B140 Dynamic Brake
Technical Manual

Part Number 4201-227 Revision B

IMPORTANT

Read and understand the procedures described in this manual before attempting to install or commission your unit.

If in doubt, before proceeding, please contact Bardac Drives at:

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IMPORTANT NOTES

The B140 operates a **HIGH POWER DC CIRCUIT AT LETHAL VOLTAGES**. Great care **MUST** be taken in the application and protection of the B140 and the load resistors.

The heat generated, by the resistors connected to the B140 operating under full power or **FAULT CONDITIONS,** can reach up to 220kW. The design of the system must include **FAIL-SAFE** protection to prevent a **FIRE HAZARD** under all conditions.

The B140 operates at **RECTIFIED MAINS POTENTIAL**. Up to 735Vdc may be present whenever the mains supply is present. Ensure the B140 Brake System, including any Motor Controller and load bank it is connected to, are **COMPLETELY DISCHARGED** before removing the Gland Plate, cover or attempting any maintenance. This includes operation of the Master/ Slave and Sense Volts dipswitch.

The B140 provides functional braking. It is not a safety brake and should not be employed as such. A separate mechanical safety brake must be used where necessary.

It is the responsibility for the installer to ensure that all the manufacturer's recommendations are followed and that any site specific, local and national **safety and electrical regulations for installation and operation** are complied with.

Both the Gland Plate and Gland Plate cover must be installed correctly (see Figure 2.2) for the B140 to acheive the specified IP20 rating.

SECTION 1: INTRODUCTION

Utilisation of a dynamic brake system provides the Elite Series of AC motor controllers with the ability to cope with regeneration as may be experienced during the deceleration of a high inertia load (e.g., a large fan or centrifuge), or a regenerative load (e.g., lowering of a crane hoist). The dynamic brake system converts this regenerative energy to heat in the dynamic brake resistor. Thus control of the motor is maintained.

The B140 is the main power switching element of such a dynamic brake system.

The B140 can be controlled by an external trigger signal (such as provided by the Elite Series) or by the built-in voltage sensing circuit. An output is provided for slaving multiple B140 to provide extra braking capability. A fail-safe no fault relay indicates fault status.

The B140 can switch up to 300A at 735Vdc into a resistive load. Up to 220kW of regenerated power may be switched by each B140.

A dynamic brake resistor will need to be selected and purchased to suit the individual application.

The B140 measures a compact 387 x 154.5 x 189.5mm which can be fitted in the plinth and termination areas of the 170-660A Ultradrive Elite Series.

Plug-in control terminals allow for speedy change-over should the unit require relocation or service.

SECTION 2: ELECTRICAL SPECIFICATIONS & TECHNICAL DATA

Note: For operation outside of these parameters, contact the Manufacturer.

ELECTRICAL SPECIFICATION:

Dynamic brake switching voltage (switch selectable)	390Vdc or 735Vdc
Maximum switch current	300A (R=2.4Ω @ 735Vdc)
Continuous current rating	140A (R=5.2Ω @ 735Vdc)
Minimum resistor rating	2.4Ω

For current greater than 140A, refer to the derating chart shown in Figure 2.1, or Section 3.6 for multiple B140 units.

