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Simulation and Analysis of Transformer Inrush Current and Reduction Technique

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***Abstract*—inrush current are high magnitude harmonic current generated when electrical device core are driven into saturation during starting. That high magnitude of current cause effect on device like a loss of life, relay mis-operation, power quality reduction, potential damage. This paper presents simulation of 450 MVA, 500/230 KV power transformer for analysis of inrush current. Inrush current is present in transformer as well as in motor in electrical devices. There are three type of inrush current energization inrush, recovery inrush, and sympatric inrush.**

***Index Terms*—inrush current, energization inrush, recovery inrush, sympatric inrush**

I. Introduction

Transformer is important component of power system, for transforming electrical energy between two or more circuits without changing frequency. Now in the starting of transformer, it is draw high current for establish magnetic flux which is called inrush current. That current contain high harmonics. Inrush current will occurs when unloaded transformer is energization, external fault occur in power system, recovery of voltage after clearing fault, out of phase synchronizing of generator. Inrush current also present in the fresh transformer. High magnitude of inrush is depends on turn ON point of voltage wave, when transformer is off after some operation or test then some amount of residual flux is present in the transformer core, the shape of saturation curve, normal flux density which is used for operation of particular transformer. There are three type of inrush current energization inrush current, recovery inrush current, sympatric inrush current. Energization inrush current is defined as the inrush occurs when transformer is switch ON, Recovery inrush is defined as the inrush occurs when transformer is switched ON after clearing the fault, sympatric inrush is defined as the inrush occurs when two transformer are connected in parallel and one transformer sense current due to second transformer energization.

There are different methods use for reducing transformer inrush current like neutral resister method, sequential phase energization method, control switching method, pre fluxing method.

I.INRUSH CURRENT

Energization inrush can produce in the large current magnitudes and is the most commonly researched form of inrush. . Fig 1 shows that in the steady state flux in a transformer lags the applied voltage by 90˚.

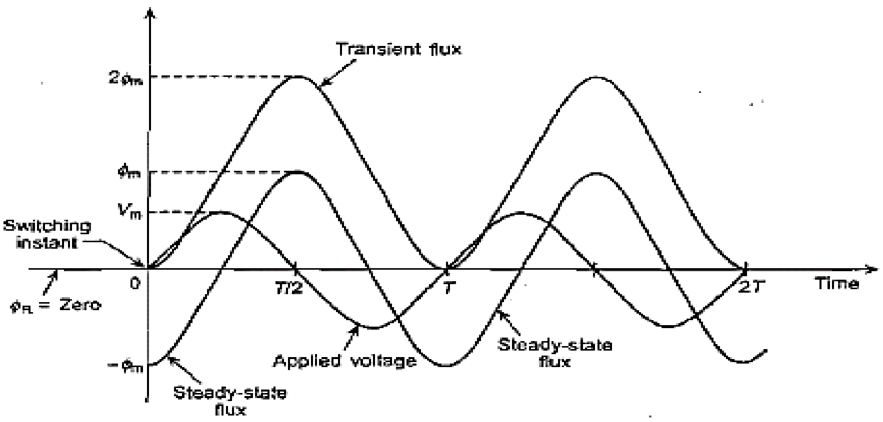

Fig 1 flux and voltage at energization

The point when voltage passes through zero and becomes positive, the flux should be increasing at its negative maximum value, The flux changes from $-\Phi_m$ to $+\Phi_m$ in half cycle. Therefore, the change in flux is 2Φm in half cycle time period. This depicts the steady state condition.

