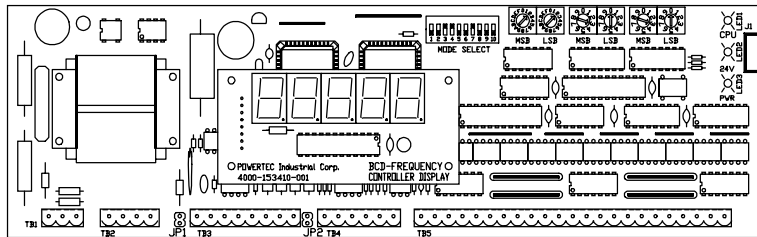


POWERTEC

Industrial Motors

BCD  **MAX**™

Part Number 153-400-002



MICROPROCESSOR BASED
BRUSHLESS D.C.
MOTOR CONTROL

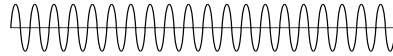
INSTALLATION AND OPERATION INSTRUCTION MANUAL

Revision A
December 21, 1995

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POWERTEC Publication #BCDMAXIM

INTRODUCTION



As the computer revolution takes greater control of industrial processes, the need for more intimate control of the process parameters grows. This is making it more necessary to control the important characteristics of motors directly from computers and process controllers. Such control cannot wait for operator intervention when changes occur in milliseconds and tolerances are measured in thousandths of a second.

Since the Brushless DC motor and its control are digitally based, it is a natural for a computer controlled environment.

POWERTEC Industrial Motors, already far ahead of the motor and control industry in Brushless DC motor design, fabrication, and application, is meeting the need for exact speed control with a microprocessor-based digital speed and ratio control - the BCDMAX.

For people who desire front panel control with a keypad, POWERTEC produces the DIGIMAX speed/ratio controller to interface with POWERTEC's motor controls. The BCDMAX is very similar to the DIGIMAX, but there are several important differences which gives each its own personality.

The most prominent difference is that the BCDMAX speeds and ratios are controlled by a 5 decade (20 line) Binary Coded Decimal input. This enables the user to use a simple control means (thumbwheel switches, which are easier to understand and set than keypads), or to connect to a digital output card or cards of a PLC or computer (20 outputs for all five digits). For simple speed control applications, the use of communications is made unnecessary. However, for those applications where communications ARE desired, an RS-485 communications port is built in to set speeds and read parameters.

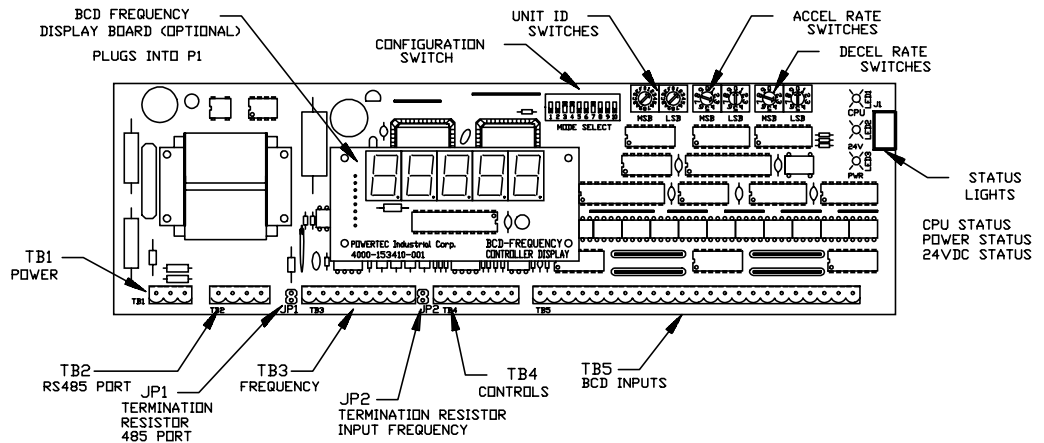
The parameters of the BCDMAX are set with configuration switches. There are switches for acceleration, deceleration, unit ID, and mode. Status is indicated by a set of light emitting diodes.

The BCDMAX is capable of operating as a MASTER unit, generating its own speeds, or as a SLAVE, following a reference frequency from another BCDMAX, a DFS-1, or a computer.

Capable of operating independently or in networks, the BCDMAX is programmable by PC board mounted switches. A single computer port may be used to set speed and monitor up to 32 units in an RS-485 communications link. A plug-in option allows speed display.

