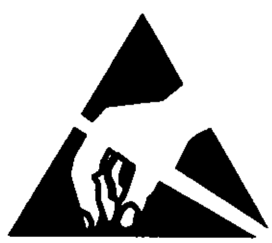
9
UHF Transmitter Type 2950 & 2957

9.1 Introduction

The transmitter is synthesiser driven and direct frequency modulated.

Minimal audio processing occurs in the transmitter module. It is intended that this takes place in the Type 2737 Controller Module.



CAUTION

The UHF Transmitter module contains semi-conductor components that are sensitive to electrostatic damage.

Electrostatic sensitive devices should only be stored and transported inside electrically conductive static shielding bags. Repair work on the modules should be performed at “electrostatically safe work stations” where the work bench surface; soldering iron and the operator are all earthed to prevent the build up of harmful electrostatic charges.

CAUTION

The RF devices used in the transmitter module (for example, the RF Power output module) may contain beryllium dioxide. These devices must not be broken, ground, hammered or tampered with in any way, and should be disposed of in a safe manner as specified in local environmental and safety legislation. If safe disposal is a problem, they should be sealed in an appropriate container and returned to Exicom for disposal. In this case, it is the senders' responsibility to ensure that all precautions are taken to ensure safe delivery to Exicom.

9.2 Specifications

Transmitter Type	Synthesised with direct frequency modulation
Synthesiser Step Size	5 kHz or 6.25 kHz
Frequency Bands (MHz) **Module No.:** Tx 2957 Tx 2950	 335-356 380-403,403-423, 410-430, 430-450, 450-470 470-490, 480-500, 490-512
Output Impedance	50 Ω
RF Output Power	1-15 W < 470 MHz, 1-13 W > 470 MHz
RF Power Regulation **Over specified bandwidth** **With Supply Voltage** **With Temperature**	 ± 0.5 dB ± 1 dB for 10.6 V_{DC} to 15.5 V_{DC} ± 1 dB for -30 °C to +55 °C
Duty Cycle	100% from -30 °C to +55 °C up to an altitude of 3000 m
Frequency Stability	±1.0 ppm from -30 °C to +55 °C and with a supply voltage of 10.6 V_{DC} to 15.5 V_{DC}
Spurious Outputs	< 0.25 µW (-36 dBm) from 100 kHz to 4 GHz
Adjacent Channel Power	<-25 dBm for 25 kHz Channel Spacing <-18 dBm for 12.5kHz Channel Spacing
VSWR Protection	Withstands VSWR of 20:1 at any phase angle
Thermal Protection	Integral. RF output power automatically reduced when module heatsink temperature reaches 95 °C ± 5 °C
Modulation **Distortion** **Deviation**	Direct frequency modulation <1.0% at 3 kHz deviation weighted Adjustable 1.5 kHz to 5 kHz
Modulation Input Impedance	Hi "Z" (36 kΩ) differential input
Modulation Input	775 mV_{rms}
Audio Frequency Response	±0.3 dB from 300 Hz to 8.2 kHz with DC response option
Hum and Noise	>39 dB unweighted wide band >45 dB unweighted narrow band
Transmitter Switching Bandwidth	21 MHz for 335 to 356 MHz band 23 MHz for 380 to 403 MHz band 20 MHz for 403 to 512 MHz band **Note:** frequency changes greater than ±1.5 MHz will require resetting of the VCO centre frequency.
Residual AM	<0.5%
Carrier Leakage	<-65 dBm

Environmental	Operates within -30 °C to +55 °C, up to 95% relative humidity, non-condensing	
Operational Voltage Range	10.6 V_{DC} to 15.5 V_{DC}	
Maximum DC Supply Current at 13.8 VDC input (Typical measurements only)	Standby, non-fast key configuration	15 mA
	Standby, Fast Key configuration	110 mA
	Tx keyed, 1 Watt output from Duplexer (approx. 1.3 W from Tx)	1.2 A
	Tx keyed, 10 Watts output from Duplexer (approx. 13 W from Tx)	3.0 A
Maximum Tx key up delay[1] (Typical measurements only)	Non-fast key configuration	100 ms
	Fast Key configuration	3.0 ms

9.3 Circuit Description

The following section provides a detailed description of the operation of the circuit.

9.3.1 Voltage Controlled Oscillator (VCO) and Modulator

CAUTION

The transmitter VCO is **NOT** field serviceable. Repairing and testing of the VCO is best done in the factory.

The VCO contains the resonator, oscillator and frequency control varicap, in a factory-enclosed assembly. The VCO is tuneable via a trimmer that is accessible through the top of the shield.

9.3.2 Frequency Synthesiser Circuitry

When the transmitter is powered-up, the three parallel to serial converters, U303, U304 and U305 receive inputs from the DIP switch SW301 and the Hexadecimal frequency select switches, SW302, SW303 and SW304. The DIP switch sets the frequency band of the transmitter, and the other three switches select the channel the transmitter is tuned too. Refer to Section 9.4 for further details.

These parallel inputs are fed or "clocked" serially to pin 12 of the microcontroller U302. The twenty-four clock pulses required by U303, U304 and U305 are generated by U302.

The channel spacing is set to 5 kHz if R305 is fitted; otherwise, the default setting is 6.25 kHz. U302 uses this input and the data it receives on pin 12 to derive the frequency data sent to the Phase Locked Loop IC U307. U307 compares the output from the VCO on pin 8 with the TCXO signal on pin 1 to derive the VCO control signal, which it outputs on pin 5. The signal is then filtered by the loop filter operational amplifier U308. The output signal from the filter, VCOTUNE, controls the VCO and can be monitored on TP301.

[1] Delay from "key up" signal input to 50% power present at the RF output connector

U307 also sends status information from pin 7 to U302, which indicates whether U307 has successfully "locked" to the required frequency. When U307 has achieved frequency lock, U302 takes pin 17 low. The output from pin 17 is the LOCK_DET signal; this can be monitored on TP403.

Figure 9.2 shows the location of R305 on the module PCB.

9.3.3 Reference Oscillator

This comprises a 9.60 MHz TCXO. A trimmer on the TCXO can be adjusted so that the TCXO provides exactly 9.600000 MHz.

9.3.4 VCO Supply

U401 is a switching regulator that inverts its supply voltage when used with C405 and C407. This voltage is applied to bias the VCO and the audio stage.

9.3.5 Audio Line Input and Level Control

Balanced audio input of 775 mV_{rms} (for nominal deviation) is applied to pins 8 and 20 (SK101) which is protected against Electromagnetic Interference (EMI) by the inductor capacitor filters (L106, L107 and C125, C126, C128 and C129). This signal is applied to U101D, which provides common mode rejection against external hum and noise at the two-wire line input. This voltage may be monitored at TP102 and TP104.

The test point TP107 may be used for fault tracing, with an oscilloscope. A 775 mV_{rms} sinewave at this point should cause 3 kHz of FM deviation.

Audio limiting and filtering is external to the transmitter.

9.3.6 RF Driver

Q501 a dual gate FET and Q502 form a broad band RF amplifier with 30 dB gain and 400 mW output capability. Gate 2 of Q501 regulates the transmitter output power by adjusting the stage gain.

The input to Q501 is via C501, L508 and L501. These components form an impedance matching network; similar matching is used between Q501 and Q502. Output matching to 50 Ω is performed by a modified pi network C523, C527, C528 and L509. All of these networks are relatively low Q giving 1dB bandwidths of at least 40 MHz at UHF frequencies.

9.3.7 RF Power Amplifier

The power amplifier consists of a broad band hybrid power module. RF drive is fed to the power amplifier via a coaxial cable. U601 is supplied with 10 V on pin 2 and 12 V on pins 3 and 4. Thermal protection is given by U653 (refer to Section 9.3.11).

9.3.8 Dual Directional Coupler

Output of the power amplifier module is fed via a low pass elliptical filter to the dual directional coupler. This provides sample voltages for forward and reflected power, which are used to give an indication of the VSWR of the transmitter load. The forward power voltage is also used in the power control loop to keep the transmitter output power constant.

9.3.9 High Pass Filtering

The RF output from the power amplifier module is also fed to an absorptive high pass elliptical filter. This keeps the harmonic energy to a minimum.

9.3.10 RF Power Output Control

Voltage from the forward power port of the dual directional coupler feeds the constant output power loop. The loop consists of U702B and Q501 with RV701 enabling the transmitter output power to be adjusted from 1 W to 15 W.

As the voltage at the forward power port of the dual directional coupler increases, the voltage on Gate 2 of Q501 is reduced by the control loop and so the transmitter output power is reduced (and vice versa). This keeps the output power constant for supply voltage variations.

By grounding the base of Q702 through D710 at pin 5 of the rear panel socket (thus interrupting the constant power loop), the power output can be reduced externally, e.g. from the receiver module when the receiver is overloaded.

9.3.11 Thermal Protection of the RF Power Amplifier Module

U653 is mounted on the flange of U601 and increases its output voltage at a rate of 10 mV/°C. When its output reaches 950mV (indicating a heatsink temperature of 95°C); it turns Q701 on, which reduces Q702 emitter voltage. This controls the operation of the output power control loop reducing the power output of the transmitter until thermal equilibrium is reached.

9.3.12 VSWR Alarm

The forward and reflected power voltages from the dual directional coupler are fed to a differential amplifier U702/A via two logarithmic elements contained in D703. The output of U702/A is thus a function of VSWR and is fed to the monitor. Q704 switches the VSWR ALARM and its threshold is set by RV702.

9.3.13 Audio and Synthesiser Power Supply

This 10 V supply is based on U152, which uses a 4 V reference, set up by R151 and R152. This is compared to a feedback voltage and varies the conduction of Q152 via Q151 to maintain 10 V. U151 is an unswitched 8 V regulator which supplies U152B and the 4 V reference. U152A is switched on at Tx power up and may be permanently powered up by the "fast key" shunt PL151. This provides for faster Tx activation as the synthesiser is maintained powered on and in a locked state.

9.3.14 RF Power Supply

This 10 V supply has the same operation as the audio and synthesiser power supply. It is only switched on when the synthesiser is locked and the transmitter enabled, being switched via R655 by a low on the RF_EN line. Q652 is able to supply the higher current demands of pin 2 of U601 and the driver stage.

D603, a red LED on the module front panel, indicates when the RF power supply is enabled. This only occurs when synthesiser lock is established and the Tx_key line is pulled low. The LED may flicker at turn on as the power supply settles.

9.3.15 Monitor Facilities

Eight monitor inputs are examined with the aid of a 1 of 8 analogue multiplexer U701. Any one of these eight inputs may be selected to be connected to the controller via rear plug pins 2, 3, 13 and 14.

The outputs can be read on the Type 2737 Controller module (see Section 6), or the level meter on the Test Unit Type 2501.

The analogue monitor outputs, their binary coded decimal number designation and associated pins on U701 are shown below.

Decimal No.	Function	Pin No. on U701
0	Forward Power	13
1	VSWR	14
2	Lock Detect	15
3	Control Loop Voltage	12
4	0 V	1
5	Driver Output	5
6	Module Temp	2
7	+10 V Regulator Output	4

9.4 Transmitter Frequency Selection

9.4.1 General

The transmitter frequencies are selected using three Hexadecimal switches (SW302, SW303 and SW304) accessed through holes in the transmitter shroud. Figure 9.1 shows the position of the switches.

DIP Switch SW301 is used to select the operational RF band. Note that SW301 is pre-set at time of manufacture and should not adjusted unless to resolve incorrect selection. SW301 can only be accessed with the shroud removed.

Refer to Sections 9.4.5 and 9.6.2 for shroud removal details.

Note: The selected transmit frequencies are restricted to those with 5 kHz or 6.25 kHz synthesiser increments. If R305 is fitted to the module PCB, the synthesiser step size will be 5 kHz, otherwise the synthesiser step size is 6.25 kHz (default). Figure 9.2 shows the location of R305 on the module PCB.

DIP Switch SW301 RF band selection chart

RF Band (MHz)	Position 1	Position 2	Position 3	Position 4	Position 5	Position 6	Position 7	Position 8
450-470	ON	ON	ON	ON	ON	ON	ON	ON
335-356[1]	ON	ON	ON	ON	OFF	OFF	OFF	ON
380-403	ON	ON	ON	ON	ON	ON	ON	OFF
403-423	ON	ON	ON	ON	OFF	ON	ON	OFF
410-430	ON	ON	ON	ON	ON	OFF	ON	OFF
430-450	ON	ON	ON	ON	OFF	OFF	ON	OFF
470-490	ON	ON	ON	ON	ON	ON	OFF	OFF
480-500	ON	ON	ON	ON	OFF	ON	OFF	OFF
490-512	ON	ON	ON	ON	ON	OFF	OFF	OFF

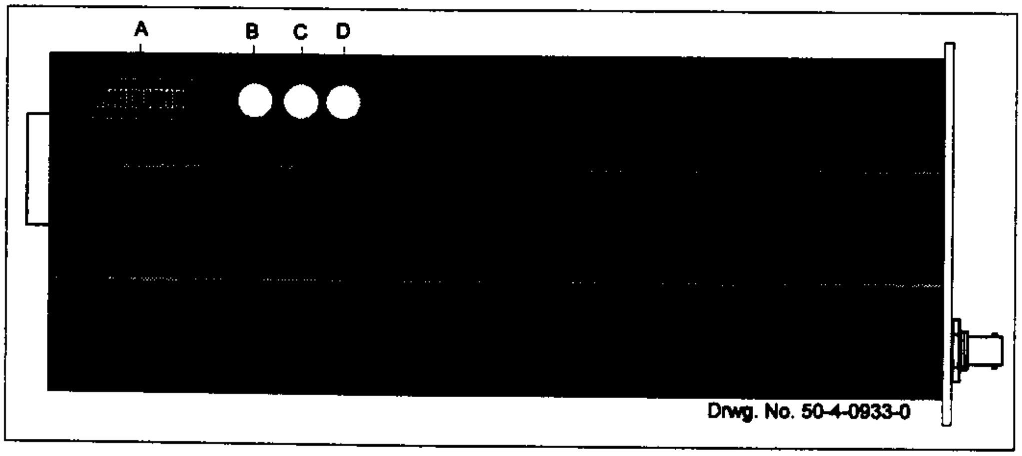


Figure 9.1: Frequency Selection Switches

Key

A SW301 (located inside module shroud)
B SW304 (Most Significant Bit)
C SW303
D SW302 (Least Significant Bit)

[1] Module type 2957, other RF bands refer to module type 2950 only.

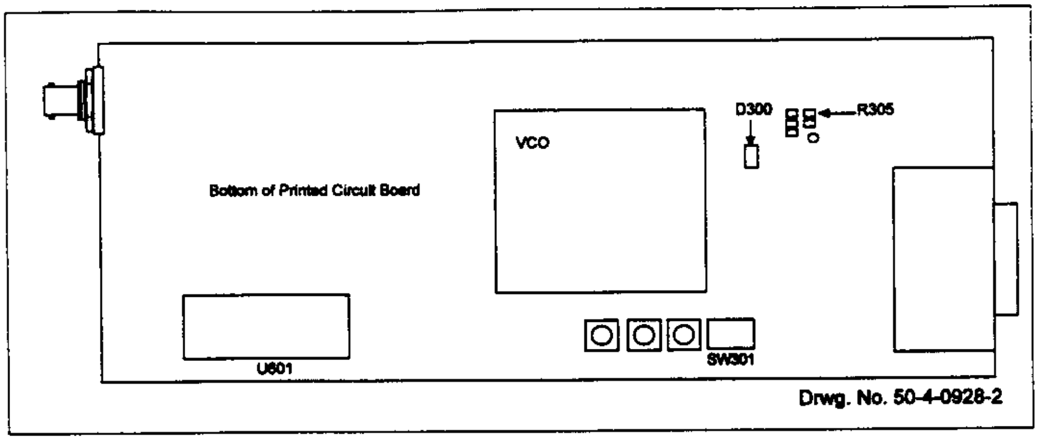


Figure 9.2: Position of Tx module synthesiser increment setting resistor R305

Frequency Selection Procedure

The transmitter frequencies are selected using three Hexadecimal switches (SW302, SW303, and SW304).

