AN OPTIMUM METHOD FOR OBTAINING HIGHER INDUCED VOLTAGE IN TRANSFORMER

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Abstract— This paper proposes a novel method for obtaining higher voltage by transformer, unlike increasing frequency, number of turns. This has been achieved by adding a capacitor in series with the primary side of the transformer, by which greater induced EMF has been obtained by cancelling the choke effect of the inductor. To test the effectiveness of the proposed method, *State Space model of the transformer has been developed* and the analysis has been made by using the same for various load conditions.

***Index Terms*—State space modeling, Transformer, Voltage magnification.**

I. INTRODUCTION

Transformer is a static device; it works on the principle of Mutual Induction.
The governing equation is:

$$E=4.44.f.N.\Phi_m \text{ Volt ……… (Eq 1)}$$

From (Eq 1) it is clear that induced EMF (E) in transformer can be increased in various ways. (1) Increasing the frequency (f), hence reducing the size of the transformer for given output voltage, but it has inherent defect of increasing the hysteresis and the eddy current losses necessitating superior core material. This also results in increased skin effect. (2) Increasing number of turns (N) in coil, but this result in increased size, cost and voltage regulation. (3) Alternate approach to enhance voltage is by establishing more flux (Φ_m) , which can be obtained in two ways. (i) Reducing the resistance of coil, which results in increased primary current. There exists a lower limit to this for a given voltage. (ii) Producing more current through coil by high primary voltage and thus more flux. The latter approach is not optimal because the prime purpose is to boost low input voltage.

Proposed solution for boosting voltage

If two straight conductors are placed near each other the mutual induction is not appreciable. Hence coil is required instead of a conductor, but there is choke effect due to coil, which limits current and hence flux, thus limiting induced EMF. To obtain a higher voltage with constant number of turns, frequency and supply voltage, the choke effect needs to be removed but not coil as it is very much necessary for transformer action. Hence choke effect is compensated by series capacitive reactance *,the circuit is taken to near resonance but not resonance, as there* *exists one particular frequency(Eq.2) for which voltage across inductor would be maximum***[1]** ,which would dictate the value of capacitance (C) to be placed in series with primary side of transformer :

$$f_L = \frac{1}{2\pi\sqrt{(LC-\frac{R^2C^2}{2})}} \text{ .... (Eq.2)}$$

For measured self inductance and resistance of the coil, for supply frequency, C can be calculated from (Eq.2) and as shown in Fig.1 at supply frequency maximum voltage can be obtained which is much greater than the supply voltage -voltage magnification.

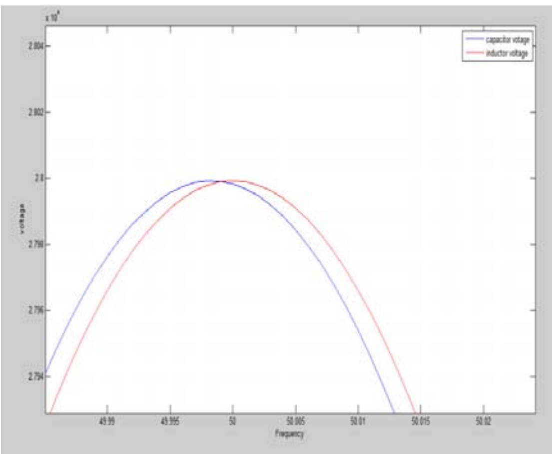

Fig .1

II. STATE SPACE MODELING

State Space model of transformer without capacitor

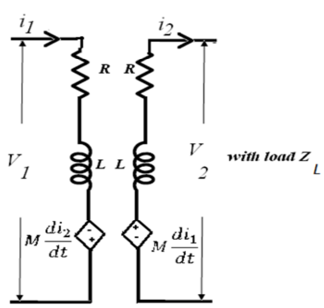

Fig.2 **[2]**

State space equations are:

$$\begin{bmatrix}\dot{x}_1\\ \dot{x}_2\end{bmatrix} = \begin{bmatrix}\frac{-RL}{L^2-M^2} & \frac{-RM-MZ_L}{L^2-M^2}\\ \frac{-RM}{L^2-M^2} & \frac{-RL-LZ_L}{L^2-M^2}\end{bmatrix}\begin{bmatrix}x_1\\ x_2\end{bmatrix} + \begin{bmatrix}\frac{L}{L^2-M^2}\\ \frac{M}{L^2-M^2}\end{bmatrix} U$$

$$Y = \begin{bmatrix}0 & Z_L\end{bmatrix}\begin{bmatrix}x_1\\ x_2\end{bmatrix}$$

State Space Model of transformer with capacitor

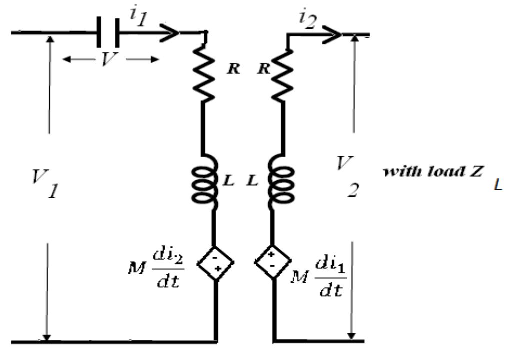

Fig. 3

State space Equations are:

$$\begin{bmatrix}\dot{x}_1\\ \dot{x}_2\\ \dot{x}_3\end{bmatrix} = \begin{bmatrix}\frac{-RL}{L^2-M^2} & \frac{-RM-MZ_L}{L^2-M^2} & \frac{-L}{L^2-M^2}\\ \frac{-RM}{L^2-M^2} & \frac{-RL-LZ_L}{L^2-M^2} & \frac{-M}{L^2-M^2}\\ \frac{1}{C} & 0 & 0\end{bmatrix}\begin{bmatrix}x_1\\ x_2\\ x_3\end{bmatrix} + \begin{bmatrix}\frac{L}{L^2-M^2}\\ \frac{M}{L^2-M^2}\\ 0\end{bmatrix} U$$

$$Y = \begin{bmatrix}0 & Z_L & 0\end{bmatrix}\begin{bmatrix}x_1\\ x_2\\ x_3\end{bmatrix}$$

The parameters Where

x_1, x_2, x_3, U, Y are i_1, i_2, V, V_1 and V_2 respectively.

III. SIMULINK MODELING & RESULTS

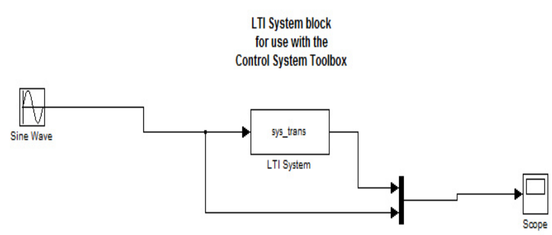

Fig. 4

for the simulation has been chosen from a practical transformer by using LCR meter for a 2 KVA/ 230//230 V. Self Inductance(L) is 0.31H, Resistance (R) is 0.8Ω, Capacitance(C) calculated using (Eq. 2) for line frequency (f_L) 50 Hz is 3.26853558 µF. Mutual inductance (M) =k$\sqrt{L^2}$.Coefficient of coupling (k) =0.998.

Fig.5 shows the output voltage after placing the capacitor C as shown in Fig.3 with Z_L =1KΩ.

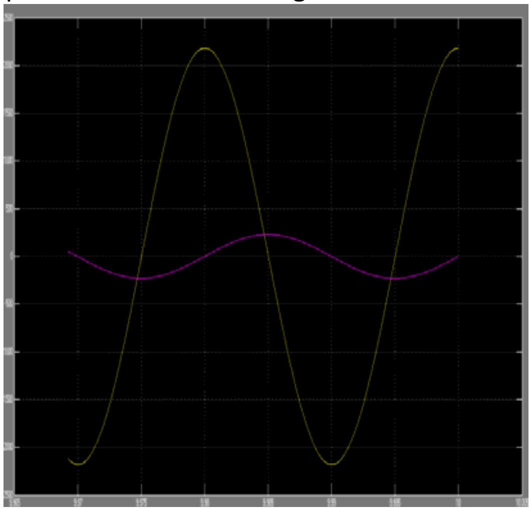

Fig.5 Input Voltage (230 V) Vs time and Output Voltage (3.2KV peak) Vs time for resistive load.

Load Modeling and Stability:

Response of the system for inductive and capacitive loads is also investigated and output voltage has been found to be enhanced. The system is found to be stable for input with harmonics (Shown in Fig.6)

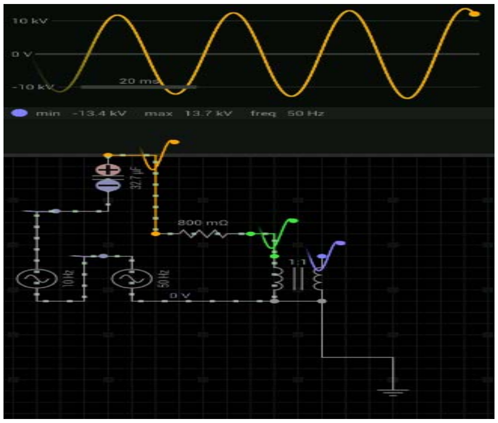

Fig. 6 Input voltage is superimposed with 10 Hz /1V Peak sinusoidal input.

IV. Conclusion

The results show that output voltage of 1:1 transformer is very high, i.e. *stepping up of voltage can be obtained using 1:1 transformer*. This has been achieved by taking the primary of the transformer to near resonance. The effectiveness of the method has been tested in *Matlab Simulink*® Environment by using State Space Analysis. It has been tested for various types of loads by using *EveryCircuit®*. This method can be used in various applications where very high boosting of voltage is required.

REFERENCES

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