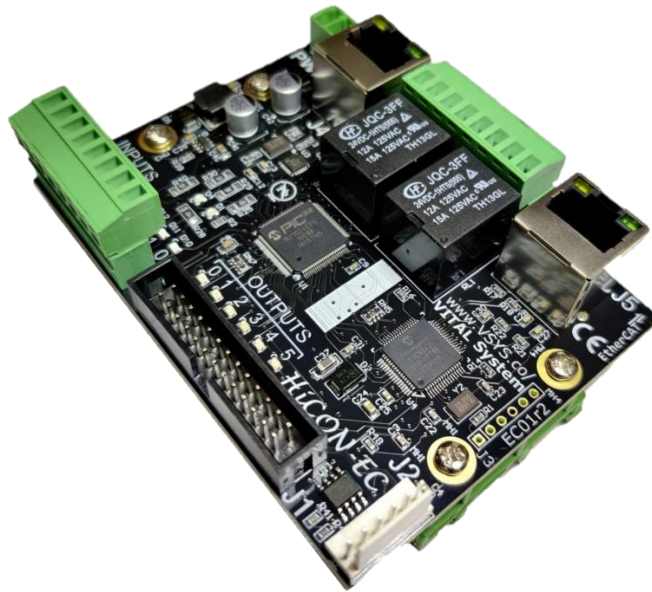


# EC01 EtherCAT Motion Controller

Ethernet Motion Controller



## EC01 User Guide

Version 1.35

(Updated January 22, 2024)



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Atlanta, GA USA

For more information, please visit the product web page:

[www.vitalssystem.com/ec01](http://www.vitalssystem.com/ec01)

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## License Agreement

Before using the HiCON and accompanying software tools, please take a moment to go thru this License agreement. Any use of this hardware and software indicates your acceptance to this agreement.

It is the nature of all machine tools that they are dangerous devices. In order to be permitted to use HiCON on any machine you must agree to the following license:

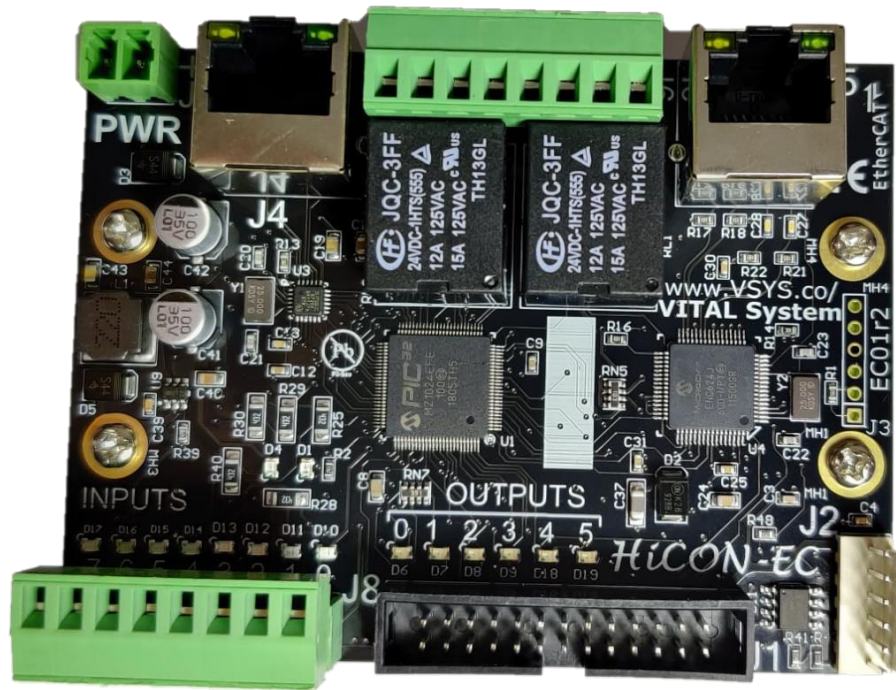
I agree that no-one other than the owner of this machine, will, under any circumstances be responsible, for the operation, safety, and use of this machine. I agree there is no situation under which I would consider Vital Systems, or any of its distributors to be responsible for any losses, damages, or other misfortunes suffered through the use of the HiCON board and its software. I understand that the HiCON board is very complex, and though the engineers make every effort to achieve a bug free environment, that I will hold no-one other than myself responsible for mistakes, errors, material loss, personal damages, secondary damages, faults or errors of any kind, caused by any circumstance, any bugs, or any undesired response by the board and its software while running my machine or device.

