Using GSM-Modules to Control the street lighting AND Industrial Electric Power Supply Systems

N. Matanov[1], R. Pachamanov[2], D. Bibev[3], A.Pachamanov[4]

Abstract – **The possibilities of using the GSM technology for controlling the outdoor lighting systems and electric power supply objects are analyzed in this paper. Opportunities for data exchange using GSM network are discussed – between regional informational systems and power supply objects by a local area network. The costs of using the services of a GSM operator in Bulgaria are evaluated as an alternative of using a single radio channel and conventional systems for data exchange.**

Keywords – **Control, GSM-modules, Electric Power Supply**

I. Introduction

A. Control Systems Using a H.F. Radio Channel

A system for centralized control of the street lighting of Sofia using a high-frequency radio channel was developed during the period 1982-1988 [1,2]. A centralized radio control system removes the need for a large number of photocells and clocks with astronomical devices on site that are normally used for turning on and off the street lighting systems. Selective control based on the natural illuminance (with thresholds 10, 20, 40, 60 and 80 lx for the different categories of streets) improves traffic safety and reduces electricity consumption. Operating under the so-called "midnight regime" (the lamps work at 50% of their nominal flux after 10pm) reduces the amount of electric power consumed by an additional 30% [3].

Since the system is idle for a large part of the day, it is also used for control of central stations for heating installations in Sofia. One main disadvantage of the system is the lack of feedback regarding the execution of the given commands the installation of sending-receiving devices instead of receiving devices on site increases the cost of the system, and the system was not completed in that respect [1]. That is why the protocol used is to send the commands many times. This reduces to a minimum the possibility that a command will not be executed.

The controlling computer in the dispatcher station is connected through RS232 with a central station. The latter transmits information to re-transmitting stations that cover the desired region (Fig. 1). The controlling software carries out

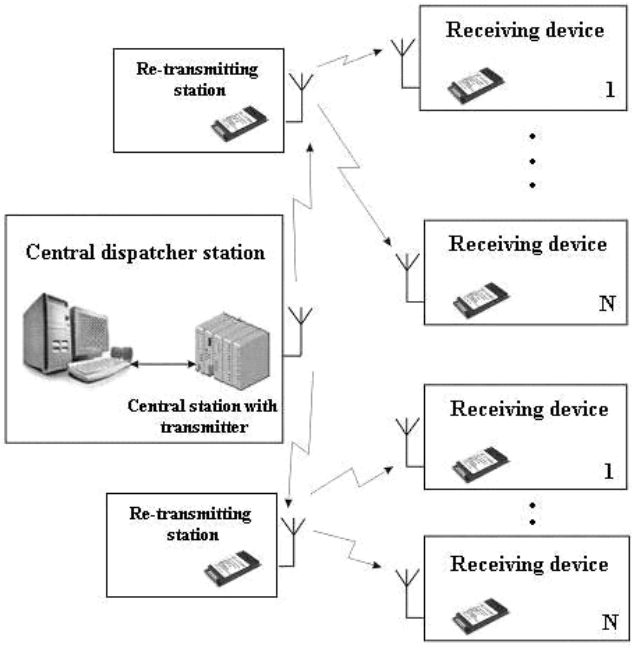

Fig. 1. Block diagram of the centralized H.F. radio channel system for street lighting control in Sofia [1]

three types of control of the street lighting installations [2]: a) simultaneously for all street lighting installations, covered by the system; b) according to specific regions (25 in Sofia); c) according to categories of streets (major avenues, large streets, small local streets); under three operating regimes: a) automatic; b) software-controlled (according to the astronomical calendar and system clock); c) manual.

The automatic regime uses a signal from a central photocell that measures the natural illuminance. The signal turns the street lighting installation on when the natural illuminance moves between 100 and 4 lx, and turns the lighting installations off when the natural illuminance moves between 4 and 100 lx. The threshold level is selected according to the category of street. If a signal is not received for a given time period, the system becomes software-controlled. Both software and automatic control require specifying a threshold of illuminance. The latter threshold determines the astronomic calendar used for control.

