TRUST™
AUTOMATION, INC.

TA333-E01

MEDIUM POWER LINEAR SERVO DRIVE

OPERATING MANUAL

Revision v 1.0

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Do not attempt to service this product yourself except as authorized and explained in this operation manual. Failure to follow recommendations may result in product and/or personal injury.

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1.0 Features and Setup

1.1 Introduction

The TA333-E01 is a 4th generation Trust Automation Linear Drive featuring a true Class-AB linear amplifier with pure analog throughput at virtually infinite resolution and is free from digital conversion losses. This versatile Linear Drive is an excellent choice for a variety of different servo motors and applications that require high resolution positioning and/or ultra low noise applications with sensitive measuring equipment, (e.g. transducers, sensors, etc.)

The TA333-E01 is a highly configurable device with four common configuration modes:

- Drive one brushless motor using external sinusoidal commutation.
- Use Hall Effect sensor feedback for smooth internally commutated trapezoidal operation.
- Supports one or two brush or voice coil type motors.
- Drive a two coil stepper motor under sinusoidal control.

The TA333-E01 features Digital on-the-fly gain control (Dynamic Transconductance or DTS). This allows an application to modify the drive transconductance on-the-fly, permitting both high acceleration control and high resolution control. Normally one of these parameters is sacrificed in favor of the other due to DAC limitations at the driving motion controller.

Why use a Trust Automation linear amplifier?
The majority of motion control applications use PWM (Pulse Width Modulated) drives. PWM drives are very efficient, but are electrically noisy as they operate by pulsing the motor at full supply voltage at typical frequencies of 4 kHz to 30 kHz. This pulsing tends to saturate everything electrically in the surroundings, often including the intended operation. A second side effect of using PWM drives shows up in ultra-high precision systems requiring nanometer precision. Due to the pulsing nature of the PWM drive, the motor will tend to dither causing position error that cannot be tuned out.

The TA333-E01 features a true Class-AB linear power stage with a fast current feedback loop to put it in torque mode. This means that the output is a pure current signal with virtually no distortion around zero, eliminating all of the side effects of a PWM drive. Some Class-C linear designs, which have a dead band at zero volts out, attempt to mask this with a fast current loop. This works for some applications, but performance will suffer in ultra-high precision applications.

Two important considerations where linear servo amplifiers are utilized are cooling and power supply selection. A linear servo amplifier acts similarly to a large electronic variable resistor. Any power supply voltage not delivered to the load is dumped as heat into the heatsink. Power supply voltages should be matched closely to the required load voltage with a small margin for overhead. Excessive supply voltage will result in amplifier overheating. Cooling linear servo amplifiers is often overlooked or not well understood. Many products are available with similar current output specifications, but require the user to supply heatsinks or fans. The TA333-E01 incorporates a large heatsink with integral cooling fans to accommodate most demanding applications provided there is adequate air space around the chassis and the ambient temperature does not exceed specification. The TA333-E01 intelligently monitors temperature and compensates its internal dissipation to protect the drive from damage due to high temperatures. The TA333-E01 has a serial diagnostics port to monitor application performance and power levels to aid in assuring optimal performance and a long life.

All Trust Automation drive products are built for safety, installation ease and long life. The TA333-E01 offers a fully isolated user interface for safe operation in high voltage applications. In addition the housing reduces the risk of operator injury and protects the drive, ensuring longer useful life. All connections utilize pluggable terminal connectors making them easy to install and remove while reducing risk of connection error.

1.2 Setup

The TA333-E01 is configurable for several drive motor type options and configurations. All configurations require the use of bipolar supplies that can be in the range of 24 to 100V. Current outputs are adjustable from 10 to 25A.

Some of these options are shown in the application example section.

1.3 Drive Modes

Sinusoidal

Sinusoidal commutation of three-phase brushless servo motors plus a linear drive power stage eliminates the familiar cogging and torque ripple problems that plague most trapezoidal digital drives. Control is consistent and smooth at any velocity.

In sinusoidal mode, the TA333-E01 is designed to accept two command signals (A and B @ ±10V) from a motion controller that is performing the commutation based upon encoder feedback. The TA333-E01 derives the third phase internally (C = - (A+B)). (See application example 5.1)

Trapezoidal
Trapezoidal operation is the simplest configuration used to drive a DC brushless motor. The TA333-E01 reduces the audible tick often associated with Hall commutation by smoothing the transitions without sacrificing performance. As a practical limitation, Hall commutation is limited to ~ 3 kHz throughput. In this mode, the motors Hall Sensors are connected to J4. If the motor has differential Hall outputs, only connect the “+” Hall outputs to J4 and leave the “–” Hall signals unconnected. (Do not tie to ground, the motor will be damaged.)

The motion command signal (±10V) is connected to the “A” command input. (See application example 5.2)

Brushed-Bridge
Brushed-bridge mode supports operating a traditional brushed or voice coil-type motor, bridged across the A & C output phases. The command signal (±10V) is connected to the “A” command input. (See application example 5.3)

Brushed-Dual
This mode supports driving two independent brushed or voice coil-type motors. This mode could also be used to drive a stepper motor in sinusoidal mode. The first motor (winding) would be connected to the “A” phase output and the common ground of the bipolar power supply. The second motor (winding) would connect to the “B” phase output and the common ground. The command inputs (±10V) are connected to the “A” and “B” command inputs. (See application examples 5.5 and 5.6)

1.4 Command Input

Motion command connections to the TA333-E01 are made at J3. Inputs are provided for two of the three phases (A and B) and the TA333-E01 can derive the third phase (C = - (A+B)) in sinusoidal applications. The inputs are common-mode terminated at 10K and there is no need to ground an input if it is unused. The input range is set to ±10V commands.

Differential Inputs
Using differential input helps reduce or eliminate potential noise susceptibility from other sources. Connect the motion controller ± command outputs to the TA333-E01 ± inputs at J3. For best immunity use a twisted pair cable. Terminate the motion controller signal ground to the TA333-E01 ISO ground connection at J3. (See application examples 5.1)

Single-Ended Inputs
Many motion controllers only offer single-ended command signals with a common ground. Single-ended configurations are accommodated by referencing the A+ and B+ signals to the command output and referencing the A- and B- signals to the motion controller signal ground. It is good practice to use a twisted pair cable for the "+" command, terminating the "-" command at the controller signal ground. Terminate the motion controller signal ground to the TA333-E01 ISO ground connection at J3. (See application example 5.3)

1.5 Upgrading from a TA320 or TA333-D01

When changing a preexisting application from a TA320 or TA333-D01, the command signal polarity must be reversed to maintain the application's direction of motion.

The original TA320 and TA333-D01 linear amplifiers operated with inverted outputs, meaning a positive command induces a negative current. The TA333-E01 is a non-inverting amplifier (positive command = positive current)

Examples:

- Differential inputs would place the motion controller's + signal on the TA333-E01 – command input and the controller's – signal on the TA333-E01 + command input.
- Single-ended configurations place the motion controller's command output on the TA333-E01 - command inputs and terminate the TA333-E01's + command inputs to the motion controller's signal ground and the TA333-E01 ISO Ground connection.

1.6 Transconductance Ratio

The TA333-E01 operates in current mode (commonly referred to Torque mode). For a given input voltage, the TA333-E01 will output a proportional current by raising the output voltage until the commanded current is drawn. As current flow in a motor is directly proportional to torque, it is common to refer to this as "Torque mode". The ratio between the command voltage and the output current is referred to as the "Transconductance Ratio," which is measured in amps per volt and is expressed by the following equation:

$$gm = Io / Vc$$

gm = current gain (Transconductance)
Io = output current
Vc = command voltage

Example:

If: Io desired = 15A and Vc (max) = 10V

Then: gm = 15 / 10 or 1.5A/V

For every 1 Volt of command 1.5A of current will be driven.

Note: *Current output is limited by Ohm's Law (I = Vsupply / Rmotor)*

TA333-E01 is factory configured for 10A, 15A, 20A and 25A for a commanded input voltage of ±10V, set at SW1, positions 3 and 4. (See table 4.9)

Note: *25A output duration is limited by the SOA graph and temperature. (See SOA section 2.4)*

Custom Transconductance ratios can be preset by the factory. Please contact support@trustautomation.com to discuss your requirements.

1.7 Thermal Limits

The TA333-E01 is internally thermally protected with integral variable speed cooling fans. The heatsink temperature is monitored and the fan speed is automatically adjusted to maintain a safe operating temperature. If the heatsink temperature rises to 70°C, a FAULT output is generated but the drive will continue to operate. If FAULT is ignored and the heatsink temperature rises to 90°C, the drive will shutdown. When the heatsink temperature drops below 40°C, the drive can be re-enabled by toggling the enable line.

1.8 Dynamic Transconductance Selection

A feature pioneered by Trust Automation, Dynamic Transconductance, or DTS, enables on-the-fly changes to the transconductance settings. This feature is advantageous in frictionless systems (i.e., air bearing systems) where start, stop and turn around currents are high, but moving currents are very low.

Due to the digital nature of most motion controllers there is limited DAC resolution to cover both the high and low currents with sufficient resolution. By switching the transconductance on the fly, the motion controller's DAC can be utilized at its full resolution for both high current moves and precision motion.

The DTS inputs are logically "OR"ed with the DTS switch inputs. In this way a highest current setting can be chosen by the switches and logic can "OR" with this data to set a lower setting.

The TA333-E01 accomplishes this by allowing the motion controller to logically control the DTS bits D0 and D1 through pins 5 and 6 of J3 (5V TTL).

1.9 Enable Input

The ENABLE input can be selected as active-high or active-low logic at SW1 position 1. (See table 4.8)

The input must be pulled to logic low (ISO GND) or logic high (ISO +5) for the TA333-E01 to operate. The ENABLE line is pulled up internally to ISO +5. The TA333-E01 provides an isolated +5V source at connector J3 and J4 with a maximum draw of 100mA. If the application requires more current, the user must supply an external 5V that must be referenced to the ISO ground connection.

The TA333-E01 must not be enabled during power up. If the drive is powered up when enabled, the drive will not enable and will assert FAULT. The ENABLE input must then be cleared and re-asserted to enable the drive.

Note: *A minimum sinking capability (IOL) of 5mA is required.*

Note: *Logic low input minimum voltage (VIL) is 0.8V. Logic high input minimum voltage (VIH) is 2.0V with a maximum on 5.2V.*

See circuit in the following figure:

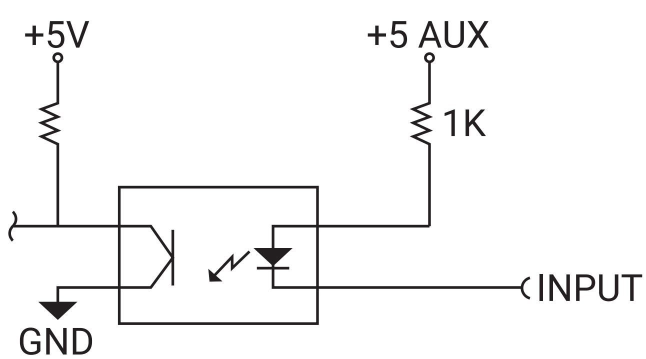


Figure 1 - Enable Circuit

1.10 Fault Output

The TA333-E01 FAULT output is selectable as active-high or active-low logic, set at SW1 position 2. (See table 4.8) The TA333-E01 will assert FAULT upon over-current or thermal overload based on the SOA graph. (See section 2.4) Past FAULT information is stored in internal memory and may be accessed at the serial monitoring port. (See section 1.16)
Note: Logic output high minimum voltage (VOH) is 2.5V. Logic output low maximum voltage (VOL) is 0.8V.

