Precision Motion Controls

VS Series Motors and Drives

Operator's Manual
PN 04-01810 Rev. A

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The VS drive is not line isolated. Use a 3 pin power plug only. The terminals of motor connector contains high voltage, Do not probe the connector with power on, this could damage the drive or result in body injury.

Introduction

Theory

Efficient Drive

The VS Series drive is a high performance pulse-width modulation microstepping drive. This bipolar drive contains a variable supply in the front end and standard H bridge amplifier on the motor driver side. The voltage to the motor driver is adjusted to compensate for the motor back EMF voltage loss and the current charging requirement, based on the speed, motor size, and the current of the winding. The VS series drive reduces the motor heating due to the hysteresis and eddy current losses while increasing the speed-torque curve when compared to conventional motor drivers.

Noise reduction

Electrical noise is a common problem associated with the pulse-width modulation drives. The fast switching speeds of MOSFET's help reduce the energy losses due to the switching, but they also generate electrical noise to surrounding devices. The higher the voltage swings, the more noise a drive produces. The noise passes through the power supply wire and is also radiated by the cable and case of the motor. Normally, adding a filter on the input line AC power supply will eliminate most EMI from the supply line. The high frequency noise generated by the cable and motor case is a noise source that is difficult to eliminate. Since the VS series has considerably lower voltage on the drive when the motor is standing still, the EMI generated by the switching is considerably less than normal drives.

Description

The VS series drive is a 6 amp 170 volt drive, made of a reliable MOSFET H bridge drive construction. The drive has a current monitor in the driver side to provide short circuit protection. The drive has its own self contained power supply, relieving the customer of the responsibility and cost of supplying one. The amplifier operates at a 20 kHz pulse-width modulation rate, this is above the human hearing response level and below the point where the motor magnetics become inefficient. The VS Drive can be ordered with a variety of motors ranging from 60 to 1200 in-oz. of torque; the motor case sizes range from NEMA 23 to 42. The drive has the following dip switch selectable steps/revolution (51200; 50000; 25600; 25000; 10000; 6400; 2000; and 400).

The system offers 3rd. harmonic waveform selection to provide smooth movement with a wide selection of motors. The test mode, auto-shutdown (motor current reduces to 1/2 when not running) and motor current up to 6 amp are all selectable from dip switches.

The drive responds to three input signals; a step pulse, direction, and remote disable. The remote disable input removes power from the drive so that the motor can be turned by hand. The remote disable may also be used as a safety limit since it overrides any of the other drive signals. All inputs are optically isolated to prevent ground loops to connecting equipment.

The Fault+, Fault- output is the collector and emitter of a opto transistor . The Fault' transistor will be turned on when an undervoltage, over-current, or over-temperature condition occur. When the Fault is activated, the power needs to be recycled. This allows the user to correct the fault condition before continuing.

Pin outs for the connectors and box dimensions are described in appendix C.

Features

The VS series drive combines the features of being able to use low inductance motors for high speed and power out while minimizing generated RFI by only supplying the voltage to the motor that is required for the current speed. This reduces stress on the motor and electronics thus increasing its' life and reliability. An additional benefit is that this approach also reduces the heat and electrical noise generated by the drive.

The drive has a dip switch selectable auto-standby mode, that reduces the current to half after 2 seconds of no motor movement. This will further reduce heat generated by the motor. Due to the motor detent torque and other nonlinear properties a shift in position of up to 5 usteps on the 50000 step /revolution setting may occur. If this can not be tolerated then the auto-standby option should not be used.

The over-temperature feature monitors the temperature inside the drive. If the internal temperature rises above 60 degrees centigrade the drive goes to a shutdown mode. The over-temperature LED will be illuminated. The power must be turned off to reset the drive. If this happens mount the drive so that the heat sink fins are running in the vertical direction. Another cause could be that the ambient air around the drive is exceeding 40 degrees centigrade. This LED is also used as indicator in the power-up sequence diagnosis.

