

OPERATION**A. Introduction**

It should be noted that, although the 1830 occupies two card slots, only one plugs into the VMEbus backplane. The VMEbus backplane IACK jumper should be removed for the slot in which the 1830 plugs into the backplane, but should remain installed for the slot in which the 1830 is not plugged into the backplane. Also, because the bus grant signals are not connected on the 1830, no bus grant jumpers should be installed. Operation of the 1830 Motor Controller begins with its installation into a VMEbus backplane, and is followed by connection of a motor-driver. The Motor Controller may then be self-tested to ensure that it is operating normally (as described in the "Installation" section above). In addition, the JOG inputs may be used to move the motor with host processor control. Beyond that, all interaction with the Motor Controller must be done through a host processor VMEbus card inserted elsewhere in the VMEbus backplane.

The 1830 appears to the host processor as a block of 256 bytes on a 256 byte boundary. Because only the low order byte of the data bus is used, only odd byte addresses are accessed. Of these, the even word addresses access the data input and output, and the odd word addresses access the control and standby bytes.

The 1830 should be reset using the board reset bit in the Control Byte (bit 7).

The following sections describe how to connect a motor-driver assembly to the 1830, suggest ways to avoid problems in operating the target motion control system and how to interface the following inputs and outputs.

1. Remote power shutdown (output)
2. Trigger inputs (inputs)
3. Programmable outputs

B. Connecting the Motor

One cable is supplied with the 1830 Motor Controller which connects the 1830 (J4) to a motor-driver. A 25 pin D-connector is supplied which may be used to create a cable to plug into the 1830 auxilliary connector (J3).

J4 BULKHEAD CONNECTOR LISTING

<u>"D" connector</u>	<u>Pin Number</u>	<u>Function</u>	<u>Wire Color*</u>
	1	Step output	Red
	2	Direction output	Green
	3	CW step output**	n/a
	4	CCW step output**	n/a
	5	Shield	Shield
	8	M-D +5 volts	**
	13	TTL Stepout	
	14	Step return	Black
	15	Direction return	White
	16	Shutdown out	Blue
	17	Shutdown out return	Brown
	20	DC common	**
	24	DC common	**
	25	TTL DIR out	

The connections not shown above are not used.

* The wire colors shown correspond to a standard Compumotor motor-driver.

** These outputs are used with non-Compumotor motor-drivers.

TABLE 2

A non-Compumotor motor-driver, such as a 200/400 steps-per-revolution motor, may also be controlled. If the non-Compumotor motor-driver uses step and direction lines it may be wired the same as a Compumotor motor-driver. If the non-Compumotor motor-driver uses clockwise (CW) and counter-clockwise (CCW) control lines use pins 3 and 4 instead of 1 and 2 above. The CW and CCW outputs are open collector and so should be pulled-up to operate properly. Five volts (250 milliamps maximum) may be found on pin 8 for this purpose. DC common (circuit ground) is found on pins 20 and 24.

The output driver for the step and direction control lines is a 75174 which provides current for the standard Compumotor motor/driver optically-coupled interface (typically 20 milliamps). The output voltage for this device is specified to not drop below 3 volts when high, but will not generally approach 5 volts - the standard TTL high level. Therefore a non-Compumotor motor-driver if voltage, and not current, driven should be able to operate with a 3-5 volt high signal. TTL step and direction outputs are provided for applications which require true TTL outputs for these signals. See Appendix C for connector pinout listings.

C. Remote Power Shutdown

The Remote Power Shutdown (RPS) control line is a Compumotor feature that allows the motor to be shutdown (all torque removed) for the purpose of motor-driver cooling or to allow the user to manually position the load. Although the standard Compumotor motor-driver is rated for a 100 percent duty cycle it is sometimes advantageous to shut down the motor-driver to lessen the amount of heat dissipated into a given environment. Additionally, since stepper motors have full rated torque at zero velocity, it becomes very difficult to manually position the motor's load with power applied to the motor. Rather than remove power from the motor-driver under these conditions Compumotor has provided the Remote Power Shutdown feature.

