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Application Note

Basler's Digital Excitation Retrofit Solutions Improve Maintainability and Performance when Replacing the "Diactor"

The General Electric type GDA "Diactor" was one of the most popular automatic voltage regulators provided worldwide throughout the mid 1930s to early 1970s. It is found in generator controls used with a diverse range of land-based prime movers that include diesel engines, hydro, steam, and gas turbines generally between 2 and 25 megawatts in capacity. Figure 1 depicts the Diactor accompanied by its "Auxiliary Box". Electrical and mechanical deterioration and obsolescence of the product are forcing owners to search for new retrofit solutions. Increased integrated functions, reliability, performance and less maintenance are a few of the benefits to be recognized when retrofitting these obsolete voltage regulators with solid state, digital products to facilitate power plant automation projects.

This Application Note describes the fundamental operation of the Diactor and provides Basler Electric's solution for replacing this obsolete electromechanical voltage regulator.

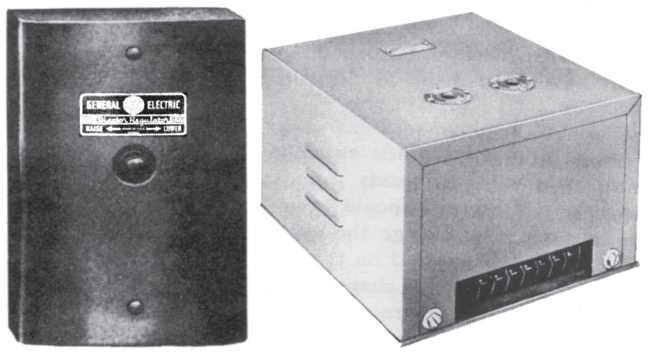

Figure 1: Diactor Voltage Regulator and Auxiliary Box with Cover

How It Works

Depending on the size of the generator, various model numbers of the GDA (29 through 34) Diactor were applied in series with an exciter shunt field rheostat. The GDA Diactor consists of the regulator that contains a voltage sensitive element, rheostatic elements and an auxiliary box that contains the regulator stabilizer, metallic rectifier, main resistor, and compensating rheostat. The voltage sensitive element of the regulator was mechanically linked to the carbon pile stacks of the rheostatic element. Depending on generator output voltage, the mechanical link exerted vertical pressure that caused the carbon pile stack to tilt forward or backward. As the stack was tilted forward, silver buttons in the stack assembly shorted out and caused the resistance of the element to decrease. Conversely, if the stack were tilted backward, the resistance of the element increased. The varying resistance in series with the exciter shunt field changes the excitation current in the field winding.

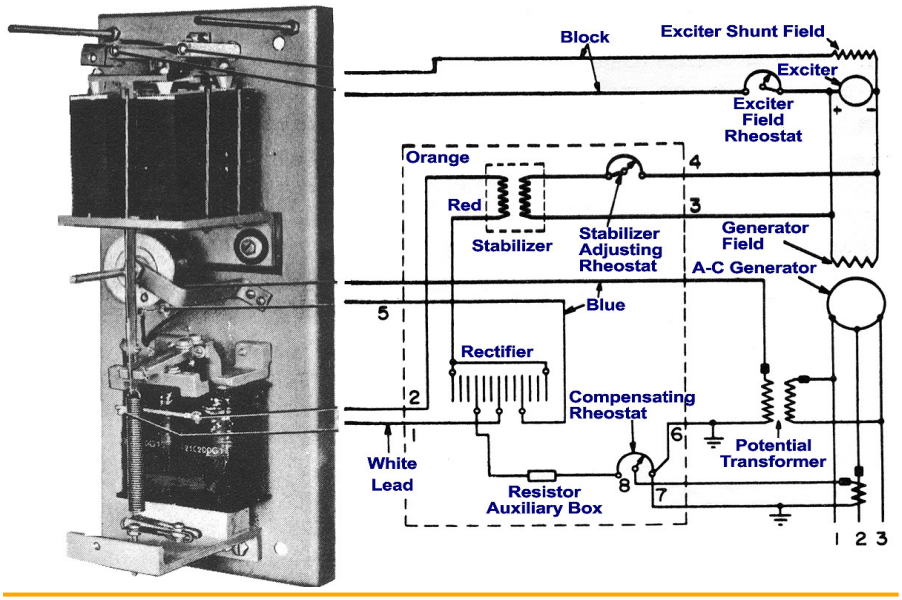

Figure 2: Type GDA-32 diactor regulator typical interconnection.

