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: Sep-2015

Warranty

FreeWave Technologies, Inc. warrants your FreeWave® Wireless Data Radio 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 evaluation 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.

Safety Information

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

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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, Division2.

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 +7.5 to +30.0 VDC.
- Input voltage for the I2-IOM-U is +6.0 to +30.0 VDC.
- Input voltage for the I2-IOS-C-U is +6.0 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.

The content of this guide covers FreeWave Technologies, Inc. models sold under FCC ID: KNY-6231812519 (FGR models) and KNY-42182112519 (FGR2 models).

All models sold under the FCC ID(s) listed above must be installed professionally and are only approved for use when installed in devices produced by FreeWave Technologies or third party OEMs with the express written approval of FreeWave Technologies, Inc. Changes or modifications should not be made to the device.

Warning! The FGR2-IOS-C-U, FGR2-IOS-CE-U, FGRIO-M, and FGR2-IO-IOE models have a maximum transmitted output power of 1 W. The antennas used must provide a separation distance of at least 23 cm from all persons and must not be co-located or operate in conjunction with any other antenna or transmitter.

Warning! The FGRIO-S model has a maximum transmitted output power of 100 mW. The antennas used must provide a separation distance of at least 23 cm from all persons and must not be co-located or operate in conjunction with any other antenna or transmitter.

FCC NEMA Installation and Label

Where applicable, the models described in this guide must be installed in a NEMA enclosure. When 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: KNY-6231812519 (FGR models) and KNY-42182112519 (FGR2 models).**"

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.

Schedule of Limitations

- Provision shall be made to prevent the rated voltage being exceeded by the transient disturbances of more than 140% of the peak rated voltage.
- The system shall be mounted in an ATEX certified enclosure with a minimum ingress protection rating of at least IP54 as defined in EN60529 and used in an environment of not more than pollution degree 2.
- The enclosure must have a door or cover accessible only by the use of a tool.
- Ambient Temperature -40°C to +75°C.
- Supply conductors should be a minimum 85°C.

Table Of Contents

Preface

This manual provides information specifically about using FreeWave I/O Master and I/O Slave radios in a wire replacement I/O system, and covers these models:

Note: If using these I/O Slaves or I/O expansion radio bases in a Modbus I/O system, see the **Modbus I/O User Manual**.

I/O Masters	I/O Slaves	I/O Expansion Radio Base
• FGRIO-M	• FGRIO-S (board level) • FGR2-IOS-C-U (board level) • FGR2-IOS-CE-U (enclosed)	• FGR2-IO-IOE

This document includes this information about using these radio models to set up a wire replacement I/O system:

- A basic introduction to both wire replacement and Modbus I/O to help use the correct application.
- Radio configuration including:
  - An introduction to the configuration tools.
  - How to access configuration parameters.
  - I/O Master and I/O Slave specific setup.
  - Additional radio communication settings.
- Installation and basic wiring diagrams.
- Terminal block diagrams and radio specifications.

Additional Information

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

- 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
- LUM0010AC Modbus I/O User Manual: Using the I/O radio family in a Modbus I/O system.

Note: All FreeWave documentation is available at www.freewave.com.

Terminology

- 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.

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, 8:00 AM to 5:00 PM Mountain Time (GMT -7).

- Call toll-free at 1.866.923.6168.
- In Colorado, call 303.381.9200.
- Contact us through e-mail at moreinfo@freewave.com.

Printing this Document

This document is set to print double-sided with a front cover and a back cover. Viewing this document online with a PDF viewer, may show pages intentionally left blank to accommodate the double-sided printing.

Document Styles

This document uses these styles:

- FreeWave applications appear as: **FreeWave**.
- Parameter setting text appears as: **[Page=radioSettings]**
- File names appear as: **configuration.cfg**.
- File paths appear as: **C:\Program Files (x86)\FreeWave Technologies**.

- User-entered text appears as: **xxxxxxxxx**.
- 3rd-party names appear as: **Notepad**®.

Caution: Indicates a situation that **MAY** cause damage to personnel, the radio, data, or network.

Example: Provides example information of the related text.

FreeWave Recommends: Identifies FreeWave recommendation information.

Important!: Provides semi-cautionary information relevant to the text or procedure.

Note: Emphasis of specific information relevant to the text or procedure.

Provides time saving or informative suggestions about using the product.

Warning! Indicates a situation that **WILL** cause damage to personnel, the radio, data, or network.

Documentation Feedback

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

1. Introduction

Wireless I/O communication is applicable in multiple industries including oil and gas, waste water management, irrigation, and utilities.

Example: 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.

Wireless I/O provides a cost effective, accurate, and reliable solution for application monitoring and control needs.

FreeWave radios provide these 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.
  - Connect FreeWave I/O Slave radios to sensors, transmitters, and switches to monitor and control devices.
- **Modbus I/O** - 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 describes how to set up FreeWave radios for use in a **wire replacement** I/O system.

Note: For information about setting up FreeWave radios for use in a Modbus I/O system, including Modbus register map details, see the **LUM0010AC Modbus IO User Manual**.

1.1 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. **Note**: For information about the serial base models, see the LUM0017AB IO Expansion User Manual. **Important!**: This document does NOT provide information about the serial bases or expansion models.	N/A	x
IOEX-4440 IOEX-4422	• Expansion models that can be added to a radio base or serial base device to expand the number of I/O channels available.	N/A	x

Model	Description	Wire Replacement I/O	Modbus I/O

IOEX-4404	• 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.
	Note: For information about the expansion models, see the LUM0017AB IO Expansion User Manual.
	Important!: This document does NOT provide information about the serial bases or expansion models.		

1.2 Wire Replacement I/O Systems

A wire replacement I/O system can exist as:

- a standalone system with an I/O Master (FGRIO-M) and
- a maximum of four I/O Slaves, not exceeding the Master's I/O terminal port count.

Example 1

- 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.

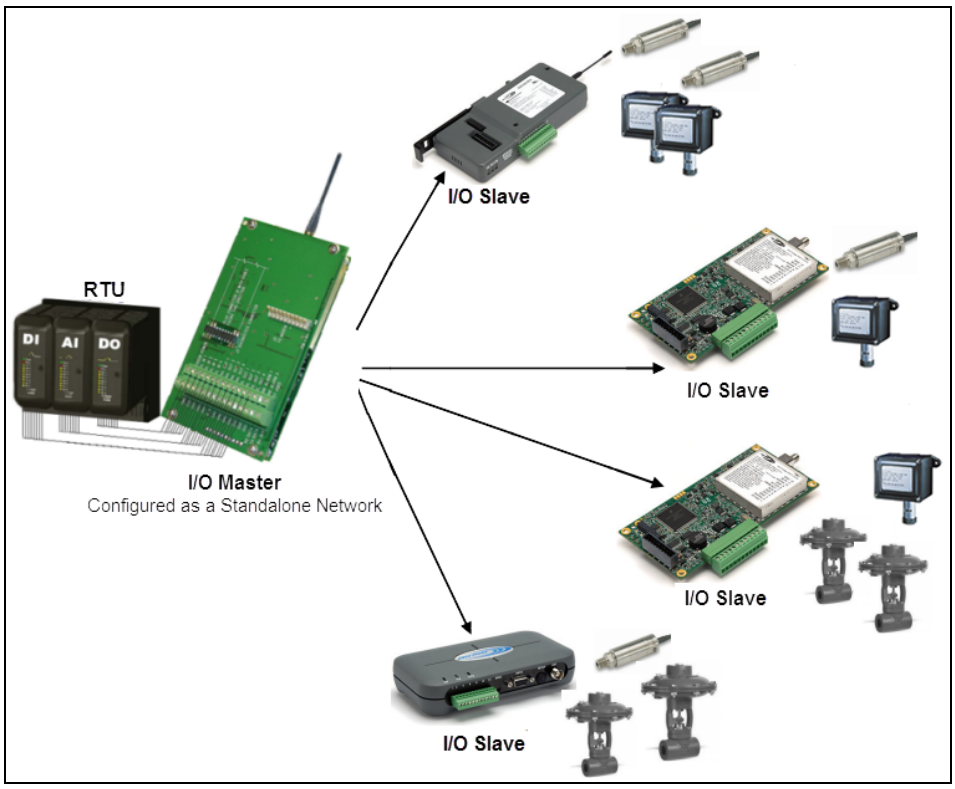


Figure 1: Example 1

A wire replacement I/O system can also be integrated into a FreeWave radio network.

Example 2

- the I/O Master is not the Master radio 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.

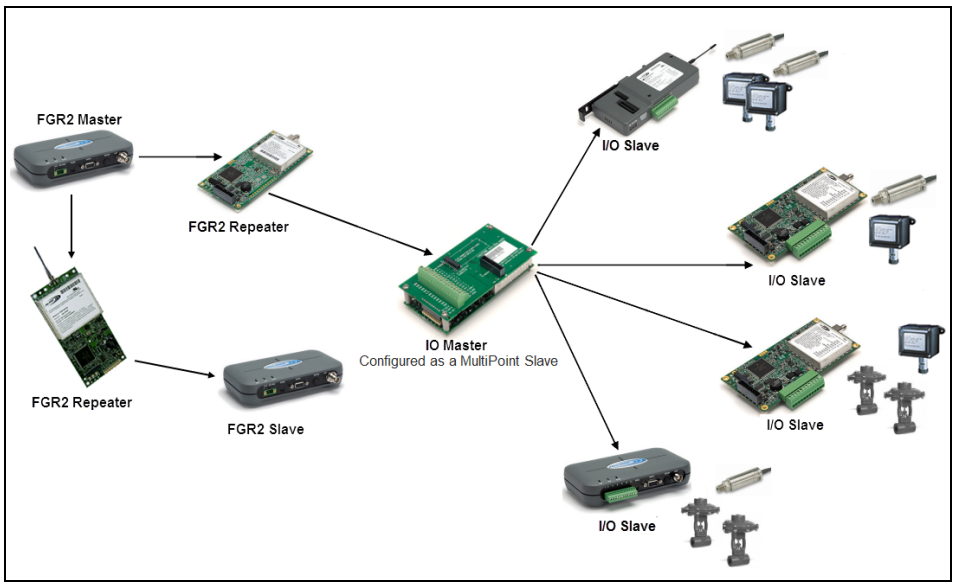


Figure 2: Example 2

1.3 Configuration Tool Options

Note: The terms **modem** and **radio** 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 the same when referring to FreeWave products.

When the radio is in **Setup** mode, use these setup tools to configure the settings on the radio:

- **Tool Suite** - **Tool Suite** is the current configuration software and replaces EZConfig, and is the recommended method for programming your radios.
  - It provides a group of tools for configuring the devices in the network and for monitoring the network's performance. Using the **Configuration** application in **Tool Suite**, you can program changes to the radio's settings.
  - **Tool Suite** is available for download from www.freewave.com.
- **Terminal Emulator** - A terminal emulator program (e.g., **HyperTerminal** or **TeraTerm**) offers many of the same configuration options that are available in the Configuration application in **Tool Suite**.
  - If using versions of the **Windows**® operating system prior to **Windows**® **7**, **HyperTerminal** is included in the operating system installation.
  - Use a chosen terminal emulator program to program the radio.
  - The **Setup Terminal** application in **Tool Suite** provides the same interface that is available using a terminal emulator.

1.3.1 Tool Suite and Terminal Emulators

If using a terminal emulator, the tabs for a device in Tool Suite mirror the **Setup** main menu selections.

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**.

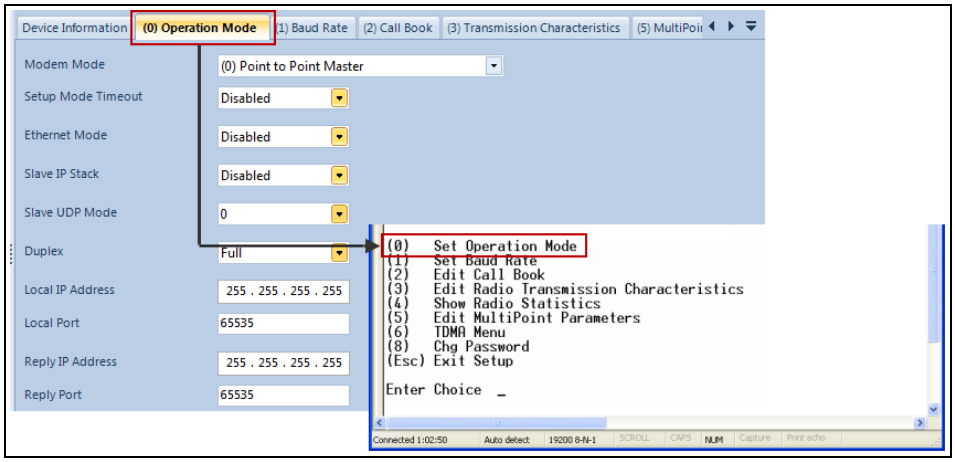


Figure 3: Example of the same options in Tool Suite and Terminal Emulator

Tip! Use the **Setup Terminal** application in Tool Suite to use and view the terminal menus. It appears with the same menus and programming settings when using a terminal emulator.

Note: 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.

1.4 Radio Setup Mode

To read the current settings from or to program a radio, the radio must be in Setup mode. When a radio is in Setup mode, all three LEDs appear as solid green (● ● ●).

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 34).

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 radio. For more information, see Setup Port (on page 33).

Use the **Setup Mode Timeout** parameter on the **Operation Mode** tab to set the radio to exit Setup Mode automatically. When the setting is enabled, if the radio has not received any menu

selections or programming information within 5 seconds, it exits Setup and resumes its previous mode.

1.4.1 Using Tool Suite to Connect to and Program Radios

To read and program a radio using **Tool Suite**, to connect the radio to a computer that runs the **Tool Suite** software.

Use **Tool Suite** to set up a template version of a radio. Templates include settings that apply to more than one radio in the network.

Procedure

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

   FreeWave Recommends: Use a diagnostic cable and the diagnostic port.

2. Connect the power supply to the radio and the power source and turn on the radio.
3. With the radio connected to the computer in **Tool Suite**, click **Configuration** in the Application pane to open the Configuration application.
4. Verify the correct port is selected in the **Com Port** field in the Configuration ribbon.
5. To place enclosed radios in Setup mode, press the Setup button on the back of the FreeWave radio.

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

   To place board-level radios into Setup Mode:

   a. Short pins 2 & 4 (Brown to Black) on the 10 pin header next to the LEDs.

   b. 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 radio's current settings.
7. Make the necessary parameter changes and do one of the following to send the changes to the radio:

   a. To send only the changed parameters, on 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 radio.

   b. To send all the settings for all parameters, within the Configuration application in the Network Title ribbon, click All.

   c. To set a device back to its factory default settings, within the Configuration application in the Network Title ribbon, click Default.

1.4.2 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 radio, open a session, and ensure that the port settings are set to the following for a proper connection to the radio:

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

These access the radio's **Setup** menu using the Setup Terminal application in **Tool Suite**. Setup Terminal contains the port settings above, by default.

Note: For more information about using **Tool Suite**, see the **Tool Suite User Manual** available by selecting **File > Help** in the **Tool Suite** software.

Procedure

1. Plug a serial cable into the Com 1 of the radio.
2. Connect the cable to a Com port on the computer running **Tool Suite**.
3. Connect the radio to a power source.
4. Open **Tool Suite**.
5. On the **Applications** pane, select **Setup Terminal**.
6. Click the **Connection** list box arrow and select the COM port on the computer the radio is connected to.

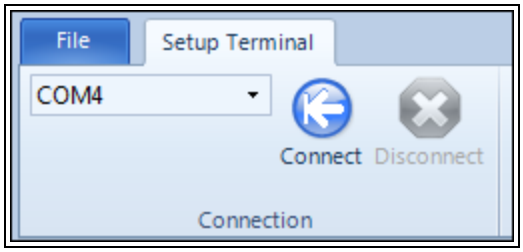


Figure 4: Tool Suite Connection list box

7. Click **Connect**.
8. To connect the to the radio, in enclosed radios, press the **Setup** button on the back of the FreeWave radio.

9. If connected to the diagnostics port, press <Shift+U> (Capital 'U') to activate the **Setup** menu.

View the Setup menu in Board-level Radios

1. Short pins 2 & 4 (Brown to Black) on the 10 pin header next to the LEDs.
2. If using a data cable (Part Number: ASC3610DB or ASC3610DJ), press the Setup button.
3. If using the gray ribbon diagnostic cable (Part Number: AC2009DC) or the black diagnostic cable (Part Number: ASC0409DC), press <Shift+U> (capital U) to activate the Setup menu.

When Setup is activated, the FreeWave Setup Main Menu appears in the terminal emulator window.

