Application Note

Basler's DECS-450: A voltage regulator for Alterrex™ Systems

Alterrex Voltage Regulator Replacement

Just as the Alterrex water-cooled bridges (See Application Note EX-ALT2) have come to their end of life, the same is true for the 50-year-old voltage regulator that drives the rotating exciter shunt field to control the generator output voltage. Because of reliability concerns, extensive North American Electric Reliability Corporation (NERC) testing compliance, and obsolescence of the existing system, replacing the voltage regulator has become a logical choice.

Figure 1: New Alterrex Digital Voltage Regulators Mounted in Cabinet

In defining the voltage regulator, much has changed from the basic voltage regulator functions of the past. Today, in addition to the basic voltage regulator and manual control functions, other new functions include:

- Automatic voltage regulator with 0.1% accuracy
    - Dual PID gain setting groups for both the DECS-450 and the power system stabilizer for optimum tuning
    - Reactive droop and line drop compensation, network load line sharing
- Auto tuning of the voltage regulator PID gains
- Field current or field voltage regulator for standby mode and NERC testing
- Var/Power factor control
- Limiters; V/Hz, Excitation (minimum and maximum), var limiter, and stator current limiter
- Voltage matching and auto synchronizing capability
- Autotracking for bumpless transfer between automatic voltage regulator (AVR) and manual control and redundant controllers
- Power system stabilizer, type 2C, integral of accelerating power
- Phase plot compensator for power system stabilizer assisted tuning
- Built-in dynamic analyzer for measuring frequency response of generator and excitation system using Signal Generator inputs
- Real time chart recorder, data logging including oscillography and sequence of event information for data capture
- Communications: Ethernet, USB, or RS-485 (Modbus®)
- Protection:
    - Field overvoltage
    - Generator over/under voltage
    - Field overcurrent
    - Loss of voltage sensing
    - Loss of field
    - Volts/Hertz
- Auto Sync option indication
- IRIG-B time synchronization stamp
- Generator field temperature monitoring
- BESTCOMS*Plus*® common operating software to Basler Electric product family

The functions above represent the typical features of most excitation systems. Accompanying these typical features are enhancements to provide a more fault-tolerant control system. See Figure 2.

Excitation Redundancy

Figure 2 illustrates a typical excitation system with complete redundancy of the voltage regulator, firing circuit, and rectifier bridge. Note that each digital controller contains all the features described above. Each control includes watchdog monitoring of the microprocessor, along with an external field overcurrent monitoring system to determine if the operating digital controller has failed. If an issue within the primary channel is detected, an automatic transfer forces control to the backup channel to maintain constant generator voltage regulation.

Along with the dual channel controllers, redundant power rectifier bridges and redundant firing circuits are provided. Each rectifier bridge consists of six (6) SCRs to control the exciter shunt field, accompanied by RC snubbers, an exciter field discharge circuit, and an ac power interrupt. The power rectifier bridges are 200% rated output. If a bridge power fuse fails, the backup bridge immediately picks up the balance required to meet the field requirements. The rectifier bridge is designed to provide

200% field forcing into the exciter shunt field. Transfer to the redundant bridge rectifier/firing circuit is accomplished either by bridge fuse failure or by a firing circuit watchdog detection.

