URT500
RADIO MODEM

SETUP, INSTALLATION, OPERATION & PROGRAMMING MANUAL

CONTENTS

1 INTRODUCTION

1.1 PRODUCTS COVERED

This manual covers the URT500 low current, high performance radio modem designed for data applications in commercial and industrial systems.

The URT500 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 configure, program, install, and operate the products in various applications. Point to point, point to multi-point and network configurations can be accommodated by selecting the appropriate mode.

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

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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

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1.2.4 SAFETY CRITICAL APPLICATIONS

The URT500 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 URT 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 licenses from the local authorities.

2 PRODUCT OVERVIEW

2.1 GENERAL

The state-of-the-art URT500 telemetry radios have been specifically produced for the UK Utility market following significant demand for a product which has both analogue and digital interfaces to allow it to be used in legacy systems having a mixture of internal and external modems.

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 to the receiver threshold.

The URT500 is available with a variety of mounting plates to ensure mechanical compatibility with as broad a range of existing installations as possible.

Although backwardly compatible with a number of other manufacturer's products, the new URT500 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, extremely low power consumption, new Windows 95, 98, 2000 and XP programming software, advanced management features (including over-air re-configuration), and the possibility of future firmware upgrades without the need for expensive hardware replacement.

The URT500 is a derivative of our tried and tested SRT470 & ART400 radio modems and has 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 and to provide an easy upgrade path, from audio to digital, to networked systems. The large flash memory enables future upgrades to be easily implemented in the existing hardware.

The URT500 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.

Through the use of advanced DSP technology, the radios have been designed to have extremely sensitive receivers, combined with exceptionally low power consumption. 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.

2.2 TRANSMITTER

The transmitter frequency can be user programmed anywhere within it's pre-aligned bandwidth, which is sufficiently wide to allow operation on both the old and the new UK MPT1411/VNS2111 bandplans without re-alignment.

The transmit power can be set accurately within the range 50mW to 5W 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 to 12MHz (+ 6MHz from centre frequency), full details are in the technical specification section. This is sufficient to allow operation on both the old and the new UK MPT1411/VNS2111 bandplans without re-alignment.

2.4 MPU CONTROL & INTERFACE BOARD

The Microprocessor (MPU) control & interface board is the heart of the product and at the centre is a 128k flash microprocessor that controls all the interface circuits to the radio modules and external input/outputs. 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 board contains all necessary electronic potentiometers for full remote alignment and control, these settings and other parameters are stored within the MPU's non-volatile EEPROM.

2.5 PROCESSOR FIRMWARE/SOFTWARE

The processor has 128k of flash memory from which the code is executed and internal 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.

2.6 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.

2.7 PROGRAMMING & CONFIGURATION

Apart from internal factory set-up links, all the parameters of the URT500 are PC programmable via the serial 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.
For additional memory space (should it be required) a piggy back memory board with a further 512k is available to download new code to the processor.

2.8 SOFT MODEM:

The URT500 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.

2.9 MODES OF OPERATION & PROTOCOL HANDLING

The basic modes of operation of the radio modem are as follows:

2.9.1 DUMB MODEM

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 receipt of serial data, with CTS providing an optional flow control.
This configuration is useful when expanding older systems where the radios must be compatible with others of a different manufacture.

2.9.2 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.

2.9.3 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.

2.10 ADDITIONAL FEATURES

The URT500 incorporates the following additional features which enhance the usability of the product and assist with the operation and maintenance of systems using the product:-

2.10.1 STATUS LED'S:

The URT Radio Modems have a number of front panel LED's to enable the operator to see at a glance the status of the product and the serial data port.

2.10.2 ANALOGUE RSSI OUTPUT

In addition to the ability to get a reading of the receive signal strength using a connected PC, the URT500 also has a voltage output which is proportional to the signal strength to assist with antenna alignment and network troubleshooting.

2.10.3 TIME-OUT TIMER

The transmitter within the URT500 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.

2.10.4 SQUELCH TAIL ELIMINATOR

Where the presence of a Mute (Squelch) tail may cause problems at the end of a message, a simple packetising option can be enabled to resolve the situation.

2.10.5 POWER-SAVE MODES

The URT500 has both internally controlled and externally controlled power-save modes to reduce overall power consumption to extremely low levels for operation on sites without mains power.

2.10.6 FORWARD ERROR CORRECTION

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

3 SPECIFICATIONS

3.1 TECHNICAL SPECIFICATIONS

3.1.1 GENERAL

Frequency Range:	New and old MPT1411 bands without re-alignment. Other allocations in the range 406 – 512MHz are possible.	
Power Requirements:	12VDC (10V – 15.5DC)	
	Standby:	<75uA
	Receiver on & decoding:	<70mA
	Transmitting:	300mA to 2.1A dependent on Tx power
Number of Channels:	80 sequential or 32 discrete user programmable channels.	
Min. Programmable Channel Step:	6.25kHz	
Channel Spacing:	12.5kHz	
Operating Temp. Stability:	2ppm –30 to +60ºC	
Construction:	Milled aluminium enclosure with EMC shielded high impact polycarbonate end-caps	
Size:	100mm W x 130mm L x 45mm H	
Mounting:	DIN rail, or can be screwed to a flat surface using adaptor plate.	
Weight:	620g	
Connectors:	Main	25-way D-Type Male
	RF	BNC
Led Indicators:	TX, Busy, System, RXD, TXD, RTS, CTS, DCD, DTR	