Frequency selection can be determined using one of two methods:

- > Determine the Hexadecimal switch settings for any specified frequency (Conversion of given Frequency to Hexadecimal number),
- > Calculate the operating frequency from given Hexadecimal switch settings (Conversion of given Hexadecimal number to required Frequency)

9.4.2 Determining Hexadecimal Switch Settings For A Given Frequency

The correct hexadecimal (base 16) switch setting to obtain a required frequency is calculated as follows.

$$\text{Switch Setting} = \text{Hex}\left[\frac{\text{Required freq. (MHz) - start freq. (MHz)}}{\text{Synthesiser Step Size (MHz)}}\right]$$

Example:

Start frequency	= 450.000 MHz (450 to 470 MHz band transmitter)
Required frequency	= 465.750 MHz
Synthesiser Step Size	= 6.25 kHz

Step 1

Calculate Decimal Number (base 10)

$$\frac{465.750 - 450.0}{0.00625} = 2520$$

This number represents the total number of 6.25 kHz steps above the start frequency necessary to achieve the required transmit frequency.

Step 2

Convert 2520 to a hexadecimal number to suit the frequency selection switches:

2520 ÷ 256 = 9.84375.

9 is a whole number so this is the correct setting for SW304 (MSB)

Step 3

Multiply the remainder (0.84375) by 256 = 216.

216 ÷ 16 = 13.5.

13 is a whole number, use the table below to convert 13 to the correct Hexadecimal setting.

Hex Digit	0	1	2	3	4	5	6	7	8	9	A	B	C	**D**	E	F
Number	0	1	2	3	4	5	6	7	8	9	10	11	12	**13**	14	15

D is the correct setting for SW303.

Step 4

Multiply the remainder (0.50) by 16 = 8.

8 is a whole number so this is the correct setting for SW302 (LSB)

Note: If the final figure is not a whole digit you have made an error in your calculations, or you have attempted to set a frequency which is not in the 5.0 or 6.25 kHz channel spacing band plan, and therefore not allowable.

Conversion complete 2520 = **9D8** Hexadecimal (base 16)

This setting of the Hexadecimal Switches will produce the required frequency of 465.750 MHz for a transmitter in the 450 - 470MHz band with 6.25 kHz channel spacing

9.4.3 Calculate the operating frequency for given Hexadecimal switch settings

To convert the hexadecimal (base 16) switch settings to a decimal number (base 10), convert each setting to a number between 0 and 15 using the chart below:

Hex Digit	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
Number	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15

Using the same example as in Section 9.4.2 above:

Switch setting **9D8** can be converted as follows:

From the table above, **9** = 9, **D** = 13 and **8** = 8

Step 1

Multiply the most significant number by 256:

9 × 256 = 2304.

Step 2

Multiply the middle number by 16:

13 x 16 = 208.

Step 3

Add the least significant number to the two numbers above:

8 + 208 + 2304 = 2520

9D8 Hexadecimal = 2520 in decimal.

Step 4

Convert 2520 into the actual operating frequency using the following formula:

F = switch setting (decimal) x frequency increment size + start frequency

As mentioned earlier, frequency increment size is either 5.0 kHz or 6.25 kHz (default). The start frequency can be read from the module handle label.

Assuming an increment size of 6.25 kHz, 2520 can be converted thus:

(2520 x 6.25 kHz) + 450 MHz = 15.750 MHz + 450 MHz = 465.750 MHz.

9.4.4 VCO Centre Frequency Adjustment

When changing the transmit frequency by more than ±1.5 MHz it will be necessary to reset the VCO centre frequency. The adjustment, C202, can only be accessed with the transmit module's shroud removed.

Refer to Sections 9.4.5 and 9.6.2 for shroud removal details.

Connect an RF power meter and a 50 Ohm load to the module's RF output.

Use a cable extender (available from Exicom) to connect the module's rear connector (SK101) to the Condor link.

Using a multimeter, set to DC volts, monitor between ground and the "Loop Volts" test point TP301 (located adjacent to the forward power adjustment RV701).

With the frequency selection switches set to the desired frequency, key the transmitter. Adjust the variable capacitor C202 (accessible through the VCO cover) until the transmitter produces forward power. Adjust C202 so that:

> 5 volts is measured on TP301 or

> the voltage measured on TP301 reaches a maximum value (tuned frequency is at the lower end of the transmitter module's frequency capability) or

> the voltage measured on TP301 reaches a minimum value (tuned frequency is at the upper end of the transmitter module's frequency capability).

9.4.5 Mechanical Access To The Transmitter Module

1 Turn off the power supply to the terminal, remove the terminal from the wall, and separate the terminal from all cabling, including the antenna cable.

Lay the terminal on a flat surface, with the base plate uppermost.

2 Remove the three screws complete with washers at the bottom of the terminal (see Figure 9.3) and store them in a safe place.

3 Remove the three screws located at the top of the chassis and store them in a safe place.

4 Turn the terminal over so that the cover is now uppermost and lift the cover off the terminal.

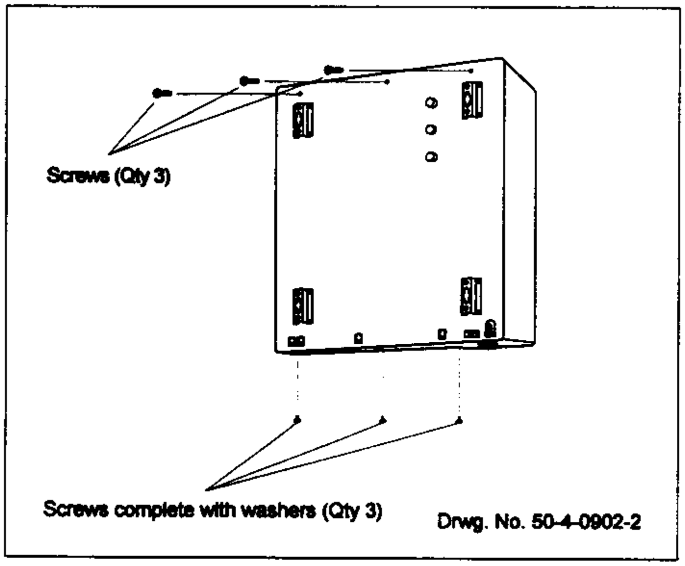


Figure 9.3: Wall Mount Cover Removal

5 Perform any electrical adjustments as required. See Sections 9.4.2 and 9.4.3.

6 Replace the cover over the chassis then lay the terminal on a flat surface with the chassis uppermost

7 Replace and tighten each of the screws complete with washers removed in step (2)

8 Replace and tighten each of the three screws removed in step (3).

9 Connect the terminal to the cabling, and fit the terminal into position on the wall.

10 Apply power to the terminal.

9.5 Transmitter Output Power Adjustment

9.5.1 General

The transmitter output power is adjusted using a multi-turn potentiometer in the transmitter module. Rotating the potentiometer in a clockwise direction increases the power and rotating in an anti-clockwise direction decreases the power. The potentiometer is adjusted through a hole on the right hand side of the module shroud (see Figure 9.4).

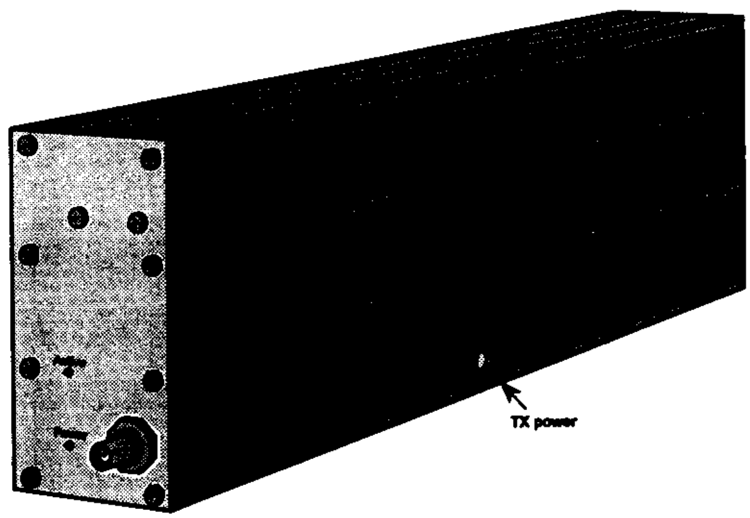


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Figure 9.4: Transmitter Module Power Adjustment

To adjust the output power of a transmitter module in a wall mount terminal, proceed as follows:

1. Transmitter output power can be adjusted without removing the cover. Leave all cabling connected and lift terminal off the wall.
2. Activate the terminal.
3. Identify the hole on the underside of the terminal through which the potentiometer can be adjusted ,
4. Using a suitable screwdriver, adjust the potentiometer as required. Check the transmitter output power using an in-line RF Wattmeter in the antenna feeder.
5. After re-calibrating the transmitter, replace the terminal on the wall. Ensure that all cables are connected and secure.
6. Perform a final check on the terminal to ensure correct operation.

9.6 Transmitter Alignment Procedure

9.6.1 Test Equipment Required

> Exicom Test Unit Type 2501,

> Communications Test Set with 600 Ω Adapter,

> Modulation meter,

> 1 GHz Frequency counter,

> RF Power Meter, e.g. Bird 43 Thruline or equivalent, with 25C and 25D elements,

> RF in-line Attenuator, 50 Ohm, 15 Watt minimum, 30 dB e.g. Bird Tenuline or equivalent,

> RF in-line Attenuator, 50 Ohm, 15 Watt minimum, 3 dB e.g. Bird Tenuline or equivalent,

> 20 MHz (or greater) oscilloscope,

> 13.8 V 5 A DC Power supply,

> Digital Volt Meter (DVM).

9.6.2 Preparation

For the full alignment procedure to be performed the transmitter module must be removed from the terminal and the PCB must then be removed from the module shroud.

1. Refer to steps (1) to (4) of Section 9.4.5 for wall mount cover removal details.
2. Identify and remove the three small screws and the three Hex bolts (and associated washers) on the underside of the chassis that hold the transmitter module in position. Put the screws, bolts and washers in a safe place for refitting the PCB.
3. Remove the duplexer lead from the transmitter front panel. Pull the transmitter module away from the motherboard PCB, taking care to ensure the module PCB connector comes out cleanly from the socket on the motherboard PCB.
4 In the transmitter module faceplate undo each of the eight screws along the faceplate (see Figure 9.5). Put the screws in a safe place for refitting the PCB.

   Note: The face plate screws have No.2 Japan Industry Standard (JIS) heads. Damage to screw heads may result if the incorrect screw tips are used. The closest alternative is a No.2 Phillips.

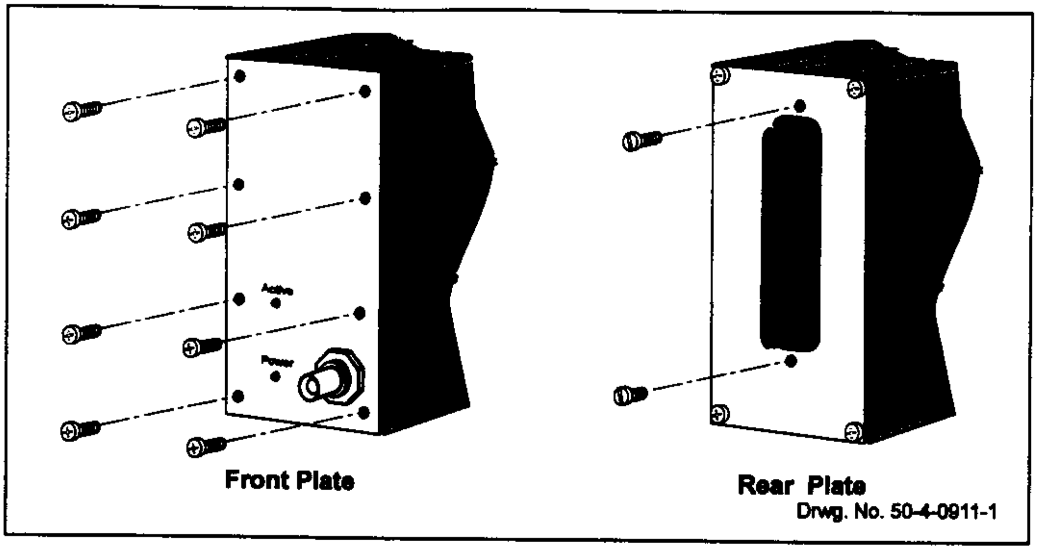

Figure 9.5: Module Face and Rear Plate Screws

5. In the module rear plate, undo the two screws on either side of the connector that protrudes through the plate (see Figure 9.5). Put the screws in a safe place for refitting the PCB.

6. Extract the transmitter PCB from the module by pulling gently on the front plate.

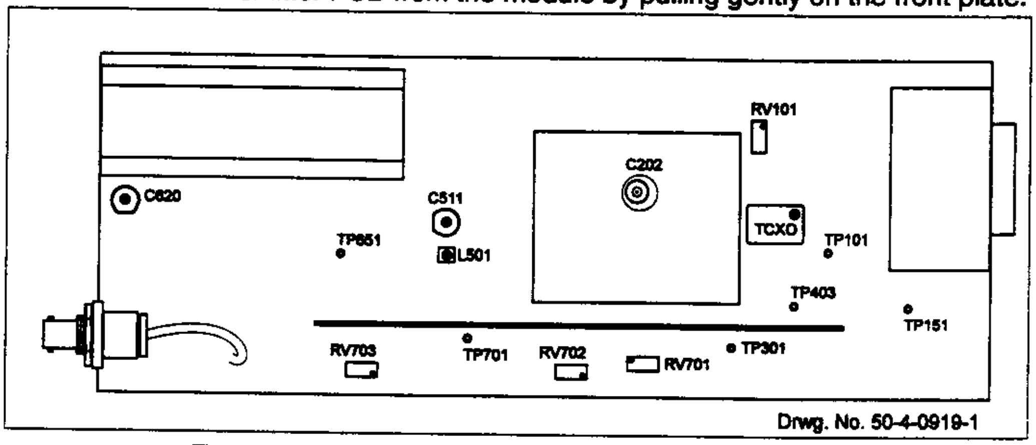

Figure 9.6: UHF Transmitter Type 2950 & 2957 Alignment Points

9.6.3 Alignment and Functional Checks

Note: Do not use an extender cable except for fault finding as it produces significant voltage drop at high output power settings.

1. On the PCB, turn RV701 (RF Power) fully anti-clockwise to give minimum power setting, and turn RV101 (frequency deviation control) fully anti-clockwise to give zero deviation.
2. Check the setting of DIP switch SW301 for the required frequency band and channel spacing, check if R305 is fitted (refer to Figure 9.2) and set the frequency switches SW302, SW303 and SW304 to the middle of the band. Refer to Section 9.4 for details.
3. Connect the power supply and the digital voltmeter to the Test Unit, and then use a short ribbon cable to connect the Test Unit to the rear plug on the transmitter PCB. Finally, use a short length of co-axial cable to connect the RF output plug on the transmitter PCB to the RF power meter, terminated with a 30 dB attenuator. Refer to Figure 9.7 for connection details.
4. Set the DVM Output switch on the Test Unit to "Supply Voltage". Apply power to the Test Unit, and adjust the power supply to give 13.8 V as measured by the digital voltmeter.
5. Set the DVM Output switch on the Test Unit to "Monitor Output", and the Tx,Rx switch to "Tx,Rx".
6. Check that the transmitter VCO is locked by observing the "Active" LED on the transmitter front panel. If this is unlit, set the monitor output select switch on the Test Unit to "2" (Lock Detect), and adjust C202 until the analogue meter on the Test Unit reads less than 2.0 (Synthesiser locked) at which point the LED should come on.

   Check that the transmitter locks reliably by toggling the Tx,Rx switch on the Test Unit to Tx,Rx several times.
7. Set the monitor output select switch on the Test Unit to "3" (Loop Volts). If necessary, adjust the VCO trimmer capacitance slightly to move the meter reading as close as possible to the centre of the meter range. This corresponds to a reading of 5 V on the digital voltmeter (as measured on TP301)
8. Set the monitor output select switch on the Test Unit to "7" (+10 V Regulator Output) and check that the analogue meter on the Test Unit reads more than 7.6 (RF power supply on). This corresponds to a reading of 2.4 V on the digital voltmeter.
9. Set the hexadecimal switches to the high band edge frequency, and set the monitor output select switch on the Test Unit to "0" (Forward Power). Adjust L501 and C511 on the PCB for a maximum reading on the Test Unit analogue meter.
10. Set the hexadecimal switches to the mid-band frequency, set the monitor output select switch on the Test Unit to "5" (Driver Output), and adjust RV701 for approximately 5 W on the power meter. Then adjust C620 for a dip in the reading on the Test Unit analogue meter.

