

TECHNICAL PROPOSAL

Control Upgrade UNITROL® 6000

X-POWER



Project Chisenau	OPP Number OPP-24-6074489
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1 Introduction

The proposed System type SES is based on over hundred years of know-how and proven technology. SES systems can be applied to all sorts of synchronous generators and motors. The system as described hereinafter is optimized to meet the functionality, performance and reliability that were requested in your enquiry.

The excitation system is a member of the UNITROL® 6000 product range. It uses powerful AC800PEC controllers with a 64-bit IEEE floating point unit for the highest performance demands.

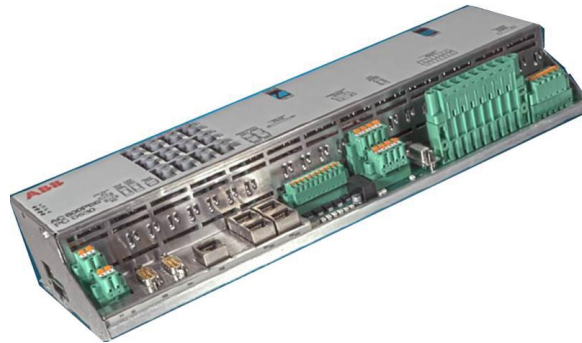


Figure 1: UNITROL6000 Controller (PEC)

The digital Automatic Voltage Regulator (AVR) is based on a powerful state-of-the-art 64-bit Controller that combines the floating-point computing performance of a CPU with the flexibility and high speed capability of an FPGA (Field Programmable Gate Array). It not only controls the output of the reliable and efficient thyristor power converters, but it also provides limiters, monitoring functions, transient recorders and other control circuits as listed in the scope of supply. Together with the robust field suppression, equipment operation within safe machine limits is always guaranteed.

This offer covers the design, engineering, manufacturing, factory testing and supply of a System for the project in **Moldova**.

Short project description

Having a short background about your interest, ABB proposes to upgrade your excitation unit type **UN6000 X-power** at Chisenau Power Plant for the **Unit 1,2,3**.

This offer supersedes any previous version.

In line with the technological progress which happened during the last 28 years, the capability of the new generation of electronic systems has drastically improved. The new generation makes it possible to substantially enhance the volume of data to be processed. As such, the new generation of control elements can improve the availability, reliability, and performance of excitation systems.

This ABB business serves customers with energy-efficient and reliable products to improve customers' productivity, including drives, motors and generators, low voltage products, and power electronics. More than one million products are shipped daily to end customers and channel partners, spanning a wide range of industry and utility operations, plus commercial and residential buildings.

ABB Switzerland Ltd is the global center of excellence for R&D, engineering, and manufacturing of UNITROL® Automatic Voltage Regulators (AVR), Static Excitation Systems (SES) and SYNCHROTECT® synchronizing equipment.

For more detailed information please visit us at www.abb.com/unitrol and www.abb.com/synchrotact.

2 Control Upgrade

2.1 What is a "Control Upgrade"?

Physical aging processes and the lack of availability of individual components on the marketplace will make it difficult and more expensive to operate plants on a long-term strategy without further improvements. For a Control upgrade, all components which are at the end of their life cycle will be replaced by the latest electronics generation (see Figure 2).

The content of the original control cabinet will be substituted by the latest generation of equipment, based on our UNITROL 6000 platform. ABB has designed a standardized control upgrade plate which is pre-assembled, wired and tested in the factory and then installed and connected to the original customer terminals in the existing control cabinet to provide you with a technical solution to upgrade your Excitation System to the latest and most powerful excitation technology on the market. An additional highlight of a control upgrade is the implementation of a regular touch panel (ECT) in the front door of the control cabinet. A detailed description of the innovations mentioned is defined in **Chapter 3.2**.

