



FGR2-IO In Modbus

June 17, 2008

Purpose:

To define the procedure for operating the FGR2-IO radio in Modbus:

Equipment requirements: (Firmware 2.44 or greater in the FGR and 9.67 or greater in the FGR2-IO)

- 1) FGR series FreeWave radio to be installed as the MultiPoint Master and Repeater (if required). FGR2-IO installed as a Modbus slave or slave/repeater.
- 2) Modbus WILL NOT work with DGR series radios.

Setup:

The following are the system setup requirements.

NOTE: EZConfig will be capable of supporting the radio setup functions of this document. However, the radio setup is written from the perspective of the user working with HyperTerminal (or similar terminal program).

- 1) The Modbus Network Master must be set as follows:
 - a. Menu 0 – set the FGR Master to (2) Multipoint Master.
 - b. Menu 1 – Modbus RTU set to 1



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LUM0011AA Rev A

Modbus

```
Comm 1 - HyperTerminal
File Edit View Call Transfer Help
(ESC) Exit Setup
Enter Choice
                                SET BAUD RATE
                                Modem Baud is 019200

(0) 230,400
(1) 115,200
(2) 76,800
(3) 57,600
(4) 38,400
(5) 19,200
(6) 9,600
(7) 4,800
(8) 2,400
(9) 1,200
(A) Data, Parity 0
(B) MODBUS RTU 1
(C) RS232/485 0
(D) Setup Port 3
(E) TurnOffDelay 4 TurnOnDelay 0
(F) FlowControl 0
(ESC) Exit to Main Menu
Enter Choice

Connected 0:00:24 ANSIW 19200 8-N-1 SCROLL CAPS NUM Capture Print echo
```

FGR Master Menu 1

- c. Menu 2 – Not Applicable
- d. Menu 3 – Set FreqKey as necessary

```
Comm 1 - HyperTerminal
File Edit View Call Transfer Help
(8) Chg Password
(ESC) Exit Setup
Enter Choice
                                RADIO PARAMETERS

WARNING: Do not change parameters without reading manual

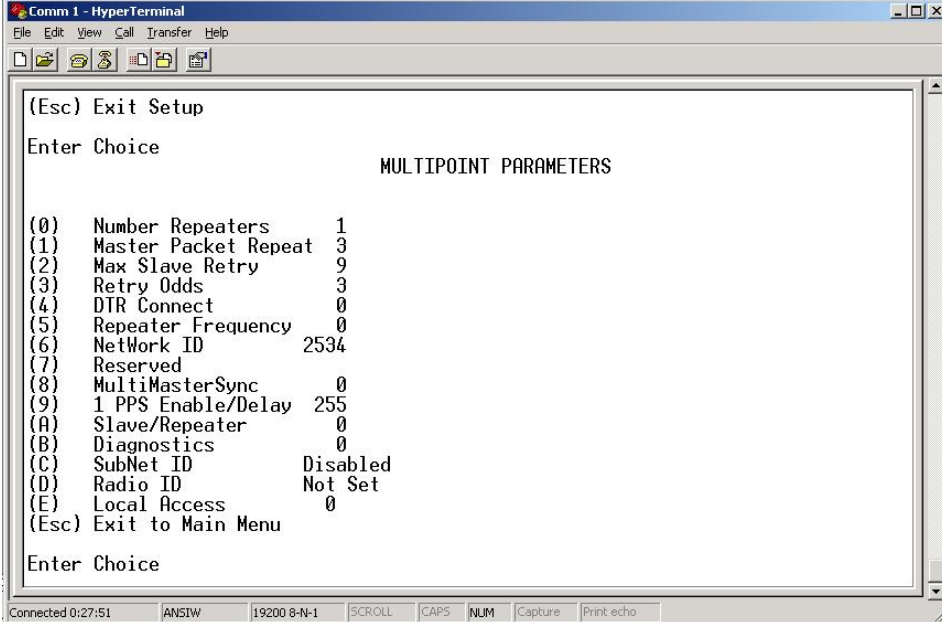
(0) FreqKey 5
(1) Max Packet Size 2
(2) Min Packet Size 2
(3) Xmit Rate 1
(4) RF Data Rate 3
(5) RF Xmit Power 10
(6) Slave Security 0
(7) RTS to CTS 0
(8) Retry Time Out 255
(9) Lowpower Mode 0
(A) High Noise 0
(B) MCU Speed 0
(C) RemoteLED 0
(ESC) Exit to Main Menu
Enter Choice

Connected 0:11:09 ANSIW 19200 8-N-1 SCROLL CAPS NUM Capture Print echo
```



Modbus

- e. Menu 3 – Set Max and Min Packet sizes to match the FGR Master. NOTE: 2 and 2 is the Minimum size that should be used.
 - i. This is the recommended packet size as it should handle most Modbus packets with the best throughput.
- f. Other settings in menu 3 are to be set at the users' discretion according to the FreeWave User Manual.



```
Comm 1 - HyperTerminal
File Edit View Call Transfer Help
(ESC) Exit Setup
Enter Choice
MULTIPOINT PARAMETERS
(0) Number Repeaters      1
(1) Master Packet Repeat  3
(2) Max Slave Retry       9
(3) Retry Odds            3
(4) DTR Connect          0
(5) Repeater Frequency    0
(6) Network ID            2534
(7) Reserved
(8) MultiMasterSync       0
(9) 1 PPS Enable/Delay    255
(A) Slave/Repeater        0
(B) Diagnostics           0
(C) SubNet ID             Disabled
(D) Radio ID              Not Set
(E) Local Access          0
(ESC) Exit to Main Menu
Enter Choice
Connected 0:27:51  ANSIW  19200 8-N-1  SCROLL  CAPS  NUM  Capture  Print echo
```