I fully accept all responsibility for the operation of this machine while under the control of HiCON, and for its operation by others who may use the machine. It is my responsibility to warn any others who may operate any device under the control of HiCON board of the limitations so imposed.

I fully accept the above statements, and I will comply at all times with standard operating procedures and safety requirements pertinent to my area or country, and will endeavor to ensure the safety of all operators, as well as anyone near or in the area of my machine.

**WARNING:** Machines in motion can be extremely dangerous! It is the responsibility of the user to design effective error handling and safety protection as part of the system. VITAL Systems shall not be liable or responsible for any incidental or consequential damages. By using the HiCON motion controller, you agree to the license agreement.

## 1. Overview



The EC01 EtherCAT Master is the latest addition to our HICON series. Designed for use with Mach4 via the HiCON plugin, the EC01 provides a cost effective EtherCAT Master solution that can interface with the PC directly over Ethernet. The EC01 does not require any specialized computer or motherboard to operate. For OEM custom software applications, we also offer SDK support for EC01.

### Key Features

- EtherCAT Master capable of controlling up to 12 EtherCAT motors concurrently
- EtherCAT configuration software EC-Link for easy configuration
- Mach4 plugin for EtherCAT
- Built on the reliable HiCON Platform
- Cost effective high quality EtherCAT Solution
- 36 Digital IO (24 In/12 Out) and 2 Relays on board

## 2. EC01 Specifications

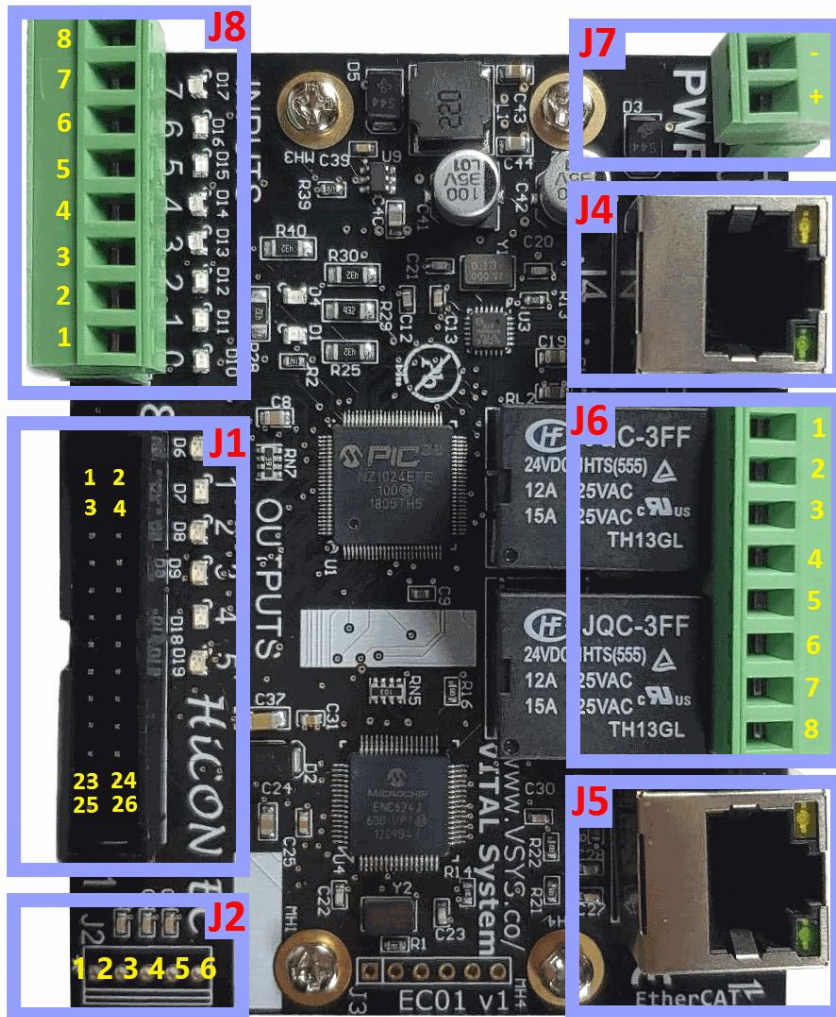
- All devices like I/O modules and Drives must have Distributed Clock support with 1ms cycle time DC can be 32bit/64bit (recommended)
- EtherCAT drives must have support for Cyclic Synchronous Position (CSP) and CiA402 protocol
- Maximum of 12 slaves on the network (Visit the product page for latest skew information)
- Maximum of 16 PDO mappings per slave (8 per direction: Rx & Tx PDO)
- Maximum of 32 objects per PDO mapping
- Maximum of 128 Inputs and 128 Outputs per slave
- All PDO mappings must be **byte** aligned. In case of digital I/O they can be **nibble** aligned and placed at the end of the network if they are not byte aligned.
- Maximum of 20 SDO per slave
- SDO data types supported INT8, INT16, INT32, INT64, UINT8, UINT16, UINT32, UINT64, FLOAT/REAL32, DOUBLE/REAL64
- LRW commands are used for communication.

