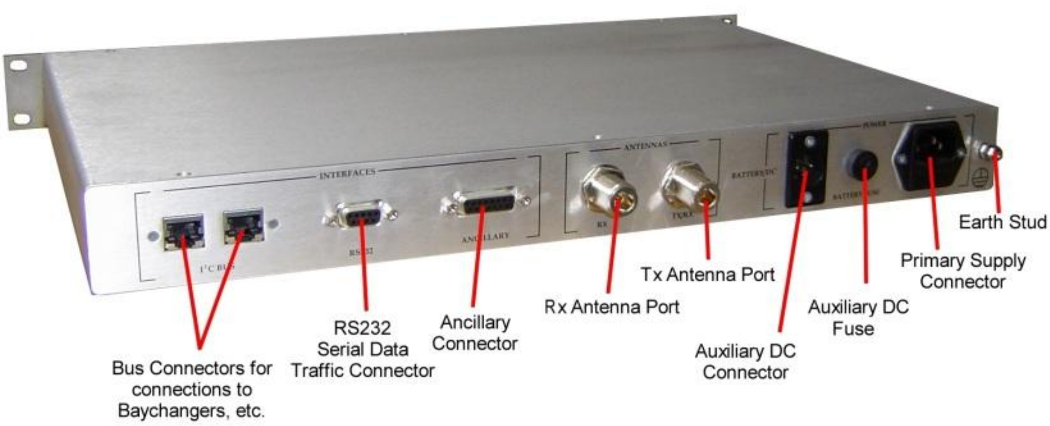
# XRT9000 SERIES
# TELEMETRY BASE STATION

## SETUP, INSTALLATION
## &
## OPERATING MANUAL


XRT Series
LED Indicator Panel
Channel Selection Switches
Programming Port


INTERFACES
ANTENNAS
POWER
RS232
ANCILLARY
Earth Stud
Primary Supply Connector
Tx Antenna Port
Rx Antenna Port
Auxiliary DC Fuse
Auxiliary DC Connector
Ancillary Connector
RS232 Serial Data Traffic Connector
Bus Connectors for connections to Baychangers, etc.

# CONTENTS

# 1 INTRODUCTION

## 1.1 PRODUCTS COVERED

This manual covers the XRT9000 range of 19" rack mounting scanning telemetry base-stations. They are high performance radio modems designed for high duty cycle data applications in commercial and industrial systems.

The XRT9000 is an advanced, simplex/half-duplex, data radio with both an audio interface for external modem operation and a serial port providing a true digital interface with speeds and data formats programmable to offer maximum compatibility with existing systems and other manufacturers' products.

Information is provided to assist with configuration, installation, and operation of the products in point-to-point, point-to-multipoint and network configurations. A separate programming manual covers the use of the associated programming and configuration software.

With the built-in test software, first line "Go/No-Go" testing can be easily performed. Component level servicing is not covered in this document. If the product fails its first line testing it should be returned to a service centre.

## 1.2 IMPORTANT NOTICES

### 1.2.1 Copyright



### 1.2.2 Right to Change

In the interest of improvement, R.F. Technologies reserves the right to change the technical specifications or functions of its product without notice.

### 1.2.3 Software

R.F. Technologies Ltd software is delivered "as is". R.F. Technologies Ltd does not grant any kind of warranty or guarantee on its saleability or it's suitability for use in specific applications. Under no circumstances is R.F. Technologies liable for any damages arising from using the software.
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### 1.2.4 Safety Critical Applications

The XRT9000 has not been designed for, nor is it intended for, use in safety critical or life support applications. No functional warranty is given if the product is used in such applications.

### 1.2.5 Use

The XRT9000 radio modems have been designed to work on various licensed and license-free frequency bands in use around the world. In the license-free bands, the user must ensure that the radio modem is used under the terms & conditions applicable to the use of the bands concerned.
In licensed bands, the user must obtain permission and the necessary licences from the local authorities and operate the radio within the provisions of such licences.

# 2 PRODUCT OVERVIEW

## 2.1 GENERAL

The XRT9000 base-stations are high specification products which have both analogue and digital interfaces to allow them to be used in both new and legacy systems. The radios can accept RS232 data inputs directly, but have auxiliary 600 ohm audio interfaces to allow use with an external modem if required. While using the internal modem, the over-air data rate can be set to a range of values between 150 baud and 9,600 baud. If high speeds are not required, the modem can be set to a slower over-air rate to take advantage of the associated improvement in the receiver threshold.

The XRT9000 is supplied in a 1U rack mountable shelf which can be supplied for 110/220V AC mains supplies , 24V DC supplies or 48V DC supplies. In each case there is an auxiliary 12V DC facility. This can be used with an external 12V supply or can be connected to a rechargeable battery to provide supply protection. While the primary supply is present, the unit provides an output to recharge the battery, but if the primary supply fails, the XRT automatically takes power from the battery or external 12V supply.

Although having been designed with as near an open architecture as possible, to allow it to inter-work with many legacy products still operating in the field today, the new XRT9000 is an advanced, state-of-the-art radio incorporating many enhanced features such as: band reversal capability, outstanding radio performance, over-air data rates up to 9,600bps in a 12.5kHz channel, support for 1800/1200Hz FFSK data for compatibility with CML modem based products, new Windows 95, 98, 2000 and XP programming software, advanced management features, and the possibility of future firmware upgrades without the need for expensive hardware replacement.

The DSP based design of the XRT9000 and the large internal flash memory enables future upgrades to be easily implemented in the existing hardware.

The radios have been designed to have extremely sensitive receivers, and incorporate very low group delay filters to provide the best path for high speed digital signals. When running at the full 9,600 baud rate, an optional Forward Error Corrector can be switched in to further enhance the receiver performance at very low receive signal levels.

The separate Tx and Rx RF modules each incorporate their own synthesiser to enable full duplex operation. In simplex/half duplex operation the dual synthesisers facilitate very fast turn around times.

The XRT9000 meets licence-exempt ETS300-220, licensed ETS300-113 and the VNS2111 (MPT1411) specifications at all internal modem data rates up to and including 9,600 baud.

## 2.2 TRANSMITTER

The transmitter frequency can be user programmed anywhere within the pre-aligned bandwidth detailed in the technical specification section.
Two transmit power versions are available. The standard version covers the range 50mW to 5W while the high power version covers 500mW to 10W. The exact power required can be accurately set within these ranges under software control.

## 2.3 RECEIVER

The receiver is a very low current double conversion superheterodyne with an active balanced mixer for very good intermodulation performance. Careful attention to spurious response, adjacent channel and blocking performance, makes the product ideal for crowded telemetry channels.
To achieve high performance, the programmable bandwidth of the receiver has been limited by factory aligned filters to 12MHz ( ± 6MHz from centre frequency). Should re-alignment be required, the unit can be returned to our service centre.

## 2.4 MICROPROCESSOR CONTROL & INTERFACE BOARD

The microprocessor control & interface board is the heart of the product and at the centre is a microprocessor that controls all the interface circuits to the radio modules and external input/outputs. The board contains all necessary electronic potentiometers for full remote alignment. As well as the control functions, the processor provides DSP functionality that enables full duplex modem operation between 150 – 9600bps with the option of FEC at 9600bps. The processor has 128k of flash memory from which the code is executed and internal non-volatile EEPROM for storing programmed parameters. As only about 50% of the memory space is used at the moment, there is plenty of space for future upgrades and custom applications.

## 2.5 CUSTOM SOFTWARE

Custom software or protocols for specific client applications, can be written and included as PC programmable options in relatively short time scales and normally at nominal costs. Further details can be obtained from the sales office.

## 2.6 PROGRAMMING & CONFIGURATION

Apart from internal factory set-up links, all the parameters of the XRT9000 are PC programmable via the programming port, the serial traffic port or over the radio link via a special secure mode.
Full details of all the programmable parameters are covered in the separate programming manual.

## 2.7 SOFT MODEM

The XRT9000 has a “soft modem” which offers unparalleled performance and flexibility over a wide range of speeds and formats and enables future formats to be downloaded from a PC or over the air. Within a 12.5kHz channel, the unit can be programmed for 150-2400bps FSK/FFSK with Bell202 & V23 supported, 4800bps GMSK & 9600bps 4 Level FSK.

## 2.8 MODES OF OPERATION & PROTOCOL HANDLING

The basic modes of operation of the base-station are as follows:

### 2.8.1 Dumb modem

The radio has no knowledge of the data it is transmitting, data is simply transmitted and received under hardware control.
Transmission control can either use RTS control signals or be configured for automatic initiation of transmission on receipt of serial data at the traffic interface.
In either case, the radio provides a CTS output which can optionally be used for flow control.
The XRT9000 incorporates an internal buffer to cope with situations where the interface data rate is higher than the over-air rate.
This “dumb modem” configuration is useful when expanding older systems where the radios must be compatible with others of a different manufacture.

### 2.8.2 Protocol specific modem

The radio recognises a complete frame and only transmits and receives data conforming to that format. No addressing of radios or routing of data is performed. Protocols such as MODBUS & DNP3 can be supported in this way.

### 2.8.3 Routing modem

The radios recognise a protocol specific frame and the address to which the frame is to be sent. Routing information must be stored in each radio for each destination address that requires the use of repeaters. Any radio in the system can operate as a repeater. The radio does not perform any acknowledgement or retries. Any protocol using a fixed address field such as MODBUS can be supported.

## 2.9 ADDITIONAL FEATURES

The XRT9000 incorporates the following additional features which enhance the usability of the product and assist with the operation and maintenance of systems using the product:-

### 2.9.1 Status LEDs

The XRT9000 Radio Modems have a number of front panel LEDs to enable the operator to see at a glance the status of the product and the serial data port.

### 2.9.2 Dedicated Programming Port

In addition to the 9-way D-Type RS232 connector on the rear panel for data traffic, there is a further 9-way connector on the front panel which is solely for programming, configuration and network management. This allows the system to be monitored and configured without removing the traffic connector and without moving away from the selected RF channel. The radio automatically recognises all traffic on the programming port as management instructions and it is not necessary to select the programming mode on the front panel switches when using this port.

### 2.9.3 Analogue RSSI Output

In addition to the ability to get a reading of the receive signal strength using a connected PC, the XRT9000 also has a voltage output which is proportional to the signal strength to assist with antenna alignment and network troubleshooting.

### 2.9.4 Time-out Timer

The transmitter within the XRT9000 has a user programmable time-out timer which allows the maximum continuous transmission time to be set in order to prevent channel blocking due to a fault.

### 2.9.5 Squelch Tail Eliminator

As a user programmable option, the ZRT can also operate in a packetisation mode where framing characters are added at the start and end of the user's message prior to transmission and stripped off again at the receive end prior to passing the user data to the interface connector. This can be useful in getting rid of any spurious characters which may otherwise be generated at the end of messages by squelch noise as the receiver mutes and which can affect old or non-tolerant protocols.

### 2.9.6 Forward Error Correction

When using the internal modem at 9600bps, an optional Forward Error Corrector can be switched in to improve the receiver threshold.

### 2.9.7 Temperature Readings

The temperature of the processor board can be measured via a connected PC or over the air to assist in the diagnosis of faults.

### 2.9.8 Internal Voltage Measurement

The internal unregulated supply voltage (12V nominal) can be measured via a connected PC or over the air to assist in diagnosis of faults.

### 2.9.9 Digital Inputs & Outputs

The XRT9000 Series has two local inputs and two outputs that can be configured and used with the management and diagnostics software.

### 2.9.10 Frequency Netting

The receiver or transmitter frequency offset of any outstation radio or repeater can be measured with respect to the frequencies of the XRT9000 base-station. If an offset is outside reasonable limits, a global or individual command will re-align the remote radio oscillators to that of the XRT9000 base station.

# 3 SPECIFICATIONS

## 3.1 TECHNICAL SPECIFICATIONS

### 3.1.1 General

| | |
|---|---|
| Frequency Range: | Full MPT1411/VNS2111 band without re-alignment.<br>Other allocations in the range 406 – 512MHz are possible. |
| Power Requirements: | 110/220 V AC or 24V DC (19-36V) or 48V DC (36V-72V)<br>additional 12V DC (10V – 15.5V DC) input available on all versions |
| Power Consumption: | Receiver only: < 3W<br>Transmitting: < 40W (5W version) or < 100W (10W version) |
| Aux DC Output Fuse: | 4A quick-blow 20mm mounted on rear panel. |
| Internal Charger Fuse: | 20mm quick-blow mounted internally on charger board.<br>5W version:- 4A<br>10W version:- 10A |
| Number of Channels: | 80 sequential or 32 discrete user programmable channels. |
| Min. Programmable Channel Step: | 6.25kHz |
| Channel Spacing: | 12.5kHz |
| Operating Temp. Stability: | 1ppm –20 to +60ºC |
| Construction: | 19" rack mountable 1U aluminium enclosure. |
| Size: | 5W version:- 44.5mm H x 438mm W x 295mm D (excluding handles, mounting brackets & connectors)<br>10W version:- 44.5mm H x 438mm W x 350mm D (excluding handles, mounting brackets & connectors) |
| Mounting: | 19" rack mount using front panel mountings |
| Weight: | 5W version:- 3.5kg     10W version:- 4kg |

Connectors:

| | |
|---|---|
| RS232 Traffic | 9-way D-Type Female |
| RS232 Programming | 9-way D-Type Female |
| Ancillary Connections | 15-way D-Type Female |
| I²C Bus Connectors | 10-way RJ45 Socket (2 off) |
| Tx Antenna | Type N Female (50 ohm) |
| Rx Antenna | Type N Female (50 ohm) |
| Primary AC Supply | IEC (alternative to DC connector below) |
| Primary DC supply | XLR (alternative to AC connector above) |
| Auxiliary 12V | 3-pin XLR Male |

Led Indicators: Power, Tx, Rx Busy, System, RXD, TXD, RTS, CTS, DCD, DTR, RI, DSR

### 3.1.2 Transmitter

| | |
|---|---|
| RF Output Power: | 5W version :- 50mW to 5W<br>10W version:- 500mW to 10W |
| Bandwidth: | 12MHz without re-alignment |
| Tx Duty Cycle: | up to 100% (10W version may require forced-air cooling of the rack when operated at 100%) |
| Internal Modulation: | Programmable FFSK, 2 Level FSK, 4 level FSK & GMSK. |
| Analogue Mode: | Programmable audio input levels from +3Bm to -30dBm into 600ohm, selectable for pre-emphasised or flat response. |
| Max. Deviation: | ± 7.5kHz |
| Tx Intermodulation: | 40dB at 5Watt without needing an external circulator |
| Adj. Channel Power: | >65dB down at 12.5kHz |
| Spurious Emissions: | As per ETS300-113 |
| Rise Time: | < 5mS |

### 3.1.3 Receiver

| | |
|---|---|
| Sensitivity: | 0.25uV (-120dBm) for 12dB SINAD de-emphasised<br>0.355uV (-117dBm) for 12dB SINAD flat |
| Bandwidth: | 12MHz without re-alignment |
| Spurious Response: | > 80dB |
| Blocking: | > 90dB relative to 1uV |
| Intermodulation: | > 70dB (2 signal)<br>> 65dB (3 signal) |
| Adjacent Channel: | > 70dB down at 12.5KHz |
| IF Frequencies: | 45MHz and 455KHz |
| Spurious Emissions: | < ETS 300-113 |
| Analogue Mode: | Programmable audio output levels in the range +3dBm to -30dBm into 600ohm, selectable for de-emphasised or flat response. Programmable mute enable. |
| Mute Response Time: | < 3msec |

### 3.1.4 Internal Modem

| | |
|---|---|
| Serial Comms: | Asynchronous or Synchronous with custom software.<br>Baud rate programmable between 150bps and 38400bps |
| Interface: | Selectable RS232 or 5V TTL inverted/non-inverted, |
| Parity: | Programmable odd, Even or None |
| NRZI: | On or Off |
| Stop bits: | Programmable 1 or 2 |
| Data Bits: | Programmable 7 or 8 |
| Signalling Formats: | Programmable V23 or Bell202 up to 1200 baud, FFSK at 2400 baud, GMSK at 4800 baud, 4 level FSK at 9600 baud. |
| Synchronous/Async. | Programmable either up to 1200bps, above 1200bps synchronous |
| Over-air Baud Rate: | 150 – 9600bps within 12.5kHz |
| Bit Error Rate: | 150 - 2400 baud, less than 1 x 10-3 at –120dBm<br>4800 baud, less than 1 x 10-3 at –117dBm<br>9600 baud, less than 1 x 10-3 at –115dBm (FEC on)<br>9600 baud, less than 1 x 10-3 at –112dBm (FEC off)<br>The bit error rates quoted above are for fixed messages representing typical data sent over the link. The BER should not be directly compared with other manufactures figures unless the data format is known, as many manufacturers quote a BER based on a simple alternating data pattern, which will generally give much better BER results. |
| F.E.C. | Forward Error Correction programmable on or off at 9600bps. |

*In the interest of improvement the above specifications are subject to change without notice.*

## 3.2 APPROVALS AND LICENSING

The XRT9000 has been designed to meet the relevant standards as outlined below. Should others be required, please contact the sales office.

