Configure Your Ethernet I/O System: A Hands-On Tutorial

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KEYWORDS

Ethernet , I/O, SCADA, OPC, HMI, webserver, Java, XML, HTTP, TCP/IP, ModbusTCP, server, client

ABSTRACT

Currently, many instrument & control vendors offer modular, ethernet I/O systems that can be used as a relatively low-cost method of bringing field devices from your plant into a computer SCADA or control system using the ethernet. These systems can be configured quickly and communicate with each other AND other computers over standard ethernet using off-the-shelf ethernet hubs, switches, and/or routers and viewed from a browser, a spreadsheet, or your third-party HMI. Learn how to configure AND implement ethernet I/O systems for your plant. This tutorial will have hardware and software to allow attendees to actually program the systems.

INTRODUCTION

Industrial automation professionals use the same steps today as they have been using since the first pneumatic control system nearly seventy years ago and the first electronic distributed control system nearly thirty years ago. Today, instead of running pneumatic tubes or electronic wires from each device in the field, each field device can have a unique address and be connected via the Ethernet. The industrial automation professional still must keep track of each device, program (and often reprogram), and maintain all these devices.

With the proliferation of the internet infrastructure and the increased capabilities of internet communication, new equipment and the associated programming software for that hardware are becoming increasingly available to industrial automation professionals to implement in plants giving plant operations increased real-time process information from those processes. Measurement and control devices distributed in the field (sometimes very remotely) can be connected to each other, to central monitoring facilities, and to remote sites where technicians can maintain and troubleshoot problems with the equipment via the internet.

This paper and the associated tutorial will show the reader and/or tutorial attendee how to design, program, implement, and troubleshoot the equipment from three representative vendors by showing the respective software used to program and communicate with each of the hardware devices with screen prints from the programs as well as sample third-party interface software (i.e.; HMI's) that can be used by operators, engineers, and technicians. In this paper and tutorial, Modbus TCP and OPC communication will be used.

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HARDWARE

The hardware used for the tutorial was provided by the three vendors that all have long and successful histories of providing industrially-proven instrumentation controllers, signal conversion devices, isolators, and connectors to both end-users and OEM manufacturers.

Author's Note: Many other suppliers provide similar products and the selection of these three only reflects this author's familiarity with them and should not be interpreted as a negative reference toward other vendors. In fact, the three vendor's hardware used in this tutorial is listed alphabetically so as not to indicate a preference for any of these vendors.

In this tutorial an off-the-shelf 400 MHz Dell Inspiron 7000 laptop running Windows 2000 Professional operating system was connected to an off the shelf 3COM four-port hub to which each of the respective ethernet interface modules was also connected using standard CAT 5 10/100 ethernet cables.

Moore Industries Net Concentrator System (NCS)

The NCS system uses a Ethernet Interface Module (EIM) (the left-hand module with the ethernet CAT5 cable connected) to allow communication between the two input/output modules to its right and the operator and/or programmer through the human machine interface (HMI). That HMI can be either a third party-supplied package, a custom-written Visual Basic / Visual C++ application, and many others.

OPTO 22 Snap Ultimate I/O Learning Center

The OPTO 22 Snap Ultimate I/O system uses a Snap Ultimate Brain (the left-hand module mounted on the standard 35 mm DIN rail behind the inclined panel with the switches and dials, the ethernet CAT5 cable is connected to the black square on the back-left of the Ultimate Brain) to allow communication between the five input/output modules to its right. Immediately to the right of the Snap Ultimate Brain is is a four-digital input I/O module, to its right is a four-digital output I/O module, to its right is a two-analog input I/O module, to its right is a two-analog output I/O module, and to its right is a temperature input I/O module.

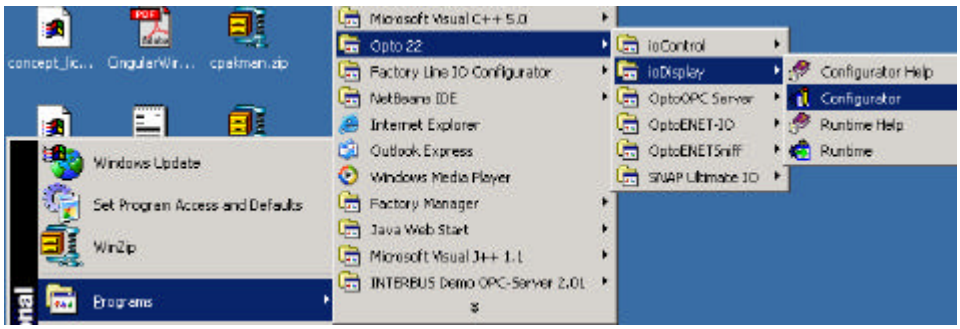
Phoenix Contact Inline IO System

The Phoenix Contact FactoryLine (InLine) I/O system uses a Ethernet Bus Coupler (to the left, the ethernet CAT5 cable is connected to the black square on the lower-left of the bus coupler) to allow communication between the five input/output modules pictured below it, the left-most I/O module is a four-digital input, the middle-left I/O module is a four-digital output the, right-middle I/O module is a two-analog input, and the right-most I/O module is a two-analog output. Like the Moore Industries NCS and OPTO 22 Ultimate I/O systems, all these modules mount on a standard 35 mm DIN rail.

