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# EvoDrive ST-PCB

# INTEGRATION MANUAL

EVA Robotics | FW-UM007 Rev D | December 2013




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# 1. Important Information

## 1.1 Intended Use

The EvoDrive series of stepper motor controllers are intended to control and drive sub-horsepower stepper motors. They are intended to be used as components in larger systems or products.

The EvoDrive products have been designed to all applicable safety standards but they are not intended to implement safety functions. The risk of unexpected or un-braked movements can not be sufficiently mitigated without additional safety provisions.

For this reason, personnel must never be in any danger zone actuated by an EvoDrive product unless additional safety equipment prevents personal danger. This applies to operation as well as service and maintenance of the product or system.

In all cases the applicable safety regulations and the specified operating conditions, such as environmental conditions and specified technical data, must be observed.

The EvoDrive may be one component of more complex systems, all machinery, EMC, and safety regulations that apply to the system as a whole must be observed before installation and operation.

To prevent personal injury and damage to property, damaged EvoDrive products must not be installed or operated.

Changes and modifications to the EvoDrive are prohibited and will void any warranty and liability.

The EvoDrive is not intended for use in explosive environments.


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## 1.2 Qualification of personnel

The safe and successful integration of the EvoDrive requires a certain level of competency in designing and working with motor drive technologies.

Only engineers/technicians who are familiar with and understand the contents of the EvoDrive documentation are authorised to integrate the EvoDrive ST-PCB.

The system designers must be able to identify, assess, and mitigate the risks inherent in the operation of mechatronic systems.

The designers must be familiar with the relevant standards and regulations that apply to the end product or system.

## 1.3 Safety Labels

This manual may contain warnings and cautions which, when properly followed, can prevent personal injury and damage to the EvoDrive.



**Caution.** This label will be used to bring attention to a general caution or warning which provides important information to protect against injury to an operator or damage to equipment.



**Electrical Hazard.** This label will be used to warn the reader of an electrical hazard.



**Mechanical Hazard.** This safety label will be used to warn the reader of a mechanical hazard.


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## 1.4 General Safety Instructions

### Hazardous Voltages



While the EvoDrive does not operate at hazardous voltages, the use of open frame power supplies, or non-conforming wiring practices, such as routing EvoDrive cables together with high voltage cables, may expose the EvoDrive to hazardous voltages under fault conditions.

This will result in damage to the EvoDrive and may result in injury or death to the operator.

### Loss of Control



The system designer must assess the hazards and risks inherent in safety critical functions, and implement controls to mitigate the risk.

Some examples of failure modes that should be considered include:

- Unexpected delays in commands or responses
- Loss of power and restart
- Failure of sensors and signals
- Over-Temperature cut-outs and fire hazards

Failure to observe the relevant safety and risk management standards may result in death or injury to the operator.

### High Temperatures



The EvoDrive will typically run much cooler than other stepper motor controllers when in closed loop mode.

When operating in an open-loop mode it is still possible to generate high temperatures when driving or holding the motor with high current levels.

In this situation the stepper motor and EvoDrive controller temperatures can both exceed 60°C.


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# 2. Introduction

This integration manual will provide the detail required to safely and effectively integrate the EvoDrive ST-PCB into your design. This manual should be read and understood together with the EvoDrive Programmers Manual.

The EvoDrive ST-PCB represents a completely new way of controlling stepper motors and therefore, how they are used.

As an open-loop controller the EvoDrive ST-PCB provides the equivalent of 512 micro-step accuracy with exceptionally smooth current control. This results in incredibly quiet and smooth motion control.

As a closed-loop controller the EvoDrive moves away from traditional drive technology and transforms the humble stepper motor into a true servo motor with a high dynamic bandwidth and exceptional efficiency.

This is achieved through a series of cascaded control systems, some traditional, and some proprietary which together form what we call the Phase Vector Drive system.

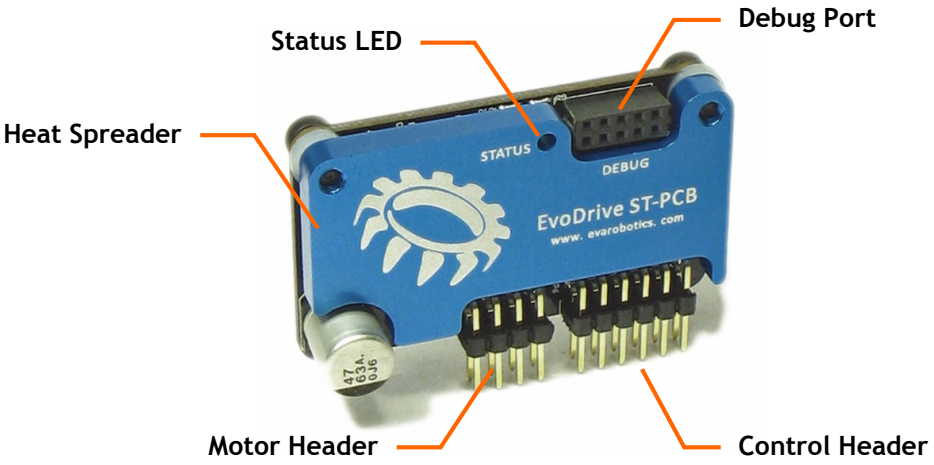
The EvoDrive ST-PCB is provides access to this advanced control via simple, intuitive commands, which are optimised for embedded communications.

The EvoDrive ST-PCB is entirely self-contained, and places minimal restrictions on the system designer in terms of mounting and PCB layout.


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## 2.1 EvoDrive ST-PCB Overview




The EvoDrive ST-PCB is a self-contained module that contains all components necessary for the closed-loop control of any stepper motor.

The ST-PCB has two physical interfaces:

- The PCB header is a dual row, 0.1”, PCB header which provides pins for power, motor connections, communications, and grounding.
- The debug port allows the EvoDrive ST-PCB to be monitored and configured in-situ. The ST-PCB Debugger (FW-A103) provides a USB interface to this port that allows the EvoLink Software to communicate with the ST-PCB.

The Status LED is a combination red and blue LED which provides instant status feedback.

- The Blue in the status LED is on whenever the Vector Drive is enabled and ready to control the motor.
- The Red in the status LED will pulse a heartbeat (two quick successive pulses) every 5 seconds while there are no errors.
- If there is an error condition then the Red LED will flash the status number every five seconds.

The EvoDrive ST-PCB includes an anodised aluminium heat spreader to help dissipate heat from the drive circuitry.


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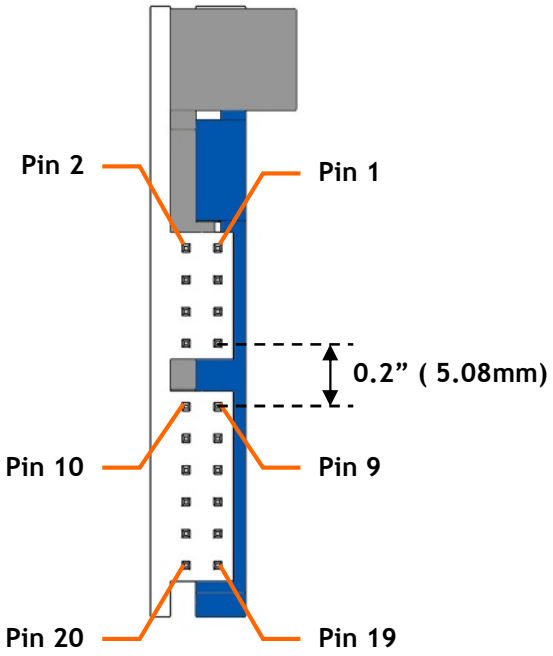
# 3. Integration

## 3.1 Pin Assignments

The EvoDrive ST-PCB has two groups of header pins to provide polarity when mounting the EvoDrive to a female socket.

The header pins are on a 0.1” pitch. The two groups of headers are positioned so the gap is the same as a missing pair of pins.

The pin numbering is shown below, as viewed from the bottom of the EvoDrive ST-PCB.





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| Pin # | Signal | Alt. Signal | Description |
|---|---|---|---|
| 1 | B+ | - | Stepper Motor Phase B+ |
| 2 | A+ | - | Stepper Motor Phase A+ |
| 3 | B- | - | Stepper Motor Phase B- |
| 4 | A- | - | Stepper Motor Phase A- |
| 5, 6 | PV+ | - | Stepper Motor Power (12 – 48V DC) |
| 7. 8 | PGND | - | Stepper Motor Ground<br>**Must be connected to SGND** – see section 3.3 |
| 9 | SGND | - | Signal (Logic) Ground<br>**Must be connected to PGND** – see section 3.3 |
| 10 | En | - | Drive Output Enable.<br>When driven low, or left unconnected, this pin will disable the motor drive output.<br>When driven high, the EvoDrive has control of the drive electronics. |
| 11 | 5V | - | Logic power supply. (5V DC) |
| 12 | EncB | - | Encoder Channel B input. |
| 13 | Input 4 (STEP) | MISO<br><br>RS485 Tx Enable | STEP pulse input (Digital Input 4)<br><br>Alt 1: SPI Master In Slave Out<br><br>Alt 2: RS485 Tx Enable output |
| 14 | EncI | | Encoder Index pulse input. |
| 15 | Input 3 (DIR) | MOSI | DIR signal input (Digital Input 3)<br><br>Alt: SPI Master Out Slave In |
| 16 | EncA | | Encoder Channel A input. |
| 17 | Input 2 (CW) | CS | CW pulse input (Digital Input 2)<br><br>Alt: SPI Chip Select. Active Low.<br>The Host should drive this pin low when sending a data frame to the EvoDrive. |
| 18 | Tx | - | UART Tx.<br>Host Rx should be connected to this pin. |
| 19 | Input 1 (CCW) | SCLK | CCW pulse input (Digital Input 1)<br><br>Alt: SPI Clock input. |
| 20 | Rx | - | UART Rx.<br>Host Tx should be connected to this pin. |


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## 3.2 EvoDrive ST-PCB Placement

### Mounting

The EvoDrive ST-PCB can be soldered directly to the Host PCB or mounted in a female socket.

When mounting in a socket, the polarity of the EvoDrive mounting should be preserved by using two separate sockets or by blanking two holes with polarising pins ( e.g. digikey part #708-1261 ).

When mounting directly to the PCB, the long pin length allows the package to be offset from the PCB, allowing components and tracks to be cleared.

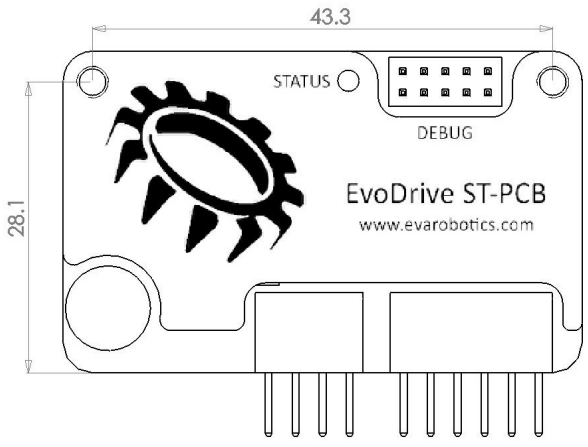
### Heat Dissipation

The EvoDrive ST-PCB will not normally require external heat-sinks when running in a closed-loop mode.