## 3. Setup Guide

When setting up the EC01 for the first time, please follow along the [EC01 Quick Start Guide](#) available on our website. This will walk through each of the necessary steps one at a time with pictures to help you get your system up and running. There is also a video version of this guide available [here](#).

## 4. EC01 Hardware Interface

The EC01 has several interface ports and indicator LEDs. The figure below shows a top view of the EC01 board with interface ports and other components:



|    |  |
|----|--|
| J1 | Digital I/O Expansion port (8 Output, 16 Input)                                  |
| J2 | Analog output 0-10V and Encoder (A,B,Z)  |
| J4 | LAN Ethernet Connection to PC (Mach4)  |
| J5 | EtherCAT Network to Slave Devices  |
| J6 | Four Isolated Digital Outputs 0..3 (NPN Sinking) and two Relay N.O. Dry contacts |
| J7 | Power Input, +24VDC, 500mA   |
| J8 | Eight Isolated Digital Inputs (NPN Sinking)                                      |

## 4.1. Power Supply (J7)

| J9 Pin# | Function                         |
|---------|----------------------------------|
| +       | +12 - 28VDC (Polarity Protected) |
| -       | Ground                           |

- Unit requires at least 15W power input.
- If more devices are connected to the unit, a bigger power supply may be required.

## 4.2. Ethernet Ports (J4, J5)

### J4 LAN Ethernet Port:

The EC01 controller has an Ethernet Port that allows the user to make a PC connection using an Ethernet cable. Connect to PC directly or via an Ethernet Hub or switch. For more detailed information see section [3. Network Connection Setup](#). The EC01 supports both 10 MBit and 100 Mbit network speeds. TCP/IP network protocol in UDP mode is used for PC communications.

### J5 Ethercat Interface Ethernet Port:

The EC01 controller has an Ethernet Port that which it uses to connect to a slave group using EtherCAT protocol. The EC01 supports both 10 MBit and 100 Mbit network speeds.

## 4.3. Spindle Analog Output and Encoder (J2)

J2 plug provides analog output 0-10v to command the VFD for spindle, as well as a 5v encoder channel to capture rotation RPM and encoder counts.

### J2 Pin Assignments:

| J2 Pin | Function                  |  |
|--------|---------------------------|--|
| 1      | Ground                    |  |
| 2      | Analog Output (0V - 10V)  | Max Current Draw 10mA                        |
| 3      | Encoder – A               | Up to 5V can be applied to this input        |
| 4      | Encoder – B               | Up to 5V can be applied to this input        |
| 5      | Encoder – Z (Index Pulse) | Up to 5V can be applied to this input        |
| 6      | +5V                       | Max Current Draw 75mA to power your encoder. |

## 4.4. Digital I/O (J1, J6, J8)

The EC01 controller has two normally open relay contacts, eight isolated NPN inputs, four isolated NPN outputs, as well as an expansion port to add 16 input and 8 outputs using external breakout board [pn 7535](#).

### Digital Outputs - J6

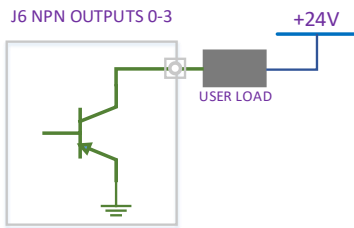
The NPN outputs can drive load connected to 24v. These output switches the 0v side of the load.