See circuit in the following figure:

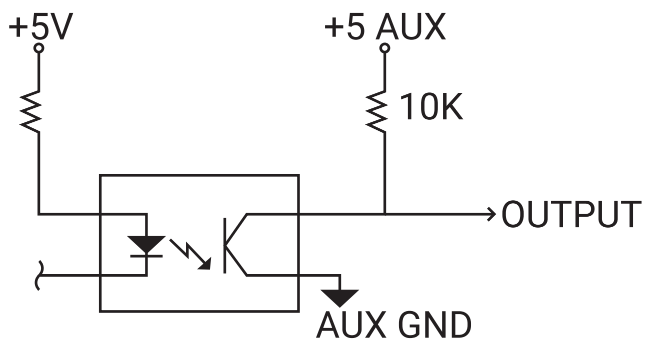


Figure 2 - Fault Circuit

1.11 Ground Connections

Command and Signal Logic

Connections to a motion controller must be referenced to ISO ground at J2. These signals include Enable, FAULT, DTS and the analog command inputs. For single-ended command signals, reference the TA333-E01 command A- and B- inputs to ISO ground on connector J2.

ISO Ground and all user interface signals on J2, J3 and J4 are isolated from drive power GND and the External 24V GND with a minimum 1500V High-pot separation.

1.12 Drive Power Supply

A pair of matching power supplies (24V to 100V) must be used to power the TA333-E01. A high quality switching supply is suitable for most applications. These supplies tend to be small, affordable, and highly available. Trust Automation recommends supplies with an output ripple less than 100mV. Some high quality supplies available offer less than 50mV. In some cases, particularly where there is great concern for noise interference, a linear power supply, regulated or unregulated, will be required. For unregulated supplies, verify that the voltage supplied either at V+ or at V- does not exceed the absolute maximum supply voltage of 100V. Also note that the supplies must be within 12V of each other or a supply fault will be generated.

When using the TA333-E01 or any linear servo amplifier, power supply voltage that is not delivered to the motor will be lost as heat in the amplifier. (See section 1.14)

When selecting supplies for a given motor application it is recommended that the total voltage be approximately 20V more than the required motor voltage. (The TA333-E01 can drive to within ~ 8V of the supply). Excessive supply voltages will result in higher peak wattage dissipation. Reference the SOA graph for actual currents allowed. (See section 2.4)

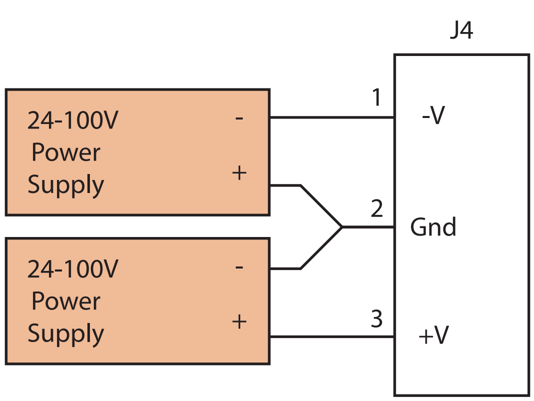


Figure 3 - Drive Power Connection

Connect the positive supply positive (+) to V+ and the positive supply negative (-) to GND. Connect the negative supply positive (+) to GND and the negative supply negative (-) to V-. (See figure 3 above)

Note: *When designing a system E-stop, never cut the motor leads. Doing so will result in a runaway condition and may damage the TA333-E01. Always cut the incoming DC supply, (crowbar with a low value resistor), to the TA333-E01 to produce a rapid stop.*

1.13 Optional external 24VDC Supply

The TA333-E01 internal logic may optionally be powered by an external 24VDC (±5%) source for convenience when using serial monitoring or in extremely noise sensitive applications. The external power connection is at J1. The internal 24V source provides power by default automatically but is disabled if an external source is connected.

1.14 Power Dissipation Calculations

Since the TA333-E01 Power stage is linear, voltage not applied to the motor is converted directly to heat. Heat generated by the drive is directly proportional to the voltage drop (across the amplifier) multiplied by the motor current. (Think of a linear amplifier as a large variable resistor, current out = current in.) Heat dissipation is a critical factor when the motor is in a stalled motion condition. (low voltage at the motor, but high current output). The heatsink is limited to a maximum of 600W continuous dissipation. Peak dissipation is limited to 1350W for a very short time period (<1ms). A practical design should limit peak dissipation to 1000W or less. Actual dissipation limits depend on specific conditions including temperature, load dynamics and event time. For most accurate peak dissipation allowable, see the SOA chart, section 2.4.

The TA333-E01 features a microprocessor that constantly monitors the wattage across the drive to protect the Class-AB power stage from damage. At any given moment in time there is one power device (upper or lower) that is handling the majority of the drive wattage regardless of whether the load is a floating brushless motor or a ground-referenced brushed-type load. Calculations are based on the highest current and voltage across any phase with respect to the power supply ground.

When predicting SOA wattage limits with a brushless motor (or single brushed-type motor in bridge mode), use half of the expected voltage across any pair of phase leads against the voltage of one of the two supplies.

For a brushed-type load that is directly referenced to the power supply ground, use the full predicted voltage across the motor against one of the two supplies.

Brushless example:
Assume you have a pair of 72V supplies and a motor that is expected to require 15A peak load at a phase voltage requirement of 20V according to our calculations. Because a brushless motor voltage is specified as phase to phase, we will divide the predicted voltage in half to give a ground referenced motor voltage of 10V.

PD = Imotor (Vsupply – Vmotor)

Imotor = 15A [calculated based on required torque]

Vmotor = 10V [calculated based on velocity]

Vsupply = 72V [one of two 48V supplies]

PD = 15A (72V-10V)

= 930W *

** This is just over the 600W continuous dissipation rating so there will be a short time limit applied based on the SOA chart before a fault will be generated. See the SOA chart, section 2.4.*

Dual brushed example:
Assume a pair of 48V supplies and a motor that is expected at any one time to require 10A peak load at a phase voltage requirement of 12V according to calculations. Because the motor(s) are referenced to the power supply ground, the calculations are based on the full motor voltage.

PD = Imotor (Vsupply – Vmotor)

Imotor = 10A [calculated based on required torque]

Vmotor = 12V [calculated based on velocity]

Vsupply = 48V [one of two 48V supplies]

PD = 10A (48V-12V)

= 360W *

** This is under the 600W continuous dissipation rating, but the current is over the 6A continuous, so there will be a time limit applied based on the SOA chart before FAULT is generated (10A @ 30c = ~3.2sec before fault). (See SOA chart, section 2.4)*

1.15 Motor Connections

The TA333-E01 motor connections are made at connector J5. The available output voltage is limited to the supply voltage, less approximately 8V off each rail. With ±48V supplies, there will be 80V available across the motor before the output starts to clip. Pin 1 on J5 is earth ground and is electrically isolated from all power connections. By physically connecting the TA333-E01 chassis and the motor chassis to an earth ground, immunity from external noise sources is increased.

Note: *When designing a system E-stop, never cut the motor leads. This will result in a runaway condition and may damage the TA333-E01. Always cut the incoming DC supply, (crowbar with a low value resistor) to the TA333-E01 to produce a rapid stop.*

Brushless motor

The phase outputs, A,B and C correlate to most motor callouts as U, V and W and in some cases they are referred to as R, S and T. *(See application examples 5.1 and 5.2)*

Brushed motor in Bridged mode

To drive a single brush type motor in bridged mode, connect the motor (+) lead to the A phase output and the motor (–) lead to the C phase output. This configuration allows the full bipolar supply voltage to be driven across the motor in any direction of rotation. The motor can be a traditional brush type motor or a voice coil type.

(See application example 5.3)

Dual Brushed Motor Mode

Two independent motors or one stepper type motor may be driven in this configuration. For two brushed-type motors (or voice coils) connect the (+) lead of the first motor to the A phase output (drive with the A command) and connect the (–) lead to the power supply common (Pin 2 on J6). Connect the second motor (+) to the B phase output (drive with the B command) and the (–) lead to the power supply common. (See application example 5.5)

Stepper Motor

Two coil sets on a stepper type motor may be driven in this configuration. This configuration is the same as the dual brushed mode except that the two coil sets are in the same motor. The linear commands are driven on command A and B with a motion controller setup to drive a stepper motor sinusoidally. (See application example 5.6)

1.16 Serial monitoring

The TA333-E01 has a high speed data port for monitoring drive performance and logging of fault conditions. The five pin port at J2 provides access to a TTL serial data stream presented at 230,400 baud. Set up a terminal program (such as HyperTerminal) with the baud rate set to 230,400 bits per second, 8-bit data, no parity, 1 stop bit, and flow control to no handshaking.

An optional TTL to USB serial cable may be ordered as CBLZ-0910-01 to facilitate connection to a PC.

Reference the FTDI installation guide for installing the TTL to USB serial cable. (www.ftdichip.com VCP drivers)

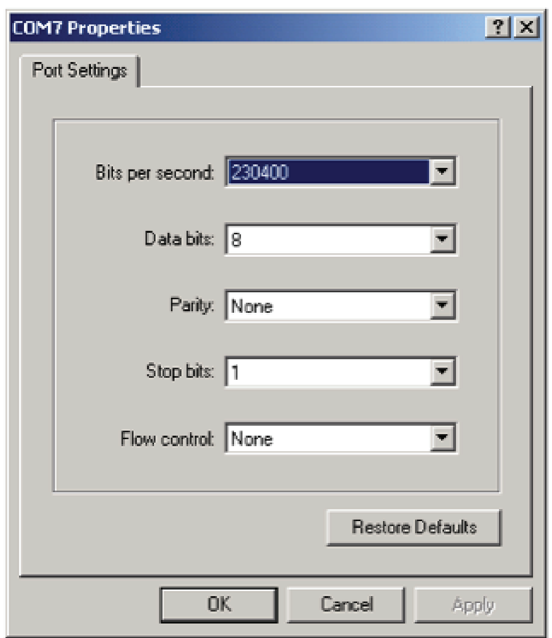


Figure 4 - Com Port Settings for Serial Communication

```
TA333 R 1.4
Brushless Mode
```

Figure 5 - Firmware Version and Drive Mode

Once the TA333-E01 in enabled, data will begin transmitting in the following format:

```
Faults, Temp, Phase, +Supply, -Supply, Current, Wattage

0x0000,22,1,24,-24,0,9
0x0000,22,1,24,-24,0,9
0x0000,22,1,24,-24,0,9
0x0000,22,1,24,-24,0,9
0x0000,22,1,24,-24,0,9
0x0000,22,1,24,-24,0,9
```

Figure 6 - Data Transmission Format, HyperTerminal

Figure 6 shows the drive is set to brushless motor mode, there are no faults, the heatsink is at 22°C, the positive supply is at 24V and the negative supply is at 24V. There is less than 1A current flow and integer math has placed the dissipation at 9W.

