Quality-power energises print

A power quality system analyst with over 30 years of industry expertise, Shridhar Visvanathan, Principal Consultant of Online Systems and the Electronic and Electrical Safety Consultant for BMPA, is here to guide Print Bulletin readers in efficiently and effectively handling power issues.

Electrical power? Well, so far we have taken it for granted in our lives, personal and business!

A basic necessity

Ever since the Thomas Alva Edison innovated and commercialised the electrical light bulb back in 1879, the power of electrical energy entered our homes and lives. Since, the lives of modern humankind have changed to such an extent that we cannot imagine our lives without electrical energy, and all the advancements that it powered for the past two centuries.

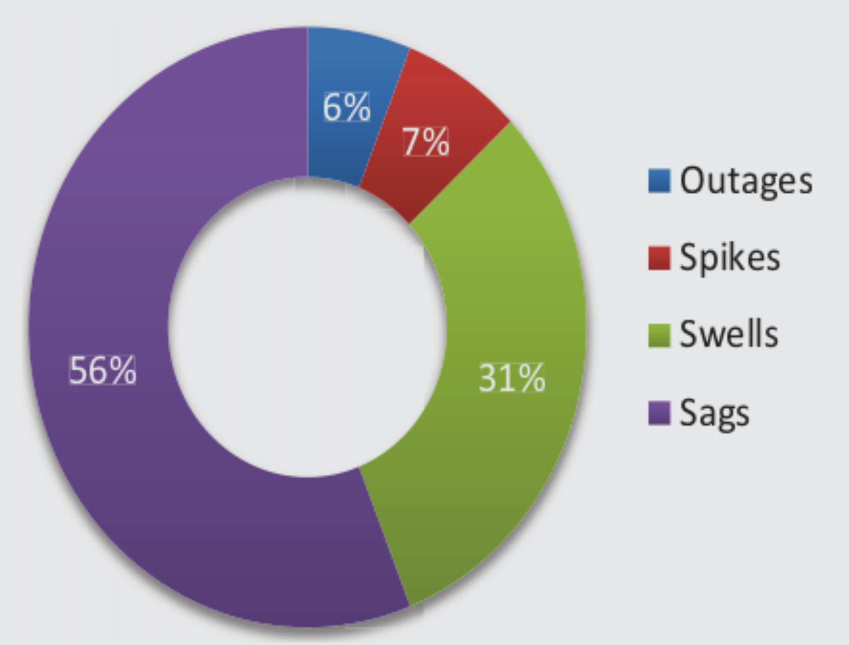
Electrical energy has become humankind's basic necessity. Much like the continuous supply of clean air, clean water, organic food, pollutant-free environment, the good quality (or what we term conditioned) electrical power supply is necessary for the modern civilisations to function smoothly in the connected day and age.

...but we have had electricity for centuries now!

Not just in print, but in much of our technology-supported lives, the machines have changed rapidly. From purely mechanical, electro-mechanical, the modern day machines – or gadgets we refer to them – have become increasingly sophisticated.

Take, for example, the earlier range of print and packaging machinery were analogue-controlled and used linear power supplies. These machines generated less electrical noise or pollution up-stream hence they were less impacted by power issues – voltage fluctuations, for example. The only problem of high and low voltage condition attributed to the power source and these were quickly corrected using the voltage stabilisers, primarily an electro-mechanical device.

In contrast, the modern state-of-the-art machines use highly refined semiconductor-controlled rectifier (SCR) or switched-mode power supply (SMPS) power supplies, variable drives controllers, and more such technologies to generate harmonic currents and address the issues of electrical noise upstream.



Swells	Sags or dips
System fault conditions	Associated with system faults
Switching on a large capacitor bank	Switching of heavy loads
Switching off a large load	Starting of large motors

Major power quality issues in manufacturing process

The functioning and control of these modern machines have also increasingly become digital and microprocessor-controlled; no doubt it has enhanced the features and efficiency. These electronic controls are, however, sensitive to electrical aberrations which are well beyond the correction capability of the simple voltage stabiliser – an earlier era technology made for analogue machines.

Understand the complexity of power

Let us understand the concept of 'power quality' in the manufacturing process. Poor power quality is characterised by electrical disturbances such as transients, surges, voltage sags, swells, supply interruptions, electrical noise, and harmonics.

The disturbances can originate externally without warning but are often generated within your factory. About 75% of electrical disturbances that cause poor power quality come from within the manufacturing facility. Powering on and off very large equipment, wiring errors, poorly specified or improperly serviced power supplies in equipment, grounding loops and even regular daily operations can impose power quality issues that lead to production disturbances and lost output.

Severe weather, utility fault clearing, power line accidents and other external network issues like grid switching or power-factor correction capacitors represent the remaining 25% of power quality problems. These disturbances often generate voltage sags, spikes or sometimes power interruptions that can instantly damage equipment. Worst of all, these incidents are entirely unpredictable and beyond anyone's control.

Okay, stabilisers are not enough? What is then?

Let us not discard the voltage stabilisers so quickly.

Typically, one solution is not enough to ensure reliable and constant power. Due to the numerous sources and types of power disturbances, maintaining power quality requires a multi-tiered approach. Protecting your facility begins by isolating all power-offending devices, such as the drives, the motors, the welders and the large compressors. Essential and sensitive equipment – PLC, drives, industrial automation systems and electronic controls, to name a few – must be safeguarded to ensure seamless performance and arrest costly downtimes.

It is also critical to recognise the need for high performance power conversion products, including Ferro-Transformers, AVC, K-Factor and Drive Isolation Transformers, Critical Power Conditioners, but not least, all panel points should utilise noise filters and Surge Protective Devices.

Don't miss the next article in the series to learn about the different types of electrical disturbances, the causes and the impact on equipment, and how to mitigate these issues by deploying the appropriate power solutions.

