SST PROVIDES POWER SOLUTIONS FOR THE NEW E-CONOMY!

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INTRODUCTION

The US industrial economy has been powered by the electric grid for the past 100 years. The quality of the electrical power has been key to economic growth and to improving industrial productivity levels. In the industrial economy, power quality was measured by the number of power interruptions, typically 2-3 per year. In the new digital economy, this definition is very limited, and does not adequately address equipment and process sensitivity. Microprocessors, communications, and process control equipment, the building blocks of the new digital and Internet economy, are often disrupted by very short duration voltage dips and sags which occur 20-30 times per year, leading to more frequent and costly process and economic disruptions, even as the 'lights stay on.'

Soft Switching Technologies (SST) has patent-protected proprietary power solutions for the *New E-conomy*. The Dynamic Sag Corrector™ (*DySC*™- pronounced 'disk'), SST's first product in this market, solves over 90% of all power quality problems (including all voltage sags and dips) using only power electronics, with no batteries, transformers, or moving parts. The *DySC*™ is a proven product that is uniquely positioned in this existing, large, rapidly growing and essentially unserved market. It is modular, small size, maintenance free, highly efficient and has long life. This proven technology platform can also be used to connect and control distributed resource technologies including fuel cells, microturbines and flywheels to the customer or utility grid.

The term 'power quality' has recently achieved a high level of visibility due to the needs of the digital economy. The term is sometimes also used in the context of emerging power technologies that describe new types of energy sources and storage technologies, as well as for distributed resources and generation, because of synergy between these technology areas. Experts agree that a thriving *New E-conomy* is extremely dependent on good power quality, and the cost of poor power quality to the US economy is estimated to be over $150 billion per year.

The power quality and distributed resources markets are poised for significant change and growth. The successful IPO's of companies such as Capstone Turbine, and the continuing visibility of companies such as Ballard, Plug Power, Active Power, Power One, and American Superconductor has drawn attention to the role distributed technologies can play in the *New E-conomy* and the deregulating utility industry. Incisive papers by the Gilder Group, Cambridge Energy Research Associates, Merrill Lynch, New York Times, Bear Stearns, etc. have identified the power-related problems that *New E-conomy* industries will have to overcome to remain competitive. A significant amount of venture and investment capital is funding the development of new technologies and products to meet customer needs. All these solutions need power electronics for power conversion, control, and connection to the electric grid. SST is well positioned to deliver not only solutions for power quality applications, but also for connecting distributed resources to the grid and participating in the high growth segments of the power technology market.

THE POWER QUALITY SPACE (PQ SPACE)

Utilities attempt to deliver voltage within a 'nominal' range, typically +/-10% of a 'nominal' value, to its customers at all times. A power quality 'event' occurs whenever the voltage deviates from this 'nominal' band, even for a very short time. Computers, digital controllers, and sophisticated industrial processes are at the heart of the *New E-conomy* and can shutdown when the voltage fluctuates from the nominal band for as little as 0.02 seconds (such short duration 'events' are often referred to as voltage sags). The old industrial economy used less sophisticated electro-mechanical devices that were not sensitive to voltage sags, but only to longer outages. SST's *DySC*™ provides a new power quality solution to meet the needs of the *New E-conomy*!

Process sensitivity to voltage sags abound in virtually every industry sector. Examples include:

- Outdoor Technologies Inc., a plastics extruder in Mississippi, experienced a shut down of its 14 extrusion lines between 10-15 times a year. Each shutdown entailed a 4-6 hour restart process and generated a mountain of scrap. Monitoring the incoming power with the help of the local utility revealed that voltage sags of less than ¼ second duration, primarily a result of nearby thunderstorms, caused virtually all the plant shutdowns.
- Ford Motor, along with all automotive manufacturers, loses anywhere from 10-30 cars when production is interrupted by a voltage sag at an assembly plant. Such 'events' occur 10-20 times per year at each plant.
- Fiber-optic cable bundles, at the heart of the telecom revolution, can snap when a voltage sag is encountered during the manufacturing process costing manufacturers, such as Lucent Technologies, millions of dollars every year.
- Semiconductor fabrication houses such as Intel and IBM lose millions of dollars a year in chips due to voltage sags. As a result, the semiconductor industry is the first industry group to formulate and to enforce a voltage sag susceptibility standard (SEMI F-47), which will specifically protect equipment and processes from voltage sags. This trend is sure to be followed by other industry groups.

SST has installations in key industry sectors, including each of the above examples that have demonstrated the viability and cost effectiveness of the *DySC*™ solution.

Most power quality 'events' are caused by factors outside a utility's control and thus can never be totally eliminated. Causes include lightning storms, squirrels in transformers, damage to utility poles, and faults in industrial plants or on the utility grid. The occurrence of such an 'event' causes a line fault resulting in the tripping of utility-protective switchgear on the specific utility line where the 'fault' occurs. However, until the fault clears (typically less than 0.15 seconds), very high currents flow in the utility system causing a short duration voltage dip or voltage sag as far as 50 to 100 miles from the location of the fault. As there could be hundreds of electric lines in that 50 to 100 mile radius, and only one faulted line which possibly suffers an actual outage, the number of voltage sag 'events' at any location vastly outnumbers longer duration outage type of 'events'. Several studies have confirmed that while a typical utility customer experiences 2-3 outages per year, they may experience 25-30 short duration voltage sags and momentary loss of power 'events' per year.

