Review of Ultra Isolation Transformer Testing

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Abstract **-** Many sophisticated electronics equipments and rapidly expanding computer-control systems and information networks are sensitive to line transients, spikes and notches and they must be protected from high voltage surges and made immune from noise. Unfortunately, due to power electronic circuits, welders, variable speed drives, and SCR controls used in computers and many other electrical systems, electrical noise is introduced on the facility's own power distribution system which leads to the corruption of the clean power. If they are not suppressed, they can cause memory loss in computers, component failure, scrambled data transmission, etc.

For AC systems, electrical noise is a distortion of the normal sine wave. Some effects noise has on electrical systems are data loss, computer lock-up, equipment malfunction, and occasionally destruction .These impulses are of very short duration of the order of the order of a microsecond to very few milliseconds. But their amplitude can range from hundreds to thousands of volts. They can be caused by lightning, mains line switching air conditioning or switching of any heavy duty machinery. Therefore, noise attenuation devices are a necessity. Although it is impossible to totally eliminate electrical noise, it is possible to drastically reduce it to tolerable levels. Electrical noise attenuation devices, such as, TVSS (Transient Voltage Surge Suppression), noise filters and shielded isolation transformers reduce electrical noise to safe levels.

The objective of this project is to design a testing unit for ultra isolation transformer for measuring its common mode noise attenuation capability. Noise attenuation is expressed as a ratio of the output transient energy (Vto) to the input transient energy (Vti), or by decibels (dB). The Common mode noise rejection should be about -100 dB. If this condition is satisfied, then we can conclude that the ultra isolation transformer under test is able to eliminate common mode noise providing electrostatic shielding and protection against spikes, surges and transient noise.

Keywords *- ultra isolation transformer; common mode noise rejection;*

I. INTRODUCTION

Present day electronics are far more sophisticated than ever imagined. Any electrical system, particularly microprocessor based equipment such as industrial computers and data acquisition systems require clean, noise-free power to perform optimally. The power supplies we use today are of the non-linear switch-mode topology. By the nature of their design, switch-mode power supplies are moderately immune to voltage variations [1]. On the other hand, they are quite susceptible to damage or limited life resulting from voltage excursions and long duration transients that occur in periods longer than the switching frequency of the switch-mode power supplies [2]. These impulses are of very short duration of the order of the order of a microsecond to very few milliseconds. But their amplitude can range from hundreds to thousands of volts. They can be caused by lightning, mains line switching air conditioning or switching of any heavy duty machinery.

It is imperative to protect the sensitive electronic equipment from harsh electrical environments; especially when time and production is at stake. The proper way of accomplishing the necessary protection is by resorting to the fundamentals of power conditioning (isolation and single point grounding).The transformer must be designed for the special needs of the switch-mode power supply in order to obtain the maximum effectiveness.

Transformers such as ultra isolation transformer reduce electrical noise to safe levels. Although it is impossible to totally eliminate electrical noise, it is possible to drastically reduce it to tolerable levels. Ultra isolation transformer provides electrical and electrostatic isolation with the most effective screening of spikes, surges and transients. It predominantly eliminates the common mode noise and transverse mode noise and provides noise or interference free power.

The proposed system will be helpful in determining the common mode noise rejection capability of an ultra isolation transformer. It is designed to test the ability of transformer to generate clean noise free output voltage. Noise attenuation is expressed as a ratio of the output transient energy (Vto) to the input transient energy (Vti), or by decibels (dB).

There are two main types of noise, common mode and normal mode (also known as transverse mode). If a severe common-mode surge, such as a lightning surge, enters into a massive loop and comes into power lines by induction coupling, it propagates through the lines as a traveling wave. The wave runs along a pair of lines in the same direction until it reaches an isolation transformer installed for surge protection. It is not difficult to prevent such a surge from entering into electric devices by electric conduction. Entry can be prevented by carefully insulating the separate coils in the transformer with high-quality insulation material.

II. PROBLEM STATEMENT

Electrical noises can interfere in the operation of digital electronic equipment, microprocessors, sensitive devices, remote control equipments, and telecommunication equipments. Ultra isolation transformer eliminates all types of electrical noises predominantly common mode noises and transverse mode noise providing noise or interference free power. It provides electrical and electrostatic isolation with most effective screening of spikes, surges and transients.

