



RFSCADA16 RFSCADA4

Remote Terminal Unit

*Installation, Configuration &
Programming Manual*

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TERMS & CONDITIONS

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TERMS & CONDITIONS

Customer and Data Delivery Devices LLC ("DDD") agree that the purchase and sales of DDD hardware and software products ("the Products") are made under these terms and conditions, and that DDD SHALL NOT BE BOUND BY CUSTOMER'S ADDITIONAL OR DIFFERENT TERMS. Customer's order and purchase of the Products shall constitute acceptance of these terms and conditions.

1. TITLE

Title to the Products shall pass at DDD's plant; however, if Customer is the United States or any political subdivision of the United States, title shall pass at Customer's plant. DDD retains a security interest and right of possession in the Products until Customer makes full payment.

2. TAXES

Product prices are exclusive of, and Customer shall pay, applicable sales, use, service, value added or like taxes, unless Customer has provided DDD with an appropriate exemption certificate for the delivery destination acceptable to the applicable taxing authorities.

3. PRICES AND PAYMENT

All quotations shall expire sixty (60) days from date of issuance, unless otherwise set forth on the quotation or agreed in writing. Customer shall make payment in full prior to or upon delivery by cashier's check, credit card, or money order, unless DDD approves Customer for credit terms. If DDD approves Customer's credit application, payment shall be due no later than 30 days from the date of DDD's invoice. All sums not paid when due shall accrue interest daily at the lesser of a monthly rate of 1.5% or the highest rate permissible by law on the unpaid balance until paid in full. Payments for orders shall be made in U.S. Dollars. In the event of any order for several units, each unit(s) will be invoiced when shipped. Exceptions may be made for government purchase orders.

4. ORDERS

All orders are subject to acceptance by DDD. DDD's booking of an order shall constitute its acceptance of an order.

5. DELIVERY

DDD shall deliver the Products to a carrier at DDD's plant and, if the Products are sold to a Customer outside the United States, shall clear the Products for export destined outside the United States. Customer shall pay all freight charges, applicable import duties, and other necessary fees and shall bear the risks of carrying out customs formalities and clearance.

Orders are entered as close as possible to the Customer's requested shipment date, if any. Shipment dates are scheduled after acceptance of orders and receipt of necessary documents. Claims for shipment shortage shall be deemed waived unless presented to DDD in writing within twenty one (21) days of shipment.

6. LIMITED WARRANTY

DDD hardware Products are warranted against defects in materials and workmanship for one year from the date DDD ships the Products to Customer. All software Products are licensed to Customer under the terms of the appropriate DDD license. For a period of ninety (90) days from the Delivery Date, DDD software Products (when properly installed) (a) will perform substantially in accordance with the accompanying written materials, and (b) the medium on which the software product is recorded will be free from defects in materials and workmanship under normal use and service. Any replacement of a licensed software product will be warranted for the remainder of the original warranty period or thirty (30) days, whichever is longer. Customer must obtain a Return Material Authorization number from DDD before returning any Products under warranty to DDD. Customer shall pay expenses for shipment of repaired or replacement Products to and from DDD. After examining and testing a returned product, if DDD concludes that a returned product is not defective, Customer will be notified, the product returned at Customer's expense, and a charge made for examination and testing. This Limited Warranty is void if failure of the Products has resulted from accident, abuse, misapplication, improper calibration by Customer, Customer supplied third party software not intended for use with the applicable DDD software, utilization of an improper hardware or software key or unauthorized maintenance or repair.

7. CUSTOMER REMEDIES

DDD's sole obligation (and Customer's sole remedy) with respect to the foregoing Limited Warranty shall be to, at its option, return the fees paid or repair/replace any defective Products, provided that DDD receives written notice of such defects during the applicable warranty period. Customer may not bring an action to enforce its remedies under the foregoing Limited Warranty more than one (1) year after the accrual of such cause of action.

8. RETURN/CANCELLATION/CHANGE POLICY

Customer may return unwanted Products within thirty (30) days of the Delivery Date. Customer shall pay a fifteen percent (15%) restocking charge on any unwanted Products returned to DDD. No returns will be accepted after the thirty (30) day period has expired. Where special equipment or services are involved, Customer shall be responsible for all related work in progress; however, DDD shall take responsible steps to mitigate

damages immediately upon receipt of a written cancellation notice from Customer. A Return-Material Authorization number must be obtained from DDD for return of any Products. DDD may terminate any order if any representations made by Customer to DDD are false or misleading. Changes to orders shall not be binding upon nor be put into effect by DDD unless confirmed in writing by DDD's appropriate representative.

9. NO OTHER WARRANTIES

EXCEPT AS EXPRESSLY SET FORTH ABOVE, THE PRODUCTS ARE PROVIDED "AS IS" WITHOUT WARRANTY OF ANY KIND, AND NO OTHER WARRANTIES, EITHER EXPRESSED OR IMPLIED ARE MADE WITH RESPECT TO THE PRODUCTS, INCLUDING BUT NOT LIMITED TO ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, TITLE OR NON-INFRINGEMENT OR ANY OTHER WARRANTIES THAT MAY ARISE FROM USAGE OF TRADE OR COURSE OF DEALING. DDD DOES NOT WARRANT, GUARANTEE, OR MAKE ANY REPRESENTATIONS REGARDING THE USE OF OR THE RESULTS OF THE USE OF THE PRODUCTS IN TERMS OF CORRECTNESS, ACCURACY, RELIABILITY, OR OTHERWISE AND DOES NOT WARRANT THAT THE OPERATION OF THE PRODUCTS WILL BE UNINTERRUPTED OR ERROR FREE. DDD EXPRESSLY DISCLAIMS ANY WARRANTIES NOT STATED HEREIN.

10. NO LIABILITY FOR CONSEQUENTIAL DAMAGES

The entire liability of DDD and its licensors, distributors, and suppliers (including its and their directors, officers, employees, and agents) is set forth above. To the maximum extent permitted by applicable law, in no event shall DDD and its licensors, distributors, and suppliers (including its and their directors, officers, employees, and agents) be liable for any damages, including, but not limited to, any special, direct, indirect, incidental, exemplary, or consequential damages, expenses, lost profits, lost savings, business interruption, lost business information, or any other RTU Manual Version 1.5 damages arising out of the use or inability to use the Products, even if DDD or its licensors, distributors, and suppliers have been advised of the possibility of such damages. Customer acknowledges that the applicable purchase price or license fee for the Products reflects this allocation of risk. Because some states/jurisdictions do not allow the exclusion or limitation of liability for consequential or incidental damages, the above limitation may not apply. If the foregoing limitation of liability is not enforceable because an DDD product sold or licensed to Customer is determined by a court of competent jurisdiction in a final, non-appealable judgment to be defective and to have directly caused bodily injury, death, or property damage, in no event shall DDD's liability for property damage exceed the greater of \$5,000 or fees paid for the specific product that caused such damage.

11. WARNING

(1) DDD PRODUCTS ARE NOT DESIGNED WITH COMPONENTS AND TESTING FOR A LEVEL OF RELIABILITY SUITABLE FOR USE IN OR IN CONNECTION WITH SURGICAL IMPLANTS OR AS CRITICAL COMPONENTS IN ANY LIFE SUPPORT SYSTEMS WHOSE FAILURE TO PERFORM CAN REASONABLY BE EXPECTED TO CAUSE SIGNIFICANT INJURY TO A HUMAN. (2) IN ANY APPLICATION, INCLUDING THE ABOVE, RELIABILITY OF OPERATION OF THE SOFTWARE PRODUCTS CAN BE IMPAIRED BY ADVERSE FACTORS, INCLUDING BUT NOT LIMITED TO FLUCTUATIONS IN ELECTRICAL POWER SUPPLY, COMPUTER HARDWARE MALFUNCTIONS, COMPUTER OPERATING SYSTEM SOFTWARE FITNESS, FITNESS OF COMPILERS AND DEVELOPMENT SOFTWARE USED TO DEVELOP AN APPLICATION, INSTALLATION ERRORS, SOFTWARE AND HARDWARE COMPATIBILITY PROBLEMS, MALFUNCTIONS OR FAILURES OF ELECTRONIC MONITORING OR CONTROL DEVICES, TRANSIENT FAILURES OF ELECTRONIC SYSTEMS (HARDWARE AND/OR SOFTWARE), UNANTICIPATED USES OR MISUSES, OR ERRORS ON THE PART OF THE USER OR APPLICATIONS DESIGNER (ADVERSE FACTORS SUCH AS THESE ARE HEREAFTER COLLECTIVELY TERMED "SYSTEM FAILURES"). ANY APPLICATION WHERE A SYSTEM FAILURE WOULD CREATE A RISK OF HARM TO PROPERTY OR PERSONS (INCLUDING THE RISK OF BODILY INJURY AND DEATH) SHOULD NOT BE RELIANT SOLELY UPON ONE FORM OF ELECTRONIC SYSTEM DUE TO THE RISK OF SYSTEM FAILURE. TO AVOID DAMAGE, INJURY, OR DEATH, THE USER OR APPLICATION DESIGNER MUST TAKE REASONABLY PRUDENT STEPS TO PROTECT AGAINST SYSTEM FAILURES, INCLUDING BUT NOT LIMITED TO BACK-UP OR SHUT DOWN MECHANISMS. BECAUSE EACH END-USER SYSTEM IS CUSTOMIZED AND DIFFERS FROM DDD'S TESTING PLATFORMS AND BECAUSE A USER OR APPLICATION DESIGNER MAY USE DDD PRODUCTS IN COMBINATION WITH OTHER PRODUCTS IN A MANNER NOT EVALUATED OR CONTEMPLATED BY DDD, THE USER OR APPLICATION DESIGNER IS ULTIMATELY RESPONSIBLE FOR VERIFYING AND VALIDATING THE SUITABILITY OF DDD PRODUCTS WHENEVER DDD PRODUCTS ARE INCORPORATED IN A SYSTEM OR APPLICATION, INCLUDING, WITHOUT LIMITATION, THE APPROPRIATE DESIGN, PROCESS AND SAFETY LEVEL OF SUCH SYSTEM OR APPLICATION.

12. FORCE MAJEURE

DDD shall be excused for any delay or failure to perform due to any cause beyond its reasonable control, including but not limited to acts of governments, natural catastrophes, acts of Customer, interruptions of transportation or inability to obtain necessary labor or materials. DDD's estimated shipping schedule shall be extended by a period of time equal to the time lost because of any excusable delay. In the event DDD is unable to perform in whole or in part because of any excusable failure to perform, DDD may cancel orders without liability to Customer.

13. LIMITED INDEMNITY AGAINST INFRINGEMENT

DDD shall, at its own expense, defend any litigation resulting from sales of the Products to the extent that such litigation alleges that the Products or any part thereof infringes any United States patent, copyright, or trademark, provided that such claim does not arise from the use of the Products in combination with equipment or devices not made by DDD or from modification of the Products, and further provided that Customer notifies DDD immediately upon its obtaining notice of such impending claim and cooperates fully with DDD in preparing a defense. If Customer provides to DDD the authority, assistance, and information DDD needs to defend or settle such claim, DDD shall pay any final award of damages in such suit and any expense Customer incurs at DDD's written request, but DDD shall not be liable for a settlement made without its prior written consent. If the Products are held to be infringing and the use thereof is enjoined, DDD shall, at its option, either (i) procure for the Customer the right to use the Products, (ii) replace the Products with others which do not constitute infringement, or (iii) remove the infringing Products and refund the payment(s) made therefore by Customer. The foregoing states the Customer's sole remedy for, and DDD's entire liability and responsibility for, infringement of any patent, trademark, or copyright relating to the Products provided hereunder. THIS LIMITED INDEMNITY IS IN LIEU OF ANY OTHER STATUTORY OR IMPLIED WARRANTY AGAINST INFRINGEMENT.

14. ACKNOWLEDGMENT/GOVERNING LAW

Customer acknowledges reading these Terms and Conditions, understands them and agrees to be bound by them. A waiver of any provision of this agreement shall not be construed as a waiver or modification of any other term hereof. With respect to all orders accepted by DDD, disputes arising in connection with these Terms and Conditions of Sale shall be governed by the laws of the State of Oklahoma without regard to principles of conflicts of laws.

15. APPLICATION LIABILITY

DDD assumes the buyer to be an expert in his intended application of DDD products. DDD claims no special expertise in the application of its products into the buyer's equipment. DDD accepts no responsibility for

the buyer's selection and use of DDD products. Buyer's interpretation and implementation of application suggestions and recommendations by DDD, general or specific, transmitted verbally, electronically or in writing, published or unpublished, is strictly at the buyers own risk.

16. FCC COMPLIANCE WARNING

The RTU device may contain a transmitter module FCC ID:OUR9X-TREAM or FCC ID:OUR9XTEND. The transmitter module complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) The device may not cause harmful interference, and (2) the device must accept any interference that may cause undesired operation.

17. FCC RF EXPOSURE WARNING

In order to comply with the FCC RF exposure requirements the ISM RTU units may only be used with approved antennas that have been tested with it. A minimum separation distance of 20cm must be maintained from the antenna to any nearby persons. The RTU unit is not classified as a portable device per FCC Section 2.1093

GENERAL SAFETY INSTRUCTIONS

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GENERAL SAFETY INSTRUCTIONS

Warnings in this manual appear in either of two ways:



DANGER

1. Danger warnings

The danger warning symbol is an exclamation mark enclosed in a triangle which precedes letters spelling the word “DANGER”. The Danger warning symbol is used to indicate situations, locations and conditions that can cause serious injury or death.



2. Caution Warnings

The caution warning symbol is an exclamation mark enclosed in a triangle which precedes letters spelling the word “CAUTION”. The Caution warning symbol is used to indicate situations and conditions that can cause operator injury and/or equipment damage.

Other warning symbols may appear along with the Danger and Caution symbol and are used to specify special hazards. These warnings describe particular areas where special care and/or procedures are required in order to prevent serious injury and possible death.



Electrical Warnings – The electrical warning symbol is a lightning bolt mark enclosed in a triangle. The electrical warning symbol is used to indicate high voltage locations and conditions that may cause serious injury or death if proper precautions are not observed.

For the purposes of this manual and product labels, a Qualified Person is one who is familiar with the installation, construction, operation and maintenance of the equipment and the hazards involved. This person must:

1. Carefully read and understand the entire manual.
2. Be trained and authorized to safely energize, de-energize, clear faults, ground, lockout and tag circuits and equipment in accordance with established safety practices.
3. Be trained in the proper care and use of protective equipment such as safety shoes, rubber gloves, hard hats, safety glasses, face shields etc. in accordance with established safety practices.
4. Be trained in rendering first aid.

Manual Revisions

3.8 June 2006	Introduction of 16ADI9DO. Repeater Mode.
3.9 June 2006	Repeater mode additions. Example screenshots updated. Timeout resolution on V3.x F/W explained.
4.0 August 2006	Corrections to terminology & p/n's.
4.1 Sept. 2006	Additional Modbus registers added
4.2 December 2006	Embedded f/w changes noted
5.0 June 2007	4ADI-5DO2; Replace 8ADI-9DO & 4ADI-5DO with 4ADI-5DO2
5.1 Apr 2008	Pulse counting operation added.
5.2 June 2009	Modbus polling added, extra Modbus registers, digital hold mode, eight additional tank control routines.

RFScada Embedded Firmware Revisions

1.0 March 2003	First production release
2.0 April 2004	Support for LMR radios. Field f/w upgrades possible.
2.2 May 2004	Support for RF4 series
2.3 Sept. 2004	Support for 1 Watt ISM radios
2.6 Jan 2005	Extended Modbus support.
3.0 March 2006	Support for RF16 series. Repeater mode added.
3.2 May 2006	Extended timeouts implemented
3.5 June 2006	Correction to prevent possibility of RS-485 driver locking on.
3.6 Sept 2006	Modification to correct for packet ID bug in 1 Watt ISM radio module.
3.7 Sept 2006	Added Modbus registers 1020 to 1027, correct bug with Modbus register 609
3.8 Dec. 2006	Correct bug with Modbus command 6. Support for RF4V2. Correct bug that could cause Unit0 Analog1 value to overwrite Unit 1 Analog 1 value.
3.9 Jun 2007	Modbus command 4 added. Modbus RS-232 / RS-485 interface baud rate changes added. Addition of special mode 4 supporting additional tank level control mode.
4.0 Apr 2008	Pulse counting capability added.
4.2 Jun 2009	8 more tank level controls added, polling of 4 Modbus devices, digital hold mode, automatic store of tank control set points.

INTRODUCTION

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Remote Terminal Unit

Introduction

RFScada units provide a complete, high reliability, long range, bi-directional wireless transmission and reception interface that allows remote monitoring and control of multiple analog and discrete signals. The states of contact or logic level inputs plus analog inputs are transmitted from every unit. Each unit also has relay contact outputs, and may have optional analog outputs. A system comprises 1 to 32 (255 in some cases) units, and simple configuration at the factory or in the field allows each output on every unit to be driven from any input on any unit. Modbus capability, at every unit, is also standard for additional control and monitoring options. The RFScada system has many applications in the SCADA, oil, gas, water, waste water, security and other industrial fields.

This manual covers installation and operation of different RFScada models, the 16ADI-9D2AO and the 4ADI-5DO2. Although they have different inputs and outputs the models are very similar, and general configuration is similar for all models. This manual generally shows examples using the 16ADI-9DO, and where relevant differences between the models are explained. Additionally these RFScada devices are available with a choice of wireless transmission options, including none, high power spread spectrum and licensed VHF or UHF radios of various powers. Another chapter explains configuration and operation with the various wireless options.

The many features of RFScada devices include.....

- ❖ Reliable, oil field proven industrial grade components throughout.
- ❖ Highest data integrity, with secure error rejecting data encryption to prevent the possibility of false signals.
- ❖ High speed, fully bi-directional and continuous signal exchange ensures each unit is capable of controlling, monitoring and verifying signals at all the other units – continuous, positive verification of correct operation at all units.
- ❖ Out of the box ‘Plug and Play’ operation, typically no user programming, configuration or adjustments normally required. Duplicate remote relays, switches and analog signals without any connecting ‘wires’.
- ❖ All units revert to a known state upon communication loss, either local or remote, within a programmable time delay, may also be configured to continue operation with signal loss.
- ❖ Additional relay output in each unit indicates the state of the system communication status.

-
- ❖ Built in dual power supply options, 115 VAC and 10 to 28 Volts DC, easily operate from solar.
 - ❖ Quickly and easily add wireless I/O to existing systems; compatible with virtually all SCADA systems, supporting inputs and outputs that may be analog, digital and Modbus.
 - ❖ Standard (900MHz) radios using the internal antenna have a typical line of sight range of 5 to 10 miles and up to 40 miles with an external antenna. Additional models support extended transmission distances, non 'line-of sight' operation, multiple frequency options and repeater modes.
 - ❖ Completely prepackaged solution in a corrosion resistant, NEMA 4X enclosure ready to be installed in virtually any location, requires just power and signal connection for operation. Most applications will not require an external antenna.
 - ❖ Several radio options available. All units may use 1 Watt 900MHz ISM band radios that are fully FCC approved, requiring no license for ownership or operation in the USA. Licensed radios may also be used; standard units use VHF or UHF radios rated at 1, 2 or 5 Watts
 - ❖ Many built in routines are standard, such as analog tank level control, duplex toggling pumps, dry contact tank level, flow meter pulse counting etc. These functions often eliminate the need for a separate PLC.
 - ❖ Directly supported by DAQFactory; Labview, Visual Basic, Visual C, Intellution, Wonderware etc may all interface to RFScada devices via standard Modbus commands.

*DIFFERENCES 4ADI-5D02 &
16ADI-9D2A0*

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Summary of 4ADI-5D02 and 16ADI-9D2A0 Differences

This manual describes two similar but different models, the 4ADI-5D02 and the 4ADI-5D02. Following are the main differences between units.

	4ADI-5D0	16ADI-9D2A0	Comments
Number of Analog Inputs	4	8	May also be used as digital inputs and pulse counting inputs.
Analog Outputs	0	2x 4-20mA. More as plug in option.	
Number of Digital Inputs	4 (up to 4 more using analogs)	8 (up to 8 more using analogs)	
Number of Digital Outputs	4 plus 1 Status	8 plus 1 status	
ISM Signal Strength	Yes	Yes	
Temperature Measurement	Yes	Yes	

Note: The 4ADI-5D02 replaces an earlier model, the 4ADI-5D0. The main differences between the two are that the 4ADI-5D02 supports direct connection to external radios without requiring an additional RADINT option board; and the 4ADI-5D02 analog inputs may be also be used as digital inputs or pulse counting inputs.

SPECIFICATIONS

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RFScada Model 16ADI-9D2AO Specifications

Due to continual improvements all published specifications are subject to change. SS1 option shown, SS1, V1, V2, V5, U1, U2, U5 radio specifications differ.

AC Operating voltage	85 - 140 VAC 48 – 62 Hz (85 – 264 VAC 48 – 62Hz if protective MOV changed)
AC Power supply certification	UL, CE, CISPR/FCC Class B
DC Input Operating voltage (note 2)	10 to 28 Volts DC
DC Output Power (note 3)	14.4 Volts DC 1 Amp
AC Power consumption	<0.5 Amp
DC Power consumption (at 12VDC)	0.07 Amp no active relays or 4-20mA; 0.28 Amp with all relays & 4-20mA active
On board AC input fuse rating	2 Amp 115 VAC
AC Input transient protection	Yes, 10,000A 120 Joule 150 V MOV on board
DC Input transient protection	Yes, electronic fuse and 1500W MOV on board
Enclosure rating	UL 508, CSA and NEMA 1,2,3,4,4X,12, 13 IEC 529, IP66
Enclosure type	Fiberglass with stainless steel hardware
Enclosure door closure types	Lockable snap latch or screw close available
Dimensions	11.75 H x 11.75 W x 6.75 D inches
Weight	8 Pounds
Storage temperature rating	-40°C to +85 °C
Operating temperature rating	-10°C to +75 °C (0 to 40 °C for AC powered version)
Humidity	15-95% non-condensing
Minimum telemetry update rate	5 times per second standard ISM (bi-directional)
Transmission method	Bi-directional, mode and modulation type depend on model
Operating frequency	148-174MHz VHF band, 450-490 MHz UHF band, 902-928 MHz ISM band
RF data encryption method	Proprietary 16 bit cyclic redundancy checking with 50 channel hopping
Signal data encryption method	Proprietary rolling code plus 16 bit cyclic redundancy check
Internal antenna supplied	Yes, 2.1 dB Gain omni-directional half wave dipole (ISM)
Range with internal antenna	Up to 20 miles line of sight depending on radio option.
Range with external antenna	Up to 75 miles depending on radio option.
License required (USA)	Not for SS, SS1 versions, yes for V1, V2, V5, U1, U2 and U5 versions
FCC approved	Yes
Network status transmitted	Yes
Units in a network	1 to 32 (255 under PC control)
Repeater Mode	Standard
Maximum number of inputs in a network	504, 252 digital & 252 analog (4032, 2016 digital & 2016 analog under PC control)
Maximum number of outputs in a network	500, 252 digital & 248 analog (4000, 2016 digital & 1984 analog under PC control)
Output signal source	Any output may be driven by any input, user programmable
Digital Input signal channels transmitted (per unit)	8 plus communication state
Digital Input channel signal type	Low voltage (5V) contacts or logic level
Digital Input signal voltage required	None
Digital Input signal transient protection	Yes, 600W TVS surge and RF filters
Digital Input signal status indication	Yes, on board LED's, one per channel.
Digital Input signal cable length	Maximum 250 feet recommended
Digital Input signal de-bounce	Approximately 0.25 second

time	
Analog Input channels transmitted (per unit)	8 plus temperature, DC Voltage and radio signal strength (SS1 version)
Analog Input signal type	4-20 mA grounded, 0-5 Volt DC, 0-10 Volt DC, Digital jumper selectable.
Analog Input transducer on board power supply	On board 15 VDC with AC power or ~1 Volt below DC supply Voltage.
Transducer on board power supply protection	Yes, current limited with electronic fuse
Analog Input transducer power source	May be external or use on board supply
Analog Input transient protection	Yes, 600W TVS surge and RF filters
Analog Input signal cable length	Max. 250 feet recommended
Analog Input signal accuracy	0.024% (12 bit analog to digital conversion)
Digital output (received) signal channels	8
Digital output (received) status channels	1 for system status
Digital output (received) relay contact ratings	SPDT 10 Amp at 115 VAC, 5 Amp at 30 VDC
Digital output (received) signal indication	Yes, 8 on board LED's, one per channel, show relay states
Digital output (received) system status indication	Yes, on board LED shows system status
Analog 4-20 mA outputs capability	2 Standard
Modbus capability	Built in, every unit is a Modbus RTU slave
Modbus interface built in	Yes, both RS-232 and 2 wire RS-485 on board automatic selection
Inputs that may be monitored by Modbus	Every analog input, digital input, temperature and DC voltage
Outputs that may be controlled by Modbus	Every analog output and digital output
Time to default outputs after signal loss	User adjustable, 20 seconds to over 7 days
Additional status LED's	7, two each for data transmission/ reception plus one for Modbus / system activity

Notes:

1. Generic radio parameters refer to the ISM version.
2. The unit may be powered from either AC source or DC source, or a combination of both.
3. This DC output is available for external 4-20mA transducers and an external radio.

DEVICE UNPACKING & VERIFICATION

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Device Unpacking, Verification and Permanent Installation.

Unpacking:

First carefully unpack the units and verify all the contents are complete, intact and match the items ordered. (Note that the OEM versions may differ from the table below). If there are any discrepancies then please contact Data Delivery Devices LLC for assistance.

4ADI-5D02	16ADI-9D2AO	Description
1	1	RFScada device (may be either screw close or lockable latch door closing type)
4	4	Stainless steel mounting lugs.
4	4	Stainless steel lug screws.
1	1	User Manual.
1	1	Test AC power cord with 3 conductor Phoenix connector
1	2	2-conductor Phoenix connector for external DC power
1	1	2-conductor Mini Phoenix connector for 4-20 mA transducer power source
2	4	8-conductor Mini Phoenix connector for analog and digital input signals
1	1	3-conductor Mini Phoenix connector for system status output relay
2	4	6-conductor Mini Phoenix connectors for 8 output relays.
-	1	4-conductor Mini Phoenix connector for 4-20mA analog output
1	1	0.125"–0.250" Cable entry flange.
1	1	0.250"–0.375" Cable entry flange.
1	1	RFScada Configuration Software and Manual on CD-ROM
4	8	TyWraps
4	8	TyWrap Pads
1	1	20mm 2 Amp 250 V fuses (spare).

Device Verification:

This procedure will allow the operator to verify the units are functioning correctly and will support the required range before permanently installing the units. It does not require connection to any input or output signals, as visual indicators on the RFScada units will confirm correct operation. This is an easy and quick method to do in the field that does not need any special tools.

Open a unit, verify it has not been damaged and there are no loose components in the housing.



DANGER



Possibly lethal line voltages will be present on the unit's circuit board when connected to AC line power. Before attempting to gain access, test or modify connections refer to a qualified electrician for assistance, instructions on safe operation and to ensure that connections meet all applicable safety procedures, standards and codes.

To use AC power the test lead must be connected first to the 3-pin connector J1 on the unit, then plugged into an AC power source.

The operation of the unit and the status indicators will depend on whether another matched RFScada device is running and within range. If the device is not communicating with another unit then either the green 'Transmit' LED will quickly flash (approximately twice a second), indicating that this is the system 'master' trying to contact other units but no other LED's will flash. Alternatively the red 'receive' LED will slowly flash, about once every 2 seconds, indicating that this is a 'slave' unit waiting to receive data from the system 'master'. The green LED on each unit illuminates each time the device transmits data, and the red LED illuminates each time the unit receives data. If the 'Transmit' LED and 'Receive' LED flash in rapid succession (normal operation) then this device is successfully communicating with another device. For this to occur the main board, including the transmitters and receivers on each unit must all be operating correctly. Furthermore, if every unit that the system is configured for is communicating correctly the 'system status' LED and relay by J11 will be active on every unit. Once units are communicating connect a short piece of wire between terminals 1 and 2 of a Mini Phoenix eight pin plug P12. Plug this eight conductor plug into the corresponding connector (J12) on one of the devices and the 'local status' green LED by the connector should illuminate, this provides local indication showing the state of the digital / switch input. Almost immediately a relay click should be heard from the other unit, and the corresponding 'output' indicating red LED will become illuminated on the other device by the relay just activated. This verifies that the input status on one device activates an 'output' relay on the remote device. Note that the RFScada devices may be configured to drive any relay from any input source on any unit, so depending on the configuration setting programmed at the factory other relays may activate. (The default configuration is to route inputs 1-8 to relays 1-8 on opposite units). This routing may be changed by the user if required, see further on for details. The relay test procedure may be repeated for all eight input channels on both units if required.

Once the basic device functionality has been completed the devices may be moved to the final location for range verification. With the devices operating temporarily locate the first unit at its desired position and move the second unit towards its final location. By watching the 'system status' LED on either unit, or the transmit and receive LED's the range may be verified. Remember that the 'system status' LED will only illuminate if all units in a system are communicating correctly with a continuous, full, complete and verified data exchange, so signal transmission and reception may be monitored from any unit. The state of the inputs and outputs has no bearing on the range, and the state of the inputs does not matter to test the range. Providing the DC or line Voltage are within specifications the range is the same whether the units operate from AC or DC power. If the required range cannot be achieved see the section on troubleshooting to resolve the problem.

After the Device and range verification have been completed the devices may be permanently installed.

Permanent Device Installation:

Establish a route and entry point for both the power and signal cables to enter the cabinet. Generally the best entry point is on the bottom side of the cabinet to minimize the possibility of cable damage.

Mount the cabinet using the four stainless steel screws and lugs provided in the kit, use type 222 Loctite applied to the screw threads if the cabinet is to be mounted in a location subject to vibration. Since the cable entry points are usually not known until installation, the cabinets are supplied without any holes and the customer may drill the cabinet then install the cable clamps in a suitable position. Use caution when drilling the cabinet and always ensure that any power is removed from the device beforehand, otherwise damage to the device and serious injury may occur.

Be especially careful by the  antenna, it is securely located to both the board via a precision connector and to the panel or PCB via a non metallic stand. Do not attempt to lift the panel by the antenna since damage to the main board and antenna will result. The antenna connector is very fragile and easily damaged.

Before drilling the cabinet it is usually best to remove the main internal panel that holds the circuit board and internal antenna to prevent damage to the device. To do this carefully remove the 4 stainless steel screws that mount the main panel to the cabinet. Use caution removing these since the screw threads

have been treated with low strength thread locker to prevent loosening due to vibration.

Once the panel has been removed from the cabinet, drill holes large enough (commonly available 'step' drills are very useful for these size holes) for the cable clamps or conduit fittings and install the clamps tightly. Remove any dust or particles remaining from drilling, then replace the panel in the cabinet and complete wiring of the inputs, outputs and power to the device. Secure power and signal cables to the inside of the case using Ty-Wraps included with the unit. Close the front door and secure with a suitable padlock (latch close version) or by tightening the door closing screws (screw close version).



Possibly lethal line voltages will be present on the unit's circuit board when connected to AC line power. Before attempting to gain access, test or modify connections refer to a Qualified Person for assistance, instructions on safe operation and to ensure that connections meet all applicable safety procedures, standards and codes. The front door should always be securely closed either by using a suitable padlock (latch close version) or by tightening the door closing screws (screw close version) to prevent access by unauthorized personnel.

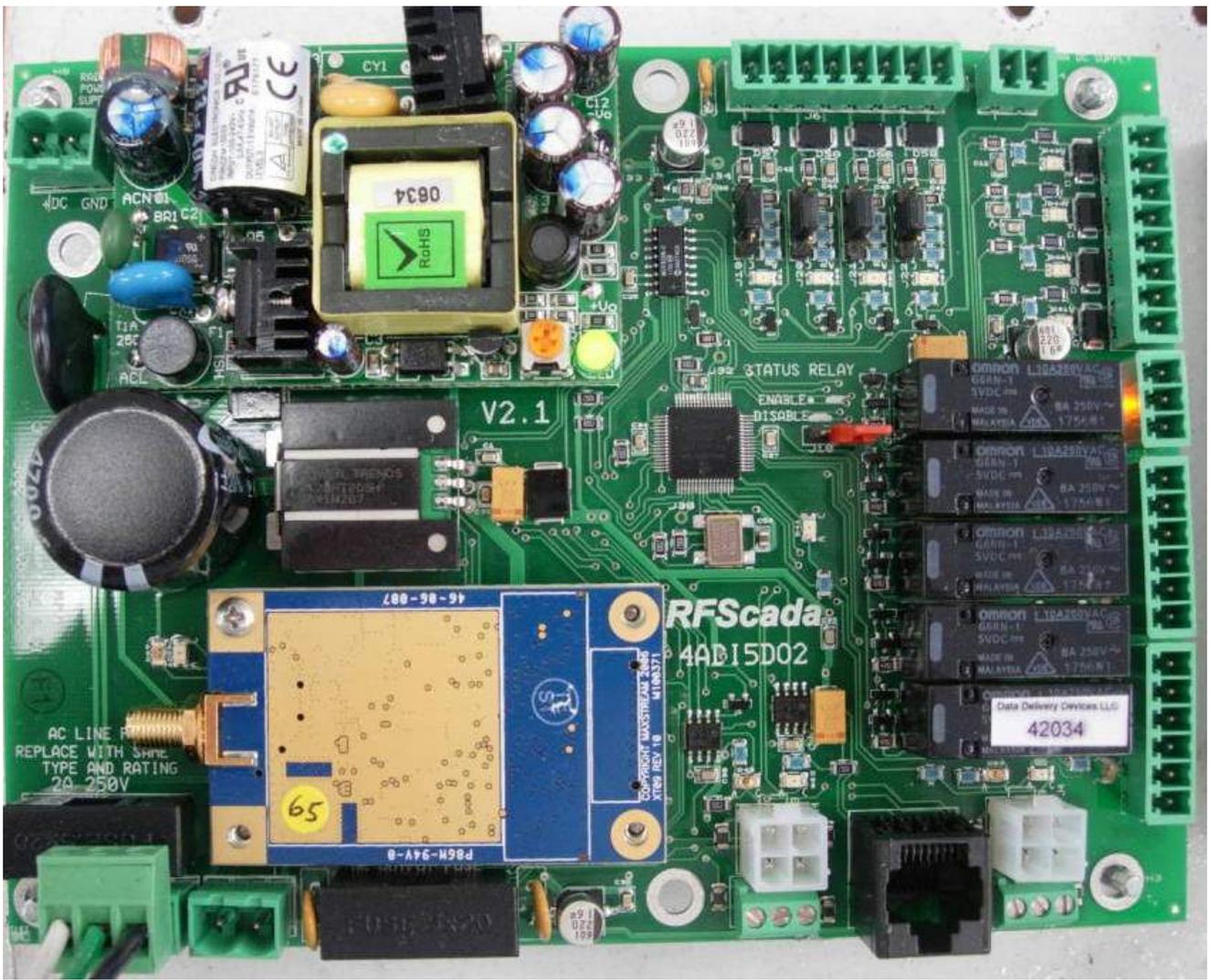
Apply power to the unit and verify correct operation.

