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Methods for Short Circuit Analysis in ANSI and IEC Standards

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ABSTRACT: As industry expands, so does the complexity of the power system network. It is vulnerable to a variety of disruptions and requires immediate attention. In terms of both economic and safety considerations, the proper method for calculating short-circuit currents is critical. Using the Electrical Transient Analyzer Program (ETAP) software, a short-circuit investigation of a typical power distribution system in an industrial site is conducted. Investigations are made into various techniques of calculating fault currents in the system. According to IEC and ANSI/IEEE standards, this study shows the most significant correlations between the typical magnitudes of short-circuit currents. On the basis of a typical MV Industrial network, this comparison has been made.

KEYWORDS: Short circuit Calculations, IEC60909, ANSI C37.

I. INTRODUCTION

Because of the intricate electromagnetic and thermal mechanisms that lead to short circuits in electrical systems, transients and electrodynamic forces are generated in those systems. Considering both the technical and economic implications of a short circuit is critical when sizing equipment. This has to deal with the costs of switching, measuring, and safeguarding the components of the power system. As a result, it is necessary to develop methods that are easy to follow and accurate enough for specific goals. These methods are included in the standard recommendations that have been developed over many years in several countries. The VDE0102 standard was the first of its kind to be introduced in Germany in 1929.

As a starting point, there are various standards for calculating short-circuit current, with the oldest one being the most fundamental and the others being its variations and expansions.

As of right now, the most often used standard is the IEC 60909 one. The IEC standard covers both the maximum and minimum values of short-circuit currents. Simply short-circuit currents required for switchgear selection are included in the American standard because they are only a subset of a wider standard outlining the parameters and requirements for medium-voltage switchgear.

IEC minimal fault and ANSI 30 cycle calculation are two methodologies for relay coordination. This paper shows an example of a calculation on an MV Industrial network. Analyzing the differences between two approaches might shed light on the implications of those discrepancies for our conclusions when we apply various calculating techniques. To find out more about this, we've conducted this investigation. Only willingly used copies of the European and American versions are allowed to be used (in the U.S. standard defined as IEEE Recommended Practice).

Power system components, such as transformers and cables, must be able to withstand a short circuit current at fault. Insulation and protective systems must be designed to account for the short circuit current that occurs during a fault. A short circuit can cause electrical insulation to suffer from structural, mechanical, and thermal stresses.

II. SHORT CIRCUIT ANALYSIS

One of the most common causes of a short circuit is the failure of electrical insulation, as well as human mistake and other factors. As a result, the fault current becomes extremely enormous, far exceeding the whole load current. When a short circuit occurs, the impedance of the interconnecting circuits determines how much current can flow. Shock and fire hazards are all possibilities when there is a short circuit in a power supply or other electrical system. Protection devices are selected and coordinated based on short circuit analysis results.

ANSI C-37 and IEC 60909 standards are used to examine the average plant's short circuit characteristics in ETAP in this article. This section explains the short circuit current calculations in more depth. IEC uses current-based calculations, while ANSI uses impedance-based calculations.

III. IEC STANDARD (IEC60909)

The short circuit performance of a typical plant is being examined using IEC 60909. Initial symmetrical current is calculated according to IEC 60909 standard utilizing nominal voltage, voltage factor (C), and the equivalent impedance at the fault location as well as IEC 60909's voltage factor.

Method A, Method B, and Method C are utilized to determine the peak current magnitudes. It's called "k" and it's determined by taking the smallest ratio of R/X from the entire network, but only if 80 percent of the current at the fault point is included. Using method-B, known as the ratio at short circuit position, the value of "k" is derived by multiplying with a safety factor of 1.15 to account for the aforementioned errors. Approach-C, known as the equivalent frequency method, uses the frequency altered R/X to calculate the value of "k." R/X is calculated at a lower frequency and then multiplied by a frequency-dependent multiplying factor in this method. Method C was utilized in this paper to perform the calculations.

Equivalent source voltages are defined by the IEC standard using the voltage factor "c" in relation to the network's rated voltage. According to Table I, this component can be taken into account when calculating.

This equation yields the rms value of the periodic component of the short-circuit current at time t = 0, which is used in calculations to estimate the initial symmetrical short-circuit current I_k:

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

Table I. Values of Voltage Factors Recommended

Nominal voltage Un	Voltage factor cfor 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

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

Peak short-circuit current IP, 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 readfrom the graph k = f(X/R), contained in IEC 60909.

Symmetric short-circuit breaking current is the average short-circuit current, rms, when the disconnecting device separates from a short-circuited source.

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

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

A graph or a computation utilizing the equations in IEC 60909 can be used to determine the q and M factors.