- g. Menu 5 – Set Number Repeaters to 0 if there are no Repeaters in the net work or 1 if there are 1 or more Repeaters in the network.
 - h. Set Master Packet Repeat according to network interference conditions and message reliability requirements. A setting of 2 or greater is recommended.
 - i. Set NetworkID to a unique value from 0 to 4095.
 - i. DO NOT USE 255. This enables the CallBook (Menu 2).
 - j. Other settings in menu 5 are to be set at the users' discretion according to the FreeWave User Manual.
- 2) The Modbus Slave must be set as follows:
- a. Menu 0 – set the FGRIIO Slave to (3) Multipoint Slave, or (7) Multipoint Repeater.
 - i. DO NOT SET TO FGRIIO SLAVE (E)



Modbus

```
radio2 - HyperTerminal
File Edit View Call Transfer Help
(3) Edit Radio Transmission Characteristics
(4) Show Radio Statistics
(5) Edit MultiPoint Parameters
(8) Chg Password
(9) FGRI0 Setup
(Esc) Exit Setup

Enter Choice

                               SET MODEM MODE
                               Modem Mode is 3

(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) FGRI0 Slave (NOT IO-MODBUS)
(Esc) Exit to Main Menu

Enter Choice

Connected 0:35:04  ANSII  19200 8-N-1  SCROLL  CAPS  NUM  Capture  Print echo
```

b. Menu 1 –set Modbus RTU to “1”.

```
Comm 1 - HyperTerminal
File Edit View Call Transfer Help
(Esc) Exit Setup

Enter Choice

                               SET BAUD RATE
                               Modem Baud is 019200

(0) 230,400
(1) 115,200
(2) 76,800
(3) 57,600
(4) 38,400
(5) 19,200
(6) 9,600
(7) 4,800
(8) 2,400
(9) 1,200
(A) Data, Parity 0
(B) MODBus RTU 1
(C) RS232/485 0
(D) Setup Port 3
(E) TurnOffDelay 4 TurnOnDelay 0
(F) FlowControl 0
(Esc) Exit to Main Menu
Enter Choice

Connected 0:00:24  ANSIW  19200 8-N-1  SCROLL  CAPS  NUM  Capture  Print echo
```

c. Menu 2 – Not Applicable

d. Menu 3 – Set FreqKey as necessary to match the Master or Repeater.



Modbus

```
Comm 1 - HyperTerminal
File Edit View Call Transfer Help
(9) FGRI0 Setup
(Esc) Exit Setup

Enter Choice

                                RADIO PARAMETERS

WARNING: Do not change parameters without reading manual

(0) FreqKey           5
(1) Max Packet Size  2
(2) Min Packet Size  2
(3) Xmit Rate        1
(4) RF Data Rate     3
(5) RF Xmit Power    10
(6) Slave Security   0
(7) RTS to CTS       0
(8) Retry Time Out  64
(9) Lowpower Mode    0
(A) High Noise       0
(B) MCU Speed        0
(C) RemoteLED        0
(Esc) Exit to Main Menu

Enter Choice _
```

- e. Menu 3 – Set Max and Min Packet sizes to match the Master.
- f. Menu 3 – Set Retry Time Out; >= 64 is recommended.
- g. Other settings in Menu 3 are to be set at the users' discretion according to the FreeWave User Manual.
- h. Menu 5 – Set Master Packet Repeat to match the FGR Master.
- i. Menu 5 – Set NetworkID to match the Master.
- j. Other settings in menu 5 are to be set at the users' discretion according to the FreeWave User Manual.

```
Comm 1 - HyperTerminal
File Edit View Call Transfer Help
(Esc) Exit Setup

Enter Choice

                                MULTIPPOINT PARAMETERS

(0) Number Repeaters      1
(1) Master Packet Repeat  3
(2) Max Slave Retry       9
(3) Retry Odds            3
(4) DTR Connect           0
(5) Repeater Frequency    0
(6) NetWork ID            2534
(7) Reserved
(8) MultiMasterSync       0
(9) 1 PPS Enable/Delay    255
(A) Slave/Repeater        0
(B) Diagnostics           0
(C) SubNet ID             Disabled
(D) Radio ID              Not Set
(E) Local Access          0
(Esc) Exit to Main Menu

Enter Choice
```

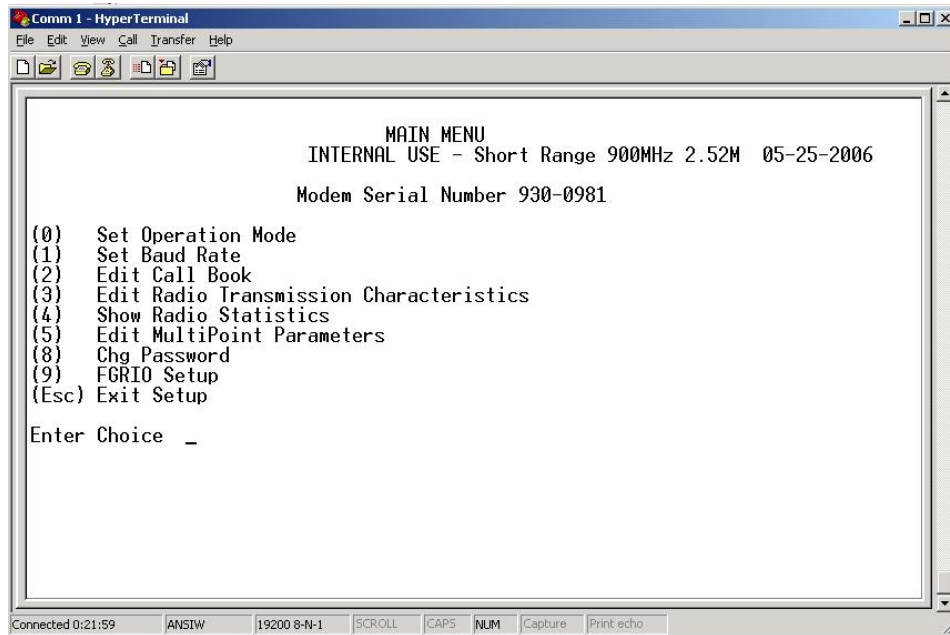


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- 3) New options have been added to support basic Modbus operation in Menu 9 FGRI0 Setup. Additional features have been added that are not in the menu. A complete register map and textual descriptions of its entries are found later in this document. Setup of these features can be accomplished by the Freewave Tools Suite or direct Modbus commands.



```
Comm 1 - HyperTerminal
File Edit View Call Transfer Help
MAIN MENU
INTERNAL USE - Short Range 900MHz 2.52M 05-25-2006
Modem Serial Number 930-0981
(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) FGRI0 Setup
(Esc) Exit Setup
Enter Choice _
```

