07 - 10 September 2009

PROCEEDINGS

54. IWK

Internationales Wissenschaftliches Kolloquium

International Scientific Colloquium

Information Technology and Electrical Engineering - Devices and Systems, Materials and Technologies for the Future

Faculty of Electrical Engineering and Information Technology

TECHNISCHE UNIVERSITÄT ILMENAU

Impressum

Herausgeber: Der Rektor der Technischen Universität Ilmenau
Univ.-Prof. Dr. rer. nat. habil. Dr. h. c. Prof. h. c.
Peter Scharff

Redaktion: Referat Marketing
Andrea Schneider

Fakultät für Elektrotechnik und Informationstechnik
Univ.-Prof. Dr.-Ing. Frank Berger

Redaktionsschluss: 17. August 2009

Technische Realisierung (USB-Flash-Ausgabe):
Institut für Medientechnik an der TU Ilmenau
Dipl.-Ing. Christian Weigel
Dipl.-Ing. Helge Drumm

Technische Realisierung (Online-Ausgabe):
Universitätsbibliothek Ilmenau
ilmedia
Postfach 10 05 65
98684 Ilmenau

Verlag: isle
Verlag ISLE, Betriebsstätte des ISLE e.V.
Werner-von-Siemens-Str. 16
98693 Ilmenau

ISBN (USB-Flash-Ausgabe): 978-3-938843-45-1
ISBN (Druckausgabe der Kurzfassungen): 978-3-938843-44-4

Startseite / Index:
http://www.db-thueringen.de/servlets/DocumentServlet?id=14089

ELECTRONIC INTRUDER ALARM SYSTEMS IN OBJECT PROTECTION

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ABSTRACT

The main task of the electronic intruder alarm system (EIAS) is early signalization of an intruder or an attempt to get into the protected area (object) or of a non-verified activity. On its own or with human help it accelerates transmission about the intruder to responsible persons. Suitably it complements and increases the quality of classical and regime protection as part of the integrated security system.

Index Terms – electronic intruder alarm system (EIAS), ground perimeter system (GPS), passive infrared detector (PIR)

1. INTRODUCTION

Recently the biggest threat upon security is the increasing change in the nature of the attacks with attempt to conduct burglary, terrorist sabotage or another attack with aim to damage or destroy the protected object or person inside. Therefore the necessary part of protection of important objects like airports, military areas, nuclear electricity objects, industrial objects and so on is the use of electronic intruder alarm systems.

Protection of life and property has always been the basic condition of survival of the human race. Threatening danger could stem from the forces of nature (lightning, fires, floods) or from human beings. Primary mechanical barriers were levers, fences, doors which protected people from a direct danger of the attack. With the development of technology people started using the electric energy for the protection of objects against intruders. Electronic sensors, acoustic, capacitance, microwave and pyro-electric sensors, started being applied. Nowadays sophisticated protection systems based on, *eg*, neuron networks, biometric systems, camera systems with video-detection working in visible and infrared ranges of the spectrum are increasingly used.

The first known electrical security system was designed by Austus Pope in 1853 (Somerville, MA, USA). It consisted of a contact (window, doors, *etc*) and a bell with battery. Later, in 1854, Holmes (Boston, MA, USA) installed the first security system connected with a police station.

This contribution is about the issues of outdoor alarm systems, their division and basic description. In the contribution we focus mainly on external security of objects. We present a brief comparison of individual basic principles of object protection for external perimetric protection. With regard to the minimum disturbance and non-detectability, we describe a system suitable for practical realization and utilization in terrain. The result of this work is a functional concept of an external intruder alarm system which allows recognizing the type of disruption of the protected area. We focused mainly on the design of an EIAS based on pressure hose-pipes, its functional principle and characteristics. For the purpose of practical application of such a principle in object protection, we worked out a basic configuration of the central unit of the GPS system using a digital signal microprocessor in order to manage the activity, collect the data and take logical decisions. After choosing the suitable components we suggested the wiring diagram and created a PCB board for the central unit. Subsequently we created a master program which was debugged and applied in the GPS system. The resulting system was tested in real conditions in external areas of FEI STU. Three different types of disruption were simulated and for each type a typical response was chosen and evaluated. For improving the parameters of this system it would be possible to increase its sensitivity to vibrations which spread out through the solid environment (when placed under asphalt, concrete) as well, using a vibration sensor (piezoelectric crystal) applied to the hosepipe ending with a membrane. Electric voltage generated by the crystal after being processed by the processor control unit is compared with the pressure sensor signal and on the basis of “learnt” characteristics it evaluates the arising of alarm. In this way the GPS system is able to detect with prediction different kinds of disruption, identify them and therefore considerably increases the intruder alarm system protection level.

