EMBEDDED
SYSTEMS
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PEAK AND ESACADEMY
CANOpen
PRODUCT GUIDE

PEAK
System

This CANOpen product guide was written to help CANOpen integrators and developers with limited CANOpen experience to get a better understanding of the CANOpen functions and their usage in tools and products.
If you do not yet have a firm knowledge about CANOpen we recommend that you read this guide from start to finish. For further reading we recommend our book: »Embedded Networking with CAN and CANOpen«.

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[1|NETWORKS]

THE INCREASING POPULARITY OF EMBEDDED NETWORKING

Market research conducted by Embedded Systems Programming Magazine showed that today more than 50% of all embedded applications developed use multiple microcontrollers. These microcontrollers typically have some communication channels between them, referred to as "Embedded Networks".

Engineers face many options when selecting an Embedded Network. In the past, self-developed serial busses based on something like I2C or RS-485 were commonly used. Such proprietary solutions have several drawbacks. They are harder to maintain and expand when the system grows, new personnel have to be trained for the in-house standard and there are no third parties to provide off-the-shelf development tools or modules.

For CANOpen, a variety of tools and products are available, starting with source code libraries over single-chip solutions and plug-in modules up to plug-and-play sensors and actuators. This allows engineers developing an application to focus on the area of their expertise and use off-the-shelf products for standard I/Os, encoders, drives, etc.

CANOPEN AND OTHER NETWORKS

In comparison to other embedded networking technologies and field busses, CANOpen has several benefits. First, the standards are open in multiple ways. They are openly available via download from the CAN in Automation User's Group web pages for royalty-free implementation. Secondly, they are modular and engineers may cherry-pick and select the communication features needed in their application and to an extend they are open for certain enhancements in order to fine-tune application specific requirements.

We would like to point out that CANOpen is not locked to a specific physical layer. Although CANOpen was originally designed to work on CAN – Controller Area Network – there are CANOpen dialects today running on regular serial networks such as RS-485 as well as a high-end version using real-time capable Ethernet communication.

All the openness comes at a price: For newcomers it can be hard to make the selection of their tools and products without existing in-depth experience with CANOpen.

[2|TECHNOLOGY]

CANOPEN BASICS AND TERMINOLOGY

THIS SECTION SUMMARIZES SOME OF THE MAIN
FEATURES AND TERMS USED IN CANOPEN.

In CANOpen, a network segment consists of a limited number of nodes, typically referred to as CANOpen Slaves. Although not required for all applications, some networks may also use an NMT (Network Management) Master and several managers, such as a Configuration Manager which monitors and ensures the proper configuration of the CANOpen slaves.

In regards to the messages communicated in CANOpen, all messages have a message identifier and are broadcast to all nodes. Determined by their configuration, nodes know which messages with their identifiers they are consuming and ignore all others.

THE OBJECT DICTIONARY

Each node has all communicated data structured into an Object Dictionary which is a kind of look-up table containing all configuration and process data. The Object Dictionary (OD) is organized using a 16-bit Index and an 8-bit Subindex, so a parameter in the OD can be identified by something like [1000h,00h] – here the Index is 1000h and the Subindex is 0. For various devices and applications the CANOpen standards define which OD entries are used for which purpose. For example, all CANOpen devices store their Serial Number at [1018h,04h].

The figure [below] shows the mandatory Object Dictionary entries that all CANOpen nodes must have.

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INDEX	SUBINDEX	TYPE	DESCRIPTION
1000h	0	UNSIGNED32	Device Type Information
1001h	0	UNSIGNED8	Error Register
1018h			Identity Object
	0	UNSIGNED8	= 4 (Number of sub-index entries)
	1	UNSIGNED32	Vendor ID
	2	UNSIGNED32	Product Code
	3	UNSIGNED32	Revision Number
	4	UNSIGNED32	Serial Number

MESSAGE TYPES

There are two major message types used to communicate data, the PDOs (Process Data Objects) and the SDOs (Service Data Objects). The SDOs are used for a point to point connection and typically are only initiated by the master/manager. With SDOs the master/manager can make a read or write access to any single Object Dictionary entry of any connected node.

The PDOs are highly configurable and are used for optimized process data transfer by allowing multiple Object Dictionary entries of one node to be stored in one CAN message. PDOs have communication parameters and mapping parameters.

