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Simulation of Relay Coordination by Labview and the Effect of Relay Coordination on Cost

Hasan Çimen[1,a], Recep Akkan[1] and İsmail Yabanova[1]

[1]Afyon Kocatepe University Technology Faculty, Electrical-Electronics Department, ANS Kampusu,Afyonkarahisar, TURKEY

hcimen@aku.edu.tr

Abstract. In this study, it is emphasized that simulation of the avoidance of unnecessary energy cuts in a sample electricity distribution network. The electricity cut-off costs can be decreased by ensuring that relay coordination end only at the source of the fault from the point of failure. Over currents are calculated and the sample network is simulated in the LabVIEW environment. The parameters of delayed overcurrent trip setting (I>), instantaneous overcurrent trip setting (I>>), delayed ground overcurrent trip setting (Io>), instantaneous ground current trip setting (Io>>) are set according to a specific logic in relay coordination. As a result, you can get an idea about how much profit can be made by doing the relay coordination correctly and the amount of unnecessarily avoided energy. It is aimed with the application of this simulation in the real field that electrically operated materials of the people, who are unnecessarily energy-consuming, have less damage and that the energy-selling company loses less money.

1. Introduction

One of the most important protection elements in the transmission and distribution of electrical energy is the overcurrent protection relays. Every part required for the integration of transmission and distribution is protected by suitable breakers at the time of failure and damage to all equipment in this integration is prevented. The duty of the overcurrent protection relays (digital, mechanical) is to separate the faulty output from the system in the case of a failure, to send an immediate trip signal to the breaker and to help the personnel inform the type, duration and time of the fault by keeping in its own memory (at least 20 records) [1].

Reliability in distribution systems is very important. This reliability is directly related to the adjustment and operation of the relays. Reports by the North American Reliability Council notes that protection systems often play a role in failures in power distribution systems. For the period from 1984 to 1988, the study of significant failures reported and outlined by the Council states that protection relays play a role in 73.5% of the main faults somehow. The reliability analysis of the protection relays is the measurement of faulty or improper operation of the protection relays [2].

This study was carried out upon the fact that there is non-conforming operation of 15 breakers and relays located in İhsaniye region and that it is consequently seen that settlements, agricultural irrigation transformers etc. are de-energized needlessly. Many studies related to relay coordination have been carried out. In one of these, the article titled "Adaptive protection testbed using real time and hardware -in-the-loop simulation", Montenegro, Montoya and Ramos propose an alternative

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method for coordination of overcurrent protection devices with two co-simulation techniques. These are real-time simulation and hardware-loop simulation. These simulations were performed using the IEEE 13-Nodes test system in different software (PSAT® and LABVIEW®) [3]. In this article, we have seen that the over-current protection relays on the simulation have worked in a harmonious way after the required safety distances have been entered into the LabVIEW program and the multipliers that need to be entered into the overcurrent protection relays are calculated considering the field environment rather than the computer environment.
In this study, digital and mechanical relays in the field are set. Settings are calculated on the LabVIEW program and entered into the relays in the field in the most appropriate way. The time multipliers calculated on the LabVIEW program are 0,11-0.13 etc., the values closest to these values have been entered into the mechanical relays in such a way as to minimize the relay coordination because these values couldn’t have been entered into mechanical relays.

2. Overcurrent Protection Relay

The overcurrent protection relays must be selective, reliable, easily adjustable and economical. The overcurrent protection relays send a trip signal to the breakers if the current exceeds the current set. They flow current through by current transformers. The current transformer helps the relays to read the nominal current by reducing the current in the normal line. For example; 150-300/5-5 current transformer etc.

2.1 Current-Time Characteristics in Overcurrent Relay

T=(K/((G/G_s)^L-1)+C)×TM(s) (1)

T : Trip time (seconds)

K,C,L : Coefficients

G : Input current (Fault current)

Gs : Capture current set

TM : Time multiplier

The overcurrent protection relays operate according to equation (1). When the equation in (1) is taken into consideration, the coefficients according to the relay characteristics and standards are as follows.

