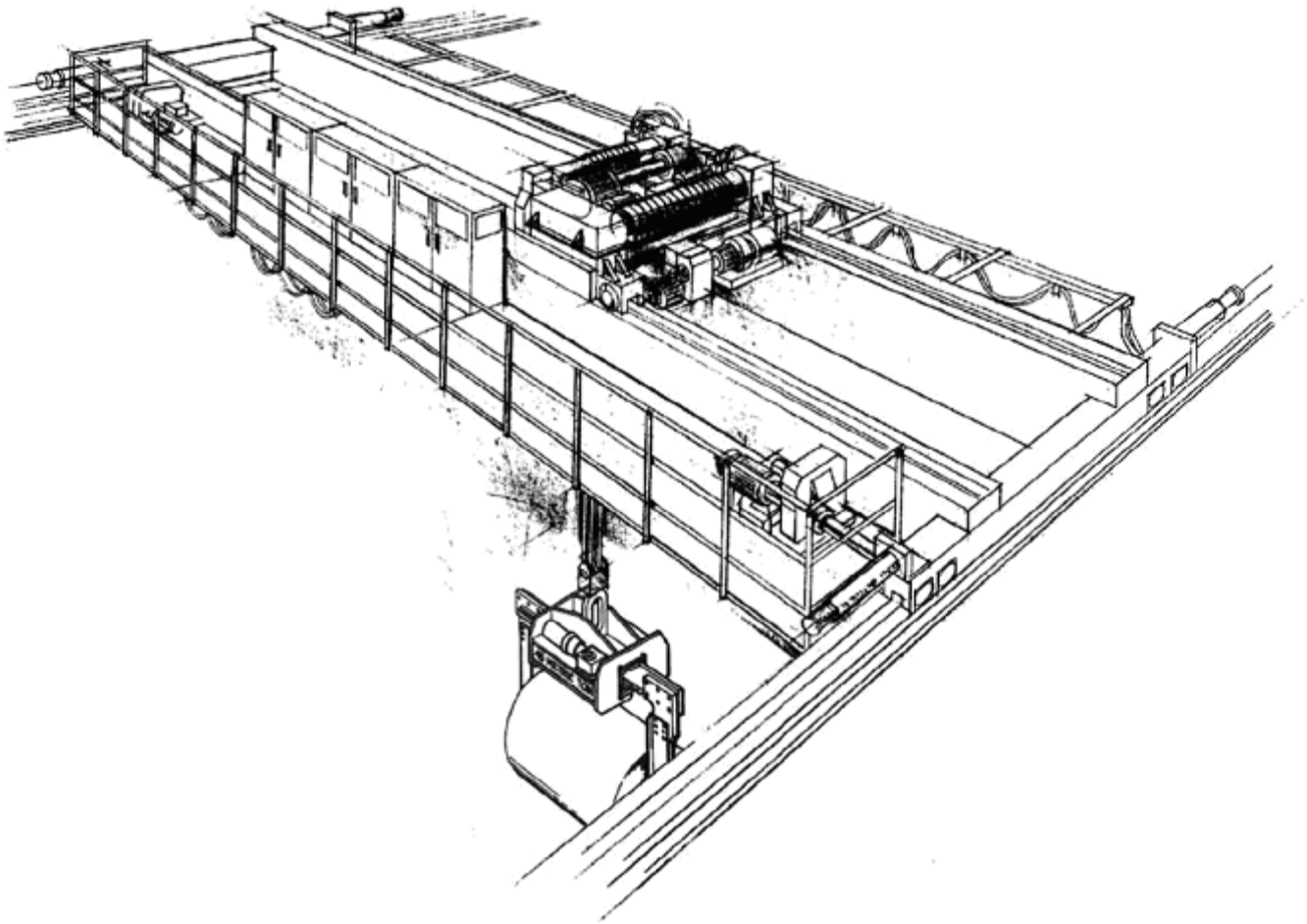


IMPULSE™ VG+ Series 3

Foot Brake / Static Stepless
Simulation Software
Instruction Manual

MAGNETEK
MATERIAL HANDLING

Software #8180.4 November 2009
Part Number: 140-10344-R3

DANGER, *WARNING*, *CAUTION*, and *NOTE*

Statements

DANGER, WARNING, CAUTION, and *Note* statements maybe used in this manual to emphasize important and critical information. You must read these statements to help ensure safety and to prevent product damage.

***NOTE**: A NOTE statement is used to notify of installation, operation, programming, or maintenance information that is important, but not hazard-related.*

Warning

Improper programming of a drive can lead to unexpected, undesirable, or unsafe operation or performance of the drive.

Disclaimer of Warranty

Magnetek hereafter referred to as Company, assumes no responsibility for improper programming of a drive by untrained personnel. A drive should only be programmed by a trained technician who has read and understands the contents of this manual. Improper programming of a drive can lead to unexpected, undesirable, or unsafe operation or performance of the drive. This may result in damage to equipment or personal injury. Company shall not be liable for economic loss, property damage, or other consequential damages or physical injury sustained by the purchaser or by any third party as a result of such programming. Company neither assumes nor authorizes any other person to assume for Company any other liability in connection with the sale or use of this product.

Table of Contents

Introduction to Foot Brake Operated Cranes (Traverse Motions only)

The purpose of this software is to provide an effective means to control an electric overhead bridge traveling crane that may or may not utilize a hydraulic or electronic foot brake to slow or stop the motion of the bridge or trolley. The hydraulic brake is operated in a similar fashion to that of an automobile where a master cylinder is operated by a foot pedal which in turn transmits hydraulic pressure to engage the brake or brakes. The hydraulic pressure and therefore braking torque developed by the master cylinder is proportional to the amount of force applied to the foot pedal. By contrast, the same principal is true when using the BrakeTronic™ Controller, except that the thruster braking torque is controlled electronically by a pedal operated potentiometer.

Since the braking on these types of crane can be controlled by the operator rather than a ramped deceleration time as it is on most modern VFD (Variable Frequency Drive) driven cranes, the crane is essentially coasting when the crane operator moves the master switch to the neutral position. The master switch can be thought of and also compared to the accelerator in an automobile. It is the means by which the crane operator commands motion, direction, torque/speed, acceleration and a variable amount of dynamic braking torque to assist the foot pedal operated brake(s).

Some of the features of this software are listed below and are explained in further detail throughout this document:

- Generally this software is applied to Cab Operated Cranes
- V/F with PG control method available. Similar to standard Crane & Hoist software, but allows for restarting coasting crane.
- Flux Vector Torque Control. Similar to Static Stepless Control.
- Foot Pedal Micro Switch input - Software knows when the Foot Brake is being applied.
- Variable Torque Reverse Plugging (Torque Limited - (Flux Vector)) - Motor assisted braking.
- Brake Stand Prevention - Prevents driving into the brake, helps prevent additional wear and tear.
- Speed / Torque Limiting - Independently programmable speed and torque limits. (analog or digital).
- Torque is directly proportional to master switch position.
- Multi-Step Digital Torque References.
- Speed Search - Motor begins operating at the exact speed the crane is coasting for a smooth start.
- Extremely responsive controls - minimum waiting for magnetic field decay in rotor prior to start.
- Easy to retrofit - Compatible with most motors and foot brake systems already in existence.
- Full Control of Crane - Start / stop speed is independent of acceleration / deceleration times (Torque Control).
- Variable Speed controls - Independently control maximum speed and torque level

Differences in Control Methods and How the Operator Will Control the Crane

Table 1: Control Methods and Associated Stopping Methods

Control Method (A1-02)	Flux Vector	Flux Vector, V/F, Open Loop and V/F with PG
Motion (A1-03)	A1-03 = 3 (Traverse Torque Control, Static Stepless Simulation)	A1-03 = 0 (Traverse)(Std C&H Software)
Stopping Method (B3-03)	B3-03 = Coast to Stop	B3-03 = Ramp to Stop
Brakes	Dynamic, Footbrake or motor brake(s) which generally become an Emergency / parking brake	Motor Brake(s) are controlled by the drive and are parking brakes that set when the crane reaches zero speed.
Master Switch Action	Description of Control	
Bridge Forward / Reverse - From stopped state, operator moves master switch full ON.	Crane will accelerate to a maximum speed as fast as it can within torque limit settings. The rate at which is does so is with respect to the deflection of the master switch. (Deflection is the distance the operator pushes/pulls the master switch in either direction. More deflection equals more torque.) Full deflection will yield full motor torque, half will yield half motor torque. (Each detent can have a programmable Torque Ref or a stepless reference may be used to set up a torque to deflection ratio).	Crane will accelerate to commanded speed. Each speed point is programmed or stepless. Acceleration time is programmable.
Neutral	Output to Motor is off. Crane is coasting.	The crane will begin to decelerate down to zero speed following a programmed deceleration time. Once zero speed is reached, a parking brake is commanded to set.
Reverse Plug (Direction change)	The crane will begin to decelerate at a rate proportional to the deflection of the master switch and eventually change direction. A Footbrake may also be applied to assist w/ braking.	Crane will begin to decelerate from current speed according a Reverse Plug deceleration time and eventually change direction and accelerate in the opposite direction up to the currently commanded speed. Note: Reverse Plug Acc/Dec times are optional.
Foot Brake ON - Brake Stand Prevention (Manual braking)	Can be used to do all braking or can be used to assist Dynamic braking of the drive(s). Brake stand prevention is optional since the motion is not following a programmed acceleration / deceleration time. Restart is possible at anytime, even if the crane is in motion.	Must use a micro switch from brake pedal or hydraulic pressure switch to signal drive to turn off while the brake is applied so that the drive(s)/motor(s) are not attempting to decelerate through the brake. **Restarting is not possible until motion has completely stopped.**
Bridge Forward / Reverse - From running / coasting state, operator moves master switch to Half deflection.	From it's present speed, the crane may accelerate to a maximum speed within the commanded torque settings. The rate at which it does so is with respect to the deflection of the master switch. Full on will yield full motor torque, half on will yield half motor torque (Each detent is a programmable Torque Ref). Note: Half on may be enough torque to keep the crane at a constant speed without applying full motor torque.	The Crane must reach zero speed before attempting to initiate a new run command.

