WIRELESS LOCAL NETWORKS TO RECORD THE RAILWAY TRAFFIC CONTROL EQUIPMENT DATA

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Summary Article presents a concept of a distributed diagnostic railway traffic control system using the short – range wireless networks as a main communication medium.

1. INTRODUCTION

Development of railway traffic management systems from their complexity point of view, increase of speed and throughput of modernized railway lines as well as expansion of areas covered by the management enforce development of diagnostic systems, exceeding with their complexity the ones offered by the traffic protection equipment manufacturers. We have to emphasize a big disproportion of the diagnostic level between the interlocking and actuating equipment.

Diagnostics of the interlocking equipment requiring a full integration with the controlled equipment and applies to both technical diagnostics and the self-control of realized interlocks, it is imposed by regulations and constitutes a significant part of the interlock realization procedure.

Diagnostics of the actuating equipment such as point drives, lights, gate drives etc is limited to the status control, without any possibility of remote diagnostics of their working parameters, Although this solution ensures safety of traffic, the lack of possibility of continuous remote control of equipment operating parameters has its impact over the operating value of line and station.

The purpose of this article is to present a concept of a distributed diagnostic system using the short-range wireless networks as a main communication medium.

## 2. LIMITATIONS AND REQUIREMENTS OF THE SYSTEM

The actuating equipment of railway traffic management, because of its wide scattering, requires use of a decentralized set of telemetric module and centralized data acquisition device. At the same time, a large differentiation of equipment covered by the diagnostics requires application of measurement modules with various degree of complexity while still able to perform to the same communication standard. Table 1 presents selected parameters of instance actuating devices covered by the diagnostic supervision of system under consideration. As shown from the preliminary list presented, the requirements set for the telemetric modules are mostly high because of a considerable number of measurement inputs. We have to emphasize that a majority of equipment that requires control is located at a large distance from data acquisition devices, which, at a significant number of measurement points, may constitute a serious obstacle both in use of cable connection and radio connection over the entire area subject to control.

Tab. 1. Selected parameters of instance actuating devices

Device	Measured parameters	Expected number of necessary inputs	Measurement location
Point drive	humidity, temperature, vibrations, setting currents, control currents, voltages, position,	10 analog inputs 2 digital inputs	drive housing
Light signal	voltages	1 analog input per each supply transformer	relay room
Level crossing gate drive	humidity, temperature, vibrations, voltage, current, position	7 analog inputs 2 digital inputs	drive housing

Because of the above, and taking into account the specific character of railway station construction (groups of single type equipment over a small area, but at the large distance from service posts) the most appropriate solution seems to be construction of measurement networks based on data GPS/GPRS transmission (Fig. 1) or in a tree topology using the radio and cable connections and grouping the devices operating in the collection points, sending these collective data to the central diagnostic system (Fig.2).
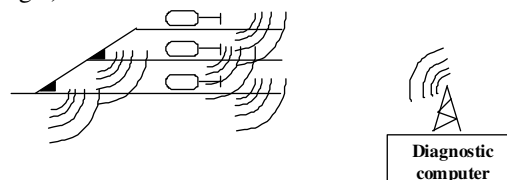
Fig. 1. Instance of a diagram of diagnostic system using GPS/GPRS

3. SECURITY OF TELEMETRIC DATA

Transmission of data from telemetric devices does not require use of data protection systems against errors (coding), obsoleteness (time stamp) or infringement of sequential character (sequential numbers). Also the high level of reliability at the level of transmission medium should not be treated

as a basic criterion, as with the lack of time limitations for delivery of data from the
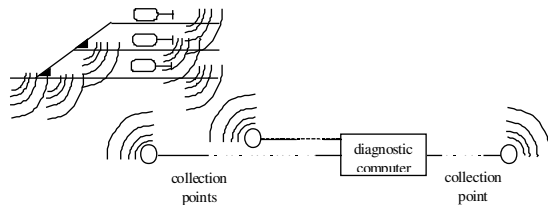

Fig. 2. Instance of a diagram of diagnostic system using radio and cable connections

measurement system, the reliability may be achieved using such mechanisms as multiple repetitions with confirmation, until the correct information is received.