3.1.2 TRANSMITTER:

RF Output Power:	50mW to 5Watts
Bandwidth:	New and old MPT1411 bands without re-alignment
Duty Cycle	up to 70%
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:	± 2.5kHz
Adj. Channel Power:	>65dB at 12.5kHz
Spurious Emissions:	As per EN 300 113
Rise Time:	≤ 8mS

3.1.3 RECEIVER:

Sensitivity:	0.25uV (-120dBm) for 12dB SINAD de-emphasised 0.355uV (-117dBm) for 12dB SINAD flat
Bandwidth:	New and old MPT1411 band without re-alignment Nominal pre-aligned bandwidth 12MHz.
Spurious Response:	> 80dB
Blocking:	> 90dB relative to 1uV
Intermodulation:	> 70dB
Adjacent Channel:	> 65dB at 12.5KHz
IF Frequencies:	45MHz and 455KHz
Spurious Emissions:	< EN 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. Baud rate programmable between 150bps and 38400bps
Interface:	Selectable RS232 or 5V TTL plus 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, Bell202, up to 1200 baud, 2400 baud FFSK, 4800 baud GMSK, 9600 baud 4 level FSK.
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 4800 baud, less than 1 x 10-3 at –117dBm 9600 baud, less than 1 x 10-3 at –115dBm (FEC on) 9600 baud, less than 1 x 10-3 at –112dBm (FEC off) 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.

3.2 APPROVALS AND LICENSING

The URT500 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
ETS301-489:	The unit meets the required CE specification and carries a CE Mark.

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

4 PRE-PROGRAMMED CHANNEL PLANS

Using the PC configuration software, the URT500 can be programmed with a number of standard channel plans. These currently include all MPT1411 or all MPT1329 channels. Further standard channel plans such as the revised MPT1411/VNS2111 allocations may become available in later releases of the configuration software once full details of the proposed frequencies are available. 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

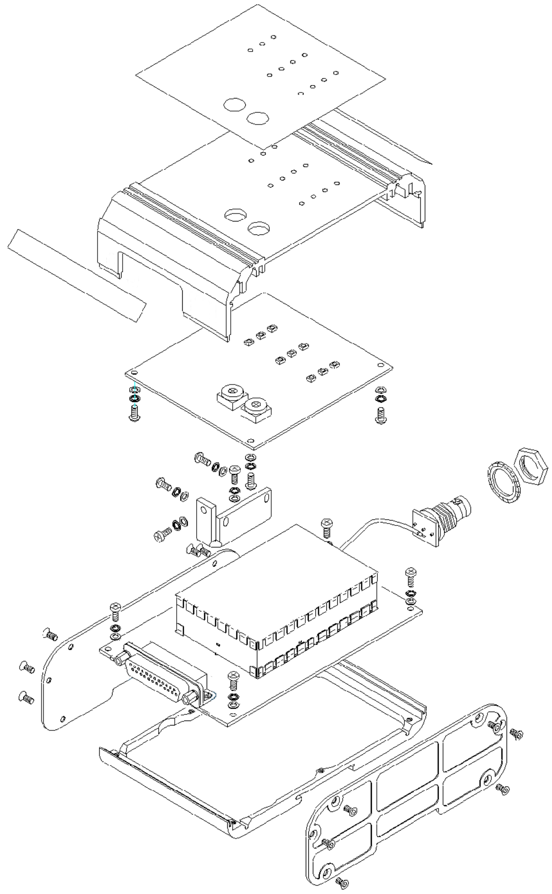
The URT500 can be programmed to operate on the full MPT1329 band of channels with access to channels 26, 27 & 32 denied, in line with MPT1329 band plan.
The radio should be programmed for a maximum power level of 500mW.

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	459.9000 Not Used
34	459.9125
35	459.9250
36	459.9375
37	459.5000 Guard Ch.

5 SET-UP & INTERFACING

5.1 INTERNAL LINKS

The exploded view shows the main components of the radio modem; the milled enclosure, MPU control & interface board, transceiver module and LED board. Access to the internal links requires removal of the screws attaching the end-caps and removal of the covers. The LED board is attached to the top cover and connects to the main board connector JP3.