However when driving in open-loop mode, or if high drive currents are normally required, heat dissipation can be improved by providing air flow past the EvoDrive module.

The EvoDrive has a thermal overload shutdown which will activate when the drive electronics reach 120 degrees C.

Bracing the EvoDrive to a chassis, or bonding to an external heatsink (if necessary), can be accomplished by using the M3 threaded holes on the heat spreader:





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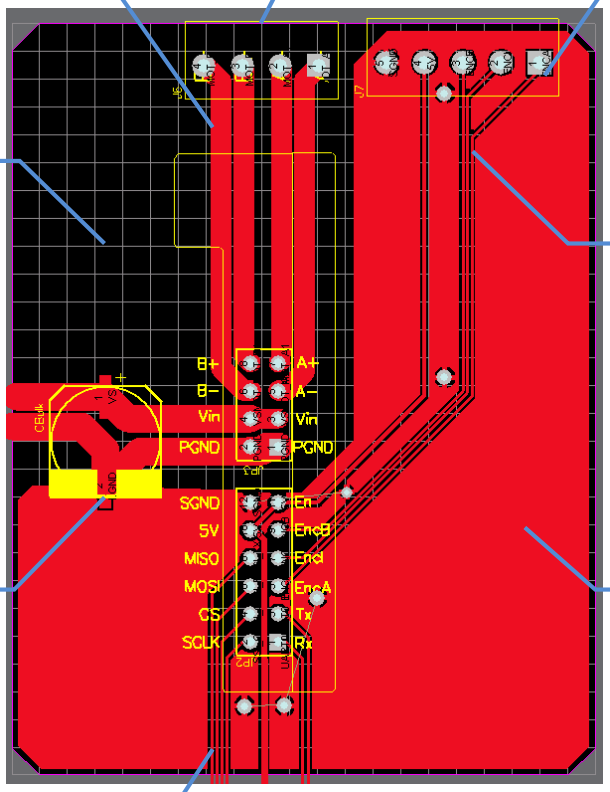
## 3.3 PCB Layout

### Signal Routing

The EvoDrive ST-PCB switches high currents to drive the stepper motor. Careful PCB layout is required to ensure EM emissions are reduced.

The EvoDrive ST-PCB has been designed to segregate the high current circuits from the logic and communications signals to facilitate a clean, low-noise design.

An idealised layout is shown below to highlight some good design principles.




Route the motor tracks (A+,A-) and (B+,B-) so they form as small a loop as possible

Separate the motor and encoder cables wherever possible.

Use SGND as the encoder ground, not PGND

Do not place PV+ or PGND traces over any SGND or 5V power plane

For extra noise suppression, place ferrite beads close to the connector, but not over the ground plane.

PGND and SGND should be connected at one point. Ideally the negative pin of a bulk electrolytic capacitor

Heavy power planes can sink unanticipated noise sources and provide extra capacitance.

Never run signal traces under, or parallel with, the motor traces.


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## Grounding

The grounding of the EvoDrive ST-PCB is critical to suppressing unwanted electrical noise.

The EvoDrive ST-PCB has two ground references. PGND, the drive power ground, and SGND, the logic signal ground.



**PGND and SGND must be connected for the EvoDrive to function correctly.**

This connection should be made as close to the EvoDrive ST-PCB as possible, ideally at the negative pin of a bulk capacitor.

A bulk electrolytic capacitor will serve three purposes:

- Add local capacitance to supply a fast current source and sink for the motor.
- Provide a clean reference between SGND and PGND at each EvoDrive.
- Keep high frequency current loops, caused by switching transients, as small as possible.

The recommended value for this bulk capacitor is 100uF. Ensure the voltage rating of the capacitor is well above the drive voltage (e.g. 63V) to avoid damage from the motor's back EMF and de-rating of the capacitor.


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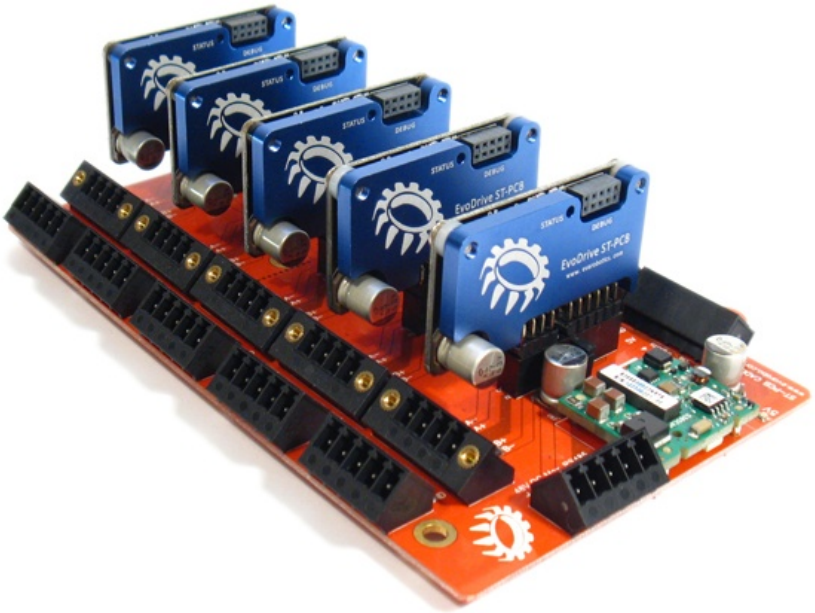
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## 3.4 ST-PCB Caddy

The EvoDrive ST-PCB is an embedded module designed to provide the full closed-loop performance of the EvoDrive at a low BOM cost for product designers.

However sometimes it can be too costly or time consuming to design your own support electronics.

In this situation the ST-PCB Caddy provides full support electronics for up to five EvoDrive ST-PCB modules.



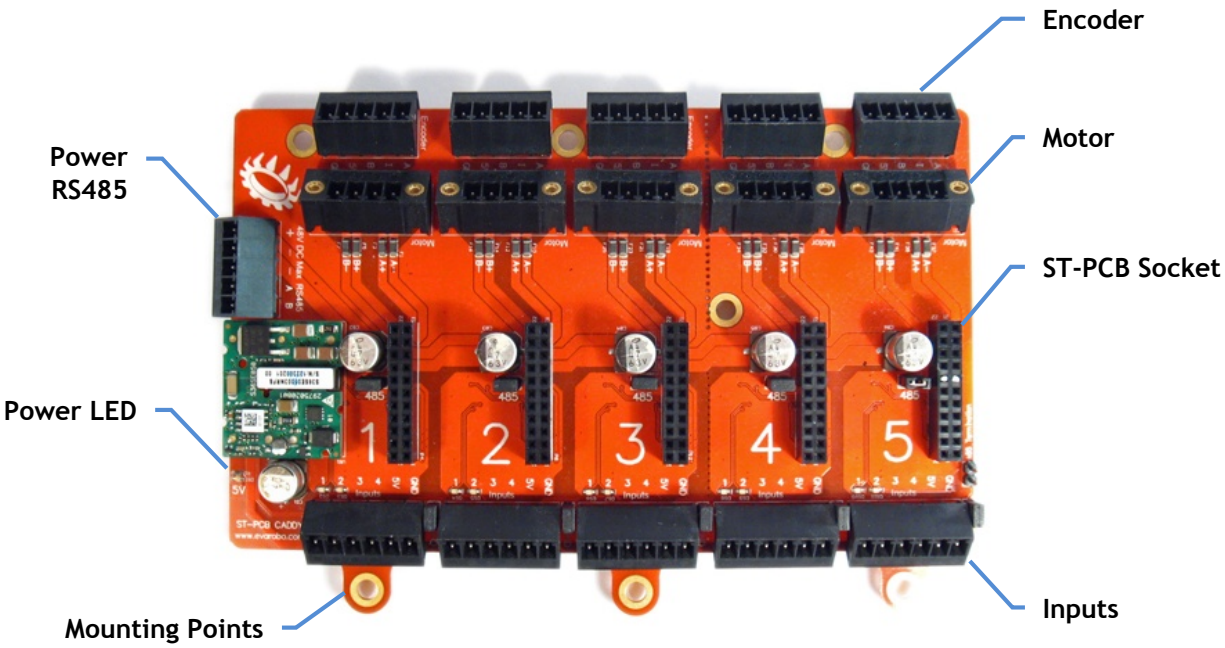

The ST-PCB Caddy has the following features:

- Single voltage input (12-48VDC)
- Opto-isolated inputs to each ST-PCB module.
- On board RS485 bus to each module, with a single connection to the ST-PCB Caddy.
- On board bulk capacitance, EM Filtering, and layout for EMC to ensure minimal electrical noise.
- Screw Terminal headers for easy connectivity.


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## Connectors




All connectors on the ST-PCB Caddy are 3.81mm pitch pluggable screw terminals (eurostyle). These are a very common type of connector supported by many manufacturers. It allows the flexibility to source specific orientations and termination options. Below are a handful of compatible part numbers:

| Manufacturer | Motor (Flanged 4-way) | Power/Encoder (5-way) | Inputs (6-way) |
|---|---|---|---|
| Weidmuller | 1793060000 | 1792890000 | 1792900000 |
| Phoenix Contact | 1827729 | 1803604 | 1839652 |
| TE Connectivity | 284511-4 | 284507-5 | 284507-6 |
| FCI | 20020012-D041B01LF | 20020004-D051B01LF | 20020013-D061B01LF |

The pin assignments for all connectors are shown in the table below. They are also printed on the Caddy PCB.

| Pin | Motor | Encoder | Power/485 | Inputs |
|---|---|---|---|---|
| 1 | Phase A- | Channel A | Power +ve | Input 1 |
| 2 | Phase A+ | Index (I) | GND | Input 2 |
| 3 | Phase B+ | Channel B | GND | Input 3 |
| 4 | Phase B- | 5V | RS485 A | Input 4 |
| 5 | | GND | RS485 B | 5V |
| 6 | | | | Input GND |


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## Power Supply

The EvoDrive ST-PCB requires power for the motor (12-48V) and a separate 5V supply for logic.

The ST-PCB Caddy has an on-board 5V regulator to provide power to each module. Therefore only motor power needs to be provided.

