IO Expansion

User & Installation Manual

For part numbers:

IOE-X-4422P
IOE-X-4422PC

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Regulatory

The following regulatory information applies to all IO Expansion Modules.

UL: Underwriters Laboratories

This equipment is suitable for use in Class I, Division 2, Groups A, B, C and D or non-hazardous locations only.

The connectors shall not be connected or disconnected while circuit is live unless area is known to be non-hazardous.

WARNING: EXPLOSION HAZARD: Substitution of any component may impair suitability for Class I, Division 2.

Input power and all I/O power, except relay output contacts, shall be derived from a single Class 2 power source.

FCC: Federal Communications Commission

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.

General Information

The IO Expansion product family provides expandable digital input, digital output, analog input and analog output capabilities for any device with a Modbus controller. The IO Expansion Module can be added to Freewave radios to create a Modbus network with a scalable number inputs and outputs. Each IO Expansion Module also includes universally configurable pins providing total flexibility.

There are three components to the IO Expansion family:
- Radio Base (part number FGR2-IO-IOE)
- Serial Base (part number IOE-X-4422PC)
- Expansion Module (part number IOE-X-4422P)

The Radio Base and Serial Base are the foundation for IO Expansion because they provide the communication link to stacked Expansion Modules. The Base modules determine whether communication to the Expansion Modules occurs wirelessly or locally. Expansion Modules placed on top of a Radio Base can be polled and controlled wirelessly across FreeWave's wireless serial networks. Expansion Modules placed on top of a Serial Base can be used to provide local IO to any equipment with a serial interface (RS232, RS422 or RS485).

Up to 15 Expansion Modules can be stacked on top of a base, providing up to 192 IO points when stacked on a Serial Base.

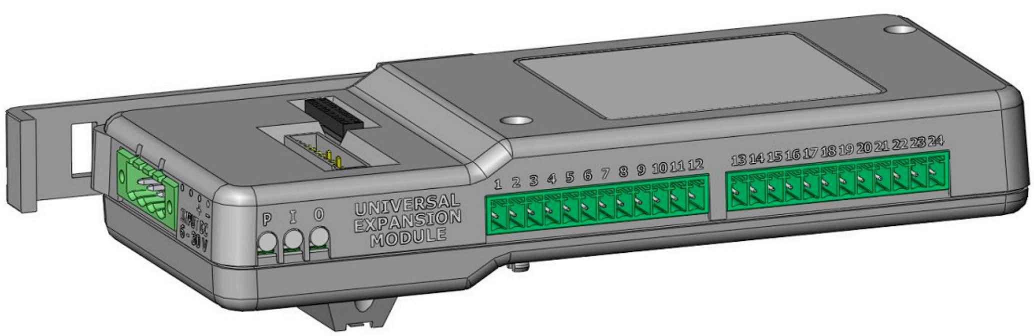

Figure 1. IO Expansion Module.

Stacking IO Expansion Modules

The bottom unit in a stack of IO Expansion modules is referred to as the base. The base unit must be one of the following:

- Serial Base (e.g. IOE-X-4422PC)
- Radio Base (e.g. FGR2-IO-IOE, I2-IO-IOE)

The modules that stack on top of base modules are called Expansion Modules. At the time of publishing this document, the only available Expansion Module is:

- Universal Expansion Module (e.g. IOE-X-4422P)

The total number of modules in a stack Up to fifteen (15) "P" modules can be stacked on top of a base module. The "P" modules alone will not communicate. Figure 14 shows a typical IO Expansion stack, consisting of two "P" modules stacked on top of a FGR2-IO-IOE serial radio. In this case, the base module is the FGR2-IO-IOE radio.

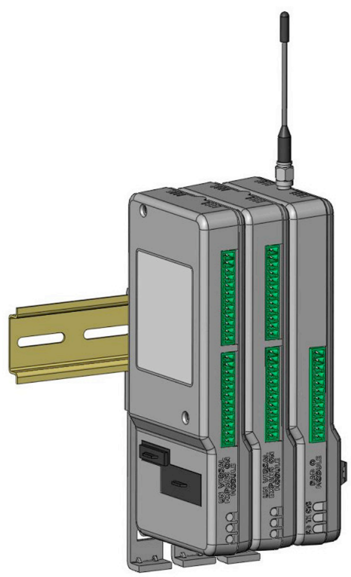

Figure 14. Two Expansion Modules stacked on a Radio Base and mounted on a DIN rail.

Powering IO Expansion Modules

The IO Expansion module requires an input voltage between 6V and 30V. All IO Expansion modules in a stack share power through the interface connectors. By providing power to one module in an IO Expansion stack, all modules will be powered.

The modules can be powered through the 10-pin serial connector or through the 4-pin power connector on the end of the unit. An 800 mA power supply is included with the IO Expansion module. Depending on the number of stacked modules and the amount of current they source to external equipment, the 800mA power supply may be insufficient. An alternate power supply with a higher current rating may be needed.

To power the modules through the 10-pin serial connector, first plug the supplied power supply into a mains outlet. Then, insert the male barrel plug into the female barrel receptacle on the data cable (Freewave part number ASC3610DJ). Connect the data cable to the stack of expansion modules.

To power the modules through the 4-pin power connector on the end of the module, connect ground to pin 1 and the active power line to pin 2 of the connector. Figure 5 in this document shows the pin-out for the power connector. The silkscreen text beside the 4-pin power connector can be used as a connection reference: "+ -", "INPUT DC", "6 – 30V".

Configuring IO Expansion Modules

Setting the radio network settings, serial communication settings, input and output channel configuration for IO Expansion products is done with the Tool Suite configuration software.

Tool Suite

Tool Suite is a configuration and diagnostic program developed for almost all of FreeWave Technologies' products. Tool Suite is available from the FreeWave Technologies web site.

Step 1: Stack Expansion Modules

Stack all Expansion Modules on a Radio Base for wireless communication or a Serial Base for local communication. Power the stack.

Step 2: Power the Stack

Stack all Expansion Modules on a Radio Base for wireless communication or a Serial Base for local communication. Power the stack.

Step 3: Connect to Computer

Use the data cable (FreeWave part number ASC3610DK) or diagnostic cable (part ASC2009DC) to connect the stack of Expansion Modules to the computer with Tool Suite.

If using the 10-pin data cable, and not the 20-pin diagnostic cable, press and hold the reset button. Upon entering configuration mode, the three LEDs on a Radio Base will be solid green. Upon entering configuration mode, the three LEDs on a Serial Base will flash green on and off continuously.

Step 3: Read Stack in Tool Suite

Start the Tool Suite configuration program. Click the “Read Radio” button if using a Radio Based stack. Click the “Read Serial Base” button if using a Serial Based stack. Figure 15 shows the location of the buttons. Upon a successful read, the hardware devices are shown in the “Devices” column in the same order as they are stacked.

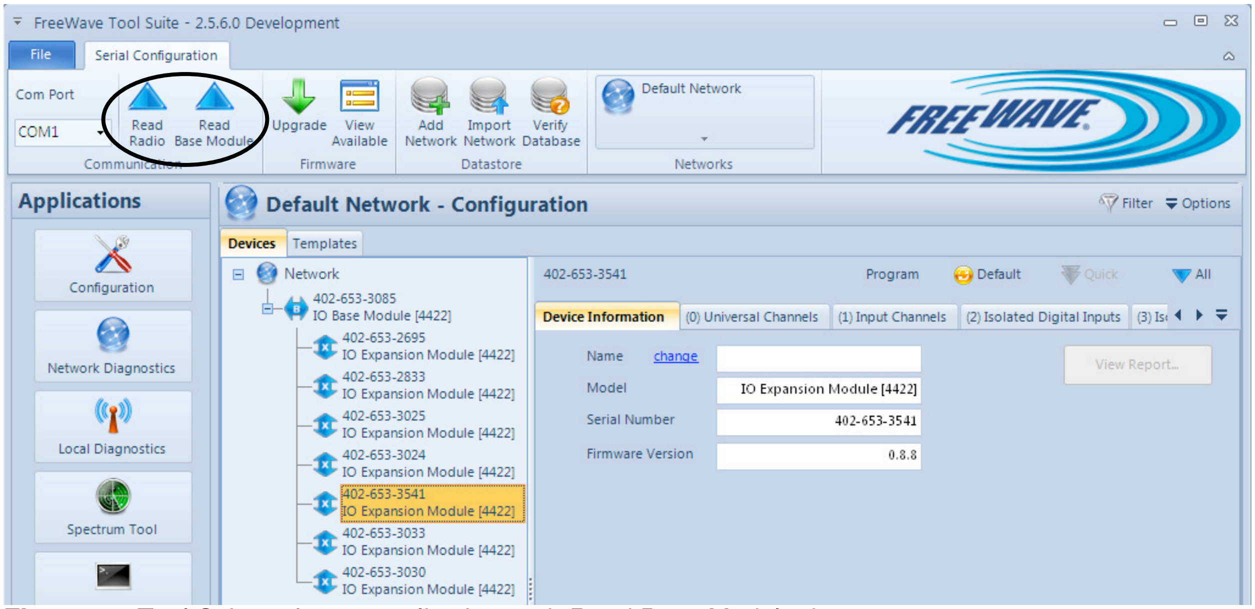

Figure 15. Tool Suite software application and “Read Base Module” button.

