A COMPARISON OF VARIOUS METHOD FOR REDUCING INRUSH CURRENT OF TRANSFORMER

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Abstract- - At the time of transformer energization, a high current will be drawn by the transformer. This current is called transient inrush current and it may rise to ten times the nominal full load current of transformer during operation. This current often affects the power system quality and may disrupt the operation of sensitive electrical loads such as computer and medical equipment connected to the system. Conventionally, controlled switching or point on wave switching was the method being used to counter the problem, but this method requires the knowledge of residual fluxes of transformer before energization. Hence, proposes a new technique is proposed for inrush current reduction of transformers. we compare Pre – fluxing technique, Diode bridge DC reactor method of mitigation technique for inrush current in transformer.

Index Terms— Transformer, Inrush current , Pre-fluxing technique, Diode bridge DC reactor, MATLAB

I. INTRODUCTION

Power transformer is a very expensive and vital component of electrical power system. If powewr transformer experiences fault; it is necessary to take out of service as fast as possible so that damage is minimized. One of the major fault occurring in transformer is the transient. A transient is a high voltage or current spike of 15 microseconds in duration. Due to this transients, the transformer operates inefficiently and interrupt and inadvertent the protection of transformer. the un controlled energization of transformer produce high inrush currents, which can decrease the life of transformer because of high mechanical and electrical stresses involved, and it can also lead the mal function of protective relays. These current depends upon various operating conditions, magnitude of the voltage, switching on angle, which way transformer energized, residual flux, and hysteresis characteristics phase angle of source voltage. The main technique for reducing of magnetizing inrush currents include removal of residual flux, adjustment of the phase angle of source voltage, insertion of resistance, PWM inverters an others. Control switching is mostly usable technique to reduce inrush current but it require measuring the residual flux and it is difficult to measure instantaneous magnitude of residual flux and direction at the instant of tansformer exercitation

II. PRE FLUXING TECHNIQUE

This research presented an inrush current reduction strategy which sets the residual flux of three phase transformer to a large magnitude and specific polarity in this method known as pre fluxing technique and then energizes the transformer at specified system voltage angle based on the flux polarity. This strategy has advantage over some of the presently suggested reduction strategy, including removing the need for residual flux measurements during transformer de energization.

A) MITIGATION OF INRUSH CURRENT USING PREFLUXING DEVICE

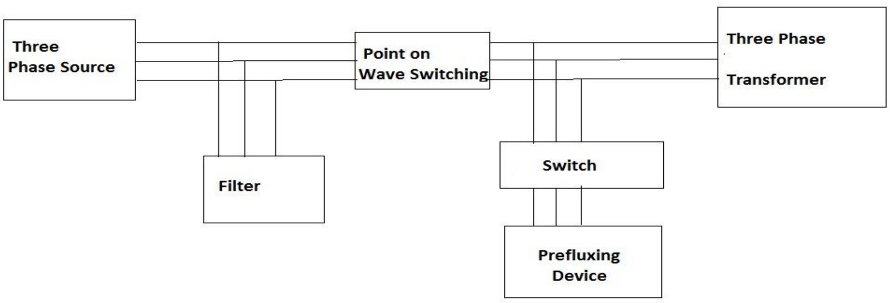

Figure 1. Connection of pre-fluxing device in a three phase power transformer

As controlled switching had been the most popular technique to mitigate inrush current. The most important important aspect in this method is knowledge of residual flux of transformer. Many techniques had been suggested to obtain residual flux in the basis of the instant of transformer was previously turned off, But it is slightly tedious process.

To make a user free from the knowledge of residual flux. Here is a new technique to set the initial flux of transformer to a desired value. This is called a pre fluxing. The innovation behind the pre fluxing inrush current reduction strategy lies in the pre fluxing device itself. The pre fluxing device is charged to user specified voltage and discharged in transformer when closing the isolator switch. It is necessary for the pre fluxing device set the residual flux of a transformer as high as possible to minimize the inrush current but also to do so efficiently. Here is inrush current reduction strategy in two parts

1) Using pre fluxing device set the residual flux of a transformer to maximum achievable value when transformer de-energized
2) Second part of process control the circuit breaker to energize the transformer.