Controlling the Generator Output

Figure 2 shows how the regulator was typically interconnected to the generator. The generator could be prepared for operating in the manual mode by first turning the field rheostat "in" and turning the Diactor voltage adjust rheostat to "raise" until all of the silver buttons were shorted. Then, excitation was controlled by manually adjusting the exciter field rheostat to change field current and, consequently,

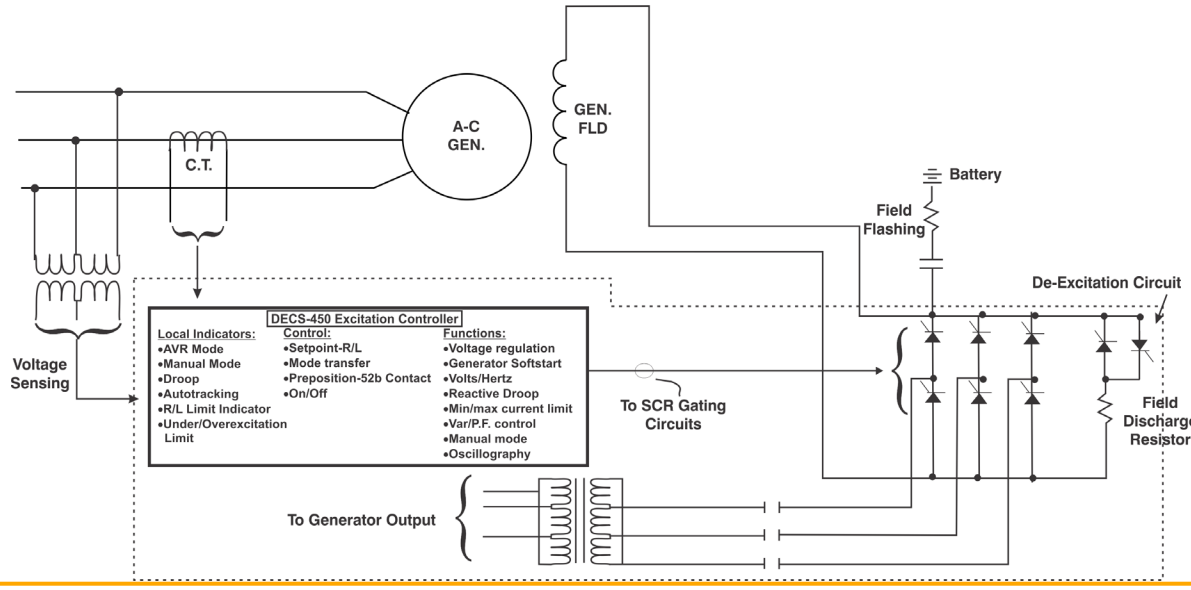

Figure 3: The replacement of the Diactor and rotary exciter for a static exciter interfacing a power transformer, DECS-450 controller, and power rectifier bridge to the main field.

vary the generator output voltage. When the system was in the automatic mode, the Diactor's resistance adjustment range was sufficient to control the exciter over the entire range of voltage and load conditions of the a-c generator. Many generators are required to operate in parallel. For these applications, a current transformer in the generator output provided information to the auxiliary box circuitry for reactive load sharing.

Basler's Retrofit Solutions

Basler Electric recommends two solutions for retrofitting the Diactor voltage regulator.

1. The Diactor, field rheostat and rotary exciter can be replaced for a static exciter to work directly into the main field of the generator via the slip ring and brush assembly using a DECS-450 excitation system. See Figures 3 and 4.
2. The Diactor and exciter field rheostat can be removed and a digital voltage regulator with independent manual voltage control can be installed to work directly into the exciter shunt field using an SGC-250N excitation system. See Figures 6 and 7.

Static Exciter System

If the d-c rotary exciter is in poor condition and a possible candidate for a rewind or commutator rebuild, or if other exciter maintenance is excessive, the preferred solution is to work directly into the main generator field. (See Figure 3.) Benefits of the static exciter include improved system performance during system disturbances, high operating efficiency, and minimal maintenance costs.

The static exciter contains a power rectifier bridge and power potential transformer sized to meet the rated load excitation requirements of the generator rotor. The shunt static exciter is equipped with a digital controller with 0.1% voltage regulation accuracy. The system can be controlled locally and/or remotely using switches and contacts. Modbus® protocol is available with the digital DECS-450 excitation system for remote communication. Remote control with the digital system can be extremely simplified with an optional model IDP-801 remote display panel. This touch-sensitive device provides complete control and metering and annunciates critical excitation system functions (see Figure 5). A manual control mode is a standard feature.

