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Impact of replacement of conventional recloser with PulseCloser

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The conventional recloser stresses the circuit with current fault every time it switches into a fault. During reclosing operation of Automatic Recloser, powerful transient processes occurs and significant amount of energy is feeding the fault, resulting in system-damaging and voltage sags. Replacing conventional recloser with PulseCloser minimizes these effects and creates the possibility to use multiple reclosing even when traditional autoreclosing can not be allowed.

This paper analyzes transient processes during simulation traditional and PulseCloser operation. Simulations are performed using ATP software. The simulations show the remarkable difference in current versus time during fault testing in the transmission line equipped with conventional recloser and PulseCloser. The analysis justifies the replacement of Conventional Recloser with PulseCloser.

Keywords: Power system, automatic recloser, PulseCloser, transient processes, ATP software

Introduction

The electric power system is equipped with fault interrupting system to protect the transmission and distribution networks from overcurrents and overvoltages caused during short circuits. The faults on transmission and distribution networks could be:

- unstable/transient, upon the operation of relay protection electric, the arc is eliminated and the fault disappears, or
- permanent, after the operation of relay protection the fault is not eliminated.

Various studies have shown that 70-90% of the faults occurred in overhead lines are transient (IEEE, 1984). Therefore, the overhead lines beside relay protection are equipped with automatic recloser that realizes the reclosing of the line (after the line trippment) by relay protection, in order to identify the transient faults and reclose the line in the normal operation where the fault is eliminated (a successful operation).

Long term experience in the operation of electric power system shows that the success rates of autoreclosing operation vary according to the voltage level of networks from 50-90% (IEEE, 1998). Çelo and Sula (1993), Çelo, Bashari, and Meksi (1995) indicate that the statistics of the success rates of autoreclosing for Albanian Electric Power System is 80% in 220kV network, 73% in 110kV network, and around 60% in 35 kv network. Consequently, the transmission lines beside the relay protection are also equipped with autoreclosing.

In case of transient faults, the autoreclosing minimizes the outage time for consumers, maintains the system stability, reduces the fault period that brings minor faults and facilitates the operators' work of the system in restoring the normal operation as well as ensuring the operation of automated substations (ABB, 1994; Basler Electric, 1998).

According to IEEE Std 37.60-2003, low and medium voltage lines are mainly supplied with three-pole autorecloser which enable a reclose for the three phases of the circuit breaker. Alternatively, high and very high voltage lines, in which most of the faults are phase to ground, are mainly supplied with single-pole autorecloser.

The single-pole autoreclosing allows the two-phase operation of the transmission lines, when the faulted phase is triped-out. In this case the stability limit is higher than during the three-pole ones. During the permanent fault, autorecloser will apply the current fault to equipments and may have adverse affects on system stability. In contrast to traditional autorecloser, PulseCloser sends an impulse and intelligently identifies the fault type.

PulseCloser

PulseCloser technology is based on the latest developments of power electronic and computer techniques. This technology stands on former knowledge, that could not be used without the above technological developments. To explain the main idea of the PulseCloser we will simulate a short circuit in a RL circuit. Once a short circuit occurs, the transient current waveforms depend on the point of the voltage wave where short circuit occurs. Figure 1 shows the RL circuit simulated by means of Transients Alternative Program (ATP) software, which is widely used for numerical simulation of electromagnetic and electromechanical transient processes in electric power system.

The oscillograms in Figure 2 show the remarkable difference in the first half of sinusoidal current during two different short circuit points (0 and 118 degrees) on the voltage wave. In the second case we can see a pulseshape of the first half sinusoids current. The PulseCloser technology uses that impulse to control the type of fault.

