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DIAGNOSTICS OF AUTOMOBILE POWER SYSTEM VIA INTERNET

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The paper deals with specific automated measurement network system based on Internet, which is applied in automotive electronics, especially monitoring the automobile power supply system. The first part describes in more detail every essential part of the measurement system. Second part deals with Internet usage, wireless communication interface and remote control of the system.

Key words: automated measurement network, Internet based diagnostics, measurement bus.

Introduction. In recent years, automotive industry becomes very influential, and not only in the economics of Slovak Republic. The trends in development brought also new requirements for diagnostic systems and subsequent error detection. Normally these two processes focus on hidden mistakes and errors that occur/happen while automobiles are commonly used on daily basis. Therefore, there is a demand to develop a diagnostic system of power supply of automobile that enables to measure disorders of power supply system. Data measured would be thanks to Internet sent to expert system that will process the data and tries to detect the reason why error has occurred.

It is necessary to point out due to fact that it is a newly developed algorithm of measurements it is not possible to connect the automobile to metallic communication network. Therefore, only wireless technologies are applied in the process of measuring. They are based on mobile network GSM and wireless network Wifi. Both networks enable to connect the measurement apparatus/system positioned in the automobile to the Internet and allow to measure real time. It is necessary to underline that above mentioned technologies have disadvantages that can cause loss of measured data. For this reason long lasting data acquisition is needed to eliminate/reduce certain failures.

Automated measurement chain. General flow diagram of automated measurement chain is displayed on Figure 1. Measurement chain has 1 or more sensors at the input. Using sensor on the input a mutual interaction between measured object (measured parameter of certain natural phenomena or technological process) and measurement system can occur.

In the sensor element a measured parameter changes into other physical or chemical quantity. Mostly it is quantity that can be easily transformed into electrical quantity.

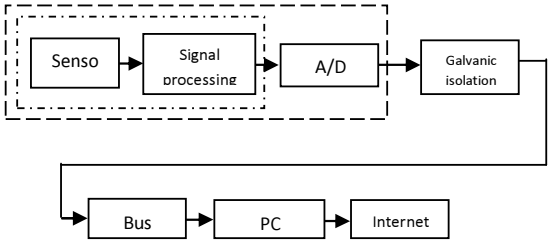


Figure 1 – Automated measurement chain

Physical or chemical quantity that originates from the interaction of observed (measured) quantity with sensor has only rarely the value or character that can be directly measured or used for further processing. It has to be properly pre-processed and modified in the block for signal processing. This pre-processing includes amplification, filtering, other signal processing, e.g. output impedance, to achieve a source of voltage or current etc.

Processed signal is conveyed on the input of the analog-dialog converter (A/D) where the analog data are transformed into digital code. It is advisable to galvanically separate the further part of the measurement chain due to protect bus. Then the digital data are sent to bus. Using bus the data are transferred in the digital form to computer where they are processed. These data can be distributed further to distant computer via Internet connection.

The trends in development, e.g. an integration and minimalization of particular machine parts, have brought also changes into measurement chain. Some blocks are integrated into 1 entity or they are eliminated at all. For example sensor and block for signal processing can be integrated into one united block (it is displayed with dash-and-dot line on Figure 1), eventually also A/D converter can be implemented into this block additionally (as displayed with dashed line on Figure 1). The galvanic part is often skipped because new types of data buses are short-circuit-proof. In this way the flow diagram can be simplified with no

influence on its functionality. The simplification is only a consequence of implementing new trends into automated measurement chain.

Design of an architecture. Architecture of particular connection is displayed on Figure 2. It is not focused on the data sampling directly, as this topic will be described in following chapters. It is devoted to „bus“ – part of the measuring device that is responsible for transfer of measured data to the device that will assess/evaluate them – to an expert system.

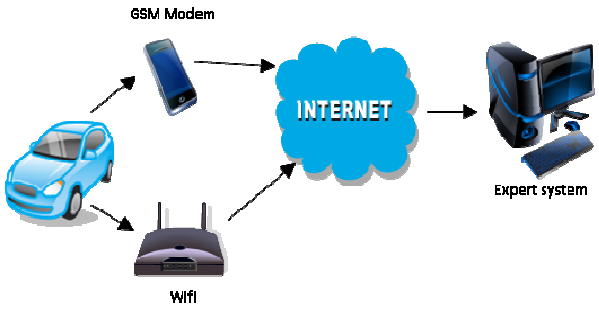


Figure 2 – Design of architecture for distant measurements in automobile

As it is apparent from the figure above, Figure 2, automobile has embedded GSM modem, device enabling the connection to the wireless network (in our case it is WiFi network). Mobile operator (in our case GSM networks) and access point (for wireless network) enable the connection of automobile to worldwide web - Internet. Using internet connection automobile would be connected to expert system, eventually to computer selected by the producing company.

