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USER MANUAL

Accessory 8D Option 2

Voltage to Frequency Converter Board

3Ax-602234-xUxx

October 24, 2003



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To report errors or inconsistencies, call or email:

Delta Tau Data Systems, Inc. Technical Support

Phone: (818) 717-5656

Fax: (818) 998-7807

Email: support@deltatau.com

Website: <http://www.deltatau.com>

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INTRODUCTION

Accessory 8D (ACC-8D) Option 2 is a standalone printed circuit board that is connected to PMAC or Turbo PMAC via ACC-8D, the Terminal Block board. Option 2 provides four voltage-to-frequency converters (V-to-F) that allow the PMAC to drive four standard stepper motor drives. The output of Option 2 is a set of four pulse and direction signals at TTL levels. The input is a set of four analog magnitude commands coupled with digital direction bits. The PMAC supplies the input to the Option 2 board via ACC-8D (J5 connector), which should be connected to the ACC-8D, Option 2 board (J1 connector) via the supplied 16-pin flat cable. For more information on ACC-8D, refer to the ACC-8D manual, which is provided separately.

The pulses to the stepper driver can represent full steps, half steps or microsteps. This is dependent on the driver itself, not on the PMAC or this option. The stepper-motor systems can be operated either open loop or closed-loop, individually selectable for each axis. If operating the axis open loop, feed the pulse and direction signals back into a PMAC encoder port through a cable provided to fool the PMAC into thinking it has feedback. If operating it closed loop, connect the actual encoder lines to the PMAC encoder port, just as for a regular servomotor.

The output frequency range must be selected at the time of ordering this option board. The choices are as follows:

	Frequency Range	Pulse Width
Option 2A	0 - 10 kHz	20 μ sec
Option 2B	0 - 50 kHz	4 μ sec
Option 2C	0 - 100 kHz	2 μ sec
Option 2D	0 - 500 kHz	400 nsec
Option 2E	0 - 1 MHz	200 nsec
Option 2F	0 - 2 MHz	100 nsec

For a maximum frequency between two of these values, choose the next value higher than the desired maximum, and limit PMAC's analog output in software (parameter Ix69 for motor x). PMAC's 16-bit DACs will still provide extremely high resolution.

POWER SUPPLY REQUIREMENTS

The J1 connector pins 13 to 16 are used to bring in the ± 12 to ± 15 V power supply requirements for this board (typically from the ACC-8D terminal block; see pin definition listing on Option 2's J1 connector). The A+15V (pin 14 of J1) input's current requirement is approximately 300mA. The A-15V (pin 16 of J1) input's current requirement is approximately 200mA.

Note

These power supply requirements are additional to the requirements for the PMAC and any other accessories supplied via the Analog power supply connected to the terminal block.

Power Requirements

5V	15V	-15V	Other 24V etc.
350mA	300mA	200mA	N/A

Note

If the bus (PC, VME or STD32) power supply is used instead of an external power supply for the PMAC board itself, an additional ± 12 to ± 15 V power supply is required for this board (the current rating is still 300mA for the A+15V input and 200mA for the A-15V input). This is because the bus (PC, VME or STD32) ± 12 V power supply is not brought out to the terminal block and therefore cannot be used for ACC-8D Option 2.

The optional A+V (+5V to +15V) input brought in from TB1 pins 1 and 2 are used only for the output stage pull-up resistors. The default value for each of these resistors is 510 Ω . Since there are eight pull-up resistors, the current requirement is a maximum of 235mA.

Note

The power supply inputs from J1 are still required regardless of the optional use of TB1 pins 1 and 2.

PMAC AND TURBO PMAC SETUP CONSIDERATIONS

In order to get the analog magnitude (absolute value) and digital direction signals that this option requires, PMAC parameters must be changed. For non-turbo PMACs, these variables are Ix02 and Ix25 and for Turbo, they are Ixx24 and Ixx96 for each motor involved. PMAC's default parameter values provide a signed analog signal, and the other line is used as an amplifier-enable signal; not a direction bit. This default set-up is suitable for driving the standard DC servo amplifier and not stepper motor drives.

To allow stepper motor drive's standard magnitude and direction input for PMAC's, set bit 16 of Ix02 variable to 1. This instructs PMAC to output 16-bit absolute voltage on DAC. In addition, set bit 16 of the Ix25 variable (for PMAC) and Ix24 variable (for Turbo PMAC) to 1. This allows the standard amplifier-enable line to be used as the direction bit. It is easiest to specify these variables in hexadecimal form here (with a \$ prefix).

Example PMAC: To use DAC1 for motor 1 in the magnitude and direction mode, set-up these variables in the following way:

I102 = \$1C003 I125 = \$1C000

To allow stepper motor drive's standard magnitude and direction input for Turbo PMAC, change Ixx96 from its default value of 0 to 1. By setting Ixx96 to 1, the commanded output value is the absolute value (magnitude) of what the servo calculates, and the sign (direction) is output on the AENAn/DIRn line of the set of flags addressed by Ixx25 (polarity determined by jumper E17 or E17x). In this case, bit 16 of Ixx24 should also be set to 1 to disable the amplifier-enable function for that line.

Example Turbo PMAC: To use DAC1 for motor 1 in the magnitude and direction mode, set-up these variables in the following way:

I196 = \$1 I124 = \$10000

To eliminate the V-to-F converter bias (offset), there are two choices available. The analog pots R3A to R3D, connected to the four V-to-F converters, may be used to remove larger offsets. Alternatively, Ix79 may be used to eliminate small offsets (low frequency pulse trains) at zero demand velocity. Use either or both of these if the motor has a tendency to hunt for position when it should be stopped firm. Adjust to the point where it is noticeably stopped, so as not to create a dead band in operation. (See the graphs at the end of this section.)

Note

The bi-directional DAC bias, Ix29, should be set to zero for proper offset operation in the sign and magnitude mode.

To connect the first pulse-and-direction signal pair back to a PMAC encoder (to run the axis open-loop), connect JENC1 on the Option 2 board to J1A on the main ACC-8D board with the 10-pin flat cable provided. For the second signal pair, connect Option 2's JENC2 to ACC-8D's J2A. For the third pair, connect JENC3 to J3A; and for the fourth pair, connect JENC4 to J4A. These feedback signals go through optocouplers on the Option 2 board, so the circuits on Option 2 are kept isolated from the PMAC digital circuitry (they are tied to PMAC's analog output circuitry). This pulse train provides the feedback signal, which PMAC requires to close its position loop. On a regular PMAC set the Encoder I-Variable (I900, I905, I910....) for any encoder getting this pulse train to pulse-and-direction decode (0 or 4) instead of quadrature decode. On a Turbo PMAC set the Encoder I-Variable (I7mn0 - For Servo IC m Channel n, where m = 0 to 9, and n = 1 to 4) for any encoder getting this pulse train to pulse-and-direction decode (0 or 4) instead of quadrature decode.

Example PMAC: To accept pulse and CW direction for encoder 1, I900 should be set to 0.

