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HISTORY

SST 2018 – CONFERENCE PROGRAM

Conference venue: Hotel Osijek, Šamačka ul. 4, 31000, Osijek, Croatia

Wednesday, 10 October 2018

Greetings
(Room A – Lipa)

9:00 AM – 9:15 AM

General Chair: Professor Drago Žagar, Ph.D.

Audio, Image and Video Processing
(Room A – Lipa)

9:15 AM – 10:35 AM

Chair: Mario Vranješ

Thursday, 11 October 2018

E-Health
(Room A – Lipa)

8:30 AM – 9:30 AM

Chair: Marijan Herceg

Luka Bartolić, Bruno Zorić, Goran Martinović
E-Gluko: A Ubiquitous System for Health Status Monitoring and Tracking in Diabetes Patients

Friday, 12 October 2018

Internet of Things and Cyber Security
(Room A – Lipa)

9:00 AM – 10:00 AM

Chairs: Darko Andročec, Krešimir Grgić

Dijana Oreški, Darko Andročec
Hybrid Data Mining Approaches for Intrusion Detection in the Internet of Things

Hrvoje Leventić, Tomislav Keser, Krešimir Vdovjak
A Fast One-Pixel Wide Contour Detection Method for Shapes Contour Traversal in Binary Images

Tomislav Keser, Krešimir Nenadić, Gabrijela Kramar, Hrvoje Radman
Feature Extraction Based on Directional Contour Tracing Descriptor

Davor Kedačić, Marijan Herceg, Vukota Peković and Velibor Mihić
Application for Testing of Video and Subtitle Synchronization

Nenad Pekez, Nives Kaprocki, Jelena Kovačević
Firmware Update Procedure for Audio Systems based on CS4953xx DSP family

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Smart Power Systems and Electrical Drives (Room B – Kesten)

9:15 AM – 10:35 AM

Chairs: Marinko Stojkov, Denis Pelin

Vedrana Jerković Štil, Krešimir Miklošević, Željko Špoljarić, Goran Kurtović
Induction Motor Sensorless and Closed Loop Torque Control in Frequency Converters

Andrej Brandis, Denis Pelin, Matej Žnidarec, Viktor Varjú
Performance Analysis of Switching Techniques for Induction Motor Drives and Experimental Verification with Smart Didactic System

Marjan Ugljar, Tin Benšić, Marinko Barukčić
Space Vector Modulation Implementation on RTOS/FPGA Embedded System

Antun Stoić, Marinko Stojkov, Ivan Samardžić, Miroslav Duspara
Energy Efficiency in Machine Tool

Luka Filipović, Marijan Herceg, Tomislav Matić
Influence of Human Body Motion on DCSK Performance over HBC Channel

Filip Novoselnik, Ratko Grbić, Irena Galić, Filip Dorić
Automatic White Blood Cell Detection and Identification Using Convolutional Neural Network

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ICT in Power Systems (Room B – Kesten)

8:30 AM – 9:30 AM

Chairs: Srete Nikolovski, Dragan Mlakić

Srete Nikolovski, Dragan Mlakić and Hamid Reza Baghaee
Arc Flash Incident Energy Simulation in PV Power Plant Connected to Distribution Network

Domagoj Talapko, Sejid Tešnjak, Hrvoje Glavaš
Comparison of Electrical Architectures for Support of the Software Defined Data Centres

Hrvoje Glavaš, Frano Zovko-Ribić, Dražen Dorić, Domagoj Talapko
Development of Energy Management Standards

Keynote Lecture (Room A – Lipa)

9:40 AM – 10:40 AM

Thomas Pock, Learning Better Models for Inverse Problem in Imaging

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Coffee Break

10:40 AM – 11:00 AM

Opening Ceremony (Room A – Lipa)

Marko Pavelić, Zvonimir Lončarić, Marin Vuković, Mario Kušek
Internet of Things Cyber Security: Smart Door Lock System

Edi Muskardin, Marija Brkić Bakarić and Maja Matetić
Implementation of Hashing Algorithms in Stream Mining