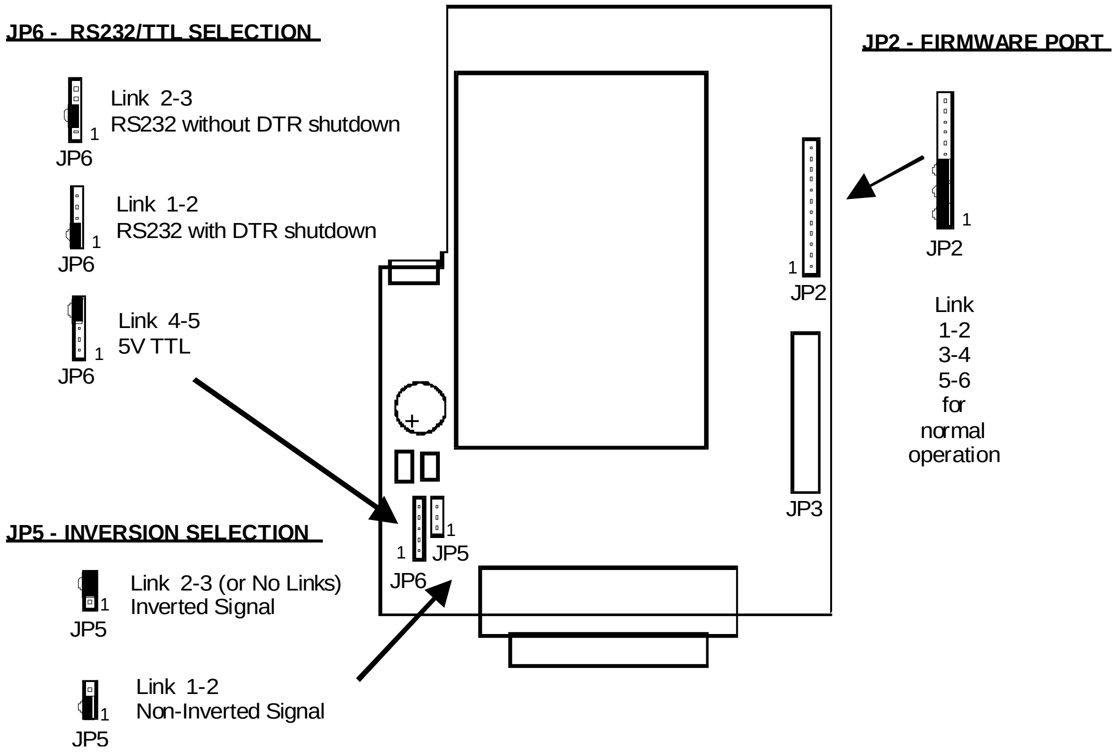


5.1.1 FIRMWARE DOWNLOAD PORT

JP2 is a firmware download port and is used during production to download firmware into the processor's flash memory. Once programmed the 3 jumpers are installed linking 1-2, 3-4 & 5-6 for normal operation. For upgrades the links are removed and new firmware is loaded via JP2 using the appropriate interface hardware.

5.1.2 RS232 & 5VTTL SERIAL INTERFACE

The URT500 serial port can be programmed to operate at speeds from 150 – 38400bps and is used to program the modem, control the modem during testing and for transferring data over the radio link when in operation.
Internal links can be set to provide full RS232 or 5V TTL signal levels, either mode can be run true or inverted. Unless otherwise specified the product is shipped set for "True RS232" operation. Should these parameters need to be changed, the following can be used as a guide.



Note: 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.

5.1.3 RS485 CONNECTION

For RS485 and RS422 operation, an external adaptor is required. Further information is available from the sales office

5.1.4 INTERFACE PORT PIN CONNECTIONS

The URT Series is equipped with a 25 way male D connector for all data, audio, power and auxiliary connections. The pins of this connector are allocated as follows:-

1.	GND:	GROUND
2.	TXD:	Transmit Data
3.	RXD:	Receive Data
4.	RTS:	Request to Send /Tx Enable in Audio Mode
5.	CTS:	Clear to Send
6.	DSR:	Data Set Ready
7.	GND:	GROUND (for Cathode of LED)
8.	DCD:	Data Carrier Detect
9.	GND:	GROUND (0Vdc Input)
10.	PWR:	+12Vdc Input
11.	XMDI:	Audio Input
12.	-	Not Used
13.	-	Not Used
14.	-	Not Used
15.	SPARE:	Do Not Connect This Pin
16.	-	Not Used
17.	RSSI:	Voltage Output in range 0 to +5Vdc
18.	+5V:	+5Vdc Out
19.	TxLED:	Anode line for LED
20.	DTR:	Data Terminal Ready
21.	GND:	GROUND (0Vdc Input)
22.	.PWR:	+12Vdc Input
23.	-	Reserved for PCCEN
24.	XMDO:	Audio Output
25.	GND:	GROUND

In the event of a polarity reversal on the power supply pins, the circuit board is protected by diodes and fuses.

When using an external modem, the transmitter can be keyed up by applying +5Vdc to pin 4 (RTS). Open circuit or 0Vdc on this pin will select receive.

Pin 19 can source 3mA to drive an external low current LED to indicate that the Transmitter is active. The LED should be connected with its anode to pin19 and it’s cathode to Ground.

Pin 23 is reserved for physical compatibility with the CCEN (Channel Change Enable) line on a CMD400, but this feature is not implemented in the URT500.

Note that pre-assembled cables procured from sources other than RF DataTech may be incompatible with the pin usage on the URT500 and may cause damage to the URT500 or any other equipment to which it is connected. It is important to use the correct cables for the radio, both when connecting traffic and when programming.

5.2 SWITCHES

The two front panel BCD switches select channels or, if both are set to zero, program mode is entered. When viewing a URT500 with the aerial connector at the top, 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.

5.3 PROGRAMMING

Apart from the link selectable options, firmware download and RS232/5VTTL selection, all the parameters of the URT500 can be programmed via the serial port using either DOS or Windows based software or over the radio link via the URT's secure "over air programming mode". The individual program can be stored on disc for future use or printed. Full details of all the programmable parameters are covered in the separate programming manual.