FIGURE 1. SHORT CIRCUIT IN A RL CIRCUIT

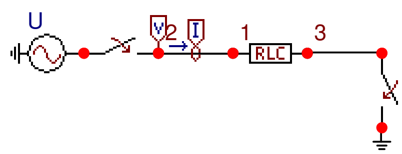


FIGURE 2. SHORT CIRCUIT CURRENTS AT POINT 0^0 AND 118^0 ON THE VOLTAGE WAVE

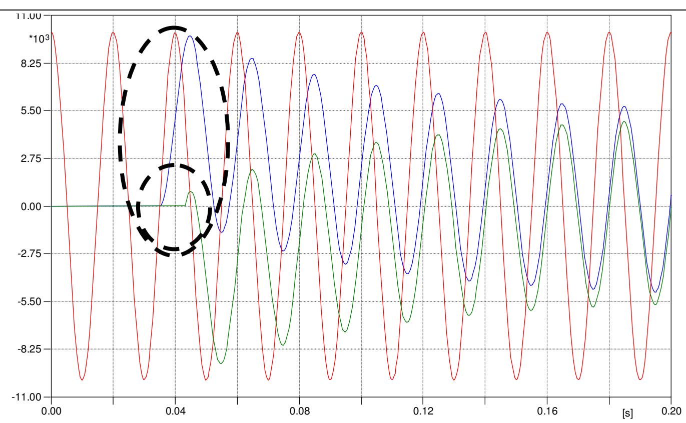
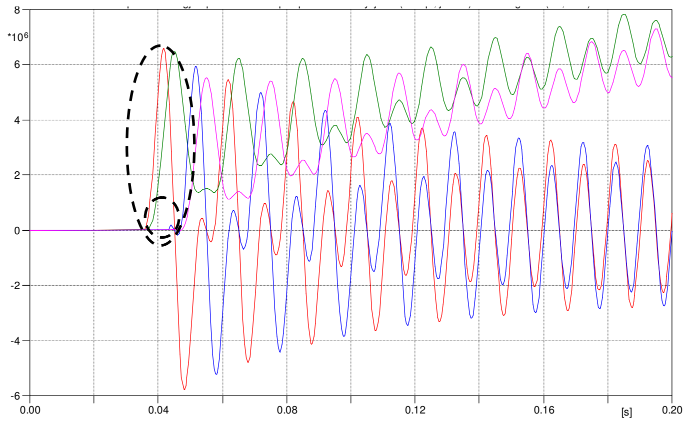
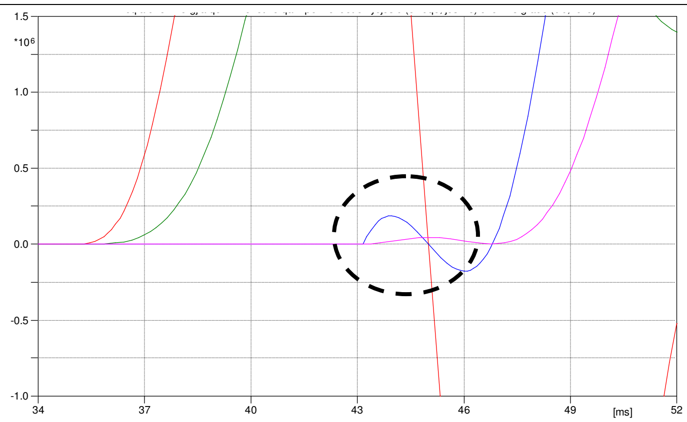


Figure 3a shows the oscillograms of developed power and energy during two different short circuit points (0 and 118 degrees), while in Figure 3b is presented the zoom of the oscillograms for short circuit on point 118 degrees. It can be shown that during the first half of sinusoids, the developed power and energy is much smaller than in the first case.

FIGURE 3. POWER AND ENERGY DEVELOPED DURING SHORT CIRCUIT IN RL CIRCUIT AT POINT 0^0 AND 118^0 ON THE VOLTAGE WAVE



a)



b)

The conventional autorecloser recloses the scheme to test the existence of the fault. During permanent fault the recloser releases a considerable amount of energy in the place of fault, by bringing concerns to the system and causing voltage fluctuations.

PulseCloser verifies if the line is unfaulted before reclosure, by sending a standard current impulse of 5 milliseconds. The short time duration of the fault reduces the energy developed on power system elements. Relative energy that is released I^2*t during the reclosing operation is less than 2% of the energy released in case of conventional reclosing.

Consequently, PulseCloser can realize multiple tests to determine the presence of the fault. It stresses the system elements only at the initial moment of the fault, increasing the lifetime of equipments, reducing the damages, improving operation security of the system and the quality of electricity. Figure 4 shows the operation scheme for two types of autorecloser.