### 3.2.1 UK Approvals

MPT1411/VNS2111: The unit has been tested to MPT1411 and the replacement VNS2111 for licensed applications with a maximum data rate of 9600bps within a 12.5 kHz channel. A licence is required and the permitted output power is normally stated on the licence.

BS2011: The unit complies with the vibration specification BS2011.

### 3.2.2 European Approvals

ETS300-220 The unit meets the specification for European licensed exempt communications with a maximum RF power level of 500mW. Please note the permitted power level may vary from country to country.

ETS300-113 The unit meets the specification for licensed data radios provided that for fixed station (Base Station) applications on common sites, the use of an external circulator will be required to meet the transmitter intermodulation response. Details of suitable units are available from the sales office.

ETS301-489: The unit meets the required CE specification and carries a CE Mark.

EN60950 The unit meets the relevant requirements of this safety specification.

### 3.2.3 European Declaration of Conformance

Hereby, RF DataTech declares that the XRT9000 Series of Radio Modems is in compliance with the essential requirements and other relevant provisions of Directive 1999/5/EC.

# 4 PRE-PROGRAMMED CHANNEL PLANS

Using the PC configuration software, the XRT9000 can be programmed with a number of standard channel plans. These currently include all MPT1411 or all MPT1329 channels. Further standard channel plans may become available in later releases of the configuration software. A mixture of channels from different channel plans can also be entered discretely using the software.

The following tables show the channel numbers and associated frequencies for various channel plans:-

## 4.1 UK MPT1411/VNS2111 CHANNELS

| CHANNEL | SCANNER | OUTSTATIONS |
|---|---|---|
| 1 | 457.50625 | 463.00625 |
| 2 | 457.51875 | 463.01875 |
| 3 | 457.53125 | 463.03125 |
| 4 | 457.54375 | 463.04375 |
| 5 | 457.55625 | 463.05625 |
| 6 | 457.56875 | 463.06875 |
| 7 | 457.58125 | 463.08125 |
| 8 | 457.59375 | 463.09375 |
| 9 | 457.60625 | 463.10625 |
| 10 | 457.61875 | 463.11875 |
| 11 | 457.63125 | 463.13125 |
| 12 | 457.64375 | 463.14375 |
| 13 | 457.65625 | 463.15625 |
| 14 | 457.66875 | 463.16875 |
| 15 | 457.68125 | 463.18125 |
| 16 | 457.69375 | 463.19375 |
| 17 | 457.70625 | 463.20625 |
| 18 | 457.71875 | 463.21875 |
| 19 | 457.73125 | 463.23125 |
| 20 | 457.74375 | 463.24375 |
| 21 | 457.75625 | 463.25625 |
| 22 | 457.76875 | 463.26875 |
| 23 | 457.78125 | 463.28125 |
| 24 | 457.79375 | 463.29375 |
| 25 | 457.80625 | 463.30625 |
| 26 | 457.81875 | 463.31875 |
| 27 | 457.83125 | 463.33125 |
| 28 | 457.84375 | 463.34375 |
| 29 | 457.85625 | 463.35625 |
| 30 | 457.86875 | 463.36875 |
| 31 | 457.88125 | 463.38125 |
| 32 | 457.89375 | 463.39375 |
| 33 | 457.90625 | 463.40625 |
| 34 | 457.91875 | 463.41875 |
| 35 | 457.93125 | 463.43125 |
| 36 | 457.94375 | 463.44375 |

| | | |
|---|---|---|
| 37 | 457.95625 | 463.45625 |
| 38 | 457.96875 | 463.46875 |
| 39 | 457.98125 | 463.48125 |
| 40 | 457.99375 | 463.49375 |
| 41 | 458.00625 | 463.50625 |
| 42 | 458.01875 | 463.51875 |
| 43 | 458.03125 | 463.53125 |
| 44 | 458.04375 | 463.54375 |
| 45 | 458.05625 | 463.55625 |
| 46 | 458.06875 | 463.56875 |
| 47 | 458.08125 | 463.58125 |
| 48 | 458.09375 | 463.59375 |
| 49 | 458.10625 | 463.60625 |
| 50 | 458.11875 | 463.61875 |
| 51 | 458.13125 | 463.63125 |
| 52 | 458.14375 | 463.64375 |
| 53 | 458.15625 | 463.65625 |
| 54 | 458.16875 | 463.66875 |
| 55 | 458.18125 | 463.68125 |
| 56 | 458.19375 | 463.69375 |
| 57 | 458.20625 | 463.70625 |
| 58 | 458.21875 | 463.71875 |
| 59 | 458.23125 | 463.73125 |
| 60 | 458.24375 | 463.74375 |
| 61 | 458.25625 | 463.75625 |
| 62 | 458.26875 | 463.76875 |
| 63 | 458.28125 | 463.78125 |
| 64 | 458.29375 | 463.79375 |
| 65 | 458.30625 | 463.80625 |
| 66 | 458.31875 | 463.81875 |
| 67 | 458.33125 | 463.83125 |
| 68 | 458.34375 | 463.84375 |
| 69 | 458.35625 | 463.85625 |
| 70 | 458.36875 | 463.86875 |
| 71 | 458.38125 | 463.88125 |
| 72 | 458.39375 | 463.89375 |
| 73 | 458.40625 | 463.90625 |
| 74 | 458.41875 | 463.91875 |
| 75 | 458.43125 | 463.93125 |
| 76 | 458.44375 | 463.94375 |
| 77 | 458.45625 | 463.95625 |
| 78 | 458.46875 | 463.96875 |
| 79 | 458.48125 | 463.98125 |
| 80 | 458.49375 | 463.99375 |

## 4.2 UK MPT1329 CHANNELS

The XRT9000 can be programmed to operate on the full MPT1329 band of channels with access to channels 26, 27 & 32 denied, in line with MPT1329 band plan.
The radio should be programmed for a maximum power level of 500mW.

| CHANNEL | FREQUENCY |
|---|---|
| 1 | 458.5000 Guard Ch. |
| 2 | 458.5125 |
| 3 | 458.5250 |
| 4 | 458.5375 |
| 5 | 458.5500 |
| 6 | 458.5625 |
| 7 | 458.5750 |
| 8 | 458.5875 |
| 9 | 458.6000 |
| 10 | 458.6125 |
| 11 | 458.6250 |
| 12 | 458.6375 |
| 13 | 458.6500 |
| 14 | 458.6625 |
| 15 | 458.6750 |
| 16 | 458.6875 |
| 17 | 458.7000 |
| 18 | 458.7125 |
| 19 | 458.7250 |
| 20 | 458.7375 |
| 21 | 458.7500 |
| 22 | 458.7625 |
| 23 | 458.7750 |
| 24 | 458.7875 |
| 25 | 458.8000 |
| 26 | 458.8125 |
| 27 | 458.8250 Not Used |
| 28 | 458.8375 Not Used |
| 29 | 458.8500 |
| 30 | 458.8625 |
| 31 | 458.8750 |
| 32 | 458.8875 |
| 33 | 458.9000 Not Used |
| 34 | 458.9125 |
| 35 | 458.9250 |
| 36 | 458.9375 |
| 37 | 458.9500 Guard Ch. |

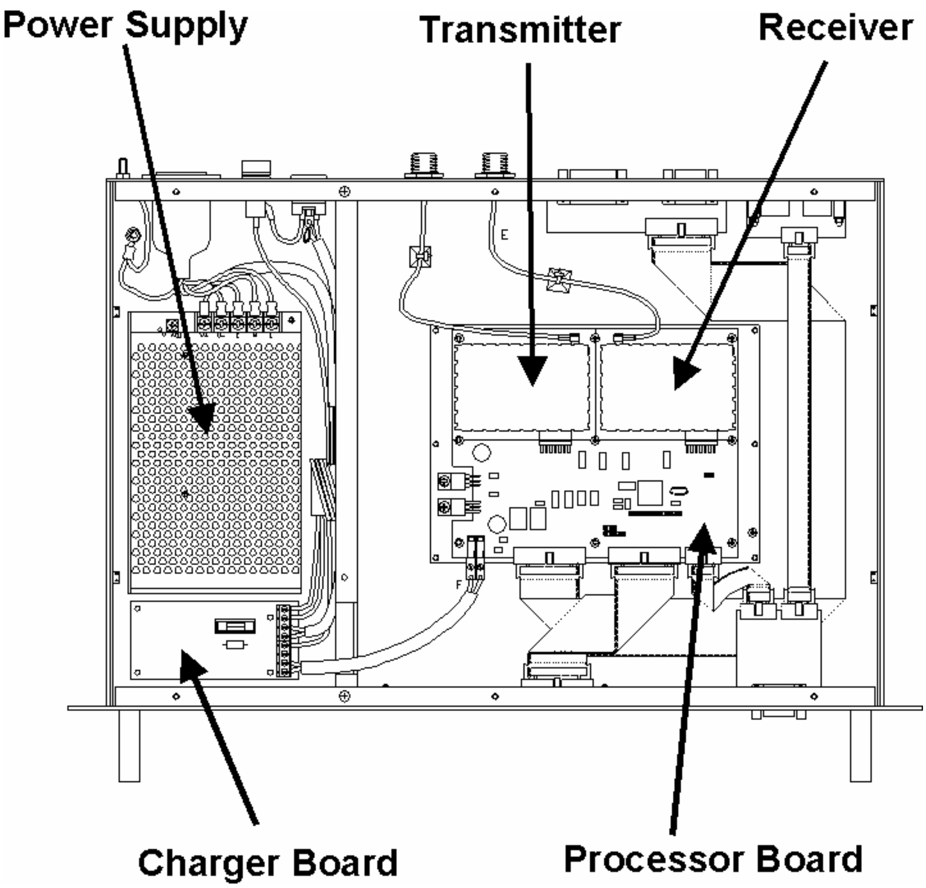
# 5 SET-UP & INTERFACING

## 5.1 INTERNAL CONSTRUCTION

The assembly drawing below shows the main components of the XRT9000.

⚠ Note:- Due to the presence of high voltages within the assembly, the unit should be isolated from all power sources before removing any covers. Do not attempt to remove the covers from the internal power supply module, as high stored voltages may be present in this module even when the external power feeds are disconnected.

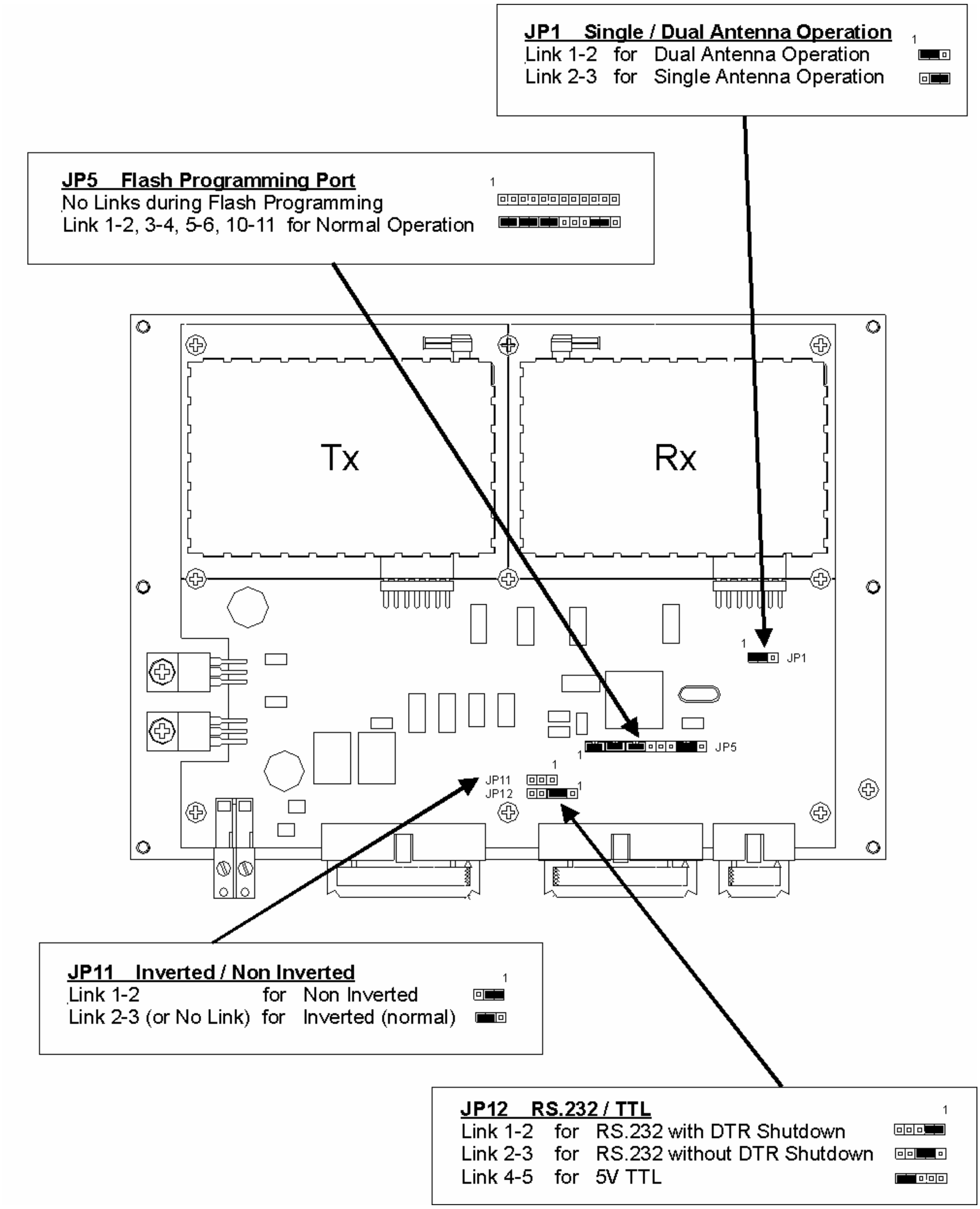
⚠ Note:- With the exception of the removable links described below and replaceable fuses, there are no user settable controls inside the case. No attempt should be made to repair the unit except by experienced RF personnel with high specification RF test equipment. Adjusting any of the controls within the RF modules may degrade the transceiver's performance or put its operation outside the approved specification.



## 5.2 INTERNAL LINKS

There are a number of operating configurations which are set using links on the processor board. These include selection of dual or single antenna operation, RS.232 or TTL interfaces, etc.

The following diagram shows the position of the links for each of the available settings.

