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:

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 50Ω, 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: 600Ω 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, 50Ω; RF detecting element 50W and 5W for appropriate frequency ranges (e.g. Bird Meter 6154 or 611).
- RF power attenuator, 50Ω, 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.

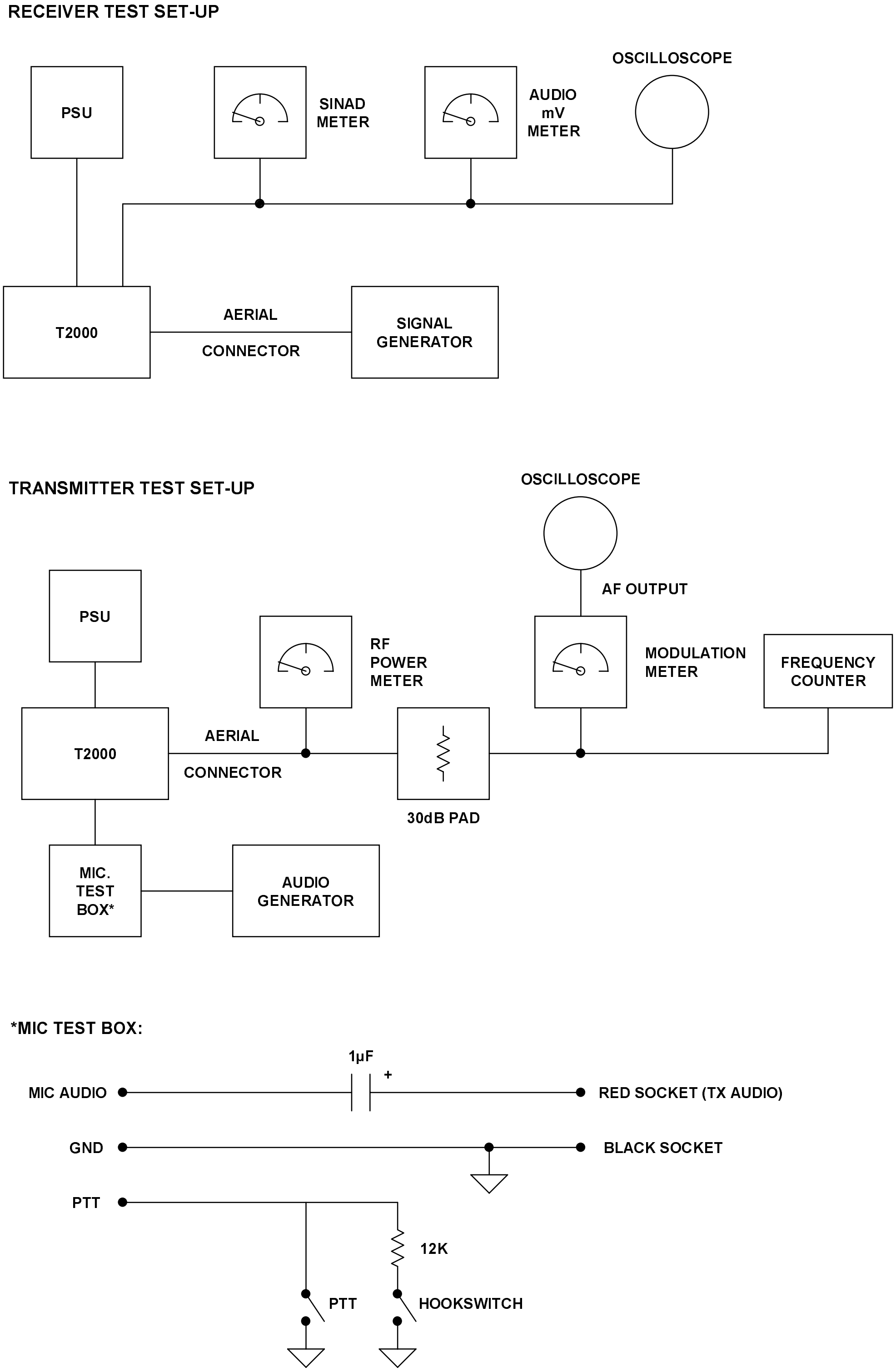

Figure 4.1 Suggested Test Equipment Set-Up

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 ±3kHz (±2.4kHz) [±1.5kHz] 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 ±5kHz (±4kHz) [±2.5kHz] 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 ±5kHz (±4kHz) [±2.5kHz] deviation at 1kHz AF.

Set the volume control to the onset of clipping.

The receiver output should be 4.2Vrms across 4Ω 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 ±3kHz (±2.4kHz) [±1.5kHz] 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 ±3kHz (±2.4kHz) [±1.5kHz] 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** (Fn) 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 ±5kHz (±4kHz) [±2.5kHz] 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 ±5kHz (±4kHz) [±2.5kHz] 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 ±3kHz (±2.4kHz) [±1.5kHz] deviation at 1kHz AF.

Set the signal generator output level to give a 20dB 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 ±5kHz (±4kHz) [±2.5kHz].

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.