- a. Below shows the menu with Modbus enabled. (press 5 to toggle function)
- b. Option 0, the value set is in .28 second units. This sets the duration after loss of communication before entering default condition. e.g. A value of 36 = 10 seconds.
- c. Options 3-4 Digital Def1 and Digital Def2. This controls the state of the digital output defaults invoked on loss of communication. See option 0 below for timing.
 - i. On = energized (Contact to GND is closed)
 - ii. Off = not energized (Contact is open)
 - iii. Unchanged = if communication is lost, do not change state.

Note: If programming a DO to turn on after loss of link ensure that the energized device can sustain that state undamaged in case the loss is lengthy. A new feature in FGR2-IOS allows the DO to be energized for only a user-specified duration. See "Coil" #27 (PLC numbering convention) titled "DO's Bi-Stable" for details.



Modbus

```
radio - HyperTerminal
File Edit View Call Transfer Help
Enter Choice
FGPIO Setup
(0) Default Delay      20
(1)
(2)
(3) Digital Def1      On
(4) Digital Def2      On
(5) IO MODBus         Enabled
(6) Sensor Power Default On
(7) DI1 Counter Edge  Falling
(8) DI2 Counter Edge  Falling
(9) ModBus ID         11
(A) Clear Counter 1 on Read No
(B) Clear Counter 2 on Read No
(C) AI1 Custom Offset 00000 Clipped at zero.
(D) AI2 Custom Offset 00000 Clipped at zero.
(E) DI1 Pull Up/Down  Up
(F) DI2 Pull Up/Down  Up
(G) 16 Bit MODBus Address Disabled
(H) Local MODBus Parse
(Esc) Exit to Main Menu
Enter Choice _
```

Connected 1:09:30 ANSIW 19200 8-N-1 SCROLL CAPS NUM Capture Print echo

- d. Option 5 IO Modbus toggles between Modbus and Non-Modbus setup modes. Menus 0, 1, 2, 3 also need value changes to switch modes.
- e. Option 6 Sensor Power Default at power-on toggles On or Off.
- f. Options 7-8 DI1 and DI2 Counter Edge Toggles between Rising or Falling edge.
- g. Option 9 Modbus ID value selectable from 1– 246, or from 1-65535 if option G (16 Bit Modbus Address) is enabled.
- h. Options A and B Clear Counter (1 or 2) on Read. Clears the count on the given DI input immediately after Read. This prevents loss of counts which could occur between a Read operation and a later Clear operation. NOTE: Clear on Read only works when both 16 bit registers are read together in a single Modbus poll.
- i. Options C and D are user-entered values to subtract from the AI1 and AI2 MSW (Most Significant Word) measurements to provide zero-shifted versions of AI1 and AI2. The results can be either clipped at zero or allowed to wrap to full scale. See the memory map for further information.
- j. Options E and F control power-up states of the internal resistors (10Kohms) connected to the DI's. They can pull up, such as when using a closed-contact-to-GND switch input, pull down so that unused inputs read "0" as DI's or ~0 as auxiliary analogs, or float to not load analog inputs.
- k. Option G toggles between 8 Bit and 16 Bit Modbus addressing.
- l. Option H invokes Local Modbus Parsing. This option is used to set coils and holding registers unsupported in these menus (e.g. Holding register 40006 DO Mono stable timeout) or to execute a Modbus setup script. It is not possible to operate the IO functions in this mode, as the inputs are not refreshed and the outputs are disabled. A terminal program is used to enter this mode, after which the communication is diverted to a Modbus control program, such as the Freewave Modbus Demo utility (available free of charge from Freewave Technologies), or one of the user's choice. Subsequent communication is by valid Modbus RTU messages.



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When complete, return to normal radio operation is done by cycling power, pressing the Reset button or writing a "1" to coil 32 (PLC address convention).