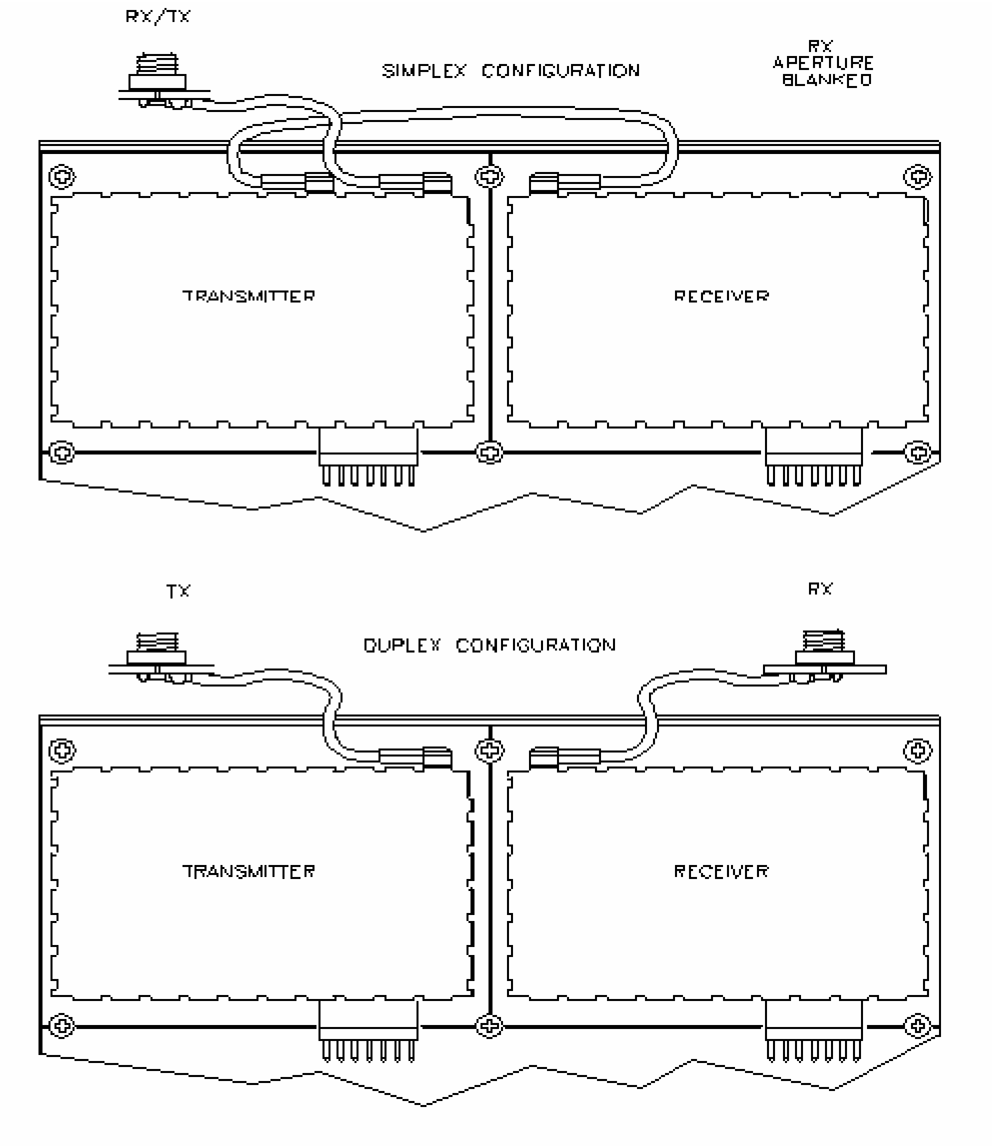


### 5.2.1 Single or Dual Antenna Operation

The XRT9000 is normally factory configured for either Simplex single antenna or Simplex/Duplex dual antenna operation. With the correct parts the conversion from one to the other takes only a few minutes.

For two antenna operation individual coaxes from the receiver and the transmitter module connect to separate N-Type connectors on the chassis. Link JP1 on the processor board should be set with pins 1 and 2 linked.

For single antenna operation the receiver 's internal antenna connector is connected to the Rx port on the transmitter module and a blanking cap is fitted where the Rx N-Type would normally be fitted. The Rx port on the transmitter is a pin diode switched output with isolation to stop excessive RF power being fed into the receiver during transmit. Linking pins 2 and 3 of link JP1, as shown in the diagram above, sets a hard wired control line that switches off the receiver's front end during transmission for additional protection.



### 5.2.2 Internal Firmware Download Port

JP5 is a firmware download port and is used during production to download firmware directly into the processor's flash memory. Once programmed the 4 jumpers are installed linking 1-2, 3-4, 5-6 & 10-11 for normal operation. For upgrades, the links can be removed and new firmware loaded via JP5 using the appropriate interface hardware. Firmware upgrades can also be carried out through the external serial programming port, in which case the links are left in their normal operating positions.

### 5.2.3 RS.232 or 5V TTL Serial Interface

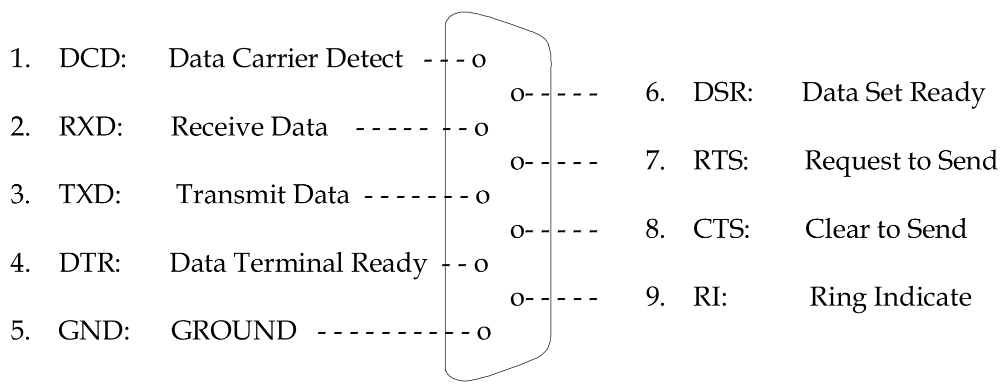
The XRT9000 serial traffic port on the rear panel can be programmed to operate at speeds from 150 – 38,400bps. Internal links JP11 & JP12 can be set to provide full RS232 or 5V TTL signal levels, with either mode set for true or inverted. Unless otherwise specified the product is shipped set for "True RS232" operation, i.e. links set for RS.232 and Inverted. Should these parameters need to be changed, the link settings for all available configurations are shown in the diagram.

The –5V generator for the RS232 interface is turned off if 5VTTL is selected, and also while DTR is inactive if the DTR shutdown link option is enabled. The latter option is complemented by the software DTR shutdown option which causes the processor to shut down all the radio circuits while DTR is inactive. For lowest current consumption both options must be enabled, but where power consumption is non critical, faster operation will be achieved if the shutdown options are not enabled.

## 5.3 CONNECTOR PINOUTS

### 5.3.1 Rear Panel RS.232 Serial Data Connector

The XRT9000 Series is equipped with a 9 way female D connector on the rear panel for serial data traffic connections. The pins of this connector conform to standard RS.232 allocations as follows:-




### 5.3.2 Front Panel Programming Port

The front panel programming port is a 9-way D-Type connector whose pin allocations are the same as the RS.232 serial data connector above. For programming purposes, it is only necessary to connect TXD (pin 3), RXD (pin 2) & GND (pin 5).

### 5.3.3 Rear Panel Auxiliary Connector

The rear panel auxiliary connector is a 15-way D-Type connector whose pin allocations are shown below.

| Pin | Allocation |
|---|---|
| 1. | Tx Audio IN (600 ohm - balanced) |
| 9. | Tx Audio IN (600 ohm - balanced) |
| 2. | RX Audio OUT (600 ohm - balanced) |
| 10 | Rx Audio OUT (600 ohm - balanced) |
| 3. | Ground |
| 11. | Ground |
| 4. | Unregulated +Ve Supply Out |
| 12. | Not Connected |
| 5. | Digital Output 1 |
| 13. | Digital Output 0 |
| 6. | Digital Input 1 |
| 14. | Digital Input 0 / PTT (in External Modem configuration) |
| 7. | External Rx Busy LED Anode |
| 15. | External Tx LED Anode |
| 8. | RSSI (Voltage output in range 0 to +5Vdc) |

When using an external modem, the transmitter can be keyed up by applying a ground to pin 14 (PTT). Open circuit or a +Vdc voltage on this pin will select receive.

The digital inputs and outputs are for use in connection with the external network management software which is available as an option.

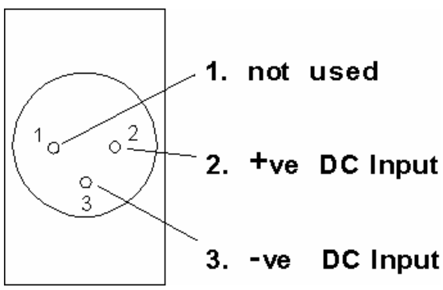
Pins 7 & 15 can source 3mA to drive external low current LEDs to indicate that the receiver has detected a carrier or that the transmitter is active respectively. The LEDs should be connected with their anodes to the specified pins and with their cathodes to Ground.

Note that pre-assembled standard cables procured from sources other than RF DataTech may be incompatible with the product-specific pin usage on this connector and may cause damage to the XRT9000 or any other equipment to which it is connected. It is important to use the correct cables for the radio.

### 5.3.4 Primary DC Power Connector (for DC versions only)

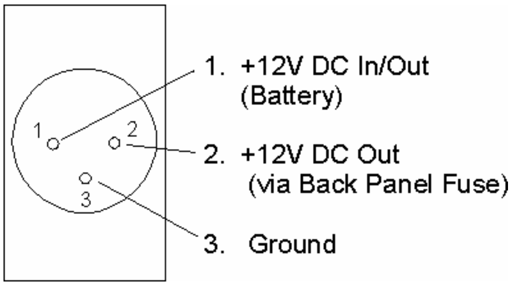
The primary power connector on DC versions is a 3 pin Male XLR. The DC inputs are floating and can be connected with either polarity grounded.

For 24V versions, supply feeds in the range 19Vdc to 36Vdc are acceptable.
For 48V versions, supply feeds in the range 36Vdc to 72Vdc are acceptable.

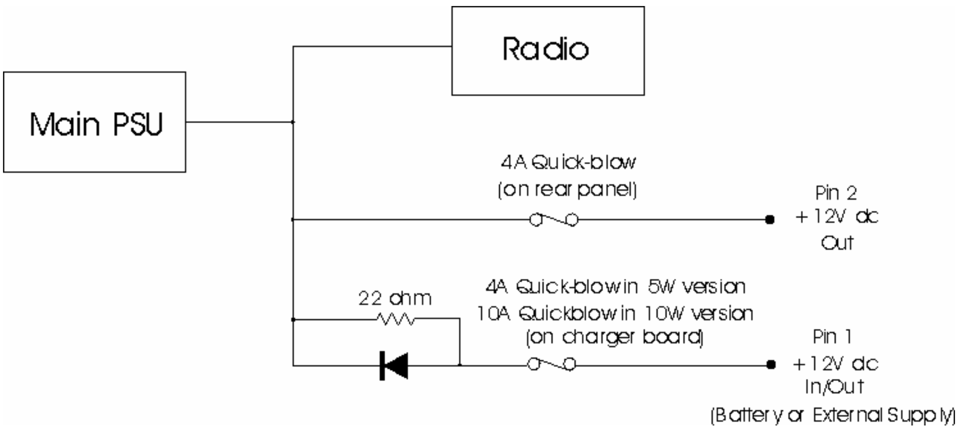


### 5.3.5 Auxiliary DC Connector

The auxiliary DC connector is a 3 pin Male XLR. This connector allow connection of an external 12V re-chargeable battery to pin 1. While the main supply is present, the battery will be charged, but if the main supply fails, the XRT9000 will be powered from the battery.
Pin 2 is an auxiliary fused 12V output for feeding external equipment. This output comes via the fuse which is accessible on the rear panel.
The diagram below shows the connector as seen when looking at the rear panel of the XRT9000 from the outside.




The associated internal circuitry is depicted below:-




### 5.3.6 I²C Internal & External Bus

The XRT9000 Series features an I²C Bus which is used to communicate with other modules over short or medium distances. The main feature of the bus is its address mode, which will only wake up modules that are being addressed, thereby ensuring low power operation.
There are two RJ45 bus connectors on the rear panel with the following pinouts:-

| *Pin No.* | *Description* |
|---|---|
| 1 & 2 | Nominal 12VDC direct feed via a fuse & Over voltage Protection |
| 3 & 4 | N/C |
| 5 | SDA I²C Data Line |
| 6 | SCK I²C Clock Line |
| 7 | I.O. Reset |
| 8 | I.O. Interrupt |
| 9 & 10 | Ground |

### 5.3.7 RS.485 Interface

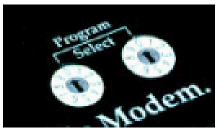
For RS.485 and RS.422 operation, an external adaptor is required. Further information is available from the sales office

## 5.4 ANTENNA PORTS

The antenna connections are 50 ohm Type-N connectors. The transmitter port should be connected to a suitable antenna or terminated in a 50 ohm load whenever the transmitter is activated. Transmission at high powers into an open circuit may cause excessive current to be drawn from the supply and damage could occur.
As an extra-cost option, the XRT9000 is available with the standard antenna connectors replaced by in-line N-Type surge arrestors.

## 5.5 CHANNEL SWITCHES

The two front panel BCD switches select channels or, if both are set to zero, allows programming of the radio through the rear connector which is normally used for traffic connections. Programming is always possible through the front panel programming port irrespective of the position of the switches.
When viewing the XRT9000 from the front, the left hand rotary switch is the "tens" switch and the right is the "units" switch, thus to set channel 37 set the left switch to 3 and the right to 7.




## 5.6 PROGRAMMING

Apart from the link selectable options such as single/dual antenna operation and RS232/5VTTL selection described above, all the other parameters of the XRT9000 can be programmed using Windows based software, either locally or over the radio link. The individual configuration file for any given radio can be stored on disc for future use or printed. Full details of all the programmable parameters are covered in the separate WinA4P Programming Manual.

The management or configuration computer can be locally connected to the radio either via the rear traffic port with the switches set to 00 or via the dedicated front panel programming port with the switches set for any valid channel. This allows the system to be monitored and configured without removing the traffic connector and without moving away from the selected RF channel.

## 5.7 CHANNEL SELECTION

The XRT9000 can be user programmed, either locally or across the radio link, with up to 80 sequential or 32 discrete simplex or semi-duplex channels. Once programmed, the channels can then be selected via rotary switches on the front panel. The configuration/management software also allows the switch positions to be over-ridden and the frequencies set directly under software control.

## 5.8 RF POWER

The XRT9000 transmitter power is adjustable under software control from 50mW to 5 Watts on the Standard Power version or from 500mW to 10W on the High Power version, with an accuracy of +/-1dB. There are no internal power adjustment points inside the unit. All power setting is done under the control of the configuration software.

