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GENERAL DESCRIPTION

The Model 5310/5410 microstepping motor drive module is a high efficiency bipolar chopper utilizing Pulse Width Modulation to electronically control the motor winding currents. The drive accepts step pulse, direction, and current control inputs, and supplies the correct outputs for driving two-phase stepping motors. The three logic signal inputs are optically isolated.

The 5310/5410 supplies regulated phase currents form supply voltages between 18 and 75 Vdc. The power stages are protected against overheating and phase-to-phase and phase to ground short circuits. The presence of a short circuit is indicated by an illuminated LED and an output logic signal. The short circuit detector clears automatically when the fault is cleared.

An Idle Current Reduction (ICR) feature allows motor winding currents to be automatically reduced by 50% during motor standstill periods. ICR begins one second after the last input step pulse occurs, and may be enabled or disabled by the user by a circuit board jumper. One logic input has been provided to allow the user to program output current levels to the motor. The programmable current levels available are 0 and rated. Due to sine/cosine current excitation in the microstepping mode, the actual RMS current level while microstepping (1/2, 1/5, 1/25, and 1/125 step) is 70% of the full step rated current. The microstep current boost feature allows the motor microstep current to be boosted 1.4 times at step rates above 500 full steps per second. Boosting the 70% rated current by a factor of 1.4 brings winding current back to rated levels. The current boost feature is switch selectable.

The 5310/5410 drive module has additional circuitry to eliminate midrange frequency instability. Midrange instability can be explained as a region of potential instability that occurs as a result of the electronic, magnetic, and mechanical characteristics of any stepping motor system. The circuitry used to control this phenomenon does so by advancing or delaying the switching of the output transistors with respect to the incoming pulse train. This should be taken into account if the user is attempting to employ pulse placement techniques. The midrange stability feature can be enabled or disabled by the user with a circuit board jumper.

The driver retains the high efficiency and excellent stepping motor characteristics of a chopper in a small rugged package. The use of high speed MOSFET power devices, allows the chopping frequency to be set to approximately 20 kHz, eliminating the audible noise.

The 5310/5410 Bipolar Drive Module is also packaged with power supplies in the model 5430 drive package and in a completely integrated package with an indexer and power supplies in the model 5445 indexer/drive package.

SPECIFICATIONS

Model :	5310/5410	
Circuit Type:	Two-phase bipolar, chopper current regulated.	
Driver Voltage Input (Voltage Per Phase To Motor):	18-75 Vdc	
Rated Driver Current (Motor Phase Current)	<u>5310</u>	<u>5410</u>
Full Step :	2.5 +/- .1 Amp	5.0 +/- .1 Amp
Microstep :	1.75 +/- .1 Amp	3.5 +/- .1 Amp
Micro step with current boost on above 500 full steps / sec. :	2.5 +/- .1 Amp	5.0 +/- .1 Amp
ICR Feature:	Idle Current Reduction circuit reduces motor current 50% during motor idle periods. ICR starts one second after last step input pulse prior to motor standstill. ICR is enabled or disabled by S1 position 6. (See Figure 3.)	
External Current Control:	One optically isolated logic signal input allows external motor current selections of 0 and rated current. Optically isolated TTL or open collector with external pull-up resistor required,10 mA minimum sink current. Ref. Fig. 6, Note 7.	
Chopper Frequency:	20 kHz, nominal	
STEP Pulse Input:	Optically isolated TTL, or open collector with external pull-up resistor required, 10 mA minimum sink current. Ref. Fig. 6, Note 7. 1.0 usec minimum pulse duration. Motor will step on the low-to-high transition of the input pulse.	

DIRECTION Input:	Optically isolated TTL, or open collector with external pull-up resistor required, 10 mA minimum sink current. Ref. Fig. 6, Note 7. For standard Sigma wiring (see Appendix).
Microstep Current Boost:	With current boost enabled, driver microstep current is boosted 1.4 times rated microstepping current at step rates above 500 full steps per second. With current boost disabled, driver supplies rated microstep current at all step rates.
Maximum Pulse Rate:	40,000 pulses/second - full-step 80,000 pulses/second - half-step 500,000 pulses/second - 1/5, 1/25 and 1/125 step
Minimum Ramp Time:	50 milliseconds.
Logic Power Input:	12 +/- 5% Vdc, 200 mA, max.
Optoisolator Power Input:	5 to 30 Vdc, 40 mA, max. (Requires external resistor, see Note 2, Figure 6.)
Driver State Generator Transition Delay Relative To Input Step:	(1) With stability control circuit enabled, at pulse frequencies less than 500 full steps per second, delay is less than 500 usec. At frequencies greater than 500 full steps per second, delay is less than 270o of the input pulse period. (2) With stability control circuit disabled, delay is less than 10 usec at all step frequencies.
DIRECTION And STEP Timing:	DIRECTION input must be present 100 usec before and 25 usec after the rising edge of the STEP transition.
Step Size Selection:	Full, half, 1/5, 1/25, 1/125 step via DIP switch. (See Figure 3)

Stability Control Selection:	Stability control enabled or disabled position 5. (See Figure 3.)
Disable LED Indication:	DS1 LED illuminates for internal driver disable conditions (overcurrent, overtemperature, invalid DIP switch setting).
Operating Temperature Range (With convection cooling, unit mounted vertically).	0 to 60 Degrees C ambient air, 0 to 85 degrees C heatsink temperature at transistor mounting surface.
Humidity Range:	0 to 95%, noncondensing.
Storage Temperature Range:	-25o to +100oC.
Module Dimensions :	8.01 x 4.73 x 1.90 in. (DxWxH).
Module Weight:	1.5 lb nominal.
Mounting:	Bottom panel: four 0.181 in. slots on 7.62 in. x 3.33 in. centers.
Power Supply Connector:	Phoenix pluggable screw connector - supplied
Signal Connector:	ITT Cannon DAP-15SAA. Mating connector: ITT Cannon DA-15P with ITT Cannon shell DA110963-2 or equivalents.
Motor Connector:	Phoenix pluggable screw connector - supplied

INSTALLATION INSTRUCTIONS

Initial Inspection

Carefully inspect the shipping carton for any evidence of physical abuse or damage. Report such findings immediately to your receiving department and to the carrier. Pacific Scientific cannot be responsible for transit damage.

Unpack the shipping carton and inspect the unit for damage, cracks, and broken or loose parts. Save the packing materials until functional checks have been completed.

Mounting

- Note -

To avoid ground loops, the 5310/5410 module must be electrically isolated from all electrically grounded mounting surfaces.

The module is mechanically fastened into place by means of four 0.181 in. slots located on 3.33 in. x 7.62 in. centers at the bottom panel. The slots are sized to accept #6 mounting hardware; mounting for convection cooling at high ambient temperature must be in the vertical position. Refer to Figure 2.