## Opto-Isolated Inputs

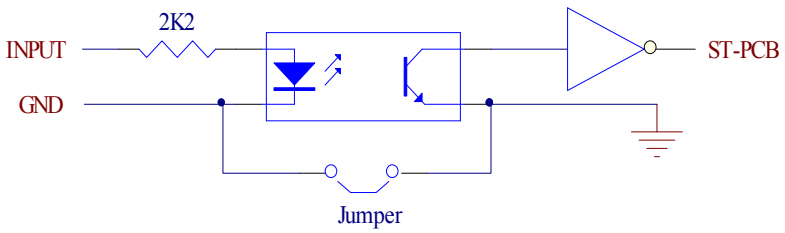
The EvoDrive ST-PCB digital inputs are used to run triggered programs or for STEP/DIR control from an external motion controller. The inputs on the EvoDrive ST-PCB module are CMOS inputs only suitable for use with embedded controllers.

The ST-PCB Caddy optically isolates the inputs so the EvoDrive ST-PCB can be used with a wide range of commercial and industrial motion controllers (with outputs up to 24V).

The input connector for each module provides four inputs and a local ground return. All four inputs share the same ground return.

If the outputs of your motion controller are unsuitable for optical inputs, then the input ground can be connected to the ST-PCB ground by fitting a shunt to the **GND** jumper next to each input connector. A 5V rail is also provided which can be used as a pull-up for open-collector outputs.

The input circuit (equivalent) is shown below:




Note that if the RS485 bus is used, Input 4 cannot be driven externally.


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## RS485

The ST-PCB Caddy includes an RS485 bus on board. Each EvoDrive ST-PCB module has an RS485 transceiver that is enabled by placing a shunt on the **485** jumper next each module.

Note that input 4 is shared with the RS485 transceiver, so when RS485 is enabled input 4 cannot be used.

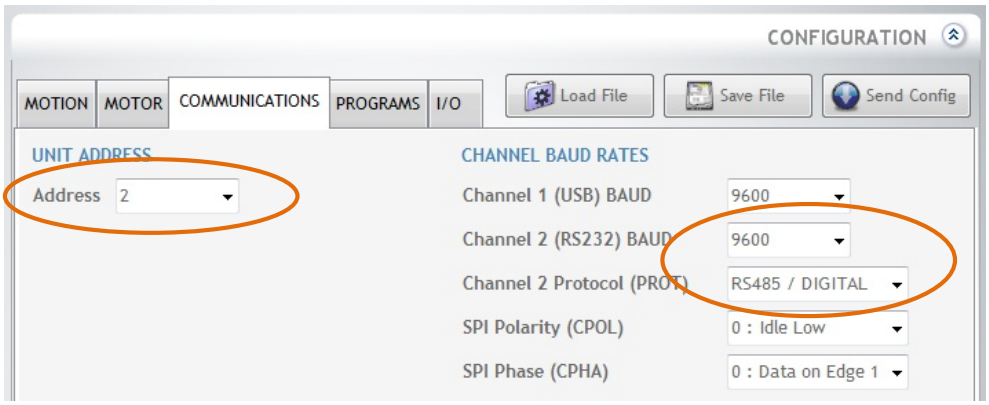
There is a single connection to the RS485 bus on the ST-PCB Caddy power connector. This allows your controller to communicate with each EvoDrive ST-PCB module serially.

To use the RS485 bus, each EvoDrive ST-PCB module should be configured as follows:

**Address**: Use EvoLink to assign a unique address to each EvoDrive ST-PCB Module.

**BAUD Rate**: Ensure each module has the same BAUD rate on Channel 2.

**Enable RS485**: To enable RS485 select **RS485/DIGITAL** for the Channel 2 Protocol.




The RS485 bus inludes a 120 Ohm termination resistor with is enabled by placing a jumper on the **485 Termination** jumper.


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# 4. Serial Control

The EvoDrive ST-PCB is typically controlled via commands sent from a Host controller, on one of two serial interfaces, UART or SPI.

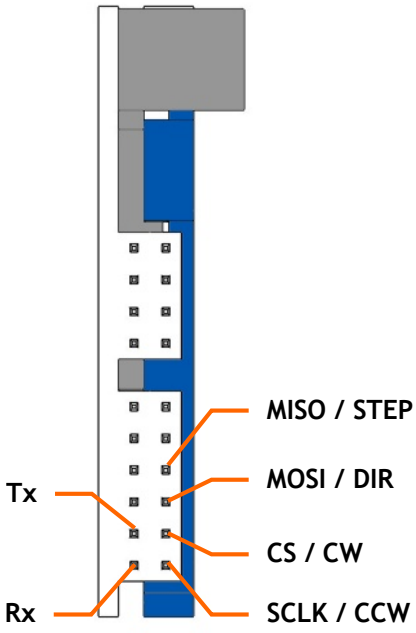
By default, the UART interface is enabled and the SPI interface is disabled. By enabling the SPI interface (see **PROT** command in the EvoDrive Programmers Manual) the UART and digital input controls are disabled.

## 4.1 UART

The UART interface is a standard UART connection at CMOS voltage levels. This interface is designed for direct interfacing with the UART of embedded devices.

A standard RS232 serial interface can be implemented by adding an RS232 transceiver, such as the MAX3311, between the serial port and the EvoDrive ST-PCB.

A standard RS485 serial interface can be implemented by adding an RS485 transceiver, such as the LTC2856, between the serial port and the EvoDrive ST-PCB. In this mode, Digital Pin 4 (MISO / STEP) is used as the RS485 turn-around (Tx Enable) Pin.




See **PROT** command in the EvoDrive Programmers Manual for more information on configuring the UART mode.

The default UART interface parameters are

- Baud Rate **9600**
- Data Bits **8**
- Stop Bits **1**
- Parity **None**
- Max input buffer **64 characters**

All standard BAUD rates up to 115200 bps are supported and can be configured via EvoLink or the **BAUD** command.


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## 4.2 SPI

The SPI interface supports the full-duplex synchronous serial protocol as defined by Motorola. The SPI interface is intended for high-speed embedded communications.

The SPI interface uses 8-bit data frames at clock speeds up to 4MHz. The SPI frame format is configurable with two parameters, SPI Polarity and SPI Phase.

SPI Polarity, the equivalent to Motorola's CPOL bit, controls the polarity of the clock signal.

- When Polarity = 0, the clock idle state is low.
- When Polarity = 1, the clock idle state is high.

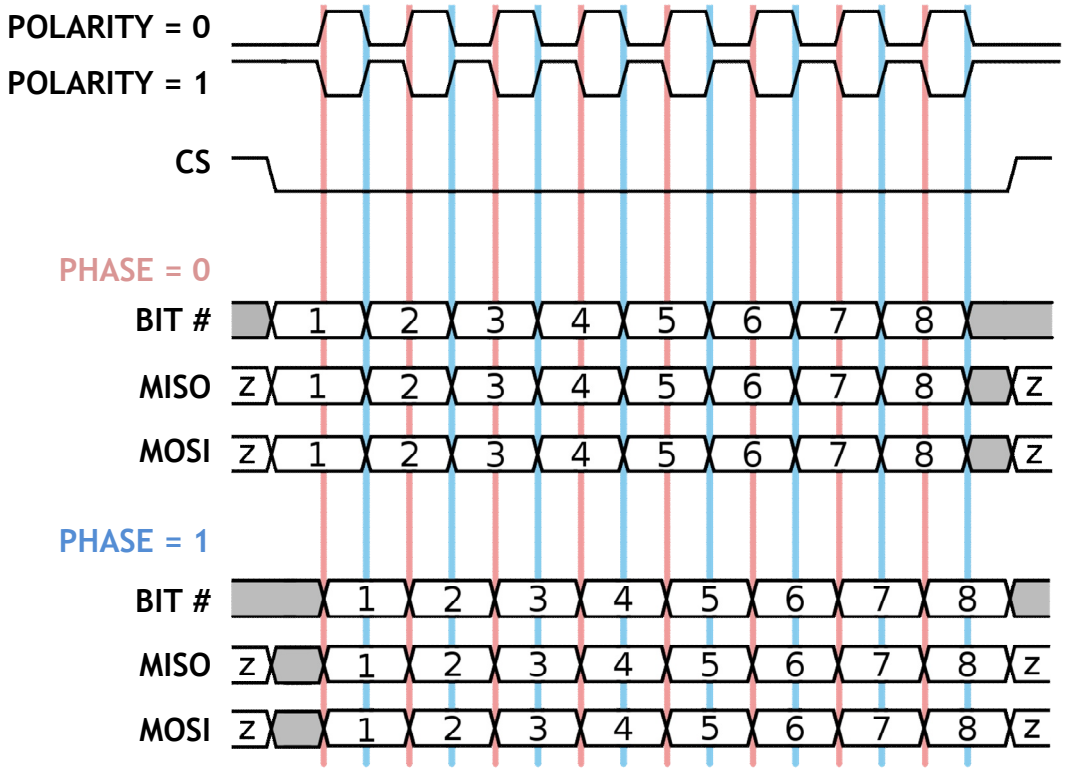
SPI Phase, the equivalent to Motorola's CPHA bit, controls which clock edge latches the data bits.

- When Phase = 0, data is read on the first clock edge
- When Phase = 1, data is read on the second clock edge

The SPI Polarity and Phase values are configured via EvoLink or via the **CPOL** and **CPHA** commands.


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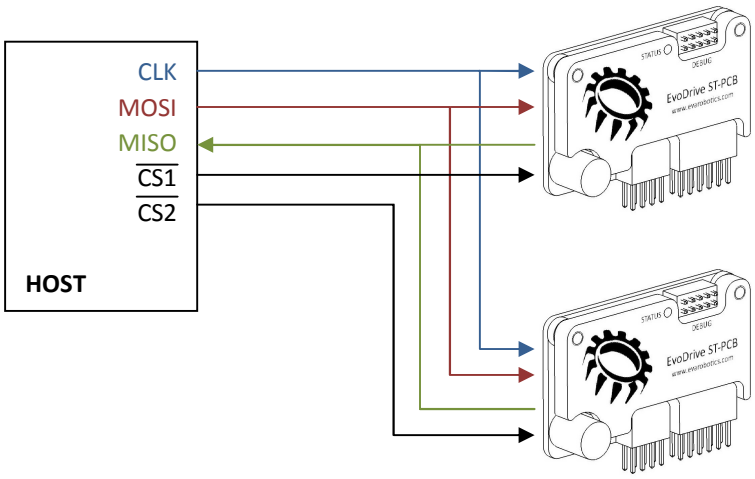
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### SPI Multi-drop bus

The SPI interface allows for multiple slave EvoDrive ST-PCB modules to be controlled from a single master using a parallel bus configuration.

The MISO and MOSI signals are routed to each EvoDrive ST-PCB. The CS line (active low) selects the EvoDrive that the host wishes to control. As a safety measure, each EvoDrive can also be configured with a unique address which confirms the command is intended for the signalled EvoDrive.

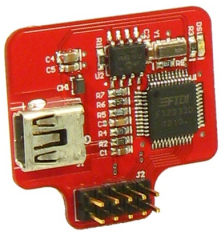




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## 4.3 USB Debug Interface



The USB Debug port is a dedicated communications channel that can be accessed via the USB Debugger (FW-A103).

