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Application Note

Upgrade of an ABB Unitrol M Excitation System with a Basler Electric DECS-2100

At the Piedra del Águila Hydroelectric Power Station (Figure 1), located on the Limay river in Patagonia, Argentina, there are four identical power generation units which date back to the early 1990s. Each power unit consists of a Francis turbine with a 430 MVA Electrosila generator controlled by an ABB Unitrol M excitation system (Figure 2). The analog-technology Unitrol M was developed in the 1970s and continued to be sold until the mid-1990s.

Figure 1. Piedra del Águila Hydroelectric Power Station

During startup these shunt-type excitation systems need an auxiliary source to build generator voltage because the residual voltage of the generator is too small.

The original voltage regulator has a manual and automatic channel each made up of different electronic modules that perform specific functions, such as: AVR (automatic voltage regulation), current limiters, overexcitation limiter, PSS (power system stabilizer), FCR (field current regulation), and trip control. Each generator has a maximum field requirement of 2,460 Adc with a ceiling voltage of 1,380 Vdc.

The excitation system is one of the critical components of the power station and a failure could cause damage to the generator that may result in costly downtime and repairs. The probability of failure increases for systems that have reached the end of their operational life. Considering all of the above, it was decided to perform a system update.

Current Operating Conditions

Manufacture of the ABB Unitrol M ended in the mid-1990s along with the possibility to procure spare parts and specialized technical maintenance for this equipment. Thus, it would be very difficult to repair any failure, resulting in large financial losses. However, the power generation parts have a longer lifespan. Thyristor bridges, transformers and switches generally continue to be reliable for many more years. A common practice in the power generation field is to keep the power generation components, due to their high cost, and replace only the control components.

Upgrading to the Basler DECS-2100

Basler specializes in the design and manufacture of excitation systems for new and retrofit installations. Retrofit applications include the GE EX2000 and Bus-Fed, Basler SSE and SSE-N, Cutler-Hammer MGR, and other ABB and Toshiba systems. Because of this expertise, Basler was selected to provide the excitation system upgrade at Piedra del Águila power station. For this Unitrol M application, a Basler DECS-2100 Digital Excitation Control System was selected. This solution enabled the customer to retain the existing power rectifier bridges, field starting voltage transformer, ac/dc switches, discharge circuit, and the excitation power potential transformer.

Figure 2. Unitrol M System Cabinet

As part of the upgrade, the original control panels were part of a 19-inch rack assembly. This rack assembly's, pulse transformers and other electronic components were removed. All these components were replaced by custom-manufactured mounting plates designed to be easily installed into the existing cabinets. The size of each custom mounting plate depend on the requirements of each system.

Implementation

The main components in the upgraded excitation system are described in the following paragraphs.

Rectifier Bridges

At the Piedra del Águila Hydroelectric Power Station, the excitation system consists of three rectifier bridges operating in parallel at a maximum field current of 2,460 Adc and a maximum current per bridge of 1,580 Adc with a ceiling voltage of 1,380 Vdc.

ECM-2 Excitation Control Module

This system uses two ECM-2s; one of them operates as the main controller and the other as a backup. The ECM-2 provides the core functions of regulation, input sensing, and thyristor firing control in a DECS-2100. Thyristor firing pulses are transmitted to the BCM-2 Bridge Control Module via fiber optic cables.

In addition, each ECM-2 has redundant power supply inputs and digital and analog inputs and outputs. A DIOM-2 Digital Input/Output Module and an AIOM-2 Analog Input/Output Module were implemented to expand the number of digital and analog inputs and outputs for each ECM-2. Compatible with many communication protocols, the ECM-2 offers two Ethernet ports, a USB port, an RS-232 port, and an RS-485 port. Figure 3 shows a new excitation control cabinet fitted with ECM-2s, DIOM-2s, and AIOM-2s.

