

# **T2000 Series II Service Manual**

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## About This Manual

**Scope** This manual contains general, technical and servicing information on T2000 Series II mobile two-way radios.

**Format** We have published this manual in a ring binder so that "revision packages" containing additional information can be added as required.

**Revision Packages** Revision packages will normally be published to coincide with the release of information on a new PCB, and may also contain additions or corrections pertaining to other parts of the manual.

If you return the customer registration card at the front of this manual, you will be notified when revision packages containing new PCB information and/or text are available. You may then order as many packages as you require from your local Tait Company. Revision packages are supplied ready-punched for inclusion in your manual.

**Revision Control** Each page in this manual has a date of issue. This is to comply with various Quality Standards, but will also serve to identify which pages have been updated and when. Each page and its publication date is listed in the "List of Effective Pages", and a new list containing any new/revised pages and their publication dates will be sent with each revision package.



Any portion of text that has been changed is marked by a vertical line (as shown at left) in the outer margin of the page. Where the removal of an entire paragraph means there is no text left to mark, an arrow (as shown at left) will appear in the outer margin. The number beside the arrow will indicate how many paragraphs have been deleted.

The manual issue and revision status are indicated by the last three digits of the manual product code. These digits start at 100 and will increment through 101, 102, 103, etc., as revision packages are published, e.g:

issue status 3 01 revision status

Thus, Issue 301 indicates the first revision to issue 3, and means that one package should have been added to the manual. The issue digit will only change if there is a major product revision, or if the number of revision packages to be included means that the manual becomes difficult to use, at which point a new issue manual will be published in a new ring binder.

**PCB Information** PCB information is provided for all current issue PCBs, as well as all previous issue PCBs manufactured in production quantities, and is grouped according to PCB. Thus, you will find the parts list, grid reference index (if necessary), PCB layouts and circuit diagram(s) for each individual PCB grouped together.

**Errors**

If you find an error in this manual, or have a suggestion on how it might be improved, please do not hesitate to contact the Technical Writer, Product Support Group, Tait Mobile Radio Division, Tait Electronics Ltd, P.O. Box 1645, Christchurch, New Zealand.

## Technical Information

Any enquiries regarding this manual or the equipment it describes should be addressed in the first instance to your nearest approved Tait Dealer or Service Centre. Further technical assistance may be obtained from the Product Support Group, Tait Mobile Radio Division, Tait Electronics Ltd, Christchurch, New Zealand.

## Updating Equipment And Manuals

In the interests of improving performance, reliability or servicing, Tait Electronics Ltd reserve the right to update their equipment and/or manuals without prior notice.

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Service Manuals should be ordered from your nearest Tait Branch or approved Dealer. When ordering, quote the Tait product code and, where applicable, the version.

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# 1 General Information

This Section introduces the T2000 Series II radio, describing models and features available and their performance.

The following topics are covered in this Section:

| Section    | Title                              | Page        |
|------------|------------------------------------|-------------|
| <b>1.1</b> | <b>Introduction</b>                | <b>1.2</b>  |
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## 1.1 Introduction

The T2000 Series II is a high performance mobile two way radio. It covers ten frequency bands between 66 and 870MHz, and is available in both trunked and conventional models.

Operation of the T2000 is by handheld microphone, a press-to-talk switch and a range of front panel function keys. The T2020 and T2040 models are fitted with an LCD display and alphanumeric keypad.

Most of the functions of the T2000 are microprocessor controlled. The system software is stored in a read only memory (ROM), while the data is stored in a non-volatile memory for ease of programming. Operational parameters can be programmed without opening the radio, via the front panel microphone socket.

The T2000 uses a synthesiser with a single VCO switched between transmit and receive. A plug-in TCXO PCB is used to provide a highly stable reference frequency, and dual point modulation gives a flat modulation response at the synthesiser.

The standard T2000 RF power output is 25W, except in the T2000-800 which delivers 15W. The receiver is electronically tuned across the entire frequency band and contains an IF noise blanker and RSSI facility. A maximum of 4W of audio is delivered to a 4 $\Omega$  speaker.

The RF and logic PCBs are shielded from each other in a diecast aluminium chassis, and are connected by two plug-in looms. The T2000 top and bottom covers are also diecast aluminium.

There is provision within the radio to mount option PCBs and a 9 or 15 way output connector which is used for options requiring connection to external equipment. Standard options include hands-free operation, line control interface, signalling and data transmission.

The DC supply to the radio must be negative earth and may be between 10.8 and 16V. The T2000 is protected against reversal of the DC supply and is provided with overvoltage protection.

If further information is required about the T2000 or this Manual, it may be obtained from Tait Electronics Ltd or accredited agents. When requesting this information, please quote the equipment product code (e.g. T2010-512-002) and serial number. In the case of the Service Manual, quote the product code (e.g. M2000-00-300), and for circuit diagrams quote the 'Title', 'Internal Part Number' (IPN) and 'Issue'.

## 1.2 Specifications

### 1.2.1 Introduction

The performance figures given are typical figures, unless otherwise indicated, for equipment operating at standard room temperature. Where applicable, the test methods used to obtain the following performance figures are those described in the European specification ETS 300-086.

Details of test methods and the conditions which apply for type approval testing in all countries can be obtained from Tait Electronics Ltd.

### 1.2.2 General

|                      |                       |
|----------------------|-----------------------|
| Modulation Type      | .. FM                 |
| Frequency Ranges:    |                       |
| T2000-100            | .. 220 to 270MHz      |
| T2000-200            | .. 66 to 88MHz        |
| T2000-300            | .. 136 to 174MHz      |
| T2000-400            | .. 175 to 225MHz      |
| T2000-500            | .. 400 to 470MHz      |
| T2000-600            | .. 450 to 520MHz      |
| T2000-700            | .. 330 to 360MHz      |
| T2000-800            | .. 800 to 870MHz (Tx) |
|                      | .. 851 to 870MHz (Rx) |
| T2000-900            | .. 360 to 400MHz      |
| T2000-000            | .. 500 to 530MHz      |
| Frequency Increment: |                       |
| All Except T2000-800 | .. 5 or 6.25kHz       |
| T2000-800            | .. 12.5kHz            |
| Number Of Channels:  |                       |
| T2010                | .. 4                  |
| T2015                | .. 24                 |
| T2020                | .. 100                |
| Bandwidth            | .. 7.5, 12 or 15kHz   |
| Switching Range:     |                       |
| T2000-200            | .. 22MHz              |
| T2000-300            | .. 38MHz              |
| T2000-400, T2000-100 | .. 50MHz              |
| T2000-500, T2000-600 | .. 70MHz              |
| T2000-700            | .. 30MHz              |
| T2000-800            | .. 70MHz (Tx)         |
|                      | .. 19MHz (Rx)         |
| T2000-900            | .. 40MHz              |

## Tx/Rx Offset:

|                      |               |
|----------------------|---------------|
| T2000-200            | .. 0 to 22MHz |
| T2000-300            | .. 0 to 38MHz |
| T2000-400, T2000-100 | .. 0 to 50MHz |
| T2000-500, T2000-600 | .. 0 to 70MHz |
| T2000-700            | .. 0 to 30MHz |
| T2000-800            | .. 0 to 45MHz |
| T2000-900            | .. 0 to 40MHz |

## Supply Voltage:

|                                   |                                                                    |
|-----------------------------------|--------------------------------------------------------------------|
| Operating Range                   | .. 10.8V to 16V DC                                                 |
| Standard Test Voltage             | .. 13.8V DC                                                        |
| Polarity                          | .. negative earth                                                  |
| Polarity & Overvoltage Protection | .. internal transorb crowbar                                       |
| Brown-out Recovery                | .. <2s to full operation following supply fluctuations below 10.8V |

## Supply Current:

|              |                                                                   |
|--------------|-------------------------------------------------------------------|
| Economy Mode | .. <270mA (T201X/T203X/T2060) or<br>.. <350mA (T2020/T2040/T2050) |
|--------------|-------------------------------------------------------------------|

## Receiver:

|           |                                                                 |
|-----------|-----------------------------------------------------------------|
| Squelched | .. 320mA (T201X/T203X/T2060) or<br>.. 472mA (T2020/T2040/T2050) |
|-----------|-----------------------------------------------------------------|

## Full Audio

.. 1.2A

## Transmit:

|                             |         |
|-----------------------------|---------|
| T2000-200, -300, -400, -800 | .. 6A   |
| T2000-500                   | .. 6.8A |
| T2000-600                   | .. 7A   |
| T2000-100, -700, -900       | .. 6.8A |
| T2000-000                   | .. 7.5A |

## Tx/Rx Changeover Switching

.. solid state

## Operating Temperature Range

.. -30°C to +60°C ambient

## Programming

.. clone or PC program via mic. socket

## Antenna:

|           |                                          |
|-----------|------------------------------------------|
| Impedance | .. 50Ω (nominal)                         |
| Connector | .. BNC (UHF optional on VHF radios only) |

## Power/Speaker Connector

.. 7 way automotive type

## Options Connector

.. 9 or 15 way high density D-range  
(optional)

## Radio Unit Dimensions:

|        |          |
|--------|----------|
| Depth  | .. 150mm |
| Width  | .. 150mm |
| Height | .. 45mm  |

## Front Panel Dimensions:

|        |          |
|--------|----------|
| Depth  | .. 25mm  |
| Width  | .. 158mm |
| Height | .. 51mm  |

## Remote Control Head Dimensions:

|                               |          |
|-------------------------------|----------|
| Length                        | .. 26mm  |
| Width                         | .. 159mm |
| Height                        | .. 51mm  |
| Weight (radio & control head) | .. 1.2kg |

### 1.2.3 Receiver Performance

## Type:

|                      |                                      |
|----------------------|--------------------------------------|
| All Except T2000-200 | .. triple conversion superheterodyne |
| T2000-200            | .. dual conversion superheterodyne   |

## Sensitivity:

|                           |                        |
|---------------------------|------------------------|
| 12dB Sinad                | .. better than -117dBm |
| 20dB Sinad (psophometric) | .. better than -113dBm |
| 20dB Quieting             | .. better than -113dBm |

## IF Amplifiers:

## Frequencies:

|                                   |                                |
|-----------------------------------|--------------------------------|
| T2000-200                         | .. 10.7MHz and 455kHz          |
| T2000-100, -300, -400             | .. 27.7MHz, 10.7MHz and 455kHz |
| T2000-500, -600, -700, -900, -000 | .. 49.1MHz, 10.7MHz and 455kHz |
| T2000-800                         | .. 61.9MHz, 10.7MHz and 455kHz |

## First Local Oscillator Injection (with respect to signal):

|                                                     |              |
|-----------------------------------------------------|--------------|
| T2000-200, -300                                     | .. high side |
| T2000-100, -400, -500, -600, -700, -800, -900, -000 | .. low side  |

## Second Local Oscillator Injection (with respect to signal):

|                                               |              |
|-----------------------------------------------|--------------|
| T2000-100, -300, -400                         | .. high side |
| T2000-200, -500, -600, -700, -800, -900, -000 | .. low side  |

## Third Local Oscillator Injection (with respect to signal):

|                                         |             |
|-----------------------------------------|-------------|
| T2000-100, -300, -400                   | .. low side |
| T2000-500, -600, -700, -800, -900, -000 | .. low side |

## Bandwidth:

|             |           |
|-------------|-----------|
| Narrow Band | .. 7.5kHz |
| Medium Band | .. 12kHz  |
| Wide Band   | .. 15kHz  |

## Signal-to-Noise Ratio (with respect to 100% deviation, at RF level of -47dBm):

|                      |         |
|----------------------|---------|
| Narrow Band          | .. 45dB |
| Medium Band          | .. 48dB |
| Wide Band            |         |
| All Except T2000-800 | .. 50dB |
| T2000-800            | .. 45dB |

## Audio:

|                               |                                                                |
|-------------------------------|----------------------------------------------------------------|
| Minimum Load Impedance        | .. $2\Omega$                                                   |
| Rated Power (into $4\Omega$ ) | .. 4W (at 1kHz)                                                |
| Distortion:                   |                                                                |
| @ Rated Power (1kHz)          | .. <5%                                                         |
| @ 0.5W (0.3 to 3.0kHz)        | .. <3% (narrow band)<br><2.5% (medium band)<br><2% (wide band) |
| Response                      | .. within +1, -3dB of 6dB/octave<br>de-emphasis                |
| Bandwidth                     | .. 300Hz to 3kHz                                               |

Selectivity .. better than 70dB

## Spurious Response Attenuation

|                            |                    |
|----------------------------|--------------------|
| All Except T2000-000, -800 | .. 75dB (80dB EIA) |
| T2000-000                  | .. 60dB            |
| T2000-800                  | .. 70dB (70dB EIA) |

Intermodulation Response Attenuation .. 66dB (75dB EIA)

Spurious Emissions  
(conducted & radiated to 1GHz) .. better than -57dBm

Spurious Emissions  
(conducted & radiated 1 to 4GHz) .. better than -47dBm

Blocking .. better than -23dBm

## Co-channel Rejection:

|             |                    |
|-------------|--------------------|
| Narrow Band | .. better than 9dB |
| Medium Band | .. better than 7dB |
| Wide Band   | .. better than 6dB |

Group Delay ..  $\pm 50\mu\text{s}$  (300Hz to 3kHz)

## Squelch:

|              |               |
|--------------|---------------|
| Preset Level | .. 11dB sinad |
| Ratio        | .. >70dB      |

Voting Levels .. >20dB sinad  
(applies to T2020 only)

## 1.2.4 Transmitter Performance

### Power Output:

#### Maximum:

|                      |        |
|----------------------|--------|
| All Except T2000-800 | .. 30W |
| T2000-8000           | .. 25W |

#### High (high setting):

|                      |        |
|----------------------|--------|
| All Except T2000-800 | .. 25W |
| T2000-8000           | .. 15W |

#### Low (low setting):

|                                   |             |
|-----------------------------------|-------------|
| T2000-200, -300, -400             | .. 1 to 25W |
| T2000-100, -500, -600, -700, -900 | .. 5 to 25W |
| T2000-800                         | .. 5 to 15W |

#### Low Power Version

.. 1 to 7W (T2000-500, -600)

### Duty Cycle (33%)

.. 2 minutes Tx, 4 minutes Rx

### Lock Up Time (synthesiser)

.. 25ms (from PTT to 90% output power within 2kHz, not including micro. delay)

### Spurious Emissions (conducted & radiated to 1GHz)

.. better than -36dBm

### Spurious Emissions (conducted & radiated to 1 to 4GHz)

.. better than -30dBm

### Adjacent Channel Power:

|             |                       |
|-------------|-----------------------|
| Narrow Band | .. better than -65dBc |
| Medium Band | .. -70dBc             |
| Wide Band   | .. -80dBc             |

### Group Delay

.. +200/-50 $\mu$ s (300Hz to 3kHz)

### Modulation System:

Type .. direct FM

#### Deviation Limiting:

|             |                              |
|-------------|------------------------------|
| Narrow Band | .. $\pm 2.5$ kHz (peak) max. |
| Medium Band | .. $\pm 4$ kHz (peak) max.   |
| Wide Band   | .. $\pm 5$ kHz (peak) max.   |

#### Bandwidth:

|                    |                                                                       |
|--------------------|-----------------------------------------------------------------------|
| Narrow Band        | .. 300Hz to 2.55kHz below limiting or<br>450Hz to 2.55kHz in limiting |
| Medium & Wide Band | .. 300Hz to 3kHz below limiting or<br>450Hz to 3kHz in limiting       |

### Responses:

|                |                                                  |
|----------------|--------------------------------------------------|
| In Limiting    | .. within +0dB, -4dB of maximum system deviation |
| Below Limiting | .. within +1, -3dB of 6dB/octave pre-emphasis    |
| Above 3kHz     | .. greater than 25dB/octave roll-off             |

**Audio:**

Microphone Type .. dynamic or electret  
 Input For 60% Deviation .. 1.5mVrms maximum (at 1kHz)

Distortion .. 5%

**Hum & Noise:**

All Except T2000-800:  
     Narrow Band .. 39dB  
     Medium Band .. 43dB  
     Wide Band .. 45dB  
 T2000-800:  
     Wide Band .. 40dB

**Mismatch Capability:**

Ruggedness .. 2 minutes transmission into infinite VSWR  
 Stability .. VSWR 5:1 (all phase angles)

Transmit Timer (non-trunking models) .. programmable up to 4 minutes, or continuous.

**1.2.5 Frequency Reference**

Oscillator Frequency .. 12.8MHz

Crystal Stability And Source Details .. see table below:

| Product Code | Frequency Tolerance (ppm) | Temperature Range (°C) | Frequency Source                |
|--------------|---------------------------|------------------------|---------------------------------|
| T2XX-XX1     | ±5                        | -10 to +60             | TE/45 xtal                      |
| T2XX-XX3*    | ±3                        | -30 to +60             | VXO-2605A Module                |
| T2XX-XX5     | ±2.5                      | -30 to +60             | VXO-2605A-1 Module <sup>†</sup> |
| T2XX-XX6     | ±2.0                      | -30 to +60             | TDC 60281 Module <sup>†</sup>   |

\*. Not fitted to T2000-200 due to low modulatability.

†. Fitted only to 400MHz versions and above, due to low modulatability.

## 1.2.6 Trunking

### 1.2.6.1 T2030, T2035, T2040 & T2050 Models

Data Modulation .. as per MPT1317

Data Deviation (Tx: 60% full system deviation):

|             |           |
|-------------|-----------|
| Narrow Band | .. 1.5kHz |
| Medium Band | .. 2.4kHz |
| Wide Band   | .. 3kHz   |

### 1.2.6.2 T2060 Model

System .. LTR<sup>®</sup> trunked<sup>1</sup>, systems x groups = 24

Data Deviation (Tx) .. 1kHz

## 1.3 Operating Instructions

Refer to the User's Guide supplied with the radio. These are also available separately under the following IPNs:

|             |              |
|-------------|--------------|
| T2010/T2015 | 459-20100-0X |
| T2020       | 459-20200-0X |
| T2030/T2035 | 459-20300-0X |
| T2040       | 459-20400-0X |
| T2060       | 459-20600-0X |

Comprehensive Operator's Manuals are also available for T2020 and T2040 radios. These Manuals cover such topics as advanced user operations and the use of trunked radios for data applications. These are available under the following IPNs:

|       |              |
|-------|--------------|
| T2020 | 409-20200-0X |
| T2040 | 409-20400-0X |

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1. LTR<sup>®</sup> is a trademark of E F Johnson & Co.

## 1.4 Product Codes

The 3 groups of digits in a T2000 product code provide information about the radio's model, RF type and options fitted, according to the conventions described below.

The following explanation of the T2000 product codes is not intended to suggest that any combination of features is necessarily available in any one radio. For details regarding availability of specific T2000 radios, consult your nearest Tait dealer or subsidiary.

### Model

The Model group indicates the basic features of the radio, as follows:

|                      |       |                                          |                      |
|----------------------|-------|------------------------------------------|----------------------|
| <b>T20XX-XXX-XXX</b> | T2010 | 4 channels                               |                      |
|                      | T2015 | 24 channels                              |                      |
|                      | T2020 | 100 channels                             |                      |
|                      | T2030 | 4 calls, all preset                      | trunked              |
|                      | T2035 | 1000 calls, including 20 preset          | trunked              |
|                      | T2040 | dialled calls                            | trunked              |
|                      | T2050 | dual mode T2040 or T2020 operation       | trunked, non-trunked |
|                      | T2060 | LTR <sup>®</sup> , systems x groups = 24 | trunked              |

### RF Type

RF Type group uses 3 digits to indicate the basic RF configuration of the radio.

The first digit in the RF Type group designates frequency band.

|                             |                                                         |
|-----------------------------|---------------------------------------------------------|
| <b>T20XX-<u>X</u>XX-XXX</b> | '1' for 220 to 270MHz                                   |
|                             | '2' for 66 to 88MHz                                     |
|                             | '3' for 136 to 174MHz                                   |
|                             | '4' for 175 to 225MHz                                   |
|                             | '5' for 400 to 470MHz                                   |
|                             | '6' for 450 to 520MHz                                   |
|                             | '7' for 330 to 360MHz                                   |
|                             | '8' for 800 to 870MHz transmit<br>851 to 870MHz receive |
|                             | '9' for 360 to 400MHz                                   |
|                             | '0' for 500 to 530MHz                                   |

The second digit in the RF Type group designates radio IF bandwidth.

|                             |                               |
|-----------------------------|-------------------------------|
| <b>T20XX-X<u>X</u>X-XXX</b> | '1' for wide band (15kHz)     |
|                             | '2' for narrow band (7.5kHz)  |
|                             | '3' for medium band (12.5kHz) |

The third digit in the RF Type group designates frequency stability.

|                             |                                             |
|-----------------------------|---------------------------------------------|
| <b>T20XX-XX<u>X</u>-XXX</b> | refer to "Frequency Reference" on page 1.8. |
|-----------------------------|---------------------------------------------|

### Options

|                             |                                                                                                                                                                           |
|-----------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>T20XX-XXX-<u>XXX</u></b> | The third group of digits covers a wide range of software and market specific options. The large number of options and their frequent changes preclude listing them here. |
|-----------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

## 2 Circuit Description

This Section describes the operation of the basic circuit blocks found in the T2000 radio. Refer also to the circuit diagrams in Section 7 of this Manual.

The following topics are covered in this Section:

| Section     | Title                                                          | Page        |
|-------------|----------------------------------------------------------------|-------------|
| <b>2.1</b>  | <b>Design Overview</b>                                         | <b>2.2</b>  |
| <b>2.2</b>  | <b>Synthesiser</b>                                             | <b>2.3</b>  |
| <b>2.3</b>  | <b>Audio &amp; Regulators</b>                                  | <b>2.4</b>  |
| <b>2.4</b>  | <b>TCXO/TX Audio PCB</b>                                       | <b>2.4</b>  |
| <b>2.5</b>  | <b>IF PCB</b>                                                  | <b>2.5</b>  |
| <b>2.6</b>  | <b>T2000-100 &amp; -400 RF PCB</b>                             | <b>2.6</b>  |
| 2.6.1       | T2000-100 & -400 Receiver                                      | 2.6         |
| 2.6.2       | T2000-100 & -400 Exciter                                       | 2.7         |
| 2.6.3       | T2000-100 & -400 Power Amplifier                               | 2.7         |
| <b>2.7</b>  | <b>T2000-200 RF PCB</b>                                        | <b>2.8</b>  |
| 2.7.1       | T2000-200 Receiver                                             | 2.8         |
| 2.7.2       | T2000-200 Exciter                                              | 2.9         |
| 2.7.3       | T2000-200 Power Amplifier                                      | 2.9         |
| <b>2.8</b>  | <b>T2000-300 RF PCB</b>                                        | <b>2.10</b> |
| 2.8.1       | T2000-300 Receiver                                             | 2.10        |
| 2.8.2       | T2000-300 Exciter                                              | 2.11        |
| 2.8.3       | T2000-300 Power Amplifier                                      | 2.11        |
| <b>2.9</b>  | <b>T2000-500, T2000-600, T2000-700, -900 &amp; -000 RF PCB</b> | <b>2.12</b> |
| 2.9.1       | T2000-500, -600, -700, -900 & -000 Receiver                    | 2.12        |
| 2.9.2       | T2000-500, -600, -700 -900 & -000 Exciter                      | 2.13        |
| 2.9.3       | T2000-500, -600, -700, -900 & -000 Power Amplifier             | 2.13        |
| <b>2.10</b> | <b>T2000-800 RF PCB</b>                                        | <b>2.14</b> |
| 2.10.1      | T2000-800 Receiver                                             | 2.14        |
| 2.10.2      | T2000-800 Exciter                                              | 2.15        |
| 2.10.2      | T2000-800 Power Amplifier                                      | 2.15        |
| <b>2.11</b> | <b>Control Module</b>                                          | <b>2.16</b> |
| 2.11.1      | T2010 & T2015 HC05 Logic PCB                                   | 2.16        |
| 2.11.2      | T2020, T203X, T2040, T2050 & T2060 HC11 Logic PCB              | 2.19        |

## 2.1 Design Overview

The T2000 radio is made up of two modules, the RF module and the control module. The RF module consists of an RF PCB unique to each frequency band with common plug-in IF and TCXO/Tx audio PCBs, determining the frequency stability and reference frequency. The control module consists of a logic PCB and a control head PCB. Each control module is unique to each T2000 model, i.e. T2010, T2015, T2020, T203X, T2040 or T2050.

The following circuit blocks are located in the RF module:

- The synthesiser, containing the
  - Tx/Rx VCO
  - plug-in TCXO and Tx audio PCB
  - Tx/Rx switching.
- The regulators and audio power amplifier.
- The receiver, containing the
  - front end
  - mixer
  - noise blanker
  - mute circuit
  - RSSI
  - plug-in IF PCB.
- The exciter, RF power amplifier and power control circuit.

The following circuit blocks are located in the control module:

- The microprocessor control circuitry.
- Audio processing.
- Control head.
- Options connectors (refer to Section 5.9, “Options Interface Specifications”).

## 2.2 Synthesiser

Synthesiser IC201 (MC145158) receives channel and reference frequency information from the microprocessor via a three line serial interface:

- DATA - synthesiser data: A counter: 7 bits  
M counter: 10 bits  
Ref. counter: 14 bits
- CLK - synthesiser clock
- ENABLE - synthesiser latch.

Once the data has been latched in, the synthesiser IC processes the incoming signals;  $f_{in}$  from the prescaler IC and  $f_{ref}$  from the temperature compensated crystal oscillator (TCXO) operating at 12.8MHz. The TCXO signal is divided by the reference counter to provide 5kHz, 6.25kHz or 12.5kHz at the phase detector. IC201 generates the modulus control at the appropriate time to change the dividing factor for the prescaler. The phase detector outputs are summed and fed via the integrator to the control line. The VCO frequency increases with a positive change in control line voltage.

The synthesiser produces a signal called LCK-DET which is fed to the exciter after some processing to prevent transmission when the synthesiser is out of lock. The LCK-DET signal is also fed to the I/O bus of the control circuitry, where the signal is used for features such as scanning. The time lapse between the synthesiser latch pulse and the lock detect line going low is typically 15ms (maximum is 20ms).

The T2000 uses a dual point modulation system which allows the radio to be modulated at frequencies below the loop filter cut-off frequency (approximately 400Hz). In this system, modulation is supplied to both the VCO and TCXO. When both the reference and VCO are modulated below the cut-off frequency of the loop filter, the phase detector cannot detect a difference between  $f_{in}$  and  $f_{ref}$  and will not generate corrective signals. The modulation bandwidth is therefore dependent only on the audio and coupling circuits.

## 2.3 Audio & Regulators

The nominal supply voltage of the T2000 is 13.8VDC but satisfactory operation is possible from supply voltages of between 10.8 and 16V. Power for the radio is switched via the volume control and switch on the control head.

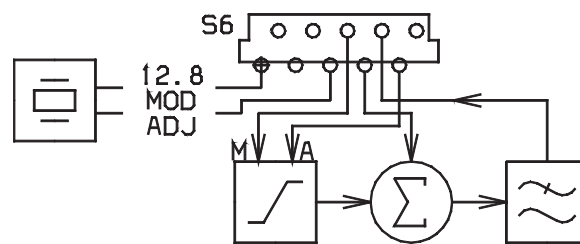
Overvoltage protection is provided in the form of an 18V zener diode. This will suppress transient spikes but prolonged overvoltage will cause the device to fail short circuit.

On the RF PCB, two regulated power supply rails of 8V and 5V are provided as well as a 30V supply from an inverter. The 30V supply is used to feed the synthesiser loop filter and the receiver front end tuning. A switched 8V line is used to enable the transmitter and disable the receiver.

13.8V is applied directly to the RF and audio power amplifiers, with the audio power amplifier rated for a standard output of 4Wrms into 4 $\Omega$ , at a nominal supply voltage of 13.8V.

## 2.4 TCXO/TX Audio PCB

The TCXO/Tx audio PCB provides the temperature compensated 12.8MHz reference frequency for the synthesiser and a times-three multiplier in the receiver. The PCB also contains the Tx audio limiter, deviation level potentiometer and low pass filter. The TCXO fine frequency adjustment is provided by a ten turn potentiometer. Narrow or wide band deviation and TCXO frequency stability with temperature are determined solely by this PCB.



**Figure 2.1 T2000 TCXO/TX Audio PCB Block Diagram**

## 2.5 IF PCB

The 10.7MHz signal from the RF PCB feeds Q104, passes through a crystal filter (X101) and is amplified by Q111 and Q112 before passing through a 10.7MHz ceramic filter to a mixer/oscillator (Q113). This 455kHz mixer output is further filtered and amplified by CF102, CF103 and Q114, then passes back to the RF PCB where it is demodulated by IC101. The RSSI function is internal to IC101.

The demodulated signal is filtered and compensated on the IF PCB before passing to the logic PCB via the RF PCB. Narrow band or wide band response is determined solely by the IF PCB.

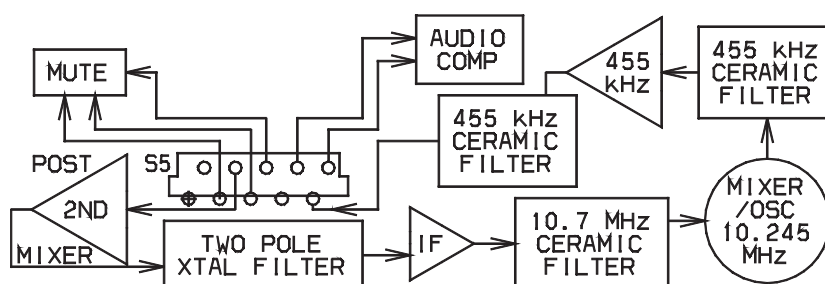


Figure 2.2 T2000 IF PCB Block Diagram

The processed transmit audio passes to the RF PCB where it is split into a VCO modulation path and a TCXO modulation path. The TCXO path passes through a potentiometer to enable the dual point modulation to be correctly adjusted, and then returns to the TCXO/Tx audio PCB.