The data stream may be stopped by transmitting “**s**” followed by “Rtn.” The data stream will resume upon sending the “**s**” + “Rtn” sequence again. Data layout is formatted as:

Data field	Data Name	Description
1	Fault	Amp fault data (See fault chart)
2	Temp, Celsius	Temp. of heat sink, SOA de-rated as temperature rises
3	Phase Voltage	The captured phase voltage
4	+ Supply V	Positive supply voltage
5	- Supply V	Negative supply voltage
6	Phase Current	The highest captured phase current
7	Wattage	Amp dissipation wattage based on data gathered

Table 1 - Data Transmission Format

Faults are formatted as:

Fault	Data Name	Description
0x0000	No Fault	Operation Normal
0x0002	Temp	Over temp fault at 70c, the TA333-E01 will disable at 90c
0x0001	Supply	Under voltage at 20V, Over voltage at 80V
0x0004	Current	Over current fault based on time limit and SOA
0x0008	Wattage	Over continuous wattage based on time and SOA
0x0010	Peak Wattage	Peak wattage limit based on time and SOA
0x0020	Enable	Enable fault if drive is powered up in the enabled state

Table 2 - Fault Codes

The TA333-E01 captures the last ten fault conditions that have occurred. This data can be accessed by sending “p” followed by “Rtn” either before enabling or after sending the stop (“s”) command.

```
0x0021,28,1,1,1,0,0
0x0020,0,0,0,0,0,0
0x0020,0,0,0,0,0,0
0x0001,28,14,60,1,3,138
0x0001,28,1,1,1,0,0
0x0001,28,1,3,-3,0,0
0x0001,28,1,5,1,0,0
0x0020,0,0,0,0,0,0
0x0020,0,0,0,0,0,0
0x0021,28,1,2,-12,0,0
```

Figure 7 - Sample Fault Printout

If the TA333-E01 is powered up with the optional 24V input and the enable signal is active, two faults will be generated. The first reported fault will be 0x0020 enable fault followed by 0x0021, indicating there is a supply fault in addition to an enable fault.

2.0 General Specifications

2.1 Electrical Specifications

Feature	Units	Value
Supply Voltage (Bipolar)	V	± 24 – ± 100V
Equivalent Motor Voltage	V	0V to 200V - 8V
External 24V Supply	VDC	24 ± 5% @ 1.0A
Maximum Output Current	A	25 (See SOA Chart section 2.4)
Continuous Output Current	A	6 RMS (8.6 Peak)
Quiescent Bias Current	A	~0.5 (Class A/B biasing current)
Fault	V	5V TTL Level 0 or 1
Enable	V	5V TTL Level 0 or 1
Command Input	V	±10 (±12 absolute max)
Command Input Impedance	kΩ	10
Torque Gain	A/V	1.0 - 2.5
Bandwidth	kHz	5.0 (0.820mh / 0.65 Ω Load)
Harmonic Distortion THD	%	0.036 (Voltage to Current)
Signal to Noise ratio SNR	db	-79.06 (1A @ 1Khz)
Trapezoidal Bandwidth	kHz	3.0 (Consult factory for higher speeds)
Min Load Inductance	mh	0.100
Min non-inductive load	Ω	2.0

Table 3 - Electrical Specifications

2.2 Mechanical Specifications

Feature	Units	Value
Length	in (cm)	14.90 (37.85)
Width	in (cm)	7.69 (19.53)
Height	in (cm)	4.70 (11.94)
Weight	lb (kg)	13.5 (6.12)

Table 4 - Mechanical Specifications

2.3 Environmental Specifications

Feature	Details
Maximum Altitude	6,560ft (2,000 meters)
Temperature (ambient)	
Normal operation	5° C to +40° C
Temperature de-rating	See SOA Chart – Section 2.4
Storage	-40° C to +70° C
Heatsink	+70° C Maximum
Heat Dissipation (@ 25° C)	
Continuous	600W
Peak	1350W, See SOA Chart – Section 2.4
Airflow	Internal fans, variable speed, thermally controlled
Humidity	
Operating	10% to 70%, non-condensing
Storage	10% to 95%, non-condensing
Pollution Degree 2	Non-Conductive, non-condensing

Table 5 - Electrical Specifications

2.4 TA333-E01 Safe Operating Area Curve (SOA)

The TA333-E01 features a microprocessor that constantly monitors the operating conditions on the amplifier to prevent damage. This processor continuously calculates the dissipated wattage and sets a fault threshold based on heatsink temperature, supply voltage and motor current. The formulas for calculated limits are current, wattage and temperature.

Current Limit

For currents that result in a dissipation wattage below 600W, the processor limits the time logarithmically from infinite time at 6A down to 500ms at 25A (see current vs. time graph).

Wattage Limit

If the resulting dissipation wattage exceeds 600W, the time to fault is much shorter as it is now operating in the “knee” of the SOA curve (See wattage vs. time graph)

Temperature limit

The microprocessor also takes into account the heatsink temperature when calculating the wattage time limit. Time to fault is de-rated at about 15ms per 20°C rise. If the heatsink temperature exceeds 70°C a Fault will be generated, and at 90°C the drive will shutdown.