The USB Debugger provides a virtual RS232 port, which accepts all the same commands as the Host communications channels. All commands are processed independently of the Host commands so the EvoDrive can be monitored and configured using EvoLink or any serial terminal program while the EvoDrive is in situ and operating.



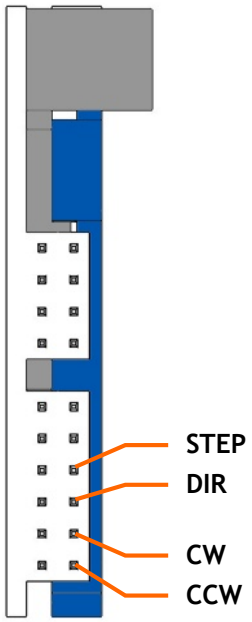
When using both communications channels, care must be taken that you do not send conflicting commands. The most recent command on either channel will take priority.


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# 5. Digital Input Control

## 5.1 CNC Control




The EvoDrive ST-PCB can be controlled via its digital inputs rather than serial communications. This form of control is useful when interfacing with CNC motion controllers or when implementing complex movement profiles.

The digital input pins are shared with the SPI serial bus. These pins are configured for digital control by default.

Several modes of digital control are supported simultaneously via four input pins.

- CW: The motor is stepped clockwise on each rising edge.
- CCW: The motor is stepped counter-clockwise on each rising edge.
- STEP: The motor is stepped in a direction determined by the DIR pin.
    - DIR = 1 - The motor is stepped clockwise
    - DIR = 0 - The motor is stepped counter-clockwise.

To enable electronic gearing and replacement of legacy controllers, the step size is defined by the **RES** command. For example, if the User Resolution is 400, then one edge on the control input would move the motor 1/400$^{th}$ of a revolution.

See the Resolution section in the EvoDrive Programmers Manual for more information.

### Digital Input parameters

- The maximum step update rate is 90KHz.
- The digital inputs have a weak pull-down and so must be driven high.
- The input pins are 5V tolerant but are triggered at 3.3V CMOS levels:
    - Low Level Input Voltage: 0 – 1.3 VDC
    - High Level Input Voltage: 2.0 – 5 VDC

**For multiple-axes and opto-isolated inputs see the ST-PCB Caddy (Section 3.4)**


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## Configuration

The digital inputs are configured using the Triggered Programs. The following commands configure the inputs for digital control:

**#STEP** : The input edge is used to step the motor in Step/Dir mode. This can be the positive, negative, or both edges.

**#DIR** : The input is used as the direction reference in Step/Dir mode. High is clockwise, Low is counter-clockwise.

**#CW** : The input edge is used to step the motor clockwise.

**#CCW** : The input edge is used to step the motor counter-clockwise.

The digital control modes are only active while the EvoDrive is in a position holding mode. In other words, if the EvoDrive is maintaining a velocity, torque, or the motor outputs are disabled, then the Step/Dir and CW/CCW signals will not be followed.

This is a safety mechanism to prevent the EvoDrive moving after a collision error. It also allows for a supervisory mode where a master can over-ride the CNC signals and move the motor with serial commands if necessary.

To place the EvoDrive into a position holding mode, a P command (Absolute Position) or an R command (Relative Position) should be sent.

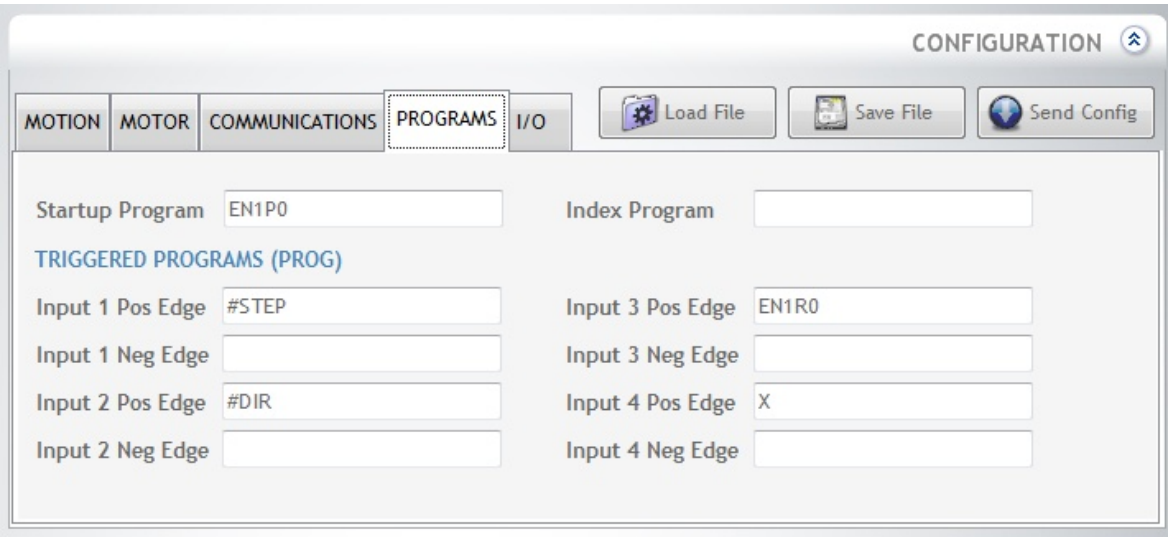
For CNC applications it is recommended to change the start-up program (S0) to **EN1P0** . This means the EvoDrive is in the correct mode after power-up.

It is also advisable to add the triggered program **EN1R0** to one of the digital inputs. This input will then act as a reset switch that recovers the EvoDrive out of any error state (e.g. Collision alarm etc).


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For simplicity, the following example shows a typical CNC configuration in EvoLink.




The startup program will ensure the EvoDrive is in a position holding mode immediately after power on.

Input 1 is used for the STEP signal. Only the positive edge is used therefore 1 STEP pulse = 1 step.

Input 2 is used for the DIR signal.

Input 3 is wired for a reset input – this will re-enable the drive and place it in a position holding mode after collision errors etc.

Input 4 is wired as an emergency stop.


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## 5.2 Triggered Programs

The inputs used for digital input control are configured using triggered programs.

By changing the programs, the action of the digital inputs can be changed to implement different digital input control, such as stepping on falling edges rather than rising edges.

The digital inputs can also be configured to perform short programs, such as starting and stopping the motor, homing the motor, or moving to predefined positions.

The digital inputs can also be configured for safety functions such as performing a controlled shutdown, an emergency stop, or reducing the drive torque.

See Triggered Programs in the EvoDrive Programmers Manual for more information.


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# 6. Power Supply Selection

The power supply design is a critical part of any drive system. Not only does it provide power when needed, but it also protects system components from surges, back EMF, and electrical noise. Power supplies must source and sink large amounts of energy whilst maintaining a steady voltage rail for consistent performance.

## Voltage Rating

Generally speaking, a higher supply voltage allows for a higher maximum motor speed. However it is very important to factor in the effects of back EMF and allow margin for this. See the discussion on Back EMF below.



The maximum input voltage of the EvoDrive ST-17 is 48VDC, so the recommended supply voltage for most applications is 24-48VDC.

A regulated power supply is more expensive than an unregulated linear supply, but it will be better at maintaining a voltage output while the load of the motor changes. This is important for two reasons

1. It helps prevent the supply voltage from dropping below the minimum working voltage of the EvoDrive.
2. It helps prevent the supply voltage from exceeding the maximum input voltage of the EvoDrive, potentially damaging the drive electronics.

## Current Rating

The current rating of the power supply must be greater than the desired drive current of the motor.

If the current rating of the power supply is larger than this then the power supply will be able to handle fluctuations in load better, and will *generally* produce less EMC emissions.

Obviously the current draw of all motors must be added together to get the total current load of the power supply. For example if a product has three


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EvoDrive units, one driving at 1 Amp and two driving at 1.5 Amps then the power supply should be rated to 4 Amps plus a healthy margin ( 20 – 50 %).

### Back EMF

Whenever a stepper motor is spinning it is generating a voltage that opposes the power supply. This voltage is called the Back EMF.

The Back EMF determines how quickly current can be established in the motor windings. For example, when using a 24V supply at low speeds, the back EMF is small, let's say 2V. That means there is 22V of potential to generate current in the windings. The current control is fast and responsive.

But at high speeds the Back EMF can approach the supply voltage, let say 20V. Now there is only 4V of potential to produce the required current. The current control is slow and becoming insufficient. This speed is often called the 'base' speed of the motor and effectively limits the top speed of the motor.

When all is well, the back EMF is not visible. That is, the power supply will regulate to its supply voltage despite changes in Back EMF.



However, fast deceleration or sudden changes in speed cause the motor currents to change polarity. This means the power supply voltage is suddenly added to the back EMF, and it is possible to exceed the maximum input voltage of the EvoDrive which will permanently damage the product.

The severity of the surge is dependant on the motor speed, deceleration, and inertia of the load.

This can be better understood by realising that the power supply must sink the energy stored in the system in order to slow it down. If the motor is driving a large heavy load, then slow decelerations and torque changes are required to let the power supply remove energy from the system whilst still regulating the voltage. Of course if there is a lot of friction or viscous damping in the system, then a lot of the energy will be dissipated in the mechanics and the load on the power supply is reduced.



It is recommended that when tuning the motion profiles of the system the supply voltage is monitored to ensure no dangerous spikes or surges are being generated.


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### Protection

In a fault mode, the motor windings are shorted and current recirculates through the motor. In this way Back EMF is contained to the motor and dissipates into heat as the motor slows. This protects the power supply and the EvoDrive from sudden voltage surges.

But in situations described above, when the power supply must actively remove energy from a moving system through deceleration, it is possible that the power supply voltage will increase significantly.



It is recommended that a power supply with over and under voltage protection be selected. These usually shut down the power supply if the output voltage exceeds a certain amount (eg 15% rated voltage).

This prevents voltage surges from exceeding the maximum safe input of the EvoDrive and will help protect the EvoDrive from damage.



Where the power supply cannot be relied upon to manage the surge voltage, a surge suppression device such as a TVS Diode should be placed as close to the EvoDrive as possible, ideally immediately next to the bulk capacitor. The TVS should protect motor power rail. The TVS should be rated for as much power as possible (several KW at least).


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# 7. Motor Selection

The EvoDrive ST-PCB can drive any bipolar or unipolar stepper motor with up to 3 amps winding current.

Obviously your application will place size and power constraints on the stepper motor selection and that will normally determine the motor you will use. Within those bounds however, the following considerations may help you select the right stepper motor.