## 2.6 T2000-100 & -400 RF PCB

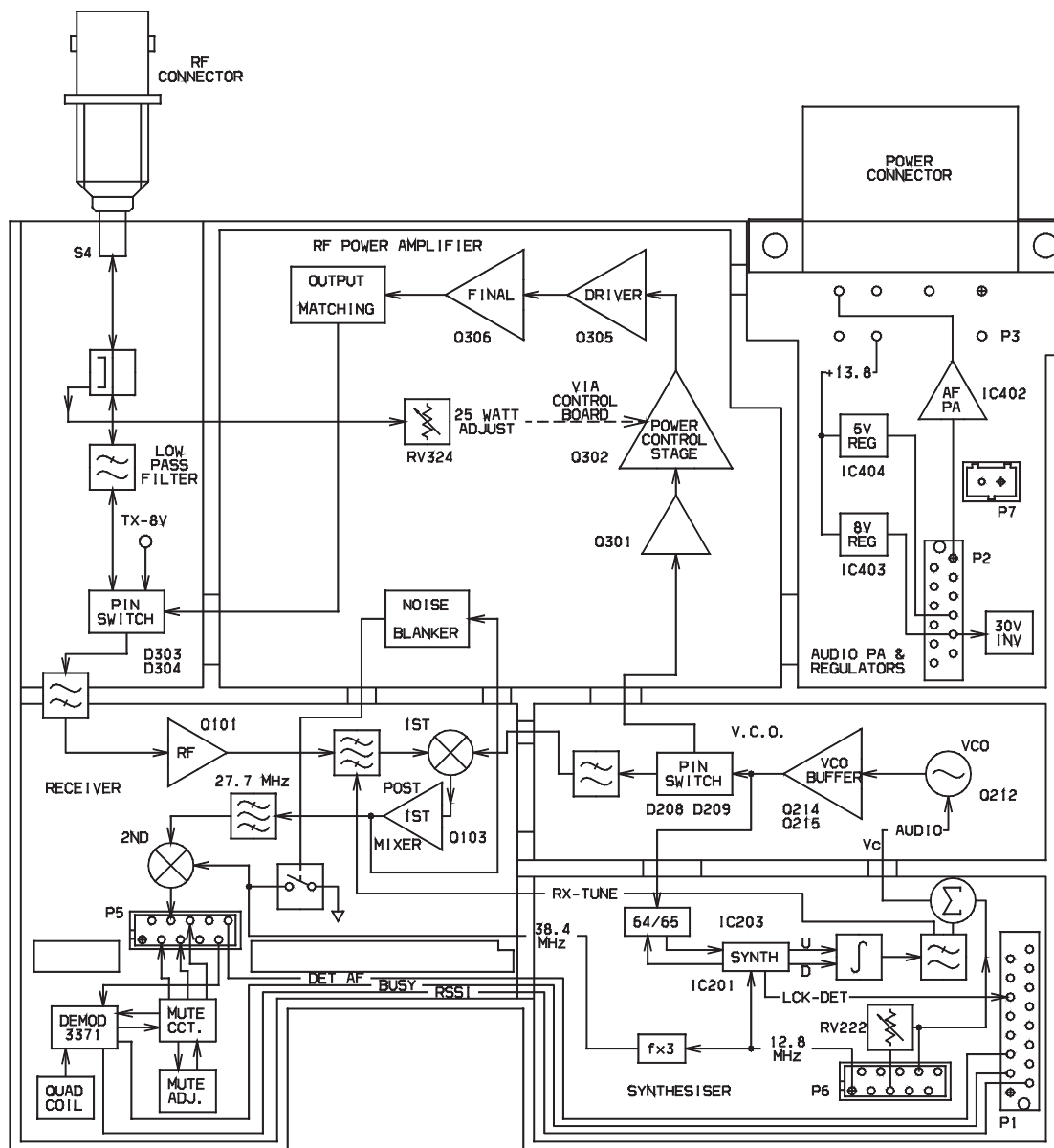


Figure 2.3 T2000-100 & -400 RF PCB Block Diagram

### 2.6.1 T2000-100 & -400 Receiver

The incoming signal from the antenna via the PIN switch passes through a high pass filter to the RF amplifier, Q101. The 50Ω output from the amplifier is coupled to a varicap tuned triplet which provides the spurious response rejection necessary for the first mixer. An attenuator is provided at the output to allow for fine adjustment of the front end gain.

The VCO output is fed to the first double balanced mixer via a low pass filter to reduce harmonic content. The VCO signal is 27.7MHz below the RF signal and the first mixer output (at 27.7MHz) feeds the first post-mixer buffer, Q103. The output of Q103 feeds both a delay line and the noise blanker circuit.

L114 and L116 form a  $50\Omega$  delay line which provides the spurious response rejection necessary for the second mixer. L114 and L116 also provide the delay necessary for the noise blanker to detect and clamp noise pulses. The local oscillator signal of 38.4MHz for the second double balanced mixer is provided by the 12.8MHz reference via a tripler circuit, and the 10.7MHz output feeds the plug-in IF PCB. Each sub-block within the front end has been designed with  $50\Omega$  terminations for ease of testing and fault finding.

## 2.6.2 T2000-100 & -400 Exciter

The VCO output from the PIN switch is amplified to 900mW by a two stage broad band exciter (Q301 and Q302) with approximately 22dB of gain. Q301 is operating into compression to prevent changes in VCO drive affecting output power.

This output power is controlled by varying the collector voltage on Q302, via Q303, Q304 and the feedback loop from the PA. The power settings (maximum, high and low) are under microprocessor control and are set for each channel by programming.

R308, R309, R310 and R313 form a 2dB attenuator, reducing the output to approximately 550mW and also providing good isolation between the exciter and PA.

## 2.6.3 T2000-100 & -400 Power Amplifier

The 550mW exciter output is amplified to 30W by Q305 and Q306. Q305 has a small amount of bias applied (via R319, D302, R322 and R315) to provide stability at low power levels.

The T2000-100 power amplifier has no tuning, and when the output power is set to 25W the variation across the 50MHz switching range should be less than  $\pm 2W$ .

The high level RF signal passes via the Tx/Rx PIN switch, the low pass filter and directional coupler to the antenna connector. The power level is sensed by D301 on the directional coupler and this voltage is fed back to the power control operational amplifier via RV324. RV324 on the RF PCB sets the high power and RV507 on the logic PCB will adjust the low power.

## 2.7 T2000-200 RF PCB

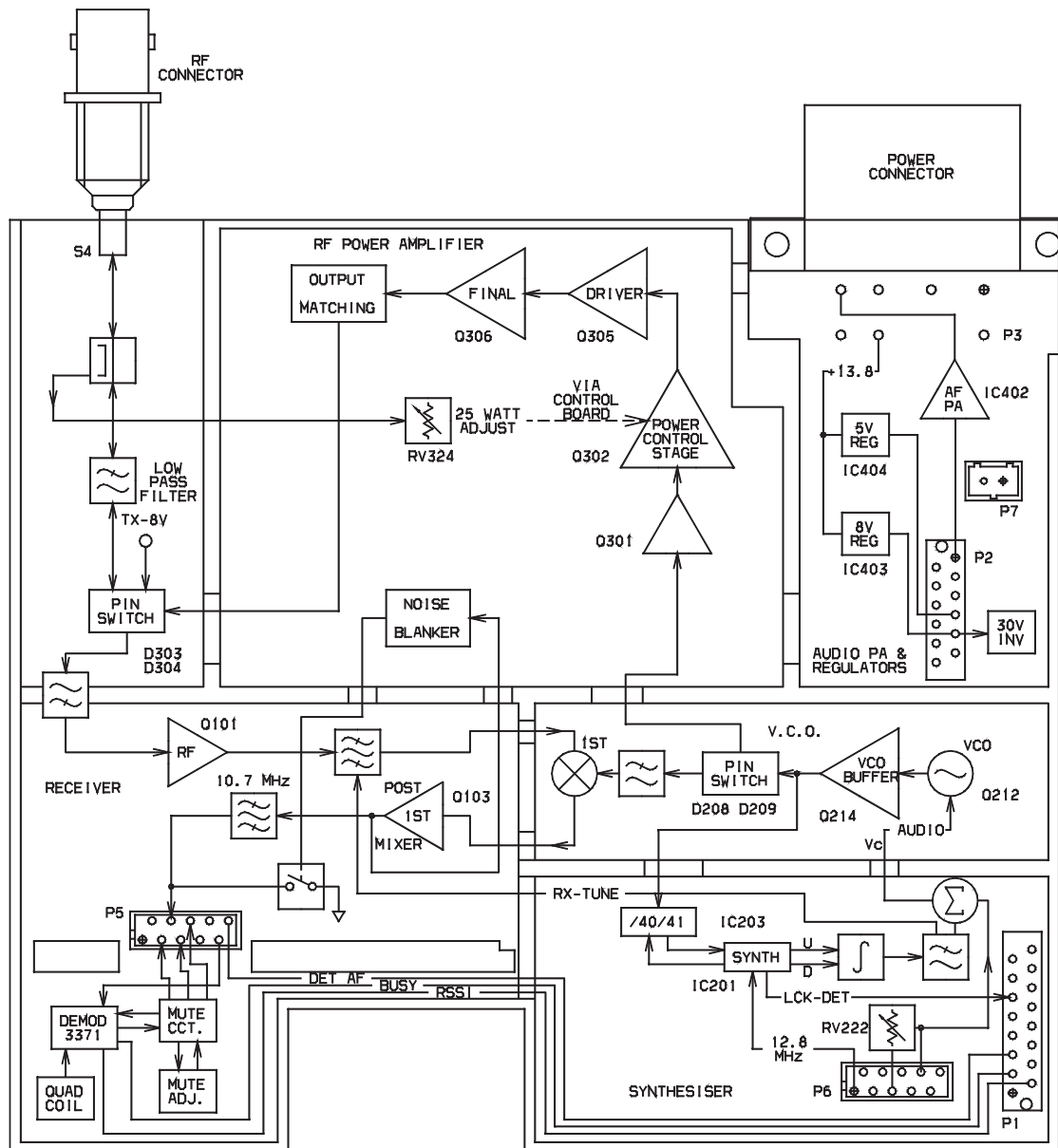


Figure 2.4 T2000-200 RF PCB Block Diagram

### 2.7.1 T2000-200 Receiver

The incoming signal from the antenna via the PIN switch passes through a high pass filter to the RF amplifier, Q101. The 50Ω output from the amplifier is coupled to a varicap tuned triplet that provides the spurious response rejection necessary for the first mixer. An attenuator is provided at the output to allow for fine adjustment of the front end gain.

The VCO output is fed to the first double balanced mixer via a low pass filter to reduce harmonic content. The VCO signal is 10.7MHz above the RF signal and the first mixer output (at 10.7MHz) feeds the first post-mixer buffer, Q103. The output of Q103 feeds both a delay line and the noise blanker circuit.

L114 and L116 form a  $50\Omega$  delay line that provides the delay necessary for the noise blanker to detect and clamp noise pulses and also provides a high impedance point for the signal to be clamped.

The 10.7MHz output feeds the plug-in IF PCB through R128, R129 and R132 which provide the attenuation equivalent to the second mixer of the T2000-300, T2000-400, T2000-500 or T2000-600.

Each sub-block within the front end has been designed with  $50\Omega$  terminations for ease of testing and fault finding.

### 2.7.2 T2000-200 Exciter

The VCO output from the PIN switch is amplified to 500mW by a two stage broad band exciter (Q301 and Q302) with approximately 21dB of gain. Q301 is operating into compression to prevent changes in VCO drive affecting output power. This output power is controlled by varying the collector voltage on Q302, via Q303, Q304 and the feedback loop from the PA. The power settings (maximum, high and low) are under microprocessor control and are set for each channel by programming. R308A, R308, R309 and R310 provide approximately 1dB of attenuation and isolation between the exciter and power amplifier.

### 2.7.3 T2000-200 Power Amplifier

The 500mW exciter output is amplified to 30W by Q305 and Q306. The T2000-200 power amplifier has no tuning, and when the output power is set to 25W the variation across the 22MHz switching range should be less than  $\pm 2W$ .

The high level RF signal passes via the Tx/Rx PIN switch, the low pass filter and the directional coupler to the antenna connector. The power level is sensed by D301 on the directional coupler and this voltage is fed back to the power control operational amplifier via RV324. RV324 on the RF PCB sets the high power and RV507 on the logic PCB will adjust the low power.

## 2.8 T2000-300 RF PCB

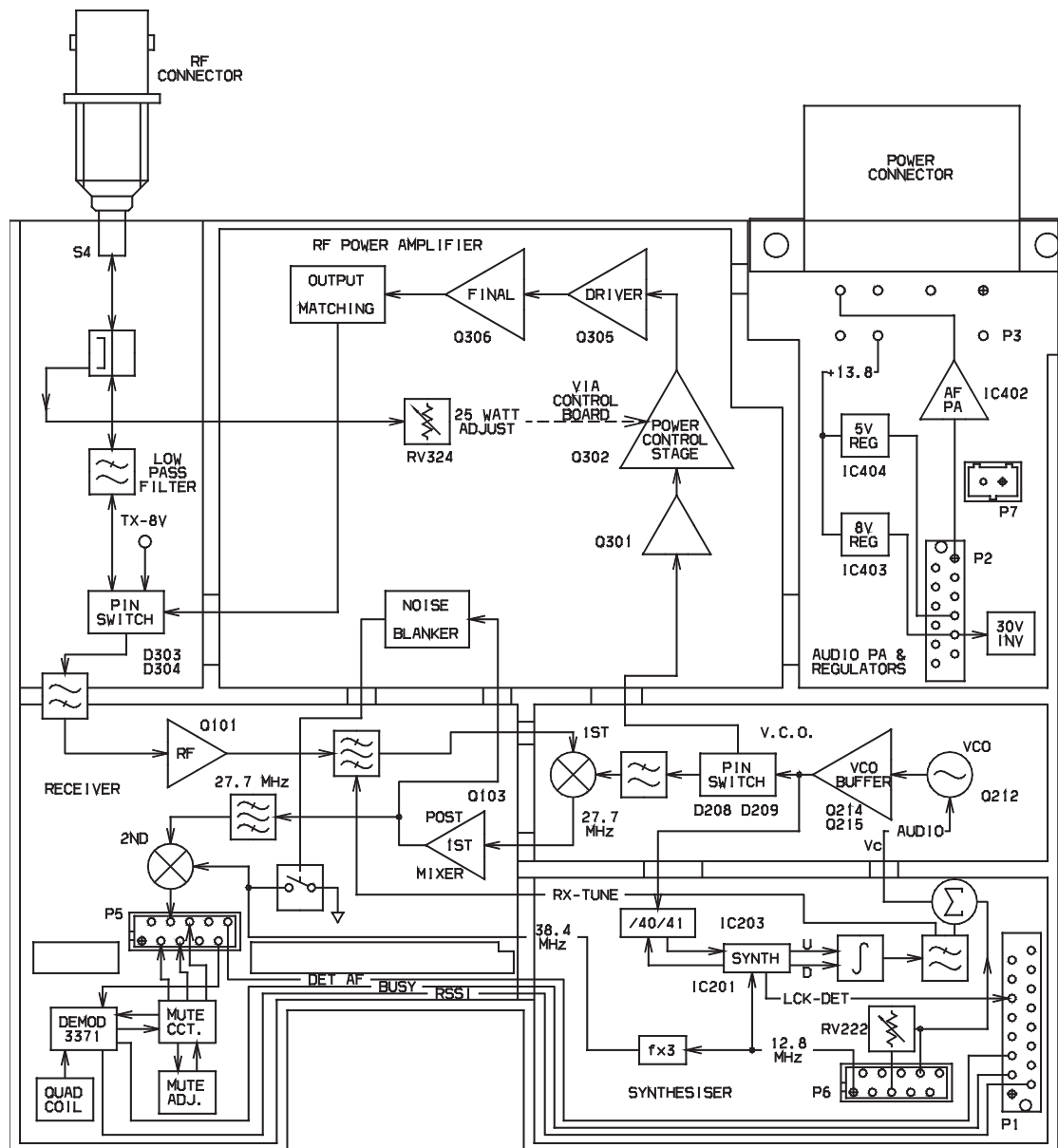


Figure 2.5 T2000-300 RF PCB Block Diagram

### 2.8.1 T2000-300 Receiver

The incoming signal from the antenna via the PIN switch passes through a high pass filter to the RF amplifier, Q101. The 50Ω output from the amplifier is coupled to a varicap tuned triplet which provides the spurious response rejection necessary for the first mixer. An attenuator is provided at the output to allow for fine adjustment of the front end gain.

The VCO output is fed to the first double balanced mixer via a low pass filter to reduce harmonic content. The VCO signal is 27.7MHz above the RF signal and the first mixer output (at 27.7MHz) feeds the first post-mixer buffer, Q103. The output of Q103 feeds both a delay line and the noise blanker circuit.

L114 and L116 form a  $50\Omega$  delay line which provides the spurious response rejection necessary for the second mixer. L114 and L116 also provide the delay necessary for the noise blanker to detect and clamp noise pulses. The local oscillator signal of 38.4MHz for the second double balanced mixer is provided by the 12.8MHz reference via a tripler circuit, and the 10.7MHz output feeds the plug-in IF PCB.

Each sub-block within the front end has been designed with  $50\Omega$  terminations for ease of testing and fault finding.

## 2.8.2 T2000-300 Exciter

The VCO output from the PIN switch is amplified to 1W by a two stage broad band exciter (Q301 and Q302) with approximately 22dB of gain. Q301 is operating into compression to prevent changes in VCO drive affecting output power.

This output power is controlled by varying the collector voltage on Q302, via Q303, Q304 and the feedback loop from the PA. The power settings (maximum, high and low) are under microprocessor control and are set for each channel by programming.

R308, R309, R310 and R313 form a 2.7dB attenuator, reducing the output to approximately 550mW and also providing good isolation between the exciter and PA.

## 2.8.3 T2000-300 Power Amplifier

The 550mW exciter output is amplified to 30W by Q305 and Q306. Q305 has a small amount of bias applied (via R319, D302, R322 and R315) to provide stability at low power levels.

The T2000-300 power amplifier has no tuning, and when the output power is set to 25W the variation across the 38MHz switching range should be less than  $\pm 2\text{W}$ .

The high level RF signal passes via the Tx/Rx PIN switch, the low pass filter and directional coupler to the antenna connector. The power level is sensed by D301 on the directional coupler and this voltage is fed back to the power control operational amplifier via RV324. RV324 on the RF PCB sets the high power and RV507 on the logic PCB will adjust the low power.

## 2.9 T2000-500, T2000-600, T2000-700, -900 & -000 RF PCB

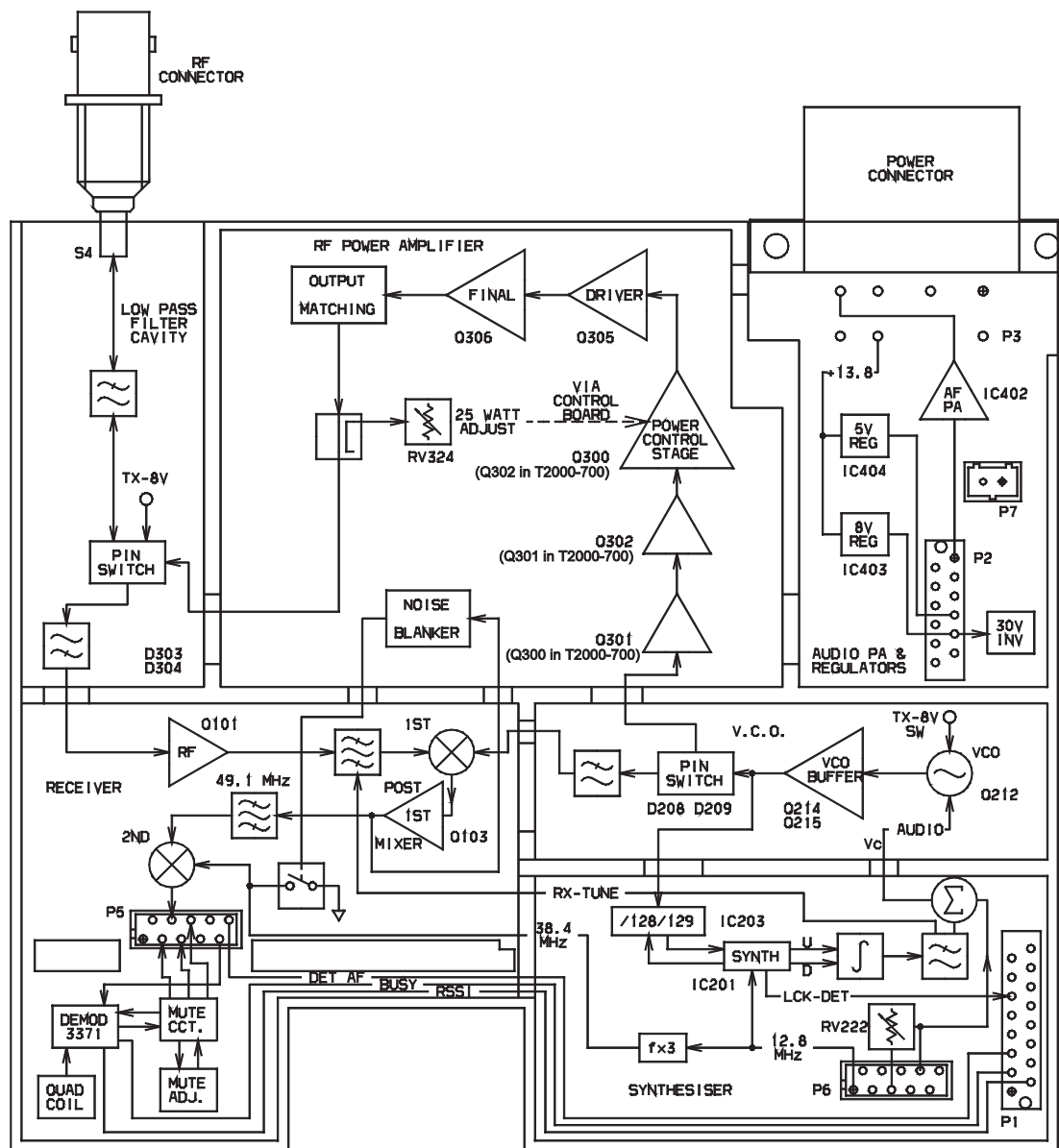


Figure 2.6 T2000-500, -600, -700, -900 & -000 RF PCB Block Diagram

### 2.9.1 T2000-500, -600, -700, -900 & -000 Receiver

The incoming signal from the antenna via the PIN switch passes through a high pass filter to the RF amplifier, Q101. The 50Ω output from the amplifier is coupled to a varicap tuned triplet which provides the spurious response rejection necessary for the first mixer. An attenuator is provided at the output to allow for fine adjustment of the front end gain.

The VCO output is fed to the first double balanced mixer via a low pass filter to reduce harmonic content. The VCO signal is 49.1MHz below the RF signal and the first mixer output (at 49.1MHz) feeds the first post-mixer buffer, Q103. The output of Q103 feeds both a delay line and the noise blanker circuit.

L114 and L116 form a 50 $\Omega$  delay line which provides the spurious response rejection necessary for the second mixer. L114 and L116 also provide the delay necessary for the noise blanker to detect and clamp noise pulses. The local oscillator signal of 38.4MHz for the second double balanced mixer is provided by the 12.8MHz reference via a tripler circuit, and the 10.7MHz output feeds the plug-in IF PCB. Each sub-block within the front end has been designed with 50 $\Omega$  terminations for ease of testing and fault finding.

### **2.9.2 T2000-500, -600, -700 -900 & -000 Exciter**

The VCO output from the PIN switch is amplified to 2W by a three stage broad band exciter (Q300, Q301 and Q302) with approximately 28dB of gain. The first stage (Q301 in the T2000-500/600, and Q300 in the T2000-700) operates into compression to prevent changes in VCO drive affecting output power.

This output power is controlled by varying the collector voltage on Q300, via Q303, Q304 and the feedback loop from the PA. The power settings (maximum, high and low) are under microprocessor control and are set for each channel by programming.

### **2.9.3 T2000-500, -600, -700, -900 & -000 Power Amplifier**

The 2W exciter output is amplified to 30W by Q305 and Q306. The T2000-500/600/700 power amplifier has no tuning, and when the output power is set to 25W the variation across the switching range should be less than  $\pm 2$ W.

The high level RF signal passes via the directional coupler, the Tx/Rx PIN switch and the low pass filter to the antenna connector. The power level is sensed by D301 on the directional coupler and this voltage is fed back to the power control operational amplifier via RV324. RV324 on the RF PCB sets the high power and RV507 on the logic PCB will adjust the low power.

## 2.10 T2000-800 RF PCB

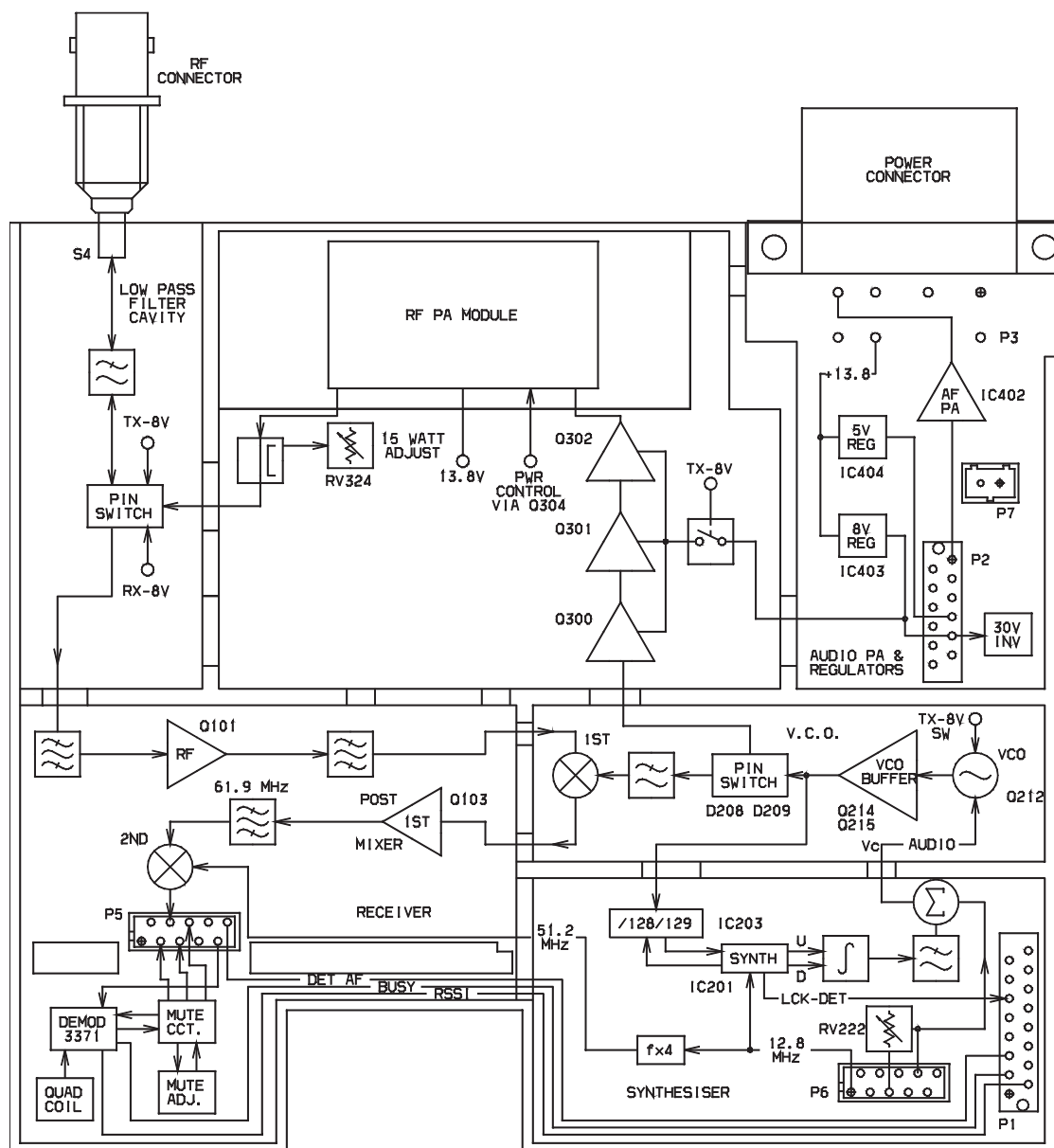


Figure 2.7 T2000-800 RF PCB Block Diagram

### 2.10.1 T2000-800 Receiver

The incoming signal from the antenna via the PIN switch passes through a band pass filter to the RF amplifier, Q101. The 50Ω output from the amplifier is coupled to a second band pass filter, and these two filters provide the spurious response rejection necessary for the first mixer. An attenuator is provided at the output to allow for fine adjustment of the front end gain.

The VCO output is fed to the first double balanced mixer via a low pass filter to reduce harmonic content. The VCO signal is 61.9MHz below the RF signal and the first mixer output (at 61.9MHz) feeds the first post-mixer buffer, Q103. The output of Q103 feeds a band pass filter.

L114 and L116 form a  $50\Omega$  band pass filter which provides the spurious response rejection necessary for the second mixer. The local oscillator signal of 51.2MHz for the second double balanced mixer is provided by the 12.8MHz reference via a times 4 multiplier circuit, and the 10.7MHz output feeds the plug-in IF PCB.

Each sub-block within the front end has been designed with  $50\Omega$  terminations for ease of testing and fault finding.

### 2.10.2 T2000-800 Exciter

The VCO output from the PIN switch is amplified to 0.5W by a three stage broad band exciter (Q300, Q301 and Q302) with approximately 21dB of gain. Q300 is operating into compression to prevent changes in VCO drive affecting output power.

This output power is controlled by varying the voltage on IC405 pin2, via Q303, Q304 and the feedback loop from the PA. The power settings (maximum, high and low) are under microprocessor control and are set for each channel by programming.

### 2.10.3 T2000-800 Power Amplifier

The 0.5W exciter output is amplified to 20W by IC405. The T2000-800 power amplifier has no tuning, and when the output power is set to 15W the variation across the 70MHz switching range should be less than  $\pm 1W$ .

The high level RF signal passes via the directional coupler, the Tx/Rx PIN switch and the low pass filter to the antenna connector. The power level is sensed by D301 on the directional coupler and this voltage is fed back to the power control operational amplifier via RV324. RV324 on the RF PCB sets the high power and RV507 on the logic PCB will adjust the low power.

## 2.11 Control Module

The primary task of the control section in the T2000 is to control the state of the radio at all times, based both on user input, and activity of the internal circuitry. To achieve this, the control section monitors the radio's operation and responds to any changes with various control signals.

The input shift registers are read by the microprocessor approximately 100 times per second. The output shift registers are updated only when a control signal is required to change, and the miscellaneous I/O is continually scanned.

In the majority of cases, a control output will change only in response to an input stimulus, e.g. a control head key being pressed, receiver busy, etc. Some outputs may be affected by more than one input or a sequence of events; this is particularly so in the case of the mute gate control line. Its operation may be affected by a number of external conditions and even some generated in the microprocessor.

For operation of the T2000 Series II control heads, refer to Figures 2.8 to 2.10.

### 2.11.1 T2010 & T2015 HC05 Logic PCB

Transmitter speech from the microphone is preamplified and fed into an automatic level control circuit which also has two mute facilities (one for options and one for the microprocessor). The speech is pre-emphasised and high pass filtered to reduce CTCSS components, then passes via the RF PCB to the limiter on the TCXO/Tx audio PCB.

DCS/CTCSS signals are generated by the microprocessor and are filtered by a low pass filter before being passed to the level potentiometer on the TCXO/Tx audio PCB. A five tone Selcall module is available which is directly interfaced to the microprocessor. Selcall tones are fed to the limiter on the TCXO/Tx audio PCB.

Receiver audio from the IF PCB passes through a low pass filter where it is split into signalling and speech paths. Five tone signals are coupled to the five tone module. DCS/CTCSS passes through a low pass filter and limiter before arriving at the microprocessor. Speech is de-emphasised and passed through one or two high pass filters, depending on the signalling used. Processed speech passes through the mute to an amplifier where speech and progress tones are summed. The signal then passes via the volume control to the audio power amplifier on the RF PCB.