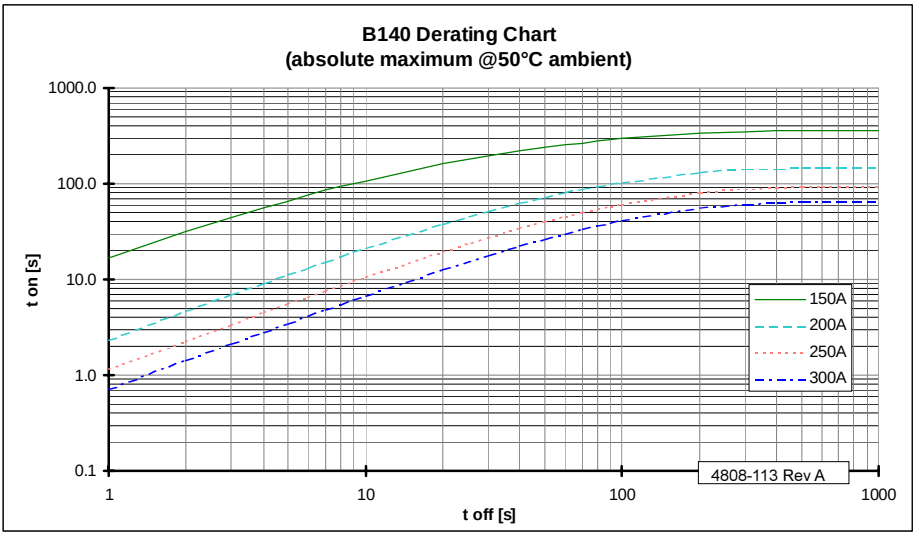

Figure 2.1: Derating at 50°C Ambient for Periodic Duty

PROTECTION:

IGBT desaturation trip	Trip when switching into short circuited resistor
IGBT heatsink over temperature	Trip when IGBT heatsink over 90°C
Resistor open circuit	Trip when switching into open-circuit resistor
Overheated resistor	Configurable for external resistor overheat

BRAKE VOLTAGE CONTROL:

Mode selection	Slave (by external controller) Master (internal sensing circuit)

	These selections are manually selected by the user
Voltage selection	390Vdc / 735Vdc

OUTPUTS:

Fail-safe no fault relay	Normally closed; Opens under fault condition or no power. Non-latching
Slave DB control	13mA current output

ENVIRONMENTAL SPECIFICATION:

Protection standard	IP20: Protected against accidental electrical contact. Maximum Pollution degree 2, (non-corrosive environment)
Operating temperature	0 to 50°C
Relative humidity (Rh)	80% @ 31°C to 50% @ 50°C
Storage temperature	-25°C to 80°C
Altitude	1000m
Altitude derating (for >1000m)	-1% per 100m; 3000m max.

Note: Both the Gland Plate and Gland Plate cover must be installed correctly as in Figure 2.2 to achieve specified IP20 rating and EMC compliance.
All packaging is recyclable.

FASTENERS:

Power Terminals:	(4)	M8 x 25 fastener with bolts, nuts and washers.
Mounting:	(4)	M5 fastener with washer.

DIMENSIONS:

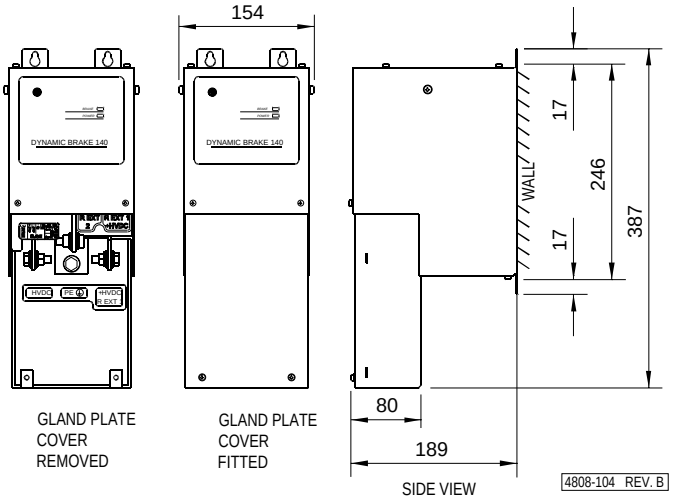

Figure 2.2: B140 External Dimensions

SECTION 3: UNPACKING, INSTALLATION AND CONNECTION

3.1 INSTALLING THE B140

The B140 must be installed in a suitable environment as detailed below. As with all equipment, the cleaner, cooler and more vibration free, the longer and more trouble free will be the life of the B140.

The ambient temperature must not be below 0°C, and must not exceed the B140 specification of 50°C; maximum relative humidity should be less than 80% at 31°C (decreasing linearly to 50% relative humidity at 50°C). There must be no condensation. Do not mount the B140 in direct sunlight.

