configure the radio.

1. In the Key Settings form, set one function key to Action Digital Output Line.

2. In the PTT / PTT form, set the Advanced PTT group to:
   - PTT Transmission Type: Voice
   - PTT State Is Reflected: checked
   - PTT Priority: Highest
   - Audio Source: CH_MIC

3. In the Digital tab of the Programmable I/O form, carry out the following settings:

Pin	Direction	Action	Active	Debounce	Signal state
IOP_GPIO1	Output	Reflect PTT Status	Low	None	Momentary
IOP_GPIO2	Output	F1 Key Status	High	None	Momentary
IOP_GPIO3	Input	Toggle F1 Key LED	High	0	None

4. In the Audio tab of the Programmable I/O form, carry out the following settings:

Rx / PTT Type	Tap In	Tap In Type	Tap In Unmute	Tap Out	Tap Out Type	Tap Out Unmute
Rx	R7	E - Splice	Busy Detect	R7	E - Splice	Busy Detect
EPTT1	T4	E - Splice	On PTT	T4	E - Splice	On PTT

Operation

With the TM8115, one function key can be programmed to toggle between Clear and Secure mode. The Secure LED lights up when the radio is in Secure mode. The radio has no facility to change the decryption/encryption code via the user interface.

When the radio is set to Clear mode (unencrypted), the encryption module does not affect the radio operation.

Unencrypted messages received while the radio is in Secure mode will be received as normal, i.e. the radio does not apply any decryption.

To initiate a secure call:

1. Press the Clear/Secure function key (if not already in Secure mode). The Secure LED lights up.

2. Press PTT to set up a call (assuming the other party has valid decryption). You must wait at least 0.5 s before speaking to allow the receiving encryption module to synchronise.

3. Carry out the call in standard manner.

The radio will stay in Secure mode until the Clear/Secure function key is pressed again.

The coding or setup of the encryption module can only be changed via the over-the-air rekeying protocol (OTAR) provided by the module manufacturer. For further information refer to the manufacturer's documentation.

Radio performance degradation is to be expected when encryption is active. The main effects are reduced radio range and audio quality.

Testing

With encryption off:

1. Check that the radio powers up normally, with the normal display messages and confirmation tones.
2. Check that receive and transmit audio are functioning, using a service instrument or another radio on the same channel.

With encryption on:

1. Check that the radio receives and transmits, using another TM8000 radio with the same encryption module, programmed with the same codes, on the same channel.
2. Listen for the synchronisation pulses that occur approximately once a second, added by encryption, to confirm encryption is active.

5.2.2 ANI Module

Automatic Number Identification (ANI) modules can be installed in portable or mobile radios. When the ANI module is installed, each radio transmission can have a unique number attached to it to assist dispatchers in identifying the source of transmission.

Note The TM8000 also offers built-in ANI capabilities. For more information refer to the online help of the programming application.

Interface Specification

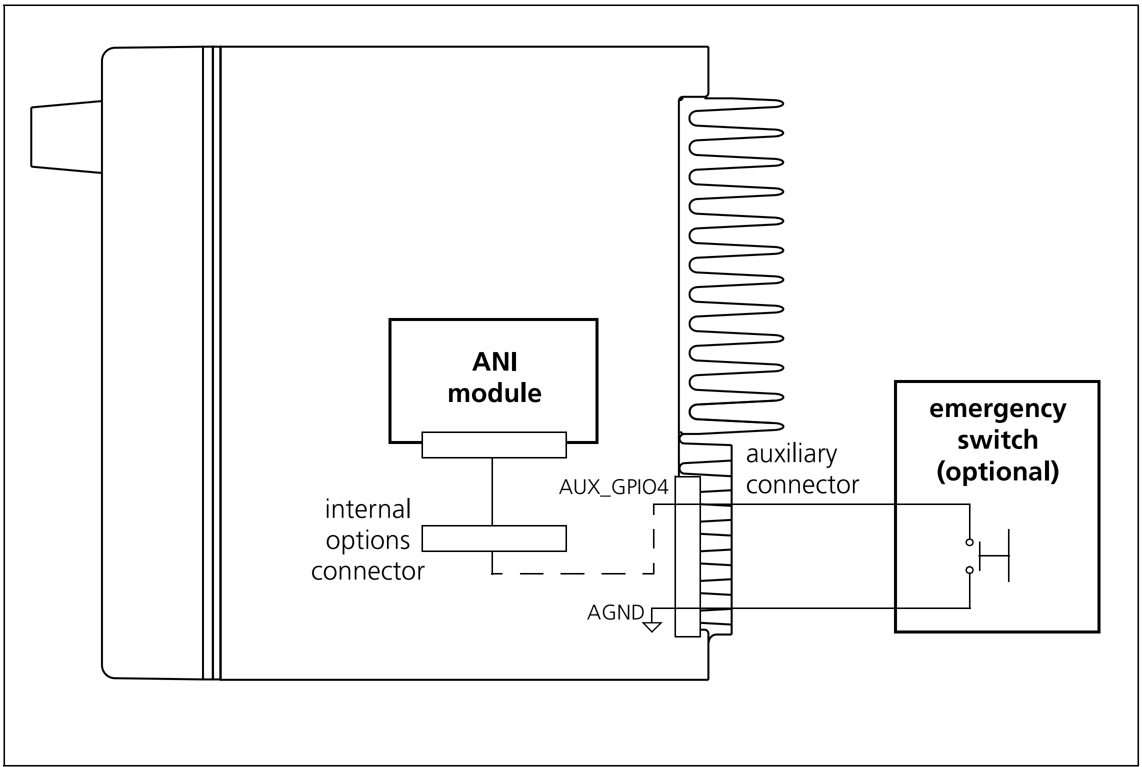
The ANI module is mounted inside the radio body where it connects to the internal options connector via a standard 1.27 mm pitch ribbon cable.

An optional emergency switch can be connected to AUX_GPIO4 and AGND of the auxiliary connector.

The internal options connector is described on page 28.

Figure 5.8 shows the diagram of an ANI module interfaced with the internal options connector inside the radio body.

