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POWER SUPPLY DESIGN FOR HOME APPLIANCE WITH CONSIDERATION OF POWER QUALITY EVENTS

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ABSTRACT

Both electric utilities and end users of electric power are becoming increasingly concerned about the quality of electric power. Newer-generation load equipment, with microprocessor-based controls and power electronic devices, is more sensitive to power quality variations than was equipment used in the past. So now a day's study of the power quality events while designing the power supply board is most important.

KEYWORDS: X2 & Y2 Capacitor, MOV – Metal Oxide Varistor

INTRODUCTION

Power quality monitoring is the process of gathering, analyzing, and interpreting raw measurement data into useful information. The process of gathering data is usually carried out by continuous measurement of voltage and current over an extended period. The process of analysis and interpretation has been traditionally performed manually, but recent advances in signal processing and artificial intelligence fields have made it possible to design and implement intelligent systems to automatically analyze and interpret raw data into useful information with minimum human intervention.

Study of Power quality events done in following steps

- Decide objective -Monitoring as part of an enhanced power quality service.
- Determining what to monitor.
- Choosing monitoring locations.
- Setting monitor thresholds.
- Quantities and duration to measure
- Define Power quality Measurement equipment Power quality data analysis using standards.
- Last step is use of Data analysis for enhancing the power quality of latest equipment. This paper gives you idea about the enhancing the power quality of power supply board of Home appliance with the suggestion of equipments to be used to get better quality of Power supply board.

Power Quality in Power Distribution System - Most of the more important international standards define power quality as the physical characteristics of the electrical supply provided under normal operating conditions that do not disrupt or disturb the customer's processes. Therefore, a power quality problem exists if any voltage, current or frequency

deviation results in a failure or in a bad operation of customer's equipment. However, it is important to notice that the quality of power supply implies basically voltage quality and supply reliability. A voltage quality problem relates to any failure of equipment due to deviations of the line voltage from its nominal characteristics, and the supply reliability is characterized by its adequacy (ability to supply the load), security (ability to withstand sudden disturbances such as system faults) and availability (focusing especially on long interruptions). Power Quality From Design Side - The performance of each and every electronic system or electronic circuit depends upon the power supply that energizes the circuit or system. It provides required current to the circuit. Any disturbance noise in this power supply can cause problem in working or operation of circuit. If there is any deviation in this power supply level the circuit may not work properly. The accuracy and precision of circuit operation depends upon it. In some of the circuits all the calibration are done at this voltage level.

So all these calibrations becomes false if there is fluctuation in supply level

There are two types of power supplies

- Unregulated power supply
- Regulated power supply

Unregulated supply is used in some circuits where there is no much change in required load current. The load current remains fixed or deviation is very less. Because in such supply

- The output voltage reduces as load current increases
- The ripple in output voltage increases as load current increases

So this kind of supply can not be used where there is noticeable change in load current frequently. But although many circuits works on unregulated supply because it requires very few components and design is also very simple. Also some fluctuation in supply level can be tolerated due to load current change. The regulated power supply is required in digital circuits, the circuits in which the components cannot tolerate even 1% change in supply level like micro controller, micro processor etc.

SOLUTIONS TO POWER QUALITY PROBLEM

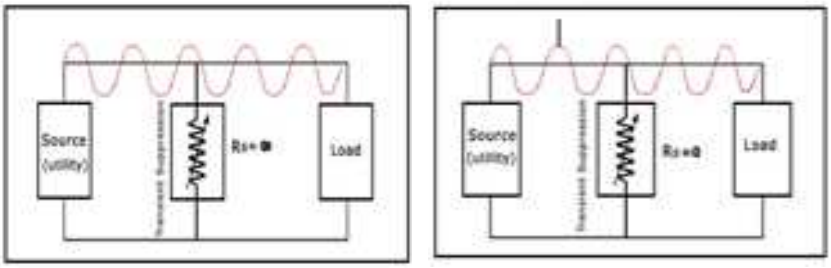
There are two approaches to the mitigation of power quality problems. The first approach is called load conditioning, which ensures that the equipment is less sensitive to power disturbances, allowing the operation even under significant voltage distortion. The other solution is to install line conditioning systems that suppress or counteracts the power system disturbances. Solutions for load conditioning approach by selecting proper components used in power supply design.

