Power and Distribution Transformers

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Abstract:

First of all we have to know what transformers are and how they work. A transformer is an electrical device that transfers energy between two or more circuits through electromagnetic induction. A varying current in the transformer's primary winding creates a varying magnetic flux in the core and a varying magnetic field impinging on the secondary winding. This varying magnetic field at the secondary induces a varying electromotive force (EMF) or voltage in the secondary winding. Making use of Faraday's Law in conjunction with high magnetic permeability core properties, transformers can thus be designed to efficiently change AC voltages from one voltage level to another within power networks.

Keywords:

Power transformer, distribution transformer,

KVA (kilovolt ampere).

I. Introduction

A distribution transformer is a transformer that provides the final voltage transformation in the electric power distribution system, stepping down the voltage used in the distribution lines to the level used by the customer. The invention of a practical efficient transformer made AC power distribution feasible; a system using distribution transformer was demonstrated as early as 1882. If mounted on a utility pole, they are called pole-mount transformers. If the distribution lines are located at ground level or underground, distribution transformers are mounted on concrete pads and locked in steel cases, thus known as pad-mount transformers.

Distribution transformers normally have ratings up to 200 KVA, although some national standards can describe units up to 5000 KVA as distribution transformers. Since distribution transformers are energized for 24 hours a day (even when they don't carry any load), reducing iron losses has an important role in their design. As they usually don't operate at full load, they are designed to have maximum efficiency at lower loads. To have a better efficiency, voltage regulation in these transformers should be kept to a minimum. Hence they are designed to have small leakage reactance.

II. Classification

Distribution transformers are classified into different categories based on certain factors such as:

1. Mounting location - pole, pad, underground vault.

2. Type of insulation - liquid-immersed or dry-type.

3. Number of Phases - single-phase or three-phase.

4. Voltage class

5. Basic impulse insulation level (BIL).

III. It's Use

Distribution transformers are normally located at a service drop, where wires run from a utility pole or underground power lines to a customer's premises. They are often used for the power supply of facilities outside settlements, such as isolated houses, farmyards or pumping stations at voltages below 30 kV. Another application is the power supply of the overhead wire of railways electrified with AC. In this case single phase distribution transformers are used.

The number of customers fed by a single distribution transformer varies depending on the number of customers in an area. Several homes may be fed off a single transformer in urban areas; rural distribution may require one transformer per customer. Many large buildings have electric service provided at primary distribution voltage. These buildings have customer-owned transformers in the basement for step-down purposes. In a secondary network system as used in urban areas, many distribution transformers may be connected in parallel, each equipped with its own network protector circuit breaker to isolate it from the secondary network in case of a fault.

Distribution transformers are also found in the power collector networks of wind farms, where they step up power from each wind turbine to connect to a substation that may be several miles (kilometres) distant.

IV. Connections

Figure 1. Phase-to-phase transformer in Britain

Both pole-mount and pad-mount transformers convert the high 'primary' voltage of the overhead and underground distribution lines to the lower 'secondary' voltage of the distribution wires inside the building. The primaries use the three-phase system. Main distribution lines always have three wires, while smaller "laterals" (close to the customer) may include one or two phases, used to serve all customers with single-phase power.

Figure 2. Three Phase distribution transformer in Syria.

If three-phase service is desired, one must have a three-phase supply. Primaries provide power at the standard distribution voltages used in the area; these range from as low as 2300 volts to about 35,000 volts depending on local distribution practice and standards; often 11,000 V (50 Hz systems) and 13,800 V (60 Hz) systems are used but many other voltages are standard.

V. Differences

Power transformers are used in transmission network of higher voltages for step-up and step down application (400 kV, 200 kV, 110 kV, 66 kV, 33kV) and are generally rated above 200MVA.

Distribution transformers are used for lower voltage distribution networks as a means to end user connectivity. (11kV, 6.6 kV, 3.3 kV, 440V, 230V) and are generally rated less than 200 MVA.

VI. Transformer Size / Insulation Level

Power transformer is used for the transmission purpose at heavy load, high voltage greater than 33 KV & 100% efficiency. It also having a big in size as compare to distribution transformer, it used in generating station and Transmission substation .high insulation level.

The distribution transformer is used for the distribution of electrical energy at low voltage as less than 33KV in industrial purpose and 440v-220v in domestic purpose. It work at low efficiency at 50-70%, small size, easy in installation, having low magnetic losses & it is not always fully loaded.

VII. Iron Losses and Copper Losses

Power Transformers are used in Transmission network so they do not directly connect to the consumers, so load fluctuations are very less. These are loaded fully during 24 hr's a day, so Cu losses & Fe losses takes place throughout day the specific weight i.e. (iron weight)/(cu weight) is very less.

Power Transformers are used in Distribution Network so directly connected to the consumer so load fluctuations are very high. these are not loaded fully at all time so iron losses takes place 24hr a day and cu losses takes place based on load cycle. the specific weight is more i.e. (iron weight)/(cu weight).average loads are about only 75% of full load and these are designed in such a way that max efficiency occurs at 75% of full load.

Power transformers are used for transmission as a step up devices so that the I2r loss can be minimized for a given power flow.

Distribution transformers obviously cannot be designed like this. Hence the all-day-efficiency comes into picture while designing it. It depends on the typical load cycle for which it has to supply. Definitely Core design will be done to take care of peak load and as well as all-day-efficiency. It is a bargain between these two points. In Power Transformer the flux density is higher than the distribution transformer.

Types of Distribution Transformer

There are two main categories of distribution transformers:

1. Liquid filled Transformer.

Liquid filled (using mineral oil or replacement fluids such as synthetic or natural esters) and dry type. The liquid filled transformers are the most compact and cost efficient solution, whereas dry type transformers are preferred in environments where fire safety is of special importance such as, for example, underground substations, mining sites, marine and some industrial applications.

2. Dry Transformer.

Standard versions of distribution transformers are cooled passively as the heat generated by losses is transported away from the core by natural convection of the insulation medium. In the case of liquid filled products, this heat is then transported through the tank walls by thermal conduction and removed by the natural or forced convection of air. Dry transformers in closed environments usually have a forced internal convection flow of air to ensure sufficient cooling of the transformer core.

Dubai's 868m high Burj Khalifa building is equipped with 78 ABB dry type transformers.

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