Example Turbo PMAC: To accept pulse and CCW direction for encoder 1, I7010 should be set to 4.

To run the stepper motors closed loop (i.e. use feedback from an actual encoder), do not use these cables. Instead, wire the encoder signals directly to the ACC-8D board, just as for a servo motor. Keep Encoder I-Variable 0 set for quadrature decode.

Example PMAC: To accept $\times 4$ quadrature decode for encoder 2, I900 should be set to 3 or 7.

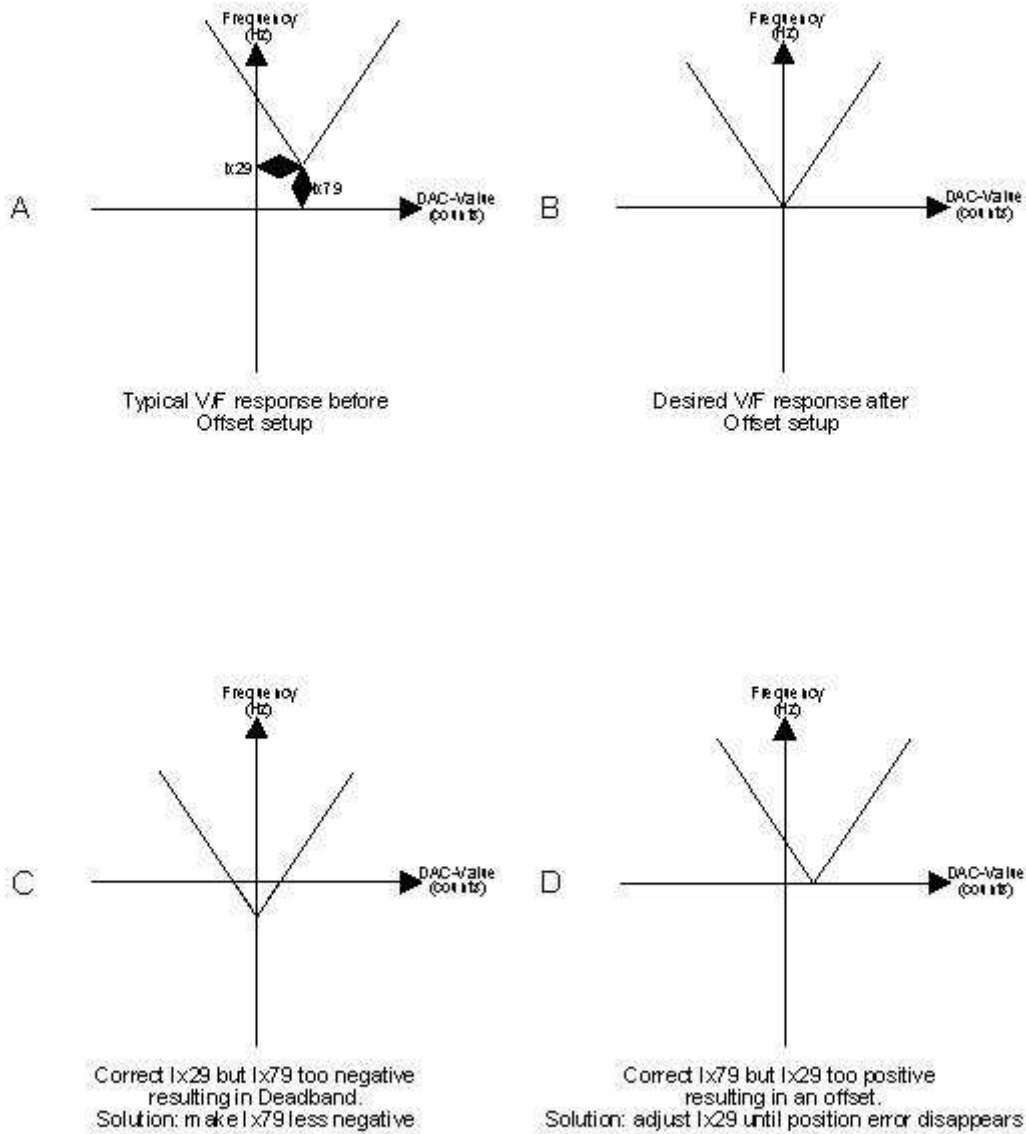
Example Turbo PMAC: To accept $\times 4$ quadrature decode for encoder 2, I7010 should be set to 3 or 7.

The pulse and direction outputs to the stepper drivers come off the Option 2 board from its own terminal block TB1. These outputs are referenced to PMAC's analog ground. With Option 2 board jumper E1 OFF, the high level is +5V. With this jumper ON, the high level is PMAC's +12V to +15V analog supply. If a voltage supply (+5V to +15V) is brought in on TB1 pin 1, this will provide the high level.

For stepper motor drives equipped with optically isolated pulse and direction inputs, we recommend bringing in a voltage supply on TB1, Pin 1. For proper operation of the Option 2 board in conjunction with the optically isolated drives, each pulse and direction output from the Option 2 board should be connected to the negative (-) pulse and direction input of the stepper motor drives, respectively. The +V supply input of the Option 2 board (Pin 1 of TB1) should be connected to the positive (+) pulse and direction inputs of the stepper drivers. (See the enclosed connection schematic).

The J2 connector provides four high-true enable-bit inputs, one for each channel. PMAC's normal amplifier-enable output has been stolen to provide a direction bit for each channel. To use these inputs, provide the hardware lines and software control. Remember that these inputs are referenced to PMAC's analog ground, so if something is wired direct from PMAC's digital circuitry, optical isolation will not be present. These inputs are pulled up on the Option 2 board to +5V (enabled).

RELATIONSHIPS BETWEEN V/F OUTPUT AND IX29, IX79



PMAC AND TURBO PMAC SETUP FOR STEPPER MOTOR CONTROL

CAUTION

Carefully read the relevant sections of the PMAC User Manual (I-variable Definition Section) and the ACC-8D Option 2 Manual prior to executing the following procedure. Also, be sure that the V/F board is correctly connected to the PMAC board via ACC-8D.

Note

The setup procedure for the V/F board's operation is detailed in a step-by-step fashion.

Open Loop Setup

CAUTION

Disconnect the stepper driver from PMAC.

PMAC and Turbo PMAC Jumpers

Direction Output (AENA) Polarity Jumpers

Leave these jumpers at the factory default settings (for PMAC-PC there is only one jumper).

