Review of MVA Method for Fault Current Estimation and Simulation with Software

E. Raju[1] G. Lova Raju[2] A.Siva Sarpakara Rao[3] Shanmukha Sriram Saladi[4]
[1,2,3,4]Assistant Professor
[1,2,3,4]Department of Electrical & Electronics Engineering
[1,2,3]BVC Engineering College(A), India [4]BVC Institute Of Technology & Science, India

Abstract— There are various methods available for estimation of fault currents in any Electrical Power network or system like per unit and impedance or ohmic methods which are more complex and requires to remember so many formulae. There is a simple method called as Power MVA method in which there is no need to remember any formulae except a minimum basic knowledge of series parallel resistance networks. But the calculations should be so accurate such that the sizing of electrical equipment and proper relay co-ordination can be done by the designer of system. To explain it in detail, a simple practical example from a nearby Industry is taken and estimates are done with Power MVA method. Also same are simulated with a software and the results are compared for their accuracy.

Keywords: Faults, MVA Method, Power System Analysis Software, Symmetrical, Induction Motor, Lump Load

I. Introduction

Fault Current calculations are one of the most important tasks undertaken in power system planning and operation. Switchgear selection, protection settings and coordination require comprehensive, detailed and accurate calculations. A significant effort has been made by engineers and technocrats to improve the calculation methods and compile the fault calculation standards and guidelines to be more suitable for industrial applications which are in line with national and International Standards.

Short circuit currents impose the most serious general hazard to power distribution system components and are the prime concerns in developing and applying protection systems. Fortunately, short circuit currents are relatively easy to calculate. The application of three or four fundamental concepts of circuit analysis will derive the basic nature of short circuit currents. These concepts will be stated and utilized in a step-by step development. The three phase bolted short circuit currents are the basic reference quantities in a system study. In all cases, knowledge of the three phase bolted fault value is wanted and needs to be singled out for independent treatment. This will set the pattern to be used in other cases.

There are different methods avialable in standard literature on fault current calculations:

1) Ohmic Method (not preferred)
2) Per Unit Method (Most Common)
3) MVA Method (Quick & Easy which is proposed now)

Ohmic Method is nothing but transferring all impedances to high/low voltage side of transformer using square of transformer turn ratio using AC circuit theory knowledge, Voltage & Current dividers, Thevenin & Norton equivalents, Kramer's Rule, etc.

Per unit fault calculations is a method whereby system impedances and quantities are normalised across different voltage levels to a common base. By removing the impact of varying voltages, the necessary calculations are simplified. To use the per unit method, we normalise all the system impedances (and admittances) within the network under consideration to a common base. These normalised impedances are known as per unit impedances. Any per unit impedance will have the same value on both the primary and secondary of a transformer and is independent of voltage level. A network of per unit impedances can then be solved using standard network analysis. From this fault level can be readily determined. The MVA method is a modification of the Ohmic method where the impedance of a circuit equals the sum of the impedances of components constituting the circuit. Using the admittances, it follows that the reciprocal of the system impedance is the sum of the reciprocals of the admittances of the components. By very definition, the circuit component admittance is the maximum current or KVA at unit voltage which would flow through the circuit or component to a short circuit or fault when supplied from a source of infinite capacity. In practice, the MVA method is used by separating the circuit into components and calculating each component with its own infinite bus. The basic procedure to determine the fault current at any point in the system, first we will draw a Single line diagram showing all of the sources of short-circuit current feeding into the fault, as well as the impedances of the circuit components. To begin the study, the system components, including those of the utility system, are to be represented as impedances in the diagram. The impedance tables given in the Data Section by the equipment manufacturer include three phase and single phase transformers, current transformers, safety switches, circuit breakers, cable, and bus way shall be referred. These tables can be used from the manufacturers web sites. It must be understood that short circuit calculations are performed without current limiting devices in the system. Calculations are done as though these devices are replaced with copper bars, to determine the maximum "available" short circuit current. This is necessary to project how the system and the current limiting devices will perform.

II. Description

Electrical powers system is growing in size and complexity in all sectors such as generation, transmission, distribution and load systems. Electrical fault is an abnormal condition, caused by equipment failures such as transformers and rotating machines, human errors and environmental conditions. Theses faults cause interruption to electric flows, equipment damages and even cause death of humans, birds and animals. There are mainly two types of faults in the electrical power system. Those are symmetrical and unsymmetrical faults.

A. Symmetrical Faults

These are very severe faults and occur infrequently in the power systems. These are also called as balanced faults and are of two types namely line to line to line to ground (L-L-L-G) and line to line to line (L-L-L).

