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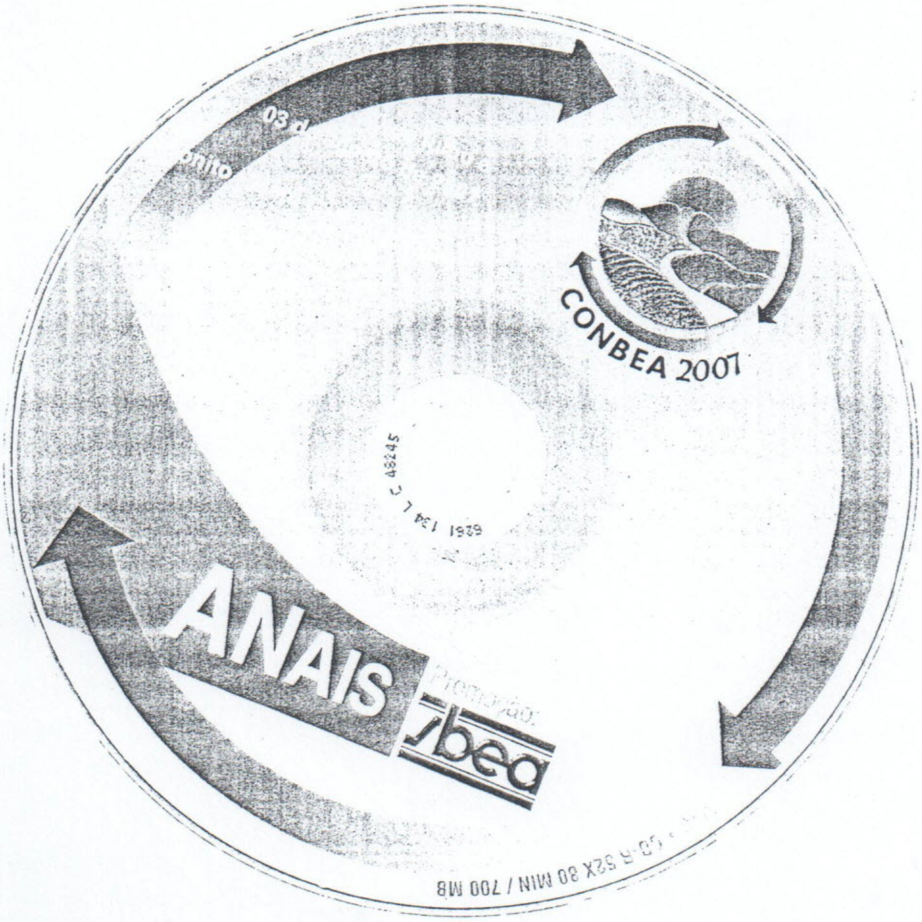
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DEVELOPMENT OF AN ANALYSIS AND TEST TOOL OF ISO 11783 NETWORKS FOR AGRICULTURAL MACHINERY

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ABSTRACT: The ISO 11783 (also called ISOBUS) standard communication link is a common tendency to integrate different devices on agricultural machinery through an embedded control network. The ISOBUS uses the Controller Area Network (CAN) as a data link protocol to perform the data communication and provides significant opportunities to improve the service process for agricultural equipment. The development of tools to diagnostic errors, test ECUs (electronic control units) and monitor the network traffic represents one of the main challenges related to the use of ISO 11783 networks. This fact has motivated the development of these kinds of tools. This work presents the development of a support tool to analyze the network messages and test the operation of the ECUs for ISO 11783 networks in agricultural machinery. The analysis tool was built using the LabVIEW of the National Instruments and consists in a serial RS232 interface to an ECU designed for the communication with the ECUS over the ISOBUS network. An experiment with an ISOBUS network was done to demonstrate and verify the application of the analysis tool developed. A commercial tool - CANoe.ISO11783 of Vector- was used in this experiment doing the same operation of the developed tool and the data messages logged through the network bus for both tools was compared.
KEYWORDS: ISOBUS, Serial RS232 Interface, network analysis

