samlexpower®

Battery Guard

Models:
BG-40
BG-60
BG-200

Owner's Manual

Please read this manual BEFORE operating the units.

OWNER'S MANUAL: Battery Guard | Index

SECTION 1 | Description & Features

1.1 DESCRIPTION

BG Series Battery Guard is a protection device that prevents 12V / 24V batteries from deep discharge. This type of device is also called **L**ow **V**oltage **D**isconnect (*LVD*). It also disconnects the load in case of over voltage that may be caused by defective battery charger.

1.2 FEATURES

- Uses micro-controller for easy programmability, faster response and higher efficiency (*consumes less than 4 mA from the battery*).
- Choice of 3 Models: BG-40 (*40 Ampere*), BG-60 (*60 Ampere*) or BG-200 (*200 Ampere*)
- Nominal voltage of battery (*12V or 24V*) is detected automatically
- 10 programming options for combinations of low voltage disconnection / reconnection thresholds to accommodate various battery discharge rates
- Over voltage disconnect / reconnect for load protection
- On / off control for external relay for starting / stopping of generator / battery charger at the programmed value of disconnect / reconnect threshold of battery voltage
- Remote on/off control of load using external rocker / toggle switch
- Local monitoring of operational status using built-in LED
- Remote monitoring of low / high voltage disconnection of load through external buzzer or LED
- Water-tight and dust-tight with Ingress Protection (*IP*) rating: IP-66
- CE marked and complies with EMI / EMC requirements

SECTION 2 | Layout & Dimensions

2.1 LAYOUT

Layout of BG-200 is given at Fig 2.3. Layout of BG-40 / BG-60 is given at Fig 2.2.

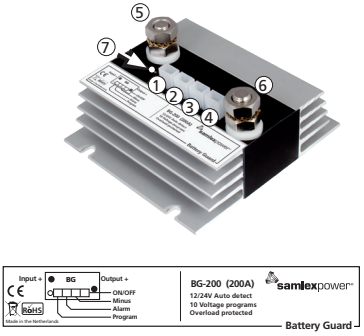


Fig 2.1 Layout of BG-200

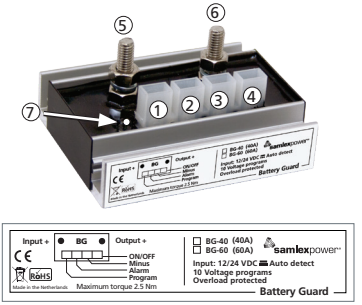


Fig 2.2 Layout of BG-40/60

LEGEND FOR FIGS 2.1 and 2.2		
Item No.	Description	Specifications
1	Male Quick Disconnect Terminal marked "Program". Used for programming (*Refer to Sections 6.2 and 6.3*)	Tab width: 0.25" / 6.35mm
2	Male Quick Disconnect Terminal marked "Alarm" for external buzzer / LED alarm (*Sections 3.3.1 / 3.4.2.1*) or for external relay function (*Section 3.5*).	Tab width: 0.25" / 6.35mm
3	Male Quick Disconnect Terminal marked "Minus": • For feeding battery Negative connection for internal control circuitry • For remote On/Off of load (*Refer to Section 3.6*)	Tab width: 0.25" / 6.35mm
4	Male Quick Disconnect Terminal marked "ON/OFF" for remote On/Off of load (*Refer to Section 3.6*)	Tab width: 0.25" / 6.35mm
5	Terminal Stud marked "Input +". Used for connecting to the Battery Plus Terminal	• BG-200 (*Fig 2.1*): o M10 X 1.5mm pitch • BG-40/60 (*Fig 2.2*): o M6 X 1.0mm pitch
6	Terminal Stud marked "Output +. Used for connecting to the Positive input connection of the DC load(s)	
7	Status LED: (*Refer to Section 3.7*)	Blue color LED

SECTION 2 | Layout & Dimensions

2.2 DIMENSIONS

Dimensions of BG-200 are given at Fig 2.3. Dimensions of BG-40 / BG-60 are given at Fig 2.4

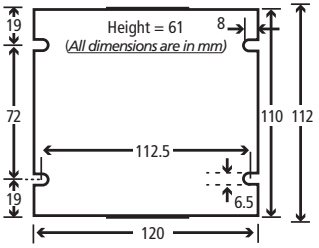


Fig 2.3 Dimensions BG-200

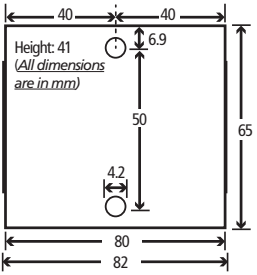


Fig 2.4 Dimensions BG-40/60

SECTION 3 | Principles of Operation

3.1 GENERAL

BG Series Battery Guard is a protection device that prevents 12V / 24V batteries from deep discharge. This type of device is also called a **L**ow **V**oltage battery **D**isconnect (*LVD*). Battery Positive is connected to terminal marked "Input +" (*5 in Figs 2.1 / 2.2*) and the load is connected to terminal marked "Output +" (*6 in Figs 2.1 / 2.2*). It uses Power MOSFET Switch (*MOSFET :* **M**etal **O**xide **S**emiconductor **F**ield **E**ffect **T**ransistor) connected in series between terminals marked "Input +" and "Output +". *As compared to relay-based switching, MOSFET based switching ensures increased lifetime as there are no moving parts to wear and no contacts to pit or build up carbon. Also, MOSFET uses lesser power compared to a relay.*

When the battery voltage seen at the terminal marked "Input +" drops to the programmed value of "Disconnect Voltage" (*Columns 2 & 4 in Table Fig. 6.1 under Section 6.2*), the series connected MOSFET Switch opens and disconnects the load connected to the terminal marked "Output +". Once the battery is recharged to the programmed value of "Reconnect Voltage" (*Columns 3 & 5 in Table 6.1 under Section 6.2*), the series connected MOSFET Switch closes and reconnects the load to the battery. *The load is also disconnected in case of over voltage condition of the battery that may be caused by defective battery charger (See Section 3.4.2*)

A micro-controller is used for programming, monitoring and control. Use of micro-controller provides easy programmability, faster response and higher efficiency (*consumes less than 4 mA from the battery*).

SECTION 3 | Principles of Operation

3.2 AUTOMATIC SENSING OF BATTERY NOMINAL VOLTAGE (12V / 24V)

BG-200/60/40 are designed to protect 12V or 24V nominal batteries. There is no setting required to select the nominal voltage of the battery being used. *Nominal voltage of the battery is detected automatically as follows*:

- 8 to 20 VDC is automatically detected as 12V Nominal Battery
- 20 to 35VDC is detected as 24V battery

3.3 BATTERY LOW VOLTAGE DISCONNECT / RECONNECT

BG-200/60/40 have 10 programmable combinations of "Disconnect Voltage" thresholds [*Columns 2 and 4 in Table 6.1 under Section 6.2*] to disconnect the load to prevent deep discharge of the battery and corresponding "Reconnect Voltage" thresholds (*Column 3 and 5 in Table 6.1 under Section 6.2*) to reconnect the load automatically when the battery is recharged (*Program Nos. 1 to 10 in Table 6.1 under Column 1 in Table 6.1*). This protection is explained in the succeeding paragraphs.