The PDO Communication Parameters configure the CAN message identifier used for a PDO and the message triggering option. Changing the message identifier of a PDO is referred to as PDO linking. There a various triggering options for TPDOs (Transmit PDOs) which will be discussed in more detail below.

The PDO Mapping Parameters configure the data contents of a PDO - which Object Dictionary entries of a node are stored in the data field of a PDO.
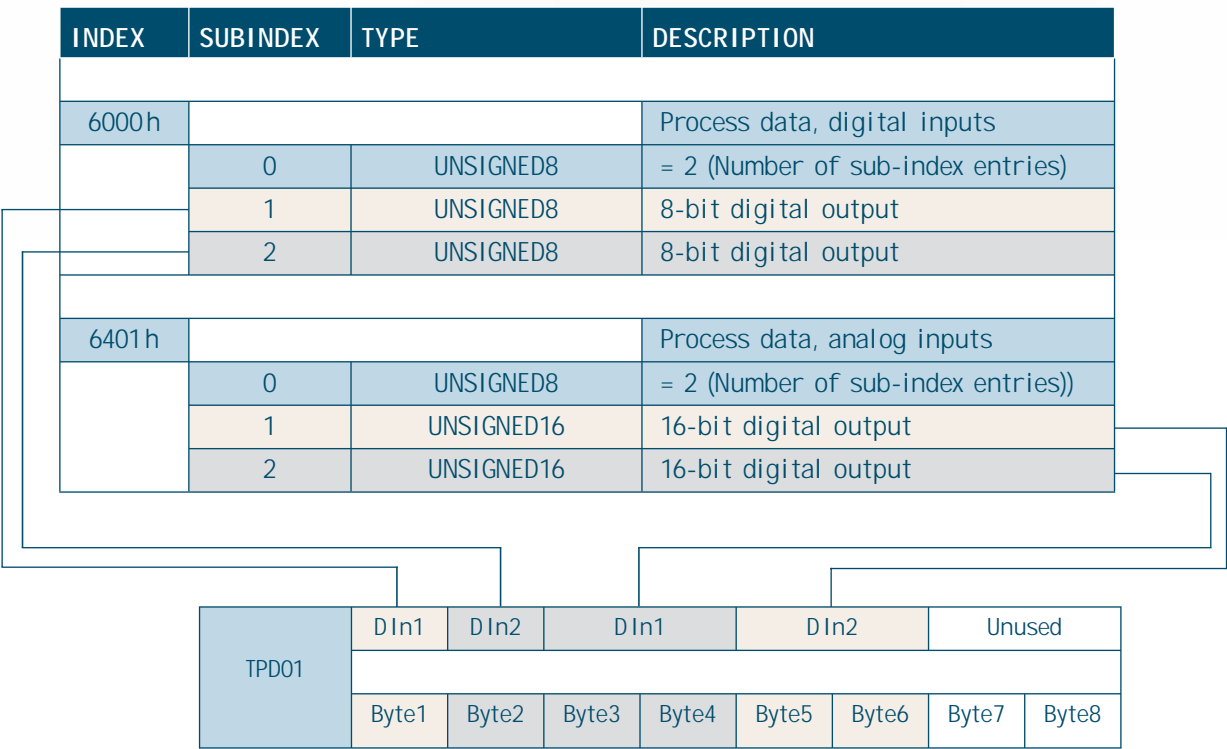
The figure below shows an example of PDO mapping. Here multiple Object Dictionary entries are mappen into TPDO1.

THE EDS – ELECTRONIC DATA SHEET AND DCF – DEVICE CONFIGURATION FILE

In CANOpen, the Object Dictionary layout of nodes are described in the so-called EDS files, the Electronic Data Sheets. EDS files are ASCII files with a specific format describing all the Object Dictionary entries supported by a CANOpen device. Not only is every supported OD entry associated with a symbolic name, the EDS also contains information like data types, data direction and other options.

Manufacturers of CANOpen conformant devices deliver their products with an EDS. Engineers developing their own CANOpen conformant devices need to create the EDS file(s) for their product(s). Although one could edit EDS files with an ASCII editor it is not very feasible to do so, as the format is very strict and hard to maintain when making manual changes.

Device Configuration Files - DCFs - are EDS files that include actual values for Object Dictionary entries in a particular device. They are the storage format of choice to save and restore the configuration of nodes in the network.