Controlled strategies for the C.B. switching

1) **Rapid closing** - First close one phase and remaining two within quarter cycle which is required the knowledge of residual flux in all three phase and independent pole breaker control and model transient performance of transformer.

2) **Delay closing** - Close most one phase and remaining two within 2-3 cycles. It requires the knowledge of residual fluxin one phase. Any independent pole breaker control, but not require the transformer parametric data.
3) **Simultaneous closing**- Close three phase together at an optimum point for the residual flux pattern. It does not require independent pole breaker control, but residual flux knowledge in all the three phase.

The device is used when transformer is isolated from the power system and connects across the one transformer primary winding. Relatively inexpensive isolator switch can be used to connect the device to transformer. The pre fluxing device is sized to operate around the transformers magnetizing current level, so the capacitor, diode and switch be sized for a fraction of the transformer rated current. The device will feed some amount of DC flux before the energization of transformer. When transformer is energized at the same instant the pre fluxing device will be separated by circuit breaker or isolated switch. Set the residual flux in transformer primary winding. The capacitor will be charged according to the maximum value of transformer. It should be almost equal to the maximum value of flux.

B) MATLAB Simulink model of inrush current mitigation using pre fluxing technique

Three phase transformer having a rating of 300MVA, 11 Kv/400 kv, 50 Hz connected to a supply source as shown in figure. A three phase 11 Kv source connected with the transformer. The core magnetization induction is 8.4 mH the core is used with specifies initial fluxes and saturated core. Saturation characteristic [i1 , phi1 ; i2 , phi2 ; ...] (pu) = [0 0;0.0024 1.2;1 1.52] Initial fluxes [phi0A , phi0B , phi0C] (pu): = [0.8 - 0.8 0.8].

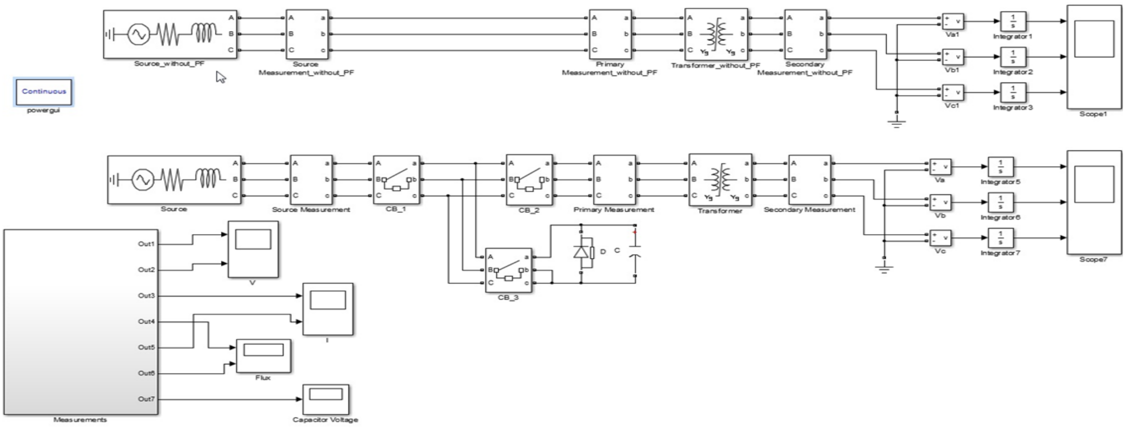

Fig 2. MATLAB Simulink model of inrush current mitigation using pre fluxing technique

III. DIODE BRIDGE DC REACTOR TECHNIQUE

Most of the inrush current reduction techniques based on eliminating asymmetry in the core flux. Here a new external control circuit for inrush current reducing using a control less diode bridge type DC reactor. The device connects in series with transformer and it use a single coilwithout any other control or measurement circuit. The Resistance of DC reactor is modeled with small Resistance & inductance. Using a super conducting coil coil the DC reactor resistance would be equal with zero. By increasing the inductance of L_d we can decrease the ripple current of I_d , Therfore DC reactor not have significant role on normal operation.

