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Automated Testing System for Cable Assemblies Used in Automotive Industry

Adrian Ioan Lita
Applied Electronics, Information Engineering Department
"Politehnica" University of Bucharest
Bucharest, Romania
ioan.lita@upit.ro

Daniel Alexandru Visan, Laurentiu Mihai Ionescu,
Alin Gheorghita Mazare
Electronics, Computers, Electrical Engineering Department
University of Pitesti
Pitesti, Romania
daniel.visan@upit.ro

***Abstract*—In this paper is presented a versatile cable assemblies testing system designed for applications in automotive industry. The implementation of the proposed equipment is based on the NI USB 6212 data acquisition board that is used together with a proprietary LabVIEW application which controls the operation of the whole system. The experimental stand contains a set of specialized connectors used for interconnecting the acquisition system with the ends of the tested cables. Using a predefined set of templates, the system can verify accurately and quickly the correctitude of the connections for cable assemblies having until nine wires. The templates used for tests can be configured by the user. Once the equipment is initially configured, the tests can be performed in an automated manner. The obtained results are presented on a user friendly interface contained by the LabVIEW software application. The proposed system can be used for testing both signal and power cable assemblies, including flexible interconnection structures. The design offers the advantage of a very versatile structure that can be adapted to a multitude of cable types that are encountered in the automotive industry.**

Keywords— cable assemblies; automated test; data acquisition;

I. Introduction

With the accelerated expansion of the electric and electronic systems that are embedded into the modern cars, the complexity and the requirements regarding the design of the automotive cable assemblies has dramatically increased. In these context cable assemblies known also as harnesses has gained a tremendous importance in the design and fabrication processes of the modern cars. From many points of view the cable assemblies that are embedded into a car is relatively similar with an interconnection structure for the electronic circuits, of course at a different scale and with slightly different characteristics and performance requirements. The automotive cable assemblies are essential for the correct operation of all interconnected systems but also exert a direct impact on the global reliability of the entire automobile. In addition, a failed or erroneously connected wire in an automotive cable assembly can affect seriously the safety of the passengers, this been a very important problem that requires very high standards of quality for the manufacturing processes. The complete testing of all cable assembly has imposed as standard in the automotive industry. This paper proposes an improved design of an automated testing system that can be used both for signal and power automotive cable assemblies [1], [2].

II. The Structure of the Testing System

The simplified structure of the test system is presented in Fig. 1. As can be seen, the hardware architecture of the system is based on NI USB 6212 data acquisition board that is interfaced with an extension module containing the specialized connectors necessary for attaching the tested cable assemblies. The system is designed to operate with multiple testing sets of codes for increasing the accuracy of the performed verifications and for eliminating as much is possible the apparition of subsequent minor or major defects for the systems that exists on an automobile. The proposed testing system cannot verify if a particular cabling layout is correctly designed. For example it cannot notify the user if the main supply circuit has a certain color, a required wire section or even a précised resistivity of the cable's material. The basic test performed by the automated system presented in this paper is that of continuity and correctness of connections in the interface connectors. After performing the tests, the system can provide some of the following results: correct connection, erroneous connection and interrupted connection. If all the wires that compose the verified cable assembly pass the tests of continuity and correctitude of connections, then the system will display a positive result. The ports P0.<0...8> and respectively P2.<0...7> and P1.0 of the NI USB 6212 data acquisition board are used for connecting the tested cables. The port P0.<0...8> is configured as output and the P2.<0...7> and P1.0 will operate as inputs for the data acquisition system [3].

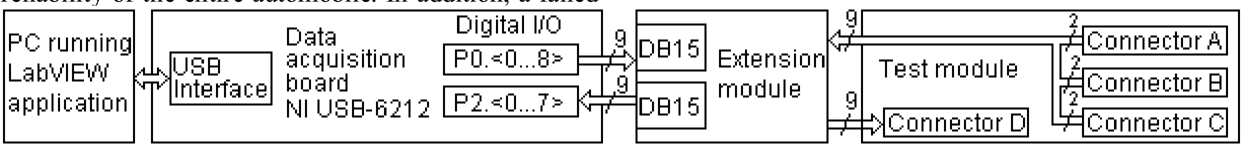

Fig. 1. The general structure of the automated system used for testing the cable assemblies encountered in the automotive industry.

