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ELECTRICAL POWER ENGINEERING

Power System Fault Analysis of Myanma Electric Power System by MATLAB

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Abstract— **This paper presents the maximum fault currents for each system voltage level during balanced and unbalanced faults (symmetrical and unsymmetrical faults) at various locations in the national grid system. Myanma Electric Power Enterprise's (MEPE's) power system adopts the solidly grounded system, in which it is expected that ground fault currents increase as the power system grows large. Therefore, the appropriate countermeasures are prepared for the anticipated future problems in the power system. To solve this problem, fault currents, bus voltages and line currents are calculated by using MATLAB and required impedances data are collected from MEPE. The results obtained from fault calculations serve to determine relay settings and coordination, power system planning, stability and reliability of the power system operation. This research is intended to prevent and reduce system blackouts and also to improve protection schemes in present and future power system.**

Keywords— **maximum fault currents, system voltage, balanced and unbalanced faults, impedances data, protection schemes**

I. INTRODUCTION

THE electric power is generated in the power plant and then transmitted and distributed via a large interconnected power system. The high voltage level is raised by the transformer before the power is transmitted in order to reduce power transmission losses. The pivotal objective of all the power systems is to maintain a continuous power supply.

However, lightening or other accidental events, which is called a fault, can occur on the power system. In that case, there can be severe damage to the equipments due to the fault currents which are usually larger than normal operating currents. This leads to long-term power loss. In order to prevent such disturbances, it is necessary to disconnect the faulty part from the healthy remaining power system by the protective relaying system as soon as possible. If the fault is cleared in the power system, the relay system attempts to connect the remaining power system and so the lines can work normally. That is why, the result of fault calculation is very important to determine circuit breakers capacity and protective relays performance. As a result, the optimum protective relaying system avoids relay operations as well as reduces losses and discontinuity in power supply.

For that reason, power system fault analysis is a vital importance in power system protection. It consists of determining line currents and bus voltages during symmetrical and unsymmetrical fault conditions. Symmetrical three phase fault currents are performed to define the rated breaking currents of circuit breakers. Most of the faults that occur on power system are unsymmetrical, which include single line-to-ground fault, line-to-line fault, and double line-to-ground fault. Among them, ground faults are the most frequently occurring form of faults in power system including transmission and distribution lines. So, ground fault analysis by MATLAB is required for all major buses in whole system based on symmetrical impedances data such as positive sequence, negative sequence, and zero sequence impedance. The electromagnetic transient program (EMTP) has been used to generate reliable fault data which can be used for evaluating fault location accuracy.

II. STUDY AREA

This paper is concerned with a fault study on Myanma Electric Power System which focuses on 84 buses system. This system consists of 25 generators, 30 transmission lines (230 kV), 28 transmission lines (132 kV), 17 transmission lines (66 kV), and 9 transmission lines (33 kV).

The generating power stations are Lawpita, Hlawga, Thaketa, Shwedaung, Thaton, Paunglaung, Shweli, Tikyit, Kinda, BHP (1), Mone, Mann, Kyunchaung, Sedawgyi, Kengtaung, Myanaung, Zawgyi (1), Zawgyi (2), Zaungtu, Ahlone, Mawlamyaing, Ywama, Kapaung, Yenwe and Thapanseik.

Transmission lines (230 kV) are Taungoo, Tharyargone, Kamanet, Myaungtagar, Taungdwingyi, Thephyu, Pyinmana, Naypyitaw, Paunglaung, Hlaingtharyar, Baynitnaung, Athoke, Shweli, Mansan, Shwemyo, Tharzi, Shwesaryan, Belin, Meiktila and Steelmill, and three winding transformers (230 kV) Taungdwingyi, Thazi, Bayintnaung, Tharyargone, Hlawga, Thaketa, Shwedaung, Lawpita, Thaton and Shwesaryan.

Transmission lines (132 kV) are Lawpita, Tigyit, Kalaw, Kinda, Yinmarbin, BHP (1), Chauk, Tanyaung, Magwe, Mone, Naungbingyi, Monywa, Sedawgyi, Letpanhla, Ngapyawding, Kyaukpahtoe, Mandalay, Aungpinle, Inngon, Myanchan, Kengtong, Nansam, Pinpet and Pyinoolwin, and three winding transformers (132 kV) are Kalaw, Ngapyawdine, Kyunchaung and Kamarnat.

Transmission lines (66 kV) are Thaketa, Shwedaung, Thaton, Kyunchaung, Pyay, Myanaung, Aungthabye, Zawgyi (1), Zawgyi (2), Zaungtu, Thida, Sinmalike, Pa-an and Seinpamyaing, and three winding transformer (66 kV) are Kamarnet, Ahlone and Ywama.