Figure 4: DECS-450 prepackaged static excitation system offers higher efficiency and minimal maintenance costs for main field applications.

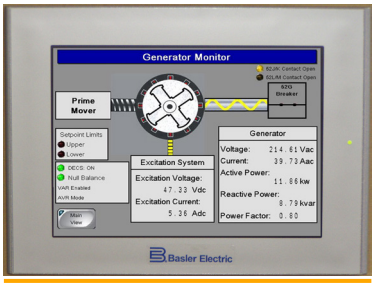

Figure 5: Touch Screen Interactive Display Panel, IDP-801 can be used with the SGC-250N or DECS-450.

The power rectifier bridge can be either a 3 SCR semi-converting bridge or a 6 SCR full converting bridge capable of positive and negative field forcing. Generators rated above 10 MW are usually fitted with the full converter bridge that also includes a crowbar circuit and field discharge resistor that eliminates the need for the dc field breaker.

Voltage Regulator System

For systems where the rotary exciter is in good condition, the rotary exciter can be retained, and the exciter field rheostat and Diactor is replaced with a digital excitation control system working into the exciter shunt field.
In most retrofit applications where the Diactor is replaced and the rotating exciter is retained, the SGC-250N provides the best solution. A single SGC-250N can be flush mounted through a door or projection mounted from internal walls in existing enclosures.

Basler Electric also has solutions to provide pre-engineered packages such as the SGC-250N Synchronous Generator Controller shown in the photograph and simplified drawing in Figures 6 and 7. The SGC-250N can be mounted in existing enclosures or can be configured in its own NEMA 1 type freestanding enclosure. With automatic fault transfer to the backup regulator offered by the SGC-250N, ultra high reliability can be attained to keep the generator online.

Most features and tools of the DECS-450 digital controller are also included in the SGC-250N such as oscillography and Modbus communication protocol. Protective functions and excitation limiters included in each DECS system keep the generator operating within its designed parameters.

Figure 6: Prepackaged Basler SGC-250N.

Tips for Applying the SGC-250N Synchronous Generator Controller

In order for the Diactor to function, there was a common connection between the exciter shunt field and armature. To retrofit the GDA Diactor to the SGC-250N, the exciter shunt field should be electrically isolated as shown in Figure 8.

The majority of Diactor applications used rotating exciters with rated output voltage of 125 Vdc and the SGC-250N performs in this application because it can operate at up to 125 Vdc nominal output voltage on a continuous basis.