## 5.9 STATUS LEDS

The XRT9000 has a number of LEDs to enable the operator to see at a glance the status of the product and the serial port:-

| | |
|---|---|
| On | Power On |
| RX | RF Carrier Detect/Busy |
| TX | Transmit |
| SYS | System (see below) |
| RTS | Request to Send |
| CTS | Clear to Send |
| DCD | Data Carrier Detect |
| DTR | Data Terminal Ready |
| RXD | Receive Data |
| TXD | Transmit Data |

### 5.9.1 System LED

With the Exception of the System LED the remainder are self explanatory. The System LED lights when the radio is being programmed and is also used as a quick check as to the status of the unit. If any alarms are detected it will flash out an Error number

### 5.9.2 Error Number

The modem reports errors using the LED display. Firstly the BUSY led will come on and the SYS led will flash a number of times, the BUSY led will then go out again and if the fault persists the procedure will be repeated. An error number can be determined by counting the number of times the SYS led flashes while the BUSY led is on.

| ERROR No | FAULT |
|---|---|
| 1 | Position of the channel switches has changed. |
| 2 | A channel has been loaded that has no RX frequency programmed. |
| 3 | Transmission has been attempted on a channel that has no TX frequency programmed. |
| 4 | The receiver synthesiser phase locked loop has failed to lock due to bad channel data or programming of an out range frequency. |
| 5 | The transmitter synthesiser phase locked loop has failed to lock due to bad channel data or programming of an out range frequency. |
| 6 | The contents of the microprocessor's EEPROM are corrupted (failed checksum) in the general program area. |
| 7 | Internal comms with a high power amplifier have failed. |
| 8 | The contents of the microprocessor's EEPROM are corrupted (failed checksum) in the calibration area. |
| 9 | The contents of the microprocessor's EEPROM are corrupted (failed checksum) in the factory program area. |
| 10 | No POCSAG message stored for repeat test. |
| 11 | Rotary channel switch position overridden by software. |
| 12 | Tx power setting out of range. |
| 13 | Packet Mode cycle pointer invalid. |
| 14 | Bad routing table area EEPROM checksum. |
| 15 | $I^2C$ Bus initialisation error. |

## 5.10 TIME-OUT-TIMER

The transmitter within the XRT9000 has a time-out timer which allows the maximum continuous transmission time to be set in order to prevent channel blocking due to a host fault. The timer works in all modes (external/internal modem) and is programmable in one second steps between 0 and 255 seconds. If not required the timer can be programmed off.
If the timer is enabled and the selected time is exceeded, transmission will cease until the action that normally causes transmission is removed and then re-applied. More explicitly; in external modem mode the transmit enable line (DI0) must be released and then lowered again, in internal modem modes with RTC/CTS handshake enabled RTS must be dropped and then raised again, or if handshake is not enabled character transmission must be suspended for at least two character periods at the serial port baud rate. In all modes the modem's SYS led is flashed at least twice when time-out occurs, the flashing continues while lockout is in force.
The lockout timer is disabled if the lockout time is set to 0. The lockout timer can be operated in "resettable" or "cumulative" mode, in resettable mode the timer restarts each time a transmission is made, in cumulative mode the timer counts up during transmit, and down during receive. If the timer counts up to the lockout time during transmit, lockout occurs; this will eventually happen if the radio spends more than half of its time transmitting. Lockout in this mode is indefinite and can only be reset by powering the radio off.

## 5.11 POWER SAVE MODE

The XRT9000 is equipped with an internal and external power save mode. These are outlined below:

### 5.11.1 Internal Power Save

In this mode the microprocessor switches the transceiver off and after a pre-programmed time (Save on time) switches the unit back on (Save off time). If a carrier is not detected then the transceiver again switches off. If during the time the transceiver is awake a carrier is received, the unit will stay on. After the carrier drops out the receiver will stay on until the programmed resume time elapses. Once the resume time has elapsed the unit will return to its power save mode. The Save On/Off and Resume time are all programmable via the PC program. Obviously the amount of power saved increases with the programmed save on/off ratio, however with power save enabled long lead times must be programmed to wake up the unit before communication can take place. Therefore it may not be possible to run all applications under the power save mode due to the turn around times required by the host system. In some circumstances it is possible to achieve power save and fast polling since if polling of all outstations is carried out in cycles with a reasonable gap between each cycle, a long initial poll can be used to wake up all stations, the resume timer will then restart each time an outstation is polled allowing fast access, when the cycle is complete all stations will return to power save after the resume time has expired.

### 5.11.2 External Power Save

Under this mode the on/off ratio is controlled externally via the DTR line (DTR shut down must first be enabled using the set up program). In this mode more of the modem's circuits are shutdown (including the microprocessor), this saves more power but care must be taken to ensure that the modem is enabled when a transmission is to take place. Note that there is a hardware link option to allow the serial port to shut off when DTR is not active; this allows the radio current to be reduced to its bare minimum. In applications where DTR is not connected this link option must of course be disabled.

## 5.12 "RSSI" RECEIVE SIGNAL STRENGTH INDICATION

The XRT9000 produces an internal DC signal which is proportional to the received signal strength. The DC signal is passed to the internal MPU where it accurately measures its value by an internal A-D converter. The radios are individually calibrated during production so that signal strength can then be read in dB micro volts on a PC connected to the programming port or remotely over the air.
In addition to this PC capability, a 0 to 5Vdc voltage proportional to the received signal strength is also available directly on the auxiliary connector.

Typical DC voltages verses Signal levels are shown below:-

| RF Sig | 0.3µV | 0.35µV | 0.5µV | 0.8µV | 1µV | 2µV | 3µV | 4µV | 5µV |
|---|---|---|---|---|---|---|---|---|---|
| DC V | 1.25 | 1.25 | 1.35 | 1.44 | 1.49 | 1.66 | 1.75 | 1.80 | 1.88 |

## 5.13 TEMPERATURE MEASUREMENT

Within the XRT9000 is a thermistor which in turn is connected to an A-D on the processor. This is used to measure the internal temperature of the module and to compensate for temperature changes. The temperature in degrees C/F is available via a connected PC or over the radio link via the network management software.

## 5.14 SUPPLY VOLTAGE MEASUREMENT

The nominal 12V internal unregulated supply is monitored via an A-D on the processor and the actual voltage can in be read from a connected PC or over the radio link via network management software.

## 5.15 FREQUENCY OFFSET RE-ALIGNMENT

The network management software, enables selected outstations/repeaters or all outstations and repeaters within a system to have the frequency of the receiver and transmitter checked against the base station and any offset flagged as a percentage.
The decision can then be made to press the auto re-alignment button that will align all the outstations and repeaters to the frequency of the base station and flag up the new offset percentages, which should be very near to zero.
This facility is designed to minimise the effects of long term drift or can be used to individually re-align an outstation should there be large environmental differences, for example. the base station is +50 deg and the outstation is at –30deg. While it will still work the performance could be improved if the two were locked.

## 5.16 EXTERNAL I/O

The XRT9000 is equipped with two digital inputs and two digital outputs that can be accessed via the management software. The inputs & outputs are protected to +30V DC with the open collector outputs capable of sinking up to 1A.

# 6 ANALOGUE MODES OF OPERATION

## 6.1 ANALOGUE CAPABILITY

In addition to the serial data path the XRT9000 has an audio interface for external modem connection. This allows use with older systems that employ private wires with external V23 or Bell 202 modems.

The selection of internal modem or external audio operation is made using the configuration software.

The inputs and outputs both have balanced 600ohm interfaces, but it should be noted that the external audio path is not suitable for GMSK or multi-level signalling at baud rates above 2400 baud.

When using external audio mode, the signal path can be programmed for flat or a pre/de-emphasised response, for compatibility with older systems. When de/pre-emphasised is selected a 300Hz low pass filter is switched in on the Rx path.

The input/output levels can be adjusted using the configuration software over the range of +3dBm to -20dBm into 600 ohms. Unless otherwise requested, the default factory setting is –13dBm.

The Rx audio output can be programmed to either mute or remain non muted in the absence of a received carrier.

Note that the network management features and the monitoring of remote radios over the air is not possible when operating in analogue mode, because these management signals rely on the packetisation option which can only be implemented when using the XRT9000 internal modem.

## 6.2 KEYING THE TRANSMITTER IN AUDIO MODE

In the external audio mode there are two options for keying the transmitter.

The first is the use of hardware PTT (Push to Talk) using the dedicated input pin on the interface connector. Grounding this pin will select Transmit.

The second is the use of the Tone Operated Switch (TOX). The TOX can be programmed to key the radio on detection of either V23 mode 2 or Bell 202 tones. Other tone sets can be provided for, by special order. Detection of the selected format will key up the transmitter and forward the incoming data. It should be noted that a pre-amble of 10-15milli-seconds duration consisting of data, single tone or alternating will be required so the decoder can lock on and activate TX enable. To ensure that the radio does not key-up on noise, the TOX circuit checks for valid modem tones, not just the presence of some audio, before keying the radio.

## 6.3 LEADOUT DELAY

The lead out delay is the time the transmitter stays up after the audio data finishes, this is to ensure that there is a known minimum quiet time after the end of valid message characters before any mute noises appear which could corrupt data that is not framed, not packetised and does not have an end of message character. This delay period is programmable between 0 & 256 milliseconds.

# 7 DIGITAL MODES OF OPERATION

## 7.1 DIGITAL MODES OF OPERATION

This section serves as a guide to the various ways the XRT9000 Series can transfer digital information via its serial port in point to point links, point to multi-point (scanning telemetry) systems and networks employing store and forward repeater nodes.
Due to the exceptionally large flash memory space available within the XRT9000, we are able to support various PC selectable modes of operation to suit many different applications.
At the time of writing this manual, Transparent mode, Hayes "AT", MODBUS and RFT Routing Modes are supported, with DNP3, IEC870 and MX25 modes under development. The basic modes of operation of the radio modem are outlined below.

## 7.2 INTERNAL MODEM

The ZRT features an internal "soft modem" which offers unparalleled performance and flexibility over a wide range of speeds and formats. Data is presented to the modem via the RS232 serial connection at speeds between 150 and 38400 and then transmitted at the programmed radio baud rate. Buffering is provided when the external interface data rate is higher than the radio transmission rate.

### 7.2.1 Modulation & Tone-sets

Within a 12.5kHz channel, the over-air transmission from the unit can be programmed for a range of speeds. For 150, 300, 600,1200, the modulation is FFSK with Bell 202 and V.23 (Mode 2) tone-sets both supported. At these lower speeds, it is also possible to select a protocol specific MPT1327 mode which uses a 1200/1800Hz tone-set to allow compatibility with number of additional modems from other manufacturers. At 2400bps the modulation is coherent FFSK,at 4800bps it is GMSK and at 9600bps it is 4-Level FSK.
If operating at speeds up to and including 1200bps and compatibility with other equipment is not required, the use of the Bell 202 tone-set is recommended, as this will give the best link performance.

### 7.2.2 Synchronous /Asynchronous Modem Operation

The radio modem can be programmed for asynchronous or synchronous operation at baud rates up to 1200. At baud rates of 2400 or more, modem operation may only be synchronous. This relates to the over-air signal and has no bearing on the format of the data presented at the serial interface port

In synchronous mode inverted NRZI encoding is used where a one is represented by a transition in the binary data, every transmitted bit fits into a time slot defined by the baud rate, this allows a phase locked loop to lock on to the data stream to give better performance in noisy conditions, the inverted NRZI encoding allows this to continue even when the signal is idling sending stop bits. The inverted NRZI encoding gives a further advantage with GMSK signalling since the polarity of the signal is unimportant.

In asynchronous mode NRZ encoding is used where a "one" tone represents a binary one, and a "zero" tone a binary zero, whilst each character consists of bits of equal duration defined by the baud rate, the time between the end of a stop bit and a following start bit may be arbitrary. This prevents the implementation of a phase locked loop to improve signal to noise performance but does allow use within older systems that do not implement synchronous transmission or NRZI encoding.

If compatibility with other radios is not required, the use of the synchronous mode is recommended, as this will give best link performance.

## 7.3 RADIO DATA FORMATS

The data rate over the air can be set up independently of the rate set for the serial interface, but the over-air rate should be set either at the same speed or a lower speed than the serial interface rate. The radio baud rate should be set at the minimum possible to maintain the required throughput, lower speeds will give better results in poor signal conditions

The radio signal can be set up to operate using 7 or 8 bit data, 1 or 2 stop bits, and odd, even or no parity. This setting is also independent of the serial port setup. This flexibility allows compatibility with other radios.

When using the XRT9000 in conjunction with CMD400 radios manufactured by Pacscom Ltd, it should be noted that the CMD400 does not set these parameters independently. With one exception the radio signal format in the CMD400 is set to be the same as that of the serial port even though the baud rates can be different. The exception is mode C where the radio signal format did not include parity. If compatibility with this radio is required in Mode C, parity must be disabled in the XRT9000 radio signal regardless of the serial port configuration. Later versions of the CMD400 had an additional mode entitled "mode C plus parity" in which parity was included, use of this mode did not give rise to the exception.

When the radio baud is set for 9600 baud, an extra eight synchronisation bits are sent after every 8 data bytes. For a data format of 8 bits, no parity and 1 stop bit this represents a redundancy of 9%.

If the Forward Error Corrector is enabled (option only available at 9,600bps), the selected radio signal format is over-ridden as detailed below.

## 7.4 FORWARD ERROR CORRECTOR

At 9600bps there is also a programmable option to switch in a forward error corrector. When switched on, the over-air data format changes to a fixed format using 14 bit words. These comprise 8 data bits, 5 CRC (Cyclic Redundancy Check) bits and a flag bit which is used to differentiate control and data functions in messages. An additional 14 bit synchronisation word is also sent after every 8 data words. The effect of this redundancy on a typical 9600bps link configuration is to reduce the effective data transfer rate to around 6300bps.

The error corrector is aimed at improving performance in weak signal conditions, rather than recovering data in deep fades or burst-error conditions. An error rate of 1x10-4 with the FEC switched off will typically improve by a factor of 2000 to around 5 in 10-7 when it is switched on, but an initial error rate of 1x10-3 with it off will only improve by a factor of around 250 to something like 4x10-5 when it is switched on.

In terms of receiver sensitivity, the 1x10-6 threshold improves by around 0.4uV (or 6.4dB) when the FEC is switched on.

The forward error corrector is not available at lower data rates as it offers no significant performance enhancement at these lower rates

## 7.5 SQUELCH TAIL (DRIBBLE BITS) ELIMINATION

The XRT9000 has an optional packetisation mode which can be enabled using the configuration program. This adds framing characters at the start and end of the user's message prior to transmission. The additional information is stripped off the messages at the receiver prior to passing the data to the interface connector. Packetisation can be useful in getting rid of any spurious characters which may otherwise be generated at the end of messages by squelch noise as the receiver mutes and which can affect old or non-tolerant protocols.

It is important to note that packetisation must be set the same on all radios operating together. All radios must have it selected or all radios must have it de-selected.

## 7.6 SERIAL INTERFACE & HANDSHAKING

The serial interface can be programmed either to use RTS/CTS handshaking to initiate transmission, or to transmit whenever data is present at the serial input. In the latter mode CTS is still operated to implement flow control but can be ignored unless message sizes exceed 1k byte and the serial port baud rate is higher than the radio signal baud rate. For compatibility with legacy systems, these handshaking modes are compatible with the PACScom CMD400 modes A, C and D. Mode B (byte stuffing mode) is not supported.

### 7.6.1 Transmission Using RTS/CTS Handshaking

If handshaking is enabled transmission is started by operating RTS, CTS can then be monitored for flow control purposes. In the idle state CTS is inactive, when RTS is operated CTS will become active immediately and data may be input to the serial port, when all data has been loaded to the serial port RTS should be dropped, transmission will continue until all data in the serial input buffer has been sent, then CTS will become inactive and transmission will cease. During transmission the amount of data in the serial buffer is checked by the radio, if the buffer becomes ¾ full CTS is dropped to request the host to stop loading data, CTS is activated again when the buffer is reduced to ¼ full. To prevent timing problems data will still be accepted into the buffer when CTS is de-activated due to buffer filling during transmit, however any data received once CTS has dropped at the end of a transmission will be discarded, this prevents such data from being prefixed to the beginning of the next message.