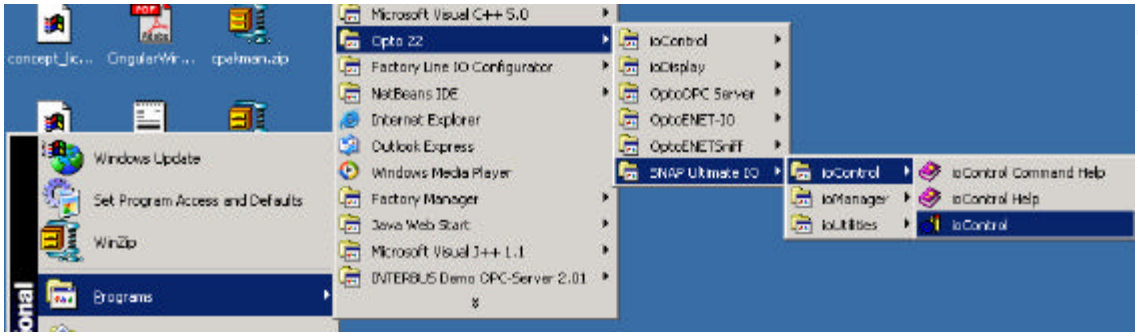
SOFTWARE

In this tutorial Microsoft Windows-based software is used to communicate with and program each of the equipment. In the next seven pages screen prints from the programs will show the six basic steps necessary to bring the hardware into operation:

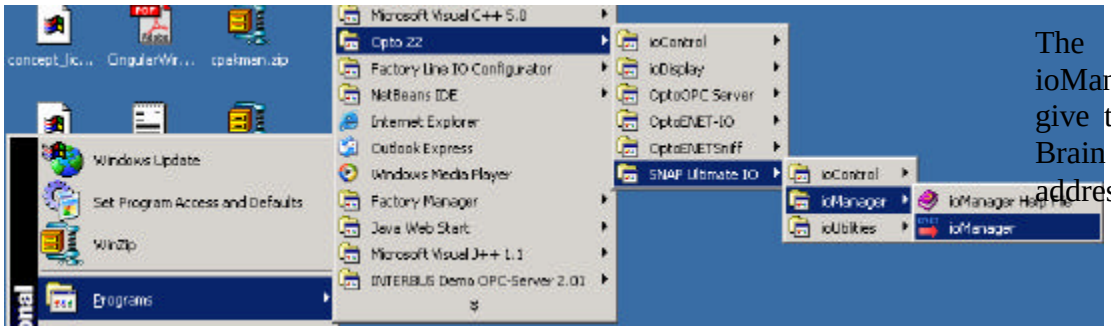
1. identify and address the interface hardware (give it a unique TCPIP address) across the Ethernet
    - NACClient
    - ioManager
    - FactoryLine IO Browser
2. let the interface hardware identify and address input/output modules
    - NCS Config
    - ioManager
    - FactoryLine IO Browser
3. determine which communication protocol will be used and how the I/O is mapped
    - Modbus TCP
    - OLE for Process Control (OPC)
4. Program the controller
    - ISaGRAF Workbench IEC 1131 language
    - IOControl flowcharts
5. Configure the OPC Server - if OPC is used
    - FactoryLine OPC Configurator & Interbus OPC Server
    - OPTO OPC Server
    - Moore OPC Server
6. Configure a Human Machine Interface (HMI) of some kind
    - Graphical displays supplied by the hardware provider
    - Graphical displays supplied by a 3rd-party provider
        - Wonderware InTouch
        - CiTect SCADA HMI
    - HTML
    - XML
    - Custom Visual Basic and/or Visual C++ application
        - OPTOENETDemo
        - ModScan32 (from Win-Tech)
        - Modbucfg (from modbus.org)



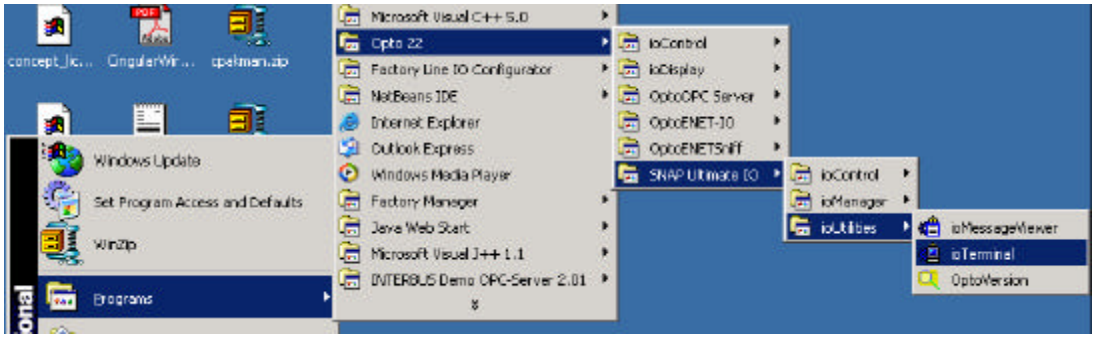
The OPTO22 ioDisplay Configurator is used to configure the OPTO22 HMI.



The ioControl program is used to program the control charts in the OPTO22 Snap Ultimate Brain.



The OPTO22 ioManager is used to give the Snap Ultimate Brain a unique TCPIP address.