Table 1. Table of relay coefficients

Types of Characteristics	Standard	K	L	C
Standard Inverse	IEC	0,14	0,02	0
Very Inverse	IEC	13,5	1	0
Extremely Inverse	IEC	80	2	0
Moderate Inverse	ANSI/IEEE	0,0515	0,02	0,114
Very	ANSI/IEEE	19,61	2	0,491

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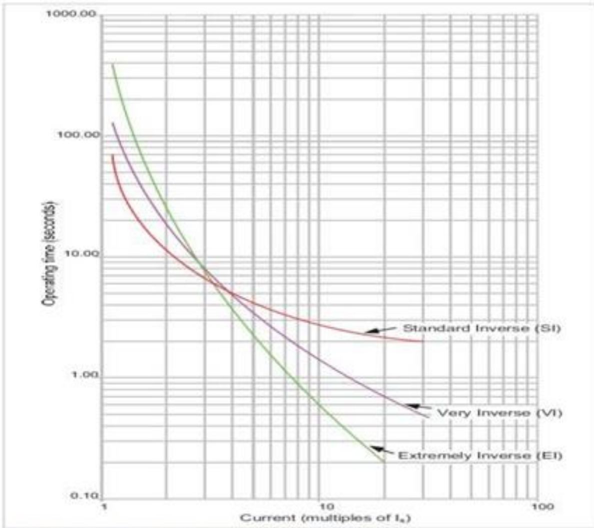
Inverse				
Extremely Inverse	ANSI/IEEE	28,2	2	0,1217

The coefficients K, L, C vary according to the type of curve used (Standard Inverse, Very Inverse etc.) while calculating the opening time of the overcurrent protection relay as shown in Table 1 (0,14-0,02-0 / 13,5-1-0 etc.).



IEC 60255 IDMT relay characteristics; TMS=1.0

Figure 1. Representation of trip times of the relays according to curve types under IEC standard [5]

If the overcurrent protection relays are adjusted according to the fixed time characteristic, they wait for the set time until the set current is exceeded and send the trip signal. If they are set according to the other characteristics, they operate in such a way that the signal sending time decreases as the fault current increases according to their type [4].

3. Ihsaniye Region Where Sample Application is carried out

The transformer power supplying the settlements in İhsaniye region is about 6,6 MVA. Besides, it also creates a burden since there are spa tourism (Gazlıgöl etc.) and hotels in the region. These loads are controlled by 15 breakers, 15 disconnectors and 15 overcurrent protection relays. In addition to the special lines in the region, there is approximately 145 km of line (pigeon, raven, swallow) with different sections at the OG(34,5 kV) (except for AG).

