AB5 Driver
User Manual

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EN 61800-3:1996 + A11: 2000 for second environment.
EN 61000-3-2:2000, EN 61000-3-3:1995 + A1: 2001.
FCC 47 CFR: 2002 part 15, subpart B.
EN 61010 – 1:2001.

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List of Abbreviations

A	Ampere
AC	Alternating Current
DC	Direct Current
LED	Light Emitting Diode
mA	Milliampere
mW	Milliwatt
PWM	Pulse Width Modulation
TTL	Transistor-Transistor Logic
Vrms	Volts Root Mean Square

1 AB5 Description

1.1 General

The AB5 is a 24V single axis amplifier box for driving Nanomotion Piezo-Ceramic motors, which eliminates the “dead zone” previously associated with Piezo-Ceramic operation. It interfaces between the input command from a controller or joystick to the motor. As a result, it provides the smooth control of a DC motor and the accuracy and stability of a Piezo motor.

The AB5 box consists of three cards that convert the input command signal into the output voltage necessary for Nanomotion motors. The Logic and Driver cards are common to all AB5 configurations, while the Personality card is configuration specific and can be replaced when a motor type or number is changed.

1.2 Main Features

High precision (11 bits) control of the output power stage

Zero Dead Band

Drives up to four HR8 motors

Four operation modes:
Velocity, Step, and Brake On/Off

Interface to an analog command

Modular design to allow replacement of configuration specific Personality cards.

Discrete inputs enabling feedback from external sources, such as, limit switches, emergency stop command, etc.

Three color LED indicators

Over Current, Over Voltage, and No Load protections

Minimized sensitivity to cable length

User defined ENABLE input logic.

1.3 Operating Principles Overview

All piezo-ceramic motors operation principles are based on the inherent friction generated between the motor and the slide.

The AB5 driver eliminates this inherent friction between motor and slide, by using a “brake off” principle of operation.

In order to better understand the “brake off” let us imagine that we stop an automobile at a traffic light while on an incline. We have two options while waiting for the light to change.

Option 1 (other drivers operation principles): Engage gear in neutral and use the break to remain in place. This results in a “dead zone” where no movement occurs until a minimum of pressure on the gas pedal is reached.

Option 2 (AB5 operation principle): Remain in gear with an equilibrium of the clutch and gas holding us in place. Even the slightest increase in pressure on the gas pedal combined with a decrease in pressure on the clutch causes the automobile to move. The amount of pressure applied to the clutch and the amount of pressure applied to the gas pedal are the factors that cause the vehicle to move.

By letting the motor vibrate in a certain, unique way, the “dead zone” phenomena, associated with the friction of the piezo-ceramic motor is bypassed. It is hence clear that even when zero command voltage is applied, and no motion is generated, the motor is still excited and thus consumes energy and is heated up.

The driver’s output at zero command is system dependant and is affected by various factors, including the gravitational pull of an incline or decline, slide friction, vacuum/ non vacuum etc. This output level can be user defined according to the specific system requirements, see section 3.1.

2 Connections and I/O Settings

2.1 Front Panel Description

The AB5 front panel (see Figure 1) contains the following connectors and indicators:

- Control Terminal
- Motor Output Port
- I/O Port
- Power/Enable Indicators
- Ground Screw

Figure 1: AB5 Driver Front Panel

2.1.1 Front Panel Connectors

Connector	Description
Control terminal	5 pin connector – Receives +24V from an external source and provides direct control over the motor ENABLE signal and the analog control signal (+Vin and/or -Vin). (Mating connector is by Wieland, p/n 25.621.0553.0)
I/O Port	25 pins D-type female connector - Interfaces to the control source (joystick or controller)
Motor Out	9 pins D-type male connector -Interfaces to the motor. See also Table 6, Table 7 and Table 8

2.1.2 Front Panel LED Indicators

CONDITION	POWER	ENABLE
Vcc < 4.6V	Off	Off
Vcc > 4.6V; Motor not connected	Green	Off
Motor connected and disabled	Green	Orange
Motor enabled	Green	Green
Over Current / Over Voltage	Green	Red

2.2 Motion Control Interfaces

The AB5 Driver Box can receive the input signals either from a motion controller or from a joystick. The schematic diagrams of the motion controllers and joystick connections to the AB5 Driver Box are provided in following sections.