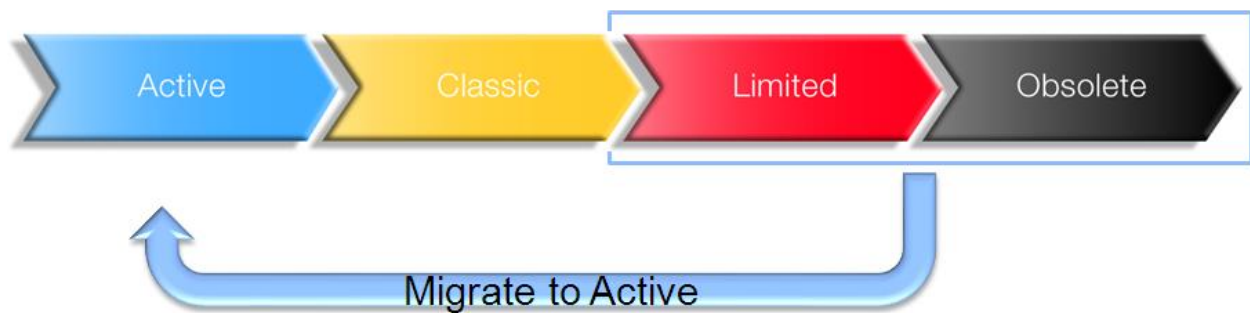


Figure 2: Control Upgrade out of the Product Life Cycle

The proposed offer of a Control-Upgrade for a **Static Excitation System (SES)** type UNITROL® 6000 is based on over hundred years of know-how and proven technology. UNITROL® 6000 excitation systems can be applied to all sorts of synchronous generators and motors. The system as described hereinafter is optimized to meet the functionality, performance and reliability that were requested in your enquiry.

2.2 What are your advantages with a control upgrade?

There are several customer benefits related to control upgrades.

- *Economic aspects:*
 - Hardware price is below a new excitation system due to the reuses of costly components with less critical life cycle (eg, converters, field switches, transformers etc.)
 - Reuse of customer terminals/ busbars as well as prefabricated and tested modules will shorten shutdown and commissioning time to a minimum
 - Medium/ long term scheduling of the upgrade, giving you the possibility to plan the budget and best time slot for implementation.

- *Project execution aspects:*
 - Easy to transport (no cubicles)
 - Foundations and external bus ducts or terminals do not require any modification
 - Implementation of the upgrade is made during a standard revision of the generator (we calculated some 3 weeks for dismantling the electronic parts, installing the new electronic elements and re-commissioning the UNITROL system).

- *Technological aspects:*
 - Benefit of the unique ABB technology with optical communication between boards and standardized Software development environment
 - New interfaces for enhanced functionality (control terminals for control and converter cabinet)
 - New technology offering additional functions, extended storage capacity and faster response time, due to the state-of-the-art controller capabilities (fast signal analysis, event recorder, control panel in the control room if requested, latest PSS standards, etc...)
 - Possibility to integrate additional features such as remote control terminal (remote ECT) etc.
 - Possibility to integrate the excitation system in a modern power plant control system

- *Warranty aspects:*
 - Full ABB warranty for the new control parts
 - Long-term spare parts availability at lower price for the control part
 - Long-term availability of engineering and support competencies

3 Technical Specification

3.1 Permissible Ambient Conditions

Symbol	Description	Value	Unit	Remark
T_{des}	System design ambient temperature	0 .. +45	°C	
T_{sto}	Temperature range during storage	-25 .. +55	°C	
	Max. humidity (no condensation)	95	%	
H	Altitude of installation	<1000	m.a.s.l.	
	Mechanical vibrations and earthquake withstand	10 ...150 Hz: 0.2g / axis 1 ... 33 Hz: 0.2g / axis		IEC 60255-21-1: 1988 class 1 IEEE 344:2004 standard

3.2 AC 800PEC Controller benefits

The PC D530 A Communication Control and Measurement device (CCM) is an intelligent control and measurement device with a specially designed customer interface as required within UNITROL 6000 Excitation Control Systems.

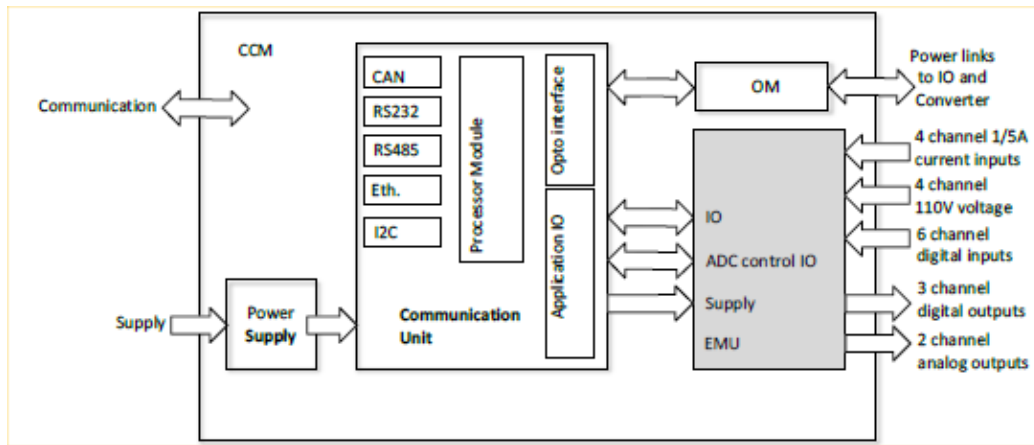
The device is based on the AC 800PEC control platform and includes the powerful PP E100 A or processor module. A four port Ethernet switch, a panel interface, a RS485 Modbus and a CAN interface are available for communication. In case of other fieldbus requirements, a FIG fieldbus module can be adapted additionally.