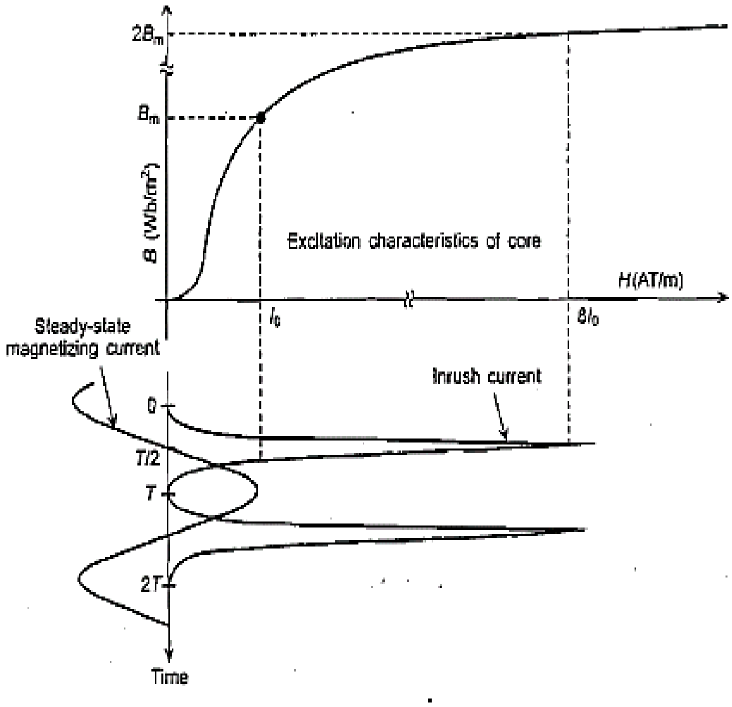

Fig 2 steady state magnetizing current of transformer

Suppose in the voltage waveform, the transformer is energized at positive(+ve) zero crossing as shown in fig1 and also assume that the residual flux is negligible. Thus, initially the flux is zero however further the flux must have the similar rate of change and similar waveform because it is in the steady-state. Thus, the flux must reach a highest value of 2Φm in T/2 time period. magnetizing current with a non-sinusoidal waveform can be caused to draw due to a flux demand of 2Φm drive the transformer internally into saturation and this all happens when power transformers run near to the knee of the saturation curve.

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 as in fig 2

I.MATHEMATICAL DERIVATION FOR INRUSH CURRENT

The secondary side is open, the transformer takes exciting (or no load) current from the supply mains. The magnetizing component of current, 90 lagging the applied voltage V1, is much larger than the core-loss component of current, the transformer at no load behave almost like a simple inductive reactor. That means the primary induced emf is equal and opposite to applied voltage.

$$V = V_m \sin(\omega t + \theta)$$

Transformer flux

$$\phi = \phi_m \sin \omega t$$

$$V = N \frac{d\phi}{dt}$$

$$N \frac{d\phi}{dt} = V_m \sin(\omega t + \theta)$$

$$d\phi = \frac{V_m}{N} \sin(\omega t + \theta) dt$$

$$\phi = \frac{V_m}{N}\int \sin(\omega t + \theta)dt$$

$$\phi = -\frac{V_m}{N\omega}\cos(\omega t + \theta)dt + k$$

when t=o, $\phi = \phi_R$ = residual flux.Then value of k can be found out from the initial condition

$$k = \phi_R + \left(\frac{V_m}{N\omega}\right)\cos\theta$$

$$\phi = \phi_R + \left(\frac{V_m}{N\omega}\right)\cos\theta - \left(\frac{V_m}{N\omega}\right)\cos(\omega t + \theta)$$

II. DIFFERENT METHODS OF REDUCTION

different methods are use for reducing inrush current. Reduction of inrush current is necessary because if inrush will present in the system it will cause a problem like relay mis operation, power quality reduction, it also may happens that loss of transformer or transformer life reduction. Sequential phase energization techniques in that delay provide between phase energization and that is use full for reducing inrush current, control switching method in that method we can start the transformer at that switching angle where minimum inrush current will there in the system.