NOTE:

The motor may be operated with minimum control signals applied to the Control Terminal:
+24V,GND, +VIN, -VIN, ENABLE_IN.

2.2.1 Analog Controller Connection

There are two options of an analog connection of a motion controller to the AB5 Driver Box:

Differential connection (see Figure 2)

Single-Ended Connection (see Figure 3)

The differential connection enhances noise immunity.

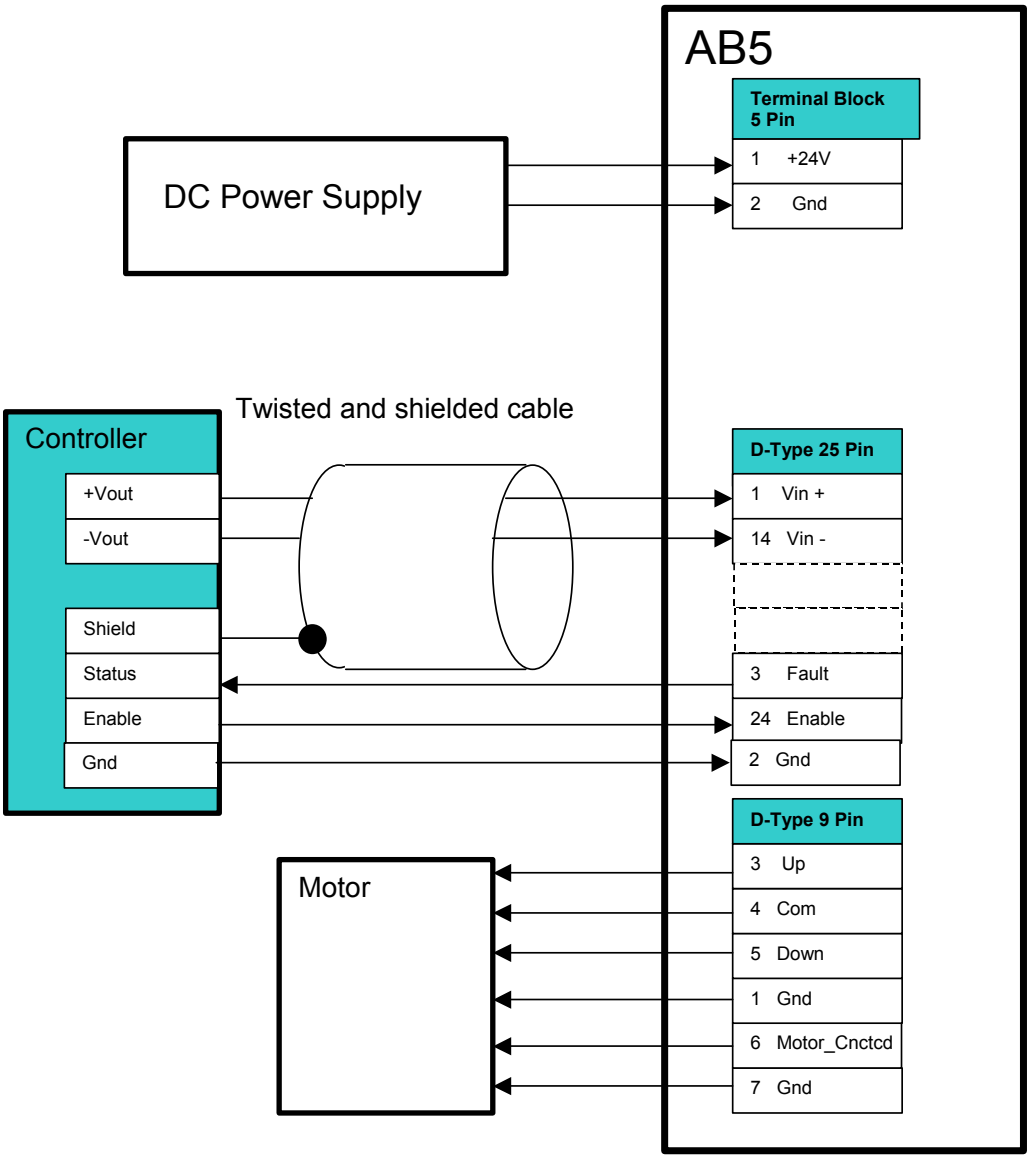

Figure 2: Differential Analog Input Connection

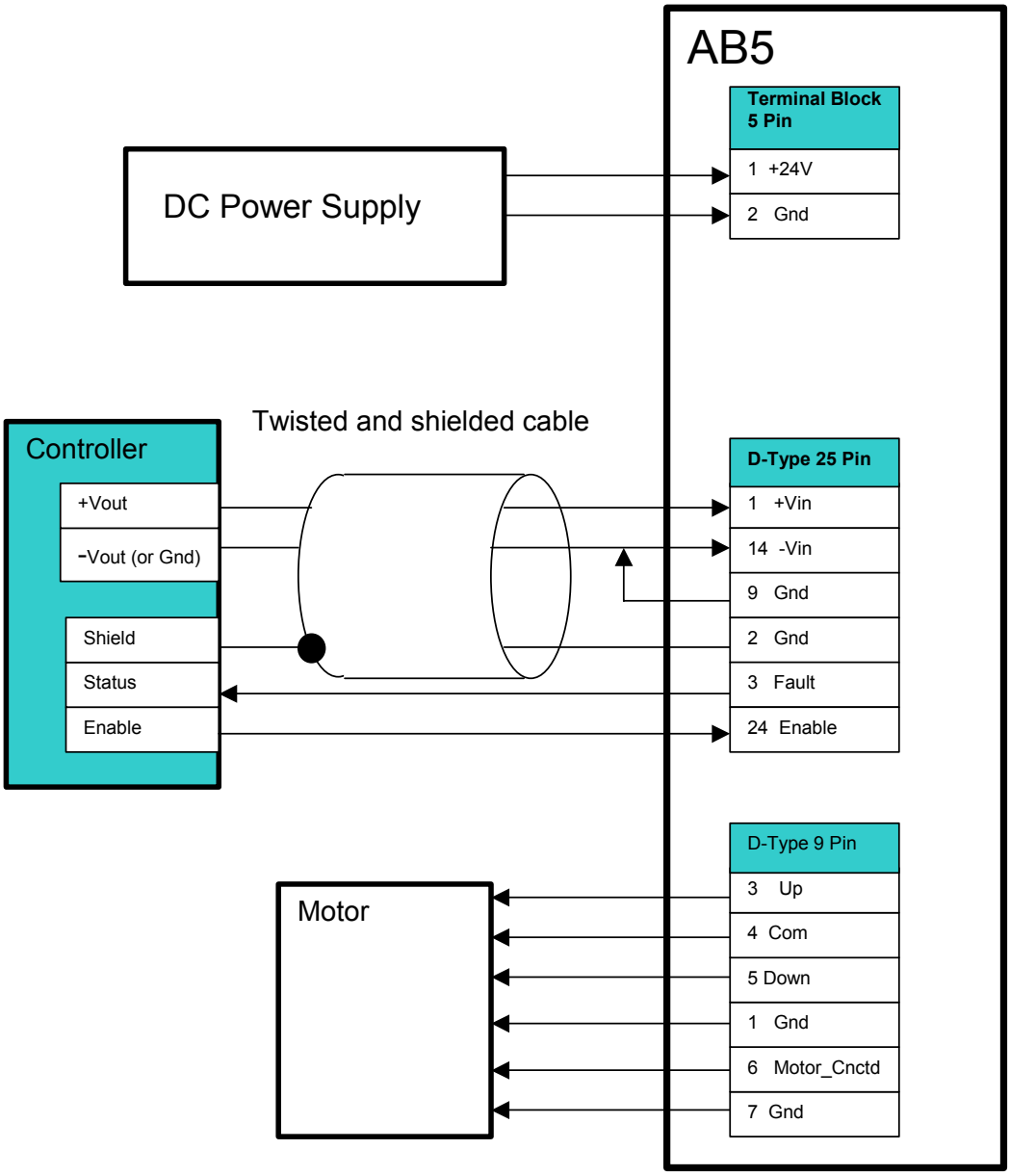

Figure 3: Non-Differential (single-ended) Analog Input Connection.

2.2.2 Joystick Connection

Using the joystick for supplying the command voltage to the AB5 Driver Box allows the user to manually drive the motor without using a motion controller.