Included with each drive module is an electrical isolation kit consisting of a thermally conducting plastic sheet to be inserted between the module and the mounting surface. Also included in the isolation kit are four nylon shoulder washers sized for #6 mounting screws or threaded studs. The shoulder washers are to be installed at the drive module's mounting slots.

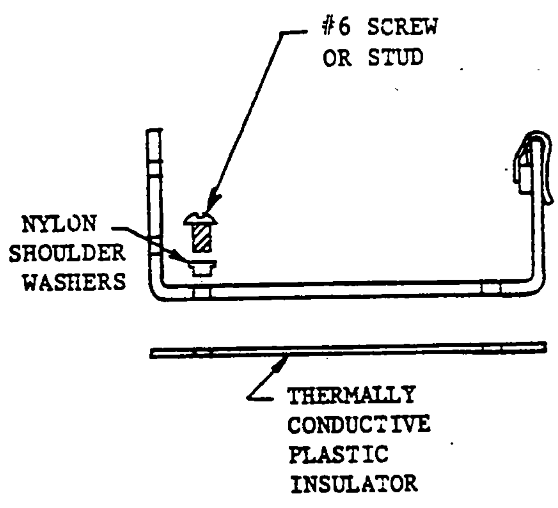


Figure 1
Electrical Isolation Kit

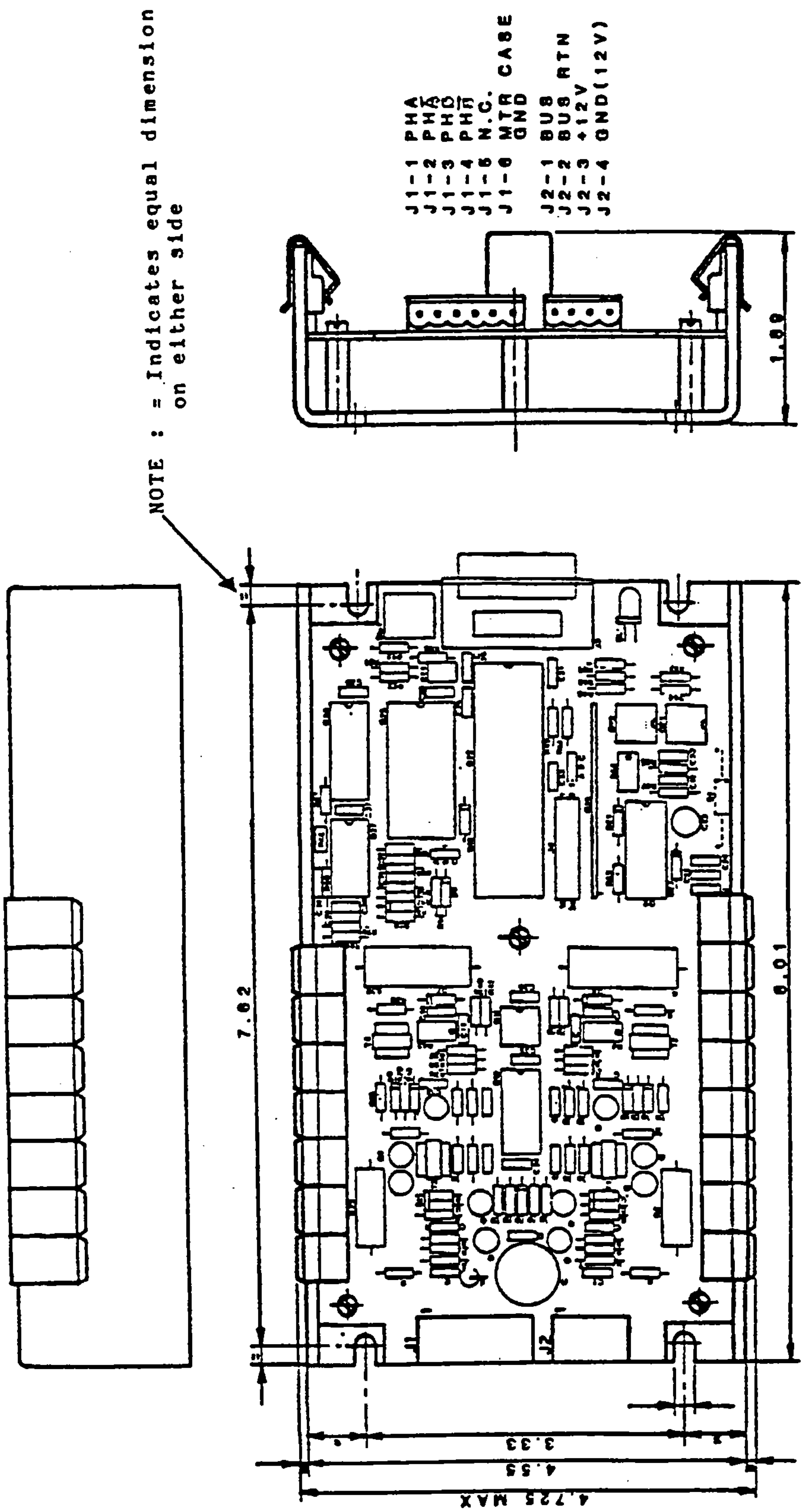


FIGURE 2

MECHANICAL OUTLINE AND MOUNTING DIMENSIONS

Electrical Connections

> \- Note -
> See the Signal Descriptions section of this manual for a description of the electrical signals appearing at each drive module connector. Refer to figure 3 for connector locations.

1. Motor Connections J1. Output currents to the motor phase windings are via a 6-circuit Phoenix type pluggable screw connector. The terminals will accept #14 to #22 AWG. The motor leads for each phase should be twisted together in a tight twist to minimize radiated energy.

2. Power Input Connector J2. Power is input to the module through J2 which is a phoenix type pluggable screw connector. The terminals will accept #14 to #22 gage wire.

3. Signal Connector J3. The 15 pin type "D" signal connector is located at the front of the module as shown in Figure 7. See the Specifications section of this manual for part numbers. The Signal Description section of this manual identifies the signal levels appropriate for the connector and the pinout.

Power Supply Requirements

The 5310/5410 drive requires two power supplies. The power connections are made to the unit through J2 a 4 position pluggable screw terminal connector. Refer to figure 3 for J3 location.

1. A +12 +/- .6 Volt DC regulated logic supply at .3 Amps maximum is required. The logic supply should be well by passed in close proximity to the drive and not exceed the voltage levels given. In a multi axis application utilizing a common 12 volt supply, each drive must be well bypassed with a minimum of 100 uf 25 volt cap paralleled by a .1 uf ceramic cap. It is preferable to run each power connection from supply to drive and not daisy chain power connections. The power supply leads should be twisted.

