

Study Committee C4

Power System Technical Performance

Paper ID: 850

SYSTEM FOR AUTOMATIC EVALUATION OF LIGHTNING EFFECTS ON TRANSMISSION LINE AND SUBSTATION EQUIPMENT

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Motivation

- Some extreme lightning events cause line outages due to back flashover phenomena (BFO)
 - A subsequent service intervention is time-consuming and expensive
- Lightning with small current amplitudes can strike the phase conductor without BFO
 - This can be dangerous for installed equipment, especially in the case of de-energized lines

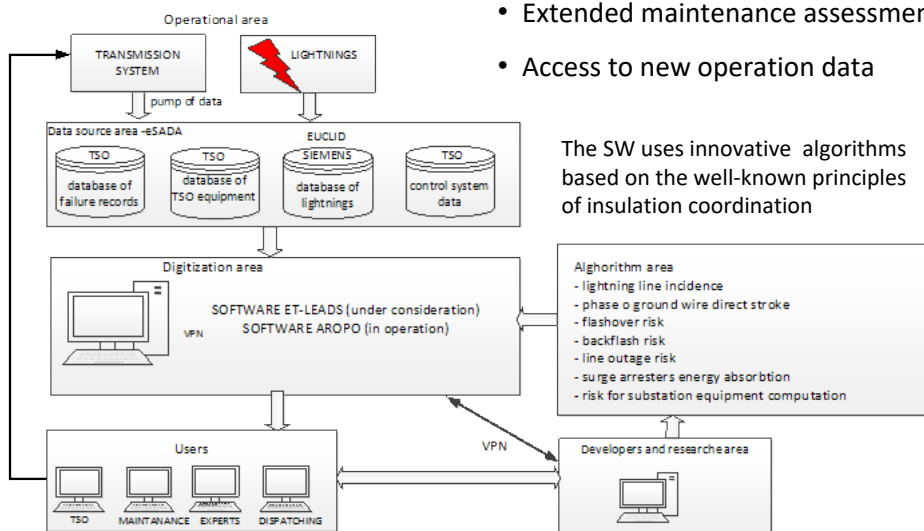
Approach

- The new system for lightning events automatic evaluation (ET-LEADS software) was proposed

ET-LEADS Software Benefits

- A new tool for network operators
- Accurate and fast failure identification and localization
- Significant reduction of line outages caused by lightning events
- Determination of risks to substation equipment in a very short time
- Extended maintenance assessment
- Access to new operation data

Concept of Proposed ET-LEADS Software



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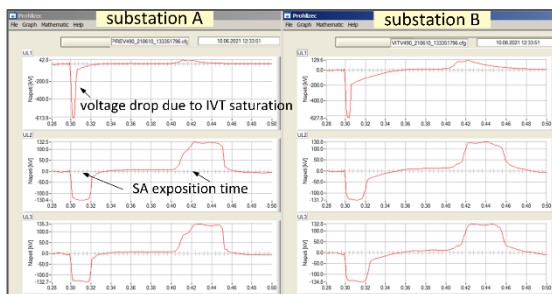
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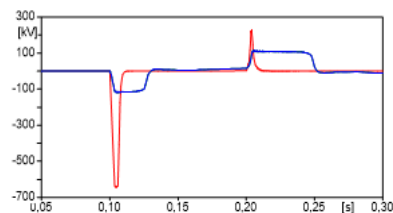
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Case study 1: PREDICTION OF SURGE ARRESTER FAILURE

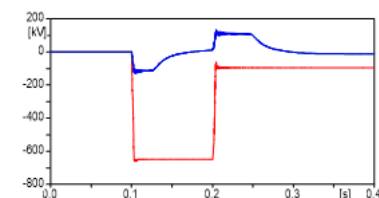
- The PREPETI module of the AROPO software reported a significant overvoltage at both sides of the de-energized and ungrounded 400-kV line
- The recorded waveforms do not show real overvoltage waveforms due to the oversaturation of the IVTs
- The true overvoltage waveforms were estimated by the EMT numerical simulation



Simulated voltages on the secondary side of IVTs



Simulated voltages on the primary side of IVTs (surge arrester exposure)

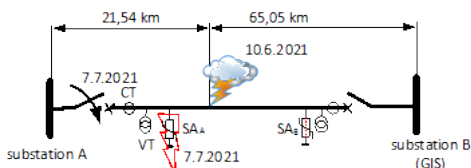


$$V_p = 630 \text{ kV}, I_{ch} = 189 \text{ A}, t_p = 100 \text{ ms}$$

- If the ET-LEADS system was in operation, the high risk of surge arrester failure would be indicated
- The overvoltage was caused by the lightning event – see the database table of coupled lightning detection and transmission line position data

DT	AMP	LINEDISTANCE	DISTANCEA	DISTANCEB	
10.6.2021 12:13	-10	CG	307,8	15306	71283
10.6.2021 12:13	-8	CG	362,1	15302	71287
2021-06-10 12:19:47.054	-5	CG	945,5	23462	63127
10.6.2021 12:30	-6	CG	641,1	19986	66603
10.6.2021 12:30	-2	CG	176,3	20021	66568
10.6.2021 12:33	-21	CG	21,9	21541	65048