INTRODUCTION: The amount of information needed by farmers is increasing quickly in the agricultural business. Tractors and implements are becoming more complex, relying on large quantities of electronic data to work properly. The number of electronic devices in agricultural machinery is increasing (STONE et al., 1999) and demanding development in communication networks (AUERNHAMMER & SPECKMAN, 2006). A technology that has strong potential to be apply on these devices interconnection is the CAN protocol. The use of CAN in the agricultural area is confirmed in SUVINEN & SAARILAHTI (2006). The implementation of the ISO11783 standard represents the standardization of the CAN protocol and constitutes the main target of development as described in BENNEWEISS (2005). OKSANEN et al. (2005) describe the implementation of the ISOBUS and compatible components as virtual terminal (VT), tractor ECU and task controller. The ISOBUS provides a standard communication interface between tractors and farming implements. One of the challenges related to the project of ISO 11783 networks is the development of support tools to diagnostic errors, test ECUs and monitor the network (JENSEN, 2004). Academic works (HOFSTEE & GOENSE, 1999; GODOY, 2007) and private companies motivated by this fact have developed specific tools to perform these tasks. Following this guideline, this work presents and evaluates a simple analysis tool with the functionalities of monitor, log and analyze the CAN messages and test the ECUs connected to an ISOBUS network. The tool is based in a serial RS232 data exchange between the software developed and the hardware of an ECU responsible to the data acquisition of the network. An experiment with an simulated ISOBUS network, a commercial tool CANoe.ISO11783 (VECTOR, 2007) and the analysis tool developed was done to verify and check the use of the tool.

MATERIAL AND METHODS: The requirements for the development of the analysis tool were divided as review of ISO 11783, development of the ECU and design of the ECU to RS232 interface.

Review of the ISO 11783

The ISO 11783 standard is based on CAN protocol, which has been used for a long time in the agricultural industry. ISO 11783 is composed of 14 different parts that are based on the OSI (Open System Interconnect model). The physical and data link layers are based on CAN 2.0b protocol (Stone et al., 1999). CAN 2.0b specify the length of message identifier to 29 bits and the length of message data to 64 bit. The data bus speed is 250 kbit/s and the maximum total length of the bus is 40 m, whereby the ECU distance minimum is 0,1 m. The number of ECU on a bus segment is limited to 30. The wiring used is a 4-conductor, unshielded, and twisted cable for the CAN network. Information is encoded in the CAN identifier (source address, target address and data contents), whereby two Protocol Data Units (PDU) are differentiated: PDU1 and PDU2 as shown in Figure 1. PDU1 format allows for peer-to-peer communication, and the PDU2 format for broadcast communication.

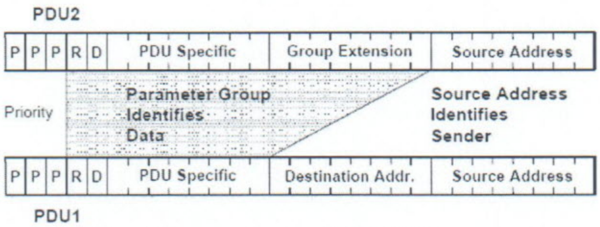
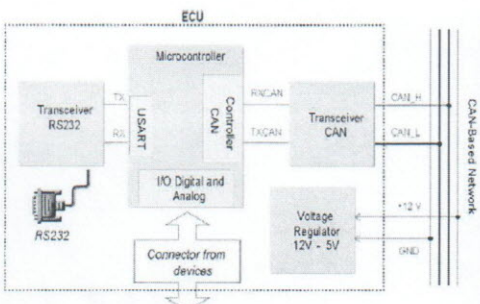


FIGURE 1. Message format and identifier structure of ISOBUS

The signals to be transmitted are combined into Parameter Groups, and each group is assigned a unique Parameter Group Number (PGN). The Parameter Group definitions include the transmit frequency, priority and physical units of all signals. Five message types are supported: command, request, broadcast/response, acknowledgement and group function. These message types are recognized by PGN and their information within data field. Network Management controls the assignment of addresses during boot-up of the ECUs. These addresses are assigned aided by Address Claim Mechanism. Address conflicts between ECUs are resolved by using unique device NAME, which at the same time describes each ECU functionality. This allows all other nodes to recognize the functionality available in the network.

