Complete — Power Quality

Recognize electrical disturbances

Understand their impact

Select the correct power solution

EGS Electrical Group
SOLA/ HEVI-DUTY

Total Power Quality Solutions
(800) 377-4384
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Powering performance.

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Reliable Power is Quality Power

As factory automation continues to evolve with the movement of data centers from computer rooms to the factory floor, the importance of power quality has escalated. The inclusion of more sensitive electronic equipment in industrial processes demands the delivery of clean and stable power. Even the smallest service or process interruption can have a devastating effect on the efficiency and productivity of a company.

Productivity and Protection

Protection from power disruptions is more important than ever. Computers, data storage systems and safety equipment are just a few examples of areas sensitive to power interruption. Lost performance, data and equipment due to a power disturbance leads to a loss in productivity and profitability.

Disturbance	Cost/Event
Voltage Sags	$ 7,694
Momentary Outage	$11,027
1 Hr Outage: Notice	$22,973
1 Hr Outage: No Notice	$39,459
4 Hr Outage	$74,835

Cost of poor power quality and downtime according to 1996 Duke Power Survey

Industrial power quality products from Sola/Hevi-Duty protect your processes and equipment from the adverse effects of electrical disturbances. Combining conditioned incoming power with compatible power conversion components ensures your system's reliability which, in turn, keeps your productivity levels high. High power quality protects your investment, leads to lower operating costs and keeps you in control of your systems and equipment.

Factory automation equipment requires protection from electrical disturbances.

Do You Have a Power Quality Problem?

Obvious signs of a power quality problem include flickering lights, damaged equipment or a complete loss of power. Shorter than expected life span of equipment or unexplained shutdowns can also be a result of power quality problems.

Costly disruptions on the factory floor can be reduced by conditioning incoming power.

Those highly susceptible to poor power quality may experience:

- Power trips
- Erratic equipment performance
- Incorrect data

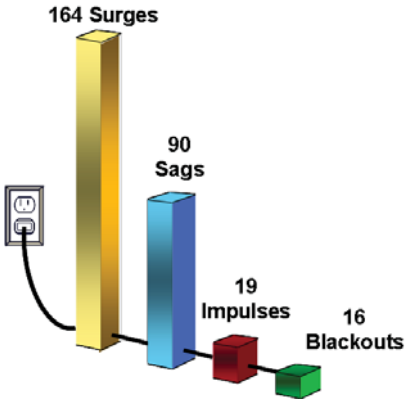
Protect Your Investment

Sola/Hevi-Duty has been a trusted name in power conversion and power quality since 1915 providing total system and facility solutions. Our products offer superior quality and field proven reliability that will keep your facility and equipment performing 24/7.

Total Power Quality Solutions

What Causes Poor Power Quality?

Poor power quality is caused by electrical disturbances such as transients, surges, sags, blackouts and harmonics. These disturbances can be generated within a facility or delivered through utility power. Within a facility, the powering on and off of very large equipment along with the harmonics and transients created by other electronic equipment may cause internal disturbances during normal daily operation.



Average distribution of common power disturbances faced by facilities during one year period.

Wiring errors, grounding loops and overloaded systems have also become more common as capacity levels are pushed and companies turn to outside contractors rather than in-house electricians. Lower quality or poorly specified power conversion products also lead to problems when an incorrectly sized product is mismatched with an application.

Weather disturbances can wreak havoc on an electrical system.

Although 80% of power quality problems are caused internally, 20% are delivered through the incoming utility power. The systems are regionally dependent and developments such as weather, utility fault clearing or accidents to power lines impact the quality of power coming into your facility. Network issues such as grid switching and power factor correction capacitors also create disturbances that are beyond your control until they reach your equipment.

Critical equipment should be protected to prevent data loss and corruption.

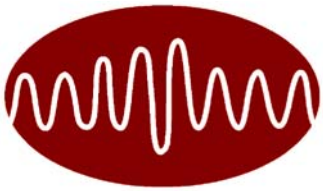
Maintain High Power Quality

A multi-level protection approach needs to be taken to achieve and maintain a high level of power quality within a facility. One solution is typically not enough to ensure reliable power due to the variable causes of each power disturbance. Some basic strategies include:

- Isolate all power offending devices such as drives, motors, welders and large compressors.
- Protect all expensive or sensitive equipment such as PLCs, monitors, drives, vision systems, industrial computers, etc.
- Specify the best power conversion products including K-Factor and Drive Isolation transformers.
- Use basic surge protection at each panel point.

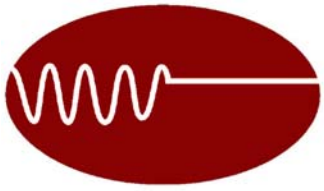
Uninterruptible Power Systems provide protection from power interruptions.

There are many types of power disturbances as listed below.



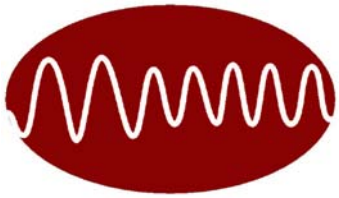
Voltage Surges or Swells

A line swell, also called a voltage surge, is a temporary rise in the voltage level lasting at least one half cycle. Voltage swells can be caused by high-power electric motors, switching off, and the normal cycling of HVAC systems.



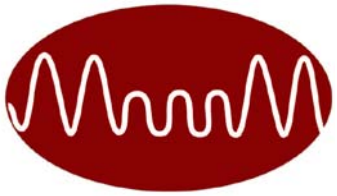
Blackouts

During a blackout, all power is lost, ranging from milliseconds to hours, or even longer. To keep critical equipment running, a new power source must be provided either from stored energy (Uninterruptible Power Supplies) or from a mechanical generator.



Brownouts

During periods of high power demand, the power utility may intentionally reduce line voltage by up to 15%. Brownouts can last up to several days and create many forms of abnormal equipment behavior.

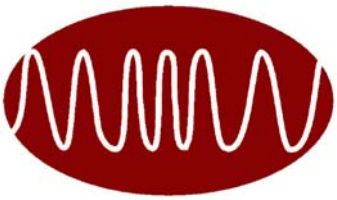


Voltage Sags

A line sag, sometimes called a voltage dip, is a temporary decrease in the voltage level lasting at least one half cycle. Sags are usually caused by sudden nearby increases in the electrical load and can degrade equipment performance for several seconds at a time.

