VeeArc™

Series 98
Solid-state Electronic Motor Brake

Contents

** ***Warning*** **

User assumes full responsibility for his application. Caution must be exercised when using any Dynamic Braking motor control product. <u>The absence of the BRAKE ON LED DOES NOT indicate that motor rotation has stopped</u>. Only with the use of a motion-sensing device (not supplied by VeeArc, LLC. with the controller) can the rotation of the motor be determined.

This in not intended as an emergency stop control, loss of AC power will cause the Brake to NOT FUNCTION!

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A. Introduction

This manual includes information relating to the theory of operation, installation, troubleshooting, and repair of the Series 98 DC injection brake as supplied by VeeArc, LLC.

These solid state brake systems are generally applicable to any high inertial load such as flywheel, grinding wheel, circular saw, band saw, and centrifuge, just to name a few.

The electronic brake is very useful in stopping the motion quickly. Even though many high inertial loads have hydraulic or pneumatic driven mechanical brakes; these mechanical systems can quickly go out of adjustment and then the load literally coasts to a stop, which may take up to half an hour. Mechanical braking systems also wear out causing the need for maintenance and replacement of parts for proper operation. The electronic brake can typically stop these loads in less than a minute thus greatly increasing production time by decreasing the unproductive time required for the load to coast to a stop. They also work very well in conjunction with mechanical breaking systems. The electronic brake stops the load without the use of the mechanical system, and the mechanical system then holds the load after motion has stopped, virtually eliminating the wear associated with stopping via a mechanical system alone.

Electronic breaking systems are easy to install, efficient means of stopping motion; and depending on your specific system and production, can have payback times as short as a couple of months.

B. System Considerations

Precautions

While the specific operation of the brake circuitry will be covered in the following sections, several system wide issues and precautions will be addressed in this section.

1. Motor overload protection relays

a. In general the overload heaters should be placed to protect the motor during both running and braking. However because high horsepower motors need to use current transformers to supply the heater current rather than running the motor current directly through the overload relay heaters, it may be physically easier to only measure motor running current and not include the DC braking current which is not sensed by the current transformer.

b. Please note that brake control coil 1B-2 and power control relay (2TB-6) must be connected in series with the motor overload relay normally closed contact. Brake control power is removed from 1B-5 by CR1 when the overload relay is tripped. **If the overload relay trips braking cannot occur.**

2. Brake circuit fuses

a. Fuses of the dual element RK-1 type are used in series with the diode and SCR in the brake circuit to protect the wiring and components from destruction. Whenever either of these fuses open, the SCR and diode must be checked for proper operation before reenergizing the circuit.

3. Auxiliary Interlock switches

a. A standard electromechanical air break contact is used to provide electrical interlocking with the brake to the run contactor. It should be wired in series with the run contactor coil to prevent run during braking. A normally closed contact to provide interlocking from the motor contactor to the brake is also required to prevent braking during running.

b. It is imperative that only one of the contactors be closed at a time and that the normally closed interlock switches accurately reflect the status of the power contacts of the contactor. For example, these normally closed contacts must be open under any condition where the power contacts are closed, even under conditions of welded contacts where there can be some armature movement, but no power contact movement. Some contactors may require early make late break type contacts to meet these requirements.

4. Power Factor Correcting capacitors

a. Power Factor Correcting capacitors must be placed on the input (L1, L2) side of the VeeArc Series 98 Brake. If the capacitors were to be placed on the output (T1, T2) side of the VeeArc unit, the high surge currents, which occur during capacitor charging, will damage the SCR in the sold state brake. Generally an auxiliary contactor must be used to connect the capacitors while the motor is running and disconnect them during braking and when the motor is off.

5. Zero Speed Switches

a. When zero speed switches are used to sense motor rotation and direction, they should not be connected to the same two motor leads where the DC braking voltage is applied. Typically the braking voltage is applied to T1 and T2, therefore the zero speed switch should be connected to T2 and T3.

Important notes when using Power Factor Correcting Capacitors

When using power factor correcting capacitors, they must be connected to the line side (L1, L2) of the motor control. Damage will result to the control if they are connected directly to the motor. When an isolation contactor or motor starter is used along with power factor correcting capacitors, see page (??), of this publication for the required control wiring. Damage to the control may occur if this wiring method is not used.

C. Theory of Operation

Most motor loads are allowed to coast to rest. The friction of bearings, gears, etc. slow down the machine. This is easily implemented and generally acceptable. Two alternate methods are also available; soft-stop and braking. A soft stop extends the stop time of the motor compared to coasting to rest. A brake shortens the stop time of the motor compared to coasting to rest.

When the motor is to be stopped faster than coasting, a DC current is injected into two windings of the motor.

When DC is injected, the synchronous speed of the motor is zero RPM. The motor produces a braking torque to bring the load to a stop. The amount of braking torque is increased as the injected current is increased thereby shortening the stopping time. Braking works well on high inertia, low friction loads such as punch presses, wood chippers, spindle heads, saws and grinders. Also, brakes work well on conveyor systems for quick stopping for open loop positioning of loads.

D. Electrical Data

Temperature Range	0° to 50°C (32°to 122°F), inside enclosure
Input Voltage Variations	+/- 15% of NEMA nominal motor voltage
Duty Cycle	25% - braking should not be operated more than15 min/hour.
Recommended Fuse Style	Type RK-1 Dual Element Partial List of Manufacturers

Manufacturer	Type	Voltage
Bussman	LPN-RK	(250V or less)
	LPS-RK	(600V or less)
Reliance	LEN-RK	(250V or less)
	LES-RK	(600V or less)
Gould	A2D( )R	(250V or less)
	A6D( )R	(600V or less)
Little Fuse	LLN-RK	(250V or less)
	LLS-RK	(250V or less)

Fusing will protect wiring and controller from destruction but may allow excessive current to damage SCR modules, which would require replacement or service before reenergizing controller.