This method can be explained with two modes of operation.

1) Charging mode
2) Discharging mode

Here the line and DC reactor current waveform during energization transformer with the inrush current limiter. The reactor current I_d is a rectified current in normal operation. The applied voltage is sinusoidal.

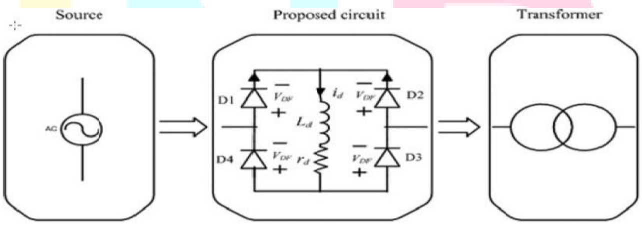

Figure 3. Power circuit topology of proposed ICL

A) Charging mode - The transformer energized at t = t_0 and the line current begin to increase. The charging mode begins at t = t_0 and continuous untill t = t_2. At t = t_0 the diode D1 and D3 turn on and DC reactor current in series with transformer. At t = t_1 transformer saturate and magnetising inductance changes its value from Lns to Lsa. The voltage across Ld cause the limitation of inrush current of transformer. The operation of DC reactor leads inrush current limiting between t_0 to t_2.

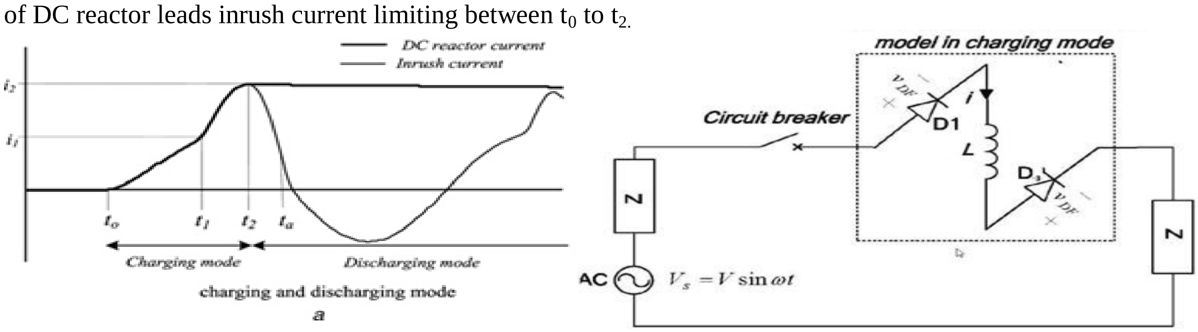

Figure 4. the line and DC reactor waveform

B) Discharging mode – At t = t_2 discharging mode starts untill t = t_3 and inrush current limiter retreat from power circuit. The discharging mode begins at t = t_2 when the inrush current reaches to its maximum value. During these mode begins the inrush current is less than DC reactor current and all of diodes turn on because of charge current of DC reactor.