CAUTION: Position may be lost when shutting down the motor and then powering it back up again. When position must be maintained while the motor is in the Shutdown condition a friction lock or brake should be used to maintain shaft position.

Remote Power Shutdown is found on pins 16 and 17 of the motor driver bulkhead connector. Pin 16 goes high with reference to pin 17 when RPS is activated. RPS is controlled with commands 12h and 13h of the command language, or the Shutdown input line on the Auxiliary connector, J3, pin 19 (active low). The motor will not be shutdown if the motor is moving; should the motor be moving when the RPS command is received the 1830 will ignore the command. See the section "Programming, Command Language" for more details.

D. Trigger Inputs

The trigger inputs (also called trigger "bits") consist of six inputs on the Auxiliary connector, J3. The 1830 may be programmed to electronically "watch" any one of these inputs and perform a predefined function when the proper signal appears. Two of these inputs (1 and 6) deliver an interrupt to the 8088 microprocessor on the 1830 circuit card upon a positive going trigger, providing very fast response to input signals. The other trigger inputs (2-5) are level sensitive and so are a little more flexible than 1 and 6 but are also a bit slower.

Trigger inputs 1 and 6 must make a low to high transition to be considered active. Trigger 1 requires a hold time of 500 microseconds to be recognized, and Trigger 6 requires 1 millisecond. Following this there must be a dwell period of at least two milliseconds before the input makes another positive going transition if it is to be recognized as a Trigger.

Trigger inputs 2-5 may be either a high or low level to indicate an active condition. Selection of the level triggering

is done when issuing the command. The signal must remain active for a minimum of four milliseconds for it to be recognized.

All trigger related commands allow only one trigger input to be specified for use at a given time. Thus, checking for an AND condition to occur on the trigger inputs is not possible.

There are 11 trigger input related commands; of these, nine use only triggers 1 and 6. Command 2C, "Wait for trigger "X" to go active" is the only command which allows you to use a level sensitive input or an edge sensitive input. This command allows interruption of a sequence of moves until some external event comes true. Refer to the section "Programming, Command Language" for more information on these commands.

Trigger input signals must be able to drive one standard TTL load. For our purposes here this means the trigger input should be able to source 1 milliamp and sink 2 milliamps. The Auxiliary connectory may be connected to external signal sources by running a 25-pin shielded cable from the D-type bulkhead connector in the VMEbus housing to the motion control system.

<u>Command (in hex)</u>	<u>Command description, event occurs when trigger "X" goes active.</u>	<u>Triggers used</u>
2C	Wait, continue on trigger	1 thru 6
74	Stop motion	1 or 6
75	Discontinue sequence buffer	1 or 6
76	Suspend sequence buffer	1 or 6
77	Discontinue singular command	1 or 6
7C	Kill motion	1 or 6
7D	Kill the sequence buffer	1 or 6
7E	Kill singular command, wait for cont.	1 or 6
7F	Kill velocity-streaming buffer	1 or 6
AC	Interrupt	1 or 6
94	Request state of trigger inputs	2 thru 5

Table 3.

Trigger Input Commands

Following is an illustration of an active level sensitive trigger bit (triggers 2-5).

