# White Paper
## Product Specification Guide: PC-Based Plug-In I/O



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## OVERVIEW

One of the leading topics of discussion in the instrumentation and control system trade journals and industry circles is PC-based control. There have been countless articles, theories, and opinions of how PC-based control is implemented and what components of software provide the solution. One glaring omission in the debate is the process of selecting PC-based plug-in I/O. This white paper will bring to light some of the options available to complete the PC-based control picture.

This specification guide to PC-based plug-in I/O will attempt to highlight some of the features, benefits, and limitations of the plug-in I/O system. We will focus on PC-based control and data acquisition using modular construction. Most systems will offer a design featuring one or more intelligent I/O units into which a variety of signal conditioning and power control modules can be installed. These I/O units communicate to the PC over a bus or network.

## DISTRIBUTED FEATURES

**Flexibility** - Place the I/O near the control hardware or the data source. Current estimates for industrial wiring in Southern California range from $700 to $1,500 to run eight pairs of line voltage or control signal wires 100 feet in conduit. Moving the I/O to the source can save most of that cost in that only communication wires are needed.

**Scalability** - Most projects grow. The more flexible the system, the wider variety of uses that will be suggested for it. A good rule of thumb is that the system will grow by at least 50 percent from concept to completion. Plug-in I/O systems are usually multiplexed architectures allowing I/O to be added in small increments at small costs, without the risk of running out of system capacity.

**Centralized Control** - Upgrades and retrofits to existing systems are often located in a single control location. All of the processing power is still available, although you may not realize the installation savings of a new distributed system.

**Distributed Control** - Many distributed I/O systems can take advantage of existing networks for the overall sharing of data and for communication of production data to the rest of an enterprise. The real-time availability of data is a primary motivation for businesses to automate.

## INTELLIGENT FEATURES

**Distribution of Processing Power** - The use of processors in today's world is growing at an unprecedented rate. We can find processors in everything from toasters to watches to automobile systems. (Some current estimates have the cost of electronics and processors in select automobiles outweighing the cost of the steel content.) The same rings true for PC-based plug-in I/O. With the ubiquity of processors in many industries and products, costs are driven to new lows. Now the benefits of distributed processing can be realized in I/O systems. When choosing I/O for your application, investigate processing options and how it can provide overall system performance and ease of use.

Some of the more common I/O processing features available are PID loop control, latching, thermocouple linearization, counting, totalization, pulse width measurement, ramping, filtering, averaging, and so on.

**Flexibility** - Performance of a distributed I/O system tends to be independent of the overall system size because each I/O unit has its own processor. An I/O unit is typically comprised of plug-in I/O, a mounting rack, and a local I/O processor, commonly referred to as a brain board. It is possible to add a few I/O points here or there without impacting overall system performance. Adding or moving I/O points is both easy and inexpensive in a distributed system.

**Engineering Units** - As mentioned above, local intelligence at the I/O level can relieve the main processor from tedious, repetitive tasks such as conversion of raw data (volts, milliamps, counts, etc.) to application-specific engineering units. Local intelligence at the I/O level can speed program development by allowing the engineer to work in familiar units and eliminate the possibility of conversion errors. Work with analog signals in relevant terms: temperature, pressure, flow, etc.

**Isolation** - Isolation protects the control hardware from the real-world electrical elements. Most plug-in I/O uses optical isolation, transformer isolation, or a combination of the two. Separating field power and grounds from the control system logic protects the PC and the control hardware and reduces installation problems by eliminating ground loops. The cost premium of isolated plug-in I/O is negligible, therefore, insist on isolation when you evaluate systems.

**Speed** - Local processing of speed-sensitive data dramatically increases system performance. Functions at the I/O processor level such as counting, latching, pulsing, and period measurement require no system communication, resulting in high performance and increased fault tolerance.

**Noise Immunity** - Shorter wire-runs mean less induced noise and reduced line losses. Isolation eliminates ground-related noise problems and provides high common-mode noise rejection.

## PLUG-IN FEATURES

**Mix/Match Signal Types**

• *Analog* - Many applications require only one or two channels of pressure, flow, or temperature data. Plug-in I/O allows you to buy only what you need, and still be able to expand your system when circumstances change. Pressure, flow, temperature, speed, totalization, and other measurements can occur on a single rack of plug-in I/O and its associated processor.

