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Review On Controlling and Minimize of Three Phase Transformer Inrush Current

Vijay Maind[1],S.H.Thakare[2],Y.P.Sushir[3].
[1]*PG Student ,Electrical department, Dr.V.B.Kolte Collage of Engineering Malkapur, Maharashtra, India.*
[2,3] *Professor ,Electrical department, Dr.V.B.Kolte Collage of Engineering Malkapur, Maharashtra, India.*

ABSTRACT

In power system transformer is main component. When the transformer is magnetized with no load or light load, the primary winding draws a high or maximum current in which it has a rich second harmonic. This presenting current magnetizes the inrush current and can increase two to ten times the normal current, the effect of the inrush current in the transformer core is deeply saturated, thereby reducing the service life, significant voltage drop, insulation weakens the electrical and mechanical vibration in the coil, the protection relay fails and the fuse element melts. Any factor related to the problem of poor transmission power quality, sensitive electrical equipment such as computers and medical equipment connected to the system. Therefore, minimizing and controlling the transformer inrush current has become one of the most challenging task for the power industry. Some of the methods are discussed like point on wave switching, source resistance, pre-fluxing method has described this paper.

Keyword: - Power transformer, point on wave switching, source resistance, Inrush current, residual flux

1. INTRODUCTION: -

Transformer is a static device. It is used to step up voltage to transmit the power at high voltage level, to minimize the transmission line losses and improve the efficiency of the transmission line. For distribution line, it step down voltage to get the voltage at distribution level [1-2]. So, they need stability, security and protection of transformer are necessary and important to the power quality. The differential protection relay, which is the conventional protection system in large transformers, does not work correctly during the magnetizing condition.

M.Steurer examined the effect of the inrush current on the transformer winding and his result shows that the peak inrush current of 70% is equal to that of a short circuit [3] The phenomenon is generally observed when connecting a transformer with a light load at the power supply. When the transformer is energized, a transient current of 5 to 6 times the rated current flows for several cycles. The effect of the inrush current has transformer protection devices, which generally reduce the quality of the power system. The mechanical structures of the transformer can be destroyed due to the increased magnetic forces caused by the inrush current. In the worst case, activation occurs when the primary winding is connected in an instant around the zero crossing of the primary voltage. During such a start, the core will be saturated. When a power transformer is turned on from the primary side, keeping the secondary winding of the transformer circuit open, it acts as a simple inductance. If the transformer is turned on at the instant of zero voltage, the flux wave starts from the same origin as the voltage waveform, the flux value at the end of the first half cycle of the voltage waveform will be double the flux peak. The transformer core is generally saturated just above the maximum steady state flux value. When turning on the transformer, the maximum flux value will jump to twice its maximum steady state value. Since, after the maximum steady state flux value, the core becomes saturated, the current required to produce the rest of the flux will be very high. Therefore, the primary of the transformer will draw a very high peak current from the source which is called magnetizing inrush current in the transformer or simply inrush current in the transformer. Although the magnitude of the inrush current is very high, it generally does not create any permanent failure in the transformer, as it exists for a very short time. However, the inrush current in the power transformer is a problem. Therefore, the inrush current can be limited by controlled switching, which requires an additional control circuit. The method of controlling the firing angle never works in practice due to uncertainties such as the parameters of the spring and the flux remaining in the switch and the phase of the source that supplies power to the switch coil, among others. In this way inrush current reduction is over [5].

1.2 Impact of magnetizing inrush current in transformer [2].

1) The Impact of a transformer is reduced due to the increase of iron losses with the increased inrush current.
2) The increase of the temperature of the iron core which become dangerous to the lamination's insulation's.
3) Transformer inrush current causes electrical and mechanical vibrations in coil, reduced life-span.
4) Mis-operation of the protective relays and melting of fuse elements.
5) Circuit breakers and fuses over sizing due to inrush current.

2. THE FACTOR AFFECTING ON THE VALUE OF INRUSH CURRENT:-

There are following factor which affect the inrush current value. Every factor has been observed in different previous works, while in the present work more than one factor will be examined and compared.

2.1 **Series resistance: -**

In this case, the resistance available between the transformer and the source, affects the inrush current. If the line resistance between the transformer and the source is maximum, it will minimize the inrush current and increase the decay rate, so the transformer located near the generator has the maximum inrush current because the line resistance between the transformer and the generators is minimum [2]..

2.2 **Switching angle**: -

This study observed that, when minimizing the flux will minimize the inrush current. Switch closing at peak voltage (i.e., 90 degree) will minimize the transient flux generated by the transformer, this will result into reduction of transient inrush current to a value from its initial value. [4]

2.3 **Inrush current under load: -**

When transformer is magnetized, with connecting a load on its secondary, inrush current effects on the value of load power factor. If the value of power factor of the transformer is a unit and under heavy load, the maximum value of inrush current is low. When power factor is reduced, the value of inrush currents will increase [2].