- All three LEDs on the radio light green ( ) and stay green as long as the radio is in Setup mode.
- The main setup menu appears:

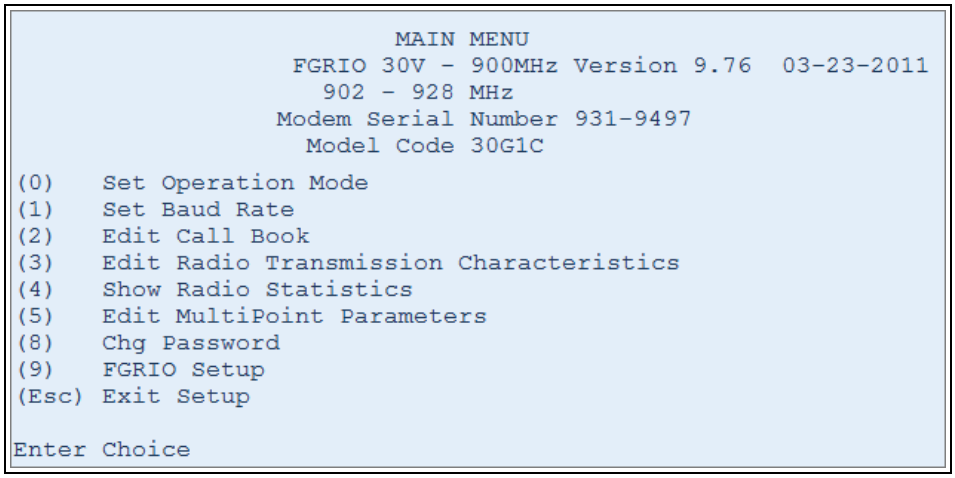


Figure 5: Example: Tool Suite IO Main Menu

Important!: When navigating through the **Setup** menu and making changes to the parameters, the parameters are sent to the radio **immediately**.

Note: See Troubleshooting Terminal Emulators (on page 127) for more information.

1.5 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

2. Configuring an I/O Master

This section 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 Radios (on page 21) and then use the information in this section to:

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 section 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.

Note: For more information, see Other Radio Settings (on page 57).

2.1 Configuring an I/O Master

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.

Note: 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 this procedure can be changed or remain at the factory default setting.

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

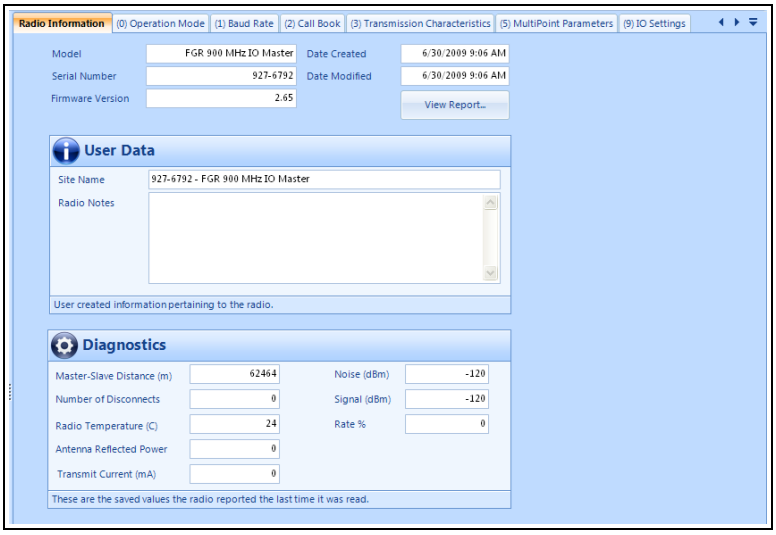


Figure 6: Tool Suite Radio Information tab

5. Click the **Operation Mode** tab.
6. In the **Modem Mode** field, select one of these options:
   - **(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.
7. Verify the **Repeaters** parameter is set to **Enabled** in the serial network Master.

Note: The Ethernet options that are shown in this tab do NOT apply to an I/O Master and should be left at their factory default settings.

8. If **(E) FGRIO** is selected in Step 6, continue with the next step because the **Baud Rate** tab settings do not apply.
   If **(3) Point to MultiPoint Slave** is selected in Step 6, click the **Baud Rate** tab and set these parameters to match the device that is connected to the radio's data port.
   - Baud Rate
   - Data Parity
   - Serial Interface
   - Flow Control
9. Click the **Call Book** tab.
10. Enter the I/O Slaves' serial numbers in the **Number** column.

    Note: The **Repeater 1** and **Repeater 2** columns remain black because Repeaters are NOT used in a wire replacement network.

11. Click the **Transmission Characteristic** tab and set these parameters:
    - **Frequency Key** - If **(E) FGRIO** was selected in Step 6, select a unique key.

      FreeWave Recommends: Change the key from the default setting of **5**.

      Note: If **(3) Point to MultiPoint Slave** is selected in Step 6, 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.

      Note: If **(3) Point to MultiPoint Slave** is selected in Step 4, both the **Max** and **Min Packet Sizes** must match the network Master.
    - **RF Data Rate** - Set to **Normal**.
12. Click the **MultiPoint Parameters** tab and set these parameters:
    - **Master Packet Repeat** - Set to **3**.
    - **Network ID** - If **(E) FGRIO** was selected in Step 6, enter a unique number between 1 and 4095 (except 255).

Note: If **(3) Point to MultiPoint Slave** is selected in Step 4, the **Network ID** must match the network Master.

- **Repeaters** - Set to **On**.
- **Subnet ID** - If **(3) Point to MultiPoint Slave** is selected in Step 6:
  - Set the **Rx** portion of the subnet to **0**.
  - Set the **Tx** portion to **F** if the I/O Master links directly to the network Master.

13. Click the **I/O Settings** tab and set these parameters:
    - **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.

    Note: The I/O Slaves are labeled by their position in the Master's **Call Book**.

    Example: **Slave 0** refers to the serial number in entry to call **0**.

14. Send the settings to the radio using the **All** or **Quick** options on the **Network Title** ribbon in **Tool Suite**.

2.2 I/O Masters in Tool Suite

- When reading an I/O Master radio's settings through **Tool Suite**, the radio appears as a FGR 900 MHz I/O Master.
- If a radio template was created for an I/O Master in the Configuration application in **Tool Suite**, select FGR 900 MHz Master as the radio type.

Note: For more information about using Tool Suite, see the **Tool Suite User Manual** available by selecting **File > Help** in the Tool Suite software.

2.3 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 its Modem Mode (or Operation Mode). The mode tells the radio what network type it is in and what role it plays and enables other settings for that radio.

Set the modem mode in the **Operation Mode** tab, using the **Modem Mode** field.

Note: These settings are available in the Operation Mode menu in the terminal interface.

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

- **(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.

Important!: 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.

2.4 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 radio and the instrument or computer to which the radio's data port is connected.

Important!: These settings are unique to each radio, 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.

2.4.1 Baud Rate

Baud Rate	
Setting	**Description**
Default Setting:	115200
Options:	600, 1200, 2400, 4800, 9600, 19200, 38400, 57600, 76800, 115200, 230400
Terminal Menu:	(1) Set Baud Rate
Description:	This is the communication rate between the radio's data port and the instrument to which it is connected. • This setting is independent from the Baud Rate for the other radios 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. **FreeWave Recommends**: With a **Baud Rate** setting of 38,400 or higher, 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.

2.4.2 Data Parity

Data Parity	
Setting	**Description**
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 radios. The default setting is **8-None-1** and is the most commonly used serial communications protocol. This table describes each option:

Option	Data Bits	Parity	Stop Bits
0	8	None	1

Data Parity	
Setting	**Description**

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

2.4.3 Flow Control

Flow Control	
Setting	**Description**
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 radio. **FreeWave Recommends**: Use **Flow Control** if the Baud Rate is higher than 19200.

2.4.4 Modbus RTU

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

Modbus RTU	
Setting	**Description**
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 radio to wait for an

Modbus RTU	
Setting	**Description**
	amount of time “gathering” data before sending out the radio link. • 0 (Disabled) - The radio 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 radio 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 radio waits for 6 slots, gathering data up the whole time. At the end of the 6 slots, the radio sends all received data in one “burst.” This is the appropriate setting for most Modbus RTU devices. • 2 or higher - The radio waits for a number of slots calculated using the following formula: (Modbus RTU setting + Master Packet Repeat setting + 1) x 2 **Example**: In a radio where the **Modbus RTU** setting is **2** and the **Master Packet Repeat** setting is **3**, the radio waits for (2 + 3 + 1) x 2, or 12 slots.

2.4.5 Serial Interface

Serial Interface	
Setting	**Description**
Default Setting:	(0) RS232

Options:	• (0) RS232 - Also used for TTL.
	• (1) RS422 -
	  • **Modbus RTU** must be enabled
	  • **Turn Off Delay** set to at least **4**.
	• (2) RS485 -
	  • **Modbus RTU** must be enabled
	  • **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 radio.
	  • When the radio is not sending data to the serial port, CD is de-asserted.
	  • When the radio is sending data to the serial port, CD is asserted.
	  • The CD line no longer has any radio link state functionality.

Serial Interface	
Setting	**Description**
	• **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. **Note**: If set to anything other than **0**, the **Setup Port** parameter on 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.

2.4.6 Setup Port

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

Setup Port	
Setting	**Description**
Default Setting:	(3) Both
Options:	• (1) Main Only - Programming and reading a radio's setup information is done through the data port. • (2) Diagnostics Only - Programming and reading a radio'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 radio'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 radio, Main or Diagnostics, is used to access the parameter settings in **Tool Suite** or enter the Setup main menu in the terminal interface.

2.4.7 Turn Off Delay

Turn Off Delay	
Setting	**Description**
Default Setting:	0

Turn Off Delay	
Setting	**Description**
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 radio 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.
	  • **Turn Off Delay** must be set to a value of at least 4 for RS422 and RS485 operation.
	  • 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.

2.4.8 Turn On Delay

Turn On Delay	
Setting	**Description**
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.

2.4.9 Use Break to Access Setup

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

Use Break to Access Setup	
Setting	**Description**
Default Setting:	Disabled
Options:	• (0) - Disabled - The break command is disabled in the radio.

Use Break to Access Setup	
Setting	**Description**
	• (1) - Enabled - The Setup menu is set at 19200 bps. • (2) - Enabled - The Setup menu is set 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 radio 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. **Example**: 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.

2.5 Establishing Communication with I/O Slaves

For the I/O Master to communicate with the I/O Slaves, it needs to know what other devices are available for it to communicate with.

Important!: On an I/O Master, 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 radios.
  - The **Repeater** columns must be left blank because 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 these guidelines.
  - The value can be any value between 0 and 4095, except 255.
  - Avoid using numbers that coincide with nearby landmarks or highways.

FreeWave Recommends: Use an ID of four characters.

Example: Use the last four digits of the I/O Master's serial number. This ensures the number is 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.

2.6 Setting I/O Master RF Transmission Characteristics

The **Transmission Characteristics** parameters are used to change settings that determine how data is sent between radios in the network.

In an I/O Master, set these parameters in the **Transmission Characteristics** tab.

Note: Many of these parameters must be maintained throughout the network for proper functionality. These parameters are also available in the **Edit Radio Transmission Characteristics** menu in the terminal interface.

- 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 57).

2.6.1 Frequency Key - 900MHz

Frequency Key	
Setting	**Description**
Default Setting:	5
Options:	0 to 9 and A to E **Important!**: Do NOT use **Frequency Key E** with the 915-928 MHz, 916-920 MHz, and 921-928 MHz hop tables. **Important!**: 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**: Change the Frequency Key setting to an option that is NOT 5.
Terminal Menu:	(3) Edit Radio Transmission Characteristics > (0) FreqKey
Description:	• Fifteen choices are available for the **Frequency Key** (0-9 and A-E) setting, representing 15 different pseudo-random hop patterns.

Frequency Key	
Setting	**Description**
	• Hopping patterns minimize the interference with other FreeWave radios operating in the area. • 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 radios may hop on in the 902-928MHz band. **Example**: If 10 pairs of FreeWave radios are operating on different networks in close proximity, setting a different **Frequency Key** value reduces the chance that radios 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. Tip! Gain additional network separation by adjusting the **Max Packet Size** and **Minimum Packet Size**.

2.6.2 Max Packet Size and Min Packet Size

Max Packet Size and Min Packet Size	
Setting	**Description**
Default Options:	Max Packet Size = 8 Min Packet Size = 9
Options:	• Any number between 0 and 9. • If the I/O Master's Modem Mode is set to **(3) Point to MultiPoint Slave**, the **Maximum Packet Size** and **Minimum Packet Size** MUST match the network Master. **FreeWave Recommends**: In a wire replacement I/O system, set both the **Maximum Packet Size** and **Minimum Packet Size** to **2** or higher.
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. • If using Digital Inputs and Outputs for pulse counting, the packet size effects how many pulses the I/O System can register.

Max Packet Size and Min Packet Size	
Setting	**Description**
	• At a packet size of **Max = 2 Min = 2**, the maximum available count would be 6Hz. • At a packet size of **Max = 9 Min = 9**, the maximum available count would be 3Hz. • The pulse state must last for a 50% duty-cycle (that is, a 3Hz pulse needs to last at least 166.6ms and a 6Hz pulse needs to last at least 83.3ms).

This table provides the available packet sizes in bytes for an I/O System by chartering the **Maximum Packet Size** and **Minimum Packet Size** setting when the **RF Data Rate** is set to **3**.

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

2.6.3 RF Data Rate

RF Data Rate	
Setting	**Description**
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 radios, including any serial radios in the network, must be set to an **RF Data Rate** of **3**.

2.7 Setting I/O Master MultiPoint Parameters

The MultiPoint Parameter options are used to change several different parameters in the radio that determine the characteristics of a MultiPoint network.

In an I/O Master, set these parameters in the **MultiPoint Parameters** tab.

Note: 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 35).
- 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 67).

2.7.1 Master Packet Repeat

Master Packet Repeat	
Setting	**Description**
Default Setting:	3
Options:	In a wire replacement I/O system, the I/O Master must have a **Master Packet Repeat** parameter setting of **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 acknowledgments, 100% confidence every Slave has received every packet cannot be met.

2.7.2 Repeaters

Repeaters	
Setting	**Description**
Default Setting	Enabled

Repeaters	
Setting	**Description**
Options:	(0) Disabled, (1) Enabled
Terminal Menu:	(5) MultiPoint Parameters > (0) Number Repeaters
Setting:	• This setting MUST be set to **Enabled** for all radios in the wire replacement I/O network, including any serial radios in an integrated network. • 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**.

2.7.3 Subnet ID - I/O Master

Subnet ID	
Setting	**Description**
Default Setting:	F, F
Options:	• Any number between 0 and 9 • 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 radio 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**.

2.8 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**.

Note: This setting is available in option **0** in the **FGRIO Setup** menu in the terminal interface.

After enabling I/O, set these parameters in the IO Settings tab.

- Sensor Power
- Default Delay
- Default Output

Use the **Analog Out** and **Digital Out** fields in the **IO Settings** tab to map the I/O Master's outputs to the I/O Slave inputs.

Note: For more information about mapping analog and digital outputs, see Mapping I/O Master Outputs to I/O Slave Inputs (on page 42).

2.8.1 Default Delay

Default Delay	
Setting	**Description**
Default Setting:	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. **Example**: A value of 36 represents 36 x 0.28 = 10.08 seconds. Set between 0 and 255 using these examples as guidelines: • 1 = 0.28 seconds • 4 = 1.12 seconds • 25 = 7 seconds • 255 = 71.4 seconds

2.8.2 Default Output

Default Output	
Setting	**Description**
Default Setting:	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.

2.8.3 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.

Note: 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.

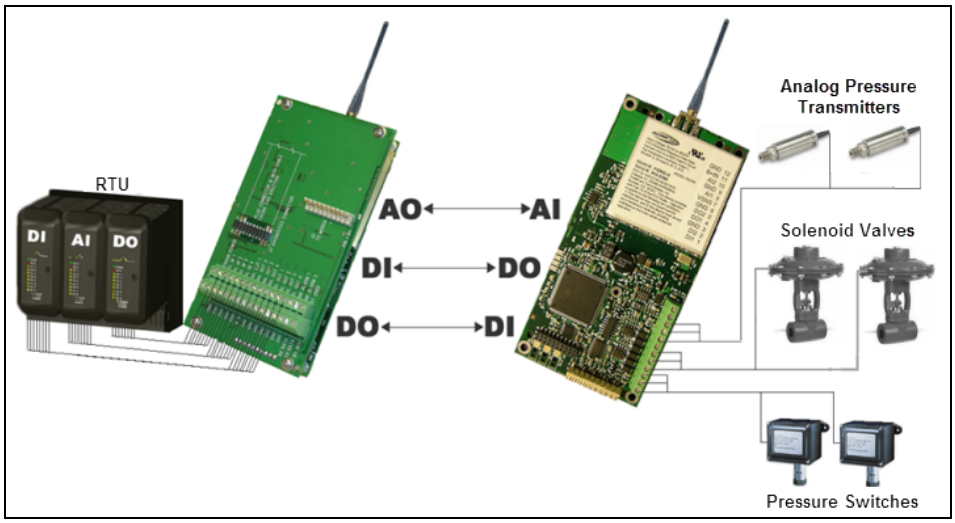


Figure 7: Mapping Diagram

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**, click 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**.

