Load Equalizer Transformer

Mahesh Yanagimath
Department of Electrical & Electronics Engg.
Hirasugar Institute of Technology,Nidasoshi
Dist:Belagavi, Karnataka,India
maheshyanagimath.eee@hsit.ac.in

Purnima I Savadatti
Department of Electrical Engineering
Dr.A.D.Shinde, College of Engineering,
Bhadagaon, Gadhinglaj, India
purnimamy2013@gmail.com

Pallavi P.Dixit
Department of Electrical Engineering
Dr.A.D.Shinde College of Engineering,
Bhadagaon. Gadhinglaj, India
pallavispdixit@gmail.com

ABSTRACT

Distribution Transformer plays a crucial role in the power distribution network. Failure of distribution transformer results into interruption of power supply to consumers. This disruption affects the economy of nation in the form of loss of revenue, materials, repairing charges etc. Nowadays in India three phase unbalancing is a major problem. And there is a unexpected power cut due to overloading, sudden rise in surge voltage, fluctuation in the voltage supply. It may cause heavy damage to household equipment, costly equipment in substation and industry. The faulty distribution system can lead some areas overloaded and some areas with less loaded. So to avoid these condition, controlling of the power and hence, controlling of the load is required in this areas. It leads to the load balancing technique, which is the process to prevent the system from the overloading condition. In this paper we are going to explain the details of load balancing and steps to design and implement load balancing in the power distribution system.

Keywords—Load balancing, Distribution transformer etc.

I. INTRODUCTION

Now a day's demand of electricity is increasing continuously due to various reasons of human beings. Industrial load is also increasing day by day. In industry majority of the load is inductive in nature. So they consume the reactive power which will affect the generation of plant. Then additional power required also increases the generation or increases KVA rating of the transformer. Once the power transmission to sub-system is done the next thing is to distribute the Power among all the consumers. The faulty distribution system can lead some areas overloaded and some areas with less loaded. So to avoid these condition, controlling of the power and hence, controlling of the load is required. Hence for this load balancing technique the only process which prevents the system from the overloading condition.

II. METHODOLOGY

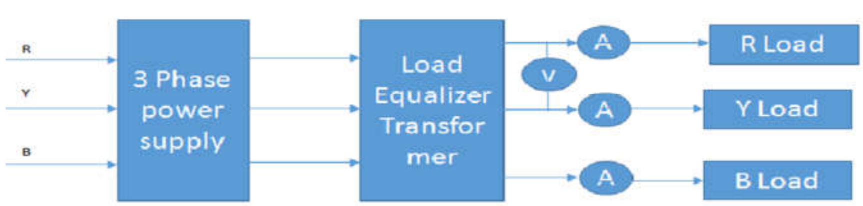

Figure 1: Block Diagram of Load Equalizer Transformer.

In a symmetric three-phase power supply system, three conductors each carry an alternating current of the same frequency and voltage amplitude relative to a common reference but with a phase difference of one third of a cycle between each is considered. The phase order is 1-2-3. This cycle repeats with the of the frequency power system. Ideally, each phase's voltage, current, and power is offset from the others' by 120°.

The main objectives of Load Equalizer Transformer are

a. To obtain balance in three phase load.
b. To provide protection against overloading & under loading.
c. To improve the utilization factor.

In distribution transformer, there is a chance of burning of one phase due to unbalanced load. To minimize this problem also to improve the utility factor of transmission line we are planning to do some additional changes at secondary side of transformer.

A. Load Equalizer transformer:

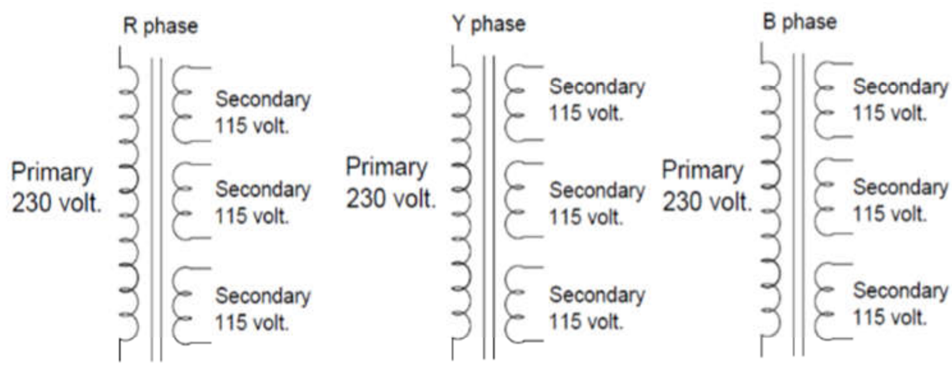

Figure.2: Winding Mounting Diagram

As shown in the above diagram at the primary side, the three phase AC supply is given to the three primary windings of the transformer having a rating of 2 KVA. Primary side voltage level is 440V and at the secondary side each winding of the transformer, each primary winding is divided into 1/3 part of its secondary. Therefore at the secondary side 1/3 supply will get from the primary side of each phase. As shown in above figure.2 the internal connections of the secondary winding takes place to avoid short circuit, the direction of current will changed by changing the direction of coil. Due to this three phase to three phase connection is given out from the transformer.

