

# Power Quality Events and Protection at Designing of Power Supply Board

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**Abstract:** Power quality concern is big problem for electric utilities and customer of electric power. In upcoming year's use of new equipment & microprocessor-based controlling devices are more delicate to power quality variations. So now a day's study of the power quality events while designing the power supply board is most important. In the Home appliance industry functioning of the appliance is depends upon the Power supply at users & as we all know that India have many Power Quality variation problems. This paper gives you idea about the enhancing the power quality of power supply board for Home appliance with the suggestion of equipments to be used to get better quality of Power supply board.

**Keywords:** Power Quality, Power Quality events, X2 & Y2 Capacitor, MOV – Metal Oxide varistor L to G – Line to neutral , N – G – Neutral to Ground.

## 1. Introduction – Power Quality, Monitoring, Analyzing

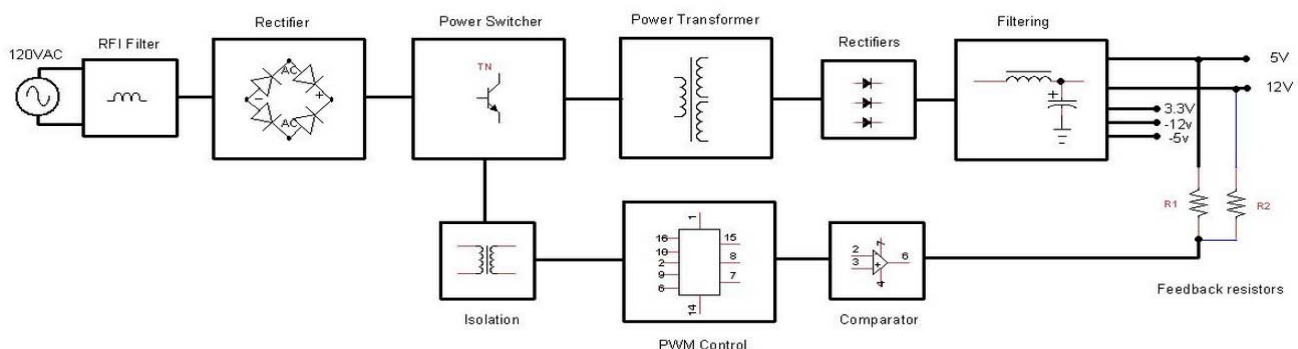
Power Quality defines as “The power problem which cause change in voltage, current, and frequency deviations that result in failure sometimes misoperation of customer product”. There are many Power quality events which affects on power quality directly or indirectly. There are some standards like IEEE & IEC standards which classified and describe the power quality events into different category.

The classified power quality events are Transients (Impulsive/Oscillatory), long duration voltage variations (Overvoltage/Undervoltage), Sustained Interruption, Short duration voltage variations (Interruption/Sags), Swells , Voltage Imbalance, Waveform distortion (DC Offset, Harmonics, Interharmonics, Notching, Noise) etc. As we all know that many of the advance technology products use the Electronic board for control and precise operation. Similarly

Home appliance product also has the Power supply board of (230/120VoltAC - 12/05Volt DC). Many new technology product use the User interface device where some components work on 12 Volt Dc or 5 Volt DC. In such case Power supply board is used which will give step down voltage from 230 to 5 volt. But As in India there is lot of variation in supply because of Power quality event, so every designer need to take care of PQ events at designing stage. This paper will give the idea about, what components are needed for protection from PQ events with efficient design of Power supply board.

Power supply Design can be of two types – as discussed below;

- A) Unregulated power supply Design
- B) Regulated power supply Design



**Figure 1:** Regulated Power Supply Board Block Diagram

Where unregulated supply is used in some circuits where there is no much change in required load current and the load current remains fixed/deviation is very less. Because the output voltage reduces as load current increases & the ripple in output voltage increases as load current increases.

