OPERATOR'S MANUAL FOR THE SERIAL LOAD ENCODED DC MOTOR DRIVE POSITIONING SYSTEM WITH MANUAL CONTROLS AND HOME

PN: EDO101

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CHAPTER 1: GENERAL DESCRIPTION

The Aerotech Serial Load Encoded DC Motor Drive consists of the equipment needed to convert serial clock and direction commands into motor shaft position change. The system consists of the Serial Load Card, a servo controller (amplifier) with external ±15V supplies, an encoder, a motor tachometer and a 5V power supply. A position read-out is optional, requiring a 5V/14V power supply. Also optional is a front panel switch assembly.

This manual deals with the installation, adjustment, operation, maintenance and troubleshooting of the SL motor drive system. The manual for the servo controller that is being used will also be needed.

CHAPTER 2: SPECIFICATIONS

Specifications given are for the Serial Load Card. Specifications for the servo controller can be found in its manual, and encoder specifications vary with the type of encoder selected.

SECTION 2-1 ELECTRICAL SPECIFICATIONS

±15V supply voltage range	±11V to ±17V
+5V supply voltage range	+4.5V to +5.5V
Output voltage range	±10V
Minimum output load impedance	600 ohms
Encoder inputs common mode voltage range	±10V
Sin and Cos input impedance	20K ohms
Marker input impedance	10K ohms
Maximum encoder signal frequency	100K lines/sec
Digital input impedance (J1, J2 inputs)	100K ohms
Maximum clock input frequency	150KHz

Clock Pulse Train Characteristics (J1-3):

Minimum time in high state	1 uSec
Minimum time in low state	5 uSec

Directional Change: Direction must not change during an interval beginning 1uSec before clock rising edge and ending 1uSec after clock falling edge.

$\overline{\text{LMT}}$ input response time	1 mSec

Digital outputs:

Voltage swing	0 to 5V
Output source current	-.44 mA
Output sink current	.44 mA
Readout CW $\overline{\text{CL}}$ and CCW $\overline{\text{CL}}$ pulse width	1 uSec

SECTION 2-2 MECHANICAL AND ENVIRONMENTAL SPECIFICATIONS

Board dimensions	7 1/2" x 6 1/2" x 3/4"
Mounting dimensions	6 7/8" x 6 1/8" or 5 7/8" or 5 5/8" (1/8" required below board surface)
Operating temperature range	0° to 50°C
Storage temperature range	-55° to 125°C

CHAPTER 3: INSTALLATION

SECTION 3-1 AC POWER REQUIREMENTS

The power required for the system depends on the servo controller used. A system with a 4020 servo controller requires 200 watts, 6020 requires 300 watts, 6020HR-10 amp continuous requires 600 watts, 6040 requires 900 watts and 8030 requires 1200 watts. Unless specified otherwise, the AC line must be 115 VAC ±10%, 50/60 Hz.

SECTION 3-2 SL CARD INTERFACING

Each jack on the Serial Load Card usually has the required interfacing for one assembly in an Aerotech positioning system. J1 interfaces to an indexer or a serial input. J2 accepts the Front Panel Switch Assembly to operate the manual controls. J3 has the inputs for the encoder signals. J4 has the interconnection to the power amplifier. J5 has the signals needed by the readout. J6 connections are to both the 5V supply and limit switches. J7 provides a combination of J1 and J2 connections for special requirements.

A. INDEXER/REMOTE INTERFACE J1

All signals at J1 are 5V digital CMOS logic. Also, logic power is provided on the jack.

J1-1 +V	5V DC output.
J1-2 COM	Board common.
J1-3 Rem CL	When card is in remote mode, pulses on this input line increment the position of the motor. The leading edge of the pulse readies the card to increment and the falling edge causes the increment of position.
J1-4 Rem DIR	This line determines the direction of position change in remote mode. A high on this line causes the pulses of J1-3 to increment the motor position in a CW direction. A low causes the increments

to be in a CCW direction (CW and CCW refer to rotation of the motor shaft seen when looking into the mounting flange of the motor).

J1-5 $\overline{\text{Reset}}$ — This line, when pulsed low, resets the position counters and stops motor movement. If neither limit input is pulled low, the reset signal will terminate a home cycle and reset the readout. The SL card pulls this line low for approximately 10 mSec when the home cycle is complete.

J1-6 Key — There is no signal on this line. The pin is missing and the hole in the plug corresponding to this pin should be plugged so that the connector cannot be inserted incorrectly.

J1-7 CZ — Count zero is a signal that goes high when the counters on the card hold a count of zero. This condition occurs when the motor has made the increments of position that have been commanded by clock and direction. CZ also goes high when the card has been reset (by command, by completion of the home cycle, or by hitting a limit).

J1-8 $\overline{\text{LMT}}$ — This output goes low when a limit has been sensed on either the CW or CCW limit input.

J1-9 $\overline{\text{Go Home}}$ — A falling edge on this line initiates the home cycle. It will not be recognized if $\overline{\text{reset}}$ is low at the time.

J1-10 At Home — This signal goes high at the completion of the home cycle. After going home, it will go high every time the marker pulse occurs on the encoder. When another $\overline{\text{Go Home}}$ is given, it will stay low until the completion of the home cycle.

B. FRONT PANEL INTERFACE J2

J2 is a 16-pin DIP socket designed to connect to the Aerotech Front Panel Switch Assembly by way of a ribbon cable.

J2-1 $\overline{\text{LMT}}$ — This output is connected to J1-8, and goes low when a limit is reached.

J2-2 $\overline{\text{Reset}}$ — This line is connected to J1-5. Pulling this signal low causes a card reset. Completion of a home cycle pulls this line low.

J2-3 $\overline{\text{Go}}$ $\overline{\text{Home}}$ — This input is connected to J1-9, a falling edge will initiate a home cycle.

J2-4 Step NC — This signal input is meant to connect to the normally closed contact of a momentary contact SPDT switch. If the moving contact of the switch is connected to ground and the step NO input connection at J2-12 is connected to the normally open contact, pressing and releasing the switch will cause one pulse to be generated. This will increment the motor position one step if the unit is in the local mode.

J2-5 $\overline{\text{Slew}}$ — This input, when pulled low, causes a pulse train to be generated internally that will slew the motor if the SL card is in the local mode.

J2-6 SP — Spare pin.

J2-7 SP — Spare pin.

J2-8 At Home — This output is connected to J1-10. This output goes high when the home cycle is complete, and everytime the marker comes up on the encoder thereafter.

J2-9 CZ — The count zero output is connected to J1-7. It goes high when the motor is in the position commanded by the input pulses and direction line.

J2-10 SP — Spare pin.

J2-11 LCL Dir — This input controls the direction of the motor in the local mode. A high causes CW rotation (when shaft is viewed looking into the mounting flange of the motor). A low causes CCW rotation.

J2-12 Step NO — This input is to be connected to the normally open contact of the SPDT switch mentioned in the description of J2-4.

J2-13 Com — Card Common.

J2-14 +V — +5V DC output that normally powers an Aerotech Front Panel Switch Assembly.

J2-15 SP — Spare pin.

J2-16 LCL/REM — This input determines the source of clock and direction commands that the card follows. When J2-16 is low, the clock pulses at J1-3 and the direction level at J1-4 are followed by the card. When J2-16 is high , the card follows the pulse commands generated from step and $\overline{\text{slew}}$ commands and the local direction input at J2-11.

C. ENCODER INTERFACE J3

The signals from the encoder come onto the SL Card at J3. They are three differential analog pairs for sin, cos and marker.

J3-1 COS — Cosine signal. DC level that goes from approximately 2V to approximately 3V and back to 2V once for every line of the encoder's movement.

J3-2 $\overline{\text{COS}}$ — $\overline{\text{Cosine}}$ signal. Same levels as Cos but variation of voltage is 180 degrees out of phase with cos signal.

J3-3 SIN — Sine signal. Same levels as Cos and $\overline{\text{Cos}}$, but signal is 90 degrees out of phase with Cos signal. When encoder is driven by motor turning CW, Sin signal lags Cos signal by 1/4 cycle.

J3-4 $\overline{\text{SIN}}$ — $\overline{\text{Sine}}$ signal. Same levels as Sin signal but 180 degrees out of phase with Sine signal. Voltage variation leads Cos signal by 90 degrees when motor turns CW.

J3-5 Marker Signal — Normally low but goes high once every revolution of a rotary encoder. It is used as absolute position reference in home cycle. It should go high for an interval that is centered on a positive peak of the Cos signal.

J3-6 $\overline{\text{M}}$ — $\overline{\text{Marker}}$ pulse. This signal is opposite in polarity to the marker signal. Certain encoders may have digital outputs for marker signals. If so, they may be missing either M or $\overline{\text{M}}$.

D. SERVO CONTROLLER INTERFACE J4

This jack contains the interface needed between the SL Card and an Aerotech amplifier that is set up in a rate loop with a motor-mounted tachometer.