Transmission lines (33 kV) are Hlawga, Mann, Ahlone, Mawlamying, Ywama, Kapaung, Yenwe, Thapanseik and Kantbalu.

III. METHODOLOGY

This paper addresses fault calculation with the following assumptions.

(1) In the fault analysis of a large power system usually the negative-sequence network impedances are assumed to be identical to the positive-sequence values.

(2) The impedances to positive and negative-sequence currents, z_1 and z_2, are equal in any static circuit and may be considered approximately equal in synchronous machines and subtransient conditions.

(3) Zero-sequence impedance has slight difference to leakage reactance. When the difference is ignored, it has the same value as the positive-sequence value.

(4) All voltages sources assume a one per unit magnitude and zero relative phase, which is equivalent to neglecting the prefault load current contribution.

(5) All shunt capacitances and loads are neglected.

(6) Neglect the mutual coupling effects.

In this paper, per unit quantities are used throughout fault current calculation by MATLAB program. A fault represents a structural network which is caused by the additional impedance at the place of fault. If the fault impedance is zero, the fault is referred to as the bolted fault or solid fault. The results are calculated for bolted fault, Z_f = 0, and are considered fault impedance, Z_f = j0.1. The Electromagnetic Transient Program (EMTP) has been used to generate reliable fault data used for evaluation of fault location accuracy. The function sgmfault.m is executed using four MATLAB functions, zbuild.m, lgfault.m, llfault.m and dlgfault.m.

Zbus=zbuild(zdata) is developed for the formation of the bus impedance matrix. A program symfault(zdata, bus,V) is developed for systematic computation of three phase balanced faults for a large interconnected power system. These functions named lgfault(zdata0, zbus0, zdata1, Zbus1, zdata2, Zbus2,V), llfault(zdata1, Zbus1, zdata2, Zbus2,V) and dlgfault(zdata0, Zbus0,zdata1, Zbus1, zdata2, Zbus2,V) are developed for the line-to-ground, line-to-line, and double line-to-ground fault studies.

The following experimental procedures are performed to compute the fault currents, line currents and bus voltages.

(1) Put in positive sequence and negative sequence data for generator, transformer and transmission lines

(2) Insert zero sequence data for generator, transformer and transmission lines

(3) Input Z_f data into the progam

(4) Insert bus number

(5) Calculate fault current, bus voltages and line currents for three phase fault

(6) Type in "yes" for another fault location

(7) Slot the another bus number and calculate fault current, line currents, bus voltages and then keep on computing until bus number 84

(8) Repeat the above strategy to work out single line-to-ground fault, line-to-line fault and double line-to-ground fault

(9) Illustrate the output curves for four types of fault in each different voltage level

(10) Find out the maximum fault current among 84 buses for each voltage level.

IV. RESULTS AND DISCUSSION

The results are calculated for two fault impedances; Z_f = 0 and Z_f = j0.1. For Z_f = 0, or Z_f = j0.1 , the maximum fault current in 230kV bus is Pyinmana, the maximum fault current in 132 kV bus is Tigyit, the maximum fault current in 66kV is Thaketa, the maximum fault current in 33kV is Hlawga. The data mention that Z_f = 0 generates larger fault current than Z_f = j0.1. Fig. 1 shows fault currents for 84 buses due to three phase fault, single line-to-ground fault, line-to-line fault and doulble line to ground fault with Z_f = 0. Fig. 2 represents all types of fault currents with Z_f = j0.1. Fig. 3 illustrates fault currents for 230 kV lines with Z_f = 0. Fig. 4 establishes fault currents for 132 kV lines with Z_f = 0. Fig. 5 illustrates fault currents for 66 kV lines with Z_f = 0. Fig. 6 demonstrates fault currents for 33 kV lines with Z_f = 0. Fig. 7,8,9 & 10 show faults currents for each voltage level with Z_f = j0.1.

The fault calculation resulted by MATLAB provides the maximum fault current for each voltage level as shown in Table I.

For 230 kV lines, bus number 11 is the maximum fault current for three phase fault and line-to-line fault but the maximum fault current for single line-to-ground fault and double line-to-ground fault is bus number 18. For 132 kV lines, bus number 26 is the maximum fault current for three phase fault and line-to-line fault but the maximun fault current for single line-to-ground fault and double line-to-ground fault is bus number 1.