11. On the Transmitter PCB, adjust RV701 for required RF output power measured on the power meter.

    Note: Allow for approximately 1 dB loss in the Duplexer after the transmitter is fitted back into the terminal.

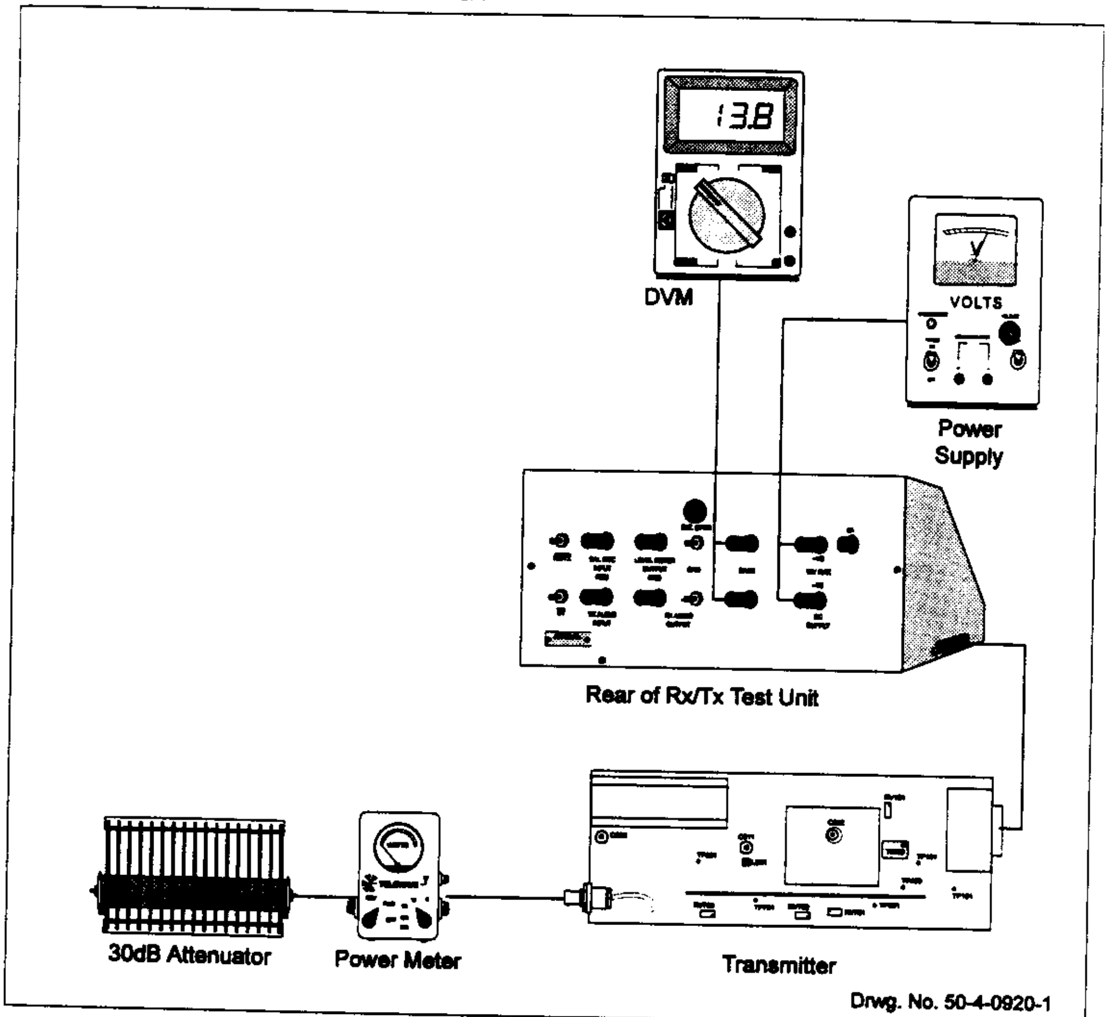

Figure 9.7: Alignment and Functional Checks Set-up

9.6.4 Modulation Deviation Setting

1. Connect the transmitter PCB to the test equipment as shown in Figure 9.8.
2. Set the radio test set to input a 500 mV_{rms} 1 kHz tone to the Tx Audio input on the Test Unit, and then use the test set to monitor both deviation and distortion at the transmitter RF output.
3. For transmitters using 12.5 kHz channel spacing turn RV101 fully anti-clockwise, then adjust RV101 clockwise on the PCB for a frequency deviation of ± 1.5 kHz.
4. For transmitters using 25 kHz channel spacing, turn RV101 fully anti-clockwise, and increase the audio signal input level to 775 mV_{rms}. Then adjust RV101 clockwise on the PCB for a frequency deviation of ± 3 kHz.

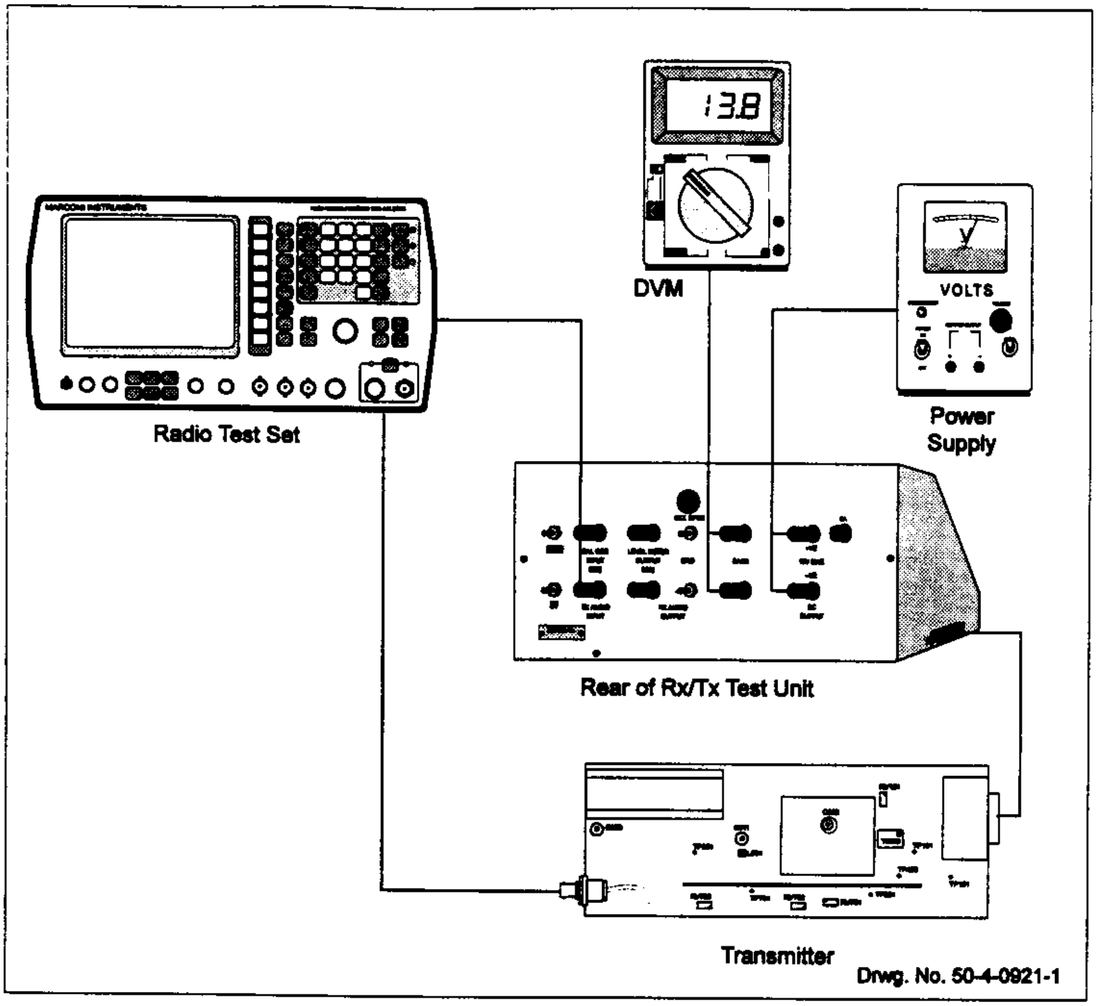

Figure 9.8: Modulation Deviation Set-up

9.6.5 Oscillator Frequency

1. Connect the transmitter PCB to the test equipment as shown in Figure 9.7. Connect the frequency counter to the output of the attenuator. Allow the equipment to be fully warmed up, then turn the modulation down to 0 mV_{rms}.

2. Monitor the transmitter frequency with the frequency counter, and check that it corresponds to that set on the frequency switches to within ±100 Hz. If this is not the case, adjust the TCXO on the transmitter PCB until the output frequency fulfils this condition.

9.6.6 VSWR Alarm

1. Connect the transmitter PCB to the test equipment as shown in Figure 9.7.

2. Set the monitor output select switch on the Test Unit to "1" (VSWR), and adjust RV701 on the transmitter PCB until the power meter reads 5 W,

3. Connect the DVM across TP703 and TP704 on the transmitter PCB, and connect 0.5 Metres of un-terminated coaxial cable to the RF connector on the transmitter PCB front panel.

4. Adjust RV703 on the transmitter PCB for a reading of 0 ± 10 mV on the Test Unit analogue meter (this sets the zero balance for the VSWR bridge).
5. Connect a 3 dB 50 Ω attenuator to the transmitter RF output.
6. Connect the un-terminated coaxial cable to the output of the attenuator (this gives a 3:1 mismatch).
7. Adjust RV702 on the transmitter PCB so that the VSWR alarm LED on the Test Unit just lights.

9.6.7 Completion of Transmitter Alignment

1. Insert the PCB through the front of the module shroud, taking care to line up the connector with the hole in the rear plate.
2. Using the two screws kept from the removal of the PCB, insert a screw into each hole in the PCB connector, do not fully tighten at this time (see Figure 9.5)
3. Using the eight screws kept from the removal of the PCB, insert a screw into each hole in the module faceplate; (See Figure 9.5). Ensure all screws are securely fastened in the module front and rear plates.
4. Align the module into position on the wall mount chassis, taking care that the holes in the module shroud line up with the holes in the chassis, and that the PCB connector on the module fits cleanly into the socket on the motherboard.
5. Using the three screws kept from the removal of the module, insert a screw into each hole in the module. Insert the three Hex bolts and washers kept from the removal of the module. Tighten all screws and bolts to secure the module.
6. Refer to steps (6) to (10) of the wall mount procedure in Section 9.4.5 Mechanical Access for cover replacement details.

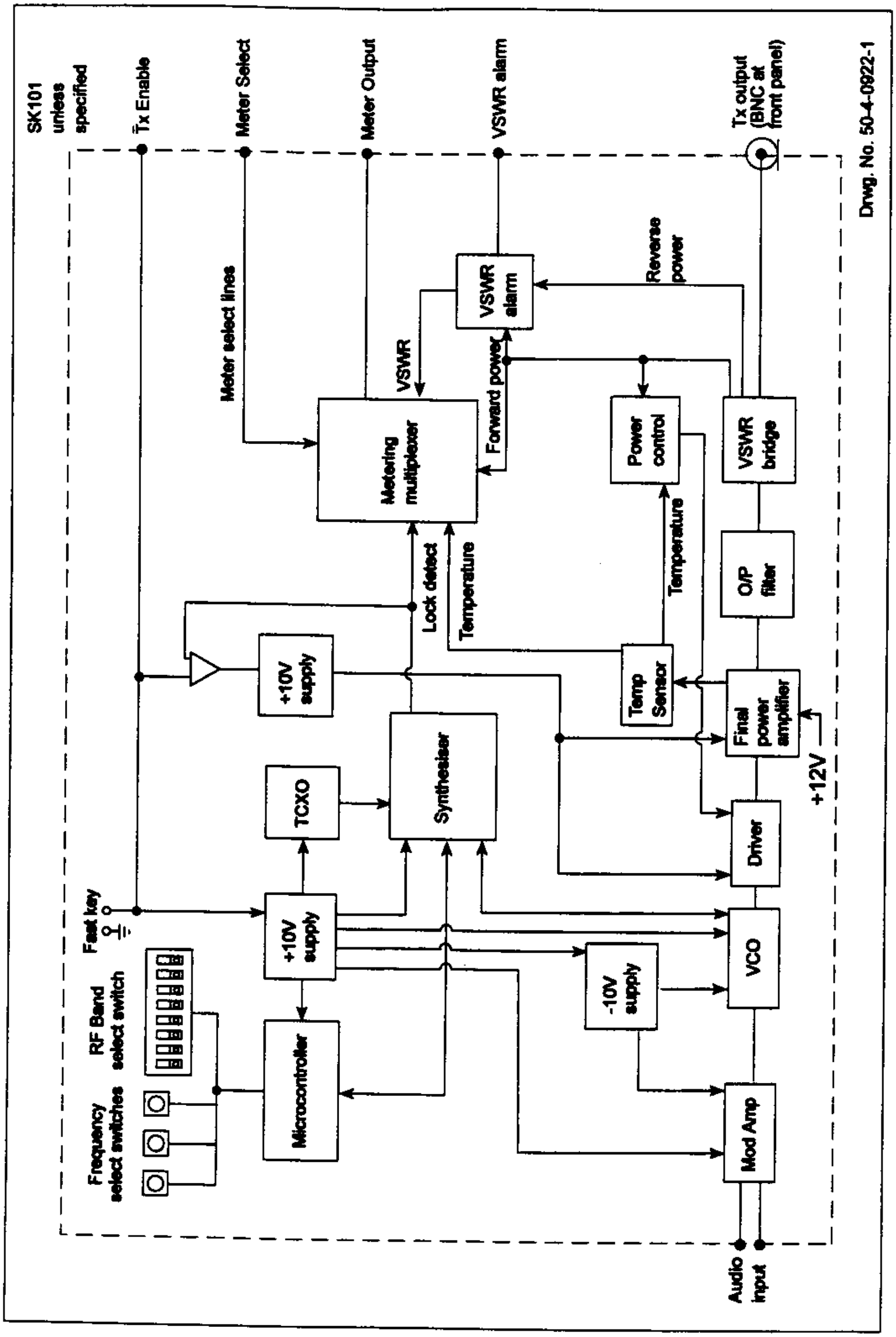

Figure 9.9: UHF Transmitter Block Diagram

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10
VHF and UHF Duplexers Type 2824

10.1 Introduction

The Duplexer contains two sections, a high pass notch and a low pass notch.

Connection to the Duplexer of the receiver and transmitter is dependant on their relative operating frequencies. The unit operating at the highest frequency is connected to the high pass port labelled "H".

The lower frequency unit is connected to the low pass port labelled "L". Antenna connection is made to the extended "N" connector at the rear of the Duplexer.

The following method of tuning the Duplexer involves the use of the receiver in conjunction with the control module as a signal level monitor. The control module is set to align mode and the monitor is switched to Rx position 0 (signal level).

Alternatively the duplexer may be tuned with a Condor receiver on the appropriate frequencies, with these units operating from the Exicom Transmitter/Receiver Test Unit type 2501.

The Condor receiver is synthesised and UHF equipment can be quickly switched between transmit and receive frequencies for this alignment. VHF receivers may not cover both channel frequencies without re-tuning their VCO so use of both receivers may be required.

10.2 Specifications

The duplex filter type 2824 specification characterises this unit for all bands.

Type	Bandstop - bandstop, 4 cavity resonator

Terminations

Antenna	Type N female
RF Modules	Highpass (HP) and lowpass (LP) connections, BNC male on flying leads
Bands Covered (MHz)	68-78, 72-82, 78-88, 148-162, 159-174, 403-423, 410-430, 430-450, 450-470, 470-500, 490-512
Max Input Power	50 Watts
Temperature Range	-30°C to +60°C
Humidity Range	0 - 95% non condensing.

Insertion Loss	1.5dB Max HP port to antenna or LP port to antenna (dependent on Tx - Rx separation)
Tx Noise Suppression at Rx Frequency	60dB minimum
Rx isolation at Tx Frequency	60dB minimum.
Antenna Port Return Loss	10dB minimum (dependent on Tx - Rx separation)
HP, LP Port Return Loss	10dB minimum (dependent on Tx - Rx separation)
Tx - Rx Separation	
68 - 88MHz sub-bands	4.0 to 6.0MHz
148 - 174MHz sub-bands	4.5 to 10.0MHz
403 - 512MHz sub-bands	5.0 to 10MHz

10.3 Alignment Procedures

10.3.1 Instruments Required

> Condor with transmitter and receiver set to required frequencies.

