OPERATOR'S MANUAL
FOR THE
4005/4006 STEPPING
MOTOR TRANSLATOR

PN: EDA108

AEROTECH, INC., 101 Zeta Drive, Pittsburgh, PA 15238
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May, 1987

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ADDENDUM NOTICE FOR REV. D AND ABOVE 630-1052 MODULE ASSEMBLIES:

J1 was a 6 pin connector and is now a 10 pin connector. The same pin numbers are now used, except pin 6 (low/high current command) is now pin 7. Pin 6 is now a keying pin.

For other pin-out information, see the system print or drawing 630D1052 Rev. D and above.

CHAPTER 1: INTRODUCTION

SECTION 1-1 GENERAL DESCRIPTION

The Aerotech Model 4005 (40 volt, 5 amp/phase) stepping motor drive was designed to drive 2, 3 and 4 inch frame size, 4 phase bidirectional stepping motors. The module contains a power supply, power amplifier, sequencing logic to convert input pulses directly to step information, a front end incorporating an internal clock generator to provide slew and step capability, and logic for incorporation of limit switches.

Total CMOS logic operating at 5 or 12 volts provides excellent noise immunity. The unipolar chopper drive, operating from 40V, commands rapid motor current response for high stepping rates while maintaining unequaled efficiency. A unique switching technique provides efficient, adjustable, high voltage suppression for the fast current decay required in high stepping rate applications. No external resistors or components are required for operation; simply add a 115 or 230 VAC supply, clock and direction or slew and step commands, and the motor.

SECTION 1-2 FRONT END

The front end incorporates an internal oscillator and a single pulse debounce latch to generate a local clock for the sequencer.

There is also a local direction input. Either these local clock and direction signals or another clock-direction pair, called remote clock and direction, can be selected for routing to the sequencer by applying the appropriate logic level to the "LCL/REM" input at J2-16. The front end also has limits logic circuitry that can accept signals from a limit switch assembly. Once a limit switch is closed, clock signals driving the motor further into the limit are inhibited, but changing direction removes the inhibit from the clock signal so that the motor can move back from the limit.

SECTION 1-3 SEQUENCER

The sequencing logic is capable of operation in the two-phase-on, one-phase-on, full-step or half-step sequence; selection is accomplished by logic commands. The adjustable output current can be reduced (to approximately 60% of the set value) by a logic command, permitting reduced power levels when desired.

SECTION 1-4 POWER SUPPLY

The fused, isolated, internal power supply operates from 115 or 230 VAC and provides all necessary operating voltages in addition to regulated +5 VDC (+12 VDC option) and unregulated ±40 VDC for external use.

SECTION 1-5 SYSTEM CAPABILITY

The module mates with the optional Front Panel Switch Assembly, or can mate to either the 10KR, Model 10D or 20D Indexer, or the Parallel Incremental Card.

CHAPTER 2: SPECIFICATIONS

SECTION 2-1 MAXIMUM RATINGS

Peak Output Voltage	40 Volts
Continuous Output Current	5 amps/phase
Operating Temperature	0 to 50 C
Storage Temperature	-30 C to 85 C
AC Line Voltage	125/250 VAC depending on transformer connections

SECTION 2-2 MECHANICAL CHARACTERISTICS

Weight	14 lbs.
Dimensions	6.2" wide x 7.5" long x 6" high
Mounting dimensions	5 1/2" x 3 5/8"
Mounting screws	1/4-20, 3/8" maximum depth into baseplate.

SECTION 2-3 ELECTRICAL CHARACTERISTICS

Input Power	100-125 VAC, 200-250 VAC; 50-60 HZ
Output Power	
Maximum @ 5A/0	270 Watts
Continuous	160 Watts
Switching Frequency, constant	5KHz; 16KHz (Ultrasonic Option)
External Factor (2.5mH load)	1.005

External Supply Availability	
+40 VDC Unregulated	.5 amps
-40 VDC Unregulated	.1 amps
+5 VDC Regulated	.05 amps
Internal Clock Frequency	100-1000 Steps/sec
Input Clock Frequency	0 to 20 KHz
Input Impedance: Clock, Full/ Half, one/two, step, slew LCL/Rem, Direction, LO I and Limits	0.1 M
Input Signal Levels	0 to +5V or +12V, depending on logic power setup
Minimum Clock Pulse Width (Clock occurs on positive going edge)	2 uS
Minimum time for Clock at 0 level	2 uS
Minimum time between clock Leading edge and DIR Transition	± 600 nS

Heatsink Temperature Rise above ambient, C	HORIZONTAL	VERTICAL	FAN COOLED (100CFM)
5 amp output	60	40	10
3 amp output (J1-6 Open)	40	30	5

CHAPTER 3: INSTALLATION AND OPERATION

SECTION 3-1 CONTROL HOOK UP CONSIDERATIONS

The 4005 stepping motor drive can be operated in local mode from switches or in remote mode from external clock and direction. It has an internal clock generator to operate manually at start/stop speeds with only a few external switches. For automated or high speed use, the 4005 can be run from external clock and direction inputs. Accordingly, the inputs required for using the 4005 by itself are grouped on J2, and the inputs required for use wth external clock and direction are grouped on J1. It is also possible to switch from one mode to another without rewiring since a logic input called local/remote has been included in the unit.