B. Using GSM for Controlling Outdoor Lighting Systems and Substations

During the years after developing the system for radio management the information technologies improved a lot. One of them is the GSM which in a case of a little number of re-

[1]Nikolay Matanov, Electric Power Supply and Equipment Department, Technical University – Sofia, nsm@tu-sofia.bg

[2]Radostin Pachamanov, Faculty of Communications and Communication Technologies, Technical University – Sofia, radostin_ap@abv.bg

[3]Dimitar Bibev, Electric Power Supply and Equipment Department, Technical University – Sofia, dbib@tusofia.bg

[4]Angel Pachamanov, Electric Power Supply and Equipment Department, Technical University – Sofia, pach@tu-sofia.bg

ceivers (for example when turning on street lighting not from electric boxes, but from transforming stations) makes unnecessary developing of local area radio networks with preserved radio frequency. Using the GSM-modules for transmitting data is very convenient for long distances – for example constructing regional controller's posts of similar power objects. The main advantage consists in the fact that already built network of an acting operator is used. So it is unnecessary to make investments for creating your own network. Nowadays when the GSM network is well developed it is quite convenient to use it for transmitting information between the observed objects and a controlling post with a random location as there is a good cover almost everywhere in the country.

II. The Essence of the Problem

A. Special Features when Using a GSM-Network for Exchange Information between Controller's Posts and Subordinated Stations

The exchange of information is realized through GSM-modules controlled by microcontrollers or computers. There are two main possibilities to transfer data between GSM networks.

The first one is by means of SMS (SMS - Short Message Service) which are up to 160 symbol messages. Through these 160 symbols it is possible to transfer information between supervising post (with computer or a central station type SCADA – Supervisory Control And Data Acquisition) and controlled posts which are situated in the transformation stations in the built-up areas or in the substations in power objects in the industry. The advantage of this variant is that the GSM-standard is used which provides the correct receiving of the SMS – i.e. the received message is identical with the transmitted. Another advantage is that this type of service is very cheap. Disadvantage of using SMS is the fact that this service doesn't have a priority, i.e. a message in a GSM network is going to be sent only if the network is not overloaded (the transfer of SMS is realized through signalization channels which are usually used for controlling the calls). Because of that it is possible an SMS sent to be delayed or even not received. Therefore using SMS for transferring information is convenient only when most the SMS-s transfer similar information, for instance when presenting information concerning the status of power objects – in that case the possible loss or delay of some messages is not crucial for describing the process (systems for telesignaling). With improvement of the mobile networks of the GSM-operators the quality of this service (SMS) could be increased and therefore the reliability of this type of transferring information in systems for tele-signaling could be increased.

The second way for information transferring is by using the service "data transfer" of GSM-operators. The GSM-phone/module needs a modem in order to use this service. The so-called "data number" is preliminary paid to the operator and "transparent" mode of transferring information in the GSM network is provided (the system doesn't change your information when operating with it). The transferring information sides get access to the network as the modem provides the information to be in conformity with the GSM standard. The network commutes calls between subscribers and the following transmitting of the information differs from the standard conversation by the fact that the analog to digital conversion is missing. For this reason this service is much cheaper than the standard conversation. After realizing the connection the data exchange can be provided by random protocol, because of the "transparent" mode of data transfer. Therefore it is possible to create more complicated protocol for data exchange, different from the previous variant for transfer through SMS with only 160 symbols. The GSM-modules offered now at the market (modem + GSM transceiver) [6,7] permit building the controlling system on subscribers principle (Fig. 2).

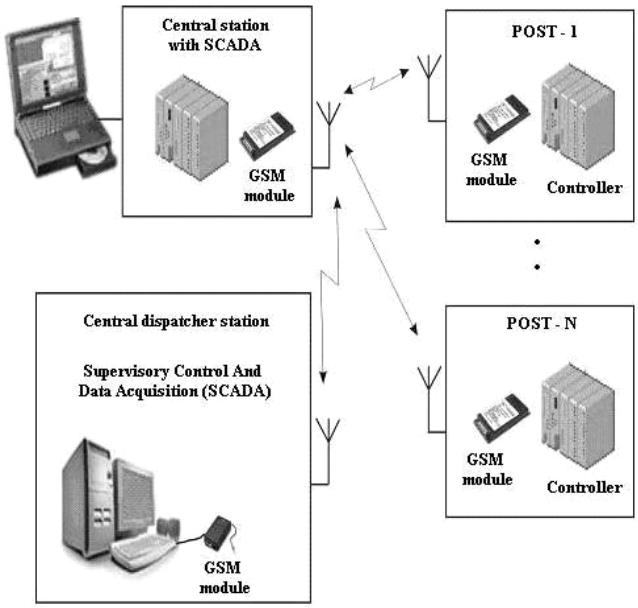

Fig. 2. Diagram for controlling distant power objects (substations) by GSM-modules

B. Data Exchange through GSM-Network between Dispatcher Station and Local Systems for Data Exchange

Local area networks for information exchange between controlled devices and local base station (Fig. 3) are developed for power objects in industry as well as for road devices. These objects are situated in separate substations in industry and in road areas they could be found at comparatively big distances – for example road tunnels with lighting installation, ventilation, fire and other safety systems.