2. The main motor power supply can vary from +12 to 75 volt maximum at a maximum current of 7.5 amps and does not have to be a regulated supply. The upper limit on the supply can not be exceeded for safe reliable operation. Because of the nature of a PWM chopper drive which requires pulse currents, the inductance of the wiring connecting the external power supply to the module becomes significant. Excessive interconnecting wire inductance could produce large voltage spikes at the power input terminals of the drive module and could cause improper operation of the unit. The supply should be bypassesd by an external capacitor located not more than 2 ft from the drive. The external cap should be rated to handle 5 amps RMS ripple current with a minimum value of 4400 microfarads and a 100 volt rating. It is extremely important not to exceed the maximum supply voltage rating of 75 volts even on a transient basis. The gage wire is determined by the distance from the power supply with a lower gage wire (heaver) with the drive located further from the supply. The minimum recommend wire size is 16 gage. The power supply leads should be twisted to minimize radiated noise.

In order to prevent noise from the motor leads, which due to the switching nature of the drive is high, from being picked up int the power supplies the power supply leads and the motor leads should not be bundled together. Optionally the logic supply leads may be shielded. Internally in the drive the +12 volt supply is connected to the motor power supply, an external connection should not be made as this could cause a ground loop.

Another consideration for the motor power supply is the possibility of energy being returned to the supply from the load under deceleration. This phenomenon is called regenative energy and most often associated fast deceleration and high inertial loads. Refer to the application considerations section.

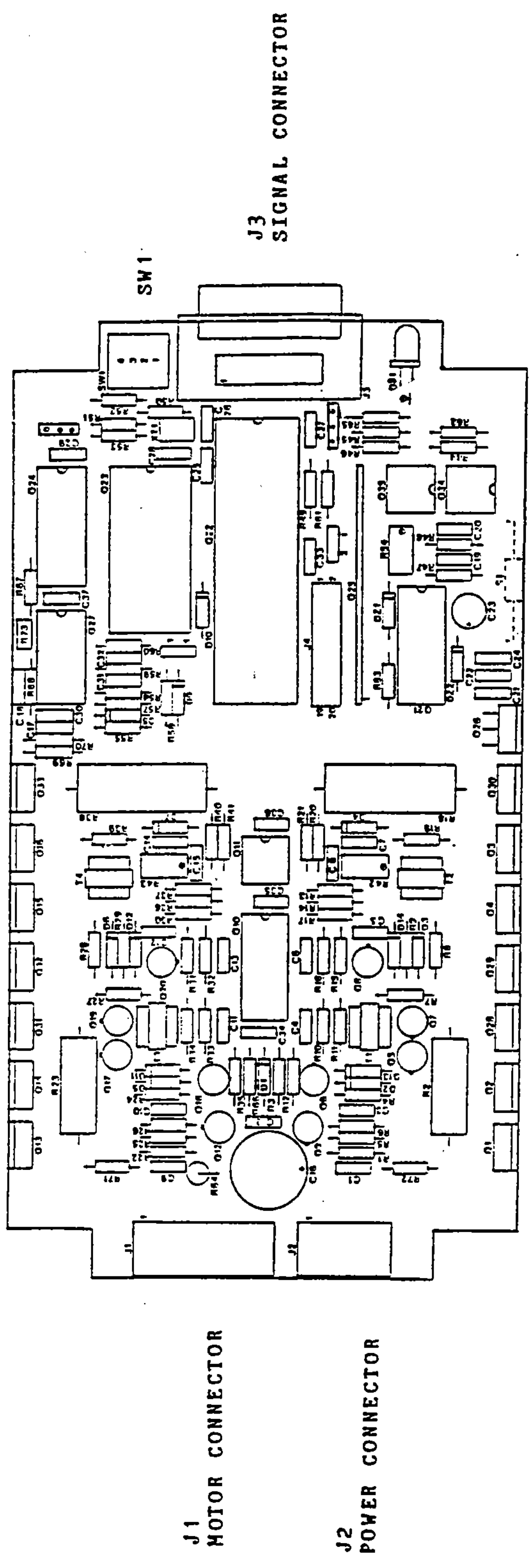


FIGURE 3

CONNECTOR AND JUMPER LOCATIONS

Switch Selectable Functions

1. Stepping Size. Selection of the full, 1/2, 1/5, 1/25 or 1/125 step mode is accomplished via DIP switch S1 positions 1, 2, and 3. The table below shows the switch selection options.

STEP MODE	DIP SWITCH SETTINGS 1	2	3
1	0	0	0
1/2	1	0	1
1/5	1	0	0
1/25	0	1	0
1/125	0	0	1

Table of DIP Switch Settings

2. Microstep Current Boost. The current boost selection sets the drive current in microstep mode at speeds above 500 Full Steps/Sec. With current boost enabled, driver microstep current is boosted 1.4 times rated microstepping current at step rates above 500 full steps per second. With current boost disabled, driver supplies rated microstep current at all step rates.

Dip Switch Position 4	Function
OPEN	Current Boost Disabled
CLOSED	Current Boost Enabled

3. Stability Control. Enabling or disabling the stability control circuit is accomplished by means of position 5 of the dip switch.

With stability control circuit enabled, the step input timing is modified to control and maintain synchronous motor speed in the midrange instability region of the stepping motor system's torque vs. speed curve. When disabled, the stability control circuit has no effect on input pulse timing.

Dip Switch Position 5	Function
OPEN	Stability Control Enabled
CLOSED	Stability Control Disabled

4. Idle Current Reduction. Enabling or disabling the ICR circuit is accomplished by means of Dip Switch Position 6. When enabled Idle Current Reduction will reduce phase current flowing to both motor windings to one-half the nominal value after not receiving a step input pulse for approximately one second. Current will remain at this reduced level until a step pulse is received by the drive. At this time phase current(s) will return to their previously set values and stepping will occur.

Current reduction is useful to conserve energy at standstill or to allow the motor to cool in high duty cycle applications. It should be noted that the holding torque genereated by the motor will also be reduced by approximately 50% when ICR is enabled.

Dip Switch Position 6	Function
Open	ICR ENABLED
Closed	ICR DISABLED

DIP SWITCH FUNCTION SUMMARY

Drive Selectable Functions (refer to Figure 3)

S1-1: Microstep Setting
S1-2: Microstep Setting
S1-3: Microstep Setting

Note that open = "1" and closed = "0".

Step Mode	Dip Switch Position 1	2	3
1	0	0	0
1/2	1	0	1
1/5	1	0	0
1/25	0	1	0
1/125	0	0	1

S1-4: Microstep Current Boost Above 500 SPS
Closed = Enable Current Boost
Open = Disable Current Boost

S1-5: Mid-Range Stability Control
Closed = Disable Stability Control
Open = Enabled Stability Control

S1-6: Idle Current Reduction
Closed = Disable Idle Current Reduction
Open = Enable Idle Current Reduction

SIGNAL DESCRIPTIONS

Motor Connector - J1

Recommended minimum input conductors are #16 AWG, twisted pair. Conductor shielding is not required.