5.4 CHANNEL SELECTION

The URT500 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.

5.5 RF POWER

The URT500 transmitter power is adjustable under software control from 50mW to 5 Watts with an accuracy of +/-1dB. There are no internal power adjustment points inside the modem. The configuration/management software provided allows the RF power level to be programmed directly in Watts or milliwatts, either locally or over the air.

5.6 INTERNAL MODEM

The internal modem can operate at speeds between 150 and 9600 baud, at speeds up to 1200 baud FFSK signalling is used with either Bell 202 or V23 mode 2 tone sets. 2400 baud uses a 1200/2400 Hz coherent FFSK tone set, 4800 baud uses GMSK, and 9600 baud uses four level FSK with the programmable option of adding forward error correction at 9600bps.

5.7 FORWARD ERROR CORRECTION

When forward error correction is switched off the radio signal employs a standard asynchronous format using a start bit, 7 or 8 data bits, odd, even or no parity, and 1 or 2 stop bits. If this format is programmed to match the serial port and runs at the same speed there is no overhead, data is transmitted over air at the same speed as it is received at the serial port. The exception to this is a radio baud setting of 9600 baud, where 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%.

Forward error correction (FEC) is a programmable option at speeds of 9600 baud. When forward error correction is switched on, the radio signal changes to a fixed format where 14 bits are used to convey every data byte. The 14 bit words comprise of 8 data bits with 5 CRC bits used to perform error correction, and one flag bit used to differentiate control and data functions in messages. An additional 14 bit frame synchronisation word is sent after every 8 data words. For a serial port data format of 8 bits no parity this represents an increased redundancy of 28% over the 9% redundancy when FEC is disabled. This overhead in the URT effectively reduces the over-air data speed to about 6300bps.

The CRC used in the forward error correction system has been optimised to detect and correct errors in the modulation scheme employed by the 9600 baud encoder. It is aimed at improving performance in weak signal conditions, rather than recovering data in fades or burst error conditions. The latter requires data interleaving and packeting that can result in large frames for small amounts of data, and hence unpredictable message lengths.

The improvement in error rate when using FEC is reduced as the initial error rate gets worse. For example an initial error rate of 1x10-4 is improved by a factor of 2000 to 5x10-7, whereas an initial error rate of 1x10-3 is only improved by a factor of 250 to 4x10-5. In terms of receiver sensitivity the 1x10-6 error rate threshold is moved down by 0.4uV (or 6.4dBm) when FEC is switched on.

5.8 SQUELCH TAIL (DRIBBLE BITS) ELIMINATION

The “EDIT MODEM/INTERFACE” menu of the software set-up programme includes a field entitled “MESSAGE PACKETING”. If this option is turned on radio messages are framed with special control characters, if the “INTERFACE PROTOCOL” option is set to “NONE” only two characters are used, one to identify the start of the message, and one to identify the end. This allows the random characters that sometimes appear at the end of messages (called the squelch tail or dribble bits) to be eliminated. Note that once this option is enabled the radio signal is no longer compatible with other manufacturer’s systems, or with other URT radios in which the option is disabled.

5.9 STATUS LED’S:

The URT has a number of LED’s to enable the operator to see at a glance the status of the product and the serial port:-

RX	RF Carrier Detect/Busy
TX	Transmit
SYS	System
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 in two ways, 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. Alternatively the error can be read by monitoring the serial port using a PC comms program running at 9600 baud, 8 data bits, 1 stop bit and no parity. An "E" is output followed by the error number. Error numbers for both modes are as follows;

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	The programmed R.F. power setting is out of range.

5.10 TIME-OUT-TIMER

The transmitter within the URT500 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 CONSUMPTION

The URT is a very low power product and is ideal for operation from batteries with solar power backup. The information below is intended to help the user decide on the best battery and solar cell size for operation at non powered sites.

5.11.1 TRANSMITTER RF POWER VERSES CURRENT

TX Power	5W	4W	3W	2W	1W	500mW	200mW	100mW	50mW
Max. Current	2.1A	1.8A	1.6A	1.3A	950mA	675mA	500mA	390mA	300mA

5.12 POWER SAVE MODE

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

5.12.1 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: 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.

5.12.2 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.

5.13 "RSSI" RECEIVE SIGNAL STRENGTH INDICATION

The URT500 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 serial port.

In addition to this PC capability, a 0 to 5Vdc voltage proportional to the received signal strength is also available directly on the interface connector.

6 ANALOGUE MODES OF OPERATION

6.1 ANALOGUE CAPABILITY

In addition to the serial data path the URT500 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. It should be noted that the external audio path is AC coupled and so is not suitable for GMSK or multi-level signalling at baud rates above 2400 baud.

6.2 EXTERNAL AUDIO & MODEM INTERFACE

The selection of internal modem or external audio operation is made using the configuration software. If programmed for external audio the signal path can be programmed for flat or a pre/de-emphasised response, for compatibility with older systems. 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 external Rx audio can be programmed for muted or non muted operation in the absence of a carrier.

6.3 KEYING THE TRANSMITTER IN AUDIO MODE

In the external audio mode there are two options for keying the transmitter; first using the dedicated input pin on the interface connector, or secondly by using 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.