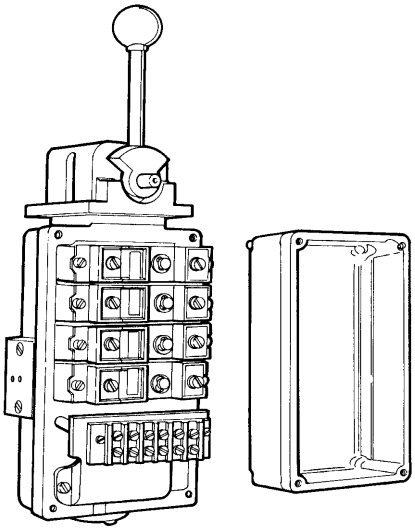
Controlling the Bridge / Trolley

1. Traversing - (Flux Vector - Torque Control)

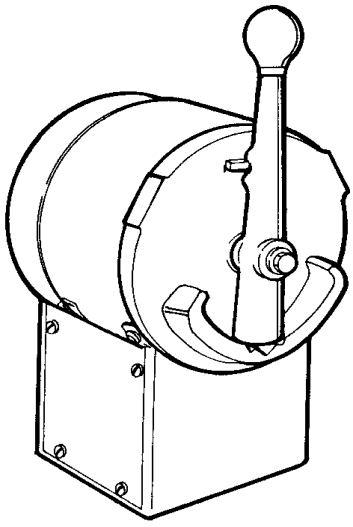
A master switch performs two separate functions in the control system. First, there is a set of contacts operated by a cam shaft. When the master switch is moved from the neutral position in either direction, the contacts close. This set of contacts is used as a run command to the VFD. Second, the master switch provides a continuously variable voltage to the VFD which internally correlates to a **torque reference**. The magnitude of the torque reference is proportional to the master switch position which gives the crane operator the capability to control the torque over the full range from minimum to maximum deflection. Not only is the torque exerted at the motor shaft proportional to the master switch position, but it is regulated at that value as the crane accelerates or decelerates. The end result being that as torque is applied to the motor, the crane begins to move in the commanded direction at the commanded amount of torque. As more torque is applied, the crane will accelerate or decelerate faster. The maximum speed is limited by parameter settings in the software. Once the maximum speed is reached, the internal torque reference will automatically be reduced to prevent the crane from accelerating beyond the maximum speed setting regardless of the master switch position. The amount of time for the crane to accelerate from zero speed to maximum speed is dependent on the amount of torque reference given through the master switch. If a very slow speed and acceleration is required, then a very fine movement of the master switch in the desired direction will yield those results. This is very helpful where a rapid acceleration would cause load swing.

Figure 1 - Typical Master Switches

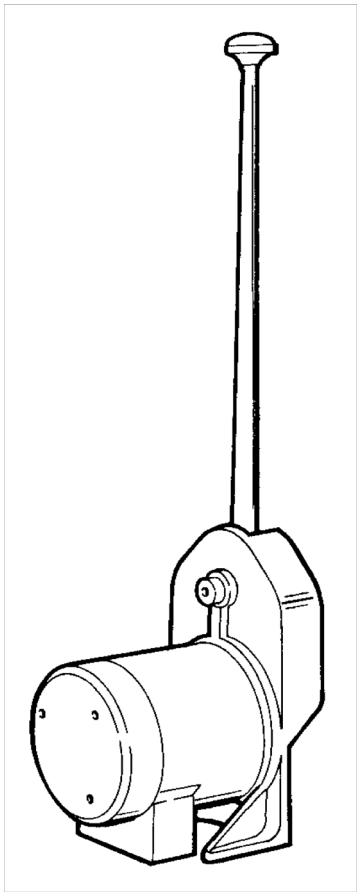
Master Switches come in many variations. In general they all have either stepped contacts that give a run direction and reference associated with each detent or they give a run direction and a stepless analog signal. Some Master switches may only give one contact closure and then a bi-directional analog signal. Some master switches incorporate springs that return the master switch to the "neutral" or center position automatically.



P&H SIR Induction Master Switch



Shelf Mounted Induction Master Switch



Base Mounted Induction Master Switch

2. Stopping

Once the bridge or trolley is in motion and the crane operator has moved the master switch to the neutral position, the motion is considered to be coasting and will continue to do so until one or all of the following occur:

·Mechanical friction and wind resistance slow or stop motion over time

·The crane operator applies the brakes by stepping on the brake pedal

·The crane operator moves the master switch to apply torque in the opposite direction the motion is coasting (Plugging).

·Any combination of the above.

3. Plugging

Plugging is a term that has carried over from traditional contactor control where a motor is connected directly to the line through the use of reversing contactors. Plugging is defined as a control function that provides braking by reversing the motor line voltage polarity or phase sequence so that the motor develops a counter torque that exerts retarding force. This method of slowing or stopping the crane is inherently detrimental to the motor and controls as it subjects them to several times the amount of nominal current.

Since the use of VFDs, it is no longer necessary to reverse the voltage polarity through the use of reversing contactors. The voltage and frequency applied to the motor by the VFD can be controlled through software. Torque control allows the crane operator to apply an adjustable amount of retarding torque to the motor by simply moving the master switch to the direction opposite of the cranes motion. The maximum amount of retarding torque that can be applied is limited by parameters in the software. This helps to insure a smooth transition from coasting to slowing down and is non destructive to the controls or the crane itself.

4. The Foot Brake, Plugging and Brake Stand Prevention

The hydraulic brake is operated by a foot pedal which forces hydraulic fluid from the master cylinder to the brake. When the crane operator steps on the foot pedal, two things happen in the controller software. A contact closure is made in the hydraulic brake circuit when the crane operator applies pressure to the foot pedal. The contact closure can be in the form of a micro switch attached to the pedal or a hydraulic pressure switch in the hydraulic circuit. The electrical signal is routed to the VFD and signals the software that crane operator has applied the hydraulic brake or brakes. When this is the case, the software will prevent the motor from driving into the brakes (Brake Stand Prevention). This saves wear and tear on the controls, brakes and the crane itself. This is possible since the VFD knows the speed and direction the crane is moving by the pulse train it is receiving from the encoder circuit. The same principal holds true when using Braketronic™. A signal must come from the foot pedal to the VFD.

The following are possible scenarios when the foot brake is being applied:

<table>
<tr><th>Crane Direction</th><th>Master Switch Torque Polarity</th><th>Torque Output to Motor</th><th>Keypad Display</th></tr>
<tr><td rowspan="2">Forward</td><td>Forward</td><td>Zero Torque Output</td><td>BRAKE STAND
Footbrake On</td></tr>
<tr><td>Reverse</td><td rowspan="2">Reverse Plug
(Follow Master Switch)</td><td rowspan="2">Normal Display</td></tr>
<tr><td rowspan="2">Reverse</td><td>Forward</td></tr>
<tr><td>Reverse</td><td>Zero Torque Output</td><td rowspan="3">BRAKE STAND
Footbrake On</td></tr>
<tr><td rowspan="2">Stopped
(Zero Speed)</td><td>Forward</td><td rowspan="2">Zero Torque Output</td></tr>
<tr><td>Reverse</td></tr>
</table>