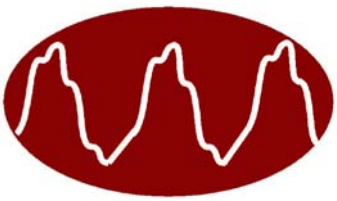
Voltage Transients or Spikes (Impulses)

Sudden massive increases in voltage, such as those caused by lightning striking a power line or the nearby ground, can cause a damaging voltage pulse to enter electronic equipment and destroy sensitive solid-state circuitry. Lasting only a few milliseconds, storm-induced voltage transient spikes are responsible for huge losses every year.



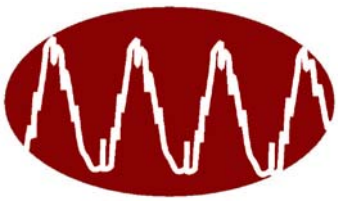
Frequency Variations

Rare in utility power, frequency variations are most common with back-up power systems such as standby generators. Many UPS's cannot handle frequency problems, which can cause system crashes and equipment damage. And, of course, it can negate the value of having back-up capability!



Harmonics

Non-linear loads such as personal computers, office equipment, variable-frequency drives and solid-state electronics use switchmode power supplies to generate DC voltage, sometimes causing currents that are out of phase with voltage. These harmonics distort voltage waveforms, and can cause overheating, nuisance tripping, and the loosening of electrical connectors.



Electrical Noise

Random electrical disturbances can be caused by distant lightning, switching power supplies, electronic circuits, poor brush contacts on motors, utility switching and many other sources. These random noise signals are superimposed on voltage waveforms, and can cause computer bugs, glitches, and other problems that are difficult to diagnose.

Power Quality Disturbances and Solutions

Impulse (Transient/Spike)

Definition	Narrow, high voltage or current impulse superimposed on the AC
Causes	Utility grid switching
	Contactor opening or closing
	Heavy industrial equipment starting
	Lightning
Effects	Equipment failure or damage
	System lock-up
	Data corruption/loss
	Component stress that can lead to breakdown
Solution	**Surge Protective Device** Power Conditioner

STV100K *STV25K*

Protection & Features:

- Limits loads exposure to high voltages
- Prevents damage due to dielectric breakdown
- Reduces data errors and lock-ups
- Low cost, economical
- Sinewave tracking adds parallel filter
- Decreases rise time of impulse
- Attenuates lower energy impulses

Electrical Noise

Definition	Low amplitude, low current, high frequency disturbances
Causes	Non-linear loads
	Other loads
	Improper grounding
	Loose wiring
	Electromagnetic interference
Effects	Perceived software errors
	System lock-up
Solution	**Isolation Transformer** Power Conditioner UPS

Isolation Transformers

Protection & Features:

- Physical separation from input to output
- Very good common mode noise attenuation
- Good attenuation of low level impulses
- Shielding increases attenuation
- Provides improved attenuation of normal mode noise and impulses
- Step-Up or Step-Down voltage

Sag

Definition	Temporary drop in RMS voltage, may last for several cycles.
Causes	Large load start-up (ex. motors, air conditioner)
	Utility switching
Effects	Hardware crashes (ex. PLCs)
	Occasional equipment failure
	Reduced efficiency and life span of electrical equipment
Solutions	**UPS** Power Conditioner Voltage Regulator Power Supplies with sag immunity

Surge (Swell)

Definition	Temporary rise in RMS voltage, may last for several cycles.
Causes	Large load turning off (ex. motors, air conditioner)
	Utility shedding loads
Effects	Hardware damage
	Bright light
Solutions	UPS **Power Conditioner** Voltage Regulator

UPS

Solatron™ Plus Power Conditioner

Protection & Features:

- Provides battery back-up when AC line voltage is not within normal operating values or fails completely
- Highly effective power conditioning
- Advanced voltage regulation provides clean power to load during abnormal input voltage conditions
- On-line models include sinewave correction

Protection & Features:

- Excel at tightly regulating voltage
- Provide superior noise attenuation
- Designed to withstand the harshest electrical environments
- With no moving parts, units are virtually maintenance free

Power Quality Disturbances and Solutions

Brownout

Definition	Temporary drop in RMS voltage, may last for several hours.
Causes	High demand on utility grid
	Service located at the end of grid
Effects	Hardware crashes
	Occasional equipment failure
	Reduced efficiency and life span of electrical equipment particularly motors.
Solution	**Voltage Regulator**

MCR Voltage Regulator

Protection & Features:

- Provides excellent filtering to protect equipment from damage caused by majority of disruptions
- ±3% output voltage regulation
- Includes noise attenuation and harmonic filtering
- Exceptional circuit protection achieved through galvanic isolation
- No maintenance required

Harmonics

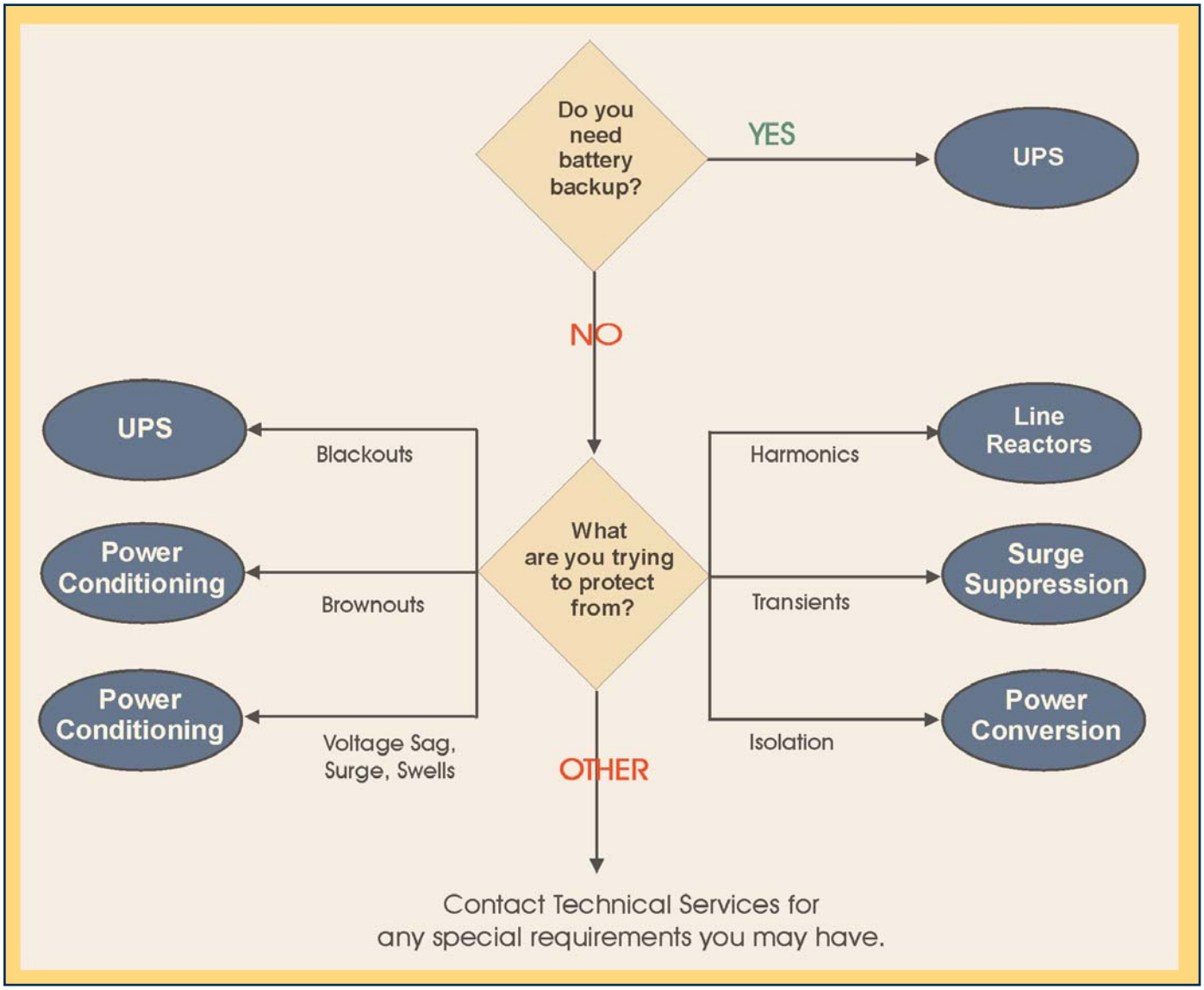
Definition	Distortion to the sinewave
Causes	Switch mode power supplies
	Non-linear loads
	Variable frequency drives
Effects	High neutral current
	Overheated neutral conductors and transformers
	Voltage distortion
	Breaker tripping
	Loss of system capacity
Solutions	**Line Reactor** **K-Rated Transformers** **UPS** **Power Conditioner**

