Proof your CANopen products – conformance and interoperability

Holger Zeltwanger
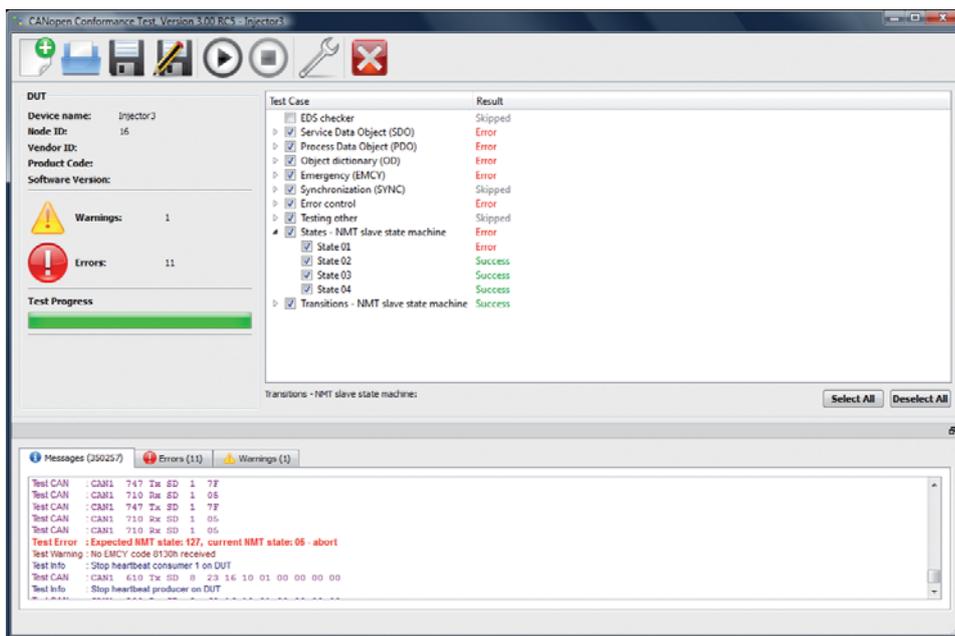

Figure 1: Current CANopen Conformance Test (CCT) tool

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Definitions
◆ Compatibility:
Capability to exist or perform in harmonious, agreeable, or congenial combination with others.

◆ Conformance:
Compliance in actions, behavior, etc., with certain accepted standards or specifications.

◆ Compliancy:
A disposition or tendency to yield to the will of others.

◆ Interoperability:
The ability of systems or units to provide services to and accept services from other systems or units, in order to operate effectively together.

◆ Interchangeability:
The ability to be replaced by another entity without additional configuration effort.

Links
www.can-cia.org
www.ixxat.com
www.kuebler.com
www.maxonmotor.com
www.microcontrol.net
www.ni.com
www.port.de
www.posital.com
www.schneider-electric.com
www.vector.com

The bell rings. The apprentice opens the door of the CiA office. The postman hands-over a package, which Oskar Kaplun, one of CiA's engineers performing the conformance tests, already expects. He opens the package. It contains the CANopen device to be tested, and the related Electronic Data Sheet (EDS) and the handbook, of course. He switches on the PC, which runs the CANopen Conformance Testing (CCT) software. The engineer working with CiA since three years powers the device, sets the CAN bit-rates of the tool and the devices to 250 kbit/s, and connects the bus-lines. This is the maximum bit-rate, which this device-under-test (DUT) supports.

> *In my 10 years experience, about 50 per cent of the devices submitted for CANopen conformance testing pass the tests without serious problems, the others require a review of the software and a second test session or more.*
>
> *Thilo Schumann*

After reading-in the EDS, he checks its conformity by means of the free-of-charge EDS checker maintained by Vector Informatik (Germany). After some minor corrections of the EDS, he links it to the test tool and starts the test procedure. Before he has set the node-ID to a random value. The conformance test runs more or less automatically. He goes back to his desk continuing editing CANopen profile specifications and answering technical question by email.