### 7.6.2 Transmission Without Hardware Handshaking

If RTS/CTS handshaking is disabled the radio will start transmission as soon as data is received at the serial port, transmission ceases as soon as the serial buffer has been emptied and a period equivalent to two characters at the radio signal baud rate has elapsed. It is important to note that since transmission ceases as soon as a two character delay in the incoming data stream is seen, data characters in a message must be presented in a continuous back to back stream.

In this mode CTS is still used to indicate the serial buffer fill level in the same way as described in the section on transmission using handshake, the difference is that in the idle state CTS is always active indicating readiness to accept data. In most applications CTS can be ignored as messages are likely to be smaller than the serial input buffer (1k byte), bear in mind also that if the radio baud rate and data format is the same as that configured for the serial port the buffer is being emptied as fast as it is being filled and so buffer overrun is unlikely.

### 7.6.3 Data Reception

Any data received by the radio is simply output to the serial port, the DCD line can be programmed to operate in three different modes to assist the host. Firstly by indicating that a carrier is detected on the radio channel, this is useful if a busy lockout function is required (although this can be dangerous if the channel is susceptible to interference as well as wanted signals), secondly DCD can indicate presence of a carrier and a valid data signal, data will normally be output under this circumstance, the third mode behaves in the same way as the second except that DCD remains active until all data has been output to the serial port after the signal has gone, this allows DCD to be used as a wake up signal.

## 7.7 TRANSMIT & RECEIVE TIMING

The XRT9000 is able to operate in full duplex, semi-duplex and simplex modes. In full duplex mode the radio can transmit and receive data at the same time, in order to do this the transmit and receive frequencies must be spaced sufficiently far apart to prevent the transmitted signal interfering with received signal.

Semi-duplex mode is similar in that two well spaced frequencies are used but data is only sent in one direction at a time, radios that do not have separate synthesisers for transmit and receive cannot operate in full duplex mode, they can operate in half duplex mode but must reload their synthesiser when changing direction, the XRT9000 does not have this limitation as it is equipped with two synthesisers.

In simplex mode the same channel is used for transmit and receive, the radio synthesiser must be reloaded whether one or two synthesisers are fitted. Radios with one synthesiser must reload to account for the I.F. offset used by the receiver, radios with two synthesisers must reload to prevent leakage from the transmitter blocking the receiver.

The time taken to switch from receive to transmit and vice versa is the same on the XRT9000 for full duplex and half duplex modes, in fact the radio does not differentiate between them. In simplex mode this time is increased because of the synthesiser reload and lock times.

In order to reduce adjacent channel interference in line with ETS300-113, the power output from the transmitter has finite rise and fall times, a distant receiving radio will therefore see an incoming signal later than a nearby one. The receiving radio also requires time for the carrier detect circuit to operate and for the modem to lock on to the incoming audio signal.
If running in full duplex mode these are the only timing considerations required and can be catered for using the programmable "lead in delay", the major part of the time is required for the modem to lock on to the incoming data stream and this is dependant on the radio signal baud rate. Minimum timings are given below:

| Baud Rate | Lead in Delay(Minimum) |
|---|---|
| 150 | 80ms |
| 300 | 60ms |
| 600 | 40ms |
| 1200 | 40ms |
| 2400 | 40ms |
| 4800 | 20ms |
| 9600 | 30ms |

For a two frequency simplex (Semi-duplex) or a duplex channel, the Tx & Rx synthesisers remain loaded and hence there is only the Tx rise time to consider. If single frequency operation is required additional time is required for the transmit synthesiser to be loaded and locked prior to transmission and to be shifted away from the receive channel when transmission ceases. This timing constraint is important when deciding how soon after receiving a message a reply may be sent. For single frequency operation the XRT9000 is ready to receive data approximately 25ms after transmission ceases. It is therefore necessary to either wait this length of time after receiving a message before sending a reply or to extend the lead in delay by the same amount to hold off transmission of the data.

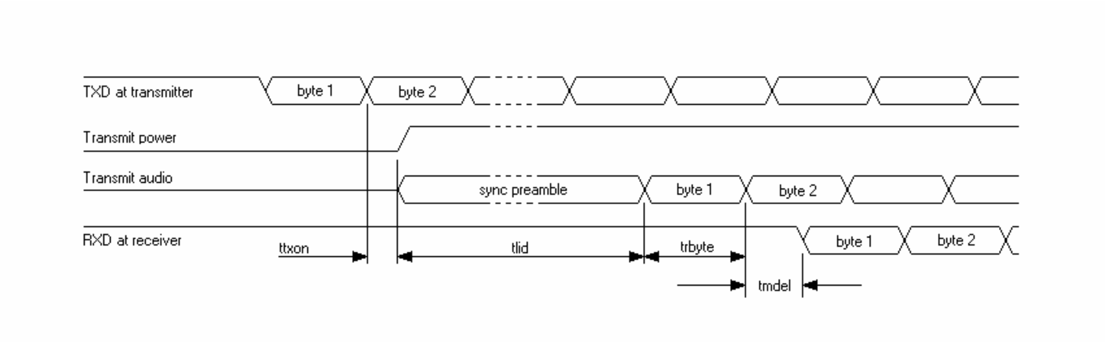
For applications where power save is in use the lead in delay should be extended to allow the receiving device to wake up. The time required can be calculated by adding the save on time to the save off time and adding 10 percent, e.g. for a save on time setting of 800ms and a save off time of 200ms the lead in delay should be 1100ms.

Care must be taken when replying to a previously transmitting XRT9000 when RTS/CTS handshake is not being used, in this mode the transmitting device will wait for two character times before turning off its carrier and may therefore miss the beginning of a reply if it comes too soon, this may be overcome either by imposing an additional two character delay in the controlling device or by extending the lead in delay by that amount.

The XRT9000 also has a facility for imposing a lead out delay, which is the time that the carrier remains on after transmission of the message is complete. This delay can normally be left at zero as it is only of use where a controller makes use of the DCD signal to suppress data processing but suffers some delay in processing received data.

### 7.7.1 Receive to Transmit Switching Time

When using the internal modem the action that initiates transmission can be either receipt of a character at the serial port or the operation of RTS. These examples use the first mode. The radio does nothing until the stop bit of the first character for transmission has been received, the transmitter is then started:




The time delay between receipt of the stop bit for the first character to be transmitted at the transmitting radio and output of the start bit of that character at the receiving radio is the sum of the values ttxon, tlid, trbyte, and tmdel shown in the diagram above. Values for these parameters are indicated below:

TABLE A: Timing values for duplex and simplex modes are as follows:

| symbol | Description | Semi-duplex | simplex |
|---|---|---|---|
| ttxon | Time from external action to commencing transmission | 9ms | 9ms |
| tlid | Duration of synchronisation transmission (lead in delay) | Table B | Table B |
| trbyte | Duration of 1 byte at radio signal baud rate | Table C | Table C |
| tmdel | Modem decode latency | Table D | Table D |

TABLE B: The lead in delay is a programmable parameter but minimum values dependant on baud rate must be adhered to. However, in a scanning system with the base station on continuous transmit the base station lead in delay can be set for Zero (thereby saving valuable time) as the internal outstation modems will always be synchronised.

| Baud | 150 | 300 | 600 | 1200 | 2400 | 4800 | 9600 |
|---|---|---|---|---|---|---|---|
| Min tlid | 80ms | 60ms | 40ms | 40ms | 40ms | 20ms | 30ms |

TABLE C: The duration of a byte at the radio baud rate is dependant upon the data format employed, the table below assumes a format of one start bit, 8 data bits, no parity and 1 stop bit, i.e. a total of 10 bits per character. If another format is used the appropriate correction must be made.

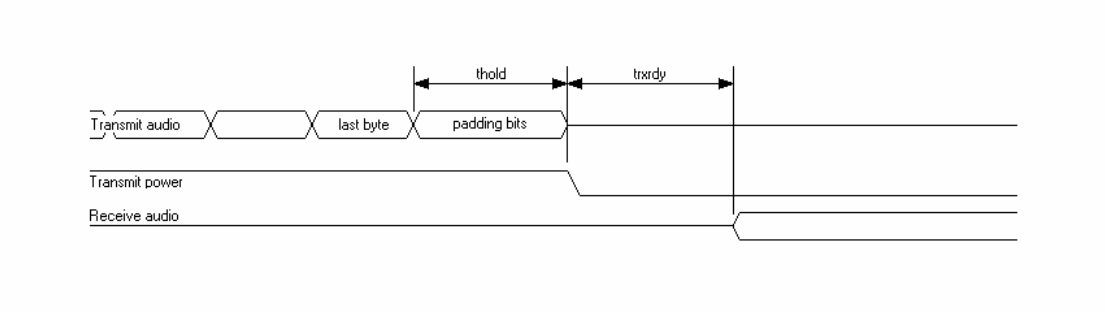
| Baud | 150 | 300 | 600 | 1200 | 2400 | 4800 | 9600 |
|---|---|---|---|---|---|---|---|
| trbyte | 66.7ms | 33.3ms | 16.7ms | 8.3ms | 4.17ms | 2.08ms | 1.04ms |

TABLE D: The modem decode latency takes into account delays introduced by hardware and software filters. The total delay is baud rate dependant:

| Baud | 150 | 300 | 600 | 1200 | 2400 | 4800 | 9600 |
|---|---|---|---|---|---|---|---|
| tmdel | 6.9ms | 3.5ms | 1.7ms | 1.3ms | 1ms | 1ms | 1ms |

### 7.7.2 Message Duration
The time taken to transmit a message can be simply derived by multiplying the number of characters in a message by the values given in table C making any appropriate corrections for data format. The exception is 9600 baud where extra synchronisation sent during the message must be taken into account, 8 synchronisation bits lasting a total of 0.833ms are sent after every eighth message character.

### 7.7.3 Transmit to Receive Switching Time
In full or semi-duplex operation transmit to receive switching time does not need to be considered as the receive path is maintained during a transmission, in simplex operation some time must be allowed to reload the transmitter synthesiser to stop it from interfering with the receiver. The diagram below indicates the minimum time in which the radio is able to receive a signal after completing a transmission.




| symbol | Description | value |
|---|---|---|
| thold | Period for which carrier is held up after sending last data byte | 2.5ms + LOD |
| trxrdy | Time to reload transmit synthesiser in simplex mode | 6ms |

During the time thold the radio transmits some padding bits to allow for propagation delays in the receiving device before shutting off the carrier, this prevents possible chopping of the message tail. The time thold is composed of a fixed 2.5ms period plus the programmable value LOD (lead out delay). LOD is normally set to zero. After the time trxrdy has expired the radio is ready to receive a new signal.

*N.B. If RTS/CTS handshaking is not used the transmitter is turned on whenever data is received at the serial port, the transmitter is left on until all buffered data has been transmitted and no data has been input for a time equivalent to the length of two characters at the radio baud rate (refer to table C). In general data transmitted by the radio is delayed with respect to its receipt at the serial port by the receive to transmit switching time, if the*
*radio baud rate and serial port baud rate and both data formats are the same this delay remains constant throughout the transmission. At the higher baud rates this delay is generally greater than the length of two characters and so the procedure to stop transmission is started as soon as the last character has been sent, at the lower baud rates however it is possible that the time thold is extended while the radio waits for the two character timeout to expire, this can also happen if data characters are not loaded back to back into the serial port.*

## 7.8 OPERATING MODES

### 7.8.1 Transparent Mode
In this mode, the radio has no knowledge of the data it is transmitting, data is simply transmitted and received under hardware control with the option of RTS control or initiation of transmit after receiving serial data, with CTS providing an optional flow control. This configuration is useful when expanding older systems where the radios must be compatible with other manufacturers equipment.

### 7.8.2 Protocol Specific Mode

The radio recognises a complete frame and only transmits and receives data conforming to that format. No addressing of radios or routing of data is performed. Protocols such as MODBUS & DNP3 can be supported in this way.

### 7.8.3 Routing Mode

The radios recognise a protocol specific frame and the address to which the frame is to be sent. Routing information must be stored in each radio for each destination address that requires the use of repeaters or store & forward nodes. Any radio in the system can operate as a repeater/store & forward node. The radio does not perform any acknowledgement or retries. Any protocol using a fixed address field such as MODBUS, RFT ROUTING can be supported.

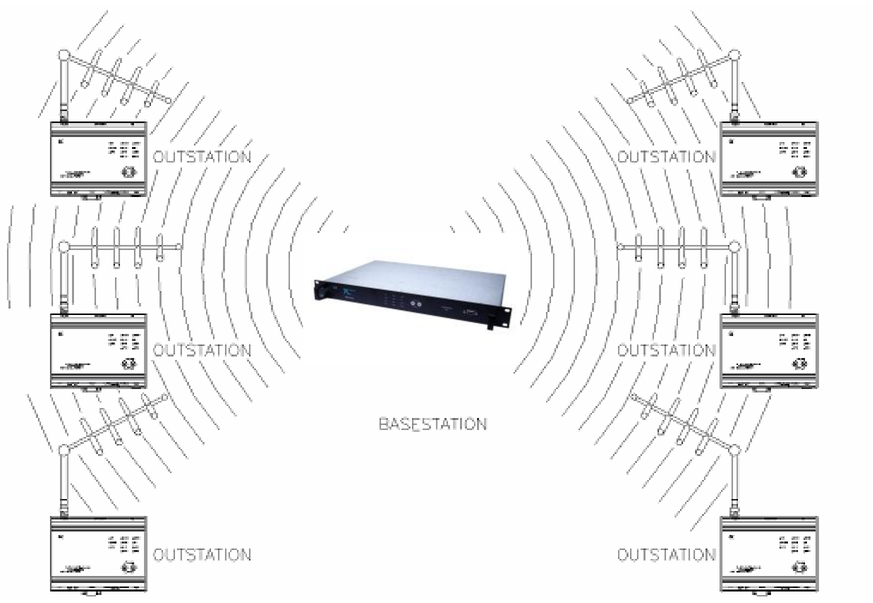
## 7.9 APPLICATIONS

### 7.9.1 Point-to-Point Link

In the simplest of form of operation the XRT9000 can be used as a point to point link where data is simply and quickly transferred from one location to another.
In this mode the XRT9000 can either operate transparently with data applied to the serial port or with RTS & CTS as a flow control.

### 7.9.2 Point-to-Multipoint (Scanning Telemetry Systems)

The typical scanning telemetry system consists of a base station polling multiple outstations. For greater data collection speeds the base station is normally operated in a full duplex mode with the transmitter permanently keyed, this eliminates the TX rise time and will keep the outstations modems synchronised so little or no pre-amble (lead-in time) is required. Matching DIN rail mountable remote radios from the ART series and the SRT series are available for use with the XRT9000.




### 7.9.3 Repeater / Store & Forward Operation

Once the system ceases to be point to point or point to multi-point because of range or terrain, different approaches have to be taken to suit individual applications. Some of these will involve the routing of data via “Repeater” or “Store & Forward” nodes, which are both outlined below. The XRT9000 series supports up to six repeaters within one link, although the more repeaters used, the greater the signal strength has to be at each receiver, as there will be some accumulative degradation over the whole link.