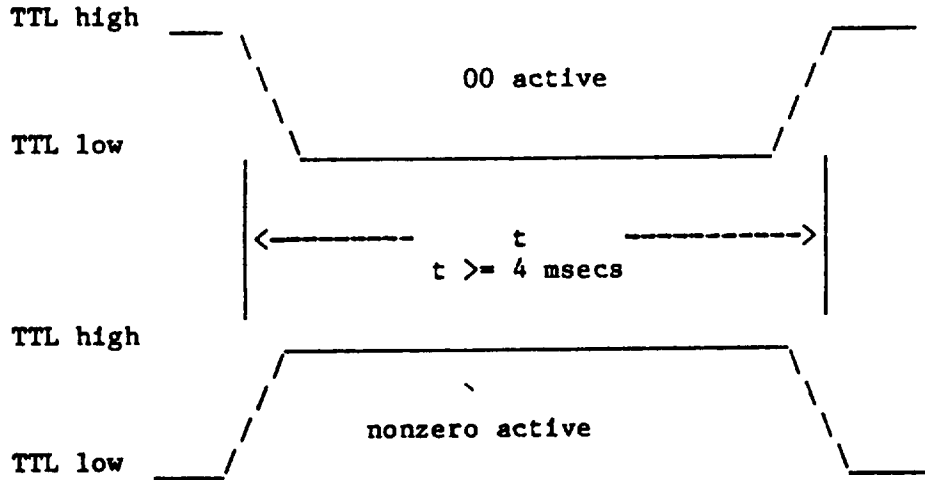


Figure 1.

The following illustration is of an active rising edge sensitive trigger (triggers 1 and 6).

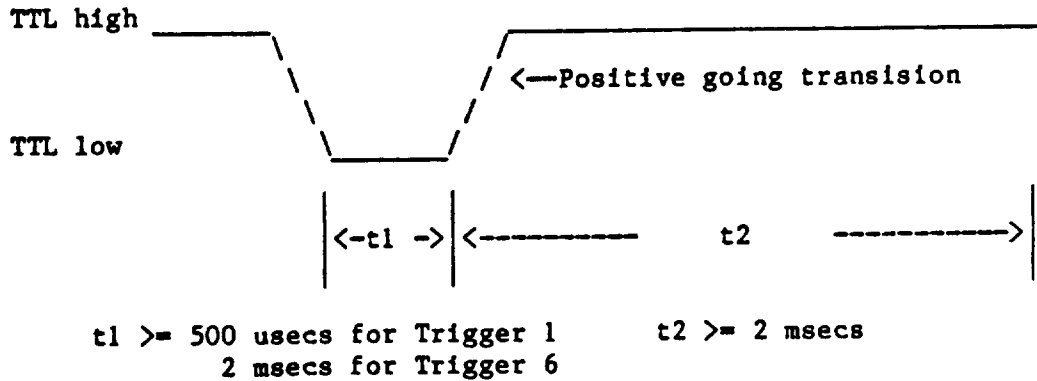


Figure 2.

Following is a list of the pin connections for the trigger inputs on J3, the Auxiliary connector.

<u>Pin Number</u>	<u>Description</u>	
4	Trigger input 1	*DC common
9	Trigger input 2	(signal ground) may
17	Trigger input 3	be found on pins
18	Trigger input 4	14,15,16,23 and 25
8	Trigger input 5	
3	Trigger input 6	

Table 4.

E. Programmable Outputs

The programmable outputs on the 1830 allow you to directly control two high current outputs on the Auxiliary connector of the 1830. Commands OB and OC (hex) set and reset (make high or low, respectively) these outputs.

These outputs can sink or source 60 milliamps and are short circuit protected (albeit for short periods of time). They may be used to trigger an external event during, or at the completion of, some Compumotor driven action.

The programmable output bits are found on pins 1 and 2 of J3, the Auxiliary connector.

F. Jog Inputs

The 1830 provides three inputs on the auxiliary connector J3 which allow the operator to move the motor without giving commands from the VME host computer. These inputs are all active low, so no motion will occur if they are left disconnected or if wiring breaks. The three inputs are JOGNEG (Pin 7), JOGPOS (Pin 5) and JOGLO (Pin 6).

The JOG inputs may be defined to have two sets of meaning. Please refer to the description of Command 11H in Appendix A. Under the "Zero" definition, the following table describes the move started when the inputs go to the state listed (1=High).

<u>JOGLO</u>	<u>JOGPOS</u>	<u>JOGNEG</u>	<u>MOVE #</u>
1	1	1	N/A
1	1	0	3DH
1	0	1	3EH
1	0	0	N/A
0	1	1	N/A
0	1	0	3FH
0	0	1	40H
0	0	0	N/A

Under the "non-zero" definition, the JOGPOS and JOGNEG inputs take the new labels of JOG and JOGDIR, respectively. The following table shows the move started when the inputs go to the state listed (1=high, 0=low). The "non-zero" mode makes the 1830 compatible with Compumotor joysticks.

