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WIRELESS MONITORING SYSTEM FOR ENERGETIC PARAMETERS FROM TRACTION SUBSTATIONS

BY

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Abstract. The design and application of the hardware and software structures for the monitoring and control of the electro energetic systems assures an efficient development of the units for production, transport and distribution of energy, allows the exploitation without risks of the energetic installations, contributes to the cutting off of the unjustified expenses regarding the process quality and allow the production and consumption of energy at optimum costs. In this way the paper presents a wireless monitoring system for the energetic parameters from traction substations organized on a SCADA system with two levels: local (that contains Data acquisition systems mounted at the level of each traction substation) and central (for centralized processing of the data from the local level).

Key words: data acquisition; dispatching; measurement; programmable logic devices; transducers.

1. Introduction

The modernization of electrical traction substations implies the replacement of the old installations from inside the electrical substations that

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supply electrical energy to the contact network, with modern automated installations, and also adding of monitoring, protection and control systems for operative drive through dispatcher of the electrical traction subsystems (Bailey & Wright, 2003; Bo *et al.*, 2016; Gheorghiu, 2007).

The main tasks of the monitoring system, organized on the SCADA system, can be grouped in:

– informing the staff within the exploitation on the state and energetic parameters from the level of each traction subsystem by using human – machine interfaces (MMI - Man Machine Interface);

– assisting the staff within the exploitation in taking decisions on executing imposed maneuvers on planned operations (connection/ disconnection, isolation from the high voltage electrical network, etc.) and operations on bringing the system to normal operation in post breakdown;

– alarm in case of undesired events (abnormal functioning of the composing equipment);

– creating an events history for the events that occurred in a certain period of time, with the moment that these happened, for later analysis.

Achieving these tasks implies the SCADA system to realize the following operations:

– taking, receiving and data interchanging;

– validation, processing, displaying and data archiving;

– issuing and execution of commands in electrical traction substations.

Real time execution of these operations allows the operator (dispatcher) to monitor the functioning of the installations, to decide the actions which have to be done and to remotely interfere if he considers that it’s necessary (Dobriceanu, 2003; Moga, 2000).

By using the human – machine interface, the information processed by the system is presented to the dispatcher staff and they can send commands to the process or they can request certain information like:

a) visualizing the technological schemes;

b) showing the analogical measures that can be done in digital format, diagrams, etc.;

c) showing the events and alarms;

d) inserting data in databases;

e) printing the desired information to a printer;

f) performing the applications execution control, etc.

2. Overview of Traction Substation and Monitoring Points

There is a great variety of electrical traction systems that were built targeting specific use (for urban transport, suburban or interurban transport) according to the zone and available technology at the specific moment.

In present time there has been recorded a permanent development in the electrical traction domain, this being determined by the high development of the power electronics and microprocessors, fact that lead to fundamental changes in designing, building and functioning of the electrical traction systems.

Electrical traction substations are fixed installations for connecting to the electro energetic high voltage system and for adapting the parameters for the electrical energy to necessities of electrical tractions, most often continuous voltage, having the value 750 V (for trams, metro) (Fig. 1).

