

Review scientific paper/Pregledni naučni rad

IMPORTANCE OF LIGHTNING ACTIVITY MONITORING SYSTEMS FOR TRANSMISSION LINE LIGHTNING PERFORMANCE IMPROVEMENT STUDIES

ZNAČAJ SISTEMA ZA MONITORING ATMOSFERSKIH PRAŽNJEŃA U PROVOĐENJU STUDIJA ZA UNAPREĐENJE PERFORMANSI PRIJENOSNIH LINIJA

Selma Grebović¹, Mirza Batalović¹, Adis Balota², Nermin Oprašić¹

Abstract: Line surge arresters are mainly used for transmission line lightning performance improvement. Calculation of energy stresses of lines surge arrester is of extreme importance for the selection of the arrester class. Energy stresses of transmission line surge arresters due to multicomponent lightning flashes are analysed in this paper. To obtain lightning data two approaches were used: direct measurements using instrumented towers and lightning location systems. Both lightning monitoring systems are described. Data obtained from lightning monitoring systems are compared and used in simulations. Detailed modelling procedure for a transient analysis of the transmission lines is also described. Multicomponent lightning flash and 110 kV transmission line were modelled using Electromagnetic Transient Program - Restructured Version (EMTP – RV). The arrester current shapes and arrester energy duties are presented in order to clearly show influence of lightning current parameters to arrester energy duty.

Keywords: lightning direct measurements, lightning location system, modelling, surge arrester

Sažetak: Linijski odvodnici prenapona se uglavnom koriste za unapređenje performansi prijenosnih linija. Proračun energetske naprezanja linijskih odvodnika prenapona je od velike važnosti za izbor energetske klase odvodnika prenapona. U ovom radu su analizirana energetska naprezanja odvodnika prenapona nastala usljed atmosferskih pražnjenja sa više komponenti. Za dobivanje podataka o munji korištena su dva pristupa: direktna mjerenja pomoću tornjeva na kojim je instalirana oprema za mjerenje struja munja i sistemi za lociranje atmosferskih pražnjenja. Opisana su oba sistema za nadzor atmosferskih pražnjenja. Podaci dobiveni na osnovu oba sistema za nadzor su poređeni i korišteni u provedenim simulacijama. Procedura modeliranja prijenosne linije za tranzijentne studije je detaljno opisana. Atmosfersko pražnjenje sa više komponenti i 110 kV prijenosna linija su modelirani koristeći programski paket EMTP – RV. Struje kroz odvodnike prenapona i energetska naprezanja odvodnika prenapona su prikazana da bi se jasno pokazao utjecaj parametara struje munje na energiju odvodnika prenapona.

Ključne riječi: direktna mjerenja struja munja, sistemi za lociranje atmosferskih pražnjenja, modeliranje, odvodnik prenapona

INTRODUCTION

Based on previous research it can be concluded that concept of power systems represents a great benefit for engineering practice in general. Electrical power systems are the backbone of modern life, they are exposed to different environmental conditions and its reliable and safe operation depends upon different parameters. The need for reliability improvement and robustness reduction of power systems makes protection of equipment and power transmission and distribution lines against lightning-related effects a primary concern. Evaluation of lightning parameters provides convenient platform that helps the

scientific and engineering community to assess lightning effects and to design effective protection systems.

Secured and safe electrical supply is a must and it is generally based on power studies. Real systems are much more complex than the available simulations of power systems. The reliable model should be an appropriate approximation of the real systems and at the same time not so complex and user friendly. When calculating line surge arrester energy duty, numerical tools are very important for the calculation of the transient stresses. For that purpose a software tool EMTP - RV (ElectroMagnetic Transient Program - Restructured Version) is used. The quality of results is mainly based on a proper modelling of all transmission line components and lightning current source.

In this paper two approaches were used to obtain lightning data for lightning current modelling: direct measure-

¹ Faculty of Electrical Engineering Sarajevo, Bosnia and Herzegovina

² Faculty of Information Technology, Montenegro

sgrebovic@gmail.com

Paper submitted: September 2020 Paper accepted: October 2020

ments using instrumented towers and lightning location systems. Lightning location systems do not provide data about front and tail time of lightning current waveform. It is well known that front time has a high influence on insulation in power systems, while, for example, energy stresses of surge arresters strongly depends on tail time of overvoltage wave [1]. Therefore, when conducting simulations of power system transients it is necessary to predict this data, as it is recommended in the CIGRE Brochure 549 (2013) and the last IEEE review of parameters of lightning strokes (2005) [2], [3]. For the direct measurements approach, it is possible to determine all of the important parameters including lightning stroke wave front and tail time. Many authors calculated energy stresses of surge arresters due to multicomponent lightning flashes, but, to the best author's knowledge, this is the first time that energy stresses of surge arresters due to multicomponent lightning flashes obtained from different monitoring systems are being calculated and compared. This paper illustrates differences in modelling lightning current source when lightning location system data is used and when data is obtained from direct measurements.

