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APPLYING A NON-TYPICAL ELECTRICAL LINE IN BURGLARY PROTECTION

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Radoje Jevtić[1], Milan Blagojević[2]

[1]Nikola Tesla School of Electrical Engineering
[2]The Faculty of Occupational Safety
E-mail: milan.jvtc@gmail.com

Abstract. *Fire and burglary detection systems are systems that present a combination of the most advanced electrical, mechanical, hydraulic and optical solutions for the purpose of protecting human lives, the living and working environment and material properties. The basic components of these systems are detectors. Detectors can be of different types, depending on practical solutions, prices and other technical properties. As detectors, different types of non-typical lines can be used, such as coaxial cables or special constructed electrical lines depending on the purpose. The change in some of the parameters of noted detectors, such as their capacity, impedance, resistance or the like, according to temperature, pressure, torsion or other disturbances, can be used for the detection of burglary or fire. This paper is just a small part of a large study being carried out for the purpose of the realization of a PhD thesis entitled Fire and burglary protection using non-typical electric lines which was approved by the University of Niš, evidence number 8/20-01-003/11-019.*

Key words: *Non-typical electrical line, Coaxial cable, Burglary*

1. INTRODUCTION

Technological advances lead to the advance of many modern systems including fire and burglary protection systems. Fire and burglary detection systems belong to the class of real time systems that have a primary goal – the detection of fire at an early stage. They can be constructed as separate systems, which depend on the purpose, but they can also be constructed as one unique system capable of identifying different disturbances and undertaking proper actions. The basic component of this type of system is the detector of phenomena related to fire or burglary disturbance - smoke, heat, flame, gaseous components of combustion pressure, impact or the like. All of them must have specifications such as sensibility, inertia, a ranging zone and disturbance protection. From the aspect of technology, fire and burglary detectors should be appropriate according to

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conditions such as the measuring range, selectivity, the type of exit value, environmental conditions, etc.

The protection of some large objects where it is important to, beside the detection of fire or burglary and an appropriate response in the sense of action, determine of the right distance from where the fire has started, represents special cases of fire and burglary protection. This is important for tunnels, hangars and similar objects where the length of object can be considerable. That means that the fire or burglary detectors should be distributed according to the full length of the object, in the appropriate place and at the appropriate altitude, they should be easy to install and capable of having an adequate reaction for an adequate amount of time.

In the case of heat detectors, it is important to note that they do not have a unique principle of realization because the energy of fire can be detected in many different ways. For that purpose large group of sensors elements based on the expansion of metals, the dependence of the electric resistance on temperature, the dependence of electric capacity on temperature, the melting speed of alloy, the speed of the propagation of fluids, coaxial and temperature cables, and the dependence of magnetic induction on temperature were used.

The same applies for burglary protection also. Burglary detectors can consist of different elements, electrical components or devices that have to be sensitive to pressure, impact, noise, striking, touch, temperature and the like.

The different types of heat-sensitive cables were the first and the oldest way for the linear detection of fire, especially in tunnels. The main problems related to this type of fire detectors were slow response without the possibility of determining distance from fire center. This applies to the linear detection of burglary. It is important to note that in some cases it is not important to detect the precise place of the disturbance, as it is important to detect the disturbance itself, which is enough for proper safety action [1, 11, 12].

Generally, a lot of electrical lines and cables have several temperature- or pressure-dependent parameters such as resistance, capacity, time delay, input or output current, input or output voltage, phase and others, whose change could be used for fire or burglary detection. Of course, there is the possibility for the production of a special, non-typical electric cable appropriate for some conditions that can be used for fire and burglary detection [7, 8].

Coaxial cables have their own property in the sense of changing resistance, capacity and impedance according to temperature, pressure or similar disturbances. Limited to an appropriate length, they present the capacitors with determined capacity, depending on the type of cable and their dielectric and isolation. This kind of capacitor is implemented in the appropriate electrical circuit where the change in capacity due to temperature can change some other values, such as voltage or current, and can make a resonance or a delay in the signal through the coaxial line. All these changes could be measured in a reliable way with reliable instruments. Also, there are some techniques that could be used for the precise determination of the place of the disturbance, such as, for example, impulse reflectometry [3, 4, 10].