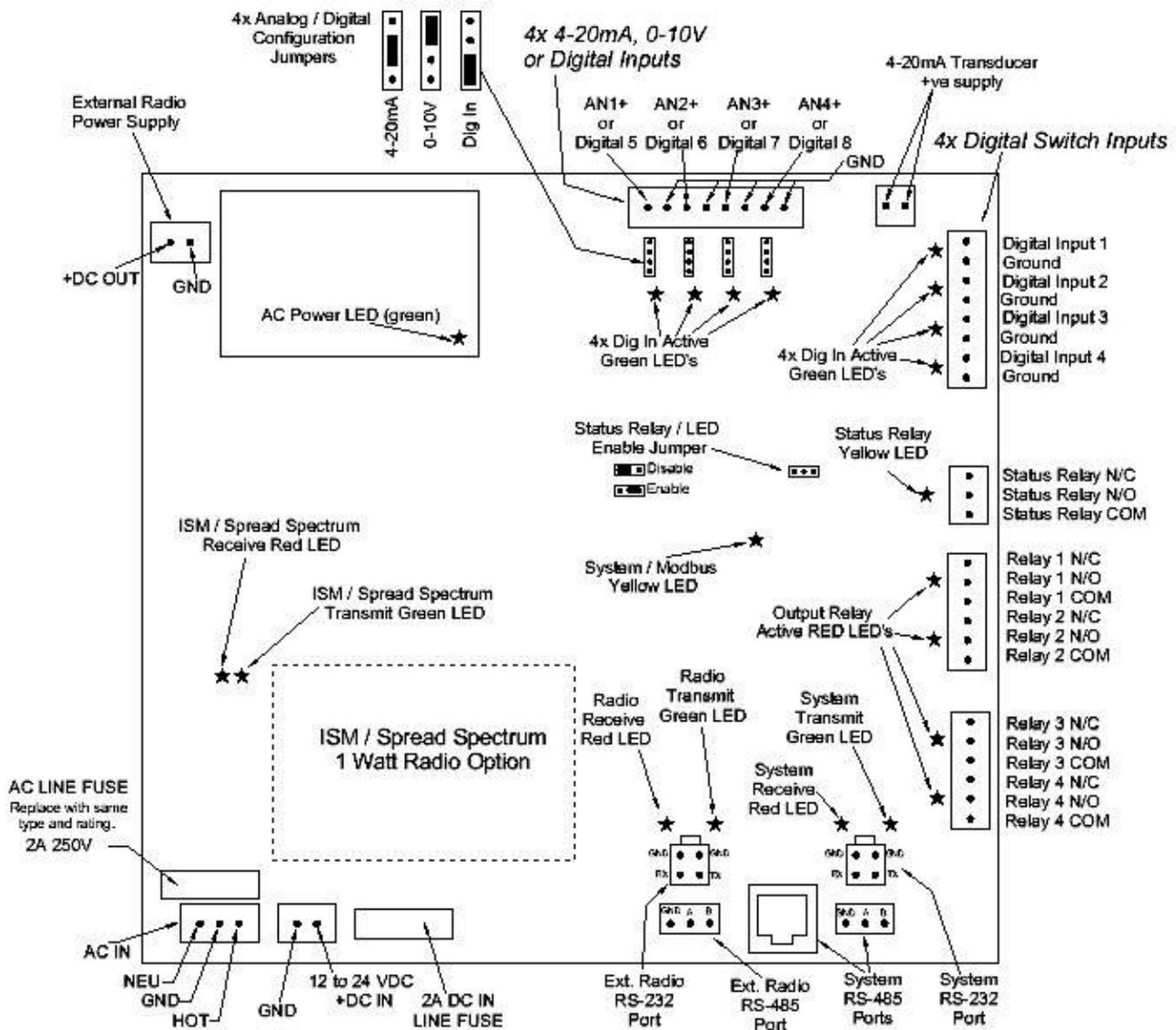
***COMPONENT IDENTIFICATION,
SIGNAL & WIRING REFERENCE***

RFSCADA16 RFSCADA4

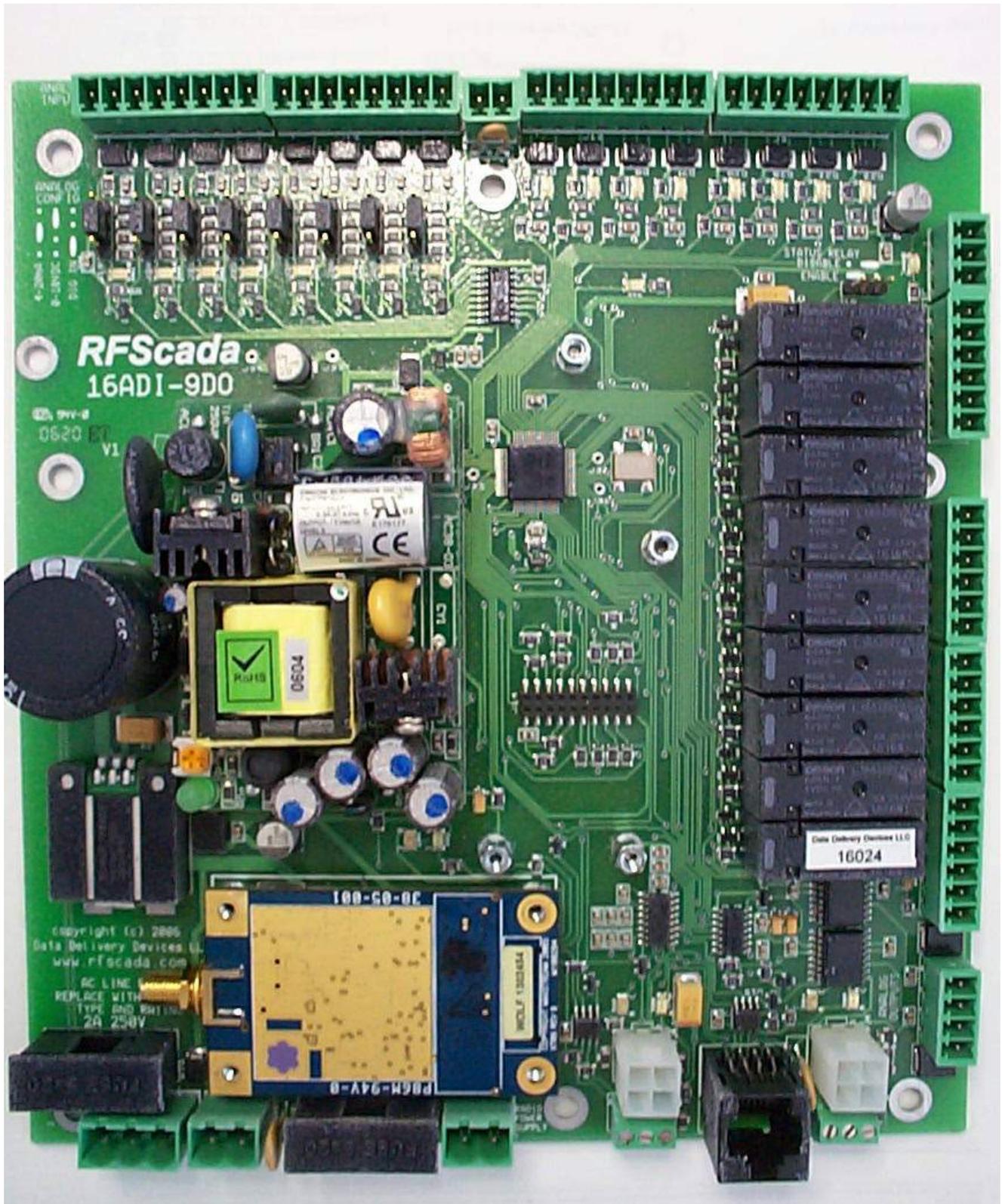
Remote Terminal Unit

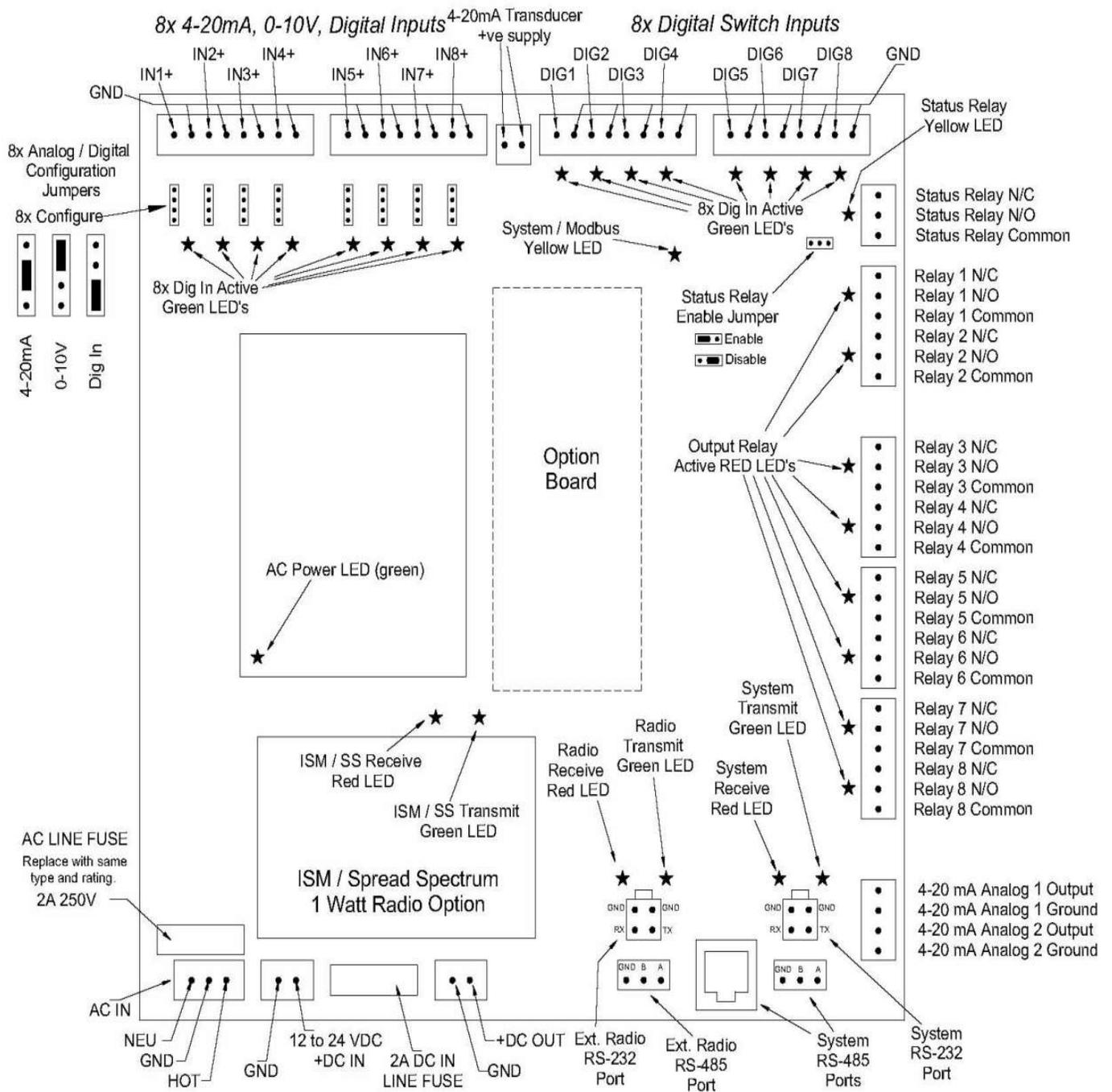
4ADI-5D02 Component / Connection Identification





16ADI-9D2A0 Component / Connection Identification





The following chart lists the connections and basic functions of all pins. Refer to the detailed notes for an explanation of each function. Items marked ‘*’ apply to the 16ADI-9D2AO only. Note that the connector nomenclature is the same for all boards, for example J1 is the AC power connection on the 4ADI-5D02 and the 16ADI-9D2AO models.

Ref	Pin	Function
J1	1	117 VAC Line Hot AC power in
J1	2	Ground In
J1	3	117 VAC Line Neutral AC power in
J18	1	4-20 mA transducer positive power supply output
J18	2	4-20 mA transducer positive power supply output
J6	1	Analog Channel One positive input
J6	2	Analog Channel One return (connected to ground)
J6	3	Analog Channel Two positive input
J6	4	Analog Channel Two return (connected to ground)
J6	5	Analog Channel Three positive input
J6	6	Analog Channel Three return (connected to ground)
J6	7	Analog Channel Four positive input
J6	8	Analog Channel Four return (connected to ground)
J10*	1	Analog Channel Five positive input
J10*	2	Analog Channel Five return (connected to ground)
J10*	3	Analog Channel Six positive input
J10*	4	Analog Channel Six return (connected to ground)
J10*	5	Analog Channel Seven positive input
J10*	6	Analog Channel Seven return (connected to ground)
J10*	7	Analog Channel Eight positive input
J10*	8	Analog Channel Eight return (connected to ground)
J12	1	Local contact input One (5 Volt DC via 1 K Ohm pull up resistor)
J12	2	Local contact input One (connected to ground)
J12	3	Local contact input Two (5 Volt DC via 1 K Ohm pull up resistor)
J12	4	Local contact input Two (connected to ground)
J12	5	Local contact input Three (5 Volt DC via 1 K

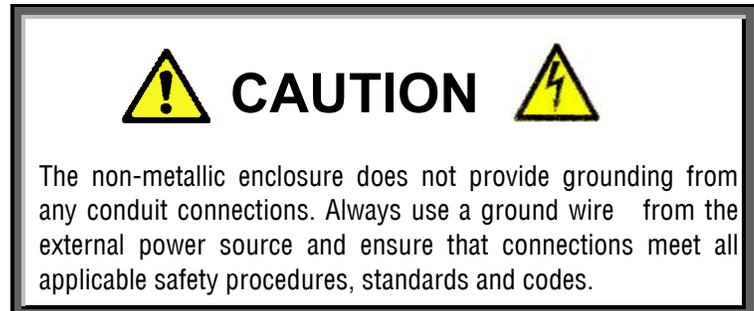
		Ohm pull up resistor)
J12	6	Local contact input Three (connected to ground)
J12	7	Local contact input Four (5 Volt DC via 1 K Ohm pull up resistor)
J12	8	Local contact input Four (connected to ground)
J3*	1	Local contact input Five (5 Volt DC via 1 K Ohm pull up resistor)
J3*	2	Local contact input Five (connected to ground)
J3*	3	Local contact input Six (5 Volt DC via 1 K Ohm pull up resistor)
J3*	4	Local contact input Six (connected to ground)
J3*	5	Local contact input Seven (5 Volt DC via 1 K Ohm pull up resistor)
J3*	6	Local contact input Seven (connected to ground)
J3*	7	Local contact input Eight (5 Volt DC via 1 K Ohm pull up resistor)
J3*	8	Local contact input Eight (connected to ground)
J11	1	Network status relay contact normally closed
J11	2	Network status relay contact normally open
J11	3	Network status relay contact common
J4	1	Relay one contact normally closed
J4	2	Relay one contact normally open
J4	3	Relay one contact common
J4	4	Relay two contact normally closed
J4	5	Relay two contact normally open
J4	6	Relay two contact common
J5	1	Relay three contact normally closed
J5	2	Relay three contact normally open
J5	3	Relay three contact common
J5	4	Relay four contact normally closed
J5	5	Relay four contact normally open
J5	6	Relay four contact common
J7*	1	Relay five contact normally closed
J7*	2	Relay five contact normally open
J7*	3	Relay five contact common
J7*	4	Relay six contact normally closed
J7*	5	Relay six contact normally open
J7*	6	Relay six contact common
J8*	1	Relay seven contact normally closed
J8*	2	Relay seven contact normally open
J8*	3	Relay seven contact common
J8*	4	Relay eight contact normally closed

J8*	5	Relay eight contact normally open
J8*	6	Relay eight contact common
J15	1	RS-232 Modbus Transmit Data
J15	2	RS-232 Modbus Receive Data
J15	3	RS-232 Modbus Ground
J16	1	RS-485 Modbus 'A' Transmit / Receive Data
J16	2	RS-485 Modbus 'B' Transmit / Receive Data
J16	3	RS-485 Modbus Ground
J16	4	RS-485 Modbus Ground
J16A	1-8	RS-485 Modbus connection & power to RFScada display unit
J2	1	External DC Voltage input positive 10 to 28 Volts DC
J2	2	External DC Voltage input negative (connected to ground)
J17	1	Fused DC Supply Output positive (for external radio, (4ADI-5DO only)
J17	2	DC Supply Output negative (connected to ground, for external radio, 4ADI-5DO only)
J19	1	RS-232 External Radio Transmit Data
J19	2	RS-232 External Radio Receive Data
J19	3	RS-232 External Radio Ground
J20	1	RS-485 External Radio 'A' Transmit / Receive Data
J20	2	RS-484 External Radio 'B' Transmit / Receive Data
J20	3	RS-485 External Radio Ground
J29*	1	Analog Output 1
J29*	2	Analog Output 1 Ground
J29*	3	Analog Output 2
J29*	4	Analog Output 2 Ground

All signals are identified by the preceding diagram and chart. Note that not all the connections need to be used; these will vary depending on the application.

J1, AC Line Input

This is 115 VAC line power and ground connection to the unit. Note, depending upon local codes grounding may also need to be provided from the steel plate which supports the main board.



If the RFScada unit is operating from an external DC supply this connector may not be used. Note that when the connector is plugged in it prevents access to the units AC fuse; power must be removed to change the fuse. The RFScada units have extensive AC and DC surge and lightning protection, including 150 VAC MOV protection across the AC input after the main fuse. 150 Volt devices are used instead of the more common 130 Volt devices to prevent nuisance trips that may be caused by unstable power surges, weak power systems, operation from generators etc. The RFScada units may operate either from 115 AC power or low Voltage DC, both may be safely connected at the same time. Both of these units have an AC power supply capable of operating from 85 to 264 VAC, however the 150V AC MOV is normally installed across the AC line input. If operation at higher than 140 VAC is required please contact the factory for information on ordering a unit with a higher voltage rating or for information on installing a higher rated MOV in the field.

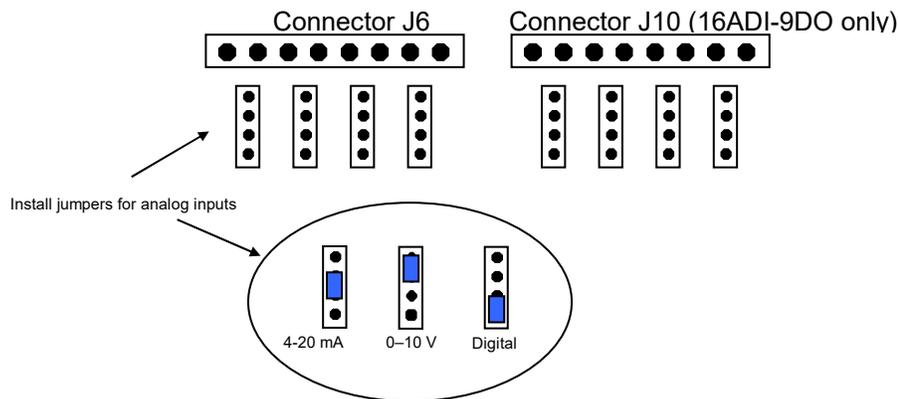
J18, 4-20mA Transducer Power Supply Output

This connector provides a DC power supply for external 4-20mA transducers that require power. The DC voltage is approximately 15 Volts DC when the RFScada device is operating from AC power, and approximately 1 Volt less than the DC Voltage if operating from DC power. This supply is protected on the RFScada board with an electronic fuse, and if too much current is drawn the load will have to be removed then restored before power is returned.

J6, J10 Analog Inputs

There are the eight analog inputs to 16ADI-9D2AO and four on the 4ADI-5DO2. The analog inputs may be individually configured, in the field for 4-20mA, 0-10 Volts DC or digital type input.

Configuring Analog Inputs of 4ADI-5DO2 and 16ADI-9D2AO



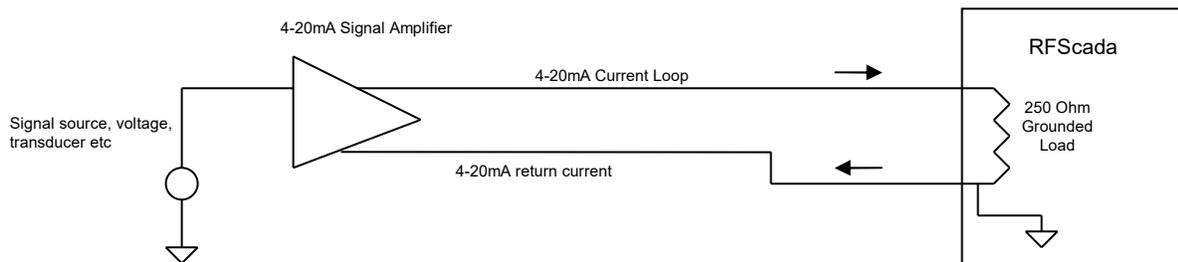
When configured for 4-20 mA each of the inputs presents a load of 250 Ohms to ground for the external circuit, so each input may also be used for a 0 to 5 Volt DC input providing the external circuit is capable of driving the load. Each analog input is protected against overloads to approximately 14 Volts DC by TVSS devices on the board that will clamp signals above that level. Permanent damage to the external or input circuitry may occur above these levels. If possible a current limited power supply, or even a resistor in series with each current loop, may be used to limit current in case the external 4-20mA transducer is accidentally shorted or fails. The full scale reading will occur at 20mA input current, so no indication will occur if the input current limit is exceeded. The RFScada units have a built in power supply specifically for external 4-20 mA transducers, or external signal sources may supply the 4-20mA power required. Note that all references to 4-20mA input actually allow accurate signal measurements from 0 to 20mA, so broken 4-20mA 'loops' may reliably detected. See the following examples for some connection possibilities.

When the units are configured for 0-10VDC each analog input presents a load of 2KOhms to the applied signal.

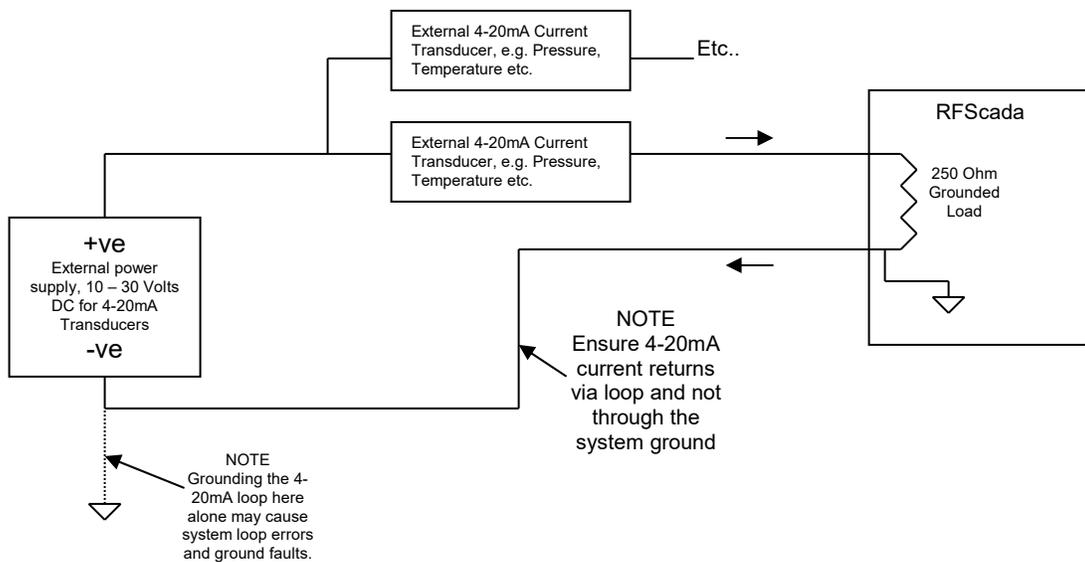
If the analog inputs are configured for 'digital operation' then the analog inputs may be used as a standard digital input or for pulse counting. For the 4ADI-5DO2 analog input 1 will appear as digital input 5, analog input 2 as digital input 6, analog input 3 as digital input 7 and analog input 4 as digital input 8. These

may be used as standard digital signal sources for output control. For the 16ADI-5DO the analog inputs appear as digital inputs 9 to 16 when configured for digital operation. In this case PC scada software may read the additional digital inputs, but they cannot be used as digital 'sources' in stand alone systems.

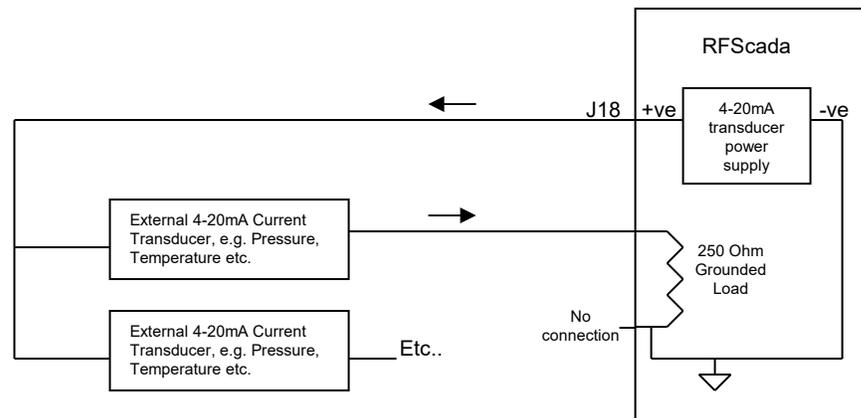
External signal amplifier, PLC or PC with analog 4-20mA output



External DC power supply and 4-20mA transducers



External transducers using RFScada's built in 4-20mA transducer power source

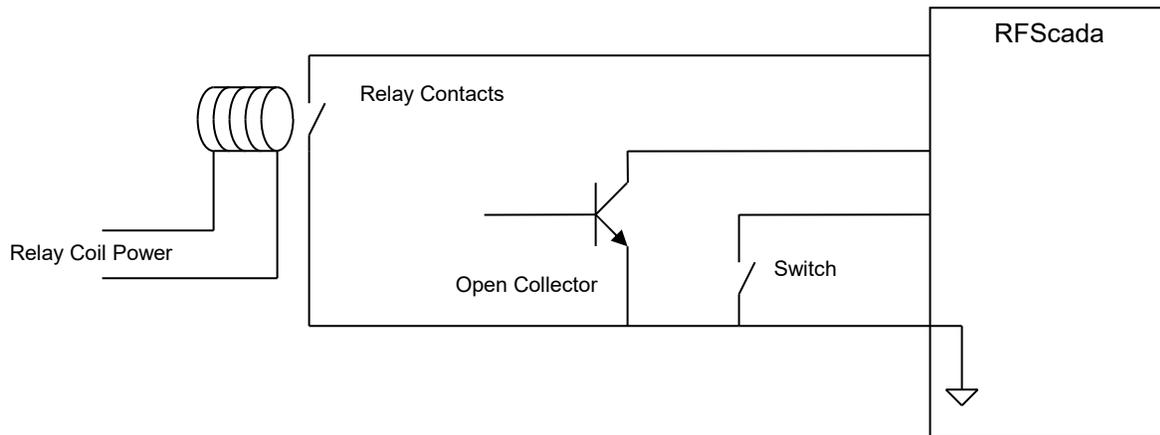


If possible each input should have its own current return (the even numbered pins on these connectors) to maintain highest accuracy, however they may share ground connections in some cases to save wiring. Do not use the system ground as a return for the current loops when using an external supply, as it may cause errors and external 'ground fault' protectors may trip. Since each input is grounded the RFScada unit must be the only 'grounded' part of the current loop if several devices are in series in a 4-20mA loop. The hardware converter for each analog input measures at 12 Bit accuracy, but the readings are converted to 10 bit resolution for transmission (0.09775% accuracy, representing 0.01955mA per bit). There are several ways to supply 4-20mA signals and power to the RFScada units, the previous diagrams shows some possibilities.

J12, J3 Local Contact Inputs

These are transient protected, dry-contact switch or logic level inputs to the RFScada device. Each of the inputs is pulled up to 5 Volts DC via a 1K Ohm resistor, so the inputs may be activated either by a shorting switch contact to ground or they may be directly driven from an 'open collector' logic level.

Examples of Digital Signal Input Methods



Each input connection has a corresponding ground connection on connectors J12 and J3, but it is permissible for these switch inputs to share a common ground connection to save on wiring. Note that each of these inputs is protected from Voltage surges and impulses by individual TVSS surge protectors, which short-out negative Voltages and clip any Voltage spikes above approx 6 Volts DC, preventing damage to the RFScada unit. **Under no circumstances should any external voltage be applied to these connectors, as damage may occur.** Since these inputs are protected from Voltage spikes and surges the input signals may be run substantial distances without risk of damage. When each input is 'active', i.e. shorted to ground, a corresponding green LED will illuminate next to the active input. If a TVSS input protection device had been damaged due to excessive input current the LED may remain on and the input appear to be active all the time, even with no input switch or signal connected.

J11 Network Status Relay Contacts

J11 is connected to the contacts of a single-pole double-throw relay, which respond to the state of the system 'network' state. This relay and LED will be continually energized (LED on), when this unit *and all other configured units in this network* are successfully operating and communicating amongst one another. If this relay and LED is slowly toggling on and off it indicates *that this unit and the master unit* are successfully communicating, but at least one unit in the network is not responding. In this case normally all outputs, both analog and digital, will revert to an inactive (i.e. off) state. (See the section on 'Comm Fail Override' options for alternative methods of operation). If this relay and LED are continually off it indicates

that this unit and the master unit are not communicating, and again all outputs, both analog and digital, will revert to an inactive (i.e. off) state.

This LED and relay are very useful, as they indicate status of the complete system from every unit, if the LED and relay are active the complete network and all units are operating correctly. The relay contact is rated for 8 Amps at 115 VAC, or 5 Amps at 30 V DC. If loads greater than this are to be controlled a suitable larger capacity relay could be driven from these.

For some solar powered applications where power consumption is important this relay may be disabled, so saving power (approx. 30mA on 12 VDC systems). The relay may be disabled by moving a jumper on the board. All the software settings are unaffected by this jumper; it merely physically disables power to the relay. Once the system has been verified fully operational the jumper may be placed in the power save position; of course it may be placed back in the normal position to verify correct operation at any time.

These connect to the contacts of single-pole double-throw relays, with each relay driven from its 'configured' input signal source. Each relay has a corresponding red status LED by the connector, for visual indication of the output state. Note that the relays will normally only become active when the system network status is good; (see the section on 'Comm Fail Override' options for alternative methods of operation). Each relay contact is rated for 8 Amps at 115 VAC, or 5 Amps at 30 V DC. If loads greater than this are to be controlled a suitable larger capacity relay could be driven from these.

This connector brings out the Modbus, or configuration communications signals from the RFScada unit at RS-232 levels. Note that the RFScada boards have both RS-232 and RS-485 interfaces built in, normally only one is used at a time. The changeover between RS-232 and RS-485 is automatic. Refer to the 'Modbus Configuration, Control and Monitoring' section for further details on PC programming and connection.

This connector brings out the Modbus, or configuration communications signals from the RFScada unit at RS-485 levels. Note that the RFScada boards have both RS-232 and RS-485 interfaces built in, normally only one is used at a time. The changeover between RS-232 and RS-485 is automatic. Refer to the 'Modbus Configuration, Control and Monitoring' section for further details on PC programming and connection.

J4, J5, J7 & J8 Output Relay Contacts

System Modbus RS-232

System Modbus RS-485

External Radio / RFScada Network RS-232

This connector brings out the communications signals from the RFScada unit to other RFScada units at RS-232 levels. Note that the RFScada boards have direct board mounted ISM radio, RS-232 and RS-485 interfaces built in. Depending on attached radios it may be possible to operate more than one interface at the same time. The changeover between RS-232 and RS-485 is automatic.

External Radio / RFScada Network RS-485

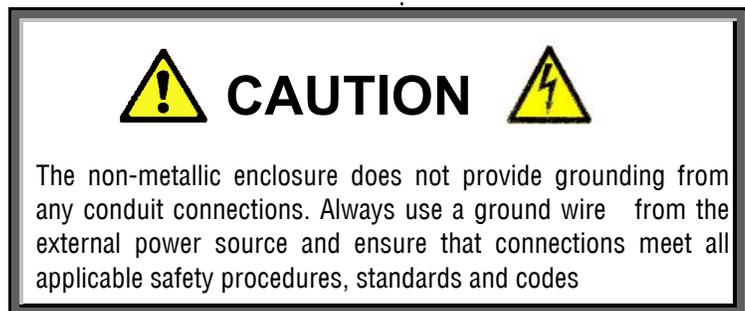
This connector brings out the communications signals from the RFScada unit to other RFScada units at RS-485 levels. Note that the RFScada boards have direct board mounted ISM radio, RS-232 and RS-485 interfaces built in. Depending on attached radios it may be possible to operate more than one interface at the same time. The changeover between RS-232 and RS-485 is automatic.

J2, External 10 to 28 Volt DC Input

This is the low voltage input power connector, and if used may be connected to a 10 to 28 Volts DC external power source. Note that pin 2 is connected to ground on the circuit board and is common to all the other pins that connect to ground. If an external ground is not connected via the 115 VAC power connector (J1), then an external ground should be connected to this pin. Note, depending upon local codes grounding may also need to be provided from the steel plate which supports the main board.

The units are diode protected from reverse polarity, have an electronic fuse protecting the on board components, a mechanical (2A 250VDC) fuse protecting the 'pass thru' external radio connection and are also protected by a TVSS surge protectors (33 Volt rating) so care should be taken to prevent exceeding the DC Voltage rating.

If the DC Voltage exceeds the rating the unit may shutdown due to the electronic fuse tripping. If this occurs DC power will need to be removed and restored after a few seconds to resume normal operation.



The RFScada units may operate either from 115 Volts AC power or low Voltage DC, both may be connected at the same time.

RFSkada Network Transmit / Receive LED's

These two LED's (red receive, green transmit) illuminate each time the unit completes a data transmission or verified data reception with another RFSkada device. Normally the two LED's will be flashing in sequence as the unit communicates with other units. If the unit receives data not intended for it the red LED may flash but not the green; so in systems with more than one slave the receive LED may flash many times before a transmission occurs. If the receive LED flashes quickly but the transmit LED never flashes it is possible the master is configured not to communicate with this particular slave unit. If the receive LED flashes slowly (approximately once per second) it indicates that this slave unit is not detecting any transmitted data. If the transmit LED flashes but not the receive LED it indicates that this unit is the network master but no slaves are responding to the transmitted data. These two LED's give a quick indication of communications, and are very useful in the case of marginal data communications, configuration setup or antenna adjustments. Remember that the yellow 'network state' LED and relay will also give indication of the network status at all times.

I SM High Power Radio Transmit / Receive LED's

These two LED's (red receive, green transmit) illuminate each time data is transmitted or received from the ISM spread spectrum high power radio transceiver. Depending on the mode it is programmed to operate in the LED's may flash multiple times for each transmission and reception. These LED's are not used with any other radio option.

System Transmit / Receive LED's

These two LED's (red receive, green transmit) illuminate each time the unit completes a data transmission or verified data reception with a PC or other connected device via Modbus. If the unit receives data not intended for it or does not understand the data then the red LED may flash but not the green.

System / Modbus LED

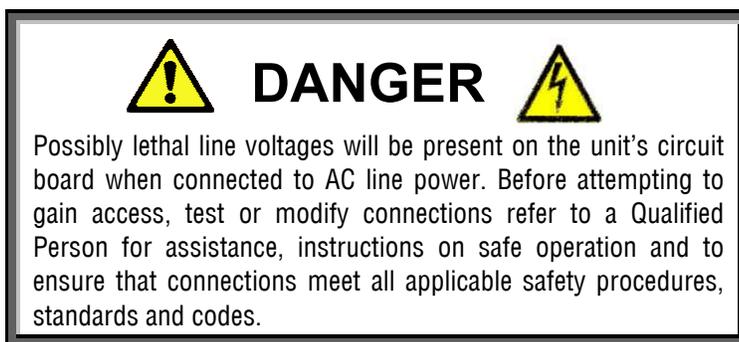
This yellow system / Modbus LED indicates system activity, such as during a power up, each Modbus or configuration data reception. It will also flash slowly for a few seconds when configuration settings are being stored in the non volatile memory.

Antenna Connector

If board mounted radio options are installed this connection will be used for either the internal or external antenna. Note that this precision connector is very fragile; care should be taken when removing or installing antenna connectors. Do not use the internal antenna to support the board assembly if it has to be removed. See the section on external antennas for more details.

F1, AC Power Fuse

A user replaceable fuse and a transient arresting MOV protect the board.



The fuse will blow if there is a malfunction in the circuit, or a voltage greater than the board rating is applied to the AC line input. The fuse is located underneath a safety cover. To test and replace the fuse proceed as follows:

First remove the AC and DC (if used) power to the unit. Then open the unit and unplug the AC power connector J1 to allow access to the fuse. Remove the fuse safety cover which also holds the fuse. Using an Ohm Meter measure the resistance of the fuse, if the resistance is high or infinite the fuse has failed and needs to be replaced. If it has failed discard and replace with a spare 2 Amp 250VAC fuse that is supplied with the unit. Do not use a fuse with any other rating. Replace the fuse safety cover. To check AC operation any external DC supply, if connected, must also be removed. If the unit does not power up correctly please contact Data Delivery Devices LLC for assistance. Once correct operation has been verified the DC supply, if used, may be re-connected.

**SYSTEM CONFIGURATION &
PROGRAMMING**

**RFSCADA16
RFSCADA4**

Remote Terminal Unit

System Configuration

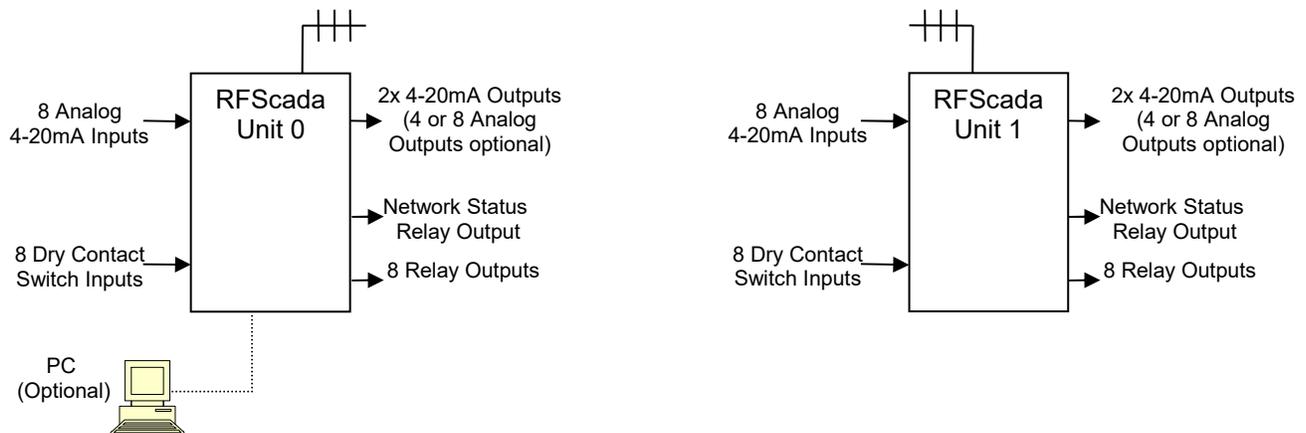
When the RFScada units are shipped they will already be configured for the final application, and no further programming, configuration or adjustments are required. Each unit stores its own settings inside non volatile memory where they will remain until the unit is reconfigured. Connection to power is not required to maintain these settings, there are no batteries or similar volatile devices required for storage.

It may, however be necessary to change settings in the field if additional units are added to the system or changes in the configured settings are desired. It may also be desirable to monitor and possibly control conditions at various units using a computer. The RFScada units have this capability built in, and by using a standard PC with suitable software virtually every input, output and configuration setting may be monitored or changed by the user, even remotely over a phone line. It is also possible to permanently store new configuration settings in each unit.

PC software provided allows units to be reconfigured. The software also has basic monitoring and control capability, to allow the user to monitor or make simple control adjustments in the field. Some basic configurations follow, then details for using the configuration software.

There are literally millions of ways that the RFScada units may be configured, routing signals from any input on any unit to any output on any unit in a system. The following diagrams contain examples to explain some of the possible configurations.

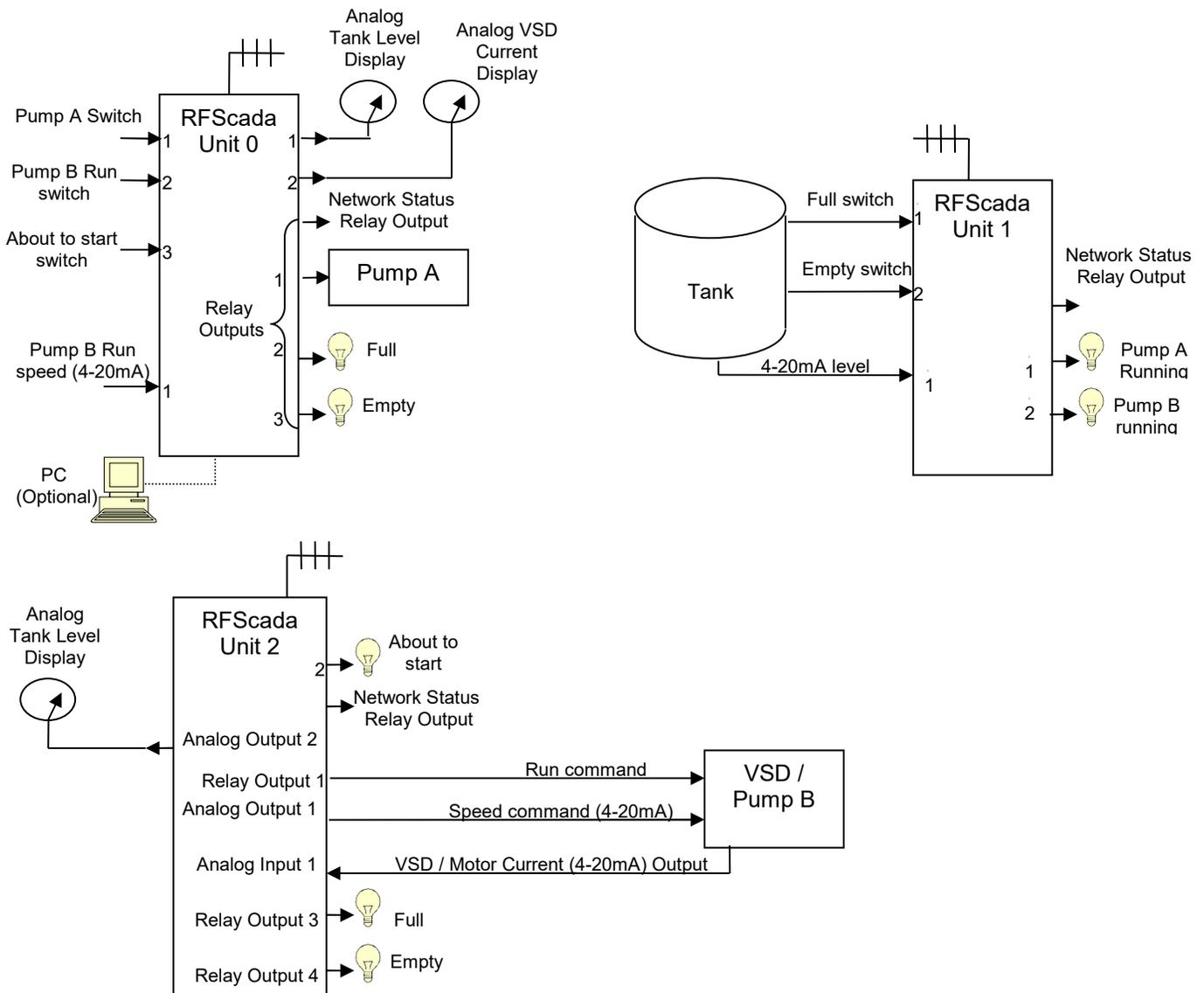
Basic system with two units



Here the eight digital switch inputs from unit 0 are mimicked by the eight output relays on unit 1. The eight digital switch inputs from unit 1 are mimicked by the eight output relays on unit 0. Two analog inputs from unit 0 are transmitted to unit 1. Standard units have 2 analog outputs, but 4 or 8 channel output options are available. If any of these options are installed in unit 1 then each analog output on unit 1 will mimic the corresponding analog inputs on unit 0. Similarly, unit 1's analog inputs are transmitted to unit 0, which will output them if the analog output options are installed. The network status output relay on each unit will indicate verified communications between units. By changing the system configuration any input may drive any output, so for example switch input 3 on unit 0 may be configured to control relays 4 & 8 on unit 0, plus relays 1, 3 & 4 on unit 1. Similarly analog input 6 on unit 1 may be configured to drive analog output 1 & 2 on unit 0 plus analog outputs 1 & 2 on unit 1. Although not required, a PC may simultaneously be connected (either locally or via a modem) to monitor every analog and digital input on the network; the PC may also be used to override or force any analog or digital input, allowing complete monitoring and control capability for the whole wireless system.

Simple system with three units

In this example a remote tank is filled from two pumps in separate locations. The tank has a full and empty pressure switch, plus a 4-20mA liquid level transducer. One pump, marked A, is controlled by a relay on unit 0. The second pump, marked B, is driven via a variable speed drive, which in turn is stopped and started plus the speed is controlled via the RFScada units. Here is how the signals are routed. The full and empty switches on unit 1 are sent to the full and empty status lamps on units 0 and 2. The tank level measured at the analog input of unit 1 is sent to the analog output 1 on unit 0 for local level display at unit 0, and also to analog output 2 on unit 2, for tank level indication at the VSD pump station. A switch input on unit 0 controls the relay output for pump A on unit 0, plus the warning light A at the tank. Switch input 2 on unit 0 drives the



VSD start contact, driven via an output relay on unit 2 plus a warning light B at the tank. The VSD speed command is sent to an analog output on unit 2 from an analog input on unit 0. The pump B motor current is sent from an analog input on unit 2 to be displayed on an analog meter, output at unit 0.