Figure 2 - Typical Hydraulic Circuit

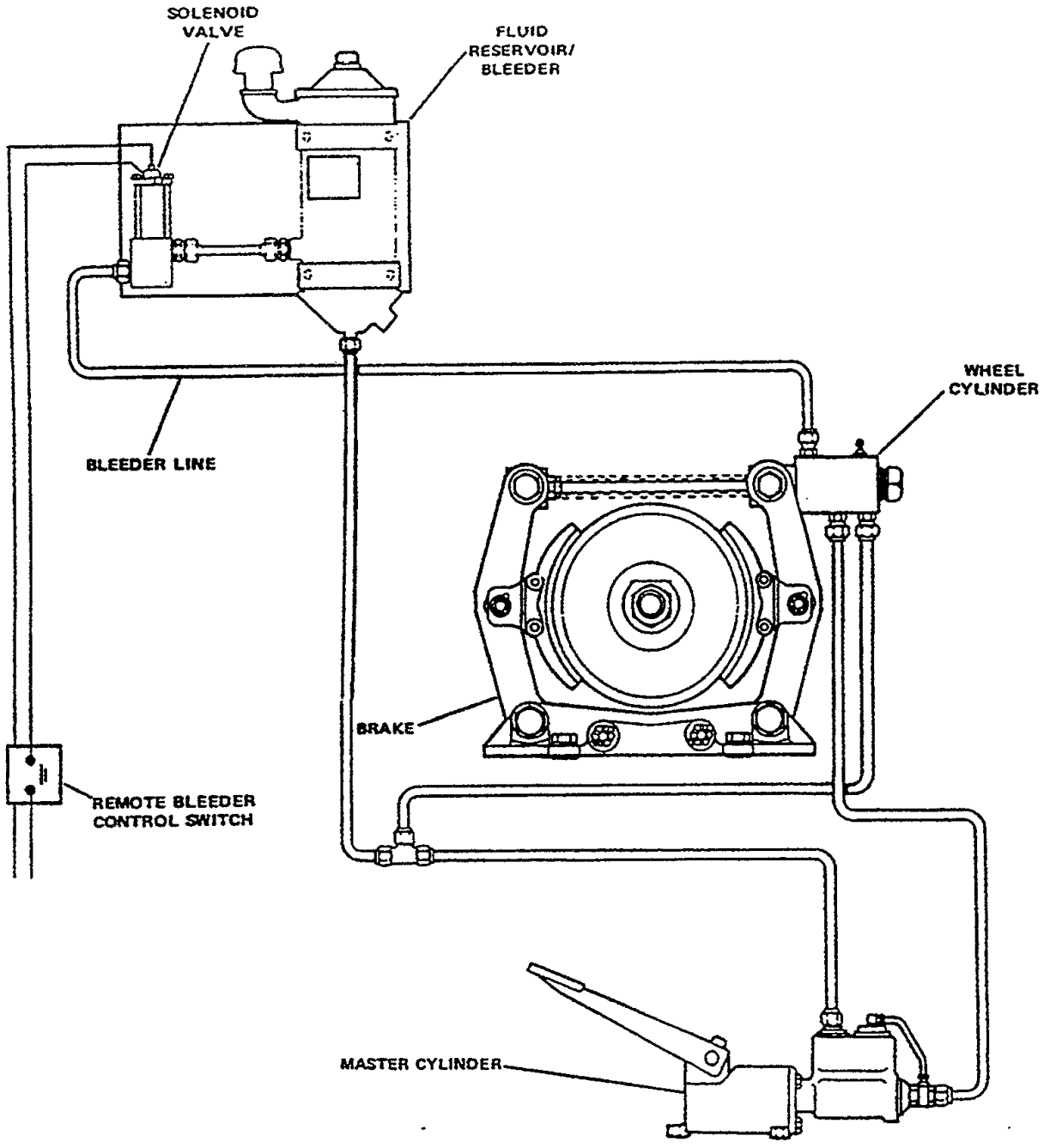
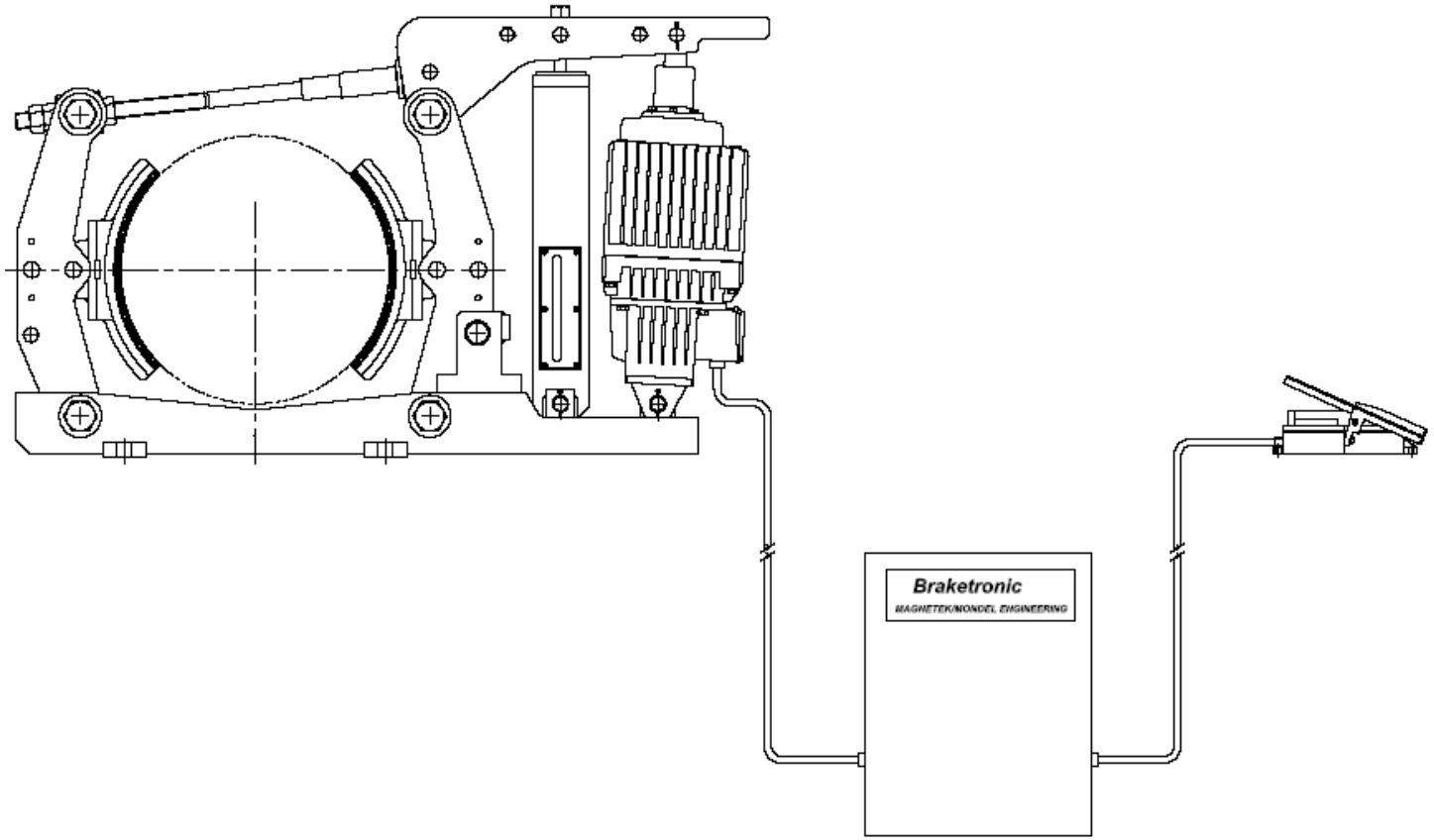


Figure 3 - Typical Braketronic System



5. Open-Circuit Voltage Decay and Starting into a Rotating Motor (Speed Search)

In traditional Reversing Contactor Control, when the master switch is in the neutral position, the contactors are de-energized and the circuit to the motor is opened. The crane is typically coasting at some speed and the residual voltage and current in the motor begins to decay as the rotor demagnetizes. The amount of time for the voltage/current to decay is dependent on several variables: Motor horsepower, Motor type, Load, temperature, etc. When the master switch is moved from the neutral position, line voltage and frequency is applied to the coasting motor. After some amount of time, the speed of the crane and hence the motor speed has decreased from friction or the brake(s) being applied. When the motor is re-energized, its rotation is not synchronous with that of the line voltage/frequency being applied. The residual voltage in the motor also may not have completely decayed prior to the circuit closing again. Since the motors duty is to follow the direction and frequency of the line voltage being applied, in doing so it will either accelerate or decelerate the crane to follow its commanded speed and direction. This can cause sizeable current transients, vibration and significant wear to the motor, controls and machinery over time. The effects can be more than tripled when the controls are Reverse Plugged.

Through the use of a VFD and this software, it is possible to program the motor time constant for each motor and eliminate the excessive current transients. These parameters will change automatically based on the inverter Horse Power rating. If the exact motor time constant is known (via the motor manufacture), it can be entered into L2-03. Furthermore, the current is reduced significantly in comparison by knowing in advance the speed of the motor shaft and matching that frequency when restarting the motion while the crane is coasting.