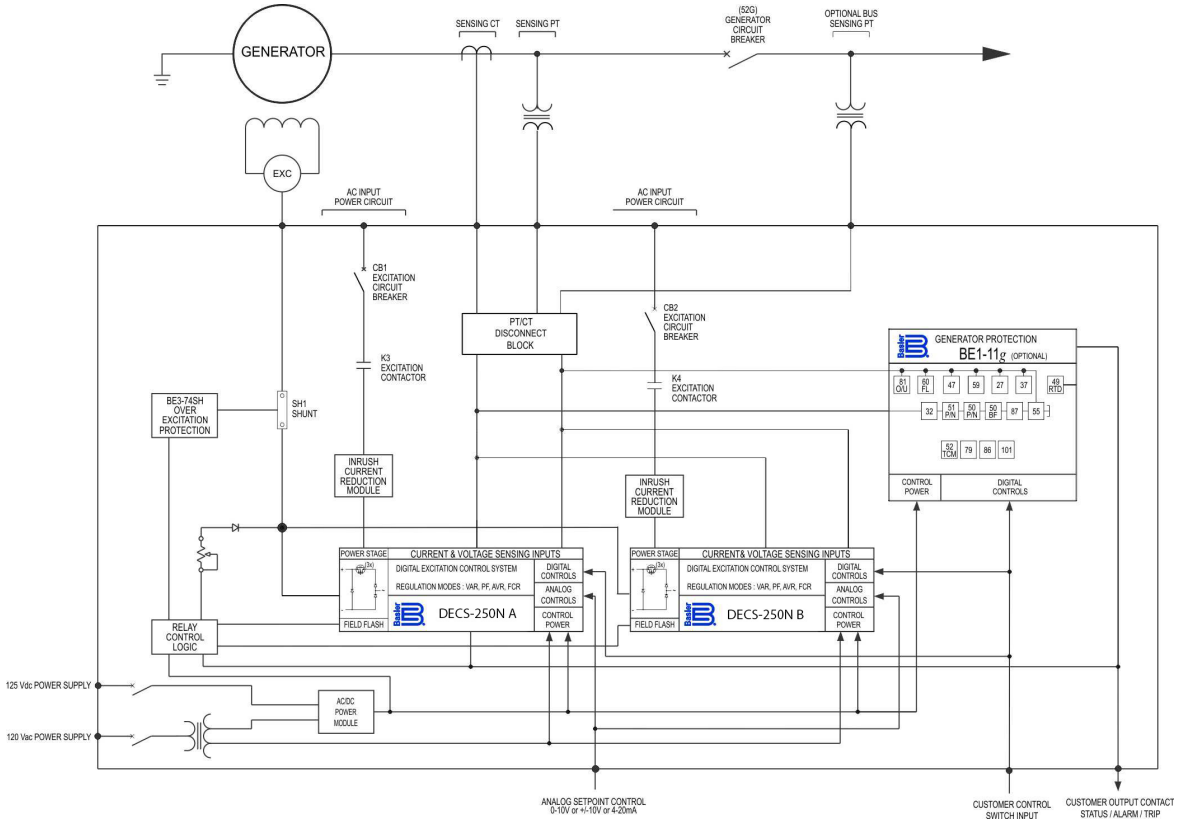

Figure 7: Simplified system interconnection drawing for the SGC-250N

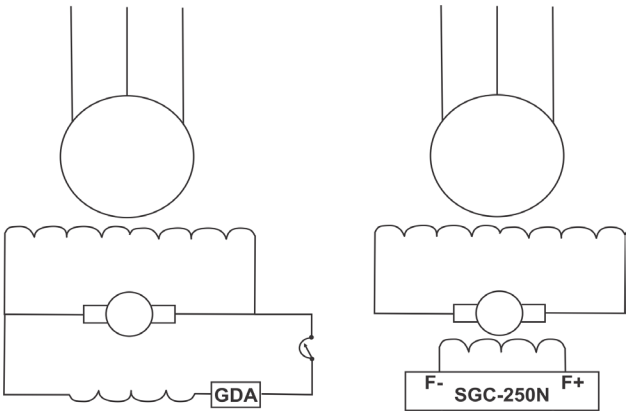

Figure 8: Exciter Field Connections

However, if the rotating exciter has rated output voltage of 250 Vdc, a dc voltmeter should be placed across the exciter shunt field while the generator is operating at rated output. If the measured dc voltage is greater than 125 Vdc, measure the exciter field current and contact a Basler Electric Technical Support Specialist for further guidance.

Unlike the Diactor, the SGC-250N requires an external power source for control power to the electronic circuits. Usually, redundant control power sources, 125 Vdc and 120 Vac, are applied simultaneously to assure reliable operation. A 24/48 Vdc power supply option is also available.

A single phase or three phase operating power (bridge power) source needs to be applied to the SGC-250. The operating power could be derived from several sources such as shunt powered from the generator terminals through a stepdown power potential transformer (PPT) or from a separate, highly reliable ac station power source. See SGC-250 product bulletin or instruction manual for input power specifications.

The DECS-250N excitation system is a sophisticated system and it controls excitation using a different principle than how the GDA Diactor operated. The control scheme requires modifications such as adding an Excitation Start/Stop control switch as well as other contact inputs like a 52 b for online/offline operation. Please contact a Basler Technical Support Specialist or an Excitation System Application Specialist for further assistance.

DECS-250N and DECS-450 Auto Tuning

The DECS-250N and DECS-450 have a feature called PID auto tuning via BESTCOMS*Plus*® operating software. Auto tuning is used during commissioning with the generator spinning. After initiation, the auto tuning feature is performed in less than a minute that will determine the PID gains for the generator. It accomplishes this with the spinning machine open circuited 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 Exciter (te) (where applicable) and 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.

DECS-250N and DECS-450 Phase Plot Compensator

A Phase Plot Compensator is provided with the Dynamic Frequency Analyzer to assist in evaluating the Power System Stabilizer Lead/Lag time filters selected that are derived from the Frequency Response of the generator system. Proper compensation is required for all systems that require a Power System Stabilizer. See Figure 9. When the red and blue curves align in the Phase Lag graph below, proper compensation is achieved and test validation is then required.

