

Simple Methods for Calculating Short Circuit Current Without a Computer

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A Short Circuit analysis is used to determine the magnitude of short circuit current the system is capable of producing and compares that magnitude with the interrupting rating of the overcurrent protective devices (OCPD). Since the interrupting ratings are based by the standards, the methods used in conducting a short circuit analysis must conform to the procedures which the standard making organizations specify for this purpose. In the United States, the American National Standards Institute (ANSI) publishes both the standards for equipment and the application guides, which describes the calculation methods.

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.

A device that interrupts short circuit current, is a device connected into an electric circuit to provide protection against excessive damage when a short circuit occurs. It provides this protection by automatically interrupting the large value of current flow, so the device should be rated to interrupt and stop the flow of fault current without damage to the overcurrent protection device. The OCPD will also provide automatic interruption of overload currents.

Listed here are reference values that will be needed in the calculation of fault current.

Impedance Values for Three phase transformers

HV Rating	2.4KV – 13.8KV	300 – 500KVA	Not less than 4.5%
HV Rating	2.4KV – 13.8KV	750 – 2500KVA	5.75%
General Purpose	less than 600V	15 – 1000KVA	3% to 5.75%

Reactance Values for Induction and Synchronous Machine

	X" Subtransient
Salient pole Gen 12 pole	0.16
14 pole	0.21
Synchronous motor 6 pole	0.15
8-14 pole	0.20
Induction motor above 600V	0.17
Induction motor below 600V	0.25

TRANSFORMER FAULT CURRENT

Calculating the Short Circuit Current when there is a Transformer in the circuit. Every transformer has “ %” impedance value stamped on the nameplate. Why is it stamped? It is stamped because it is a tested value after the transformer has been manufactured. The test is as follows: A voltmeter is connected to the primary of the transformer and the secondary 3-Phase windings are bolted together with an ampere meter to read the value of current flowing in the 3-Phase bolted fault on the secondary. The voltage is brought up in steps until the secondary full load current is reached on the ampere meter connected on the transformer secondary.

So what does this mean for a 1000KVA 13.8KV – 480Y/277V.

First you will need to know the transformer Full Load Amps

$$\text{Full Load Ampere} = \text{KVA} / 1.73 \times \text{L-L KV}$$

$$\text{FLA} = 1000 / 1.732 \times 0.48$$

$$\text{FLA} = 1,202.85$$

The 1000KVA 480V secondary full load ampere is 1,202A.

When the secondary ampere meter reads 1,202A and the primary Voltage Meter reads 793.5V. The percent of impedance value is $793.5 / 13800 = 0.0575$. Therefore;
 $\% Z = 0.0575 \times 100 = 5.75\%$

This shows that if there was a 3-Phase Bolted fault on the secondary of the transformer then the maximum fault current that could flow through the transformer would be the ratio of $100 / 5.75$ times the FLA of the transformer, or $17.39 \times \text{the FLA} = 20,903\text{A}$

Based on the infinite source method at the primary of the transformer. A quick calculation for the Maximum Fault Current at the transformer secondary terminals is
 $FC = FLA / \%PU Z \quad FC = 1202 / 0.0575 = 20,904A$

This quick calculation can help you determine the fault current on the secondary of a transformer for the purpose of selecting the correct overcurrent protective devices that can interrupt the available fault current. The main breaker that is to be installed in the circuit on the secondary of the transformer has to have a KA Interrupting Rating greater than 21,000A. Be aware that feeder breakers should include the estimated motor contribution too. If the actual connected motors are not known, then assume the contribution to be 4 x FLA of the transformer. Therefore, in this case the feeders would be sized at $20.904 + (4 \times 1202 = 25,712 \text{ Amps})$

GENERATOR FAULT CURRENT

Generator fault current differs from a Transformer. Below, we will walk through a 1000KVA example.

800KW 0.8% PF 1000KVA 480V 1,202FLA

$$KVA = KW / PF$$

$$KVA = 800 / .8$$

$$KVA = 1000$$

$$FLA = KVA / 1.732 \times L-L \text{ Volts}$$

$$FLA = 1000 / 1.732 \times 0.48$$

$$FLA = 1,202$$

(As listed in the table for generator subtransient X'' values is 0.16)

$$FC = FLA / X''$$

$$FC = 1202 / 0.16$$

$$FC = 7,513A$$

So, the fault current of a 1000KVA Generator is a lot less than a 1000KVA transformer. The reason is the impedance value at the transformer and Generator reactance values are very different. Transformer 5.75% vs. a Generator 16%

SYSTEM FAULT CURRENT

Below is a quick way to get a MVA calculated value. 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.

Utility MVA at the Primary of the Transformer

$$MVAsc = 500MVA$$

Transformer Data

$$13.8KV - 480Y/277V$$

$$1000KVA Transformer \quad Z = 5.75\%$$

MVA Value

$$1000KVA / 1000 = 1 MVA$$

$$MVA Value = 1MVA / Z_{pu} = 1MVA / .0575 = 17.39 MVA$$

Use the admittance method to calculate Fault Current

$$1 / \text{Utility MVA} + 1 / \text{Trans MVA} = 1 / MVAsc$$

$$1 / 500 + 1 / 17.39 = 1 / MVAsc$$

$$0.002 + 0.06 = 1 / MVAsc$$

$$MVAsc = 1 / (0.002 + 0.06)$$

$$MVAsc = 16.129$$

$$FC \text{ at } 480V = MVAsc / (1.73 \times 0.48)$$

$$FC = 16.129 / 0.8304$$

$$FC = 19.423KA$$

$$FC = 19,423 A$$

The 480V Fault Current Value at the secondary of the 1000KVA transformer based on an Infinite Utility Source at the Primary of the transformer as calculated in the Transformer Fault Current section in this article is 20,904A

The 480V Fault Current Value at the secondary of the 1000KVA transformer based on a 500MVA Utility Source at the Primary of the transformer as calculated in the System Fault Current section in this article is 19,432A

The 480V Fault Current Value at the secondary of the 1000KVA transformer based on a 250MVA Utility Source at the Primary of the transformer the calculated value is 18,790A

When the cable and its length is added to the circuit the fault current in a 480V system will decrease to a smaller value. To add cable into your calculation use the formula. Cable MVA Value $MVA_{sc} = KV^2 / Z \text{ cable}$. Use the cable X & R values to calculate the Z value then add to the Admittance calculation as shown in this article.

The conclusion is that you need to know the fault current value in a system to select and install the correct Overcurrent Protective Devices (OCPD). The available FC will be reduced as shown in the calculations when the fault current value at the primary of the transformer is reduced. If the infinite method is applied when calculating fault current and 4 x FLA is added for motor contributions, then the fault current value that is obtained will be very conservative. This means the calculated value in reality will never be reached, so you reduce any potential overcurrent protection device failures due to fault current.