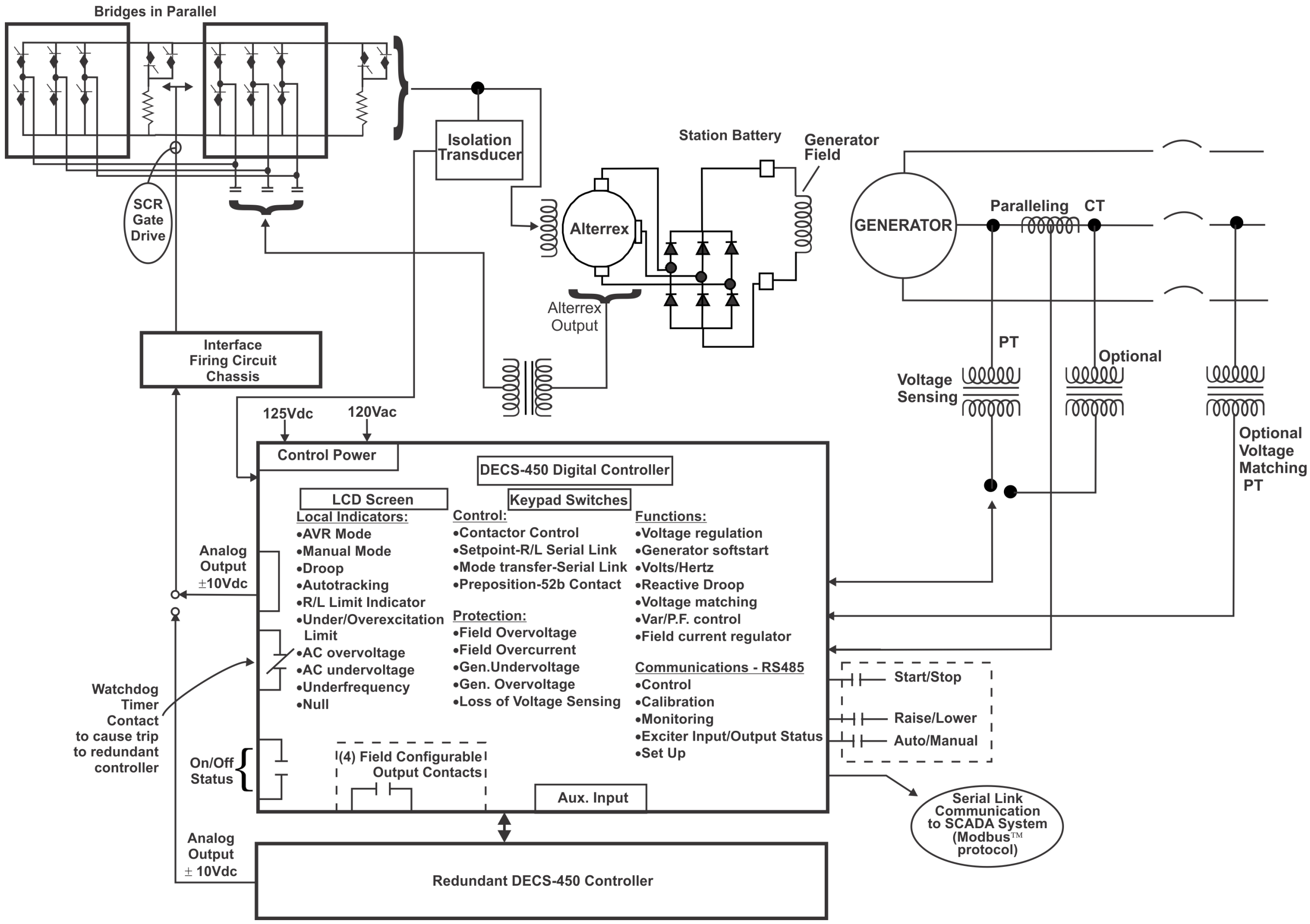

Figure 2: Block Diagram of New Voltage Regulator System

Redundant Voltage Sensing Input

Manual control has been the typical backup of choice in the event of a failed sensing fuse for the regulator instrument voltage transformer (VT). Today, a backup set of instrument VTs often is implemented for the voltage regulator sensing inputs. If a VT fuse fails on the primary VT set, a ANSII device 60 balance relay causes the system to transfer control to the alternate set of VTs. This allows the system to meet NERC requirements by continuing to operate in AVR mode.

Power Supply Inputs

The existing Alterrex voltage regulator obtained bridge power from the output of the Alterrex exciter via the node power transformer which provides power into the SCR rectifier bridge. As the power output from the Alterrex exciter varies, so does the power supplied to the rectifier bridge. This affects the level of field forcing available to drive the exciter shunt field. See Figure 3.

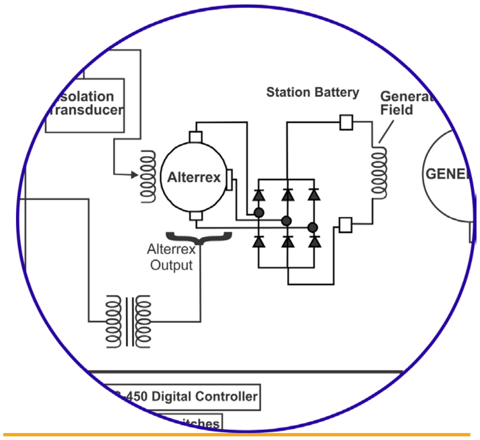

Figure 3: Alterrex Power Output Driving the Excitation Rectifier

When the generator voltage dips because of a system disturbance, so does the rectifier bridge field forcing that compromises the system voltage response. This causes a slow voltage recovery.