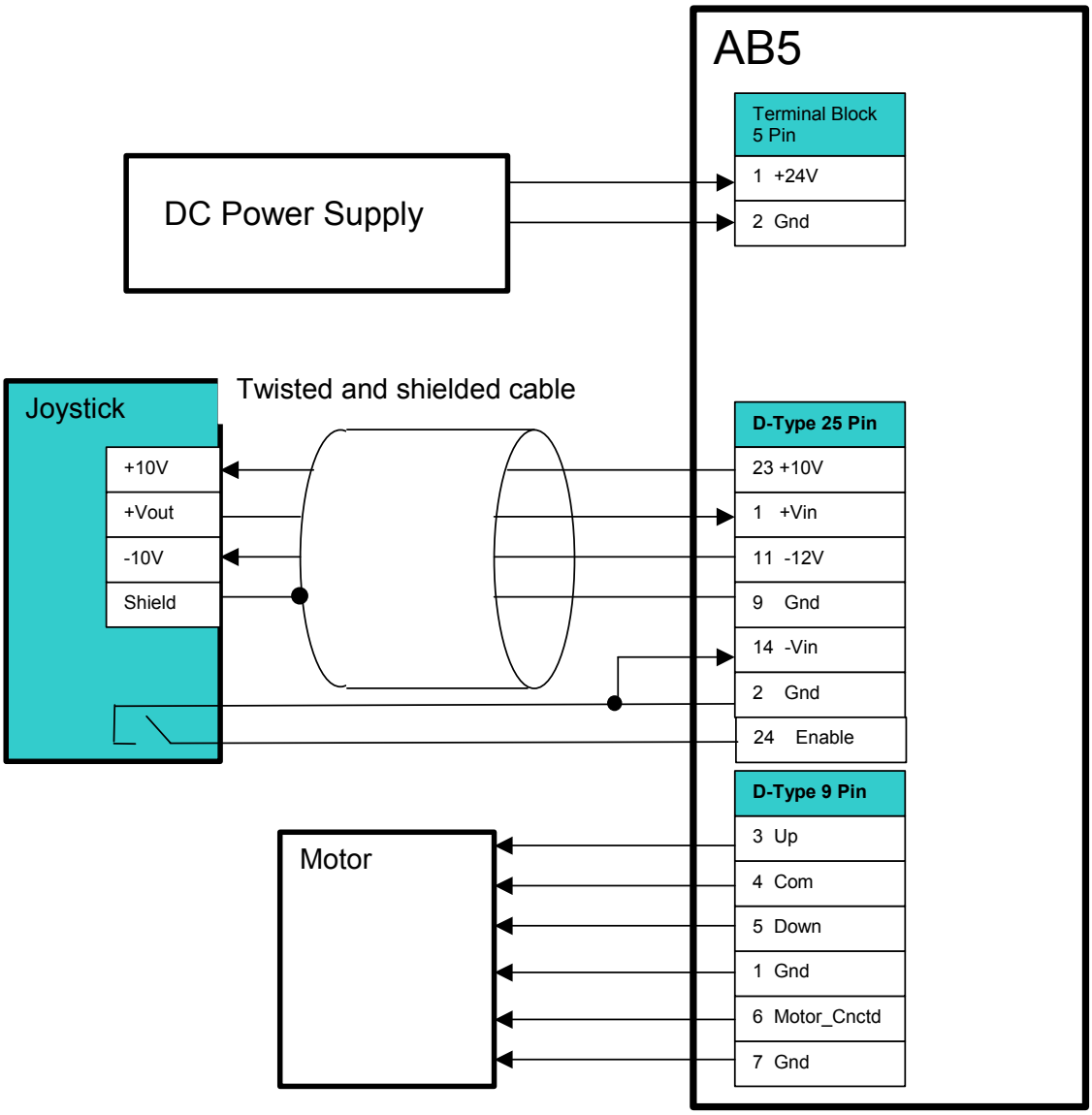

Figure 4: Joystick Connection

2.3 Cable Connections

Connect the following groups of cables together, isolating each of the signals:

POWER SUPPLIES – use 22 AWG (or lower AWG) wires for the power supplies. For noisy surroundings, it is recommended to twist the ground line and the power line together.

ANALOG COMMAND – a twisted shielded cable is recommended.