Conformance testing is like spell and grammar checking in Word. The CCT software tool generates test pattern, sends them via the bus to the DUT, and evaluates the responded CAN frames with expected test results as specified

Testing

Conformance test limits

The CANopen conformance test plan covers just the CiA 301 functionality. Additional tests for CiA 302 functions need to be specified. Test plans for the CANopen profiles have been partly developed, but they have not been implemented in the current CANopen Conformance Test (CCT) tool. This will be done by plug-ins on request of CiA's Special Interest Groups. However, such profile tests require an upper tester, which is device-dependent. This upper tester needs communication to existing lower tester, which is the CCT software tool running on a Windows PC.

Interoperability test limits

The current CANopen interoperability test stand in the CiA office is based on a mid-range PLC. It is intended to use also other host controllers with NMT master functionality. Most of the currently performed test procedures derive from Schneider Electric's internal test experiences gained in its own test center in the last couple of years. CANopen devices implementing an application profile could not be tested in this system. For them plug-fests or demonstrators only integrating devices compliant to the same application profile are the right choice to test interoperability.
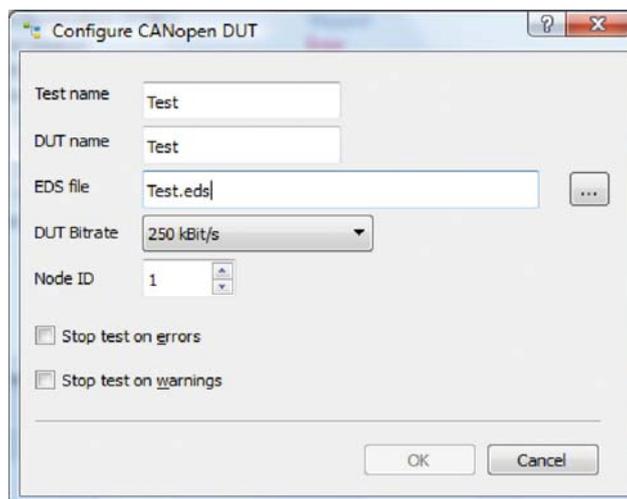

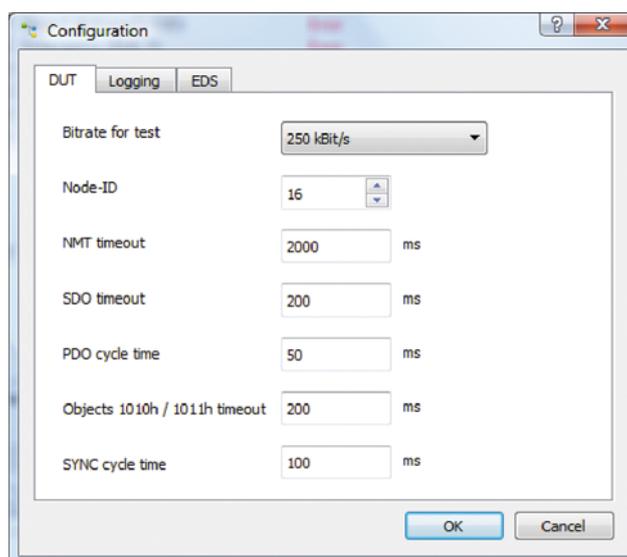*Figure 2: Test start window of the current CCT tool*

Figure 3: Configuration of communication parameters with the current CCT tool

in the CANopen conformance test plan specification. The test pattern depends on the CANopen functionality of the DUT as described in its EDS. This means, the DUT is tested against its own description. If the received responses are not conformant to the CiA 301 test specification, the CCT software generates a failure report or in some cases just a warning.

From time to time, Oskar Kaplun or another CiA engineer goes into the test room to look on the test progress. This device is a good one, passing most of the test successfully. Just a few warnings and one

failure happened. With the test report he goes to Thilo Schumann responsible for CANopen conformance testing services in order to discuss the test result. The failure is not a failure: It is

> " *For interoperability testing we organize plug-fests, we provide a 'golden' CANopen system, and we build demonstrators for dedicated CANopen application profiles.* "
>
> *Reiner Zitzmann*

caused by a known error in the test tool. The warnings are also no failures: They are just hints for the device designer that the tested unit could not be used for all applications. Normally, this should be mentioned in the

handbook as application limits.

