(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
7 December 2006 (07.12.2006)

PCT

(10) International Publication Number
WO 2006/129999 A1

(51) International Patent Classification:
H04B 3/46 (2006.01) *G01R 31/02* (2006.01)
H04M 3/30 (2006.01) *G01R 31/11* (2006.01)
G01R 31/08 (2006.01)

(21) International Application Number:
PCT/NL2005/000394

(22) International Filing Date: 31 May 2005 (31.05.2005)

(25) Filing Language: English

(26) Publication Language: English

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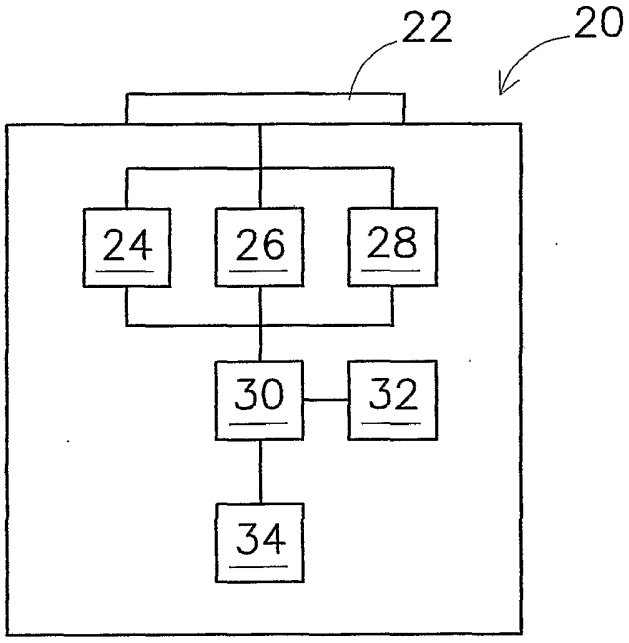
(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SM, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: NETWORK BUS DIAGNOSIS SYSTEM



(57) Abstract: A diagnosis method for diagnosing a data network of an automotive vehicle comprises a voltage measurement to determine a short circuit in the data network, a termination resistance measurement to determine termination failure, and a time domain reflectometry measurement to determine a location of an anomaly possibly present in the data network. A device for performing the above method comprises measurement systems for performing the above-mentioned measurements. The device may further comprise a processing unit and a memory for storing build information of the automotive vehicle being diagnosed such that the device may present clear information on the kind of failure and the location of the failure in the specific automotive vehicle.

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Title: Network bus diagnosis system

The present invention relates to a network diagnosis method and device for diagnosing a data network comprised in an automotive vehicle.

Nowadays, many automotive vehicles comprise data networks connecting a number of operative elements with each other. For example, the data network may connect one or more sensors, one or more control systems (electronic control unit, ECU) and one or more actuators with each other. The data network may comprise a number of communication lines providing the connections between the operative elements. Usually, the network further comprises a connector for enabling a connection with an external device, such as a diagnosis device. Such a diagnosis device may communicate via the data network with one or more of the operative elements. Thus, for example, if the vehicle malfunctions, an operator may analyse the state of an operative element and/or reprogram an ECU.

However, malfunctioning of an ECU or a failure in the wiring of the data network may result in an inability to make a connection to one or more operative elements. In such a case the operator needs to check each ECU independently and check the network wiring in order to repair the vehicle. Since a vehicle may comprise many ECU's per network, repair of such a failure may be time-consuming, thereby incurring high costs.

It is desirable to have a data network analysis method and device in order to facilitate easy, fast and thereby cheap diagnosis of the data network.

In an aspect, the present invention provides an analysis method for diagnosing an automotive vehicle data network, the data network operatively coupling at least two operative elements and comprising a number of communication lines, the method comprising: measuring a voltage of a communication line and comparing the measured voltage with a predetermined voltage level in order to determine whether the communication line is shorted; determining a termination resistance of a communication line, and comparing the determined termination resistance with a predetermined termination

resistance; and performing a time domain reflectometry, TDR, measurement for localizing an anomaly in the data network.

If no communication connection can be made to an operative element, a communication failure of the data network may be the cause. The communication failure may be due to a defect operative element, e.g. ECU, or due to a wiring failure, such as a wire break or a short circuit.

If a short circuit is present in the network, a voltage on the shorted communication line deviates from a predetermined voltage level. Therefore, measuring the voltage of the communication line may be an indicator for a short circuit. The measurement does not provide information on where the short circuit is localized. If no short circuit is present, the measured voltage is substantially equal to the predetermined voltage level.