The table summarizes the signal routing.

Signal Output	Signal Source
Unit 0 Relay 1	Unit 0 Digital Input 1
Unit 0 Relay 2	Unit 1 Digital Input 1
Unit 0 Relay 3	Unit 1 Digital Input 2
Unit 1 Relay 1	Unit 0 Digital Input 1
Unit 1 Relay 2	Unit 0 Digital Input 2
Unit 2 Relay 1	Unit 0 Digital Input 2
Unit 2 Relay 2	Unit 0 Digital Input 3
Unit 2 Relay 3	Unit 1 Digital Input 1
Unit 2 Relay 4	Unit 1 Digital Input 2
Unit 0 Analog 1	Unit 1 Analog Input 1
Unit 0 Analog 2	Unit 2 Analog Input 1
Unit 2 Analog 1	Unit 0 Analog Input 1
Unit 2 Analog 2	Unit 1 Analog Input 1

Even with simple systems such as this and just a few signals it can quickly become complicated. With the capability for 16 inputs and 16 outputs on every unit, and 32 units in a system it can become very complex. Fortunately the RFScada units may easily be configured using software supplied by Data Delivery Devices LLC. Configuring the units is straightforward, quick and often requires just configuring a single unit. It may even be performed via a phone line if suitable modems are available.

First of all a basic understanding of how the complete system operates will make it easier to understand the configuration process. One unit in a system is designated the 'master' unit, and is identified by its ID of zero. There must be one, and only one master in a system. This master unit contains all of the configuration settings for the complete system, in an essentially similar (but much larger) form to the table above. It polls each configured 'slave' unit in turn, collects analog and digital data from all units in a system, and at the same time it sends the correct data to each unit that requires it, routing data depending upon the masters system configuration table.

Each slave device in a system must also have a unique id, which can be 1 to 31 (255 if a PC is used). The master will only communicate with slaves it is configured for, so time is not spent polling unused units. All units, the master and all slaves, are physically similar (apart from optional plug in boards) and only differ in how they are configured, meaning any unit damaged in the field may be replaced with another after a

simple configuration change. The only reason to configure slave units is to assign id's (or to change a few specialized settings such as timeouts or Modbus settings); since **all signal routing is performed by the master unit**. The configuration software allows the factory and user to route these signals as desired. The configuration may then be permanently stored in the RFScada master units memory.

Using the Configuration Program.

We will use the above example of a tank and two pumps to step through complete configuration of three RFScada units, routing all the required analog and digital inputs and outputs. To use the configuration program first a suitable cable is required, to connect between the PC and the RFScada device. Usually a standard PC RS-232 connection is used. (details about the RS-485 interface are described further on in the Modbus section). It is assumed that the RS-232 interface will be used here, although the configuration program may use either interface.

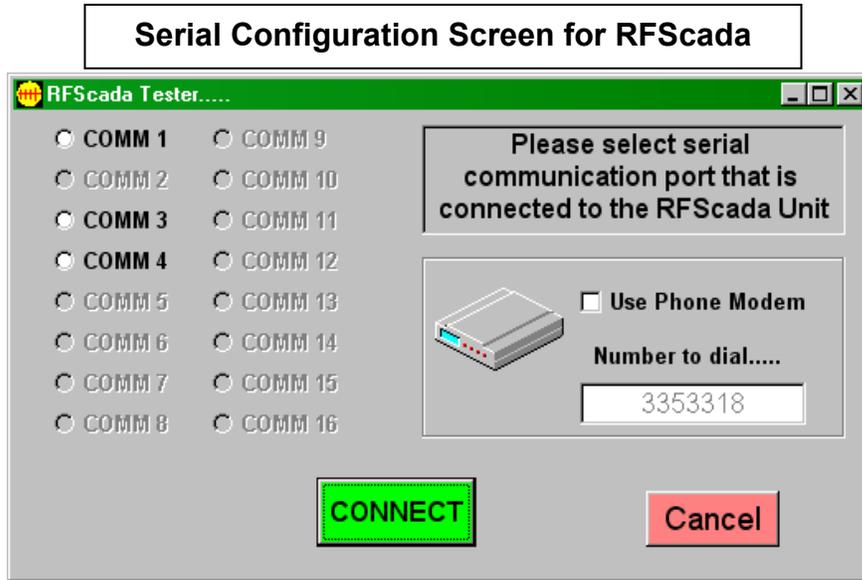
Standard PC's have an RS-232 serial port (typically a 9 pin male connector, occasionally a male 25 pin on the rear of the PC) which connects via a suitable cable to J15 on the RFScada board. A suitable cable is available from Data Delivery Devices LLC for connection to a PC's RS-232 port, or use the following table for connections if constructing you own cable.

<i>PC RS-232 to RFScada Interface Connections</i>			
Signal	9 Pin PC Serial Port	25 Pin PC Serial Port	RFScada
Received Data to PC	Pin 2	Pin 3	J15 Pin 1
Transmit Data from PC	Pin 3	Pin 2	J15 Pin 2
Ground	Pin 5	Pin 7	J15 Pin 3
Shield Ground	Shield	Shield	J15 Pin 4

Instructions for installing the configuration software are supplied with it, so they are not repeated here. Note that in the following diagrams the actual screen shots and colors may vary somewhat, depending on factors such as the computer type, screen resolution, number of colors and the version of Windows being run.

When first started the program will prompt the user for the appropriate serial port to use. The program will locate, test and enable selection of suitable and available serial ports on the PC. The program automatically searches for 16 serial ports even

though few PC's have more than two; this is primarily for PC's with shared 'modem pool' modem or communication ports. In the following example three ports are available. If the connection to the RFScada unit is via a phone line and modems then check the appropriate box and enter the phone number to dial. Note that even if the PC modem is an 'internal' unit it will usually have a 'comm' port associated with it, in this case the appropriate port must also be checked. Once the serial port details have been selected click 'OK' and the main configuration program will start.



As soon as the main screen appears the program will start trying to communicate with an RFScada unit. If it is unable to locate a unit within a few seconds an error message is displayed. The user may then try to correct the problem, or manually load configuration settings from a configuration file (see further on for details on loading configuration files). Depending on the connected units configuration one of two screens will be displayed. If the unit is already configured as a 'slave' a screen similar to the following will appear.

Example Configuration Screen for a unit configured as a Slave (ID 1 to 31)

Click button to read configuration of connected unit

This unit's configuration type (master or slave) and drop down ID selector

This unit's drop down timeout selector

Modbus specific settings for this unit (often not used).

This units S/W version

Restores settings to defaults

Writes present settings to RFScada RAM configuration memory

Writes present settings to RFScada EEPROM non-volatile configuration memory

If the screen does not look like this but rather looks like the 'master' configuration screen (see example further on) simply click on the units 'configuration type' drop down selector and change the value to 1; the screen will then switch to a 'slave' configuration screen as above.

On a slave configuration screen several items are displayed, some may be changed by the user and others are fixed. First of all the button on the top left hand side allows the user to read

the settings of any RFScada unit connected. Note that the configuration settings are read into the PC from the RFScada device on startup and read again each time this button is clicked. The settings inside the PC and displayed by this program may be changed by the user, but they ***will not be changed in the attached RFScada unit until the user clicks on one of the two 'write to RFScada' buttons*** on the lower right hand side. At the top center on the screen is the units configuration ID. This is the units present ID, which for a slave unit is always between 1 and 31. Each slave in a system must have its own unique ID; they do not need to be sequential. By clicking on the drop down ID box the user may change this units ID, note that changing it to zero will effectively change this whole screen to a 'Master configuration' screen, see later for details on it. Below the ID field is this units timeout. It is the maximum time that ***this unit*** will maintain its present state after loss of verified communications to the master unit, it may be changed by the user. Note that it is not the 'network status' timeout referred to in other parts of this manual, but a timeout for loss of communications between this unit and the master. When the mouse is moved to this location the cursor changes; clicking the timeout will then bring up a window where the timeout may be changed. The timeout may be extended to over a week; however for most applications it will be set to just a minute or two; as outputs may be held active for this length of time without signals from the master. Note that the delay time resolution is in 10 second increments; setting the timeout to 30 seconds means it may occur anywhere between 20 and 30 seconds. Below the timeout is the version of software installed in the RFScada unit. The three Modbus related settings are in the top right hand corner, they are not normally used for most applications. The Modbus section discusses these settings in detail and explains their use; unless a Modbus connection is made to this physical unit these settings will have no affect on operation.

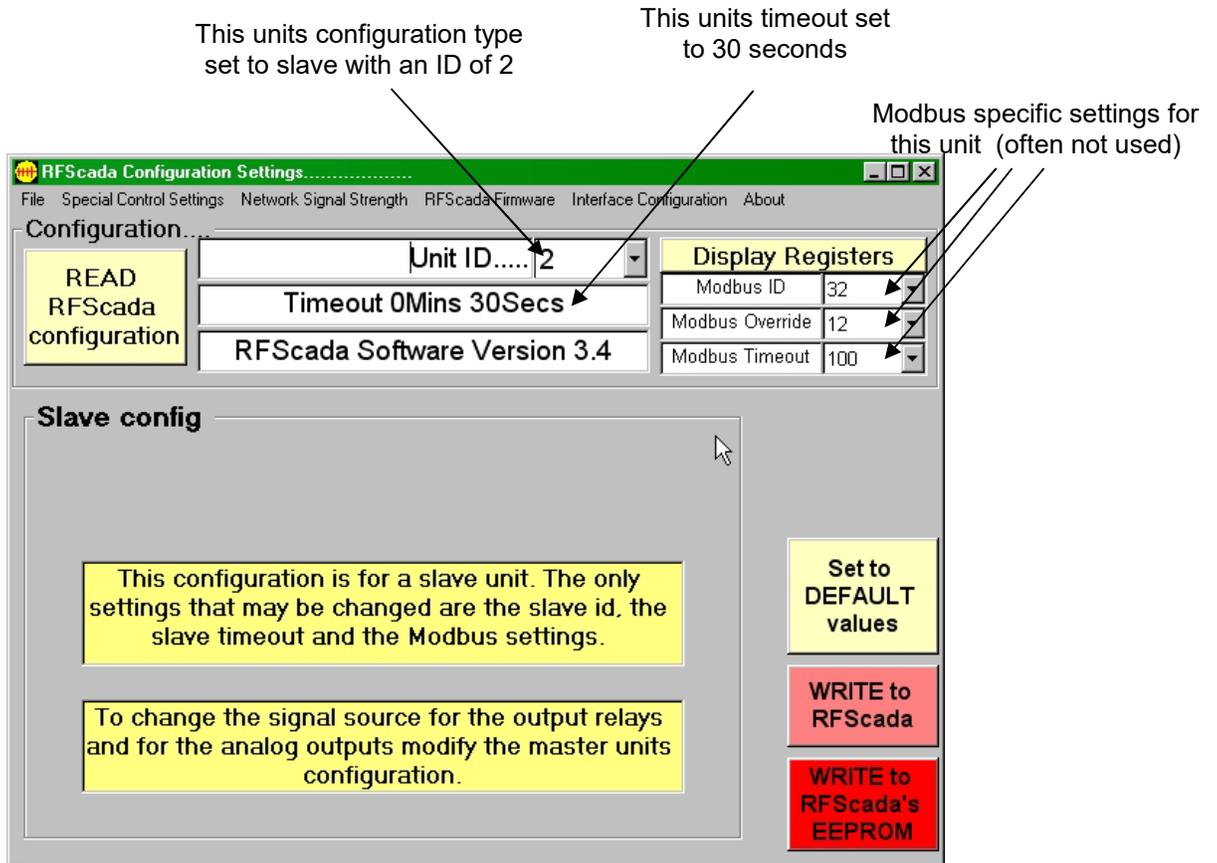
The 'Default Values' button changes settings to default factory values, it is mainly used in the Master configuration mode but also resets timers and Modbus settings in the Slave configuration mode here. The 'Write to RFScada' button will copy all settings from the PC program to the attached RFScada units RAM memory, immediately overwriting any existing settings. This is a useful way to test configuration changes quickly and easily, and these settings will remain in the RFScada unit ***until power is lost or they are overwritten again***. When lost power is restored the RFScada configuration settings are copied from non-volatile EEPROM to RAM, so any changes that are not stored in non volatile memory are lost. ***To permanently store settings so they will be restored after power failures the button in the lower right hand corner, 'Write to RFScada's EEPROM' must be used.*** It takes a few seconds to complete a write to the

RFScada configuration registers, so status is displayed to the user during these writes. Also, to ensure that these write buttons were not accidentally clicked a warning will appear and the user must confirm the action before the writes commence.

If this units configuration ID is not already set to one change it to 1 using the drop down ID selector. The timeout, shown set to 1 minute, will be suitable as this units relays just operate the two status lamps for pump A and pump B next to the tank. It means the lamps will remain on (or off) for 1 minute after communications have failed between this and the master unit. Now the settings need to be written to the RFScada's EEPROM. Click the button 'Write to RFScada's EEPROM' in the lower right hand corner of the screen, a warning and confirmation screen will be shown. This completes the configuration for unit 1, which now has its configuration stored in non-volatile memory. Although not necessary, power may be cycled to the RFScada unit, then the settings may be re-read to verify that they are correct. We can now disconnect this unit; it may be useful to mark its ID with a label for future reference since all units, including masters and slaves, may look physically identical but will act and respond differently.

The second unit, unit 2 in the above example, may now be connected and it too can be configured as a slave in a similar manner. Read its existing settings by clicking the 'Read RFScada Configuration' button. Set its ID to 2 as in the following diagram. This time we would like existing outputs to remain for 30 seconds in the case of communication failure, so the VSD will keep running in the event that power is briefly lost then restored at the master unit 0. After 30 seconds of lost communications all outputs at unit 2 will return to default (i.e. off) values. Again the Modbus settings at this unit do not matter. Save the settings into unit 2 by clicking on the button 'Write to RFScada's EEPROM' in the lower right hand corner of the screen and mark unit 2 for identification later.

Example Configuration Screen for a unit configured as a Slave with ID 2



Now it is time to connect and configure the master unit, which will route signals to both of the slaves. Once connected click on the 'Read RFSkada Configuration' button to read the settings from the unit. If a 'Slave configuration' type screen appears change the units ID to 'Master' (0), and a screen similar to the following will appear. Many of the master configuration settings and adjustments are similar in form and function to the slave configuration. The main difference, however, is the addition of a slider to select the slave, an enable button and two 'tables' that allow the source signal selection. The slider changes the unit number that is presently displayed and may be edited, in this diagram it actually refers to the master unit, or itself. By adjusting the slider each of up to 32 units may be selected for display. The checkbox enables or disables the selected unit, in this case the checkbox is checked but it may not be modified by the user, since the master unit is always enabled in a system.

Example Configuration Screen for a unit configured as the System Master (ID of 0)

Text displays which units configuration is displayed

Slider selects unit whose configuration is displayed

Click button to read configuration of connected unit

This units configuration type (master or slave) and ID

This units S/W version

Unchecked indicates unit outputs will be sourced from physical inputs

Modbus specific settings for this unit (often not used)

This units timeout

Displays Modbus ID, Modbus Override, Modbus Timeout

Selects special control modes

Control Mode: Normal

Unit Enabled Modbus Only

Relay Signal Source

Relay	Unit	Digital Input							
1	1	1	2	3	4	5	6	7	8
2	1	1	2	3	4	5	6	7	8
3	1	1	2	3	4	5	6	7	8
4	1	1	2	3	4	5	6	7	8
5	1	1	2	3	4	5	6	7	8
6	1	1	2	3	4	5	6	7	8
7	1	1	2	3	4	5	6	7	8
8	1	1	2	3	4	5	6	7	8

Analog Output Signal Source

Chan	Unit	Analog Input							
1	1	1	2	3	4	5	6	7	8
2	1	1	2	3	4	5	6	7	8
3	1	1	2	3	4	5	6	7	8
4	1	1	2	3	4	5	6	7	8
5	1	1	2	3	4	5	6	7	8
6	1	1	2	3	4	5	6	7	8
7	1	1	2	3	4	5	6	7	8
8	1	1	2	3	4	5	6	7	8

Box checked indicates this unit is enabled

Unit that supplies relay signal for relay 5

Input channel that supplies relay signal for relay 5

Unit that supplies analog signal for analog output 7

Input channel that supplies analog output signal for analog output 7

Writes present settings to RFScada RAM configuration memory

Writes present settings to RFScada EEPROM non-volatile configuration memory

Set to DEFAULT values

Restores settings to defaults

WRITE to RFScada

WRITE to RFScada's EEPROM

The lower left section shows a column of relay numbers, 1 to 8, which cannot be changed by the user. These refer to the eight output relays on the presently selected unit, in this case 0, the master. Next is a column showing units, these refer to the *unit that supplies the signal* for each relay. The user may select 0 to 31 as the unit source for each relay, here it shows each relay

using unit 1 as the signal source. To the right of the unit column are eight rows of selector 'boxes'. The boxes indicate the *digital input channel from the selected unit that supplies the signal for each relay*. By clicking on these boxes the user may change the digital input to be used as the signal source. Only one box may be selected per relay although all relays may share similar digital input 'sources'. The analog outputs are configured in a similar manner to the relays, with each output being matched to a source unit and channel.

Adjust the settings so they match the following picture, which is for routing the master, (unit 0) outputs. The unused outputs may be signal sourced from an unused unit and or input as shown, so power will not be wasted by energizing unused relays.

Configuration Screen showing the master (Unit 0) Relay and Analog Outputs

This indicates outputs being configured are the master units.

Relay 1 on the Master Unit will be driven by digital input 1 on unit 0

Relay 2 on the Master Unit will be driven by digital input 1 on unit 1

Relay 3 on the Master Unit will be driven by digital input 2 on unit 1

Relays 4 to 8 on the Master Unit will all be driven by digital input 8 on unused unit 31, i.e. disabled

Analog output 1 on the Master Unit will be driven by analog input 1 on unit 1

Analog output 2 on the Master Unit will be driven by analog input 2 on unit 2

RFSkada Configuration Settings

File Special Control Settings Network Signal Strength RFSkada Firmware Interface Configuration About

Configuration

READ RFSkada configuration **System Master (0) Master** **Display Registers**

Timeout 2Mins 30Secs

RFSkada Software Version 3.4

Modbus ID 32

Modbus Override 12

Modbus Timeout 60

Master Output Signal Source

Unit Enabled Modbus Only Control Mode Normal

Relay Signal Source			Analog Output Signal Source		
Relay	Unit	Digital Input	Chan	Unit	Analog Input
1	0	1	1	1	1
2	1	1	2	2	2
3	1	2	31	31	1
4	31	8	31	31	2
5	31	8	31	31	3
6	31	8	31	31	4
7	31	8	31	31	5
8	31	8	31	31	6

Set to DEFAULT values

WRITE to RFSkada

WRITE to RFSkada's EEPROM

Once the screen has been set to route the outputs of interest the next units routing may be configured. There is no need to store modified settings in the RFScada unit yet, as changes made will be retained in the configuration program unless new ones are loaded from an RFScada device. Click on the slider and move it to the right, so the routing for unit 1 is displayed. If the signal routing boxes are 'grayed', i.e. not enabled, then check the 'Unit Enabled' check box to both enable the unit and routing adjustments.

Configuration Screen showing Unit 1 Relay and Analog Output Signal Sourcing

Unchecked indicates unit 1 outputs will be sourced from discrete inputs

Checked indicates master will communicate with unit 1

This indicates outputs being configured are for Slave Unit 1.

Relay 1 on Unit 1 will be driven by digital input 1 on unit 0

Relay 2 on Unit 1 will be driven by digital input 2 on unit 0

Relays 3 to 8 on the Unit 1 will all be driven by digital input 5 on unit 0, i.e. unused

Analog output configuration does not matter, since unit 1 does not have any analog outputs

The screenshot shows the 'RFScada Configuration Settings' window. At the top, there's a menu bar with 'File', 'Special Control Settings', 'Network Signal Strength', 'RFScada Firmware', and 'About'. Below the menu bar, there are several control elements: a 'READ RFScada configuration' button, 'System Master (0)' and 'Master' dropdowns, a 'Timeout (seconds)' field set to '15', and 'RFScada Software Version 2.1'. To the right, a 'Display Registers' section shows 'Modbus ID' (5), 'Modbus Override Time' (20), and 'Modbus mS Timeout' (50). The main section is titled 'Unit 1 Output Signal Source'. It features a 'Unit Enabled' checkbox (checked) and a 'Modbus Only' checkbox (unchecked). Below this are two tables: 'Relay Signal Source' and 'Analog Output Signal Source'. The 'Relay Signal Source' table has columns for 'Relay', 'Unit', and 'Digital Input'. The 'Analog Output Signal Source' table has columns for 'Chan', 'Unit', and 'Analog Input'. On the right side of the main section, there are buttons for 'Set to DEFAULT values', 'WRITE to RFScada', and 'WRITE to RFScada's EEPROM'. A 'Control Mode' dropdown is set to 'Normal'.

Note that the text above the slider indicates these signal routings are for Unit 1. The settings and adjustments may again be changed so they match desired routing, and any unused outputs may be signal sourced from an unused unit. Since this unit does not have an analog output option the analog routing will have no effect. Once all settings are correct adjust the slider to display unit 2's routing. Unit 2's settings are shown on the following diagram. Again, note that unused relay or analog outputs maybe routed anywhere. Make sure the 'Unit Enabled' box is checked, to ensure that the master will include unit 2 in network communications.

Configuration Screen showing Unit 2 Relay and Analog Output Signal Sourcing

Unchecked indicates unit 2 outputs will be sourced from discrete inputs

Checked indicates master will communicate with unit 2

This indicates outputs being configured are for Slave Unit 2.

Relay 1 on Unit 2 will be driven by digital input 2 on unit 0

Relay 2 on Unit 2 driven by input 3 on unit 0

Relay 3 on Unit 2 driven by input 1 on unit 1

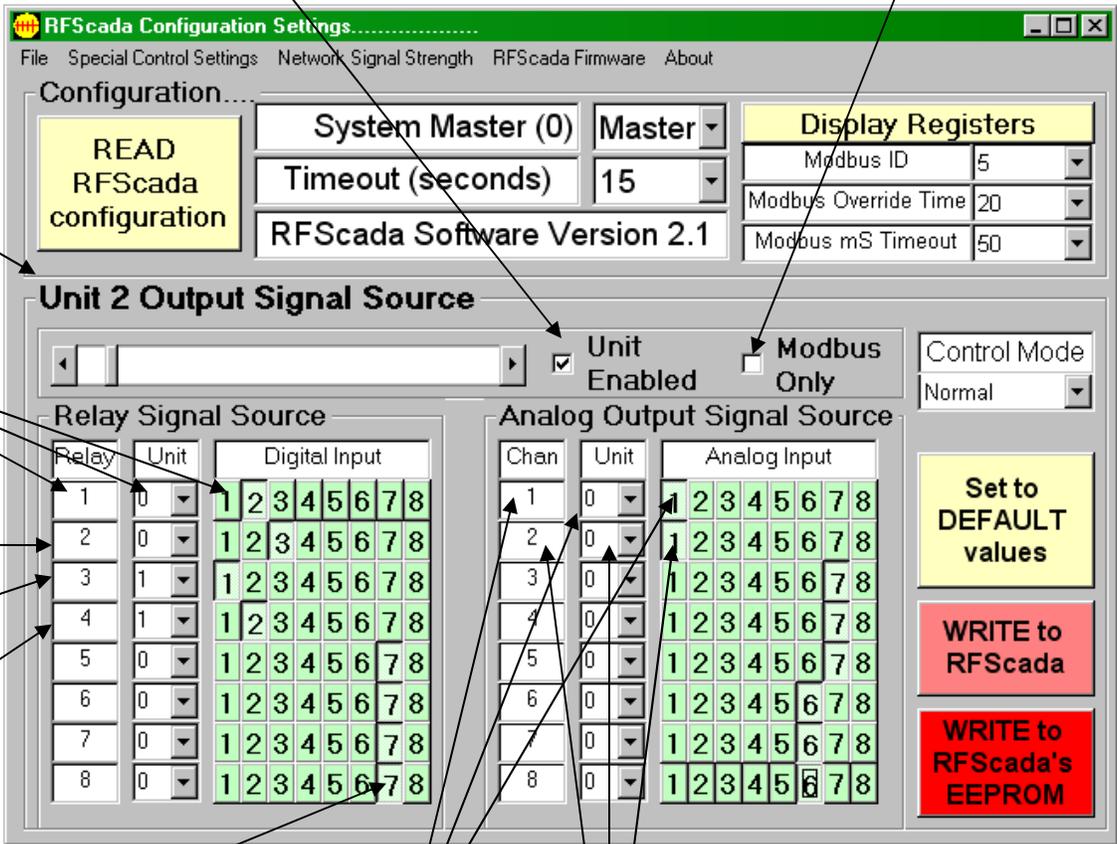
Relay 4 on Unit 2 driven by input 2 on unit 1

Relays 5 to 8 on the Unit 2 will all be driven by digital input 7 on unit 0, i.e. unused

Analog output 1 on Unit 2 will be driven by analog input 1 on unit 0

Analog output 2 on Unit 2 will be driven by analog input 1 on unit 1

Analog output configuration does not matter for channels 3 to 8



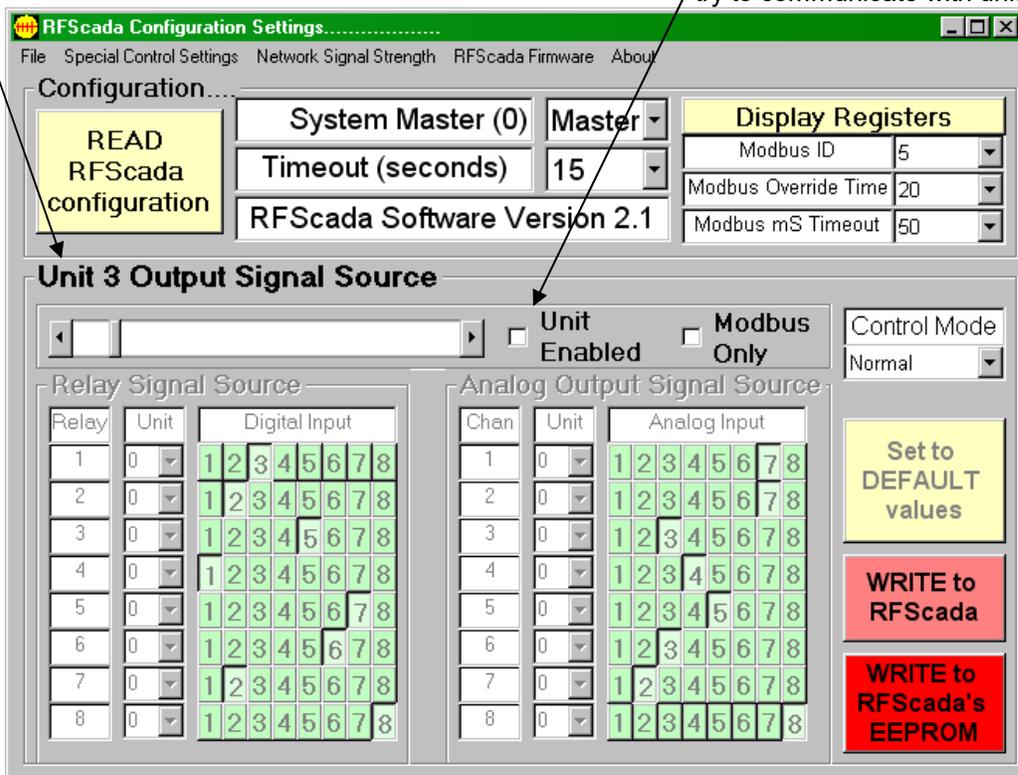
We have now almost completed the system configuration. We have set up output signal routing for the master unit (0) plus output signal routing for units 1 and 2. By checking the 'Unit Enabled' box when units 1 and 2 routing was displayed the configuration program was informed that the master needs to communicate with units 1 & 2; this RFSkada network will consist of three units, the master plus units 1 and 2.

All that remains is to verify that the master will not try to communicate with other units, and finally we can store all of these configuration settings in the master. Click on the slider again to view the routing for unit 3 (even though we do not wish to use unit 3). Since we do not want to try to communicate with unit 3 the 'Unit Enabled' check box should **not** be checked. This means the master will not attempt to communicate with it. The master will report a good network status, both via the status LED & relay plus to all other units, when it successfully communicates with all enabled units. So we must ensure that this box is not checked for unit 3 and it is not checked for the remaining 28 other possible units (ID's of 4 to 31). When the 'Unit Enabled' box is not checked the relay and analog output routing sections are disabled since they do not serve any purpose on unused units.

Example Configuration Screen for an Unused Unit Routing (ID of 3 shown)

This indicates configuration for slave Unit 3

Un-checked indicates master will NOT try to communicate with unit 3



Relay output routing is disabled since this unit is not enabled

Analog output routing is disabled since this unit is not enabled

By adjusting the slider all remaining possible configurations for slave ID's will quickly scroll by, and within a couple of seconds the user can verify that no other slave units are enabled. If they are enabled the corresponding 'Unit Enabled' check box may be un-checked.

Finally we can write these settings to the master unit. To save the system configuration click on the 'Write to RFSkada's EEPROM' button to store these settings in the RFSkada master units non-volatile memory. If the previously configured slave units are operating nearby several clicks may be heard as all of the units will start to communicate using the new configuration settings. All the analog and digital signals should now be routed to match the example of the tank and two pumps. The whole process took just minutes and all settings are permanently stored in the RFSkada units. The settings may also be stored on the local PC in a plain text file (actually as a list of Modbus registers and contents, see the Modbus section for further details) so they can be easily be copied into another system in the future. To save the configuration select the 'File - Save' menu, a prompt appears for a file name and location to save the settings as. A saved configuration may also be loaded in a similar manner using the 'File - Load' menu.

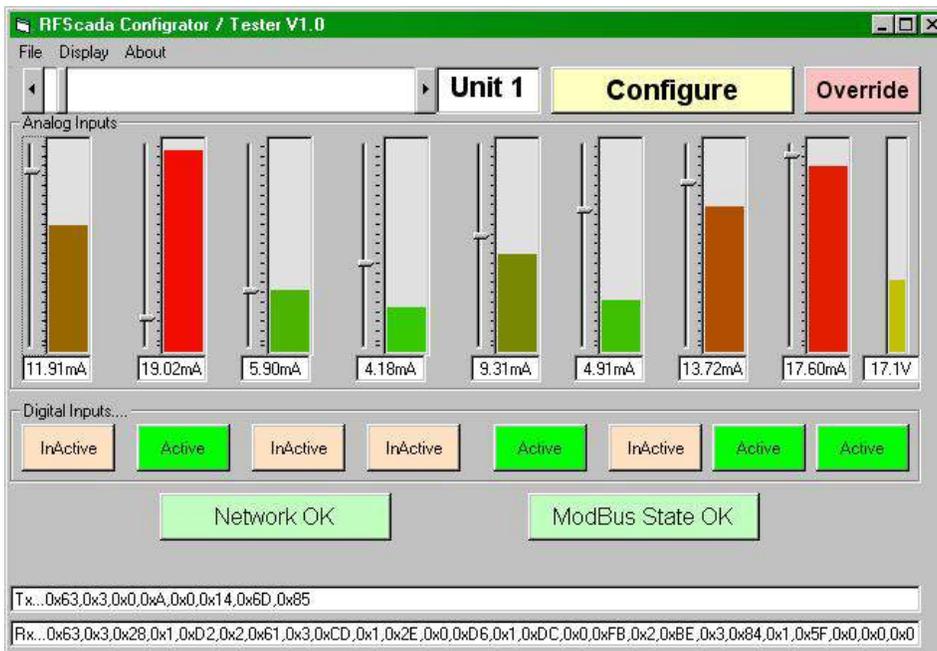
*MONITORING & OVERRIDING
REAL TIME INPUTS*

RFSCADA16 RFSCADA4

Remote Terminal Unit

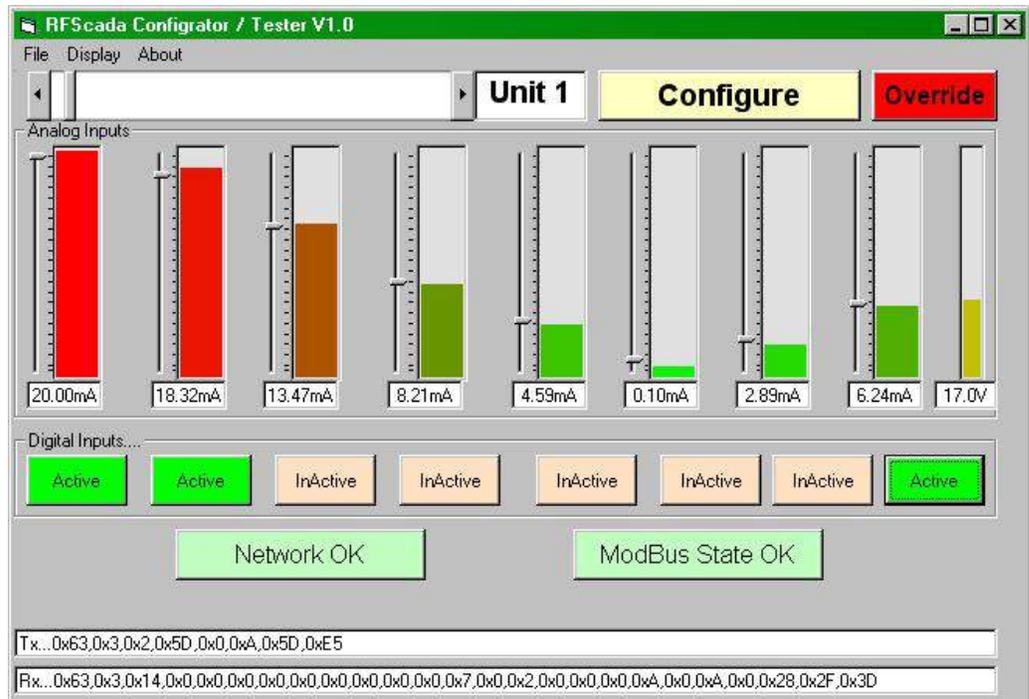
Monitoring and Overriding Real Time Inputs

Once the system is configured all units should communicate correctly with each other. By selecting 'Display Registers' from



the configuration program another screen is displayed, with graphs showing analog levels and 8 indicators for digital inputs. If the Modbus connected unit is a slave, all of the connected units analog and digital inputs may be monitored at once. If the Modbus connected unit is the master then **every unit's** analog and digital inputs may be monitored at once. Use the slider to select the unit to display. This is a very quick and easy way to monitor every input – even those miles away!. The DC Voltage measured at every unit is also displayed on the right hand side, very useful to see and monitor on remote solar powered systems. The two larger indicators below the digital input indicators show the real time 'Modbus State' between the PC and connected unit, the 'Network State' shows the real time condition of the RFScada network, in a similar mode to the 'Network state' LED on each unit. Additionally the actual Modbus data transmitted and received from the connected unit may be displayed at the bottom of the screen if required.

When displaying information from 4ADI-5DO2 units analog channel six displays the ambient temperature on the printed circuit board. The temperature is approximately (reading * 0.4902) - 60 in °Celsius, or $32 + (((\text{reading} * 0.4902) - 60) * 9) / 5$ in °Fahrenheit. When using the ISM high power option analog channel 5 corresponds to the received signal strength at that unit, so it is possible to read the signal strength at remote sites. The scale is from 0 (no signal) to approximately 290 (full signal). Note that it is normal for the reading to fluctuate.



Furthermore, every input, both analog and digital, may be 'overridden' using this display. Click on the 'override' button, which will start to flash. Now each input state display button may be clicked and will toggle between Active and Inactive, this will have the same effect as physically activating that particular digital input, which is being overridden for the selected unit. Similarly, the sliders next to each analog input display may be adjusted, and this will have the effect of overriding each analog input on the selected unit. This makes it very easy to test configurations and different setups, without requiring the actual final connected hardware. From the master units location (or via a serial port, phone/modem etc. connection to the master unit) complete setups can be tested, every remote input may be overridden and monitored, and system integrity can be verified. All signal routing (and special modes of operation) will still occur normally, as this mode effectively overrides the selected units inputs only, all other inputs on other units will still operate normally, and all outputs will operate normally, so it's very easy to see the effect of input changes on complex systems.

It is even possible to override units not configured for operation; so if another configured unit is set with the un-configured units inputs as its signal source it will react to Modbus overridden signals. This allows Modbus control of all outputs without overriding any physical 'active' unit. When the override button is clicked again the button will stop flashing, the display will revert to normal operation, and the unit which was being overridden will revert to providing normal data from its standard analog and digital inputs.

This change back to normal operation will be delayed until the programmed 'Modbus Override' time expires, typically several seconds. Allowing the unit to remain in the 'overridden' mode for a programmable time has several benefits. Although the RFScada configuration program 'register override' mode may be used for testing and configuration purposes it also provides complete monitoring and control capability of the whole system via Modbus.

Some users will want purchase or design their own control routines to run on a PC or PLC that (via Modbus) controls and/or monitors an RFScada network. This may be done using products such as DAQFactory®, Visual Basic®, Labview®, Wonderware® etc. or supplied by vendors such as Data Delivery Devices LLC. These programs continually read and write data on the RFScada network and since the data is continuously being written the RFScada network will output signals depending on a combination of the RFScada system configuration, the actual input signals and the Modbus 'overridden' signals. Any units that have been configured for 'Modbus only' control will only react to Modbus commands from the control system; typically this mode is for systems that rely on a PC to control the whole system. However, if the PC fails or loses power for example, once the 'Modbus Override' time expires without the connected RFScada receiving any valid Modbus data the RFScada reverts to the standard mode, which should be configured for a 'failsafe' condition. Therefore the complete system could revert to a known, safe condition in the case of a PC hardware or software failure.

To summarize, the RFScada system may be used in several ways.

- 1. As a standalone system it can route any analog input on any unit to any one (or more) analog outputs on any units. It also routes any digital input on any unit to any one (or more) digital outputs on any units. All units are aware of, and continually indicate, the confirmed operational status of all other units. If any unit fails all units can revert to a known state within a user programmed time.**
- 2. All of (1) plus the built in control routines, for complete, automated pump and tank control using either analog and/or digital inputs.**

-
- 3. All of (1) and (2) with the addition of monitoring any analog and digital input remotely using an RS-232, RS-485 or phone/modem connection via Modbus.**
 - 4. All of (1), (2) and (3) with the capability of overriding any analog and digital input remotely using an RS-232, RS-485 or phone/modem connection via Modbus.**
 - 5. All inputs may be monitored using an RS-232, RS-485 or phone/modem connection via Modbus using a program such as DAQFactory. All outputs may be directly controlled with the same program.**

This flexibility allows simple or very complex systems to be assembled, with many options possible. Call Data Delivery Devices LLC for advice on how your specific application may be configured; since units are pre-configured at the factory even complex systems usually require no setup in the field.

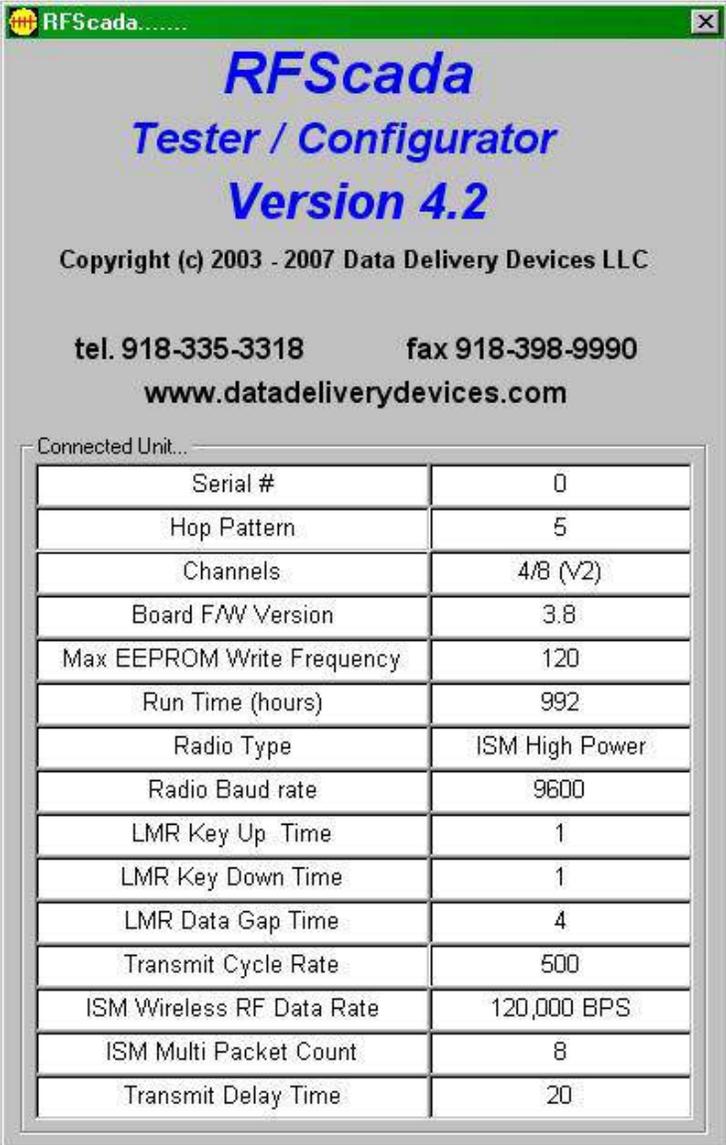
*GENERAL SYSTEM
INFORMATION*

RFSCADA16 RFSCADA4

Remote Terminal Unit

General System Information

Selecting the about menu from the RFScada configuration & tester program will display current information about the connected unit. An example of a typical display is shown below. Typically these parameters are set at the factory or depend on the units configuration.