1. Motor Phase A Outputs. Terminals J1-1 and J1-2 are the phase A outputs to the stepping motor.

2. Motor Phase B Outputs. Terminals J1-3 and J1-4 are the phase B outputs to the stepping motor.

3. Driver Ground. Terminal J1-6 is connected to the internal driver bus ground. The motor case should be connected tot his point to reduce switching noise in the overall system.

Power Supply Input Connector - J2

Recommended minimum power input conductors are #16 AWG, twisted pair. Conductor shielding is not required.

J2 - 1 : motor power +18 to +75 volt DC MAXIMUM @ 10 Amps
J2 - 2 : motor power return
J2 - 3 : logic power +12 +/- 5% @ 200 MA
J2 - 4 : logic power return

NOTE : The logic supply and motor power supply returns are connected internally in the drive. It is preferable not to connect them together externally.

Phoenix pluggable screw connector 4 position - supplied

Signal Connector - J3.

1. STEP Signal Input (J3-1). The input pulse train that causes the motor to step is applied at this pin. The step will occur on the low-to-high transition of the STEP pulse; the STEP pulse must have a minimum duration of 1.0 usec. Figure 4 illustrates the STEP input circuit and figure 5 step input timing.

2. DIRECTION Signal Input (J3-2). For a given connection of motor phase windings, this input determines the direction of rotation of the stepping motor. If standard Sigma wiring is followed, and the desired motor direction is incorrect, reversing the connections of one of the stepping motor phase windings will cause a reversal of the effect of the DIRECTION input. Figure 4 illustrates the DIRECTION input circuit.

3. 2.5 or 5 Vdc Output (J3-5). This output will supply up to 15 mA for optically isolating the output status signals.

4. Signal Ground (J3-6, J3-7). These pins connect to the drive module's ground bus and are used with DISABLE signal inputs.

5. DISABLE Signal Input (J3-8). Connecting this pin to J3-5 disables the translator within the drive module, removing current from the motor phase windings and preventing stepping motor operation. DISABLE active also causes a DISABLE STATE output at J3-13 (Item #8 of this section).

WARNING!

Do not use DISABLE for safety positive shutdown.

6. Optical Coupler Power Input (J3-9). This input requires a separate 5 to 30 Vdc at 40 mA maximum to power the optoisolators within the drive module. Voltages higher than 5 Vdc require an additional resistance in the input logic lines (refer to Figure 6).

7. Current Control Input (J3-10). This input is used to control the phase currents to the motor. The input is normally a logic high ("1"). A logic high will configure the driver for rated current levels, while a logic low ("0") will command zero current through the motor windings. See the Appendix for application considerations.

8. DISABLE STATE Output (J3-13). This open collector (20V/20 mA max.) logic output indicates the drive module has been forced into a disabled condition because of an internal or external disable input. Refer to the Disable Indicator Section in the Appendix of this manual.

9. Internal connections. J3 pins 4, 12, and 15 are connected to the step size selection switch. No connections should be made to these pins.

