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DeviceNet simplifies warehouse design

A DeviceNet I/O controller is being used to upgrade a PLC-based mobile pallet racking system. Custom designed for low temperature requirements, the board implements a slave DeviceNet function, combined with two types of I/O: solid-state relay outputs to switch the contactors for the motors that move the racks, and opto-isolated digital inputs for manual command devices and the sensors on the racks which provide position information. This article reviews the application, the solution provided, and introduces the DeviceNet specification.

FOREWORD

A custom-designed low-temperature DeviceNet fieldbus controller -- believed to be the first in the world -- is helping to dramatically speed the design and installation of materials handling systems for cold storage warehouses. Developed by HM Computing for Barpro Storage Systems, the controller replaces the hard-wired I/O that controls its mobile pallet racking system, with a low-cost network module.

Distributed I/O allows Barpro to design and install custom materials handling systems much faster. Previously, each new warehouse control system required dedicated software. Systems can now be configured from one standard program.

Similar gains are made on the hardware side. Wiring up a warehouse used to involve a custom star-configuration cabling layout - which fed into a termination and interface panel which was custom-built for each installation. Each mobile rack is now hooked up to a common control network cable which daisy-chains around the warehouse. This feeds directly into the host PLC-based control station and man machine interface.

This factor alone reduces the number of connections that have to be made during installation by typically 30%, and as much as 50% for large projects. It can easily translate into a week or more of installation/commissioning time. This is a major advantage for most users, who typically need to start seeing a return on their warehouse investment very rapidly once the decision to build has been taken, or minimal disruption if an existing warehouse is being upgraded to higher density storage systems.

Barpro is also reaping one extra benefit from the new architecture. The underlying network makes it very easy to extend the control system. Previously, engineers had to install extra custom cable runs all the way back to the termination panel, make hardware changes by adding relays and connectors (the panel could be 3m2 or more), and then rewrite the PLC software program. Barpro always tried to anticipate future modifications in the original design, but if a change was not foreseeable, it could involve several days of modifications - most of which are made more difficult because of cold working conditions. Now, extra racks can be added by simply tapping onto the cable and then making configuration changes to the software. Provided the change does not exceed the loading requirements - no hardware changes are required at the host PLC control panel.

Barpro had been considering an upgrade to fieldbus architecture for its control systems for some time, but had been hampered by the fact that much of its work is in the cold storage field, necessitating extended temperature capability for the hardware. The CAN network with the DeviceNet protocol was preferred, because of its exceptional reliability, but it could find no supplier who offered low temperature modules.

Barpro took the decision to commission its own slave I/O module. UK-based HM Computing won the contract because of experience designing similar embedded controllers, and its range of back-up services such as small batch manufacturing and fixed-price repairs.

The design called for a DeviceNet slave with two types of I/O: solid-state relay outputs to switch the contactors for the motors that move the racks, and opto-isolated digital inputs for manual command devices and the sensors on the racks which provide position information.

HM Computing had already developed DeviceNet slave code for a microcontroller range available in extended temperature format, and by being able to re-use this existing software, the development cycle was very fast, with Barpro getting its first sample within 12 weeks - and a right-first-time design which worked immediately.

CUSTOM SLAVE CONTROLLER

Consisting of up to 8 solid state relay outputs and up to 16 opto-isolated digital inputs, the custom DeviceNet node is based on the Siemens 515C microcontroller, running with a 10MHz clock. This device is 8051-compatible, but twice as fast for the same clock speed, and features an integrated CAN interface. Its 2kbytes of on-chip RAM is sufficient to run the DeviceNet slave stack.

Due to the high integration of I/O on the microcontroller, only signal conditioning and drivers needed to be added to provide the complete solution - together with Flash memory for the code, and voltage regulation.

A node address is set by using small rotary-encoded

Baud rate	100% thick cable	100% thin cable
125 kbps	500 meters	100 meters
250 kbps	250 meters	100 meters
500 kbps	100 meters	100 meters

Table 1. Trunk cable length specification.

Baud rate	Maximum	Cumulative
125 kbps	6 meters	156 meters
250 kbps	6 meters	78 meters
500 kbps	6 meters	39 meters

Table 2. Drop cable length specification.

switches. All components are specified to industrial temperature range and many hundreds of these modules are now in service, operating at temperatures down to -20 C, 24 hours a day. The small number of devices used contributes to this module's small size reliability.

Although Barpro typically require only a few inputs for each rack, and a couple of outputs, HM Computing designed the I/O portion of the board to accommodate up to 24 I/O lines, to build in flexibility for Barpro to integrate extra features in the future. Boards are then supplied populated with the I/O levels that Barpro need for each individual application.

A number of other useful features were added to simplify systems building: LED status indicators were fitted on each I/O line to speed commissioning and maintenance, and the module was fitted with a rectifier to allow it to operate from 24VAC (as well as DeviceNet-specified 24VDC) - the same power source that is used for the motor contactors and mobile control circuits.

PLC HOST

The distributed I/O modules link into an Omron PLC fitted with a standard DeviceNet scanner module. The number of I/O modules on each network varies from typically 4 or 5, to 30 plus, depending on the size of the warehouse project.

The CAN network was preferred by Barpro primarily for its excellent noise immunity - a feature which derives from an original design goal of the bus which was reliable operation in the extremely harsh environment of the automobile. The field bus uses a non-return-to-zero bit coding method. This minimises electro-magnetic emissions - and has an excellent Hamming distance of 6 -- a leading figure for fieldbuses. One of the prime benefits for Barpro is the ability to run motor cabling alongside the control network, a major space- and time-saving feature.

