EUROPEAN ACADEMIC RESEARCH
Vol. IV, Issue 2/ May 2016

Impact Factor: 3.4546 (UIF)
DRJI Value: 5.9 (B+)

ISSN 2286-4822
www.euacademic.org

Evaluating the activation of auto recloser relays in power distribution grid of Masjed Soleiman City

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Abstract:

Auto-recloser relays are the only relays in the power grids, which unlike other relays, issue switch connection command. These relays are used in order to reduce off time on feeder in substations. Currently, distribution in the mentioned stations is in off state due to the instability of the electricity distribution grid. The purpose of this paper is to economic and technical investigation of re-activating auto recloser relays in power distribution grid of Masjed Soleiman City, which is in off state. The results show that activation of the mentioned relays in this power distribution grid is not recommended due to the lack of economic justification or insufficient equipment of its distribution grid such as sectionalizer.

Key words: activation of auto recloser relays, power distribution grid, Masjed Soleiman City

INTRODUCTION

Nowadays, the electrical energy is an integral part of human life. Advanced and industrial life of consumers requires a source of electrical energy with reliable and high quality. To provide such a purpose, it is necessary to minimize the interruption in electrification. Distribution grids have not a high reliability due to its radial structure. In distribution grids, protection is done at the beginning of the feeder, and the occurrence of any event makes leads to outage in the entire feeder. For this purpose, auto recloser relays are used to reduce transient outages.

Unfortunately, these relays in Khozestan Province are kept in off state for fear of being a permanent short-circuit fault. Because, reconnecting the switch when the fault is permanent and it is not met can lead to worse problems or even irreparable damages. The older generation of reclosing relays is not able to detect permanent or transient fault. If they became active, they may make problems for the grid. However, the new generation of reclosing relays is able to detect permanent and transient fault. However, the results show that using this type of technology in the new generation of auto recloser relays is not reliable. For example, it uses faulty phase voltage harmonic fault to detect the healthy phase in source [1]. In addition, neural networks are used in other methods. Aggarwal et al. passed the one of the healthy phases from a filter. Then, they calculated the power of high-frequency components in the output signal of the filter and compared them. In case of exceeding this power from a threshold level, the fault is transient and otherwise, it is permanent [2]. [3] has introduced a detector based on fuzzy inference. However, all the mentioned methods have disadvantages and cannot ensure distribution companies in activating auto recloser relays. Specifically, the maximum faults are in the distribution sector and the mentioned methods are recommended in the transmission sector. Although studies have been done to enable the relay in the distribution grid [4] [5].

In this paper, initially the faults in a sample feeder were analyzed in the city of Masjed Soleiman to separate the faults whose connection by auto recloser relays can benefit the grid economically. Then, the sample grid is simulated in

EMTP/WORK software. The main disadvantage of the relay that is switch connection in the permanent state of the fault in the grid is occurred to evaluate the stability of grid equipment against permanent fault such as three-phase fault. After comparing them, the best recommendation in relation to the activation or non-activation of auto recloser relays will be given in Masjed Soleiman distribution grid.

1. ANALYSIS OF OCCURRED FAULTS IN A SAMPLE FEEDER IN THE CITY OF MASJED SOLEIMAN

In order to economic investigation of auto recloser relays for being in the circuit, feeder outages in the city of Masjed Soleiman was evaluated in one year. The results can be seen in Figure 1.

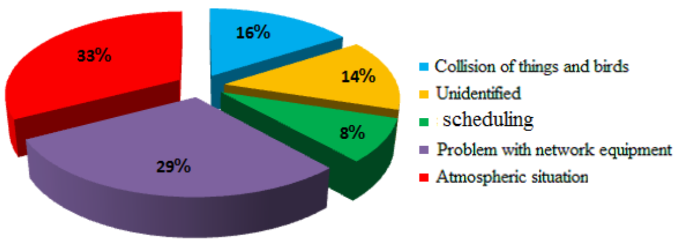

Figure 1: Annual fault analysis of the sample feeder

The mentioned outages were divided in to 5 categories caused by objects' collision, atmospheric conditions, schedule, uncertain, and problems in the equipment of distribution grid. There are 3 categories of faults in mentioned outages, which are required to be visited before the connection command. Because permanent state is more likely in these three states, though, short circuit has been announced as the most important factor in grid visiting. In case of colliding an external object to the grid or occurring a problem in the distribution grid, it is better to visit the grid until re-energizing by auto recloser relays. But only an outage factor can be connected by the relay in the grid, which is uncertainty of the outage cause. If there was no problem in the grid, line reconnection command by the relay seems to be logical. 14% of outages in the sample grid were unspecified while according to Figure 2, this factor allocates the least undistributed energy to itself (12135.5 kWh).