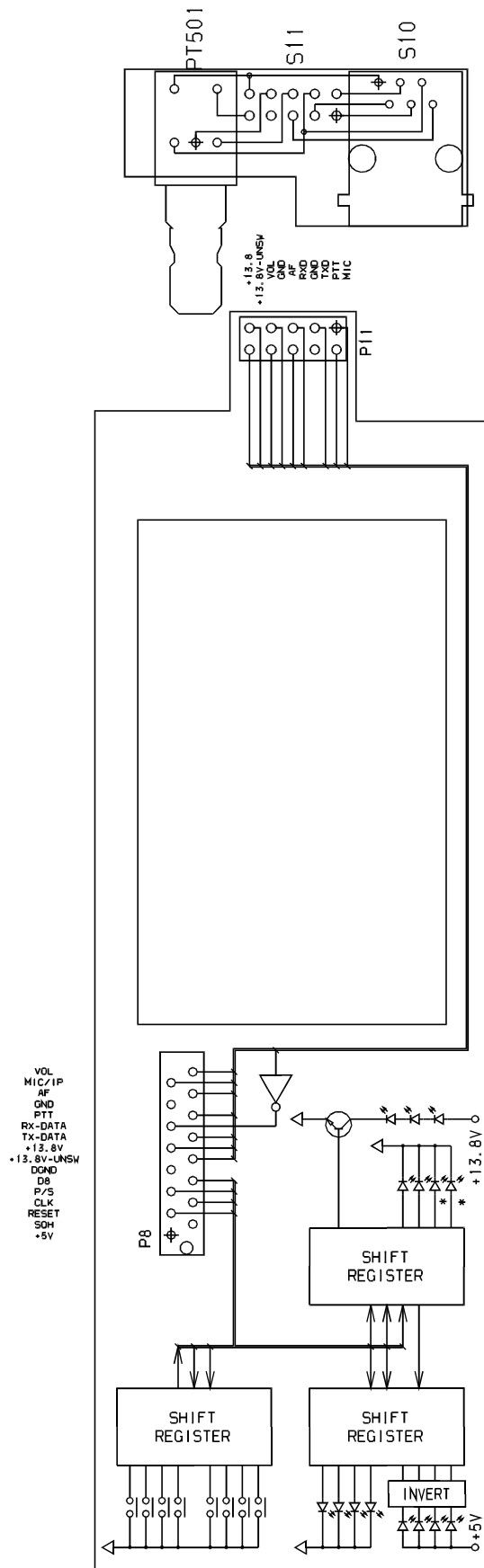


Figure 2.8 2010 &amp; T2030 Control Head Block Diagram

\* Only fitted in T2030

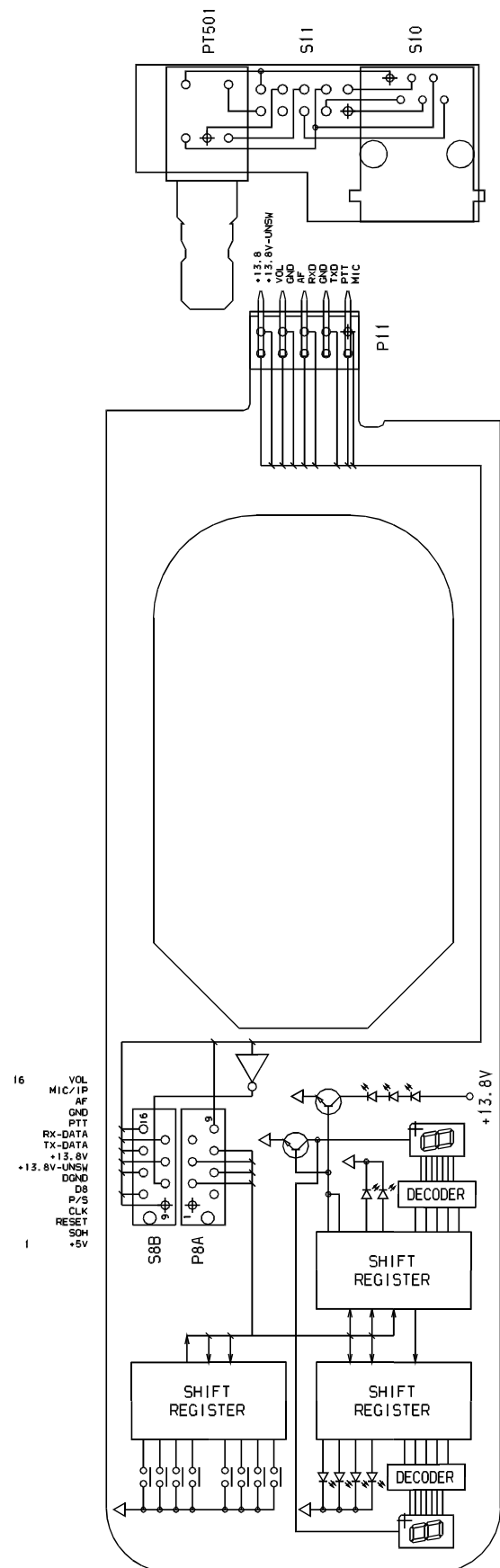


Figure 2.9 T2015 &amp; T2060 Control Head Block Diagram

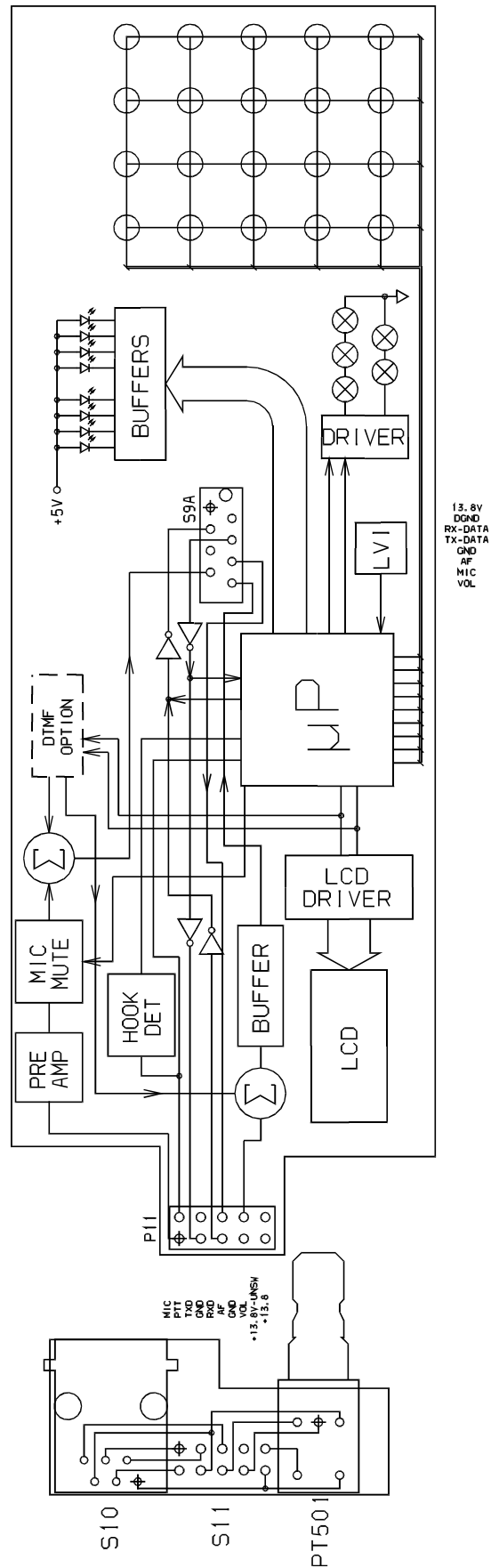


Figure 2.10 T2020, T2040 & T2050 Control Head Block Diagram

## 2.11.2 T2020, T203X, T2040, T2050 & T2060 HC11 Logic PCB

Transmitter speech from the microphone is preamplified and fed into an automatic level control circuit which also has three mute facilities (one for options and two for the microprocessor). The speech is pre-emphasised and high pass filtered to reduce CTCSS components. The speech passes via the RF PCB to the limiter on the TCXO/Tx audio PCB.

The FFSK modem tones pass through a level potentiometer before being fed to the limiter on the TCXO/Tx audio PCB. DCS/CTCSS signals are generated by the microprocessor and are filtered by a low pass filter before being passed to the level potentiometer on the TCXO/Tx audio PCB.

Five tone Selcall and DTMF modules are both available to directly interface to the microprocessor. Selcall tones are fed to the limiter on the TCXO/Tx audio PCB and DTMF tones are summed at the automatic level control.

Receiver audio from the IF PCB passes through a low pass filter where it is split into signalling and speech paths. Five tone signals are coupled to the five tone module. DCS/CTCSS passes through a low pass filter and limiter before arriving at the microprocessor. FFSK modem signals pass through a buffer amplifier before the modem input.

Speech is de-emphasised and passed through one or two high pass filters, depending on what signalling is used. Processed speech passes through the mute to an amplifier where speech and progress tones are summed. The signal then passes via the volume control to the audio power amplifier, on the RF PCB.



# 3 Introduction To Servicing

This Section provides information necessary for servicing T2000 Series II radios, and covers the following topics:

| Section    | Title                                                | Page        |
|------------|------------------------------------------------------|-------------|
| <b>3.1</b> | <b>Servicing Precautions</b>                         | <b>3.2</b>  |
| 3.1.1      | Caution: Accidental Transmit                         | 3.2         |
| 3.1.2      | Caution: Antenna Loading                             | 3.2         |
| 3.1.3      | Caution: Beryllium Oxide & Power Transistors         | 3.2         |
| 3.1.4      | Caution: CMOS Devices                                | 3.2         |
| 3.1.5      | Caution: Screw Head Types                            | 3.3         |
| <b>3.2</b> | <b>Disassembly Instructions</b>                      | <b>3.5</b>  |
| 3.2.1      | To Gain Access To The Logic PCB                      | 3.5         |
| 3.2.2      | To Remove The Bottom Cover And Microprocessor Shield | 3.5         |
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| 3.2.5      | To Detach The EMC Filter PCB                         | 3.11        |
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## 3.1 Servicing Precautions



### 3.1.1 Caution: Accidental Transmit

Under certain circumstances the microprocessor can key the transmitter. Ensure that all instruments are protected from accidental transmit at all times.



### 3.1.2 Caution: Antenna Loading

The equipment has been designed to operate with a  $50\Omega$  termination impedance, but will tolerate a wide range of antenna loading conditions. However, it is strongly recommended that the transmitter is not operated in the absence of a suitable load. Failure to observe this precaution may result in damage to the transmitter power output stage.



### 3.1.3 Caution: Beryllium Oxide & Power Transistors

The RF power transistors in the T2000 all contain some beryllium oxide. This substance, while perfectly harmless in its normal solid form, can become a severe health hazard when it has been reduced to dust.

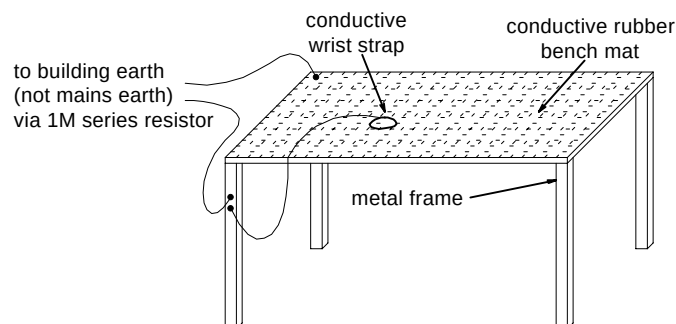
For this reason the RF power transistors should not be scratched, mutilated, filed, machined, or physically damaged in any way that can produce dust particles.



### 3.1.4 Caution: CMOS Devices

This equipment contains CMOS Devices which are susceptible to damage from static charges. Care when handling these devices is essential. For correct handling procedures refer to manufacturers' data books covering CMOS devices, e.g. Philips Data Handbook Covering CMOS Devices; Motorola CMOS Data Book Section 5 (Handling Procedures), etc.

The following diagram shows a typical anti-static bench set-up.



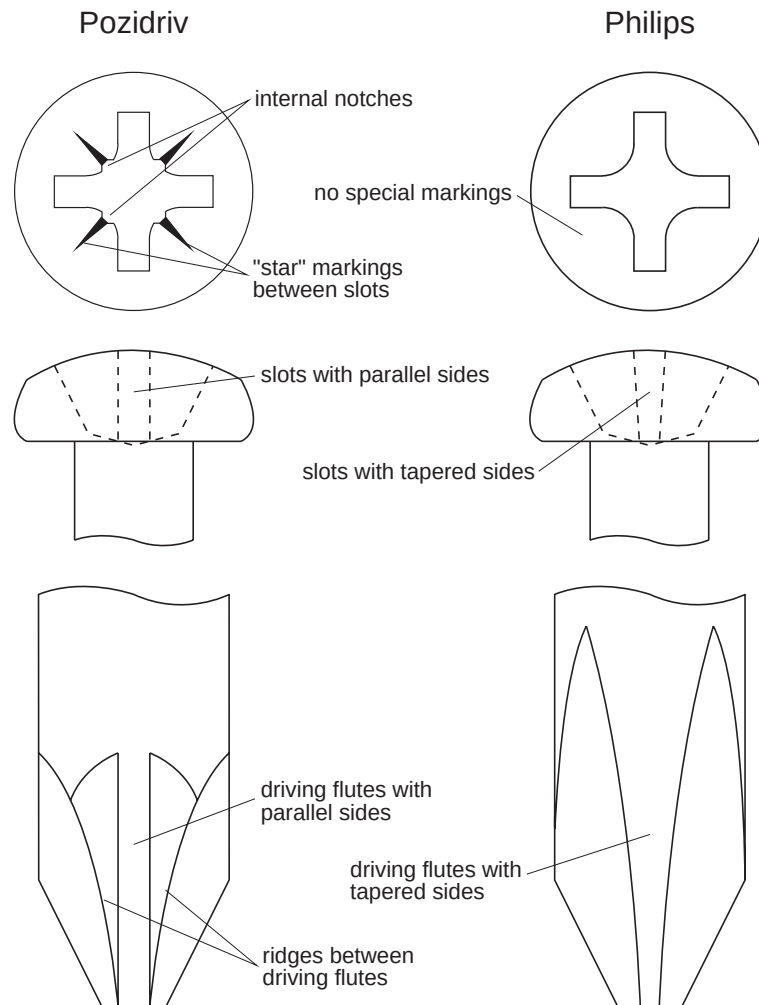
**Figure 3.1 Anti-Static Bench Set-Up**



### 3.1.5 Caution: Screw Head Types

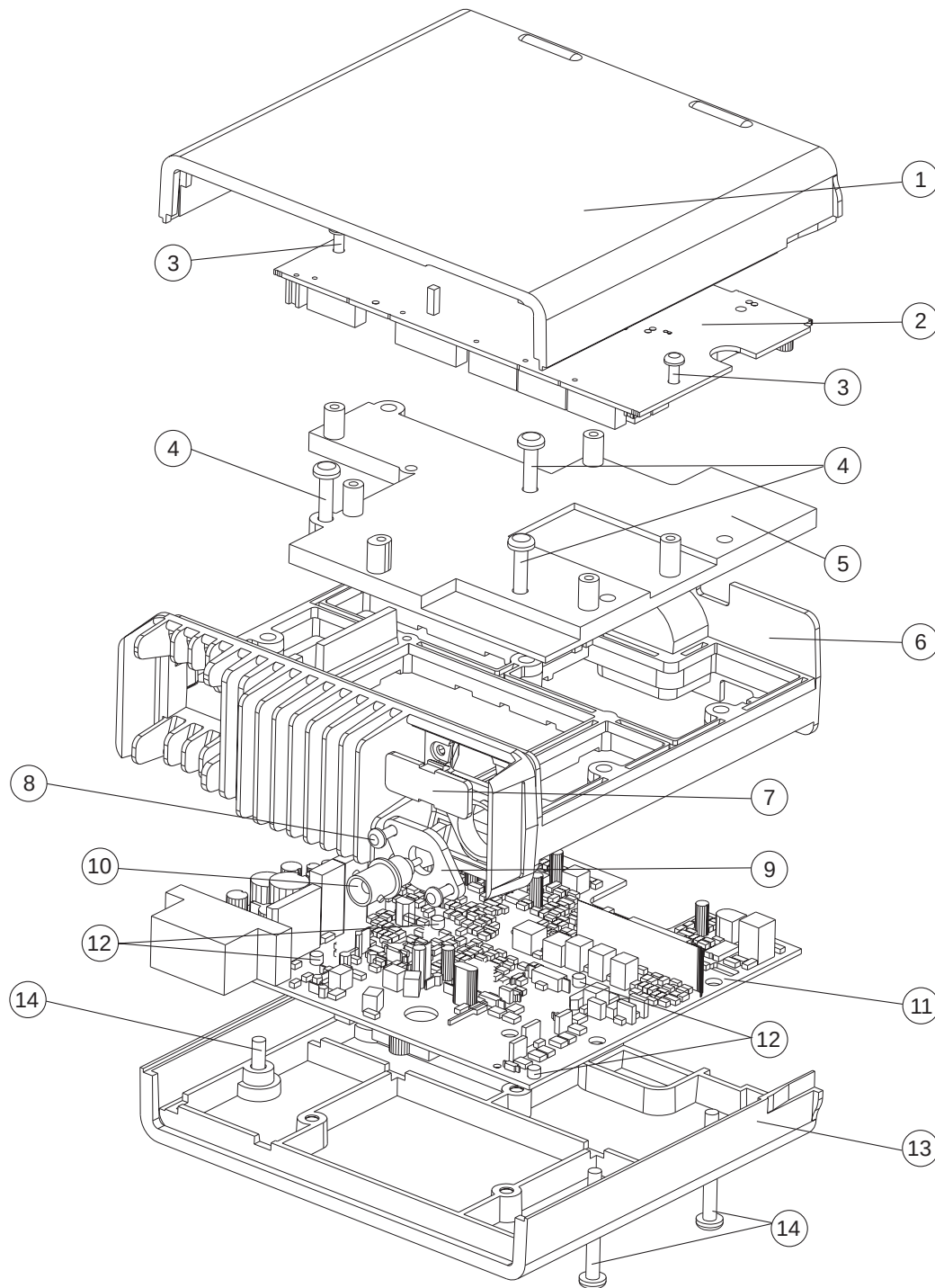
Pozidriv screws are the preferred standard on all T2000 series equipment. Pozidriv No. 1 and 2 screwdrivers will fit all pozidriv screws used in the T2000: Philips cross-head screwdrivers are *not* satisfactory for use on these screws.

The following diagram identifies the differences between Philips and Pozidriv screwdrivers.



**Figure 3.2 Screwdriver Identification**

The diagrams on the following pages show the types of screws used in the T2000 Series II radios, their locations and torque specifications.



| Item | Description                                      | IPN                           | Quantity | Torque (in.lb) |
|------|--------------------------------------------------|-------------------------------|----------|----------------|
| 1    | TOP COVER                                        | 303-23134-01                  | 1        |                |
| 2    | LOGIC PCB                                        | SEE PARTS LIST                | 1        |                |
| 3    | SCREW M3X8 PANPOZI TAPTITE (LOGIC PCB SCREWS)    | 349-00020-32                  | 3        | 8              |
| 4    | MACHINE SCREW M4X25 (MICRO. SHIELD SCREWS)       | 345-00050-18                  | 3        | 12             |
| 5    | MICROPROCESSOR SHIELD                            | 319-01164-XX                  | 1        |                |
| 6    | CHASSIS                                          | 308-13093-XX                  | 1        |                |
| 7    | D-RANGE BLANKING PLATE                           | 360-01053-XX                  | 1        |                |
| 8    | SCREW M3X8 PANPOZI TAPTITE (RF CONNECTOR SCREWS) | 349-00020-32                  | 2        | 8              |
| 9    | RF CONNECTOR PLATE                               | SEE PARTS LIST<br>(SECTION 7) | 1        |                |
| 10   | RF CONNECTOR                                     |                               | 1        |                |
| 11   | RF PCB                                           |                               | 1        |                |
| 12   | SCREW M3X8 PANPOZI TAPTITE (RF PCB SCREWS)       | 349-00020-32                  | 4        | 8              |
| 13   | BOTTOM COVER                                     | 303-23135-XX                  | 1        |                |
| 14   | M4X35 PANPOZI TAPTITE (BOTTOM COVER SCREWS)      | 349-00020-49                  | 4        | 12             |

Figure 3.3 T2000 Series II Radio Assembly

## 3.2 Disassembly Instructions



**Caution:** To carry out alignment it is necessary to remove only the top cover (1) and logic PCB retaining screws (3). It is essential that the bottom cover (13) and microprocessor shield (5) with its three retaining screws (4) are torqued down as specified in Figure 3.3.



**Caution:** Various electronic components within the radio can be damaged by electrostatic discharge. A properly grounded earth mat and wrist strap should be used at all times (refer to Section 3.1.4).

### 3.2.1 To Gain Access To The Logic PCB

Refer to Figure 3.3.

Remove the top cover (1) by unscrewing the four bottom cover screws (14).

Remove the three logic PCB retaining screws (3).

It should now be possible to open out the logic PCB (2), giving access to both sides of the logic PCB, and access to the RF PCB (11) tuning points, audio, plug-in TCXO PCB and loop filter components.

### 3.2.2 To Remove The Bottom Cover And Microprocessor Shield

Refer to Figure 3.3.

Remove the top cover and logic PCB screws as instructed in Section 3.2.1, then remove the three microprocessor shield retaining screws (4).

Remove the screw securing the earthing wire from the control head to the microprocessor shield.

It should now be possible to lift off the microprocessor shield (5) and the bottom cover (13).

This will give access to both sides of the RF PCB and IF PCBs, and enable the control head to be removed.

### 3.2.3 To Detach The Control Head

#### 3.2.3.1 Locally Mounted Models

Remove all covers, as instructed in Section 3.2.2.

Unplug the loom running between the control head and the logic PCB.

**Note:** In EMC model radios, the loom connects to a Micromatch connector on the EMC filter PCB (refer to Section 3.2.5).

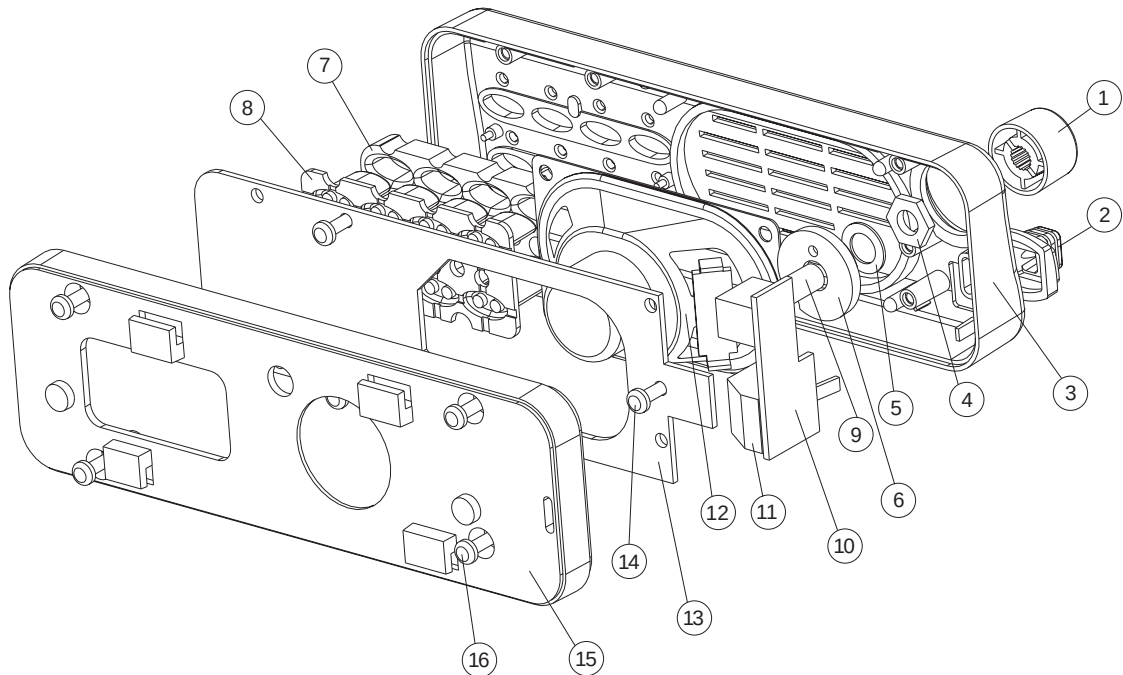
#### 3.2.3.2 Remotely Mounted Models

**I** Remove the four screws on the front of the radio dummy front panel. This will give access to the control head loom, which can now be unplugged.

**Note:** In EMC model radios, the loom connects to a Micromatch connector on the EMC filter PCB (refer to Section 3.2.5).

### 3.2.4 To Disassemble The Control Head

#### 3.2.4.1 T2010, T2015, T203X & T2060 Radios



| Item | Description                                      | IPN                        | Quantity | Torque (in.lb) |
|------|--------------------------------------------------|----------------------------|----------|----------------|
| 1    | KNOB                                             | 311-01042-XX               | 1        |                |
| 2    | MICROPHONE GROMMET                               | 360-02003-XX               | 1        |                |
| 3    | FRONT PANEL                                      | 316-03095-XX               | 1        |                |
| 4    | VOLUME POT NUT                                   | SEE PARTS LIST (SECTION 7) | 1        |                |
| 5    | VOLUME POT WASHER                                |                            | 1        |                |
| 6    | VOLUME POT LIGHTSPREADER                         | 304-07037-XX               | 1        |                |
| 7    | LIGHTSPREADER BUTTON                             | 304-07035-XX               | 1        |                |
| 8    | BASIC KEYPAD                                     | 311-03095-XX               | 1        |                |
| 9    | VOLUME POT                                       | SEE PARTS LIST (SECTION 7) | 1        |                |
| 10   | POT PCB                                          |                            | 1        |                |
| 11   | MICROPHONE CONNECTOR                             |                            | 1        |                |
| 12   | SPEAKER                                          | 250-00010-19               | 1        |                |
| 13   | CONTROL HEAD PCB (T2010, T2015, T203X, OR T2060) | SEE PARTS LIST             | 1        |                |
| 14   | NO 4X3/8 SCREW (CONTROL HEAD SCREWS)             | 349-00010-22               | 3        | 8              |
| 15   | ADAPTOR PLATE                                    | 301-00001-XX               | 1        |                |
| 16   | NO 4X5/8 SCREW (ADAPTOR PLATE SCREWS)            | 349-00010-24               | 4        | 8              |

**Figure 3.4 T2010, T2015 & T203X Control Head Assembly**

Refer to Figure 3.4.

Remove the control head from the main chassis, as instructed in Section 3.2.3.

Remove the four adaptor plate retaining screws (16).

Remove the control head PCB retaining screws (14).



The screws used in the control head are No. 4 Plastites, and should not be confused with the M3 screws used elsewhere. When being replaced, the No. 4 Plastite screws must be tightened to a torque of 8in.lb (0.9Nm).

With the control head face down, gently remove the PCB (13), along with the keypad (8) and lightspreader (7).

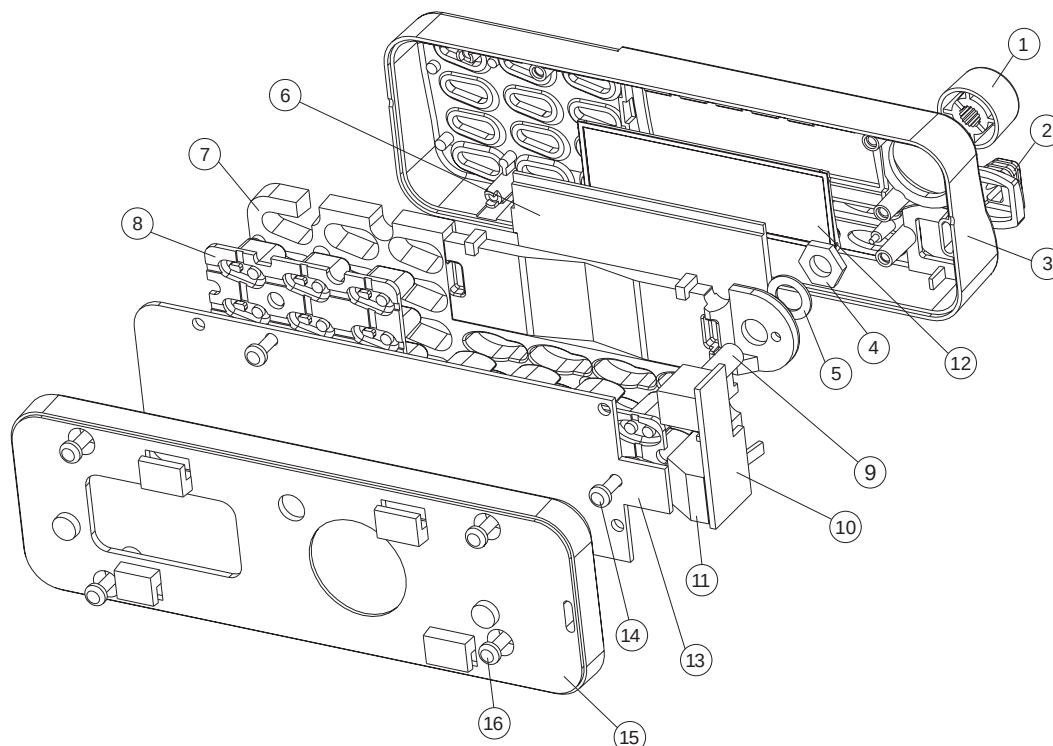


**Do not disturb the positioning or height of the LEDs, as this is critical for reassembly.**

Remove the speaker by carefully removing the four speaker retaining spire nuts.

Remove of the volume knob (1) and volume pot nut (5) to access the volume knob light spreader (6).

### 3.2.4.2 T2020, T2040 & T2050 Radios



| Item | Description                              | IPN                           | Quantity | Torque (in.lb) |
|------|------------------------------------------|-------------------------------|----------|----------------|
| 1    | KNOB                                     | 311-01042-XX                  | 1        |                |
| 2    | MICROPHONE GROMMET                       | 360-02003-XX                  | 1        |                |
| 3    | FRONT PANEL                              | 316-06427-XX                  | 1        |                |
| 4    | VOLUME POT NUT                           | SEE PARTS LIST<br>(SECTION 7) | 1        |                |
| 5    | VOLUME POT WASHER                        |                               | 1        |                |
| 6    | LIQUID CRYSTAL DISPLAY (LCD)             | 008-02029-XX                  | 1        |                |
| 7    | LIGHTSPREADER                            | 304-07036-XX                  | 1        |                |
| 8    | ENHANCED KEYPAD                          | 311-03096-XX                  | 1        |                |
| 9    | VOLUME POT                               | SEE PARTS LIST<br>(SECTION 7) | 1        |                |
| 10   | POT PCB                                  |                               | 1        |                |
| 11   | MICROPHONE CONNECTOR                     |                               | 1        |                |
| 12   | LENS                                     | 312-01046-XX                  | 1        |                |
| 13   | CONTROL HEAD PCB (T2020, T2040 OR T2050) | SEE PARTS LIST                | 1        |                |
| 14   | NO 4X3/8 SCREW (CONTROL HEAD SCREWS)     | 349-00010-22                  | 3        | 8              |
| 15   | ADAPTOR PLATE                            | 301-00001-XX                  | 1        |                |
| 16   | NO 4X5/8 SCREW (ADAPTOR PLATE SCREWS)    | 349-00010-24                  | 4        | 8              |

**Figure 3.5 T2020, T2040 & T2050 Control Head Assembly - Locally Mounted**

Refer to Figure 3.5 and Figure 3.6.