For 66 kV lines, bus number 6 is the maximum fault current for three phase fault, single line-to-ground fault, line-to-line fault and double line-to-ground fault. For 33 kV lines, bus number 5 is the maximum fault current for three phase fault, single line-to-ground fault, line-to-line fault and double line-to-ground fault. These results for maximum fault current corresponding to the bus number is identical for Z_f = 0 and Z_f = j0.1.

TABLE I
MAXIMUM FAULTS CURRENT FOR EACH VOLTAGE LEVEL

Voltage level / Fault Type	Fault Current (p.u)		Sub Station
	$Z_f = 0$	$Z_f = j0.1$	
230 kV			
Three Phase Fault	24.8243	7.1333	Pyinmana
Single Line-to-Ground	25.1585	7.1567	Shweli
Line-to-Line	21.4985	9.6002	Pyinmana
Double Line-to-Ground	26.4489	4.2052	Shweli
132 kV			
Three Phase Fault	19.5708	6.6395	Tikyit
Single Line-to-Ground	17.2583	6.3382	Lawpita
Line-to-Line	16.9488	8.5969	Tikyit
Double Line-to-Ground	16.1128	3.8175	Lawpita
66 kV			
Three Phase Fault	19.7755	6.6434	Thaketa
Single Line-to-Ground	19.0627	6.5608	Thaketa
Line-to-Line	17.1261	8.6141	Thaketa
Double Line-to-Ground	18.3993	3.9322	Thaketa
33 kV			
Three Phase Fault	17.4619	6.3597	Hlawga
Single Line-to-Ground	18.7368	6.5209	Hlawga
Line-to-Line	15.1225	8.0750	Hlawga
Double Line-to-Ground	20.2118	4.0086	Hlawga

V. CONCLUSION

Fault current data of major points in power system from this paper is most important for determining the optimum relay setting values, selecting the appropriate relaying scheme, analyzing the relay operation behavior and protecting the electric equipments from the faults. As various power system information and related data are accumulated, data shall be used more efficiently in the power system for stable and reliable operation. The result of present and future power system studies prevent and reduce system blackouts. The provision of proper power system operation and protection schemes should go abreast of the power system construction to ensure to provide stable and continuous power system as well as safety and reliability in power system.

Fig. 1 Fault Current vs. Bus number of Three Phase, Single Line-to-Ground fault, Line-to-Line Fault and Double Line-to-Ground Fault with $Z_f = 0$ for 230 kV, 132 kV,66 kV and 33 kV

Fig. 2 Fault Current vs. Bus number of Three Phase, Single Line-to-Ground fault, Line-to-Line Fault and Double Line-to-Ground Fault with $Z_f = j0.1$ for 230 kV, 132 kV,66 kV and 33 kV

Fig. 3 Fault Current vs. Bus Number of Three Phase Fault, Line-to-Line Fault and Double Line-to-Line Ground Fault with $Z_f = 0$ for 230 kV

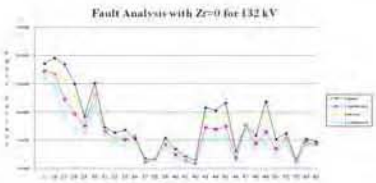

Fig. 4 Fault Current vs. Bus Number of Three Phase Fault, Line-to-Line Fault and Double Line-to-Line Ground Fault with $Z_f = 0$ for 132 kV

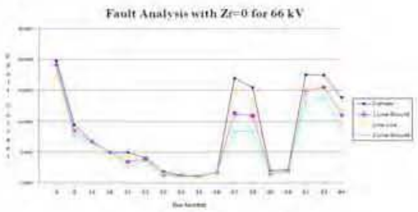

Fig. 5 Fault Current vs. Bus Number of Three Phase Fault, Line-to-Line Fault and Double Line-to-Line Ground Fault with $Z_f = 0$ for 66 kV

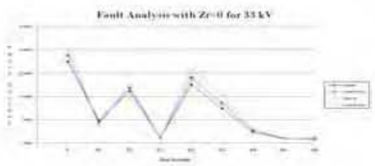

Fig. 6 Fault Current vs. Bus Number of Three Phase Fault, Line-to-Line Fault and Double Line-to-Line Ground Fault with $Z_f = 0$ for 33 kV

Fig. 7 Fault Current vs. Bus Number of Three Phase Fault, Line-to-Line Fault and Double Line-to-Line Ground Fault with $Z_f = j0.1$ for 230 kV

Fig. 8 Fault Current vs. Bus Number of Three Phase Fault, Line-to-Line Fault and Double Line-to-Line Ground Fault with $Z_f = j0.1$ for 132 kV