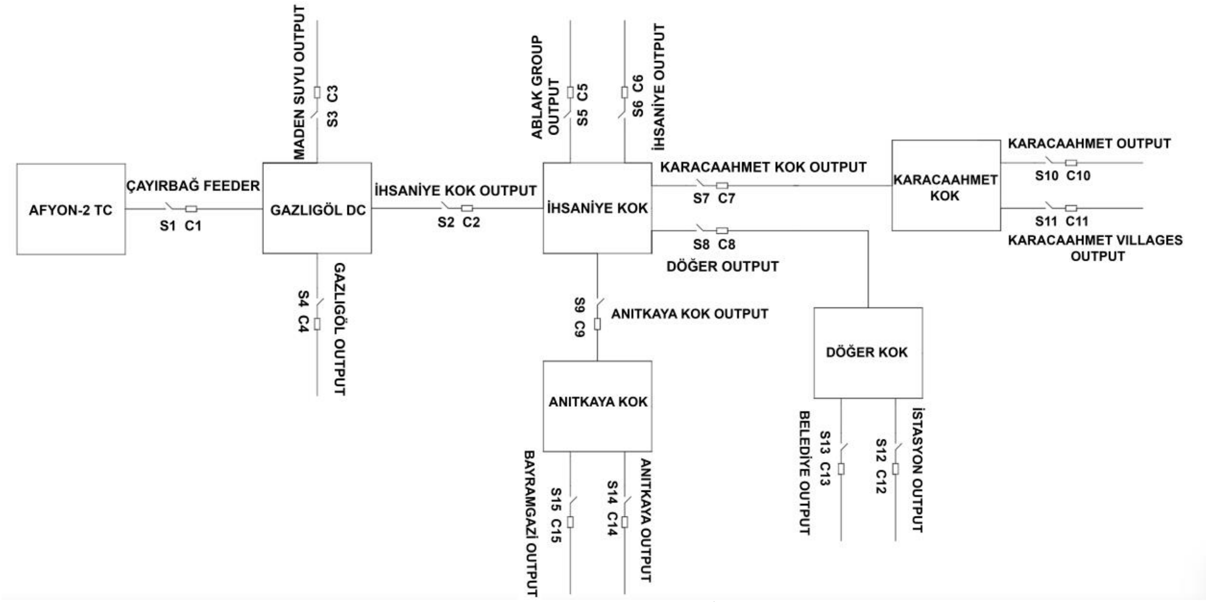


Figure 2. Single line diagram of İhsaniye region

If we refer to the reasons that cause unnecessary energy cuts in the first section of İhsaniye region; the reasons for this energy cut can be very different. For example, technical reasons (Conductor Error, Transformer Error, Trip Signal, Short Circuit Failure and Other Defective Equipment, Isolator Cracking), weather conditions (snowstorm, tropical storms, heavy rainfall, lightning strike, severe wind, solar storm, extreme temperatures), natural disasters (earthquakes, avalanches, tidal waves, landslides and hurricanes), capacity (over-demand and overload of the system), lack of maintenance, animal (snake, cat, raccoon, bird), human (operator error, cut or stealing of conductor and equipment), tree (tree overturning and elongated tree branches), accident (fire, truck or crane crash, traffic accident, drop of the tree branches on the conductor), cut (the raw material used in the generation of electricity cannot be provided) and unknown (other non-recorded reasons for cut) etc. According to the records, the most common cause of energy cut is wind and rain with 31,4%. This factor is followed by equipment failure with 19,9%, ice storm with 11,1%, hose or tropical storm with 10,1%, lightning strike with 8,8%, operator error with 8,5%, fire with 5,6%, voltage drop with 3,9%, earthquake with 1,6% and deliberate reasons (sabotage) with 0,7% [6].

The purpose of relay coordination is to isolate the faulty part from the system with the reaction of all the elements of the system (breaker, relay etc.) as soon as possible when the relay is set with optimum values [7-8-9].

4. Method and Relay Coordination with LabView

Overcurrent protection relays send trip signal to breaker in case of failure. In practice, the nearest relay should be able to detect the fault and the nearest breaker should be able to clean failure as main purposes of the relay coordination in case there is short circuit (or failure). Because it cleans, other breakers must remain in the off position. The tripping time of the relay must be kept as short as possible because the line remains stable and other relay and breakers are not affected by sudden load changes. However, this short retention process must be done precisely that it doesn’t affect relay coordination.

- I> : It is the symbol used for delayed overcurrent trip adjustment.
- I>> : It is the symbol used for sudden overcurrent trip adjustment.
- Io> : It is the symbol used for delayed ground overcurrent trip adjustment.

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- Io>> : It is the symbol used for sudden ground current trip adjustment

Such problems as opening two breakers and not opening by inappropriate breaker originating from previous miscalculations due to mechanic relay in İhsaniye region (such multipliers as 0,13-0,17 cannot be entered) and lack of suitable current transformers etc. have been tried to be solved. This solution process was done by making simulation program on LabVIEW and considering the field environment. For example, it is seen that the opening time is 150 ms in the catalog information of a breaker, this time increases to 200-220 ms in the field environment (such reasons as 10 years of usage and opening and closing for many times). In this article, a solution (appropriate safety period) is presented by taking most field conditions including them into account.