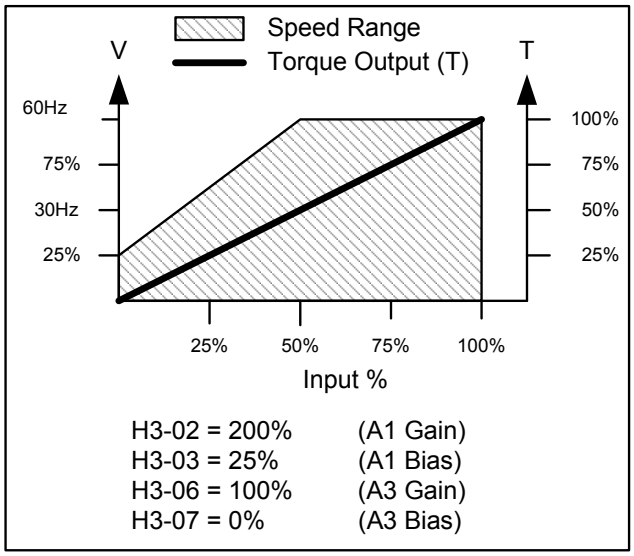
6. Variable Speed Limits for Stepped, and Stepless (analog) Input.

In Variable Speed Limit mode, a master switch serves two functions. First, a set of contacts close and an input on the VFD is activated. This starts the motor spinning. Second, the master switch provides a voltage proportional to the deflection. This voltage is connected to two inputs on the VFD, one for torque reference and one for variable speed limit. Without variable speed limits, the motor will accelerate up to full speed at a rate determined by the input torque level. With variable speed limits activated, the motor will accelerate up to the variable speed limit at the input torque level. When the speed limit has been reached, the torque is reduced to whatever level is required to maintain that speed. In this way a small amount of master switch deflection can be used to precisely position the load.

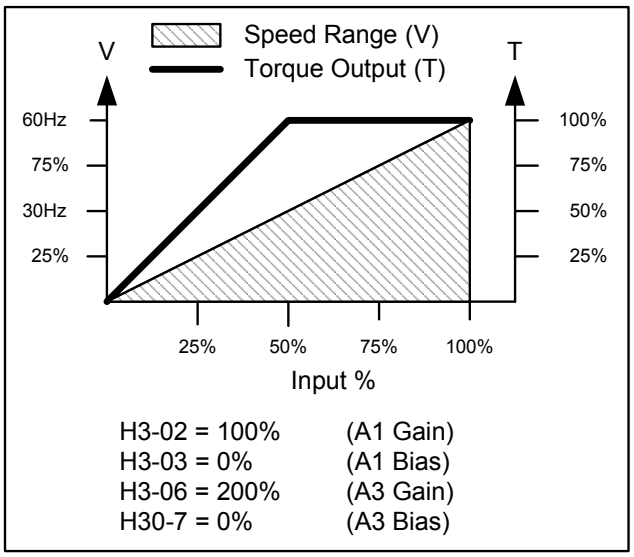
When the operator reduces the amount of deflection on the master switch, the torque and speed limits will both be simultaneously reduced. At this moment, the motor will be spinning faster than is allowed by the variable speed limits. The motor will coast with no output torque until the motor has decelerated to the new speed limit value. The VFD will then reapply torque, up to the torque limit as input from the master switch, to maintain that speed. Reverse torque is not applied to decelerate the motor to the new variable speed limit. To decelerate the load quicker the operator must reverse plug.

In most Bi-Polar or Uni-Polar configurations, a jumper wire is placed between the A1 and A3 terminals. The analog signal from the master switch is then wired to the A1 terminal. The torque and speed reference use the same input voltage, and can be controlled by H3-0x parameters. See Figure 4 for examples. In a multi-step input configuration, there are no wiring changes from a typical VFD Multi-Step system. The variable speed limits are stepped with the input torque levels. Step 1 input from the master switch will activate Torque-Ref 1 (B7-01) and Speed-Ref 1 (B1-01), Step 2 input from the master switch will activate Torque-Ref 2 (B7-02) and Speed-Ref 2 (B1-02), and so on. See Figure 5 for examples.

Figure 4 - Example Variable Speed Limits Profiles, Stepless Input



Linear torque, slight speed limiting. Some speed control at lower input levels, but does not limit the speed at the upper end. Output torque is the same as in a typical Static Stepless Simulation system.



High torque, linear speed. In this configuration the output torque is very high, but the output speed will increase at a constant rate as the master switch is moved through its range.

Figure 5 - Uni-Polar Stepless Input Wiring

Note: Bi-polar (-10VDC - +10VDC) is also available.

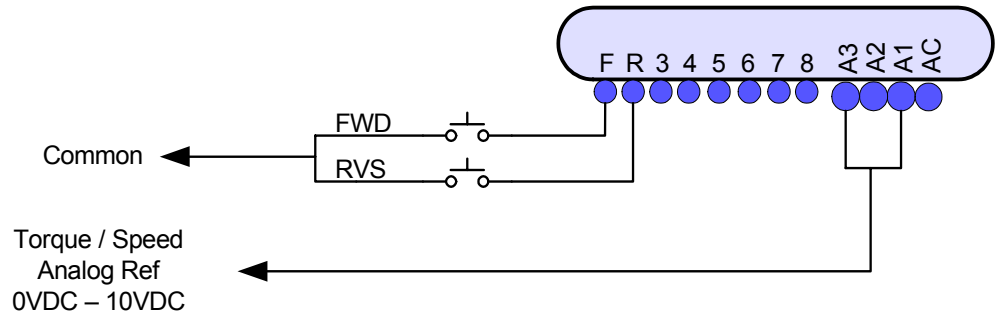
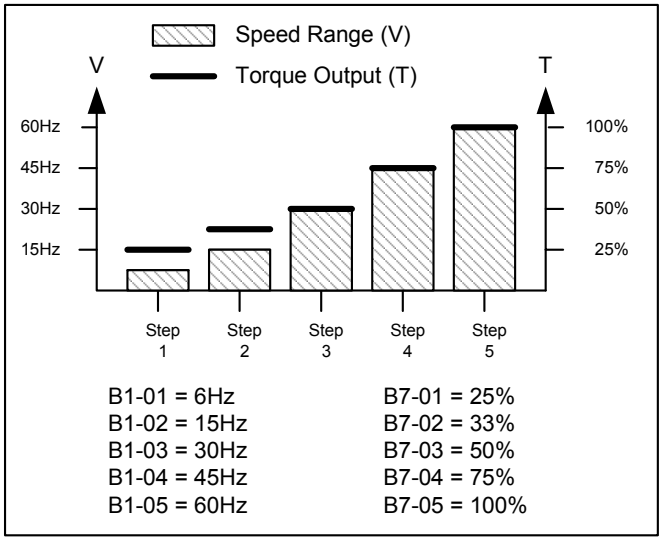
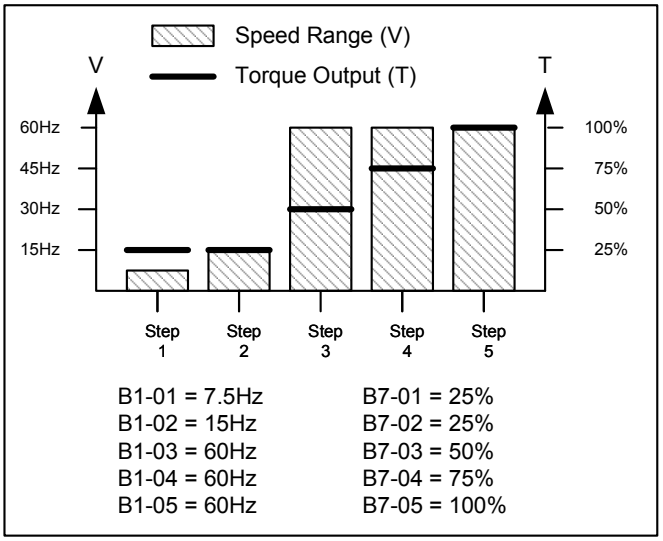


Figure 6 - Example Variable Speed Limits Profiles, 5-Step Input



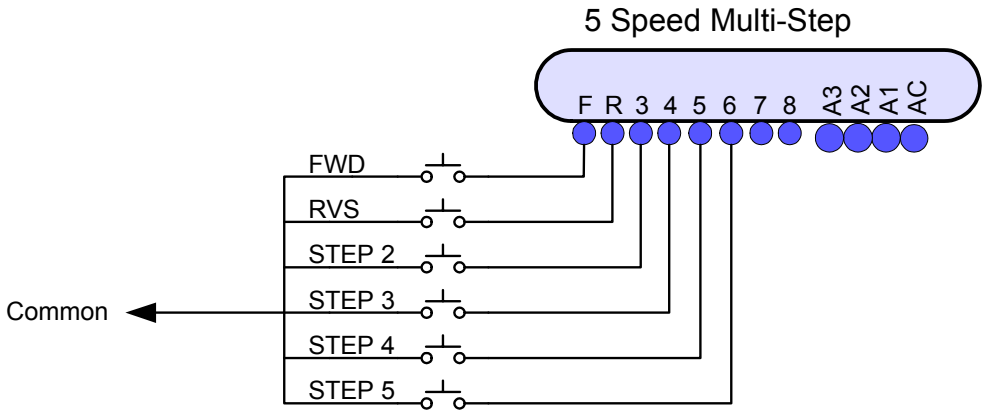
Stepped torque and speed. The output torque and speed limits increase at a constant rate as the master switch is moved through its range.



