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Application Note

Improved Solutions for Aging SCT/PPT Voltage Regulators

In the 1970s, main field static excitation systems became increasingly popular for medium and large synchronous machines used with gas and steam turbine generators. See Figure 1. Due to their isolated locations, many of these systems were designed with the ability to maintain fault current into the system or bus voltage support during a system fault.

For such systems, potential bus fed static exciters that derive the power from the generator output, were insufficient. Instead, compound-type static exciters became popular.

These systems, with the trade name "SCT/PPT", used a combination of linear reactors, saturable power current transformers, and a power potential transformer that had outputs connected together to provide an ac voltage into a rectifier bridge to supply power for the main generator field. The generator voltage was regulated by an automatic voltage regulator via a control winding embedded in the saturable power current transformer.

SCT/PPT systems were popular with the pulp and paper industry, municipals, and utility power plants. These systems have become difficult to maintain as worn out mechanisms such as open potentiometers, shorting transformers, failing semiconductors, and defective motor-operated potentiometers have turned into an unpopular frustration.

Figure 1: In the 1970s, main field excitation systems were popular for medium and large synchronous machines used with gas and steam turbine generators like this one.

This Application Note provides solutions for the aging voltage regulator situation, where obsolescence of parts has made it difficult to achieve reliable operation.

How It Works

The power current transformers, as shown in Figure 3, were inserted into the generator output via the neutral side of the machine (one for each phase). The power current transformers included a control winding in which dc current could be applied to affect magnetic saturation. The secondary of the power current transformers was delta connected and in parallel with a set of linear reactors connected in series with the delta secondaries of the power potential transformer.

Figure 2: Power Magnetics, such as these, were an integral part of the SCT/PPT system.

While the primary of the power transformer was connected in a wye across the generator output, the combined output of the SCT and PPT was connected to a three phase power diode rectifier bridge that connected to the generator field.

The phasor summation between the PPT/linear reactor set and SCT provided the correct compensated voltage and current to the generator field for all types of load at any power factor.

A voltage regulator, with reactive current compensation, underexcitation limiting and manual voltage mode, was provided to control the generator output via the control winding of the saturable current transformers.

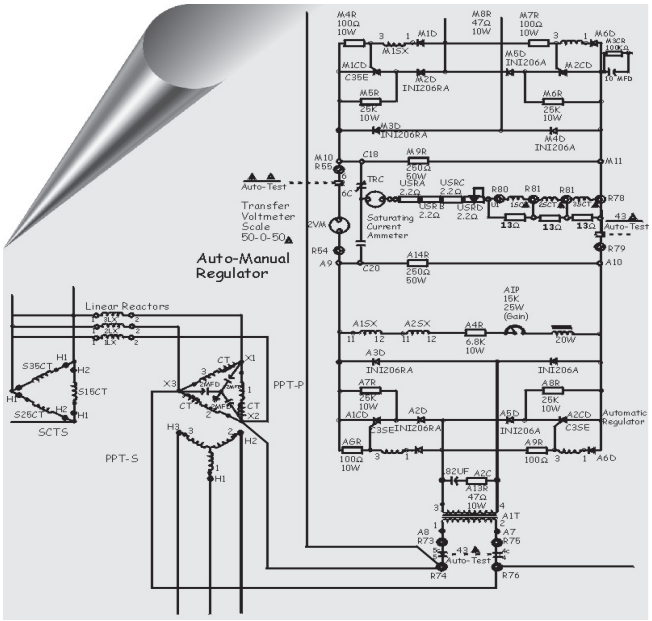

Figure 3: In the 1970s, SCT/PPT systems like this one were used in industry and utility applications.

However, the SCT/PPT voltage regulator was uniquely different. Its output works through the control winding of the saturable transformer but opposite in magnitude from the voltage that appeared at the generator field.

During normal steady state operation, the control current remained essentially constant. If a disturbance occurred, causing a drop in terminal voltage, the voltage regulator temporarily reduced its output, decreasing the dc saturation of the saturable current transformers. This caused an increase of ac voltage at its output available for rectification for the generator field.

If the terminal voltage rose, the voltage regulator increased its output, increasing the dc saturation of the SCT transformer, which resulted in a decrease in generator voltage and restoration to normal generator voltage.