III. The Software Application

The software application for the system used for testing the automotive cable assemblies is realized in LabVIEW. The state diagram of the main software module of this application is presented in Fig. 2. As can be remarked from this picture, when the system is started, the operation begins with a set of initializations of the internal state variables and other internal resources, including the connection ports of the data acquisition system implemented with NI USB 6212 board. In this stage is initiated also the USB communication between external module implemented with NI USB 6212 and a local processing PC that runs the LabVIEW software control application. After the initialization phase is displayed the user interface and is waited the beginning of the test. The operator must properly connect the tested cable assemblies to the dedicated connectors that exist on the test module and after securing the ends of the cable can perform the tests. A set of test codes representing eight binary combinations are applied to the output lines of the port P0.<0...8> that is specific to NI USB 6212 data acquisition ports. The preset binary combinations are also used as templates into the comparison process performed at the ends of the tested cable assemblies. If the system is not entered into the diagnosis mode, then is no longer realized the binary comparison between the received codes and the initial templates that were sent through the cable. In this case the system only displays the binary values that are sent and received through the tested cable on a set of LEDs. The general view of the system's graphical interface is presented in Fig. 3. There are used multiple red and green LEDs to indicate the state of the performed tests. The results are displayed in the table form, in the right of the interface. As can be seen in Fig. 3, the system's graphical interface is very user friendly containing only the minimum number of control buttons and indicators. The testing speed of the cables can be changed between 10ms and 1000ms. The variation domain of this important parameter is closely interconnected with the performances of the used data acquisition board [4].

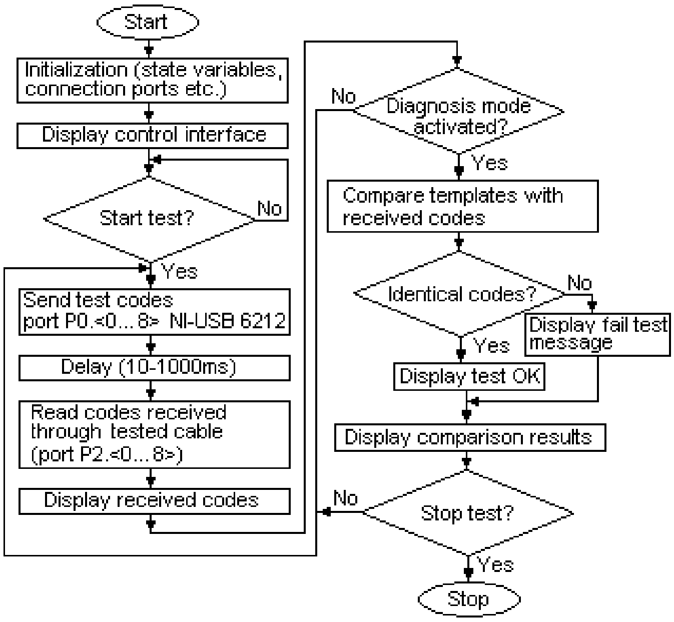

Fig. 2. The state diagram of the LabVIEW application that controls the operation of the system used for testing the automotive cable assemblies.

