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# Magnetic Inrush Current of Transformer Reduce By Point Wave Switching Method with MATLAB Simulation Results

Sachin R. Chavan [1], M. S. Potdar [2]
PG Student [1], Assistant Professor [2]
Dept. of Electrical Engineering, PES College of Engineering
Aurangabad (MS) - India

## ABSTRACT
At the time of transformer energization, a high current will be drawn by the transformer. This current is mentioned transient inrush current and it may rise to ten times the nominal full load current of transformer during operation .This current can produce mechanical stress to the transformer, causes protection system malfunction and it often affect the power system quality and may disrupt the operation of sensitive electrical loads such as computers and medical equipment connected to the system. Energization transients current reduce by use of point on wave switching at the time transformer is initially connected to supply. In this paper the simulations and the experimental results on a three-phase transformer for reduction of inrush currents. An electronic devices three-phase switching controller has been designed and some thyristors are used for switching power to the transformers**.** Reduction of magnetic inrush current and the way to control of energization transients currents have become important concerns to the power industry for engineers.
***Keywords:- (****Transformer current, magnetic inrush current)*

## I. INTRODUCTION
Inrush currents from transformer and reactor energization have always been a concern in power industry. Over the past several decades, a few methods have been proposed to limit the inrush currents. Representative examples point wave switching method and the pre insertion of series resistors. Two recent developments in power industry have reignited interests in finding better methods for controlling inrush currents. One of them is the deregulation of electricity market. More and more independent power producers and co-generators are taking advantage of the situation. Their proposed generators often need to have the generator transformers energized from the system side due to cost considerations. This results in the problem of large inrush currents being injected into the supply system. Another development is the increased awareness on power quality. The power quality consequences of inrush currents.

can be quite detrimental. Examples are motor tripping, relay disoperation and so on. There is still a need to find simpler and low cost schemes to limit the inrush currents. Independent power producers are especially interested in such techniques. The idea presented in this paper is by observation and research. In view of the fact that the inrush currents are always unbalanced among three phases, a neutral resistor could provide some damping to the currents. But this is the basis of the proposed idea. But this idea is not permanent and convenient The idea is further improved by introducing delayed energization of each phase of the transformer by point wave switching method. This improvement has made the proposed scheme almost as effective by point wave switching method the performance and characteristics of the proposed method have been investigated using simulations and experiments. Very encouraging results have been observed. This paper explains the proposed idea and presents its performance characteristics. The results are obtained from simulation and experimental studies.

## II. REASONS & EFFECT
When the transformer is charged, a transient current known as magnetizing inrush current (of magnitude as high as 10times of rated current) flows in to the system. This is due to the nonlinear relationship of flux and magnetizing current as transformer core is in saturation mode. It is not only the high magnitude of inrush current but its composition (rich in DC component and harmonics) and duration are also the cause of concern which severely affects the stability of the system. Factors contributing to the magnitude and duration of inrush current are Magnitude of residual flux in transformer core, Nonlinear magnetizing characteristic of transformer core, Magnitude of source voltage at the switching instant and Impedance and short circuit power of the source.

***The key adverse effects include-***

A. Mechanical and electrical stresses in windings:

The amplitude of inrush current can be equal to that of the short circuit current and may last longer depending on system configuration. This can seriously damage the windings through excessive mechanical stresses

B. Harmonic resonant over voltages:

Transformer inrush currents are rich in harmonics and in the event of resonance, a sustained Harmonic resonant over voltages may exist and if these over voltages last for a long period of time, they may eventually damage the equipment.

C. Mall operation of protective relays

D. Voltage dips:

Due to high magnitude and asymmetrical nature of inrush current a voltage dip is observed by the system. The magnitude, duration and unbalance of voltages in the respective phases are function of system impedance, source, transformer capacities etc

## III. PROPOSED SCHEME

When a transformer is energized, then depending on its switching at and high magnetic flux in the transformer core, it may produce a high transient magnetic inrush currents is produce which up to ten cycle times of its rated no-load current. The magnetizing inrush currents in power transformers can cause electromechanical shock on transformer bushings, core and windings, malfunctioning of protection systems fail and create saturation in the core severe power quality reduce problem created in the power transformer. The magnetic inrush currents in transformer may last in about 10 cycles. Energization magnetic current reduce the performance of a transformer. The design of a device to control in order to provide voltage delay angle controlled switching device to connect the rated voltage to transformer primary circuit at the starting current can be very effective. The point on wave control is designed to energize the transformer at the optimal point on wave the voltage waveform, and its intention is to reduce transformer transient inrush at the time of energization of starting current.