### J6 Pin Assignments:

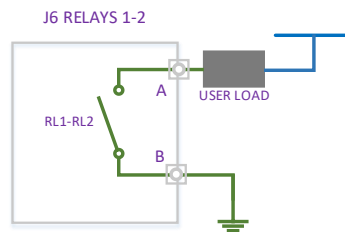
| J6 Pin# | Function                              |
|---------|---------------------------------------|
| 1       | Digital Output 0, Mach4 Port 11 Pin 0 |
| 2       | Digital Output 1, Mach4 Port 11 Pin 1 |
| 3       | Digital Output 2, Mach4 Port 11 Pin 2 |
| 4       | Digital Output 3, Mach4 Port 11 Pin 3 |
| 5       | Relay N.O. 1 – Mach4 Port 11 Pin 4    |
| 6       |                                       |
| 7       | Relay N.O. 2 – Mach4 Port 11 Pin 5    |
| 8       |                                       |

### J6 Outputs and Relay Circuit Diagrams

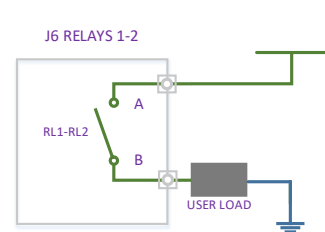
NPN Output Diagram (PIN 1-4)



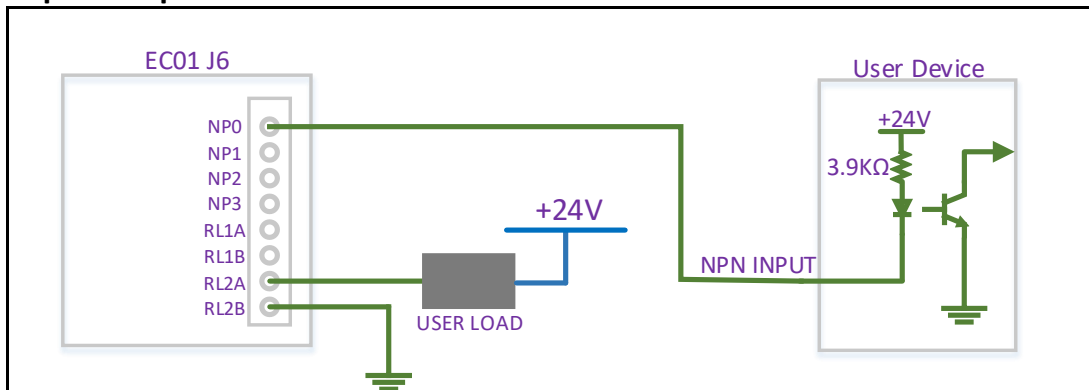
Relay Setup Method 1



Relay Setup Method 2



### J6 Example Setup



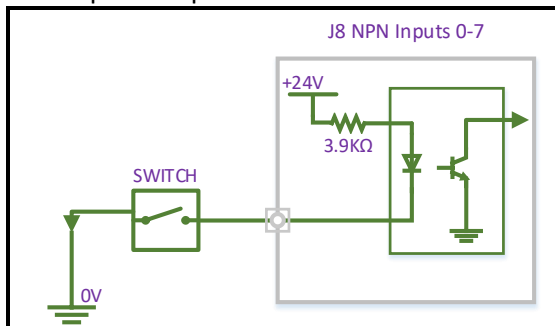


**J8 (24V) NPN Digital Inputs:** These inputs are triggered by connecting the input pin to 0v or Gnd, either by a switch or open-drain circuit. Voltage above 5v to 24v will not trigger the input.

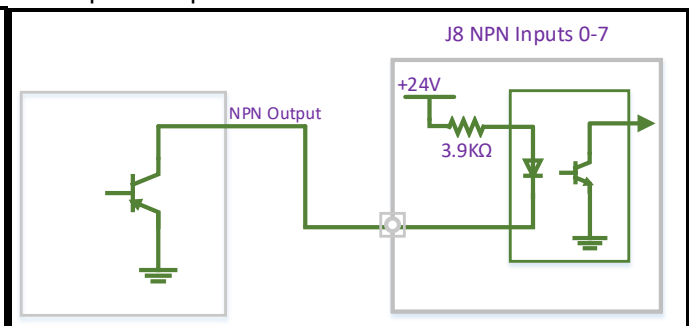
| J8 Pin# | Function                              |
|---------|---------------------------------------|
| 1       | Digital Input 0, Mach4 Port 11 Pin 0  |
| 2       | Digital Input 1, Mach4 Port 11 Pin 1  |
| 3       | Digital Input 2, Mach4 Port 11, Pin 2 |
| 4       | Digital Input 3, Mach4 Port 11, Pin 3 |
| 5       | Digital Input 4, Mach4 Port 11, Pin 4 |
| 6       | Digital Input 5, Mach4 Port 11, Pin 5 |
| 7       | Digital Input 6, Mach4 Port 11, Pin 6 |
| 8       | Digital Input 7, Mach4 Port 11, Pin 7 |