RFScada
Tester / Configurator
Version 4.2

Copyright (c) 2003 - 2007 Data Delivery Devices LLC

tel. 918-335-3318 fax 918-398-9990
www.datadeliverydevices.com

Connected Unit...

Serial #	0
Hop Pattern	5
Channels	4/8 (V2)
Board FW Version	3.8
Max EEPROM Write Frequency	120
Run Time (hours)	992
Radio Type	ISM High Power
Radio Baud rate	9600
LMR Key Up Time	1
LMR Key Down Time	1
LMR Data Gap Time	4
Transmit Cycle Rate	500
ISM Wireless RF Data Rate	120,000 BPS
ISM Multi Packet Count	8
Transmit Delay Time	20

OPTION BOARDS

RFSCADA16 RFSCADA4

Remote Terminal Unit

Option Boards

Options are available from Data Delivery Devices LLC to add additional functionality to the RFSkada system. These boards plug into a connector and are secured to standoffs already mounted on the lower half of the main board. Some option boards may be stacked for maximum flexibility.

*SPECTRUM ANALYZER MODE
& NETWORK INTEGRITY*

**RFSCADA16
RFSCADA4**

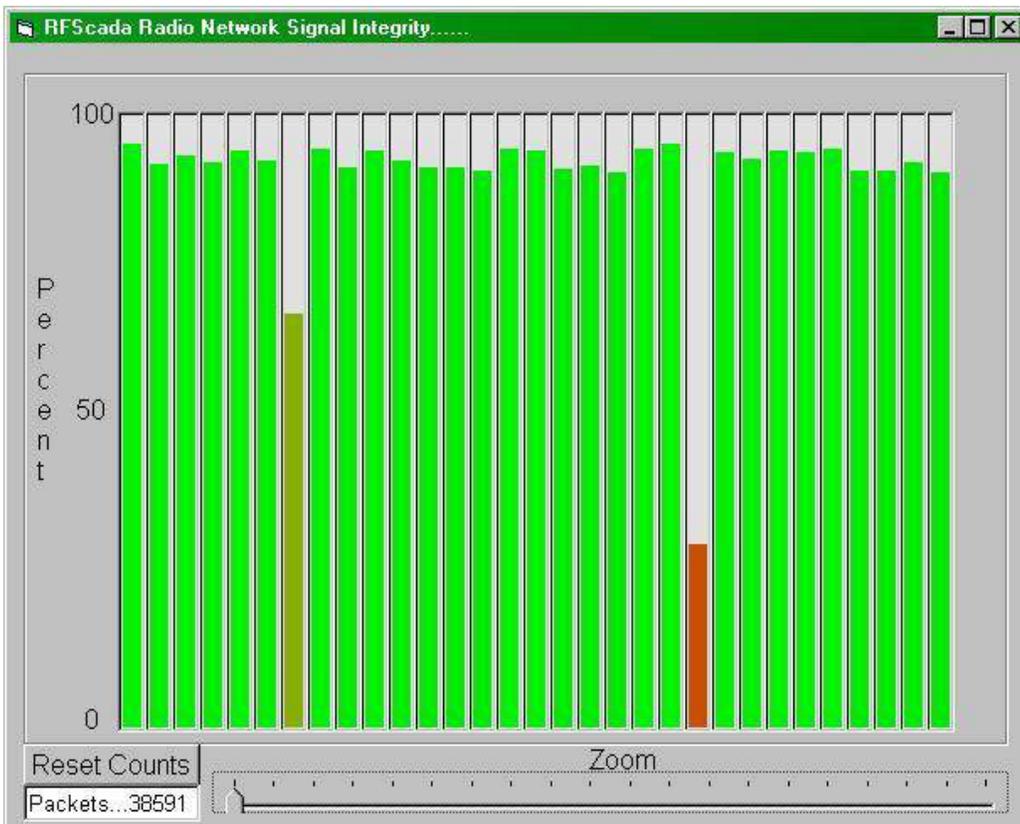
Remote Terminal Unit

Spectrum Analyzer Mode and Network Integrity

The RFScada units have extensive checksum and error detection for all exchanged data; any corrupted data is completely ignored by the system. If corrupted data continues to arrive without a good data packet for longer than the programmed 'timeout' value units will revert to a default state (unless the 'comm fail override' mode is enabled). As explained earlier the radio network state may be continually monitored from all units. For systems with many distributed units, in areas of heavy radio interference or many obstacles blocking reception an indication of relative signal integrity can be very useful. It allows identification of units in the network that may have a damaged antenna, require an additional directional antenna or perhaps need relocation.

The RFScada master unit keeps a continual log of data integrity, and when connected to a PC running the configuration and programming software the user may display a live spectrum analyzer display of data exchanged between all units. Operation is very straightforward, once the main program is running and connected to the master unit select 'Network Signal Strength' from the menu. Note that the connection must be to the master unit, as it is the only unit that has logged information on all data exchanged between units in the system.

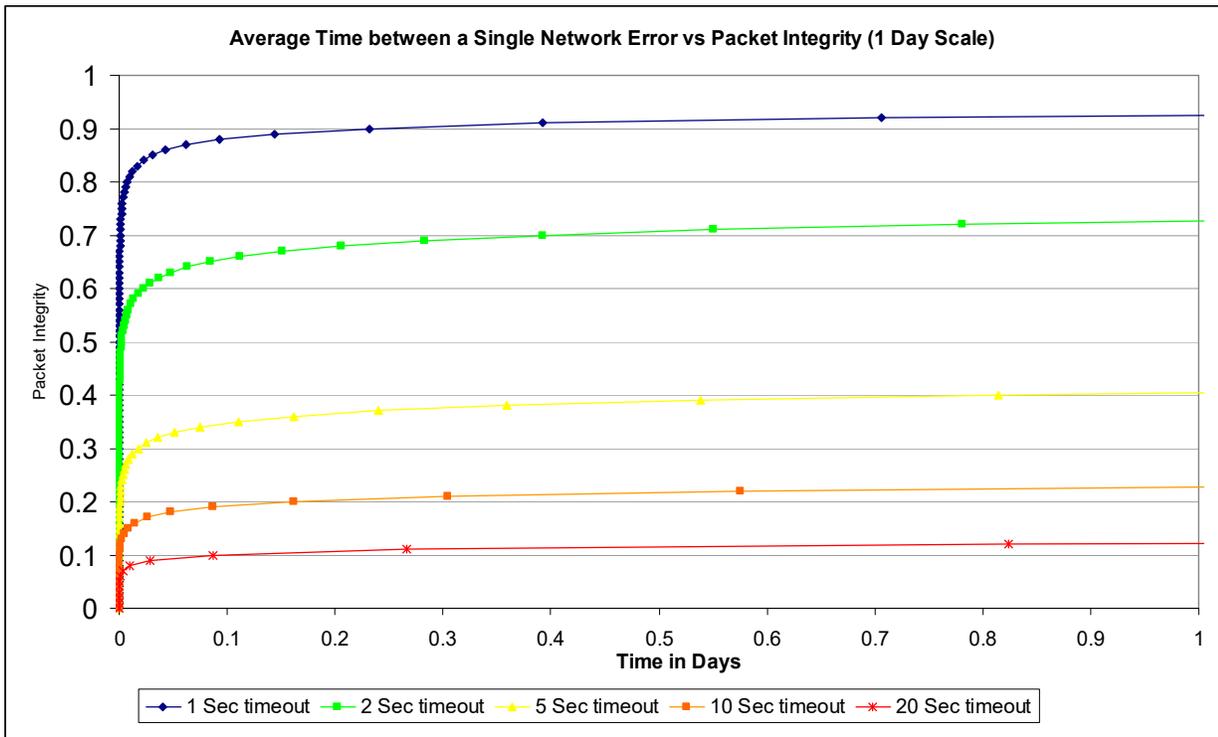
A screen similar to the following will be displayed:



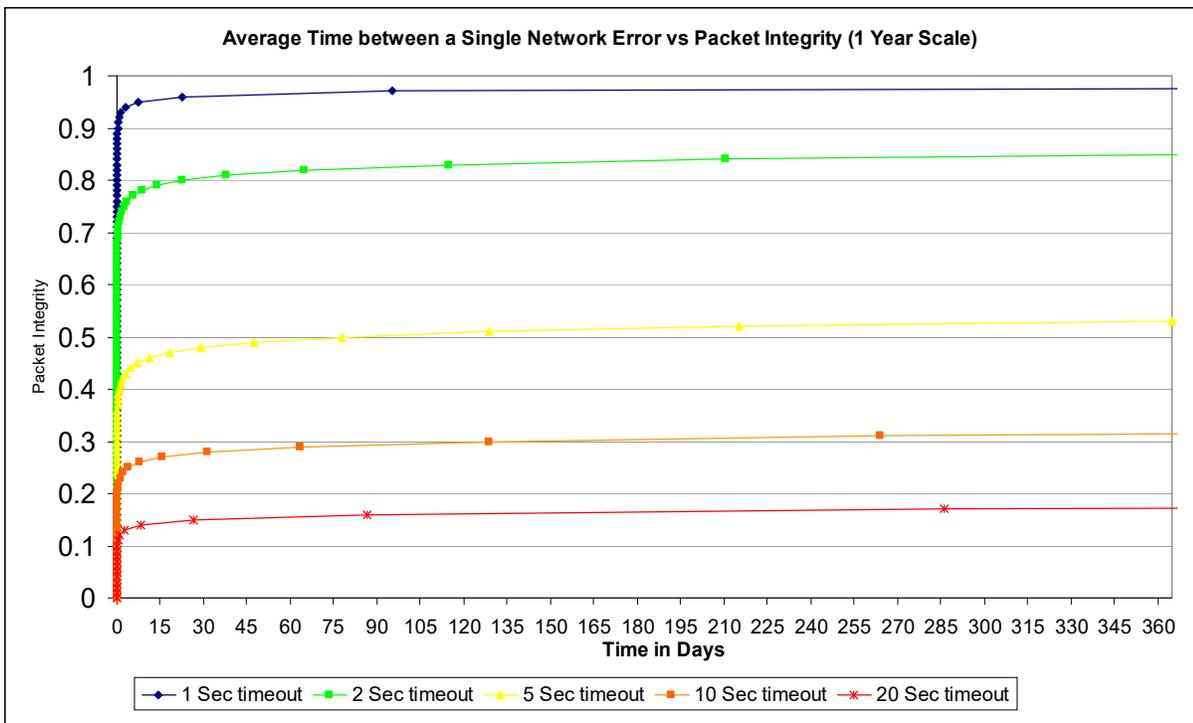
The 31 vertical columns represent the 31 possible slave units that may be in a system, unused ID's will have a vertical value of zero. The scale may be zoomed in by adjusting the zoom slider, and the accumulated packet counts being used for the analysis may be reset by selecting the 'reset counts' button. This is useful if a change has been made and the effects may be quickly observed. Note that larger samples give more accurate results. Moving the mouse pointer over each column will display the unit number and signal integrity as a percentage. In the example shown above there are 31 slave units in the network, and all but two have good signal integrity above 90%. Unit 7, showing an integrity of 67.9%, is located in another building some distance away with the antenna removed. Unit 22, with an integrity of 29.4% is in a remote location and has a directional Yagi antenna installed, but the antenna is aimed away from the master unit so nearly all of its signal is miss-directed. It is obvious from the spectrum analyzer where there is room for improvement in this system; but as will be shown it is still possible to operate the RFScada system with heavy interference and signal loss.

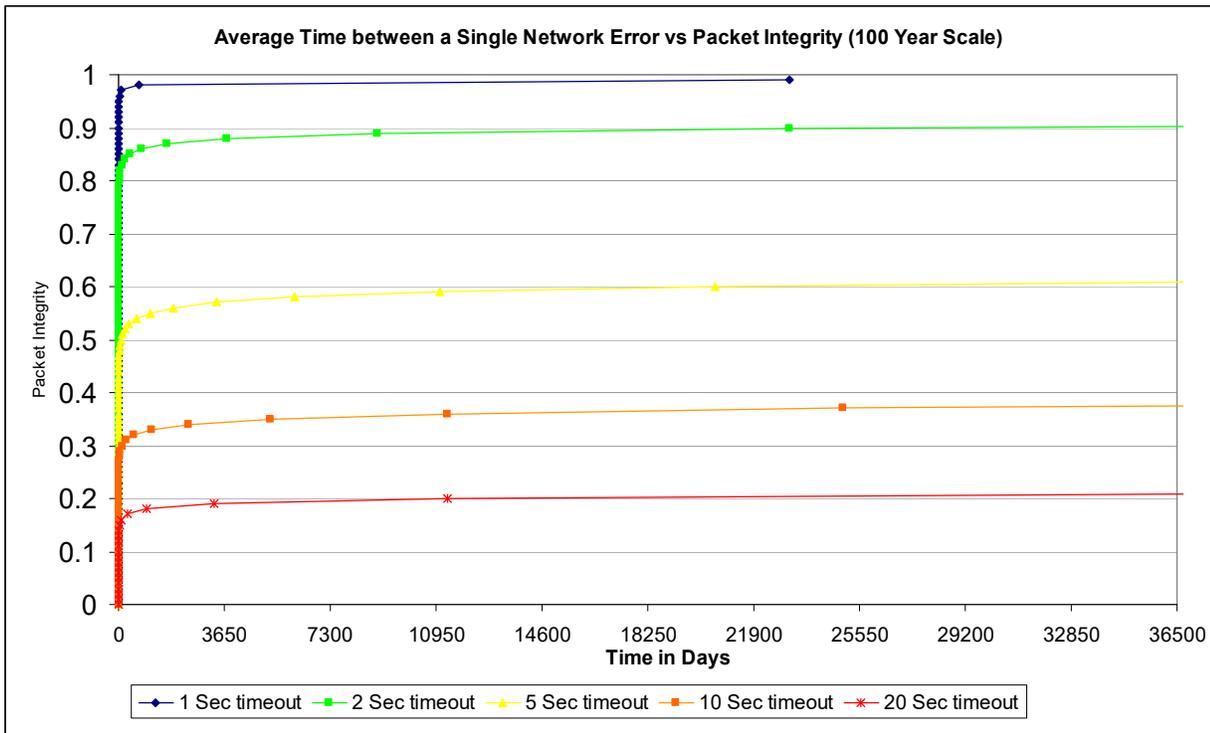
The signal integrity is defined as the number of good, verified packets received from a slave unit divided by the number of packets transmitted to the slave. In a perfect environment this value should be 100%, if every packet transmitted had a perfect response. In reality radio signals are subject to a constant barrage of interference, including random radio energy in the atmosphere, interfering devices such as cellular phones, microwave ovens, motor controls, vehicle engine controls, radio energy emitted from electrical discharges such as lightning many miles away etc. For this reason the RFScada units do not revert to a default state as soon as one corrupted packet arrives; rather they keep trying to communicate and maintain the current output values until another good packet is exchanged or the programmable timeout expires.

By ensuring that the signal integrity is as good as may be reasonably expected under the circumstances and by selecting timeout values that are not too short, the statistically calculated time between any single 'network error' will typically be in hundreds or thousands of years. The following graphs give an indication of the expected time between a single network error, where units would change to a default setting for a complete network scan time (0.15 seconds to approx. 5 seconds with ISM spread spectrum radios, and depending on the number of units in the network).



The graphs are identical, with identical data, but with 'zoomed in' time scales to see detail in the curves. They show time on the X axis as 1 day, 1 year and 100 years. Note that five data curves are shown, corresponding to timeout settings of 1, 2, 5, 10 and 20 seconds (the RFScada default setting is 10 seconds). As may be seen from the graphs, the timeout setting has a great influence on the packet integrity required to maintain reliable operation.





As an example we will assume the packet integrity is 80%. If the timeout is set at one second the system will probably generate a network error within a few minutes; for two seconds probably about 30 days, 5 seconds approximately once every 1,890,410,959 years. The RFScada default value of 10 seconds allows ample tolerance for reliable communications; even with a signal integrity value of 37% an error would only be expected once every 68 years. Extending the timeout to 20 seconds lowers the signal integrity required to approximately 20% for a similar time between errors. The timeout will probably never need to be changed unless the application has exceptional circumstances.

In most circumstances, over a long time period external radio interference will increase, buildings will appear, trees will grow, traffic will become more dense etc., so although the default settings may appear to be extremely conservative it is recommended that the timeout not be reduced from the default values unless absolutely necessary.

SPECIAL CONTROL MODES

RFSCADA16 RFSCADA4

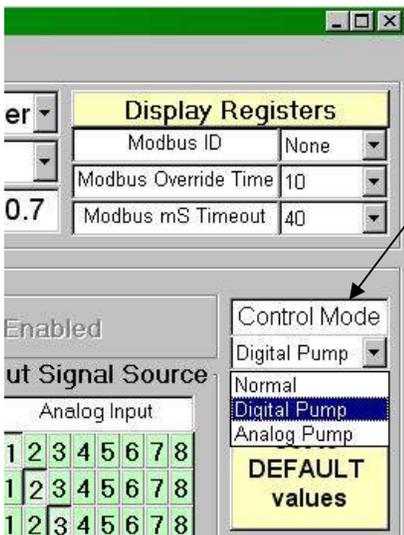
Remote Terminal Unit

Special Control Modes

The RFScada units allow remote signal routing of analog and digital signals. In some situations additional control modes are needed, for example controlling outputs depending on input conditions, or sequences of input conditions. Typically a PLC or similar control computer is used to provide this control 'logic'. The RFScada devices have certain control routines built in, for common control applications, saving the expense of additional controls. The special control modes may be enabled via Modbus register 615, or by using the drop down 'Control Mode' selection in the configuration program. All other RFScada functions operate normally even when the special control mode is enabled.

Generally all of the special control modes operate by 'overwriting' the non-existent unit 31's registers, so the special modes may only run in systems with less than 30 units. Each mode has specific registers in Unit 31 assigned for specific functions, depending on the mode selected. By routing signals in the normal way to and from Unit 31's registers any input or output on the system may be used as the control logic 'source' and 'destination'. A physical unit assigned to 'Unit 31' need not be present for special control mode operation, and the master configuration should be set to 'disable' unit 31, although it may be temporarily enabled to allow changes in Unit 31 routing and assignments.

Additional control modes may have been added since this was written, please contact the factory for further details or special requirements.



Digital Pump(s) Control Mode (1)

This mode is typically used to control the level in a tank, where the tank is equipped with a 'Full' level switch and also an 'Low' level switch. The tank is filled by one or more pumps, driven from relay outputs on the RFScaDa. In normal operation the pump is on until both the low and full inputs are active, when the pump will switch off (i.e. tank is full). The pump will remain off until both the full and low inputs become inactive, when the pump will turn back on (i.e. the level is just below the low switch). An error relay output will activate (and the pump / pumps will shut off) if just the 'full' but not the 'low' switch is active, since this condition should never occur in normal operation. Additional inputs can also be used to force the pump / pumps off and activate the error relay, these inputs would typically be connected to access door switches, gate interlocks etc. The full and low inputs may be supplied by any digital input on the network, and the pump and error relays may be any one (or more) relays on the network.

Many systems just run one pump at a time but have two for backup purposes, and a common requirement is to operate them sequentially, to verify operation of both units and to share wear between them. The control mode supports toggling of dual pumps, effectively replacing more external control logic.

In this mode the following assignments need to be made.

Unit 31 Relay 1 must be assigned to the 'Full' input (any digital input on any physical unit)

Unit 31 Relay 2 must be assigned to the 'Low' input (any digital input on any physical unit)

Unit 31 Relay 3 may be assigned to cause an error (Optional, any digital input on any unit)

Unit 31 Relay 4 may be assigned to cause an error (Optional, any digital input on any unit)

Unit 31 Relay 5 may be assigned to cause an error (Optional, any digital input on any unit)

Unit 31 Relay 6 may be assigned to cause an error (Optional, any digital input on any unit)

Unit 31 Relay 7 may be assigned to cause an error (Optional, any digital input on any unit)

Unit 31 Relay 8 may be assigned to cause an error (Optional, any digital input on any unit)

Unit 31 Digital Input 1 is 'active' to run a single pump. (assign pump relay to this input)

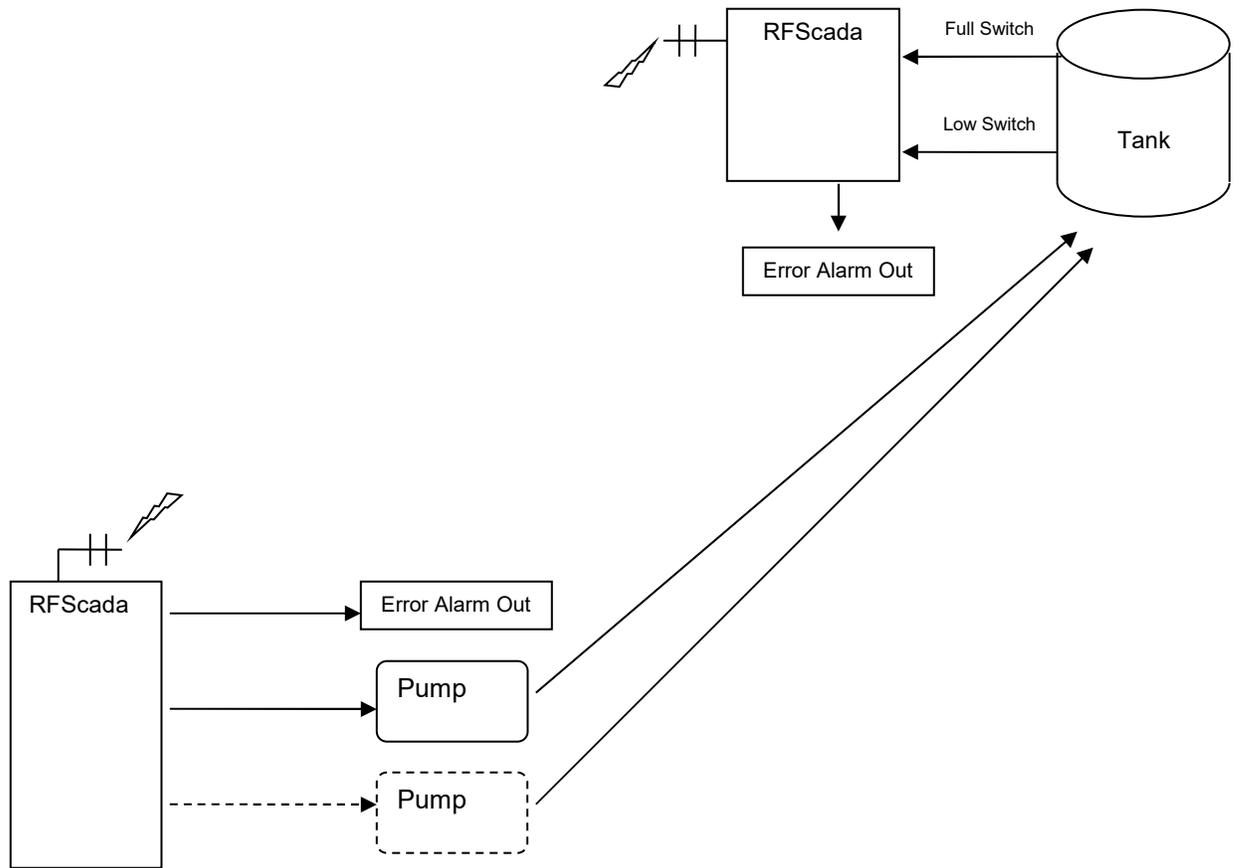
Unit 31 Digital Input 2 is 'active' to for an error. (assign error relay to this input)

Unit 31 Digital Input 3 is 'active' to run the toggling pump 1. (assign pump 1 relay to this input)

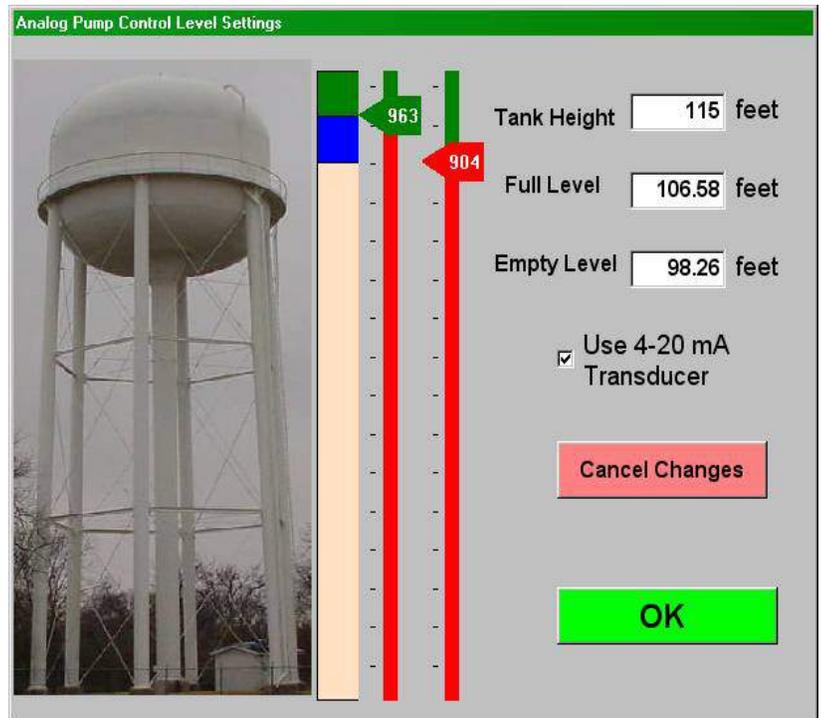
Unit 31 Digital Input 4 is 'active' to run the toggling pump 2. (assign pump 2 relay to this input)

Note that if the error shutdowns are not used ensure that the Unit 31 relays 3 to 8 are not assigned to active inputs as that may cause false error shutdowns.

Complete, Standalone, Remote Pump & Tank
Control System Using
RFScada Digital Pump Control Mode



Analog Pump(s) Control Mode (2)



This mode is typically used to control the level in a tank, where the tank is equipped with an analog level transducer. Two analog 'trigger' levels are set by the operator by using the configuration program, one for the full tank level and another for the empty tank level. The tank is filled by one or more pumps, driven from relay outputs on the RFScada. In normal operation the pump is on until the measured level is above the full set point, when the pump will switch off (i.e. tank is full). The pump will remain off until the level drops below the 'empty' set point, when the pump will turn back on. The dialog to set the full and empty points may be found by using the 'Special Control Settings' menu. The units are displayed in raw analog input levels for the 4-20mA input, from 0 to 1023, (4mA = 204, 20mA = 1023) and may be scaled to match the tanks feet, PSI or whatever scale is used. The actual reading being measured may be viewed on the 'Display Registers' screen.

Additional inputs can also be used to force the pump / pumps off and activate the error relay, these inputs would typically be connected to access door switches, gate interlocks, tank overflow switch etc. The analog level may be supplied by any analog input on the network, and the pump and error relays may be any one (or more) relays on the network.

Many systems just run one pump at a time but have two for backup purposes, and a common requirement is to operate them sequentially, to verify operation of both units and to share wear between them. The control mode 2 also supports toggling of dual pumps, effectively replacing more external control logic.

In this mode the following assignments need to be made.

Unit 31 Analog Output 1 must be assigned to the level transducer source (any analog input on any physical unit)

Unit 31 Relay 1 may be assigned to cause an error (Optional, any digital input on any unit)

Unit 31 Relay 2 may be assigned to cause an error (Optional, any digital input on any unit)

Unit 31 Relay 3 may be assigned to cause an error (Optional, any digital input on any unit)

Unit 31 Relay 4 may be assigned to cause an error (Optional, any digital input on any unit)

Unit 31 Relay 5 may be assigned to cause an error (Optional, any digital input on any unit)

Unit 31 Relay 6 may be assigned to cause an error (Optional, any digital input on any unit)

Unit 31 Relay 7 may be assigned to cause an error (Optional, any digital input on any unit)

Unit 31 Relay 8 may be assigned to cause an error (Optional, any digital input on any unit)

Unit 31 Digital Input 1 is 'active' to run a single pump. (assign pump relay to this input)

Unit 31 Digital Input 2 is 'active' to indicate an error shutdown. (assign error relay to this input)

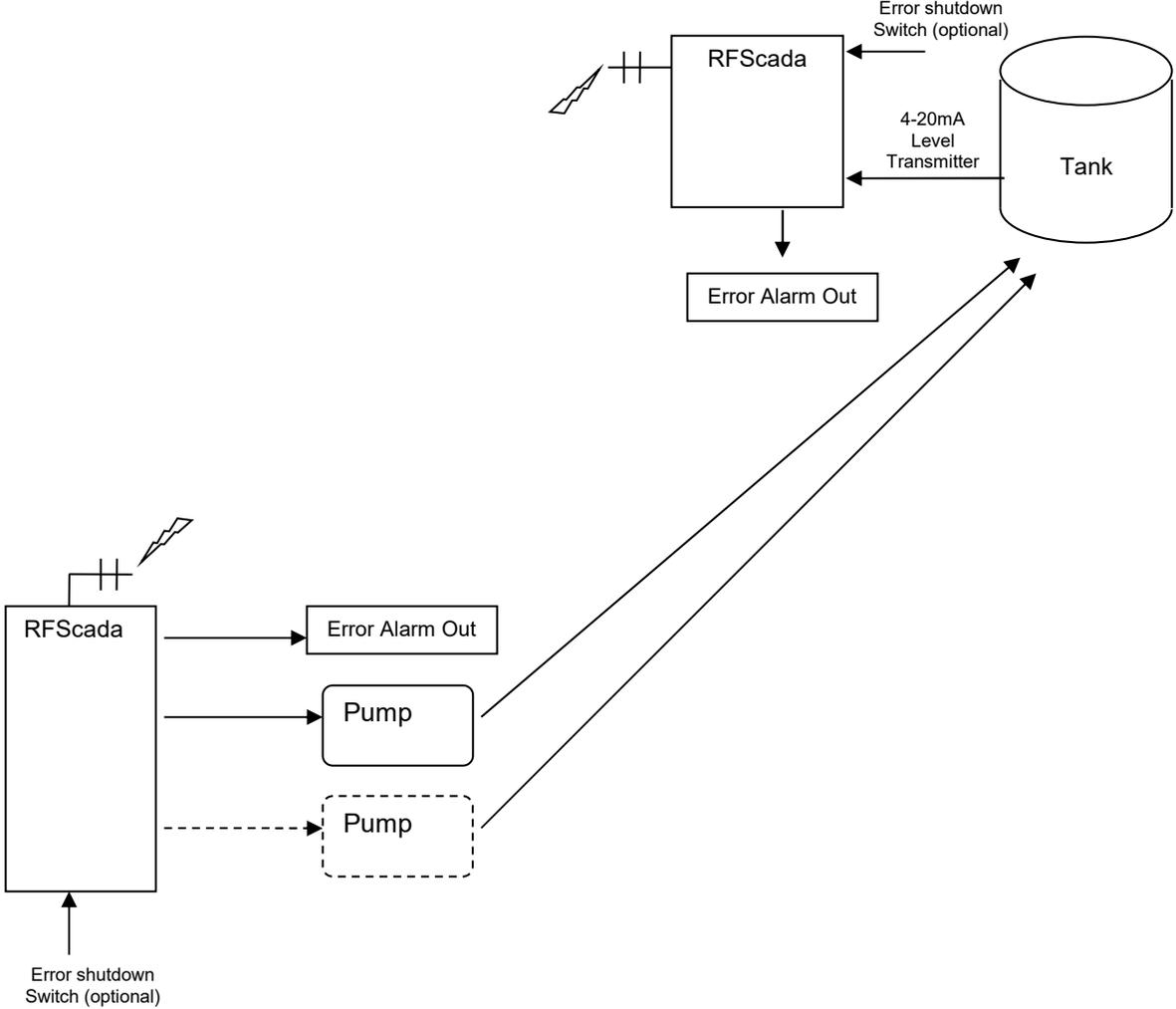
Unit 31 Digital Input 3 is 'active' to run the toggling pump 1. (assign pump 1 relay to this input)

Unit 31 Digital Input 4 is 'active' to run the toggling pump 2. (assign pump 2 relay to this input)

If the error shutdowns are not used ensure that the Unit 31 relays 1 to 8 are not assigned to active inputs as that may cause false error shutdowns.

NOTE: With version 4.2 and later firmware the control high and low set points will automatically be saved to the RFScada memory if the set points have not been changed for more than 2 minutes. This allows control set points to be adjusted and saved using a Modbus connected flat panel or similar display/data entry device without requiring a PC.

Complete, Standalone, Remote Pump & Tank Control System Using RFScada Analog Pump Control Mode



Analog / Digital Store Control Mode (3)

In some situations it may be required for the RFSkada system to store (and preserve through power fails) analog and digital values. In a typical application analog process values may be written via Modbus to an RFSkada device, which outputs these values as normal to another device depending on its configuration. Rather than being a typical constant Modbus connection, these writes to the RFSkada device may occur sporadically, for example via a low orbiting satellite that may only be in contact occasionally or perhaps via a dial up phone line that incurs call charges. If power to the RFSkada is interrupted a requirement may be to maintain the values that were written before the power failed. Selecting the Store control mode allows these functions.

In this mode the following registers are affected.

Unit 31 Analog inputs 1 to 8 (Modbus Registers 311 to 318) and Unit 31 Digital input (register 310) will retain their last written value indefinitely. Even if the Modbus timeout occurs these registers will be preserved. These registers are stored in non-volatile memory which has a write limitation of 1 million writes, so the RFSkada will only store the value in non volatile memory if it has not changed for more than two minutes (this time is pre-set at the factory, it may be displayed in the 'About' menu using the configuration software). Therefore for the process values to be stored correctly the power must remain on and the process values must not change for at least two minutes.

Analog Pump(s) Control Mode with Analog Trip Levels (4)

This mode is typically used to control the level in a tank, where the tank is equipped with an analog level transducer. Two analog 'trigger' levels may be set by the operator using any two analog inputs, one for the full tank level and another for the empty tank level. The tank is filled by one or more pumps, driven from relay outputs on the RFScada. In normal operation the pump is on until the measured level is above the full set point, when the pump will switch off (i.e. tank is full). The pump will remain off until the level drops below the 'empty' set point, when the pump will turn back on. Once this mode is enabled and correct inputs are assigned for the signal and two trip points the tank high and low trip points may be adjusted by varying the two analog inputs assigned to the trips. Since the RFScada board provides power for 4-20mA transducers a complete control system just requires 2 resistors and 2 potentiometers. Once configured the trip points may be adjusted without requiring a computer.

Digital inputs can also be used to force the pump / pumps off and activate the error relay, these inputs would typically be connected to access door switches, gate interlocks, tank overflow switch etc. The analog level may be supplied by any analog input on the network, and the pump and error relays may be any one (or more) relays on the network. For example, the trip point adjustment potentiometers could be two analog inputs on an RFScada at the pump house, miles from another RFScada at the tank.

Many systems just run one pump at a time but have two for backup purposes, and a common requirement is to operate them sequentially, to verify operation of both units and to share wear between them. The control mode 4 also supports toggling of dual pumps, effectively replacing more external control logic. In this mode the following assignments need to be made.

Unit 31 Analog Output 1 must be assigned to the level transducer source (any analog input on any physical unit)

Unit 31 Analog Output 2 must be assigned to the high trip level source (any analog input on any physical unit)

Unit 31 Analog Output 3 must be assigned to the low trip level source (any analog input on any physical unit)

Unit 31 Relay 1 may be assigned to cause an error (Optional, any digital input on any unit)

Unit 31 Relay 2 may be assigned to cause an error (Optional, any digital input on any unit)

Unit 31 Relay 3 may be assigned to cause an error (Optional, any digital input on any unit)

Unit 31 Relay 4 may be assigned to cause an error (Optional, any digital input on any unit)

Unit 31 Relay 5 may be assigned to cause an error (Optional, any digital input on any unit)

Unit 31 Relay 6 may be assigned to cause an error (Optional, any digital input on any unit)

Unit 31 Relay 7 may be assigned to cause an error (Optional, any digital input on any unit)

Unit 31 Relay 8 may be assigned to cause an error (Optional, any digital input on any unit)

Unit 31 Digital Input 1 is 'active' to run a single pump. (assign pump relay to this input)

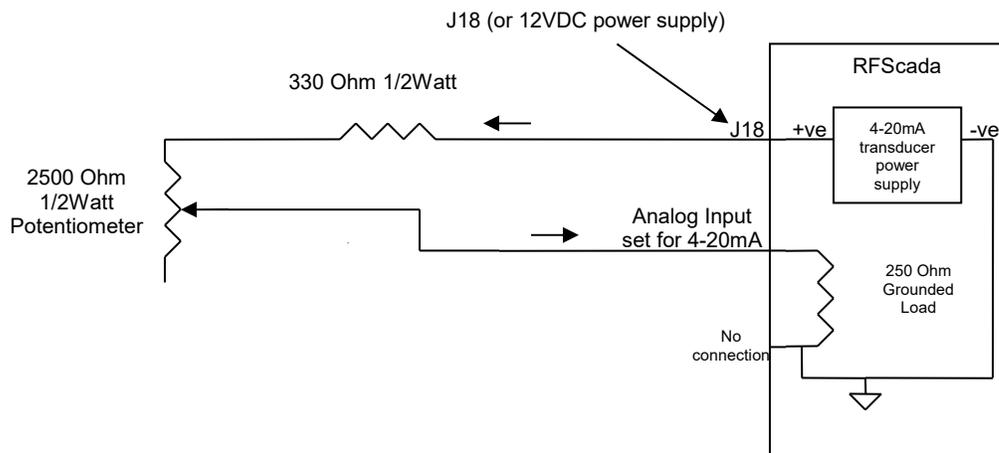
Unit 31 Digital Input 2 is 'active' to indicate an error shutdown. (assign error relay to this input). This is active if any of the error inputs are active or the high trip point input is below the low trip point.

Unit 31 Digital Input 3 is 'active' to run the toggling pump 1. (assign pump 1 relay to this input)

Unit 31 Digital Input 4 is 'active' to run the toggling pump 2. (assign pump 2 relay to this input)

Note that if the error shutdowns are not used ensure that the Unit 31 relays 1 to 8 are not assigned to active inputs as that may cause false error shutdowns.

Example showing adjustable trip point for tank control

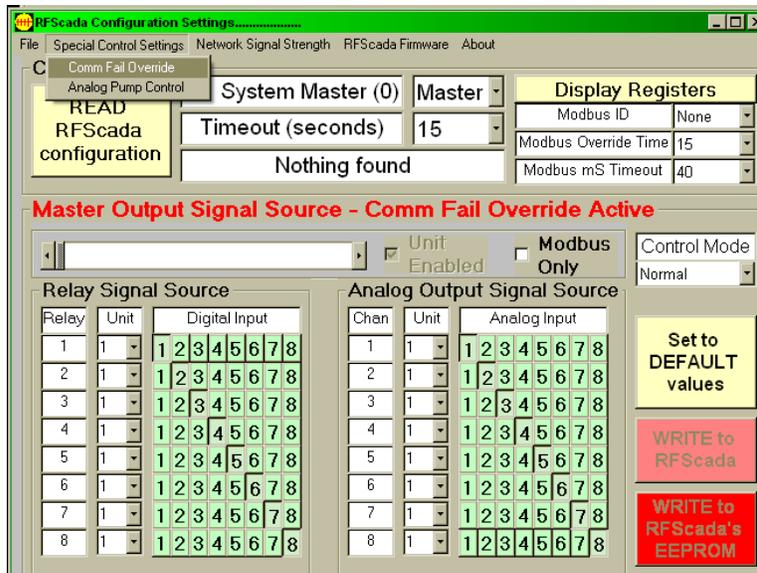


Standalone 'Master' System with no slaves.