For better presentation of lightning effects inside power systems, surge arrester energy duty for 110 kV transmission line is calculated. Multicomponent lightning flash recorded on the 12th of January 2016, in the Lovćen mountain region, was analysed and used in simulations. The rest of the paper is organized as follows. Lightning activity monitoring system, as well as lightning location system are described in Section 1. Lightning location system data and data from direct measurements are presented in Section 2. Transmission line modelling procedure for transient studies is given in Section 3. Study cases, simulation results and discussion are given in Section 4. Conclusions are provided in Section 5.

1. LIGHTNING MONITORING SYSTEMS

Lightning monitoring systems are of great importance in transient studies for power systems. Modern lightning activity monitoring systems provide accurate and useful data for specific regions. Basic data about lightning location system and system for direct measurements that are used for purposes of this paper are given below.

1.1. Lightning Location System (LINET)

Use of the lightning locating system is well known within different sectors. Each lightning detection sensor consists of the following three parts [4]: LINET field antenna (LFA), GPS antenna and LINET field processor (LFP). LINET field antenna and GPS antenna are usually installed on roof, while LINET field processor is placed inside of building on distance of 30 meters (Figure 1).

LINET sensors utilize VLF/LF frequency ranges and detect magnetic flux at the moment of an atmospheric discharge [5].

Formatted lightning data from modern lightning location systems include: time and date of lightning stroke, GPS coordinates (2D), lightning current amplitude, lightning type, height (for inter - cloud lightning) and 2D statistical error.



Figure 1: LINET field antenna (LFA), GPS antenna (left) and LINET field processor (LFP) (right)

1.2. Lightning Activity Monitoring System (LAMS)

Lightning activity monitoring system for direct measurements of lightning current (LAMS) was installed on the broadcasting tower Lovćen in 2015. This monitoring system, with four embedded and integrated sensors: electric field sensor, transient recorders, current transformer and IP camera, is capable of real time remote monitoring. Shapes of a lightning current are recorded by a current transformer. An industrial computer (Figure 2) records data from current transformer installed on the tower top. All data is transferred in real time via Internet to the central server and stored into the integral information system.



Figure 2: Installation of current transformer (left), monitoring system with industrial computer, GPS receiver and acquisition card (right) [5]

More details about complete monitoring system and system of connections and links to transport recorded data are given in [6] - [8].

2. LIGHTNING DATA

A winter thunderstorm was observed in a mountain Lovćen region. This area is well known as a region with a very high lightning activity. The thunderstorm on the 12th of January 2016 was recorded using lightning location system (LINET) and using monitoring system in real-time for the measurement of the direct lightning current (LAMS).

The LAMS monitoring system measured 5 strokes, while at the same time LLS detected 21 stroke. Greater number of detected strokes can be explained by the larger detection area, as well as higher sensitivity of the LLS. Some of the strokes detected by both systems are quite well matched in time and amplitudes. According to usual clustering criterion: all strokes that appear in time interval of 1 s belongs to same lightning flash. In this case all 5 recorded strokes were registered in time interval of 420 ms which means that all of them belongs to one multicomponent lightning flash. Registered data by both systems are given in Table I.

Table I: Recorded LAMS and LINET data (January 12, 2016)

	Measured date Timestamp	I_{max} (kA)- LAMS	t_f (μs) - LAMS	t_t (μs) - LAMS	I_{max} (kA)- LLS
1	2016.01.12 22:49:09,055986	-7.020	3.2326	86.0096	-10.6
2	2016.01.12 22:49:09,183157	-6.720	158.7070	344.1669	-6.1
3	2016.01.12 22:49:09,199222	-7.840	170.8766	330.6621	-7.4
4	2016.01.12 22:49:09,450662	-9.710	114.8474	332.0839	-8.9
5	2016.01.12 22:49:09,471441	-11.712	73.9342	206.4861	-14.8

Lightning monitoring system LAMS (for direct measurements) provides data about current peak, front and tail time, this data is presented in columns 3,4 and 5 in Table I. Lightning location system provides data about current peak and these data are presented in column 6 in Table I.

Table II shows determined interstroke time intervals for analysed multicomponent lightning flash.

Table II: Interstroke time intervals

Time interval between components	Interval duration (ms)
1 and 2	127.1710
2 and 3	16.0650
3 and 4	251.4400
4 and 5	20.7790

In order to successfully calculate line surge arrester energy duty due to lightning discharges it is necessary to identify the parameters of lightning current:

- shape of the lightning current (peak value, front time, tail time and duration),
- polarity and
- multiplicity - number of components of the flash.