The Solutions: Voltage Regulator or Static Exciter Replacement

Voltage Regulator Replacement

The power magnetics and power bridges in most of today's SCT/PPT systems are in good condition but the voltage regulator has presented problems of system reliability. For these systems, the preferred solution is upgrading the existing voltage regulator to a new excitation controller that includes:

- 0.1% voltage regulation accuracy
- Manual control
- Underexcitation, overexcitation, var, and V/Hz limiters

Additional features available with the upgrade

In addition to the basic system, additional features with the new equipment package for control and protection include:

- Six-channel real-time chart recording
- Dynamic system analyzer for performing a generator frequency response with a Phase Plot Compensator to assist in evaluating power system stabilizer performance based upon the selection of lead/lag filters.
- Online and offline excitation limiting
- Automatic var/PF control
- Autotracking/autofollower circuit
- Auto Synchronizing option (25A)
- Generator voltage softstart
- Reactive droop, line drop compensation, network reactive line sharing compensation
- Hardwire contact control
- Oscillography
- Built-in reference adjusters
- PID Auto Tuning
- Power System Stabilizer, Type Integral of Accelerating Power (optional)
- Modbus® for monitoring and control
- Protection
- Loss of field
- Loss of voltage sensing and transfer to manual
- Generator overvoltage
- Generator undervoltage
- Field overvoltage
- Field overcurrent
- Volts/Hertz
- Field overtemperature

Like the old system, the new excitation controller provides dc into the control winding of the saturable current transformer. Unlike the old equipment, the output of a new excitation system provides both positive and negative voltage to the control winding to speed the response at the generator output. For some applications where a power system stabilizer may be required, the power system stabilizer function can be added as an integral part of the DECS-450 controller.

Figure 4 is a block diagram of the new excitation system interfacing to the existing control winding. The existing 480 vac supply provides power to the rectifier bridge for control. The new system is offered in a pre-engineered, prepackaged and tested pan chassis system to speed installation and commissioning and to take advantage of existing cubicle space.

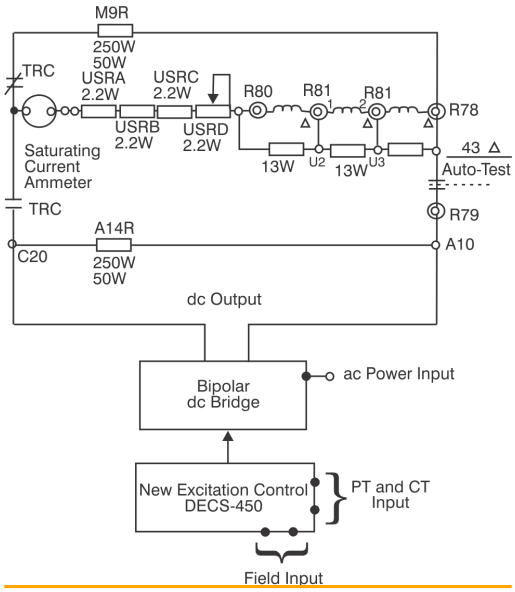

Figure 4: Block diagram of new excitation system interfacing with SCT control windingsutilized in DECS-450 pan chassis

Complete Static Exciter Replacement

If the existing power magnetics fail or are in poor condition, a retrofit to a new potential source static exciter system can be provided. See Figure 5.

Experience has shown that this option is common practice for the steam turbine applications because, typically, there is more space available in the power plant than in the GAC of the combustion turbine. The new static exciter consists of the DECS-450 digital controller with new, full converting power rectifier bridge and power potential transformer in a factory built NEMA 1 type enclosure as shown on the right in Figure 5.

The old static exciter components, including the power magnetics, are removed with the exception of the saturable power current transformers that are typically retired in place.

DECS-450 Auto Tuning

New features in the DECS-450 is PID auto tuning via BESTCOMS*Plus*® operating software, similar to that provided in the DECS-250N product line. Auto tuning is used during commissioning with the generator spinning. After initiation, the auto tuning is performed in less than a minute that will determine the PID gains for the controller. It accomplishes this with the spinning machine open circuit by performing number of voltage step changes to the generator output resulting in suggested gains. Additionally, the auto tuning will determine the machine Time Constants of the Generator (T'do"), which is required data for generator modeling. The PID auto tuning process speeds commissioning to enable the generator to become fully operational sooner to the system.