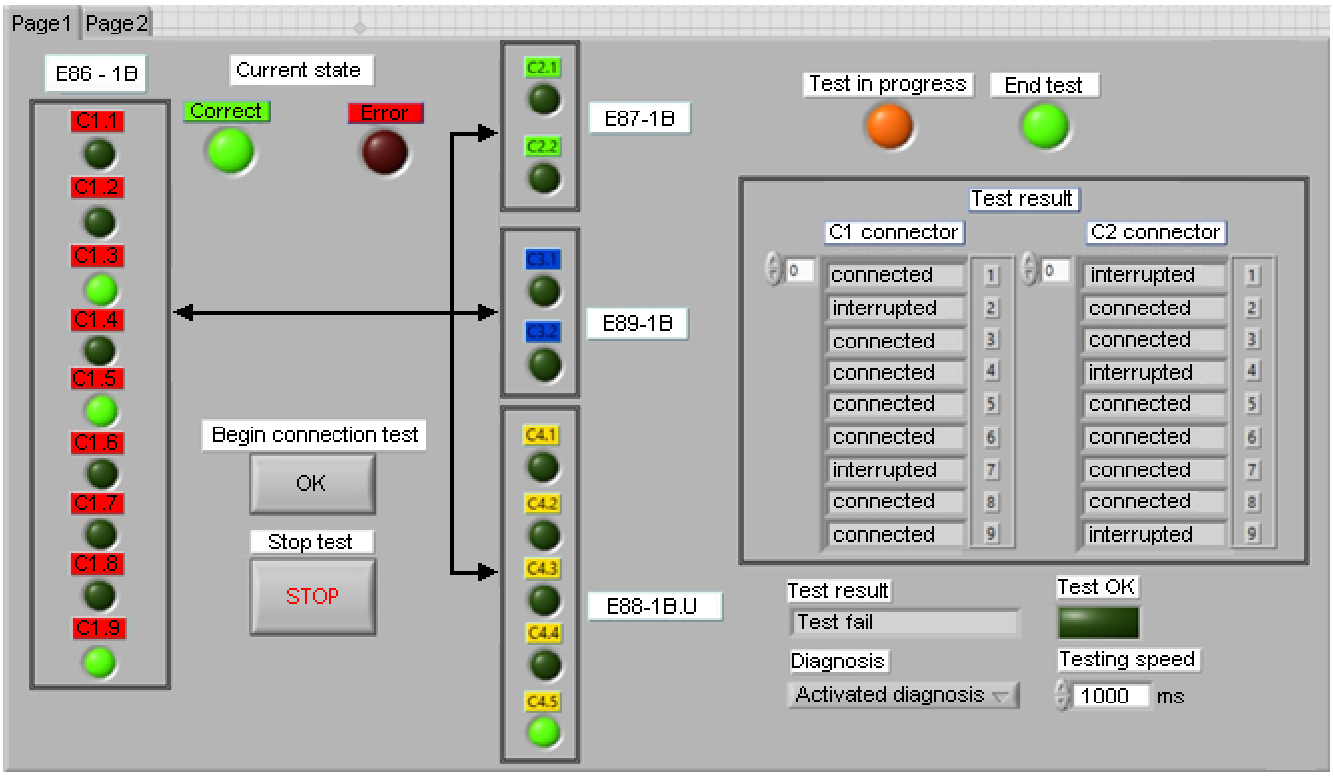

Fig. 3. The interface of the LabVIEW application used for controlling the automated testing system.

IV. Implementation And Results

The implementation of the LabVIEW application used for controlling the automated testing system is presented in the Fig. 4. For its multiple advantages regarding the implementation speed and the versatility, in the proposed design was used the graphical programming language specific to the LabVIEW software development environment. The main elements of the diagram are grouped into loop having the number of cycles correlated with the number of terminals that are specific to the tested cable. The data acquisition system communicate with the PC through the USB interface, allowing bidirectional data transfers between the test system and the control application realized in LabVIEW. As can be remarked, there is a close correspondence between the front panel presented in Fig. 3 and the actual diagram of the application presented in Fig. 4. The testing system contains, on the front panel of the application, a set of LED indicators for continuously displaying the state of the input terminals, denoted E87-1B, E89-1B and E88*1B.U, and the output connector E86-1B. These indicators appear also in the diagram form Fig. 4 been denoted C1.1-C1.9 and C2.1-C4.5. The templates used for tests can be configured by the user, offering the required adaptability for the system to operate with a large variety of automotive cable assemblies. The start of the cable verification is initiated by the "while" loop from the left part of the diagram presented in Fig. 4. A set of state variable are used to control the process. The "Begin connection test" button is directly wired to the control loop condition element, so the entire test process can be started through this element. The "Test Ok" is the state variable that stores the final result of the performed test.