Microgrids (Room B – Kesten)

9:00 AM – 10:00 AM

Chair: Danijel Topić

Dragan Mlakić, Hamid Reza Baghaee, Srete Nikolovski
Islanding Detection in Microgrids including VSC-based Renewable/Distributed Energy Resources: An AI-based Technique

Matej Žnidarec, Danijel Topić, Damir Šljivac, Zvonimir Klaić, Andrej Brandis
Influence of Load Peak Shaving on Battery System Capacity in an Islanded Building Microgrid

Heidi Marguš, Matej Žnidarec, Damir Šljivac
Achieving Nearly Zero Energy Standard and Island Operation of FERIT Osijek Microgrid

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Coffee Break

10:00 AM – 10:30 AM

Round Table (Room A – Lipa)

10:30 AM – 12:00 AM

Moderator: **Damir Šljivac**
Smart Energy in Rural Areas

Technical Lecture (Room A – Lipa)

Coffee Break

10:35 AM – 11:00 AM

Modelling and Smart Measurements
(Room B – Kesten)

11:00 AM – 1:00 PM

Chair: Slavko Rupčić

Jure Konjevod, Petar Mostarac, Martin Dadić, Roman Malarić
Analysis and Development of Digital Sampling Wattmeter Components for Precise Electric Power Measurement

Lajos Józsa, Ivica Petrović, Hrvoje Glavaš and Marko Vukobratović
Installation Lines Testing by Impulse Reflectometry Based Method

Ivan Raguž, Dražan Kozak, Krešimir Crnogorac, Mladen Hercog
Designing and Calibration Of The System For Remote Strain Control

Branimir Ivšić, Martin Dadić and Roman Malarić
Cut-off Frequency Optimization of Ultraspherical Microstrip Filter

Dina Jukić, Željko Hederić, Marinko Barukčić, Ivan Mijić
Effects of Water Capillary Action on Capacitance of Parallel Plate Capacitor

Vanja Mandrić Radivojević, Slavko Rupčić, Nataša Nešić, Goran Benšić
Radiation Pattern of the Spherical Antenna Array Based on Archimedean Spiral

Lunch

1:00 PM – 2:00 PM

Keynote Lecture
(Room A – Lipa)

11:00 AM – 11:30 AM

Chairs: TBA

Keynote Lecture
(Room A – Lipa)

11:30 AM – 12:30 PM

Davor Pavuna, On Quantum Computing, Kurzweil Singularity and Beyond

Lunch (Restaurant)

12:30 PM – 1:30 PM

PhD Forum ICT
(Room A – Lipa)

1:30 PM – 3:00 PM

Smart Energy
(Room B – Kesten)

1:30 PM – 2:50 PM

Chairs: Viktor Lovrenčić, Damir Šljivac

Ružica Kljajić, Martin Ivić, Goran Knežević
The Optimal Bid of the Thermal Power Plants on a Day-Ahead Market

Mladen Antolić, Boris Fažo, Srete Nikolovski, Zoran Baus
Active demand energy services decomposition

Alessandro Niccolai, Alberto Dolara, Francesco Grimaccia
Analysis of Photovoltaic Five-Parameter Model

Viktor Lovrenčić, Srete Nikolovski, Thomas Jordan, Marius Engebrethsen, Ana Lovrenčič
Computer Aided Arc Flash Risk Assessment According to IEEE and DGUV Standards

12:00 AM – 1:00 PM

Marko Bunić, M.Sc.E.E., Siemens d.d., Zagreb
The Way to Digital Transformation, How Future Factories Work

Closing Ceremony
(Room A – Lipa)

1:00 PM – 1:15 PM

Coffee and Light Lunch

1:15 PM – 2:15 PM

3:00 PM – 4:00 PM

Edgar Weippl, Research Methods and Examples of Research in Distributed Systems Security

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Coffee Break

4:00 PM – 4:30 PM

Computational Intelligence (Room A – Lipa)

4:30 PM – 5:50 PM

Chair: Damir Filko

Andreas Dyrøy Jansson, Bernt Arild Bremdal
Genetic Algorithm for Adaptable Design using Crowdsourced Learning as Fitness Measure

