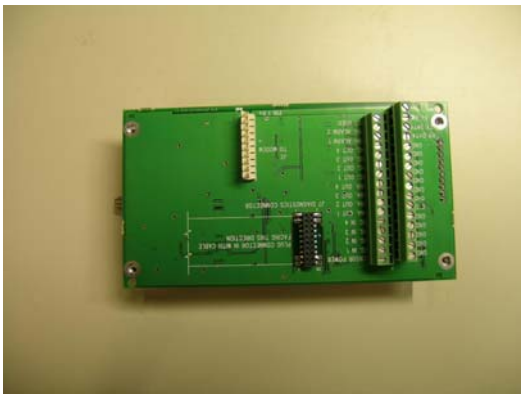
FGRIO System User Manual

Version 8.2



FGRIO Master
FGRIO-M

FGRIO Slave
FGRIO-S

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LUM00008AC Rev A

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Description

This is an addendum to the Spread Spectrum Wireless Data Transceiver User Manual. It covers details applicable specifically to using the FreeWave FGRIO Master and Slave modems. Please use this addendum in conjunction with the User Manual.

The FreeWave Technologies FGRIO System provides outstanding performance and versatility in wireless transmission of process-control signals. FGRIO offers "transparent" acquisition, transport and reconstruction of analog, digital and power signals, eliminating the need for associated buried wiring. The RTU requires no altered programming. The FGRIO is Class 1 Div 2 approval pending and is lower-cost and provides better signal integrity than vulnerable wiring.

The FGRIO System is based upon wireless RF Technologies. RF is subject to interference and communication interruptions. It should not be expected, therefore to provide 100% communication 100% of the time. The FGRIO System should not be used without proper provisions to insure safety upon loss of radio communications.

Glossary

FGRIO Master– FreeWave wireless radio transceiver that operates as a Master for up to 4 FGRIO Slaves, and, operates as a Slave in a point to multipoint network. The FGRIO Master can receive over air a total of 4 analog input signals and 4 digital input signals from up to 4 FGRIO Slaves. It can also transmit up to 4 digital output signals over air to the FGRIO Slaves.

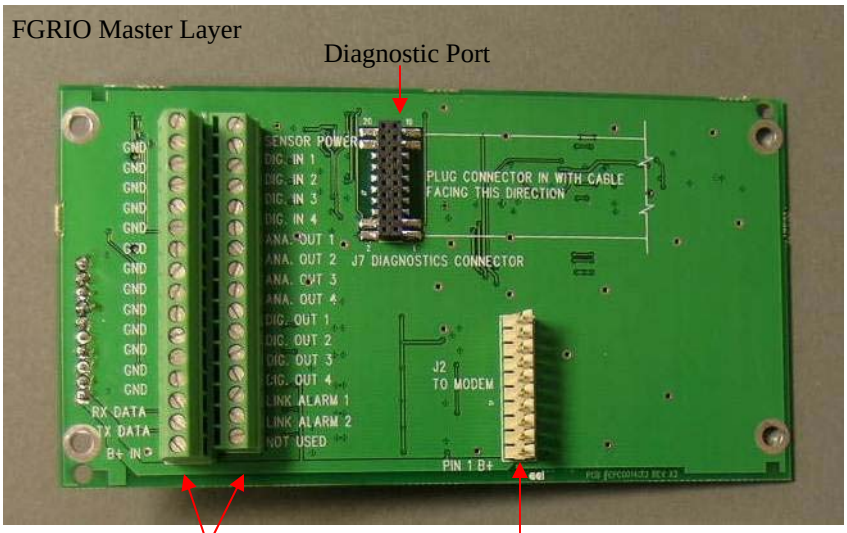
FGRIO Slave– FreeWave wireless radio transceiver that accepts up to 2 analog and 2 digital input signals from a sensor, then transmits those signals over air to the FGRIO Master. The FGRIO Slave also receives over air 2 digital output signals and a sensor power control signal from the FGRIO Master.