All these parameters are needed to get accurate results in insulation coordination studies.

Available LINET data was enough to determine: lightning stroke current peak, stroke polarity, number of components in flash and interstroke intervals, however front time, tail time and duration of the strokes were still missing. Therefore, these parameters were selected according to CIGRE and IEEE recommendations [2], [3], [9]. According to [2], data for the front and tail time are given below.

- Positive first stroke: 22/230 μs with 5% probability of being exceeded;
- Negative first stroke: 18/200 μs with 5% probability of being exceeded;
- Negative subsequent stroke: 4.5/140 μs with 5% probability of being exceeded.

Using the LINET data, recommended data by standards, and appropriate mathematical model (in this case double exponential function) it is possible to make reconstruction of recorded lightning flash. Multicomponent flash was generated with MATLAB and it is shown in Figure 3.

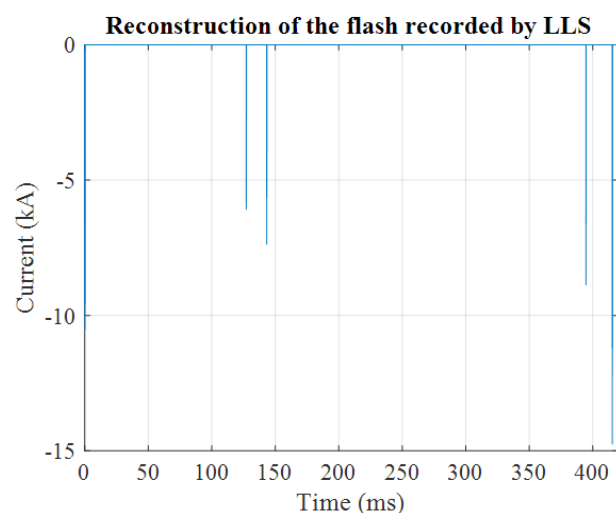


Figure 3: Reconstruction of the flash recorded by LLS

All required lightning current parameters, including the front time and tail time, can be determined only from direct measurements (if the lightning current shape is recorded). Figure 4 shows multicomponent lightning flash recorded by LAMS.

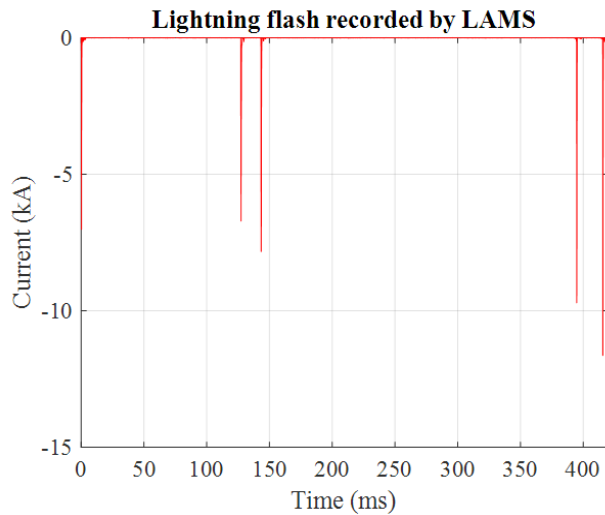


Figure 4: Lightning flash recorded by LAMS

3. MODELLING PROCEDURE

Simulations for a transient analysis of the transmission lines are commonly based on a model that consist of only a few towers on both sides from the point of the lightning's impact. Complete transmission line with substations on both ends is created in the EMTP - RV for the purpose of the transient analyses and calculation of energy stresses of line surge arresters due to multicomponent lightning flash described in Section 2.

The transmission line model consists of several parts like towers, insulators, phase conductors, line surge arresters and tower footing resistance.

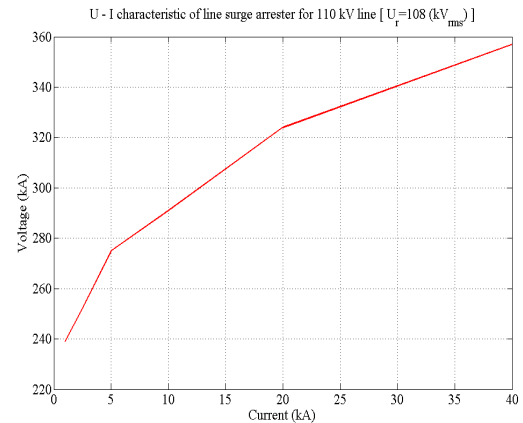
To model shield wires and phase conductors, the EMTP - RV block Constant Parameter (CP) line, which is classified as a frequency independent transmission line model is used. Its main advantage is computational speed. It is less precise than frequency dependent line and cable models, but it can be successfully used in analysis of problems with limited frequency dispersion. The CP line parameters are calculated at a given frequency and that is why it is labelled as a frequency independent line. The CP line is a distributed parameter model [10], [11]. The shield wire and the phase conductors are subdivided into segments. Each span of 300 m is divided into two segments to enable a connection between the current source and the middle of the span for the shield wire and the phase conductors.

