

# KBBW Series

## Battery Powered DC/DC Low Voltage Motor Speed Control

Rated for 12 and 24 Volt DC Permanent Magnet Motors  
from Subfractional thru 1/2 HP (0.37 kW) Continuous Duty

### Typical Applications

- Carts • Feeders • Solar Pumps • Hoists • Pitching Machines
- Boat Lifts • Polishers • Light Duty Conveyors • Portable Pumps
- Electric Boats • Chemical Feeders • Metering Pumps • Salt Spreaders



### Standard Features

**Plug-In Horsepower Resistor®:** Automatically calibrates the IR Compensation and Current Limit settings when used on various horsepower motors. Supplied separately by your distributor.

**Short Circuit Protection:** Prevents drive failure if a short circuit occurs at the motor.

**Undervoltage Protection:** Shuts down the drive if the input voltage goes below the lower limit of the operating range. The drive will resume operation when the input voltage returns.

**Quick-Connect Terminals:** Battery, Motor, and Inhibit.

**Inhibit Circuit:** Can be used to stop and start the drive electronically with a switch or contact.\*

**Signal Inputs:** 5 kΩ potentiometer (supplied), 0-5 Volt DC analog signal, or PWM microprocessor output signal.

### Trimpot Adjustments

Minimum Speed (MIN)	Maximum Speed (MAX)	Acceleration (ACCEL)
Deceleration (DECEL)	Current Limit (CL)	IR Compensation (IR)

### Optional Accessory

**Auxiliary Heat Sink Kit (Part No. 9142):** Increases the drive's current rating from 14 Amps DC to 20 Amps DC.



Model KBBW-12 (Part No. 9140)  
Model KBBW-22 (Part No. 9141)

### Description

The KBBW Series of Pulse Width Modulated (PWM) DC/DC motor speed controls provide excellent dynamic response to load variations. The efficient PWM waveform produces an almost pure DC current to the motor (form factor <1.05), which provides low audible motor noise and long brush life. Pulse-by-pulse current limit provides short circuit protection and prevents control damage due to shorted motors. Excellent load regulation is achieved with armature feedback.

The Plug-In Horsepower Resistor® (supplied separately) eliminates the need for recalibrating the IR Compensation and Current Limit settings when the control is used on various horsepower motors. Quick-connect terminals are standard for all connections to the drive. Adjustable trimpots allow the drive to be tailored to specific applications. The Inhibit Circuit can be used to stop and start the drive electronically with a switch or contact.

The 5 kΩ potentiometer (supplied), a 0-5 Volt DC analog signal, or a PWM microprocessor output signal can be used to control motor speed. The optional Auxiliary Heat Sink Kit (Part No. 9142) increases the drive's current rating from 14 Amps DC to 20 Amps DC.

### General Performance Specifications

Model KBBW-12 Input Voltage Range (Volts DC)	10 – 15
Model KBBW-22 Input Voltage Range (Volts DC)	20 – 30
Model KBBW-12 Output Voltage Range (Volts DC)	0 – 12**
Model KBBW-22 Output Voltage Range (Volts DC)	0 – 24**
Speed Range (Ratio)	50:1
Operating Frequency (kHz)	>16
Form Factor (RMS/Average Amps)	<1.05
Input Regulation (% Base Speed)	0.5
Load Regulation (% Base Speed)	1***
Minimum Speed Trimpot (MIN) Range (% Base Speed)	0 – 30
Maximum Speed Trimpot (MAX) Range (% Base Speed)	60 – 100
Acceleration Trimpot (ACCEL) Range (Seconds)	0.1 – 10
Deceleration Trimpot (DECEL) Range (Seconds)	0.1 – 10
Current Limit Trimpot (CL) Range (% Range Setting)	0 – 200
IR Compensation Trimpot (IR) Range (% Rating)	0 – 30
Analog Input Voltage (Voltage Following) (Volts DC)	0 – 5
Main Speed Potentiometer (1/4 Watt) (Ω)	5k
Operating Temperature Range (°C / °F)	0 – 40 / 32 – 104
Operating Humidity Range (% Relative, Non-Condensing)	0 – 95
Storage Temperature (°C / °F)	-25 – +85 / -13 – +185

\*See Safety Warning on page 2. \*\*The maximum output voltage is nominally 0.5 Volts DC less than the input voltage. \*\*\*Based on a motor having linear IR Compensation characteristics.

### Electrical Ratings\*

Model Number	Part Number	Input Voltage (Volts DC)	Rating without Auxiliary Heat Sink		Rating with Auxiliary Heat Sink	
			Maximum Continuous Load Current (Amps DC)	Maximum Horsepower HP (kW)	Maximum Continuous Load Current (Amps DC)	Maximum Horsepower HP (kW)
KBBW-12	9140	12	14	1/6 (0.12)	20	1/4 (0.18)
KBBW-22	9141	24	14	1/3 (0.25)	20	1/2 (0.37)

\*Suggested Fuse or Circuit Breaker Rating: 20 Amps for 14 Amps load current and 25 Amps for 20 Amps load current.