SLR Line Reactor

Protection & Features:

- Inductive filter prevents damage due to capacitor or large load switching
- Reduces stress on drive components
- Removes harmonics and keeps line voltage smooth through notching
- Eliminates drive cross-talk and interference
- Reduces nuisance tripping

Whether protecting expensive equipment from sags and swells or ensuring the delivery of clean safe power, Sola/Hevi-Duty's power quality products can be used individually or in combination to provide a complete solution.



Matching Protection to Sensitive Loads

Most electronic equipment is designed to operate in a clean commercial or lab-based industrial environment. When utilized in demanding applications, sensitive equipment requires protection from inevitable power disturbances. Different loads are affected by different disturbances and, as a result, require different levels of protection.

Sensitive equipment is often at risk in a demanding factory environment.

Disturbance	Sensitive Loads	Sola/Hevi-Duty Solutions
Impulses	• Microprocessors • PLCs • Instrumentation • Counting applications • Certain grade power supplies	 *Surge Protective Device*  *Isolation Transformer*  *UPS*
Voltage Sags **Swells** **Brownouts**	• Motors • Compressors (HVAC) • Test & measurement equipment • Lighting	 *Constant Voltage Transformer*  *Power Conditioner*  *UPS*
Power Interruptions	• Computers • Data storage systems • Alarm systems • Safety equipment • Automated processes	 *S1K UPS (Off-Line)*  *S2K/S3K UPS (Interactive)*  *S4K UPS (On-Line)*  *S5K UPS (Modular)*

Surge Protective Device (SPD)

Our line of surge suppression products provide protection against damaging transients. Available in DIN Rail or Panel Mount configurations, these devices provide sinewave tracking, LED status indication and form “C” dry contacts.

Applications

- Industrial Panels
- Building Automation Systems
- AC Distribution Panels

Constant Voltage Transformers Hardwired CVS & MCR Series

Constant Voltage Transformers are excellent for industrial applications requiring tight voltage regulation. Using a patented ferroresonant transformer technology, the CVS and MCR series provide the trusted solution against power disturbances.

Applications

- Factory Automation
- Programmable Logic Controllers
- Laboratory and Test Equipment
- Robotics
- Industrial Panels
- Security Systems

MCR Portable Series Power Line Conditioning with Voltage Regulation

The MCR provides excellent noise filtering and surge protection to protect connected equipment from damage, degradation or misoperation. These units are a perfect choice where dirty power caused by impulses, swell, sags, brownouts and waveform distortion can lead to costly downtime because of damaged equipment.

Applications

- Computers/ Printers
- POS terminals
- Laboratory equipment
- Telephone/FAX systems
- Security systems
- LAN networks

SOLATRON™ Plus Three Phase Power Conditioner

The rugged design of the SOLATRON™ Plus series ensures high performance through inductive loads and poor power factor. This power quality solution for three phase equipment is able to handle many power quality problems including isolation, voltage regulation and surge protection. The lack of fans or batteries ensures long life and maintenance free reliability.

Applications

- Automatic Packaging Machinery
- Data Rooms
- UPS Bypass Circuits
- Retail Store

Off-Line UPS

Units provide economical protection from damaging impulses and power interruptions for smaller, less critical, stand-alone applications. Ideal for personal computers and workstations which can tolerate the 2-4 ms of transfer time when the UPS switches from AC input to battery.

SDU DIN Rail Series

The SDU DIN Rail UPS combines an industry leading compact design with a wide operation temperature range and unique installation options. These units include easy to wire screw terminations for critical devices needing battery back up such as computer based control systems.

Applications

- Programmable Logic Controllers
- Robotics
- Computer-based control systems
- Factory Automation
- Conveying Equipment

S1K Series

These units include separate outlets; one for critical devices needing battery back up such as the CPU while the other surge-protected only outlet is for non-critical devices like printers and fax machines. The S1K is ideal for office and POS use.

Applications

- PCs
- Workstations
- Computer Terminals

Line-Interactive UPS

This technology provides highly effective power conditioning plus battery back-up. Advanced voltage regulation allows the UPS to provide clean power to the load while conserving battery even during abnormal input voltage conditions. This is particularly applicable in areas where power outages are rare but where there are frequent power fluctuations.

S2K Series

S3K & SK32U Series

These units protect against over and under voltages by raising and lowering utility power to the right level for sensitive equipment. Most power corrections are accomplished without transferring to the internal battery. Utility power is continually protected and internal battery life is optimized. The S3K2U is the ideal choice for networking or process control racks.