Further on it serves as a signal conditioner as required in synchronous machine excitation systems.

Eight fast measurement inputs allow detection of three-phase machine currents and voltages and one-phase bus bar current and voltage.

For control purposes the device provides 6 optically isolated digital 24/48 Volts inputs, two relays and one isolated electronic output. Finally, two isolated analog outputs are also available.

- Powerful processor mode PP E100 A with dual core CPU and FPGA
- 4 Port Ethernet communication switch interface
- Control panel serial interface
- RS485 CAN interface
- Up to 6 optical modules with max. 18 optical links
- 6 fast digital 24V inputs isolated with opto-couplers
- 4 systems control LEDs
- 2 digital relay outputs and one galvanically isolated electronic 24V fast output
- 4 current measuring inputs and 1 Ampere ac
- 4 voltage inputs 110 Vac
- 2 galvanically isolated analog outputs with +/-10 V
- High reliability
- Operating temperature range -25 ... +70°C



3.3 Function of AC800PEC control system

3.3.1 Operation

Control / Metering

Control and operation of the excitation system is designed by the AC 800PEC, ABB's fully digital regulation and control system. The AC 800PEC digital regulation offers very accurate and fast responsive control, extensive excitation monitoring, overall system supervision and a most flexible and reliable operation.

Data / Event Recording

The internal **event recorder** function can handle and store up to 2000 events, each provided with a real-time stamp. The **data recorder** contains an un-configurable part fixed to record 64 signals / 2000 data points each, and a free configurable part that can record 8 signals / 2000 data points each. The display and analysis of the recorded data is done by means of the Excitation Control Terminal Software (ECT SW). If the AVR/SES is equipped with an **Excitation Control Terminal (ECT)**, the recorded data are downloaded into its memory to be available independently of the main controller.

3.3.2 Standard Software Features

- Voltage Regulator with PID filter (AUTO operating mode)
- Field current regulator with PI filter (MAN operating mode)
- Reactive and/or active current droop /compensation
- Limiter circuits for:
 - Maximum and minimum field current
 - Maximum stator current
 - P/Q underexcitation
 - Volts/Hertz
- Loss of field (40) Protection
- Instantaneous excitation trip for protection purposes
- Actual value monitoring
- Field Flashing time Limitation
- Soft start
- Power Factor / Reactive Load Control
- Generator PT Monitoring
- Bi-directional follow-up function for bumpless transfer between channels / regulator modes
- Manual Limitation

3.3.3 Power System Stabilizer – PSS (optional)

For many years, ABB has been deeply involved in the development and application of Power System Stabilizers. The PSS function improves the stability of the generator and the transmission system as a whole by using the excitation to damp power oscillations.

PSS types available for UNITROL6000:

- Acc. to IEEE Std. 421.5-2005 PSS2B - PSS Design Report with Grid Code Compliance (Optional)

A PSS Questionnaire form must be filled out by the customer and submitted to ABB prior to the project execution. This type of PSS site tuning assumes that all data regarding the machine and network (as specified in the PSS study questionnaire) are available.

3.3.4 PSS Grid Code Compliance Test (Optional)

Inputs from the customer

- Completed DETAILED-PSS Questionnaire (ABB Doc No. 3BHS125885 E53) including all Gen'set data
- Customers' AVR and PSS design specification (to be advice with customer/Grid owner)
- Detailed specification of simulations to be conducted
- Detailed specification of on-site tests to be conducted

Services/Documents delivered to the customer

- Parameter sets for the unit to be commissioned
- Design report including:
 - Step-response simulation as reference for the site test
 - Simulations to be conducted according customers' specification
 - Preparation / procedure for site-tests to be conducted
- Specified tests, conducted during commissioning
- Commissioning report, containing step-response test conducted during commissioning
- Grid code compliance report with evaluation of expected values out of design report and measured data on-site

NOTE

- Study is based on a Single Machine Infinite Bus Power System.
- Limiters, governors and auxiliary equipment (etc.) are not in the scope of the design and simulation report unless explicitly agreed!