The B140 must be mounted vertically (refer to Figure 3.1) with the back panel to the wall to ensure proper cooling. Allow 150mm of free air space vertically and 50mm of free air space horizontally from other equipment or the localised maximum ambient air temperature may exceed specifications of 50°C. Ensure that the airflow from the fan is not obstructed.

Avoid mounting multiple B140 inline above other air cooled units to prevent accumulated air heating. Ensure dirt does not form on the heatsink by occasionally cleaning the fins with compressed air.

If the B140 is mounted in a cabinet, ensure that sufficient cooling is available to prevent the localised air ambient exceeding specification of 50°C (refer PDL Application note 4216-008, Fully Enclosed Drive Cabinet Sizing).

The maximum cable length allowed between the B140 and the Elite Series is 2 metres.
The maximum cable length allowed between the B140 and the resistor is 20 metres.

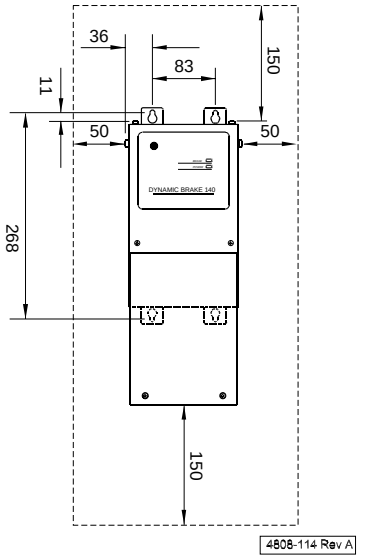

Figure 3.1: Mounting of the B140 indicating 150mm clear air space top and bottom and 50mm air space on sides

3.2 UNPACKING AND ASSEMBLY OF THE B140

The B140 is packaged in a recyclable cardboard carton. Please recycle this carton and packaging materials thoughtfully, if not retaining them.

When received, the B140 gland plate and gland plate cover need to be removed as per Figure 3.2 and the clear protective cover removed and discarded. The installer will need to attach the gland plate after drilling the appropriately sized gland holes, refer to Figure 3.1 for mounting details.

Mounting brackets (4 of) are supplied with the unit that slide into the four slots (2 Top, 2 Bottom) in the base of the unit. These should slide home securely and clip-lock together. The gland plate and gland plate cover must be attached correctly prior to operation of the B140 using M4 x 10 screws supplied. If the unit is to be used without the gland plate and cover then the B140 must be mounted in a suitable enclosure. The dynamic brake should be mounted to the wall before the attachment of the gland plate to allow access to the bottom mounting bolts.

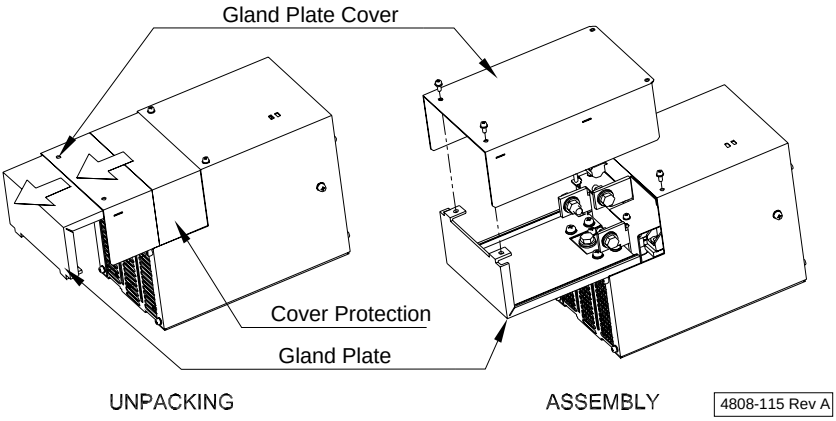

Figure 3.2: Unpacking from shipping position and assembly of gland plate and cover

3.3 POWER WIRING CONNECTIONS

Some applications will require a mechanical brake as a safety measure in the event of dynamic brake failure. The output of the B140 no fault relay can be used to operate the mechanical brake.

When utilising the B140 with the Elite Series refer to Figure 3.3 for the connection details.

