Overcurrent Protection of Radial Distribution Network

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Abstract – *Overcurrent relay is a device used in the protection of the power system network when there is any presence of fault. This paper presents the performance of overcurrent protection of radial distribution network. The response of the current and the IDMT relays in the network were simulated in PSCAD software by the determination of pickup current and time dial settings (TMS). The simulation results are obtained and verified by the calculation using the formula as shown in the content. The simulation results also shown that the chosen pickup current and time dial settings were able to provide full protection of the network.*

Keywords: *Overcurrent protection, Plug setting (PS), Plug setting multiplier (PSM), Time Multiplier setting (TMS)*

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I. Introduction

One of the important components in protection system is the overcurrent relay which is used to protect the large apparatus in distribution network such as line cables, transformers and the loads [1]-[2]. Successful operation of the overcurrent relay operation depends on the setting of pickup current and time dial settings. The relay will operate when the fault current is larger than the pickup current [3]-[5] and time taken to trip depends on the time dial setting. Therefore, the pickup current and time dial settings are essential to ensure the reliability of the relay to operate successfully during fault conditions.

In this paper, the overcurrent relay pickup current and time dial settings are determined using the PSCAD software. The result shows that the setting obtained from the simulation will result in successful relay operation.

II. Distribution Network Model

Fig. 1 shows a simple radial distribution network consists of a three-phase source with voltage rating of 11kV, 4MVA transformer of 11/3.3kV and load of 2MW each. The network has been modelled in PSCAD software. The load is equipped with R1, R2, R3 and R4 overcurrent relay. The parameters such as plug setting (PS), plug setting multiplier (PSM) and time multiplier setting (TMS) are added in the software to determine the performance of relays are shown Fig 2.

The pickup current of the relay can be determined manually by Eq.1 [6]-[7].

$$\text{Pickup current} = 125\% \times I_{rms} \tag{1}$$

The values of plug setting (PS) are required to calculate the plug setting multiplier (PSM). The value of the time multiplier setting (TMS) and the operation time of the relays can be obtained by using Eq. (2), (3) and (4) respectively [8]-[10].

$$PS\% = \frac{I_L}{CT\ ratio \times I_{relay\ rating}} \text{ x } 100\% \tag{2}$$

$$PSM = \frac{I_f}{PS \times CT\ ratio \times I_{relay\ rating}} \tag{3}$$

$$t_{ope} = \frac{0.14\,TMS}{PSM^{0.02}-1} \tag{4}$$

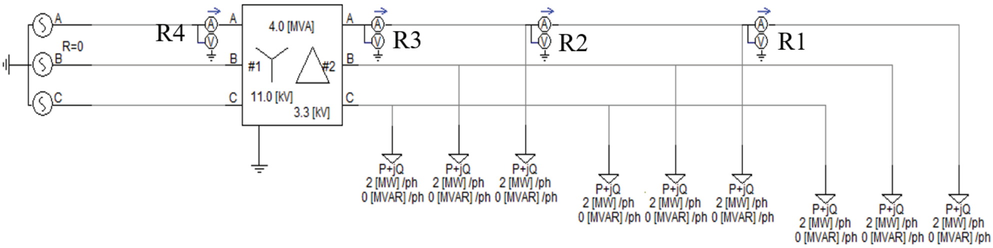

Fig. 1. Radial distribution network

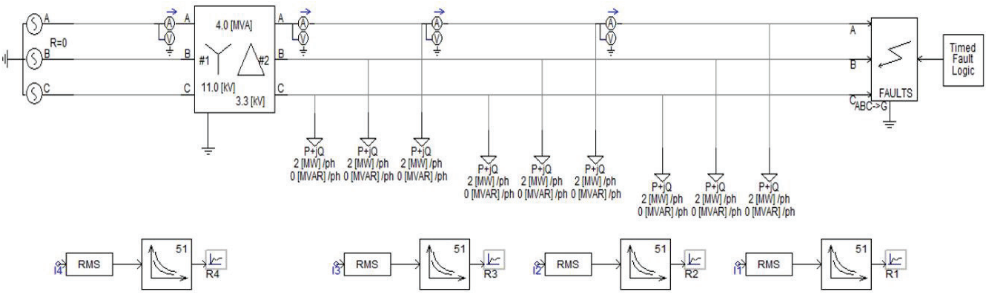

Fig. 2. Radial distribution network with presence of fault at load 1

III. Results and Discussion

The simulation is shown in Fig 3. The voltage at the primary side of the transformer is 6.651kV whereas the current flow at secondary side of the transformer is 1.737kV.

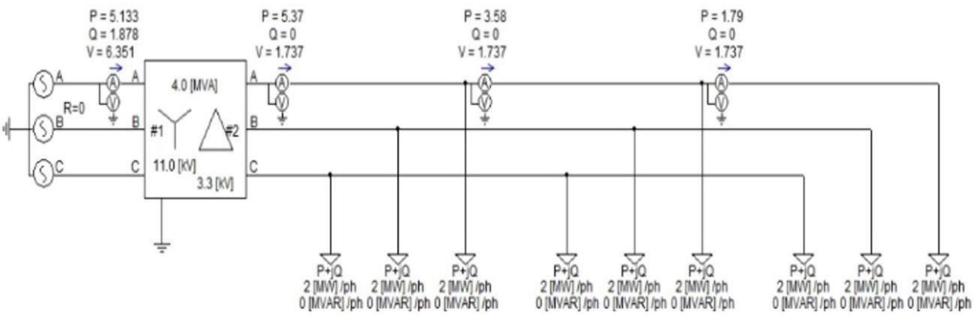

Fig. 3. Simulated result of radial distribution network

From the simulation of the network, the amount of load is 2MW at the point of relay R1. The rms value of current, $I1_{rms}$ flowing at that point is 1.022kA. At relay R2, the amount of load is 4MW where the rms value of current, $I2_{rms}$ is 2.054kA. Then, the rms current of $I3_{rms}$ and $I4_{rms}$ at relay R3 and R4 with load of 6MW is 3.047kA and 0.807kA. The responses of the current at different points are shown in Fig 4.

