Testing and Validation of a CAN Protocol Network Nodes

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Abstract: CAN stands for Controller Area Network. It is communication protocol which is mainly used in digital network of automotive cars, Industrial, Medical and Scientific systems for routing sensor data between equipment. The main advantages are its accuracy, low noise, high reliability, low cost, simple wiring, ease of use and less maintenance requirements.

To meet the stringent requirements for accuracy, reliability, low noise interference and simple wiring with long service life, there is an increasing demand for efficient testing and validation test methods for CAN networks, this paper test set up mainly cover the CAN physical transmission layer by connecting CAN nodes directly. To test the prototype UWASA node for conformance to the CANopen CiA DS301 (CAN in Automation Draft Specification 301) and to develop the testing software for the performance test according to an internal CANopen Device Specification which describe the automatic test software for testing and validating that against the CiA DS401 standard.

Keywords: CAN, CANopen protocol, Node Test, validation etc

I. INTRODUCTION

This paper presents a hardware and software set up for validation and testing of CANopen protocol which is type Control Area Network (CAN) communication protocol and interfacing it with UWASA node. The UWASA Node is a modular and stackable wireless sensor node developed for wireless automation (Yigitler, 2010), (Virrankoski, 2012).While planning any testing and validating a project for protocol, it is critical to develop a test protocol. Understanding the study objectives and methods will help to ensure a successful testing project and mitigate risk. The protocol should convey a clear understanding of why and how the testing will be completed, what the necessary materials are and most importantly, how the data will be presented and analysed for the tests. This CAN protocol testing set up with UWASA node serves as the main communication tool for capturing expectations, acceptance criteria, regulatory requirements and applicable standards, and walks us through the steps to create a plan for the project. It's almost like a map. Also this software documents test information accordingly for repeatability in the future, and for keeping the team on the same page with revision control.

II. CANOPEN CONFORMATION TEST

The CANopen Conformance Test (CCT) used to check hardware of CANopen devices is compliant to the CiA DS301 CANopen specification. This specification uses both analog and digital module interfacing.
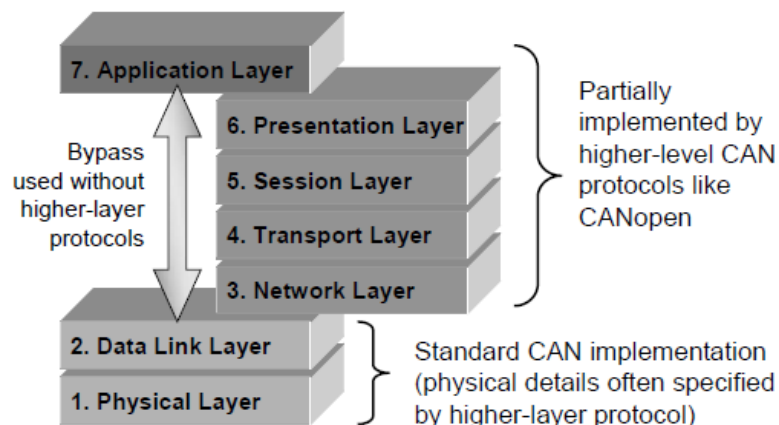

Fig 1 Network layers in CAN protocol

There is official CANopen conformance test software that can be used to test the UWASA Node against the latest CiA DS301 standard. The test tool is made by CAN in Automation. This software testing mainly used for application layer only but can also be used for other layer application. Figure 1 show the OSI model layers defined for CAN protocols this paper deal only with physical layer. Developing a CANopen testing hardware and detecting potential communication errors before they occurs in the synchronous analysis of both physical and logical can layers. Developers need bit-accurate insights into signal variations in the physical layers which is analyse for testing.

III. HARDWARE AND SOFTWARE SET-UP

The performance test hardware & software environment should be set-up. The CAN interface used in this test is called Kvaser Black Bird Semi Pro, which is a CAN-LAN converter which has two CAN nodes depending on the application. In the performance test two channels of Kvaser Black Bird Semi Pro and the UWASA Node are connected to the CAN-bus. Network The CANtrace3.9 is used to monitor the CAN-bus traffic during the test. Figure 1 shows the hardware connection of the performance test set-up.

The performance test software language is written in C++. It is a windows 64 console application. The software was developed using Microsoft. Since the Kvaser Black Bird Semi Pro is used in the testing and validation, some functions of the Kvaser CANlib Application Programming Interface (API) are implemented before developing the test cases. The Kvaser driver class is already built to interface Kvaser CANlib API and there is a ready-to-use test framework, which asserts if two values are equal or non-equal and asserts if one value is true or false. Therefore our main job has been to develop the test cases in the form to True or False.
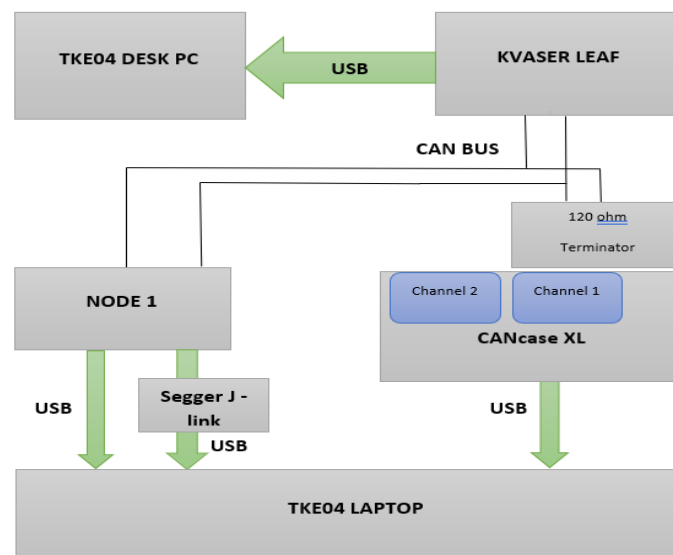