Figure 5.8 Diagram of ANI module connected to radio



Configure the internal options interface as described in Table 5.6:

Table 5.6 ANI module interface specification

ANI module	Internal options connector		Description/parameter	Specification
Signal	Pin	Signal		
Power	1	13V8_SW	Switched and unregulated power from radio.	
GND	3	AGND	Analog ground.	
PTT in/out[a]	9	IOP_GPIO1	Control head PTT signal from radio. Action: Active State: Module logic threshold required:	 Reflect PTT Status Low 3V3 CMOS-compatible[b]
Emergency input	10	IOP_GPIO2	Emergency signal from radio. Signal mirrored from auxiliary connector. Action: Active State: Module logic threshold required:	 Mirrored from AUX_GPIO4[c] Low 3V3 CMOS-compatible[b]
Mic mute	11	IOP_GPIO3	Mic mute signal to radio. Used as PTT input in order to switch audio source from radio mic to ANI. Action: Active State:	 External PTT2 Low
Module tone out	6	AUD_TAP_IN	Tone output to radio. Audio tap input point: Audio tap input unmuting: Signal level required: AUD_TAP_IN input impedance:	 Use T5-A Use 'on PTT' 690 mV_{p-p} (60% RSD[d]) 100 kΩ typical

a. If the ANI module has separate PTT in and out signals, tie these together on the module. This will disable the modules on-board Tx timer. Ensure the radios Tx timer duration is set as you require.

b. If the module input is 5V CMOS, a 3.3 kΩ pullup to 5 V must be fitted on the module.

c. The radios emergency mode should be disabled if the modules emergency features are used.

d. RSD = Rated System Deviation

Radio Programming

Use the programming application to configure the radio.

1. In the Digital tab of the Programmable I/O form, carry out the following settings:

Pin	Direction	Action	Active	Debounce	Signal state	Mirrored to
AUX_GPIO4	Input	No action	High	100	None	IOP_GPIO2
IOP_GPIO1	Output	Reflect PTT Status	None	None	Momentary	None
IOP_GPIO2	Output	No action	None	None	Momentary	None
IOP_GPIO3	Input	External PTT2	None	0	None	None

2. In the Audio tab of the Programmable I/O form, carry out the following settings:

Rx / PTT Type	Tap In	Tap In Type	Tap In Unmute	Tap Out	Tap Out Type	Tap Out Unmute
EPTT2	T5	A - Bypass In	On PTT	None	C - Bypass Out	On PTT

3. In the PTT / PTT form, set the Advanced PTT group to:
   - PTT Transmission Type: Voice
   - PTT State Is Reflected: checked
   - PTT Priority: Medium
   - Audio Source: CH_MIC
4. In the PTT / External PTT1 form, set the Advanced EPTT1 group to:
   - PTT Transmission Type: None
   - PTT State Is Reflected: cleared
5. In the PTT / External PTT2 form, set the Advanced EPTT2 group to:
   - PTT Transmission Type: Voice
   - PTT State Is Reflected: cleared
   - PTT Priority: Highest
   - Audio Source: Audio Tap In

ANI Module Programming

Refer to the manufacturer's documentation.

6 Replacing the Tait T2000-A81 Board

This chapter describes the issues regarding the transfer from a combination of Tait 2000 radio and T2000-A81 board to the TM8000 mobile radio. It will also help integrators who are considering interfacing an external product to the TM8000 auxiliary connector.

The T2000-A81 board is a low-cost interface board, which permits the break out of a number of options connections of the T201X mobile radio. It allows third-party devices such as mobile data terminals or data modems to be connected to the T201X.

6.1 Differences Between the TM8000 and T2000-A81 Interfaces

It is important to understand that there are some differences between the TM8000 and T2000-A81 interfaces.

1. Physical connector – The T2000-A81 uses a high-density 15-way D-range connector (three rows of five pins). The TM8000 auxiliary connector is a standard miniature 15-way D-range connector (one row of seven and one row of eight pins). The auxiliary connector is described on page 20.

2. Technology – The T2000-A81 is a PCB-based hardware interface and none of the connections to the T201X are programmable. On the other hand all of the digital I/O lines on the auxiliary connector on the TM8000 are programmable to a wide range of functions.

3. Signal levels – Due to the nature of the two radio designs both the digital interface and analogue levels will have differing levels. The current handling capability of digital outputs may also vary. The tap-in and tap-out audio lines in the TM8000 are designed to provide access to a number of points in the audio chain. The input and output level for these taps has been set at –10 dBm for 60% of full system deviation. The tap points are illustrated in “Audio Tap In and Tap Out Lines” on page 80.

4. Microphone mute – While the TM8000 does offer an equivalent microphone mute function (see “Mute External Audio Input” on page 57) the preferred means of muting the microphone is to use audio steering based on the three PTT lines provided by the product. In this case the fist microphone PTT is used only to indicate to the third-party device that it is being activated. This action can be mirrored in a digital output.

5. RSSI output – The RSSI output of the TM8000 is committed to a pin on the auxiliary connector.

6. Serial lines – The serial lines (TXD and RXD) on the TM8000 are committed and should be used for channel control in preference to BCD.

Due to the design differences between the T201X/T2000-A81 combination and the TM8000 auxiliary connector, Tait recommends that integrators apply all 3DK information for this work.

6.2 Configuring the TM8000

As the TM8000 is a highly configurable radio in terms of digital I/O, multiple PTT line control and audio tap in and out points, familiarise yourself with the programming application.

Note Tait Electronics can provide a training module that covers this area.

Table 6.1 describes the T2000-A81 connections and a suggested arrangement for using the TM8000 lines for a similar application.

The TM8000 auxiliary connector is described on page 20.

Table 6.1 T2000-81 and TM8000 interface specification

T2000-A81 connector		***T2000 options signal***	***T2000 radio options line***	***T2000 comment***
	TM8000 auxiliary connector	**TM8000 auxiliary signal**	**TM8000 designation**	**TM8000 comment**
1		*+13.8V switched*	*S14 pin 1*	*Current limit 200mA*
	8	+13V8_SW	+13V8_SW	Current limit 1000mA
2		*PTT-FROM-OPTION*	*S14 pin 6*	*Microphone PTT active low*[a]
	10	AUX_GPIO4	GPIO4	Programmed to mirror microphone PTT action
3		*TX-SIG-IN*	*S13 pin 8*	*To limiter, flat response 470kΩ input impedance, requires* $2.5\,V_{p\text{-}p}$ *to drive*
	7	AUD_TAP_IN	AUDIO TAP IN	Programmable tap point into audio chain 600Ω –10dBm level
4		*GND*	*S13 pin 11*	*Ground*
	15	AGND	AGND	Ground
5		*DET-AF-OUT*	*S13 pin 1*	*Flat audio un-muted* $400\,mV_{p\text{-}p}$[b]
	13	AUD_TAP_OUT	AUDIO TAP OUT	Programmable tap point from the audio chain 600Ω –10dBm level
6		*Not used*	*Not used*	*Available for custom signal*
	6	RSSI	RSSI	Committed analogue output of the RSSI level