Remove the control head from the main chassis, as instructed in Section 3.2.3.

Remove the four adaptor plate/remote back panel retaining screws (16). Remote mounted models also have two captive nuts (17) fitted in the back cover.

**Note:** EMC model radios have 4 ESD plugs fitted over the remote back panel screws. These will need to be removed to access the remote back panel screws.

Remove the control head PCB retaining screws (14).



The screws used in the control head are No. 4 Plastites, and should not be confused with the M3 screws used elsewhere. When being replaced, the No. 4 Plastite screws must be tightened to a torque of 8in.lb (0.9Nm).

With the control head face down, gently remove the PCB (13), along with the keypad (8) and lightspreader (7).



**Do not disturb the positioning or height of the LEDs, as this is critical for reassembly.**

Carefully remove the LCD (6) and lens (12).

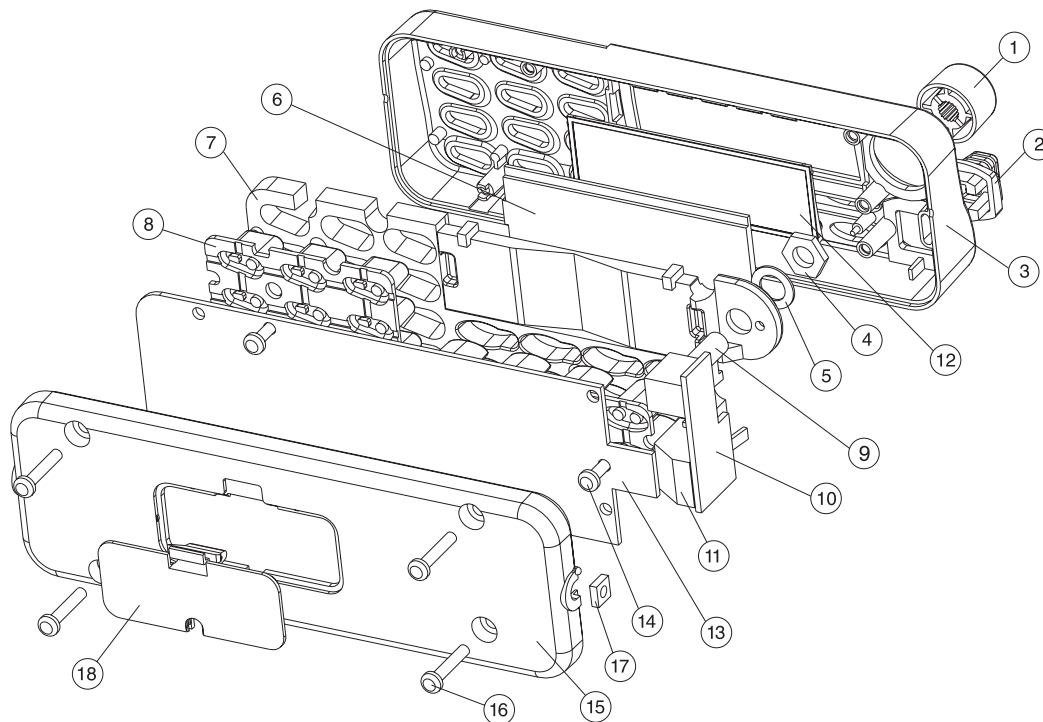
Lay the front panel (3) on a horizontal surface, with the light spreader (7) in place.

Remove the volume knob (1) and volume knob nut (5) to access the lightspreader and keypad (8).

Before reassembly, the LCD and PCB edge connectors should be wiped with alcohol.



**Take care to ensure the alcohol does not come in contact with the coating on the light spreader, as this will dissolve on contact with alcohol.**



| Item | Description                              | IPN                        | Quantity | Torque (in.lb) |
|------|------------------------------------------|----------------------------|----------|----------------|
| 1    | KNOB                                     |                            | 1        |                |
| 2    | MICROPHONE GROMMET                       | 360-02003-XX               | 1        |                |
| 3    | FRONT PANEL                              | 316-06427-XX               | 1        |                |
| 4    | VOLUME POT NUT                           | SEE PARTS LIST (SECTION 7) | 1        |                |
| 5    | VOLUME POT WASHER                        |                            | 1        |                |
| 6    | LIQUID CRYSTAL DISPLAY (LCD)             | 008-02029-XX               | 1        |                |
| 7    | LIGHTSPREADER                            | 304-07036-XX               | 1        |                |
| 8    | ENHANCED KEYPAD                          | 311-03096-XX               | 1        |                |
| 9    | VOLUME POT                               |                            | 1        |                |
| 10   | POT PCB                                  | SEE PARTS LIST (SECTION 7) | 1        |                |
| 11   | MICROPHONE CONNECTOR                     |                            | 1        |                |
| 12   | LENS                                     | 312-01046-XX               | 1        |                |
| 13   | CONTROL HEAD PCB (T2020, T2040 OR T2050) | SEE SECTION 7 PARTS        | 1        |                |
| 14   | NO 4X3/8 SCREW (CONTROL HEAD SCREWS)     | 349-00010-22               | 3        | 8              |
| 15   | REMOTE BACK PANEL                        | 318-08432-XX               | 1        |                |
| 16   | NO 4X5/8 SCREW (REMOTE BACK SCREWS)      | 349-00010-24               | 4        | 8              |
| 17   | CAPTIVE NUT M4 PRESSED                   | 352-00010-17               | 2        |                |
| 18   | REMOTING CONNECTOR COVER                 | 316-85125-XX               | 1        |                |

**Figure 3.6 T2020, T2040 & T2050 Control Head Assembly - Remotely Mounted**

### 3.2.5 To Detach The EMC Filter PCB

Refer to Figure 3.7.

Remove the top cover and open the logic PCB, as described in Section 3.2.1.

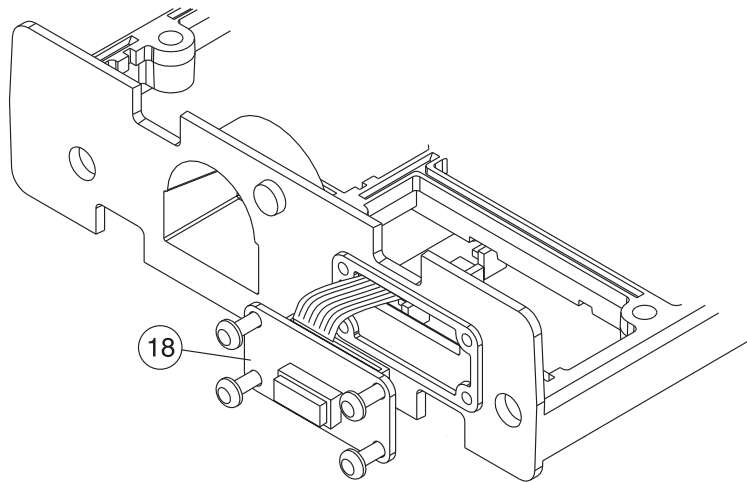
Remove the microprocessor shield and bottom cover, as described in Section 3.2.2.

The control head (locally mounted models) or dummy front panel (remotely mounted models) can now be removed.

Unplug the loom running between the logic PCB and EMC filter PCB (18).

Unplug the loom running between the EMC filter PCB and the control head.

Remove the 4 EMC filter PCB retaining screws. The EMC filter PCB can now be lifted from the chassis.



**Figure 3.7** *EMC Filter PCB Mounting*

### 3.2.6 To Remote A Locally Mounted T2020, T2040 & T2050

Refer to Section 8.16, "T2000-A03/-A04/-A16 Remote Loom Kits".

## 3.3 Power Amplifier - Special Instructions



**Caution:** As the location of certain components in the PA is critical to performance, it is important that any components removed or disturbed are refitted in exactly the same location.

### 3.3.1 To Replace PA Transistors

Desolder the tabs by heating them with a soldering iron, then lifting them up towards the transistor with a thin stainless steel spike or screwdriver.

Unscrew the transistor mounting stud nut or screws and remove the transistor.

Trim the tabs of the replacement to make them similar to the faulty item, then lightly tin the underside of the tabs.

Apply a thin layer of heatsink compound to the underside of the transistor.

Screw the transistor tightly to the heatsink then solder the tabs.



**Do not solder the tabs before tightening the screws or nut, as this will fracture the device.**

### 3.3.2 To Remove Case Mica Capacitors

Apply a heavy duty soldering iron to the top of the capacitor case.

When the solder is molten, ease the capacitor away from the PCB with a thin stainless steel spike or screwdriver.

## 3.4 Repair

### 3.4.1 Surface Mount Devices



**Caution:** Surface mount devices require special storage, handling, removal and replacement techniques. This equipment should be serviced only by an approved Tait Dealer or Service Centre equipped with the necessary facilities. Repairs attempted with incorrect equipment or by untrained personnel may result in permanent damage. If in doubt, contact Tait Electronics Ltd or your nearest Tait Branch or Subsidiary.

#### 3.4.1.1 Surface Mount Device (SMD) Precautions

The following points must be observed when servicing SMDs:

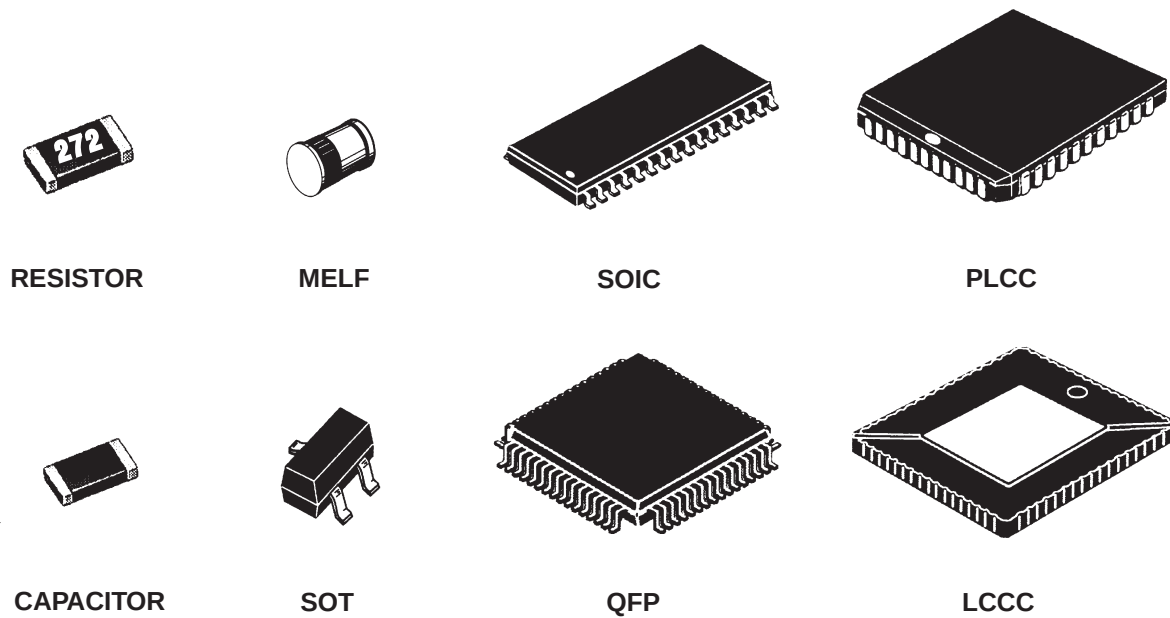
- Carry out all servicing in a static safe work area (refer to Figure 3.1).
- Always observe static precautions when handling or carrying SMDs. Carry in foil, anti static bags or in trays and anti-static tubes for fine pitch ICs.
- Use appropriate tools when working with SMDs (refer to 3.4.1.2).
- Do not use soldering irons on surface mount capacitors, resistors, SOIC and SOT components.
- Use new solder when replacing SMDs.
- Use the correct amount of solder (refer to Figure 3.9).
- Never reuse old SMDs.
- Do not use SMDs that have been dropped.

#### 3.4.1.2 Servicing Equipment Required

- Hot air tool or heat gun: adjustable temperature is required and a regulated hot air blower. The nozzle is changed according to the size of the SMDs.
- Weller Pyrophen®: this is a butane hot air tool, and is hotter than a heat gun. For use only for resistors, capacitors and SOTs.
- Solder paste dispenser or syringe: for SMD placement.
- Tweezers: for use when handling SMDs.
- Solderwick: for removing solder on SMD pads or for removing excess solder or bridging on multi-leg components.

- Soldering iron: for use on electrolytic capacitors and plastic coated devices that may be damaged by a heat gun.
- Microscope: for individual SMD inspection and for SMD replacement.

Use the following diagram to identify types of SMD components.



*Figure 3.8 Identifying SMD Components*

### **3.4.1.3 Removal & Replacement Of SMD Components**

Refer to Figure 3.9.

#### **(a) Capacitors, Resistors, MELF & SOT**

Hold the nozzle of the hot air tool above the component and keep it moving to ensure that the PCB is not damaged.

Remove the SMD and clean away any glue using the hot air tool and a pair of tweezers.

Remove any excess solder from the pads using solderwick.

Deposit a small amount of solder paste on the pads using the solder paste dispenser or syringe.

Apply heat evenly to both sides of the device using the hot air gun or Weller Pyro-pen<sup>®</sup>, until all the paste has reflowed. As this happens, the device will self-align on the pads. If necessary, use tweezers to prevent the SMD from moving while heat is being applied.

#### **(b) SOIC, VSO, QFP, LCCC & PLCC**

Hold the nozzle of the hot air tool on top of the leads and keep it moving to ensure that the PCB is not damaged. A hot air tool with the correct size nozzle must be used.

After a few seconds heating, use a very gentle twisting motion to allow the device to move away from its associated pads.

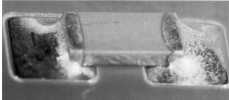
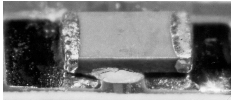
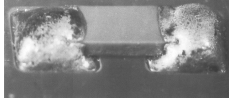
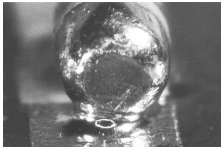
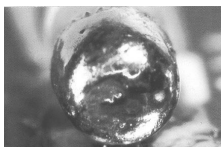
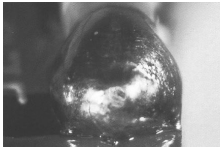
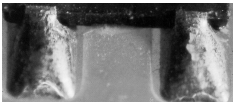
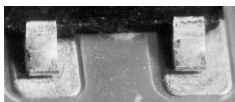
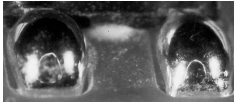
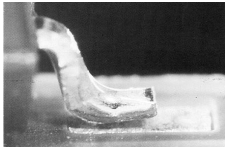
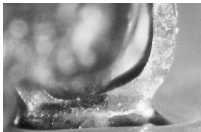
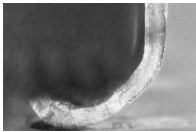
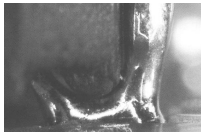
Carefully remove all excess solder from the pads using a soldering iron and solderwick.

Apply an even amount of solder paste along the full length of the pads, using flux where necessary.

Align the device accurately on the pads and apply a slight pressure with the tweezers to hold in place.

Hold the heat nozzle at an angle and move it slowly along the leads, ensuring that the paste reflows properly.

If any fine bridges occur, use a spike or solderwick to clear. If this is necessary, apply more solder paste before using the hot air gun again.

|                         | adaquate solder                                                                     | insufficient solder                                                                 | excess solder                                                                         |
|-------------------------|-------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|
| capacitor<br>& resistor |    |    |    |
| MELF                    |    |    |    |
| SOT                     |  |  |  |
| SOIC<br>(gull leads)    |  |  |  |
| PLCC<br>(J leads)       |  |  |  |

**Figure 3.9 SMD Soldering Guide**

### 3.4.1.4 Common Causes Of SMD Failure

#### (a) Cracked SMD

Most often occurs with capacitors, caused by:

- Thermal shock: if the SMD is heated too rapidly either it will crack or internal seals will be lost, resulting in premature failure.
- In-service temperature changes that cause invisible micro-cracks. These start at or just under the end termination and will spread throughout the device over a long period of time.

#### (b) Solder Joint Failure

- Stress causing flexing of the PCB leads to a cracked joint.
- Excessive or too little solder results in a poor quality joint.
- Various soldering process defects such as solder balling, device misalignment, solder bridging and glue defects.

#### (c) Static Electricity Damage

If static electricity damage is suspected, remove and replace the component.

## 3.4.2 Leaded Component Removal

Whenever components are removed from or fitted to the PCB, care must be taken to avoid damage to the track. The two satisfactory methods of removing components from PTH PCBs are detailed below.

### 3.4.2.1 Desoldering Iron Method

Use a desoldering station, e.g. Philips SBC 314 or Pace MBT-100E for this method.

Place the tip over the lead and, as the solder starts to melt, move the tip with a circular motion.

Start the suction and continue the movement until 3 or 4 circles have been completed.

Remove the tip while continuing suction to ensure that all solder is removed from the joint, then stop the suction.

Before pulling the lead out, ensure it is not stuck to the plating. If the lead is still not free, resolder the joint and try again.

The desoldering iron does not usually have enough heat to desolder leads from the ground plane. Additional heat may be applied by holding a soldering iron on the tip of the desoldering iron (this may require a helper).

### **3.4.2.2 Component Cutting Method**

Cut the leads on the component side of the PCB.

Heat the solder joint sufficiently to allow easy removal of the lead by drawing it out from the component side: do not use undue force.

Fill the hole with solder and then clear with solderwick.

## **3.5 Programming**

Refer to the T2000 programming manual supplied with the T2000 programming kit, and Section 9 of this manual.

## 4 Functional Tests

This Section details test procedures will confirm that the T2000 has been adjusted correctly and is fully operational.

The following topics are covered:

| Section    | Title                                          | Page       |
|------------|------------------------------------------------|------------|
| <b>4.1</b> | <b>Test Equipment Required</b>                 | <b>4.2</b> |
| <b>4.2</b> | <b>Connecting The Radio</b>                    | <b>4.3</b> |
| <b>4.3</b> | <b>Trunked Radios</b>                          | <b>4.4</b> |
| 4.3.1      | Trunking System Check                          | 4.4        |
| <b>4.4</b> | <b>Receiver Performance Tests</b>              | <b>4.5</b> |
| 4.4.1      | To Check The Squelch Operation                 | 4.5        |
| 4.4.2      | To Check The Squelch Ratio                     | 4.5        |
| 4.4.3      | To Check The Audio Output Level And Distortion | 4.6        |
| 4.4.4      | To Check The Sinad Sensitivity                 | 4.6        |
| 4.4.5      | To Check The Signal+Noise To Noise Ratio       | 4.7        |
| 4.4.6      | To Check The Ultimate Signal To Noise Ratio    | 4.7        |
| 4.4.7      | RSSI                                           | 4.7        |
| 4.4.8      | To Check The Operation Of The Noise Blanker    | 4.8        |
| <b>4.5</b> | <b>Transmitter Performance Tests</b>           | <b>4.9</b> |
| 4.5.1      | Audio Processor                                | 4.9        |
| 4.5.1.1    | To Check The Limiter Circuit Operation         | 4.9        |
| 4.5.1.2    | To Check The Audio ALC Operation               | 4.9        |
| 4.5.1.3    | To Check The Gain Of The Audio Processor       | 4.10       |
| 4.5.2      | Modulation Characteristics                     | 4.10       |
| 4.5.2.1    | To Check The Above Limiting Response           | 4.10       |
| 4.5.2.2    | To Check The Below Limiting Response           | 4.10       |
| 4.5.3      | To Check The RF Power Control Circuit          | 4.11       |

## 4.1 Test Equipment Required

The following equipment is required for functional testing.

- Power supply cord, wired as shown in Section 8.3.
- Power supply adjustable between 9 & 16V DC, with a capacity of at least 8A.
- VHF or UHF signal generator: good quality FM 50 $\Omega$ , usable from 0.1V (-127dBm) to 200mV (0dBm) pd (e.g. HP8640B, Marconi 2019).
- Frequency counter: 10Hz to 650MHz, 2ppm stability, with at least a 2s time base resolution (e.g. Opto).
- Audio signal generator: 600 $\Omega$  output, -50 to 0dB level, fully adjustable, sine wave output 10Hz to 100kHz (e.g. Trio 203, HP204C/D).
- FM deviation meter (e.g. Sayrosa 257 or 252), with the following specifications:
  - low residual FM
  - resolution down to a full scale of 1kHz and a minimum of 10kHz
  - maximum positive and negative peak display
  - 15kHz low pass filter
  - detected audio output facility.

**Note:** When using with LTR or DCS, the deviation meter must have a good low frequency response, to avoid incorrect deviation readings.

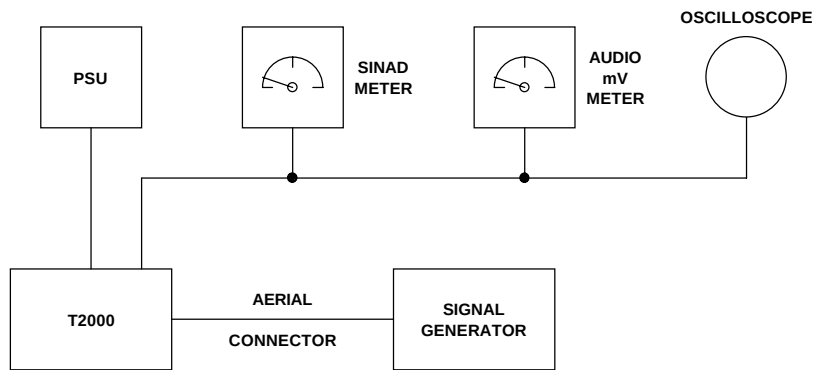
- Sinad meter or audio distortion analyser, 1kHz notch type (e.g. HP334A, HP339A or Helper Instruments Sinadder).
- AC millivoltmeter (e.g. Trio VT-106).
- Digital multimeter (e.g. Fluke 75).
- 20MHz dual channel oscilloscope and X10 . X1 scope probes (e.g. Trio CS1022).
- RF power meter, 50 $\Omega$ ; RF detecting element 50W and 5W for appropriate frequency ranges (e.g. Bird Meter 6154 or 611).
- RF power attenuator, 50 $\Omega$ , total attenuation 30dB (e.g. Weinschel 40-40-33 30dB, 150W).
- Microphone test box (refer to Figure 4.1).

A multifunction test set may be used as long as it has the appropriate function to perform the calibration correctly e.g. Rhode & Schwarz CMS52 Radio Communications Test Set, with a high stability oscillator.

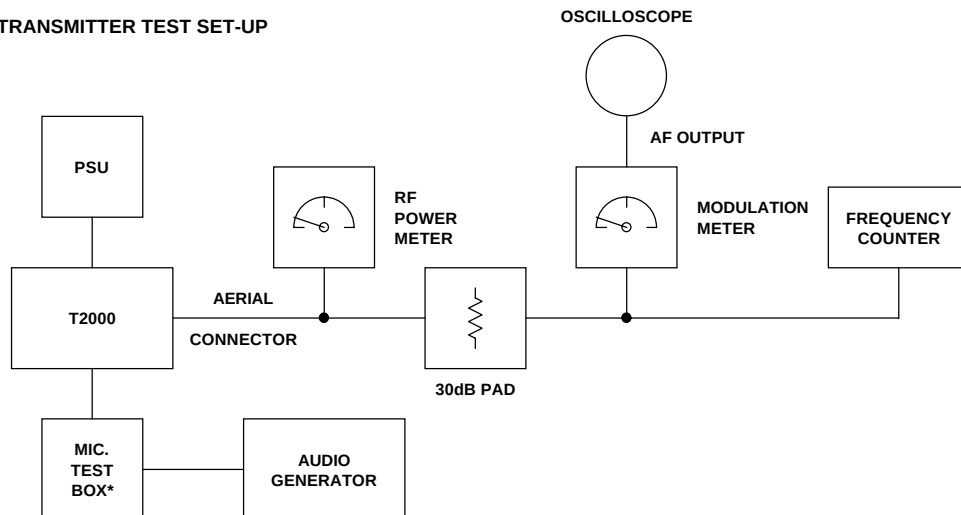
## 4.2 Connecting The Radio

The following diagram shows a suggested test equipment set-up.

RECEIVER TEST SET-UP



TRANSMITTER TEST SET-UP



\*MIC TEST BOX:

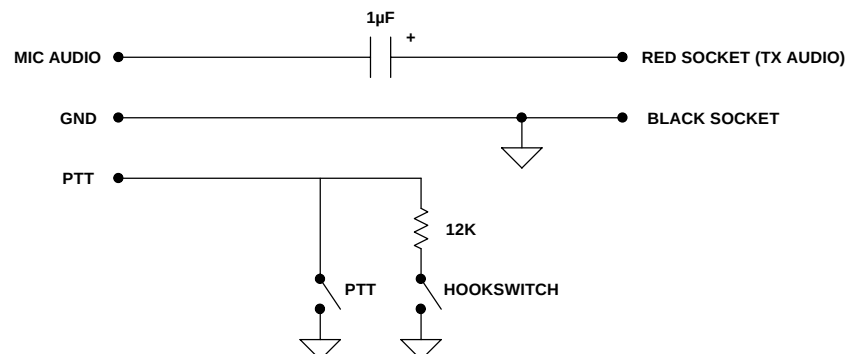


Figure 4.1 Suggested Test Equipment Set-Up

## 4.3 Trunked Radios

The 'test' facility enables T2000 trunked radios to emulate a multichannel radio, using the frequencies reserved for trunking.

For a description of how to put the radio in test mode, refer to Section 5.8, "Trunked Radios: Test Mode". Once the radio is in test mode, functional testing can be carried out as described in Section 4.4 and Section 4.5.

**Caution:** When in test mode, connect the antenna socket to a dummy load to prevent interference with trunking systems. Avoid testing on channels in use locally.

### 4.3.1 Trunking System Check

Connect the radio to an antenna and switch on.

Check that the radio locks onto the system:

**T203X radios:** the **SVC** LED illuminates.

**T2040 radios:** the **SVC** annunciator will appear in the control head display.

The following parameters relating to the local trunking system base station must be correctly programmed before the mobile will lock onto the system:

- Base station channel numbers and frequencies.
- Network ID.
- Zone and area field length.
- Base station control channel number in the hunt list.
- Valid acquisition authorisation code (for test purposes this can be set to 'none', which allows total access).

Initiate a call to a known unit identity. For test purposes this can be your own identity.

Check that:

- The radio beeps.
- A 0.5s ringing tone is sounded.
- The receiver unmutes.
- T203X: The **GO** LED illuminates.
- T2040: the **GO** annunciator comes on.

## 4.4 Receiver Performance Tests

In this Section, deviation settings are given first for wide band, followed by settings for medium band in brackets ( ) and settings for narrow band in square brackets [ ].

### 4.4.1 To Check The Squelch Operation

Connect a sinad meter across the speaker terminals.

Connect an on-channel RF signal generator to the antenna input terminal.

Disable any signalling control in T2010 or T2020 models by using the monitor function. The control head **monitor** LED should now be active.

Reduce the signal generator output level to -127dBm, modulated to  $\pm 3\text{kHz}$  ( $\pm 2.4\text{kHz}$ ) [ $\pm 1.5\text{kHz}$ ] deviation at 1kHz AF.

Increase the RF output level until the squelch gate just opens.

Check that the reading on the sinad meter is between 8 and 14dB.

Reduce the signal generator output and check that the squelch gate closes within 4dB of the original RF level.

### 4.4.2 To Check The Squelch Ratio

Set the signal generator output level to -47dBm, modulated to  $\pm 5\text{kHz}$  ( $\pm 4\text{kHz}$ ) [ $\pm 2.5\text{kHz}$ ] deviation at 1kHz AF.

Replace the sinad meter with an audio millivoltmeter across the speaker terminals.

Adjust the volume control to the onset of clipping.

Reduce the signal generator output level to -127dBm.

The fall in output is the 'squelch ratio', and this should be at least 70dB.

### 4.4.3 To Check The Audio Output Level And Distortion

Connect an audio millivoltmeter and an oscilloscope across the speaker terminals.

Connect an on-channel RF signal generator to the antenna input socket, with the output set to -107dBm (1V) modulated to  $\pm 5\text{kHz}$  ( $\pm 4\text{kHz}$ ) [ $\pm 2.5\text{kHz}$ ] deviation at 1kHz AF.

Set the volume control to the onset of clipping.

The receiver output should be 4.2Vrms across  $4\Omega$  at +13.8V supply.

Check the distortion with the aid of a distortion analyser connected across the speaker terminals.

The distortion should not exceed 5%.

### 4.4.4 To Check The Sinad Sensitivity

Connect a sinad meter across the speaker terminals.

Connect the signal generator to the antenna input terminal.

Set the signal generator accurately on the receive frequency.

Set the modulation for  $\pm 3\text{kHz}$  ( $\pm 2.4\text{kHz}$ ) [ $\pm 1.5\text{kHz}$ ] deviation at 1kHz AF.

Increase the signal generator output until a 20dB sinad is reached.

Switch off the signal generator modulation.

Couple a 10.7MHz reference oscillator loosely into the receiver IF stage, tune the signal generator for a zero beat, then uncouple the reference oscillator.

Set the signal generator deviation to  $\pm 3\text{kHz}$  ( $\pm 2.4\text{kHz}$ ) [ $\pm 1.5\text{kHz}$ ] at 1kHz AF.

**Note:** The modulating frequency must match the notch of the sinad meter.

Set the signal generator output level to -127dBm.

Disable the squelch control circuitry using the **monitor** key  on the T2010, T2015, T2020, T2050 or T2060, the **function**  key on the T203X, or "function 21" on the T2040. The LED should then flash.

Increase the signal generator output level until a sinad of 12dB is reached.

The signal generator output should not be greater than -117dBm and is typically -119dBm.

#### 4.4.5 To Check The Signal+Noise To Noise Ratio

Set the signal generator output level to -107dBm modulated to  $\pm 5\text{kHz}$  ( $\pm 4\text{kHz}$ ) [ $\pm 2.5\text{kHz}$ ] deviation at 1kHz AF.

Connect an audio millivoltmeter across the speaker terminals.

Set the volume control for a reading of 0.8V (0dBm) on a convenient scale on the millivoltmeter.

Switch off the signal generator modulation.

Note the reading on the millivoltmeter.

The fall in reading when the modulation is switched off should typically be 30dB (28dB) [25dB].

#### 4.4.6 To Check The Ultimate Signal To Noise Ratio

**Note:** A good quality RF signal generator with low residual FM must be used for this check (e.g. HP8640B or 8656).

Set the signal generator to give an on-channel signal, modulated to  $\pm 5\text{kHz}$  ( $\pm 4\text{kHz}$ ) [ $\pm 2.5\text{kHz}$ ] with a 1kHz tone.

Set the signal generator output level to -47dBm.

Connect an AC millivoltmeter across the speaker terminals.

Adjust the volume control for a reading of 0.8V (0dBm) on a convenient scale.

Turn off the signal generator modulation.

Note the reading on the millivoltmeter.

The fall in reading when the modulation is switched off should be at least 50dB (48dB) [45dB].

#### 4.4.7 RSSI

Set the signal generator to give an unmodulated signal at an output level of -120dBm.