Brake Time Adjustment Range	.5 to 30 seconds Braking time of the motor will vary depending on the frictional load and inertial characteristics of the system.
Brake Torque Adj. Range	10 to 250% of full load torque, 15 to 300% of full load current

Input Coil Specifications	Isolation between logic & power	1500VAC optical isolation
	Input current	10ma typical @ 120VAC
	On-state voltage	85VAC minimum
	On-state current	6ma minimum
	Off-state voltage	40VAC minimum
	Off-state current	3ma maximum
	Input impedance	13K ohm Typical
Output Specifications	Isolation between logic & power	1500VAC optical isolation
	Rating	10A make, 1A break @120VAC
	On-voltage drop	1.2VAC typical

D. Electrical Data

In general, a DC current of 3 to 5 times the full load AC current will stop a motor in the same amount of time as it takes for the motor to start across the line. This braking time is dependent on the motor load, inertia, speed and DC current.

The following equations can be used to more precisely determine the Brake Torque and Time for a given motor current.

Equation (1), to determine Brake Torque:

$$T_B = k \times I_B (lb - ft)$$

where: *k* = .4 for 230VAC operation
.8 for 460VAC operation
1 for 575VAC operation

Equation (2), to determine Brake Time:

$$t = \frac{WK^2 \times \Delta RPM}{308 \times T_B}$$

where: $T_B =$ Brake Torque (lb – ft) from equation (1)
t = Time to Brake (seconds)
$WK^2 =$ Moment of Inertia of total load $(lb \times ft^2)$

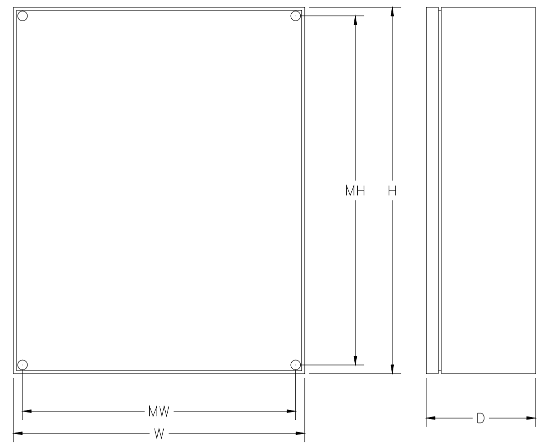
E. Dimensions and Installation

The Series 98 is available as an open panel mount control or in an enclosure. When supplied in an enclosure all control circuitry is housed in a sturdy steel enclosure with a gray paint finish. When not supplied with an enclosure, the controller should be mounted in an auxiliary enclosure of the type and class required for any given installation. All enclosures supplied are based on the controller being operated in an ambient temperature of no greater than 50°C (12°F). For operating temperatures above 50°C, consult the factory. For NEMA class enclosures of styles different from those indicated, consult the factory.

1. Remove the controller from the carton. Check for signs of shipping damage to the case and cover.

2. Check the controller nameplate to insure correct application to your motor voltage and size.

3. Refer to the dimensional drawing for dimensions.



NEMA 12 Enclosure Dimensions

For enclosure dimension information contact the factory.

F. Wiring

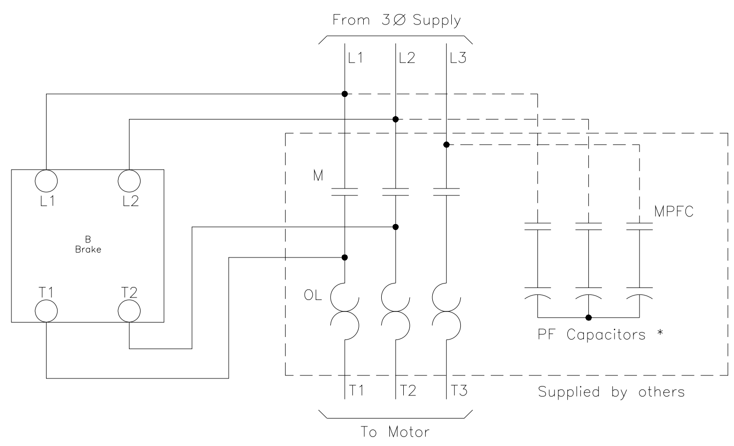
The Series 98 should be wired into the motor circuit as shown to the right. It can be used with an electro-mechanical motor starter or a solid-state motor control product. When a solid-state motor control is used it must be isolated from the power source or the motor while braking current is applied to the motor.

Note: When using power factor correcting capacitors, they must be isolated from the output of the brake. Damage may result to the control if they are connected directly to the motor.

When used with an electromechanical motor starter.

Input terminals L1 and L2 on the brake terminal block should be wired to terminals L1 and L2 of the motor starter.

Output terminals T1 and T2 on the brake terminal block should be wired to terminals T1 and T2 of the motor starter.



Series 98 with an electromachanical motor starter

* If used, reconnect PF Capacitors as shown.

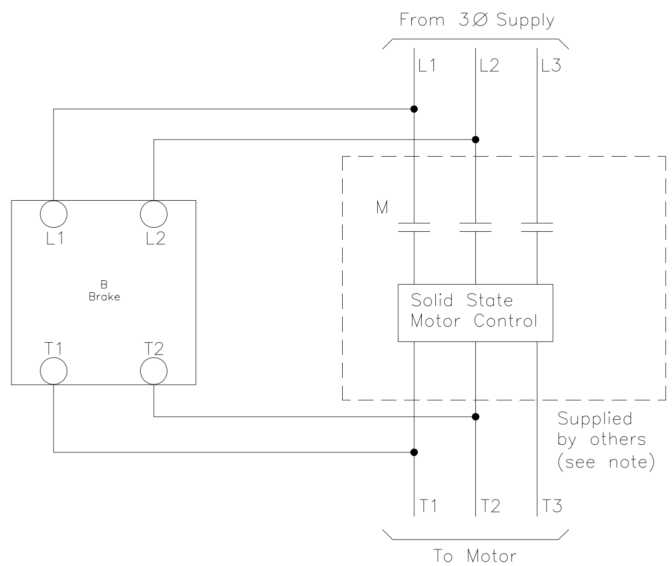
When used with a solid-state motor control.

Input terminals L1 and L2 on the brake terminal block should be wired directly to the 3∅ power source.

Output terminals T1 and T2 on the brake terminal block should be wired to terminals T1 and T2 of the solid-state motor control or motor.