In a transformer circuit the voltage and the current waveform are 90° away apart from each other. Transformer current and flux are normally in phase so angle between current and flux is zero voltage and flux are 90° apart as well as shown in fig 1. Without point on wave Switching, magnetic inrush current a transformer may result in core saturation, power quality decrease where, a small increase of flux which leads to a large increase in current as shown in fig 2.

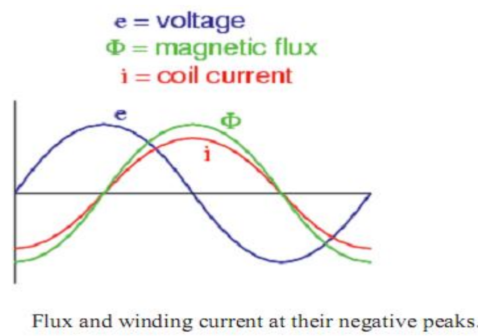


Fig 1: Voltage, current and flux waveform

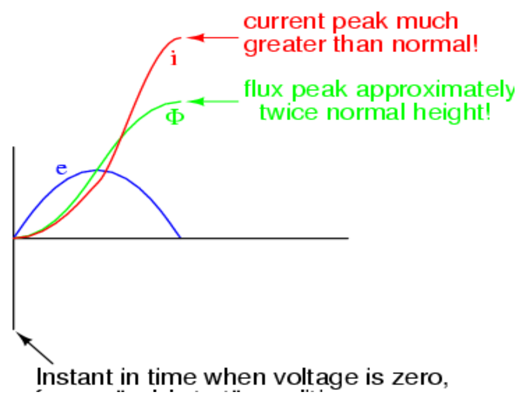


Fig 2: Transient magnetic inrush current

## IV. INRUSH CURRENT

The transient component Φt will be decay according to the circuit time constant (L/R) which is constant, the flux transient will through a maximum value of 2Φm So this phenomenon called as doubling effect. The corresponding exciting current is be very high as the core gets deep saturation region of magnetization (Bm=2*1.4=2.8T); which may indeed be as high the normal exciting current, (normal exciting current being 0.05 pu) producing electromagnetic forces 25 times the normal rated current. This is why windings of highly transformer strong braced.

$$\Phi t = (\Phi m + \Phi r) e\hat{}\left(-\frac{r1t}{L1}\right) - \Phi t \cos wt$$

At wt=$\pi$ from the instant of closing the switch equation becomes

$\Phi t = (\Phi m + \Phi r)\, e^{(-r1\pi / L1\omega)} - \Phi m \cos \pi$

Usually $\omega L1 >> \pi\, r1$, consequently $e^{(-r1\pi / L1\omega)}$ $[\omega t = \pi]$

In subsequent half periods Φt gradually decease till it reduces and the core flux requires the steady-state value. Because of the low time constant of the transformer circuit, distortion effects will be generated of the transient may last several seconds. The transformer switching transient pluses is referred to as the inrush current. The initial core flux is not be zero as assumed above but some residual flux value Φr. Because of retentivity, as shown in fig the transient will now be even more severe, resultan Φt= Φm+ Φr and the core flux will now go through the high value of (2 Φm+ Φr) as shown in fig 3.