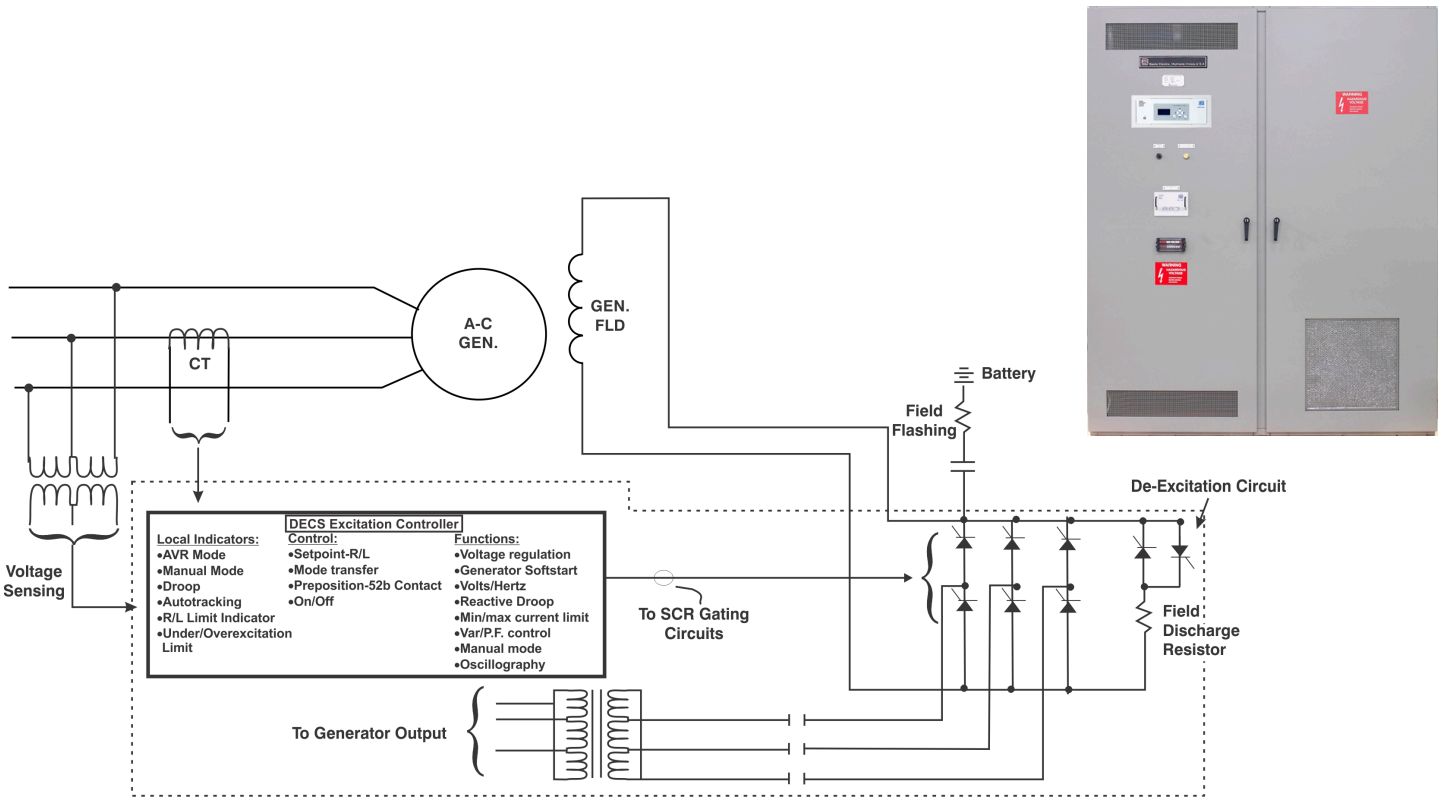

Figure 5: The complete static exciter replacement includes a DECS-450 with new, full converting power rectifier bridge and power potential transformer in a factory-built NEMA 1 type enclosure

DECS-450 Phase Plot Compensator

A Phase Plot Compensators is provided with the Dynamic Frequency Analyzer to assist in evaluating the Power System Stabilizer Lead Lag time filters that are derived from the Frequency Response of the generator system. When the red and blue curves align in the Phase Lag graph, the proper compensation has been achieved and test validation is then required. See Figure 6.