According to the single line diagram of İhsaniye region, which is shown in Figure 2, because Madensuyu and Gazlıgöl outputs from Gazlıgöl DM, Ablak Group and Central İhsaniye outputs from İhsaniye KÖK (Breaker Measure Box), Bayramgazi and Anıtkaya outputs from Anıtkaya KÖK, Municipality and Station outputs from Döğer KÖK and Karacaahmet and Karacaahmet Villages outputs from Karacaahmet KÖK are the last outputs, they are activated with the value (I>> and Io>>), I>> is 5 times greater than the value I> with a delay of 30 ms and the value Io>> is also 6 times greater than the value Io> with a delay of 30 ms in overcurrent and ground protections.

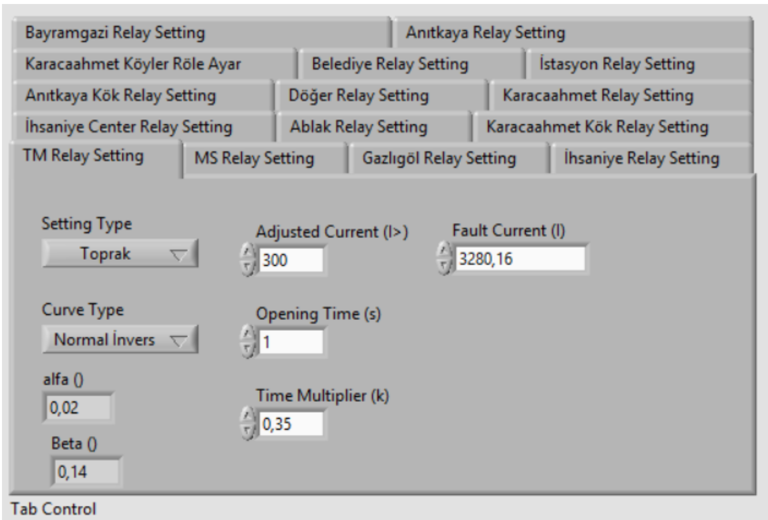

Figure 3. Relay settings of Afyon-2 TM based on LabVIEW

When calculating the I> values (the values of Afyon-2 TM are NI, 300 A, Multiplier 0,35), it is aimed to get the least pulse on conductor and protection elements and to open the breaker by sending the signal to the relay in any fault in the shortest while by considering the loads pulled by every one of exit. For example, according to the equation (1), the relay of Afyon-2 TM waits for 1 s for a fault of 3280,16 A in the overcurrent. The relay of Mineral Water exit from Gazlıgöl DM (NI, 156 A, Multiplier 0,07) waits for 156 ms (approximately 150 ms) for the same fault. Multipliers are calculated on the Labview Program by leaving 275 ms safety time while setting the previous outputs from the last output according to single line diagram.

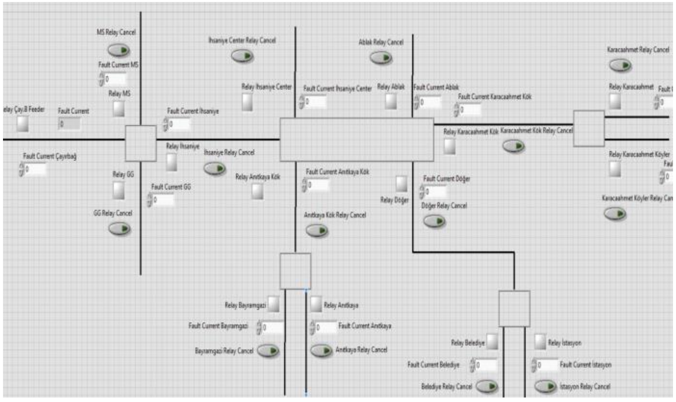

Figure 4. Interface of the program written on LabVIEW for relay coordination.

The malfunctions occurring at any output on the program in Figure 4 are entered in the fault current box. If the entered fault current is higher than the set current, the trip time is calculated automatically according to the curve type and the relay turns on in the calculated time and illuminated the on light for 3 sec (Figure 5).