The OPTO22 ioTerminal is used to communicate DIRECTLY with the Snap Ultimate Brain.

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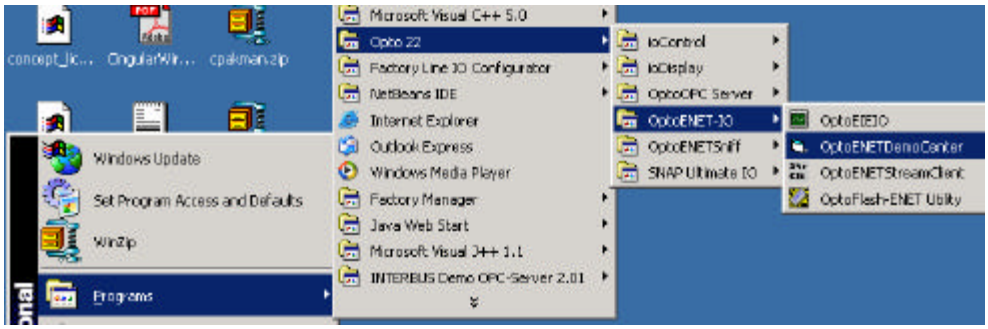
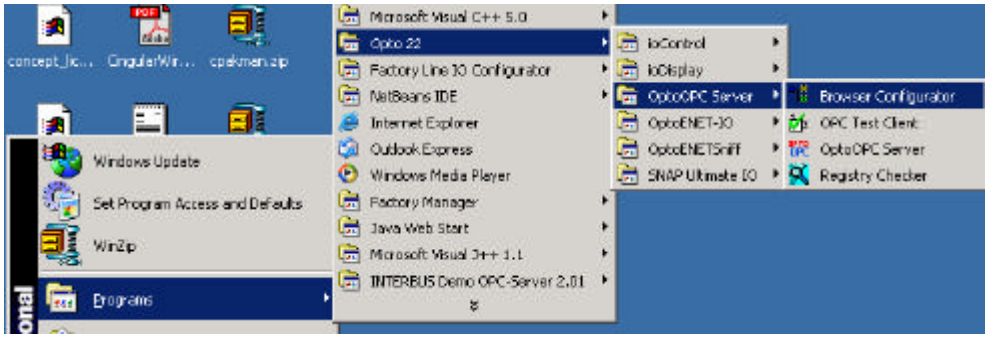
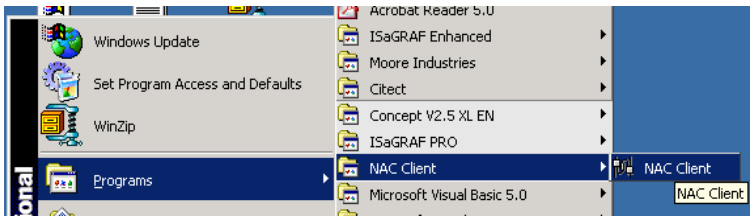


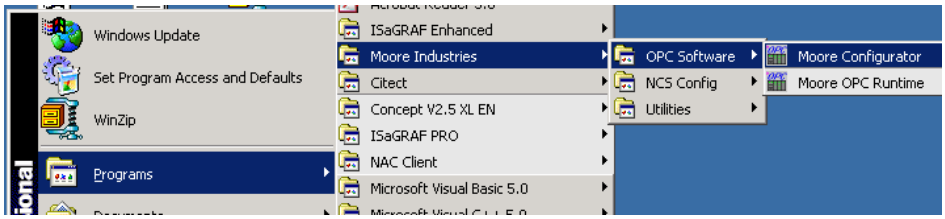
The OptoENETDemoCenter is a dynamic pictorial of the OPTO Learning Center.
(See the bottom of page 9.)



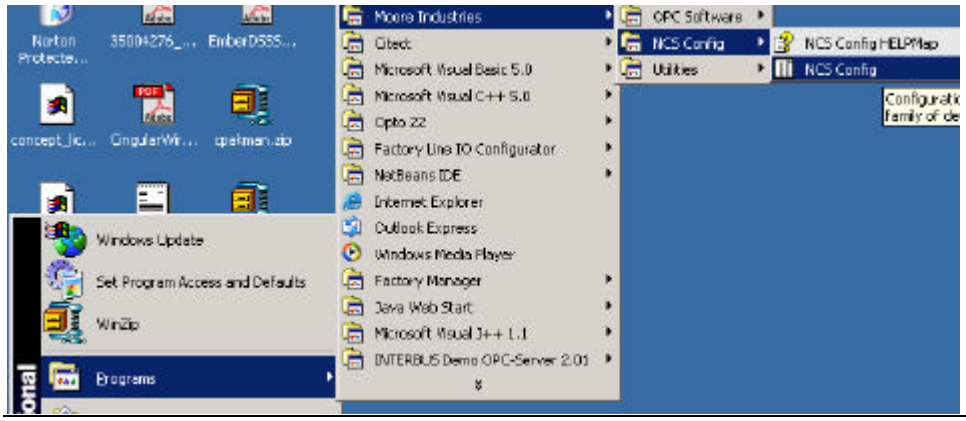
This is used to configure OPTO22's OPC server, "Opto22.OpcServer.2".