Dražen Bajer, Bruno Zorić, Goran Martinović
Empirical Analysis of Artificial Bee Colony Algorithm Parameters

Bruno Zoric, Dražen Bajer and Goran Martinović
Utilising Filter Inferred Information in Nature-inspired Hybrid Feature Selection

Denis Vajak, Ratko Grbić, Mario Vranješ, Dejan Stefanović
Environment for Automated Functional Testing of Mobile Applications

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Robotics and Industrial Systems (Room B – Kesten)

4:30 PM – 5:30 PM

Chair: Robert Cupec

Soujanya Mantravadi, Charles Møller, Flemming Max Møller Christensen
Perspectives on Real-Time Information Sharing through Smart

Excursion, Gala Dinner and Awards Ceremony

3:30 PM – 10:00 PM

Factories: Visibility via Enterprise Integration

Zoltán Jakó, Ádám Knapp
Business Scenarios and Data Flow in NeMo Hyper-Network

Alejandro R. Barroso, Roque Saltaren, Gerardo Portilla, Juan S. Cely, Marco Carpio
Smooth Path Planner for Dynamic Simulators Based on Cable-Driven Parallel Robots

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6.00 PM -7.00 PM City Tour (Starts from the hotel Osijek)

7:30 PM – 10:00 PM Welcome Reception (Restaurant Muzej okusa)

FERIT

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Instalation lines testing by Impulse Reflectometry based method

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***Abstract*— This article analyses the working principles and the possibility to applicate impulse reflectometry in finding defects and failures discontinuities of installation cables, as well as finding discontinuities in the lines. Based on the theory of wave travel, mentioned reflections of impulses are done by measuring instruments, whose purpose is to determine the discontinuity - change in impedance along the line. This physical property is used as the traveling waves behave specifically while crossing discontinuities. Waveforms that are presented in this paper can be also observed in practical applications and examples of those applications are also given in this paper. Based on the information provided by proposed method it is possible to determine the type of cable fault, intentional - for example, unauthorized consumption or unintentional - mistake due to a malfunction. In addition, if proposed method is properly employed, it is possible to locate the exact defect location in the conductor with high accuracy.**

***Keywords*—cable fault, discontinuity, fault location, impulse reflectometry**

I. Introduction

Reflectometry methods have been used for locating faults sending a high frequency signal down the line, which reflects back at impedance mismatches such as open or short circuits, gauge changes and specially in bridged taps[1-5].

The difference (time delay) between the incident and reflected signal is used to locate the impedance discontinuity on the wire. The nature of the input signal is used to classify each type of reflectometry test. Time Domain Reflectometry (TDR) uses a fast rise time pulse. [6–9] Frequency Domain Reflectometry (FDR) including Phase Detection Reflectometry (PD-FDR), and Mixed Signal Reflectometry (MSR), uses sine-wave signals to locate the fault on the wire. Multicarrier Reflectometry (MCR) uses a combination of sine waves with random phases [9]. Sequence Time Domain Reflectometry (STDR) uses a pseudo-noise sequence (PN sequence), and Spread Spectrum Time Domain Reflectometry (SSTDR) uses a sine-wave-modulated PN sequence [9,10].

The rapid development of telecommunications and energy grids has resulted in an increase in the number of failures, especially in urban areas. These failures and errors can occur on cables in the ground, wall etc. Finding those failures and errors can be very time consuming and difficult to detect by standard methods [11,13,14] . This led to the development of a device and method for measuring defects on cables with the principle of reflection of the emitted impulses of the fault location, which requires maximum efficiency in their finding and correction. The described method is called Arc Reflection Method (ARM) and it is proven in the field of locating high-ohm faults without errors and it has become the standard method for locating faults with high resistance in the measuring systems of all cable manufacturers. ARM is the most frequently used and easiest method to implement method today for locating high-ohm faults and disturbances in a cable that can occur occasionally. ARM light arc method has been more refined, so that it now uses a new method ARM PLUS with double impact that creates an even stronger light arc in the fault area that lasts even longer without changing the fault impendence. The fault stays high-ohm and the reflectometer can show it on the display. The impedance is not changed and the fault did not become low-ohm, and with percussive voltage method the fault can be easily seen and micro-located [12].