This mode allows remote control and monitoring of a single unit. Simply set the units configuration as a Master and disable all slave units. By using Modbus or the configuration program all the inputs and outputs on this unit may be monitored and controlled remotely, via the RS-232, RS-485 or over a phone line if suitable modems are used. Since the unit does not expect a response from any other units it may be operated in a standalone mode without any errors being generated. It may also be configured to route all its own inputs to outputs.

Comm Fail Override Mode.

Normally the RFScada devices will only maintain outputs when all of the units in a network are communicating correctly. If communications are lost then all remaining units still communicating will turn off all outputs (analog and relays) and the communication status relay and LED (by J11) will toggle. For most applications this is the optimum way to handle signal loss; as a failure anywhere in the system will result in the complete system shutdown, and typically alarm generation, plus complete network integrity may be monitored from all locations. For some specialized applications it would be better for the remaining units to maintain outputs, and the RFScada devices may be programmed to operate this way. This may be required for example where several remote pumps, each controlled by an RFScada device, fill a common tank where another RFScada device monitors the fluid level then sends commands to the remote pumps. If one well is down for service its RFScada device may be without power, resulting in communications failure in the network and a shutdown of the remaining wells. By selecting the 'Comm Fail Override' mode the remaining units may continue operation when signals are lost from one (or more) units. The slaves will not be aware that one (or more) other slaves are not operating. The master unit will toggle the comms status LED and relay however, so the error will be detected. If response from all slave devices is lost the masters 'comms status' relay and LED will become inactive. The 'comm fail override' mode may be selected from a menu when the master configuration screen is displayed. A warning will be displayed during selection and when the feature is enabled.

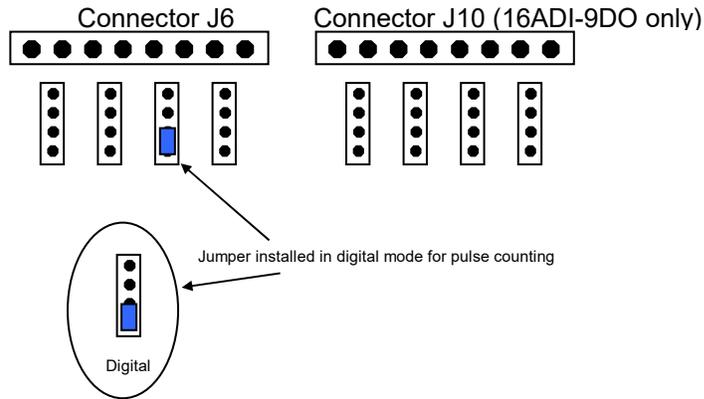


As always ensure that the settings are saved using the 'Write to RFScada EEPROM' button so the changes will survive subsequent power fails.

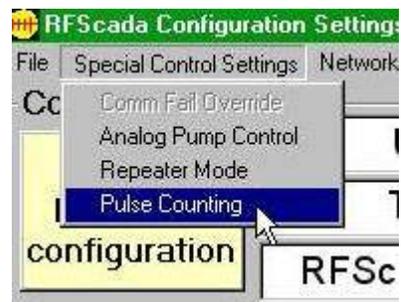
Pulse Counting Mode.

The RFScada devices may be configured so one or more analog inputs may be used for pulse counting operation. In this mode analog inputs set for pulse mode no longer return the analog value measured at the input, but rather will return a count of cumulative edges (both rising and falling) detected on that analog input. To enable pulse counting proceed as follows. First the analog inputs that are to be used for pulse counting need to be configured as digital inputs, refer to the diagram below and see previous sections for complete details. The pulse input would typically be supplied from a switch, a set of 'dry contacts' (usually a relay) or an opto-isolator transistor output. Note that some opto-isolator transistor outputs are polarity sensitive; if it does not work try reversing the input connections. As the pulse source changes state so the green LED near the input should reflect the changing condition.

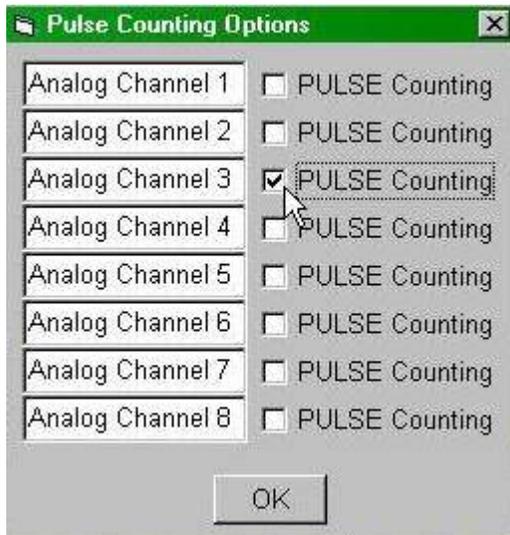
Configuring Analog Inputs of 4ADI-5DO2 and 16ADI-9D2AO for pulse counting



Next connect to the unit that is to be configured for pulse counting with the PC configuration software. Note that the firmware installed in the RFScada board needs to be version 4.0 or later to support pulse counting, and the PC configuration software needs to be version 4.4 or later. It does not matter which version of firmware is installed in other boards in the system. Select the menu located in the 'Special Control Settings' called Pulse Counting.



A small dialog will appear with checkboxes to allow pulse counting to be enabled by input channel. Note that for the 4ADI-5D02 model

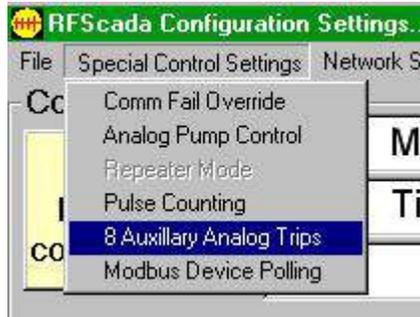


inputs 5 to 8 will have no effect. In the diagram analog input 3 is set for pulse counting and all other analog channels operate as normal. Once the selections have been made exit this dialog and save the settings to the unit. Now the

analog input will show an accumulation of pulses rather than the actual analog value; this may be observed by clicking on "Disp Regs". The pulse count increments with each edge or change in state; so the count will actually be double the number of pulses. The count will be correct for systems that output a state change for each unit of measure. The count will wrap at 1023 back to 0 and will start again, so as long as the value is read before another 1024 edges have been detected an accurate count can always be obtained. The maximum pulse frequency that may be accurately counted is in excess of 200 pulses per second.

Auxiliary Analog Trips Mode.

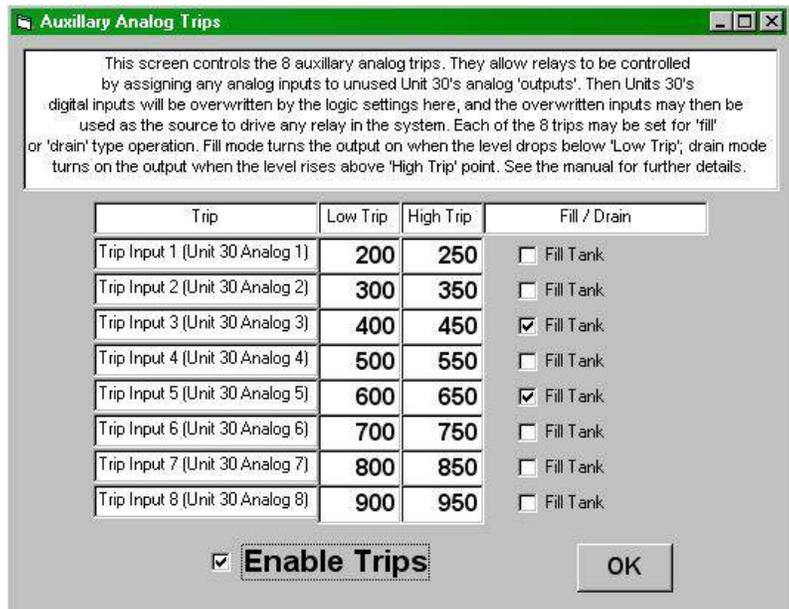
Single tank level control with several modes of operation is



already incorporated into the RFScada, for full details of the many modes see earlier in this chapter. Sometimes more than 1 tank level needs to be controlled, or additional outputs such as alarms based on transducer

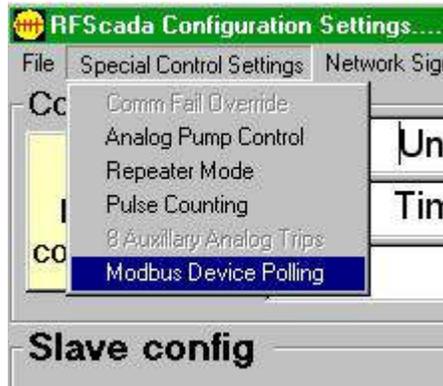
failures need to be provided. The auxiliary trip mode provides this capability, and it may be used in conjunction with the standard tank control mode. The mode operates by overriding the digital inputs to unit 309, which is not physically in the system. The mode is configured in the master RFScada, but of course the signal sources and destination controls may be in any unit. Select the 8 Auxiliary Analog Trips from the special control settings menu, and a dialog will appear with the control settings. The trip on and off points are specified in raw analog to digital converter units, which range from 0 to 1023 so may need to be adjusted as needed. If the input is set for 0 to 20mA then 0mA corresponds to 0 and 1023 is full scale at 20mA. The checkboxes select whether the overwritten 'input' is to be active when the analog level is above the high trip point or below the low trip point, effectively provided fill or drain control.

In a similar way to the main level control, Unit 30's digital 'inputs' will be overwritten depending on the level of the analog input being monitored and the high / low trip points.

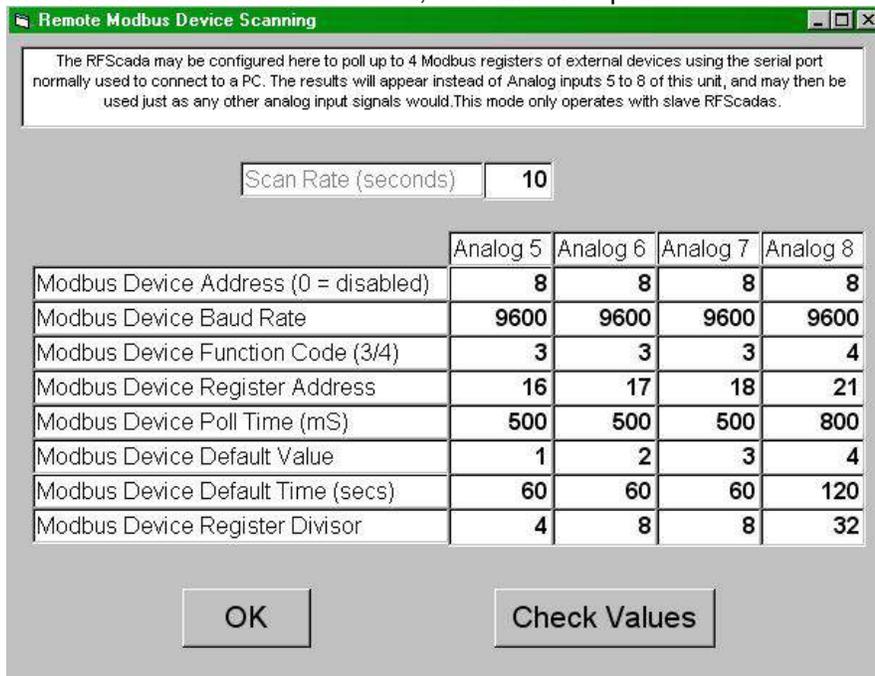


Modbus Device Polling Mode.

An RFSkada slave device may be configured so it can poll an additional Modbus device via the serial port (RS-232, RS-485 or both together) which is usually used for direct PC connection. The polled device registers may replace the analog inputs 5 to 8 of the slave RFSkada device; and may then be used



as signal sources just as the analog inputs would normally be. This allows third party Modbus devices such as energy meters, water circulators etc. to be remotely monitored via the RFSkada network, and saves the cost of additional radios and communication networks for these devices. The RFSkada slave device must have firmware version 4.2 or later installed, and the PC software used to configure it must be version 4.6 or later. To enable Modbus device polling first select the Modbus Device Polling menu in the Special Control Settings. A dialog with several settings will appear. Each entry may be set by typing directly in the boxes, then pressing 'enter' will validate the entry. Values out of range will be rejected. The first entry is for scan rate, and is the time the RFSkada board will wait between polling different devices. Each of the four Analog registers that may be overwritten by polled devices has 8 settings. The first is the Modbus address or ID of the device, 1-255. If it is set to zero then this Modbus device is disabled, and will not be polled.



The next sets the device baud rate, most common baud rates are supported and each device may have a different baud rate. The function code may 3 or 4, many Modbus devices reply with the same data for either command. Next is the Modbus register address. For many PC applications the addresses are shown as starting at 30001 or 40001, however this 3xxx or 4xxx offset is usually subtracted by the PC application before sending data to the physical device, and it will probably need to be subtracted before entering it here. Note that some devices start numbering at 0 and some 1, so some experimenting may be required to read the correct register. The poll time determines how long the RFSkada board will wait for a response from the polled device; typical values may be 200-500mS for 9600 baud devices and perhaps 1000mS for 1200 baud devices. The RFSkada will maintain the last polled reading but if the 'default time' expires without another good reading from the device then it will change the value to the default setting. The RFSkada protocol supports analog transmissions with 10 bits of resolution; but some of the polled registers may be higher resolution so they may be divided here by a fixed divisor; this also allows conversion to engineering units with some devices.

Once Modbus polling is activated (by setting any Modbus device address to a non zero value) polling is scheduled to begin. Polling may cause confusion if the board is also being accessed by a PC or other device at the same time using the same serial port. Therefore if the RFSkada board receives a poll request, such as from the PC, it will automatically switch from being a Modbus 'master' polling other devices and revert to a Modbus 'slave'. It will suspend its own polling until 30 seconds after the last remote poll is received.

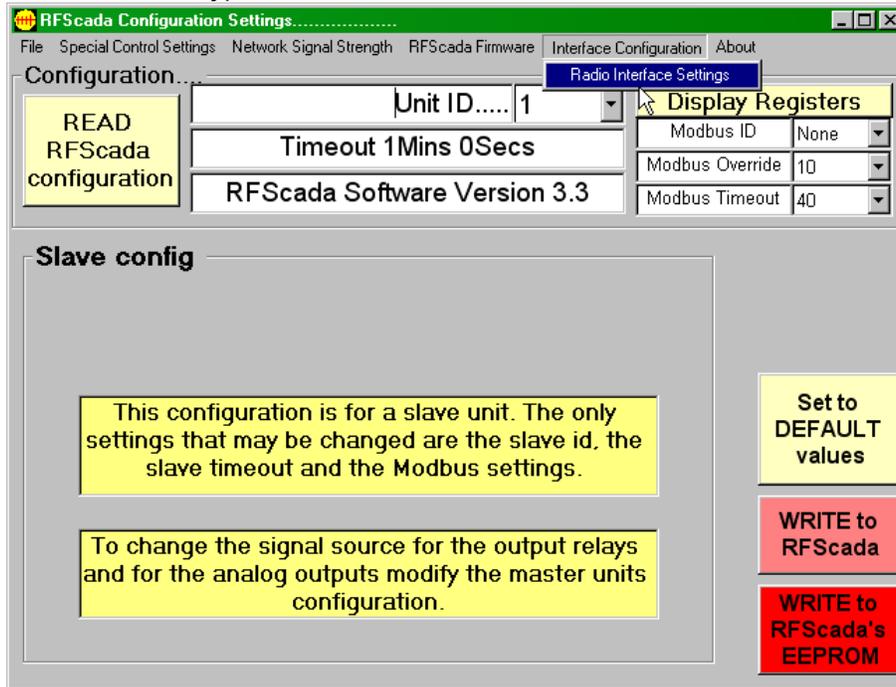
*RADIO INTERFACE
CONFIGURATION*

RFSCADA16 RFSCADA4

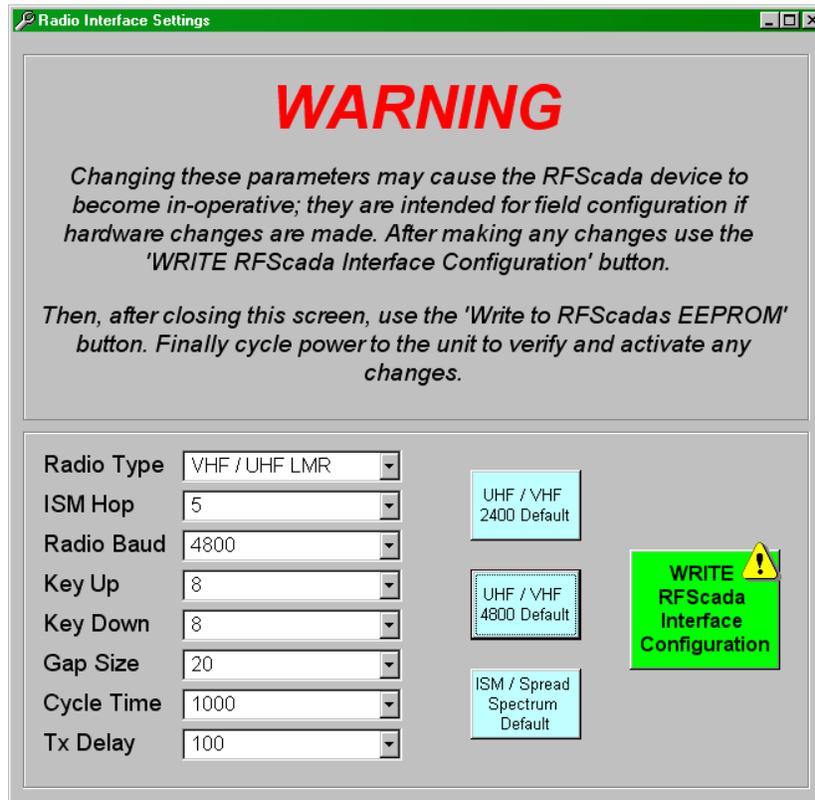
Remote Terminal Unit

Radio Interface Configuration.

Normally RFScada devices are supplied fully configured for the final application. Some OEM's may re-configure the device in the field to accommodate different types of radio or networks.



The following screen has various adjustments that may be changed for various interface combinations. Common ones may have the default values set by clicking on the appropriate button.



Be sure to follow the directions and verify that all parameters are saved to ensure correct operation. A brief explanation of the parameters follows.

Radio Type. This controls initialization data that is sent to the radios upon power up. For example spread spectrum radios typically require different initialization data, most LMR radios (or direct connections) require none.

ISM Hop is the hop pattern for the ISM radios, and may be compared to a channel. Different systems that are not required to communicate with each other but are in close proximity require different hop patterns. For example, two boxes that talk to each other (and nothing else) may be set to hop pattern 3, and another pair of boxes that are within range but must not communicate with the first two may be set to hop pattern 4. This parameter has no effect when UHF or VHF radios are used.

Radio Baud. Is the radio interface baud rate; varies by radio.

Key Up and Key Down are millisecond timers associated with radios that have hardware Tx control.

Gap Size. This is the size (in milliseconds) that a gap must exist in the received radio data before the RFScada unit will process it. It is used to ensure received data packets are complete before processing them.

Cycle Time. This is the time (in milliseconds) before the master will send out the next data packet if it did not receive a response to the last transmission. Note that it is not the fastest 'cycle time' that the master may communicate; it will normally advance to the next data transmission as soon as it has received a response from its last transmission, which is usually significantly faster. However, extra time must be factored into the cycle time since transmissions may be going through and returning via repeaters that the master has no knowledge of. As an example, with ISM radios it typically takes approx. 150mS for a complete cycle between the master and a slave. If the slave goes through a repeater it may be approx. 300mS; through two daisy chained repeaters 450mS. The default time of 500mS (for ISM) allows for a repeater depth of two; but the cycle time would need to be increased for a longer repeater daisy chain. If the master does not get a response from a slave it will wait the cycle time, in this case 500mS, before starting the next transmission.

Tx Delay. This is the time delay the unit will wait before transmitting after a good reception has occurred. It is required to allow the radio that just transmitted time to power down its transmitter section; as some radios hold the transmitter on for a while after the data has been transmitted. By waiting for this time to expire the unit can ensure that radio traffic won't be corrupted by two radios transmitting at the same time.

REPEATER MODE

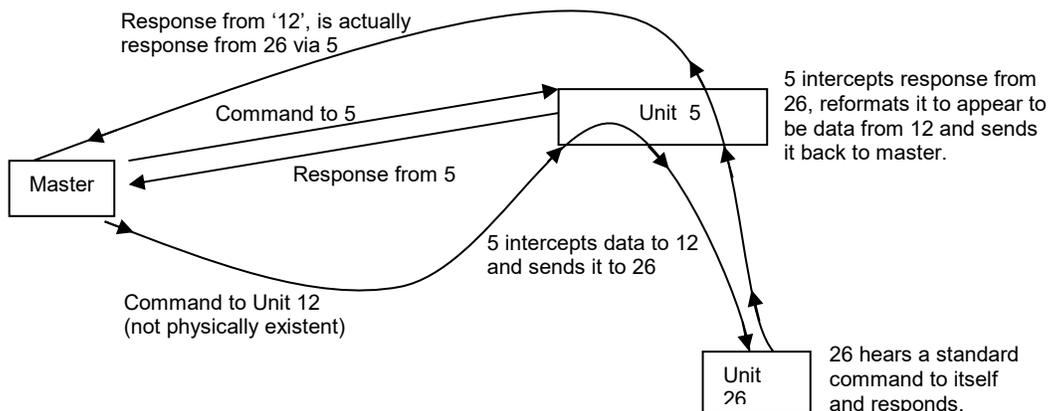
RFSCADA16
RFSCADA4

Remote Terminal Unit

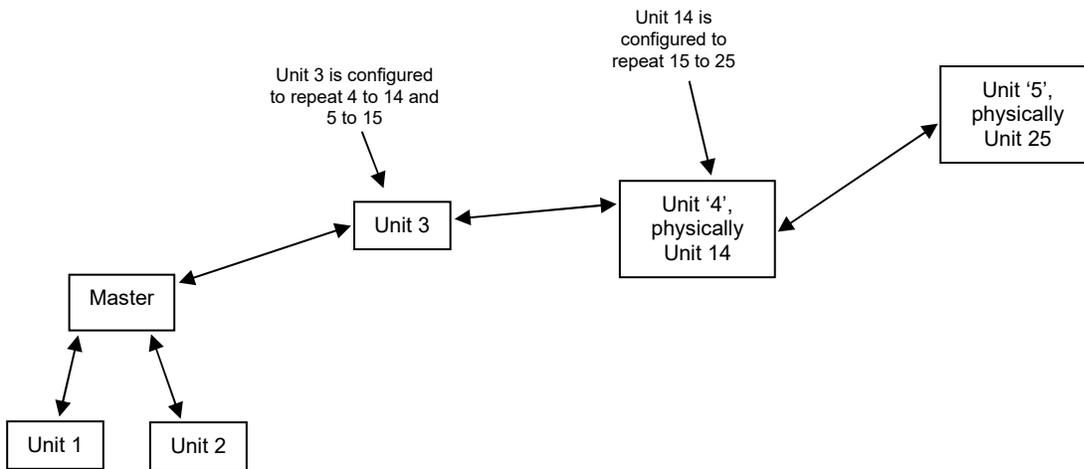
RFScada Repeater Mode.

In normal installations one RFScada device is set up as the master unit, which polls all slave units in turn reading and writing data to them. This means that the master unit must be able to communicate directly with all RFScada slave devices in the network. For some installations such as pipelines it may not be possible to obtain reliable communications between the master and all the slave units due to distances or obstructions. In these cases slave units may be configured to act as repeaters, passing the data between the master and other slaves. Repeater operation is as follows.

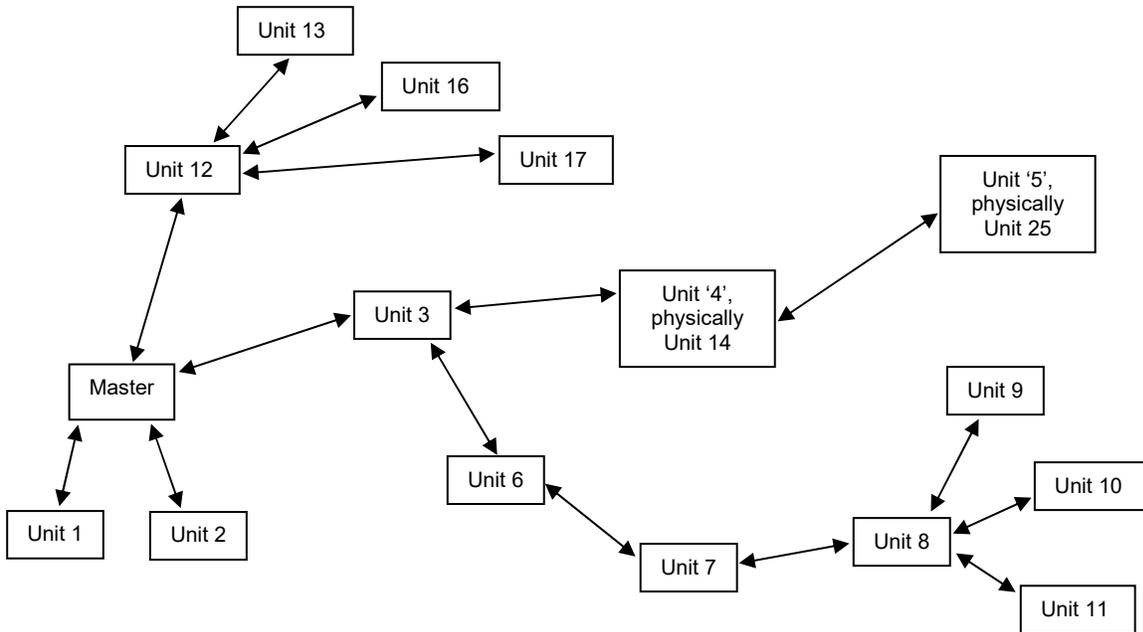
Basic Repeater Operation. The concept is fairly straightforward, example ID's are referenced to make the example easier to follow. A repeater may be any slave unit that is configured to recognize and react to data intended for its own ID (e.g. 5), just like any other slave. However, it is also configured to recognize data intended for the 'target' slave unit (12). When it recognizes this data it translates the data to another target address (26) which the master is not set to communicate with. Unit 5 will then impersonate a master unit by transmitting the data on to the target slave (26), which will then respond back to the repeating slave (5). The repeating slave (5) will take the response from (26), reconfigure it to look like data from (12) and return it to the master unit. The result is that the master is communicating with two slaves, one (5) and the other which it thinks is (12) but is actually physical unit (26), relayed back via (5). The master unit is not even aware of the existence of a repeater unit.



and thinks it got a direct response from unit 5. In a similar manner when the master sends a command for unit 4 it is intercepted by unit 3 which translates it to unit 14 data, communicates with unit 14 then returns the response to the master as if it was a response from unit 4. In all of these examples the master unit is not aware that repeaters are in the system. The daisy chained repeaters may be extended for more than two repeaters.

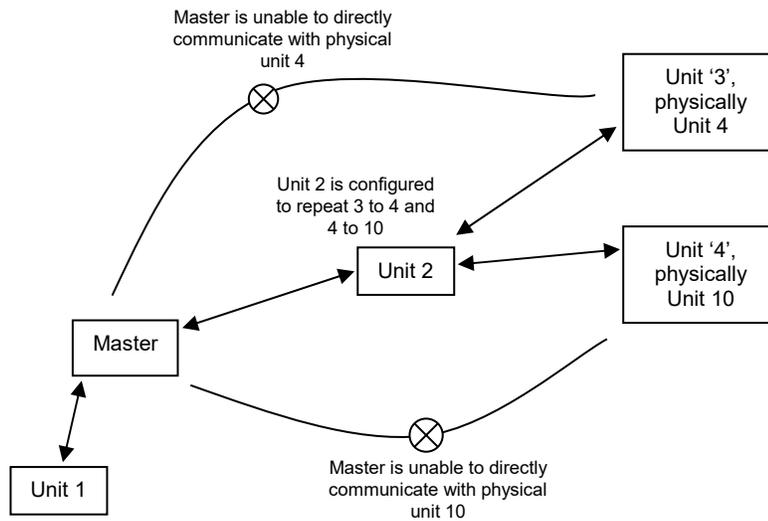


Complex Repeater Operation. Multiple repeaters may be daisy chained in series, repeaters may be on additional daisy chains branching off the original chain and multiple units may be accessed via any unit in the system for very complex configurations.



Repeater Considerations.

The techniques used for repeater operation depend on repeating slaves translating data intended for physically 'non-existent' slave units. The ID's used for the non-existent and the physical units cannot be the same if there is any possibility that the master may receive transmissions from the remote slave, so to operate a unit via a single repeater actually requires two slave "ID's". Operating a unit via two daisy chained repeaters consumes 3 ID's, and so on. On small systems this is not a problem, but may be a consideration in larger systems if the units have firmware installed before 5.0 that just supports one master and 31 slave unit's. It is possible to reuse an ID in a repeater to remote slave link provided the master is unable to communicate with the remote slave; this would only be required in cases where all ID's had been consumed. An example is shown below. The master is enabled to communicate with units 1, 2, 3 & 4.



If communications to a repeater are lost then communication to all subsequent units receiving signals via the repeater will be lost too.

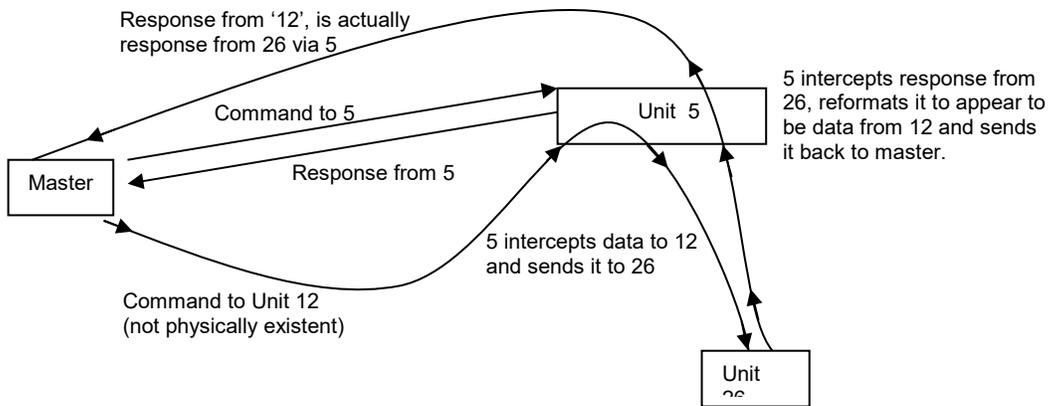
Another factor to consider when using repeater mode are the time delays associated with transmission of data back and forth between all the repeaters, so timeout settings and scanning rates may need to be adjusted as the repeater depth is increased; this may be done from the 'radio config' settings. The default settings allow for two daisy chained repeaters which would cover most normal operations.

Repeater Requirements and Configuration.

To function as a repeater a slave must have version 3.3 or later firmware installed, although the master and other slaves in the system only require version 2.6 or later. In a system such as this the total number of slaves units is limited to 31.

If version 5.0 or later is installed in *all* of the units then a total of 255 slave units are possible, expanding the possible permutations.

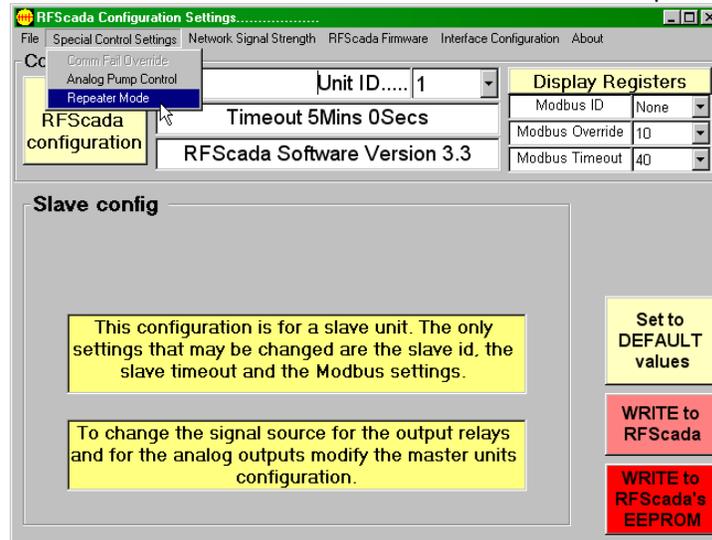
Configuration is straightforward. First assign ID's for units in the system, which will make the process more straightforward. The configuration for the first example will be explained



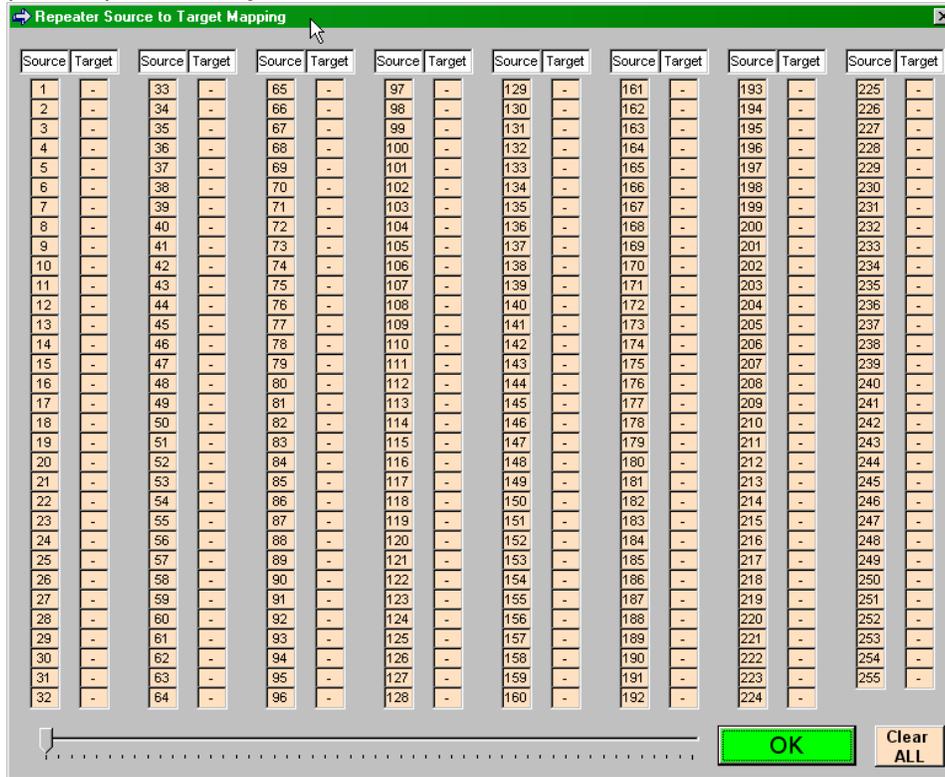
Master Config: Enable it to communicate with 2 units, ID's 5 and 12. Save the configuration.

Unit "12" This unit will be addressed by the master as 12. It is actually configured with an ID of 26. Configure it as a slave with an ID of 26, repeater mode off.

Unit 5 This unit will be the repeater. It has an ID of its own as 5, so set its ID as 5. Any reads or writes the master requests from Unit 5 will come directly to and from this unit. Also, select the repeater menu to enable the repeater configuration screen. If the unit attached to the configuration program is capable of repeater operation a menu called 'Repeater Mode' will be enabled in the special settings menus.

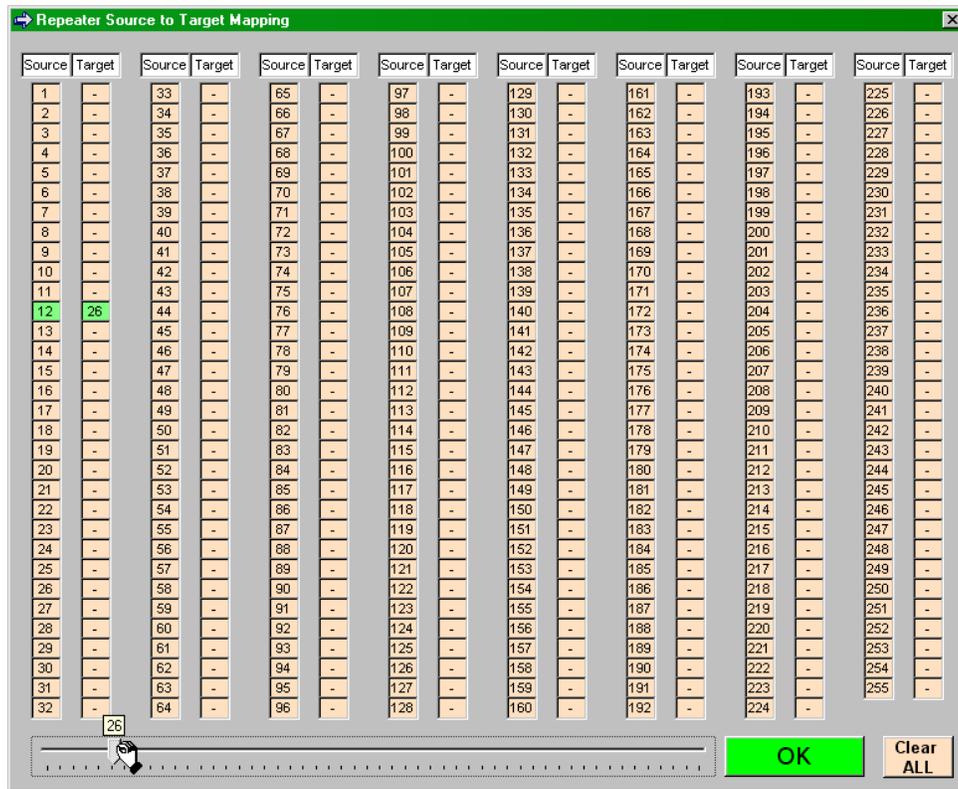


This will bring up the Repeater Configuration screen as shown.

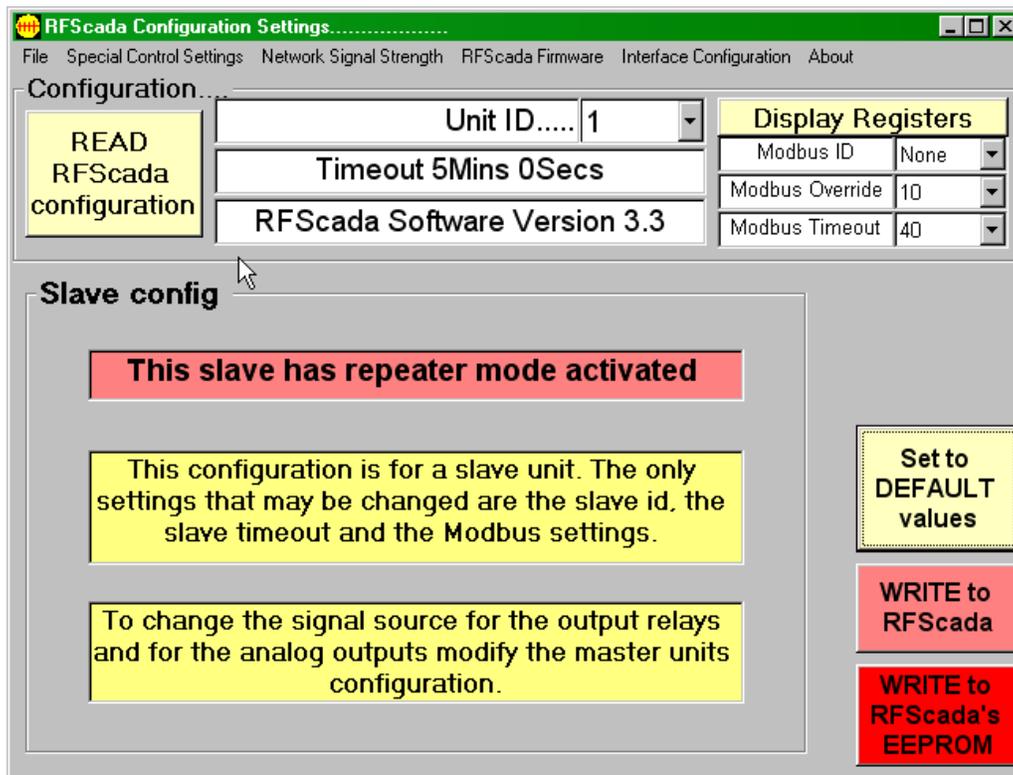


In the screen above all the sources are set to OFF, hence there are presently no repeater functions selected for this unit.

