

Application Note

Retrofitting a Vintage BJ-30 Excitation System Improves Performance and Serviceability

In the 1930s, inroads were being made to improve transient stability in the generating system, but unlike today's excitation systems, the vintage excitation systems of the past commonly used electromechanical technology utilizing contactors and motor-driven rheostats for field control, hence very slow in responding to system disturbances. One of these popular designs was the BJ-30 voltage regulator manufactured by Westinghouse Electric. The BJ-30 was utilized on a variety of synchronous machine applications including medium to large hydro turbines and steam driven ac generators, as well as synchronous condensers. This Application Note discusses the mechanics and operation of the BJ-30 voltage regulator and provides a replacement solution for this aging excitation system. See Figures 1 and 2.

How It Works

The rotating machinery in these generating systems included the ac generator, main exciter and pilot exciter. The BJ-30 reacted to minor deviations in generator terminal voltage to control the generator output by varying the resistance of a high wattage motor-driven rheostat, shown in Figure 2, and consequently the voltage applied to the main exciter field. The pilot exciter (if

provided) supplied the power for the main exciter field. The dc required for the motorized rheostat could be provided from either the main exciter armature output or the pilot exciter noted above. For large variations in voltage, high-speed contactors would cut in or short out blocks of resistance in the exciter field circuit as the motor-driven rheostat

turned at the maximum speed possible to reach the new position. Shorting out a block of resistance via contacts was a method of providing "field forcing". This would improve the transient response of the system while adding in a block of resistance provided a method of "field reducing" in the field circuit.

In some circumstances, the main exciter output voltage needed to be less than the voltage produced by residual magnetism in the field poles for a synchronous condenser used to reduce system voltage caused by high line charging. To accomplish this, a current through the differential or bucking field was applied to produce a magnetic flux in the opposite direction to the main exciter shunt field flux. This had the effect of reducing the main exciter output voltage to zero. See Figure 3 for a typical interconnection diagram of a BJ-30 voltage regulating system.

Maintaining the BJ-30 has become difficult because of the age of the equipment and obsolescence of parts. Other concerns include the wearout of mechanical devices including the pilot and main exciter, and maintenance problems typical of commutator deterioration.

The Solution

Basler Electric has two possible solutions for retrofitting the obsolete BJ-30 regulating system:

1. The preferred solution replaces the BJ-30, main exciter and pilot exciter with a solid state, static excitation system working directly into the main generator field using a DECS-450 excitation system.
1. The pilot exciter is replaced with a bi-directional voltage regulator connected into the main exciter field using a DECS-250N excitation system.



Figure 2: BJ-30 Contactor Panel and Main Exciter Field Rheostat

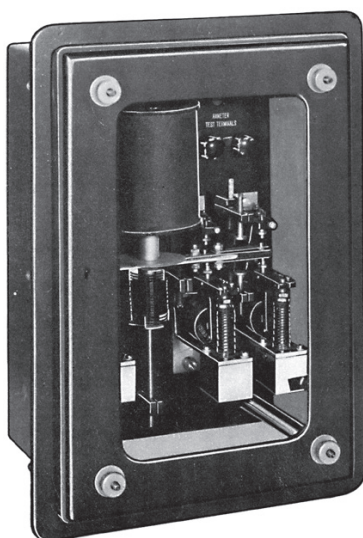


Figure 1: BJ-30 Voltage Regulator Control Element

Voltage Regulator System

(Eliminates the BJ-30 and Pilot Exciter)

For some systems, where the rotating exciter is in good condition and only the BJ-30 or pilot exciter has operational problems, the more appealing solution may be to retain the rotating exciter and utilize only the exciter shunt field for excitation control of the synchronous generator.

A positive and negative field forcing excitation system achieves fast changes in generator output and eliminates the need for the use of the differential field, and it can be terminated. See Figure 5 for changes involved with the DECS-250N excitation system. The new excitation system will eliminate the need for the pilot exciter and all of the components of the BJ-30 including the motorized exciter field rheostat.

Here a DECS-250N (Positive and Negative Field Forcing) can be used for exciter field systems rated at 20 Adc continuous or less, or a DECS-450 system where the field current is greater than 20 Adc. The excitation system includes high voltage regulation accuracy, dc field current

regulator, dc voltage regulator, VAR/PF control, excitation limiters, and auto-tracking follower circuits for bumpless transfer between operating modes plus additional features to provide a complete and automatic control system to regulate the generator output.

With a customizable PID network, tuned stability parameters provide extremely fast response to system disturbances.

Power for the excitation system can be derived from the station power source, however, reliability of the source must be considered. Loss of the power source under load will result in loss of excitation to the generator and subsequent pole slip. Alternatively, the new excitation system can derive its power from the generator output. The power potential transformer primary voltage matches the generator output while the secondary voltage matches the ac voltage required to provide the continuous and forcing requirements of the exciter field. The volt ampere requirements of the exciter field need to be obtained in order to properly select the excitation system power ratings.

