SG102

Smart Grid Power Distribution & Energy Management

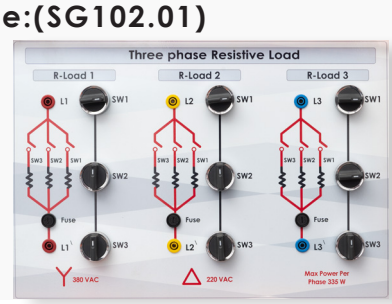
Overview

Smart Grid Power Distribution & Energy Management teaches the basics of dynamic loads, power distribution, and the impact of complex loads on the grid. It covers the difference between isolators and circuit breakers, safe switching practices, and the role of double busbars. It also explains how reactive power affects the system and how capacitor banks reduce stress by compensating lagging power. However, switching capacitors can cause high currents and potential risks like self-excitation in motors. The asynchronous motor used shows that power factor and reactive power vary with load, so fixed compensation is only ideal at one operating point.



Specifications

Three Phase Resistive Load Module Code:(SG102.01)

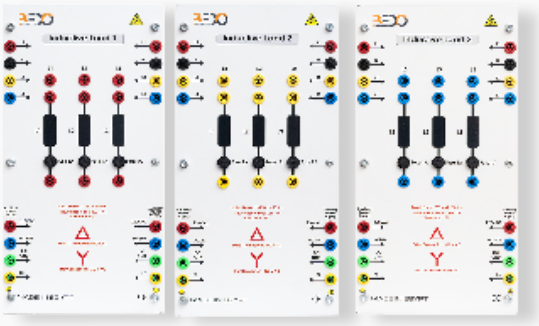


- This module can be used as a static active power load. The resistive power demand per phase is incremented in discrete steps.
- Technical Data:
  - » Rated operating voltage: 400 VAC, 50/60Hz
  - » Number of steps per phase: 7

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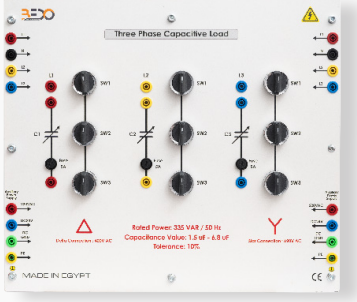
» Minimum loading capability per phase: 72 Watt
» Maximum loading capability per phase: 340 Watt
» Protected with thermal switches at 165 degree Celsius

Three Phase Inductive Load Module Code: (SG102.02)



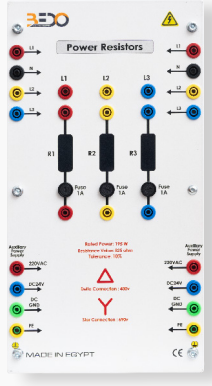
- Three Phase Inductive Load Module can be used as a static reactive power load. The inductive power demand per phase is incremented in discrete steps. Rated operating voltage: 400VAC, 50/60 Hz
- Technical Data:
  - » Number of steps per phase: 7
  - » Inductance range:1.5H to 7H
  - » Minimum loading capability per phase: 73 VAR
  - » Maximum loading capability per phase: 335 VAR

Three Phase Capacitive Load Module Code: (SG102.03)



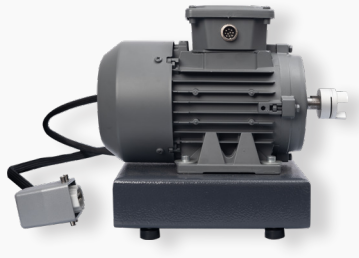
- Three Phase Capacitive Load Module can be used as a reactive power compensator. The amount of reactive power compensated per phase is incremented in discrete steps.
- Technical Data:
  - » Rated operating voltage: 400VAC, 50/60Hz
  - » Number of steps per phase: 7
  - » Capictance Renge:1.5uF to 6.8uF
  - » Minimum loading capability per phase: 75 VAR
  - » Maximum loading capability per phase: 335 VAR

Power Resistors Module Code: (SG102.04)



- This module contains resistors rated for high power applications. It can be used as a three-phase load, but unlike the Three-phase Resistive load, the resistance value is fixed. The resistors are accessible through a 4mm banana terminal.
- Technical Data:
  - » Number of resistors: 3
  - » Rated operating voltage: 400VAC, 50/60Hz
  - » Rated power: 195W
  - » Resistance value: 825 ohm
  - » Auxiliary supply: 24V DC, 1A
  - » Protected with thermal switches at 165 degree Celsius