3.3.1 Battery Low Voltage Alarm

NOTE: For this alarm to be activated, *select Program No.11 – Alarm [Table 6.1 under Section 6.2]*. This is the Default Option.

3.3.1.1 Connections and Operation of Battery Low Voltage Alarm:

Refer to Connection Diagrams at Figures 5.1/5.2 under Section 5.3

Connect the Positive (+) of external Buzzer (*Rated at 3 to 30 VDC, with current draw < 500mA*) or the Positive (+) of LED (*5mm diameter LED with series current limiting resistor rated at 1/4 Watt, 2K Ohm*) to the Battery Positive terminal marked "Input +" [*5 in Figs 5.1 / 5.2 under Section 5.3.2*]. Connect the Negative (—) of the Buzzer / LED to the Quick Disconnect Terminal marked "Alarm" [*2 in Fig 5.1 / 5.2 under Section 5.3*]. This "Alarm" terminal is internally connected to the Battery (—) [*Terminal marked "Minus" (3 in Figs 5.1 and 5.2 under Section 5.3*)] through series connected internal Transistor Switch. *Hence, the Buzzer / LED will be activated only when the "Alarm" terminal gets connected to the Battery Negative internally when the series connected internal Transistor Switch is turned ON*.

If the battery voltage drops to the programmed value of "Disconnect Voltage" threshold [*Columns 2 and 4 in Table 6.1 under Section 6.2*] for a continuous "Detect Time" of 15 sec, the internal Transistor Switch will close and the external Buzzer / LED alarm will be switched ON. Detect time of 15 sec has been provided to prevent false triggering of the alarm due to short-term dip in the battery voltage resulting from starting of heavy DC load(s):

- The internal MOSFET Switch connected in series between terminals marked "Input +" (*5 in Figs 5.1 and 5.2 under Section 5.3*) and "Output +" (*6 in Figs 5.1 and 5.2 under Section 5.3*) will be ON and the load will remain connected to the battery

- Blue colored local Status LED on the unit [*7 in Figs 5.1 and 5.2 under Section 5.3*] will be ON steady indicating that the load has NOT been disconnected yet

This alarm condition warns the user of impending battery low voltage disconnect condition (*Section 3.3.2*). If the above battery low voltage condition continues beyond 15 sec, then at 90 sec from the time the voltage dropped to the above programmed value of "Disconnect Voltage" threshold [*Columns 2 and 4 in Table 6.1under Section 6.2*], this alarm will be switched OFF. At the same time, the load will be disconnected (*Refer to Section 3.3.2 for details*).

NOTE: *The above Low Voltage Alarm will remain ON for a period of 75 sec after activation and will then be switched off automatically*

3.3.2 Battery Low Voltage Disconnect

If the battery voltage drops to the programmed value of "Disconnect Voltage" [*Columns 2 and 4 in Table 6.1under Section 6.2*] for a continuous period of 90 sec, the internal MOSFET Switch connected in series between terminals marked "Input +" (*5 in Figs 5.1 and 5.2 under Section 5.3*) and "Output +" (*6 in Figs 5.1 and 5.2 under Section 5.3*) will disconnect the load from the battery. Detect time of 90 sec is used to allow for short-term battery voltage drop caused by temporary heavy-duty loads. The programmed value of "Disconnect Voltage" will depend upon the desired State of Discharge of the loaded battery at which the load is required to be disconnected. *The State of Discharge of loaded Lead Acid Battery may be estimated based on its battery terminal voltage and the C-rate of Discharge* [*Refer to Section 4.3 for details*].

The following will be observed indicating disconnection of load due to Battery Low Voltage Disconnect:

- The load will be disconnected from the battery
- External Buzzer / LED alarm for Low Voltage Alarm will be OFF (*See Section 3.3.1.1*)
- Blue colored local Status LED on the unit [*7 in Figs 5.1 and 5.2 under Section 5.3*] will be switched off

3.3.3 Battery Low Voltage Reconnect

After the load has been disconnected due to the battery voltage dropping to the programmed value of "Disconnect Voltage" [*Columns 2 and 4 in Table 6.1 under Section 6.2*] for a continuous period of 90 sec (*Refer to Section 3.3.2 for details*), the battery will be required to be recharged to automatically reconnect the load at the programmed value of "Reconnect Voltage" [*Columns 3 and 5 in Table 6.1 under Section 6.2*] if sustained for 1 sec. The programmed value of "Reconnect Voltage" will depend upon the desired State of Charge of the battery at which the load is required to be reconnected. The State of Charge of Lead Acid Battery may be estimated based on its battery terminal voltage and the C-rate of Charge [*Refer to Section 4.3 for details*]. The following will be observed on reconnection of the load:

- Internal MOSFET Switch connected in series between the Battery Plus Terminal marked "Input +" (*5 in Figs 5.1 and 5.2 under Section 5.3*) and the Load Terminal

marked "Output +" (*6 in Figs 5.1 and 5.2 under Section 5.3*) will close and the load will be re-connected to the battery

- Blue colored local Status LED on the unit [*7 in Fig 2.1 / 2.2*] will be lighted steady to indicate re-connection of load

3.4 BATTERY OVER VOLTAGE DISCONNECT / RECONNECT AND ALARM

3.4.1 Battery Over Voltage Disconnect / Reconnect

To prevent damage to the load due to battery over voltage, the load will be disconnected / reconnected by the internal MOSFET Switch as follows:

- **12V Nominal Battery**: The load will be disconnected when the battery voltage is >16 V for 0.5 sec. *The load will be automatically re-connected when the battery voltage drops to 15.8V or lower for 2 sec*
- **24V Nominal Battery**: The load will be disconnected when the battery voltage is >32 V for 0.5 sec. *The load will be automatically re-connected when the battery voltage drops to 31.6V or lower for 2 sec*

When the above battery over voltage disconnection occurs, the following will be observed:

- Internal MOSFET Switch connected in series with the Battery Plus terminal marked "Input +" (*5 in Figs 5.1 and 5.2 under Section 5.3*) and Load Plus terminal marked "Output +" (*6 in Figs 5.1 and 5.2 under Section 5.3*) will open and the load will be disconnected from the battery
- Blue colored local Status LED on the unit [*7 in Fig 5.1 / 5.2 under Section 5.3*] will be switched OFF to indicate disconnection of load
- 1 sec pulsing Buzzer / LED alarm will be activated [*See Section 3.4.2 for details*]

3.4.2 Over Voltage Disconnect Alarm

NOTE: For this alarm to be activated, select "Program No. 11 – Alarm" from programming options under Column 1 of Table 6.1 under Section 6.2

3.4.2.1 Connections and Operation of Battery Over Voltage Disconnect Alarm:

Refer to Connection Diagrams at Fig 5.1/5.2 under Section 5.3

Connect the Positive (+) of external Buzzer (*Rated at 3 to 30 VDC, with current draw < 500mA*) or the Positive (+) of LED (*5mm diameter LED with series current limiting resistor rated at 1/4 Watt, 2K Ohm*) to the Battery Positive terminal marked "Input +" [*5 in Figs 5.1 / 5.2 under Section 5.3.2*]. Connect the Negative (—) of the Buzzer / LED to the Quick Disconnect Terminal marked "Alarm" [*2 in Fig 5.1 / 5.2 under Section 5.3*]. This "Alarm" terminal is internally connected to the Battery (—) through series connected internal Transistor Switch.