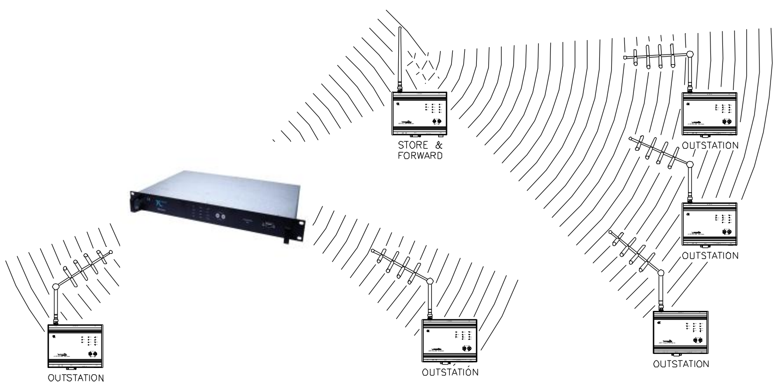
#### 7.9.3.1 Single Frequency Simplex Store & Forward Operation

For systems using single frequency simplex channels, Store & Forward (S&F) where the incoming message is stored and then re-transmitted is the only practical solution.
The incoming message is received by the S&F node and the address is checked against a list held in the S&F node's memory. If the address on the incoming message matches one on the radios internal routing list, the MPU will key up the transmitter and pass the message on.
In a relatively simple S&F forward operation with only one repeater stage the address can be the final destination address. So for a signal to go from A> C via repeater B, the address header would be C. Repeater B would start to receive the message from A and would check the address C against the stored routing table. If it finds a match, the transmitter will pass on the message.

In a more complex system with multiple repeaters, A> B> C> D the address can again be the final destination D and first repeater B will check the address and forward it on to the 2nd repeater C which will in turn pass it on to D and so on.

Depending on the application & software, all or some of the messages may be forwarded.

For simple systems this method can produce a satisfactory solution as all the data the repeater receives will either be for the local site via the RS232 port or for onward transmission.




A typical single unit "Store & Forward" application

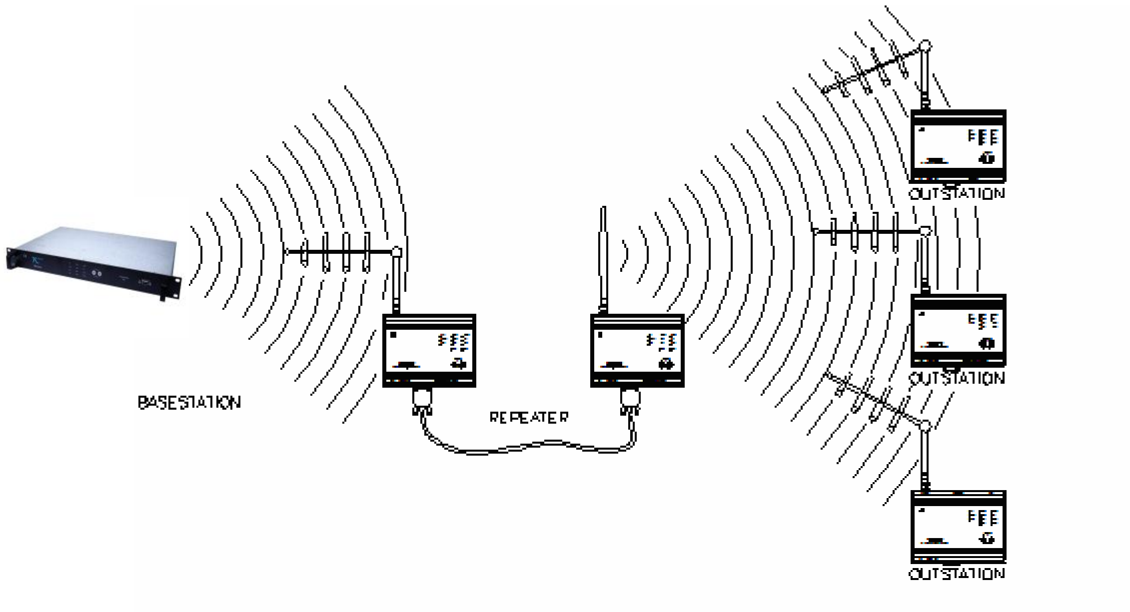
#### 7.9.3.2 Multiple Frequency Simplex Store & Forward/Repeater Operation

If the outgoing message channel at the S&F node is different from the incoming message channel, it is possible to receive the message, store it, change frequency and re-transmit it. The S&F node will then wait for a reply on the new channel and store it, change to the other channel and return the reply. It is obvious that there can be various timing problems with this set-up and a lot more time will be required, so a system supporting this mode of operation would be inherently slow. Further more, as there would have to be a default state for S&F node, calls could only be initiated from one direction. Hence, we do not support this mode of operation.

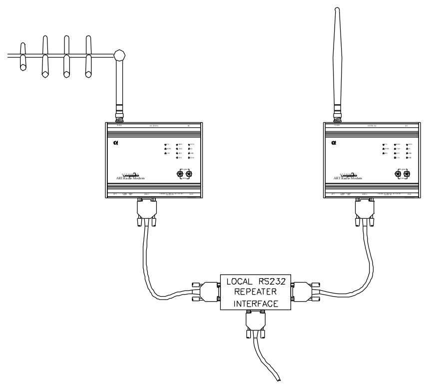
A better solution is the use of two units connected together via a S&F cable. When one unit receives the incoming signal, it buffers the message, turns on the other unit's transmitter and commences the transmission. The same applies in the opposite direction. There will be a time delay with this set-up, as the receiver has to detect the carrier and then turn on the other unit's transmitter. The advantages are; the receivers in both directions are always active and so either direction may initiate a call, and different antennas for each radio can be used to suit different applications and provide additional isolation.

#### 7.9.3.3 Dual Frequency Repeater Node

A repeater will have split receiver & transmitter frequencies with enough separation to enable simultaneous transmitter and receiver operation via two radios connected to two separate antennas, or to a single antenna via a duplexer.
The repeater will have same frequencies as the base and outstations, but reversed.
A signal received by one receiver at a repeater site will trigger the transmitter in the other unit and data will be passed on.




A Typical two unit "Store & Forward"/Repeater application




Two unit "Store & Forward"/Repeater with local RS232 connection

#### 7.9.3.4 Reporting by Exception:

Store & Forward forms the basis for a routing network, where messages can start from any point in the systems, such a system if often known as "reporting by exception", where a change in parameters at a location (Node) is detected and the change is sent to the monitoring centre via preset or dynamic routing.

# 8 PROTOCOLS

## 8.1 STORE & FORWARD BASED ON CLIENT PROTOCOL.

A Store and Forward configuration can re-transmit all traffic it receives and in some applications, where there may be only one repeater serving many outstations, this may be required. However, to conserve valuable air time and avoid the possibility of collisions due to coverage overlaps with other repeaters transmitting at the same time, normally only messages that require forwarding by specific repeaters are re-transmitted.
This is achieved by stripping out the addresses of incoming messages, comparing the address with the list of outstation addresses stored in the unit and only forwarding on those that match. However, this format requires knowledge of the client's message structure and where the address in the message can be found.
There is normally local communication at the store and forward site, via the RS232 port.
We have written various store & forward drivers to cope with a number of client specific message formats and are always happy to write new drivers as and when required. Further information is available from the sales office.

## 8.2 HAYES AT MODE

The XRT9000 series radios can be programmed to run a Hayes AT command set that allows dial up networking on a radio system with support for low power operation. Any radios in the system can be used as relays, and as routes are defined in the dial up command there is no need to store routing tables in the radios themselves. Remote programming is also enabled whenever Hayes At mode is enabled.

When "HAYES AT" mode is enabled in the "EDIT MODEM/INTERFACE" menu of the setup programme the "NETWORK ID" and "RADIO ADDRESS" fields must be filled out such that every radio in a system has the same network id, but a different radio address. Notes should be kept detailing the installation of radios and their addresses. It is also possible to set addresses by accessing the Hayes type "S" registers from the host equipment, this allows all radios to have the same setup and so to be interchangeable in the field.

### 8.2.1 AT Command Summary

Commands are not case sensitive, when entered from a keyboard the backspace key may be used to delete errors. Every command except the escape code (default +++) must begin with the AT prefix and be terminated with a carriage return. The maximum command line length is 40 characters. More than one command may be entered on a line and spaces may be entered between commands, only the first command on a line should be prefixed by "AT".

The following commands are supported, brackets indicate an optional parameter or character, the S registers referred to are used to store parameters relevant to this mode of operation, they may be also accessed using the PC setup programme:

AT — Attention. Required command prefix, except with the escape code (default +++). Use alone to test for the OK result code.

D (rrr,rrr..)ddd — Dial. The optional relay addresses (rrr) and the destination address (ddd) should be entered as three digit decimal values in the range 001 to 255. Relay addresses must be entered in the order they will be encountered with the first relay address appearing immediately after the D character. Once entered the radio will attempt to establish a link through the relays with the destination.

For example;

ATD003 — Dial out directly to radio number 3

ATD001002003 Dial out to radio number 3, using radios 1 and 2 as relays.

N.B. there are two special functions of the dial up command, these are effected by preceding the route with 8 or 9, both of these functions are used by diagnostics software and should not be used by the application.

O Switch from command mode to transparent mode. Once transparent mode is entered no more AT commands will be interpreted, transparent mode is terminated with the escape code.

H Hang up. The hang up command disconnects a link and should be issued to the radio through which the link was originally established using the dial command. If transparent mode has been entered the escape code must first be issued to return to command mode. Note that a faster disconnect is possible using the DTR hardware handshake line.

&V View the settings of all of the S registers and also the error code reporting mode. The values in the S registers are loaded from Eeprom on power up or following a reset command, they may be subsequently modified using other commands, issuing "AT&V" views the active values held in volatile memory, not those stored in Eeprom.

&W Write the active S register values to Eeprom. This causes the S register values to be preserved following loss of power or a reset.

Z Software reset. The radio is re-initialised and the S registers are overwritten with the values stored in Eeprom.

Sr? Display the value of S register r. For example issuing "ATS23?" displays the value of S register 23. The value r can be in the range 0 to 31.

Sr=n Sets the value of S register r to the decimal value n. For example issuing the command "ATS23=34" sets S register 23 to 34 decimal. The value n may be in the range 0 to 255. The value r may be in the range 0 to 31, however not all locations are used, and some are read only. Attempting to write to an S register that is not used or that is read only causes the error result code to be returned.

V(n) Sets verbal or numeric result codes. Result codes are returned for most AT commands and can be numeric (suitable for automated operation) or verbal (suited for keyboard operation), the value of n determines the mode, if 0 numeric mode is set, if 1 verbal mode is set, omission of the value n causes numeric mode to be set. For example issuing ATV1 sets verbal mode. Note that storing the active configuration using the AT&W command does not store verbal/numeric mode, verbal mode is always restored at power up or reset.

Q(n) Enables/disables result codes according to the value n. A value of 0 enables codes, a value of 1 disables them, omission of n enables codes. Note that storing the active configuration using the AT&W command does not store this status, codes are always enabled at power up or reset.

I(0) Information. The zero suffix may be omitted. This command returns a text string giving information about the radio and its firmware version.

An example text exchange is given below:

| TEXT SENT | TEXT RECEIVED | |
|---|---|---|
| ATS23=2 V Q | OK | The radio address is set to 2 and verbal result codes are enabled. |
| ATD005004 | NO ANSWER 005 | A dial out to radio 4 via radio 5 was attempted but radio 5 did not respond. |
| ATD006004 | CONNECT | A dial out to radio 4 via radio 6 was attempted and the connection was successful. |
| ATO | | Transparent mode was entered, no result code is returned for this command. |
| Hello Fred | Hello Bill | Fred and Bill exchange data. This data can be text or binary information, the link is transparent to all except the escape code. |
| +++ | | The escape code was entered, no response is given to the code. |
| ATH | OK | The link was disconnected. |
| ABC | ERROR | The command was not understood as it is not valid. |

### 8.2.2 Serial Port Handshaking With Hayes AT Mode

The DTR, DSR, DCD,CTS and RI lines are all used in Hayes mode, RTS can also be used as an option. DTR is used to tell the radio that the connected host is awake and is a command to the radio to exit power save mode (if enabled), DSR provides confirmation of this action to the host. DCD is used to indicate to the host that a link has been set up and that a transparent connection to the other end exists. CTS is used to provide flow control, RI indicates an incoming call, it may be used as an outstation wake up signal. RTS can optionally be used to hold the transmitter on while a message is loaded, this is required to prevent messages being broken up if delays occur in serial input, this can cause loss of parts of messages if relays are used.

### 8.2.3 Power Saving in Hayes AT Mode

The radio can be operated with or without power save enabled, typical applications might utilise power save for some outstation radios, whilst relay stations would operate without power save, this minimises call set up times. The power save duty cycle can be modified to provide the best optimum between call set up time and power saving.

The power save period is set in the main edit menu of the set up programme under the heading "PSAVE ON TIME". To enable power save the "RADIO ADDRESS" must be greater than or equal to "MIN PWR SAVE ADDRESS" and less than or equal to "MAX PWR SAVE ADDRESS". This scheme is used so that a radio knows whether it has to issue "wake up" calls when dialling another radio.

As an example setting "PSAVE ON TIME" to 5 seconds causes the radio to power down for 5 seconds, the receiver is then switched on and a check is made for the presence of a radio carrier, if none is seen the radio powers down again. If a carrier is detected the radio waits for a period long enough to identify an incoming "wake up" signal, this period is calculated by the radio according to the programmed radio signal baud rate. If no wake up call is seen the radio powers down again, if so the radio stays awake allowing a link to be established, it returns to the cyclic power save mode when the link is cleared down.

Note that if "DTR SHUTDOWN" is enabled a radio remains completely shut down while DTR is inactive, it will not wake up according to the power save timer to see if any incoming messages are present. This mode should therefore only be used in conjunction with real time message scheduling.

### 8.2.4 Programming Precaution

When the master station or relay radios send an outward bound message, the address of the radio to which the message is being sent is checked against the min and max power save addresses, if a power saved radio is indicated a cyclic wake up message is sent for the period indicated by the programmed power save on time. If a power saved radio is not indicated a quick wake up message is sent immediately. These parameters along with some others are also used to calculate a timeout time in the event that no reply is received. It is therefore essential that all radios in a system are programmed with the same parameters even if not power saved, otherwise communications will fail.

### 8.2.5 Call Set-Up Procedure

Any radio in the network may be asked by its host to set up a data link to another radio, this link may involve forwarding through intermediate radios. The radio must then set up that link and inform the host of success or failure, if successful the radio can then be asked to enter a transparent mode where data applied is simply passed across the network to and from the final destination. Transparent mode will then be terminated by the host and the radio will then terminate the link.

A radio will spend most of its time idling, if power save is enabled its processor will be shut down conserving power, the host can wake up the radio by asserting DTR, when awake the radio will respond by asserting DSR. The radio will now be in a control mode where it can respond to Hayes AT commands to set up a link, once the link is established the host is informed by the returned AT error code that it may ask the radio to enter transparent mode, when this is done DCD is raised and the host may communicate over the network. When it has finished it may terminate transparent mode either by using the AT escape code and then asking the radio to hang the link, or by dropping DTR, the radio will then inform other elements of the link that the transaction is complete, and drop DCD. If DTR is not active the radio will then return to sleep. If the link fails in transparent mode the radio must inform its host, since it is in transparent mode it can only do this by dropping DCD. The host should then terminate in the usual manner, and if necessary attempt the procedure again.

If "RTS/CTS HANDSHAKE" is enabled RTS is only needed during transparent mode, the transmitter will be keyed as long as RTS is asserted and message data can be loaded, CTS provides flow control. RTS/CTS operation in this mode is identical to that when no interface protocol is selected. It is not necessary to operate RTS in command mode when issuing AT commands.

If a radio receives a request to set up a link with itself as the destination it will raise RI to wake up its host, if auto answer is disabled ("AUTO ANSWER TIME"=0), it will wait for the "HOST INACTIVITY TIME" for the host to accept the call by raising DTR and issuing an ATO command, DSR will be raised in immediate response to DTR. If auto answer is enabled the radio will wait for the number of seconds programmed as the "AUTO ANSWER TIME", it will then enter transparent mode automatically but only if DTR has been raised. In either scenario DCD is raised as soon as transparent mode is entered and the calling radio is informed that the link is valid. The link will normally be terminated by the calling party, the radio will inform its host that this has happened by dropping DCD, the host should then use the AT escape code to terminate transparent mode or drop DTR. If DTR is not active DSR will be dropped and the radio will return to sleep.