DISCRETE INPUTS – These signals are not sensitive to noise and can be grouped together in the same harness with any of the other groups.

2.3.1 Grounding the Driver – IMPORTANT !

ATTENTION:

To ensure that minor electric shock does not occur, the ground screw on the bottom left of the front panel MUST be connected to the infrastructure earth.

2.4 Motor Connections

The “Motor Connected” signal is available only at the motor connector, where it is shorted to ground (see Table 7). This ensures that unprotected motor pins will not be exposed to high voltage when the motor is not connected.

If more than one motor is connected to the AB5, use a suitable branch cable.

If the motor type or the number of motor elements is changed, consult Nanomotion for the appropriate driver configuration changes that may be required.

NOTE:

The circuit will only close if a motor is connected to each of the branches. The motors will not work if even one of the branches of the cable is not connected to a motor.

2.4.1 Motor Cable Length

The maximum allowed total cable length connecting the AB5 to the motor(s) is 20 meters for the HR types and 10 meters for the ST. Minimum length is 0.5m.

NOTE:

Use Nanomotion standard cables. Branching is possible to two and four identical motors. Branch cables must be of identical length, the sum of which not exceeding the allowed total cable length.

Nanomotion can guarantee proper driver and motor performance only when Nanomotion standard cables are used.

2.5 Opto-isolated Inputs

The following inputs are opto-isolated and are activated “low”, i.e by shorting them to ground (see Table 8 for more details):

Emergency_Stop. Disables the AB5 output.

Enable_Sign_In. Changes Enable_In input logic to active “high”.

Enable_In. Enables driver operation**;** Should be activated before the motor can be run.

Step_Mode. Enables Step mode operation

Brake_In. Disables the AB5 output.

Set_Offset_Level. Adjust zero command level.

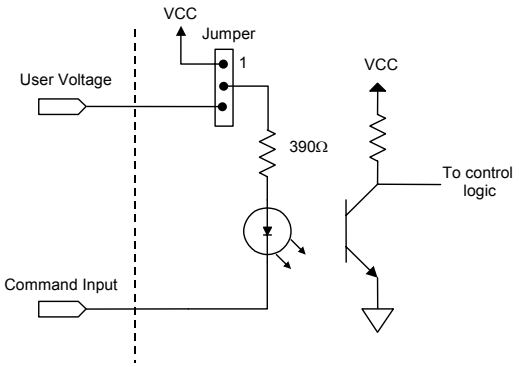

Figure 5: Opto-Isolated Input Interface

2.5.1 Voltage Source Configuration

The opto-isolated input signals (2.2.1) are activated as short-to-ground. The voltage for the opto-isolated circuit (see Figure 6) is provided by either the internal +3.3V supply (default state) or an external voltage supply via pin 13 on the I/O Port connector. The input to be activated should be shorted to external voltage supply ground.

Configure jumper JP2 on the top AB5 card according to the voltage source:

Pin 1 shorted to Pin 2, for an internal +3.3V source (default factory setting)

Pin 3 shorted to Pin 4, for an external +3.3V voltage source

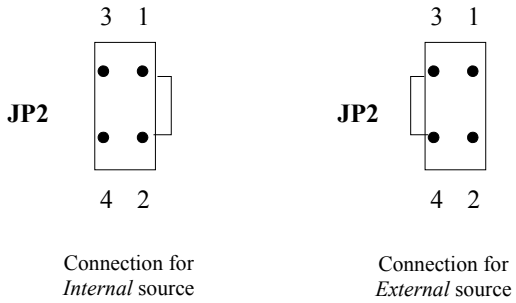

Figure 6: Jumper 2 Configuration

ATTENTION:

Do not short other pins on JP2. Doing so shorts the external power supply to the +3.3V supply! The input circuit is limited to sink up to 10 mA but not less than 3 mA.

2.6 Fault Output

The Fault Output follows open collector logic. When activated ("low"), it disables the driver under the following conditions:

Over-current

Over voltage

Connecting the motor when the power supply is already connected and turned on, may sometimes result in Fault. To avoid this, please first connect the motor and finally the power supply.