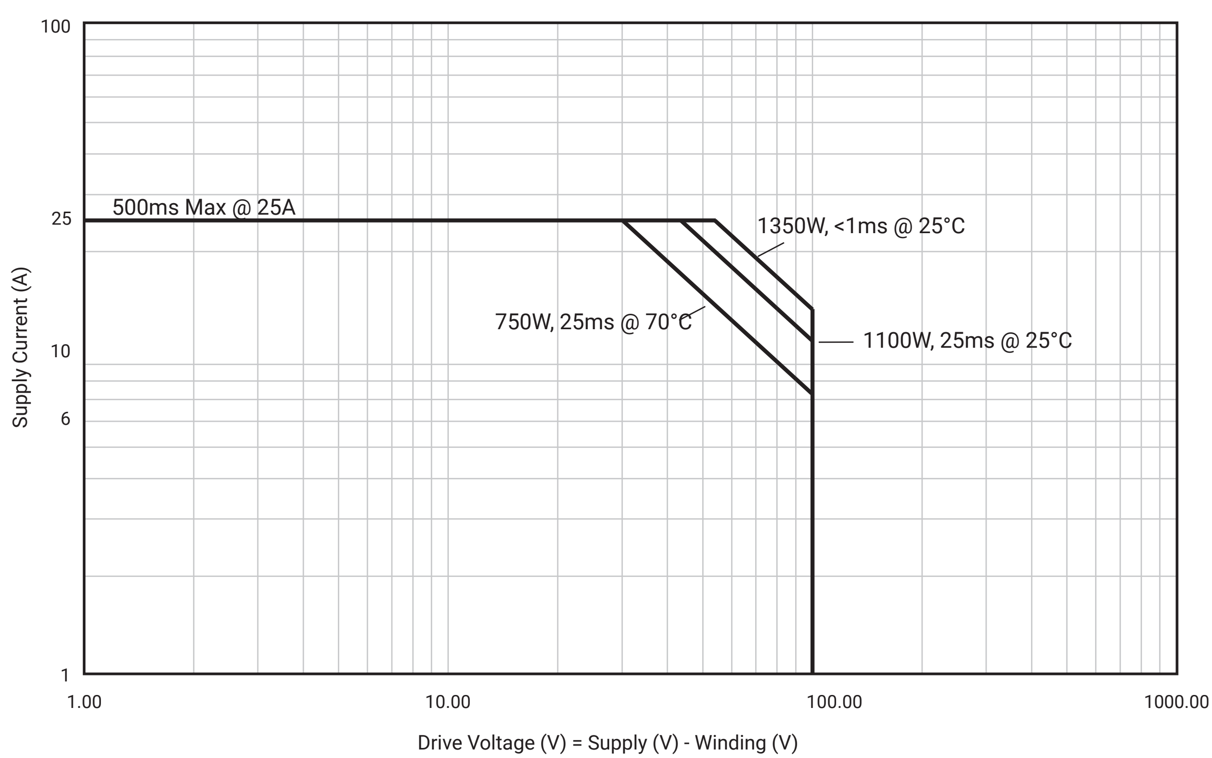


Figure 8 - TA333-E01 SOA Curve

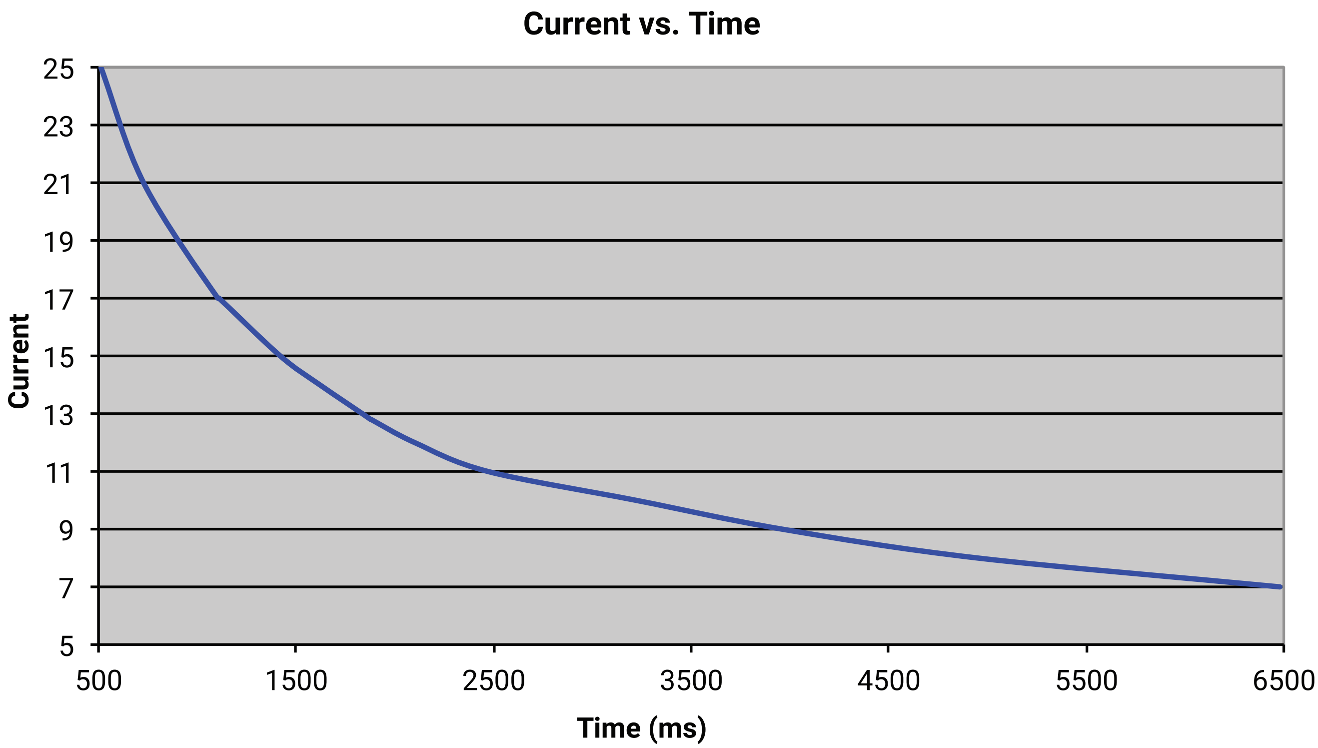


Figure 9 - Output Current vs. Time Graph for Time to Fault at ~30˚C

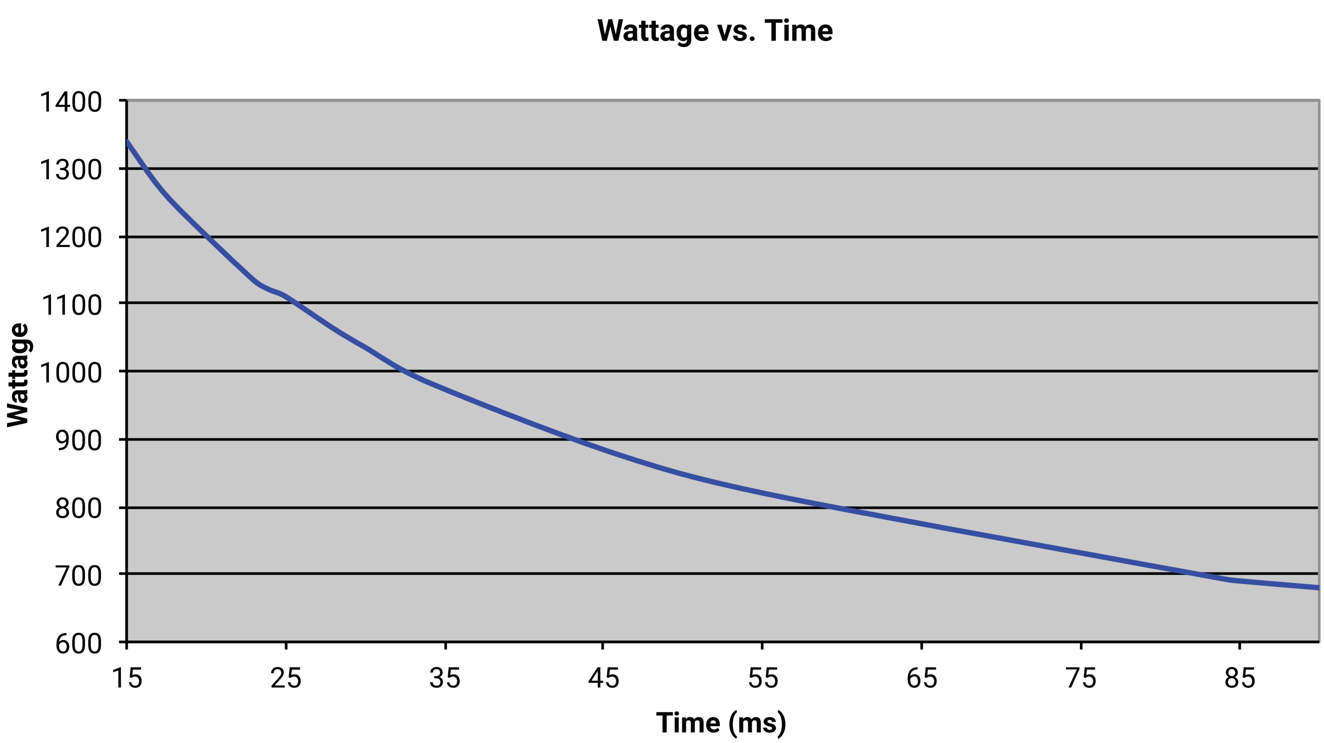


Figure 10 - Dissipation Wattage vs. Time for Time to Fault at ~30˚C

Power (W) min	1	401	496	612	694	743	801	901	1001	1101	1148	1201	1258	1321	1390	1467	1553	1651	1761	1886	2031	2201
Power (W) max	400	495	611	693	742	800	900	1000	1100	1147	1200	1257	1320	1389	1466	1552	1650	1760	1885	2030	2200	2400
Temp	Continuous										Operational (ms)											
25°C							45	33	25	22	20	17	15	13	11	9	8	7	5	4	3	3
30°C						58	41	31	23	21	18	16	14	12	10	9	7	6	5	4	3	
35°C					66	53	38	28	21	19	17	15	13	11	9	8	7	6	5	4		
40°C				73	60	48	34	25	19	17	15	13	11	10	8	7	6	5	4			
45°C				66	54	43	31	23	17	15	14	12	10	9	8	6	5	5				
50°C			84	59	48	39	28	20	16	14	12	11	9	8	7	6	5					
55°C			74	52	43	34	24	18	14	12	11	9	8	7	6	5						
60°C			65	45	37	30	21	16	12	11	9	8	7	6	5							
65°C			56	39	32	26	18	14	10	9	8	7	6	5								
70°C		85	47	33	27	22	15	11	9	8	7	6	5									
>70°C	Operational (ms)													Shutdown								

Figure 11 – Temperature Derating, Time to Fault for Dissipation Wattages vs. Heatsink Temperature

Example (How to use the above chart)
If wattage is between 1101 to 1147 @ 60°C, then you have 11ms before the unit will shut down.

2.5 TA333-E01 Output Frequency Response

The TA333-E01 design provides a relatively flat current output response up to 5 kHz for most motors.

Lower inductance motors (0.10mH) will yield a higher bandwidth and higher inductance motors (10-15mH) will yield a lower bandwidth. There is no actual limit on how high the inductance can be, but there are practical limitations based on Ohm's Law that limit actual bandwidth response in a motor. Excessively low inductances (<0.1mH) can result in current loop instability and result in uncontrolled oscillations.

The TA333-E01 has been factory tuned to give optimal performance over a wide variety of industry standard motors. If the intended application for the TA333-E01 requires a motor outside the usual inductance range, and the full 5 kHz throughput is required, please contact support@trustautomation.com to discuss your requirements.

The following was plotted with a 1V command into a 0.820mH load with a DC resistance of 0.65Ω.

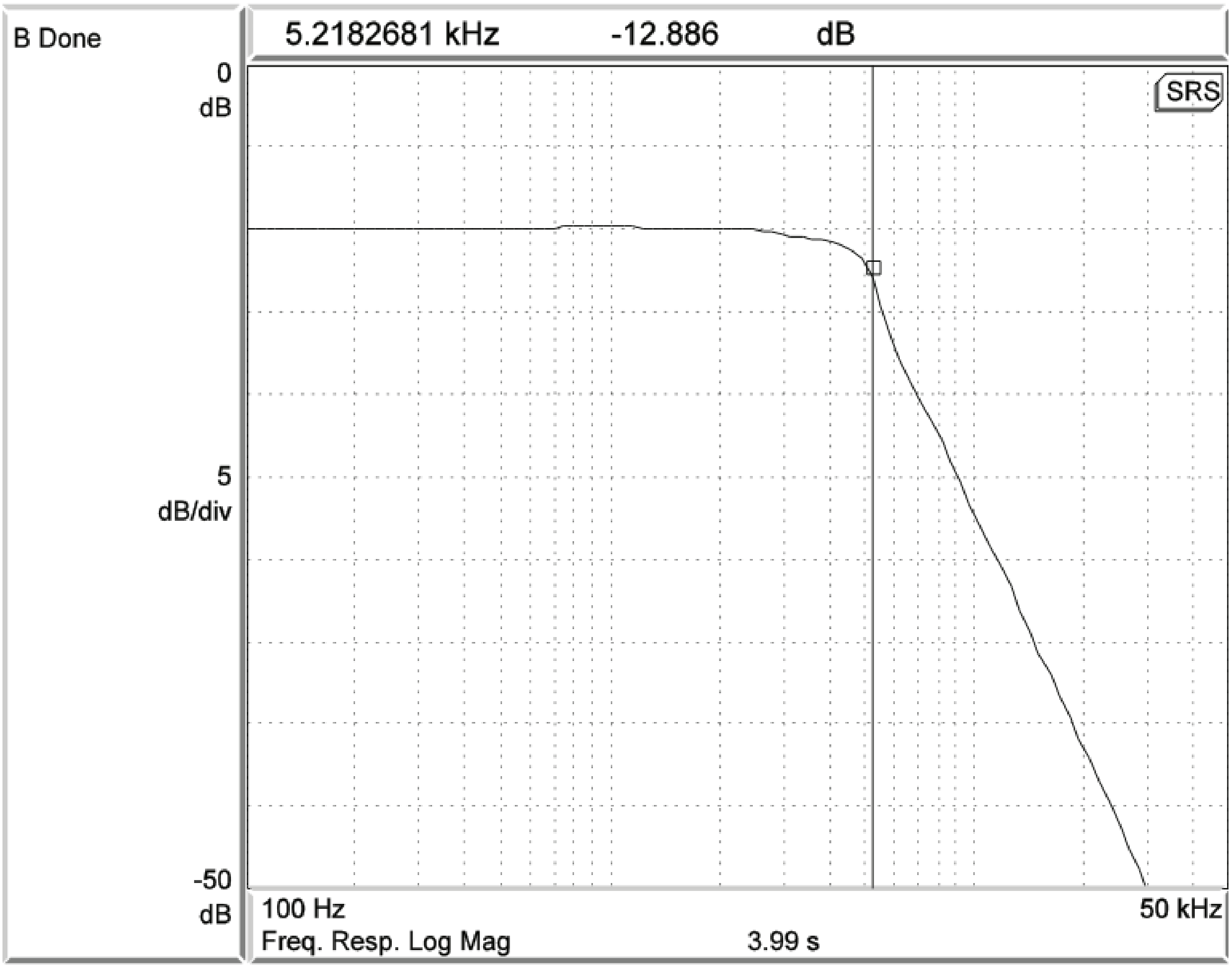


Figure 12 - TA333-E01 Frequency Response

3.0 Mechanical Information

The TA333-E01 must be mounted in such a way that there is clear airflow into and out of the heatsink and integral cooling fans. Ideally there would be at least 4” of clearance on both ends. For best results mount the TA333-E01 vertically with the nose up (air flow exit), to take advantage of the chimney effect of heat rising.