4. MEASUREMENT MODULES

During selection of measurement modules the following should be taken into account. :
-    Type and quantity of required inputs;
-    Method of measurement data transmission;
-    Method of system supply;
-    Dimension of devices taking into account the local limitations.

An important aspect is realization of communication standards by the modules – such a system may be created in a step by step manner, thus use of closed solutions may affect the development of the system.

Having the above in mind two solutions may be taken into account: use ready-made telemetric modules or development of specialized telemetric modules based upon the single-chip microcomputers.

Ready-made telemetric modules

Among the large offer of telemetric modules that may be used in the designed system, the most worth of our attention are those using package communication GPRS. Typical devices consist of a PLC controller with digital-analog inputs/outputs and a GPS/GPRS module, thus constituting a fully functional measurement device that in addition removes disadvantages of construction of a cable and radio network. In the case of a transmission that uses GPS we have to take into consideration the additional costs resulting from customer charges due to the use of package transmission. For instance, for a point drive that is set about 50 times a day on a large station, taking the average setting time about 3 s and assuming, in accordance with the Shannon's theorem that the sampling frequency is equal to 100 Hz, and that the module enables sending of a full collection of events together with a time stamp from the entire drive operating period in one package, we have to expect monthly transfers at a level not exceeding 7 MB.

In the case of telemetric modules their price is also not without meaning. Although typical telemetric modules are rather on less expensive side, the ones adapted to the quickly variable data transmission are much more costly. Thus, as a rather serious alternative, consideration should be given to the development of author's telemetric modules with application of single-chip microcomputers, while maintaining the condition of realization of a common communication standard within the entire system.

Author's telemetric module

While developing a telemetric module design the attention should be paid especially to the widespread use of solutions applied not only in terms of communication standards, but also equipment and software ones.

Type and number of required inputs

In order to limit the impact of number of analog and digital inputs on the selection of central unit we have to take into consideration a possibility to use external A/C transducers, analog keys and multiplexers while taking into account the extension of measurement data processing time. Such an analysis cannot be created apart from other factors influencing the selection of the system.

Transmission of measurement data

The assumed model of telemetric module network operating in a tree topology enables to reduce the number of cable connections between the measurement module and diagnostic computer to the functional minimum through use of intermediate collection points. Because of expected small distances in the system of collection points and measurement module sets the most obvious solution is to use short-range radio connection within the collection point, which means avoiding troublesome cabling, ensuring a quick connection of new equipment to the network and at the same time separate the electric telemetric modules electrically from other elements of the system. In accordance with [1] and based upon the first analysis of market offer of communication modules for data transmission purposes in the micro-controller systems, two frequencies of system operation were selected: 433,05-434,79MHz and 868,0-868,6MHz, while the further analysis of possible advantages has indicated the final selection of first frequency range. This frequency is dedicated to the telemetric applications and common character of equipment solutions that use this frequency is also an important factor of the selection. The power of transmitter operating in this band is limited to 10 mW by regulations (as measured at the distance of 10 m from the transmitter, with a channel 25 kHz wide and a possibility to use connectible antennae. Whilst maintaining the power limitation, we have to reckon with the low ranges – transmission at top speed may take place on the 50 m distance at the most, and the maximum distance between transceivers is 2 km.

Because of the significant distance between the collective points and the central data acquisition centre, communication in his relation should be based on a wire transmission. A preliminary analysis of solutions available on the market indicates a possibility to use Ethernet network that besides good transmission parameters, features also low installation and operation costs.