The NAC Client is used to give the NCS EIM a unique TCPIP address.



This is used to configure the Moore Industries OPC server.



The NCS Config is used to address the I/O modules to the NCS EIM.

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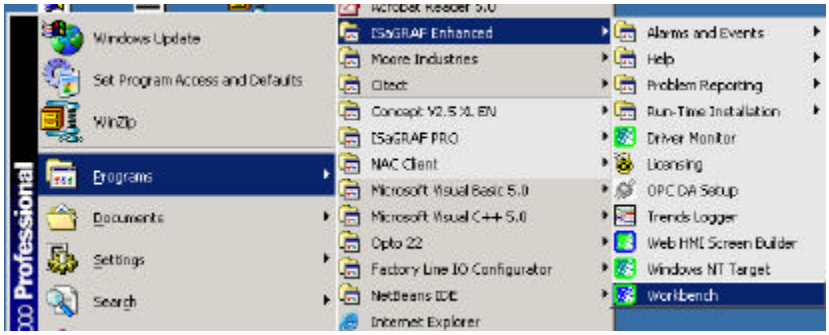
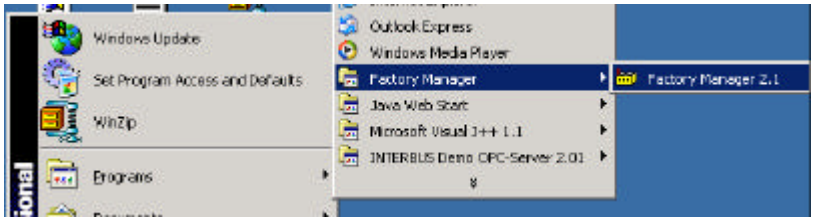
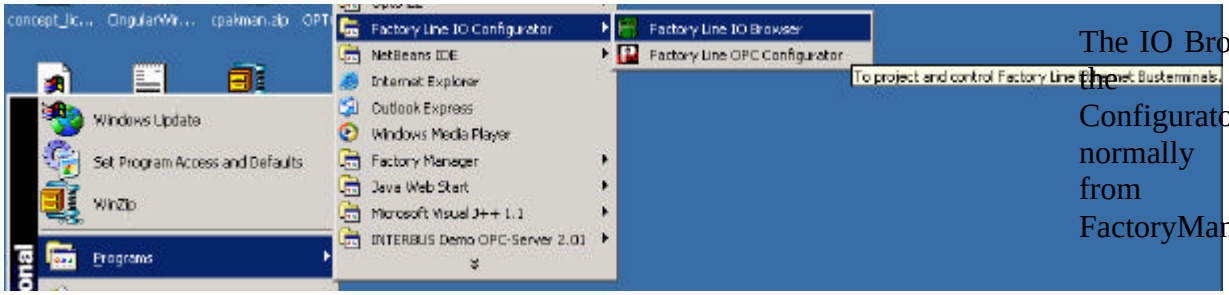


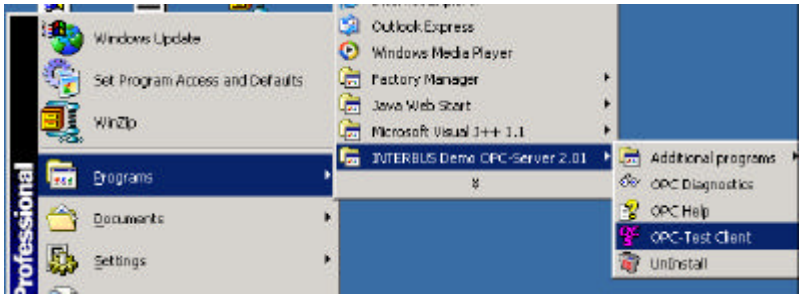
The ISaGRAF Enhanced Workbench is a, IEC-1131-compliant (meaning it uses ladder, function blocks, structured text, and sequential function charts) programming tool used to program and monitor the Moore NCS EIM.



The FactoryManager is the main interface program to program and monitor the Phoenix Contact FactoryLine InLine I/O devices. From it, you can search for a module with the Network Spy.



The IO Browser and the OPC Configurator are normally accessed from the FactoryManager.



The OPC Test Client is used to check the configuration completed in the OPC Configurator