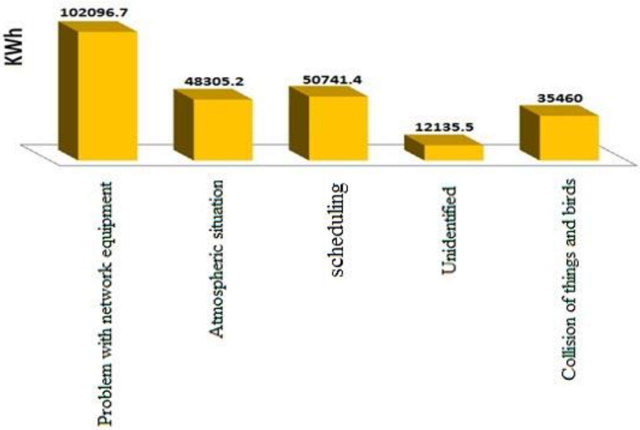

Figure 2: undistributed energy resulting from faults in the sample feeder

If we consider the price of each kilowatt-hour energy 150 tooman with subsidized fuel, the amount of undistributed energy that could reach the consumers by auto recloser relay command is less than 2 million tooman. This small amount is insignificant versus the price of feeder switch, which is about 20 million tooman. In addition, it could be removed in auto recloser relay re-command when there is a permanent fault on the grid, and it cannot be justified economically.

2. CALCULATION OF OVERVOLTAGE AND SWITCH CURRENT OF SAMPLE FEEDER AT THE MOMENT OF LINE CONNECTION BY AUTO RECLOSER RELAY IN PERMANENT FAULT STATE

Given that the most severe type of transmission fault in terms of short circuit power transmission is three-phase fault [6], we applied this type of fault in the sample feeder simulation to consider the worst conditions in the grid.

Each three-phase system's vector can be divided into three components that two of which, are in the opposite direction of the rotation and one component is in the same phase. These three mentioned components are named positive, negative, and zero. In Figure 3 and 4, the phase voltage analysis to the mentioned components is shown in the grid. The relationship between the components is shown as follows [6].

$$\begin{aligned} \overline{E_a} &= \overline{E_1} + \overline{E_2} + \overline{E_0} \\ \overline{E_b} &= a^2\overline{E_1} + a\overline{E_2} + \overline{E_0} \\ \overline{E_c} &= a\overline{E_1} + a^2\overline{E_2} + a^2\overline{E_0} \end{aligned} \quad (1)$$

$$\begin{aligned} \overline{E_1} &= \frac{1}{3}(\overline{E_a} + a\overline{E_b} + a^2\overline{E_c}) \\ \overline{E_2} &= \frac{1}{3}(\overline{E_a} + a^2\overline{E_b} + a\ \overline{E_c}) \\ \overline{E_0} &= \frac{1}{3}(\overline{E_a} + \overline{E_b} + \overline{E_c}) \end{aligned} \quad (2)$$