B. Unsymmetrical Faults

These are very common and less severe than symmetrical faults. There are mainly three types namely line to ground (L-G), line to line (L-L) and double line to ground (L-L-G) faults. Most of the faults under the category L-L-L and L-G and hence the scope of this paper is re4srticted to these two faults only. To confirm that the MVA method is simple and accurate t5o estimate above referred fault currents, a nearby Industry is visited and it's power scheme as shown in Fig. 1 is taken as an example:

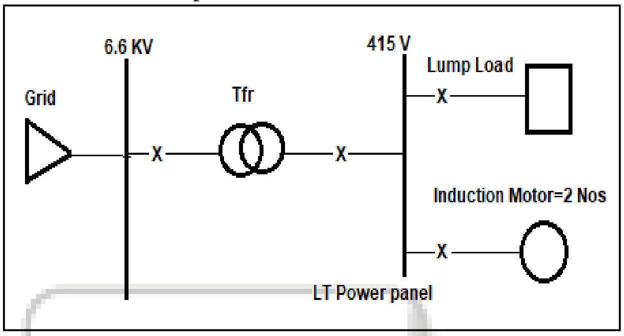

Fig. 1: Power schematic diagram

It is getting supply from the Grid at 6.6 KV level with a fault capacity of 250 MVA.

The incoming voltage is stepped down to 415 Volts with a Step down transformer of 630 KVA, 6.6/0.4125 V, 4 % Impedance voltage, DyN11 with solidly grounded neutral. The industry is having following Loads:

1) Two number of squirrel cage Induction Motors of each 3 phase, 415 V, 100 KW, 0.85 pf, 118 KVA, 85% efficiency, 1460 RPM, DOL starting, 25% impedance to drive the Pump loads.
2) One number of Lump Load (mostly lighting, heating, air conditioning and ventilation loads), 3 phase, 100 KW, 415 V, 0.75 pf, 133 KVA, 80% efficiency, 20% impedance with all the loads having sufficient earthing connections and all the protections.

III. ESTIMATION OF FAULT CURRENTS WITH MVA METHOD

The MVA method is fast and simple as compared to the per unit or ohmic methods. There is no need to convert to an MVA base or worry about voltage levels. This is a useful method to obtain an estimated value of fault current. The elements have to be converted to an MVA value and then the circuit is converted to admittance values.

A. L-L-L fault:

It is proposed to calculate phase short circuit (L-L-L) fault current by creating a fault on 415 V bus as shown in Fig. 2.

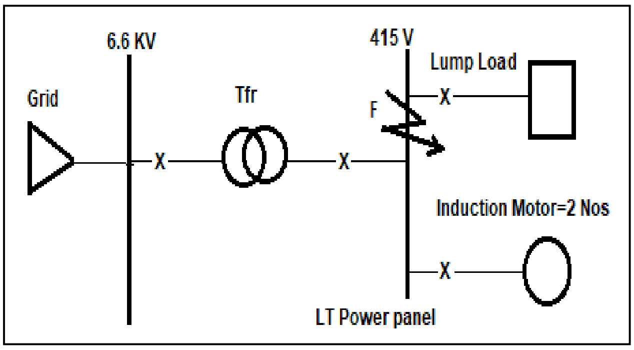

Fig. 2: Fault location

Fault MVA of each component:
Grid = 250 MVA (Given)
Tfr = KVA/(1000 X % Z/100) = 0.63/0.04 = 15.75 MVA
Motors = 2 X 0.118/0.25 = 0.94 MVA
Limp load = 0.133/0.2 = 0.67 MVA
Now the fault MVA diagram is shown in Fig. 3.

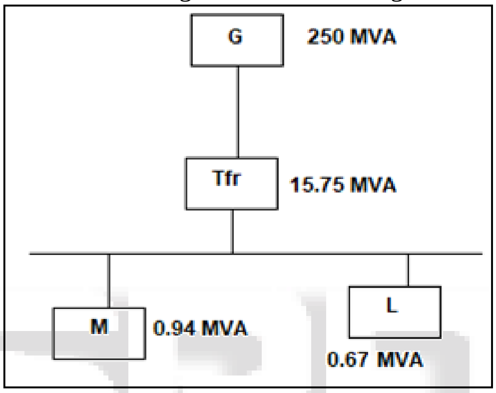

Fig. 3: Fault MVA diagram

Above diagram is reduced with the simple rule of treating them as parallel resistor circuit if they are in series and vice versa.