- Stepper frame size is not important to the EvoDrive ST-PCB.
- The EvoDrive can drive up to 3 amps. However this does not restrict you from using stepper motors with other current ratings. Smaller current ratings can be configured, and higher current ratings can still be driven up to 3 amps.
- Currents at the stepper motor current rating will usually saturate the motor magnetic circuit. For best performance, try running the stepper motor at 80% of its current rating.
- Stepper motors are optimised for low-speed torque, and so is the EvoDrive. A motor with a high stall-torque value will provide the smoothest and quietest motion control.
- The motor step size is a trade-off between speed and accuracy when driving in open-loop mode. When in closed-loop mode, the accuracy is set by the encoder, so there is less need for a small step size. In fact, larger step sizes will provide a better servo response.
- A dual shaft motor is very convenient when using an encoder for closed loop control.
- The EvoDrive tuning is optimised for high-torque stepper motors. Other motors may produce a high-pitch ‘squeal’ or operate with a jerky motion. Use the Motor Calibration function in EvoLink to auto-tune the EvoDrive to these motors.

Note that these are guidelines only and may not reflect the requirements of your application. If you would like more specific assistance, please contact EVA Robotics.


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## 7.1 Encoder

A key question when commissioning a new design is whether to use closed loop or open loop control.

Below are some advantages and disadvantages to consider when choosing a control mode.

### Open Loop

- Open loop is cheaper since there is no need for an encoder.
- The EvoDrive ST-PCB will implement a quiet and smooth open loop control.
- Little to no tuning is required to achieve tight, accurate control.
- It is very inefficient because the maximum drive current is used all the time.
- The motor and controller may run hot.
- If the drive current cannot overcome obstacles, the motor will lose sync with a sudden loss in torque.
- The motor must be driven much more conservatively to avoid losing sync.
- Collisions are not detected.

### Closed Loop

An encoder is required for closed loop control. Two encoder resolutions are available from EVA Robotics as well as the option of using a third party encoder.

- More accurate position control.
- The motor will run smoother and quieter.
- The motor has greater dynamic range (it can achieve greater speeds and apply more torque at high speed, than in open-loop).
- The motor and controller runs much cooler and more efficiently.
- Torque output can be monitored and/or controlled.
- The motor will not lose sync – it will attempt to push through obstacles.
- Collision detection is possible.
- Less safety margin is required when selecting a motor.
- Tuning may be required to achieve a desired system performance. Though the default tuning is usually suitable.


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## Encoder Resolution

Any quadrature encoder can be used as long as it has a resolution greater than 8192 counts per revolution.

The encoder provides two resolutions that define the control performance:

**Position resolution**: This is equal to half the encoder resolution. So with a 8192 count encoder the output can be controlled to ± 0.044 degrees.

**Control resolution**: This is the torque resolution available to the control loop to control the motor. An 8192 encoder provides a control resolution of ± 2.5% on a 1.8 degree motor.

The control resolution doesn't sound very accurate but this is actually more than enough for most applications. Because the control is closed loop, as long as you have enough torque overhead the motor will follow the trajectory profile at a much finer resolution than in open loop.

As the encoder resolution increases so does the control resolution. For example a 16 384 count encoder has a torque resolution of ± 1.2% and will satisfy the most demanding torque control applications.


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# 8. EvoLink

EvoLink is control and diagnostics software for the EvoDrive ST-PCB. It can be used during product development to help develop and tune applications. It can also be used in a production or service environment for configuration or debugging.

EvoLink provides easy access to the EvoDrive's command set and should be used with reference to the EvoDrive Programmers Manual.

## 8.1 Installation

The latest version of EvoLink can be downloaded from www.evarobotics.com.

EvoLink is distributed as an executable installer. Running the installer will install EvoLink and the USB drivers required to communicate with the ST-PCB Debugger.

EvoLink requires the .Net Framework V3.5 or higher. A separate installer for the .Net Framework V3.5 is included in the EvoLink installation. Alternatively the latest .Net Framework can be downloaded from Microsoft or requested from EVA Robotics.


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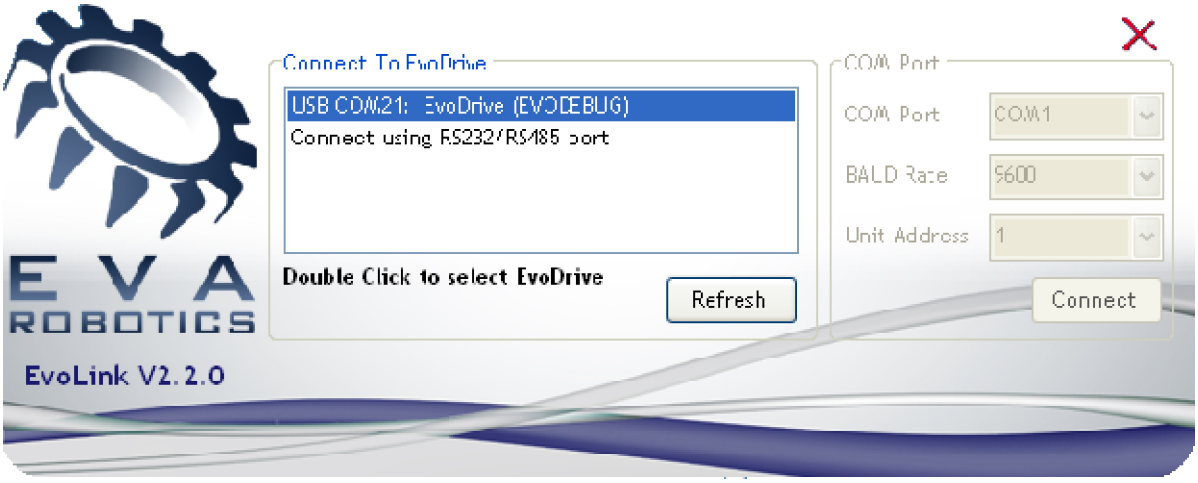
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## 8.2 Connect Page

When EvoLink is first launched the connection options are presented.

If the EvoDrive is connected to the PC via the ST-PCB Debugger, then it will be listed in the **Connect To EvoDrive** panel. To connect to the EvoDrive double click on the line that identifies the EvoDrive.

To connect to an EvoDrive over RS232, select **Connect using RS232/RS485 port**. Then enter the connection details into the **COM Port** panel and press **Connect**.




## 8.3 Main Page

The main page provides access to all the EvoDrive functions and features.

Most functions are grouped onto expandable panels that allow easy access to different EvoDrive functions on the fly. Panels can be opened or closed in any order and at any time to customise the available information.


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The main panels and features are summarised below:



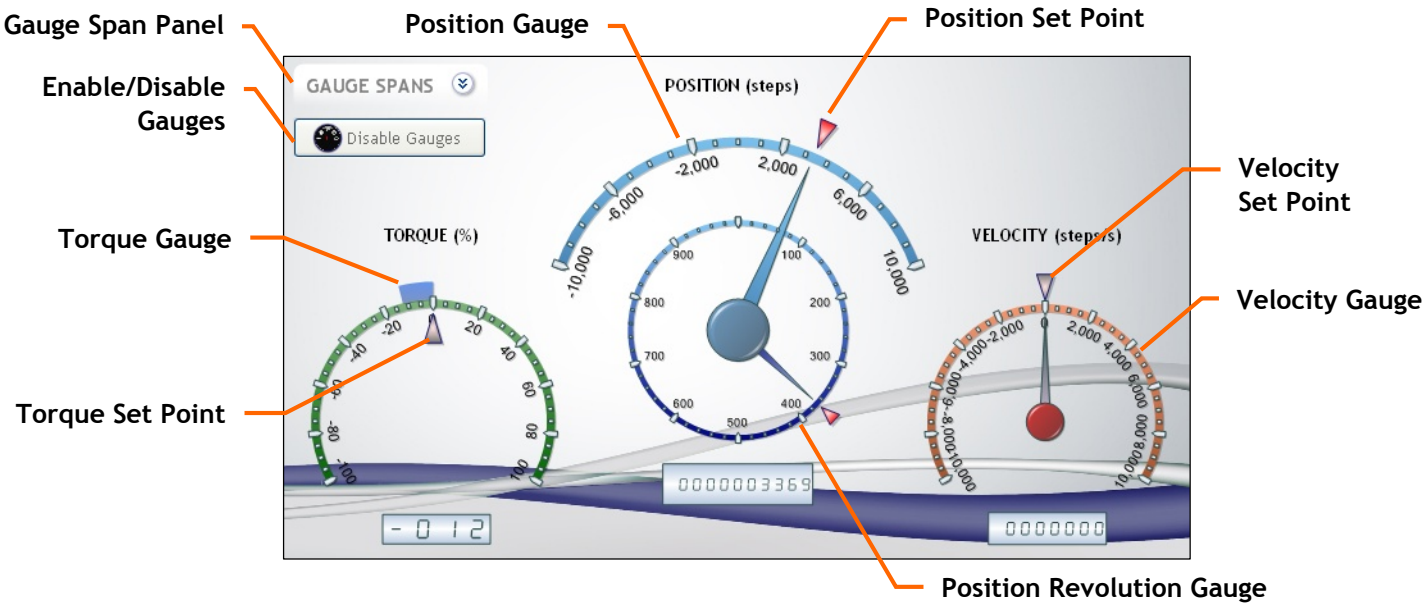

- **Emergency Stop.** This button will immediately disable the EvoDrive ST-PCB outputs and couple the motor windings together.
- **Information Panels.** These provide status information on the EvoDrive ST-PCB including I/O states and error conditions.
- **Quick Set Points**. This is an easy way to set the EvoDrive set-points while the **Commands** panel is closed.
- **EvoDrive Configuration**. This panel allows the EvoDrive configuration to be modified, backed up, and restored.
- **EvoDrive Commands.** This panel provides access to some common functions as well as the ability to send any command string or script file.
- **Chart**. This panel allows real time data such as position or torque to be plotted, saved, and exported.
- **Gauge Controls**. The gauges provide real time torque, position, and velocity data from the motor. They also allow the torque, position, and velocity set-points to be set graphically.


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## 8.4 Control Gauges

The control gauges provide an intuitive method of controlling the EvoDrive while providing real time feedback.




The gauges provide real time feedback for motor torque, position, and velocity. Each gauge has a numerical and a graphical readout which are updated approximately 10 times per second.

Each gauge also has a set point marker which will be either red or grey. The set point markers can be selected by clicking once on the triangular marker, and dragged to create a new set point. The active set point is coloured red while the inactive set points are grey.

Note: Double clicking on any set point marker will change the set point to 0.

The position gauge has a smaller scale with its own pointer and set point marker. This gauge represents the position within the current motor revolution. Changing the set point on this gauge allows the position to be fine tuned within one revolution of the current position.

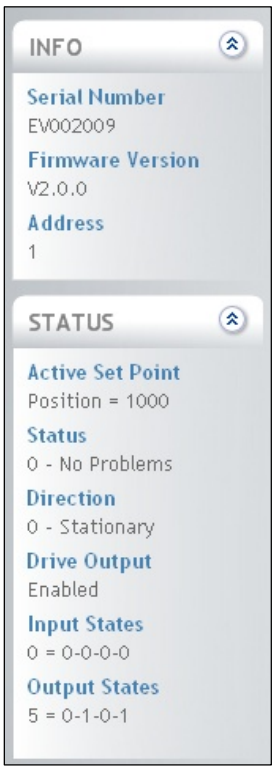
The gauge spans can be adjusted by opening the **Gauge Spans** panel in the upper left corner. Setting the gauge span to actual limits as defined by your application allows quick and intuitive control of the motor during development.