Screened cables should be utilised for all wiring to ensure EMC compliance. Cable screens should be correctly earthed.

Connect the supply protective earth conductor to the B140 protective earth (PE) terminal (⏚).

Separate control and power wiring by at least 300mm.

3.3.1 ELITE SERIES TO B140 ±HVDC BUS CONNECTION

WARNING: Isolate the drive to be connected and allow stored charge to dissipate before proceeding.

Due to the high switching speed and current of the B140, special wiring practices must be observed. A multicore cable connecting the HVDC bus terminals is strongly recommended. Alternatively, two separate single core cables, securely cable tied together at 200mm intervals without any gaps between them, may be used to connect the Elite Series to the B140. This minimises the cable inductance.

Connect the Elite Series (+) and (-) HVDC bus terminals to the B140 +HVDC and -HVDC terminals as per Figure 3.3, using a low inductance cable of shortest possible length (less than two metres). Be careful to observe correct polarity.

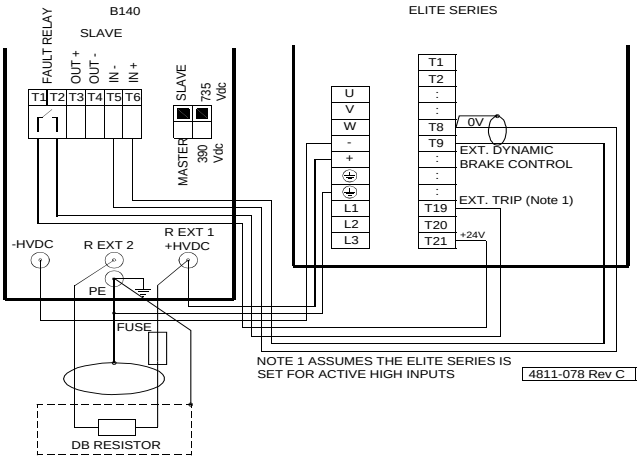

Figure 3.3: Details of the Elite Series to B140 Connection

3.3.2 DYNAMIC BRAKE RESISTOR CONNECTION

The external resistor **MUST** be of non-inductive construction.

For additional protection of the B140, the use of extremely fast acting fuses of correct rating is recommended (e.g. Ferraz Shawmut 1021 CP URB 26 x 60/100 or equivalent). Further fuses can be added to protect the Dynamic Brake resistor.

Due to the high switching speed and current of the B140, special wiring practices must be observed. A screened multicore cable to the dynamic brake resistor is strongly recommended. Alternatively, two separate single core cables, securely cable tied together at 200mm intervals without any gaps between them, may be used to connect the resistor to the B140. This minimises the cable inductance.

The dynamic brake resistor is connected to the terminals labelled **R EXT 1** and **R EXT 2** using low inductance cable, as in Figure 3.3.

The maximum cable length allowed between the B140 and the external resistor is 20 metres.

Cable sizing may be selected utilising the Average Brake Resistor Current (I_{AV}) instead of the Peak current rating:

$$I_{AV}=I_{PK} \times D_R$$

3.4 ELITE SERIES CONTROL WIRING CONNECTION

WARNING: Do no operate the dipswitch when live. Isolate the brake and allow stored charge to dissipate before proceeding.

When the B140 is connected to the PDL Elite Series Motor Controllers, connect the dynamic brake control output of the Elite Series 0V and External Dynamic Brake Control terminals (Elite Series Terminals T8 and T9) to the B140 control input **SLAVE IN–** and **SLAVE IN+** terminals, as shown in Figure 3.3 .

Set the **DB CONTROL** switch of the B140 to the **SLAVE** position. In this mode the position of the **SENSE VOLTS** switch is immaterial.

When the B140 is used as **MASTER** control, set the B140 control switch to **MASTER** position. In addition, set the **SENSE VOLTS** switch per Table 3.1.

EARTHING OF CONTROL 0V

To comply with the requirement of a Class 1 earthing system, the B140 control 0V must be linked to earth at some point. Connection of multiple earth points may cause earth loops and should be avoided. Control 0V point is allowed to float up to ±50Vdc (30Vac) from chassis earth.