Measuring system is devoted to diagnostics of power supply of the automobile. Therefore, the daily diagnostic measurement will run with speed of GSM network which is sufficient for this purpose. Entire system is designed to be running daily, for its operation the benefit of the GSM network – wide coverage – can be utilized. WiFi network will be used only during service interventions and for check-up of measuring hardware, or its set-up respectively. It can also be used for creating a back-up of measured data that are stored in the measurement apparatus. WiFi networks of this kind would be built at specialized service workplaces, from which one can very quickly connect to the expert system. Based on the data comparison the database of measured data can be restored in case there are data damaged while data transfer via GSM network. Expert system would be able to restore and renew the missing data and it would achieve complete overview about power supply system of particular automobile.

According to the measured data analysis service providing workplaces would be able to modify time intervals for switching off the particular systems running in the automobile after switching off the engine. In the moment when the engine is turned off, system that steers the entire automobile, is still functioning and gradually controls the engine’s parameters, turns on and off the particular subsidiary systems, e.g. air-conditioning, auto-radio, alarm system etc. During controlling the mentioned functions and while managing subsidiary systems there can be particular systems left running. This can contribute to the fact that the systems are worn out very early and they are out of order or accidental failures occur. These failures cannot be uncovered by routine check-ups at service oriented workplaces. The main reason is that the automobile cannot be checked while running. It is the main benefits of the expert system (ES).

Realization of measurement chain. The entire diagnostic system consists of 2 main parts.

The first part is hardware. The entire automated measurement chain is made in hardware. The control unit is the core of the entire system. It operates all subsidiary circuits that measure voltage and current directly on the accumulator. The measured values are subsequently digitalized using analog-dialog converter and then they are stored into back-up memory. Control/Master/Steering circuit assures that there is connection to Internet using GSM modem. Measured data are than directly sent via Internet to expert system where they are processed and evaluated.

The second part is a design and realization of an expert system. This system is characterized by different algorithms for evaluation that cooperates closely together and process measured data. The core of the entire system is based on the server applications that will be described in detail in the further chapters of the paper.

A. Hardware of diagnostic system

The flow chart of the hardware part of the measurement chain consists of the main blocks displayed on the Figure 3.

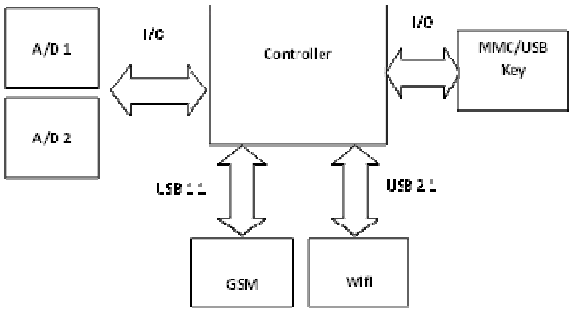


Figure 3 – A flow chart of the measuring chain

The core of the measurement chain is control unit that controls the operation of all the rest circuits and it ensures the connection to Internet network. Measurement is directly enabled by a pair of analog-dialog converters. These converters detect the voltage

and current directly on the battery and then subsequently they convert the measured analog data to digital form. These data are stored by control unit to USB memory stick or to MMC memory card and later it sends them to expert system using GSM modem. Wifi connection is used to update and change set-up of the control unit.

B. Software part of the diagnostic system – Expert system

The main task of the expert system (ES) is to evaluate and store measured data. These data are sent in regular intervals to measurement apparatus in form of a file. FTP server is commonly used to communicate with the measurement apparatus. It has to have correct configuration and save the received files to disc to the precisely defined target.