### Plug-In Horsepower Resistor® Chart\*

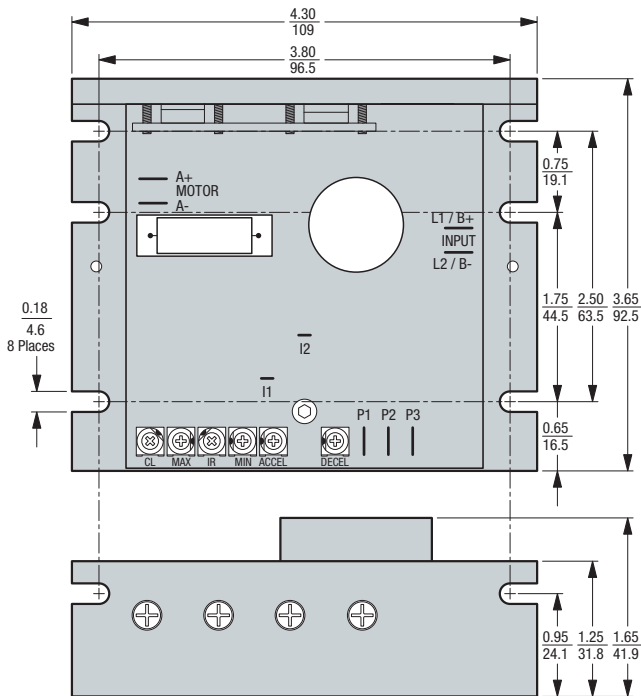
Motor Current (Amps DC)	Plug-In Horsepower Resistor®		Motor Horsepower – HP (kW)	
	Ω	KB Part No. (Individual)	Model KBBW-12	Model KBBW-22
20	0.006	9850	1/4 (0.18)	1/2 (0.37)
14	0.01	9843	1/6 (0.12)	1/3 (0.25)
10	0.015	9842	1/8 (0.09)	1/4 (0.18)
6	0.025	9841	1/14 (0.05)	1/7 (0.11)

\*For a motor current that is not listed on the chart, use the next lower value Plug-In Horsepower Resistor®. Supplied separately by your distributor.