Although the lightning response of a transmission line tower is an electromagnetic phenomenon, the representation of a tower is made in circuit terms, that is, the tower is represented by means of several line sections and circuit elements that are assembled with taking the tower structure into account. Each tower is divided into four parts. The first part is the section of the tower from the bottom crossarm to the ground, the second part is the section between the tower top and the top crossarm. The third and fourth parts are sections between the crossarms. All four sections are modelled as the inductance branches. Tower surge impedance is calculated according to the tower shape theory. A branch

inductance is determined according to the section length, the tower surge impedance and the propagation velocity. The wave propagation speed on the tower was taken to be equal to the velocity of light [1], [12], [13], [14].

Insulators are modelled as Air Gap elements, which operate based on equal area flashover model.

Used arrester has the following characteristics [12]: rated voltage: 108 kVrms, MCOV: 86 kV, IEC class: II, nominal discharge current: 10 kA. The non - linear behaviour of line surge arrester is represented by the U - I characteristic 8/20 μ s shown in Figure 5.

Figure 5: Arrester U - I characteristic 8/20 μ s

The lightning energy E (in Joules) absorbed by an arrester can be determined according to relation [15]:

$$E = \int_{t_0}^t u(t) i(t) dt \quad (1)$$

where

$u(t)$ is the residual voltage of arrester in kV and $i(t)$ is the value of discharge current through arrester in kA.

When the absorbed energy by the arrester exceeds their maximum acceptable level of energy than they will fail (be damaged).

Tower footing resistance is represented with fixed resistance value since the current conducted through is relatively low and does not initiate the soil ionization.

The overall substation models are derived from the substation layout drawings and based on standards and recommendations. When performing lightning transient study it is very important to correctly model substation elements. Best is to take substation element data from the equipment manufacturer data sheets or from the measurements (if available). References [16], [17] and [18] suggest substation element models for transient studies.

Multicomponent lightning flashes simulated in EMTP - RV were based on data for flash described in Section 2 (recorded by LLS and measured directly by LAMS). It was implemented in EMTP - RV using an ideal current source (I - point by point source).

4. CASE STUDY

Line surge arrester energy duty was calculated for 110 kV transmission line. Complete transmission line was modelled in EMTP - RV with substations on both ends of the line. It is assumed that this line operates in a region with very high soil resistivity and very high lightning incidence. Value of tower footing resistance near the point of lightning impact is 30Ω .

Due to described conditions line surge arresters were installed on all three phases on towers near the point of lightning impact. Energy capability of used line surge arresters is 450 kJ.

Lightning flash hits top phase conductor at the middle of the span as it is shown in Figure 6.

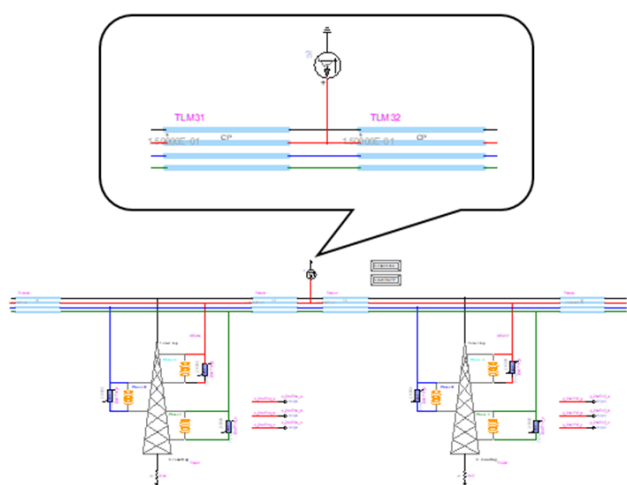


Figure 6: Lightning flash hits top phase conductor at the middle of the span

Two cases were considered:

- Line surge arrester energy duty due to reconstructed multicomponent lightning flash based on; data recorded by LLS, standards and recommendations;
- Line surge arrester energy duty due to multicomponent lightning flash recorded by LAMS.

These two cases are compared and analysed.

The arrester current and energy duty are considered for arresters installed on the top phase conductor (this arrester is the most stressed) of both towers (right and left from the point of lightning impact). Two nearest line surge arresters were considered because gapless surge arresters were used and they have very important and useful feature to share energy. The arrester current and the energy duty for the flashes from Section 2 are represented in the figures from Figure 7 to Figure 12. The energy duty is shown for the duration time of the multicomponent lightning flash.