Step 4: Configure Channels and Communication Settings

Select the desired pin function for each pair of pins on the module. Universal, analog input, isolated digital input and isolated digital output channels are grouped for easy configuration in one location. Channels 1 through 4 are universal pairs and can be configured as digital outputs, digital inputs, analog outputs or analog inputs. If using an analog function, be sure to select the correct mode (voltage mode or current mode). See the device’s technical specification for more information on different analog modes.

Step 5: Write Settings to Stack

For each module in the stack, select that module in the “Devices” column and press the program “All” button. Doing so will write the channel and communication settings to the selected module. Repeat for each module in the stack. Figure 16 shows the location of the program “All” button.

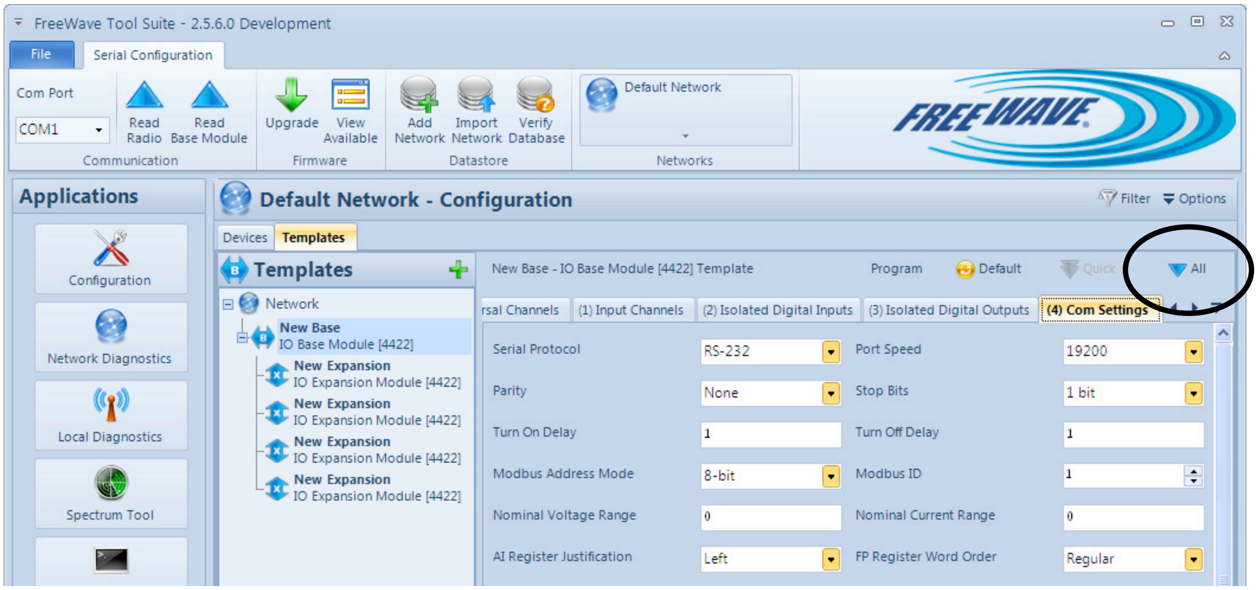

Figure 15. Tool Suite software application and program "All" button.

Ordering Information

The part numbers for the IO Expansion modules were assembled to provide a clear explanation of each module's feature set. Each character in the part number string has a meaning. The definition of each character set is listed below.

Expansion Module:
- IOE-X-4422P

Serial Base:
- IOE-X-4422PC

Radios Base:
- FGR2-IO-IOE

IO Expansion Module Part Numbering:	**IOE – X – 4 4 2 2 P C**
Number of universally configurable channels (non-isolated)	**4**
Number of analog input channels (non-isolated)	**4**
Number of optically isolated, digital input channels	**2**
Number of relay, digital output channels	**2**
High-efficiency, on-board logic voltage power supply present	**P**
If C, then module is a Serial Base	**C**

Note: If you have a need for a different combination of inputs or outputs at high order volumes, we are happy to customize your build. For the fastest possible delivery the total number of dedicated digital input and dedicated digital output outputs should equal 4. If necessary, we can increase or decrease the total number of dedicated digital inputs and outputs.

Note: The IO Expansion modules ending in “P” are referred to as “P” modules. The IO Expansion modules ending in “PC” are referred to as “PC” modules. See the section “Stacking IO Expansion Modules” for more information.

Physical Description

The IO Expansion mechanical dimensions are shown in table 1. The measurements in inches are rounded to the nearest eighth (1/8) of an inch.

Table 1. IO Expansion Modules physical properties.

Module	Length (in.)	Width (in.)	Depth (in.)	Weight (lbs)
IOE-X-4422-P	7 ⅛	3 ⅛	1 ½	0.35
IOE-X-4422-PC	7 ⅛	3 ⅜	1 ½	0.36

The IO Expansion Module has three connectors intended for user access. The two 12-pin connectors on the side of the module (shown in figure 2) are used for signal inputs and outputs. Consult the connector and pin descriptions for more information.

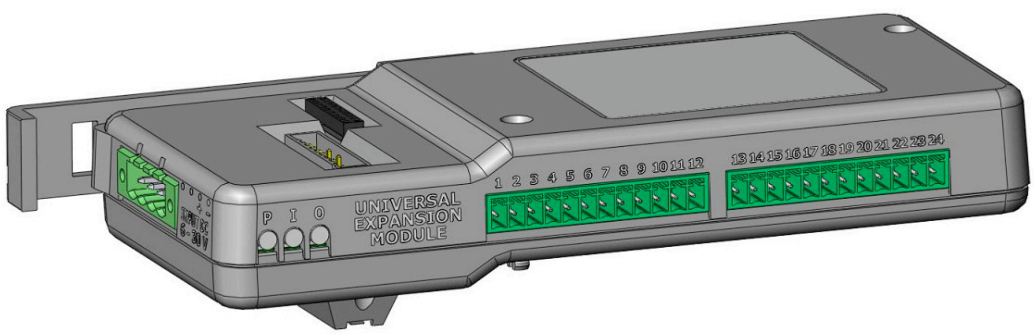

Figure 2. Side view IO Expansion Module showing IO connectors.

The 4-pin connector on the end of the unit (shown in figure 3) is for power. The silkscreen beside the power connector identifies the positive and negative terminals to apply power to the module. Consult the connector and pin descriptions for more information.

Figure 3. End view of IO Expansion Module showing power connector.

There are also two connectors embedded in the top surface of all IO Expansion Modules (shown in figures 2 and 3). These connectors serve as diagnostic and communication interfaces between IO Expansion Modules when multiple devices are stacked together. There are also two connectors on the bottom surface of “P” modules. The “PC” modules lack the diagnostic and communication connectors on the bottom surface since the “PC” modules serve as the base module.

Connector Description

There are five connectors on the IO Expansion modules. The description for each connector follows.

Input/Output Connectors

The two twelve-pin connectors on the side of the module are used for signal inputs and outputs. Table 2 summarizes the pin functionality and figure 4 shows the pin numbering. The four basic IO channel functions are:

- universally configurable,
- configurable input,
- optically isolated, digital input channels, and
- relay, digital output channels.

For more detailed information on specific pins, see that channel type's specific description.

Table 2. IO connector description for **IOE-X-4422P** and **IOE-X-4422PC** products.

Pin #	Pin Name	Modbus Ref.	Description
1+	Universal 1 +	IO channel 1	Universally configurable channel 1
1–	Universal 1 –	-	Signal ground for universal 1
2+	Universal 2 +	IO channel 2	Universally configurable channel 2
2–	Universal 2 –	-	Signal ground for universal 2
3+	Universal 3 +	IO Channel 3	Universally configurable channel 3
3–	Universal 3 –	-	Signal ground for universal 3
4+	Universal 4 +	IO Channel 4	Universally configurable channel 4
4–	Universal 4 –	-	Signal ground for universal 4
5+	Configurable Input 1 +	IO Channel 5	Configurable input channel 1
5–	Configurable Input 1 –	-	Signal ground for configurable input 1
6+	Configurable Input 2 +	IO Channel 6	Configurable input channel 2
6–	Configurable Input 2 –	-	Signal ground for configurable input 2
7+	Configurable Input 3 +	IO Channel 7	Configurable input channel 3
7–	Configurable Input 3 –	-	Signal ground for configurable input 3
8+	Configurable Input 4 +	IO Channel 8	Configurable input channel 4
8–	Configurable Input 4 –	-	Signal ground for configurable input 4
9+	Isolated Digital Input 1+	IO Channel 9	Isolated digital input channel 1
9–	Isolated Digital Input 1–	-	Signal ground for digital input 1
10+	Isolated Digital Input 2+	IO Channel 10	Isolated digital input channel 2
10–	Isolated Digital Input 2–	-	Signal ground for digital input 2
11+	Relay Output 1+	IO Channel 11	Relay output channel 1
11–	Relay Output 1 –	-	Signal ground for relay output 1
12+	Relay Output 2 +	IO Channel 12	Relay output channel 2
12–	Relay Output 2 –	-	Signal ground for relay output 2

The "Modbus Ref." entry in table 2 is the name of the signal as referenced in the Modbus register maps of appendix B.

