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# Analysis of OCR Setting and GFR 20 kV Power Transformer Substation Kualanamu North Sumatra

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**Abstract**
Protective relay is a tool which works automatically to adjust input of an electrical circuit that is trip or alarm due to interference, in order to secure and prevent damage to equipment due to interference. PT. PLN (State Electrical Company) is as the only State-Owned Enterprises in supplying of electricity with the level of good quality, continuity, reliability, and efficiency. To solve the disruption installed security equipment that is to relate between the safety equipment with the relay is necessary to localize the disturbance area and maintain reliability of the electrical system. By having the research on the data setting and test results from OCR and GFR, so the current settings obtained (Iset = 1030 A) and (Io = 100 A) is incoming, Power transformer 2 is bigger than Repeater (Iset = 720 and Io = 60 A ), The setting is longer (2,4107 seconds compared 1,446 seconds), the value of the OCR Relay (Is) relay settings obtained from the calculation result, the data setting, and the test results on the maintenance can be said to have the same result that is primary = 1 A and secondary 1 A The value of the GFR (Io) current relay setting on the test result and the setting data have a value smaller than the count of Z (0.5: 1- 1,5) Ampere. This result is caused in calculating based on P3B Java Bali, the overall setting of OCR and GFR in substation can be concluded in good condition and meet the standards.


*Key-word: - Anilysis, setting OCR dan GFR, 20kV transformer, Substation, Kualanamu North Sumatera ,*

## 1. Introduction

Relay protection is a tool that works automatically to set input of an electrical circuit that is tripped or alarm due to interference. Relay protection is widely used in electrical installations to protect and prevent damage to equipment. PT. PLN (Persero) as the only State-Owned Enterprises in the supplying of electricity with the level of good quality, continuity, reliability, and efficient efficiency. In electrical distribution system, there are many disturbances caused by the natural state, dispensing wire breaks, damage to the generator, overload and short circuit interruption. The disturbance will result in interruption of electrical distribution to consumer that can cause disadvantage to PT PLN and consumers. To solve the disturbance and protect the equipment then installed the safety equipments that is coordination between the safety equipments with the relay is needed to localize the disturbance area and maintain the reliability of the electrical system.

The distribution of electrical from the transformer through a 20 kV repeater to the people is also equipped with a protection system that is OCR (Over Current Relay) and GFR (Ground Fault Relay) serves as a backup relay for outside interference and as the main safeguard on the repeaters. OCR and GFR relays use current as an indication if electrical current passes beyond the setting limit, it will work by ordering the power breaker to disconnect the electrical power supply system. In order to work properly, the relay setting must be done correctly.

## 2. Methodology

The data used in the research of Substation of Kualanamu Power Transformer 2 accommodates the repeater KU1, KU2, KU3 and KU4 as shown in the existing data. It is expected to distribute with the relay setting to operate well protecting the electrical equipments from short circuit current from keeping electrical power reliable. Therefore, the analysis of overcurrent relay (OCR) and Ground Fault Relay (GFR) and inverters of power transformes 2 in substation Kualanamu. The data required for this analysis is as follows:

3. The data of Transformer power
4. Merk = GPAUWELS
5. Standard = IEC 60076
6. No Serie = 3011090084
7. Power = 30 MA
8. Teg Primer/Teg Sekunder = 150kV/20kV
9. Impedansi (Z%) = 12,415 %
10. Frequensi = 50 Hz
11. Current Rasio = 115/866 A
12. Trms = 0,37
13. Rasio CT = 1000/1
14. Nominal current = 866
15. Hubungan Belitan trafo = YNynO(d5)
16. Ground Resistor = 40 Ohm