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## 8.5 Information Panels

### Info Panel



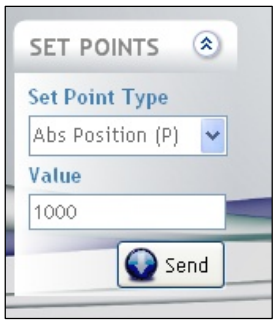

The **Info** panel contains the EvoDrive's serial number, firmware version, and bus address.

### Status Panel

The **Status** panel provides real time status information on the EvoDrive. This information is updated twice per second.

- **Active Set Point**: Displays the current set point type and value.
- **Status**: Displays the current status code and a short description.
- **Direction**: Displays the current direction code and description.
- **Drive Output**: Shows the status of the vector drive – **Enabled** or **Disabled**.
- **Input States**: Shows the decimal value returned by the DI command, and a bit value for each input (Input4 ➔ Input 1).
- **Output States**: Is not applicable to the EvoDrive ST-PCB.

## 8.6 Quick Set Point Panel




The **Quick Set Points** panel provides another simple interface for changing the set points. It is useful while using the **Chart** panel or to send an exact set point to the EvoDrive.


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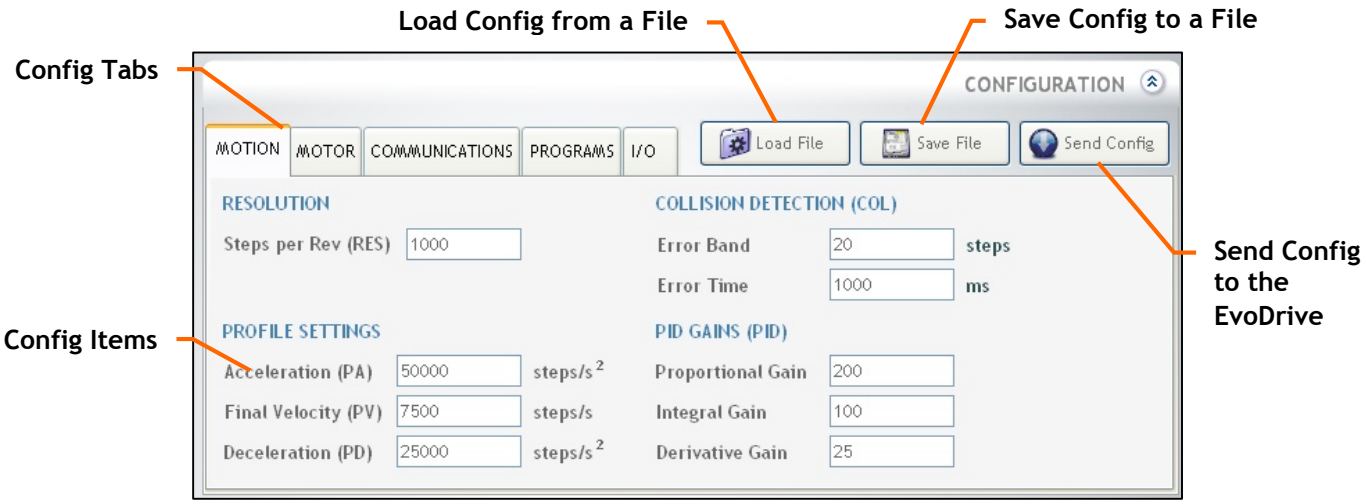
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## 8.7 Configuration Panel

The **Configuration** panel allows the EvoDrive ST-PCB configuration to be read, modified and saved.

The EvoDrive configuration is all the non-volatile drive parameters. All configuration items are set programmatically. Where a configuration item is associated with a particular command, that command is shown in brackets ().

For more information on individual configuration items see the EvoDrive Programmers Manual.




When the **Configuration** panel is opened the EvoDrive configuration will be uploaded for display.

All configuration items are shown in UserStep units (defined by **Steps per Rev**). Changing the **Steps Per Rev** value will automatically change all other values that are dependant on it.


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### Modifying Configuration Items

Changing the value of a configuration item does not change the value on the EvoDrive. All changes remain local until the **Send Config** button is pressed.

When **Send Config** is pressed all values are saved to non-volatile memory on the EvoDrive. Most take affect immediately.

Some values, such as the BAUD rates, require the EvoDrive to be reset before the changes take effect. If a reset is required you will be prompted before resetting the EvoDrive.

### Backing up Configuration

The EvoDrive configuration can be saved to a configuration backup file (.evo) by pressing the **Save File** button. A browse window will be opened to allow you to select a location and filename for the backup.

### Restoring Configuration

Pressing the **Load File** button will prompt you to select a configuration backup file (.evo).

Selecting a file will load the values from the backup onto the screen. Press the **Send Config** button to save these values to the EvoDrive.

Note that restoring the configuration will not change the EvoDrive serial number or firmware.



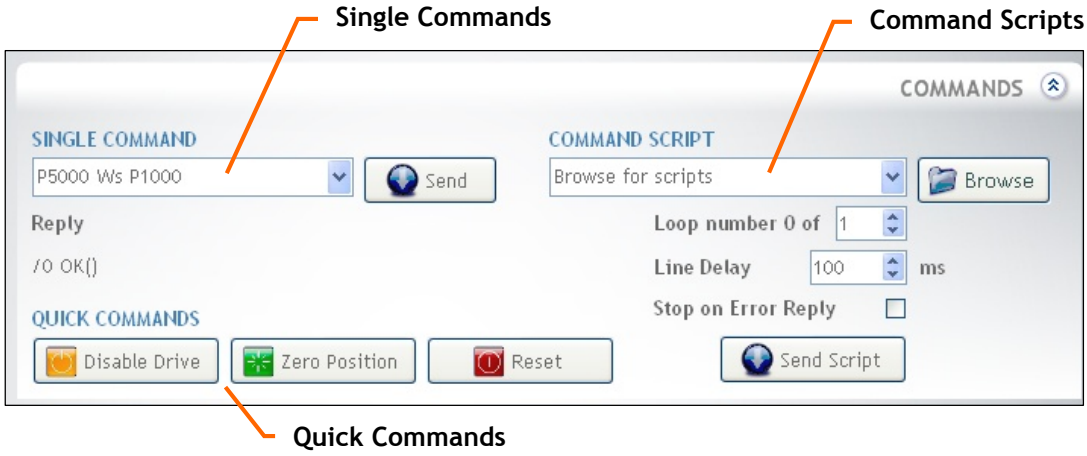
Once overwritten the EvoDrive configuration cannot be recovered.


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## 8.8 Commands Panel

The commands panel provides an interface for sending raw commands directly to the EvoDrive. The three functional areas of the Command panel are shown below.




### Quick commands

These buttons allow quick access to three common commands used during development:

- **Enable**/Disable the vector drive (EN command)
- **Zero** the current position (Z command)
- **Reset** the EvoDrive (Reset() command)

### Single Command String

Single command lines can be sent directly to the EvoDrive by typing the command into the text box and pressing the **Send** button.

Note that the header (/), the address, and the terminating (**CR**) characters do not need to be included in the command, these will be added automatically.

The text box is the top of a drop down list which contains a history of all sent commands. Previous commands can be selected from the drop down list and resent by pressing the **Send** button.

The reply from the EvoDrive is displayed under the **Reply** heading.


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## Command Script Files

A script file is a text file containing multiple commands. An example is shown below.

```
# Example Script File
# EvoDrive ST-PCB

Prompt(Watch out! The EvoDrive is about to spin)

V5000
Pause(3000)
Prompt(Well… I told you.)
```

Each line in the text file is a new command. The commands will be sent to the EvoDrive one line at a time. For each command the EvoDrive reply will be shown under the **Reply** heading.

Script files are sent to the EvoDrive according to the following options:

- **Loop Number**: This sets how many times the script file should be repeated.
- **Line Delay**: The line delay is the time in milliseconds between each line in the script file being sent. The default is 100ms.
- **Stop on Error Reply**: If this is set then the script file will be aborted if the EvoDrive returns an error reply.

There are three special commands which will not be sent to the EvoDrive:

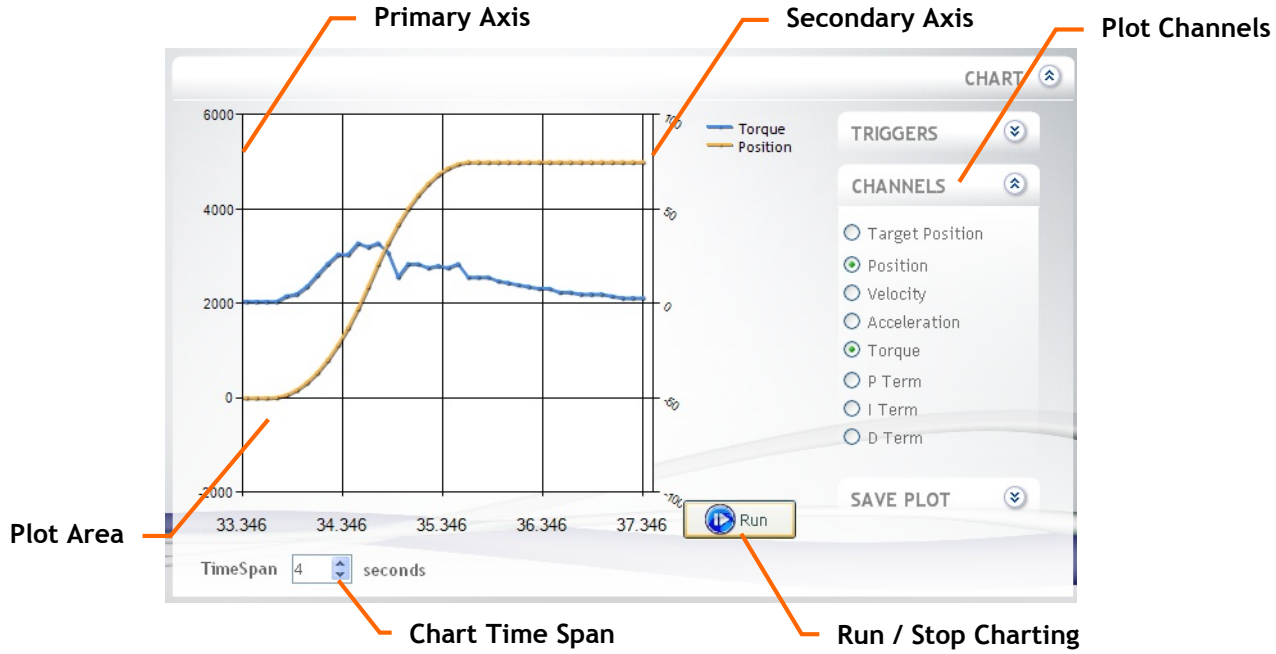
- **#** : Denotes a comment line
- **pause(x)** : Will pause the script for x milliseconds
- **prompt(x)** : Will cause a message box to be displayed to the user with the message x. This message must be acknowledged before continuing the script.