Table 6.1 T2000-81 and TM8000 interface specification (continued)

T2000-A81 connector		*T2000 options signal*	*T2000 radio options line*	*T2000 comment*
	TM8000 auxiliary connector	**TM8000 auxiliary signal**	**TM8000 designation**	**TM8000 comment**
7		*BUSY*	*Buffered S14-3*	*Open collector active on busy*
	2	AUX_GPIO5	GPIO5	Program to provide a busy output open collector
8		*MIC-MUTE*	*S14-8*	*Apply +5V to mute 200kΩ input impedance*
	12	AUX_GPI1	GPI1	Program as EPTT1 for data transmission
9		*GND*	*S13 pin 11*	*Ground*
	14	AUX_MIC_AUD	Microphone input	Input for handsfree microphone
10		*BCD-0*	*S15 pin 5*	*BCD on V2.05 firmware*[c]
	5	AUX_GPI2	GPI2	Program as input BCD line 0
11		*SIG-SQ*	*S14 pin 9*	*Mutes radio on pulling this line to ground*
	4	AUX_GPI3	GPI3	Program to mute audio to the loudspeaker
12		*Not used*	*Not used*	*Available for custom signal. In a special build this line may be used as a programming output*
	11	AUX_TXD	Serial transmit line	This line is committed to serial transmission
13		*Not used*	*Not used*	*Available for custom signal. In a special build this line may be used as a Programming input*
	3	AUX_RXD	Serial receive line	This line is committed to serial reception
14		*PTT-TO-OPTION*	*S14 pin 5*	*PTT signal from the outside world active low*[a]
	9	AUX_GPIO6	GPIO6	Program as EPTT2 for voice transmission via the fist or handsfree microphone
15		*RSSI / BCD-1*	*With link 3: RSSI (S14 pin 15). With link 4: BCD-1 (S15 pin 4). Only one link can be selected at a time*	*RSSI voltage for signal strength, or BCD for V2.05 firmware only*[c]
	1	AUX_GPIO7	GPIO7	Program as input BCD line 1

a. The PTT-FROM-OPTION and the PTT-TO-OPTION are normally connected together on the radio logic PCB by R513 and D500. Removal of these components allows the external control device to decide how PTT is controlled.

b. The receive audio path out of the T2000 could be altered to a point which is muted or gated by altering the linking on the T2000-A81 board.

c. The BCD signal lines referred to in the table relate to V2.05 firmware for the T201X only. I/O pads are provided on S15 for linking in the case of other T201X firmware variants.

7 Power Sense Options

The TM8000 radio allows the configuration of different power sense options to control how the radio is powered up and down.

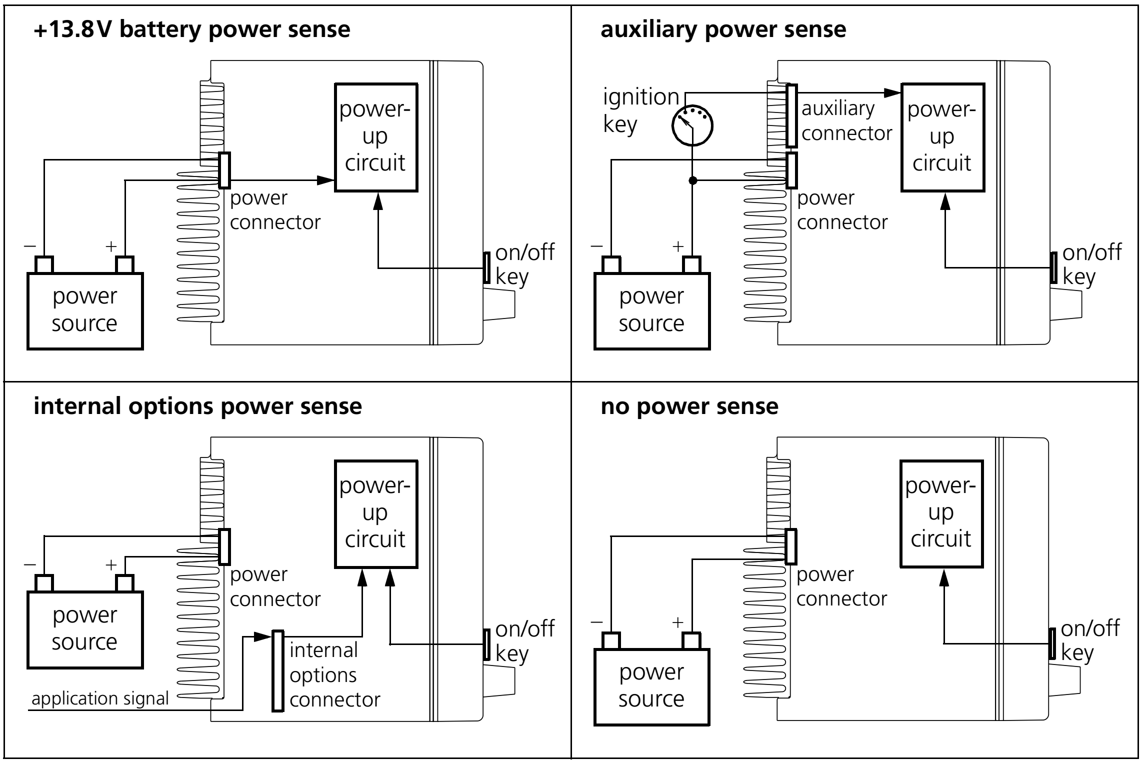
The power sense options are:

- 13.8V battery power sense
- auxiliary power sense (ignition sense)
- internal options power sense
- no power sense (on/off key control only)

In addition to any of these power sense options, an emergency power sense input can be configured to allow the activation of the emergency mode using an external emergency switch.

Figure 7.1 shows simplified block diagrams of the power sense options.

Figure 7.1 Simplified block diagrams of power sense options



Important Although it is possible to connect the radio in line with the vehicle ignition, this installation method is not recommended, as it may draw too much current resulting in damage to the wiring and key column. This may also cause the supply voltage of the radio to drop below the specified level. Use the ‘auxiliary power sense’ option for vehicle installations (current consumption <1mA).

Hardware Links

The different power sense options have to be facilitated by hardware means, as the software cannot act before it is powered up. The radio provides four hardware links (LK1 to LK4) which can be configured to attain the power sense option desired. This is described in "Configuring the Hardware Links LK1 to LK4" on page 126.