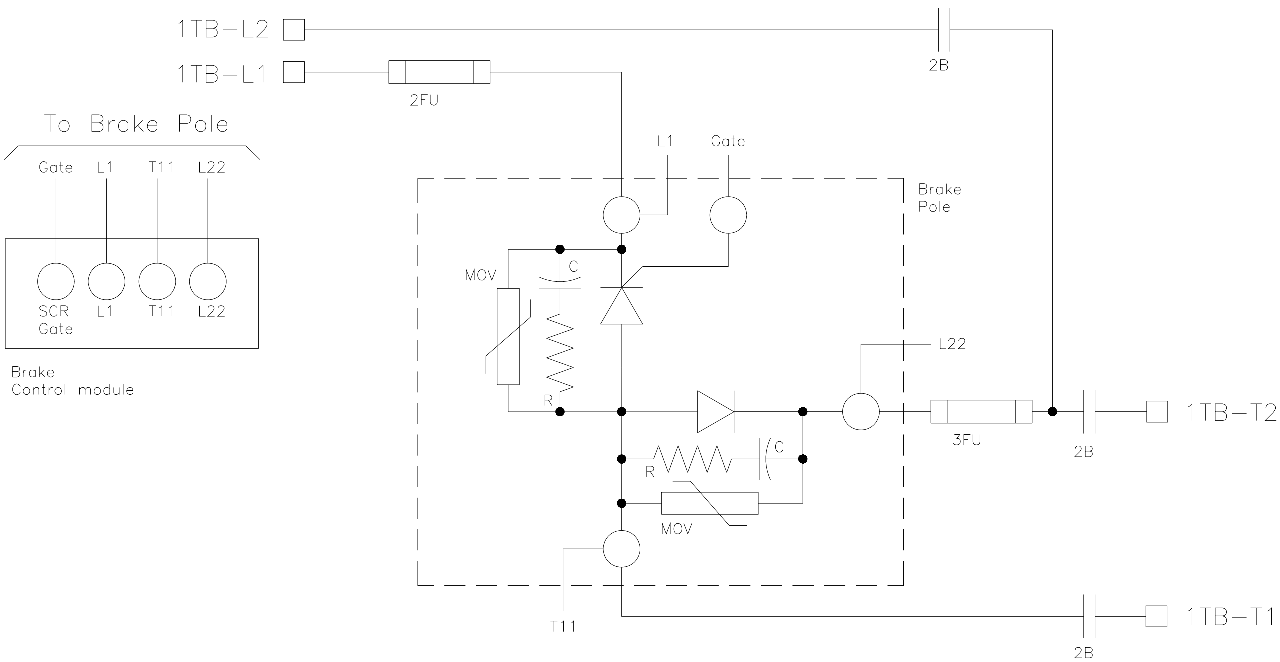
Isolating contactor may be before or after the solid-state motor control except when the motor control is a variable frequency drive. When a variable frequency drive is used, the isolation contactor must be after the variable frequency drive.

Solid-state equipment may require the isolation contactor (M) be placed on its load side. The presence of DC voltage on the output may cause damage to the solid-state equipment.



Power Connections

1. Only two supply voltage power connections are required for the brake. L1 must be connected to 1TB-L1, which goes to the fuse (2 FU) in series with the brake SCR. L2 must be connected to 1TB-L2, which goes to the brake contactor 2B. Likewise, the brake output connections are from brake contactor (2B) to the corresponding terminals (1TB-T1 and 1TB-T2) on the starter (M) or motor.



2. Single phase 120VAC capable of supplying a 250VA load is required to power the brake controller board (1B) and brake contactor (2B). The hot side of the 120VAC line should be connected to terminal 1X1 on 2TB and the neutral side connection is made from terminal 6 on 2TB through the overload relay contact. This is done to insure that braking action will not occur after the overload trips.

NOTE – Unit is delivered with wiring on CPT for 460 VAC operation, if operating voltage is 240 VAC the CPT must be rewired on the primary side for 240 VAC.

Control Wiring

A simplified wiring diagram is shown to the right. This wiring method can be used to start and stop the motor and control the electronic brake.

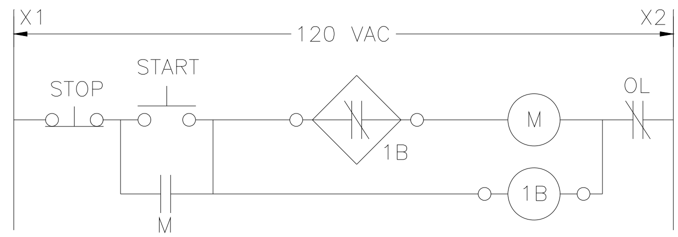
When the start button is pushed, coils "M" and "1B" will be energized. Contactor "M" will close applying 3∅ power to the motor.

When the stop button is pushed, power will be removed from coils "M" and "1B". Contactor "M" will open removing 3∅ power from the motor.

When power is removed from coil "1B" the brake circuit of the Series 98 will be activated. Normally closed contact "1B" will open inhibiting coil "M" from being energized while braking voltage is being applied. Once braking voltage is removed contact "1B" will again close, allowing 3∅ motor power to be applied.

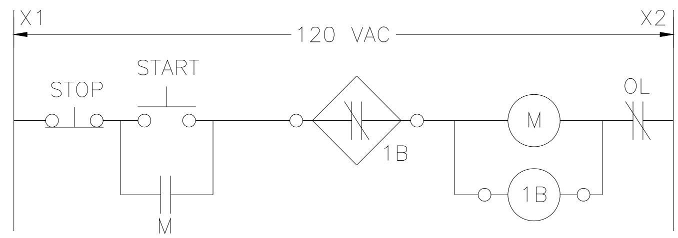
If the "1B" coil is reenergized during braking, the brake cycle is ended and the "1B" contact will close allowing the motor contactor coil "M" to restart the motor.

Typical control wiring for motor restart during braking.



The circuit can be changed to inhibit the motor from being restarted until the end of the braking cycle. The drawing to the right illustrates how this would be done.

Typical control wiring for restart after braking has ended.



WARNING

The normally closed contact (1B), on the printed circuit board must be connected in series with the motor starter or isolation contactor as shown (above). Failure to do so may result in the brake and motor starter being energized at the same time, damaging one or both controllers.