Conformance testing is like spell and grammar checking. This means, even if the device has passed the conformance testing successfully, this doesn't guarantee interoperability with other CANopen devices. Of course, CANopen conformance tested devices have a higher probability to be interoperable compared with such that have not passed the test. However, like in human communication, you can respect grammar rules and spelling, but your discussion partner misinterprets or misunderstands you. In particular, the conversation between males and females is sometimes behaving like this. On the other hand, if two dialog partners violate the grammar rule in the same manner, they will understand each other. They are interoperable. If in CANopen you violate the rule of the length of an SDO (service data object) message (it has to be 8 byte), and the involved CANopen devices accept that, they are interoperable but not conformant to CiA 301.

CiA members (ESD, Micro Control, Port, and Sandvik) have developed jointly the new CANopen Conformance Test software. It overcomes some problems of the predecessor, which has been pre-developed by National Instruments (NI) end of the last century. A couple of years ago, NI has handed-over it to CiA office for further maintenance and further development. The new CANopen Comformance Test software uses the same low-level software interface to the CAN hardware – the COTI interface. Several vendors of PC/CAN interfaces support this interface (you find a list of tested ▷
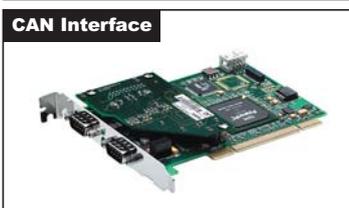
Figure 4: Lower profile test principle

Inside figure:

CANopen specifications (1)

Electronic data-sheet (2)

Lower profile test (LPT)

Upper profile test (UPT)

I/O lines

Device under test (DUT)

Test request

CAN messages

Test response

(1) As COBD (CANopen object dictionary database) defined in CiA 306-2
(2) In *ASCII* (CiA 306-1) or *XML* (CiA 311) format
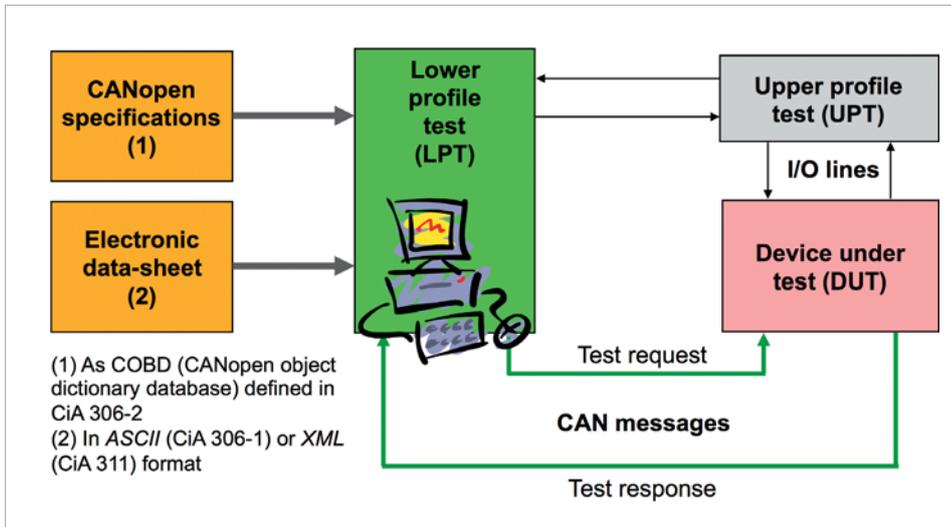
products on CiA's website). It is intended that CiA members get the CCT software tool on request free-of-charge. Non-members may buy it from CiA. The conformance testing of devices by CiA is still a service to be paid. Of course, device designers may test the devices by themselves, which is so-to-say a self-certification. However, testing what you have developed by your own is like checking the text you have written yourself. You will not detect all your spelling and grammar errors – you will read over some of them. The same may happen when you test your device by yourself. This is why an increasing number of companies submit their CANopen devices for independent conformance certification to CiA. It is not that expensive (for details see CiA's website).