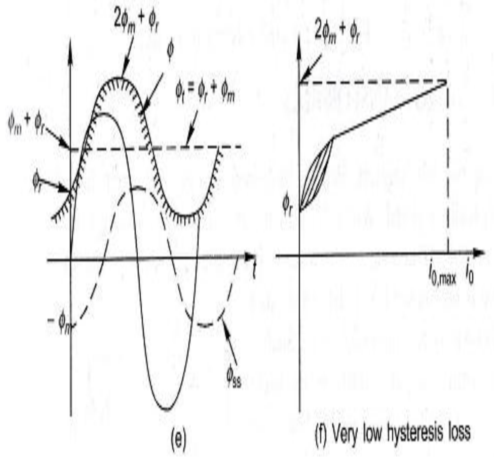


Fig 3: Magnetic inrush current

## V. CIRCUIT DESCRIPTION

An IC TCA785 as a zero crossing detector was used to control the phase shift of the thyristor at the angle between 0 degree to 90 degree. The angle of thyristor is reduce then magnetic inrush current is reduce. Tha angle of thyristor is depending on magnetic inrush current. The phase angle control, microcontroller, optcoupler, phase detector electronics devices are used to control the magnetic inrush current. The switched dinister diode thyristor devices are capable for switching current pulse. The principal of switched dinister diode thyristor operation are considering powerful control from blocking conducting state. During working of transformer high magnetic inrush current is rapidly am simultaneously filled by an electronic hole plasma. Fig 4 connection of magnetic inrush current with load Fig show the main circuit diagram, the primary of the transformer is connected to the point on wave switching circuit. In this circuit TRIAC is used to switching the cycle during the inrush current is drawn. The TRIAC first terminal is connected to supply side and second terminal is connected to the load side. The gate terminal of the TRIAC is connected to the optocoupler. The input of the optocoupler is the output of the peak detector circuit. The devices are used in each phase for controlling the magnetic inrush currentThe peak detector detect the first peak value and send the these signal to the optocoupler . The TRIAC fires to control the phase angle in between 0 to 90 degree. After closing the cycle the relay is operate to trip the Circuit

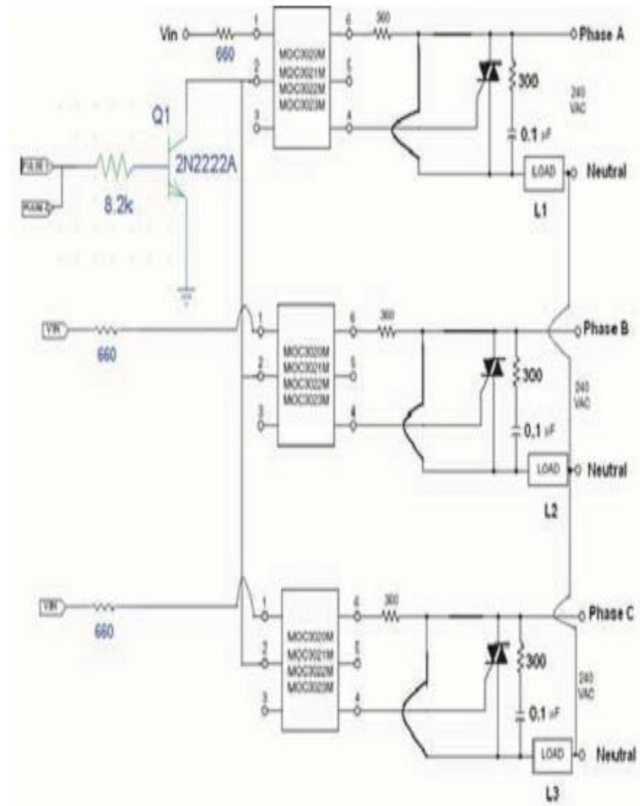


Fig 4: Circuit description

The magnetic inrush current is reduce 2 to 3 times which is before the 6 to 7 times full load current This occur due to magnetic circuit current lags by an angle.

## VI. SIMULATION RESULTS

Matlab simulink has been used to simulate inrush current of a three-phase, 450 kVA, 500kV/230kV, Grounded Y/D transformer, and the initial transformer fluxes have been considered. Magnetizing inrush current at these conditions was very high (up to 1800 Amps) as it is shown in Figure. To simulate reduction of current inrush, supply voltage for phase A was initially connected at zero degree waveform for this simulation. For 50 Hz supply we can write; Time duration for 50 cycles = 1,000 msec. Time duration for one cycle = 20 msec. Time duration for cycle passing from 0° to 90° = 5 msec. For circuit breakers closing time in sequence of ABC, firstly assume that we supply phase A at zero degree waveform as mentioned. Phase A will have its maximum voltage at 90° in 5 msec time. Next, phase B is connected 120° apart from phase A, therefore: 120° + 90° = 210°, and the time duration for the cycle passing from 0° to 210° = 11.666 msec. Next for phase C: 240°+90° = 330°, and time duration is 18.333 msec for cycle to pass from 0° to 330°. Following closing times of 5 msec, 11.666 msec, and 18.333 msec for circuit breakers of phase ABC, the reduction of inrush current was remarkable