> Signal generator (eg. HP8640B).

> Power meter (eg. Bird 43 and 50Ω / 20 watt load).

10.3.2 Tuning Instructions

Tuning slugs are numbered from left to right. The left hand slug is adjacent to the Transmitter module.

1. With control module in align mode (see 2737 Controller Module) and monitor set to Rx position 0, (or use the transmitter and receiver Test Unit Type 2501 which provides the monitor function). This allows measurement of receive signal level.

   Set up the equipment as follows:

2. Use the receiver which is tuned to the "low" link frequency

   Connect it to the antenna port.

   Connect the signal generator to the "H" port and set its frequency to the receive frequency.

   Connect a 50Ω load to the "L" port.

3. Adjust generator level to read 7 on the monitor, loosen the slug locking nut and turn slug 1 for a dip in the meter reading. Increase the generator level to read 7 on the monitor as necessary. Tighten the lock nut when this adjustment is complete.
4. To adjust slug 2 repeat step 3 above.
5. Remove the original receiver and then select the receiver which is tuned to the "High" link frequency.

   Connect it to the antenna port.

6. Connect the signal generator to the "L" port and set its frequency to the "High" receiver frequency.

   Connect a 50Ω load to the "H" port.

7. Adjust generator level to read 7 on the monitor, loosen the locking nut and turn slug 3 for a dip in the meter reading. Increase the generator level to read 7 on the monitor as necessary. Again tighten the locking nut on completion.
8. To adjust slug 4 repeat step 7 above.

Set up the system for normal operation (ie. with Tx and Rx connected to their respective "H" or "L" ports) and a 50Ω power meter with load connected to the "N" (antenna) port of the duplexer.

With the control module monitor set to Tx position 1 key the transmitter and check that the monitor just reads zero, and that the power output on the meter is not less than 70% of the power directly out of the Tx module.

The duplexer is now tuned.

Note: If only one Condor terminal is available, note the synthesiser switch settings for transmitter and receiver and use the available receiver on both high and low frequencies for Duplexer adjustment. It is necessary to interrupt the receiver power supply in order to load new synthesiser switch settings. Return receiver to its original switch settings on completion of alignment.

12
Mains Power Supply Type 2828

12.1 Introduction

This module is a switchmode power supply operating in flyback mode. This section provides a detailed circuit description, test procedure and some suggestions for fault finding.

12.2 Circuit Description

12.2.1 Input Circuit

AC input is filtered by C1-C6 and L1 and taken to the bridge rectifier D2 to D5. This rectifier may be configured as a bridge for 230V AC operation or as a voltage doubler for 110V AC operation, depending on the position of the voltage selector plug. The rectified DC (about 300V) is then taken to the transformer T1 and switching MOSFET Q1.

Q1 is a MOSFET switch operating at about 180kHz and controlled using pulse width modulation (PWM). It is protected by a catcher winding connected by diodes D10 and D11. This limits peak voltages on Q1 to approximately 750V at full load.

C14 and C17 provide additional protection with fast transients.

12.2.2 Output Circuit

The output of T1 is rectified by D104 and filtered by C110-C114 and L110-L113. R112 provides a small minimum load to ensure correct operation at zero load.

12.2.3 Start-up Circuit

When input power is connected to the unit, relay RLY1 is not energised. The input AC is rectified by D1 and taken through R3 and R4 to the series regulator Q2 which limits the DC voltage to the control circuitry to approximately 15V.

The output of Q2 powers the control circuitry (via the series switch Q4) and the low/high voltage input comparator IC1.

IC1 is an open collector comparator. Three outputs are connected in parallel, so that if the input is too high or too low, or the temperature is too high, the common output is pulled low by one of the comparators.

Start up occurs when the voltage at IC1/C pin 11 reaches the 5.6V reference (D30). When this occurs IC1/C output switches high. IC1/D and IC1/B outputs are already off. R42 and C21 provide a delay of about one second before the inverting output of IC1/A goes high. IC1/A output then pulls low. This turns the series switch Q4 on and provides power to the main control circuit.

IC1/B monitors the input voltage through R12 and R20/21. If this voltage is too high (above 275 V on 230V AC supply), IC1/B turns on and shuts down the supply.

Similarly, IC1/D monitors the temperature sensor thermistor R23 (near to the pillar holding MOSFET Q1). If the temperature rises above about 100°C, IC1/D turns on and shuts down the unit.

12.2.4 Pulse Width Modulation (PWM) Control Circuit

IC2/C is a comparator connected as a sawtooth generator operating at about 180kHz. It produces an asymmetrical sawtooth wave, with peak voltage at about 11V and the trough at about 1 to 2V.

The sawtooth waveform is taken to the inverting inputs of the pair of parallel-comparators IC2/A and IC2/B. The other inputs of IC2/A and IC2/B are taken to a feedback voltage. At full load the feedback voltage is about 5V, and the output duty cycle from the comparators is about 50%. At low loads, the output feedback voltage decreases and thus the comparator duty cycle reduces.

Q5 and Q6 provide buffering for the output from the comparators to the MOSFET Q1.

12.2.5 Current Limiting

The current through MOSFET Q1 is monitored by the source resistor R17. This voltage is taken to the inverting input of IC2/D. The non-inverting input of IC2/D is divided down from Q2 output, plus a small proportion of the MOSFET gate drive signal (through R64).

When the peak current through Q2 reaches the pre-set current limit point, IC2/D output pulls low and turns off IC2/A and IC2/B, turning off the MOSFET.

This is a peak primary current limit , which gives MOSFET protection and an approximate input power limiting effect. Total power, rather than output current is controlled. This means that output current into a short circuit will be considerably greater than the rated output current at 13.8V output.

12.2.6 Voltage Feedback

The voltage at the output is taken to IC104 via an adjustable voltage divider. IC104 acts as a controlled zener. When the reference input for the controlled divider is lower than 2.5V, no current flows through the cathode. As the reference voltage increases, corresponding to high output, increasing current will flow through the cathode.

Cathode current is taken through the optocoupler IC3 and pulls the main PWM comparator inputs low and reduces the duty cycle.

Similarly a low output voltage will decrease cathode current and allow the feedback input to the comparators to increase.

12.2.7 Over-voltage Protection

The output voltage is also taken via a divider to IC106. When the output reaches the pre-set over-voltage shutdown point, IC106 will turn on and turn on Q100. This puts current through optocoupler IC4 and pulls the input to IC1/C low. This causes IC1/C output to go low and switches off the power supply.

The power supply will try to switch on again after the input turn on delay of about 1 second. If the output fault is still present the unit will switch off again.

12.3 Power Supply Installation

Note: Ensure that the power supply is set up for the correct mains voltage by checking the linking on the PCB. P1 is bridged to P2 to select mains voltages in the range 184 to 276V AC (230V nominal), or bridged to P3 to select mains voltages in the range 88 to 132V AC (110V nominal). Refer to Figure 12.1 to locate P1,2,3.

Rack Mount Condor

The power supply for this option is mounted on the inside right of the Condor rack mount shelf.

Wall Mount Condor

The power supply is normally mounted on the wall adjacent to the Condor. If the wall mount Condor is mounted on the optional rack mount tray the power supply mounts on the right hand side of the rack mount tray in the holes provided.

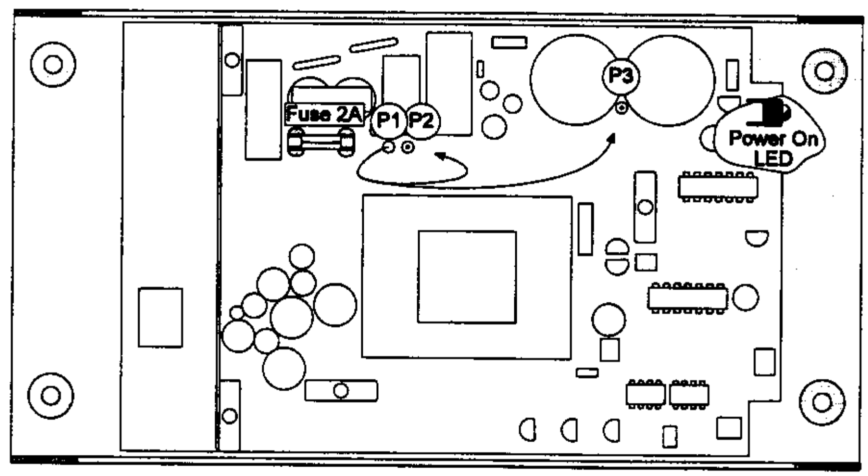

Figure 12.1 2828 Power Supply

12.4 Fault Finding

Note: Because of the high voltages present always exercise extreme care when servicing. An isolation transformer is necessary for all work with the cover removed.

Ensure that the drain voltage on Q1 is always kept to less than 1000V. When testing the unit after major repairs, always check the drain voltage using a 1k ohm resistor soldered onto the drain pad under the PCB, with the scope probe clipped onto this. Refer to Figure 12.2 below.

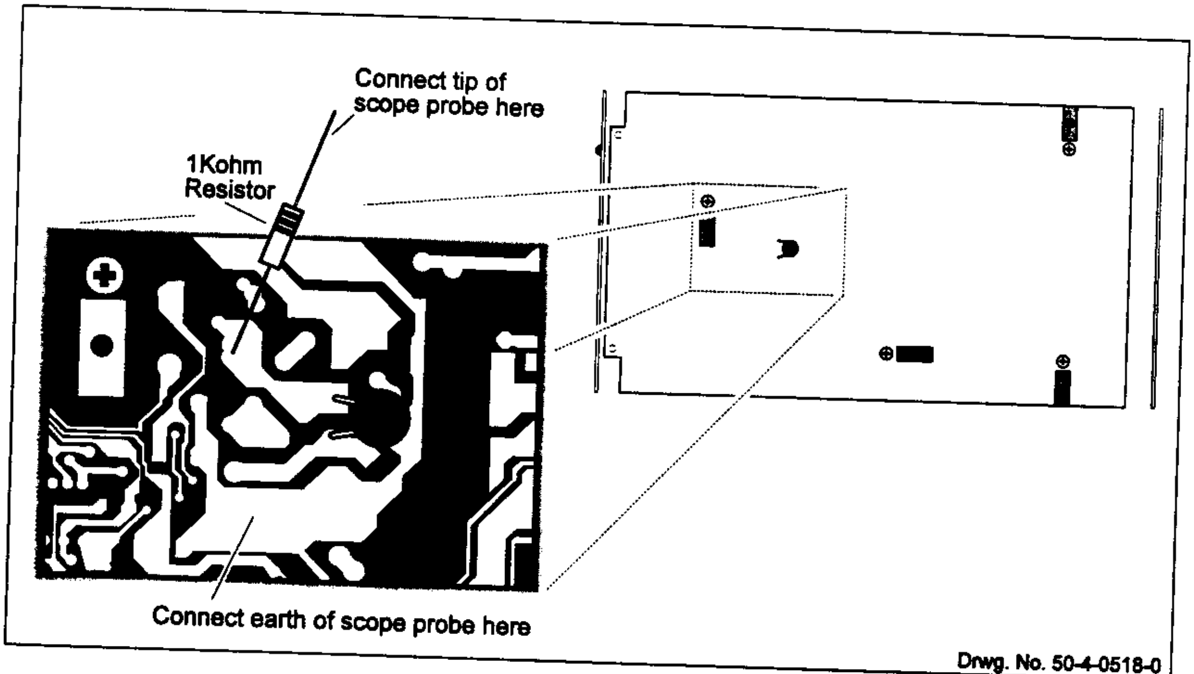

Figure 12.2 Connection Points to Measure the Drain Voltage of Q1

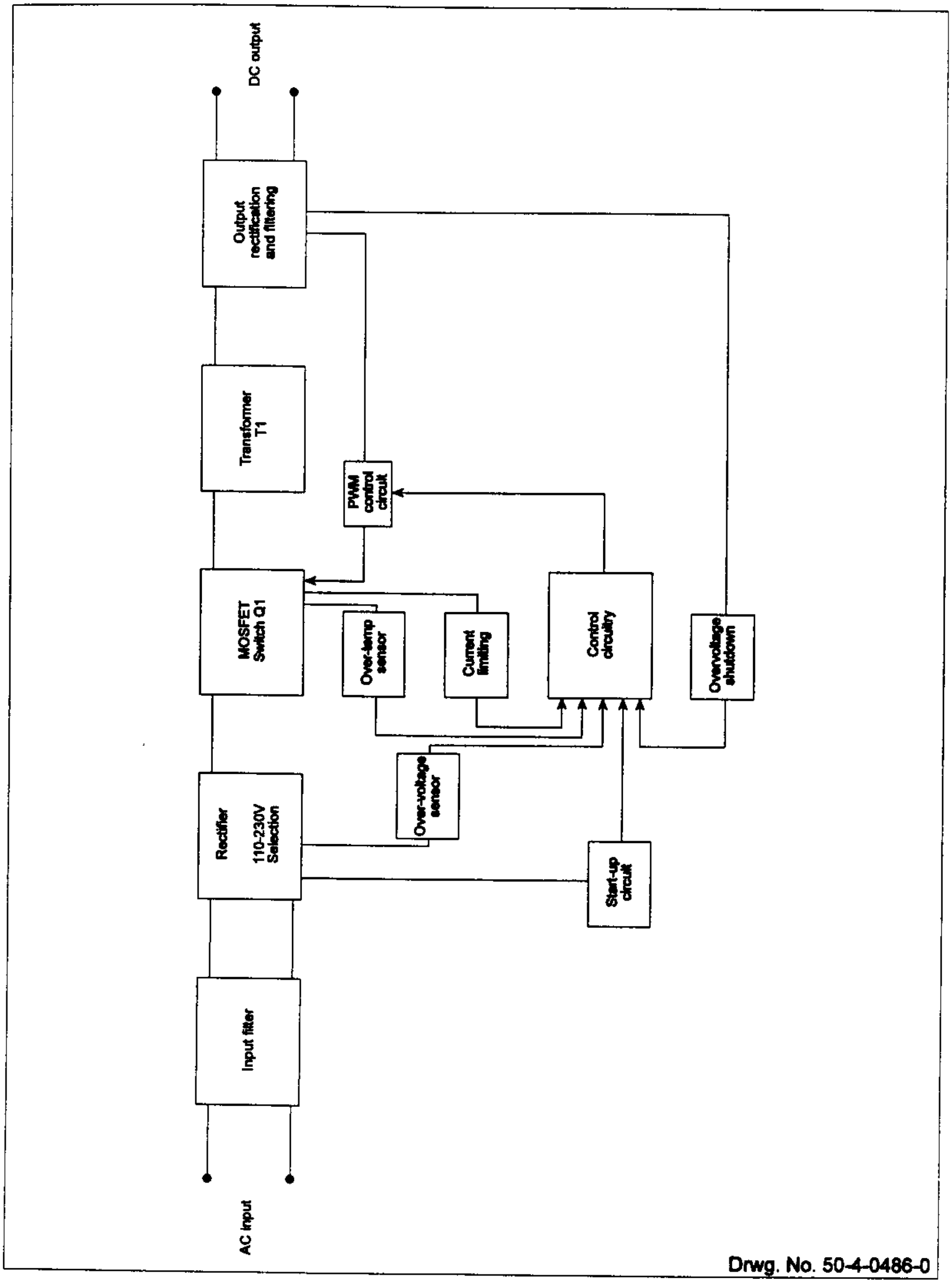

Figure 12.3 Mains Power Supply Type 2828 Block Diagram

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13
DC-DC Converter Type 2461

13.1 Specifications

Input	22 to 70VDC either polarity earthed
Output	13.5V at 4A DC load
Output Ripple	Less than 0.5mV psophometrically weighted
Input Protection	Polarity reversal, undervoltage, overvoltage
Input Fuse	5A 20mm or 30mm (internal)
Isolation	Input, output and frame DC isolated
Output Protection	Short circuit proof. Overvoltage protected
Indicators	Front panel LED, power on digital monitoring

13.2 Circuit Description

The power supply is designed to power a nominal 13.5V to the Condor link terminal from a nominal 24V or 48V supply. The basic configuration is a switched mode converter with input and output DC isolated. Regulation is achieved by optically coupled feedback controlling pulse width.