Map I/O Master Outputs to I/O Slave Inputs in the Terminal Interface

1. Verify the I/O Master is in Setup mode and connected to a terminal interface.
2. On the main **Setup** menu, click **(2) Call Book**.
3. Determine which I/O Slave to map to the I/O Master and the **I/O Master's Call Book Entry** number that lists that I/O Slave's serial number.
4. Determine which analog or digital input from the I/O Slave to map to the I/O Master.

   Note: 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.

5. Using this table, find the number listed at this intersection:
   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.

	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

6. In the terminal interface, press <Esc> to return to the main **Setup** menu and select **(9) FGRIO Setup**.
7. Select the output from the I/O Master to connect to the input from the I/O Slave and enter the number to the left of the selected output.
8. Enter the number found in Step 5.

   Note: This number should display to the right of the selected output.

9. Press <Esc> and repeat Steps 5 to 8 for additional connections.
10. Press <Esc> to return to the main **Setup** menu.
11. Press <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:

1. Verify the **Call Book** entry # of I/O Slave #930-0004.

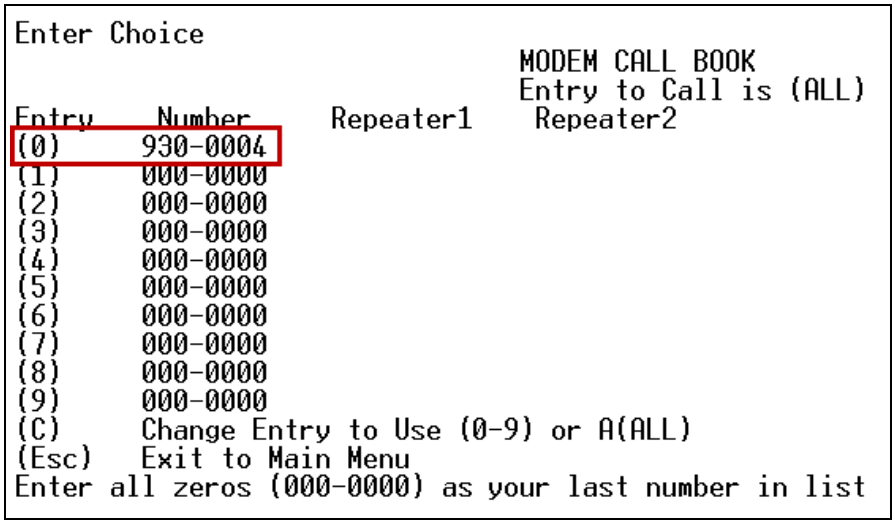


Figure 8: Example of I/O Slave #

   The entry number is **0**.

2. Use the table to find **Call Book** entry # 0.
3. View the column for I/O Slave **Analog Input #2**.
   The value listed is **2**.
4. Enter a **2** for **Analog Output #1** of the I/O Master.

2.8.4 Sensor Power

Sensor Power	
Setting	**Description**
Default Setting:	(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.

Sensor Power	
Setting	**Description**
	• 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.

3. Configuring an I/O Slave

This section 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 Radios (on page 21) 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.

Important!: The settings in this section are 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.

Note: For more information, see Other Radio Settings (on page 57).

3.1 Configuring an I/O Slave

This section describes how to quickly set an I/O Slave in a wire replacement I/O network.

Note: 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 this procedure can be changed or remain at the factory default setting.

Important!: 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 radio to the serial port of a computer either through a serial cable or using the diagnostics cable.
2. Connect the radio to a power source (+6.0 to +30.0 VDC).
3. Open **Tool Suite** and click **Configuration** in the **Application** pane.
4. Click **Read Radio** to read the radio's current settings.

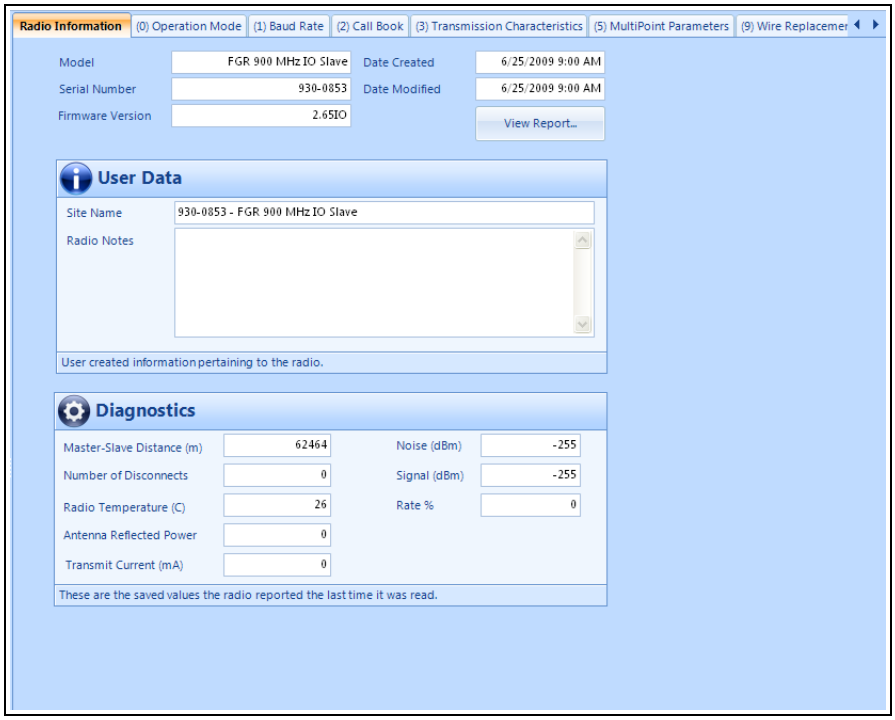


Figure 9: Tool Suite Radio Information tab

5. Click the **Operation Mode** tab.
6. Select either the **(E) FGRIO Slave (Wire Replacement)** or **(E) FGRIO Slave (NOT IO-MODBUS)**, depending on the version of **Tool Suite**.
7. Click the **Call Book** tab.

8. Enter the I/O Master's serial numbers in the **Number** column.

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

9. Click the **Transmission Characteristic** tab and set these parameters to the same settings as the I/O Master:
   - Frequency Key
   - Hop Table Version
   - Hop Table Size
   - Maximum Packet Size
   - Minimum Packet Size
   - RF Data Rate
10. Click the **MultiPoint Parameters** tab and set these 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.

11. Click the **Wire Replacement** tab and set these parameters:
    - **Digital Out 1 and Digital Out 2** - Mapped to the Digital Inputs of the I/O Master.

      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 configuring an FGR2-IOS-CE-U (an enclosed radio 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 the device is powered on 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

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

3.2 I/O Slaves in Tool Suite

When reading 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, or FGR2 900 MHz I/O Slave (Enclosed).

When creating a radio template for an I/O Slave in the Configuration application in **Tool Suite**, select these radio types to ensure that the proper settings appear:

- 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.

Note: For more information about using **Tool Suite**, see the **Tool Suite User Manual** available by selecting **File > Help** in the **Tool Suite** software.

3.3 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 its Operation Mode or Modem Mode. The mode tells the radio what network type it is in and what role it plays.

- The mode selected enables other settings for that radio.
- 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 the 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.

3.4 Establishing Communication with the I/O Master

For the I/O Slave to communicate with the I/O Master, the I/O Slave needs to know which radio is the I/O Master. In a wire replacement I/O system, set **both** the **Call Book** and the **Network ID** to establish communication between the I/O Slave and I/O Master.

Note: 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**
  - 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.

3.5 I/O Slave RF Transmission Characteristics

The Transmission Characteristics parameters are used to change settings that determine how data is sent between radios in the network. In each I/O Slave in the wire replacement I/O system, set these 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 be changed or remain at their factory default settings to establish a link with the I/O Master.

Note: Each of the additional parameters is described in detail in Setting Other RF Transmission Characteristics (on page 57).

3.6 I/O Slave MultiPoint Parameters

The MultiPoint Parameter options are used to change several different parameters in the radio that determine the characteristics of a MultiPoint network.

In an I/O Slave, set these 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 be changed or remain at their factory default settings. Each of the additional parameters is described in detail in Setting Other MultiPoint Parameters (on page 67).

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.

3.7 I/O Slave Wire Replacement Parameters

The other Wire Replacement options are used 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.

Note: These settings are available in the FGRIO **Setup** menu in the terminal interface.

Important!: The **Fast AI (DI1) and Fast AI (DI2)** settings doNOT apply to wire replacement I/O. If 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**.

3.7.1 Digital Output 1 and Digital Output 2

Digital Output 1 and Digital Output 2	
Setting	**Description**
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.

3.7.2 AI1 250 Ohms and AI2 250 Ohms

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

AI1 250 Ohms and AI2 250 Ohms	
Setting	**Description**
Default Setting:	Disabled
Options:	Disabled, Enabled

AI1 250 Ohms and AI2 250 Ohms	
Setting	**Description**
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 a 4-20 mA sensor. • When enabled, the resistor can take the place of an inline resistor between the device and the Slave's analog input.

3.7.3 DI1 150 Ohms and DI2 150 Ohms

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

DI1 150 Ohms and DI2 150 Ohms	
Setting	**Description**
Default Setting:	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.

3.7.4 Default Delay

Default Delay	
Setting	**Description**
Default Setting:	0
Options	Any number between 0 and 255, representing 0.28 second units
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. **Example**: A value of 36 represents 36 x 0.28 = 10.08 seconds.

Default Delay	
Setting	**Description**
	Set between 0 and 255 using these examples as guidelines: • 1 = 0.28 seconds • 4 = 1.12 seconds • 25 = 7 seconds • 255 = 71.4 seconds

3.7.5 Digital Output 1 Default and Digital Output 2 Default

Digital Output 1 Default and Digital Output 2 Default	
Setting	**Description**
Default Setting:	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 Output returns to when the device is powered up or when the device loses its link to the Master in the network. **Note**: If programming a Digital Output to turn on after it loses a link, verify the energized device can sustain the state undamaged, in case the loss is lengthy.

3.7.6 DI1 Pullup and DI2 Pullup

DI1 Pullup and DI2 Pullup	
Setting	**Description**
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.

DI1 Pullup and DI2 Pullup	
Setting	**Description**
	• 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:	**Important!**: When toggling this coil between **ON** and **OFF**, the device automatically reboots. • 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.

3.7.7 DO Bi-Stable

DO Bi-Stable	
Setting	**Description**
Default Setting:	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.

3.7.8 DO Monostable Time

DO Monostable Time	
Setting	**Description**
Default Setting:	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.
	• 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.

4. Other Radio Settings

The settings described in this section are not required to establish a wire replacement I/O system, but are available on both the I/O Master and I/O Slave radios. Set the additional radio transmission and MultiPoint parameters in this section as needed based on the network needs.

4.1 Setting Other RF Transmission Characteristics

The settings 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. Set these parameters in the **Transmission Characteristics** tab.

Note: These settings are available in the Edit Radio Transmission Characteristics menu in the terminal interface.

4.1.1 Frequency Zones - 900MHz

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

Frequency Zones - 900MHz	
Setting	**Description**
Default:	All zones selected
Options:	See below.
Terminal Menu:	(3) Edit Radio Transmission Characteristics > (0) FreqKey > F > (3) Frequency Zone

Frequency Zones - 900MHz	
Setting	**Description**

Description:	This parameter 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 shown in LSB to MSB, these bits directly represent the zones that the radio operates on from lowest frequency to highest.
	  • A value of **1** in the bit sequence instructs the radio to operate within the represented band.
	  • A value of **0** instructs the radio to bypass the represented band.
	Important!: This feature should only be used with the standard hop table.
	• Set the **Hop Table Version** to **902-928 MHz** when using **Frequency Zones**.
	  • When selecting another **Hop Table Version**, the limitations of that selection are also applied to the hopping pattern.
	Example: If **916-920** is selected as the **Hop Table Version**, only the middle of the band is available in the pattern. Then, if Frequency Zones 5, 6, 7, 8, and 9 are set to **0**, NO allowable frequencies are available for the radio 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

Zone Number	Beginning Freq. (MHz)	Ending Freq. (MHz)	Number Of Channels
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

Enable Frequency Zones in Tool Suite

1. In the Tool Suite Configuration application, select the device to program.
2. Click the **(3) Transmission Characteristics** tab.
3. Click **Frequency Zones**to view the frequency zones available.
4. Select the check boxes next to the Frequency Zones to enable.

Enable Frequency Zones in the Terminal Interface

1. On the main Setup menu, click **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).

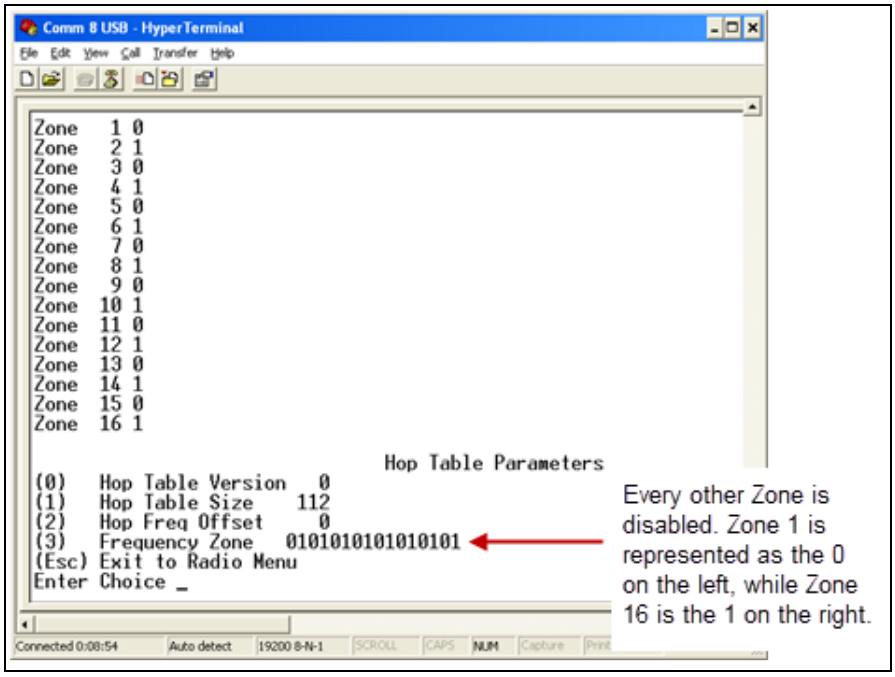


Figure 10: Example: Frequency Zones in the Terminal Interface

4.1.2 High Noise

High Noise	
Setting	**Description**
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.

4.1.3 Hop Table Size - 900MHz

Important!: All radios in a network MUST have identical **Hop Table** settings to communicate properly.

Hop Table Size - 900MHz	
Setting	**Description**
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**: Use **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.

4.1.4 Hop Table Version - 900MHz

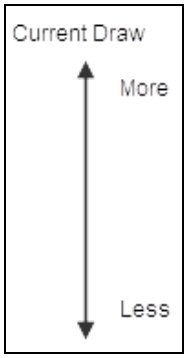
Note: All radios in a network must have identical Hop Table settings to communicate properly.

Hop Table Version - 900MHz	
Setting	**Description**
Default Setting:	902-928 MHz
Options:	• 902-911 - 919-928 MHz • Uses 902-928 MHz with center frequencies of 911-919 MHz notched out. • 902-928 MHz, full band • 902-915 MHz • 903.744-926.3232 MHz • 915-928 MHz • 916-920 MHz • 921-928 MHz **Important!**: 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 radio uses.

