Report on lab# 1

Law, Security

Lab Report

Objective: To explore the characteristics of three single-phase transformers in a three-phase configuration.

Figure 1: Lab 1, Diagram.

- Star- Star (Y-Y) Connection

In star- star or Y-Y connection, each phase is 120° out of period with the extra two periods. In the same way, each secondary winding is 120° out of phase with the other two phases. Every primary winding is magnetically connected with secondary winding using the common leg. When talking about primary to secondary phases we will see that there is no phase difference in primary-secondary connections. It simplifies that both, primary and derived are in-phase with all supplementary parts. It can be imagined as both primary and secondary having same patterns of windings so that there is no phase difference. Y-Y transformers need lesser winding turns.

EL= EP/3

Line voltage or in other words phase-neutral voltage is 57° of the phase to voltage. This can be seen through calculations made in our experiment indicated by 53°, 73°, and -67°.

Figure 2: Currents and Voltages in Y-Y Connections.

Magnetizing currents in the 3- phase transformer are not sinusoidal. Exciting voltages are sinusoidal and magnetizing currents have significant quantities of odd-harmonic components.

Phase and Line Voltages

In an ideal three-phase transformer the phase voltage is 1/ (3)1/2 the line current. The quantity of twirls per stage and quantity of insulation required minimum. There is a phase shift of 30° between the phase voltages and line voltages on both main and derived are in-phase with each other. The ratio of voltages on primary and secondary sides is equal to the transformation ratio of transformers. The star- star connection works well for a balanced load. If the load is unbalanced, the neutral shifts. To avoid this, pin-up point of the main is necessary to be associated to the pin-up point of the producer. Let VL1 be the line voltage on the primary side. The phase voltage on the primary (VPh1) is given by,

VPh1 = VL/ (3)1/2

VPh1 = 1/a {VL1/ (3)1/2}

Since Ip = IL, the current throughout the windings is high. The windings must have a large cross-section and must be mechanically strong so that they can bear heavy loads and short circuit. These values are also same in performing experiments where both line and phase voltages are 37. 4 mA.

- Star- Delta Connection

In star-delta connections, it is a 30° phase difference between primary and secondary line voltages. The neutral is available on the primary side and the secondary allows the flow of third harmonic. The main function of these types of transformer is to step down voltages and they can be seen at the distribution side in the transmission network. The shift in the phase of primary and secondary sides can be shown in the readings of experiment, primary: 100° and secondary 136°.

VPh2 = 1/a VPh1 = VL1/ a (3)1/2.

Turns ratio, a = VPh1/VPh2

This difference in voltages is also shown in the readings 15 and 26 V from experiment.

Lab#2

Objective: To explore the characteristics of AC power in single-phase and three-phase configurations.

Figure 3: AC Power Analysis.

- Single Phase Circuit

A conventional single-phase circuit consists of voltage or current sources and impedances (resistance, capacitance, and inductance) connected with these sources. These components are connected in series or in parallel.

Figure 4: A simple single-phase R-L-C circuit.

Instantaneous Power

Instantaneous power has a constant (average power) which depends on rms voltage, rms current and power factor cosØ as well as a time varying term, which has a frequency twice that of the source. The voltage and current sources, both produce sinusoidal voltage and current waves. Voltage can found by following expression:

In above expression v (t) = instantaneous voltage.

Vrms = Root mean square voltage. ω = Angular frequency.

f = frequency of the source.

Here VP = Peak Voltage.

Similarly, current in a single-phase AC circuit can be calculated by following formulas:

‘ Z’ is the combined impedance of the entire circuit. The phase of the circuit can be measured by the formula:

The measured phases of the experiment are 120°, -115°, and 118°.

- Three- Phase circuits

Three-phase circuits, there exists a neutral point, which is grounded. Three-phase voltages have equal magnitudes and they differ only in phases. The phase difference or phase shift for each phase in a three-phase system is 120°.

Figure 5: Three-phase voltages and phase shifts.

Phasor diagram is used to visualize the system voltages. Three- phase systems have two common configurations known as wyes connections and delta connections respectively. Wye systems have two types of voltages known as line-to-neutral and line-to-line voltages. The line-to-line voltages are shifted with 120°. Line-to-line voltage also leads line-to-neutral voltage by 30°.

- Power Calculations

Power is the multiplication of current and voltage for both single-phase and three-phase systems. AC power has three components known as true, reactive, and apparent power. Power factor is the ration of real power and apparent power.

P = true power.

Q = reactive power.

S = apparent power.