Data OCR dan GFR Sisi Incoming 20kV TD 2 Gi Kualanmu

| OCR | | GFR | |
|---|---|---|---|
| Merk | Scheneider Electrik | Merk | Scheneider Electrik |
| Type | Sepam 1000 | Type | Sepam 1000 |
| No.Seri | 10230499 | No.Seri | 10230499 |
| Iset(A) | 1 | Io(A) | 0.1 |
| Iset(prim)(A) | 1000 | Io(prim)(A) | 100 |
| Rasio CT | 1000/1 | Rasio CT | 1000/1 |
| Tms | 0,24 | Tms | 0.18 |
| Karakteristik | Standar Inverse | Karakteristik | Standar Inverse |
| I Instan(A) | BLOCK | I Instan(A) | BLOCK |

Data OCR dan GFR Penyulang KU1 Gardu Induk Kualanmu

| OCR | | GFR | |
|---|---|---|---|
| Merk | Scheneider Electrik | Merk | Scheneider Electrik |
| Type | Sepam 1000 | Type | Sepam 1000 |
| No.Seri | 10170019 | No.Seri | 10170019 |
| Iset(A) | 5,5 | Io(A) | 0,5 |
| Iset(prim)(A) | 440 | Io(prim)(A) | 40 |
| Rasio CT | 400/5 | Rasio CT | 440/5 |
| Tms | 0,18 | Tms | 0.14 |
| Karakteristik | Standar Inverse | Karakteristik | Standar Inverse |
| I Instan(A) | 34.625 | I Instan(A) | 3 |

Data OCR dan GFR Penyulang KU2 Gardu Induk Kualanmu

| OCR | | GFR | |
|---|---|---|---|
| Merk | Scheneider Electrik | Merk | Scheneider Electrik |
| Type | Sepam 1000 | Type | Sepam 1000 |
| No.Seri | 10110063 | No.Seri | 10110063 |
| Iset(A) | 5,5 | Io(A) | 0,5 |
| Iset(prim)(A) | 440 | Io(prim)(A) | 40 |
| Rasio CT | 400/5 | Rasio CT | 440/5 |
| Tms | 0,2 | Tms | 0.16 |
| Karakteristik | Standar Inverse | Karakteristik | Standar Inverse |
| I Instan(A) | 34.625 | I Instan(A) | 3 |

Data OCR dan GFR Penyulang KU3 Gardu Induk Kualanmu

| OCR | | GFR | |
|---|---|---|---|
| Merk | Scheneider Electrik | Merk | Scheneider Electrik |
| Type | Sepam 1000 | Type | Sepam 1000 |
| No.Seri | 10110063 | No.Seri | 10110063 |
| Iset(A) | 5,5 | Io(A) | 0,5 |
| Iset(prim)(A) | 440 | Io(prim)(A) | 40 |
| Rasio CT | 400/5 | Rasio CT | 440/5 |
| Tms | 0,2 | Tms | 0.16 |
| Karakteristik | Standar Inverse | Karakteristik | Standar Inverse |
| I Instan(A) | 34.625 | I Instan(A) | 3 |

Data OCR dan GFR Penyulang KU4 Gardu Induk Kualanmu

| OCR | | GFR | |
|---|---|---|---|
| Merk | Scheneider Electrik | Merk | Scheneider Electrik |
| Type | Sepam 1000 | Type | Sepam 1000 |
| No.Seri | 10110063 | No.Seri | 10110063 |
| Iset(A) | 6 | Io(A) | 0,5 |
| Iset(prim)(A) | 720 | Io(prim)(A) | 60 |
| Rasio CT | 600/5 | Rasio CT | 660/5 |
| Tms | 0,18 | Tms | 0.14 |
| Karakteristik | Standar Inverse | Karakteristik | Standar Inverse |
| I Instan(A) | BLOCK | I Instan(A) | BLOCK |