<table>
<tr><th colspan="2">Hop Table Version - 900MHz</th></tr>
<tr><th>Setting</th><th>Description</th></tr>
<tr><td></td><td>In the terminal interface, enter the number that corresponds to the frequency band:
<table>
<tr><th>Number to Enter in Terminal Menu</th><th>Frequency Band</th></tr>
<tr><td>0</td><td>902-928 MHz, uses the full band</td></tr>
<tr><td>1</td><td>915-928 MHz</td></tr>
<tr><td>2</td><td>903.744-926.3232 MHz</td></tr>
<tr><td>3</td><td>916-920 MHz</td></tr>
<tr><td>4</td><td>921-928 MHz</td></tr>
<tr><td>5</td><td>902-911_919-928 MHz, uses 902-928 MHz with center frequencies of 911-919 MHz notched out.</td></tr>
<tr><td>6</td><td>902-915 MHz</td></tr>
</table></td></tr>
</table>

4.1.5 Low Power Mode

Low Power Mode	
Setting	**Description**
Default Setting:	0
Options:	Any number between 0 and 31. **Note**: 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 radio's LEDs. • When set to **2** through **31**, the radio sleeps between slots. • When the radio is asleep, it hears nothing from the I/O Master. **Example**: At a setting of **2** the radio sleeps 1 out of 2 slots; at a setting of **3** the radio sleeps 2 out of 3 slots, and so on. This 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, radio remains awake, radio is listening to the I/O Master's transmissions on every slot. In this case, the radio needs to be awakened before it is able to send data to the I/O Master.
	2	LEDs dimmed, radio sleeps every other slot.
	3	LEDs dimmed, radio sleeps 2 of 3 slots.
	4-31	LEDs dimmed, radio sleeps the number of slots corresponding to the setting. **Example**: Using a setting of 31, the radio sleeps 30 of 31 slots.

- 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:
  - 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).

4.1.6 MCU Speed

MCU Speed	
Setting	**Description**
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 radio.

4.1.7 Remote LED

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

Remote LED	
Setting	**Description**
Default Setting:	(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 using a radio with the optional 20-pin connector, 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.

4.1.8 Retry Timeout

Retry Timeout	
Setting	**Description**
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.

Retry Timeout	
Setting	**Description**
	• 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.

4.1.9 RTS to CTS

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

4.1.10 Slave Security

Slave Security	
Setting	**Description**
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.

4.1.11 Transmit Power

Transmit Power	
Setting	**Description**
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 radio. • A setting of 10 is approximately 1 W of output power.

Transmit Power	
Setting	**Description**

	FreeWave Recommends: In a wire replacement application, use a low setting, such as 2 or 3 because the signal does not likely need to travel a great distance.
	• With a higher power setting with radios within close range can increase the amount of noise in the system.
	  • When testing radios that are in close proximity to one another, set the **Transmit Power** to a low number.
	  • When deploying radios to the field, raise the **Transmit Power** number accordingly.

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

Setting	Transmit 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

4.1.12 Transmit Rate

Transmit Rate	
Setting	**Description**
Default Setting:	(1) Normal
Options:	(0) Diagnostics

Transmit Rate	
Setting	**Description**
	(1) Normal
Terminal Menu:	(3) Edit Transmission Characteristics > (3) Xmit Rate
Description:	The setting for normal operation of the radio is **1**. • When set to **0**, the radios transmit back and forth continuously regardless if they have any actual data. • **0** should only be used 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.

4.2 Setting Other MultiPoint Parameters

Set these 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.

4.2.1 1 PPS Enable Delay

1 PPS Enable Delay	
Setting	**Description**
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.

Setup 1PPS Enable/Delay

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

Note: 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.

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 radio 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.

4.2.2 Diagnostics

Diagnostics	
Setting	**Description**
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. **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. **Note**: Diagnostics is always secondary to actual transmitted data.

4.2.3 DTR Connect

DTR Connect	
Setting	**Description**
Default Setting:	(0) Off

DTR Connect	
Setting	**Description**
Options:	• (0) Off - When set to off in the Slave, the radio 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 radio transmits data in bursts.
Terminal Menu:	(5) MultiPoint parameters > (4) DTR Connect

Description:	• Determines how the radio 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 radio has two separate transmit and receive user data buffers.
	  • These buffers are 2 Kbytes each. In case of a buffer overflow, the radio outputs unpredictable data.

4.2.4 Local Mode

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

4.2.5 Max Slave Retry

Max Slave Retry	
Setting	**Description**
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 acknowledgment from the I/O Master.

4.2.6 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.

Note: This setting does not apply because a wire replacement I/O system has only one Master.

4.2.7 Radio ID

Radio ID	
Setting	**Description**
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 radio with an arbitrary, user-defined, 4-digit number that identifies the radio in Diagnostics mode.

4.2.8 Radio Name

Radio Name	
Setting	**Description**
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 radio a name, such as its location. • Naming radios can be helpful to identify a radio when in Diagnostics mode.

4.2.9 Repeater Frequency

Repeater Frequency is used when a parallel Repeater is present.

Note: This setting does not apply to an I/O Master or an I/O Slave because a wire replacement I/O system cannot contain Repeaters.

4.2.10 Retry Odds

Retry Odds	
Setting	**Description**
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.
	  Example: Consider 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 the 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.
	FreeWave Recommends: A **Retry Odds** set to **0** is recommended for most networks.

4.2.11 Slave/Repeater

The **Slave/Repeater** parameter allows a radio to switch between Slave and Repeater functions.

Important!: This parameter must remain set to **Disabled** because a wire replacement I/O system cannot contain a Repeater.

5. Installing and Wiring Components

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

5.1 Wiring an I/O Master

The terminal block on the I/O Master can accept a single wire of a maximum size of 16 gauge (1.31 mm²). Smaller wire is required for 2 wires, or wire and resistor connected into the same screw terminal.

5.1.1 Screw Torque

For all connections, use these tightening torque minimum and maximum:

- **Minimum**: 0.22 Nm
- **Maximum**: 0.25 Nm

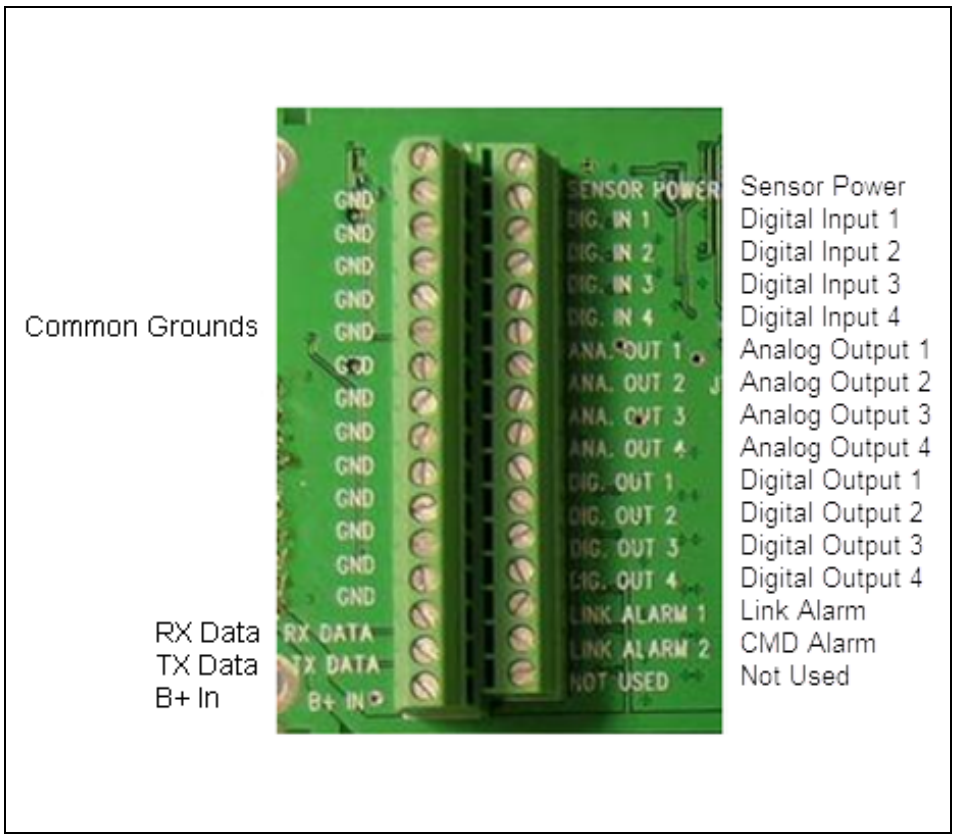


Figure 11: FGRIO-M Terminal Block

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

5.1.2 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.
- Use 16 AWG (1.31 mm²) for this connection. Pin 1 on the connector is the pin closest to the edge of the board.

5.1.3 Tx Data and Rx Data

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

5.1.4 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 44).

When connecting the **Sensor Power** terminal, consider:

- 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, use **Tool Suite** to change the **Sensor Power** parameter setting on the I/O Master to **1** or **Gated**.
  - For more information, see the **Sensor Power** parameter description in Sensor Power (on page 44).

5.1.5 Digital Inputs

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

1. 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.
2. Connect the Ground wire from the RTU to any of the Ground screw terminals on the I/O Master's terminal block.

Note: Some RTUs use isolated I/O and may require a ground connection for each input and output.

5.1.6 Analog Outputs

The Analog Outputs on the terminal block are 1-5 V at low current.

Caution: 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 these steps to connect the Analog Outputs on the I/O Master to the end device:

1. 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).
2. Connect a common Ground.

Note: 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.

5.1.7 Digital Outputs

The Digital Outputs on the I/O Master actively drives Low (0.4V) and High (4.0V).

1. Remove any RTU input pull-up resistor, if less than 10 KΩ.
2. Verify signal levels meet the RTU input requirements after connection to the RTU.

Warning! The I/O Master Digital Outputs source about 4 mA. It is NOT designed to drive relays or solenoids.

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

1. 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).
2. Connect a common Ground.

FreeWave Recommends: Run 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.

5.1.8 Link Alarms

Complete these steps when connecting link alarms from the I/O Master to the end device.

1. Connect a wire from the Link Alarm 1 screw terminal to the Link Alarm screw terminal on the RTU.
   Link Alarm 1 is an alarm reflecting loss of communication on any path.
2. Connect a wire from the Link Alarm 2 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.

5.2 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.

5.2.1 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.

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.

5.2.2 Digital Inputs

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

1. 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.
2. 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.
3. If 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.

5.2.3 Digital Outputs

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 54).

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

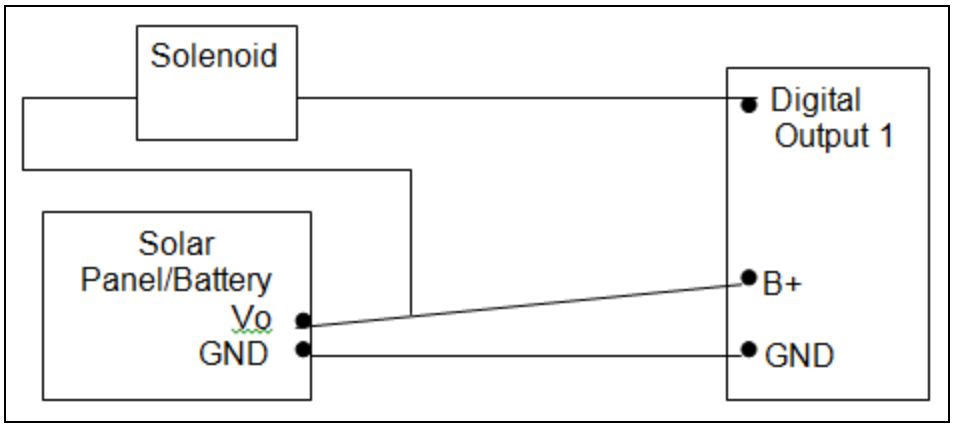


Figure 12: Example: Digital Output Wiring

5.2.4 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

This procedure is used when connecting a 4-20 mA sensor to Analog Input 1 or Analog Input 2 on an I/O Slave.

Important!: A resistor (249 Ω or 250 Ω) is required to convert 4-20 mA from the sensor to 1-5 V.

Procedure

1. If using a board-level I/O Slave, 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.

> **Note**: The resistor produces a 1-5 V signal across it when 4-20 mA flows throw it.
> If using an FGR2-IOS-CE-U (ruggedized enclosure), a resistor exists within the radio to enable or disable. This resistor takes the place of an inline resistor.

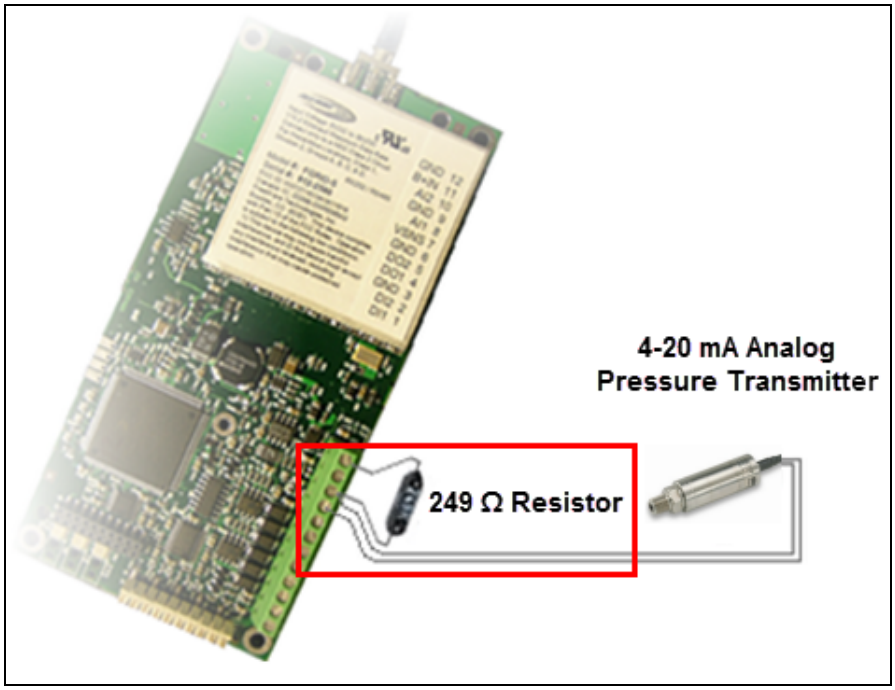


Figure 13: Example: 249 Ω Resistor

2. Enable the resistor between the 4-20 mA sensor and the analog input using the **AI1 250 Ohms** or **AI2 250 Ohms** parameter in the **Wire Replacement** tab in **Tool Suite**.

> **Note**: The internal resistor powers on after the radio powers on and boots up.

> **Important!**: Verify the correct radio voltage is supplied.

3. Connect the Sensor Power Supply (High) wire to VSNS screw terminal #7 on the terminal block of the I/O Slave.
4. 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.

This diagram illustrates a board-level wiring installation.

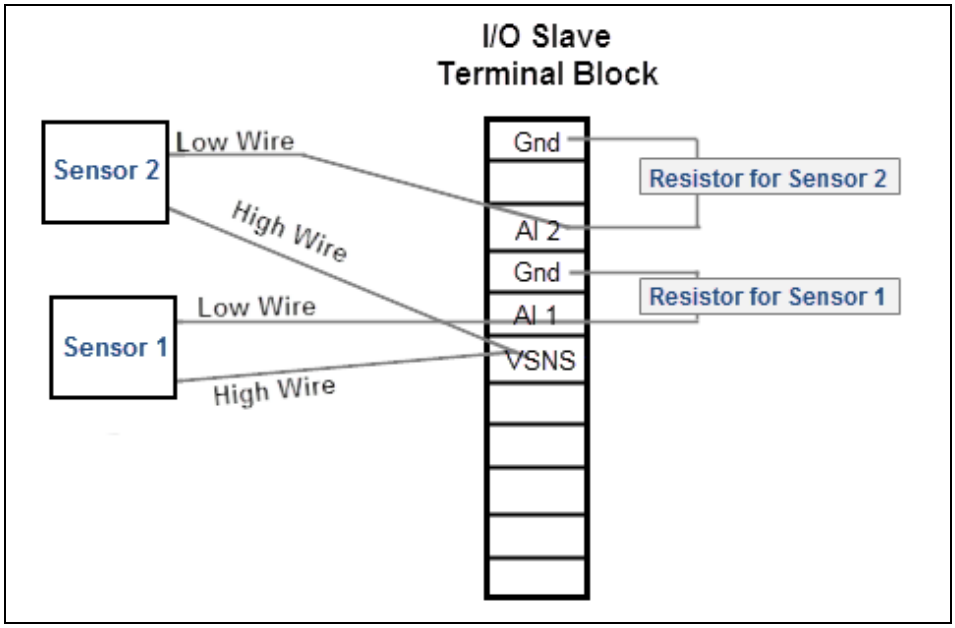


Figure 14: Board-level Wiring Installation

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 83) 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.

Note: 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.