BCM-2 Bridge Control Module

This system uses three BCM-2s: one for each rectifier bridge. The BCM-2 controls the output of a power bridge by generating the gating pulses for the six thyristors of each rectifier bridge. Up to 16 parallel power bridges and BCM-2s may be used in a DECS-2100 system to achieve the required current level or provide redundancy. The BCM-2 transmits operational status and alarms of each rectifier bridge back to the ECM-2 via fiber optic cables. Figure 4 shows one of the rectifier bridges with its BCM-2, IT-2 (Isolation Transducer), and the ac input conduction monitors.

Figure 3. New Excitation Control Cabinet

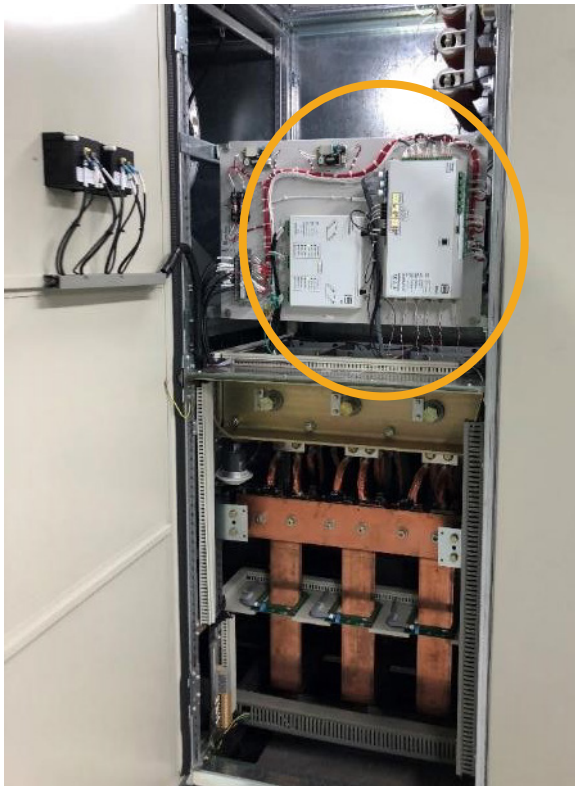

Figure 4. Rectifier Bridge, BCM-2, and IT-2

IT-2 Isolation Transducer

This system uses seven IT-2 modules: three for monitoring the rectifier bridges (one per bridge), two for monitoring the field (one per ECM-2), and two for monitoring the excitation transformer (one per ECM-2). The IT-2 monitors voltage and current and electrically isolates the DECS-2100 from those parameters. The output of each IT-2 channel is transmitted to the BCM-2 or ECM-2. A BCM-2 and its IT-2 are shown in Figure 4, the field monitoring IT-2 plate is shown in Figure 5 and the excitation transformer monitoring IT-2 plate is shown in Figure 6.

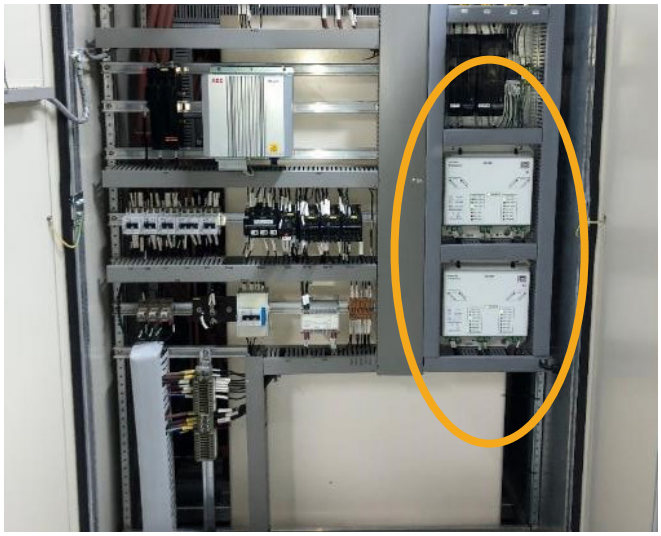

Figure 5. IT-2 transducers for field voltage and current measurement

Figure 6. IT-2 transducers for measuring the excitation transformer voltage

Excitation Transformer

Synchronization of the thyristors' firing pulses is determined by measurement of the excitation transformer's secondary voltage. Figure 7 shows a bank of three single-phase transformers that make up the excitation transformer. The excitation transformer's overcurrent protection relay was replaced by a BE1-11*t* protection relay as shown in Figure 8.