III. SIMULATION OF INRUSH CURRENT

Simulation model of inrush current is as shown in fig 4.1. the system consists of three phase source, breakers, voltage and current measurement, transformer and load. 138 MVA transformer 72/13.8 KV

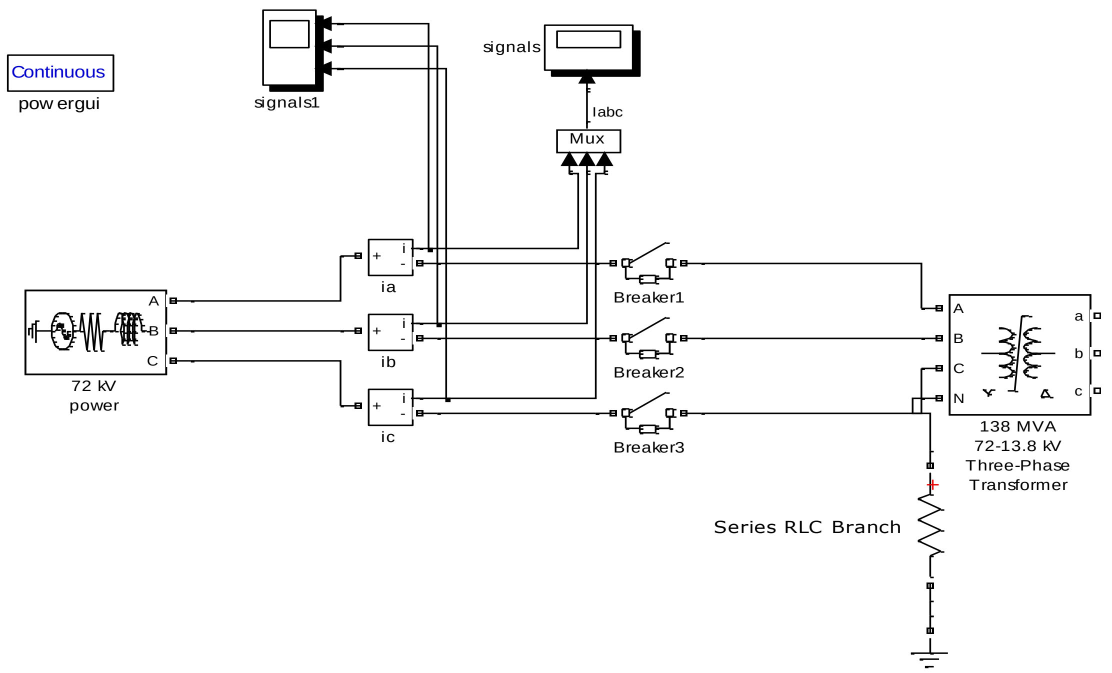

fig. 3 Simulation model for inrush current analysis

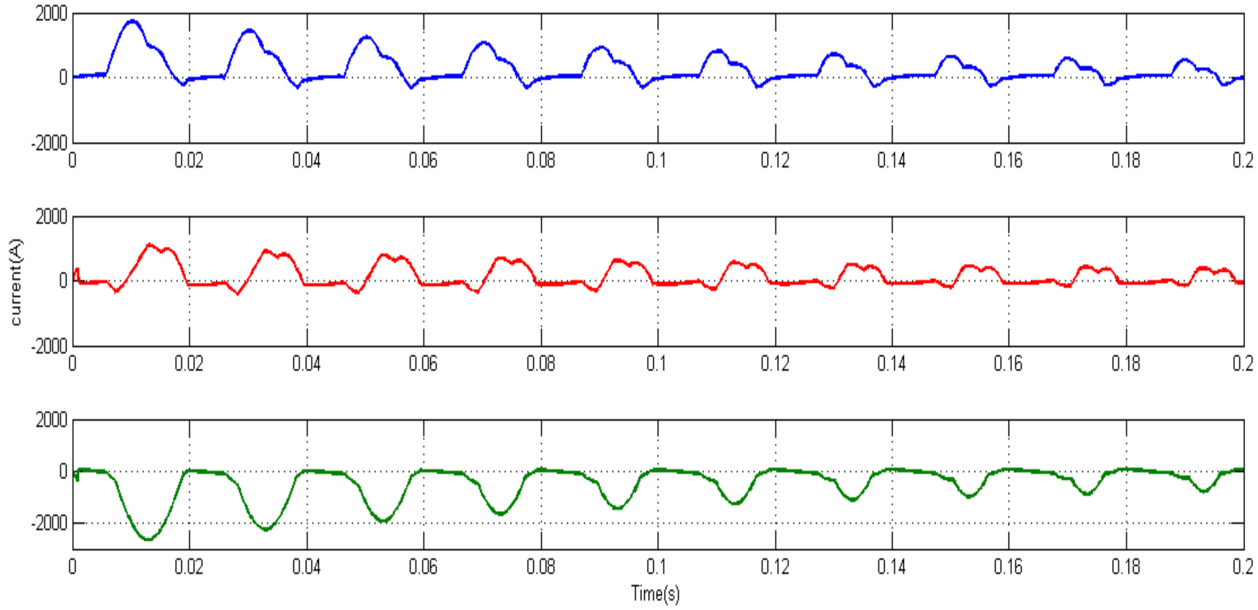

Fig 4 transformer switch on at 0 degree respect to phase R without load

IV. SEQUENTIAL PHASE ENERGIZATION TECHNIQUE

In that method all phases are energize in sequence after one phase reached to it steady state value the second phase will energize, and after reaching second phase energization third phase will energize, in that method neutral resister is connected with supply side, which is react as a series connected resister and helps for reducing inrush current.

Here the simulation for inrush current for 30KV and 138MVA is taken[1] Without any method analysis of transformer inrush current, it will observe that if there is not using any method for reducing inrush current then the reduction of peck will take more time to reach it steady state value.

Here we can use the Y/Δ configuration for transformer, 30KVA 120/208 three phase transformer, circuit breaker is use for sequential phase energization, connect neutral resister at primary side, here different value is use for neutral resister it will 2.5Ω, 5Ω, 10Ω, and 20Ω for analysis of impact of neutral resister on inrush current

