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doi:10.15199/48.2022.10.13

Performance of ground fault relay on Feedera incoming substation 15 short circuit in substation 14 Plaju utilities PT. Pertamina (Persero) refinery unit III Plaju – Sungai Gerong

Abstract *The distribution network of PT. Pertamina (Persero) Refinery unit 3 Plaju - Sungai Gerong uses an underground cable type of conductor, where most of the switchbreakers and relays at substation 14 Plaju are still analog. one of which is the ground fault relay (GFR) on feeder A incoming substation 15 on substation 14 Plaju, for a long time the relay has not been reset, causing a tendency to reduce the sensitivity level of the relay in securing the system when a fault occurs (short circuit).), to overcome this, it is necessary to evaluate and reset the fault relay to ground. Evaluation is done by calculating the fault current of 3 phase, 2 phase, and 1 phase to ground to determine the magnitude of the fault current in the feeder A delivery line and compare it to determine the ideal ground fault relay (GFR) setting. Based on the calculation, ideally setting the ground fault relay (GFR) for incoming substation 15 breaker at substation 14 Plaju on feeder A side 12 kV forIsetprimary 32.244 Aand Isesecondary t is0.107 A with t (time) 0.298 s while on the feeder side 6.6 kV, namely the primary Iset of 25.795 A and the secondary Iset of 0.081 A with t (time) of 0.308 s*

Streszczenie. Sieć dystrybucyjna PT. Pertamina (Persero) Jednostka rafineryjna 3 Plaju - Sungai Gerong wykorzystuje przewód typu podziemnego kabla, w którym większość wyłączników i przekaźników w podstacji 14 Plaju jest nadal analogowa. jednym z nich jest przekaźnik ziemnozwarciowy (GFR) na linii zasilającej Podstacja przychodząca 15 na podstacji 14 Plaju, przez długi czas przekaźnik nie był resetowany, co powoduje tendencję do zmniejszania poziomu czułości przekaźnika w zabezpieczaniu systemu, gdy wystąpi usterka (zwarcie).), aby temu zaradzić, konieczne jest oszacowanie i zresetowanie przekaźnika błędu do masy. Oceny dokonuje się poprzez obliczenie prądu zwarciowego 3-fazowego, 2-fazowego i 1-fazowego do ziemi w celu określenia wielkości prądu zwarciowego w linii zasilającej A i porównanie go w celu określenia idealnego ustawienia przekaźnika zwarcia doziemnego (GFR). W oparciu o obliczenia, najlepiej ustawić przekaźnik ziemnozwarciowy (GFR) dla przychodzącego wyłącznika podstacji 15 w podstacji 14 Plaju po stronie linii A 12 kV dla Isetprimary 32,244 Ai Isesecondary t jest 0,107 A z t (czas) 0,298 s po stronie linii 6,6 kV, czyli Iset pierwotny 25,795 A i Iset wtórny 0,081 A z t (czas) 0,308 s. (***Działanie przekaźnika ziemnozwarciowego na podstacji przychodzącej Feedera 15 Zwarcie w podstacji 14 Plaju media PT. Rafineria Pertamina (Persero) III Plaju – Sungai Gerong***)

Keywords: Switchbreaker, Relay, Feeder A, Substation**..**
Słowa kluczowe: przekaźniki ziemnozwarciowe, błąd uziemienia, zwarcia

Introduction

One of the role of the utility unit as a provider of electrical energy needs and distributing it to the Plaju-Sungai gerong refinery, has 3 units of gas turbine generators each with a capacity of 30 MW with a generating capacity of 15 MW per day. [1], has a working area of approximately ± 1774 hectar

es, which is sufficient Large and complex electricity supply is supplied entirely from gas turbine synchronous generators with a maximum voltage of 12 kV distributed through the main substation (substation 2001 K) Plaju to other substations

The development of the electrical system is often faced with disturbance problems that arise both from internal factors and from external factors of the electric power system, disturbances in the electric power system are abnormal conditions (interferences) where this situation can cause a large short-circuit fault current when the disturbance occurs. , the current flowing in the transmission line leading to the center of the disturbance becomes very large so that it will affect the stability of the whole system [2].