If the predetermined voltage level is present on the communication lines, the termination resistor of the communication line may be defect resulting in the malfunctioning of the communication line. Likewise, if there is a break in the wiring of the network, a measurement of the termination resistance will result in an incorrect resistance value. Therefore, the termination resistance of the communication line may be measured, for example by providing a known current and measuring a resulting voltage of the communication line, in order to determine a wire break or a defect termination resistor.

To localize a suspected or unsuspected anomaly in the data network, a Time Domain Reflectometry (TDR) measurement may be performed. The TDR measurement provides information on a distance from a predetermined location to the anomaly location.

Combining the results of the above-described three measurements: voltage level, termination resistance and TDR, provides the operator with information on the kind and location of an anomaly. With this information he is enabled to determine how to proceed to repair the vehicle. In particular, if an operative element, e.g. an ECU, is defect, it may short circuit the communication line of the data network, thereby disabling communication with every operative element connected to the data network. Conventionally, in that case, the operator needs to check each operative element and the wiring in order to find the failure. With the method according to the present invention, the operator is enabled to determine that there is a short circuit using the voltage measurement and that the short circuit is

located in an ECU. Moreover, the operator is enabled to determine in which operative element the short circuit is present by comparing the measured distance with build information of the vehicle. Thus, with a simple sequence of meaurements, the operator only needs to check, and possibly replace, one ECU instead of possibly checking each ECU connected to the data network and the wiring of the network.

The method according to the present invention may be employed for a data network using any kind of network protocol. The method may as well be used *mutatis mutandis* for diagnosing an optical network. For example, the TDR measurement may be performed using light reflectometry; a light output level measurement may be performed instead of a voltage measurement and a light attenuation measurement may indicate the termination resistance.

In a further aspect, the present invention provides a device for performing the above method. The device comprises an input-output (I/O) connector for enabling a connection to a network connector of the data network. The device further comprises: a voltage measurement system configured to measure a voltage of a communication line; a resistance measurement system configured to determine a termination resistance of a communication line; and a signal generator and a signal receiver configured to perform a TDR measurement on a communication line.

In an embodiment of the device according to the present invention, the device comprises a memory storing build information of the automotive vehicle being diagnosed; a processing device for comparing the TDR measurement result with the build information and determining a failure location; and an output device for indicating said failure location. The memory stores information on the vehicle, in particular information on the wiring and operative elements of the data network of the vehicle. Comparing the result of the TDR measurement, i.e. a distance from a connection location to an anomaly in the network, may provide information on the location of the anomaly and in particular on which ECU is defect. The comparison may be performed by a processing device that accesses the memory and receives the TDR measurement result. The result of the comparison may be shown to the operator on an output device, such as a display.

The memory may store information of a number of vehicles. In an embodiment, the memory may be a reprogrammable or a replaceable memory in order to provide the device with build information specific to the vehicle being diagnosed.

Further advantages and features of the invention will become clear from a description of the appended drawings, showing non-limiting embodiments of the invention, in which:

Fig. 1 illustrates a data network of an automotive vehicle; and
Fig. 2 illustrates an embodiment of an analysis device according to the present invention.

Fig. 1 shows a schematic diagram of a data network 2 of an automotive vehicle. The network 2 comprises wiring 3 connecting a number of operative elements, such as an electronic control unit (ECU) 4, a sensor 6 and an actuator 8. For example, the sensor 6 provides data via the data network to the ECU 4 and in response to the data received from the sensor 6 the ECU 4 sends a control signal via the data network 3 to the actuator 8.

The data network 3 may be a bus network, such as a CAN network, using a number of communication lines. For correct operation of the network 3, the communication lines may be terminated by termination resistors 10. E.g. for diagnosing or setting up one or more of the operative elements, a connector 12 may be provided to enable a connection to an external device such as an analysis device. However, to diagnose an operative element, the communication over the network 3 needs to function correctly.

If no communication is possible with any of the operative elements 4, 6, 8 connected to the data network 3, the data network 3 malfunctions due to one or more of a number of possible failures. In general, the failure may be a short circuit or may be an open circuit. These failures may be due to a failure in the wiring or due to a failure in one or more of the operative elements. In any of these cases, since no communication is possible, an operator or repairperson needs to verify each element connected to the network and/or the wiring. Thereto, the operator needs to dismount a lot of parts of the vehicle to gain access to the elements and to verify them. Thereafter, each dismounted part needs to be mounted again. Thus, conventionally, a lot of work is incurred, when the network 3 does not function properly.

Fig. 2 schematically shows an analysis device 20 for analyzing a data network, such as shown in Fig. 1, in a case that the data network malfunctions and it is not possible to communicate with one or more of the operative elements connected to the data network. The

analysis device 20 is provided with a connector 22 for making a suitable connection to the data network and a number of systems 24 - 34 for performing the analysis and presenting the results thereof.