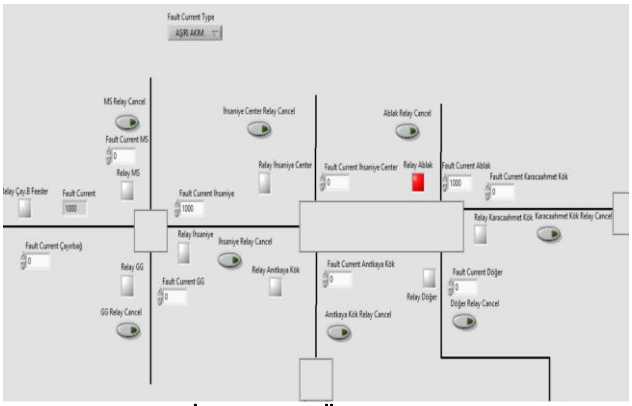

Figure 5. Sample failure from İhsaniye KÖK Ablak exit and activation of the relay

The program has been prepared by considering the actual field events. For example, if the protection elements on a KÖK are disabled (failure of Bar-24, damage to the cable that provides 220 V AC, etc.), the relays will not work and the KÖK will remain unprotected. We can provide this event with the relay cancel button on the program. When the relay cancel button is pressed, the activation and protection of the relay according to the settings of the relay is ensured because the relay right in front of it is activated (Figure 6).

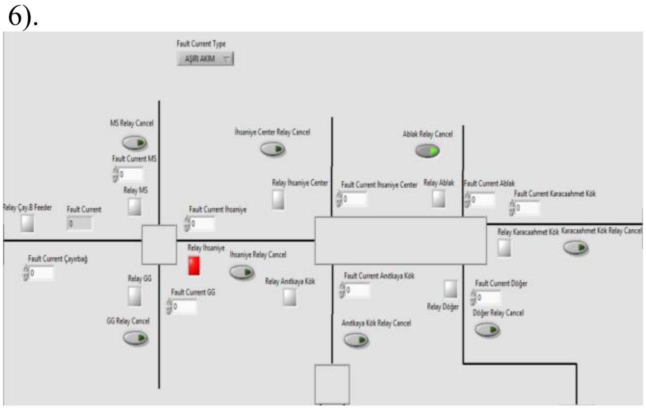

Figure 6. Activation of the previous relay when the relay of İhsaniye KÖK Ablak exit is canceled

5. The Effect of Relay Coordination on the Number of Breaker Trip and Cost

If the appropriate circuit breaker and line section are installed and appropriate relay values are entered after the operation, K9 breaker could have decreased from 300 trips to 156 trips with a difference of 144 and K2 breaker could have decreased from 360 trips to 132 trips with a difference of 228 averagely in a year. In total, it could have decreased from 660 trips to 288 trips with 372 times less power outages (Figure 7).

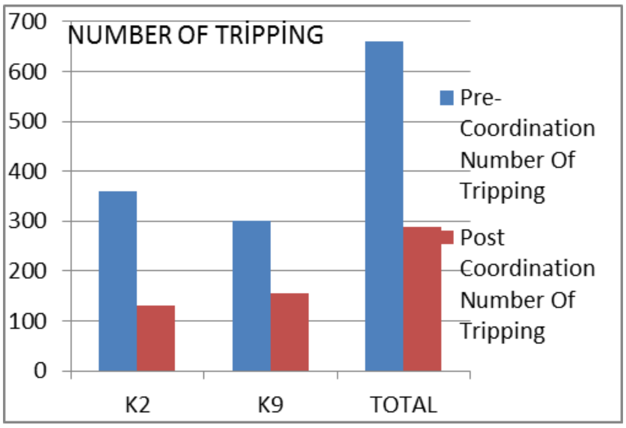

Figure 7. Number of trips before and after coordination (per year)

When the number of opening in the region per year is decreased to that in Figure 7, this has also benefited greatly from the cost. When the unit price of the energy that the energy-selling company received the distribution price is considered for September 2018 (0,137331 TL/kWh = 0,022417 $/kWh), while the previous loss was 162 546,624 TL = 26 532,593 $, the current loss is 63 549,876 TL = 10 373,288 $ with less loss of 98 996,748 TL = 16 159,305 $ (Figure 8) [10].