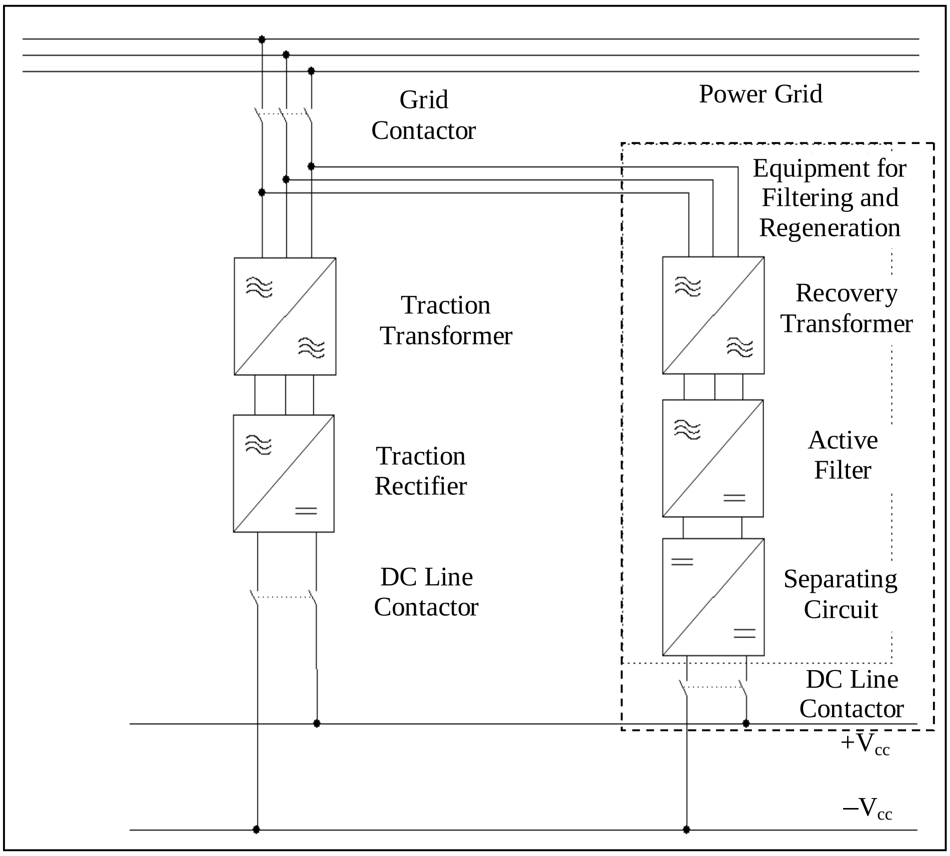

Fig. 1 – The block diagram of the Electrical traction substation.

There is imposed the necessity of measuring the instant values for:

– 2 alternative voltages: 33 kV, 50 Hz, (TU1 and TU2);

– 2 continuous voltages: 600÷2,000 V, 1,200÷2,000 V (TU3 and TU4);

– 6 alternative currents on medium voltage: 0÷80 A, 40÷2,500 Hz, (TI1, TI2, TI3, TI4, TI5, TI6);

– 2 continuous currents: 0÷1,200 A (TI7, TI8).

There is presented the block diagram that underlines the placement of the measuring points for the voltages and currents from the electrical traction substation (Fig. 2).