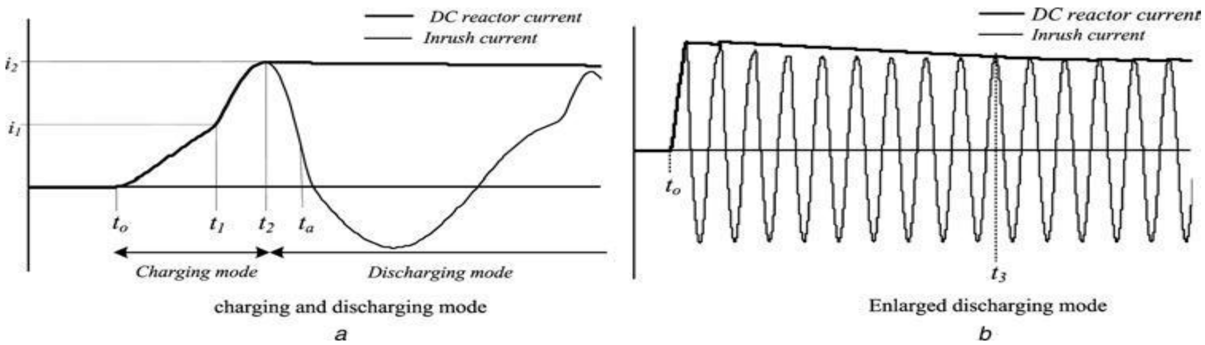

Figure 5. Charging and discharging mode of DC reactor

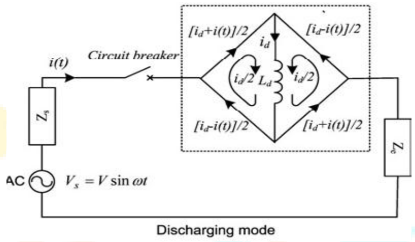

Figure 6. Discharging mode.

Indeed the DC reactor is short circuit by diodes and it has no effect on circuit operation. At t = t_a Lm changes its value from Lsa to Lns again. At t = t_3 the reactor current reaches again to load current as shown in figure. Between t_2 and t_3 DC reactor has no effect on circuit operation because of the DC reactor carries almost DC current. The propose ICL limits the inrush current without any considerable effect on steady state operation.

A) MATLAB Simulink model of inrush current mitigation using Diode bridge DC reactor

Three phase transformer having a rating of 300MVA, 11 Kv/400 kv, 50 Hz connected to a supply source as shown in figure. A three phase 11 Kv source connected with the transformer. The core magnetization induction is 8.4 mH the core is used with specifies initial fluxes and saturated core. Saturation characteristic [i1 , phi1 ; i2 , phi2 ; ...] (pu) = [0 0;0.0024 1.2;1 1.52] Initial fluxes [phi0A , phi0B , phi0C] (pu): = [0.8 -0.8 0.8].