4) Modbus Register Map

REGISTER MAP FOR FGR2-IOS FIRMWARE 9.67					
COLOR KEY					
Read Only, RO	Read/Write, RW		Non-Volatile on PWR cycle, 10,000-write lifetime limit	New Feature	
TYPE	ADDRESS		ENTITY	BITS	NOTES
	PROTOCOL	PLC			All addresses described are "PLC" numbers
"COIL"	0	1	DO1	1	On Read, returns actual state if ~= Command; Power-up Default = OFF
"COIL"	1	2	DO2	1	On Read, returns actual state if ~= Command; Power-up Default = OFF
"COIL"	2	3	SENSOR PWR	1	On Read, returns actual state if ~= Command
"COIL"	3	4	SENSOR DEFAULT	1	Default = OFF
"COIL"	4	5	DO1 FAULT	1	Auto-Clears fault if successful retry
"COIL"	5	6	DO2 FAULT	1	Auto-Clears fault if successful retry
"COIL"	6	7	SENSOR PWR FAULT	1	Auto-Clears fault if successful retry
"COIL"	7	8	COMM FAIL FAULT LATCH	1	DOx have defaulted, clear by user
"COIL"	8	9	CLR CNTR1 ON RD	1	Default OFF
"COIL"	9	10	CLR CNTR2 ON RD	1	Default OFF
"COIL"	10	11	CNTR1 INC ON 0-1 EDGE	1	Default OFF; Increment on 1-0 Edge
"COIL"	11	12	CNTR2 INC ON 0-1 EDGE	1	Default OFF; Increment on 1-0 Edge
"COIL"	12	13	DO1 LEAVE UNCHANGED	1	Default ON, Overrides DO1 Default
"COIL"	13	14	DO2 LEAVE UNCHANGED	1	Default ON, Overrides DO2 Default
"COIL"	14	15	DO1 DEFAULT STATE	1	Default OFF
"COIL"	15	16	DO2 DEFAULT STATE	1	Default OFF
"COIL"	16	17	CNTR1 INC LATCH	1	ON at inc; OFF by user
"COIL"	17	18	CNTR2 INC LATCH	1	ON at inc; OFF by user
"COIL"	18	19	CNTR1 CLEAR	1	Default OFF, pulsed so Read = always OFF
"COIL"	19	20	CNTR2 CLEAR	1	Default OFF, pulsed so Read = always OFF
"COIL"	20	21	AI1 OFFSET CLIP AT 0	1	Default ON
"COIL"	21	22	AI2 OFFSET CLIP AT 0	1	Default ON
"COIL"	22	23	Reserved	1	
"COIL"	23	24	Reserved	1	
"COIL"	24	25	DI1 PULLUP	1	Default ON, OFF = PULLDOWN
"COIL"	25	26	DI2 PULLUP	1	Default ON, OFF = PULLDOWN
"COIL"	26	27	DO's BI-STABLE	1	Default ON, OFF = Monostable (1-shot)
"COIL"	27	28	AO1/VSNS LEAVE UNCH	1	Default ON, Overrides AO1/VSNS Default Cmd



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"COIL"	28	29	AO2 LEAVE UNCHANGED	1	Default ON, Overrides AO2 Default Command
"COIL"	29	30	DEBOUNCE COUNTERS IN	1	Default ON; OFF for High Speed Counting
"COIL"	30	31	FILTER COUNTERS IN	1	Default ON; OFF for High Speed Counting
"COIL"	31	32	RESET RADIO	1	Always Reads OFF; Write ON for Reset
"COIL"	32	33	FAST AI(DI1)	1	Default ON = Samples, OFF=Filtered Average
"COIL"	33	34	FAST AI(DI2)	1	Default ON = Samples, OFF=Filtered Average
"COIL"	34	35	DI1 PULLUP ACTIVE	1	Default ON; OFF Overrides DI1PULLUP
"COIL"	35	36	DI2 PULLUP ACTIVE	1	Default ON; OFF Overrides DI2PULLUP
"COIL"	36	37	AI1 250 OHM PD ACTIVE	1	Default OFF, Enclosure Model Only
"COIL"	37	38	AI2 250 OHM PD ACTIVE	1	Default OFF, Enclosure Model Only
"COIL"	38	39	DI1 125 OHM PD ACTIVE	1	Default OFF, Enclosure Model Only
"COIL"	39	40	DI2 125 OHM PD ACTIVE	1	Default OFF, Enclosure Model Only
"COIL"	40	41	Reserved	1	
"COIL"	41	42	Reserved	1	
"COIL"	42	43	Reserved	1	
"COIL"	43	44	Reserved	1	
"COIL"	44	45	AI1 250 OHM PD FAULT	1	Enc. Model Only; Auto-Clears if succ. retry
"COIL"	45	46	AI2 250 OHM PD FAULT	1	Enc. Model Only; Auto-Clears if succ. retry
"COIL"	46	47	DI1 125 OHM PD FAULT	1	Enc. Model Only; Auto-Clears if succ. retry
"COIL"	47	48	DI2 125 OHM PD FAULT	1	Enc. Model Only; Auto-Clears if succ. retry
DISCRETE IN	10000	10001	DI1	1	Real-Time state of DI1; "1" = DI1 > 1.75V
DISCRETE IN	10001	10002	DI2	1	Real-Time state of DI2; "1" = DI2 > 1.75V
DISCRETE IN	10002	10003	DI of AI1	1	Compare of AI1: "1" = AI1 > 1.65V
DISCRETE IN	10003	10004	DI of AI2	1	Compare of AI2: "1" = AI2 > 1.65V
DISCRETE IN	10004	10005	DTR	1	Real-Time state of IODTR line on J3
INPUT REG	30000	30001	AI1 MSW	16	Upper 16 bits; msb=5V, lsb=152.587uV
INPUT REG	30001	30002	A1 LSW	16	Lower bits, lsb=2.3283nV
INPUT REG	30002	30003	AI2 MSW	16	Upper 16 bits; msb=5V, lsb=152.587uV
INPUT REG	30003	30004	A2 LSW	16	Lower bits, lsb=2.3283nV
INPUT REG	30004	30005	DI1 COUNTER MSW	16	Upper 16 bits of 32 bit counter
INPUT REG	30005	30006	DI1 COUNTER LSW	16	Lower 16 bits of 32 bit counter
INPUT REG	30006	30007	DI2 COUNTER MSW	16	Upper 16 bits of 32 bit counter
INPUT REG	30007	30008	DI2 COUNTER LSW	16	Lower 16 bits of 32 bit counter
INPUT REG	30008	30009	Vbatt	16	Supply Voltage; 0-33.164V, lsb=506.04uV
INPUT REG	30009	30010	degC	16	Signed degC temperature of radio PCB
INPUT REG	30010	30011	ALL DI'S	16	10016:10001, unused bits = 0's
INPUT REG	30011	30012	ALL COILS 16:1	16	PLC Addresses 16:1, but Read-Only
INPUT REG	30012	30013	ALL COILS 32:17	16	PLC Addresses 32:17, but Read-Only
INPUT REG	30013	30014	AI1 MSW Offset Result	16	AI1 MSW - AI1 USER OFFSET