Figure 4 illustrates the recommended solution that provides the best performance for generator voltage response.

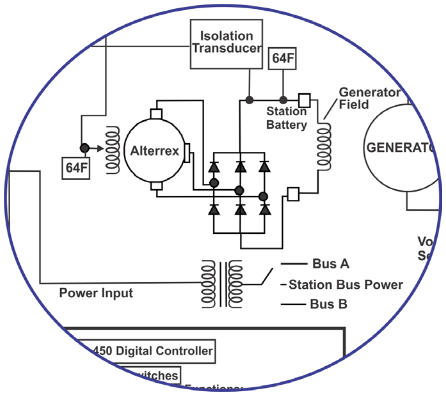

Figure 4: Excitation Powered by Station Power

Here, the excitation power source is derived from station power. For additional reliability, two power sources are utilized. When one power source is lost, the other power source is available to immediately provide power to the rectifier bridge. An automatic transfer switch with a very short cycle time is utilized to avoid a bump of reactive power at the machine output.

In some cases, rather than using a transfer switch between the two (2) station power sources, two (2) power transformers are utilized with each connected to a rectifier bridge and firing circuit. While both transformers are energized, only one rectifier bridge and firing circuit is enabled. A 60 balance function is used to monitor the secondary power transformer's voltage. If the primary voltage source is lost, the 60 voltage balance function immediately enables the redundant bridge rectifier with its backup voltage source. See Figure 5.

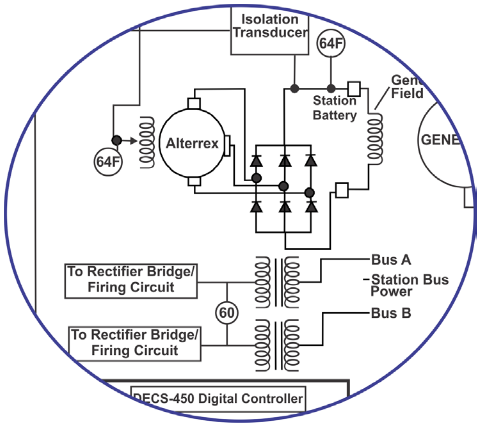

Figure 5: Block Diagram using two PPTs, one connected to each Station Power Source

As noted, the voltage response of the excitation system is compromised when the Alterrex rotating exciter output is utilized. When attempting to meet NERC's performance guidelines for meeting transient and steady state stability in the power system, the use of station power is much more effective, offering a superior solution for performance.

Figure 6 shows the comparison in voltage system response between the existing Alterrex power output and a new digital excitation system that uses station power.

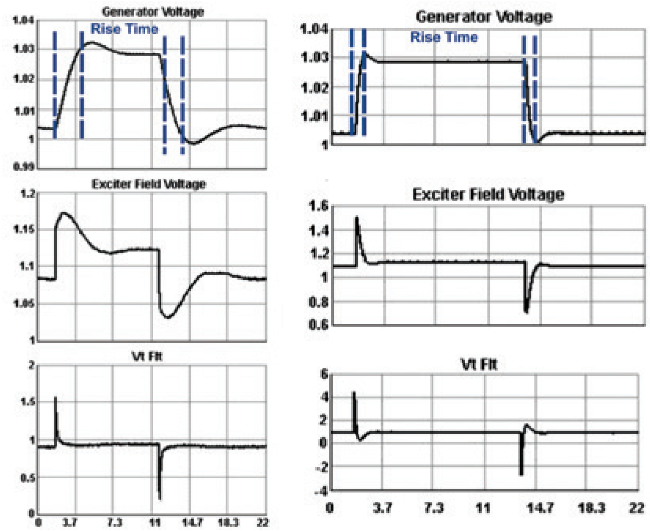

Figure 6: In a simulation profile, Alterrex AVR performance using Alterrex exciter output is compared to digital control using station power

With the old excitation system, a +2% generator voltage step is introduced with the generator circuit breaker open. Notice the generator voltage rise time is very sluggish at 2 seconds as it attempts to recover generator terminal voltage. However, the digital controller, with the same generator voltage step applied, has only a 0.2 second voltage rise time. For a -2% voltage step down, the generator voltage has an approximate 3 second decay time versus the new digital AVR that provides a 0.3 second decay time. As noted in Figure 6, the type of power source dictates the AVR response. Station power provides the best solution, especially when a power system stabilizer is needed.

