Testing and Diagnostics of Neutral Earthing Current on 500kV/150 kV Inter Bus Transformer in Tasikmalaya EHV Main Sub Station

Mr.J.Kotaiah
Asst.Professor,EEE,SBIT
Khammam,TS,India
jupellikotaiah@gmail.com

Mrs.M.Sirisha
Asst.Professor,EEE,SBIT
Khammam,TS,India
sirishalaxman79@gmail.com

Mr.B.Hanuman
Asst.Professor,EEE,SBIT
Khammam,TS,India
bhanuman205@gmail.com

Abstract

In a fire at the Tasikmalaya EHV main substation on January 28, 2009, a phase-R, 166 MVA, 500kV/150 kV inter bus Power Transformer was destroyed, knocking off power to the JAMALI (JAVA-MADURA-BALI) interconnection system. The root of the issue has not been identified. Even after switching out the IBT's power transformer, the neutral earthing current continues to exhibit strange behaviour. Despite the little load, it was found that the neutral earthing current was much higher than in any other IBT transformer. We'll be collecting measurements, running simulations, and analysing data to find out what's up with the Ynyd-configured IBT 500/150 kV power transformer's abnormal neutral earthing current. To compare with other common situations, neutral earthing current was measured at three locations, including the Tasikmalaya EHV main substation, using true rms current recording for one week. Using a true rms current meter, we will determine whether or not a delta tertiary winding on an IBT transformer successfully reduces the zero-sequence current and whether or not there is a dc component on the neutral current due to geomagnetic field interference. The analytical and simulation results corroborated the measurement findings as well. The results of the simulations and analyses show that the total resultant neutral earthing current should be zero when there is no insulation leakage to ground. This is the case regardless of how skewed, balanced, or unbalanced the situation is.

Keyword:

neutral current, non-linear transformers, single- and three-phase transformers, transformers with less-than-ideal properties, and three-phase transformers.

Introduction

In a three-phase system, the neutral current is just the sum of the currents in the other two phases. All three phases will have currents that are equal in amplitude but 120 degrees out of phase with one another when the load is in equilibrium or resistive. This function allows us to offer a neutral cable in a four- or five-wire system, which is useful given that the neutral cable cross-section in a three-wire system may be rather small or eliminated completely. This is a theoretical need, but in reality, it is difficult to achieve. The current taken by the load is typically determined by inductive loads. PLN has made changes to the network's voltage levels by reducing the impedance losses to guarantee the safety and security of consumer-level devices. There is less unbalanced current and fewer harmonics at the source because the transformers are configured differently for each voltage level. Some transformers utilize a delta tertiary winding

to reduce the damage done by a fault current [1]. For the same reason that the main side currents sum to zero and no sequence currents are wasted, the load side of the transformer is also a Delta-Wye. Since a low voltage transformer's main side has no current, the sum of the three phase currents in the previous

segment will be 0. The transformer and supporting infrastructure must be in top condition. We'll use these values to conduct an analysis of the real world, checking first to see whether the transformer and power grid are perfect, then testing to see if neutral current occurs, and then identifying any non-ideal factors that may have contributed to its occurrence. If you transpose the phase twice, each phase will have the same capacitance to ground, which will decrease the capacitance imbalance in the network. This study analyses the consequences of utilizing a subpar transformer by looking at how the neutral current reacts to non-linearity in the core transformer.

Measurements of the neutral current at Tasikmalaya's primary EHV substation

The 500 MVA transformer of the Tasikmalaya EHV main Substation has a three-leg YNynd5 configuration [2] and uses a single-phase transformer core. (To get a picture, look at Fig. 1)
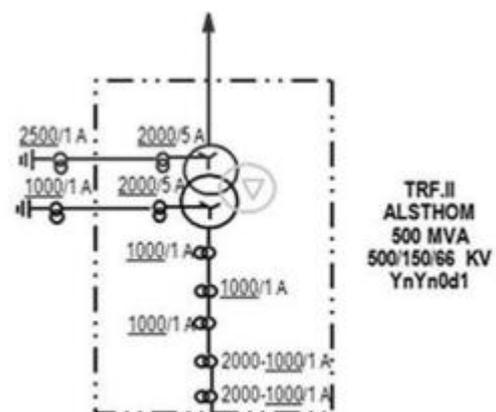