The over-current indicator means that too much current was being drawn through the motor transistors. Check your motor for a short or for a short across the motor terminals. The drive must be turned off to make these checks.

The step indicator LED is turned on when pulses are received by the drive. The LED will turn off if pulses are not received for 2 seconds. This will also correspond to the time when the auto-standby is energized (if enabled).

The undervoltage LED is triggered when the line voltage drops below 90 VAC. If this condition is detected then the current to the motor is set to zero and the drive goes to a shutdown mode. The power to the drive must be turned off and then back on to recover. This LED is also used as indicator in the power-up sequence diagnosis.

The Power LED indicates that the internal 5 volts supply of the drive is operational. This LED should always be illuminated if the drive has AC power applied to it.

Power up sequence

The system upon power up tests to see if a motor is connected and that is within the parameter for the motor and current selected. The power up check consists of four measurements. The error conditions associated with these errors are as follows:

Error 1 occurs if no switching of the H bridge is detected. This is generally caused by a motor not being connected. The over-temperature and undervoltage LEDs will be on. Generally one of the other tests will fail first.

Error 2 is caused if the pulse-width modulation to the motor is not at 20 kHz. The undervoltage LED will blink. This could be caused by the motor not being connected.

Error 3 checks for a 50% duty cycle at no current. This indicates the motor is not connected or connected improperly. The over-temperature LED will blink if this condition is detected.

Error 4 indicates the pulsewidth duty cycle is not within the expected limits for the current selected. This indicates you selected the wrong motor type or current for the actual motor used. Check the current setting and motor selection. The over-temperature and undervoltage LEDs will both blink.

Error	Undervoltage LED	Overtemp LED	Possible cause
1	On	On	Motor is not connected to the drive or too large of a current for the motor.
2	Blink	Off	Motor is not connected to the drive.
3	Off	Blink	Motor is not connected to the drive, Check motor connector.
4	Blink	Blink	Current selected doesn't match with the motor.

Warranty

PMC's VS drives have a one year warranty against manufacturing defects from the date of purchase. If your unit should ever fail, and you wish to send it back for repair, you should first obtain the following information:

1. Get the serial number from the defective unit.
2. Check purchase date to see if the unit is under warranty. If not, obtain a purchase order number for repair costs.
3. Call Precision Motion Controls for a return authorization (408) 298-0898.
4. Ship to :

Precision Motion Controls
2530 Berryessa Rd. #209
San Jose, CA 95132

Attention RMA #_____

Installation

Unpacking

When unpacking your unit verify that the unit was not damaged during shipping. Report any damage found to the shipper. Check the box contents against the packing slip. The box will contain the driver, AC line

cord, mounting brackets and a motor (if one was ordered with the drive).
Connect the motor to the driver box, check the dip switch selection for the motor size, and current setting then plug in the AC line cord to a 115 VAC outlet. Verify the power LED is illuminated and all the LEDs are off. Feel the shaft of the motor and verify that the motor is producing torque. If you are able to move the motor shaft the motor does not have torque; unplug the line cord. Check if any of the motor wires have come out of the connector. Contact the factory for a return authorization if the above check proves negative.

Remove power from the drive; Place the dip switch in the test position (see table 2) and plug the drive in. The motor will rotate in the CCW direction continuously. Remove power and put the test switch to the normal position.

CAUTION, always disconnect the AC power prior to connecting or disconnecting the motor to the box.

Mounting

The VS Drive comes with mounting brackets to facilitate mounting. The unit may be mounted in any direction. For motor currents between 3 to 6 amps the box should be mounted with the heat sink fins running in the vertical direction to help cooling. See appendix C for a detailed drawing of the motors and the box.

Warning : Only use 1/4" long 4/40 screw to mount the bracket to the drive. Using longer screw can damage the drive.

Cooling

The surrounding temperature of the environment should not exceed 40 degrees centigrade. If the driver needs to be in a warmer environment, consult the factory for recommendations. The temperature of the heat sink should not exceed 60 degrees centigrade.