SECTION 3 | Principles of Operation

Activation of Alarm: If the battery voltage rises to >16 V for 12V battery or > 32V for 24V battery for for 0.5 sec, the internal Transistor Switch connected in series between the terminal marked"Alarm"and the Battery (—) [*Terminal marked "Minus" (3 in Figs 5.1 and 5.2 under Section 5.3*)] will turn ON at interval of 1 sec. *This will result in the terminal marked "Alarm" getting switched to the Battery (—) once per sec to produce Buzzer / LED alarm* ***pulsing at 1 sec interval***.

De-activation of Alarm: The alarm will be de-activated when the battery voltage drops to < 15.8V / 31.6V for 2 sec and the load will be reconnected

3.5 RELAY FUNCTION FOR AUTOMATIC STARTING / STOPPPING OF BATTERY CHARGER / GENERATOR TO RE-CHARGE DISCHARGED BATTERY

3.5.1 A "Relay Function" has been provided for automatic recharging of discharged battery by starting external Battery Charger /Generator at the programmed threshold of battery low "Disconnect Voltage" [*Section 3.3.2*] and stopping at the programmed threshold of "Reconnect Voltage" (*Section 3.3.3*)

NOTE: For this function to be activated, select Programming Option 12 - Relay [*See Column 1 in Table 6.1 under Section 6.2*]

3.5.2 Connections and Operation

Refer to Connection Diagrams at Figs 5.1/5.2 under Section 5.3

Starting and stopping of the Battery Charger / Generator is carried out through switching of Normally Open (NO), potential free contacts of an external SPST Relay (*Relay coil rated at 3 to 30 VDC, with current draw < 500mA*)

Connect the Positive (+) of the external SPST Relay coil to the Battery (+) Terminal Stud marked "Input +" [*5 in Figs 5.1 / 5.2 under Section 5.3*]. Connect the Negative (—) of the Relay coil to the Quick Disconnect Terminal marked "Alarm" [*2 in Fig 5.1 / 5.2 under Section 5.3*]. This "Alarm" terminal is internally connected to the Battery (—) [*Terminal marked "Minus" (3 in Figs 5.1 and 5.2 under Section 5.3*)] through series connected internal Transistor Switch. *Hence, the external SPST Relay will be energized only when the "Alarm" terminal gets connected to the Battery Negative internally when the series connected internal Transistor Switch is turned ON*.

3.5.3 Operation of Relay Function

Switching ON of Generator / Battery Charger: When the battery voltage drops to the programmed value of "Disconnect Voltage" [*Columns 2 and 4 in Table 6.1under Section 6.2*] for a continuous detect time of 15 sec, the internal Transistor Switch in series with the "Alarm" Terminal and Battery Negative will close and the external SPST Relay coil will be energized. Normally Open (NO) contacts of the SPST Relay will close to switch on the Generator / Battery Charger to start charging the battery. [***NOTE****: Detect*

time of 15 sec has been provided to prevent false triggering of the relay due to short-term dip in the battery voltage resulting from starting of heavy DC load(s)].

a) At this point, battery charging starts *but the internal MOSFET Switch in series with the Battery Plus Terminal marked "Input +"* (*5 in Figs 5.1 and 5.2 under Section 5.3*) *and the Load Plus Terminal marked "Output +"* (*6 in Figs 5.1 and 5.2 under Section 5.3*) *will still be in ON condition and the load will be powered by the Generator / Battery Charger / Battery*

   - The Blue colored local Status LED [*7 in Fig 5.1 / 5.2 under Section 5.3*] *will be in ON condition* to indicate that the load has *still NOT been disconnected* from the battery.

b) If the current drawn by the load is more than the Bulk Stage Charging Current capacity of the Battery Charger, the battery voltage will NOT rise above the programmed value of "Disconnect Voltage" [*Columns 2 and 4 in Table 6.1, Section 6.2*] because the battery will still be drained at current = (*Load Current – Bulk Stage Charging Current rating of the Charger*). When the battery voltage remains at or below the programmed value of "Disconnect Voltage" continuously for 90 sec from the time the battery voltage dropped to the programmed value of "Disconnect Voltage", the internal Transistor Switch in series with the terminal marked "Alarm" (*2 in Figs 5.1/ 5.2 under Section 5.3*) and the Battery (—) [*Terminal marked "Minus"*(*3 in Figs 5.1 and 5.2 under Section 5.3*)] will be latched in ON condition and the following will be observed:

   - Internal MOSFET Switch in series with the Battery Plus Terminal marked "Input +" (*5 in Figs 5.1 and 5.2 under Section 5.3*) and the Load Plus Terminal marked "Output +" (*6 in Figs 5.1 and 5.2 under Section 5.3*) will open and the load will be disconnected from the battery
   - Blue colored, local Status LED [*7 in Fig 5.1 / 5.2 under Section 5.3*] will be switched OFF to indicate disconnection of load

c) Automatic Stopping of Generator / Charger at "Reconnection Voltage": When the load is disconnected from the battery as described at 3.5.3 (b) above, full charging current from the Generator / Battery charger will be used to charge the battery. When the battery voltage rises to the programmed value of Reconnect Voltage [*Columns 3 and 5 in Table 6.1 under Section 6.2*], the internal Transistor Switch in series with the terminal marked "Alarm" (*2 in Figs 5.1 / 5.2 under Section 5.3*) and the Battery (—) [*Terminal marked "Minus"*(*3 in Figs 5.1 and 5.2 under Section 5.3*)] will open and the external SPST Relay will be de-energized to stop the Generator / Battery Charger

   - Internal MOSFET Switch in series with the Battery Plus Terminal marked "Input +" (*5 in Figs 5.1 and 5.2 under Section 5.3*) and the Load Plus Terminal marked "Output +" (*6 in Figs 5.1 and 5.2 under Section 5.3*) will close and the load will be reconnected to the battery
   - Blue colored, local Status LED on the unit [*7 in Fig 5.1 / 5.2 under Section 5.3*] will be switched ON to indicate reconnection of load

NOTE: *If the battery voltage rises above the programmed value of "Disconnect Voltage" threshold [Columns 2 and 4 in Table 6.1 under Section 6.2] between 15 and 90 sec from the time it dropped to the programmed value of "Disconnect Voltage" threshold, the internal Transistor Switch will open, the external SPST Relay will be de-energized and the Battery Charger / Generator will be switched off*

3.6 REMOTE SWITCHING OFF / SWITCHING ON OF LOAD

Refer to Connection Diagrams at Figs 5.1/5.2 under Section 5.3

The load can be switched On / Off from remote location as follows:

Connect Single Pole Single Throw (SPST) Rocker / Toggle Switch to the Quick Disconnect Terminals marked "MINUS" (*3 in Figs 5.1 / 2.2 under Section 5.3*) and "ON/OFF" (*4 in Figs 5.1 / 2.2 under Section 5.3*). The current drawn by this circuit is very low (*<10mA*). Hence, a small size of the Rocker / Toggle Switch can be used. Similarly, thinner wire size, say AWG#22 / AWG#24 may be used (*e.g. telephone wire*)

a) When the Rocker / Toggle Switch is turned ON [*Quick Disconnect Terminals marked "MINUS" and "ON/OFF will be shorted*], the internal MOSFET Switch in series with the Battery Plus marked "Input +" (*5 in Figs 5.1 / 5.2 under Section 5.3*) and Load Plus marked "Output +" (*6 in Figs 5.1 / 5.2 under Section 5.3*) will turn off and consequently, the load will switch OFF immediately
   - Blue colored, local Status LED [*7 in Figs 5.1 and 5.2 under Section 5.3*] will be switched off

b) When the Rocker / Toggle Switch is turned off, *the load will be reconnected after around 1 sec of switching off.*
   - Blue colored local Status LED [*7 in Fig 5.1 / 5.2 under Section 5.3*] will be lighted steady to indicate re-connection of load

3.7 STATUS LED

Blue colored Status LED [*7 in Figs 5.1 and 5.2 under Section 5.3*] has been provided on the unit for indicating the following conditions:

Steady ON: Indicates that the load is connected to the battery

OFF: Indicates that the load is disconnected from the battery (i) due to Battery Low Voltage Disconnect [*See Section 3.3.2*] or, (ii) due to Battery Over Voltage Disconnect [*See Section 3.4.1*] or (iii) Switched off remotely (*See Section 3.6*)

This LED is also used during programming. *Refer to Section 6.3*

SECTION 4 | Determining State of Charge/Discharge of Lead Acid Battery Based on Terminal Voltage & Rate of Charge/ Discharge (C-rate)

4.1 GENERAL

Charge / Discharge Curves as shown in Fig 4.1 are used to determine the State of Charge / Discharge of Lead Acid Battery based on its terminal voltage and the rate of charge / discharge current specified as "C-rate" (*See Section 4.2 below*). Details of using Charge / Discharge Curves in Fig 4.1 to determine State of Charge / Discharge of Lead Acid Battery are explained in the succeeding Sections.

Information given in this Section will help in selecting the appropriate Program No. related to programming of battery disconnect / reconnect voltage thresholds. Please see Section 3.3 for more details

4.2 C-rate OF CHARGE / DISCHARGE

The rate of charge / discharge of a battery is normally expressed in "C-rate" which is a *multiple* of the *numerical value* of the battery's Ampere Hour (Ah) Capacity (C). Few examples of C-rates for 100Ah capacity battery (C=100Ah) are given below:

- 2C = (2x100) A = 200A (*As the battery capacity is 100 Ah, the battery will be completely discharged in 0.5 Hrs.*)
- 1C = (1x 100) A = 100A (*As the battery capacity is 100 Ah, the battery will be completely discharged in 1 Hr.*)
- 0.2C (or C/5) = (0.2 x 100) A = 20A (*As the battery capacity is 100 Ah, the battery will be completely discharged in 5 Hrs.*)

4.2.1 Example for Determining C-rate of Charge for Particular Value of Charge Current:

- Determine the Ah capacity (C) of the battery – say 100 Ah (C=100 Ah)
- Determine the value of charge current – say 10 Amperes
- C-rate of charge at 10A = *Multiple* of numerical value Ampere Hour Capacity (C) = (10 ÷ 100) C = 1/10 C or 0.1C

4.2.2 Example for Determining C-rate of Discharge for Particular Value of Discharge Current:

- Determine the Ah capacity (C) of the battery – say 100 Ah (C=100)
- Determine the value of discharge current – say 20 Amperes
- C-rate of discharge at 20A = *Multiple* of numerical value of Ah Capacity (C) = (20 ÷ 100) C = 1/5 C or 0.2C

4.2.3 Reduction in Battery Capacity Due to Higher Charge / Discharge Current (C-rate)

4.2.3.1 Batteries have internal resistance (*in the order of milliohms*) which is the sum of its internal electrical and electrochemical resistances (R). When current (I) flows through the battery, there is an IR voltage drop across the internal resistance (R) which decreases the terminal voltage of the battery during discharge and increases the voltage needed to charge the battery, thus reducing its effective capacity. *Hence, for determining the true state of charge / discharge based on terminal voltage of the battery, the value of charge / discharge current (C-rate) is also required to be considered*

4.2.3.2 Battery Capacity Rating at Specified C-rate: As explained at Section 4.2.3.1 above, the capacity of battery reduces as the discharge current increases (*due to "Peukert's Effect"*). Hence, the manufacturers specify the C-rate of discharge at which the battery capacity is rated. Capacities of automotive batteries are normally specified at C-rate of C/20 (0.05C). *For example, a 100Ah Lead Acid Automotive Battery specified at C-rate of C/20 (0.05C) / 5A will be reduced to only 70 Ah at C-rate of C/5 (0.2C) / 20A*

4.3 CHARGE /DISCHARGE CURVES TO DETERMINE THE STATE OF CHARGE OF LEAD ACID BATTERY BASED ON ITS TERMINAL VOLTAGE AND C-rates OF CHARGE / DISCHARGE

4.3.1 Fig 4.1 shows examples of State of Charge / Discharge Curves for different C-rates for typical 12V / 24V Lead Acid Battery at 80°F / 26.7°C. *These curves are used to determine the State of Charge / Discharge of the battery based on its terminal voltage*.

The Y-Axis shows the terminal voltage of the battery. The X-Axis shows % State of Charge. % State of Discharge can be converted to % State of Charge using formula:

- % State of Charge = (100% - % State of Discharge) e.g. 80% State of Discharge = 100%-80% = 20% State of Charge

4.3.2 Example of Determining State of Charge (using Fig 4.1) when Charging 12V, 100Ah Battery at C-rate of 0.1C or C/10 or 10A: *Refer to Charge Curve marked C\10 of the upper 4 curves marked "CHARGE"*. States of Charge at different battery terminal voltages will be: (a) At 15.3V = 100% charged; (b) At14.3V = 90% charged; (c) At 13.5V = 70% charged; (d) At 12.5V = 15% charged

4.3.3 Example of Determining State of Discharge (using Fig 4.1) when Discharging 12V, 100Ah Battery at C-rate of 0.33C or C/3 or 33.3A: *Refer to Charge Curve marked C\3 of the lower 4 curves marked "DISCHARGE"*. States of Discharge at different battery terminal voltages will be: [a] At 9.5V = 100% discharged (*0% charged*); [b] At 10.4V = 80% discharged (*20% charged*): [c] At 11.5V = 28% discharged (*72% charged*) and [d] 11.75V = 0% discharged (*100% charged*)

SECTION 4 | Determining State of Charge/Discharge of Lead Acid Battery Based on Terminal Voltage & Rate of Charge/ Discharge (C-rate)