FIGURE 4. THE OPERATION SCHEME OF AUTORECLOSERS

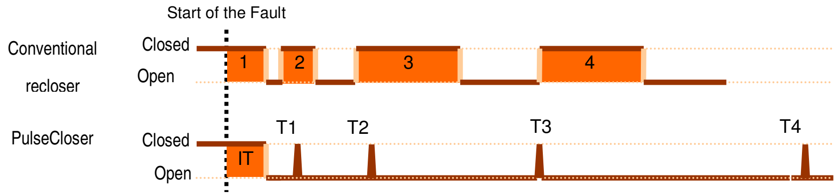


FIGURE 5. THE OPERATION CHARACTERISTIC
OF CONVENTIONAL RECLOSER

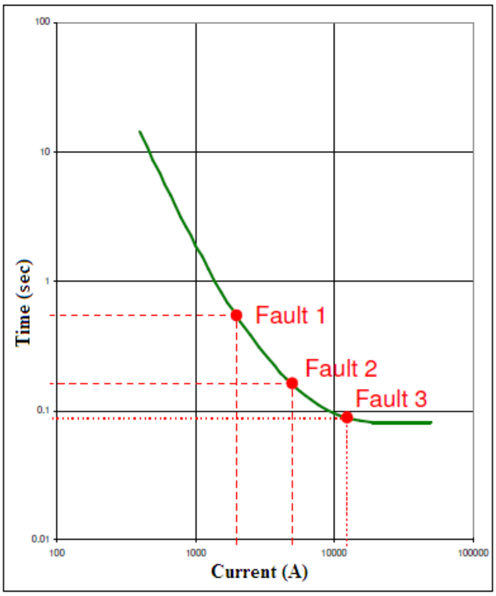


TABLE 1. CURRENTS AND DEVELOPED ENERGY DURING THE OPERATION
OF TWO TYPES OF RECLOSERS

	Current (A)	Time duration (sec)	I^2t (A^2sek)
Fault 1			
Conventional recloser	2000	0.5420	2168000
PulseCloser	930	0.0053	4800 (0.22%)
Fault 2			
Conventional recloser	5000	0.1620	4050000
PulseCloser	2460	0.0055	34400 (0.85%)
Fault3			
Conventional recloser	12500	0.088	13750000
PulseCloser	6380	0.0056	236900 (1.72%)

The amplitude, the duration and the energy developed for three different fault currents are chosen to compare the impact of conventional recloser and Pulsecloser. The operation characteristic of conventional recloser, for minimal interrupting rating of 400A, is given in Figure 5.

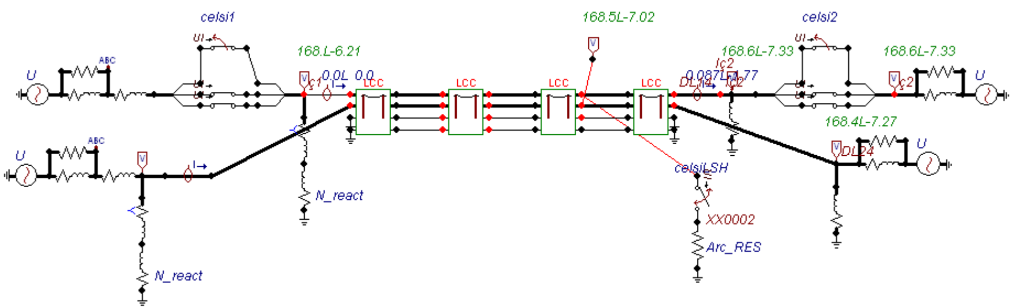
Table 1 shows effective values of currents and developed energy for traditional autoreclosing and Pulseclosing operation. The comparison of the these values shows the decrease of currents and electrodynamics forces in the case of PulseCloser use.

Transient processes during operation of traditional recloser and PulseCloser

During the construction of new lines or the rehabilitation of existing ones is important to evaluate the operation of different reclosers in order to decide about the appropriate recloser to be used. To evaluate the operation of PulseCloser and traditional recloser the real transmission lines are simulated by using ATP software. The transmission lines considered for simulations is the double circuit 220 kV overhead transmission lines Vau Deje - Tirana, 76.8 km length with ACO-400 mm² conductor and C 50 mm² ground conductor with towers type Z - 2 and the total capacity of 325 MW.

The transmission lines Vau Deje-Tirana are connected to 220 kV sending busbars of Vau Deje substation and 220 kV receiving busbars of Tirana substation. The line is constructed in 1971 and is equipped with single pole recloser. Figure 6 shows the connection scheme of the 220 kV transmission lines Vau Deje - Tirana realized in ATP software.