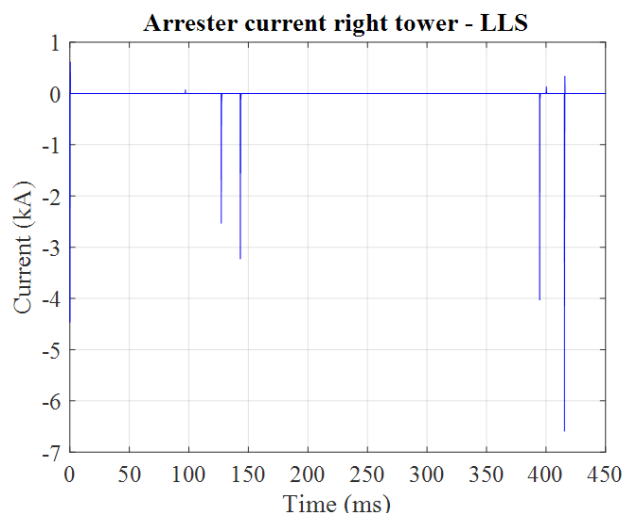


Figure 7: Arrester current due to flash based on LLS data (arrester installed on top phase on right tower)

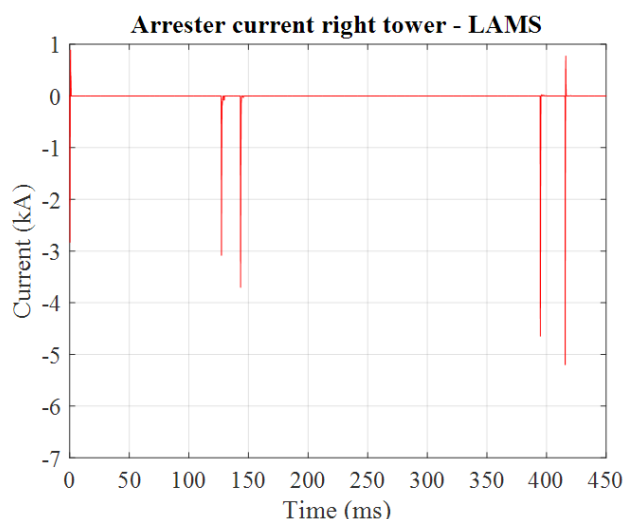


Figure 8: Arrester current due to flash based on LAMS data (arrester installed on top phase on right tower)

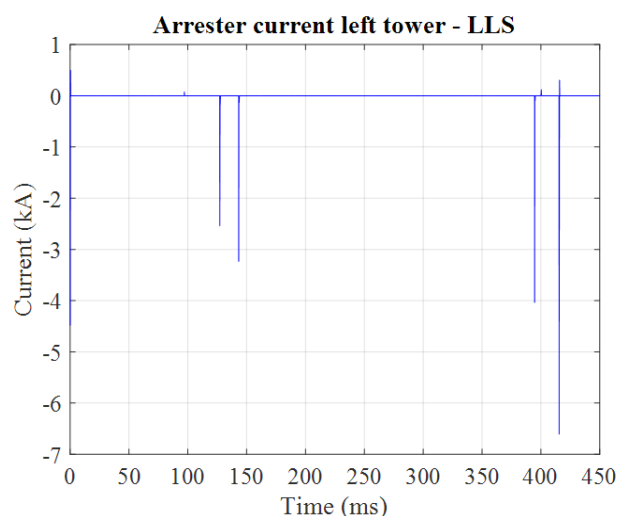


Figure 9: Arrester current due to flash based on LLS data (arrester installed on top phase on left tower)

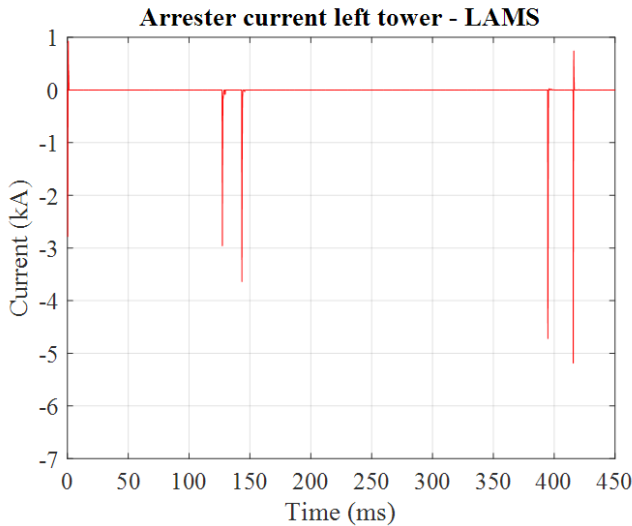


Figure 10: Arrester current due to flash based on LLS data (arrester installed on top phase on left tower)