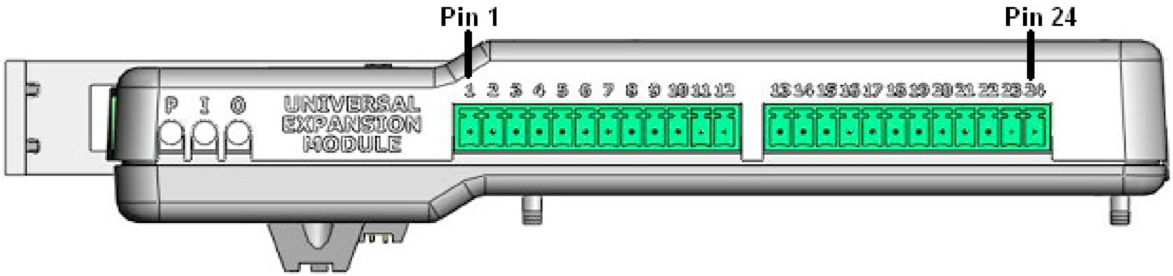

Figure 4. Side view of IO Expansion Module showing IO connectors.

Power Connector

The four-pin power connector at the end of module is used to supply power to the device. Figure 5 shows the pin numbering and table 3 contains pin specific information.

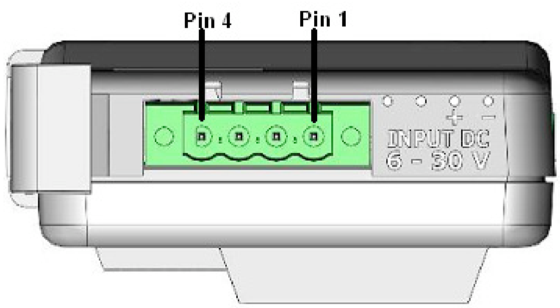

Figure 5. End view of IO Expansion Module showing power connector.

Table 3. Pin description of 4-pin power connector.

Pin number	Pin Name	Description
1	Ground (GND)	Device ground, power return.
2	Power (V_{DD})	Device power supply
3	Ground (GND)	Device ground, power return.
4	Reserved	Do not connect, reserved for future use.

Data Connector

The ten-pin power connector on top of the module can be used for stack configuration and serial communications to a local serial interface. Power can also be applied through the data connector by the barrel-type power connector on FreeWave's standard data cable.

Diagnostic Connector

The twenty-pin diagnostic connector on top of the module can be used to configure the IO Expansion stack.

LED Description

The three Light Emitting Diodes (LEDs) located on the side of the IO expansion modules represent power, inbound communication and outbound communication. They are labeled P, I and O, respectively.

Power LED

The power LED indicates that power is being supplied to the IO expansion module. The LED will be solid green when the board is powered in regular power mode. In low power mode the LED will flash green.

Inbound LED

The inbound LED indicates that an inbound message is being received by the module. Communication originates at the base of the IO expansion stack and propagates upwards to the stacked modules. The light will flash red when the module is receiving and green when the module is transmitting.

Outbound LED

The outbound LED indicates that an outbound message is propagating from the P Module toward the base of the stack, and from the PC module to the external equipment. The light will flash red when the module is receiving and green when the module is transmitting.

LED Status: Firmware Upgrade

The beginning of a firmware upgrade is indicated to the user by flashing all LEDs red once. When the firmware upgrade is complete, all LEDs will flash red multiple times.

LED Status: Communication Reset

A communication reset is indicated to the user by a single flash of the Inbound and Outbound LEDs.

Channel Description: Universal

The non-isolated, universal channels can be configured individually by the user to act as an analog input (AI), analog output (AO), digital input (DI), or digital output (DO). The following sub-sections describe each setting in detail.

Universal: Analog Input

When configured as an analog input, the universal pin is capable of operating in two modes: voltage mode (AI-V) or current mode (AI-I). In both modes, the Analog-to-Digital Converters (ADC) offer up to 20-bit resolution, allowing implementation in the most critical variables of a system. The justification can be set to left-justified to provide poll a single 16-bit word to obtain the 16-bit reading, or the full 20-bit value can be accessed by reading two words separately.

In both modes, the analog input channels provide voltage and current readings with 20-bit resolution. Depending on the operation mode, the floating point register for each channel will return a normalized voltage reading in Volts (V) or a normalized current reading in milli-Amps (mA).

Nominal Current/Voltage Range

The user has the ability to change the nominal voltage range and nominal current range. With the nominal range settings, the IO Expansion module returns ADC integer results on a user-specified scale. For example, the user can change the nominal voltage range to 10.0V so that the expansion module will return the maximum ADC integer result when a 10.0V signal is applied. Likewise, the user can change the nominal current range to 40mA to have max ADC count at 40mA. By default, the nominal voltage range and nominal current range are set to their full-scale levels (25.0V and 100mA respectively). The normalized, floating-point values remain in mV and µA regardless of nominal range settings.

For data compatibility with FGR-IO and FGR2-IO devices, set the nominal voltage range to 10.0V in voltage-mode. If using a 250Ω external sense resistor on the FGR-IO or FGR2-IO unit, set the nominal current range on the IO Expansion module to 40mA. If using a 125Ω sense resistor, set the nominal current range on the IO Expansion module to 80mA. If using a different resistor value, use the following formula to determine the correct IO Expansion nominal current rage:

Nominal Current Range (mA) =

$$= 1000 * V_{REF,FGR}\ (V) / R_{SNS,FGR}\ (\Omega) =$$
$$= 1000 * 10.0V / R_{SNS,FGR}\ (\Omega)$$

In voltage mode the pin will act as an analog input with high input impedance and scaling. The full scale input voltage is 25V, but a voltage up to 30V can be applied to the pin without damaging the device if the device's power supply is also 30V. Figure 6 shows an example wiring set-up for the pins in voltage mode.

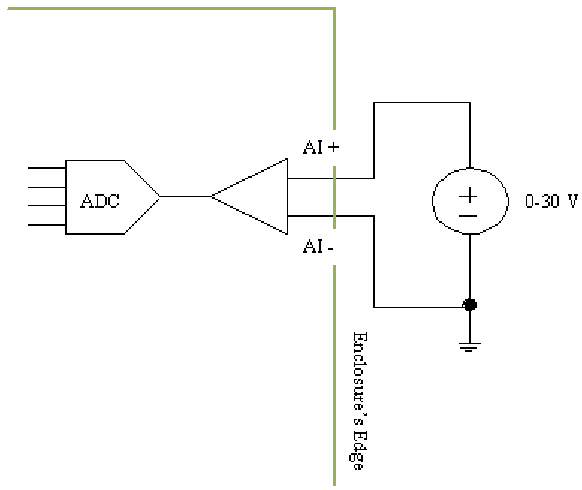

Figure 6. Sample wiring diagram for voltage-mode, analog inputs.

In current mode, a 250 Ohm sense resistor is switched in between the two terminals, converting the external 4-20 mA signal to a 1-5V signal on the IO Expansion module. This signal is then scaled and converted to a digital value. In AI-I mode, the input voltage to the terminal is continuously monitored to protect against overheating. Figure 7 shows an example wiring set-up for the pins in AI-I mode.

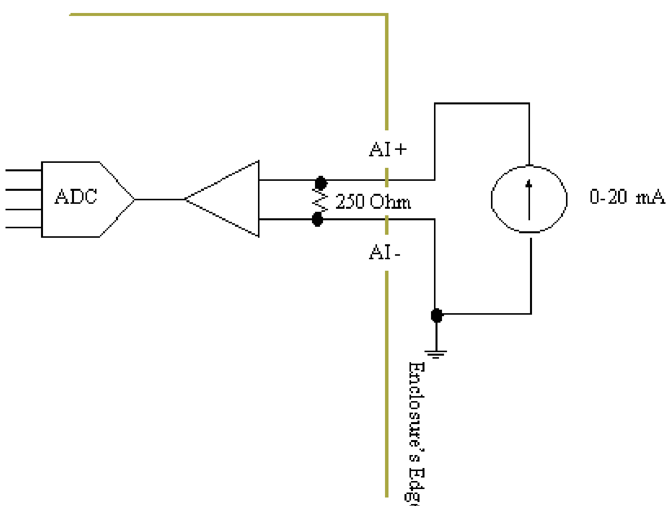

Figure 7. Sample wiring diagram for current-mode, analog inputs.

Universal: Analog Output

When functioning as an analog output, the universal pins are capable of operating in two modes: Sensor Power Mode or 4-20mA Output Mode.

In Sensor Power Mode (AO-V), the AO pin is capable of providing current at the same voltage level as the input voltage supplied to the radio. The pin is capable of providing approximately 150 mA of current if the supply voltage is 12 V.

In 4-20mA Output Mode (AO-I), the pin will attempt to source the proper current, regardless of what resistance is applied. The typical termination resistor used is 250 Ohms, implying a 1-5V output voltage. Figure 8 shows two example wiring set-ups for the analog output configured pins.