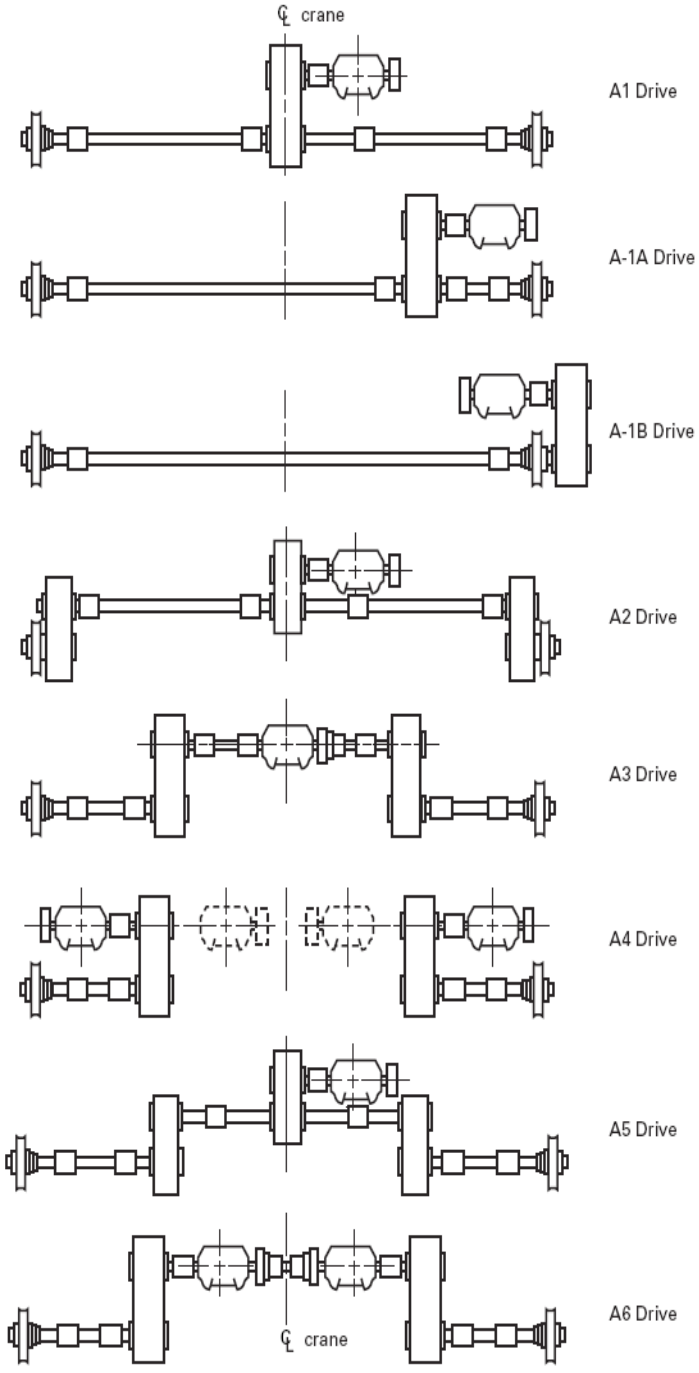
Stepped torque, limited speed at low end. At low input levels, the output speed of the drive is very limited. After step two, the drive returns to a typical Static Stepless Simulation type of response.

Figure 7 - Stepped Input Wiring

Note: 2 and 3 Step configurations also available.



Typical Mechanical Arrangement of Bridge / Trolley Drives



A-1 Drive. The motor is located near the center of the bridge/trolley and is connected by means of a flexible coupling to a self-contained gear reduction unit also located at the center of the bridge/trolley, which is connected to the line shaft by solid or half-flexible couplings. The line shaft is in turn connected to the bridge/trolley wheel axles by means of floating shafts with half-flexible couplings.

A-1A Drive. Same as A-1 drive, except the self-contained gear reduction unit is located closer to one of the bridge/trolley wheel axles.

A-1B Drive (Trolley Only). Same as A-1 drive, except the self-contained gear reduction unit is located outside the trolley frame close to one of the trolley wheel axles.

A-2 Drive. The motor is connected by means of a flexible coupling to a self-contained gear reduction unit located at the center of the bridge/trolley. The wheels are driven through gears which are either pressed or keyed to their axles or which are attached directly to the wheel**.**

A-3 Drive. The motor is located at the center of the bridge/trolley and is connected directly to the line shaft by half-flexible couplings. Self-contained gear reduction units located near each end of the bridge/trolley are connected to the wheel axles by means of floating shafts with half-flexible couplings or directly with full-flexible couplings.

A-4 Drive. The motors are located near each end of the bridge/trolley without torque shafts. The motors are connected to self-contained gear reduction units by means of flexible couplings. The gear reduction units are connected to the bridge/trolley wheel axles by means of floating shafts with half-flexible couplings or directly coupled by means of full-flexible couplings.

A-5 Drive. The motor is located near the center of the bridge/trolley and is connected by means of a flexible coupling to a self-contained gear reduction unit located near the center of the bridge/trolley. This reduction unit is connected by sections of line shaft having solid or half-flexible couplings to self-contained gear reduction units located near each end of the bridge/trolley, and these in turn connect to wheel axles by means of floating shafts with half-flexible couplings or directly by means of full-flexible couplings.

A-6 Drive. The motors are located near each end of the bridge/trolley and are connected with a torque shaft. On the drive end, the motors are connected to self-contained gear reduction units by means of flexible couplings. Gear reduction units are connected to wheel axles by means of floating shafts with half-flexible couplings.

Programming

Table 2: Parameters

Function	Parameter	Name (Display)	Content	Range	Initial Value	Access Level
Initialization: A1	A1-02	**Control Method**	0: V/F Control (w/o PG) 1: V/F Control w/ PG (PG = Encoder) 2: Open Loop Vector 3: Flux Vector	0 ~ 3	3	Adv
	A1-03	Motion Selection (**Select Motion**)	Application motion is selected. 0: Traverse 1: Standard Hoist (w/ Mechanical Load Brake) 2: No Load Brake Hoist (NLB Hoist) 3: Traverse - Torque Control	0 ~ 3	3*	Adv
	A1-04	Speed Reference Select (**Speed Reference**)	0: 2-Spd Multi-Step 1: 3-Spd Multi-Step 2: 5-Spd Multi-Step 3: 2-Step Infinitely Variable *(Infinitely Variable is not selectable when A1-03 = 3) 4: 3-Step Infinitely Variable *(Infinitely Variable is not selectable when A1-03 = 3) 5: Uni-Polar Analog (0-10V, 4-20ma) 6: Bi-Polar Analog (-10V to + 10V) 7: G5IN4 Opt Card (Other than MFI H1-01 ~ 06) 8: Serial Opt Card	0 ~ 8	1	Adv
Frequency Reference B1	B1-01	Frequency Reference 1 (**Reference 1**)	Sets the Speed 1 frequency	0.00 ~ 150.00 Hz	15 *	Adv
	B1-02	Frequency Reference 2 (**Reference 2**)	Sets the Speed 2 frequency	0.00 ~ 150.00 Hz	30 *	Adv
	B1-03	Frequency Reference 3 (**Reference 3**)	Sets the Speed 3 frequency	0.00 ~ 150.00 Hz	60 *	Adv
	B1-04	Frequency Reference 4 (**Reference 4**)	Sets the Speed 4 frequency	0.00 ~ 150.00 Hz	45 *	Adv
	B1-05	Frequency Reference 5 (**Reference 5**)	Sets the Speed 5 frequency	0.00 ~ 150.00 Hz	60 *	Adv
Foot Brake Setup: B7	B7-01	**Torque-Ref 1**	Torque reference when a digital multi-step torque reference is used. H1-0x = 0 ~ 3. (A1-04 = 0,1 or 2 and B7-06 = Enabled).	0 ~ 300 %	20 *	Adv
	B7-02	**Torque-Ref 2**			40 *	Adv
	B7-03	**Torque-Ref 3**			60 *	Adv
	B7-04	**Torque-Ref 4**			80 *	Adv
	B7-05	**Torque-Ref 5**			100 *	Adv
	B7-06	Digital Torque Ref 0/1 **(Digital Tref 0/1)**	When a multi-step master switch is used, it is possible to input up to 5 preset torque references by enabling B7-06. B7-06 is changed automatically by X-press programming. 0: Disabled 1: Enabled	0, 1	1 *	Adv
	B7-07	**Foot Brake Action**	Action taken when the foot brake is applied. MFDI must be programmed for 67H. Note: There is a 500ms delay before any action is taken. This helps prevent nuisance shut downs by accidentally bumping the brake pedal or master switch. 0: Disabled 1: Turn Output Off - Inverter Output is Always Base Blocked. 2: Brake Stand Prevention - Inverter Output is Base Blocked if driving into the brake. *(B7-07 = 2 is only possible when A1-03 = 3)	0 ~ 2	2	Adv
	B7-08	**Var Speed Limits**	Limit output frequency of drive. Uses traditional speed reference parameters (B1-0x, Analog Input) for limit frequency. 0: Disabled 1: Enabled	0 ~ 1	0	Adv