FIGURE 6. DOUBLE CIRCUIT TRANSMISSION LINES VAU DEJE – TIRANA IN ATP SOFTWARE

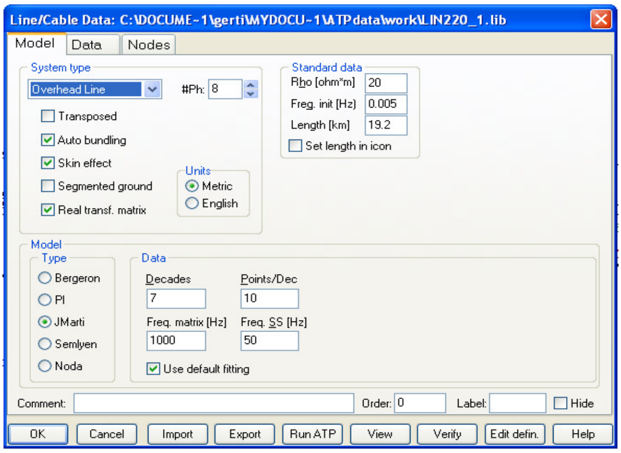


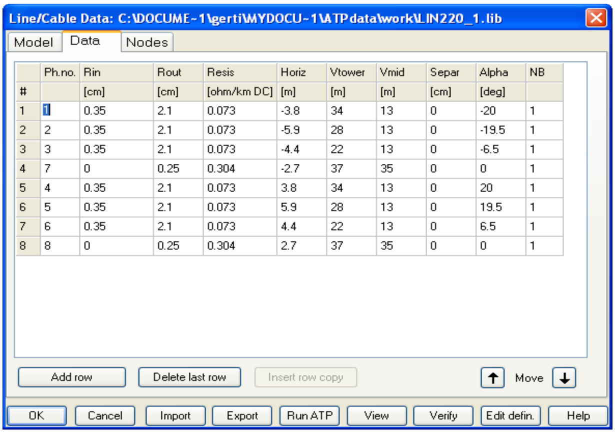
The transmission lines are divided in four sections, each with 19.2 km length. During the simulation, JMartin model is selected to model the transmission lines. Figure 7 shows the interface of ATP software for data line and the model selection.

Current simulations consider the maximum load demand of winter 2009. The lines are double feed; the power system is represented respectively by an emf with the amplitude 183.4 kV and the phase -4.5 degrees in Vau Deje bus as well as the amplitude 171.2 kV and the phase -10.4 degrees in Tirana bus. Both sides of the lines are equipped with time depend circuit breakers, through which can be modeled the operation of reclosers. Single-pole reclosers are used. Circuit breaker C1 is placed at the sending side, in Vau Deje substation, circuit breaker C2 is placed in Tirana substation, while circuit breaker C3 simulates the short circuit.

Figure 8 shows the diagram that models the operation of impulse recloser (first impulse permanent fault, second impulse transient fault) in circuit breakers C1 and C3.

FIGURE 7. THE INTERFACE OF ATP SOFTWARE





#	Ph.no.	Rin [cm]	Rout [cm]	Resis [ohm/km DC]	Horiz [m]	Vtower [m]	Vmid [m]	Separ [cm]	Alpha [deg]	NB
1	1	0.35	2.1	0.073	-3.8	34	13	0	-20	1
2	2	0.35	2.1	0.073	-5.9	28	13	0	-19.5	1
3	3	0.35	2.1	0.073	-4.4	22	13	0	-6.5	1
4	7	0	0.25	0.304	-2.7	37	35	0	0	1
5	4	0.35	2.1	0.073	3.8	34	13	0	20	1
6	5	0.35	2.1	0.073	5.9	28	13	0	19.5	1
7	6	0.35	2.1	0.073	4.4	22	13	0	6.5	1
8	8	0	0.25	0.304	2.7	37	35	0	0	1