INDEX	SUBINDEX	TYPE	DESCRIPTION
6000h			Process data, digital inputs
	0	UNSIGNED8	= 2 (Number of sub-index entries)
	1	UNSIGNED8	8-bit digital output
	2	UNSIGNED8	8-bit digital output
6401h			Process data, analog inputs
	0	UNSIGNED8	= 2 (Number of sub-index entries))
	1	UNSIGNED16	16-bit digital output
	2	UNSIGNED16	16-bit digital output

TPDO1	DIn1	DIn2	DIn1	DIn2	Unused
	Byte1	Byte2	Byte3	Byte4	Byte5	Byte6	Byte7	Byte8

[3 | SOFTWARE]

MONITORING CANOPEN NETWORKS WITH PCANOPEN MAGIC

The PCANOpen Magic software utility is a basic network configuration tool and monitor. The software works with any PEAK CAN interface and can be used to access a live CANopen network. All OD entries of a node are accessible by directly specifying the index and subindex.

All communication is captured into a trace buffer and displayed along with the appropriate CANopen interpretation.

From within the network overview window PCANOpen Magic can start an active scan cycle to detect all live CANOpen nodes attached to the network. The Network Overview windows shows basic information about each node in a table, including device type information, manufacturer and product ID:

TYPICAL USAGE

PCANOpen Magic is suitable for quick tests with minimal, pre-configured CANOpen nodes and networks. Here, pre-configured means that all PDO parameters are hard-coded into the nodes – after power-up the nodes know what their parameters are and they just start operating using them.

As each configuration access requires the entry of the hexadecimal Index and Subindex it is not suitable for making lengthy PDO configurations that require changing dozens of OD entries in the right sequence

EDS EDITOR CANOPEN ARCHITECT EDS

CANOpen Architect EDS is an EDS/DCF editor to greatly simplify the task of maintaining EDS and DCF files. All file content is visualized based on symbolic information. Pull down menus, checkmarks and other standard selection elements are used to simplify the configuration of Object Dictionary entries. An intelligent copy/paste implementation supports the user by eliminating unneccessary repetitive tasks and speeding up the editing process.

TYPICAL USAGE

With CANOpen Architect EDS developers can generate and maintain the EDS and DCF files for their CANOpen devices.
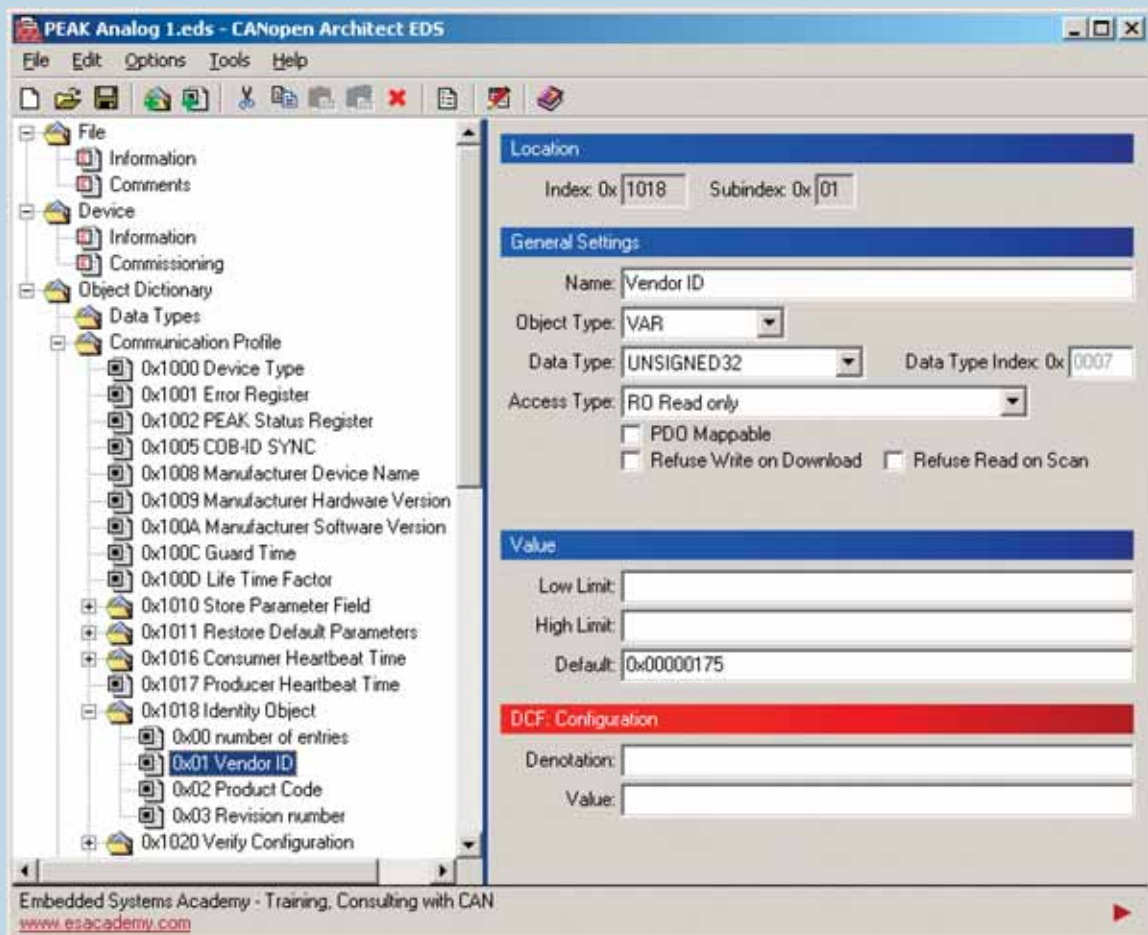
# CONFIGURING AND ANALYZING CANOPEN NETWORKS WITH PCANOPEN MAGIC PRO