2. The Experiment

The complete experiment was realized in laboratory 113 and long hallway in front of the laboratory in the Nikola Tesla School of Electrical Engineering in Niš at a working temperature of 16, 22°C and normal humidity. For the experiment, a special cable was constructed. The outer part of cable was made of PVC material 2mm thick. The cross section of cable takes the form of a square, with dimensions 14mm × 14mm. Inside the cable, there were two metal strips made of aluminum, 1mm thick. Between the strips, there was PE foam, with an approximate dielectric constant $\varepsilon_r \approx 1,53$. The complete cable was constructed from twenty parts, where the length of every part was 5m.

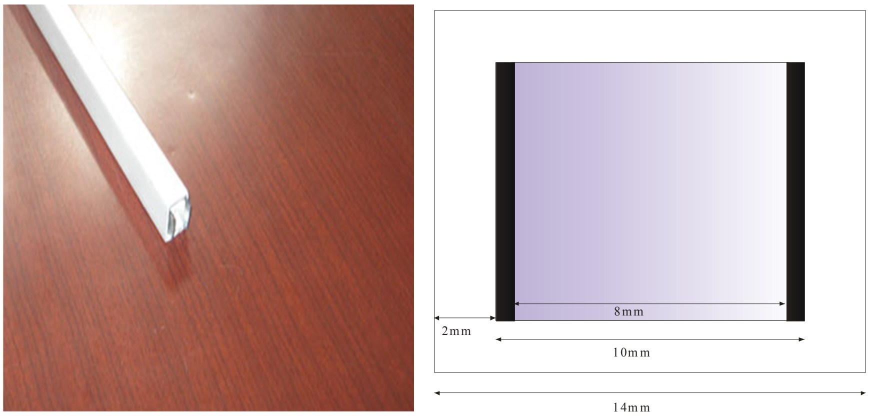

Fig. 1 The cable (left) and its cross section with dimensions (right)

This was done because this way of protection implies that the form of the protected area should be a polygon. The cables are connected one to another by welding and they represented serially linked capacitors. The connected cables, in polygon form, are switched in the bridge circuit shown in figure 2. The connected cable has its own capacity, and it is marked as C_1. In the opposite bridge branch, there is capacity C_2, an adjustable capacitor whose capacity is set to be equal to capacity C_1. For the constructed cable, for 100m length of cable, the calculated value for C_1 is 1,623 nF, while the measured value for C_1 is 1,628 nF. The values for other elements are R=1000 kΩ, R1=5000 kΩ and C=1 μF, respectively. The resonance circuit was supplied with an alternate voltage amplitude of U = 10 V at a frequency of f = 1 kHz, and as the generator, the function generator with sinusoid signals was used. A lower frequency was selected to eliminate possible parasite effects at higher frequencies. The measuring instruments were the MASTECH company instruments, MS8221C model and Data Logger multimeter C-122. The function generator was the Peak Tech 4025 model. All of elements in the electrical circuit were adjusted.

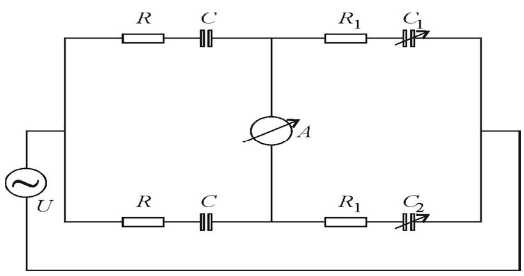

Fig. 2 The electrical resonance bridge circuit used in the experiment

In the normal state, the bridge is balanced and there is no current through the instrument. The basic idea is that if there is any pressure on the cable that causes displacement or bending, there will be a change in its capacitance and thus disturbed disturbance in the balance of the bridge, which will be detected by a particular value of current through the instrument. The pressure disturbance on the cable was simulated with PCE-FM 200, a device for measuring force. The cable was exposed to different forces, whose values changed from 10 N to 30 N in the steps of 5 N and, according to these disturbances, the current values through the instrument in the electrical bridge were recorded. The direction of the pressure disturbance is from up to down or inverse, because this disturbance will cause a change in the capacity of the cable and that can be detected by the measuring instrument. The stronger the force of the cable, the bigger the current flowing through the instrument [2, 5, 6, 9, 13].