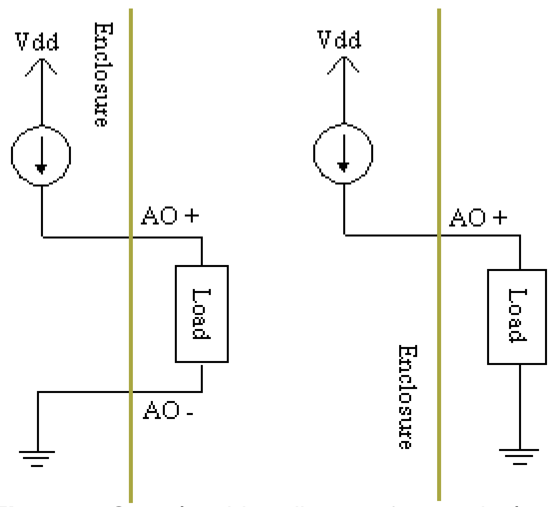

Figure 8. Sample wiring diagram for non-isolated, analog outputs.

Universal: Digital Input

When functioning as a digital input, applying a voltage above 3.0V on the positive terminal will register as logic high and applying a voltage less than 2.5V will return logic low. The digital input configured universal pins can also provide counting up to 10Hz.

The universal channel digital inputs can also be configured to enable an internal pull-up or pull-down resistor. Figure 9 shows 3 wiring diagrams for the digital input configured pins.

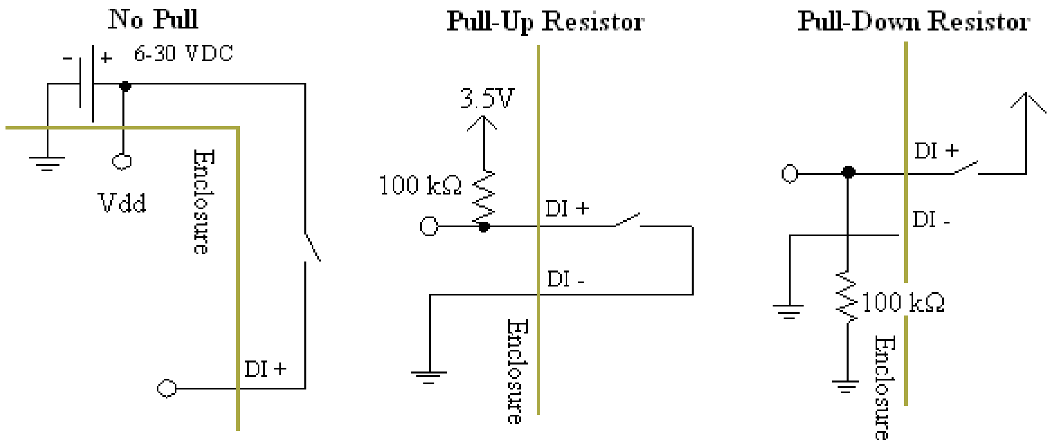

Figure 9. Sample wiring diagram for non-isolated, digital inputs.

Universal: Digital Output

When functioning as a digital output, the universal pins are configured as open drain drivers. This allows the pin to sink up to 1 Amp to ground, be electrically open, or tri-stated. Figure 10 shows an example of a wiring set-up for the digital output configured pins.

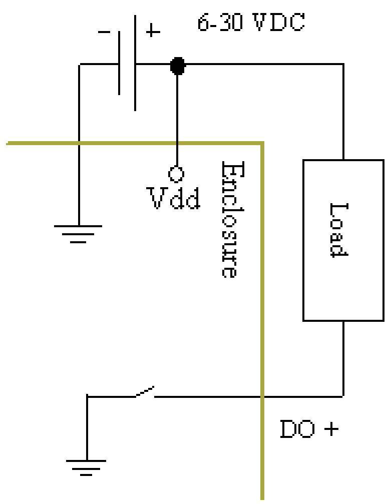

Figure 10. Sample wiring diagram for non-isolated, digital outputs.

The digital output current is continuously sampled to protect against overheating. Instantaneous over-current protection is provided by hardware.

Note: In a Class I, Division 2 installation, any load connected to the interface pins on this equipment requiring a positive voltage rail must use the same power source as used to power this equipment.

Note: The source voltage on the power supply driving the load must always be less than the source voltage on the IO Expansion module power supply. Each digital output on the IO Expansion module contains a Schottky diode equivalent to the power supply in order to prevent damage caused by fly-back current. If the source voltage on the power supply driving the load is higher than the source voltage on the IO Expansion module power supply, then the Schottky diode would allow the output pin to sink current. This can prevent the coil current from shutting off and cause an over voltage condition in the IO Expansion module.

Channel Description: Analog Input

The non-isolated, configurable input channels can be used as analog or digital inputs.

Analog Input: Analog

The analog input pins have the same characteristics and operation modes as the analog input configured universal pins. In both analog input modes the ADCs offer up to 20-bit resolution, allowing implementation in the most critical variables of a system. The bit alignment can be set to provide 16-bit resolution by reading a single word, or the full 20-bit value can be accessed by reading two words separately.

In voltage mode, the pin will act as an analog input with pseudo isolation and scaling, allowing a full input range of 0-30V on the terminal (25 V will be the approximate upper limit of the accurate range).

In current mode, a 250 Ohm termination resistor is placed between the two terminals, converting a supplied 4-20 mA signal to a 1-5V signal on the board. This signal is then scaled and converted. In AI-I mode, the input voltage to the terminal is continuously monitored to protect against overheating.

In both modes, the analog input channels provide voltage and current readings with 20-bit resolution. Depending on the operation mode, the floating point register for each channel will return a normalized voltage reading in Volts (V) or a normalized current reading in milli-Amps (mA).

The user has the ability to change the nominal voltage range and nominal current range so that the IO Expansion module returns ADC integer results on a user-specified scale. For example, the user can change the nominal voltage range to 10.0V to have max ADC count at 10.0V. Likewise, the user can change the nominal current range to 40mA to have max ADC count at 40mA. By default, the nominal voltage range and nominal current range are set to their full-scale levels (25.0V and 100mA respectively). The normalized, floating-point values remain in mV and µA regardless of nominal range settings.

For data compatibility with FGR-IO and FGR2-IO devices, set the nominal voltage range to 10.0V in voltage-mode. If using a 250Ω external sense resistor on the FGR-IO or

FGR2-IO unit, set the nominal current range on the IO Expansion module to 40mA. If using a 125Ω sense resistor, set the nominal current range on the IO Expansion module to 80mA. If using a different resistor value, use the following formula to determine the correct IO Expansion nominal current rage:

IOX nominal current range (mA) =

$= 1000 * V_{REF,FGR} (V) / R_{SNS,FGR} (\Omega) =$

$= 1000 * 10.0V / R_{SNS,FGR} (\Omega)$

Analog Input: Digital

When functioning as a non-isolated digital input, an applied voltage above 3.0V on the terminal of the universal pins will register as logic high and an applied voltage less than 2.5V will return logic low. When configured as digital inputs, the channel can also provide pulse counting up to 10Hz. The configurable input channels do not have selectable pull-up or pull-down resistors.

Channel Description: Isolated Digital Input

The optically isolated digital input pins accept an input voltage range of 0V to 30V (AC or DC). The inputs are dual polarity, making connections simple. Applying a voltage difference across the two pins above 3.2V will return logic high, while a voltage difference below 1.2V will return logic low. The isolated digital input pins can also provide fast counting capabilities up to 10 kHz. Figure 11 shows a sample wiring set-up for the isolated digital input pins.

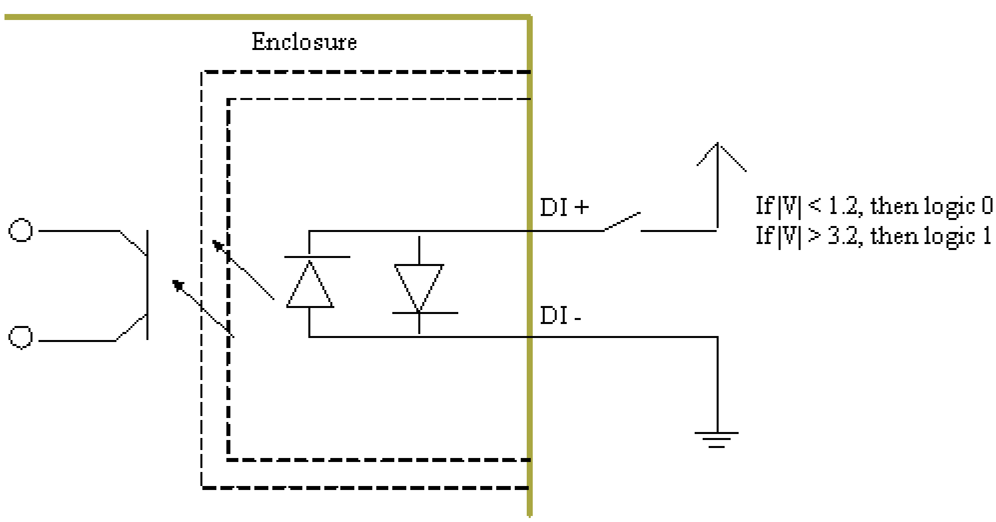

Figure 11. Sample wiring diagram for isolated digital inputs.