Wiring

Motor Connections

The drive, if purchased with a motor, comes with a connector attached to the motor; otherwise a connector with screw mounting will be supplied. The center pin is for connection of the motor cable shield. The center pin is connected to earth ground and the shield is connected to the motor case; if the motor is mounted to a potential other than earth ground do not connect the shield to the center pin.

A+	(Green)
A-	(White)

Shield (Earth gnd)
B+ (Black)
B- (Red)

Line Power

The correct line cord is supplied for connection of 115 VAC power. Make sure that the unit is plugged into a wall socket with earth ground.

Warning : Always use the 3 pin plug . Failure to do so could result in bodily injury.

Indexer Connections

The STEP+, STEP-, DIRECTION+, DIRECTION-, SHUTDOWN, SHUTDOWN-, signals are inputs to the drive. Each signal is connected to a optocoupler with a 470 ohm resistor in series. A 5-10ma. current should be applied to the optocoupler input. A 5v driving source will meet the requirement. The FAULT+, FAULT-, signals are the outputs from the drive. They are connected to the collector, emitter of the transistor inside the optocoupler individually. A maximum 5ma. will conduct through the transistor when the FAULT condition occurs. See appendix A for a typical indexer connection.

The STEP+, STEP-, DIRECTION+, DIRECTION-, signals are required for operation of the motor. The signals are photo-coupled to eliminate ground loops. The direction signal must not change 50 usec prior to the step going positive. A remote shutdown is provided to remove power from the drive without removing power from the box . The FAULT output is turned on when an overtemperature, overcurrent, undervoltage or power-up sequence failure conditions occur. This can be used as an status input to the controller.

25 pin "D" connector
1 Step +
14 Step -
2 Direction +
15 Direction -
16 Shutdown +
17 Shutdown -
9 Fault+
21 Fault-
A typical wiring connection of the drive is in appendix A for your reference..

Switch Settings

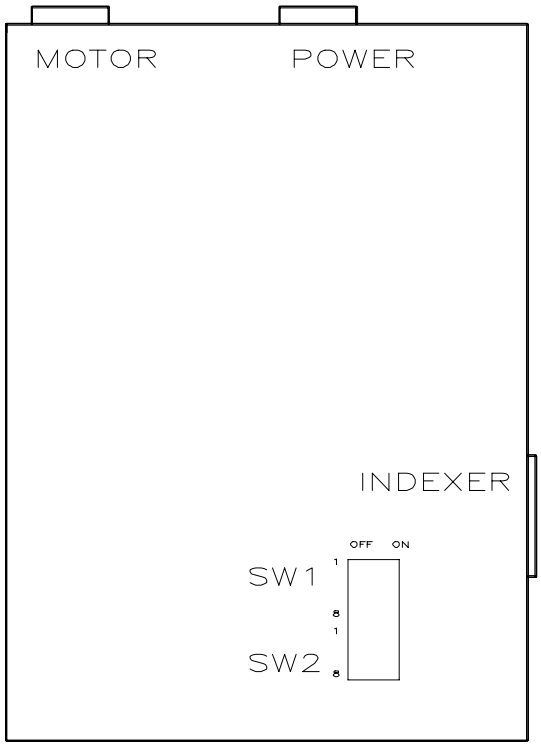
The switches are only read once after power-up. Disconnect AC power from the unit prior to attempting to change any switch settings.

There are 2 switches accessible from under the box. The switches control the following functions.

* Step size selection

* 3rd. harmonic selection
* Test mode
* Auto-standby current reduction
* Motor selection
* The current selection

The following drawing shows the location of the dip switch in the bottom view of the box.