Increase the input level in 10dB steps over the 50dB dynamic range and monitor the RSSI output on pin 15 of S14 (logic PCB).

Ensure the output varies approximately 540mV/10dB over the dynamic range.

#### **4.4.8 To Check The Operation Of The Noise Blanker**

Connect an ignition noise simulator and an RF signal generator to the receiver antenna input.

Set the signal generator modulation for  $\pm 3\text{kHz}$  ( $\pm 2.4\text{kHz}$ ) [ $\pm 1.5\text{kHz}$ ] deviation at  $1\text{kHz}$  AF.

Set the signal generator output level to give a  $20\text{dB}$  sinad.

Listen to the receiver output and check the operation of the noise blanker by temporarily short circuiting R135 on the RF PCB to ground, thus disabling the noise blanker.

The noise blanker should give a marked reduction in noise over a wide range of noise input amplitudes.

## 4.5 Transmitter Performance Tests

In this Section, deviation settings are given first for wide band, followed by settings for medium band in brackets ( ) and settings for narrow band in square brackets [ ].

### 4.5.1 Audio Processor

#### 4.5.1.1 To Check The Limiter Circuit Operation

Connect an oscilloscope to monitor the waveform at TSP901 (TCXO PCB).

Plug the microphone test lead into the control head microphone input socket.

Apply a 1kHz sine wave.

Slowly increase the sine wave output level until the waveform begins to distort (squaring), indicating that limiting has commenced.

Any further increase in sine wave output level should not increase the amplitude of the waveform.

#### 4.5.1.2 To Check The Audio ALC Operation

Connect an oscilloscope to monitor the waveform at TP606 (logic PCB).

Apply a 1kHz sine wave.

Connect an EVM to the junction of R667 and C639.

Increase the sine wave output level to 10dB above the limiting level, as described in Section 4.5.1.1.

Note the amplitude on the oscilloscope, then increase the output level by another 10dB.

Check that the amplitude of the waveform does not increase or distort significantly.

The EVM should show a positive DC reading.

### 4.5.1.3 To Check The Gain Of The Audio Processor

Connect the T2000 antenna output via a 30dB attenuator to a modulation meter.

Plug the microphone test lead into the control head microphone input socket.

Apply a 1kHz sine wave and adjust the output level to give a 3kHz (2.4kHz) [1.5kHz] deviation reading on the modulation meter.

Connect a millivoltmeter across the input of the microphone test box and check for a reading of approximately 1mVrms on the millivoltmeter.

**Note:** The audio processor gain must be checked at a level below that at which the audio ALC or limiting are influencing the measurements.

## 4.5.2 Modulation Characteristics

### 4.5.2.1 To Check The Above Limiting Response

Connect the T2000 antenna output via a 30dB attenuator to a modulation meter.

Plug the microphone test lead into the control head microphone input socket.

Apply a 1kHz sine wave and increase the output level to 20dB above the limiting level, as described in Section 4.5.1.1.

Vary the frequency of the sine wave generator between 0.3 and 5kHz.

Note the reading on the modulation meter.

The deviation should not exceed  $\pm 5\text{kHz}$  ( $\pm 4\text{kHz}$ ) [ $\pm 2.5\text{kHz}$ ].

Between 450Hz and 3kHz (3kHz) [2.55kHz] the deviation should be within 4dB of maximum.

Above 3kHz the deviation should decrease by more than 25dB/octave.

### 4.5.2.2 To Check The Below Limiting Response

Decrease the sine wave generator output level to 10dB below the limiting level, as described in Section 4.5.1.1.

Sweep the sine wave from 0.3 to 10kHz.

Note the reading on the modulation meter.

From 300Hz to 3kHz (3kHz) [2.55kHz] the deviation should increase at the rate of 6dB/octave (+1, -3dB) relative to 1kHz.

Above 3kHz the deviation should decrease by more than 25dB/octave.

### **4.5.3 To Check The RF Power Control Circuit**

Connect an RF power meter to the transmitter output.

Select a channel programmed for high power (25W).

Close the PTT switch.

Vary the supply voltage between 10.8 and 16V.

Above 13.8V the RF power output should not increase by more than 2W.

At 10.8V the RF power output should be more than 16W.



# 5 Fault Finding

This Section provides general fault finding assistance, and is intended to be used in conjunction with the circuit descriptions and block diagrams in Section 2 and the circuit diagrams and PCB information in Section 7.

The following topics are covered in this Section:

| Section     | Title                                           | Page        |
|-------------|-------------------------------------------------|-------------|
| <b>5.1</b>  | <b>Servicing Warning</b>                        | <b>5.2</b>  |
| <b>5.2</b>  | <b>Visual Checks</b>                            | <b>5.2</b>  |
| <b>5.3</b>  | <b>Component Checks</b>                         | <b>5.2</b>  |
| 5.5.1       | Transistor Check                                | 5.2         |
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| <b>5.4</b>  | <b>DC Checks</b>                                | <b>5.3</b>  |
| <b>5.5</b>  | <b>Receiver RF Checks</b>                       | <b>5.4</b>  |
| 5.5.1       | VCO Frequency                                   | 5.4         |
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| 5.5.3       | RF Sensitivity                                  | 5.5         |
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| <b>5.7</b>  | <b>Trunked Radios: System Check</b>             | <b>5.6</b>  |
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| 5.8.3       | Computer Controlled Test Mode (CCTM)            | 5.9         |
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| 5.8.5.1     | Resetting The Radio                             | 5.11        |
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| 5.8.6       | Trunked Radios: Radio Mode/Status Display Codes | 5.15        |
| <b>5.9</b>  | <b>Options Interface Specifications</b>         | <b>5.17</b> |
| <b>5.10</b> | <b>Fault Finding Charts</b>                     | <b>5.20</b> |

## 5.1 Servicing Warning

T2000 Series II radios require specialised servicing techniques. Before attempting any disassembly or repair, refer to Section 3, "Introduction To Servicing".

Repairs attempted with incorrect equipment or by untrained personnel may result in permanent damage. If in doubt, contact Tait Electronics Ltd or your nearest Tait Branch or Subsidiary.

## 5.2 Visual Checks

Check that the radio is suitable for the required frequency range and IF bandwidth (refer to Section 1.4, "Product Codes").

Check that the programmed frequencies are correct.

Remove the covers from the T2000 and inspect the PCBs for damaged or broken components, paying particular attention to the surface mounted devices (SMDs).

Check for obvious mechanical faults in the PCBs, controls, microphone, etc.

Check for defective solder joints.

**Note:** If repair or replacement is considered necessary, refer to Section 3.4, "Repair".

## 5.3 Component Checks

### 5.3.1 Transistor Check

Measure the forward and reverse resistance of the transistor junctions, first making sure that the transistor is not shunted by some circuit resistance.

**Note:** A 20k $\Omega$ /V or better multimeter should be used for taking the measurements, using only the medium or low resistance ranges.

Check the collector current drawn by the transistor.

### 5.3.2 Integrated Circuit (IC) Check

Measure the DC operating voltages of the IC. Due to the catastrophic nature of most IC failures, the pin voltages will usually be markedly different from the recommended values in the presence of a fault. The recommended values can be obtained from either the circuit diagram or the component data catalogue.

## **5.4 DC Checks**

Refer to the “Radio Won’t Switch On” fault finding chart in Section 5.10.1.

Check all regulated supply voltages for the correct voltage levels. DC levels can be checked using the voltage information on the circuit diagrams.

## 5.5 Receiver RF Checks

### 5.5.1 VCO Frequency

Check that the VCO is phase locked.

Connect a frequency counter (level +10dBm) to the VCO input to the mixer (junction of C241 and L109).

Monitor the local oscillator frequency and check that it is above or below the required receive frequency according to the following list:

| Model         | Local Oscillator Frequency |
|---------------|----------------------------|
| T2000-100     | 27.7MHz below              |
| T2000-200     | 10.7MHz above              |
| T2000-300     | 27.7MHz above              |
| T2000-400     | 27.7MHz below              |
| 2000-500      | 49.1MHz below              |
| T2000-600     | 49.1MHz below              |
| T2000-700/900 | 49.1MHz below              |
| T2000-800     | 61.9MHz below              |

### 5.5.2 Control Line Voltages

The following table gives approximate control line voltage for receive and transmit at the band edges.

| Model     | Frequency (MHz) | Receive Control Line |                          | Transmit Control Line |                          |
|-----------|-----------------|----------------------|--------------------------|-----------------------|--------------------------|
|           |                 | VCO Frequency (MHz)  | Control Line Voltage (V) | VCO Frequency (MHz)   | Control Line Voltage (V) |
| T2000-100 | 220             | 192.3                | 4.5±0.5                  | 220                   | 7.6±0.5                  |
|           | 270             | 242.3                | 9.8±1                    | 270                   | 12.7±1                   |
| T2000-200 | 66              | 76.7                 | 7.3±0.6                  | 66                    | 4.5±0.6                  |
|           | 88              | 98.7                 | 13.8±1                   | 88                    | 11±1                     |
| T2000-300 | 136             | 163.7                | 7.5±0.6                  | 136                   | 4.5±0.6                  |
|           | 174             | 201.7                | 13±1                     | 174                   | 9.2±1V                   |
| T2000-400 | 175             | 147.3                | 4.5±0.6                  | 175                   | 7.8±0.7                  |
|           | 225             | 197.3                | 10.6±1                   | 225                   | 13.8±1                   |
| 2000-500  | 400             | 350.9                | 2.5±0.5                  | 400                   | 3±0.6                    |
|           | 470             | 420.9                | 13±1                     | 470                   | 13.5±0.7                 |
| T2000-600 | 450             | 400.9                | 2.5±0.5                  | 450                   | 2.2±0.5                  |
|           | 520             | 470.9                | 13±1                     | 520                   | 13.5±1                   |
| T2000-700 | 330             | 280.9                | 2.5±0.5                  | 330                   | 8.5±0.7                  |
|           | 360             | 310.9                | 6.3±0.7                  | 360                   | 12.3±0.7                 |
| T2000-800 | 851             | 789.1                | 1.8±0.5                  | 806                   | 3.8±0.5                  |
|           |                 |                      |                          | 825                   | 6.5±0.5                  |
|           | 870             | 808.1                | 4.5±0.5                  | 851                   | 9.5±0.5                  |
|           |                 |                      |                          | 870                   | 12.0±0.5                 |
| T2000-900 | 360             | 310.9                | 2±0.5                    | 360                   | 8±1                      |
|           | 400             | 350.9                | 7.5±1                    | 400                   | 12.5±1                   |

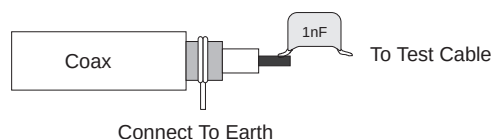
### 5.5.3 RF Sensitivity

Refer to the “Synthesiser Faults”, “Receiver Front End Faults” and “Receiver IF Faults” fault finding charts in Section 5.10.

Check that the VCO is on the correct frequency, and that the receiver is correctly aligned.

Check that the sensitivity into the front end is -119dBm (typical).

If the sensitivity is low (less than -117dBm), the fault can be traced by measuring the sensitivity into successive circuit blocks. Prepare a test cable by connecting a 1nF capacitor to the end of a length of coaxial cable, as shown below.



**Figure 5.1 RF Test Cable**

**Note:** Before using the test cable, ensure the coax braid is connected to an earth point on the PCB.

Using the RF test cable, apply a modulated signal to test points in the first IF section, at the first IF frequency, as follows:

| Model         | First IF Frequency (MHz) |
|---------------|--------------------------|
| T2000-100     | 27.7                     |
| T2000-200     | 10.7                     |
| T2000-300     | 27.7                     |
| T2000-400     | 27.7                     |
| 2000-500      | 49.1                     |
| T2000-600     | 49.1                     |
| T2000-700/900 | 49.1                     |
| T2000-800     | 61.9                     |

Alternatively, apply an on-channel RF signal to the front end test points.

Poor sensitivity indicates a fault in one of the circuit blocks following the test point. For typical sensitivity levels, refer to the fault finding charts.

**Note:** Poor sensitivity at the mixer input can be caused by lack of drive level from the VCO.

## 5.6 Transmitter RF Checks

Measure in-circuit RF levels with an RF probe. Typical RF levels can be found in the “Transmitter RF Low Power Faults” fault finding chart, in Section 5.10.8.

**Note:** Shorten the RF probe earth lead to a minimum.

## 5.7 Trunked Radios: System Check

### 5.7.1 Base Station Check

This checks that the local base station repeater is on air and checks that the correct base station frequency is programmed into the radio.

#### 5.7.1.1 T2030 Radios

Reprogram the first normal hunt channel to be the base station repeater channel number.

Enter test mode (refer to Section 5.8, “Trunked Radios: Test Mode”).

Press the front panel  key, and the FFSK should be audible.

#### 5.7.1.2 T2040 Radios

Enter test mode (refer to Section 5.8, “Trunked Radios: Test Mode”).

Enter the base station repeater channel number, and the FFSK should be audible.

### 5.7.2 Base Station Control Channel Hunt

This checks that the radio is hunting the base station control channel. Refer to the “Trunked Radios: Radio Won’t Acquire A Control Channel” fault finding chart in Section 5.10.11.

**Note:** Do *not* enter test mode.

Monitor pin 15 of IC510 (modem IC) on the T2030 or T2040 logic PCB, with a scope probe.

FFSK should be visible for 100ms as the radio scans (hunts) through the channels.

If the radio does not lock onto the required channel, this indicates one of the following faults:

- The parameters on the network identity page are incorrect.
- The acquisition authorisation is incorrect.
- The signal is not opening the mute (receiver mute fault, refer to the “Receiver Mute Faults” fault finding chart in Section 5.10.6).
- The programmed logical channel number is incorrect (even if the frequencies are correct).

## 5.8 Trunked Radios: Test Mode

### 5.8.1 Test Mode Overview

The test mode facility enables the trunked radio to emulate a multichannel radio, utilising the frequencies reserved for trunking. The radio can then be tested and aligned, as described in Section 4 and Section 6.

There are two test modes provided: manual and computer controlled.

- **Manual Test Mode (MTM):** Commands are entered and test results are displayed using the keys, LEDs and the display on the control head.
- **Computer Controlled Test Mode (CCTM):** Test commands are accepted via the serial port of the radio, and test results are returned as required. Although this mode is primarily intended for automated production testing, it may also be useful in the field.

No test facilities have been provided for functions relating to non-trunked operating mode (e.g. CTCSS), as these functions can be easily tested in non-trunked mode.

Within this Section, the following conventions apply:

- Characters within “ ” indicate a string sent or received via the serial communications port of the radio, e.g. a command code or an error code.
- Numbers without “ ” are function numbers, manually entered via the control head in MTM to select particular test functions.

**Caution:** When in test mode, connect the antenna socket to a dummy load to prevent interference with trunking systems. Avoid testing on channels in use locally.

### 5.8.2 Manual Test Mode (MTM)

Switch the radio off and remove the top cover.

Place a temporary link across the two pads labelled **TEST MODE** on the logic PCB.

Switch on the radio:

- **T2030 radios:** all the front panel indicators will illuminate briefly.
- **T2035 and T2060 radios:** the display will show “- -” for a short time.
- **T2040 radios:** the control head will display “**TEST MODE**” for a short time.

Remove the link. The radio will remain in test mode until it is next switched off.

In MTM, the following operations are common to T203X, T2040 and T2060 radios:

- A short beep is sounded after every key press.
- All models accept the reset command character (^).
- The microphone PTT switch functions as in normal operation, i.e. a PTT press/release selects transmit and receive respectively.
- LEDs or LCD annunciators are used to indicate transmit, synthesiser lock status and receive signal detect status (refer to Table 5.2, "Radio Mode/Status Display").

**Note 1:** MTM can also be selected by sending the MTM select command while in CCTM or program mode (refer to Table 5.1, "T2000 Test Facilities"), then switching the radio off then on again.

**Note 2:** This mode selection is 'sticky', in that the radio will always power-up in MTM if no serial device logs on, regardless of the state of the test link. This automatic mode selection can only be cleared by sending the appropriate command (refer to Table 5.1, "T2000 Test Facilities").

**Note 3:** Increment channels in MTM by shorting S14 pin 10 (/EMRGNCY) to ground. When the highest channel is reached, the next increment selects the lowest channel.

### 5.8.2.1 T2030 & T2035 MTM Operation

#### T2030 Radios

Four preset channels are available via the four preset keys **C1** to **C4**, and their associated LEDs show the current channel. All four channels can be programmed to any frequency within the full coverage band of the radio.

- **C1** selects the channel with the lowest number (i.e. the lowest channel in the network).
- **C2** selects halfway between the highest and lowest channels available, rounding up to the nearest channel.
- **C3** selects the channel with the highest number (i.e. the highest channel in the network).
- **C4** selects the first channel in the normal hunt list.

#### T2035 Radios

- To select a channel, enter the channel number required using the front panel keys, and press the **call** key **Ⓢ**.
- The **clear** key **ⓧ** enables & disables the minimum shift keying (MSK) modem transmit, and the **clear** LED momentarily shows status. Action of the key is push-on/push-off. When the modem transmit is enabled, the microphone audio is muted and when the modem transmit is disabled, the microphone audio is unmuted.

When the radio is in receive, the modem transmit is temporarily disabled (and the microphone audio is muted), but this is not shown by the **clear** LED.

- The **despatch** key  selects MSK modem transmit test patterns. The **despatch** LED is off for zeros, on for ones and flashing when preamble is being sent. Successive depressions of the key will scroll through the three states. Whenever the **despatch** key  is pressed, the modem transmit is enabled unless the radio is in receive, in which case the **clear** LED will illuminate momentarily.
- The **queue** key  controls the transmit power output of the radio. The **queue** LED is off for low power, on for high power and flashes when maximum power has been selected. Successive depressions of the key will scroll through the three states.  
Each time the channel is changed, the transmit power is reset to the level programmed for the new channel and is indicated by the **queue** LED.

### 5.8.2.2 T2040 & T2050 MTM Operation

Test functions are selected by entering a two digit number followed by the **terminator** key .

Channels are selected by pressing the  key ("Chan" will appear in the display), followed by a one to four digit channel number and terminated with the **terminator**  key.

After every valid command execution, a confirmation will appear in the control head display in the form of a message. A confirmation tone is also sounded. Entries that are invalid for any reason, e.g. an invalid function or channel number, result in a displayed message and a warning tone.

### 5.8.3 Computer Controlled Test Mode (CCTM)

In CCTM, test commands are accepted via the serial port of the radio and test results are returned as required. To send and receive commands from the radio it is necessary to run a 'dumb terminal' emulation program on a PC.

The serial communications port parameters are as follows:

- Logic levels:  
Out: 0V = '1', +5V = '0'  
In: -12V to 0V = '1', +3V to +12V = '0'
- A programming lead may be used to convert the output to RS232 voltage levels.
- No handshaking (RTS, CTS etc. not implemented).
- Full duplex.
- 4,800 baud.
- One start bit, eight data bits, one stop bit, no parity.
- Flow control:  $X_{on}/X_{off}$

### 5.8.3.1 CCTM Selection

After power-up, a reset command or a hardware reset, the radio sends the logon prompt character "v". Replying with an ASCII "%" within 500ms of the prompt will put the radio in CCTM.

The radio will confirm engagement of CCTM by sending the prompt "-", preceded by a "CR".

**Note:** If no reply is received within the required period, the radio will engage normal trunked mode, or MTM if the test link is fitted or the 'sticky' MTM is active.

If CCTM is engaged when the test link is fitted, the radio sends an error message and gives a unique error indication (refer to Table 5.2, "Radio Mode/Status Display").

While in CCTM, MTM can be selected (refer to Section 5.8.2). This will not come into effect until after the next power-up or reset. To re-engage CCTM without switching the radio off then on, a reset command can be sent to reset the radio and restart logon prompting.

### 5.8.3.2 CCTM Protocol

- The radio accepts commands in any of the following formats:
  - A two digit ASCII string selects the corresponding test function.
  - A "\*" character followed by a one to four digit channel number (in ASCII) sets the radio to that channel.
- Each command must be terminated with an ASCII "CR" character to initiate execution of the command.
  - If the command requires no reply, the radio then responds with a "-" prompt character.
  - If a reply is required, the radio responds with a data string followed by a "CR" and a "-" prompt. The "-" prompt indicates that the radio is ready to accept the next command.
- There is only ever a single reply string to any command.
- Invalid commands, e.g. an invalid function number or channel number or invalid characters in a command, cause a "{C01}", followed by "CR" and "-", to be sent in reply, indicating a command error.
- In CCTM the radio will accept a reset command character (refer to Section 5.8.5).
- ASCII line feed characters are permitted at any time, but are ignored so that test commands may be terminated with "CR" or "LF".
- All switches (including PTT, hook etc), keys and displays on the front panel or control head of the radio are disabled while in CCTM, and no tones are sounded.

## 5.8.4 Power-Up State

When manual or automated test mode is engaged after logon, the radio will be in the following state, where applicable to particular radio models. The numbers in brackets refers to the test facility, as described in Table 5.1, "T2000 Test Facilities".

- Synthesiser programmed to the last selected channel.
- Modem transmit off (13).
- Force receive audio muted if in transmit mode (20).
- Force receive audio unmuted if in receive mode (21).
- Microphone audio muted if in receive mode (22).
- Microphone audio unmuted if in transmit mode (23).
- Radio power amplifier enabled (31).
- Radio set to receive if PTT released on power-up (32).
- Radio set to transmit if PTT pressed at power-up (33).
- 13.8V switched supply on / ECN off (43).
- Radio not in state for current measurement test (45).
- Microprocessor clock rate set as programmed for the channel if in receive mode.
- Microprocessor clock rate 'normal' if in transmit mode (70).
- Radio transmit power set as programmed for the channel.

The behaviour of the front panel or control head digital display and/or LEDs is described in Table 5.2, "Radio Mode/Status Display".

## 5.8.5 Test Facilities Available

### 5.8.5.1 Resetting The Radio

The radio may be reset at any time in any of the following ways:

- Switch the radio off then on again.
- Momentarily connect the microprocessor 'reset' pin to ground (pads are provided on the enhanced control PCB).
- Send a reset command character (^) over the serial communications port (refer to Table 5.1).

**Note:** The radio will not respond to the reset character after an EPROM or RAM test failure.

### 5.8.5.2 Test Facilities Table

The following table lists the test facilities available in MTM and CCTM for the T203X, T2040 and T2050. Facilities for the T2010, T2015 and T2020 are also listed for comparison, and further information about the tests is listed following the table.

Within the table, a '-' indicates the corresponding facility is not available, and "nnnn" is a one to four digit channel number (leading zeros are permitted).

|                                             | T2010/T2015                |      | T2020                      |      | T203X                                                                                                                                                                           |      | T2040/T2050 |      |
|---------------------------------------------|----------------------------|------|----------------------------|------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|-------------|------|
|                                             | Normal                     | CCTM | Normal                     | CCTM | Man                                                                                                                                                                             | Auto | Man         | Auto |
| <b>Signalling functions:</b>                |                            |      |                            |      |                                                                                                                                                                                 |      |             |      |
| 10. set modem to send zeros                 | -                          | -    | -                          | -    |  &<br> keys | 10   | 10          | "10" |
| 11. set modem to send ones                  | -                          | -    | -                          | -    |                                                                                                                                                                                 | 11   | 11          | "11" |
| 12. set modem to send preamble              | -                          | -    | -                          | -    |                                                                                                                                                                                 | 12   | 12          | "12" |
| 13. disable modem Tx                        | -                          | -    | -                          | -    |                                                                                                                                                                                 | 13   | 13          | "13" |
| 14. read modem Rx state                     | -                          | -    | -                          | -    | -                                                                                                                                                                               | 14   | -           | "14" |
| 15. disable subaudible signal               | } by<br>channel<br>speaker | -    | } by<br>channel<br>speaker | "15" | -                                                                                                                                                                               | -    | -           | -    |
| 16. enable subaudible signal                |                            | -    |                            | "16" | -                                                                                                                                                                               | -    | -           | -    |
| 17. read signalling decode status           |                            | "17" |                            | "17" | -                                                                                                                                                                               | -    | -           | -    |
| <b>Mute functions:</b>                      |                            |      |                            |      |                                                                                                                                                                                 |      |             |      |
| 20. force Rx audio muted                    | -                          | -    | -                          | "20" | -                                                                                                                                                                               | "20" | 20          | "20" |
| 21. force Rx audio unmuted                  | l-MON*                     | "21" | l-MON                      | "21" |                                                                                               | "21" | 21          | "21" |
| 22. mute microphone audio                   | -                          | "22" | -                          | "22" | -                                                                                                                                                                               | "22" | 22          | "22" |
| 23. unmute microphone audio                 | -                          | "23" | -                          | "23" | -                                                                                                                                                                               | "23" | 23          | "23" |
| 24. let squelch control Rx audio            | s-MON                      | "24" | s-MON                      | "24" |                                                                                              | "24" | 24          | "24" |
| 25. read squelch Rx busy status             | -                          | -    | -                          | "25" | -                                                                                                                                                                               | "25" | -           | "25" |
| 26. relax Rx audio mute control             | s-MON                      | "26" | s-MON                      | "26" | -                                                                                                                                                                               | -    | -           | -    |
| <b>Radio Rx/Tx functions:</b>               |                            |      |                            |      |                                                                                                                                                                                 |      |             |      |
| 30. inhibit the PA (Tx mode)                | -                          | -    | -                          | -    | -                                                                                                                                                                               | "30" | 30          | "30" |
| 31. enable the PA (Tx mode)                 | -                          | -    | -                          | -    | -                                                                                                                                                                               | "31" | 31          | "31" |
| 32. set radio to Rx                         | see                        | "32" | see                        | "32" | -                                                                                                                                                                               | "32" | 32          | "32" |
| 33. set radio to Tx                         | below                      | "33" | below                      | "33" | -                                                                                                                                                                               | "33" | 33          | "33" |
| 34. set PA to low power                     |                            | "34" |                            | "34" | use                                                                                                                                                                             | "34" | 34          | "34" |
| 35. set PA to high power                    | } by<br>channel            | "35" | } by<br>channel            | "35" |  or                                                                                         | "35" | 35          | "35" |
| 36. set PA to max power                     |                            | "36" |                            | "36" |  key                                                                                        | "36" | 36          | "36" |
| 37. relax PA power control                  |                            | "37" |                            | "37" | -                                                                                                                                                                               | -    | -           | -    |
| <b>Power supply functions</b>               |                            |      |                            |      |                                                                                                                                                                                 |      |             |      |
| 42. 13.8VSW off /ECN on                     | -                          | -    | -                          | "42" | -                                                                                                                                                                               | "42" | 42          | "42" |
| 43. 13.8VSW on /ECN off                     | -                          | -    | -                          | "43" | -                                                                                                                                                                               | "43" | 43          | "43" |
| 44. set radio state for current measurement | -                          | -    | -                          | -    | -                                                                                                                                                                               | "44" | -           | "44" |
| 45. cancel current measurement state        | -                          | -    | -                          | -    | -                                                                                                                                                                               | "45" | -           | "45" |
| <b>RSSI functions:</b>                      |                            |      |                            |      |                                                                                                                                                                                 |      |             |      |
| 61. Set L1 threshold                        | -                          | -    | -                          | -    | -                                                                                                                                                                               | "61" | 61          | "61" |
| 62. set L2 threshold                        | -                          | -    | -                          | -    | -                                                                                                                                                                               | "62" | 62          | "62" |
| 63. read averaged RSSI level                | -                          | -    | -                          | "63" | -                                                                                                                                                                               | "63" | 63          | "63" |
| 64. read L1                                 | -                          | -    | -                          | -    | -                                                                                                                                                                               | "64" | 64          | "64" |
| 65 read L2                                  | -                          | -    | -                          | -    | -                                                                                                                                                                               | "65" | 65          | "65" |
| <b>Miscellaneous functions:</b>             |                            |      |                            |      |                                                                                                                                                                                 |      |             |      |
| 70. select normal µP clock rate             | -                          | -    | } by<br>channel            | "70" | -                                                                                                                                                                               | "70" | 70          | "70" |
| 71. select birdie µP clock rate             | -                          | -    |                            | "71" | -                                                                                                                                                                               | "71" | 71          | "71" |
| 72. read synth. lock status                 | -                          | -    |                            | "72" | -                                                                                                                                                                               | "72" | -           | "72" |
| 73. relax µP clock control                  | -                          | -    |                            | "73" | -                                                                                                                                                                               | -    | -           | -    |

|                                                   | T2010/T2015                                         |               | T2020                 |        | T203X                                                                    |        | T2040/T2050 |        |
|---------------------------------------------------|-----------------------------------------------------|---------------|-----------------------|--------|--------------------------------------------------------------------------|--------|-------------|--------|
|                                                   | Normal                                              | CCTM          | Normal                | CCTM   | Man                                                                      | Auto   | Man         | Auto   |
| <b>Special functions:</b>                         |                                                     |               |                       |        |                                                                          |        |             |        |
| 92. set 'sticky' MTM                              | -                                                   | -             | -                     | -      | -                                                                        | "92"   | -           | "92"   |
| 93. clear 'sticky' MTM                            | -                                                   | -             | -                     | -      | -                                                                        | "93"   | -           | "93"   |
| 94. read serial number                            | -                                                   | "94"          | -                     | "94"   | -                                                                        | "94"   | -           | "94"   |
| 95. read factory model ID                         | -                                                   | "95"          | -                     | "95"   | -                                                                        | "95"   | -           | "95"   |
| 99. get current channel number                    | -                                                   | -             | -                     | -      | -                                                                        | -      | -           | -      |
| <b>Radio channel control:</b><br>select a channel | T2010:<br>① to<br>④<br><br>T2015:<br>▲<br>▼<br>keys |               |                       |        | T2030:<br>C1 to<br>C4<br><br>T2035:<br>Select<br>channel<br>& press<br>δ |        |             |        |
|                                                   |                                                     | "*n"          | chan                  | "*nnn" |                                                                          | "*nnn" | *nnn        | "*nnn" |
| <b>Single character commands:</b>                 |                                                     |               |                       |        |                                                                          |        |             |        |
| reset the radio                                   | "^"                                                 | "^"           | "^"                   | "^"    | "^"                                                                      | "^"    | "^"         | "^"    |
| select programming mode                           | "#"                                                 | "#"           | "#"                   | "#"    | "#"                                                                      | "#"    | "#"         | "#"    |
| select auto test mode                             | "%"                                                 | "%"           | "%"                   | "%"    | "%"                                                                      | "%"    | "%"         | "%"    |
| <b>Radio controls &amp; indicators:</b>           |                                                     |               |                       |        |                                                                          |        |             |        |
| PTT press = select Tx mode                        | yes                                                 | -             | yes                   | -      | yes                                                                      | -      | yes         | -      |
| PTT release = select Rx mode                      | yes                                                 | -             | yes                   | -      | yes                                                                      | -      | yes         | -      |
| channel increment input                           | -                                                   | -             | -                     | -      | pin 10, S14                                                              | -      | ECR         | -      |
| Tx indicator                                      | Tx                                                  | Tx            | Tx                    | -      | TX                                                                       | -      | TX          | -      |
| synth. out of lock indicator                      | flash<br>chan                                       | flash<br>chan | flash<br>TX &<br>BUSY | -      | SVC                                                                      | -      | SVC         | -      |
| RF signal detected indicator                      | LED<br>BUSY                                         | LED<br>BUSY   | BUSY                  | -      | GO                                                                       | -      | GO          | -      |

\* 'l-MON' & 's-MON' indicate a long (>1s) and a short (<1s) press of the **monitor** key , respectively.