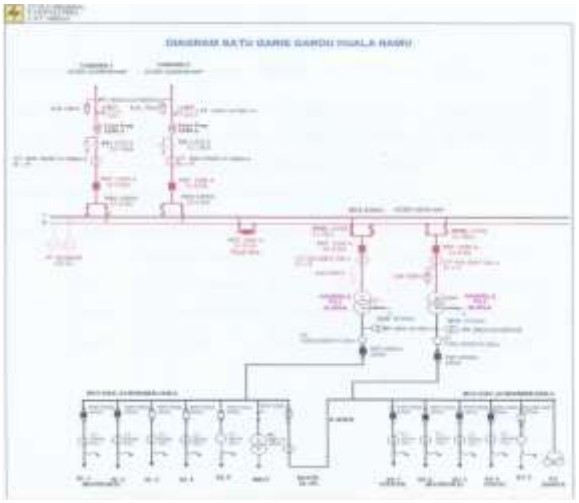

Figure. Single Line Diagram of Substation Kualanamu

## Result and Discussion

### Calculating current and operating settings of OCR and GFR relays

Calculate OCR and GFR relay settings by calculating current and operating time based on existing theory and data, therefore calculating using formula based on IEC and SPLN. With the results of Iset and TMS calculations of OCR and GFR relays based on the theoretical basis of the data then the data calculation results can be seen in Table

Hasil Perhitungan setting relay OCR

| Feeder | Ratio CT | I nom | I set (prim) A | | I set (sek) A | | TMS | | | T (detik) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | 110 % | 120 % | 110 % | 120 % | 2 x Is | 3 x Is | 5 x Is | |
| Inc TD2 | 1000/1 | 866 | 952 | 1093 | 0,9 | 1 | 0,12 | 0,317 | 0,467 | 2 |
| KU 1 | 400/1 | 400 | 440 | 480 | 5,5 | 6 | 0,099 | 0,158 | 0,233 | 1 |
| KU 2 | 400/1 | 400 | 440 | 480 | 5,5 | 6 | 0,099 | 0,158 | 0,233 | 1 |
| KU 3 | 400/1 | 400 | 440 | 480 | 5,5 | 6 | 0,099 | 0,158 | 0,233 | 1 |
| KU 4 | 600/1 | 600 | 660 | 720 | 5,5 | 6 | 0,099 | 0,158 | 0,233 | 1 |

Hasil Perhitungan setting relay GFR

| Feeder | Ratio CT | I nom | Io (prim) A | | I set (sek) A | | TMS | | | T (detik) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | 20% | 30% | 20% | 30% | 2 x Is | 3 x Is | 5 x Is | |
| Inc TD2 | 1000/1 | 866 | 170 | 260 | 0,17 | 0,26 | 0,12 | 0,317 | 0,467 | 2 |
| KU 1 | 400/1 | 400 | 80 | 120 | 1 | 1,5 | 0,099 | 0,158 | 0,233 | 1 |
| KU 2 | 400/1 | 400 | 80 | 120 | 1 | 1,5 | 0,099 | 0,158 | 0,233 | 1 |
| KU 3 | 400/1 | 400 | 80 | 120 | 1 | 1,5 | 0,099 | 0,158 | 0,233 | 1 |
| KU 4 | 600/1 | 600 | 170 | 180 | 1 | 1,5 | 0,099 | 0,158 | 0,233 | 1 |

From Tables, the value of OCR and GFR relay operating time settings on incoming power transformer 2 is longer than other repeater. The value of OCR and GFR primary side setting in the incoming is greater than the repeater, but on the secondary side, the OCR and GFR current setting values are greater. This happens because the incoming CT ratio is 1000/1 while in the incoming is 1000/1 whereas in the 400/5 and 600/5.

### Calculating current Setting Relay based on data field

OCR and GFR relay setting data is very important to know capability of an equipment, current, relay operating time and as a reference in testing the relay during maintenance. From the data field obtained by counting 3 times experiment that is 2.3 and 5 times the disruption current. Based on the calculation result, the relay data settings of OCR and GFR substations kualanamu.