As the benefit of this kind of measurement is long-term data acquisition, the size of the measured data is enormous. To process that amount of the data, the best solution seems to be a database system that is predetermined to processing and storing the big amount of data. This database system cannot process the measured data in detailed way. Therefore, it is necessary to connect it to a tool that is able to process the measured data. The best solution seems to be PHP scripts that can manage to cooperate closely with database system. A great advantage of this solution is that the measured data can be schematically displayed on WWW page. In this way the measured data can be visualized and also and when using appropriate settings of processing scripts, the error or any abnormality can be detected. In order to ensure the consistent function of the ES, the following 4 programs are necessary to create the main structure of the system:

FTP *– server*

MySQL *– database system*

Apache *–HTTP server*

PHP *– script language*

All these programs are freeware available on Internet. Therefore, there are no special program related costs needed to creating and building ES. FTP server will not be described in detail. It serves for receiving the data that are transferred from measurement apparatus directly from automobile. There are 3 important applications that play a key role and that are a core of the ES.

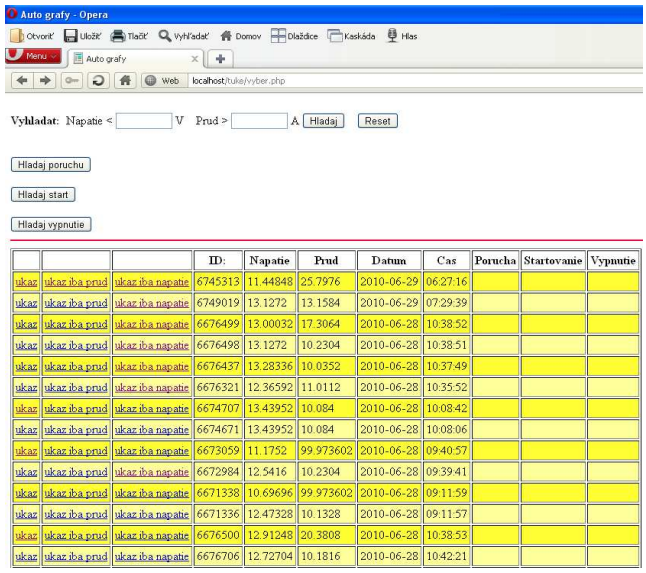
Entire expert system comprises of above mentioned combination of applications based on the client/server architecture. Main/master computer acting as „a server“ plays the main role of receiving the measured data using FTP server and storing them into the MySQL database. This server has Apache and PHP installed. It is actually the interface for communication evaluation. Computer in the role of „a client“ connects to server via Internet browser. Then the measured data are displayed directly on the Internet web page and the option to look for the failures can start. In this way, the measured data are provided as accessible to different users. It assures the multifuncionality of the entire system. The operation of the system is automated and there is need to have only minimal administration of the operator to govern it.

Measured data processing.

A. Description of basic interface

After connecting to the server via Internet browser, there is a main workplace of ES displayed. The table displayed in the workplace, consists of 100 last measured values. To display the measured data there is a link with title „show/display“ that can (after its activating) show measured voltage and current at the same time. Other two buttons within the chart/table serve for displaying either current or voltage („only current“ or „only voltage“). The range of the measured data is ±100 for better graphical representation as to display only one value is not very reasonable. Figure 4 and Figure 5 show the main table and graphical representation of measured values.

The basic interfaces of ES includes also implemented browsing buttons „Search for failure“, „Start the search“, „Search for turned off“. They are searching for the required functions for predefined conditions. After notification of them, they are displayed in the chart. Specific button „Search“, serves for the identification of the users that match the given criteria for voltage and current. The „Reset“ button is cancelling the selection of the user and the last updated measured data are displayed in the table.