Step size selection

Table1: step size selection

Steps/rev	Switch 1-1	Switch 1-2	Switch 1-3
50800	off	off	off
25600	on	off	off
10000	off	on	off
2000	on	on	off
51200	off	off	on
25600	on	off	on
6400	off	on	on
400	on	on	on

Refer to table 1 for the step size selections, which are selected with dip switch 1-1 through 1-3. There are 8 different step size selections in the drive. The finer steps will give you less vibration and finer positioning, but you need to generate a higher pulse rate to make the motor move the same speed. The maximum step rate is 2 MHz.

3rd. harmonic selection

Table 2: 3rd. Harmonic Selection

Waveshape	Switch 4	Switch 1-5	Switch 1-6	Switch 1-7
0% sine	on	on	on	x
+2% harmonic	off	on	on	x
-2% harmonic	on	off	on	x
4%	off	off	on	x
Reserve	on	on	off	x
Extended power up check	off	on	off	x
Reserve	on	off	off	x
Test	off	off	off	x
Autostandby	x	x	x	off

Refer to table 2 for 3rd. harmonic selection. The 3rd. harmonic correction is selected with dip switches 1-4 through 1-6. The 3rd. harmonic will help provide even steps and minimize motor vibration for various motor. If you use motors that have a large detent torque compared to the motor torque, you may need to select a waveform other than sine. The wave shape corrections are based on a percentage of third harmonic distortion. The extended power-up mode is intended for non PMC supplied motors that may have non standard windings.

Test mode

This mode is entered upon power up if switch 1-4 to 1-6 are off. The motor will rotate in the CCW direction at 0.5 rev/sec. Power must be turned off and the switches put in the waveshape position to leave this mode. Refer to table 2 for the switch setting.

Auto-standby

In the auto-standby mode the drive reduces the current to 1/2 the rated current after approximately 2 seconds if no input pulses are received. This can be used to minimize motor heating and heat dissipation by the drive. This will have some effect on the motor position and should

not be used if a slight change in your stop position cannot be tolerated. The position shift due to current reduction is about 5% of a motor cardinal step (8 usteps for a system with 50000 step resolution). This mode is activated by putting switch 1-7 in the off position. Refer to table 2.

Current setting

Table 4: Current and motor selection

Model	S2-3	S2-4	S2-5	S2-6	S2-7	S2-8	Current	Motor Selection
VS-60-S	off	on	off	off	on	on	1.22A	23-1
VS-60-P	on	on	on	off	off	on	2.25A	23-1
VS-90-S	on	on	on	on	off	on	1.5A	23-2
VS-90-P	off	on	on	on	on	off	3.09A	23-2
VS-120-S	on	off	on	on	off	on	1.69A	23-3
VS-120-P	off	on	off	on	on	off	3.47A	23-3
VS-140-S	off	off	off	on	off	on	2.16A	34-1
VS-140-P	off	off	off	off	on	off	4.41A	34-1
VS-260-S	on	off	off	off	off	on	2.81A	34-2
VS-260-P	on	on	off	off	off	off	5.63A	34-2
VS-380-S	off	on	off	on	on	off	3.47A	34-3
VS-380-P	off	off	off	off	off	off	6.00A	34-3
Vs-600-S	off	off	on	off	off	on	2.53A	42-1
VS-600-P	on	off	off	on	off	off	5.06A	42-1
VS-1200-S	off	on	off	on	on	off	3.47A	42-2
VS-800-P	off	off	on	on	off	off	4.86A	42-2
Current of each switch	.095	0.19	0.38	0.76	1.52	3.04	6 A	

Disconnect AC power from the unit prior to attempting to change any switch settings.
The last 6 switches of dip switch 2 are the current setting and are approximately 94 ma. per bit. The off position of the switch selects the current; switch 8 is the most significant bit. The bottom row of table 4 lists the current for each switch. The motors supplied by PMC run from 1 amp to 6 amps. Refer to table 4 for the current setting of different models.