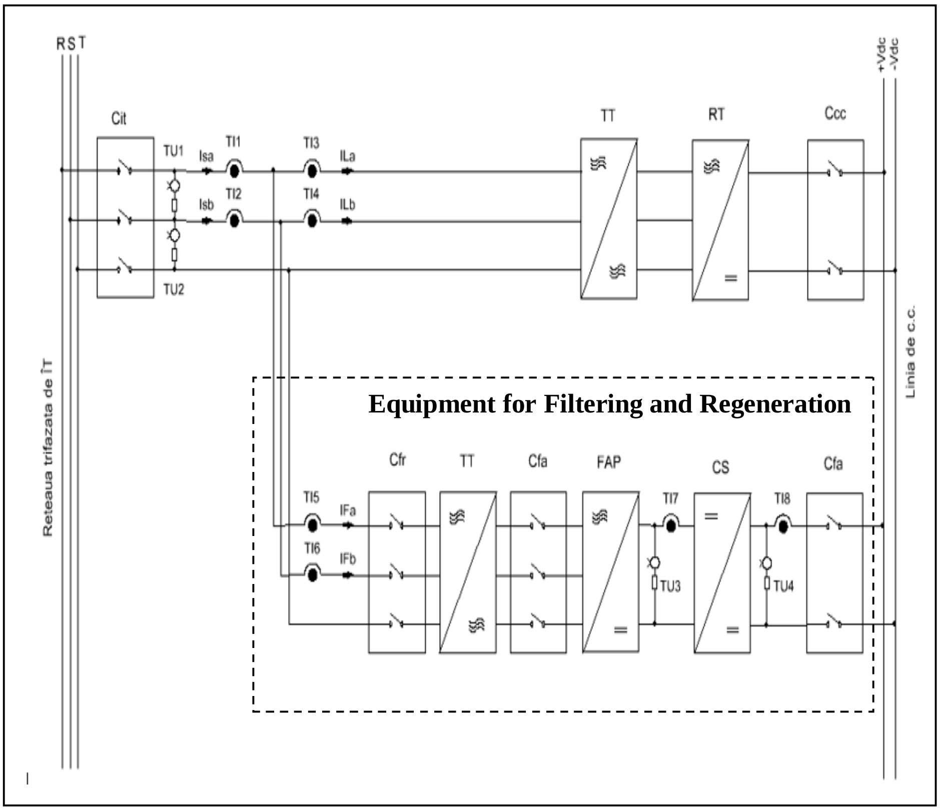

Fig. 2 – Block diagram that underlines the placement of the measuring points for the electrical traction substation.

3. Architecture of the Monitoring System

The rapid evolution in computing and communications in the last period opens the way to real time monitoring of remote activities.

This way the parameters at the level of the electrical traction substation can be transferred to a central point (at city level or country level) and properly processed for underlining parameters of interest.

Data transfer between each electrical traction subsystem and the central point (dispatcher) can be done using modern Wireless technologies using GSM networks that use GPRS offered by the GSM providers using the Mobile Internet option, and that allows sending of information from the traction substations directly to the internet network (Taylor & Kazemzadeh, 2009; Grasberg & Osterlund, 2001; Wester *et al.*, 2015; Fang, 2016).

For the monitoring system for the energetic parameters from the electrical traction substations (Fig. 3), there is used a centralized architecture, organized on two levels:

1º Level 1 – *Local* that contains Data acquisition systems mounted at the level of each traction substation, that presents information regarding the electrical parameters;

2º Level 2 – *Central (Dispatcher)* has at its core a centralized data processing center that contains computing systems in a redundant cluster type configuration.

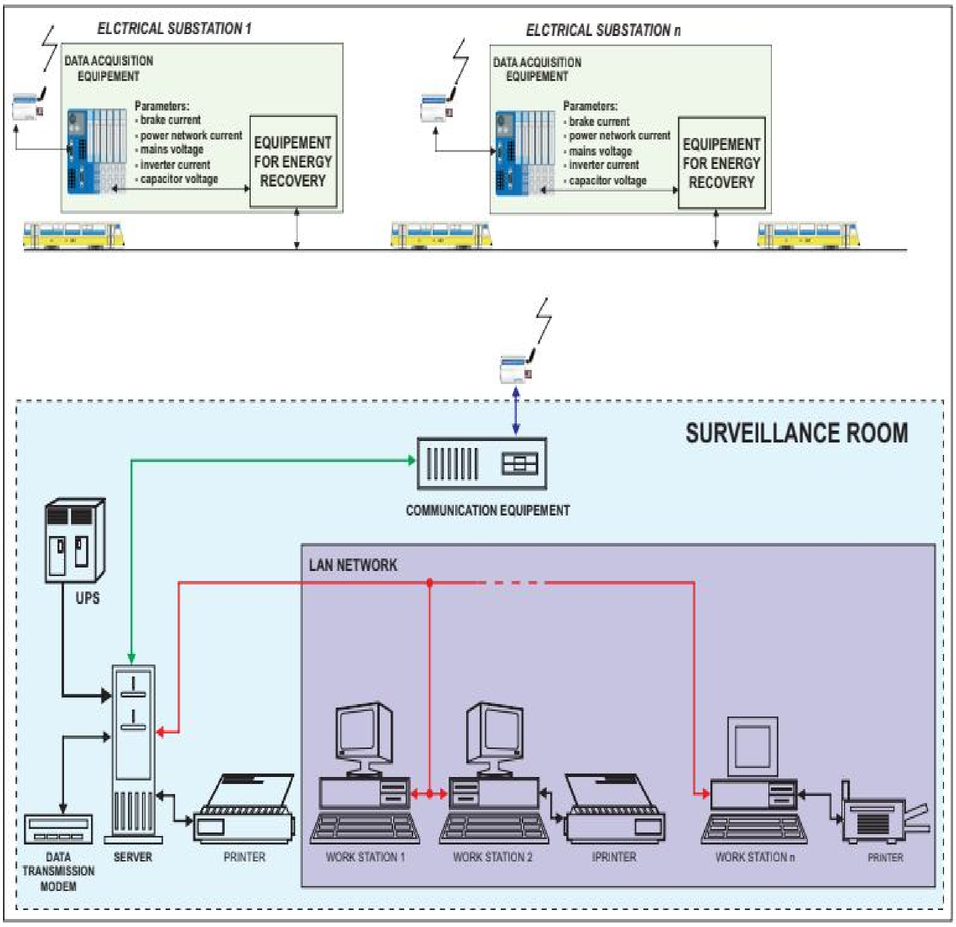

Fig. 3 – Block diagram of the monitoring system.