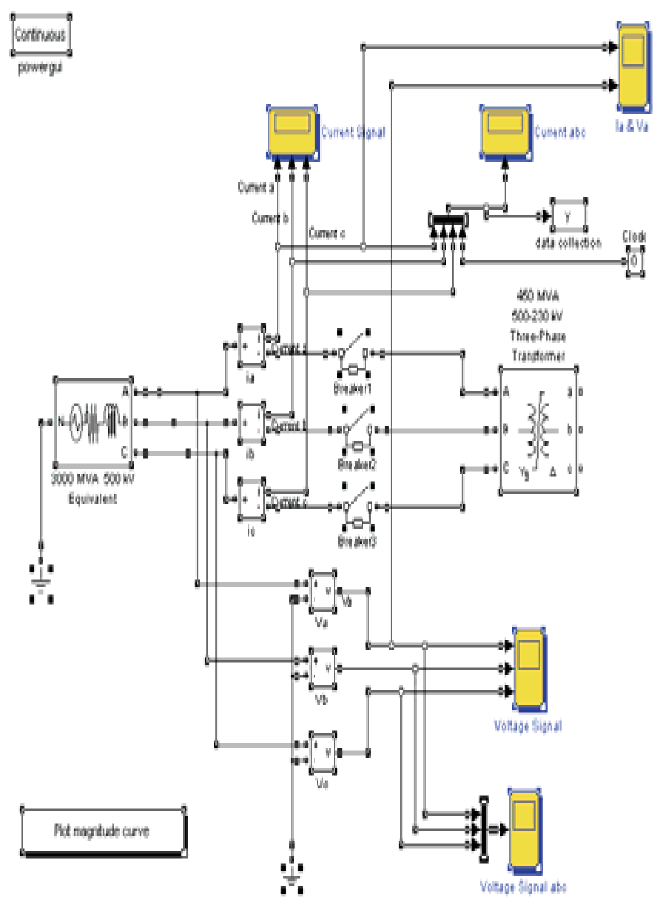


Fig 5: Reduce the magnetic inrush current

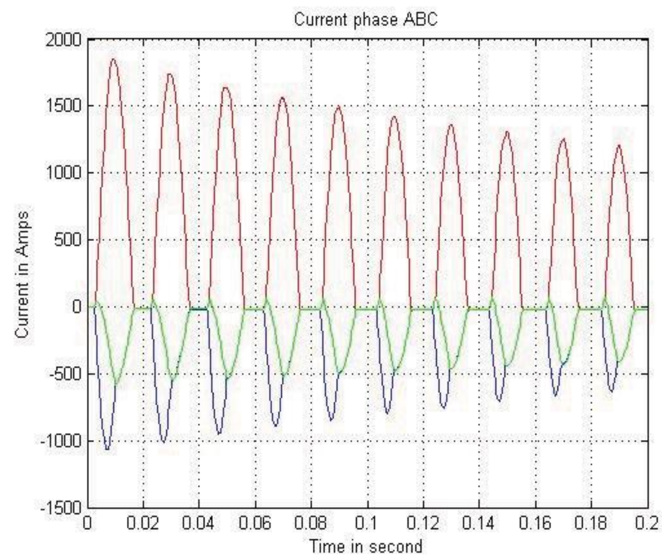


Figure 6: Current ABC at zero degree voltage applied

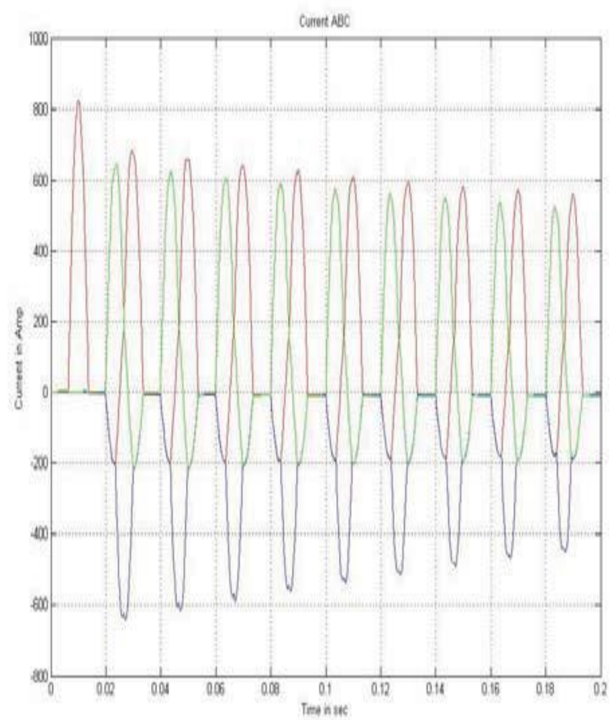


Figure 7: Reduction of inrush currents at sequential closing of CBs

## VII.CONCLUSION

Inrush current produced in single phase and three-phase Transformers can be controlled by long pulse duration due to lagging of current with respect to voltage. When the firing angle delay increases, the inrush current in the transformer is reduced. The deduction of inrush current at the higher angle waveform of applied voltage closer to 90 degrees was the most. This paper discuss on the reduce the magnetic inrush current by point on wave switching method. The magnetic inrush current is reducing using the delay angle of thyristor. The system performance is improved; saturation on the system is also reduced.

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