Applications

- PCs
- PLCs
- Robotics and process control
- Automatic service & dispensing equipment
- Workstations
- Computer peripherals
- Industrial automation systems

On-Line UPS

This alternative provides true on-line performance accomplished through double conversion technology. Input power is continually regulated and conditioned to provide the critical load with a clean, pure sinewave power source as well as battery back-up.

S4K2U Industrial On-Line Series

The S4K2U series eliminates a wide range of power problems (spikes, surges and extended overvoltage, noise and other transients, sags and extended brownouts), even difficult-to-track harmonics and dangerous frequency variations that are common with standby generator operation. The slim 2U (3.5") package maximizes available space.

S4K4U Industrial On-Line Series

The S4K4U Series provides flexible output voltage, an integrated maintenance bypass switch and internal batteries all in a slim 4U (7.0") enclosure. The dual inverter design allows flexible output voltage to meet mixed load voltage requirements. The UPS automatically configures the output voltage to match the input configuration without requiring tap selections. The standard maintenance bypass switch provides an additional level of protection.

Applications

- Industrial Computers
- Industrial Automation Systems
- Enterprise telecommunication systems
- Pharmaceutical and medical equipment
- Robotics and process controls
- Network servers
- Printing and publishing machinery

Modular UPS

These on-line double conversion units are designed for easy upgrades and maximum flexibility. By adding modules, users can reach higher VA ratings (up to 20 KVA maximum), extend runtimes or add N+x parallel redundancy. Configurations can be cost-effectively upgraded keeping modular units current without a large reinvestment in a new system.

S5K Modular Series

Designed to be fully configured, tested and shipped in the configuration you need, the 5K Modular is scalable from 4 to 20 kVA. The optional N+x redundancy provides a fault-tolerant group of power modules and controls. Each modular component can be hot-swapped making it easy to increase power or extend back-up runtime without interrupting power to the load.

Applications

- Network servers
- Enterprise telecommunications systems
- LAN gateways, bridges and routers
- Mini-computers, superservers and server clusters
- Clusters of PCs or workstations and peripherals
- RAID arrays and other large-scale data handling systems

Drive Isolation Transformers vs. Line Reactors

Drive Isolation Transformers are specifically designed for use with SCR controlled variable speed motor drives. They isolate variable speed drives from other non-linear devices on the same circuit provide and handle large voltage changes.

Line Reactors oppose any rapid change in electrical current and "smooth" out disturbances. They are smaller, lighter and less expensive than drive transformers, however, they do not provide isolation or step-up or step-down voltages.

Drive Isolation Transformers

Designed for use with SCR (Silicon Control Rectifier) variable speed motor drive applications, drive isolation transformers magnetically isolate the incoming line from the motor drive. These units also provide a voltage change to match the required voltage of the SCR drive. Standard designs are delta primary and wye secondary to match the common power sources required in most three phase rectifier circuits.

Applications

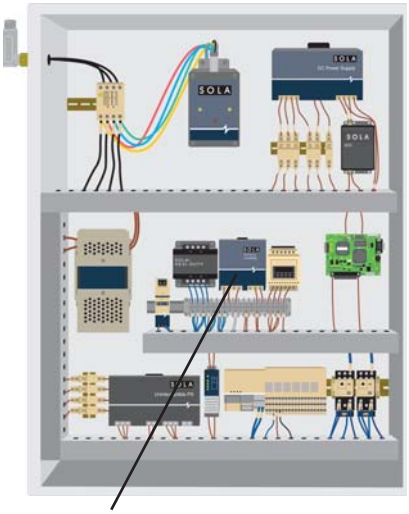
- SCR Variable Speed Drives

SLR Line Reactors

The SLR Series is a CE style, DIN Rail Mounted line reactor that provides safe, compact protection for high frequency drives and electronic equipment. The SLR inductive filter prevents damage to any three phase electronic system plagued by capacitor or large load switching. Other benefits include reduced harmonics and input line distortion.

Applications

- Variable Frequency Drives
- Conveyors
- Robotics
- Any three phase electronic products subject to high current anomalies such as Power Factor Correction capacitor switching.



The SLR provides reliable drive protection for machinery powered by control cabinets.

Finding Immunity to Voltage Sags

One of the most frequent power quality disturbances is not a complete loss of power but rather a short loss of line voltage. Known as 'voltage sag', this often underestimated and overlooked event accounts for a significant portion of lost revenue due to equipment damage and production downtime. In the blink of an eye, sags in voltage can bring production to a halt.

Sags can stress components over time, resulting in premature wear and failure. For processes relying on high speed, any interruption can lead to significant production shortages. Interruptions to processes requiring hours to create one part or a single batch of parts have a significant impact on company profits. Shutdowns result in scrapped work, production shortages, lower service levels for customers and less income for the company. Fortunately, there are ways to prevent sags from disrupting operations.

Many manufacturing and process industries focus on preventing/mitigating sags to maintain maximum competitiveness, productivity and quality. The Semiconductor Equipment and Materials Institute (SEMI) has gone so far as to establish a minimum standard with regard to sag immunity performance for semiconductor tools and equipment. The SEMI F47 standard* introduces a well-conceived, voltage-to-time curve to which most equipment will be exposed during normal operation. SEMI has also developed a specific method for testing and reporting.

The curve in Figure 1 depicts the minimum hold-up time in seconds (X axis) relative to the percentage of normal line voltage (Y axis). SEMI F47 specifies equipment must be able to tolerate 50-per cent line voltage for 200 ms, 70-percent line voltage for 500 ms and up to one second for 80-percent line voltage.

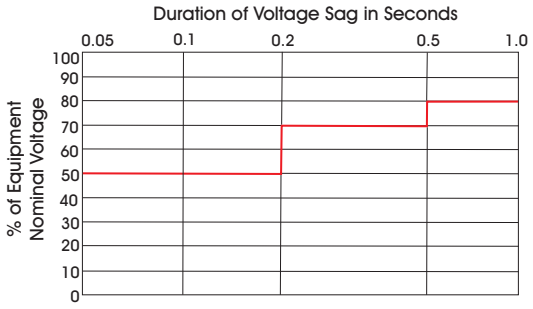


Figure 1: *SEMI F47 Curve*

* SEMI F47-0200, Specification for Semiconductor Processing Equipment Voltage Sag Immunity.