R_G and R_{Tfr} = 250x15.75/(250+15.75)=14.82 MVA

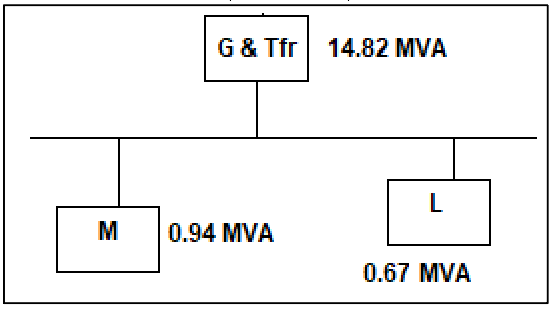

Fig. 4: Reduced MVA diagram

SC MVA at F = 14.82+0.94+0.67 = 16.43 MVA

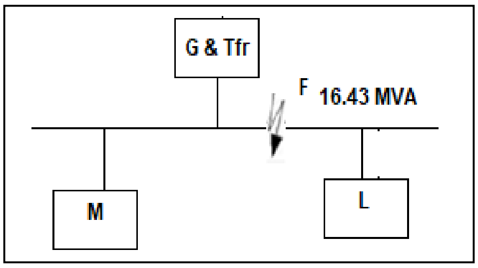

Fig. 5: Final MVA diagram

Now the fault current at F is calculated as follows:
Short circuit Fault current at F=16.43/ (√3 x 0.415) = 22.86 KA.

B. L-G fault:

It is proposed to calculate the phase to earth (L-G) fault current by creating a fault on 415 V bus as shown in Fig. 6

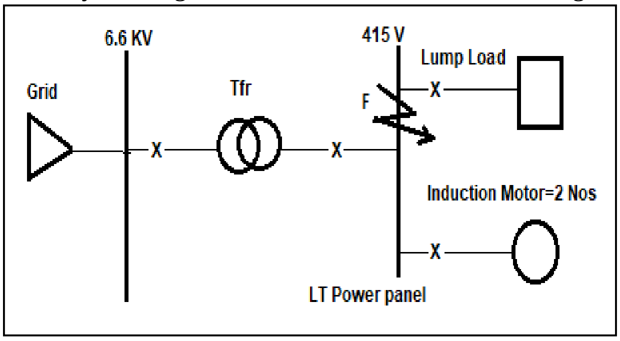

Fig. 6: LG fault

The delta winding of Transformer blocks zero phase sequence (ZPS) currents entering from grid side. The negative phase sequence(NPS) impedance will be same as that of PPS. Also the ZPS impedance of transformer and loads will be generally 50% of PPS impedance. Therefore, all the ZPS MVA will be double of PPS or NPS.

MVA(ZPS) of Tfr = 2x15.75= 31.5 MVA

MVA(ZPS) of Motors = 2x0.94= 1.88 MVA

MVA(ZPS) of Load = 2x0.67= 1.33MVA

Total ZPS MVA=31.5+1.88+1.33=34.71

Now the fault MVA diagram is shown in Fig. 7.

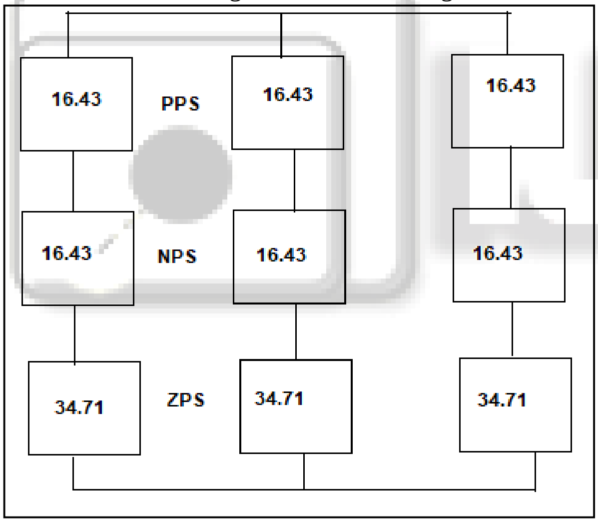

Fig. 7: LG fault

The net ZPS MVA = 3 times of equivalent of all three components.

MVA = 3x6.64=19.92

Now the fault current at F is calculated as follows:

Earth fault current at F=19.92/(√3 x 0.415) = 27.7 KA.

IV. SIMULATION OF FAULT WITH A SOFTWARE PROGRAM

The L-L-L fault (symmetrical) scenario is simulated in a power system analysis / simulation software to find out the authenticity and accuracy of MVA method. On completion of simulation, the result of screen shot is shown in Fig. 8. The screen shot indicates both the calculated values and simulated values are almost same with marginal error.