VOLTAGE RATING MAINS SUPPLY	SWITCH POSITION
230V	390Vdc
400V	735Vdc

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Table 3.1: B140 Sense Volts Switch

3.5 MASTER/SLAVE CONTROL SETTING

When utilising the B140 with the Elite Series, the B140 is typically configured to run in the Slave Control Mode. In this mode, the Elite Series controls when the B140 switches on.

Alternatively, the B140 may be configured in Master Control Mode where the B140 itself monitors the DC bus voltage and automatically switches on as required.

3.6 CONNECTION OF MULTIPLE B140 UNITS

Where the application requires more braking current than the rating of a single B140, multiple B140 units can be connected in parallel.

The first B140 may be configured as MASTER or SLAVE. All other B140 units must be configured as SLAVE.

Connect the **SLAVE OUT+** to the **SLAVE IN+** of the cascaded B140.
Connect the **SLAVE OUT–** to the **SLAVE IN–** of the cascaded B140.

Each B140 unit must have a separate dynamic brake resistor.

3.7 FAIL-SAFE NO FAULT RELAY CONNECTION

The B140 Fail-safe No Fault **RELAY** is closed during normal operation. The relay contacts open when the power is removed or a fault has occurred. The terminals are labelled with the relay symbol. The following faults are signalled via an internal LED on the Dynamic Brake PCB:

- **Desaturation of the IGBT** possible cause: resistor short circuit, faulty wiring, over current.

- **IGBT overtemperature** possible cause: output current exceeded, insufficient cooling of heatsink.
- **Resistor open circuit** possible cause: faulty resistor or resistor wiring, no resistor attached.

Note: The internal LED is for fault finding only and is only clearly visible when the gland plate cover is removed. This is a potentially fatal operation and should only be carried out by qualified personnel.

If the B140 trips out for any reason, the dynamic braking effect will be lost. Under this circumstance, certain loads may require additional or back up mechanical braking. The contacts of the fail-safe no fault relay should be used to trigger the mechanical brake.

Alternatively, the B140 fail-safe no fault relay can be used to signal to the Elite Series that a External Trip is required (using the Elite External Trip/PTC input; Terminal T19) and then the Elite Series controls the mechanical brake via its own Fault Relay. When multiple B140s are used, the individual fault relays should be connected in series.

The B140 automatically resets the fault condition if the fault has been removed. There is no external reset and the fault is not latched.

3.8 MOUNTING OF THE DYNAMIC BRAKE RESISTOR

Careful consideration must be given to the mounting of dynamic brake resistors. These devices must dissipate large amounts of power and will often attain high temperatures. The resistors must be provided with sufficient cool air to allow normal cooling. The hot air exhaust must be vented well clear of equipment or materials that can be damaged by high temperatures. Any objects heated by convection and conduction may also create safety or fire hazards. Ensure that the material the resistors is mounted to is suitable for the operating conditions and temperatures (refer Section 4.1 for resistor selection).

3.9 RESISTOR THERMAL PROTECTION

A failure of the B140 may cause the resistors to be turned **ON** permanently. Unless preventative action is taken, the power generated could easily lead to the destruction of low duty cycle resistors or fire.

In addition, a malcalibrated thermal model will not adequately protect a resistor. As a result, the resistor may be damaged, causing loss of control of the motor, and possibly a fire hazard.

To prevent such occurrences, it is advisable to provide additional over-temperature protection such as thermal fuses or a latching type microtherm mounted near the resistor.

The microtherm should be connected in series with the B140 Fail-safe No Fault **RELAY** and the Elite Series External Trip/PTC circuit.

Thermal fuses or thermostats fitted to the resisor bank and connected to the coil of a contactor in the AC Motor Controller supply, will provide a second level of protection.

Better protection is afforded by also controlling a DC rated contactor wired in series with the dynamic brake resistor. This also provides protection in the case of the B140 failing and permanently switching on. The resistor contactor must be DC rated, **NEVER** substitute an AC rated contactor!

