Wire Replacement I/O (900 MHz)

I/O Masters: FGRIO-M

I/O Slaves: FGRIO-S
FGR2-IOS-C-U
FGR2-IOS-CE-U
FGR2-IO-IOE

User Manual and Reference Guide

Part Number: LUM0008AG
Revision: D
Last Updated: 01/25/2013

Safety Information

Warning! ***Do not*** remove or insert diagnostics cable while circuit is live.

Warranty

FreeWave Technologies, Inc. warrants your FreeWave® Wireless Data Transceiver against defects in materials and manufacturing for a period of three years from the date of shipment, depending on model number. In the event of a Product failure due to materials or workmanship, FreeWave will, at its discretion, repair or replace the Product. For evaultation of Warranty coverage, return the Product to FreeWave upon receiving a Return Material Authorization (RMA).

In no event will FreeWave Technologies, Inc., its suppliers, or its licensors be liable for any damages arising from the use of or inability to use this Product. This includes business interruption, loss of business information, or other loss which may arise from the use of this Product. OEM customer's warranty periods can vary.

Warranty Policy will **not apply** in the following circumstances:

1. If Product repair, adjustments, or parts replacements are required due to accident, neglect, or undue physical, electrical, or electromagnetic stress.
2. If Product is used outside of FreeWave specifications as stated in the Product's data sheet.
3. If Product has been modified, repaired, or altered by Customer unless FreeWave specifically authorized such alterations in each instance in writing. This includes the addition of conformal coating.

Special Rate Replacement Option

A special rate replacement option is offered to non-warranty returns or upgrades. The option to purchase the replacement unit at this special rate is only valid for that RMA. The special replacement rate option expires if not exercised within 30 days of final disposition of RMA.

Restricted Rights

Any product names mentioned in this manual may be trademarks or registered trademarks of their respective companies and are hereby acknowledged.

This manual is for use by purchasers and other authorized users of FreeWave products.

No part of this manual may be reproduced or transmitted in any form or by any means, electronic or mechanical, or for any purpose without the express written permission of FreeWave Technologies, Inc. FreeWave reserves the right to make changes to this manual without notice. FreeWave assumes no responsibility or liability for the use of this manual or the infringement of any copyright or other proprietary right.

FreeWave products are designed and manufactured in the United States of America.

FreeWave Technologies, Inc.
Boulder, CO
303.381.9200
Toll Free: 1.866.923.6168
Fax: 303.786.9948
www.freewave.com

Printed in the United States of America.
Copyright © 2013 by FreeWave Technologies, Inc. All rights reserved.

FreeWave Technologies, Inc. products may be subject to control by the Export Administration Regulations (EAR) and/or the International Traffic in Arms Regulations (ITAR). Export, re-export, or transfer of these products without required authorization from the U.S. Department of Commerce, Bureau of Industry and Security, or the U.S. Department of State, Directorate of Defense Trade Controls, as applicable, is prohibited. Any party exporting, re-exporting, or transferring FreeWave products is responsible for obtaining all necessary U.S. government authorizations required to ensure compliance with these and other applicable U.S. laws. Consult with your legal counsel for further guidance.

UL Notifications

Models FGRIO-M, FGRIO-S, FGR2-IOS-C-U, FGR2-IOS-CE-U, and FGR2-IO-IOE are suitable for use in Class I, Division 2, Groups A, B, C, and D or non-hazardous locations only. Do not connect or disconnect any connectors while the circuit is live unless the area is known to be non-hazardous.

Warning! EXPLOSION HAZARD - SUBSTITUTION OF COMPONENTS MAY IMPAIR SUITABILITY FOR CLASS1, DIVISION 2.

Warning! DO NOT REMOVE OR INSERT THE DIAGNOSTICS CABLE WHILE THE CIRCUIT IS LIVE UNLESS THE AREA IS KNOWN TO BE FREE OF IGNITION CONCENTRATIONS OR FLAMMABLE GASES AND VAPORS.

Input voltage for the FGR2-IOS-C-U, FGR2-IOS-CE-U, FGR2-IO-IOE, is +6.0 to +30.0 VDC.

Input voltage for the FGRIO-S is +6.0 to +20.0 VDC.

Input voltage for the FGRIO-M is +7.0 to +30.0 VDC.

Important: Input power shall be derived from a single Class 2 power source.

FCC Notifications

This device complies with part 15 of the FCC rules. Operation is subject to the following two conditions: 1) This device may not cause harmful interference and 2) this device must accept any interference received, including interference that may cause undesired operation.

This device must be operated as supplied by FreeWave Technologies, Inc. Changes or modifications should not be made to the device without the express written approval of FreeWave Technologies, Inc..

Warning! The FGRIO-S, FGR2-IOS-C-U, FGR2-IOS-CE-U, FGRIO-M, and FGR2-IO-IOE models have a maximum transmitted output power of 1 W. It is recommended that the transmit antenna be kept at least 23 cm away from nearby persons to satisfy FCC RF exposure requirements.

Warning! The FGRIO-S models have a maximum transmitted output power of 100 mw. It is recommended that the transmit antenna be kept at least 20 cm away from nearby persons to satisfy FCC RF exposure requirements.

Whenever any FreeWave Technologies, Inc. module is placed inside an enclosure, a label must be placed on the outside of the enclosure. The label must include the text "Contains: FCC ID" (with the module's FCC ID number).

IC Notifications

This device complies with Industry Canada license-exempt RSS standard(s). Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Ce dispositif est conforme aux normes permis-exemptes du Canada RSS d'industrie. L'opération est sujette aux deux conditions suivantes : (1) ce dispositif peut ne pas causer l'interférence, et (2) ce dispositif doit accepter n'importe quelle interférence, y compris l'interférence qui peut causer le fonctionnement peu désiré du dispositif.

Table Of Contents

Preface ..... **ix**

Chapter 1: Introduction **1**

I/O Product Family 2

Wire Replacement I/O Systems 3

Configuration Tool Options 4

Tool Suite and Terminal Emulators 5

Transceiver Setup Mode 5

Using Tool Suite to Connect to and Program Transceivers 6

Accessing the Setup Menu Using a Terminal Emulator 7

Troubleshooting Terminal Emulators 8

LED Indications 9

Chapter 2: Configuring an I/O Master **11**

Configuring an I/O Master Quick Start 11

I/O Masters in Tool Suite 14

Setting the I/O Master's Role in the Network 14

Establishing Communication Between the I/O Master's Data Port and an End Device 14

Baud Rate 15

Data Parity 15

Flow Control 15

Modbus RTU 16

Serial Interface 16

Setup Port 17

Turn Off Delay 17

Turn On Delay 18

Use Break to Access Setup 18

Establishing Communication with I/O Slaves 18

Setting I/O Master RF Transmission Characteristics 19

Frequency Key 19

Max Packet Size and Min Packet Size 20

RF Data Rate 21

Setting I/O Master MultiPoint Parameters 21

Master Packet Repeat 21

Repeaters 22

Subnet ID 22

Setting I/O Master Wire Replacement Parameters 22
Sensor Power 23
Default Delay 23
Default Output 23
Mapping I/O Master Outputs to I/O Slave Inputs 24
Chapter 3: Configuring an I/O Slave 27
Configuring an I/O Slave Quick Start 27
I/O Slaves in Tool Suite 29
Setting the I/O Slave's Role in the Network 30
Establishing Communication with the I/O Master 30
I/O Slave RF Transmission Characteristics 30
I/O Slave MultiPoint Parameters 31
I/O Slave Wire Replacement Parameters 31
Digital Output 1 and Digital Output 2 31
AI1 250 Ohms and AI2 250 Ohms 31
DI1 150 Ohms and DI2 150 Ohms 32
DI1 Pullup and DI2 Pullup 32
DO Bi-Stable 32
DO Monostable Time 33
Digital Output 1 Default and Digital Output 2 Default 33
Default Delay 33
Chapter 4: Other Transceiver Settings 35
Setting Other RF Transmission Characteristics 35
Frequency Zones 35
Hop Table Size 37
Hop Table Version 38
High Noise 38
Low Power Mode 39
MCU Speed 40
Remote LED 40
Retry Timeout 41
RTS to CTS 41
Slave Security 41
Transmit Power 41
Transmit Rate 42
Setting Other MultiPoint Parameters 42

1 PPS Enable Delay 43
Diagnostics 43
DTR Connect 44
Local Mode 44
Max Slave Retry 44
Multi-Master Synch 45
Radio ID 45
Radio Name 45
Repeater Frequency 45
Retry Odds 45
Slave/Repeater 46
Chapter 5: Installing and Wiring Components in a Wire Replacement I/O System 47
Wiring an I/O Master 47
Radio Power 48
Tx Data and Rx Data 48
Sensor Power 48
Digital Inputs 49
Analog Outputs 49
Digital Outputs 49
Link Alarms 50
Wiring I/O Slaves 50
Radio Power 50
Digital Inputs 50
Digital Outputs 50
Wiring I/O Slaves to 4-20 mA Sensors 51
Connecting a 4-20 mA Sensor to Analog Input 1 or Analog Input 2 51
Connecting a 4-20 mA Sensor to Analog Input 3 or Analog Input 4 53
Wiring I/O Slaves to 1-5 V Sensors 54
Connecting a 1-5 Volt Sensor to Analog Input 1 or Analog Input 2 54
Connecting 1-5 Volt Sensor to Analog Input 3 or Analog Input 4 55
1-5 Volt Sensor Signal Coupling for Analog Input 3 and Analog Input 4 55
Plunger Lift Example 58
I/O Master to the RTU 58
I/O Slave to the Well Head 59
Terminal Port Mappings within Tool Suite 60
Emergency Shut Off Example 61

I/O Master to the Emergency Shut-Off ... 61
I/O Slave to the RTU at Each Well Sites ... 62
Terminal Port Mappings within Tool Suite ... 62
Tank Level Example ... 63
I/O Master to the RTU ... 63
I/O Slave to the Well Head ... 63
Terminal Port Mappings within Tool Suite ... 64
Tubing Pressure Example ... 65
I/O Master to the RTU ... 65
I/O Slave to the Well Head ... 65
Terminal Port Mappings within Tool Suite ... 66
Chapter 6: Viewing Radio Statistics ... 67
Antenna Reflected Power ... 67
Master-Slave Distance ... 68
Noise Level ... 68
Number of Disconnects ... 68
Radio Temperature ... 68
Rate % ... 68
Signal Level ... 69
Transmit Current ... 69
Chapter 7: Additional Information ... 71
Frequently Asked Questions ... 72
FGR2-IO-IOE Ports ... 73
FGR2-IO-IOE Terminal Block Layout ... 73
FGR2-IO-IOE Specifications ... 74
FGR2-IOS-CE-U Ports ... 76
FGR2-IOS-C-U ... 76
FGR2-IOS-C-U/FGR2-IOS-CE-U Terminal Block Layout ... 77
FGR2-IOS-C-U/FGR2-IOS-CE-U Specifications ... 78
FGRIO-S Ports ... 80
FGRIO-S Terminal Block Layout ... 80
FGRIO-S Specifications ... 81
FGRIO-M Ports ... 83
FGRIO-M Terminal Block Layout ... 83
FGRIO-M Specifications ... 84
Index ... 89

Preface

This manual covers details applicable specifically to using FreeWave I/O Master and I/O Slave radios in a wire replacement I/O system, and covers the following models:

I/O Masters

- FGRIO-M

I/O Slaves

- FGRIO-S (board level)
- FGR2-IOS-C-U (board level)
- FGR2-IOS-CE-U (enclosed)

I/O Expansion Radio Base

- FGR2-IO-IOE

If you are using the I/O Slaves or I/O expansion radio bases above in a Modbus I/O system, see the *Modbus I/O User Manual*.

The settings and features available on the above models are very similar. This document includes the following information about using these transceiver models to set up a wire replacement I/O system:

- A basic introduction to both wire replacement and Modbus I/O to help determine if you are using the correct application.
- Transceiver configuration including an introduction to the configuration tools, how to access configuration parameters, I/O Master and I/O Slave specific setup, and additional radio communication settings.
- Installation and basic wiring diagrams for common instrumentation such as 4-20 mA sensors.
- Terminal block diagrams and transceiver specifications.

For information about the firmware releases that apply to the transceivers described in this manual, see Appendix A.

Additional Information

In addition to the content in this document, also refer to the following:

- Application note #5480, *Driving Relays with FGRIO-M Digital Outputs*
- Application note #5482, *FGRIO Signal Replication with 4-20 mA Signals*
- Application note #5493, *Wireless Signal Replication with Plunger Arrival Sensors*
- *Modbus I/O User Manual and Reference Guide* for information specific to using the I/O radio family in a Modbus I/O system.

All FreeWave documentation is available on the *User Manual and System Tools* CD and at www.freewave.com.

Notational Conventions

This document uses the following notational conventions:

- **Bold** - Indicates items that you select, parameter settings, and parameter names.
-  **Warning!** - Indicates a situation that may cause damage to the transceiver, data, or network.
-  - Provides time saving or informative suggestions about using the product.

When used in this manual, the term I/O System refers to any network that uses an I/O Master in conjunction with at least one I/O Slave.

The term I/O Slave refers to any of the I/O Slaves that can be placed in a wire replacement system.

Printing this Document

This document is set to print double-sided with a front cover and a back cover. If you are viewing this document online with a PDF viewer, you may see pages that are intentionally left blank to accommodate the double-sided printing.

Contacting FreeWave Technical Support

For up-to-date troubleshooting information, check the Support page at www.freewave.com.

FreeWave provides technical support Monday through Friday, 7:30 AM to 5:30 PM Mountain Time (GMT -7). Call toll-free at 1.866.923.6168, within Colorado call 303.381.9200, or contact us through email at moreinfo@freewave.com.

Documentation Feedback

Send comments or questions about this document's content to techpubs@freewave.com. Include the title of the document or the document's part number and revision letter (found in the footer) in your email.

Chapter 1: Introduction

Wireless I/O communication is applicable in multiple industries including oil and gas, waste water management, irrigation, and utilities. You can use wireless I/O communication to monitor multi-well pad sites and underground storage capacity, control plunger lift, control lift stations and water quality, or report on groundwater use. The implementations are numerous and wireless I/O provides a cost effective, accurate, and reliable solution for your application monitoring and control needs.

FreeWave transceivers provide the following I/O interfaces:

- **Wire Replacement** - Provides an alternative in situations where running wires is costly or not possible. Connect a FreeWave I/O Master radio to a PLC or RTU device and FreeWave I/O Slave radios to sensors, transmitters, and switches to monitor and control devices.
- **Modbus I/O** - Much like wire replacement, a Modbus I/O system provides an alternative to running wires, but also takes advantage of Modbus Polling capabilities to monitor, configure, and control a device.

This document discusses how to set up FreeWave transceivers for use in a ***wire replacement*** I/O system. For information about setting up FreeWave transceivers for use in a Modbus I/O system, including Modbus register map details, see the *Modbus I/O User Manual and Reference Guide*.

I/O Product Family

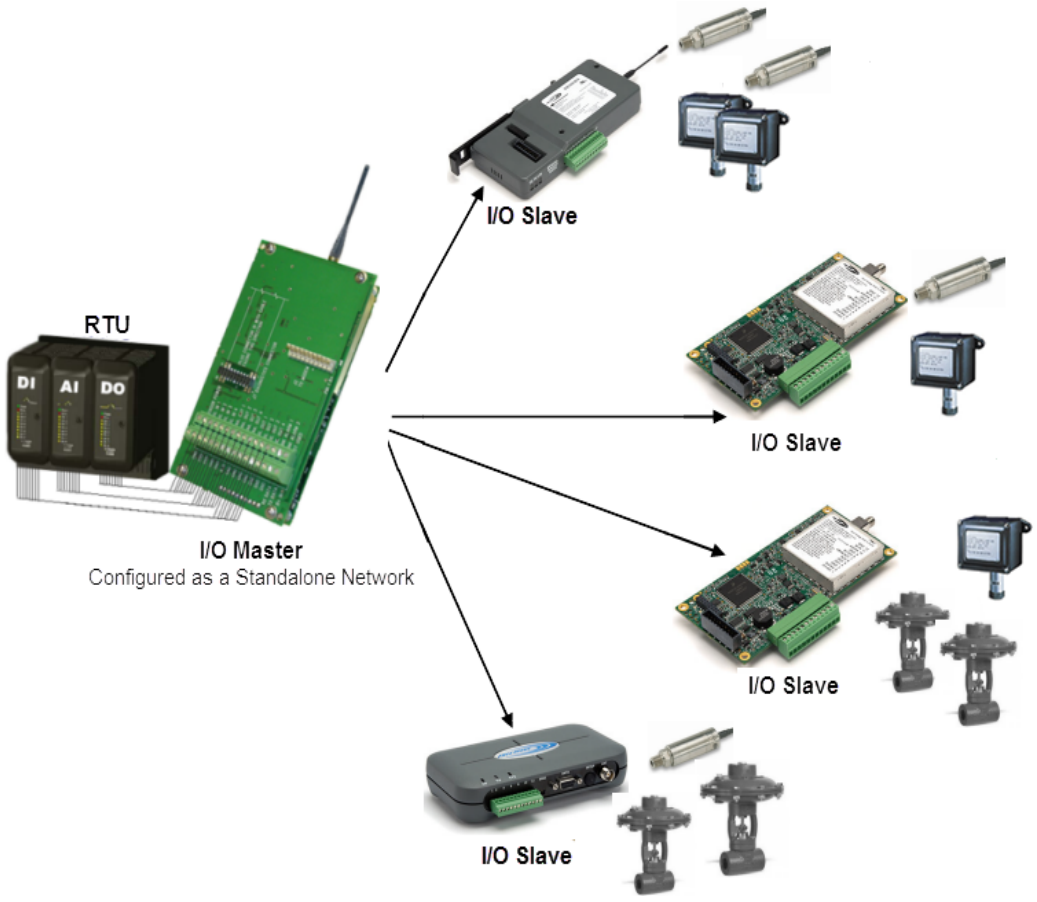
The FreeWave I/O product family consists of products for both signal replication (wire replacement I/O) and Modbus I/O integrations, including the ability to expand the number of inputs and output available using expansion modules.

Model	Description	Wire Replacement I/O	Modbus I/O
I/O Slaves			
FGR2-IOS-C-U FGR2-IOS-CE-U	In the Modbus mode, FGR2-IOS models can be directly connected as an I/O peripheral to a SCADA network. In wire replacement I/O (wireless signal replication), the FGR2-IOS models can operate as a Slaves linked to an FGRIO-M (Master) radio. The FGR2-IOS-CE-U version includes internal switchable and protected resistors for convenience when using 4-20 mA sensors.	x	x
FGR2-IO-IOE	A radio base that supports adding expansion modes in a Modbus I/O system. In Modbus mode the FGR2-IO-IOE can provide wireless I/O to a SCADA network. In wire replacement , the FGR2-IO-IOE can operate as a Slave linked to an FGRIO-M (Master).	x	x
I/O Master			
FGRIO-M	The FGRIO-M can operate as a Master in a 900 MHz I/O network. The FGRIO-M must have firmware 2.54 or higher installed to support wire replacement applications.	x	N/A
I/O Expansion			
IOE-4440 IOE-4422 IOE-4404	Serial bases that provides expandable, wired I/O. For information about the serial base models, see the *I/O Expansion User Manual and Reference Guide*. This document does not provide information about the serial bases or expansion models.	N/A	x

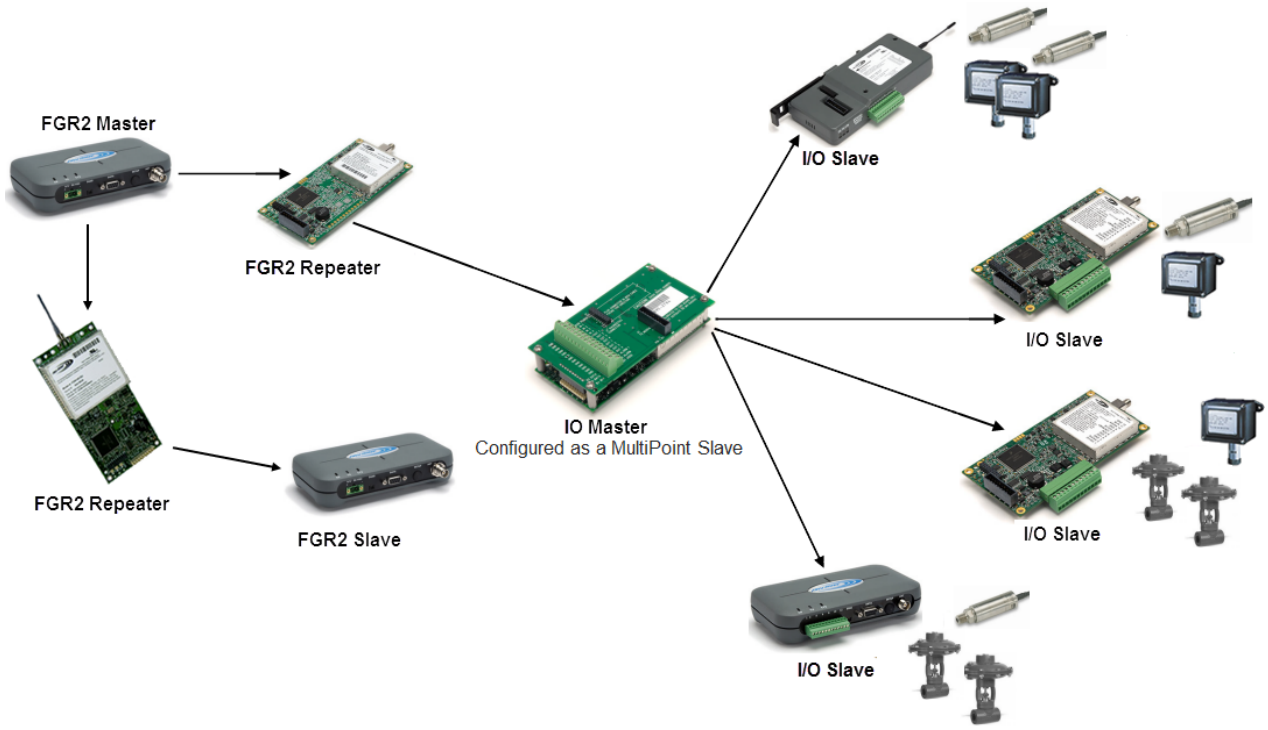
Model	Description	Wire Replacement I/O	Modbus I/O
IOEX-4440 IOEX-4422 IOEX-4404	Expansion models that can be added to a radio base or serial base device to expand the number of I/O channels available. Expansion Modules on their own do not communicate. They must be connected to a Radio Base or a Serial Base. Different isolated channels are available depending on the model number. For information about the expansion models, see the *I/O Expansion User Manual and Reference Guide*. This document does not provide information about the serial bases or expansion models.	N/A	x

Wire Replacement I/O Systems

A wire replacement I/O system can exists as a standalone system with an I/O Master (FGRIO-M) and up to four I/O Slaves, not exceeding the Master's I/O terminal port count. In the example below, the FGRIO-M is configured as an FGRIO Master with I/O enabled. The Slaves are configured as FGRIO Slaves (Not IO-Modbus), which enables the wire replacement settings.



A wire replacement I/O system can also be integrated into a FreeWave transceiver network. In the example below, the I/O Master is not the Master transceiver in the network. It is configured as a MultiPoint Slave, and can still be connected to up to four I/O Slaves, not exceeding the Master's I/O terminal port count.



Configuration Tool Options

Note: The terms modem and transceiver are used interchangeably in this document and in the text within the setup tools. While the words have different meanings, the two terms should be treated as one and the same when referring to FreeWave products.

When the transceiver is in Setup mode, you can use the following setup tools to configure the settings on the transceiver:

- **Tool Suite** - Tool Suite is the current configuration software and replaces EZConfig, and is the recommended method for programming your transceivers.

  It provides a group of tools for configuring the devices in your network and for monitoring your network's performance. Using the Configuration application within Tool Suite, you can program changes to your transceiver's settings. Tool Suite is available on the *User Manual and System Tools* CD and is also available for download from www.freewave.com.

  For more information about using Tool Suite, see the *Tool Suite User Manual* available on the *User Manual and System Tools* CD or by selecting **File > Help** in the Tool Suite software.

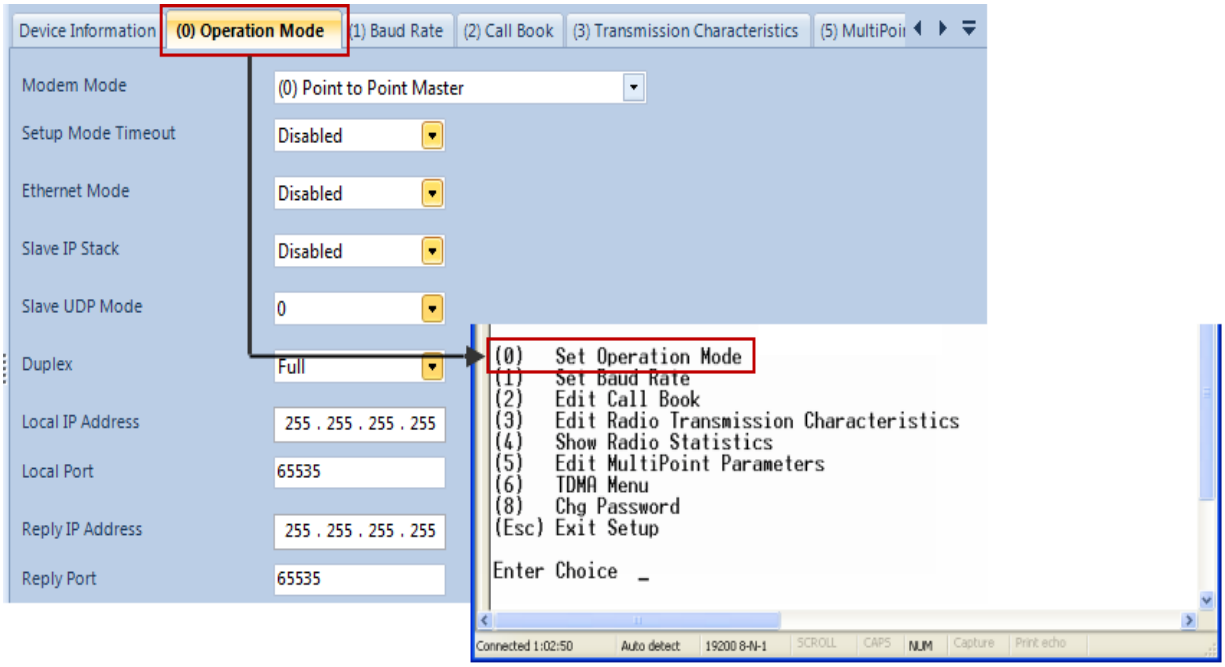
- **Terminal Emulator** - A terminal emulator program, such as HyperTerminal or TeraTerm, offers many of the same configuration options that are available in the Configuration application in Tool Suite. Terminal emulators vary in cost, and several are downloadable free of charge. If you run

versions of the Windows operating system prior to Windows 7, HyperTerminal is included in the operating system installation.