This paper is organised as follows: the second chapter introduces the theoretical working principal of impulse reflectometry, the velocity of spreading impulse, and the reflection factor is described. In the third chapter the most frequent types of characteristic responses of faults, defects and discontinuities that occur in low and high-voltage networks are theoretically described. The fourth chapter brings an example of usage and measurement of the reflectometer and in the end the final considerations is given.

II. Working Principle of Impulse Reflectometry

Impulse reflectometry provides a visual representation of the fault type and location in the cable, which allows registration of multiple failures on the measured cable and, with the appropriate procedures, can determine their distance from the observing point. Measurement accuracy depends on a number of factors, primarily the error which brings the instrument itself, but also on the technical documentation of cables. When using the instrument that, for example, contributes to the error of only ± 5 ‰, the location of the fault can be determined if the cable length is less than 10 km. In that case the deviation in the fault location result would be ± 50 m.

Physically, it would ultimately mean the excavation route of the cable in the length of 100 m.

Impulse reflectometry is based on the reflection that occurs in places of impedance discontinuity along the cable. Schematic representation and working principle is given in Figure 1.

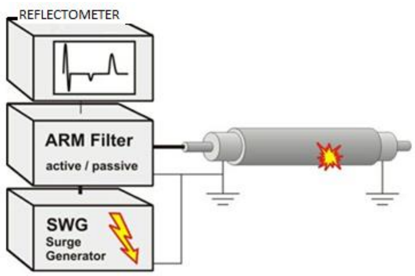


Fig. 1. *Schematic view of the reflectometer*

Discontinuities are defined as places where the input impedance of the line and the rest of the line differ from its characteristic impedance. The working principle of reflectometer is based on a principle similar to radars. The device is connected to one end of the cable, between the two conductors, and emits a short-term impulse. The impulse travels along the conductor and, at the site of the fault, the other end of the cable or any other change in the geometry of the conductor, because of the sudden change of impedance, two new waves will occur, one being just a passing wave because it passes into another medium or to the other end of the cable, and the other one more or less reflects and returns to the measuring device. Based on the time measured from the departure of the impulses from the measuring point to the return of the reflected impulses the distance to the impedance changes or damage can be determined.

A. *Velocity of the spreading impulse*

To more accurately determine the location of impedances change by measuring time, it is necessary to know the velocity at which the impulse travels through the observed cable. A measure of how the construction of the cable affects the speed of the impulse is specifically dependent on the type of the cable. It is dependent on the insulation of the cable, the cross-sectional geometry and the relative dielectric constant. Velocity of the impulse is expressed by unit (m/µs) or by relation impulse velocity / light velocity, whereas the light velocity in air is 300 m/µs. Velocity of impulses can usually be entered before measurement, and accuracy depends on the technology, the stability of insulation, aging of the medium, temperature, humidity, and can vary by several percentages depending on the observed conditions or over time.

B. *Reflection Factor*

Reflection factor is the ratio of the amplitude of the reflected impulse ($\mathrm{U_r}$) and the initial impulse ($\mathrm{U_p}$). It allows us to indirectly, through the size and polarity of the reflected impulse, determine the size and type of fault (non-homogeneous spaces) on the observed pair of cable conductors. Size of the reflection coefficient has a major impact on the quality of transmission. The display of the device, when measuring, shows different reflected impulses, which cause non-homogeneous places - the change in impedance along the observed conductor.