The BCDMAX is simple to install, simple to set up, and simple to use.

BCD MAX™



DIMENSIONS: 11.0" W x 3.25"H x 2.50"D

Snap Trak Mount, supplied with snap track mounting bracket.

POWER: 110VAC/230VAC 6 VA

May also be powered by 24VDC @ 250mA.

The BCDMAX is a frequency generator controlled by a strobed 5 digit parallel binary coded decimal input from thumbwheel switches, or from a process controller, or from a computer. The BCDMAX reads up to five digits of an input number which may be a speed command or a ratio. The board has its own power supplies.

The BCDMAX may act as a Master or as a Slave. As a Master, it generates a very accurate frequency, based upon the BCD input number, from a crystal oscillator. As a slave, the BCDMAX multiplies and divides a reference frequency (supplied from another master BCDMAX, a DFS-1, or a user source) to obtain the ratio required. The input frequency must be 16 times the output frequency.

Note: A slave BCDMAX cannot provide the reference frequency to another BCDMAX except through a CRM option (Cascade Ratio Multiplier [part no. 153-430]).

There is a configuration switch which allows the BCDMAX to be tailored to the drive it is giving a reference to and the application. The configuration switch has settings for:

- | | |
|---------------------------|--------------------|
| 1. Encoder feedback rate | 4. Master or Slave |
| 2. Motor Base Speed | 5. Accel Range |
| 3. Unit ID extended range | 6. Decel Range |

There are numeric switches on the BCDMAX to set the acceleration rate and deceleration rate (0.0 to 9.9 seconds and 0 to 99 second ranges, independently settable by switch selection).

The BCDMAX has a built in RS-485 communications port. Through the communications link, status may be read and speeds and ratios may be read and set by a simple binary protocol. Parameters ARE NOT programmable and the communications link is limited to 32 BCDMAX stations. If remote controllability beyond setting and reading speeds is required via communications, use a DIGIMAX® (Option D10.0) or a DFS-1.

Thumbwheel BCD switches ARE NOT INCLUDED with the board (Option D29.3).

The BCD-FREQUENCY CONTROLLER DISPLAY illustrated above is AN EXTRA COST OPTION (option D29.2). It displays five digits of information, which may be a frequency or an RPM.

TERMINAL STRIP ASSIGNMENTS

		BCDMAX Binary Coded Decimal Inputs	
BCDMAX Power Input		NO.	Function
TB1	NO. 1	1	+24VDC output (fused at .25 Amp for all terminals)
	Function 115VAC Hot (this is the fused side)	2	Strobe Input (+24VDC to activate)
	NO. 2	3	Units Digit - Binary 1
	Function Earth Ground (see text and illustration on page 3)	4	Units Digit - Binary 2
	NO. 3	5	Units Digit - Binary 4
	Function 115VAC Neutral (does not have to be grounded)	6	Units Digit - Binary 8
		7	Tens Digit - Binary 1
		8	Tens Digit - Binary 2
		TB5 9	Tens Digit - Binary 4
	BCDMAX RS485	10	Tens Digit - Binary 8
TB2	NO. 1	11	Hundreds Digit - Binary 1
	Function +24VDC (fused at .25 Amp for all terminals)	12	Hundreds Digit - Binary 2
	NO. 2	13	Hundreds Digit - Binary 4
	Function RS485 Receive Transmit +	14	Hundreds Digit - Binary 8
	NO. 3	15	Thousands Digit - Binary 1
	Function RS485 Receive Transmit -	16	Thousands Digit - Binary 2
	NO. 4	17	Thousands Digit - Binary 4
	Function Shield tie point	18	Thousands Digit - Binary 8
		19	Ten Thousands Digit - Binary 1
		20	Ten Thousands Digit - Binary 2
		21	Ten Thousands Digit - Binary 4
		22	Ten Thousands Digit - Binary 8
		23	Binary Coded Decimal Inputs Common
	BCDMAX FREQUENCY INPUTS		
TB3	NO. 1		
	Function +24VDC output (fused at .25 Amp for all terminals)		
	NO. 2		
	Function Frequency output to motor control (see page 4)		
	NO. 3		
	Function BCDMAX Supply Common		
	NO. 4		
	Function Master Frequency Reference Output + (line driver)		
NO. 5			
Function Master Frequency Reference Output - (line driver)			
NO. 6			
Function Shield tie point (except source)			
NO. 7			
Function Slave Frequency Reference Input + (line driver)			
NO. 8			
Function Slave Frequency Reference Input - (line driver)			
	BCDMAX CONTROL INPUTS		
TB4	NO. 1		
	Function +24VDC output (fused at .25 Amp for all terminals)		
	NO. 2		
	Function Emergency Stop Input (+24VDC to activate)		
	NO. 3		
	Function Run Command Input (+24VDC to activate)		
NO. 4			
Function Control Common (isolated from supply common)			
NO. 5			
Function Tachometer Input + (for display)			
NO. 6			
Function Tachometer Input - (for display)			