Control circuitry and Wiring

1. In most motor control situations it is desirable that the motor running circuitry be the ‘master’ or lead condition and the motor braking circuitry be the ‘slave’ or subservient condition. Basically this means that braking occurs only when the motor is not required to run. Normal operation would be that motor braking would occur immediately after the motor running condition was terminated. In the unusual case where motor running was called for before the braking cycle was complete, the motor running request would override the braking, braking would immediately cease and the motor would begin running again.

   The brake control module contains sequential timing to help prevent overlapping of the motor run and motor brake function. Overlapping of these functions causes the braking diode to be connected between T1 and T2 at the same time that the starter is applying AC voltage to these motor leads. The diode will forward biased during half of each cycle, which causes a phase to phase fault and undesirable high currents.

2. Sequence of operation during braking

   When the 1B coil senses the motor stop request the following braking cycle is initiated

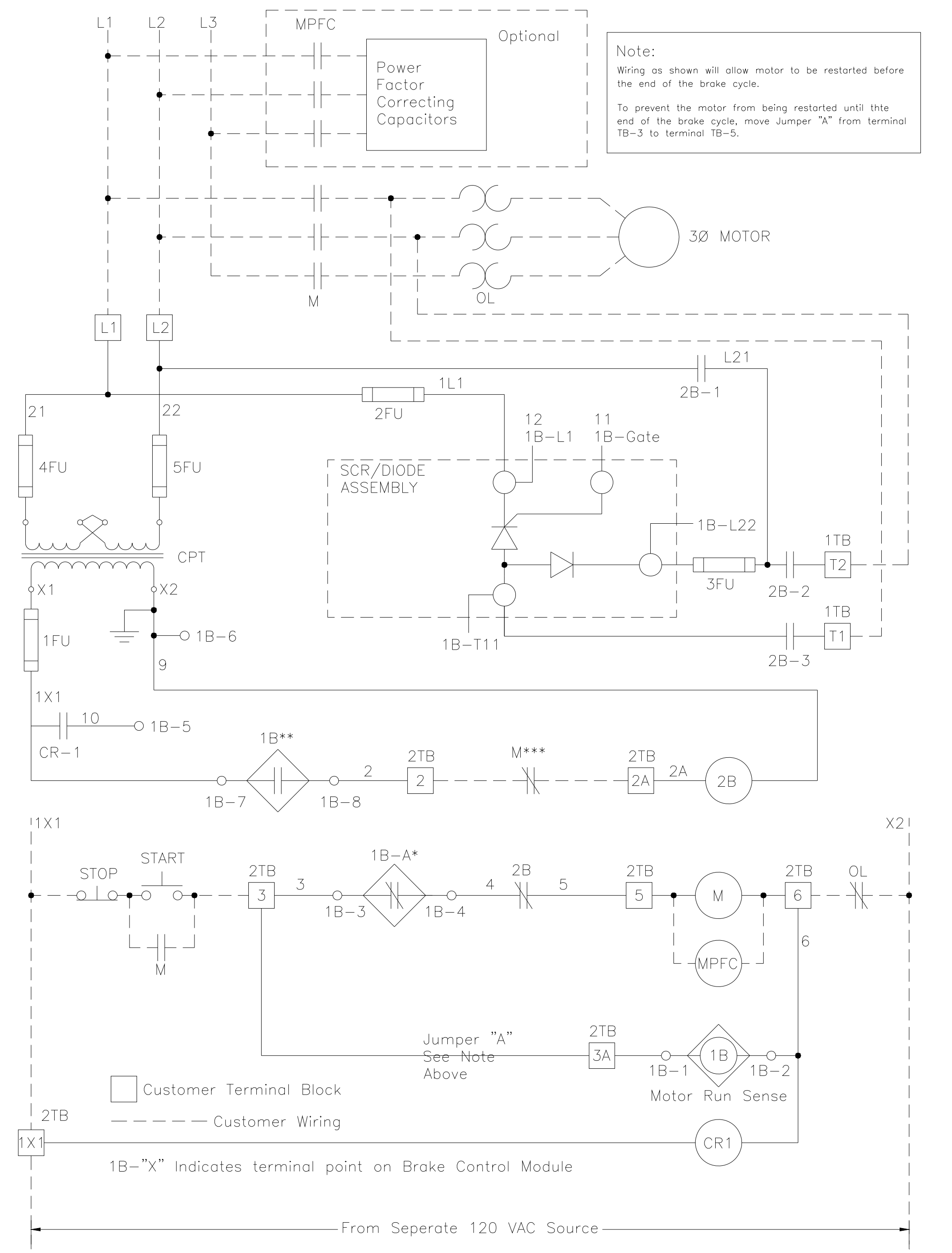
   a. The normally closed brake interlock 1B-A is opened to prevent M from being energized.

   b. After an internal time delay of about 100 milliseconds the normally open contacts of 1B closes and energizes the brake contactor 2B.

   c. After another delay the brake logic circuitry turns on the gate signal to the brake SCR which generates the DC braking voltage.

   d. When the braking time has ended, the above steps a, b, and c are reversed. First, the SCR gate signal is removed, then the brake power contactor coil, 2B, is de-energized and finally the 1B-A interlock closed permitting the motor to run again.

   e. As previously mentioned, it is very important that the motor running and braking functions do not overlap. It is imperative that the motor run contactor has an auxiliary interlock switch mounted on it that accurately reflects the status of its 3 phase AC power contacts. This switch is wired in series with the coil of the brake power contactor to help insure that simultaneous closure of the motor run and motor brake contactor never occurs. Likewise, VeeArc supplies both a solid-state logic contact and auxiliary interlock from the brake contactor, which must be wired in series with the motor run contactor coil.



* Contact Opens During Brake Operation

** Contact Closes During Brake Operation

*** Must be early break, late make (normally closed) contact to accurately reflect status of power contacts on M. See Section B, Precautions

G. Adjustments

There are only two adjustments to make on the brake control module. The BRAKE TORQUE adjustment varies the value of DC voltage, which is applied to motor leads T1 and T2. The BRAKE TIME adjustment varies the length of time that the DC voltage is applies. For a high inertia system such as a press flywheel and motor in less than a minute without causing undue stress on the drive train, such as making the belts smoke. This can be achieved by turning the BRAKE TIME adjustment fully clockwise, (maximum) and the BRAKE TORQUE adjustment fully counter clockwise (minimum) and then clockwise about one eighth of a turn as described next. Ideally the flywheel should stop about two seconds before the BRAKE ON light goes out.