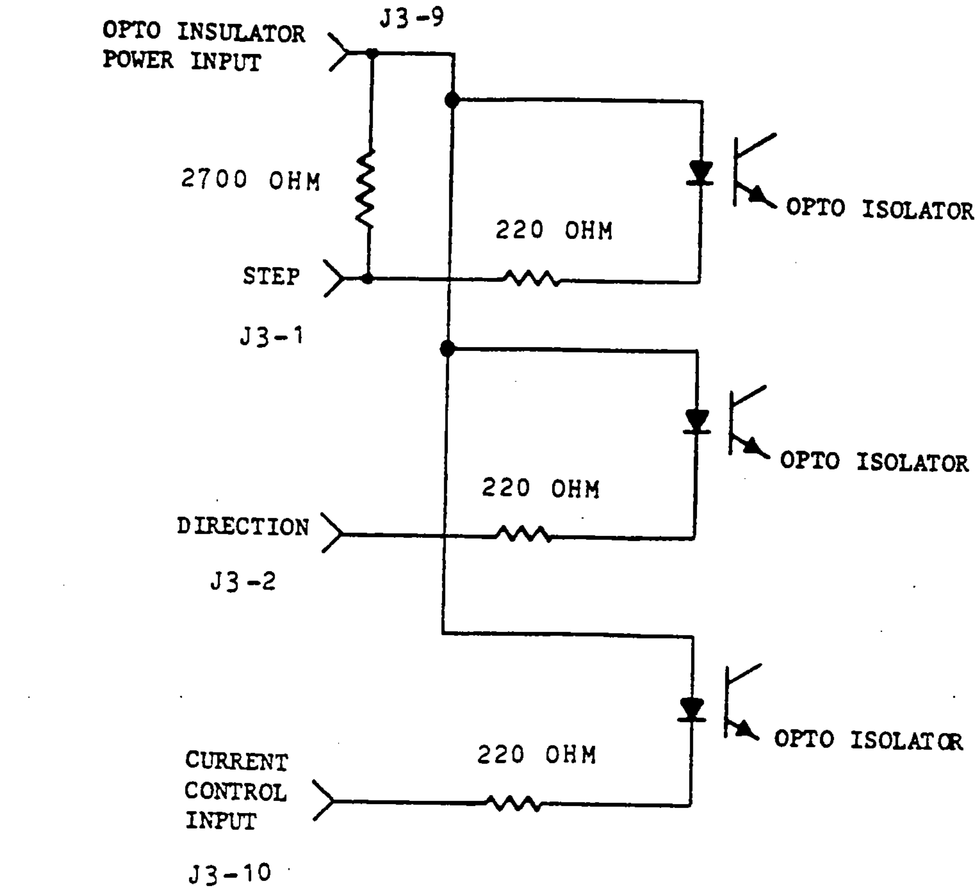


FIGURE 4

STEP, DIRECTION AND CURRENT CONTROL INPUT CIRCUITS

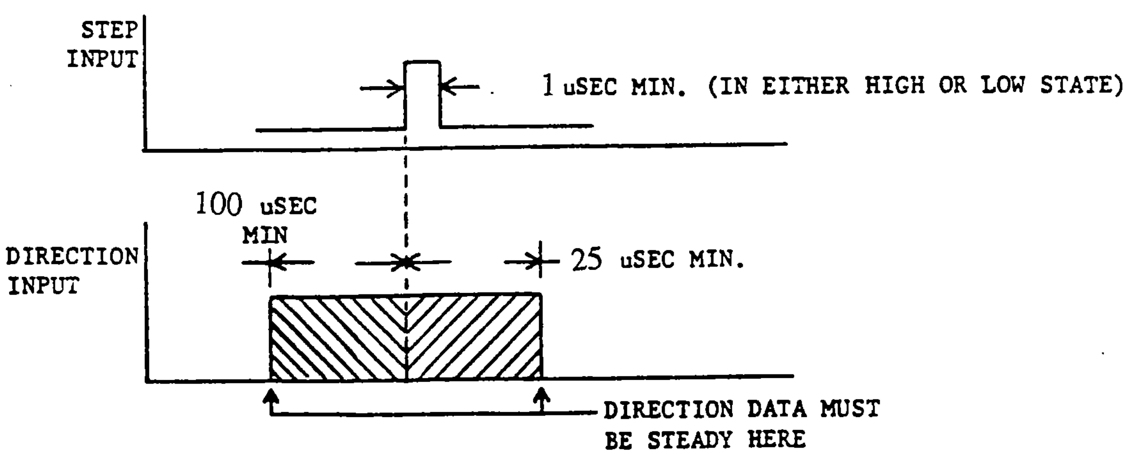
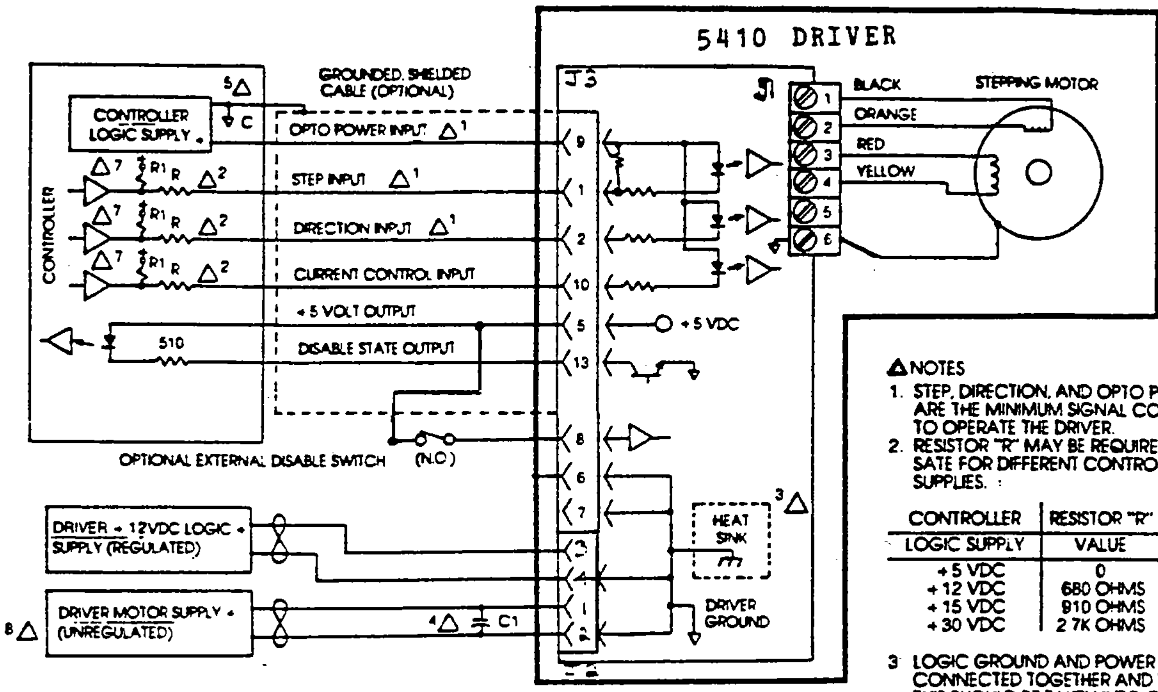


FIGURE 5

STEP AND DIRECTION SIGNAL TIMING



NOTES

1. STEP, DIRECTION, AND OPTO POWER INPUTS ARE THE MINIMUM SIGNAL CONNECTIONS NEED TO OPERATE THE DRIVER.
2. RESISTOR "R" MAY BE REQUIRED TO COMPENSATE FOR DIFFERENT CONTROLLER LOGIC SUPPLIES.

CONTROLLER LOGIC SUPPLY	RESISTOR "R" VALUE
+5 VDC	0
+12 VDC	680 OHMS
+15 VDC	910 OHMS
+30 VDC	2.7K OHMS

3. LOGIC GROUND AND POWER GROUND ARE CONNECTED TOGETHER AND TO THE HEAT SINK. THIS SHOULD BE TAKEN INTO CONSIDERATION WHEN MOUNTING THE UNIT.
4. C1 IS A HIGH RIPPLE CURRENT CAPACITOR LOCATED AT DRIVER.
5. DRIVER GROUND (⏚) MAY BE EXTERNALLY CONNECTED TO CONTROLLER GROUND (⏚ C) AT ONLY ONE POINT TO AVOID A GROUND LOOP
6. OPTIONAL MOTOR CASE GROUND TO REDUCE ELECTRICAL NOISE.
7. IF OPEN COLLECTOR LOGIC IS USED, "R1" IS REQUIRED FOR PROPER OPERATION. 2.7K OHMS TYPICAL VALUE.
8. SEE 3080 SERIES DATA SHEET FOR 3083B TRANSFORMER DETAILS

FIGURE 6

CONNECTION DIAGRAM

THEORY OF OPERATION

The Model 5310/5410 drive module contains a translator circuit that translates STEP and DIRECTION signal inputs into switching signals sent to the phase A and phase B power amplifiers, a stability control circuit, a logic power supply that feeds regulated +5 Vdc to various logic circuits within the drive module, and phase A and phase B power amplifiers that supply correctly sequenced current pulses to the phase A and phase B step motor windings. In addition, the module contains phase A and phase B overcurrent sense circuits that protect against short circuit conditions.

The translator accepts STEP input pulses of a minimum 1.0 usec duration from an indexer or other pulse source, and outputs current control signals that switch the power circuits in the phase A and phase B power amplifiers. The step motor will advance one full step or one microstep for each STEP pulse received. Selection of either the full step or microstep mode is done by means of a DIP switch in the translator circuit. Setting the switches in the proper positions selects either full, 1/2, 1/5, 1/25, or 1/125 step mode. The motor will step on the low-to-high transition of the STEP input pulse.

For a given set of motor phase winding connections, the DIRECTION input to the translator determines the direction of rotation of the stepping motor. Reversing the connections to one phase winding reverses the direction of shaft rotation and therefore reverses the effect of the DIRECTION input. The DIRECTION input must be present a minimum of 100 usec before and after the low-to-high transition of the STEP pulse. Figure 5 shows the required timing relationship between the STEP and DIRECTION inputs.

Microstepping is achieved by controlling the currents of the phase A winding and the phase B winding in a sine/cosine analog relationship. This drive technique results in increased positional resolution and velocity smoothness over that of conventional full or half-step driver designs using constant square wave current control.

The microstepping driver receives step pulses and direction signals from an external controller. Each step pulse causes the driver to increment or decrement the motor phase currents in order to move the motor shaft one microstep. The motor will rotate at a rate equal to the input step pulse frequency multiplied by the microstep scale factor. A DIP switch located on the driver provides five selectable microstep pulse increments from one to 1/125 of full step.