<u>JOG(JOGPOS)</u>	<u>JOGLO</u>	<u>JOGDIR(JOGNEG)</u>	<u>MOVE #</u>
1	X	X	---
0	1	1	3DH
0	1	0	3EH
0	0	1	3FH
0	0	0	40H

The "Zero" definition is the power-up default. Both of the above sets of labels for these inputs assume that the moves are continuous moves and have the characteristics described below. In practice, any move definition may be given for these moves.

MOVE #	ATTRIBUTE
3DH	Normal speed, negative direction
3EH	Normal speed, positive direction
3FH	Low speed, negative direction
40H	Low speed, positive direction

Moves 3DH, 3EH, 3FH and 40H are the only moves which are given a power-up default definition.

- #3DH = CE, 3D, 00, 00, 00, 61, A8, 00, 01, 86, A0, FF
negative, continuous, velocity=25,000, accel=100,000
- #3EH = CE, 3E, 00, 00, 00, 61, A8, 00, 01, 86, A0, 00
positive, continuous, velocity=25,000, accel=100,000
- #3FH = CE, 3F, 00, 00, 00, 09, C4, 00, 01, 86, A0, FF
negative, continuous, velocity=2500, accel=100,000
- #40H = CE, 40, 00, 00, 00, 09, C4, 00, 01, 86, A0, 00
positive, continuous, velocity=2500, accel=100,000

The JOG inputs are polled at intervals that may be as short as 2 msec or as long as 30 msec, depending on how busy the 1830 is doing other things. For the following discussion, the term "jog state" will refer to a combination of the three jog inputs which start a move (3DH through 40H) under one of the two jog input definitions described above. The JOG inputs are ignored if enabled by a 10H command.

When the jog inputs change state to a jog state, any motion is stopped immediately (i.e., "killed"), and a command to perform

the move number defined by that jog state is executed automatically. This results in the indexer beginning the jog move.

When the jog inputs change from a jog state to a non-jog state, a stop motion command only is executed automatically.

Because moves 3DH through 40H may be defined however the user wants, the jog inputs may be used to execute a variety of functions without requiring host commands. These inputs should not be used, however, while the host is attempting to execute motion command, because move commands started by the jog inputs will pre-empt command from the host, and vice-versa. To avoid this possibility, the Disable/Enable jog inputs command may be issued by the host. Please refer to the 10H command description in Appendix A.

G. External Frequency Input

This input allows the use of an externally supplied time base for the move profile generation. It may be selected for use only in continuous move definition through the velocity range field in the move definition (velocity range "6" = external frequency). This allows the user to select a time base other than those provided internally by the 1830, and to alter the frequency during the course of a move. By altering the frequency during the move, the user can create non-linear move profiles with changing velocities.

The input may also be used in conjunction with the jog inputs to form a joystick interface for use with the Compumotor Model 852 Joystick. By defining the JOG moves with external frequency, and using the non-zero jog input definition, the following connections form the joystick interface:

<u>852</u>	<u>1830</u>
DIR OUT	JOG DIR
AT ZERO	JOG
STEP OUT	EXTERNAL FREQ. IN
+5V IN	+5V OUT
GND	GND

This interface description assumes that moves 3DH and 3FH are continuous moves in the negative direction, and that moves 3EH and 40H are continuous moves in the positive direction.

H. Encoder Interface

The Encoder interface on the 1830 allows the 1830 to respond to an incremental encoder for positioning purposes. The interface is not designed to monitor/correct-for velocity errors;

the interface allows verification of position, and motor stall detection.