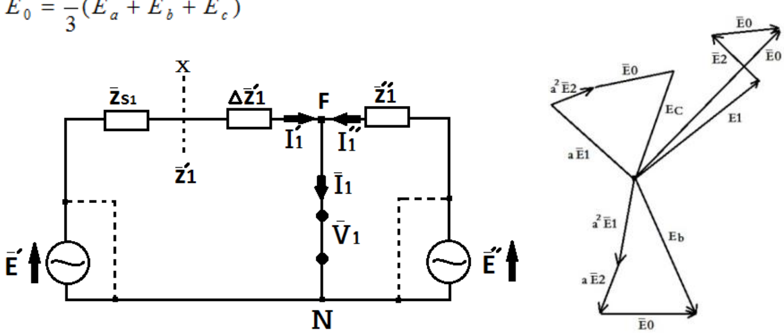

Figure 3: Analysis of a voltage system to symmetrical components

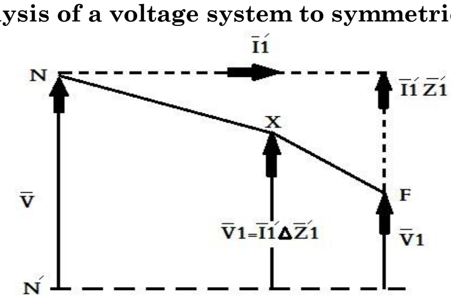

Figure 4: Positive component diagram of simple system with a fault at point F

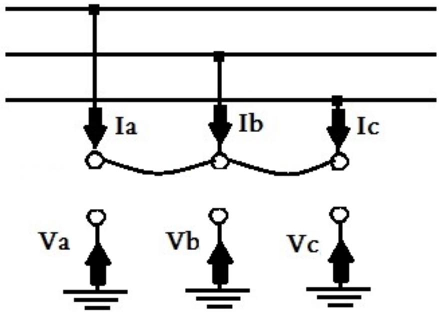

Figure 5: The three phase short circuit

According to Figure 5 in the three-phase or three-phase short circuit to the ground, we will have:

$Va = 0 \qquad Ia = ?$

$Vb = 0 \qquad Ib = ?$

$Vc = 0 \qquad Ic = ?$

Considering Equation 2, we will have:

$$V_{a1} = \frac{1}{3}(V_a + aV_b + a^2V_c) = \frac{1}{3}(1 + a + a^2)V_a = 0$$

$$V_{a2} = \frac{1}{3}(V_a + a^2V_b + aV_c) = \frac{1}{3}(1 + a + a^2)V_a = 0 \qquad (3)$$

$$V_{a0} = \frac{1}{3}(V_a + V_b + V_c) = 0$$

As we know, $1 + a + a^2 = 0$, thus, the equivalent circuit of the grid's three-phase short circuit will be in the form of Figure 6.

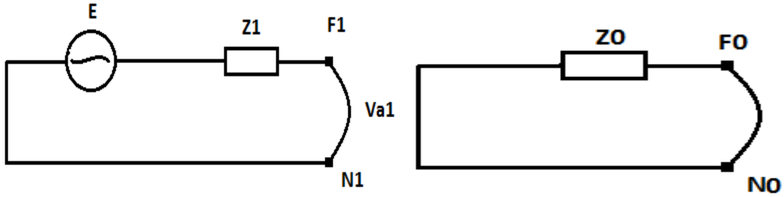

Figure 6: The equivalent circuit of grid's three-phase short circuit

And, we have:

$$V_{a1} = E - I_{a1}Z = 0 \longrightarrow I_{a1} = \frac{E}{Z_1}$$

$$V_{a2} = 0 \qquad V_{a0} = 0 \longrightarrow I_{a2} = 0 \quad I_{a0} = 0$$

As a result:

$$I_a = I_{a1} + I_{a2} + I_{a0} = \frac{E}{Z_1}$$

$$I_b = a^2 I_{a1} + aI_{a2} + I_{a0} = a^2 \frac{E}{Z_1}$$

$$I_c = aI_{a1} + a^2 I_{a2} + I_{a0} = a\frac{E}{Z_1} \qquad (4)$$

Therefore, in this case, the final amount of current, which depends on the voltage and impedance line include:

$$|Ia| + |Ib| + |Ic| = \left|\frac{E}{Z_1}\right| \qquad (5)$$

To calculate the overvoltage and the current of the sample feeder current in the city of Masjed Soleiman at the moment of line connection by auto recloser relay in the permanent fault state (three phase fault), we simulated the 33kV sample feeder grid with 9MW in EMTP/WORK as in Figure 7. The objective is to evaluate the stability of the feeder against the permanent fault at reconnecting moment of the distribution line by the relay.