Table 2: Parameters

Function	Parameter	Name (Display)	Content	Range	Initial Value	Access Level
Torque Control: D5	D5-01	**Torque Control**	Selects Speed or Torque control. The torque reference is set via analog input A2 or A3 when it is set for "torque reference" (H3-05 or H3-09 = 13H). Torque reference is set as a percentage of motor rated torque. To use this function for switching between speed and torque control, set to 0 and set a multi-function input to "Speed / Torque Control Change" (H1-0x = 34H). 0: Speed Control (Controlled by D4-01 ~ 07) 1: Torque Control	0, 1	0 *	Adv
	D5-02	**Torque Ref Filter**	Primary Delay time for Torque Reference Input. This setting will help eliminate noise spikes. Increase setting if Instability or vibration occurs during Torque Control.	0 ~ 1000 msec	0	Adv
	D5-03	**Speed Limit Sel**	Sets the speed limit command method for the torque control method. 1: Analog Input - Limited by the output of the soft starter (B3-01 selection and active acceleration/deceleration and S-curve settings). 2: Program Setting - Limited by D5-04 setting value.	1, 2	2	Adv
	D5-04	**Speed Limit Val**	Speed Limit Value % E1-04. Setting is used when D5-03 = 2. Sets the Forward Speed Limit.	-120 ~ +120 %	100	Adv
	D5-05	**Speed Limit Bias**	Speed Limit Bias % E1-04 Sets the Reverse Speed Limit.	0 ~ 120 %	100	Adv
	D5-06	**Ref Hold Time**	Speed / Torque Switching Timer Sets the delay time from inputting the multi-function input "Speed / Torque Control Change" (from On to OFF or OFF to ON) until the control is actually changed. This function is enabled when the multi-function input "Speed / Torque Control Change" (H1-0x, C9-0x = 34H) is programmed to an input terminal. While in the Speed / Torque control switching timer, the analog inputs hold the value present at the time "Speed / Torque Control Change" is received.	0 ~ 1000 ms	0	Adv
*** See parameter changed by X-Press Programming for correct initial value.**						

Table 3: Monitors

Monitors Selectable by: F4-01, F4-03, H4-01, H4-04, H6-06, O1-01

Function	Monitor	Name (Display)	Content	Output Signal Level at Multi-function Analog Output	Min. Unit	Range	Access Level
Monitor: U1	U1-09	**Torque Reference**	**Torque Reference** Displays the torque reference to motor.	10V: Motor Rated Torque (0 ~ ±10V applicable)	0.01Hz	0 ~ E1-04	Adv

Table 4: Multi-function Digital Inputs selectable by H1-0x and C9-0x (MFDI)

Setting Value	Name (Display)	Function	Access Level
67H	**Foot Brake In**	Off: Foot brake is not applied. On: Foot brake is being applied. Take action according to B7-07.	Adv

Table 5: X-Press Programming (A1-03 = 3 - Traverse - Torque Control (Static Stepless Simulation))

A1-04	Description	B1-01	B1-02	B1-03	B1-04	B1-05	B1-06	B1-07	B1-08	B1-09	B1-10	B1-11	B1-12	B1-13	B1-14	B1-15	B1-16	B1-17	B1-18	B2-01	B2-03	B3-03	B5-01	B5-02	B7-01	B7-02	B7-03	B7-04	B7-05
		Speed 1	Speed 2	Speed 3	Speed 4	Speed 5	Speed 6	Speed 7	Speed 8	Speed 9	Speed 10	Speed 11	Speed 12	Speed 13	Speed 14	Speed 15	Speed 16	Jog Ref	Ref Prior-ity	Ref. Upper Limit	Ref. Lower Limit	Stop Method	Accel Time 1	Decel Time 1	Torq Ref 1	Torq Ref 2	Torq Ref 3	Torq Ref 4	Torq Ref 5
0	2-Speed Multi-Step	20.00	60.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.00	0	100.0	2.0	1	10.0	10.0	25	100	0	0	0
1	3-Speed Multi-Step	15.00	30.00	60.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.00	0	100.0	2.0	1	10.0	10.0	25	60	100	0	0
2	5-Speed Multi-Step	6.00	15.00	30.00	45.00	60.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.00	0	100.0	2.0	1	10.0	10.0	20	40	60	80	100
* 3	2-Step Inf. Variable	6.00	0.00	0.00	0.00	60.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.00	0	100.0	2.0	1	10.0	10.0	0	0	0	0	0
* 4	3-Step Inf. Variable	6.00	0.00	0.00	0.00	60.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.00	0	100.0	2.0	1	10.0	10.0	0	0	0	0	0
5	Uni-Polar Analog	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.00	0	100.0	2.0	1	10.0	10.0	0	0	0	0	0
6	Bi-Polar Analog	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.00	0	100.0	2.0	1	10.0	10.0	0	0	0	0	0
7	G5IN4 Opt. Card	15.00	30.00	60.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.00	0	100.0	2.0	1	10.0	10.0	20	40	60	80	100
8	Serial Opt. Card	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.00	0	100.0	2.0	1	10.0	10.0	0	0	0	0	0
* INFINITELY VARIABLE IS NOT AVAILABLE IN TORQUE CONTROL MODE.																													

A1-04	Description	B7-06	C1-01	C1-03	C3-07	C8-10	D5-01	D9-01	D9-02	D9-03	E1-03	H1-01	H1-02	H1-03	H1-04	H1-05	H1-06	H2-01	H2-02	H2-03	H3-01	H3-04	H3-05
		Digital Tref 0/1	Quick Stop 0/1	Rev Plug 0/1	Action @ LL2/ UL2	Load Float Time	Torque Control Sel	S-Curve Accel at Start	S-Curve Accel at End	S-Curve Decel at Start	V/F Selection	Terminal S3 Select	Terminal S4 Select	Terminal S5 Select	Terminal S6 Select	Terminal S7 Select	Terminal S8 Select	Terminal M1 / M2 Select	Terminal M3 / M4 Select	Terminal M5 / M6 Select	Terminal A1 Signal	Terminal A3 Signal	Terminal A3 Select
0	2-Speed Multi-Step	1	0	1	2	0	1	1.50	1.50	1.50	0F	00	0F	0F	0F	0F	0F	0F	0F	0F	0	0	1F
1	3-Speed Multi-Step	1	0	1	2	0	1	1.50	1.50	1.50	0F	00	01	0F	0F	0F	0F	0F	0F	0F	0	0	1F
2	5-Speed Multi-Step	1	0	1	2	0	1	1.50	1.50	1.50	0F	00	01	02	03	0F	0F	0F	0F	0F	0	0	1F
* 3	2-Step Inf. Variable	0	0	1	2	0	0	1.50	1.50	1.50	0F	05	0F	0F	0F	0F	0F	0F	0F	0F	0	0	1F
* 4	3-Step Inf. Variable	0	0	1	2	0	0	1.50	1.50	1.50	0F	04	05	0F	0F	0F	0F	0F	0F	0F	0	0	1F
5	Uni-Polar Analog	0	0	1	2	0	1	1.50	1.50	1.50	0F	0F	0F	0F	0F	0F	0F	0F	0F	0F	0	0	13
6	Bi-Polar Analog	0	0	1	2	0	1	1.50	1.50	1.50	0F	0F	0F	0F	0F	0F	0F	0F	0F	0F	0	1	13
7	G5IN4 Opt. Card	0	0	1	2	0	1	1.50	1.50	1.50	0F	0F	0F	0F	0F	0F	0F	0F	0F	0F	0	0	1F
8	Serial Opt. Card	0	0	1	2	0	1	1.50	1.50	1.50	0F	0F	0F	0F	0F	0F	0F	0F	0F	0F	0	0	1F
* INFINITELY VARIABLE IS NOT AVAILABLE IN TORQUE CONTROL MODE.																							

Table 6: Stopping Method Selection (B3-03)

Control Method	Motion	Stopping Method
A1-02	**A1-03**	**B3-03**
V/F w/ PG	0: Traverse	0: Decelerate to Stop 1: Coast to Stop 2: DC Injection Braking 4: Decel with timer
	1: Standard Hoist	0: Decelerate to Stop 1: Coast to Stop 2: DC Injection Braking
Flux Vector	0: Traverse	0: Decelerate to Stop 1: Coast to Stop 4: Decel with timer
	2: NLB Hoist	0: Decelerate to Stop 1: Coast to Stop 6: No Load Brake
	3: Trav - Torq Ctrl	1: Coast to Stop

Alarms

Table 7: Alarms

Alarm Display	Description	Cause	Corrective Action
BRAKE STAND	**Foot Brake On**	The Footbrake is being applied.	1. None may be required. When crane is stopped, Display will indicate that the Foot brake is being applied. 2. Operator is stepping on the brake and attempting to drive in the same direction. 3. Verify the correct setting of B7-07.