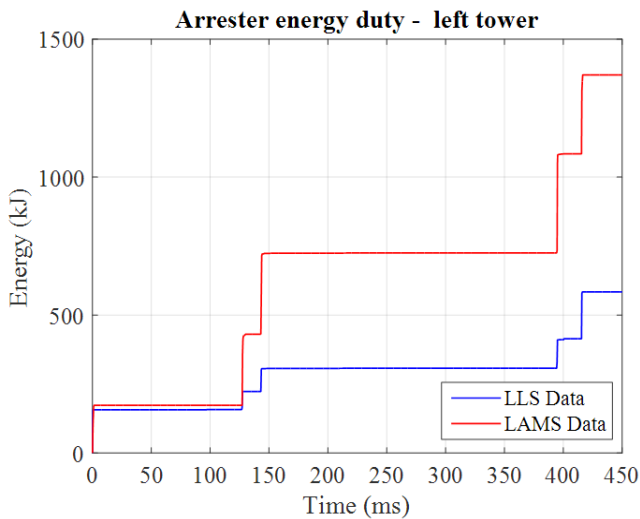


Figure 11: Arrester energy duty due to multicomponent flash based on LLS data (blue) and based on LAMS data (red) - arrester installed on left tower

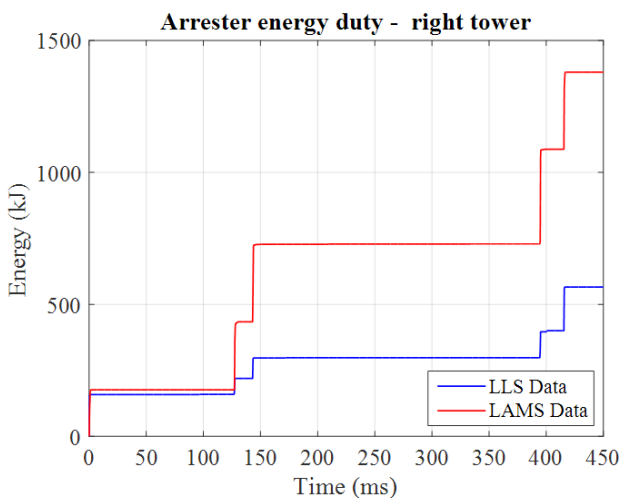


Figure 12: Arrester energy duty due to multicomponent flash based on LLS data (blue) and based on LAMS data (red) - arrester installed on right tower

Firstly it should be noted that arrester currents and energy duties are very similar for both considered arresters (arresters installed on right and left tower from the point of lightning impact). This fact can be explained with assumed conditions: the same value of tower footing resistance for both towers as well as same ground resistivity. Aim of this assumption was to show gapless arrester feature to share energy. Also, two towers are at a short distance, distance of only one span (about 300 meters) and they probably have similar grounding.

It is interesting to compare peaks of lightning currents and arrester currents. Comparison is given in Table III.

Table III: Comparison of lightning currents and arrester currents

Stroke	I_{maxLLS} (kA)	$I_{maxLAMS}$ (kA)	$I_{arr-LLS-left}/$ $I_{arr-LLS-right}$ (kA)	$I_{arr-LLS-left}/$ $I_{arr-LLS-right}$ (kA)
1	-10.600	-7.020	-4.63903	-2.78305
			-4.28573	-2.83271
2	-6.100	-6.720	-2.61218	-2.95967
			-2.44522	-3.08563
3	-7.400	-7.840	-3.32719	-3.63950
			-3.11521	-3.70415
4	-8.900	-9.710	-4.15004	-4.72157
			-3.89031	-4.64909
5	-14.800	-11.712	-6.83730	-5.18720
			-6.32118	-5.20109

All five components can be noted and the arrester current has the same duration as the original lightning flash. The arrester current peaks are not as high as peaks of the original lightning flash. It is confirmed that in case of higher lightning current peaks, the arrester current is also higher. Table III shows deviations in lightning stroke peaks recorded by different systems (LLS and LAMS). Therefore, arrester current peaks are also different. For example LLS recorded first stroke in a flash with amplitude of -10.6 kA, while LAMS recorded the same stroke but with amplitude of -7.020 kA. As it can be seen in Table III arrester current due to stroke based on LLS data is -4.63903 kA, while arrester current due to same flash recorded by LAMS is -2.78305 kA. These differences are quite large, but used line surge arrester has nominal discharge current of 10 kA.