Assuming that the damping of the impulse is very small, one can consider that the reflected impulses have relatively same amplitude on the screen as well as the site reflection. According to the size and polarity of the reflected impulse it is easy to conclude about the type of change in impedance on the basis of the reflectivity factor r which is shown as the ratio of the amplitude of the reflected U_r and the progressive wave (impulse) U_p described by (1):

$$r = \frac{U_r}{U_p} \tag{1}$$

The general expression for the reflection coefficient $\bar{r}$ on the end of the line, when the line is closed with impedance $\overline{Z_p}$, is described by the equation (2):

$$\bar{r} = = \frac{\bar{Z}p - \bar{Z}c}{\bar{Z}p + \bar{Z}c} \ ; \ 0 \le |\bar{r}| \le 1 \tag{2}$$

Whereas $\bar{Z}p$ represents impedance of the reflected location and $\bar{Z}c$ implies the characteristic impedance of the observed cable.

III. CHARACTERISTIC RESPONSES OF FAULTS AND FAILURES

In this chapter, a typical conductor conditions are observed, such as short circuit, disruption, compound of cables, cable connections, and cable branching.

A. *Conductor short circuit*

Reflection factor at conductor short circuit, where the impedance at the site of reflection is $Z_p = 0$, can be described by the equation (3):

$$\bar{r} = \lim_{Zp \to 0} \frac{\bar{Z}p - \bar{Z}c}{\bar{Z}p + \bar{Z}c} = -1 \tag{3}$$

At the short circuit location, a complete reflection of the impulse occurs. The minus sign means that impulse during the reflection changes polarity. Figure 3 provides an overview of reflections at short-circuited conductor.

Fig. 2. *Reflection at a short-circuited conductor*

The amplitude of the reflected impulse is actually slightly lower than the initial impulse because of actual damping of the impulse measured on cable.

B. *Conductor disruption*

Reflection factor at a disruption point or at the end of the conductor where the impedance $Z_p = \infty$, can be displayed by the equation (4):

$$\bar{r} = \lim_{Zp \to \infty} \frac{\bar{Z}p - \bar{Z}c}{\bar{Z}p + \bar{Z}c} = +1 \tag{4}$$

The reflected impulse has the same polarity and approximately equal amplitude of the initial pulse. Figure 3 gives an overview of the wave reflection at a disrupt conductor.

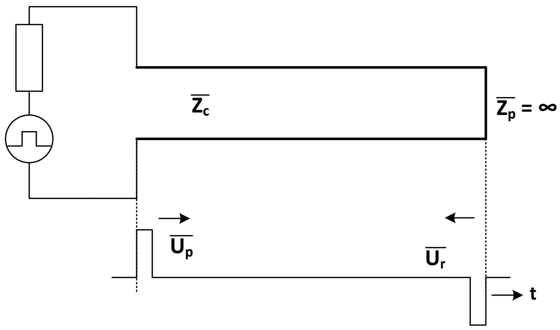


Fig. 3. *Reflection of a disrupt conductor*

C. Compound of the same cables

Cable with characteristic impedance $\overline{Z}c$ continued with exactly the same cable or a cable with the same properties and the same impedance where $\overline{Z}p = \overline{Z}c$, is given by the equation 5:

$$\bar{r} = \lim_{Zp \to Zc} \frac{\overline{Z}p - \overline{Z}c}{\overline{Z}p + \overline{Z}c} = 0 \tag{5}$$

At the connection point there is no reflection, and in reality, because of the changes in the geometry of the cable, at the connection a little reflected impulse appears. Figure 4 provides an overview of the wave reflections in the cable of the same type or the same properties.

Fig. 4. *Reflection at the connection point of the conductors with same properties*

D. Connection of different cables

At the connection point of two different cables, a partial reflection appears with amplitude and polarity dependent on impedance relations. If $\overline{Z}p < \overline{Z}c$ reflection factor is negative and less than 100% and generates a, more or less, reflected pulse of negative polarity.

If $\overline{Z}p > \overline{Z}c$ reflection factor is positive and less than 100% and a response appears on the screen with the reflected positive pulse amplitude dependent on the ratio of $\overline{Z}p$ and $\overline{Z}c$.

E. Cable branch

If a measured cable has a branch derived by a cable with impedance Z_O the reflection factor is calculated from the equation 6:

$$\bar{r} = \frac{-1}{1+\frac{2Z_0}{Z_c}} \tag{6}$$

Figure 5 gives an overview of the reflection wave that is reflected at the separation of the conductors.