Should you have any power-solution related queries or any questions related to this special feature, please write to admin@bmpa.org.

A silicon controlled rectifier or semiconductor-controlled rectifier is a four-layer solid-state current-controlling device. The principle of four-layer p-n-p-n switching was developed by Moll, Tanenbaum, Goldey and Holonyak of Bell Laboratories in 1956. The practical demonstration of silicon controlled switching and detailed theoretical behavior of a device in agreement with the experimental results was presented by Dr Ian M. Mackintosh of Bell Laboratories in January 1958. The name "silicon controlled rectifier" is General Electric's trade name for a type of thyristor. The SCR was developed by a team of power engineers led by Gordon Hall and commercialised by Frank W. "Bill" Gutzwiller in 1957.

Source: en.wikipedia.org

Disrupt the power disturbances

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In this article we shall learn more about different electrical disturbances, their impact on the machines used in a typical manufacturing set up in the print industry and the selection of appropriate solutions to tackle with the power disturbances.

Voltage surge that is line swell

A voltage surge, also referred to as an over voltage or a line swell, is a temporary voltage level increase for durations ranging from a half cycle (10 ms) to a several cycles. For reference, consider that a second is equal to 50 cycles, or 1000 milliseconds (ms)

Voltage surges can be caused by large load shut-downs, such as switching off high-power electric motors and large rated compressors of Air-con plant. They can also be caused externally as loads are shed from the utility.

Surges and swells can lead to significant equipment and control electronic failures.

Solutions: Online Active Voltage Conditioner or AVC, Online Uninterrupted Power Supply or UPS, and Ferro-transformer.

Power interruptions

Power interruptions are a complete loss of voltage for an extended period of time.

It is caused by the total power disruption that is typically caused by the high tension (HT) line tripping and failure in the utility's generation or the distribution network.

Industrial-grade, online UPS are apt solutions to deal with power interruptions. Image: ABB power conditioners, Wikipedia

Power interruptions halt production and can decrease the lifespan of electrical equipment. The sudden, unexpected nature of most power interruptions can also create hardware failures and crashes in Programmable Logic Controllers (PLCs) hard-disks and control electronics.

Solutions: Online UPS and industrial grade inverters (< 10 ms transfer).

Brownouts

Brownouts, or voltage reductions, are conditions in which the supplied voltage level has been restricted below normal minimum levels for an extended period that may last hours.

Overcapacity and other electrical network issues can force utilities to intentionally create a brownout condition to compensate for high demand on the electrical power grid.

Brownouts can negatively impact the efficiency and life span of electrical equipment. They can also result in hardware crashes and occasional equipment failure.

Solutions: Automatic Voltage Stabilizers

Voltage Sags

Voltage sags, also known as under-voltage, are a temporary decrease in the voltage level. The drop typically lasts at least one half cycle, but can endure for up to several cycles.

Voltage sags are a result of large load start-up and utility switching. While short-lived, these disturbances can reduce the efficiency and lifespan of equipment & cause electronic failures. Voltage sags are a persistent, unpredictable phenomena.

Thought short-lived, the repeated exposure to voltage sags can result in hardware failures and crashes in PLCs and other control electronics.

Solutions: Online Active Voltage Conditioner or AVC, Online Uninterrupted Power Supply or UPS, and Ferro-transformer.

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In continuation from the first article, published in December 2017, this article will share information about different electrical disturbances, including voltage transients, frequency variations, harmonic distortion, and electrical noise. These disturbances have a profound adverse impact on the machines used in a typical manufacturing set up in the print industry and the selection of appropriate solutions to tackle with the power disturbances.

Voltage transients

Voltage transients, also called spikes and impulses, are the result of a sudden massive increases in voltage. Also prevalent when the mains supply resumes abruptly.

Voltage transients can come from outside the facility through lightening strikes, power outages and utility grid switching. They can also originate inside the facility from short circuits, tripped breakers, and the start-up of heavy equipment.

Sensitive electronic equipment face the highest risk from voltage transients. These disruptions may cause system lock-up of failure, which can corrupt or lead to loss of valuable data.

Solutions: Isolation and ferro-transformer, and surge protection device offer apt solution for the mitigation of the impact from spikes. The surge protection devices alone offer very limited protection from the disruption.

Frequency variations

While rate in utility power, frequency variations are most common with standby generators. Frequency variations can exist if local power generation has poor speed regulations or they may be caused through the faults in the system. This disturbance can also be created by the disconnection of a large load or source of generation in the grid.

The standby generators have a limited capacity, therefore, when the load change occurs, the frequency varies before it is governed.

Frequency variations beyond the tolerance of the equipment can cause system crashes and severe equipment damage.

Solutions: Online UPS and frequency converter.

Harmonic distortion

Voltage distortion is created by multiples of the fundamental frequency, for example, 150 Hz in a 50 Hz system. This sine-wave distortion is typically generated by non-linear loads, similar to switch mode power supplies used by computers, office equipment, variable frequency drives, solid-state electronics, and UPS systems with Silicon-Controlled Rectifier (SCR).

Harmonics represent trouble for equipment throughout industrial facilities by overheating neutral conductors and transformers, tripping breakers, creating a high neutral current, reducing system capacities, and even loosening electrical connectors.

Solutions: K-rated Transformers, Harmonic Filters, Ferro-transformers, and Drive Isolation Transformers provide apt solutions to deal with harmonic distortion.

What is K-factor?

As Schneider Electric website describes it, "K-factor is a weighting of the harmonic load currents according to their effects on transformer heating, as derived from ANSI/IEEE C57.110. The higher the K-factor, the greater the harmonic heating effects."