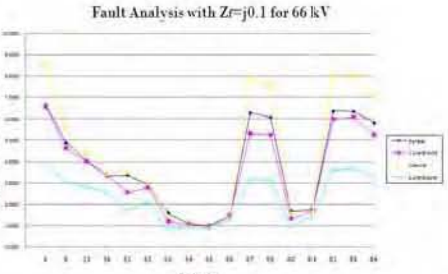

Fig. 9 Fault Current vs. Bus Number of Three Phase Fault, Line-to-Line Fault and Double Line-to-Line Ground Fault with $Z_f = j0.1$ for 66 kV

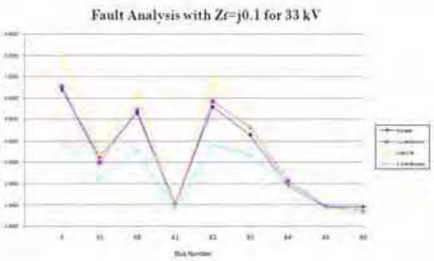

Fig. 10 Fault Current vs. Bus Number of Three Phase Fault Line-to-Line Fault and Double Line-to-Line Ground Fault with $Z_f = j0.1$ for 33 kV

APPENDIX

The national grid of Myanma Electric Power System is shown in appendix A, and flowchart of the MATLAB program "sgmfault.m" is shown in appendix B.