So, unregulated supply cannot be used where there is noticeable change in load current frequently. Requirement of very few components and simple use make the use of unregulated power supply easier and some fluctuation in supply level can be tolerated due to load current change. Opposite to these the regulated power supply is used in

digital circuits, the circuits in which the components cannot tolerate even 1% change in supply level, like micro controller, micro processor etc. Refer Figure 1 attached block diagram for Regulated Power supply board.

Many times in the design it is very important to have Power quality Evaluation procedure. Evaluation of power quality procedure uses the following steps refer fig 2. At Evaluation first step of *identify problem category* includes monitoring as well as Historical data analysis. Where “the process of collecting data, and translate collected data into useful information by analyzing it called Power Quality Monitoring”.

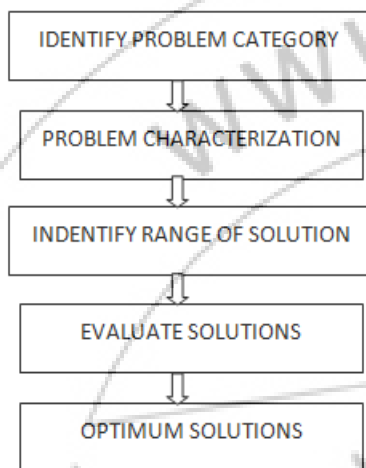


Figure 2: Evaluation Process

The power data collection is usually done by recording of voltage in Volts and current in Ampere for an extended time. Now days at monitoring first we need to define the location and equipment for measurement with defining the type of data need to measure. In our example of power supply design, similarly the customer location get decide by the failure rate in s the past from data collection. The data collected by the use of ACR Power watch meter, & events measured as per following Thresholds.

1. Hot to Neutral Thresholds: Surge voltage (Vrms) : 240 , Sag Voltage (Vrms):150, Impulse Deviation (V)2500
2. Neutral to Ground Thresholds: Surge voltage 255(Vrms), Impulse Deviation: 2550 , Line frequency (Hz) : 50, Line Voltage (Vrms): 234, Ground Voltage (Vrms)
3. Frequency Thresholds:
  - Minimum (Hz):48.0
  - Maximum (Hz):52.0

Last step is use of Data analysis for enhancing the power quality of latest equipment. The outcome from data analysis can be in the form of graphical view of in the form of data analysis sheet.

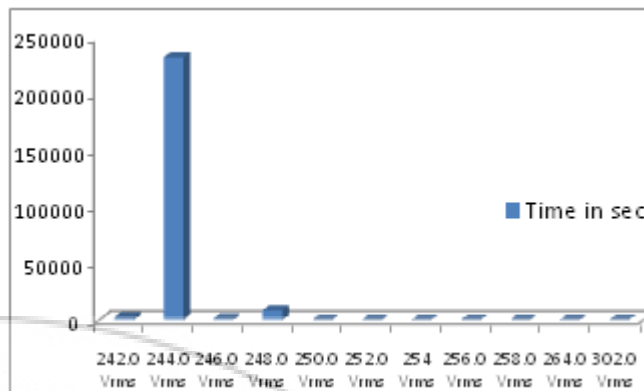


Figure 3: Output of Data Analysis

Data Analysis is nothing but the *Problem characterization* step where we can get the data of most dangerous event and actual time of stay that particular event. From Data Analysis we can conclude that, H N surge is the most concern area so designing starts according to that.

## 2. Solutions to Power Quality Problems

The mitigation of power quality problem can be done by two methods. The first method is load conditioning, which take cares that the component strongly avoids the effect because of power disturbances and allow to operate the component under small change in voltage distortion whereas line conditioning system is the second solution that suppress and counteracts on the power system disturbances. At designing stage many times selection of load conditioning approach for complete Power supply board is prefer by selecting proper components according to line conditioning approach.

## 3. Protection From Surges – Metal Oxide Varistor

Varistor is an electronic device like diode. Varistor having nonlinear current–voltage characteristic. The long form of Varistor name is variable resistor. Varistor main function is protection from transient voltages.