A. INPUT ELECTRICAL CHARACTERISTICS

Most inputs to the module are standard CMOS inputs with 100K input pull-up resistors to the logic supply (+V). Leaving an input open is equivalent to putting a "1" level on the input. Grounding the input is equivalent to a "0" level. One input on J2-7, one/two phase on, has a 1K input pull-down resistor to ground. Leaving this input open is equivalent to putting a "0" level on that input, and a logic "1" level or V+ is needed for a input high state. J1-3 remote clock has a 100K pull-down resistor to ground.

B. LOCAL/REMOTE MODE

The local/remote mode is the key to the flexibility of the 4005. When a logic "1" is present at J2-16 (LCL/RMT), the signal from the local clock generator is routed to the sequencer which generates the sequence of drive signals for each winding of the motor. Also the DIR (direction) input at J2-11 is routed to the sequencer. When a logic "0" is present at J2-16, the signals from the internal clock generator and J2-11 (DIR) are ignored, while the signals on J1-3 (remote clock) and J1-4 (remote direction) are the ones that are routed to the sequencer. If the

unit is to be run only from remote clock and direction inputs, provision for jumpering the LCL/REM input to ground has been provided. Inserting a jumper between points 3 and 4 will lock the unit in remote mode.

C. LOCAL MODE OPERATION

If the 4005 is to be operated by itself, it should be placed in local mode by letting J2-16 go high. This will allow the local direction input and the local clock generator to input to the sequencer. The local clock generator consists of two parts; a single step debounce latch requiring two inputs. These inputs, called NO (normally open) on J2-12 and NC (normally closed) on J2-4, are meant to be connected to the normally open and normally closed contacts of an SPDT momentary action pushbutton. The moving contact of the pushbutton should be connected to ground (J2-13). Pressing and releasing the pushbutton will send just one clock pulse to the sequencer and the motor will advance one step. The slew oscillator has one input at J2-5. Grounding this input will turn this oscillator on and a constant frequency pulse train will be sent on the sequencer. Also, in local mode, the DIR input at J2-11 is routed to the sequencer.

D. REMOTE MODE OPERATION

If the unit is to be operated in the remote mode, either J2-16 should be grounded or a jumper should be inserted at points 3 and 4. When this is done, the local clock generator is isolated from the rest of the unit and the local direction input J2-11 is ignored. Instead J1-3 remote clock, and J1-4 remote direction, are patched to the sequencer. The inputs on J2 other than the step inputs, slew, and direction are still effective.

The Remote input jack J1 has been designed to interface completely to Aerotech clock and direction generating modules, such as the 10KR high speed ramper, or the Parallel Incremental Stepping Motor Card. The 4005 sends +40V and ground to these modules for module power on J1-1 and J1-2, respectively. J1-5 is an input for the Reset signal that is routed to the accessory readout (see section 3-1F for further description of the readout connections). J1-6 is LO/HI current (see section 3-1G). It is on this jack since it is usually generated in the same equipment that generates the clock and direction signals.

E. LIMITS

The 4005 can restrict the range of travel of the load the motor is driving. The limit circuitry prevents the motor from advancing beyond a point sensed by an external limit switch or external limit sensing logic.

The limits logic circuit of the 4005 has two inputs; CW LMT and CCW LMT (clockwise limit lo and counterclockwise limit lo) on TB1-13 and 14 respectively. These inputs are meant to be connected to normally open switches that close to ground when a limit is reached, but logic signals can also be used ("0" = limit reached). Since a logic "1" on the DIR input to the sequencer is taken to mean clockwise rotation of the motor, CW LMT input is effective when the DIR input to the sequencer is a "1".

When a limit input is said to be effective, it means that a "LO" level on it will cause the clock input to the sequencer to be interrupted. If the DIR signal to the sequencer changes while the clock is interrupted by one of the limit inputs, that change will make the limit input no longer effective, and the clock signal to the sequencer will no longer be interrupted.

