



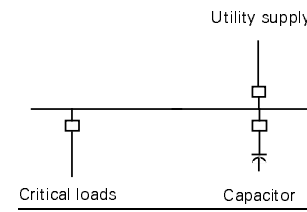
## Applying Voltage Disturbance Remediation Systems

Voltage interruptions, dips, and sags can cause disruptions of industrial production and commercial services. These interruptions in turn lead to significant costs to businesses (please refer to GET-8057 for more information). Many systems are available for controlling the impact of these disturbances on the production process. This Application Note presents an overview of these systems and a guide to the appropriate applications.

### System Descriptions

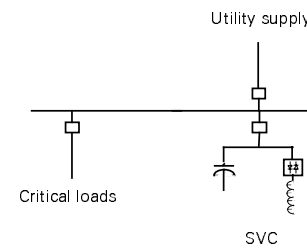
#### Mechanically Switched Capacitors (MSC)

Conventional power factor capacitors that are automatically switched on to support voltage at a desired level.



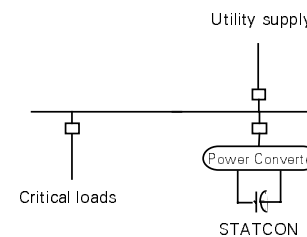
#### Static VAR Control (SVC)

Devices that support voltage by supplying reactive volt-amperes (VARs) from conventional capacitors and that can control this supply dynamically by electronically modulating var absorption in shunt reactors.



#### Static Condenser (STATCON)

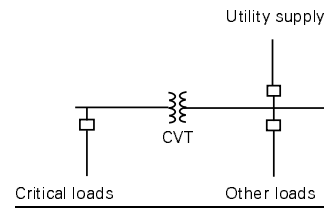
Electronic devices that supply reactive volt-amperes (VARs) dynamically to correct for voltage dips due to remote faults, motor starting, or load cycling. STATCON offers better response time than SVC, and may be preferable if the depth of the voltage disturbance is severe.





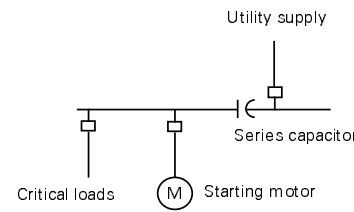
### Constant-Voltage Transformers (CVT)

Special transformers that can maintain rated output voltage to compensate for voltage sags and dips of moderate depth (also called “ferroresonant transformers”).



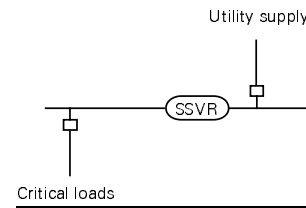
### Distribution Series Capacitors (DSC)

Capacitors that are inserted in series in the distribution circuit to reduce the effective reactance to the source. Effective in reducing voltage sag due to nearby large loads and motor starting.



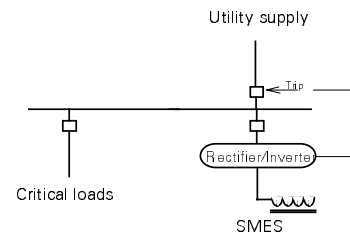
### Static Series Voltage Regulators (SSVR)

Devices that corrects voltage dips and sags due to nearby unbalanced faults or extended-duration unbalanced loading. Especially effective for maintaining production continuity during single-phase-to-ground faults on utility supply.



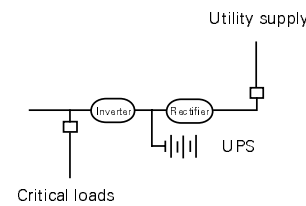
### Superconducting Magnetic Energy Storage (SMES)

Devices that store energy in an electromagnetic field within a supercooled electromagnet and can rapidly release that energy upon demand from the power system. SMES systems are characterized by their ability to supply fairly large amounts of energy over short periods of time, usually seconds or less.



### Uninterruptible Power Supply (UPS)

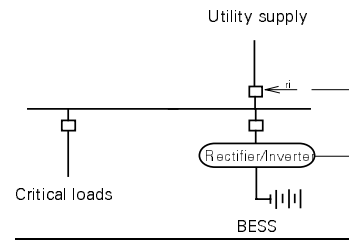
Devices that supply critical loads over a dc link supported by a storage battery that is trickle-charged from the power system. UPS systems are usually designed to provide power long enough to permit an orderly shutdown of the process, typically 15 minutes.