The Encoder interface is a very powerful feature of the 1830. It allows definition of the number of pulses sent to the motor for how many pulses are expected from the encoder (command B0h). Because of this it is possible to use virtually any resolution encoder. Further, the encoder need not be mounted directly on the motor. In situations where the load could be in a different place from that of the motor, such as when a gear train of some sort is involved, the encoder may be mounted where it will do the most good. An example of this is driving the load through a series of gears. It would be very nice to be able to ignore the backlash induced by the geartrain and get down to business. Putting the encoder on the load would cause any closed-loop move (you may choose either open- or closed-loop moves at any time) to automatically compensate for backlash and gear ratios in the gear train.

1. Electrical Considerations

A schematic of the encoder input is shown in Appendix E. Connections for the encoder connector may be found in Appendix C.

A and B channel inputs are required for position tracking and stall detection, the home input is only required if a home position is needed. The home input need not come from the encoder either. The home input may come from any appropriate TTL compatible switch as referenced in the installation section of this manual. For example, using a linear encoder on an X-Y stage you may want to utilize the home line on the encoder because that input goes active only once in the entire range of travel, is similar in electrical characteristics to the A and B channel inputs and can be wired in the same harness as the other encoder inputs.

A rotary encoder, on the other hand, which is attached directly to the motor gives its home indication once per revolution. This is of little value in most applications. To get around having the once per revolution home mark the encoder has a home enable input which, when inactive, causes the home input to be ignored. Thus, another switch is required that will be active only when the motor is within one revolution of the home area.

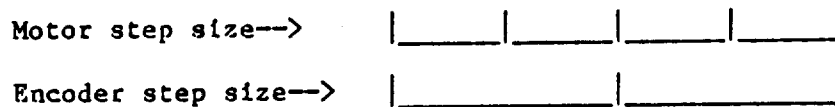
2. Encoder Resolution (lines).

The resolution of the encoder, usually given in lines, is multiplied by four times by the 1830. This is done through a quadrature detection technique. Thus, if you have a 1,000 line incremental encoder, the 1830 will see it as a 4,000 line encoder. This is also known as specifying the post-quadrature enco-

der resolution. When specifying the number of motor steps to encoder steps (command B0) you must specify the encoder resolution multiplied by four.

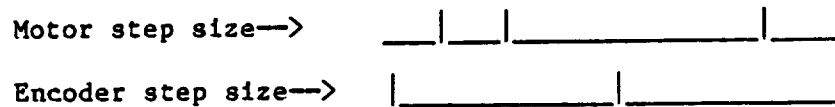
3. Usable Encoder Resolution

The ratio of motor pulses to encoder pulses should probably not get smaller than 2:1. The reason for this is a practical one, and is not restricted by the 1830. Simply stated, as the distance moved by a single motor step approaches the size of an encoder step it becomes increasingly difficult to position the motor accurately. Consider the following diagram.



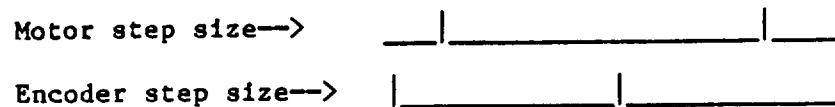
Motor steps equal one-half an encoder step

In this example the motor steps are half the size of the encoder steps. On paper, this might lead you to assume that there is plenty of room for the motor to find a particular encoder position. In reality, because of the elastic nature of step motors, it may be difficult for the motor to actually find the desired position. Consider the case where the motor step size is different in each direction of motor travel. This would be true any time the motor is changing direction while driving a frictional load.



Motor steps are one-half an encoder step, step size is not equal.

In the above grossly exaggerated example there are still four motor steps to two encoder steps, but it is not clear where each will fall. It is possible that the backlash caused by frictional loading on the motor will vary the step size enough to make it difficult for the motor to position exactly on the desired encoder position.



Motor steps are larger than encoder step

Should motor steps ever exceed the size of encoder steps, the motor would probably never find its desired position, especially if the load is subject to vibration. Even if it is not, the

likelihood of the motor positioning correctly and sitting still are small. When the motor steps are larger than encoder steps it is likely that the motor will never sit still while position maintenance is enabled (command 18h).

4. Encoder hookup (Compumotor encoders)

Compumotor provides optional motor mounted encoders on most motor sizes. The encoders have a resolution of 1,000 encoder lines. Compumotor encoders are pre-wired at the factory to connect directly with the 1830.