FIGURE 8. OPERATION DIAGRAM OF IMPULSE RECLOSER

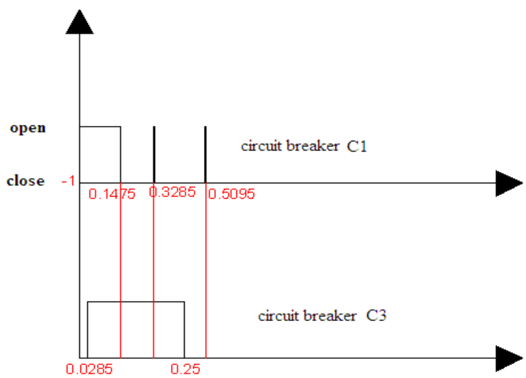


FIGURE 9. OPERATION DIAGRAM OF TRADITIONAL RECLOSER

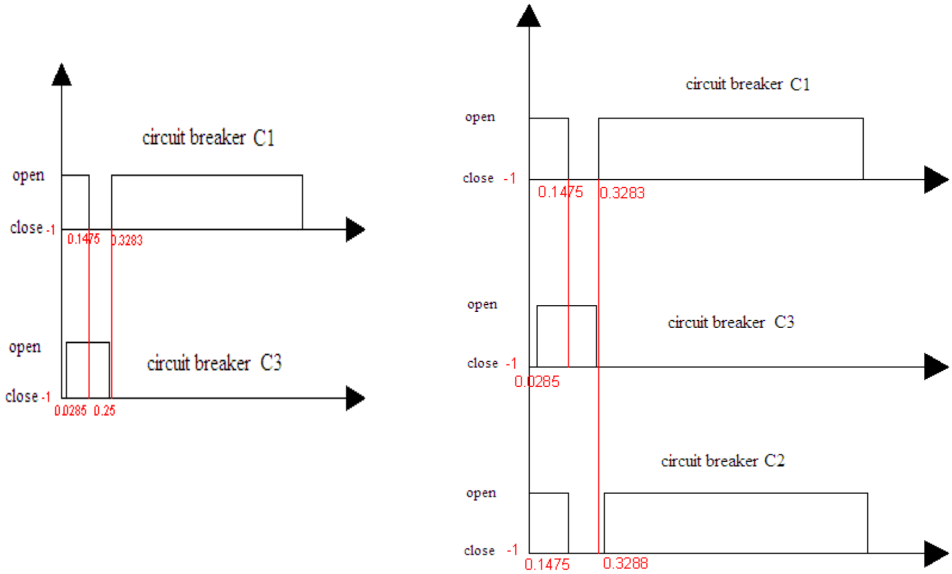
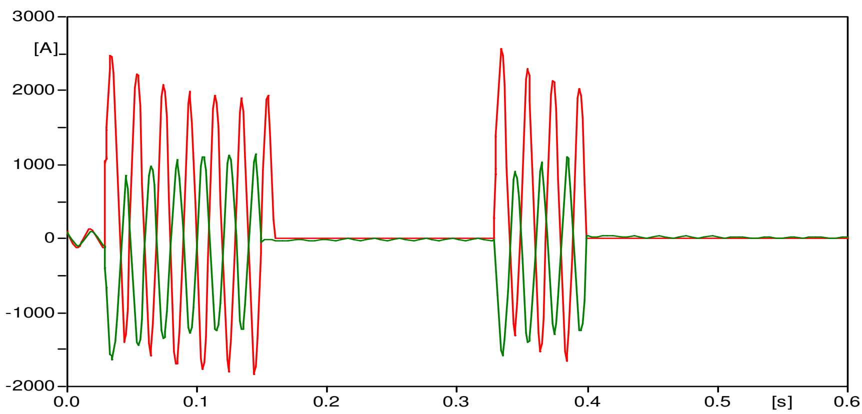


FIGURE 10. THE CURRENT IN PHASE A DURING THE UNSUCCESSFUL OPERATION OF TRADITIONAL RECLOSER



A single phase with ground short circuit at the end of section 3 in phase A of line 1, at a distance of 57.6km from the Vau Deje bus is simulated. Three different cases are simulated in order to compare the results of reclosing operation:

- Unsuccessful operation of traditional recloser (permanent short circuit);
- Successful operation of traditional recloser (transient short circuit);
- Operations of impulse recloser (PulseCloser).

Unsuccessful operation of traditional recloser (permanent short circuit)

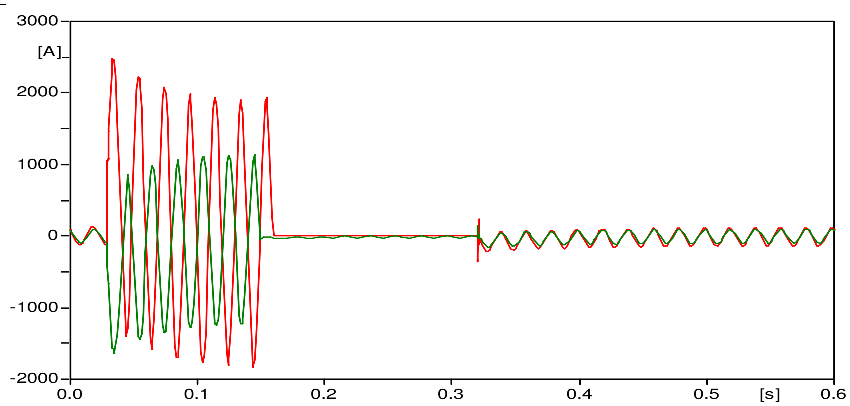
A stable short circuit at time 0.0285sec is simulated. The set time of relay protection is 0.1475 sec while the delay time of recloser is 0.181sec. At the same time the recloser will send the signal to switch on the phase A. Since the short circuit is stable, the recloser has to switch off again after a delay time of 0.07 sec. The results of simulation are given in Figure 10. The green line gives the phase A current at the sending side of the line, in the circuit breaker C1 and the red line gives the phase A current at the receiving side, in circuit breaker C2.