If the flywheel does not stop within the set time, the BRAKE TORQUE adjustment must be increased by turning it clockwise about one eighth of a turn. Do not make large changes in the BRAKE TORQUE adjustment as this could cause the belts to smoke from excessive braking torque and possibly blow the fuse in series with the brake diode (3FU).

If the flywheel stops a long time before the BRAKE ON light goes out and the belts smoke, reduce the BRAKE TORQUE adjustment slightly (about one sixteenth of a turn). If the belts don't smoke, then the BRAKE TIME adjustment may be decreased by turning this adjustment counter clockwise.

All Series 98 Brakes contain two field adjustable functions, which allow them to be set up for optimum performance. Each adjustment is a single turn rotary potentiometer.

The Brake Torque adjustment should be set for the amount of braking torque required to stop the motor. The Brake Time adjustment should be set so that the time period ends just after the motor stops rotating.

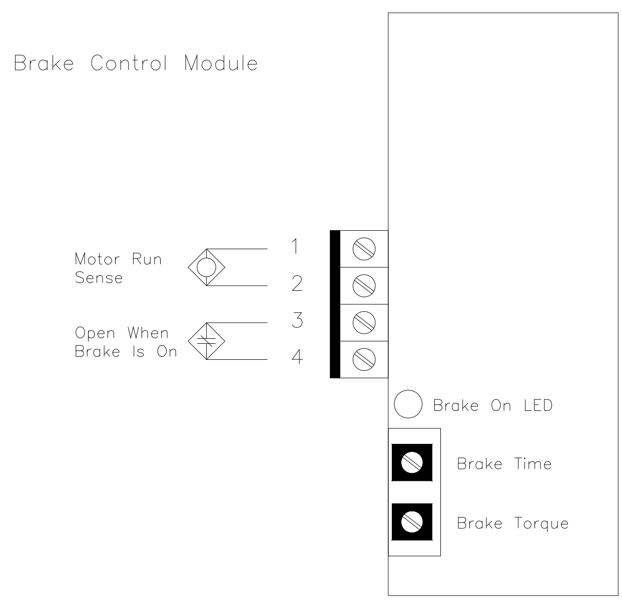
If the Brake Time adjustment is set too short, the brake voltage may not be applied long enough to stop the motor. If the Brake Time adjustment is set too long, the brake voltage will continue to be applied to the motor after it has come to a stop and heat up the motor windings.

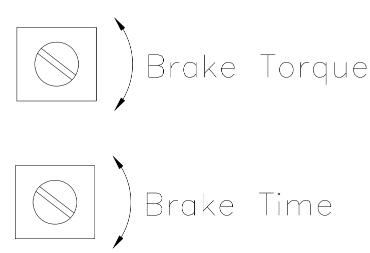
To properly set-up the control:

1. Set the Brake Time adjustment fully clockwise (long).

2. Adjust the Brake Torque adjustment so that the required amount of braking torque is applied to the motor. Start with a setting of approximately ¼ turn from the minimum setting. Readjust as necessary to obtain a smooth, safe stop.

3. After the braking torque is acceptable, set the Brake Time adjustment so that the DC applied voltage stops one to two seconds after the motor stops turning. This could be determined by observing the Brake On indicator. The light should turn off one or two seconds after the motor stops turning.





H. Troubleshooting

1. “BRAKE ON” LIGHT DOES NOT COME ON.

a. Check for proper coil connection to 1B-1 and 1B-2.

b. Check for 120VAC power to 1B-5 and 1B-6.

c. Replace brake control module

2. “BRAKE ON” LIGHT COMES ON, BRAKE CONTACTOR DOES NOT PULL IN.

a. Check for closed interlocks from “M”

b. Check for closed switch out of brake control module (1B-7 & 1B-8).

c. Check for proper coil voltage on brake contactor (120VAC standard).

3. “BRAKE ON” LIGHT COMES ON, BRAKE CONTACTOR PULLS IN, NO BRAKING OCCURS.

a. Check for DC voltage across T1 and T2. BRAKE TORQUE adjustment may be too far CCW.

b. Check for blown fuses 3FU and/or 2FU.

c. Check for proper power wiring into and out of brake power pole.

d. Check all connections between G1, L22, L1, T11 (module and pole).

e. Check wires into brake SCR for good connections to SCR.

f. Replace control module and/or fuses and/or SCR module.

WARNING

User assumes full responsibility for his application. Caution must be exercised when using any Dynamic Braking motor control product. The absence of the BRAKE ON light DOES NOT indicate that motor rotation has stopped. Only with the use of a motion sensing device (not supplied by VeeArc, LLC. with the controller) can the rotation of the motor be determined.

NOTE: When using power factor correcting capacitors, they must be isolated from the output of the brake. Damage may result to the control if they are connected directly to the motor.

I. Spare Parts

Brake Control Module

200/230/460VAC	18A – 69A	D81510-005	78A – 720A	D81510-002
460/575VAC	18A – 69A	D81510-006	78A – 720A	D81510-004

Brake Power Poles

Control Style	Current Rating Amps	200/230VAC	230/460VAC	460/575VAC
I	18	D81073-064	D81073-064	D81073-067
K	28	D81073-065	D81073-065	D81073-067
N	54	D81073-066	D81073-066	D81073-069
P	69	D81073-075	D81073-075	D81073-076
Q	78	D81073-088	D81073-088	D81073-090
R	104	D81092-055	D81092-055	D81092-056
S	130	D81092-037	D81092-037	D81092-038
T	157	D81092-052	D81092-052	D81092-053
U	191	D81092-040	D81092-040	D81092-041
V	252	D81092-042	D81092-042	D81092-044
W	348	D81092-046	D81092-046	D81092-047
X	420	D81092-049	D81092-049	D81092-050
Y	480	D83208-029	D83208-029	D83208-030