Hasil data waktu kerja setting relay GFR

| Feeder | Ratio CT | I nom | Io (prim) A | Io (sek) A | I Inst (A) | KAR | T (detik) | | | TMS |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | 2 x Is | 3 x Is | 5 x Is | |
| Inc TD2 | 1000/1 | 866 | 100 | 0,1 | BLOCK | SI | 1,805 | 1,134 | 0,77 | 0,18 |
| KU 1 | 400/1 | 400 | 40 | 0,5 | 3 | SI | 1,404 | 0,882 | 0,6 | 0,14 |
| KU 2 | 400/1 | 400 | 40 | 0,5 | 3 | SI | 1,604 | 1,008 | 0,685 | 0,16 |
| KU 3 | 400/1 | 400 | 40 | 0,5 | 3 | SI | 1,604 | 1,008 | 0,685 | 0,16 |
| KU 4 | 600/1 | 600 | 60 | 0,5 | BLOCK | SI | 1,404 | 0,882 | 0,6 | 0,14 |

Hasil data waktu kerja setting relay OCR

| Feeder | Ratio CT | I nom | I set (prim) A | I set (sek) A | I Inst (A) | KAR | T (detik) | | | TMS |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | 2 x Is | 3 x Is | 5 x Is | |
| Inc TD2 | 1000/1 | 866 | 0,9 | 1 | BLOCK | SI | 2,407 | 1,512 | 1,027 | 0,24 |
| KU 1 | 400/1 | 400 | 5,5 | 6 | 34,625 | SI | 1,805 | 1,134 | 0,77 | 0,18 |
| KU 2 | 400/1 | 400 | 5,5 | 6 | 34,625 | SI | 2,005 | 1,26 | 0,855 | 0,2 |
| KU 3 | 400/1 | 400 | 5,5 | 6 | 34,625 | SI | 2,005 | 1,26 | 0,855 | 0,2 |
| KU 4 | 600/1 | 600 | 5,5 | 6 | BLOCK | SI | 1,805 | 1,134 | 0,77 | 0,18 |

From Tables the TMS values of OCR and GFR relays in power transformers 2 are larger than repeater, it is intended to obtain OCR and GFR relay operating time settings longer than other repeaters, but on the secondary side, the current setting values of OCR and GFR is greater. This is due to the incoming CT ratio of 1000/1 on the 400/5 and 600/5 feeders.

**Testing Results OCR and GFR relay settings**

On April 20, 2017 the maintenance had been done 2 years power transformer Substation Kualanamu. Maintenance is done by keeping the equipment to keep working in good condition and maximize for the realization of the reliability of the electrical system. At the 2nd year maintenance of 2 substation Kualanamu power transformer testing equipment and protection systems are performed on the power transformer track 2, one of testing is OCR and GFR relay testing on 20kV side. Here is the results of OCR and GFR relay test side of 20kV power transformer 2 substation Kualanamu.

Hasil data pengujian setting relay OCR

| Feeder | Ratio CT | I nom | I set (prim) A | I set (sek) A | I hurt (A) | KAR | T (detik) 2 x Is | T (detik) 3 x Is | T (detik) 5 x Is | TMS |
|---|---|---|---|---|---|---|---|---|---|---|
| Inc TD2 | 1000/1 | 866 | 1000 | 1,03 | BLOCK | SI | 7,4112 | 4,6455 | 3,1421 | 0,73 |
| KU 1 | 400/1 | 400 | 440 | 5,5 | 43,4 | SI | 1,3403 | 0,7176 | 0,4811 | 0,33 |
| KU 2 | 400/1 | 400 | 440 | 5,5 | 43,4 | SI | 1,2246 | 0,7209 | 4,4849 | 0,33 |
| KU 3 | 400/1 | 400 | 440 | 5,5 | 43,4 | SI | 1,3344 | 0,7088 | 0,4909 | 0,33 |
| KU 4 | 600/1 | 660 | 720 | 6 | 28,91 | SI | 0,6247 | 0,387 | 0,3478 | 0,18 |