Detailed process

1. The customer completes the DETAILED-PSS Questionnaire.
In order to avoid additional service costs for PSS parameter determination, the customer has to complete the PSS Questionnaire on time, for the PSS design being handled during the regular excitation design process.

2. ABB checks the consistency of the parameter provided by its customer.
Should there be an inconsistency, the customer is informed and can revise the input parameters. An additional effort for determining PSS parameters on-site will be needed if the provided parameters are not sufficient to obtain suitable results.

Please note that the design cannot be done as long as the required data is not available.

3. PSS and AVR Design process is undertaken by ABB who:
 - Calculates the corresponding PSS Settings with SMTS simulation tool as starting point for further tunings
 - Undertakes an additional verification of the settings using simulation equipment
 - Additional tuning for finding optimum settings over a specified frequency range
 - Generation of expected values as benchmark for site tests
 - Generates a specific commissioning procedure included in the design report
 - Containing simulations conducted for the specific grid code compliance tests as benchmark for site tests:

- Simulation of AVR Step-response tests (Offline)
- Simulation of AVR Step-response tests (with PSS ON/OFF)
- Specific simulations according to customer's specification
- Deliver a Design report / Commissioning procedure to the customer

Scope of commissioning test of the PSS function:

(Additional commissioning cost based on MD Rates)

- Step-response test (with PSS ON/OFF)
- Increasing the PSS gain (KS1) starting from very small values up to the designated value derived from the design report
- Special Tests to be performed according to requirements. For example only:
 - AVR frequency response test (verification of AVR transfer function)
 - PSS frequency response test (verification of PSS transfer function)
- Power Spectrum Analysis (verification of damping influence over a specified frequency range)
 - Closed loop testing of the Excitation-System + Synchronous Generator
- Commissioning report
- Grid code compliance report

NOTE:

The lead time to deliver PSS Grid Code Compliance study is up to several months.

This scope will be done in cooperation with R&D in Turgi, Switzerland.

Please make sure that the delivery time is acceptable by the grid owner.

3.3.5 Human-Machine Interface (HMI)

The Converter Control Panel (CCP) is used for monitoring a converter of the UNITROL6000 excitation system. Each converter has its own panel which is connected to the Control Converter Interface (CCI) of the corresponding converter.

- Status LED
- Display
- Keypad



Figure 3: Converter Control Panel

The ECT is a powerful industrial PC with a user-friendly Human-Machine Interface that runs independently of the control CPU. The ECT can be added to an excitation system to support the operating and maintenance staff. The TFT touch screen provides the operator with a range of selectable screens showing information about the power status of the system in graphical and numerical form. Additionally, authorized engineers can read and adjust all parameter values. Further, analysis tools for troubleshooting are available as well. The ECT includes long-time recordings and AUTO save functions. These are indispensable features for quick and precise analyses.

- Operations
- Power chart
- Slow, fast trending and transient recorder
- Events, event logger
- Parameters. Settings
- HMI language in English



Figure 4: Control Terminal

3.3.6 Serial Communication to the Excitation System

Not applicable, hardwired connection only.

3.3.7 Converter Electronics

The power converter electronics of the existing converter will be **completely replaced** by the electronics of the UNITROL 6000, consisting of the modules **CCI**, **CSI** and **GDI** as listed below.