It can be noticed that during the short circuit, the current in circuit breaker C1 reaches the maximum value of 1642 A, while the current in normal operation was about 99A. During recloser, this current reaches the value of 1363 A. On the other hand, the current in the circuit breaker C2 reaches a value of about 2475A, while during recloser reaches the value 2593A. Consequently, these currents are approximately 25-times higher compared to the normal operation.

Successful operation of traditional recloser (transient short circuit)

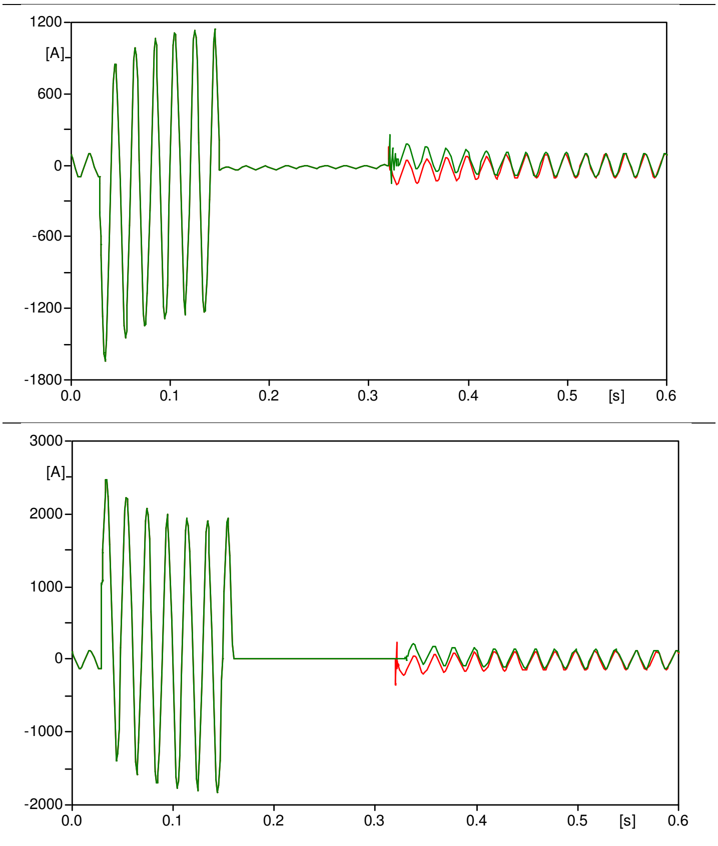
Let's analyse the operation of traditional reclosing when the short circuit is transient and the reclosing operation is successful. Thus, it is supposed that the short circuit happens again at t_1 = 0.0285 sec and is extinguished at t_3 = 0.25 sec. At the time t_2 = 0.1475 sec the faulted phase A is switch off. As the short circuit is transient, the recloser will switch on the phase A in normal operation at time t_4=0.32 sec. The results of simulation are given in Figure 11. The green line gives the phase A current at the sending side of the line, in the circuit breaker C1 and the red line gives the phase A current at the receiving side, circuit breaker C2.

FIGURE 11. THE CURRENT IN PHASE A DURING THE SUCCESSFUL OPERATION OF TRADITIONAL RECLOSER



We can see that during recloser the current is much lower. Due to the line energization a very short transient process at the range of milliseconds is observed. If the operations of the reclosing at both side of the line are not synchronized, we will see a difference in the transient process. Figure 12 shows the currents at the sending and receiving sides of the line in both cases (red for synchronized operation and green for asynchronized one).

FIGURE 12. THE CURRENT IN PHASE A DURING THE SUCCESSFUL OPERATION OF TRADITIONAL RECLOSER, IN THE CASES OF SYNCHRONIZED AND ASYNCHRONIZED RECLOSING



Operations of impulse recloser (PulseCloser)

In this case we will analyse the operation of impulse recloser of type PulseCloser by simulating a multiplied reclosing operation (first impulse permanent fault, second impulse transient fault). PulseCloser sends an impulse to verify if the short circuit is permanent. The results of simulation are given in Figure 13. The green line gives the phase A current at the sending side of the line, in the circuit breaker C1 and the red line gives the phase A currents at the receiving side of the line, circuit breaker C2.

Figure 13 shows that during the short circuit, the currents in circuit breakers C1 and C2 reaches the maximum value of 1642 A and 2475 A, respectively. Subsequently, the faulted phase will switch off.