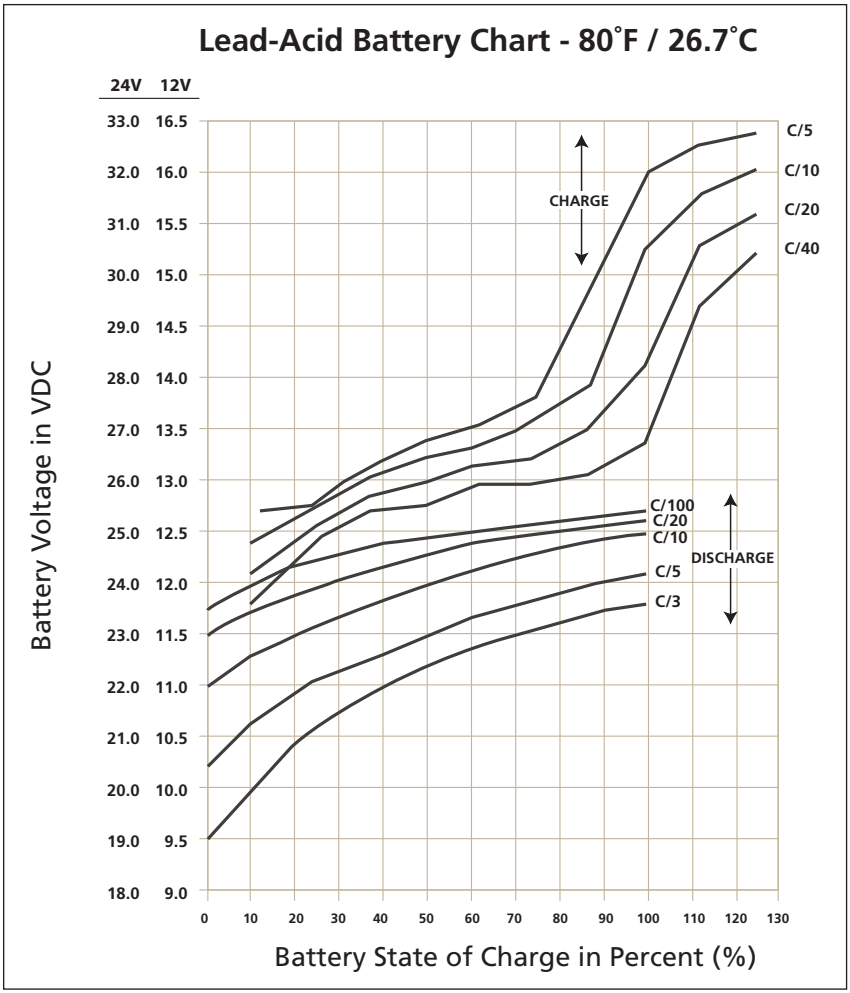


Fig 4.1 State of Charge versus Battery Terminal Voltage for 12V / 24V Battery

SECTION 5 | Installation

5.1 GENERAL

The unit is water-tight and dust-tight with Ingress Protection (IP) Rating: IP-66. Install in a cool and well-ventilated space.

5.2 INPUT AND OUTPUT CONNECTIONS

5.2.1 Details of input and output connections are shown as follows:

- Under layout information: Fig 2.1 for BG-200 and Fig 2.2 for BG-40/60
- Under Connection Diagrams: Figs 5.1 for BG-200 and Fig 5.2 for BG-40/60

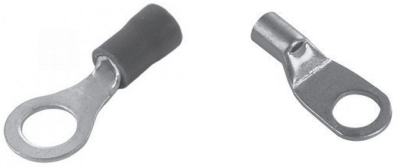
5.2.2 Terminal Lugs for Control Wiring:

Male Quick Disconnect Terminals 1, 2, 3 and 4 [*Figs 2.1 / 2.2 and Figs 5.1 / 5.2*] have Tab width of 0.25" / 6.35mm. Mating insulated, female Quick Disconnect terminal lugs (*for Tab width of 0.25" / 6.35mm*) will be required to be crimped to the control wiring connected to these terminals. Picture of this terminal is given below for guidance.

See Section 5.4.2 for details

5.2.3 Terminal Lugs for Battery and Load Wiring:

Ring Type of terminal lugs will be required to be crimped to the wiring to be connected to Terminal Stud marked "Input+" (*5 in Figs 5.1 / 5.2 under Section 5.3*) for Battery (+) connection and Terminal Stud marked "Load+" (*6 in Figs 5.1 / 5.2 under Section 5.3*) for Load (+) connection. Pictures of terminal lugs that can be used are shown below for guidance:



See Section 5.4.1 for details

Sizes of the above terminal lugs will be as follows:

BG-200: To fit stud size M10 and wire size as per selection based on Table 5.1 (*Section 5.4.1*)
BG-40/60: To fit stud size M6 and wire size as per selection based on Table 5.1 (*Section 5.4.1*)

WARNING!

Please ensure that exposed metal portion of the lugs are insulated if non-insulated lugs are used.

ATTENTION!

Veuillez vous assurer que la partie métallique exposée des cosses est isolée si des cosses non isolées sont utilisées.

5.3 CONNECTION DIAGRAMS

Connection diagrams are given at Fig 5.1 for BG-200 and Fig 5.2 for BG-40 / BG-60

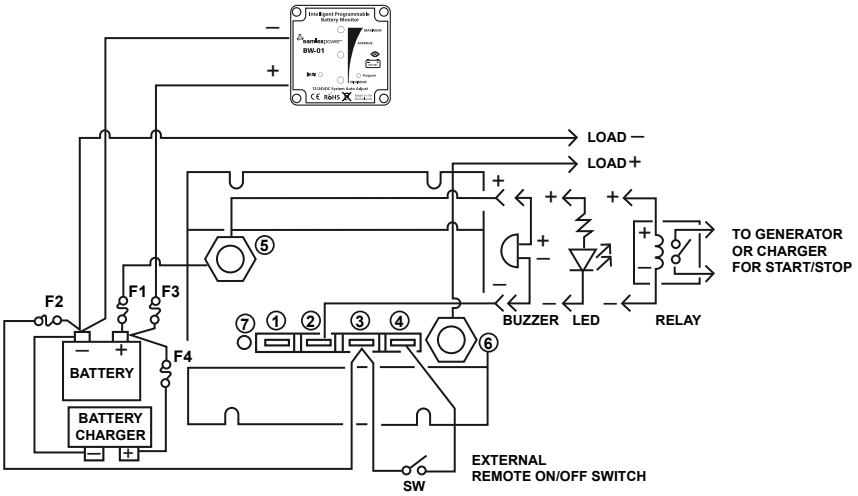
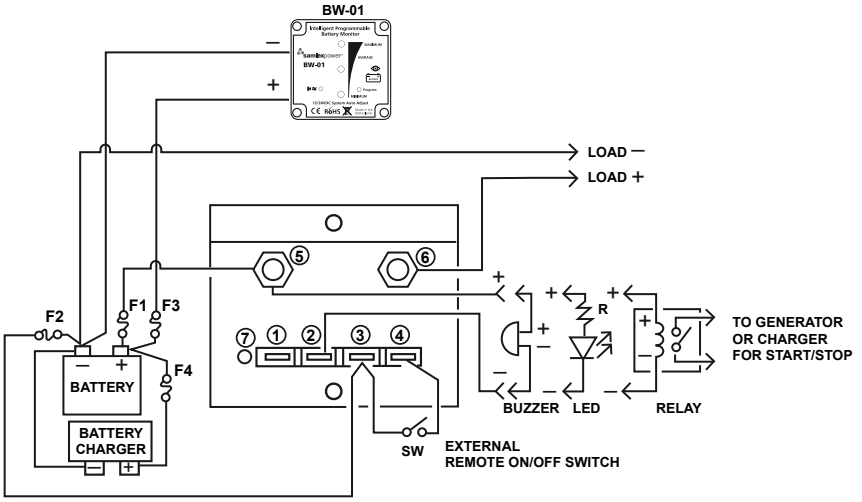