The writing operation of the binary values into the data acquisition registries is preceded by a conversion from decimal to 16 bits word of the values representing the templates used for cable testing. The templates are generated randomly with a specialized algorithm based on Gold code which ensures the very low correlation between the generated values.

The decision function that is used for certify the correctitude of the connections for a certain cable assembly is based on Boolean logic elements taken from the specialized libraries of LabVIEW. The decision is made for every pin of the connector where the cables is linked, the results been stored into a matrix and displayed on the application interface into a table form. For every wire of the cable is identified which of the three possible cases is valid: correct connection, inverted connection or inverted connection. If there are no other imposed constraints regarding the testing methodology, then for every cable assembly must choose the lowest possible testing speed. This mode of operation is preferable for reducing the interferences and distortions of the test signals caused by the parasitic elements that are associated with the large length of the tested cables [5].

However, the phenomena encountered by the high frequencies test signals could be used into a more complex testing system to determine other significant parameters of the cable assemblies, such are: the specific impedance, the material resistivity, coupling factors, electromagnetic radiation emission coefficient etc. In the majority of the situation this determinations are not necessary because the cables are used at very low frequencies or even in direct current applications.

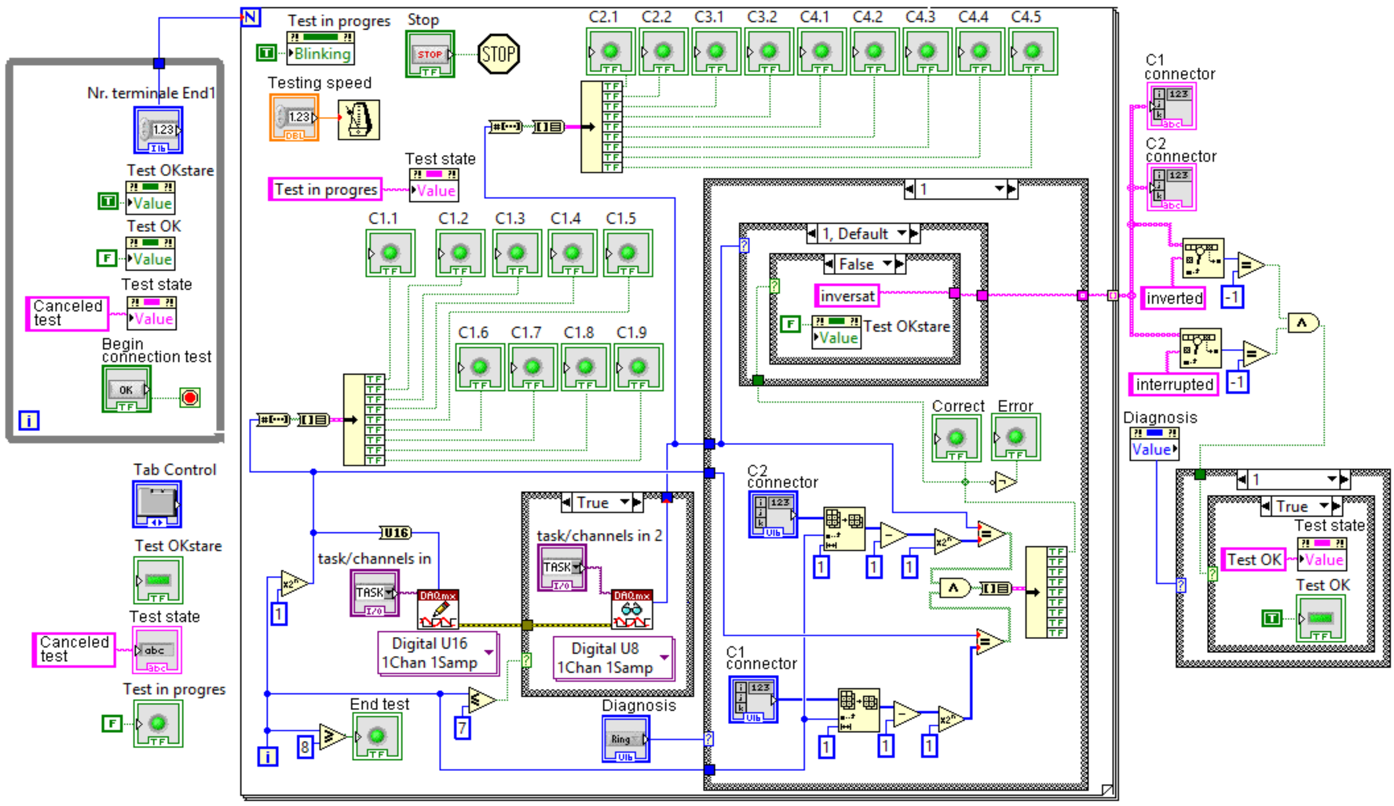

Fig. 4. The diagram of the LabVIEW application used for controlling the automated testing system.

In the Fig. 5 is presented the aspect of the extension module with two DB 15 connectors for data acquisition board and two regular connectors for physical interfaces with the ends of the tested cable. An example of automotive cable assembly connected to the physical interfaces of the test system is shown in Fig. 6. The ends of the cable assembly are firmly locked into the receptacles of the physical interfaces of the test system.