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INPUT REG	30014	30015	AI2 MSW Offset Result	16	AI2 MSW - AI2 USER OFFSET
INPUT REG	30015	30016	AI(DI1)	16	0-3.5Vin; lsb=53.406uV
INPUT REG	30016	30017	AI(DI2)	16	0-3.5Vin; lsb=53.406uV
INPUT REG	30017	30018	AI1	32FP	IEEE754 Short Float in unscaled Volts
INPUT REG	30019	30020	AI2	32FP	IEEE754 Short Float in unscaled Volts
INPUT REG	30021	30022	AI(DI1)	32FP	IEEE754 Short Float in unscaled Volts
INPUT REG	30023	30024	AI(DI2)	32FP	IEEE754 Short Float in unscaled Volts
INPUT REG	30025	30026	Vbatt	32FP	IEEE754 Short Float in unscaled Volts
INPUT REG	30027	30028	degC	32FP	IEEE754 Short Float in unscaled Celsius
INPUT REG	30029	30030	DO1 CURRENT	16	lsb=534uA, Res=34mA; Not Accurate in Fault
INPUT REG	30030	30031	DO2 CURRENT	16	lsb=534uA, Res=34mA; Not Accurate in Fault
INPUT REG	30031	30032	Reserved1	16	
INPUT REG	30032	30033	Reserved2	16	
INPUT REG	30033	30034	ALL COILS 48:33	16	PLC Addresses 48:33, but Read-Only
HOLDING REG	40002	40003	DO's DEFAULT DELAY	16	.28 sec units of Retry Timeout to DO Defaults
HOLDING REG	40003	40004	AI1 USER OFFSET	16	Value to subtract from 30001 for 30014
HOLDING REG	40004	40005	AI2 USER OFFSET	16	Value to subtract from 30002 for 30015
HOLDING REG	40005	40006	DO MONOSTABLE TIME	16	Duration of DO ON, if 27 OFF, ~.15sec/count, range 0-255
HOLDING REG	40006	40007	AO1 Command	16	0-22mA: lsb=335.693nA
HOLDING REG	40007	40008	AO2 Command	16	0-22mA: lsb=335.693nA
HOLDING REG	40008	40009	AO1/VSNS Default Cmd	16	0-22mA: lsb=335.693nA
HOLDING REG	40009	40010	AO2 Default Command	16	0-22mA: lsb=335.693nA
HOLDING REG	40010	40011	AO1 Customer Offset	16	Added to 40007 lsb=335.693nA
HOLDING REG	40011	40012	AO2 Customer Offset	16	Added to 40008 lsb=335.693nA

Explanatory Notes by PLC Address:

Note: The radio will treat requested register addresses below 00256 as implicitly referencing higher registers according to the command code issued.

For example a command to "Read Holding Register 00003" will return the contents of register 40003, as the Holding Registers all reside at 40000 and above.

Similarly, a command to "Read Discrete Input 00002" will return the state of address 10002.

A request to "Read Coil 00002" will return the state of address 00002, as the coils actually are resident at addresses below 256.



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1 Discrete Output #1 (DO1)

Emulates a contact closure to GND using a solid-state device. Rated current is 2.0 Amps maximum; protection algorithms will shut OFF the DO at about 2.25 Amps. See “coil” 5 for Fault sensing and coils 13, 15 and register 40003 for Default settings. Coil 27 and Register 40006 allow automatic shut OFF of the DO after an interval.

2 DO2; Similar operation to DO1

3 Sensor Power

Radio power-on default controlled by coil 4. See coil 7 for Fault sensing. The I/O terminal is now shared with Analog Output AO1. Activation of this coil overrides any setting of AO1.

4 Sensor Power-On Default

Factory Pre-set to OFF. Previous models used a Pre-set of ON, but this is changed for compatibility with the Lowpower modes now operable.

5 DO1 FAULT

DO1 Current is sensed and turned OFF if $> 2.25A$ nominal, resulting in ON condition of this synthetic “coil”. Radio periodically turns DO1 back ON and checks for persistence of Fault. If Fault condition ends, this coil automatically reverts to OFF.

6 DO2 FAULT; Similar operation to coil 5.

7 SENSOR POWER FAULT

Similar operation to coils 5, 6, except Fault threshold is $>50mA$. An algorithm allows the Fault threshold to be exceeded for several milliseconds to allow charging of external sensor bypass capacitors. Sensors having large bypass capacitance may nevertheless force this Fault and not be usable with the Sensor Power output. Such devices may be low-side switched with a DO or permanently powered by B+ IN.

It is possible to achieve an extra pseudo-DI function by powering a resistor connected to a contact closure whose other side is GND. The resistor must be sized to draw $> 55mA$ from a voltage 2.0V less than the lowest expected value of B+ IN. Closure causes a “1” on Read of this coil. Since the re-try duty cycle of the 55mA current is low, only about 1mA of extra average supply current results. Any powered sensors present would need to be powered by direct connection to B+ IN.

8 COMM FAIL FAULT LATCH

In case of communication failure, DO's can be set up to go to Default states under control of coils 13-16. This coil serves to inform (after communication is restored) that the link was lost long enough to activate the Defaults. This coil remains ON until turned OFF by Modbus command.

9 CLEAR COUNTER 1 ON READ

If ON, this coil causes the DI1 counter to be cleared automatically when Read, preventing loss of counts occurring between a Read and subsequent Clear (see coil 19). This coil only functions if the Read is of both registers 30005 and 30006. Factory Pre-set is OFF, so that DI1 Counter accumulates up to a maximum value of 4,294,967,295.