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

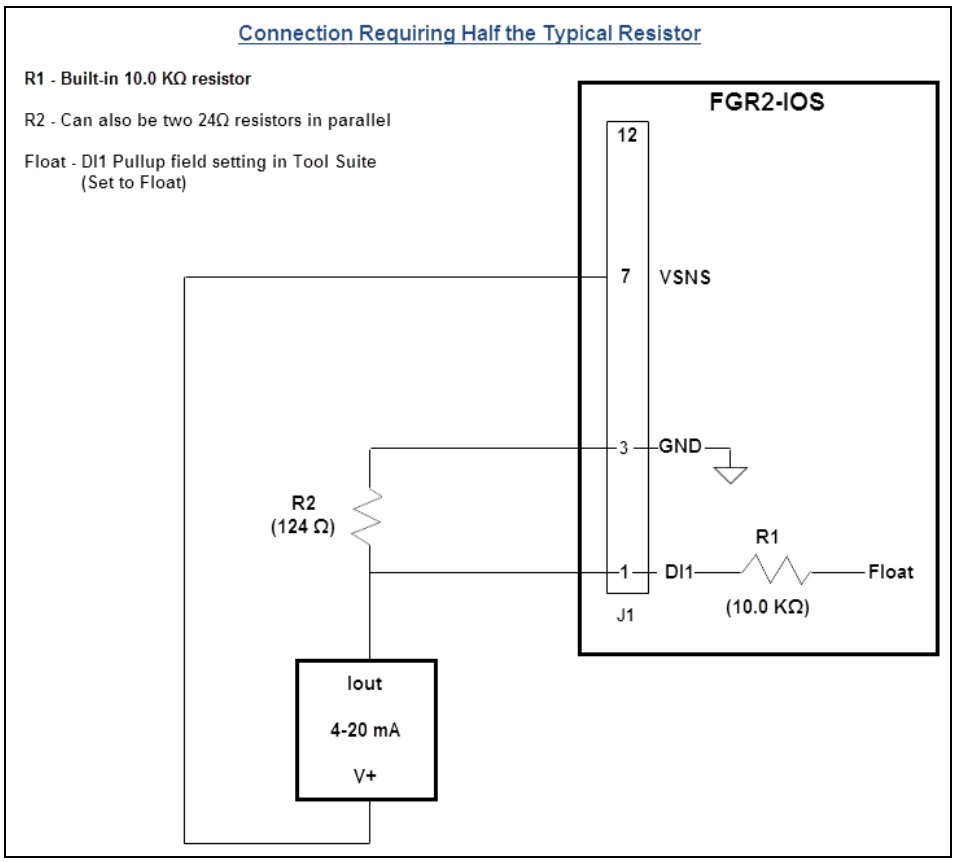


Figure 15: Connection of a 4-20 mA Sensor to Analog Input 3, with Half the Typical Resistor

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

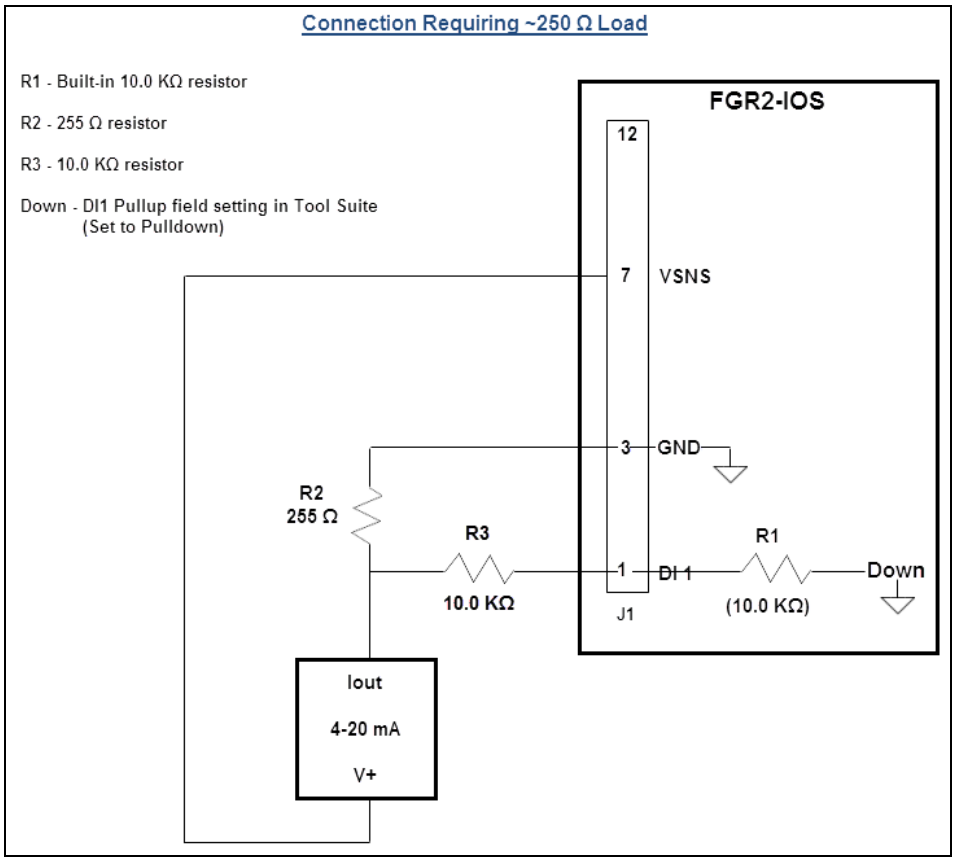


Figure 16: Connection of a 4-20 mA Sensor to Analog Input 3 Requiring an Approximately 250 Ohm Load

5.2.5 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 recommended for the most critical variables in a system.

Note: If 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.

1. Connect the sensor's Ground wire to Ground screw terminal #3, 9, or 12 on the terminal block of the I/O Slave.
2. 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.
3. 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 Modbus 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. 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

For the 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.
  - With firmware 2.25IO and later, the resistor can also be commanded to pull down to GND or "float" unconnected.
    - See DI1 Pullup and DI2 Pullup (on page 54).

These options are useful for Analog Input connections.

- **Signal Level Reduction** - 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.

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

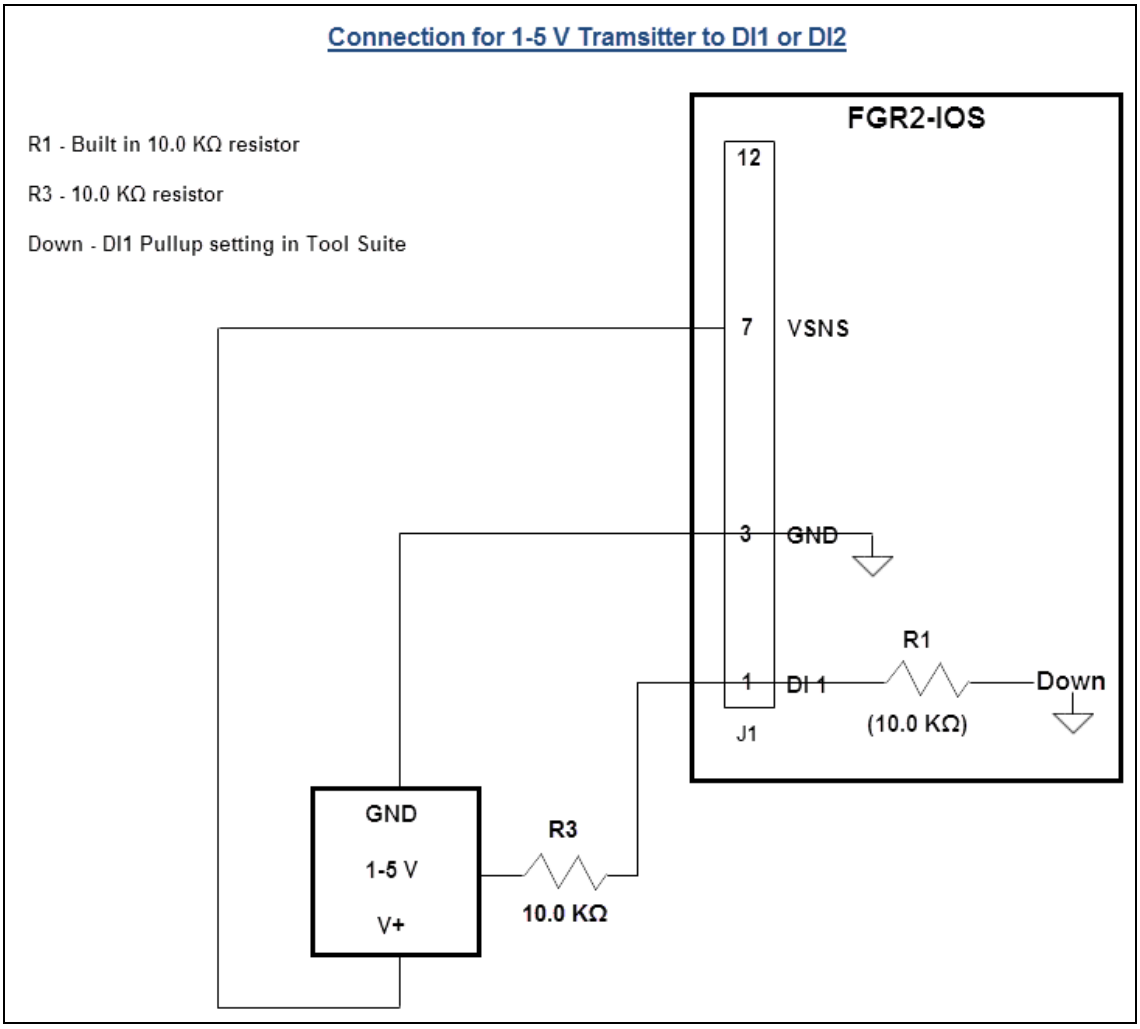


Figure 17: Connection of a 1-5 V Transmitter to Analog Input #3

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

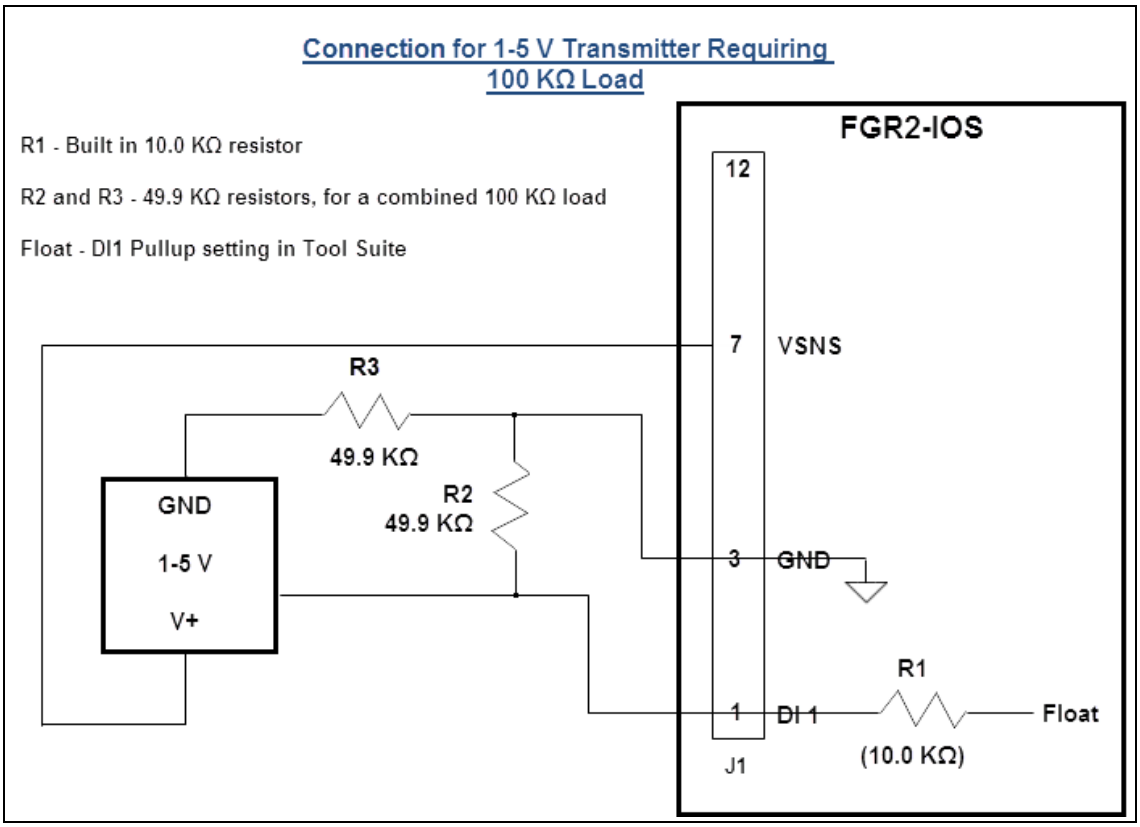


Figure 18: Connection of a 1-5 V Transmitter Requiring 100 KΩ Load

5.3 Plunger Lift Example

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

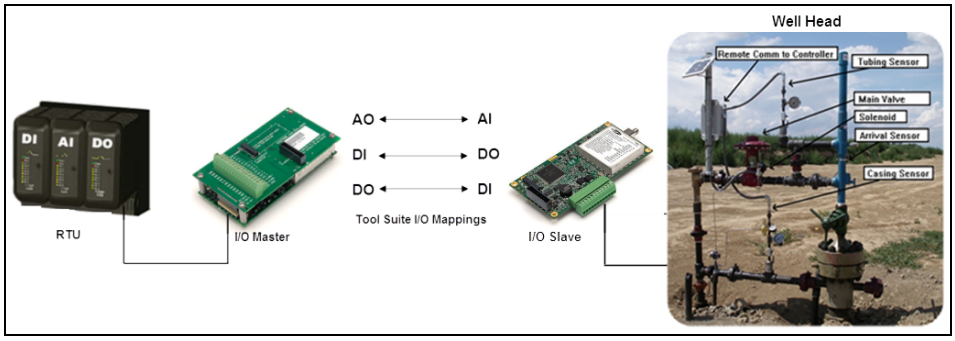


Figure 19: Example of Wire Replacement Plunger Lift

Note: The wiring portion of the illustration is detailed in these sections.

5.3.1 I/O Master to the RTU

1. Wire these terminal ports on the I/O Master to the RTU:
   a. DI1 to RTU Digital Input for the plunger arrival sensor.
   b. AO1 to RTU Analog Input for tubing sensor.
   c. AO2 to RTU Analog Input for casing sensor.
   d. DO1 to RTU Digital Output for solenoid valve.

   Note: The valve can be run in two lines, one for valve open and one for valve closed.

2. Link Alarm to RTU Digital Input to for alarm if link is lost to the I/O Slave.

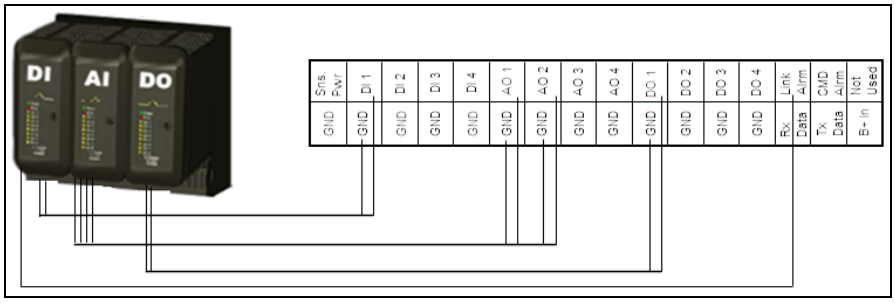


Figure 20: Using DO2 on the I/O Master, this example uses a single line.

5.3.2 I/O Slave to the Well Head

1. Wire the terminal ports on the I/O Slave to the casing pressure sensor and the tubing sensor (see example image).
2. 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.

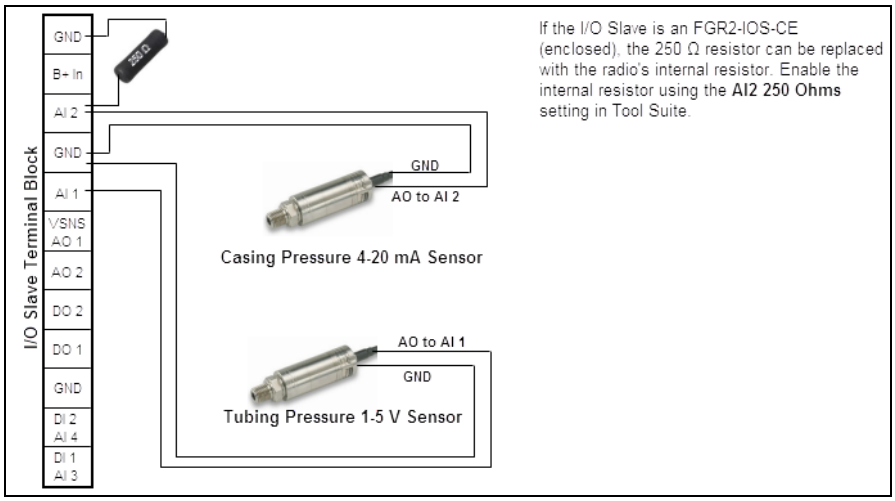


Figure 21: Wire the terminal ports on the I/O Slave to the casing pressure sensor and the tubing sensor.