Reactive Power: Components like inductors and capacitors known as reactive components dissipate zero power. However, the drop voltage and draw currents and give the impression of dissipating power. This power is known as reactive power and measured in a unit known as volt-amp-reactive or (VAR).

True Power: it is the actual amount of power consumed by the circuit and its units are watts.

Apparent Power: It is the combination of true and reactive power. It is simply the product of circuit’s voltage and current. It is represented by the symbol (VA).

Formulas for each of the powers are given below:

Power factor: True Power/Apparent Power.

Power measured in the experiments are 39, 33. 45, and phase currents are 33 and 14. 38.

Lab #3

Objective: To observe Thevinin’s theory and star-delta conversion.

- Thevinin’s Theorem: Any two- terminal of a set-up of any amount of resistors, current sources, and/or voltage resources can be condensed to one voltage source in series with a resistance. The voltage appearing at the output terminal of the obtained equivalent circuit is known as Thevinin’s voltage and the resistance is called Thevinin’s Resistance.

Procedure

- Locate the two output terminals.
- Remove anything from the circuit that is not to be well thought-out part of the supply.

- Find the open circuit voltage across these terminals. This voltage is known as Thevinin's equivalent voltage VTH.

- All sources are turned off and replaced by a characteristic resistance.

- Find the resistance across the terminals known as source resistance Rs.

Similarly, to the three terminal systems every circuit can have an equivalent star and delta impendence. Star and delta impendence can determine which circuit is to be connected.

Za= Z1Z2Z1+Z2+Z3 Z1= ZA+ZC+ZAZCZB

Figure 6: Thevinin Theorem.

In the lab, we have observed a circuit similar to the circuit shown in fig-6. We apply calculations. We apply the procedure mention to find Thevinin's Voltage and Thevinin's Resistance. We were given V = 929 V and I = 335 mA. From Ohm's law, it is derived thatR= VI. So we will getR= 929335,

= 2773. 13 Ω. Thevinin's Theorem simplifies a large circuit into two components only known as resistance and voltage source only. One can solve number of resistances and source with help of two simple equations given below:

and.

Equivalent Resistance is measured by replacing a voltage source with a short circuit and a current source by an open circuit. The technique can be shown with the help of following diagram:

Figure 7: Thevinin's Resistance.

Resulting circuit in its simplest form is represented in following diagram:

Figure 8: Thevinin’s Equivalent Circuit.

In the lab the Thevinin’s resistance for the circuit can be RTH = 2. 9 KΩ.

- Converting for Star to Delta

Branches in an electrical system can be connected with each other in a number of forms, but most important among them is either a star or a delta form. In delta connection, branches are connected in a way to form a close loop. Three branches are connected from nose to tail forming a triangular closed loop. On the other hand, when either terminal or three branches are connected to each other on a single common point it is said to be in Wye, Y or star connection. These connections can be transformed into each other when required. The transformation is often done for the sake of simplicity.

Figure 9: Converting Delta to Star.

The equations can be obtainable in an exchange form based on the whole confrontation (Rd) of R1, R2, and R3 (as though they were located in sequence):

Rd = R1+R2+R3

And:

RA = (R1*R3) / Rd

RB = (R2*R3) / Rd

RC = (R1*R2) / Rd, in lab same values were,

Ra = 2, 8075Ω.

Rb = 1, 3225Ω.

Rc = 0, 9125Ω.

Lab # 4

Objective: To observe the characteristics of different over- current protection technologies and variants.

Need for Circuit Protection

There are several reasons for which circuits need protection and some of them are discussed below:

- Temperature

It is a well-known fact that current flow in a conductor causes it to heat. It has been observed that the greater the current greater will be the head produced. Excess heat is damaging to the electrical components in the appliances and sometimes damages the insulation over the conductor. For this reason, conductors have their current ratings.

Excess current is called over current. An over current may occur from a short circuit, overload, and ground fault.

- Overloads

An overload occurs when too many devices are operating in an electrical circuit or due to electrical utensils is prepared to effort further than its evaluation, or in other terms capabilities. When overload damage to the connected electrical components or conductors that supply current to the equipment can occur. It can be avoided by using a protection device that can shut down operations when overload occurs.

- Short Circuit

A short circuit is a low confrontation path for current created when two bare conductors touch each other. When a short circuit occurs, it can cause decrease in resistance and an increase in high current. Current caused due to short circuits are higher than normal operating voltages.