1.0 INPUTS AND OUTPUTS

1 POWER SUPPLY The BCDMAX is designed to operate on 115VAC, single phase, 60 hertz power connected to TB1. This power should come from a clean source such as power used for instrumentation or control circuits. The supply power should be 115VAC +/- 10%. The BCDMAX is a precision instrument. There is line filtering on the input, extra power supply filtering, and other noise prevention circuitry, but power line noise may still cause problems if the power source is too dirty. For best results, using a 110VAC supply transformer with a Faraday shield is strongly recommended.

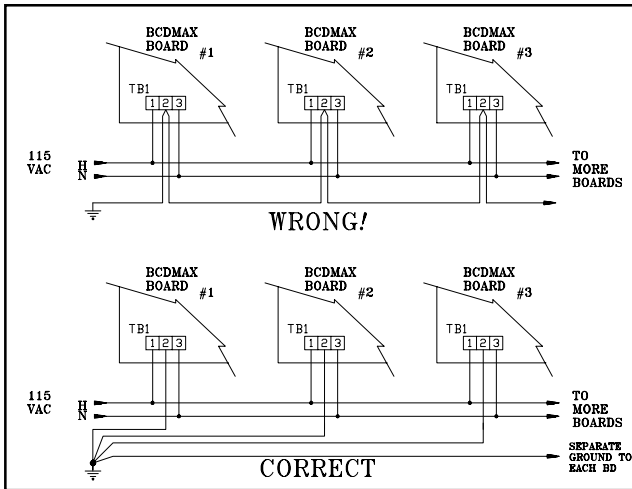


Figure 1: How to connect the grounds to BCDMAX boards when several are being used in a system.

Although it is possible to modify a board to operate on 230VAC, this practice is to be discouraged. If the user modifies a BCDMAX board for use with a 230VAC supply, it will be at the user's risk! Boards modified by the factory for 220VAC operation must be supplied by a control or instrumentation transformer with a 220VAC secondary and a Faraday shield for extra noise protection.

Connect the Hot (High) side of the AC power to terminal 1 on TB1 and the neutral (or Low side) to TB1 terminal 3. Terminal 2 should be connected to earth ground at the same point at which the drive which is controlled by the BCDMAX is connected to earth ground. If several BCDMAX boards are used in the same system, the power may be daisy-chained between boards, but DO NOT daisy chain the grounds. Connect each ground wire to the appropriate drive's earth ground with its own wire (by NEMA standards, the wire should be green). For best results, use an AWG #16 or larger ground wire for short runs and larger wires for longer runs.

12 RS-485 COMMUNICATIONS

The communications link is connected to the BCDMAX at TB-2. Pin1 (the left pin) has no connection on the board. Pin 2 is the RS-485+ and pin 3 is the RS-485-. Pin 4 is for the shield connection. Shielded twisted pair cable with a 120 ohm impedance is required for the communications cable, even between boards in the same enclosure. This cable must be kept as far as possible from power wiring and motor wiring.

There are 255 unique addresses for the BCDMAX. The address is selected by switches SW2-SW3. Local operation is selected by unit I.D. 0 (zero).

A communications link may be composed of BCDMAX units, DFS-1 units, and other POWERTEC made communications modules. These may total up to 32 units.

The host PLC, computer, or other control module should be terminated with a 120 ohm resistor at its comm port (this is normally built in). Jumper JP1 (120 ohm termination) on the BCDMAX should be removed from all but the last BCDMAX board in the link.

The BCDMAX operates at a fixed communications speed of 9600 baud. The format is 8 data bits, no parity, one stop bit (9600, 8, n, 1). There are commands to read status and parameter settings and to set speeds and ratios and read speeds and ratios. The protocol is the same binary protocol used in the DFS-1, DIGIMAX IV, and other POWERTEC communications products.