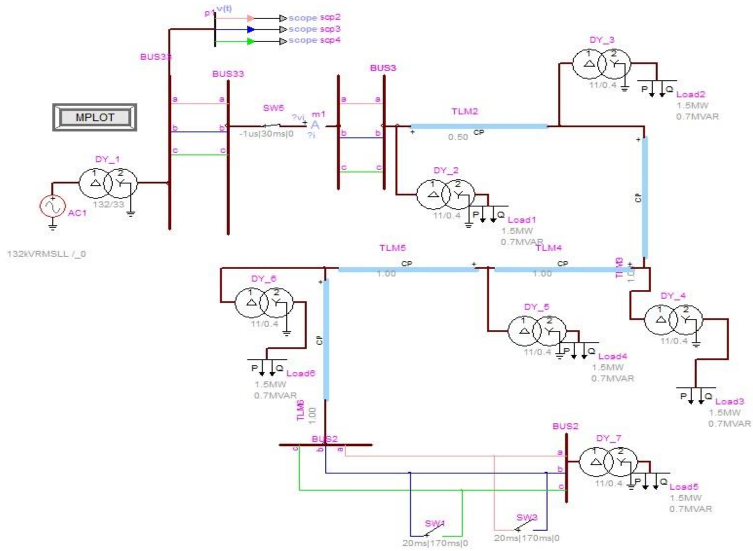

Figure 7: Simulation of sample feeder in EMTP/WORK software

Technical specifications of the feeder are given in Table 1 for comparison. In the simulation, three-phase permanent fault is considered in both the end and beginning of the line. The switch will be cut off automatically 30 millisecond after the onset of the permanent fault. While re-connection command will be issued by the auto recloser relay at the time of 70 milliseconds. Figures 8 to 11 show the overvoltage and applied current to the switch in a permanent fault at the beginning and end of the feeder.

Table 1: Technical specifications of the sample feeder

Manufacturer's name	Pars Switch
Switch type	Gas SF6
Nominal current (A)	1600
Nominal voltage (KV)	36
Power Outage (KA)	25
Plug power (KA)	63
Gas pressure (bar)	3.5

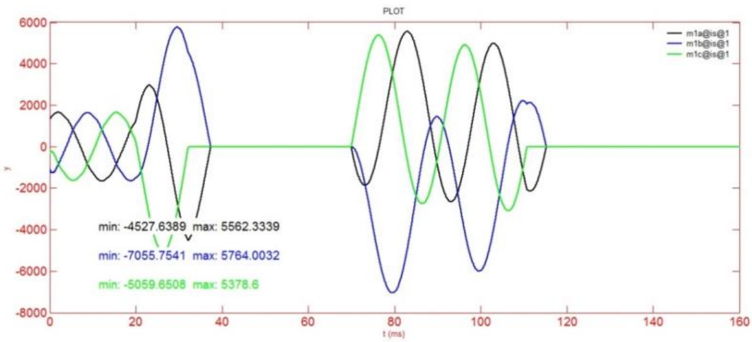

Figure 8: The applied overcurrent on the sample feeder switch at the moment of connect command in auto recloser in a permanent fault state at the end of the line

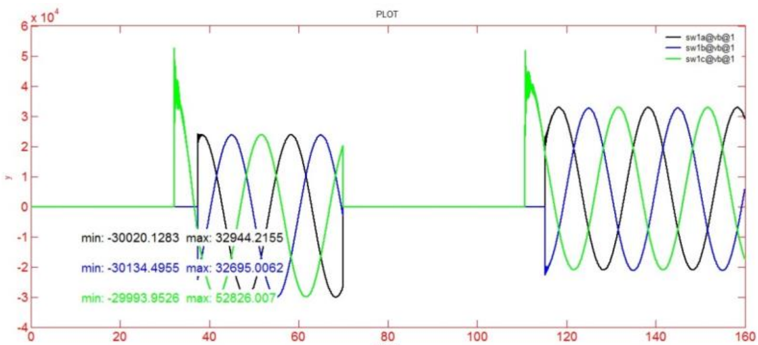

Figure 9: The applied overvoltage on the sample feeder switch at the moment of connect command in auto recloser in a permanent fault state at the end of the line

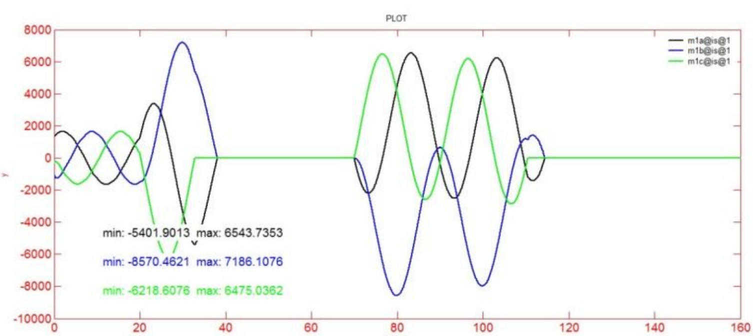

Figure 10: The applied overcurrent on the sample feeder switch at the moment of connect command in auto recloser in a permanent fault state at the beginning of the line