Identifying the Sensitive Types

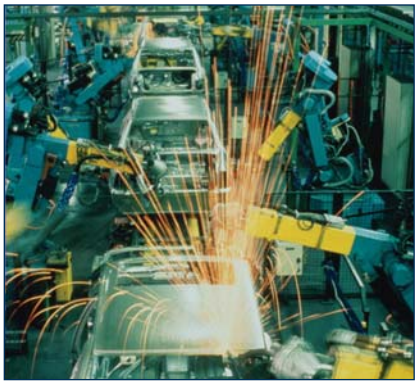
Most motors, lighting and indicators can tolerate sags of short duration with negligible detriment to production (perhaps a fan slows down briefly or a light flickers, but production goes on). The most sag-sensitive, and usually most critical, component is the AC/DC power supply used to power all DC control and logic circuits.

Any type of computing or automation equipment must use an AC/DC power supply to supply the right power level for chips and components. The majority of power supplies on the market currently average 10 ms to 20 ms of hold-up time at full load. These devices will not meet the sag immunity performance needed to work during common sag events without special considerations undertaken by the system designer.

SDN DIN Rail Power Supplies

Solution

The most effective way to prevent sags from disrupting operations is to employ a SDN DIN Rail power supply meeting SEMI's standard at full power and all voltage ranges. This gives the designer maximum flexibility with minimum design effort. The SDN family of power supplies provides industry leading performance with a true industrial grade design and high quality that meets difficult industrial environmental conditions including high shock, vibration and wide temperature ranges over the long life cycle of the industrial equipment.



Voltage sags may cause production interruptions and damage

Glossary of Terms

AC (Alternating Current)

Current that reverses direction in response to voltage that is changing polarity.

Attenuation

Decrease in signal voltage or power.

Battery Run Time

The amount of time (in minutes) a battery system can support a load.

Blackout

Slang term for the total loss of electrical power for more than one minute.

Bypass

A mechanical or electronic switch to provide an alternate path for the line current.

CE Mark (Conformité Européenne)

A marking that shows the product meets the fundamental safety, health, environmental and consumer protection requirements of the European Community.

Common-Mode Noise

Noise that occurs between the current carrying conductors and ground.

Constant Current Power Supply

A power supply that regulates its output current for changes in line, load, ambient temperature, and time.

Constant Voltage Power Supply

A power supply that regulates its' output voltages for changes in line, load, ambient temperature, and time.

CVT (Constant Voltage Transformer)

A power conditioner that provides a stable and regulated sinewave output voltage.

Continuous Duty

The service requirement that demands operation at a constant load for an indefinite period of time.

Control Transformer

Usually referred to as an Industrial Control transformer. Designed for good voltage regulation characteristics when low power factor and /or large inrush currents are drawn (5 to 15 times normal).

Cross-Regulation

In a multiple output power supply, the percent voltage change at one output caused by the load change on another output.

Crowbar

An overvoltage protection circuit which rapidly places a low resistance shunt across the power supply output terminals if a predetermined voltage is exceeded.

CSA

Canadian Standard Association.

DC (Direct Current)

Current that flows in only one direction.

Derating

The specified reduction in an operating parameter to improve reliability.

Differential Mode Noise

Noise that occurs between the current carrying conductors.

DIN Rail

A standard rail (typically 35 mm wide) that mounts to the chassis and allows other electrical components to be installed and replaced easily.

Drift

The change in output voltage of a power supply over a specified period of time, following a warm-up period, with all other operating parameters such as line, load, and ambient temperature held constant.

Dynamic Load Regulation

The ratio of change in output voltage to change in load current.

Eddy Currents

Additional currents caused by a magnetic field.

Efficiency

A measure of energy loss in a circuit.

EMC (Electromagnetic Compatibility)

A directive necessary to get the CE Mark, which shows the electrical device will not create high levels of EMI and will not fail due to normal levels of EMI.

Encapsulated

A method of sealing a device with epoxy to resist environmental effects.

Ferroresonance

A method of producing a constant voltage by use of a special saturated transformer. Invented and patented by Joseph Sola in 1938.

Ferroresonant Power Supply

A stabilized power supply (CVDC) driven by a constant voltage transformer.

Filter

A device that reduces unwanted electrical noise.

Foldback Current Limiting

A power supply output protection circuit whereby the output current decreases with increasing overload, reaching a minimum at short circuit.

Force Air Cooled

A means of accelerating heat dissipation to lower the temperature rise of an electrical device.

Frequency (Hertz)

Cycles per second.

Harmonics Distortion

The distortion of the AC waveform due to the addition of sine waves of different frequencies being added to the AC voltage.

Holdup Time

The length of time a power supply's output voltage remains within specifications following the loss of input power.

Impulse

A high amplitude, short duration spike (milliseconds) superimposed on the normal voltage or current.

Input Line Filter

A low-pass or band-reject filter at the input of a power supply which reduces line noise fed to the supply. This filter may be external to the device.

Input Voltage Range

The high and low input voltage limits within which a device meets its specifications.

Inrush Current

The peak instantaneous input current drawn by a device at turn-on.

Inrush Current Limiting

A circuit which limits the inrush current during turn-on of a device.

KVA Rating

A measurement of apparent power. 1 KVA = 1000 VA.

KW Rating (kilowatts)

A measurement of real power delivered to a load
1 KW = 1000 VA x Power Factor

Line Regulation

The change in output voltage due to a variation in input voltage.

Linear Power Supply

A power supply that uses a control device, like a transistor, in series (or parallel) with the load. The control device adjusts the effective resistance to give a constant voltage output.

Load Regulation

The change in output voltage due to a variation in load.

Noise/Electrical Noise

Also called electromagnetic interference, or EMI. Unwanted electrical signals that produce undesirable effects and otherwise disrupt the control system circuits.

Off-Line UPS

A UPS where the inverter is normally off until there is a power failure. Also known as a Standby UPS.

On-Line UPS

A UPS where the inverter is always powering the load. AC is converted to DC to charge the battery then DC is converted to AC to power the load. On-Line UPS are often referred to as "Stand-by UPS" or "Double Conversion UPS".

Output Current Limiting

An output protection feature which limits the output current to a predetermined value in order to prevent damage to the device under overload conditions.

Output Voltage

The nominal value of the voltage at the output terminals of a device.

Overshoot

A transient change in output voltage, in excess of specified output accuracy limits, which can occur when a power supply is turned on or off, or when there is a step change in line or load.

OVP (Overvoltage Protection)

A power supply feature which shuts down the supply, or crowbars or clamps the output, when its voltage exceeds a preset level.

Parallel Operation

The connection of the outputs of two or more identical devices to obtain a higher output power.

PARD (Periodic and Random Deviation)

A term used for the sum of all ripple and noise components measured over a specified band width and stated in either peak-to-peak or RMS values.

PE (Protective Earthing)

The incoming earthing conductor provided by the utility.