K-factor	Application
K-1	Standard transformers Standard lighting Motors
K-4	Induction heater Silicon-Controlled Rectifier AC Drive
K-9	DC Drive
K-13	School pulse lighting Hospital
K-20	Data processing computers Computer room

Electrical noise

Electrical noise is a low amplitude, low current, high-frequency disturbance. Electrical noise can be caused from both, inside and outside the facility. It can also be generated by powerful electric disruptions, normal equipment operations or poor maintenance. Distant lightening strikes, switching power supplies, electronic circuits, poor brush contacts on motors, improper wiring, and utility switching are a few examples of the source of electrical noise.

These random noise signals are superimposed on voltage waveforms and can cause electronics to hand, glitches and other hard-to-diagnose maladies. They also produce undesirable effects in the circuits of control electronics.

Solutions: Ferro-transformer, Isolation Transformers, and Critical Power Conditioners provide adequate protection from electrical noise.

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BE 'GROUNDED', BE SAFE

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Earthing in electrical network plays a critical and significant purpose for the safety and security of the equipment and the human resource working with the equipment. The two article series will detail the purpose and importance of earthing, methods and measurements to achieve safe and effective earthing connection for your electrical network.

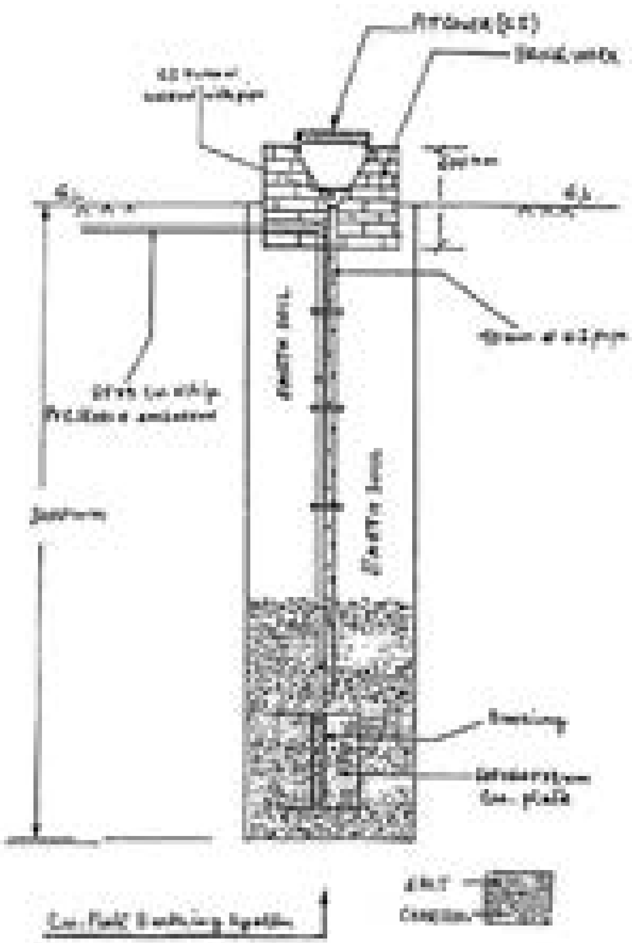
The process of electrically connecting to the earth is called 'earthing'; In Europe, particularly, it is known as 'grounding'.

The purpose of earthing or grounding

The safety for human life and equipment

- To save human life from the danger of electrical shock or blowing a fuse in an electrical network, that is, to provide an alternative path for the fault current to flow so that it will not endanger the user.

A crocodile clip attached to a wire provides earthing to the aircraft on the airfield. Image: Vantey (copyleft), Wikipedia



Cross-section of the earthing pit. Image: provided by the author

- To protect buildings, machinery and appliances under fault conditions.
- To provide safe path to dissipate the short circuit currents.
- To provide stable platform for the operation of sensitive electronic equipment. To maintain the voltage at any part of an electrical system at a known value to prevent over current or excessive voltage to the appliances or equipment

Over voltage protection

Line surges or unintentional contact with higher voltage lines can cause dangerously high voltages to the electrical distribution system. Earthing provides an alternative path around the electrical system to minimise damages in the electrical system.

Voltage stabilisation (a common reference point)

There are many sources of electricity; every transformer can be considered a separate source. If there was no common reference point for all these voltage sources, it would be extremely difficult to calculate their relationships to each other. The earth is the most omnipresent conductive surface, hence, it was adopted in the annals of electrical distribution systems as a nearly universal standard for all electric systems.

Conventional methods of earthing

Plate-type Earthing

For the plate-type earthing, the normal practice is to use:

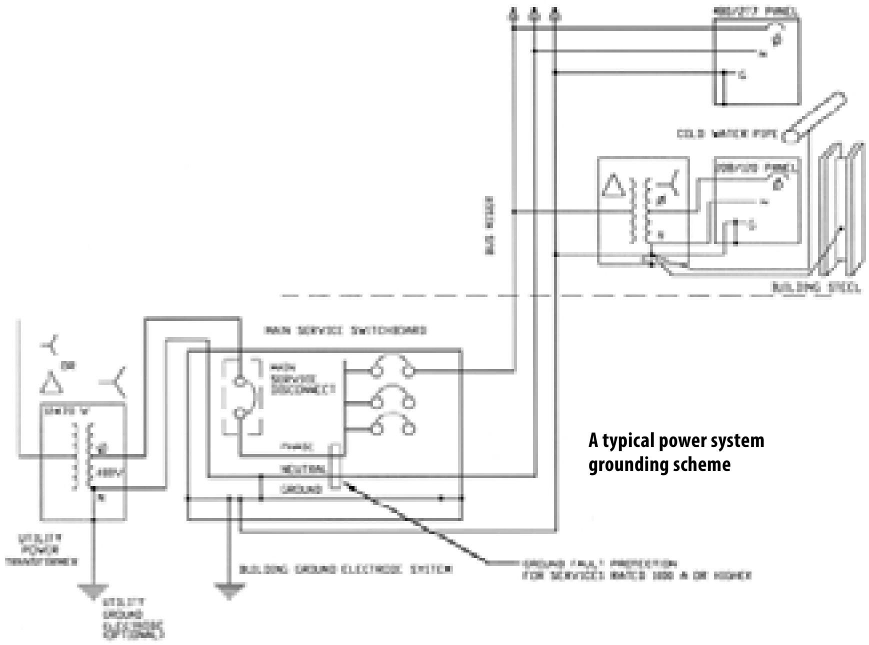
- Galvanised iron plate measuring 600 mm x 600 mm x 10 mm or copper plate measuring 600 mm x 600 mm x 3.15 mm