The PCANOpen Magic Pro software is a network configuration tool and analyzer. The software works with any PEAK CAN interface and can access a live CANOpen network. All OD entries of a node are accessible by directly specifying the index and subindex.

All communication is captured into a trace buffer and displayed along with a high resolution timestamp and the appropriate CANOpen interpretation.

To simplify the configuration of PDOs, PCANOpen Magic Pro features a dedicated PDO Configuration Window. For the selected node, this window displays all PDO configuration and mapping parameters at a glance. If a node supports dynamic PDO parameters (PDO parameters configurable, read-write) then changes may directly be made in the PDO configuration window and are immediately communicated to the node.

PCANOpen Magic Pro also supports using EDS files. An EDS file can be associated with a node on the network in the network list and once the association is made all OD entries can be addressed not only by their Index and Subindex but also by their symbol name.
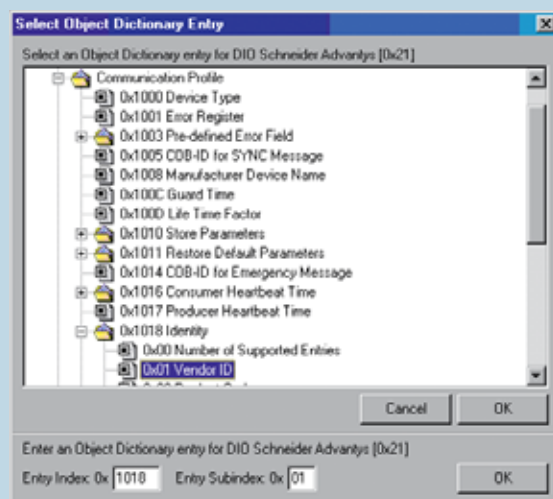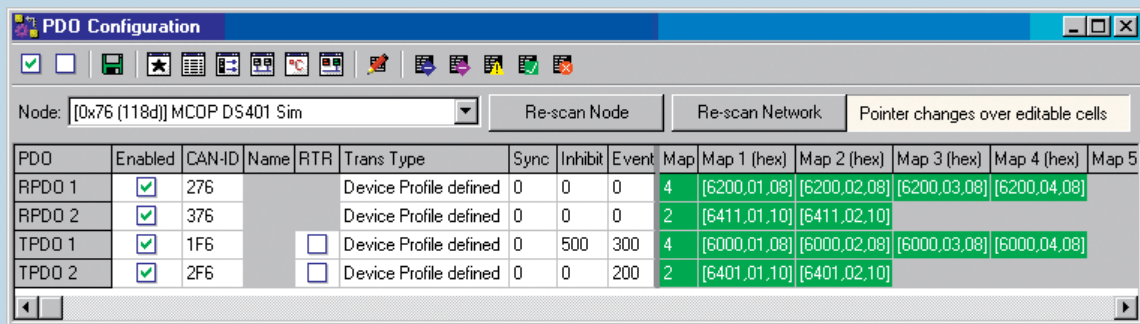
Once a node has been configured, its configuration may be stored into a DCF (Device Configuration File). For that, PCANOpen Magic Pro scans/reads all variable OD entries and stores their current contents into a DCF. Optionally the configuration of all nodes in a network can be read in one go allowing to store a network's entire configuration into a single NCF (Network Configuration File). The file format is compatible with the CANOpen PC Development Kit which is described in the next section.