Figure 7. Excitation Transformer Bank (3 x 1,300 kVA - 15,750 kV / 1,120 V)

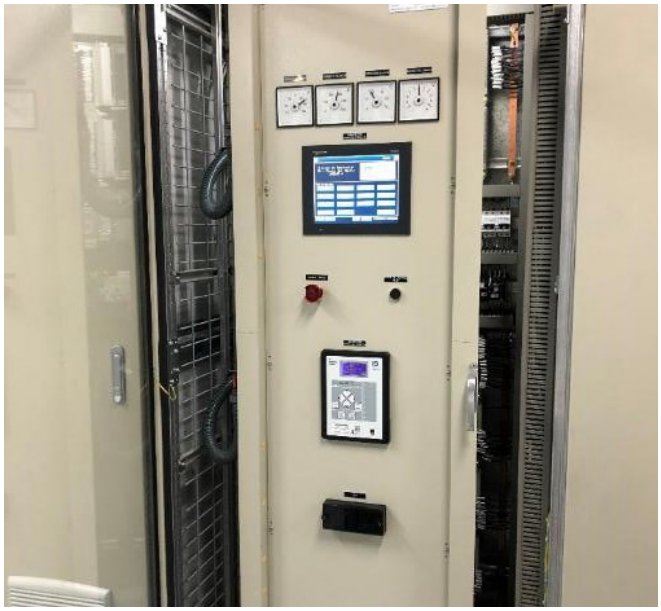

Figure 8. New front end of the cabinet with BE1-11*t* protection relay

DXCB-2 De-Excitation/Crowbar Module

The field electronic discharge and crowbar systems were replaced by a pair of DXCB-2 modules while retaining the original nonlinear discharge resistor. The DXCB-2 protects the generator field and exciter circuits by providing a low-impedance path for currents that would otherwise cause excessively high transient voltage or damaging arcs. A DXCB-2 module has two modes of operation: de-excitation (DX) or crowbar (CB). In DX mode, the DXCB-2 module provides a path for the generator field current when its field breaker is opening or when the normal path is not available. In CB mode, the DXCB-2 module provides a low-resistance path for large positive voltages across the generator field and exciter bridge. See Figure 9.

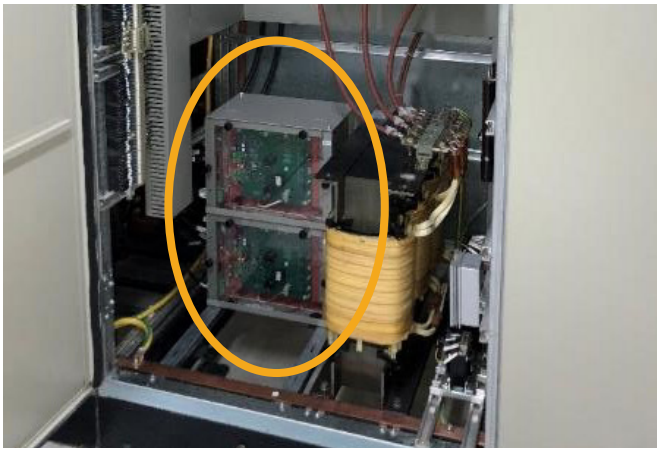

Figure 9. DXCB-2 modules (field discharge)

Field Ground Detector

The Field Ground Detector module continuously monitors the field circuit to detect ground faults. Ground faults are detected by measuring the ground leakage current. The ground leakage current is determined by measuring the voltage drop in a resistor shunt within the Field Ground Detector. The resistance value of the grounded rotor is observed through the software.