The complete hardware architecture of the proposed test system can be remarked in Fig. 7. Also, an example of layout for a simple cable assembly that was used for verifying the correct operation of the system is presented in Fig. 8. In the proposed design, the number of the connectors used for inserting the ends of the tested cables is limited to four due to the resources offered by the data acquisition board.

Fig. 5. The aspect of the extension module having two DB 15 connectors (black color) and two regular connector (blue color).

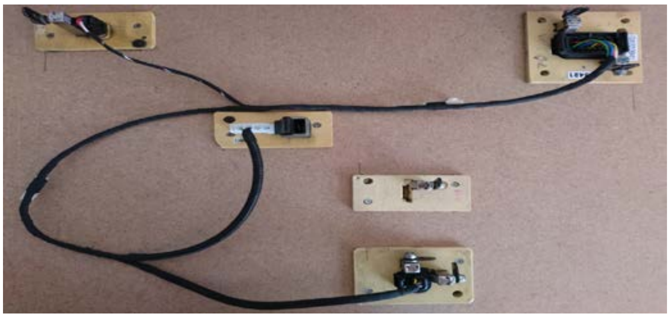

Fig. 6. An example of automotive cable assembly connected to the test system and ready for verification.

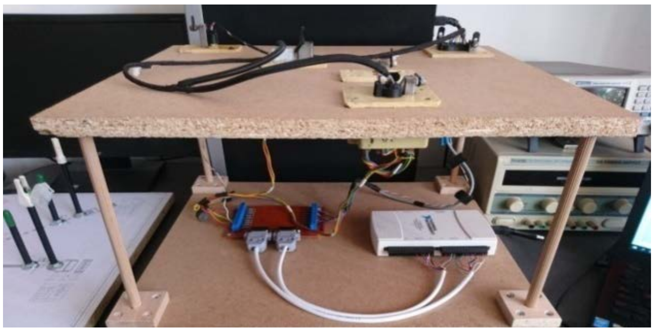

Fig. 7. The prototype of the test system containing the data acquisition and the extension modules.

Fig. 8. The layout design of a simplified automotive cable assembly used for verifying the correct operation of the proposed system.

V. Conclusions

With the increasing length and the layout complexity of automotive cable assemblies the testing methods in this field gained a special importance for the design and fabrication processes of the modern cars. This is because the cable assemblies, considered as distributed interconnection structures, are essential for the correct operation, safety and reliability of all connected systems into a car. The system presented in this paper represent a integrated hardware and software solution designed for automated testing of various cable assemblies used in automotive industry. Using a predefined set of templates, the system can verify accurately and quickly the correctitude of the connections for cable assemblies having until nine wires. The templates used for tests can be configured by the user.The application for controlling the test system assumed many features from the LabVIEW software development environment, including an very fast and easy implementation correlated with a good versatility and a very user friendly interface for the proposed design.For extending the number of physical connectors used for attaching the cable assemblies to the testing system, a higher speed data acquisition speed and a input multiplexer must be employed.

Acknowledgment

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