Special Function Compatibility and Limitations Matrix

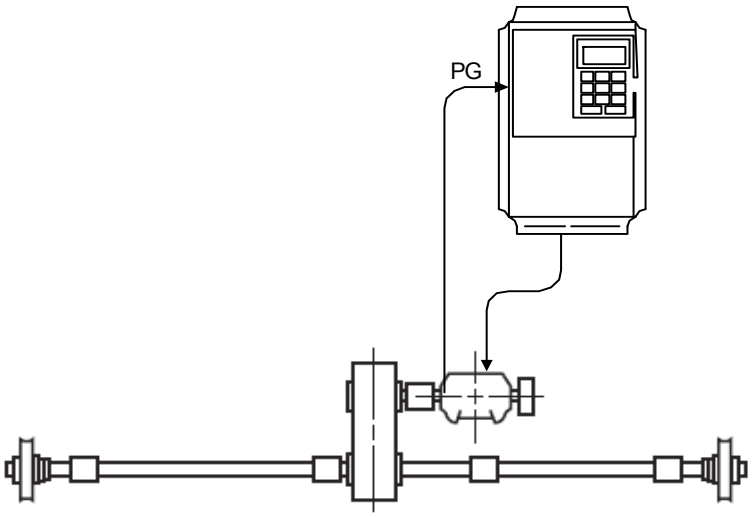
Due to the nature of Torque Control, certain functions may be disabled or have special limitations.

SPECIAL FUNCTION	Use in Traverse - Torque Control Mode?	Remark
MOP (Motor Operated Potentiometer) / TRIM Control: B4-01 is disabled (Hold Fref), B4-02, MFDI 38H, 3DH, 3EH, 45H, 46H	No	Can not select MFDI's when A1-03 = Trav - Torque Control.
Accel / Decel: B5 Group, MFDI 1AH, 1BH, 1CH, 40H,	No	
Speed Search: B6 Group, MFDI 4DH, 4EH, 50H	Yes	Speed search is automatic in this software
Jump Frequencies: B8 Group	No	
Quick Stop: C1-01, C1-02	No	Depends on Stopping Method
Reverse Plug: C1-03 ~ C1-05	Yes	C1-03 ~ C1-05 not used for Trav - Torq Control. Plugging is accomplished by reversing the Torque Ref.
Micro Speed:C2 Group, MFDI EH, 10H	Yes	Uses D5-04 instead of freq. Does not work in Rev Direction for A1-04 = Bi-Polar Analog.
Travel Limits:C3 Group, MFDI 6H ~ DH, 12H, 62H	Yes	Does not work in Rev Direction for A1-04 = Bi-Polar Analog.
Load Float: Automatic (C8-10)	No	
Load Float by MFDI: MFDI 11H or 35H	No	
Load Check: C5 Group	No	Function is Disabled
Ultra-Lift	No	Function is Disabled
Torque Limit: C7 Group, MFDI 14H (C7-05 - Alt. T. Lim)	Yes	C7 Group has priority over analog / digital T-Ref. (MFDI 14H = C7-01 ~ 04 * C705) = TRef Max.
No Load Brake Hoist:A1-03, C8 Group	No	
Traverse: A1-03 = 0	Yes	Functions same as Standard Software
Standard Hoist: A1-03 (Hoist Has a Mechanical Load Brake)	No	Masked by Password 2
Brake Answerback: C8 Group, MFDI 58H	Yes	No BE5 when B3-03 = Coast to Stop.
G5IN4: C9 Group	Yes	
Weight Measurement: C10 Group (Weight Limit Output by Load Cell input to set MFDO 33H)	No	
Slack Cable: C11 Group	No	Function is Disabled
Snap Shaft (Drive Train Discontinuity): C11 Group	Yes	Requires PG-Z2 hardware.
Timer Functions:C12 Group	Yes	
Maintenance Timer: C12-05, C12-06, MFDO 37H, U1-52	Yes	Uses Speed Limit maintenace gain.
Inching / Indexing Control: C13 Group - MFDI 17 ~ 19H, 60H	No	
Swing Stop: C14 Group	No	
DC Injection: D1 Group	Yes	
Slip Compensation: D2 Group	Yes	
Automatic Speed Regulation (ASR): D4 Group	Yes	
Torque Control: D5 Group - MFDI 34H	Yes	
Droop Control: D6 Group	No	
PID Control: D7 Group, MFAI B, C, MFDI 48H ~ 4BH	No	
Dwell: D8 Group	No	Disabled
S-Curve Accel / Decel: D9 Group	No	When Acc/Dec Times are used, S-curves are used.
V/F Pattern: E1 Group	Yes	
Motor 2: E3 ~ E4 Group , MFDI 41H	Yes	
Serial / High Speed Communications: H5, F6 Group	Yes	Modbus, Modbus +, Modbus TCP, Profibus When using communications for Control, Set B2-03 = Comms, (B3-01 = 1 Terminals to use digital Multi-Step Tref). T-Ref can also be sent by comms, but then a torque limit must also be sent when running in speed control.
Pulse Input / Output: H6 Group	No	
Motor Overload Protection: L1 Group	Yes	

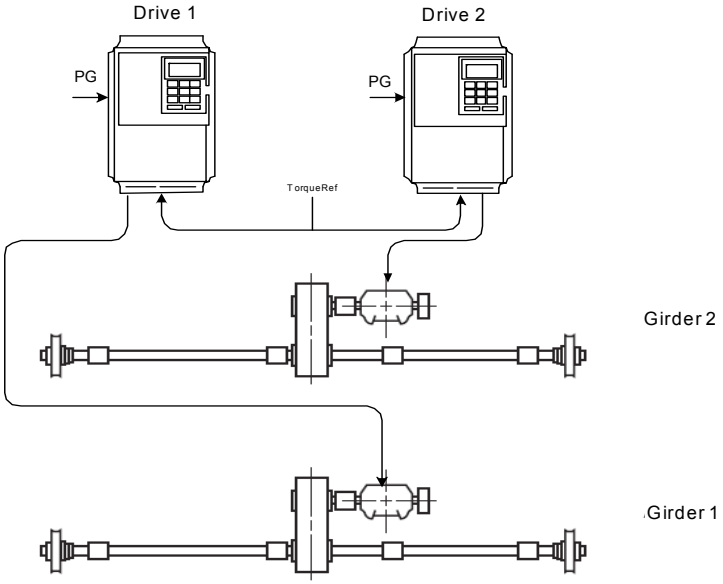
SPECIAL FUNCTION	Use in Traverse - Torque Control Mode?	Remark
PowerLoss RideThrough: L2 Group	Yes	
Stall Prevention: L3 Group	No	
Speed Agree: L4 Group	Yes	
Under / Over Torque Detection: L6 Group, MFDI 70 - OT / UT 0/1	Yes	
Hardware Protection: L8 Group	Yes	
Automatic Fault Reset: L9 Group	Yes	
Jog Control: B1-17, MFDI 15H, 16H	No	
Drive Enable: MFDI 55H	Yes	
Allow Run at Powerup: B3-10	Yes	
DO-02C, DO-08 (Digital Output option Cards): F5 Group	Yes	
Phantom Fault: MFDI 5FH, 63H	Yes	
BE6 Up Speed Limit: C8-17, MFDI 5BH	No	
Brake Test: MFDI 61H	Yes	D5-01 must be temporarily set to speed control
Load Share: MFDI 66H	No	
Fault Annunciation: MFDO 40 ~ FFH	Yes	
Load Cell: MFAI 16H, MFDO 33H, C10-01 = 4	No	
Hook Height (Height Measurement): U1-50, U1-51	No	
Local Remote Control by Mode/Service Key or by MFDI 31H	Yes	Only Run Ref. Will not work for Torque Ref.
Change Motor Rotation: B3-04	Yes	
Change Encoder Phases: F1-05	Yes	
Load Float Extension Time by MFDI 5D	No	
BE6 / BE8 detection	No	
PGO Hardware failure detection for CH1 and CH2 of PG-Z2 (PG-T2 - CH1)	Yes	
AI-14B	Yes	Make sure other I/O cards are not using 2CN.
Load Catch (BE8)	No	
DI-08	Yes	Make sure other I/O cards are not using 2CN.
DI-16H	Yes	Make sure other I/O cards are not using 2CN.
Test Mode 0/1by MFDI 71H - L5 Group	Yes	D5-01 must be temporarily set to speed control
Klixon MFDI 56H, 57H, C3-11	Yes	

