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Short Review Paper

A study on harmonic mitigation by using isolation transformer

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Abstract

With the development of electronics technology, the loads of power system become more efficient in terms of power consumption but more nonlinear in nature. This nonlinearity nature of loads causes development of harmonic contents in system. The harmonics not only distort the current and voltage waveforms of its own, but also, that of other system connected to it. The use of Isolation transformer is one of the solutions to this problem. This paper discusses about the Isolation Transformer, which is a harmonic mitigation technique. Harmonic contents in any system cause different problems like poor power factor and, hence, it results in lower efficiency of system. The main function of Isolation Transformer is to pass the common mode noise and transverse mode noise to prevent the connected system from above mentioned problems. This paper includes basic principle of working, construction, operation and normal circuit connection of Isolation transformer.

Keywords: Isolation Transformer, Faraday Shield, Electrostatic Shielding, Dedicated Transformer, Drive Isolation Transformer.

Introduction

This paper gives a review on Isolation Transformer and its different forms according to different loads. The working of Isolation Transformer is based on principle of "Faraday Shield or Cage". It uses an electrostatic shield in between the primary and secondary winding. Sometimes, it is known as Dedicated transformer (if N_1 is not equal to N_2) (N_1 is primary turns and N_2 is secondary turns) and, sometimes, as Drive isolation transformer (if it is used before an adjustable speed drive system). The principle, construction and operation are explained further. The construction of Isolation Transformer is based on SQUARE D Company[1].

Principle of working of isolation transformer

The working principle of Isolation transformer is based on the Faraday Screen or Shield. A transformer with unit transformation ratio (i.e. 1:1) is supplied with an earthed "Electrostatic shield" i.e. the shield is connected to earth, so that it transfers the undesired waves to the earth. This shield provides low impedance path due to reactance coupling in between primary-secondary winding to the shield, to reduce transients, noises and zero sequence currents exist under abnormal condition and helps to bypass the common modes disturbances to their generating winding side (either windings of transformer)[2,3]. The following figures show two cases.

Figure-1 shows the travelling of transients due to capacitive coupling between primary and secondary windings and affect the sensitive loads in terms of inefficient performance.

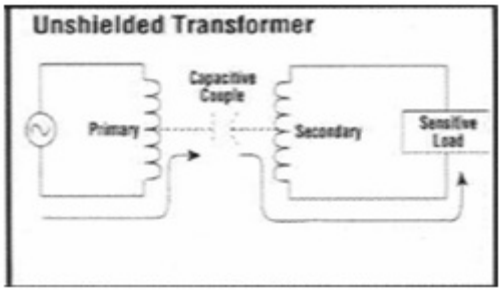

Figure-1: Unshielded Transformer.

Figure-2 is of a transformer with electrostatic shield, which helps to bypass the transients to ground, coming from primary winding.

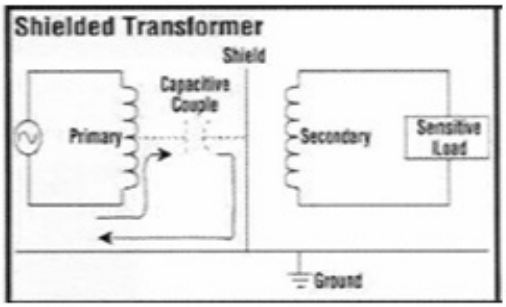

Figure-2: Shielded Transformer.

Figure-3 shows a general isolation transformer with its typical features, i.e. Unity Transformation Ratio and an extra "Barrier made up of Dielectric material" or insulation between windings. It can be termed as Double insulation.

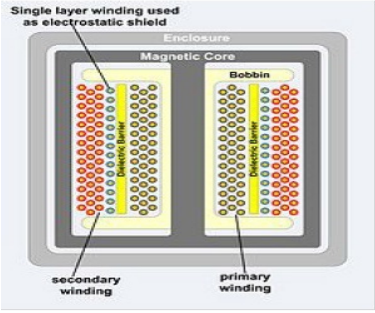

Figure-3: General Isolation Transformer.

Figure-4 shows the circuit symbol used for the transformer with electrostatic screen preventing capacitive coupling between the windings. The dotted line indicates the electrostatic shield.

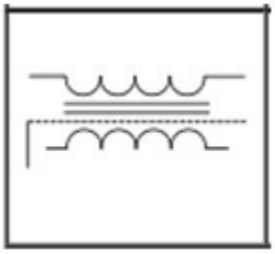

Figure-4: Symbol for Isolation Transformer.