As mentioned above, conformance testing doesn't guarantee interoperability to other devices. If one device produces EMCY (emergency) messages and the other can't consume them, they are not interoperable. In order to examine interoperability, CiA offers since some years the so-called plug-fests. There, CiA members connect their CANopen products and prove if they can communicate. This includes the testing of physical transmission limits, exchanging SDOs and Heartbeats as well as interpreting the exchanged PDOs (process data objects). The CANopen SIGs (Special ▷

The 'golden' CANopen network

At the CiA booth on SPS/IPC/Drives 2012 exhibition in Nuremberg (Germany), the interoperability test system will be shown. In contrast to the CANopen conformance test, the aim of the interoperability test is to assure that the CANopen device is capable of interacting with a variety of other CANopen devices (made by different manufacturers), all integrated and communicating with one another in one network. The test stand was built up with CANopen devices provided by CiA member companies such as Fritz Kübler, Ixxat Automation, Maxon Precision Motors, Micro Control, Port as well as Posital, Schneider Electric Automation and Vector Informatik.

The heart of the test stand is the mid-range Modicon M340 programmable logic controller by Schneider Electric. Further CANopen devices are I/O modules, encoders, drives, temperature sensors, and so on. The network is dimensioned to run all recommended CANopen bit-rates (1000, 800, 500, 250, 125, 50, and 20 kbit/s).

The device under test (DUT) is connected with a stub cable to the network and is afterwards integrated to the PLC's network setup by an engineer of CiA. The configuration as such, depends on a variety of possible test sequences that can be chosen. The test sequences include stress tests affecting the physical layer as well as a variety of other tests that aim on checking if the DUT's CANopen functionality behaves properly.

When it comes to tests affecting the physical layer, CiA engineers trigger various emulations of line failures, short circuits as well as interruptions to check how the DUT responds. However, the main focus of the interoperability test lies on checking if the implemented CANopen functions work properly during interaction with other devices on the network. CiA staff worked out a series of test sequences including basic tests, checking the heartbeat functionality, up to advanced device tests in which node-ID or the bit-rate are changed with the usage of the LSS (layer setting services). One of the important basic test issues lies in the testing of the RPDOs (receive process data objects) and/or TPDOs (transmit process data objects) behavior. CiA's engineers take a thorough look on the range of possibilities that can be used when working with RPDOs and/or TPDOs, for example, how the possible TPDO scheduling modes work. This does not only mean configuring a TPDO with the PLC and checking, if an event or the event-timer causes the PDO transmission. Also, cyclic or acyclic transmission is checked as well as the SYNC counter (if implemented).

To make the variety of test sequences practically relevant, most of the tests are fulfilled with different busloads. Different scenarios are distinguished in case usage of different busloads – a low, an average and a high busload. With the resulting information, device manufacturers are able to get a statement at what busload their devices are still able to communicate correctly.

The service of interoperability testing aims to really see, where the problems are when devices are integrated in networks in the field. Often it is not enough to be compliant to the CiA 301 specification.

Mark Buchert

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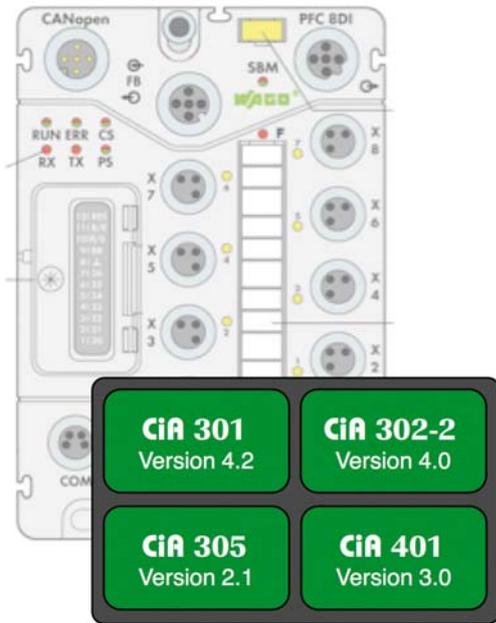
Figure 5: Example CiA-profile compliance label, which could be printed on the product