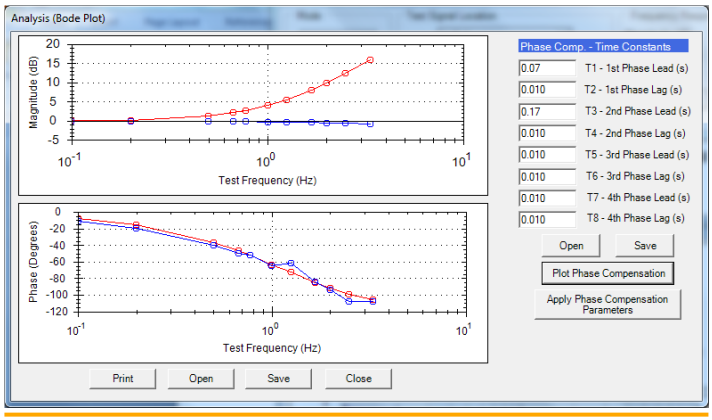

Figure 9: Frequency Response Results using Built-in Dynamic Analyzer

DECS-250N and DECS-450 Features

- UL Recognized, CSA Qualified, CE Compliant
- Oscillography - 1,200 points, 6 programmable parameters, holds up to 6 records
- Meets ANSI C37.90.1 for Surge Withstand and Fast Transient
- Meets RFI (Radio Frequency Interference)
- Meets Conducted and Radiated Noise per IEC 60255-22-6 (Conducted) & 60255-22-3 (Radiated)
- Field current or field voltage regulator for standby mode and NERC testing
- Operating Temperature Range –40° to 60°C
- Voltage Regulation - 0.1% Accuracy for the DECS-450 and 0.2% Accuracy for the DECS-250N
- DECS-250N can be used for systems whose fields do not exceed 20 Adc continuous, DECS-450 for all systems greater than 20 Adc continuous
- Var/Power Factor Controller
- Automatic Nulling - Nulling between operating modes and redundant DECS
- Selectable Underfrequency or Volts/Hertz Ratio Limiter
- Minimum Excitation Limiter - Flexible 5 point map on real/ reactive power axis or Internal generated UEL curve
- Maximum Excitation Limiter
- Var Limiter
- Stator Current Limiter
- Dual PID Setting Groups - Allows for programmed changes in PID gain settings for use with Power System Stabilizer or alternate transmission systems
- Auto Tuning of the Voltage Regulator PID gains
- Auto Voltage Matching - Automatically matches generator voltage to bus voltage
- Auto Synchronizing (Device 25A) option
- Autotracking for bumpless transfer between Automatic Voltage Regulator (AVR), manual control, and Redundant Controller when included
- 3 Preposition Set points - Programmable for AVR, Manual, Var/PF Controller
- Reactive Droop or Line Drop Compensation, Network Reactive line sharing via Ethernet communications for multiple machine on a single bus
- Loss of Voltage Sensing - Transfers to manual control automatically due to loss of voltage sensing at the voltage regulator
- Sequence of events - stores 2,047 records
- Real time chart recorder, data logging including oscillography and sequence of event information for data capture up to six channels
- Built-in Dynamic Analyzer for measuring frequency response of generator and excitation system using Signal Generator
- Protection
  - Generator Overvoltage
  - Generator Undervoltage
  - Loss of Voltage Sensing
  - Field Overvoltage with Dual Settings Groups
  - Field Overcurrent with Dual Settings
  - Generator Overfrequency
  - Generator Underfrequency
  - Generator Reverse Power
  - Generator Loss of Excitation
  - Synch Check when 25A is disabled
  - Exciter Diode Monitor for Brushless Exciters
  - Generator Below 10Hz
  - Volts per Hertz: coordinates with the V/Hz limiter function
  - Loss of Field Isolation Transducer
  - Control Power Input Failure
  - Crowbar Activated
  - Field Over Temperature
  - Watchdog Timer: monitors the microprocessors and provides a trip contact if a microprocessor fault occurs
- Redundant Controller
- Field overvoltage, generator over/ undervoltage, field overcurrent, and loss of field protections have dual set points selectable via programmable logic
- HMI Metering, Operating Screen - Metering, Control, Annunciation
- IRIG-B Time Synchronization stamp
- Generator Field Temperature Monitoring (Static Exciter)
- 5 Analog Transducers Outputs
- Optional Built-in Power System Stabilizer, Type 2A/2B/2C, Integral of Accelerating Power
- Phase Plot Compensator for Power System Stabilizer assisted tuning
- 6 SCR Bridge Rectifier
- RS-485
- Ethernet over Modbus® TCP
- BESTCOMS*Plus*® common operating software to Basler Electric product family
- BESTlogic™*Plus* programmable logic
- Expandable Inputs and Outputs via remote modules

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 10.