- Plate buried at the depth of 8 feet in the vertical position and GI strip of size 50 mm x 6 mm bolted with the plate is brought up to the ground level

These types of earth pit are generally filled with the alternate layers of charcoal and salt up to four feet from the bottom of the pit.

Pipe type Earthing

For Pipe type earthing, normal practice is to use GI pipe [C-class] of 75 mm diameter, 10 feet long welded with 75 mm diameter GI flange having six holes for the connection of earth wires and inserted in ground by auger method. These types of earth pit are also generally filled with alternate layer of charcoal & salt or earth reactivation compound



A typical power system grounding scheme

Method for Construction of Earthing Pit

- Excavation on earth for a normal earth pit size is 1.5 m x 1.5 m x 3.0 m
- Use 600 mm x 600 mm x 10 mm GI Plate or bigger size for more contact of earth and reduce earth resistance
- Make a mixture of wood coal, powder salt and sand all in equal part
- The salt percolates and coal absorbs water keeping the soil wet
- Coal is made of carbon which is a good conductor, minimising the earth resistance
- Salt acts as electrolyte to form conductivity between GI Plate, coal and earth
- Sand is used to form porosity to cycle water and humidity around the mixture
- Put GI Plate (earth plate) admeasuring 500 mm x 500 mm x 10 mm in the mid of mixture
- Use Double GI Strip size 30 mm x 10 mm to connect GI Plate to system earthling
- It is be better to use GI Pipe of size 2.5" diameter with a flange on the top of GI Pipe to cover GI Strip from earth plate to the top flange
- Cover the top of GI pipe with a T-joint to avoid clogging of pipe with dust & mud and also pour water time to time through this pipe to bottom of earth plate
- Maintain less than one Ohm resistance from earth pit conductor to a distance of 15 m around the earth pit with another conductor dip in the earth
- Check voltage between earth pit conductors to the neutral of the mains supply 220V AC 50 Hz; it should be at least 2.0 Volts less, 1.0 Volts less is the ideal

1.5 m copper earthing bars. Image: Barbirossa (CC3.0), Wikipedia

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In the previous article, we learned about the need and the imporance of eathing in an electrical network, and the different methods of earthing. In this article, we shall learn more about the various factors that affect earth's restivity; it is important to understand these factors to ensure optimum conditions for enhanced earthing during different seasons, and at different times of the day. As a thumb-rule, lower the resitivity of soil, better the earthing it provides to the electrical systems.

Soil Resistivity

It is the resistance of soil to the passage of electric current. The earth resistance value of an earthing pit depends on soil resistivity. It varies from soil to soil. It depends on the physical composition of the soil, moisture levels, dissolved salts, grain size and distribution, seasonal variations, current magnitude, and more such factors.

Soil Condition

Different soil conditions have varied soil resistivity. Soil plays a critical role in determining the performance of an electrode in earthing pit. Most of the soils are very poor conductors – thus have very high resisitivity value – of electricity when they are completely dry. Soil resistivity is measured in ohm metres or ohm centimetres. If soil is dry then soil resistivity value will be very high. If soil resistivity is high, earth resistance of electrode will also be high. On the other hand, soil with low resistivity is highly corrosive.

Moisture

Conduction of electricity in soil is through water, therefore, moisture content in soil has a great influence on resistivity value of the soil. The resistivity of soil can be determined by the quantity of water held by the soil and resistivity of the water itself. The resistance of soil drops quickly to a more or less steady minimum value at about 15% moisture in the soil, and any further increase of moisture levels in soil have little effect on soil resistivity. At many locations water table goes down in dry weather conditions, therefore, it is essential to pour water in and around the earth pit to maintain moisture in dry weather conditions.

Dissolved salts

Pure water is poor conductor of electricity. Resistivity of soil depends on resistivity of water, which, in turn depends on the amount and nature of salts dissolved in it. A small quantity of salts in water reduces soil resistivity by 80%. The common salt is most effective in improving conductivity of soil but it also corrodes metal, therefore, its use is discouraged.

Treatments for minimising earth resistance

- Tighten the joints and remove any oxidation on the joints
- Pour sufficient water in the soil around the earth electrode
- Use bigger sized earth electrode
- Electrode should be connected in parallel
- Earth pit of more depth, width, and breadth

Climatic conditions

Increase or decrease of moisture content determines the increase or decrease of soil resistivity. Therefore, in dry whether resistivity will be very high and in monsoon months the resistivity will be low.

Physical composition

Different soil composition gives different average resistivity. Based on the type of soil, the resistivity of clay soil may be in the range of 4–150 ohm-metre, whereas for rocky or gravel soils it may be well above 1,000 ohm-metre.

Location of the earthing pit

The location also contributes to resistivity to a great extent. In a sloping landscape, or in a land that is made up of soil, or areas which are hilly, rocky or sandy, water runs off quickly and during dry weather conditions the water table rapidly drops. In such situations back fill compound will not be able to attract moisture, as the soil around the pit would be dry. The earth pits located in such areas must be watered at frequent intervals, particularly during dry weather conditions to maintain optimium resistivity.

