Inverse Definite Overcurrent Relay Response at Pencawang Masuk Utama Pagoh, Johor

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Abstract – *This paper focuses on modelling 132/11kV Pencawang Masuk Utama (PMU) Pagoh, Johor for assessing the Inverse Definite Minimum Time (IDMT) overcurrent relay in terms of relay response time using PSCAD software and comparing them with the calculated value. The relay is subjected to various fault conditions such as three phase fault, double phase and single-phase faults at different points of the network to observe the operating time. To ensure the reliability of the overcurrent relay, the response time was analysed. The response time were then being verified accordingly and the simulation result shows that the relay response time closely match the calculated value.*

Keywords: *PSCAD, plug setting. Relay operating time, Standard inverse of characteristic curve,*

Article History
Received 11 January 2024
Received in revised form 24 January 2024
Accepted 7 May 2024

I. Introduction

In medium voltage power lines, the overcurrent relay protection is the most widely employed protection against line-to-line problems. To ensure reliability, speed of operation, sensitivity, and selectivity, the setting of the relay needs top priority. Malfunction of relay tends to interrupt power delivery [1] – [5]. This paper presents the main parameter analysis between calculated values for relay setting and compares them using simulation in PSCAD software. The purpose of the paper is to verify the two main settings of relay, mainly known as Plug Setting Multiplier (PSM) and Time Multiplier Setting (TMS) at Pencawang Masuk Utama Pagoh power lines. Next, the calculated PSM and TMS will be compared by the simulation to meet the requirements for selectivity and sensitivity of the relay.

II. Network Model

The Pencawang Masuk Utama (PMU) Pagoh is used in the simulation. The system voltage is 132kV and connected to an 11kV network via stepdown transformer as shown in Fig. 1. Then from 11kv it was further stepdown to low voltage network (400V, 230V) for consumer usage. For simplification of the study, the network was divided into 5 zones of operation.

For the effective overcurrent relay operation in protecting the power system, the plug setting and the time response among different relays are crucial. Therefore, the calculation for pick up current and Time Multiplier Setting (TMS) has been done manually. The plug-setting multiplier, PSM, is defined as follows [6] – [9]:

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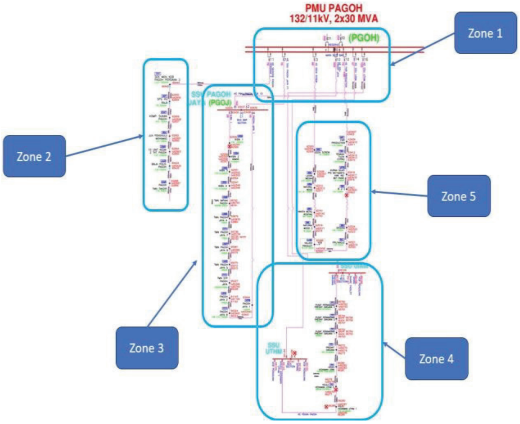

Fig. 1: PMU Pagoh

$$PSM = \frac{I_{relay}}{PS} \quad (1)$$

where, I_{relay} is the current through the relay operating coil and PS is the plug-setting of the relay. Also, the operating time of the relay can be calculated as follows [10] – [14]:

$$T_{op} = 0.14 * \frac{TMS}{PSM0.02-1} \quad (2)$$

where, PSM is the plug-setting multiplier and TMS is the time-multiplier setting of the relay.

III. Interpretation of the Single Line Diagram

Fig 2 shows the single line diagram of the PMU Pagoh.

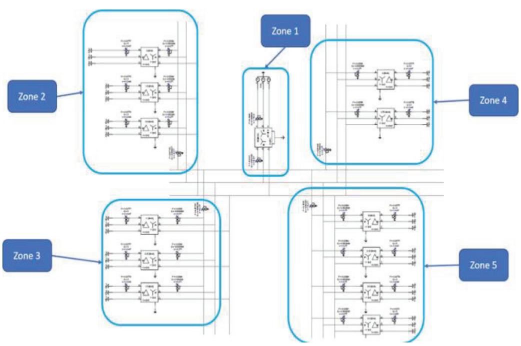

Fig. 2: Simulation diagram according to zone.