You can use the terminal emulator program of your choice to program the transceiver. The Setup Terminal application within Tool Suite provides the same interface that is available using a terminal emulator.

Tool Suite and Terminal Emulators

If you are using a terminal emulator, the tabs for a device in Tool Suite mirror the Setup main menu selections. For example, option **0** from the Setup main menu in the terminal menu setup is **Set Operation Mode**. The corresponding configuration tab for the device in Tool Suite is **(0) Operation Mode**.



You can also use the Setup Terminal application within Tool Suite to use and view the terminal menus. It displays the same menus and provides the same programming settings as you see using a terminal emulator.

Throughout this document, if the setup procedure in the terminal emulator is different than the procedure in Tool Suite, the terminal instructions are also included.

Transceiver Setup Mode

To read the current settings from or to program a transceiver, the transceiver must be in Setup mode. When a transceiver is in Setup mode, all three LEDs display solid green . See the sections below for details about how to access the transceiver's Setup mode using Tool Suite or the terminal interface.

Note: OEM boards may also enter Setup when Pin 2 on a 10-point connector or Pin 8 on a 24-pin connector is grounded, or using a break command. For more information about the break command, see "Use Break to Access Setup" on page 18.

The **Setup Port** parameter in the Baud Rate tab determines whether the main data port or the diagnostics port is used to access the setup parameters for the transceiver. For more information, see "Setup Port" on page 17.

Using the **Setup Mode Timeout** parameter in the Operation Mode tab, you can set the transceiver to exit Setup Mode automatically. When the setting is enabled, if the transceiver has not received any menu selections or programming information within 5 seconds, it exits Setup and resumes its previous mode.

Using Tool Suite to Connect to and Program Transceivers

To read and program a transceiver using Tool Suite, you need to connect the transceiver to a computer that runs the Tool Suite software. You can also use Tool Suite to set up a template version of a transceiver. Templates include settings that apply to more than one transceiver in your network. For more information about using templates, see the *Tool Suite User Manual* available from the **File > Help** menu within the application.

1. Connect a serial or diagnostic cable between the computer or laptop and the transceiver.

   Using a diagnostic cable and the diagnostic port is recommended.
2. Connect the power supply to the transceiver and the power source and turn on the transceiver.
3. With the transceiver connected to the computer in Tool Suite, click **Configuration** in the Application pane to display the Configuration application.
4. Ensure the correct port is selected in the **Com Port** field in the Configuration ribbon.
5. To place enclosed transceivers in Setup mode, press the Setup button on the back of the FreeWave transceiver.

   If you are connected to the diagnostics port, the transceiver changes to Setup mode automatically when you click **Read Radio** in Tool Suite.

   To place board-level transceivers into Setup Mode:

   - Short pins 2 & 4 (Brown to Black) on the 10 pin header next to the LEDs.
   - If using a data cable (FreeWave part number: ASC3610DB or ASC3610DJ), press the Setup button on the data cable.
6. Click **Read Radio** in the Configuration ribbon to read the transceiver's current settings.
7. Make the necessary parameter changes and do one of the following to send the changes to the transceiver:

   - To send only the parameters you have changed, within the Configuration application in the Network Title ribbon, click **Quick**. This option is only available if you clicked **Read Radio** and are not sending parameter settings from a template to the transceiver.
   - To send all the settings for all parameters, within the Configuration application in the Network Title ribbon, click **All**.
   - To set a device back to its factory default settings, within the Configuration application in the Network Title ribbon, click **Default**.

For more information about using Tool Suite, see the *Tool Suite User Manual* available on the *User Manual and System Tools* CD or by selecting **File > Help** in the Tool Suite software.

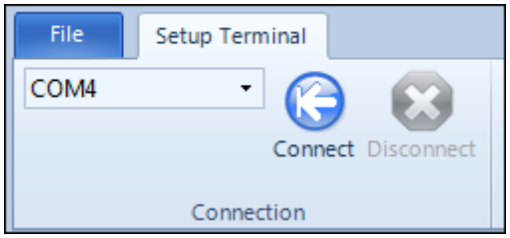
Accessing the Setup Menu Using a Terminal Emulator

Use a terminal emulator of your choice to access the Setup menu. For any terminal emulator application, plug the serial cable into a com port on the transceiver, open a session and ensure that the port settings are set to the following for a proper connection to the transceiver:

Port Setting	Select
Bits per second	19200
Data Bits	8
Parity	None
Stop Bits	1
Flow Control	None

The instructions below describe how to access the transceiver's Setup menu using the Setup Terminal application within Tool Suite. Setup Terminal contains the port settings above, by default. For more information about using Tool Suite, see the *Tool Suite User Manual* available on the *User Manual and System Tools* CD or by selecting **File > Help** in the Tool Suite software.

1. Plug a serial cable into Com 1 and connect it to the computer running Tool Suite and connect the transceiver to power.
2. Open Tool Suite and select Setup Terminal in the Applications pane.
3. From the drop-down list at the top left of the window, select the Com port on the computer to which the transceiver is connected.



4. Click **Connect**.
5. To connect the to the transceiver, in enclosed radios, press the Setup button on the back of the FreeWave transceiver. If connected to the diagnostics port, type **U** (Capital 'U') to invoke the Setup menu.

   To display the Setup menu in board level radios:

   - Short pins 2 & 4 (Brown to Black) on the 10 pin header next to the LEDs.
   - If using a data cable (P/N ASC3610DB or ASC3610DJ), press the Setup button. If using the gray ribbon diagnostic cable (P/N AC2009DC), or the black diagnostic cable (P/N ASC0409DC), press **Shift-U** (capital U) to invoke the Setup menu.

   When Setup is invoked, the FreeWave Setup Main Menu displays in the terminal emulator window. All three LEDs on the transceiver light green and stay green as long as the transceiver is in Setup mode. The main setup menu displays, which looks similar to the following:

```
                          MAIN MENU
                  FGRIO 30V - 900MHz Version 9.76  03-23-2011
                    902 - 928 MHz
                 Modem Serial Number 931-9497
                   Model Code 30G1C
(0)   Set Operation Mode
(1)   Set Baud Rate
(2)   Edit Call Book
(3)   Edit Radio Transmission Characteristics
(4)   Show Radio Statistics
(5)   Edit MultiPoint Parameters
(8)   Chg Password
(9)   FGRIO Setup
(Esc) Exit Setup

Enter Choice
```

As you navigate through the Setup menu and make changes to the parameters, the parameters are sent to the transceiver ***immediately***.

Troubleshooting Terminal Emulators

The following are some common issues encountered while using terminal emulators

Nothing displays on the screen after placing the transceiver into Setup mode.

This usually indicates one of two things; either the wrong Com port is selected or a null modem cable is being used. Change the Com port, verify the cable, and attempt to connect again.

In addition, if the radio has been previously configured, you could be using the wrong port to access the Setup menu. For more information, see "Setup Port" on page 17.Try connecting to the other port.

Unreadable characters display on the screen after placing the transceiver into Setup mode.

This typically indicates a baud rate mismatch. Unreadable characters before grounding the pin indicates Diagnostics is enabled and the terminal emulator is connected to the Diagnostics pins. Update the terminal emulator's baud rate to 19200 and reconnect to the transceiver.

The Setup menu displays on the screen, but nothing happens when keys on the keyboard are pressed.

This usually indicates flow control is turned on in a three-wire connection (Rx, Tx, and Gnd). Update the terminal emulator's flow control setting to None and reconnect to the transceiver.

A connection exists, the terminal emulator is receiving data, and some data is correct, but the remaining data is in unrecognizable characters.

This usually indicates a parity mismatch. Ensure that the parity of the transceiver and the parity of emulator are set the same.

LED Indications

	FGRIO Master			FGRIO Slave		
Condition	Carrier Detect (CD)	Transmit (Tx)	Clear to Send (CTS)	Carrier Detect (CD)	Transmit (Tx)	Clear to Send (CTS)
I/O Slave linked to I/O Master in a standalone network	Solid green bright	Solid red dim	Blinking red	Blinking green	Blinking red	Blinking red
I/O Master linked to the network Master and the I/O Slave linked to the I/O Master	Solid green bright	Solid red dim	Flickering red	Blinking green	Blinking red	Blinking red

Chapter 2: Configuring an I/O Master

This chapter provides information about configuring an I/O Master in both a standalone and integrated wire replacement network. Connect to and read the settings from the I/O Master in Tool Suite as described in "Using Tool Suite to Connect to and Program Transceivers" on page 6 and then use the information in this section to complete the following.

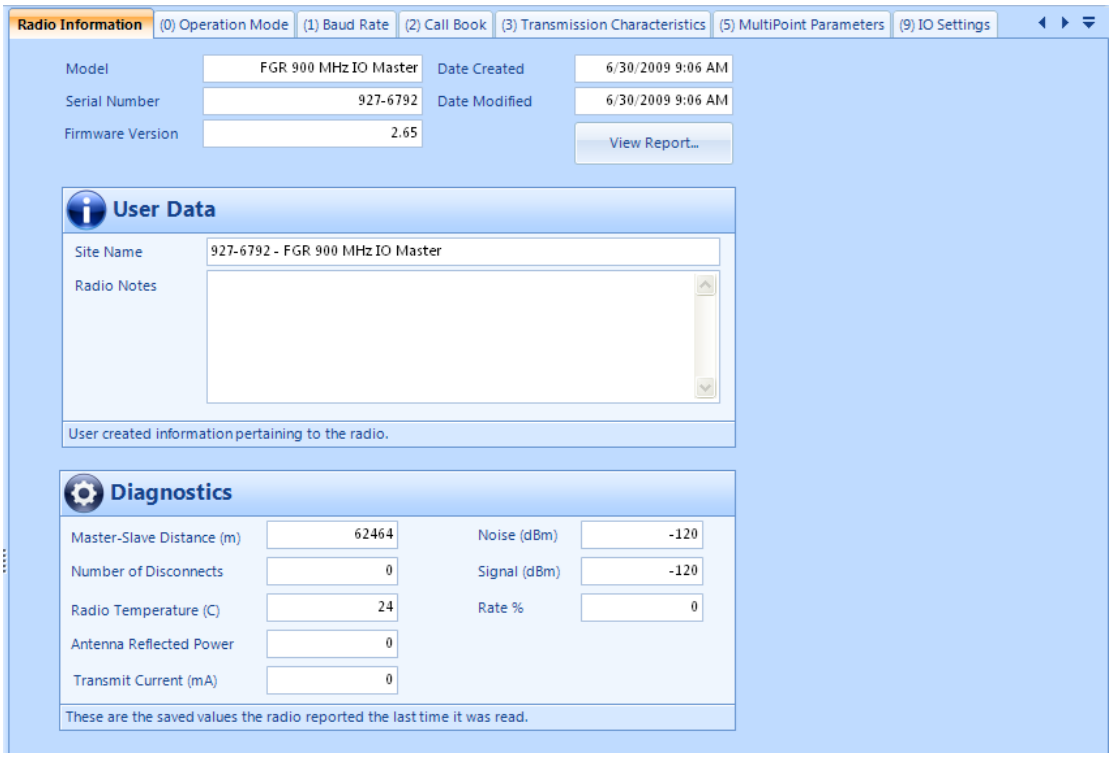
1. Set the I/O Master's role in the network in the Operation Mode tab.
2. If the I/O Master's data port is connected to an end device, configure settings in the Baud Rate tab to match the device that is connected to the data port.
3. Establish communication with the I/O Slaves using the Call Book in the Call Book tab and the Network ID in the MultiPoint Parameters tab.
4. Set the data transmission settings in the Transmission Characteristics tab to determine how data is sent between the I/O Master and the I/O Slaves.
5. Set additional parameters specific that apply to a wire replacement I/O system in the MultiPoint Parameters tab.
6. Enable the I/O Master for I/O, set the output default states, and map the outputs to the I/O Slave inputs using the settings in the IO Settings tab.

The settings discussed in this chapter are those required for wire replacement I/O and to establish a connection with the I/O Slaves in the wire replacement system. Other radio settings are available on the I/O Master that can be set at your discretion. For more information, see "Other Transceiver Settings" on page 35.

Configuring an I/O Master Quick Start

This section describes how to quickly get the I/O Master in a wire replacement I/O network setup and communicating with the I/O Slaves. It covers only the settings required for radio communication to and from the I/O Master and the I/O Slaves. Parameter settings not included in the procedure below can be set at your discretion or remain at the factory default setting. .

1. Connect the transceiver to the serial port of a computer either through a serial cable or using the diagnostics cable. Make sure to connect the radio to a power source (+7.0 to +30.0 VDC).
2. Open Tool Suite and click **Configuration** in the Application pane.
3. Click **Read Radio** to read the transceiver's current settings.



4. Click the Operation Mode tab and select from one of the following options in the **Modem Mode** field:
   - **(E) FGRIO Master** - Select this mode when the I/O Master is a standalone I/O system and is connected to only I/O Slaves.
   - **(3) Point to MultiPoint Slave** - Select this option if the I/O Master is part of a larger network and serves as a MultiPoint Slave that is connected to the I/O Slaves. Configure the other, non-modbus radios in the network accordingly. Ensure the **Repeaters** parameter is set to **Enabled** in the serial network Master.

   The Ethernet options that display in this tab do not apply to an I/O Master and should be left at their factory default settings.
5. If you selected **(E) FGRIO** in step 4, continue with the next step as the Baud Rate tab settings do not apply. If you selected **(3) Point to MultiPoint Slave** in step 4, click the Baud Rate tab and set the following parameters to match the device that is connected to the transceiver's data port.
   - Baud Rate
   - Data Parity
   - Serial Interface
   - Flow Control

6. Click the Call Book tab and enter the I/O Slaves' serial numbers in the **Number** column.

   The **Repeater 1** and **Repeater 2** columns remain black as Repeaters are not used in a wire replacement network.

7. Click the Transmission Characteristic tab and set the following:

   - **Frequency Key** - If you selected **(E) FGRIO** in step 4, select a unique key. FreeWave recommends changing the key from the default setting of **5**.

     If you selected **(3) Point to MultiPoint Slave** in step 4, the **Frequency Key** must match the network Master.

   - **Hop Table Version** - Leave at the factory default **902-928 MHz**.
   - **Hop Table Size** - Leave at the factory default **112**.
   - **Max Packet Size** - Set to **2** or higher.
   - **Min Packet Size** - Set to **2** or higher.

     If you selected **(3) Point to MultiPoint Slave** in step 4, both the **Max** and **Min Packet Sizes** must match the network Master.

   - **RF Data Rate** - Set to **Normal**.

8. Click the MultiPoint Parameters tab and set the following:

   - **Master Packet Repeat** - Set to **3**.
   - **Network ID** - If you selected **(E) FGRIO**, enter a unique number between 1 and 4095 (except 255).

     If you selected **(3) Point to MultiPoint Slave** in step 4, the **Network ID** must match the network Master.

   - **Repeaters** - Set to **On**.
   - **Subnet ID** - If you selected **(3) Point to MultiPoint Slave** in step 4, set the **Rx** portion of the subnet to **0** and the **Tx** portion to **F** if the I/O Master links directly to the network Master.

9. Click the I/O Settings tab and set the following:

   - **Enable FGRIO** - Set to **On**.
   - **Sensor Power** - A setting of **Always On** supplies continuous power to the VSNS (pin 7) of the I/O Slave. Use **Gated** when the RTU provides a switched power output to control the power of the analog sensor loop at the I/O Slave.
   - **Default Delay** - Enter the amount of time that the I/O Master waits before issuing a link alarm due to loss of communication to an I/O Slave. A setting of:
     - **1** = 1/6 second
     - **6** = 1 second
     - **42** = 7 seconds
     - **252** = 42 seconds
   - **Analog Out 1 through Digital Out 4** - Map the I/O Master outputs to the I/O Slave inputs. Select the appropriate I/O Slave input from the drop-down list next to the output.

The I/O Slaves are labeled by their position in the Master's Call Book. For example, Slave 0 refers to the serial number in entry to call **0**.

10. Send the settings to the transceiver using the **All** or **Quick** options in the Network Title ribbon within Tool Suite.

I/O Masters in Tool Suite

When you read an I/O Master radio's settings through Tool Suite, the radio displays as an FGR 900 MHz I/O Master.

If you create a radio template for an I/O Master in the Configuration application within Tool Suite, select FGR 900 MHz Master as the radio type.

For more information about using Tool Suite, see the *Tool Suite User Manual* available on the *User Manual and System Tools* CD or by selecting **File > Help** in the Tool Suite software.

Setting the I/O Master's Role in the Network

The first parameter to set in the I/O Master in a wire replacement I/O system is to select its Modem Mode (or Operation Mode). The mode tells the transceiver what network type it is in and what role it plays and enables other settings for that transceiver.

Set the modem mode in the Operation Mode tab, using the **Modem Mode** field. These settings are available in the Operation Mode menu in the terminal interface.

In a wire replacement I/O system, assign one of the following Operation Modes to the I/O Master transceiver:

- **(E) FGRIO Master** - Select this mode when the I/O Master is a standalone I/O system and is connected to only I/O Slaves.
- **(3) Point to MultiPoint Slave** - Select this option if the I/O Master is part of a larger network and serves as a MultiPoint Slave that is connected to the I/O Slaves. Configure the other, non-modbus radios in the network accordingly.

The modem mode is the only setting that is required in the Operation Mode tab. The Ethernet settings available are not used in a wire replacement network and should be left at the factory default.

Establishing Communication Between the I/O Master's Data Port and an End Device

The settings in the Baud Rate tab are the communication settings between the transceiver and the instrument or computer to which the transceiver's data port is connected. These settings are unique to each transceiver, and do not need to match across the network.

- If the I/O Master's **Modem Mode** is set to **(E) FGIO Master** the I/O Master is set to run in a standalone wire replacement system and all the settings in the Baud Rate tab can remain at their default settings.
- If the I/O Master's **Modem Mode** is set to **(3) Point to MultiPoint Slave**, the I/O Master is part of a larger radio network and the settings described below must match the device that is connected to the data port.

Baud Rate

Default Setting: 115200

Options: 600, 1200, 2400, 4800, 9600, 19200, 38400, 57600, 76800, 115200, 230400

Terminal Menu: (1) Set Baud Rate

Description: The communication rate between the transceiver's data port and the instrument to which it is connected. This setting is independent from the baud rate for the other transceivers in the network. Set the baud rate to the highest level supported by the device to which it is connected. With a poor radio link, however, this may actually result in slower data communications.

With a **Baud Rate** setting of 38,400 or higher, FreeWave recommends that you use the Flow Control lines.

Note: The Setup port baud rate always defaults to **19,200** no matter how the data port Baud Rate is set.

Data Parity

Default Setting: 0 (8, N, 1)

Options: See table below.

Terminal Menu: (1) Set Baud Rate > (A) Data Parity

Description: Six data word length and parity configurations are available for use with FreeWave transceivers. The default setting is **8-None-1** and is the most commonly used serial communications protocol.

The following table describes each option:

Option	Data Bits	Parity	Stop Bits
0	8	None	1
1	7	Even	1
2	7	Odd	1
3	8	None	2
4	8	Even	1
5	8	Odd	1

Flow Control

Default Setting: (0) None

Options:

- **(0) None** - No flow control CTS is active and de-asserts when buffering is 98% full. Can pass XON/XOFF data but does not use it in any way.
- **(1) RTS** - Uses standard RTS/CTS control lines.

- **(2) DTR**

Terminal Menu: (2) Set Baud Rate > (F) FlowControl

Description: Specifies the hardware flow control for the data port on the transceiver. FreeWave recommends using **Flow Control** if you are using a baud rate higher than 19200.

Modbus RTU

Note: When using the transceiver in **Modbus RTU** mode, the **Master Packet Repeat** setting in the MultiPoint Parameters tab must match in every transceiver. The **Modbus RTU** mode must be set to **1** when transceivers are configured in RS485 or RS422 mode.

Default Setting: 0 (Disabled)

Options: 0 to 9

Terminal Menu: (1) Set Baud Rate > (B) Modbus RTU

Description: A setting other than **0** in this parameter causes the transceiver to wait for an amount of time "gathering" data before sending out the radio link.

- **0 (Disabled)** - The transceiver sends data out through its radio link as soon as the data is received into the serial port. This is the default setting
- **1** - The transceiver waits for a number of slots equal to two times the **Master Packet Repeat** setting before sending the received data out the radio link. For example, if the **Master Packet Repeat** parameter is set to **3**, the transceiver waits for 6 slots, gathering data up the whole time. At the end of the 6 slots, the transceiver sends all received data in one "burst." This is the appropriate setting for most Modbus RTU devices.
- **2 or higher** - The transceiver waits for a number of slots calculated using the following formula:

  (Modbus RTU setting + Master Packet Repeat setting + 1) x 2

For example, in a transceiver where the **Modbus RTU** setting is **2** and the **Master Packet Repeat** setting is **3**, the transceiver waits for (2 + 3 + 1) x 2, or 12 slots.

Serial Interface

Default Setting: (0) RS232

Options: **(0) RS232** - Also used for TTL.

(1) RS422 - **Modbus RTU** must be enabled and **Turn Off Delay** set to at least **4**.

(2) RS485 - **Modbus RTU** must be enabled and **Turn Off Delay** set to at least **4**.

(3) DOT - DOT causes the CD line to indicate when data is transmitted on the

serial port from the transceiver. When the transceiver is not sending data to the serial port, CD is de-asserted. When the transceiver is sending data to the serial port, CD is asserted. The CD line no longer has any radio link state functionality. **Turn Off Delay** works as described in all radios. **Turn On Delay** works as described on any Slave or Slave/Repeater - it has no functionality on the Master.

If set to anything other than **0**, the **Setup Port** parameter in the Baud Rate tab must be set to **Diagnostics Only**.

Terminal Menu: (1) Set Baud Rate > (C) RS232/485

Description: Use this option to set the protocol of the data port.

Setup Port

Important: Do not change this setting unless the correct programming cable is available for the new setting.

Default Setting: (3) Both

Options:

- **(1) Main Only** - Programming and reading a transceiver's setup information is done through the data port.
- **(2) Diagnostics Only** - Programming and reading a transceiver's setup information is done through the diagnostic port. If the **Serial interface** is set to anything other than RS232, then the **Setup Port** must be set to **Diagnostics Only**.
- **(3) Both** - Programming and reading a transceiver's setup information is done through either the data port or the diagnostic port .

Terminal Menu: (1) Set Baud Rate > (D) Setup Port

Description: Determines which port on the transceiver, Main or Diagnostics, is used to access the parameter settings in Tool Suite or enter the Setup main menu in the terminal interface.

Turn Off Delay

Default Setting: 0

Options: Any number between 0 and 9.

Terminal Menu: (1) Edit Baud Rate > Turn Off Delay

Description: Specifies the time after the end of transmission of a character to the RS485 bus that the transceiver stops driving the bus and releases the bus to other devices. The units are ¼ of a character with a range from 0 to 9. An entry of 4 means a delay equivalent to the duration of a full character. The default is zero delay.

For data rates of 1200 bits/S or slower, avoid setting the **Turn Off Delay**

parameter higher than **4**. At those rates the functionality of the microprocessor changes so that a **Turn Off Delay** of **5** has the same effect as if set to **1**, and a setting of **6** has the same effect as **2**, and so on.

Note: Turn Off Delay must be set to a value of at least **4** for RS422 and RS485 operation.

Turn On Delay

Default Setting:	0 ms
Options:	Any number between 1 and 9 ms.
Terminal Menu:	(1) Set Baud Rate > (E) Turn On Delay
Description:	Sets the delay between when the line drivers are turned on and when the data leaves the data port.

Use Break to Access Setup

Note: This setting is typically only used in OEM scenarios.

Default Setting:	Disabled
Options:	• **(0) - Disabled** - The break command is disabled in the radio. • **(1) - Enabled** - The Setup menu is sent at 19200 bps. • **(2) - Enabled** - The Setup menu is sent at the radio's current baud rate. This setting is only available through the terminal interface
Terminal Menu:	(2) Set Baud Rate > (G) Use break to access setup
Description:	Enables a break command to put the transceiver into Setup mode over the data port. To send a break character the end device must hold the Tx data line in the space voltage level for longer than 1 character time. If a character is defined as having 1 start bit, 8 data bits, and 1 stop bit, the character time is 10 bits, thus the Tx data line must be held in the space voltage level for a period of time longer than 10 bits.

Establishing Communication with I/O Slaves

For the I/O Master to communicate with the I/O Slaves, you need to tell the I/O Master what other devices are available for it to communicate with. On an I/O Master, you must set both the Call Book ***and*** the Network ID to establish communication with the I/O Slaves. Setting both the Call Book and the Network ID is unique to wire replacement I/O and must be done for both integrated and standalone applications.