Constructions and operations

The shield or screen used between Primary and secondary winding of Isolation transformer is a sheet of copper or a single layer of insulated wire or conductor but it must be connected to earth[1]. Generally, the transformation ratio is unity and the typical configuration of it is delta primary and wye secondary for power quality purpose[2]. Isolation transformer is used in different places with some modifications in their constructions but using same principle.

Dedicated isolation transformer: It is the isolation transformer with non unity transformation ratio. It is used to reduce low- and high- frequency electrical noises and transients. It is used to reduce interharmonics, voltage notching, capacitor switching and lightening transients. It also allows user to define new ground reference that will limit the neutral to ground voltages at sensitive loads[4].

Drive isolation transformer: It is the isolation transformer used before the adjustable drives (either AC or DC motors). It provides reactive control of current harmonics. It decreases current waveform distortion and improves power factor. It reduces voltage waveform distortion and prevent from affecting the sensitive loads. It is either static bridges or SCR switch input type. It can be operated in two ways: i. If its secondary is ungrounded or resistor grounded with high value of resistance is used, and then the electrostatic shield may be useful. ii. If its secondary is grounded, the common mode noise from primary side cannot be induced between the neutral and ground because all noises are grounded, i.e. the electrostatic shield is not useful here[5].

The two main function of this Drive isolation transformer is reduction in harmonic distortion and voltage notching. The Figure-5 shows Drive isolation transformers in which, it reduces effects of harmonic voltage distortion of adjustable frequency and dc drives. It can be seen that it is connected before the drive and, it prevents other loads from harmonic distortion produced due to different drive system.

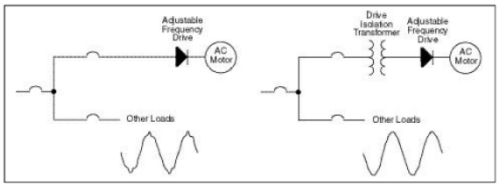

Figure-5: Drive isolation transformer.

Similarly in Figure-6, it is used to reduce source voltage notching.

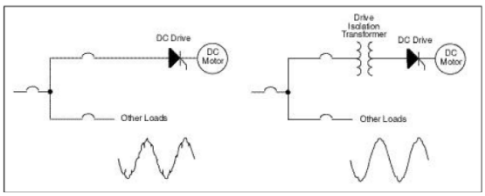

Figure-6: Drive isolation transformer.

In a transformer without electrostatic shielding, a capacitive coupling between primary and secondary winding is present. The common mode noise or line to ground transient can travel by this electrostatic coupling due to capacitance exists in between primary and secondary winding. This capacitive coupling is also responsible for introduction of nonlinear distortion at low frequency[1]. But an isolation transformer with an electrostatic shield can capacitively short circuit to ground, i.e. provide a low resistance path to ground for unwanted high frequency signals. This electrostatic Faraday shield mainly protects the sensitive devices from the common modes electrical noises and transient[6]. In this case, the harmonics are attenuated by factors varying from 1.9 to 5.4[7]. Figure-7 shows common mode noise attenuation by using shielded isolation transformer. Then, the secondary side is less affected. If an attenuating filter is used then, the common mode noise doesn't need to consider.

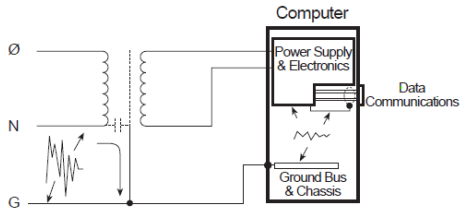

Figure-7: Common mode noise attenuation by using shielded isolation transformer.

The Figure-8 shows the transverse mode attenuation through an isolation transformer.

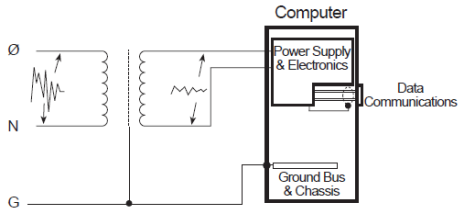

Figure-8: Transverse mode noise attenuation by using shielded isolation transformer.

Usage

It is most important in case, where the secondary winding of transformer is ungrounded. Transients on high voltage side of a transformer can drastically increase the surge voltage seen on ungrounded secondary winding as compared to that on grounded winding[7].

Figure-9: An example of 1:1 isolation transformer with 230/230 V (from wikipedia).

Conclusion

The principle of working and operation of Isolation transformer is explained above. It can be concluded as the isolation transformer has similarity with normal transformer in terms of isolated electrical network but closed magnetic circuit. But it is differ in terms of some additional features as unity transformation ratio, electromagnetic Faraday shield or screen and typical configuration of windings (delta primary and wye secondary). It can be used with harmonic generating equipments because it limits the effects of harmonics on other connected system. It cannot eliminate harmonics completely[8].

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