For example, the DIR input is a "1" and the motor is turning clockwise. The CW LMT limit switch is activated and CW LMT goes low, interrupting the clock and stopping the motor. The operator changes directions, the CW LMT input is now no longer effective, and the clock input is no longer interrupted. The motor begins to turn counterclockwise and the CW limit switch now opens. Once the CW limit switch opens it is then again possible to operate the motor in the clockwise direction.

If limits are not needed, the inputs can be left open.

F. READOUT

If it is desired to know the number of steps the motor has moved from a reference point, an external readout can be used. J3 of the 4005 contains three signal outputs that can be sent to the external readout. They are Reset on J3-5 clock on J3-3 and DIR on J3-4. Clock and DIR are the signals that go to the sequencer, whatever mode the unit is in. The Reset signal is not used by the 4005. It can be brought in from a switch or other piece of equipment on J2-2 or J1-5. If there is no connection on either of these points J2-7 will go to a "1".

G. LO/HI CURRENT

The 4005 has an adjustment called "current adjust" (see chapter 4). This sends the current through the windings of the motor. This current would flow while the motor is not stepping, causing heat and wasting energy. To reduce the current flowing through the motor, an input has been provided called LO/HI current on J1-6. When J1-7 is a "0" the current through the motor is constrained to the level set by the "current adjust". When J1-7 is a "1" the current limit is reduced to approximately 50% of its set value.

Since leaving this input open puts a "1" on the input, this input should be grounded if this feature is not to be used. The Aerotech 10KR, 10D, 20D, and PISM cards have a signal output called CZ, designed to attach to this input which will reduce the motor current about 20mS after the motor stops stepping.

H. SEQUENCER INPUTS

J2 also has full/half step control on J2-6 and one/two phase on control at J2-7. They go directly to the sequencer and affect the sequence of the individual winding on commands. A logic "1" on J2-6 causes the motor shaft to turn through a 1.8 degree step angle with each clock pulse. If a logic "0" is present at J2-6, the motor moves through a 0.9 degree step angle with each clock pulse. Leaving J2-6 open causes a logic "1" to be present and full step operation will occur.

The other sequencer input on J2-7, one/two phase on, only has an effect in full-step mode. In the full-step mode, there are two windings of the motor on at any instant. However, a stepping motor can be operated in full-step mode with only one winding on at any instant. This reduces current consumption, but it also reduces motor torque, and makes the motor more susceptible to drop-out. A "1" on J2-7 causes the unit to operate in one-phase-on mode. No connection causes a "0" to be present and the unit will run in 2-phase-on mode.

I. AEROTECH FRONT PANEL SWITCH ASSEMBLY

The Aerotech front panel switch assembly C690-1056 is a useful accessory for the 4005 when it is used in the local mode. It's use greatly simplifies the wiring of the switches for local mode operation. S1 (momentary action) connects correctly to the step NO and NC inputs. S2 (alternate action) connects to the DIR input. S3

(momentary action) connects to the slew input. S4 (momentary action) connects to the reset input. S5 (alternate action) switches the outputs of the switch assembly between two output jacks for X-Y systems. S6 (alternate action) will provide the switching function needed for the LCL/REM command, provided pin 16 of the output jack used is jumpered to either terminal A or B of S6. S7 is meant to be used with other Aerotech equipment. S8 (alternate action) connects to the full/half step input. All these connections (except LCL/REM) are made between the switch assembly and the 4005 and are made at one time with a 16 conductor ribbon cable and two press-on DIP plugs.

The 4005 input "one/two phase on" is not connected to the switch assembly but most users will leave this input unconnected. All switches are mounted on a common frame and the assembly requires one rectangular cutout and two screw holes for panel mounting.

SECTION 3-2 OTHER HOOK UP CONSIDERATIONS

A. 5V/12V LOGIC LEVEL SELECTION

The 4005 comes standard with a logic supply level of +5V, allowing it to interface with TTL logic levels. However, logic operation at 12V is possible. To convert the 4005 to 12V logic, the printed circuit trace between jumper points 6 and 7 must be cut and a jumper inserted between points 5 and 6.

B. MOTOR CONNECTION

Connection terminals for the motor are on TB1. The four phases are connected as:

OA to TB1-9
OB to TB1-10
OC to TB1-11
OD to TB1-12

The two power leads are connected at TB1-7 and TB1-8, which connect through fuses to the +40 supply. Since the coding of motor connections is not standardized, figure 1, a timing diagram of the sequence that the outputs follow, can be found in the appendix. This can be compared to the motor spec. sheet to determine the correct wiring of the motor.