*The Operation of a MOV is shown in the figure 4 below.*

The resistance of the MOV is high at normal condition. First, consider the MOV as an open-circuit as shown in figure 4-a for normal working conditions. The Varistor component starts working when the voltage exceeds from its define (Threshold) voltage level by making the resistance of the MOV to drop and reaches to zero which cause high current to pass through it to give protection for the remaining circuit. This is shown in the figure 4(b) for transient/ Failure condition. At very small impedance, it allows to pass very high current to pass by itself because at this condition voltage across it is huge. The Metal oxide varistor always connected in parallel with the load. After the transient voltage passes through the equipment, then Varistor waits for the next surge appear. This is shown in the figure 4(c) for transient condition gone & normal condition achieve again.

## METAL OXIDE VARISTOR (MOV)-CURRENT DIVIDER

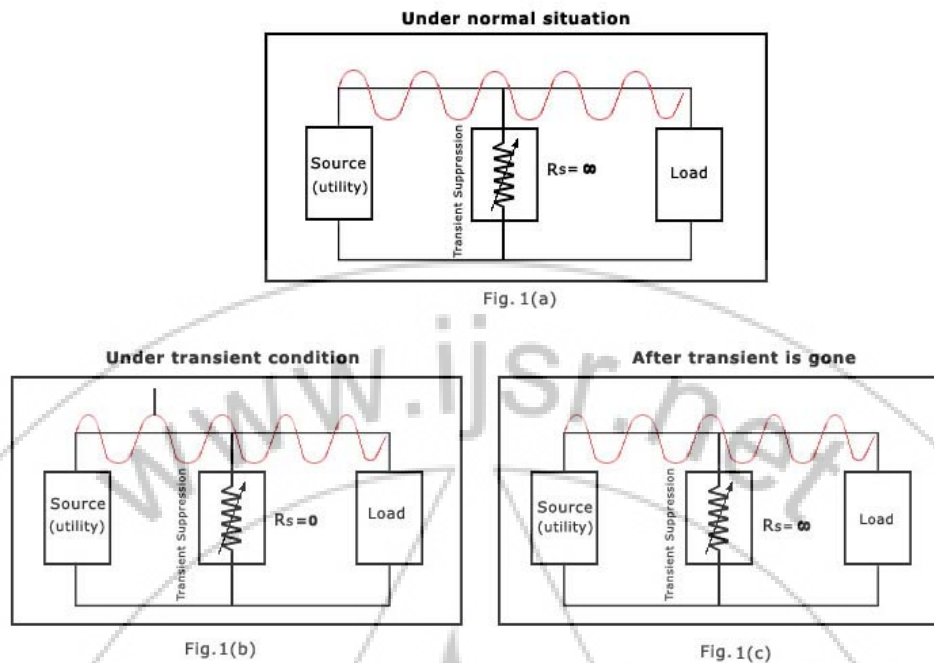


Figure 4: MOV Operation

#### 4. EMI Suppression Capacitors

Electromagnetic Interference Suppression Capacitors - means capacitors which are used to reduce electromagnetic interference. Many times EMI Suppression capacitor are exposed to overvoltage's and transients, which could damage it completely because they are connected directly to the line. For this reason, the EMI suppression capacitors are classified into two groups as per EN and IEC standards.

##### 4.1 X Capacitors

Capacitors used for L-to-L and L-to-N connection applications called X Capacitors. The failure of the X capacitor doesn't convert it into hazardous electrical shock

##### 4.2 Y Capacitors

Y capacitors are intended for L-to-G or N-to-G connection, where failure of the Y capacitor needs to face a hazardous electrical shock. Electrical, mechanical reliability and limited capacitance get improved with the use of Y-capacitors, which also results to eliminate short-circuits.

#### 5. Overload Protection from Design & Load Connected - Fuse

Better design electrical and electronic circuits also consider the protection from over currents in the form of short-circuits and overload. The Over current and short circuit is very dangerous to equipment and mainly to human life so the use of fuses and circuit breakers will give protection from hazardous condition. Fuse selection can be done by considering the following features.