Note that if DTR is dropped before a dial up command has been completed the link members will be left in an undefined state waiting to time out. Also if the dialling radio is power saved it will return to sleep before completing transmission of the AT error code to the host resulting in corrupt serial data. It is therefore recommended that DTR should not be dropped until commands have been completed and the appropriate error codes returned. The operation of the hardware handshakes lines can be summarised as follows:

DTR when raised is a signal to the radio to wake up and enter command mode. Dropping DTR cancels all operations and returns the radio to idle.

DSR when raised provides acknowledgement that the radio is awake, or when dropped that the radio is entering idle.

DCD when raised is an indication that a link has been established and that transparent mode is active, it is dropped when the link fails or is terminated.

RI when raised is an indication that an incoming call is being received.

CTS indicates that there is space in the serial input buffer.

RTS is optionally used to key the transmitter in transparent mode.

### 8.2.6 Radio Routing

Routing is determined by the dial up command used by the calling host. Radios will pass on route information to all members of a link at the point of call set up. When a radio calls another radio either because its host has requested a dial up or because it has been told by another radio that it is to be part of a link, it first sends a wake up request to the next radio in the route and waits for a reply, when this is received the route information is sent, no reply is required to this message, the next message expected is a link fail or link established message originating from the final destination radio. When received the link established message is forwarded on to the original calling radio. If a radio fails to respond to the wake up signal the radio calling it will return the address of the failed radio in the link fail message, a final destination radio may also reply with a message indicating that the destination host did not respond to the wake up procedure. This data is returned to the host by appending the "NO ANSWER" error message with the failed address in ASCII numerals or the message "NO PICK UP". If no link failed/established message is received "NO ANSWER" is returned on its own.

### 8.2.7 Implemented S Registers

The S register values can also be programmed using the A4P setup programme, the implemented registers are listed by function in the "EDIT MODEM/INTERFACE" menu.

| | | |
|---|---|---|
| S0 | AUTO ANSWER | Sets the number of seconds to wait after raising RI before entering transparent mode or if zero waits for the host to respond with an ATO command (up to the time set by S21). |
| S1 | Not implemented. | |
| S2 | ESCAPE CHARACTER | Sets the value used for the 3 character escape code. |
| S3-11 | Not implemented. | |
| S12 | GUARD TIME | Sets the time in 20ms units required to separate the escape code sequence from other data. |
| S13 | NETWORD ID LSB | Both bytes are transmitted and checked |
| S14 | NETWORK ID MSB | as part of every radio message. |

| | | |
|---|---|---|
| S15 | MIN POWER SAVE ADDRESS | All radios within the range max to min |
| S16 | MAX POWER SAVED ADDRESS | inclusive will operate in power saved mode Any comms with destination addresses in this range will start with a long wake up message. |

S17 RADIO SIGNAL BAUD AND FORMAT (read only register)

| | |
|---|---|
| Bit 0-2 | baud rate (0=150, 2=600, … 6=9600) |
| Bit 3 | 1=Asynchronous mode, 0=Synchronous mode |
| Bit 4 | 1=Parity Enabled |
| Bit 5 | 1=Odd parity, 0=Even Parity |
| Bit 6 | 1=7 bit data, 0=8 bit data |
| Bit 7 | 1=2 stop bits, 0=1 stop bit |

This register is read by some of the diagnostic programmes available in order to determine message times and hence timeouts.

| | | |
|---|---|---|
| S18 | HOST INACTIVITY TIME | The time for which a radio will wait for its host to wake up after raising RI if auto answer is disabled. |

S19-22 Not implemented.

S23 RADIO ADDRESS

S24-31 Not implemented

## 8.3 MODBUS

### 8.3.1 Setting Up MODBUS Operation

The XRT9000 can be programmed to transport “MODBUS ASCII” or “MODBUS RTU” format messages in single master systems. These options are selected as the “INTERFACE PROTOCOL” in the “EDIT MODE/INTERFACE” menu. It is not necessary for all radios to run the same Modbus interface, “MODBUS ASCII” and “MODBUS RTU” modes can be mixed within a system. Remote programming is always enabled when either Modbus interface is enabled.

When Modbus modes are enabled the “NETWORK ID” and “RADIO ADDRESS” fields must be filled out such that every radio in a system has the same network id, but a different radio address. Notes should be kept detailing the installation of radios and their addresses.

When transporting Modbus messages the master station radio must be programmed with a routing table, this is also accessed in the “EDIT MODEM/INTERFACE” menu by setting “ROUTING TABLE” to “ON” and selecting “EDIT ROUTING TABLE”. This selection leads to several pages of Modbus addresses, the route by which every Modbus address is reached must then be entered, for example if the Modbus device with address 37 is physically connected to the radio with radio address 23, and radio 23 is accessed from the base station via relay radios 4 and 19, then the field entitled “MBUS 37” should be loaded with the route “4,19,23”. If the Modbus devices with Modbus addresses 65 and 93 are physically connected to radio 45 and no relays are required then the fields entitled “MBUS 65” and “MBUS 93” should both be loaded with “45”.

If no routing table is loaded or a Modbus address cannot be found in the routing table the radio assumes that the destination radio address is the same as the Modbus address and that no relays are required. This can be taken advantage of in simple schemes where no more than one Modbus device is connected to any one radio.

### 8.3.2 MODBUS Operation

Operation in Modbus modes relies on the master/slave poll/reply nature of Modbus. The set up of the radios does not differentiate between a master and slave, the only difference in practice would be that the master station radio will be loaded with a routing table. There is no restriction on the number of masters in a system, but they should all be loaded with routing tables.

When a poll is initiated at a master station radio the destination Modbus address in the Modbus message is looked up in the routing table to determine the addresses of the radio(s) required to complete the link, the message is then sent and all the radios expect to send a reply back the same way. Once this reply has been sent the radios are all ready to start another poll/reply sequence.

If a radio is specified as a relay in a link any connected Modbus devices will not be aware of comms that take place as no activity occurs on the serial port in this state. This may cause problems however if more than one master exists in a system as a radio that is being used as a link in a relay is not available to transmit messages.

### 8.3.3 Power-Save Operation With MODBUS

When Modbus modes are enabled in the configuration programme two further fields appear entitled “MIN PWR SAVE ADDRESS” and “MAX PWR SAVE ADDRESS”, if power save operation is not required set both these fields to zero.

If power save operation is required it is enabled by setting the “RADIO ADDRESS” to a value greater or equal to “MIN PWR SAVE ADDRESS” and less than or equal to “MAX PWR SAVE ADDRESS”. The radio will then enter low power standby mode for the time programmed in the “PSAVE ON TIME” field in the main edit menu, it will then wake up and check for an incoming signal, if none is present it will return to sleep and repeat the cycle. If a signal is detected the radio will stay awake until a reply to the outward bound message has been returned.

When the master station or relay radios send an outward bound message, the address of the radio to which the message is being sent is checked against the min and max power save addresses, if a power saved radio is indicated a cyclic wake up message is sent for the period indicated by the programmed power save on time before the actual data message is sent, if a power saved radio is not indicated the data message is sent immediately. These parameters along with some others are also used to calculate a timeout time in the event that no reply is received. It is therefore essential that all radios in a system are programmed with the same parameters even if not power saved, otherwise communications will fail.

Note that if “DTR SHUTDOWN” is enabled a radio remains completely shut down while DTR is inactive, it will not wake up according to the power save timer to see if any incoming messages are present. This mode should therefore only be used in conjunction with real time message scheduling.

### 8.3.4 Serial Port Handshaking With MODBUS

When Modbus modes are enabled the RS232 port lines DTR, DSR and RI, can be used to assist in power saving the host Modbus device. The RTS and CTS lines are not used and the “RTS/CTS HANDSHAKE” option in the “EDIT MODEM/INTERFACE” menu of the A4P programme should be set to “OFF”. The RI (ring indicator) line is asserted when a radio detects an incoming message, it can be used to wake up a Modbus slave device, when the Modbus slave is ready to accept data it should assert DTR, DSR will be asserted in response and the received message will be output to the Modbus device. The “HOST INACTIVITY TIME” field in the set up programme defines a time limit for the Modbus device to assert DTR in response to RI, if this time limit is exceeded RI is dropped and the radio sends back a reply indicating the destination device failed to respond and the link is cancelled. This time is also used to define the time limit for the Modbus device to reply to the incoming message, if the time limit is not exceeded the reply is sent back to the master station and RI is dropped. The Modbus slave may then release DTR and return to power save mode. Note that as long as DTR is asserted the radio will not return to its power save mode (if enabled in the setup programme). DSR will remain asserted in this case.

The master station can also control the power saving of its radio using DTR, the radio will operate in power save mode as long as DTR is not active, asserting DTR wakes the radio, DSR is asserted in return to indicate that the radio is awake and ready to accept data.

If use of the handshake lines is not required DTR should be connected either to a voltage of +3.5 to +15V such that sleep mode is never allowed or at slave sites it can be connected to RI so that the radio stays awake as long as RI is asserted.

### 8.3.5 Timeouts in MODBUS Modes

When a transmission from a master station radio is made in Modbus mode the radio will calculate a timeout for a reply, this calculation is based on many configuration parameters including the radio baud rate, lead in delay, host inactivity time, maximum message length, power save timing etc. If power saving is enabled and the baud rate is low this time can be large (the calculation limits the result to a maximum of 4.25 minutes. To reduce the possibility of “hung” radios the destination radio will send a link closing message if the destination Modbus slave does not reply. This link closing message is only used by the radios to close the link, it is not passed to the Modbus master.

If the Modbus master itself times out before the radio link does, it can send another poll, radios along the link will cancel the previous route and set up the new one. The exception to this is the previous destination radio if it is still trying to wake up its Modbus slave, it will ignore the new message and try to download its original message when the slave awakes, a conflict will then arise if a reply is sent. To avoid this situation the Modbus master timeout time should allow the maximum “HOST INACTIVITY TIME” to expire plus the time required to get a message and its reply through the link.

## 8.4 RFT ROUTING PROTOCOL

### 8.4.1 Setting Up RFT Routing Operation

The XRT9000 can be programmed to route non-specific protocol messages in single master systems using “RFT ROUTING” mode. This mode supports relay messaging. This option is selected as the “INTERFACE PROTOCOL” in the “EDIT MODEM/INTERFACE” menu. Remote programming is always enabled when this mode is enabled.

In describing operation the address contained in the host system message will be referred to as the “protocol address” and address programmed in the radio under the “RADIO ADDRESS” field in the setup program will be referred to as the “radio address”.

RFT Routing mode is controlled at the master station by picking out an 8 bit protocol address field in the message to be sent, this address is then looked up in the routing table stored in the master station radio. The routing table can contain the radio address (as programmed in the RADIO ADDRESS field in the setup program) of a single radio connected to the required destination device or a list of relay radio addresses plus the destination radio address. The message is then transmitted from the base station radio as a packet with the routing information prefixed to it. The message is then relayed through any relay radios specified until it reaches the destination radio where it is output from the serial port in its original form with the packet information removed. During this process each radio considers itself to be part of an established link. A reply is then expected, however the outstation radios are not programmed with routing tables, a reply issued is assumed to be destined to the master station. The address in the protocol message is therefore not checked and the reply is simply sent back down the established link to the master station radio where it is output from the serial port. As the reply is passed back the link members no longer consider themselves to be part of an established link and return to idle.

Note that there is no differentiation in operating mode between a relay radio and an outstation radio, if an outstation radio is specified as a relay in a link any device connected to the serial port will be unaware of relay communications taking place.

The packet used to transfer protocol messages specifies the route to be taken and also the current stage in the route, it is therefore of no concern if radios further down a relay link "hear" the message before they are expected to repeat it, they will ignore the message until specifically requested to repeat it.

The position of the address in the protocol field is specified using the "ADDRESS OFFSET" parameter in the setup programme. A setting of 0 specifies zero offset, i.e. the address is the first byte in the message, an offset of 6 specifies the 7th message byte and so on. 16 bit addressing or more is not supported as a maximum of only 256 destinations can be supported by the routing table. If the protocol message format does use 16 bit addressing specify the offset for the least significant byte and try to ensure that no two devices use the same l.s.b. in their address.

In order to determine the position of the address in a protocol message the radio has to know where the message starts and ends, this can be done in one of two ways: If the RTS/CTS HANDSHAKE option is turned on RTS should be activated before commencing a message, CTS will be activated in response and the message may be loaded, the first character received after CTS becomes active is considered to be the start of the message. Transmission will start as soon as enough characters have been loaded for the protocol address to be extracted and the route determined from the routing table. Transmission continues until RTS is de-activated, CTS will drop when transmission is complete. CTS may also drop if the serial input buffer becomes more than ¾ full to implement flow control, if this happens RTS should be kept active until CTS is re-activated, more characters may then be loaded or RTS may be dropped.

If the RTS/CTS HANDSHAKE option is turned off, the radio relies on gaps in the serial data to determine the start and end of messages. A gap equivalent to two character periods at the serial port baud rate is treated as a message end. The first character received after such a gap is treated as the first character of the next message.

When RFT ROUTING mode is enabled the "NETWORK ID" and "RADIO ADDRESS" fields must be filled out such that every radio in a system has the same network id, but a different radio address. Notes should be kept detailing the installation of radios and their addresses.

The master station radio must be programmed with a routing table, this is accessed in the "EDIT MODEM/INTERFACE" menu by setting "ROUTING TABLE" to "ON" and selecting "EDIT ROUTING TABLE". This selection leads to several pages of protocol addresses, the route by which every protocol address is reached must then be entered, for example if the device with protocol address 37 is physically connected to the radio with radio address 23, and radio 23 is accessed from the base station via relay radios 4 and 19, then the field entitled "ADDR 37" should be loaded with the route "4,19,23". If the devices with protocol addresses 65 and 93 are physically connected to radio 45 and no relays are required then the fields entitled "ADDR 65" and "ADDR 93" should both be loaded with "45".

If no routing table is loaded or a protocol address cannot be found in the routing table the radio assumes that the destination radio address is the same as the protocol address and that no relays are required. This can be taken advantage of in simple schemes where no more than one device is connected to any one radio.

### 8.4.2 Power-Save Operation With RFT Routing

When RFT ROUTING mode is enabled in the configuration programme two further fields appear entitled "MIN PWR SAVE ADDRESS" and "MAX PWR SAVE ADDRESS", if power save operation is not required set both these fields to zero.

If power save operation is required it is enabled by setting the "RADIO ADDRESS" to a value greater or equal to "MIN PWR SAVE ADDRESS" and less than or equal to "MAX PWR SAVE ADDRESS". The radio will then enter low power standby mode for the time programmed in the "PSAVE ON TIME" field in the main edit menu, it will then wake up and check for an incoming signal, if none is present it will return to sleep and repeat the cycle. If a signal is detected the radio will stay awake until a reply to the outward bound message has been returned.

When the master station or relay radios send an outward bound message, the address of the radio to which the message is being sent is checked against the min and max power save addresses, if a power saved radio is indicated a cyclic wake up message is sent for the period indicated by the programmed power save on time before the actual data message is sent, if a power saved radio is not indicated the data message is sent immediately. These parameters along with some others are also used to calculate a timeout time in the event that no reply is received. It is therefore essential that all radios in a system are programmed with the same parameters even if not power saved, otherwise communications will fail.

Note that if "DTR SHUTDOWN" is enabled a radio remains completely shut down while DTR is inactive, it will not wake up according to the power save timer to see if any incoming messages are present. This mode should therefore only be used in conjunction with real time message scheduling.