E17 (PMAC-PC, Turbo PMAC-PC, Acc-24P)	Jumper Installed for all channels
E17A-D (PMAC-Lite, PMAC-VME, PMAC-STD)	No Jumpers Installed for appropriate channels
E17A-D (PMAC-STD 2nd piggyback board)	No Jumpers Installed for appropriate channels
E17E-H (PMAC-VME Opt. 1 piggyback board)	No Jumpers Installed for appropriate channels

The Encoder Single-ended/Differential

These jumpers should be set to single-ended as follows (these are the default settings):

E18	Jumper pins 1 to 2 for Encoder Channel 5
E19	Jumper pins 1 to 2 for Encoder Channel 6
E20	Jumper pins 1 to 2 for Encoder Channel 7
E21	Jumper pins 1 to 2 for Encoder Channel 8
E24	Jumper pins 1 to 2 for Encoder Channel 1
E25	Jumper pins 1 to 2 for Encoder Channel 2
E26	Jumper pins 1 to 2 for Encoder Channel 3
E27	Jumper pins 1 to 2 for Encoder Channel 4
E18-27	Jumper 1-2 for any additional Acc-24P Channels

PMAC I-Variables

Initialization

For each motor channel, set all I-variables be set to the factory default values as shown in the PMAC User Manual. To do so, use the command **Ix00 . . Ix86=***, where **x** is the motor number. Alternatively, use the **\$\$\$***** command to reinitialize the entire card.

Activate Motors

Make sure that Ix00=1 for each motor planning to be used.

Address I-Variables

Change the I-variables as follows, where **x** stands for the motor/channel number:

Ix02= \$1_ _ _ _ (where _ _ _ _ is the current address)

Example: For motor 1, I102=\$1C003

This changes the 16th bit to 1. This bit changes DAC 1's operation from bipolar to unipolar with a direction bit (through AENAx/DIRx).

Ix25=\$1_ _ _ _ (where _ _ _ _ is the current address)

Example: For motor 1, I125=\$1C000

This disables the Amplifier Enable function and allows the AENA1 to be used as DIR1.

Example: I125=\$3C000

Note

If limit switches are not used, then the limits may be disabled by writing 1 into bit 17 of Ix25.

Encoder Decode I-Variables

Set the following I-variables for pulse and direction feedback decode as follows (assuming the default setting for E17s as described above):

For channel 1	I900=0
For channel 2	I905=0
For channel 3	I910=0
For channel 4	I915=0
For channel 5	I920=0
For channel 6	I925=0
For channel 7	I930=0
For channel 8	I935=0

Offset I-Variables

Change the I-variable Ix29=0 where **x** stands for the motor/channel number. This will be adjusted later for the elimination of directional bias.

Ix79=0 will be adjusted later for the elimination of the zero volt residual frequency offset (unidirectional offset).

Servo Gain I-Variables

Set the following I-variables to zero:

Ix31=0, Ix33=0, Ix35=0

Proportional Gain and Velocity Feedforward Gain

Set the proportional gain and the velocity feedforward gain as follows:

V/F Freq. (kHz)	Ix30 ^{1,2}	Ix32 ³
10 (Opt.2A)	5,500,000	1000
50 (Opt.2B)	1,100,000	1000
100(Opt.2C)	550,000	1000
500(Opt.2D)	110,000	1000
1000(Opt.2E)	55,000	1000
2000(Opt.2F)	27,500	1000

¹ It is assumed that Ix08=96 (default factory setup). In the event Ix08 has been changed, adjust Ix30 such that the product Ix08*Ix30 remains constant for each setup. **Example:** for the 100 kHz option (Opt. 2C) if Ix08=64, then Ix30 should be set to $550,000 * 96 / 64 = 825,000$.

² These Ix30 values are designed for a closed loop position response with a natural frequency of approximately 100 Hz and a damping ratio of 1.

³It is assumed that the servo-sampling rate is at 2.26 kHz. (Default for 20 MHz PMAC). For sampling rates other than default, multiply the above value of Ix32 by the ratio of the expression [Servo Freq. (kHz)/ 2.26]. **Example:** If Servo Frequency jumper is set for (see E3 to E6) 4.52 kHz, then $Ix32 = 1000 * [4.52 / 2.26] = 2000$.

Issue the on-line command **#xJ/** for the appropriate motor **x** and open up the position display box in the Executive software using the F7 soft key. It should be at a stationary position. Next, issue a **J=0** command. If not already at position zero, there should be a change in position towards zero. At this stage, the position loop is closed and offset adjustment can proceed.

Direction Check

Issue a small positive open loop output command to the motor (e.g. **#1010**) Monitor the position of the motor, with the F7 position window of the Executive Program. The reported position should be changing in the positive direction. Now issue a negative open loop output command (e.g. **#10-10**). The reported position should be changing in the negative direction. If the direction is wrong, recheck E17 jumper setting and Encoder Decode I-variable. (See the PMAC Jumpers and the Encoder Decode I-variables sections of this manual.)

Offset Setup

The zero volt residual frequency offset (unidirectional offset), Ix79, is a parameter whose fine adjustment is important for proper stepper motor operation. The function of Ix79 is the same as the adjustment pots on the V/F board. Prior to its adjustment, retain its value at zero and carry out the following steps:

- In the Executive program, use the F7 key to look at the position window.
- If the motor position shows hunting, adjust the corresponding pot (R3A to R3D) such that it just jitters one to two count in either direction.
- If the motor position does not show hunting, adjust the corresponding pot (R3A to R3D) so that it just starts to do so. Then reverse slightly so that the hunting is reduced to one to two counts.
- Now adjust the value of Ix79 so that it just stops hunting all together (a positive value of Ix79 would tend to increase hunting; too large a negative value may cause an unacceptable level of deadband).

- Now issue a **J=xxxx** command (**xxxx** should be a safe distance of 1000). If the motor does not eventually reach (or goes beyond) the end point, adjust Ix29 so that the actual position matches the desired position. Repeat this in the reverse direction by issuing the **J=-xxxx** command and fine adjusting Ix29. Once the offset is eliminated, the wedge would touch the origin, which is the ideal situation.
- Now, connect the stepper driver to the V/F Board.

Acceleration & Speed I-Variable Adjustment

Adjust Ix16 to Ix23 for the particular motor so that top speed and slew rates are not violated (otherwise the stepper might stall). For program moves, adjust Ix87 to Ix89 for the same reason.

At this stage, Ix29 and Ix79 may need readjustment for possible analog offsets due to the connection of the stepper motor driver to the V/F board. (See the Address I-variables section of this manual.) To do so, repeat the steps in the previous section, Offset Setup.

Direction Polarity Change

At this stage, the stepper should be movable in either direction in a stable manner. However, if the desired positive direction is the opposite of the actual positive direction, (i.e. If clockwise rotation should be positive but actually the counter clockwise rotations occur under positive direction moves) then both E17 Jumpers and the Encoder Decode I-variables should be changed appropriately. To change E17 jumpers, simply reverse the setting instruction described in the Direction Output (AENA) Polarity Jumpers section of this manual. In addition, the appropriate Encoder Decode I-variable should be changed from 0 to 4 (e.g. I900=4, etc.).

End of Open Loop Procedure

If using the Open Loop Setup Procedure, go to the Using the Executive Tuner section of this manual.

Turbo PMAC I-Variables

Initialization

For each motor channel, set all I-variables to the factory default values as shown in the Turbo PMAC User Manual. To do so, use the command **Ixx00 . . Ixx99=***, where **x** is the motor number. Alternatively, use the **\$\$\$***** command to reinitialize the entire card.