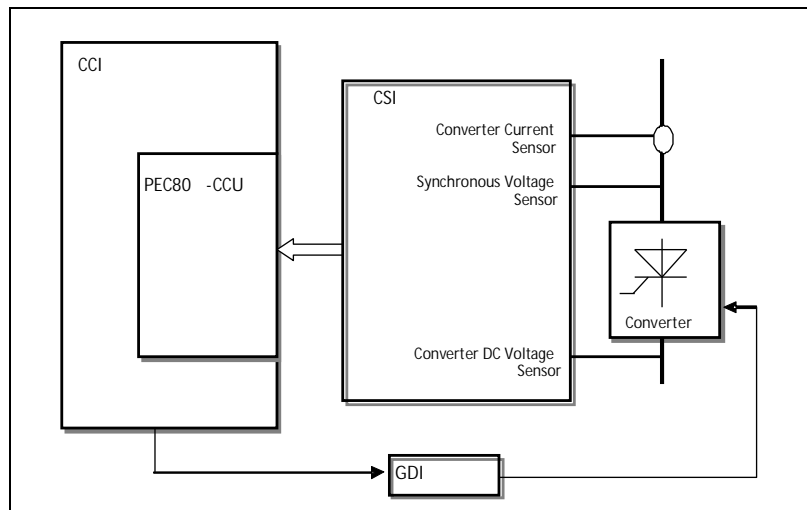


Figure 5: Converter electronics

Converter Control Interface (CCI)

The Converter Control Interface (CCI) is a decentralized and regulating device control on the converter module. It serves as an interface to the GDI, CSI and SCI. The device is based on the AC 800PEC control platform and includes the processor module PEC80 PM, the converter control unit PEC80 CCU, the power supply PEC80 PS and the optical module PEC80 OM. The CCI combines the Gate Control Unit (GCU), Converter Current Equalizing Control (CCEC) and converter synchronization functions. Its main function is to generate the chain of the gate pulses to the Gate Driver Interface (GDI) for the 3-phase full wave bridge operation.

Gate Driver Interface (GDI)

The Gate Driver Interface (GDI) amplifies the pulses and brings the necessary triggering pulses via the transformers to the thyristors.

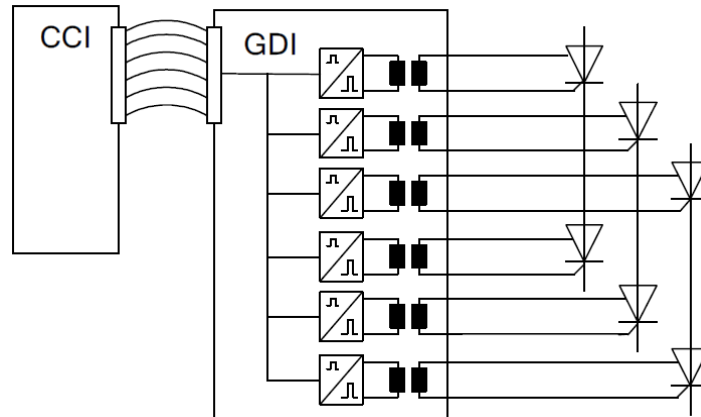
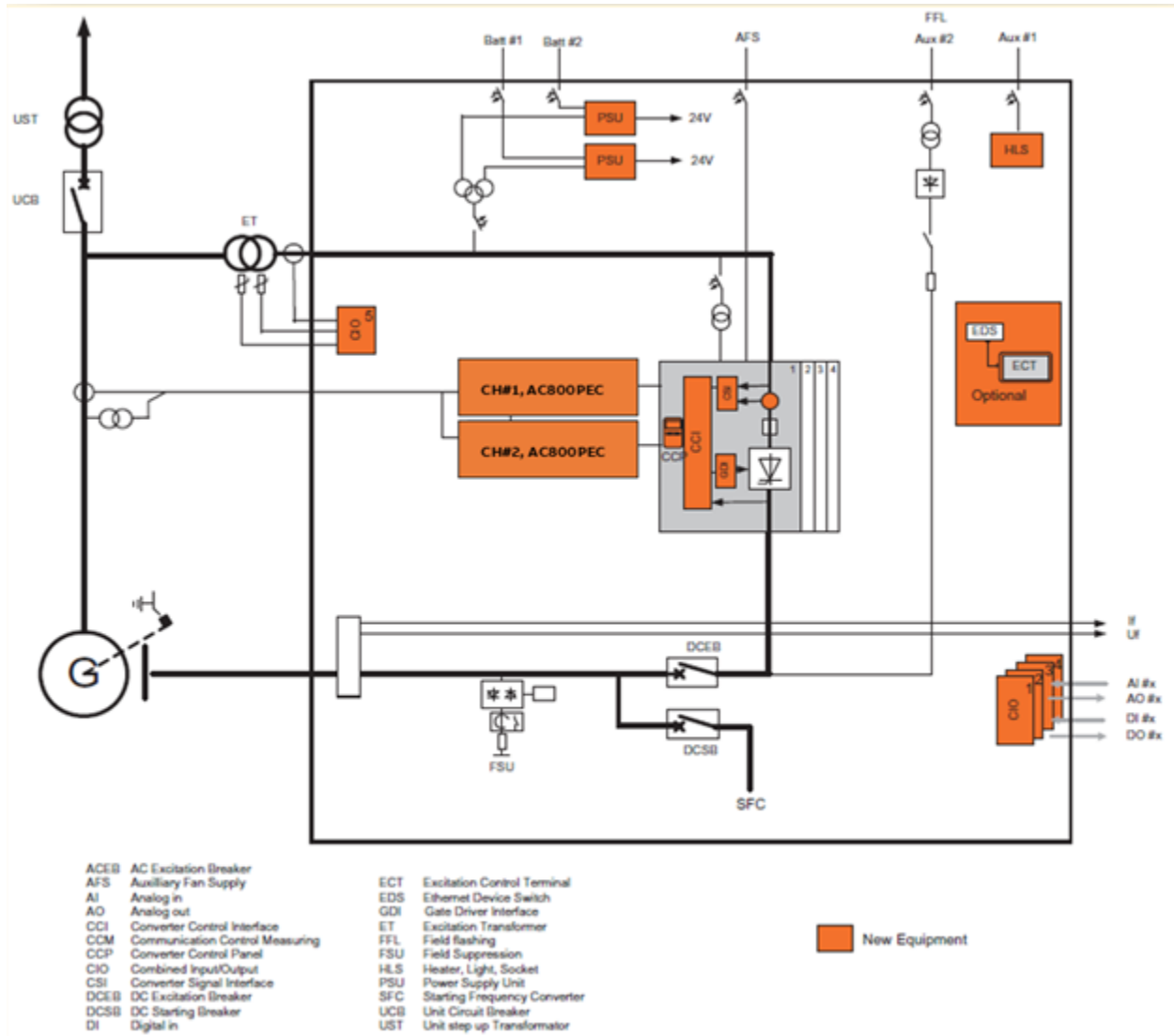