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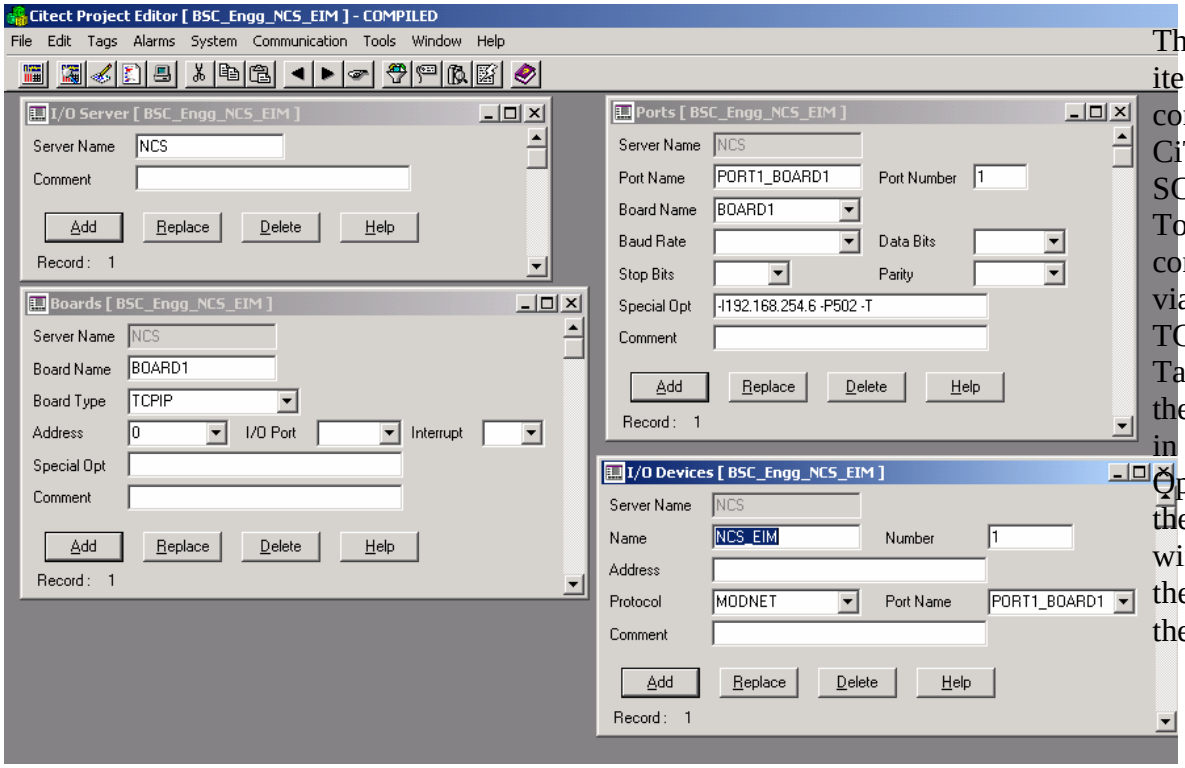
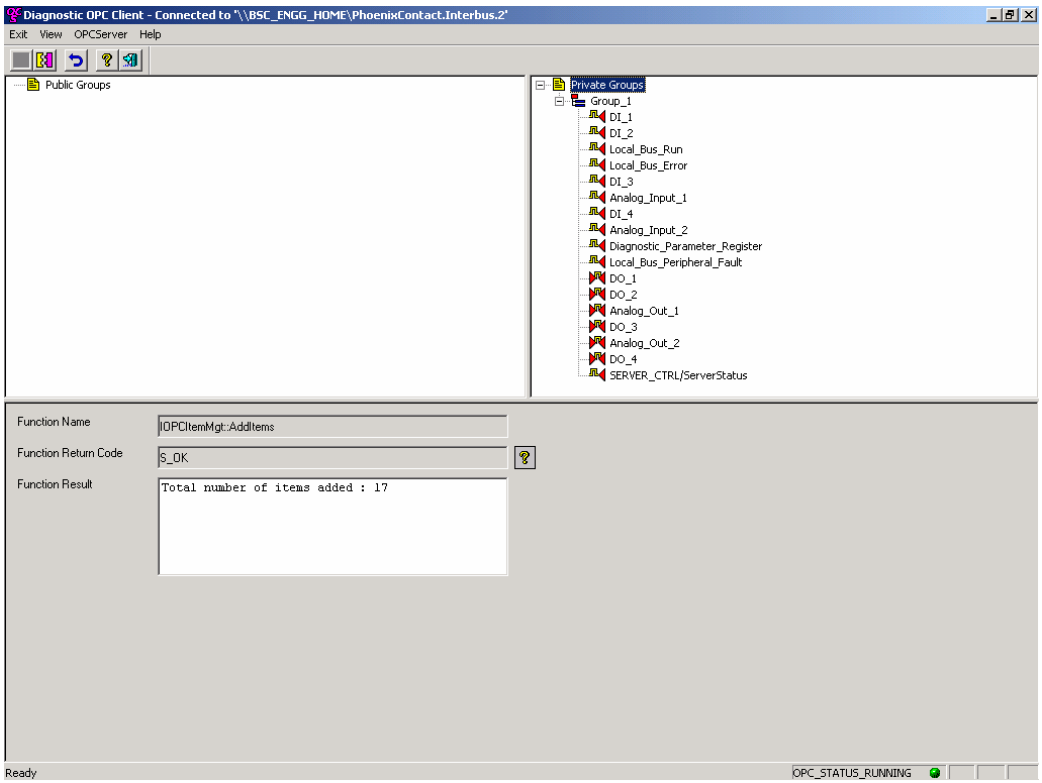


These four items must be configured in CiTect SCADA HMI To communicate via Modbus TCP. Take note of the IP address in the "Special Opt" box in the "Ports" window; it is the address of the NCS EIM.



This is the OPC test client for the Phoenix Contact FactoryLine InLine I/O OPC Configurator. The CiTect SCADA HMI AND Wonderware InTouch have both been programmed to access the Phoenix Contact I/O through the "PhoenixContact.Interbus.2" OPC Server.