The saved configurations can also be restored to the nodes, ensuring that the nodes are initialized with a known configuration.

TYPICAL USAGE

System integrators as well as developers can use PCANOpen Magic Pro to configure and analyze CANOpen networks. PCANOpen Magic Pro is especially useful for networks with nodes that use configurable PDO parameters.

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ACCESSING A CANOPEN NETWORK FROM A PC USING THE CANOPEN PC DEVELOPER'S KIT

The CANOpen PC Developer's Kit primarily consists of a Microsoft Windows DLL providing the major functions of PCANOpen Magic Pro to a customized application. Like the other software products with access to live CANOpen networks, this product supports all PEAK CAN interfaces.

Besides standard functions like reading or writing individual OD entries the DLL functions provided also include a complete network scan function as well as a function to restore DCFs or NCFs as generated by PCANOpen Magic Pro.

PDO communications are performed using the generic CAN transmit and receive functions.

TYPICAL USAGE

The two primary usages for the CANOpen PC Developer's Kit are extended testing and/or automated configuration of CANOpen networks.

If a device needs extended tests to be conducted on it, the DLL can be used to trigger programmed sequences with OD accesses. An application example for such an extended test would be the testing typically conducted at the end of the manufacturing line of a CANOpen device.

As there is no additional royalty or license fee charged for using the DLL in multiple systems it can also be used in minimal CANOpen masters/managers. If an application uses a minimal master/manager based on a Microsoft Windows operating system, then this DLL can be used to quickly verify if all required nodes are present and ensure a certain configuration.

In combination with PCANOpen Magic Pro and the NCF a network's configuration can easily be duplicated to multiple networks – one file contains all the configuration.

DEVELOPMENT SYSTEM CANOPEN MAGIC PRODS

The high-end version PCANOpen Magic ProDS has all the features of PCANOpen Magic Pro plus a simulation module and CANOpen source code. The system is delivered with several simulation models of different CANOpen devices. Without needing additional hardware, a network can quickly be expanded by adding a number of simulated nodes to the system. From the network side a simulated node looks as "real" as the physical nodes as it will respond to all CANOpen messages just like the real node would. On the PC side the I/Os are visualized in the simulation windows, allowing the user to change input data manually.
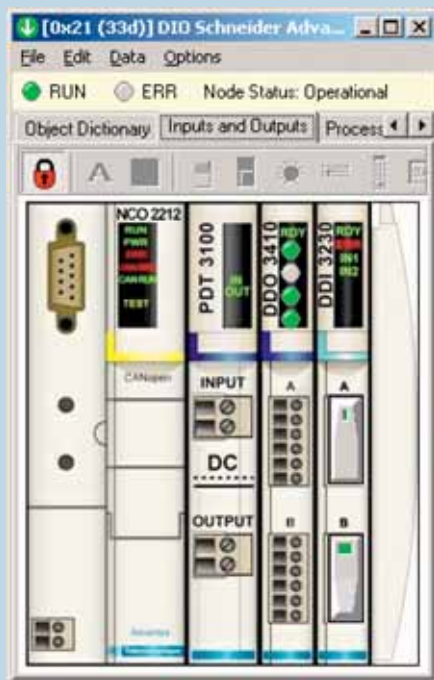
One of the available simulated nodes is a data stimulation node that produces test data. It provides several options for continuous automated signal changes including counters and waveforms.
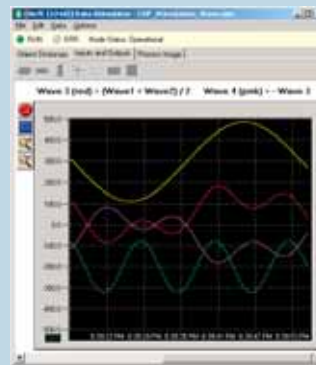
The source code included with the development system is MicroCANOpen Plus, an expanded version of the popular MicroCANOpen (www.MicroCANOpen. com). The source code comes with an interface to the simulation module so that the code developed can be compiled on the PC (for example using Borland C) and integrated into the simulation. This simulation interface can also be used by other popular CANOpen source codes such as CMX-CANOpen.