Development of the ECU for the Tool

The ECU is the hardware responsible for the control and data acquisition of the devices, for the CAN communication between the ECUs and for the serial RS232 data exchange between the ECU and the computer that has the tool software. Figure 2 presents the schematic diagram of a standard ECU with CAN communications capabilities and illustrates the final ECU developed for the tool.



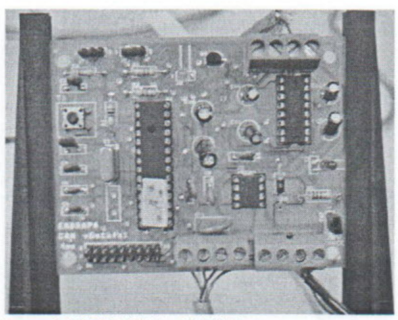


FIGURE 2. Schematic diagram and the final ECU developed (SOUSA, 2002)

Figure 2 shows that the ECU has three main components: the microcontroller, the CAN and the RS232 transceiver. The microcontroller utilized was the PIC18F258. This chip provides the logic operations for the CAN protocol communication and to implement the programs for data acquisition of the devices connected to the I/O ports, such as sensors and actuators. A MCP2551 transceiver was incorporated into the ECU to provide switching between the digital TTL logic of the microcontroller and the differential output required on the CAN bus. In addition, a MAX232 transceiver provides switching between the TTL logic and the output required by the serial RS232 port.

ECU to Serial R232 Interface

RS232 is the most known serial port used in transmitting the data in communication and interface. There are two basic types of serial communications, synchronous and asynchronous. The RS232 uses the asynchronous and does not require sending and receiving idle characters. An ECU to RS232 interface was designed to interchange the ISOBUS message information with a task computer. The interface was designed by configuring a specialized high-speed serial communication in the microcontroller of the ECU. This ECU had a single objective: to receive all messages from the CAN bus at a baud rate of 250 kbits/sec and retransmit the messages via an RS232 link to the computer that has the analysis tool software. The CAN messages were retransmitted via RS232 through a protocol created that transforms the ISO 11783 message in a string of data as shown in Figure 3.

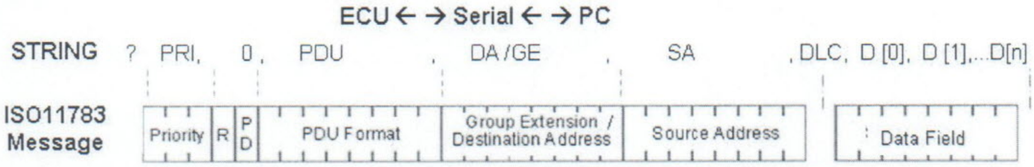


FIGURE 3. Protocol for the serial communication between the ECU and the tool (GODOY, 2007)

Finally, the software of the analysis tool was built using the LabVIEW (NI, 2006). This software is responsible to receive the messages transmitted by the ECU and identify the type of message received.

RESULTS AND DISCUSSION: An experiment was done to check the results of the analysis tool. In this experiment, the communication tests were done with the baud rate of 57600 BPS for the RS232 and the ISOBUS network assembled as shown in Figure 4.

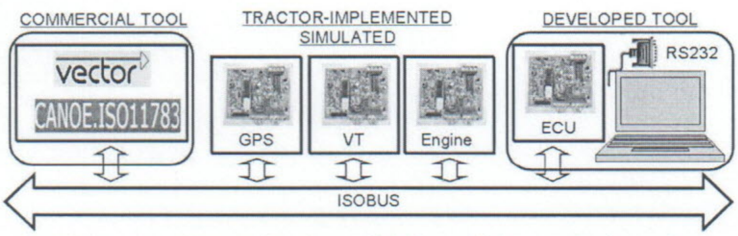


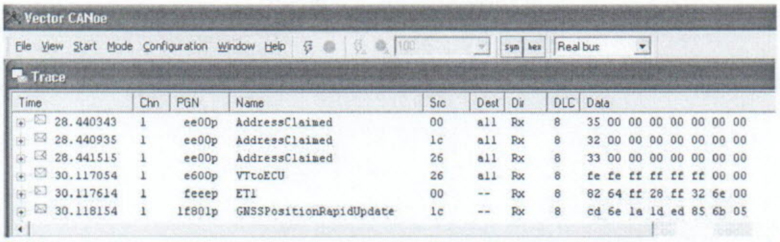
FIGURE 4. Schematic of the experiment for the validation of the analysis tool