Figure 6: GDI module

Converter Signal Interface (CSI)

The Converter Signal Interface (CSI) is a resistive voltage divider used to measure the synchronous and the DC voltage on the converter. It also contains a passive demagnetizing function for the converter current transformer. The CSI is a passive device and does not require a power supply.

4 Scope of Supply



Item 1: Control Plate

4.1 Control Plate

The control plate for installation at the local control cubicle is equipped with all necessary ABB's proven apparatus, completely wired and factory tested. For a standard Control Upgrade solution – **Three (3) converter system, dual-channel**, - the control plate is equipped with the following parts:

- 2x AC800 PEC Controller, Board type PC D530 A102
- 3x combined Input Output (CIO) type PC D235
 - Interfacing digital and analogue plant control signals per CIO module:
 - 12 Digital Inputs 24/48V

- 16 Digital Outputs
- 6 Analog Inputs
- 3 Analog Outputs
- 3 PT100 or 2 PTC Inputs for transformer temperature
- Ethernet Interfaces
- Sockets, Relays, MCB
- 2x Power Supply Unit (PSU) including Input Coupling Unit and Power Pack
 - 24 VDC level with highest reliability
 - 24 VDC without repercussion

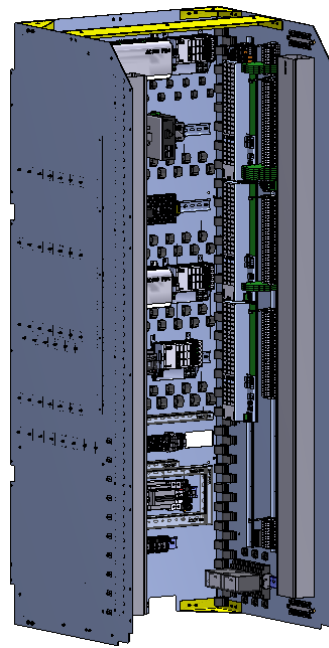
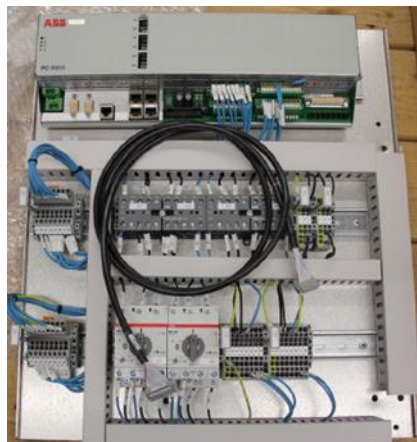


