# Investigation of Overcurrent Relay Tripping Time Protection Using PSCAD Software

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**Abstract** – *This paper studied the modelling of 132/33/11kV overcurrent protection by using PSCAD software. The objective of this project is to compare between IEC 60255 Standard and IEEE C37.112 Standard overcurrent relay response time in the event of fault current. The parameters of Plug Setting (PS) and Time Multiplier Setting (TMS) were set in each of relays to observe the relay response time. The results show both standards produce very similar time responses of the relay operation.*

***Keywords***: *overcurrent protection, PSCAD, plug setting, relay operating time, standard inverse of characteristic curve,*

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## I. Introduction

Power system consists of generation, transmission, and distribution elements. All the elements need to be protected from overcurrent in the event of short circuit to prevent electricity failure that will harm human beings. This is due to the overcurrent will produce a very high current exceeding the rated current capacity, hence it will overload the circuit and cause short circuit conditions [1]-[3].

Statistics reveal that close to 200 workers lose their lives each year after being electrocuted. A 50 to 150 milliamperes current flows in the body in one second may enough to cause death. Therefore overcurrent protection relay has to response fast enough to isolate the fault current. Both IEC 60255 standard and IEEE C37.112 standard require the overcurrent relay to trip in a split of milliseconds [4]-[6].

The IEC 60255 has been adopted as a Malaysian Standard as recommended by the Working Group on Protection Relay Devices under the authority of the Industry Standards Committee on Generation, Transmission and Distribution of Energy, while IEEE C37.112 is a standard for relay characteristic curve which mainly used in North America [7]-[10].

Thus, this study is to model an overcurrent relay and analyze the relay performance in terms of tripping time during fault conditions. Three case studies were simulated in PSCAD software to observe the tripping time. The case includes a three-phase fault at different load location (1 and 2) and at the transformer. Then the tripping time comparison between the IEC 60255 standard and IEEE C37.112 standard is analyzed and concluded.

## II. Network Model

Fig. 1 shows the network for the simulation test, the network consists of one generator supplying the electricity using one 60MVA 132/33kV transformer. Then the 33kV network is being stepped down to 11kV using two 30MVA transformers operating in parallel position. Finally, the 11kV network is connected to one 0.3MVA transformer to distribution level 415kV. R1-R12 are the overcurrent relays located in various locations in the system. Load 1 and load 2 are connected at 11kV bus and 33kV bus respectively. To observe response time of the relays, faults are simulated at Load 1, Load 2 and at the 60MVA transformers.

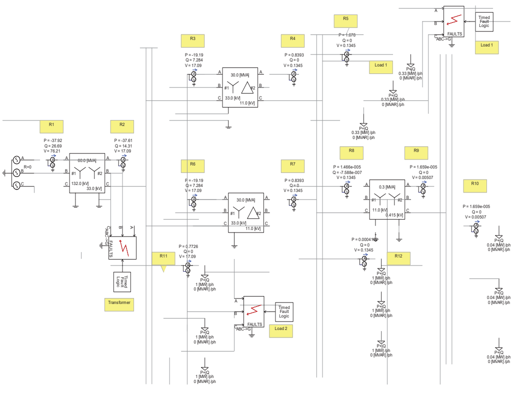

Fig. 1. Network Model

## III. Results and discussion

The simulation is conducted with a three-phase fault at different locations. The discrimination time between relays is observed and discussed in detail in the following section.

### *A. Case 1 (three-phase fault at Load 1)*

A three-phase fault is applied at Load 1 at *t* = 2s. Then tripping time for relays R5, R4, R3, R2 and R1 are recorded as shown in Fig. 2. It can be seen from Fig. 2 that the discrimination time between the relays is almost 0.5s. Table I shows the comparison between calculation and simulation of relay operating time are closely matched, which indicates all the settings for respective relays are performing well for a three-phase fault event.

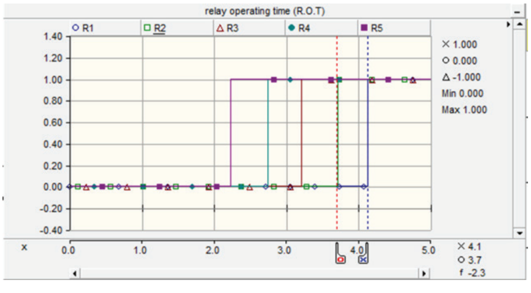


Fig. 1. Relay Operating Time (R.O.T) Load 1

TABLE I
COMPARISON OF SIMULATION AND CALCULATION LOAD 1

| Relay | Calculation Tripping Time (sec) | Calculated Timed Fault Logic (sec) | Simulation (sec) |
|---|---|---|---|
| *R5* | 0.21 | 2.21 | 2.2 |
| *R4* | 0.61 | 2.61 | 2.7 |
| *R3* | 1.1 | 3.1 | 3.2 |
| *R2* | 1.41 | 3.41 | 3.41 |
| *R1* | 1.81 | 3.81 | 3.81 |

### *B. Case 2 (three-phase fault at Load 2)*

The simulation has been repeated for a three-phase-fault at load 2. Each relay time that involves which are R11, R2 and R1 have been recorded as shown in Fig. 3. The relays tripping time for PSCAD is recorded as shown in Fig. 3. Similarly, the time is then compared with calculation value and has been summarized in Table II.