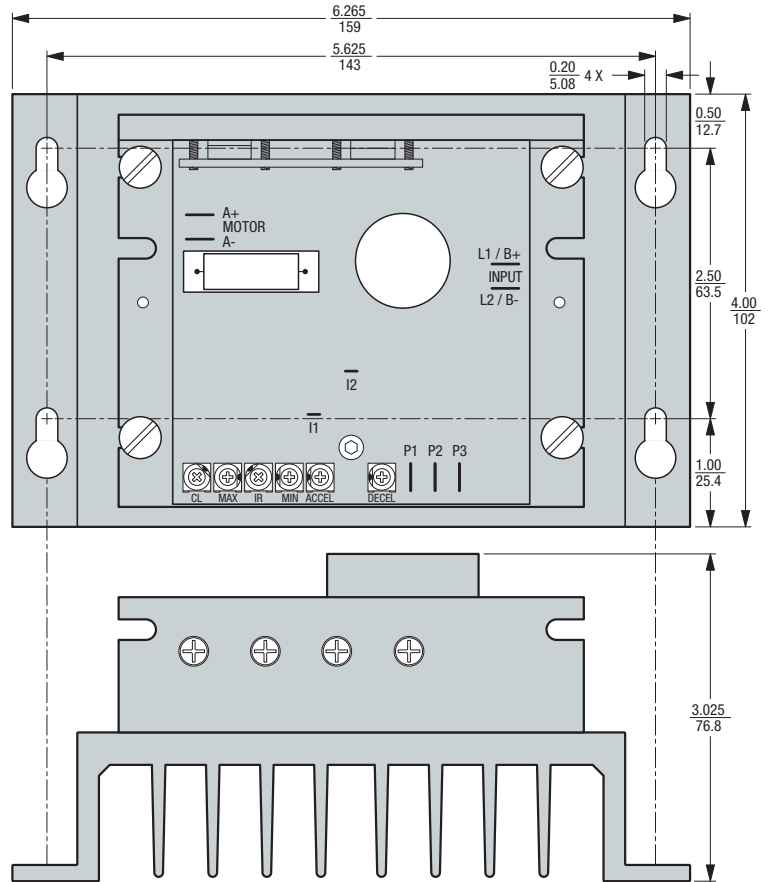


### Mechanical Specifications (Inches/mm)

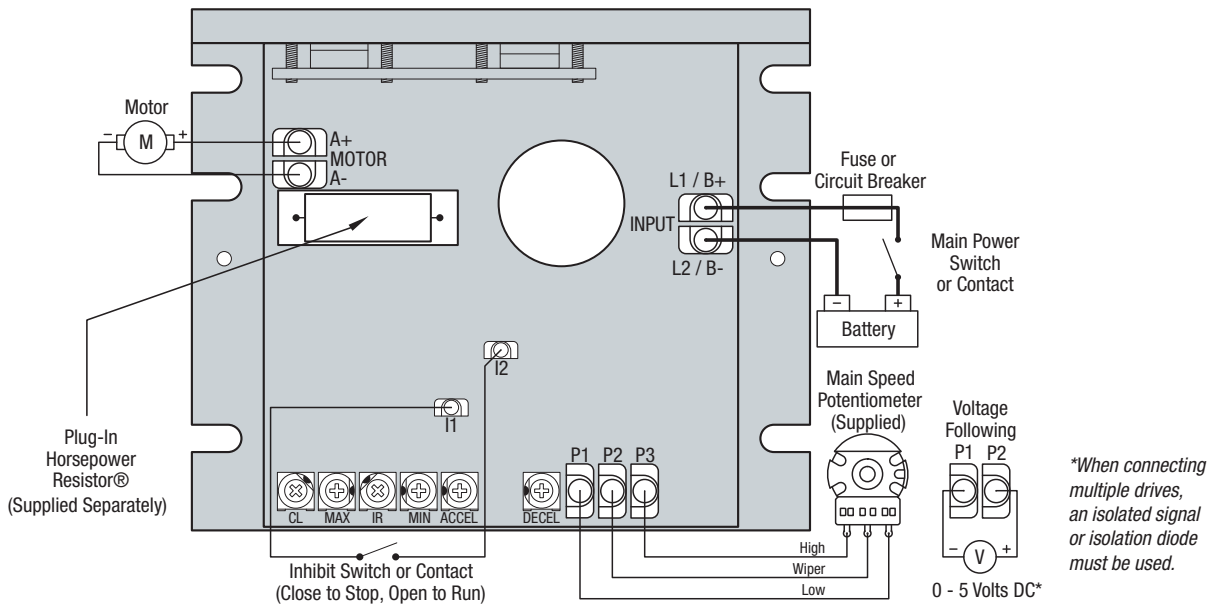
Without Optional Auxiliary Heat Sink



With Optional Auxiliary Heat Sink



### General Connections Diagram and Control Layout



*\*When connecting multiple drives, an isolated signal or isolation diode must be used.*



**Warning!** Inhibit is never to be used as a safety disconnect since it is not fail-safe. Disconnect the DC input power for this purpose.

Represented by:



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# KBBW SERIES INSTALLATION AND OPERATION INSTRUCTIONS

**These Installation and Operation Instructions Cover Models KBBW-12 (Part No. 9140) and KBBW-22 (Part No. 9141)**



**SAFETY WARNING ON PAGE 4 MUST BE READ AND UNDERSTOOD BEFORE PROCEEDING!**

## 1 INTRODUCTION

### DESCRIPTION

Thank you for purchasing the KBBW Series Pulse Width Modulated (PWM) DC/DC Low Voltage Motor speed control. KB Electronics, Inc. is committed to providing total customer satisfaction by providing quality products that are easy to install and operate.

The KBBW Series of Pulse Width Modulated (PWM) DC/DC motor speed controls provide excellent dynamic response to load variations. The efficient PWM waveform produces an almost pure DC current to the motor (form factor <1.05), low audible motor noise, and provides long brush life. Pulse-by-pulse current limit provides short circuit protection and prevents control damage due to shorted motors. Armature feedback provides excellent load regulation.

The Plug-In Horsepower Resistor® (PHR) (supplied separately) eliminates the need for recalibrating the IR Compensation and Current Limit settings when the control is used on various horsepower motors. Quick-connect terminals are standard for all connections to the drive. Adjustable trimpots allow the drive to be tailored to specific applications. The Inhibit Circuit can be used to stop and start the drive electronically with a switch or contact.

The 5 kΩ potentiometer (supplied), a 0 – 5 Volt DC analog signal, or a PWM microprocessor output signal can be used to control motor speed.\*

The optional Auxiliary Heat Sink Kit (Part No. 9142) increases the drive's current rating from 14 Amps DC to 20 Amps DC.

### STANDARD FEATURES

- **Plug-In Horsepower Resistor® (PHR):** Automatically calibrates the IR Compensation and Current Limit settings when used on various horsepower motors. Supplied separately by your distributor.
- **Short Circuit protection:** Prevents drive failure if a short circuit occurs at the motor.
- **Undervoltage protection:** Shuts down the drive if the input voltage goes below the lower limit of the operating range. The drive will resume operation when the input voltage returns.
- **Quick-Connect Terminals:** Battery Input, Motor, and Inhibit.
- **Inhibit Circuit:** Can be used to stop and start the drive electronically with a switch or contact.
- **Signal Inputs:** 5 kΩ potentiometer (supplied), 0 – 5 Volt DC analog signal, or PWM microprocessor output signal.\*

### TRIMPOT ADJUSTMENTS

- **Minimum Speed (MIN):** Sets the minimum speed of the motor.
- **Maximum Speed (MAX):** Sets the maximum speed of the motor.
- **Acceleration (ACCEL):** Sets the amount of time for the motor to accelerate from zero speed to full speed.
- **Deceleration (DECEL):** Sets the amount of time for the motor to decelerate from full speed to zero speed.
- **Current Limit (CL):** Sets the current limit (overload) which limits the maximum current to the motor.
- **IR Compensation (IR):** Sets the amount of compensating voltage required to keep the motor speed constant under varying loads.

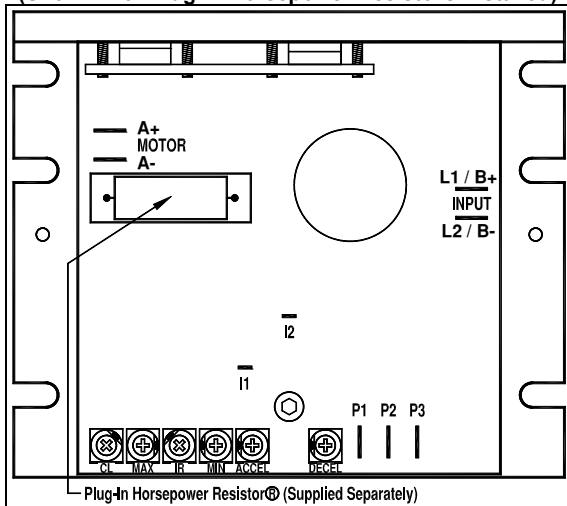
### OPTIONAL ACCESSORY

- **Auxiliary Heat Sink Kit (Part No. 9142):** Increases the drive's current rating from 14 Amps DC to 20 Amps DC.