The input from a nominal 24V or 48V supply is via fuse FS1. 20mm or 30mm fuses can be fitted by modifying the position of the input terminal of the fuseholder. Polarity protection is provided by D2. Overvoltage input shutdown above 60V is provided by D1, D5 and TR1. Pulse width modulator IC2 drives power FETs TR6 and TR7 with a 100kHz square wave via complementary symmetry driver TR3, TR4. During the off period D11 conducts due to the collapsing magnetic field in T1 returning this energy to the supply capacitors. During the "on" period current from T1 secondary feeds via one of the D14 diodes into L7 the switchmode inductor. In the "off" period the other D14 flywheel diode conducts to transfer the L7 stored energy to the output capacitors.

Output voltage is sensed by D16 and optically coupled via IC1 to control the duty cycle of IC2.

Power FET current is sensed at source resistors R19, R31 and R32. Average current is sensed at IC2 pin 4 and peak current at pin 10 to provide protective shutdown of IC2 output. A soft start power supply turn on characteristic is provided by C13 to limit inrush currents. Output overvoltage protection for inductive load transients is provided by 16V VDR R30. Extensive onboard RFI suppression and input/output filtering ensure a low level of conducted and radiated emissions.

13.3 Servicing

No setting up adjustments are provided. Link J1 is provided in the drain connection of power FETs TR6 and TR7. During servicing of faulty units disconnecting this link will enable the supply to be tested up to the FET gates where a 10V peak to peak square wave 100kHz wave-form with less than 50% duty cycle should be observed on a CRO. The 1k ohm 5W resistor across J1 enables the power FETs to be checked without risk of damage to them.

A 100kHz sawtooth waveform of less than 50% duty cycle will be present on the FET drains. Peak to peak amplitude is half supply voltage. ie. 12V p-p for a 24V power supply, or 24V p-p for a 48V power supply.

Operation of the overvoltage shutdown can be checked at this time.

Do not close J1 until these conditions have been met. Operate the supply from a 0-65V supply current limited to 3A. It should start up at 19V input and shut down at 72V.

Full load input current is 2.25A at 23V input and 1A at 56V.

With a short circuited output, input current is limited to less than 1.5A.

17

System Setup

17.1 Introduction

This chapter describes how to set up the audio levels and transmitter power for the Condor. The operations described here should normally performed by qualified technicians in a repair or service centre.

17.2 Identity Codes

In telephone mode, communication between the exchange and subscriber radio terminals is preceded by an identity code handshake. Both terminals must therefore be set to the same ident code before any bench testing or field installation can begin.

Setting of ident codes is described in Section 6.1 of this manual.

17.3 Level Alignment Procedure

This procedure allows bench checking of a Condor link before field installation. It assumes that individual modules within the Condor terminals have been aligned using the module Test Units (refer to the SR210/310 and Condor Test Units Manual).

Connect the subscriber and exchange terminals back to back via 100dB of attenuation. Coaxial T-connectors connected to the low power (output) side of the 30dB power attenuators provide monitoring for each transmitter in turn with modulation meter and frequency counter.

This alignment gives the following system levels:

Subscriber transmit 1kHz at 0dBm --> 3kHz deviation ± 10% --> exchange receive -3dBm

Exchange transmit 1kHz at -7dBm --> 3kHz deviation ± 10% --> subscriber receive -10dBm

17.3.1 Subscriber to Exchange Alignment (S --> E)

(1) Connect the modulation meter so that it measures deviation of the subscriber terminal transmitter,

(2) Connect a 600Ω level meter to the 2-wire line connections of the exchange terminal. This is best done across the gas discharge arrestor on the motherboard,

(3) Connect a 600Ω audio generator to the 2-wire line connections of the subscriber terminal with frequency set to 1000Hz and level to 0dBm,

(4) Adjust RV3 in the 2587 subscriber line interface to give approximately 2.5kHz deviation for 25kHz channel spacing or 1.25kHz for 12.5kHz channel spacing,

(5) Adjust RV4 in the 2586 exchange line interface, to give output of -3dBm on the level meter,

(7) Reduce the input level by 20dB and check the frequency response is within +1dB, -4dB of the 1kHz level.

17.3.2 Exchange to Subscriber Alignment (E --> S)

(1) Connect the modulation meter to measure the deviation of the exchange terminal transmitter,

(2) Connect the level meter to the 2-wire output of the subscriber terminal,

(3) Connect the audio generator to the 2-wire input of the exchange terminal with frequency set to 1000Hz and level to -7dBm,

(4) Adjust RV2 in the 2586 exchange line interface to give approximately 2.5kHz deviation for 25kHz channel spacing or 1.25kHz for 12.5kHz channel spacing,

(5) Adjust RV1 in the 2587 subscriber line interface for an output level of -10dBm,

(6) Reduce the input level by 20dB and check for a frequency response, 300Hz to 3400Hz, of +1dB, -4dB relative to the level of 1kHz

Note: The subscriber terminal provides a 2-wire loop current of approx 25mA (45mA for party line). This DC current can produce errors in some audio test equipment due to transformer core magnetisation.

(8) Connect a test telephone to the subscriber terminal and connect the exchange terminal to the exchange test line. Check for correct call establishment in both directions. Description of correct call establishment is detailed in "Link Operation Sequences" Section 3.6 of this manual.

17.4 Transmitter Power Adjustment

To adjust the transmitter power, first remove the plastic hole cover underneath the transmitter module. This gives access to power control adjustment RV1 in the transmitter.

17.5 Test and Alignment Aids

Four separate Test Units are manufactured to simplify test and alignment of the Condor modules. They are intended for use by regional module repair centres. Field repair is on a module replacement basis. The units are:

>	Controller/Multiplexer Test Unit	Type 2504
>	Tx/Rx Test Unit	Type 2501
>	Subscriber Interface Test Unit	Type 2502
>	Exchange Interface Test Unit	Type 2503

The SR210/310 and Condor Test Unit Manual details alignment and test sequences to allow a rapid return to service for the modules.

In addition to Test Units an extender cable set is available (Type 2464). A set of cables comprises one each of 64-way, 50-way, 24-way and 14-way extension cables and connectors.

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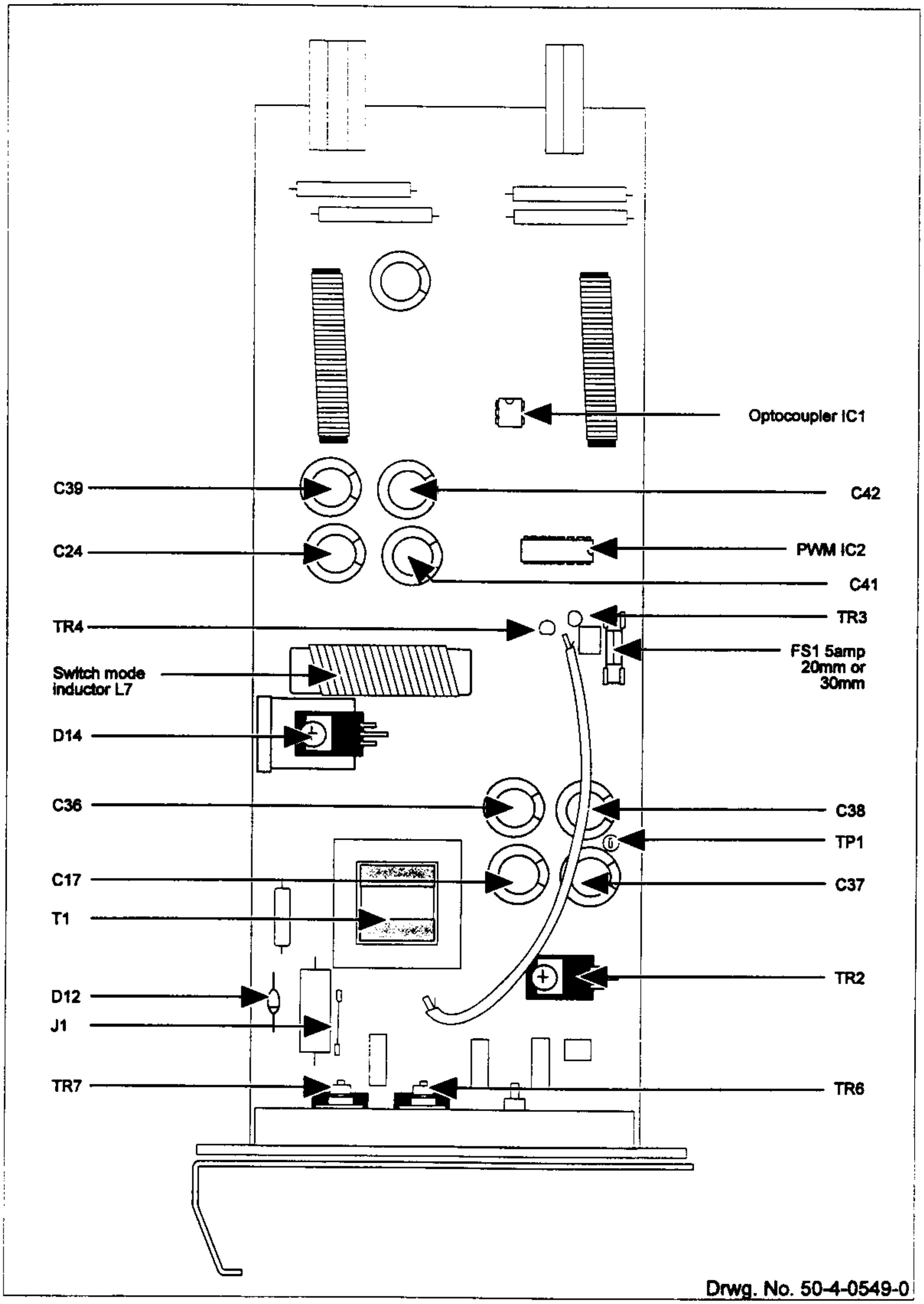
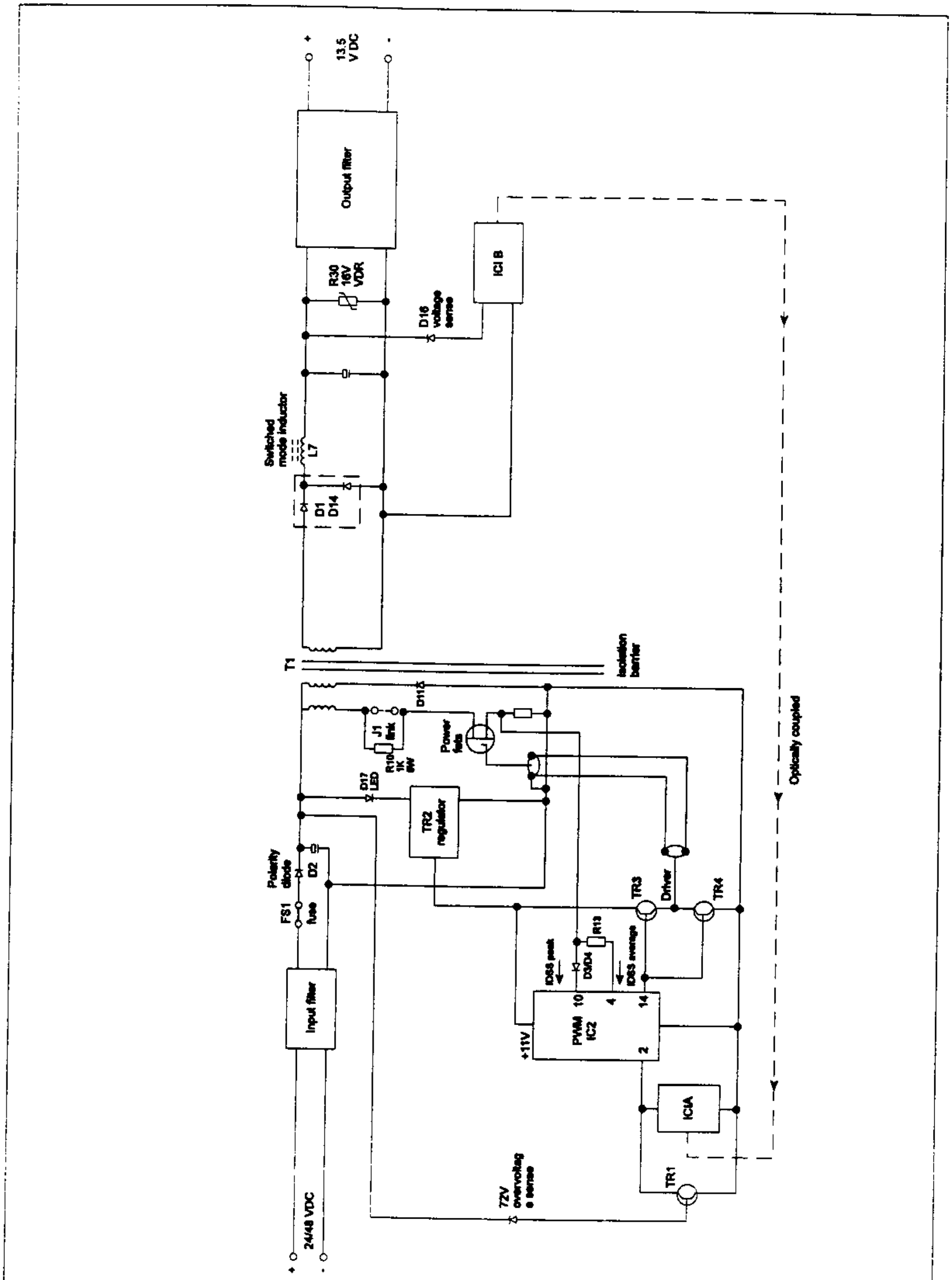


Figure 13.1 DC-DC Converter Type 2461



Drwg. No. 50-4-0483-0

Figure 13.2 DC-DC Converter Type 2461 Block Diagram *Drg. no. 26-2-0381-2*

PART ONE

CONDOR

STANDARD CONFIGURATION

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1 Introduction

1.1 General

The Condor is a single channel, duplex radio link providing communication between two terminals in fixed installations. Communication is via a channel with normal telephone bandwidth ie. 300Hz - 3400Hz. The Condor is duplex allowing the user to both listen and speak at the same time.

1.1.1 Application

The Condor is used for three different applications: telephone, payphone or non-telephone. When used to provide a telephone or payphone, one Condor terminal is connected to a telephone or payphone, and the other to a Telephone Exchange. When used in non-telephone applications, the Condor provides a voice channel on demand. These three modes are described in more detail below.

1.1.2 Radio Bands

The Condor is available in a number of radio bands. Within each band, a pair of frequencies is chosen and dialled up on switches in the receiver and transmitter modules. For more information on radio bands, refer to the Condor Installation Guide and to Sections 7, 8 and 9 of this manual.

1.1.3 Line Interface Modules

The Condor 2825 Line Interface Module can be set for either an exchange terminal or a subscriber terminal. As a subscriber terminal, the interface can be set for one telephone or two telephones (normal or high current). As an exchange terminal, the interface can be set for two wires or four wires plus E and M signalling. For more information on the 2825 Line Interface, refer to Section 11 of this manual.

The 2586 Exchange Line Interface and the 2857 Subscriber Line Interface can only be used for their specific function ie. Subscriber or Exchange. The two line interfaces are used when payphone facilities are required and are fully compatible with 50Hz longitudinal meter pulse, 12 or 16kHz meter pulse or line reversal payphones. For more information on the 2586 and 2587 line interfaces refer to Sections 18 and 19 of this manual.

1.1.4 Telephone Applications

When used as a telephone link, the Condor enables a telephone to operate as if it is connected to the exchange by wire, instead of radio. Under normal conditions, the user is not aware that a radio is being used. Both pulse dial and DTMF dial telephones operate normally. The ringing cadence sent to the telephone is the same as the exchange sends and most exchange tones are heard as normal. The only noticeable differences are:

> Dial tone is not received until about 1.5 seconds after the handset is lifted,

> There is an additional tone (link busy), which is heard if the radio path fails.

Payphone operation also supports the detection and generation of payphone signalling. This enables correct operation of any payphone connected to the subscriber terminal.