Figure 7: Control panel for installation in local control cubicle

4.2 Converter Material (depending on the number of converters)

The converter material will be **delivered loose** with installation material for fixing at each converter

- **3x Converter Signal Interface (CSI)**, board type UA D209
 - Used for Thyristor Bridge measurement, located at each converter
 - 3-phase voltage measurement
 - 3-phase current measurement
 - Field voltage measurement
 - Demagnetizer for CT
 - Interface to CCI
- **3x Converter Control Interface (CCI)**, board type PC D231 UC D240



- Fan control
- Used for monitoring, control and protection of Thyristor Bridge
- Digital I/O for converter control
- Current equalizing
- Ethernet and CAN interface
- Interface to GDI
- **3x Gate Driver Interface (GDI)**, board type UNS 0881
 - Final pulse stage card for Thyristor ignition
 - Six pulse transformer
 - Interface to CCI
- **3x Converter Control Panel (CCP)**
 - Front panel instrument at each converter for indication like:
 - Field voltage

- Field current etc.
- The CCP has a 90° indication and will be connected via Ethernet cable. Dimension 72 x 72 mm.
- 3x Current Transformer (CT), three CTs per Converter including cabling connections

4.3 Bulk Material

The control material will be delivered loose.

- 1x ECT: **Excitation Control Terminal**
Including Moxa Switch and separate power supply

General Note:

The new doors are not scope of CHABB.

4.5 Documentation

All documentation will be submitted in **English** in one electronic version (USB stick) per unit.

The documentation of the existing equipment will remain valid. The mechanical layout corresponds to the current ABB standard layout, the mechanical redesign of the customer cubicle is not part of the scope of supply. We will provide information about the new exchanged part as listed below:

Project drawings

- Mechanical schematic diagram of the standard ABB U-plate in PDF or AUTOCAD DXF format.
- Electrical schematic diagram of the standard ABB U-plate in PDF format including the list of components. The remaining components of the original system will not be indicated or only with simplified representations. Therefore, the schematic diagram of the original unit will still be required especially for the power part of the system.
- In addition to this, interfacing terminal and signal list to the old system in EXCEL format.

Test reports

- Factory test report (packed with the equipment)
- Commissioning test report (two months after commissioning release)
- PSS Test Report will be handled separately with Grid Owner

Sets of Manuals (packed with the equipment)

- Equipment hardware (based on UN6000 description for the new components)
- Operational and Maintenance manual based on UN6000

Not in scope of supply:

- Project-specific installation and commissioning instruction.
- Any required document in another language is not part of the CHABB scope.

List of UNITROL Standard Documents (after factory delivery)

- HW schematics drawings (included equipment list and signal list)
- Mechanical Layout (included outer layout, IP class, weight, clearance, cable connection info)
- Test report
- Functional description
- CE Declaration of conformity
- User Manual

4.6 Standard and Quality Assurance

UNITROL® 6000 excitation control equipment is designed in accordance with the latest international standards listed below which comply with and exceed the requirements of most national standards.

Safety Standards

DIN EN ISO 12100-1:2003	Safety of machinery - Basic concepts, general principles for design - Part 1: Basic terminology, methodology
DIN EN ISO 12100-2:2003	Safety of machinery - Basic concepts, general principles for design - Part 2: Technical principles
EN 60204-1:2006	Safety of machinery - Electrical equipment of machines - Part 1: General requirements

Quality Standards

ISO 9001:2000	Quality Management System
ISO 14001:2004	Environmental Management System, Safety at Work Management System, Health and Safety
OHSAS 18001:2007	Safety at Work Management System, Health and Safety Management System

SQS herewith certifies that ABB Switzerland Ltd, CH-5300 Turgi, Switzerland has a management system which meets the requirements of the normative bases.