J4-1 Analog Out — This is the output of the SL Card. It is an analog voltage between + and - 10V that acts as a rate command to the motor-amplifier combination. If CW rotation is required, the SL Card puts out a negative voltage; if CCW rotation is required, it puts out a positive voltage. The magnitude of the voltage is the magnitude of motor speed desired.

J4-2 SP — Spare pin.

J4-3 Home Lmt — Optional home limit.

J4-4 Com — Board common.

J4-5 +15 — Input for +15V (or +12V) power from amplifier.

J4-6 -15V — Input for -15V (or -12V) power from amplifier.

E. READOUT INTERFACE J5

The signals needed for the readout are on J5. Power for the readout comes from a separate supply.

J5-1 Home Lmt — Optional home limit.

J5-2 SP — Spare pin.

J5-3 CW $\overline{CL}$ — A normally high output that pulses low once (X1) or twice (X2) for every line passing through the encoder when the motor turns CW.

J5-4 CCW $\overline{CL}$ — Similar to J5-3, but pulses low if motor is turning CCW.

J5-5 $\overline{RES}$ — Readout $\overline{Reset}$. Normally high, but goes low to reset readout. It goes low for 10 mSec when power is applied. It goes low when J1-5 or J2-2, $\overline{Reset}$ commands, are pulled low if not in limit, and it goes low for 10 uSec when home cycle is completed.

J5-6 SP — Spare pin.

F. POWER SUPPLY AND LIMITS INTERFACE J6

This jack interfaces to two units; the logic power supply and the limit sensors.

J6-1 PS+5 — This is the logic power input for the board. It is to be connected to the +5V output of the power supply.

J6-2 PS Com — This is the card ground that should be connected to the common output of the power supply.

J6-3 Limit +5 — This output supplies +5V to the limit sensor.

J6-4 Limit Com — This is card ground that should be connected to the common on the limit sensor.

J6-5 CW $\overline{\text{LMT}}$ — This input should be pulled low by the sensor that detects the limit of motor CW travel.

J6-6 CCW $\overline{\text{LMT}}$ — This input should be pulled low by the sensor that detects the limit of motor CCW travel.

G. CONTROL INTERFACE J7

This connector is a combination of connectors J1 and J2.

J7-1 LCL DIR — Same as J2-11

J7-2 Step NO — Same as J2-12

J7-3 At Home — Same as J1-10

J7-4 LCL/REM — Same as J2-16

J7-5 Go Home — Same as J1-9

J7-6 CZ — Same as J1-7

J7-7 Step NC — Same as J2-4

J7-8 Reset — Same as J1-5

J7-9 LMT — Same as J1-8

J7-10 Slew — Same as J2-5

J7-11 REM DIR — Same as J1-4

J7-12	REM CLK	Same as J1-3
J7-13	Com	Same as J2-13
J7-14	Com	Same as J1-2
J7-15	+5V	Same as J1-1
J7-16	N.C.	Spare

SECTION 3-3 SERVO CONTROLLER INTERFACING

The different Aerotech servo controllers have different connection numbering. However, they all require the same signals for operation. Accordingly, this section uses signal names but no numbers. Consult the manual for the particular servo controller for the connection numbers needed.

INPUT 1 This is the input on the amplifier for the output of the SL Card. Negative voltage commands CW rotation.

INPUT 3 This is the input for the feedback voltage from the tachometer (tach+). The voltage here should go positive for CW rotation.

+15V +15V supply for the SL card.

-15V -15V supply for the SL card.

Common Should be connected to SL card common. Common is also the return for the tachometer (tach-).

Motor+ This is the source for motor current when the motor turns CW and the sink for the motor current when the motor turns CCW. Connect to + terminal of motor.

Motor- This is the sink for motor current when the motor turns CW and the source for motor current when the motor turns CCW. Connect to - terminal of motor.

AC High Connect to "hot" or black wire from AC power. This AC line is fused.

AC Low Connect to neutral or white wire from AC power. This AC line is unfused.

SECTION 3-4 MOTOR/TACH/ENCODER INTERFACING

A. MOTOR/TACH POLARITY

Remove motor fuse and connect a voltmeter across the motor terminals. Turn motor shaft CW. If a positive voltage is developed, the + lead of the voltmeter is on the motor+ terminal. If a negative voltage is developed, the - lead of the voltmeter is on the motor+ terminal. Of course, the other terminal is the motor- terminal.

The tach polarity is determined in the same manner.

B. ENCODER POLARITY

See section 3-2C for a description of the phase relationship between the encoder signals to determine the identity of the signals from the encoder.

CHAPTER 4: OPERATION

SECTION 4-1 FOLLOWING A SERIAL COMMAND

The Aerotech Serial Load Card has been designed to develop a command voltage that is sent to an amplifier and motor configured in a rate loop (see figure 1). A rate loop is an amplifier and a motor with a tachometer. The tachometer generates a voltage proportional to velocity that is summed with the input command to the amplifier. This configuration makes the motor run at a velocity proportional to the input command voltage.

This command voltage is the voltage at the output of the serial load card. It is the output of a D/A converter that is fed by a digital number representing the difference between the number of command pulses that are received and the number of position feedback pulses from the encoder that are received.

When the system is in position (the motor is where it has been commanded to be) the difference between the command pulses received and the encoder pulses received is zero. If the direction input is high (CW DIR) and a pulse train is received on the clock input, the voltage out of the SL Card will go negative. This will cause the motor to begin turning CW. The motor's turning will cause the encoder to output signals which generate feedback pulses in the SL card. The feedback pulses count down the SL Card's counter and the command pulses count it up. As the motor accelerates the feedback pulses are generated more rapidly, and the output voltage goes negative at a slower rate. Eventually the motor will be spinning at a rate that causes the feedback pulses to be generated at the same rate as the command pulses. When this happens, the difference between the number of command pulses received and the number of feedback pulses received doesn't change, and that difference, inputting the D/A converter, is proportional to the velocity of the motor.

When the command pulse train ceases, the feedback pulses from the encoder rapidly count down the number in the D/A, and the output voltage returns toward zero. This causes the encoder to generate feedback pulses at a slower rate, and the output voltage returns to zero at a slower rate. By the time the encoder pulses have reached the number of command pulses received, the difference, and therefore the output voltage and the velocity have all reached zero. The motor is once again in the position to which it was commanded.

While the motor is at its commanded position the signal CZ (count zero) goes high. This signifies a count of zero in the counter and a signal called analog lock is sent to the rate loop.

SECTION 4-2 ANALOG LOCK

The analog lock signal is a segment of a sine wave derived from the output of the encoder. This signal level goes from negative to positive as the encoder turns CW. This voltage is fed into the rate loop input. This allows the motor to stop in a position where this signal is at a zero volts level. If, for some reason, the motor turns slightly CW, this level will go positive, and command the motor to turn CCW. If the motor turns slightly CCW, the level of the analog lock voltage will go negative, commanding CW rotation. Thus a stable rest point is created where the analog lock voltage is zero.

SECTION 4-3 LOCAL/REMOTE MODE

The command inputs can come from two sources: the remote serial input on J1, or manual controls operated by switches connected through J2. The input selection is made by a digital input called local/remote mode on J2-16. When this input is high, local mode is selected. The remote inputs for clock and direction are ignored, and the local direction command on J2-11 and an internal signal called local clock become the commands followed by the card. If the local/remote input is low, then the local direction command and the local clock are ignored while remote clock, J1-3 and remote direction, J1-4 become the input commands.

The local clock signal is generated from slew and step commands on J2. Single steps are generated from a debounce latch operated from an SPDT switch. An input called $\overline{\text{Slew}}$ turns on an oscillator that provides a pulse train. The pulse train and the single steps comprise local clock.

SECTION 4-4 RESET OPERATION

The $\overline{\text{Reset}}$ input to the card, when pulled low, causes the counters to reset to zero. This causes the output voltage to go to zero, and the motor to stop. If the system is not in limit, a low on the $\overline{\text{reset}}$ input will cause the R.O. $\overline{\text{reset}}$ output to go low, resetting the readout. Also, if there is no limit, a low on $\overline{\text{reset}}$ will terminate a home cycle.

SECTION 4-5 X1/X2 RESOLUTION

The resolution of the system is the change in position caused by one command pulse. Normally, the SL Card is in X1 mode and one clock pulse will cause the motor to turn a distance corresponding to one line of the encoder. The SL Card can be configured in X2 mode, however, by inserting a jumper between two pads. This causes the motor to move a distance represented by one-half an encoder line for each clock pulse.

SECTION 4-6 LIMIT SENSING

The SL Card includes circuitry for incorporating limit sensing to prevent the motor moving its load beyond desired points in both directions. Two inputs, CW and CCW $\overline{\text{LMT}}$, can be pulled low by limit switches or other sensors. If either limit goes low, the counters on the SL Card are reset and the motor will stop. Also, if the CW limit goes low, further CW commands are inhibited, and if the CCW limit goes low, further CCW commands are inhibited.