### 8.4.3 Serial Port Handshaking With RFT Routing

When RFT ROUTING mode is enabled the RS232 port lines DTR, DSR and RI, can be used to assist in power saving the host device. The RTS and CTS lines are optionally used according to the "RTS/CTS HANDSHAKE" option in the "EDIT MODEM/INTERFACE" menu for flow control. The RI (ring indicator) line is asserted when a radio detects an incoming message, it can be used to wake up an outstation slave device, when the slave is ready to accept data it should assert DTR, DSR will be asserted in response and the received message will be output to the device. The "HOST INACTIVITY TIME" field in the set up programme defines a time limit for the device to assert DTR in response to RI, if this time limit is exceeded RI is dropped and the radio sends back a reply indicating the destination device failed to respond and the link is cancelled (this message is not output to the device connected to the master station serial port). This time is also used to define the time limit for the device to reply to the incoming message, if the time limit is not exceeded the reply is sent back to the master station and RI is dropped. The slave may then release DTR and return to power save mode. Note that as long as DTR is asserted the radio will not return to its power save mode (if enabled in the setup programme). DSR will remain asserted in this case.

The master station can also control the power saving of its radio using DTR, the radio will operate in power save mode as long as DTR is not active, asserting DTR wakes the radio, DSR is asserted in return to indicate that the radio is awake and ready to accept data.

If use of the handshake lines is not required DTR should be connected either to a voltage of +3.5 to +15V such that sleep mode is never allowed or at slave sites it can be connected to RI so that the radio stays awake as long as RI is asserted.

### 8.4.4 Timeouts in RFT Routing Mode

When a transmission from a master station radio is made in RFT ROUTING mode the radio will calculate a timeout for a reply, this calculation is based on many configuration parameters including the radio baud rate, lead in delay, host inactivity time, maximum message length, power save timing etc. If power saving is enabled and the baud rate is low this time can be large (the calculation limits the result to a maximum of 4.25 minutes. To reduce the possibility of "hung" radios the destination radio will send a link closing message if the destination slave does not reply. This link closing message is only used by the radios to close the link, it is not passed to the device connected to the master station radio.

If the device connected to the master station radio itself times out before the radio link does, it can send another poll, radios along the link will cancel the previous route and set up the new one. The exception to this is the previous destination radio if it is still trying to wake up its slave, it will ignore the new message and try to download its original message when the slave awakes, a conflict will then arise if a reply is sent. To avoid this situation the master timeout time should allow the maximum "HOST INACTIVITY TIME" to expire plus the time required to get a message and its reply through the link.

# 9 INSTALLATION

## 9.1 INTRODUCTION

With correct installation and configuration, the XRT9000 Series of 19" rack mountable radio base-stations should ensure reliable data communications for many years.

The most important installation points to remember are:

- Safe installation of power supply feeds.
- Suitable choice of mounting position in rack and adequate cooling.
- Suitable antenna system mounted at the correct height & polarisation to achieve the required distance.
- Suitable circulators or branching filters for common antenna operation or shared sites.
- Correct equipment configuration.

## 9.2 POWER SUPPLIES

The XRT9000 is available in a 110/220V AC mains version, a 24V DC version and a 48V DC version.

Care should be taken to ensure that the supplies are connected safely and in accordance with all relevant wiring regulations.

⚠ Note:- Due to the presence of high voltages within the assembly, the unit should be isolated from all power sources before removing any covers. Do not attempt to remove the covers from the internal power supply module, as high stored voltages may be present in this module even when the external power feeds are disconnected.

Although the XRT9000 is internally fused, primary supply feeds should incorporate suitable fuses or circuit breakers to protect the associated wiring in the event of a fault. Recommended ratings are:-

| Supply | Fuse Rating (5W version) | Fuse Rating (10W version) |
|---|---|---|
| 110V AC | 3A | 3A |
| 220V AC | 3A | 3A |
| 24V DC | 5A | 10A |
| 48V DC | 5A | 5A |

In the event that the auxiliary 12V supply feed is used, there is an internal quick-blow fuse in this supply line, 4A in 5W version and 10A in 10W version, but it is recommended that any additional external fuse or circuit breaker used should be rated at not less than 5A for the 5W version and 10A for the 10W version.

⚠ Note:- For safe operation, the equipment casing must be earthed. A suitable earth stud is provided on the rear panel for attachment of a safety earth.

## 9.3 MOUNTING LOCATION

The XRT9000 should be securely mounted using the fixing holes on the front mounting flanges. Care should be taken to ensure adequate ventilation around the unit and to avoid locating the unit next to external heat sources.
To avoid risk of equipment damage, fire or electric shock, do not expose this equipment to rain or significant condensation.

## 9.4 EFFECTIVE RADIATED POWER (ERP)

The Radio Frequency (RF) transmit power allowed can be specified either as the terminated power output from the antenna socket or as the ERP.

The "terminated power into 50 ohms" for the XRT9000 would be the power set by the user with the configuration software. The maximum settings possible are either 5W or 10W depending on the model concerned.

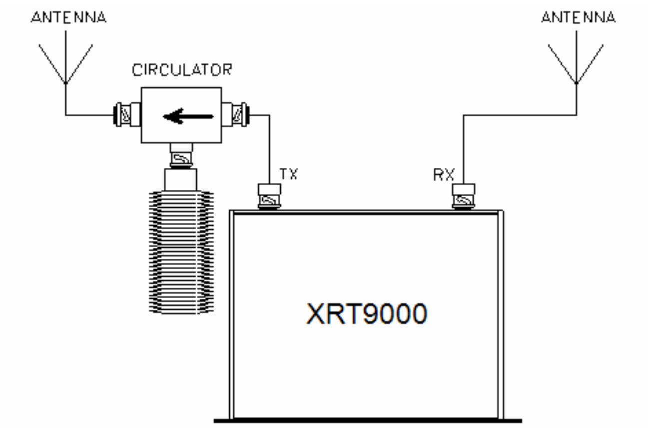
The "ERP" is the actual radiated power, taking into account the gain/loss of the antenna and loss in the feeder. Hence, if we use an aerial with a Gain of 3dB (x2) and assume no loss in the cable, the ERP with a transmitter output of 5W would be 10W.

Care must be taken when setting the power within a regulated system, as licensed RF power is often specified as maximum ERP.

For licensed operation, the XRT9000 should never be operated at a transmit power exceeding that permitted by the licence. For unlicensed operation, the relevant national or international power restrictions for the band concerned should be observed.

## 9.5 CIRCULATORS

For common base station sites (sites with multiple transmitters and receivers) there may be a requirement to minimise the possibility of transmitter intermodulation.
Transmitter intermodulation is caused by very high level signals mixing with the transmitted signal in the final power amplifier. As the final amplifier is normally non linear, mixing products will occur that could cause interference to other users on the site.
The intermodulation rejection level of the XRT9000 on it's own is about 15dB. For ETS300-113 common base standards 40 or 70db is a requirement. This level of intermodulation can easily be achieved with the use of external circulators. Such circulators may already form part of the antenna system on a site or can be obtained from the sales office.




NOTE: A circulator is a directional device and if put in the receivers path would block any incoming signals. Hence, it can only be used in the transmitter path and so the XRT9000 has to be configured with separate Tx and Rx antenna ports for this application. An external duplexer or Tx/Rx switch can be used on the antenna side of circulator if single antenna operation is required.

# 9.6 ANTENNAS & COAXIAL FEEDERS

## 9.6.1 Antennas

Apart from the radio itself, the antenna is probably the most important part of the system. The wrong choice or a bad installation will almost certainly impede the product's performance. Depending on the application either an omni-directional or directional antenna will be required.

## 9.6.2 Types of Antennas

We can offer a complete range of antennas to suit all applications; details of some of the more popular ones are outlined below:

| Antenna Types | Typical Gain | Polarisation | Use |
|---|---|---|---|
| Vertical Whip | 0dB | Vertical | In-house testing and local use |
| Helical | - 3dB | Vertical | |
| End Fed Dipole | 0dB | Vertical | Local Scanner or Multi-point system |
| Folded Dipole | 0dB | Vertical/Horizontal | |
| 6dB Co-linear | +6dB | Vertical | Wide area Scanner |
| 3dB Co-linear | +3dB | Vertical | |
| 12 Element Yagi | +12dB | Vertical/Horizontal | Outstation or point to point link |
| 4 Element Yagi | +8dB | Vertical/Horizontal | |
| Corner Reflector | +10dB | Vertical/Horizontal | Outstations in areas of bad interference or where radiation must be kept to a minimum |

## 9.6.3 Directional Antennas

For point to point communications, a directional Yagi or corner reflector is probably the best type of antenna to use. As directional antennas provide relatively high gain in the forward direction within a limited beamwidth and very good rejection of unwanted signals at the rear. The number of elements and hence the size, will depend on the gain and beam width required. Yagi antennas can be used in the vertical (vertically polarised) or horizontal (Horizontally polarised) but communicating products should be fitted with antennas of the same orientation, if not a loss of signal strength will occur. Vertical and horizontal propagation can be very useful on single or repeater sites where isolation is required between communication paths. Using polarised antennas for each path will increase the isolation which will reduce possible interference.

## 9.6.4 Omni-Directional Antennas

With approximately 360 degree radiation pattern, this type of antenna is ideal for a scanning base-station or where communication to a group of widely dispersed outstations is required.

## 9.6.5 Antenna Mounting

Location: The antenna should be mounted in a clear area, as far away as possible from obstructions such as metal constructions, buildings and foliage.

Height: The XRT9000 operates in the UHF band, which requires near line of sight communication. Hence, for extended ranges the height of the antenna is important.

### 9.6.6 Polarisation

A Yagi or corner reflector antenna can be mounted for vertical or horizontal polarisation. Scanning systems employing a vertically polarised antenna will necessitate the outstation antennas to be of the same orientation. In vertical polarisation the elements are perpendicular to the ground. By selecting a different polarisation from that of an interfering signal, unwanted signals can be reduced by as much as 18dB, however, such systems require detailed planning.

### 9.6.7 Alignment

If a directional antenna is to be used, it will need to be accurately aligned with the distant radio site. A map and compass can be used, but the final adjustment should be performed by measuring the receive signal strength (RSSI) from the scanner, as outlined in the operations section and adjusting the antenna for maximum received signal.

### 9.6.8 Coaxial Feeder Cable

As with the antenna, the use of the wrong coax feeder can seriously affect the performance of the system. Hence, the coax cable should be selected to give a low loss over the distance required. As a rule of thumb, never operate a system with a feeder loss of more than 3dB.

To illustrate the point, a 3dB loss in the feeder will result in a 50% loss in transmitted RF power and a 50% reduction in the received signal strength. Therefore, double the received signal strength will be required for the same bit error rate. Although increasing the RF power will compensate for the loss in transmitted power, there is no effective way to improve the received signal strength.

Coax cable should be installed in accordance with the manufacturers' instructions, with cable runs kept as short as possible. Sharp bends, kinks and cable strain must be avoided at all costs. If long term reliability is required, the cable must be securely mounted to avoid excessive movement and longitudinal strain, due to high winds, rain and snow.

### 9.6.9 Signal Loss Verses Cable Length at 500MHz

| Cable Type | Attenuation Per 100ft | Attenuation per 100M |
|---|---|---|
| RG58 | 13.0dB | 37.0dB |
| RG213 | 6.0dB | 17.5dB |
| LDF2-50 3/8inch Foam Heliax | 2.44dB | 8.0dB |
| LDF4-50 1/2inch Foam Heliax | 1.60dB | 5.26dB |
| LDF5-50 7/8inch Foam Heliax | 0.883dB | 2.9dB |
| LDF6-50 1-1/4inch Foam Heliax | 0.654dB | 2.15dB |
| LDF7-50 1-5/8inch Foam Heliax | 0.547dB | 1.79dB |

### 9.6.10 Coax, Connectors

50 Ohm coax connectors of a good quality should be used, termination must be in accordance with the manufacturer's specification, any special tools required to terminate the connectors must be used. Connectors exposed to the environment should be sealed to prevent the ingress of moisture. If the cable is penetrated by water a high loss will occur and the cable will need to be replaced. Once assembled it is advisable to test the cable and connectors for open and short circuits.

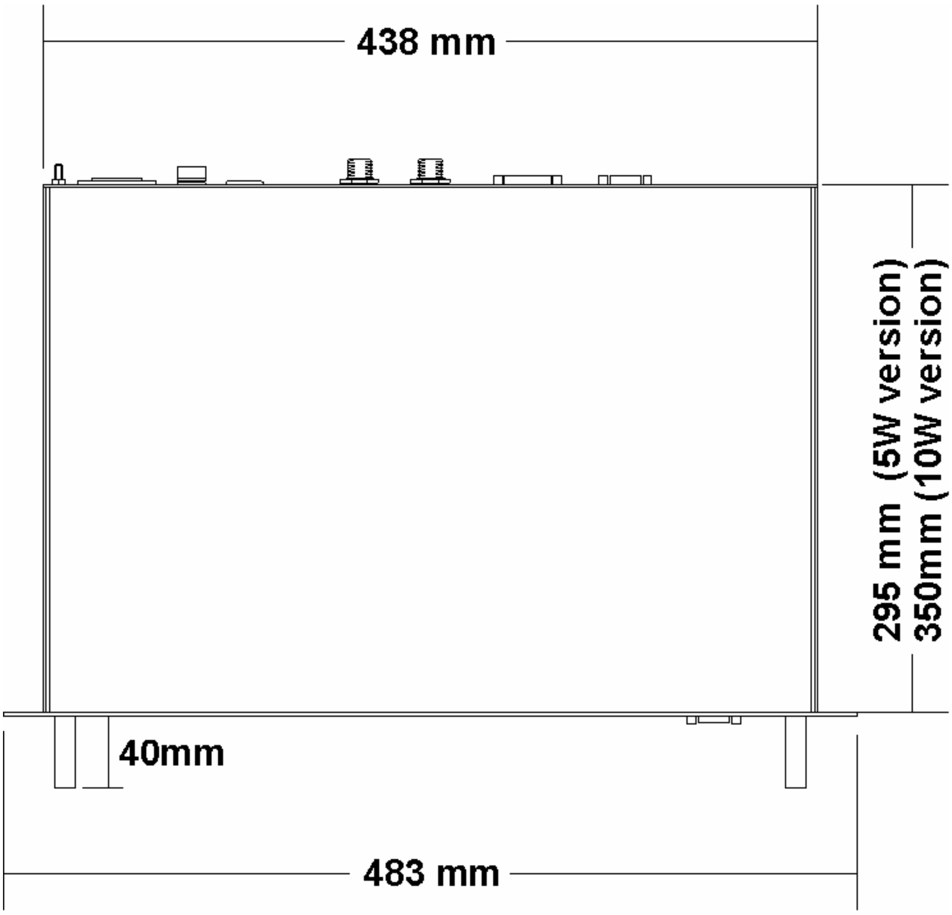
### 9.6.11 VSWR Measurement

Voltage standing wave ratio (VSWR) is the ratio of detected volts from the forward RF power, to the detected volts from the reflected (returned) RF power. This ratio is used to measure the combined coax cable and antenna match. A good match will ensure that most of the RF Power is radiated, whereas a bad match will result in the reflection of a large amount of the power, thereby reducing the transmitter's range. A perfect match will give a 1:1 ratio and bad match will give 2:1 or higher. For guidance, a good system will measure between 1.2:1 and 1.5:1.

### 9.6.12 Lightning Arresters

At high or exposed sites, the use of a lightning arrester is recommended. This in-line device fits between the antenna and the product with an earth strap connected to ground. Should a lightning strike occur, most of the energy should be diverted to ground leaving the equipment with little or no damage. As an option, the XRT9000 is available with in-line surge arrestors fitted instead of the standard N-Type connectors on the rear panel.

## 9.7 XRT9000 DIMENSIONS




The XRT is a 19" rack mounting shelf and is 1U high, i.e. 44.5mm.

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