- In the I/O Master's **Call Book** tab, enter the serial number for each I/O Slave in the network, up to a maximum of four transceivers. The Repeater columns must be left blank as Repeaters are not used in a wire replacement I/O network.
- In the I/O Master's MultiPoint Parameters tab, enter an ID in the **Network ID** field that meets the guidelines below. Transceivers from the factory have a default ID of **255**.

- The value can be any value between 0 and 4095, except 255.
- To help ensure your ID is unique to your network, avoid using numbers that coincide with nearby landmarks or highways.
- FreeWave recommends an ID of four characters. For example, the last four digits of the I/O Master's serial number, which is ensured to be unique and does not overlap with other nearby FreeWave networks.
- If the I/O Master's **Modem Mode** is set to **(3) Point to MultiPoint Slave**, its **Network ID** must match the network's Master.

Setting I/O Master RF Transmission Characteristics

The Transmission Characteristics parameters allow you to modify settings that determine how data is sent between transceivers in your network. Many of these parameters must be maintained throughout the network for proper functionality.

In an I/O Master, you must set the following parameters in the Transmission Characteristics tab. These parameters are also available in the Edit Radio Transmission Characteristics menu in the terminal interface. Each required parameter is described in more detail below:

- Frequency Key
- Max Packet Size
- Min Packet Size
- RF Data Rate

The remaining parameters in the Transmission Characteristics tab can remain at their factory default settings to establish a link with the I/O Slaves. Each of the additional parameters is described in detail in "Setting Other RF Transmission Characteristics" on page 35.

Frequency Key

Default Setting:	5
Options:	0 to 9 and A to E **Note:** Do not use Frequency Key **E** with the 915-928 MHz, 916-920 MHz, and 921-928 MHz hop tables. In an I/O Master whose **Modem Mode** is set to **(3) Point to MultiPoint Slave**, the **Frequency Key** must match the Master in the network. FreeWave recommends changing the Frequency Key setting to an option other than **5**.
Terminal Menu:	(3) Edit Radio Transmission Characteristics > (0) FreqKey
Description:	Fifteen choices are available for the **Frequency Key** setting, representing 15 different pseudo-random hop patterns. Hopping patterns minimize the interference with other FreeWave transceivers operating in the area. For example, if 10 pairs of FreeWave transceivers are operating on different networks in close proximity, setting a different **Frequency Key** value reduces

the chance that transceivers hop to the same frequency at the same time. If two networks were to hop to the same frequency, the next hop would be to a different frequency for both networks.

You can gain additional network separation by adjusting the **Max Packet Size** and **Minimum Packet Size**.

Use the **Hop Table Version**, **Hop Table Size**, and **Frequency Zone** fields to define more network differentiation by way of limiting the number and location of frequencies the transceivers may hop on in the 902-928 MHz band.

Max Packet Size and Min Packet Size

Default Options: Max Packet Size = 8
Min Packet Size = 9

Options: Any number between 0 and 9.

In a wire replacement I/O system, FreeWave recommends setting both the **Max** and **Min Packet Sizes** to **2** or higher.

If the I/O Master's Modem Mode is set to **(3) Point to MultiPoint Slave**, the **Max** and **Min Packet Sizes** must match the network Master.

Terminal Menu: (3) Edit Transmission Characteristics > (1) Max Packet Size and (2) Min Packet Size

Setting: Both the I/O Master and I/O Slaves require a minimum combined packet size of 48 bytes. The table below provides the available packet sizes in bytes for an I/O System by chartering the Min Packet Size and Max Packet Size setting when the **RF Data Rate** is set to **3**.

If using Digital Inputs and Outputs for pulse counting, the packet size effects how many pulses the I/O System can register. At a packet size of **Max = 2 Min = 2**, the maximum available count would be 6 Hz. At a packet size of **Max = 9 Min = 9**, the maximum available count would be 3 Hz. The pulse state must last for a 50% duty-cycle (that is, a 3 Hz pulse needs to last at least 166.6 ms and a 6 Hz pulse needs to last at least 83.3 ms).

	Combined Packet Size Definition with RF Data Rate of 3							
	Maximum Setting							
Minimum Setting	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
2	48	64	80	96	112	128	144	160
3	52	68	84	100	116	132	148	167
4	56	72	88	104	120	136	152	168
5	60	76	92	108	124	140	156	172
6	64	80	96	112	128	144	160	176
7	68	84	100	116	132	148	164	180
8	72	88	104	120	136	152	168	184
9	76	92	108	124	140	156	172	188

RF Data Rate

Default Setting	(3) Normal
Options:	(2) High, (3) Normal
Terminal Menu:	(3) Edit Transmission Characteristics > (4) RF Data Rate
Setting:	The **RF Data Rate** must be set to **(3) Normal** in wire replacement I/O systems. In an integrated wire replacement I/O system, all transceivers, including any serial radios in the network, must be set to an **RF Data Rate** of **3**.

Setting I/O Master MultiPoint Parameters

The MultiPoint Parameter options allow you to modify several different parameters in the transceiver that determine the characteristics of a MultiPoint network.

In an I/O Master, you must set the following parameters in the MultiPoint Parameters tab. These settings are available in the MultiPoint Parameters menu in the terminal interface.

- Master Packet Repeat
- Repeaters
- Network ID - See "Establishing Communication with I/O Slaves" on page 18.
- Subnet ID - Only required if the I/O Master's **Modem Mode** is set to **(3) Point to MultiPoint Slave**) and subnet IDs are using the radio network.

The remaining parameters in the MultiPoint Parameters tab can remain at their factory default settings to establish a link with the I/O Slaves. Each of the additional parameters is described in detail in "Setting Other MultiPoint Parameters" on page 42.

Master Packet Repeat

Default:	3
Options:	In a wire replacement I/O system, the I/O Master must have a **Master Packet Repeat** parameter setting to **3**.
Terminal Menu:	(5) Edit MultiPoint Parameters > (1) Master Packet Repeat
Description	In a Point-to-MultiPoint network, Slaves do not acknowledge transmissions from the Master. If Slaves did acknowledge all data transmissions, in a large network, the Master would soon become overwhelmed with acknowledgments from the Slaves. Without acknowledgements, 100% confidence every Slave has received every packet cannot be met.

Repeaters

Default Setting	Enabled
Options:	(0) Disabled, (1) Enabled
Terminal Menu:	(5) MultiPoint Parameters > (0) Number Repeaters
Setting:	This setting must be set to **Enabled** for all transceivers in the wire replacement I/O network, including any serial transceivers in an integrated network. **Note:** If the wire replacement I/O system is integrated into a radio network, the network's Master must also have the **Repeaters** setting set to **Enabled**.

Subnet ID

Default:	F, F
Options:	Any number between 0 and 9 or any letter between A and F.
Terminal Menu:	(5) Edit MultiPoint Parameters > (C) Subnet ID
Description	The Subnet ID setting only applies in an I/O Master when its Modem Mode is set to **(3) Point to MultiPoint Slave**. If the I/O Master is in a standalone system with a **Modem Mode** setting of **(3) FGRIO Master**, both the Rx and Tx components of the Subnet ID should be set to F. Two components exist with regard to the Subnet ID: • **Rx** - This setting identifies which transceiver the I/O Master listens to. . In an I/O Master in an integrated system, set the **Rx** component to the same setting as the **Tx** component on the network Master to which the I/O Master connects. In the terminal menu, this is the **Rcv Subnet ID**. • **Tx** - This setting identifies the ID on which this device transmits, and in turn which devices listen to it. In an I/O Master in an integrated wire replacement I/O system, set the **Tx** component to **F**.

Setting I/O Master Wire Replacement Parameters

To enable I/O functionality in the I/O Master, set the **Enable I/O** option in the **IO Settings** tab to **Enabled**. This setting is available in option **0** in the FGRIO Setup menu in the terminal interface.

After enabling I/O, set the following parameters in the IO Settings tab. Each parameter is described in more detail below.

- Sensor Power
- Default Delay
- Default Output

Use the **Analog Out** and **Digital Out** fields within the IO Settings tab to map the I/O Master's outputs to the I/O Slave inputs. For more information about mapping analog and digital outputs, see "Mapping I/O Master Outputs to I/O Slave Inputs " on page 24.

Sensor Power

Default: (0) Always On

Options:
- **(0) Always On** - Supplies continuous power to the VSNS port (Pin 7) of the I/O Slave.
- **(1) Gated** - Controls the VSNS port of all I/O Slaves communicating with the I/O Master. Applying a voltage of greater than 1.75 VDC to the I/O Master's Sensor Power input port connects the VSNS port of every connected Short-Range I/O Slave and I/O Slave to its supply voltage. Applying less than 1.75 VDC to the I/O Master's Sensor Power input port turns off the VSNS port of all connected Short-Range I/O Slaves and I/O Slaves

Terminal Menu: (9) FGRIO Setup > (A) Sensor Pwr

Description Determines the behavior of the Sensor Power terminal.

Default Delay

Default: 255

Options: Any number between 0 and 255, representing 0.28 second units (see below)

Terminal Menu: (9) FGRIO Setup > (9) Timeout

Description: Determines the amount of time to wait before issuing a Link Alarm due to loss of communication between the I/O Master and /IO Slave.

The value is set in 0.28 second units. For example, a value of 36 represents 36 x 0.28 = 10.08 seconds.

Set between 0 and 255 using the following examples as guidelines:

- 1 = 0.28 seconds
- 25 = 7 seconds
- 4 = 1.12 seconds
- 255 = 71.4 seconds

Default Output

Default: Unchanged

Options:
- On - Returns the outputs to an On state.
- Off - Returns the output to an Off state.
- Unchanged - The outputs remain at the state they were in when the communication was lost.

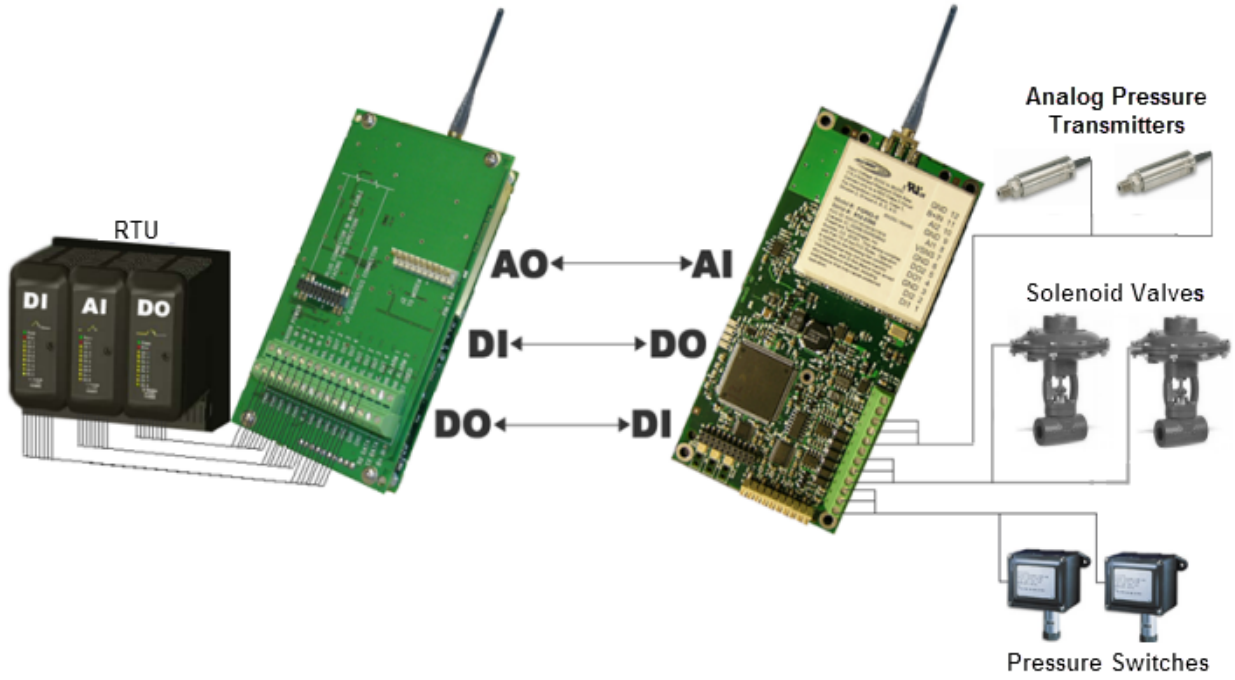
Terminal Menu: (9) FGRIO Setup > Default Output

Description: Sets the state the output returns to when you power up the device, or the

device loses its link with the instrument to which it is attached. The outputs return to this state after the amount of time has passed in the **Default Delay** parameter.

Mapping I/O Master Outputs to I/O Slave Inputs

Map the I/O Master Outputs to the I/O Slave inputs to match the network wiring. The I/O mapping fields are available in the I/O Settings tab in Tool Suite and the FGRIO Setup menu in the terminal interface.



To map I/O Master outputs to I/O Slave inputs in Tool Suite:

1. With the I/O Master in Setup mode and connected to Tool suite, select the IO Settings tab.
2. Using the **Analog Out 1** to **Digital Out 4** fields, select the outputs and inputs to the appropriate I/O Slave input or output.

   Slaves are labeled in the drop-down list by their serial numbers, as they are entered in the I/O Master's Call book.

To map I/O Master outputs to I/O Slave inputs in the terminal interface:

1. With the I/O Master in Setup mode and connected to a terminal interface, select **(2) Call Book** from the main Setup menu.
2. Determine which I/O Slave you are mapping to the I/O Master and note the I/O Master's Call Book Entry number that lists that I/O Slave's serial number.
3. Determine which analog or digital input from the I/O Slave you want to map to the I/O Master.

   This input could be Analog Input (AI) #1, AI #2, AI #3, AI #4, or Digital Input (DI) #1, or DI #2; depending on which sensor(s) the I/O Slave is connected.

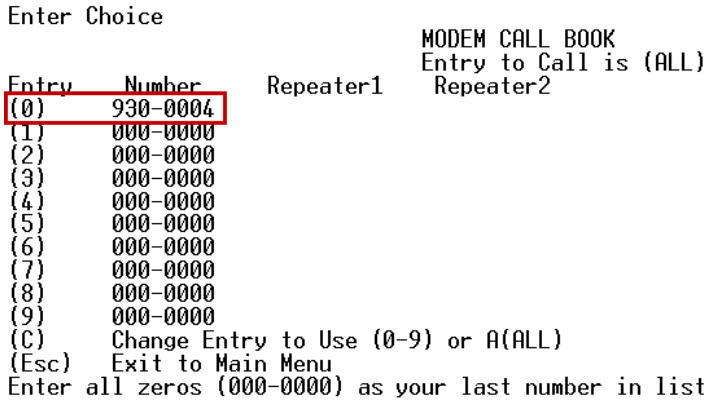
4. Using the table below, find the intersection between the I/O Master's Call Book Entry number found in step 3 and the selected input from the I/O Slave found in step 4. Note the number listed at this intersection.

	AI#1	AI#2	AI#3	AI#4	DI#1	DI#2
I/O Master Call Book Entry #0	1	2	9	10	1	2
I/O Master Call Book Entry #1	3	4	11	12	3	4
I/O Master Call Book Entry #2	5	6	13	14	5	6
I/O Master Call Book Entry #3	7	8	15	16	7	8

5. In the terminal interface, press **Esc** to return to the main Setup menu and select **(9) FGRIO Setup**.
6. Select which output from the I/O Master you would like to "connect" to the input from the I/O Slave and enter the number to the left of the selected output.
7. Enter the number found in step 4. This number should display to the right of the selected output.
8. Press **Esc** and repeat steps 5 and 6 for additional connections.
9. Press **Esc** until you return to the main Setup menu and **Esc** again to exit Setup mode.

Example:

To map **Analog Output 1** of the I/O Master to **Analog Input 2** of the I/O Slave (serial # 930-0004), entry **(5) Analog Out1** in the FGRIO Setup menu has a value of **2**. This is calculated by first checking the Call Book entry # of I/O Slave #930-0004.



The entry number is **0**. Next, go to the table above, find call book entry # 0, then go to the column for I/O Slave **Analog Input #2**. The value listed is **2**. Enter a **2** for **Analog Output #1** of the I/O Master.

Chapter 3: Configuring an I/O Slave

This chapter provides information about the configuration of an I/O Slave in a wire replacement I/O system. Connect to and read the settings from the I/O Slave in Tool Suite as described in "Using Tool Suite to Connect to and Program Transceivers" on page 6 and then use the information in this section to complete the following:

1. Set the I/O Slave's role in the network in the Operation Mode tab.
2. Establish communication with the I/O Master using the Call Book in the Call Book tab and the Network ID in the MultiPoint Parameters tab.
3. Set the data transmission settings in the Transmission Characteristics tab to determine how data is sent to the I/O Master.
4. Set additional parameters specific that apply to a wire replacement I/O system in the MultiPoint Parameters tab.
5. Set the output default states and map the I/O Slave outputs to the I/O Master inputs using the settings in the Wire Replacement tab.

The settings discussed in this chapter are those required for wire replacement I/O and to establish a connection with the I/O Master in the wire replacement system. Other radio settings are available on the I/O Slaves that can be set at your discretion. For more information, see "Other Transceiver Settings" on page 35.

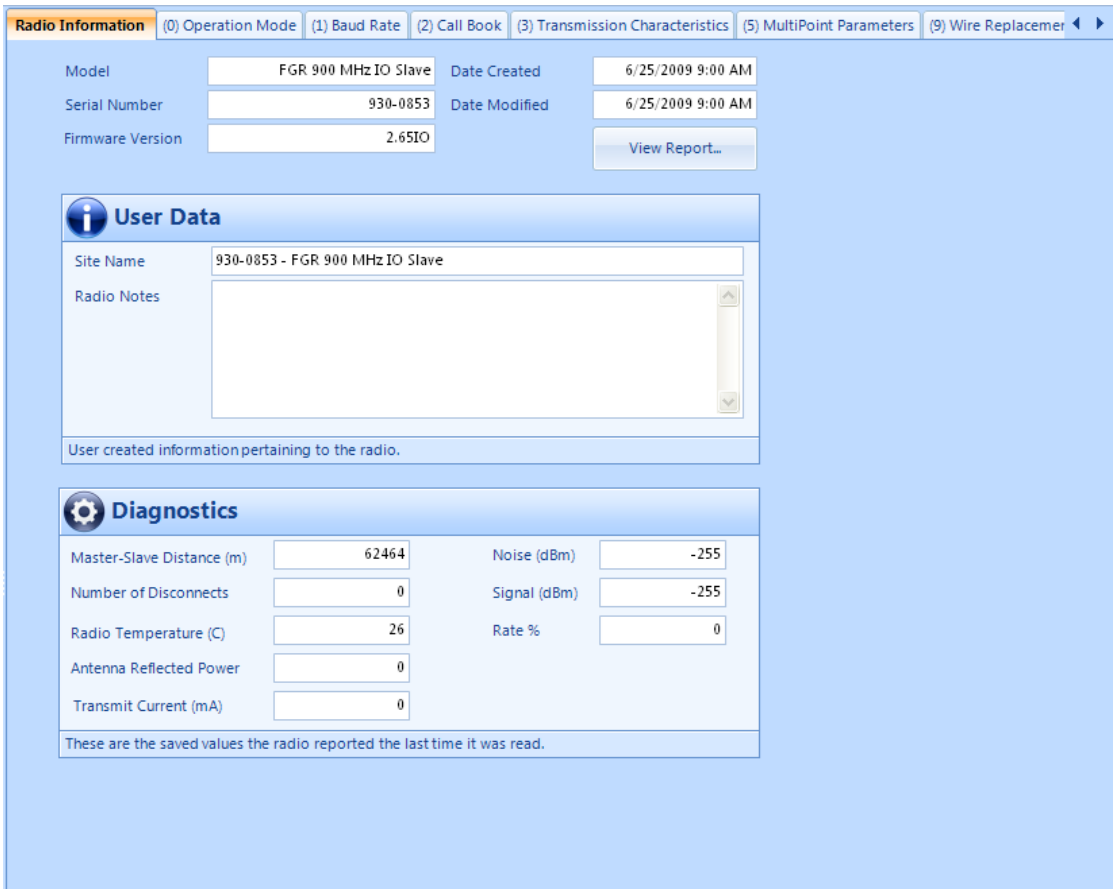
Configuring an I/O Slave Quick Start

This section describes how to quickly set an I/O Slave in a wire replacement I/O network. Parameter settings not included in the procedure below can be set at your discretion or remain at the factory default setting. .

Note: In an I/O Slave, the serial port is disabled. Therefore, the I/O Slaves do not use any settings in the Baud Rate tab.

1. Connect the transceiver to the serial port of a computer either through a serial cable or using the diagnostics cable. Make sure to connect the radio to a power source (+6.0 to +30.0 VDC).

2. Open Tool Suite and click **Configuration** in the Application pane.
3. Click **Read Radio** to read the transceiver's current settings.



4. Click the Operation Mode tab and select **(E) FGRIO Slave (Wire Replacement)** or **(E) FGRIO Slave (NOT IO-MODBUS)**, depending on your version of Tool Suite.
5. Click the Call Book tab and enter the I/O Master's serial numbers in the Number column.

   The **Repeater 1** and **Repeater 2** columns remain black as Repeaters are not used in a wire replacement network.
6. Click the Transmission Characteristic tab and set the following parameters to the same settings as the I/O Master:

   - **Frequency Key**
   - **Hop Table Version**
   - **Hop Table Size**
   - **Max** and **Min Packet Sizes**
   - **RF Data Rate**

7. Click the MultiPoint Parameters tab and set the following parameters to match the I/O Master:
   - **Master Packet Repeat**
   - **Network ID**
   - **Repeaters**

   Note: Subnet IDs are not used in I/O Slaves in a wire replacement network.
8. Click the Wire Replacement tab and set the following:
   - **Digital Out 1 and Digital Out 2** - Mapped to the Digital Inputs of the I/O Master.

     For example, if you select Master DI#1 in the Digital Out 1 field, the I/O Master Digital Input 1 controls Digital Output 1 on the I/O Slave radio.
   - **AI1 250 Ohms and AI2 250 Ohms** - If you are configuring an FGR2-IOS-CE-U (an enclosed transceiver without an expansion port), set the power-up state of the internal resistor 250 Ω resistor when connecting the I/O Slave's Analog Inputs to an 4-20 mA sensor.
   - **DI1 Pullup and DI2 Pullup** - Sets the power-up state of the internal resistor (10 Kohms) connected to the Digital Inputs. They can pull up, such as when using a closed-contact-to-GND switch input, pull down so that unused inputs read 0 as DIs or ~0 as auxiliary analogs, or float to not load analog inputs.
   - **Digital Out 1 Default and Digital Out 2 Default** - Select the state to which the Digital Output returns to when you power up the device, or the device loses its link to the I/O Master in the network.
   - **Default Delay** - Enter the amount of time that the I/O Slave waits before entering the default state defined in **Digital Out 1 Default** and **Digital Out 2 Default**. A setting of:
     - **1** = 1/6 second
     - **6** = 1 second
     - **42** = 7 seconds
     - **252** = 42 seconds
9. Send the settings to the transceiver using the **All** or **Quick** options in the Network Title ribbon within Tool Suite.

I/O Slaves in Tool Suite

When you read an I/O Slave's settings through Tool Suite, the radio displays as an FGR 900 MHz I/O Slave, FGR2 900 MHz I/O Slave, FGR2 900 MHz I/O Slave (Enclosed).

If you create a radio template for an I/O Slave in the Configuration application within Tool Suite, select the correct radio type to ensure that the proper settings display. Select one of the following radio types:

- FGR 900 MHz I/O Slave - For the FGRIO-S model.
- FGR2 900 MHz I/O Slave - For the FGR2-IOS-C-U (board-level) and the FGR2-IO-IOE models
- FGR2 900 MHz I/O Slave (Enclosed) - For the FGR2-IOS-CE-U model. This options exposes additional settings in the Wire Replacement tab for the internal resistors available only in this model.

For more information about using Tool Suite, see the *Tool Suite User Manual* available on the *User Manual and System Tools* CD or by selecting **File > Help** in the Tool Suite software.

Setting the I/O Slave's Role in the Network

The first parameter to set in an I/O Slave in a wire replacement I/O system is to select its Operation Mode or Modem Mode. The mode tells the transceiver what network type it is in and what role it plays.

The mode you select enables other settings for that transceiver. Set the Modem Mode in the Operation Mode tab, using the **Modem Mode** field. These settings are available in the Operation Mode menu in the terminal interface.

In a wire replacement I/O system, assign each I/O Slave the **(E) FGRIO Slave (Wire Replacement)**or **(E) FGRIO Slave (NOT IO-MODBUS)** operation mode, depending on your version of Tool Suite. Selecting this option enables the wire replacement options in the Wire Replacement tab.

Note: An I/O Slave is automatically enabled for I/O functionality based on the Modem Mode setting.

Establishing Communication with the I/O Master

For the I/O Slave to communicate with the I/O Master, you need to tell the I/O Slave which radio is the I/O Master. In a wire replacement I/O system, you must set ***both*** the Call Book and the Network ID to establish communication between the I/O Slave and I/O Master. Setting both the Call Book and the Network ID is unique to wire replacement I/O and must be done for both integrated and standalone applications.

- In each I/O Slave's Call Book tab, enter the I/O Master's serial number as entry number 0 and set the **Entry to Call** option to **0**.
- In each I/O Slave's MultiPoint Parameters tab, enter the same **Network ID** that is defined in the I/O Master.

I/O Slave RF Transmission Characteristics

The Transmission Characteristics parameters allow you to modify settings that determine how data is sent between transceivers in your network. In each I/O Slave in the wire replacement I/O system, set the following parameters to match those set in the I/O Master:

- Frequency Key
- Hop Table Version
- Hop Table Size
- Max and Min Packet Size
- RF Data Rate

The remaining parameters in the Transmission Characteristics tab can remain at their factory default settings to establish a link with the I/O Master or can be set at your discretion. Each of the additional parameters is described in detail in "Setting Other RF Transmission Characteristics" on page 35.