It can be seen form Fig 2 that the network is divided into 5 zones. Each zone contains their own transformer, consumer load and IDMT relay. Then each zone is further expanded to provide relay location as shown in Fig. 3 and Fig. 4. The overall network with IDMT relay has been modelled in PSCAD software. For simulation purpose, the system has been subjected to various type of fault i.e. three-phase short-circuit fault. The operating time of the relay has been recorded and then compared between the manual calculation. The summary of Plug setting and TMS calculation is shown in Table 1.

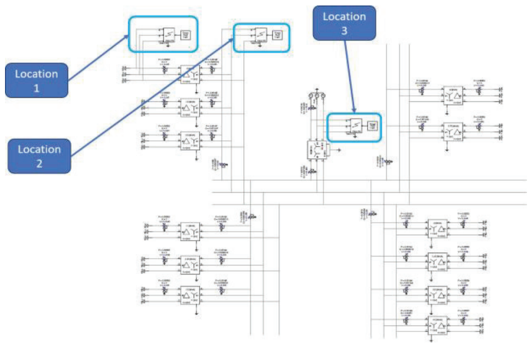

Fig. 3: Network with labelled location.

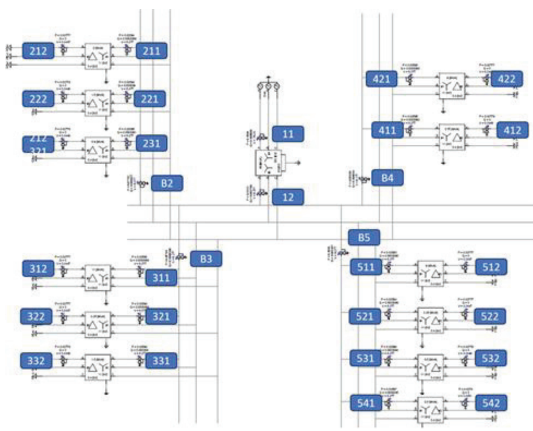

Fig. 4: Network with labelled relay.

TABLE I
CALCULATION FOR PSM AND TMS

Type	Relay	PSM	TMS
IDMT	212	4.9756	0.1000
	211	2.8726	0.1390
	B2	1.3185	0.0572
	B2	7.1643	0.1000
	11	15241.7619	0.1000
	212	6.7850	0.1000
	211	3.9173	0.1650
	B2	1.7825	0.1128
	B2	9.9296	0.1000
	11	152417.5416	0.1000
	212	5.3565	0.1000
	211	3.5603	0.1637
	B2	1.6264	0.0992
	B2	8.3405	0.1000
	11	26399.4984	0.1000
	212	4.3255	0.1000
	211	2.8726	0.1460
	B2	1.3185	0.0592

IV. Simulation Result

After mathematical computation, the PSCAD software is utilized to simulate the relay operation. Typical faults such as three-phase to ground fault, double line, and double to ground are simulated to observe the relay operating time. The time to apply fault is set at 1s. The duration of the fault is 5s. Three selected locations are presented here for simplification. The time response of the respective relay is shown in Fig. 5, Fig. 6 and Fig. 7.

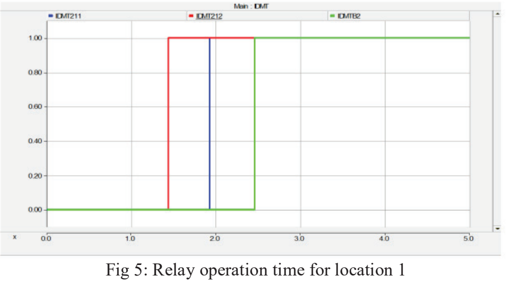

Fig 5: Relay operation time for location 1

From Fig. 5, for a three-phase fault at location 1 at 1s, it can be seen that Relay 211, Relay 212 and Relay B2 operating times are 1.4390s, 1.9220s and 2.4530s respectively.