The result of this work is implemented in a functional external security system which could possibly be further extended and elaborated to a highly sophisticated one. Its biggest advantages are especially its invisibility and possibility of copying any kind of surface.

2. MECHANICAL PROTECTION SYSTEM

Basic security elements are parts of a mechanical protection system. Their task from the point of view of the crises management is to make it harder or practically impossible to get to the protected area which is expressed by the maximum length of the time interval necessary for reaching the protected interest. The basic quality sign of the mechanical protection system is the time they are able to resist the intruder. This is expressed by the number of resists units (in the case of the safe system or length of the time interval which is necessary to break them). We can express this quality by the coefficient of risk „*K*“ ($K=2T_N/T_{ro}$) which determines the quality of the protections, where T_N is the sum of all individual times of breaking the mechanical protections (doors, windows, *etc*) and T_{ro} is the time of reaction of the security guard. The optimum interval of K is 8 - 10.

3. ELECTRONIC INTRUDER ALARM SYSTEM

3.1. **Protection of the boundaries of the object**

For signalizing disruption of walls, doors, windows, most frequently magnetic detectors, glass break detectors, vibration detectors, infrared barriers, *etc*, are used.

3.2. **Protection of the indoor perimeter**

To signalize disruption of the delimited area (or perimeter) inside of objects, most frequently passive infrared, ultrasonic, microwave, or combinations of detectors are used.

3.3. **Protection of outer perimeter – signalized**

Disruption of the outdoor perimeter – on the boundary of the estate (fences, outer doors, *etc*): magnetic contacts, active infrared (AIR), driveway sensor fault wire fence, buried line detectors, fence motion detection system (guard wire), GPS are used most frequently.

3.4. **Protection of special objects**

Safe weapons, code-machines, *etc*: the most frequently are used seismic detectors, capacitance detectors, PIR 360, infrared barriers, *etc*.

3.5. **Protection of the persons**

PA, personal attack, panic attack signalizes a direct attack on persons. The most frequently are used PA, money bill – trap, *etc*.

4. DESIGN OF OUTDOOR PERIMETER PROTECTION SYSTEM

Department of Microelectronics FEI STU Bratislava Slovakia has focused on the design and implementation of the EIAS, for a long time. The achieved results are applied in various organizations as well as in education of students.

4.1. **Outdoor perimetric intrusion detection system**

The most important as well as most expensive EIAS are those which protect or signalize disruption of outdoor parts of objects. Construction of outdoor detectors must be suitable for the outer environment. The system is designed for a length of 100 - 200 m, while the indoor system for only 10 - 20 m. Another difference is the shape of the security area, and the great number of various types of motions to which they must not be sensitive. It is waving of grass, motion of the leaves and tree branches, bushes stream of the atmosphere, wind, snow and rain.

The basic request upon outdoor detectors is temperature resistance, independence of the effect of frost or snow and therefore they often have inner heating.

4.2. **Principle of action**

The task in designing the system using the pressure pipes was to propose a highly efficient and inexpensive security system of for protecting outer area. The advantage of this GPS is the possibility of height and terrain copying. After seeding grass, the system is invisible and it is impossible to locate it. By suitable detecting of the signals it has a reliable detection of intrusion and low influence of interference of false alarms. Ground pressure pipes present a hydraulic pressure detector in which a non-freezing liquid affects the transmitter of sound (more precisely: changes of ground pressure) whose changes are consequently monitored. When the intruder crosses the protected area, the seismic wave spreading trough the earth starts up. The seismic wave causes an acoustic wave in the pressure pipe. Changes of the pressure in the pipe are measured by the pressure sensor whose signal is processed. If the signal exceeds a given limit, alarm is switched on.