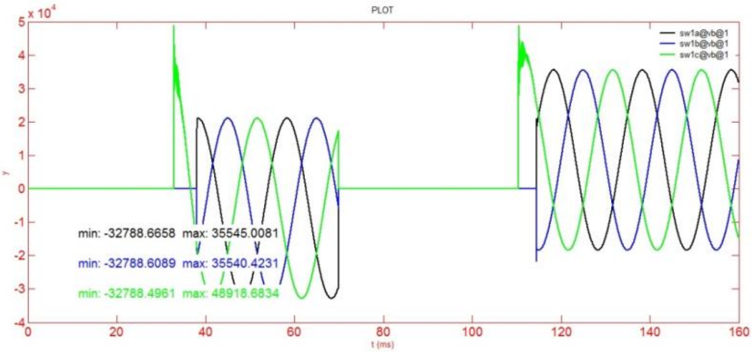

Figure 11: The applied overvoltage on the sample feeder switch at the moment of connect command in auto recloser in a permanent fault state at the beginning of the line

According to the above figures, the highest applied voltage will be at the moment of grid connection by auto recloser relay in the permanent fault state in phase C with about 52.8kV. This overvoltage occurs when the fault occur at the end of the feeder. This overvoltage, which is higher than the nominal voltage of the switch, can defect its insulation in case of applying more than the switch resistance time against the fault. In addition, since the overvoltage is created simultaneously with distancing among the contacts, the speed of this distancing should large enough so that it does not restart the arc.

The highest overcurrent to the switch is when the fault is created at the beginning of the feeder. The results show that this overcurrent is about 8.5kA. However, this overcurrent is more than the nominal current of the switch, but this value is less than the outage power of the switch and it does not cause a problem for it.

CONCLUSION

According to the results of this paper, connection by auto recloser relay is logical only in a small part of outages. However, reconnecting the relay is not allowed in outages caused by objects' collision because of the separation of objects from the grid or problems in the distribution grid due to the removal and replacement of faulty equipment. The applied overcurrent and overvoltage imposed by the permanent faults at the time of reconnection command of auto recloser relays is harmful for the grid and does not justify the use of relays. Given that the maximum faults occurs in the distribution grid, and most of the distribution grids such as Masjed Soleiman distribution grid has been created aerial, it is logical to keep the auto recloser relay in the off state and to visit the grid before energizing. Using auto recloser relays is not recommended currently because of the instability of the distribution grid and inability of the relay in detecting the stable fault from the transient one.

REFERENCES

[1] Aggarwal. R.K, Johns. A.T, Dunn. R.W, Fitton. D.S, "Neural Network Based Adaptive Single-Pole Autoreclsure Technique for EHV Transmission System ", IEEE Proc-Gener Transm. Distrib, vol. 141, no. 2, pp:155-160, 1994.

[2]Bo. Z.Q, Aggarwal. R.K, Johns. A.T, "A Novel Technique to Distinguish Between Transient and Permanet Fault Based on Detection of Current Transient", Proceeding of 4th international Conference on Advances in power system control, Operation and Mnagment. Pp: 217-220, 1997.

[3] Lin. X, Liu. P, "Method of Distinguishing Between Instant and Permanet Fault of Transmission Line Based on Fussy Decision, IEEE Catalog No. 98EX137, pp: 455-460, 1998.

[4] Niko Sadeghi, Fatemeh Elshan, Niki moslemi, Davoud Jalali, "reviewing the choice of filtering equipment of air distribution grids and its impact on reliability indices", Seventeenth national Conference on Electricity Naji Networks, Tehran, 1391.

[5] Naji Qadrnzhad, Meysam Ghaolami, Leila Rashidi, "providing an efficient method for optimal protection and coordination of distribution and subtransmission grids in Sanandaj city and assessment of their performance", Seventh Conference of the power system protection and control, utilities University of Technology, 1391.

[6] Mojtaba Khadarzadh, Mohammad Martajy, Ali Safar Nourollah, Ismail Hamadani Gulshan, Fundamentals of Power Protection Systems", published by the utilities industry.