Dynamic Load Module Code: (SG102.05)

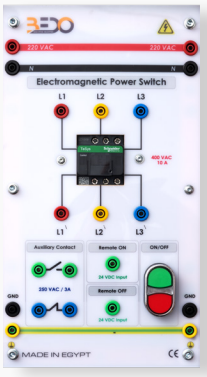


- Three Phase Inductive Load Module comprises a three-phase squirrel cage motor which can be used as an electrical load. The active power demanded from the grid is variable depending on the mechanical load applied to the motor

shaft. This machine can be used for injecting active power to the grid by rotating the motor shaft beyond the rated synchronous speed. The reactive power can be supplied from grid only or from compensation capacitors.

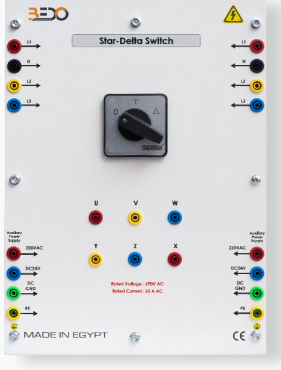
- Technical data:
  - » Nominal shaft speed: 1400 rpm
  - » Rated output power: 300W
  - » Rated input voltage: 220 VAC / 380 VAC (Delta-Star)
  - » Rated operating frequency: 50Hz

Electromagnetic Power Switch
Code: (SG102.06)



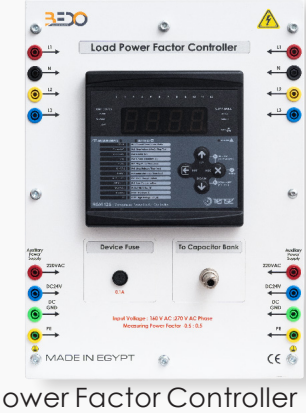
- Electromagnetic Power Switch can be used as a power cut off switch for three-phase applications. The power module can be operated manually and remotely.
- Technical data:
  - » Rated remote signal voltage: 24 VDC / 0.5 A or dry contact
  - » Normally-open push button for enabling three-phase output
  - » Auxiliary contacts (1N.O + 1N.C)
  - » Digital input terminal for overriding pushbutton using external control signal
  - » Power contacts rated capability: 400VAC VAC / 10 A
  - » Auxiliary contacts rated capability: 250VAC, 3A

Star-Delta Power Switch
Code: (SG102.07)



- Star-Delta Power Switch is a manual switch which alters the stator winding connections of three phase squirrel cage motor. Due to the high inrush current caused by motor starting for large motors, the motor can be started at low voltage to limit the starting current. When the motor slip reaches a certain limit, the motor can be supplied with its rated voltage. The stator windings of the motor are fed to this module and which are then internally connected either Delta or in Star configuration depending on the status of an external switch set by the user.
- Technical data:
  - » Rated input voltage: 400VAC, 50Hz
  - » Rated input current: 10A

Load Power Factor Controller
Code: (SG102.08)



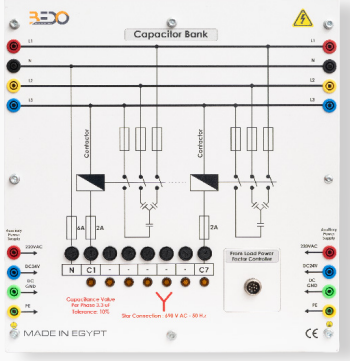
- Load Power Factor Controller comprises a reactive power controller that continuously measures the load current and applied voltage across the load to measure the power factor.
- If load power factor is below unity, the controller automatically activates the contactors which connect capacitor banks to the grid. By connecting capacitors, the inductive power demanded from the grid is compensated.
- The capacitors are added in such a way that when capacitive reactive power balance the inductive reactive power, the regulation stops to prevent over compensation.
- Technical data:
  - » Self-powered module through measuring input (No auxiliary supply required)

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» Display: 7-seg display (4-digit)
» Measured power factor range: 0.5(cap) ...0.5(ind)
» Self-powered module through measuring input (No auxiliary supply required)
» Minimum rated measuring voltage input: 160 VAC, 50Hz
» Number of load regulation steps: 8
» Control relay output: (1x common contact) + (7x NO contact)
» Automatic Current Transformer Test
» Maximum rated measuring voltage input: 270 VAC, 50Hz
» Rated load current input: 5A
» Current Sensitivity: 100mA