Fig. 1. Schematic of Tasikmalaya EHV Station transformer

To monitoring the measurement of neutral current trending, we installed data logger to the transformer with time stamp for sampling every 5 minutes. We also managed to take a wave shape snapshot of the neutral current every three hours. Fig. 2 and Fig. 3 are the example snapshot of the neutral current which took on 27 April 2012 [2]:
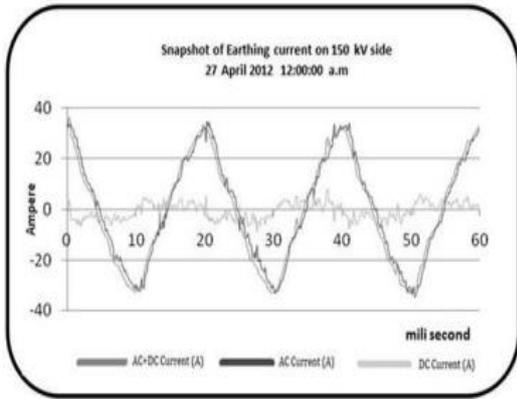

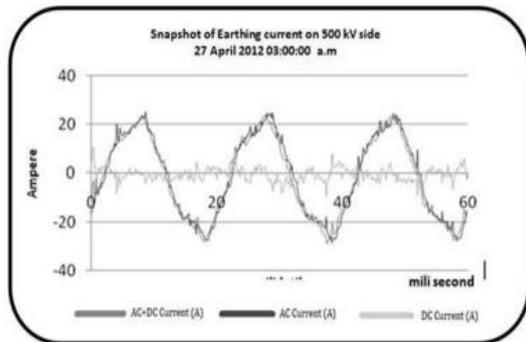**Fig. 2. Snapshot of Earthing current on 150 kV side**

Fig. 3. Snapshot of Earthing current on 500 kV

side We used two current clamp, AC and AC-DC clamp, to measure the neutral. To get the DC current we used Eq. (1) [3] :

$$I_{DC} = \sqrt{I_{AC-DC} - I_{AC}}$$

We also did neutral current measurements on the 500 kV side (primary) and 150 kV side (secondary) by using pliers amperage on April 26, 2012 [2]with the following measurements as shown below (table 1)

Table 1 Measurement Results of Neutral Current

Time	Primary Side	Secondary Side
09.45 a.m	16,7 A	21,3 A
6.00 p.m	20 A	32,6 A

From the measurement results above can be seen that the primary side neutral current is not a result

of the neutral current secondary side completely. Eq. (2) shows the relationship between primer current and secondary current of the transformer.

$$I_r = \frac{N_s}{N_p} I_s$$

in the same way that the main side's total three-phase current follows the same pattern. The results of it have been less than desirable. Network and non-ideal transformer capacitance imbalance prompted this investigation.

The outcomes of the experimental lab work

Several transformers are used to mimic a network in the lab, with each one representing a different voltage level typical of the transformers on a given network. There is no leakage capacitance added to the system. Here are the outcomes [2] when applying a balanced resistive load. (Check out Figures 4 and 5)
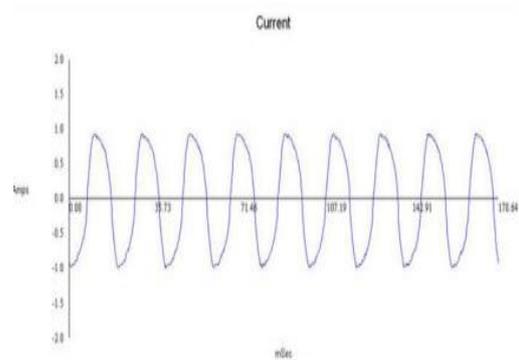

Fig. 4. Neutral current experimental results on secondary side of the tested transformer
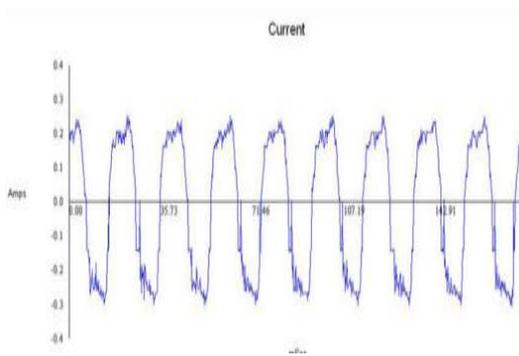