Protection from Surges – Metal Oxide Varistor

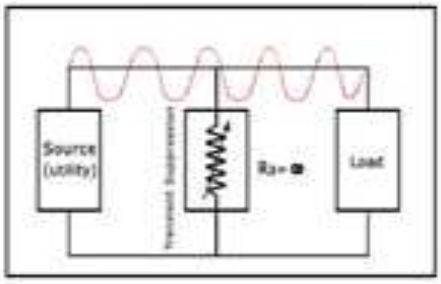
A varistor is an electronic component with a "diode-like" nonlinear current–voltage characteristic. The name is a portmanteau of variable resistor. Varistors are often used to protect circuits against excessive transient voltages by incorporating them into the circuit in such a way that, when triggered, they will shunt the current created by the high voltage away from sensitive components. A varistor is also known as voltage-dependent resistor (VDR). A varistor's function is to conduct significantly increased current when voltage is excessive.

The working of a MOV is shown in the figure below.

The resistance of the MOV is very high. First, let us consider the component to have an open-circuit as shown in Figure 1(a). The component starts conducting as soon as the voltage across it reaches the threshold voltage. When it exceeds the threshold voltage, the resistance in the MOV makes a huge drop and reaches zero. This is shown in the figure 1(b). As the device has very small impedance at this time due to the heavy voltage across it, all the current will pass through the metal oxide varistor itself. The component has to be connected in parallel to the load. The maximum voltage that will pass through the load will be the sum of the voltage that appears across the wiring and disconnect given for the device. The clamp voltage across the MOV will also be added. After the transient voltage passes through the component, the MOV will again wait for the next transient voltage. This is shown in the figure 1(c).



(a) Under Normal Situation **(b) Under Transient Condition**



(c) After Transient is Gone

Figure 1: Metal Oxide Varistor (MOV) Current Divider

EMI Suppression Capacitors

EMI suppression capacitors, as the name implies, are used to reduce electromagnetic interference. They are connected directly to line and are therefore exposed to over voltages and transients, which could damage the capacitors. For this reason, EMI suppression capacitors must comply with the requirements of the following safety standards like EN 60384-14 / IEC 60384-14, 2nd edition, UL 1414 (across the line and line bypass application), UL1283 (electromagnetic interference filters), CSA C22.2, No.1 and CSA C22.2, No.8, CQC (GB/T 14472-1998).

Table 1: For X Capacitors

Sub-Class	Peak Pulse Voltage Vp in Operation	Application	Peak Values of Surge Voltage Vp (Before Endurance Test)
X1	2.5 kV < Vp < 4.0 kV	High pulse application	CR < 1.0 mF: Vp = 4.0 kV
			CR > 1.0 mF: Vp = 4.0/√ CR kV (enter CR in mF)
X2	Vp < 2.5 kV	General purpose	CR < 1.0 mF: Vp = 2.5 kV
			CR > 1.0 mF:(enter CR in mF) Vp = 2.5/√ CR kV
X3	Vp < 1.2 kV	General purpose	No test

Classification of EMI Suppression Capacitors

EN 60384-14 and IEC 60384-14 divide EMI suppression capacitors into two groups:

- **X Capacitors (For Line-to-Line or Line-to-Neutral Connection)**

These are capacitors for applications in which failure of the capacitor will not lead to a dangerous electrical shock. EN 60384-14 divides X capacitors into 3 sub-classes according to the peak pulse voltage to which they are exposed in operation, in addition to the rated voltage. This kind of impulse can be caused by lightning in overhead cables, switching surges in neighboring equipment or in the device in which the capacitor is used to suppress interferences.

- **Y Capacitor (Line-to-Ground or Neutral-to-Ground Connection)**

These capacitors are intended for use where failure of the capacitor could result in a dangerous Electrical shock. Y capacitors are capacitors of enhanced electrical and mechanical reliability and Limited capacitance. The enhanced electrical and mechanical reliability are intended to eliminate short-circuits in the capacitor. Limitation of the capacitance is intended to reduce the current passing through the capacitor when AC voltage is applied and to reduce the energy content of the capacitor to a limit that is not dangerous when DC voltage is applied. Y capacitors are used in electrical equipment and machines to bridge operational insulation that provides safety, in connection with additional protective measures, in order to avert danger to humans and animals. EN 60384-14 divides Y capacitors into the following sub-classes:

Table 2: Sub-Class Y3 Corresponds to Class Y as Described in IEC 60384-14 (1st Edition)

Sub-Class	Type of Bridged Insulation	Rated AC Voltage	Peak Values of Surge Voltage Vp (Before Endurance test)
Y1	Double or reinforced insulation	VR < 250 V	8.0 kV
Y2	Basic or supplementary insulation	150 V < VR < 250 V	5.0 kV
Y3	Basic or supplementary insulation	150 V < VR < 250 V	No test
Y4	Basic or supplementary insulation	VR < 150 V	2.5 kV

Some Important Tests to IEC/EN 60384-14

- **Impulse Voltage Test**
- **Endurance Test**

Capacitors are tested with a voltage of 1.25 times the rated voltage for class X2 and 1.7 times for class Y2 at the upper category temperature for 1000 h. Each hour the test voltage is increased to 1000 VRMS, 50 Hz for a period of 0.1 s.