The configuration of the system shown on Fig. 3 is applicable for medium distance between the controlled posts. For example distances between the devices in local control systems in road tunnels are from one to several kilometers. The system, shown on Fig. 4, is applicable for industrial enterprises or centralized management of equipment in trafostations or regional substations where the local systems have dozens or hundreds meters line length.

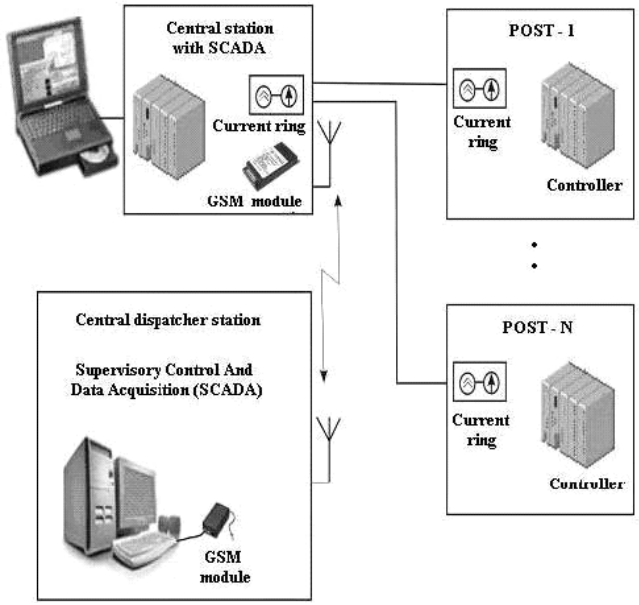

Fig. 3. Variant for using GSM-modules as connection between local base stations and regional dispatcher station – the local base stations contain a central station SCADA type, exchanging information by a current ring with controlled posts situated several kilometers away.

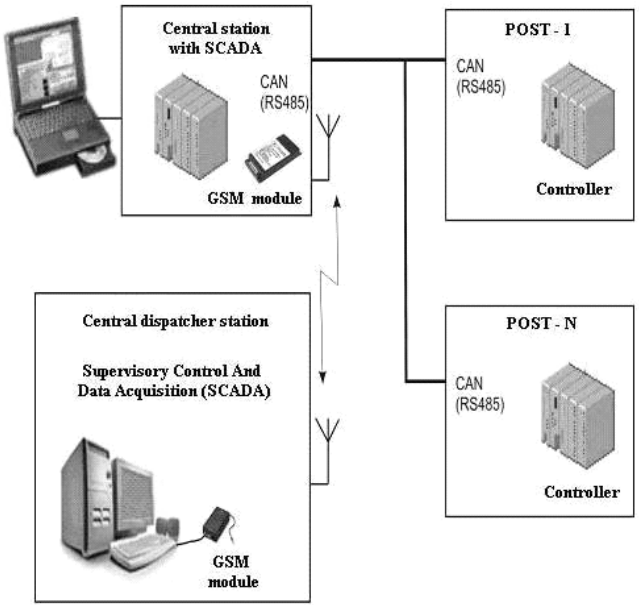

Fig. 4. Variant for using GSM-modules when connecting local base stations with regional dispatcher's station - the local base stations contain central station type SCADA exchanging information with the controlled posts situated on dozens (CAN) or hundreds (RS485) meters.

In both cases the connection between the central stations of local area networks and the dispatcher's point is by using a GSM network and the distance is not significant. A typical feature of the discussed schemes is the fact that the local systems fulfill their functions independently and the staff at the dispatcher's point is involved only when an extraordinary circumstance appears. So the main function of the dispatcher's station is to collect information on purpose of observations of the processes.

C. An Example for Developing a Regional Dispatcher's Point for Road Tunnels

There are four road tunnels each of them with two independent tubes on "Hemus" highway. Two of them ("Vitinia" and "Praveshki hanove") have local information control systems built [8]. During the following years similar systems will be created on the tunnels "Topli dol" and "Echemishka". Constructing of regional dispatcher's station for the four tunnels (Fig. 3) is convenient to be established at one of the command rooms in the tunnel substations which are situated in 30 kilometer section of the "Hemus" highway. The latter will allow decreasing the staff on duty to two persons (for the four tunnels) and the off duty staff can be retrained to maintaining the equipment, working during the day. Thus the preliminary designed schedules for increasing the energy effectiveness of the tunnel lighting on "Hemus" highway can be fulfilled.