Interest Groups) Lift control systems and Sub-sea instruments do that regularly. The SIG Lift has also initiated the production of demonstrators. These are real CANopen Lift control systems based on Ci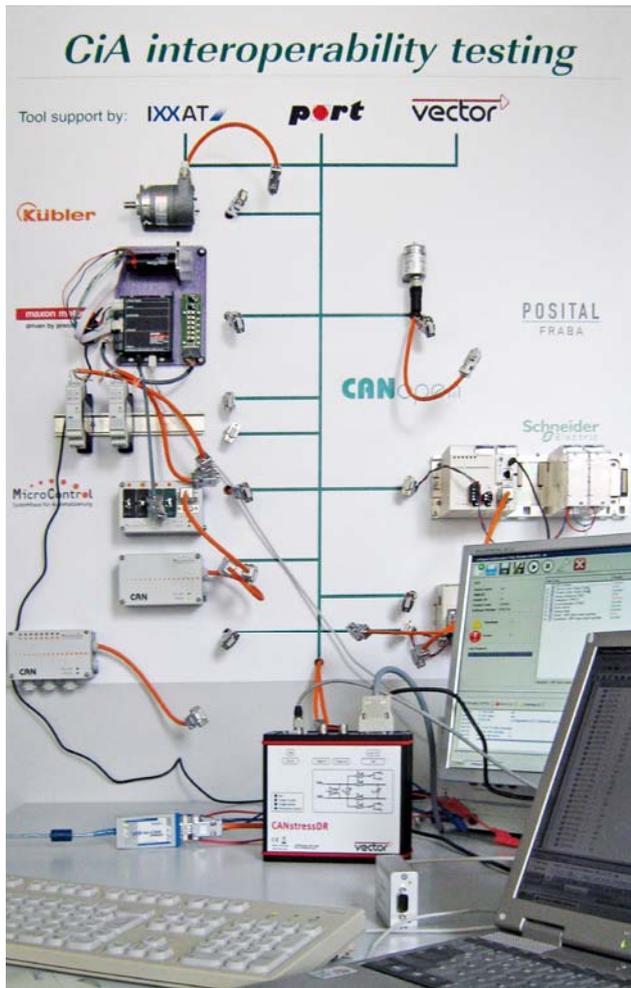A 417 compliant devices. Today there are three CANopen Lift systems realized, which are shown on fairs and conferences. Already in 2008, CiA members have exhibited a CleANopen (CiA 422) demonstrator comprising devices for refuse collecting vehicles from different manufacturers.

Since summer of this year, CiA has also setup a 'golden' CANopen network. It comprises a PLC with NMT master functionality and several CANopen NMT slave devices. This CANopen system is used to prove the interoperability of any submitted device. You may send your device to CiA. Oskar Kaplun or Reiner Zitzmann will integrate this device into the system and perform functional as well as stress tests.

In order to support CANopen system designers, it would be helpful, when CANopen device manufacturers would provide a compliance statement. That is that you reference the version of the CiA specifications, which have been implemented. For example: CiA 301 version 4.2, CiA 302-2 version 4.0, CiA 305 version 1.0, CiA 406 version 2.0, and so on. It would also be nice to have a standardized CANopen compliance label, which could be printed on the product, if space is available.

If you like to substitute a CANopen device by another CANopen device from a different manufacturer, it may happen that there is no product with the same functionality available on the market. Of course, in some cases it is possible to configure the other device to integrate it into your system or you can adjust your application software. This is because most of the CiA specifications provide many optional functions. To make it easier for system designers, CiA started to reduce the possible number of variants by means of specifying several device classes for each profile. The profiles supporting such classes include CiA 425-2 (contrast media injectors) and CiA 851 (truck-mounted cranes). Also CiA 402 (electrical drives and motion controllers) specifies implicitly some device classes.

Oskar Kaplun finishes the paperwork for the performed CANopen conformance test. He prints the test results, adds his test report including hints how to improve the device, and provides all necessary information for CiA's book keeping department in order to write the invoice. The apprentice packs the tested device and the necessary custom declaration, and calls the transport agency. The next device for CANopen conformance testing may arrive. Maybe it is yours. ◄

Figure 6: CiA's interoperability testing system