I/O Slave MultiPoint Parameters

The MultiPoint Parameter options allow you to modify several different parameters in the transceiver that determine the characteristics of a MultiPoint network.

In an I/O Slave, set the following parameters in the MultiPoint Parameters tab to match the I/O Master:

- Master Packet Repeat
- Network ID
- Repeaters

The remaining parameters in the MultiPoint Parameters tab can remain at their factory default settings. Each of the additional parameters is described in detail in "Setting Other MultiPoint Parameters" on page 42.

Note: Subnet IDs are not used in I/O Slave's in a wire replacement I/O system, as there is only one I/O Master and no Repeaters in the wire replacement I/O system.

I/O Slave Wire Replacement Parameters

The other Wire Replacement options allow to set specific parameters to determine the behavior of the Digital Outputs and Digital Inputs on the I/O Slave.

Set the parameters in each I/O Slave's Wire Replacement tab using the descriptions below. These settings are available in the FGRIO Setup menu in the terminal interface.

Note: The **Fast AI (DI1) and Fast AI (DI2)** settings do not apply to wire replacement I/O. In addition, if you are configuring an I/O Slave using the terminal interface, **AI (DI1) Filter** and **AI (DI2) Filter** parameters available in the FGRIO Setup menu do not apply to wire replacement I/O and the **IO Modbus** setting in the FGRIO Setup menu must be set to **Disabled**.

Digital Output 1 and Digital Output 2

Default Setting:	None
Options:	Master Digital Input ports labeled 1 to 4.
Terminal Menu:	(9) FGRIO Setup > (1) Digital Out 1 (9) FGRIO Setup > (2) Digital Out 2
Description:	Map each of the I/O Slave digital outputs to the I/O Master digital inputs to match the network wiring. The I/O Master's digital inputs are labeled 1 to 4.

AI1 250 Ohms and AI2 250 Ohms

Note: Applies only to the FGR2-IOS-CE-U model.

Default:	Disabled
Options:	Disabled, Enabled
Terminal Menu:	(9) FGRIO Setup > (I) AI (DI1) Filter (9) FGRIO Setup > (J) AI (DI2) Filter

Description: The FGR2-IO2-CE-U includes a switchable and protected 250 Ω resistor when connecting the I/O Slave to an 4-20 mA sensor. When enabled, the resistor can take the place of an inline resistor between the device and the I/O Slave's analog input.

DI1 150 Ohms and DI2 150 Ohms

Note: Applies only to the FGR2-IOS-CE-U model.

Default: Disabled

Options: Disabled, Enabled

Terminal Menu: (9) FGRIO Setup > (I) AI (DI1) Filter
(9) FGRIO Setup > (J) AI (DI2) Filter

Description: The FGR2-IO2-CE-U includes a switchable and protected 150 Ω resistor for use when using 4-20 mA sensors. When enabled, the resistor can take the place of an inline resistor between the device and the I/O Slave's analog input.

DI1 Pullup and DI2 Pullup

Default Setting: Pullup

Options:

- **Pullup** - The 10 KΩ internal resistor attached to the input is connected to the 3.3 V logic supply to provide a pull up for connecting closed-contact-to-GND sensors.
- **Pulldown** - The 10 KΩ internal resistor attached to the input is connected to GND to provide a pull up for connecting closed-contact-to-voltage sensors.
- **Float** - The internal resistor is not connected, allowing the connected sensor to provide greater than 1.75 VDC for High and less than 1.75 VDC for Low.

Terminal Menu: (9) FGRIO Setup > (E) DI1 Pull Up/Down and (F) DI2 Pull Up/Down

Description: These parameters control the power-up states of the internal resistor (10 KΩ) connected to the Digital Inputs. They can pull up, such as when using a closed-contact-to-GND switch input, pull down so that unused inputs read "0" as DIs or ~0 as auxiliary analogs, or float to not load analog inputs.

DO Bi-Stable

Default: Constant

Options:

- **Constant** - The Digital Output remains on for as long as the I/O Master's associated Digital Input is connected to Ground. When the I/O Master's Digital Input is no longer grounded, the Digital Output is OFF.
- **Auto-OFF** - The Digital Output remains on for the duration set in the **DO Monostable Time** parameter or until the I/O Master's associated Digital Input is no longer grounded, whichever is shorter. The Digital Output does not respond again to the I/O Master's Digital Input being grounded until the Digital Input has been disconnected from Ground

Terminal Menu: (9) FGRIO Setup > ???

Description: Controls how the Digital Outputs respond to ON commands.

If set to Auto-OFF, also set the **DO Monostable Time** parameter.

DO Monostable Time

Default: 0

Options: Any number between 0 and 255.

Terminal Menu: (9) FGRIO Setup > ???

Description: Sets the length of time the Digital Output remains on when the **DO Bi-Stable** parameter is set to **Auto-OFF**. The amount of time is approximately **0.15 seconds x DO Monostable Time**.

Note: A setting of **0** causes the Digital Output to turn off at an unspecified amount of time. This time is always less than 0.15 seconds, but the actual time may vary.

Digital Output 1 Default and Digital Output 2 Default

Default: Output ON

Options:

- **Output On** - Energized. Contact to ground is closed. (Conducting to GND, 2 Amps max)
- **Output Off** - Not energized. Contact open.
- **No Change** - Make no change in state when communication is lost.

Terminal Menu: (9) FGRIO Setup > (3) Digital Def1 and (4) Digital Def2

Description: Sets the state the Digital Input returns to when you power up the device, or the device loses its link to the I/O Master in the network.

If programming a Digital Output to turn on after it loses a link, ensure that the energized device can sustain the state undamaged, in case the loss is lengthy.

Default Delay

Default: 0

Options Any number between 0 and 255, representing 0.28 second units (see below)

Terminal Menu: (9) FGRIO Setup > (9) Default Delay

Description: This setting determines the amount of time to wait before setting the Digital Outputs to their Default settings due to loss of communication between the I/O Master and I/O Slave.

The value is set in 0.28 second units. For example, a value of 36 represents 36 x 0.28 = 10.08 seconds.

Set between 0 and 255 using the following examples as guidelines:

- 1 = 0.28 seconds
- 4 = 1.12 seconds
- 25 = 7 seconds
- 255 = 71.4 seconds

Chapter 4: Other Transceiver Settings

The settings discussed in this chapter are those that are not required to establish a wire replacement I/O system, but are available on both the I/O Master and I/O Slave transceivers. Set the additional radio transmission and MultiPoint parameters in this chapter at your discretion based on your network needs.

Setting Other RF Transmission Characteristics

Set the following parameters in the Transmission Characteristics tab. These settings are available in the Edit Radio Transmission Characteristics menu in the terminal interface, and apply to both standalone or integrated wire replacement I/O systems and to both I/O Master and I/O Slave models unless indicated otherwise in their description.

Frequency Zones

Note: This setting only needs to be set on the I/O Master.

Default Setting:	All zones selected
Options:	See below.
Terminal Menu:	(3) Edit Radio Transmission Characteristics > (0) FreqKey > F > (3) Frequency Zone
Description:	Divides the available band (902 MHz to 928 MHz) into smaller bands. In this case 16 smaller bands each consisting of 5, 7, and 8 frequency channels are created depending on the frequency zone. These 16 zones are stored in a Word, which is made up of 16 bits numbered 0 to 15. When displayed in LSB to MSB, these bits directly represent the zones that the transceiver operates on from lowest frequency to highest. A value of **1** in the bit sequence instructs the transceiver to operate within the represented band. A value of **0** instructs the transceiver to bypass the

represented band. This feature should only be used with the standard hop table.

Note: You must set the **Hop Table Version** to **902-928 MHz** when using frequency zones. If you select another **Hop Table Version**, the limitations of that selection would be applied to the hopping pattern as well. For example, if you select **916-920** as the **Hop Table Version**, only the middle of the band would be available in the pattern. Then, if frequency zones **5**, **6**, **7**, **8**, and **9** were set to **0**, no allowable frequencies would be available for the transceiver to use.

Warning! FCC regulations require a minimum of 50 separate channels be used within a hop pattern. Use the table below to determine the number of frequency zones required for legal communication.

EXAMPLE:

1. Using zones 1-7 is equal to 49 channels; this is not legal according to the FCC.

2. Using Zones 0-6 is equal to 50 channels; this is legal according to the FCC.

Zone Number	Beginning Freq. (MHz)	Ending Freq. (MHz)	Number Of Channels
1	902.2464	903.8592	8
2	904.0896	905.4720	7
3	905.7024	907.0848	7
4	907.3152	908.6976	7
5	908.9280	910.3104	7
6	910.5408	911.9232	7
7	912.1536	913.5360	7
8	913.7664	915.1488	7
9	915.3792	916.7616	7
10	916.9920	918.6048	8
11	918.8352	920.2176	7
12	920.4480	921.8304	7
13	922.0608	923.4432	7
14	923.6736	925.0560	7
15	925.2864	926.6688	7
16	926.8992	927.8208	5

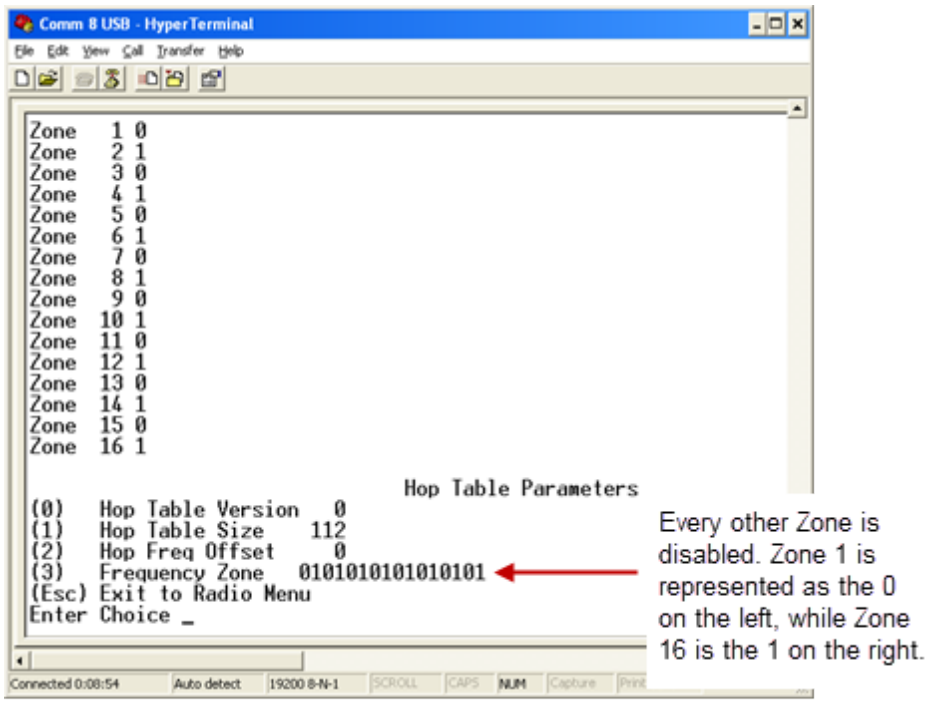
To enable Frequency Zones in Tool Suite:

1. In the Tool Suite Configuration application, select the device to program and click the **(3) Transmission Characteristics** tab.

2. Click **Frequency Zones** in the Transmission Characteristics tab to display the frequency zones available.
3. Select the check boxes next to the Frequency Zones to enable.

To enable Frequency Zones in the terminal interface:

1. From the main Setup menu, select **3 Edit Radio Transmission Characteristics**.
2. Select option **0 FreqKey**.
3. Select **F** for More.
4. Select option **3 Frequency Zone**.
5. Enter **1** to enable a frequency zone and **0** to disable a frequency zone. Frequency Zone entries begin with **1** (LSB) and continue through **16** (MSB).



Hop Table Size

Note: All transceivers in a network must have identical **Hop Table** settings to communicate properly.

Default Setting:	112
Options:	50 to 112
Terminal Menu:	(3) Edit Radio Transmission Characteristics > (0) FreqKey > F > (1) Hop Table Size
Description:	Defines how many separate channels a given network uses. FreeWave recommends using **Frequency Zones** instead of the **Hop Table Size** setting.

Warning! FCC regulations require a minimum of 50 separate frequency channels be used within a hop pattern. Using the Standard hop table, a minimum of 5 frequency zones are required for legal communication.

Hop Table Version

Note: All transceivers in a network must have identical **Hop Table** settings to communicate properly.

Default Setting: 902-928 MHz

Options:

- 902-928 MHz, full band
- 915-928 MHz
- 903.744-926.3232 MHz
- 916-920 MHz
- 921-928 MHz
- 902-911 - 919-928 MHz, uses 902-928 MHz with center frequencies of 911-919 MHz notched out
- 902-915 MHz

Do not use **Frequency Key E** (916-920 MHz) with the 915-928 MHz, 916-920 MHz, and 921-928 MHz hop tables.

Terminal Menu: (3) Edit Radio Transmission Characteristics > (0) FreqKey > F > (0) Hop Table Version

Description: Determines the section of the 900 MHz band the transceiver uses.

In the terminal interface, enter the number that corresponds to the frequency band:

Number to Enter in Terminal Menu	Frequency Band
0	902-928 MHz, uses the full band
1	915-928 MHz
2	903.744-926.3232 MHz
3	916-920 MHz
4	921-928 MHz
5	902-911_919-928 MHz, uses 902-928 MHz with center frequencies of 911-919 MHz notched out
6	902-915 MHz

High Noise

Default Setting: (0) Disabled

Options: (0) Disabled

(1) Enabled

Terminal Menu: (3) Edit Radio Transmission Characteristics > (A) High Noise

Description: Use to determine if out-of-band interference is affecting a radio link. Enabling this parameter provides a reduction of gain in the front end circuit thereby decreasing the effect of any out-of- band noise. The results are seen as a lower signal value and a much lower noise value (as found in Radio Statistics or Diagnostics). If the noise is not reduced by a greater amount than the signal, the interference is most likely an in-band issue.

When a noise problem is shown to be helped using the High Noise option, chances are that the noise may be further decreased using a bandpass filter available from FreeWave.

Low Power Mode

Default Setting: 0

Options: Any number between 0 and 31. The higher the number, the greater the power consumption decrease.

Terminal Menu: (3) Edit Radio Transmission Characteristics > (9) Low Power Mode

Description: Allows a MultiPoint Slave to consume less power, primarily by dimming the transceiver's LEDs.

When set to **2** through **31**, the transceiver sleeps between slots. For example, at a setting of **2** the transceiver sleeps 1 out of 2 slots; at a setting of **3** the transceiver sleeps 2 out of 3 slots, and so on.

When the transceiver is asleep, it hears nothing from the I/O Master.

The following table shows the changes at different **Low Power Mode** settings. The actual current draw depends on many factors. The table below gives only a qualitative indication of supply current savings. A low number reduces latency and a high number reduces current consumption.

Setting	Description
0	Low power, disabled.
1	LEDs dimmed, transceiver remains awake, transceiver is listening to the I/O Master's transmissions on every slot. In this case, the transceiver needs to be awakened before it is able to send data to the I/O Master.
2	LEDs dimmed, transceiver sleeps every other slot.
3	LEDs dimmed, transceiver sleeps 2 of 3 slots.
4-31	LEDs dimmed, transceiver sleeps the number of slots corresponding to the setting. For example, with a setting of 31 the transceiver sleeps 30 of 31 slots.

Note the following about the **Low Power Mode** parameter:

- Power savings occur only when the I/O Slave is linked. No power savings occur when the I/O Slave is transmitting data. **Low Power Mode** is of little value when a I/O Slave has a constant, high throughput. **MCU Speed** must be set to **0** and **RF Data Rate** must be set to **3** for **Low Power Mode** to operate properly.
- The diagnostic pins must be disabled or terminated to a cable for the Sleep current in Lower Power Mode to match the specifications. To disable the diagnostic pins, ensure the following are set:
    - In the Baud Rate tab, the **Setup Port** parameter is set to **1 (Main Only)**.
    - In the MultiPoint Parameters tab, the **Diagnostics** parameter is set to **0** (Off).

MCU Speed

Default Setting: (0) Normal

Options:
- **(0) Normal (low speed)** - Reduces current consumption.
- **(1) Fast (high speed)** - Required for 230 Kbaud and greater data port rate.

Terminal Menu: (3) Edit Radio Transmission Characteristics > (B) MCU Speed

Description: Controls the speed of the Micro Controller Unit (MCU) in the transceiver.

Remote LED

Note: This feature is only available on an I/O Master.

Default: (0) Local Only

Options
- **(0) Local Only** - Only the LEDs on the radio board are enabled.
- **(1) Remote and Local** - LEDs on the radio board and remote LEDs through the diagnostic port are enabled.
- **(2) Remote Only** - LEDs on the radio board are disabled. Remote LEDs through the diagnostic port are enabled.

Terminal Menu: (3) Edit Radio Transmission Characteristics > (C) Remote LED

Description: If you are using a transceiver with the optional 20-pin connector, you can use this option to connect remote LEDs through the diagnostics port. By turning off the on-board LEDs (setting = 2) the current consumption is reduced.

To reduce current consumption in Slaves, use **Low Power** (setting = **1**). Remote LED drives the Diagnostic port, which has a small amount of current draw.

When using remote LEDs, the center (TX) LED does not output a signal for a green LED when in Setup mode. The Green TX LED has no remote pinout.

Retry Timeout

Default Setting:	255
Options:	Any number between 0 and 255.
Terminal Menu:	(3) Edit Transmission Characteristics > (8) Retry Time Out
I/O Slave Setting:	By lowering the **Retry Timeout** setting, the inactive link time between the I/O Master and the I/O Slave can be reduced when going from autonomous mode to connecting back to the serial radio network. If the serial radio network Master goes down, the I/O Master and I/O Slave continues to operate in autonomous mode. When the serial network Master comes back up, the I/O Master breaks the link with the Slave to re-establish a link with the serial network Master. After the I/O Master is linked to the serial network Master, then the I/O Slave are able to link back to the I/O Master. With a lower **Retry Timeout** setting, the I/O Master is more likely to drop the link to its serial network Master when the incoming signal becomes poor.

RTS to CTS

This parameter does not apply in a wire replacement I/O system.

Slave Security

Default Setting:	(0) On
Options:	(0) On (1) Off
Terminal Menu:	(3) Edit Transmission Characteristics > (6) Slave Security
Description:	In a wire replacement I/O system, leave this parameter set to **On**. A setting of **On** means only the Master listed in the I/O Slave's call book can link to that slave.

Transmit Power

Default Setting:	10
Options:	Any number between 0 and 10.
Terminal Menu:	(3) Edit Transmission Characteristics > (5) RF Xmit Power
Description:	Sets the output power of the transceiver. A setting of **10** is approximately 1 W of output power. In a wire replacement application, FreeWave recommends using a low setting, such as 2 or 3 because the signal does not likely need to travel a great distance.

Note: With a higher power setting with transceivers within close range can increase the amount of noise in the system. When testing transceivers at your facility and they are in close proximity to one another, set the **Transmit Power** to a low number. When you deploy transceivers to the field, raise the **Transmit Power** number accordingly.

Important: The following table is for reference only. All **Transmit Power** settings between **0** and **9** are approximate.

Setting	Power (in mW)
0	5
1	10
2	35
3	80
4	140
5	230
6	330
7	480
8	600
9	800
10	1000

Transmit Rate

Default Setting:	(1) Normal
Options:	(0) Diagnostics
	(1) Normal
Terminal Menu:	(3) Edit Transmission Characteristics > (3) Xmit Rate
Description:	The setting for normal operation of the transceiver is **1**. When set to **0**, the transceivers transmit back and forth continuously regardless if they have any actual data. **0** should be used only as a diagnostic tool and not for normal operation. The strength of the signal may be gauged by the Clear to Send (CTS) LED. A solid red CTS LED indicates a strong signal; a blinking CTS LED indicates a weaker signal.

Setting Other MultiPoint Parameters

Set the following parameters in the MultiPoint Parameters tab. These settings are available in the MultiPoint Parameters menu in the terminal interface and apply to both standalone or integrated wire replacement I/O systems and to I/O Master and I/O Slave models unless indicated otherwise in their description.

1 PPS Enable Delay

Default Setting:	255
Options:	255 to disable 1 PPS 0 to 254 to enter the delay
Terminal Menu:	(5) Edit MultiPoint Parameters > (9) 1 PPS Enable/Delay
Description:	The **1 PPS Enable/Delay** setting allows a 1 PPS signal to propagate from the I/O Master to all I/O Slaves in a MultiPoint network. When this parameter is enabled a properly generated pulse applied on the DTR line of the I/O Master provides a 1 PPS pulse on the CD line of any I/O Slave in the network. Follow the steps below to use the **1 PPS Enable/Delay** feature.

To setup 1PPS Enable/Delay:

1. Set the **1 PPS Enable/Delay** parameter to **0** in the Master.

   The I/O Master must have a 1 PPS pulse on the DTR pin.
2. Enable the **1 PPS Enable/Delay** parameter on the I/O Slaves.

To calibrate an I/O Slave in 1PPS Enable/Delay mode:

1. Trigger an oscilloscope on the 1 PPS pulse on the DTR line of the I/O Master.
2. Monitor the CD line of the I/O Slave.
3. If the timing on the I/O Slave differs from the I/O Master it may be adjusted using the value in the I/O Slave's **1 PPS Enable/Delay** parameter. The difference in time between each incremental integer value is 542.534 ns. Changing the parameter to higher values decreases the I/O Slave time delay and changing the parameter to lower values increases the time delay.

When properly calibrated, the CD line I/O Slave transceiver outputs a pulse that goes high for about 2 ms in synch with the 1 PPS pulse on the I/O Master. The output on the I/O Slave occurs within 20 microseconds of the input to the I/O Master.

Important: When **1 PPS** is enabled, the I/O Master must have a 1 PPS pulse on its DTR pin, otherwise the RF network does not function.

Diagnostics

Default Setting:	0 (Disabled)
Options:	Any number between 0 and 128
Terminal Menu:	(5) Edit MultiPoint Parameters > (B) Diagnostics
Description:	Allows diagnostics data in the Network Diagnostics application within Tool Suite to be viewed at the I/O Master in parallel with application data. The setting in this parameter determines how many slots out of 128 are dedicated to diagnostics. For example, if set to **10**, 1 out of every 10 data slots is for

diagnostics data; if set to **100**, 1 out of every 100 data slots is for diagnostics data.

Diagnostics is always secondary to actual transmitted data.

For more information, see "Reading Diagnostics in Tool Suite" on page 1.

DTR Connect

Default Setting: (0) Off

Options:
- **(0) Off** - When set to off in the Slave, the transceiver transmits when the data is received.
- **(1) DTR Sensing** - Forms a Point-to-Point link with the I/O Master when the DTR line is high to send data.
- **(2) Burst Mode** - The transceiver transmits data in bursts.

Terminal Menu: (5) MultiPoint parameters > (4) DTR Connect

Description: Determines how the transceiver sends its data. This mode is valuable when a network has many low data rate devices and you want to increase overall network capacity.

If **DTR Connect** is set to **1** and the **RTS to CTS** function is enabled on the radio, then **RTS to CTS** takes precedence over **DTR Connect**.

If **DTR Connect** is set to **2** and **RTS to CTS** is enabled, then **RTS to CTS** is ignored. The transceiver has two separate transmit and receive user data buffers. These buffers are 2 Kbytes each. In case of a buffer overflow, the transceiver outputs unpredictable data.

Local Mode

This parameter does not apply in a wire replacement I/O system.

Max Slave Retry

Default Setting: 9

Options: Any number between 0 and 9.

Terminal Menu: (5) Edit MultiPoint Parameters > (2) Max Slave Retry

Description: Defines how many times the I/O Slave attempts to retransmit a packet to the I/O Master before beginning to use a back-off algorithm (defined by the **Retry Odds** parameter). I/O Slave retries stop when the I/O Slave receives an acknowledgement from the I/O Master.

Multi-Master Synch

The **Multi-Master Synch** setting is reserved for applications with concentrations of Master units where it is necessary to reduce interference between the Masters. Because a wire replacement I/O system has only one Master, this setting does not apply.

Radio ID

Default Setting:	Blank
Options:	Any 4 digit, user-defined number.
Terminal Menu:	(5) Edit MultiPoint Parameters > (D) Radio ID
Description:	Use this option to designate a transceiver with an arbitrary, user-defined, 4-digit number that identifies the transceiver in Diagnostics mode.

Radio Name

Default Setting:	Blank
Options:	Any combination of letters or numbers up to 20 characters
Terminal Menu:	(5) Edit MultiPoint Parameters > (G) Radio Name
Description:	Use this parameter to give a transceiver a name, such as its location. Naming transceivers can be helpful to identify a transceiver when in Diagnostics mode.

Repeater Frequency

Repeater Frequency is used in situations where a parallel Repeater is present. A wire replacement I/O system cannot contain Repeaters; therefore, this setting does not apply to an I/O Master or an I/O Slave.

Retry Odds

Default Setting:	0
Options:	Any number between 0 and 9.
Terminal Menu:	(5) Edit MultiPoint Parameters > (3) Retry Odds
Description:	While packets transmitted from the I/O Master to the I/O Slaves are not acknowledged, packets transmitted from I/O Slaves to the I/O Master are acknowledged. It is possible that more than one I/O Slave attempts to transmit to the I/O Master at the same time. Therefore, it is important that a protocol exists to resolve contention for the I/O Master between I/O Slaves. This is addressed through the **Max Slave Retry** and **Retry Odds** parameters. After the I/O Slave has unsuccessfully attempted to transmit the packet the number of times specified in the **Max Slave Retry** parameter, it attempts to transmit to the I/O Master on a random basis. The **Retry Odds** parameter determines the probability that the Slave attempts to retransmit the packet to the I/O Master; a low setting assigns low odds to the I/O Slave attempting to transmit.

Conversely, a high setting assigns higher odds.

An example of how this parameter might be used would be when considering two different I/O Slaves in a MultiPoint network, one with a strong RF link and the other with a weak RF link to the I/O Master. If an I/O Slave has a weak or poor link, set **Retry Odds** to **0** as it may become a "chatty" Slave and lockup your network, causing a loss of communication.