Hasil data pengujian setting relay GFR

| Feeder | Ratio CT | I nom | Io (prim) A | Io (sek) A | I hurt (A) | KAR | T (detik) 2 x Is | T (detik) 3 x Is | T (detik) 5 x Is | TMS |
|---|---|---|---|---|---|---|---|---|---|---|
| Inc TD2 | 1000/1 | 866 | 100 | 0,1 | BLOCK | SI | 2,3344 | 1,4651 | 1,0012 | 0,23 |
| KU 1 | 400/1 | 400 | 40 | 0,5 | 3 | SI | 0,5212 | 0,3298 | 0,2202 | 0,15 |
| KU 2 | 400/1 | 400 | 40 | 0,5 | 3 | SI | 0,5069 | 0,3264 | 0,2286 | 0,15 |
| KU 3 | 400/1 | 400 | 40 | 0,5 | 3 | SI | 0,5215 | 0,3304 | 0,2208 | 0,15 |
| KU 4 | 600/1 | 660 | 60 | 0,5 | 28,91 | SI | 0,5268 | 0,2866 | 0,0467 | 0,15 |

From Table TMS values of OCR and GFR relays on power transformers is greater than repeater, it is intended to obtain operating time relay OCR and GFR longer than repeater. The value of the OCR and GFR current settings of the incoming primary side is greater than the repeater, but on the secondary side, the OCR and GFR current setting values are greater. This happens because the incoming CT ratio is 1000/1 while in the 400/5 and 600/5 repeaters

**Analysis of Results Calculation, Setting Data and Test Results of OCR Relay and GFR substation Kualanamu**

From the overall calculation on the table it can be seen that the operating time of the relay is faster with the incoming operating time and the relay workflow in the repeater is smaller than the incoming. It aims to provide repeater relay opportunities to work first as a primary safeguard in case of short circuit breaks on repeater and distribution networks, and to be a safeguard of incoming reserves and power transformers if the relay on the repeater does not work.

Analyze OCR setting current comparison

Perbandingan arus setting ( I set) OCR

| FEEDER | Hasil Perhitungan | | Data setting | | Hasil Pengujian | |
|---|---|---|---|---|---|---|
| | OCR | | OCR | | OCR | |
| | Is (prim) A | Is Sek) A | Is (prim) A | Is Sek) A | Is (prim) A | Is Sek) A |
| Inc TD2 | 952 – 1039 | 0,9 -1 | 1000 | 1 | 1030 | 1,03 |
| KU 1 | 440 – 480 | 5,5 - 6 | 440 | 5,5 | 440 | 5,5 |
| KU 2 | 440 – 480 | 5,5 - 6 | 440 | 5,5 | 440 | 5,5 |
| KU 3 | 440 – 480 | 5,5 - 6 | 440 | 5,5 | 440 | 5,5 |
| KU 4 | 660 – 720 | 5,5 - 6 | 720 | 6 | 660 | 6 |

Base on Table can be analyzed that from the calculation results, data settings and test results on maintenance, has the value of OCR relay current settings which can be said the same. Current settings on incoming is greater than repeater because current-carrying capability on incoming equipment is greater than repeater equipment. This is incoming to accommodate the load on all repeater in the power transformer 2. In the incoming power transformer, the current setting (Iset) on the test results is larger than the data setting and calculation results, even though the CT ratio is 1000/1 while the 866 A, this is still understandable because CT is more sensitive than power transformer.

