Modbus Input/Output (I/O) Interface Module General Discussion

Introduction

A data acquisition and control system (industrial process controller or PLC) must have a way of accessing real-world input data from sensors and switches and a way of sending control information to relays and other control actuators. These functions are accomplished with devices called Input/Output (I/O) interface modules. The actual sensors and actuators are wired to the I/O modules. Then the I/O modules are all connected together over a communication cable (fieldbus) to the controller.

These interface modules my be located next to the process controller or distributed over a larger geographic area such as in different buildings and enclosures located where the measurements and control need to be made. Connecting I/O modules to the controller is done over wring cable called a fieldbus. This is a cable that connects to the controller and the first I/O module. A second cable connects to the first I/O module and runs to the second I/O module. From here a third cable can connect the second I/O module to the third, etc. This is called daisy chain wiring.

There are several different fieldbus systems in widespread use but the one we use is called serial Modbus and is an open standard used world wide. There are gateways that connect serial Modbus to virtually any other fieldbus. Our system uses the industry standard RS485 voltage levels on 2 wires to transfer the messages between the controller (master) and I/O modules (slaves). The cable requires two additional conductors for ground (GND or Common) and +5 volts for a total of four wires. The two wires for the communication should be one twisted pair and the two wires for power and ground should be a second twisted pair. Category 5 wire can be used but is prone to breaking because it is a single small solid wire. A better choice is 22 gage (or larger) multi-strand double twisted pair sensor cable.

This serial Modbus RS485 fieldbus my be up to 4000 feet long with up to 31 I/O modules (with the controller making a total of 32 drops). Other considerations such as data point throughput may limit the number of nodes to something less. Our eICIS/ICON controller can support up to four separate Modbus buses running simultaneously.

Types of I/O Modules

I/O interface modules use two types of data, digital and analog. In Modbus terminology a digital input is called a discrete input and a digital output is called a coil. Analog inputs are called input registers and analog outputs are called holding registers. I do not like the Modbus terminology and will hence forth use digital and analog inputs and outputs.

Digital inputs allow access to the state of a digital sensor, such as a float switch, and sends one of two numbers, 0 or 1. The signal can be a high or low voltage, a high or low current or an open or closed switch. In addition to simply measuring the state, the on/off transitions can be counted for total accumulation (such as a tipping bucket rain gage to measure precipitation). Additionally, some sensors such as contact closure anemometers close a

switch at a rate proportional to the measurement (for example wind speed). In this case the frequency of the on/off pulses can be measured. The only difference between event counting and frequency measurement is that in event counting the count is never reset to 0 and for frequency, the count is reset to 0 at the start of each second and the number of counts for the one second period is reported. Notice that in the case of event counting and frequency measurement, although the input is digital (a string of two different states only), the result is an analog value (number of counts or frequency) and can vary from 0 to 65535 although some inputs may be limited to a lower maximum value.

Digital outputs turn devices on or off. They can be in the form of two voltage states, two current states or the open and closing of a switch (relay).

Analog inputs allow reading values with more than two states. Examples include sensors for flow, pressure, temperature, humidity, light, turbidity, gas levels (ambient, stack and liquids) and PH to name just a few. These sensors usually output a voltage or current that varies from a 0 or low value to a higher value such as 5 volts but as a continuous range. This signal is then converted to a digital reading by an analog to digital (A-D) converter. A-D converters work with different step sizes (resolution). A 12 bit A-D can break the sensor reading into 4096 different steps that range from 0 to 4095. A 10 bit A-D converter breaks the steps into 1024 increments (0 to 1023). An 8 bit A-D breaks the steps into 256 (0-255). As an example, a wind direction sensor my output a voltage from 0 to 5 volts for a direction of 0 to 360 degrees. If a 10 bit A-D is used, then as the reading varies from 0 to 1023, the actual direction angle varies from 0 to 359. Therefore the raw A-D reading must be multiplied by 0.351 to get degrees. This conversion would be performed by the process controller.

To output analog output control signals, a digital to analog (D-A) converter is required. This device converts a digital number to a proportional voltage or current. Just like A-D converters, D-A converters can have resolutions of 8, 10, 12 or more bits. As described above, an 8 bit D-A would have a numeric range of 0 to 255, a 10 bit would be 0-1023 and a 12 bit 0 to 4095. This proportional output voltage or current can then be used to control proportional actuators such as valve positioners.