1.1.5 Non-Telephone (Point-to-Point) Applications

When set in point-to-point mode, the Condor acts as a simple duplex radio. The radio link is set up when one of the terminals receives an M-wire providing a voice or data path from one terminal to the other. M-wire into one terminal is forwarded as E-wire out of the other terminal. Removal of the M-wire closes the link down. There are two basic Point to Point modes:

> Normal - in this mode only the terminal which has an M-wire signal into it will transmit;

> Trunking - in this mode when one terminal is triggered by an M-wire, a duplex link will set up. The link remains until half a second after both M-wires are removed.

For more information about non-telephone applications refer to the 2737 module, Section 6 of this manual or contact your Condor supplier.

1.2 Cautionary Notes

1.2.1 Screw Sizes

Screws in this equipment have **No. 2 JIS** heads (Japan Industry Standard) Damage to screw heads may result if the incorrect screw tips are used. The closest alternative is **No. 2 Phillips**

1.2.2 Electrostatic Damage

CAUTION

The Condor uses a number of semi-conductor devices which are sensitive to electrostatic damage. You should assume that every IC is sensitive to static electricity.

Please take adequate care in the handling and storage of such devices when carrying out any service work on the equipment.

Electrostatic sensitive devices should only be stored and transported inside electrically conductive static shielding bags.

Repair work on equipment containing these devices should be carried out only at "electrostatic-safe work stations", where the work bench surface, soldering iron and the operator are all earthed to prevent the build up of harmful electrostatic charges.

1.3 How To Use This Manual

This manual is divided into two parts.

- **Part One** details the Condor used with the 2825 Line Interface, allowing normal phone or point-to-point operation.
- **Part Two** details the Condor using the 2856 and 2587 Line Interfaces which enable payphone operation. The modules common to both systems configurations are covered in Part One and should be referred to when reading Part Two.

The **Condor Technical Manual** is one of a set of three Condor manuals. It describes how the Condor works. The other two texts are:

- **Condor Installation Manual:** This manual describes how to install the Condor. This manual is supplied with every Condor terminal.
- **SR210/310 and Condor Test Units Manual:** This manual describes how to set up, test and fault-find the modules.

You need this Manual if you want to know:

- What the Condor is, and what it does (Section 1);
- What specifications it meets (Section 2 and 16);
- How the Condor works as a system (Section 3);
- How to set up a Condor link (Section 4 and 17);
- How each of the modules work (all other chapters).

3
System Operation

3.1 Introduction

This chapter describes how the Condor works as a system. It includes a description of the Condor and its features. It details the sequence of events for the Condor in several modes of operation. It includes a fault-finding guide which can be used to isolate faulty modules.

3.1.1 Labelling

All modules in the Condor are labelled with a Type Number and a Serial Number. The Type Number is of the form 61-2737-00001.

Where the first two digits (61) indicate the product family; the next four (2737 in this example) indicates the module type; and the last five indicate the variant. Modules are normally referred to using only the four digits of the module type. So the example module would be referred to as a "2737".

3.2 Features

The Condor Radio Link offers a number of improved performance features.

3.2.1 Modular Construction

The Condor is a full duplex modular radio link system. Hardware and software flexibility allows the equipment to be adapted to different applications. The Terminal Housing type 2823 uses a motherboard to connect the following modules:

UHF Receiver	type 2801 or VHF Receiver type 2803
Duplexer	type 2824
Transmitter	type 2802
Controller	type 2737
Line Interface	type 2825 or Exchange 2586 or Subscriber 2587

Compander type 2819 is fitted to the Controller type 2737 when the Condor is configured for payphone operation.

External power supplies allow operation from AC mains or 24-48V batteries. Modules are interchangeable, allowing rapid service. The line interface is strapped for use as either an exchange terminal or a subscriber terminal.

3.2.2 RF Channel Planning

The equipment is designed for 25/30kHz channelling. The two transmitters in a link can be spaced at 5MHz - 10MHz (UHF) or 4.6MHz-10MHz/4.0MHz-6MHz (VHF band dependent). The transmitter power output is adjustable from 10W at the duplexer output to less than 1W duplexer output. We recommend using the low powers for minimum current consumption and maximum frequency re-use.

Transmitters and receivers can be re-channelled by resetting hexadecimal switches.

Duplexers require re-tuning for change of receiver or transmitter frequencies greater than 200kHz.

To save power at the subscriber terminal, the receiver in the subscriber terminal cycles on and off when the link is idle. The receiver stays on for about 150ms, then off for about 450ms. The receiver in the exchange terminal is continuously powered.

3.2.3 Link Supervision

A number of supervisory functions are provided as standard. Tone pips are used to indicate three conditions:

> low battery volts;

> high SWR;

> low receive signal.

The meter on the front panel of the controller module provides monitoring of test points in the transmitter, receiver and controller modules.

3.2.4 Ident Codes

As a telephone link, ident codes are used to ensure that link setup only occurs between mating terminals. There are 32 distinct ident codes available, to allow maximum frequency re-use with minimum interference. Out of band FSK signalling is used to transfer signalling information between the two link ends. The FSK signalling is also used to carry all ringing, dialling and calling functions of the normal system. FSK must be present for the link to operate. It is also used to provide remote testing of the radio link.

3.2.5 Interfacing

The line interface provides full 2-wire hybrid facilities for exchange or subscriber use. The exchange terminal, in addition, can provide full 4-wire plus E and M. The interface incorporates a 50V line supply and ringing generator for direct connection to a telephone over long 2-wire lines.

The exchange terminal can be attached to a microwave trunk circuit, if the line interface is set up for 4-wire operation. This allows provision of spur telephone links from a microwave bearer system. Positive or negative M-wire operation can be selected.

Both terminals may be operated in 4-wire mode to provide half-duplex or full-duplex linking. Under these conditions the out of band FSK tones are used directly for M-wire/E-wire signalling.

Full secondary lightning protection is provided for the 2-wire line connection using a three terminal gas discharge arrestor. 500V isolation is provided within the housing and line interface modules for the 2-wire path.

3.2.6 Serviceability

Modules can be pre-aligned, then used to replace faulty modules without further adjustment in the field. Remote testing facilities are incorporated to enable location of equipment faults without disturbing the subscriber.

3.3 General System Description

3.3.1 Mechanical

The Radio Link System comprises a Terminal Housing equipped with a number of individual plug-in modules which are fastened to the base of the housing. The electrical components are mounted on printed wiring boards, which slide into guides within the module extrusion. Module covers are detached by removing the front panel screws and the two rear connector mounting screws.

3.3.2 Frequency Range

The RF units are normally supplied for operation in a specific band. Frequency selection within a band is achieved with hexadecimal switches.

Standard bands are (MHz):

68-78, 72-82, 78-88, 148 -162, 159-174, 403-423, 410- 430, 430-450, 450-470 , 470-490, 490-512.

3.3.3 Modulation

The equipment is frequency modulated and provides a base band of 300Hz to 3.4kHz. Out of band signalling is accomplished with 4kHz frequency shift keying. The signalling system operates at 150 bauds. The receiver bandwidth is 12kHz (25kHz band plan) or 7.5kHz (12.5kHz band plan), and the receiver is equipped with AFC to minimise frequency error distortion.

3.3.4 Logic

All module inputs and outputs are "active low" or of open collector form with pull-up resistors on the destination board. This allows modules to be removed from a powered system with minimum interaction.

3.3.5 Power Supply Polarity

The Condor requires a nominal 12 volt negative earth external power source with 4 amp capability. For normal operation the power supply voltage must be between 10.8V and 15.5V.

Note: The Condor housing metalwork is directly connected to the negative supply terminal.

> **CAUTION**
>
> Supply voltage above 15.5V may cause conduction of the rack protection zener diode. This diode provides the transient and reverse polarity protection for the equipment by rupturing the supply fuse.

3.3.6 2-Wire Line Protection

A gas discharge arrestor provides secondary lightning protection for the 2-wire line connection.

Note: A substantial earth connection is necessary for maximum protection

3.3.7 Overload Protection

The transmitter module incorporates thermal protection circuitry to produce gradual turndown in the event of overload. This results in gradual power reduction at high heatsink temperatures until equilibrium is reached.

Since the duplexer is a bandstop type filter, it is possible in cases of severe mistuning to have considerable transmit powers present at the receiver port. Two levels of protection are provided. Firstly, at the receiver front end a diode is used to reflect high energy input signals. Secondly, a high signal detector has access via the motherboard to the transmitter power reduce control line. It is thus possible to power the system without damage, even in cases where the duplexer may be severely mistuned.

3.4 System Software

3.4.1 Software Control

The Controller 2737 has an embedded micro controller. This controls the operation of each end of the link, and the communication between link ends via the signalling channel. The link operation sequences described later are all done by the micro controllers.

Within the 2737 are a row of programming pins called the ident pins. These interface to the microprocessor, and select the function performed by the terminal. In telephone mode, they select the link ident code. In point-to-point mode, several options may be selected, and are discussed later.

3.4.2 Software Labelling

The microprocessor uses software stored in the interchangeable EPROM. The EPROM window is covered with a label on which is printed a coded description of the software version. The version number is included in the EPROM program, so that the EPROM can still be identified if the label is missing.

3.5 System Operating Modes

3.5.1 Telephone Mode

Controller pin pairs 1 to 5 Linked in any chosen combination

In telephone mode including Payphone, the Condor link provides a direct replacement of the 2-wire telephone line in a public switched telephone network. Strappings on the 2825 Line Interface define whether the terminal is an exchange end or subscriber end. Standard call supervisory functions conveyed by the signalling channel are reproduced at each terminal so that the telephone apparatus and exchange equipment operate as if they were directly connected. Link selection of the 5 ident pin pairs provides an ident code which is transmitted end to end to ensure only correctly mating terminals are involved in the call.

3.5.2 Point to Point Mode

Pin pair 7 Linked

In point-to-point mode the Condor provides independent end to end control for the transmission of telemetry and data information between central and remotely situated sites, or for the connection of two exchanges. Both terminals have line interfaces working in 4-wire E and M mode. The out of band signalling tones are used directly for M-wire/E-wire control.

3.5.3 Align Mode

Pin pair 6 Linked

Align mode provides a means of evaluating the performance of the link system and the RF path between two terminals without requiring line looping or M-wire/E-wire control. Transmitter and receiver are both activated and all audio mutes are released.

Note: There is no transmission of signalling tones in this mode so transmitter deviation is reduced from normal operating values by a peak value of 650Hz with 25kHz channel spacing, or 325Hz with 12.5kHz channel spacing.

3.6 Link Operation Sequences

3.6.1 Telephone Mode:

Subscriber Originating Call (Subscriber Makes A Call)

This is best described as a sequence of operations from initiation.

(a) Subscriber lifts hand set and loops the line.

(b) Loop is detected and the controller is awakened.

(c) The subs transmitter is powered and ident codes are sent to the exchange terminal.

(d) Exchange terminal sees a valid signal from its receiver and powers its controller which checks for correct ident code.

(e) When correct ident code is seen the exchange terminal turns on its transmitter and sends its ident code to the subs terminal.

(f) On receipt of correct ident the subs terminal stops sending ident and sends status data ie. sub ON. Audio mute is cleared and the speech loop relay energised.

(g) On receipt of status data the exchange end stops sending idents and starts sending status. It also loops the exchange line, energises the speech loop relay and clears the audio mute to allow transmission of dial tone from the exchange.

(h) DTMF dialling will pass over the speech path allowing completion of call setup.

(i) The subs terminal passes dial tone to the sub. At the first loop break it sets audio mute. It then proceeds to time the dial pulses to establish their validity and to count them.

(j) When an interdigital pause is detected the dial pulse count is processed and sent by the signalling as BCD data to the exchange terminal. The subscriber audio mute is then released.

(k) The exchange terminal detects that a dialled digit has been received and converts the digit back into dial pulses. Speech loop relay is cleared and audio paths muted while dialling is in progress. The speech path is re-established on each completion of dialling.

(l) Clearing of the call is initiated by the subscriber going on hook whereupon the subs terminal sends sub OFF status to the exchange terminal and proceeds to time out and power down.

(m) Receipt of sub OFF status at the exchange terminal clears the speech loop and line loop and the exchange terminal also proceeds to power down.

Subscriber Terminating Call (Subscriber's Telephone Rings)

(a) Incoming ringing is detected and powers the exchange terminal controller, which proceeds to time the first ring cadence, while also trying to establish the radio link. Ident signalling is used in the same way as described in steps (c) to (g) above, with the subscriber and exchange roles reversed. When establishing the link from the exchange end there is a delay between powering the transmitter and activation of the signalling, to allow capture of the cycling subs receiver.

(b) If the first ring cadence is between approx 2.5 seconds and 5 seconds then the link is set up for a long ring test. The long ring test opens the audio path in both directions, but does not loop the exchange line. Any alarm tones present will be heard at both ends of the link but the subscriber will not be alerted. The test continues for 20 seconds and the link then reverts to its rest state. If the subscriber makes a real call during the test, the call will set up normally, but without a further ident sequence. The test state will be cleared by the intrusion.

(c) Once the link is established, the exchange terminal sends the ring information to the subs terminal as part of its status data. The ring information is updated every 100 milliseconds, so it is necessary to pre-process the ringing cadences to minimise distortion of ringing information.

(d) At the subscriber terminal the ringer generator is sent to line under control of the reconstituted cadence information.

(e) When the subscriber answers, the loop detect circuitry operates to disconnect the ringer generator (loop detect is active during ringing) and line looped is sent to the exchange terminal via the data channel. Speech loop relay is operated and the audio mute released.

(f) The exchange terminal now loops the exchange line, operates the speech loop relay and releases the audio mute to complete the speech path. The call is now established.

(g) The subscriber terminal recognises switch hook flash as a loop break of between 88 and 500 milliseconds. This is regenerated at the exchange terminal as a 250 millisecond break allowing access to exchange feature functions.

(h) If the subscriber loop is opened for longer than 500 milliseconds the link will clear down, as in the Subscriber Originated Call above. The exchange terminal will be commanded off so that the audio path will be muted before the RF path is lost.

(i) If the calling party terminates the call then the normal exchange tones will be sent to the subscriber to tell him to hang up.

Failure Modes

The controller program allows two seconds break in received carrier before clearing the link and powering down. If the sub is off hook when the link clears down, he will receive busy tone.

If the link fails to set up properly then the sub gets a busy tone if he initiated the call.

Data errors in the signalling path are protected by parity checking and sequential message comparison. Up to 2 seconds of continuous data errors are allowed before clear down occurs. A minimum signal/noise ratio of 20dB is required for the link system to operate. This is the system threshold level internally set up in the receiver.

3.6.2 Point-to-Point Mode (Pin 7 Linked on Controller)

Basic Point-to-Point

This mode is commonly used for linking of talk-through radio repeater systems where it offers the advantage of noise tail suppression.

The sequence of operations is as follows:

(a) M-wire (push to talk line) is grounded

(b) M-wire is detected and the controller is awakened

(c) The transmitter is powered and the lower frequency signalling tone sent to the remote terminal.

(d) At the remote terminal receipt of signal valid from the receiver wakes the controller.

(e) On detection of the low frequency signalling tone the remote terminal controller lifts the audio mute and pulls the E wire output to ground (equipment frame).

(f) Operation in the reverse direction is identical to the above and independent of it. If both controllers are already awake the M-wire to E-wire delay may be reduced slightly from its normal 70 milliseconds.

(g) At the end of transmission M wire is released.

(h) The controller changes from low to high frequency signalling tone.

(i) After 10 milliseconds the controller de-powers the transmitter and if the return path is not active, goes back to sleep.

(j) At the remote terminal the change over from low to high signalling tone activates the audio mute to prevent receiver noise tail being passed into the external network. E-wire is also released.

(k) The remote end controller now expects shutdown of received signal and the corresponding noise tail from the receiver prior to clearance of the 'signal valid' input.

(l) Since the noise tail would contain frequency components in the signalling channel the controller is programmed to ignore signalling tone information for 70 milliseconds after the transition of tone frequencies from low to high.

(m) The receiver loses its received signal and after a short delay cancels its signal valid output.

(n) The controller returns to its sleep mode after completion of time-out and loss of signal valid.

Trunking Mode (Pin pairs 7 and 2 Linked on Controller)

Trunking Mode provides a transmitter hold period of 500 milliseconds and in addition gives a return audio path after activation from either end. The signalling channel provides a slow (150 baud) data channel for the user in both directions.

Operation in trunking mode is as follows:

(a) M-wire is grounded at the A terminal for a minimum of 25 milliseconds.