Simulation for 138 MVA 72/13.8KV transformer with neutral resister value is 10Ω

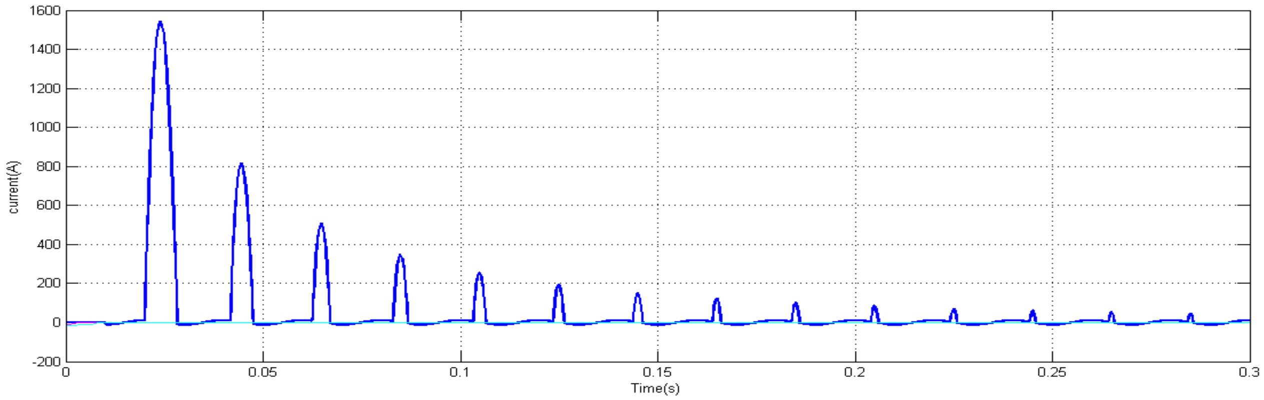

Fig 5 Phase A energization

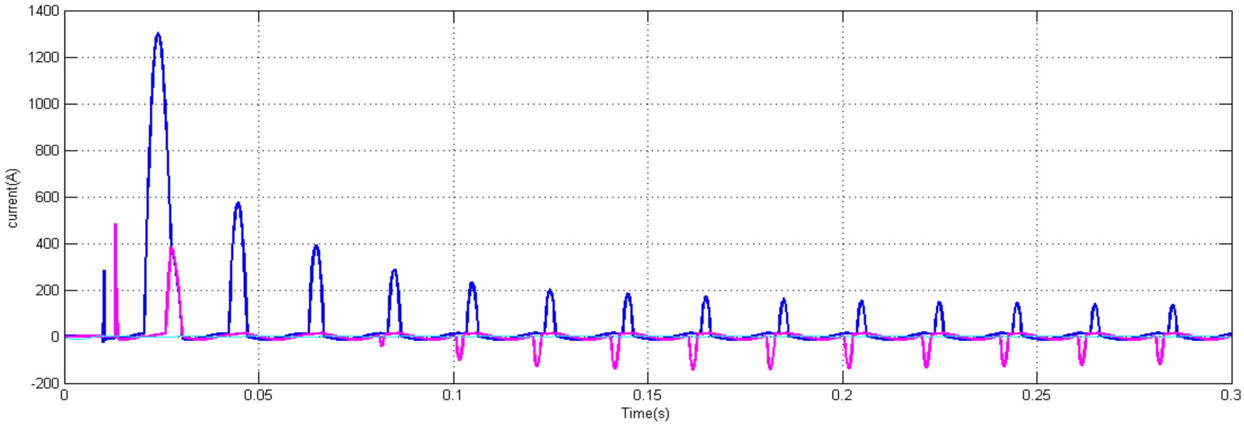

Fig 6 Phase B energization

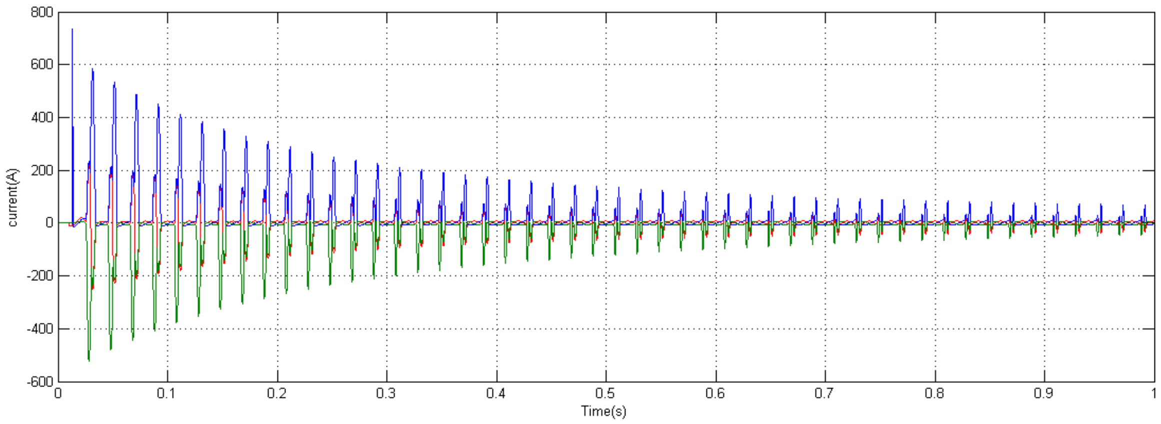

Fig 7 Phase C energization

Simulation for 30 KVA 120/208KV transformer with neutral resister value is 2.5Ω

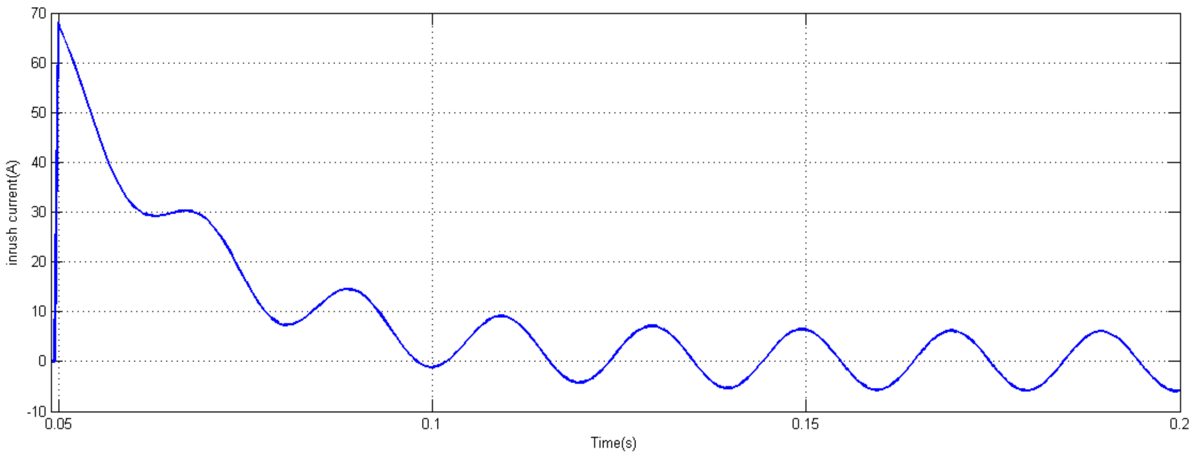

Fig 8 Phase A energization

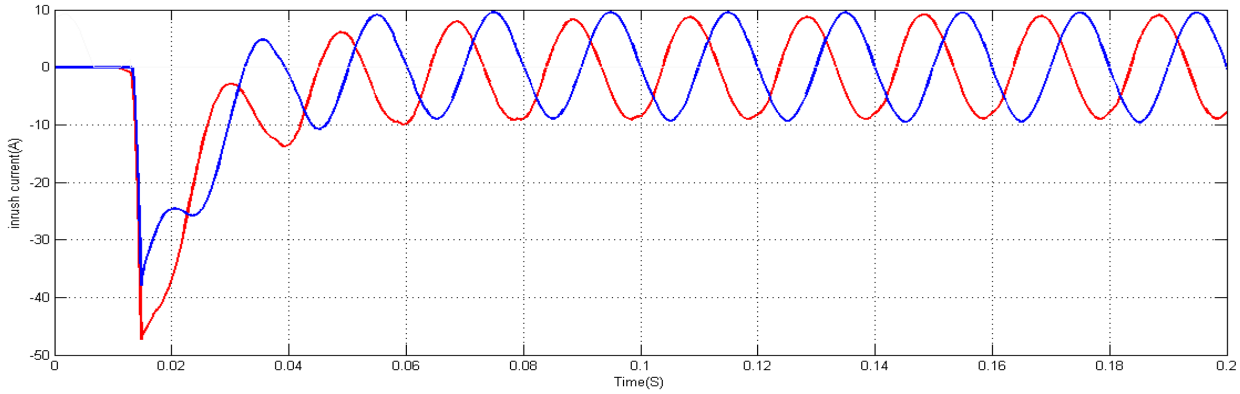

Fig 9 Phase B energization