• *Digital* - Easily combine different levels of AC and DC input and output signals on the same I/O unit. Special features such as latching, counting, pulsing, and time measurement are often software-selectable and configurable to a single I/O channel. This allows mixing different digital I/O requirements on a single rack.

**Easy Maintenance** - Most field failures are easily diagnosed to a single, low-cost plug-in module that can be replaced in minutes by technician-level personnel. Additionally, rather than pulling an entire bank of I/O off-line for a single channel failure, plug-in type I/O allows the technician to simply replace the offending I/O module without impacting the rest of the system.

**Low Spare Parts Inventory** - Only one or two of each module type is sufficient for even very large installations. This reduces spare parts inventory requirements, translating to a reduced dollar investment overall.

**Easy to Modify** - Distributed I/O locations can be added at low incremental cost. There is no point beyond which adding a few more points requires a new chassis or system.

## HARDWARE

**Solid State** - Having no moving parts translates to having an infinite life. Solid-state plug-in I/O generally has no failure mode related to numbers of cycles, making it the perfect choice for highly repetitive situations.

**Connections** - Field-wiring connections are made either directly to the plug-in I/O module, or to a terminal on a mounting base into which the module is placed. Both methods have advantages.

• Direct Module Connection makes field wiring accessible and can often shorten installation time. For some installations, however, the easy accessibility to connections is a problem.

• Hazardous explosive environments require the use of equipment that cannot cause ignition of the explosive atmosphere under any failure or operating conditions. A requirement for explosive certification is that no spark-producing activity can occur without the use of a tool. This means that wiring in an explosive environment must be protected from access or tampering by some kind of cover or other access-restricting device. Mounting-base connections are better for these applications.

**Mounting** - Components of plug-in I/O systems can be mounted in any attitude. If a large amount of power is being controlled, orient the mounting base so that natural air flow can cool the modules. This also provides flexibility in mounting options for out of the ordinary application requirements.

**Temperature** - One characteristic of solid-state switching devices is that they can create heat. A good rule of thumb is that solid-state relays will produce about one watt of heat for every one amp that is controlled. If you can touch a module without burning your finger, it is not too hot! Furthermore, most plug-in I/O offers ambient temperature specifications of at least 0–70°C.

**Humidity** - Most plug-in I/O modules are hermetically sealed for use in any non-condensing environment. Typical specs are 0-95 percent relative humidity.

**Serviceability** - Choose a vendor with worldwide sales support. Most plug-in I/O has onboard diagnostics for easy troubleshooting.

### SOFTWARE

Once you have chosen a vendor who can supply the I/O requirements listed above, the next logical step is to determine its compatibility with your software choice. There are many angles to how you implement the software component of PC-based control. Some of these options are listed below.

**Protocols/Drivers** - One important consideration once you've chosen the plug-in I/O system of choice is the method of communication to the I/O. One of the reasons for choosing PC-based control is freedom from being locked into a vendors' proprietary interface. Be sure to choose an I/O vendor who provides an interface or driver to the I/O system that is fully documented and in the public domain.

There are several ways to achieve this. One approach is to bet the control system on one of the open bus protocols available in the market today. The reality is that many engineers question which of the buses will survive the current debates and rhetoric of bus choices today. With that in mind, a better plan would be to choose a modular system that can accommodate any fluctuations in the bus wars.

And of course, if any of the buses available today do not fit your business or application requirements, ensure that the I/O vendor offers a software development toolkit that can provide you with the necessary information, tools, and sample code that will get your project on course to completion.

**Control Software** - Quite a few vendors offer a control programming language and/or runtime environment that must interface with the plug-in I/O system. Here again is where the communications interface or driver plays an important role. But equally important is the ability for the control software program to expose all of the functionality of the I/O system. There is less to gain by choosing an interface driver and control software that only accesses a subset of the functionality the I/O system has to offer.

**Data Acquisition** - If your needs are only data acquisition, the software requirements may be less stringent. But again, a widely supported and available interface is extremely important.

### CHOOSING A VENDOR

**Reputation** - Establish communications with current customers. Ask for references and case studies. Check out World Wide Web content. If all of your control or data acquisition software choices claim compatibility with "Product X," check out Product X. There is probably a reason it is the de facto standard.

**Reliability** - Talk to your maintenance staff. They know which equipment never breaks, and which equipment never works! Find a vendor who has established reliability as the cornerstone to its products.