##### Features of Fuse Selection

- Lead Free
- Reduced PCB space requirements
- Direct solder able or plug-in versions
- Internationally approved –
- Low internal resistance
- Shock safe casing
- Halogen free

##### 5.1 Noise/Harmonics Suppression – Filters

The application of Harmonic filters is to filter out the amplitude of one or more harmonic currents or harmonic voltages. Main function of Filters is Protection of specific pieces of equipment as well as it also reduce harmonics at the source. Filters are get tuned at particular frequency before use in the application, where as resonant frequencies get shift near to the characteristic harmonics of the source because of improper tuned filters. Since Large size of harmonic filters may cause the problem of, space requirements and budgeted for.

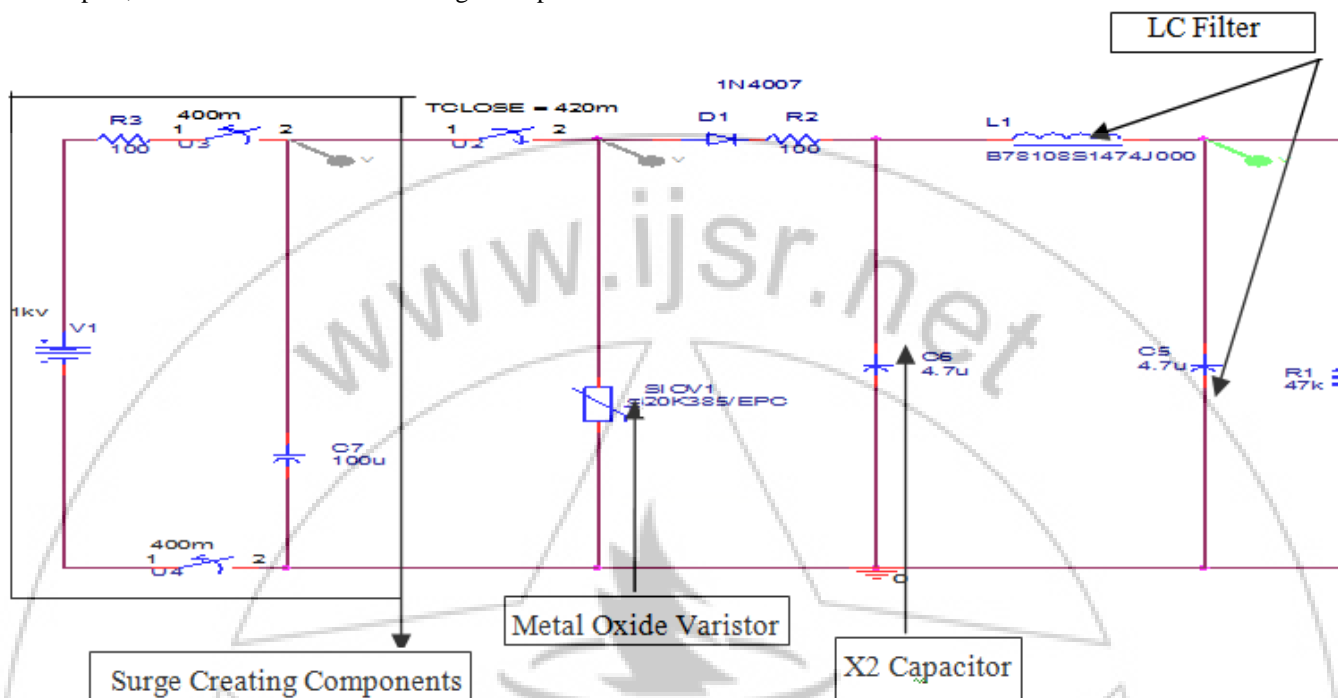
Filters are classified as Active Filter & Passive Filter

- *Active Filter* defines as filter which uses in recent power electronic equipments for eliminating harmonic distortion.
- *Passive Filter* includes inductors, capacitors, and resistors in various types of combination to eliminate one or more harmonics. The Basic combination of LC filter uses an inductor in series with a shunt capacitor. These LC Filters short-circuits the major distorting harmonic component from the system by providing very low impedance to the harmonic frequency. The LC filter shunts the harmonic energy to ground.