The objective of this project is to design a testing unit for ultra isolation transformer for measuring its common mode noise attenuation capability. This common mode noise attenuation capability is measured by: CMNR = 20log (Vo=Vi). The Common mode noise rejection should be about -100 dB. If this condition is satisfied, then we can conclude that the ultra isolation transformer under test is able to eliminate common mode noise and provide electrostatic shielding and protection against spikes, surges and transient noise.

III. LITERATURE REVIEW

A. Ultra Isolation Transformer

With ever increasing use of precision electrical equipment, the requirement for clean and regulated power is a must. Due to the advent of switch-mode power supplies and other non-linear loads, transformers that provide excellent power conditioning capabilities and can handle high harmonic currents are a necessity to ensure that your equipment operates smoothly and without any upsets [2].

The correct transformer must be designed well below its saturation level for quick recovery and the high crest factor demand of the switch mode power supply [2]. It is also mandatory that the ratio of inductance (XL) to resistance (R) is higher than a standard linear load designs to prevent over voltage stress on the solid state switching devices at the moment of a transient. The transformer must exhibit an exceptionally low inner winding capacitance (typically .001pf) to eliminate coupling of high frequency common mode noise generated by the load. Transient filter networks are also necessary to effectively enhance the transverse mode rejection and the efficiency of the transformer should be 98% or better.

In ultra isolation transformer the primary and secondary of the transformer are wound on separate cores ,multiple shielded and fully isolated from each other and ground to ensure extremely low inter winding capacitance. It acts as an effective, low pass filter and suppresses line transients, spikes and galvanic leakage to protect the system. Due to the total isolation from mains line the ultra isolation transformer output is extremely safe to handle and suitable for medical application as well.

With very special construction all types of electrical noise predominantly common mode noise is eliminated by this UIT. Since it isolates primary and secondary and separated neutral to ground bond on the secondary side it can be used to create separately derived source to combat current loops. High insulating materials with special shielding techniques attenuate common mode noise as well minimize transverse mode noise.

The specially selected core with its magnetic properties exhibit sufficient leakage inductance to attenuate noise with proper transfer of fundamental power frequency. The UIT is designed with split winding construction and bipolar connections to reduce coupling capacitance of winding.

B. Noise sources

Noise is generally caused by electromagnetic interference (EMI), radio frequency interference (RFI), and ground loops.

1. EMI

Electronic equipment can be divided into two main EMI categories. The first category comprises intentional radiator devices such as radio and television transmitters, citizen's band and amateur radio transceivers, cellular telephones, radar and electronic navigation systems etc., wherever rf signals are being deliberately emitted.

The second category is composed of unintentional radiators such as computers, home television and stereo sets, office equipment—such as printers, copiers, fax machines, etc., fluorescent lights, power tools, and power lines. This category causes the most problems for systems, devices, and designers.

There are, of course, natural sources of EMI such as lightning, cosmic radiation, solar radiation, and nuclear decay.

Most electronic equipment has an EMI filter on the front end of the power supply. EMI may be radiated and can couple into the system through the metallic enclosures or through the data lines. Unshielded twisted pair (UTP) wiring is a likely candidate for noise pickup. This is especially likely if there is an inadequate ground, or the cable is routed close to a noise source.

2. RFI

RFI is the propagation via radiation (electromagnetic waves in free space) and by conduction over signal lines and ac power distribution systems. There are two modes of propagation.

The first mode is radiated. One of the most significant contributors to radiated RFI is the ac power cord. The power cord is often a very efficient antenna since its length approaches a quarter wave length for RFI frequencies present in digital equipment and switching power supplies.

The second mode, conducted, is induced over the ac power system in two ways. Common-mode (asymmetrical) RFI is present on both the line and neutral current paths with reference to the ground or the earth path. Differential (symmetrical) RFI is present as a voltage between the line and neutral leads.

3. Ground Loops

Ground loops can cause data errors, component failures, lock-ups, and, worst case, even cause safety hazards. When ground loops are formed, the current that flows in the system ground is very unpredictable. This ground current can be caused by voltage differences, induction from other cables or devices, wiring errors, ground faults, and normal equipment leakage. The currents can be dc, 60 Hz, or very high frequency.