Programmable I/O

After configuration of the hardware links, care should be taken to configure the corresponding I/O lines accordingly. With some link settings, certain lines will not be able to be used as general purpose I/O. Refer to "Radio Programming" on page 130.

Power-On Mode

In addition to the power sense options, with the '13.8V battery power sense', 'auxiliary power sense' and 'internal options power sense' configurations, the power-on mode of the radio must be programmed to be either on or to return to its previous state when the power sense signal was removed. For information on programming the power-on mode refer to the online help of the programming software.

On/Off Key

The on/off key on the control head (TM8115 only) can be used with any of the power sense options to turn the radio on and off.

The power sense options and the emergency power sense are described in the following sections.

7.1 13.8V Battery Power Sense

When this option is chosen and the radio is connected to power, the radio will enter the programmed power-on mode. The on/off key can then be used to turn the radio on and off.

This option has the disadvantage that when turned off (using the on/off button) the radio still draws approx. 28mA because it enters stand-by mode and does not shut down completely.

Note The power consumption of the 'no power sense' option is <1mA.

Applications

Use this option:

- when the radio is used in a remote location (if the power is cut, the radio does not need to be turned back on once power is restored)
- when a control head is not fitted (no on/off key)
- when the radio is used with a desktop supply with its own power switch
- when wiring the positive power terminal of the radio directly to the vehicle ignition (not recommended)
- where the radio needs to be on or at least responsive at all times when power is connected (emergency services)

7.2 Auxiliary Power Sense (Ignition Sense)

'Auxiliary power sense' uses a digital input line to power the radio up and down. This is used to turn the radio off when the ignition key is off to avoid flattening the battery. Similarly, the digital input can be used to turn the radio on only when it is needed.

When the digital input line becomes active, the radio will enter the programmed power-on mode.

'Auxiliary power sense' uses the AUX_GPI3 line of the auxiliary connector and is connected to the power-up circuitry via hardware link LK2. This line is active high with ≥2.6V on and ≤0.7V off. The input will respond to logic signals from 2.6V to the radio supply voltage.

The on/off key can be used to turn the radio on and off (with the radio off and the line active, the radio draws approx. 28mA).

When the line becomes inactive, it completely turns off the radio regardless of whether it was on or in stand-by mode (the radio now draws < 1mA).

Applications

Use this option:

- for installations in vehicles (where the radio turns off when the ignition is turned off, and the radio can be programmed to be either on or to return to the previous state on power-up).
- telemetry applications which may have a limited power source (where the radio is only to turn on when an external digital signal is applied).

7.3 Internal Options Power Sense

This power sense option is very similar to the 'auxiliary power sense' option described above. If the hardware links are set for this option, the IOP_GPIO7 line of the internal options connector can be used to power the radio up and down. This line is also active high with ≥2.6V on and ≤0.7V off, but is only tolerant to signals up to 5V.

The behaviour of the on/off key is the same as with 'auxiliary power sense'.

Application

Use this option when an internal options board is used to control the turning on and off of the radio.

Note 'Auxiliary power sense' and 'internal options sense' can be used together. The overall response is an OR function, i.e. if one signal becomes active, the radio is powered up, and both signals have to go inactive for the radio to power down.

7.4 No Power Sense (On/Off Key Only)

With this option, the on/off key is the only way to power up the radio. Use this option, when the ‘auxiliary’ or ‘internal options power sense’ options are not required and when it is not important if the radio does not power up when the radio is initially connected to power. The advantage of this option over ‘13.8V battery power sense’ is that the radio draws < 1 mA when off.

Application

Use this option, when the radio needs to respond only to control head key presses, the radio must always be off when power is applied, and use minimal power when off.

7.5 Emergency Power Sense

Emergency control is usually installed in situations where the radio user could be in possible danger (e.g. taxis, armoured vehicles, police etc.) or where there could be a medical emergency (e.g. buses etc.). An emergency call or programmable key press can activate emergency mode. As a programmable option, emergency mode can also be activated by pressing a hidden emergency button for two seconds.

‘Emergency power sense’ uses the AUX_GPI2 line of the auxiliary connector and is connected to the power-up circuitry via hardware link LK3. This line is active low ≤ 0.7V and has an internal pull-up to the radio supply voltage. Activation of ‘emergency power sense’ will power up the radio and enter the emergency mode.

Note The emergency mode can also be entered through the input lines of the internal options connector, however these input lines do not use ‘emergency power sense’ and the radio will not be powered up.

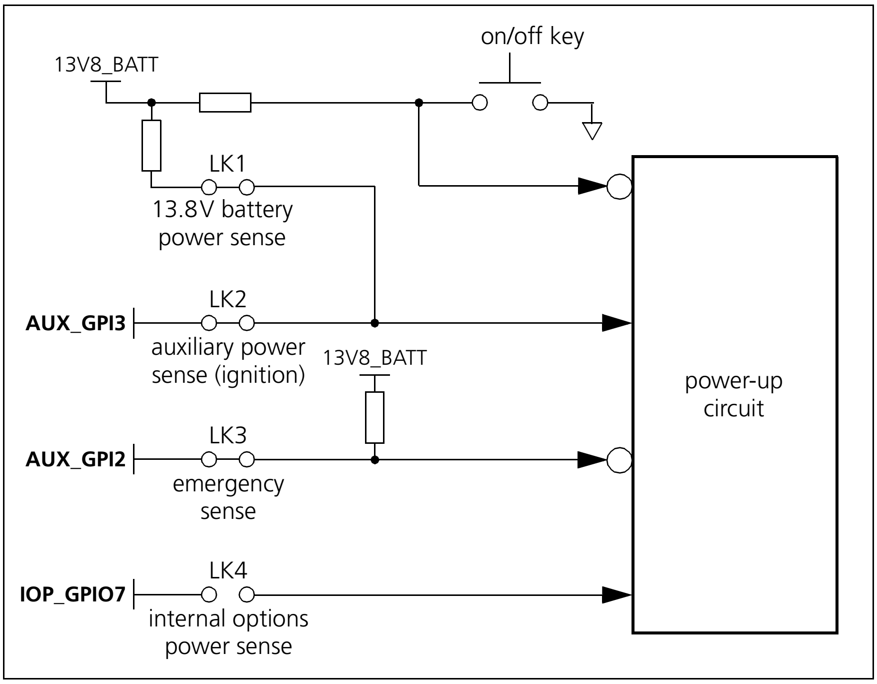
For more information on the emergency mode see the online help of the programming application.