In our example we need the source to be 12, and the target 26. Click on either the box marked 12 or the blank box next to it. As the slider at the bottom of the screen is adjusted so the target corresponding to source will change. Adjust it until the target is displayed as 26.



All other units (in this example) should remain at 'OFF'. Click 'OK' to close the repeater screen. The configuration program will display a message indicating when a slave is configured for repeater operation.



Save the modified slave unit settings to complete the configuration.

Note if this unit was to repeat to multiple slaves the configuration process would be to simply adjust each slider as required; there are no changes to the master or other slave units required for repeater operation. On systems with firmware earlier than 5.0 an adjustment to the master cycle time may be required depending on the installed radios, contact the factory for assistance with this adjustment.

RADIO OPTIONS

RFSCADA16
RFSCADA4

Remote Terminal Unit

Radio Options

The RFScada devices described in this manual may operate with many different wireless (and hard wired) communication options. The most popular units have high power (1 Watt) ISM 902-928MHz spread spectrum radios installed, but these are not suitable for all applications. The following table summarizes current standard options; please note that the flexible 'generic' radio interface available on the RFScada board supports other radio frequency and power options not described here. Please consult with the factory for other possible radio installations, including operation with existing radios.

Radio Option	Radio Location	Notes
None	No radio	For direct PC connection or using a single shared radio between multiple connected RFScada boards.
902-928MHz ISM High Power	RFScada board	Low RF cost, highest power license free operation. Range up to 40 miles line of sight.
148-174MHz VHF 1, 2 Watt	RFScada case	Low – Medium RF cost on. Much better range and non line of sight coverage than ISM, especially in rural, hilly environments. FCC license required. Largest antenna required for optimum performance.
148-174MHz VHF 5 Watt	RFScada case	Medium RF cost. Best range and non line of sight coverage in rural environments. FCC license required. Largest antenna required for optimum performance.
450-490 MHz UHF 1, 2 Watt	RFScada case	Low-medium RF cost. Much better range and non line of sight coverage than ISM, especially in urban, reflective (buildings etc.) environments. FCC license required. Medium size antenna required for optimum performance.
450-490 MHz UHF 5 Watt	RFScada case	Medium RF cost. Best range and non line of sight coverage in urban, reflective (buildings etc.) environments. FCC license required. Medium size antenna required for optimum performance.

All units in a network need to have the same type of radio option installed to be able to communicate correctly; so when selecting a radio system it is important to consider all locations that may eventually have to communicate in the network.

Typical examples show RFScada devices with license free ISM modules with external and internal antennas installed.

Below shows RFScada 4ADI-5D02 and 16ADI-9D2A0 units with 5 Watt radio transmitters installed. Note that both boards provide power for the radio, an additional power supply is not needed for the radios.

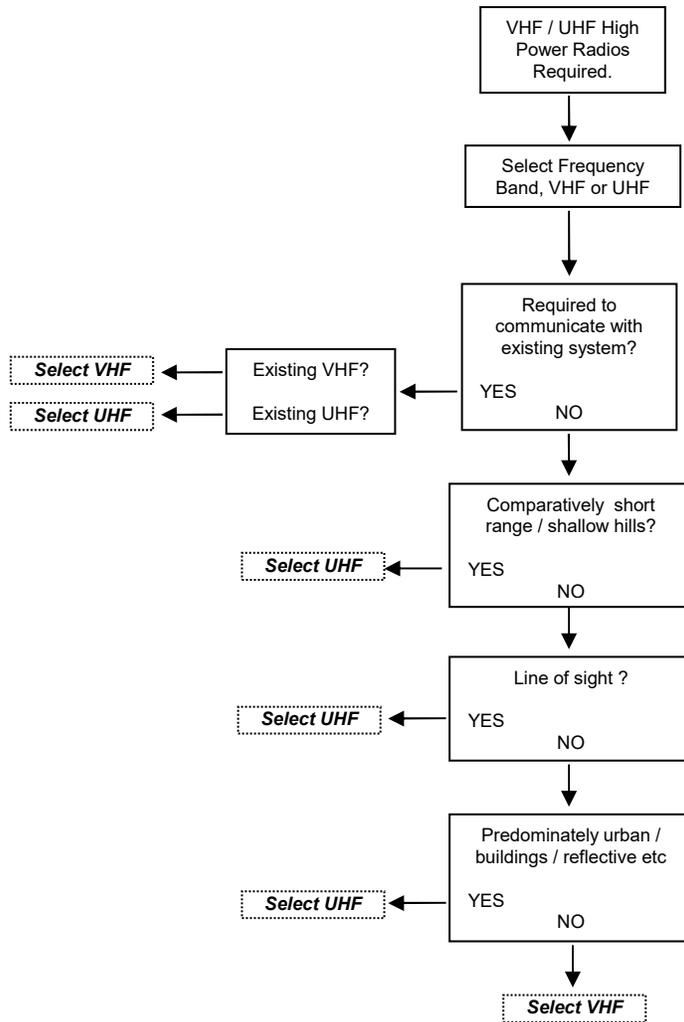


VHF / UHF Operating Frequency and Power Selection.

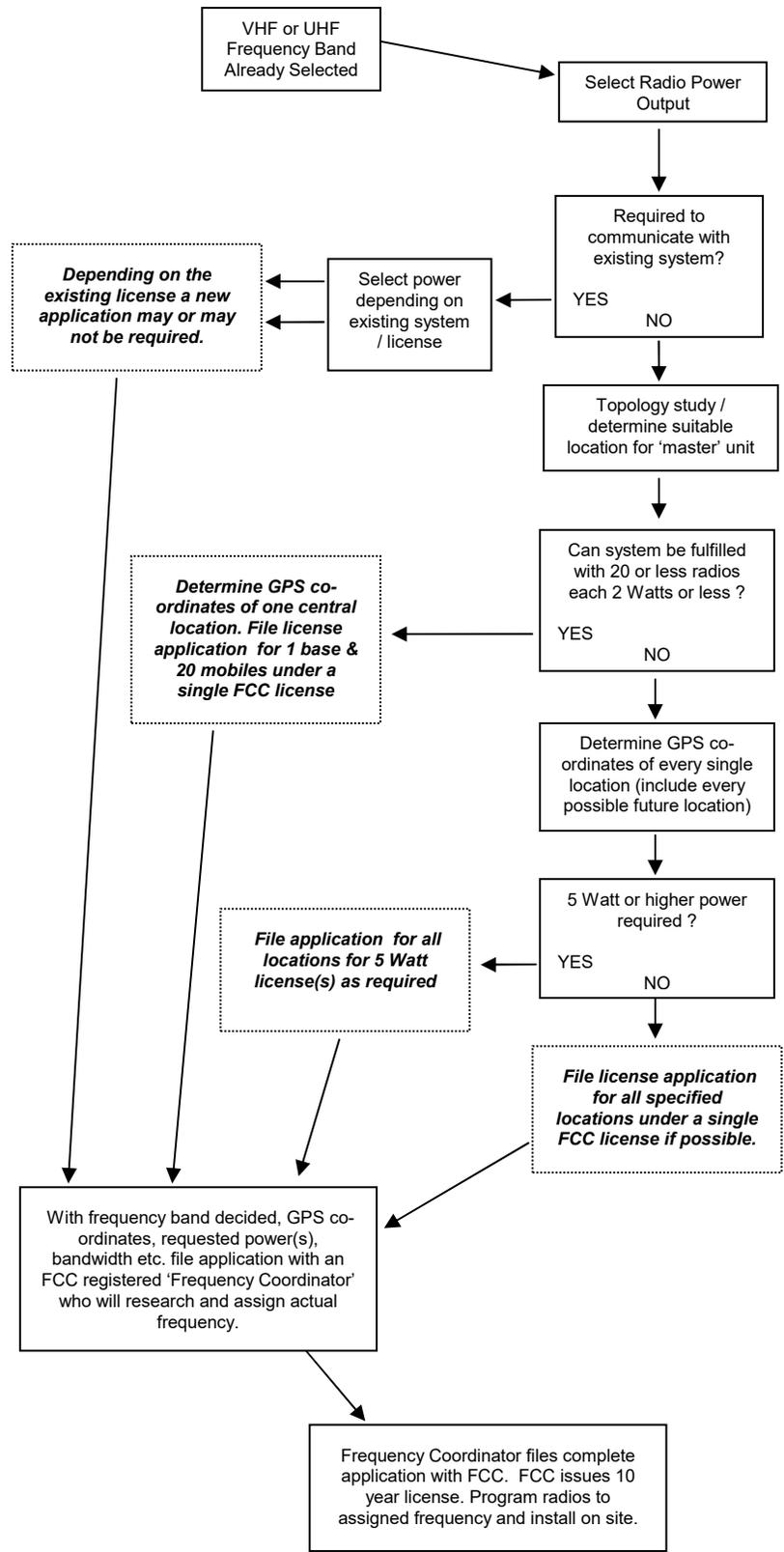
Selecting the optimal frequency band has several implications when using the VHF and UHF radios. In most cases either frequency band will give excellent results; however license and antenna factors should also be evaluated when deciding which range to use as it can have significant affect on the complete system cost. For example, as a general rule UHF units require lower cost and physically smaller antennas than VHF units; if power outputs are limited to two watts the FCC license process may be quicker, more economical and easier to expand in the future. Many users feel that the best approach to radio selection is to simply choose the highest power available; but this is often not a sensible approach, especially if additional units may need to be added to the system in the future. The following two flow charts give an overview of the typical frequency and power selection process; note however that many other factors can influence the decisions and each system needs to be evaluated individually.



Typical VHF / UHF Radio Band Selection Flowchart



Typical VHF / UHF Radio Power Selection & FCC License Application Process Flowchart



*ADVANCED RADIO AND
NETWORK DIAGNOSTICS*

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Remote Terminal Unit

Advanced Radio and Network Diagnostics.

For monitoring complex systems and troubleshooting individual radios an additional software tool, RFMonitor is provided. This software program connects directly via the PC's serial port to a radio module or radio modem (not an RFScada unit) and allows the PC to monitor over the air radio traffic in real time. It can show transmitted data to and from all units which can be very useful on complicated systems. Typically VHF and UHF radios have antennas that may require tuning for the assigned frequency, this requires radios to transmit continuously for a few seconds while power levels are measured. The RFMonitor program may directly control transmission of the VHF and UHF radios, controlling transmission for limited times to allow the antennas to be correctly adjusted. The program also has a built in SWR calculator, and various ways to display raw data exchanged between RFScada devices. The RFMonitor program is not intended for end user use but rather system installers. To be able to monitor and display real time over the air data it does require a PC that is reasonably fast with XP or Windows 2000 installed. Contact Data Delivery Devices LLC for information on obtaining the RFMonitor program.

The screenshot displays the RFScada - Air Packet Monitor V1.8 interface. It is divided into three main sections: 'Live Air Monitor - Decoded', 'Live Air Monitor - Raw', and 'Transmit Test'. The 'Decoded' section shows a grid of 32 rows (0-31) and 16 columns. Each row contains 'FROM' and 'TO' fields with a color-coded status bar (1-8) and a series of 16 data points (1023). The 'Raw' section shows a similar grid with raw data points. The 'Transmit Test' section is currently empty. At the bottom, there are control buttons for 'no signal', 'OPEN', 'CLOSED', 'LAST', 'Running', and 'CLEAR'. There are also radio buttons for 'RAW' and 'CONVERTED', and a 'SERIAL PORT' dropdown menu. A hex address bar at the very bottom shows: 0x43,0x3C,0x3,0x59,0xBF,0x67,0xE1,0x2E,0x36,0x11,0x3A,0x45,0x70,0x56,0x55,0x9,0x50,0x3B,0x43,0x3C,0x23,0x0,0x0,0x0,0x1,0x0,0x0,0x0,0x0,0x25,0x0,0x0,0x6.



EXTERNAL ANTENNAS

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RFSCADA4

Remote Terminal Unit

External Antennas.

In some situations, due to distance, obstacles or other factors an external antenna may need to be installed on one or more units. There are several sizes and styles available from Data Delivery Devices LLC, depending on the application. FCC approved Yagi type antennas and omni-directional models are offered for operation with the device.

CAUTION

In order to comply with the FCC RF exposure requirements RFSkada units may only be used with approved antennas that have been tested with it. A minimum separation distance of 20cm must be maintained from the antenna to any nearby persons. The RFSkada units are not classified as portable devices per FCC Section 2.1093

Typically an antenna cable 'pigtail' is used for the ISM radio options; it brings the signal from the radio module to a bulkhead female 'N' type feed thru. Here a surge arrestor may be directly installed if required, then the antenna cable connects to that. Depending on the model the surge arrestor may be mounted inside the cabinet if required; ensure that the surge arrestor case or block is securely grounded directly to the main input ground or ground rod. The surge arrestor has a field



replaceable element, to access it remove the screw on the side of the arrestor. The total installed cost of Yagi antennas including the cable, surge arrestor, pole (if needed), time and labor required etc. is usually insignificant between the

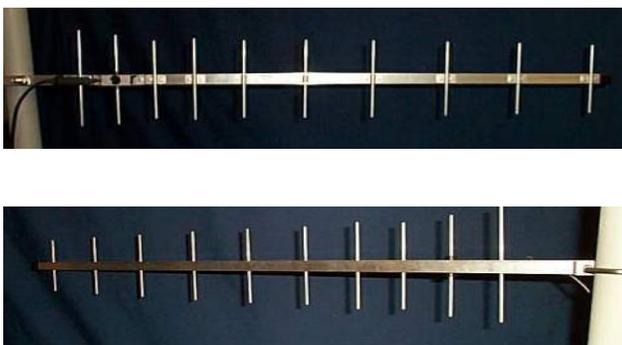
larger and smaller antennas, so generally the higher gain antennas are recommended unless space prevents it. There is a better chance that a higher gain antenna will give satisfactory performance without requiring an external antenna on the other unit.



All of the antennas should be mounted with the short elements in the same direction, usually vertically. This discourages birds and other pests from remaining on the antennas, plus it helps to prevent heavy ice accumulation in extreme weather situations. The antennas should be aimed towards each other as shown below.



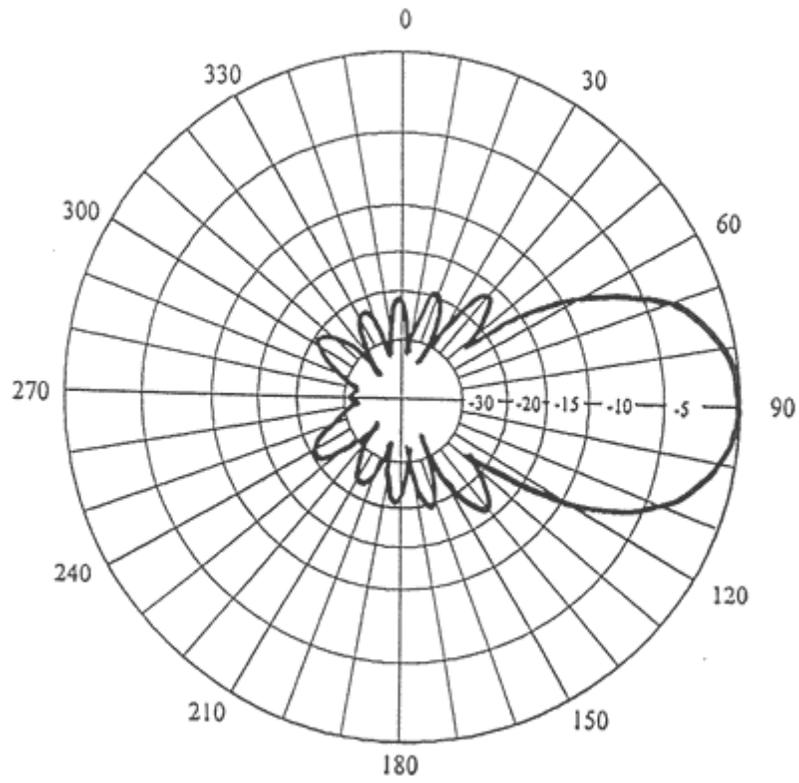
Normal Orientation for Yagi Antennas



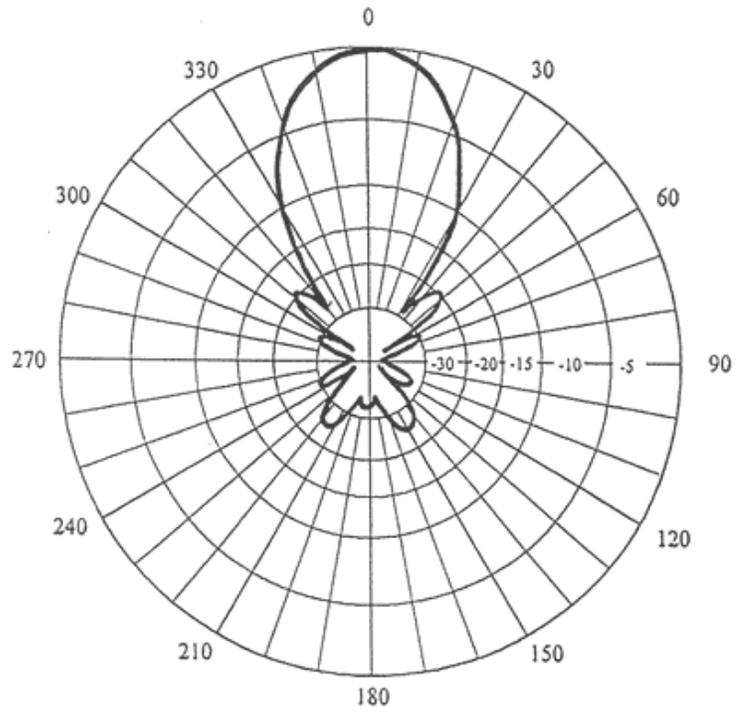
Several styles of antennas are available, including short Yagis, low profile antennas, omni-directional whip types etc. The antenna signal dispersion patterns are shown. One (the E-Plane) shows the radiation pattern as viewed from above; the other (H Plane) shows the pattern viewed from the side.



E plane



H plane



*DAQ FACTORY
CONFIGURATION &
OPERATION*

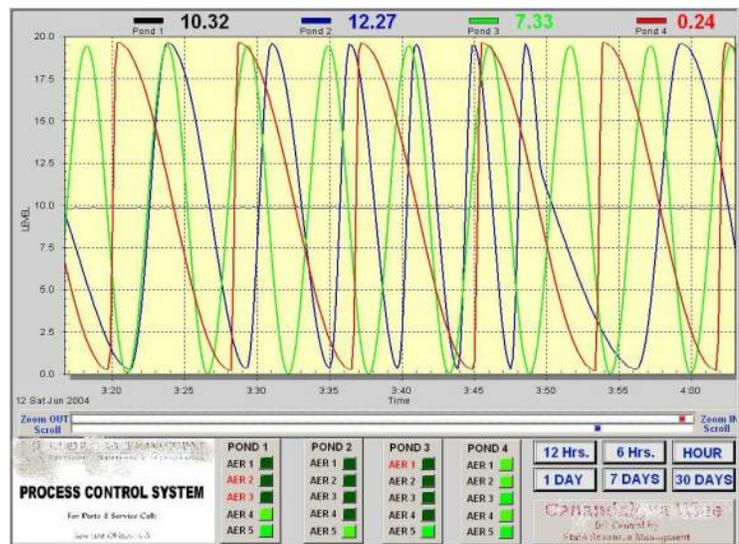
RFSCADA16 RFSCADA4

Remote Terminal Unit

DAQFactory Configuration and Operation.

DAQFactory is a very powerful process control, monitoring and acquisition program available from Azeotech (<http://www.azeotech.com>). Running on a PC DAQFactory comes with built support for connecting to an RFScada device, so a complete application may be built very quickly without requiring complex details such as Modbus addresses, I/O maps etc.

Due to the speed of application development and the built in drivers PC applications connected to an RFScada system are possible that would not have been economically feasible in the past. Data Delivery Devices LLC can provide the final application tailored to your requirements or the end user may write his own application using the developer version of DAQFactory.

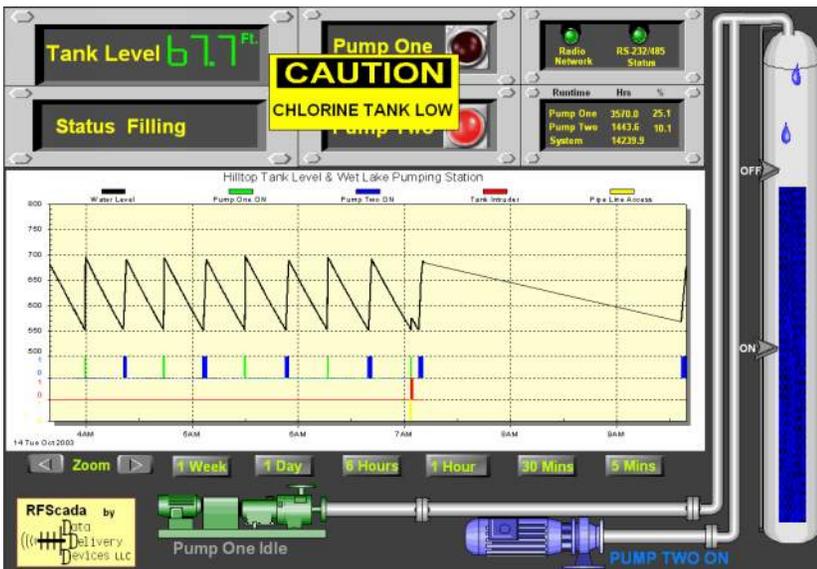


This gives an overview of configuring DAQFactory for operation with the RFScada units, plus accessing all of the RFScada status, inputs and outputs from within the DAQFactory developer version. For full details of DAQFactory programming and operation please refer to the DAQFactory manuals.

Verifying Installation. When creating channels in DAQFactory 'RFScada' should appear in the available device list. If it does not then verify the two files RFScada.dll and RFScada.dds are in the main DAQFactory directory and restart DAQFactory.

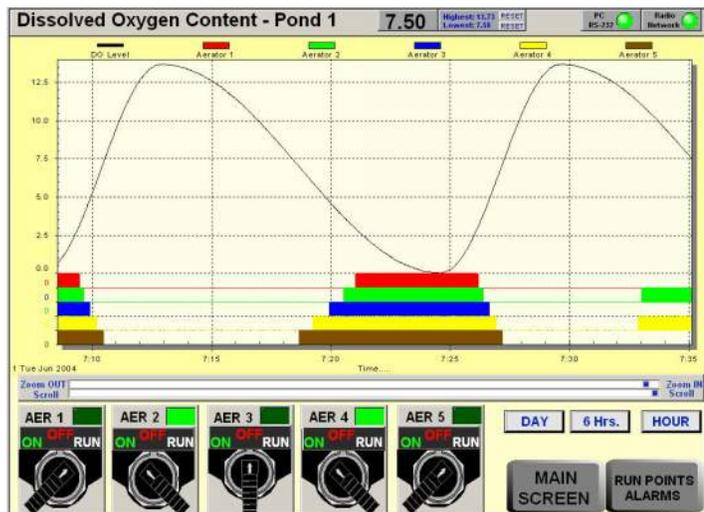
RFScada Configuration. The RFScada units all need to be correctly configured before operating with DAQFactory. There are several modes of operation with many complex routing combinations and settings possible. Typically a physically non-existent 'virtual' units registers will be overwritten by DAQFactory for outputs, and the RFScada master device will then route these overwritten registers to appropriate physical outputs. Use the RFScada configuration program to initially setup the RFScada devices for required routing.

DAQFactory 'Device Number' and RFScada 'Units'. In all DAQFactory access and commands the DAQFactory 'device number' corresponds to the RFScada physical (or virtual) unit, even if the unit is not connected to the PC serial port. This is because all RFScada units in a system continually exchange data via the radio network, with the 'master' unit, 0, accumulating input data from all the slave units then sending output data to all the slaves per the preset configuration. The 'master' RFScada unit, which has an assigned unit ID 0 is Device 0 in DAQFactory. The slave and any 'virtual' RFScada units will have ID's of 1 to 31 which are also their Device numbers in DAQFactory. When DAQFactory accesses a Device number other than 0 it is actually reading or writing to the physical RFScada Unit 0 (master) which is connected to the PC's serial port; RFScada Unit 0 will then read or write data via radio to the requested RFScada unit. All of this reading, writing, storing and forwarding occurs inside the RFScada Unit 0, and is completely transparent to the user and DAQFactory. For example, to access Unit 7, even though it is not physically connected to the PC (and it may be many miles away) in the DAQFactory channel setup assign the Device to 7.



Physical Interface. The physical serial port connection from the PC running DAQFactory must be made to the RFScada device that is configured as the master, as it is the only device in an RFScada network with access to all of the RFScada network registers. The serial port connection may either be RS-232 or RS-485 (2 wire hardware automatic). All serial port parameters except the COM port are assigned automatically.

DAQFactory Serial Port Selection. Before any DAQFactory access to the RFScada network is possible the COM port must be selected from within DAQFactory. A DAQFactory 'channel command' may be used to do this. First create a DAQFactory channel with the following properties, Device Type: RFScada; Device Number: 0; I/O Type: Command. Now when this channel is set to a value from within DAQFactory the value will become the serial port used for RFScada access. So simply assign a value of 1 to 16 to set the connected COM port. Once set the COM port is typically never changed, so it may easily be set once in the initial startup sequence.



DAQFactory Serial Port Status. There are many possible serial port errors that could occur during communication between the PC running DAQFactory and the RFScada units, for example the user could attempt to select a non existent serial port or the serial cable could be unplugged. The status of serial port communications may be monitored from within DAQFactory and of course it may be used to initiate alarms and warnings. To access the serial port status set up a channel as Device Type: RFScada; Device Number: 0; I/O Type: Special; Channel: 1. Reading the channel will return the serial port state, with the following meanings:

0	Correct operation
1 to 4	Failed to initialize
5 – 9	Internal initialization errors
10 - 12	Failed to read correctly
13 to 16	Failed to write correctly

RFScada Radio Network Status. If there are multiple physical RFScada units in the system then the RFScada units will continually communicate amongst themselves via the built in radios. The status of this radio network may be monitored from DAQFactory, and of course it may be used to initiate alarms and warnings. To access the RFScada radio network status set up a channel as Device Type: RFScada; Device Number: 0; I/O Type: Special; Channel: 2. Reading the channel will return the radio network status, with the following meanings.

0	Correct operation, every unit is communicating correctly.
1	Some, but not all RFScada 'slave' units are responding to radio signals from the RFScada 'master' unit.
2	None of the RFScada 'slave' units are responding to radio signals from the RFScada 'master' unit.

If the radio network status is 1 it is possible to find out which units are not operating correctly, refer to the RFScada individual network status.

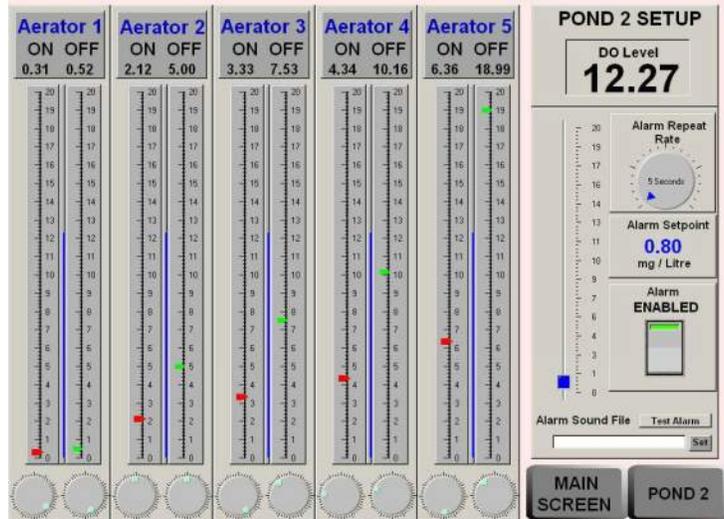
RFScada Individual Network Status. This returns the operational status of an individual RFScada unit. To access a units status set up a channel as Device Type: RFScada; Device Number: The units ID, 0 to 31; I/O Type: Special; Channel: 0. Reading the channel will return units radio network status. 0 means the unit is responding correctly, and 1 indicates that there is no response from the unit. Typically this status would only be read after an error was reported from reading the RFScada Radio Network Status, since it is much easier to read a single summary status than poll each individually.

RFScada Software Version. The software version installed in the RFScada master unit may be read. To access the RFScada software version set up a channel as Device Type: RFScada; Device Number: 0; I/O Type: Special; Channel: 3. Reading the channel will return the software version as a number, e.g. 24 means software version 2.4

Local and Remote Analog Inputs. Analog inputs from every RFScada unit in a system may be read using the 'A to D' read function. To read an input set up a channel with Device Type: RFScada; Device Number: The units ID, 0 to 31; I/O Type: A to D; Channel: the units channel, 1 to 8. Reading the channel will

return the analog input as a number from 0 to 1023, which corresponds to 0 - 20mA.

Local and Remote Digital Inputs. Digital inputs from every RFScada unit in a system may be read using the 'Dig In' read function. To read an input set up a channel with Device Type: RFScada; Device Number: The units ID, 0 to 31; I/O Type: Dig In; Channel: the units channel, 1 to 8. Reading the channel will return the digital input as a number, either 0 for the input open circuit or 1 if the input is shorted.



Local and Remote Analog Outputs. Analog outputs on every RFScada unit in a system may be written to by 'overriding' analog inputs that are then routed by the RFScada master unit to the desired analog output(s). (refer to the rest of this manual for a full explanation). Typically a non-existent 'virtual' units analog input is over written, and this is then routed wherever it is desired. To do this set up a channel that will use the 'D to A' write function. Use Device Type: RFScada; Device Number: The units ID, 0 to 31; I/O Type: D to A; Channel: the units channel, 1 to 8. Write to the channel a value from 0 to 1023, which corresponds to 0 - 20mA.

Local and Remote Digital Outputs. Digital outputs on every RFScada unit in a system may be written to by 'overriding' digital inputs that are then routed by the RFScada master unit to the desired digital output(s). (refer to the rest of this manual for a full explanation). Typically a non-existent 'virtual' units digital input is over written, and this is then routed wherever it is desired. To do this set up a channel that will use the 'Dig Out' write function. Use Device Type: RFScada; Device Number: The units ID, 0 to 31; I/O Type: Dig Out; Channel: the units channel, 1 to 8. Write to the channel either a 1 (relay active, normally open contacts closed) or 0 (relay inactive, normally open contacts open).

Cautions when Writing to Outputs. The RFSkada Units are designed for operation in many diverse applications, and may control devices such as motors and pumps. It is possible during operation that the PC could fail, it may lose power or the serial connection between the PC and the RFSkada Unit is lost for some reason. If this occurs it is important that the RFSkada sets all of its outputs to the default 'off' state, (Analog outputs at 0 mA, all digital output relays off) to prevent any possible hazards or equipment damage. For this reason the RFSkada Unit has a user programmable 'Modbus Override Time' value that needs to be set appropriately for the application (the default is 10 seconds). If a Modbus write to 'overwritten' registers does not occur within this time all overwritten registers on that unit will revert to the default state. So, in the DAQFactory application any output writes will need to be repeated by DAQFactory within the 'Modbus Override Time' to prevent written values reverting to default values. Just writing to a single output, either analog or digital, on a unit will reset that units timeout and all overwritten values on that unit will remain without requiring any other writes, since the timeout is for the unit as a whole and not for individual registers. A simple DAQFactory 'Sequence' that keeps writing more frequently than the Modbus override time to any register on any overwritten Unit will allow correct operation.

*MODBUS CONFIGURATION,
CONTROL AND MONITORING*

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Remote Terminal Unit

Modbus Configuration, Control and Monitoring

When the RFScada units are shipped they will usually be configured for the final application, and no further programming, configuration or adjustments are required. Each unit stores its own settings inside non volatile memory where they will remain until the unit is reconfigured. Connection to power is not required to maintain these settings, there are no batteries or similar volatile devices required for storage.

It may, however be necessary to change settings in the field if additional units are added to the system or changes in the configured settings are desired. It may also be desirable to monitor and possibly control conditions at various units using a computer. The RFScada units have this capability built in, via an industry standard protocol called Modbus, and by using a standard PC with suitable software every input, output and configuration setting may be monitored or changed in the field by the user. It is also possible to permanently store new configuration settings in each unit.

PC software supplied allows units to be reconfigured in the field. The software also has basic monitoring and control capability, to allow the user to monitor or make simple control adjustments in the field, primarily intended for testing and demonstration. The complete Modbus map is also included here, so users may also connect to the RFScada devices using their own software via applications such as DAQFactory, LabView, Wonderware, Visual Basic etc.

Physical Interface.

The RFScada devices have two types of interface supplied as standard, called RS-232 and RS-485. Each interface has its own physical connector, with the RS-232 connector being a 4 pin Molex type socket on the lower right hand side of the board marked J15, and the RS-485 connector is a three pin terminal block marked J16. Only one interface is usually used at a time, however the RFScada will automatically use which ever interface is connected.

Standard PC's have an RS-232 serial port (typically a 9 pin male connector, occasionally a male 25 pin on the rear of the PC) which connects via a suitable cable to J15 on the RFScada board. A suitable cable is available from Data Delivery Devices LLC for connection to a PC's RS-232 port, or use the following table for connections if constructing you own cable.

<i>PC RS-232 to RFScada Interface Connections</i>			
Signal	9 Pin PC Serial Port	25 Pin PC Serial Port	RFScada
Received Data to PC	Pin 2	Pin 3	J15 Pin 1
Transmit Data from PC	Pin 3	Pin 2	J15 Pin 2
Ground	Pin 5	Pin 7	J15 Pin 3
Shield Ground	Shield	Shield	J15 Pin 4

For many industrial environments or locations which require long cable runs a standard called RS-485 is often used instead of RS-232, as it is far less prone to interference and many devices may be connected in parallel to a single interface cable. Low cost converters and other interface devices, such as electrical isolators, are available to allow a PC's standard RS-232 serial port to convert RS-232 data to the RS-485 standard. There are several versions of RS-485 available, the RFScada units conform to the most popular, called 2 wire since just two wires plus ground are required for interconnection. The following table lists the connections.

<i>RS-485 to RFScada Interface Connections</i>	
Signal	Connection
Ground	J16 Pin 3
A (transmit & receive)	J16 Pin 1
B (transmit & receive)	J16 Pin 2

RS-485 networks often use a terminator resistor, value 120 Ohm at either end of a transmission line. The RFScada units do not have this resistor on the main board, to allow it to be connected at any point. If the RFScada unit is the last device on the RS-485 network a 120 Ohm resistor may be connected between the A & B connections. As an additional precaution when using extreme cable lengths a 100 Ohm resistor is sometimes installed in series with the shield between devices. If a large ground Voltage difference appears between the two sites the resistor prevents heavy currents flowing in the shield between locations. Note that many devices supporting RS-485 have reversed nomenclature for the A & B connections; if communication errors exist try reversing the A & B connections.

Software Interface.

Suitable software is required on a PC to communicate with the RFScada devices. Software may be downloaded from the Data Delivery Devices website at no charge to provide configuration and basic monitoring of the units; this software is actually communicating with the RFScada devices via Modbus, using the following commands and Modbus 'map'. It may be a useful starting point before attempting to connect using custom Modbus software; the Data Delivery Devices software may be used to verify hardware cables and connections first.



CAUTION

When using Modbus to access the RFScada devices care must be taken as it is possible to activate outputs, completely alter the operation of individual units, the complete system and even render units inoperable until re-programmed for the desired operation. If the units are remote, for example being accessed via a Modem, it is possible to write values that effectively disable remote Modbus access. It is recommended that any changes be thoroughly tested with all external circuitry disconnected to verify correct operation before final connection. Remember to write changes to non volatile memory so they will remain after power is cycled to the device.

The connection data rate is usually fixed at 9600 baud, no parity with one stop bit; although it may be changed for special applications. It will always be 9600 for at least 30 seconds after power is applied (see register 1015 for details). The units will respond to four Modbus commands, command 3 (0x03 hex) which allows the user to read one or more registers at once, command 4, command 6 (0x06 hex) to write to a single register and command 16 (0x10 hex) which allows one or more registers to be written at once. Nearly all of the registers may be written to, with the exception of a few, such as the software version installed (register 609) which can only be read with command 3. To allow easy 'block writes' of register areas that may contain a read only register no errors will be reported via Modbus for attempted writes to read-only registers; they will simply not be written. It is important to understand the method of communication between RFScada units, as although all registers are available in every unit only a few are updated in 'slaves', whereas all registers are updated at the 'Master' unit, designated 0. To determine the type of unit read register 608, if it is zero this unit is the RFScada system 'master' and all registers are accessible. Under normal circumstances Modbus access and control would be at unit 0, allowing full access to the system. Access at slaves is primarily intended for testing, to

change local settings, such as a timeout value, or to override and 'force' local inputs via Modbus. In the following descriptions it is assumed that the Modbus connection is made to the master unit, 0.

When connected via Modbus to a slave unit (i.e. the units id is 1 to 31) the only registers that have significance are the 10 related to that units id (for example 170 to 179 for unit 17, 30 to 39 for unit 3 etc), registers 608 to 614, register 1015 and register 3318.

Register Descriptions:

The first 320 registers supply present readings and status for the units, with each unit having 10 registers. The first is the state of the 8 digital input switches, with a zero bit indicating an input switch is open. Bit 8, (which cannot be overwritten via Modbus, see explanation later) indicates if this unit is correctly communicating with the system master unit. The next 8 registers correspond to the user analog inputs, each being a 10 bit resolution input, with 20mA being a full scale reading of 1023. 0 corresponds to 0.0 mA, so it is possible to tell if a 4-20mA loop device is indicating minimum output or if the loop has been broken. The last register is the analog measurement of the DC voltage on the RFScada board, and may be used for general indication or for early warning of failing power, for example from a solar power supply. It is typically around 18 Volts DC when the unit is operating at 115 VAC, or about 1 Volt below the DC input Voltage if operating from an external DC power supply. Approximately 51 Volts DC is the full scale input for this reading, so values about 340 -380 are normal when operating on 115 VAC line input.

Any of these 320 registers may be forced or 'overridden' via Modbus, to override local or remote conditions. Outputs on all units that rely on 'Modbus overridden' input registers as their signal 'source' will now output signals using these 'Modbus overwritten' values as sources. The RFScada 'real' values, taken from external sensors and switches for that relevant unit, will be blocked while overwritten via Modbus. All input registers for an overridden unit will be locked, so even if just the digital inputs on unit 12 are Modbus overridden all of unit 12's registers are held at the present state. The Modbus overridden values will remain current until Modbus write commands for that particular units registers have not occurred for the time specified in the 'Modbus override time' register, 613. Once the registers have not been overwritten for that time the registers will automatically revert to sourcing signals from system read inputs, such as analog inputs and switches. This allows great flexibility, as any input on any unit may effectively be overridden via Modbus for testing or control purposes. Once Modbus overrides stop the unit will revert to normal operation. Only registers associated with 'Modbus overridden' ones are affected,

and all other operations, including control, communications, monitoring and Modbus activity continue to occur normally. For applications that require some outputs to be driven only from Modbus simply configure those outputs to be driven from an unused unit ID, then they will only be updated from Modbus.

The next 128 registers, from 320 to 447, control configuration for all the relay signal sources. These registers are similar to one another, and just differ by the relay, the unit and input bit that they refer to. Each relay is individually controlled by a digital input (or the Modbus register corresponding to that input). For example, register 368 configures relay 1 and 2 on unit 12. The least significant byte controls the signal source for relay 1, and the most significant byte relay 2. In each byte the most significant 5 bits are the source unit ID for the relay signal, and the least significant 3 bits are the digital input bit. So, in this case if the lower byte was 11011010 Binary (218 decimal or 0xDA hex) relay 1 in unit 12 would be driven by digital input 3 on unit 27. If the upper byte was 01100111 Binary (103 decimal or 0x67 hex) relay 2 in unit 12 would be driven by digital input 8 on unit 12 (its own unit). Each relay output may be sourced from any digital input, so it is possible to drive multiple relays on multiple units from the same digital input.