**Table 5.1 T2000 Test Facilities**

- In MTM, functions **10 - 13, 21**, channel selection and PTT control of receive/transmit are all required for MPT1352 testing. Type approval testing requires the channel increment facility using an external input.
- All test function requests are valid when the radio is in either receive or transmit but some functions (**10, 11, 12, 21, 23** and **24**) take effect only when the radio is in the appropriate mode.
- **10 - 13, 22, 23**: When any of the functions which set the modem sending test data are selected (functions **10 - 12**), the microphone audio is automatically muted. When the microphone audio is unmuted using function **23**, the modem transmit is disabled.

**When the radio is in receive, the microphone audio is temporarily muted and the modem transmit is temporarily disabled. This prevents any unwanted TCXO modulation which may occur on radios with dual point modulation.**

**These automatically selected states can be overridden until the next transmit to receive transition. If microphone unmute or modem transmit enable is requested when the radio is in receive, these functions will not be actioned until the radio is in transmit.**

- **10, 11, 12**: The two modem data states selected by functions 10 and 11 are '0' = 1800Hz tone and '1' = 1200Hz tone respectively. Preamble, selected by function 12, is alternating 1800 and 1200Hz tones at a rate of 1200 baud.

- **14, 25, 72:** These functions return a Boolean radio status value, either a '0' or a '1', as follows:

| Return Value                       | '0'                   | '1'                |
|------------------------------------|-----------------------|--------------------|
| <b>14</b> - read modem Rx state    | data = 0              | data = 1           |
| <b>25</b> - read Rx busy state     | no RF signal detected | RF signal detected |
| <b>72</b> - read synth lock status | out of lock           | in lock            |

- **20:** The receive audio is muted temporarily to quieten the speaker whenever the radio is in transmit. This state may be temporarily overridden until the next receive to transmit transition. If 'force Rx audio unmuted' (**21**) or 'let squelch control Rx audio' (**24**) is requested when the radio is in transmit, the function will not be selected until after the radio is in receive.
- **32, 33:** Functions 32 and 33 are provided in MTM so that the radio transmit state can be sustained without the need to hold the PTT depressed. Caution must be exercised to prevent the power amplifier from overheating.
- **42, 43:** Select economy/non-economy state. In economy state the audio power amplifier is disabled and the front panel backlighting is set to its programmed economy state. In non-economy state, the audio power amplifier is enabled and the backlighting is set to its normal programmed state.
- **44, 45:** Engage/disengage radio state for measurement of typical trunked mode supply current drain. In this state only the 'SVC' and 'C1' LEDs are switched on and non-economy state is selected (function **43**). Upon disengagement, the previous display is reinstated but the economiser state is not altered.
- **61, 62:** To set up the RSSI thresholds, apply an RF signal to the radio (on an appropriate receive channel) at the threshold level. Allow at least 400ms for the RSSI averaging to settle, then select function **61** or **62** as required.

The averaged RSSI threshold value (in decimal full scale = 255) is either displayed if in MTM or returned via the serial port if the radio is under computer control. The value is also stored in the radio's database (in the microprocessor EEPROM) and the database checksum is automatically updated.

- **63:** In MTM, function 63 gives a regularly updated display of the averaged RSSI value. The leftmost decimal point will light when the RSSI level equals or exceeds L1, and the rightmost decimal point will light when the RSSI level equals or exceeds L2.

In CCTM a single averaged RSSI value is returned.

**At least 400ms should be allowed after any change in signal level for the returned value to be accurate.**

- **94:** Returns the serial number part of the radio's ESN as a number of up to 6 digits with leading zeros suppressed.
- **95:** Returns the factory programmed 'factory model ID' as a string of six decimal digits.
- **99:** This function is intended to allow easy modification of the current channel number via the number entry keys.

## 5.8.6 Trunked Radios: Radio Mode/Status Display Codes

The mode or status of the radio is indicated by the behaviour of:

- the monitor LEDs (ML1 and ML2) on the top side of the logic PCB
- the radio control head LEDs.

Unless otherwise stated, the two monitor LEDs behave as in normal operation:

- ML2 is off
- ML1 flashes at a rate of 1Hz to indicate watchdog timer 'kick' activity
- In normal trunked radio mode, ML2 flashes at a rate of several Hertz. This indicates control channel hunt or codeword reception on a control channel.

A value in brackets { } with a mode/status description indicates that the radio sends an error message via the serial port upon engaging that mode/status.

This table identifies display states for trunked radios, with non-trunked models for comparison.

| Mode/State                                                    | T2010/T2015                                                                   | T2020                                                                        | T2030/T2035                                                                                                              | T2040                                                                        |
|---------------------------------------------------------------|-------------------------------------------------------------------------------|------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------|
| <b>CONFIG error</b>                                           |                                                                               | Monitor LEDs flashing together. Display shows "CONF-ERR"                     | Monitor LEDs flashing together. Top & bottom row LEDs flashing. C1 LED on (if fitted)                                    | Monitor LEDs flashing together. Display shows "CONF-ERR"                     |
| <b>CONFIG register programmed</b>                             |                                                                               | Display shows "CONF-PGM"                                                     | Display undefined                                                                                                        | Display shows "CONF-PGM"                                                     |
| <b>ROM or RAM test failure</b>                                | CTCSS output toggling. Display undefined                                      | Tone output toggling. Display undefined                                      | Tone output toggling. LEDs undefined                                                                                     | Tone output toggling. Display undefined                                      |
| <b>ESN checksum error {X31}<br/>(go to program mode)</b>      |                                                                               |                                                                              | As for program mode + CLR LED flashing. T2035: display shows "-U1"                                                       | Display shows "ESN-ERR"                                                      |
| <b>Database checksum error {X32}<br/>(go to program mode)</b> | As for program mode.<br>2010: all channel LEDs on<br>2015: display shows "00" | Display shows "-PROG-"<br>Top row LEDs on                                    | As for program mode + DESP LED flashing.<br>T2035: display shows "-U2"                                                   | Display shows "-DATA-ERR-"<br>Top row LEDs on.                               |
| <b>System error {Enn}</b>                                     |                                                                               | Monitor LEDs alternately flashing "-ERROR nn" in display (nn = error number) | Monitor LEDs & top row LEDs flashing.<br>2 digit BCD error number on bottom rows.<br>T2035: display flashes error number | Monitor LEDs alternately flashing. "ERROR nn" in display (nn = error number) |
| <b>MOBD link left in &amp; CONFIG register OK {X06}</b>       |                                                                               | Display error shows "MOBD-ERR"                                               | Top & bottom row LEDs flashing + C2 LED on (if fitted)                                                                   | Display shows "MOBD-ERR"                                                     |
| <b>Logon with test link in {X07}</b>                          |                                                                               |                                                                              | Top & bottom row LEDs flashing + C3 LED on (if fitted)                                                                   | Display shows "TLINK-ERR"                                                    |
| <b>Key/LED test failure {X04}</b>                             |                                                                               |                                                                              | LED flashing shows error - all LEDs to right & below on                                                                  |                                                                              |

| Mode/State                                         | T2010/T2015                                                                                                                                                                                                  | T2020                                                                                                | T2030/T2035                                                                                                                                                                | T2040                                                                                                                    |
|----------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------|
| <b>Program mode</b>                                | 2010: all channel LEDs on<br>2015: display shows "00"                                                                                                                                                        | Display shows "-PROG-"<br>Top row LEDs on                                                            | Top row + C1 LEDs all on (if fitted)<br>T2033/35: display shows "-UU"                                                                                                      | Display shows "-PROG-"<br>Top row LEDs on                                                                                |
| <b>Cloning mode</b>                                | AUX LED flashing.<br>AUX/SCAN LEDs flash if clone failed.<br>Target radio in programming mode.                                                                                                               | Display shows "CLONING" Top row LEDs on. Target radio in programming mode.                           |                                                                                                                                                                            |                                                                                                                          |
| <b>Manual Test Mode (MTM)</b>                      |                                                                                                                                                                                                              |                                                                                                      | All LEDs on for a short time then indicate radio status.<br>C1 to C4 show last channel (if fitted).<br>T2035: display shows "- - -" briefly                                | Display shows "chan xxxx" (xxxx = last channel number). LEDs indicate radio status                                       |
| <b>Key pressed at power-up (control head test)</b> | [AUX] = clone<br>[CALL] = program                                                                                                                                                                            | Any key on the control head & any mode.<br>All LEDs & all LCD segments are set flashing indefinitely | C1 key (if fitted) in MTM<br>- a front panel key / LED test is initiated - all LEDs on initially                                                                           | Any key on the control head & any mode. All LEDs & all LCD segments are set flashing indefinitely                        |
| <b>Computer Controlled Test Mode (CCTM)</b>        | Front panel shows normal radio state (not a separate mode)                                                                                                                                                   | Display shows "-AUTOTEST-" Top row LEDs on                                                           | Top row + C2 LEDs (if fitted) all on.<br>T2035: display shows "- - -" continuously                                                                                         | Display shows "AUTOTEST"<br>Top row of LEDs on                                                                           |
| <b>CCI mode</b>                                    |                                                                                                                                                                                                              | Normal display "CCI BUSY" & top row LEDs on when processing a command or in 'lockout all' mode       |                                                                                                                                                                            | Normal display "CCI BUSY" & top row LEDs on when processing a command or in 'lockout all' mode.                          |
| <b>Normal radio mode</b>                           | No special power-up sequence - normal radio state immediately displayed                                                                                                                                      | Programmable power-up message displayed for a short time then normal radio display (default mode)    | T2030: own number as CD on 3 rows of LEDs, then last number on C1 to C4 & DESP LEDs. Others as labelled.<br>T2035: Own number briefly on display, then last number called. | Own number displayed for a short time after power-up then programmable power-up message followed by normal radio display |
| <b>PTT on power-up in MTM or normal mode</b>       | Software version # indicated for a short time as "h.nn". "h" is shown with the Busy and TX LEDs as a hex number. "n's" are indicated by the two lower rows of LEDs (2010), or by the channel display (2015). | Display shows "xxxx nn.mm" for a short time, nn = major, mm = minor version number                   | T2030: 3 rows of LEDs display the software version # for a short time as h.nn (h is a hex number) then as per selected mode.<br>T2035: software version number on display. | Display shows "xxxx nn.mm" for a short time, nn = major mm = minor version number, then as per selected mode             |

Table 5.2 Radio Mode/Status Display

## 5.9 Options Interface Specifications

The options connectors, S13 and S14, are located on the top side of the T2000 logic PCBs, and are provided for use with plug-on accessory PCBs.

The following tables describe the signals available on these connectors, and also on S15 (T2010 & T2015 logic PCB).

| Connection (to/from)                        | Pin No. | Used for                      | Level for 1kHz AF 60% FM  | $Z_1$<br>$\Omega$ | $Z_0$<br>$\Omega$ | Min.<br>$Z_L$ | DC Level | Slope dB/8 | LF -3dB Hz     | HF -3dB Hz |
|---------------------------------------------|---------|-------------------------------|---------------------------|-------------------|-------------------|---------------|----------|------------|----------------|------------|
| DET-AF-OUT (from detector via 3kHz LPF)     | S13-1   | CTCSS data, DCS, Selcall      | 400mVp-p                  |                   | <1k               | 1k            | 3.3V     | flat       | 10             | 3.4k       |
| ALC-IN (to compressor)                      | S13-2   |                               | 0.2Vp-p                   | 2.2k              |                   |               | 0V       | +6         | 0.25k          | 3.4k       |
| RX-LINE-OUT (de-emphasised receiver audio)  | S13-3   | to accessory line interface   | 0.4Vp-p                   |                   | 100               | 10k           | 3.3V     | -6         | 0.23k or 0.35k | 3.4k       |
| TX-LINE-OUT (from ALC)                      | S13-4   | to accessory                  | 1.2Vp-p                   |                   | <1k               | 1k            | 3.3V     | flat       | 70             | 33k        |
| RX-LINE-IN (to squelch element)             | S13-5   | from accessory                | 0.4Vp-p                   | 5k*               |                   |               | 3.3V     | flat       | 0.18k          | 20k        |
| TX-LINE-IN (to pre-emphasis)                | S13-6   | from accessory line interface | 1.2Vp-p                   | 5k*               |                   |               | 3.3V     | +6V        | 0.25k          | 3k         |
| RX-GTD-AF (Rx Audio from after squelch)     | S13-7   | line interface                | 0.4Vp-p                   |                   | 10k               | 0.2M          | 3.3V     | flat       | 0.23k or 0.35k | 3.4k       |
| TX-SIG-IN (to limiter)                      | S13-8   | data Selcall                  | 2.5Vp-p                   | 470k              |                   |               | 3.3V     | flat       | 4              | 3.4k       |
| RX-BEEP (to AF PA with min. volume stop)    | S13-9   | sidetone                      | 0.5Vp-p                   | 470k              |                   |               | AC       | flat       | 0.18k          | 20k        |
| TX-LF-SIG (to LPF)                          | S13-10  | CTCSS, DCS                    | 5.0Vp-p for 12% deviation | 2.2k              |                   |               | 3.3V     | flat       | 4              | 3.4k       |
| OPTIONS-GND (connected to ground on RF PCB) | S13-11  |                               |                           |                   |                   |               |          |            |                |            |

\* An accessory with low impedance outputs (<10 $\Omega$ ) may be connected without removing 10k $\Omega$  links R638 and R673

**Table 5.3 Options Connectors - Audio Signal Specifications**

| Connection (to/from) | Pin No. | Function                                 | Available Current                                          |
|----------------------|---------|------------------------------------------|------------------------------------------------------------|
| +13.8V-UNSW          | S13-12  | - emergency: to bypass the on/off switch | 0.5A                                                       |
| +13.8V               | S14-1   | - supply to options with own regulators  | 200mA (remote loom resistance = 0.43 $\Omega$ /loop meter) |
| +5V                  | S14-2   | supply to options                        | 150mA                                                      |

**Table 5.4 Options Connectors - Supply Voltage Specifications**

| Connection                                   | Pin No.                                                 | Function                                                                                | Logic Levels   | Logic Sense      | Sink $I_{\max}$ | Source $I_{\max}$ | $Z_{in}$ |
|----------------------------------------------|---------------------------------------------------------|-----------------------------------------------------------------------------------------|----------------|------------------|-----------------|-------------------|----------|
| BUSY                                         | S14-3                                                   | carrier detect<br>opening time: <35ms<br>closing time: <20ms<br>(8dB sinad, 6dB margin) | 0V 5V          | 0V = busy        | 0.5mA           | 0.1mA             |          |
| RX-GATE                                      | S14-4                                                   | Rx audio gate information                                                               | 5V CMOS        | 5V = audio       | 1.5mA           | 0.3mA             |          |
| /PTT-TO-OPT                                  | S14-5                                                   | from mic.; linked to 18                                                                 | pull-up        | 0V = Tx          | 1.5mA           | 50 $\mu$ A        | 2k7      |
| /PTT-FRM-OPT                                 | S14-6                                                   | Tx                                                                                      | 5V CMOS        | 0V = Tx          |                 |                   | CMOS     |
| /IN-LOCK                                     | S14-7                                                   | synthesiser lock detect<br>(lock-up time: <20ms)                                        | 0V 5V          | 0V = lock        | 0.2mA           | 0.2mA             |          |
| MIC-MUTE                                     | S14-8                                                   | disables AF from mic. only                                                              | 5V CMOS        | 5V = mute        |                 |                   | 200k     |
| /SIG-SQLCH                                   | S14-9                                                   | Rx audio gate control                                                                   | open c.        | 0V = AF muted    |                 |                   | 47k      |
| /EMERGENCY                                   | S14-10                                                  | starts s/w sequence                                                                     | open c.        | 0V = emergency   |                 |                   | 10k      |
| CALL-SW                                      | S14-11                                                  | front panel control                                                                     | 5V CMOS        |                  | 1.5mA           | 0.3mA             |          |
| HUSH                                         | S14-12                                                  | car radio mute output                                                                   | 5V CMOS        |                  | 1.5mA           | 0.3mA             |          |
| AUX-ON/OFF                                   | S14-13                                                  | front panel control                                                                     | 5V CMOS        |                  | 1.5mA           | 0.3mA             |          |
| HORN                                         | S14-14                                                  | Selcall horn alert                                                                      | 5V CMOS        |                  | 1.5mA           | 0.3mA             |          |
| RSSI                                         | S14-15                                                  | Rx signal strength                                                                      | 0 - 50 $\mu$ A | 0.8 $\mu$ A/dB   |                 |                   |          |
| EXTERNAL                                     | S14-16                                                  | line to power plug                                                                      |                |                  |                 |                   |          |
| BCD0<br>BCD1<br>BCD2<br>BCD3<br>BCD4<br>BCD5 | S15-9<br>S15-10<br>S15-11<br>S15-12<br>S15-13<br>S15-13 | channel change option<br>on T201X*                                                      | 0 - 5V CMOS    | 0V = 0<br>5V = 1 |                 |                   | 10k      |

\* Refer to BCD selection table.

**Table 5.5 Options Connectors - Logic Signal Specifications**

The following table shows the BCD codes for T2010 and T2015 radios under external channel control.

**Note:** T2010 has 4 channels accessible by BCD and T2015 has 24 channels accessible by BCD

| BCD Channel Number Codes |       |       |       |       |       | BCD Number | Channel Number |
|--------------------------|-------|-------|-------|-------|-------|------------|----------------|
| BCD-5                    | BCD-4 | BCD-3 | BCD-2 | BCD-1 | BCD-0 |            |                |
| 0                        | 0     | 0     | 0     | 0     | 0     | 0          | 1              |
| 0                        | 0     | 0     | 0     | 0     | 1     | 1          | 2              |
| 0                        | 0     | 0     | 0     | 1     | 0     | 2          | 3              |
| 0                        | 0     | 0     | 0     | 1     | 1     | 3          | 4              |
| 0                        | 0     | 0     | 1     | 0     | 0     | 4          | 5              |
| 0                        | 0     | 0     | 1     | 0     | 1     | 5          | 6              |

| BCD Channel Number Codes |       |       |       |       |       | BCD Number | Channel Number |
|--------------------------|-------|-------|-------|-------|-------|------------|----------------|
| BCD-5                    | BCD-4 | BCD-3 | BCD-2 | BCD-1 | BCD-0 |            |                |
| 0                        | 0     | 0     | 1     | 1     | 0     | 6          | 7              |
| 0                        | 0     | 0     | 1     | 1     | 1     | 7          | 8              |
| 0                        | 0     | 1     | 0     | 0     | 0     | 8          | 9              |
| 0                        | 0     | 1     | 0     | 0     | 1     | 9          | 10             |
| 0                        | 1     | 0     | 0     | 0     | 0     | 10         | 11             |
| 0                        | 1     | 0     | 0     | 0     | 1     | 11         | 12             |
| 0                        | 1     | 0     | 0     | 1     | 0     | 12         | 13             |
| 0                        | 1     | 0     | 0     | 1     | 1     | 13         | 14             |
| 0                        | 1     | 0     | 1     | 0     | 0     | 14         | 15             |
| 0                        | 1     | 0     | 1     | 0     | 1     | 15         | 16             |
| 0                        | 1     | 0     | 1     | 1     | 0     | 16         | 17             |
| 0                        | 1     | 0     | 1     | 1     | 1     | 17         | 18             |
| 0                        | 1     | 1     | 0     | 0     | 0     | 18         | 19             |
| 0                        | 1     | 1     | 0     | 0     | 1     | 19         | 20             |
| 1                        | 0     | 0     | 0     | 0     | 0     | 20         | 21             |
| 1                        | 0     | 0     | 0     | 0     | 1     | 21         | 22             |
| 1                        | 0     | 0     | 0     | 1     | 0     | 22         | 23             |
| 1                        | 0     | 0     | 0     | 1     | 1     | 23         | 24             |

*Table 5.6 BCD Channel Selection (T2010 & T2015 only)*

## Connectors S16, S17 and S18

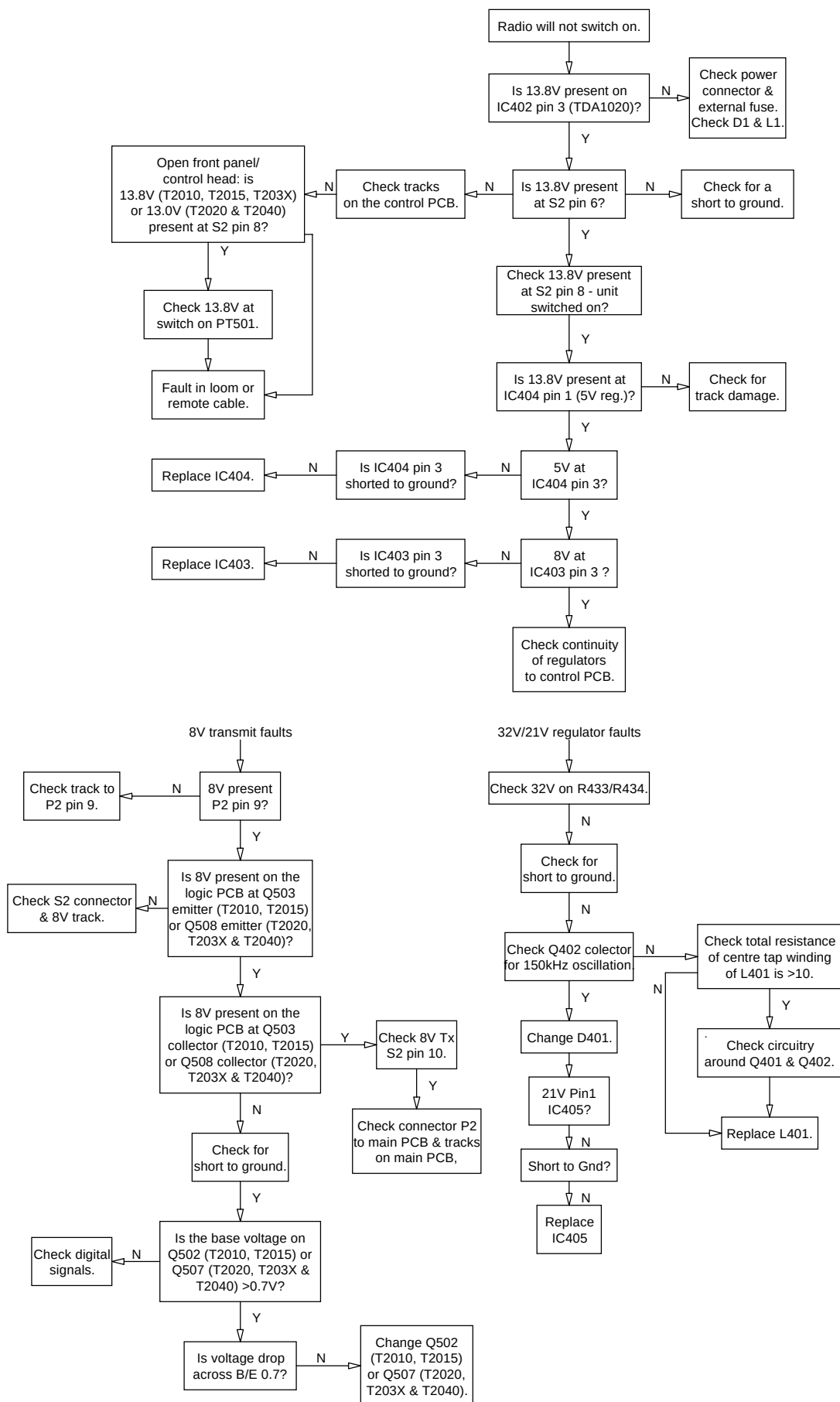
Additional microprocessor control signals are available on the T2020, T203X, T2040, T2050 and T2060 HC11 logic PCB (PCB IPN 220-01344-0X), on connectors S16, S17 and S18.

## 5.10 Fault Finding Charts

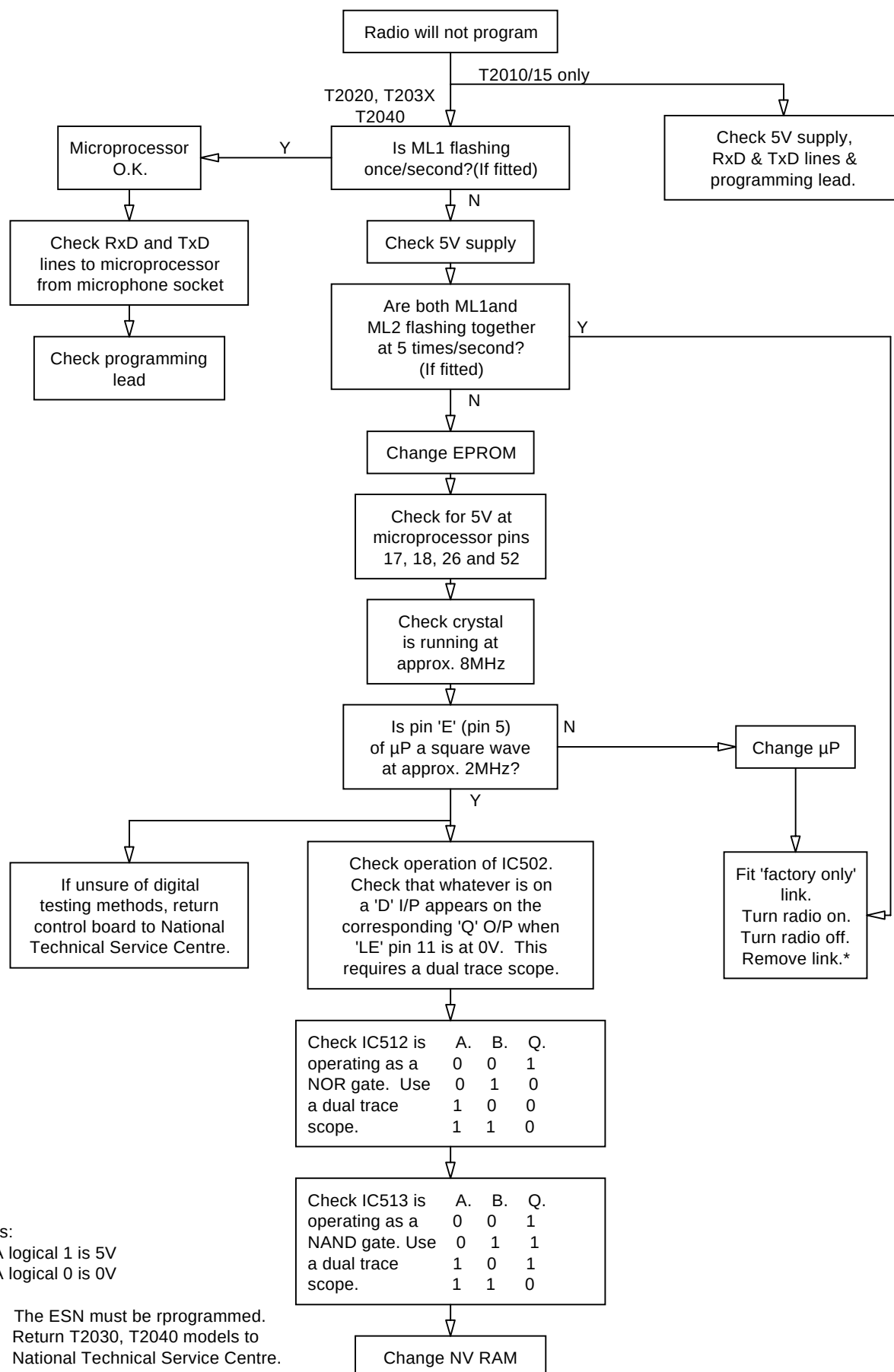
The fault finding charts listed below are intended to be used in conjunction with the circuit diagrams and other PCB information found in Section 7, and with the circuit descriptions and block diagrams found in Section 2.

| Section | Title                                                 | Page |
|---------|-------------------------------------------------------|------|
| 5.10.1  | Radio Won't Switch On                                 | 5.21 |
| 5.10.2  | Radio Won't Program                                   | 5.22 |
| 5.10.3  | Synthesiser Faults                                    | 5.23 |
| 5.10.4  | Receiver Front End Faults                             | 5.24 |
| 5.10.5  | Receiver IF Faults                                    | 5.25 |
| 5.10.6  | Receiver Mute Faults                                  | 5.26 |
| 5.10.7  | No Audio On Receive                                   | 5.27 |
| 5.10.8  | Transmitter RF Low Power Faults                       | 5.28 |
| 5.10.9  | Transmitter Power Control Faults                      | 5.30 |
| 5.10.10 | Transmit Audio Absent                                 | 5.31 |
| 5.10.11 | Trunked Radios: Radio Won't Acquire A Control Channel | 5.32 |