PI Filter

A commonly used filter at the input of a switching supply or DC/DC converter to reduce reflected ripple current. The filter usually consists of two parallel capacitors and a series inductance and is generally built into the supply.

Post Regulator

A linear regulator used on the output of a switching power supply to improve line and load regulation and reduce output ripple voltage.

Glossary of Terms

Power Boost™

Describes the advanced overload capability of the SDN and SDP power supplies to power high inrush loads without oversizing.

Power Factor

The ratio of true power (Watts) to apparent power (VA).

Power Fail Detection

A power supply option which monitors the input voltage and provides an isolated logic output signal when there is loss of line voltage.

Pre-regulation

The regulation at the front-end of a power supply, generally by a type of switching regulator, this is followed by output regulation, usually by a linear type regulator.

Rated Output Current

The continuous load current that a device was designed to provide.

Redundancy

The addition of extra devices to provide a backup in the event of the loss of one of those devices.

Remote Sensing

The ability for a power supply to sample the load voltage located a distance away, and adjust for the resulting voltage drop.

Reverse Voltage Protection

A feature which protects a power supply against a reverse voltage applied at the input or output terminals.

Ripple

A small AC voltage on the DC output of a power supply that remains after filtering.

Ripple and Noise

A small AC voltage on the output of a power supply at a specified bandwidth. This is the result of feed through of the rectified line frequency, internal switching transients and other random noise.

Sag

A temporary drop in the RMS voltage, which may last from one cycle to a few seconds.

Short-Circuit Protection

A feature which protects the device from a short-circuit so that the device will not be damaged.

Swell

A temporary increase in the RMS voltage, which may last from a half cycle to a few seconds.

Switching Frequency

The rate at which the voltage is switched in a DC-DC converter or switching power supply.

Switching Regulator

A high efficiency circuit used to regulate output voltages.

Switchmode Power Supplies (SMPS)

A power supply that uses a switching regulator.

Thermal Protection

An internal safeguard circuit that shuts down the unit in the event of excess internal temperatures.

THD (Total Harmonic Distortion)

The ratio of the harmonic content to the fundamental frequency expressed as a percent of the fundamental.

Transfer Time

The amount of time a device takes to switch from one mode of operation to another.

Transformer

An electrical device that changes AC voltage from one level to another.

Transient

A high amplitude, short duration (milliseconds) spike superimposed on the normal voltage or current. Sometimes called a **spike** or a **surge**.

Transient Recovery Time

The time required for the output voltage of a device to settle within specified output accuracy limits following a step change in output load current or a step change in input voltage.

UL (Underwriters Laboratories)

Acronym for Underwriters Laboratories tested.

UL Recognized

Designation given to components that when used properly in an end product are deemed to be safe.

UL Listed

Designation given to products ready for end use.

Undervoltage

*See **Brownout.***

UPS (Uninterruptible Power Supply)

A device which supplies power to the critical load when the existing AC line voltage is not within normal operating values, or fails completely.

VA (Voltamp)

A measure of power. 1000 VA = 1 KVA.

Q. What is a constant voltage power conditioner?

A. Although a constant voltage power conditioner (sometimes referred to as constant voltage transformer or voltage regulator) is a transformer-like device, its design and function are totally different. The function of a constant voltage power conditioner is to provide a voltage across its secondary terminals within a specified tolerance (usually ±5%) as long as the voltage impressed on the primary is within the specified bandwidth (usually +10% to -20%).

Q. What are the differences between Sola power conditioners?

A. All three products use Sola's patented ferroresonant technology. The primary design considerations for the CVS series were voltage stabilization and magnetic isolation. This group provides ±1% output voltage regulation with an input voltage range of +10%/-20% with moderate (1000:1) normal (transverse) noise attenuation.

The MCR series was designed to address both voltage regulation and magnetic isolation. This group offers ±3% output regulation with an input range of +10%/-20% but also offers magnetic isolation for excellent 1,000,000:1 common mode and 1000:1 normal (transverse) mode attenuation.

The MPC series incorporates all of the benefits of the MCR series in addition to exceeding the low leakage current requirements of UL 544 and providing identifiable output receptacles to indicate they are safe for hospital grade use (orange with green triangles).

The Three Phase power conditioners utilize micro-processor-based tap switching technology to provide ±5% regulation in three phase installations. The CVS, MCR and MPC are single phase only.

Q. Are there any special considerations needed when I select a constant voltage power conditioner?

A. Special consideration must be given to the type of load to be powered (inductive loads need to be sized to start up currents), load power factor, ambient temperature and where the unit will be installed.

Q. What exactly is Ferroresonance?

A. Ferroresonance is the principle behind Sola's very popular CVS, MCR and MPC power conditioners. Ferroresonance is the property of a transformer design in which the transformer contains two separate magnetic paths with limited coupling between them. The output contains a parallel resonant tank circuit and draws power from the primary to replace power delivered to the load. Note that "resonance" in ferroresonance is similar to that in linear circuits with series or parallel inductors and capacitors, where the impedance peaks at a particular frequency. In a nonlinear circuit, such as Sola's ferroresonant transformers, "resonance" is used to reduce changes in supply voltage to provide a more consistent voltage to the load.

A magnetic device is nonlinear. Its reluctance changes abruptly above a certain magnetic flux density. At this point, the magnetic device is defined as being in saturation. The design of the Sola transformer allows one magnetic path (the resonant path) to be in saturation, while the other is not (See Figure 2). As a result, further change in the primary voltage will not translate into changes in the saturated or secondary voltage and voltage regulation results.

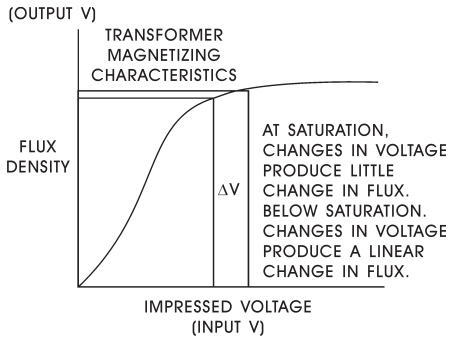


Figure 2: *CVT Saturation Curve*

Q. Will harmonic currents affect ferroresonant power conditioners?

A. A Sola ferroresonant power conditioner will have essentially harmonic-free output because of the addition of a neutralizing coil. This coil neutralizes the harmonics in a manner best explained by first considering the device as a conventional transformer with the neutralizing coil disconnected. Though this coil is now open circuited, it has a voltage induced in it as a portion of the magnetic flux passes through the center leg of the core to the outer legs. Since some of the primary flux links this coil, fundamental voltage is present. The resultant voltage has a high odd-harmonic content due to the leakage flux from the output winding.