The three phase transformer is constructed by considering following points. The primary winding of transformer is connected in delta connection. After the primary, the secondary winding of the transformer is wound on the primary in the 1/3 part of the primary that means the secondary is in 3 parts on single phase primary winding having ½ turns in each 1/3 part of secondary winding of each core limb. In each phase primary winding is having 3 layers of 67 turns. Therefore total primary turns are 201. And in secondary winding there are 6 layers of turns arranged in descending order in which the 1st layer is having 20 turns 2nd layer is having 19 turns3rd layer contains 18 turns 4th layer contains 17 turns 5th layer contains 16 turns and last 6th layer contain 15 turns, in this way the total secondary turns are 105 turns in each phase. Like this the construction of coil or winding of transformer is done.

The reason of doing this type secondary winding is to avoid loose winding turns and it will tightly mounted as well as the we get three parts of primary winding and having ½ turns with respect to primary winding. Therefore our secondary connection is established in this configuration. The connections of Transformer winding is as shown in figure 3.

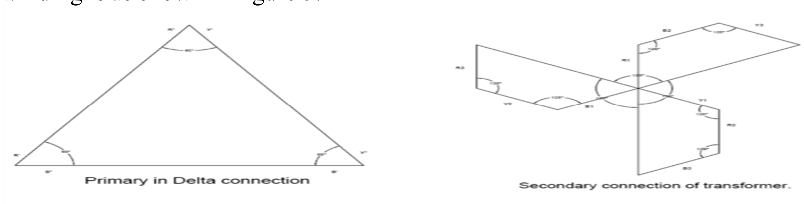

Figure. 3: Connection Diagram of Transformer.

The above phasor diagram shows the connections of our load equalizer transformer as well as the phase angle of each winding. In our load equalizer transformer the primary is connected in delta connection and the secondary connection is as shown in above figure 3. In the secondary winding connection, the 1/3 part of each phase is connected in the configuration in which there are two windings which are same or in positive direction but the central winding is in opposite or in negative direction. Therefore in phasor diagram the direction of each middle winding is in opposite direction with respect to the direction of that phase. The reason is to get the voltage at the secondary side equal to the primary side voltage because in the secondary side each 1/3 part get ½ turns of primary turns.

Now each and every phase of the secondary is connected in 120◦ phase angle therefore the resultant of the each secondary phase is also in 120◦. Therefore no any phase angle regulator is needed for our transformer.

The connections diagram of secondary winding is as shown below:

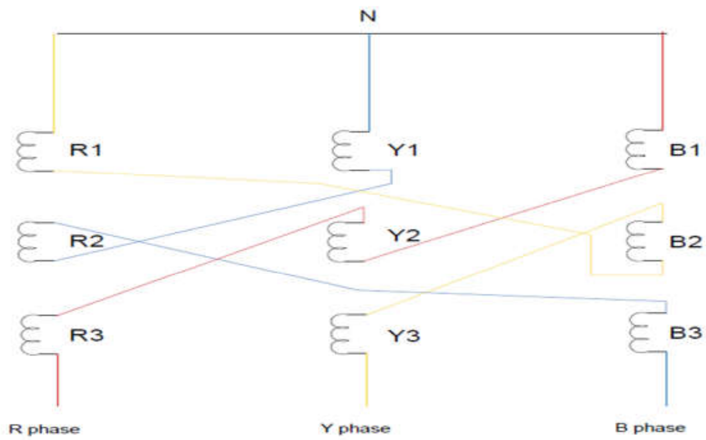

Figure. 4: Internal connections of transformer.

The secondary winding connections of load equiliser transformer is as shown in above fig. As per the phasor diagram the two windings are in same direction but one is in opposite direction that we can see here in above figure. Now we will discuss configuration of each

R phase : The R phase is configured from B1, Y2, and R3. The end terminal of B1 is connected to the end terminal of Y2, and the starting terminal of Y2 is connected to the starting terminal of R3 and end terminal of R3 is given out for load connecting terminal. Therefore this phase is considered as R phase.

Y phase : The Y phase is configured from R1, B2, and Y3. The end terminal of R1 is connected to the end terminal of B2, and the starting terminal of B2 is connected to the starting terminal of Y3 and end terminal of Y3 is given out for load connecting terminal. Therefore this phase is considered as Y phase.