- The surge arrester in the L1 phase, which was damaged by the lightning event, was short-circuited and completely destroyed due to the high-energy absorption after the power line energization



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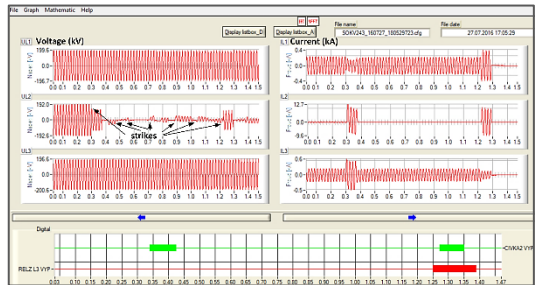
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Case study 2: FAST ROUTE TO CAUSE IDENTIFICATION OF POWER LINE OUTAGE

- Investigation of the 220-kV outage is presented
- The unsuccessful reclosing operation occurred after short-circuit on the power line
- The results of transient analyzes were not available for TSO operation staff

- Time-consuming inspections and on-site diagnostics of the power line and installed equipment had to be performed

Failure record of the short-circuit event and following unsuccessful reclosing



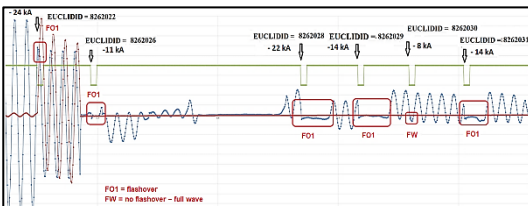
EUCLID ID	AMPLITUDE	STROKE/NO.	LONGITUDE	LATITUDE	SUBJECT CODE	SUBJECT TYPE	DIR/ANGLE	DIR/ANGLE	DIR/ANGLE	DIR/ANGLE	DIR/ANGLE	DIR/ANGLE	
826202	2816-07-27 17:05:28.051	-17	CG	16.73913	46.9649	VOL1_453888	US25F9	678.180239	342360	395.07253705584	0	SR1+GA-AD14	Stroke 0.295
826203	2816-07-27 17:05:28.076	-13	CG	16.73959	46.96514	VOL1_453888	US25F9	688.98702624079	395.07253705584	0	SR1+GA-AD14	Stroke 0.295	
826202	2816-07-27 17:05:28.222	-34	CG	16.74264	46.9649	VOL1_453888	US25F9	148.26212687360	395.07253705584	0	SR1+GA-AD14	Stroke 0.295	
826206	2816-07-27 17:05:28.812	-11	CG	16.74025	46.9649	VOL1_453888	US25F9	138.52005774584	395.07253705584	0	SR1+GA-AD14	Stroke 0.295	
826209	2816-07-27 17:05:29.161	-22	CG	16.74076	46.9649	VOL1_453888	US25F9	115.40900874894	395.07253705584	0	SR1+GA-AD14	Stroke 0.295	
826209	2816-07-27 17:05:29.266	-14	CG	16.74037	46.9649	VOL1_453888	US25F9	97.08071886320	395.07253705584	0	SR1+GA-AD14	Stroke 0.295	
826200	2816-07-27 17:05:28.341	6	CG	16.74660	46.96473	VOL1_453888	US25F9	73.744205926545	395.07253705584	0	SR1+GA-AD14	Stroke 0.295	
826201	2816-07-27 17:05:28.432	-14	CG	16.74173	46.9642	VOL1_453888	US25F9	59.837700988801	395.07253705584	0	SR1+GA-AD14	Stroke 0.295	
826202	2816-07-27 17:05:28.619	8	CG	16.74842	46.96524	VOL1_453888	US25F9	128.308707707441	395.07253705584	0	SR1+GA-AD14	Stroke 0.295	
826202	2816-07-27 17:05:28.777	4	CG	16.75201	46.96377	VOL1_453888	US25F9	503.91945214864	395.07253705584	0	SR1+GA-AD14	Stroke 0.295	

EUCLID data from the time of the incident

EUCLID ID	I_p (kA)	Associated attribute description	Attribute
8262022	-24	Incidence of lightning stroke with transmission line	UDV
		Direct stroke with probability of 0.3	3-PU
		Flashover	FO1
		Coupling with AROPO unsuccessful reclosing record	FOOZSYN
8262030	-8	Incidence of lightning stroke with transmission line	UDV
		Direct stroke with probability of 0.3	3-PU
		No flashover – full wave	FW
		Incidence of lightning stroke with transmission line	UDV
8262032	-8	Direct stroke with probability of 0.3	3 PU
		Flashover	FO1
		Coupling with AROPO unsuccessful reclosing record	FOOZSYN

ET-LEADS output attributes for the three lightning events

Failure record of the short-circuit event and following unsuccessful reclosing association with direct stroke to power line



- The ET-LEADS algorithms for equipment failure do not find any relevant risk
- If the ET-LEADS system was in operation, the line outage time would be significantly reduced