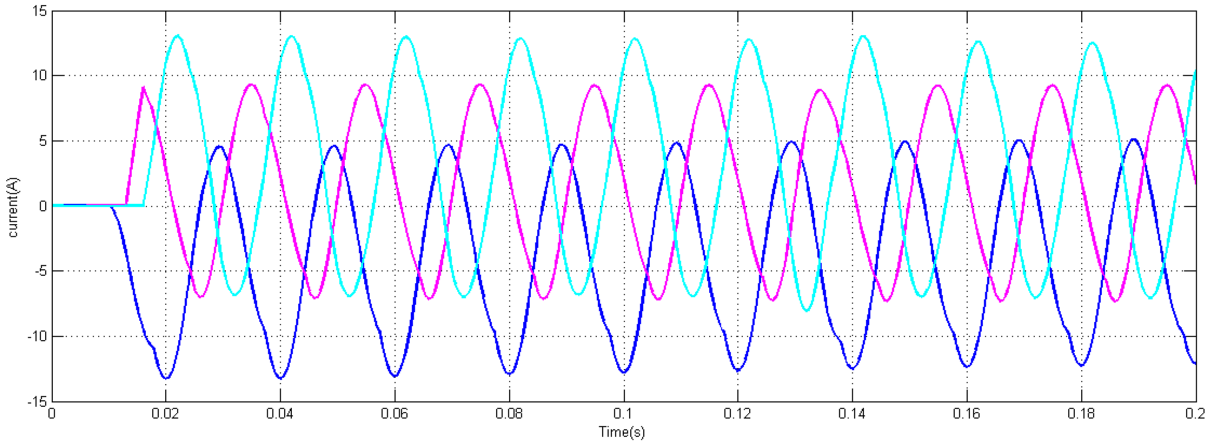

Fig 10 Phase C energization

Simulation for 30 KVA 120/208KV transformer with neutral resister value is 5Ω

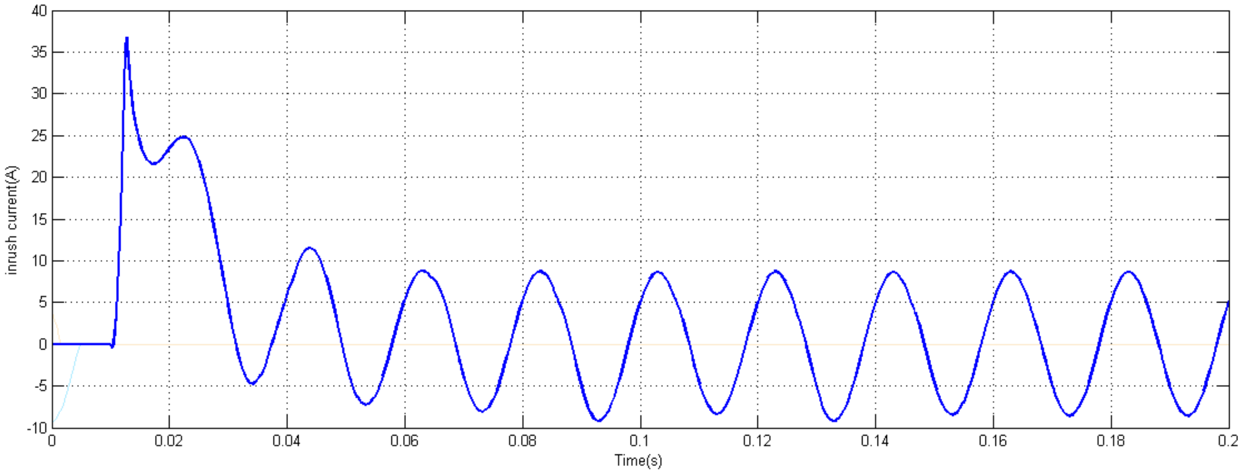

Fig 11 Phase A energization

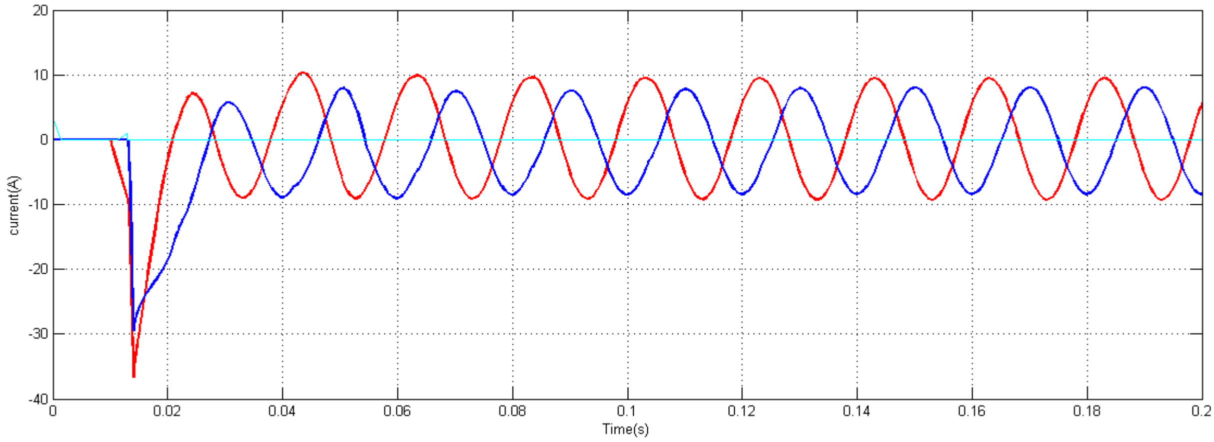

Fig 12 Phase B energization

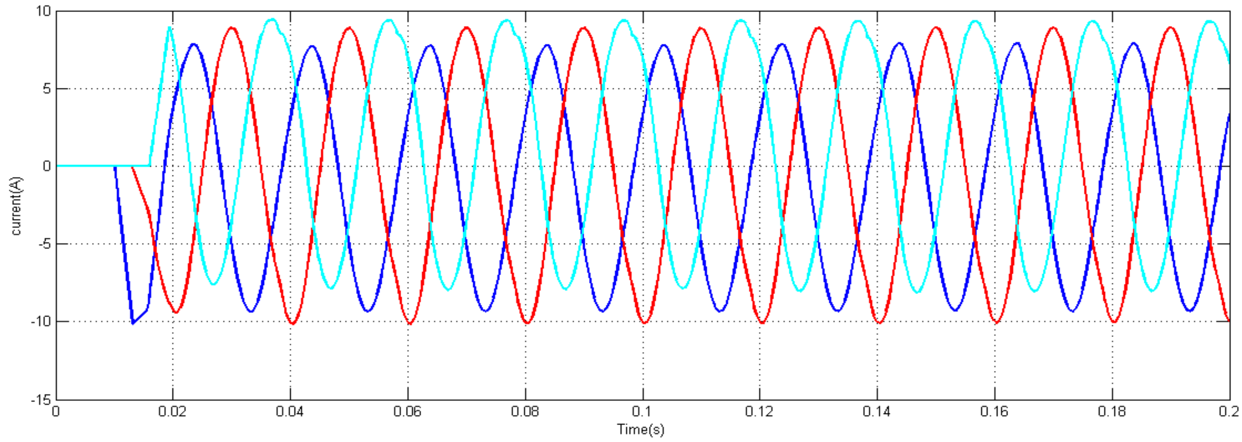

Fig 13 Phase C energization

CONCLUSION

The inrush current of a power transformer is almost entirely unidirectional and can be many times larger than the full load current. Analysis