So we need a protection system that is able to work properly and optimally and is expected to be able to detect and be able to secure a normal circuit so that the value of the short circuit fault current on the distribution network is obtained as well as determining the settings for the ground fault relay (GFR) on feeder A incoming substation 15 at Substation 14 Plaju.

Literature review

FAULTS

A fault in a circuit is any failure which interferes with the normal flow of current. Most faults on transmission lines of 115 kV and higher are caused by lightning, which results in the flashover of insulators. The high voltage between a conductor and the grounded supporting tower causes ionization, which provides a path to ground for the charge induced by the lightning stroke [3]

Classification of Faults Based on Their Symmetry

Asymmetrical Faults

Is a faults that causes the voltage and current flowing in each phase to be unbalanced, this disturbance consists of:

1. Single-phase short-circuit to ground fault
2. Two-phase short circuit fault
3. Two-phase short circuit to ground fault

Symmetrical Fault

is a fault that occurs in all phases so that the current and voltage of each phase remain balanced after the disturbance occurs. This disorder consists of:

1. Three-phase short-circuit fault
2. Three-phase short-circuit to ground

Short Circuit Electrical Current Disturbance

Short-circuit faults cause a large current to flow to the fault point, as a result of which the voltage around the fault can decrease significantly. The large current flow is the sum of the contribution currents coming from the generator and induction motor. Short circuit faults can be two-phase, three-phase, single-phase to ground, two-phase to ground, or 3-phase to ground. Transmission line if the short-circuit disturbance is allowed to last for a long time in a power system will cause a lot of unwanted things to happen [4]

1. Reduced stability limits for power systems.
2. Damage to nearby equipment By faults caused by unbalanced currents, or low voltages caused by short

circuits.

3. Damage to nearby equipment By faults caused by unbalanced currents, or low voltages caused by short circuits.
4. Explosions that may occur in equipment containing insulating oil during a short circuit, and which may cause a fire so that it can endanger people who handle it and damage other equipment.
5. The fragmentation of the entire service area of the power system by a series of security measures taken by different security systems is known as "chasecading

Type of Short Circuit Fault

Single phase to ground short circuit fault

By using the theory of symmetrical components, namely based on positive sequence components, negative sequence components and zero sequence components [5],[6]

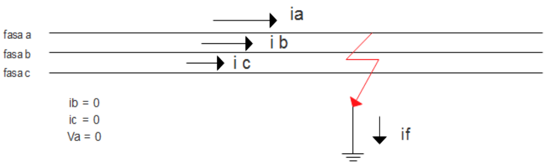

Fig 1. Single phase short circuit to ground

So that :

(1) $$I\ A1 = \frac{Vf}{Z0 + Z1 + Z2}$$

Two-phase short-circuit fault

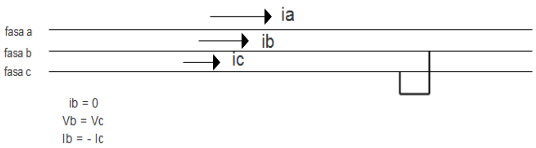

Fig 2. Two-phase short circuit Gangguan

So that :

(2) $$Ia1 = \frac{Vf}{Z1 + Z2}$$

Two-phase short circuit to ground

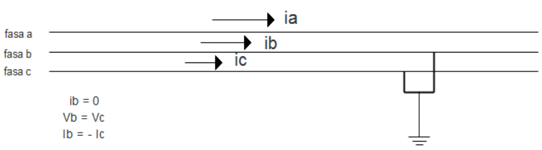

Fig 3. Two-phase short circuit to ground

So that :