Fig 5.1 Connection Diagram for BG-200
Fig 5.2 Connection Diagram for BG-40 / BG-60



LEGEND FOR FIGS 5.1 and 5.2		
Item No.	Description	Function
1	Male Quick Disconnect Terminal marked "Program". [*Tab width: 0.25" / 6.35mm*]	For programming (*Section 6.3*)
2	Male Quick Disconnect Terminal marked "Alarm". [*Tab width: 0.25" / 6.35mm*]	• For external buzzer / LED alarm (*Sections 3.3.1 / 3.4.2.1*) • For external relay function (*Section 3.5*)
3	Male Quick Disconnect Terminal marked "Minus". [*Tab width: 0.25" / 6.35mm*]	• For feeding battery (—) connection for internal control circuitry • For remote On/Off of load (*Section 3.6*)
4	Male Quick Disconnect Terminal marked "ON/OFF". [*Tab width: 0.25" / 6.35mm*]	For remote On/Off of load (*Section 3.6*)
5	Terminal Stud marked "Input +" • BG-200 (*Fig 5.1*): o M10 X 1.5mm pitch • BG-40/60 (*Fig 5.2*): o M6 X 1.0mm pitch	For connection to (+) terminal of the battery
6	Terminal Stud marked "Output +" • BG-200 (*Fig 5.1*): o M10 X 1.5mm pitch • BG-40/60 (*Fig 5.2*): o M6 X 1.0mm pitch	For connection to (+) terminal of the load
		continued on next page...

LEGEND FOR FIGS 5.1 and 5.2 cont.		
7	Blue Status LED	• Indicates load connect / disconnect status during operation (*Section 3.7)* • During programming, the number of LED blinks shows the selected Program Number (*Section 6.3*)
SW	External switch or potential free, Normally Open (NO) relay contact (*Optional, not supplied*)	For remote on/off control of load(s). (*See Section 3.6)*
BW-01	Battery Monitor, Samlex Model BW-01 (*Optional, not supplied*)	For monitoring State of Charge of the battery
Fuse F1	• **BG-200**: 250A • **BG-60**: 70A • **BG-40**: 50A (*Not supplied*)	For ground fault in cable connecting (+) terminal of the battery to Terminal Stud marked "Input +" (5)
Fuse F2	1 Amp (*Not supplied*)	For overload protection of internal control circuit
Fuse F3	1 Amp (*Not supplied*)	For (i) Overload in Battery Monitor BW-01 and (ii) Ground fault / short circuit in battery connection wiring to Battery Monitor BW-01
Fuse F4	Amp capacity based on Amp rating of the Battery Charger	For ground fault / short circuit in battery connection wiring for battery charger
Buzzer	Piezo-electric Type Buzzer rated at 3 to 30 VDC, with current draw < 500mA) (*Not supplied*)	For external Battery Low Voltage Alarm (*Section 3.3.1*) and Battery Over Voltage Disconnect Alarm (*Section 3.4.2*)
LED	5mm diameter LED with series current limiting resistor "R" rated at 1/4 Watt, 2K Ohm (*Not supplied*)	For external Battery Low Voltage Alarm (*See Section 3.3.1*) and Battery Over Voltage Alarm (*See Section 3.4.2*) **WARNING!** Please ensure that resistor "R" rated 1/4 Watt, 2K Ohm is soldered in series with the LED to limit current flow through the LED. *If this resistor is not used, Transistor Switch inside the BG will be damaged!*
Relay	SPST Relay with relay coil rated at 3 to 30 VDC, with current draw < 500mA (*Not supplied*)	Dry contact switching signal for starting external Generator / Battery Charger when Battery Low Voltage Disconnect occurs (*See Section 3.5*)
Battery Charger	Battery Charger (*Not supplied*)	• Bulk State Charging Current capacity of the charger should normally be limited to 1/5th to 1/10th of the Ampere Hour (Ah) capacity of the battery / battery bank. Please confirm with the battery manufacturer • Pay attention to Warning at Section 5.3.1

5.3.1 Connecting Battery Charger

WARNING!

Refer to Connection Diagrams at Figs 5.1 and 5.2
Please ensure that the Battery Charger is connected on the battery side (*as shown*) and NOT on the load side. Connecting the Battery Charger on the load side will damage the internal Body Diode of the MOSFET Switch of the BG Unit because the battery charger will continue to charge the battery even when the internal MOSFET Switch is off (*through the series connected Body Diode of the MOSFET*).

ATTENTION!

Reportez-vous au schéma de connexion aux figures 5.1 et 5.2
Veuillez vous assurer que le chargeur de batterie est connecté du côté de la batterie (comme illustré) et NON côté charge. La connexion du chargeur de batterie côté charge endommagera la diode de corps interne du commutateur MOSFET de l'unité BG car le chargeur de batterie continuera à charger la batterie même lorsque le commutateur MOSFET interne est éteint (*via la diode de corps connectée en série du MOSFET*).

5.3.2 Connecting External Buzzer / LED for Battery Low Voltage / Battery Over Voltage Alarms:

Refer to Connection Diagram at Figs 5.1/5.2.

For details of connections and operation, see Sections 3.3.1.1 and 3.4.2

5.3.3 Connecting External Relay for Automatic Starting/Stopping of Battery Charger/ Generator to Recharge Discharged Battery:

Refer to Section 3.5.2 for details.

5.4 Wiring and Fuses

5.4.1 Wiring and Fuses for Battery / Load Connections: Refer to Tables 5.1 and 5.2 for wiring and fuse sizing for battery and load connections. *For information on Terminal Lugs, please refer to Section 5.2.3*.