\*When connecting multiple drives, an isolated signal or isolation diode must be used.

**FIGURE 1  
CONTROL LAYOUT**

(Shown with Plug-In Horsepower Resistor® Installed)\*



\*A Plug-In Horsepower Resistor® must be installed for the drive to operate. See Table 3 on page 2.

**TABLE 1  
GENERAL PERFORMANCE SPECIFICATIONS**

Description	Specification	Factory Setting
Model KBBW-12 Input Voltage Range (Volts DC)	10 – 15	—
Model KBBW-22 Input Voltage Range (Volts DC)	20 – 30	—
Model KBBW-12 Output Voltage Range (Volts DC)	0 – 12*	—
Model KBBW-22 Output Voltage Range (Volts DC)	0 – 24*	—
Speed Range (Ratio)	50:1	—
Operating Frequency (kHz)	>16	—
Form Factor (RMS/Average Amps)	<1.05	—
Input Regulation (% Base Speed)	0.5	—
Load Regulation (% Base Speed)	1**	—
Minimum Speed Trimpot (MIN) Range (% Base Speed)	0 – 30	0
Maximum Speed Trimpot (MAX) Range (% Base Speed)	60 – 100	100
Acceleration Trimpot (ACCEL) Range (Seconds)	0.1 – 10	2.5
Deceleration Trimpot (DECEL) Range (Seconds)	0.1 – 10	2.5
Current Limit Trimpot (CL) Range (% Range Setting)	0 – 200	150
IR Compensation Trimpot (IR) Range (% Rating)	0 – 30	—
Analog Input Voltage (Voltage Following) (Volts DC)	0 – 5	—
Main Speed Potentiometer (1/4 Watt) (Ω)	5k	—
Operating Temperature Range (°C / °F)	0 – 40 / 32 – 104	—
Operating Humidity Range (% Relative, Non-Condensing)	0 – 95	—
Storage Temperature (°C / °F)	-25 – +85 / -13 – +185	—

\*The maximum output voltage is nominally 0.5 Volts DC less than the input voltage.

\*\*Based on a motor having linear IR Compensation characteristics.

**TABLE 2**  
**ELECTRICAL RATINGS\***

Model No.	Part No.	Input Voltage (Volts DC)	Rating Without Auxiliary Heat Sink		Rating With Auxiliary Heat Sink	
			Maximum Continuous Load Current (Amps DC)	Maximum Horsepower (HP (kW))	Maximum Continuous Load Current (Amps DC)	Maximum Horsepower (HP (kW))
KBBW-12	9140	12	14	1/6 (0.12)	20	1/4 (0.18)
KBBW-22	9141	24	14	1/3 (0.25)	20	1/2 (0.37)

\*Suggested Fuse or Circuit Breaker Rating: 20 Amps for 14 Amps load current and 25 Amps for 20 Amps load current.

## 2 PLUG-IN HORSEPOWER RESISTOR® (PHR)

The PHR is supplied by your distributor and must be installed for the drive to operate. It is used to automatically calibrate the IR Compensation and Current Limit based on motor horsepower. It eliminates the need to recalibrate the drive in most applications. Select the appropriate PHR in accordance with Table 3. Be sure it is inserted completely into the mating sockets and installed as shown in Figure 1 on page 1.