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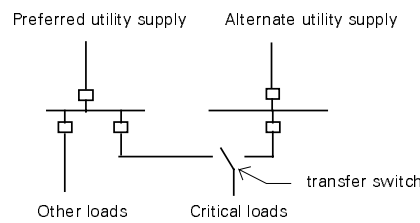
## Battery Energy Storage Systems (BESS)

Devices that store energy in a conventional storage battery that is constantly trickle-charged from the power system, and can return that energy to the ac system when required. BESS systems are characterized by their ability to store and supply moderate amounts of energy over fairly long time periods, often minutes to hours.



## Fast-Transfer

Technique of rapidly transferring a critical load from one power supply to an alternative, using either mechanical or static switching devices.



## Cogeneration

Generation installed within the industrial or commercial system. Unlike “emergency generation” that is normally idle and is expected to function only after an interruption, “cogeneration” operates continuously so that it is available at the instant that interruption of the commercial supply takes place.

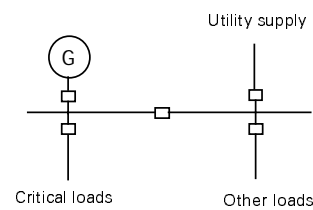


Table 1 summarizes the correlation between system vulnerability, disturbance characterization and the available solutions. This table can be used as a selection matrix to aid in determining the right solution for the problem.



**Table 1**  
**Options for Remediating Voltage Interruptions**

<b>Duration</b>	<b>&lt; 1 Cycle</b>		<b>1-10 Cycles</b>		<b>Cycles-Seconds</b>		<b>Seconds-Minutes</b>		<b>Minutes-Hours-Days</b>
<b>Cause</b>	Switching, Commutation		Fault Depression		Fault Depression		Utility Trip & reclose		Permanent Interruption
<b>CBEMA Limits</b>	+10%, -50%		+8%, -20%		+7%, -15%		+6%, -13%		+6%, -13%
<b>Topology</b>	1-phase	3-phase	1-phase	3-phase	1-phase	3-phase	1-phase	3-phase	3-phase
<b>Relative Likelihood</b>	100%		90%	10%	90%	10%	90% start 1-phase; 98% reclose 3-phase		
<b>Issue</b>									
<b>Voltage</b>									
<b>Energy</b>									
<b>Remediation</b>	Isolate Critical Loads		Isolate Critical Loads		Local Voltage Support		One Pole Trip/Reclose		Local Voltage Support
	Local Voltage Support		Local Voltage Support		Ride-Through Power		Local Voltage Support		
					Faster Fault Clearing		Local Voltage Support		
					Faster Source Transfer		Ride-Through Power		
<b>Tools &amp; Techniques</b>	SSVR		SSVR	SMES	SSVR	Fast Transfer	SSVR	Fast Transfer	BESS Cogeneration
	STATCON UPS		STATCON/SVC DSC UPS BESS <sup>(2)</sup> CVT <sup>(3)</sup>		STATCON/SVC DSC UPS BESS <sup>(2)</sup> CVT <sup>(3)</sup>		UPS BESS <sup>(2)</sup> MSC CVT <sup>(3)</sup>		CVT <sup>(3)</sup>

- (1) The ability of STATCON to limit extremely short-duration voltage dips is determined by the depth of the dip.  
 (2) Fast isolation from the fault is important to maximize the ability of BESS to sustain voltage during faults.  
 (3) Constant voltage transformers are effective only if the voltage disturbance is relatively shallow.

This Application Note is one of a series being produced by GE Power Systems Energy Consulting to address specific issues in power quality affecting utility, industrial, and commercial businesses. Another note is available on:

- Assessing the Cost of Voltage Disturbances
- Increase the Reliability of Power Distribution to Critical Loads

For copies of the above bulletin, for a complete and up-to-date listing of available bulletins, or to discuss specific concerns on areas of power quality or electrical power systems, please contact:

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