Activate Motors

Make sure that Ixx00=1 for each motor planning to be used.

Address I-Variables

Change the following I-variables, where **x** stands for the motor/channel number:

Ixx96= \$1

Example: For motor 1, I196=\$1

This bit changes the command output value to an absolute value (magnitude) of what the servo calculates, and the sign (direction) is output on the AENAn/DIRn line of the set of flags addressed by Ixx25.

Change Bit 16 of Ixx24 to 1 to disable the amplifier-enable function.

Example: For motor 1, I124=\$10000

This disables the Amplifier Enable function and allows the AENA1 to be used as DIR1. If limit switches are not used, then the limits may be disabled by writing 1 into bit 17 of Ix24.

Example: I124=\$30000

Encoder Decode I-variables

Set the following I-variables for pulse and direction feedback decode as follows (assuming the default setting for E17s as described previously):

For channel 1	I7010=0
For channel 2	I7020=0
For channel 3	I7030=0
For channel 4	I7040=0
For channel 5	I7110=0
For channel 6	I7120=0
For channel 7	I7130=0
For channel 8	I7140=0

Offset I-variables

Change the $I_{xx29}=0$ I-variable, where x stands for the motor/channel number. This will be adjusted later for the elimination of directional bias.

$I_{xx79}=0$ will be adjusted later for the elimination of the zero volt residual frequency offset (unidirectional offset).

Servo Gain I-variables

Set the following I-variables to zero:

$I_{xx31}=0$, $I_{xx33}=0$, $I_{xx35}=0$

Proportional Gain and Velocity Feedforward Gain

Set the proportional gain and the velocity feedforward gain as follows:

V/F Freq. (kHz)	$I_{x30}^{1,2}$	I_{x32}^3
10 (Opt.2A)	5,500,000	1000
50 (Opt.2B)	1,100,000	1000
100(Opt.2C)	550,000	1000
500(Opt.2D)	110,000	1000
1000(Opt.2E)	55,000	1000
2000(Opt.2F)	27,500	1000

¹ It is assumed that $I_{x08}=96$ (default factory setup). In the event I_{x08} has been changed, adjust I_{x30} such that the product $I_{x08} \cdot I_{x30}$ remains constant for each setup. **Example:** For the 100 kHz option (Opt. 2C) if $I_{x08}=64$, then I_{x30} should be set to $550,000 \cdot 96/64=825,000$.

² These I_{x30} values are designed for a closed loop position response with a natural frequency of approximately 100 Hz and a damping ratio of 1.

³It is assumed that the servo-sampling rate is at 2.26 kHz. (Default for 20 MHz PMAC). For sampling rates other than default, multiply the above value of I_{x32} by the ratio of the expression [Servo Freq. (kHz)/ 2.26]. **Example:** If Servo Frequency jumper is set for (see E3 to E6) 4.52 kHz, then $I_{x32}=1000 \cdot [4.52/2.26]=2000$.

Issue the on-line command $\#xxJ/$ for the appropriate motor x and open up the position display box in the Executive software using the F7 soft key. It should be at a stationary position. Next, issue a $J=0$ command. If not already at position zero, there should be a change in position towards zero. At this stage, the position loop is closed and offset adjustment can proceed.

Direction Check

Issue a small positive open loop output command to the motor (e.g. #1010) Monitor the position of the motor with the F7 position window of the Executive Program. The reported position should be changing in the positive direction. Now issue a negative open loop output command (e.g. #10-10). The reported position should be changing in the negative direction. If the direction is wrong, recheck E17 jumper setting. (See the PMAC Jumpers and the Encoder Decode I-variables sections of this manual.)

Offset Setup

The zero volt residual frequency offset (unidirectional offset), Ixx79, is a parameter whose fine adjustment is important for proper stepper motor operation. The function of Ixx79 is the same as the adjustment pots on the V/F board. Prior to its adjustment, retain its value at zero and carry out the following steps:

- In the Executive program, use the F7 key to look at the position window.
- If the motor position shows hunting, adjust the corresponding pot (R3A to R3D) such that it just jitters one to two count in either direction.
- If the motor position does not show hunting, adjust the corresponding pot (R3A to R3D) so that it just starts to do so. Then reverse slightly so that the hunting is reduced to one to two counts.
- Now adjust the value of Ixx79 so that it just stops hunting all together (a positive value of Ixx79 would tend to increase hunting; too large a negative value may cause an unacceptable level of deadband).
- Now issue a **J=xxxx** command (xxxx should be a safe distance of 1000). If the motor does not eventually reach (or goes beyond) the end point, adjust Ix29 so that the actual position matches the desired position. Repeat this in the reverse direction by issuing the **J=-xxxx** command and fine adjusting Ixx29. Once the offset is eliminated, the wedge will touch the origin, which is the ideal situation.
- Now, connect the stepper driver to the V/F Board.

Acceleration & Speed I-Variable Adjustment

Adjust Ixx16 to Ixx23 for the particular motor so that top speed and slew rates are not violated (otherwise the stepper might stall). For program moves, adjust Ixx87 to Ixx89 for the same reason.

At this stage, Ixx29 and Ixx79 may need readjustment for possible analog offsets due to the connection of the stepper motor driver to the V/F board. (As outlined in the Address I-variables section of this manual.) To do so, repeat the steps in the previous Offset Setup section.

Direction Polarity Change

At this stage, the stepper should be movable in either direction in a stable manner. However, if the desired positive direction is the opposite of the actual positive direction, (i.e., Clockwise rotation should be positive but actually the counter clockwise rotations occur under positive direction moves) then both E17 Jumpers and the Encoder Decode I-variables should be changed appropriately. To change E17 jumpers, simply reverse the setting instruction described in Direction Output (AENA) Polarity Jumpers. In addition, the appropriate Encoder Decode I-variable should be changed from 0 to 4 (e.g. I900=4 etc).

End of Open Loop Procedure

If using the Open Loop Setup Procedure, go to the Using the Executive Tuner section of this manual.

Closed Loop Setup

CAUTION

Disconnect the stepper driver from PMAC.

PMAC and Turbo PMAC Jumpers

Direction Output (AENA) Polarity Jumpers

Leave these jumpers at the factory default settings (for PMAC-PC there is only one jumper):

E17 (PMAC-PC, Turbo PMAC-PC, Acc-24P)	Jumper Installed for all channels
E17A-D (PMAC-Lite, PMAC-VME, PMAC-STD)	No Jumpers Installed for appropriate channels
E17A-D (PMAC-STD 2nd piggyback board)	No Jumpers Installed for appropriate channels
E17E-H (PMAC-VME Opt. 1 piggyback board)	No Jumpers Installed for appropriate channels

Encoder Jumpers

The Encoder Single-ended/Differential Control jumpers (E18-E27) should be set to single-ended (pins 1 to 2) or differential (pins 2 to 3) according to the type of encoder used.