Fig. 2 Block diagram of performance test set up

According to the Wärtsilä CANopen Device Specification and the CiA 313 CANopen Performance Testing, the following items should be tested.

IV. PERFORMANCE TEST

When we used the CANopen standard there are no specific performance criteria. However, it specifies how to measure and evaluate the performance criteria and test it. In most applications, CANopen products should meet their manufacturers' specific performance criteria. In this thesis, the performance of the UWASA Node was tested against the Wärtsilä CANopen Device Specification (WCDS, an internal document). The performance test software with generic test cases is made during this project. To introduce the performance test software and how to use it to test the UWASA Node as an example the performance test hardware environment should be set-up. The CAN interface used in this test is called Kvaser Black Bird Semi Pro, which is a CAN-WLAN converter that can have one, two or three CAN channels depending on the application. Here we used only two channels. The CANopen conformance test can be started after building the testing environment. The CCT software consists of the EDS test and the device test. Before the test starts, some parameters need to be set. The UWASA Node used the following parameters:

- Node ID: 1
- Baud rate: 500 kbps
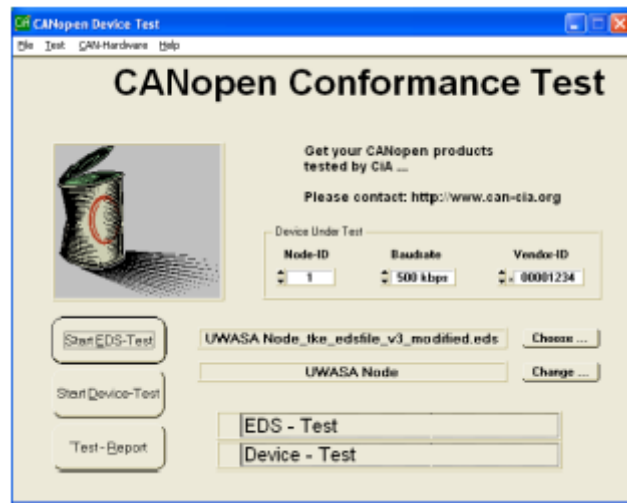- Vendor ID: 1234 (a temporary vendor ID, only used at current stage)

Fig. 3 CANopen Conformance Test Tool Interface.