(3) $$IA1 = \frac{Vf}{Z1 + \frac{Z2Z0}{Z2+Z0}}$$

Three-phase short-circuit fault

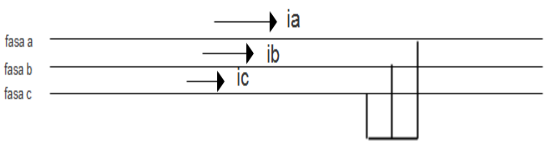

Fig 4. 3-phase short circuit fault

Obtained:

(4) $$IA = IA1$$

so that ,

(5) $$IA = \frac{Vf}{Z1}$$

Terms of Safety Relay (Protection system)

1. Quick to react
2. Selective
3. Sensitive / Sensitive
4. Reliable / Reliability
5. Simplicity

What is meant by selective here is ability to coodinate security of the system as a whole

Security Area (Protective zone)

In order to obtain a fairly good safety system in the electric power system, the power system is divided into several security areas, namely with the minimum possible termination of the sub-system. What is meant by the above information are:

1. Generator
2. Power transformer
3. Bus-bar
4. Transmission, sub-transmission, distribution and load

The division into the 4 security areas above is carried out in an overlapping manner, as shown in the image below;

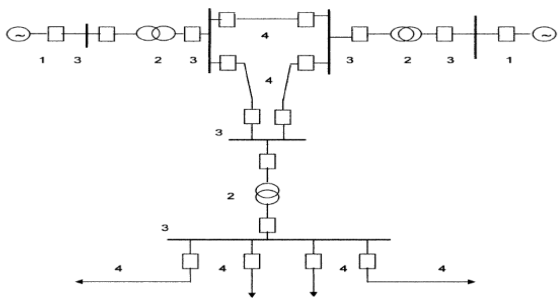

Fig 6. One line diagram of an electric power system with its safety zones

What is meant by mutual coverage is that in an area where the security system can function, this is necessary to avoid the possibility of an unsafe area.[7]

Ground Fault Relay

Basically the ground fault relay is an overcurrent relay that is used to secure ground faults, namely 1 phase or 2 phases to ground. This relay is installed on high-voltage, medium-voltage networks, as well as on power transformer safety and serves to secure electrical equipment due to phase-to-ground faults. Protection against ground faults is more sensitive than inter-phase faults.

This protection can be done using a relay that will only respond to the presence of system residual current, because the residual component only appears when the fault current flows to ground. Overall, the low tuning of the ground fault relay allows the ground fault relay to be very useful, not only against ground faults, but further against almost any fault, but may be limited by the magnitude of the ground impedance or by the ground resistance. residual components are extracted by connecting the CT (Current Transformer) network in paralle. [8]

Residual Current

The residual current is the zero sequence current of a value of the symmetry component. This zero-sequence current occurs in the return line or neutral line. In a balanced system there is no zero sequence current. [9][10]

Research methods

Research Time and Place.

This research started from April 2018 which is located at Utillities PT. Pertamina (Persero) Refinery unit 3 Plaju-Sungai Gerong.

Calculation Method.

Calculations in this study were done manually. In addition, literature studies were also carried out, primary and secondary data collection, as well as direct observations on the ground fault relay installed on the distribution network system of substation 14 Plaju incoming substation 15 Plaju