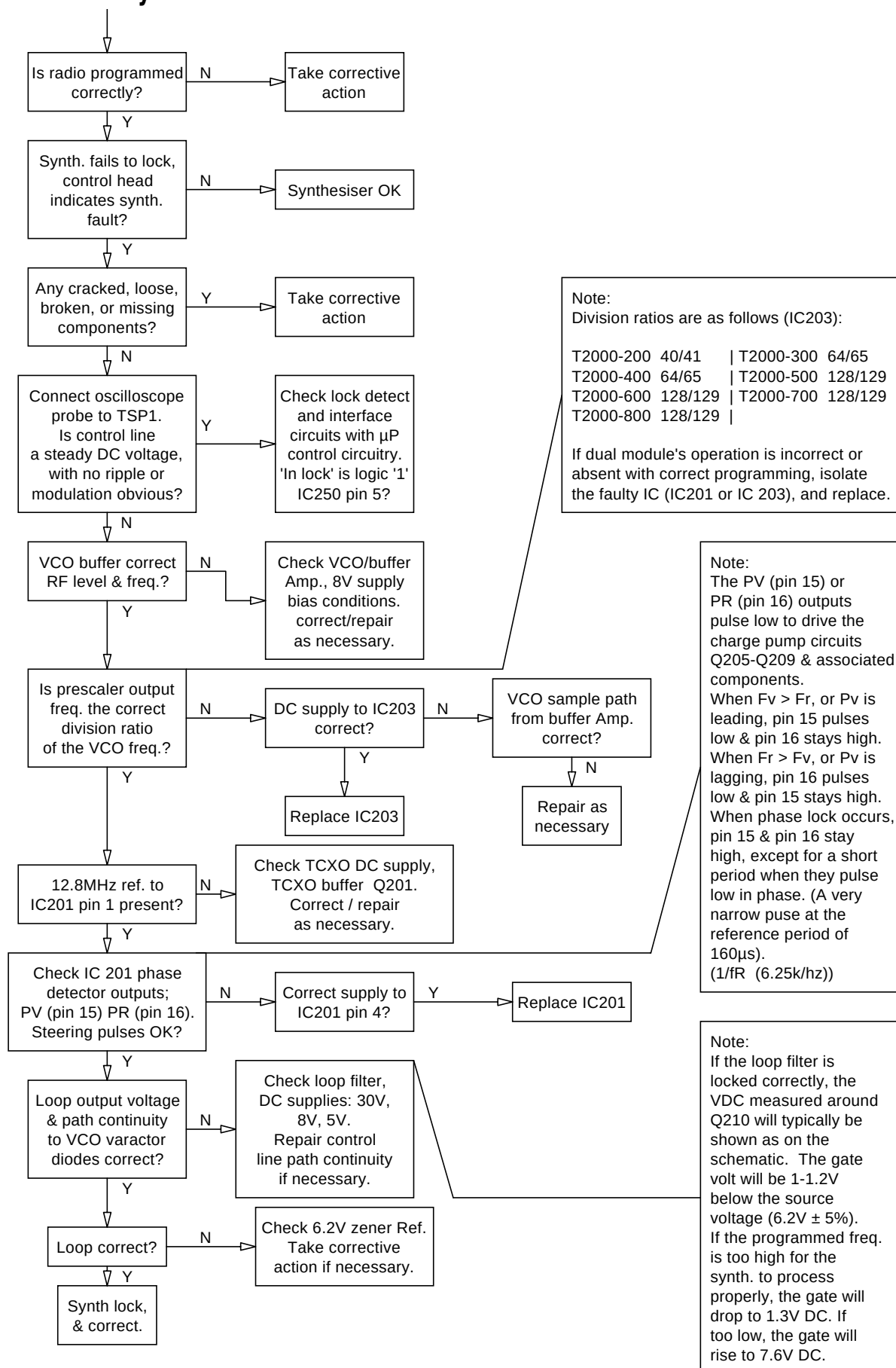
### 5.10.1 Radio Won't Switch On



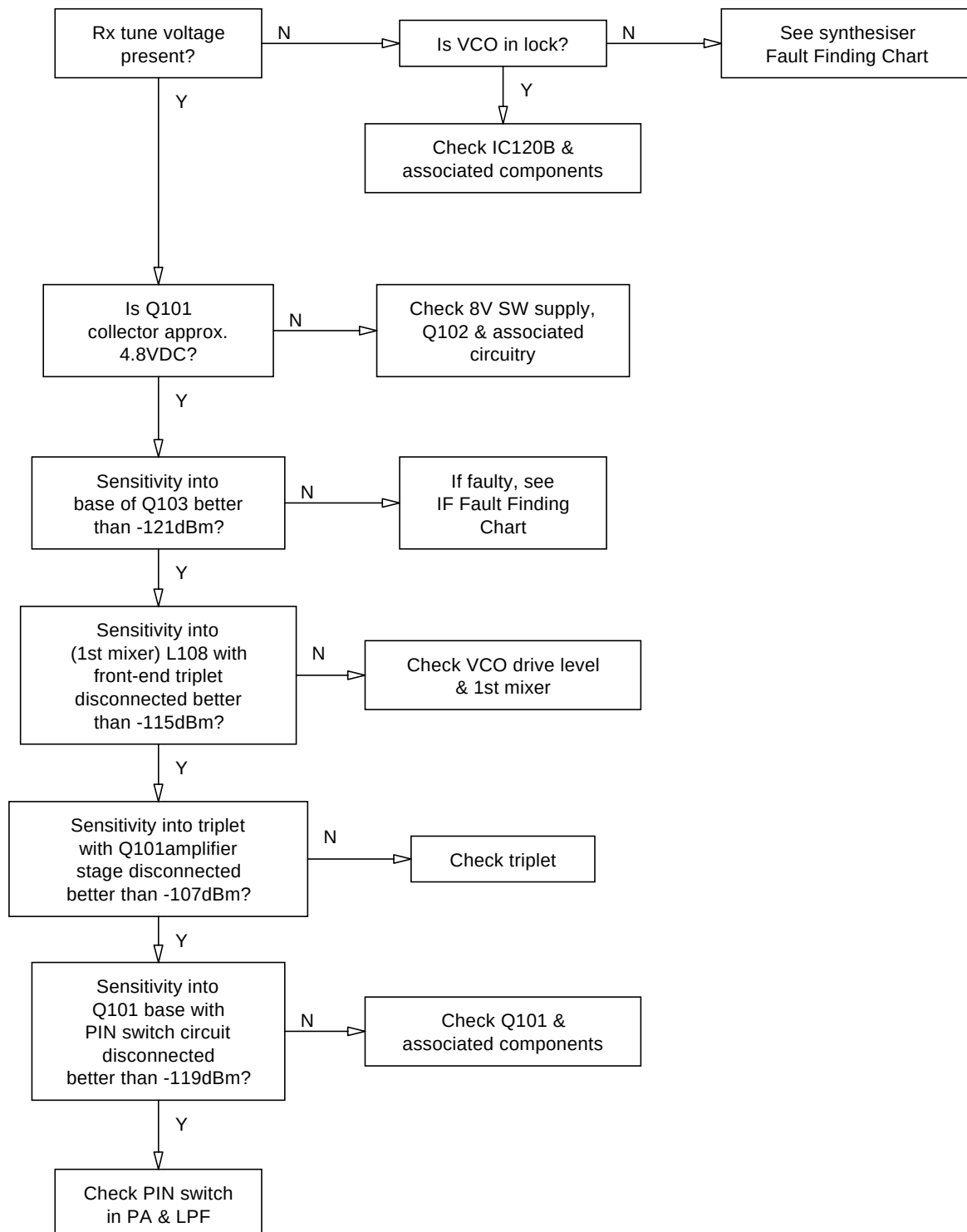
## 5.10.2 Radio Won't Program



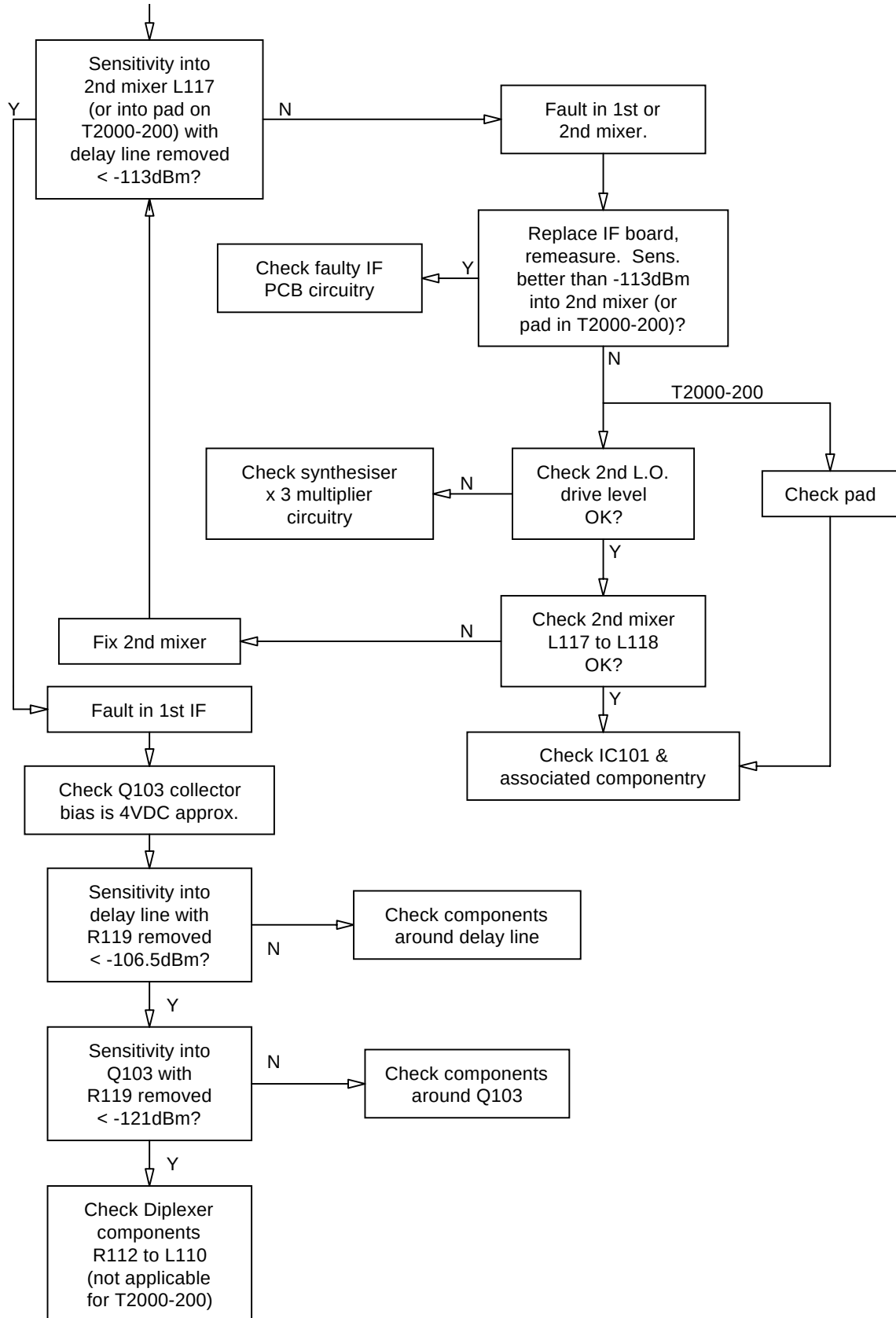
### 5.10.3 Synthesiser Faults



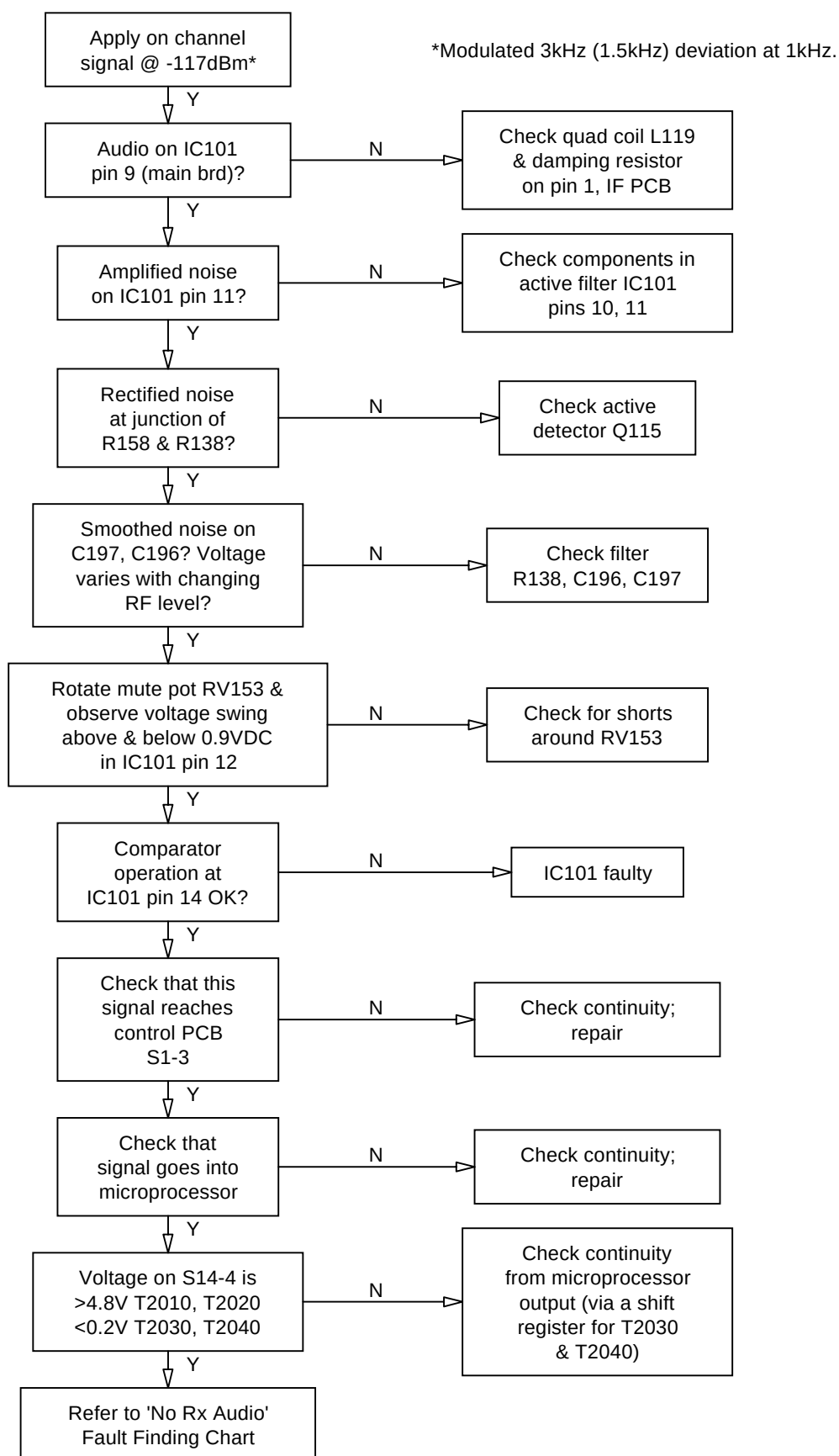
### 5.10.4 Receiver Front End Faults



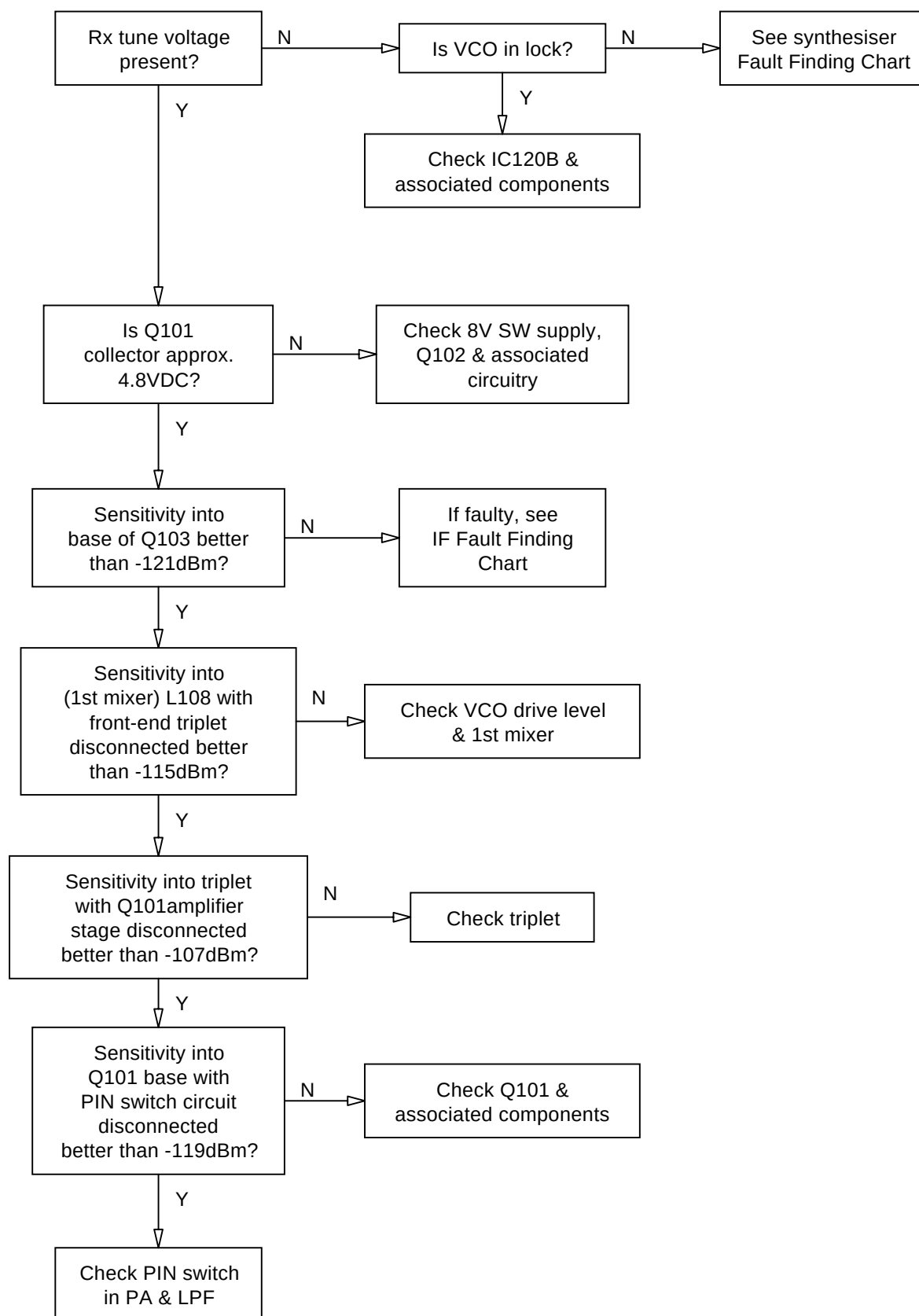
### 5.10.5 Receiver IF Faults



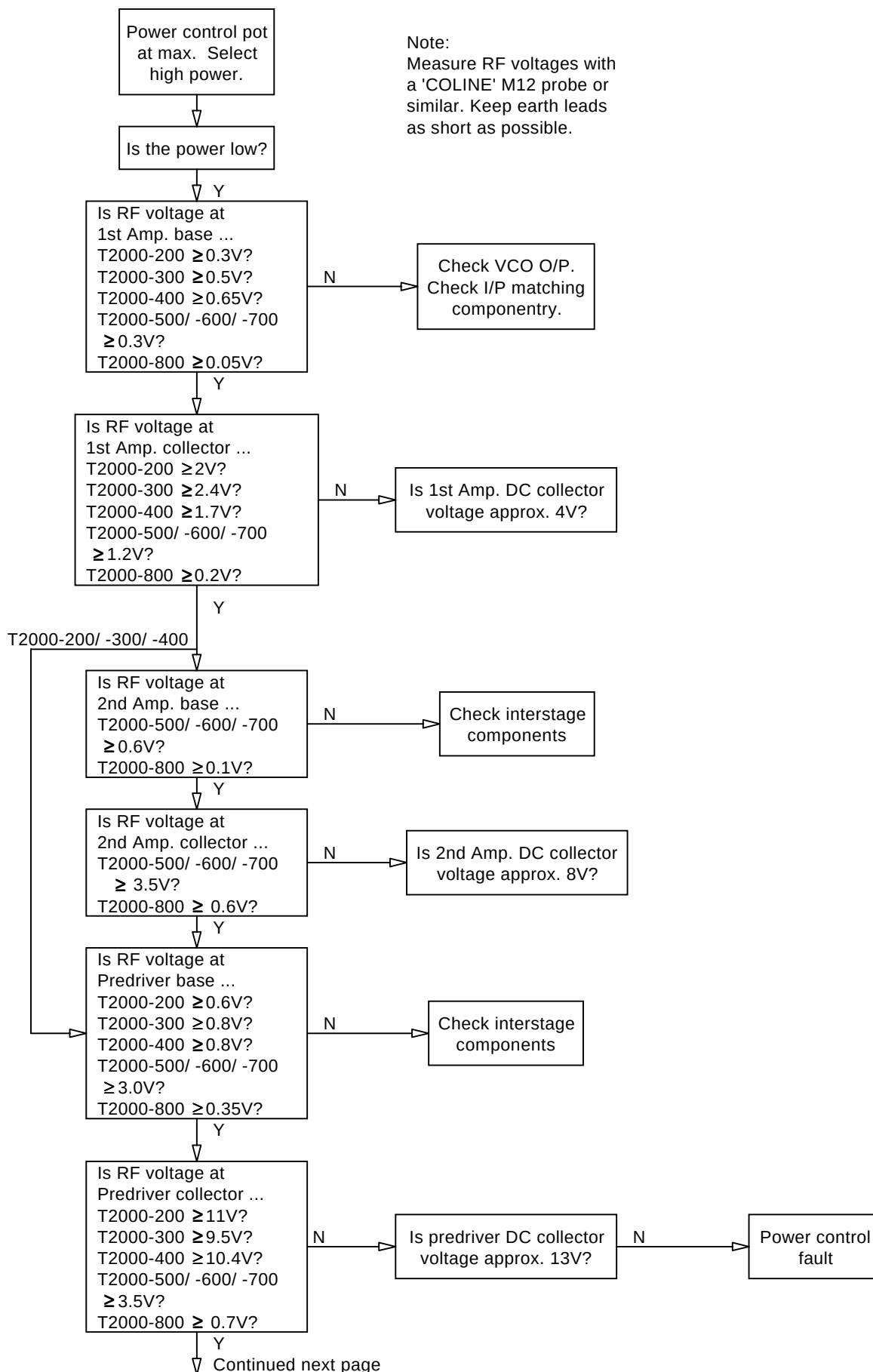
## 5.10.6 Receiver Mute Faults

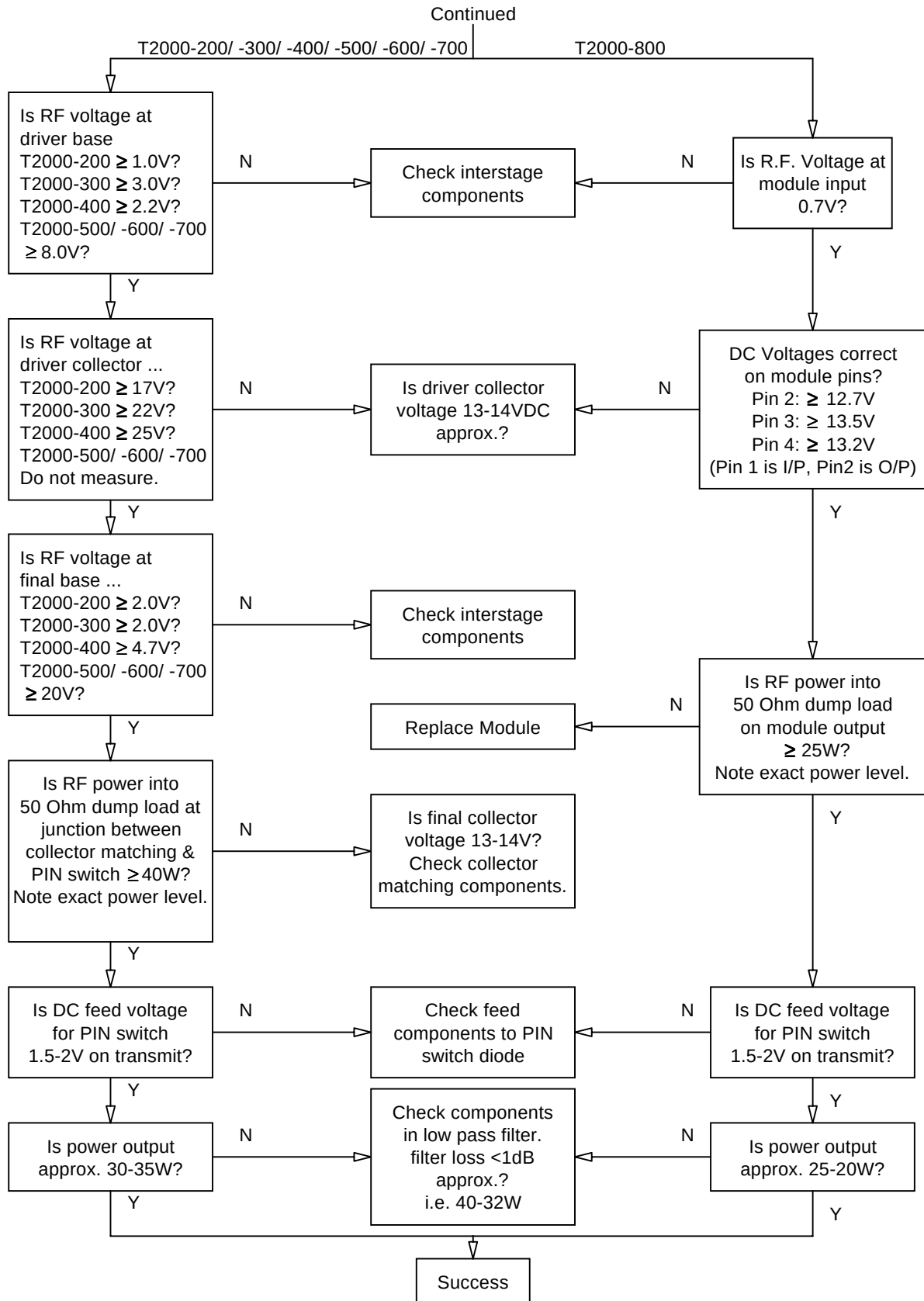


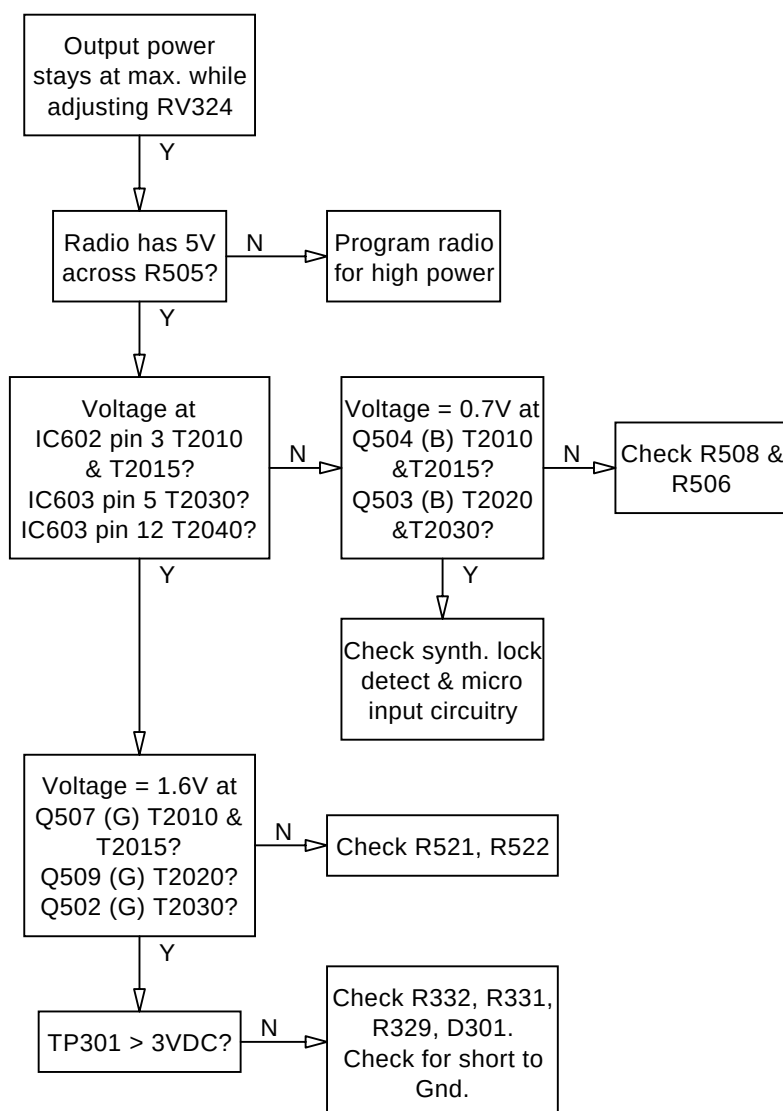
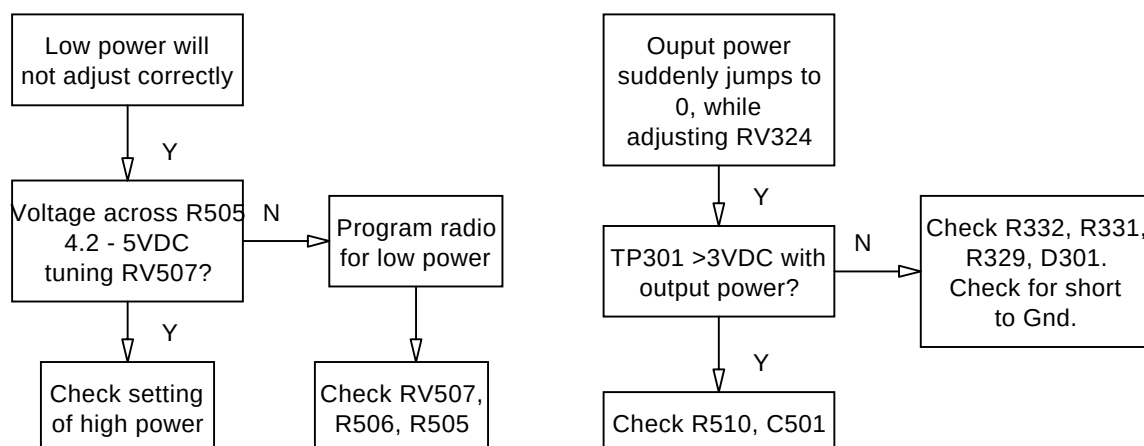
### 5.10.7 No Audio On Receive



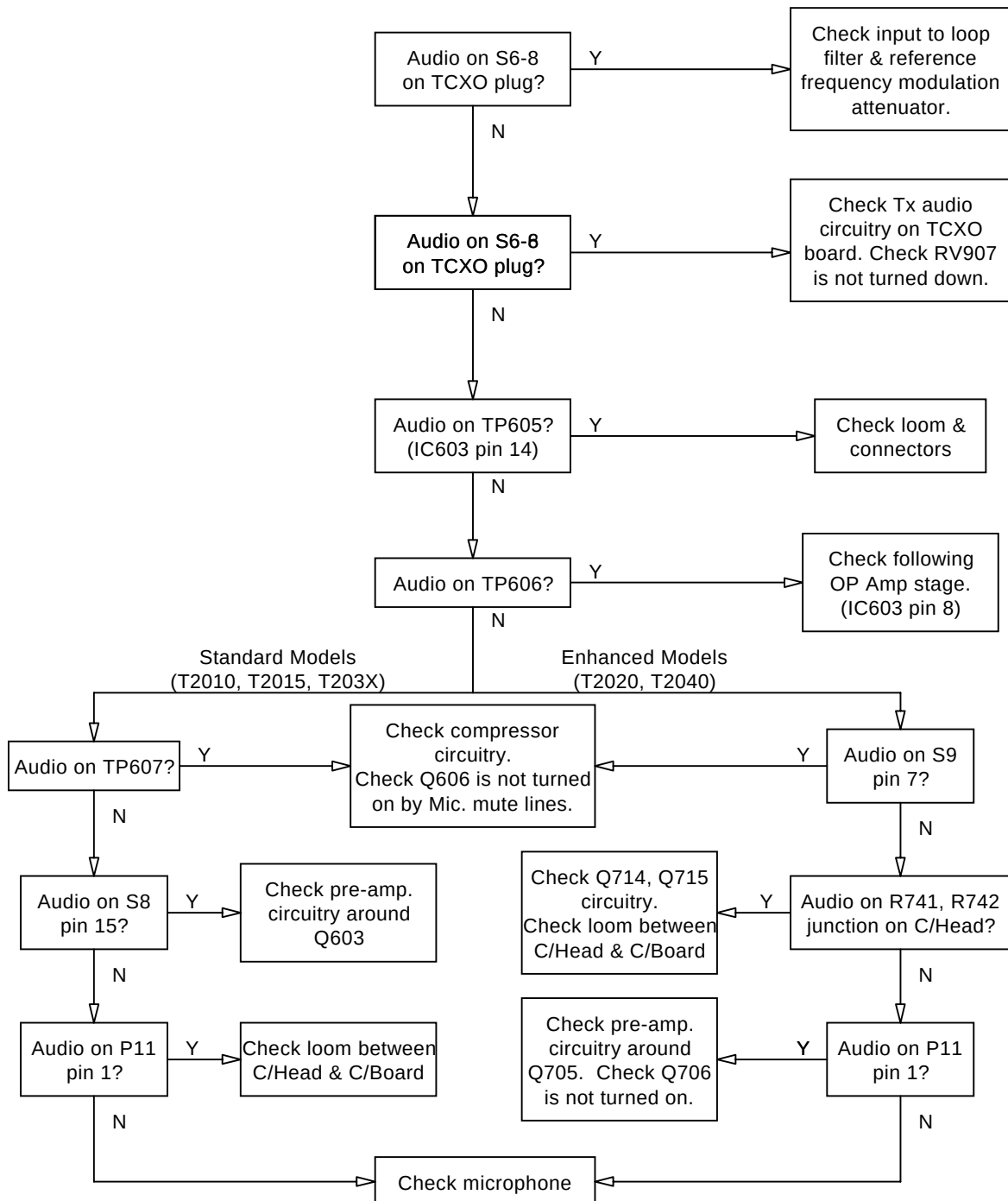
### 5.10.8 Transmitter RF Low Power Faults