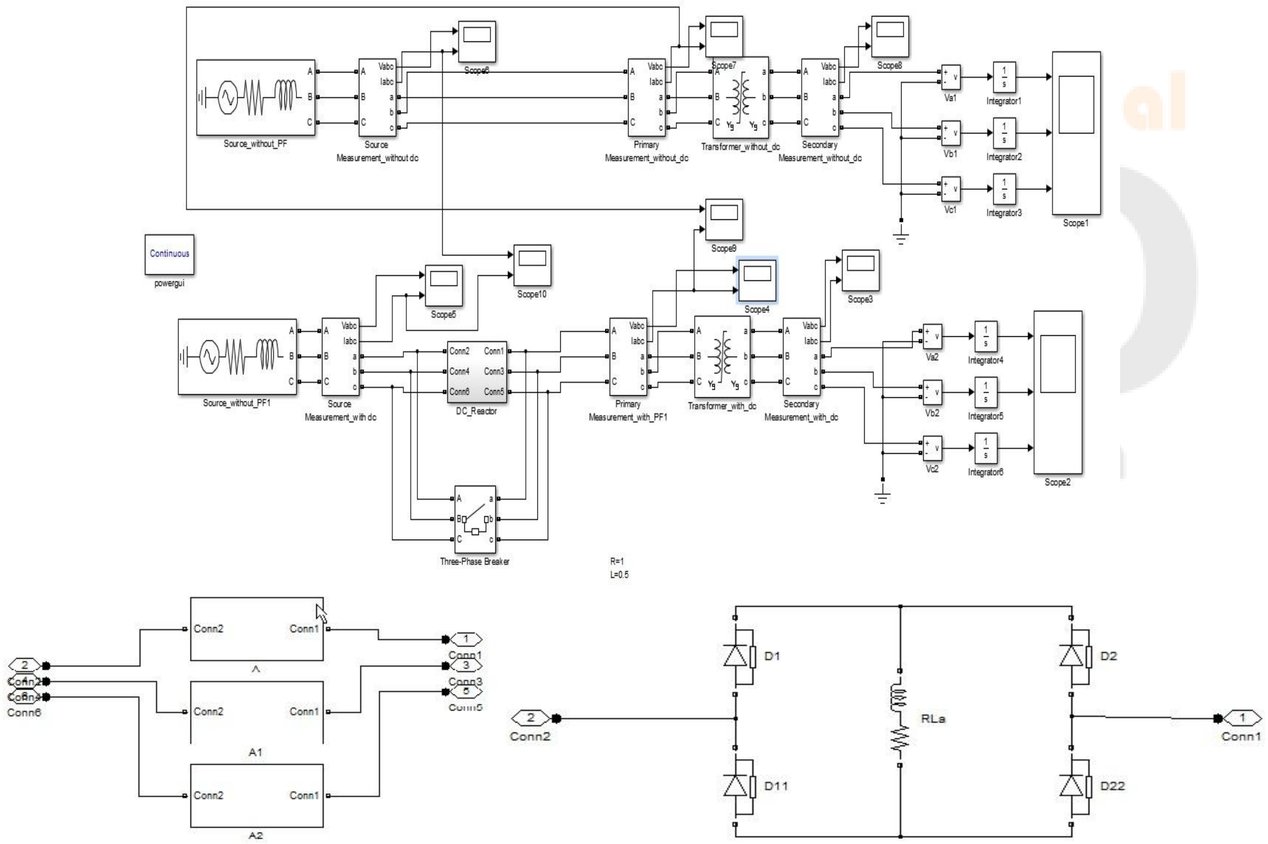

Figure 7. MATLAB Simulink model of inrush current mitigation using Diode bridge DC reactor

IV. OUTPUT WAVE FORM OF PRIMARY WINDING IN TRANSFORMER WITH PRE FLUXING TECHNIQUE AND DIODE BREIDGE DC REACTOR TECHNIQUE.

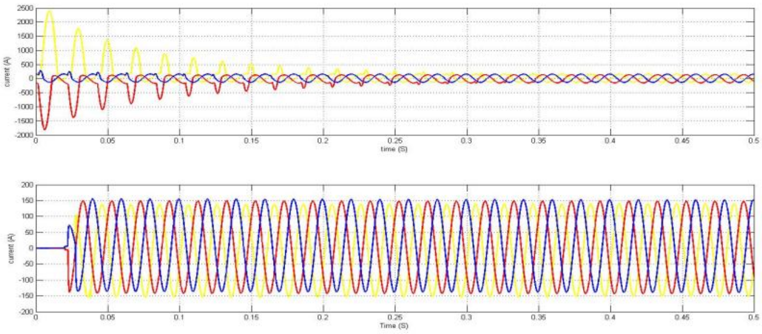

Fig. 8. Primary current wave form of primary windingwith and without pre fluxing technique

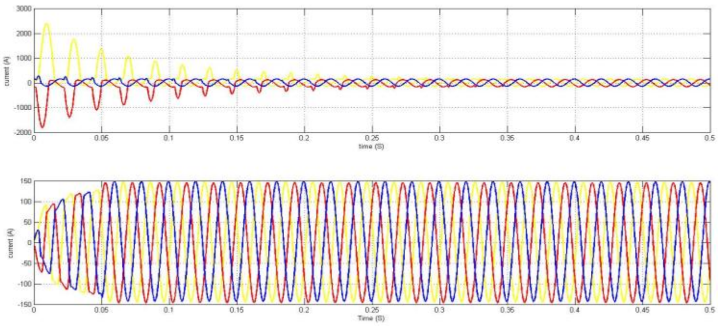

Fig. current wave form of primary winding with and without dc reactor

V CONCLUSION

MATLAB simulation are carried out to verify the method of Pre-fluxing and Diode bridge DC reactor method to reduce inrush current. From the results obtained main conclusions can be summarized from table shown as above.

Technique	Current without limiter	Current with limiter	Time required to settle down the current	Advantage
Pre fluxing type inrush current limiter	2480 A	150 A	0.15 Second	Flexible to apply all range of transformer, device can operate at low level voltage
DC reactor type inrush current limiter	2480 A	150 A	0.15 Second	No need to external charging circuit, easy to implement, cost efficient and excellent

Table 1. comparison of inrush current reducing technique

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