The motor frequency output is at TB3 terminal 2. The output at TB3 terminal 2 is a square wave with a +24VDC peak and a low output of less than 1VDC. The output can source up to 10mA or sink up to 40mA. Terminal 3 on TB3 is the common. +24VDC

is available at TB3 terminal 1 for use with this output. A load of up to 40 mA (minimum resistance of 600 ohms) may be connected between terminal 2 and terminal 1 ; or, a load of up to 10mA (minimum resistance of 2400 ohms) may be connected between terminals 2 and 3.

13 FREQUENCY INPUTS AND OUTPUTS

The frequency output at TB3 terminal 2 is determined in the MASTER mode (MODE SELECT switch position 8 is Open) by the speed SETPOINT at the BCD inputs and by the settings of the Encoder PPR on MODE SELECT switch positions 1, 2, and 3. If the switches in MODE SELECT switch positions 1, 2, and 3 are set to O-O-C (O=open, C= closed), the feedback rate is 120 pulses per revolution, and the frequency output at TB3 terminal 2 will be 2 times the motor RPM, in hertz. A 1750 RPM 4 pole motor with a standard encoder requires a frequency of 3500 hertz at full speed. Lower speeds of the motor require proportionally smaller frequencies.

The maximum frequency out is determined by the settings of the MODE SELECT switch positions 1 through 6. Positions 1, 2, and 3 select the encoder PPR and positions 4, 5, and 6 select the maximum motor speed. For settings of 120 PPR (O-O-C on 1, 2, and 3) and 2500 RPM (C-O-C on 4, 5, and 6) the maximum output frequency from the BCDMAX will be 5000 Hertz at TB3 terminal 2.

TB3 terminal 4 and 5 is a Master Frequency Reference output. This output is a differential line driver which is half of a line driver and receiver pair built into a single integrated circuit. When this output is used as a Master Frequency Reference, it is capable of driving up to 15 compatible receivers on other BCDMAX boards, DFS-1 boards, or other compatible devices using a frequency which is 16 times the motor speed frequency. There is a 120 ohm termination resistor built into the Frequency Output circuits of all BCDMAX boards.

The Slave Reference Frequency Input is the other half of the Master Reference Frequency Output integrated circuit. A 120 ohm resistor MAY be connected into the circuit at TB3 terminals 7 and 8 by installing a jumper at JP2. Jumper JP2 should ONLY be installed on the LAST BCDMAX in the Reference Frequency string IF it is also the last comm port in the link. In other words, there is only ONE 120 ohm resistor installed at the Master end and ONE 120 ohm resistor installed at the LAST SLAVE.

The Master Reference Frequency/Slave Reference Frequency connections MUST BE TREATED AS A COMMUNICATIONS CHANNEL and connected with the proper cable, while observing all of the precautions against noise and other potential problems which come along with communications channels.

The use of twisted pair, shielded, wire is MANDATORY. The wiring for the Reference Frequency must be kept away from power wiring and motor wiring so that it does not pick up noise. Proper termination and shielding of the cables is very important, and neglecting to wire properly may cause undesirable results.

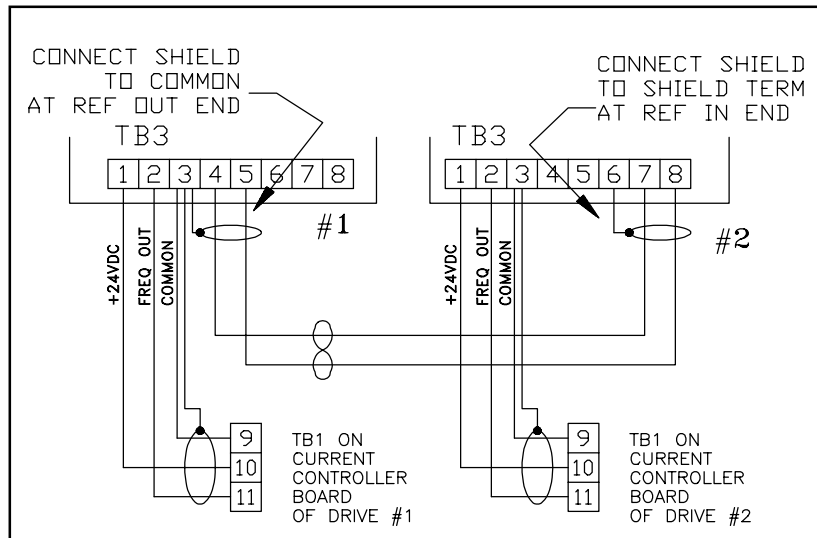


Figure 2: Connections on the Frequency Input/Output Terminal Strip TB3. JP2 must be installed on #2 board.