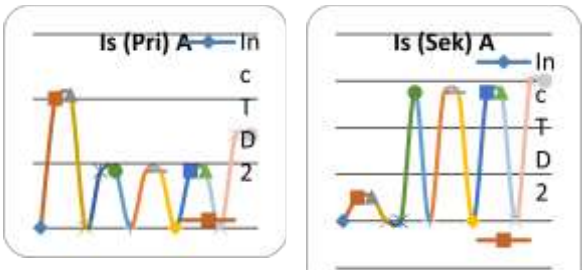


Figure. The comparison graph of current setting Is Relay OCR

**Analysis of TMS Relay OCR time comparison**

Perbandingan waktu kerja TMS relay OCR

| FEEDER | Data Hasil perhitungan | | | | Data setting | | | | Hasil Pengujian | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | TMS | | | T(detik) | T (detik) | | | TMS | T (detik) | | | TMS |
| | 2 x Is | 3 x Is | 5 x Is | | 2 x Is | 3 x Is | 5 x Is | | 2 x Is | 3 x Is | 5 x Is | |
| Inc TD2 | 0,12 | 0,317 | 0,467 | 2 | 2,407 | 1,512 | 1,027 | 0,24 | 7,4112 | 4,8455 | 3,1421 | 0,73 |
| KU 1 | 0,099 | 0,158 | 0,233 | 1 | 1,805 | 1,134 | 0,77 | 0,18 | 1,1433 | 0,7176 | 0,4811 | 0,33 |
| KU 2 | 0,099 | 0,158 | 0,233 | 1 | 2,005 | 1,26 | 0,855 | 0,2 | 1,2246 | 0,7209 | 0,4849 | 0,33 |
| KU 3 | 0,099 | 0,158 | 0,233 | 1 | 2,005 | 1,26 | 0,855 | 0,2 | 1,1334 | 0,7088 | 0,4909 | 0,33 |
| KU 4 | 0,099 | 0,158 | 0,233 | 1 | 2,005 | 1,134 | 0,77 | 0,18 | 0,6247 | 0,387 | 0,0476 | 0,18 |

Based on table on incoming power transformer 2 can be seen TMS value from result of calculation, setting data and test result at maintenance have different TMS value, where TMS value on result of test larger (0,73). But it can be proved by the time relay by converting the test results into the formula to calculate the relay operating time is still in standard Inverse (SI).

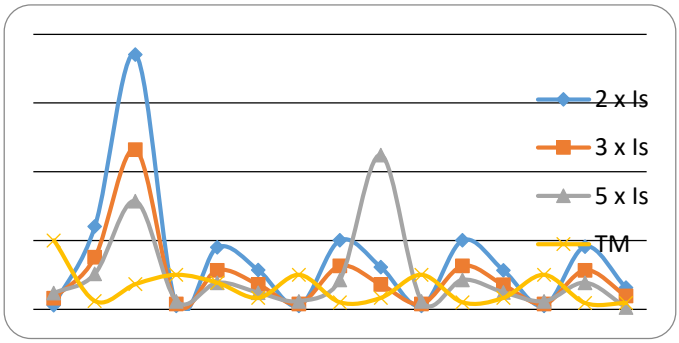


Figure.Comparison graph operating time and TMS Relay OCR

**Analysis comparisen operating time TMS Relay OCR**
**Analysis comparison current setting (Io) Relay GFR**

Perbandingan arus setting (Io) relay GFR

| FEEDER | Hasil Perhitungan | | Data setting | | Hasil Pengujian | |
|---|---|---|---|---|---|---|
| | GFR | | GFR | | GFR | |
| | Io (prim) A | Io Sek) A | Is (prim) A | Io Sek) A | Io (prim) A | Io Sek) A |
| Inc TD2 | 170 – 260 | 0,17 -0,26 | 100 | 0,1 | 100 | 0,1 |
| KU 1 | 80 – 120 | 1 – 1,5 | 40 | 0,5 | 40 | 0,5 |
| KU 2 | 80 – 120 | 1 – 1,5 | 40 | 0,5 | 40 | 0,5 |
| KU 3 | 80 – 120 | 1 – 1,5 | 40 | 0,5 | 40 | 0,5 |
| KU 4 | 120 – 180 | 1 – 1,5 | 60 | 0,5 | 60 | 0,5 |

Based on table 4.9 can be seen value curren ( *Io*) on test result is lower than calculating result and setting. This happens because on setting system protection P3B in Sumatera ground transformer system uses NGR, which generally have a smaller capability than the liquid and solid ground systems that exist in P3B Java Bali. In determining value current setting GFR must observe coordinating setting in substation which has yang menilai NGR transformer, transformer capacity and short circuit current in substation Kualanamu. . Unlike the P3B Java Bali which already has a better electrical system.