7.6 Configuring the Hardware Links LK1 to LK4

The different power sense options have to be facilitated by hardware means, as the software cannot act before it is powered up. The radio provides four hardware links (LK1 to LK4) which can be configured to attain the power sense option desired.

Figure 7.2 shows a block diagram of the hardware links LK1 to LK4.

Figure 7.2 Block diagram of hardware links LK1 to LK4



The radio is powered up if one or more of these inputs is active.

Table 7.1 shows the configuration of the hardware links LK1, LK2 and LK4 for the individual power sense options. It also lists the dependence of the power sense options with respect to the GPI lines, which can or cannot be used.

Table 7.1 Configuration of hardware links and GPI lines for power sense options

Power sense option	Links required	Configuration of remaining links and use of AUX_GPI3 and IOP_GPIO7	Voltages required
13.8V battery power sense	LK1 in LK4 out	LK2 in: AUX_GPI3 must be left floating. LK2 out: AUX_GPI3 can be used as GPI[a]. IOP_GPIO7 can be used as GPIO.	10.8V≤ supply≤16V
auxiliary power sense	LK2 in LK4 out	LK1 in: Input line must sink <1mA from AUX_GPI3 (which is pulled to 13.8V by a 33kΩ resistor). LK1 out: Input line must be active high[b]. IOP_GPIO7 can be used as GPIO.	AUX_GPI3≤0.7V off AUX_GPI3≥2.6V high (active) ignition-sense tolerant to 3.3V, 5V and 12V
internal power sense	LK1 out LK2 out LK4 in	 AUX_GPI3 can be used as GPI. With LK4 in, the input line must be active high[c].	IOP_GPIO7≤0.7V off IOP_GPIO7≥2.6V high (active) ignition-sense tolerant to 3.3V and 5V only
no power sense	LK1 out LK2 out LK4 out	 AUX_GPI3 can be used as GPI. IOP_GPIO7 can be used as GPIO.	10.8V≤ supply≤16V

a. If LK2 is out and AUX_GPIO is not used, R775 (33k) should be placed to ensure that AUX_GPI3 does not float (R775 is not placed by factory default).

b. If LK1 is out and R775 is placed, AUX_GPI3 should be driven low as well.

c. If LK 4 is in and R723 is placed, IOP_GPIO7 should be driven low as well. (R723 is placed by factory default.)

Table 7.2 shows the configuration of 'emergency power sense'. 'Emergency power sense' can be configured with any of the above power sense options.

Table 7.2 Configuration of hardware link LK3 and AUX_GPI2 for 'emergency power sense'

External push-button or toggle switch required to enter emergency mode	Links required	Implications on AUX_GPI2	Voltages required
Yes	LK3 in	AUX_GPI2 must be connected to an external (hidden) push-button or toggle switch, which connects it to ground.	≤0.7V active, floating inactive
No	LK3 in LK3 out	AUX_GPI2 must be left floating AUX_GPI2 can be used as GPI.	

[Figure 7.3](#) shows the positions of hardware links LK1…4 on the main board assembly. [Figure 7.4](#) shows the positions of the resistors R775 and R723 on the main board assembly

Follow the instructions of the TM8100 Service Manual on removing and fitting the radio lid, the main board assembly, and SMD components.