Table 1: Simulation Performance Data of the Power Sourcing Types between the Alterrex Excitation System and the Station Power

Generator Open Circuit Step Response		
	Alterrex AVR	New Digital AVR
AVR Power	Alterrex Output	Station Power
+2% Voltage Step	2 Seconds	.2 Seconds
-2% Voltage Step	3 Seconds	.3 Seconds

Additional Features of the DECS-450 Auto Tuning

For easier tuning of voltage regulator gains, the DECS-450 includes a PID auto tuning feature via the BESTCOMS*Plus*® operating software. Auto tuning is used during commissioning with the generator spinning. After initiation of Auto Tune, in less than a minute, the PID gains are determined along with the Time Constants of the Exciter (te) and Generator (T'do"), which is required data for generator modeling. The process speeds commissioning.

Main Field Current Measurements

To further modernize the Alterrex excitation system for better control, the new excitation system measures the main field current directly from the generator rotor for the overexcitation limiter (OEL) and the field current regulator. It is no longer required to measure the exciter shunt field current and estimate the main field current in an attempt to achieve adequate main field current limiting. Instead, an isolation transducer located at the generator rotor output provides input data of both the main field current via a shunt and for field voltage measured directly across the main field. The voltage regulator acts upon the exciter shunt field to regulate the maximum allowable main field current. Figure 7 illustrates the overexcitation limiter performance during a system validation test. Notice that the over excitation limiter responds in only 0.666 seconds, exhibiting very stable response for a 500 MW generator.

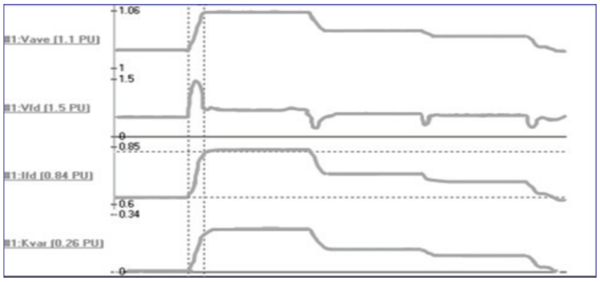

Figure 7: Overexcitation Limiter Testing

Additionally, by monitoring the main field voltage and current, it allows for calculation of the main field temperature measured in degrees, either Fahrenheit "F" or Celsius "C".

Testing Tools in the Digital Excitation System

The availability of a machine is always critical during the commissioning of newly installed equipment. Since downtime is costly, any testing tool included in the excitation system that does not require external test equipment saves time during hookup and tear down which, in turn, translates into machine availability. A Real Time Chart Recorder, that is included in BESTCOMS*Plus* operating software, can monitor a variety of machine parameters such as generator voltage, field voltage, and field current, and provide immediate feedback of machine performance. Figure 8 illustrates voltage step responses performed using a Real Time Chart Recorder. In this example, generator voltage versus field voltage is monitored to determine proper gain selection of the digital excitation system for optimum machine performance. Other selected parameters can allow testing of the under- and overexcitation limiters to verify their proper operation.

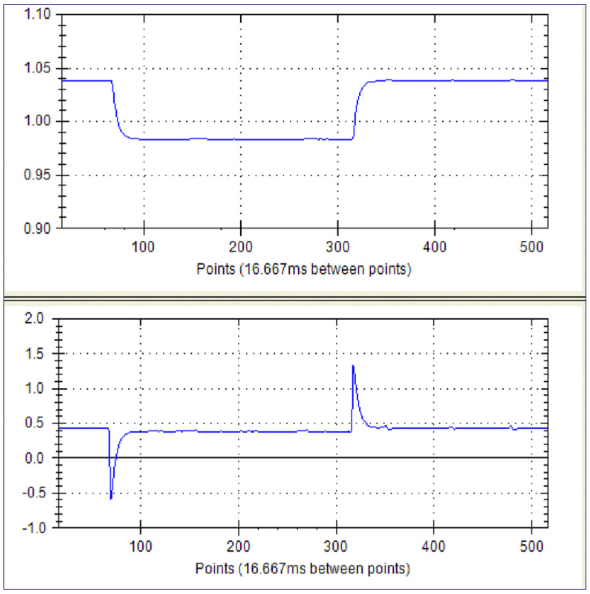

Figure 8: 5% Generator Voltage Step Change using Built-in Chart Recorder Software Function