Fig. 5. Neutral current experimental results on primary side of the tested transformer

Current rating of the tested transformer is 4 A on the secondary side (150 V) so that the neutral current on the secondary side is about 1.8% (0.073), while the neutral current on primary side about 1.66% (0.02 A) from its current rating. With rating of 500 MVA transformer, the nominal current is :

$$I_N = \frac{S_N}{\sqrt{3}V_N}$$

VN is the line-to-line nominal voltage. So that the current rating on the 500 kV side is 577, 35 A and on the 150 kV side is 1924.5 A. From these, we get a large percentage of neutral current to nominal current is 1.7% (32.6) for the 150 kV side and 3.46% (20 A) on the measurement at 06.00 p.m. Magnetization currents in the transformer can reach 5% of full load current for a transformer made of hot rolled steel and can be smaller 0.5% of full-load current by using modern technology core making, cold rolled steel [1]. The magnetization current in the transformer is not sinusoidal. The higher frequency components in the magnetization current are due to magnetic saturation in the transformer core [4]. As described above, the neutral current is the sum of the three phase currents. Although the three-phase current has the same shape but differ 120o each phase, the sum will always be zero if the shape of the three-phase current is a pure sine. Infect, transformer magnetization current is not a pure sine. This causes the sum of the magnetization current transformer is not always zero and will flow through the neutral on primary side of the transformer No load test on load side connected to the network is performed to look neutral current on the transformer test without no load at secondary side of transformer lowest voltage level. These results are shown below [2] (Fig. 6 and Fig. 7).
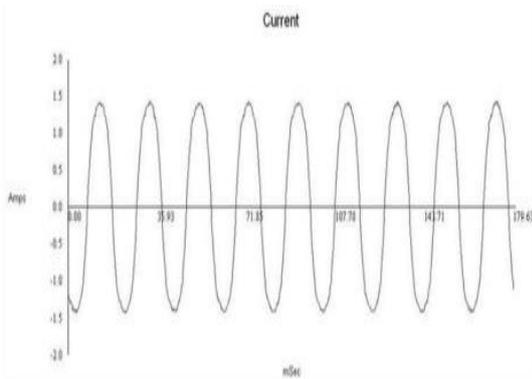

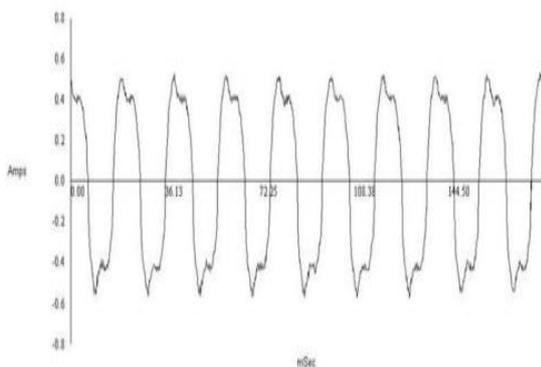*Fig. 6. Neutral current of secondary side on No load condition (0,11 A}*

Fig. 7. Neutral current of primary side on No load condition (0,04A)

These findings demonstrate that load is not the sole contributor to the transformer's neutral current. Since magnetization is voltage-dependent, the neutral current under no load is larger than the neutral current under load [5]. Because of the impedance of the transformer and wires, the network's voltage under full load will be lower than its voltage at no load. That's why it's true that magnetization currents are higher when the load is off than when it's on. The experimental findings further demonstrate the existence of magnetization current in the transformer. In a perfect transformer, current would not flow under the unload network situation. In reality, a current does flow. This is because the transformer's minimum magnetization current is drawn from the primary side. Currents for magnetization will come down from the secondary side of the transformer. Both the magnetization current and the primary current of the transformer will flow via the secondary winding. Also, transformers up high