IV. ANSI STANDARD (C37)

It was decided to use three distinct networks in order to conduct the ANSI-required short circuit current calculations. The fault current is calculated in a 12 cycle network using the sub-transient reactance of the network components, and the resulting network is known as a sub-transient network. Momentary short circuit current is calculated after the first half of a cycle of the fault incidence, in this example The fault current is calculated using the transient reactance of network components in a 1 12 to 4-cycle network, and this network is known as a transient network. Short-circuit current is computed after four cycles of the fault occurrence in this network The fault current and the steady state short circuit current in a 30-cycle network are both calculated using the network components' steady state reactance.

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-circuits current I peak in ANSI C37 is the peak current ($I_{\_ (Peak)}$) defined as

I_ (Peak) =√2. I_sym(1+e^ $^{(-2\pi ft/ ((x/r))}$))

There are two stages to estimating the maximum current. In order to compute peak current, you first need to know the value of the relative time (it will always be a little less than half of the cycle). An inductance of L=x/t / (2) and a time constant, t, are included in the equation (independent of frequency) that describes the disappearance of the periodic component in the equation (x/t) = t = N/T where T is the duration of the network cycle. E (-2R/(x.T)NT) =e+2N/(x-R), which is independent of frequency, is the outcome. It's obvious that the ratio x/r must be set at the frequency of 50 Hz, which is the frequency of the calculation.

When selecting interrupting current for asymmetrical faults, the ANSI 1 12- 4 cycles calculation is applied.

Methods used by the ANSI and IEC to calculate X/R are different.

Reactance and resistance should be set separately in order to calculate the X/R ratio, according to ANSI C37, although all reactance should be omitted from this calculation. This method is recommended by ANSI C37. Because each branch of a network supplied from multiple sources has a unique value of the time constant of decay of a periodic component, the complicated calculation of the resulting short-circuit impedance does not yield the correct X/R ratio. However, the simplified method ensures that the peak current produced by the network is constant.

Only the reactance of individual network parts is taken into account when computing the first cycle's current values in medium voltage networks, but both reactance and resistance are advised in low voltage ones. Transformer impedance correction factors are not included in the ANSI/IEEE standards. Reactance multipliers for synchronous and induction motors, on the other hand, need to be used appropriately (separate for 12 cycle current and breaking current) (Table II). Assuming c = 1, the supply network impedance is calculated. The ANSI approach uses a 30-cycle fault current computation to determine equipment rating, whereas IEC uses an initial symmetrical short-circuit current (Ik").) to determine equipment rating.

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

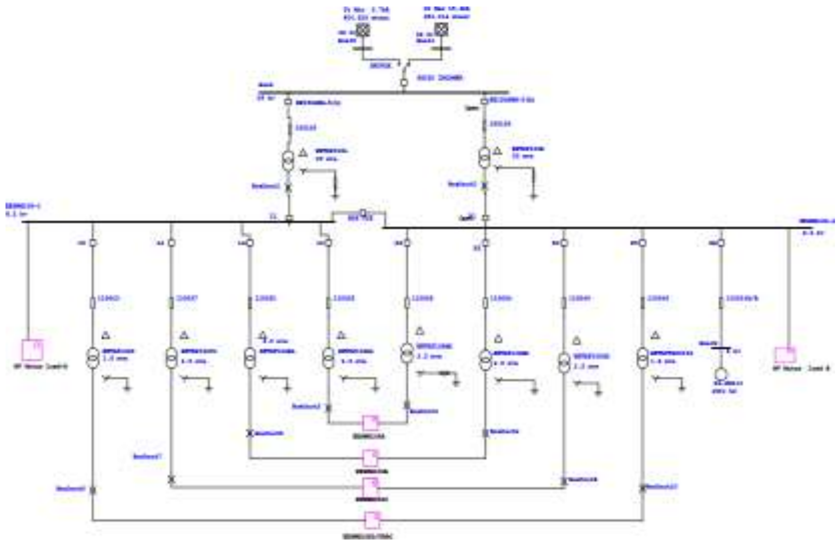

Fig. 1 ETAP Single line diagram of an Industrial network

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.

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

Analyzing all currents using ANSI C37 resulted in lower results by roughly 10% compared to results based on IEC60909 calculations. According to IEC 60909, which does not employ the "c factor" in ANSI C37, but the equipment selection process is based on IEC or ANSI depending on the region and standards that are relevant to the project. The problem of calculating short-circuit currents is particularly important because of the economic elements of switchgear selection and the assurance of safety standards for supply continuity. In general, IEC's calculations are more conservative, resulting in greater short circuit values. However, depending on the X/R system, it is possible to obtain larger short circuit values using the ANSI technique than the IEC way. From 1 12 to 4 cycles of breakers interrupting, the ANSI multiplier factor changes and may result in a larger breaking current.

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