

TO REDUCE THE MAGNETIC INRUSH CURRENT BY POINT WAVE SWITCHING METHOD

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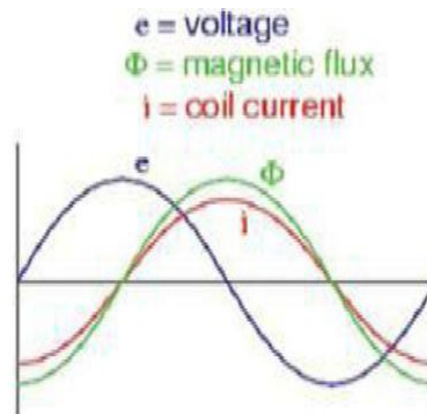
Abstract- In power transformer initially current is very high magnitude, which cause the produce the harmonics current and transformer core saturated during the period of initial current and initial current is known as magnetic inrush current. During this period loss of transformer life, protective devices, as well as power quality is reduce. So this initial current is reducing is very important, controlled transformer switching can provided to reduce the magnetic inrush current. This paper shows the practical consideration of elimination magnetic inrush current as well as experimental result of simulation and hardware of limiting the inrush current. In this paper use a thyristor to control the angle of voltage upto the eight to ten cycles. This paper shows the theory to explain and characteristics sequential phase enerization depend upon the magnetic inrush current scheme.

Index Term- Switching Devices, Thyristor, Optocoupler, Inrush Current, And Transformer.

I. INTRODUCTION

The essential components in a power system are the power transformer and their reliability is very important as well as maintains their power quality. When the transformer is energized, the transient current is drawn at the initial period. This current rise up to the ten cycles, and this current is 5 to 6 times more than the rated current. The inrush current has various effects on the protective devices; the mechanical structure of the transformer may be damage as well as power quality is reducing of the power system. The magnitude of magnetic inrush current is very large but it does not produce any permanent fault in power transformer as it remain exists for very short period of time. But still remain the magnetic inrush current in power transformer is a problem, because it disturb with the operation of circuits as they has been designed to function. Some effects of large magnetic inrush current include the protective device fuse or breaker detection as well as interruptions, arcing and failure of primary circuit components, such as switches. High magnetizing inrush current in transformer also necessitate over-sizing of fuses or breakers.

One of the phases switching point on wave control method is designed to energize the power transformer at the optimal point on the voltage waveform, and its intention is to reduce transformer at initial magnetic transient inrush at the time of energization. In a transformer the voltage and the current waveform are 90° apart from each other. Transformer current and flux are normally in phase with each other. So the voltage and current or flux are 90° apart as shown in Figure:1. Without using the switching the point wave method, energizing a transformer may produce the core saturation, the protective device should not operate at suitable time and place where, a small increase a magnetic flux which leads to a large increase in current as shown in Figure1



Flux and winding current at their negative peaks..

Figure 1: voltage, flux and current waveform

saturated, the current required to produce rest of flux will be very high. So transformer primary will draw a very high peaky current from the source which is called magnetizing inrush current in transformer or simply inrush current in transformer.

A. WHAT IS INRUSH CURRENT?

When an unloaded transformer is switched on to normal voltage on its primary side or when a short circuit occurs on its secondary side. The phenomenon pertaining to the switching on of an unloaded transformer is referred to as inrush phenomena. When the secondary side is open, the transformer takes only exciting (no load) current, from the supply mains. Since the magnetizing component of current, 90 degree lagging the applied voltage V_1 is much larger than the core loss component of current as shown in Figure 3. The transformers at no load behave almost like a simple inductive reactor. As a result of it, the primary induced emf is equal & opposite to the applied voltage if small leakage impedance drops at no load is neglected.