At time t = 0.3285 sec, the recloser send an impulse with 0.003 sec length. The currents peak values in circuit breakers C1 and C2 reach respectively the maximum value of 680A and 872A, identifying a stable short circuit. Another impulse with the same length 0.003 sec is send at time t = 0.5098 sec. In the second case, the currents peak values in circuit breaker C1 and C2 declines to 153A and 330A, identifying that the short circuit is extinguished.

FIGURE 13. THE CURRENT IN PHASE A DURING THE OPERATION OF IMPULSE RECLOSING, FIRST IMPULSE THE SHORT CIRCUIT IS STABLE WHILE IN THE SECOND IMPULSE IS EXTINGUISHED

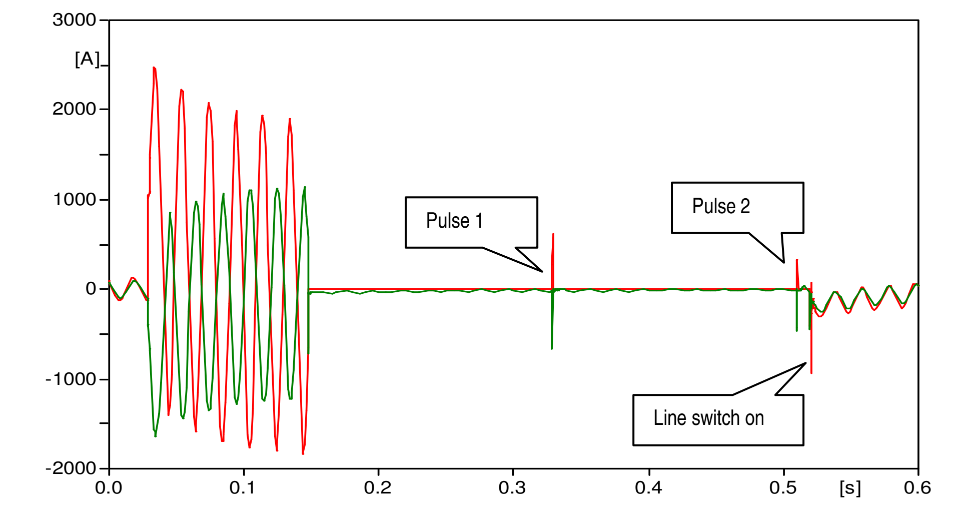
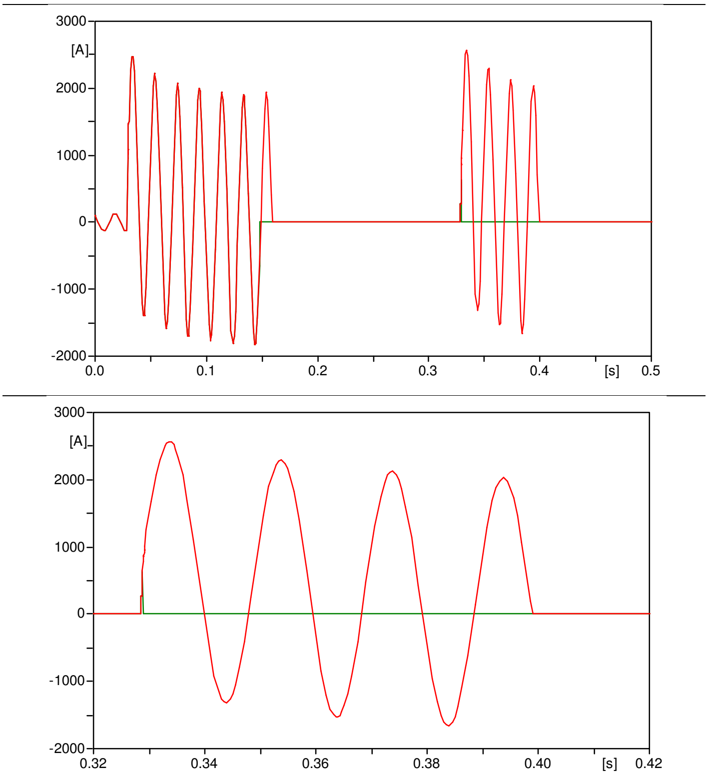