The monitoring system allows:

1º taking electrical measures for the electronic equipment for recovering the additional energy induced in the transport lines when the electrical vehicles break;

2º supervision of the equipment for recovering energy;

3º sending the acquired data from each traction substation to the central point (dispatcher) for monitoring, analysis and processing, by using a Wireless connection with GPRS radio modems.

4. Presentation of the Data Acquisition System at the Electrical Traction Substation Level

4.1. Structure of the Data Acquisition System

The data acquisition system (Fig. 4), is composed of:

1. *Transducers* that assure taking specific signals for the functioning of the force equipment from the traction substation:

– *voltage signals*, are done with the help of dedicated voltage transducers TU1...TU4 of measuring transformer type;

– *current signals,* are done by using dedicated current transducers TI1...TI8 of current transformer type, I_n/1A or I_n/5A.

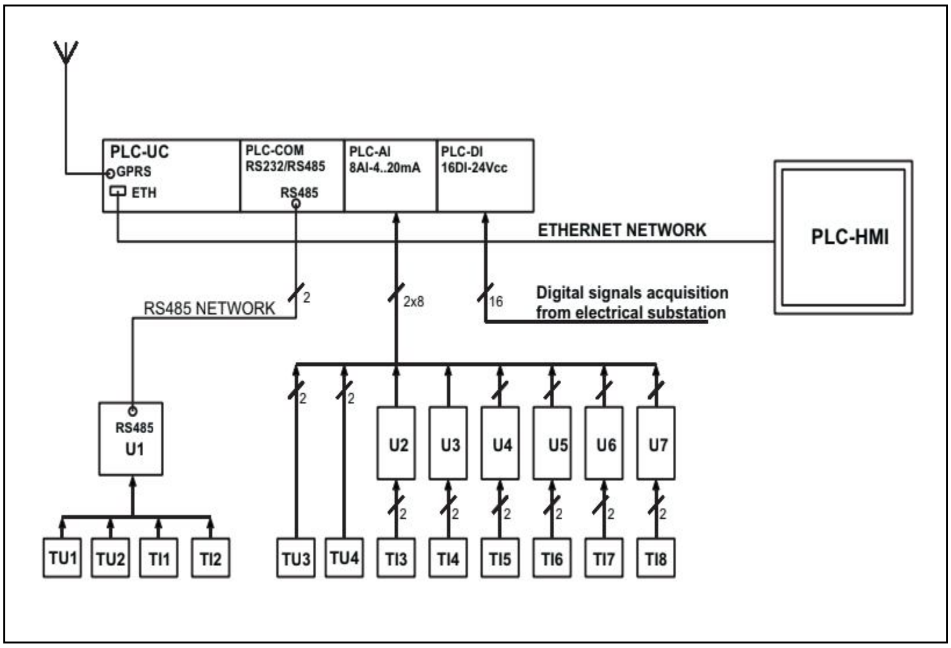

Fig. 4 – Block diagram of the data acquisition system.

2. *Network analyzer* U1 which assures the taking of the energetic parameters specific to the traction substation. The data taken and processed by this is transferred, by using a RS485 serial link using the MODBUS RTU protocol, to the PLC and from this, by using the GPRS connection, to the central point.

3. *Signal conditioners* U2...U7 that assure the signal adaptation from the output of the transducers to the level of input signal in the analogical input module of the PLC.

4. *PLC equipment with input-output modules that assure:*

– taking 16 digital inputs;

– taking 8 analogical inputs;

– communication with the energetic data acquisition equipment by using a RS485 serial link using the MODBUS RTU communication protocol;

– communication with the central point (dispatcher) by using the integrated GPRS modem.