When **Retry Odds** is set to **0**, after the I/O Slave has exhausted the number of retries set in the **Max Slave Retry** parameter and still not gained the I/O Master's attention, the I/O Slave's data buffer is purged. A **Retry Odds** set to **0** is recommended for most networks.

Slave/Repeater

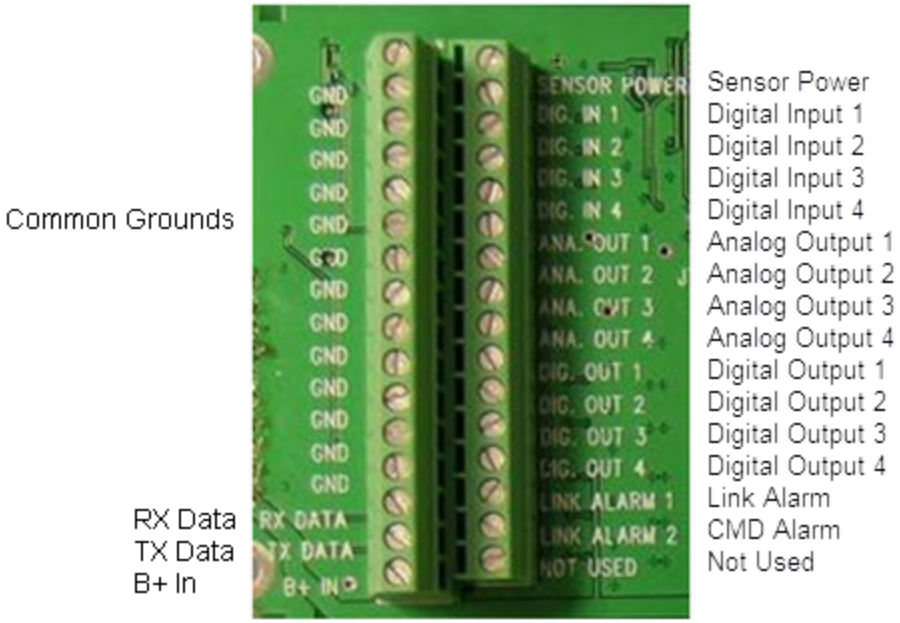
The Slave/Repeater parameter allows a transceiver to switch between Slave and Repeater functions. A wire replacement I/O system cannot contain a Repeater; therefore, this parameter must remain set to **Disabled**.

Chapter 5: Installing and Wiring Components in a Wire Replacement I/O System

Use the information in this chapter to wire an I/O Master to a device such as an RTU and to wire an I/O Slave to end device such as pressure sensor or switch.

Wiring an I/O Master

The terminal block on the I/O Master can accept a single wire up to 16 gauge. Smaller wire is required for 2 wires, or wire and resistor connected into the same screw terminal.



The terminal blocks and their wiring considerations are addressed from top to bottom, starting on the left side of the terminal block.

Radio Power

Power (B+) is available on the screw terminal of the I/O Master terminal block or through Pin 1 on the 10 pin header connector. Pin 1 on the connector is the pin closest to the edge of the board.

Tx Data and Rx Data

Transmit Data (Tx Data) and Receive Data (Rx Data) are available on the screw terminals or through Pins 5 and 7 respectively, on the 10 pin header connector. Pin 1 on the connector is the pin closest to the edge of the board and Pin 10 is closest to the inside of the board.

Sensor Power

To minimize power drain of the I/O solar power or battery system, the I/O Master terminal block includes an input terminal called Sensor Power. Sensor Power has an internal 10 KΩ pull-down to Ground.

The Sensor Power parameter setting in the IO Settings tab in Tool Suite determines the Sensor Power behavior. When in **Gated** mode, the Sensor Power terminal both activates sensor power at the controlled I/O Slaves, and activates Analog Outputs at the I/O Master interface board. For more information, see "Sensor Power" on page 23.

Consider the following when connecting the Sensor Power terminal:

- If the RTU provides a switched Sensor Power output, connect it to this terminal. Verify that the level at Sensor Power falls to less than 1.0 V when de-asserted to ensure the I/O Slaves mirror. If not, connect additional pull down resistance externally.
- The state of Sensor Power can be mirrored at the I/O Slave, powering or disconnecting any connected sensors. To activate this control, change the Sensor Power parameter setting on the I/O Master using Tool Suite to **1** or **Gated**. For more information, see the Sensor Power parameter description on page 23.

Digital Inputs

Complete the following to connect the Digital Inputs on the I/O Master to the end device.

- Connect the Digital Output wires from the RTU to Digital Input 1, 2, 3, or 4 screw terminals on the terminal block of the I/O Master.
- Connect the Ground wire from the RTU to any of the Ground screw terminals on the I/O Master's terminal block. Some RTUs use isolated I/O and may require a ground connection for each input and output.

Analog Outputs

The Analog Outputs on the terminal block are 1-5 V at low current; therefore, any 4-20 mA current sensing resistor on the RTU ***must be removed***. To determine whether RTU-internal resistors are active, test the link with a full scale input.

Complete the following to connect the Analog Outputs on the I/O Master to the end device:

- Connect the Analog Output wires from the Analog Outputs 1, 2, 3, or 4 screw terminals on the I/O Master terminal block to the Analog Inputs on the end device (RTU).
- Connect a common Ground. FreeWave recommends running a Ground wire from any I/O Master Ground screw terminal to Ground on the RTU.

An Analog Output on the I/O Master that is outputting an I/O Slave's Analog Input remains at the last reported value if communication to that I/O Slave is lost.

Digital Outputs

The Digital Outputs on the I/O Master actively drives Low (0.4 V) and High (4.0 V). Remove any RTU input pull-up resistor, if less than 10 KΩ. Verify that signal levels meet the RTU input requirements after connection to the RTU.

Warning! The I/O Master Digital Outputs source about 4 mA; therefore, it is not designed to drive relays or solenoids.

Complete the following to connect the Digital Outputs on the I/O Master to the end device.

- Connect the Digital Output wires from the Digital Output 1, 2 ,3, or 4 screw terminals on the I/O Master terminal block to the Digital Inputs of the end device (RTU).
- Connect a common Ground. FreeWave recommends running a Ground wire from the I/O Master Ground screw terminal to Ground on the RTU.

A Digital Output on the I/O Master that is outputting an I/O Slave's Digital Input remains at the last reported value if communication to that I/O Slave is lost.

Link Alarms

Consider the following when connecting link alarms from the I/O Master to the end device.

- Link Alarm 1 is an alarm reflecting loss of communication on any path. Connect a wire from the Link Alarm 1 screw terminal to the Link Alarm screw terminal on the RTU.
- Link Alarm 2 (CMD Alarm) indicates that a Digital Output or Sensor Power command was not carried out due to an over-current fault. Connect a wire from the Link Alarm 2 screw terminal to the Link Alarm screw terminal on the RTU.

Wiring I/O Slaves

I/O Slaves replicate the states of the Digital Inputs and sensor power inputs of the I/O Master as Digital Outputs. The terminal block on the I/O Slave can accept a single wire up to 16 gauge. Smaller wire is required for 2 wires, or wire and resistor connected into the same screw terminal.

Radio Power

Power is available on screw terminal #11 (B+ In) of the I/O Slave terminal block or through Pin 1 on the 10 pin header connector. You can use either to power the I/O Slave. Pin 1 on the connector is the pin closest to the edge of the board and Pin 10 is closest to the inside of the board.

Digital Inputs

Complete the following when connecting the I/O Slave to a digital end device, such as a pressure switch:

- Connect the end device output wire to Digital Input 1 screw terminal # 1 or Digital Input 2 screw terminal # 2 on the terminal block of the I/O Slave.
- Connect the ground wire from the end device to Ground screw terminal # 3, 9, or 12 on the terminal block of the I/O Slave. If the Ground wire is not returned to the radio, the potential difference between the radio's Ground and the end device Ground should not exceed 1 V.

If you are wiring a 3-wire digital transducer, set up similarly to the 1-5 V analog sensor, except connect the signal wire to a Digital Input.

Digital Outputs

Consider the following when connecting the I/O Slave to a digital end device, such as a solenoid valve:

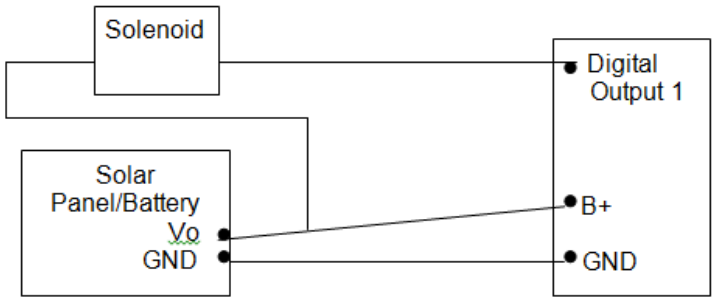
- Both Digital Outputs (screw terminal #4 and 5) are closed contact to ground. The outputs connect to Ground when 0 (zero) volts is connected to the controlling I/O Master Digital Input.
- The current rating for a Digital Output is 2 amps or less. The Digital Output self-protects if a current of more than 2.5 amps is drawn and automatically retries at 0.16 second intervals.
- If power on the end device is not driven from the same power supply as the I/O Slave, that source must be equal to or less than the radio's power supply voltage.

  Within the radio, a 3 amp rated Schottky diode is connected from each Digital Output to the radio power supply terminal for clamping a solenoid fly back current. If the relay supply voltage exceeds

the radio supply voltage, then current would flow through that diode back to the radio, preventing coil current from shutting off and potentially causing an over-voltage condition.

- A Digital Output on the I/O Slave that is outputting an I/O Master's Digital Input takes the state set in the **Digital Out 1 Default** and **Digital Out 2 Default** parameters in Tool Suite if communication to the I/O Master is lost and the **Default Delay** expires. For more information about the default settings, see "Digital Output 1 Default and Digital Output 2 Default" on page 33.

The following diagram illustrates the typical Digital Output wiring between a solenoid and the I/O Slave:



Wiring I/O Slaves to 4-20 mA Sensors

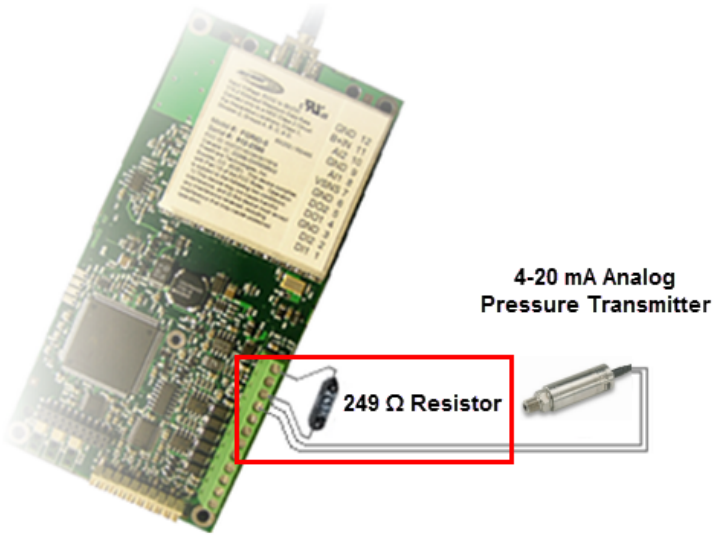
A common measurement interface for sensing equipment is a 4-20 mA current output. The current amplitude correlates to a specific measurement (pressure, temperature, flow rate, etc.). Limitations of the FGRIO-M force the output of the signal to be a 1-5 V analog voltage.

The information in this section provides details for wiring the I/O Slaves Analog Inputs to 4-20 mA sensors, including details about installing external resistors required to convert the signal to 1 to 5 V.

Connecting a 4-20 mA Sensor to Analog Input 1 or Analog Input 2

Complete the following when connecting a 4-20 mA sensor to Analog Input 1 or Analog Input 2 on an I/O Slave. A resistor (249 Ω or 250 Ω) is required to convert 4-20 mA from the sensor to 1-5 V.

- If you are using a board-level I/O Slave, such as an FGR2-IOS-C-U, place the resistor between the Analog Input (terminal #8 or #10) and the Ground screw terminal (terminal #6, #9 or #12) of the I/O Slave. The resistor produces a 1-5 V signal across it when 4-20 mA flows throw it.

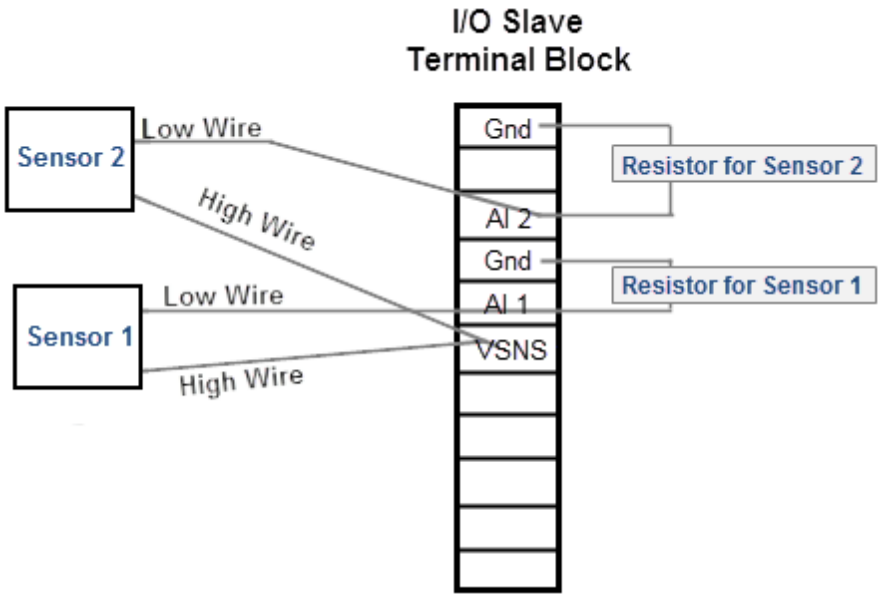


If you are using an FGR2-IOS-CE-U (ruggedized enclosure), a resistor exists within the transceiver that you can enable or disable. This resistor takes the place of an inline resistor. To enable the resistor between the 4-20 mA sensor and the analog input, enable the **AI1 250 Ohms** or **AI2 250 Ohms** parameter in the Wire Replacement tab in Tool Suite.

The internal resistor powers on after the transceiver powers on and boots up. Ensure you are supplying the correct transceiver voltage.

- Connect the Sensor Power Supply (High) wire to VSNS screw terminal #7 on the terminal block of the I/O Slave.
- Connect the Sensor Output (Low) wire to the same Analog Input (terminal #8 or #10) as the resistor on the terminal block of the I/O Slave.

The following diagram illustrates a board-level wiring installation.

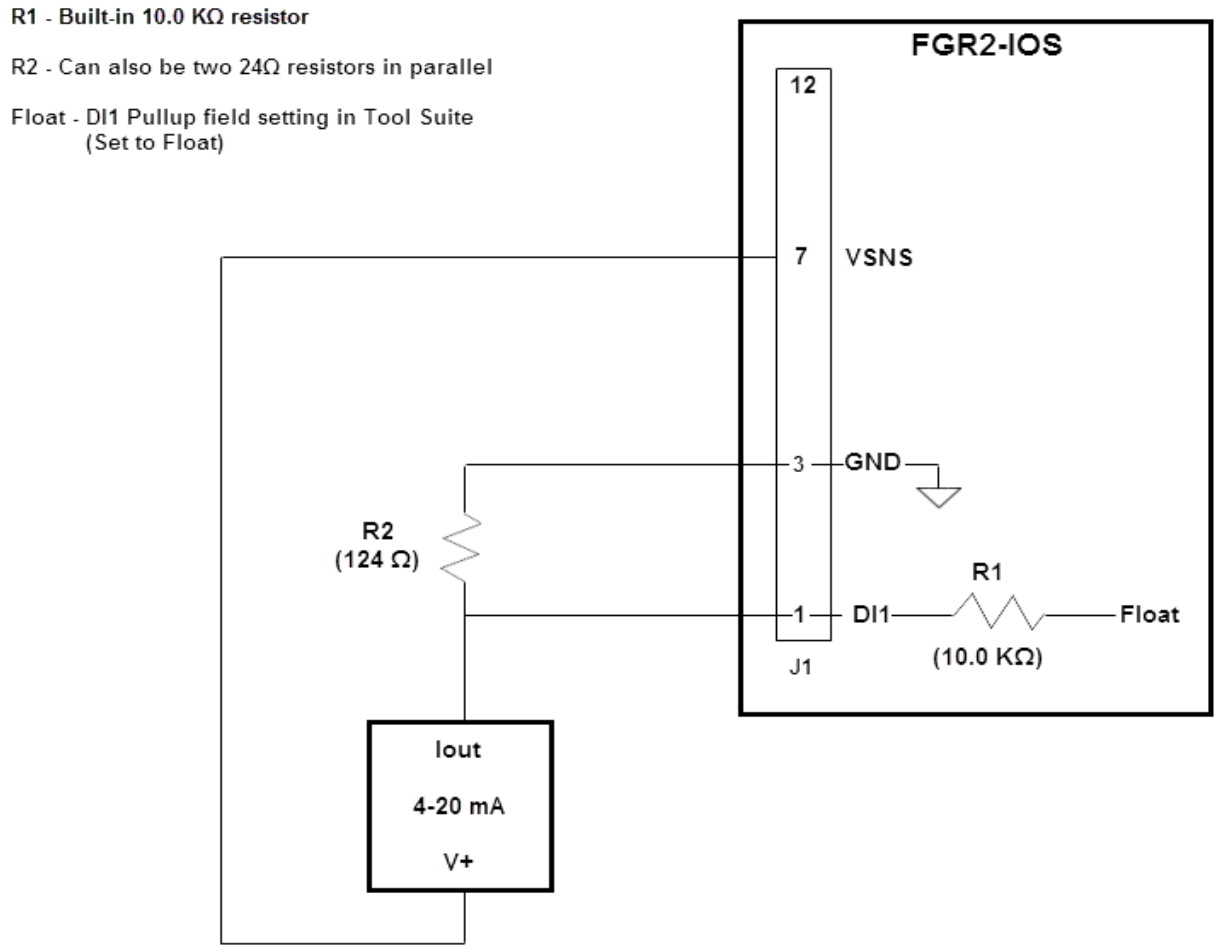


Connecting a 4-20 mA Sensor to Analog Input 3 or Analog Input 4

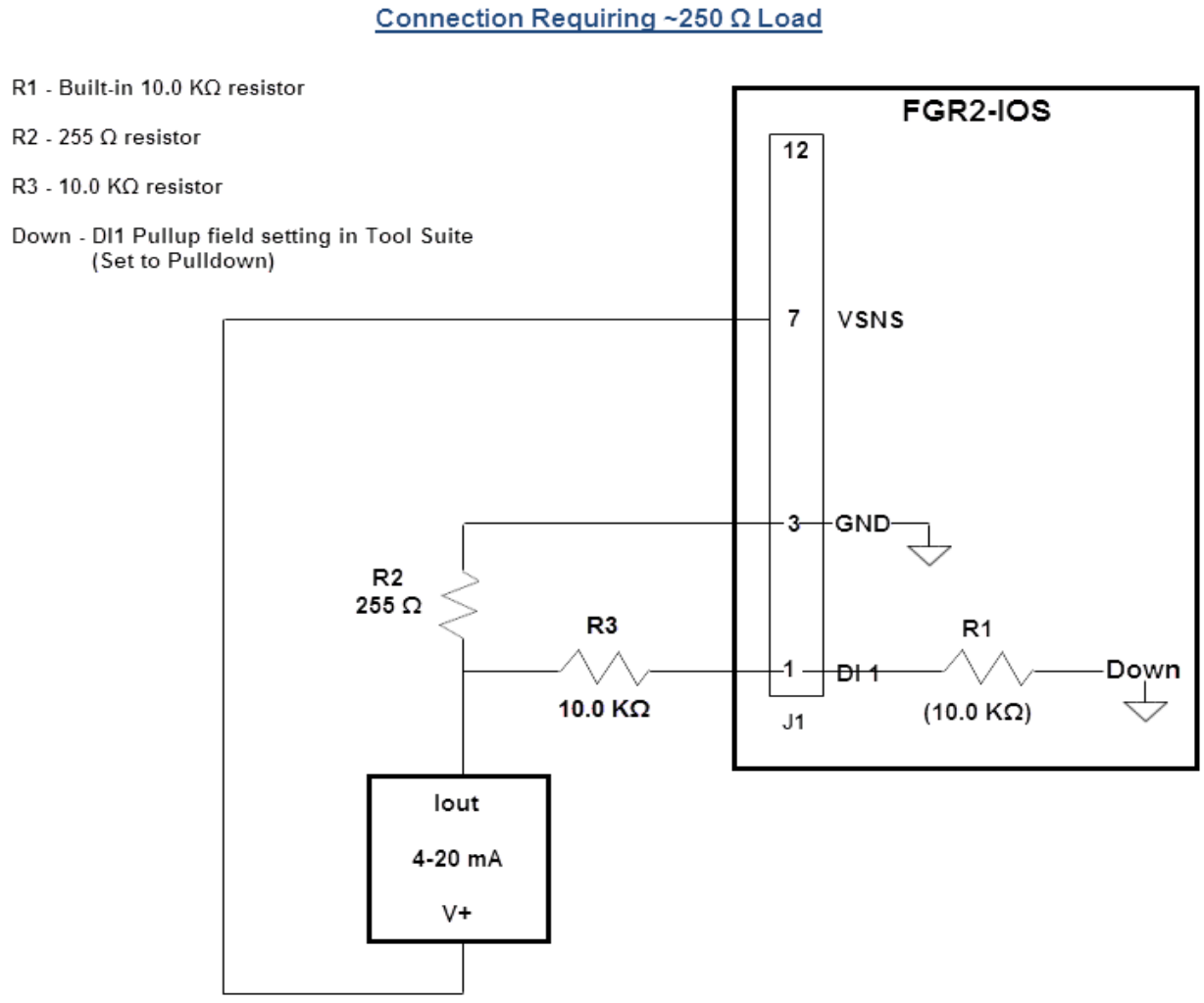
The same accuracy and signal level reduction considerations stated in "Connecting 1-5 Volt Sensor to Analog Input 3 or Analog Input 4" on page 55 apply when using a 4-20 mA sensor. The switched voltage source at screw terminal #7 is designed to drive only two 4-20 mA transmitters to full scale. If a system uses more than two, power the additional transmitters from a separate supply, such as directly from the battery or another DC supply.

The following diagram illustrates the connection of a 4-20 mA sensor to Analog Input 3, with half the typical resistor:

Connection Requiring Half the Typical Resistor



The following diagram illustrates the connection of a 4-20 mA sensor to Analog Input 3 requiring an approximately 250 ohm load:



Wiring I/O Slaves to 1-5 V Sensors

The information in this section provides details for wiring the I/O Slaves Analog Inputs to 1-5 V sensors.

Connecting a 1-5 Volt Sensor to Analog Input 1 or Analog Input 2

Analog Input 1 or Analog Input 2 screw terminal #8 and #10 are usable with 0.1 V to 5.625 V input voltages (compatible with most 1-5 V and 4-20 mA transmitters) and load the input with about 100 Kohm to GND. They also offer accuracy of ± 0.1% with 16-bit resolution and are therefore recommended for the most critical variables in a system.

Note: If you are using an FGR2-IOS-CE-U, ensure the **AI1 250 Ohms** and **AI2 250 Ohms** settings in the Wire Replacement tab in Tool Suite are disabled. The internal resistor is not required when connecting to a 1-5 V sensor.

Use a 3-wire connection to connect a 1-5 V sensor to either Analog Input 1 or Analog Input 2 on the I/O Slave.

- Connect the sensor's Ground wire to Ground screw terminal #3, 9, or 12 on the terminal block of the I/O Slave.
- Connect the sensor's Power wire to the VSNS screw terminal #7 on the terminal block of the I/O Slave. Rated total current draw from VSNS is 40 mA or less.
- Connect the senor's output wire to Analog Input 1 or Analog Input 2 screw terminal #8 and #10.

Connecting 1-5 Volt Sensor to Analog Input 3 or Analog Input 4

The Digital Inputs on the I/O Slave may be digitized to 10-bit resolution and mapped to Analog Outputs on the I/O Master. This mapping allows up to four analog transducers to be connected to a single remote I/O Slave.

Note: In the FGRIO-S radio, this feature requires firmware version of 2.65IO or higher.

The Analog Inputs formed from the Digital Inputs at screw terminal #1 and screw terminal #2 are directly usable with signals only from 0.1 V to 2.812 V in wire replacement mode. Input loading can be selected as 10 KΩ to GND or unloaded (>1 MΩ).