Inverter Drive Configurations by Mechanical Arrangement

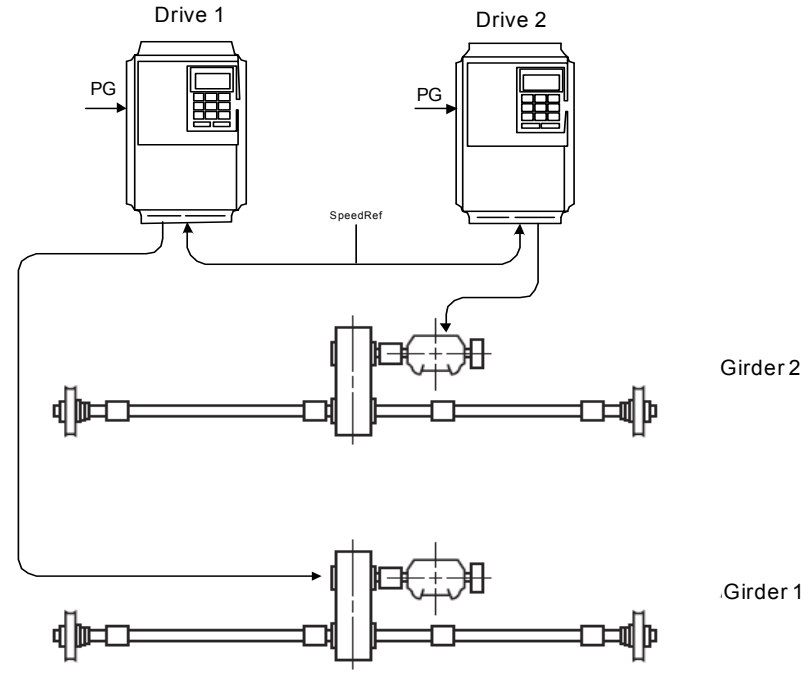
Since it is not practical to cover all possible scenarios, several common and not so common configurations are covered in this section. These are simple one line diagrams to help determine how many drives are required for an application and what their control methods may need to be. Reference Table 1: Control Methods and Associated Stopping Methods to help determine how the crane should operate.



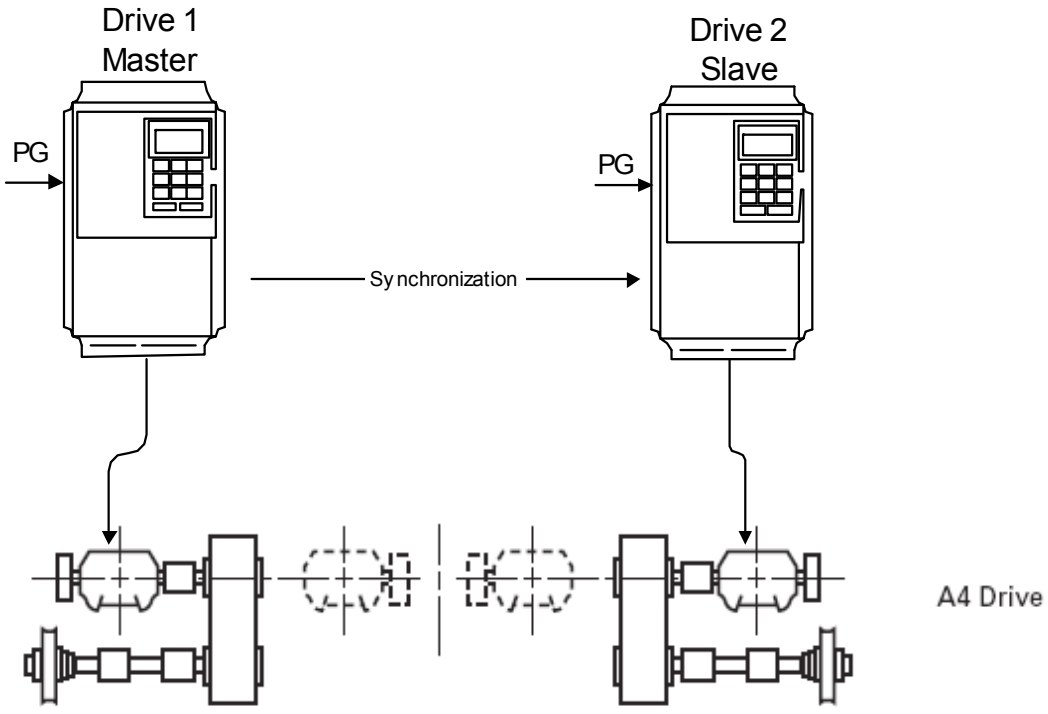
This VFD configuration applies to single A-1, A-1A, A-1B, A-2, A-3 and A-5 mechanical arrangements. In this configuration, a single inverter is connected to a single motor.



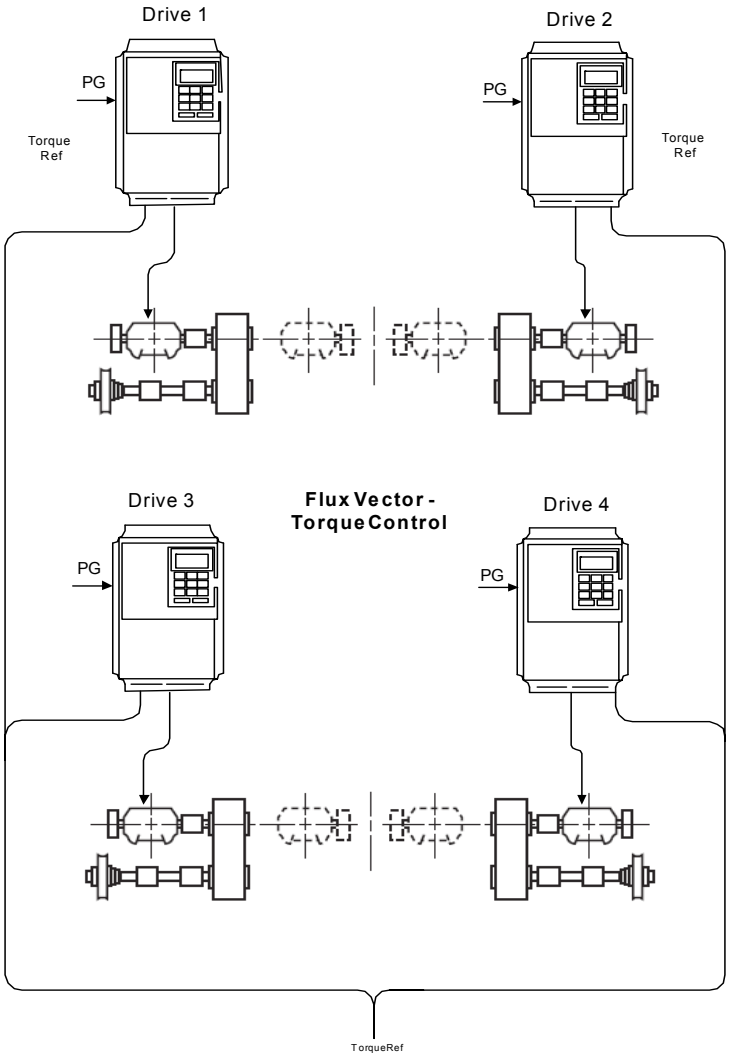
This VFD configuration applies to double A-1, A-1A, A-1B, A-2, A-3 and A-5 mechanical arrangements. In this configuration, each inverter is connected to a single motor. The control method shown is **Flux Vector - Torque Control** with both VFDs having identical wiring and programming. This configuration provides redundancy in case of electrical or mechanical problems.



This VFD configuration applies to double A-1, A-1A, A-1B, A-2, A-3 and A-5 mechanical arrangements. In this configuration, each inverter is connected to a single motor. This configuration provides redundancy in case of electrical or mechanical problems. In the event of a failure, either girder can be driven independently, however acc/dec times should be doubled and the crane capacity should be reduced while using only one drive.



This VFD configuration applies to single A-4 mechanical arrangements. In this configuration, each inverter is connected to a single motor. The control method shown is **Flux Vector - Torque Control**. Drive 1 is the master drive. Drive 2 is electronically "line shafting" the two end trucks with synchronization software.



This VFD configuration applies to double A-4 mechanical arrangements. In this configuration, each inverter is connected to a single motor. The control method shown is **Flux Vector - Torque Control**. All VFDs are wired and programmed identically. This configuration does not offer any kind of end truck synchronization and primarily relies on the rigidity of the crane structure to help prevent skewing. This is generally applied to very large Bridge structures. If any drive were to fail, the crane could still be operational if the drive were bypassed. Drives do not necessarily need to be interlocked, to operate (unless they are controlling a brake), but a fault status light or the like should be used to signal the operator cab that all drives are in operation.

This applies to single A-6 mechanical arrangements. In this configuration, each inverter is connected to a single motor. The control method shown is **Flux Vector - Torque Control** with both VFDs having identical wiring and programming. This configuration provides redundancy in case of electrical problems.