SECTION 4: APPLICATION RECOMMENDATIONS

One of the most common applications for the B140 is to aid in the rapid deceleration of loads that have a high level of inertia (e.g., large fans or centrifuges).

In this type of application, when the AC motor controller begins to decelerate the load, the slip speed of the motor can become negative. This causes the motor to regenerate energy charging the DC Bus capacitors, increasing the DC Bus voltage. The dynamic brake is turned on when the DC Bus voltage reaches a preset level.

The B140 has the ability to monitor the DC Bus voltage directly using an internal voltage sensor (Master Control Mode - refer Section 3.5), or utilise an external controller to monitor and direct the B140 when to switch on (Slave Control Mode - refer Section 3.5).

When the B140 switches on, the dynamic brake resistor is connected across the DC Bus thus dissipating the regenerated energy and controlling the DC Bus voltage. Figure 4.1 shows the configuration for the dynamic brake system.

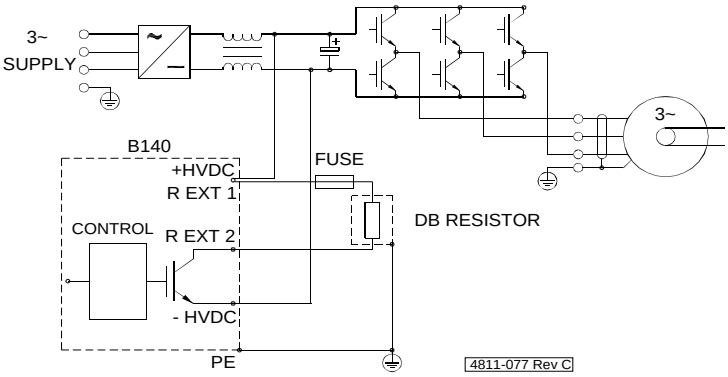

Figure 4.1: B140 Operational Schematic

The effect of this action is that the mechanical energy in the load that is reflected back into the DC Bus, is converted to heat in the brake resistor and the control of the motor deceleration is maintained.

If the level of regeneration exceeds the capability of the dynamic brake system the DC Bus voltage will continue to rise. This will cause the AC motor controller to hardware voltage limit or trigger a HVDC fault. In either case, the motor controller will have lost control of the motor. This is an undesirable situation and should be rectified by either increasing the thermal capacity of the dynamic braking resistors and/or paralleling up multiple B140 units (refer Section 3.6).

4.1 DYNAMIC BRAKE RESISTOR SELECTION

The external resistor MUST be of non-inductive construction.

To select the appropriate power rating and thermal capacity of the dynamic brake resistor, a number of requirements must be determined and calculated. For application advice on resistor sizing and cabling requirements please request assistance from PDL Electronics Ltd or its agent.

4.1.1 PEAK INSTANTANEOUS REGENERATED POWER (P_{GPK})

This is the absolute maximum peak power generated from the load that must be absorbed by the dynamic brake resistor. This value is used to determine the minimum resistance of the dynamic brake resistor. Therefore, select a dynamic brake resistor with a Peak Power rating (P_{RPK}) greater than the Peak Instantaneous Regenerated Power (P_{GPK}).

In all cases, do not select a dynamic brake resistor such that the B140 maximum switch current of 300A is exceeded.

4.1.2 SHORT TERM AVERAGE REGENERATED POWER (P_{GAV})

This is the average power generated by the load over a short term repetitive cycle. Ensure that the resistor has a continuous power rating greater than the Short Term Average Regenerated Power (P_{GAV}) of the load.

4.1.3 THE DYNAMIC BRAKE RESISTOR DUTY RATING (D_R)

The allowable short term dynamic brake Duty Rating (D_R) of the dynamic brake resistor must be known for correct protection of the resistor. This value will be required when commissioning the B140 (refer Section 6).

The allowable short term dynamic brake Duty Rating (D_R) can be calculated from the following equation:

$$D_R = (P_{GPK}/P_{GAV}) \times 100\%$$

The actual brake resistor Average Dissipated Power is (P_{RAV})

$$P_{RAV} = (P_{GPK} \times D_R) / 100\%$$

If the Average Power Dissipated (P_{RAV}) is greater than the rating of any available resistor, then multiple B140 and resistors could be used in parallel (refer to Section 3.6).