6.4 PROGRAMMABLE AUDIO PARAMETERS:

6.4.1 INTERFACE & MODE

The Audio Mode selects the interface and path of the signals within the URT500 and when the 2/4 wire port is used, it should either be set for :

6.4.1.1 Ex Audio-PTT

Selects the 2/4Wire Audio interface and external PTT (TX Enable) and routes the audio via internal level amplifiers to & from the transmitter & receiver modules respectively.

6.4.1.2 Ex Audio-TOX

This is the same as the EX AUDIO-PTT but routes the audio input via a Tone Operated Switch (TOX) which can be set to detect V23 or BELL202 formats. 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.

6.4.2 FFSK TONE SET

In EX AUDIO-TOX the ART can either be set to detect incoming V23 or BELL202 tone sets.

6.4.3 LINE LEVEL

The interface level is normally factory set for –13dBm, but can be adjusted between –20 to +3dB from the CALIBRATE MENU by following the instructions.

6.4.4 AUDIO RESPONSE

This option sets the response of the receiver's and transmitter's audio path to either flat or de-/pre-emphasised. When de-/pre-emphasised is selected a 300Hz low pass filter is switched in on the Rx path.

6.4.5 CARRIER MUTE

The receive audio path can be set to mute when no incoming carrier is detected if this option is turned on.

6.4.6 LEADOUT DELAY

The lead out delay is the time the transmitter stays up after the audio data finishes, this is to avoid mute noises that could corrupt data that is not framed, packeted and does not have an end of message character. This is programmable between 0 & 256milli seconds

7 DIGITAL MODES OF OPERATION

7.1 DIGITAL MODES OF OPERATION

This section serves as a guide to the various ways the URT 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 URT500, 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, 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 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. These handshaking modes are compatible with the old Communique CMD400 modes A, C and D. Mode B (byte stuffing mode) is not supported.

7.2.1 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.

7.2.2 TRANSMISSION WITHOUT HARDWARE HANDSHAKE

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.

7.2.3 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.

7.3 TRANSMIT & RECEIVE TIMING

The URT500 only operates in a simplex or semi-duplex mode. In simplex mode the receive and transmit frequencies are the same, where as in the semi-duplex mode they are different.
In either mode data is only sent in one direction at a time as the radios do not have separate synthesisers for transmit and receive. If full duplex mode is required (transmit & receive at the same time) the ART product should be considered.

In simplex/semi-duplex mode, the radio synthesiser must be reloaded each time Receive or Transmit is selected. Although relatively small the synthesiser loading time must be taken into account when looking at data transfer 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.

When using the URT500, there are a few timing considerations to be taken into account. The main one is the programmable "lead in delay", which is required for the modem to lock on to the incoming data stream and 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

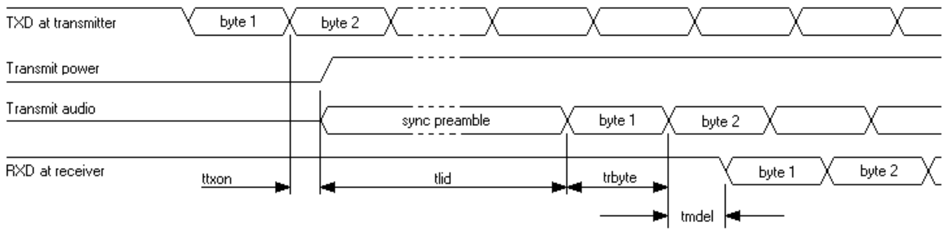
For simplex/semi-duplex operation, time is required for the transmit and receiver synthesiser to be loaded and locked prior to transmission/reception. This timing constraint is important when deciding how soon after receiving a message a reply may be sent. For simplex/semi-duplex operation the URT500 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 URT500 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 URT500 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.

7.3.1 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:

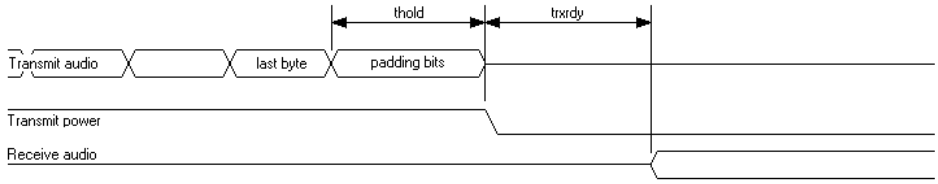
Baud	150	300	600	1200	2400	4800	9600
tmdel	6.9ms	3.5ms	1.7ms	1.3ms	1ms	1ms	1ms

7.3.2 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.

7.3.3 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.

7.4 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 URT500 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 URT500 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.

7.4.1 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.

7.5 OPERATING MODES

7.5.1 TRANSPARENT 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 others of
various manufacturers.

7.5.2 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.

7.5.3 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.