B phase: The B phase is configured from Y1, R2, and B3. The end terminal of Y1 is connected to the end terminal of R2, and the starting terminal of R2 is connected to the starting terminal of B3 and end terminal of B3 is given out for load connecting terminal. Therefore this phase is considered as B phase.

III. HARDWARE DESIGN

A. Stampings: The magnetic circuit usually know as the "transformer core", is designed to provide a path for the magnetic field to flow around, which is necessary for induction of the voltage between the two windings. As well as for providing a low reluctance path for the magnetic field. The core is designed to prevent circulating electric currents within the iron core itself. Circulating currents called "eddy currents", causes heating and energy losses within the core which decreases the transformers efficiency.

In the Load equalizing transformer there are 3 types of I shaped windings which are used for manufacturing the core. The "1mm" aluminum material is used for the manufacturing the stamping of the transformer. There hardly 27kg stampings are used for manufacturing the 2 KVA transformers. The sizes of these stampings are given in below table.

Size of stampings	Kg
26*4cm	18kg
20*4cm	4.5kg
15*4cm	4.5kg

Table 1. Size of stampings

The 26*4cm sized stampings are used for the vertical limbs of the transformer core. There are 18kg stampings are used for the total three vertical limbs of transformer core manufacturing. And 20*4cm sized stampings are used for horizontal limbs of core there are 4.5kg stampings are used in the horizontal limb of core manufacturing. The 15*4cm sized stampings are used in 4.5 kg stampings required for another horizontal limb.

Figure.5: Stampings of the core.

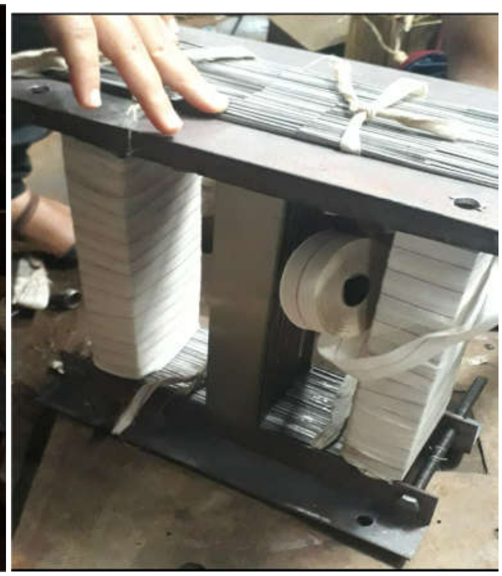

Figure: 6 Core of Transformer

Transformer design make following quantities are minimum.

- Total Volume
- Total weight
- Total cost
- Total loss

All these quantities vary with ratio of $r = \emptyset m/AT$, then $r \propto \emptyset$ so, large cross section area is required which increase the volume, weight, high cost.

$$r = \frac{\emptyset m}{AT} \text{ --------(1)}$$

and $$r \propto \emptyset$$

Where, r – Resistance, $\emptyset m$ –Flux, A –Area of stamping and T -Turns

The resistance is directly proportional to the flux produced in the core. There if the resistance is increased then the flux will also increase and the inversely proportional to ampere turns. In the core type of transformer the ratio of depth to width of core varies between 1.45 to 2. In our 2KVA transformer the depth is 8cm and the width is 24cm. Therefore the depth to width ratio of our transformer is 1:4. In Transformer core designing there is always changing direction method is used for the construction of core. The 20cm stamping bunch is used in upper limb between the two vertical limbs. The two 15cm bunch of stampings are in lower limb of transformer core besides the central limb. After the 1st iteration the 15cm bunch of stampings are used in the upper sided limb and 20cm bunch of stamping is used in lower sided limb again after 2nd iteration continue the 1st iteration in these way we constructed the core from bunch 3 stampings.

B. Primary Winding

At the time of starting of making coil firstly we wound the primary winding and after the primary winding the secondary winding is wounded on it. In primary winding, height of window of core is 22cm. In that core 72 turns are mounted in one layer of coil having gauge of 14 SWG aluminum wire. Therefore 3 layers of 72 turns in each layer primary winding are constructed to get 216 turns for our proper output voltage. The 14 SWG aluminum Wire is used for the winding of transformer as per the consideration of window spacing between each limb for easily mounts on the core comfortably. Because of choosing small gauge wire the large numbers of turns are mounted in the one layer in this way the number of layers also reduced and as the number of layers are reduced, the coils are easily mounted on the core.

Parameters	Values
Turns per Phase	216 turns
Total no. of Phases	3
Total no. of turns	648 turns

Table.2. For primary winding turns

A primary winding is the winding of a transformer that is connected to and receives energy from an external source of electrons. A transformer is an electromagnetic device that has a primary winding and a secondary winding that transfer energy from one electrical circuit to another by magnetic coupling without moving parts. The primary winding is analogous to the input shaft and the secondary winding to the output shaft. A primary winding is the winding of a transformer that is connected to and receives energy from an external source of electrons.