PMAC I-Variables

Initialization

For each particular motor channel, set all I-variables to the factory default values as shown in the PMAC User Manual. To do so, use the command **Ix00 . . Ix86=***, where **x** is the motor number. Alternatively, use **\$\$\$***** command to reinitialize the entire card.

Activate Motor

Make sure that **Ix00=1** for each motor planning to be used.

Address I-Variables

Change the **Ix02** I-variables as follows, where **x** stands for the motor/channel number:

Ix02= \$1_ _ _ _ (where **_ _ _ _** is the current address)

Example: For motor 1, **I102=\$1C003**

This changes the 16th bit to 1. This bit changes DAC 1's operation from bipolar to unipolar with a direction bit (through AENAx/DIRx).

Ix25=\$1_ _ _ _ (where **_ _ _ _** is the current address)

Example: For motor 1, **I125=\$1C000**

This disables the Amplifier Enable function and allows the AENA1 to be used as DIR1.

Note

If limit switches are not used, then the limits may be disabled by writing 1 into bit 17 of **Ix25**. Example **I125=\$3C000**

Encoder Decode I-variables

Set **I900** to **I935** for A quad B decode with the desired multiplication factor.

Offset I-Variables

Change the following I-variables where **x** stands for the motor/channel number:

I_{x29}=0

This will be adjusted later for the elimination of directional bias.

I_{x79}=0

This will be adjusted later for the elimination of the zero volt residual frequency offset (unidirectional offset).

Servo Gain I-variables

Set all the following I-variables to zero:

I_{x31}=0, I_{x33}=0, I_{x35}=0

Proportional Gain and Velocity Feedforward Gain

The following are values suggested as a starting point for the proportional gain and the velocity feedforward gain. In closed loop mode, these gains may require further tuning after the initial setup. To fine-tune these motors, use the parabolic move of the Executive program's Tuning section.

V/F Freq. (kHz)	I _{x30} ^{1,2}	I _{x32} ³
10 (Opt.2A)	343,750	14,670
50 (Opt.2B)	68,750	14,670
100(Opt.2C)	34,375	14,670
500(Opt.2D)	6,875	14,670
1000(Opt.2E)	3,437	14,670
2000(Opt.2F)	1,718	14,670

¹ It is assumed that I_{x08}=96 (default factory setup). In the event I_{x08} has been changed, adjust I_{x30} such that the product I_{x08}*I_{x30} remains constant for each setup. **Example:** For the 100 kHz option (Option 2C) if I_{x08}=64, then I_{x30} should be set to 34,375*96/64=51,562.

² These I_{x30} values are designed for a closed loop position response with a natural frequency of approximately 25 Hz and a damping ratio of 1.

³It is assumed that the servo-sampling rate is at 2.26 kHz. (Default for 20 MHz PMAC). For sampling rates other than default, multiply the above value of I_{x32} by the ratio of the expression [Servo Freq. (kHz)/ 2.2]. **Example:** If Servo Frequency jumper is set for (see E3 to E6) 4.52 kHz., then I_{x32}=14,670*[4.52/2.26]=29,340.

Now, connect the stepper driver to the V/F Board.

Issue the on-line command **#xJ/** for the appropriate motor **x** and open up the position display box in the Executive software using the F7 soft key. It should be in a stationary position. Issue a **J=0** command. If not already at position zero, notice a change in position towards zero. At this stage, the position loop is closed and offset adjustment can proceed.

Direction Check

Issue a small positive open loop output command to the motor (e.g. **#1010**). Monitor the position of the motor with the F7 position window of the Executive Program. The reported position should be changing in the positive direction. Now issue a negative open loop output command (e.g. **#10-10**). The reported position should be changing in the negative direction. If the direction is wrong, recheck E17 jumper setting. The PMAC Jumpers or Encoder Decode I-variable must be changed. (See the PMAC Jumpers and Encoder Decode I-variables sections of this manual.)

Offset Setup

Ix79, the zero volt residual frequency offset (unidirectional offset), is a parameter whose fine adjustment is important for proper stepper motor operation. The function of Ix79 is the same as the adjustment pots on the V/F board. Prior to its adjustment, retain its value at zero and carry out the following steps:

- In the Executive program, use the F7 key to look at the position window.
- If the motor position shows hunting, adjust the corresponding pot (R3A to R3D) such that it just jitters one to two counts in either direction.
- If the motor position does not show hunting, adjust the corresponding pot (R3A to R3D) so that it just starts to do so. Then reverse slightly so that the hunting is reduced to one to two counts.
- Now adjust the value of Ix79 so that it just stops hunting all together (a positive value of Ix79 would tend to increase hunting; too large a negative value may cause an unacceptable level of deadband).
- Now issue a **J=xxxx** command (**xxxx** should be a safe distance of 1000). If the motor does not eventually reach (or goes beyond) the end point, adjust Ix29 such that the actual position matches the desired position. Repeat this in the reverse direction by issuing a **J=-xxxx** command and fine adjusting Ix29. Once the offset is eliminated, the wedge would just touch the origin, which is the ideal situation.

Acceleration & Speed I-Variable Adjustment

Adjust Ix16 to Ix23 for the particular motor such that top speed and slew rates are not violated (otherwise the stepper might stall). Also, for program moves, adjust Ix87 to Ix89 for the same reason.

At this stage, Ix29 and Ix79 may need adjustment for possible analog offsets due to the connection of the stepper motor driver to the V/F board. (See the Address I-variables section of this manual.) To do so, repeat the steps outlined in the previous section, Offset Setup.

Direction Polarity Change

At this stage, the stepper should be movable in either direction in a stable manner. However, if the desired positive direction is the opposite of the actual positive direction (i.e. Clockwise rotation should be positive but actually the counter clockwise rotations occur under positive direction moves) then both E17 Jumpers and the Encoder Decode I-variables should be changed appropriately. To change E17 jumpers, simply reverse the setting instruction of Direction Output (AENA) Polarity Jumpers. The appropriate Encoder Decode I-variable should also be changed. (See the Encoder Decode I-Variables section of this manual.)

Turbo PMAC I-Variables

Initialization

For each motor channel, set all I-variables be set to the factory default values as shown in the Turbo PMAC User Manual. To do so, use the **Ixx00 . . Ixx99=*** command where **x** is the motor number. Alternatively, use the **\$\$\$**** command to reinitialize the entire card.

Activate Motors

Make sure that Ixx00=1 for each motor planning to be used.

Address I-Variables

Change the following I-variables where **x** stands for the motor/channel number:

Ixx96= \$1

Example: For motor 1, I196=\$1

This bit changes the command output value to an absolute value (magnitude) of what the servo calculates, and the sign (direction) is output on the AENAn/DIRn line of the set of flags addressed by Ixx25.