Capacitor Bank Module Code:(SG102.9)

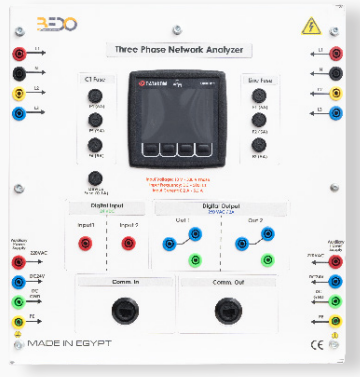
- Capacitor Bank Module contains a set



of three-phase capacitors which are connected to contactors. When these contactors are activated, the capacitors are linked to the grid. To activate these contactors, a signal should be received from the load power factor controller. These capacitors injects reactive power to the grid, therefore, inductive loads are compensated and the only power demanded from the grid is the active power. Hence, with the help of this module load power factor approaches unity.

- Technical data:
  » Number of controlled contactors: 7
  » Signal for activating contactors: 220VAC, 50Hz
  » Capacitor bank configuration: Threephase star-connected load
  » Capacitor bank value per step: 3x 1.5uF
  » Rated operating voltage applied across capacitor bank: 460 VAC, 50Hz

Three Phase Network Analyzer Code: (SG102.10)



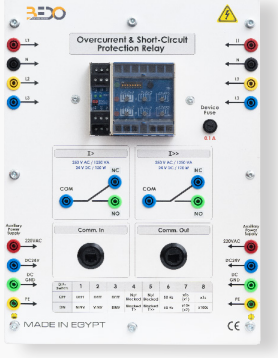
- The unit contains a power quality meter that measures the electrical parameters of three phase electricity, as well as able to draw variables versus time and draw vector diagrams. In addition, the unit can be interfaced with a SCADA system through ethernet to monitor all readings.
- Technical data:
  » Universal supply input (both AC & DC): 220 V AC, DC
  » Measurement inputs voltage: » 10 - 300 V AC,
  » Measuring current: 0.2 – 5.50 A AC
  » Measuring frequency: DC – 500Hz
  » True RMS measurements 3.5" TFT LCD, 320x240 pixels
  » Internal battery backed-up real time clock
  » Harmonic distortion display (63 harmonics) Oscilloscope
  » Waveform display
  » Phasor diagram display
  » Max demand display
  » 2x configurable relay outputs
  » 2x opto-isolated, configurable digital inputs
  » Dual active-reactive power counters
  » Both mains & generator energy metering
  » Voltage transformer ratio for MV applications
  » Supported wiring topologies:
  » 3 phases, 4 wires (star)

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- » 3 phases, 3 wires, 3 CTs
- » 3 phases, 3 wires, 2 CTs (L1-L2)
- » 3 phases, 3 wires, 2 CTs (L1-L3)
- » 3 phases, 4 wires, delta
- » 2 phases, 3 wires, L1-L2
- » 1 phase, 2 wires (L-N)

- Measurements:
  - » Phase to phase voltages: U12-U23-U31- Uavg
  - » Phase to neutral voltages: V1-V2-V3- Vavg
  - » Phase currents: I1-I2-I3-Ineutral-Iavg
  - » Active power: P1-P2-P3-Psum
  - » Reactive power: Q1-Q2-Q3-Qsum
  - » Apparent power: S1-S2-S3-Ssum
  - » Power factor (cos-phi): cos1-cos2-cos3- ∑cos
  - » Active power counters: pc1-pc2
  - » Reactive power counters: qc1-qc2
  - » Phase to neutral voltages vector angles
  - » Phase to phase voltages vector angles

Overcurrent & Short-Circuit Protection Relay
Code: (SG102.11)