SECTION 4-7 HOME

The Serial Load Card incorporates a home circuit to provide an absolute position reference capability. When a Go Home command is given, the home circuit on the SL Card assumes control of the clock and direction commands, and commands the motor through a home cycle. The home cycle

begins with the motor turning CCW at the slew rate. When the CCW limit is reached, the motor changes direction. Once the motor pulls out of the CCW limit, the home circuit looks for a marker pulse from the encoder. When the marker pulse appears, the motor stops, a signal called At Home goes high, and a reset pulse is sent out on the reset input. A readout reset pulse is also sent out, and the home circuit yields its control of clock and direction.

CHAPTER 5: ADJUSTMENTS, JUMPERS AND COMPONENTS

SECTION 5-1 ADJUSTMENTS

If the system has been shipped with an Aerotech stage, all adjustments have been made at the factory, otherwise the system has been adjusted with an unloaded motor. Adding considerable inertia and friction will usually require adjustment of servo gain (section 5-1D) and may require adjustment of Sin Lock (section 5-1E).

If the motor overshoots position or has very slow response, the servo gain may be misadjusted. If the motor jitters when in position, the analog detent may require adjustment. See assembly drawing for adjustment locations.

A. SLEW/HOME FREQUENCY R8

The clock frequency during slew and home commands can be adjusted at R8. CW rotation increases the clock frequency.

B. MARKER BALANCE R21

The width of the marker pulse can be adjusted at R21 if the encoder sends out M and $\overline{M}$ signals that are analog levels. CW rotation narrows the width of the marker pulse, and CCW rotation widens it. The marker width should be adjusted so that the marker at TP4 is high for one of the positive half cycles of the Cos^2 square wave at TP6 and low for the other positive half cycles on either side.

If the encoder used has digital (TTL/CMOS compatible) outputs, it may have as outputs M an $\overline{M}$; $\overline{M}$ only or M only. If the encoder has an $\overline{M}$ output only, cut trace between pads 7 and 8 and jumper between pads 8 and 9. If voltage TP4 stays near +15V, turn R21 CW. If TP5 voltage stays near -15V, turn R21 CCW. (For systems with $\overline{M}$ output only, where jumper modification on pads 7, 8 and 9 has been done, reverse direction of R21 rotation.)

C. SIGN SYMMETRY AND ANALOG BALANCE R72 AND R59

These two adjustments ensure the desired operation of the D/A converter. R72 ensures that a change in the input count produces a monotonic change in output voltage. The analog balance adjustments assures that a zero input count produces zero volts out. These two adjustments interact so they should be adjusted by the following procedures.

PROCEDURE A: USE IF PADS 20 AND 22 ARE JUMPERED

1. Jumper M10-5 or 6 to ground (or jumper between pads 18 and 19 - X2 mode.
2. Turn R55 full CCW.
3. Remove motor fuse.
4. Turn on power.
5. Take one step CCW.
6. Measure voltage at TP5 with an oscilloscope or meter capable of resolving 1 mV. Adjust R59, analog balance, for 10 mV ±1mV at TP5.
7. Reset system.
8. Adjust R72, Sign Symmetry Adjust, for 0 mV ±1mV at TP5.
9. Adjustment of R59 and R72 is now complete. Remove jumper.

PROCEDURE B: USE IF PADS 21 AND 22 ARE JUMPERED

1. Same as above.
2. Same as above.
3. Same as above.
4. Same as above.

5. Adjust R59, Analog Balance, for 0V ±1mV at TP5.

6. Take 1 step CCW.

7. Adjust R72, Sign Symmetry Adjust, for +10mV ±1 at TP5.

8. Adjustment of R59 and R72 is now complete. Remove jumper.

D. SERVO GAIN

Refer to servo controller manual for location adjustments. Typically, only Input Scale Factor 1 will require adjustment. To start from scratch: turn Gain CW, input 1 CCW, input 3 mid-range. Adjust: Gain CCW until rate loop oscillates, then turn CW until oscillation stops and 1/8 turn further. Turn SL Card R55 1/8 turn from full CCW. Execute 200 step increments and observe system response at SL Card TP5. As input 1 pot on the servo controller is adjusted CW, system will come into position sooner. Adjust input 1 CW until system overshoots (voltage at TP5 crosses through zero, then returns to zero) then adjust input 1 CCW until system comes into position without overshoot.

E. SIN LOCK R55

The Sin Lock Adjustment varies the gain of the encoder sine wave that if fed into the motor amplifier when the system is in position. If this gain is too high, the system will oscillate or ring. If the gain is too low, the system will not accurately maintain position. Motor fuse must be in place for adjustment.

To adjust the gain, observe the signal at TP2 with an oscilloscope. If DC level is not 0V ±.2V, adjust the offset adjust on the amplifier so that it is. Command one step. The signal at TP2 should form one wavelength of a sine wave (one half wavelength in X2 mode). If there is ringing present at the end of the sine wave, or if the system oscillates, the gain is too high. Turn R55 CCW. If the last part of the sine wave

is slow returning to zero, or if it doesn't return to zero, the gain is too low, and R55 should be turned CW. If turning R55 has no effect, the Balance Adjust Pot on the amplifier is misadjusted. Turn R55 full CW, turn the amplifier Balance Adjust Pot back and forth until a range of adjustment is found where the system oscillates. Set the amplifer Offset Adjust in the middle of this range and turn R55 CCW until oscillation stops. Proceed as before to set the gain of the sin lock and when done, correct the DC value of TP2 by adjusting the amplifier Balance Adjust.

SECTION 5-2 JUMPER SELECTIONS

A. HOME DIRECTION SELECTION (PADS 1-6)

As manufactured, the home cycle rotates the motor CCW until the CCW limit is reached. Reaching the limit causes the direction command to reverse, and the motor will stop when the first marker comes up on the encoder. Therefore, the home position is close to the CCW limit. If the home position is desired to be near the CW limit, the directions commanded by the home circuit must be reverse; and the limit input to the home circuit must be changed to the CW limit. Cut the trace between pads 2 and 3, and insert a jumper between pads 1 and 2 to change the home direction polarities; cut the trace between 5 and 6 and insert a jumper between pads 4 and 5 to connect the CW $\overline{\text{LMT}}$ to the home circuit.

B. M BALANCE ADJUSTMENT (PADS 7-9)

The marker balance adjustment R21 connects to the - input of the marker comparator. This makes the adjustment useful when both M and $\overline{\text{M}}$ signals, or M alone, are present. If the encoder used has only an $\overline{\text{M}}$ output, however, the adjustment will not have the desired effect. Therefore, if an encoder with only an $\overline{\text{M}}$ output is used, cut trace between pads 7 and 8 and jumper between pads 8 and 9.

C. HARDWIRED REMOTE MODE (PADS 10-13)

If the Serial Load Card is to be used in remote mode only, without connection to J2, a jumper between pads 10 and 11 will put the card in remote mode, and a jumper between pads 12 and 13 will ensure that the step debounce latch does not inhibit the clock commands during a home cycle.

D. SIN AND COS FILTER OPTION (PADS 14-17)

If the SL Card is operated in an electrically noisy environment, some noise voltage may appear at the input of the sin and cos comparators. This may be bad enough to cause false transistions on the Sin^2 and Cos^2 waveforms, and false position feedback signals. If this problem is encountered, the first thing to try would be to increase the value of C14 and C19. This may degrade performance at high command frequencies. If the problem cannot be solved in this way without erratic operation at high speeds, then traces 14-15 and 16-17 should be cut and factory select (F.S.) components L1, L2, R31, R40, C18 and C31 should be installed. This will insert an L-C filter between the input op-amp and the comparator.

E. X2 SELECTION (PADS 18-19)

As delivered, the Serial Load Card is configured in X1 mode. This means that one command pulse causes motor movement equal to one encoder line. To double this resolution (one command pulse causes movement equal to 1/2 encoder line), jumper between pads 18 and 19.

F. SIGN SYMMETRY CORRECTION DIRECTION (PADS 20-22)

This jumper should not require change unless M2 has been replaced. To determine where to put the jumper, remove motor fuse, temporarily jumper in X2 mode, and turn R72 CCW. Reset system, measure voltage at TP5 with a meter that can resolve 1mV. Adjust R59

for 0mV ±1mV at TP5. Command one step CCW. If TP5 voltage is greater than 10mV, jumper 21 to 22. If voltage is less than 10mV, jumper 20 to 22. Follow procedure A or procedure B from section 5-1C to readjust R72 and R59.

SECTION 5-3 CHANGEABLE COMPONENTS

Certain components on the SL Card are mounted on stand-off terminals to facilitate changing values. Refer to the servo controller manual for its changeable components.

A. SLEW/HOME FREQUENCY C1

The range to frequencies available for slew and home commands can be changed by changing C1. A smaller capacitor will move the range upward in frequency.

B. OUTPUT NON-LINEARITY CONVERSION R56, R57, D4 AND D5

Some applications may be found where the response to small commands cannot be made fast enough without making the response to large commands too fast. In these instances, a non-linear output from the D/A is desired. Increasing the value of R56 and installing D4, D5 and R57 will cause a non-linear characteristic out of the D/A. For small commands the transfer characteristic is determined by R56. Increasing its value increases the mV/bit characteristic of the D/A for small numbers. This characteristic extends from 0V to ± the breakpoint voltage. The breakpoint voltage depends on the diodes used for D4 and D5. Germanium diodes (1N191, etc.) cause a breakpoint voltage of about ±.3V and silicon diodes (1N914, etc.) cause about ±.6V. Above the breakpoint voltage the mV/bit characteristic is determined by R57 as well as R56. Decreasing the value of R57 decreases the mV/bit characteristic above the breakpoint voltage.

