High-precision frequency measurement with
eXtreme Fast Control technology

12 MW Energy Storage System ensures reliable power supply through frequency control

Key Yo, Managing Director of Tri-TEK (left) and Lee In-Eung, Managing Director of the Power21 Corporation, in front of a control cabinet

Korea depends almost entirely on imported energy and regularly suffers from power shortfalls at peak times, making reliable supply of power and grid safety significant concerns. In order to protect against grid fluctuations, Korean engineering firm, Power21 has developed an Energy Storage System (ESS) for frequency control. The system is already successfully deployed in power supplier, KEPCO's (Korea Electric Power Corporation) West Anseong substation. The frequency control algorithm runs on Beckhoff CX5020 Embedded PCs and leverages EL3773 EtherCAT Terminals with eXtreme Fast Control (XFC) technology to perform high-precision frequency measurement.

The energy storage and frequency control system from Power21 ensures an uninterrupted supply of power by maintaining the ideal balance between generated and consumed electricity. A small percentage of the total generated electricity (5 percent in this case) is reserved as additional capacity for power output and is stored in accumulators. The energy storage system detects momentary frequency changes (60 ± 0.01 Hz) in the grid within 20 ms; the grid frequency is regulated by the storage or output of energy.

The Energy Storage System (ESS) developed by Power21 consists of three main elements: the Power Conversion System (PCS), the Power Management System (PMS) which measures the frequency and controls, and finally, the accumulators. The central control platform of the PCS module – virtually a frequency controller master – is a CX5020 Embedded PC with TwinCAT 3 automation software and inline EtherCAT Terminals for the I/O system. Frequency control algorithms and the system control for the 12 MW ESS run on the CX Embedded PCs, which is divided into three 4 MW frequency controllers. This protects the Energy Storage System against failures and ensures that the ESS has a completely redundant design. EtherCAT communication adds a wealth of built-in diagnostic functionality.

With TwinCAT 3 software from Beckhoff installed on the CX5020s, the frequency control algorithm written in C/C++ runs without large-scale modifications before putting a system into operation. This is possible because the controller doesn't have to be adapted and linked to individual I/O points or internal variables, which opens up previously unimagined opportunities for smart grids. A further advantage results from the integration of TwinCAT Scope View into the HMI application from Power21. This enables the operator to easily check data trends, increasing data reliability and making monitoring and analysis more convenient.

High-speed frequency detection and response times
To enable the Energy Storage System to control frequency fluctuations with high precision, the response time of the current converter in the grid must be made within 200 ms. It receives the voltage from the input at a speed of 200 µs using the EL3773 EtherCAT oversampling terminal. „The frequency measurement algorithm from Power21 detects frequency changes in less than 20 ms and measures frequencies with a resolution of 0.0001 Hz, whereas competitors

barely achieve values of 150 ms with a resolution of 0.001 Hz," explains Lee In-Eung, Managing Director of Power21.

Critical operational data are acquired and stored as a CSV file in a local PMS server. The frequency controllers sample these data at intervals of 20 ms, and the server summarizes all data acquired from the frequency controller in a data buffer until it is full. Data is then dispatched in order to minimize network utilization. Further analysis data and status information are stored in a database.

ESS management software – optimized for global communication
Based on the openness and expandability of the PC-based control platform, the Power Management System (PMS) can communicate with the Power Conversion System (PCS) via standard protocols such as the DNP3 telecontrol protocol, IEC 61850, Modbus or CANopen. „This represents a significant advantage with regard to worldwide use of the energy storage system we developed," says Lee In-Eung. Various gateways complying with IEC 61970, a standard for application program interfaces in energy management systems, can be created using function blocks in TwinCAT PLC software. In addition, efforts are being made to harmonize IEC 61970 with IEC 61850, which is available as a TwinCAT library.

„All performance requirements were either fulfilled or exceeded during the final acceptance and evaluation of the frequency control/energy storage system installed in the substation in West Anseong, both for the testing of the response time and response capacity as well as the calculation of the control speed," explains Lee In-Eung. „As with the results of the simulation performed beforehand, the bandwidth for the control of the frequency improved by replacing existing frequency reserve generators – a function of the new 500 MW ESS." Recently, the government of South Korea has been promoting energy storage systems with an appropriate compensation system. As a result, Power21 has set an ambitious goal to offer energy storage systems with a rating of 100 GW by the year 2020.

Further information:
http://eng.power21.co.kr/main.html
www.tritek.co.kr