Figure 7.3 Positions of LK 1…4 on the main board assembly

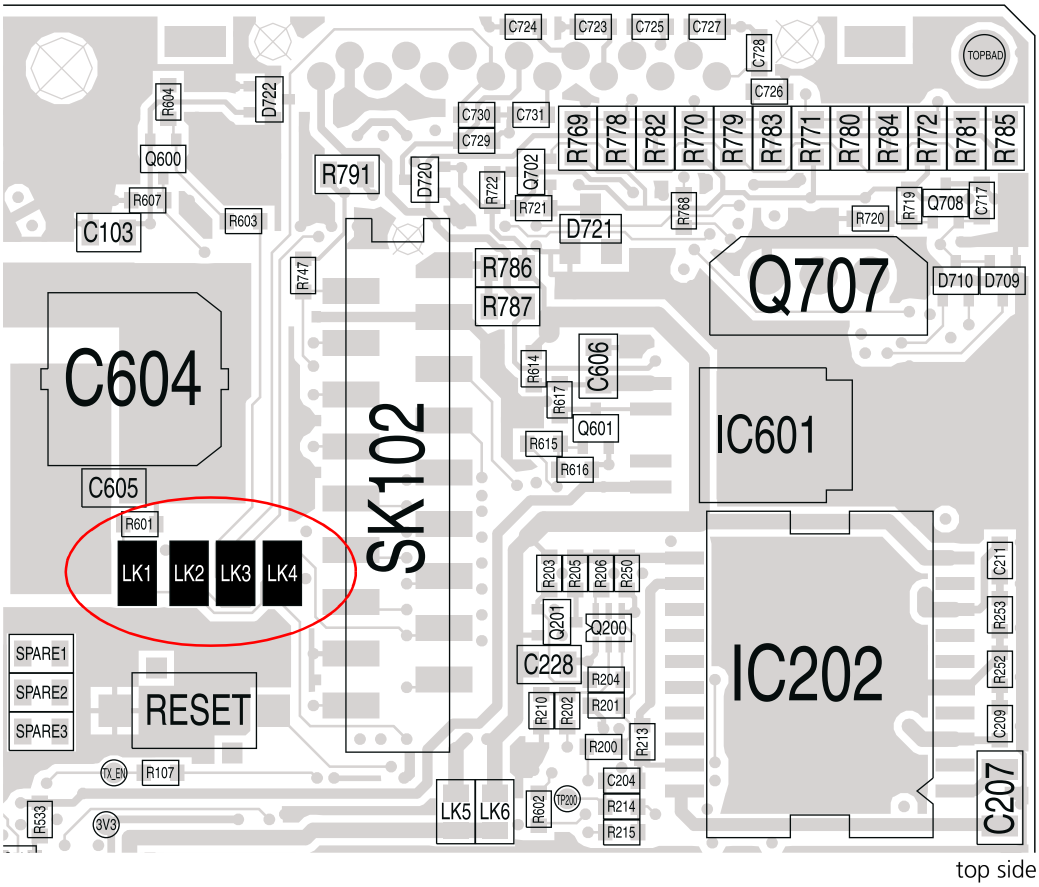
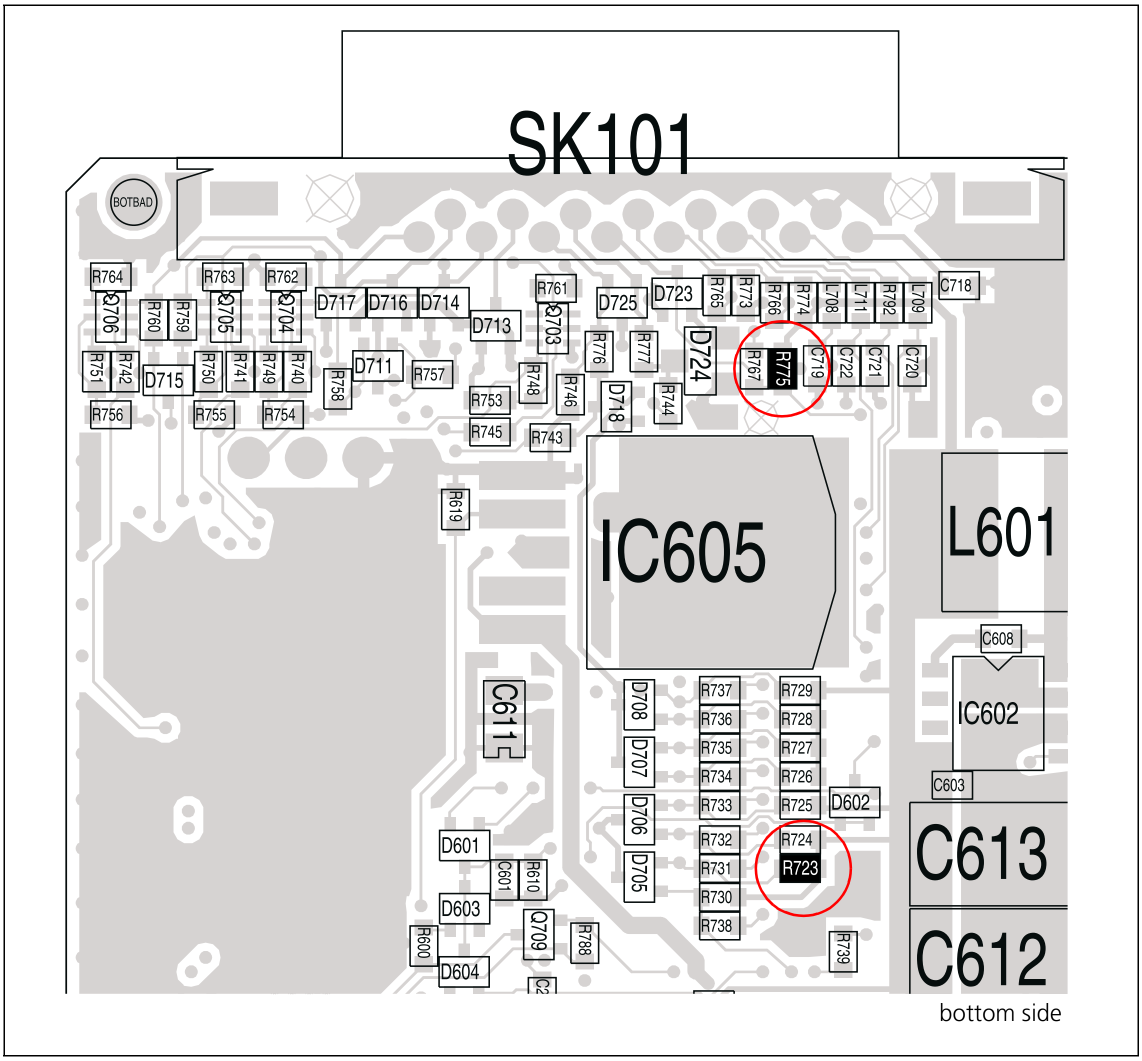


Figure 7.4 Positions of R723 and R775 on the main board assembly



7.7 Radio Programming

Programmable I/O

Table 7.3 shows the programming of the input lines in the Digital tab of the Programmable I/O form of the programming application. For more information refer to "Digital Input Lines" on page 39 and the online help of the programming application.

Table 7.3 Programming the power sense options

Power sense option	Pin	Direction	Action	Active
13.8V battery power sense	none			
auxiliary power sense	AUX_GPI3	Input	Power Sense (Ignition)	High
internal power sense	IOP_GPIO7	Input	Power Sense (Ignition)	High
no power sense	none			
emergency power sense	AUX_GPI2	Input	Enter Emergency Mode	Low

Note If AUX_GPI3 is configured for 'auxiliary power sense' or IOP_GPIO7 is programmed for 'internal options power sense', these input lines can no longer be used as general inputs. In order to prevent any other action to be accidentally programmed for one of these input lines, these input lines should be set to 'Power Sense (Ignition)'. This setting itself has no function.

Power-On Mode

With the '13.8V battery power sense', 'auxiliary power sense' and 'internal options power sense' configurations, the power-on mode of the radio must be programmed to be either on or to return to its previous state from when the power sense signal was removed. For information on programming the power-on mode refer to the online help of the programming software.

8 Connector Power Supply Options

Power from the radios primary power source is fed to the auxiliary, internal options, control-head and microphone connectors. Whether power to these connectors is unswitched, switched or not supplied is determined by hardware links LK5 and LK6 as shown in Figure 8.1 and Table 8.1.