10 CLEAR COUNTER 2 ON READ; Similar operation to coil 9.

11 CNTR1 INC ON 0-1 EDGE

Factory Pre-set is OFF, so that falling edges of DI1 cause the Counter to increment. Change of this setting by Modbus command may cause a false increment.

12 CNTR2 INC ON 0-1 EDGE; Similar to coil 11.

13 DO1 LEAVE UNCHANGED



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Factory Pre-set ON. Users may not want the radio to automatically enter defined Default states after communication loss. This coil takes precedence over the Default State setting of coil 15.

14 DO2 LEAVE UNCHANGED; Similar to coil 13.

15 DO1 DEFAULT STATE

Factory Pre-set OFF. If coil 13 is OFF and communication is lost longer than the timeout of register 40003, DO1 will go to the state of this coil. If the default is to be ON, coil 27 can optionally force shutoff of DO1 after a delay set in register 40006.

16 DO2 DEFAULT STATE; Similar to coil 15.

17 CNTR1 INC LATCH

Power-on state is OFF. Latch is set ON when an increment event occurs on DI1 and can only be cleared to OFF by Modbus command. This is useful for single event detection, such as plunger arrival.

18 CNTR2 INC LATCH; Similar to coil 17

19 CNTR1 CLEAR

Forced reset to zero of DI1 Counter. Setting this coil to ON clears the counter and this coil, so that a Read of this coil is always OFF.

20 CNTR2 CLEAR; Similar to coil 19.

21 AI1 OFFSET CLIP AT 0

ON: Unsigned Offset calculation ($30014 = 30001 - 40004$) forced to zero in case: $(40004) > (30001)$.
OFF: Unsigned Offset calculation ($30014 = 30001 - 40004$) allowed to wrap in case: $(40004) > (30001)$.
For example, if $(40004) = (30001) + 1$,
 $(30014) = 65,535$.

22 AI2 OFFSET CLIP AT 0; similar to coil 21.

25 DI1 PULLUP

Default is ON; a 10Kohm internal resistor attached to the input is connected to the 3.5V logic supply to provide a pullup for closed-contact-to-GND sensors. Turning this coil OFF connects the resistor as a pulldown to GND for use with closed-contact-to-voltage sensors. Any write to this coil will turn 35 ON to enable the connecting driver. Writing OFF to 35 will override this setting and the resistor will float.

26 DI2 PULLUP; similar to 25.

27 DO's BI-STABLE

Default is ON; states of DO1 and DO2 are persistent unless changed by Modbus command or Communication Loss Defaults.

If coil 27 is reset to OFF (mono-stable), a DO ON state will timeout after an interval set in register 40006. In case a Communication Loss Default turns ON the DO, a single ON interval will occur even if the link repeatedly restores and fails. Clearing the Comm Fail Fault Latch at coil 8 will re-arm for Communication Loss Default events to turn ON the DO. Each actual Modbus ON command to a DO results in a new ON interval.

The automatic timeout mode is useful if the DO is connected to a device which is not rated for continuous ON, so that link or SCADA outages don't damage it. Also, Modbus traffic may be reduced, as the need to command a DO back OFF may be eliminated.

28 AO1/VSNS LEAVE UNCHANGED

Default is ON. This coil overrides the Communication Loss Default setting for the AO1/VSNS output at register 40009. If set to OFF, then a Communication Loss Default event will apply the value in register 40009.



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29 AO2 LEAVE UNCHANGED; similar to coil 28.

30 DEBOUNCE COUNTERS IN

When OFF, the 32-bit counters driven by DI-1 and DI-2 are capable of counting signals with each logic state duration greater than 500usec, so count rates to 1000Hz are possible for input duty-cycles of 40-60%. At lower rates, the duty-cycle may vary further, so long as each phase remains greater than 500usec.

When ON, and coil 32 is OFF, count rates from 10-25 Hz are possible, depending on packet size, with the associated requirement for logic state duration varying from 50msec to 20msec. This mode prevents switch bounce activity (up to the minimum logic state duration) from causing extra counts. When ON, and the Lowpower mode setting in menu 3 is non-zero, the above 10-25 Hz count rates are halved to 5-12 Hz.

31 FILTER COUNTERS IN

When OFF, counting rates are as determined by the state of coil 30. When ON, automatically asserting coil 30, a digital lowpass filter is applied to the packet rate DI-1 or DI-2 samples to reduce the probability of noise or power-line hum causing extra counts. Maximum count rate is less than 1Hz as a result. For the filter to operate on a desired DIx, the associated FASTAI(DIx) coil (33 or 34) must be OFF. Effectiveness of the filter against power line coupling is dependant on packet size; optimal rejection is achieved with packet sizes of 4,4.

32 RESET RADIO

Writing ON to this coil causes the radio to immediately execute the power-on routines as though power had been cycled. Therefore, no response is transmitted and a Timeout Error at the Modbus controller may result. This coil defaults to OFF at power-up, so it will always read as OFF.

33 FAST AI(DI1)

Default is asserted, so that analog samples of the DI1 input are reported individually and reflect changes on the input immediately. The input should be verified to be free of external noise or power line hum, or the samples may inaccurately reflect an extreme value of the disturbance. Writing a "0" engages a lowpass filter to average the samples, so that settling of the reported value will take several seconds, depending on packet size. Once settled, the final value will have reduced variation due to the external disturbance. Rejection of power line hum is dependant on packet size, with optimal rejection at packet sizes 4, 4.

34 FAST AI(DI2); similar to 33.

35 DI1 PULLUP ACTIVE

When asserted, enables the driver that connects the internal 10Kohm resistor at DI1 to either the 3.5V logic supply or GND, as commanded by 25. If cleared, the resistor will float so the input will be high-impedance. Any write to 25 will assert this coil.

36 DI2 PULLUP ACTIVE; similar to 35.

37 AI1 250 OHM PULLDOWN ACTIVE (Enclosure Model Only)

In the enclosure model, assertion of this coil connects a 250 Ohm resistor between AI1 and GND. If AI1 reads a voltage > 5.625V, the pulldown is released to protect against overheating of the resistor and semiconductor switch.