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## 8.9 Chart Panel

The **Chart** panel allows certain EvoDrive parameters to be plotted against time. This is a very useful tool during development to view motion profiles, torque levels or while tuning the PID gains.




### Plotting Data

The **Channels** panel contains the data available for plotting. Up to 5 channels can be selected at any one time.

Press the **Run/Stop** button to start and stop the chart. Data will be streamed from the EvoDrive at the fastest rate allowed by the BAUD rate. The data will be plotted immediately and the plot area will scale itself to contain all data.

Changing the **TimeSpan** value will change the span of the X (time) axis. A value of 0 will display all data. All other values will display the latest **TimeSpan** seconds of data as a rolling plot.

The **Position**, **Velocity** and **Acceleration** channels will be plotted against the primary axis. **Torque** and **PID Terms** will be plotted against the secondary axis.

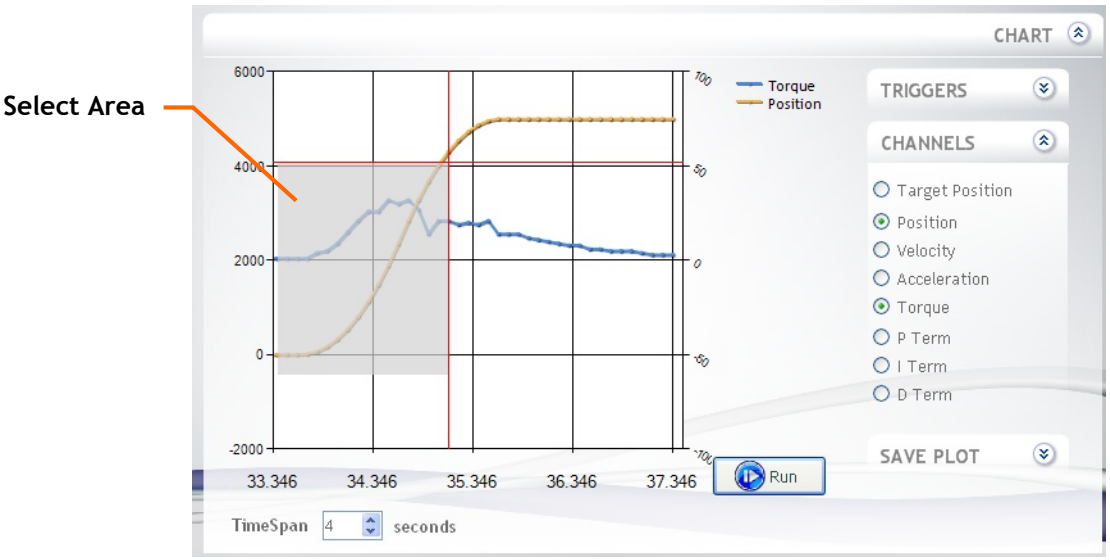

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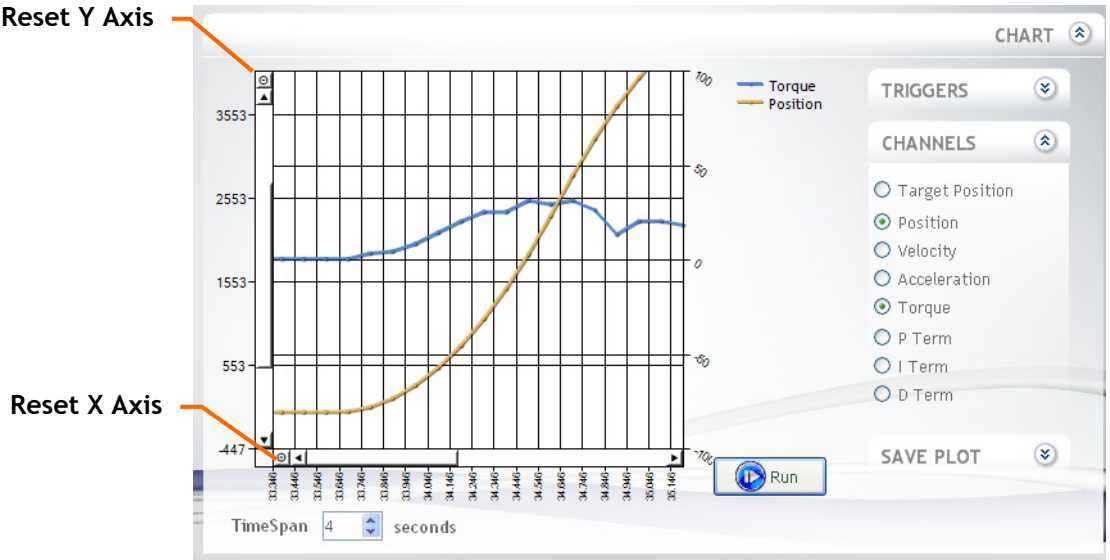
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## Viewing Data

After stopping the data capture, the data view can be expanded by selecting an area on the plot.

Select the area by clicking and dragging the mouse over the area of interest.



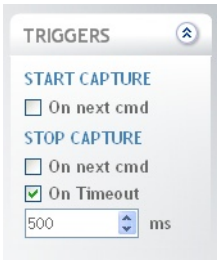

Zooming in on the data will enable scroll bars on the X and Y axes which allow the selected area to be adjusted in each axis.

At one end of each scroll bar is a small reset button which will return the axis to its original scale.


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## Capture Triggers




The **Triggers** panel contains options for starting and stopping the chart.

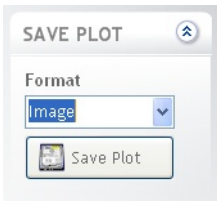
When the **Start On Next Command** option is selected, pressing the **Run** button will arm the chart. But the chart will not start to capture data until another command has been sent to the EvoDrive. Any command will trigger the chart to begin.

When the **Stop On Next Command** option is selected, the chart will stop the next time a command is sent to the EvoDrive.

If both **Start On Next Command** and **Stop On Next Command** options are selected, then the chart will begin on the first command, and it will stop on the second command.

If the **Stop On Timeout** option is enabled, the chart will stop *x* milliseconds after the chart was started, *x* being the value shown under the **Stop On Timeout** option.

## Saving Data




The Save Plot panel provides options for exporting the data.

Image will save the plot area to an image file. Several different formats are supported including JPG, BMP and GIF.

Data will save the raw data to a .csv (Comma Delimited) text file. This file can then be opened in Excel or other spreadsheet/graphing software for further analysis and presentation.


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## 8.10 Motor Calibration

To get the best performance out of any motor/encoder combination, EvoLink can be used to automatically calibrate the hardware.

The calibration will detect the winding parameters of the motor. It will also detect any small errors between the motor position and encoder feedback. These errors may be due to manufacturing tolerances in the motor or non-linearity in the encoder, or a combination of both.

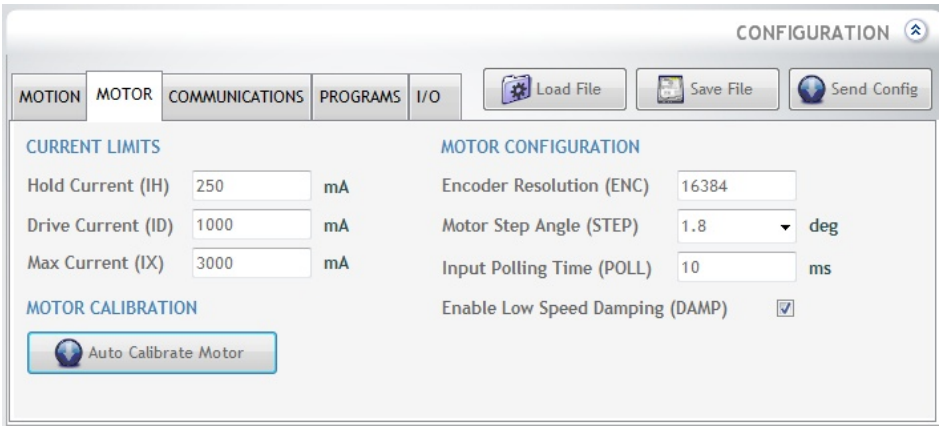
Calibration is specific to a particular motor and encoder combination. Calibration values cannot be moved from one EvoDrive to another. If a motor or encoder is replaced, or even taken apart and then re-assembled, the calibration may need to be performed again.

### Starting Calibration



Before calibrating the motor, ensure power is connected to the EvoDrive, and disconnect the motor from any loads to ensure the motor shaft can move freely.

Open the Configuration Panel. On the **Motor** Tab, press the **Auto Calibrate Motor** button.

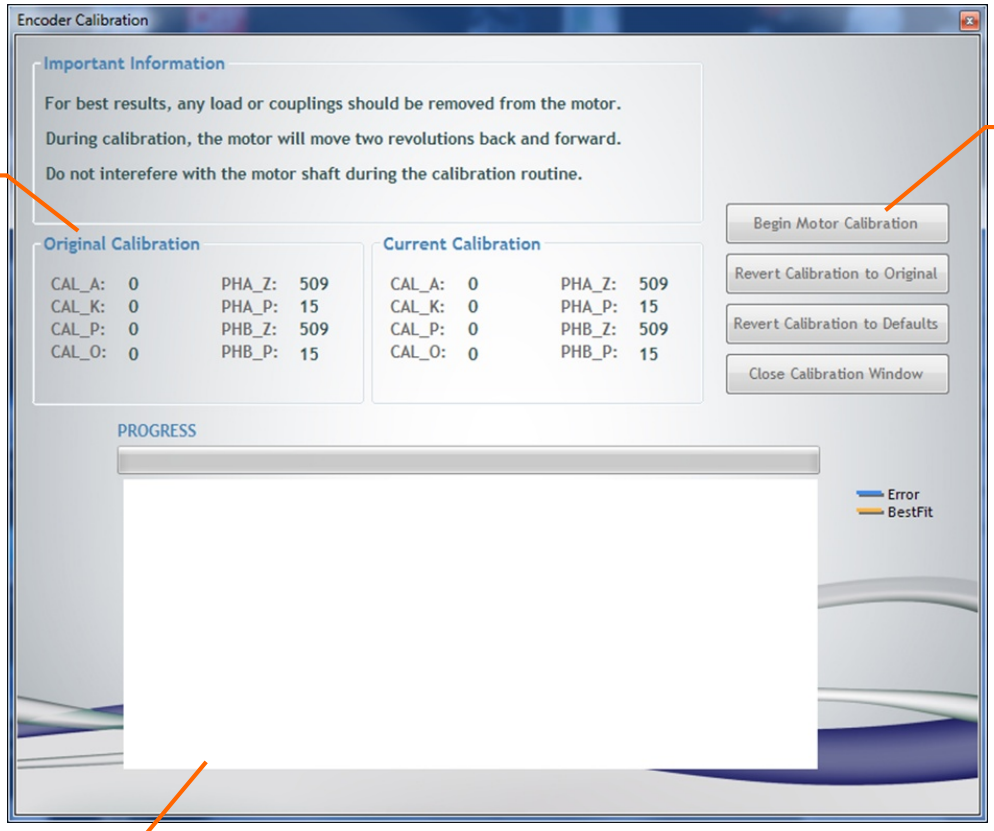



If there is no encoder attached (and configured) on the EvoDrive, then the motor will be calibrated immediately. This will produce a short beep or hiss from the motor, then a prompt will appear to say the calibration is complete.