C. AC POWER INPUT

Power requirement is less than 2 amp, 115V AC or 1 amp, 230 VAC. A 50/60 Hz source must be used for the fan. If a fan cooled unit is not required (discuss application with the factory), a 50 to 400 Hz source may be used. Line voltages may vary +10 - 15%. AC power is connected to TB1-1 and -2, figure 2. AC HI should be connected to TB1-1, the fused input. If operation from 230 VAC is desired see schematic note 1.

D. SUPPLIES AVAILABLE FOR EXTERNAL USE

The 4005 furnishes DC power for external use. The logic supply @ 20 mA is available at J2-14. +40 VDC unregulated at 0.5 amp is available at J1-1 and TB1-4. -40VDC at 100 mA is available at TB1-5. +5V or +12V at 30 mA is available at TB1-6 (see section 3-2A).

SECTION 3-3 ADJUSTMENTS

A. MOTOR CURRENT - 4005

Motor current can be adjusted by removing fuse F2 or F3 and replacing it with a DC ammeter, positive lead on clip at edge of board. Connect

the motor per section 3-2B and turn R39 full CW (minimum current position). Connect J1-7 to ground. Apply AC power and adjust R39 for the desired (motor not stepping) current. Remove AC power, the ground from J1-7, and replace the fuse.

B. SUPPRESSION VOLTAGE - 4005

This adjustment has been made at the factory and should not require further adjustment. Any change in this voltage will require motor current re-adjustment. Connect an oscilloscope between GND on TB1-3 and a cathode of D1 to D4. Adjust R20 (CW decreases voltage) so that the peaks of the voltage are less than 80 volts. This voltage may be decreased to any value from 40 to 80V.

C. INTERNAL CLOCK FREQUENCY

The internal clock frequency can be adjusted by grounding J2-5 and observing the frequency at terminal post 2 (TP2). Adjustment is made at R8. If a step rate higher than the maximum attainable from adjusting R8 is desired, R7 can be removed and a lower value substituted.

D. LO I CURRENT LEVEL ADJUSTMENT

Normally a LO I command reduces the current level by about 50%. If a different percentage reduction is desired, R38 can be changed to a different value. Set the current limit as per section 3-3A, but maintain AC power and leave the ammeter connected. Now remove the ground from J1-7 and observe the current. If this LO I current level is too high, insert a larger value resistor in place of R38; if too low, a smaller value. Remove AC power and replace fuse.

CHAPTER 4: MAINTENANCE

SECTION 4-1 PERIODIC MAINTENANCE

The 4005 requires no periodic maintenance. The adjustments of section 3-3 may be performed periodically if the adjusted values are critical to its use. If operated in a dirty environment, the PC card and heat sink should be kept clean enough to see what color is under the dirt. Electricity conductive dirt (metal chips, etc.) should be kept away from the unit.

SECTION 4-2 TROUBLESHOOTING

Field reports have shown that the majority of problems associated with the 4005 were problems caused by other components in the system in which it was used. If a problem with the 4005 is suspected, the 4005 should be first checked to verify that it is defective. The 4005 should be placed in local mode, and given a slew command. If connected, the limit inputs should be disconnected. The motor should step. If the motor does not step correctly, the continuity of the windings should be checked.

To test the integrity of each of the four-phase output stages, the unit should be placed in local mode and single stepped. The timing diagram in the appendix should be consulted to verify that the proper sequence of phase on commands is being generated and the voltage to ground of the outputs should be as shown in figure 1, appendix.

Since the four output transistors Q1 - Q4 are vulnerable to an incorrect connection or a shorted motor winding, they account for the majority of field failures. When they fail, they fail by shorting collector to emitter. This shorts a motor winding to ground, and blows a fuse. An ohmmeter can be used to check for shorted output transistors. First remove AC power and motor connections and connect the negative lead of the ohmmeter to ground. Touch the positive lead successively to TB1-9, 10, 11 and 12. If the meter indicates a short, the transistor associated with that output should be replaced. When replacing

transistors, be sure to use the insulator between the transistor and the heatsink. Verify the transistor and heatsink have no electrical continuity between them by using an ohmmeter set for the highest range.

Warranty and Field Service Policy

Aerotech, Inc., warrants its products to be free from defects caused by faulty materials or poor workmanship for a period of one year from date of shipment from Aerotech. Seller's liability is limited to replacing, repairing or issuing credit, as its option, for any products which are returned by the original purchaser during the one-year period. Seller 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 seller in specifications or drawings previously or subsequently provided seller, and whether or not seller's products are specifically designed and/or manufactured by seller 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.

RETURNING GOODS PROCEDURE

Claims for incorrect or defective materials must be filed within thirty (30) days from delivery at buyer's place of business. No units or systems may be returned, in or out of warranty, without first obtaining approval from the seller, and no claim will be allowed nor credit given for units or systems returned without such approval.