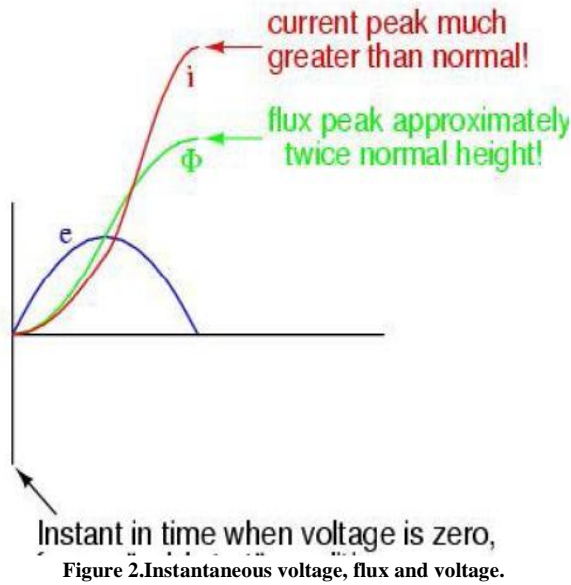


Figure 2. Instantaneous voltage, flux and current.

When a power transformer is switched on from primary side, keeping its secondary circuit open, it acts as a simple inductance. If the transformer is switched on at the instant of voltage zero, the flux wave is initiated from the same origin as voltage waveform; the value of flux at the end of first half cycle of the voltage waveform will be twice the maximum flux. The transformer cores are generally saturated just above the maximum steady state value of flux. During switching on the transformer, the maximum value of flux will jump to double of its steady state maximum value. As, after steady state maximum value of flux, the core becomes

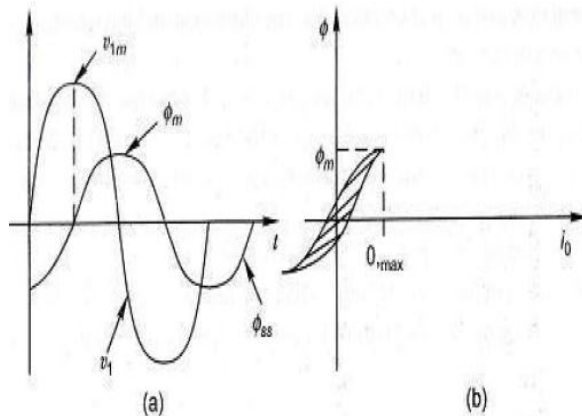


Figure 3: Core loss component of current or magnetic flux.

The severity of switching transient is related to instant when the voltage wave is switched on; the worst conditions being when applied voltage has zero value at instant of switching as shown in Figure 4. It is assumed that the steady state value of flux demand at this instant is $-\Phi_m$ while the flux can only start value (in the inductive circuit). As a consequent a transient flux component $\Phi_t = \Phi_m$ originates so that the resultant flux is $(\Phi_t + \Phi_{ss})$ which has zero value at the instant of switching.

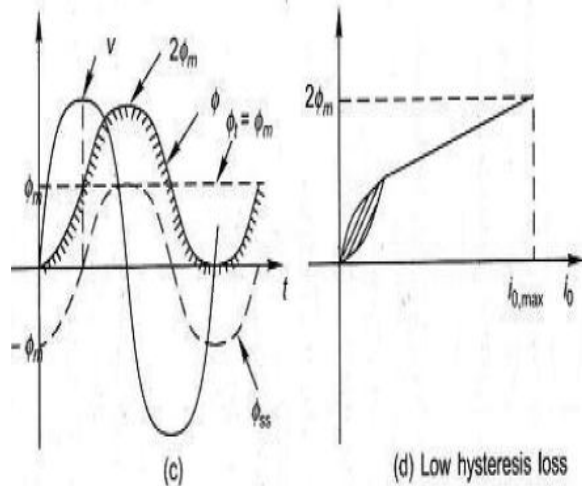


Figure 4: Voltage value at instant switching.