Solutions are available

Solutions are available to retrofit the Diactor for new excitation systems that will improve performance and offer years of additional service for existing generator systems.

For More Information

For more information, call 618.654.2341 to consult with a Basler Excitation System Application Specialist or visit www.basler.com to download a DECS-450 or DECS-250N product bulletin.

For technical papers on auto tuning and phase plot compensation visit www.basler.com.

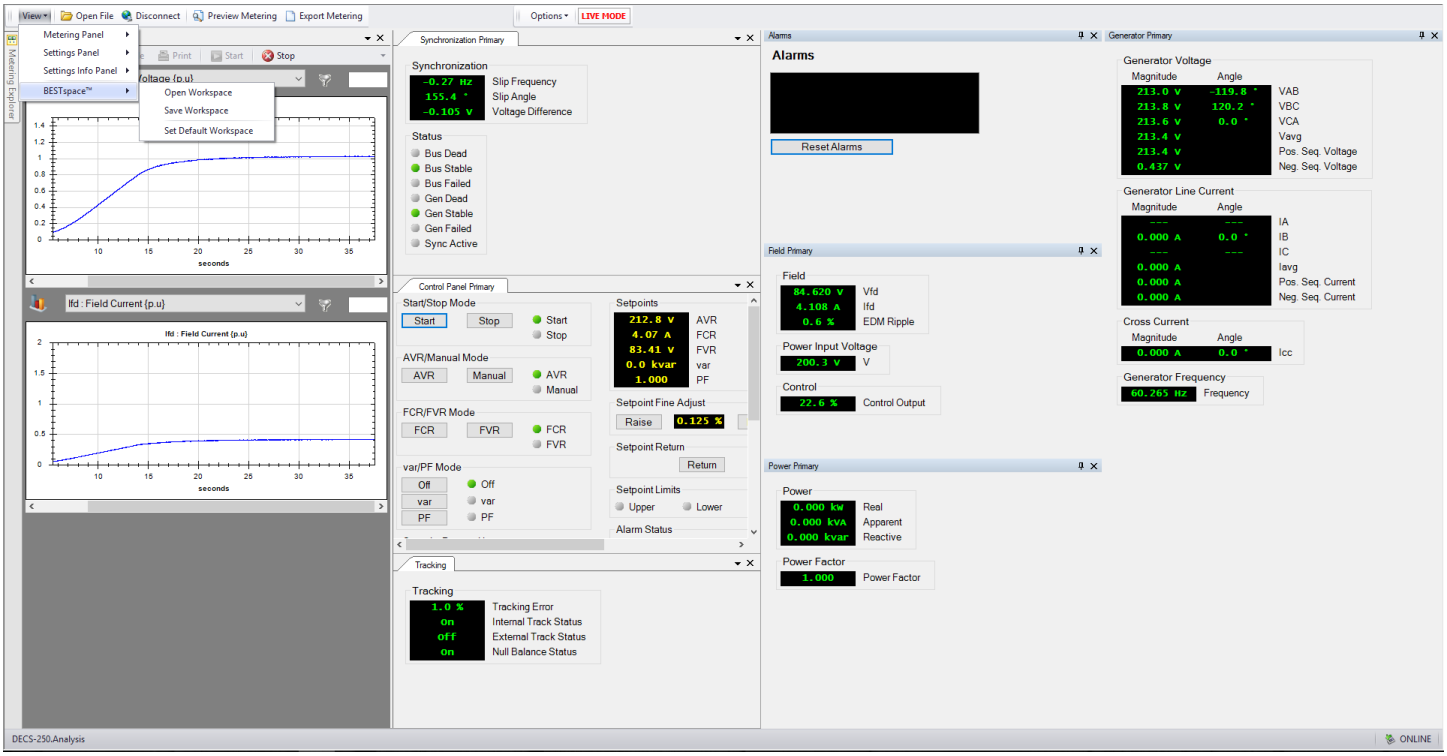

Figure 10: BESTspace

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