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If there is an encoder attached, then the following window will be displayed.




This window shows the original calibration values currently stored in the EvoDrive. You can reset the calibration values to default settings by pressing the **Revert Calibration to Defaults** button.

To begin the motor/encoder calibration, press the **Begin Motor Calibration** button.

The motor will turn 1-2 full revolutions clockwise and then counter-clockwise. While the motor is turning, the position error is displayed on the graph. The error is in degrees. This error will be compensated for by the EvoDrive after calibration.


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Once the motor has finished moving, the actual and a best-fit error curve are plotted together in the results window. The **Current Calibration** group shows the updated calibration values.




To cancel the calibration and return to the original calibration values press the **Revert Calibration to Original** button.

Otherwise, to save the new calibration values and exit, press the **Close Calibration Window** button.


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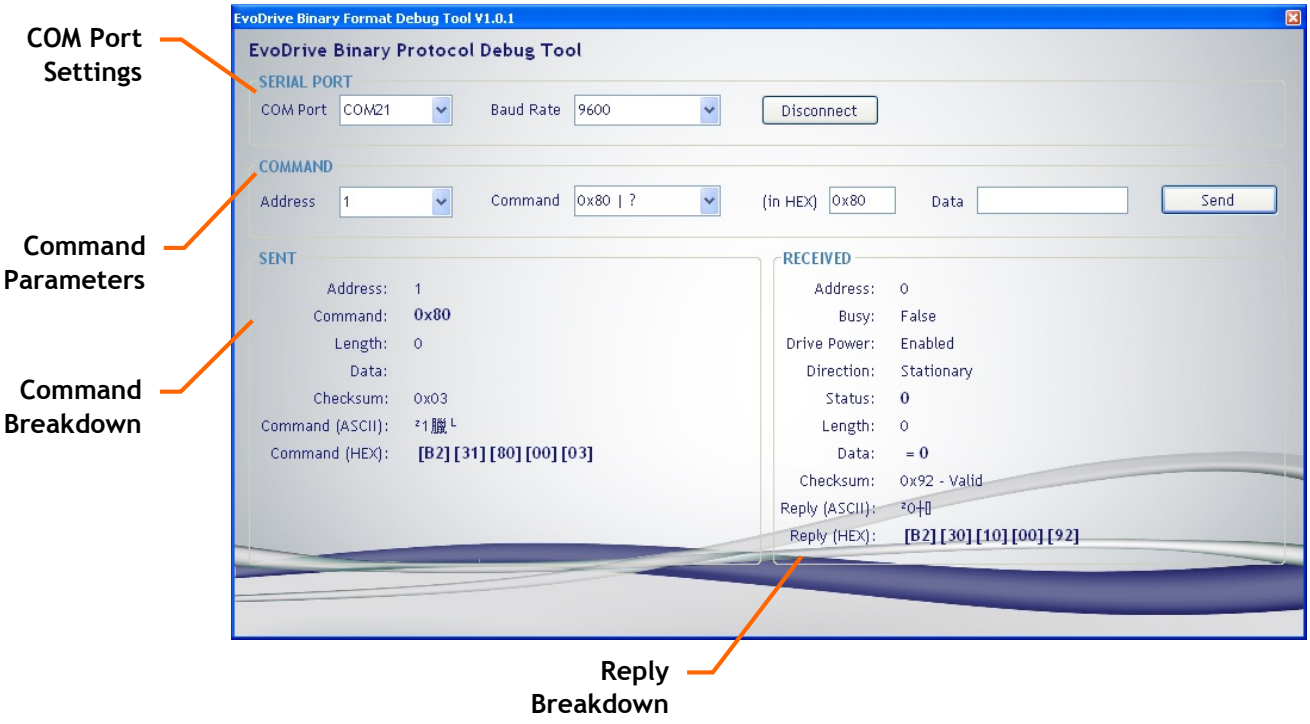
# 9. Binary Command Format Tool

The binary protocol debug tool is a software application that allows commands to be sent to the EvoDrive ST-PCB using the binary command protocol.

The software displays a component breakdown of the command and the reply. It also shows the commands in both their extended ASCII and Hex formats.

The software helps developers build their binary interface faster, and helps to validate that their drivers are interpreting EvoDrive binary replies correctly.

For more information on the binary protocol, see the EvoDrive Programmers Manual.





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# 10. Specifications

## Absolute Maximum Ratings

| | |
|---|---|
| **Motor Power Supply** | 60V DC |
| **Peak Motor Current** | 7.1A |
| **Logic Power Supply** | 5.5V DC |
| **Encoder Inputs** | 5.5V DC |
| **Signal Pins** | 5.5V DC |

## Typical Electrical Characteristics

| | |
|---|---|
| **Motor Power Supply** | 12V - 48V DC |
| **Motor Current Rating** | 2.2A RMS 3.1A Peak |
| **Logic Power Supply** | 4.5V - 5V DC |
| **Logic Power Requirements** | 150mA max |
| **Encoder Signal Inputs** | 2.8V - 5V DC |
| **Signal Pin High-Level Input** | 2V - 5V DC |
| **Signal Pin Low-Level Input** | 0V – 1.3V DC |
| **Signal Pin High-Level Output** | 2.4V DC minimum |
| **Signal Pin Low-Level Output** | 0.4V DC maximum |
| **Signal Pin High-Level Source Current** | 2mA |
| **Signal Pin Low-Level Sink Current** | 2mA |

## Vector Drive

| | |
|---|---|
| **Maximum Drive Speed** | Up to 3000 RPM |
| **Maximum Resolution** | 102 400 steps per revolution |
| **Motor Compatibility** | Bi-polar stepper motors.<br>Any step size (0.9° ➔ 7.2° step). |


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## Communications

| | |
|---|---|
| **Independent Channels** | 2 |
| **Channel 1 Interfaces** | USB via ST-PCB Debugger. |
| **Channel 2 Interfaces** | UART<br>SPI |
| **USB** | USB V2.0<br>Mini-B Connector |
| **UART Maximum BAUD Rate** | 115 200 bps |
| **SPI Maximum Clock Rate** | 4 MHz |
| **Max Command Buffer** | 128 Characters |

## Digital Inputs

| | |
|---|---|
| **General Purpose Inputs** | 4 |
| **Digital Control Modes** | Step/Dir<br>CW/CCW |
| **Digital Input Low-Level Voltage** | 0 – 1.3 VDC |
| **Digital Input High-Level Voltage** | 2.0 – 5 VDC |
| **Maximum pulse frequency** | 90KHz |

## Triggered Programs

| | |
|---|---|
| **Number of Programs** | 9, 1 per trigger source |
| **Program Length** | 64 Characters |

## Encoders

| | |
|---|---|
| **FW-A002 Resolution** | 8,192 Counts per Rev |
| **FW-A009 Resolution** | 16,384 Counts per Rev |
| **Encoder Compatibility** | Quadrature Encoders<br>Resolution of 8,192 counts after quadrature or greater.<br>3.3V or 5V supply. |


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## Environmental

| | |
|---|---|
| **Operating Temperature** | -20°C – 60°C |
| **Operating Relative Humidity** | 8% - 80% non-condensing |
| **Storage Temperature** | -40°C – 80°C |
| **Storage Humidity** | 5 – 95% non-condensing |

## Regulatory

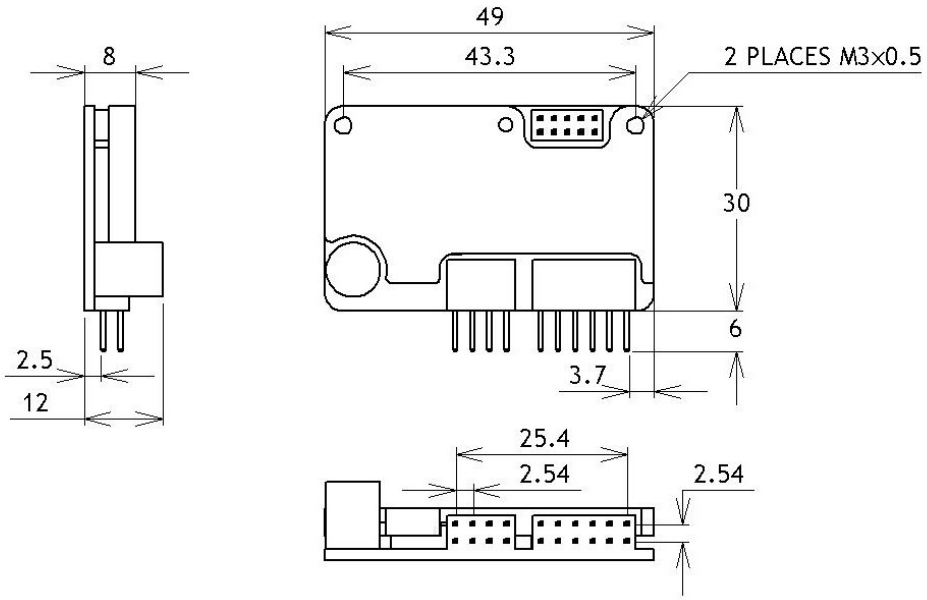
| | |
|---|---|
| **Circuit Ratings** | All circuits are SELV |


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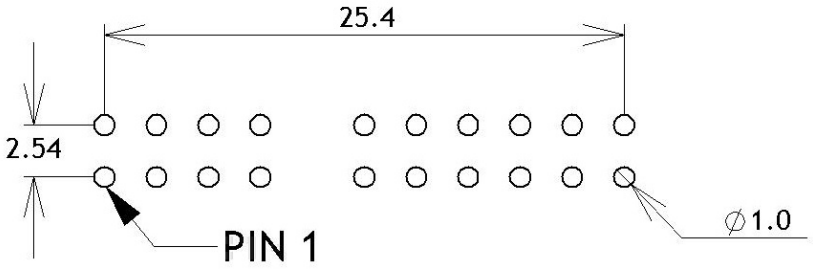
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## 10.1 Mechanical Specifications

### EvoDrive ST-PCB (FW-A101)




### Recommended PCB Pad Pattern





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