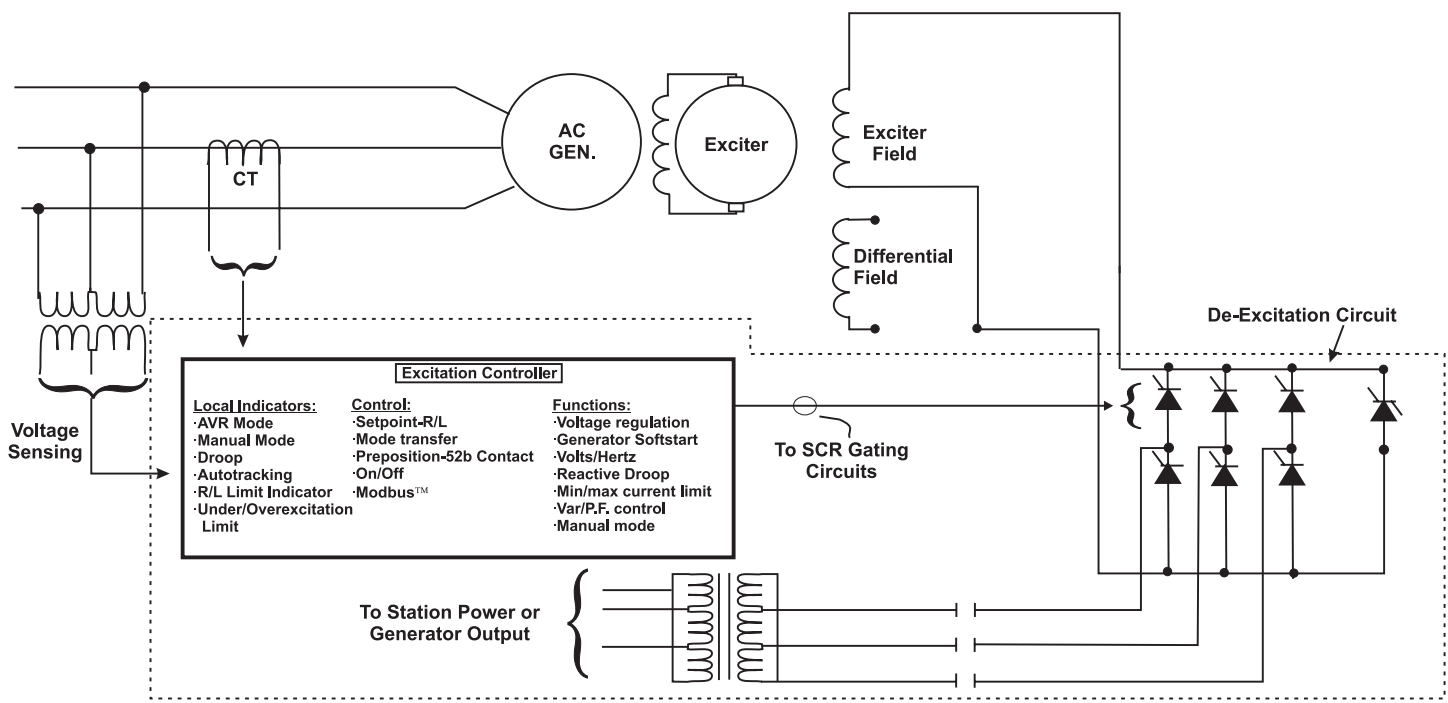


Figure 5: New voltage regulator interface with rotating exciter field.

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
- BESTCOMSPiPlus® common operating software to Basler Electric product family
- BESTlogic™Plus programmable logic
- Expandable Inputs and Outputs via remote modules

DECS-250N and DECS-450 Auto Tuning

The DECS-250/N and DECS-450 have a feature called PID auto tuning via BESTCOMSPPlus® 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 (T_e) (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 6. When the red and blue curves align in the Phase Lag graph,

proper compensation is achieved and test validation is then required.