4.1.4 DYNAMIC BRAKE RESISTOR THERMAL TIME CONSTANT (τ_R)

The dynamic brake resistor Thermal Time Constant (τ_R) must be known for correct protection of the resistor. This value will be required when commissioning the B140 with a PDL Electronics Elite Series AC Motor Controller (refer Section 6).

If the Thermal Time Constant (τ_R) for the resistor is not available from the resistor manufacturer, it must be measured. This process is as follows:

- Measure the room temperature (T_{AMB})
- Apply 50-100% of the Average Dissipated Power (P_{RAV}) to the resistor mounted in its normal configuration.
- Allow the resistor surface temperature to stabilise (T_R).
- Record T_R. Remove power to resistor and record the time taken to reach 36% of T_R-T_{AMB}.
- This time is the Thermal Time Constant (τ_R) of the resistor. If τ_R is greater than 120s, use 120s to protect the B140.

4.2 USING THE B140 WITH OTHER AC MOTOR CONTROLLERS

The B140 may be used with other AC motor controllers such as the PDL Electronics Microdrive-i (UDi) Series and the Microvector-i (MVi) Series.

In addition, the B140 may be utilised with other manufacturer's AC motor controllers when set to Master Control Mode (refer Section 3.5). In this mode the B140 internally monitors and controls the switching on and off, of the dynamic brake resistor.

Contact the manufacturer or its agent for further information when utilising the B140 with product other than PDL Elite Series.

SECTION 5: ELECTROMAGNETIC COMPATIBILITY (EMC) AND SAFETY

5.1 CONTROL CABLES

The B140 has the ability to be controlled from an external source (i.e., Slave Mode see Section 3.5). When configured to do so, screened control cables must be used for the connection between the B140 and the external controller. There are no exceptions if you expect reliability. The screen should be connected to 0V on the control board of the external controller (irrespective of whether the control board is earthed or floating) as a radio frequency (RF) return. Avoid using long twisted leads (pigtails) for the screen connection as this twisting increases the RF impedance (reducing the effectiveness of the screen).

The B140 has an optically isolated input for external control. This prevents earth loops in the control wiring. An example of where this is useful is where multiple B140 are controlled using the same signal source.

Avoid running control cables in parallel with power cables with a spacing less than 300mm. Cross control cables at right angles to power cables to avoid magnetically induced interference.

5.2 DC BUS CABLES

DC bus connections between the Elite Series and the B140 may use unscreened cable. If screened cable is used, connect the screen at both the drive and the B140 to provide an RF return path. This prevents the B140 cabinet becoming a RF source, coupling into the local metalwork and the earthing system. Connect all earths (input, output and cabinet) together at one star point.

5.3 RESISTOR CABLES

Screened output power cables to any external resistor must be used for the B140 to comply with EMC regulations. A ferrite toroid (Siemens R100, B64290-L84-X35) should also be fitted to an unscreened portion of both resistor cables. This should be as close as practical to the B140. Both cables must be wound together (Bifilar) **THREE** times through the core centre. Connect the screen at both the B140 and resistor ends to provide an RF return path. This prevents the resistor frame becoming a RF source, coupling into the local metalwork and the earthing system. Avoid using long twisted leads (pigtails) for the screen connection as this twisting increases the RF impedance (reducing the effectiveness of the screen). Connect all earths (input, output and cabinet) together at one star point.

Local regulations may require that a separate earth be run to the resistor for safety requirements. It is recommended that three-core cable plus screen is used in these applications.

Screened cables and the ferrite toroid to the resistor prevent high speed switching noise from being radiated to the environment (for maximum cable length refer Section 3.3.2). Generally, it is better to keep resistor cables as short as possible to reduce capacitive charging currents due to cable capacitance and limit the peak voltage at the resistor terminals.

If unscreened cables to any external resistor are used or the ferrite toroid is omitted, EMC regulations may not be complied with.