- Instantaneous overcurrent (ANSI:50) protection is where a protective relay initiates a breaker trip based on current exceeding a pre-programmed “pickup” value for any length of time. Time overcurrent protection (ANSI:51) is where a protective relay initiates a breaker trip based on the combination of overcurrent magnitude and overcurrent duration, the relay tripping sooner with greater current magnitude.
- This is a more sophisticated form of overcurrent protection than instantaneous, expressed as a “time curve” relating overcurrent magnitude to trip time
- Technical data:
  - » Auxiliary supply voltage: 200 to 275 VAC, Hz= 40…70
  - » Serial data exchange via RS485 interface through external module
  - » Number of relay output: 2
  - » Contact type: 1x changeover contact for each trip relay
  - » Maximum breaking capacity: ohmic 1250 VA @250VAC or 120 W @ 24VDC
  - » Resetting time from pickup: <50ms
  - » Returning time from trip: 200ms
  - » Current input signal: 5A or 1A
  - » By adjusting the DIP switches it is possible to select from the following tripping characteristics:
  - » Definite time overcurrent protection (DMT)
  - » Definite-Time Overcurrent Protection parameter setting:
    - I>: 0.5 … 2 × I n (continuously regulated)
    - I>>: 1 … 15 × I n (continuously regulated)
    - TI>: 0 … 1 sec / 0 …10 sec / 0 …100 sec ((continuouslyregulated))
    - TI>>: 0… 2.5sec (continuously regulated)
  - » Inverse time overcurrent protection (IDMT) with selectable tripping characteristics
  - » Normal Inverse
  - » Very Inverse
  - » Extremely Inverse
  - » Inverse-Time Overcurrent Protection parameter setting:
    - I>: 0.5 … 2 × I n (continuously regulated)
    - I>>: 1 … 15 × I n (continuously regulated)
    - tI>: 0.1 … 2 s (continuously regulated)

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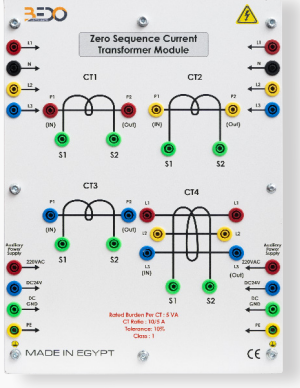
- tI>>: 0 ... 2.5 s (continuously regulated)

AC Loads Module
Code: (SG102.12)



- Ac Loads Module is designed to simulate a real AC Load, using three different types of lamps. The module contains halogen lamp, LED lamp and an energy saving lamp. This module helps students access different load wattage on the experiment.
- Technical data:
  - » Lamps operating voltage: 220V AC, 50Hz
  - » Number of Halogen lamp: 2
  - » Number of LED Lamp: 2
  - » Number of Energy saving lamp: 2
  - » Halogen lamp power rating: 50W
  - » LED lamp power rating: 12W
  - » Energy saving lamp power rating: 5W

Zero Sequence Current Transformer Module
Code: (SG102.13)



- Zero Sequence Current Transformer Module consists of current transformers connected on each of the phases in a threephase system. This forms a core balance current transformer that detects the presence of zero sequence currents during short circuit fault conditions such as the occurrence of a single line to ground fault that causes unbalanced currents in three-phase systems. The vector sum of current is measured. When the three-phase load connected to the line is unbalanced, then neutral current is not zero, and the zero-sequence current at this time is the unbalanced current (In).
- Technical data:
  - » Number of Current transformers: 3
  - » Current transformer rating: 10/5 A
  - » Rated burden per CT: 5VA

Servo Test Stand
Code: (SG102.14)



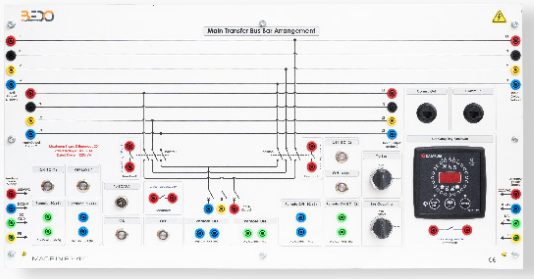
- The servo-machine test bench is a complete testing system for examining electrical machines and drives. It consists of a digital controller, a brake and the software.
- HMI screen technical Data:
  - » Color touch display
  - » Four-quadrant operation monitor
  - » Virtual button for selecting one of the following modes:
  - » Speed control mode with developed torque limit
  - » Torque control mode with overspeed limit
  - » Display preset torque reference and speed reference
  - » Monitoring actual torque and speed applied on motor shaft
  - » Calculate motor efficiency based on measured electrical input and mechanical horse power
  - » Isolated USB interface
  - » Servo motor technical data:
  - » Maximum shaft speed: 3000 RPM

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» Rated operating voltage: 3-phase input, 220V AC (L-L)
» Maximum operating current: 12.75A
» Motor Power Capacity: 2 kW
» Feedback incremental encoder resolution: 3000 pulses/ revolution
» Braking system for stalling shaft