of a typical inrush current waveform using a matlab simulation shows that all harmonic components are present. But the 2nd harmonic component is high then other harmonic.

Inrush current is high at no load, Increased loading on the system introduces very valuable damping, which reduces the magnitude of any over current produced.

For reducing inrush current we have apply sequential phase energization technique for reducing inrush current we have observe valuable damping in Phase A and time duration of reduction is reducing.

Reference

[1] Y. Cui, S. G. Abdulsalam, S. Chen, and W. Xu, "A sequential phase energization technique for transformer inrush current reduction - Part I: Simulation and experimental results," *IEEE Trans. Power Deliv.*, vol. 20, no. 2 I, pp. 943–949, 2005.

[2] T. Specht, "Transformer inrush and rectifier transient currents," *IEEE Trans. Power App. Syst.*, vol. 88, no. 4, pp. 269–276, Apr. 1969.

[3] CIGRE working group task force 13.07, Controlled switching of HVAC circuit breakers, in 1st Part Elektra, no. 183, pp. 43–73, Apr. 1999.

[4] , "Controlled switching of HVAC circuit breakers," *2nd Part Elektra*, no. 185, pp. 37–57, Aug. 1999.
[5] K. Smith, L. Ran, and B. Leyman, "Analysis of transformer inrush transients in offshore electrical systems," *Proc. Inst. Elect. Eng., Gen. Transm. Distrib.*, vol. 146, no. 1, pp. 89–95, Jun. 1999.
[6] Westinghouse, *Electrical Transmission and Distribution Reference Book*. Chicago: The Lakeside Press, R. R. Donnelley & Sons Company,1944, pp. 411–417.