System power supply

A variety of available voltages in the equipment being controlled, sometimes possible to obtain only by use of measurement transformers from the control systems (point driver) indicates a Reed to use low Power systems with low Power supply voltages. Method of power supply is determined by the capabilities of controlled devices and should not be considered separately.

Device dimensions

Similarly as in the case of power supply system analysis, this parameter also is strongly conditioned by the local limitations (such as inside space in the point drive), and which is important, it depends not only of the type of device, but is also determined by its specific type.

Collection points

Collection points should ensure data collection from the devices located in their operating range and export of these data to the remote diagnostic data server. As the functional range of collection points is not conditioned by the type and range of measurement data, thus the functional definitions of the collection point are a basis of the system operation.

Communication between the telemetric modules and a collection point and wire communication with the diagnostic server require realization of two separate communication standards, This suggests justification for modular construction of the collection point.
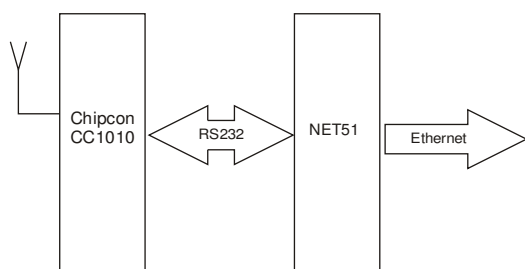

Fig. 3. Modular diagram of a collection point

Fig. 3 presents a block diagram of the designed collection point. For the purpose of collection point communication with the measurement modules the CC1010 chip by Chipcon company was used being a combination of the single-chip microcomputer and a versatile transceiver. The purpose of this chip is to collect measurement data from the telemetric modules and then sending them through a RS232 connector to the transmitting system NET51

communicating with the remote diagnostic data server. NET51 family modules are dedicated devices for operation in the distributed telemetric, alarm, measurement and control systems and using TCP/IP protocol set for communication. These modules are designed for use in the network terminations, where they may be used as network interfaces for a broad range of detectors and meters of physical parameters. Locally such a module allows the communication with the environment (Fig. 4) through 8 I/O lines, an I2C interface (master mode) and serial port (TTL levels. The RS232 interface may operate with speeds from 300 to 11520 bps and supports most of the transmission formats used.

A feature that discerns NET51 is a built-in SPIKE interpreter (Fig. 4) that realizes users software. A programming possibility enables querying the external devices, operation of memory contents and dynamic creation of contents of WWW locations and XML files. The described language makes available several arithmetic and logic operators, control instructions and network functions for communication through TCP or UDP. This module may be remote controlled through a direct TCP connection or using WWW or WAP explorer (for example in the mobile phone).
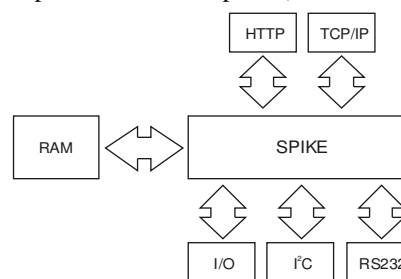

Fig. 4.Functional diagram of SPIKE architecture

Diagnostic data server

Both in the case of use of ready made telemetric modules using GSM/GPRS communication, and in the case of proprietary telemetric modules with proposed architecture of collection points, the database server may be of open PC-based built operating on a commonly used system and user software. For testing purposes, a PC computer was selected with the installed Linux (or BSD), PHP, SQL database software installed.

Telemetric module described on an instance of point drive control.

The earlier experiments [3] have proven that based upon the known shape of setting currents and voltages we may determine the setting resistance of drive-point system. The knowledge of voltages and currents in the control circuit enables determination of present status of the drive and condition of cable joints. The full knowledge about the current and voltage characteristics as a function of other parameters (such as vibrations) acquired during the system operating tests allows for further

interpretation of results, enabling, for example, statement of the fact of a turnout being split.

