Mitigation Solutions for Power Quality Issues in the United Kingdom

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Almost all the gas compressor stations in the United Kingdom use gas turbines to compress gas for UK utility distribution. As part of the National Grid emissions reduction commitment, these gas turbines will eventually be replaced by variable speed drives (VSDs) that will control large electrical motors and will be supplied from the local electricity network.

Large Siemens variable speed drives (VSDs) are already installed in several gas compressor stations in the UK. Siemens PTI was asked to investigate the power quality issues that the operation of the VSDs may cause for the network and for other customers connected in the area.

The main objectives of the Siemens PTI investigations were:

- To check the power quality compliance against the UK Engineering Recommendations (ERs), ER-P28 (Planning Limits for Voltage Fluctuations Caused by Industrial, Commercial and Domestic Equipment in the UK) and ER G5/4-1 (Planning Levels for Harmonic Voltage Distortion and the Connection of Non-Linear Equipment to Transmission Systems and Distribution Networks in the UK).
- To provide recommendations to mitigate the power quality issues if necessary and in accordance with the UK ERs P28 and G5/4-1.

Excessive voltage fluctuations, or flickers, can cause significant discomfort to utility customers and hence induce severe customer complaints. ER-P28 sets the limits to allow the system to accept fluctuation in loads without an excessive risk of causing unacceptable levels of flickers. The ER-P28 limits set the allowable magnitude of the voltage change caused by a fluctuating load regardless of the voltage change shape (whether it is a step change, ramp or spikes, etc.), as well as the frequency of such changes in the observation period. The ER also sets out the recommended different stages of assessments suitable for different scenarios.

Power system harmonics are generally defined as voltage or current components with integer multiples of the fundamental frequency. These harmonics can lead to severe distortion in the voltage and current waveforms in the power systems. This distortion can lead to severe impacts such as the mal-operation of system protection equipment and decrease in equipment life span. ER G5/4-1 sets out the allowable limits of planning levels of harmonic voltage distortion for the connection of non-linear equipment to the UK networks; it also considers the potential impact of the new equipment on the present surrounding system.

Siemens PTI’s PSS®SINCAL was used to perform the power quality studies for the RMS voltage change and harmonics. An Electromagnetic Transients (EMT) transformer energisation inrush study was also performed using PSS®SINCAL which utilizes the PSS®NETOMAC engine in the background.

Applying the general philosophies for the different ERs as stated in the above paragraphs, Siemens PTI UK recently determined the power quality mitigation solutions associated with a 35 MW VSD installed in a gas compressor station that is connected to the local electricity network through a four winding transformer; the fourth winding of the transformer is used to connect the corresponding harmonic filters. As a result of the power quality studies using PSS®SINCAL, the original system with the VSD configuration was found to require modifications and new equipment to ensure compliance with the P28 as well as with the G5/4-1 ERs. The modifications include additional reactive power compensation to alleviate the voltage variations at the point of connection (PoC), the modification of the existing harmonic
filter to target the critical harmonic frequencies as well as the installation of a new harmonic filter to reduce the harmonic voltage distortion to an acceptable level.

The studies were carried out using the powerful simulations and graphic capabilities of PSS®SINCAL. Example results from these studies are shown in Figures 1, 2, 3 and 4. This report was delivered on time and on budget to the customer in late May 2011.

![Voltage at PoC During Normal Start Sequence](image-url)

Figure 1: Voltage Step Change during VSD Starting Sequence and Normal Operation
Voltage at the PoC During Normal Stop for 4800 rpm

Figure 2: Voltage Step Change during VSD Normal Shutdown Sequence

Network Harmonic Impedance at PoC - Circuit Outage

Figure 3: Harmonic Impedance at the PoC during Network Contingency
Figure 4: Harmonic Voltage Distortion at the PoC during Different Scenarios with Mitigation