The transient component Φ_t will decay according to the circuit time constant (L/R) which is negligible, the flux transient will go through a maximum value of $2\Phi_m$ a phenomenon called doubling effect. The corresponding exciting current will be very large as the core goes into deep saturation region of magnetization ($B_m = 2 * 1.4 = 2.8T$); it may indeed be as 100 times the normal exciting current, i.e. 5pu (normal exciting being 0.05 pu) producing electromagnetic forces 25 times the normal. This is why windings of large transformer must be strongly braced. In subsequent half periods Φ_t gradually decays till it vanishes and the core flux acquires the steady-state value. Because of the low time constant of the transformer circuit, distortion effects of the transient may last several seconds. The transformer switching transient is referred to as the inrush current. The initial core flux will not be zero as assumed above but will have some residual value Φ_r . Because of retentivity, as shown in Figure the transient will now be even more severe, $\Phi_t = \Phi_m + \Phi_r$ And the core flux will now go through the maximum value of $(2\Phi_m + \Phi_r)$ as shown in Figure 5.

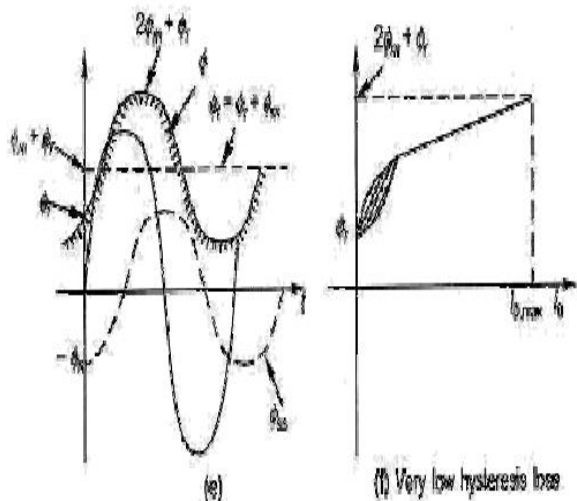


Figure 5: Instantaneous value of core flux

II. SIMULATION AND RESULT

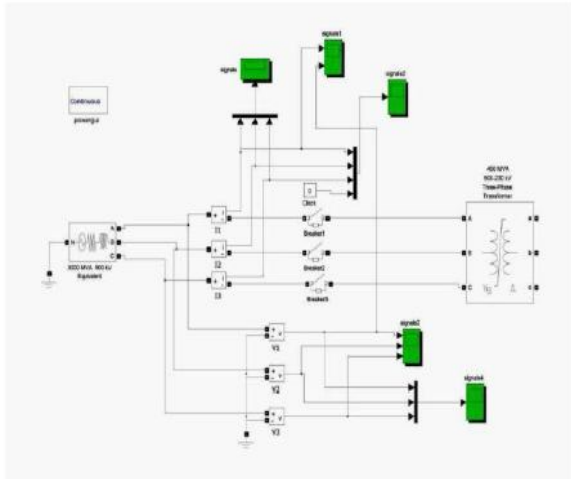


Figure 6: MATLAB Simulation of three phase magnetic inrush current.

The MATLAB simulation has been used to 1 KVA 240/110 VOLT transformer. For 50 Hz supply frequency Time duration for one cycle = 20 msec. Time duration for 50 cycle =1000 msec. Time duration for 0 to 90 degree= 5 msec.

For Y phase is 120 degree apart from the R phase, therefore $120+90=210$, and cycle passing through the 0 to 210 degree is 11.66msec. Next for B phase $240+90=330$ degree and cycle passing through 0 to 330 is 18.33 msec.

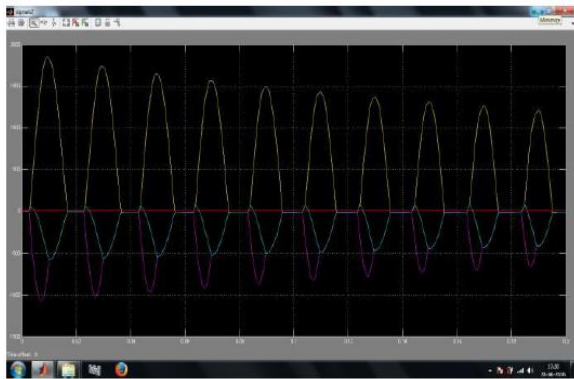


Figure 7: The magnetic inrush current at first ten cycle.