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

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

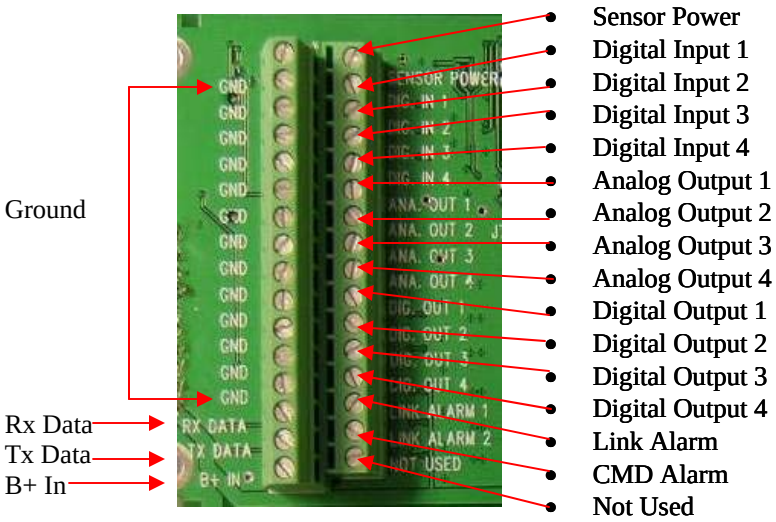
Diagrams

Fig. 1



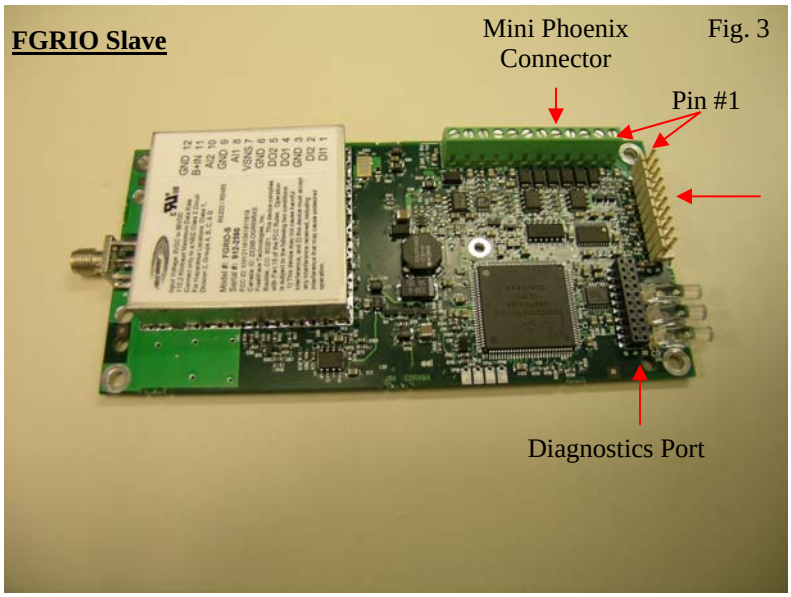
FGRIO Master
Mini Phoenix Connectors

Fig. 2

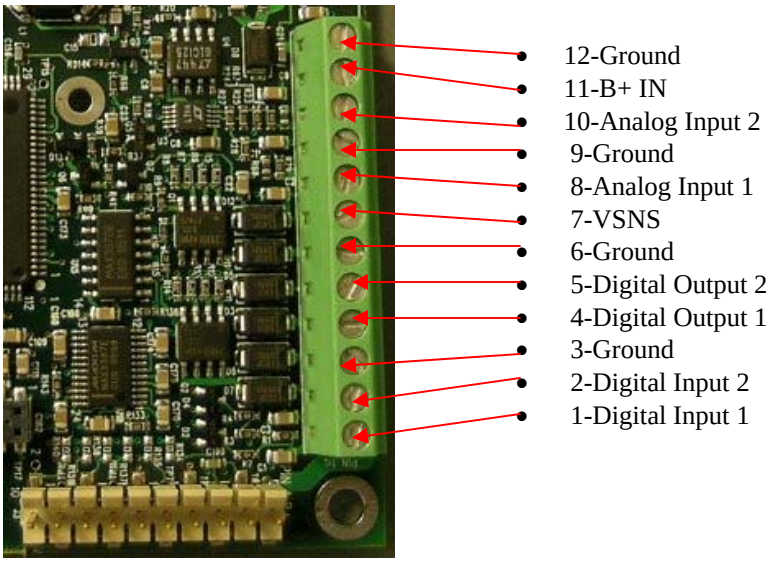


Diagrams (cont.)

FGRIO Slave Fig. 3



FGRIO Slave Mini Phoenix Connector Fig. 4



Set Up with HyperTerminal

FGRIO Master– In order for the I/O System to function properly, the following settings must be programmed. For all other settings not listed below, please refer to the User Manual.

(0) Operation Mode

(3) **Point to MultiPoint Slave**– Choose this setting when the FGRIO System is being integrated into an FGR FreeWave Network. The IO functionality is turned on in Menu 9– FGRIO Set Up of HyperTerminal.

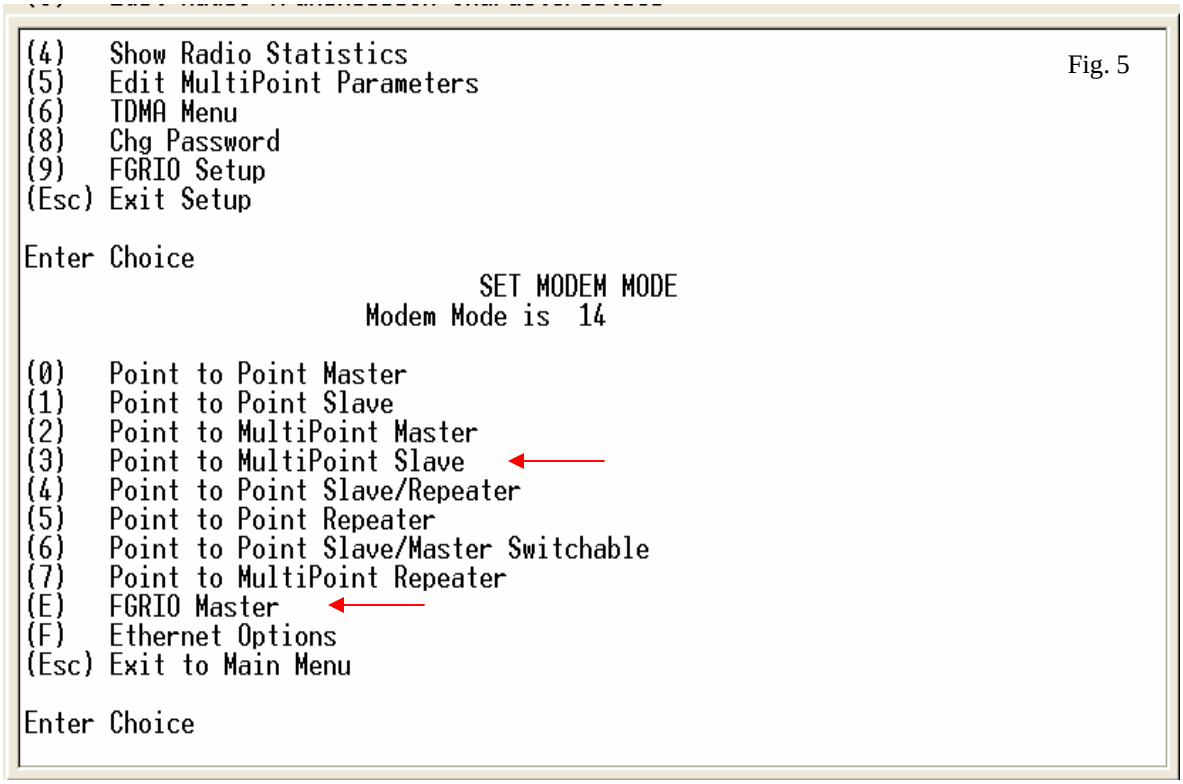


Fig. 5

Note: Setting (E), **FGRIO Master**, should only be selected when the FGRIO System is operating independently of an FGR FreeWave Network.