Table 5.1 Recommended Cable / Fuse Sizes for Battery / Load Connections: 12V Battery

Model No. (1)	Rated Current (2)	NEC Ampacity (3)	Cable Size for 3' Distance (4)	Cable Size for 6' Distance (5)	Cable Size for 10' Distance (6)	Fuse Size (7)
BG-200	200A	250A	AWG#2	AWG#2/0	AWG#4/0	250A
BG-60	60A	75A	AWG#8	AWG#4	AWG#2	75A
BG-40	40A	50A	AWG#10	AWG#6	AWG#4	50A

Table 5.2 Recommended Cable / Fuse Sizes for Battery / Load Connections: 24V Battery						
Model No. (1)	**Rated Current (2)**	**NEC Ampacity (3)**	**Cable Size for 3' Distance (4)**	**Cable Size for 6' Distance (5)**	**Cable Size for 10' Distance (6)**	**Fuse Size (7)**
BG-200	200A	250A	AWG#1	AWG#1	AWG#1/0	250A
BG-60	60A	75A	AWG#8	AWG#8	AWG#6	75A
BG-40	40A	50A	AWG#10	AWG#10	AWG#8	50A

NOTES for Tables 5.1 and 5.2

1. Column (3) is the NEC (*National Electrical Code - USA*) Ampacity for Feeder Circuit Conductors and is = 125% of the rated current.
2. Distance of 3ft, 6ft and 10ft shown in Columns (4) to (6) is the routed distance between the battery and the load
3. Columns (4) to (6) show the wiring conductor size based on the following 2 considerations. ***NOTE:*** *Thicker conductor of the following 2 considerations has been considered*
   a) As per ISO 10133 for NEC Ampacity at Column (3)
   b) Voltage drop limited to 2% of 12V (*0.24V*) / 24V (*0.48V*). Voltage drop has been calculated by multiplying the rated current at Column (2) by the resistance of the copper conductor (*for determining resistance, the total length of conductor has been taken as 2 times the routed distance between the battery and the load to cover 2 lengths of Positive and Negative cable conductors*)
4. Column (7) shows the Fuse rating based on the following considerations:
   a) Not less than NEC Ampacity (*Column 3*)
   b) Closest Standard Ampere Rating of Fuse (*Closest to Column 3*)
   c) Type of Fuse: Fast Acting and suitable for 12V / 24V battery circuits
5. Refer to Section 5.2.3 for information on Terminal Lugs for cable connection

5.4.2 Wiring and Fuses for Control Circuitry: Wiring connected to the following control circuit terminals carry very low current of less than 1 Amp. Flexible wiring size AWG #18 to 22 may be used. Details are given below in Table 5.3.

Table 5.3 Wire Sizing and Connector for Control Terminals			
Item No. in Figs 5.1/5.2	**Description**	**Wire Sizing**	**Terminal Lug for Wiring connected to the BG**
1	Male Quick Disconnect Terminal marked "Program"	Flexible Wiring: AWG# 18 to 22	Mating insulated, female Quick Disconnect terminal lugs (*for Tab width of 0.25" / 6.35mm*) will be required to be crimped to the wiring connected to these terminals. Picture of this terminal is given below for guidance:  *Refer to Section 5.2.2 for details*
2	Male Quick Disconnect Terminal marked "Alarm"		
3	Male Quick Disconnect Terminal marked "Minus"		
4	Male Quick Disconnect Terminal marked AZ"ON/OFF"		

SECTION 6 | Operation & Programming

6.1 OPERATION

6.1.1 Normal Operation

12V / 24V battery is sensed automatically:
- 8 to 20 VDC is detected as 12V Battery
- 20 to 35VDC is detected as 24V battery

The unit will start operating when (+) terminal of the battery is connected to the Battery Terminal Stud marked "Input +" [*5 in Figs 5.1 / 5.2 under Section 5.3*] and the (–) terminal of the battery is connected to the Male Quick Disconnect terminal marked "Minus" [*3 in Figs 5.1 / 5.2 under Section 5.3*]. Blue Status LED [*7 in Figs 5.1 / 5.2 under Section 5.3*] will be lighted steady [*within 3 to 4 sec of application of battery input voltage to terminals marked "Input +" and "Minus"*]

The unit will operate normally when the battery voltage is > than the "Disconnect Voltage" threshold of the selected Programming Option (*Program Nos 1 to 10 in Table 6.1*). The following will be observed:
- The internal Mosfet Switch connecting Battery Terminal Stud marked "Input +" [*5 in Figs 5.1 / 5.2 under Section 5.3*] and Load Terminal Stud marked "Output +" [*6 in Figs 5.1 / 5.2 under Section 5.3*] will CLOSE and the battery will be connected to the load.
- Blue Status LED [*7 in Figs 5.1 / 5.2 under Section 5.3*] will be lighted steady [*within 3 to 4 sec of application of battery input voltage to terminals marked "Input +" and "Minus"*]

6.1.2 Other Operational Information

Please refer to the following Sections for other operational information:
- Section 3.3 for battery low voltage disconnect / reconnect and alarm
- Section 3.4 for battery over voltage disconnect / reconnect and alarm
- Section 3.5 for Relay Function to start / stop external battery charger / generator at programmed threshold of Disconnect Voltage
- Section 3.6 for remote switching off / switching on of load
- Section 3.7 for Status LED
- Section 4 for help in selecting the appropriate Program No. [*Table 6.1 under Section 6.2*] related to programming of battery disconnect / reconnect voltage thresholds [*Explained in Section 3.3*]

6.2 PROGRAMMING OPTIONS

Table 6.1 shows the various programming options.

12V / 24V battery is sensed automatically:
- 8 to 20 VDC is detected as 12V Battery
- 20 to 35VDC is detected as 24V battery

Table 6.1 Programming Options				
Program No. (*Column 1*)	Programming Options for 12V Battery		Programming Options for 24V Battery	
	Disconnect Voltage (*Column 2*)	Reconnect Voltage (*Column 3*)	Disconnect Voltage (*Column 4*)	Reconnect Voltage (*Column 5*)
1 (*Default*)	10.50V	12.00V	21.00V	24.00V
2	10.00V	11.50V	20.00V	23.00V
3	9.50V	11.50V	19.00V	23.00V
4	11.25V	13.25V	22.50V	26.50V
5	11.50V	13.80V	23.00V	27.60V
6	10.50V	12.80V	21.00V	25.60V
7	11.50V	12.80V	23.00V	25.60V
8	11.80V	12.80V	23.60V	25.60V
9	12.00V	13.00V	24.00V	26.00V
10	10.00V	13.20V	20.00V	26.40V
11 (*Default*)	Alarm			
12	Relay			

6.3 PROGRAMMING PROCEDURE

6.3.1 General Information

Table 6.1 provides details of 12 Program Nos. At any given time, 2 Program Nos will be active as follows:

- Any one of Program Nos 1 to 10 to set the desired thresholds of Low Voltage Disconnect and Alarm [*For details, see Section 3.3*]
- Any one of Program No. 11 for Alarm Function [*For details see Section 3.3.1*] OR Program No. 12 for Relay Function [*For details see Section 3.5*]

6.3.2 Programming Procedure

6.3.2.1 Equipment and Accessories Required: The following will be required to carry out programming:

a) DC Power Source: One of the following DC power sources will be required to power the unit to carry out programming:

i. A charged 12V battery [*Terminal voltage above 12V*] or 24V battery [*Terminal voltage above 24V*], **OR**

i. DC Power Supply:
   - 12V DC Power Supply: Terminal voltage 13.5 to 13.8VDC
   - 24V DC Power Supply: 27.0 to 27.6VDC

b) Wiring: Following wiring will be required:
   - 2 pieces of 1 to 2 ft of AWG # 18-22 flexible wiring with female Quick Disconnect terminal lug on one end (*for Tab width of 0.25" / 6.35mm*). See Section 5.4.2 for details.