Simulating and modelling:

transformer nonlinearity of fact, there is no way to really construct the ideal transformer [4]. In a real transformer, the windings' impedance and the core's nonlinearity both play a role. The permeability of a transformer core varies as a function of flux density[5]. The duality of electric-magnetic circuits allowed us to derive the equivalent circuit model. Our magnetic circuit uses individual magnetic components that are both discrete and lumped together. Assuming the flow density throughout is constant. The Tasikmalaya EHV Substation's non-ideal transformers necessitated modelling the equivalent circuit of a three-phase transformer consisting of three single-phase transformer core types, each of which has three legs and three windings on each phase (see Fig. 8 [6]). The three-phase single-transformer shown in Figure 8 Three-legged, three-wound, core type See Fig. 9 [6] for an illustration of the magnetic circuit we constructed using three single-phase transformers, each with three legs and windings.
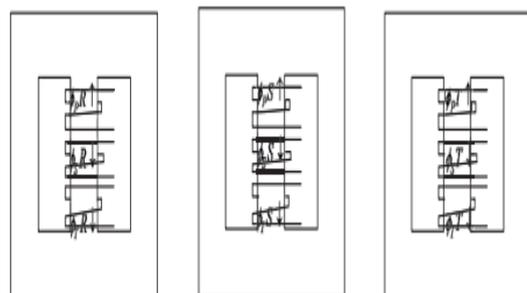

Fig. 8. Three single phase transformer Core type that have three legs and three windings

We created a magnetic circuit from three single phase transformer three legs and three windings, without ignored the flux leakages, see Fig. 9 [6].
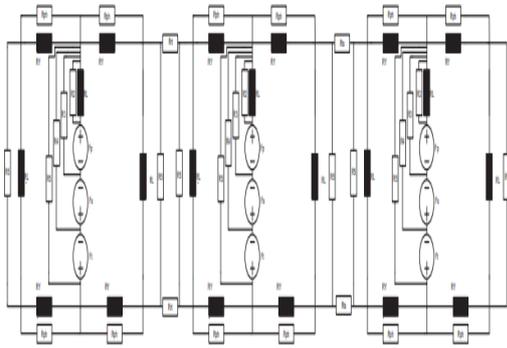

Fig. 9. Magnetic circuit of three single phase transformer Core type that have three legs and three windings

As shown in Fig. 10 [6], we then used the duality of electric-magnetic circuits to convert the magnetic circuit into an electric circuit.

Analysis

The waveforms of the neutral current measured in the laboratory are consistent with those found in the transformer at the Tasikmalaya EHV Main Station. Hot-rolled steel is used for the core of both transformers. The percentage of neutral currents never rises over 4%. The simulation results demonstrate that the neutral earthing current is created by the non-linear transformer core. Conclusion: Tasikmalaya EHV Main Station's transformer is of poor quality.

Conclusions

As a result of a subpar transformer at the EVH Station and the transformers that feed into it, the Tasikmalaya EHV Main Station has issues with neutral earthing current. A sine current is not suitable for magnetizing any transformer. In a three-phase transformer, a neutral earthing current flows between the primary and secondary windings if the sum of the magnetization currents in any one phase is greater than zero. Using tertiary windings linked to the main winding in a delta arrangement has the potential to decrease the neutral earthing current. This will cause the magnetization currents on the delta winding to rotate, which may result in the presence of harmonics.

References

[1] Heathcote, J. Martin, "J&P Transformer Book, 12th ed", Newnes.Madras:1998.

[2] Agus Purwadi, Nana Heryana, Didit PC, Anang Mawardi, Buyung S Munir,Didik F. Dakhlan, Dedi S, "Research Report : Kajian Arus Pentanahan Netral Transformator Daya Inter-Bus 500 kV/150 kV di Gardu Induk Tegangan Ekstra Tinggi (GITET) Tasikmalaya", PT.PLN R &D , 2012.

[3] Gill, Paul. "Electrical Power Equipment Maintenance And Testing, Second Edition".CRC Press. New York: 2009.

[4] Chapman, J., Stephen, "Electric Machinery Fundamentals 2nd ed", Mc Graw-Hill International Edition, Singapore: 1991.

[5] Slemon, G., R., "Equivalent Circuits for Trasnformers and Machines Including Non-Linear Effect", Monograph No. 68, SupplySection, July 15th, 1953. p. 129-143.

[6] Khorasani, G. Pouria, Deihimi, Ali, "A New Modeling of Matlab Transformer for Accurate Simulation of Ferroresonance", Powereng 2009, March. 18-20, 2009 .p. 529-534.