			ID:	Napatie	Prud	Datum	Cas	Porucha	Startovanie	Vypnutie
ukaz	ukaz iba prud	ukaz iba napatie	6745313	11.44848	25.7976	2010-06-29	06:27:16			
ukaz	ukaz iba prud	ukaz iba napatie	6749019	13.1272	13.1584	2010-06-29	07:29:39			
ukaz	ukaz iba prud	ukaz iba napatie	6676499	13.00032	17.3064	2010-06-28	10:38:52			
ukaz	ukaz iba prud	ukaz iba napatie	6676498	13.1272	10.2304	2010-06-28	10:38:51			
ukaz	ukaz iba prud	ukaz iba napatie	6676437	13.28336	10.0352	2010-06-28	10:37:49			
ukaz	ukaz iba prud	ukaz iba napatie	6676321	12.36592	11.0112	2010-06-28	10:35:52			
ukaz	ukaz iba prud	ukaz iba napatie	6674707	13.43952	10.084	2010-06-28	10:08:42			
ukaz	ukaz iba prud	ukaz iba napatie	6674671	13.43952	10.084	2010-06-28	10:08:06			
ukaz	ukaz iba prud	ukaz iba napatie	6673059	11.1752	99.973602	2010-06-28	09:40:57			
ukaz	ukaz iba prud	ukaz iba napatie	6672984	12.5416	10.2304	2010-06-28	09:39:41			
ukaz	ukaz iba prud	ukaz iba napatie	6671338	10.69696	99.973602	2010-06-28	09:11:59			
ukaz	ukaz iba prud	ukaz iba napatie	6671336	12.47328	10.1328	2010-06-28	09:11:57			
ukaz	ukaz iba prud	ukaz iba napatie	6676500	12.91248	20.3808	2010-06-28	10:38:53			
ukaz	ukaz iba prud	ukaz iba napatie	6676706	12.72704	10.1816	2010-06-28	10:42:21			

Figure 4 – Basic chart of the main interface

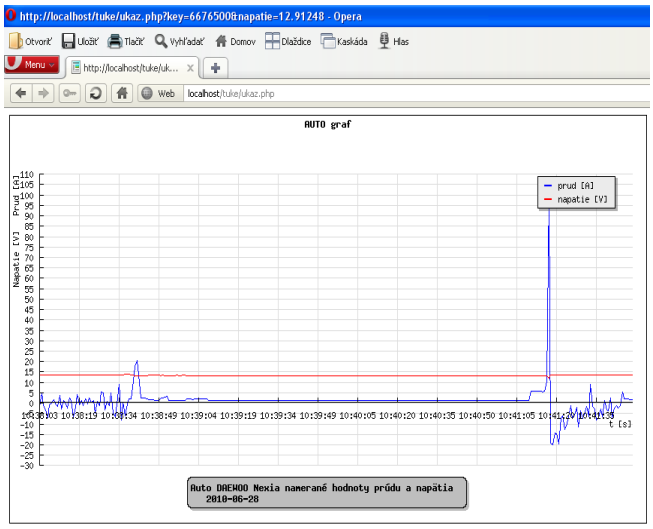


Figure 5 – Graphical representation of voltage and current

B. Assessment/evaluation of measured data

Measured data sent by measuring setup are displayed after they are received and they are processed and evaluated by expert system made of above mentioned components that saves the data into the database. This database forms data in the charts as Figure 4 shows. The data are then processed to further step – data processing. Based on the criteria set by the system, ES can find the disorders, errors and failures.

The record in the table is automatically updated after time interval that can be set by the operator. The table consists of last received data achieved from the measurement apparatus. If there is any discrepancy detected, the special mark is added to the table in order to easily identify its occurrence. The discrepancy does not always equal to failure or error. ES detects the information about switching on and off the automobile. Therefore, table has more columns in order to implement more marks or notes. Figure 6 provides the example of the table.

			ID:	Napatie	Prud	Datum	Cas	Porucha	Startovanie	Vypnutie
ukaz	ukaz iba prud	ukaz iba napatie	6678913	10.61888	99.973602	2010-06-28	11:19:30		X	
ukaz	ukaz iba prud	ukaz iba napatie	6676707	11.52656	99.973602	2010-06-28	10:42:22		X	
ukaz	ukaz iba prud	ukaz iba napatie	6673059	11.1752	99.973602	2010-06-28	09:40:57		X	
ukaz	ukaz iba prud	ukaz iba napatie	6671338	10.69696	99.973602	2010-06-28	09:11:59		X	
ukaz	ukaz iba prud	ukaz iba napatie	6595261	11.11664	76.793602	2010-06-27	11:11:20		X	
ukaz	ukaz iba prud	ukaz iba napatie	6584171	9.4672	84.211197	2010-06-27	07:54:39		X	
ukaz	ukaz iba prud	ukaz iba napatie	6515130	9.87712	94.947197	2010-06-26	12:12:25		X	
ukaz	ukaz iba prud	ukaz iba napatie	6517779	10.76528	99.973602	2010-06-26	12:57:01		X	
ukaz	ukaz iba prud	ukaz iba napatie	6427807	9.69168	88.896004	2010-06-25	11:32:24		X	
ukaz	ukaz iba prud	ukaz iba napatie	6349355	10.79456	99.973602	2010-06-24	13:01:45		X	
ukaz	ukaz iba prud	ukaz iba napatie	6259331	11.43872	80.502403	2010-06-23	11:36:16		X	
ukaz	ukaz iba prud	ukaz iba napatie	6253813	9.3696	99.973602	2010-06-23	10:03:22		X	

Figure 6 – Table representation of voltage and current

As it can be seen at the figure above, table comprises of the columns with information about the voltage, current, date and time. Column with ID is a special identification item according to which one can identify particular record and distinguish it among the others in the database.