Set Up with HyperTerminal (cont.)

FGRIO Master

(2) Call Book– FGRIO Slaves' serial numbers must be programmed in the FGRIO Master's Call Book. In addition, the Network ID must be set to the same ID as the rest of the network. Programming both the Call Book and Network ID settings is unique to the FGRIO System and must be done for both integrated and stand alone applications.

(3) Radio Transmission Characteristics

(1) Max Packet Size and (2) Min Packet Size– The FGRIO System requires a packet size of 48 Bytes. The following is a list of the available packet sizes that can be used.

Maximum Packet Size Definition with RF Date Rate of 3 Fig. 6

	Max Setting									
Min Setting	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
0				56	72	88	104	120	136	152
1				60	76	92	108	124	140	156
2			48	64	80	96	112	128	144	160
3			52	68	84	100	116	132	148	164
4			56	72	88	104	120	136	152	168
5			60	76	92	108	124	140	156	172
6		48	64	80	96	112	128	144	160	176
7		52	68	84	100	116	132	148	164	180
8		56	72	88	104	120	136	152	168	184
9		60	76	92	108	124	140	156	172	188

(4) RF Data Rate– The RF Date must be set to 3 when using the FGRIO System. This is for applications that are stand alone or when integrated into an existing FGR network.

MultiPoint Parameters-

(0) Number Repeaters– This setting must be set to 1 for all FGR and FGRIO radios in the Network.

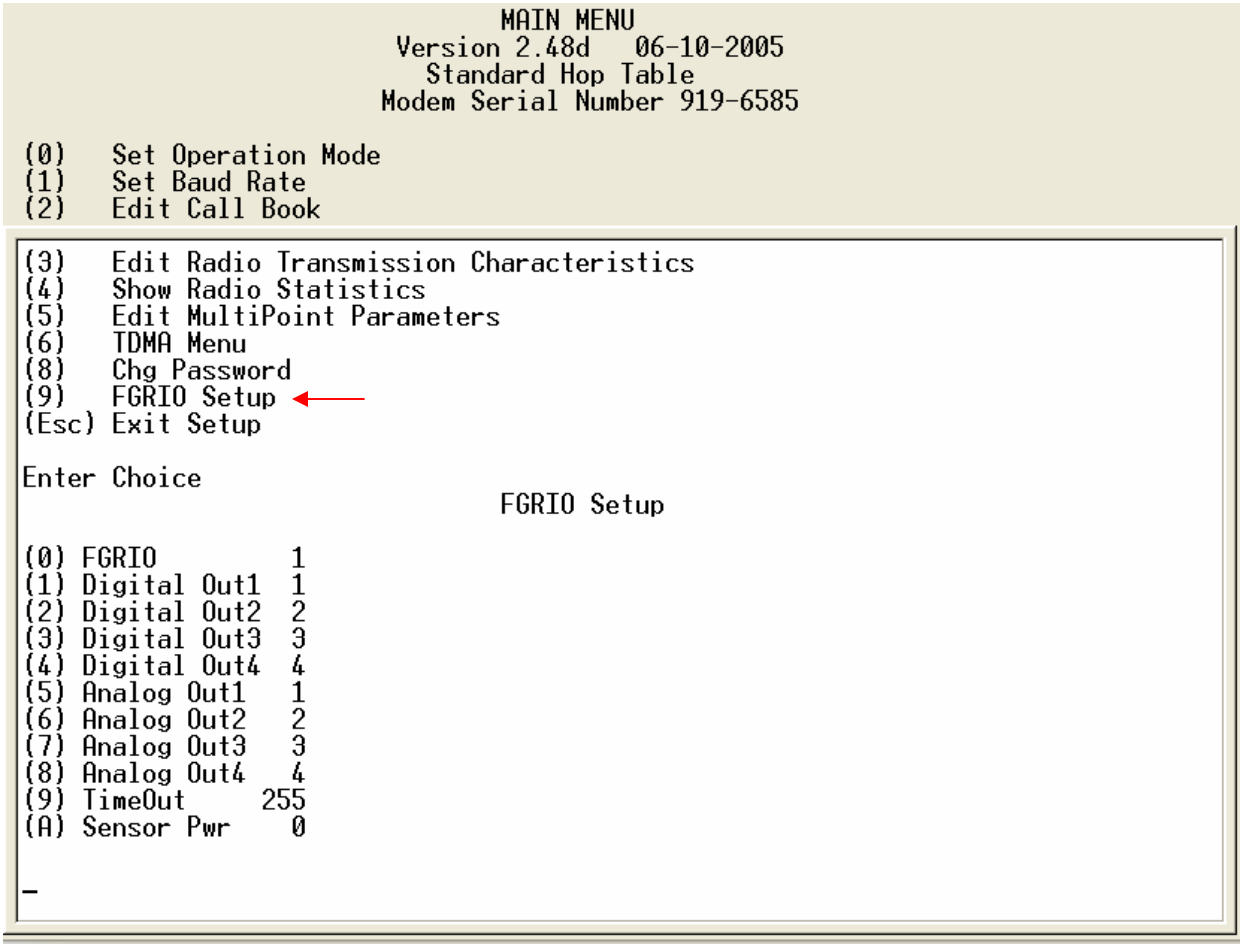
(6) Network ID– In addition to entering the FGRIO Slaves' serial numbers in the Call Book, the Network ID being used for the Network must be set from 1-4095 except 255. Programming both the Call Book and Network ID settings is unique to the FGRIO System and must be done for both integrated and stand alone applications.