4.3. **Description of GPS system**

Almost the whole system, except of the measuring unit, is placed in the ground. According to the need of sensitivity of the system, the depth of placing is in the range of 15 to 30 cm under the ground. The sensitivity depends on the type of soil and its strength. The length of one zone of the system can be 100 - 150 m. The pressure bearing medium has to be non-freezing. The detection pipe transmits changes of the pressure of the liquid from the outer environment to the pressure detector. We used a MVq hose with diameter 14 mm and wall thickness 2 mm. The system was designed in double configuration according to Fig. 1. The difference of pressure between the two pipes is measured, which excludes the static pressure of the soil acting on both pipes. The closing vent placed between the pipes compensates the pressures between them. We use a differential pressure sensor SIEMENS QBE 63 - DP1 with pressure range 0 - 10 kPa and output 0 - 10V for measuring the differences of the pressure. The maxim allowed pressure ($P_1>P_2$) 75 kPa must not act permanently. It belongs to intelligent sensors. It is integrated, calibrated and has a temperature compensation (–40°C to 120°C).

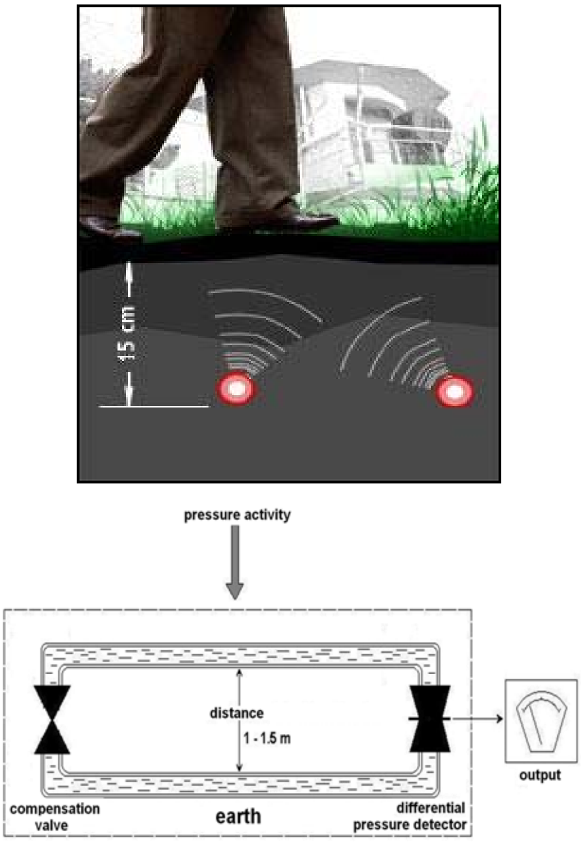


Figure 1 Basic configuration of two detecting pipes in GPS system

4.4. **Construction of the system**

The system was designed and constructed on one PCB with minimized influence of possible individual parts by shielding the whole system (Fig. 2).

The most important task in measuring the signal in the security system is to prevent false alarms, *ie*, to set the boundaries of interfering influences. The GPS system is resistant to environmental conditions since it is placed underground and so it is resistant to high frequency interference (EMC). The most frequent source of false alarms are vibrations created by the traffic seismic activity and by crossing animals. This is why the minimum pressure changes should be set higher than the changes of interfering influences. We set the limit of alarm after exceeding the limit of 30 kg, according to the static measuring this level of voltage on the pressure sensor is 1.5 V at a temperature of about 20°C.

For controlling and measuring we used microprocessor MICROCHIP Ds 30 F 3010. Basic configuration of the unit is in Fig. 3.