NOTE: ***The Fault output is capable of sinking a maximum of 20 mA, and is not protected from over current.***

2.7 Before Operating the Motor

Before operating the AB5, verify the following:

- Jumper JP2 is set to the required mode of operation (see section 2.5.1)
- Mechanical screws lock all connectors
- The external power supply is capable of supplying the required power consumption of the AB5 (see Table 2)
- There is no command when switching the power to "ON"
- All motors are correctly mounted.

ATTENTION:

The command should be limited according to the envelope of performance of the motor. Refer to the Motor User Manual.

Driver should be grounded to infrastructure earth before operating.

3 AB5 Operation

3.1 Set Offset Procedure

Set Offset calibrates the “zero command” for each specific motor and system. Each new motor should be calibrated using the Set-Offset procedure before being used. This is necessary to prevent slide movement when the zero command is applied.

3.1.1 Setting the Offset

1. Toggle Enable off and then on again before starting the adjustment.
2. Apply the zero command and see if there is slide movement.
3. Adjust the command voltage level until the slide movement stops.
4. While still applying the above command level, momentarily short pin 19 to ground. The driver “remembers” this level of command as its zero. (Max 2.5V)
5. Apply now zero command level and verify that the slide is in standstill.

3.2 Operation Modes

Both Enable_In and Motor_Connected inputs must be active for operation, regardless of the operation mode.

The AB5 can be operated in one of the three operation modes listed below.

Velocity (AC) Mode, in which the motor is driven continuously.

Step Mode, in which the driver output is turned OFF and ON at hardware, predefined intervals, thus driving the motor in discrete steps.

Brake On Mode, while in Velocity Mode,enables holding force to be turned ON or OFF, as desired by the user.

3.2.1 Velocity Mode Operation

In this operation mode, the motor is driven continuously by applying the analog command voltage (± 10 V) using a relevant interface device (joystick or motion controller). This is the driver default.

3.2.2 Step Mode Operation

In this operation mode, the driver output to the motor is turned on and off for fixed time intervals defined in the hardware as follows:

ON phase - 1/16 second

OFF phase - 0.5 second

The amplitude of the output corresponds to the analog command input value and thus determines the speed of the motor.

3.2.2.1 Enabling the Step Mode

Short pin 16 to ground to enable Step mode operation.

3.2.3 Brake On Mode

This option is used when the inherent break force of the motor is needed. The driver is disabled and the motor is turned off. (NOTE: although the driver is disabled, there is no reseting, as is the case when disabling is carried by the Emergency Stop or by the Enable_in inputs)

3.2.3.1 Enabling the Break_on

Short pin 17 to ground to enable the break. Disconnect it from ground to get the Break_Off.

4 Specifications

4.1 Parameters and Conditions

Table 1: Electrical Specifications

Power Input	+24 VDC ±5% (stabilized)
Power Consumption without Load	+24 VDC/200 mA

Table 2: Recommended Power Supplies

Supply Voltage	**Maximum Current Consumption**	**Applicable For**
+24 VDC ±5%	2A	E1 to E4
	3A	E8
	6A	E16.
	12A	E32

Table 3: Physical Properties

Weight	450g

Table 4: Environmental Conditions

Operating Temperature	0°C to 50°C
Storage Temperature	-40°C to 70°C
Operating Humidity	Up to 80% Non-condensing