RETURNED GOODS WARRANTY DETERMINATION

If possible, after approval from Aerotech, the defective unit or system is to be returned to the factory with statement of problem and transportation prepaid (no c.o.d. or collect freight shipments will be accepted). After Aerotech's in-plant examination, warranty or out-of-warranty status will be determined. If upon Aerotech's examination of such unit or system, warrantied defects exist, then the unit or system will be repaired at no charge and shipped, prepaid, back to the buyer. If an out-of-warranty situation exists, the buyer shall be notified of the repair cost immediately. At such time, the buyer must issue a purchase order to cover the cost of the repair or authorize the unit or system to be shipped back as is, at the buyer's expense.

ON-SITE WARRANTY REPAIR

If the system or unit cannot be made functional by telephone assistance or by sending and having customer install replacement parts, and cannot be returned to the Aerotech factory for repair, and if it is determined that 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 bona-fide purchase order to Aerotech covering all transportation and subsistence costs, regardless of warranty determination. If the Aerotech field service representative determines during his on-site repair that the system or unit's problem is not warranty-related, then the prevailing service charge per hour (eight-hour minimum) shall be assessed against the issued purchase order.

NON-WARRANTY FIELD SERVICE

If system or unit cannot be made functional by no-charge telephone assistance or purchased replacement parts, and cannot be returned to the Aerotech factory 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 bona-fide purchase order to Aerotech covering all transportation and subsistence costs and the prevailing cost per hour (eight-hour minimum) including travel time necessary to complete the repair.

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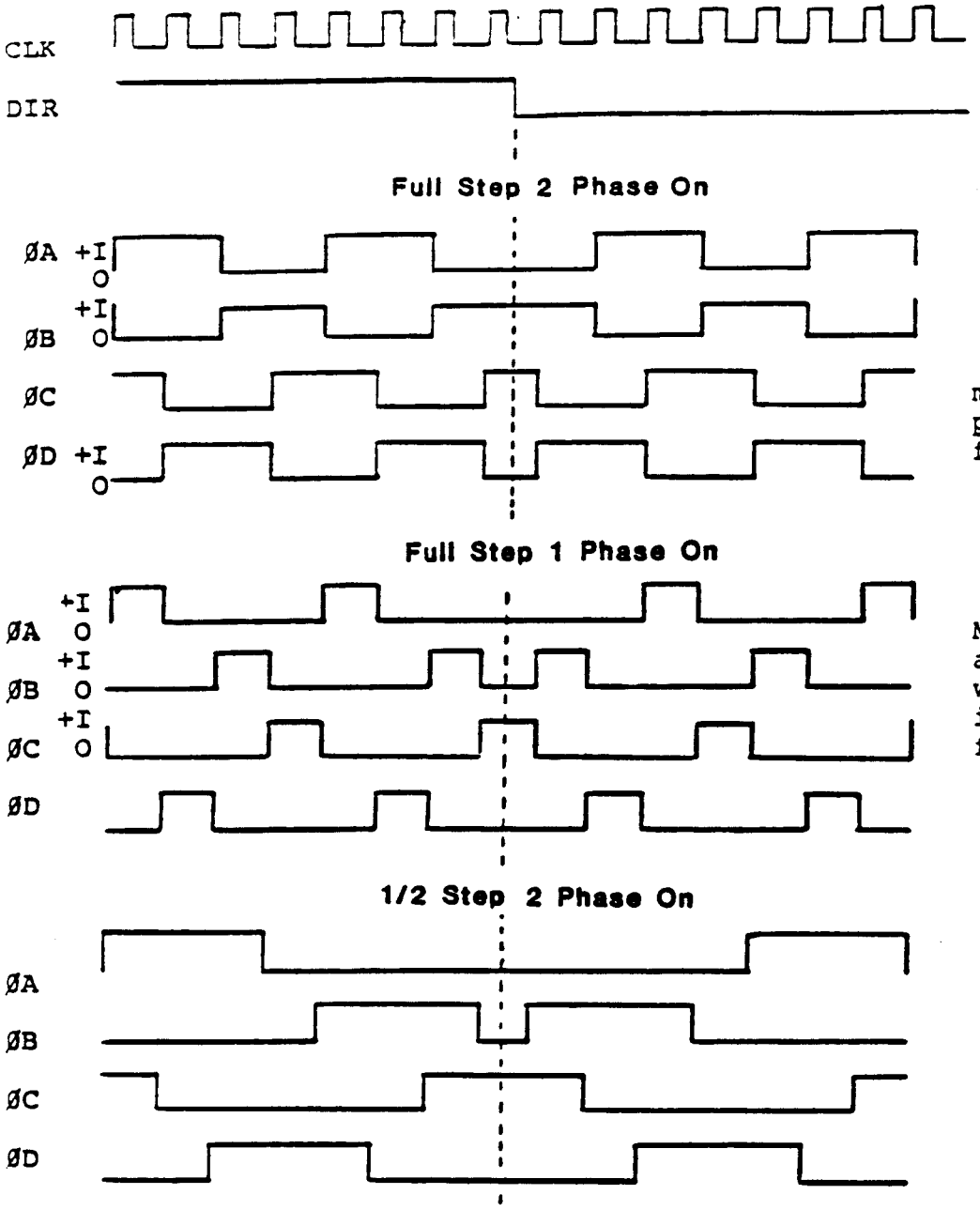
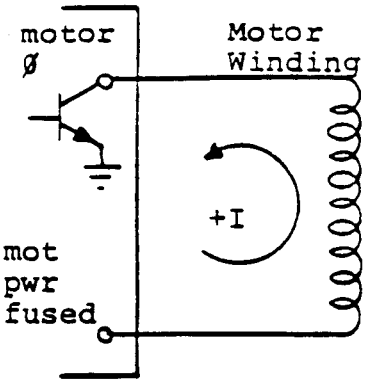
Fig. 1: Nominal Current Timing Diagram-4005