Utility Reliability Metrics

Utility reliability can be measured using two distinct metrics:

- The more commonly used metric, as proposed by Mark Mills and Peter Huber of The Gilder Group, uses the percentage of time that the utility voltage is outside the nominal band as a measure of the utility reliability. As an example, consider a typical annual distribution of 25 'events' for a 'good' utility supply, of which 22 events are of less than ¼ second duration, with one event each of 2 seconds, 5 minutes, and 30 minutes. For this particular scenario considered here, the time that the utility is out of nominal band is 2107.5 seconds per year, giving a reliability level of 4 nines (99.99%). This metric is effective for many old economy processes and for simple loads such as lighting and heating.

Table 1: Distribution of Power Quality 'Events' for Typical Industrial Customer

Type of Events	Normal Utility (#events/yr)	Premium Utility (#events/yr)
< ¼ second duration	22	22
¼ second to 2 seconds	1	0
2 seconds to 5 minutes	1	0
>5 minutes (½ hour typical)	1	0

- Another metric that may be more meaningful for the *New E-conomy* is based on the amount of downtime that a process actually experiences due to a power quality 'event'. If the down time experienced is ½ hour for each ¼ second voltage sag, the impact on the process is the same as if a much longer outage had occurred giving a reliability level that is 7,200 times worse than calculated from the previous metric. This multiplier is defined as a 'downtime amplification factor' (DAF). For the typical case above, this gives an effective total downtime of 12.5 hours per year (½ hr x 25 events).

The DAF has a huge and often unrecognized impact on the effective reliability level that is perceived by the *New E-conomy* customer. High DAF levels can also be correlated with high cost of downtime and loss of productivity.

A process with a low DAF is impacted only by longer duration outages. These occur infrequently (2-3 times per year) and require solutions such as local and back-up generators, fuel cells, and microturbines. These solutions have a slow response time and cannot protect against short duration voltage sags.

Processes with a high DAF are impacted by both voltage sags and outages and experience 25-30 'events' per year. Both voltage sags and outages effectively shut down the process. Solving the voltage sag problem using a 'power quality' solution eliminates over 90% of their problem (see Table 2).

Industries that have a high cost of downtime, such as semiconductors and automobile manufacturing, often request a second independent power feed from the utility, of course at significant additional cost. This 'premium utility' connection eliminates the longer duration outages, leaving only the voltage sags to be corrected. For processes with low DAF, a typical premium utility feed is out of the nominal band for less than 5.5 seconds per year, a reliability level of 6 nines (99.9999%). This level is considered adequate for all but the most demanding applications (see Table 2).

For processes with a premium utility feed but a high DAF, the 22 remaining events of ¼ second each would still bring the process down for over 11 hours per year, not much better than the normal utility feed case. Processes such as server farms, semiconductor chip fabrication and an increasingly larger share of the old economy, would encounter significant problems here, even with the premium utility feed. However, if the voltage sag problem could be solved, it would effectively cure 100% of the problem (see Table 2). Differentiating between low and high DAF situations is even more important for premium utility connections.

Existing Power Quality Solutions

The existing power quality solutions market is focused on the 'old paradigm', protection against 2-3 outages per year. Back-up generators (market size>$3 billion/year) protect against long term outages, uninterruptible power supplies (>$4 billion/year) protect computers from short outages, and line conditioners (>$350 million/year) protect industrial controls from brownouts. These solutions fall short of addressing the needs of the *New E-conomy*.

Most new solutions fall into either the back-up or UPS category. Fuel cells and microturbines, which have the market buzzing, are really on-site and back-up power supply solutions and are not very effective for high DAF processes where power interruptions may be momentary but process interruptions are much longer. These solutions ideally target the high potential distributed resources market. If energy storage and the required power conditioning are added to the back-up solution, then 100% of the problem can be solved for both low DAF and high DAF processes, but at significantly higher cost.

Flywheel and superconducting magnetic energy storage (SMES) systems are essentially UPS replacements that eliminate batteries and use alternative energy storage media that are currently much more expensive. The cost trade-off is against battery maintenance requirements, its limited life, and the difficulty of operating UPS units in demanding industrial environments. UPS and equivalent solutions (in particular those without batteries) can protect against short duration 'events', but not against long and sustained outages. It should be noted that virtually all the new solutions require power electronics to convert, control, and connect to deliver the power. In addition, they require substantial energy storage and/or a continuous source of energy. These technology components significantly add to the cost of the solutions.

The Dynamic Sag Corrector™

Creating a new category power quality solution, the internationally patented Dynamic Sag Corrector™ (*DySC*™-pronounced 'disk') from Soft Switching Technologies specifically targets high DAF processes. It uses only power electronics with virtually no energy storage to protect against all short duration 'events', voltage sags, and momentary loss of power. It has the smallest size, lowest initial cost, lowest operating cost, highest efficiency, and is designed to handle demanding industrial loads.