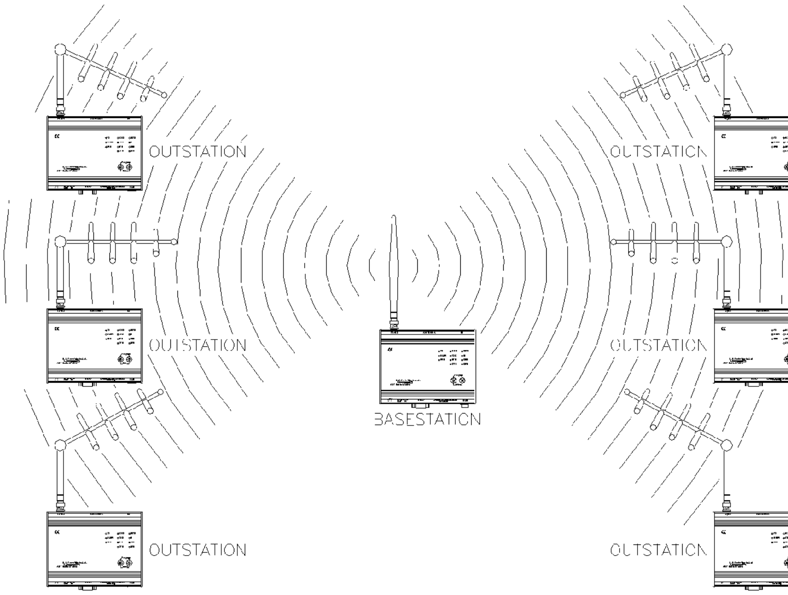
7.6 APPLICATIONS

7.6.1 POINT TO POINT LINK

In the simplest of form of operation the URT500 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 URT500 can either operate transparently with data applied to the serial port or with RTS & CTS as a flow control.

7.6.2 POINT TO MULTI-POINT (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.
A matching 19" mountable basestation, the XRT9000, is available for use with the URT500.



7.6.3 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. In addition to being used at an outstation, the URT can also act as a store & forward or repeater node. The URT 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.

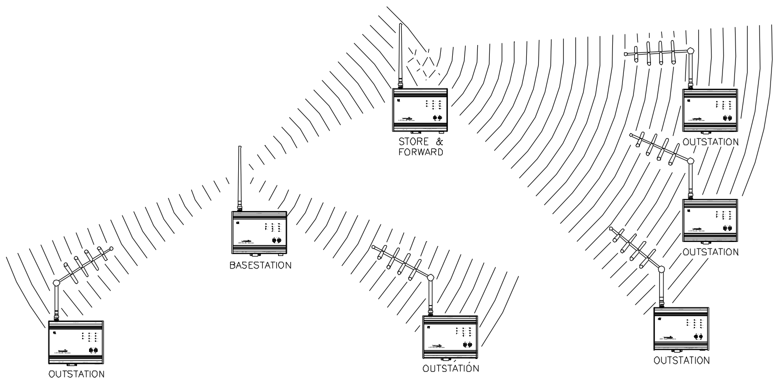
7.6.3.1 Single Frequency Simplex Store & Forward Operation

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 URT500's 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

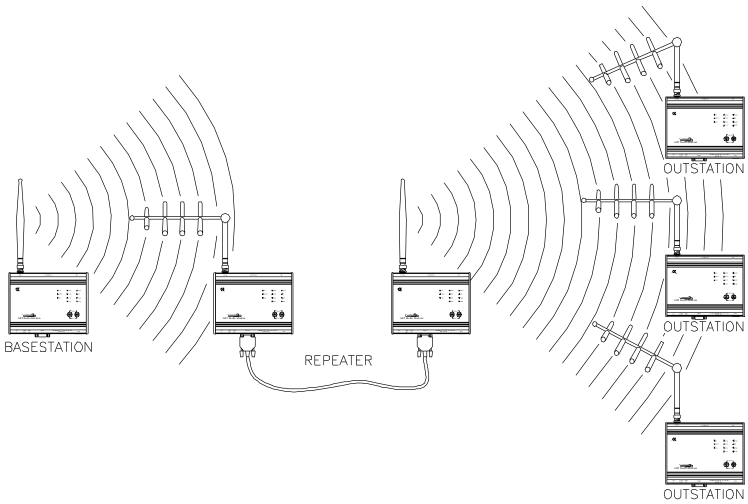
7.6.3.2 Multiple Frequency Simplex Store & Forward/Repeater Operation

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.

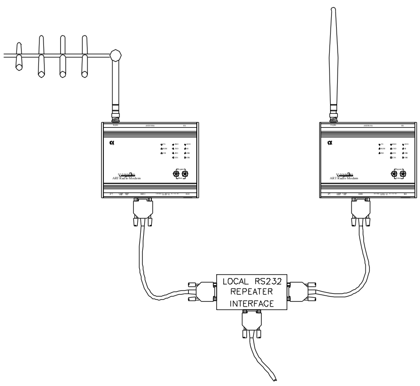
A better solution is the use of two units connected together via a S&F cable. When one unit receives the incoming signal, it buffers the message, turns on the other unit's transmitter and commences the transmission. The same applies in the opposite direction. There will be a time delay with this set-up, 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.

7.6.3.3 Dual Frequency Repeater Node

A repeater will have split receiver & transmitter frequencies with enough separation to enable simultaneous transmitter and receiver operation via two URT500s 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

7.6.3.4 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 A CLIENTS 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 MODBUS

8.2.1 SETTING UP MODBUS OPERATION

The URT500 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.

8.2.2 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.

8.2.3 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.

8.2.4 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.

8.2.5 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.