**TABLE 3**  
**PLUG-IN HORSEPOWER RESISTOR® CHART\***

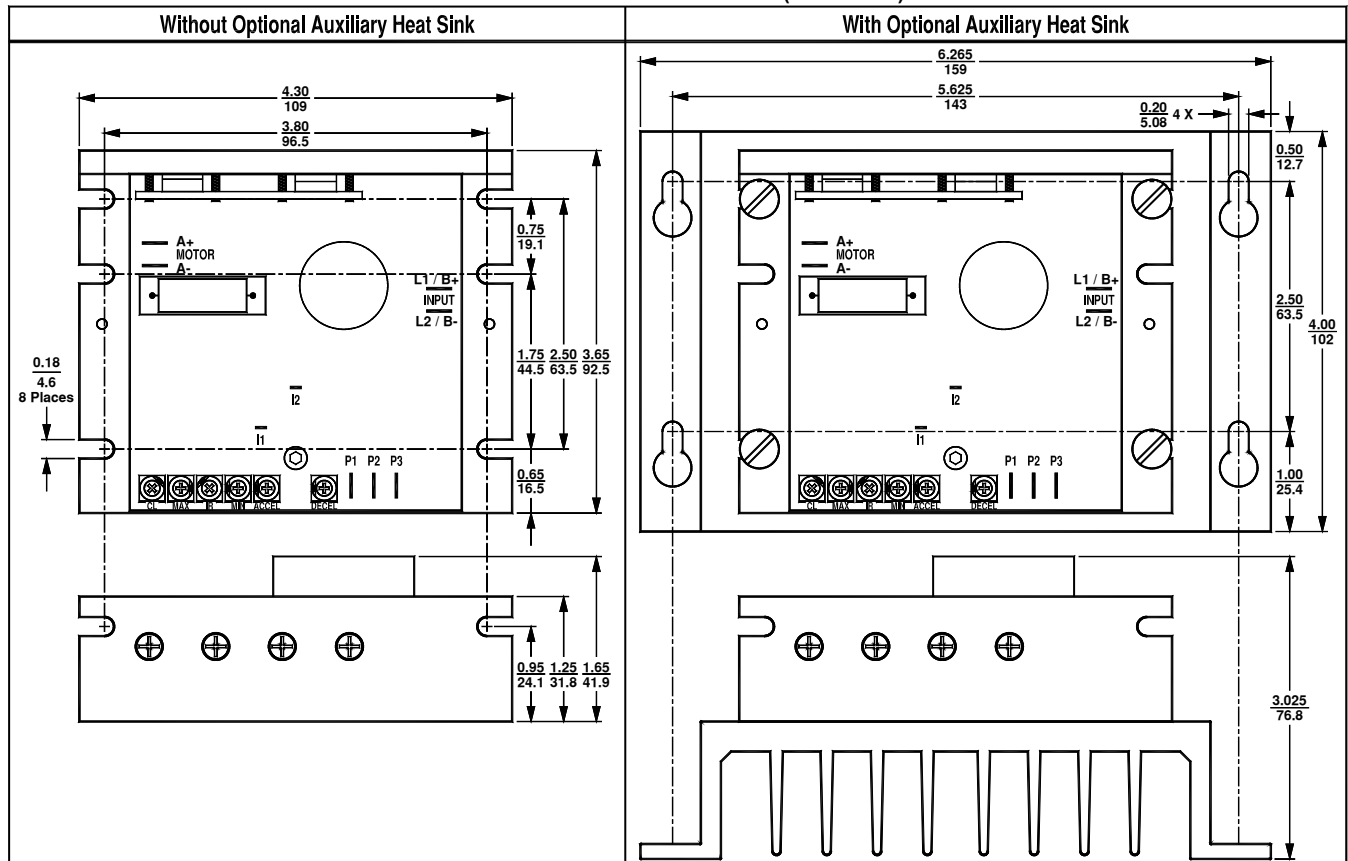
Motor Current (Amps DC)	Plug-In Horsepower Resistor®		Motor Horsepower (HP (kW))	
	Ω	KB Part No. (Individual)	Model KBBW-12	Model KBBW-22
20	0.006	9850	1/4 (0.18)	1/2 (0.37)
14	0.01	9843	1/6 (0.12)	1/3 (0.25)
10	0.015	9842	1/8 (0.09)	1/4 (0.18)
6	0.025	9841	1/14 (0.05)	1/7 (0.11)

\*For a motor current that is not listed on the chart, use the next lower value Plug-In Horsepower Resistor®. Supplied separately by your distributor.

## 3 MOUNTING INSTRUCTIONS

The drive should be mounted on a flat surface and located in an area where it will not be exposed to contaminants such as water, metal chips, solvents, or excessive vibration. When mounting the drive in an enclosure, the enclosure should be large enough to allow proper heat dissipation so that the ambient temperature does not exceed 40 °C (104 °F) at full rating. See Figure 2.

**FIGURE 2**  
**MECHANICAL SPECIFICATIONS (INCH / mm)**



## 4 ELECTRICAL CONNECTIONS

See Figure 3 for the general connections to the drive.

**WARNING!** Disconnect the main power before making connections to the drive. Read Safety Warning on page 4.

**4.1 DC Input:** Connect the positive (+) lead to Terminal L1/B+ and the negative (-) lead to Terminal L2/B-. Be sure the DC input corresponds to the drive voltage rating, as shown in Table 2 on page 2.

**Caution!** Connecting the battery incorrectly will permanently damage the drive.

**4.2 DC Input Fusing:** The drive does not contain a DC input fuse. It is suggested that a fuse be installed in series with the positive (+) DC input going to Terminal L1/B+. For a 14 Amp load current, install a 20 Amp fuse or circuit breaker. For a 20 Amp load current install a 25 Amp fuse or circuit breaker.

**4.3 Motor Armature:** Connect the positive (+) lead to Terminal A+ and the negative (-) lead to Terminal A-. Be sure the motor voltage corresponds to the drive output voltage rating, as shown in Table 2 on page 2.

**Note:** If the motor rotates in the incorrect direction, it will be necessary to disconnect the DC input power and reverse the armature leads.

**4.4 Inhibit Switch or Contact:** The drive can be electronically stopped and started with an Inhibit switch or contact connected to Terminals I1 and I2. When the switch or contact is closed, the motor will coast to stop. When the switch or contact is opened, the motor will run at the Main Speed Potentiometer or signal input setting.

**Warning!** Inhibit is never to be used as a safety disconnect since it is not fail-safe. Use only the DC input for this purpose.

**4.5 Signal Input:** The drive can be operated with a 5 kΩ Main Speed Potentiometer (supplied), a 0 – 5 Volt DC analog signal, or an isolated PWM microprocessor signal. See Figures 4 – 6.

**Note:** When connecting multiple drives, an isolated signal or isolation diode must be used.

### 4.5.1 Main Speed Potentiometer:

Connect the potentiometer low side to Terminal P1, the wiper to Terminal P2, and the high side to Terminal P3. See Figure 4.