Set Up with HyperTerminal (cont.)

FGRIO Master

(9) FGRIO Setup– Outputs on the FGRIO Master are mapped to inputs on the FGRIO Slave.

Fig. 7



Set Up with Hyper Terminal (cont.)

FGRIO Master

(9) FGRIO Setup (cont.)

(0) FGRIO 1– Must be set to 1 to enable I/O functions

(1) to (8)- To map the FGRIO Master output to the correct FGRIO Slave input, use the following table: Fig. 8

	FGRIO-M Call Book Entry # 0		FGRIO-M Call Book Entry # 1		FGRIO-M Call Book Entry #2		FGRIO-M Call Book Entry # 3	
FGRIO Master Output	**Input #1**	**Input #2**	**Input #1**	**Input #2**	**Input #1**	**Input #2**	**Input #1**	**Input #2**
Output #1	1	2 ←	3	4	5	6	7	8
Output #2	1	2	3	4	5	6	7	8
Output #3	1	2	3	4	5	6	7	8
Output #4	1	2	3	4	5	6	7	8

1. Select which FGRIO Slave you are mapping to the FGRIO Master. This is determined by the Call Book Entry # that lists the FGRIO Slave's serial number in the FGRIO Master's Call Book.
2. Next, determine if you are mapping Analog/Digital Input # 1 or # 2 of the FGRIO Slave to the FGRIO Master.
3. Enter the value listed in the table for the Analog or Digital Output of the FGRIO Master in Menu 9 of HyperTerminal.
4. Map unused FGRIO Master Analog/Digital Outputs to "0". Multiple FGRIO Master Outputs will not mirror the same FGRIO Slave Input.

EXAMPLE

To map Analog Output 1 of the FGRIO Master to Analog Input 2 of the FGRIO Slave (serial # 930-004), entry (5) in the FGRIO Setup menu will have a value of 2. This is calculated by first checking the Call Book entry # of FGRIO Slave #930-004 (See Figure 8). The entry # is 0. Next, go to the table above, find call book entry # 0, then go to the column for FGRIO Slave Analog Input #2. The value listed is 2. A 2 will be entered for Analog Output #1 of the FGRIO Master.

```
Enter Choice                                        MODEM CALL BOOK
                                                    Entry to Call is (ALL)
Entry    Number     Repeater1    Repeater2
(0)      930-0004 ←
(1)      000-0000
(2)      000-0000
(3)      000-0000
(4)      000-0000
(5)      000-0000
(6)      000-0000
(7)      000-0000
(8)      000-0000
(9)      000-0000
(C)      Change Entry to Use (0-9) or A(ALL)
(Esc)    Exit to Main Menu
Enter all zeros (000-0000) as your last number in list
```

Fig. 9

Set Up with HyperTerminal (cont.)

FGRIO Master

(9) FGRIO Setup (cont.)

(9) TimeOut– 0-255. This setting determines the amount of time to wait before issuing a Link Alarm due to loss of communication between the FGRIO Master and FGRIO Slave. A setting of 1 = 1/6 second

6 = 1 second
42 = 7 seconds
252 = 42 seconds

(A) Sensor Pwr– 0 or 1. A setting of 0 supplies continuous power to the sensor at the FGRIO Slave. A setting of 1, "Gated", is used when the RTU provides a switched power output to control powering the sensors at the FGRIO Slave and analog outputs of the FGRIO Master on and off.

FGRIO Slave- In order for the I/O System to function properly, the following settings must be programmed. For all other settings not listed below, please refer to the User Manual.

(0) Operation Mode

(E) **FGRIO Slave**

Fig. 10

```
                              MAIN MENU
                     Short Range 900MHz 2.50c  06-06-2005

                     Modem Serial Number 930-0019

(0)   Set Operation Mode
(1)   Set Baud Rate
(2)   Edit Call Book
(3)   Edit Radio Transmission Characteristics
(4)   Show Radio Statistics
(5)   Edit MultiPoint Parameters
(8)   Chg Password
(9)   FGRIO Setup
(Esc) Exit Setup

Enter Choice
                                 SET MODEM MODE
                     Modem Mode is  14

(0)   Point to Point Master
(1)   Point to Point Slave
(2)   Point to MultiPoint Master
(3)   Point to MultiPoint Slave
(4)   Point to Point Slave/Repeater
(5)   Point to Point Repeater
(6)   Point to Point Slave/Master Switchable
(7)   Point to MultiPoint Repeater
(E)   FGRIO Slave  <----
(Esc) Exit to Main Menu

Enter Choice  _
```

Set Up with HyperTerminal (cont.)

FGRIO Slave

(2) Call Book– The FGRIO Master's serial number must be programmed as entry #0 in the FGRIO Slave's Call Book. Set "Entry to Call" to 0. In addition, the Network ID must be set to the same ID as the rest of the network. Programming both the Call Book and Network ID settings is unique only to the FGRIO System and must be done for both integrated and stand alone applications.

(3) Radio Transmission Characteristics

(1) Max Packet Size and (2) Min Packet Size– The FGRIO System requires a packet size of 48 Bytes. The following is a list of the available packet sizes that can be used.

Maximum Packet Size Definition with RF Date Rate of 3 Fig. 11

	Max Setting									
Min Setting	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
0				56	72	88	104	120	136	152
1				60	76	92	108	124	140	156
2			48	64	80	96	112	128	144	160
3			52	68	84	100	116	132	148	164
4			56	72	88	104	120	136	152	168
5			60	76	92	108	124	140	156	172
6		48	64	80	96	112	128	144	160	176
7		52	68	84	100	116	132	148	164	180
8		56	72	88	104	120	136	152	168	184
9		60	76	92	108	124	140	156	172	188

(4) RF Data Rate– The RF Date must be set to 3 when using the FGRIO System. This is for applications that are stand alone or when integrated into an existing FGR network.