2.4 Residual flux density: -

The transformer made from ferromagnetic material. Because of hysteresis effect residual flux will present in it. Residual fluxes are the main cause of inrush current and depend on core material characteristics [2]

3.FLUX AND INRUSH CURRENT RELATIONSHIP : -

The appearance of the discharged current when energizing a transformer, both from steady state or for the transient state and its relationship with the waveform of the magnetic flux. It is an evidence of the existence of a residual flux value at the moment of the excitation of the transformer leads to a peak current (its values can be 10 times higher than the rated current), on the other hand (steady state), i.e. when the transformer is excited without the appearance of this transient current, there is only the magnetizing current.

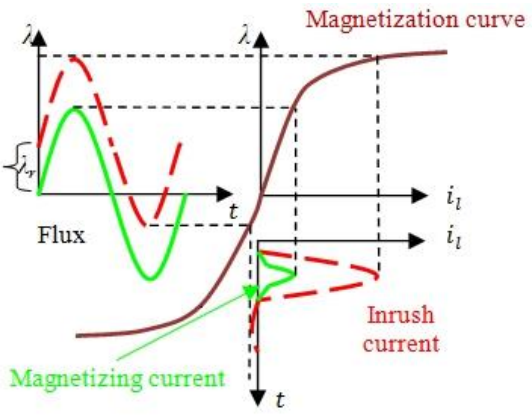

Fig-1: Flux Vs Magnetizing current of unloaded transformer (transient and steady state)

4.DIFFRENT TECHNIQUES AND STUDIES FOR MINIMIZE INRUSH CURRENT :

There are three different methods and techniques to reduce the magnetizing inrush current in three phase power transformer, they are as follows.

4.1 Point on wave switching: -

Mitigation of inrush current during a transformer, using point on wave control is meant to energize the transformer at the optimal point on wave the voltage waveform, and its purpose is to minimize transformer transient inrush current at the time of starting. during a transformer circuit the voltage and current waveform are 90° apart from each other. Transformer current and flux are generally in phase so angle between current and flux is zero, voltage and flux are 90° apart also as shown in fig2[8].

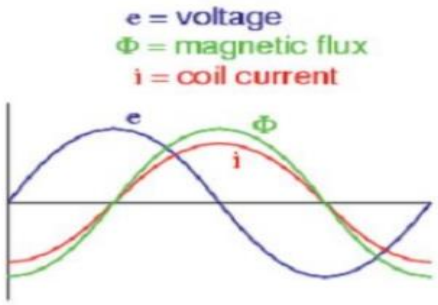

Fig-2: Voltage, current, flux waveform

Initial condition, if the switching angle is zero, at that moment the voltage waveform passes through the zero value. At now, the core flux reaches its maximum a value of 2Φnormal + Φresidual. That's the reason core of the transformer works at maximum flux is greater than 2 time higher than maximum normal core flux. Therefore, during this condition, the transformer absorbs the maximum current [2]. So that the changing firing switching angle from 0° to 45°, 90°, 145° various results are observed.

Case 1. switching angle 0° degree: - When transformer magnetized at 0° degree (for voltage wave) the value of flux and current is maximum.

Case 2. switching angle 90 degree: - When transformer magnetized at 90° degree (for voltage wave) the value of flux and current is minimum.

Analysis done on inrush current of three phase transformer using MATLAB as shown in fig. 3

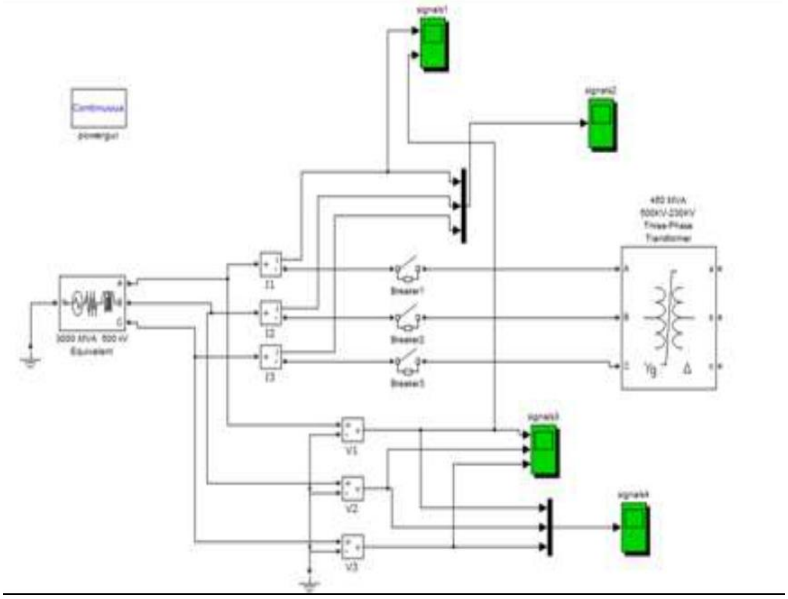

Fig- 3: MATLAB Simulink model using point on wave switching

4.2 impact of source resistance: -

The impact of source resistance Rs is increased by using different value, with consider the switching angle (θ) is 0°. The impact of source resistance has been considered by increasing Rt. It is observed that as source resistance increases the magnitude of inrush current decreases. Also, it causes faster decay in the magnitude of inrush current. [2]. Thus, it can be seen that transformers display higher amount of inrush current because of source resistance. So, transformer which are located nearer to the generating plants should have more inrush current than those who located away from generating plant. Figure (4) shows that source resistance increases using different value the magnitude of inrush current decreases and also leads to faster decay of amplitude in inrush current [6]