4x Main & Transfer Bus Bar Arrangement Module

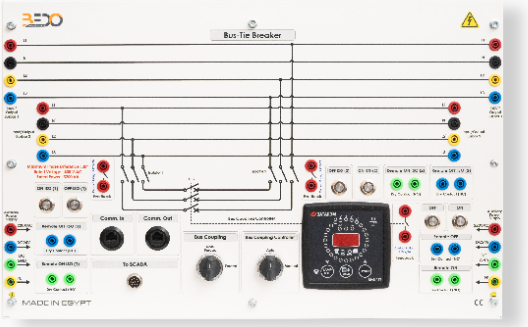
Code : (SG102.15)



- This module comprises a two section bus bars known as the main and transfer bus arrangement. There are two busbar schemes, first is the main bus and the other is transfer bus. A main advantage is that whole of the load is transferred to the transfer busbar when maintenance or repair are being done on the main busbar. The arrangement consists of two bus bars, two double isolating switch and one circuit breaker.
- Technical data:
  - » Selector to switch between manual and SCADA control
  - » Manual activation switch for isolator and circuit breaker
  - » Digital input for isolator and circuit breaker activation from SCADA system
  - » Rated digital input signal: 24V DC
  - » Auxiliary normally-open dry contact used as feedback signal to SCADA for isolator and circuit breaker status
  - » Bus rated voltage: 400V AC
  - » Bus rated power transfer: 3200 VA
  - » Overcurrent: 5 A, tripping time of 1 s
  - » Overvoltage: 460 V AC, tripping time of 1 s (maximum voltage between phases)
  - » Maximum phase difference: 30° (maximum phase angle between 2 corresponding outer conductors)
  - » Maximum voltage difference: 35 V (maximum voltage difference between 2 corresponding outer conductors).
  - » Number of Ethernet ports: 2
  - » Exchange of data through SCADA software

Bus-Tie Breaker Module

Code: (SG102.16)

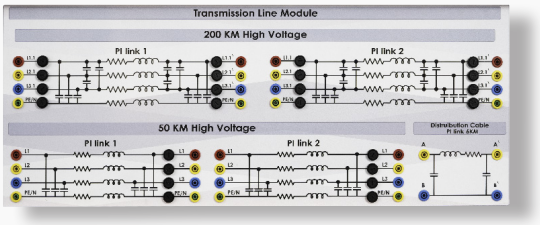


- Unlike the main and transfer bus bar arrangement module, this module does not contain any incoming or outgoing feeders. Its main role is couple two bus bars together only during a load transfer.
- Technical data:
  - » Selector to switch between manual and SCADA control
  - » Manual activation switch for isolator and circuit breaker
  - » Digital input for isolator and circuit breaker activation from SCADA system
  - » Rated digital input signal: 24V DC
  - » Bus rated voltage: 400V AC
  - » Bus rated power transfer: 3200 VA
  - » Overcurrent: 5 A, tripping time of 1 s
  - » Overvoltage: 460 V AC, tripping time of 1 s (maximum voltage between phases)
  - » Maximum phase difference: 30° (maximum phase angle between 2 corresponding outer conductors)
  - » Maximum voltage difference: 35 V (maximum voltage difference between 2 corresponding outer conductors).
  - » Number of Ethernet ports: 2

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» Exchange of data through SCADA software

Transmission Line Length: 150km
Code: (SG102.17)



- Three-phase line simulation of a high voltage overhead power line with fixed for measuring various operational states (open-line, matched, Short Circuit. Scale factor 1/1000 for current and voltage.
- Technical data:
  - » Resistance per phase: 3,6Ohm
  - » Inductance per phase: 115mH
  - » Capacity per phase: Line-to-ground: 2 x 4 µF
  - » Max power consumption: 400 W
  - » Voltage: up to 3x 400V; 50/60Hz
  - » Current: up to 2A

Experiments

- Single Busbar Operation with One Incoming Feeder
- Single Busbar Operation with Two Incoming Feeder
- Double Busbar operation with two incoming feeders
- Recording the characteristic values of the squirrel cage asynchronous machine
- Squirrel-cage Motor as Asynchronous Generator
- Busbar changing without interruption
- Determining the Reactive Power Demand
- Calculating the required value of capacitor bank for reactive power compensation
- Automatic Reactive Power Compensation
- Co-ordination of Over current and short circuits
- Single Compensation of an Asynchronous Machine

Scope of Delivery

- Smart Grid Power Distribution & Energy Management (SG102)
- Hard copy user manual

Required for Operation

- Machine & Drive Lab Supply Unit (ML100)

Options

- Digital content (BI01)

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