Cooling System

The original Unitrol M system had a dedicated PLC to resolve automation logistics related to the cooling system of the rectifier bridges. The cooling system is comprised of a redundant air/water exchanger system. Figure 10 shows the complete set of three rectifiers, the redundant cooling system, the cabinet containing the field switch, and the new cabinet that contains the DECS-2100.

Figure 10. Rectifier Bridges / Cooling System

IDP-1201 Interactive Display Panel

An IDP-1201 was included in the upgrade. The IDP-1201 is a high-resolution, color touch screen interface that enables monitoring and control of a DECS-2100 excitation system. See Figure 11.

Figure 11. Excitation system's HMI

Testing the Thyristor Bridges

During the assembly of the new excitation system, each thyristor's curve was plotted and its current was measured according to JEDEC JC-22 and EIA RS-397 testing standards to verify that the thyristors were working properly.

Software

Basler Electric's BESTCOMS™*Pro* software (Figure 13) communicates directly with the ECM-2 through Ethernet or USB. This user-friendly, Windows®-based software is a sophisticated tool for configuring, monitoring, and maintaining the DECS-2100 and its modules. It has a real-time recorder that captures up to six machine parameters as they occur, eliminating the need to use an external recorder. This recorder is very useful during commissioning or routine testing stages.

An event recorder, provided in the ECM-2, can be set to trigger when certain conditions are met and begin recording to catch disturbances such as voltage on the generator terminals or reactive power.

An easy-to-use analysis system is included to decrease the time needed to perform the frequency response tests between the generator and the excitation system. The frequency response validates the transfer function with the excitation system and provides the means to develop the required adjustments in the power system stabilizer. The ECM-2 may perform simultaneous frequency response tests with different parameters and different inputs and outputs.

For More Information

For product orders, questions, and additional information, including more application notes, product bulletins and instruction manuals, visit www.basler.com, contact your Application Engineer, or contact Technical Support at +1 618.654.2341.

Figure 13. BESTCOMS™*Pro* software used for the system's configuration and testing

DECS-2100 Features

- 0.1% voltage regulation accuracy
- Control modes with auto tracking
  - Automatic voltage regulator
  - Manual (field current and voltage)
  - Var
  - PF
- High side voltage regulation mode
- Dual and supervisory channel options
- Integrated PSS Type 2A/2B/2C
- Interactive Display Panel for local and/or remote monitoring and control
- Real-time monitoring with up to six parameters
- Sequence of events recording
- Oscillography
- System simulation mode
  - Time response
  - Frequency response
- Automatic synchronizer
- Auto tuning
- Communication:
  - Two Ethernet ports
  - USB
  - Fiber-optic for bridge firing and monitoring
  - RS-485
  - RS-232
- Programmable inputs and outputs
- IRIG-B time synchronization
- Protection:
  - Field overvoltage
  - Generator overvoltage and undervoltage
  - Bridge overtemperature
  - Field flashing
  - Field overtemperature
  - Loss of excitation
  - Loss of voltage sensing
  - Overcurrent
  - Overexcitation
  - PPT fuse failure
  - Thyristor conduction monitor
  - Watchdog
  - Exciter/main field ground protection
- Limiters
  - Maximum field current
  - Minimum field current
  - Overexcitation
  - Underexcitation
  - Stator current
  - Temperature compensation
  - Volts per hertz
- Dual PID settings groups

Basler Electric®

Highland, Illinois USA
Tel +1 618.654.2341
Fax +1 618.654.2351
email: info@basler.com

Suzhou, P.R. China
Tel +86 512.8227.2888
Fax +86 512.8227.2887
email: chinainfo@basler.com

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