C. SERVO CONTROLLER COMPENSATION

The frequency response of the servo controller can be tailored, if necessary, by changing components on the servo controller PC Card. Consult the manual of the servo controller that is being used.

CHAPTER 6: MAINTENANCE

Maintenance requirements are minimal. Biannual maintenance may consist of removing accumulated dust from the forced air cooled servo controller, and if desired, checking encoder magnitudes and offset. After 3,000 to 5,000 hours of operation the motor and tachometer brushes can be checked.

SECTION 6-1 ENCODER SIGNAL MAGNITUDE

Scope TP2 and TP3 when the motor is rotating and verify the signals are greater than 2V p/p.

SECTION 6-2 SERVO BALANCE

Check to see if the servo balance at TP2 on the SL Card is within +.2V. If not, readjust according to section 3-4.

SECTION 6-3 MOTOR AND TACH BRUSHES

The motor and tach brushes have a life of approximately 100 to 200 million revolutions (5 inch diameter motor brush life is 500 million revolutions). Brushes should be replaced when they are about 1/4 gone: if 3/8" new, replace at 9/32" length (5 inch diameter motor brush length is .68 inch new, replace at .4 inch).

CHAPTER 7: TROUBLESHOOTING

Troubleshooting will be aimed at determining if the logic card is defective; or if the servo controller, motor, tach, or encoder has failed. Troubleshooting the motor, tach, or servo controller will be found in the servo controller instruction manual.

SECTION 7-1 ENCODER

The encoder signals can be checked at SL Card J3-1 through J3-6 to see if they agree with their descriptions found in section 3-2A. Some encoders may have digital (0 to 5V TTL/CMOS compatible) outputs for the M and/or $\overline{M}$ outputs. These encoders should be checked to see that the marker response is centered at a positive peak of the COS signal.

SECTION 7-2 SYSTEM VERIFICATION

The operation of the card can be checked by observing the waveforms shown in figure 2. If it is suspected that the system is missing steps (taking too many or not enough steps), install a pointer on the motor shaft (a convenient place is the opposite end of the ball screw shaft) and place a mark in line with the pointer on the stationary parts of the stage. Then index the drive from a command generator in multiples of one revolution of motor rotation. Example: a standard 200 line encoder in X1 mode index in increments of 200 steps. In X2 mode index in increments of 400 steps.

SECTION 7-3 SERIAL LOAD CARD

Operation of the serial load card can be checked with the following tests using a standard scope or DC voltmeter.

TEST 1

Disconnect motor fuse and give a $\overline{Go}$ $\overline{Home}$ command. Output should ramp up from -10V to +10V and quickly return to -10V. (Polarity of signal should be reversed if home direction has been changed.)

TEST 2

Activate the home limit. Waveform should invert, ramping down from +10V to -10V and quickly rising back to +10V (or ramp up if home direction was changed).

TEST 3

Reset system and turn motor CW. Output should ramp up from -10V to +10V. Turn motor CCW. Output should ramp down.

SECTION 7-4 BLOWING FUSES

Normally the motor fuses (located on the power amplifier) should not blow, and the line fuse (located on the rear chassis panel) will open only for a short or failed power component. Caution should be exercised if the motor fuse blows more than once, since this indicates one of the following possibilities:

1. The system motor/amplifier has been improperly chosen for the load friction or inertia.
2. The duty cycle is too high.
3. System friction is increasing.
4. The motor is failing.
5. The servo is not adjusted properly and oscillating.

Open fuses on the power amplifier should be removed with a fuse puller after system power has been removed. Do not pry the fuse out with a screwdriver, since this may short supply voltages to unprotected components.

If replaced fuses blow immediately, even with the motor disconnected, this indicates the power amplifier has failed.

SECTION 7-5 POWER AMPLIFIER FAILURE

POWER AMPLIFIER FAILURE

A power amplifier failure usually occurs in the power stage and can usually be verified with an ohmmeter. To make this check, remove AC power, replace the blown fuse, disconnect the motor at the amplifier terminals and make the following measurements:

4020 or 2020	If fuse F1 is blowing, on an X1 ohmmeter scale, apply the + lead to +40VDC and the - lead to the -40VDC terminal. Resistance reading should be greater than 100 ohms for a good amplifier.
Fuse F2 Blowing	On an X1 ohmmeter scale, apply the + lead to the +40VDC terminal and the - lead to the output (resistance should be greater than 100 ohms), then apply the + lead to the output and the - lead to the -40VDC terminal. Resistance should be about 40 ohms, but greater than 10 ohms.
6020 or 6040	On an X1 ohmmeter scale, apply the + lead to TB2-15 and the - lead to TB2-16, then TB2-17. None of the four readings should be less than 100 ohms.

NOTE: If the ohmmeter polarities are not observed, low resistance readings will be measured even for a good amplifier.

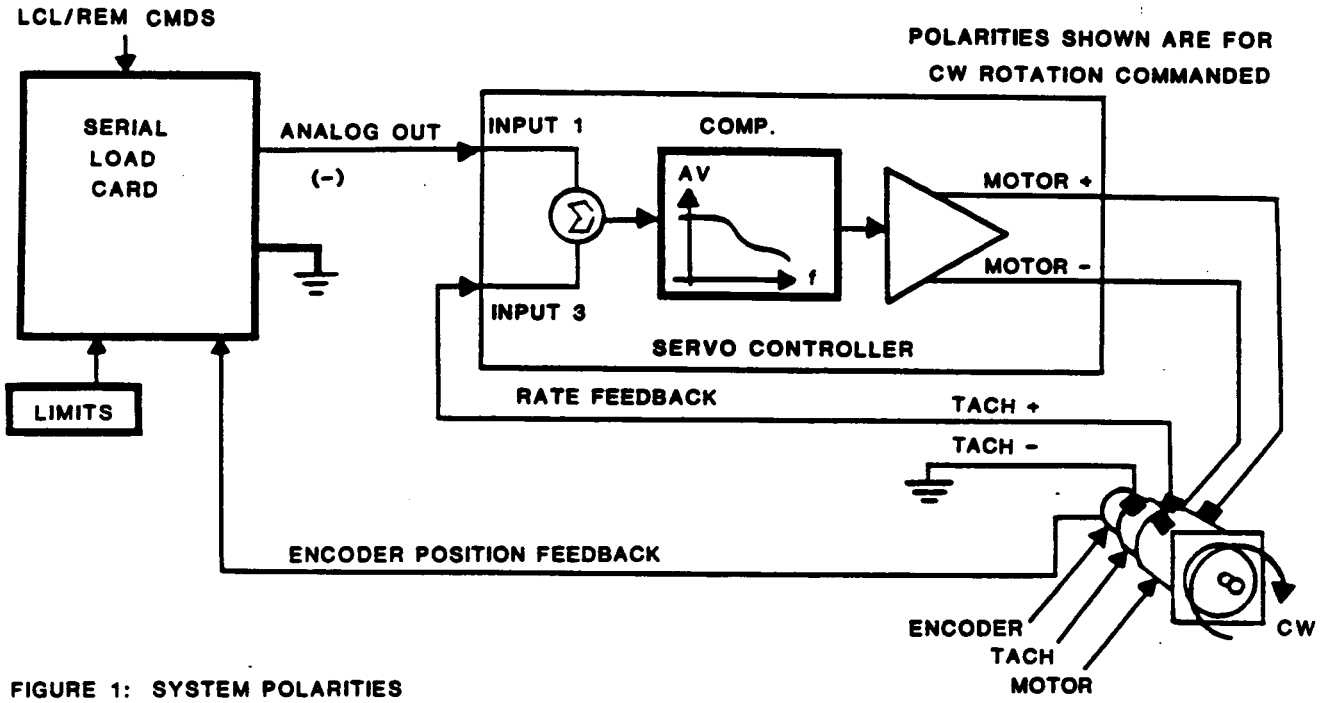
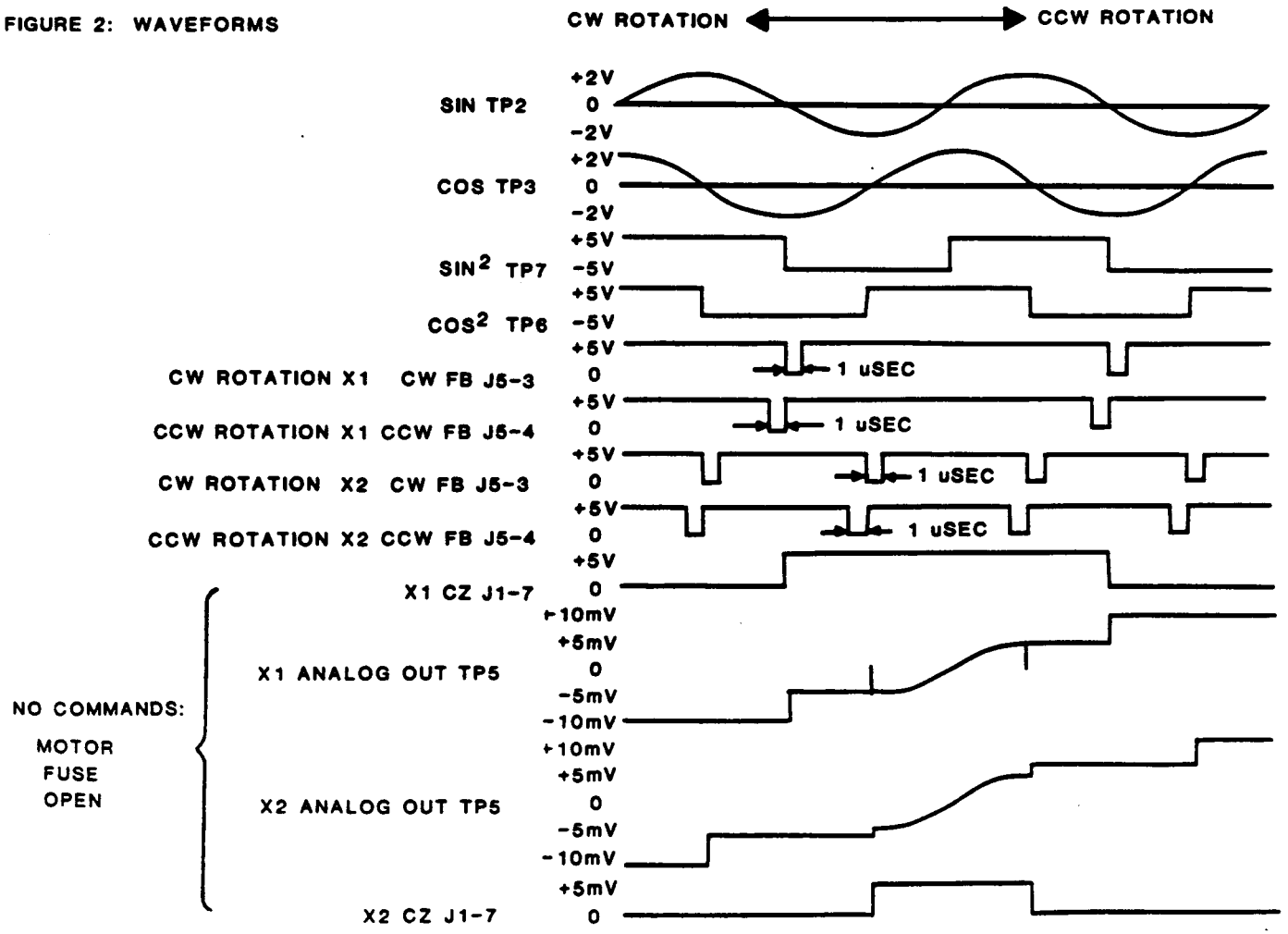