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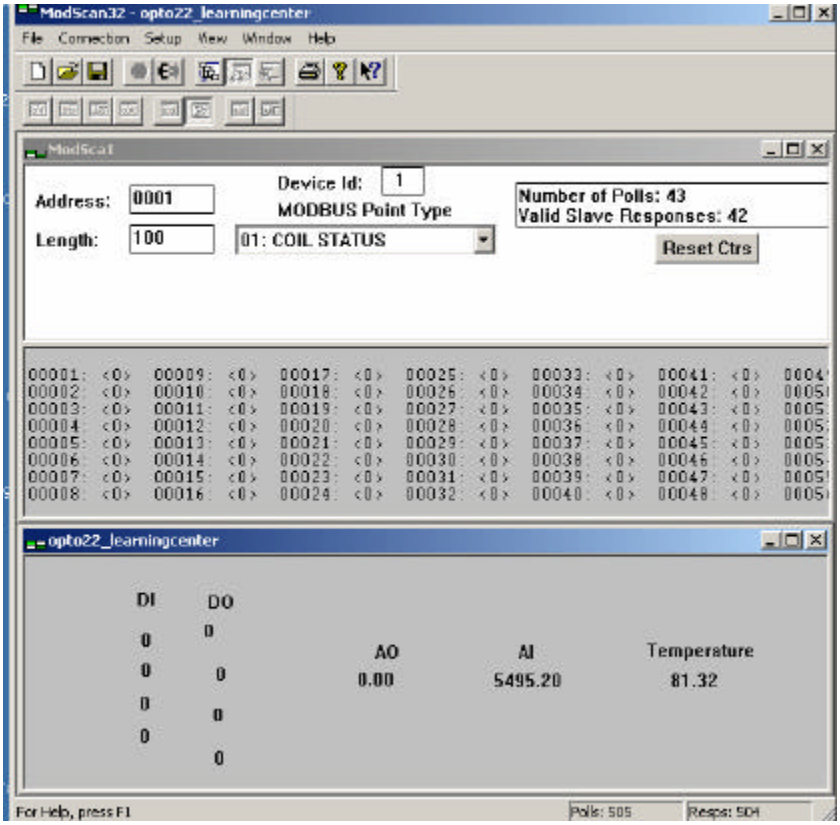
ModScan32 from Win-Tech

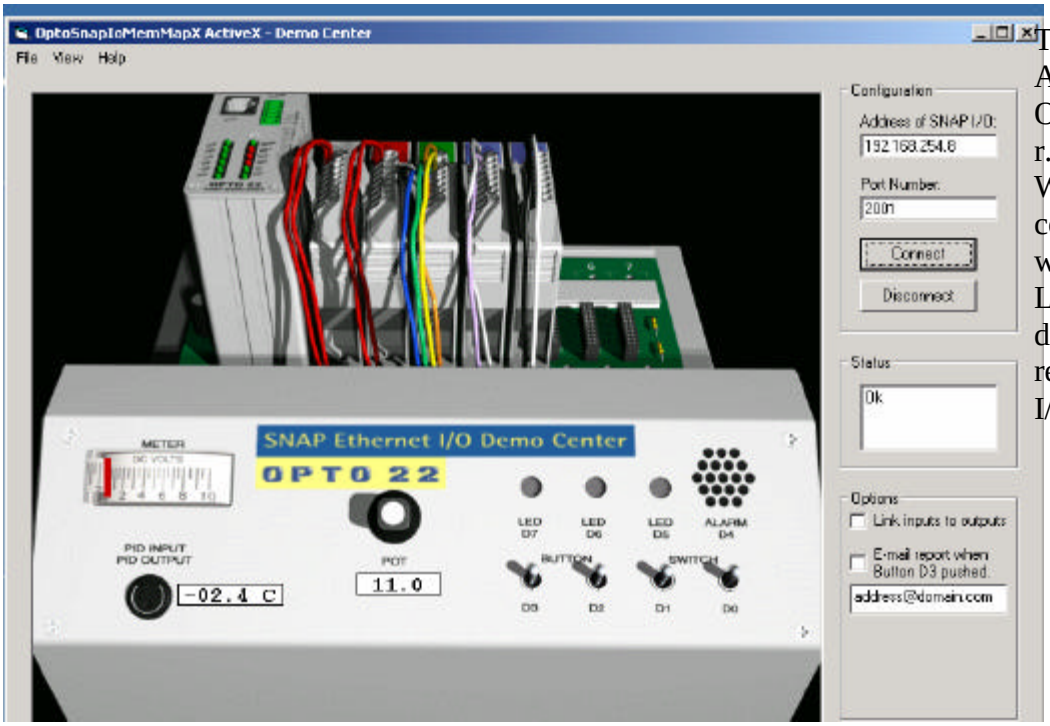


This is the operator interface for ModScan32 which is a custom Visual Basic / Visual C++ application. Here, ModScan32 is connected to the OPTO22 Ultimate Brain via modbus TCP.

In the "ModSca1" window you can select the addresses to read and/or write by selecting from the "01: COIL STATUS" drop-down box.