Channel Description: Relay Digital Output

The relay output channels provide digital output capability with single pole, single throw relays. The relays have a rated resistive load of 5A at $30V_{DC}/250V_{AC}$ and a rated inductive load of 2A at $30V_{DC}/250V_{AC}$. Since the digital outputs are true relays, significant electrical isolation is achieved. Figures 12 and 13 contain wiring diagrams for relay digital outputs.

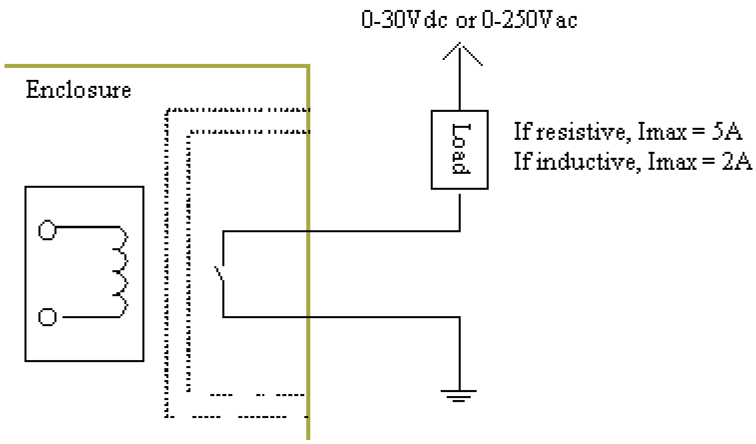

Figure 12. Sample wiring diagram for isolated relay digital outputs.

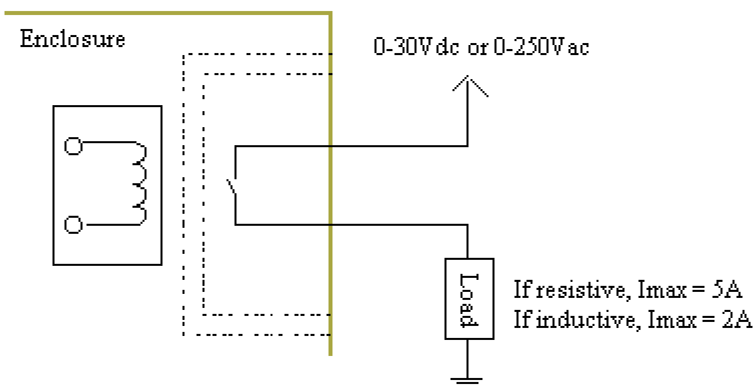

Figure 13. Sample wiring diagram for isolated relay digital output.

Detailed Register Description

This section provides additional details to select registers from the register maps located in appendix B.

Coils 73 – 83: Clear Pulse Counter

Writing a 0 to the clear pulse counter coil will perform a clear for critical pulse counting. In critical pulse counting, the number of pulses that the user last read from the pulse counter register is subtracted from the pulse counter register. This way, no pulses are lost if a pulse is counted between the time of polling the pulse count and issuing a count reset.

Writing a 1 to the clear pulse counter coil will force the pulse counter register to 0, regardless of whether the user read the actual pulse count.

Stack Register 6: Nominal Voltage Range

The Nominal Voltage Range stack register acts as the upper limit for the analog input count in voltage mode.

For example, if a user sets the Nominal Voltage Range to 10,000mV and reads the upper 16-bits of the analog input register, the module will report 65,536 when 10V is applied to the analog input. Likewise, if a user sets the Nominal Voltage Range to 5,000mV and reads the upper 16-bits of the analog input register, the module will report 65,526 when 5V is applied to the analog input.

Stack Register 7: Nominal Current Range

The Nominal Current Range stack register acts as the upper limit for the analog input count in current mode.

For example, if a user sets the Nominal Current Range to 40mA and reads the upper 16-bits of the analog input register, the module will report 65,536 when 40mA is applied to the analog input. Likewise, if a user sets the Nominal Current Range to 20mA and reads the upper 16-bits of the analog input register, the module will report 65,526 when 20mA is applied to the analog input.

Stack Register 8: Analog Input A/D Justification

The analog inputs report the analog inputs to 20-bit resolution. This is more than the 16-bits that are available in a single register. The Analog Input A/D Justification determines how the 20-bits are organized in the two input read-only registers for each channel.

When the Analog Input A/D Justification is set to ‘left,’ the most significant 16 bits of the analog input result are located in the first register and the least significant 4 bits are located in the upper 4 bits of the second register. By setting the Analog Input A/D

Justification to 'left' the user can access a 16-bit analog input result with a 16-bit single register.

When the Analog Input A/D Justification is set to 'right,' the most significant 4 bits of the analog input result are located in the first register and the least significant 16 bits are located in the second register.

Stack Register 12: Communication Failure Default Delay

The Communication Failure Default Delay register is the number of seconds beyond the last received Modbus command for a module, after which the default state of that specific module's channels will be enabled. The Communication Failure Default Delay is maintained by each individual module in a stack. A module will only re-start its Communication Failure Count when it receives a Modbus command that is specifically addressed to it, not for modules stacked above or below it.

For example, if one (1) Expansion Module is stacked on top of a Base Module and the Base Module is the only module that is regularly polled, the Expansion Module will revert to its default settings even though the base module is begin polled and remains active.

Modbus Commands

The IO Expansion modules support the following Modbus commands:

- **1: Read Coils**
- **2: Read Discrete Inputs**
- **3: Read Holding Registers**
- **4: Read Input Registers**
- **5: Write Single Coil**
- **6: Write Single Register**
- **15: Write Multiple Coils**
- **16: Write Multiple Registers**

In addition to the standard Modbus commands listed above, the IO Expansion modules also support two custom commands.

- **100: Read Stack Configuration**
- **102: Write Stack Configuration**

Custom Modbus Command 100: Read Stack Configuration

The formats of the read stack configuration request and response are shown in tables 4 and 5 respectively. The response to the read stack configuration command will be repeated as many times as there are boards on the IO Expansion stack.

Table 4. Read stack configuration command.

Byte Index	Description
0	Modbus address
1	Modbus function code (100, 0x64)
2	Address of the first register to be read, high byte
3	Address of the first register to be read, low byte
4	Number of registers to read from, high byte
5	Number of registers to read from, low byte
6	Packet CRC, high byte (calculated over all bytes)
7	Packet CRC, low byte

Table 5. Read stack configuration response.

Byte Index	Description
0	Modbus address
1	Modbus function code (100, 0x64)
2	Byte count
3	First read register, high byte
4	First read register, low byte (n registers are transmitted)
5 + 2 x n	Packet CRC, high byte (calculated over all bytes)
5 + 2 x n + 1	Packet CRC, low byte

Using tables 4 and 5, users can easily develop support for the “100” custom Modbus command for their Modbus controller.

Example:
To read the power mode of an IO Expansion module at Modbus ID 1, the user would send the hexadecimal command:
01 64 00 04 00 01 F0 03

The IO Expansion module would reply with the hexadecimal response:
01 64 02 00 00 A7 30

The meanings of the command and response strings are shown in tables 6 and 7, respectively.

Table 6. Sample read stack configuration command.

Byte index	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Byte value (hex)	***01***	***64***	***00***	***04***	***00***	***01***	***F0***	***03***
Byte value (decimal)	**1**	**100**	**0**	**4**	**0**	**1**	**240**	**3**
Modbus address	1							
Modbus function		100						
Address of first register			0	4				
Number of bytes					0	1		
Packet CRC							240	3

Table 7. Response to read stack configuration command.

Byte index	**0**	**1**	**2**	**3**	**4**	**5**	**6**
Byte value (hex)	***01***	***64***	***02***	***00***	***00***	***A7***	***30***
Byte value (decimal)	**1**	**100**	**2**	**0**	**0**	**167**	**48**

Modbus address	1						
Modbus function		100					
Byte count			2				
Register value				0	0		
Packet CRC						167	48

Custom Modbus Command 102: Write Stack Configuration

The formats of the write stack configuration request and response are shown in tables 8 and 9 respectively. Note that the write stack configuration response has the same format as the Modbus write input register command response. The response to the write stack configuration command will be repeated as many times as there are boards on the IO Expansion stack.

Table 8. Write stack configuration command.

Byte Index	Description
0	Modbus address
1	Modbus function code (102, 0x66)
2	Address of the first register to be written, high byte
3	Address of the first register to be written, low byte
4	Number of registers to write to, high byte
5	Number of registers to write to, low byte
6	Byte count to follow (= 2 * number of registers to write)
7	Value of the first register to write, high byte
8	Value of the first register to write, low byte (n registers are transmitted)
8 + 2 x n	Packet CRC, high byte (calculated over all bytes)
8 + 2 x n + 1	Packet CRC, low byte

Table 9. Write stack configuration response.

Byte Index	Description
0	Modbus address
1	Modbus function code (102, 0x66)
2	Address of the first register to be written, high byte
3	Address of the first register to be written, low byte
4	Number of registers to write to, high byte
5	Number of registers to write to, low byte
6	Packet CRC, high byte (calculated over all bytes)
7	Packet CRC, low byte

Example:

To set the power mode of an IO Expansion module at Modbus ID 1 to a value of 1, the user would send the hexadecimal command:
01 66 00 04 00 01 02 00 01 E1 1A

The IO Expansion module would reply with the hexadecimal response:
01 66 00 04 00 01 89 C3

The meanings of the command and response strings are shown in tables 10 and 11, respectively.