The sine/cosine current commands for each microstep position are digitally stored in a prom look-up table, and are processed through a digital-to-analog converter (DAC) to provide the continuous analog current command for each phase. Each current command is summed into a current feedback control circuit that regulates motor phase currents independent of voltage, temperature, or winding impedance variations.

The advantages of microstepping are low speed motor resonance problems can be substantially reduced, torque ripple is reduced, and finer positional resolution is achieved. The disadvantages are increased pulse rate required for the same velocity and reduction of low speed and holding torque.

Each power amplifier contains a chopper circuit whose function is to sense the magnitude of current in its associated phase winding and to momentarily cut off power to this winding when this current exceeds a predetermined value. Timing circuits within the chopper produce a stable chopper frequency of approximately 20 kHz that is substantially independent of phase winding inductance. The midrange stability control circuit, when enabled, controls the timing of the STEP output with respect to the input pulse command in order to maintain synchronous motor speed.

Disable Indicator

The drive module is equipped with a disable LED which illuminates for any internal driver disable condition such as overcurrent, overtemperature, or invalid switch setting. Any disable condition, in addition to lighting a LED, sends out a logic high level at J4-13 to the user's control device to flag that the driver is disabled. The following is a table of possible fault conditions.

	COMMENTS
1. DISABLE input (J3-8) is connected to J3-5 (+5 Vdc).	Check that this input is a logic low with respect to logic ground (J3-7).
2. Driver module overtemperature.	Allow the module to cool to where it will again begin to operate (85oC) and do one of the following: 1) Reduce ambient air temperature. 2) Force cool the module with a fan and avoid restricting air flow around the unit. 3) Reduce the on time of the module (duty cycle) by: a) Automatic current reduction (ICR jumper), b) Program current DISABLE using the current control feature. Note: In this state, detent torque will hold motor position.
Low logic power supply voltage.	Check the logic supply voltage. If below specifications, increase power capacity.
3. Incorrect motor connector wiring.	Check for the following: 1) Incorrect phase-to-phase motor wiring. 2) Incorrect phase-to-power-ground wiring. 3) Internal cable short circuit from phase-to-phase. 4) Internal motor phase-to-phase short circuit.
4. Power output device failure.	Return drive module to factory for repair.

Rengenative Energy

The kinetic energy stored in a rotating inertia is given by

$$KE = .5 * J * w^2$$

KE : Kinetic Energy (joules)
J : Inertia (Nm-sec^2 or kg-m^2)
w : velocity (rad/sec)

During deceleration the Kinetic Energy of the load is transferred to electrical energy where if it is less then the power losses in the drive and motor it is dissipated or if it is greater a portion is returned to the power supply. A typical power supply (such as a full-wave rectifier with capacitive input filter) will store this energy in the output capacitors of the supply. The voltage rise of a capacitor due to input energy is given by

$$V = (2 * E / C)^{.5}$$

V : voltage rise on supply (volts)
E : energy (joules)
C : capacitance of power supply (farads)

The voltage on the supply must not exceed the 75 volt maximum rating of the drive under all conditions including high line and deceleration. In the majority of systems the Kinetic Energy is dissipated in the drive and motor and the power supply voltage does not rise. In applications with high inertia loads and high running speed the possibility of regeneration must be evaluated

The best way of evaluating if regenative energy is a problem is to run the system while monitoring the supply voltage with an oscilloscope, a storage type is preferable. A meter can not be used because it will not respond to the peak value unless a peak hold circuit is used, see figure 7. Start the system with slow deceleration rates and monitor the supply to see if the voltage rises during deceleration. Slowly decrease the deceleration time, if the supply voltage rises this indicates the presence of regenative energy. If regeneration causes the supply to exceed 75 VDC peak a clamping circuit is required to dissipate the regenerated energy. Figure 8 is a schematic for an active voltage clamp circuit which when the supply voltage exceeds the set limit will switch a 25 ohm resistor across the supply to dissipate the regenative energy.