3.1 Dimensions

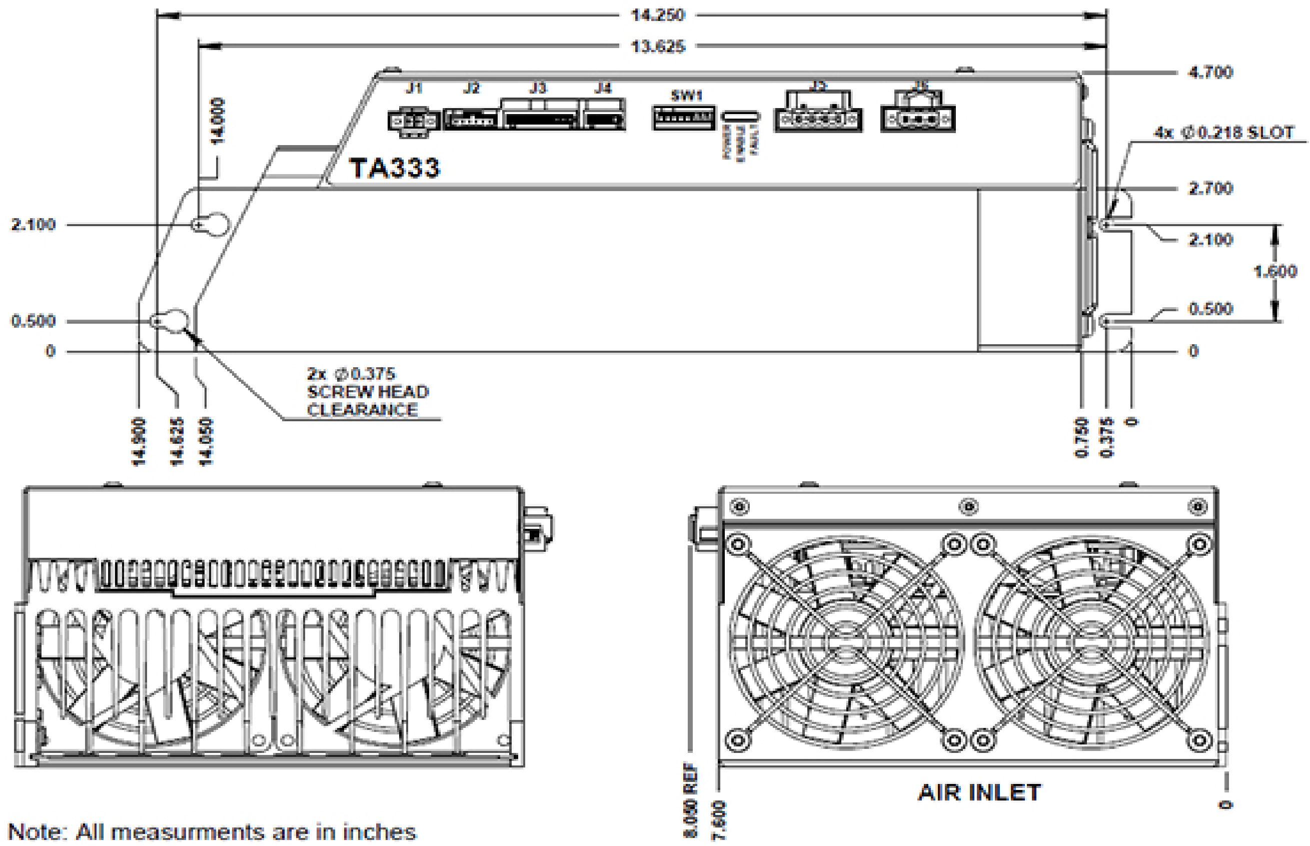


Figure 13 - TA333-E01 Mechanical Dimensions

4.0 Connector and Switch Information

4.1 Front Panel Connector and Switch Layout

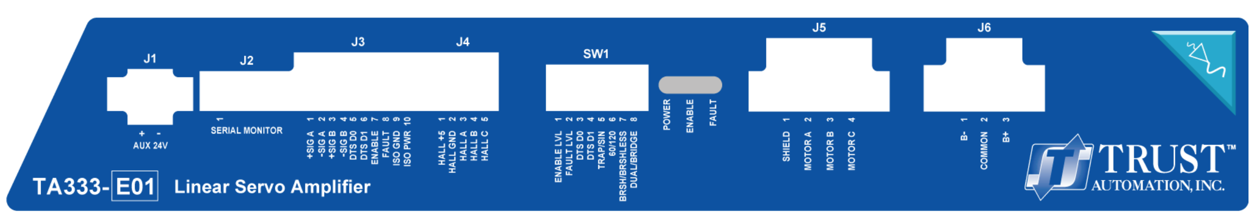


Figure 14 - TA333-E01 Front Panel

4.2 Connector Types

Connector #	# Pins	Manufacturer & Part Number	Description
J1	2	Phoenix 1827703 (Supplied by TA)	External 24VDC Supply
J2	6	FTDI P/N TTLUSB (Orderable Option, no connector supplied for J2)	TTL to USB
J3	10	Wago P/N 733-110 (Supplied by TA)	Command Signals
J4	5	Wago P/N 733-105 (Supplied by TA)	Hall Sensors
J5	4	Phoenix 1825336 (Supplied by TA)	Motor Signal
J6	3	Phoenix 1777992 (Supplied by TA)	Motor Power

Table 6 - Connector Types

4.3 J1 – External 24VDC Supply

Pin#	Description
1	24V External Supply
2	Common (Isolated)

Table 7 - External 24VDC Supply Connector

4.4 J2 – Serial Monitoring Port

Pin #	Description
1	ISO Gnd
2	CTS (Not used)
3	VISO
4	TXD
5	RXD
6	RTS (Not used)

Table 8 - Serial Monitoring Connector

J2 provides a TTL level serial port to monitor the operating conditions on the load and the internal health of the TA333-E01. The separately orderable TTL Serial to USB cable provides a convenient conversion for viewing the data with any terminal program such as Windows HyperTerminal. (See section 1.16) The J2 connector is not supplied by Trust Automation

4.5 J3 – Command Signals

Pin #	Description
1	Command Signal Input Phase A+
2	Command Signal Input Phase A-
3	Command Signal Input Phase B+
4	Command Signal Input Phase B-
5	Dynamic Transconductance Select Bit D0
6	Dynamic Transconductance Select Bit D1
7	ENABLE (Referenced to ISO Gnd)
8	FAULT (Referenced to ISO Gnd)
9	ISO Gnd
10	VISO (Internally supplied +5V@ 100ma Optical Isolation)

Table 9 - Motor Command Signals Connector

4.6 J4 – Hall Sensor Input

Pin #	Description
1	ISO +5 (20mA Maximum)
2	ISO Gnd)
3	Hall A
4	Hall B
5	Hall C

Table 10 - Motor Command Signals Connector

Note: *If the motor has differential Hall outputs, only connect the (+) Hall outputs to J4 and leave the (–) Hall signals unconnected (Do not tie to ground, the motor will be damaged.)*

Note: *If the Hall sensors require more than 20ma, an external +5V must be supplied. (See application example 5.3)*

4.7 J5 – Motor Signals

Pin #	Description
1	Shield (tied to chassis)
2	Motor Phase A
3	Motor Phase B
4	Motor Phase C

Table 11 - Motor Command Signals Connector

Note: *Phase A, B and C are the same as U, V and W or R, S and T found on most commercial motors.*

4.8 J6 – Motor Power

Pin #	Description
1	B- Supply
2	Common (Isolated)
3	B+ Supply

Table 12 - Motor Power Connector

4.8 SW1 – Switch Settings

Switch #	Function – (0 / Down / On)	Function – (1 / Up / Off)
1	/ENABLE (drive enabled on low Input)	ENABLE (drive enabled on high input)
2	/FAULT (FAULT low true output)	FAULT (FAULT high true output)
3	Gain and DTS Settings	See Following Chart for Function Selection
4	Gain and DTS Settings	See Following Chart for Function Selection
5	Trapezoidal Commutation	Sinusoidal Commutation
6	60° Hall Commutation	120° Hall Commutation
7	Brush type motor (or voice coil)	Brushless type motor
8	Dual Brush type motor (unbridged)	Single Bridged motor (bridged)

Table 13 - Motor Command Signals Connector

4.9 SW1 – Switch 3 and 4, Fixed Gain and DTS Settings

Setting	SW1-3 (DTS D0)	SW1-4 (DTS D1)
10Vin = 10A out	Down (0)	Down (0)
10Vin = 15A out	Up (1)	Down (0)
10Vin = 20A out	Down (0)	Up (1)
10Vin = 25A out	Up (1)	Up (1)
DTS Active	Up (1)	Up (1)

Table 14 - Fixed Gain and DTS Switch Settings

Note: *"Down" is toward the heatsink, "Up" is away from the heatsink*

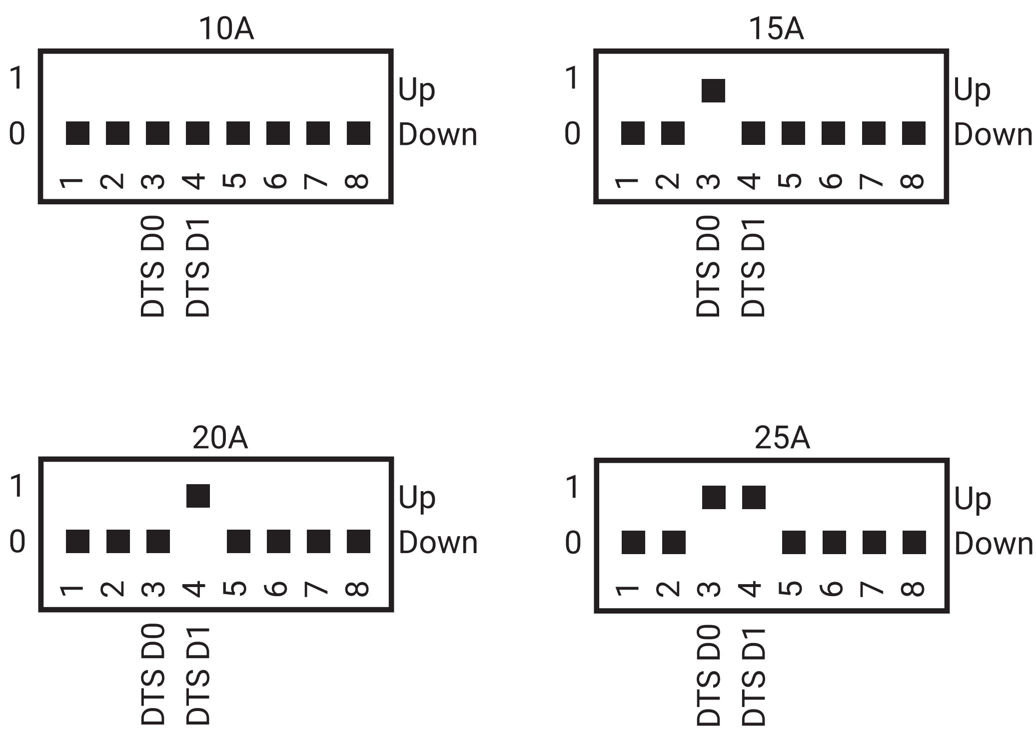


Figure 15 - SW1 DTS Settings

Note: *"Down" is toward the heatsink, "Up" is away from the heatsink*

4.10 SW1 – Switch 5-8 Motor Type

See section 1.3 for more information

Function (Motor type)	SW1-5	SW1-6	SW1-7	SW1-8
Brushless motor, Sinusoidal Commutation	Up (1)	Up (1)	Up (1)	Up (1)
Brushless motor, Trapezoidal Commutation, 120° Halls	Down (0)	Up (1)	Up (1)	Up (1)
Brushless motor, Trapezoidal Commutation, 60° Halls	Down (0)	Down (0)	Up (1)	Up (1)
Single Brushed Motor (or voice coil) Bridged Mode	Up (1)	Up (1)	Down (0)	Up (1)
Dual Brushed Motor (voice coil or stepper) (unbridged)	Up (1)	Up (1)	Down (0)	Down (0)