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APPENDIX A

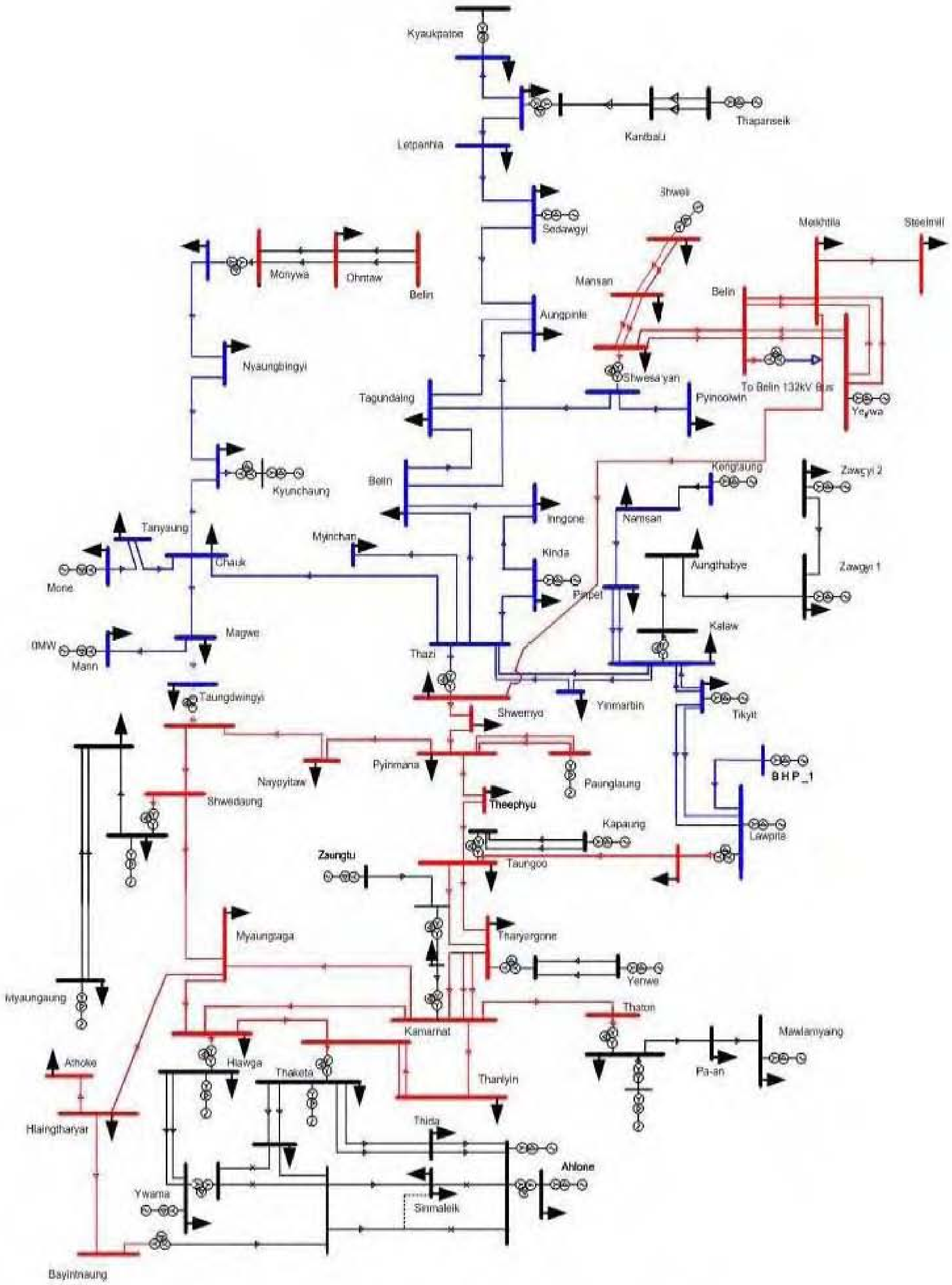

Fig. 11 The National Grid of Myanmia Electric Power System

APPENDIX B

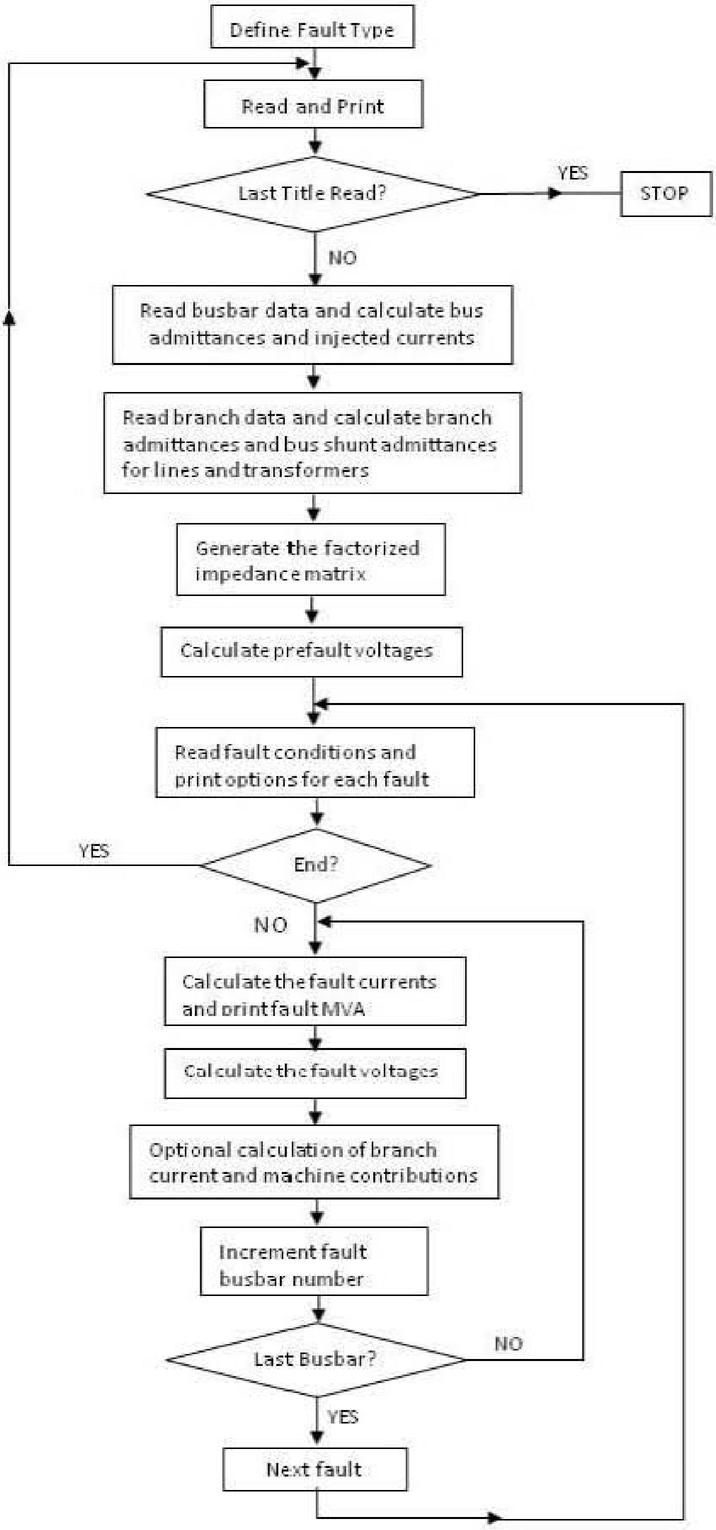

Fig. 12 Flowchart of the MATLAB program "sgmfault.m"