Range and type of measured parameters

Operating parameters of the point drive that are of special importance for the diagnostic process are: setting currents, setting voltages, control current, control voltage. For correct interpretation of the acquired values of operating parameters, the following is necessary: measurement of humidity inside the point drive, temperature measurement, vibration measurement.

Measurement of setting currents and voltages and control currents and voltages.

The correct values of currents and voltages in the setting system amount to 10 A and 380 V respectively, whereas the current and voltage in the control system should not exceed 1 A and 24 V respectively. Because of the fact that contemporary point drives are three-phase voltage operated, in order to collect a full information 3 current transformers and 2 voltage transformers shall be used in the setting circuit and 1 voltage transformer and 1 current transformer in the control circuit (number of measurement transformers may be even higher in the case of modern drives). All transformers should have an air gap for galvanic separation of measurement system from the drive circuit. A significant limitation for selection of the measurement transformer are dimensions of typical measurement probes, thus miniature custom-made measurement transformers shall be used.

Measurement of temperature and humidity

Acceptable temperature inside the point drive shall be from -40°C to +80°C, and relative humidity up to 100% [2]. In order to minimize the use of microcomputer measurement inputs the detector SHT7x of Sensirion company was used, performing the humidity measurement in the range from 0 to 100% and temperature measurement in the range from -40°C to +120°C, communicating through a 2-line digital input.

Vibration measurements

Use of vibration detector shall allow to determine the impact of rolling stock over the parameters of points drive as a function of time, which, due to the experience gained, will enable more efficient operation and elimination of hazards resulting from lack of correlation between the technical services and real condition of the drives.

In addition, vibration measurement that is performed during the setting of point drive will allow further analysis indicating correctness or lack of it in the operation of specific drive components, such as motor, gear, drive transmission system or condition of the turnout. The acceptable acceleration value for traffic protection devices should be from 0 to 20 G. In a prototype module it should encompass three axles, and the scope of recorded accelerations should be from 0 to 30 G.

For the purpose of acceleration measurements the selected detector is TO-5 of PCB Piezotronics manufacturing, operating in the defined range at the vibration frequency not exceeding 10 kHz.

Selection of processing system and communication circuits

A necessity to ensure a proper speed of data processing and transmission in the telemetric module resulted in use of CC1010 chip of Chipcon manufacturing being a combination of single-chip microcomputer and a versatile transceiver. The chip CC1010 of Chipcon manufacturing features the following specifications: integration of a transceiver with single chip microcomputer (8051 family); a possibility to set the transceiver operating frequency from 300-1000 MHz; fabricated modules hard wired to the frequencies 315/433/868/915 MHz; hardware cryptographic module (DES algorithm); 3-channel A/C transducer with 10 bit resolution; 4 timer-counters; real time clock RTC; watchdog; 26 versatile I/O lines; low power supply 2,7...3,6V and low current consumption; possibility of operation in the temperature range -40°C to +80°C; program memory of capacity 32kB Flash type; data memory with capacity 2 kB.

As shown by the above specification, this chip does not ensure support of required number of analog inputs. Thus it is necessary to use an analog multiplexer enabling sequential keying of eight analog sources. Such solution, however, does not impair the functionality of measurement system.

Chip power supply

The described chip requires supply with a minimum 5V voltage (condition for correct operation of the used analog multiplexer systems) and features a low power consumption. The power supply source with enough capacity will be a voltage transformer connected into the control circuit.

Dimensions of the device

Limitations for telemetric module that result from the controlled device dimensions in the case of points drive apply mainly to the current and voltage transformers used and a possibility of transmission antenna output.

REFERENCES

[1] *Ordinance of Minister of Infrastructure dated 6 August 2002 on radio transmitting or transceivers that may be used without permission.* Gazette of Law No 138 item1192

[2] *Safety requirements for railway traffic management systems.* CNTK, Warsaw (1998)

[3] Mikulski, J., Młyńczak, J.: *Diagnosis of Point Machines with PLC Controller Application,* Signal + Draht, (2003) 12