### J8 Circuit Diagrams

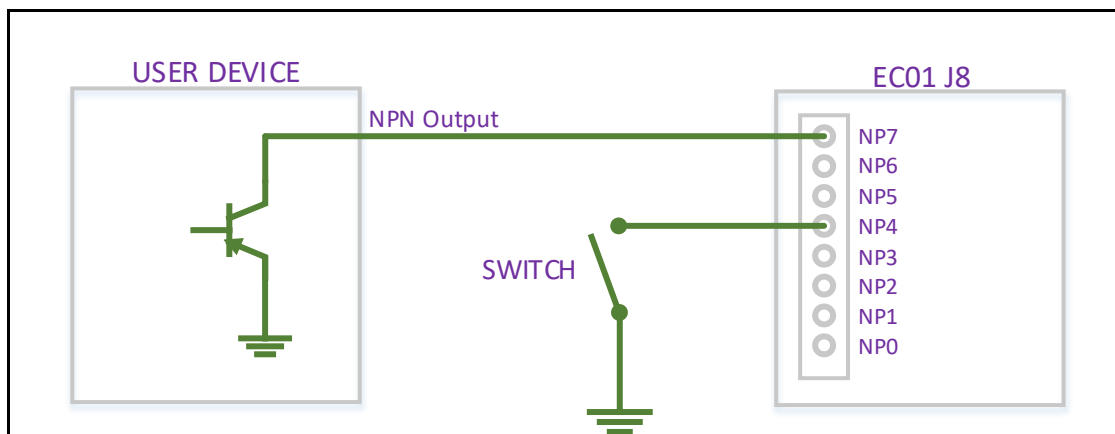
NPN Input Setup Method 1



NPN Input Setup Method 2



### J8 Example Setup



## J1 Digital I/O Expansion Port:

This port provides 16 inputs and 8 outputs. The pins on J1 are not isolated and connect directly to 3.3v circuit. Care must be taken when interfacing to these pins. Vital Systems offers 24v I/O breakout board for this plug. Please visit this [pn7535 breakout board page](#).

| J1 Pin# | Function                             | J1 Pin# | Function                             |
|---------|--------------------------------------|---------|--------------------------------------|
| 1       | Ground                               | 2       | Digital Output Mach4 Port 12, Pin 0  |
| 3       | Digital Output Mach4 Port 12, Pin 1  | 4       | Digital Output Mach4 Port 12, Pin 2  |
| 5       | Digital Output Mach4 Port 12, Pin 3  | 6       | Digital Output Mach4 Port 12, Pin 4  |
| 7       | Digital Output Mach4 Port 12, Pin 5  | 8       | Digital Output Mach4 Port 12, Pin 6  |
| 9       | Digital Output Mach4 Port 12, Pin 7  | 10      | Digital Input Mach 4 Port 12, Pin 0  |
| 11      | Digital Input Mach 4 Port 12, Pin 1  | 12      | Digital Input Mach 4 Port 12, Pin 2  |
| 13      | Digital Input Mach 4 Port 12, Pin 3  | 14      | Digital Input Mach 4 Port 12, Pin 4  |
| 15      | Digital Input Mach 4 Port 12, Pin 5  | 16      | Digital Input Mach 4 Port 12, Pin 6  |
| 17      | Digital Input Mach 4 Port 12, Pin 7  | 18      | Digital Input Mach 4 Port 12, Pin 8  |
| 19      | Digital Input Mach 4 Port 12, Pin 9  | 20      | Digital Input Mach 4 Port 12, Pin 10 |
| 21      | Digital Input Mach 4 Port 12, Pin 11 | 22      | Digital Input Mach 4 Port 12, Pin 12 |
| 23      | Digital Input Mach 4 Port 12, Pin 13 | 24      | Digital Input Mach 4 Port 12, Pin 14 |
| 25      | Digital Input Mach 4 Port 12, Pin 15 | 26      | +5V                                  |