Table 10. Sample write stack configuration command.

Byte index	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Byte value (hex)	***01***	***66***	***00***	***04***	***00***	***01***	***02***	***00***	***01***	***E1***	***1A***
Byte value (decimal)	**1**	**102**	**0**	**4**	**0**	**1**	**2**	**0**	**1**	**225**	**26**
Modbus address	1										
Modbus function		102									
Address of first register			0	4							
Number of registers					0	1					
Byte count							2				
Register value								0	1		
Packet CRC										225	26

Table 11. Response to sample write stack configuration command.

Byte index	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Byte value (hex)	***01***	***66***	***00***	***04***	***00***	***01***	***89***	***C3***
Byte value (decimal)	**1**	**102**	**0**	**4**	**0**	**1**	**137**	**195**
Modbus address	1							
Modbus function		102						
Address of first register			0	4				
Number of registers					0	1		
Packet CRC							137	195

Stack Identification Number (Stack ID)

Each module in an IO Expansion stack is automatically assigned a stack ID. The stack ID is used to create a unique register address for each module in the stack. The stack ID of the base module (PC Module or radio module) is automatically assigned to 0. The stack IDs for each additional IO Expansion Module is incremented by one.

Figure 14 shows a stack of IO Expansion modules. In the configuration shown, the stack ID of the radio is 0. The stack ID of the first IO Expansion module, connected to the radio, is 1. The stack ID of the second IO Expansion module, the module on the far left of the diagram, is 2.

Stack ID Dependent Offsets

Each IO expansion module that has a stack ID also has a stack ID dependent offset. The stack ID dependent offset is used to calculate a unique address to read and write to the IO Expansion Module. The stack ID and the stack ID dependent offset are related by the following formula:

Stack ID dependent offset = Stack ID x 200

Example:
Consider figure 14. Let's read the digital input registers for pin 17 on both IO Expansion Modules. From the connector description in table 2, we see that pin 17 corresponds to I/O Channel 9 in the Modbus protocol.

First we calculate the stack ID dependent offset for each module:

Stack ID dependent offset for first stacked module =
= (Stack ID of first IO Expansion Module) x 200 =
= 1 x 200 =
= 200

Stack ID dependent offset of second stacked module =
= (Stack ID of second IO Expansion Module) x 200 =
= 2 x 200 =
= 400

Next, we find the desired register's protocol address by consulting the register map in Appendix A. For this example, the desired register resides at protocol address 10,008.

Finally, we find the unique protocol address for I/O Channel 9 on both IO Expansion modules. The unique address is the desired protocol address (from the register map) **PLUS** the stack ID dependent offset.

Modbus address of I/O Channel 9 on first IO Expansion module =
= Desired protocol address + Stack ID dependent offset =
= 10,008 + 200 =
= 10,208

Modbus address of I/O Channel 9 on second IO Expansion module=
= Desired protocol address + Stack ID dependent offset =
= 10,008 + 400 =
= 10,408

We read the registers located at protocol address 10,208 and 10,408 to read the status of I/O Channel 9 (pin 17) on the first and second IO Expansion Modules, respectively.

Appendix A. Technical Specifications

Absolute Maximum Ratings

Storage temperature .... -65°C to +100°C
Operating temperature .... -40°C to +75°C
Voltage on any non-isolated pin with respect to GND .... -0.3V to (V_{DD} + 0.3V)
Maximum current sunk by any relay output (resistive load) 5A
Maximum current sunk by any relay output (inductive load) 2A
Maximum current sunk by any non-isolated digital output 1A
Maximum total current sunk by all channels, IOE-X-4422 .... 14A

Power Supply Characteristics

Table A1. Operating power supply voltage limits

Item	Symbol	Min	Max	Units
Supply Voltage				
IOE-X-4422P	V_{DD}	6.0	30.0	V
IOE-X-4422PC	V_{DD}	6.0	30.0	V

Table A2. Current consumption at 25°C

Item	Symbol	Typ	Max	Units
Idle Supply Current [1]				
V_{DD} = 6V	I_{DD}	23	tbd	mA
V_{DD} = 12V	I_{DD}	13	tbd	mA
V_{DD} = 24V	I_{DD}	9	tbd	mA
V_{DD} = 30V	I_{DD}	8	tbd	mA
RS232 Supply Current [2]				
V_{DD} = 6V	I_{DD}	31	tbd	mA
V_{DD} = 12V	I_{DD}	18	tbd	mA
V_{DD} = 24V	I_{DD}	12	tbd	mA
V_{DD} = 30V	I_{DD}	10	tbd	mA

Note 1: Idle supply current is measured with all channels disabled. Adding a load that is actively driven by the IO Expansion module will increase the supply current by that amount.
Note 2: RS232 supply current is measured during RS232 communication with all channels disabled.

Digital Output Characteristics

Table A4. Digital output channel specifications

Item	Symbol	Min	Typ	Max	Units
Non-Isolated, Digital Outputs					
Output-low resistance [3]	R_{OL}	600	-	-	MΩ
Output-high resistance [3]	R_{OH}	-	-	0.150	Ω
Output-high sinking current	I_{OH}	-	-	1	A
Circuitry protection soft limit (2 seconds)	$I_{DO,LIM,S}$	-	1.0	-	A
Circuitry protection hard limit (instantaneous)	$I_{DO,LIM,H}$	-	1.1	-	A
Isolated, Relay Outputs					
Output-low resistance [4]	R_{OL}	1,000	-	-	MΩ
Output-high resistance [4]	R_{OH}	-	-	0.100	Ω
Output-high sinking current, resistive load	$I_{OH,R}$	-	-	5	A
Output-high sinking current, inductive load	$I_{OH,I}$	-	-	2	A

Note 3: Output resistance for non-isolated outputs is referenced from channel return pin, or device ground if return pin is disconnected.
Note 4: Output resistance for isolated, relay outputs is measured across the channel's two pins.

Table A7. Non-isolated digital output mode, analog-to-digital converter parameters across entire operating temperature

Item	Symbol	Min	Typ	Max	Units
Digital Output Current Measurement					
Scaling factor	$F_{S,DO,I}$	-	1	-	mA/LSB
Current measurement step size (resolution) [5]	Res.	-	30	-	mA

Note 5: Digital output current measurement values are provided for a general indication of current sinking through the pin to ease failure analysis of digital outputs. Because the current measurement of non-isolated digital outputs is so coarse (in increments of 30mA) these measurements should not be used for critical accuracy calculations.

Digital Input Characteristics

Table A5. Pulse counting timing parameters

Item	Symbol	Min	Max	Units
Non-Isolated, Digital Inputs				
Input-low voltage [6]	V_{IL}	0	2.5	V
Input-high voltage [6]	V_{IH}	3.0	V_{DD}	V
Pulse width for counting	T_{PC}	50	-	ms
Pulse counting frequency	F_{PC}	-	10	Hz
Isolated, Digital Inputs				
Input-low voltage [7]	V_{IL}	0	1.2	V
Input-high voltage [7]	V_{IH}	3.2	30	V
Pulse width for counting	T_{PC}	50	-	μs
Pulse counting frequency	F_{PC}	-	10	kHz

Note 6: Input voltage for non-isolated, digital input is referenced from channel return pin, or device ground if return pin is disconnected.
Note 7: Input voltage for isolated, digital input channels is measured across the channels' two pins. The voltage is independent of polarity since the pins are dual polarity.

Analog Output Characteristics

Table A8. Digital-to-analog converter parameters across full operating temperature

Item	Symbol	Min	Typ	Max	Units
Current mode					
Analog output current [9]	I_{OUT}	0	-	50	mA
Full-scale output current	$I_{OUT,FS}$	-	65.535	-	mA
Resolution	Res.	-	16	-	Bit
Integer scaling factor [9]	$F_{S,I}$	-	1.0	-	μA/LSB
Voltage on output pin	$V_{OUT,I}$	0	-	$V_{DD} - 0.5$	V
Accuracy (at 20mA output)	ΔI_{OUT}	0	-	0.25	%
Sensor Power (Voltage mode)					
Analog output voltage	V_{OUT}	$V_{DD} - 1$	$V_{DD} - 0.5$	V_{DD}	V
Output current	$I_{OUT,V}$	0	-	50	mA

Note 9: The analog output cannot source a current that causes the output pin voltage to rise above V_{DD}. The maximum analog output current is the lesser of 65.5mA or V_{DD} / R_L, where R_L is the total resistance seen by the channel.

