Power Quality

Technical Paper
Application of Voltage Sag Mitigation Devices in Industry
In the last 5 - 10 years there has been an increasing focus upon power quality (PQ) through education by professional organizations, specialist focus groups within large industrial plants, and International PQ conferences.

Due to this increased focus the power quality worldwide has improved significantly to the extent that currently power outages and blackouts are rare.

Hence there is now an increased focus on second order problems. These can be defined as sags, brown outs, surges, dips, power factor, harmonics, flicker, etc. Consequently where previously the main solution for power problems was to apply a UPS (Uninterruptible Power Supply), there are now many more options to mitigate the “second order” problems. This paper details a new modern solution - the ABB AVC (Active Voltage Conditioner).

Vernon Pryde presents the case for the AVC...

It is interesting to note that if you analyse PQ data from multiple independent sources and compile it all together that several common points start to emerge:

- The power supply has become reliable
- Long interruptions and blackouts are rare
- Equipment has become less tolerant
- Increased focus on second order problems

Power Quality
Utilities are being pressured to improve their distribution systems. There is a professional focus on monitoring (without data it is very hard to improve) and investment in more appropriate solutions to improve reliability. This can vary from actively cutting back greenery from power lines, implementing more organised maintenance routines, feeding more sensitive customers from different power sources, and having larger sensitive customers feeding from MV transmission connected supplies - just a few of the improvements that “make the power supply more reliable”.

Power outages are not that common and in general are reducing in number. When a plant is visited, the customer often complains of power outages because the process has stopped or been interrupted by a power disturbance. However when closer inspection of the PQ data is performed we see in most cases the power has not failed but been disturbed by a PQ event. For example: examining the PQ data of a major semi-conductor FAB plant shows that in the last 10 years they haven’t had an unexpected total power supply loss/outage, however they have had significant process interruptions attributable to PQ events.

Focussing on second order problems refers to improving power factor, reducing harmonics, mitigating the effect of supply voltage sags and surges and reducing flicker.

Most equipment suppliers are in a very competitive market. To maintain profitability they have to lower manufacturing costs. This often means reducing the size of switch-mode power supply electrolytic caps (hence less ride through time), small cheaper line reactors (more susceptibility to transients), smaller wires, cheaper devices; anywhere to save costs and be more competitive. Compounding the problem is more automation, robotics, variable speed drives, PLC’s controllers, computers, etc. Overall a plant is now far more susceptible to PQ events than previously.

The key point is to recognise and acknowledge that the problem exists and regardless of how diligent the electrical authority is, there will always be PQ events afflicting your plant!

In the past many semiconductor FAB plants set up in Singapore under the promise of perfect power. All the transmission systems are underground so there are no lightening strikes, there are no car crashes into transmission line poles, no trees to grow into or be blown into lines, etc. Unfortunately although Singapore has the “best” PQ in the world, it is still not perfect. Sensitive plants still require additional protection and it is unrealistic to expect the local utility to provide perfect power. The plant needs to take some of the responsibility to improve PQ.

Improving Power Quality
By analysis and segregation where ever possible. Then application of additional protection for more sensitive equipment.
Non-Essential Support Loads: In a process plant many parts of the operation are "non-essential" meaning if they accidentally shut down they can be restarted again without detriment to the total process. Lighting going off or even blinking momentarily does not stop the process. Loss of A/C in the office block is non-essential. Also remember that the events that stop a critical process plant are just momentarily sag events. Often the A/C may only falter momentarily and be back at full power within 2 or 3 minutes ie. non-essential loads.

Critical Control Loads: At the other end of the spectrum are the critical control loads. Even a momentary “blink” can destroy data records, shut down the whole process and take hours, days or even weeks to recover, just depending on the process involved. The choice is obvious. A UPS is the best solution.

Essential Process Loads: This is the area of largest improvement where new technology can benefit the facility. Critical Control loads are best protected by UPS’s, however they have an expensive COO ("Cost of Ownership") and struggle to be justified at the “essential process load” level. This is where higher powered systems like the ABB Active Voltage Conditioner (AVC) can benefit the plant. With a significantly reduced COO they are making significant in roads into production process facilities.

The ABB Active Voltage Conditioner (AVC)

An ABB AVC uses a series connected injection transformer and a high performance inverter to monitor the incoming supply for deviations away from nominal. If the supply voltage increases or decreases the inverter injects the correction component across the "injection transformer" to neutralize the deviation. One of the key points though is the speed of response. The microprocessor analyses the supply and starts correcting any deviation within 1msec. This high speed of response makes the AVC suitable for the most sensitive of loads. Typically this is a whole semiconductor fabricating assembly plant (FAB).

Significant benefits include:
- >99% efficiency.
- No risk of dropping the load (the series injection transformer cannot decouple the load from the supply).
- No storage device to maintain.
- Small footprint.
- 208V, 400V, 480V and up to 26KV.
- Triple and quadruple redundancy.
- Sag and surge protection for loads consuming power and regenerative loads.
- Minimal maintenance requirement.
- Modular assembly to reduce spares holding.

4 Quadrant Operation: Now loads that previously could not be protected due to different quadrant power flow can be protected. The inclusion of a state of the art inverter that features both an IGBT based inverter and an IGBT based rectifier allows power to be pushed both ways by the inverter, hence full 4 quadrant control of voltage deviations. Continued over page...

Fig 2. Plant Segregation into the Various Load Criticality Areas

Fig 3. Single Line Diagram for an Active Voltage Conditioner

Fig 4. Quadrant Operation
Plant Visibility: To achieve PQ improvements within a plant it is first necessary to measure the PQ. After all if you cannot measure the PQ then how do you know the investment in mitigation equipment has been justified or is even performing.

Full internet access is available using modern smart communication systems. Multiple AVC's can be installed in a factory, sometimes in excess of 50 units with full connectivity back to the central control facility. So the operators get better visibility of their operations PQ events and performance.

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He has over twenty years involvement in the application, installation and commissioning of high power inverter based systems around the globe.