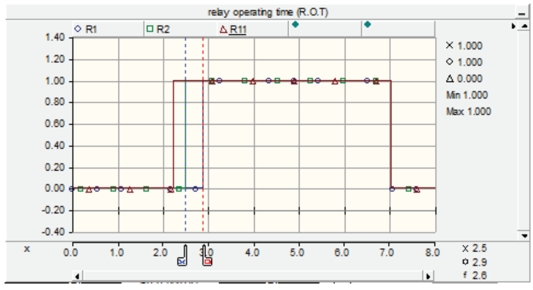


Fig. 2. Relay Operating Time (R.O.T) Load 2

It can be seen from Table II that the calculated time (timed fault logic (TFL) + t(s) and simulation tripping time are closely matched, which indicates that the relays are well performed.

TABLE II
COMPARISON OF SIMULATION AND CALCULATION LOAD 1

| Relay | Calculation Tripping Time (sec) | Calculated Timed Fault Logic (sec) | Simulation (sec) |
|---|---|---|---|
| *R11* | 0.2 | 2.2 | 2.1 |
| *R2* | 0.6 | 2.6 | 2.5 |
| *R1* | 1.0 | 3.0 | 2.9 |

### *C. Case 3 (three-phase fault at Transformer 132/33kV)*

For the final case, a three-phase fault is applied at transformer (132/33kV). This case involves R2 relay at the transformer (132/33kV) and R1 at generator source. In this situation, R2 trips first since it is the main protection relay, followed by R1 relay trip as a back-up relay if R2 fails to trip. The data of comparison between calculation and simulation are collected in Table III which indicates that the relays are properly operated.

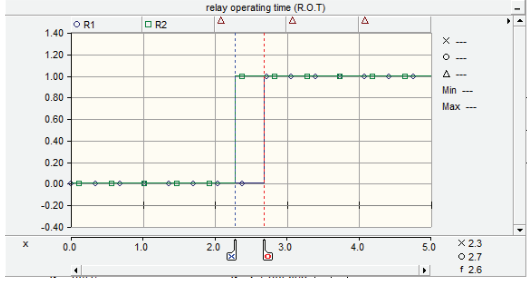


Fig. 4. Relay Operating Time (R.O.T) Transformer

TABLE III
COMPARISON OF SIMULATION AND CALCULATION TRANSFORMER

| Relay | Calculation Tripping Time (sec) | Calculated Timed Fault Logic (sec) | Simulation (sec) |
|---|---|---|---|
| *R2* | 0.3 | 2.3 | 2.3 |
| *R1* | 0.7 | 2.7 | 2.7 |

## IV. Comparison between IEC 60255 Standard and IEEE C37.112 Standard

The relays' operating time are simulated using both standards and summarized in Table IV and Table V. It can be seen that for the same fault at the same location, relays operating time using IEEE C37.122 Standard operate faster than the relays using IEC 60255 standard. For example, for a three-phase fault at Load 1, R5 relay trips in 0.1s using IEEE C37.112 compared to 0.2s trip time using IEC 60255. This concludes that the IEEE C37.112 standard shows a higher tripping sensitivity compared to IEC 60255 standard.

TABLE IV
RELAY OPERATING TIME OF IEC 60255 STANDARD

| Location of Faults (Three Phase Fault) | Relay Operating Time (sec) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | IEC 60255 Standard | | | | | | | | | | | |
| | R1 | R2 | R3 | R4 | R5 | R6 | R7 | R8 | R9 | R10 | R11 | R12 |
| At Load 1 | 2.1 | 1.7 | 1.2 | 0.7 | 0.2 | | | | | | | |
| At Load 2 | 0.9 | 0.5 | | | | | | | | | 0.2 | |
| At transformer | 0.7 | 0.3 | | | | | | | | | | |

TABLE V
RELAY OPERATING TIME OF IEEE C37.122 STANDARD

| Location of Faults (Three Phase Fault) | Relay Operating Time (sec) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | IEEE C37.122 Standard | | | | | | | | | | | |
| | R1 | R2 | R3 | R4 | R5 | R6 | R7 | R8 | R9 | R10 | R11 | R12 |
| At Load 1 | 1.7 | 1.3 | 0.9 | 0.5 | 0.1 | | | | | | | |
| At Load 2 | 0.2 | 0.1 | | | | | | | | | 0.05 | |
| At transformer | 0.2 | 0.1 | | | | | | | | | | |

## V. Conclusion

In this study, the relay operating time between American standard (IEEE C37.112) and British standard (IEC 60255) were analyzed and compared in the vicinity of three phase faults in the power system network. The overcurrent relay model was developed using PSCAD software. From the simulation, it was found that IEEE C37.112 standard tripping time shows better sensitivity compared to IEC 60255 standard, thus providing more safety fault isolation during fault conditions.


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## Conflict of Interest

The authors declare no conflict of interest in the publication process of the research article.

## Author Contributions

Author 1: supervision and draft review; Author 2: supervision and draft editing; Author 3: draft review, Author 4: reference source.

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