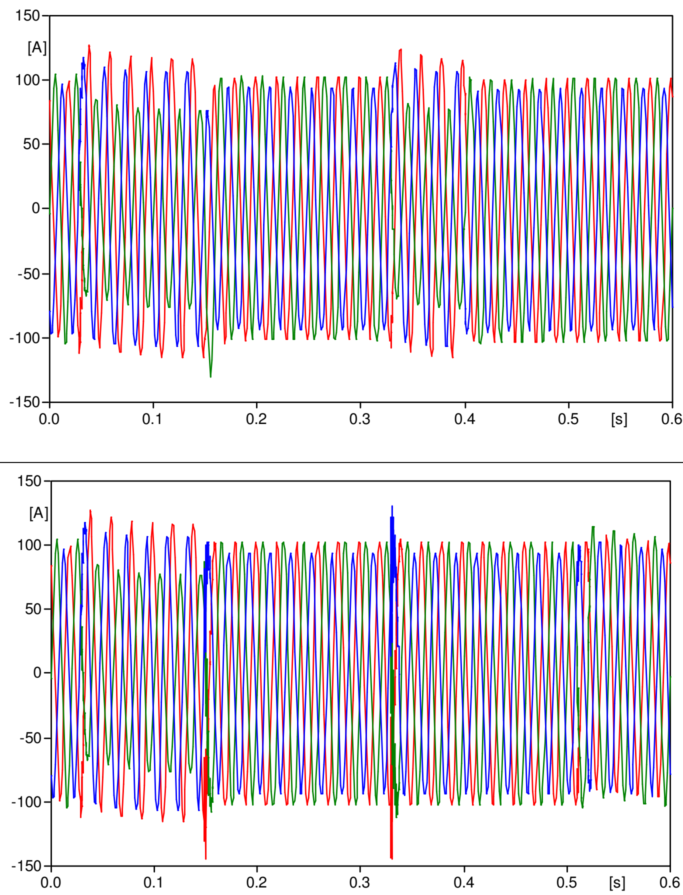
FIGURE 14. THE CURRENT IN THE CIRCUIT BREAKER C2 FOR STABLE SHORT CIRCUITS FOR CONVENTIONAL RECLOSER AND PULSECLOSER



In Figure 14 are shown the currents (zoom) in phase A of the circuit breaker C2, during the simulation of the stable short circuit for conventional reclosing (red line) and impulse reclosing (green line).

In Figure 15 is shown the currents in the second unfaulted parallel line. During the operation of the conventional recloser, the currents at unfaulted line reached the value of 123 A (about 24% higher than in the normal operation).

FIGURE 15. THE CURRENT IN THE UNFAULTED PARALLEL LINE FOR CONVENTIONAL RECLOSING AND FOR PULSECLOSER



Conclusion

During the operation of conventional reclosing, a stable fault causes powerful transient processes that bring fast amortization or damage to the equipment and relevant isolation. Impulse reclosing minimizes these processes and creates the possibility to use multiple reclose even when traditional reclosing can not be allowed.

This paper analyses the transient processes during operation of the traditional reclosing and impulse reclosing in 220 kV transmission line Vau Deje - Tirana and evaluates their impact on the elements of the system. Simulations are performed by using ATP software.

Simulations show reduction of faulted currents over 50% when impulse recloser is used. Moreover, it reduces the overall transient processes. It is evaluated that the energy released in the case of impulse recloser operation amounts about 1% of the energy produced during traditional recloser operation.

Impulse recloser increases the lifetime of the equipments by reducing the overcurrents, enhancing the stability of the system, multiplying the number of reclosing and eliminating the transient faults with a medium time duration.

This analysis justifies the recent replacement of the traditional recloser with impulse recloser (PulseCloser).

In this aspect should be seen as an opportunity in the construction of new lines as well as during the rehabilitation of existing ones.

References

ABB Electric Utility School - Reclosing; 1994

Basler Electric, Basler Electric Relay Application School - Reclosing; 1998

Çelo, M., Bashari, P., Meksi, L., 1995. "Analiza statistikore e sjelljes se mbrojtjes rele dhe automatikes ne Sistemin elektroenergjetik gjate viteve 1990-1994" Instituti Energjetik, Tirane Dhjetor.

Çelo, M., Sula, D., 1993. "Analiza statistikore e sjelljes se elementeve ne centrale dhe ne rrjetin e transmetimit 400, 220, 110, 35 kV per nje periudhe 10-vjeçare," Instituti Elektroenergjetik Tirane Korrik.

IEEE Std 37.60-2003, 2003. "IEEE Standard Requirements for Overhead, Pad-Mounted, Dry Vault, and Submersible Automatic Circuit Reclosers and Fault Interrupters for Alternating Current Systems Up to 38 kV," Institute of Electrical and Electronics Engineers, Inc.