A voltage measurement system 24 is provided in order to determine a voltage present on a communication line of the network. A communication line should have a predetermined voltage level in order to function properly. If a short circuit is present, it is most likely that the voltage on the communication line, e.g. the voltage compared to ground, is different from the predetermined voltage level. Thus, a short circuit is expected, when a voltage other than a voltage substantially equal to the predetermined voltage level is measured.

A termination resistor may be verified by providing a current to two communication lines terminated by said termination resistor and measuring the resulting voltage at the ends of said communication lines. Thereto a current source 26 may be provided and the voltage measurement system 24 may be employed. However, a person skilled in the art readily understands that other resistance measurement methods and systems exist and may be employed.

It is noted that, if a break is present in the wiring, the termination resistance measurement is likely to show an incorrect resistance, while the termination resistor is not defective. Thus, if only a resistance measurement is performed, the operator or repairperson will dismount a number of parts, replace the termination resistor and mount the parts again to find that the problem may still exist.

To localize an anomaly, such as a short circuit or a wire break, a time domain reflectometry (TDR) measurement may be performed using a suitable TDR system 28 comprising a signal generator and a signal receiver. As known to a person skilled in the art, when performing a TDR measurement, a signal is generated and provided to a signal carrier, such as a communication line. An anomaly in the carrier results in a reflection of the signal. The reflected signal is received by the signal receiver. A comparison of the generated and the received signal, and a time period lapsed between the signal generation and the receipt of the reflected signal, provide information on the distance from the signal generator and receiver to the anomaly. The comparison may as well provide further information on the anomaly found.

Using the above-described three measurements it may be derived what kind of failure causes the network failure and where the failure is located. To locate the anomaly, build information of the vehicle diagnosed is needed in order to convert the distance found through the TDR measurement into a location in the vehicle. Moreover, if the anomaly is a failure in an operative element such as an ECU, it may be derived which operative element is causing the failure.

It is noted that if a defective ECU causes an open circuit, the network may still function properly, but there is no communication possible with said ECU. If the failure in the ECU is a short circuit, the whole data network may malfunction.

In the embodiment illustrated in Fig. 2 a processing unit 30 and a memory 32 are provided. The processing unit is configured to access the memory 32, to receive and process the TDR measurement result and to provide information to an output device 34 such as a display.

The memory 32 may comprise build information on the vehicle diagnosed. The memory may be a read-only memory, but may as well be a reprogrammable and/or a replaceable memory in order to provide build information of different vehicles or types of vehicles, if needed.

The processing unit 30 is thus enabled to convert the TDR measurement result into a location in the vehicle. Thus, after a simple and fast measurement, the operator receives clear information on the location of the failure and on the kind of failure. In particular, in the embodiment illustrated in Fig. 2, all measurement systems 24, 26 and 28 are connected to the processing unit 30. The processing unit 30 may control one or more measurement systems and receive all measurement results. For example, the processing unit 30 may control the current source when measuring the termination resistance. The processing unit 30 may then convert the data received from the measurement systems into clear and simple information for an operator. The information is provided to the output system 34 from which the operator readily understands what kind of failure is present, and where the failure is located. Thus, the operator or repairperson only needs to dismount the parts that limit access to the malfunctioning operative element or wire, thereby reducing the time needed for repair and the costs incurred.

Claims

1. Analysis method for diagnosing an automotive vehicle data network, the data network operatively coupling at least two operative elements and comprising a number of communication lines, the method comprising:

- measuring a voltage of a communication line and comparing the measured voltage with a predetermined voltage level in order to determine whether the communication line is shorted;
- determining a termination resistance of a communication line, and comparing the determined termination resistance with a predetermined termination resistance; and
- performing a time domain reflectometry, TDR, measurement for localizing an anomaly in the data network.

2. Analysis method according to claim 1, wherein the termination resistance is determined by measuring a voltage of the communication line while providing a known current.

3. Analysis method according to claim 1 or 2, wherein the method further comprises comparing the TDR measurement result with build information of the diagnosed vehicle.

4. Analysis device for diagnosing an automotive vehicle data network, the data network operatively coupling at least two operative elements, comprising a number of communication lines and comprising a network connector enabling a connection to an external device, the analysis device comprising

- an input-output (I/O) connector for enabling a connection to the data network;
- a voltage measurement system configured to measure a voltage of a communication line;
- a resistance measurement system configured to determine a termination resistance of a communication line; and
- a signal generator and a signal receiver configured to perform a TDR measurement on a communication line.

5. Analysis device according to claim 4, wherein the resistance measurement system comprises a current source and a voltage measurement system configured to determine the resistance by

providing a known current to said communication line and measuring a resulting voltage of the communication line.