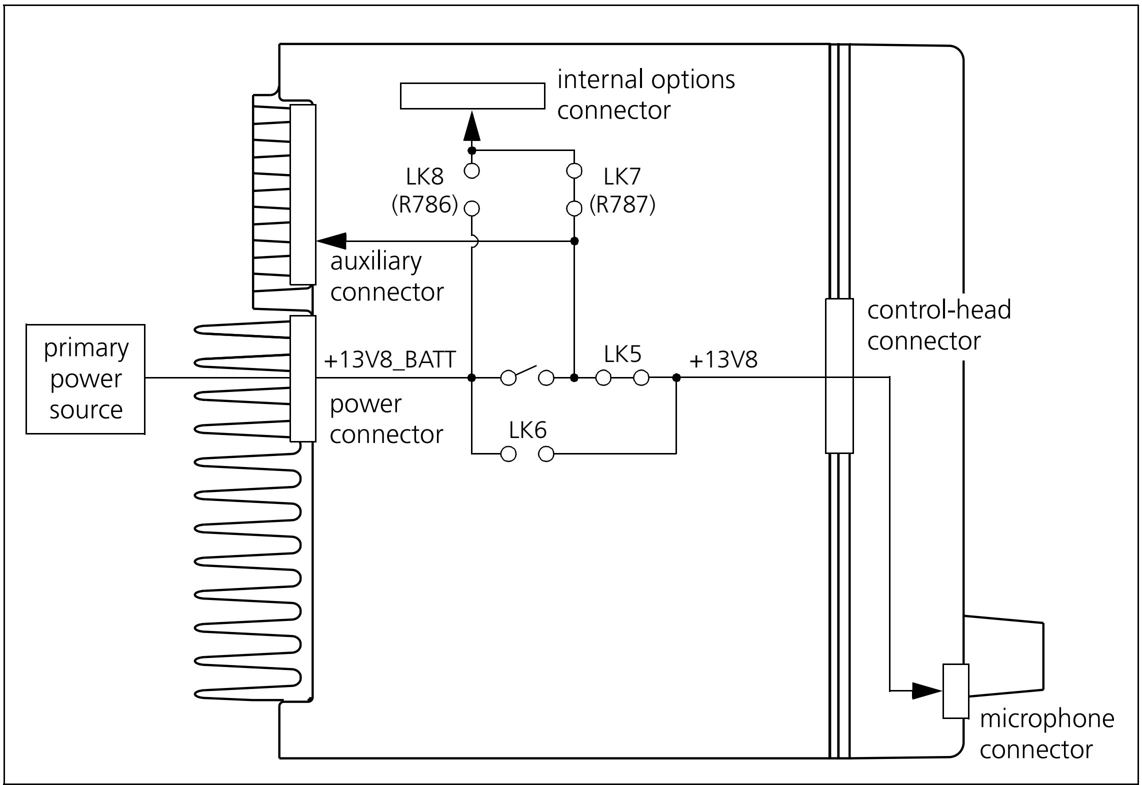
Unswitched Power

Unswitched power means that power will always be supplied to the connector while the primary power source is connected to the radio and is alive. The supply to the connector is not affected by the state of the radio.

Switched Power

Switched power means that when the radio is off or in standby mode, the power to the connector is switched off. The power will also be switched off if the primary power source voltage is outside the radio's operating range (for details refer to "Power Connector" on page 18). The switched current drawn by all connectors must not exceed 1 A in total.

Figure 8.1 Connector power distribution



Note The switched output is protected. Short-circuiting the switched power on any connector will not damage the radio. In the event of a short circuit, the current folds back to protect the switch device and connectors.

Table 8.1 Connector power supply options

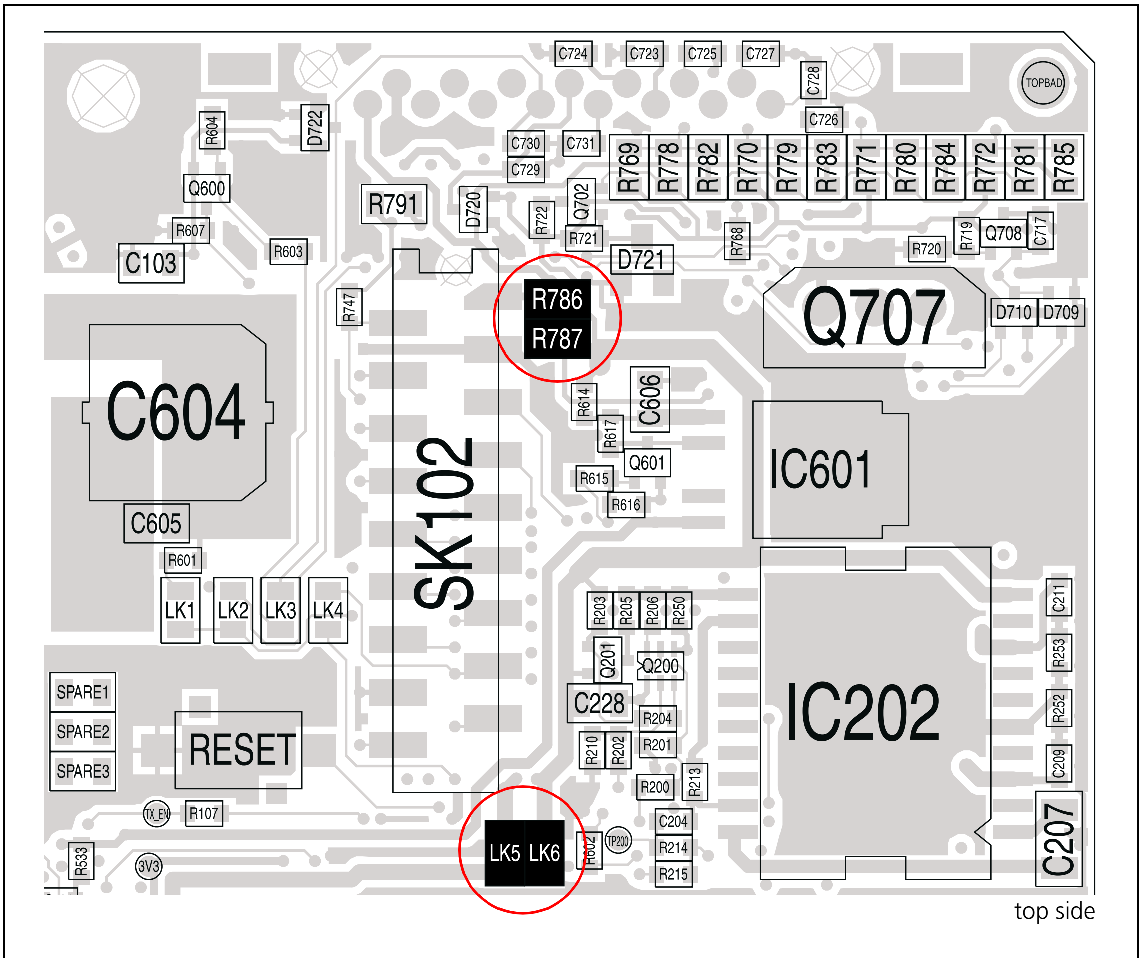
Link state				Connector power state			
LK5	**LK6**	**LK7 (R787)**	**LK8 (R786)**	**Auxiliary**	**Internal options**	**Control head**	**Microphone**
out	out	out	out	switched	no power	no power	no power
in[a]	out[a]	in[a]	out[a]	switched	switched	switched	switched
out	in	in	out	switched	switched	unswitched	unswitched
in	out	out	in	switched	unswitched	switched	switched
out	in	out	in	switched	unswitched	unswitched	unswitched
in	in	in	in	unswitched	unswitched	unswitched	unswitched

a. factory default

Figure 8.2 shows the positions of hardware links LK5, LK6, LK7 (R787) and LK8 (R786) on the main board assembly.