C. Secondary /winding: In the secondary winding of transformer the same wire is used for the secondary winding also, the secondary winding is wounded on the primary winding after its 3 primary layers were completed. At the secondary side the secondary is divided into 3 parts of the primary i.e. each part having 1/2 winding turns of the primary winding that means at the secondary side there are 105 turns are wounded on it in one part of the secondary in these way another 2 parts also constructed like these to get 1/2 supply of primary in the one coil of secondary.

In the secondary winding also the cylindrical windings are layer type and uses either circular or rectangular conductor. The layered winding may have conductors wound in one, two or more layer and therefore, accordingly called one, two or multi-layer winding. It is used for large current with number of parallel conductors located side by side in one layer. Parallel conductors have same length and located in almost same magnetic field, hence they are not transposed.

Cross over winding are used for high voltage winding of small transformer. When cylindrical windings are used for high voltage winding of small transformer, voltage between adjacent layers becomes too high and hence it becomes difficult to select thickness of interlayer insulation. Thus it is necessary to reduce interlayer insulation. It is achieved by dividing winding in number of coils separated by a distance of 0.5 to 1mm with the help of insulating washer or oil duct.

At the secondary winding 14 SWG aluminum Wire is used for the winding of transformer as per the consideration of window spacing between each limb for easily mount on the core comfortably. Because of choosing small gauge wire the large no. of turns are mounted in the one layer in these way the no. of layers also reduced and because of no. of layers reduced the coils are easily mounted on the core.

Parameters	Values
Total No. of windings on each phase	3
Total no. of layers	9
1st Layer	72
2nd Layer	72
3rd Layer	72
4th Layer	72
5th Layer	72
6th Layer	72
7th Layer	72
8th Layer	72
9th Layer	72
Total No. of turns	648

Table.3: Secondary winding turns.

IV.RESULT ANALYSIS

As per our design 2 KVA load equalizer transformer is constructed in the duration of phase 1 which is as shown in 4.

Figure.7: Load equalizer transformer.

The transformer test results are as shown below.

No Load test

In the no load test the 3 phase supply is given to its primary winding and no load current is calculated.

Phase	R	Y	B
Current	5	5	2.6
Voltage	233	238	238

Table 4: NO load test

Load test for R phase, 2KW load is given to the R phase.

Phase	R	Y	B
Current	7.2	3.3	5.6

Table 5: Load test for R phase

Load test for Y Phase, 2KW load is given to Y phase.

Phase	R	Y	B
Current	3.5	5.7	4.6

Table 6: Load test for Y Phase

Load test for B Phase, 2KW load is given to B phase.

Phase	R	Y	B
Current	7.9	6.4	1.7

Table 7: Load test for B Phase

Load test for Three Phase load, 2KW Load is given to each phase and the results are.

Phase	R	Y	B
Current	7.6	6.8	7.7

Table 8: Load Test three phase load.

V.CONCLUSION

Phase unbalancing problem occurs due to the load unbalancing conditions. This problem can be overcome by using load equalizer transformer. Now a days manual load shifting is done but to due to excessive overloading the winding of transformer burns out due to excessive overloading current. Hence to reduce this type of overloading fault conditions our three phase load equalizer transformer is very much useful and also balances the overload condition and health of the system.

REFERENCES

[1] Electrical Machinery by Dr. P. S. Bimbhra (Khanna Publishers) Electrical Machine Design.

[2] Nation al Institute of Standards and Technology (NIST), Technology Administration, U.S. Department of Commerce, “A Statistical Test Suite for Random and Pseudorandom Number Generators for Cryptographic Applications”, April 2010.

[3] Wayne Wolf “FPGA Based System Design” In Pretence Hall Modern Semiconductor Design series 1st edition 2005.

[4] Pawel Dabal, Ryszard Pelka “A chaos-based pseudo-random bit generator implemented in FPGA device.” In Design and Diagnostics of Electronic Circuits & Systems (DDECS), 2011 IEEE 14th International Symposium on 13-15 April 2011.

[5] John P. Uyemura, “Introduction to VLSI Circuit and Systems”, Wiley Publications, 2001.

[6] Yaobin Mao, Liu Cao, Wenbo Liu “Design and FPGA Implementation of a Pseudo-Random Bit Sequence Generator Using Spatiotemporal Chaos.” In 2006 International Conference on Communications, Circuits and Systems, Volume 4, 25-28 June 2006

[7] http://www.ijeatr.org/IJEATR.org/IJEATR_Vol.%202,%20No.%204,%20April%202014/Design.pdf.

[8] Three-Phase Automatic Load Balancing Applications A. Gouda*, A. Abul-Farag , H. Mostafa and Y. Gaber https://en.wikipedia.org/wiki/Main_Page.