The ISOBUS network assembled for the experiment simulates the operation of a tractor bus with a GPS, a virtual terminal and an engine ECU. Each ECU, after its initialization, sends a specific periodic message over the network as shown in Table 1.

TABLE 1. Description of the Messages

ECU	SA	PGN	PGN Name
all	-	EE00	Address Claimed
GPS	1C	1F801	GNSS Position Rapid Update
Virtual Terminal	26	E600	VT to ECU
Engine	00	FEEE	ET1

A commercial tool (CANoe.ISO11783) was used in the check process. This tool allows simulation and analysis of CAN networks such as ISO11783. CANoe was configured to do the same tasks (analyze and log messages) of the developed tool. Figures 5 and 6 shows the results of the experiment.

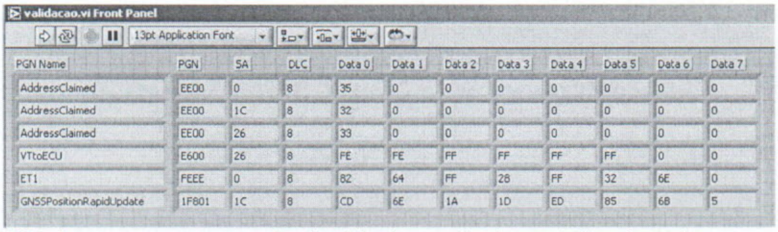


Vector CANoe

Trace

Time	Chn	PGN	Name	Src	Dest	Dir	DLC	Data
28.440343	1	ee00p	AddressClaimed	00	all	Rx	8	35 00 00 00 00 00 00 00
28.440935	1	ee00p	AddressClaimed	1c	all	Rx	8	32 00 00 00 00 00 00 00
28.441515	1	ee00p	AddressClaimed	26	all	Rx	8	33 00 00 00 00 00 00 00
30.117054	1	e600p	VTtoECU	26	all	Rx	8	fe fe ff ff ff ff 00 00
30.117614	1	feeep	ET1	00	--	Rx	8	82 64 ff 28 ff 32 6e 00
30.118154	1	1f801p	GNSSPositionRapidUpdate	1c	--	Rx	8	cd 6e 1a 1d ed 85 6b 05

FIGURE 5. ISOBUS data messages acquired with the CANoe.ISO11783 commercial tool



validacao.vi Front Panel

PGN Name	PGN	SA	DLC	Data 0	Data 1	Data 2	Data 3	Data 4	Data 5	Data 6	Data 7
AddressClaimed	EE00	0	8	35	0	0	0	0	0	0	0
AddressClaimed	EE00	1C	8	32	0	0	0	0	0	0	0
AddressClaimed	EE00	26	8	33	0	0	0	0	0	0	0
VTtoECU	E600	26	8	FE	FE	FF	FF	FF	FF	0	0
ET1	FEEE	0	8	82	64	FF	28	FF	32	6E	0
GNSSPositionRapidUpdate	1F801	1C	8	CD	6E	1A	1D	ED	85	6B	5

FIGURE 6. ISOBUS data messages acquired with the analysis tool developed

The results in Figures 5 and 6 presents the messages transmitted in the network in chronological order for both analysis tools. The comparison of these set of messages indicates that the analysis tool developed presents the same results that commercial tool used in the experiment.

CONCLUSIONS: Network analysis is a hard-working process, but is essential to verify the CAN bus behavior in different situations. The experiment demonstrated that the developed analysis tool can:

- ✓ facilitate the operation tests of the ECUs connected in the network;
- ✓ allow monitor the message traffic and analyze the message data of the ISOBUS;
- ✓ be used as a support tool in the development of ISOBUS networks in agricultural machinery.

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