**Innovation** - Cutting-edge technology has a price. Innovative applications of proven technology result in lower product cost and reduced risk.

**Size of Company** - There is not necessarily a connection between a company's size and the quality of its customer service. It does seem that some of the biggest names have forgotten the personal touch. It doesn't have to be that way. Make a "test call" to customer service.

The following tables illustrate different types of plug-in I/O, their characteristics, and how they may be used in an application:

| Module Type | Electrical Characteristics | Special Features/ Options | How Used |
|---|---|---|---|
| Low Voltage AC/DC Input | · 10–32 volts, AC or DC<br>· Input impedance >1K W<br>· Turn on/turn off time > 5 milliseconds | Manual on/off/auto switch | This workhorse module covers a wide range of 12-volt and 24-volt applications. Turn-on and turn-off times are slow to debounce mechanical switches and to work with 50 Hz and 60 Hz AC. Module of choice for switches and sensors. |
| High-Speed DC Input | · Typical 5 volts or 24 volts DC only<br>· Input impedance » 500 W for fast response<br>· Turn-on/turn-off time » 50 microseconds | | Optical and magnetic encoders; parts counting, rotary and linear position measurement. Good for measuring pulse widths and frequency; too fast for counting using mechanical switch inputs. Will output pulses if input is AC. |
| Quadrature Input | · 2.5 to 16 VDC typical<br>· 2-channel input<br>· 125 kHz, minimum 20 msec pulse<br>· input current 8 mA | | Provides high-speed up/down counting by comparing the phase relationship of a pair of input pulses from a quadrature encoder. Used to measure linear and rotary position. |
| Line Voltage AC/DC Input | · 85 - 140 volts AC<br>· 170 - 280 volts AC | Manual on/off/auto switch | Monitor pushbuttons and switches, proof contacts. Advantage; low current, noise immune. Disadvantage; wiring in conduit |
| AC Output | · 12 to 140, 24 to 280 VAC outputs<br>· Typical loads 0.5 Amp to 3 Amp | Manual on/off/auto switch | Drives resistive and inductive AC loads including contactors, motor, heaters, lamps, and solenoids. |
| DC Output | · Ranges 0 to 60 and 0 to 200 VDC<br>· Loads to 3 or 5 Amps | Manual on/off/auto switch | Device-to-device logic transfer, solenoids, lamps, motors. |
| Dry Contact Output | · 10 VA Limit<br>· 24 Volts Limit | Normally open or normally closed | Used to switch very low voltages and currents; audio, video, analog data, DC logic. |

| Module Type | Electrical Characteristics | How Used |
|---|---|---|
| Millivolt Input | 0 - 50 or 0 - 100 millivolts | Strain gauges, thermistors. |
| Voltage Input | 0 - 5 and 0 - 10 Volts | Impedance > 100 KW |
| Commercial intelligent sensors; temperature, pressure, flow, pH, humidity. | Milliamp Input | 0-20 and 4-20 mA Loops |
| Resistance = 249 W | Loop Voltage 12 to 48 Volts DC | Commercial intelligent sensors; temperature, pressure, flow, pH, humidity. Requires voltage source to power loop. Some sensors, actuators, and modules contain power supply. |
| Thermocouple Input | Non-linear, microvolt input | Traditional way to measure temperature. Requires special connections and relatively short wire runs to input device. Some modules handle multiple thermocouple types while others are dedicated to one type. |
| RTD Input (Resistance Temperature Device) | 100 W platinum and 10 V copper | A constant current through device produces a voltage that is proportional to temperature. Refrigeration and cold storage. |
| ICTD (Integrated Circuit Temperature Device) | Bias with a voltage > 5 VDC. Current is linearly proportional to temperature. | Active semiconductor sensor for ambient temperatures. L ong wire runs are not a problem; limited temperature range. |
| Rate | Typical 4-24 volt sine or square wave | Output is proportional to frequency of input. Tachometers, magnetic pickups, optical sensors, computer logic. |
| RMS | Nominal 100 VAC | Measures the heating power component of AC voltage. |
| Volts Out | 0-5 and 0-10 volts DC output | The variable voltage level is used to set temperatures, speeds, flows, etc. |
| MA Out | | The most popular way to control actuators. Loop current is powered by a DC power supply, typically 24 to 28 volts. |

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