6.3.2.2 Programming Steps

NOTE:

Before programming, disconnect all loads connected to terminal marked "Output+" (*6 in Figs 5.1/5.2 under Section 5.3*)

Step 1: *Powering on to the Unit Using one of the DC Power Sources Specified at Section 6.3.2.1(a)*

a) Attach wiring [*Section 6.3.2.1(b)*] from the Battery Terminal Stud marked "Input +" [*5 in Figs 5.1 / 5.2 under Section 5.3*] on the BG to the (+) Positive terminal of the 12V/24V DC Power Source [*Section 6.3.2.1(a)*]

b) Attach wiring [*Section 6.3.2.1(b)*] from the Male Quick Disconnect Terminal marked "Minus" [*3 in Figs 5.1 / 5.2 under Section 5.3*] on the BG to the (-) Negative terminal of the DC Power Source [*Section 6.3.2.1(a)*]

c) Within 3 to 4 sec of application of battery input voltage to the terminals marked "Input +" and "Minus", the internal Mosfet Switch will CLOSE to connect the Battery Terminal Stud marked "Input +" [*5 in Figs 5.1 / 5.2 under Section 5.3*] to the Load Terminal Stud marked "Output +" [*6 in Figs 5.1 / 5.2 under Section 5.3*].
   - The Blue Status LED [*7 in Figs 5.1 / 5.2 under Section 5.3*] will be lighted steady

Step 2: *Setting the desired Program No.(1 to 12, Table 6.1)* The Default Settings are Program Nos. 1 and 11. *Remember the desired new Program No. to be set*. Proceed as follows:

a) Attach connecting wire [*Section 6.3.1.1 (b)*] to the Male Quick Disconnect Terminal marked "Program" [*1 in Figs 5.1 / 5.2 under Section 5.3*]. Touch and continue to hold the bare end of this wire to the Battery Terminal Stud marked "Input +" [*5 in Figs 5.1 / 5.2 under Section 5.3*].
   - (+) DC input voltage will now be fed to the terminal marked "Program" [*1 in Figs 5.1 / 5.2 under Section 5.3*]

b) After around 2 sec, the Blue Status LED [*7 in Figs 5.1 / 5.2 under Section 5.3*] will switch OFF and start BLINKING with pattern of 2 sec ON and 2 sec OFF (*There will be up to 12 blinks corresponding to Program Nos. 1-12*)

c) Start counting the number of blinks as soon as blinking starts. Soon after the desired no. of blink appears (*1 to 12*), remove *(See Note 2)* the wire connection from the terminal marked "Program" [*1 in Figs 5.1 / 5.2 under Section 5.3*]

d) Blinking of LED will stop for around 2 sec and *then*,

e) The LED will blink for the number of times equal to the new Program *(See Note 2)* to confirm the new Program No. that has been set and *then*,

f) The LED will be lighted steady to signal completion of programming.

NOTES FOR SECTION 6.3.2.2 – PROGRAMMING STEPS:

1. During Step 2(c) above, please ensure that the bare end of the wire feeding (+) DC Input Voltage to the terminal marked "Program" [*1 in Figs 5.1 / 5.2 under Section 5.3*] is removed soon after the desired number of blinks relevant to the selected Program No. (*within the 2 sec of the time period the LED remains ON*). For example, if Program No. 5 is required to be set, disconnect the wire soon after the 5th blink starts (*each blink lights up the LED for 2 sec*).

2. During Step 2(e), if the number of blinks indicating confirmation are not same as the number of blinks for the desired Program No, repeat Step 2 after completion of Step 2 (f)

SECTION 7 | Specifications

PARAMETER	BG-200		BG-60		BG-40	
Battery System Voltage	12V / 24V, Auto sensing • 12V (8-20V) • 24V (20-35V)		12V / 24V, Auto sensing • 12V (8-20V) • 24V (20-35V)		12V / 24V, Auto sensing • 12V (8-20V) • 24V (20-35V)	
Current Carrying Capacity	**Continuous**	200A	Continuous	60A	Continuous	40A
	Peak	480A	Peak	120A	Peak	120A
Control and Monitoring Options	10 Disconnect / Reconnect Voltage Threshold Combinations					
	LED / Buzzer alarm drive for remote indication of load disconnection due to battery under / overvoltage					
	Relay drive for automatic starting / stopping of Battery Charger / Generator					
	Switching Off / On of load from remote location					
Self Consumption	**Internal Mosfet Switch ON**	4mA	**Internal Mosfet Switch ON**	4mA	**Internal Mosfet Switch ON**	4mA
	Internal Mosfet Switch OFF	2mA	**Internal Mosfet Switch OFF**	2mA	**Internal Mosfet Switch OFF**	2mA
Voltage Drop Across Mosfet Switch	0.125V at 200A		0.15V at 60A		0.10V at 40A	
Protection against reverse polarity of battery connection	Yes		Yes		Yes	
Overload Protection (*Disconnect load*)	• Approx. 200-210A for 5 sec • Auto-reset after 1 min		• Approx. 60-65A for 5 sec • Auto-reset after 1 min		• Approx. 40-45A for 5 sec • Auto-reset after 1 min	
Over Voltage Protection (*Disconnect load*)	**12V Battery**	16V	**12V Battery**	16V	**12V Battery**	16V
	24V Battery	32V	**24V Battery**	32V	**24V Battery**	32V
Tolerance	**Voltage**	2%	**Voltage**	2%	**Voltage**	2%
	Current	20%	**Current**	20%	**Current**	20%

SECTION 7 | Specifications

PARAMETER	BG-200		BG-60		BG-40	
Terminals	**Battery + Load +**	Stud, M10 1.5mm Pitch	**Battery + Load +**	Stud, M6 1.0mm Pitch	**Battery + Load +**	Stud, M6 X 1.0mm Pitch
	Control	Quick Disconnect Type Male Tab: 0.25" / 6.35mm	**Control**	Quick Disconnect Type Male Tab: 0.25" / 6.35mm	**Control**	Quick Disconnect Type Male Tab: 0.25" / 6.35mm
Operating Temperature Range	-10°C to +40C		-10°C to +40C		-10°C to +40C	
Enclosure	• Anodized Aluminum • **Ingress Protection:** IP-66		• Anodized Aluminum • **Ingress Protection:** IP-66		• Anodized Aluminum • **Ingress Protection:** IP-66	
Compliance	• CE Marked • **EMC:** UN Regulation ECE R10-4		• CE Marked • **EMC:** UN Regulation ECE R10-4		• CE Marked • **EMC:** UN Regulation ECE R10-4	
Dimensions (WxDxH)	112 x 120 x 61mm		82 x 65 x 41mm		82 x 65 x 41mm	
Weight	730g / 1.54lb		185g / 0.44lb		185g / 0.44lb	

NOTE: (1) Specifications are subject to change without notice (2) Battery voltages are specified at 80°F / 26.7°C