## 4.5. Electrical Characteristics

|                      | Type          | Current Rating            | Voltage Rating  |
|----------------------|---------------|---------------------------|-----------------|
| J7 Power             |               | 500 mA                    | 24V (20 to 28V) |
| J8 Inputs            | NPN (Sinking) | 10 mA                     | 3 to 24V        |
| J6 Outputs (Pin 1-4) | NPN (Sinking) | 500 mA Max per output pin | 30V Max         |
| J6 Relays (Pin 5-8)  |               | 1 Amp                     | 24V             |

| Ambient temperature    |                 | Non- operating: -50°C to +80 °C                             |
|------------------------|-----------------|---|
| Operating temperature: |                 | -40 °C to +70 °C (-40 °F to 160 °F)                         |
| Temperature shock      |                 | -40 °C to +70 °C (-40 °F to 160 °F) within 3 min            |
| Maximum humidity       | Non- operating: | up to 95% relative humidity non-condensing at 35 °C (95 °F) |

|  |            |   |
|--|------------|---|
|  | Operating: | up to 95% relative humidity<br>non-condensing at 25 °C (77 °F)<br>up to 90% relative humidity non-condensing at<br>42 °C (108 °F) |
|--|------------|---|

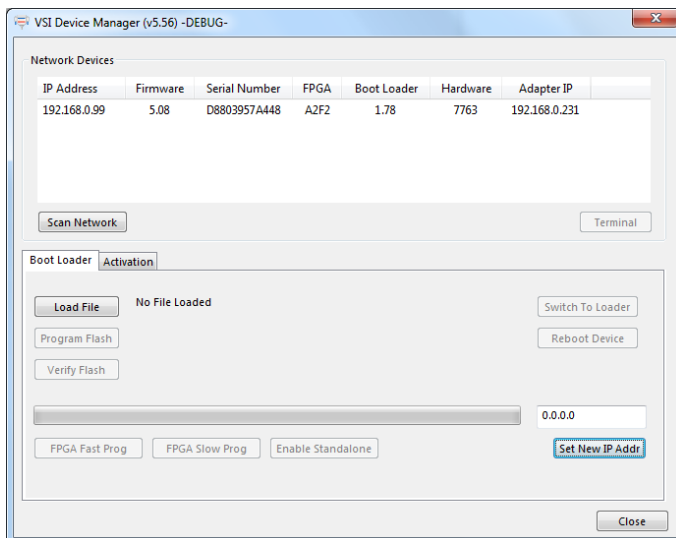
## 5. Software Components

### 5.1. HiCON Mach4 Plugin Setup

To use the HiCON plugin for Mach4, copy the M4HiCON.m4pw and M4HiCON.sig files to the “Plugins” folder in the Mach4 install directory, and enabling the plugin from within the “Plugins” tab of the Mach4 Configuration window. For detailed instructions, refer to the *Initial Setup* section of the [HiCON Mach4 Software Integration Manual](#).