FIGURE 1: SYSTEM POLARITIES

FIGURE 2: WAVEFORMS



SERVICE AND REPAIR

If under warranty, repairs of defective electrical components should not be attempted, *since to do so would void the entire warranty.*

If necessary, any on-site service should be performed by an experienced Aerotech-trained electronics technician

SHIPMENT

The procedure for shipping equipment back to Aerotech, which is described below, pertains to warranty as well as non-warranty repairs.

1. Before shipping any equipment back to Aerotech, the person making the return must call ahead for a "*Return Authorization Number*". *(Have your serial number on hand when calling.)*
2. The equipment being returned must be encased in a proper cushioning material and enclosed in a cardboard box.

Call for a "Return Authorization Number" if it is necessary to ship any part to the factory.

Warning: Damage due to improper packaging voids warranty!

Aerotech Sales and Service offices are listed on the following pages. For service and information, contact the office servicing your area.

AEROTECH, INC. SALES OFFICES

World Headquarters
AEROTECH, INC.

101 Zeta Drive
Pittsburgh, PA 15238

Phone (412) 963-7470
FAX (412) 963-7459
TWX (710) 795-3125

AEROTECH NORTHEAST
Executive Suite 120
270 Farmington Avenue
Farmington, CT 06032
Phone (203) 673-3330
or (203) 673-2503
FAX (203) 674-1536

MA, CT, VT, ME, RI, NH, eastern NY

AEROTECH CENTRAL-WEST

26791 Lake Vue Drive #8
Perrysburg, OH 43551
Phone (419) 874-3990
FAX (419) 874-4280
MI, IN, KY, western OH

AEROTECH MIDWEST
PO Box 625
Dundee, IL 60118
Phone (312) 428-5440
FAX (312) 428-5471
IL, MO, KS, WI, MN, ND, SD, IA, NE

AEROTECH, CENTRAL-EAST
856 Cottonwood Drive
Monroeville, PA 15146

Phone (412) 373-4160
FAX (412) 373-4163
WV, western PA, western NY, eastern OH

AEROTECH SOUTHWEST
6001 Village Glen Drive
#3101
Dallas, TX 75206
Phone (214) 987-4556
FAX (214) 987-4706
TX, OK, LA, AR, CO, UT,MT, WY, ID, NM

AEROTECH NORTHWEST

444 Castro Street
Suite 400
Mountain View, CA 94041
Phone (415) 967-4996
FAX (415) 967-4998
northern CA, OR, WA, NV

AEROTECH WEST

Suite 217
7002 Moody Street
La Palma, CA 90623
Phone (213) 860-7470
FAX (213) 860-4639
AZ, southern CA

AEROTECH MID-ATLANTIC
521 Kingwood Road
King of Prussia, PA 19406

Phone (215) 265-6446
FAX (215) 265-3566
MD, DC, DE, NJ, northern VA, eastern PA

AEROTECH SOUTH ATLANTIC
8804 Lomas Court
Raleigh, NC 27615
Phone (919) 848-1965
FAX (919) 848-3393
NC, TN, southern VA, AL, FL, GA, SC, MS

INTERNATIONAL SALES OFFICES

AEROTECH LTD.
3 Jupiter House, Calleva Park
Aldermaston
Berkshire RG7 4QW England
Phone (07356) 77274
TLX 847228
FAX (07356) 5022

AEROTECH GMBH
Neumeyerstrasse 90
8500 Nuernberg 10
West Germany
Phone (0911) 521031
TLX 622474
FAX (0911) 521235

AEROTECH AUSTRALASIA
224 Carr Street
Suite 7
Leederville 6007
Western Australia
Phone (619) 328-2540
FAX (619) 227-6670

INTERNATIONAL REPRESENTATIVES

BRASITEC
Rue Americo Brasiliense, 2069
Chacara Santo Antonio
Cep 04715 - Sao Paulo - SP
Brazil
Phone (5511) 523 4044
TLX 1130691 BRTC

Y. BEN MOSHE
PO Box 18125
Tel Aviv 61181
Israel
Phone (9723) 7515007
or (9723) 7513268
TLX 342436 BMS IL
FAX (9723) 727319

SIMCO
208, First Floor
Ajmeri Gate
New Delhi 110 006 India
Phone 652986
TLX 031-62176 HARS IN
FAX (9111) 510697

OPTIKON CORPORATION LTD.

410 Conestogo Road
Waterloo, Ontario
Canada, N2L 4E2
Phone 519-885-2551
FAX 519-885-4712

DONG DO TRADING CO. LTD.
Rm 903, Kwang Sung Bldg.
831-47 Youksamdong
Kangnam-Ku, Seoul, Korea
Phone (822) 556-2292
FAX (822) 556-2902
TLX 29734 DONG DO

TOKYO INSTRUMENTS INC.

Asahi-Seimei Bldg.
6-8-10 Nishikasai
Edogawa-Ku
Tokyo 134 Japan
Phone (813) 686-4711
FAX (813) 686 0831

HISCO (MALAYSIA) SDN.BHD.
1 Lorong SS13/6A
Subang Jaya Indust. Estate
47500 Petaling Jaya
Selanger, Malaysia
Phone (603) 733-4236
FAX (603) 733-6281
TLX 36226 HISCO MA

Warranty and Field Service Policy

Aerotech, Inc. warrants its products to be free from defects caused by faulty materials or poor workmanship for a minimum period of one year from date of shipment from Aerotech. Aerotech's liability is limited to replacing, repairing or issuing credit, at its option, for any products which are returned by the original purchaser during the warranty period. Aerotech makes no warranty that its products are fit for the use or purpose to which they may be put by the buyer, whether or not such use or purpose has been disclosed to Aerotech in specifications or drawings previously or subsequently provided, or whether or not Aerotech's products are specifically designed and/or manufactured for buyer's use or purpose. Aerotech's liability on any claim for loss or damage arising out of the sale, resale or use of any of its products shall in no event exceed the selling price of the unit.