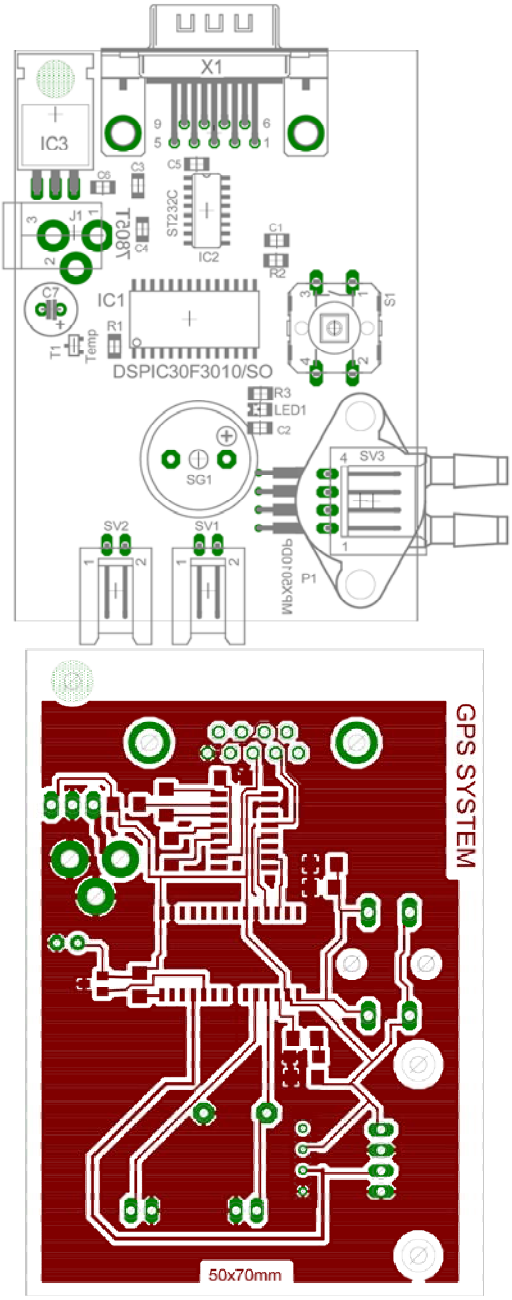


Figure 2 PCB of ground perimeter system

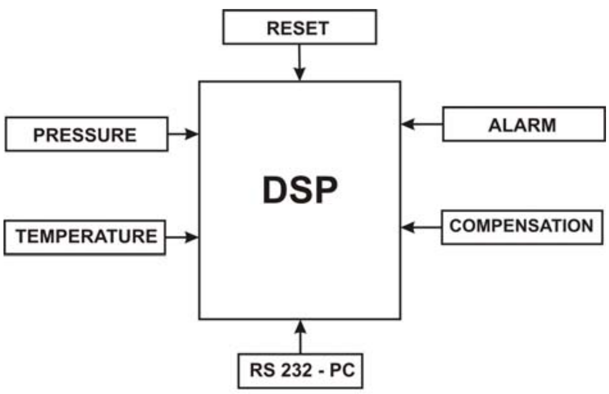


Figure 3 Input / Output parameters

We used DANFOSS EV 225 B as a compensation vent which balances the pressure in the pipes. The program controlling the whole system was designed so that the pressure of the sensor is measured 100 times per second for a time of 10 seconds. The measuring of the pressure is then interrupted for half a second and self compensation of the system with the compensation vent is performed.

Removing the "failure" of measuring during self compensation is possible by using the redundancy of two pairs of pipes with various times of compensation. The limit level of sensitivity of the system changes with the temperature of the surroundings, therefore it was necessary to measure the influence of the temperature upon the amplitude of the measured level (from –10°C to +20°C). The shape and orientation of the depicted dependence looks like the arc tangent function and therefore we were looking for the solution in this form

$$f(U_R) = A.\arctan(B.Temperature + C) + D$$

For this solution we used non-linear regression according to the Newton method by program EXCEL to express individual roots of the function *A*=0.194383, *B*=0.252382, *C*=0.355181, *D*=1.235949

$$f(U_R) = 0{,}194383.\arctan(0{,}252382.Temperature + 0{,}355181) + 1{,}23594$$

The dependence of the measured value on earth temperature is in Fig. 4.