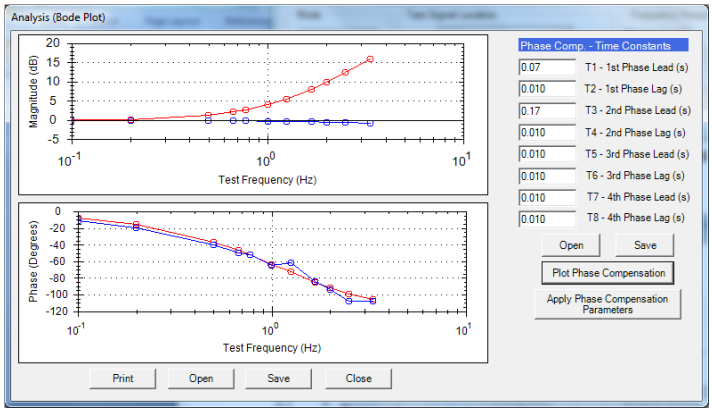

Figure 6: Frequency Response Results using Built-in Dynamic Analyzer

DECS-450 Communication Software and Embedded Tools

The DECS-450 controller is a sophisticated microprocessor based platform capable of providing all of the control, protection, and monitoring functions necessary to prevent the generator from operating outside its design parameters. Normally, initial setup is performed with the BESTCOMS*Plus*® communication software provided as part of the excitation system. A personal computer is used to run the software via a USB port or Ethernet network connection on the DECS-450 to load the settings into the DECS-450. An example of the intuitive software screens is shown in Figure 7.

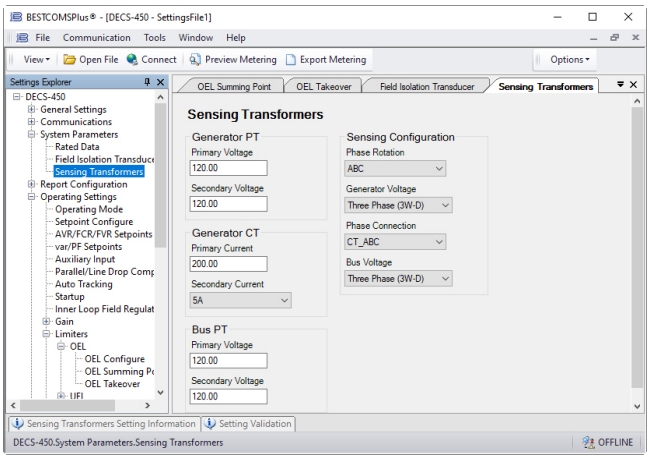

Figure 7: BESTCOMS*Plus*® software facilitates setup and testing.

Some of the tools included in the software package are Sequence of Event recorders and six-parameter oscillography with selectable pretrigger data points for troubleshooting power system disturbances. A real time monitor with up to six channels that acts as a digital strip chart recorder is extremely beneficial while performing set point step changes during tuning and commissioning, as well as for special testing purposes. See Figure 8.

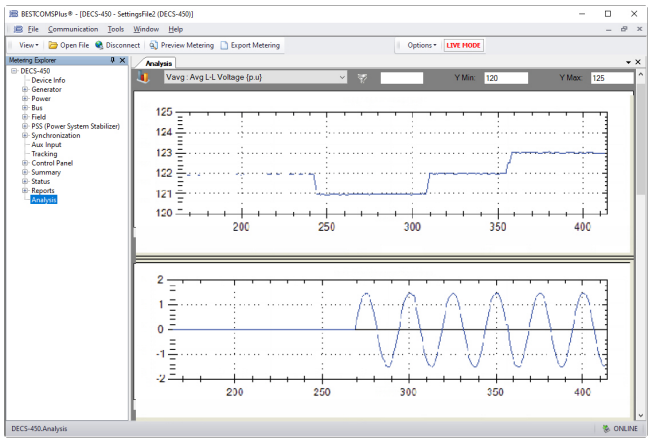

Figure 8: Online PSS and AVR testing can be monitored using the Real Time Monitoring function.