SECTION 6: COMMISSIONING INSTRUCTIONS

WARNING: **Before applying power, double check that all connections are correctly made and ensure the gland plate and gland plate cover are correctly fitted. Any incorrect connection may result in extensive damage and danger to personnel!**

When the internal voltage sensing circuit is used (Master Control mode), check that the correct activation voltage is selected. Selecting the wrong sense voltage may lead to the B140 turning on continuously, possibly exceeding the rating of the dynamic brake resistor.

On power up, the POWER LED should light and the fan should turn on. The BRAKE LED should remain off.

6.1 CONFIGURING THE ELITE SERIES

Screens D1 and D2 on the Elite Series allow the dynamic brake to be configured. Refer to the Elite Series Technical Manual (PDL Part No. 4201-180) for a detailed description of these screens.

6.1.1 THE THERMAL TIME CONSTANT

The value of the time constant entered into the Elite Series Screen D1 is the smaller of the B140 Thermal Time Constant (τ_{B140}=120s) and dynamic brake resistor Thermal Time Constant (τ_R).

Note that this resistor Thermal Time Constant (τ_R) should either be stated by the resistor manufacturer or have been measured in Section 4.1.4. Compare this value with the 120s Thermal Time Constant of the B140 and use whichever is the smaller.

If multiple B140 units are utilised with identical resistors, the value of the time constant entered into the Elite Series Screen D1 does not change. If non-identical resistors are used, then enter the smallest time constant of all the resistors and the B140.

In all cases, do not exceed 120s, which is the Thermal Time Constant of the B140.

6.1.2 THE DYNAMIC BRAKE DUTY RATING

The dynamic brake resistor Duty Rating (D_R) represents the average percentage of time the dynamic brake resistor may be operated for. The B140 Duty Rating(D_{B140}) is listed in Table 6.1. The resistor Duty Rating (D_R) was calculated in Section 4.1.3.

The value of the Duty Cycle entered in the Elite Screen D2 is the smaller of the of the dynamic brake resistor Duty Rating (D_R) and the B140 Duty Cycle (D_{B140}). A quick reference chart for the B140 Duty Rating (D_{B140}) is contained in Table 6.1. A full Duty Rating (D_{B140}) curve is contained in Figure 2.1.

If multiple B140 are utilised, the value of the combined resistor bank Duty Rating is the sum of the individual resistor Duty Ratings.i.e.;

$$D_R = D_{R1} + D_{R2} + D_{R3} + \ldots$$

Compare the B140 Duty Rating with the resistor Duty Rating (D_R) and enter the smallest value into the Elite Series Screen D2. This value will protect the B140 and the resistors.

I RESISTOR [A]	DUTY [%]
up to 140	100
150	90
200	65
250	50
300	40
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Table 6.1: B140 Duty Rating (D_{B140})

6.2 CONFIRMING SYSTEM OPERATION

Check the system operation as explained in the Elite Series Technical Manual (PDL Part No. 4201-180). Under normal regenerative operation, check Screen Z10 on the Elite Series to confirm that the Elite Series is requesting that the B140 should switch on. At the same time confirm that the BRAKE LED illuminates on the B140 indicating that the B140 is actually switching the regenerated voltage through to the brake resistor.

6.3 MAINTENANCE

Ensure that the AC motor controller and the dynamic brake system are completely discharged and locked out of service before any maintenance is started.

Periodically, the B140 heatsink should be inspected and if required, cleaned with compressed air to help prevent clogging of the fins. Additionally, the dynamic brake resistor (once cooled to room temperature) may also be cleaned with compressed air. This procedure should be done more frequently if the B140 is located in a high pollution area.

Ensure that the B140 cooling fan is operating correctly.

Ensure the resistor is clean and clear from obstruction.

6.4 MANUFACTURER'S RECOMMENDATIONS

Failure to adhere to the manufacturer's recommendations for installation, environmental conditions and electrical specifications may result in danger to personnel, damage to the B140 (and/or external equipment) and may void the warranty.

Installation Notes:

Bardac Corporation
40 Log Canoe Circle, Stevensville, MD 21666 USA
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