Mark „X“ indicates where there is a discrepancy identified. If mark X occurs in the column named as “Start”, it means that ES has found specific values for voltage and current and identified them at the start and added the identification mark in the particular column. This mark can occur also in the other columns of the table depending on the result how ES evaluates the situation.

It is not easy to imagine the entire situation only from „Start“, from information about the voltage and current in certain time. To understand the situation better, the there is a visualization of the situation provided by ES that allows to display graphically the measured events. Figure 7 presents the start of the automobile in graphical representation.

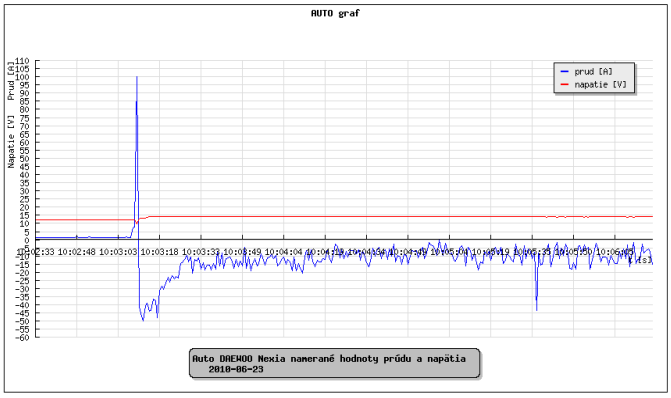


Figure 7 – Graphical representation of automobile’s start

Figure 7 has values of the voltage and current on the y-axis and time on the x-axis. The bottom part of the figure shows the information about the automobile and date of the measurement. Based on these data a general interpretation, a picture about the situation that is happening can be made. Form the figure it can be seen that start of the automobile can be characterized by great expenditures of current from the accumulator and it results to the decrease of the voltage. Based on this information, ES identified the situation as “Start”.

The other situation that system is asked to identify is turning of the engine of automobile. Turning off the automobile cannot be as clearly determined as starting the automobile. However, it is necessary to identify also the turning off and it also has characteristic features. Following Figure 8 shows the turning the automobile off.

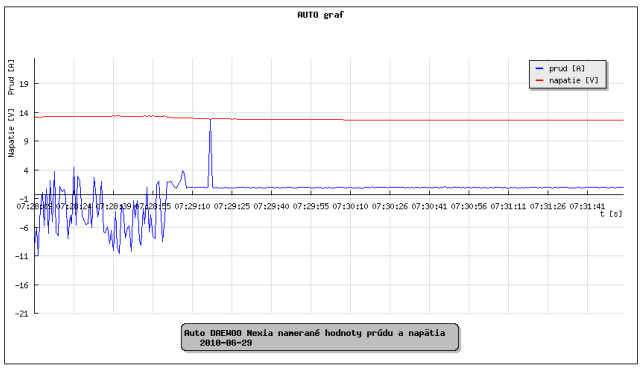


Figure 8 – Graphical representation of turning off the automobile

At the first sight it is visible that the simulation differs from the starting of the automobile. The process of turning off is defined by higher value of voltage at the moment of turning off. In that moment the charging system cannot cover the loss of energy that is spent. ES can identify the turning off the automobile based on this feature.

Figure 8 showed the standard way of turning off the automobile. Also in this process the failures can occur. They can result in decreasing the lifetime of the accumulator. These failures are caused by systems that are gradually disconnected, e.g. cooling system, alarm, radio etc. Measurements can detect these failures and they can be eliminated by correct timing of switching them off step by step. The previous text, two basic situations characteristic for normal running of the automobile was described. Correct detection of them and subsequent comparison with the recently measured data can help to eliminate and avoid the failures that can occur at starting or turning the automobile off.