Influence of tail time on line surge arrester energy duty is significant as it is presented in Table IV.

The value of tail time for reconstruction of lightning flash was taken 140 μ s (as it is recommended for negative subsequent stroke). As it can be seen from Table IV the tail times extracted from waveform obtained from direct measurement are very different from assumptions. For example second stroke in flash has the largest tail time of 344 μ s and it is 2.45 times greater than assumed tail time of 140 μ s. Tail time strongly influences line surge arrester energy duty.

Table IV: Comparison of tail times and arrester energy duties

Stroke	$t_{t-standard}$ (μs)	t_{t-LAMS} (μs)	$\frac{E_{arr-LLS-left}}{E_{arr-LLS-right}}$ (kJ)	$\frac{E_{arr-LLS-left}}{E_{arr-LLS-right}}$ (kJ)
1	200	86.0096	157.533	172.909
			156.706	176.145
2	140	344.1669	224.997	430.406
			217.046	433.487
3	140	330.6621	309.588	724.278
			294.702	727.954
4	140	332.0839	417.524	1084.140
			396.070	1087.910
5	140	206.4861	591.138	1370.390
			557.87	1379.790

The second stroke with tail time of 344 μs produces arrester energy of 430 kJ (that is almost as high as arrester's energy capability of 450 kJ), while assumed tail time of 140 μs produces arrester energy of 224 kJ. Considering energy from graphs in Figures 11 and 12 it can be seen that energy capability of line surge arrester due to reconstructed flash was exceeded after fifth stroke in flash, while energy capability due to measured flash was significantly exceeded after third stroke.

The different lightning current peaks recorded by different systems definitely influence calculation of arrester currents, but taking into account arrester nominal discharge current of 10 kA this difference is not destructive for line surge arrester. However, difference in tail times significantly influences surge arrester energy duty and wrong choice can lead to arrester damage or even surge arrester could easily blow up.

5. CONCLUSION

CIGRE brochure 63 gives comment on the selection of lightning parameters. Download negative flash is considered the most important discharge process that affects the lightning performance of transmission lines. Therefore, it is therefore recommended using parameters describing the downward negative flash to calculate the lightning performance of lines, unless another lightning data is known. Thanks to development of lightning location and measurement systems on tall towers, lightning data for different regions are now more accurate. The main advantage of advanced systems for direct measurements is the fact that they use very high sampling rate of 100 MHz or more, comparing to previous systems that provide sampling rate of 100 kHz.

Based on the result from section 4 of this paper it is possible to conclude that multicomponent lightning flashes are very destructive and they should be taken into account when dimensioning line surge arresters. This paper clearly demonstrates the importance of taking into account all facts in modelling.

An accurate knowledge of the parameters of lightning strokes is essential for the prediction of the severity of the transients generated in power systems. Lightning monitoring systems should be constantly developed and improved. To get more accurate data, these systems should be installed in different locations and regions. For future research it would be very interesting trying to find correlation between current peak and front and tail time from large dataset using predictive methods. However, no two lightning strokes are the same. With our work we have hopefully answered some questions considering interaction between lightning phenomenon and power systems, and opened more new ones.

REFERENCES

- [1] S. Grebovic, S. Pack: Energy Stresses of Transmission Line Surge Arresters due to Multicomponent Flashes, International Colloquium on Lightning and Power Systems, Bologna, Italy, June, 27 – 29, 2016
- [2] Lightning parameters for engineering applications, CIGRE Brochure 549, August 2013
- [3] Parameters of Lightning Strokes: A Review, IEEE Trans. Power Delivery, vol. 20, pp. 346 – 358, January 2005
- [4] LINET Sensor Manual, 2015
- [5] S. Grebovic, I. Uglesic, A. Balota, B. Franc: Analytics of Lightning Data Collected by Direct Measurement System and Lightning Location System, Innovative smart Grid Technologies Conference (ISGT) Europe 2018, Sarajevo, BiH, 2018
- [6] A. Balota, Dz. Strujic, S. Grebovic, H.-D. Betz: Lightning Monitoring on broadcasting tower Lovćen, ICLP 2016 - 33rd International Conference on Lightning Protection, Estoril, Portugal, September 25 - 30, 2016
- [7] A. Balota, S. Grebovic, S. Skuletic, T. Vujcic, P. Radunovic: System of Connections and Transport of Data Registered from Lightning Discharges, Journal of Microprocessors and Microsystems, Volume 63, pp. 46-54, November 2018
- [8] A. Balota, S. Grebovic, T. Sadovic: Lightning Activity Monitoring System in Real Time, MECO 2016 - 5th Mediterranean Conference on Embedded Computing, Bar, Montenegro, June 12 - 16, 2016
- [9] IEEE Guide for Improving the Lightning Performance of Electric Power Overhead Distribution Lines, IEEE Std. 1410 – 2010, January 2011
- [10] H. W. Dommel: Digital Computer Solution of Electromagnetic Transients in Single and Multiphase Networks, IEEE Transactions on Power Apparatus and Systems, Vol.88, No.4, April 1969
- [11] ElectroMagnetic Transient Program (EMTP) Theory Book., 2007
- [12] S. Sadovic, M. Babuder, M. Hrast, D. Bokal, M. Marisek, T. Sadovic: Line Surge Arrester Application on 123 kV Double Circuit Line, International Symposium on High Voltage Engineering, Johannesburg, South Africa, 2009
- [13] IEC Computational guide to insulation co-ordination and modelling of electrical networks, 2003