C. Noise Attenuation

For AC (alternating current) systems, electrical noise is a distortion of the normal sine wave. Some effects noise has on electrical systems are data loss, computer lock-up, equipment malfunction, and occasionally destruction. Therefore, noise attenuation devices are a necessity. Electrical noise attenuation devices, such as, TVSS (Transient Voltage Surge Suppression), noise filters and shielded isolation transformers reduce electrical noise to safe levels [7]. Although it is impossible to totally eliminate electrical noise, it is possible to drastically reduce it to tolerable levels. Noise attenuation is expressed as a ratio of the output transient energy (Vto) to the input transient energy

(Vti), or by decibels (dB).

Table 1 shows the relationship of this ratio to decibels.

1. Common Mode Noise

For AC power systems, the term common mode refers to noise or surge voltage disturbances that occur between the line and ground conductors, or the neutral and the ground conductors. Ideally, no common mode noise should exist between the neutral and ground conductors since they are connected [4].

Unfortunately, common mode noise finds its way into electrical systems because of noise injection into the neutral or ground conductors from overloaded power circuits, wiring faults, and other equipment on the same line. Electronic circuits must co-exist with the same grounding system as the utility [3]. The utility ground system is designed to carry all faults and any unwanted currents. Therefore, it is important to have a properly connected grounding system. The impulses on ground can rise in excess of 6000 volts into a piece of electrical equipment without any form of noise attenuation. High magnitude impulses of this nature will destroy or render any electronic circuit useless [7].

Common-mode noise impulses tend to be higher in frequency than the associated normal mode noise signal. This is to be expected since the majority of the common-mode signals originate from capacitively coupled normal mode signals. The higher the frequency, the greater the coupling among the conductors, line, neutral and ground. Electronic equipment is 10 to 100 times more sensitive to common mode noise than normal mode noise.

Conventional power transformers and isolation transformers will not block normal-mode noise impulses, but if the secondary of these transformers have the neutral bonded to ground, then they serve to convert normal-mode noise to common-mode noise. From the standpoint of microelectronic circuits, common-mode noise is more potentially harmful than normal-mode noise.

The radio frequency noise sources mentioned in the RFI section are common sources of common-mode noise.

Table 1. Noise attenuation in decibel

V_{ti}	V_{to}	Ratio	Decibel(dB)
100	1	100:1	40
1000	1	1000:1	60
1,000,000	1	1,000,000:1	120
10,000,000	1	10,000,000:1	140

2. Normal Mode Noise (Transverse Mode Noise)

The term normal mode refers to noise or surge voltage disturbances that occur between the hot and neutral conductors, or between the line conductors. Most normal mode disturbances result from load switching within a building (motor type loads being a major contributor). On rare occasions, surge voltages that come from outside of the building (i.e. lightning) enter on the hot conductor and are primarily considered normal mode since the neutral conductor is at ground voltage. Surge suppressers limit surges and sometimes normal mode noise to safer values, offering minimal protection.

By attenuating normal mode noise, electrical circuits will not feel the direct surge from the power line. This attenuation assures proper operation and no stress to the electrical components which translates to more operational uptime, as well as, less maintenance and repairs [7].

IV. CONCLUSION

The literature survey reveals that today's equipments require clean noise free power supply to perform optimally. There are various sources of noise. These noises tend to serious malfunctioning problems, data loss, component failure etc. The ultra isolation transformer is designed to eliminate these noises especially common mode noise. Conventional transformers are of almost no use in the protection of very low-immunity and large-scale computer controlled systems and networks from noise of high voltages. To protect such equipments from getting damaged from noise ultra isolation transformer can be used.

But it is necessary to test the noise rejection capability of this ultra isolation transformer in order to get the noise free supply. The noise rejection capability of ultra isolation transformer can be verified by measuring the common mode noise rejection ratio (CMNR). This parameter decides how effectively the ultra isolation transformer rejects the common mode noise. To determine this capability system has to be designed which will calculate the CMNR of the transformer under test. This system will test the transformer under various frequency and voltage conditions. It will take the average of various CMNR readings and will give the final result. From this result we can determine the noise rejection capability of the transformer under test.

V. REFERENCES

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