Modbus Communication Protocol

Modbus is a serial protocol originally developed by the industrial control manufacturer "Modicon". The Modbus control protocol has been the defacto open standard for industrial controls for over 30 years and is now maintained by the Modbus organization found at www.modbus.org.

There are two types of Modbus, one that transfers data over a serial link and another that operates over the Internet protocol TCP. Although our controllers support both types, this document describes our I/O modules which use only the serial type. For serial communication the protocol further splits into an ASCII implementation and a binary version called RTU. The RTU version is more compact and is the only version supported by our controllers and I/O modules.

Our Modbus I/O modules support the following:

- RTU protocol.
- Half duplex 2-wire RS485.
- Baud rate of 9600 or 19200.
- No parity or odd parity.
- The controller and all I/O modules on the same bus must be set for the same configuration.
- Other serial Modbus slave devices from other manufacturers may be on the same bus as long as they are configured as above.

The Modbus communication protocol has the following specifications:
- Each Modbus I/O node on a common bus network is given a unique slave unit address in the range of 1 to 254.
- Up to 254 different slaves may theoretically be connected to a single master. The RS485 electrical bus specification reduces this to 32 (one master (controller) and 31 slaves (I/O modules) and time throughput considerations my limit the number to something even smaller.
- The slaves do not respond to the master unless spoken to. (This is not a peer to peer system as some other field buses are.)
- If using our eICIS/ICON controller there can be up to four separate masters with serial buses running simultaneously.
- All slaves on the same bus receive the same message from the master. Only the slave who's address matches the address in the master message responds to the command. All the other slaves ignore the message.
- Modbus defines a digital I/O bit (discrete input or coil output) for digital inputs and outputs and an analog 16 bit register data type (input register or holding register) for analog inputs and outputs. A 16 bit register can hold a value between 0 and 65535.
- There are eight Modbus commands, read digital inputs (2), read analog inputs (4), set single digital output (5), set multiple digital outputs (15), set single analog output (6), set multiple analog outputs (16), read state of digital outputs (1) and read state of analog outputs (3) that our system supports.
- Command 5 to write 1 digital output is a special case of command 15 to write multiple digital outputs. The command 6 to write 1 analog output is a special case of command 16 to write multiple analog outputs.
- Each Modbus command consists of the slave unit address that the command is intended for, the Modbus command (1-6,15 and 16) a starting address location and the number of elements to transfer.
- If using the eICIS/ICON as the controller, all addressing starts at 1. Some Modbus vendors start addressing at 0. Add 1 to their address values when programming eICIS/ICON controllers.
- For our I/O modules, if a command is invalid for any reason, no response is sent. It is up to the master to timeout and go on. In a properly programmed system the only error that should result in no response would be a character transmission error due to noise or broken wire in the bus cable.
- If using an eICIS/ICON controller you use multiple Modmaster commands to configure, read and send data to the I/O modules.

I/O Modules
We manufacture a line of Modbus I/O boards with the following common features.
- Printed circuit board dimensions are 6" long X 4.25" wide. (Not all boards are the same height.)
- Mounts to a flat surface (usually an aluminum mounting plate) with four 1/4" standoffs and 4-40 screws.
- All field wiring connects to removable screw lug terminals for easy installation and maintenance. To remove a connector, gently rock side to side as you pull up and it should slide off the terminal posts. After wiring the connector you simply line up the posts with the connector holes and press down. If all the connectors are removed, it is possible to place the wrong connector on the wrong set of posts or shift the connector left or right one or more pins. Therefore, only remove and reconnect the connectors with power off and double check that all connectors are in the right locations before turning power back on.
- Field repair to the Integrated Circuit (IC) level if desired (all ICs are socketed with high quality, machined, gold plated sockets).
- Two separate RS485, 2-wire communication interface connectors with board power connections for easy power/communication daisy chain field wiring.
- Power required is +5V regulated.
- LED indicators for Modbus serial transmit and receive.
- Communication can be set to 9600 or 19200 baud with odd or no parity.
- Any one of the 254 Modbus slave addresses can be selected.

Refer to the specific I/O module manual for the actual address ranges and data definitions since this information is I/O module specific.

I-NETCONTROL
eICIS/ICON Overview
Richard Weaver | Rev 1.0 3/21/2008 | 1

Digital I/O Module   Analog I/O Module   Power Module   Controller Module
                                          To Dallas 1-Wire   To Other Power/I/O Module Groups

Local RS485 Modbus Fieldbus Wiring and Power   RS232 and +5V Power to Controller