6. Analysis device according to claim 4 or 5, wherein the device further comprises:

- a memory storing build information of the automotive vehicle being diagnosed;
- a processing device for comparing the TDR measurement result with the build information and determining a failure location; and
- an output device for indicating said failure location.

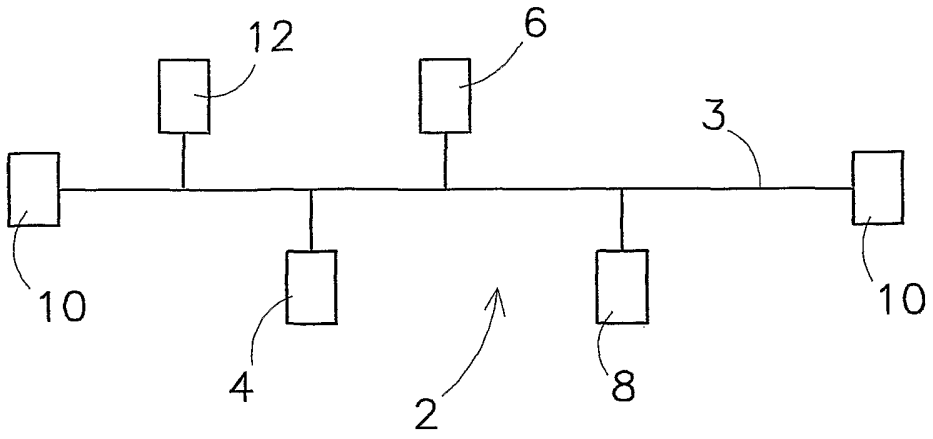

Fig 1

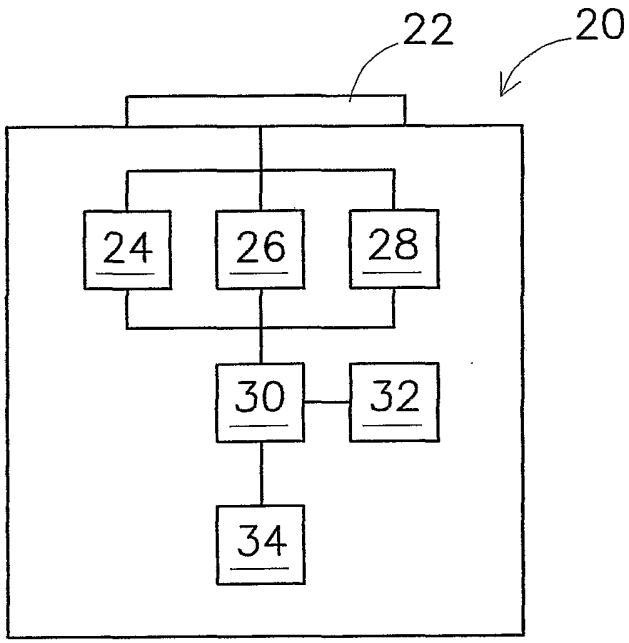

Fig 2

INTERNATIONAL SEARCH REPORT

International application No
PCT/NL2005/000394

A. CLASSIFICATION OF SUBJECT MATTER
H04B3/46 H04M3/30 G01R31/08 G01R31/02 G01R31/11

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04B H04M G01R

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	BACKER ET AL: "Telephone Access Network Measurements" TELEPHONE ACCESS NETWORK MEASUREMENTS, 1998, XP002148949 page 1 - page 4 page 9 - page 10 page 16 - page 17 page 45 - page 53	1-6
Y	the whole document	1,4
Y	WO 03/026160 A (CENTILLIUM COMMUNICATIONS, INC) 27 March 2003 (2003-03-27) abstract	1,4
A	the whole document	2,3,5,6
A	WO 01/01158 A (TELCORDIA TECHNOLOGIES, INC) 4 January 2001 (2001-01-04) the whole document	1-6

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
3 February 2006	10/02/2006

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Tx. 31 651 epo nl, Fax: (+31–70) 340–3016	Ricciardi, M

INTERNATIONAL SEARCH REPORT

International application No
PCT/NL2005/000394

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5 461 318 A (BORCHERT ET AL) 24 October 1995 (1995-10-24) the whole document	1-6
A	US 5 128 619 A (BJORK ET AL) 7 July 1992 (1992-07-07) the whole document	1-6
A	ZIEMANN P: "ADSL line qualification tests" HTTP://WWW.WG.COM/APPNOTES/ADSLTEST.HTML, 28 September 2000 (2000-09-28), XP002148948 internet the whole document	1-6

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/NL2005/000394

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