Table 5: Analog Input Specifications

Input voltage range:	±10V
Input impedance:	10kΩ
Input low pass filter:	2.7 kHz

4.2 AB5 Layout

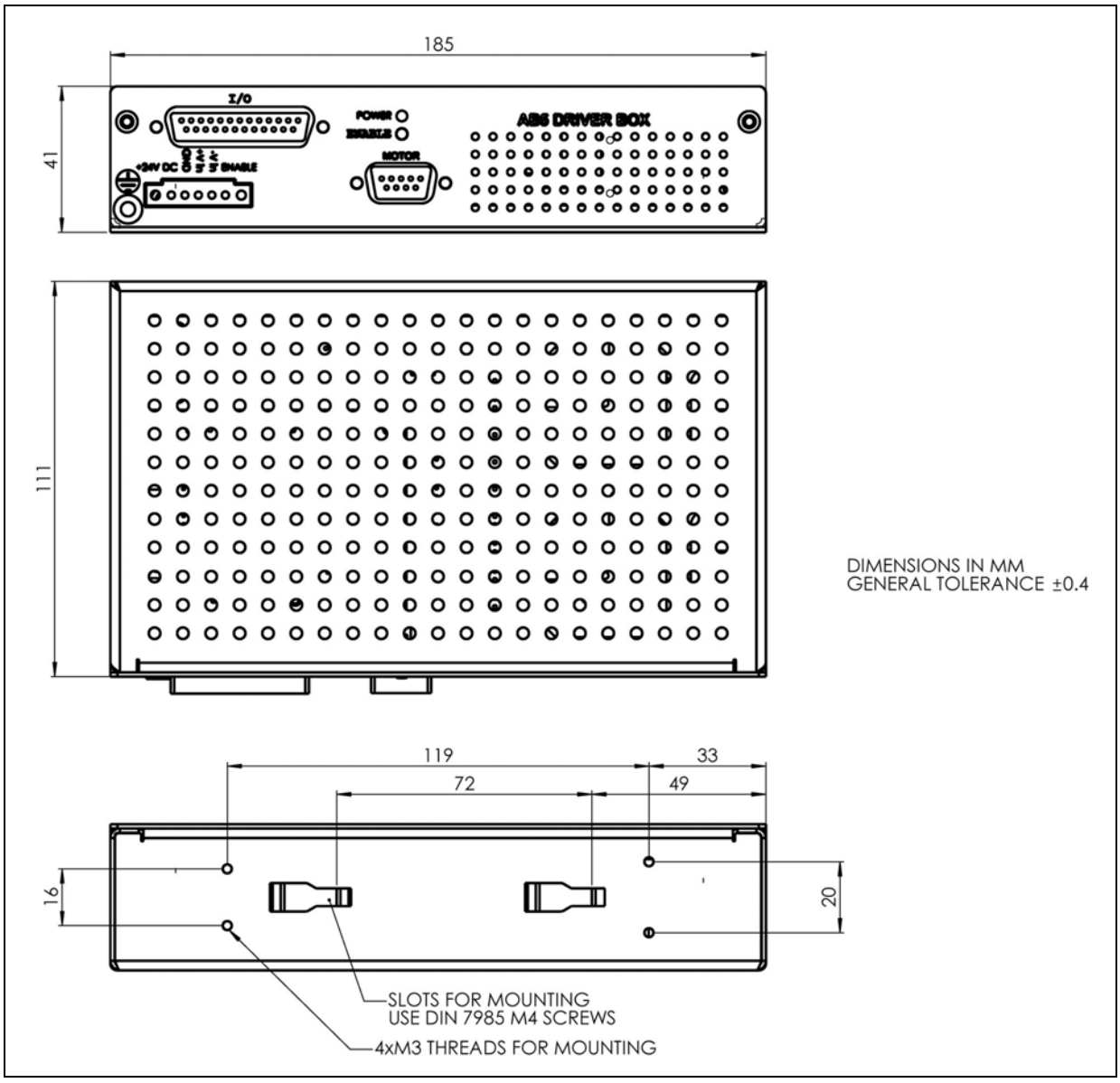

Figure 7: Mechanical Dimensions

4.3 Pin Arrangement

Table 6: Control Terminal Pin Out

Pin	Signal Name	Function	Description
1	+24V	Input	+24 VDC Power Supply
2	Gnd	Ground	
3	+Vin	Input	Analog Command from controller.
4	-Vin	Input	Analog Command from controller.
5	Enable_In	Input	Enable. See section 2.5

Table 7: Motor Output Port Pin Out

Pin	Signal Name	Function	Description
1	Gnd	Power supply ground	Safety input; shorted to pin 6 in order to verify the motor connection and to prevent driver operation without the motor.
2	N.C.	Not used	
3	Motor_Up	High voltage output	Connected to the white motor terminal.
4	Motor_Common	High voltage output	Connected to the black motor terminal.
5	Motor_Down	High voltage output	Connected to the red motor terminal.
6	Motor Connected	Input	Safety input; shorted to pin 1 in order to verify the motor connection and prevent the driver operation without the motor.
7	Gnd	Power supply ground	Shorted to the shield
8	N.C.	Not used	
9	N.C.	Not used	