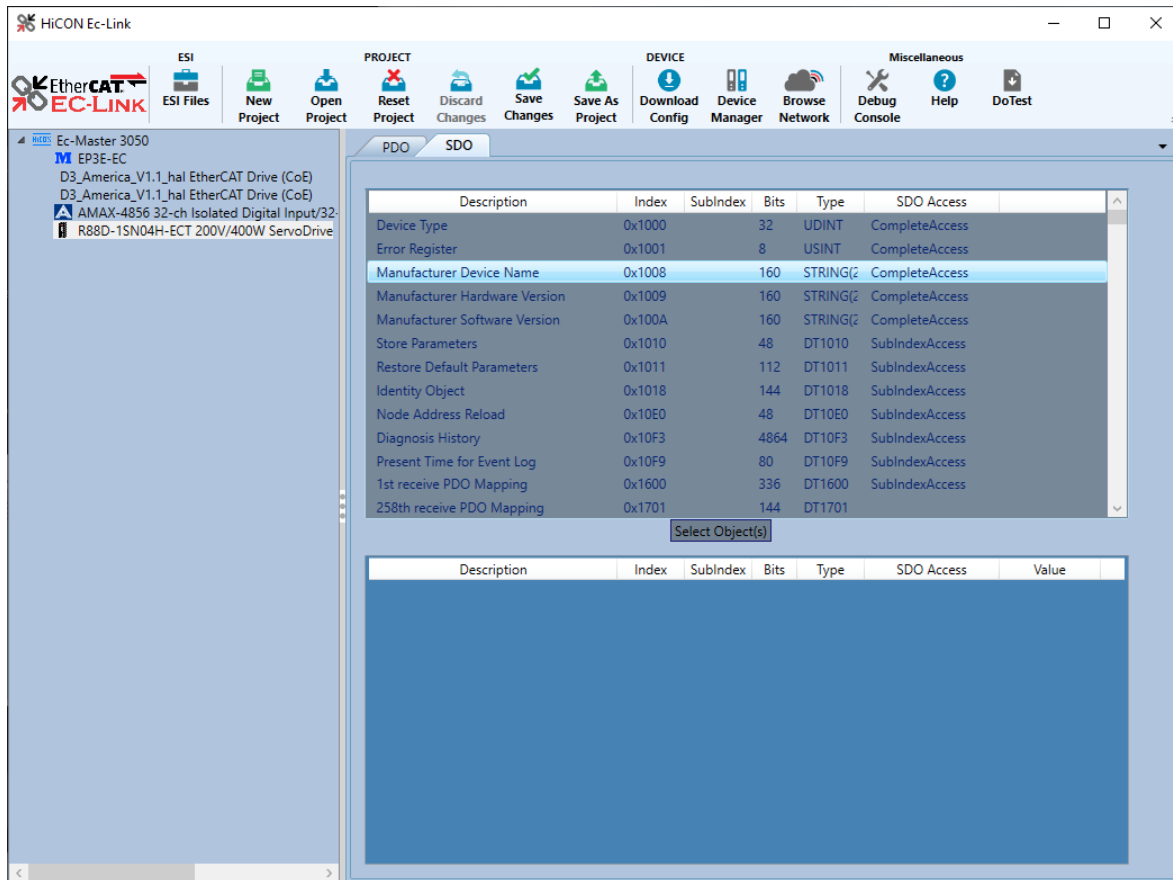
### 5.2. VSI Device Manager

In order to change or update the firmware installed on the EC01, or activate features, you will have to install the VSI Device Manager application. For instructions on using the program, see the provided [manual](#).



### 5.3. [EC-Link](#)

EC-Link is our custom designed EtherCAT configuration software. Easily setup and configure your EtherCAT master using a streamlined, reliable, and user-friendly interface. EC-Link is available for download in the downloads section of the EC01's [product page](#). Please refer to either the [written](#) or [video](#) quick-start guide for a tutorial on how to use this software.



## 6. Additional Features

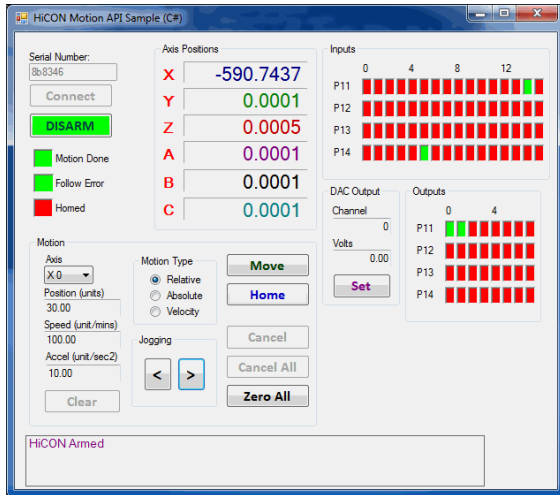
### 6.1. Extended Features

Extended features can be purchased for additional non-standard functionality. If these are purchased alongside the EC01, the unit will ship with the activations already present. However, they can also be purchased later and activated via an activation code.

- Activated Motors – Specifies how many motors the EC01 is able to control over the EtherCAT network. The default EC01 comes with 2 activated motors, but it is also available in variations of 2, 3, 4, 6, 8, and 12 activated motors.
- Custom DRO Support - This software feature allows the user to map PDOs to Mach4 Registers. For example, Torque can be mapped and viewed in Mach4 as a DRO. This Software feature is only available on 6 or more activated motor EC01.
- Extended IO – Enables the J1 digital IO port for additional 16 digital inputs and 8 digital outputs. Recommended to be used with the [7535 I/O termination board](#). It also enables Synced outputs feature in Mach4.
- Analog Input with 77ISO adapter board – Gives the EC01 a 0-10V analog input using the 77ISO Analog Voltage sensor plugged into the J1 port. This is useful for plasma application requiring isolated analog input.
- Analog Output and Encoder Input - Enables J2 to provide 0-10 analog output for spindle VFD speed, as well as encoder input channel (A, B, Z) for spindle RPM and Lathe threading. (Coming soon).
- ArcPro Plasma Screen – Enables the logic with [ArcPro Plasma Screen](#) for Torch Height Control on Plasma Tables. Requires 77ISO Analog Voltage Sensor adapter board.
- Macro Programming – For advanced users this optional software feature allows the writing of custom programs (In C language) that can be downloaded to the controller for fast execution. It allows the system to run in standalone mode as well as manipulate I/O at extremely high speeds. Most Mach4 CNC installations do not require this feature.