3. THE MEASUREMENTS AND CALCULATION RESULTS

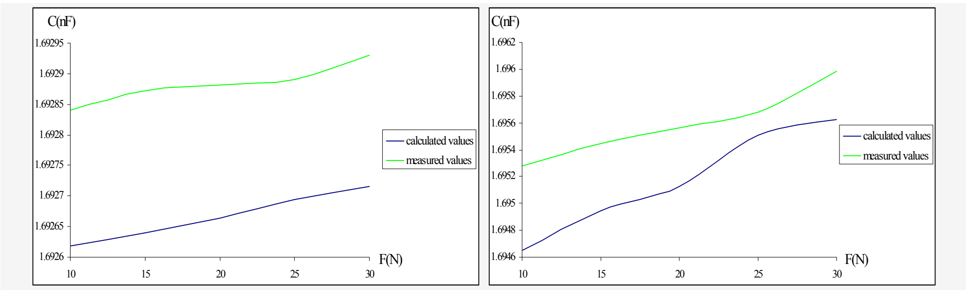

Fig. 3 Measured and calculated results of cable capacity dependence related to force for a cable disturbance part of 1cm (left) and for a cable disturbance part of 10 cm (right)

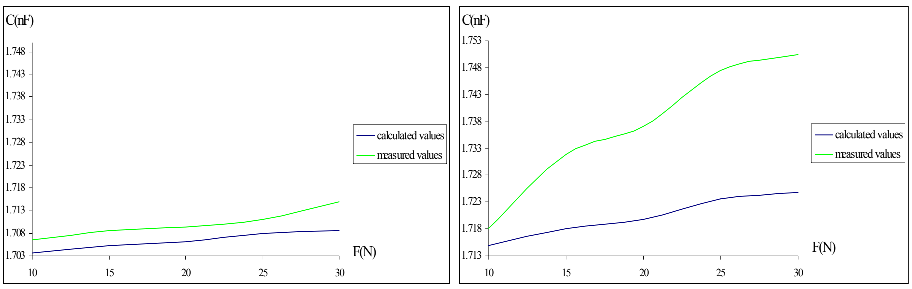

Fig. 4 Measured and calculated results of cable capacity dependence related to force for a cable disturbance part of 50cm (left) and for a cable disturbance part of 1m (right)

Due to space constraints, the measured and calculated results were shown on the same figures, although the proportion for both values was not the same. The calculated results were obtained by the MATHEMATICA 8.0.4, PSPICE 9.1 and Work Bench 5.12. The measured results were repeated several times in order to obtain as precise results as possible.

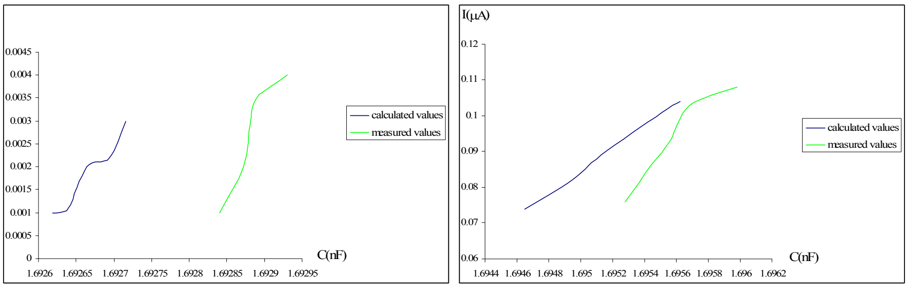

Fig. 5 Measured and calculated results of instrument current dependence related to capacity change for a cable disturbance part of 1cm (left) and a part of 10 cm (right)