Follow the instructions of the TM8100 Service Manual on removing and fitting the radio lid, the main board assembly, and SMD components.

Figure 8.2 Positions of LK5, LK6, LK7 (R787) and LK8 (R786) on the main board assembly



9 Connecting an External Alert Device

The TM8000 radio allows for output to external alert devices using the digital GPIO lines of the auxiliary connector, the internal options connector and, with the TM8105, the programming connector.

The AUX_GPIO4 line of the auxiliary connector can be fitted with a power MOSFET in order to directly connect external alert devices (e.g. flashing light, buzzer, horn relay) to the radio. With the other GPIO lines and if no power MOSFET is fitted to the AUX_GPIO4 line, the signal characteristics specified in "Description of the Radio Interfaces" apply.

This chapter describes the connection of an external alert device to the AUX_GPIO4 line of the auxiliary connector and the programming of the radio for an external alert signal.

Important Modifications to radio-frequency transmitting equipment can void the user's authority to operate the equipment. By distributing the TM8000 3DK Hardware Developer's Kit, Tait Electronics Ltd. does not accept liability for any non-compliance or infringement of intellectual property rights resulting from the application or use of this kit or information. Any person modifying Tait radio-frequency transmitting equipment is responsible for ensuring that the modified equipment meets all legal and regulatory requirements in the country of use or supply.

To connect an external alert device to the AUX_GPIO4 line of the auxiliary connector, the following steps must be carried out:

1. Fit power MOSFET Q707 and remove resistor R768.
2. Program the radio.
3. Connect the external alert device.

9.1 Fitting Power MOSFET Q707 and Removing Resistor R768

Before connecting an external alert device to the AUX_GPIO4 line, a 12A, 60V, logic level power MOSFET (ON Semiconductor[1] product MPT3055VL, www.onsemi.com) must be fitted to position Q707 and resistor R768 must be removed from the main board assembly.

Figure 9.1 shows the circuit diagram of the AUX_GPIO4 line in factory configuration. For a complete circuit diagram of the main board assembly refer to the TM8100 Service Manual.

Figure 9.1 Circuit diagram of the AUX_GPIO4 line (factory configuration)

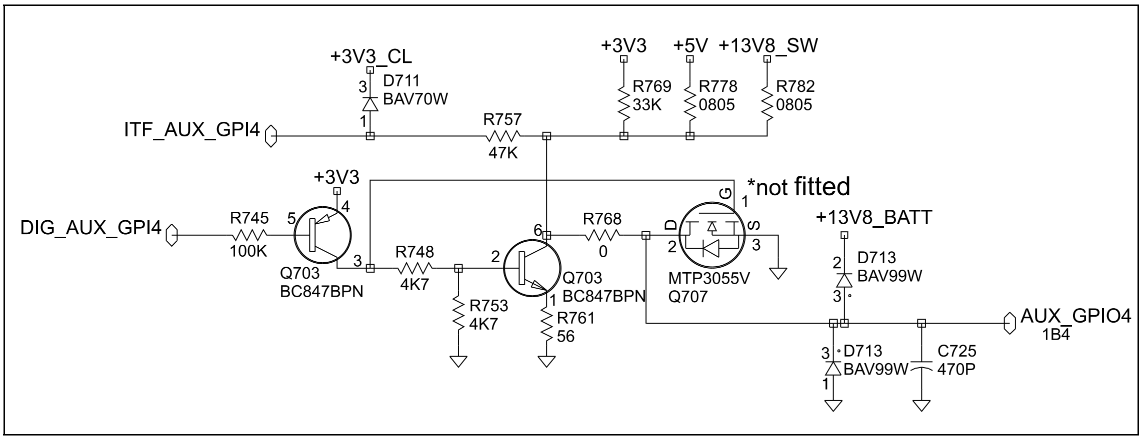
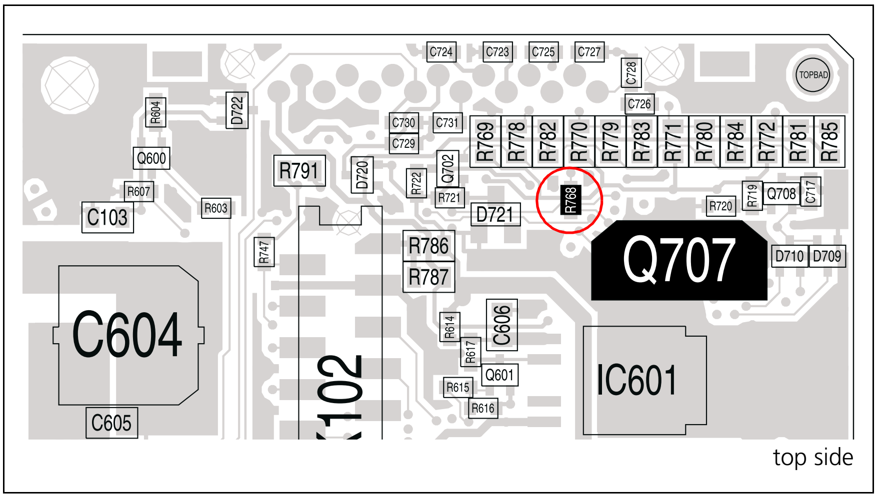


Figure 9.2 shows the positions of Q707 and R768. For a complete layout of the main board assembly refer to the TM8100 Service Manual.

Follow the instructions of the TM8100 Service Manual on removing and fitting the radio lid, the main board assembly, and standard and SMD components.

Figure 9.2 Positions of Q707 and R768 on the main board assembly



1. ON Semiconductor is a trademark of Semiconductor Components Industries, L.L.C.

9.2 Radio Programming

Programmable I/O Form

In the Digital tab of the Programmable I/O form, select the AUX_GPIO4 pin and set Direction to Output, Action to External Alert 1 or 2, Active to Low and Signal State to Momentary.

For further information on the External Alert action refer to "External Alert 1 and 2" on page 72.

Networks / Alerts Form

In the General and External Alerts tab of the Networks / Alerts form, configure the settings of the external alerts.

For further information on how to configure the Alerts form refer to the online help of the programming software.

9.3 Connecting the External Alert Device

Important While MOSFET Q707 is rated at 12 A (with heat sink), the maximum allowable current of the connector and radio's earthing system is 2 A. Therefore, a horn must not be connected directly to the radio. A horn relay must be used.

Connect the external alert device to pin 10 (AUX_GPIO4) and pin 8 (13V8_SW) of the auxiliary connector (or a different positive battery connection).