The next 128 registers, from 448 to 575, control configuration for all the analog output signal sources. These registers are similar to one another, and just differ by the analog output, the unit and analog input channel that they refer to. Each analog output is individually controlled by an analog input (or the Modbus register corresponding to that input). For example, register 491 configures analog outputs 7 and 8 on unit 10. The least significant byte controls the signal source for analog output 7, and the most significant byte analog output 8. In each byte the most significant 5 bits are the source unit ID for the analog signal, and the least significant 3 bits are the analog input channel. So, in this case if the lower byte was 11011010 Binary (218 decimal or 0xDA hex) analog output 7 in unit 10 would be driven by analog input 3 on unit 27. If the upper byte was 01100111 Binary (103 decimal or 0x67 hex) analog output 8 in unit 10 would be driven by analog input 8 on unit 12. Every analog output may be sourced from any input, so it is possible to driven multiple (or all) analog outputs from the same analog input.

The 32 registers from 576 to 607 specify if each unit is enabled. Register 576, for the system master (unit 0), must always be enabled, as it control communications between all units. If a non existent unit is enabled here the system will not operate, and indicate a 'network' error status.

Register 608 is the ID of this device. If the ID is zero this unit will be the system master, be responsible for routing all signals between units, will have virtually all of the configuration settings for the system and will control communications between all

units. One unit in a system must be the master, and there must only be one master in a system. If the ID is 1 to 31 this unit is a 'slave' unit, and just a few Modbus registers will have significance. Every slave must have a unique ID for correct operation, allowing a total of 32 units (one master plus 1 to 31 slaves) to be in one system. Slaves do not require sequential ID's, and slaves may effectively be disabled by 'un-enabling' them in the masters configuration. The 'receive data' LED will flash rapidly on a disabled slave that monitors network traffic, but since it is never addressed it will never respond and will not transmit.

Register 609 contains an image of the output relays on this unit. It is read only.

Register 610 indicates the current network state, again it is read only. If it is zero the network is operating correctly and all configured units are communicating correctly; the 'system status' LED and relay on this and all other units will be on continuously. If this register contains 1 then this unit (if not the master) and the master unit are communicating and operating correctly, but at least one unit somewhere on the network is not communicating or operating correctly. On this and all other units that are operating the 'system status' LED and relay will slowly be toggling on and off, indicating an error somewhere in the system. Bit 8 in Modbus registers 0 to 320 and Modbus registers 577 to 607 may be compared to identify the exact enabled unit (or units) that are not responding. If register 608 contains 2 then this unit is not communicating with any other unit, and the 'system status' LED and relay will be off.

Register 611 contains the user Modbus address for this device. It may be anything from 1 to 98 or 100 to 255 (default is 0, or off). Note that the RFScada units will also *always* respond to address 99 (0x63 Hex), so even if the Modbus address is zero or has accidentally been changed and subsequently lost the unit may still be accessed using address 99. The users Modbus 'silent time' (register 614) will also be ignored when accessed using address 99, see register 614 for details. Unless multiple RFScada devices are on the same Modbus network or special silent times are required it is suggested that the 'always enabled' address of 99 be used.

Register 612 contains the default 'loss of communications' timeout value. For slaves, if valid radio communications are not received by this unit within this time frame the unit will change state to indicate 'lost communications'. All outputs will change to default settings (i.e. off) and the 'system status' LED and relay will turn off. If this unit is the master this register contains the maximum time without receiving valid communications from every unit before changing state to 'network error'; where the master unit and at least one slave unit are communicating and operating correctly, but at least one unit somewhere on the network is not communicating or operating correctly. On this

and all other units that are still operating all outputs will change to default settings (i.e. off), the 'system status' LED and relay will slowly be toggling on and off, indicating an error somewhere in the system. The register time is in 10 second increments, with the default set at 6 (one minute), which is suitable for most systems with a few units and good communications. It is a 16 bit register so accommodates times to over 7 days. If many units are in a system this time may need to be extended to prevent network errors, for example caused by power being briefly interrupted on a single unit.

Register 613 contains the time in seconds before reverting to normal operation after Modbus 'override' writes. If a register is written again via Modbus within this time period it will contain the latest 'Modbus overridden' value; if the timer expires the register will revert to normal, being updated by the RFScada inputs. Each time a write occurs to the relevant units registers its timer is restarted. See the section on registers 0 to 319 for further details.

Register 614 contains the Modbus 'silent interval' time setting, in milliseconds. Modbus RTU messages start and end with a silent interval of at least 3.5 character times, which for a baud rate of 9600 bps is approximately 4mS. The RFScada units are capable of reading the Modbus message, acting on the message, formulating a reply, then start transmitting it back to the Modbus master device as soon as this 4mS time expires. The RFScada units are also capable of monitoring the Modbus data and detecting a gap between bytes in a message that is 5 mS in length for example. Normally Modbus messages from a Master, such as a local PC, will have correctly formed data packets without any gaps between bytes. However, if there are gaps between bytes of more than 4mS the RFScada units may assume the packet has ended, process it and since the packet is not complete the RFScada unit ignores the packet and does not reply. The Modbus master then signals an error reporting that the RFScada device did not reply to a Modbus message, when in fact a legal Modbus packet was not presented to the RFScada device. This type of error seldom occurs on modern PC systems with local connections, however it often occurs when a telephone modem or similar device is between units on a Modbus network. Even short packets of data sent directly between two modems often result in smaller bursts of data at the receiving modem, separated by gaps of several milliseconds. The problem may also occur when some RS-485 interface devices are used that incorporate 'automatic transmit enable' circuits; these devices often use simple RC timing circuits to enable the driver output, with the result being they may still be driving the Modbus connection and corrupting data several milliseconds after the bus should have been released, when the RFScada unit is trying to send a reply.

To overcome these problems the user may set a silent interval in register 614. It can be from 4 up to 255 milliseconds, with the default set at 40. Extending it will delay a response to the Modbus master, so it should not be extended too long, or the Modbus masters own timeout settings may need to be extended.

 **Warning !**

If this delay is set to very small values Modbus communication problems may occur, especially with remote modems and similar devices. ***It is possible to completely lose remote Modbus communications, and lose the capability to change the configuration back!*** If this occurs a direct serial connection may be required to regain Modbus control and return modified registers, such as register 614, back to values that allow functionality with connected equipment.

For this reason if an RFScada device is accessed via Modbus address 99 (0x63 Hex) it will ignore the users silent time setting and use its own setting of 100mS, therefore allowing communication with most standard devices including remote modems. This gives the user (and the RFScada configuration program) a means to restore settings that have been changed to inoperative ones. Therefore, if changes in the silent time are required a Modbus address other than 99 must be used.

If this register really needs adjusting from a remote location use caution and test any changes *before* writing them to EEPROM, so cycling power can also restore original settings. Under normal circumstances there should be no reason to change this value.

Register 615 contains the identity of any special control mode operating, it is zero for normal operation.

Register 1000 contains the hop pattern of the unit, it is read only and set at the factory.

Register 1001 contains the serial number of the unit, it is read only and set at the factory.

Register 1002 contains the number of channels this unit physically supports, it is read only and set at the factory. It is not related to the optional plug in boards.

Register 1003 contains the software version of the RFScada unit, again read only. Units do not need to have identical software versions to communicate.

Registers 1004 to 1013 contain additional factory settings that are specific to the type of radio installed.

Register 1015 contains the Modbus baud rate setting for the PC RS-232 / RS-484 interface. When the unit powers up the

interface will always be configured at 9600 baud, and if a valid Modbus command (such as one from the RFScada configuration program) is received within 30 seconds the unit will remain at 9600 baud. However if a command was not received at 9600 baud within the first 30 seconds the unit will switch to the baud rate setting in register 1015 (which is 9600 baud by default). Therefore for special applications the baud rate may be set to different values but the unit may still be accessed using the standard baud rate.

Register 3318 is the Modbus and configuration settings control register. All Modbus registers that may be written to will become effective as soon as they are written, there are no delays or power cycles required. The registers are volatile however, so changes in configuration made via Modbus will be lost when power is removed unless they are permanently stored in the RFScada non volatile memory. Register 3318 allows the current setting to be permanently saved in EEPROM memory, and they will be read back from EEPROM memory when power is restored to the unit. All registers may also be set to default settings here. To set all configuration settings to default values write the value 1234 decimal (0x04D2 hex) to register 3318. To permanently store the present settings in the RFScada EEPROM memory write the decimal value 5678 decimal (0x162E hex) to register 3318.



It takes several seconds to store all the settings in the RFScada non-volatile memory. The yellow system LED (near the center of the board) on the RFScada unit will flash rapidly during the storage process. After receiving the 'write EEPROM' command the RFScada unit will not respond to any Modbus messages until it has finished the write process, and a 'Modbus timeout' error message may occur on the Modbus master. This is normal and should not be interpreted as an error. After writing all settings verify correct operation before final connection.

The RFScada configuration program communicates to the units via Modbus. Modbus traffic to and from the units may be viewed in the bottom of the register display screen by turning on the 'view Modbus data' setting in the menu. To view the existing settings the configuration program may be used to read a units settings, then save the settings to a file. The saved file is simply a list of the Modbus register address followed by its contents.

Complete RFScada Modbus Map.

0	Unit 0 Bits 0-7 Digital Inputs, Bit 8 = COMM OK
1	Unit 0 Analog 1 10 bit result. 0 = 0 mA, 1023 = 20mA
2	Unit 0 Analog 2 10 bit result. 0 = 0 mA, 1023 = 20mA
3	Unit 0 Analog 3 10 bit result. 0 = 0 mA, 1023 = 20mA
4	Unit 0 Analog 4 10 bit result. 0 = 0 mA, 1023 = 20mA
5	Unit 0 Analog 5 10 bit result. 0 = 0 mA, 1023 = 20mA
6	Unit 0 Analog 6 10 bit result. 0 = 0 mA, 1023 = 20mA
7	Unit 0 Analog 7 10 bit result. 0 = 0 mA, 1023 = 20mA
8	Unit 0 Analog 8 10 bit result. 0 = 0 mA, 1023 = 20mA
9	Unit 0 DC Voltage 10 bit, 1023 = 51.1 Volts DC (approx)
10	Unit 1 Bits 0-7 Digital Inputs, Bit 8 = COMM OK
11	Unit 1 Analog 1 10 bit result. 0 = 0 mA, 1023 = 20mA
12	Unit 1 Analog 2 10 bit result. 0 = 0 mA, 1023 = 20mA
13	Unit 1 Analog 3 10 bit result. 0 = 0 mA, 1023 = 20mA
14	Unit 1 Analog 4 10 bit result. 0 = 0 mA, 1023 = 20mA
15	Unit 1 Analog 5 10 bit result. 0 = 0 mA, 1023 = 20mA
16	Unit 1 Analog 6 10 bit result. 0 = 0 mA, 1023 = 20mA
17	Unit 1 Analog 7 10 bit result. 0 = 0 mA, 1023 = 20mA
18	Unit 1 Analog 8 10 bit result. 0 = 0 mA, 1023 = 20mA
19	Unit 1 DC Voltage 10 bit, 1023 = 51.1 Volts DC (approx)
20	Unit 2 Bits 0-7 Digital Inputs, Bit 8 = COMM OK
21	Unit 2 Analog 1 10 bit result. 0 = 0 mA, 1023 = 20mA
22	Unit 2 Analog 2 10 bit result. 0 = 0 mA, 1023 = 20mA
23	Unit 2 Analog 3 10 bit result. 0 = 0 mA, 1023 = 20mA
24	Unit 2 Analog 4 10 bit result. 0 = 0 mA, 1023 = 20mA
25	Unit 2 Analog 5 10 bit result. 0 = 0 mA, 1023 = 20mA
26	Unit 2 Analog 6 10 bit result. 0 = 0 mA, 1023 = 20mA
27	Unit 2 Analog 7 10 bit result. 0 = 0 mA, 1023 = 20mA
28	Unit 2 Analog 8 10 bit result. 0 = 0 mA, 1023 = 20mA
29	Unit 2 DC Voltage 10 bit, 1023 = 51.1 Volts DC (approx)
30	Unit 3 Bits 0-7 Digital Inputs, Bit 8 = COMM OK
31	Unit 3 Analog 1 10 bit result. 0 = 0 mA, 1023 = 20mA
32	Unit 3 Analog 2 10 bit result. 0 = 0 mA, 1023 = 20mA
33	Unit 3 Analog 3 10 bit result. 0 = 0 mA, 1023 = 20mA
34	Unit 3 Analog 4 10 bit result. 0 = 0 mA, 1023 = 20mA
35	Unit 3 Analog 5 10 bit result. 0 = 0 mA, 1023 = 20mA
36	Unit 3 Analog 6 10 bit result. 0 = 0 mA, 1023 = 20mA
37	Unit 3 Analog 7 10 bit result. 0 = 0 mA, 1023 = 20mA
38	Unit 3 Analog 8 10 bit result. 0 = 0 mA, 1023 = 20mA
39	Unit 3 DC Voltage 10 bit, 1023 = 51.1 Volts DC (approx)
40	Unit 4 Bits 0-7 Digital Inputs, Bit 8 = COMM OK
41	Unit 4 Analog 1 10 bit result. 0 = 0 mA, 1023 = 20mA
42	Unit 4 Analog 2 10 bit result. 0 = 0 mA, 1023 = 20mA
43	Unit 4 Analog 3 10 bit result. 0 = 0 mA, 1023 = 20mA
44	Unit 4 Analog 4 10 bit result. 0 = 0 mA, 1023 = 20mA
45	Unit 4 Analog 5 10 bit result. 0 = 0 mA, 1023 = 20mA
46	Unit 4 Analog 6 10 bit result. 0 = 0 mA, 1023 = 20mA
47	Unit 4 Analog 7 10 bit result. 0 = 0 mA, 1023 = 20mA
48	Unit 4 Analog 8 10 bit result. 0 = 0 mA, 1023 = 20mA
49	Unit 4 DC Voltage 10 bit, 1023 = 51.1 Volts DC (approx)
50	Unit 5 Bits 0-7 Digital Inputs, Bit 8 = COMM OK
51	Unit 5 Analog 1 10 bit result. 0 = 0 mA, 1023 = 20mA
52	Unit 5 Analog 2 10 bit result. 0 = 0 mA, 1023 = 20mA
53	Unit 5 Analog 3 10 bit result. 0 = 0 mA, 1023 = 20mA
54	Unit 5 Analog 4 10 bit result. 0 = 0 mA, 1023 = 20mA
55	Unit 5 Analog 5 10 bit result. 0 = 0 mA, 1023 = 20mA
56	Unit 5 Analog 6 10 bit result. 0 = 0 mA, 1023 = 20mA
57	Unit 5 Analog 7 10 bit result. 0 = 0 mA, 1023 = 20mA
58	Unit 5 Analog 8 10 bit result. 0 = 0 mA, 1023 = 20mA
59	Unit 5 DC Voltage 10 bit, 1023 = 51.1 Volts DC (approx)
60	Unit 6 Bits 0-7 Digital Inputs, Bit 8 = COMM OK
61	Unit 6 Analog 1 10 bit result. 0 = 0 mA, 1023 = 20mA

62	Unit 6 Analog 2 10 bit result. 0 = 0 mA, 1023 = 20mA
63	Unit 6 Analog 3 10 bit result. 0 = 0 mA, 1023 = 20mA
64	Unit 6 Analog 4 10 bit result. 0 = 0 mA, 1023 = 20mA
65	Unit 6 Analog 5 10 bit result. 0 = 0 mA, 1023 = 20mA
66	Unit 6 Analog 6 10 bit result. 0 = 0 mA, 1023 = 20mA
67	Unit 6 Analog 7 10 bit result. 0 = 0 mA, 1023 = 20mA
68	Unit 6 Analog 8 10 bit result. 0 = 0 mA, 1023 = 20mA
69	Unit 6 DC Voltage 10 bit, 1023 = 51.1 Volts DC (approx)
70	Unit 7 Bits 0-7 Digital Inputs, Bit 8 = COMM OK
71	Unit 7 Analog 1 10 bit result. 0 = 0 mA, 1023 = 20mA
72	Unit 7 Analog 2 10 bit result. 0 = 0 mA, 1023 = 20mA
73	Unit 7 Analog 3 10 bit result. 0 = 0 mA, 1023 = 20mA
74	Unit 7 Analog 4 10 bit result. 0 = 0 mA, 1023 = 20mA
75	Unit 7 Analog 5 10 bit result. 0 = 0 mA, 1023 = 20mA
76	Unit 7 Analog 6 10 bit result. 0 = 0 mA, 1023 = 20mA
77	Unit 7 Analog 7 10 bit result. 0 = 0 mA, 1023 = 20mA
78	Unit 7 Analog 8 10 bit result. 0 = 0 mA, 1023 = 20mA
79	Unit 7 DC Voltage 10 bit, 1023 = 51.1 Volts DC (approx)
80	Unit 8 Bits 0-7 Digital Inputs, Bit 8 = COMM OK
81	Unit 8 Analog 1 10 bit result. 0 = 0 mA, 1023 = 20mA
82	Unit 8 Analog 2 10 bit result. 0 = 0 mA, 1023 = 20mA
83	Unit 8 Analog 3 10 bit result. 0 = 0 mA, 1023 = 20mA
84	Unit 8 Analog 4 10 bit result. 0 = 0 mA, 1023 = 20mA
85	Unit 8 Analog 5 10 bit result. 0 = 0 mA, 1023 = 20mA
86	Unit 8 Analog 6 10 bit result. 0 = 0 mA, 1023 = 20mA
87	Unit 8 Analog 7 10 bit result. 0 = 0 mA, 1023 = 20mA
88	Unit 8 Analog 8 10 bit result. 0 = 0 mA, 1023 = 20mA
89	Unit 8 DC Voltage 10 bit, 1023 = 51.1 Volts DC (approx)
90	Unit 9 Bits 0-7 Digital Inputs, Bit 8 = COMM OK
91	Unit 9 Analog 1 10 bit result. 0 = 0 mA, 1023 = 20mA
92	Unit 9 Analog 2 10 bit result. 0 = 0 mA, 1023 = 20mA
93	Unit 9 Analog 3 10 bit result. 0 = 0 mA, 1023 = 20mA
94	Unit 9 Analog 4 10 bit result. 0 = 0 mA, 1023 = 20mA
95	Unit 9 Analog 5 10 bit result. 0 = 0 mA, 1023 = 20mA
96	Unit 9 Analog 6 10 bit result. 0 = 0 mA, 1023 = 20mA
97	Unit 9 Analog 7 10 bit result. 0 = 0 mA, 1023 = 20mA
98	Unit 9 Analog 8 10 bit result. 0 = 0 mA, 1023 = 20mA
99	Unit 9 DC Voltage 10 bit, 1023 = 51.1 Volts DC (approx)
100	Unit 10 Bits 0-7 Digital Inputs, Bit 8 = COMM OK
101	Unit 10 Analog 1 10 bit result. 0 = 0 mA, 1023 = 20mA
102	Unit 10 Analog 2 10 bit result. 0 = 0 mA, 1023 = 20mA
103	Unit 10 Analog 3 10 bit result. 0 = 0 mA, 1023 = 20mA
104	Unit 10 Analog 4 10 bit result. 0 = 0 mA, 1023 = 20mA
105	Unit 10 Analog 5 10 bit result. 0 = 0 mA, 1023 = 20mA
106	Unit 10 Analog 6 10 bit result. 0 = 0 mA, 1023 = 20mA
107	Unit 10 Analog 7 10 bit result. 0 = 0 mA, 1023 = 20mA
108	Unit 10 Analog 8 10 bit result. 0 = 0 mA, 1023 = 20mA
109	Unit 10 DC Voltage 10 bit, 1023 = 51.1 Volts DC (approx)
110	Unit 11 Bits 0-7 Digital Inputs, Bit 8 = COMM OK
111	Unit 11 Analog 1 10 bit result. 0 = 0 mA, 1023 = 20mA
112	Unit 11 Analog 2 10 bit result. 0 = 0 mA, 1023 = 20mA
113	Unit 11 Analog 3 10 bit result. 0 = 0 mA, 1023 = 20mA
114	Unit 11 Analog 4 10 bit result. 0 = 0 mA, 1023 = 20mA
115	Unit 11 Analog 5 10 bit result. 0 = 0 mA, 1023 = 20mA
116	Unit 11 Analog 6 10 bit result. 0 = 0 mA, 1023 = 20mA
117	Unit 11 Analog 7 10 bit result. 0 = 0 mA, 1023 = 20mA
118	Unit 11 Analog 8 10 bit result. 0 = 0 mA, 1023 = 20mA
119	Unit 11 DC Voltage 10 bit, 1023 = 51.1 Volts DC (approx)
120	Unit 12 Bits 0-7 Digital Inputs, Bit 8 = COMM OK
121	Unit 12 Analog 1 10 bit result. 0 = 0 mA, 1023 = 20mA
122	Unit 12 Analog 2 10 bit result. 0 = 0 mA, 1023 = 20mA
123	Unit 12 Analog 3 10 bit result. 0 = 0 mA, 1023 = 20mA
124	Unit 12 Analog 4 10 bit result. 0 = 0 mA, 1023 = 20mA
125	Unit 12 Analog 5 10 bit result. 0 = 0 mA, 1023 = 20mA
126	Unit 12 Analog 6 10 bit result. 0 = 0 mA, 1023 = 20mA

127	Unit 12 Analog 7 10 bit result. 0 = 0 mA, 1023 = 20mA
128	Unit 12 Analog 8 10 bit result. 0 = 0 mA, 1023 = 20mA
129	Unit 12 DC Voltage 10 bit, 1023 = 51.1 Volts DC (approx)
130	Unit 13 Bits 0-7 Digital Inputs, Bit 8 = COMM OK
131	Unit 13 Analog 1 10 bit result. 0 = 0 mA, 1023 = 20mA
132	Unit 13 Analog 2 10 bit result. 0 = 0 mA, 1023 = 20mA
133	Unit 13 Analog 3 10 bit result. 0 = 0 mA, 1023 = 20mA
134	Unit 13 Analog 4 10 bit result. 0 = 0 mA, 1023 = 20mA
135	Unit 13 Analog 5 10 bit result. 0 = 0 mA, 1023 = 20mA
136	Unit 13 Analog 6 10 bit result. 0 = 0 mA, 1023 = 20mA
137	Unit 13 Analog 7 10 bit result. 0 = 0 mA, 1023 = 20mA
138	Unit 13 Analog 8 10 bit result. 0 = 0 mA, 1023 = 20mA
139	Unit 13 DC Voltage 10 bit, 1023 = 51.1 Volts DC (approx)
140	Unit 14 Bits 0-7 Digital Inputs, Bit 8 = COMM OK
141	Unit 14 Analog 1 10 bit result. 0 = 0 mA, 1023 = 20mA
142	Unit 14 Analog 2 10 bit result. 0 = 0 mA, 1023 = 20mA
143	Unit 14 Analog 3 10 bit result. 0 = 0 mA, 1023 = 20mA
144	Unit 14 Analog 4 10 bit result. 0 = 0 mA, 1023 = 20mA
145	Unit 14 Analog 5 10 bit result. 0 = 0 mA, 1023 = 20mA
146	Unit 14 Analog 6 10 bit result. 0 = 0 mA, 1023 = 20mA
147	Unit 14 Analog 7 10 bit result. 0 = 0 mA, 1023 = 20mA
148	Unit 14 Analog 8 10 bit result. 0 = 0 mA, 1023 = 20mA
149	Unit 14 DC Voltage 10 bit, 1023 = 51.1 Volts DC (approx)
150	Unit 15 Bits 0-7 Digital Inputs, Bit 8 = COMM OK
151	Unit 15 Analog 1 10 bit result. 0 = 0 mA, 1023 = 20mA
152	Unit 15 Analog 2 10 bit result. 0 = 0 mA, 1023 = 20mA
153	Unit 15 Analog 3 10 bit result. 0 = 0 mA, 1023 = 20mA
154	Unit 15 Analog 4 10 bit result. 0 = 0 mA, 1023 = 20mA
155	Unit 15 Analog 5 10 bit result. 0 = 0 mA, 1023 = 20mA
156	Unit 15 Analog 6 10 bit result. 0 = 0 mA, 1023 = 20mA
157	Unit 15 Analog 7 10 bit result. 0 = 0 mA, 1023 = 20mA
158	Unit 15 Analog 8 10 bit result. 0 = 0 mA, 1023 = 20mA
159	Unit 15 DC Voltage 10 bit, 1023 = 51.1 Volts DC (approx)
160	Unit 16 Bits 0-7 Digital Inputs, Bit 8 = COMM OK
161	Unit 16 Analog 1 10 bit result. 0 = 0 mA, 1023 = 20mA
162	Unit 16 Analog 2 10 bit result. 0 = 0 mA, 1023 = 20mA
163	Unit 16 Analog 3 10 bit result. 0 = 0 mA, 1023 = 20mA
164	Unit 16 Analog 4 10 bit result. 0 = 0 mA, 1023 = 20mA
165	Unit 16 Analog 5 10 bit result. 0 = 0 mA, 1023 = 20mA
166	Unit 16 Analog 6 10 bit result. 0 = 0 mA, 1023 = 20mA
167	Unit 16 Analog 7 10 bit result. 0 = 0 mA, 1023 = 20mA
168	Unit 16 Analog 8 10 bit result. 0 = 0 mA, 1023 = 20mA
169	Unit 16 DC Voltage 10 bit, 1023 = 51.1 Volts DC (approx)
170	Unit 17 Bits 0-7 Digital Inputs, Bit 8 = COMM OK
171	Unit 17 Analog 1 10 bit result. 0 = 0 mA, 1023 = 20mA
172	Unit 17 Analog 2 10 bit result. 0 = 0 mA, 1023 = 20mA
173	Unit 17 Analog 3 10 bit result. 0 = 0 mA, 1023 = 20mA
174	Unit 17 Analog 4 10 bit result. 0 = 0 mA, 1023 = 20mA
175	Unit 17 Analog 5 10 bit result. 0 = 0 mA, 1023 = 20mA
176	Unit 17 Analog 6 10 bit result. 0 = 0 mA, 1023 = 20mA
177	Unit 17 Analog 7 10 bit result. 0 = 0 mA, 1023 = 20mA
178	Unit 17 Analog 8 10 bit result. 0 = 0 mA, 1023 = 20mA
179	Unit 17 DC Voltage 10 bit, 1023 = 51.1 Volts DC (approx)
180	Unit 18 Bits 0-7 Digital Inputs, Bit 8 = COMM OK
181	Unit 18 Analog 1 10 bit result. 0 = 0 mA, 1023 = 20mA
182	Unit 18 Analog 2 10 bit result. 0 = 0 mA, 1023 = 20mA
183	Unit 18 Analog 3 10 bit result. 0 = 0 mA, 1023 = 20mA
184	Unit 18 Analog 4 10 bit result. 0 = 0 mA, 1023 = 20mA
185	Unit 18 Analog 5 10 bit result. 0 = 0 mA, 1023 = 20mA
186	Unit 18 Analog 6 10 bit result. 0 = 0 mA, 1023 = 20mA
187	Unit 18 Analog 7 10 bit result. 0 = 0 mA, 1023 = 20mA
188	Unit 18 Analog 8 10 bit result. 0 = 0 mA, 1023 = 20mA
189	Unit 18 DC Voltage 10 bit, 1023 = 51.1 Volts DC (approx)
190	Unit 19 Bits 0-7 Digital Inputs, Bit 8 = COMM OK
191	Unit 19 Analog 1 10 bit result. 0 = 0 mA, 1023 = 20mA

192	Unit 19 Analog 2 10 bit result. 0 = 0 mA, 1023 = 20mA
193	Unit 19 Analog 3 10 bit result. 0 = 0 mA, 1023 = 20mA
194	Unit 19 Analog 4 10 bit result. 0 = 0 mA, 1023 = 20mA
195	Unit 19 Analog 5 10 bit result. 0 = 0 mA, 1023 = 20mA
196	Unit 19 Analog 6 10 bit result. 0 = 0 mA, 1023 = 20mA
197	Unit 19 Analog 7 10 bit result. 0 = 0 mA, 1023 = 20mA
198	Unit 19 Analog 8 10 bit result. 0 = 0 mA, 1023 = 20mA
199	Unit 19 DC Voltage 10 bit, 1023 = 51.1 Volts DC (approx)
200	Unit 20 Bits 0-7 Digital Inputs, Bit 8 = COMM OK
201	Unit 20 Analog 1 10 bit result. 0 = 0 mA, 1023 = 20mA
202	Unit 20 Analog 2 10 bit result. 0 = 0 mA, 1023 = 20mA
203	Unit 20 Analog 3 10 bit result. 0 = 0 mA, 1023 = 20mA
204	Unit 20 Analog 4 10 bit result. 0 = 0 mA, 1023 = 20mA
205	Unit 20 Analog 5 10 bit result. 0 = 0 mA, 1023 = 20mA
206	Unit 20 Analog 6 10 bit result. 0 = 0 mA, 1023 = 20mA
207	Unit 20 Analog 7 10 bit result. 0 = 0 mA, 1023 = 20mA
208	Unit 20 Analog 8 10 bit result. 0 = 0 mA, 1023 = 20mA
209	Unit 20 DC Voltage 10 bit, 1023 = 51.1 Volts DC (approx)
210	Unit 21 Bits 0-7 Digital Inputs, Bit 8 = COMM OK
211	Unit 21 Analog 1 10 bit result. 0 = 0 mA, 1023 = 20mA
212	Unit 21 Analog 2 10 bit result. 0 = 0 mA, 1023 = 20mA
213	Unit 21 Analog 3 10 bit result. 0 = 0 mA, 1023 = 20mA
214	Unit 21 Analog 4 10 bit result. 0 = 0 mA, 1023 = 20mA
215	Unit 21 Analog 5 10 bit result. 0 = 0 mA, 1023 = 20mA
216	Unit 21 Analog 6 10 bit result. 0 = 0 mA, 1023 = 20mA
217	Unit 21 Analog 7 10 bit result. 0 = 0 mA, 1023 = 20mA
218	Unit 21 Analog 8 10 bit result. 0 = 0 mA, 1023 = 20mA
219	Unit 21 DC Voltage 10 bit, 1023 = 51.1 Volts DC (approx)
220	Unit 22 Bits 0-7 Digital Inputs, Bit 8 = COMM OK
221	Unit 22 Analog 1 10 bit result. 0 = 0 mA, 1023 = 20mA
222	Unit 22 Analog 2 10 bit result. 0 = 0 mA, 1023 = 20mA
223	Unit 22 Analog 3 10 bit result. 0 = 0 mA, 1023 = 20mA
224	Unit 22 Analog 4 10 bit result. 0 = 0 mA, 1023 = 20mA
225	Unit 22 Analog 5 10 bit result. 0 = 0 mA, 1023 = 20mA
226	Unit 22 Analog 6 10 bit result. 0 = 0 mA, 1023 = 20mA
227	Unit 22 Analog 7 10 bit result. 0 = 0 mA, 1023 = 20mA
228	Unit 22 Analog 8 10 bit result. 0 = 0 mA, 1023 = 20mA
229	Unit 22 DC Voltage 10 bit, 1023 = 51.1 Volts DC (approx)
230	Unit 23 Bits 0-7 Digital Inputs, Bit 8 = COMM OK
231	Unit 23 Analog 1 10 bit result. 0 = 0 mA, 1023 = 20mA
232	Unit 23 Analog 2 10 bit result. 0 = 0 mA, 1023 = 20mA
233	Unit 23 Analog 3 10 bit result. 0 = 0 mA, 1023 = 20mA
234	Unit 23 Analog 4 10 bit result. 0 = 0 mA, 1023 = 20mA
235	Unit 23 Analog 5 10 bit result. 0 = 0 mA, 1023 = 20mA
236	Unit 23 Analog 6 10 bit result. 0 = 0 mA, 1023 = 20mA
237	Unit 23 Analog 7 10 bit result. 0 = 0 mA, 1023 = 20mA
238	Unit 23 Analog 8 10 bit result. 0 = 0 mA, 1023 = 20mA
239	Unit 23 DC Voltage 10 bit, 1023 = 51.1 Volts DC (approx)
240	Unit 24 Bits 0-7 Digital Inputs, Bit 8 = COMM OK
241	Unit 24 Analog 1 10 bit result. 0 = 0 mA, 1023 = 20mA
242	Unit 24 Analog 2 10 bit result. 0 = 0 mA, 1023 = 20mA
243	Unit 24 Analog 3 10 bit result. 0 = 0 mA, 1023 = 20mA
244	Unit 24 Analog 4 10 bit result. 0 = 0 mA, 1023 = 20mA
245	Unit 24 Analog 5 10 bit result. 0 = 0 mA, 1023 = 20mA
246	Unit 24 Analog 6 10 bit result. 0 = 0 mA, 1023 = 20mA
247	Unit 24 Analog 7 10 bit result. 0 = 0 mA, 1023 = 20mA
248	Unit 24 Analog 8 10 bit result. 0 = 0 mA, 1023 = 20mA
249	Unit 24 DC Voltage 10 bit, 1023 = 51.1 Volts DC (approx)
250	Unit 25 Bits 0-7 Digital Inputs, Bit 8 = COMM OK
251	Unit 25 Analog 1 10 bit result. 0 = 0 mA, 1023 = 20mA
252	Unit 25 Analog 2 10 bit result. 0 = 0 mA, 1023 = 20mA
253	Unit 25 Analog 3 10 bit result. 0 = 0 mA, 1023 = 20mA
254	Unit 25 Analog 4 10 bit result. 0 = 0 mA, 1023 = 20mA
255	Unit 25 Analog 5 10 bit result. 0 = 0 mA, 1023 = 20mA
256	Unit 25 Analog 6 10 bit result. 0 = 0 mA, 1023 = 20mA

257	Unit 25 Analog 7 10 bit result. 0 = 0 mA, 1023 = 20mA
258	Unit 25 Analog 8 10 bit result. 0 = 0 mA, 1023 = 20mA
259	Unit 25 DC Voltage 10 bit, 1023 = 51.1 Volts DC (approx)
260	Unit 26 Bits 0-7 Digital Inputs, Bit 8 = COMM OK
261	Unit 26 Analog 1 10 bit result. 0 = 0 mA, 1023 = 20mA
262	Unit 26 Analog 2 10 bit result. 0 = 0 mA, 1023 = 20mA
263	Unit 26 Analog 3 10 bit result. 0 = 0 mA, 1023 = 20mA
264	Unit 26 Analog 4 10 bit result. 0 = 0 mA, 1023 = 20mA
265	Unit 26 Analog 5 10 bit result. 0 = 0 mA, 1023 = 20mA
266	Unit 26 Analog 6 10 bit result. 0 = 0 mA, 1023 = 20mA
267	Unit 26 Analog 7 10 bit result. 0 = 0 mA, 1023 = 20mA
268	Unit 26 Analog 8 10 bit result. 0 = 0 mA, 1023 = 20mA
269	Unit 26 DC Voltage 10 bit, 1023 = 51.1 Volts DC (approx)
270	Unit 27 Bits 0-7 Digital Inputs, Bit 8 = COMM OK
271	Unit 27 Analog 1 10 bit result. 0 = 0 mA, 1023 = 20mA
272	Unit 27 Analog 2 10 bit result. 0 = 0 mA, 1023 = 20mA
273	Unit 27 Analog 3 10 bit result. 0 = 0 mA, 1023 = 20mA
274	Unit 27 Analog 4 10 bit result. 0 = 0 mA, 1023 = 20mA
275	Unit 27 Analog 5 10 bit result. 0 = 0 mA, 1023 = 20mA
276	Unit 27 Analog 6 10 bit result. 0 = 0 mA, 1023 = 20mA
277	Unit 27 Analog 7 10 bit result. 0 = 0 mA, 1023 = 20mA
278	Unit 27 Analog 8 10 bit result. 0 = 0 mA, 1023 = 20mA
279	Unit 27 DC Voltage 10 bit, 1023 = 51.1 Volts DC (approx)
280	Unit 28 Bits 0-7 Digital Inputs, Bit 8 = COMM OK
281	Unit 28 Analog 1 10 bit result. 0 = 0 mA, 1023 = 20mA
282	Unit 28 Analog 2 10 bit result. 0 = 0 mA, 1023 = 20mA
283	Unit 28 Analog 3 10 bit result. 0 = 0 mA, 1023 = 20mA
284	Unit 28 Analog 4 10 bit result. 0 = 0 mA, 1023 = 20mA
285	Unit 28 Analog 5 10 bit result. 0 = 0 mA, 1023 = 20mA
286	Unit 28 Analog 6 10 bit result. 0 = 0 mA, 1023 = 20mA
287	Unit 28 Analog 7 10 bit result. 0 = 0 mA, 1023 = 20mA
288	Unit 28 Analog 8 10 bit result. 0 = 0 mA, 1023 = 20mA
289	Unit 28 DC Voltage 10 bit, 1023 = 51.1 Volts DC (approx)
290	Unit 29 Bits 0-7 Digital Inputs, Bit 8 = COMM OK
291	Unit 29 Analog 1 10 bit result. 0 = 0 mA, 1023 = 20mA
292	Unit 29 Analog 2 10 bit result. 0 = 0 mA, 1023 = 20mA
293	Unit 29 Analog 3 10 bit result. 0 = 0 mA, 1023 = 20mA
294	Unit 29 Analog 4 10 bit result. 0 = 0 mA, 1023 = 20mA
295	Unit 29 Analog 5 10 bit result. 0 = 0 mA, 1023 = 20mA
296	Unit 29 Analog 6 10 bit result. 0 = 0 mA, 1023 = 20mA
297	Unit 29 Analog 7 10 bit result. 0 = 0 mA, 1023 = 20mA
298	Unit 29 Analog 8 10 bit result. 0 = 0 mA, 1023 = 20mA
299	Unit 29 DC Voltage 10 bit, 1023 = 51.1 Volts DC (approx)
300	Unit 30 Bits 0-7 Digital Inputs, Bit 8 = COMM OK
301	Unit 30 Analog 1 10 bit result. 0 = 0 mA, 1023 = 20mA
302	Unit 30 Analog 2 10 bit result. 0 = 0 mA, 1023 = 20mA
303	Unit 30 Analog 3 10 bit result. 0 = 0 mA, 1023 = 20mA
304	Unit 30 Analog 4 10 bit result. 0 = 0 mA, 1023 = 20mA
305	Unit 30 Analog 5 10 bit result. 0 = 0 mA, 1023 = 20mA
306	Unit 30 Analog 6 10 bit result. 0 = 0 mA, 1023 = 20mA
307	Unit 30 Analog 7 10 bit result. 0 = 0 mA, 1023 = 20mA
308	Unit 30 Analog 8 10 bit result. 0 = 0 mA, 1023 = 20mA
309	Unit 30 DC Voltage 10 bit, 1023 = 51.1 Volts DC (approx)
310	Unit 31 its 0-7 Digital Inputs, Bit 8 = COMM OK
311	Unit 31 Analog 1 10 bit result. 0 = 0 mA, 1023 = 20mA
312	Unit 31 Analog 2 10 bit result. 0 = 0 mA, 1023 = 20mA
313	Unit 31 Analog 3 10 bit result. 0 = 0 mA, 1023 = 20mA
314	Unit 31 Analog 4 10 bit result. 0 = 0 mA, 1023 = 20mA
315	Unit 31 Analog 5 10 bit result. 0 = 0 mA, 1023 = 20mA
316	Unit 31 Analog 6 10 bit result. 0 = 0 mA, 1023 = 20mA
317	Unit 31 Analog 7 10 bit result. 0 = 0 mA, 1023 = 20mA
318	Unit 31 Analog 8 10 bit result. 0 = 0 mA, 1023 = 20mA
319	Unit 31 DC Voltage 10 bit, 1023 = 51.1 Volts DC (approx)
320	Unit 0 Relay 1 & 2 digital source byte, LS byte = Relay 1; MS 5 bits = source ID, LS 3 bits = source channel
321	Unit 0 Relay 3 & 4 digital source byte, LS byte = Relay 3; MS 5 bits = source ID, LS 3 bits = source channel