4.2. The Technique of Taking the Signals from the Electrical Traction Substation

Transducers placing (Fig. 5), and the signal taken from the traction substation are:

– *Supply network voltage* of the traction substation (signals taken by using the transducers TU1, TU2);

– *Absorbed/Generated currents* by the traction substation from/to supply network (signals taken by the transducers TI1, TI2);

– *Absorbed currents* by the traction substation (signals taken by the transducers TI3, TI4);

– *The voltage on the recovery capacitor* (signal taken by the transducer TU3);

– *Voltage on the vehicle supply line* (signal taken by the transducer TU4);

– *Generated currents* by the filtering and regeneration equipment – compensated in traction mode and active in regeneration mode (signals taken by transducers TI5, TI6);

– *Generated current by the inverter* on the intermediary circuit (signal taken by transducer TI7);

– *Break current* – current absorbed by the filtering and regeneration equipment in the vehicle break process (signal taken by transducer TI8).

4.3. The Type of Components Used in the Data Acquisition System

A. The measuring of the voltage of supply network of the electrical traction substation, measurement points TU1 and TU2, is done with voltage transformers of VRL3 type, produced by Schneider-Electric.

B. The measuring of the 2 alternative currents on medium voltage, measurement points TI1 and TI2, is done with the current transformers of RTA 36-2 type, produced by Fabbrica Transformatori di Misura.

C. Output signals of the two voltage measuring transformers and of the two current transformers are connected directly to inputs V1, V2, V3 and inputs

I1, I2 of the network analyzer EEM-MA600, denoted U1, produced by PHOENIX CONTACT.