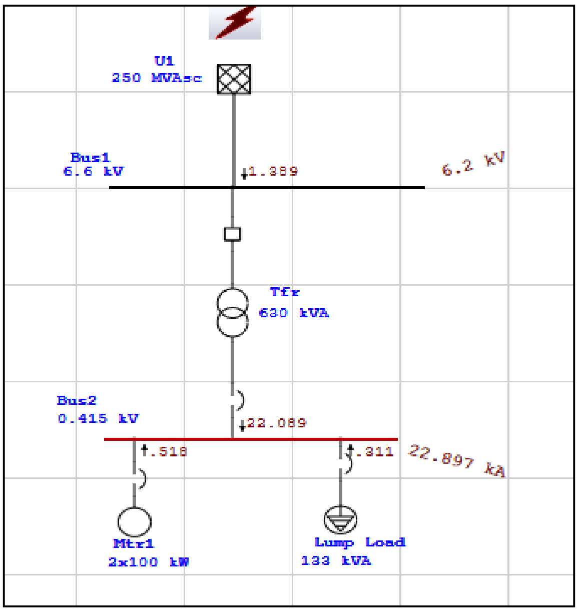

Fig. 8: Screen shot of LLL fault

The L-G fault scenario is simulated and the screen shot is shown in Fig 9.

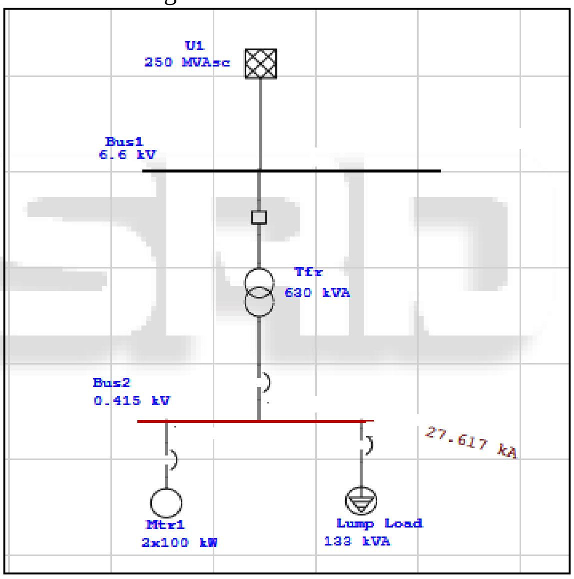

Fig. 9: Screen shot of LG fault

V. COMPARISON OF RESULTS

All the above results are shown in Table-1.

Fault Current in kA	L-L-L	L-G
MVA method	22.86	27.70
Software simulation	22.89	27.62

Table 1: Comparison

VI. CONCLUSION

It is confirmed that there is not much variation in fault current values calculated with simple MVA method and software simulations. In this MVA method the time requirement is less than that of per unit method; the base data is simplified. Since the base units are not required, estimations are simplified and the results are more accurate with low error content.

ACKNOWLEDGEMENTS

The authors would like to extend their sincere thanks to the management of BVCE(A), JNTU (K) for extending the facilities to carry out this work; and also thanks to the management & Chairman Dr. B.V. Rajesh and nearby Industry to gather the data from their works and to the management of a Consulting firm for utilizing the simulation software.

REFERENCES

[1] Sunil S.Rao, Switchgear protection and power system, Khanna Publications, 2008.
[2] BadriRam, D.Vishwakarma, Power System Protection and Switchgear, Tata Mc Graw Hill, 2011.
[3] Short Circuit Calculation Hand Book at www.arcadvisor.com.
[4] Distribution Automation Handbook, Section 8.2, Relay coordination, IMRS 757285, ABB Ltd. -2011, Finland.
[5] Recommended practice for protection and coordination of industry and commercial power system, IEEE std: 242-1975, part 7.5.2.
[6] Pedro Rodrignez, A drianv timbus, Flexible active power control of distributed power generation system during grid faults, IEEE transactions on industrial electronics vol-54, No:5 PP-2583-2592 oct- 2007.
[7] IEC 60909-0 Short Circuit Currents in three phase a.c systems, Calculation of Currents-2001.
[8] KR Padiyar, Power system dynamics stability and control, BS publications-2008.
[9] Dr Goerge Kusic, Computer aided power system analysis, CRC Press- 2008.
[10] William D. Stevenson, Elements of Power system analysis, McGraw Hills-1982.
[11] www.academia.edu/11106948/MVA_Method_Short_Circuit _ Calculation.
[12] https://nptel.ac.in/courses/108105067/30 Power system analysis.
[13] https://www.brainkart.com/article/Solved-problems-and-Examples- on-Per-Unit-Analysis_12408.
[14] https://www.vidyarthiplus.com/vp/Thread-EE6501-Power-System-Analysis-Lecture-Notes#.XOj5hnHhWM8.
[15] S.L. Uppal, S. Rao Electrical, Power Systems, Khanna publishers-1987.
[16] J. Lewis Blackburn, Thomas J. Domin, Protective Relaying: Principles and Applications, CRC press-2014.
[17] J. Lewis Blackburn, Symmetrical Components for Power Systems Engineering, CRC press-1993.
[18] Turan Gonen, Modern Power System Analysis, CRC press-2013.
[19] J. Lewis Blackburn, Symmetrical Components for Power Systems Engineering, marcel dekkel, 2013.