In the performance test two channels of Kvaser Black Bird Semi Pro and the UWASA Node are connected to the CAN-bus. The CANtrace3.9 is used to monitor the CAN-bus traffic during the test. Figure2 shows the hardware connection of the performance test set-up. The flow chart of test used to test the time (Figure 4) between two consecutive messages is shown. The test steps that are listed below have been designed in order to test the UWASA Node and to study performance test result.
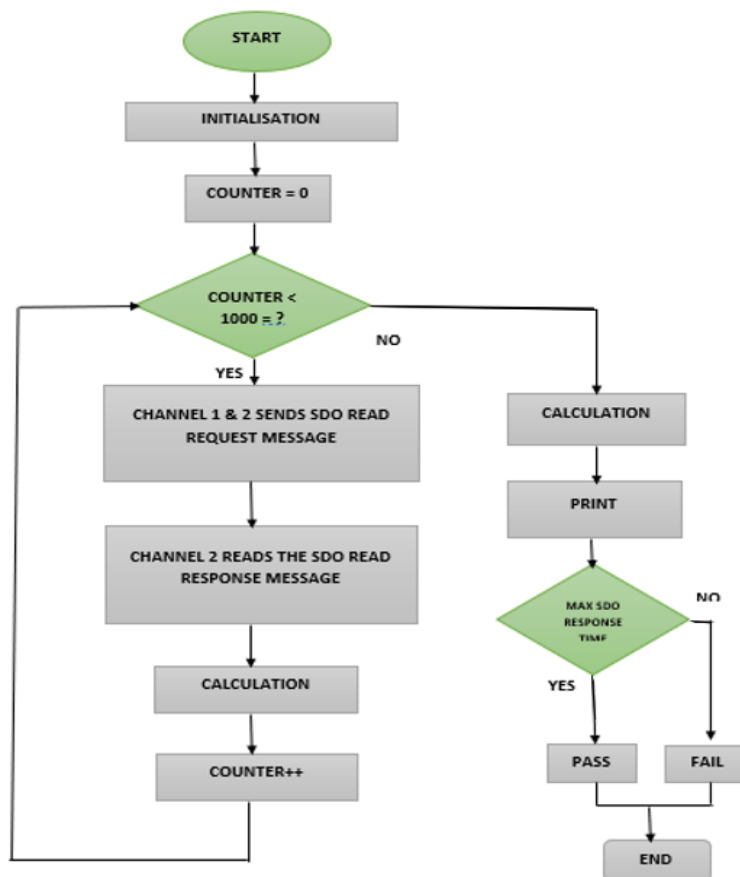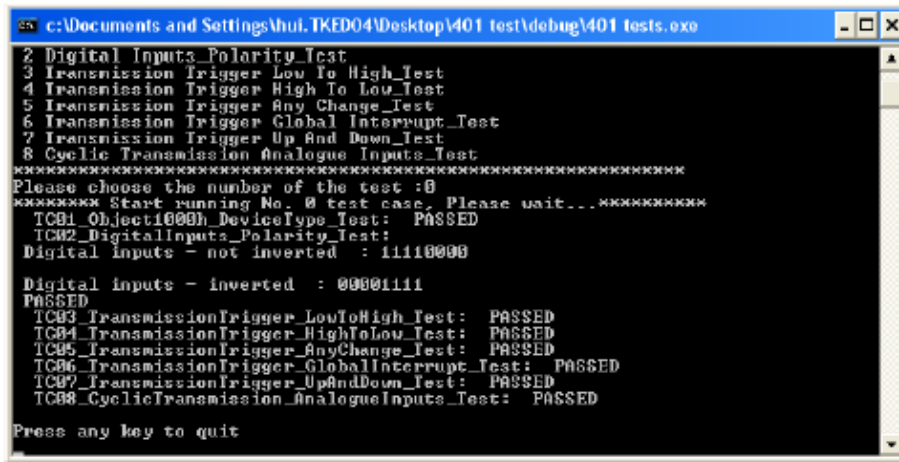

Fig. 4 Actual flow chart of Conformation test.

V. PERFORMANCE TEST RESULT

The After running this performance test software and hardware, the items in section CAN open message are tested and the test result with some relevant values (e.g. the corresponding average, Maximum and minimum times) are printed on the screen.

Then the next step is to integrate the test results to the test report for the UWASA Node.

Fig. 4 CAN in Automation DS401 Performance test result

Below is an example of the performance test result in the test report
Heartbeat Producer Deviation - 100ms
No traffic average: 55 ms
No traffic maximum: 100 ms
No traffic minimum: 1 ms
Criteria: Derivation: no more than 5%, in this case, the time should be between 95 ms and 105 ms
Result: Failed

As the text above shows, the UWASA Node has failed this test, since it has a minimum heartbeat time of 1 ms, which is much lower than 95 ms. Later on the designer will correct the source code of the UWASA Node based on this test report. The UWASA Node has passed the SDO Read/Write Response Time Test, the PDO Cycle Time Test and the Boot-up Time Test. But it fails the PDO RTR Response Time Test and the LSS Response Time Test due to the fact that it does not support the PDO RTR and the LSS functionalities. The PDO RTR and the LSS functionalities are recommended by TK Engineering Oy, thus the software designer needs to implement these two features in the UWASA Node.

Object 1000h Device Type Test. The default PDO mapping, digital inputs and analogue inputs were supported in the UWASA Node. Thus the value from bit-16 to bit-23 in object 0x1000 Device Type should be set to the corresponding value (0x5) according to the CiA DS401 standard.

Digital Inputs Polarity Test
The UWASA Node supports the polarity of the digital inputs. The corresponding bits of the digital inputs should be inverted when the polarity for the corresponding bits are enabled (Figure 8). For instance, if the digital inputs of the UWASA Node are 0xF0 and the polarity register is 0x00 (The polarity for all the 8-bits digital inputs are disabled), then the digital inputs should be 0xF0, not-inverted. If the polarity for all the 8-bits digital inputs is enabled (i.e. write 0xFF to the polarity register: object 0x6002 sub index 0x01), then the digital inputs should be 0x0F.

Transmission Trigger: Low to High Test
The UWASA Node only transmits the TPDO when the digital input changes from 0 to 1, if the corresponding bits in object 0x6007 Interrupt Mask Low To High 8 Bit are enabled and the global interrupt register (0x6005) is enabled.
In order to simulate the change of the digital inputs, a specific way of making the test was created. This needs the interaction of the designer of the source code of the UWASA Node. The idea is to create the factory test registers to work as an intermediate digital inputs/analogue inputs register.

VI. CONCLUSION

The hardware and software set up of the UWASA Node is working on the corrections based on the test reports' true or false and validates it. The automatic performance test software and the automatic CiA DS401 test software can be used in the future to test other CANopen devices with little modification of the test cases. It's also suitable for various CAN protocols.This project is only focused on of the physical layer testing, but can also be used in data link layer testing, robust testing and communication testing. This test software and hardware has scope of optimization in the future, as needed.

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