Change Bit 16 of Ixx24 to 1 to disable the amplifier-enable function

Example: For motor 1, I124=\$10000

This disables the Amplifier Enable function and allows the AENA1 to be used as DIR1. If limit switches are not used, then the limits may be disabled by writing 1 into bit 17 of Ix24. **Example:** I124=\$30000

Encoder Decode I-variables

Set the following I-variables for pulse and direction feedback decode as follows (assuming the default setting for E17 as previously described):

For channel 1	I7010=0
For channel 2	I7020=0
For channel 3	I7030=0
For channel 4	I7040=0
For channel 5	I7110=0
For channel 6	I7120=0
For channel 7	I7130=0
For channel 8	I7140=0

Offset I-variables

Change the I-variable Ixx29=0, where **x** stands for the motor/channel number. This will be adjusted later for the elimination of directional bias.

Ixx79=0 will be adjusted later for the elimination of the zero volt residual frequency offset (unidirectional offset).

Servo Gain I-variables

Set the following I-variables to zero:

Ixx31=0, Ixx33=0, Ixx35=0

Proportional Gain and Velocity Feedforward Gain

Set the proportional gain and the velocity feedforward gain as follows:

V/F Freq. (kHz)	Ix30 ^{1,2}	Ix32 ³
10 (Opt.2A)	5,500,000	1000
50 (Opt.2B)	1,100,000	1000
100(Opt.2C)	550,000	1000
500(Opt.2D)	110,000	1000
1000(Opt.2E)	55,000	1000
2000(Opt.2F)	27,500	1000

¹ It is assumed that Ix08=96 (default factory setup). In the event Ix08 has been changed, adjust Ix30 such that the product Ix08*Ix30 remains constant for each setup. **Example:** For the 100kHz option (Opt. 2C) if Ix08=64, then Ix30 should be set to 550,000*96/64=825,000.

² These Ix30 values are designed for a closed loop position response with a natural frequency of approximately 100Hz and a damping ratio of 1.

³It is assumed that the servo-sampling rate is at 2.26kHz. (Default for 20MHz PMAC). For sampling rates other than default, multiply the above value of Ix32 by the ratio of the expression [Servo Freq. (kHz)/ 2.26]. **Example:** If Servo Frequency jumper is set for (see E3 to E6) 4.52kHz, then Ix32=1000*[4.52/2.26]=2000.

Issue the on-line command **#xxJ/** for the appropriate motor **x** and open up the position display box in the Executive software using the F7 soft key. It should be at a stationary position. Next, issue a

J=0 command. If not already at position zero, there should be a change in position towards zero. At this stage, the position loop is closed and offset adjustment can proceed.

Direction Check

Issue a small positive open loop output command to the motor (e.g. **#1010**) Monitor the position of the motor, with the F7 position window of the Executive Program. The reported position should be changing in the positive direction. Now issue a negative open loop output command (e.g. **#10-10**). The reported position should be changing in the negative direction. If the direction is wrong, recheck E17 jumper setting and Encoder Decode I-variable. (See PMAC Jumpers and Encoder Decode I-variables sections of this manual.)

Offset Setup

The zero volt residual frequency offset (unidirectional offset), Ixx79, is a parameter whose fine adjustment is important for proper stepper motor operation (see the enclosed graphs). The function of Ixx79 is the same as the adjustment pots on the V/F board. Prior to its adjustment, retain its value at zero and carry out the following steps:

- In the Executive program, use the F7 key to look at the position window.
- If the motor position shows hunting, adjust the corresponding pot (R3A to R3D) such that it just jitters 1 to 2 count in either direction (referring to the graphs this occurs when the wedge just touches the horizontal axis).
- If the motor position does not show hunting, adjust the corresponding pot (R3A to R3D) such that it just starts to do so. Then reverse slightly so that the hunting is reduced to 1 to 2 counts.
- Now adjust the value of Ixx79 so that it just stops hunting all together (a positive value of Ixx79 would tend to increase hunting; too large a negative value may cause an unacceptable level of deadband).
- Now issue the **J=xxxx** command (**xxxx** should be a safe distance at 1000). If the motor does not eventually reach (or goes beyond) the end point, adjust Ix29 such that the actual position matches the desired position. Repeat this in the reverse direction by issuing the **J=-xxxx** command and fine adjusting Ixx29. Once the offset is eliminated, the wedge would touch the origin, which is the ideal situation.
- Connect the stepper driver to the V/F Board.

Acceleration & Speed I-Variable Adjustment

Adjust Ixx16 to Ixx23 for the particular motor such that top speed and slew rates are not violated (otherwise the stepper might stall). For program moves, adjust Ixx87 to Ixx89 for the same reason.

At this stage, Ixx29 and Ixx79 may need readjustment for possible analog offsets due to the connection of the stepper motor driver to the V/F board. (See the Address I-variables section of this manual.) To do so, repeat the steps outlined in the previous section, Offset Setup.

Direction Polarity Change

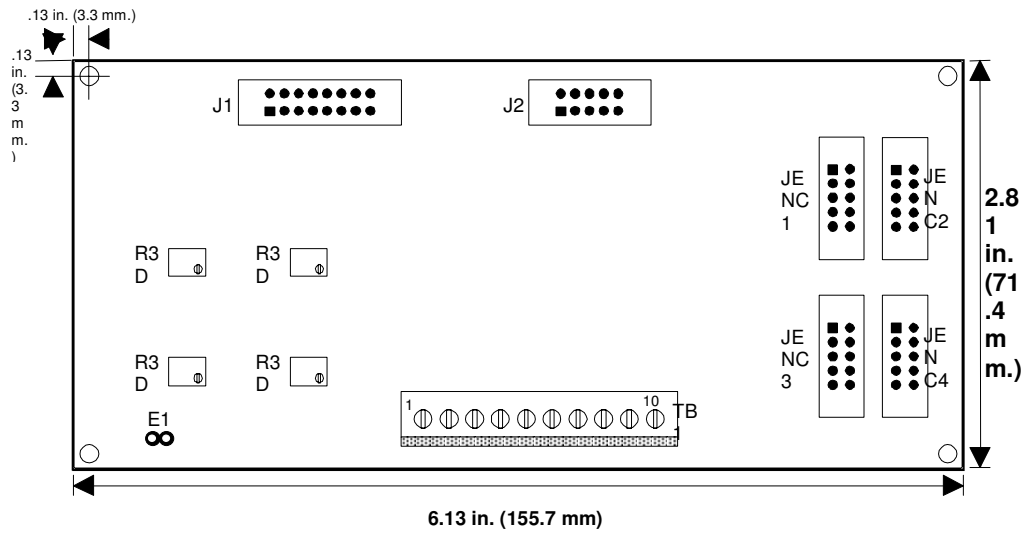
At this stage, the stepper should be movable in either direction in a stable manner. However, if the desired positive direction is the opposite of the actual positive direction, (i.e., clockwise rotation should be positive but actually the counter clockwise rotations occur under positive direction moves) then both E17 Jumpers and the Encoder Decode I-variables should be changed appropriately. To change E17 jumpers, simply reverse the setting instruction described in Direction Output (AENA) Polarity Jumpers. In addition, the appropriate Encoder Decode I-variable should be changed from 0 to 4 (e.g. I900=4 etc).