(b) Local terminal controller is awakened.

(c) Local transmitter is powered and low FSK tone sent.

(d) Remote terminal detects signal valid and wakes its controller which observes low FSK tone.

(e) Remote terminal lifts its mutes, grounds E-wire, activates its transmitter and returns high FSK tone (assuming its M-wire is not active).

(f) At the local terminal, receipt of signal valid, indicates that the remote terminal transmitter is active. The receive mute is released to establish the full 4-wire audio path (send and receive).

(g) Data may now be sent on the M-wire and received on the E-wire in either or both directions. Release of M-wire must be for less than 500 milliseconds or the link will close down.

(h) At the end of transmission M-wire is released at the local terminal (for example) and the FSK tone signals this to the remote terminal.

(i) After 500 milliseconds with no further M-wire activity both terminals close their mutes and proceed to power down. Noise tails are suppressed.

Failure Modes

Failure of the radio path in point to point mode will cause a loss of signal valid from the receiver which will in turn activate the audio mutes and clear E-wire. The noise tail will not be suppressed in this event and some spurious pulses may occur on the E wire output.

3.6.3 Alignment Mode (Pin pair 6 Linked on Controller)

When the controller is powered in align mode, the terminal will activate both transmitter and receiver and release all audio mutes. FSK tones are not generated in this mode and transmitter or receiver modules may be unplugged to disable them during tests as required.

Once initiated, operation is continuous until the pin pair 6 linking is removed or the terminal is de-powered.

Note: For measurement purposes in align mode, transmitter deviation is reduced by up to 650Hz with 25kHz channel spacing, and up to 325Hz with 12.5kHz channel spacing.

3.7 Monitoring

The digital selector switch and toggle selector switch on the front panel of the controller module allow various test points in the transmitter receiver and controller to be monitored. The test points in the receiver and transmitter provide DC voltages in the range 0V to 2.5V while the controller monitoring measures audio levels which are rectified for display on the front panel meter.

Monitor selection is as follows:

Digital Switch	Source Select Switch		
	Receiver	**Controller**	**Transmitter**
0	RSSI (Signal strength)	Tx Audio Level	Forward Power
1	Noise Voltage	Tx Signalling Level	VSWR
2	Lock Detect	Rx Audio Level	Lock Detect
3	Control Loop Volts	Rx Signalling Level	Control Loop Volts
4	Wideband Audio	Tx Audio Pre-inversion	Auto Dev Control
5	Not used	Rx Audio Pre-inversion	Driver Output
6	AFC	----------	Module Temp
7	Power Control	----------	(+10V) Regulator O/P

While the majority of monitoring readings are self evident and used mainly for tuning, there are some measurements which require further comment:

> **Receiver Signal Strength Indicator (RSSI):**
This may be used in the field to optimise alignment of antennas. It may also be used for duplexer tuning.

> **Power Control:**
The power control line is common to the transmitter and receiver and can be monitored at the controller meter. The voltage on this test position will vary with power setting. It is pulled low if excessive signal levels are present at the receiver input (eg. if duplexer is mis-tuned), causing overload detection within the receiver.

> **Tx and Rx Audio Levels:**
These points provide indication only when modulation is present on the appropriate audio path.

> **VSWR:**

The VSWR display is derived from a dual directional coupler in the transmitter. High VSWR indicates that reflected power is a significant fraction of forward power. Thus for any condition of zero forward power a high VSWR will be indicated. This could occur if for example a mis-tuned duplexer was used. The VSWR indication remains substantially constant for powers of 0.5W to 12W.

> **Module temperature:**

Here monitor access is provided to the thermal protection circuit in the transmitter. Switch temperature threshold is 95°C.

3.8 Fault Identification

Note: M-wire LED refers to D18 on the 2857 Subscriber Line Interface, D12 on the 2586 Exchange Line Interface and D23 on the 2825 Line Interface.

E-wire LED refers to D1 on the 2825 Line Interface. The 2586 Exchange Line Interface and the 2587 Subscriber Line Interface have no E-wire LED indication.

3.8.1 LED Indicators in the Condor

The module front panel LEDs allow a degree of fault localisation to the module level.

The indications are as follows:

(1) Transmitter PWR LED - Indicates power on the 12V rail of the equipment and the module.

(2) Transmitter Tx LED - Indicates transmitter active.

(3) Receiver PWR LED - Indicates receiver powered. This LED flashes at subs terminal in idle condition and is continuous at exchange terminal.

(4) Receiver Rx LED - This indicates a valid signal is being received from the distant transmitter.

(5) Controller µP LED - Indicates that processor is active.

(6) M-wire LED - Indicates that the line is looped at the subs terminal, or that ringing is being received at the exchange terminal.

(7) E-wire LED - Indicates that ringing is being sent at the subs terminal, or that the line is looped towards the exchange at the exchange terminal.

3.8.2 Idle State

In the idle state the transmitter PWR LED and receiver PWR LED will be operating - the receiver PWR LED will be flashing at the subscriber terminal.

3.8.3 Operation Sequences at the Subscriber Terminal

Subscriber Originating Call

(1) The M-wire LED illuminates, simultaneously with the controller LED.

(2) The receiver power LED illuminates continuously.

(3) The transmitter Tx LED illuminates.

(4) After a short delay the receiver Rx LED illuminates.

(5) The M-wire LED flashes for pulse dialling.

No further change occurs until the call clears.

If the remote terminal failed to answer (no transmission) then step 4 above would not occur (receiver Rx LED would remain off) and after approximately three seconds the transmitter Tx LED would extinguish also.

If the remote terminal makes a reply but its ident code is not seen as correct then step 4 above will occur but both receiver Rx LED and transmitter Tx LED will extinguish after three to four seconds.

For a normal call, extinction of the M-wire LED, controller LED, Tx LED, Rx LED and return to receiver cycling do not occur until the subscriber hangs up.

Subscriber Terminating Call

(1) The receiver power LED and Rx LED illuminate continuously, simultaneously with the controller LED.

(2) The transmitter Tx LED illuminates.

(3) The E-wire LED flashes with ringing to the subscriber.

(4) When the subs comes off hook, the M-wire LED illuminates, and the E-wire LED extinguishes.

No further change occurs until the call clears.

Extinction of the M-wire LED, controller LED, Tx LED, Rx LED and return to receiver cycling do not occur until the subscriber hangs up.

3.8.4 Operation Sequences at the Exchange Terminal

Subscriber Terminating Call

(1) The M-wire LED flashes with ringing.

(2) Simultaneously the controller LED illuminates (continuous).

(3) The transmitter Tx LED illuminates.

(4) After a short delay the receiver Rx LED illuminates.

(5) The M-wire LED continues to flash with ringing.

(6) The E-wire LED illuminates when the subscriber's line is looped.

(7) The M-wire LED is extinguished when the exchange recognises the line loop.

No further change occurs until the call clears.

If the remote terminal failed to answer (no transmission) then step 4 above would not occur (receiver Rx LED would remain off) and after approximately three seconds the transmitter Tx LED would extinguish also.

If the remote terminal makes a reply but its ident code is not seen as correct then step 4 above will occur but both receiver Rx LED and transmitter Tx LED will extinguish after three to four seconds.

If the subscriber does not answer, steps 6 and 7 do not occur.

Extinction of the E-wire LED, controller LED, Tx LED and Rx LED do not occur until the subscriber hangs up.

Subscriber Originating call

(1) The receiver Rx LED illuminates, simultaneously with the controller LED.

(2) The transmitter Tx LED illuminates.

(3) The E-wire LED illuminates as the exchange line is looped.

(4) The E-wire LED flashes with subscriber pulse dialling.

No further change occurs until the call clears.

Extinction of the E-wire LED, controller LED, Tx LED and Rx LED do not occur until the subscriber hangs up.

3.9 Remote Testing

Remote testing utilises an unusual ring cadence to provide a test access to the radio link circuit without alerting the subscriber or busying the exchange.

The Long Ring Test is initiated by sending a long burst of ringing (between 2.5 seconds and 5 seconds) to the exchange terminal. The ringing is timed and if found to be of correct length, the link sets up for the test (provided that the ident requirements have been met). For the test the 4-wire and 2-wire audio paths are completed but the exchange is not DC looped. Any tones generated by the radio link are returned to the accessing telephone test desk. The test continues for 20 seconds to allow evaluation of the link. Should the subscriber intrude by looping the line the test is immediately discontinued and dial tone will be returned to the subscriber without a further ident sequence.

The Long Ring Test can also be used where the radio link is connected to an exchange via a microwave trunk network by grounding M-wire for 4 seconds (sending ringing) and observing the receive 4-wire path to listen for tones. This only applies when the 2825 Line Interface is used.

Tone pips generated by the link are as follows:

> Single pip every five seconds indicates low battery voltage (approx 11V). The link will continue to operate for a further drop of 1-2 volts.

> Double pip every five seconds indicates a transmitter SWR fault. The SWR required to trip the alarm tones is adjustable within the transmitter module. The factory setting of 3.0:1 is recommended since the duplexer tends to reduce the antenna SWR seen at the transmitter port.

> Triple pip every five seconds indicates that receiver signal to noise ratio is only 10dB or less above the signal valid margin at which the link will trip out. The signal to noise is typically 30dB at this point and the higher receiver noise level will be audible.

The pitch of the tone pips determines their source since the subscriber terminal signals with 500Hz tones and the exchange terminal uses 2000Hz tones. Since the tones are injected into the 4-wire path they may be heard at both ends of the link. The telephone test desk can thus ascertain the likely source and nature of the fault before despatching repair services.

If the link fails to set up correctly (eg. ident failure or subscriber terminal fault) then the exchange terminal returns a one second noise burst (from its receiver) to the test operator before clearing down. Should the battery supply at the exchange terminal be too low (<9.5V), the terminal will not function at all. Testing with an inertial test set will show the presence of a 1uF ringer capacitor if the line connection to the exchange terminal is complete. The alarm tone pips are sequential so that multiple alarms may be identified.

The subscriber terminal generates a local busy tone if the link fails for any reason while the subscriber line is looped, and this disables all pip tones. The subscriber transmitter turns off when this occurs.

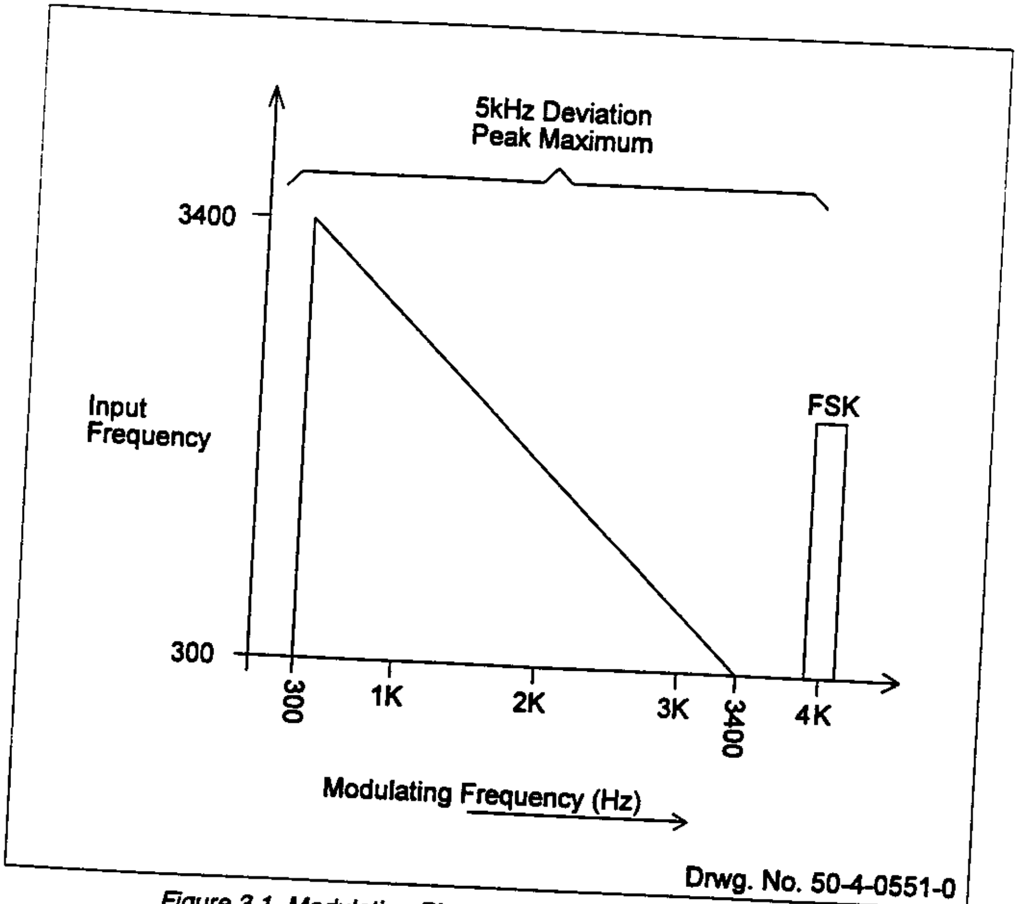

Figure 3.1 Modulation Plan for Exicom Condor Radio Link

4
System Setup

4.1 Introduction

This chapter describes how to set up the audio levels and transmitter power for the Condor. It should be read in conjunction with the Condor Installation Guide. The operations described here should normally performed by qualified technicians in a repair or service centre.

4.2 Identity Codes

In telephone mode, communication between the exchange and subscriber radio terminals is preceded by an identity code handshake. Both terminals must therefore be set to the same ident code before any bench testing or field installation can begin.

Setting of ident codes is described in the Section 6.1 of this manual.

4.3 Level Alignment Procedure

This procedure allows bench checking of a Condor link before field installation. It assumes that individual modules within the Condor terminals have been aligned using the module Test Units (refer to the SR210/310 and Condor Test Units Manual).

Equipment is arranged as described in the Condor Installation Guide, Appendix 2, with the addition of a modulation meter and coaxial T-connectors to allow checking of transmitter deviation. The modulation meter is connected at the low power (output) side of the 30dB power attenuators. A digital voltmeter (AC. RMS) is used for setting line interface voltages.

This alignment gives the following system levels:

> Subscriber transmit 1kHz at 0dBm --> 1.5kHz/3kHz deviation[1] ± 10% --> exchange receive -3dBm

> Exchange transmit 1kHz at -7dBm --> 1.5kHz/3kHz deviation[1] ± 10% --> subscriber receive -10dBm

[1] Dependant on 12.5/25kHz channel spacing. Refer to Section 2.1, Specifications.

4.3.1 Subscriber to Exchange Alignment (S --> E)

(1) Connect the modulation meter so that it measures deviation of the subscriber terminal transmitter,

(2) Connect a 600Ω level meter to the 2-wire line connections of the exchange terminal. This is best done across the gas discharge arrestor on the motherboard,

(3) Connect a 600Ω audio generator to the 2-wire line connections of the subscriber terminal with frequency set to 1000Hz and level to 0dBm. Connect a digital voltmeter (2VAC) between TP1 and TP3 on the Line Interface PCB,

(4) Adjust RV2 (Tx level) in the line interface to give 500mV AC on the DVM. This should correspond to 1.5kHz/3kHz ± 10% deviation[1] on the modulation meter,

(5) In the exchange terminal, connect the DVM between TP3 and TP4. Adjust RV3 (gain trim) in the line interface for a reading of 500mV AC on the DVM,

(6) Adjust RV1 (Rx level) to give an output of -3dBm on the level meter,

(7) Reduce the input level to -20dBm and check the frequency response is within +1dB, -4dB of the 1kHz level.

4.3.2 Exchange to Subscriber Alignment (E --> S)

(1) To align the exchange/subscriber circuit, connect the modulation meter to measure the deviation of the exchange terminal transmitter,

(2) Connect the level meter to the 2-wire output of the subscriber terminal,

(3) Connect the audio generator to the 2-wire input of the exchange terminal with frequency set to 1000Hz and level to -7dBm. Connect the digital voltmeter between TP1 and TP3 on the exchange interface PCB,

(4) Adjust RV2 (Tx level) in the line interface to give 500mV AC on the DVM. This should correspond to 1.5kHz/3kHz ± 10% deviation[1] on the modulation meter,

(5) In the subscriber terminal, connect the DVM between TP3 and TP4. Adjust RV3 (gain trim) in the line interface for a reading of 500mV AC on the DVM,

(6) Adjust RV1 (Rx level) to give an output of -10dBm on the level meter,

(7) Reduce the input level to -27dBm and check for a frequency response, 300Hz to 3400Hz, of +1dB, -4dB relative to the level of 1kHz

Note: The subscriber terminal provides a 2-wire loop current of approx 25mA (45mA for party line). This DC current can produce errors in some audio test equipment due to transformer core magnetisation.