Laser Product Warranty

Aerotech, Inc. warrants its laser products to the original purchaser for a minimum period of one year from date of shipment. This warranty covers defects in workmanship and material and is voided for all laser power supplies, plasma tubes and laser systems subject to electrical or physical abuse, tampering (such as opening the housing or removal of the serial tag) or improper operation as determined by Aerotech. This warranty is also voided for failure to comply with Aerotech's return procedures.

Return Products Procedure

Claims for shipment damage (evident or concealed) must be filed with the carrier by the buyer. Aerotech must be notified within (30) days of shipment of incorrect materials. No product may be returned, whether in warranty or out of warranty, without first obtaining approval from Aerotech. No credit will be given nor repairs made for products returned without such approval. Any returned product(s) must be accompanied by a return authorization number. The return authorization number may be obtained by calling an Aerotech service center. Products must be returned, prepaid, to an Aerotech service center (no C.O.D. or Collect Freight accepted). The status of any product returned later than (30) days after the issuance of a return authorization number will be subject to review.

Returned Product Warranty Determination

After Aerotech's examination, warranty or out-of-warranty status will be determined. If upon Aerotech's examination a warrantied defect exists, then the product(s) will be repaired at no charge and shipped, prepaid, back to the buyer. If the buyer desires an air freight return, the product(s) will be shipped collect. Warranty repairs do not extend the original warranty period.

Returned Product Non-Warranty Determination

After Aerotech's examination, the buyer shall be notified of the repair cost. At such time the buyer must issue a valid purchase order to cover the cost of the repair and freight, or authorize the product(s) to be shipped back as is, at the buyer's expense. Failure to obtain a purchase order number or approval within (30) days of notification will result in the product(s) being returned as is, at the buyer's expense. Repair work is warranted for (90) days from date of shipment. Replacement components are warranted for one year from date of shipment.

Rush Service

At times, the buyer may desire to expedite a repair. Regardless of warranty or out-of-warranty status, the buyer must issue a valid purchase order to cover the added rush service cost. Rush service is subject to Aerotech's approval.

On-Site Warranty Repair

If an Aerotech product cannot be made functional by telephone assistance or by sending and having the customer install replacement parts, and cannot be returned to the Aerotech service center for repair, and if Aerotech determines the problem could be warranty- related, then the following policy applies.

Aerotech will provide an on-site field service representative in a reasonable amount of time, provided that the customer issues a valid purchase order to Aerotech covering all transportation and subsistence costs. For warranty field repairs, the customer will not be charged for the cost of labor and material. If service is rendered at times other than normal work periods, then special service rates apply.

If during the on-site repair it is determined the problem is not warranty related, then the terms and conditions stated in the following "On-Site Non-Warranty Repair" section apply.

On-Site Non-Warranty Repair

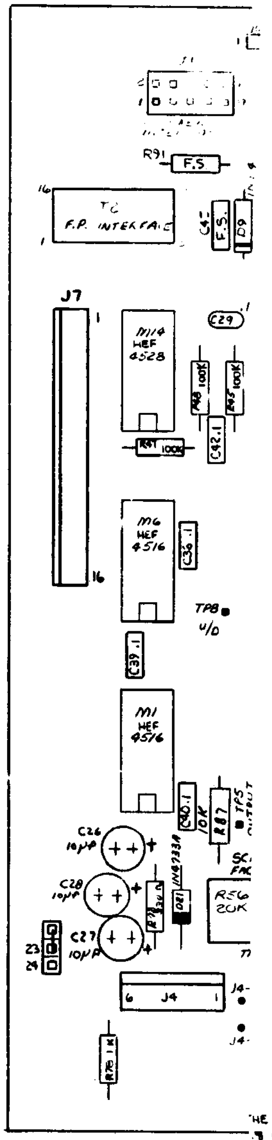
If an Aerotech product cannot be made functional by telephone assistance or purchased replacement parts, and cannot be returned to the Aerotech service center for repair, then the following field service policy applies.

Aerotech will provide an on-site field service representative in a reasonable amount of time, provided that the customer issues a valid purchase order to Aerotech covering all transportation and subsistence costs and the prevailing labor cost, including travel time, necessary to complete the repair.

AEROTECH, Inc., 101 Zeta Drive, Pittsburgh, Pennsylvania 15238

Phone (412) 963-7470 • TWX 710-795-3125 • FAX (412) 963-7459

SYM.	ZONE	DESCRIPTION	DATE	APPROVAL
A		PER ECN 0113	1/1/79	TJM
B		ADDED D7, D8, R77. R3 WAS 24/ POWER TO R3 N AS ±15V, D3 WAS R..	3/20/79	TJM
C		ADDED R78 & 79, 89 ... ERS 23,24,25,&26. CHANGED ... R11 TO 390K & R66 ... D8 TO F.S. CHANGED JUMPERS 2,3,5,&6	6/18/79	JJD
D		ADDED D22-D24, C35, R80-86, K1.N 2,4, Q1, Q2, Q9, Q10. R1-6,12 IN RESISTOR SIP, CHANGED R18 TO 1K, C14 & 19 TO 100pF, R33 43 TO 240K, R77 TO 100K, D7,8 TO IN191 ECN0140 & 0142	4/1/80	T.J.D
E		NO CHANGE THIS SHEET ECN 0172	11/17/80	T.J.D.
F		ADDED C36, R56 WAS A 10K RES. PER ECN 0203 & 0213	11/16/81	T.J.D.
G		ADDED R87-10K RES. C26, C27 & C28 WERE .1μF. ECN0336/0338	7/7/83	DJS
H		ADDED R88, C37, JUMPERS 31-33 ES11161	1/30/84	JAC
I		ECN 0386 0389	4/60/84	JAC
J		R7 WAS 27K, R53 WAS 5.6K, R45-48 WAS 39K, ADDED D11, J7, C38-C44, PINS 1 & 15 ON M4,5,14,15 TIE TO GND, M1, M6-19 CHANGED TO (HEF), J3-J6 CHANGED TO LOCKING CONN., CHANGED ALL JUMPERS TO .1 GOLD JUMPERS	6/25/85	D. Sagath
K		ADDED ECN 0493 0529 ECN0519 CHANGED ALL POTS ADDED D12 & R61 JB	12/31/85	D. Sagath
K1		CHANGE R7 FROM 10K TO 11K	11/3/87	GSW
L		ADDED ES11302, R7 25K POT WAS 11K RES	4/25/88	D. Sagath



IF THE PULSE WIDTH FROM M14 & M15 IS NOT BETWEEN .5 TO .8 USEC, CHANGE R45 - R46 TO INSURE .5 TO .8 USEC

J4 SERVO CONTROLLER INTERFACE
-15
+15
COM
OPT A
OPT HOME LMT
HOMING OUT

PART OR IDENTIFYING NO	DESCRIPTION	SPEC	MATERIAL OR NOTE	QTY. REQD

LIST OF MATERIAL

MACHINING TOLERANCE MANUAL MM-1000 APPLIES UNLESS OTHERWISE SPECIFIED

TOLERANCES ON: FRACTIONS ± 1/32, ± 1/16; DECIMALS .XX ± .01, .XXX ± .005; ANGLES ± 0°-30'

EXCEPT AS NOTED

DRAWN 9/12/78 · CHECKED 9/1/78 · DAS 9/24/78

AEROTECH, INC.
101 Zeta Drive
Pittsburgh, Pa. 15238 412-963-7470

SERIAL LOAD WITH MANUAL CONTROLS & HOME (ASSEMBLY) (FOR REV J ABOVE)