Dynamic System Analyzer with Phase Plot Compensator Assists with PSS Tuning

A Dynamic Frequency System Analyzer eliminates the need for an external test hardware interface. The Dynamic Frequency System Analyzer performs a frequency response to determine the phase lag of the selected voltage regulator gains in the digital controller combined with the generator characteristics required for model validation on large machines. Where a power system stabilizer is required, the frequency response provides information in the form of a bode plot that provides data to help the engineer determine the filter time constant in the lead and lag filters required for the power system stabilizer. See Figures 9a and 9b.

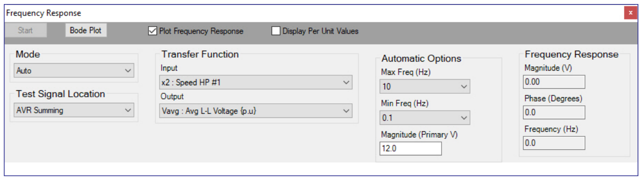

Figure 9a: Selection of Parameters for Frequency Response Test

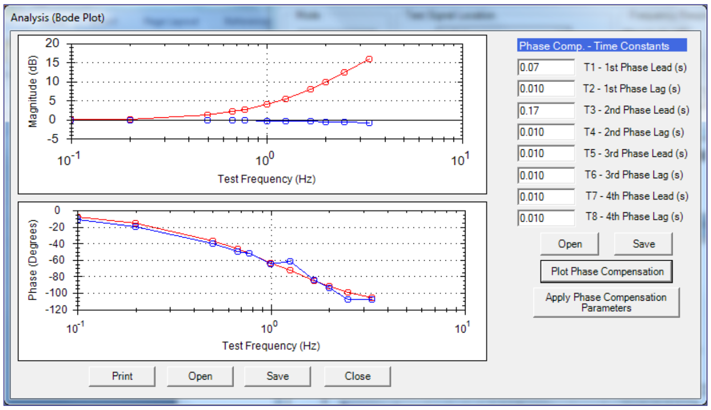

Figure 9b: Frequency Response Results using Built-in Dynamic Analyzer

The built-in Dynamic Frequency System Analyzer performs a frequency response in minutes, compared to the old hardware that required three days and machine down time for hookup and teardown.

For systems that require a power system stabilizer, a Phase Plot Compensator is provided with the Dynamic Frequency Analyzer to assist in evaluating the power system stabilizer Lead/Lag filters selection that are derived from the Frequency Response of the generator system. When the red and blue curves align in the Phase Lag graph above, proper compensation is achieved and test validation is then required. See Figure 9b.

Oscillography provides the means to capture data for analysis based upon logic settings and triggers implemented in the controller. If a system disturbance occurs, the triggers can be set to tag a data log for later evaluation. Viewing software is used to view the data.

Oscillography creates graphic images of captured data, and Sequence of Events information provides a date, time, and word description of the action that has occurred, such as start/stop command and excitation limiter activity.

NERC standards require a strong emphasis on accurate models of the excitation system. The applicable model type depends on whether the excitation system is used for a power supply into the exciter shunt field or the generator main field. For the Alterrex exciter system, the AC8B model is suggested. Figure 10 highlights a typical model.

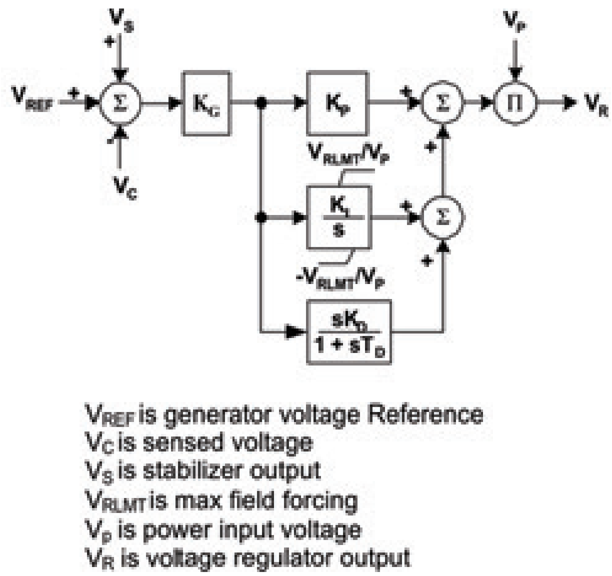

Figure 10: Simplified Block Diagram of Automatic Voltage Regulators

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 11.