This leakage flux can return to the output winding by two paths. One bypasses the neutralizing coil. The other path links the neutralizing coil completely. By controlling the reluctances of these magnetic paths, one can control the degree of secondary flux coupled to the neutralizing coil. The neutralizing coil is connected with its polarity additive to the secondary (or output coil) as shown in Figure 3. The output of the newly formed regulator has constant voltage with a waveshape almost completely free of harmonics.

The harmonics are still present in the output winding and also in the neutralizing coil. Since those harmonics present in the neutralizing coil are induced by the flux from the secondary winding, the harmonics in each coil are approximately 180° out of phase. This results in their cancellation. Proper control of turns ratio and magnetic path reluctance contribute to the generation of a sinusoidal output – even with a square wave input!

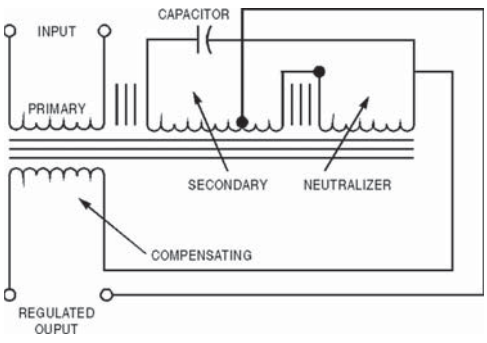


Figure 3: *CVT Schematic Diagram*

Q. Are there different constant voltage power conditioner designs?

A. Yes, there are two basic design concepts. A tap switching design utilizes an electronic circuit along with a traditional transformer core and coil assembly to control the output voltage. As a result, the output voltage tends to be a stepped waveform rather than a smooth sinewave.

A ferroresonant design utilizes the electromagnetic induction principle exclusively to produce the desired output voltage. Consequently, the output voltage waveform is a smooth sinewave. The ferroresonant design attenuates transient electrical noise, provides surge suppression per ANSI/IEEE Standards and provides a harmonic free output. These important benefits are not always available with other designs.

Q. Should I use a constant voltage power conditioner instead of a UPS?

A. The question involves two different technologies used for differing reasons. 95% of all power quality problems are caused by transient noise, voltage surges, harmonics or frequently changing voltage conditions. Ferroresonant power conditioners provide the solutions for almost all of these power quality problems.

The primary function of any uninterruptible power supply (UPS) is to provide an alternative voltage source (batteries) to a critical load for some period of time should a complete a power failure occur. Complete power failures account for less than 5% of all power quality problems. For the other 95% of all power quality problems, ***unless the UPS is the on-line version, the UPS is of no help.***

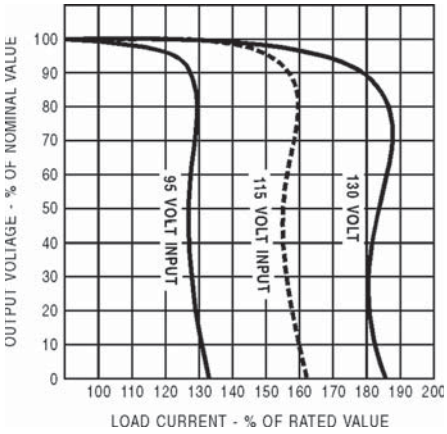


Figure 4: *CVT Output Voltage Tolerance*

Q. How should a SPD be applied?

A.
- SPDs should be installed with the shortest lead length possible and as close as possible to the load it is protecting.

- SPDs protecting panels should be wired in parallel with the service entrance or distribution panels. A disconnecting means must be provided for servicing and for short circuit and over current protection.

- When a circuit breaker cannot be installed, install a tap on the buss or lugs. Wire in a fused disconnect to provide the above mentioned protection for the SPD. This method of installation allows the SPD to be replaced safely without shutting down the power.

- SPDs must be wired and grounded according to the (NEC) National Electrical Codes.

- Using Whole Facility Protection would safeguard your electrical system against most transients. This means that the protection is staged; service entrance protection, sub-panel protection, and point of use protection.

Q. What loads should not be powered by a UPS?

A. Loads that are highly inductive may cause a UPS to malfunction. Examples of equipment that should ***not*** be powered by a UPS include:

- Air Conditioners
- Drills
- Space Heaters
- Vacuum Cleaners
- Buffing Machines
- Fans
- Laser Printers
- Transformers (step up/step down)

The majority of loads that require UPS protection are electronic type loads. For example; process control, automation equipment, computer, and telecommunication. A UPS is also recommended to support microprocessor-based technology type loads.

In addition, CVS and MCR power conditioner products are not recommended for use on the input and or output side of the UPS.

Q. Why should only an on-line UPS be used with a standby generator?

A. An on-line UPS accepts input power with relatively wide variations in voltage and frequency, a common occurrence in power produced by standby generators. The true on-line (double conversion) technology provided by an on-Line UPS handles these variations by converting the input power from AC to DC and then converting DC to AC output power. Generators should be equipped with an electronic governor to minimize frequency variations. Always check the frequency range of the generator output as the use of a mechanical governor does allow for large changes in frequency to reach the load. A wide frequency swing may cause the UPS to switch to the battery more frequently.

An off-line or line-interactive UPS is not recommended for use with a standby generator. An off-line UPS passes utility power straight through to the load. When a variation is detected, it can protect the load from the frequency variations of the standby generator by transferring to battery power. Occasionally, the input frequency will match the specifications of the off-line UPS and it will transfer back from battery. These occurrences are infrequent and short lived, but the battery may not have sufficient time to recharge. It will support the load only until it is completely depleted and then shut down the load.

A line-interactive UPS faces the same issue as the off-line. The power conditioning (tap switching) functions of the line-interactive units focus on correcting voltage variations and have no effect on frequency variations. It reacts to out-of-spec frequencies similar to the off-line UPS.

The same input frequency variations that would cause an off-line or a line-interactive UPS to transfer to battery are of little concern or have no effect on the on-line UPS. On-Line UPS's compensate for generator frequency variations while prolonging battery life.