D. Centralised control and Voltage Regime Controlling in Industrial Enterprises, Example

In some industrial enterprises some of the transformer substations are not included in dispatcher control system. At the voltage regime control among on-load-tap-changer in the main substation it is often to happen to the local power factor correction capacitors to be switched on or switched off. If the transformer substation has additional voltage regulators (Fig. 5) their managing also can be an object of dispatcher's (controller's) intervention. When telephone line to the object is missing it is appropriate to use GSM-network for realising the necessary switching over and data collection. In this case the data exchange expenses will be minimum, because the dispatcher's intervention is random and the GSM-module from the transformer substation takes initiative only in case the observed parameters exceed the limits.

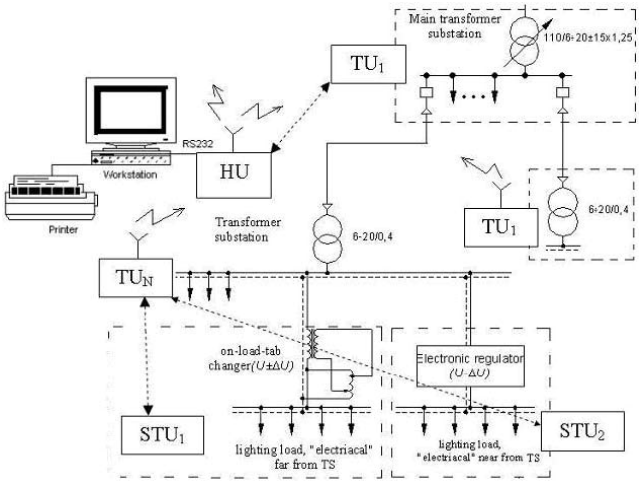

Fig. 5. Control of lighting systems voltage in industrial enterprises

III. Additional Remarks

In cases when controlled post is built as an information system the local system information is sent only if at demand or when changing the controlled parameter.

In the first case receiving tele-signaling information and possibly delivering tele-control commands will be done on behalf of the GSM-device in the controller post. In the second case renovating information to the controller post will be on behalf of the GSM device in the local system. As the demand for tele-signaling information comes from the dispatcher's post payments become minimum for most of the local stations because using prepaid exchange SIM-card (about 20 BGN annually for GSM-module). When the installations in some of the controlled energy object frequently change their status and their GSM-module is programmed to renovate the information, then paying monthly permanent tax is preferable (about 120 BGN per year + 0.05 BGN per minute for data exchange). In all cases that refers to dispatcher's post GSM-module, because the bigger part of its data exchange is on its account (recurrently inquiring information about the status of the objects in the local systems).

IV. Conclusion

The suggested organization of GSM-communications among local area networks of energy objects with random location and central dispatcher's post has significant priorities compared to the H.F.-radio-channel with preserved frequency. First it refers to using an already built network which covers the whole country. This permits connection of many self-working local systems into general regional systems – for road lighting control, traffic light systems, regional road tunnels, etc. In that case the distances between the dispatcher's post and local systems of the energy objects are not significant. Second, the data exchange could be organized so that the expenses to be minimum (one recurrently inquiring GSM-module in the dispatcher's post with monthly permanent tax and many GSM-modules in the local controlled systems with a prepaid annual tax). Last but not least we must take into account the high reliability of that kind of systems.

References

[1] [1] Vassilev N.I. and .... System for feedback of H.F. radio channel system for street lighting in Sofia. Design of devices and software. Report 1234/1989, Research Sector, Technical University-Sofia

[2] [2] Pachamanov A., K. Zaharinov, N.Vassilev. Data acquisition and control H.F. radio channel system for street lighting. Osvetlenie'93, 21-23 September 1993, Varna

[3] [3] Pachamanov A.S. About regimes of work of street lighting. "Energetika", No 3-4/ 1992, Sofia.

[4] [4] Pachamanov A., Hr.Vassilev, N.Matanov, B.Bojchev, I.Angelov. Controller for monitoring of street lighting according to the astronomic calendar. Electric power forum '98, June 10-12 1998, MDU - Varna, book II, p. 324-328

[5] [5] Bibev D., A. Pachamanov. Control and monitoring of voltage for lighting systems in industrial enterprises. ELMA02, Sofia, September 13-14, 2002

[6] [6] http://www.motorola.com

[7] [7] http://www.siemens.com

[8] [8] http://www.tunnellighting.com