Using the Executive Tuner

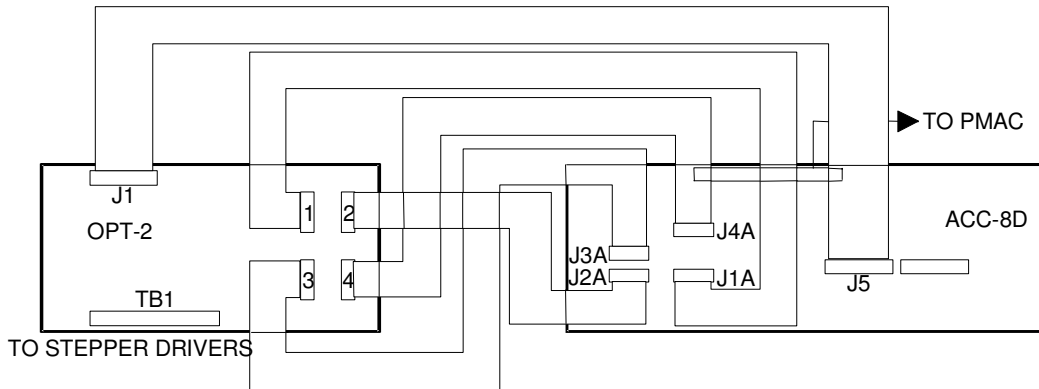
The step move should not be used if a stepper motor is physically connected to the V/F board. Usually this is because the motor will stall, especially for large step sizes. However, the parabolic move option may be used to fine-tune the proportional (Ix30) and the velocity feedforward gains as required. Again, velocity feedback (Ix31), integral (Ix33) and acceleration feedforward (Ix35) gains need not be used (i.e. Ix31=Ix33=Ix35=0).

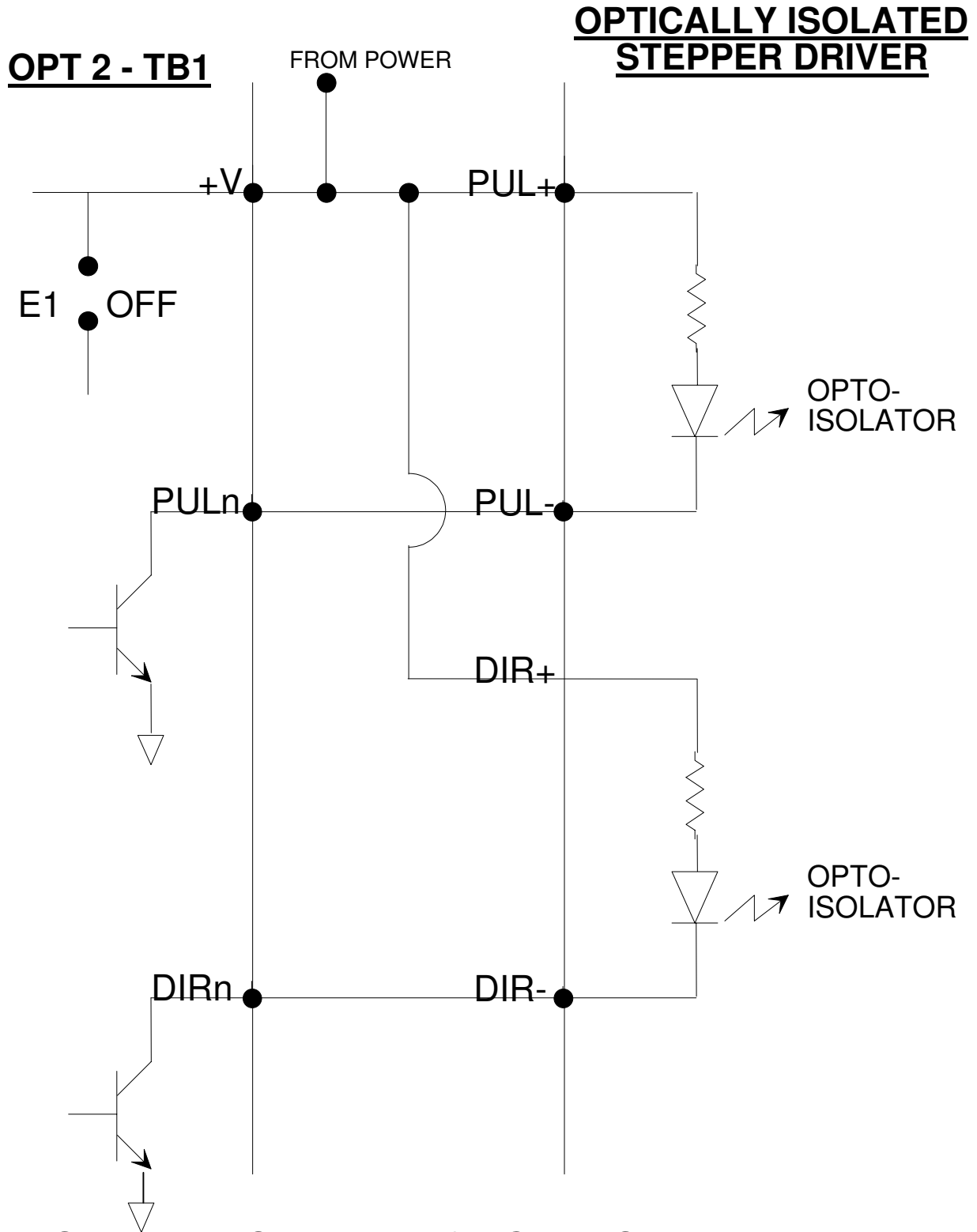
LAYOUT AND CONNECTIONS

PMAC ACC-8D OPTION 2 4 CHAN. V/F CONVERTER



CONNECTION OF PMAC ACC-8D TO ITS OPTION 2 BOARD





Suggested Connection for OPT2 Connections with Optically-Isolated Stepper Drivers

CONNECTORS AND CONNECTOR PINOUTS

Connectors

This section describes the pin definition listings of each connector.

TB1

This 10-pin terminal block provides the actual pulse and direction signals to four stepper motor drives.

J1

This connector brings in the analog magnitude signals and direction bits from ACC-8D board. It should be connected via the supplied 16-pin flat cable to ACC-8D (J5 connector).

J2

This connector allows for externally supplied enable input activation of the V-to-F converters individually. Note that PMAC's standard amplifier-enable outputs are not available to ACC-8D Option 2 board when driving stepper motors. The externally supplied enable inputs are pulled up on the Option 2 board to +5V (enabled).

JENC1

This connector allows the pulse and direction bits generated by the V-to-F converter to be fed back to ACC-8D through its connector J1A. This connection is required for open loop stepper motor position control.

JENC2

This connector allows the pulse and direction bits generated by the V-to-F converter to be fed back to ACC-8D through its connector J2A. This connection is required for open loop stepper motor position control.