Though back fill compound retains moisture under normal conditions, it gives off moisture during dry weather to the dry soil around the electrode, and in the process loses moisture over a period of time. Therefore, choose a site that is naturally not drained quickly, like slopes.

Effect of grain size and its distribution

Grain size, its distribution and closeness of packing are also contributory factors, since they control the manner in which the moisture is held in the soil.

Effect of seasonal variation on soil resistivity

Increase or decrease of moisture content in soil determines decrease or increase of soil resistivity. Thus, in dry weather resistivity will be very high and during rainy season the resistivity will be low.

Effect of current magnitude

Soil resistivity in the vicinity of ground electrode may be affected by current flowing from the electrode into the surrounding soil. The thermal characteristics and the moisture content of the soil will determine if the current of a given magnitude and the duration will cause significant drying, and thereby increase the effect of soil resistivity.

Area available

Single electrode rod or strip or plate will not achieve the desired resistance alone. If more

Megger four-terminal earth resisitance meter. Image: http://www.test4less.co.uk

number of electrodes could be installed and interconnected the desired resistance could be achieved. The distance between the electrodes must be equal to the driven depth to avoid overlapping of area of influence. Each electrode, therefore, must be outside the resistance area of the other. If the earth pits are close to each other, the resistance value will be high.

Obstructions

The soil may look good on the surface, but there may be obstructions a few feet below the surface, virgin rock, for example; in such a case resistivity will be adversely affected. Concrete structures closer to the pits also play the role of obstructions, adversely affecting resistivity.

Measuring earth resistance with earth tester

For measuring soil resistivity, earth tester is used; it is also known as Megger after the manufacturer of such meters. It has a voltage source, a meter to measure resistance in ohms, switches to change the settings. A three-point or a four-point method is used to measure soil resistivity.

GI earthing vs copper earthing

- The resistivity of the soil and the physical dimensions of the electrode play an important role of resistance of rod with the earth.
- The material resistivity is not considered important in earth resistivity.
- Any material of given dimensions would offer the same resistance to earth, except the size and the number of the earthing conductors or the protective conductors.

Pipe earthing vs plate earthing

As per IS 3043 pipe, rod or strip has a much lower resistance than a plate of equal surface area.

Amount of salt and charcoal (more than 8 kg)

To reduce soil resistivity, it is necessary to dissolve the moisture particles in the soil. Some substance like salt or charcoal is highly conductive in water solution. However, these additive substances would reduce the resistivity of the soil, only when they are dissolved in the moisture in the soil; any additional quantity then does not serve any purpose.

About five per cent moisture in salt reduces earth resistivity rapidly and further any increase in salt content will have a very little effect on soil resistivity.

The salt content is expressed in per cent by weight of the moisture content in the soil. Considering one cubic metre of soil (weight of a cubic metre of soil is ~1,140 kg), with moisture content of 10% will have about 144 kg of moisture by weight. The salt content at 5% of the 144 kg moisture will about 7.2 kg. In a one cubic metre pit, any additional amount of salt over ~7.2 kg will not have much effect in reducing the resitivity of soil.

Amount of water pouring

Moisture content is one of the controlling factors of earth resistivity. Above 20% of moisture content, the resistivity is very little affected. But below 20%, the resistivity increases rapidly with the decrease in moisture content. Lower the moisture content, higher the soil restivity.

If the moisture content is already above 20% there is no point in adding water into the earth pit, except perhaps, wasting an important and scarce national resource!

Length vs diameter of earth electrode

Apart from considerations of mechanical strength, there is little advantage to be gained from increasing the earth electrode diameter for increasing the surface area in contact with the soil.

The usual practice is to select a diameter of earth electrode that will have enough strength to enable it to be driven into the particular soil without bending or splitting. A larger diameter electrode may be more difficult to drive than smaller diameter electrode.

The depth to which an earth electrode is driven has much more influence on its electrical resistance characteristics than has its diameter.

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THE NEED FOR SPEED

A power quality system analyst with over 30 years of industry expertise, Shridhar Visvanathan, Principal Consultant of Online Systems and the Electronic and Electrical Safety Consultant for BMPA, details why speedy voltage control is the need of the hour.

Modern and sophisticated machines used in the print and packaging industry consist of mechanical parts, heating elements, dryers, blowers, drives, motors, compressed air, and last but not the least, the mico processor-controlled electronics; the real brain behind the machine operation. For the range of earlier-generation machines, however, the conventional voltage stabiliser – servo controlled – was the industry standard in providing the desired voltage to the machine, so that it could function smoothly. Control electronics being analogue were more rugged and had a better tolerance limit for voltage fluctuations. Hence the stabiliser, though very slow in response, was a good enough protection for these machines.

The new range of modern machines offers an entirely new array of functionalities with the help of the cutting-edge technology. The need for speed and diverse functions these machines provide demands that the controller matches the speed and the quick response times; the controllers had to go the digital way. These controllers are now more of an information technology device, typically with digital signal processor architecture, comprised of digital electronic cards with discrete components.

So, we may ask, how good is the conventional servo voltage stabiliser in protecting the latest generation of electronic controls? To completely answer this question, we need to understand the tolerance of the digital control electronics or the information technology equipment, as we commonly know them.

ITC Curve – power acceptability curve for information technology equipment

ITC curve is a modified version of the CBEMA power acceptability curve. The ITC curve was created in collaboration with EPRI's Power Electronics Application Center (PEAC). The intent was to derive a curve that can better reflect the performance of typical single-phase, 120 V, 60 Hz computers and their peripherals, and other information technology devices; the same ratio may be applied to devices working 230 V, 50 Hz supply in countries like India.