8.3 RFT ROUTING PROTOCOL

8.3.1 SETTING UP RFT ROUTING OPERATION

The URT500 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.

8.3.2 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.

8.3.3 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.

8.3.4 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

The URT Series are DIN rail mountable Radio Modems/Store & Forward Repeater for outstation applications. & with correct installation should ensure reliable data communications for many years. The most important installation points to remember are:

Suitable antenna system mounted at the correct height & polarisation to achieve the required distance.

Reliable power supply capable of supplying the correct voltage and current.

Correct installation for the environment

Correct interface and set-up

Assuming the unit has been correctly installed and tested at the correct data speed, the only other factors that will effect the performance, are the RF power, (Normally Specified by the regulating authority), the local topography and the weather, none of which the user can control.

9.2 POWER SUPPLIES

The URT500 can be powered from any power source provided that the voltage is between 9.6VDC & 16VDC –VE GND. If a +VE GND system is in use, an isolated converter will be required.
The URT500 requires a supply capable of providing between 300mA and 2.5A depending on the maximum transmit power required.

Under no circumstances should the output of the supply rise above 16VDC.

For 240/110VAC, 50VDC or 24VDC, R.F. Technologies produce a range of uninterruptible power supply units with an in-built charger and power fail indication. A range of suitable Gel type batteries is available should a back-up supply be required during power fail.

9.3 EFFECTIVE RADIATED POWER (ERP)

The Radio Frequency (RF) Power allowed can be specified in two ways:

The “Terminated power into 50 ohms”, which in the case of the URT500 would be a maximum of 5Watts.

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 an input of 5watts would be 10Watts.

The gain of an antenna is very useful as it enables lower power transmitters to be used in many cases in place of high power transmitters, with the advantage of a much lower current consumption.

For example if the ERP allowed for a link is 5Watts, then a URT500 operating at 5W into a unity gain antenna, would require a supply current of 2.1Amps to provide an ERP of 5Watts.
If however, we use an 8 element directional Yagi with a Gain of 10dB, we would only need 500mW of RF Power for the same performance.
With a URT500 operating at 500mW, the current consumption would only be 600mA. If the site is battery or solar powered then the saving is very significant.

Care must be taken when setting the power within a MPT1329/1411 system, as RF power is specified as maximum ERP.

9.4 ANTENNAS, COAX FEEDERS & PERIPHERALS

9.4.1 ANTENNAS
Apart from the radio modem, 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.

9.4.2 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
Patch Antenna	0dB	Vertical/Horizontal	Kiosk or Wall mounting

9.4.3 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.

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

9.4.5 PATCH OR PLATE ANTENNAS
The patch or plate antennas are normally rectangular or round, with a back plate of aluminium or stainless steel. A polycarbonate or ABS cover is fitted to protect the antenna from the environment. This type of antenna can be produced in different sizes with various radiation patterns to suit the

application. Depending on the construction and radiation pattern, the gain is usually between -3dB to + 3dB. Their use is very popular on road side kiosks, buses, trains, aircraft, or where covert communication is required.

9.4.6 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 URT500 operates in the UHF band, which requires near line of sight communication. Hence, for extended ranges the height of the antenna is important.

9.4.7 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 mixing polarisation within systems, unwanted signals can be reduced by as much as 18dB. However, such systems require detailed planning.

9.4.8 ALIGNMENT

If a directional antenna is to be used, it will need alignment with the scanner or communicating station. 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.

9.4.9 ANTENNA COAX FEEDER:

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. For outstations in the local vicinity of the scanner/ base station, the loss is not very important but for distant stations the loss is very important. As a rule of thumb, never operate a system with a 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.

9.4.10 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

9.4.11 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.

9.4.12 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.