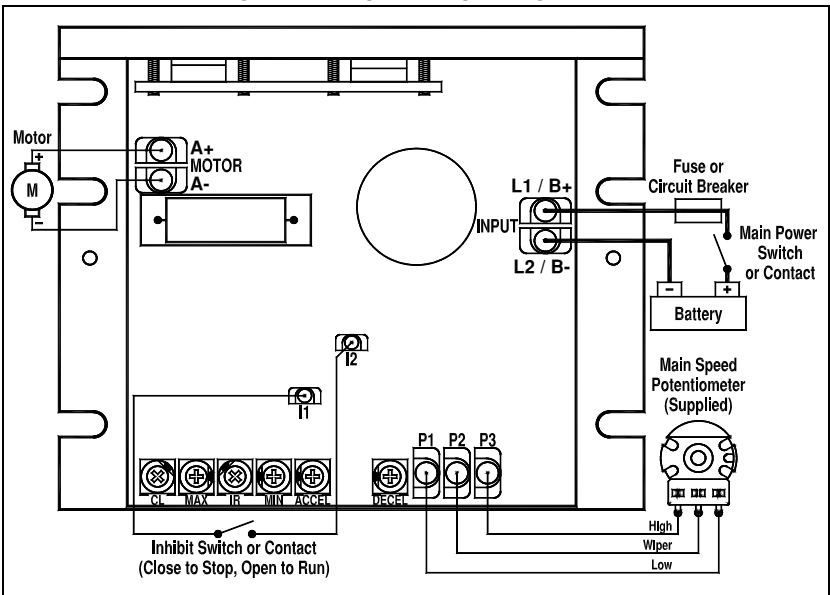
### 4.5.2 Voltage Following Signal Input:

Connect the signal input negative (-) lead to Terminal P1 and the positive (+) lead to Terminal P2 and the. See Figure 5.

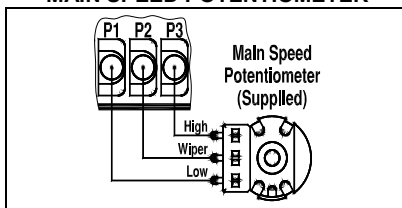
### 4.5.3 Microprocessor Signal Input:

Connect the isolated PWM signal negative (-) lead to Terminal P1, the signal lead to Terminal P2, and the positive (+) lead to Terminal P3. The output frequency must be 200 Hz or higher. See Figure 6.

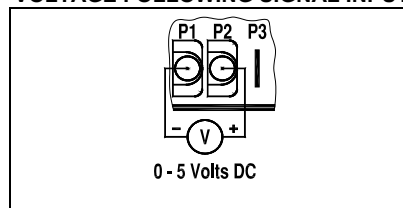
**FIGURE 3**  
GENERAL CONNECTION DIAGRAM



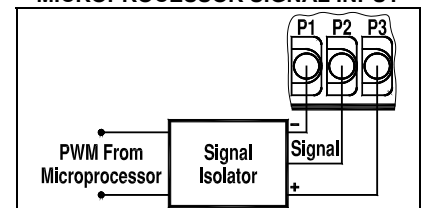
**FIGURE 4**  
MAIN SPEED POTENTIOMETER



**FIGURE 5**  
VOLTAGE FOLLOWING SIGNAL INPUT



**FIGURE 6**  
MICROPROCESSOR SIGNAL INPUT



## 5 ADJUSTABLE TRIMPOTS

The drive contains trimpots which have been factory set for most applications. Some applications may require readjustment of the trimpots in order to tailor the drive for a specific requirement. See Figures 7 – 12 for the trimpot ranges and Sections 5.1 – 5.6 on page 4 for descriptions.


**WARNING!** If possible, do not adjust trimpots with the main power applied. If adjustments are made with the main power applied, an isolated adjustment tool must be used and safety glasses must be worn. The Safety Warning on page 4 must be read and understood before proceeding.

<b>FIGURE 7</b> CL TRIMPOT RANGE (% RANGE SETTING)	<b>FIGURE 8</b> IR TRIMPOT RANGE (% RATING)	<b>FIGURE 9</b> MAX TRIMPOT RANGE (% BASE SPEED)	<b>FIGURE 10</b> MIN TRIMPOT RANGE (% BASE SPEED)	<b>FIGURE 11</b> ACCEL TRIMPOT RANGE (SECONDS)	<b>FIGURE 12</b> DECEL TRIMPOT RANGE (SECONDS)

**5.1 Current Limit Trimpot (CL):** Be sure the appropriate Plug-In Horsepower Resistor® is installed, in accordance with Table 3 on page 2. The CL Trimpot sets the current limit (overload), which limits the maximum current (torque) to the motor. The CL also limits the DC input inrush current to a safe level during startup. The CL Trimpot is factory set to 1.5 times the full load rating of the drive. To increase the current limit, rotate the CL Trimpot clockwise. To decrease the current limit, rotate the CL Trimpot counterclockwise. See Figure 7 on page 3. **Do not exceed 2 times motor current rating (maximum clockwise position).**

**To Recalibrate the CL Trimpot:**

- 1 Disconnect the DC input power and wire a DC ammeter in series with either motor armature lead.
- 2 Set the Main Speed Potentiometer to approximately 30 – 50% clockwise position.
- 3 Set the CL Trimpot fully counterclockwise.
- 4 Lock the motor shaft (be sure the CL Trimpot is set fully counterclockwise).
- 5 Apply power and rotate the CL Trimpot clockwise until the desired current reading is observed on the DC ammeter. Factory Current Limit setting is 1.5 times the full load rating of the motor.