Analog Input Characteristics

Table A6. Analog input mode, analog-to-digital converter parameters across entire operating temperature

Item	Symbol	Min	Typ	Max	Units
Analog Input Voltage Mode					
Analog input voltage – universal channel	V_{IN}	0	-	Lesser of 12.5 or V_{DD}	V
Analog input voltage – analog input channel	V_{IN}	0	-	12.5	V
Full-scale input voltage [8]	V_{FS}	-	10	-	V
Resolution	Res.	-	20	-	Bit
Scaling factor (all 20 bits) [8]	$F_{S,V,20}$	-	9.54	-	µV/LSB
Scaling factor (upper 16 bits) [8]	$F_{S,V,16}$	-	153	-	µV/LSB
Input impedance	$F_{S,V,16}$	-	360	-	kΩ
Measurement accuracy across entire operating temperature (at 5V input)	ΔV_{MEAS}	0.0	-	0.10	%
Analog Input Current Mode					
Analog input current – all channel types	I_{IN}	0	-	22	mA
Full-scale input current [8]	I_{FS}	-	40	-	mA
Resolution	Res.	-	20	-	Bit
Scaling factor (all 20 bits) [8]	$F_{S,I,20}$	-	38.1	-	nA/LSB
Scaling factor (upper 16 bits) [8]	$F_{S,I,16}$	-	610	-	nA/LSB
Input impedance	$F_{S,V,16}$	-	248	-	Ω
Measurement accuracy across entire operating temperature (at 20mA input)	ΔI_{MEAS}	0.0	-	0.10	%

Note 8: The integer scaling factor is calculated relative to the full-scale input voltage and full-scale current. By changing the “nominal voltage range” register or “nominal current range” register to any value other than the full-scale input range, the scaling factor will change accordingly so that maximum integer output occurs at that value.

Modbus Timing Parameters

Table A8. Maximum output execution delay time [10]

Stack ID		Base	1	2	15	
Item	**Symbol**					**Units**
Non-Isolated Digital Output	**Stack ID**					
Command 5 (writing 1 coil)	$T_{EXD,MAX}$	3	6	10	52	ms
Command 15 (writing 120 coils)	$T_{EXD,MAX}$	3	8	12	74	ms
Isolated Digital Output						
Command 5 (writing 1 coil)	$T_{EXD,MAX}$	17	14	18	59	ms
Command 15 (writing 120 coils)	$T_{EXD,MAX}$	18	16	21	82	ms
Analog Output						
Command 6 (writing 1 registers)	$T_{EXD,MAX}$	3	6	10	52	ms
Command 16 (writing 123 registers)	$T_{EXD,MAX}$	3	33	63	446	ms

Note 10: The output execution delay time (T_{EXD}) is the time between the end of a Modbus master’s query arriving at the slave’s data port (i.e. IO Expansion stack) and the beginning of the slave’s execution of that command (e.g. setting an output high or low).

Table A9. Maximum Modbus command response delay times [11]

Stack ID		Base	1	2	15	
Item	**Symbol**					**Units**
Command 1: Read Coils						
1 coil	$T_{RD,MAX}$	4	11	17	95	ms
160 coils	$T_{RD,MAX}$	6	14	22	125	ms
Command 2: Read Discrete Inputs						
1 discrete input	$T_{RD,MAX}$	4	11	17	95	ms
80 discrete inputs	$T_{RD,MAX}$	6	12	19	110	ms
Command 3: Read Holding Registers						
1 holding register	$T_{RD,MAX}$	4	11	17	95	ms
125 holding registers	$T_{RD,MAX}$	18	52	84	510	ms
Command 4: Read Input Registers						
1 input register	$T_{RD,MAX}$	4	11	17	95	ms
125 input registers	$T_{RD,MAX}$	18	52	84	510	ms
Command 5: Write Single Coil	$T_{RD,MAX}$	4	11	17	95	ms
Command 6: Write Single Register	$T_{RD,MAX}$	4	11	17	95	ms
Command 15: Write Multiple Coils						
2 coils	$T_{RD,MAX}$	4	11	18	99	ms
120 coils	$T_{RD,MAX}$	6	14	21	124	ms
Command 16: Write Multiple Registers						
2 holding registers	$T_{RD,MAX}$	4	11	18	103	ms
123 holding registers	$T_{RD,MAX}$	11	43	76	500	ms

Note 11: The response delay time (T_{RD}) is the time between the end of a Modbus master's query arriving at the slave's data port (i.e. IO Expansion stack) and the beginning of the slave's response.

Appendix B. Modbus register map

The following tables describe the Modbus register map for the IO Expansion Modules. The specified register addresses are decimal addresses with base = 0).

Note: To use the Modbus register address offsets in the following tables, add the stack ID dependent offset for the appropriate module in the stack.

Note: Consult the FGRIO Modbus user manual for the FGR2-IO-IOE register map.

Coil Read/Write Registers

The starting address for these registers is 0. Use Modbus commands 1 (read coils, 0x01), 5 (write single coil, 0x05), and 15 (write multiple coils, 0x0F).

Note: Tables are listed with Modbus protocol address. For PLC addresses, add 1 to each register address.

Table B1: Coil read/write registers.

Modbus Register Address	Register Name	Register Description	Data Type	Factory Default
0 – 11	DO Setting	Digital Output Setting for channels 1 to 12 0 = off, 1 = on When a non-isolated digital output is set to 1, the transistor is sinking to ground. When an isolated digital output (relay) is set to 1, the relay closes the connection between the two pins for the channel.	Bit	n/a
12 – 23	-	Reserved	-	-
24 – 35	Default Output Enable	Default Output Enable for channels 1 to 12 0 = disabled, 1 = enabled Set this coil to 1 to activate default outputs upon device power up and communication timeout. Set this coil to 0 to leave outputs in their previous state upon communication timeout.	Bit	1
36 – 47	-	Reserved	-	-
48 – 59	DO Default Setting	Digital Output Default Setting for channels 1 to 12 0 = off, 1 = on Digital outputs channels will take the state in these coils upon power up and communication timeout if the channel’s Default Output Enable coil is set to 1.	Bit	0
60 – 71	-	Reserved	-	-
72 – 83	DI Counter Clear	Digital Input Pulse Counter Clear for channels 1 to 12 Write 0 = clear DI counter since last counter read for critical counting Write 1 = clear DI counter to force 0 and lose pulses arrived since last counter read Read returns 0 always	Bit	n/a
84 – 95	-	Reserved	-	-
96 – 107	DI Counter Edge	Digital Input Pulse Counter Edge for channels 1 to 12 0 = rising, 1 = falling Set this coil to 0 to increment the digital input pulse counter on a falling edge. Set the coil to 1 to increment the digital input pulse counter on rising edge.	Bit	0
108 – 119	-	Reserved	-	-

120 – 127	AI Mode	The analog input/output mode select for channels 1 to 8 0 = voltage, 1 = current Set this coil to 0 to report voltage inputs. Set this coil to 1 to enable the internal sense resistor (roughly 248 Ohm) to allow reporting of current inputs	Bit	0
128 – 135	-	Reserved	-	-
136 – 147	DI Counter Latch	Digital Input Pulse Counter Increment Latch for channels 1 to 12 Read 0 = no counter increment since last latch clear Read 1 = counter increment occurred since last latch clear Write 0 = clear latch When this coil reports 1 then the DI Pulse Counter has been incremented.	Bit	0
148 – 159	-	Reserved	-	-

Discrete Input-Read Only Registers

The starting address for these registers can be either 0 or 10,000. Use Modbus command 2 (read discrete inputs, 0x02).

Note: Tables are listed with Modbus protocol address. For PLC addresses, add 1 to each register address.

Table B2: Discrete input read-only registers.

Modbus Register Address	Register Name	Register Description	Data Type
0 – 11	DI Result	Digital Input State for channels 1 to 12 This coil reports the value of digital inputs.	Bit
12 – 23	-	Reserved	-
24 – 35	Circuitry Protection	Circuitry Protection Active for channels 1 to 12 0 = inactive, 1 = active This coil reports 1 when an over-voltage or over-current condition is present on the channel. When the circuitry protection is activated the channel function is temporarily disabled to prevent damage to the device. After 10 seconds the channel function is enabled again and protection monitoring restarts. When these coils report 0 the channels are operating within the safe operating range.	Bit
36 – 79	-	Reserved	-

Input Read-Only Registers

The starting address for these registers can be either 0 or 30,000. Use Modbus command 4 (read input registers, 0x04).

Note: Tables are listed with Modbus protocol address. For PLC addresses, add 1 to each register address.

Table B3: Input read-only registers.