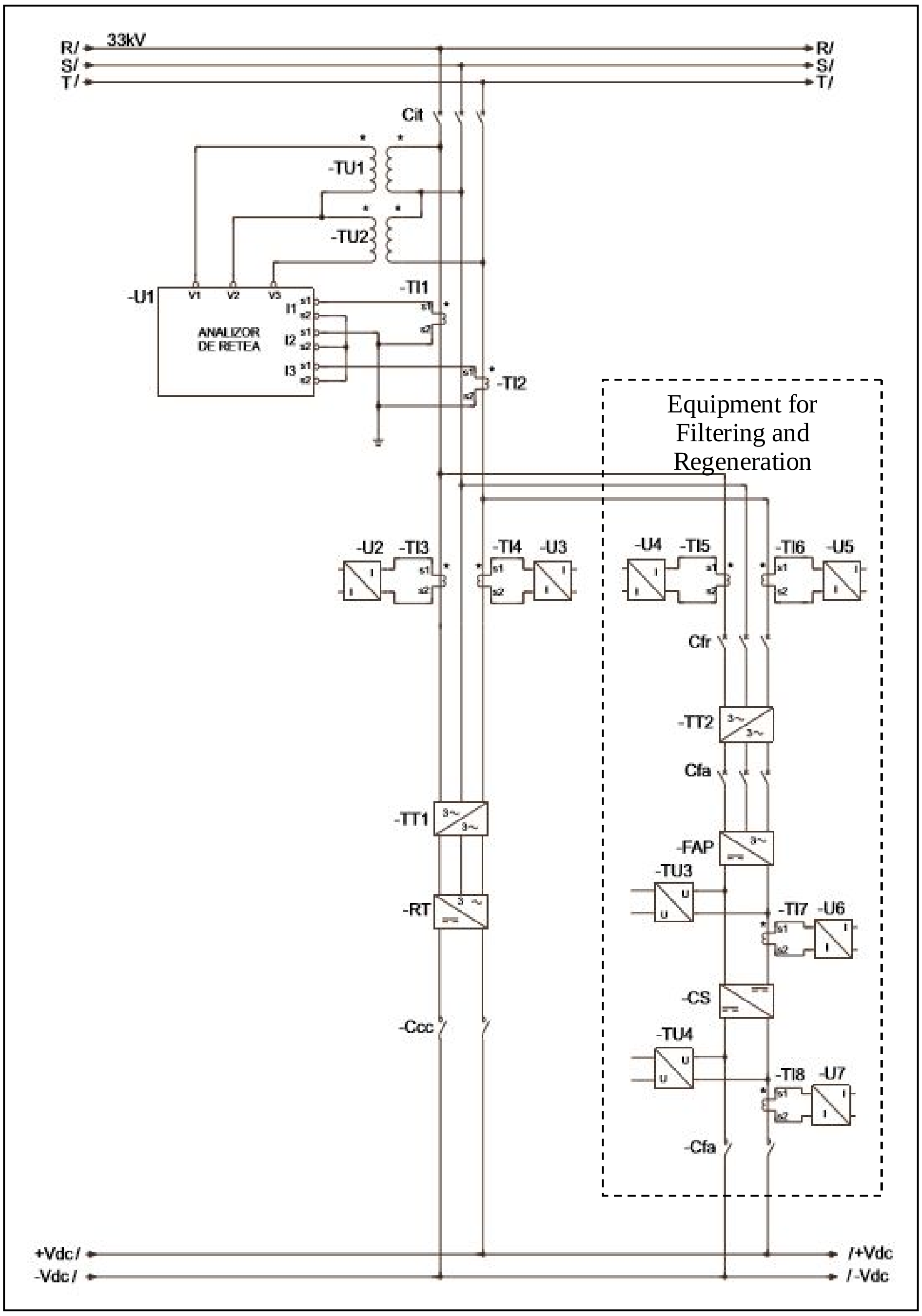

Fig. 5 – Block diagram of placing the transducers in the electrical traction substation.

D. For measuring of the 4 alternative currents on medium voltage, measuring points TI3, TI4, TI5 and TI6, there is used a measuring chain formed of the following elements:

d_1) current transformers: TI3, TI4, TI5, TI6 of type RTA 36-2;

d_2) signal conditioners of type MCR-SLP-1/5-UI-0 produced by PHOENIX CONTACT.

E. For measuring of the voltage on the compensation capacitor and for the voltage on the c.c. line measuring points TU3 and TU4, there are used two voltage transducers LEM of type CV 3-2000.

F. For measuring the currents on the c.c. side measuring points TI7, and TI8, there is used a measuring chain composed of:

f_1) current transducers LEM of type LF 2005-S/SP23;

f_2) signal conditioners of type MCR-S-1-5-UI-DCI, produced by PHOENIX CONTACT.

G. Programmable logic controller - PLC produced by PHOENIX CONTACT, that has the following structure:

g_1) Central unit module of type ILC 151 GSM/GPRS;

g_2) Digital input module of type IB IL 24DI 16;

g_3) Analogical input module of type IB IL AI8/SF-PAC;

g_4) Communication module of type IB IL RS485/422;

g_5) Source module TRIO-UPS/1AC/24DC/5, UPS incorporated.

H. HMI Display (Human Machine Interface) of type TP 3070W, produced by PHOENIX CONTACT.

5. Conclusions

The paper presents a wireless monitoring system for the energetic parameters from traction substations that have at its core a hierarchical structure, in order to inform the staff within the exploitation on the state and energetic parameters at the level of electrical traction substation and to assist the dispatcher in decision making for executing different maneuvers.

The system can be used in many practical applications because it's based on the progress gained in measurements, communication and information technology domains using latest generation components.

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SISTEM DE MONITORIZARE WIRELESS A PARAMETRILOR ENERGETICI DIN SUBSTAȚIILE DE TRACȚIUNE

(Rezumat)

Conceperea şi aplicarea structurilor hardware şi software privind monitorizarea şi controlul sistemelor electroenergetice, asigură o dezvoltare rentabilă a unităților de producere, transport şi distribuție a energiei, permit exploatarea fără riscuri a instalațiilor energetice, contribuie la eliminarea cheltuielilor nejustificate privind calitatea proceselor şi permite realizarea producției şi consumului de energie la costuri optime. În acest sens lucrarea prezintă un sistem de monitorizare wireless a parametrilor energetici din substațiile de tracțiune organizat pe structura unui sistem SCADA cu două nivele: local (ce conține Sisteme de achiziții de date montate la nivelul fiecărei substații de tracțiune) şi central (pentru prelucrare centralizată a datelor provenite de la nivelul local).