Brake Electromechanical Contactors

Control Style	Current Rating Amps	Contactor Siemens	Contactor ASEA
I	18	41NB30AFMGR	----
K	28	42DE35AF106	----
N	54	42EE35AF106	----
P	69	42FE35AF106	----
Q	78	42GE35AF106	----
R	104	42HF35AF	----
S	130	42IF35AF	----
T	157	42JB35AFD8	EH250C-1L
U	191	42RB35AFD8	EH250C-1L
V	252	42KB35AFD8	EH250C-1L
W	348	42MB35AFD8	EH550C-1L
X	400	42MB35AFD8	EH550C-1L
Y	480	42MB35AFD8	EH550C-1L

Auxiliary Interlock Switch for Furnas Contactor

Control Current Rating	
32-90 Amps	49D22125002
120-150 Amps	49D54947LB
180-480 Amps	D51130-007 left mounting
	D51130-008 right mounting

Auxiliary Interlock Switch for ASEA Contactor

All Styles — EHAX-11A or EHAX-01

Brake Fuses

Motor HP @ 460VAC	FLA per NEC table 430-150	Fuse Rating	Bussman Part #	Gould Shawmut Part #
10	14	17.5A/600VAC	LPS-RK-17.5	A6D17.5R
20	27	30A/600VAC	LPS-RK-30	A6D30R
40	52	60A/600VAC	LPS-RK-60	A6D60R
60	77	80A/600VAC	LPS-RK-80	A6D80R
75	96	100A/600VAC	LPS-RK-100	A6D100R
100	124	150A/600VAC	LPS-RK-150	A6D150R
125	156	200A/600VAC	LPS-RK-200	A6D200R
150	180	200A/600VAC	LPS-RK-200	A6D200R
200	240	250A/600VAC	LPS-RK-250	A6D250R
250	320	350A/600VAC	LPS-RK-350	A6D350R
300	360	400A/600VAC	LPS-RK-400	A6D400R
350	420	450A/600VAC	LPS-RK-450	A6D450R
400	480	500A/600VAC	LPS-RK-500	A6D500R

K. Glossary

The terms that follow relate to different aspects of solid state motor control products. These terms in some cases do not apply to all manufacturers of solid state motor control products.

Acceleration Time – The time required for a motor to go from initial to final speed.

Alternating Current (AC) – A periodic current the average of which over a period is zero and reverses at regularly recurring intervals of time and which has alternatively positive and negative values.

Ambient Temperature – The temperature of the air surrounding an electrical device. If the device is enclosed, the temperature of the air inside the enclosure is considered the ambient.

Auto Transformer Starter – An electromechanical motor starter that incorporates mechanical contactors, timers and a tapped transformer to supply reduced voltage and torque to a motor during starting.

Bimetal Overload Relay – An overload relay which utilizes a lever mechanism made of two dissimilar metals, which when heated by an overload current will bend, causing the overload relay to trip.

By-pass Contactor – An electromechanical contactor used to short out an electronic motor control while the motor is operating.

Circuit Breaker – An electrical or electronic switching device capable of making, carrying and breaking currents under normal circuit conditions and also, making, carrying for a specified time, and breaking currents under specified abnormal circuit conditions such as those of short-circuit and overload.

Class 10 Protection – A rating used to indicate an overload relay's maximum trip time of 10 seconds at 600% of full load amps.

Class 20 Protection – A rating used to indicate an overload relay's maximum trip time of 20 seconds at 600% of full load amps.

Combination Starter – A piece of equipment, which incorporates a motor starter and means for manually or automatically disconnecting power to the motor starter (i.e. MCP, disconnect or circuit breaker).

Contactor – A device, either electromechanical or solid-state used to control electric circuits by closing a physical or electrical path to allow current.

CPT (Control Power Transformer) – A transformer used to reduce the incoming line voltage to a lower voltage to be utilized in the control circuit.

CT (Current Transformer) – A transformer used to sensing motor current and supplying a reduced current value to metering or monitoring circuits.

Current (I) – The movement of electrons through a conductor and measured in amperes.

Current Limit – A method of electronic reduced voltage starting where the starting current of a motor is limited during starting to a percentage of the full voltage locked rotor current.

Decel (Decelerate) – A mode where the motor voltage is reduced from line voltage to a lower operating voltage over a period of time to bring a frictional load to a smooth stop.

Diode – A semiconductor device having two terminals and exhibiting a nonlinear voltage-current characteristic, which conducts current only in one direction.

Direct Current (DC) – Current that is either a constant value or pulsating in only one direction (polarity).

Dual Element Fuse – A fuse, which incorporates elements for overload protection and current limiting protection.

Dual Ramp Controller – A soft-start motor controller, which incorporates two independent sets of adjustments for controlling the soft-start of a motor. Sometimes used for independent control of the soft-start of a two-speed or reversing application.

Electronic Brake – A solid-state motor control, which produces an adjustable DC voltage, used to bring a motor to a stop.

Full Voltage Start – The instantaneous application of full voltage and power to a motor to cause it to begin rotating.

Heaters – Elements installed in an overload relay calibrated to a specific rating which determine the characteristics of the overload relay.

Hertz (Hz) – A unit of frequency corresponding to the number of cycles per second, used to indicate the frequency of AC voltage and current.

Horsepower (Hp) – A unit of electrical power equal to 746 watts. Used to rate the maximum amount of physical work a motor can perform.

Impedance – The total opposition a circuit offers to current, measured in ohms.

Inductive Load – A load where the alternating load current lags behind the alternating voltage as in an AC motor circuit.

Inrush Current – The current a motor draws while accelerating.

Isolation Contactor – An electromechanical device connected in series with a solid-state device, used to open the path of current to protect equipment and personnel.

Jogging – A method of operating a motor by repeatedly turning it on and off. Sometimes used to set up a piece of equipment or as an alternative to soft-start.

Line Voltage Limiter – An electronic circuit incorporated as part of a solid-state motor control to limit the maximum voltage applied to a motor.

Motor Circuit Protector (MCP) – A molded case switch protective device used in a combination starter with only a magnetic, instantaneous trip element.

Melting Alloy Overload – An overload relay that utilizes heater elements which when heated by excessive current will cause a small solder pot to melt, thus tripping the overload relay.