Fig. 5. *Reflection at the place of conductors separation*

The reflection factor in the branch is always negative, regardless of the size of the branch, and reflected impulse at the point of the branch is always the opposite polarity from the initial impulse. Figure 6 provides an overview of the actual response of the branch of the reflected pulses measured with the oscilloscope.

In real world applications there are countless possible combinations and variants where the reflectance change occurs in relation to the initial impulse in the table 1, in which an overview of some basic and most common forms of response waves for the reflected pulses is given.

F. Impact of pulse width

The amount of energy transmitted in the cable can be controlled by impulse width. By selecting the impulse width, the loss of power caused by attenuation that occurs due to the length of the measured cable can be compensated. The wider the impulse the more energy can be transferred to the cable and the impulse can travel longer along the cable until it fully attenuates. Testing should start with a shorter pulse width as the change in impedance may be at the beginning of the cable and, therefore, the pulse width can be blocked.

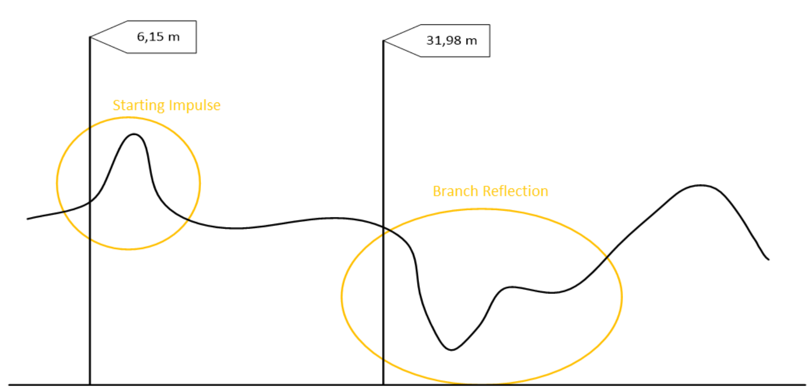
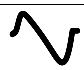


Fig. 6. *Display of some forms of oscillograms of the reflected impulse on the instrument*

TABLE I. MOST COMMON FORMS OF RESPONSE WAVES OF OSCILLOGRAMS

	Disruption/end		High-ohm connection
	Short circuit		Conductor branch
	Conductor connection		Penetration of moisture
	Wet compound		Transition of the section

Pulse width should be gradually increased until the discovery of the location with changes in impedance. It is important to point out, when it comes to tests that are related to unprivileged consumption, the cable lengths are up to 15 - 20 meters, and often much less, so then a shorter impulse width is conveniently used. When searching for a fault on a long section of the cable wider impulses should be used. The accuracy of fault detection, regardless of the pulse width, in both cases was the same. Figure 7 shows the responses of individual forms of oscilograms reflected impulses in cases of faults.

IV. EXAMPLES OF REFLECTOMETER USAGE AND MEASUREMENTS

Figure 8 presents an on-screen display of the start marker located on the length of 6.15 m as that is the length of the instruments measuring cable. After that, with the number one (1) a cable with the length 25.83 m is marked, on which there is a branch with the number two (2), and also in the spot marked with the number two (2) another cable, whose open end is shown with the number three (3), is connected.

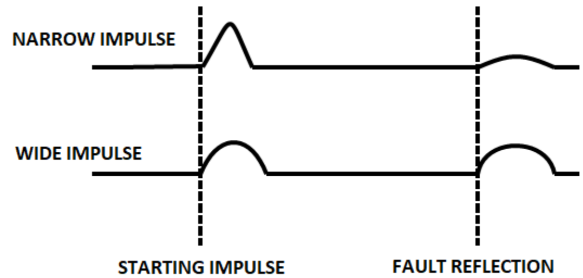


Fig. 7. *The responses of individual forms of oscillogram reflected impulses in cases of faults*

Figure 8 also gives an overview of several forms of oscilograms reflected impulses for certain types of section changes. The day is a 6.15 m long starting signal, what is the length of the measuring cable of the instrument. Then, with a number of 1 (1), a cable length of 25.83 m is marked, the end of which is marked by a number of two (2), and also at the place marked by the number of two (2) another cable is connected, the end of which is shown by row number three (3). Figure 9 shows a screen display of a conductor with the length of 25.42 m, which is short-circuited at its end. Based on such a reflective signal, it is easy to determine the type of failure or error.