Flowcharts

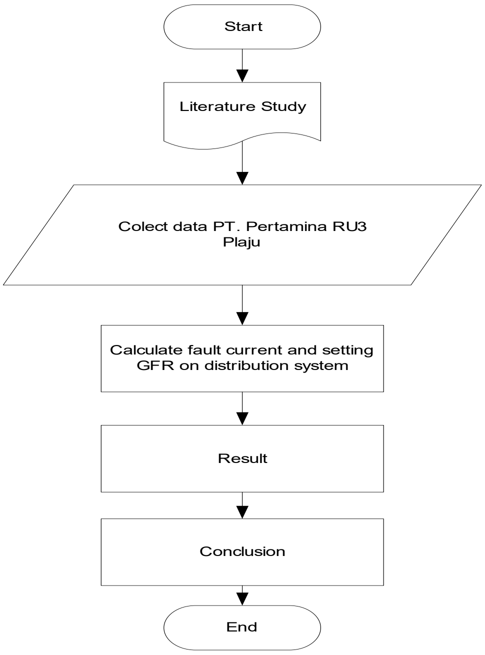

Fig 7. Research Flowchart Diagram

Results and discussion

Calculation of Short Circuit Fault Current

3-phase short circuit

Fault current calculation3-phase short circuit at a distance of 10% from substation no.14 Plaju then the calculation of 3-phase fault electric current at a distance of 10% is as follows;

$$I_{f3FASA} = \frac{\frac{12000}{\sqrt{3}}}{Z_{10eq}} = \frac{12000/\sqrt{3}}{\sqrt{(0{,}0125^2 + 0{,}3680^2)}}$$

=18816.41 A

2-phase short circuit fault

Calculation of 2-phase fault current at a distance of 10% i.e. between phases A & Bfrom substation 14 Plaju:

$$I_{f2Fasa} = \frac{If\ 3\ FASA}{2Z_{1eq}}\sqrt{3} = \left(\frac{18816{,}41}{2\ (0{,}125 + j\ 0{,}368)}\right)\sqrt{3} = 33053{,}73\ \mathbf{A}$$

Single phase short circuit to ground

Determined single-phase short-circuit fault current to groundat a distance of 10% as follows:

$$I_{f1Fasa} = \frac{3\ x\ E_{ph}}{Z1_{eq}+Z2_{eq}+Z0_{eq}} = \frac{20784{,}61}{2(0{,}125+j\ 0{,}368)+(57{,}275+j\ 0{,}813)} = 361{,}214\ A$$

it will be the same as before until the calculation of the fault current until the conductor distance is at 90%. The following table shows the total fault currents of 3 phase, 2 phase, and 1 phase to ground obtained.

Tab 1. Result of calculation of electric current disturbance

No	Distance (%)	Type of Electrical Current Disturbance (Amperes)		
		I_f 3 phase	I_f 2 phase	I_f 1 phase to ground
1	10	18816.41	33053.73	361,214
2	20	13124.08	15896.21	357,88
3	30	14424.74	18506.95	354.73
4	40	8375.49	6258.32	351.44
5	50	7063,108	4429,28	348.3
6	60	6099.84	3295.46	345.21
7	70	5364.05	1469.6	342.19
8	80	4785.33	1168,86	339.18
9	90	2736.8	788,21	322.44

Calculation of Ground Fault Relay (GFR) and TMS Settings

To determine the setting on the ground fault relay, the primary current value used is taken from the smallest 1-phase fault current to ground.

For settings on the outgoing feeder:

If 1 phase = 322.44 Amp

Primary iset = 10 % x 322.44 = 32.244 Amp

Iset sec = 32.244 x $\frac{1}{ratio\ CT}$= 32.244 x $\frac{5}{1500}$ = 0.107 A

Then the value of the equation or (normal inverse) is obtained as follows:

TMS

$$= \frac{t*\left(\left[\left[\frac{I_{F\ 1\ FASA}}{I_{Set\ primer}}\right]\right]^{0.02} - 1\right)}{0.14} = \frac{0{,}3*\left(\left[\left[\frac{322{,}44}{32{,}244}\right]\right]^{0.02} - 1\right)}{0.14}$$

$$= 0{,}101\ (\text{Tanpa Satuan})$$

$$T = \frac{0.14\ x\ Tms}{\left[\left[\frac{I_{FAULT}}{I_{Set}}\right]\right]^{0.02} - 1} = \frac{0.14\ x\ 0.101}{\left[\left[\frac{322{,}44}{32{,}244}\right]\right]^{0.02} - 1} = 0{,}298\ detik$$