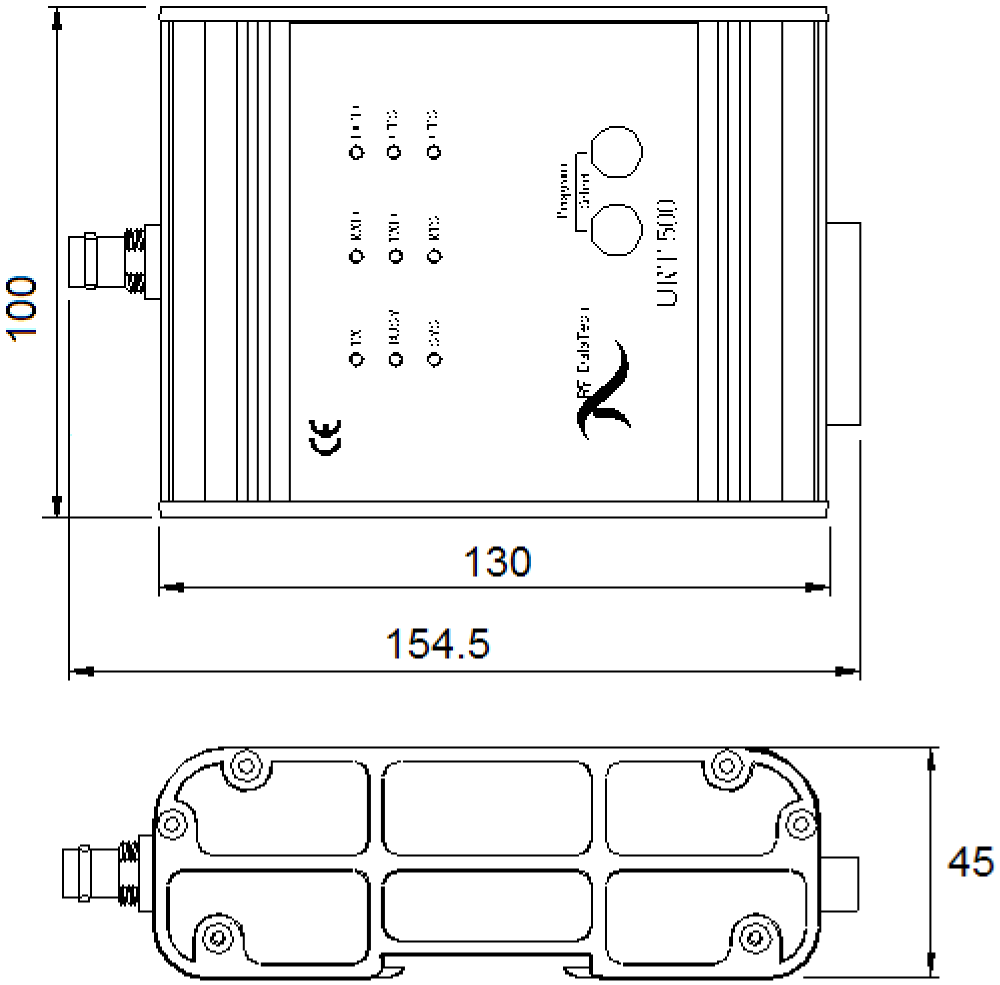
9.4.13 LIGHTNING ARRESTERS

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.

9.5 MOUNTING & INSTALLATION

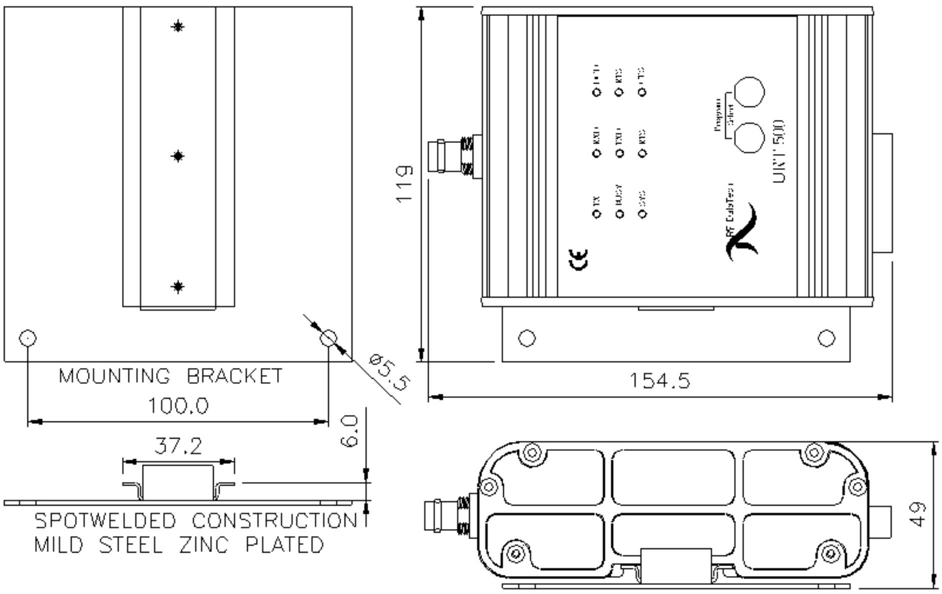
The URT500 is built into tough durable milled aluminium enclosure that can be mounted in any plane, but should not be exposed to rain etc. as the enclosure and connectors do not meet the relevant IP ratings.
If IP65, 67 or 68 is required then an additional enclosure will be required. A number of suitable enclosures are available as options.

9.5.1 URT500 DIMENSIONS



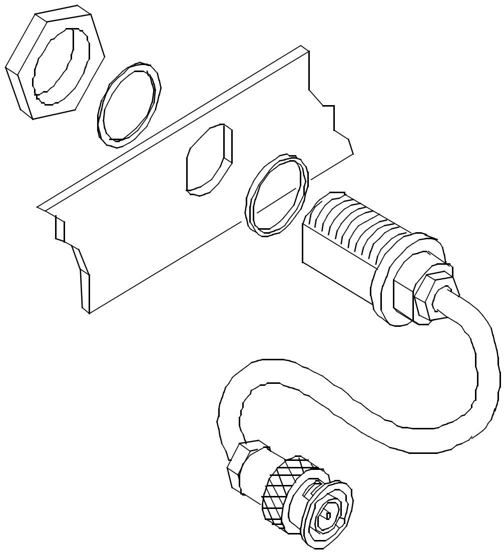
9.5.2 URT500 MOUNTING

The URT Series can be DIN rail mounted or panel mounted with the optional mounting bracket.



9.5.3 ANTENNA CONNECTION THROUGH AN ENCLOSURE:

When a URT500 is used within an enclosure, the coax antenna cable can either be brought out via a suitable gland or via the "N" type adapter kit shown below.



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