38 AI2 250 OHM PULLDOWN ACTIVE; similar to 37.

39 DI1 125 OHM PULLDOWN ACTIVE

In the enclosure model, assertion of this coil connects a 125 Ohm resistor between DI1 and GND. The resistor value is half that of the primary AI's, as the DI input range for analog signals is 0 – 3.5V. A 4-20mA transducer will thus cause a .5 – 2.5V input signal range. If DI1 reads a voltage > 3.5V, the pulldown is released to protect against overheating of the resistor and semiconductor switch.



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40 DI2 125 OHM PULLDOWN ACTIVE; similar to 39.

10001 DI1

The present state of DI1. Logic threshold is 1.15 to 2.15V.

10002 DI2; Similar to register 10001.

10003 DI OF AI1

The most recent conversion of AI1 compared to a threshold of 1.65V exactly. This comparison is made at 330msec intervals and no counting or latching functions are available. Useful for slow devices such as float switches. The AI's present a 136 Kohm resistance to GND, so a pullup resistor is required when using a contact to GND or open collector as the source.

10004 DI OF AI2; Similar to register 10003.

10005 DI of IODTR

Pin 3 of the J3 10-pin connector can be used as an auxiliary DI. The pin presents a 3 Kohm to 7 Kohm resistance to GND and a threshold voltage of up to 2.4V. For use with a contact to GND or open collector, a pullup resistor must be supplied able to pull the input above 2.4V. For example, a recommended resistor for a 12V pullup source would be 8.2 Kohm or less.

30001 AI1 MSW

The Most Significant Word of the AI1 conversion. One least-significant-bit (lsb) = 152.587uV. Although full scale would be 10V, the hardware limits the maximum to 5.625V. Most users will only require this MSW.

30002 AI1 LSW

For those users requiring the maximum possible resolution, the final 5 bits of the AI1 conversion are here, left-justified, so that the MSW, LSW register pair can be regarded as a 32-bit unsigned integer with 10V = \$FFFFFFFF.

30003 AI2 MSW; Similar to 30001.

30004 AI2 LSW; Similar to 30002.

30005 DI1 COUNTER MSW

The upper 16 bits of a 32 bit DI1 counter (unsigned) formed by registers 30005, 30006. Counter is controlled by coils 9, 11, 19. Maximum count rate is 1000 Hz with coils 30, 31 OFF. See coils 30 and 31 for count rates when they are ON.

30006 DI1 COUNTER LSW

The lower 16 bits of the 30005, 30006 Counter. Many customers will only use this LSW, but if the Clear-On-Read function of coil 9 is desired, both registers must be Read in a single command.

30007 DI2 COUNTER MSW; Similar to 30005.

30008 DI2 COUNTER LSW; Similar to 30006.

30009 Vbatt

The supply voltage to the radio as an unsigned integer in units of 506.04uV per lsb. Useful for remote monitoring of battery charge.

30010 degC

The temperature of the radio PCB as a signed integer with units of 1 degree Celsius per lsb.

30011 ALL DI'S



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For convenience, all the DI's are combined in a single word, with DI1 as lsb and unused bits Read as "0".

30012 ALL COILS 16:1

For convenience, coils 16:1 are combined in a single word, with coil 1 as lsb.

30013 ALL COILS 32:17

For convenience, coils 32:17 are combined in a single word, with coil 17 as lsb. Unused bits are Read as "0".

30014 AI1 MSW Offset Result

Some customer Modbus controllers lack a convenient means of adjusting Modbus AI readings for offset. For example, a 1-5V pressure transmitter would define 0 psi as a 1.00V output, for which the AI1 conversion MSW would be 6553. For convenience, the user can enter an unsigned integer (such as 6553) in register 40004 which will be subtracted from the AI1 MSW of register 30001 and the unsigned result placed here. No provision for multiplicative scaling is made and no corrected LSW is available. Also, negative results may be forced to \$0000 according to coil 21, or allowed to wrap modulo 65,536.

30015 AI2 MSW Offset Result; Similar to 30014.

30016 AI(DI1)

An analog voltage applied to the DI1 terminal is measured and can be read at this register. Range of the input is 0-3.5V with scale of 53.406uV/lsb. The converter used has 10-bit resolution. A simple digital lowpass filter can be applied (see coils 33, 34) to reduce the effect of random noise and has a packet-size dependant time constant of about .5 to 2 seconds. The filters' effectiveness against coherent signals, such as power line interference, varies with packet size in a complicated manner. Some combinations of packet size, interfering frequency and accuracy needed will require the interfering signal be mitigated with external filtration or shielding.

30017 AI(DI2); similar to 30016.

30018, 30019 AI1 SHORT FLOAT

This register pair, which should be read together, forms an IEEE754 standard Short (32 bit) Floating Point number which is the value in register 30001 (AI1 MSW) converted to an un-scaled voltage. Neither register 30002 (AI1 LSW) nor 40004 (AI1 User Offset) contribute to this value.

30020, 30021 AI1 SHORT FLOAT; similar to 30018, 30019.

30022, 30023 AI(DI1) SHORT FLOAT; similar to 30018, 30019.

30024, 30025 AI(DI2) SHORT FLOAT; similar to 30018, 30019.

30026, 30027 Vbatt SHORT FLOAT; similar to 30018, 30019.

30028, 30029 degC SHORT FLOAT; similar to 30018, 30019. Units are degrees Celsius.

30030 DO1 CURRENT

A coarse measure of the current being pulled to GND through DO1 (when coil 1 is ON). Scale is 534uA/lsb, but resolution is only 34.2 mA and accuracy is currently unspecified. Useful for determining if connection to a load has been lost. NOTE: This measurement is not valid in case of a DO1 Overcurrent Fault; users must poll coil 5 or register 30012 to determine Fault status.