 **Caution!** Do not leave motor shaft locked for more than 2 – 3 seconds or motor damage may result.

**5.2 IR Compensation Trimpot (IR):** Be sure the appropriate Plug-In Horsepower Resistor® is installed, in accordance with Table 3 on page 2. The IR Trimpot sets the amount of compensating voltage required to keep the motor speed constant under changing loads. If the load does not vary substantially, the IR Trimpot may be set to a minimum level (approximately 1/4 of full clockwise rotation). To increase the amount of compensating voltage, rotate the IR Trimpot clockwise. To decrease the amount of compensating voltage, rotate the IR Trimpot counterclockwise. See Figure 8 on page 3.

*Note: Excessive IR Compensation will cause the motor to become unstable, which causes cogging.*

**To Recalibrate the IR Trimpot:**

- 1 Set the IR Trimpot to approximately 25% rotation.
  - 2 Run the motor unloaded at approximately 1/3 speed and record the RPMs.
  - 3 Run the motor with the maximum load and adjust the IR Trimpot so that the motor speed equals the unloaded speed recorded in step 2.
  - 4 Remove the load and recheck the RPMs.
  - 5 If the unloaded RPM has changed, repeat steps 2 – 4 for more exact regulation.
- The control is now compensated to provide minimal speed change due to changing loads.

**5.3 Maximum Speed Trimpot (MAX):** The MAX Trimpot sets the maximum speed of the motor when the Main Speed Potentiometer is set fully clockwise. The MAX Trimpot is factory set to 100% of base motor speed. To increase the maximum speed, rotate the MAX Trimpot clockwise. To decrease the maximum speed, rotate the MAX Trimpot counterclockwise. See Figure 9 on page 3.

**Caution!** Do not set the maximum speed above the rated motor RPM since unstable motor operation may occur.

**5.4 Minimum Speed Trimpot (MIN):** The MIN Trimpot sets the minimum speed of the motor when the Main Speed Potentiometer is set fully counterclockwise. The MIN Trimpot is factory set to 0% of base motor speed. To increase the minimum speed, rotate the MIN Trimpot clockwise. To decrease the minimum speed, rotate the MIN Trimpot counterclockwise. See Figure 10 on page 3.

**5.5 Acceleration Trimpot (ACCEL):** The ACCEL Trimpot is provided to allow for a smooth start over an adjustable time period each time the DC input is applied or the Main Speed Potentiometer is adjusted to a higher speed. The ACCEL Trimpot is factory set to 2.5 seconds, which is the amount of time it will take for the motor to accelerate from zero speed to full speed. To increase the acceleration time, rotate the ACCEL Trimpot clockwise. To decrease the acceleration time, rotate the ACCEL Trimpot counterclockwise. See Figure 11 on page 3.

**5.6 Deceleration Trimpot (DECEL):** The DECEL Trimpot controls the amount of ramp-down time when the Main Speed Potentiometer is adjusted to a lower speed. The DECEL Trimpot is factory set to 2.5 seconds, which is the amount of time it will take for the motor to decelerate from full speed to zero speed. To increase the deceleration time, rotate the DECEL Trimpot clockwise. To decrease the acceleration time, rotate the DECEL Trimpot counterclockwise. See Figure 12 on page 3.

*Note: The deceleration time cannot be made less than the natural coast time of the motor and actual load.*

## 6 OPERATION

After the drive has been set up properly and wiring has been completed, the start-up procedure can begin. Before starting, be sure that the Main Speed Potentiometer is in the minimum position (fully counterclockwise). Be sure the appropriate Plug-In Horsepower Resistor® is installed, in accordance with Table 3 on page 2. To start the drive, rotate the potentiometer clockwise. The motor should begin to rotate.

**Note:** If the motor rotates in the incorrect direction, it will be necessary to disconnect the DC input power and reverse the armature leads.



**SAFETY WARNING! – PLEASE READ CAREFULLY!**

This product must be installed and serviced by a qualified technician, electrician, or electrical maintenance person familiar with its operation and the hazards involved. Proper installation, which includes electrical connections, fusing or other current protection, and grounding, can reduce the chance of electrical shocks, and/or fires, in this product or products used with this product, such as electric motors, switches, coils, solenoids, and/or relays. Do not use this drive in an explosion-proof application. Eye protection must be worn and insulated adjustment tools must be used when working with drive under power. This product is constructed of materials (plastics, metals, carbon, silicon, etc.) which may be a potential hazard. Proper shielding, grounding, and filtering of this product can reduce the emission of radio frequency interference (RFI) which may adversely affect sensitive electronic equipment. It is the responsibility of the equipment manufacturer and individual installer to supply this Safety Warning to the ultimate end user of this product. (SW 8/2012)

The drive contains electronic Start/Stop circuits, which can be used to start and stop the drive. However, these circuits are never to be used as safety disconnects since they are not fail-safe. Use only the DC input for this purpose. Be sure to read and follow all instructions carefully. Fire can result due to improper use of this product.



# KBBW AUXILIARY HEAT SINK KIT (PART NO. 9142) INSTALLATION INSTRUCTIONS AND MOUNTING TEMPLATE

## ITEMS INCLUDED WITH THIS KIT

Heat Sink, Four (4) 10-32 X 1/2" Screws, and Installation Instructions

### DESCRIPTION

The Auxiliary Heat Sink Kit increases the drive's current rating from 14 Amps DC to 20 Amps DC. See Table 1.