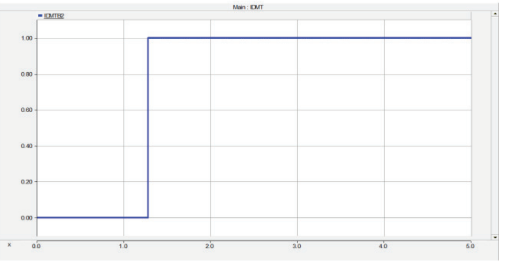

Fig. 6: Relay operation time for location 2

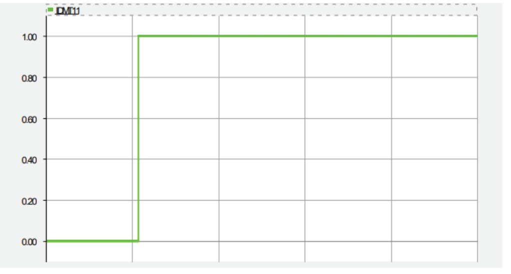

Fig. 7: Relay operation time for location 3

From Fig. 6, it can be seen that for a three-phase fault at location 2 at 1s, the Relay B2 operating time is 1.2940s. Finally, from Fig. 7, for a three-phase fault at location 3 at 1s, it can be seen that the Relay 11 operate at 1.0680s

V. Discussion

The relays' operating time were analyzed using both manual calculation and simulation has been summarized in Table 2. It can be seen that for the same fault at the same location, relay operating time using the calculated value is closely matched with the simulated relay operating time. For example, for a three-phase fault, Relay 212 response time is 1.4293s using (2) and during simulation the response time is 1.4390s. As a result, the percentage of error is very small, which is 0.67%. This verifies that the calculated PSM and TMS are accurate and consistent to use in the simulation.

VI. Conclusion

In this study, the relay operating time between standard calculated formula (2) was verified in simulation by using PSCAD software. This has been done by simulating PMU Pagoh network at Johor. The result shows that the calculated PSM and TMS are accurate and consistent to use in the simulation. The overall error between calculated and simulated value is very small and less than 2%.

TABLE II
THE RELAY'S OPERATING TIME

Fault	Relay	calculation (s)	Simulation operating time, (s)	Error, (%)
Three phases	212	1.4293	1.4390	0.6741
	211	1.9122	1.9220	0.5083
	B2	2.4435	2.4530	0.3892
	B2	1.3485	1.2940	4.2145
	11	1.0659	1.0680	0.1966
Double line	212	1.4101	1.4170	0.4853
	211	1.8911	1.8980	0.3616
	B2	2.4202	2.4280	0.3192
	B2	1.3231	1.3130	0.7664
	11	1.0620	1.0630	0.7664
Double line grounded	212	1.4710	1.4790	0.5404
	211	1.9581	1.9680	0.5026
	B2	2.4939	2.5090	0.6011
	B2	1.2881	1.2650	1.8280
	11	1.0659	1.0680	0.1966
Three phase ungrouded	212	1.3670	1.3750	0.5829
	211	1.8437	1.8490	0.2875
	B2	2.3681	2.3720	0.1664
	B2	1.3155	1.2840	2.4503
	11	1.0585	1.0680	0.8909

Acknowledgements

The authors wish to acknowledge the Universiti Teknikal Malaysia Melaka (UTeM) for providing the research platforms and facilities.

Conflict of Interest

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

Author Contributions

Author 1: Data simulation and analysis, article writing ,;Author 2: Supervision, simulation checking,; Author 3: draft review and editing,; Author 4 and 5: Review and finalized.

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