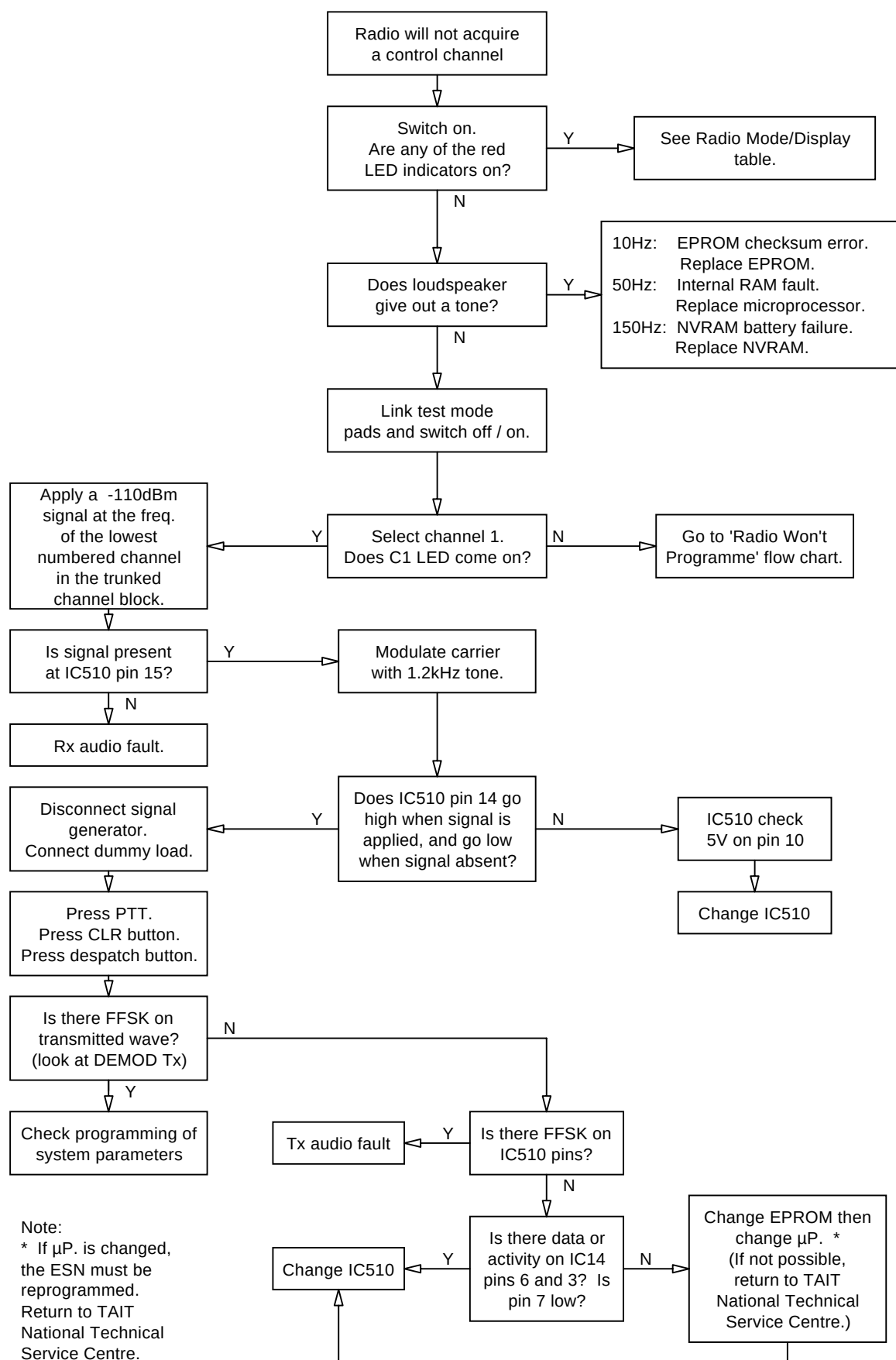


**5.10.9 Transmitter Power Control Faults**

### 5.10.10 Transmit Audio Absent



### 5.10.11 Trunked Radios: Radio Won't Acquire A Control Channel



## 6 Tuning & Adjustment

This Section details procedures for tuning and adjustment of T2000 series II radios. This is normally only required during product manufacture or after major servicing.

The following topics are covered in this Section:

| Section    | Title                                  | Page       |
|------------|----------------------------------------|------------|
| <b>6.1</b> | <b>Tuning Precautions</b>              | <b>6.2</b> |
| <b>6.2</b> | <b>Tuning &amp; Adjustment Points</b>  | <b>6.3</b> |
| <b>6.3</b> | <b>Trunked Radios</b>                  | <b>6.5</b> |
| <b>6.4</b> | <b>Transmitter Adjustments</b>         | <b>6.5</b> |
| 6.4.1      | Power Output                           | 6.5        |
| 6.4.2      | TCXO Alignment                         | 6.6        |
| 6.4.3      | Dual Point Modulation Adjustment       | 6.6        |
| 6.4.4      | CTCSS Modulation Adjustment            | 6.7        |
| 6.4.7      | Modulation Adjustment                  | 6.7        |
| 6.4.5      | LTR Code Deviation Adjustment          | 6.7        |
| 6.4.7      | Selcall Tone Deviation                 | 6.7        |
| 6.4.8      | FFSK Adjustment (Trunked Models Only)  | 6.8        |
| 6.4.8.1    | T203X Radios                           | 6.8        |
| 6.4.8.2    | T2040 Radios                           | 6.8        |
| <b>6.5</b> | <b>Receiver Adjustments</b>            | <b>6.9</b> |
| 6.5.1      | RF Alignment                           | 6.9        |
| 6.5.2      | Internal Mute Control                  | 6.10       |
| 6.5.3      | RSSI                                   | 6.10       |
| 6.5.3.1    | 'L' Level Set-Up (Trunked Radios Only) | 6.10       |

## 6.1 Tuning Precautions

Refer to Section 4.1 for a list of test equipment required and a suggested test set-up. The following precautions must be observed when carrying out the alignment procedures in this Section.

- The microprocessor shield must remain in place throughout the alignment procedure, with its 3 retaining screws torqued down to 8in.lbf (0.9Nm).

To gain access to the alignment test points and adjustment controls, it is only necessary to remove the top cover and logic PCB mounting screws (refer to Section 3.2.1).

- For accurate tuning, the test cable connecting the signal generator or power meter to the T2000 must be as short as practical and fitted with a 'mating' BNC connector.

Do not use adaptors, 'sniffer' couplings, etc., which introduce changes to cable impedance and errors in test results.

- Non-metallic tuning tools must be used for the alignment of all coil slugs. The use of metallic tools will result in tuning errors.

Tuning tools need to be of correct size to avoid the damage to coil slugs.

- The RF PA and audio output IC have a direct unswitched supply, and are therefore not controlled by the control head on/off switch. This switch removes power only from the regulated supplies.



**Caution:** Under certain circumstances the microprocessor can key the transmitter. Ensure that all instruments are protected from accidental PTT at all times.

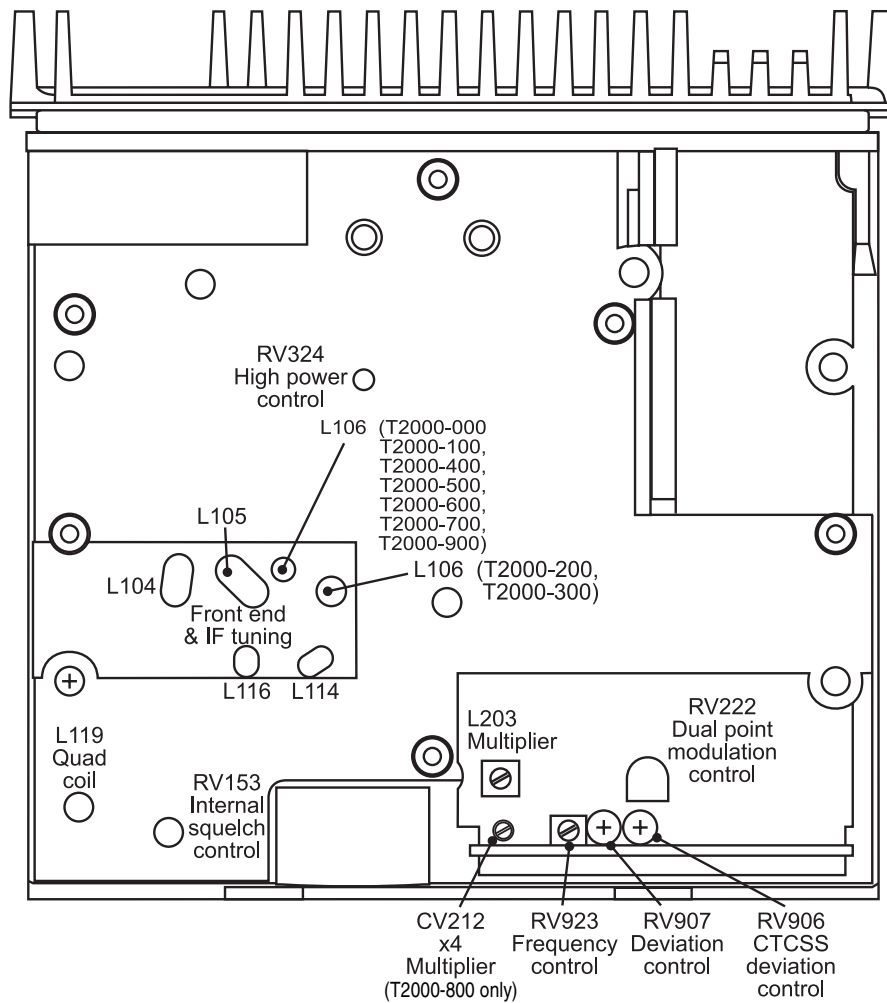
## 6.2 Tuning & Adjustment Points

The following table lists tuning and adjustment points, and Figure 6.1 shows their position on the RF and TCXO/Tx audio PCBs.

The PCB layouts in Section 7 have all relevant logic PCB test and adjustment points marked.

| Tuning/Adjustment Point: |                                                                     |                   |
|--------------------------|---------------------------------------------------------------------|-------------------|
| Designator               | Function                                                            | Location          |
| RV153                    | internal squelch control                                            | RF PCB            |
| RV222                    | dual point modulation control                                       |                   |
| RV324                    | high power control                                                  |                   |
| CV212                    | x4 multiplier<br>(only used in T2000-800)                           |                   |
| L104 to L106             | front end tuning<br>(not used in T2000-800)                         |                   |
| L114 & L116              | IF tuning                                                           |                   |
| L119                     | quad coil                                                           |                   |
| L203                     | x3 /x4 multiplier<br>(not used in T2000-200)                        |                   |
| RV906                    | CTCSS deviation control                                             | TCXO/Tx audio PCB |
| RV907                    | deviation control                                                   |                   |
| RV923                    | frequency control                                                   |                   |
| RV507                    | low power control                                                   | logic PCB         |
| #RV508                   | T2010, T2015 & T2020:<br>signalling adjust (not fitted as standard) |                   |
| #RV599                   | T203X, T2040, T2050 & T2060:<br>FFSK adjust                         |                   |
| Test Points:             |                                                                     |                   |
| Designator               | Function                                                            | Location          |
| TSP901                   | dual point modulation test point                                    | TCXO/Tx audio PCB |
| TP601                    | Rx audio (detected)                                                 | logic PCB         |
| TP602                    | Tx CTCSS                                                            |                   |
| TP603                    | Rx CTCSS                                                            |                   |
| TP604                    | Rx audio                                                            |                   |
| TP605                    | Tx audio                                                            |                   |
| TP606                    | ALC audio                                                           |                   |
| TP607                    | pre-amp output                                                      |                   |

**Table 6.1 Tuning & Adjustment Point**



**Figure 6.1 RF & TXCO/Tx Audio PCBs - Tuning & Adjustment Points-**

## 6.3 Trunked Radios

The 'test' facility enables T2000 trunked radios to emulate a multichannel radio, using the frequencies reserved for trunking.

For a description of how to put the radio in test mode, refer to Section 5.8 "Trunked Radios: Test Mode". Once the radio is in test mode, tuning and adjustment can be carried out as described in Section 6.4 and Section 6.5.

**Caution:** When in test mode, connect the antenna socket to a dummy load to prevent interference with trunking systems. Avoid testing on channels in use locally.

## 6.4 Transmitter Adjustments

In this Section, deviation settings are given first for wide band, followed by settings for medium band in brackets ( ) and settings for narrow band in square brackets [ ].

### 6.4.1 Power Output

Set up the test equipment as shown in Section 4, and close the PTT switch.

Turn RV324 fully clockwise and check that the output power is greater than 30W for all channels.

Select a channel programmed for high power and adjust RV324 for 25W.

Check that the transmit current is approximately the values stated below:

| Model         | Current |
|---------------|---------|
| T2000-100     | 6A      |
| T2000-200     | 6A      |
| T2000-300     | 6A      |
| T2000-400     | 6A      |
| T2000-500     | 6.5A    |
| T2000-600     | 7A      |
| T2000-700/900 | 6.5A    |
| T2000-800     | 6A      |

Select a channel programmed for low power and adjust RV507 for the required output power.

### 6.4.2 TCXO Alignment

Close the PTT switch and monitor the transmit frequency with a frequency counter.

Adjust RV923 on the TCXO/Tx audio PCB for a channel frequency within  $\pm 100\text{Hz}$  at ambient temperature.

### 6.4.3 Dual Point Modulation Adjustment

DC isolate the audio generator from TSP901 using a capacitor ( $10\mu\text{F}$  is sufficient).

Set the audio generator to  $7\text{kHz}$  and inject the audio into the dual point modulation input TSP901 on the TCXO/Tx audio PCB.

Close the PTT switch and select the **lowest frequency channel**.

Adjust the audio generator level to give a reading of  $\pm 5.2\text{kHz}$  deviation on the modulation meter.

Remove any filters selected on the deviation or modulation meter which could give erroneous readings.

Select the **highest frequency channel** and check that the deviation is  $\pm 4.8\text{kHz}$ .

If not, adjust the audio generator output level so that the average deviation of the two channels is  $\pm 5\text{kHz}$ .

**The difference in deviation between the two channels must be less than  $\pm 800\text{Hz}$ .**

Select the **lowest frequency channel**, set the audio generator to  $70\text{Hz}$  and inject the audio at TSP901.

Adjust RV222 to give  $\pm 4.8\text{kHz}$  deviation on the modulation meter.

Select the **highest frequency channel** and check that the deviation is  $\pm 5.2\text{kHz}$ .

If not, adjust RV222 so that the average deviation of the two channels is  $\pm 5\text{kHz}$ .

**The difference in deviation between the two channels must be less than  $\pm 400\text{Hz}$ .**

### 6.4.4 CTCSS Modulation Adjustment

The following instructions apply only to those radios with CTCSS activated and must be carried out before any further modulation adjustment can proceed.

Refer to the T2000 Programming Manual for the CTCSS channel programming instructions. The frequency range of the CTCSS tone is 67 to 250.3Hz.

Switch to any channel with CTCSS activated.

Close the PTT switch.

Adjust RV906, on the TCXO PCB, to set the CTCSS tone peak deviation for  $\pm 660\text{Hz} \pm 100\text{Hz}$  ( $\pm 530\text{Hz} \pm 80\text{Hz}$ ) [ $\pm 330\text{Hz} \pm 50\text{Hz}$ ] on the modulation meter.

### 6.4.5 LTR Code Deviation Adjustment

Close the PTT switch and set up a continuous call. This can be an LTR Repeater Talkaround call, a Repeater Interconnect Call (RIC) or an on-channel call.

Adjust RV906 on the TCXO PCB to set the LTR code deviation to  $\pm 1\text{kHz}$  ( $\pm 900\text{Hz}$ ) [ $\pm 600\text{Hz}$ ].

**Note:** The deviation meter must have a good low frequency response to avoid incorrect readings.

### 6.4.6 Modulation Adjustment

Complete the dual point modulation and CTCSS modulation adjustments (Section 6.4.3 and Section 6.4.4) before commencing the modulation adjustment.

Apply a 3kHz sine wave at a level of -40dBm to the microphone input.

Select a channel with CTCSS activated and close the PTT switch. If CTCSS is disabled, select any channel.

Adjust RV907 for a +5kHz (+4kHz) [+2.5kHz] deviation reading on the modulation meter.

Maintain the same sine wave output level and sweep the audio frequency from 300Hz to 3.3kHz.

Find the frequency of maximum '+' deviation and readjust RV907 for +5kHz (+4kHz) [+2.5kHz] deviation.

Reset the modulation meter to read '-' deviation.

Slowly sweep the audio frequency from 300Hz to 3kHz. If the '-' deviation peak is found to exceed -5kHz (-4kHz) [-2.5kHz], readjust RV907 for a peak deviation of -5kHz (-4kHz) [-2.5kHz] at that frequency.

The peak deviation should not exceed  $\pm 5\text{kHz}$  ( $\pm 4\text{kHz}$ ) [ $\pm 2.5\text{kHz}$ ] on any channel.

## 6.4.7 Selcall Tone Deviation

1  
2 >

This is normally preset at 60% of voice deviation. If adjustment is needed, fit #RV508 (refer to Section 7 for a component description) to the logic PCB, and proceed as follows.

Adjust #RV508 for  $\pm 3\text{kHz}$  ( $\pm 2.4\text{kHz}$ ) [ $\pm 1.5\text{kHz}$ ] deviation reading on the modulation meter.

Check to ensure that no limiting occurs in IC901.

## 6.4.8 FFSK Adjustment (Trunked Models Only)

### 6.4.8.1 T203X Radios

Enter test mode (refer to Section 5.8, "Trunked Radios: Test Mode").

Press the front panel **clear** key .

Adjust #RV599 for  $\pm 3\text{kHz} \pm 200\text{Hz}$  ( $\pm 2.4\text{kHz} \pm 160\text{Hz}$ ) [ $\pm 1.5\text{kHz} \pm 100\text{Hz}$ ] deviation reading on the modulation meter.

### 6.4.8.2 T2040 Radios

Enter test mode (refer to Section 5.8, "Trunked Radios: Test Mode").

Select test function 10 using the control head.

Adjust #RV599 for  $\pm 3\text{kHz} \pm 200\text{Hz}$  ( $\pm 2.4\text{kHz} \pm 160\text{Hz}$ ) [ $\pm 1.5\text{kHz} \pm 100\text{Hz}$ ] deviation reading on the modulation meter.

## 6.5 Receiver Adjustments

In this Section, deviation settings are given first for wide band, followed by settings for medium band in brackets ( ) and settings for narrow band in square brackets [ ].

### 6.5.1 RF Alignment

Set up the test equipment as shown in Section 4, and select the **highest possible frequency** in the operating band.

Set the signal generator to the required receive frequency with modulation set for  $\pm 3\text{kHz}$  ( $\pm 2.4\text{kHz}$ ) [ $\pm 1.5\text{kHz}$ ] deviation at  $1\text{kHz}$  AF and an output level of  $-100\text{dBm}$ .

Using the receiver tuning amplifier circuit shown in Figure 6.2, adjust RV1 until the voltage of point A equals  $3.0\text{V DC}$ , measured on a  $1\text{M}\Omega$  digital multimeter.

Connect the receiver tuning amplifier to the RSSI output on pin 15 of S14 (logic PCB) and monitor the output on an oscilloscope ( $1\text{V/division}$ , DC coupled).

If the output on the oscilloscope is  $0\text{V DC}$ , increase the RF input level above  $-100\text{dBm}$  until the output level just starts to rise.

Adjust L104, L106, L105, L114, L116 and L203, in this order, to give maximum amplitude.

**Note:** L203 is not used in the T2000-200.

While tuning the coils, adjust the signal generator output so that the level on the oscilloscope does not exceed  $6\text{V DC}$ .

Monitor the audio output at the speaker terminals and adjust L119 for maximum amplitude.

Set the squelch control (RV153) to minimum and connect a sinad meter across the speaker terminals.

Decrease the signal generator output until a  $12\text{dB}$  sinad is reached.

The signal generator output should not be greater than  $-117\text{dBm}$ .

Switch to the **lowest possible frequency** in the operating band, and check that the receiver sensitivity is better than  $-117\text{dBm}$ .

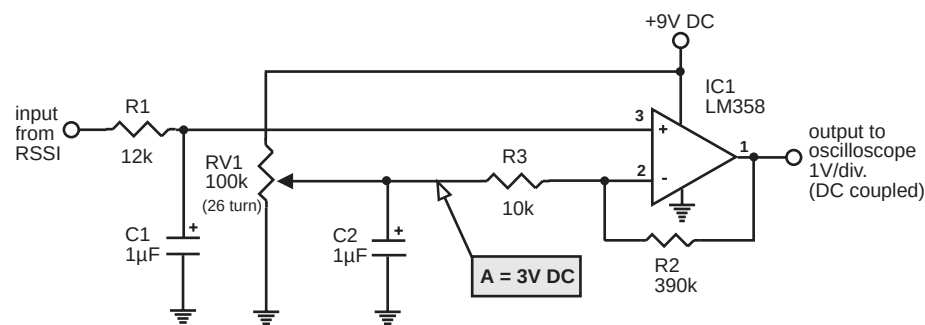


Figure 6.2 Receiver Tuning Amplifier

## 6.5.2 Internal Mute Control

If required, the mute setting can be adjusted internally as follows.

Align the receiver, as described in Section 6.5.1.

Adjust RV153 fully clockwise.

Set the signal generator to the required receive frequency.

Set the modulation for  $\pm 3\text{kHz}$  ( $\pm 2.4\text{kHz}$ ) [ $\pm 1.5\text{kHz}$ ] deviation at 1kHz AF.

Adjust the signal generator output for 11dB sinad.

Adjust RV153 so that the radio mutes then turn RV153 until the mute gate just opens.

## 6.5.3 RSSI

The T2000 RSSI is non-adjustable and should operate over an approximate 50dB range.

Monitor the RSSI output on pin 15 of S14 on the logic PCB.

Set the signal generator to the required receive frequency with modulation set for  $\pm 3\text{kHz}$  ( $\pm 2.4\text{kHz}$ ) [ $\pm 1.5\text{kHz}$ ] deviation at 1kHz AF and an output level of -70dBm.

Decrease the signal generator output in 10dB steps to -120dBm, noting the RSSI output at each step.

The RSSI should have a typical slope of approximately 540mV/10dB, from -120dBm to -70dBm RF input.

### 6.5.3.1 'L' Level Set-Up (Trunked Radios Only)

These levels are factory set at the time of manufacture and will require reprogramming only if the receiver has been realigned or has had parts replaced, or if the logic PCB has been replaced.

Set the signal generator to give an unmodulated RF signal in the centre of the trunking band.

Enter test mode.

**Note:** The T203X will need to use CCTM, as described in Section 5.8.3.

Set the signal generator to -108dBm and program 'L1' (function 61), as described in Section 5.8.5.2.

Set the signal generator to -100dBm and program 'L2' (function 62), as described in Section 5.8.5.2.

## 7 PCB Information

This Section provides parts lists, circuit diagrams and component location information on the individual PCBs within the T2000 Series II radio.

The following PCBs are covered within this Section:

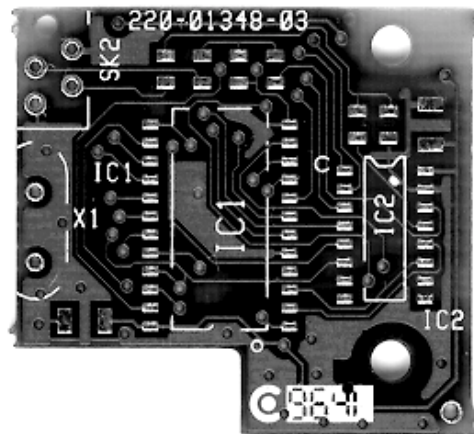
| Section | Title                                             |                                                          | Page                         | Frequency (MHz) |
|---------|---------------------------------------------------|----------------------------------------------------------|------------------------------|-----------------|
| 7.1     | T2000-100 RF PCB                                  | IPN 220-01331-02                                         | 7.1.1                        | 220 to 270      |
| 7.2     | T2000-200 RF PCB                                  | IPN 220-01202-10                                         | 7.2.1                        | 66 to 88        |
| 7.3     | T2000-300 RF PCB                                  | IPN 220-01314-01                                         | 7.3.1                        | 136 to 174      |
| 7.4     | T2000-400 RF PCB                                  | IPN 220-01204-11                                         | 7.4.1                        | 175 to 225      |
| 7.5     | T2000-500/-600 RF PCB                             | IPN 220-01205-14                                         | 7.5.1                        | 400 to 530      |
| 7.6     | T2000-700/-900 RF PCB                             | IPN 220-01289-01<br>IPN 220-01389-03                     | 7.6.1<br>7.6.11              | 330 to 400      |
| 7.7     | T2000-800 RF PCB                                  | IPN 220-01305-03                                         | 7.7.1                        | 800 to 870      |
| 7.8     | T2000 IF PCB                                      | IPN 220-01384-00                                         | 7.8.1                        |                 |
| 7.9     | T2000 TCXO/Tx Audio PCB                           | IPN 220-01389-00<br>IPN 220-01389-02                     | 7.9.1<br>7.9.7               |                 |
| 7.10    | T2010 & T2015 HC05 Logic PCB                      | IPN 220-01377-01<br>IPN 220-01377-02<br>IPN 220-01377-03 | 7.10.1<br>7.10.11<br>7.10.23 |                 |
| 7.11    | T2020, T203X, T2040, T2050 & T2060 HC11 Logic PCB | IPN 220-01344-02<br>IPN 220-01344-04                     | 7.11.1<br>7.11.13            |                 |
| 7.12    | T2010/T2030 Control Head PCB                      | IPN 220-01319-01                                         | 7.12.1                       |                 |
| 7.13    | T2015/T2060 Control Head PCB                      | IPN 220-01320-01                                         | 7.13.1                       |                 |
| 7.14    | T2020/40 /50 Control Head PCB                     | IPN 220-01321-04                                         | 7.14.1                       |                 |
| 7.15    | T2035 Control Head PCB                            | IPN 220-01322-03                                         | 7.15.1                       |                 |
| 7.16    | T2000 EMC Filter PCB                              | IPN 220-01383-01                                         | 7.16.1                       |                 |
| 7.17    | T2000 Data Interface Decoupling PCB               | IPN 220-01388-01                                         | 7.17.1                       |                 |

## PCB Identification

All PCBs are identified by a unique 10 digit 'internal part number' (IPN), e.g. 220-01330-02, which is screen printed onto the PCB (usually the top side).

The last 2 digits of this number define the issue status, which starts at 00 and increments through 01, 02, 03, etc. as the PCB is updated. Some issue PCBs never reach full production status, and are therefore not included in this manual. A letter following the 10 digit IPN has no relevance in identifying the PCB for service purposes.

In the following diagram of the T2000-66 UART PCB, the IPN is 220-01348-03, (i.e. issue 03 of the PCB).



It is important that you identify which issue PCB you are working on so that you can refer to the appropriate PCB information.

# Parts Lists

The 10 digit numbers (000-00000-00) in the parts lists are ‘internal part numbers’ (IPNs). Your spare parts orders can be handled more efficiently if you quote the IPN and provide a brief description of the part.

The components listed in the parts lists are divided into two main types: those with a circuit reference (e.g. C201, D106, R121, etc.) and those without (mechanical and miscellaneous).

Those with a circuit reference are grouped in alphabetical order and then in numerical order within each group. Each component entry comprises three or four columns, as shown below.

circuit reference - lists component in numerical order

variant column - indicates that the component is only fitted to this particular model, type or option

description - gives a brief description of the component

Internal Part Number - order the component by this number

| Ref   | VAR  | IPN          | Description                            |
|-------|------|--------------|----------------------------------------|
| C401  |      | 014-07470-00 | CAP TANT CHIP 4U7 3.5 X 2.8MM 267 SERI |
| C402  |      | 015-24100-08 | CAP CER 0805 CHIP 1N 10% X7R 50V       |
| C403  |      | 015-25100-08 | CAP CER 0805 CHIP 10N 10% X7R 50V      |
| &C404 | 3XXX | 015-21180-01 | CAP CER 0805 CHIP 1P8 +/-0.25 NPO 50V  |
| &C404 | 4XXX | 015-21220-01 | CAP CER 0805 CHIP 2P2 +/-0.25P NPO 50V |
| C405  |      | 015-21120-01 | CAP CER 0805 CHIP 1P2 +/-0.25 NPO 50V  |
| C406  |      | 015-24100-08 | CAP CER 0805 CHIP 1N 10% X7R 50V       |
| &C407 | 3XXX | 015-22680-01 | CAP CER 0805 CHIP 68P 5% NPO 50V       |
| &C407 | 4XXX | 015-22390-01 | CAP CER 0805 CHIP 39P 5% NPO 50V       |

The mechanical and miscellaneous section lists the variant and common parts in IPN order.

## Variant Parts

A variant component is one that has the same circuit reference but different value or specification in different product types, models or options. Variant components are indicated by a character prefix, such as ‘&’, ‘#’ or ‘=’.

# Locating Components

## Grid Reference Indexes

To assist in locating components and labelled pads on the PCB layouts and circuit diagrams, a component grid reference index has been provided. This index lists the components and pads in alphabetical order, along with the appropriate alphanumeric grid references, as shown below.

| Device | PCB  | Circuit |
|--------|------|---------|
| A-2    | 1:E1 | PA-B6   |
| B-2    | 1:A2 | PA-E6   |
| B-3    | 1:A3 | PA-F6   |
| B-4    | 1:A3 | PA-G6   |
| B-5    | 1:B6 | PA-J6   |
| C-1    | 1:E2 | PA-A6   |
| C-2    | 4:B3 | PA-H4   |
| C101   | 1:E1 | PA-B6   |

## Using Circuit Diagrams

Reading a circuit diagram is similar to reading a road map, in that both have an alphanumeric border. The circuit diagrams in this manual use letters to represent the horizontal axis, and numbers for the vertical axis. These circuit diagram 'grid references' are useful in following a circuit that is spread over two or more sheets.

When a line representing part of the circuitry is discontinued, a reference will be given at the end of the line to indicate where the rest of the circuitry is located. The first digit refers to the sheet number (printed on the bottom right hand corner of the circuit diagram) and the last two characters refer to the location on that sheet of the continuation of the circuit (e.g. 1-D4).

If more than one line is represented (indicated by a double thickness line), a dot with a reference label will follow the route each individual line represents.