Modbus Register Address	Register Name	Register Description	Data Type
0 – 16	AI Integer Result	Analog Input Integer Result for channels 1 through 8. The Analog Input Integers are 20-bit results. To access a 16-bit result set the AI Justification register to “left” and read the most significant register. To access a 20-bit result set the AI Justification register to “right” and read both registers at once. In voltage mode the maximum integer reading occurs when a voltage is applied to the channel that is equal to the Nominal Voltage Range. In current mode the maximum integer reading occurs when a signal equal to the Nominal Current Range is applied on the input. Follow these steps to calculate the actual input from an integer result: 1. Divide the AI Integer Result by 65,536 for 16-bit results or 1,048,576 for 20-bit results. 2. Multiply the result by the Nominal Voltage Range (10V default) setting or Nominal Current Range setting (40mA default). Register addresses per channel: • Channel 1 result stored in registers 0 and 1 • Channel 2 result stored in registers 2 and 3 • Channel 3 result stored in registers 4 and 5 • Channel 4 result stored in registers 6 and 7 • Channel 5 result stored in registers 8 and 9 • Channel 6 result stored in registers 10 and 11 • Channel 7 result stored in registers 12 and 13 • Channel 8 result stored in registers 14 and 15	Long Integer
16 – 31	-	Reserved	-
32 – 47	AI Normalized Result	Analog Input Normalized Result for channels 1 through 8. In voltage mode the AI Normalized Result is the analog input expressed in Volts and stored as a decimal (floating point). In current mode the AI Normalized Result is equal the analog input expressed in mA and stored as a decimal (floating point). Register addresses per channel: • Channel 1 result stored in registers 32 and 33 • Channel 2 result stored in registers 34 and 35 • Channel 3 result stored in registers 36 and 37 • Channel 4 result stored in registers 38 and 39 • Channel 5 result stored in registers 40 and 41 • Channel 6 result stored in registers 42 and 43 • Channel 7 result stored in registers 44 and 45 • Channel 8 result stored in registers 46 and 47	Floating Point
48 – 63	-	Reserved	-

64 – 87	DI Counter	DI Pulse Counter for channels 1 through 12 The DI Pulse Counter increments every time a rising or falling edge is seen on the input. The maximum count is 4,294,967,295. The DI Pulse counter is volatile which means the value returns to 0 when powered off. Register addresses per channel: • Channel 1 result stored in registers 64 and 65 • Channel 2 result stored in registers 66 and 67 • Channel 3 result stored in registers 68 and 69 • Channel 4 result stored in registers 70 and 71 • Channel 5 result stored in registers 72 and 73 • Channel 6 result stored in registers 74 and 75 • Channel 7 result stored in registers 76 and 77 • Channel 8 result stored in registers 78 and 79 • Channel 9 result stored in registers 80 and 81 • Channel 10 result stored in registers 82 and 83 • Channel 11 result stored in registers 84 and 85 • Channel 12 result stored in registers 86 and 87	Long Integer
88 – 111	-	Reserved	-
112 - 119	DO Current	DO Current of channels 1 through 8, in mA When non-isolated channels are configured as DO, this register reports the current to ground through the transistor.	Unsigned Word
112– 151	-	Reserved	-
152	Temperature	Module temperature, in degrees Celsius	Signed Word
153	Supply Voltage	Module supply voltage, in mV	Unsigned Word
154– 157	-	Reserved	-
158 – 159	Firmware Version	Firmware Version The major revision number is stored in register 158. The minor revision number is stored in register 159.	Unsigned Word
160 – 163	Serial Number	Serial Number The most significant word is stored in register 160. The least significant word is stored in register 163.	Unsigned Word
164 – 171	Module String	Module type string The first two ASCII characters are stored in register 164. The final two ASCII characters are stored in register 171.	Unsigned Word

Holding Read/Write Registers

The starting address for these registers can be either 0 or 40,000. Use Modbus commands 3 (read holding registers, 0x03), 6 (write single register, 0x06) and 16 (write multiple registers, 0x10).

Note: Tables are listed with Modbus protocol address. For PLC addresses, add 1 to each register address.

Table B4: Holding read/write registers.

Modbus Register Address	Register Name	Register Description	Data Type	Factory Default
0 – 3	AO Setting	Analog output count for channels 1 to 4, in µA In current mode set this register to the desired output current. In voltage mode this register is ignored because in voltage mode the analog output provides sensor power up to 50 mA.	Unsigned word	-
4 – 7	-	Reserved	-	-
8 – 11	AO Default Setting	Default analog output count for channels 1 to 4, in uA The analog output will take the state in this register upon power up or communication timeout if the channel's Default Output Enable coil is set to 1.	Unsigned word	0

12 – 15	-	Reserved	-	-
16 – 27	Channel Mode	Mode select for channels 1 to 12 0 = off, 1 = DO, 2 = DI, 3 = AO, 4 = AI Set the register to 0 to disable the channel; 1 for digital output; 2 for digital input; 3 for analog output, or 4 for analog input.	Unsigned word	0
28 – 39	-	Reserved	-	-
40 – 47	AI Filter	Analog input filter selection for channels 1 to 8 0 = disabled, 1 = 0.1 Hz, 2 = 0.04 Hz, 3 = 0.02 Hz, 4 = 0.01 Hz, 5 = 0.004 Hz Use the AI filter selection to obtain a slowly changing, stable signal. Set to 0 for a fast moving signal.	Unsigned word	0
48 – 55	-	Reserved	-	-
56 – 59	Resistor Pull	Resistor pull for channels 1 to 4 0 = disabled, 1 = 10 kOhm pull down, 2 = 10 kOhm pull up	Unsigned word	0
60 – 79	-	Reserved	-	-
80 – 91	DO Bi-Stable Time	Digital output bi-stable timeout for channels 1 to 12, in ms Set this register to any number between 1 and 60,000 for the digital output to act as a pulse output with specific time duration. Set this register to 0 to disable bi-stable mode.	Unsigned word	0
82 – 127	-	Reserved	-	-
128 *	Com Mode	Communication mode 0 = RS-232, 1 = RS-422, 2 = RS-485	Unsigned word	0
129	Com Failed Latch	Communication failed latch Read 0 = no communication timeouts have occurred Read 1 = communication timeout has occurred Write 0 to clear register.	Unsigned word	0
130 *	Com Baud Rate	Com port baud rate 0 = 110, 1 = 150, 2 = 300, 3 = 600, 4 = 1200, 5 = 2400, 6 = 4800, 7 = 9600, 8 = 14400, 9 = 19200, 10 = 28800, 11 = 38400, 12 = 57600, 13 = 76800, 14 = 115200	Unsigned word	9
131 *	Com Parity	Com port parity 0 = none, 1 = even, 2 = odd	Unsigned word	0
132 *	Com Stop Bits	Com port stop bits 0 = 1 stop bit	Unsigned word	0
133 *	Com Interval	Modbus Min Transmit Inter-Message Interval (2 to 1000ms) The interval is automatically adjusted not to be shorter than 3.5 character lengths to meet the Modbus specification. **Note:** The interval between messages at the receiver must be at least 2 ms; if the interval is less than 0.5 ms, received characters will be processed as one message; if the interval is between 0.5 and 2 ms, Modbus message processing will be un reliable.	Unsigned word	2
134 *	Com Turn-On	RS-485 Turn-on delay, in ms Set this register from 0 to 9 to set the time between RS-485 transmitter on and character transmission start	Unsigned word	1
135 *	Com Turn-Off	RS-485 Turn-off delay, in ms Set this register from 0 to 9 to set the time between character transmission end and RS-485 transmitter off	Unsigned word	1
136 * – 142 *	-	Reserved	-	-
143 *	Com Baud Override	Baud rate override If different than 0 or 0xFFFF, must know com port H/W setting values to set this register	Unsigned word	0

* **Note:** These registers are only write-able on PC Modules. The P Modules will disregard writes to these registers and return the following hard-coded values: 115.2 kbits/s baud rate, 8N1 and 2ms inter-message delay. All other parameters are not applicable for the P Modules.

Stack Configuration Read/Write Registers

Stack configuration registers are located in the Base and are shared with all Expansion Modules in a stack. Upon power-up, the Base configures attached modules with the saved settings.

The starting address for these registers is 0. Use custom Modbus commands 100 (read stack configuration, 0x64) and 102 (write stack configuration, 0x66).

Note: Tables are listed with Modbus protocol address. For PLC addresses, add 1 to each register address.

Table B5: Stack configuration read/write registers.

Modbus Register Address	Register Name	Register Description	Variable Type	Factory Default
0	-	Reserved	-	-
1	Modbus Mode	Modbus addressing mode select 0 = standard 8-bit Modbus addressing, 1 = extended 16-bit	Unsigned word	0
2	Modbus Address	Modbus address In 8-bit addressing this register can be set from 1 to 246. In 16-bit addressing, this register can be set from 1 to 65535.	Unsigned word	1
3	-	Reserved	-	-
4	Power Mode	Power mode select 0 = regular, 1 = low power mode Set the register to 1 to reduce power consumption. In low power mode, the "P" LED flashes slowly.	Unsigned word	0
5	-	Reserved	-	-
6	Nominal Voltage Range	Nominal Voltage Range, in mV Change the value in this register from 100mV to 25,000mV in 100mV steps to change the upper limit of the AI Integer Result in voltage mode. Write 0 to this register to use the default setting (10V).	Unsigned word	0
7	Nominal Current Range	Nominal Current Range, in mA Change the value in this register from 1mA to 120mA to change the upper limit of the AI Integer Result in current mode. Write 0 to this register to use the default setting (40mA).	Unsigned word	0
8	AI Justification	Analog input A/D count justification 0 = left, 1 = right	Unsigned word	0
9	FP Justification	Floating point word order 0 = regular, 1 = inverted	Unsigned word	0
10	LI Justification	Long integer word order 0 = regular, 1 = inverted	Unsigned word	0
11	-	Reserved	-	-
12	Communication Timeout	Communication Timeout Default Delay, in seconds The communication timeout default delay sets how long after a message is received by the module for the module to apply defaults. For example, using the default setting (60 seconds), a user polls the status of inputs, sets some inputs accordingly and stops communicating. Exactly 1 minute later (60 seconds) the module will apply default outputs for all channels whose Default Enable coil is set to 1.	Unsigned word	60

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