For GFR setting on incoming feeder

The primary current used for setting GFR in the incoming or incoming feeder is the same as the current drawn on the outgoing feedernamely the smallest current Sc in the feeder multiplied by a constant of 8%

If 1 phase = 322.44A

Primary Iset = 8 % x 322.44 =25,795 A

When inserted on the secondary side of the current transformer, then:

Iset sec = 25.795 x$\frac{1}{ratio\ CT}$= 32.244 x$\frac{5}{2000}$ =0.081 A

So that :

$$TMS = \frac{t*\left(\left[\left[\frac{I_{F\ 1\ FASA}}{I_{Set}}\right]\right]^{0.02} - 1\right)}{0.14} = \frac{0{,}3*\left(\left[\left[\frac{322{,}44}{25{,}795}\right]\right]^{0.02} - 1\right)}{0.14}$$

$$= 0.111\ (\text{Tanpa Satuan})$$

Then the value of t (time) is obtained

$$t = \frac{0.14\ x\ Tms}{\left[\left[\frac{I_{FAULT}}{I_{Set}}\right]\right]^{0.02} - 1} = \frac{0.14\ x\ 0.111}{\left[\left[\frac{322{,}44}{25{,}79}\right]\right]^{0.02} - 1} = 0{,}308\ detik$$

Table 2. The value of the ground fault relay setting (GFR) obtained

Parameter	feeder 12 Kv (outgoing feeders)	feeder 6.6 Kv (Incoming feeders)
I set primary	32.244 A	25,795 A
I set secondary	0.107 A	0.081 A
Tms(time multiple settings)	0.101 (without units)	0.111 (without units)
t (time)	0.298 s	0.308 s

From the results - the results of the above calculations show:

1. That the largest 3-phase short circuit fault is around 18816.41 Ampere, for 2 phases it is approx.33053.73 Ampere, for 1 phase to ground of 361.214 Ampere each at a distance of 10% while the smallest fault value for 3 phases is 2736.8 Ampere, for 2 phase fault is 788.21 Ampere, and for 1 phase to ground is 322.44 Ampere at 90% distancefrom Substation 14 Plaju incoming substation 15 Plaju with a network length of about 2.8 Km
2. The incoming Substation 15 fault relay setting to ground (GFR) on substation 14 Plaju on feeder A 12 kV for*Iset*primary 32.244 A*and Ise*secondary t is0.107 A with t (time) 0.298 s, while for the setting in feeder A 6.6 kV, namely the primary Iset of 25.795 A and the secondary Iset of 0.081 A with t (time) of 0.308 s ,which if a short circuit occurs to the ground, it can cause disturbances to other distribution systems, especially the incoming 15 network at the Plaju Substation 14 and can disrupt the frequency of the electric power system and result in trips in several important production units because the load shedding system works.

Conclution and Suggestion

Conclusion

1. The closer the fault point to the source or substation is, the greater the disturbance value, at a distance of 10%, while the smallest disturbance value occurs at the farthest distance, which is 90% of the feeder A network from substation 14 to substation 15 Plaju. This is influenced by the size of the value. Impedance on the underground conductor/cable network
2. The ideal setting of Iset & TMS is obtained for the 12 kV feeder short circuit to ground fault relay (GFR) and the 6.6 kV feeder A incoming substation 15 feeder on the 14 plaju substation by taking the smallest fault current value from a single phase short circuit current to ground which is equal to322.44 Ampere at 90% distance

Suggestion

1. Observe carefully the equipment that will be used as the object of research and understand the data needed.
2. It is better to master Etap, Matlab and other related analysis programs to simplify the research process
3. This research is the initial stage of the problems that exist in the field, further research should be carried out to get maximum results
4. Comply with regulations and prioritize security and safety when carrying out the research process in the field.

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