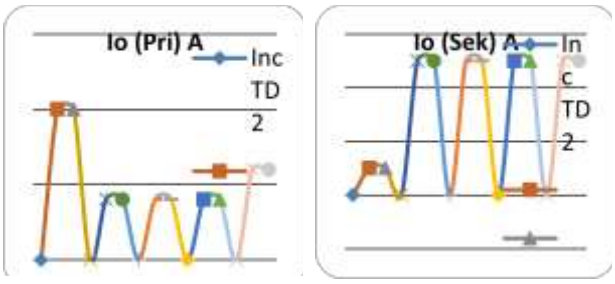


Figure.The comparison graph current setting Io Relay GFR

Perbandingan arus setting (Io) relay GFR

| FEEDER | Hasil Perhitungan | | Data setting | | Hasil Pengujian | |
|---|---|---|---|---|---|---|
| | GFR | | GFR | | GFR | |
| | Is (prim) A | Is Sek) A | Is (prim) A | Is Sek) A | Is (prim) A | Is Sek) A |
| Inc TD2 | 170 – 260 | 0,17 -0,26 | 100 | 0,1 | 100 | 0,1 |
| KU 1 | 80 – 120 | 1 – 1,5 | 40 | 0,5 | 40 | 0,5 |
| KU 2 | 80 – 120 | 1 – 1,5 | 40 | 0,5 | 40 | 0,5 |
| KU 3 | 80 – 120 | 1 – 1,5 | 40 | 0,5 | 40 | 0,5 |
| KU 4 | 120 – 180 | 1 – 1,5 | 60 | 0,5 | 60 | 0,5 |

Based on table in incoming power transformer 2, can be seen TMS value of the calculation, data setting and test results on maintenance doesn't have a different value of TMS. However, similar to OCR, it must be proved by the relay operating time by converting test result into the relay operating time calculation based on the Inverse Standard (SI).

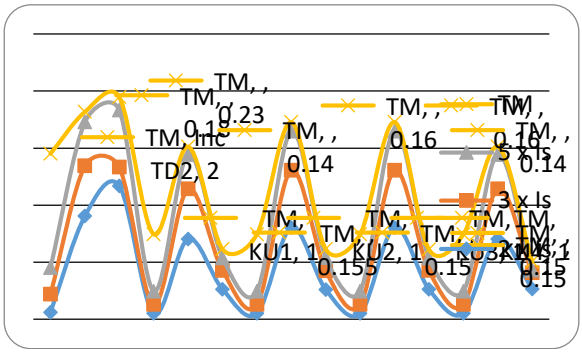


Figure.Graph of comparison operating time calculation result, data setting and testing relay GFR

## V. Conclusion

1. Data setting and test result, current setting (*Iset* =1030 A) and (*Io* = 100 A ) is incoming .
2. Power Transformer 2 is bigger than repeater (I*set* =720 and I*o* =60 A).
3. long Setting (2,4107 seconds with 1,446 seconds).
4. The value of current setting (*Is*) relay OCR which is got from calculation, data setting, and the result testing in keeping can be called that it has the same result that is primery = 1 A and secondary 1 A.
5. The current setting value of GFR (*Io*) in the result testing and data setting have lower value than calculation Z(0,5 : 1- 1,5) Ampere. This happens because in calculating on the basis of P3B Java Bali
6. in whole setting OCR and GFR which is in substation Kualanamu can be concluded in good condition and fulfil standard.

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