WHAT IS DEVICENET?

DeviceNet is an open communications link based on CAN technology to connect industrial devices (such as limit switches, photoelectric sensors, valve manifolds, motor starter, process sensors, panel displays, operator interfaces, etc.) to a network and eliminate expensive wiring. It also reduces the cost and time to wire and install industrial automation devices while providing reliable interchangeability of components from multiple vendors. The direct connectivity provides improved communication between devices as well as important device-level diagnostics not easily accessible or available through hardwired I/O interfaces. This technology is used extensively in the USA and is rapidly gaining popularity in Europe.

DeviceNet is based on the ISO standard for automotive networking known as Controller Area Networking (CAN), which is now used in many industries. Key features include:

- Low cost (based on low cost CAN chip).
- High speed. It supports three baud rates: 125, 250 and 500kbps which meets 95% of all industrial requirements.
- Reliable. It uses the well proven CAN protocol incorporated with the application layers that has undergone strict conformance testing to ensure the reliability.
- Support up to 64 active nodes. In theory, the node can be expended by using bridge system (such as CAN/CAN bridge or other gateway).
- Easy installation. Virtually 'Plug-and-Play'.

DeviceNet has defined the maximum cable lengths (trunk and drop cables) to ensure the latency of the message being sent. The upper boundaries of the trunk cable and drop cable length are shown in Table 1 and 2.

PRODUCER/CONSUMER MODEL

DeviceNet utilises a producer/consumer model of communications. With a traditional serial communication protocol such as TCP/IP, the communication mechanism is always source/destination. In this case, whenever a node wants to communicate with the other, it puts down the destination's address in the address field. This is to ensure that only the destination will receive the message. This method is efficient because it reduces the number of interrupts that the destination addresses need to serve. It also contributes to privacy. However it becomes a tedious and unnecessary waste of time when dealing with real-time con-

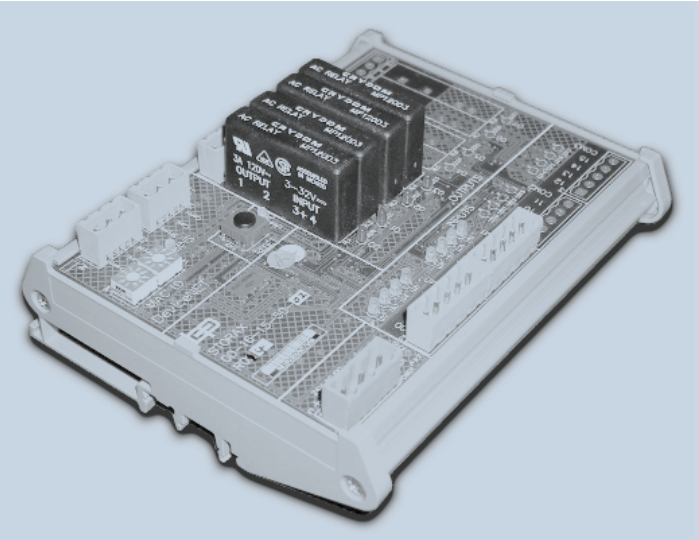

Figure 1. This computer-controlled mobile pallet racking system maximises the amount of usable space inside a warehouse.

trol, where multiple destination addresses need to be updated at the same time. The producer/consumer model is capable of handling this.

With this model, a node which transmits a message does not specify which node each message is destined for, but 'from which node the message is produced'. Receivers 'think' (have been configured) that the message is useful or meaningful to them can pick up the message and consume it.

OPEN STANDARD

HM Computing is a member of ODVA (Open DeviceNet Vendors Association) and DeviceNet UK. The ODVA is an independent supplier organisation which manages the DeviceNet specification and supports the world-wide growth of DeviceNet. ODVA works with vendors and provides assistance through developer tools, developer training, compliance testing and marketing activities. It has an international membership of more than 130 companies. ODVA publishes the DeviceNet product catalogue and supports vendor Special Interest Groups (SIGs) in developing Device Profiles for specific classes of products. DeviceNet UK has a relationship with Warwick Manufacturing Group (University of Warwick, UK) which offers a CAN laboratory for demonstrations and conformance testing. Another laboratory has been established at ASTEM RI (Advanced SofTwarE and Mechatronics Research Institute) of Kyoto, Japan. The American test lab is located at the University of Michigan.

THE NEED FOR TESTING

As the penetration of DeviceNet increases, questions concerning interoperability arise, particularly on the need for performing full interoperability testing in addition to conformance testing. In this environment, independent test facilities are growing in importance and are essential for progress of the standard. They were an essential requirement for this custom design application, because of foreseeable requirements for further expansion and upgrade, and because of an anticipated long life cycle for this product.

As DeviceNet covers a broad range of device profiles, devices that conform to the DeviceNet specification are not necessarily interoperable with each other. This is where Interoperability Testing comes in.

There are regions that are not covered (and will not be able to be covered) by the DeviceNet Conformance Test engine. While the Conformance Test engine focuses solely on the Application Layer, Interoperability Testing covers both Application Layer as well as DataLink and Physical Layers by exercising the device on a fully functional DeviceNet-connected board, in a worst case scenario. A good example is the bit-timing parameter of a CAN chip. A wrongly-configured sampling point that does not meet DeviceNet Specification may still be accepted by the Conformance Test engine. But it will most probably fail Interoperability Testing. Another example is that, when you implement your vendor specific object class/object/instance, you want to make sure that the other party is also configured to consume your message correctly.

More information from www.hmcomp.demon.co.uk ■

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