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TYPICAL USAGE
The typical usage for this product is development and/or extensive testing of CANOpen nodes. With the help of the simulation module one can quickly verify how a node under test interacts with other CANOpen nodes. Using the data stimulation node, configurable test patterns can be produced and sent to selected nodes.
The MicroCANOpen Plus source code included is suitable for many CANOpen slaves. While the PDO mapping parameters cannot be changed during operation and are hard coded, the PDO communication parameters are fully configurable during operation.

THE CANOPEN APPLICATION DEVELOPMENT CYCLE

Using PCANOpen Magic ProDS, the development of an embedded CANOpen application with the MicroCANOpen or MicroCANOpen Plus source codes can be started using the PC. The CANOpen side of the application can entirely be implemented and tested using the free Borland C compiler and the simulation module in PCANOpen Magic ProDS.

With the customizable I/O windows that include sliders and buttons, even the I/O handling can be simulated and tested to a certain extend.
After the CANOpen side of the application is fully implemented and tested, one makes the transition to the embedded target system by replacing the simulation driver in the code with the driver for the used target architecture.

FULL-FEATURED CANOPEN SOURCE CODES
The consultants of ESAcademy have experience with various commercial CANOpen source codes available including customized implementations for specialized applications. Contact us and let us know the device or application profile you need implemented and on which microcontroller architecture. We can help you make the best choice for your application.

# CANOPEN PERFORMANCE AND COMPATIBILITY TESTING WITH PCANOPEN INSPECTOR

There is an official CANOpen Conformance Test suite maintained by the CAN in Automation User's Group. Although it already does some extensive testing it does not measure performance limits. Unfortunately, some manufacturers of CANOpen devices do not clearly state the performance limits that a device has in regards to response times or minimal event times. In CANOpen, many event times can be configured down to 1ms. However, only very few high-end devices will truly operate with settings of 1ms. For example, one node might poll another every 2ms. If the polled node needs more than 2ms to respond messages will most likely get lost and a response is not generated for every poll.

The PCANOpen Inspector is a combination of hardware and software products implementing various performance tests including the performance test recommended by the CAN in Automation User's Group.

TYPICAL USAGE

Using PCANOpen Inspector one can determine the performance limits of a CANOpen node in order to find out what kind of timeouts or delays can be expected in various operating modes.

At the end of a test cycle a test report is generated showing the maximum responses and delay times measured resulting in an overall compatibility and performance score. Which timings are measured and displayed in the report is shown by the figure "Device Summary"
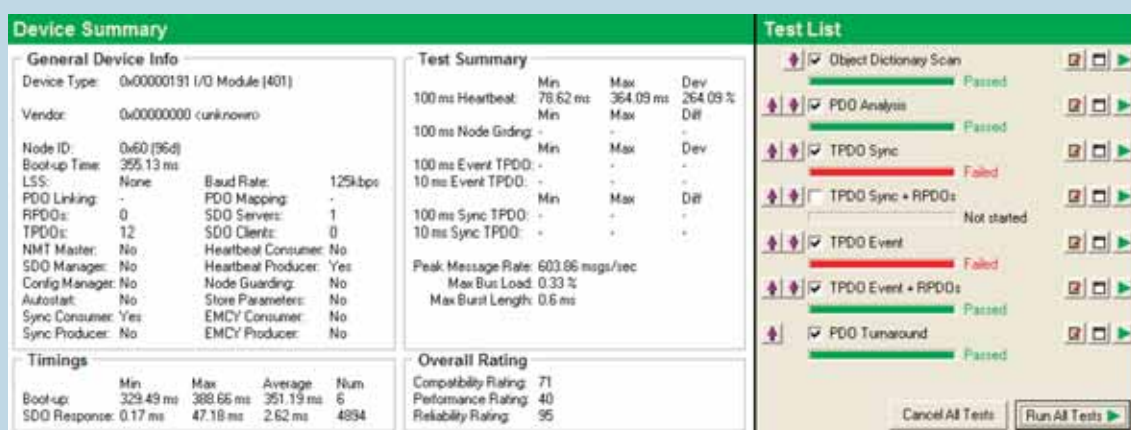
[4 | HARDWARE]