5.2 Implementation and Testing

At Evaluation step *Identify range solution, Evaluate solutions* are comes under the implementation and testing. There are many software's are used for simulation testing like Pspice, MATLAB and all. Following example shows

us the simulation of Power supply board at AC section from the Surge, EMI suppression, Noise, Overload as discussed above. Figure 5 shows testing for AC Power supply side of protection at Power Supply board.



6. Simulation Results

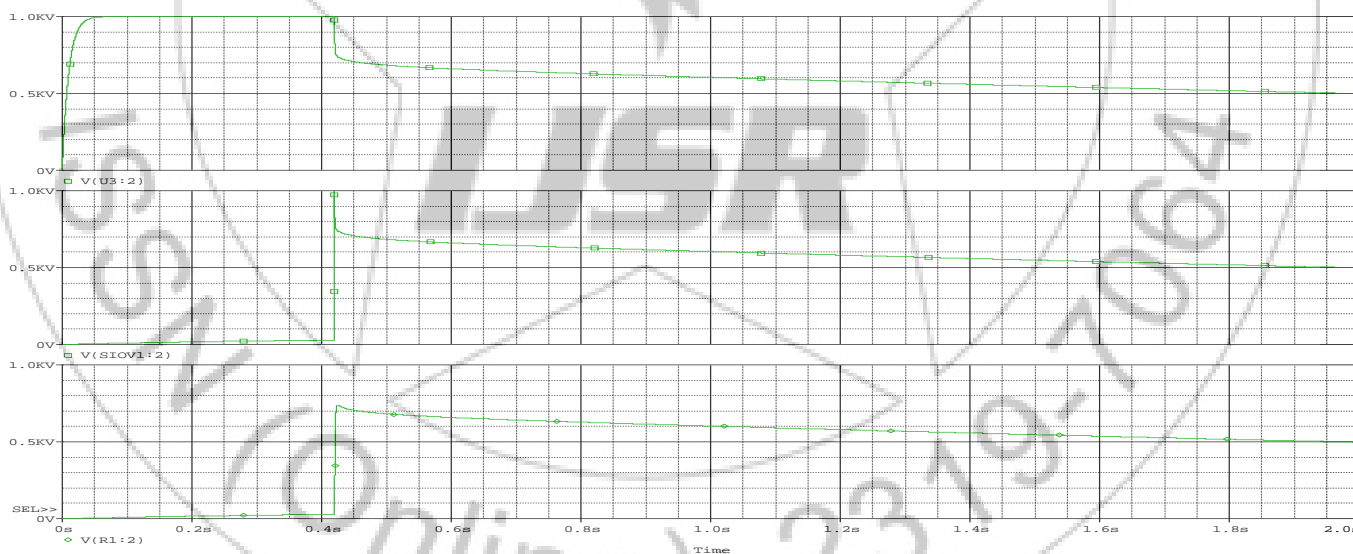


Figure 5: PSpice SIMULATION FOR AC SIDE

Description of components used are as follows - DC supply voltage gives the High voltage value to the circuit, whereas use of resistance, Capacitor C7, Switches (U3,U2,U4) creates the Surge at circuit by using the concept of Energy = (1/2 \* (CV<sup>2</sup>)) Metal Oxide Varistor (S20K385) - Surge Protection device. X2 Capacitor (C6) - Suppress or minimize any ripple or variation in input Applied to the circuit. Diode & Resistance (D1 & R2) - Clamping & reverse current protection. LC Filter (L1 & C5) - Reduced ripple content. Equivalent Resistance R1 – It is connected as load to complete the circuit. So by this way we conclude the ratings

of MOV, capacitors, fuse, and LC filter. Optimum Solution is the last step of evaluation, which is very important for getting efficient results of Design.

7. Conclusion

To get Optimum cost solution with high degree of quality, It always useful to have Power quality problem Evaluation at Designing and testing state.

## 8. Acknowledgement

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