Motor Controller – An electronic device used in conjunction with an electromechanical motor starter and AC induction motor to control one or more aspects of the motor's operation.

NEMA Type 1 – General-purpose enclosure intended for indoor use, usually ventilated.

NEMA Type 3 – Dust-tight, rain-tight, and sleet-resistant, (ice) enclosures intended for outdoor use to protect the enclosed equipment against wind-blown dust and water.

NEMA Type 3R – Rainproof and sleet-resistant, (ice) enclosures intended for outdoor use to protect the enclosed equipment against rain and are constructed so the accumulation and melting of sleet, (ice) will not damage the enclosure and its external mechanisms.

NEMA Type 4 – Watertight and dust-tight enclosure intended for indoor and outdoor use to protect the enclosed equipment from splashing water, water seepage, falling or hose-directed water and severe external condensation, constructed of steel.

NEMA Type 4X – Enclosure with the specifications of NEMA 4 except constructed of stainless steel.

NEMA Type 9 – Class II, Division 1, Group E, F, or G hazardous location enclosures intended for indoor use to prevent the entrance of explosive amounts of hazardous dust.

NEMA Type 12 – Dust-tight and drip-tight enclosure intended for indoor use to protect the enclosed equipment from fibers, flyings, lint, dust, dirt, and light splashing, seepage, dripping, and external condensation of non-corrosive liquids.

Overload Relay – A relay designed to monitor current and trip when the current rises above a predetermined value on an inverse time curve.

Over-temperature Switch – A mechanical switch used to monitor temperature and trip if the temperature rises above its predetermined trip point.

Part Winding Starter – An electromechanical motor starter, used with a specially wound motor, that applies voltage successively to the partial sections of the primary windings of the motor providing reduced starting current and torque.

Plug-Reverse – A method of stopping or reversing a motor by starting it in its opposite direction of rotation.

Power Factor – The ratio of actual power to the apparent power.

Power Module – A device, which incorporates one or more semiconductor devices and used in motor controls to control motor current and voltage.

Primary Resistance Starter – An electromechanical motor starter, which incorporates mechanical contactors and resistors to supply reduced voltage and torque to a motor during starting.

Ramped Current – A method of electronic reduced voltage starting, where the starting current of a motor is reduced during starting to zero current at power on and slowly raised to a current limit level.

Rectifier Fuse – A fuse with very quick trip characteristics, specifically designed to protect semiconductors from short circuit conditions.

Reduced Voltage Start – The application of a less than full voltage and power to a motor causing it to start with reduced torque. Also used to minimize starting inrush currents.

Resistance – The opposition a device offers to current flow when voltage is applied.

Resistive Load – A load in which the voltage is in phase with the current.

Reversing – The operation of a piece of equipment in two directions.

Revolutions per Minute (RPM) – A measure of the number of rotations made by a motor in a sixty second period.

Semiconductor – A material that changes electrical properties from that of an insulator to that of a conductor by means of electronic charge carriers, (usually electrons) concentrations increases with increasing temperature over some temperature range.

Service Factor – The overloaded rating of a motor at which it can be operate for a specified time period without damage.

Shunt Trip – A solenoid device activated by an external power source and typically installed in a protective device such as a circuit breaker or MCP to trip the protective device.

Silicon Controlled Rectifier (SCR) – A semi-conducting device that acts as a half wave AC silicon switch, which is normally an open circuit and designed to conduct in only one polarity of applied voltage when an appropriate gate signal is applied.

Single Phase Power – An alternating current circuit with only two points of power entry. Not intended to be used with controllers designed for use with three phase power.

Snubber network – A special electronic circuit used to protect semiconductors from power surges and line transients and control the solid-state switch characteristics.

Soft-stop – A method used with motors operating frictional loads, of reducing the voltage to the motor to cause it to stop smoothly, usually longer than coast to rest.

Starter – A device, either electromechanical or solid-state, which incorporates a contactor and overload relay.

Start Time Adjustment – An adjustment on a motor control, which determines the length of time it takes for the motor voltage to ramp from an initial starting value to full voltage.

Thermal Magnetic Circuit Breaker – A molded case circuit switch protective device used in combination starters with a thermal (inverse time) and magnetic (instantaneous) trip element.

Three Phase Power – An alternating current delivered through three points of entry, differing in phase successively by one third cycle, or 120 degrees.

Time Delay Relay – An electronic or electromechanical device, which delays an action by an adjustable time period. The delay may begin when a controlling signal is first applied or after it is removed.

Torque – A force that tends to produce rotation as in a motor. Measured as the product of the perpendicular force at a specified distance from the axis of rotation *(lb x ft)*.

Torque Adjustment – An adjustment on a motor controller, which allows the starting or stopping torque of a motor to be varied by increasing or decreasing the voltage applied.

Triac – A full wave AC silicon switch that is normally an open circuit and designed to conduct in either polarity of applied voltage with appropriate gate triggering.

Two Speed – The operation of a piece of equipment at two different rates of rotation using one motor.

Voltage (E) – The force that causes electrical current through a conductor.

Voltage Ramp – A method of electronic reduced voltage starting where the starting voltage of a motor is reduced at power on and then slowly brought up to full voltage.

L. Conditions of Sale

1. ACCEPTANCE

Unless otherwise stated, all quotations are made for immediate acceptance. All quotations and proposals covering Seller's products are made and all contracts or purchase orders for said products are accepted under the strict limitation that the terms and conditions set forth herein shall be applicable thereto. Any provisions on Buyer's purchase order or other documents issued by Buyer, which are at variance with or in addition to these terms and conditions, are rejected hereby.

2. PRICES

Prices are net and not subject to trade or other discounts except those which may be authorized on the face of Seller's invoice, and do not include any federal, state, county, local or other taxes, however designated, or costs of special packaging and insurance. Said charges, when applicable, shall be paid by Buyer. However Buyer may provide Seller with an appropriate tax exemption certificate acceptable to the taxing authorities.
Prices are subject to equitable adjustment at any time before delivery if necessitated by economic factors beyond Seller's reasonable control, including but not limited to factors such as supplier price increases and government actions.