The ITIC curve is used as a reference to define the withstand capability of various loads and devices for protection from power quality problems. This is because the curve applies to other equipment containing solid-state devices aside from being specifically applicable to computer-type equipment. However, one should be careful and should keep in mind that the ITIC curve is not intended to reflect the performance of all electronic-based equipment. There are too many variables – power loading, nominal operating voltage level, and process complexity, to try to apply a one-size-fits-all ITIC curve

What is CBEMA Curve

CBEMA Curve is one of the most frequently employed power acceptability curve. It was developed by the Computer Business Equipment Manufacturers Association (CBEMA) in the 1970s, as a guideline for the organisation's members in designing their power supplies. The CBEMA curve was originally derived to describe the tolerance of mainframe computer business equipment to the magnitude and duration of voltage variations on the power system. Also, the association designed the curve to point out ways in which system reliability could be provided for electronic equipment. Eventually, it became a standard design target for sensitive equipment to be applied to the power system and a common format for reporting power quality variation data. The CBEMA curve was adapted from IEEE Standard 446 (Recommended Practice for Emergency and Standby Power Systems for Industrial and Commercial Applications – Orange Book), which is typically used in the analysis of power quality monitoring results.

Source for the box: http://www.powerqualityworld.com/2011/04/cbema-curve-power-quality-standard.html

- Scope The CBEMA Curve and the Application Note illustrate an AC input voltage envelope, which typically can be tolerated by most Information Technology Equipment (ITE). It is not intended to serve as a design specification for products or AC distribution systems. The ITIC Curve describes both steady-state and transitory conditions.
- Applicability The ITIC Curve and the Application Note apply to 120 V nominal voltages obtained from 120 V, 208Y/120 V and 120/240 V 60 Hz systems. Other nominal voltages and frequencies are not explicitly considered, and it is the responsibility of the user to determine the applicability of these documents for such conditions.

Details of the components of ITC Curve

A brief description of the individual conditions that are considered in the ITIC curve is provided in this section. The term nominal voltage shall mean an ideal condition of 120 V (RMS), 60 Hz.

- Steady-State Tolerances The steady-state range is ±10% from the nominal voltage. Any voltages in this range may be present for an indefinite period and are a function of the average loadings and losses in the distribution system.
- Voltage Swell This region describes a voltage swell having an RMS amplitude of up to 120% of the RMS nominal

voltage, with a duration of up to 0.5 seconds. This transient may occur when large loads are removed from the system or when the voltage is supplied from sources other than the electric utility.

- Low-Frequency Decaying Ring-wave This region describes a decaying ring wave transient which typically results from the connection of power factor correction capacitors to an AC distribution system. The frequency of this transient may range from 200 Hz to 5 kHz, depending upon the resonant frequency of the AC distribution system. The magnitude of the transient is expressed as a percentage of the peak 60 Hz nominal voltage (not the RMS value). The amplitude of the transient varies from 140% for 200 Hz ring waves to 200% for 5 KHz ring waves, with a linear increase in amplitude and increasing frequency.

- High-Frequency Impulse and Ring-wave This region describes the transients that typically occur as a result of lightning strikes. Wave shapes applicable to this transient and general test conditions are defined in ANSI/IEEE C62.41-1991. This region of the curve deals with both amplitude and duration (energy), rather than RMS amplitude. The intent is to provide an 80 Joule minimum transient immunity.

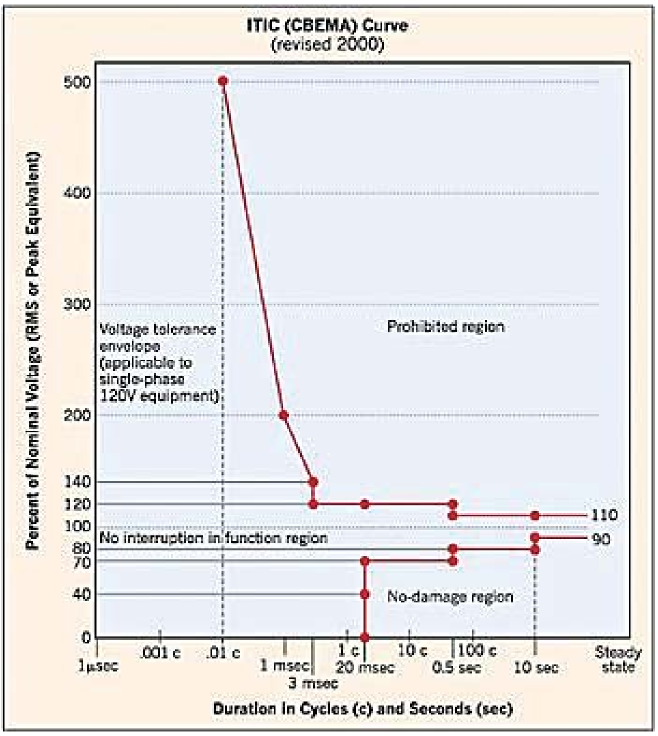
- Voltage Sags Two different RMS voltage sags are described. These transients result from the application of heavy loads, as well as fault conditions, at various points in the AC distribution system. Sags to 80% of nominal are assumed to have a typical duration of up to 10 seconds, and dips to 70% of nominal are assumed to have a duration of up to 0.5 seconds.

- Dropout A voltage dropout includes both severe RMS voltage sags and complete interruptions of the applied voltage, followed by immediate re-application of the nominal voltage. The interruption may last up to 20 milliseconds. This transient typically results from the occurrence and subsequent clearing of faults in the AC distribution system.

- No Damage Region Events in this region include sags and dropouts which are more severe than those specified in the preceding paragraphs, and continuously applied voltages which are less than the lower limit of the steady-state tolerance range. The normal functional state of the ITE is not typically expected during these conditions, but no damage to the ITE should result.