BESTspace™

The DECS-450 offers a setup commissioning tool in BESTCOMS*Plus* operating software that allows one to set up preferred monitoring screens from the Metering Explorer. BESTspace allows one to save the file as a "default" and it will come up on the preferred screen every time BESTCOMS*Plus* is opened. Valuable time saved during setup speeds the commissioning preparation time for startup. See Figure 9.

Solutions are Available

Solutions are available to retrofit the SCT/PPT voltage regulator, creating a new excitation system that improves performance and offers years of additional service for existing generator systems. See Figure 4 and 5.

For More Information

For more information, consult with an Excitation System Specialist at 618-654-2341. Please visit www.basler.com to learn more and to download the DECS-450 product bulletin.

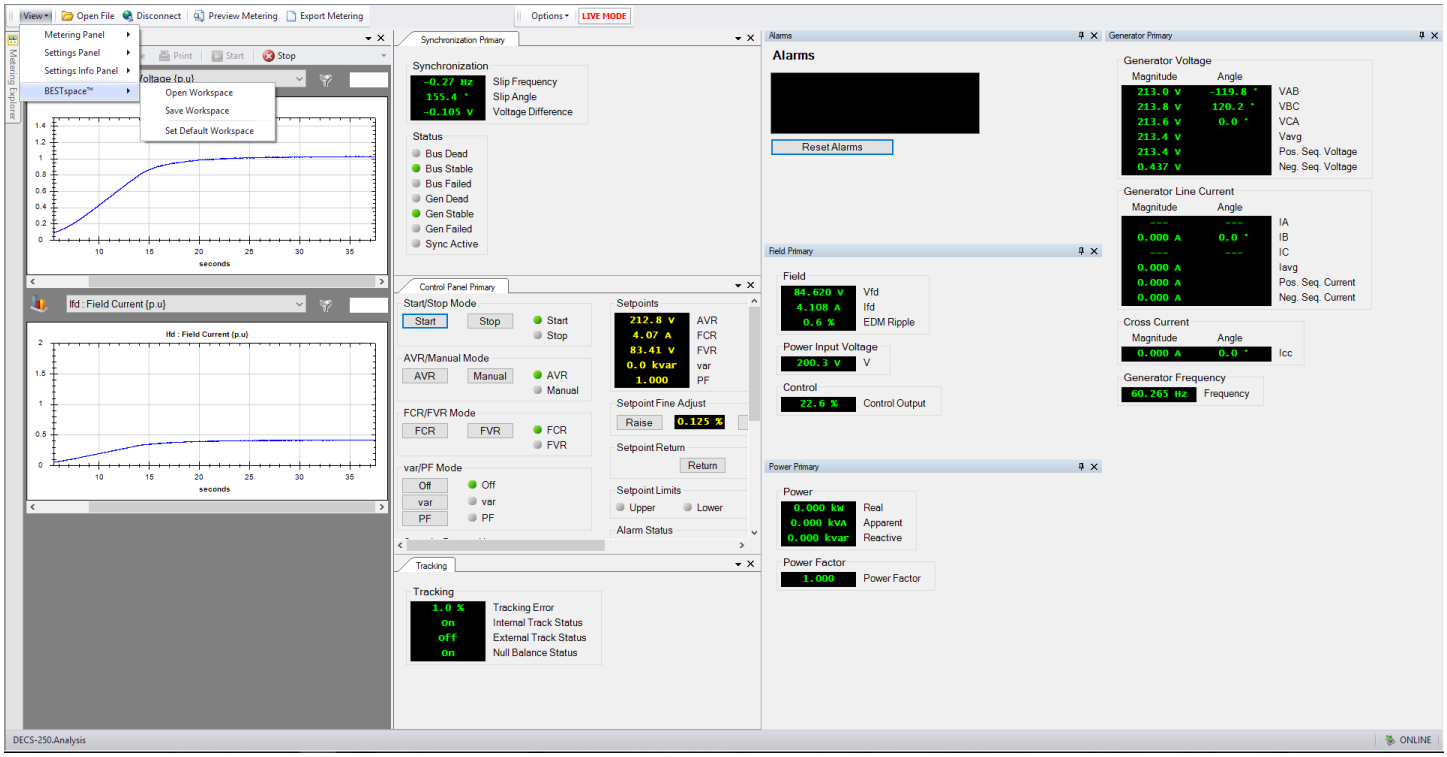

Figure 9: BESTspace

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