Motor size selection switches

Table 3

SW1-8	SW2-1	SW2-2	Motor size selection
off	off	off	42-2
off	off	on	42-1
off	on	off	34-3
off	on	on	34-2
on	off	off	34-1
on	off	on	23-3
on	on	off	23-2
on	on	on	23-1

The motor size selection switches are located at switches 1-8, 2-1 and 2-1. Refer to table 3 for the correct setting for your motor size. The motor size selected in conjunction with the current selected controls the voltage applied to the motor at various speeds. As the current decreases for a given motor size the inductance and back EMF increase; the VS therefore selects a voltage vs speed curve to compensate for this. Selecting the improper motor size may degrade your system performance. You may also fail one of the systems power up checks if the wrong motor is selected. For non PMC supplied motors refer to Appendix B for additional information.

Note: running low inductance motors at high speeds for a prolonged time may cause the motor to overheat.

Operation

Electrical

Input Power: 90 to 130 VAC 50/60 Hz

Fuse : 5 Amp (located on PC board).

Output Power: 0 to 6 Amps at 170 VDC through an H bridge driver (supply takes 5 minutes to discharge after power is removed).

Safety Features:

Short circuit protection is provided by a current monitoring circuit in the power supply line. The instantaneous supply current is monitored and if current in excess of 20 Amps is detected the output drivers are disabled. Power to the unit must be turned off and back on if an over current condition is detected. Check motor connector to verify the connector pins are not shorted.

Motor Compatibility

Motor inductance - approximately ranges from 4 to 60 mh for a PMC supplied motor. The drive has a recommended minimum inductance requirement of 1mh. Motors with less than 1mh can be used but this may cause the motor to run too hot except for the largest frame size ones. Typically as the motor inductance increases the top motor speed will decrease and motor heating will decrease. For non-PMC supplied motors, refer to the appendix B for the motor selection switches.

Motor Heating

Warning!
It is user's responsibility to carefully check the motor temperature if the motor is run for a prolong period or greater than 50% duty cycle at high speeds. We recommend that the motor case temperature should not exceed 100 degree C. The motor temperature may take long time to reach equilibrium point. Failure to do so could damage the motor.

There are 2 major causes of power losses from the motor. They are ripple current losses and the I^2R loss. Since the VS drives only produce the voltage required for the present speed, the ripple current loss is minimized, the I^2R loss is the major loss when the motor is standing still. When the motor is running, the ripple current and eddy current loss increase. We recommend that the motor temperature should not exceed 100 degree C at the case. Carefully monitor the case temperature of the motor if your application requires the motor to frequently run at high speeds.

Warning!
It is your responsibility to check the case temperature of the motor. Precision Motion Controls is not liable to the damage of the motor due to overheating.

Indexer Inputs

Input signals: Step signals have a 2 MHz rate maximum and a 250 nsec. minimum width, high and low.

Direction signals should not be changed 50 usec prior to a step pulse. This may cause the drive to interpret the step as the wrong direction.

Shutdown: Shutdown requires 1 msec. to respond (the application of this signal will cause the motor to lose sync if the step signal is applied while it is on).

All input signal are optically isolated and have a 330 ohm current limiting resistor in series. A current of 8 to 15 ma. should be applied to the optocouplers. A driving source of 5 volts will meet this requirement.

Output

Fault output : The maximum voltage between FAULT+, FAULT- is 35V . The maximum sinking current is 5ma.

PMC drives come pretested and adjusted for the motor that is supplied with the unit. No further adjustments are necessary.

"DO Not" connect or disconnect the motor with power applied to the box.