Table 15 - SW1 Motor Type Selection

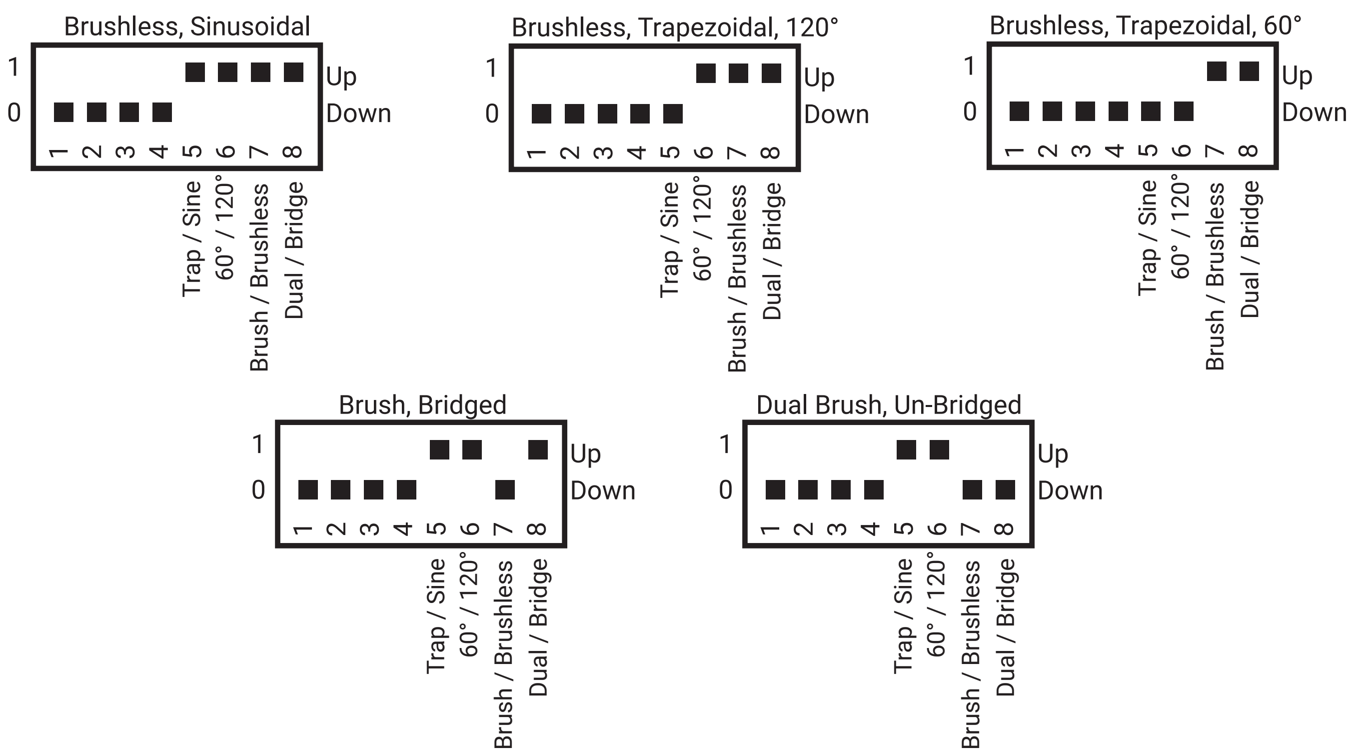


Figure 16 - SW1 Motor Type Settings

4.11 – Isolation Diagram

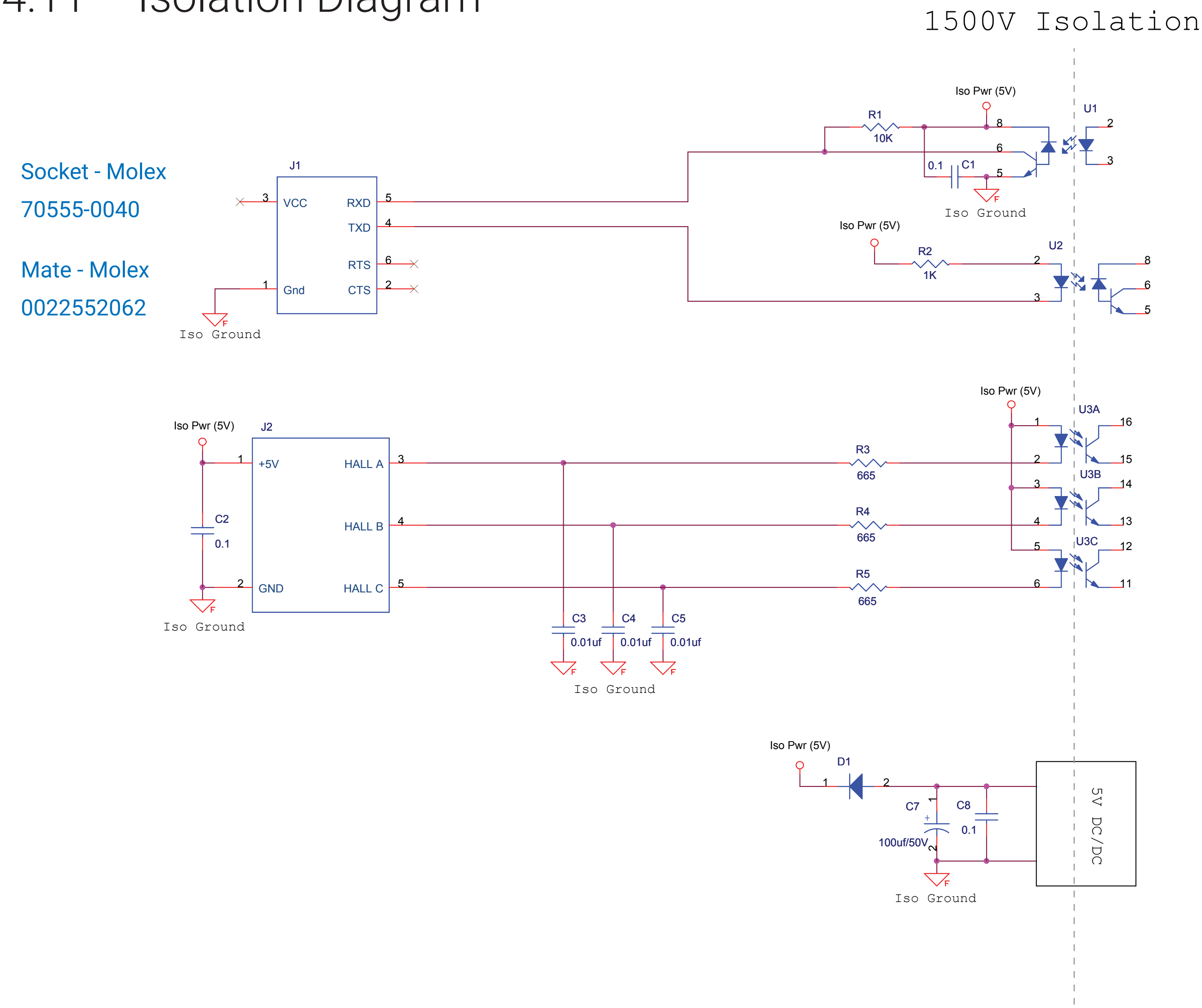


Figure 17 - TA333-E01 Isolation Diagram

4.12 – Isolation Diagram

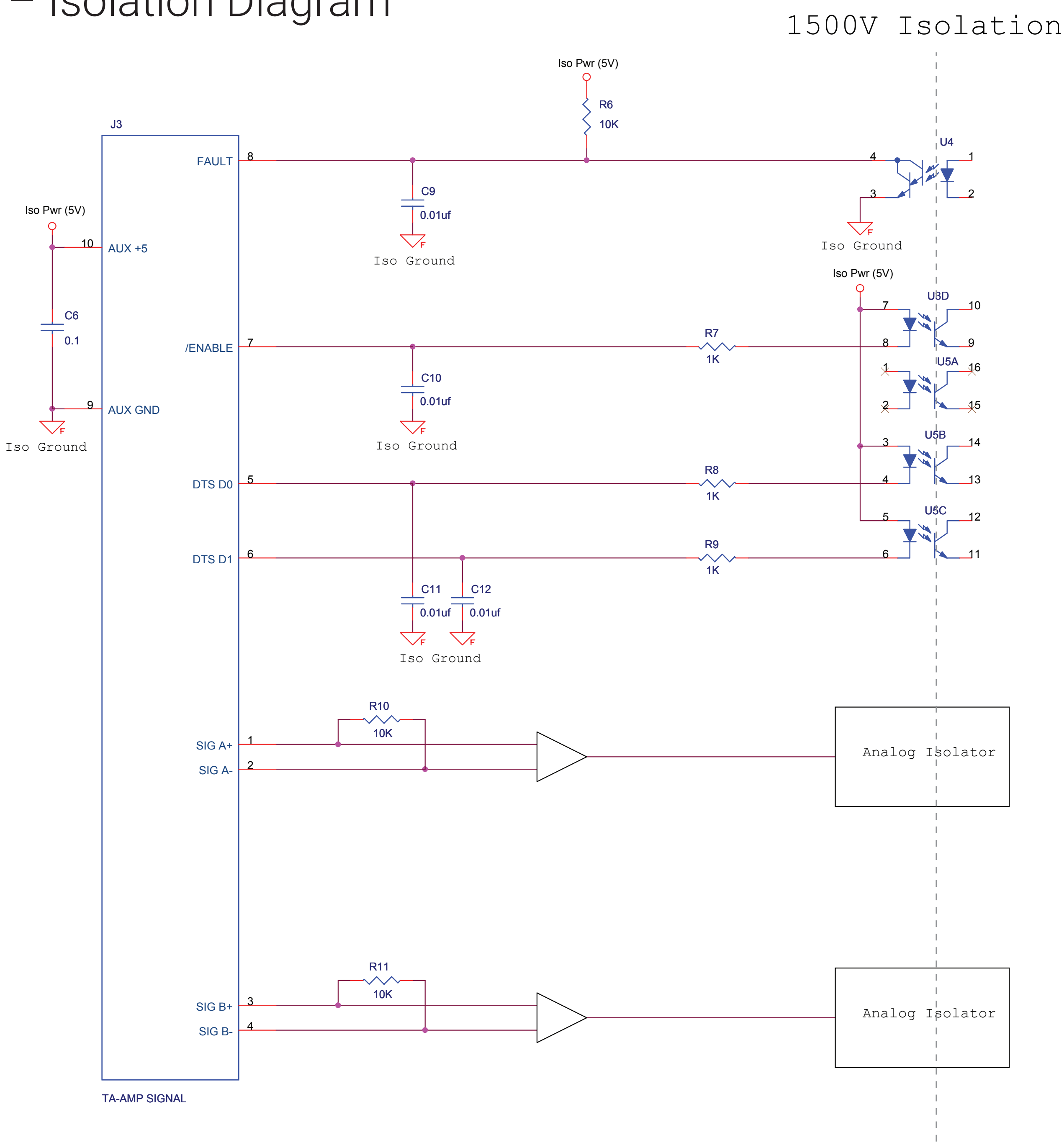
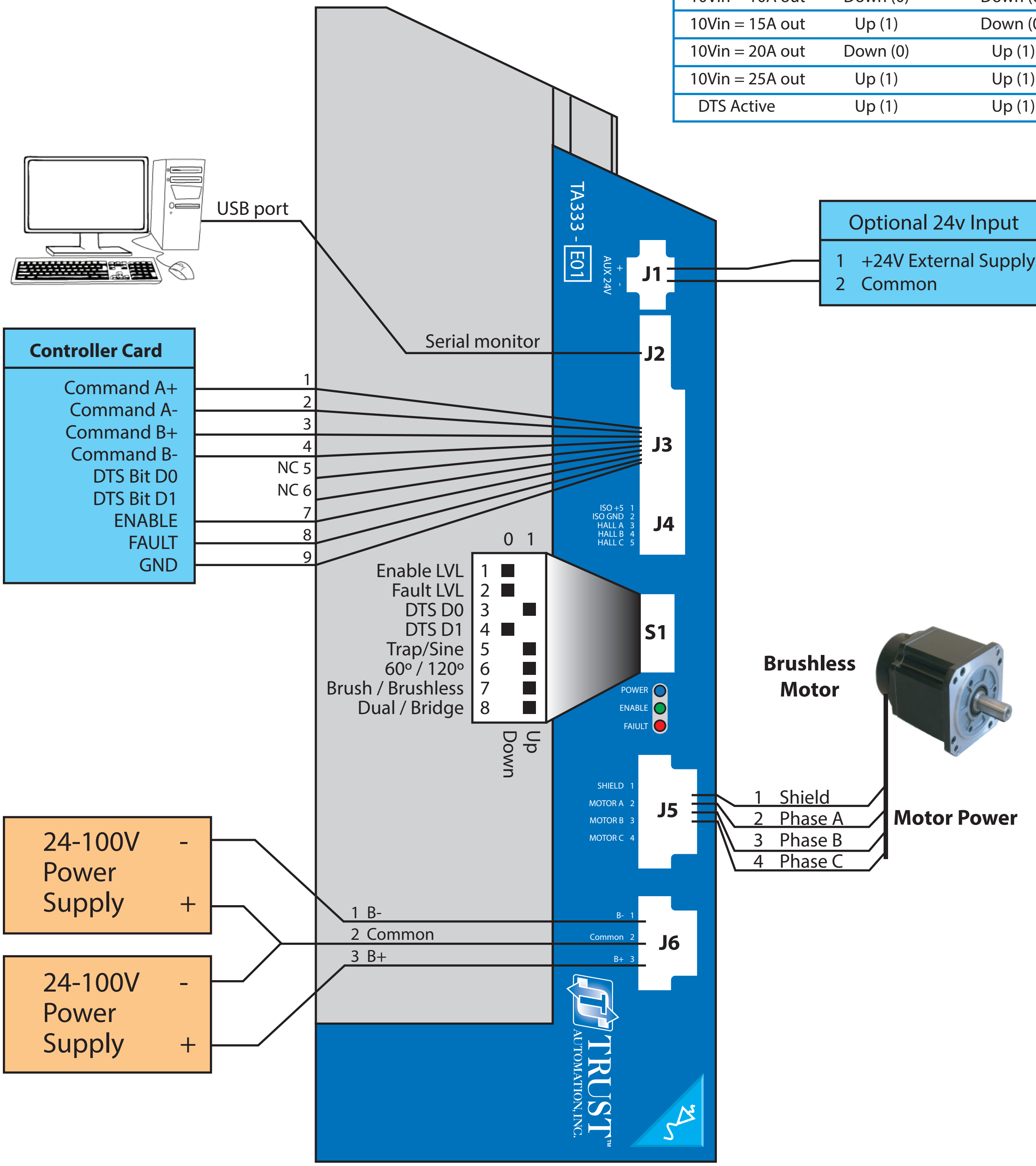