When the BCDMAX is used in the SLAVE mode (the MODE SELECT switch position 8 is Closed), the Slave Reference Frequency is first multiplied by the BASE RATIO setting which is set into the MODE SELECT switch positions 1 through 6). Then it is processed to put out the proper motor speed frequency.

14 CONTROL INPUTS The control inputs are at TB4 terminals 2 and 3. There are two commands - Emergency Stop and RUN.

You may use an external +24VDC supply to operate the inputs if the common of that supply is tied to the control input common. +24VDC is available on the BCDMAX terminal strip TB4, terminal 1 to operate the control inputs through relays, but the control input common is optically isolated from the common of the BCDMAX power supply. Therefore it is necessary to connect the control common (TB4 terminal 4) to the power supply common at TB3 terminal 3.

Both inputs must be active (+24VDC with respect to the control input common, terminal 4) at the same time for the frequency synthesizer to operate.

If the BCDMAX is operating and the RUN signal is removed, but the Emergency Stop signal is NOT removed, the BCDMAX will decelerate to a zero output frequency at a rate determined by the time dialed into the configuration switches. Upon restoration of the RUN command (while the Emergency Stop is still active) it will accelerate to the set speed at the acceleration rate determined by the time set into the configuration switches.

If the BCDMAX is operating and the Emergency Stop is removed, the output frequency is removed immediately. The same action which removes the Emergency Stop SHOULD ALSO REMOVE THE RUN INPUT! The output frequency will not be restored until the Emergency Stop signal returns and the RUN input is restored.

There is an isolated input on TB4 at terminals 5 (+) and 6 (-) into which a frequency may be input for the optional display. The input requires a square wave with a +24VDC peak and a low value of less than 1VDC. Pulse width must be at least 10 microseconds. This input is only for display purposes. The BCDMAX is an open loop speed setting device, so connecting to the tachometer input terminals is optional.