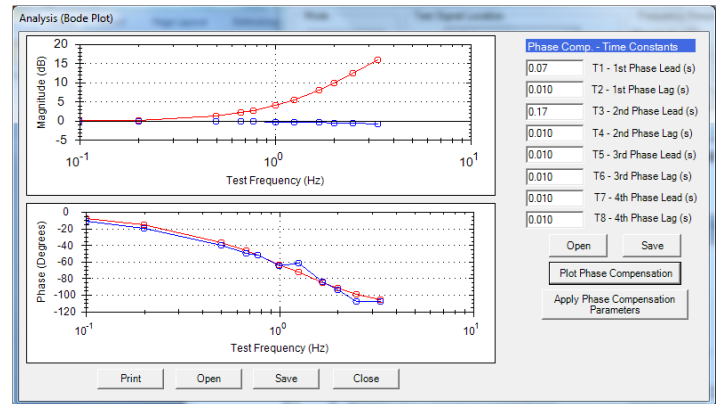


Figure 6: Frequency Response Results using Built-in Dynamic Analyzer

BESTspace™

The DECS-450 offers a setup commissioning tool in BESTCOMSPPlus 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 BESTCOMSPPlus is opened. Valuable time saved during setup speeds the commissioning preparation time for startup. See Figure 7.

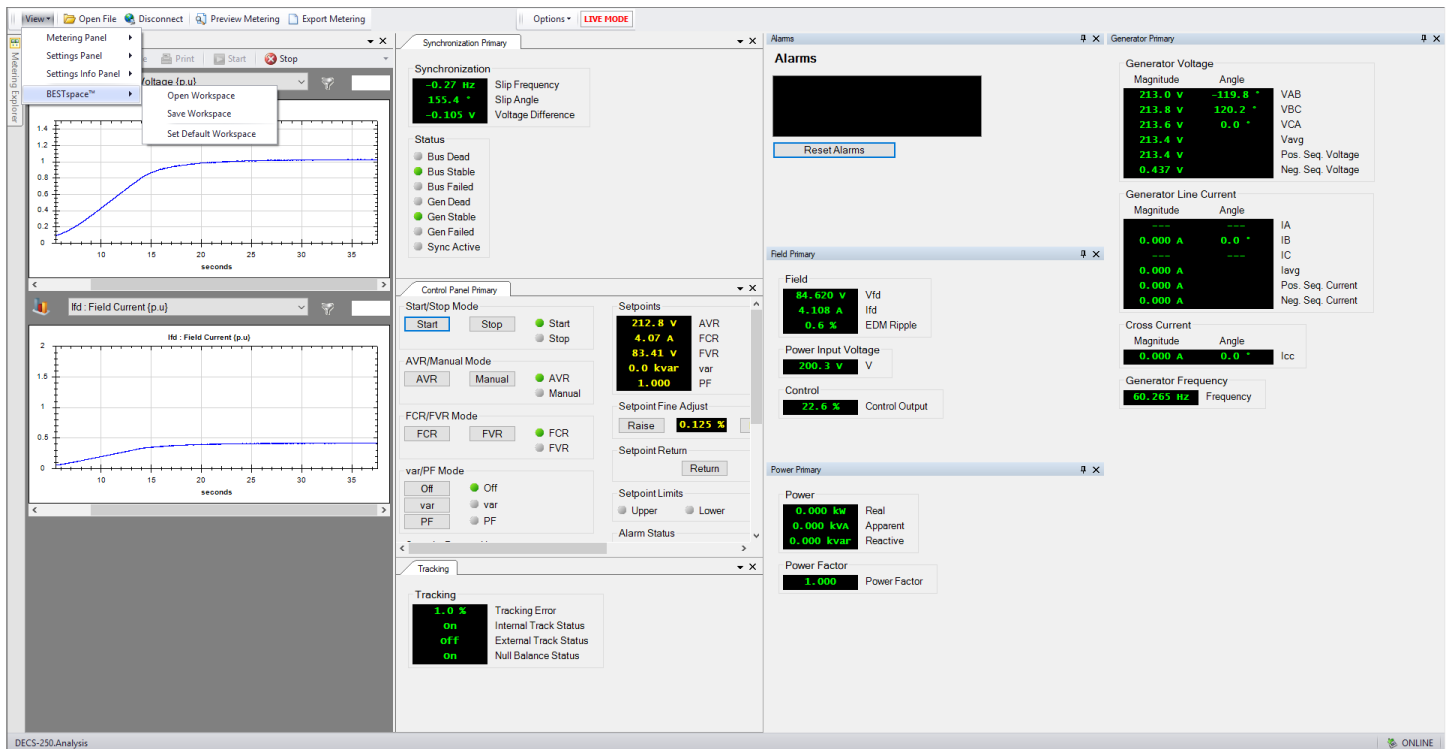


Figure 7: BESTspace

Solutions are available

Solutions are available today to retrofit the BJ-30, creating a new excitation system that will improve performance and offer years of additional service for existing generator systems. Figures 8 and 9 are examples of the digital excitation controllers mounted in NEMA 1 enclosures for exciter field and main field applications.

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 8: DECS-250N voltage regulator/excitation package eliminates the BJ-30, pilot exciter, and motor-operated rheostat.



Figure 9: DECS-450 pre-packaged excitation system of higher efficiency and minimal maintenance costs for main field applications.