30031 DO2 CURRENT; similar to 30030.

40003 DO's DEFAULT DELAY

The duration in units of .28 second that the radio DO's will hold their current values while searching for the network before invoking the Default settings of coils 13-16.



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40004 AI1 USER OFFSET

An unsigned integer to be subtracted from the AI1 MSW at register 30001, with the result placed in register 30014. Useful for translating offset sensors such as 1-5V or 4-20mA types so that their minimum output Reads as \$0000 in register 30014.

40005 AI2 USER OFFSET; Similar to 40004.

40006 DO MONOSTABLE TIME

If coil 27 is OFF, this register sets the time interval before a DO in the ON state will be automatically shut OFF. Range is 0-255 in units of ~.15 second.

40007 AO1 COMMAND

If coil 3 is OFF, this value will be applied to a Digital-to-Analog Converter (DAC) that drives a current source at the VSNS/AO1 terminal. Resultant current range is 0-22mA with scale 335.693nA/lb. The effective resolution is about 15 bits. If coil 3 (Sensor Power) is OFF and AO1 is not in use, write 0 to this register to allow a 1.5mA power supply current reduction if 40008 is 0 also.

40008 AO2 COMMAND

A current source having the same range and scale as that of 40007, except resolution is 16 bits. If not used, a value of 0 allows a 1.5mA supply current reduction if 40007 is 0 also.

40009 VSNS/AO1 DEFAULT COMMAND

If coil 28 is OFF, a Communication Loss Default event will result in this value, plus the content of 40011, being applied to the current source driving the VSNS/AO1 terminal. Range and scale is the same as 40007. The Default is static; no mono-stable timeout operation is provided. If it is desired that the full-drive (50mA) VSNS function be active during a Communication Loss Default event, coils 3 and 28 must be ON prior to the link failure.

40010 AO2 DEFAULT COMMAND

A Communication Loss Default event (with coil 29 OFF) will result in this value, plus the value in 40012, being applied to the current source driving the AO2 terminal. Range and scale is the same as 40007. The Default is static; no mono-stable timeout operation is provided.

40011 AO1 CUSTOMER OFFSET

If coil 3 is OFF, this value will be added to that in 40007 to form the control of a current source driving the VSNS/AO1 terminal. Range and scale is the same as 40007. Most commonly, the value entered will be 11916 (\$2E8C) to add 4mA, so a command of 0 will source 4mA in a 4-20mA system. Changes to this value will not be expressed until a write to 40007 occurs.

Note that this value is not applied after a power cycle; AO1 will remain at 0mA until a value is written to 40007, resulting in an output of that 40007 value plus this 40011 value. Subsequent writing of 40007 with 0 results in this 40011 value remaining the minimum analog output.

40012 AO2 CUSTOMER OFFSET

Similar to 40011, except there is no dependency on coil 3.



Modbus

FGR2-IOS (30G1C)
FIRMWARE 9.67
ERRATA
6/16/08

The following are known anomalies with the subject firmware (addresses are PLC numbering convention):

- 1). State of coil 31 (Filter Counters In) can be overridden.
Problem: For coil 31 to cause counting with Debounced AND Filtered DI, the desired DI's associated "Fast AIDI" coil (33 or 34) must be de-asserted to enable the filter.
Severity: Low; advisory only.
Workaround: Customer should clear coil 33 and/or 34 if asserting 31.
Solution: TBD.
- 2). Loss of link to Master results in continuous Search mode.
Problem: Search mode consumes more power than linked-idle, especially if Lowpower mode is active. Sustained Search will deplete a battery supply resulting in customer dissatisfaction.
Severity: Medium.
Workaround: Customers should poll units sufficiently often to detect and correct link failures before battery exhaustion.
Solution: Future firmware will switch to intermittent Search after a TBD interval of no link.
- 3). Modbus setup entries (G) and (H) are visible in menu (9) when the menu is toggled for Wire-Replacement.
Problem: Menu (9) parameters (G) and (H) are Modbus-specific, but are not blanked out in the Wire-Replacement entry mode.
Severity: Low
Workaround: Customers should ignore and not use the inappropriate entries.
Solution: Future code will blank them.
- 4). Menu (9) IO choices not locked to menu (0) Operation mode.
Problem: Failure to set menu (9) to appropriate choice (Modbus or Wire-replacement) for selected menu (0) mode (3, 7 or E) results in partially incorrect operation. Some functions may operate properly, others not.
Severity: Medium.
Workaround: Customer should check/correct menu (9) choices to reflect those for the mode selected in menu (0). Menu (0) modes 3, 7 require the Modbus choices be visible; mode E requires the Wire-Replacement (non-Modbus) choices.
Solution: Future code will automatically set the menu (9) mode.
- 5). AI1, AI2 249 Ohm Pulldowns don't recover after Fault resolved.
Problem: The AI pulldown resistors are protected in case an overvoltage exceeds 5.625V at their inputs, by releasing them from connection to GND. For a current loop transducer lacking a grounded resistor, even current within the normal 4-20mA range will drive the AI to above full scale. Although the resistors are retried periodically, the resistors are not grounded long enough for the A/D to sense the return to normal range and the Fault indication persists.
Severity: Medium.
Workaround: In Modbus mode, VSNS can be commanded OFF to allow transducers powered from it to fall into normal AI range. If transducers are powered directly from the supply, a write of ON to coil #32 will reset the radio and clear the fault indication so that correct operation resumes. In Wire Replacement mode, de-assertion of the IO-Master Sensor Power input will clear transducers so powered and controlled. If the transducers are supply-powered or the IO-Master Sensor Power is set for (continuous) "On", manual power cycling of the FGR2-IOS may be required.
Solution: Future code will extend the retry duration to allow sensing of return to normal AI range.



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