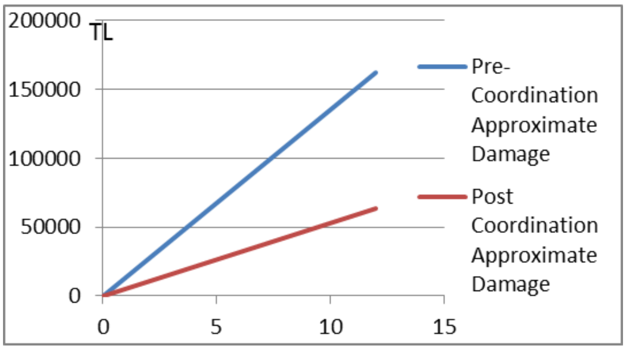

Figure 8. Approximate damage status before and after coordination (per year)

6. Conclusion

In this article, LabVIEW program has been prepared for optimum relay coordination and the decrease of the number of trips after this coordination and the effect of cost have been examined. Coordination was provided by using electronic and analog protection relays in this examination. In this way, the system will be prevented from faults coming from different points of the system.

Disabling the faulty part by intervening to the fault as soon as possible is also important for the efficiency of the system. This is possible with the values set on the relay and the appropriately selected breakers. In this study, it is seen that the breakers have less trips with the values entered on the relay.

In order to make the electrical infrastructure of the plant more reliable and robust, the use of digital protection relays instead of analog protection relays firstly requires the proper parameterization of

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these relays, the creation of the appropriate selectivity, so of the complete relay coordination. Furthermore, another advantage of using a digital relay instead of an analog relay is that the time multipliers (0,09-0,13-0,17 etc.) that cannot be entered in the formula of relay trip time can be entered more easily in the digital relay.

The study not only makes lines and KÖKs more reliable, but also has many advantages in terms of cost, operation and maintenance for the distribution company.

Acknowledgments

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References

[1] Öcalan, G. (2005). Realization of protection relay functions by using PLC and SCADA. Master Thesis, Firat University, Institute of Natural and Applied Sciences, Elazığ.
[2] Gençaydın, E., Tanrıöven, M. (2013). A review on safety assessment for protection systems in high voltage transmission systems. Journal of Engineering and Science, Manchester, Sigma 5: 86-102.
[3] Montoya, L.A., Montonegro, D., Ramos, G., (2013). Adaptive protection testbed using real time and hardware-in-the-loop simulation. IEEE Grenoble Conferences (2013), 1-4.
[4] Gürsu, B. (2014). Optimal overcurrent relay coordination in transformer stations with genetic algorithms stopped by punitive function. Journal of the Faculty of Engineering and Architecture, 665-676. Gazi University, Ankara.
[5]http://myelectrical.com/DesktopModules/SunBlog/Handlers/Print.aspx?id=159,30.03.2018
[6] Polat, S., Şekerci, H. (2015). Important electrical failure in the world and our country.
[7] Damchi, Y., Mashhadi, H.R., Sadeh, J., (2016). Optimal Coordination of Distance and Overcurrent Relays Considering a Non-Standard Tripping Characteristic for Distance Relays. The Institution of Engineering and Technology (2016), 1448-1457.
[8] Anupreyaa, K., Karthiga, S.T.C., (2016). Relay Coordination for Distribution System. 2016 Second International Conference on Science Technology Engineering and Management(ICONSTEM), 337-341.
[9] Begbagui, M., Bentarzi, H., Mati, A., (2015). A New Framework of Numerical Distance Relay Using LabVIEW. 4th International Conference on Electrical Engineering (ICEE) (2015), 1-5.
[10] https://altin.in/, 06.10.2018.
[11] Kumar, A., Thakur, M., (2016). Optimal Coordination of Directional Over Current Relays Using a Modified Real Coded Genetic Algorithm: A Comparative Study. Electrical Power and Energy Systems 82 (2016), 484-495.
[12] Begbagui, M., Bentarzi, H., Mati, A., (2015). A New Framework of Numerical Distance Relay Using LabVIEW. 4th International Conference on Electrical Engineering (ICEE) (2015)