(8) Retry Timeout– By lowering the Retry Timeout, the inactive link time between the FGRIO Master and FGRIO Slave can be reduced when going from autonomous mode to connecting back to the FGR Network. If the Network Master goes down, the FGRIO Master and Slave will continue to operate in autonomous mode. When the Network Master comes back up, the FGRIO Master will break the link with the FGRIO Slave to reestablish a link with the Network Master. Once the FGRIO Master is linked to the Network Master, then the FGRIO Slave will be able to link back to the FGRIO Master. With a lower Retry Timeout setting, it will take less time for the FGRIO Slave to link to the FGRIO Maser.

Set Up with HyperTerminal (cont.)

FGRIO Slave

(5) MultiPoint Parameters-

(0) Number Repeaters- This setting must be set to 1 for all FGR and FGRIO radios in the Network.

(6) Network ID– In addition to entering the FGRIO Master's serial number in the Call Book, the Network ID being used for the Network must be set from 1-4095, except 255. Programming both the Call Book and Network ID settings is unique only to the FGRIO System and must be done for both integrated and stand alone applications.

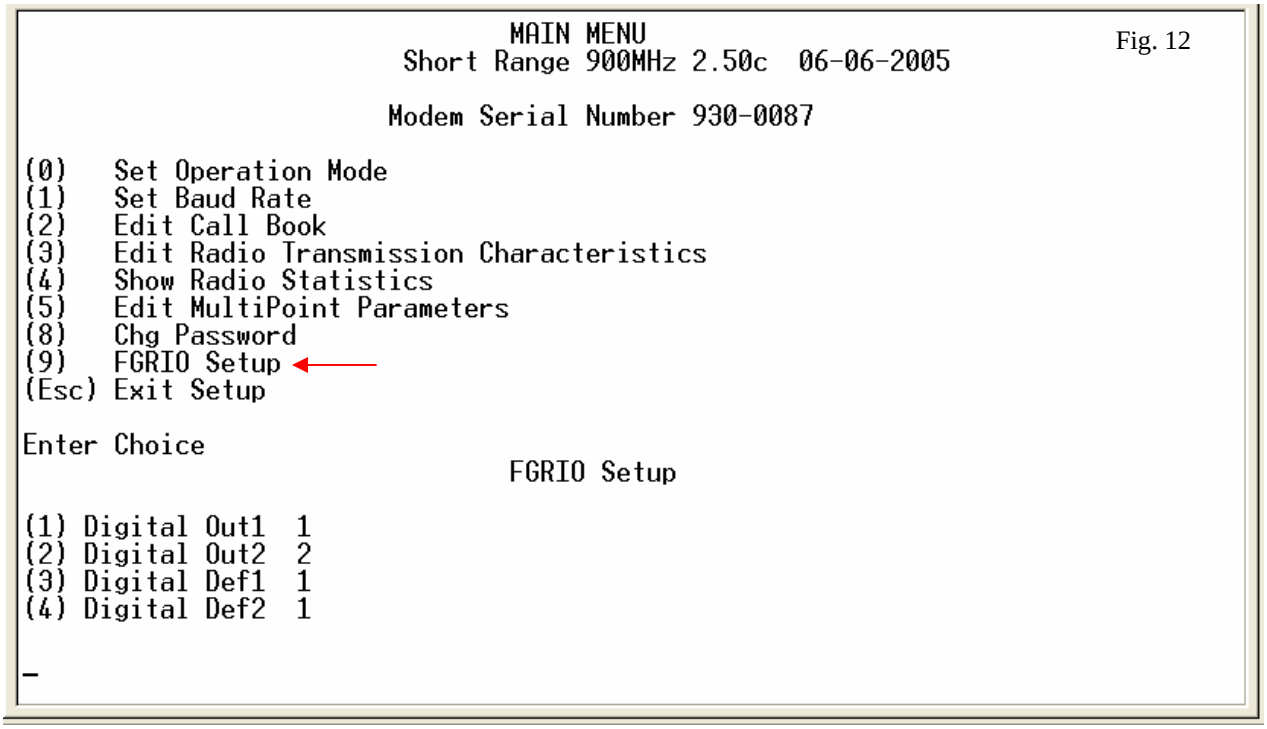


Fig. 12

(9) FGRIO Setup

(1) Digital Out1– Select the desired FGRIO Master Digital Input # (1-4) to control the FGRIO Slave Digital Output # 1.

Set Up with Hyper Terminal (cont.)

FGRIO Slave

(9) FGRIO Setup (cont.)

(2) Digital Out2– Select the desired FGRIO Master Digital Input # (1-4) to control the FGRIO Slave Digital Output # 2.

Note: Both of the FGRIO Slave Digital Ouputs may be driven by the same FGRIO Master Input.

(3) Digital Def1– Select the desired FGRIO Slave Output Default at power-on and link failure.
0= Open Drain output ON (Conducting to GND, 2 Amps max)
1= Open Drain output OFF (Non-Conducting)
2= Make no change in state.

(4) Digital Def2- Select the desired FGRIO Slave Output Default at power-on and link failure.
0= Open Drain output ON (Conducting to GND, 2 Amps max)
1= Open Drain output OFF (Non-Conducting)
2= Make no change in state.

Installation

FGRIO Slave

(1) B+ IN

- Screw Terminal #11 (B+ In) on the phoenix connector of the FGRIO Slave is the raw power for the radio. This terminal is directly connected to Pin # 1 on the 10 pin white header of the FGRIO Slave. Either one can be used to power the radio.