Based on the rms values of current flow in R1 to R4, the calculated pickup currents are listed in Table I and used in the setting of relays to obtain the operation of the relays.

When fault happened at load 1, the relays in the network will trip in sequence. In this case due the fault is at load 1, the relay R1 tripped at 0.232 second as shown in Fig 5.

TABLE I
CALCULATED RESULTS OF PICKUP CURRENT FROM I_{rms} OF THE RELAYS.

Relay	I_{rms} (kA)	Pickup current (kA)
R1	1.022	1.226
R2	2.054	2.465
R3	3.047	3.656
R4	0.807	0.968

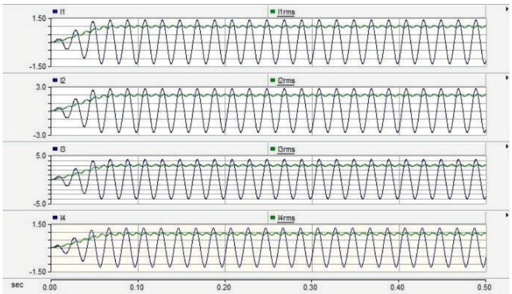

Fig. 4. Current at R1, R2, R3 and R4

Fig. 5. Operation of relay R1

Next, the simulation is tested for relay R2. When R2 detected the fault current, it will trip at 0.636 as shown Fig. 6 which 0.4 second delay from R1.

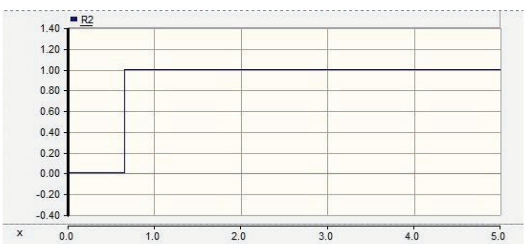

Fig. 6. Operation of relay R2

Then, it is followed by relay R3. After delay of 0.4 second, the relay R3 operated at 1.037 second as shown in Fig. 7.

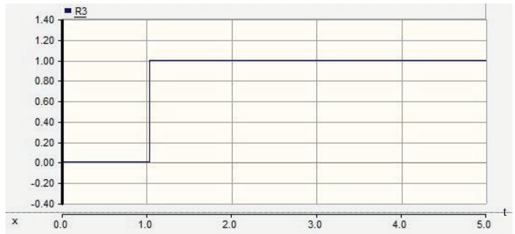

Fig. 7. Operation of relay R3

The relay R4 is located in between the generator and the transformer. When it detected the flowing of fault current, it will also delay for 0.4 second to trip after the operation of relay R3. The relay R4 operation time is 1.434 second as shown in Fig. 8.

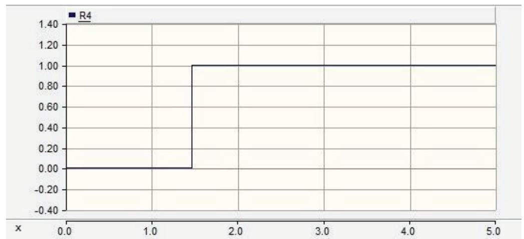

Fig. 8. Operation of relay R4

From Fig. 5 to Fig. 8, it is clearly shown that the operation of relays is successful and are in sequence. R1 detects the fault current and trip first and followed by the tripping of R2, R3 and R4, delayed for 0.4 second between each respectively.

All the simulated result from the PSCAD software is compared with the calculated value and tabulated in Table II. Table III show the calculated values.

TABLE II
CALCULATED RESULTS OF THE SETTINGS

Settings	**R1**	**R2**	**R3**	**R4**
I_L (A)	349.9	699.82	1049.73	314.92
CT ratio (A)	450/5	850/5	1500/5	400/5
PS (%)	80	90	70	80
PSM	19.44	9.15	6.67	21.875
TMS	0.1	0.2	0.284	0.65
t_{ope} (sec)	0.229	0.629	1.029	1.429

The summary of trip time of the relay between the simulation and calculation are shown in Table III.

TABLE III
RELAY OPERATING TIME COMPARISON.

Relay operating time, t_{ope}	Simulation (sec)	Calculation(sec)
R1	0.232	0.229
R2	0.636	0.629
R3	1.037	1.029
R4	1.434	1.429

From Table III, it can be noticed that the calculated value and the simulation value are almost the same. It proves that both simulation and calculation values are verified for this study.

IV. Conclusion

The setting of pickup current and relay operating time of the overcurrent relays in the radial distribution network are compared between theory calculation and using simulation PSCAD software. The results shown that the values from the calculation and simulation are almost the same. Hence, the results from simulation and calculation are verified for study purposes.

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