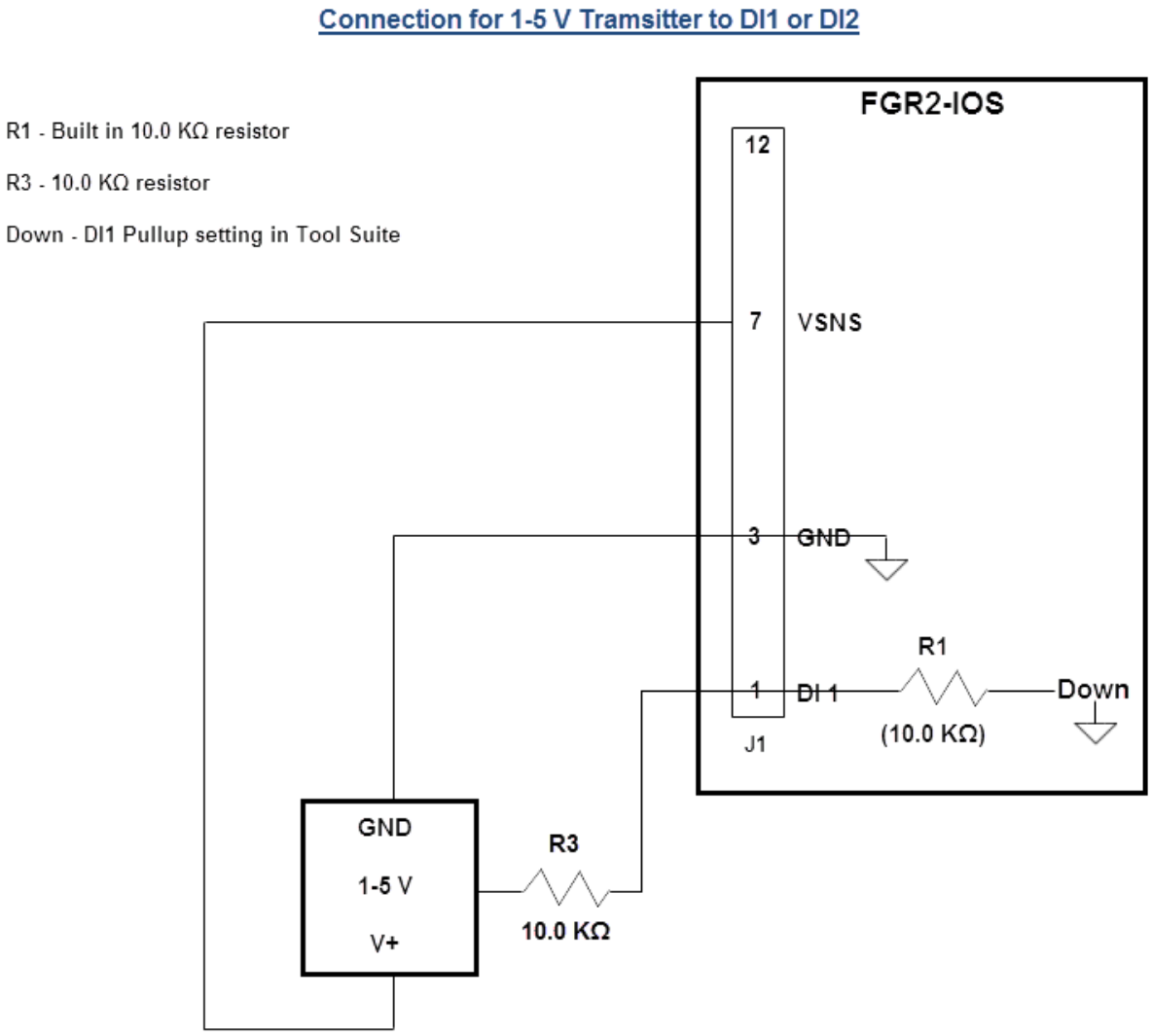
The DI accuracy is within +/-.25% and resolution is 10-bits.

1-5 Volt Sensor Signal Coupling for Analog Input 3 and Analog Input 4

Consider the following for Analog Input 3 and Analog Input 4:

- **Input Resistor** - The I/O Slave Digital Inputs provide an internal 10 KΩ resistor pull-up to the radio's 3.3 V logic supply. The resistor can also be commanded to pull down to GND or "float" unconnected. See "DI1 Pullup and DI2 Pullup" on page 32. As will be shown, these options are useful for Analog Input connections.
- **Signal Level Reduction** - As stated above, Digital Inputs #3 and #4 do not have sufficient voltage range for direct connection to typical transducer outputs, so the input must be restricted. For wire replacement, it is assumed the input signal level will be halved, and the measured value sent to the I/O Master doubled, to achieve an overall 1:1 signal reproduction.
- **VSNS Sensor Power** - The switched voltage source at screw terminal #7 is designed to drive only two 4-20 mA transmitters to full scale. Voltage output (1-5 V) transmitters usually consume less current and may allow up to four to be switched.

The following diagram illustrates the connection of a 1-5 V transmitter to Analog Input #3:



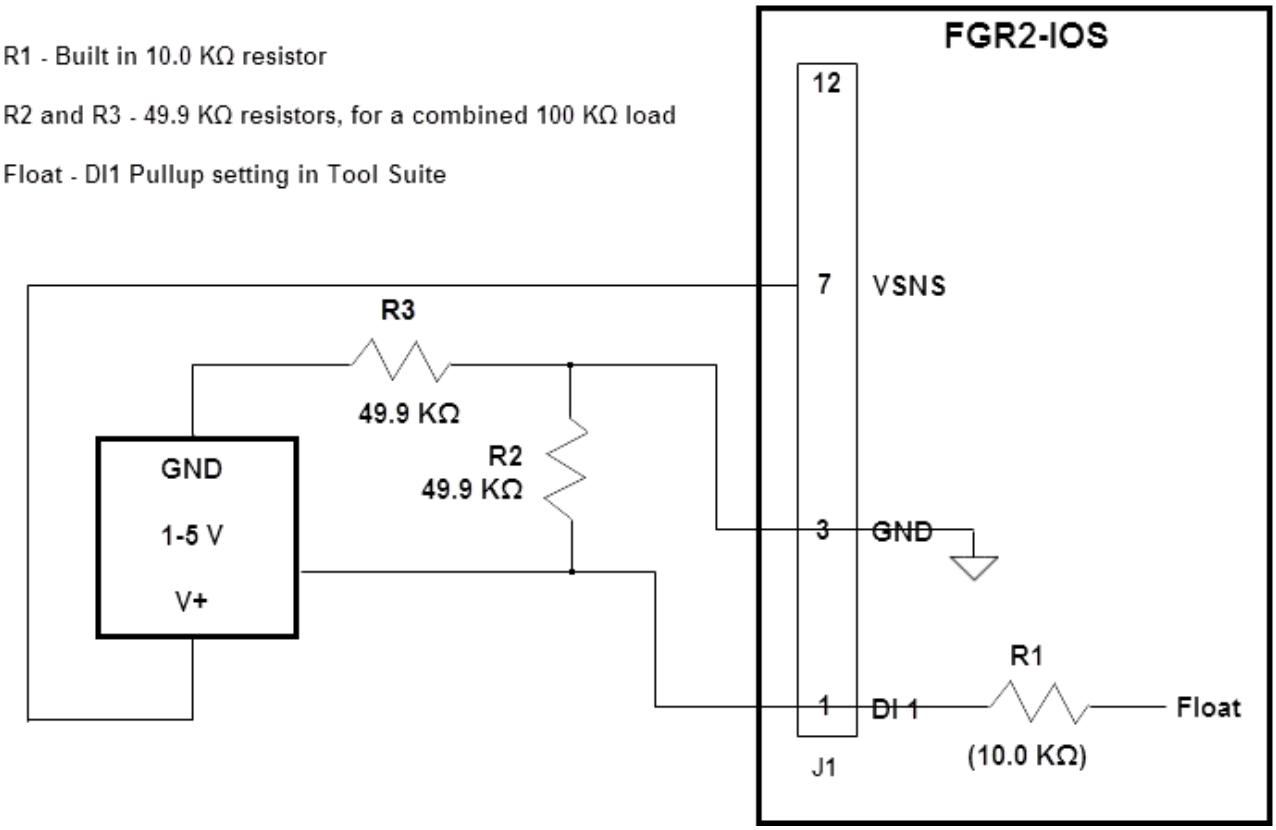
The following diagram illustrates the connection of a 1-5 V transmitter requiring 100 KΩ load:

Connection for 1-5 V Transmitter Requiring 100 KΩ Load

R1 - Built in 10.0 KΩ resistor

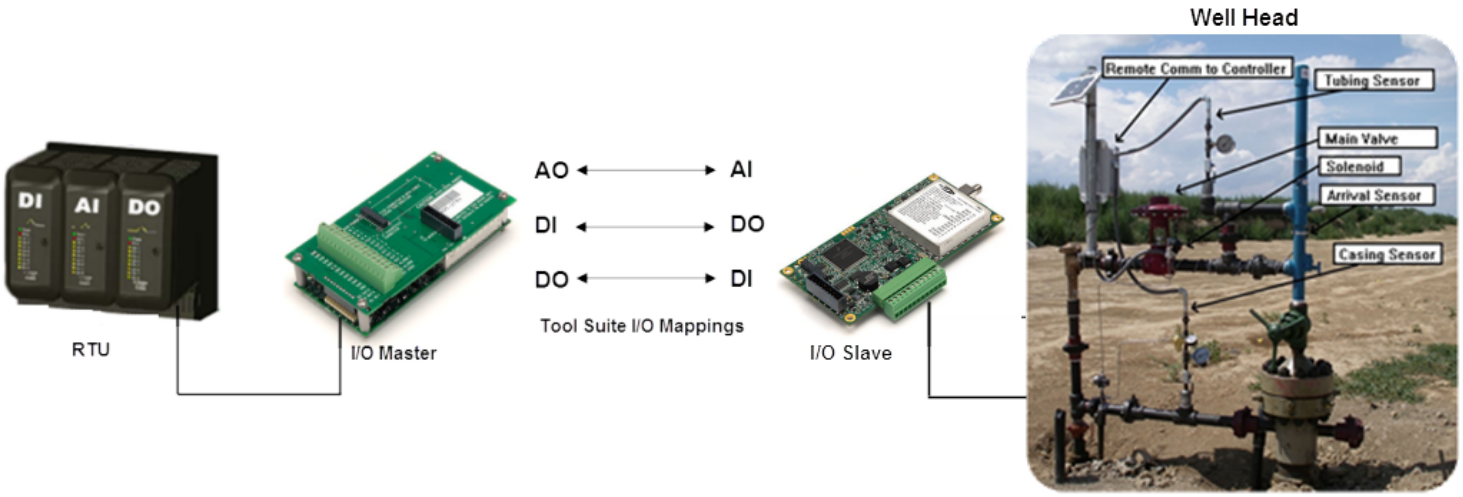
R2 and R3 - 49.9 KΩ resistors, for a combined 100 KΩ load

Float - DI1 Pullup setting in Tool Suite



Plunger Lift Example

The following example illustrates the wire replacement setup to control plunger list at a well head using a single I/O Slave.



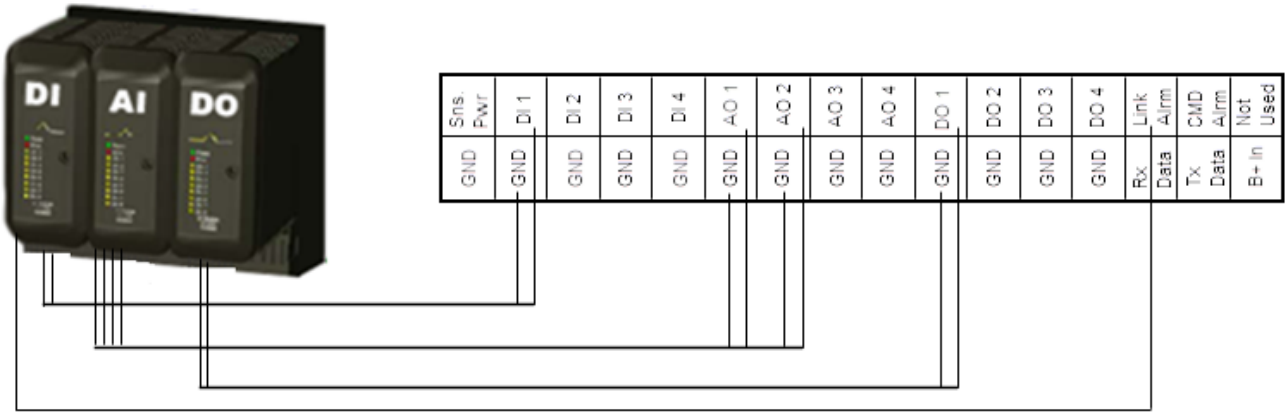
Each wiring portion of the above illustration is detailed in the sections below.

I/O Master to the RTU

Wire the following terminal ports on the I/O Master to the RTU:

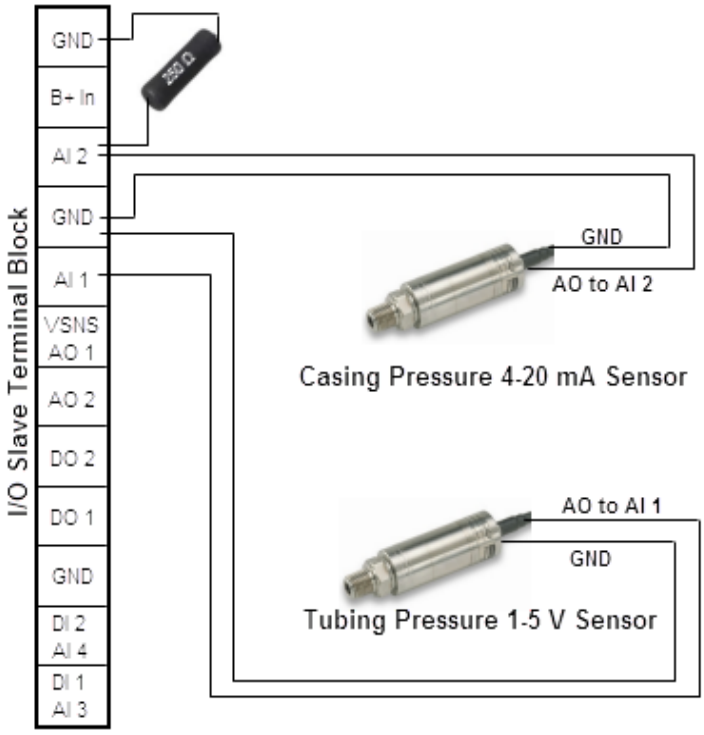
- DI1 to RTU Digital Input for the plunger arrival sensor
- AO1 to RTU Analog Input for tubing sensor
- AO2 to RTU Analog Input for casing sensor
- DO1 to RTU Digital Output for solenoid valve

  The valve can be run in two lines, one for valve open and one for valve closed. Using DO2 on the I/O Master. The example below uses a single line.
- Link Alarm to RTU Digital Input to for alarm if link is lost to the I/O Slave



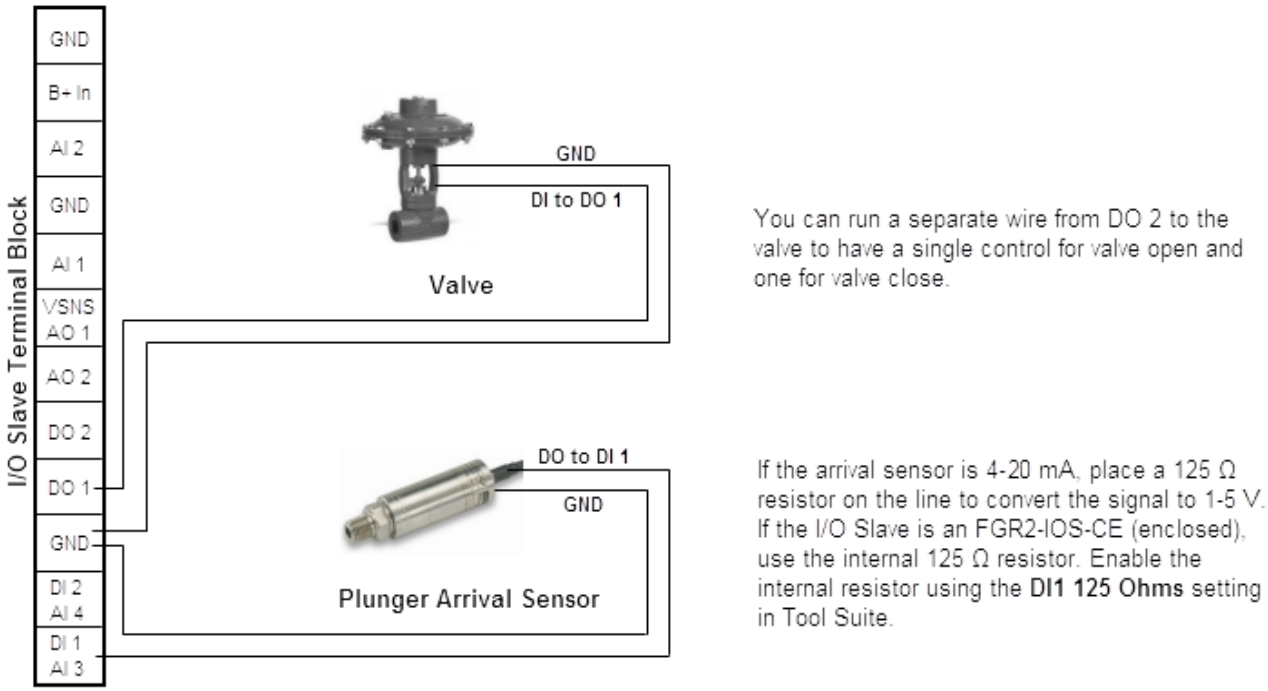
I/O Slave to the Well Head

Wire the terminal ports on the I/O Slave to the casing pressure sensor and the tubing sensor as illustrated below. Wire each sensor to ground. The resistor is used to convert the 4-20 mA signal to a 1-5 V signal that is readable at the I/O Master.



If the I/O Slave is an FGR2-IOS-CE (enclosed), the 250 Ω resistor can be replaced with the radio's internal resistor. Enable the internal resistor using the **AI2 250 Ohms** setting in Tool Suite.

Wire the terminal ports on the I/O Slave to the solenoid valve and the plunger arrival sensor as illustrated below. Wire each sensor to ground.



Terminal Port Mappings within Tool Suite

Ensure that both the I/O Master and the I/O Slave are configured as described in the other chapters within this manual and that the I/O Master can connect to the I/O Slave.

Using Tool Suite, connect to the I/O Master and select the I/O Settings tab. Map the terminal ports in the I/O Settings tab in the I/O Master to the I/O Slave as follows and send the settings to the transceiver:

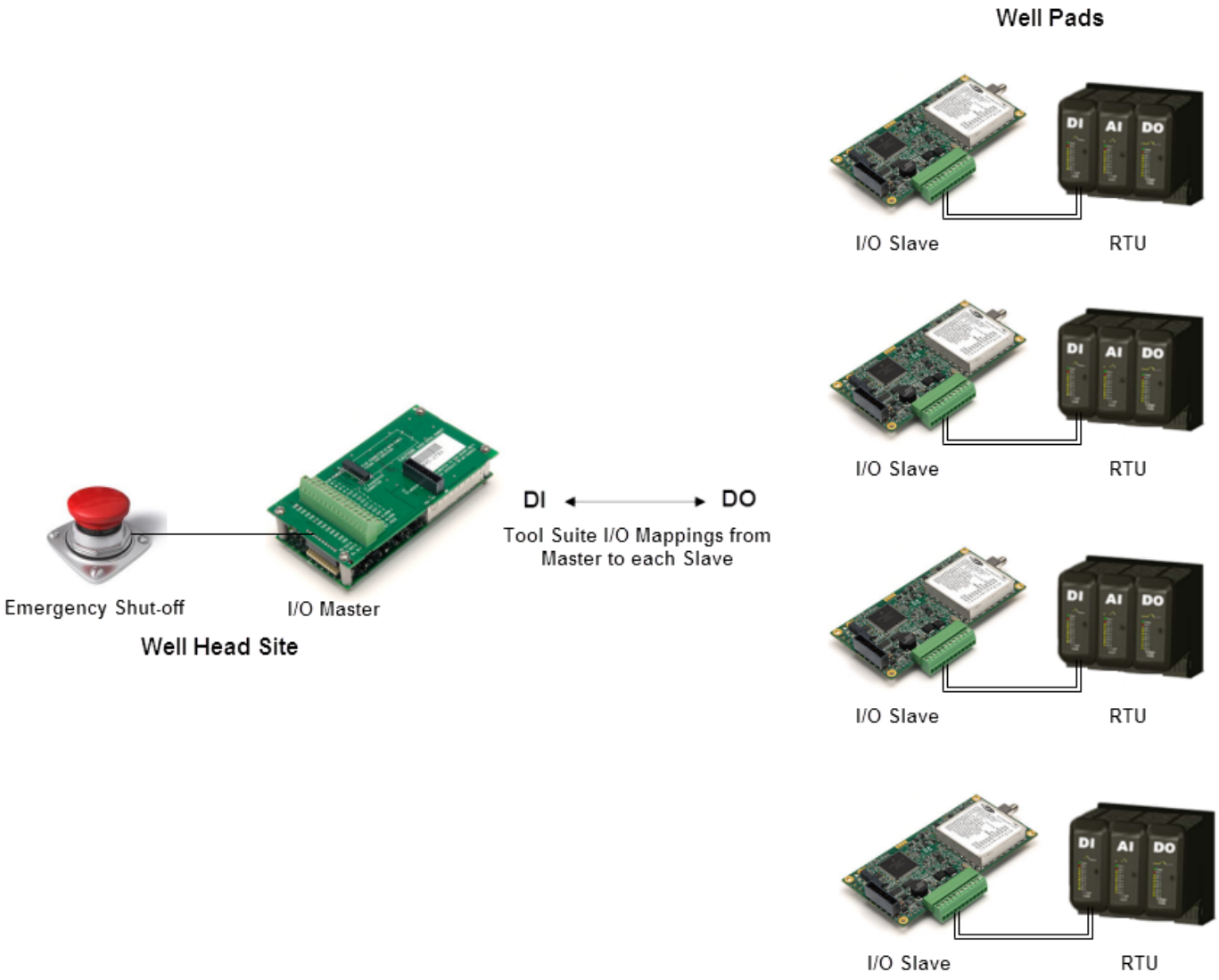
- **Analog Out 1** to **Slave AI1** for the tubing sensor
- **Analog Out 2** to **Slave AI2** for the casing sensor
- **Digital Out 1** to **Slave DI1** for the solenoid valve

Note: The I/O Slave is listed by serial number. As there is only one I/O Slave in the network in this example, only one Slave is listed in the port selection fields. If there were additional I/O Slaves in the network, each Slave to which the I/O Master is connected displays in the list.

Within Tool Suite, select the I/O Slave and select the Wire Replacement tab, set **Digital Out 1** to **Master DI1** for the solenoid valve.

Emergency Shut Off Example

The following example illustrates the wire replacement setup to control an emergency shut off for operations at a well site:

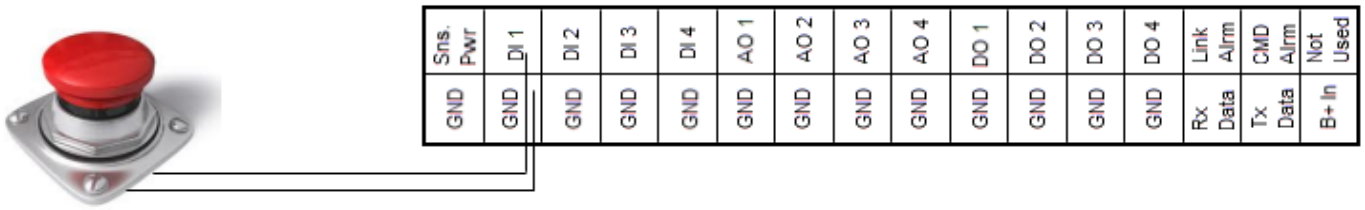


Each wiring portion of the above illustration is detailed in the sections below.

I/O Master to the Emergency Shut-Off

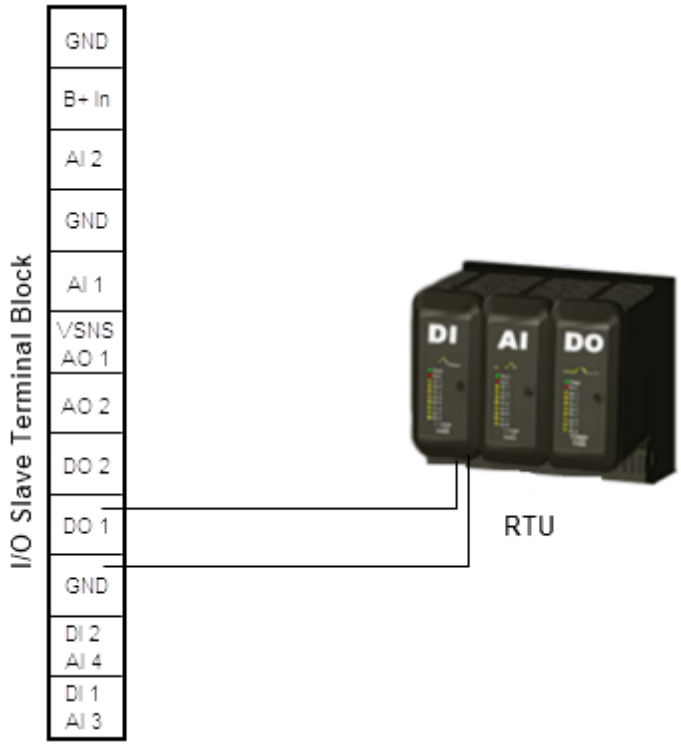
Wire the following terminal ports on the I/O Master to the emergency shut-off device:

- DI1 to Digital Input on the emergency shut-off device.



I/O Slave to the RTU at Each Well Sites

At each I/O Slave, wire the DO1 terminal port on the I/O Slave to the RTU and wire to ground.



Terminal Port Mappings within Tool Suite

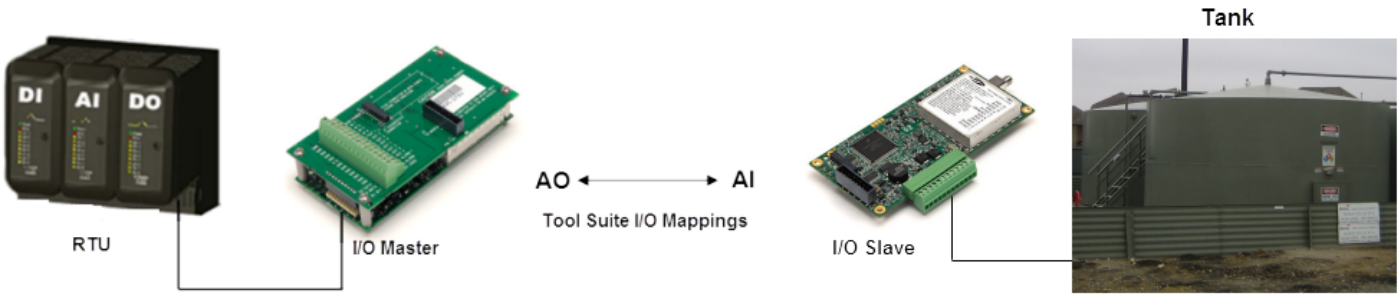
Ensure that both the I/O Master and the I/O Slave are configured as described in the other chapters within this manual and that the I/O Master can connect to the I/O Slave.