- Prohibited Region This region includes any surge or swells, which exceeds the upper limit of the envelope. If ITE is subjected to such conditions, damage may result

Now let us ask the same question again: how good is the conventional servo voltage stabiliser in protecting the new generation of electronic controls?



The answer is evident.

The servo voltage stabiliser is an electro-mechanical device, and hence any voltage fluctuation is stabilised in about 2-3 seconds since the speed of correction of a high capacity stabiliser is about 10 V per second (line to neutral) and 20 V per second is stabilisers up to 100 kva. By this time of approximately 2-3 seconds, the electronics may have suffered the damage; tolerance of digital electronics is 20 milliseconds, which is 1/50th of a second. (Reference: 1 second = 20 milliseconds) The non-electronic parts, excluding the drive, for example, of the machine would normally not be affected by this voltage fluctuation.

This leaves us with another question?

What type of voltage conditioner is to be used so that any voltage fluctuation may be corrected within 20 milliseconds (1/50th of a second)? The answer leads us to three devices: 1] Online UPS - uninterrupted power supply; 2] Online AVC System – active voltage conditioner; 3] resonance transformers.

We shall discuss the basic concepts and compare these three solutions in the subsequent issue of Print Bulletin so keep reading the article series.

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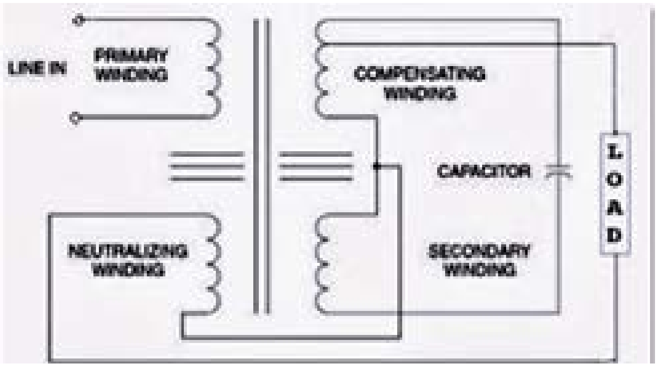
Notes: Author Shridhar V. wants to acknowledge that the fundamentals of the ITIC curve are shared from an article in the power quality world.

THE NEED FOR SPEED

A power quality system analyst with over 30 years of industry expertise, Shridhar Visvanathan, Principal Consultant of Online Systems and the Electronic and Electrical Safety Consultant for BMPA, details why speedy voltage control is the need of the hour.



A schematic diagram of Ferro-resonant transformer electricals.

Continuing our discussion from April 2018 article in Print Bulletin, let us ask the most important question that we asked ourselves right at the beginning of this series of articles: The need for speed.

How good is the conventional servo voltage stabiliser in protecting the new generation of electronic controls in print and packaging machines?

The answer is evident: the servo voltage stabiliser is an electro-mechanical device, and hence, any voltage change is stabilized in about two to three seconds; the speed of correction of high capacity stabiliser is about 10 to 20 v per second (line to neurtal). By this time the electronics may suffer damage since the tolerance for digital electronics is about 20 milliseconds or about 1/50th of a second. One second is equal to 1,000 miliseconds.

What is the solution for speed?

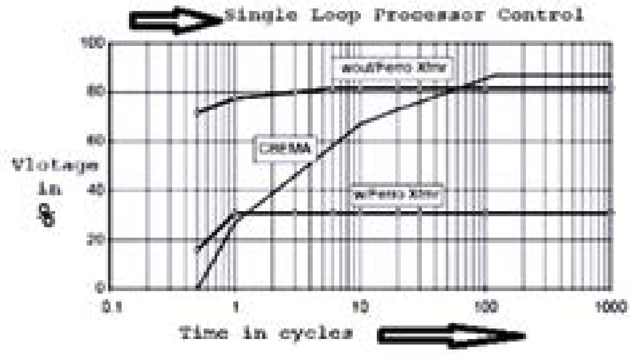
The answer leaves us with another question: what type of voltage conditioner is to be used so that any voltage fluctuation may be corrected within 20 milliseconds or 1/50th of a second? We have a few solutions in 1. Ferro-Resonance Transformers, 2. Online UPS (Uninterrupted Power Supply), and 3. Online AVC (Active Voltage Conditioner). Let us dive deep into these three solutions.

Ferro-resonant transformer (Ferros)

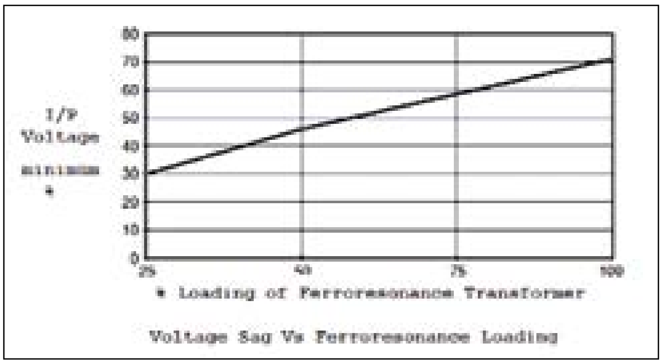
Ferro-resonant transformers also referred to as Ferros or simply, the resonant transformers can handle most voltage sag conditions. Ferros are particularly engaging for constant, low-power masses. Variable loads, particularly with high inflow current (inductive loads) are a drawback for Ferro's as a result of the tuned circuit at the output. Ferro-resonant transformers are primarily 1:1 transformers that are excited high on their saturation curves, thereby providing associate output voltage that is constant.

Speed of Voltage correction: within 1 cycle of wave form (i.e. 1/50th of a second)

Thus it is 100% of the times quicker than any conventional voltage stabiliser.