Simply said all the other situations excluding those that occur at normal running of the automobile can be classified as failures. However, this is not completely definite. Therefore, the process if setting the criteria for failure identification was the most critical and the most difficult when creating ES. For better understanding, there is situation during running the automobile displayed on Figure 9.

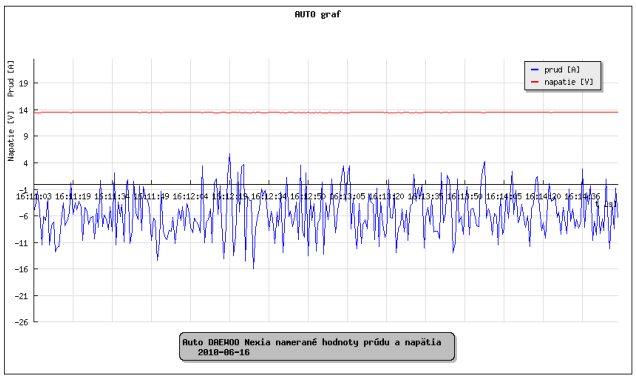


Figure 9 – Graphical representation of running automobile

Based on these conditions ES can detects and determine the failure when the automobile is running. On the following Figure 10 there is an easily identified failure of the automobile showed. We can conclude that ES can reliably identify 3 basic situations that can occur when the automobile is running. The other advantage of the ES is that it can browse the measured data and evaluate them based on the criteria set by the personnel. This helps to eliminate the possibility to skip or neglect occurred failure or error that does not match within the criteria boundaries and it to avoid its spreading.

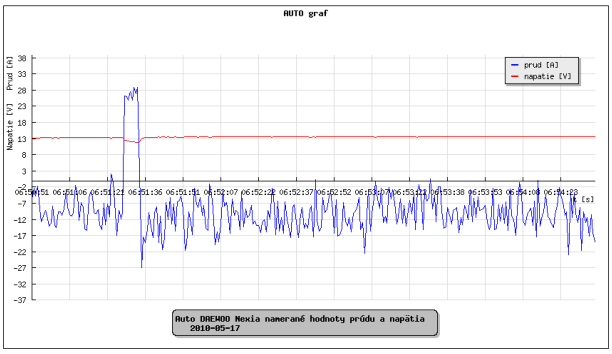


Figure 10 – Failure identified during automobile's running

It is a great benefit that system informs administrator by sending email on defined email account when the failure has occurred. In this manner, the failure can be evaluated, consulted by qualified professional and conduct the further steps. The failure that was detected by system itself is normally failure that occurred periodically or it is a single-shot error. After the situation is evaluated, the owner of automobile can be contacted and asked to com to check-up.

Conclusions. Main contribution of the research is an original design and construction of the diagnostic system for power supply of automobile based on the Internet connection for operating the diagnostics. This system in the mentioned design has never been designed or published before. Therefore, it is a unique system. The whole work provides the complex insight in the remote measurements and implementation of new trends into the automotive industry. It provides complete guidelines for the construction of the entire measurement system that cooperates with expert system for evaluation. Altogether these two systems create a complex diagnostic and measurement system.

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ДИАГНОСТИКА АВТОМОБИЛЬНЫХ СИСТЕМ ПИТАНИЯ ПОСРЕДСТВОМ ИНТЕРНЕТА

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Рассматривается конкретная автоматизированная система измерений на основе Интернета, которая применяется в автомобильной электронике, чаще всего для автомобильных систем питания. В первой части более подробно описывается каждый элемент измерительной системы. Вторая часть посвящена использованию Интернета, беспроводного коммуникационного интерфейса и удаленного управления системой.

Ключевые слова: автоматизированная измерительная сеть, Интернет-диагностика, измерительная шина.

ДІАГНОСТИКА АВТОМОБІЛЬНИХ СИСТЕМ ЖИВЛЕННЯ ЗА ДОПОМОГОЮ ІНТЕРНЕТУ

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Розглядається конкретна автоматизована вимірювальна система на основі Інтернету, що застосовується в автомобільній електроніці, найчастіше для автомобільних систем живлення. У першій частині більш докладно описується кожний елемент вимірювальної системи. Друга частина присвячена використанню Інтернету, бездротового комунікаційного інтерфейсу й віддаленого керування системою.

Ключові слова: автоматизована вимірювальна мережа, Інтернет-діагностика, вимірювальна шина.