Using Tool Suite, connect to the I/O Master and select the I/O Settings tab. Map **Digital Input 1** on the I/O Master to **Digital Output 1** on the I/O Slave.

Note: The I/O Slaves are listed by serial number.

Tank Level Example

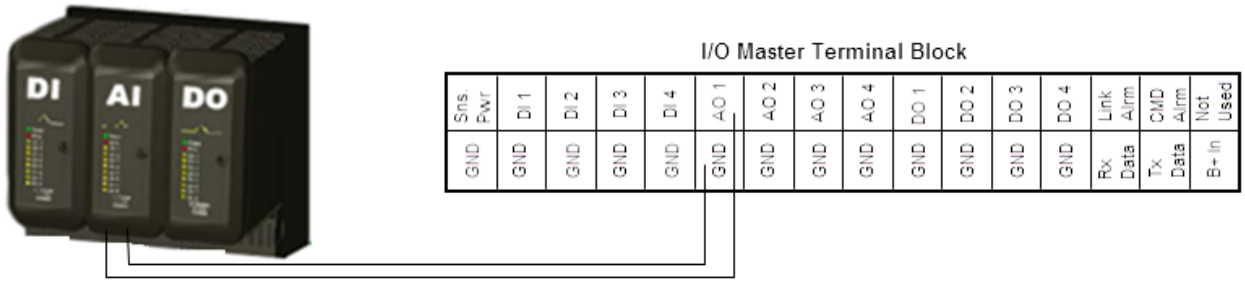
The following example illustrates the wire replacement setup to measure tank level:



Each wiring portion of the above illustration is detailed in the sections below.

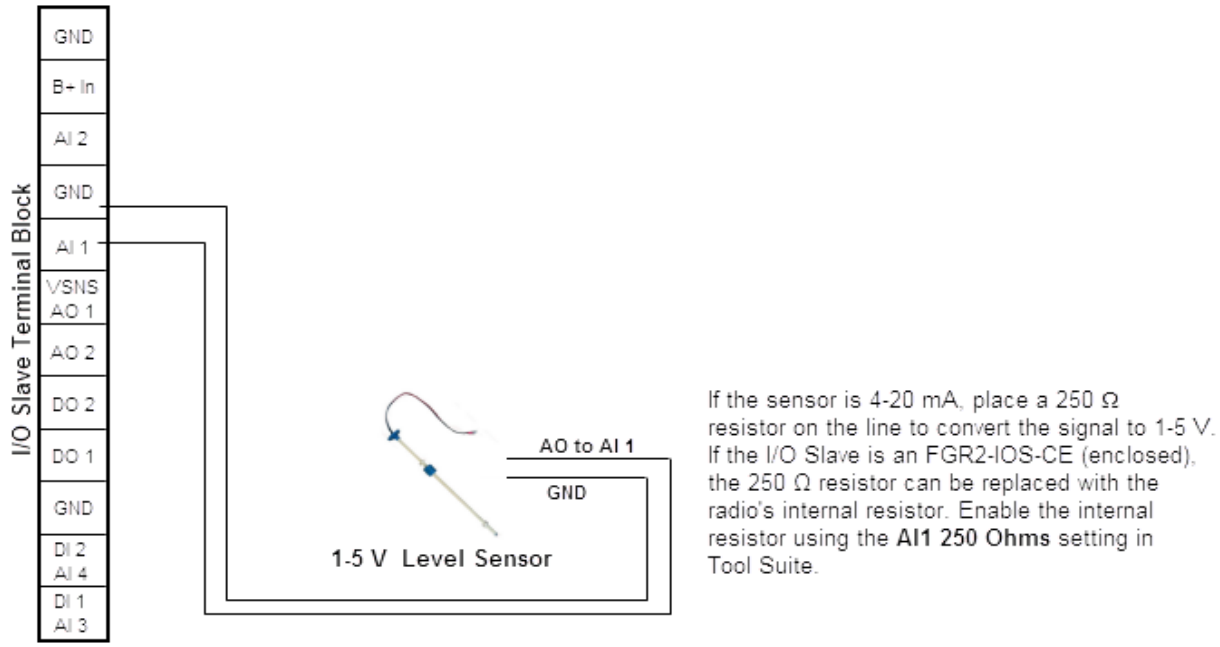
I/O Master to the RTU

Wire the AO1 to Analog Input on the RTU.



I/O Slave to the Well Head

Wire the terminal ports on the I/O Slave to the sensor and wire the sensor to ground.



Terminal Port Mappings within Tool Suite

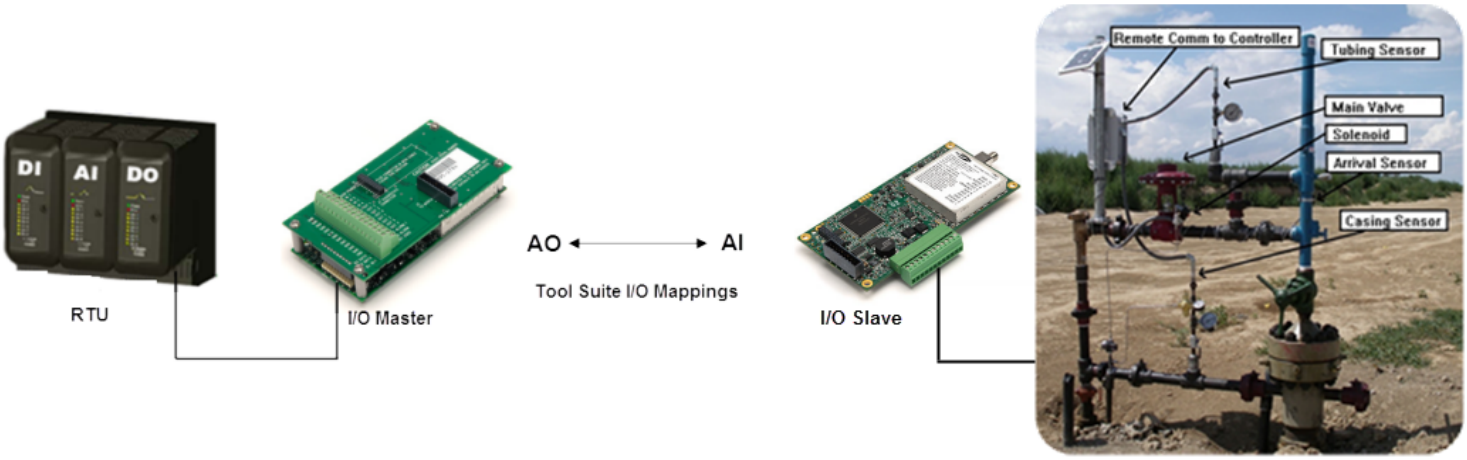
Ensure that both the I/O Master and the I/O Slave are configured as described in the other chapters within this manual and that the I/O Master can connect to the I/O Slave.

Using Tool Suite, connect to the I/O Master and select the I/O Settings tab. Map **Analog Output 1** to **Slave AI1**.

Note: The I/O Slave is listed by serial number. As there is only one I/O Slave in the network in this example, only one Slave is listed in the port selection fields. If there were additional I/O Slaves in the network, each Slave to which the I/O Master is connected displays in the list.

Tubing Pressure Example

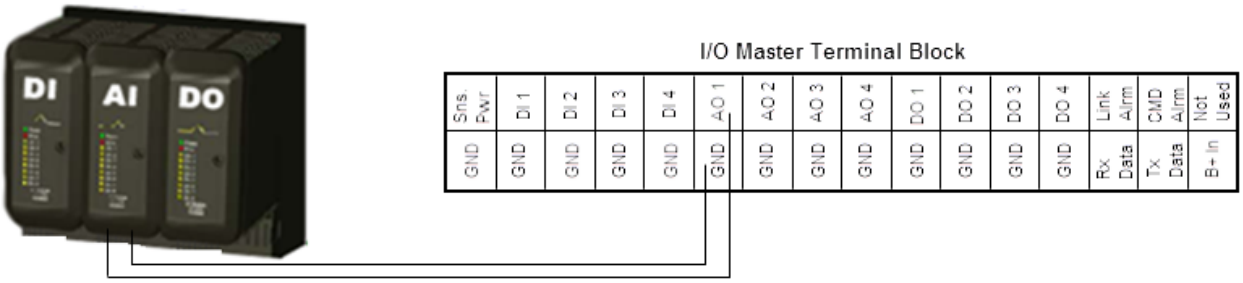
The following example illustrates the wire replacement setup for a tubing pressure sensor:



Each wiring portion of the above illustration is detailed in the sections below.

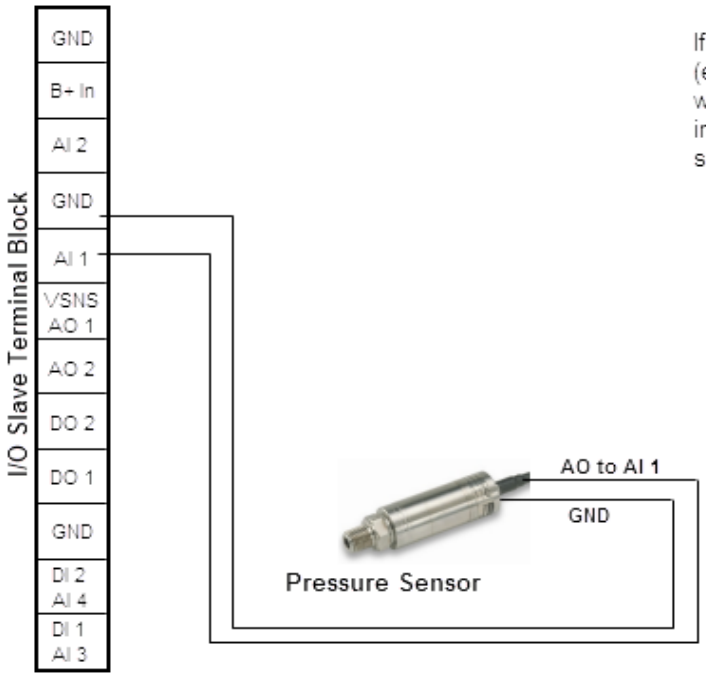
I/O Master to the RTU

Wire the AO1 to RTU Analog Input for the tubing sensor.



I/O Slave to the Well Head

Wire the terminal ports on the I/O Slave to the tubing sensor as illustrated below. Wire the sensor to ground.



If the I/O Slave is an FGR2-IOS-CE (enclosed), the 250 Ω resistor can be replaced with the radio's internal resistor. Enable the internal resistor using the **AI1 250 Ohms** setting in Tool Suite.

Terminal Port Mappings within Tool Suite

Ensure that both the I/O Master and the I/O Slave are configured as described in the other chapters within this manual and that the I/O Master can connect to the I/O Slave.

Using Tool Suite, connect to the I/O Master and select the I/O Settings tab. Map the **Analog Out 1** to **Slave AI1** for the tubing sensor

Note: The I/O Slave is listed by serial number. As there is only one I/O Slave in the network in this example, only one Slave is listed in the port selection fields. If there were additional I/O Slaves in the network, each Slave to which the I/O Master is connected displays in the list.

Chapter 6: Viewing Radio Statistics

When you read a radio the system displays data transmission statistics the transceiver has gathered during the most recent session. This information is valuable when you need to know the signal strength and noise levels of the link. Statistics are gathered during each data link and are reset when the next link begins.

In addition, you can view more data transmission characteristics in the Network Diagnostics application. For information about running network diagnostics using Tool Suite, see the *Tool Suite User Manual*.

To display the radio statistics in Tool Suite:

1. In the Tool Suite Configuration application, click **Read Radio**, and then click the Device Information tab.
2. Review the radio characteristics. Each characteristic is described in detail in the sections below.

   You can also view the same statistics using the Setup Terminal option in Tool Suite.

To display the Radio Transmission Characteristics in the terminal interface:

1. Select **(4) Show Radio Statistics** from the Setup main menu to display the following window:

   Review the radio characteristics. Each characteristic is described in detail in the sections below.

Antenna Reflected Power

This is a measurement of the transmitted power that is reflected back into the transceiver from mismatched antennas or cables, or loose connections between the transceiver and antenna. A reading of 0 to 5 is good; 5 to 20 is marginal; 20 or higher indicates that the connections should be inspected for loose connections and cable quality. A reading of 30 or higher indicates a definite problem in the system.

The most likely reason for a higher **Antenna Reflected Power** reading is a cable issue between the radio and the antenna: loose connections, cable kinks, breaks in cable shielding, moisture in the fittings or connections, etc. Less commonly, a high **Antenna Reflected Power** reading can indicate a hardware problem with the

radio itself, such as a damaged RF connector. Lastly, a high reading may indicate a problem with the antenna itself, although antenna problems are the least likely indicator.

Master-Slave Distance

The physical distance between the slave radio and the master radio in your network. This distance is most accurate at a distance greater than 2.5 miles.

Noise Level

The **Noise Level** indicates the level of background noise and interference at this transceiver and at each of the Repeaters in the link. The number is an average of the noise levels measured at each frequency in the transceiver's frequency hop table.

The individual measurement values at each frequency hop channel are shown in the frequency table. If you are viewing statistics in the terminal interface, press **Enter** when the Radio Statistics menu displays to view the frequency table.

Ideally, noise levels should be below -120 dBm. Ideally, the difference between the average signal level and average noise level should be 26 or more. Noise levels significantly higher than this are an indication of a high level of interference that may degrade the performance of the link. High noise levels can often be mitigated with band pass filters, antenna placement or antenna polarization.

Number of Disconnects

Anytime the link between the Master and the Slave is broken and the radios lose Carrier Detect.

The value indicates the total number of disconnects that have occurred from the time the transceiver is powered on until the radio is put into Setup mode. Under ideal operating conditions, the number of disconnects should be **0**. One or more disconnects may indicate a weak link, the presence of severe interference problems or loss of power to any of the radios in the link.

Note: In Tool Suite, the disconnect information is available in the Summary View in the Network Diagnostics application.

Radio Temperature

The **Radio Temperature** value is the current operating temperature of the transceiver in degrees Celsius. For proper operation, a FreeWave transceiver must be in the temperature range of -40° to +75° C. Some of the transceivers are only tested to 0° C. See the transceiver specifications later in this document for details.

Rate %

The **Rate %** measures the percentage of data packets that were successfully transmitted from the Master to the Slave on the first attempt. A number of **75** or higher indicates a robust link that provides very good performance even at high data transmission rates. A number of **15** or lower indicates a weak or marginal link that provides lower data throughput. A **Rate %** of **100%** provides approximately 100 Kbaud of bandwidth with an **RF Data Rate** setting of **3** and approximately 150 Kbaud of bandwidth with an **RF Data Rate** of **2**. These numbers are reduced approximately 50% if one or more Repeaters are in the network.

Signal Level

The **Signal Level** indicates the level of received signal at this transceiver and at each of the Repeaters in the link. For each of these, the signal source is the transceiver that transmits to it. The number is an average of the received signal levels measured at each frequency in the transceiver's frequency hop table.

The individual measurement values at each frequency hop channel are shown in the frequency table. If you are viewing statistics in the terminal interface, press **Enter** when the Radio Statistics menu displays to view the frequency table.

For a reliable link, the margin should be at least 26 dB. Low average signal levels can often be corrected with higher gain antennas, better antenna placement and/or additional Repeaters.

Note: See the installation manual for antenna and FCC requirements.

Transmit Current

The **Transmit Current** measures the current draw of the transmitter in milliamps (mA). See the transceiver specifications for typical values.

Chapter 7: Additional Information

This chapter provides the following additional information about I/O Masters, I/O Slaves in a wire replacement I/O system:

- Answers to frequently asked questions.
- Port identifications and terminal block layouts for each model.
- Product specifications.

Frequently Asked Questions

Q: Can I/O be used with a 1 Watt radio?

A: The FGRIO-M functions as a standard 900 MHz 1 Watt serial radio with a 60 mile line-of-sight range.

The FGRIO-S functions as an FGR Short Range radio with a 2 mile line-of-sight range.

The FGR2-IOS-C-U and FGR2-IOS-CE-U function as FGR2 radios with a 60 mile line-of-sight range.

Q: Can the I/O radios be repeated through our other radios to extend the range?

A: From the I/O Slave to the I/O Master, you cannot use a Repeater. When the I/O Master is integrated into a standard serial network, you can use Repeaters between the I/O Master and the Serial Master as they already are in existing FreeWave networks. The I/O Master cannot function as a Slave/Repeater.

Q: Can the I/O Master operate as Slave/Repeater in the overall network?

A: The IO Master currently does not have the capability to operate as a Slave/Repeater. It does function as the Master to the I/O Slave, and as a MultiPoint Slave to the rest of the network.

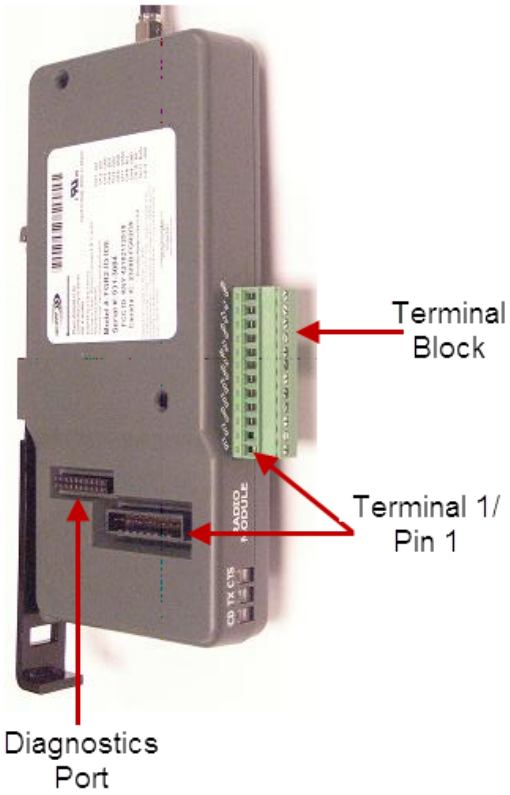
Q: Can data be sent directly from the I/O Slave to the Master of the serial network?

A: No. The wire replacement system functions as wire replacement only. The IO Slave's serial ports are inactive and do not have the capability of transmitting data directly to the Master of a serial network.

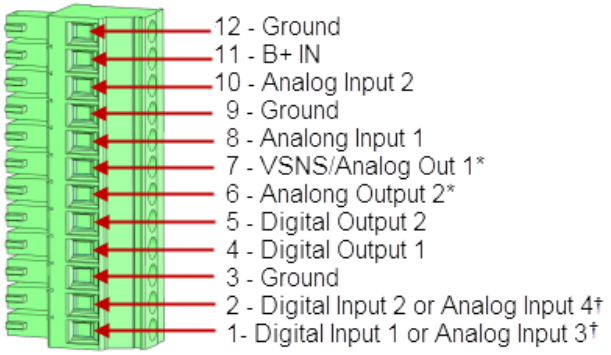
Q: What timing issues does a wire replacement system introduce?

A: Although a wire replacement system mimics a wired connection, the electronics and communication heartbeat do cause some signal delay. The worst case delay for digital signals in either direction and in the Sensor Power command from I/O Master to IO Slave is 167 ms, assuming a robust link. Worst case delay from I/O Master Sensor Power assertion to I/O Master Analog Output refresh is 700 ms.

FGR2-IO-IOE Ports



FGR2-IO-IOE Terminal Block Layout



* Analog Outputs 1 and 2 are not available in a wire replacement I/O system.

†Analog Inputs 3 and 4 are 0 to +3.3 VDC inputs. See wiring diagrams in this document for details.

FGR2-IO-IOE Specifications

The following specifications apply to the FGR2-IO-IOE. Specifications may change at any time without notice. For the most up-to-date specifications information, see the product's data sheet available at www.freewave.com.

Specifications			
Transmitter			
Frequency Range	902 – 928 MHz		
Output Power	1 W		
Range, Line of Sight (LOS)	60 miles with clear LOS		
Modulation	2 level GFSK, 115.2 Kbps		
Occupied Bandwidth	230 kHz		
Hopping Patterns	15 per Band, 105 total, user selectable		
Hopping Channels	50 to 112, user selectable		
Hopping Bands	7, user selectable		
RF Connector	Type SMA, TNC (Female connectors)		
Receiver			
Sensitivity (board-level only)	-106 dBm at 10^{-6} BER -108 dBm at 10^{-4} BER		
Selectivity	20 dB at fc ± 115 kHz 60 dB at fc ± 145 kHz		
System Gain	140 dB		
Data Transmission(1)			
Error Detection	32 bit CRC, retransmit on error		
Link Throughput	115.2 Kbps		
Data Interface	Serial		
Protocol	RS-232/422/485, 1200 baud – 115.2 Kbaud		
Data Connector	10-pin header with locking ramp 0.1 inch spacing, power/data connector		
Input		**Modbus**	**Wire Replacement**
2: Precision AIs (20 bits, 0-5.625 V, 0.1% FS Accuracy), also act as exact-threshold DIs		x	x
2: DIs with counters (32 bits, 1000 Hz), also act as aux. AIs (10 bits, 0-3.5 V, 0.25% FS Accuracy)		x	(2)

Specifications		
1: DI with pull down resistor (5 Kohm)	x	
1: DI with pulsed 50 mA pull-up for long-lines or high noise	x	
Output		
2: High Current (2 A sink to GND) DOs with current sensing and self-resetting protection	x	x(3)
1: AO - 15 bits, 4-22mA, 0.1% FS Accuracy, also acts as 50mA sensor power or DI	x	
1: AO - 16 bits, 4-22mA, 0.1% FS Accuracy	x	
Internal		
1: Battery/Supply Voltage - 10 bits, 0-30 V, 1% FS Accuracy	x	
1: Radio Temperature - 1° C units, -40° C to +70° C, 4° C accuracy	x	
Expandable I/O Stack up to 15 Expansion Modules	x	

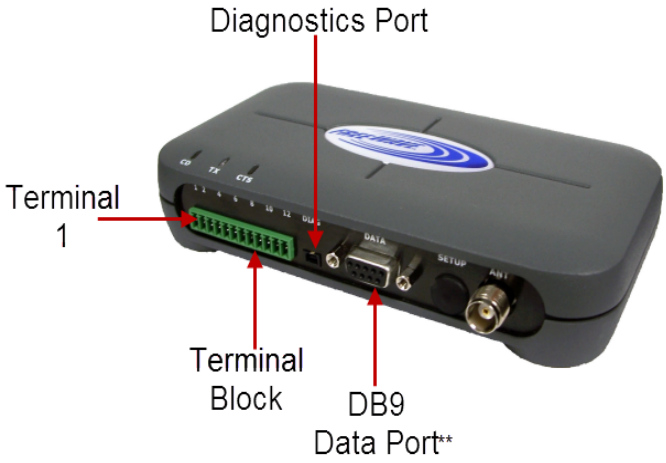
Diagnostics Interface	
Connector	Separate 20-pin PCB header

Power Requirements				
Operating Voltage	+6.0 to +30.0 VDC			
Average Current (mA) (currents shown with no AO connections made)	**Mode**	**+6.0 VDC**	**+12.0 VDC**	**+30.0 VDC**
	Transmit	800	380	170
	Receive	90	55	40
	Idle	24	16	8
	Modbus Linked Lowpower = 4	10	7	5
	Wire Replacement Linked	30	15	8

General Information	
Operating Temperature Range	-40° C to +75° C. Every radio 100% factory tested over this range.
Dimensions	Enclosure: 181 L x 80 W x 38 H (mm)
Weight	Enclosure: 163 g
Humidity	0 to 95% non-condensing

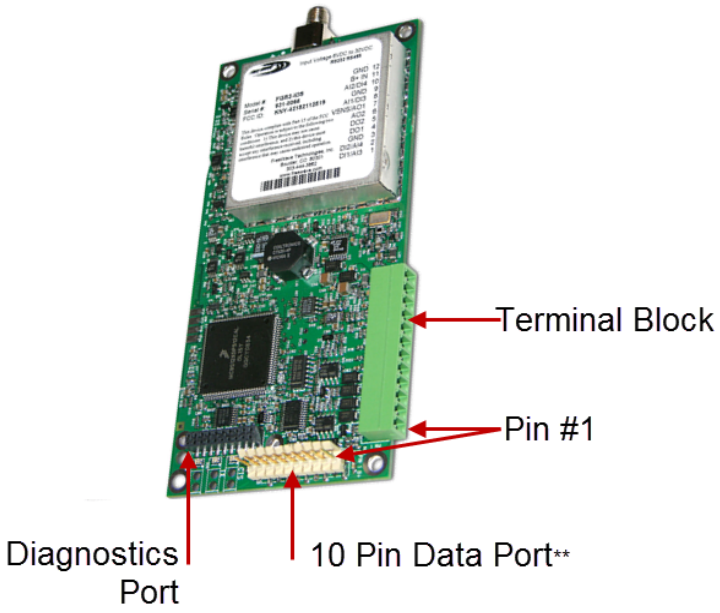
(1) Data port not operative in wire replacement mode.
(2) DIs operative, but there are no counters in Wire Replacement mode.
(3) No current sensing in wire.