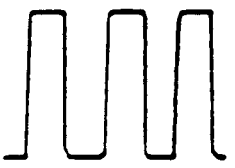




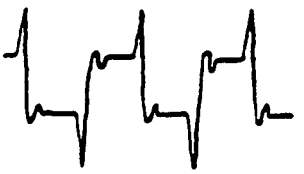
Motor and terminals are current sinks when on; source is Motor Power fused terminal.

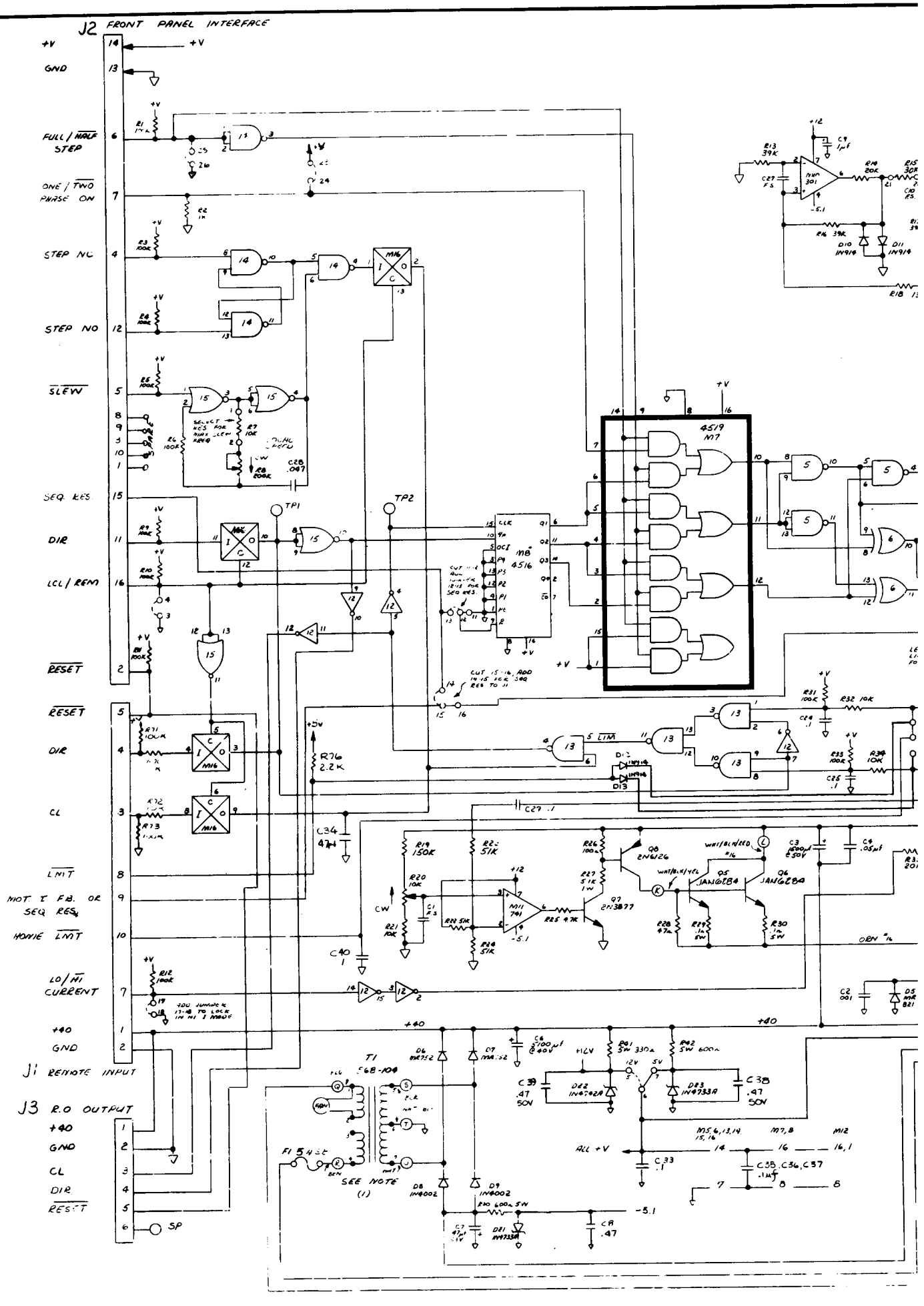