**TABLE 1: ELECTRICAL RATINGS\***

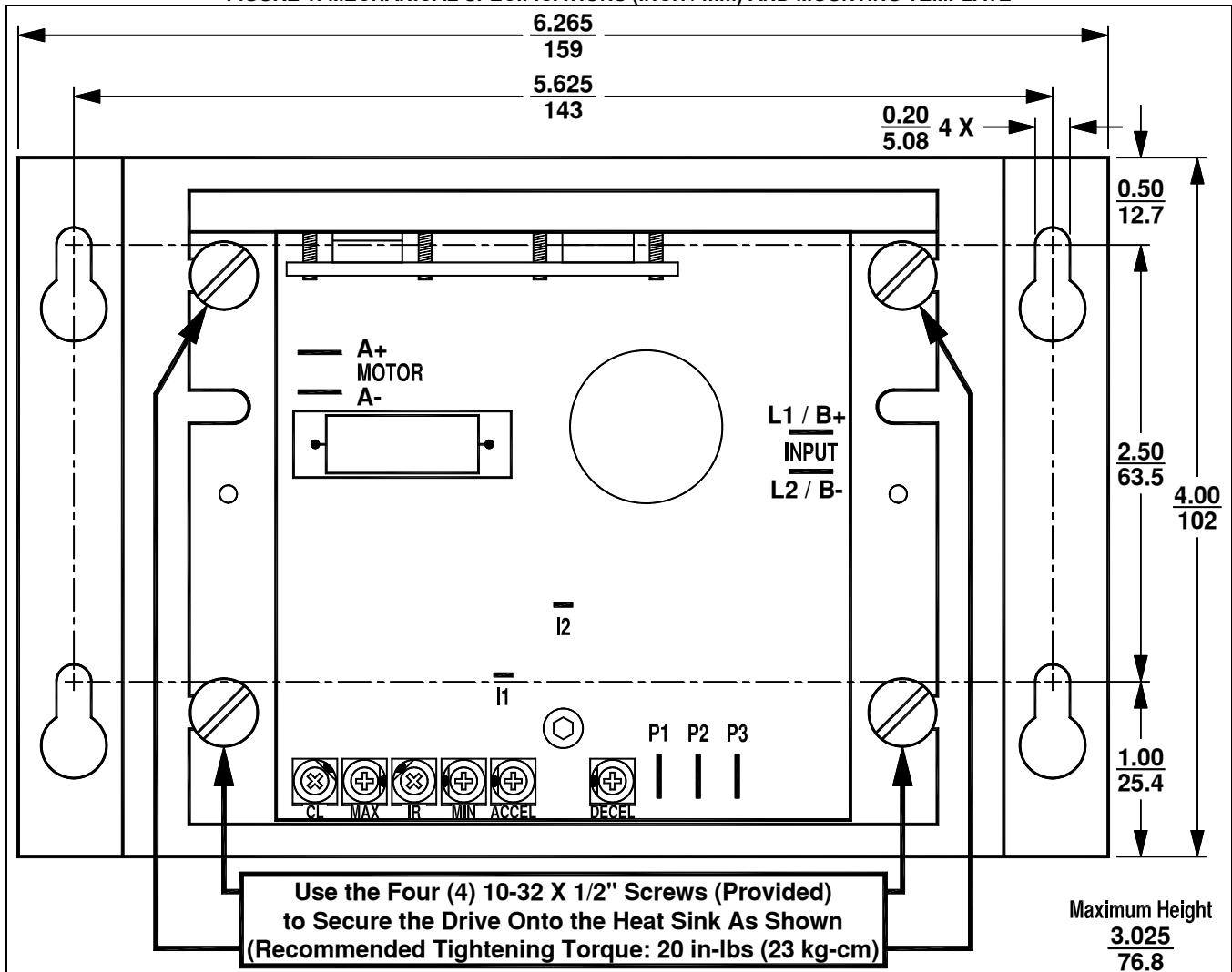
Model No.	Part No.	Input Voltage (Volts DC)	Rating Without Auxiliary Heat Sink		Rating With Auxiliary Heat Sink	
			Maximum Continuous Load Current (Amps DC)	Maximum Horsepower (HP (kW))	Maximum Continuous Load Current (Amps DC)	Maximum Horsepower (HP (kW))
KBBW-12	9140	12	14	1/6 (0.12)	20	1/4 (0.18)
KBBW-22	9141	24	14	1/3 (0.25)	20	1/2 (0.37)

\*Suggested Fuse or Circuit Breaker Rating: 20 Amps for 14 Amps load current and 25 Amps for 20 Amps load current.

### MOUNTING INSTRUCTIONS

The drive should be mounted on a flat surface and located in an area where it will not be exposed to contaminants such as water, metal chips, solvents, or excessive vibration. When mounting the drive in an enclosure, the enclosure should be large enough to allow proper heat dissipation so that the ambient temperature does not exceed 40 °C (104 °F) at full rating. Always mount the heat sink vertically, if possible, to achieve maximum efficiency. Mount the heat sink with the keyhole slots positioned as shown. See Figure 1.

**FIGURE 1: MECHANICAL SPECIFICATIONS (INCH / mm) AND MOUNTING TEMPLATE**



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