Table 8: I/O Port Pin Out

Pin	Name	Function	Description
1	V_In_Pos	Input	0 to 10VDC Analog control
2	Gnd	Ground	
3	Fault	Output	See section 2.6
4	Gnd	Ground	
5	SPI_Select	-	Disabled
6	Direction	-	Disabled
7	SPI_Data	-	Disabled
8	Acs_Int_Mode	-	Disabled
9	Gnd	-	Disabled
10	Set_Com_1	-	Disabled
11	-10V	Output	-10V supply for external device (Joystick)
12	Emergency_Stop	Input	Safety shut down See section 2.5
13	User_Voltage	Input	External power supply for the opto-isolated type inputs
14	V_In_Neg	Input	0 to -10VDC Analog control
15	Gnd	Ground	
16	Step_Mode	Input	Step mode selection
17	Brake_In	Input	Disables driver operation (without resetting)
18	SPI_Clock	-	Disabled
19	Set_Offset_Level	Input	Read command and remember as offset.
20	Enable_Sign_In	Input	When shorted to ground, the Enable_In input is active high. Otherwise, Enable_In is active low
21	NC		
22	Set_Com_2	-	Disabled
23	+10V	Output	+10v supply for external device (Joystick)
24	Enable_In	Input	Must be activated to enable driver operation
25	NC		

4.4 Envelope Of Performance (EOP) Considerations

As earlier described (section 1.3), when operating the driver in the Brake Off mode, the motor consumes power at all times, even when the control command voltage is zero, thereby reducing the thermal EOP.

Figure 8 on the next page describes the motor velocity-force curves with the allowed operation duty cycle and continued operation.

Important: If a Break Off mode is desired while working in vacuum, the following operating regime must be maintained: within the specific duty cycle stated in the chart, once the “maximal continuous operation time” has elapsed, the motor must be disabled and allowed to cool off for at least 400 seconds.

For example, looking at curve C, in vacuum, with the break off: after 280 seconds of working at the 45% duty cycle specified, the motor must be disabled for at least 400 seconds to cool off. This is true also if a smaller duty cycle is maintained.

Thermal EOP with AB5 driver					
	Duty-Cycle			Maximal continuous operation time [sec]	
Curve	Ambient - 25°C **Break Off**	Ambient - 25°C **Break On**	Vacuum **Break On**	Ambient 25°C	Vacuum
A	100%	100%	56%	-	500
B	100%	100%	54.0%	-	450
C	100%	100%	45.0%	-	280
D	100%	100%	33.0%	-	170
E	99%	99%	23.0%	-	100
F	53%	58%	15.0%	170	66
G	33%	48%	11.0%	77	44
H	17%	28%	6.5%	32	25

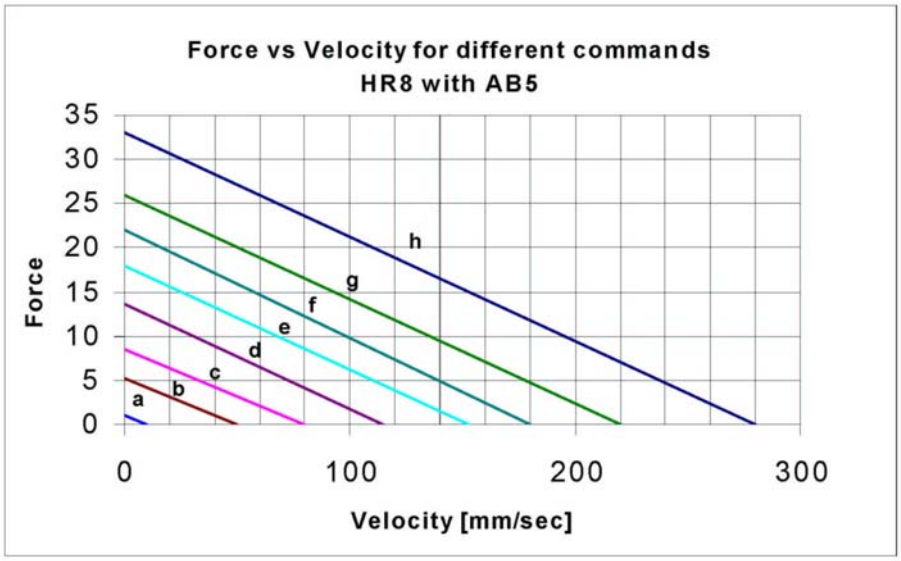

Figure 8: EOP Considerations