Fig. 1: Output Waveforms

When motor is not stepping, the outputs that are "ON" look like this.

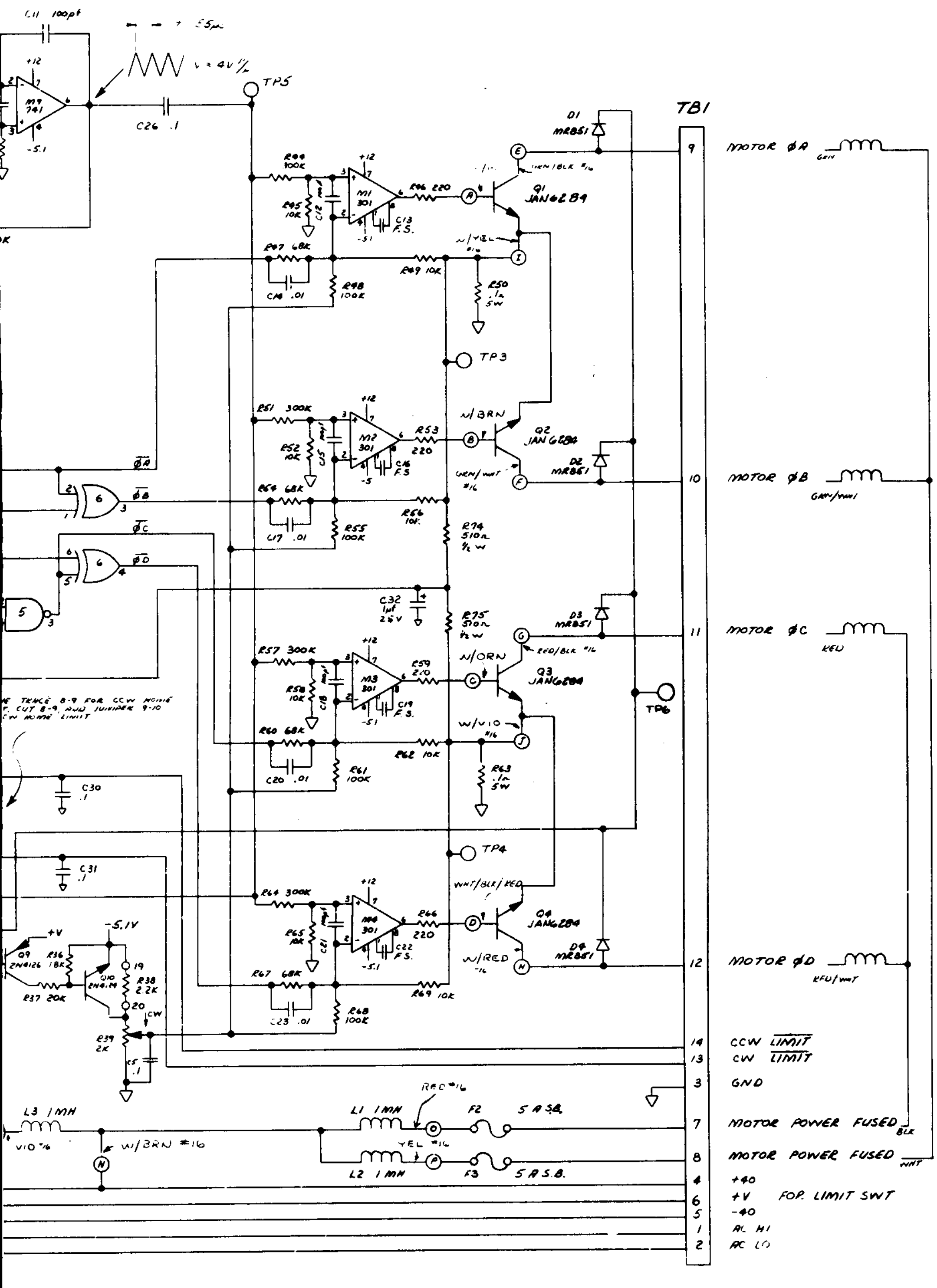


The "OFF" outputs look like this.