3. Wire the terminal ports on the I/O Slave to the solenoid valve and the plunger arrival sensor (see example image).
4. Wire each sensor to ground.

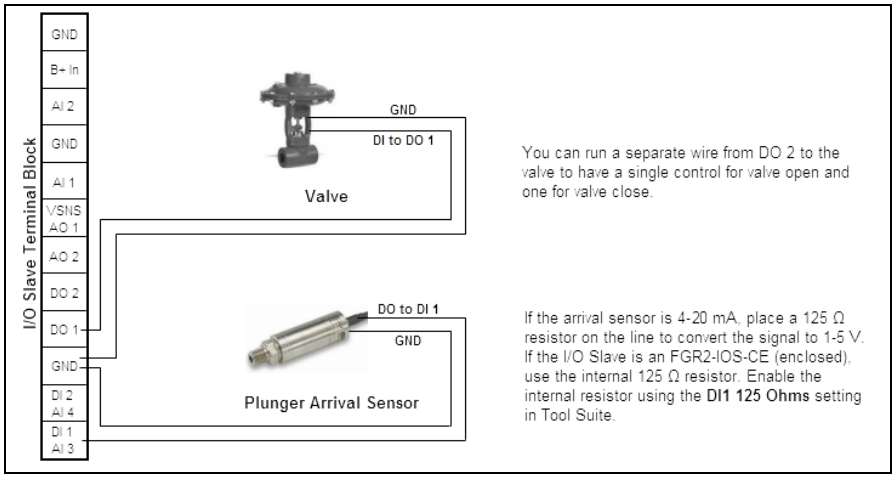


Figure 22: Wire the terminal ports on the I/O Slave to the solenoid valve and the plunger arrival sensor.

5.3.3 Terminal Port Mappings in Tool Suite

1. Verify that:
   a. both the I/O Master and the I/O Slave are configured as described in the other sections in this manual.
   b. the I/O Master can connect to the I/O Slave.
2. Using **Tool Suite**, connect to the I/O Master and select the I/O Settings tab.
3. Map the terminal ports in the **I/O Settings** tab in the I/O Master to the I/O Slave using:
   - **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.
4. Send the settings to the radio:

   Note: The I/O Slave is listed by serial number.
   This example has only one I/O Slave in the network with only one Slave is listed in the port selection fields.
   If there were additional I/O Slaves in the network, each Slave the I/O Master is connected to would appear in the list.

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

5.4 Emergency Shut Off Example

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

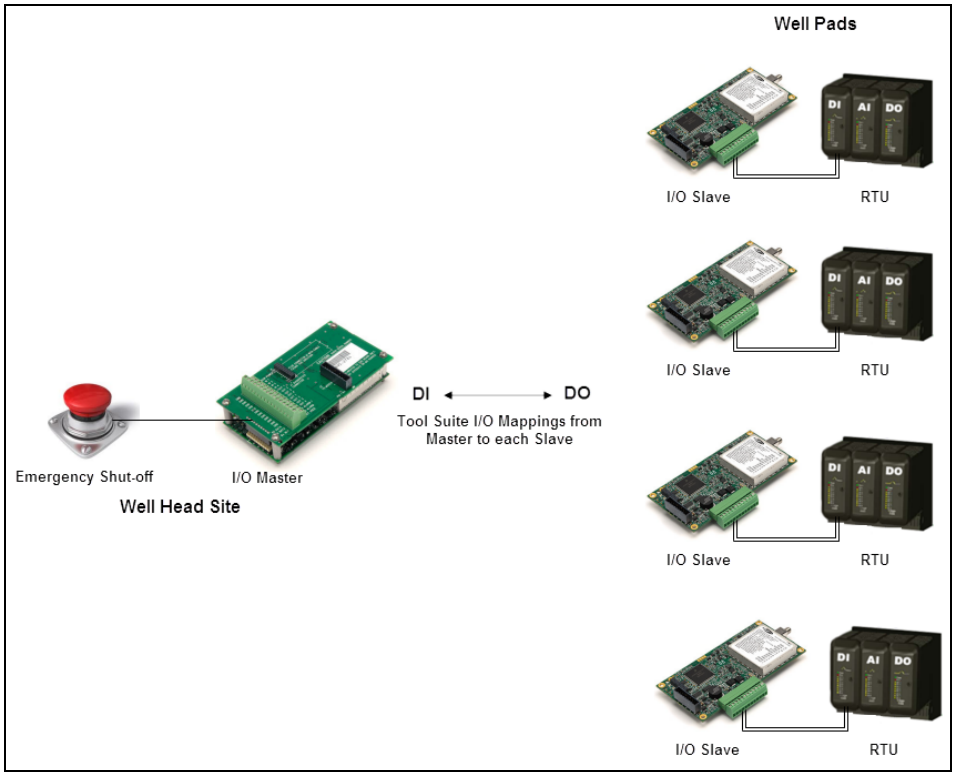


Figure 23: Emergency Shut Off Example

Note: The wiring portion of the illustration is detailed in these sections.

5.4.1 I/O Master to the Emergency Shut-Off

1. Wire the terminal ports on the I/O Master to the emergency shut-off device:
   - DI1 to the Digital Input on the emergency shut-off device.

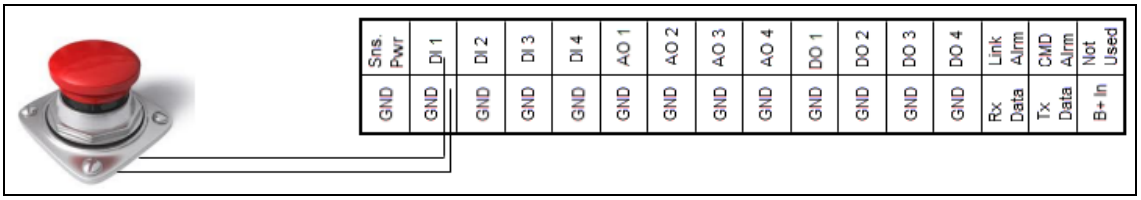


Figure 24: I/O Master to the Emergency Shut-Off

5.4.2 I/O Slave to the RTU at Each Well Sites

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

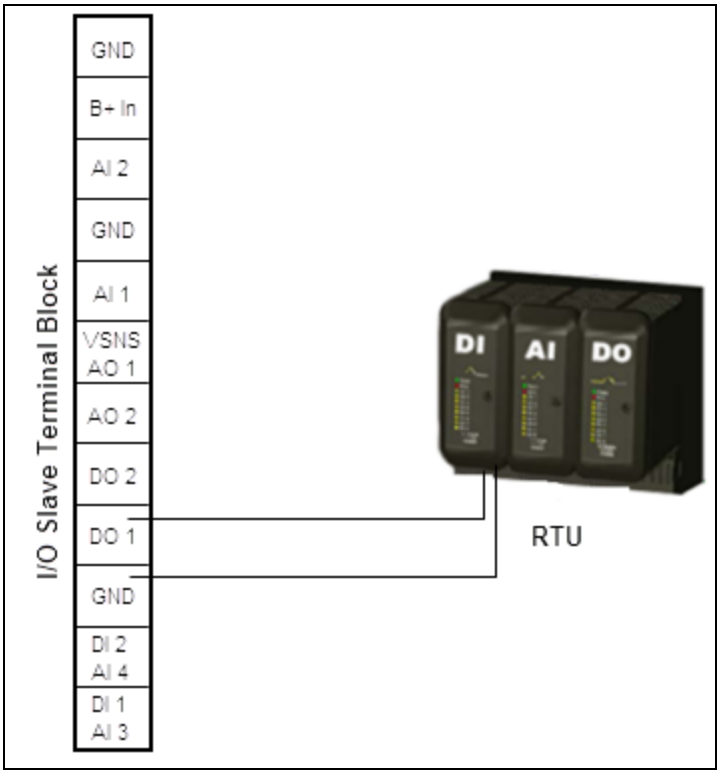


Figure 25: I/O Slave to the RTU at Each Well Sites

5.4.3 Terminal Port Mappings in Tool Suite

1. Verify that:
   a. both the I/O Master and the I/O Slave are configured.
   b. the I/O Master can connect to the I/O Slave.
2. Using **Tool Suite**, connect to the I/O Master and select the I/O Settings tab.
3. 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.

5.5 Tank Level Example

This example illustrates the wire replacement setup to measure tank level:

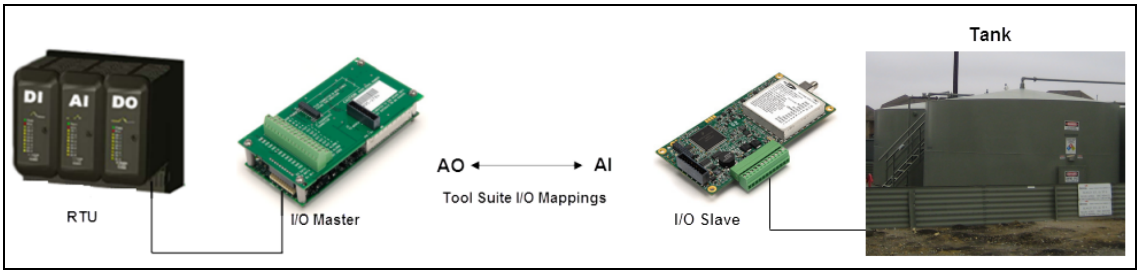


Figure 26: Example of Wire Replacement Tank Level

Note: The wiring portion of the illustration is detailed in these sections.

5.5.1 I/O Master to the RTU

1. Wire the AO1 to Analog Input on the RTU.

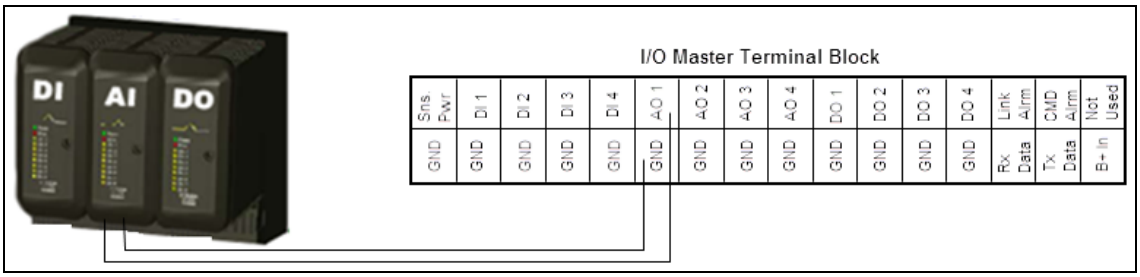


Figure 27: I/O Master to the RTU

5.5.2 I/O Slave to the Well Head

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

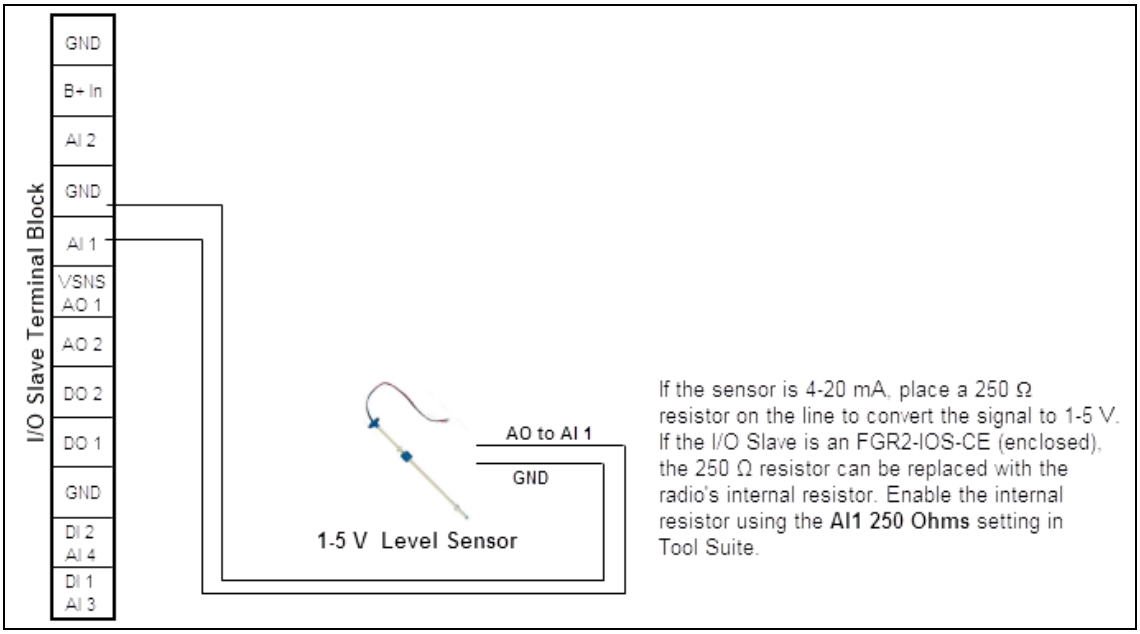


Figure 28: I/O Slave to the Well Head

5.5.3 Terminal Port Mappings in Tool Suite

1. Verify that:
   a. both the I/O Master and the I/O Slave are configured.
   b. the I/O Master can connect to the I/O Slave.
2. Using Tool Suite, connect to the I/O Master and select the **I/O Settings** tab.
3. 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.

5.6 Tubing Pressure Example

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

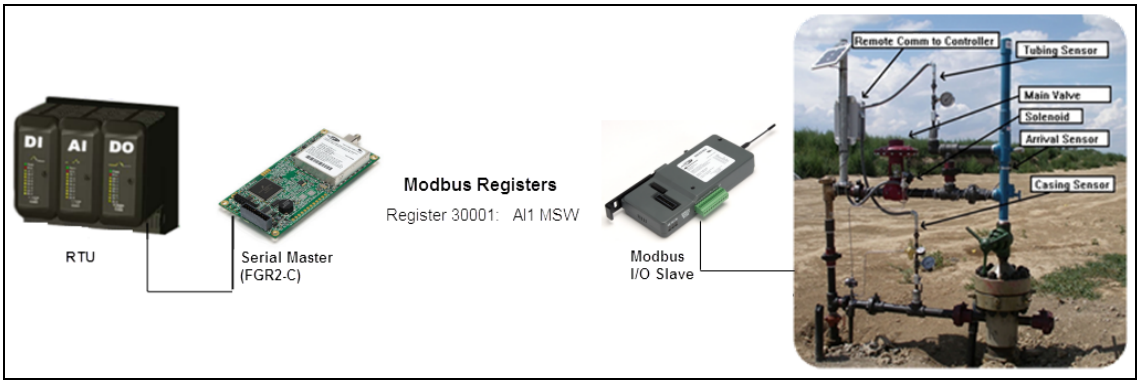


Figure 29: Wire Replacement Tubing Pressure Example

Note: The wiring portion of the illustration is detailed in these sections.