For More Information

For information on the DECS-450 and Basler's complete range of exciter solutions, visit www.basler.com to access product documentation, Application Notes, and technical papers. To discuss your application, consult Basler at 618.654.2341.

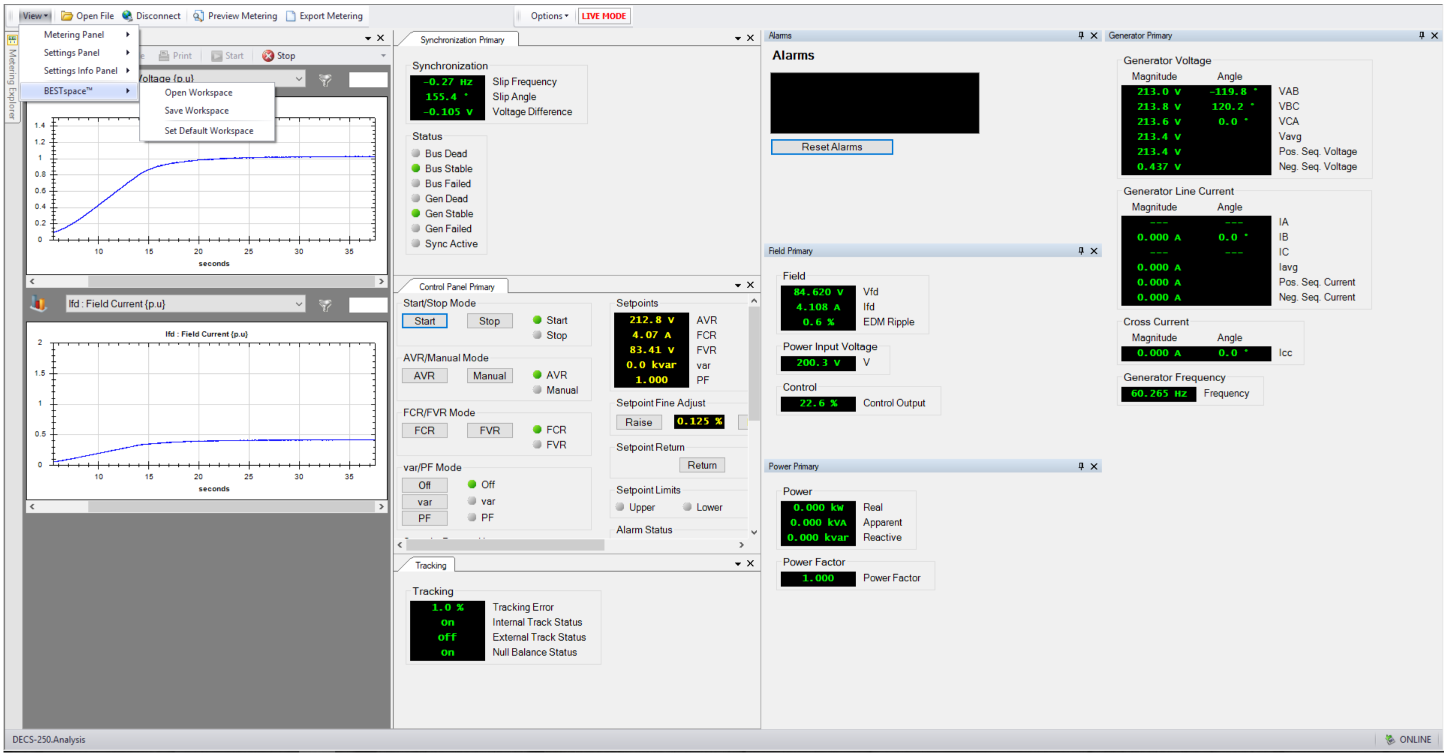

Figure 11: BESTspace

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