The *DySC*™ is available at ratings from 1.5 kVA to 2,000 kVA to protect processes at their most vulnerable points, and so at the lowest cost. For the normal utility case, the *DySC*™ reduces downtime from 45,000 seconds to less than 4,500 seconds. For the premium utility case, the *DySC*™ solves 100% of the problem, virtually eliminating downtime.

SST has sold over 100 *DySC*™ units since product introduction in mid-1999, and is protecting high DAF processes in some of the most demanding industry sectors. *DySC*™ customers include Ford, GM, Lucent, Square D, Fort James, FSI, OTI, International Rectifier, KLA Tencor, Applied Materials, M&M Mars, Nestle, Engines Inc., LTV Copperweld, Eaton, and several major utilities. The *DySC*™ is available from SST and its reseller group, as a brand labeled product from Square D, and through the Grainger catalog.

The power electronics platform used in the *DySC*™ also provides a proven building block to meet the power conditioning needs of distributed resource technologies such as fuel cells and microturbines. Combining the *DySC*™ platform with the energy source then provides a solution that covers the entire PQ Space, potentially in the most cost-effective manner.

SST has defined a substantial new market opportunity, and is a technology and market leader in this new space. There are no other products currently available with a similar feature set or user benefits. The US market for power quality solutions for high DAF processes exists today, is virtually unserved. This market segment alone is estimated to be in excess of $1.5 billion per year and growing rapidly. SST is targeting this large and growing market as a market entry point for its line of power quality and related products.

SUMMARY

Analyzing the power quality requirements of processes in the market demonstrates a clear shift to high DAF processes in the New E-conomy. It is important to map solution capabilities onto process requirements to understand the efficacy of any power quality solution. Table 2 summarizes the performance of various solutions in the PQ Space for low and high DAF processes. The ability of the *DySC*™ to solve 90% of the problems for high DAF loads for the typical utility case, and virtually 100% of the problems for the premium utility case are clearly shown. Further, the success of local generation and back-up power solutions in providing protection for low DAF loads is also clearly visible.

As electricity demand increases and the utility grid reaches capacity limits, there will be a need for substantial additional generation resources. That will be the opportunity for the distributed resources market. New technologies such as fuel cells and microturbines will have to compete with existing generation technologies. Key technical, cost, and commercial issues remain, but the prognosis is good. There is also a tremendous synergy between the power quality and distributed resources market. Companies such as SST are well positioned to take the value they are creating for customers in the power quality arena, and to apply the same power electronics building blocks to distributed generation markets.

SST is a spin-off from the prestigious WEMPEC industrial consortium at UW-Madison and was started by Dr. Deepak Divan in 1995. SST investors include the high profile Beacon Group, as well as Venture Investors, a local early stage VC group. For further information on SST's *DySC*™ products, contact Dr. Deepak Divan, President & CEO, Soft Switching Technologies Corporation, 2224 Evergreen Road #6, Middleton, WI 53562. Tel: 608-836-6552. Email: deepakd@softswitch.com. Web: www.softswitch.com.

Table 1:Efficacy of PQ Solutions for Typical Industrial Customer

PQ SOLUTION				NOMINAL UTILITY CASE			PREMIUM UTILITY CASE		
					LOW DAF	HIGH DAF		LOW DAF	HIGH DAF
		Solution Provider	Technologies Used	No. of Events Covered	Corrected Utility Out of Nominal (seconds)	Sensitive Process Down Time 1/2 hr/event# (seconds)	No. of Events Covered	Corrected Utility Out of Nominal (seconds)	Sensitive Process Down Time 1/2 hr/event# (seconds)
	No Solution		Lowest 1st Cost	0	2107.5	45,000	0	5.5	39,600
	Line Conditioner	Liebert, Sola	Magnetics	~10	2105	27,000	~10	3	22,800
	Dynamic Sag Corrector™	SST, Square D	Power Electronics	~22.5	2100	4500	~22	0	0
UPS CATEGORY	On-line UPS	Liebert, Invensys	Power Electronics Energy Storage	~23.5	1950	2700	~22	0	0
	Stand-by UPS	APC, TrippLite	Power Electronics Energy Storage	~15	2102	18,000	~12	2.5	18,000
	Flywheel UPS	Beacon Power, Active Power	Power Electronics Energy Storage	~23	1860	3600	~22	0	0
	SMES UPS	American Superconductor	Power Electronics Energy Storage	~23	1860	3600	~22	0	0
BACK-UP CATEGORY	Fuel Cells	Ballard, Plug Power	Power Electronics Energy Source	2	375	45,000	0	5.5	39,600
	Microturbines	Capstone, Allied/Honeywell	Power Electronics Energy Source	2	375	45,000	0	5.5	39,600
	Backup Generators	Coleman, Generac	Magnetics Energy Source	2	375	45,000	0	5.5	39,600
	Fully-integrated Solution	?	Power Electronics Energy Storage Energy Source	25	0	0	25	0	0

*depends on type and model of UPS.