Figure 18 - TA333-E01 Isolation Diagram

5.0 Application Examples

5.1 Brushless Motor, Sinusoidal

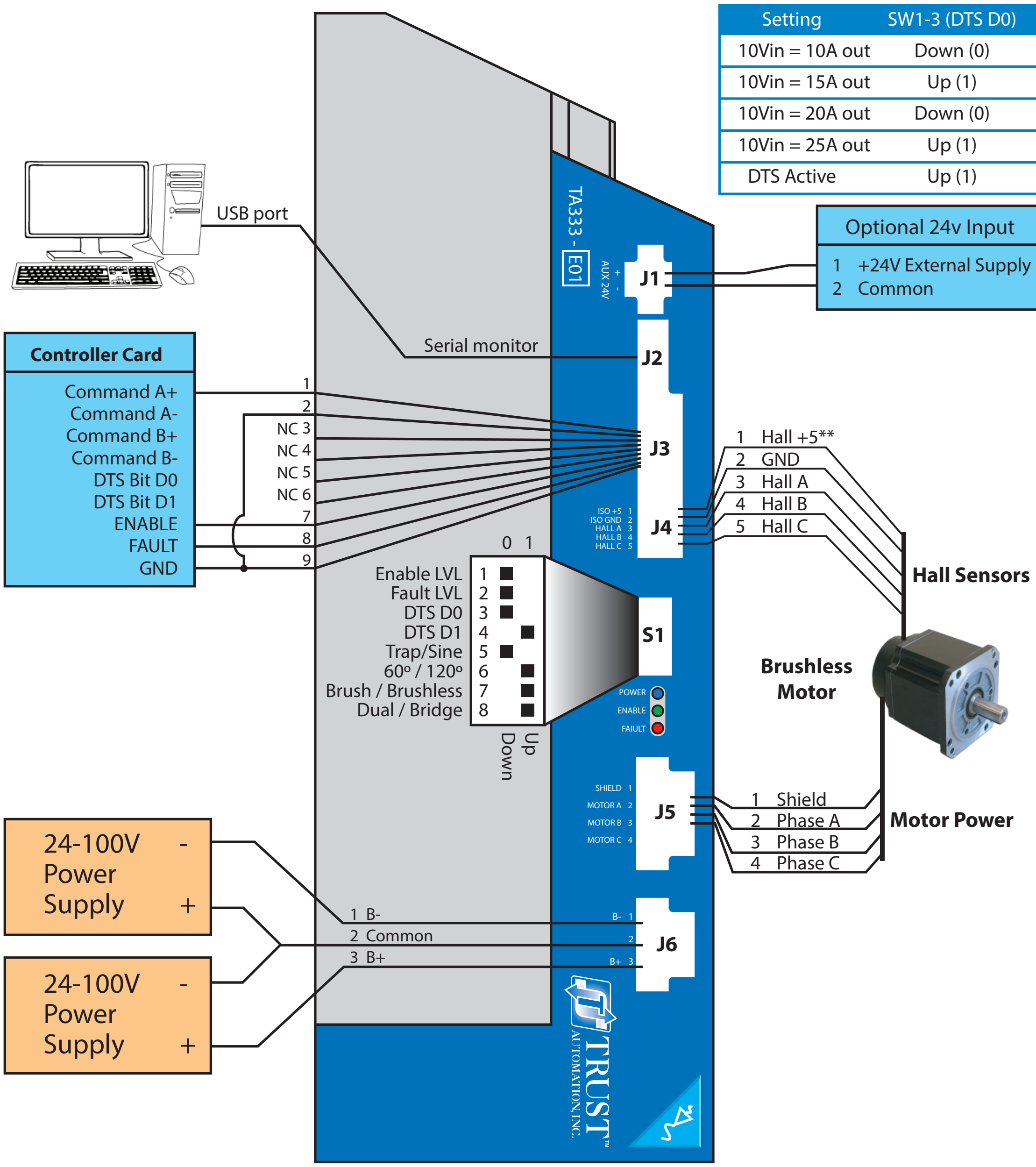
Setting	SW1-3 (DTS D0)	SW1-4 (DTS D1)
10Vin = 10A out	Down (0)	Down (0)
10Vin = 15A out	Up (1)	Down (0)
10Vin = 20A out	Down (0)	Up (1)
10Vin = 25A out	Up (1)	Up (1)
DTS Active	Up (1)	Up (1)



The figure shows the TA333-E01 operating in sinusoidal mode with differential command inputs. Active low enable, active low fault, driving a single brushless servo motor. The TA333-E01 is set for a fixed current limit of 15A with a transconductance of 1.5A/V.

5.2 Brushless Motor, Trapezoidal, Hall Commutation

Setting	SW1-3 (DTS D0)	SW1-4 (DTS D1)
10Vin = 10A out	Down (0)	Down (0)
10Vin = 15A out	Up (1)	Down (0)
10Vin = 20A out	Down (0)	Up (1)
10Vin = 25A out	Up (1)	Up (1)
DTS Active	Up (1)	Up (1)



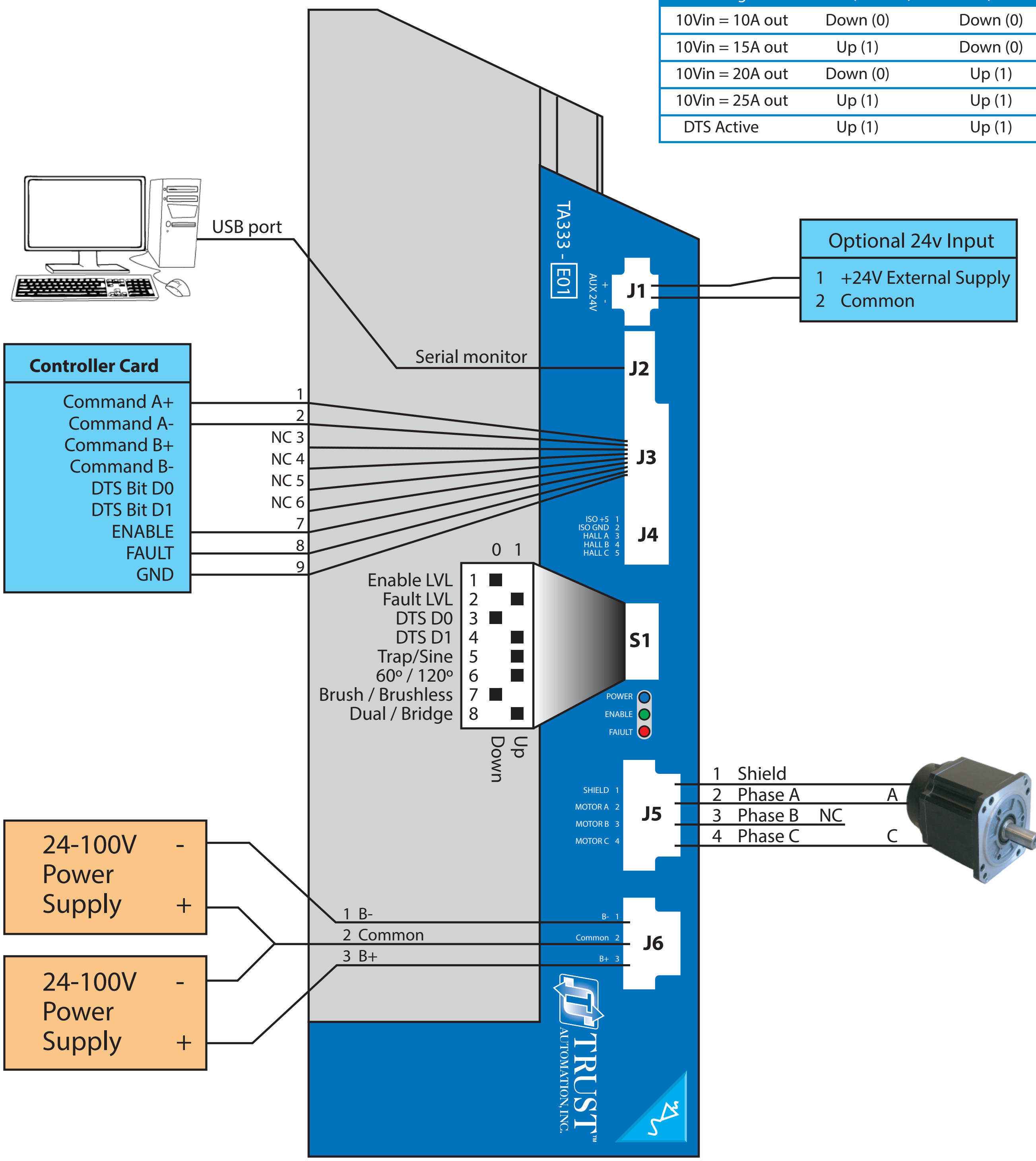
This figure shows the TA333-E01 operating in trapezoidal mode with single ended command input. Active low enable, active low fault, driving a single brushless servo motor, using Hall Effect sensors at 120° timing for trapezoidal commutation. The TA333-E01 is set for a fixed current limit of 20A with a transconductance of 2.0A/V.

Hall Sensors are connected to J4. If the motor has differential Hall outputs, only connect the + Hall outputs to J4 and leave the – Hall signals unconnected. (Do not tie to ground, the motor will be damaged.)

**Note that Hall 5V power supplied by the TA333-E01 is limited to 20ma. If the motor hall sensors require >20ma for operation, an external 5V power source must be used.