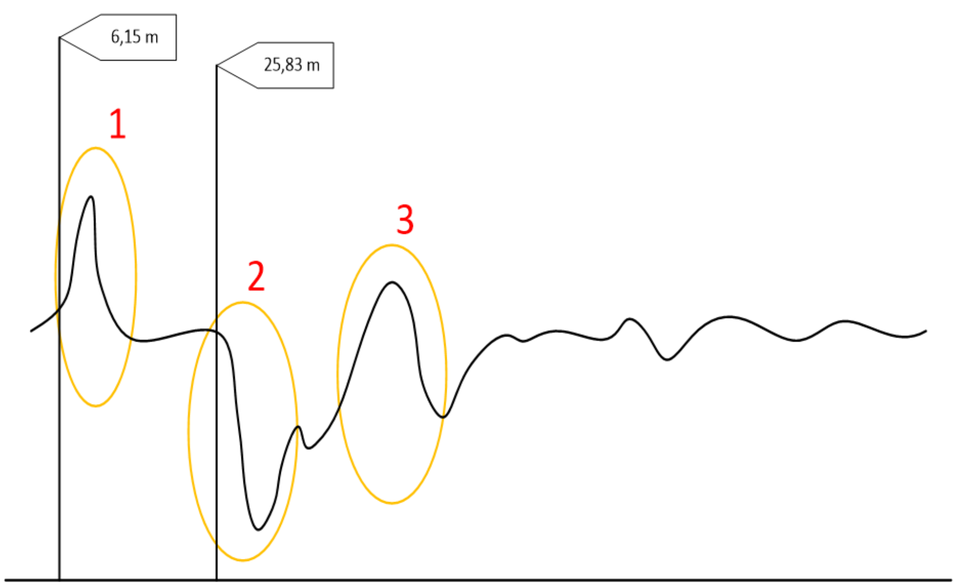


Fig. 8. *An overview of several forms of oscillogram reflected impulse for certain types of section changes*

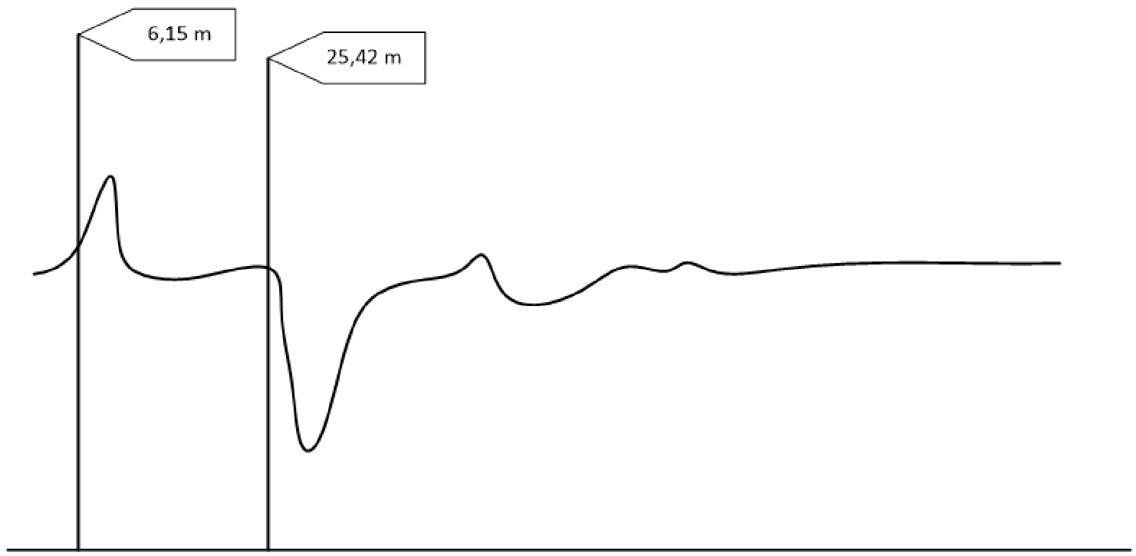


Fig. 9. *Display of a cable with the length of 25.42 m, which is short-circuited at its end*