JENC3

This connector allows the pulse and direction bits generated by the V-to-F converter to be fed back to ACC-8D through its connector J3A. This connection is required for open loop stepper motor position control.


JENC4

This connector allows the pulse and direction bits generated by the V-to-F converter to be fed back to ACC-8D through its connector J4A. This connection is required for open loop stepper motor position control.


Connector Pinouts


Option 2 J1 (16-Pin Header)			 Top View	
Pin #	Symbol	Function	Description	Notes
1	DAC1	Input	Analog out positive 1	Reference to analog ground
2	DAC1/	Input	Analog out negative 1	Reference to analog ground
3	DAC2	Input	Analog out positive 2	Reference to analog ground
4	DAC2/	Input	Analog out negative 2	Reference to analog ground
5	DAC3	Input	Analog out positive 3	Reference to analog ground
6	DAC3/	Input	Analog out negative 3	Reference to analog ground
7	DAC4	Input	Analog out positive 4	Reference to analog ground
8	DAC4/	Input	Analog out negative 4	Reference to analog ground
9	DIR1	Input	Direction bit *	Reference to analog ground
10	DIR2	Input	Direction bit 2 *	Reference to analog ground
11	DIR3	Input	Direction bit 3 *	Reference to analog ground
12	DIR4	Input	Direction bit 4 *	Reference to analog ground
13	AGND	Common	Analog ground	Power from PMACs
14	A+15V**	Input	Analog positive supply	Analog supply
15	AGND	Common	Analog ground	Is brought in
16	A-15V ***	Input	Analog negative supply	Through these pins


This connector brings in the analog magnitude signals and direction bits from the ACC-8D board.
 *The settings of Ix02 and Ix25 determine whether these lines are amplifier-enable signals or direction bit signals. Jumper E17 on PMAC determines the polarity of these signals.
 **The current requirement is 300mA.
 ***The current requirement is 200mA.


Option 2 J2 (10-Pin Header)			 Top View	
Pin #	Symbol	Function	Description	Notes
1	ENA1	Input	V/F1 enable	High-true
2	ENA2	Input	V/F2 enable	Enable
3	ENA3	Input	V/F3 enable	Internally
4	ENA4	Input	V/F4 enable	Pulled high
5	AENA/DIR1	Output	Direction bit 1	
6	AENA/DIR2	Output	Direction bit 2	
7	AENA/DIR3	Output	Direction bit 3	
8	AENA/DIR4	Output	Direction bit 4	
9	A+5V	Output		Reference to analog ground
10	AGND	Common		

This connector allows for externally supplied enable bits to control the V/F converters individually.


Option 2 JENC1 (10 Pins)				
				 Top View
Pin #	Symbol	Function	Description	Notes
1	CHA1	Output	A Channel positive	H.P. standard
2	+5V	Input	Power supply	H.P. standard
3	GND	Common	Digital ground	H.P. standard
4	CHA1/	Output	A Channel negative	Added
5	CHB1/	Output	B Channel negative	Added
6	GND	Common	Digital ground	H.P. standard
7	+5V	Input	Power supply	H.P. standard
8	CHB1	Output	B Channel positive	H.P. standard
9	+5V	Input	Power supply	H.P. standard
10	N.C.		No connect	
<p>This connector allows the pulse and direction bits generated in the V-to-F converter to be fed back to the ACC-8D through its connector J1A.</p>				

ACC-8D Option 2 JENC2 (10 Pins)				
				 Top View
Pin #	Symbol	Function	Description	Notes
1	CHA2	Output	A Channel positive	H.P. standard
2	+5V	Input	Power supply	H.P. standard
3	GND	Common	Digital ground	H.P. standard
4	CHA2/	Output	A Channel negative	Added
5	CHB2/	Output	B Channel negative	Added
6	GND	Common	Digital ground	H.P. standard
7	+5V	Input	Power supply	H.P. standard
8	CHB2	Output	B Channel positive	H.P. standard
9	+5V	Input	Power supply	H.P. standard
10	N.C.		No connect	
<p>This connector allows the pulse and direction bits generated in the V-to-F converter to be fed back to the ACC-8D through its connector J2A.</p>				

ACC-8D Option 2 JENC3 (10 Pins)				
				 Top View
Pin #	Symbol	Function	Description	Notes
1	CHA3	Output	A Channel positive	H.P. standard
2	+5V	Input	Power supply	H.P. standard
3	GND	Common	Digital ground	H.P. standard
4	CHA3/	Output	A Channel negative	Added
5	CHB3/	Output	B Channel negative	Added
6	GND	Common	Digital ground	H.P. standard
7	+5V	Input	Power supply	H.P. standard
8	CHB3	Output	B Channel positive	H.P. standard
9	+5V	Input	Power supply	H.P. standard
10	N.C.		No connect	
<p>This connector allows the pulse and direction bits generated in the V-to-F converter to be fed back to the ACC-8D through its connector J3A.</p>				


ACC-8D Option 2 JENC4 (10 Pins)				 Top View
Pin #	Symbol	Function	Description	Notes
1	CHA4	Output	A Channel positive	H.P. standard
2	+5V	Input	Power supply	H.P. standard
3	GND	Common	Digital ground	H.P. standard
4	CHA4/	Output	A Channel negative	Added
5	CHB4/	Output	B Channel negative	Added
6	GND	Common	Digital ground	H.P. standard
7	+5V	Input	Power supply	H.P. standard
8	CHB4	Output	B Channel positive	H.P. standard
9	+5V	Input	Power supply	H.P. standard
10	N.C.		No connect	

This connector allows the pulse and direction bits generated in the V-to-F converter to be fed back to the ACC-8D through its connector J4A

Option 2 TB1 (10-Pin Terminal Block)				 Top View
Pin #	Symbol	Function	Description	Notes
1	A+V	Input	Optional supply	+5V to +15V *
2	AGND	Common	Signal return	Must use
3	PUL1	Output	1 st Motor pulse	Reference to analog ground
4	DIR1	Output	1 st Motor direction	Reference to analog ground **
5	PUL2	Output	2 nd Motor pulse	Reference to analog ground
6	DIR2	Output	2 nd Motor direction	Reference to analog ground **
7	PUL3	Output	3 RD Motor pulse	Reference to analog ground
8	DIR3	Output	3 rd Motor direction	Reference to analog ground **
9	PUL4	Output	4 th Motor pulse	Reference to analog ground
10	DIR4	Output	4 th Motor direction	Reference to analog ground **

This terminal block provides the actual connection to the stepper motor drivers.
 * If not used, high signal level is +5V (with E1 OFF), or +14V (with E1 ON)
 ** Polarity controlled by PMAC jumper(s) E17.

ACC-8D OPTION 2 JUMPERS

E-Point	Physical Layout	Description	Default
E1		Jump 1-2 to make output high levels. Use PMAC +12V to +15V supply	No jumper
Remove jumper to make output high levels at +5V or external supply from TB1 Pin 1.			



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