582	Unit 6 Configuration Register. Bit 0 = 1 for enabled, 0 disabled
583	Unit 7 Configuration Register. Bit 0 = 1 for enabled, 0 disabled
584	Unit 8 Configuration Register. Bit 0 = 1 for enabled, 0 disabled
585	Unit 9 Configuration Register. Bit 0 = 1 for enabled, 0 disabled
586	Unit 10 Configuration Register. Bit 0 = 1 for enabled, 0 disabled
587	Unit 11 Configuration Register. Bit 0 = 1 for enabled, 0 disabled
588	Unit 12 Configuration Register. Bit 0 = 1 for enabled, 0 disabled
589	Unit 13 Configuration Register. Bit 0 = 1 for enabled, 0 disabled
590	Unit 14 Configuration Register. Bit 0 = 1 for enabled, 0 disabled
591	Unit 15 Configuration Register. Bit 0 = 1 for enabled, 0 disabled
592	Unit 16 Configuration Register. Bit 0 = 1 for enabled, 0 disabled
593	Unit 17 Configuration Register. Bit 0 = 1 for enabled, 0 disabled
594	Unit 18 Configuration Register. Bit 0 = 1 for enabled, 0 disabled
595	Unit 19 Configuration Register. Bit 0 = 1 for enabled, 0 disabled
596	Unit 20 Configuration Register. Bit 0 = 1 for enabled, 0 disabled
597	Unit 21 Configuration Register. Bit 0 = 1 for enabled, 0 disabled
598	Unit 22 Configuration Register. Bit 0 = 1 for enabled, 0 disabled
599	Unit 23 Configuration Register. Bit 0 = 1 for enabled, 0 disabled
600	Unit 24 Configuration Register. Bit 0 = 1 for enabled, 0 disabled
601	Unit 25 Configuration Register. Bit 0 = 1 for enabled, 0 disabled
602	Unit 26 Configuration Register. Bit 0 = 1 for enabled, 0 disabled
603	Unit 27 Configuration Register. Bit 0 = 1 for enabled, 0 disabled
604	Unit 28 Configuration Register. Bit 0 = 1 for enabled, 0 disabled
605	Unit 29 Configuration Register. Bit 0 = 1 for enabled, 0 disabled
606	Unit 30 Configuration Register. Bit 0 = 1 for enabled, 0 disabled
607	Unit 31 Configuration Register. Bit 0 = 1 for enabled, 0 disabled
608	Configuration ID of this unit. 0 = system master. 1 to 31 is a slave unit.
609	Image of the 9 output relay states. MSB is the status relay (read only)
610	Network state. 0 = OK, 1 = Network down, this link OK, 2 = Lost comms. Read only.
611	Modbus ID 0 = no second ID, 1 to 255 users Modbus ID. Unit will also always respond to Modbus address 99
612	Time before resetting to default state after loss of radio communications, in 10 second increments. Minimum 1, Max = 65535, default = 6. (10 second increments, 10 to 655350 seconds)
613	Seconds before reverting to normal register updates after Modbus override data stops. Min 1, Max 255, default 10
614	Time in millisecs before this unit processes Modbus packet. Min = 4, max = 255, default = 40 *See text for exception
615	Special control mode setting, for example pump control modes. 0 for normal operation.
616	Analog pump control mode low setting 0 – 1022
617	Analog pump control mode high setting 1 – 1023
619	Repeater target for Unit 1. 0 = repeater disabled for unit 1
620	Repeater target for Unit 2. 0 = repeater disabled for unit 2
621	Repeater target for Unit 3. 0 = repeater disabled for unit 3
622	Repeater target for Unit 4. 0 = repeater disabled for unit 4
623-649	Repeater targets for Units 5 – 31
649	Repeater target for Unit 31. 0 = repeater disabled for unit 31
650	Repeater target for Unit 32. 0 = repeater disabled for unit 32
651	Repeater target for Unit 33. 0 = repeater disabled for unit 33
652	Repeater target for Unit 34. 0 = repeater disabled for unit 34
653..797	650.....797 Repeater targets for units 35 to 179.
798	Repeater target for Unit 180. 0 = repeater disabled for unit 180
799	Repeater target for Unit 181. 0 = repeater disabled for unit 181
800	Total number of packets transmitted from master 0 -65535. Write any value to clear this and the next 31 registers
801	Total number of good packets received from Unit1
802	Total number of good packets received from Unit2
803	Total number of good packets received from Unit3
804	Total number of good packets received from Unit4
805	Total number of good packets received from Unit5
806	Total number of good packets received from Unit6
807	Total number of good packets received from Unit7
808	Total number of good packets received from Unit8
809	Total number of good packets received from Unit9
810	Total number of good packets received from Unit10
811	Total number of good packets received from Unit11
812	Total number of good packets received from Unit12
813	Total number of good packets received from Unit13
814	Total number of good packets received from Unit14
815	Total number of good packets received from Unit15

816	Total number of good packets received from Unit16
817	Total number of good packets received from Unit17
818	Total number of good packets received from Unit18
819	Total number of good packets received from Unit19
820	Total number of good packets received from Unit20
821	Total number of good packets received from Unit21
822	Total number of good packets received from Unit22
833	Total number of good packets received from Unit23
824	Total number of good packets received from Unit24
825	Total number of good packets received from Unit25
826	Total number of good packets received from Unit26
827	Total number of good packets received from Unit27
828	Total number of good packets received from Unit28
829	Total number of good packets received from Unit29
830	Total number of good packets received from Unit30
831	Total number of good packets received from Unit31
1000	Hop Pattern, read only
1001	Serial number, read only
1002	Channels, read only
1003	Software version 12 = 1.2 etc. Read Only.
1004	Seconds Modbus registers 311-318 must be stable before EEPROM write (Special mode 3) Read Only
1005	Run time in hours. Read Only
1006	Radio / Interface board type. 0 = Low power ISM Spread spectrum, 1 = Generic, 2 = ISM High Power. Read Only
1007	Radio Baud rate . Read Only
1008	Radio key up time in mS. Read Only
1009	Radio key down time in mS. Read Only
1010	Radio data gap time in mS. Read Only
1011	Transmit cycle rate in mS. Read Only
1012	ISM High power RF data rate. 0=10,000 BPS, 1=120,000 BPS. Read Only
1013	ISM High power multi-packet burst transmit mode. X + 1 = number of burst packets. Read Only
1014	Radio transmit delay time in mS
1015	Modbus / PC Interface Baud Rate 0=1200, 1=2400, 2=4800, 3=9600, 4=19200. See text description
1016	Pulse counting enable bits, 1= enable, 0=disable. 1= channel 1, 2 = channel 2, 128 = channel 8 etc. Value 0 to 255
1017	Spare / Tank control scaling.
1018	Spare / Tank control scaling.
1019	Spare MB R/W Register
1020	Image of analog 1 output level (read only)
1021	Image of analog 2 output level (read only)
1022	Image of analog 3 output level (read only)
1023	Image of analog 4 output level (read only)
1024	Image of analog 5 output level (read only)
1025	Image of analog 6 output level (read only)
1026	Image of analog 7 output level (read only)
1027	Image of analog 8 output level (read only)
1100..1173	Repeater mode targets for units 182 - 255
1173	Repeater target for Unit 255. 0 = repeater disabled for unit 255
3318	Write 1234 to restore to default settings. Write 5678 to copy all settings to EEPROM

*TYPICAL APPLICATIONS AND
INSTALLATIONS*

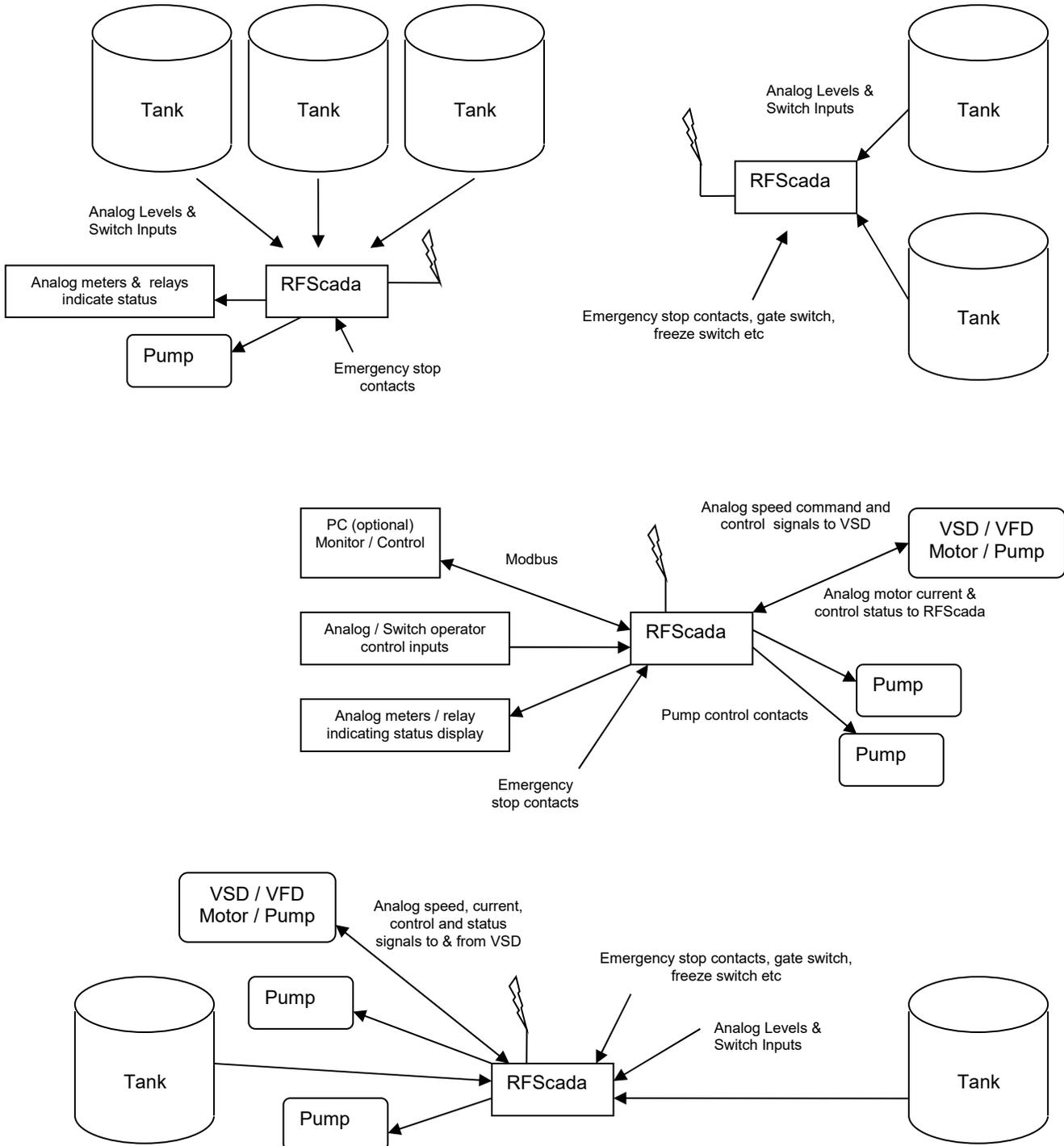
RFSCADA16 RFSCADA4

Remote Terminal Unit

Typical Applications and Installations.

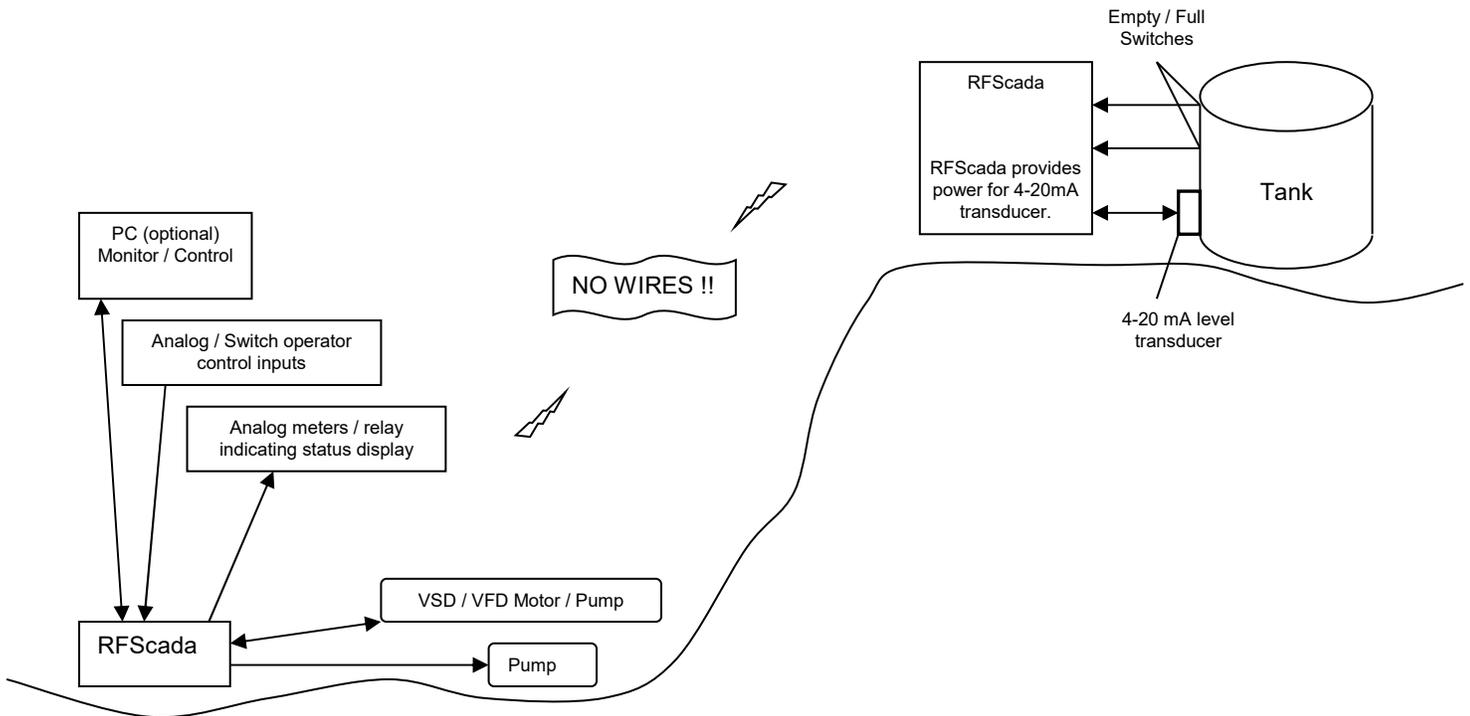
Multiple Tanks, Pumps and Remote Controls

Miles apart, without interconnecting wires, the RFScada units can control and continuously monitor multiple pumps, tanks, VSD's, switch contacts, security devices, analog signal input levels, analog output signals etc. Alarms and shutdowns may be activated from any location to indicate fault conditions; with every unit monitoring the network condition and reverting to a known state during error conditions. In this example network four RFScada units are configured so analog and digital signals may be transmitted and monitored between four locations. Up to 255 RFScada units may be in a single network, providing over 1000 inputs and outputs.



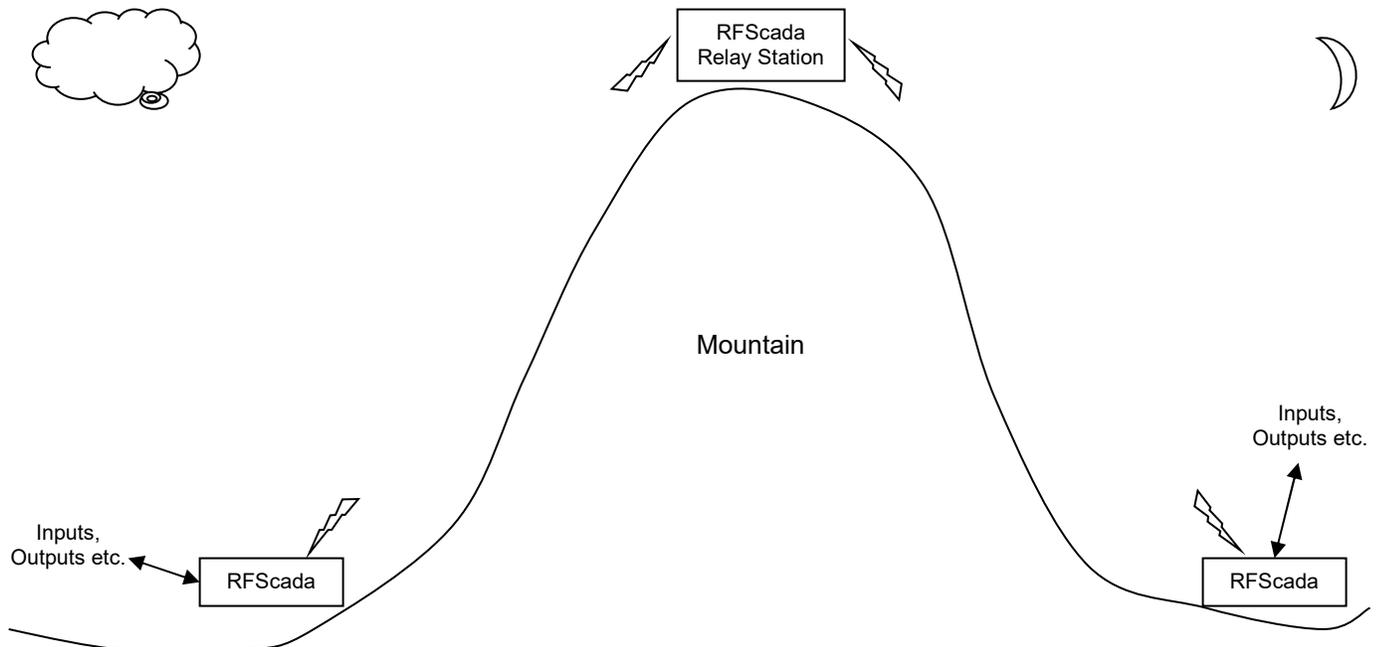
Simple Remote Tank, Local Pump Control

Here the level of a remote tank is monitored, either by an analog level transducer and / or limit switches. The local pump may be operated either via a simple contactor or an adjustable analog output signal may be supplied to control the speed of a VSD. Note that the RFScada provides a very easy interface to these devices, and even provides power to the analog tank 4-20mA pressure transducer saving additional cost.



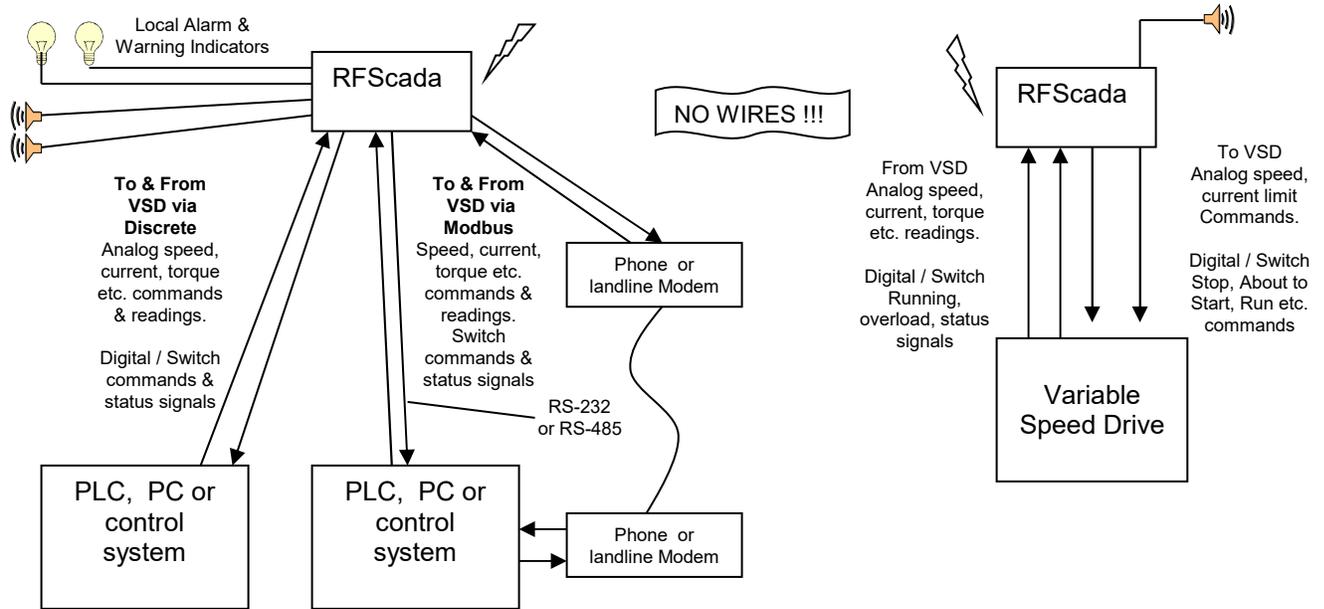
Repeater and 'Over the Hill Applications.

In some locations, particularly in mountainous regions where few man made objects exist to serve as signal reflectors, communication between units is not possible. In this case another RFScada unit may be located in a position within range of all units, and it can act as a relay station between units.



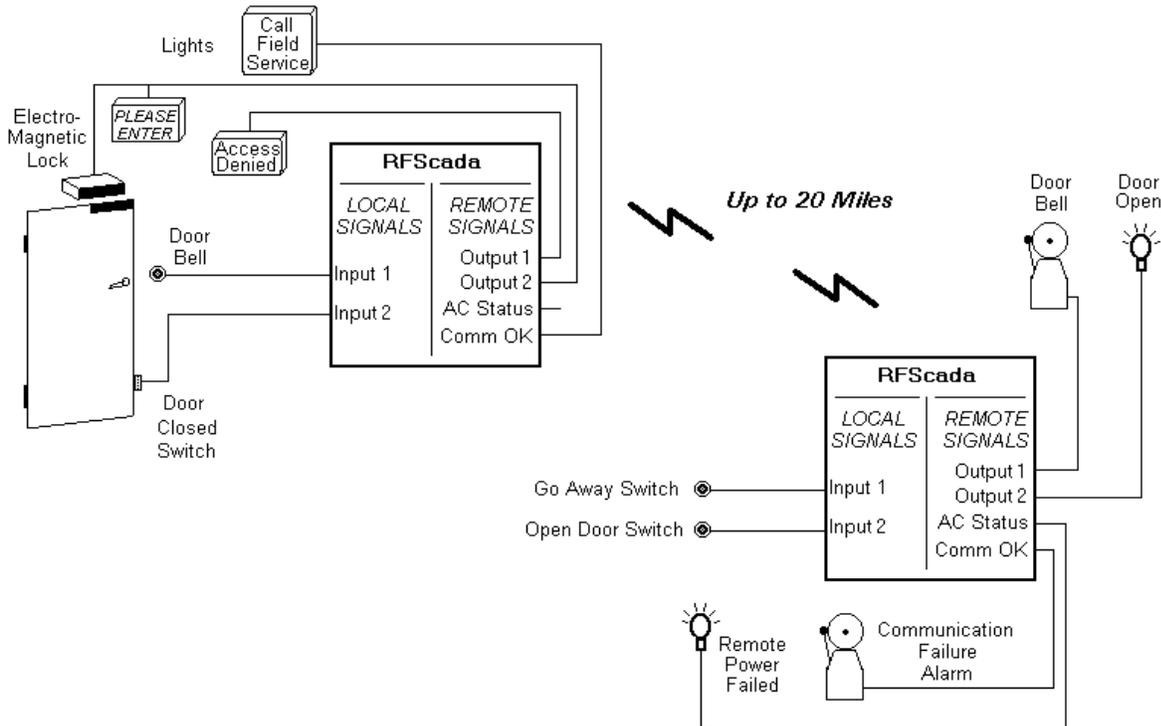
Remote Variable Speed / Variable Frequency Drive Control.

A variable speed drive may be controlled at a distance using the RFScada units. Depending on the type of drive, the drive may be stopped, started, the speed controlled and many drive parameters such as output current may be monitored for safe operation. The RFScada units can provide automatic shutdown in the case of any system or communication failures.



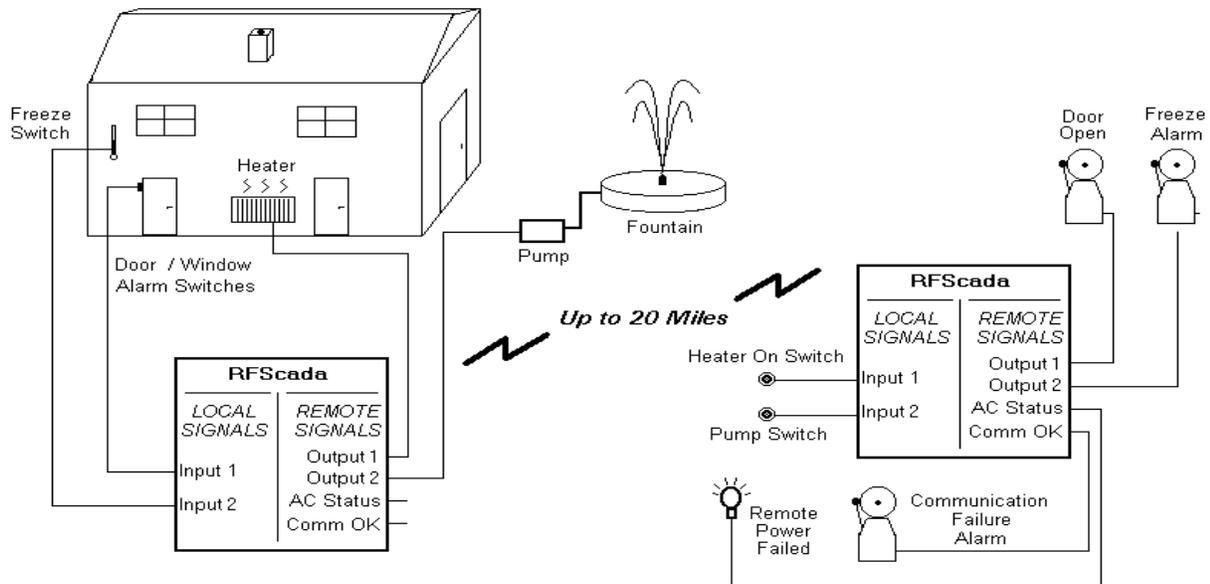
Access Control / Monitoring

Here a pair of wireless RFScada units remotely protect, monitor and control access to a secure location miles away. Alarms are activated whenever access is required or gained. The electrical lock may be controlled remotely as well as locally. Remote indication is supplied to show if the door is securely closed, when it is opened plus full visual status of conditions. Alarms indicate all faults and abnormal conditions, such as power fail or forced entry.



Security / Environmental Systems

From miles away, without interconnecting wires the RFScada units can control and continuously monitor environmental systems such as pumps, fountains, heaters and security devices. Alarms are activated to indicate any fault conditions.





*SAMPLE QUESTIONS AND
APPLICATIONS*

RFSCADA16 RFSCADA4

Remote Terminal Unit

Sample Questions and Applications.

900 MHz vs. 2.4 GHz

It seems that everywhere you look another 'spread spectrum' 2.4GHz devices comes out, including cordless phones, local wireless computer networks for homes and offices, video cameras, video links, toys etc. Isn't the very popular 2.4GHz frequency band the way to go, almost all low cost wireless devices appear to be a 2.4 GHz devices.

For a long range, high reliability product such as the RFScada device the 2.4 GHz band is a poor choice. For short range (typically less than fifty feet), generally indoor devices such as toys, video links or wireless computer networks the 2.4 GHz band has some advantages, such as using a smaller and cheaper antenna than required by 900 MHz devices. Many public places like airline terminals, hotels, hospitals, coffee houses, bookstores etc. are installing these wireless networks, and so the band has quickly become saturated with these devices, especially in urban locations. This results in interference and poor (or no) operation for devices that compete in this frequency range; and many users find that additional 2.4GHz devices will not operate satisfactorily in the vicinity of other 2.4 GHz devices. The biggest advantages of the 900 MHz ISM band is the greater range (typically at least 3 times that of 2.4GHz), reduced attenuation from rain when compared to 2.4GHz devices and lower power consumption. The 900 MHz ISM band is the best choice for license free devices such as the RFScada products, which are designed for the highest reliability, interference rejection and longest range in hostile, industrial environments.

Cordless Phone

I have a 'spread spectrum' cordless phone at the house, it does not operate more than 100 feet from the base station and it certainly does not work ¼ mile away. I understand that certain versions of the RFScada devices are also 'spread spectrum', how can they operate 1, 5 or even 40 miles away?

The main reason is power. The term 'spread spectrum' covers a general method of transmission, where transmit and receive frequencies are constantly changing or 'hopping' through various channels. This method was devised as a means to allow many devices to effectively share a bandwidth. There are several classifications allowed

by the FCC to cover different devices and applications, these classifications also govern both the RF power and antenna systems that may be used. These classifications all use the generic term 'spread spectrum' as a transmission method. The FCC designates your cordless phone and similar consumer devices as a 'portable device' with a severely limited RF power output and antenna. The RFScada is not designated in this group, and therefore may transmit both with a much higher power (up to 1 Watt in the 902-928 MHz ISM band) plus it may also use an FCC approved directional antenna that provides more system power gain in certain directions. In fact, because of the higher RF power output emitted by the RFScada unit the FCC mandates that it must maintain a separation distance of at least 20 cm (about 8 inches) to any nearby persons.

True Range

The range is mentioned as 0.25, 5 and 40 miles etc. What is the real range?

This is a very difficult question to answer, since it will vary in every installation. The actual range will depend on many factors, including the device location, height, shape of the terrain, terrain surface, obstacles, the antenna used, proximity to similar devices, radio model etc. As a very general guideline in a typical outdoor location, using the lowest power radio option available (-SS1), where each RFScada unit may be visible from the other and using the internal antennas supplied with the standard product a range of at least five miles is to be expected, and 8 miles is usually possible. A similar 'line of sight' installation, using the optional 13 dB gain Yagi antennas at each end should produce a range of 40 miles. Using the internal antenna and inside a typical factory, with moving and stationary machines, obstacles, metal walls, interfering devices and no line of sight the range may be reduced to less than a mile with ISM devices. The VHF and UHF models have much better coverage in non line of sight applications, plus have higher RF power output so coverage with those models is substantially higher. The range depends on many factors. Please consult with the factory for your specific application; If you are unsure of the best model for your application please call the factory for application assistance. If the exact site locations (GPS co-ordinates) are know a suitable solution may be recommended using topology programs at Data Delivery Devices LLC.

Evaluation units may be available for testing at your location.

Separate Transmitter and Receiver.

I ordered a transmitter for my tank and receiver for the well control. There appears to have been a mistake as both units look to be identical. Shouldn't one be a transmitter and one a receiver?

The units are identical (except for any options that may be installed). Every unit is both a transmitter and a receiver. This is the only way that units are able to positively verify correct operation of all other units. The units continually communicate with each other to ensure constant and valid data exchange. If for some reason a unit needs to be replaced (for instance it may be been damaged or stolen) then another standard unit may replace it.

System Data Verification

How do I know that the output data I receive is valid and is not interference from another device?

There are many levels of sophisticated data encryption and protection incorporated in the device. Lets follow a typical signal to see what actually happens. First of all analog and digital input data is collected at each unit. The data is encrypted in a format that incorporates a constantly changing rolling code and is then mixed with other data pertinent to the unit, such as the local DC voltage. A 16-bit cyclic redundancy check (CRC) value is then calculated for this coded data and added. Now the encrypted plus CRC coded data is passed to the RF section and transmitted using 50 constantly changing frequencies and using yet another, completely independent 16-bit CRC with a different algorithm from the first.

The remote unit receives the RF data and verifies that the 16-bit RF CRC is correct. It then further analyzes the received data and verifies that it also passes the second CRC encryption check. The remote unit then analyzes the transmitted data plus other information from the first unit. If the data is addressed to this unit it responds, then removes from this dual-verified data any information it needs. Finally this data is used to update the state of the outputs, to faithfully reflect any output states sent to it from the first unit. Any 'single bit' error in the whole process will result in an unverified data packet, and that data will be completely ignored. If 'correct and double verified' data does not arrive at a receiver within a (user

programmable) time delay the unit will extinguish the 'COMMS OK' status LED, set the 'system ok' relay output to inactive, and set all analog and digital outs to the default, off state. After good data has been received at one unit it will repeat the whole process by transmitting its own input states to the other units in a similar manner. Units will complete the whole cycle (input/encrypt, transmit data, receive data, decrypt, update outputs) several times a second to insure that the output data is valid. If any unit fails for any reason then all outputs change on all units to the default (off) state within a user set timeout.

Functional Integrity and Verification

We want to replace some competitors units that have poor range and marginal performance. Also, since we now realize the competitors units we own are just 'one way' devices we have actually been using two complete sets of them for each signal monitored, as we need to verify that they are actually functioning - data integrity is very important for this application. With the RFScada units is there a way to tell if the remote unit is receiving my signal correctly?

Yes, there is full data verification. Unlike competitors 'one way' or 'report on an event' type these maintain continuous communication and are fully bi-directional so there are several ways to verify full and correct data transfer. Since all units are identical with built in transmitters and receivers it is easy to verify reception of data remotely. First of all, by the very nature of the device if the two on board transmit and receive status LED's are quickly flashing (normal operation) the devices are both exchanging good, verified data. Secondly the 'system status' LED and relay (connector J11) will be active all the time that all of the devices are maintaining a verified data exchange. When communication is interrupted at any unit and for any reason the 'system status' LED and relay will become inactive within seconds of the interruption. If this unit is communicating correctly the LED will slowly flash and the relay will toggle slowly, indicating a problem on another unit. It is therefore possible to tell, from any unit, the status of every unit in the system. Finally, if required it is possible to manually verify complete operation of any units. Take an unused output of the remote unit and directly connect it to an unused input on the remote unit. At the 'local' unit close (short together) the input. This will cause the second

output of the remote unit to close, which is now directly wired to another input on the remote unit. This state of input two will now be transmitted back to the 'local' unit by the remote. Therefore, providing both units are functioning and communicating changing the state of the 'local' unit input will cause the monitored output at the local unit to also change, all within a second. This verifies, in order, full local data input, encryption, local RF transmission, remote RF reception, remote decryption, remote output, remote input, remote encryption, remote RF transmission, local RF reception, local decryption, local verification and local output all within a few seconds.

AC Power Loss and Generator Operation

Our remote unit is powered from a generator that automatically starts and runs for a couple of hours then stops for a few minutes. The remote unit is successfully monitoring the tank level, and continues to operate correctly when the generator is stopped, powered by the generators battery. Is it possible to also monitor when the generator is running?

Yes. Simply connect a 115 VAC relay coil across the generators 115 VAC output; connect the relays normally open contacts to any unused digital input to continually indicate the running status of the generator. If you have a computer connected via Modbus to the local RFScada device it is also possible to monitor the generators DC battery Voltage.

Interference between Multiple Units

We have a pair of RFScada units that have been operating flawlessly for some time. We now need another pair but they will be located within a couple of miles from the first. Will two pairs of RFScada interfere with each other?

Each system of up to 32 units are matched together for transmission and reception. There are ten sets of identity that the units may have, so up to ten pairs of units may all operate in close proximity so long as they all have different id's. When supplied the standard units are configured for set '5', but they can be configured to any channel. A record is kept of the units supplied for each customer, so when ordering additional units please advise if you need a replacement for a damaged one or a unit to operate on a different frequency set. There are solutions offered for applications where more than ten pairs are required to operate, or systems where there is a single 'base' master

unit and multiple slave units, please consult the factory for further details.

Rain Attenuation

Here in the jungle we often experience heavy rain. Does it affect operational range?

Heavy rain does have an affect on the range, but it is generally negligible. It attenuates the signal by approximately 0.2dB per mile for a torrential storm, which means a range difference of less than a few feet per mile.

Pampered Horses

We train and stable many valuable horses for clients on a large ranch. For security reasons we have just installed an electrically operated locking gate restricting access to the property. The gate is powered by a solar panel and 12 Volt battery since it is remote from any source of power. It also came with remote controls from the manufacturer that allow us to operate it from our vehicles when we are within 50 feet or so, but they will not operate from our main office which although visible from the gate is almost a mile away. We have considered purchasing additional remotes for staff to use, but we also have many frequent visitors and deliveries. If the gate is not staffed we install a sign that advises visitors to sound their horn on arrival, whoever is closest drives down by the gate and opens it. This most undignified entry method is obviously not acceptable for us, our clients or the horses that may be startled by the noise. The gate opener has a provision for a manual switch to allow anyone to operate the gate, but we have not installed that since it defeats the purpose of having the gate for security. The only other option available is a keypad by the gate with a code to enter, but again it is not suitable for our many visitors and vendors. We would also like to be alerted when the gate is operated so we may monitor activity. The gate installation companies we have contacted all have just one possible solution left for us - digging a trench for over two miles around the lake and across the beautifully landscaped grounds, then installing a cable connected to the gate switch; allowing us to operate the gate from the office. This 'solution' would be very disruptive to our operations, very expensive, we would not know when vehicles with remotes came or left and our clients would still be sitting in their vehicles honking the horn to gain entry. Can the RFScada solve any of these problems?

Yes, the RFScada can solve all of your problems. Here is how to do it. Install one unit at the office powered by the standard AC line. Connect a normally open push button switch to 'digital input one', this will be used to allow gate operation from the office. Connect an indicator light or alarm indicator such as a bell wired to use the relay one normally open contacts. Install the other (we will call it gate unit) by the gate control. The gate unit may be powered directly from the 12 volts DC supplied by the gate control battery and solar panel since its current draw is small. Connect the normally open contacts from relay one to the 'manual operation' switch input on the gate control. When the push button is pressed in the office the gate will operate. Now to solve the next problem, alerting office personnel when a guest arrives. A switch may be installed by the gate connected to digital input one on the gate unit. When visitors arrive they may press this button, which in turn will activate the alarm at the office. When the office personnel have verified the guest's identity they may operate the gate from the office.

Rather than having guests press a button by the gate another option is to use a motion/proximity detector or 'breaking beam' type detector ahead of the gate connected to digital input one. This detector could be situated a short distance before the gate to provide an alarm at the office before the guest arrived, minimizing any delay. As an added measure of security the second unused input to the gate unit may be wired closed, or even better connected to a tamper switch or a switch active when the gate was positively locked. Due to this the office unit would have relay output two active all the time under normal circumstances, so another alarm (or it could be wired in parallel with the first alarm) would be connected to the relay two normally closed contacts. If the secure, continuous data communication between the office and gate units were disrupted for any reason, including the gate battery failing, cut wires, theft, vandalism etc. then relay two at the office would change state alerting the office personnel.

The complete arrangement at the gate may be repeated at additional gates, without requiring additional units in the office, allowing complete, distributed security control from a central point – all without wires. The RFScada provides a complete, secure and cost effective solution that adds additional benefits without requiring extensive digging, disgruntled clients or frightened horses.

Medical Applications

We have some medical equipment that may be able to utilize RFScada units. Are they suitable for this for application?

No, they are not. The RFScada units are not authorized nor intended for life support or medical applications.

FCC License

Our old SCADA system radio modem & RTU combination has failed again and we would like to replace it with two RFScada units. Do we need to convert our present FCC license to use the RFScada devices?.

No need. No license is required to own or operate the ISM RFScada devices within the USA, and the FCC already approves them. If the RFScada devices are UHF or VHF versions they may be programmed to use the existing frequencies.

Battery Backup Operation

How can the RFScada operate with backup power when AC power is lost?

It is easy to add this capability to the RFScada, it simply requires a charge controller, battery and fuse. The RFScada can supply the power to charge the battery when AC is present. The components may be ordered for factory or field installation.

Solar Panel Operation

Can I just connect a 12 volt solar panel directly to the RFScada and operate the unit without AC power?

No, at least not at night. However, the RFScada may easily be operated from a solar panel if suitable components are used. First of all a panel must be selected that can supply several times the energy required to operate the RFScada (typically one to two watts), since the panel must both supply the unit and be capable of charging the battery in the shortest daylight available, even on a cloudy day. A system using a panel having a nominal 10 or 20 watts output typically will have an ample safety margin (depends on the site location). Secondly a battery or batteries must be selected that will be able to hold enough energy to operate the RFScada for a period of time, plus the battery must be able to withstand the sometimes fairly heavy charging and discharge cycle. Small auto or marine 'deep cycle' type batteries are most commonly used, as they are

universally available at a very reasonable cost. Finally, as mentioned earlier it is possible to damage batteries by overcharging them, so some type of charge controller is normally required. Some solar panels have the charge controller already built in, if that type of panel is used another controller is not needed.

The components required will vary depending on the location, for example Alaska in winter has very little daylight available, so a solar system there would need much greater capacity than one located in Arizona. It is usually possible to connect the RFScada directly to an existing 12 or 24 Volt solar power system that is being used to power other equipment such as RTU's or transducers, simply connect the external source to the DC input.

Cabinet Construction

The brochure states that the RFScada has a corrosion resistant NEMA 4X rated cabinet but the antenna is located inside. Doesn't the stainless steel cabinet severely restrict the unit's range?

No, the corrosion resistant NEMA 4X rated cabinet is not stainless steel but made from fiberglass with stainless steel fittings (hinge, locking latch etc.) so it has very little effect on the signal.

Mounting Inside Steel Enclosure

If the unit is mounted inside a steel electrical switchboard will the range be affected?

If using internal antennas yes, the range will be reduced if it is mounted inside a steel enclosure. Whether the attenuation will be enough to prevent operation will depend on the cabinet, distance to the other unit and all the other factors that affect range. If mounting inside a steel enclosure an external antenna may extend the range significantly.