(8) Connect a test telephone to the subscriber terminal and connect the exchange terminal to the exchange test line. Check for correct call establishment in both directions. Description of correct call establishment is detailed in "Link Operation Sequences" Section 3.6 of this manual.

[1] Dependant on 12.5/25kHz channel spacing. Refer to Section 2.1, Specifications.

4.3.3 Point-to-Point Linking Mode

Link alignment for point to point linking mode is similar in procedure to that outlined above except that the input is the 4-wire Tx pair of the first terminal with receive output at the 4-wire Rx pair of the second terminal. The M-wire of the first terminal must be grounded to the equipment case to initiate transmission.

Before beginning, check that the controller module is correctly strapped for point-to-point linking mode operation (detailed in Section 6.1.2) and that the line interfaces are strapped for 4-wire operation at both ends. Set audio generator to Tx line level and adjust RV2 for 500mV AC between TP1 and TP3, as for telephone mode (detailed above). In the line interface of the second terminal, adjust RV3 for 500mV TP3-TP4, and RV1 to set output level as required. Swap oscillator and level meter and adjust levels in the other direction.

4.4 Transmitter Power Adjustment

To adjust the transmitter power, first remove the plastic hole cover underneath the transmitter module. This gives access to power control adjustment RV1 in the transmitter.

4.5 Test And Alignment Aids

Four separate Test Units are manufactured to simplify test and alignment of the Condor modules. They are intended for use by regional module repair centres. Field repair is on a terminal replacement basis. The units are:

- Controller/Multiplexer Test Unit — Type 2504
- Tx/Rx Test Unit — Type 2501
- Subscriber Interface Test Unit — Type 2502
- Exchange Interface Test Unit — Type 2503

The SR210/310 and Condor Test Units manual details alignment and test sequences to allow a rapid return to service for the modules.

In addition to Test Units an extender cable set is available (Type 2464). A set of cables comprises one each of 64-way, 50-way, 24-way and 14-way extension cables and connectors.

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6
Controller Type 2737

6.1 Linking Arrangements

On the Controller PCB there are two parallel rows of seven connector pins, comprising PL2, the ident pins adjacent to pins 1 to 7 of the microprocessor. The outer row of pins is connected to 0V and insertion of bridging shunts between the two rows selects the type of link operation performed. Pins are numbered from the top of the board downwards.

6.1.1 Telephone Use

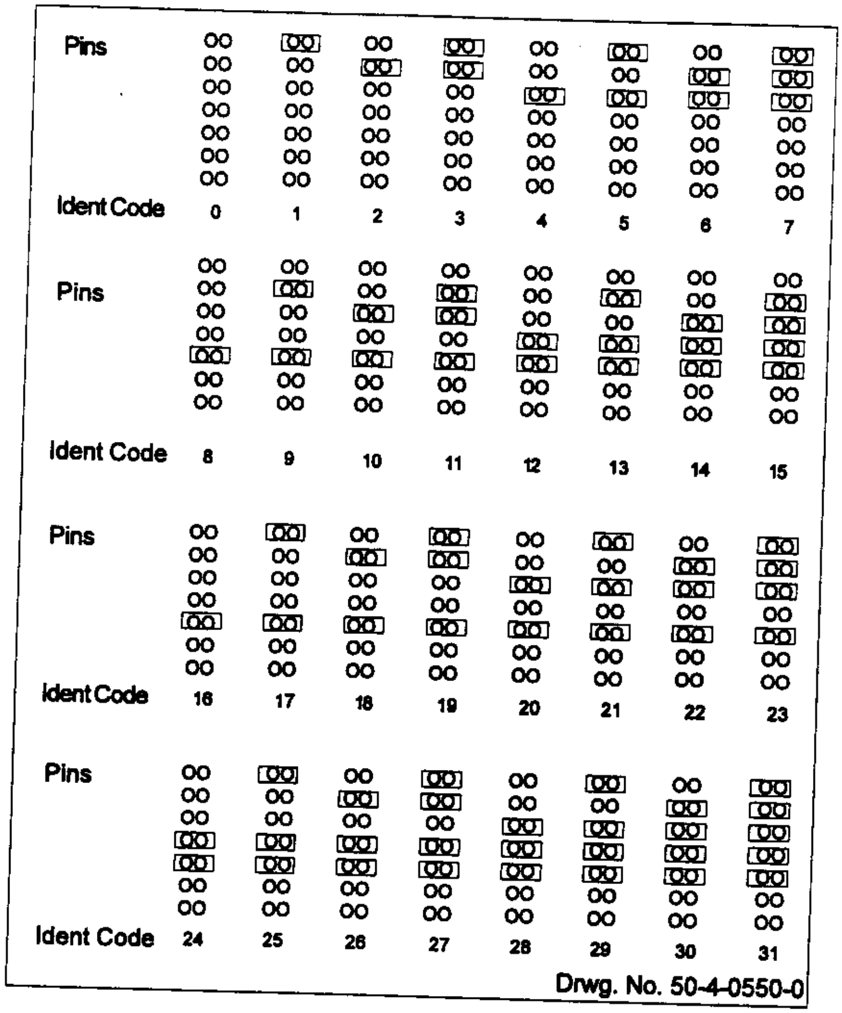
Pin pairs 1 to 5 are linked as desired to select the link ident code. The same selection must be made at both Subscriber and Exchange ends of each link. There are 32 distinct codes available.

Note: Pin pairs 6 and 7 must be left unlinked.

Recommended Standard Format For Ident Codes

If the Controller printed circuit board is viewed from the component side with the front panel to the left, the Ident Pins are immediately to the left of the microprocessor. The required ident code can be selected by strapping the pins according to the following table.

For Example :



Alarm Tones

In the telephone configuration the Line Interface defines whether the terminal is an Exchange or a Subscriber end. This also determines the pitch of the alarm tone pips which are generated. The alarm tones are injected into the 4-wire path. The Subscriber's end is two octaves lower than the Exchange end tone. (Subscriber tone = 500Hz, Exchange tone = 2000Hz)

The following alarm tone sequences are used:

Low Supply Volts	1 Beep every 5 seconds
SWR Error	2 Beeps every 5 seconds
Low SINAD	3 Beeps every 5 seconds

The above signals are sequential if more than one alarm is active.

Busy	1 Beep every 2 seconds

The Busy tone overrides the other alarm beeps. It is sent to the subscriber if the link fails to set up or if the link fails in use.

6.1.2 Point-to-Point Linking Mode

Pin pair 7 must be linked to select any point-to-point linking mode operation - see linking arrangements above. In this mode, Pin Pairs 1 to 5 cease to provide an ident code, but are used to select the point-to-point mode of operation.

Basic Point to Point:

Pin pair 7 linked, pin pair 1 and 2 unlinked.

In this mode there is no hold period for the transmitter. It closes down immediately after M-wire is released. The audio paths are muted prior to transmitter turn off to avoid noise tail. Operation of the forward and return signal paths is independent. Each signal path is established by grounding its M-wire.

Point to Point Options:

Pin pair 7 linked and other pin pairs linked will select the operation format from a number of options as follows.

250mS Tx Hold Period

Pin Pair 1 - this selects the basic point-to-point mode (remember that pin pair 7 is also linked) but with a transmitter hold period of 250 milliseconds after M-wire release. Telemetry signalling may be sent on M wire in this mode, but the return path E-wire is not activated unless the remote M-wire is grounded or is returning telemetry signals.

Trunking Mode

Pin Pair 2 - this selects a trunking mode which establishes a full 4-wire trunk (send and receive audio paths) on grounding of either M-wire for greater than 15 milliseconds.

Once activated, the link provides M-wire into E-wire out signalling at up to 150 baud in both directions as an out of band data channel. Release of M-wire (at both ends of the link) for greater than 500 milliseconds will cause the transmitter to close down and return the system to its idle condition. The audio paths are muted prior to transmitter turn off to avoid noise tail.

Trunking mode allows the link to be used for interconnection of exchanges (as a both ways trunk) whilst maintaining a low power drain in the idle situation. The mode is also useful for continuous telemetry up to 150 baud using the E and M wires whilst the audio path is used for independent DTMF signalling telephone service. No modems or external filter are required.

Disabled Alarm Tones

Pin Pair 4 - this disables the alarm pip tones where the link is used for data transmission and internal tones could interfere with the service.

6.1.3 Align Mode

Align mode is selected by linking pin pair 6. In align mode both receiver and transmitter are powered, receiver and audio mutes are released and the speech loop relay is energised. There are no signalling or alarm tones generated in align mode. Due to absence of signalling tones, transmitter deviation is reduced by up to 650Hz when using 25kHz channel spacing, and by up to 325Hz when using 12.5kHz channel spacing. Most other performance characteristics can however, be measured in this mode including audio responses, return loss etc. Transmitter or receiver modules may be unplugged to disable them for RF testing while in align mode.

Note: A description of the operation sequences for the various modes is included in the "System Operation" Section3 of this manual.

6.2. Circuit Description

6.2.1 Audio and Signalling Section

Transmit Path

The transmit audio signal enters the Controller board on pins 25/56 and feeds a pre-emphasis amplifier/clipper comprising one op/amp from IC1, transistors TR1 and TR2 and the RC feedback network R4, C4. The output on pin 1 feeds a second stage of amplification using the other op. amp from IC1, and a high level clipper stage TR3, TR4, D1 and R9.

The output on pin 7 feeds the switched-capacitor filter IC2 which runs at a 333kHz clock rate and tailors the response of the audio to cut off at 3.4kHz. Switching frequencies are removed by a following RC network, and the band limited audio signal is then input to one of the transmission gate pairs IC3. Together IC3 and IC4 comprise a modulator which provides frequency band inversion

The modulator output is filtered by IC5 to remove unwanted sidebands, filtering of the FSK tones is accomplished by dual LC circuits (L1, L2). The relative speech and signalling deviations are set by the ratio of resistors R29 and R32. Both signals can be selected for monitoring on the front panel meter.

Receive Path

The receive input on pin 44 is not de-emphasised and is immediately split into two separate paths: signalling and audio filtering. The audio path is first passed through the impedance matching circuit of IC7 which provides a small degree of amplification prior to the FSK notch filter, L3, and its associated components. The notch removes much of the received signalling tone energy from the audio path before active filtering stage IC8. The receive audio then feeds into the second transmission gate pair IC3 which together with IC4 provides the demodulation function to restore the voice frequency band. Active filtering is provided by switched capacitor filter IC9 whose 333kHz clock is gated to provide the audio mute function. The recovered audio signal is mixed with alarm tones via R56 and then de-emphasis is carried out at IC10 before the final signal is output to the line interface.

The signalling tone path is via a Q-multiplier circuit consisting of the two op. amps in IC11 which form active band pass filters centred at FSK frequency. Test points are provided for alignment (TP5 and TP6). Filtered FSK tones are fed to the third transmission gate pair in IC3 where a frequency translation to 800Hz occurs. FSK centre frequency is 4.0kHz. Receive FSK translation clock is 3.2kHz. The second op. amp of IC7 is the companion stage for this modulator, the output at pin 7 being filtered by a two stage RC network to remove switching noise and as much of the unwanted upper sideband frequencies as possible before feeding to the input of IC12, the FSK decoder.

IC12 is an XR2211 phase locked loop FSK decoder. Its centre frequency is determined by C57, R79 and RV3, the latter being adjustable for fine tuning. Detected data is output on pin 7 and 6 of IC12 and feeds the microprocessor directly. TP7 allows test access to this signal.

Clocks

All clocks are produced by the two programmable timer devices, IC20 and IC21, under the control of the processor, and are derived from the 8MHz crystal. Five timer outputs are capacitively coupled to the individual stages to provide the required DC levels. The sixth output is spare. Gating of Clock 1 from IC20 through IC17 by a signal from the processor gives direct audio muting of the receive path.

Monitoring

Monitoring for the link is done using the selector switches on the control module. The thumbwheel digital switch sets up a three bit binary code which activates the three analogue selector gates in the Tx, Rx and Control modules. These gates return the selected analogue voltage to the control module where the required voltage is selected for display. 8 points can be selected in each monitored module, although in the control module only 6 are used. Also the analogue voltages from the Rx and Tx modules are DC while the control module monitoring is for AC signal levels. Thus the output of the selector gate, IC15, feeds an op. amp and detector circuit (IC6, C79, D6 and D7), which, in turn, drives the high impedance metering circuit (TR11, TR12 and meter M).

Power Supplies

TR6 and TR7 provide the regulated 10V and 5V (Analogue Ground) for the audio and signalling section when the processor is fully awake, (ie. after receipt of a signal valid or M-wire detect). These transistors are switched by the Audio Power signal from pin 14 of the processor via TR8. TR8 ensures that the correct bias is present on the base of TR7. The front panel LED D3, is powered from the VAG supply via R89.

Analogue Ground (VAG)

Analogue Ground is required by the filter ICs and for biasing of the operational amplifiers. It is passed to the other modules via the backplane to minimise noise pick-up in the audio paths.

6.2.2 Digital Section

General

In order to minimise power consumption within the overall system, CMOS devices have been used throughout. This includes the processor itself which, in its CMOS version, has the added feature that it can be switched under software control to a low power idle state where the current drain from the +5V supply is only 2.5mA. This feature is used during the period when the link is not in use, (ie. between calls). The +5V supply is continuously present and the processor periodically wakes up and checks its inputs for any change of condition on the SIG VAL or LD/RD lines. When an active condition is detected the processor remains in the active mode and initiates the hand shaking sequence.

Power Supply

All the logic devices are powered from a continuous digital +5v supply referenced to a 5V regulator, IC13. The darlington power transistor, TR9, is switched by one half of IC14, a dual voltage comparator, which turns TR9 off if adequate supply voltage is not present.

The other half of IC14 senses low battery voltage for the generation of warning tones.

Logic

> **Watchdog.** Resetting of the processor IC16 is accomplished by a combined reset/watchdog circuit comprising two gates of IC17 and associated components, C104, TR10, R131, R138, C102 and C103. At switch on, the RC time constant of R131 and C103 keeps IC17 pin 10 low and therefore pin 8 high to provide an extended processor reset pulse. R138 and C102 with the other gate, pin 11, constitute an oscillator. When pin 11 (and pin 9) goes high for the first time after C103 has charged to the gate threshold of pin 10, pin 8 goes low and the processor starts.

With the processor functioning normally the output of IC16 pin 13 is high with low going pulses every millisecond. These pulses activate TR10 to prevent C102 from recharging, thus maintaining the gate output in a high state. If for any reason the pulses from the processor stop being generated, C102 will charge up to gate threshold, pin 11 will go low and the processor will be reset.

> **Microprocessor.** After reset the processor first initialises the I/O device, IC22, and the programmable timers IC20 and IC21. It then reads inputs from other modules in the rack via IC22, the ident links and FSK input pin 10.

Processor outputs are written to IC22 via the bus. The processor also outputs an Audio Mute control signal, an Audio Power control signal which also gates the master clock to the timers, the Alarm pip tones, and the Transmit Data all of which are used on board. FSK tones and all the clock frequencies are generated by the two timer IC's, IC20 and IC21, under processor control.

> **Input/Output.** All I/O lines are controlled by the programmable 82C55 device, IC22, which is organised into two 8-bit ports and one split 4+4 bit port. The 12 input lines to port-A and upper port-C are buffered by IC23 and IC24, which carry out a CMOS-TTL conversion. The 12 output lines from port-B and lower port-C control IC25 and IC26, Darlington transistor arrays, which drive all off-board circuits.

All board inputs and outputs are "active low" or open collector with pull-up resistors on the destination board. This allows modules to be removed from the rackframe with minimum interaction.

6.3 Alignment

CAUTION

The 2737 module contains static sensitive devices. Do not attempt service or alignment except at a static free work station.

Any failure of a Controller module in the field should be cleared by module replacement and the faulty unit repaired and aligned at an appropriately equipped service centre.

Full alignment and testing of a Controller requires a Controller/Multiplexer Test Unit type 2504 with associated measuring equipment. The procedures are fully described in the Test Unit Manual.