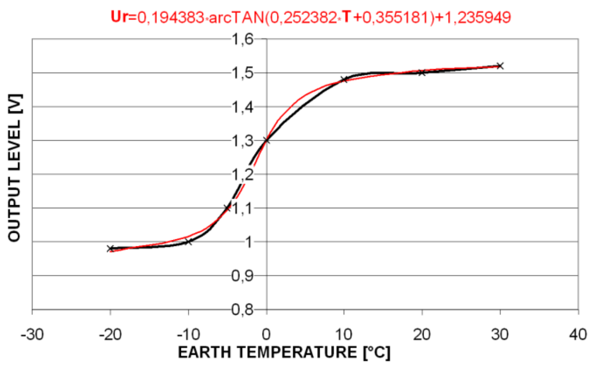


Figure 4 The dependence of the output level on earth temperature

4.5. Experimental verification of the action of GPS in real conditions

The designed and constructed system GPS was placed in the earth in a depth of 20 cm, the distance between the measuring and reference pipe was 25 cm. The reference pipe was protected by being placed into a metal pipe with diameter 30 mm. Static measurement was performed by measuring the dependence of the output signal on the distance of the detector pipes for various weights of persons as shown in Fig. 5.

The intrusion was simulated by a person with a weight of 87 kg at temperature of the surroundings about 9°C (the limit of the alarm is 1.46 V).

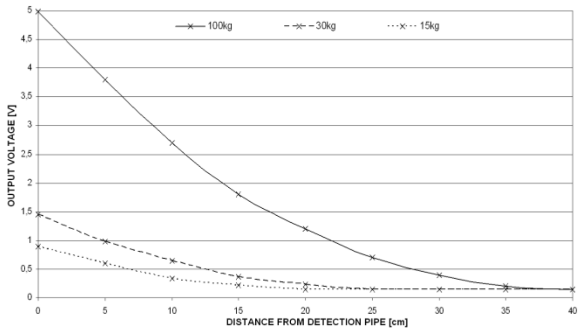


Figure 5 The dependence output signal from distance of detector pipes by various weight

We implemented the measuring by a software digital memory oscilloscope with input of the measured data through RS322 (Fig. 6).

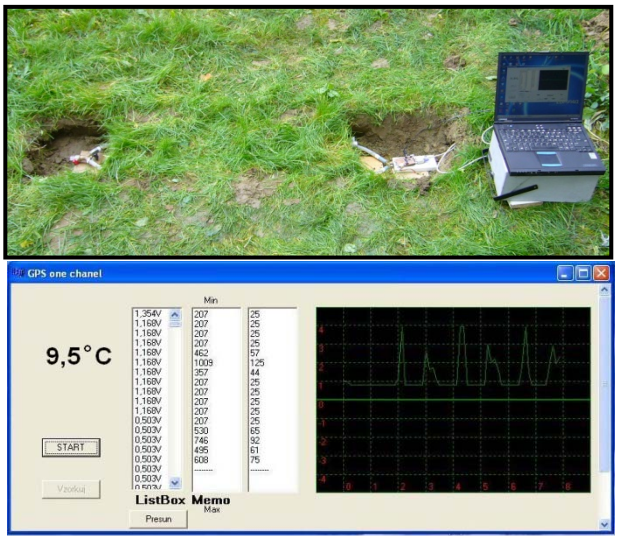


Figure 6 Measurement system in real conditions

Dynamical measurements were conducted in these simulated cases of intrusion:

I. Crossing of the intruder – contact directly above the detecting system (Fig. 7a).
II. Crossing of the intruder- attempt to jump over the detection zone (Fig. 7b).
III. Crawling of the intruder – through the detection zone (Fig. 7c).

4.5.1. Simulation of intrusion by crossing

In this case the intruder crossed directly above the detection system at a speed of about 1.5 m.s^{-1}. The measured response of the system was in the interval of 2 seconds. The output signal was made up by more impulses, and the maximum response was 4.88 V , which means a pressure of 10.3 kPa. This signal shows steps of the intruder, the system detecting the first step from a distance of 1.5 m from the sensor pipe. The output voltage is in Fig. 7a.