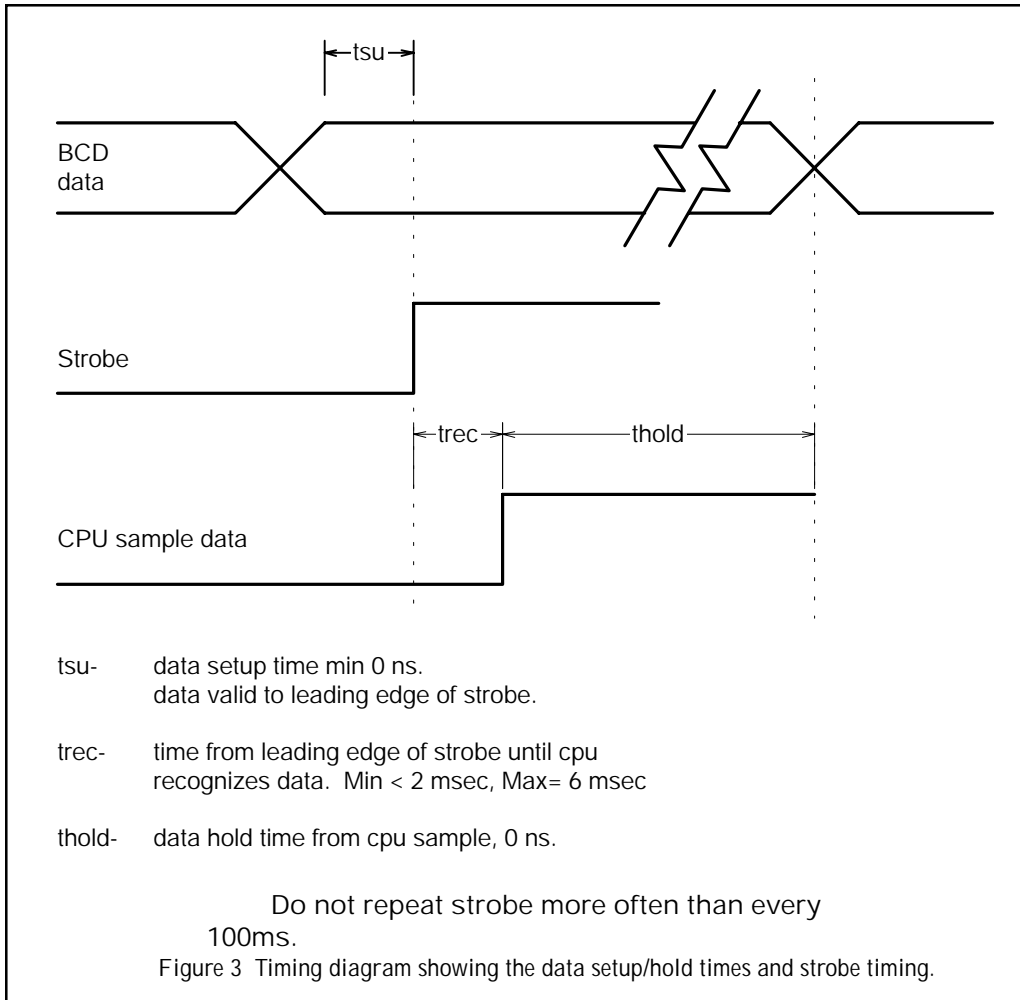
15 BINARY CODED DECIMAL INPUTS

The BCD inputs are optically isolated from the BCDMAX power common. Any +24VDC supply may be used to control the BCD inputs if the +24VDC is referenced to TB5 terminal 23. If the +24VDC at TB5 terminal 1 is to be used, TB5 terminal 23 must be connected to TB3 terminal 3 to establish the input common.

Terminal 2 on TB5 is a strobe input used to tell the BCDMAX when to read the BCD inputs (See Figure 3). When the strobe input is activated, the BCD inputs which are high (+24VDC with respect to terminal 23) will be read by the microprocessor. The inputs are read as soon as the strobe input goes high. Changing an input after the input is read will not change the value read by the microprocessor, even if the strobe is still high. The strobe must be taken low, and then high again to read the inputs again. Strobe should not be present more often than every 100ms or erratic operation could result.

The units digit begins at terminal 3 on TB4, which is the Least Significant Bit. There are four terminals per digit and five digits. Terminal 22 is the Most Significant Bit.

The BCD input speed or ratio may consist of many inputs or a single input in any digit. However, only certain combinations within each digit are valid, according to the rules for Binary Coded Decimal (BCD) numbers.



The following are valid inputs for each digit (H = +24VDC, L = 0VDC):

- L - L - L - L = 0 L - H - L - L = 4 H - L - L - L = 8
- L - L - L - H = 1 L - H - L - H = 5 H - L - L - H = 9
- L - L - H - L = 2 L - H - H - L = 6
- L - L - H - H = 3 L - H - H - H = 7

The following are ILLEGAL inputs for each digit (H = +24VDC, L = 0VDC):

- H - L - H - L = A H - H - L - H = D
- H - L - H - H = B H - H - H - L = E
- H - H - L - L = C H - H - H - H = F

These input combinations correspond to the hexadecimal digits A thru F, which are not used in Binary Coded Decimal arithmetic. If one of these combinations shows up at one of the five input digits, the CPU will generate an error signal.

2.0 CONFIGURATION



21 MODE SELECT SWITCH

ENCODER PULSES PER REVOLUTION - - The first three positions on the MODE SELECT switch are used to program the number of pulses per revolution for the motor being used. This number must be set before operating the motor.

This number is ignored in Frequency Mode.

The settings are in binary notation (O = OPEN, C = CLOSED):

1	2	3	Encoder PPR
O	O	O	60 Pulses per Revolution
O	O	C	120 Pulses per Revolution
O	C	O	240 Pulses per Revolution
O	C	C	600 Pulses per Revolution
C	O	O	1200 Pulses per Revolution
C	O	C	2400 Pulses per Revolution
C	C	O	NOT defined
C	C	C	NOT defined

BASE SPEED SETTING - - The second three positions on the MODE SELECT switch in MASTER MODE (set by the switch in position 8) sets the Base Speed, which is also considered to be the MAXIMUM Speed.

The maximum frequency output of the BCDMAX is determined by multiplying the Encoder PPR (see above) by the BASE SPEED setting and dividing by 60 for a frequency in hertz.