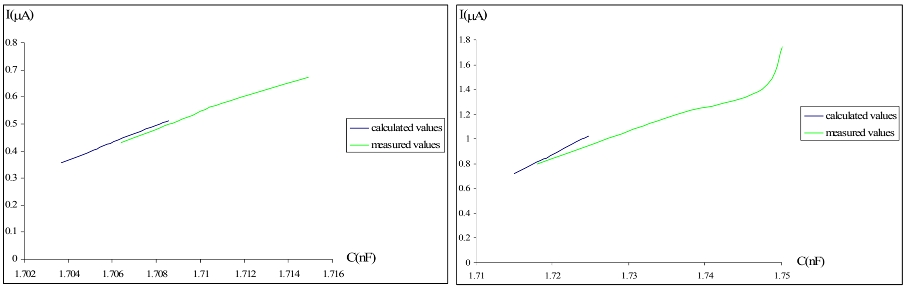

Fig. 6 Measured and calculated results of instrument current dependence related to capacity change for a cable disturbance part of 50cm (left) and a part of 1m (right)

4. Conclusion and Future Investigation

According to the aforementioned, it can be concluded that the measured results are slightly different from the calculated results, which can be seen in figures 3, 4, 5 and 6. This was expected according to the different calculating terms and technical difficulties during the experiment.

The realized results showed that particular pressure disturbances cause cable capacity changes, which also cause current to flow through the measuring instrument, which can be detected and measured. According to the pressure disturbance, different currents flow through the instrument, the stronger the pressure disturbance, the bigger the current flowing through the instrument. Instead of a measuring instrument, in real conditions, the current dependence switch would be installed and in that way, would control and provide the proper action in a burglary system. It is very important to note that this mode of protection should be used for the protection of an object in combination with some other form of burglary protection. Protection around the area can take the form of a polygon. Temperature variations of ± 20 °C have a negligible effect on the realized results.

The advantages of using this cable as a burglary detector are: simple construction, simple installation, arbitrary form around the protected object or area, disabling of false alarms which can be caused by some other disturbance such as wind, rain, animals or the like, easy settings of elements, the possibility of using it in summer and winter.

The disadvantages of using this cable as a burglary detector are: requirement of another form of burglary protection, weak reaction to disturbances from the left and right sides of the cable, the possibility of momentary interruption of the cable, the inability to determinate the distance from place where the pressure disturbance occurred, to name a few.

The achieved results present just a small part of a possible research based on using specially constructed and coaxial cables as non-typical electrical lines in fire and burglary protection systems. Our future investigations will be focused on several different tasks, as follows. The first task will be to develop mathematical functions for more precise burglary distance determination, using some other types of non-typical electrical lines such as optical cables or the like. The second step will be to examine the same parameters used in this work in order to detect fire in fire protection systems and the realization of a special non-typical electrical line that brings together fire and burglary protection purposes. The last step in this investigation will be the construction of proper hardware and software for complete automatic management of a fire and burglary protection system with non-typical electrical lines as fire or burglary detectors.

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PRIMENA NETIPIČNOG ELEKTRIČNOG VODA U SISTEMU ZA ZAŠTITU OD PROVALE

Sistemi za zaštitu od požara i provale su sistemi koji predestavljaju kombinaciju najnaprednijih električnih, mehaničkih, hidrauličnih i optičkih rešenja u cilju zaštite ljudskih života, radne i životne sredine kao i materijalnih dobara. Osnovne komponente ovih sistema su detektori. Detektori mogu biti različitih vrsta, u zavisnosti od praktičnih rešenja, cena i ostalih tehničkih karakteristika. Kao detektori se mogu upotrebiti i različite vrste netipičnih električnih vodova, kao što su koaksijalni kablovi ili specijalno konstruisani kablovi u zavisnosti od namene. Promena nekog od parametara pomenutih detektora, kao što su kapacitivnost, impedansa, otpornost ili slično u odnosu na temperaturu, pritisak, torziju ili neki drugi poremecaj može se iskoristiti za detekciju provale ili požara. Ovaj rad predstavlja mali deo istraživanja u okviru doktorske disertacije „Zaštita od požara i provale primenom netipičnih električnih vodova", odobrenog od strane Univerziteta u Nišu, sa evidencijskim brojem 8/20-01-003/11-019.

Ključne reči: *netipični električni vod, koaksijalni kabl, provala*