5.6.1 I/O Master to the RTU

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

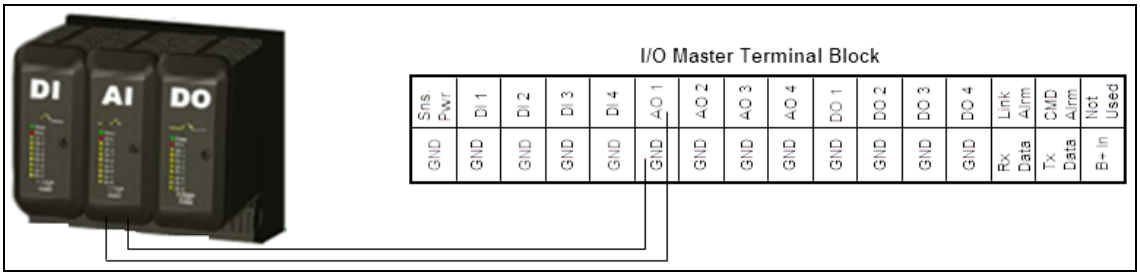


Figure 30: I/O Master to the RTU

5.6.2 I/O Slave to the Well Head

1. Wire the terminal ports on the I/O Slave to the tubing sensor.
2. Wire the sensor to ground.

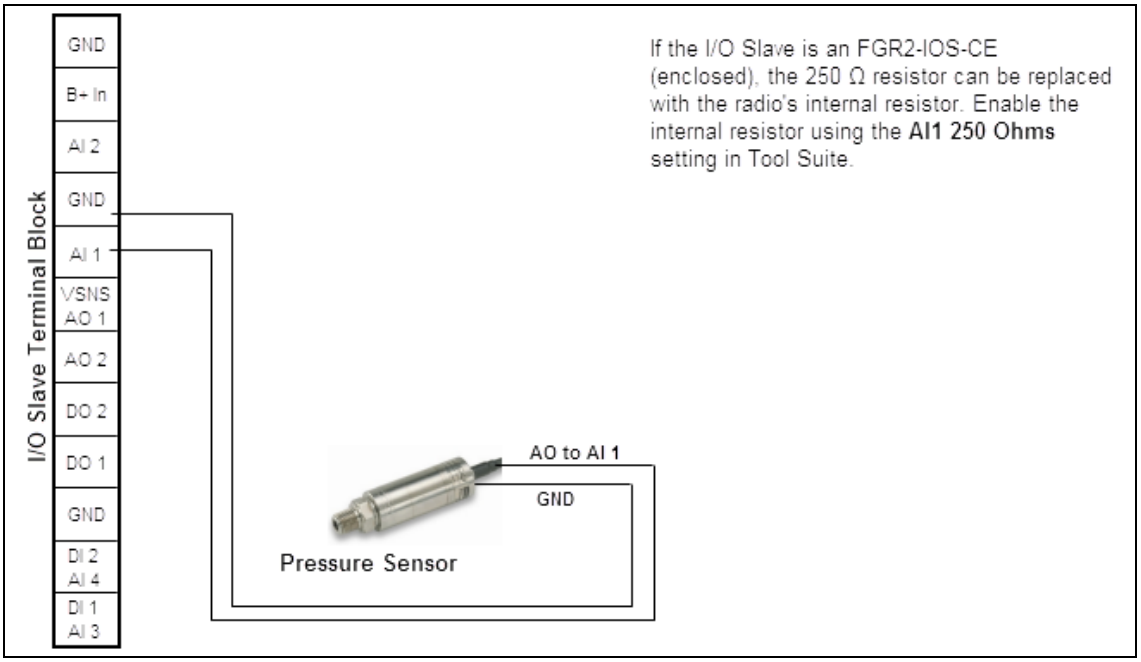


Figure 31: I/O Slave to the Well Head

5.6.3 Terminal Port Mappings in Tool Suite

1. Verify that:
   a. both the I/O Master and the I/O Slave are configured.
   b. the I/O Master can connect to the I/O Slave.
2. Using **Tool Suite**, connect to the I/O Master and select the I/O Settings tab.
3. 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.

6. Viewing Radio Statistics

When reading a radio, the system shows data transmission statistics the radio has gathered during the most recent session.

- This information is valuable 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.
- View additional data transmission characteristics in the Network Diagnostics application.

Note: For information about running network diagnostics using Tool Suite, see the **Tool Suite User Manual**.

6.1 Viewing the Radio Statistics in Tool Suite

1. In the Tool Suite Configuration application, click **Read Radio**.
2. Click the **Device Information** tab.
3. Review the radio characteristics.

Note: View the same statistics using the Tool Suite **Setup Terminal** option.

6.2 Viewing the Radio Transmission Characteristics in the Terminal Interface

1. On the **Setup** main menu, click **(4) Show Radio Statistics**.
2. Review the radio characteristics.

6.3 Antenna Reflected Power

This is a measurement of the transmitted power that is reflected back into the radio from mismatched antennas or cables, or loose connections between the radio 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.
  - 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.

6.4 Master-Slave Distance

The physical distance between the slave radio and the master radio in the network.

This distance is most accurate at a distance greater than 2.5 miles.

6.5 Noise Level

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

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

FreeWave Recommends: Ideally, noise levels should be below -120 dBm. 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.

6.6 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 radio 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.

6.7 Radio Temperature

The **Radio Temperature** value is the current operating temperature of the radio in degrees Celsius.

FreeWave Recommends: For proper operation, a FreeWave radio must be in the temperature range of -40° to +75° C.
Some of the radios are only tested to 0° C.

Note: See the radio specifications in this document for details.

6.8 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**.
  - 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.

6.9 Signal Level

The **Signal Level** indicates the level of received signal at this radio and at each of the Repeaters in the link.

- For each of these, the signal source is the radio that transmits to it.
- The number is an average of the received signal levels measured at each frequency in the radio'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 Approved Antennas (on page 125) for antenna and FCC requirements.

6.10 Transmit Current

The **Transmit Current** measures the current draw of the transmitter in milliamps (mA).

7. Specifications

These are the specifications for the Spelled out product name:

7.1 FGR2-IO-IOE Specifications

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.

FGR2-IO-IOE 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)
1: DI with pull down resistor (5 Kohm)		x	

<table>
<tr><th colspan="3">FGR2-IO-IOE Specifications</th></tr>
<tr><td>1: DI with pulsed 50 mA pull-up for long-lines or high noise</td><td>x</td><td></td></tr>
<tr><th colspan="3">Output</th></tr>
<tr><td>2: High Current (2 A sink to GND) DOs with current sensing and self-resetting protection</td><td>x</td><td>x(3)</td></tr>
<tr><td>1: AO - 15 bits, 4-22mA, 0.1% FS Accuracy, also acts as 50mA sensor power or DI</td><td>x</td><td></td></tr>
<tr><td>1: AO - 16 bits, 4-22mA, 0.1% FS Accuracy</td><td>x</td><td></td></tr>
<tr><th colspan="3">Internal</th></tr>
<tr><td>1: Battery / Supply Voltage - 10 bits, 0-30 V, 1% FS Accuracy</td><td>x</td><td></td></tr>
<tr><td>1: Radio Temperature - 1° C units, -40° C to +70° C, 4° C accuracy</td><td>x</td><td></td></tr>
<tr><td>Expandable I/O Stack up to 15 Expansion Modules</td><td>x</td><td></td></tr>
<tr><th colspan="3">Diagnostics Interface</th></tr>
<tr><td>Connector</td><td colspan="2">Separate 20-pin PCB header</td></tr>
<tr><th colspan="3">Power Requirements</th></tr>
<tr><td>Operating Voltage</td><td colspan="2">+6.0 to +30.0 VDC</td></tr>
<tr><td>Average Current (mA)
(currents shown with no AO connections made)</td><td colspan="2">
<table>
<tr><th>Mode</th><th>+6.0 VDC</th><th>+12.0 VDC</th><th>+30.0 VDC</th></tr>
<tr><td>Transmit</td><td>800</td><td>380</td><td>170</td></tr>
<tr><td>Receive</td><td>90</td><td>55</td><td>40</td></tr>
<tr><td>Idle</td><td>24</td><td>16</td><td>8</td></tr>
<tr><td>Modbus Linked Lowpower = 4</td><td>10</td><td>7</td><td>5</td></tr>
<tr><td>Wire Replacement Linked</td><td>30</td><td>15</td><td>8</td></tr>
</table>
</td></tr>
<tr><th colspan="3">Product Safety</th></tr>
<tr><td>Standards</td><td colspan="2">EN 60079-0:2012 + A11:2013 and EN 60079-15:2010</td></tr>
<tr><td>Labeling Information</td><td colspan="2">  II 3 G Ex nA IIC Gc
DEMKO 14 ATEX 1209313U</td></tr>
<tr><th colspan="3">General Information</th></tr>
<tr><td>Operating Temperature Range</td><td colspan="2">-40°C to +75°C</td></tr>
</table>

FGR2-IO-IOE Specifications	
	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.

7.2 FGR2-IOS-C-U and FGR2-IOS-CE-U Specifications

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.

FGR2-IOS-C-U and FGR2-IOS-CE-U 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)

<table>
<tr><th colspan="3">FGR2-IOS-C-U and FGR2-IOS-CE-U Specifications</th></tr>
<tr><td>2: Precision AIs (20 bits, 0-5.625 V, 0.1% FS Accuracy), also act as exact-threshold DIs</td><td>x</td><td></td></tr>
<tr><td>2: Precision AIs (20 bits, 0-5.625 V, 0.1% FS Accuracy), also act as exact-threshold DIs</td><td>x</td><td></td></tr>
<tr><th colspan="3">Output</th></tr>
<tr><td>2: High Current (2 A sink to GND) DOs with current sensing and self-resetting protection</td><td>x</td><td>x(3)</td></tr>
<tr><td>1: AO - 15 bits, 4-22mA, 0.1% FS Accuracy, also acts as 50mA sensor power or DI</td><td>x</td><td></td></tr>
<tr><td>1: AO - 16 bits, 4-22mA, 0.1% FS Accuracy</td><td>x</td><td></td></tr>
<tr><th colspan="3">Internal</th></tr>
<tr><td>1: Battery / Supply Voltage - 10 bits, 0-30 V, 1% FS Accuracy</td><td>x</td><td></td></tr>
<tr><td>1: Radio Temperature - 1° C units, -40° C to +70° C, 4° C accuracy</td><td>x</td><td></td></tr>
<tr><th colspan="3">Diagnostics Interface</th></tr>
<tr><td>Connector</td><td colspan="2">Separate 20-pin PCB header</td></tr>
<tr><th colspan="3">Power Requirements</th></tr>
<tr><td>Operating Voltage</td><td colspan="2">+6.0 to +30.0 VDC</td></tr>
<tr><td>Average Current (mA)
(currents shown with no AO connections made)</td><td colspan="2">
<table>
<tr><th>Mode</th><th>+6.0 VDC</th><th>+12.0 VDC</th><th>+30.0 VDC</th></tr>
<tr><td>Transmit</td><td>800</td><td>380</td><td>170</td></tr>
<tr><td>Receive</td><td>90</td><td>55</td><td>40</td></tr>
<tr><td>Idle</td><td>24</td><td>16</td><td>8</td></tr>
<tr><td>Modbus Linked Lowpower = 4</td><td>10</td><td>7</td><td>5</td></tr>
<tr><td>Wire Replacement Linked</td><td>30</td><td>15</td><td>8</td></tr>
</table>
</td></tr>
<tr><th colspan="3">Product Safety</th></tr>
<tr><td>Standards</td><td colspan="2">EN 60079-0:2012 + A11:2013 and EN 60079-15:2010</td></tr>
<tr><td>Labeling Information</td><td colspan="2">Ex II 3 G Ex nA IIC Gc
DEMKO 14 ATEX 1209313U</td></tr>
</table>

FGR2-IOS-C-U and FGR2-IOS-CE-U Specifications	
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.

7.3 FGRIO-M Specifications

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.

FGRIO-M 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		

<table>
<tr><th colspan="2">FGRIO-M Specifications</th></tr>
<tr><td>Data Interface</td><td>Serial</td></tr>
<tr><td>Protocol</td><td>RS 232 / 485 / 422, 1200 Baud to 115.2 Kbaud</td></tr>
<tr><td>Data Connector</td><td>10-pin header with locking ramp, 0.1 inch spacing, power/data connector</td></tr>
<tr><th colspan="2">Data Interface</th></tr>
<tr><td>Connector</td><td>Separate 20-pin PCB header</td></tr>
<tr><th colspan="2">Power Requirements</th></tr>
<tr><td>Operating Voltage</td><td>+7.0 to +30.0 VDC</td></tr>
<tr><td>Current</td><td>
<table>
<tr><th>Mode</th><th>+7.0 VDC</th><th>+12.0 VDC</th><th>+30.0 VDC</th></tr>
<tr><td>Transmit</td><td>1 A</td><td>500 mA</td><td>200 mA</td></tr>
<tr><td>Receive</td><td>140 mA</td><td>86 mA</td><td>43 mA</td></tr>
<tr><td>Idle</td><td>120 mA</td><td>70 mA</td><td>38 mA</td></tr>
</table>
</td></tr>
<tr><th colspan="2">Product Safety</th></tr>
<tr><td>Standards</td><td>EN 60079-0:2012 + A11:2013 and EN 60079-15:2010</td></tr>
<tr><td>Labeling Information</td><td>  II 3 G Ex nA IIC Gc
DEMKO 14 ATEX 1209313U</td></tr>
<tr><th colspan="2">General Information</th></tr>
<tr><td>Operating Temperature Range</td><td>-40°C to +75°C</td></tr>
<tr><td>Dimensions</td><td>140 L x 70 W x 34 H (mm)</td></tr>
<tr><td>Weight</td><td>137g</td></tr>
<tr><td>Humidity</td><td>0 to 95% non-condensing</td></tr>
</table>

7.4 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.

FGRIO-S Specifications	
Radio	
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

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

7.5 I2-IOM-U Specifications

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.

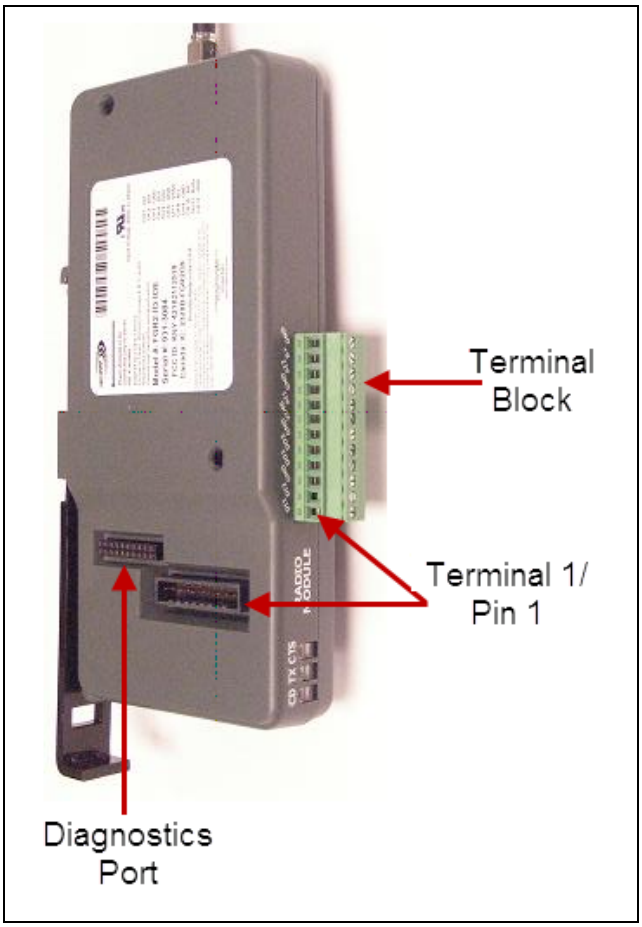
I2-IOM-U Specifications			
Transmitter			
Frequency Range	2.4 - 2.483 GHz (FHSS)		
Output Power	5 mW to 500 mW		
Range - Line of Sight	20 miles with clear LOS		
Modulation	2 level GFSK		
Occupied Bandwidth	230 kHz		
Hopping Patterns	15 per Band, 105 total user selectable		
Hopping Channels	50 to 80 out of 240 user selectable		
Hopping Bands	7, user selectable		
RF Connector	Type SMA		
Master Receiver		**Master Analog Output**	
Sensitivity	-105 dBm for BER 10^{-6} -107 dBm for BER 10^{-4}	Number of Outputs	4, can be mapped to up to 4 slaves
Selectivity	TBD	Accuracy, Resolution	+/- .1%, 16 bit
System Gain	134 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	Low Input Voltage Range	0 to 1.75 V
Signal Voltage Range	0 - 4.6 V	High Input Voltage Range	3.25 to 5.0 V
Data Transmission			
Error Detection	32 bit CRC, Retransmit on Error		
Data Encryption	Dynamic Key Substitution		

<table>
<tr><th colspan="2">I2-IOM-U Specifications</th></tr>
<tr><td>Link Throughput</td><td>115.2 kbps</td></tr>
<tr><td>Data Interface</td><td>Serial</td></tr>
<tr><td>Protocol</td><td>RS 232 / 485 / 422, 1200 Baud to 115.2 KBaud</td></tr>
<tr><td>Data Connector</td><td>10-pin header with locking ramp, 0.1 inch spacing, power/data connector</td></tr>
<tr><th colspan="2">Data Interface</th></tr>
<tr><td>Connector</td><td>Separate 20-pin PCB header</td></tr>
<tr><th colspan="2">Power Requirements</th></tr>
<tr><td>Operating Voltage</td><td>+6.0 to +30.0 VDC</td></tr>
<tr><td>Current (mA)</td><td>
<table>
<tr><th>Mode</th><th>+6.0 VDC</th><th>+12.0 VDC</th><th>+30.0 VDC</th></tr>
<tr><td>Transmit</td><td>375</td><td>295</td><td>140</td></tr>
<tr><td>Receive</td><td>120</td><td>80</td><td>51</td></tr>
<tr><td>Idle</td><td>9</td><td>5</td><td>3</td></tr>
</table>
</td></tr>
<tr><th colspan="2">General Information</th></tr>
<tr><td>Operating Temperature Range</td><td>-40°C to +75°C</td></tr>
<tr><td>Dimensions</td><td>Board Level: 140 mm L x 62 mm W x 16 mm H</td></tr>
<tr><td>Weight</td><td>Board Level: 137g</td></tr>
<tr><td>Humidity</td><td>0 to 95% non-condensing</td></tr>
</table>