V. CONCLUSION

It is known that failures with a large transitional resistance represent a significant problem in impulse reflectometry. The exception is a fault due to the moisture penetration. Although, usually, it has a contact resistance of about 100 kΩ, this defect may still be measured using the impulse reflectometer. The reason for this is the moisture which has penetrated into the cable, and thus the characteristic impedance changed. It should be noted that in this specific case the start and end of the segment cable is affected by water can be determined, except for the exact place of the damage (eg. non-hermetic cable shielding). The application of reflectometers with a TDR time base (Time Domain Reflectometers), which uses the theory of traveling waves and the principles of reflection impulses, gives the ability to detect unauthorized electricity consumption over an inappropriately made junction with the service line prior to measuring devices.

Travelling waves behave specifically while crossing discontinuities. Oscilograms of reflectometers shows a dispatched (initial) pulse generated by TDR and responses - reflections caused by impedance changes along the cable.
With this method it is possible to determine the location of a fault in the power grids of low and medium voltage, and, with the use of the shock generator, can also be used on macro-locations of high-ohm failures.

VI. REFERENCES

[1] Muharem Mehmedović, Stjepan Štefanko Teorija polja i valova, Grafika Osijek, 2010,

[2] Vojislav Bego, Mjerenja u elektrotehnici, Tehnička knjiga, Zagreb, 1975.

[3] Megger MTDR300, 3-Phase Time Domain Reflectometer Datasheet, Megger Group Limited, Dover, United Kindom

[4] M. Scott, Underground Cable Fault Locating Using the Arc Reflection Method, Electric Energy T&D Magazine, Jan/Feb 2004

[5] J.A. Strickland, Time – Domain Reflectometry Measuerments, Tektronix, Beaverton, USA, 1970.

[6] S. Galli and D.L. Waring, "Loop Make-up Identification via Single Ended Testing: Beyond Mere Loop Qualification," IEEE Journal on Selected Areas in Communications 20, pp. 923–935, June 2002.

[7] S. Galli and K.J. Kerpez, "Single-Ended Loop Make-up Identification Part I: A method of analyzing TDR measurements," IEEE Transactions on Instrumentation and Measurements 55, pp. 538–549, April 2006.

[8] K.J. Kerpez and S. Galli, "Single-Ended Loop Make-up Identification Part II: Improved Algorithms and Performance Results," IEEE Transactions on Instrumentation and Measurements 55, pp. 538–549, April 2006.

[9] C.R. Sharma and C. Furse and R.R. Harrison, "Low-Power STDR CMOS Sensor for Locating Faults in Aging Aircraft Wiring," IEEE Sensors Journal 7, pp. 43–50, January 2007.

[10] P. Smith, Spread Spectrum Time Domain Reflectometry. PhD thesis, Utah State University, 2003.

[11] .K. Jones and G.I.S. Trevio and W.W. Jones and R.H. Jonsson, "Adaptive Method and Apparatus for Transmission Line Analysis," 2002.

[12] John G. Proakis, Digital Communications, McGraw-Hill, 4th ed., 2001. 10. J.G. Proakis and M. Salehi, Communication System Engineering, Prentice-Hall, 2nd ed., 2002.

[13] .P. Smith and C. Furse and J. Gunther, "Analysis of Spread Spectrum Time Domain Reflectometry for Wire Fault Location," IEEE Sensors Journal 5, pp. 1469–1478, December 2005.

[14] C. Furse, P. Smith, M. Safavi, and C. Lo, "Feasibility of Spread Spectrum Sensors for Location of Arcs on Live Wires," IEEE Sensors Journal 5, pp. 1445–1450, December 2005.