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Comparison of ANSI –IEC Short Circuit Methods

Raghuram Chelluri [1], Mili Das Mohapatra [2]

Department of Electrical, Fluor Daniel India Pvt. LTD, New Delhi, India

ABSTRACT: Power system networks become very complex because of the industrial growth. It may be subject to various disturbances and it needs to be resolved quickly. The choice of the appropriate method for calculating short-circuit currents is therefore particularly important in terms of both economic and safety considerations. In this paper short circuit study of a typical power distribution system of an Industrial facility is performed using Electrical Transient Analyzer Program (ETAP) software. The system fault currents are investigated for different Calculation methods. The study presents the most important interrelationships that describe the characteristic magnitudes of short-circuit currents for IEC standard and for the ANSI/IEEE standard. This comparison has been done on the basis of calculations performed on a typical MV Industrial network.

KEYWORDS: Short circuit Calculations, IEC60909, ANSI C37.

I.INTRODUCTION

Short circuits in electrical power systems are associated with complex electromagnetic and thermal phenomena leading to transients and electrodynamic forces in electrical systems.As an Engineer, we need to make technical decisions of equipment sizing based on short circuit taking into account the economic aspect also. This is related to investment costs of switching, measuring, protection devices and other elements of the power system. This leads to the necessity of creating simplified, easy to apply procedures, ensuring sufficient accuracy for specific needs. These methods are contained in the standard recommendations which have been created in many countries over several decades. The first such standard was the introduced in Germany in 1929 VDE0102 standard.

The question of short-circuit current calculation is described in several standards, the fundamental one being the oldest of them, while the other documents are its repetitions with additions and extensions.Currently the most widely used is the international IEC 60909 standard. IEC standard covers the calculation of both the maximum and minimum values of short-circuit currents. The calculation procedures contained in the American standard cover essentially only the maximum short-circuit currents necessary for the selection of switching devices, since they constitute only a part of a broader standard describing the parameters and requirements for medium-voltage switchgear selection.

ANSI 30 cycle calculation is used for relay coordination while IEC minimum fault is used for relay coordination. This study presents the basic assumptions of both standards and an example of calculation on MV Industrial network. Such comparison – which is the subject of this study – can lead to better comprehension of the fundamental differences between the two approaches and detailed assessment of the impact of these differences on the results obtained using different calculation procedures. It should be also emphasized that both the European and American have the status of voluntary use (in the U.S. standard defined as IEEE Recommended Practice).

Power system components such as power cables, transformers etc should be designed to withstand the momentary short circuit current at the time of fault. The perspective short circuit current in a system during a fault is required to design the electrical insulation and the protective system. Short circuit may lead to instability, mechanical and thermal stresses on electrical insulations.

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II. SHORT CIRCUIT ANALYSIS

Short circuit is an accidental or intentional conductive path between two or more conducting part, caused by the breakdown of insulation, high surge voltage and human error. It leads to large magnitude of fault current which is greater than full load current. Short circuit current depends on the intervening circuit impedance up to the fault point. A short circuit may lead to, stability problem, mechanical and thermal stress and it may also cause fire hazard and electric shock to the working personnel. The results of short circuit analysis are used for the selection of protective devices and their coordination.

In this paper, the short circuit characteristic of the typical plant has been analyzed using ANSI C-37, IEC 60909 standards in ETAP. The detailed descriptions about the short circuit current calculations are presented in this section. Calculation methodology for IEC calculation is current based while ANSI is impedance based.

III. IEC STANDARD (IEC60909)

IEC 60909 is being used to analyse the short circuit performance of the typical plant. In IEC 60909 standard, the initial symmetrical current is obtained by using the nominal voltage, voltage factor (C) and equivalent impedance at the fault location.

Three methods namely method-A, method-B, method-C are used and the peak current magnitudes are obtained. Method-A which is known as uniform ratio, ‘k’ is determined by taking the smallest ratio of R/X from all the branches of network with 80% of current at nominal voltage at fault location is only included. In method-B which is otherwise called as ratio at short circuit location, the value of ‘k’ is obtained by multiplying with a safety factor of 1.15 to account the inaccuracies in the calculation. In method-C which is known as equivalent frequency method, the value of ‘k’ is obtained by using the frequency altered R/X. Here in this method, R/X is calculated at lower frequency and it is multiplied by a frequency dependent multiplying factor. Method C used for the calculation purpose in this paper.

The IEC standard defines the voltage of equivalent source with adjustment provided by the use of voltage factor “c” depending on the network nominal system voltage. For the purpose of calculation, this factor can be considered in accordance with Table I.