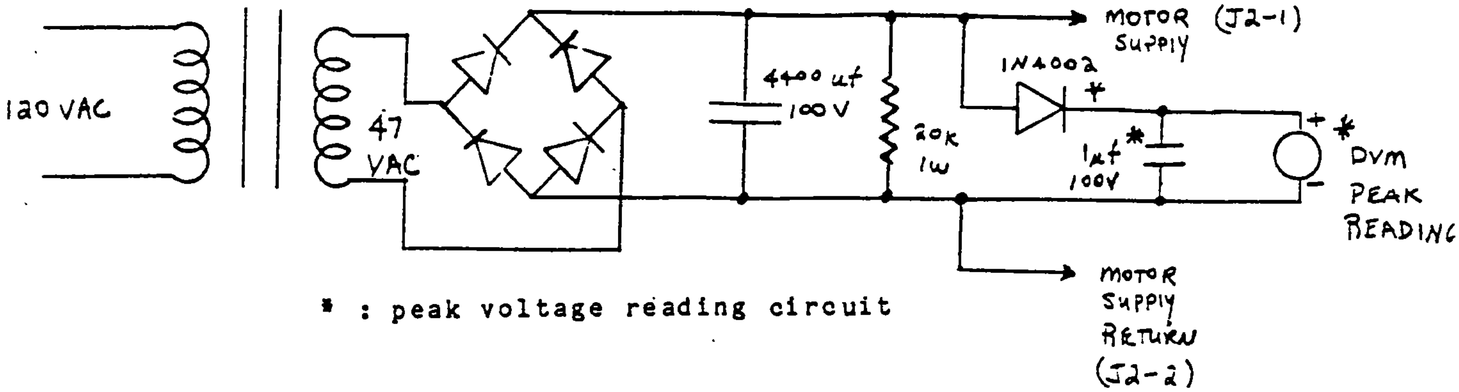


FIGURE 7

POWER SUPPLY WITH PEAK VOLTAGE READING CIRCUIT

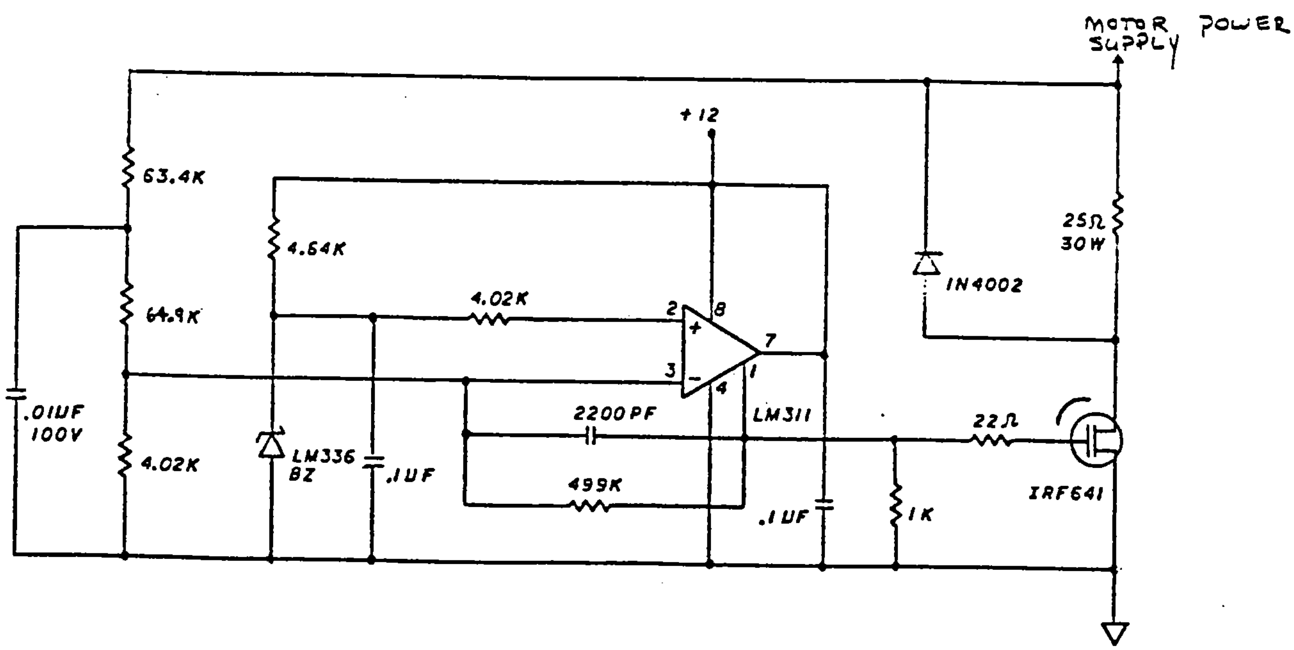


FIGURE 8

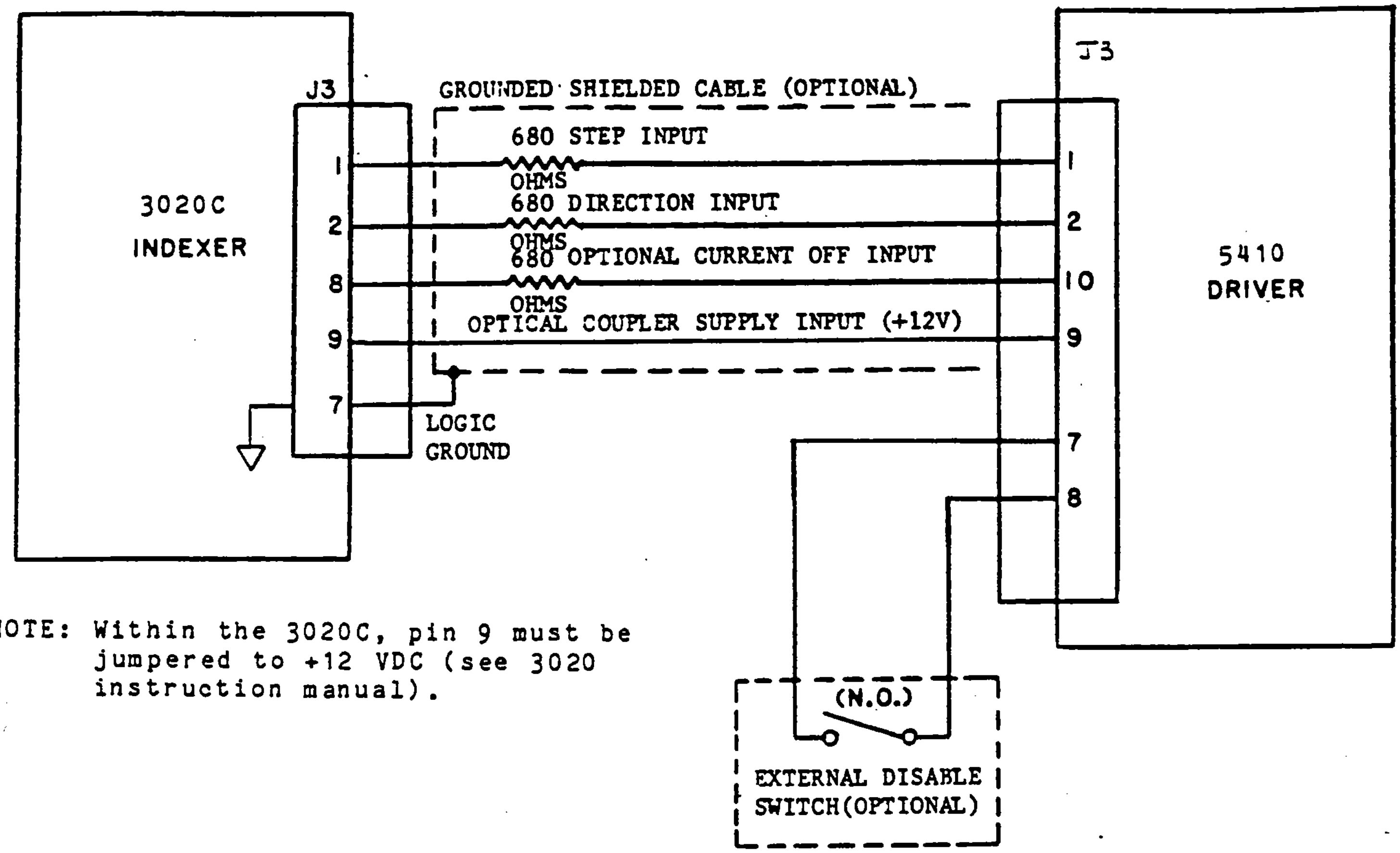
POWER SUPPLY VOLTAGE CLAMPING CIRCUIT

Sigma Line Indexer Connections

The 5310/5410 drive module accepts step and direction input to control the stepping motor. These inputs can be provided by Sigma line indexers 3020 and 3076. Figures 7 and 8 show the signal connections to the 5310/5410 for these products.

Sigma Line Motor Connections

The 5310/5410 drive module will drive any bipolar step motor rated at 5 Amps/phase. Connections for standard Sigma line and splashproof motors are given in figures 11 and 12.



NOTE: Within the 3020C, pin 9 must be jumpered to +12 VDC (see 3020 instruction manual).