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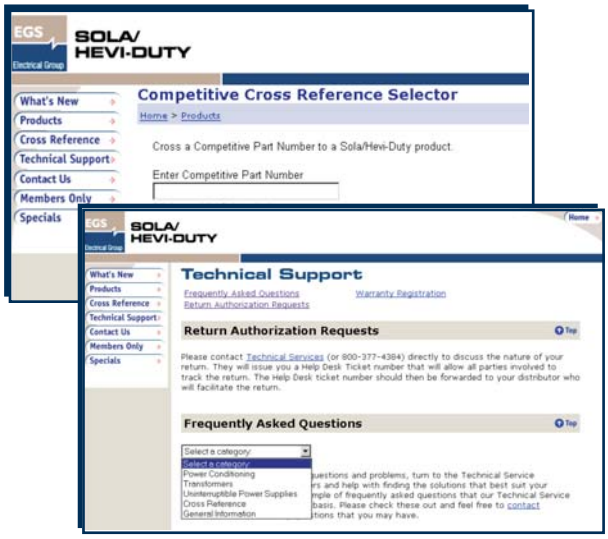

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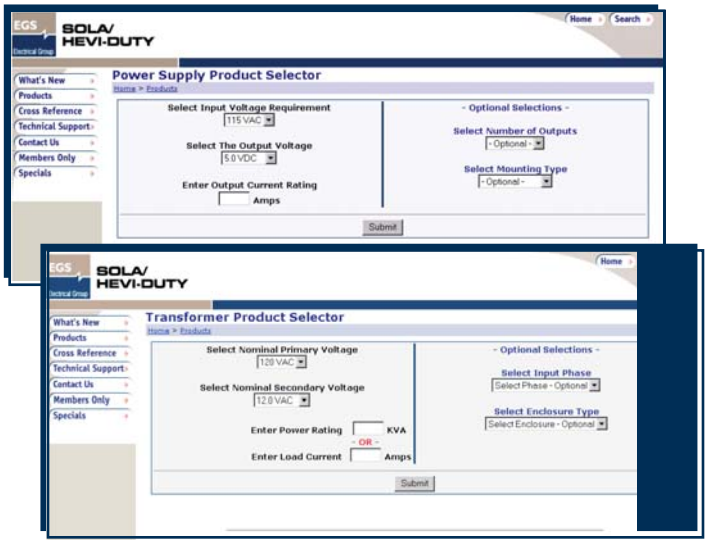
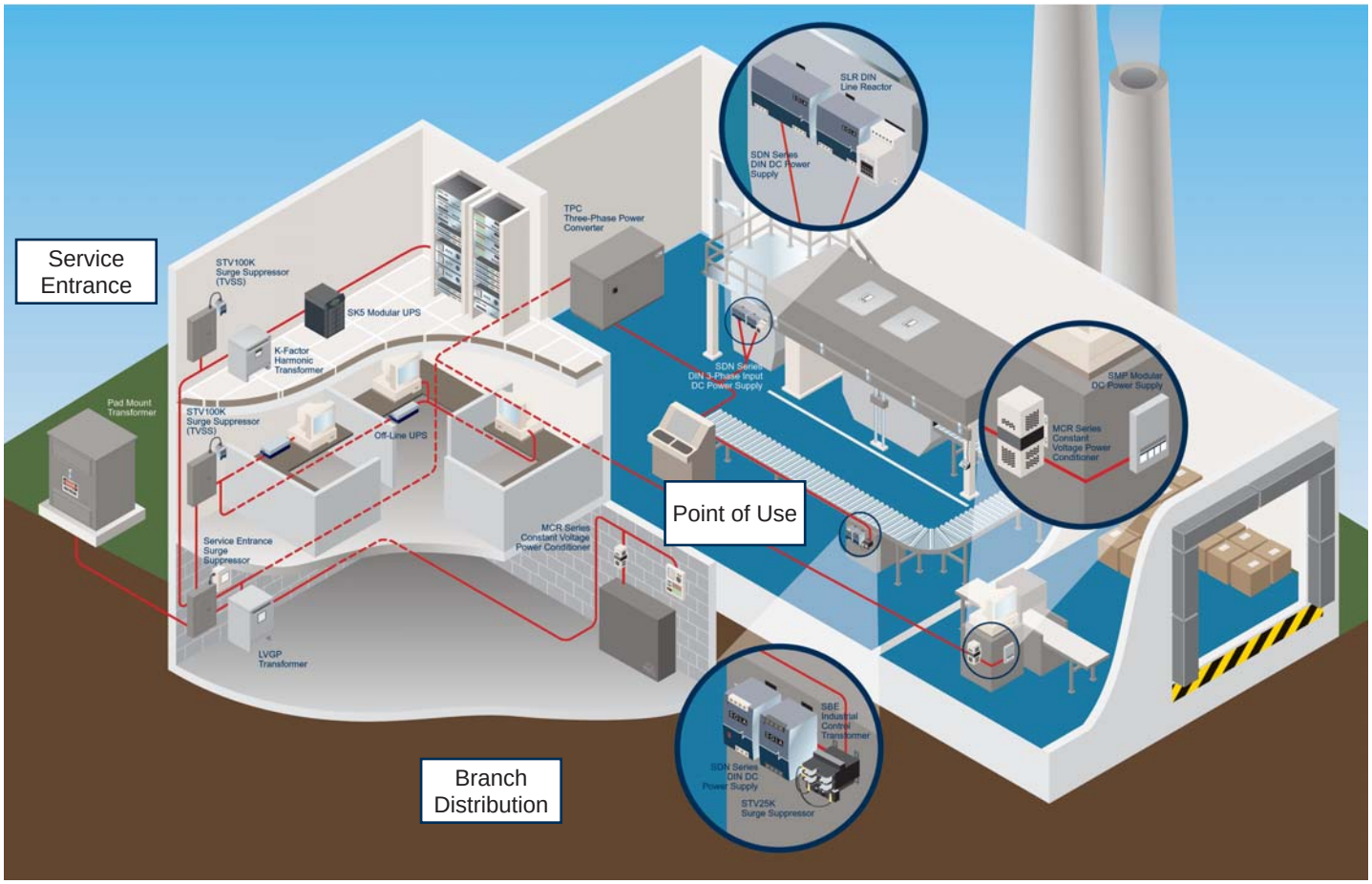


Enter your requirements, hit Submit and any matching products will list as well as links to specifications on our website.

Sola/Hevi-Duty is at work for you on the facility floor, service entrance, branch panel, power distribution points and point of use applications.

Our products power the most demanding applications and can be used in conjunction or alone to ensure controlled, reliable power to any part of the factory floor or machinery.



	Industrial Power Conversion and Protection					
	Power Conditioning	Line Reactors	Surge Suppression	Transformers	Power Supplies	UPS
Service Entrance			X	X		
Branch Panels			X	X		
Networks	X		X		X	X
Large Machinery	X	X	X	X	X	X
Process Rooms	X		X			X
PLC's & Industrial PC's	X		X	X	X	X
Ethernet & Communications			X		X	X
DeviceNet			X		X	X
Motion Control			X		X	
Drives	X	X	X	X		
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