In calculations the initial symmetrical short-circuit current I_k'' (defined as the rms value of the periodic component of the short-circuit current at time t = 0 is determined from the following equation:

$$I_k'' = \frac{C.U_n}{\sqrt{3}.\sqrt{x^2 + r^2}}$$

Table I. Values of Voltage Factors Recommended

Nominal voltage Un	Voltage factor c for calculation	
	maximum short-circuit current	minimum short-circuit current
Low voltage: 100 V to 1000 V	1.05 1.10	0.95 0.90
Medium voltage: Upto 35kV	1.1	1
High voltage: >35 kV	1.1	1

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Where C = voltage factor (Table I), U_n= nominal voltage of the network where the assumed for calculation short-circuit has occurred, r= short-circuit resistance, x = short circuit reactance.

Peak short-circuit current I_P, that is the largest instantaneous value of short-circuit current is calculated from the equation

$$I_P = \sqrt{2}.k.I_K''$$

Where k=factor for the calculation of the peak short-circuit current. Factor k can be calculated from the equation or read from the graph k = f(X/R), contained in IEC 60909.

The symmetrical short-circuit breaking current is the rms value of the short-circuit current at the instant of contact separation of the disconnecting device

Calculation of symmetrical short-circuit breaking current requires a distinction of the type of short circuit. The symmetrical short-circuit breaking current from the induction motor is calculated from

$$I_{bM} = \mu_M.q.I''_{kM}$$

It is possible to determine the q and μ_M factor by reading its value from a graph or by calculation using the equations contained in IEC 60909.

IV. ANSI STANDARD (C37)

The short circuit current calculations based on the ANSI standard has been performed in three different networks namely ½ cycle, 1 ½ to 4 cycle and 30 cycle. In ½ cycle network, the sub-transient reactance of the network components is used to calculate the fault current and the corresponding network is called as sub-transient network. Here, the momentary short circuit current is calculated after ½ cycle of the fault occurrence. In 1 ½ to 4 cycle network, the transient reactance of the network components is used to calculate the fault current and the corresponding network is called as transient network. In this network, the interrupting short circuit current is calculated after 4 cycles of the fault occurrence. In 30 cycle network, the steady state reactance of the network components is used to calculate the fault current and it is used to calculate the steady state short circuit current.

In ANSI C37, the equivalent of the initial symmetrical short circuit current I_k" is the so called first cycle duty and is calculated as

$$I_{\_sym}=E/X$$

Where E – rms (nominal) value of line-to-neutral voltage,
X – Circuit reactance value at the time of short-circuit
The equivalent of the peak short-circuit current I peak in ANSI C37 is the peak current ($I_{\_(Peak)}$) defined as

$$I_{\_(Peak)} = \sqrt{2}.\ I_{\_sym}(1+e^{\wedge\ (-2\pi ft/\ ((x/r))})$$

Estimation of the peak current value is done in two stages. The first step is to determine the value of the relative time (it will be always be a little less than half of the cycle), and the next one is to calculate the value of peak current. The factor e^ (-(r/L) t) occurring in the equation (independent of frequency) describing the process of disappearance of the periodic component, contains inductance L as L=x/ω=x .t / (2π), and time t as a multiple of the network cycle, that is t = N×T where T is the length of the network's cycle. This leads to e^ (-2πR/ ((x.T)) NT) =e^ (-2πN/ ((x/r))) that is the result which is independent of frequency. Of course, the ratio x/r must be set at the frequency for which the calculation is carried out, that is, in the actual case, of 50 Hz.

ANSI 1 ½- 4 cycles calculation is used for selection of MV interrupting current and ½ cycle for LV and asymmetrical fault.ANSI and IEC methods of X/R calculation is different .To determine the ratio X/R ANSI C37 recommends the separate setting of equivalent networks reactance (while omitting all the equivalent resistances of individual elements of the network), and assigning equivalent network's resistance while omitting all reactance. This avoids the calculations using complex numbers and it is justified by the fact that in any case the time-consuming calculation of the

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resultant short-circuit impedance does not lead to the correct value of the X/R ratio, since in a network supplied from several sources, each source branch is characterized by a distinct value of the time constant of decay of a periodic component, while the simplified method ensures that the resulting peak current values are not lower than the real ones, or provides sufficient accuracy for the proper selection of switchgear.

When calculating the current values of the first cycle in medium voltage networks, it takes into account only the reactance of individual network elements, while considering both reactance and resistance is recommended for low voltage networks. The ANSI/IEEE standards do not provide for the use of the factors correcting impedance of transformers. But there should be applied appropriate (separate for ½ cycle current and breaking current) reactance multipliers for synchronous motors and induction machines (Table II).Supply network impedance is determined for the value c = 1. Equipment rating in ANSImethoddepends on 30 cycles fault current calculation while IEC it is to be rated for initial symmetrical short-circuit current (I_k”).