(2) 1-5 Volt Sensor

- Consists of a 3 wire connection from the Sensor to the FGRIO Slave.
- Sensor Ground Wire can be connected to Ground screw terminal # 3,6,9 or 12 on the phoenix connector of the FGRIO Slave.
- Sensor Power Wire is connected to VSNS screw terminal # 7 on the phoenix connector of the FGRIO Slave. Rated total current draw from VSNS is 40mA or less.

Installation (cont.)

FGRIO Slave

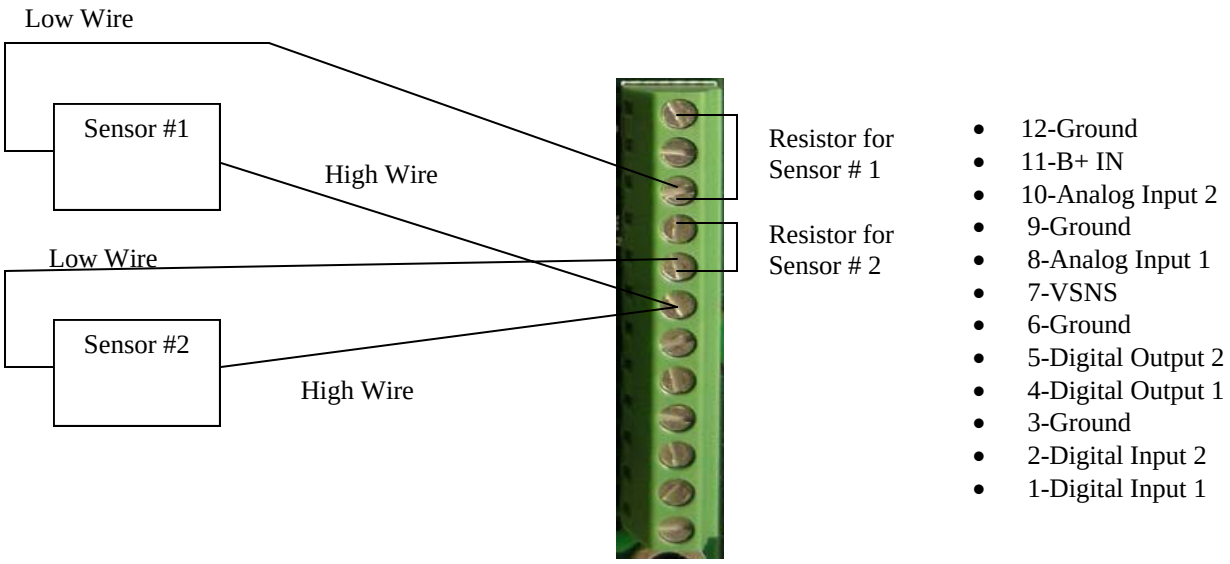
(2) 1-5 Volt Sensor

- Sensor Output Wire is connected to Analog Input 1 screw terminal # 8 or Analog Input 2 screw terminal # 10 on the phoenix connector of the FGRIO Slave.

(3) 4-20 Milliamp Sensor

- Consists of a 2 wire connection from the Sensor to the FGRIO Slave.
- An external resistor (typically 249 Ohms) is required to convert 4-20 milliamps to 1-5 volts. The resistor goes from the desired Analog Input to Ground screw terminals on the phoenix connector of the FGRIO Slave.
- Sensor Power Supply (High) Wire is connected to VSNS screw terminal #7 on the phoenix connector of the FGRIO Slave.
- Sensor Output (Low) Wire is connected to the same Analog Input as the resistor on the phoenix connector of the FGRIO Slave.

Example of two 4-20 milliamp sensors connecting to the phoenix connector of the FGRIO Slave:



Installation (cont.)

FGRIO Slave

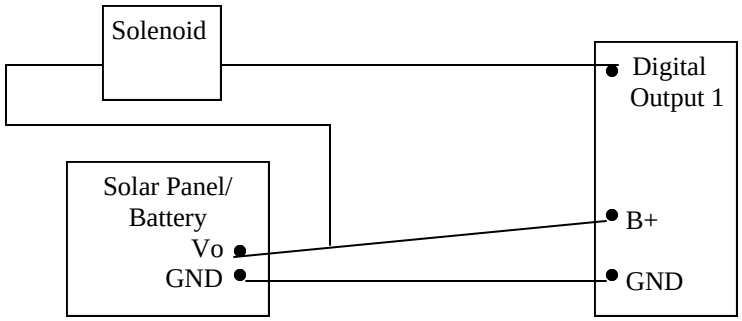
(3) Digital Input

- Switch Output Wire is connected to Digital Input 1 screw terminal # 1 or Digital Input 2 screw terminal # 2 on the phoenix connector of the FGRIO Slave.
- Switch Ground Wire is connected to Ground screw terminal # 3,6,9 or 12 on the phoenix connector of the FGRIO Slave.
  If the Switch Ground Wire is not returned to the FGRIO Slave, the potential difference between the FGRIO Slave Ground and the Dry Contact Closure (Switch) Ground should not exceed 1 Volt.
- In the case of a 3 wire digital transducer, set up similarly to the 1-5V analog sensor, except with the signal wire connected to a Digital Input.

(4) Digital Output

- Digital Output is an open drain field effect transistor connected to Ground. It connects to Ground when zero volts is connected to the controlling Master Digital Input.
- The current rating for Digital Output is 2 amps or less. The Digital Output will self-protect if a current of more than 2 1/2 amps is drawn and automatically retry at .16 second intervals.
- If power on the Solenoid (end device) is not driven from the same power supply as the FGRIO Slave, that source must be equal to or less than the FGRIO Slave power supply voltage. Within the FGRIO Slave, a 3 amp rated Schottky Diode is connected from each Digital Output to the radio power supply terminal for clamping the Solenoid fly back current. If the relay supply voltage exceeded the radio supply voltage, then current would flow through that diode back to the radio, potentially causing an overvoltage condition.