OFF-THE-SHELF CANOPEN MODULES

DIGITAL AND ANALOG I/O WITH PEAK MICROMOD CANOPENIA – INSTANT ACCESS TO CANOPEN

The PEAK MicroMod CANOpenIA modules are generic CANOpen I/O modules for digital and analog inputs and outputs. The modules are fully CANOpen compliant, all PDOs are configurable and their configuration can be stored in non-volatile memory.

The following table shows the available module combinations with their number of inputs and outputs.

DEVICE	NR ID	NR DO	NR AI	NR AO
Digital 1	8	4	0	1
Digital 2	8	4	0	1
Analog 1	8 shared AI	0	8	4
Mix 1	6	0	4	2
Mix 2	2	1	5	2

TYPICAL USAGE

The PEAK MicroMod CANOpenIA modules are used to easily integrate digital and analog I/O channels into a CANOpen network.

PCANOPEN PROTECTOR – DUAL-CHANNEL CANOPEN MANAGER

The Protector is a stand-alone CANOpen Manager with 2 CAN ports that can handle up to 125 CANOpen nodes which may be connected on either of the two ports. The smart bridge functionality ensures that only messages required in both network segments are forwarded from one segment to the other – each segment is protected from local communication in the other segment thereby increasing the overall available bandwidth.

Although the Protector can be configured and controlled with any configuration tool, the configuration is simplified when using the PCANOpen Magic Pro line of products.

A built-in long term diagnostic handler constantly monitors both network segments and remembers the highest bus load ever measured as well as the longest back-to-back message burst ever detected.

TYPICAL USAGE

The PCANOpen Protector adds another layer of security to CANOpen applications. Once the Protector is configured it ensures that the CANOpen network only starts and keeps operating as long as all mandatory nodes are present. If failures or critical situations are recognized by the diagnostics handler, the Protector can react by shutting down the network or simply make an entry into the diagnostics log.

Applications using a main controller without or with very limited CANOpen Master and Manager functionality can offload the task to manage the

CANOpen network entirely to the Protector and focus on data processing. At this level it is even possible to use a main controller with almost no CANOpen knowledge – it just needs to know a few commands and responses to talk to the Protector and the PDOs that it processes.

Applications requiring more flexibility in the physical network layout can use the Protector with its 2 CAN ports and its built-n smart bridge. The networks on both ports may operate at different bit rates allowing for a far more flexible physical layout in terms to maximum speed and distance required.

PCANOPEN 8–TO–1 GATEWAY

The PCANOpen 8to1 Gateway is a small module with 2 CAN ports. Up to 8 CANOpen nodes connected to "downlink" of the gateway are represented as a single node to the "uplink". On the "uplink" side the device presents itself as a CANOpen device with up to 8 virtual nodes implemented. These virtual nodes are a direct representation of the physical nodes connected to the "downlink" side of the gateway.

TYPICAL USAGE

The PCANOpen 8to1 Gateway allows increasing the maximum number of nodes connected to a CANOpen network from 127 to a theoretical maximum of more than 1000 nodes.

SUMMARY OF PEAK CAN INTERFACES

SPECIFICATIONS
• Baud rate settings up to 1 MBit/s
• PHILIPS SJA1000 CAN controller,16 MHz
  clock frequency
• 82C251 CAN transceiver
• Compliant with CAN specifications 2.0A (11-bit ID)
  and 2.0B (29-bit ID)
• SJA1000 hardware can be reset via software
• Device Drivers for Windows© 2000/XP/Vista
  and LINUX©
• CAN Monitor PCAN-View for Windows ©
• Interface DLL for Windows© for own Applications

ISO Versions only:
• Electrical isolation to 500 V

LIST OF PC CAN INTERFACES
Available as:
• PCI Version
• USB Version
• PC/104 Version
• PCMCIA Version
• ISA Version
• Parallel Port Version
More Info at: www.peak-system.com
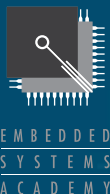
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