FGR2-IOS-CE-U Ports



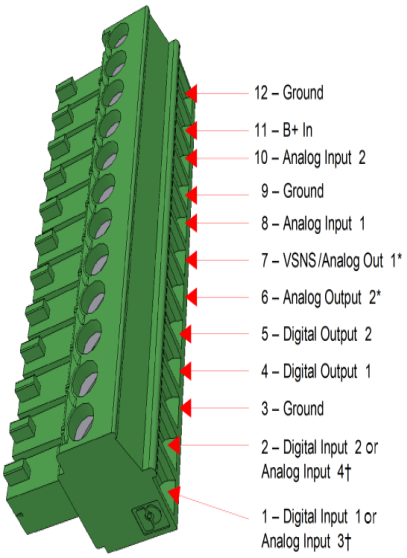
** The data port on I/O Slaves is not active in a wire replacement I/O system.

FGR2-IOS-C-U



** The data port on I/O Slaves is not active in a wire replacement I/O system.

FGR2-IOS-C-U/FGR2-IOS-CE-U Terminal Block Layout



* Analog Outputs 1 and 2 are not available in a wire replacement I/O system.

†Analog Inputs 3 and 4 are 0 to +3.3 VDC inputs. See wiring diagrams in this document for details.

FGR2-IOS-C-U/FGR2-IOS-CE-U Specifications

The following specifications apply to both the FGR2-IOS-C-U and FGR2-IOS-CE-U. Specifications may change at any time without notice. For the most up-to-date specifications information, see the product's data sheet available at www.freewave.com.

Specifications	
Transmitter	
Frequency Range	902 – 928 MHz
Output Power	1 W
Range, Line of Sight (LOS)	60 miles with clear LOS
Modulation	2 level GFSK, 115.2 Kbps
Occupied Bandwidth	230 kHz
Hopping Patterns	15 per Band, 105 total, user selectable
Hopping Channels	50 to 112, user selectable
Hopping Bands	7, user selectable
RF Connector	Type SMA, TNC (Female connectors)
Receiver	
Sensitivity (board-level only)	-107 dBm at 10^{-6} BER -109 dBm at 10^{-4} BER
Selectivity	20 dB at fc ± 115 kHz 60 dB at fc ± 145 kHz
System Gain	140 dB
Data Transmission(1)	
Error Detection	32 bit CRC, retransmit on error
Link Throughput	115.2 Kbps
Data Interface	Serial
Protocol	RS-232/422/485, 300 baud – 115.2 Kbaud
Data Connector	10-pin header with locking ramp 0.1 inch spacing, power/data connector

Input	Modbus	Wire Replacement
2: Precision AIs (20 bits, 0-5.625 V, 0.1% FS Accuracy), also act as exact-threshold DIs	x	x
2: Precision AIs (20 bits, 0-5.625 V, 0.1% FS Accuracy), also act as exact-threshold DIs	x	(2)
2: Precision AIs (20 bits, 0-5.625 V, 0.1% FS Accuracy), also act as exact-threshold DIs	x	

Specifications			
2: Precision AIs (20 bits, 0-5.625 V, 0.1% FS Accuracy), also act as exact-threshold DIs	x	
Output			
2: High Current (2 A sink to GND) DOs with current sensing and self-resetting protection	x	x(3)
1: AO - 15 bits, 4-22mA, 0.1% FS Accuracy, also acts as 50mA sensor power or DI	x	
1: AO - 16 bits, 4-22mA, 0.1% FS Accuracy	x	
Internal			
1: Battery/Supply Voltage - 10 bits, 0-30 V, 1% FS Accuracy	x	
1: Radio Temperature - 1° C units, -40° C to +70° C, 4° C accuracy	x	

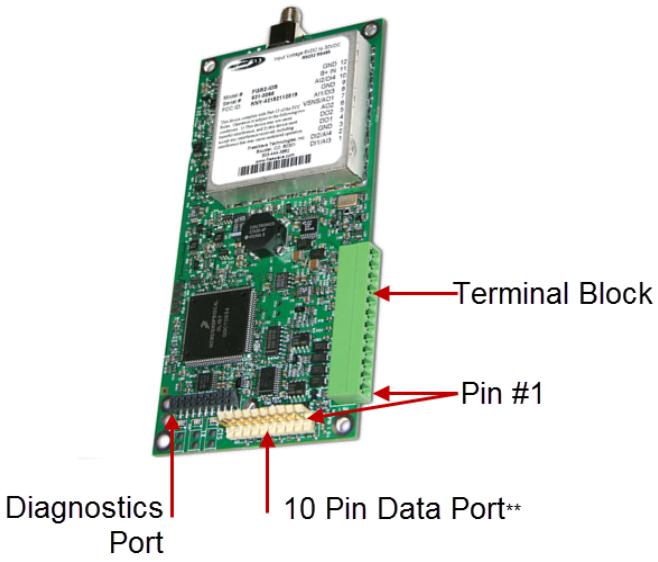
Diagnostics Interface	
Connector	Separate 20-pin PCB header

Power Requirements				
Operating Voltage	+6.0 to +30.0 VDC			
Average Current (mA) (currents shown with no AO connections made)	**Mode**	**+6.0 VDC**	**+12.0 VDC**	**+30.0 VDC**
	Transmit	800	380	170
	Receive	90	55	40
	Idle	24	16	8
	Modbus Linked Lowpower = 4	10	7	5
	Wire Replacement Linked	30	15	8

General Information	
Operating Temperature Range	-40° C to +75° C. Every radio 100% factory tested over this range.
Dimensions	Board Level: 127 L x 62 W x 16 H (mm) Enclosure: 173 L x 96 W x 35 H (mm)
Weight	Board Level: 60 g Enclosure: 509 g
Humidity	0 to 95% non-condensing

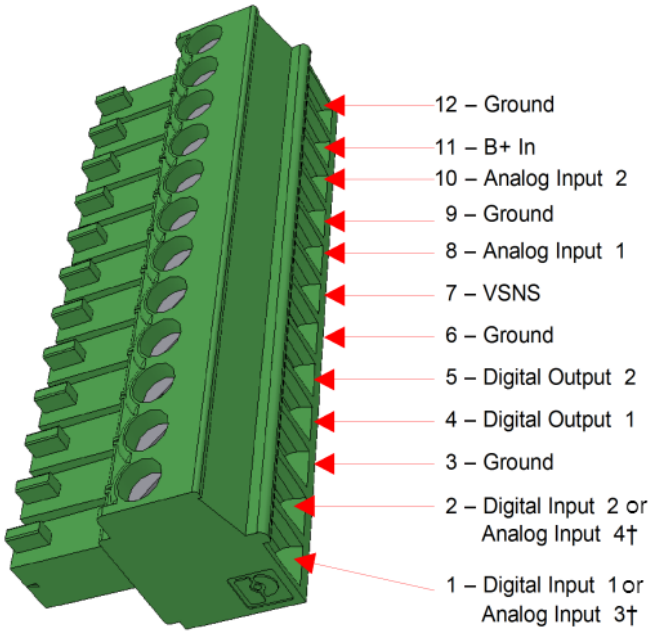
(1) Data port not operative in wire replacement mode.
(2) DIs operative, but there are no counters in Wire Replacement mode.
(3) No current sensing in wire.

FGRIO-S Ports



** The data port on I/O Slaves is not active in a wire replacement I/O system.

FGRIO-S Terminal Block Layout



† Analog Inputs 3 and 4 are 0 to +3.3 VDC inputs. See wiring diagrams in this document for details.

FGRIO-S Specifications

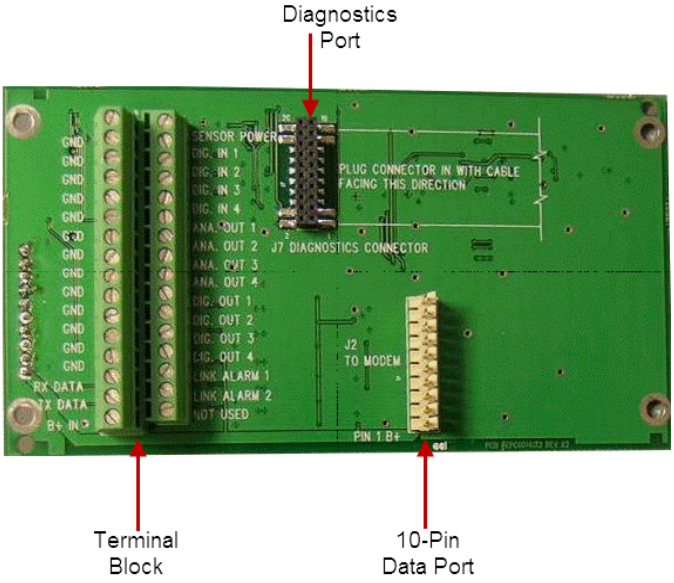
Note: FGRIO-S models are no longer available for purchase from FreeWave. FreeWave recommends the FGR2-IOS models as an over the air backwards compatible replacement.

Specifications may change at any time without notice. For the most up-to-date specifications information, see the product's data sheet available at www.freewave.com.

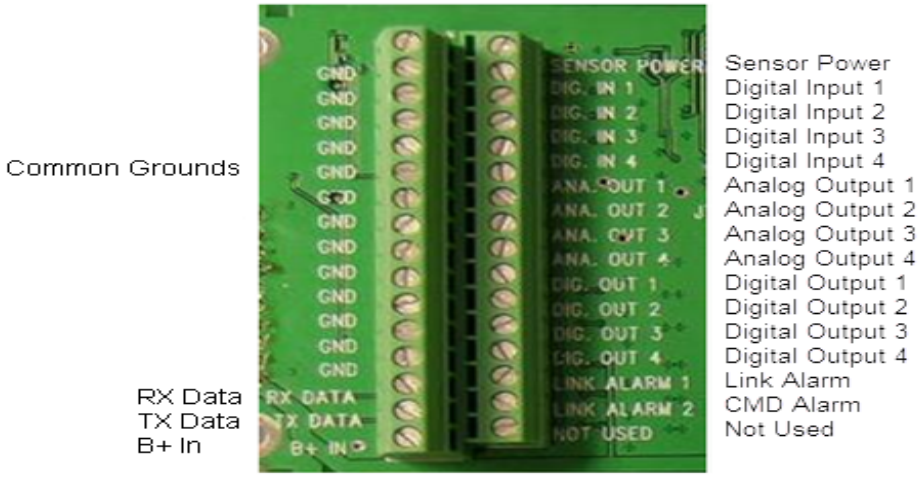
Specifications	
Transceiver	
Frequency Range	902 – 928 MHz
Output Power	100 mW
Range, Line-of-sight	2 miles
Modulation	2 level GFSK
Occupied Bandwidth	230 kHz
Hopping Patterns	15, user selectable
Hopping Channels	50 to 112, user selectable
Hopping Bands	7, user selectable
RF Connector	SMA female
Receiver	
Sensitivity	-98 dBm at 10^{-6} BER -100 dBm at 10^{-4} BER
Selectivity	20 dB at fc ± 115 kHz 60 dB at fc ± 145 kHz
System Gain	130 dB
Data Transmission	
Error Detection	32 bit CRC, retransmit on error
Link Throughput	115.2 Kbps
Data Interface	Serial
Protocol	RS-232/422/485, 300 baud – 115.2 Kbaud
Data Connector	10-pin header
Analog Inputs	
Number of Inputs	2
Accuracy, Resolution	± 0.1%, 16 bit

Specifications				
Input Range	0.2 – 5.62 V, 94 KΩ input resistance			
Digital Inputs				
Number of Inputs	2			
Input Pull-up	10 KΩ to 3.3 V			
Input Pull-down	10 KΩ to GND			
Input Connector	Mini Phoenix (3.55 mm)			
Slave Input to Master Output Delay	1 sec. maximum			
Signal Input Voltage Maximum	± 20 V			
Maximum Count Size & Rate	32 bits, 1000 Hz			
AI of DI Accuracy, Resolution	± 0.25%, 10 bit			
AI of DI Input Range	0 – 3.5 V			
Digital Output				
Number of Outputs	2			
Current Rating	2 Amps maximum			
Voltage Rating	Lesser of: 20 V or the radio supply voltage			
Diagnostic Interface				
Connector	Separate 20-pin PCB header			
Power Requirements				
Operating Voltage	+6.0 to +20.0 V DC			
Average Current Usage (mA)	**Mode**	**+6.0 VDC**	**+12.0 VDC**	**+20.0 VDC**
	Transmit	120	68	48
	Receive	68	38	28
	Linked	12	7	6
General Information				
Operating Temperature Range	-40° C to +75° C			
Dimensions	138 mm L x 76 mm W x 12 mm H			
Weight	58 g			
Humidity	0 to 95% non-condensing			

FGRIO-M Ports



FGRIO-M Terminal Block Layout



FGRIO-M Specifications

The following specifications apply to both the FGRIO-M model. Specifications may change at any time without notice. For the most up-to-date specifications information, see the product's data sheet available at www.freewave.com.

Specifications			
Transmitter			
Frequency Range	902 - 928 MHz (FHSS)		
Output Power	5 mW to 1 W		
Range - Line of Sight	60 miles		
Modulation	2 level GFSK		
Occupied Bandwidth	230 kHz		
Hopping Patterns	15 per Band, 105 total user selectable		
Hopping Channels	50 to 112, user selectable		
Hopping Bands	7, user selectable		
RF Connector	Type SMA		
Master Receiver		**Master Analog Output**	
Sensitivity	-108 dBm for BER 10^{-6} -110 dBm for BER 10^{-4}	Number of Outputs	4, can be mapped to up to 4 slaves
Selectivity	20 dB at fc ± 115 kHz, 60 dB at fc ± 145 kHz	Accuracy, Resolution	+/- .1%, 16 bit
System Gain	140 dB	Output Range	.2-5.62V, > 10 Kohm Load Resistance
Master Digital Outputs		**Master Digital Inputs**	
Number of Outputs	4 per Master Link, 1 Command Alarm	Number of Inputs	4
Output Connector	Mini Phoenix (3.55 mm)	Master Input to Slave Output Delay	1 Second Max
Slave Input to master Output Delay	1 Second Max	Voltage Range	0 to 30 V
Signal Voltage Range	0 - 4.6 V		
Data Transmission			
Error Detection	32 bit CRC, Retransmit on Error		
Data Encryption	Dynamic Key Substitution		
Link Throughput	115.2 kbps		

Specifications				
Data Interface	Serial			
Protocol	RS 232 / 485 / 422, 1200 Baud to 115.2 Kbaud			
Data Connector	10-pin header with locking ramp, 0.1 inch spacing, power/data connector			
Data Interface				
Connector	Separate 20-pin PCB header			
Power Requirements				
Operating Voltage	+7.0 to +30.0 VDC			
Current	**Mode**	**+7.0 VDC**	**+12.0 VDC**	**+30.0 VDC**
	Transmit	1 A	500 mA	200 mA
	Receive	140 mA	86 mA	43 mA
	Idle	120 mA	70 mA	38 mA
General Information				
Operating Temperature Range	-40° C to +75° C.			
Dimensions	140 L x 70 W x 34 H (mm)			
Weight	137g			
Humidity	0 to 95% non-condensing			

Glossary

Symbols

µ

Symbol notation for micro (one millionth). For example, µs is the abbreviation for microseconds.

Ω

Symbol notation for ohm, a measure of electrical resistance.

A

analog circuit

An electronic circuit that operates with currents and voltages that vary continuously with time and have no abrupt transitions between levels. Temperatures, pressures, or flow rates are all represented by analog circuits.

D

digital circuits

An electronic circuit that functions as though currents or voltages exist only at one of a set of discrete levels, all transitions between levels being ignored. The states of a digital circuit are often referred to as on or off, high or low.

I

I/O Master

Refers to FGRIO-M or I2-IOM-U FreeWave wireless radio transceivers that operate as a Master for up to four I/O Slaves and can operate as a serial MultiPoint Slave in a Point-to-MultiPoint network. The I/O Master can receive over the air a total of four analog input signals and four digital input signals from up to four I/O Slaves. It can also transmit up to four digital output signals over air to the I/O Slaves. The I/O Master does not operate as a Slave/Repeater in a serial Point-to-Multipoint radio network.

I/O Slave

Refers to an FGR2-IOS-C-U, FGR2-IOS-CE-U, I2-IOS-C-U, or FGR2-IO-IOE FreeWave wireless radio transceiver that accepts up to a total of four input signals from sensors, then transmits these signals over-the-air to the I/O Master. Two of the available four input signals can only be transmitted as analog signals and are labeled as Analog Input 1 and Analog Input 2 on the Slave's terminal block. The other two input signals may be either analog or digital inputs, depending on your needs. The I/O Slave can also receive over-the-air two digital output signals and a sensor power control signal from the I/O Master. The I/O Slave has a line-of-sight range of 60 miles.

I/O System

When used in this manual, the term I/O System refers to any network that uses an I/O Master in conjunction with an I/O Slave.

S

Short-Range I/O Slave

Refers to an FGRIO-S FreeWave wireless radio transceiver that accepts up to a total of four input signals from sensors, then transmits these signals over-the-air to the I/O Master. Two of the four available input signals can only be transmitted as analog signals and are labeled as Analog Input 1 and Analog Input 2 on the Slave's terminal block. The other two input signals may be either analog or digital inputs, depending on your needs. The I/O Slave can also receive over-the-air two digital output signals and a sensor power control signal from the I/O Master.

Serial Master

Refers to any FGRO9CSU, FGR-115RC, FGR2-C-U, FGR2-CE-U, IM-500X007, IM-800X009, IM-900X009, I2-C-U, or I2-CE radio configured as the MultiPoint Master in an integrated network.

V

VSNS

This is screw terminal # 7 on the IO Slave. This is an output used to power sensors/transmitters. This terminal mirrors the radio's supply voltage. The maximum output voltage of this terminal is 20 VDC for the FGRIO-S and 30 VDC for the FGR2-IOS-C-U, FGR2-IOS-CE-U, I2-IOS-C-U, and FGR2-IO-IOE.

Index

1

1-5 V sensor, connecting 54-55
1-5 V sensor, signal coupling 55
1 PPS Enable Delay, defined 43

4

4-20 mA sensor, connecting 51, 53

A

AI1 250 Ohms, defined 31
AI2 250 Ohms, defined 31
Antenna Reflected Power, defined 67

B

Baud Rate parameters
about 14
Baud Rate 15
Data Parity 15
Flow Control 15
Modbus RTU 16
RS232/RS485 16
Serial Interface 16
Setup Port 17
Turn Off Delay 17
Turn On Delay 18
Use Break to Access Setup 18
Baud Rate, defined 15

C

Call Book 18
configuration tools 4

D

Data Parity, defined 15
Default Delay, defined 23, 33
Default Output, defined 23
default settings 6
DI 2 Pullup, defined 32
DI1 150 Ohms, defined 32
DI1 Pullup, defined 32
DI2 150 Ohms, defined 32
diagnostics, running
identifying transceivers 45
parameter setting 43
Digital Output 1 Default, defined 33
Digital Output 1, defined 31
Digital Output 2 Default, defined 33
Digital Output 2, defined 31
DO Bi-Stable, defined 32
DO Monostable Time, defined 33
DTR Connect, defined 44

F

factory default settings 6
Fast AI (DI1), defined 31
Fast AI (DI2), defined 31
FGR2-IO-IOE
ports 73
specifications 74
terminal block 73
FGR2-IOS-C-U
ports 76
specrifications 78
terminal block 77
FGR2-IOS-CE-U
ports 76
specifications 78
terminal block 77
FGRIO-M
ports 83

specifications 84
terminal block 83
FGRIO-S
ports 80
specifications 81
terminal block 80
Flow Control, defined 15
Frequency Key
I/O Master 19
Frequency Zones, defined 35
frequently asked questions 72

G

golden settings
Frequency Key 19

H

High Noise, defined 38
Hop Table Version, defined 38
HopTable Size, defined 37
HyperTerminal
and Tool Suite 5
described 4

I

I/O Masters, configuring
about 11
Call Book 18
communication with I/O Slaves 18
Default Delay 23
Default Output 23
Frequency Key 19
Master Packet Repeat 21
Max Packet Size 20
Min Packet Size 20
Network ID 18
network role 14
outputs, mapping to I/O Slave inputs 24
Repeaters 22
RF Data Rate 21
Sensor Power 23
Subnet ID 22
Tool Suite templates 14
I/O Masters, wiring
about 47
Analog Outputs 49
Digital Inputs 49
Digital Outputs 49
Link Alarams 50
radio power 48
Rx Data 48
Sensor Power 48
Tx Data 48
I/O Setting parameters
Default Delay 23
Default Output 23
Sensor Power 23
I/O Slave
DI1 Pullup 32
DI2 Pullup 32
I/O Slave, configuring
DO Bi-Stable 32
I/O Slaves, configuring
about 27
AI1 250 Ohms 31
AI2 250 Ohms 31
Call Book 30
communication with I/O Master 30
Default Delay 33
DI1 150 Ohms 32
DI2 150 Ohms 32
Digital Outout 2 31
Digital Output 1 31, 33
Digital Output 2 33
DO Monostable 33
Frequency Key 30
Hop Table Size 30
Hop Table Version 30

Master Packet Repeat 31
Max Packet Size 30
Min Packet Size 30
Modem Mode 30
Network ID 31
network role 30
Repeaters 31
RF Data Rate 30
Tool Suite templates 29
I/O Slaves, wiring
1-5 V sensors 54
4-20 mA sensors 51
Digital Inputs 50
Digital Outputs 50
radio power 50
IC notifications iv
integrated system
I/O Master Modem Mode 14
illustrated 4
LED indications 9

L

LEDs 9
legal notifications
IC iv
Link Alarm
duration before alarm 23
Local Mode, defined 44
Low Power Mode, defined 39

M

mapping I/O Master outputs 24
Master-Slave Distance, defined 68
Master Packet Repeat, defined 21
Max Slave Retry, defined 44
Maximum Packet Size, defined 20
MCU Speed, defined 40
Minimum Packet Size, defined 20
Modbus I/O Slave
Terminal block
1-5 V sensor 54-55
4-20 mA sensor 51, 53
Modbus RTU, defined 16
Modem Mode, defined 14
Multi-Master Synch, defined 45
MultiPoint parameters
1 PPS Enable Delay 43
Diagnostics 43
DTR Connect 44
Local Mode 44
Master Packet Repeat 21
Max Slave Retry 44
Multi-Master Synch 45
Radio ID 45
Radio Name 45
Repeater Frequency 45
Repeaters 22
Retry Odds 45
Slave/Repeater 46
Subnet ID 22

N

Network ID, defined 18
Noise Level, defined 68
Number of Disconnects, defined 68

O

Operation Mode parameters
Setup Mode Timeout 6

P

packet sizes, maximum and minimum 20
parallel Repeaters
setting unique frequency 45
parameter reference
Max Slave Retry 44

ports
FGR2-IO-IOE 73
FGR2-IOS-C-U 76
FGR2-IOS-CE-U 76
FGRIO-M 83
FGRIO-S 80
power
conserving 39
Low Power Mode 39
product family 2
programming tools 5

R

Radio ID, defined 45
Radio Name, defined 45
Radio Temperature, defined 68
Rate %, defined 68
Reflected Power, defined 67
Remote LED, defined 40
Repeater Frequency, defined 45
Repeaters, defined 22
Retry Odds, defined 45
Retry Timeout, defined 41
RF Data Rate, defined 21
RS232/RS485, defined 16
RTS to CTS, defined 41

S

Sensor Power, defined 23
Serial Interface, defined 16
Setup mode
about 5
accessing using Break command 18
port assignment 17
terminal emulator 7
Tool Suite 6
Setup Mode Timeout, defined 6
Setup Port, defined 17
setup tools 4
Signal Level, defined 69
Slave Security, defined 41
Slave/Repeater, defined 46
specifications
FGR2-IO-IOE 74
FGR2-IOS-C-U 78
FGR2-IOS-CE-U 78
FGRIO-M 84
FGRIO-S 81
standalone system
I/O Master Modem Mode 14
illustrated 3
LED indications 9
statistics
viewing 67
Status parameters
Antenna Reflected Power 67
Master-Slave Distance 68
Noise Level 68
Number of Disconnects 68
Radio Temperature 68
Rate % 68
Signal Level 69
Transmit Current 69
viewing 67
Subnet ID, defined 22

T

temperature reading 68
terminal blocks
FGR2-IO-IOE 73
FGRIO-M 83
FGRIO-S 80
terminal emulator
Setup menu, accessing 7
terminal emulators
troubleshooting 8
Tool Suite
and HyperTerminal 5
connect to transceivers 6

described 4
I/O Master templates 14
I/O Slave templates 29
Transmission Characteristics parameters
Frequency Key 19
Frequency Zones 35
High Noise 38
Hop Table Size 37-38
Low Power Mode 39
Maximum Packet Size 20
MCU Speed 40
Minimum Packet Size 20
Remote LED 40
Retry Timeout 41
RF Data Rate 21
RTS to CTS 41
Slave Security 41
Transmit Power 41
Transmit Rate 42
Xmit Power 41
Xmit Rate 42
Transmit Current, defined 69
Transmit Power, defined 41
Transmit Rate, defined 42
troubleshooting
terminal emulators 8
Turn Off Delay, defined 17
Turn On Delay, defined 18

U

Use Break to Access Setup, defined 18

W

warranty ii
Wire Replacement parameters
AI1 250 Ohms 31
AI2 250 Ohms 31
Default Delay 33
DI1 150 Ohms 32
DI1 Pullup 32
DI2 150 Ohms 32
DI2 Pullup 32
Digital Output 1 31
Digital Output 2 31, 33
Digtal Output 1 33
DO Bi-Stable 32
DO Monostable 33
Fast AI (DI1) 31
Fast AI (DI2) 31
wiring examples
emergency shut off 61
plunger lift 58
tank level 63
tubing pressure 65
wiring, I/O Master
Analog Outputs 49
Digital Inputs 49
Digital Outputs 49
Link Alarms 50
radio pPower 48
Rx Data 48
Sensor Power 48
Tx Data 48
wiring, I/O Slaves
1-5 V sensors 54
4-20 mA sensors 51
Digital Inputs 50
Digital Outputs 50
radio power 50

X

Xmit Power, defined 41
Xmit Rate, defined 42


FreeWave®