Starting a big motor such as is used on winders, crushers, and large VSD drives, particularly on weak systems, results in a large voltage drop, which significantly reduces the torque of the motor. The resultant harmonic currents produced cause high voltage distortions which in turn disturbs other equipment connected to the same bus, and can exceed harmonic limits issued by the utility. In such cases, fast dynamic reactive power compensation systems that reduce harmonics to acceptable levels become essential equipment.

**Benefits of good power quality**

There are various benefits resulting from improved power quality in the mining industry. Using dynamic compensation systems to maintain the voltage level results in higher productivity of the winders. Harmonic filtering results in low voltage distortion enabling the reliable and safe operation of all the equipment connected to the supply system. Improved power quality also means benefits for the supply network, including compliance with the grid code specified by the utility and reduced voltage fluctuations and flicker.

**Operating principle**

A voltage source converter (statcom) based compensation system consists of a controllable part that can produce capacitive and inductive reactive power as well as a capacitor bank (filter) which can be connected to the system when inductive reactive power is required. The main components in a statcom system are DC capacitors used for energy storage, high frequency semiconductor switches (IGBTs) and inductors. The voltage level of the energy storage is controlled to be continuously higher than peak value of the supply system voltage. This principle enables current flow, controlled by high frequency semiconductors, from energy storage to supply system. The device can be understood as a controlled current source that provides any kind of reactive current waveform in real time.

**Harmonic performance**

A statcom does not generate harmonic currents, but it can provide active harmonic filtering removing the need for additional filter circuits. A medium voltage system can provide active filtering up to between 17 and 25th harmonic depending on the system’s supply voltage.

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**Fig. 1**: Typical statcom configuration for industrial application 12 Mvar 6.3 kV.

**Fig. 2**: Load reactive power, statcom reactive power and system reactive power.
A sophisticated control algorithm allows flexibility for users to select which harmonics are to be compensated for. The active harmonic filtering is not dependent on the system impedance.

**Reactive power response time**

The output current of the statcom is controlled by IGBTs with a switching frequency of 4 kHz. Therefore the output can be controlled 80 times per cycle in a 50 Hz system, resulting in a control and measuring response time for reactive power and voltage changes of less than 1 ms.

**Statcom overloading**

The statcom can be overloaded to provide high output power in short bursts. The overloading capacity is defined by the size of the energy storage available and the thermal limits of the semiconductors. Some systems can be overloaded up to double the rated output current for short periods of time. Since the statcom operates as a current source the output power of the system is defined in the following ways:

- **Continuous:**
  \[ Q_{\text{statcom}} = V \times I = 1 \times 1 = 100\% \]

- **Short period:**
  \[ Q_{\text{statcom}} = V \times I = 1 \times 1 \times 2 = 200\% \]

- **Short period under voltage:**
  \[ Q_{\text{statcom}} = V \times I = 0,9 \times 1 \times 2 = 180\% \]

The overloading feature of a statcom enables high performance in applications where instant short term reactive power is needed.

**Flicker reduction performance**

Flicker mitigation performance is a compensation system’s ability to reduce voltage changes, compensate reactive power, balance load and reduce harmonics. Statcoms have excellent performance in each power quality category due to the modern high speed IGBT technology employed and real time control strategy. In an electrical arc furnace application a statcom can reduce flicker by a factor of 4.5 to 5.5.

**System redundancy**

A statcom’s modules are designed to operate as standalone units. Each module has its own independent control and protection system that communicates with the human machine interface (HMI). In case a module has an internal failure, it will be disconnected from the system and the remaining modules can continue in operation, therefore total shutdown does not occur. Each module has an independent liquid to air cooling system of its own. In case of leakage or pressure drop the module will be disconnected from the...
Ciprotec, specialists in lightning and surge protection, offer solutions to protect against transient and power frequency overvoltages.

**Why protect?** Prevent damage, overheating or destruction of equipment, as well as fires or service interruptions. Use of these protectors is essential in areas where there are fluctuations in the value of the supply voltage.

Benefits include:
- continual energy efficiency
- extended equipment life
- reduced electronic waste
- reduced costs and carbon footprint

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