The following are the settings for BASE SPEED in MASTER MODE (O = OPEN, C = CLOSED):

4	5	6	Base Speed when SW1-8 = O
O	O	O	500 RPM
O	O	C	650 RPM
O	C	O	850 RPM
O	C	C	1150 RPM
C	O	O	1750 RPM
C	O	C	2500 RPM
C	C	O	3600 RPM
C	C	C	5000 RPM

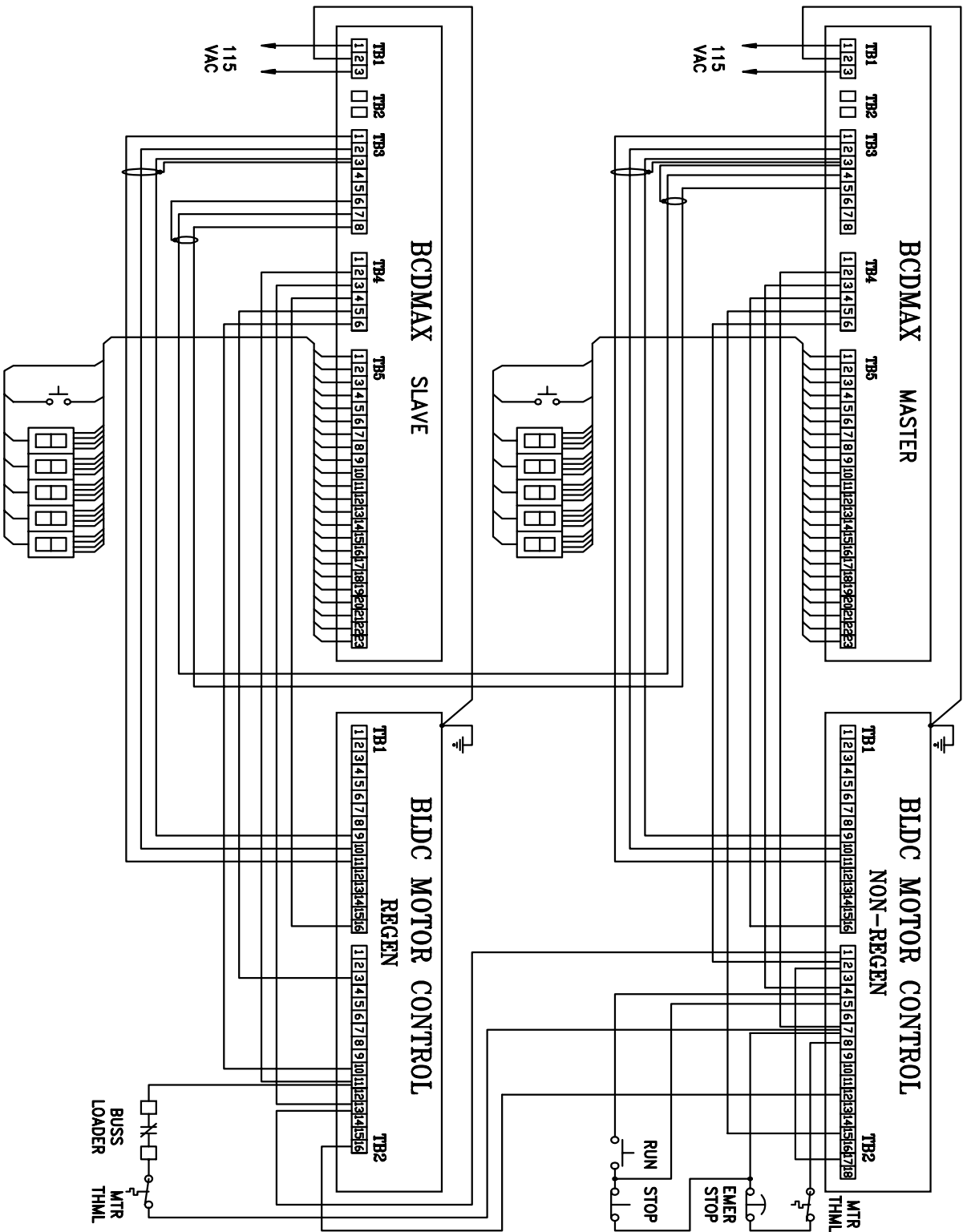


Figure 3: Wiring diagram of a minimal BCDMAX system (Master/Slave). Motor connections other than the thermal are not shown.

BASE RATIO SETTING - - The second three positions on the MODE SELECT switch in SLAVE MODE (set by the switch in position 8) sets the Base Ratio, which is the relationship between the pulse trains of the input and the output when the SETPOINT is 1.0000 and the process speeds are equal.