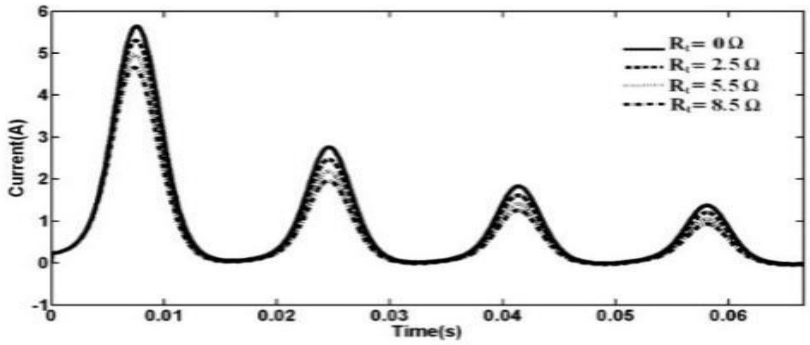

Fig-4: Effect of source resistance on the magnitude of inrush current

The effect of source resistance in the percentage of second harmonic has been shown in Fig. 5 The results show that the amount of percentage of second harmonic will be decreased by increasing the source resistance

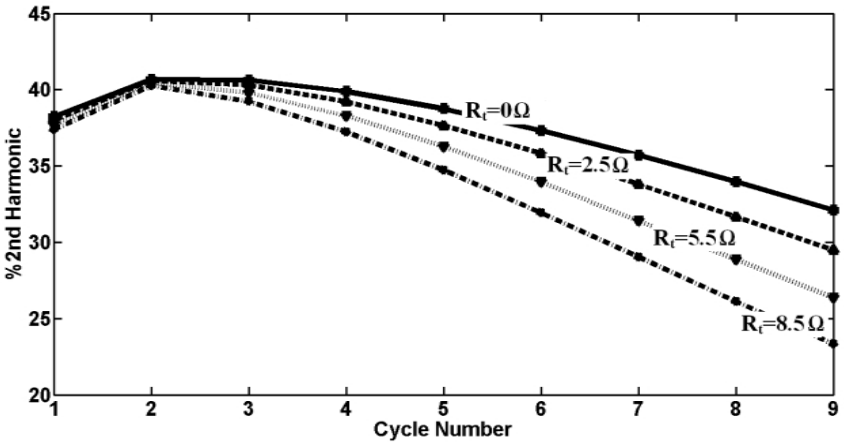

Fig-5: Effect of source resistance in the percentage second harmonic

4.3 Impact of pre-fluxing method: -

In pre-fluxing method, a pre-fluxing device is used to minimize the magnitude of the inrush current.This device consists of a capacitor, which is charged to a user-specified voltage and discharged into the transformer.During the discharge period, the switch must be closed. To reduce the magnitude of the inrush current, the residual flux of the transformer must be high. Figures 6 and 7show the pre-fluxing device and its connection on the primary side of the three-phase power transformer. The filter connected on the primary side blocks the harmonics present in the inrush current. This resulting current is also free of DC components, delaying the response of the protection system and causing the relay to mal-operation [3].

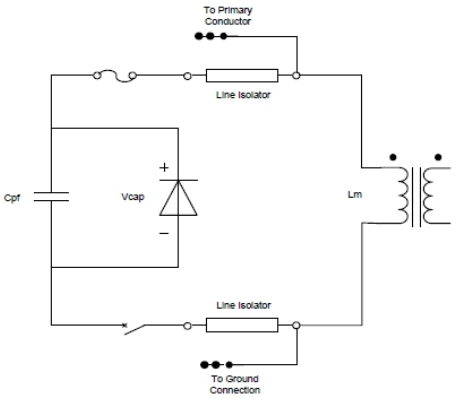

Fig-6: Pre fluxing circuit

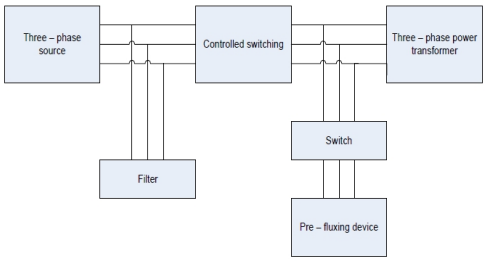

Fig -7: Pre-fluxing device at primary of power transformer

5. CONCLUSION:

This study described several methods of controlling and minimizing of the transformer inrush current. Which consists of point wave switching method which uses the technique of voltage and current wave relationship. While source resistance method uses the property of resistance which provides an opposition to current increment. Whereas with the application of pre- fluxing technique, the magnitude of inrush current is minimized considerable along with the elimination of DC component. Though above method are minimizing current successfully but due to some limitations and complication. further study is required to overcome these limitations as well as to provide a simple solution.

6. REFERENCES:-

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