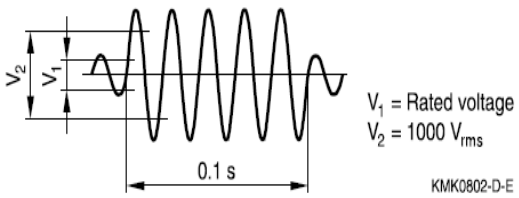


Figure 2: Endurance Test

- **Active Flammability Test**

This test is to ensure that capacitors do not ignite at a defined electrical overload. Capacitors are applied the rated

voltage at 50 Hz with 20 superimposed pulses of 2.5 kV for class X2 and 5 kV for class Y2. The rated voltage is maintained for 2 min. after the last discharge. This is a destructive test, and the failure condition is that cheesecloth around the capacitor shall not burn with a flame. No electrical measurements are required.

Figure 3: Active Flammability Test

- **Typical Application**

Depending on how they are connected, X and Y capacitors are effective against different kinds of electromagnetic interference. X capacitors connected between the line phases are effective against symmetrical interference (differential mode). Y capacitors connected between a phase and neutral (zero potential) are effective against asymmetrical interference (common mode).

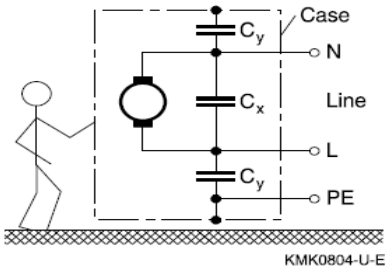


Figure 4: Application of X & Y Capacitor

Overload Protection from Design & Load Connected – Fuse

Although care is taken to properly design electrical and electronic circuits; over currents in the form of short-circuits and overload can occur. The sole purpose of fuses and circuit breakers is to protect personnel and/or equipment from serious harm when an over current condition arises. This guide is intended to help create a better understanding the various parameters of over current protection and the proper application of circuit protective devices. This guide creates a basic understanding of over current principles and applications but is not intended to supplant sound engineering principles or replace specific application testing.

FEATURES

- Lead Free
- Reduced PCB space requirements
- Direct solderable or plug-in versions
- Internationally approved –
- Low internal resistance
- Shocksafe casing
- Halogen free

Noise/Harmonics Suppression - Filters

Harmonic Filters can be used to reduce the amplitude of one or more harmonic currents or voltages. Filters may either be used to protect specific pieces of equipment, or to eliminate harmonics at the source. Since harmonic filters are relatively large, space requirements may have to be budgeted for. In some situations, improperly tuned filters may shift the resonant frequencies close to the characteristic harmonics of the source. The current of the high harmonics could excite the resonant circuit and produce excessive voltages and attract high oscillating harmonic currents from elsewhere in the system. Capacitors Harmonic amplification due to resonance associated with capacitor banks can be prevented by using converters with high pulse numbers, such as twelve pulse units, thereby reducing high-amplitude low order harmonics. A similar effect occurs with pulse width modulated converters.

Linear Passive Filter Design and Operation -A linear filter is composed of linear components, such as inductors and capacitors. It passes the basic power frequency (60 Hz) and attenuates other frequencies which are in the form of electrical noise and harmonics. Some filters are tuned circuits, which means they address a small range of frequencies. Examples of filters that are not tuned are the simple low pass filter, and the simple high pass filter. Simple low pass filters attenuate high frequencies, and have the general characteristics most desired in filters for improved power quality and noise attenuation. Simple high pass filters attenuate low frequencies. Tuned shunt filters are not used for general power quality applications. Special designs are used to attenuate harmonics. A shunt connected tuned filter, which consists of an inductor, a capacitor and a resistor, is tuned to eliminate a specific harmonic order by providing a low impedance to the harmonic frequency and shunting the harmonic energy to ground. A number of these filters may be arranged in stages, with each stage selectively filtering a given harmonic frequency. Equipment which is either sensitive to electrical noise, or which creates it, is often designed with linear filters for protection of equipment. For instance, all power supplies contain electrical filters. For harmonics, multi-staged shunt filters are most effective for mitigation of lower order harmonics.

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