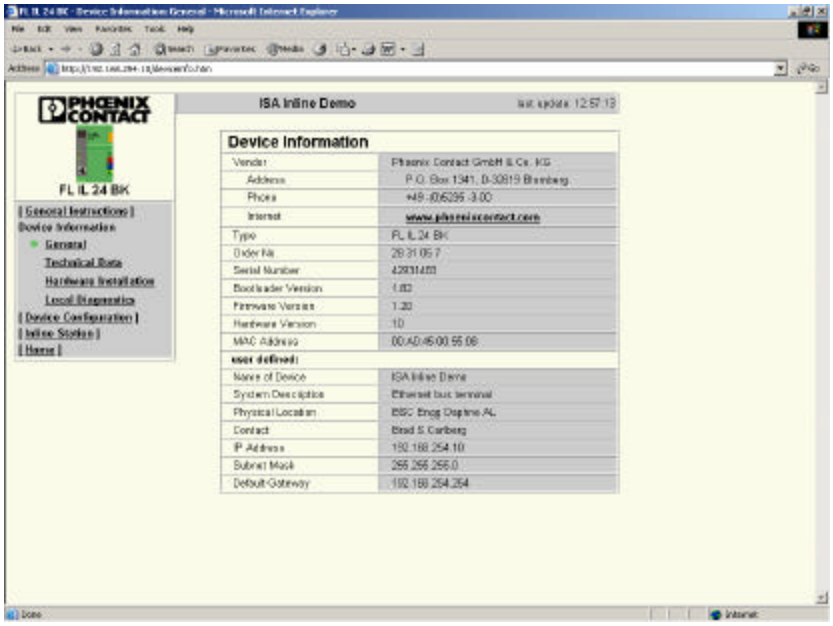
In the lower window entitled "opto22_learningcenter", each of the five I/O modules can be viewed and the output modules can be written to.

OptoENETDemoCenter

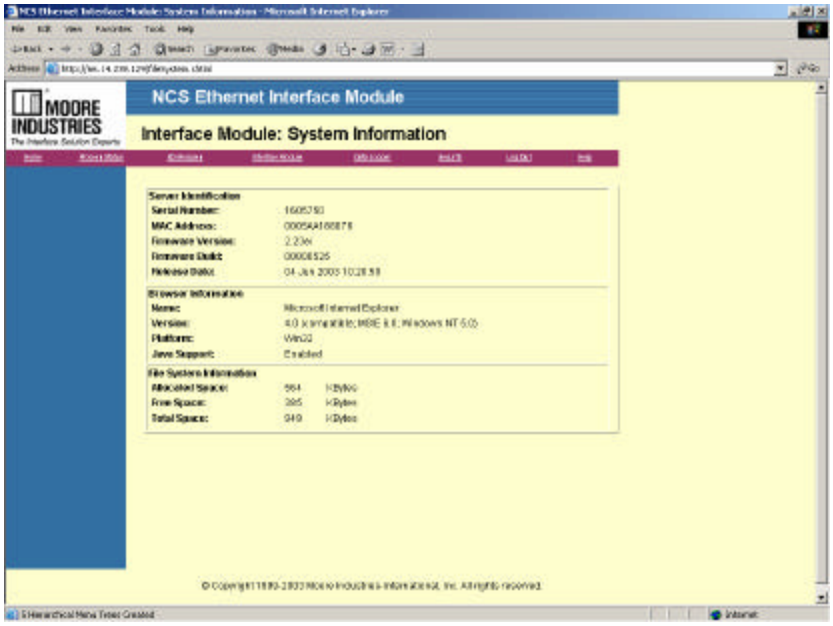


This is the custom ActiveX application OptoENETDemoCenter.

With this application connected (the Status window says ok); the LED's, switches, and displays dynamically reflect the status of the I/O



This is the webpage for the Phoenix Contact FactoryLine InLine I/O module. This page can be accessed from anywhere there is an ethernet connection.
This interface is for monitoring the status of the hardware only.
The communication interface can be configured, addressed and re-addressed, and reset if there is a communication failure.



This is the webpage for the Moore Industries Ethernet Inferface Module. This page can be access from anywhere there is an ethernet connection.
By clicking the “Process Status” link (the 2nd column), the status of the I/O connected to the EIM can be viewed.
By clicking the “IO Modules” link (the 3rd column), the I/O modules connected to the EIM can be configured.

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Sample XML Code for Phoenix Contact FactoryLine I/O (processdata.xml)

```
<?xml version="1.0" encoding="ISO-8859-1" ?>
<!DOCTYPE IL_STATION (View Source for full doctype...)>
- <IL_STATION>
- <IL_BUS_TERMINAL>
<TERMINAL_TYPE>FL IL 24 BK</TERMINAL_TYPE>
<NAME>ISA Inline Demo</NAME>
<IP_ADDRESS>192.168.254.10</IP_ADDRESS>
<MODULE_NUMBER>4</MODULE_NUMBER>
<DIAGNOSTIC_STATUS_REGISTER>224</DIAGNOSTIC_STATUS_REGISTER>
<DIAGNOSTIC_PARAMETER_REGISTER>0</DIAGNOSTIC_PARAMETER_REGISTER>
</IL_BUS_TERMINAL>
- <IL_BUS>
- <IL_MODULE number="1">
<MODULE_TYPE>DI</MODULE_TYPE>
<PD_CHANNELS>4</PD_CHANNELS>
<PD_WORDS>1</PD_WORDS>
<PD_IN word="1">0</PD_IN>
</IL_MODULE>
- <IL_MODULE number="2">
<MODULE_TYPE>DO</MODULE_TYPE>
<PD_CHANNELS>4</PD_CHANNELS>
<PD_WORDS>1</PD_WORDS>
<PD_OUT word="1">0</PD_OUT>
</IL_MODULE>
- <IL_MODULE number="3">
<MODULE_TYPE>AIO</MODULE_TYPE>
<PD_CHANNELS>2</PD_CHANNELS>
<PD_WORDS>2</PD_WORDS>
<PD_IN word="1">17773</PD_IN>
<PD_IN word="2">22</PD_IN>
<PD_OUT word="1">0</PD_OUT>
<PD_OUT word="2">0</PD_OUT>
</IL_MODULE>
- <IL_MODULE number="4">
<MODULE_TYPE>AIO</MODULE_TYPE>
<PD_CHANNELS>2</PD_CHANNELS>
<PD_WORDS>2</PD_WORDS>
<PD_IN word="1">0</PD_IN>
<PD_IN word="2">0</PD_IN>
<PD_OUT word="1">0</PD_OUT>
<PD_OUT word="2">0</PD_OUT>
</IL_MODULE>
</IL_BUS>
</IL_STATION>
```