Typical set up of Digital Output wiring between Solenoid and FGRIO Slave:



Phoenix Connector of FGRIO Slave

Installation (cont.)

FGRIO Master

(1) Rx, Tx, B+

- Receive, Transmit, and Power are available on screw terminals of the FGRIO Master phoenix connector as well as the 10 pin header.

(2) Analog Output

- The Analog Output wire is connected from the Analog Output 1,2,3 or 4 screw terminal on the FGRIO Master phoenix connector to the Analog Input of the RTU (destination device).
- Common Ground is required. It is recommended to run a Ground wire from a FGRIO Master Ground screw terminal to Ground on the RTU.

NOTE: Analog Output is 1-5 V at low current, so any 4-20 mA current sensing resistor on the RTU MUST BE REMOVED.

(3) Digital Output

- The Digital Output wire is connected from the Digital Output 1,2,3 or 4 screw terminal on the FGRIO Master phoenix connector to the Digital Input of the RTU (destination device).
- Common Ground is required. It is recommended to run a Ground wire from the FGRIO Master Ground screw terminal to Ground on the RTU.

NOTE: The Digital Output actively drives Low (.4V) and High (4.0V). Remove any RTU input pull-up resistor, if less than 10 K ohms.

(4) Digital Input

- The RTU Digital Output Wire is connected to Digital Input 1,2,3 or 4 screw terminal on the phoenix connector of the FGRIO Master. An internal 10Kohm pullup to +5V is provided.
- The RTU Ground Wire is connected to any of the Ground screw terminals on the phoenix connector of the FGRIO Master.

(5) Sensor Power

- To minimize power drain of the FGRIO Slave Solar/Battery System, an input terminal called Sensor Power is provided on the FGRIO Master phoenix connector.
- If the RTU provides a switched sensor power output, connect it to this terminal.
- The state of that sensor power will be mirrored at the FGRIO Slave, powering the sensors at the FGRIO Slave on and off. It is necessary to change FGRIO Setup sub menu (A) to "1" (Gated).
- **The sensor power terminal both activates sensor power at the controlled FGRIO Slaves, and activates Analog Outputs at the FGRIO Master interface board, when in Sensor Power "Gated" mode.**

Installation (cont.)

FGRIO Master

(6)Link Alarms

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

Note: The mini phoenix connector of the FGRIO Master and Slave can accept a single wire up to 16 gauge. Smaller wire is required for 2 wires, or wire + resistor into the same screw terminal.

Frequently Asked Questions

Q: Can FGRIO be used with a 1 watt radio?

A: The FGRIO Master operates as a standard FGR 1 watt radio with a 60 mile line of sight range. The FGRIO Slave functions as an FGR radio with a 2 mile line of sight range.

Q: Can the FGRIO radios be repeated through our other radios to extend the range?

A: From the FGRIO Slave to the FGRIO Master, repeaters cannot be used. From the FGRIO Master to the rest of the existing network, repeaters can be used as they already are in existing FreeWave networks.

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

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

Q: Can data be sent directly from the FGRIO Slave to the Master of the FreeWave network?

A: No. The FGRIO system functions as wire replacement only. The FGRIO Slave does not have the capability of transmitting data directly to the Master of the network.

Frequently Asked Questions

Q: What are the sizes of the FGRIO Master and Slave?

A: The FGRIO Slave has the same footprint as the FGRO9 family. The FGRIO Master is a standard footprint FGRO9 plus an IO Interface board on top, differing only in width at 2.75 inches.

Q: What timing issues does FGRIO introduce?

A: Although FGRIO 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 the Sensor Power command from FGRIO Master to FGRIO Slave is 167 msec, assuming a robust link. Worst case delay from FGRIO Master Sensor Power assertion to FGRIO Master Analog Output refresh is 700 msec.

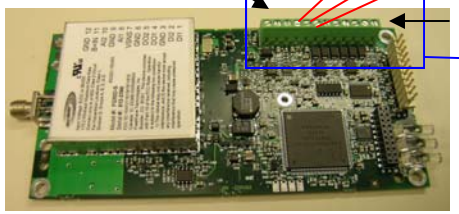
FGRIO Wiring Diagram

A 3 wire connection is made from Sensor to FGRIO Slave

1-5 V Pressure or Temperature Sensor

Screw Terminal # 12

Screw Terminal # 1



Sensor Ground Wire connects to screw terminal # 9 Ground.

1-5 V Pressure or Temperature Sensor

Sensor Power Wire connects to screw terminal # 7 VSNS.

Sensor Output Wire connects to screw terminal # 8 Analog Input 1.

Screw Terminal #12

Screw Terminal #1

Phoenix Connector of FGRIO Slave

FGRIO Slave transmits analog and digital signals over air to FGRIO Master.

Phoenix Connector of FGRIO Master

GND

Sensor Power

B+

Not Used

Sensor Power Output connects from Sensor Power screw terminal to Sensor Power Output of RTU.

Analog Output wire connects from Analog Output 1 screw terminal to Analog Input of the RTU

Ground wire connects from Ground screw terminal to Ground on the RTU

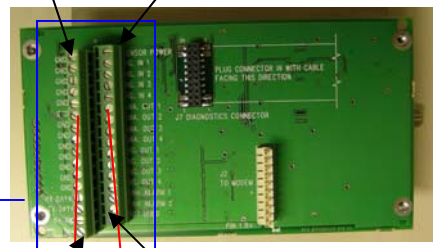
RTU

GND

Sensor Power

B+

Not Used



RTU

A 2 wire connection for analog output is made from FGRIO Master to the RTU. Sensor Power should also be connected if available.