Table II. Values of reactance multipliers to calculate the current of the ½ Cycle & breaking current

Criterion	**Multipliers for ½ cycle duty**	**Multipliers for the breaking current**
Synchronous machines		
Generators /synchronous motors	1.0	1.5
Induction machines		
>185 kW to 750kW @3600 rpm & >750kW @1800rpm	1.0	1.5
≥ 37kW	1.2	3
< 37kW	∞	∞

V. RESULT AND DISCUSSION

To illustrate the differences in the calculation of the short-circuit current according to IEC and on the other hand ANSI/IEEE standards, calculations of characteristic short-circuit currents, necessary for the selection of sample power system were conducted. Diagram of electric power network under consideration (with the rating of the individual elements, used to calculate the impedance) is shown in Fig. 1

The power distribution system consists of one 6.3kV power distribution board which is feeding the 6 kV induction motors and LV Distribution through the 6.3/ 0.415kV Power distribution transformers of 2.5 MVA.

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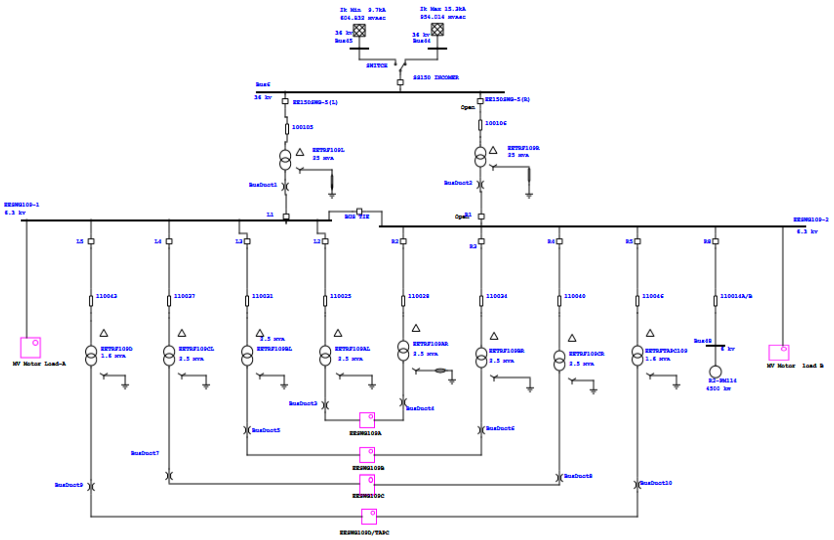
Fig. 1 ETAP Single line diagram of an Industrial network



The simulation results of short circuit current at different bus levels are as mentioned in below table III.

Table III-The calculations results of maximum short circuit currents in the example shown on fig.1

	According to IEC standard			**According to ANSI/IEEE standards**		
Fault location	I''_k	I_p	I_k	½ cycle	4 cycle	30 cycle
	Values in kA			Values in kA		
Motor Terminal	29.5	67.9	22.9	27.35	24.53	21.44
Fault kA at 6.3kV	33.4	80.7	25.7	30.77	27.52	24.14

VI.CONCLUSION

Comparative analysis of the calculation results point to the fact that the calculation of all the currents according to ANSI C37 lead to results lower by about 10 % from the results of calculations carried out according to IEC60909. This is mostly related to the use of the c factor stipulated in IEC 60909, which is not used according to ANSI C37, however equipment selection is based on ANSI or IEC as per the project location and standards applicable.Due to the economic aspects of switchgear selection and ensuring safety requirements concerning continuity of supply, the problem of calculating the short-circuit currents is of particular importance. Generally IEC is more conservative calculation and leads to higher values of Short circuit. However there is possibility of getting higher short circuit values with ANSI method compared to IEC method depending on system X/R. The ANSI multiplying factor changes with breaker interrupting cycles from 1 ½-4 cycles and may lead to higher breaking current.

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REFERENCES

[1] IEC 60909-0, Short-Circuit Currents in Three-Phase AC Systems Part 0: Calculation of currents. 2016.

[2] ANSI/IEEE Std. C37.010, IEEE Application Guide for AC High Voltage Circuit Breakers Rated on a Symmetrical Current Basis 2016.

[3] ANSI/IEEE Std 141, IEEE Recommended Practice for Electric Power Distribution for Industrial Plants (Red Book).

[4] ANSI/IEEE Std 399, IEEE Recommended Practice for Industrial and Commercial Power Systems Analysis (Brown Book).