Types of Devices for Protection

- Fuse

A fuse is a one try tool. The temperature formed by the excessive or over current caused the current carrying element in fuse to melt down and disconnect the load from the source voltage. There are generally two types of fuses known as non-time delay fuses and time-delay fuses. Non-time delay fuses have a rating of 500%, meaning that they cannot operate at the currents greater than 500%. Another type of fuses is known as time-delay fuses providing overload and short circuit protection. It causes a time delay before starting any electrical component. In the lab, we observed some fuses and it was at 290→110 A, and 100 % current fuse took minimum time of 0. 24 s to disconnect the circuit from the source. Same fuse did not disconnect the circuit from the source on the application of 40% a current. It can be concluded that greater the current greater will be the probability for the fuse to disconnect the circuit from the source. S

- Circuit Breaker

Circuit breakers provide manual means of bracing and de-bracing an electric route with automatic over current protection. Unlike fuses, circuit breakers require to be replaced when they are open. Pushing the handle back to the ‘ OFF’ position back to the ‘ ON’ position restores the circuit.

Figure 10: Operation of a Circuit Breaker.

In the lab, we observed circuit breakers and calculated the rating of three different breakers. Breaker 3 was the most sensitive breaker among them as it took only 0. 160 s to break a circuit on the application of 100% a current. At 30%, a current highest time was taken by breakers to break the circuit with breaker 1 taking 109. 2 s.

Lab # 5.

Objective: To explore power loss in magnetic circuits.

Generally, two types of losses are experienced by the magnetic circuits known as Hysteresis losses and Eddy current losses.

- Hysteresis losses

Figure 11: Hysteresis Loop.

A magnetic field is generated on the application of current to a magnetic material. This magnetic field opposes in both magnitude and direction to its cause. A loop is formed while magnetizing and demagnetizing an object and is known as hysteresis loop. It has several components representing different stages in a material discussed below.

- Retentively: it is a material’s ability to save a firm quantity of remaining captivating field when the magnetizing power is detached. It is presented by point ‘ b’ in the above figure.
- Coercive force: The amount of overturn magnetic field, which must be practical to a magnetic matter to create a magnetic flux return to zero.
- Permeability: it is the measure of the ease with which a magnetic flux is generated in a material.

It is represented by the following diagram in lab:

Figure 12: Hysteresis Curves.

- Eddy Current Losses

When a changing magnetic field cuts through a sample of magnetic materials and metal a circulating current is induced according to Faraday’s law. Eddy currents cause Joule heating and reduction in the efficiency of the material, operating under magnetic field condition. Lamination of the materials and increasing resistivity of the material are some way to reduce the effect of Eddy Currents.

Figure 13: Resistivity.

Figure 14: Variation in voltage and resulting losses.

In the lab different parameters were changed to see their impact on magnetizing materials. It was observed that with the increase of input voltage power consumption the material also increased. For instance, when the voltage was increased to 30. 6V, the current was decreased to 66mA and so was the power dissipation or consumption to 8. 5W. At the lower voltage for instance, 10. 7V the current was greater upto 210mA and the power consumption was 1. 2W. This indicated the increase in power losses. It is concluded that greater the cause; greater will be the effect. Losses were created with the same increased intensity with the increase in input effort.

Lab # 6

Objective: To explore the characteristics of harmonics.

A harmonic is a sign or signal whose incidence is an essential manifold of the incidence of some orientation signal or wave. It can also be said harmonic is a ratio of the frequency of the signal to frequency of reference signal or wave. Nearly all signals have harmonics and have harmonic frequencies. If all the energy in a signal wave is concentrated at the fundamental frequency, it is a perfect sine wave. Some waveforms contain large amount of harmonic frequencies. In communications, transmitters are designed in such a way to emit minimum of energy at harmonic frequencies. A communication device is designed to operate on a single frequency. The receiving end of a communication channel, however, is designed to receive attenuated frequencies. These frequencies are later filtered using filters to restore the original signal. In the lab, we observed different signals generated by the signal generator. These signals were the different harmonics of different waveforms. For instance, a waveform saw tooth started from 170 Hz to 216 Hz. The claim that all harmonics are themselves of sine also seemed true as sine wave changed to square wave when the frequency was changed from 629 Hz to 157 Hz.

$f_{complex} = V_o+V_1\sin(2\pi f_1 t+ \theta_1)+V_2\sin(2\pi f_2 t+ \theta_2)+V_3\sin(2\pi f_3 t+ \theta_3)+.$

Above equation, holds true because it was observed all the waveforms could be integrated to give a single base frequency. By making changes in phase, frequency and amplitude or voltage one waveform can be changed into another.