CODE IDENT. NO. 10B · SIZE D · 690D1110

SCALE 2:1 · WT · SHEET 5 OF 5

690D1110

J4 SERVO CONTROLLER INTERFACE

- -15
- +15
- COM
- OPT 'A
- OPT HOME LMT
- HOMING OUT

J5 E.D. INTERFACE

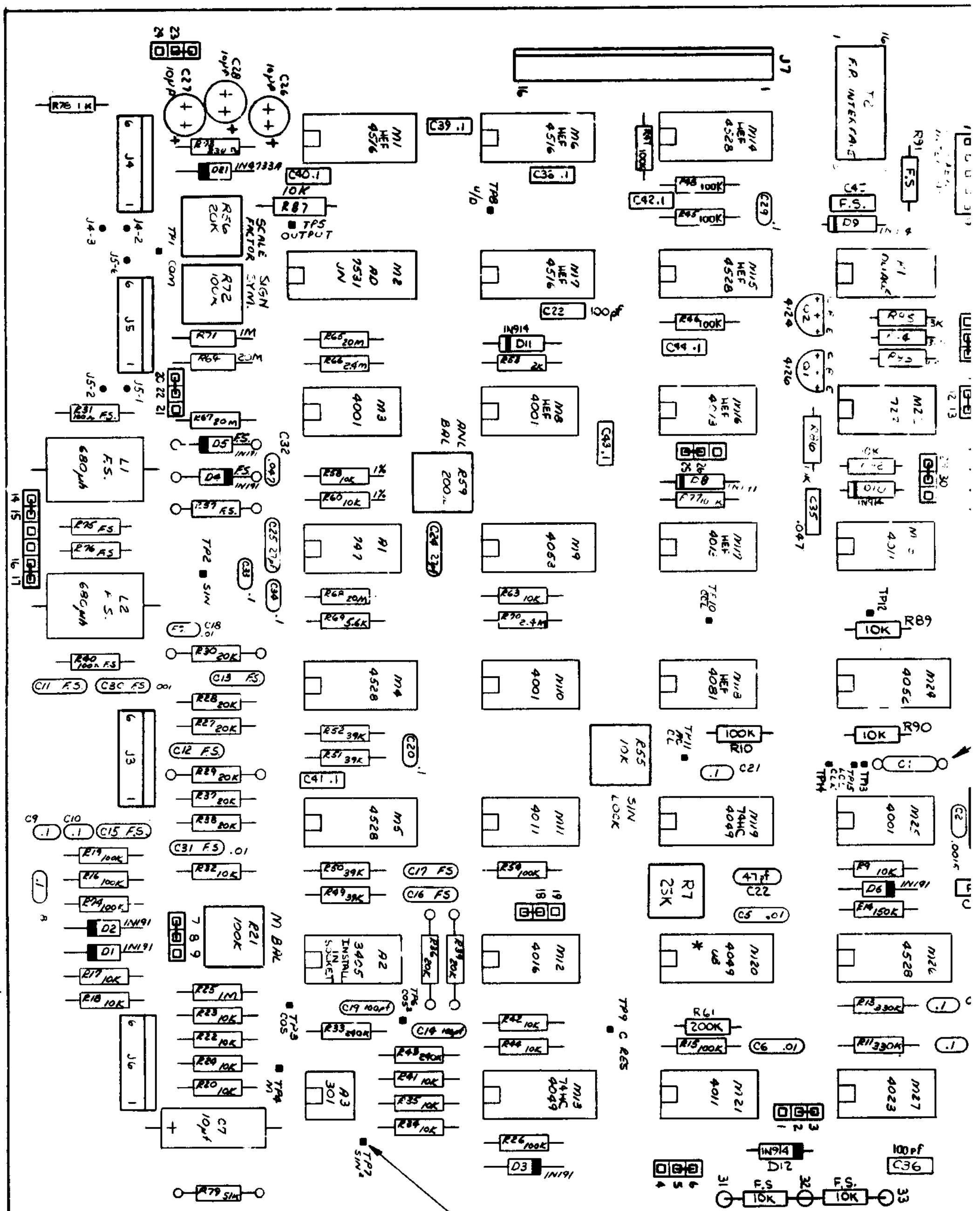
- SPARE
- RESET
- CCW CL
- CW CL
- SPARE
- OPT 'A

J3 ENCODER INTERFACE

- $\overline{M}$
- M
- $\overline{SIN}$
- SIN
- $\overline{COS}$
- COS

J6 POWER SUPPLY & LIMIT INTERFACE

- CCW LIMIT
- CW LIMIT
- LIMIT COM
- LIMIT +5
- PS COM
- PS +5

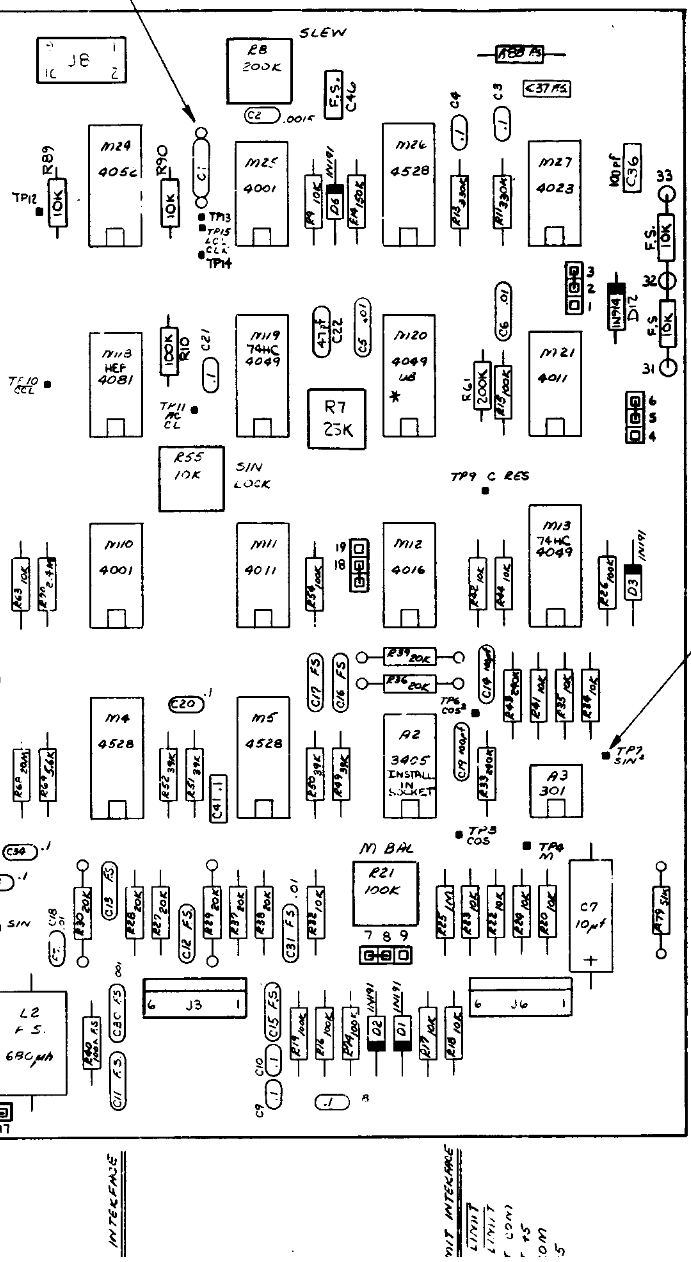


NOTE: INSERT WIRE-W... PIN IN HOL (15) TEST POINTS. (PARTS LIST ITEM... INSERT PINS F... FOIL SIDE OF ...