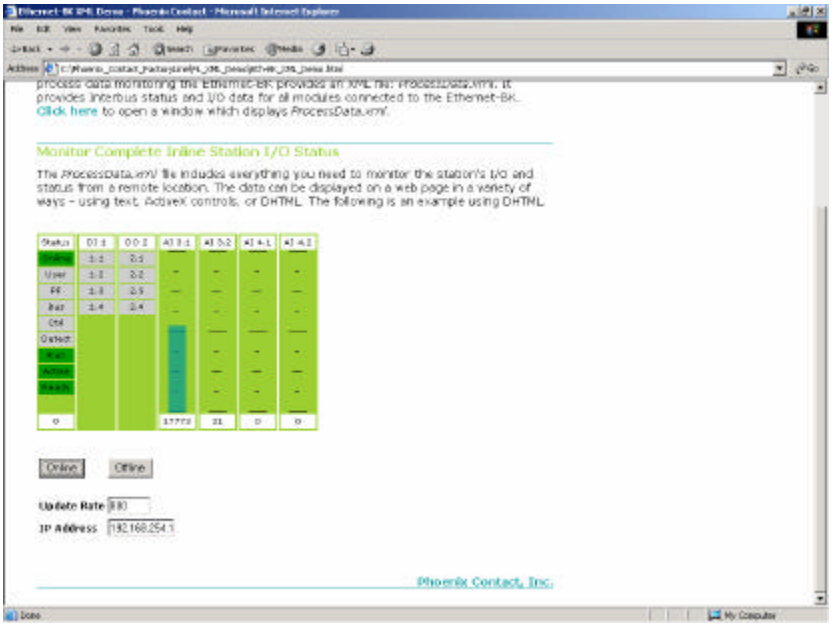
This sample XML can be used to monitor the status of the individual I/O and will dynamically update as the individual points change their state.

Each of the four I/O modules in the demo unit are listed as their particular “module type”; DI, DO, and AIO.

For example, if the the pushbuttons on the demo unit, the “0” after the PD IN word will change to 1,2, or 3 to indicate that the first, second, and both, respectively, have been pushed or energized.

Similarly, if the the potentiometer connected to the first channel of the analog input card on the demo unit is rotated clockwise (increased) counter-clockwise (decreased), the “17773” after the PD IN word will change accordingly.

Sample XML Webpage for Phoenix Contact FactoryLine I/O (Eth-BK_XML_Demo.html)



This is a dynamic html webpage that shows the status' of all of the Phoenix Contact FactoryLine I/O.
In each of the seven columns, the colors will change depending upon the status of the I/O.
For example, as the analog input PV changes, the bar graph in column 4 will raise or lower.
In columns 2 and 3, as the digital inputs and outputs change the grey squares will change to green if the I/O points are energized.
The left-most column shows the status of the interface module.

COMPARISON OF FEATURES

Obviously, each of the three vendors hardware and software have similar as well as different features. itemized in the table below:

	Net Concentrator System	Snap Ultimate I/O	FactoryLine I/O
Max. No. of I/O Modules	16	16	63
Embedded Webserver	✓		
Control Programming	✓	✓	
XML	✓		✓
HTML	✓		✓
OPC	✓	✓	✓

CONCLUSIONS & FUTURE POSSIBILITIES

With the many instrument & control vendors offering these relatively low-cost, modular, ethernet I/O systems that can be configured quickly and communicate with each other AND other computers with off-the-shelf ethernet hubs, switches, and/or routers the internet can be used as a method of bringing field devices from your plant into a computer SCADA or control system and viewed from a browser across the ethernet, somewhat VERY remotely if telephony and/or radio frequency devices are used to extend the ethernet to remote field devices.

Hopefully this tutorial has provided a starting point for the industrial automation professional beginning a long study and career implementing ethernet I/O. In this author's opinion, the future of instrumentation and automation will surely move toward greater use of ethernet for communication between devices, controllers, operator interfaces, and maintenance tools.

ACKNOWLEDGEMENTS

The ethernet I/O equipment used in this "hands-on" tutorial was invaluable for both the tutorial preparation as well as the technical conference session itself. Special thanks needs to go to Scott Saunders of Moore Industries, Larry Komarek of Phoenix Contact, and Benson Hougland of OPTO 22 for both providing the equipment and the respective software AND for technical support assistance .

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