The Figure A above shows the voltage sag ride-through improvement of a method controller (load) fed from a 120-VA Ferro-resonant electrical device. With this Ferros , the method controller will ride through voltage sag down to 30% of nominal, as opposed to 82% of nominal when used without Ferros.



The Figure B above presents the allowable voltage sag as a share of nominal voltage (that can lead to a minimum 90% voltage at the Ferro outout) versus Ferro device loading factor. At 75% loading the allowable voltage sag is 60% of nominal, which means that the ferros can output over 90% voltage as long as the input voltage is higher than 60% of nominal. This is vital since plant voltage seldom falls below 60% of nominal through voltage sag conditions (excluding the total power failure condition).

Another vital feature of the Ferros is that at at 150% loading condition the output voltage collapses to zero there by protecting the electronic load instantaneously during electrical short conditions.

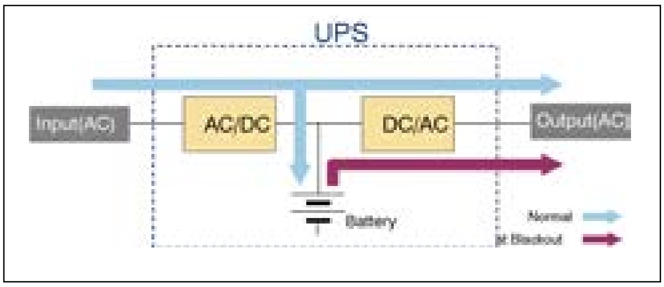


Diagram of the double conversion online UPS.

Ferros also feature mains 'isolation' characteristics along with phase shift (as compared to incoming phase) thus offer guaranteed protection against all type of electrical aberrations including spike, transient voltage, surge, electrical noise and harmonics.

The only limitation of the Ferro-resonant transformer is that it is available only in single phase models & of lower capacities from 50 VA to 5 KVA. Hence these may be smartly deployed to exclusively protect the control electronics of any machine application.

Online UPS with double conversion architecture and battery backup

1. **Operating principle and its features**
    1. At normal situation, supply mains is rectified to DC voltage by diodes, and the DC voltage is converted to AC again by inverter. Upon blackout, DC voltage from battery is converted to AC voltage by inverter. Thus, regardless of normal situation or blackout, power is fed by inverter.
    2. Switching to battery needs no interruption so that output voltage is continuous.
    3. Power source noise is cut, and output voltage and frequency are stable even when input voltage fluctuates
2. **Merits and Demerits**

    If blackout measures against every power failure is required, it would be no exaggeration to say that there is no other system than Online UPS. That said, the device becomes bigger and dramatically expensive.

    1. As a merit, Online UPS offers steady state output voltage under extreme voltage variations as well as power blackout conditions. This it accomplishes since it has a 10 to 15 min battery bank in a closed loop. Being double conversion architecture, the output power is clean & free from all type of electrical aberrations including spike, transient voltage, surge & electrical noise.
    2. The demerit of an online UPS is increased power consumption of the UPS itself (5% to 8%) as inverter is always at play. This system becomes expensive as circuit structure is complicated, further the capital cost of battery bank is quite heavy and the batteries require replacement every four years.
    3. The online UPS also needs additional space for the battery bank and the additional air-conditioning required to exhaust the 5% to 8% heat losses.

At a site that faces frequent power outage there, Online UPS is the best and only option for the smooth switch over from mains to battery backup and then to DG supply in case of extended power outages. However, at sites where power blackout is rare the client is left wondering about the additional cost incurred just to achieve a clean power source.

Online AVC system

An online AVC consists of solid state static converters that are not on the current path between the load and the utility. Instead, the corrective voltage injection is achieved by means of a transformer winding between the utility and the sensitive load. This configuration results in a very efficient method to provide instantaneous voltage correction within 20 milliseconds. Further, Online AVC requires no batteries as it draws the additional energy required during sags to make up the correction voltage from the utility supply.

Online AVC systems offer quicker return-on-investment due to low operation costs, with industry leading efficiency > 97%. The system has minimal heat loss, resulting in lower cooling and electricity costs. With zero costs associated with battery replacement, the cost of ownership is 45% less than a UPS of similar capacity.

Onlie AVC has some attractive features: Speed of Voltage correction: within one cycle of wave form, i.e. 1/50th of a second. Thus, it is 100% time quicker than any conventional voltage stabiliser, sag mitigation within 20 milliseconds, surge protection, and when desired, it may combined with a delta-star isolation transformer. It functions literally like a battery less UPS (no back up).

Thus an Online AVC is the ideal, cost effective critical power system for protection of sensitive electronic controls and the whole print packaging machine itself. Available in 3-phase capacities presently 15 kVA to 350 kVA.

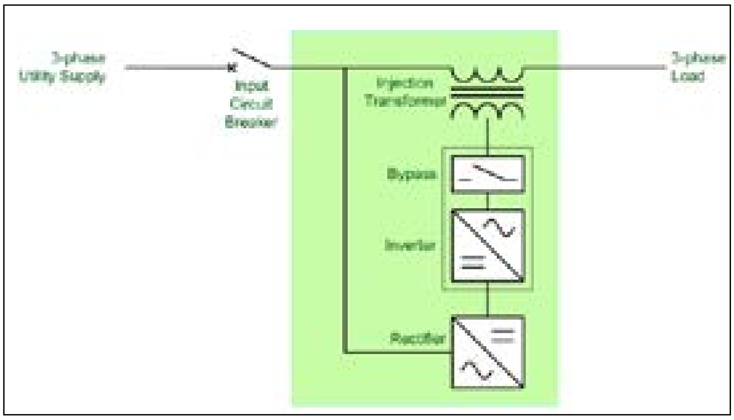


Diagram of online AVC.