J2 FRONT PANEL INTERFACE
+V
GND
FULL / HALF STEP
ONE / TWO PHASE ON
STEP NC
STEP NO
SLEW
SEQ. RES.
DIR
LCL / REM
RESET
RESET
DIR
CL
LMIT
MOT I FB. OR SEQ RES
HOMIE LMT
LO / HI CURRENT
+40
GND
J1 REMOTE INPUT
J3 R.O OUTPUT
+40
GND
CL
DIR
RESET
SP
4519
4516
TP1
TP2
+5v
-5.1
+40
+12V
5V
T1
568-104
SEE NOTE (1)
ALL +V

REVISIONS				
SYM.	ZONE	DESCRIPTION	DATE	APPROVAL
A		C28 WAS .1, R36 WAS 1K, R41 WAS 600Ω, R15 WAS 33K, ADDED C29, BRN/WHT WAS BLU/WHT, VIOLET/WHT WAS YEL/WHT, WHT/BLK RED WAS BRN/WHT.	9/19/77	TMM
B		NO CHANGE THIS SHEET	10/10/77	TMM
C		WIRE AT Q5 PIN K WAS WHT/GRN WIRE AT Q6 PIN L WAS WHT/GRN	3/15/78	DJS
D		ADDED J3, J1 WAS 6 PIN CONNECTOR, ADDED MOT. I F.B, HOME LIMIT & SEQ. BFS	[illegible]	TMM
E		ADDED TP6	7·11·79	T.J.D.
F		MADE R70 & R72 1K, WERE [illegible] [illegible] R71 NOW 100K [illegible] [illegible] R71 CONN. TO J1-4 [illegible] J1-3 SIDE OF R72, ADDED D12, 13 ECN0196 0154, U29	3/10/80	T.J.D.
G		ADDED C34 & R76, PER ECN 0309, 0316	3/1/83	TJD
H		ADDED C35 - C37 PER ECN 0329	5/11/83	JC
I		CHANGED VALUE OF Q1-Q6, F1, C8 ADDED C38 - C40 · ECN 0344	3/30/84	JAC
J		ADDED PADS 23-26	5/28/84	JAC
K		CHANGED VALUE R15	1/6/85	JAC



NOTE 1) FOR 115 V OPERATION JUMPER 1-2, 3-4
FOR 230V OPERATION JUMPER 2-3
FOR 230V OPERATION CHANGE F1 to 3A SB
2) FOR PC BOARD INFORMATION SEE 690-1074
3) PARTS NOT MOUNTED ON PC BOARD Q1-6, L1,2,3, T1, R28, 29, 30.

LAST R NUMBER - R76
LAST C NUMBER - C40
LAST Q NUMBER - Q10
LAST M NUMBER - M6
LAST D NUMBER - D13
LAST DZ NUMBER - DZ3
LAST L NUMBER - L3

DASH NO	NEXT ASSY	USED ON	NEXT ASSY	FINAL ASSY
APPLICATION			QTY REQD	

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MATERIAL	☐ STEEL ☐ ALUM ☐ CRES ☐ SEE L/M OR P/L	☐ CASTING ☐ TUBING ☐ STRUCT ☐ SEE NOTE
FINISH	☐ BLACK OXIDE ☐ BLACK ANODIZE ☐ ALODINE	☐ CLEAR ANODIZE ☐ ☐ SEE NOTE
PAINT	DO NOT PAINT SURFACES MARKED ▼ PER AEROTECH SPEC OR PER	

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TOLERANCES ON: FRACTIONS 0 TO 6 ± 1/32, 6 AND UP ± 1/16; DECIMALS .XX ± .01, .XXX ± .005; ANGLES ± 0°-30'

RMS FINISH	✓	EXCEPT AS NOTED
DRAWN	TMM	4/27/77
CHECKED	[illegible]	4/14/77
DESIGN		
ENGRG	RBP	4/14/77
PROD		
Q.A.		
APPD		

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101 Zeta Drive Pittsburgh, Pa 15238 412 963-7470

(REVISION "D" AND ABOVE)
4005 D STEPPING MOTOR DRIVE

CODE IDENT. NO.	SIZE	
9B	D	630D1052
SCALE N A	WT	SHEET