* DO NOT SUB. 3u/Pcero

APPLICATION		QTY REQD		PAINT	FINISH	MATERIAL	THIS DR... AND IS S... REPRODU...
NEXT ASSY	USED ON						

200 LINE = .0015
2000 LINE = 150pf



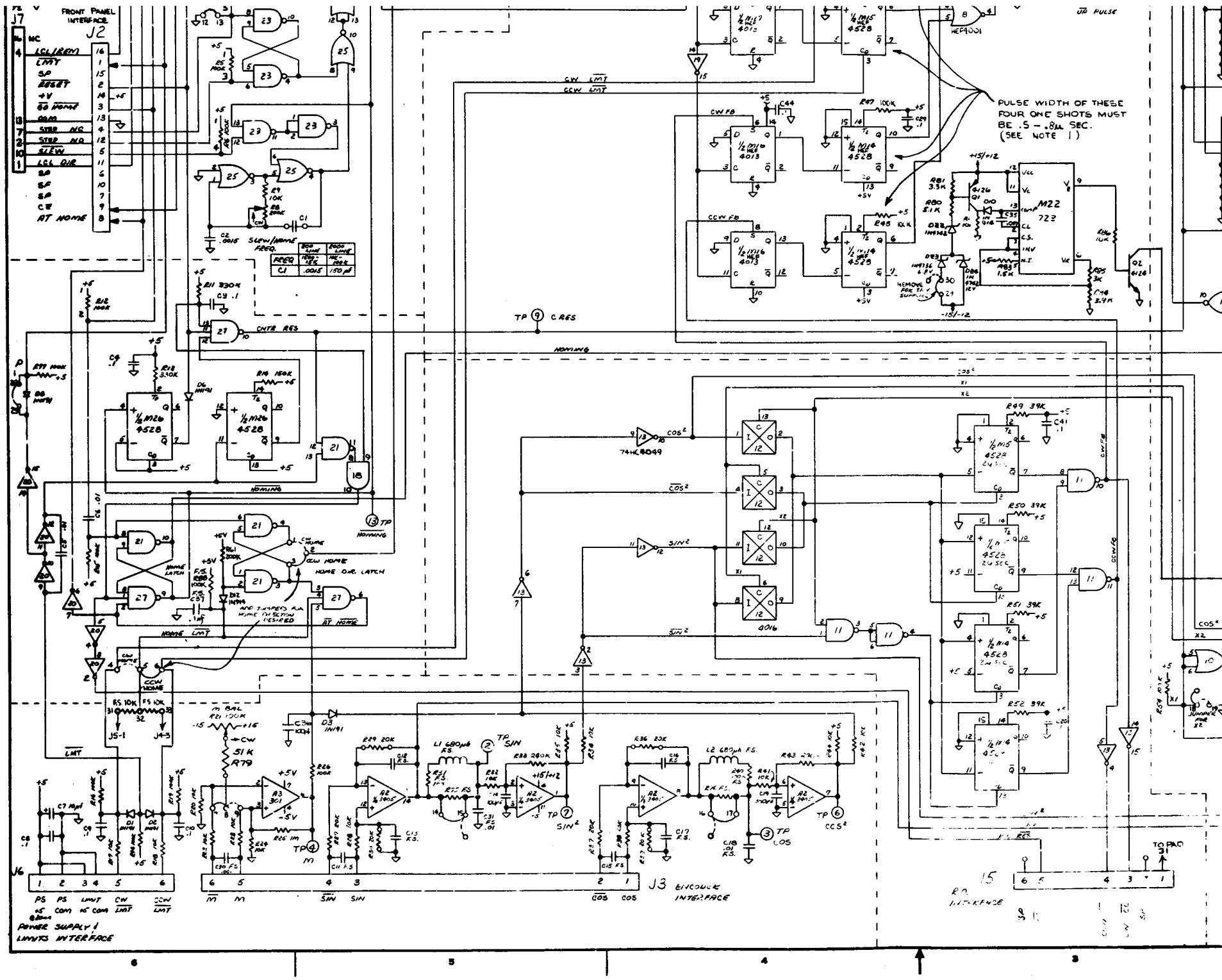
* DO NOT SUB. BUFFERED TYPE

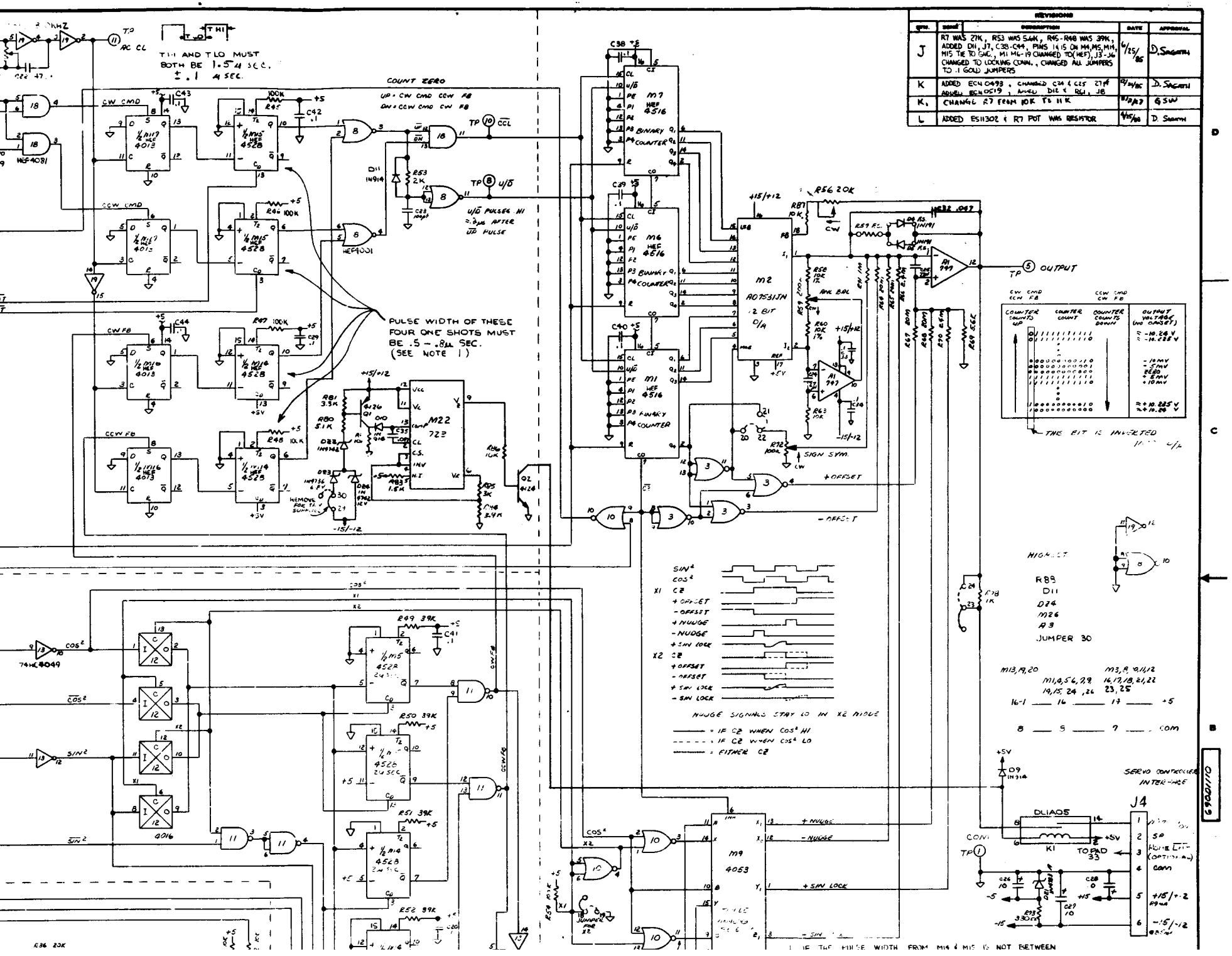
NOTE: INSERT WIRE-WRAP PIN IN ALL (15) TEST POINTS. (PARTS LIST ITEM 169) INSERT PIN'S FROM FOIL SIDE OF P.C. BOARD.

REVISIONS				
SYM.	ZONE	DESCRIPTION	DATE	APPROVAL
A		PER ECN 0113	1/1/79	TJM
B		ADDED D7,D8,R77. A3 WAS 741 POWER TO A3 WAS ±15V, D3 WAS F.S.	3/20/79	TJM
C		ADDED R78 & 79, 59 [illegible] ERS 23,24,25, & 26. CHANGED R7 [illegible] R11 TO 390K & R66 [illegible] D8 TO F.S CHANGED JUMPERS 2,3,5,&6	6/18/79	[illegible]
D		ADDED D22-D24,C35, R80-86, K1, N 22,Q1, Q2, D9, D10. R1-6,12 IN RESISTOR SIP. CHANGED R78 TO 1K, C14 & 19 TO 100pf, R33 43 TO 240K, R77 TO 100K, D7 & TO 1N191 ECN0140 & 0142	4/1/80	T.J.D
E		NO CHANGE THIS SHEET ECN 0172	11/17/80	T.J.D.
F		ADDED C36, R56 WAS A 10K RES. PER ECN 0207 & 0213	11/16/81	T.J.D.
G		ADDED R87-10K RES. C26, C27 & C28 WERE .1 µF. ECN 0336/0338	7/7/83	DJS
H		ADDED R88, C37, JUMPERS 31-33 ES11161	1/30/84	JAC
I		ECN 0386 0389	4/30/84	JAC
J		R7 WAS 27K, R53 WAS 5.6K, R45-48 WAS 39K, ADDED D11, J7, C38-C44, PINS 14 15 ON M4,5,14,15 TIE TO GND, M1, M6-19 CHANGED TO (HEF), J3-J6 CHANGED TO LOCKING CONN., CHANGED ALL JUMPERS TO .1 GOLD JUMPERS	6/25/85	D. Sagarth
K		ADDED ECN 0493 0520 ECN0519 CHANGED ALL POTS ADDED D12 & R61 J8	12/31/86	D. Sagarth
K1		CHANGE R7 FROM 10K TO 11K	4/3/87	GSW
L		ADDED ES11302, R7 25K POT WAS 11K RES	4/25/88	D. Sagarth

1) IF THE PULSE WIDTH FROM M14 & M15 IS NOT BETWEEN .5 & .8 USEC, CHANGE R45-R46 TO INSURE .5 TO .8 USEC

690D1110


FRONT PANEL INTERFACE
J2
J7
LCL JRNY
LMT
SP
RESET
+V
GO HOME
STEP N/C
STEP N/O
SLEW
LCL DIR
AT HOME
PULSE WIDTH OF THESE FOUR ONE SHOTS MUST BE .5 - .8μ SEC. (SEE NOTE 1)
CW LMT
CCW LMT
CW FB
CCW FB
HOMING
CNTR REG
TP 9 C REG
74HC4049
4016
HOME LATCH
HOME DIR. LATCH
CW HOME
CCW HOME
AT HOME
HOME LMT
SLEW/HOME FREQ.
J5-1
J4-3
J6
POWER SUPPLY / LIMITS INTERFACE
J3 ENCODER INTERFACE
TO PAD 31
TP SIN
TP COS
TP M
TP SIN²
TP COS²
M22 723



REVISIONS				
QTR.	ZONE	DESCRIPTION	DATE	APPROVAL
J		R7 WAS 27K, R53 WAS 5.6K, R45-R48 WAS 39K, ADDED D11, J7, C38-C44, PINS 14 & 15 ON M4, M5, M14, M15 TIE TO GND., M1 M6-19 CHANGED TO (HEF), J3-J6 CHANGED TO LOCKING CONN., CHANGED ALL JUMPERS TO .1 GOLD JUMPERS	6/25/85	D. SMITH
K		ADDED ECN 0498, CHANGED C24 & C25 27pF ADDED ECN 0519, ADDED D12 & R64, J8	10/24/86	D. SMITH
K1		CHANGE R7 FROM 10K TO 11K	8/18/87	G SW
L		ADDED ES11302 & R7 POT WAS RESISTOR	4/15/88	D. SMITH