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Technical Specifications
900 MHz Transceiver Specifications

Specification	
Frequency	902 to 928 MHz
Transmit	
Output Power	FGRIO-M: 5 mW to 1 W (+30 dBm) FGRIO-S: 100 mW (+20 dBm).
Range	2 miles Line Of Sight for FGRIO-S to FGRIO-M 60 miles Line of Sight for FGRIO-M to Network
Modulation	Spread spectrum GFSK, 120 Kbps
Spreading method	Frequency hopping
Occupied bandwidth @ 60dB	230 kHz
Channel Spacing	230 kHz
Receive	
Sensitivity	FGRIO-M: -110 dBm at 10-4 bit error rate; FGRIO-S: -100 dBm FGRIO-M: -108 dBm at 10-6 bit error rate; FGRIO-S: -98 dBm
Selectivity	-20 dB at f_c ± 115 kHz -60 dB at f_c ± 145 kHz
System gain	130 dB
Data transmission	
Data rate	80 kbps sustained throughput*
Error detection	32 Bit CRC, retransmit on error
Data encryption	Substitution, dynamic key
Max link throughput	80 KBaud
Data interface	RS-232/RS485 1200 Baud to 230.4 KBaud, async, full duplex
Power requirements	
Supply voltage	FGRIO-M: 6 to 30 VDC; FGRIO-S: 6-20 VDC
Transmit current at full power	6 VDC: FGRIO-M: 1000mA FGRIO-S: 125 mA 12 VDC: FGRIO-M: 500 mA FGRIO-S: 70 mA 30 VDC: FGRIO-M: 200 mA
Receive current	6 VDC: FGRIO-M: 140 mA FGRIO-S: 64mA 12 VDC: FGRIO-M: 75 mA FGRIO-S: 38 mA 30 VDC: FGRIO-M: 55 mA
Idle current	6 VDC: FGRIO-M: 37 mA FGRIO-S: 24 mA 12 VDC: FGRIO-M: 21 mA FGRIO-S: 14 mA 30 VDC: FGRIO-M: 16 mA
Sleep current	6 VDC: FGRIO-M: 12 mA 12 VDC: FGRIO-M: 6 mA 30 VDC: FGRIO-M: 5 mA
Operating modes	Point-to-Point Point to-MultiPoint FGRIO Autonomous
Operating environment	-40° C- +75° C, 0 to 95% humidity non-condensing

* At 100% receive success rate.

	FGRIO-M	FGRIO-S
Data Port	10-pin PCB connector	10-pin PCB connector
Enclosure	Bare board	Bare board
Dimensions	140 mm (L) x 70 mm (W) x 34 mm (H)	127 mm (L) x 61 mm (W) x 15.5 mm H)
Weight	140.85 g	47.0 g
Power requirements	§ 6-30 VDC § May be powered through pin "B+ IN" of Phoenix connector, or pin 1 of Data Port.	§ 6-20 VDC § May be powered through pin 11 of Phoenix connector, or pin 1 of Data Port.
Antenna	SMA female connector. External antenna required.	SMA female connector. External antenna required.
FCC Identifier	KNY-6231812519	KNY-6231812519
DOC Identifier	2329B-DGR09RAS	2329B-DGR09RAS

Analog Signals	
Number of Signals	FGRIO-S: 2 Inputs; FGRIO-M: 4 Outputs; 1 to 4 -S per -M
Analog Input Range, Resistance, Bandwidth	0-5.625V, 94Kohms, 67Hz Lowpass filter and 50/60Hz Notch
Master + Slave System Resolution	16 Bits; .0015% of FS
Master + Slave System Initial Accuracy @ +25°C	.1% of FS
Master + Slave System Temperature Drift	.14% of FS change from +25°C at -40°C or +75°C
Master + Slave System Aging Drift	.05% of FS at 6 mos., .1% at 2yrs.
Digital Signals: FGRIO-M	
Number of Inputs, Outputs	4 Inputs, 4 Outputs
Input Structure Input Threshold Low Input Threshold High Slave Input to Master Output Delay Input Applied Voltage Range ESD Immunity: Human Body Model ESD Immunity: Machine Model	9.4Kohm pull-up to 5V with in-line 8kHz Lowpass filter 1.75V Max. 3.25V Min .16 sec. Max. +/- 30V 15 KV 8 KV
Output Voltage High (Iout < 10 uA) Output Voltage Low (Iout < 10 uA) Output Voltage High (Iout = 2 mA) Output Voltage Low (Iout = 2.4 mA)	4.7V 0.2V 3.75V 0.4V
Digital Signals: FGRIO-S	
Number of Inputs, Outputs	2 Inputs, 2 Outputs
Input Structure Input Threshold Low Input Threshold High Slave Input to Master Output Delay Input Applied Voltage Range ESD Immunity: Human Body Model ESD Immunity: Machine Model	10Kohm pull-up to 3.3V with 10nF Debounce capacitor 1.2V Min. 2.3V Max. .16 sec. Max. +/- 30V 15 KV 8 KV
Output Structure Output Voltage range Output Current Sinking Output Default	Non-arcing Open-Drain FET to GND with flyback diodes 0V to Supply Voltage > 2.0 Amps; shutdown at < 2.5 Amps; 166 msec retry Programmable link-loss timeout and default state

Sensor Power: FGRIO-M	
Input Structure	10Kohm and 4.7uF pull-down to GND
Input Threshold Low	1.75V Max.
Input Threshold High	3.25V Min
Master Input to Slave Output Delay	.16 sec. Max.
Input Applied Voltage Range	+/- 30V
ESD Immunity: Human Body Model	15 KV
ESD Immunity: Machine Model	8 KV
Sensor Power: FGRIO-S	
Output Structure	Open-Drain FET to B+ In, with 10nf and flyback diodes
Output Current	> 40mA; shutdown at < 50mA; 166 msec retry.
ESD Immunity: Human Body Model	15 KV
ESD Immunity: Machine Model	8 KV