FIGURE 9

SIGNAL CONNECTIONS FOR 3020C INDEXER

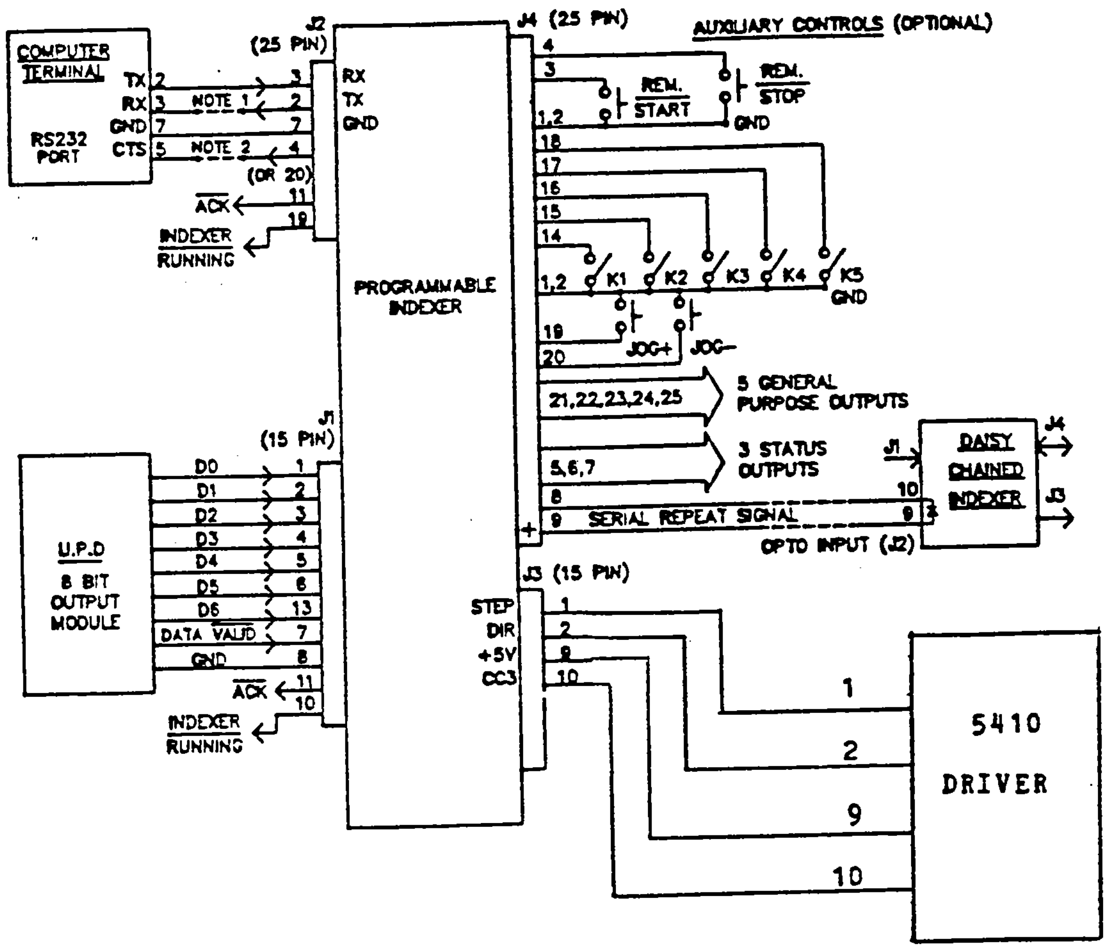
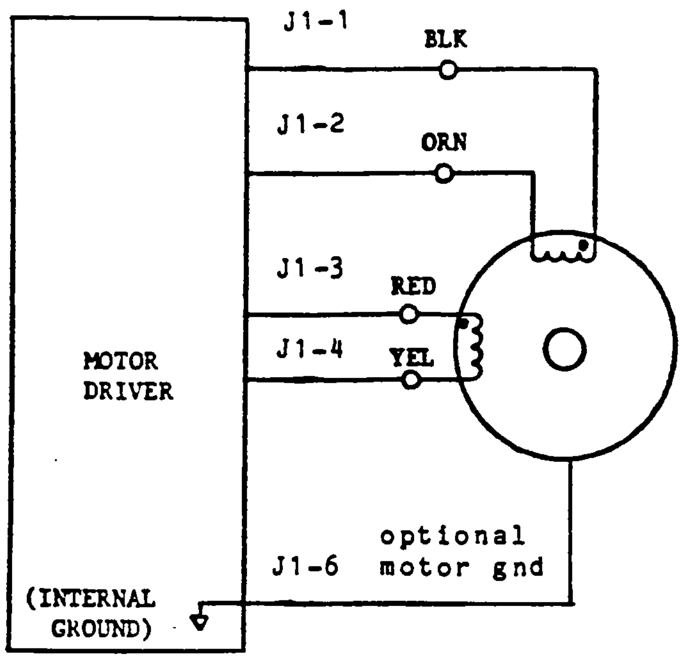
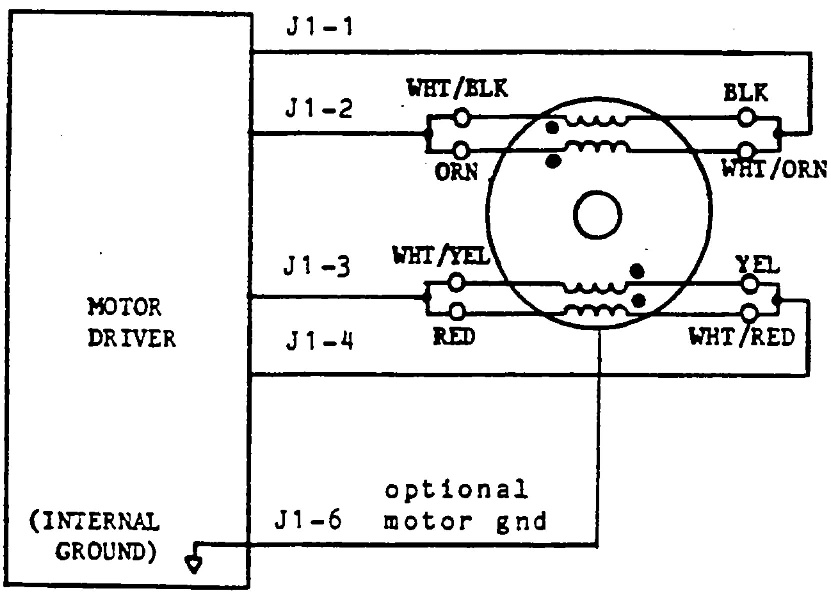


FIGURE 10

SIGNAL CONNECTIONS FOR 3076 INDEXER



4 LEAD MOTOR



8 LEAD MOTOR

FIGURE 11

STANDARD MOTOR CONNECTIONS

5410 DRIVER	SIGMA MOTOR TERMINAL BLOCK		
	4-INCH DIAMETER SPLASHPROOF		3-INCH DIA. SPLASHPROOF
	4 Lead	8 Lead	4 Lead
J1-1	1	1	2
J1-1		5	
J1-2	3	3	3
J1-2		6	
J1-3	2	2	1
J1-3		7	
J1-4	4	4	4
J1-4		8	

FIGURE 12

SPLASHPROOF MOTOR CONNECTIONS