5.3 Single brush motor or Voice coil motor, in bridge mode

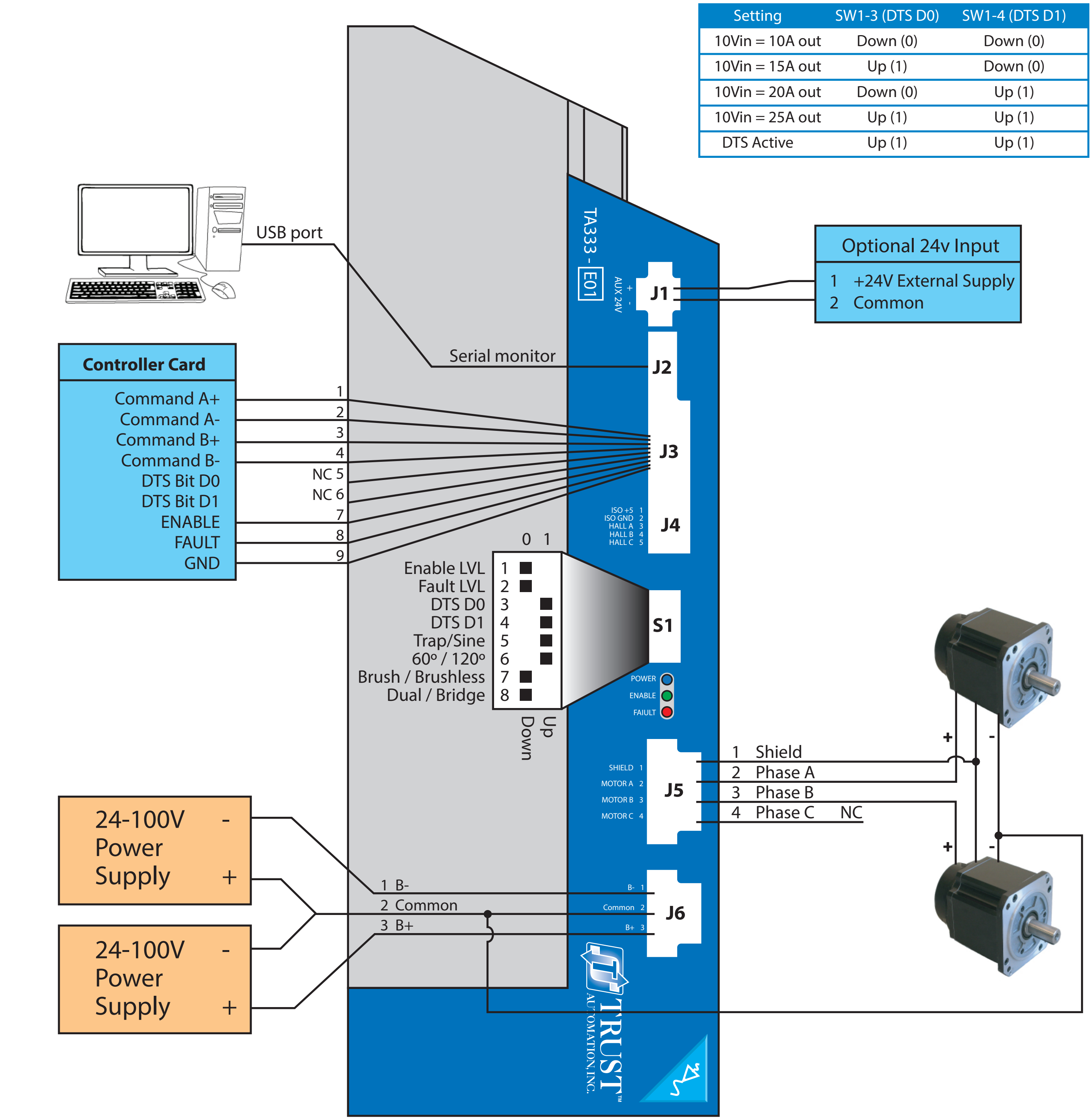
Setting	SW1-3 (DTS D0)	SW1-4 (DTS D1)
10Vin = 10A out	Down (0)	Down (0)
10Vin = 15A out	Up (1)	Down (0)
10Vin = 20A out	Down (0)	Up (1)
10Vin = 25A out	Up (1)	Up (1)
DTS Active	Up (1)	Up (1)



This figure shows the TA333-E01. Active low enable, active high fault, driving a single brushless servo or voice coil motor. The TA333-E01 is set for a fixed current limit of 20A with a transconductance of 2.0A/V

5.5 Dual Brush or Voice Coil Motor

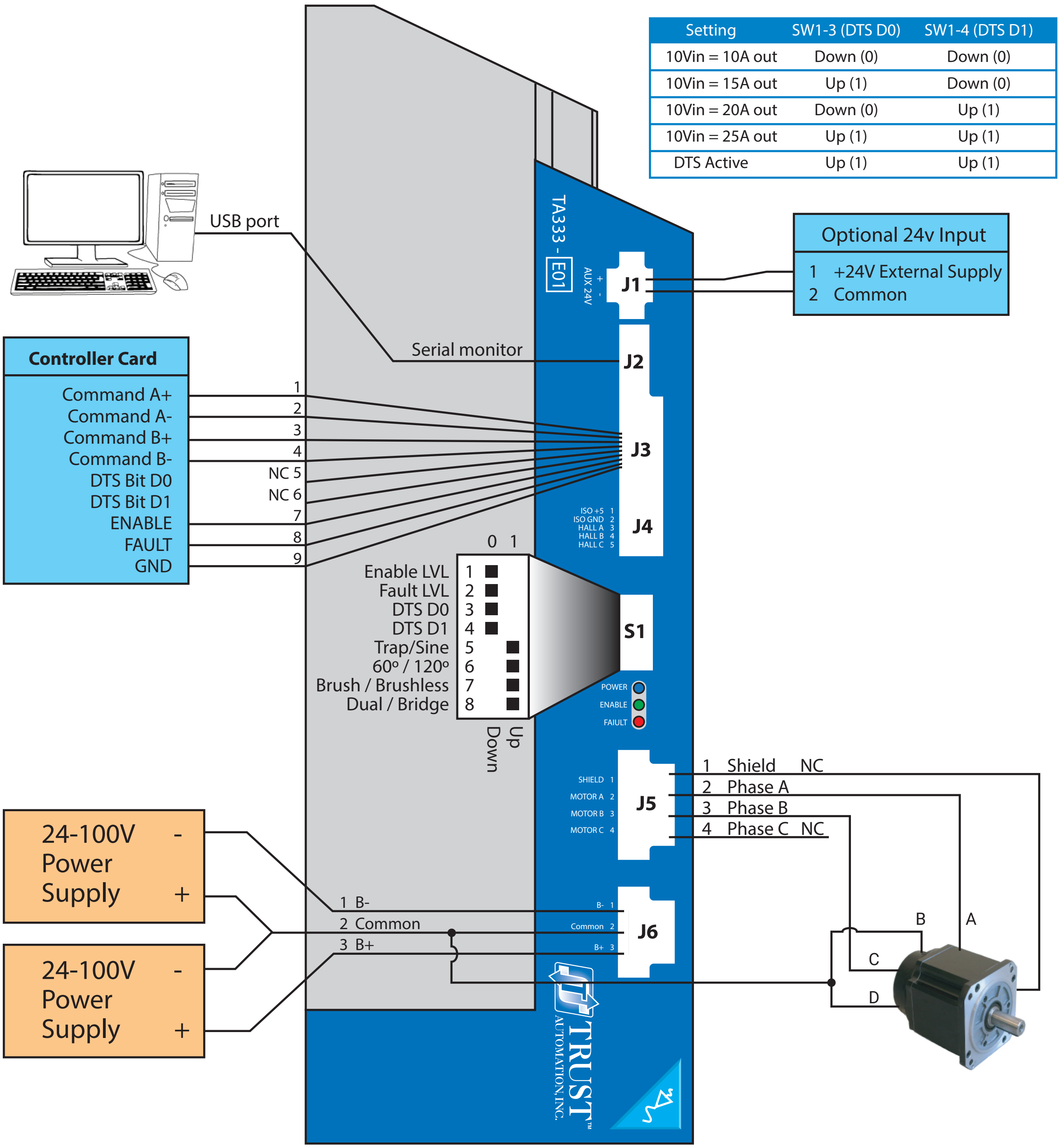
Setting	SW1-3 (DTS D0)	SW1-4 (DTS D1)
10Vin = 10A out	Down (0)	Down (0)
10Vin = 15A out	Up (1)	Down (0)
10Vin = 20A out	Down (0)	Up (1)
10Vin = 25A out	Up (1)	Up (1)
DTS Active	Up (1)	Up (1)



This figure shows the TA333-E01 operating in brushed bridge mode with differential command inputs. Active low enable, active low fault, driving a single brush type servo motor. The TA333-E01 is set for a fixed current limit of 25A with a transconductance of 2.5A/V.

5.6 Stepper Motor, Sinusoidal Commutation

Setting	SW1-3 (DTS D0)	SW1-4 (DTS D1)
10Vin = 10A out	Down (0)	Down (0)
10Vin = 15A out	Up (1)	Down (0)
10Vin = 20A out	Down (0)	Up (1)
10Vin = 25A out	Up (1)	Up (1)
DTS Active	Up (1)	Up (1)



This figure shows the TA333-E01 operating in brushed dual mode with differential command inputs. Active low enable, active low fault, driving a stepper motor sinusoidally. The TA333-E01 is set for a fixed current limit of 10A with a transconductance of 1.0A/V.

6.0 TA333-E01 Hardware Revision History

Revision	Date	Description
B.1	29 Jan 09	Increased main power fuse size
B.2	6 Jan 10	Updated firmware handling of temperature monitoring
B.3	25 Mar 13	Hardware change

7.0 TA333-E01 Manual Revision History

Revision	Date	Description
V0.10	15 Aug 08	Initial release (Alpha).
V0.11	10 Oct 08	Data corrections
V0.12	30 Jan 09	Formatting changes
V0.13	10 April 09	Release (Beta)
V0.14	03 Jul 12	Minor non-functional updates
V1.0	23 June 16	General updates

8.0 Warranty

Trust Automation, Inc.
Limited 1 Year, Non-Transferrable Warranty

GENERAL - All hardware products sold by Trust Automation Inc. are warranted against defects in material and workmanship for a period of one (1) year from the date of shipment. If you believe that a Trust Automation Inc. hardware product you have purchased has a defect in material or workmanship, or has failed during normal use within the warranty period, please contact Trust Automation Inc. at 805.544.0761 for assistance and/or a Return Material Authorization Number (RMA#).

If product repair or replacement is necessary, the Customer will be responsible for all return shipping charges, freight, insurance and proper packaging to prevent damage in transit, whether or not the product is covered by this warranty. During the warranty period, product determined by Trust Automation Inc. to be defective in form or function will be repaired or, at Trust Automation Inc.'s option, replaced at no charge. Trust Automation Inc. will pay the return shipping charges (ground for US based shipments, most economical air for international shipment. Customer may elect to change shipment method and pay the difference.), for products that have been repaired or replaced. All duties and taxes remain the responsibility of the customer. All shipments of repaired or replaced products will be EXW at Trust Automation, Inc. headquarters in San Luis Obispo, California.

For tracking purposes, products to be repaired or replaced must be returned to Trust Automation Inc. with a Trust Automation Inc. RMA#, and a Purchase Order. The minimum charge for non-warranty repair work is $130 and the standard rate is $130 per hour, plus parts. Trust Automation will provide a repair cost estimate prior to performance of out of warranty repair work. Send product to:

Trust Automation, Inc.
143 Suburban Road, Bldg. 100
San Luis Obispo, CA. 93401
ATTN: RMA# xxxxxx

Material and workmanship used in the repair and replacement of Trust Automation products under this warranty are warranted additionally against defects for a period of ninety (90) days from the date of return shipment to the customer.

LIMITATIONS - This non-transferrable warranty does not apply to damage resulting from accidents or any Customer actions, such as mishandling, misuse, improper interfacing, operation outside of design limits or unauthorized repair or modification. No other warranties are expressed or implied. Trust Automation Inc. liability shall be limited to the actual purchase price of any defective unit or units of equipment to which a claim is made and shall in no event include the Customer's manufacturing costs, lost profits or goodwill, or any other direct, indirect, special, incidental or consequential damages.