5. Encoder hookup (non-Compumotor encoders)

The encoder inputs provided on the 1830 are compatible with virtually any TTL encoder. It doesn't matter whether the encoder is load mounted or encoder mounted, or whether the encoder is rotary or linear. The 1830 may be programmed to accept any encoder resolution.

To set up the 1830 to accept encoder input it is necessary to tell the 1830 the number of encoder pulses which will be returned to the indexer for a given number of pulses sent to the motor. This is done via the B0 (hex) command.

Motor mounted rotary encoders are the easiest to specify: multiply the rated resolution of the encoder by four and enter that directly into the command.

EXAMPLE

B0 command: 25,000 / 4000 (decimal)
 Command string: B0, 61, A8, 0F, A0 (hex)
 The same ratio could be specified by:
 Command string: B0, 00, 19, 00, 04 (hex)

(commas and spaces are included for clarity only)

The above example command specifies the encoder resolution for a 1,000 line encoder, the standard offered by Compumotor. For an encoder with 4,096 lines the command would be,

B0 command: 25,000 / 16,384 (decimal)
 Command string: B0, 61, A8, 40, 00 (hex)

(commas and spaces are included for clarity only)

Note: Although this is a valid resolution, it would be somewhat high for a 25,000 steps per revolution motor, as the ratio of motor steps to encoder steps (25,000/16,384) is less

than 2:1. This could make system operation unstable as the motor would not have adequate room to position itself with respect to the encoder. Optimum operation is achieved with a ratio of about 4:1.

Encoders which are not mounted on the motor are a little more complicated to specify; the ratio of motor turns to encoder turns must be taken into account. A rotary encoder which is mounted on the load can compensate for any mechanical components between the motor and the load. A belt and pulley is a simple example of this.

For example, to specify the OB command for a motor which must turn six revolutions to turn a load mounted 1,000 line encoder one revolution would require: multiplying the encoder resolution by four (the multiplier applied by the 1830's encoder input circuitry) and then dividing by six the turns ratio) giving a result of 666.667. Written as a formula,

$$(\text{encoder resolution} * 4) / \text{number of motor turns}$$

or

$$(1,000 * 4) / 6 = 666.667$$

So the command to the 1830 would be,
 B0 command: 25,000 / 666.667 (decimal)
 or, B0 command: 75 / 2 (decimal) would give the same result.

Command string: B0, 00, 4B, 00, 02 (hex)

(commas and spaces are included for clarity only)

Linear incremental encoders may also be used. Linear encoders are usually mounted alongside some sort of screw driven apparatus such as an X-Y table. To specify the encoder ratio the number of encoder pulses per motor revolution must be known. For example, an encoder with a resolution 500 lines per inch may have an output circuit which will multiply the number of lines by four times. The 1830 would then multiply that resolution by another four times giving 8,000 encoder pulses per inch. Supposing that the X-Y table uses 10 pitch (10 turns per inch) leadscrews, the encoder returns 8,000 pulses per 10 motor revolutions. As a formula this would look like,

$((\text{encoder lines/inch} * 4) * 4) / \text{number of motor turns}$

or

$((500 * 4) * 4) / 10 = 800 \text{ (decimal)}$

So the command would be,

B0 command: 8,000 / 10 (decimal)

or, B0 command: 800 / 1 (decimal) would give the same result.

Command string: B0, 03, 20, 00, 01 (hex)

(commas and spaces are included for clarity only)

User provided encoders must be wired to the 25-pin encoder connector using the pin connection listing shown in Appendix C.

The encoder inputs must be actively driven: open-collector outputs on your encoder will not work correctly. The encoder connects to the 1830 via the 25-pin D-connector described above. The only signals required are Channel A, Channel B and ground. Channel Z should also be connected if the encoder has a Home output.

The encoder will require +5 volts DC to operate. This +5 volts may be provided by the VMEbus via the 1830's Encoder connector, pins 23-25.