The following are the settings for BASE RATIO in SLAVE MODE (O = OPEN, C = CLOSED):

4	5	6	Base Ratio when SW1-8 = C
O	O	O	0.1250
O	O	C	0.2500
O	C	O	0.5000
O	C	C	0.7500
C	O	O	1.0000
C	O	C	1.5000
C	C	O	2.0000
C	C	C	4.0000

MASTER OR SLAVE MODE - - When SW1-8 is open, the BCDMAX is in the MASTER mode. When the switch is closed, the BCDMAX is in the SLAVE mode.

In MASTER mode, the BCDMAX generates its own frequency from a crystal oscillator according to settings of Encoder PPR and the SETPOINT. This frequency is limited by the setting of BASE SPEED. The frequency is put out at terminal 2 on TB3. The frequency at TB3 terminals 4 and 5 is 16 times the frequency at TB3 terminal 2.

In SLAVE mode, the frequency at TB3 terminals 7 and 8 is multiplied by BASE RATIO (switch SW1-4, 5, and 6) and then multiplied by SETPOINT. The frequency is then scaled for Encoder PPR and sent to the motor. At the same time, the Reference Frequency Output is scaled 16 times motor output frequency, and is available at terminals 4 and 5 on TB3 of the SLAVE BCDMAX as a new Reference Frequency Output.

FREQUENCY/RPM - - When switch SW1-7 is Open (OFF) the unit operates as a frequency generator with no adjustment made for motor poles. When switch SW1-7 is Closed (ON) the unit then applies the motor pole selection to the frequency set point.

ACCELERATION TIME SETTING - - When switch SW1-9 is Open (OFF), the scale of the ACCELERATION RATE switches is 0 to 9.9 seconds. When SW1-9 is Closed (ON), the scale of the ACCELERATION RATE switches is 0 to 99 seconds. These times are given in terms of the time it takes to change from zero frequency output (0 speed) to maximum frequency output (base speed). Smaller changes in speed will take a proportionate amount of time. Changing from 0 speed to half of base speed will take 1/2 of the time set.

DECELERATION TIME SETTING - - When switch SW1-10 is Open (OFF), the scale of the DECELERATION RATE switches is 0 to 9.9 seconds. When SW1-10 is Closed (ON), the scale of the DECELERATION RATE switches is 0 to 99 seconds. These times are given in terms of the time it takes to change from maximum frequency output (base speed) to zero frequency output (0 speed). Smaller changes in speed will take a proportionate amount of time. Changing from base speed to half of base speed will take 1/2 of the time set.

UNIT ID - - The Unit ID switch is made up of two hexadecimal switches with positions 0 through F (positions 0 through 15).

If both switches are set to 0, the unit is considered to be in local mode. Any other selection determines the address of the unit 1-0XFF (1-255).

3.0 STATUS INDICATORS



There are three indicators on the BCDMAX main board for status indication. Two are single purpose indicators and the third is a multi-purpose, multi-colored LED.

24VDC OK - - This LED is lighted when the +24VDC supply of the BCDMAX is available at the terminals (TB3, TB4, and TB5 terminal 1). The supply may be lost at the terminals if there is a supply failure or if the fuse FR1 opens. Fuse FR1 is a self-healing fuse which will restore itself once the excessive current flow is stopped.

If the +24VDC LED is off, disconnect the terminal strips and the RS-485 link plugs to see if the problem is external to the board. If the LED lights up again with all the external plugs disconnected, re-connect the plugs one at a time to try to determine where the fault is.

POWER OK - - The POWER OK LED is lighted when the +5 VDC supply is operating normally. Only the RS-485 link connects externally to the +5VDC supply, so if the +5VDC LED goes off, disconnect the comm link.

CPU STATUS - - The CPU Status LED is a multi-function, multi-colored LED to indicate proper function and also to indicate system and CPU errors.

OFF - - If the CPU STATUS light is off, there is a fault condition in the CPU logic. Try to reset it by turning off the RUN circuit, then by turning off the Emergency Stop Circuit. If these actions fail, remove and re-apply power.

GREEN - - If the CPU STATUS LED is green, then the operation is normal.

RED - - If the CPU STATUS LED is glowing RED steadily, there is an illegal setup. This setup problem is most likely in the MODE SELECT switch. Check the settings of the MODE SELECT switch.

FLASHING RED - - If the CPU STATUS LED is flashing RED, there is an illegal speed command. This may be a speed command greater than maximum or an illegal BCD Input combination on one of the digits (see page 5).

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