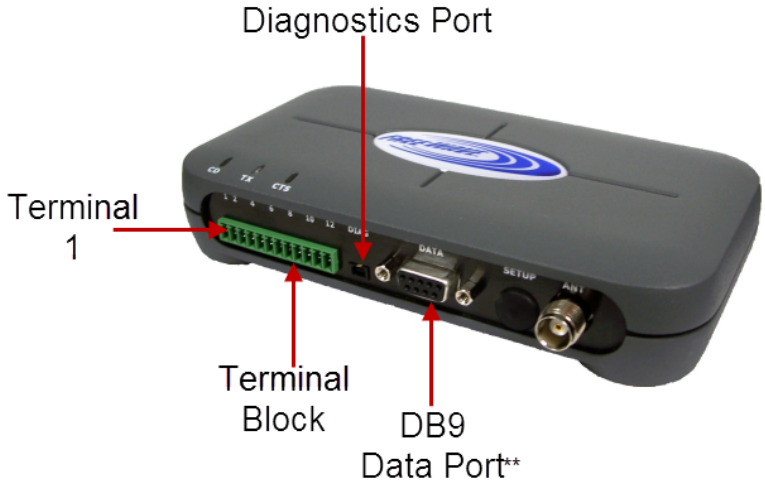
8. Ports

These are the ports for the Spelled out product name:

8.1 FGR2-IO-IOE Ports

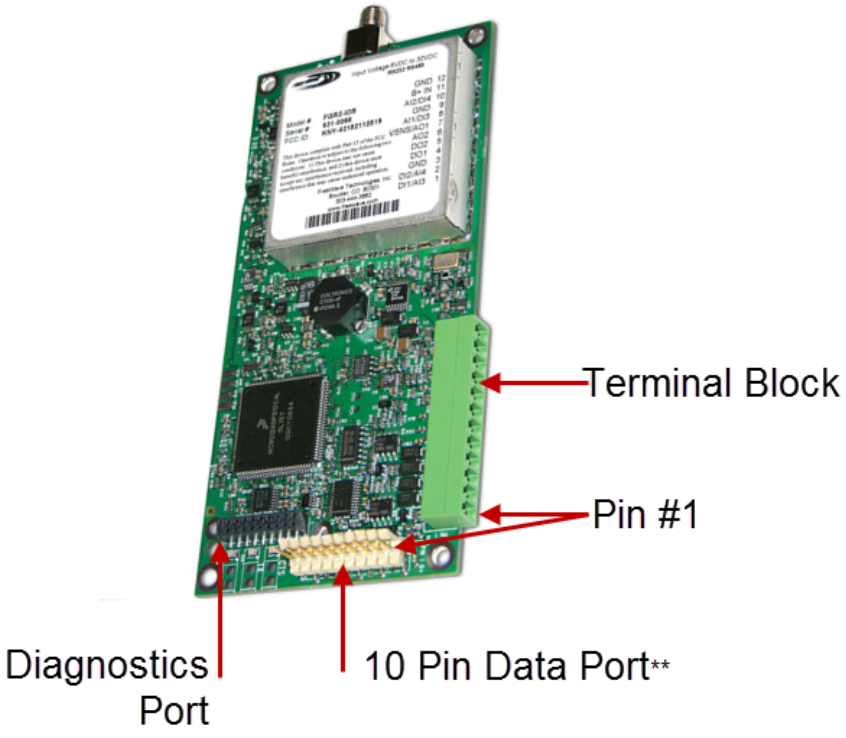


8.2 FGR2-IOS-CE-U Ports



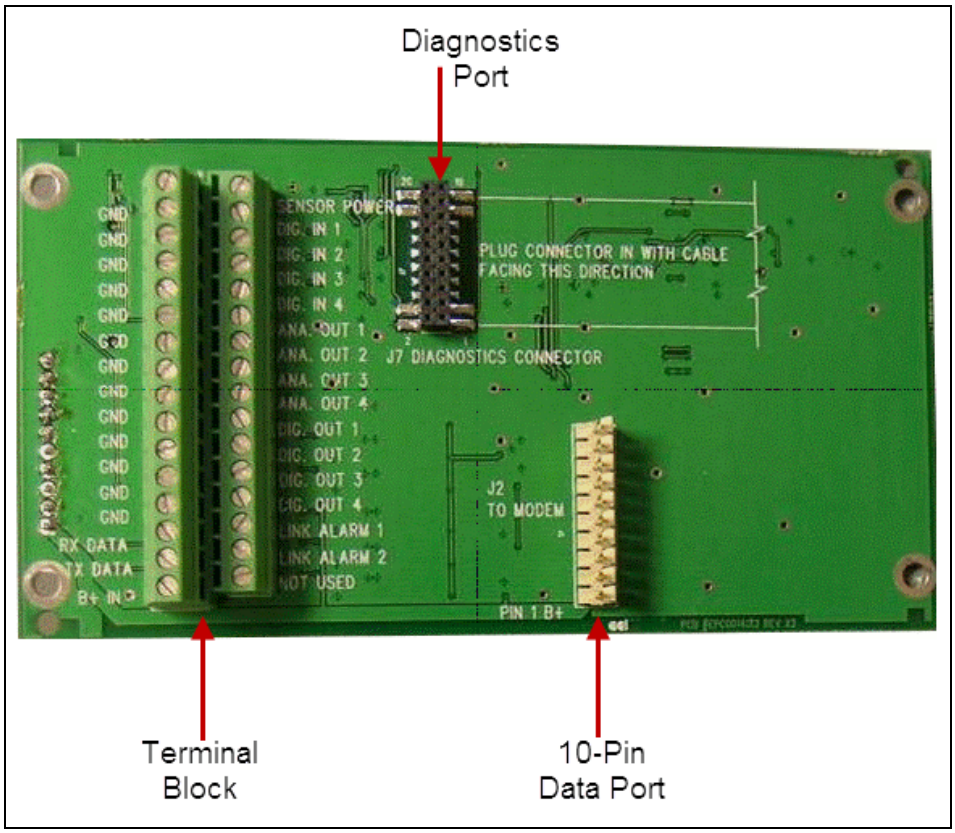
** The data port on I/O Slaves is not active in a wire replacement I/O system.

8.3 FGR2-IOS-C-U Ports

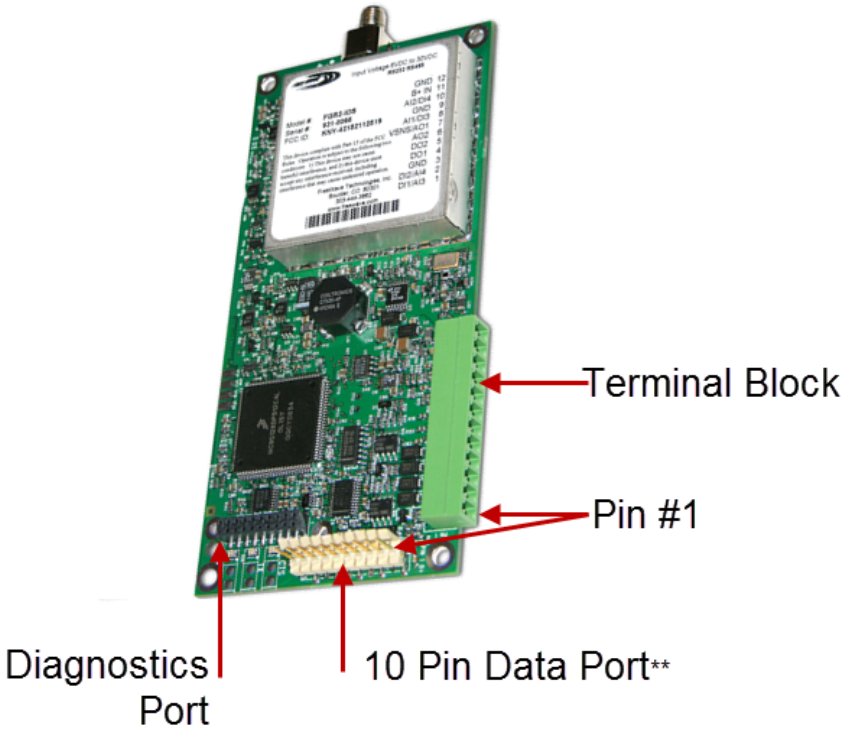


** The data port on I/O Slaves is not active in a wire replacement I/O system.

8.4 FGRIO-M Ports



8.5 FGRIO-S Ports

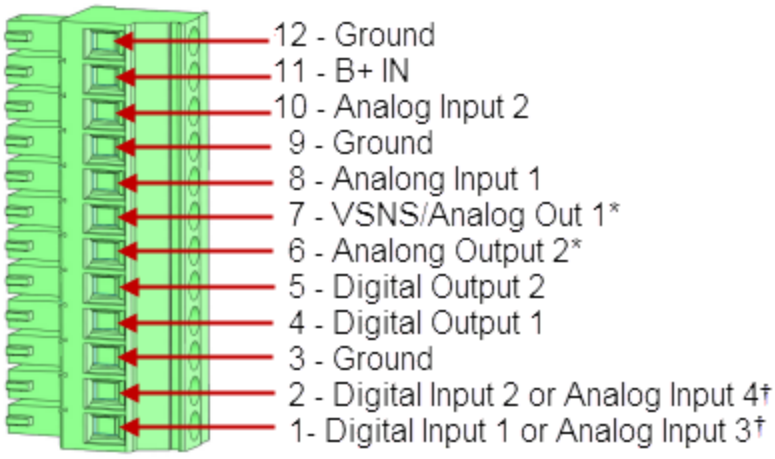


** The data port on I/O Slaves is not active in a wire replacement I/O system.

9. Terminal Block Layouts

These are the terminal block layouts for the Spelled out product name:

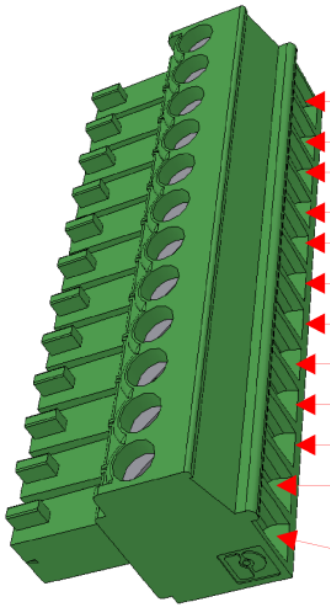
9.1 FGR2-IO-IOE Terminal Block Layout



* 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.

9.2 FGR2-IOS-C-U and FGR2-IOS-CE-U Terminal Block Layout

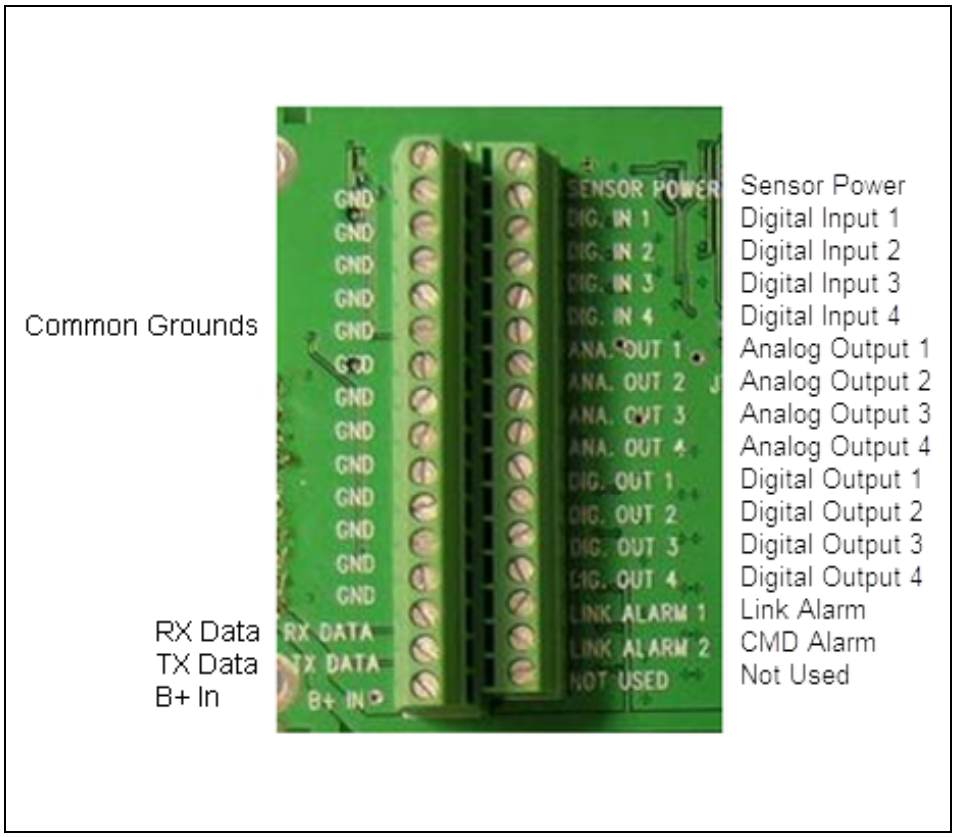


12 – Ground
11 – B+ In
10 – Analog Input 2
9 – Ground
8 – Analog Input 1
7 – VSNS/Analog Out 1*
6 – Analog Output 2*
5 – Digital Output 2
4 – Digital Output 1
3 – Ground
2 – Digital Input 2 or Analog Input 4†
1 – Digital Input 1 or Analog Input 3†

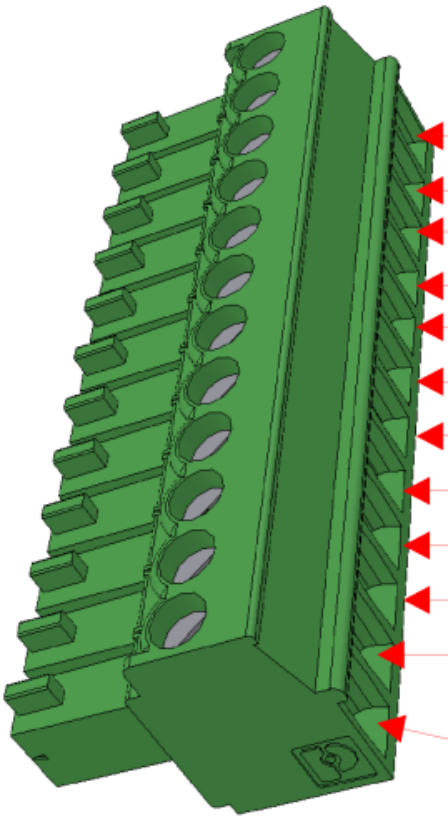
* Analog Outputs 1 and 2 are not available in a wire replacement I/O system.

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

9.3 FGRIO-M Terminal Block Layout



9.4 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.

10. Approved Antennas

10.1 900MHz Directional Antennas

900MHz Directional Antennas			
Gain (dBi)	**Manufacturer**	**Manufacturer Model Number**	**FreeWave Model Number**
6	Larsen	YA6-900	EAN0906YA
6	Bluewave	BMY890G5502N4	EAN0906YC
10	Bluewave	BMY890K5502N4	EAN0900YC
11	Larsen	YA5900-W	EAN0900YA

10.2 900MHz Omni-directional Antennas

900MHz Omni-directional Antennas			
Gain (dBi)	**Manufacturer**	**Manufacturer Model Number**	**FreeWave Model Number**
0	Mobile Mark	PSTG0-915FW	EAN0900RQ
0	Mobile Mark	PSTN3-915N	EAN0900NH
0	Mobile Mark	PSTG0-915SE	EAN0900SQ
0	Mobile Mark	PSTN3-915S	EAN0900SH
0	JEMA	JA900SS	EAN0900WR

900MHz Omni-directional Antennas			
Gain (dBi)	**Manufacturer**	**Manufacturer Model Number**	**FreeWave Model Number**
3	Maxrad	MAX-9053	EAN0900WC
5	Antennex	EB8965C	EAN0905WC
5	Maxrad	BMEFC8985HD	EAN0905WC
6	Antennex	FG9026	EAN0906NF

Appendix A: Troubleshooting Terminal Emulators

These are some common issues encountered while using terminal emulators

Nothing displays on the screen after placing the radio 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.

If the radio was previously configured, you could be using the wrong port to access the **Setup** menu.

Note: For more information, see Setup Port on page 33.Try connecting to the other port.

Unreadable characters display on the screen after placing the radio 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 radio.

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 radio.

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 radio and the parity of emulator are set the same.

Appendix B: 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.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