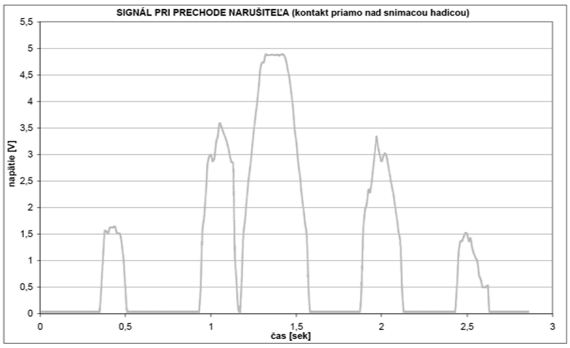
4.5.2. Simulation of intrusion by attempt of jumping over the zone

The intruder tried to jump over the detection zone in a distance of 1.5 m from the sensor pipe with a length of about 2.5 m. The output signal did not reach the full range of the sensor since the acting pressure was not directly above the measuring system (the maximum response was 3.43 V, which means pressure 7.1 kPa). The signal depicts primarily the end of jumping of the intruder by 2 peaks, subsequently the first and second legs. The output voltage is in Fig. 7b.

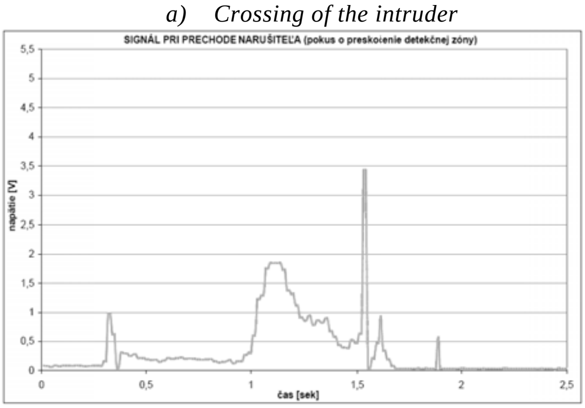
4.5.3. Simulation of the intrusion by crawling over the detection zone.

The response of the system during crawling over the detection zone at a speed of about $0.3\ m.s^{-1}$ was measured in a time interval of 9.5 s. The maximum response was 4.84 V which means pressure 10.2 kPa. The output voltage is in Fig. 7c.

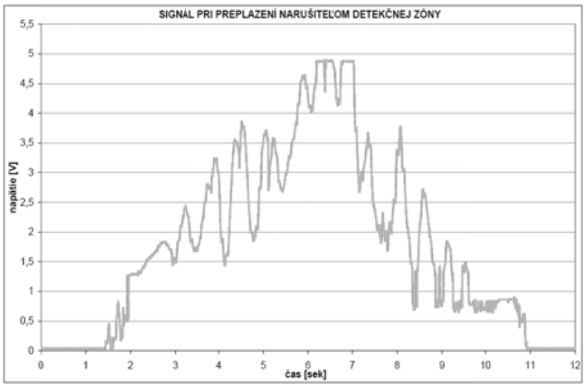
All the ways of the simulation triggered alarm. The width of the detection zone is 3 m, however, by using both active (measuring) pipes at a distance of 1.5 m it would increase to 4.5 m. This would be very difficult to get trough.



a) Crossing of the intruder



b) Jump over detection zone



c) *Crawling of the intruder*

Figure 7 Measured results in real conditions

5. CONCLUSION

The goal of this work was the analysis of the issue of security systems. We focused on the analysis of the types of electronic protection, and on designing a security system for outer protection of objects implemented by a system with pressure pipes GPS (ground perimeter system), its principle of action and properties. Basic configuration of the system, wire diagram, selection of the components, control and measurement codes for the microprocessor were made. The function in dependence on the outer temperature was experimentally verified by several types of intrusion simulation.

The result of this work is a functioning external underground security system (GPS) that reveals any kind of trespassing in the protected area.

6. ACKNOWLEDGEMENTS

The presented work was supported by the Slovak Grant Agency VEGA under project VG – 3098 – TVA – SK.

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