EC Conformity Declaration

Directive 2004/108/EC, 89/336/EC	Electromagnetic Compatibility (EMC)
Directive 2006/95/EC, 73/23/EC	Low Voltage

General Excitation System Standards

IEEE Std 421.1:2007	IEEE Standard Definitions for Excitation Systems for Synchronous Machines
IEEE Std 421.2:1990	IEEE Guide for Identification, Testing, and Evaluation of the Dynamic Performance of Excitation Control System
IEEE Std 421.4:2004	IEEE Guide for the Preparation of Excitation System Specification
IEEE Std 421.5:2005	IEEE Recommended Practice for Excitation System Models for PSS-Studies

Related Standards

IEC 60146-1-1:2009	Semiconductor Converters - General requirements and line commutated converters - Part 1-1: Specification of basic requirements
IEC 60076-1:2000	Power transformers - Part 1: General
IEC 60664-1:2007	Insulation coordination for equipment within low-voltage systems - Part 1: Principles, requirements and tests
IEC 61439-1:2009	Low voltage switchgear and control gear assemblies - Part 1: General rules
EN 50178:1998	Installation of electronic devices in heavy-current plants
IEC 61131-3:2003	Programmable controllers - Part 3: Programming languages

Environmental Standards

IEC 60068-1:1988	Environmental testing - Part 1: General and guidance
IEC 60068-2-1:2007	Environmental testing - Part 2-1: Tests - Test A: Cold
IEC 60068-2-2:2007	Environmental testing - Part 2-2: Tests - Test B: Dry heat
IEC 60068-2-30:2005	Environmental testing - Part 2-30: Tests - Test Db: Damp heat
IEC 60068-2-13:1983	Environmental testing - Part 2: Tests - Test M: Low air pressure
EN 60529:2000	Enclosure Protection Classes (DIN IP Code)
IEC 60255-21-1:1988	Electrical relays - Part 21: Vibration, shock, bump and seismic tests on measuring relays and protection equipment - Section One: Vibration tests
IEC 60255-21-3:1993	Electrical relays - Part 21: Vibration, shock, bump and seismic tests on measuring relays and protection equipment - Section 3: Seismic tests
IEEE 344:2004	IEEE Recommended Practice for Seismic Qualification of 1E Equipment for Nuclear Power Generating Stations

EMC Standards

IEC 61000-6-4:2006	EMC - Part 6-4: Generic standards, emission standard for industrial environments
IEC 61800-3:2004	Adjustable speed electrical power drive systems - Part 3: EMC product standard including specific test methods. See Annex D, Fig. D1
IEC 61000-6-2:2005	EMC - Part 6-2: Generic standards, immunity for industrial environments
IEC 61000-4-2:2008	EMC - Part 4-2: Electrostatic discharge immunity test [ESD]
IEC 61000-4-3:2007	EMC - Part 4-3: Radiated, radio-frequency electromagnetic field immunity test [RFI]
IEC 61000-4-4:2004	EMC - Part 4-4: Electrical fast transient/burst immunity test [Burst]
IEC 61000-4-5:2005	EMC - Part 4-5: Surge immunity test [Surge]
IEC 61000-4-6:2003	EMC - Part 4-6: Immunity to conducted disturbances induced by radio frequency fields [Current Injection]

IEC 61000-4-11:2004

EMC - Part 4-11: Voltage dips, short interruptions and voltage variations immunity tests

IEC 60255-22-1:2007

Electrical relays - Part 22-1: Electrical disturbance tests for measuring relays and protection equipment - 1MHz burst immunity tests [SWC]

Test Voltages

IEEE Std 421.3:1997

IEEE Standard for High-Potential Test Requirements for Excitation Systems for Synchronous Machines

IEC 60255-5:2000

Electrical relays - Part 5: Insulation tests for electrical relays

IEC 60034-1:2004

Rotating electrical machine - Part 1: Rating and performance

ANSI C50.10:1990

Rotating Machinery - Synchronous Machines

5 Materials and Services not included in this offer

All materials and services not explicitly mentioned are not part of this offer, eg:

Materials:

- All foundation and building construction and civil engineering work
- All civil work
- Auxiliary power supply for control and LV power consumers
- Control cables to switchgear system and other secondary systems
- Interconnection cables
- Supports for cables
- All wiring inside the excitation cubicle is included; however, the scope is limited to the cabinet terminals. All connection cables and bus ducts, cable trays outside excitation cubicles are not included
- All existing control cubicle external cables will be reused. If they are damaged, the clients have to provide replacement but not limited to these.

Services:

- Engineering for cable ducts
- Engineering for cable routing
- Engineering for piping routing
- Engineering for new ventilation

6 Division of Work

Any site activities are not in scope of supply and can be quoted separately upon request.

Our scope of supply is limited with our offer.

7 Compliance Response- Technical

This proposal is in line with the technical specification of your enquiry except the following points where we feel necessary to further clarify our technical offer. Comments are referred to with the same clause numbers as per our specification.

Clause	Content of Specification	Remark / Deviation