- [14] IEEE Modelling Guidelines for Fast Front Transients, Report Prepared by the Fast Front Transients Task Force of the IEEE Modelling and Analysis of System Transients Working Group, 1997
- [15] C. A. Christodoulou, I. F. Gonos, I. A. Stathopoulos: Lightning performance of high voltage transmission lines protected by surge arresters: a simulation for the Hellenic transmission network, International Conference on Lightning Protection (ICLP), Uppsala, Sweden, 2008
- [16] Task Force on Very Fast Transients in IEEE Working Group on Modelling and Analysis of System Transients Using Digital Programs, Modelling and Analysis Guidelines for very Fast Transients, IEEE Transactions on Power Delivery, Vol. 11, No. 4, October 1996
- [17] Report Prepared by the Fast Front Transients Task Force of the IEEE Modeling and Analysis of System Transients Working Group, Modelling Guidelines for very Fast Transients, IEEE Transactions on Power Delivery, Vol. 11, No. 1, January 1996
- [18] Report Prepared by the Fast Front Transients Task Force of the IEEE Modeling and Analysis of System Transients Working Group, Modelling Guidelines for very Fast Transients, December 1997

BIOGRAPHY

Selma Grebović was born in Trebinje, Bosnia and Herzegovina. She received the B.Eng. and the M.Sc. degree in electrical power engineering from the University of Sarajevo in 2008 and 2010, respectively. She also received Ph.D. degree in electrical power engineering from the Graz University of Technology (Institute for High Voltage Engineering and System Performance), Austria in 2016. She is currently an Assistant Professor at University of Sarajevo, both Faculty of Electrical Engineering and Faculty of Mechanical Engineering. She is a member of CIGRE and IEEE. Her current research interests include power system transient analyses, overvoltages and insulation co-ordination, line lightning performance, substation insulation co-ordination, switching surges, surge arresters, modern methods in insulation co-ordination, lightning protection of wind turbines, power line monitoring, advanced measurement systems and embedded systems.

Mirza Batalović was born in 1982 in Sarajevo, Bosnia and Herzegovina. He received his PhD degree in 2016 from the University of Sarajevo at the Faculty of Electrical Engineering in the field of high voltage insulation. He is currently an assistant professor at the Faculty of Electrical Engineering in Sarajevo at the Department for Power Engineering. During his academic career he also taught lectures as a part time employee at the International Burch University and at the Faculty of Mechanical Engineering. Regarding his non-academic positions, he worked as a consultant in the field of power engineering for companies Energoinvest d.d. Sarajevo and Deling d.o.o. Tuzla. He has published 13 scientific papers and participated in many industrial projects. He also received a plaque for outstanding contribution to the release of Windows 7 and Office 2012 in Bosnian Cyrillic and Bosnian Latin.

Adis Balota was born in Montenegro in 1974. He received his undergraduate in 1999 degree and M.Sc. degree in 2005 in Electrical Engineering from the Faculty of Electrical Engineering in Podgorica, University of Montenegro, and PhD degree in Technical Sciences in 2011. He is currently a Vice-Rector for Teaching at the University Mediterranean and has been a Dean of the Faculty of Information Technology at the same University since 2014. He has had a prestigious academic career from an Assistant Professor (2006) to Associate Professor (2017) at the Faculty of Information Technology, University Mediterranean. His main research interests include Power Electric Systems, especially in the area of reliability, lightning discharges, IT systems, Information System Management, Computer Systems Architecture, Information System Security and Protection, Project Management.

Nermin Oprašić was born in Sarajevo, Bosnia and Herzegovina. He received the B.Eng. and the M.Sc. degree in electrical power engineering from the University of Sarajevo in 2008 and 2010, respectively. Also he received Bachelor's Degree in Chemistry from the University of Sarajevo. His current research interests include power system transient analyses, overvoltages and insulation co-ordination, power line monitoring, advanced measurement systems and embedded systems.