3. PAYMENTS

Payment for products and all other charges shall be made in full within thirty (30) days of the date of invoice, unless otherwise specified. If, in the judgment of Seller, the financial condition of the Buyer at any time does not justify shipment on the terms of payment originally specified, Seller may require full or partial payment in advance or may ship C.O.D. In the event of the bankruptcy or insolvency of the Buyer, whether or not under the Federal bankruptcy laws, the Seller may, at its option, refuse delivery except for cash (including payment for all goods thereto delivered), stop delivery of goods in transit, reclaim the goods upon demand, or cancel or resell any order then outstanding and be entitled to reimbursement for all cancellation or resale charges.
The invoiced amount shall not be subject to set-offs for any claims by Buyer against Seller, including any claims for products returned by Buyer for repair or correction of defects. Seller reserves the right to make delivery in installments which shall be separately invoiced and paid for when due without regard to subsequent deliveries. If the invoiced amount or any part thereof is not paid by Buyer when due, Seller reserves the right to assess interest charges at eighteen percent (18%) per annum on such amounts from the date due until paid, and Buyer agrees to pay such interest charges. If shipments are delayed by Buyer, payments shall become due on the date Seller is prepared to make shipment Products held for Buyer shall be at the expense of Buyer.

4. FAIR LABOR STANDARDS ACT

Seller certifies that products furnished hereunder have been or will be produced in compliance with applicable requirements of the Fair Labor Standards Act, as amended, and regulations and orders of the United States Department of Labor issued thereunder.

5. WARRANTY

Seller warrants that on the date of shipment to Buyer the goods will be of the kind and quality described herein, merchantable, and free of defects in workmanship and material. If, within one year from date of shipment by Seller, of any item of the goods, Buyer discovers that such item was not as warranted above and promptly notifies company in writing thereof, Seller shall remedy such defects by, at Seller's option, adjustment, repair or replacement of the item. Buyer shall assume all responsibility and expense for removal, reinstallation and freight in connection with the foregoing remedy. The same obligations and conditions shall extend to replacement items furnished by Seller hereunder. Seller shall have the right of disposal of items replaced by it. Buyer shall grant Seller access to the goods at all reasonable times in order for Seller to determine any defect in the goods.

In the event that adjustment, repair or replacement does not remedy the defect, the Seller and Buyer shall negotiate in good faith an equitable adjustment in the contract price.
The Seller's responsibility does not extend to any item of the goods which has not been manufactured and sold by Seller. Such item shall be covered only by the express warranty, if any, of the manufacturer thereof. The Seller and its suppliers shall also have no responsibility if the goods have been improperly stored, handled or installed, if the goods have not been operated or maintained according to their ratings or according to instruction in Seller or supplier furnished manuals, or if unauthorized repairs or modifications have been made to the goods.
THIS WARRANTY IS EXPRESSLY IN LIEU OF ALL OTHER WARRANTIES (EXCEPT TITLE), INCLUDING BUT NOT LIMITED TO IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS AND CONSTITUTES THE ONLY WARRANTY OF SELLER, WITH RESPECT TO THE GOODS.
The foregoing states Buyers exclusive remedy against Seller and it's suppliers for any defect in the goods or for failure of the goods to be as warranted, whether Buyer's remedy is based on contract, warranty, failure of such remedy to achieve its essential purpose, tort (including negligence), strict liability, indemnity or nay other legal theory, and whether arising out of warranties, representations, instructions, installations or defects from any cause.

6. DELIVERY

Seller will not incur any liability for any delay in delivery for any reason other than an arbitrary refusal of Seller to perform. Delivery dates furnished by Seller represent the best estimates of the time required to make shipment. Delay in delivery of any installment shall not relieve Buyer of its obligation to accept remaining deliveries.

7. LIABILITY

Seller shall not be liable for any incidental, special or consequential damages of any nature whatsoever, or for any delay or loss of use (including, without limitation, lost revenues or lost profits) arising out of, resulting from, or in any way related to the sale of any products by Seller.

8. PROPRIETARY INFORMATION

Buyer agrees that any data, such as Seller's specifications, drawings, software and information (including, without limitation, designs, reports, software documentation, manuals, models, process information and the like), revealed by Seller to Buyer and containing proprietary information marked or identified as proprietary, shall be kept in confidence by Buyer with at least the same care and safeguards as are applied to Buyer's own proprietary information. Such data shall not be duplicated, disclosed to others, or used without the written permission of Seller. These obligations shall not apply to any information which is in or comes into the public domain without violation of this agreement, or is received lawfully by Buyer from a third party subsequent to this agreement; or is developed by Buyer independently and without benefit or information received from Seller.
The restrictions and obligations relating to Seller's proprietary information shall expire seven (7) years after the execution of the contract incorporating these terms and conditions, unless otherwise agreed to in writing.

9. PACKAGING AND SHIPMENT

Shipping charges will be paid by Buyer. In the absence of specific instructions, Seller will select the carrier. When applicable, Buyer shall obtain ocean freight space and marine insurance.

10. DELIVERY AND RISK OF LOSS

Unless otherwise provided for in advance, all shipments will be made F.O.B. Seller's Factory, and upon Seller's delivery of a shipment to the carrier, Buyer shall assume the risk of any loss or damage to the shipment thereafter. However, all C.O. D. shipment will be made F.O.B. destination, and title and risk of loss shall remain in Seller until delivery to Buyer.

11. GOVERNING LAW

The terms and conditions stated herein shall be governed by and construed in accordance with the laws of the State of Illinois.

12. COMPLETE AGREEMENT

The contract incorporating the terms and conditions set forth herein is a complete, final and exclusive statement of the agreement between Buyer and Seller. Any prior or contemporaneous agreements, understandings and representations, whether oral or written, are merged therein. The terms and conditions stated herein shall not be varied, supplemented, qualified, or interpreted by any prior course of dealings between the parties or by custom or usage of trade,. No modifications or additions to said contract shall be binding upon Seller unless in writing and signed by an authorized representative of Seller.

13. WAIVER

Seller's election not to enforce any provisions hereof shall not be deemed a waiver of any such provision and Seller reserves the right to enforce said provisions thereafter. Waiver by Seller of a breach of any of these terms and conditions shall not be construed as a waiver of any other breach.