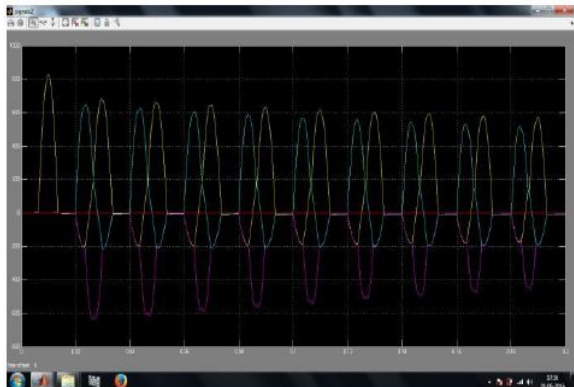


Figure 8: Reduction of magnetic inrush current up to the cycle.

III. HARDWARE MODEL

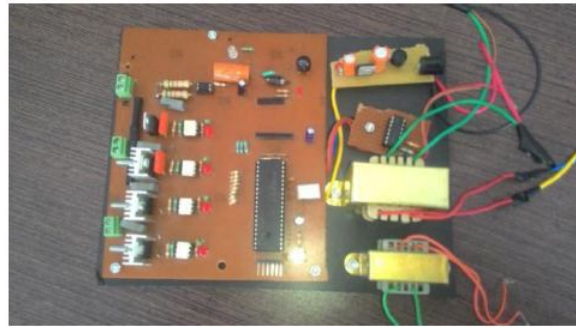


Figure 9: Connection of three phase transformer to the circuit.



Figure 10: The magnetic inrush current in the hardware on DSO display device

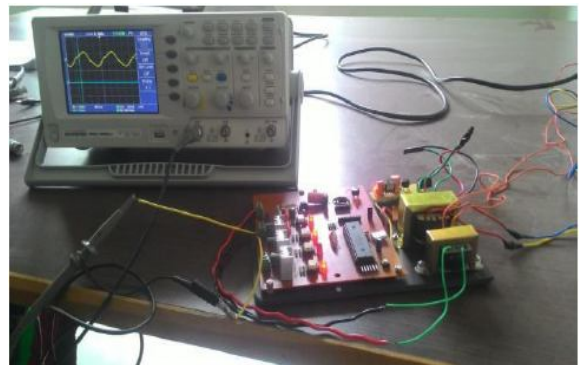


Figure 14: Magnetic inrush current reduce by point wave switching method result on DSO display device.

As shown in Figure the zero crossing detectors are used to control the phase angle of transformer. The zero crossing detector control phase angle between 0 to 90 degree. The microcontroller is used for control the thyristor angle, the triac is used for the short period of time for energization of a transformer. The power circuit is isolated from the microcontroller optocoupler is used; the triggering pulses are reach to the triac through an optocoupler. The separate switches are provided for the control the each phase as well as independent triac, optocoupler and zero crossing detector. The peak detector circuit detects the first peak cycle of the transformer and gives the signal to the microcontroller which controls the phase angle of triac by using the control the firing angle. The same procedure is followed for triggering the thyristor by other two phases. After controlling the

phase angle of triac magnetic inrush current is reduced and normal rated current in transformer.

when the firing angle is increase then magnetic inrush current is reduced.

TABLE 1: AVERAGE INRUSH CURRENT, AND TRANSFORMER VRMS AT DIFFERENT FIRING ANGLE DELAYS

Firing angle (Degree)	Avg. Line 1	Avg. Line2	Avg.Line3
	current (Ampere)	current (Ampere)	current (Ampere)
0	10.33	19.51	17.06
40	13.02	22.46	17.14
60	06.87	23.28	17.50
90	08.30	10.20	11.96

CONCLUSION

The magnetic inrush current is reducing by power transformer by using point wave switching method. Triac is used to control the phase of transformer,

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