Resonance

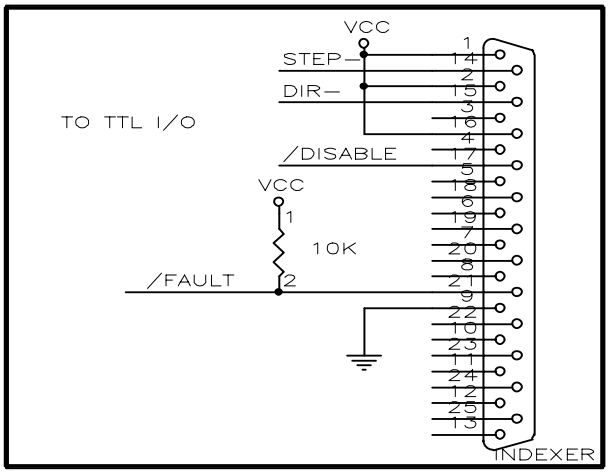
All stepper motor drives are subject to two oscillation regions; low speed (approximately 1 rev/sec) and mid range (approximately 10 to 15 rev/sec).

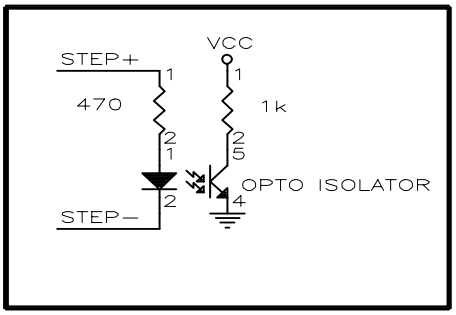
Microstepping minimizes low speed oscillation and this should not occur with PMC supplied motors. If your load has a high Q. and resonates around 200 Hz, adding extra inertia to the motor shaft may eliminate the problem.

PMC motors and drives have been matched to eliminate most mid-range instability problems.

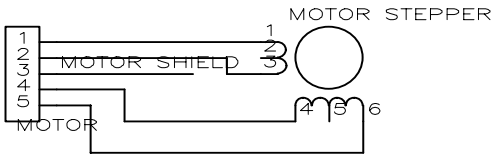
Appendix A

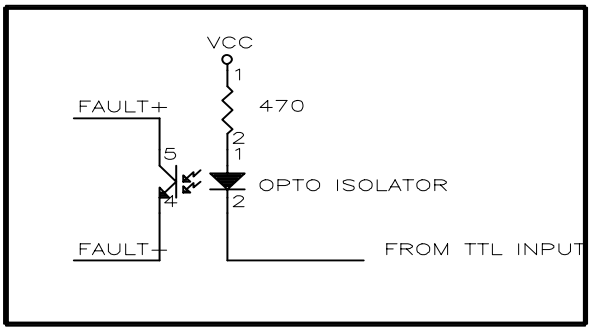
TYPICAL I/O CONNECTION





THE INPUTS CIRCUITRY





OUTPUT CIRCUITRY

Appendix B

For non PMC motors, the VS Series of drive picks one of seven internal voltage vs. speed curves based on the motor size and current selected. The curve selected for each motor size and current is listed in this appendix. Note as you increase motor size the curve number selected gets smaller for a given current. The lowest curve number represents the fastest rise in voltage vs. speed. If your motor has a rated current near the top end of a curve boundary and you are running more than the rated current you may have to select a motor size that is one size larger to get optimal performance. If you do not know your motor size measure its diameter and length; compare this to the dimensions of PMC's motors listed in appendix C.

Motor size	Curve 1	Curve 2	Curve 3	Curve 4	Curve 5	Curve 6	Curve 7
23-1	< 0.37 A	< .9 A	< 1.18 A	< 2.62 A		< 3.2 A	> 3.2 A
23-2	< 0.47 A	< 1.59 A	< 2.2 A	< 3.0 A	< 4.13 A	< 5.26 A	> 5.26A
23-3	< 0.75 A	< 1.12 A	< 2.63 A	< 4.13 A	< 5.26 A	> 5.26 A	
34-1	< 1.03 A	< 2.2 A	< 3.76A	<5.26 A	> 5.26A		
34-2	< 1.6 A	< 2.63 A	< 3.76 A	> 3.76A			
34-3	< 4.13 A	< 5.4 A	> 5.4 A				
42-1	< 5.26 A	> 5.26 A					
42-2	< 5.6 A	> 5.6 A					

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