## 6.2. Custom Software Application

Optional Custom Windows applications can be created using the **VSI Motion Control API** library. The Library is an API designed to allow communication (via Ethernet) using commands to arm/disarm, control and read I/O, and command motion among others. Sample applications and a [user guide](#) may be found [here](#).



## 7. Troubleshooting

**Category:** Hardware

**Problem:** The green LED is not lit up

**Solution:** Make sure that the power wires are adequately stripped, and use a voltmeter to verify that 24V is present on the connection. If not, then the power supply may be the issue.

**Category:** Hardware

**Problem:** The CPU blue LED does not light up

**Solution:** If the green LED is lit up and the CPU LED is not, try cycling the power. If that still doesn't work it could indicate either a hardware fault or missing or corrupt bootloader. Please email [support@vitalsystem.com](mailto:support@vitalsystem.com) for assistance.

**Category:** Hardware

**Problem:** The CPU LED blinks very rapidly and Mach cannot connect

**Solution:** In boot-loader mode or Software Exception the CPU LED blinks fast. Try cycling the power on the unit. If the blinking is still rapid, after a couple of tries, please email [support@vitalsystem.com](mailto:support@vitalsystem.com) for assistance.

**Category:** Communication

**Problem:** The device does not show up in VSI Device Manager

**Solution:**

- Make sure that a good quality CAT5e (or better) Ethernet cable is used between the controller and the PC. The EC01 supports Auto-MDIX, so cross-over or straight-through cables can be used.
- IP Address conflict. Make sure PC is set to 192.168.0.10 and the controller is set to something other than that, e.g., 192.168.0.95.
- Try disabling windows firewall temporarily to see if it interferes with the connection.
- If more than one network adapter is present (for example, a laptop with a Wi-Fi connection and Ethernet port). Try disabling the other network adapter.
- Check the RJ45 port on the controller and make sure the orange LED is lit and green LED is blinking. If not, try using a different cable.



**Category:** **Category:** Communication

**Problem:** **Problem:** Device Manager can see controller but Mach4 can't

**Solution:** **Solution:** Update the plugin and/or the firmware so they are latest. Also make sure the first three octets of the IP address are same on PC and the EC01 controller.

---

**Category:** Communication

**Problem:** I/O is shifted or I/O is not correct

**Solution:** The I/O PDO should be byte aligned if not must be placed at the end of the network. (Beckhoff modules have 4 bits each hence they must be either used in pairs or placed at the end of the network.

---

**Category:** Mach4

**Problem:** EC01 frequently errors out with the message "ERROR: Disarmed Drives unexpectedly..." on Mach4

**Solution:** Reduce the counts per unit(Also known as Gear Ratio) on the drives typical values are 10000 – 20000 (Can be set using USB software of the drive)

---

**Category:** Mach4

**Problem:** Frequent following error reported on Mach4

**Solution:** If there is no error reported on the drive and the Debug window on Mach4 says following error then it could any of these reasons

1. The counts (Gear Ratio) on the drive is high (Typical value should be 10000 – 20000 or recommended by the device manufacturer)
  2. The following error in HiCON Config is low
- 

**Category:** Motion

**Problem:** Drive status shows it is enabled, motor is energized, but motor does not respond to any motion command from Mach4.

**Solution:** Some drives require to configure the Gear ratio (or sometime referred to as E-Gear ratio). Using the drive USB software set the ratio to 10000:1 or some value that is appropriate for your machine. This ratio may also be to set via SDOs which should be defined in the user guide of the servo drive.

---

**Category:** General

**Problem:** The gantry oscillate/vibrates when cutting/moves rough/Sounds Rough

**Solution:**

1. The drives need to be tuned for the application.
2. The Drives are underpowered.
3. Set Interpolation time period value 0x60C2 subindex 1 to 1 and Interpolation time index 0x60C2 subindex 2 to -3 in EC-Link SDO configuration. (Can also set using USB software of the drive)



**Category:** General

**Problem:** The gantry oscillate/vibrates when cutting

**Solution:** The drives need to be tuned for the application. The Drives are underpowered.

---

**Category:** Motion

**Problem:** The Motor appears to only move one step when jogged as opposed to continuing to move. The position value in Mach may be jittering despite no movement being commanded.

**Solution:** This may be caused by an incorrect Peak Output Current setting. Try confirming what the correct value should be for your drive, and set the Peak Output Current SDO in ELink accordingly. (One customer needed to change it from 1000mA to 2000mA)

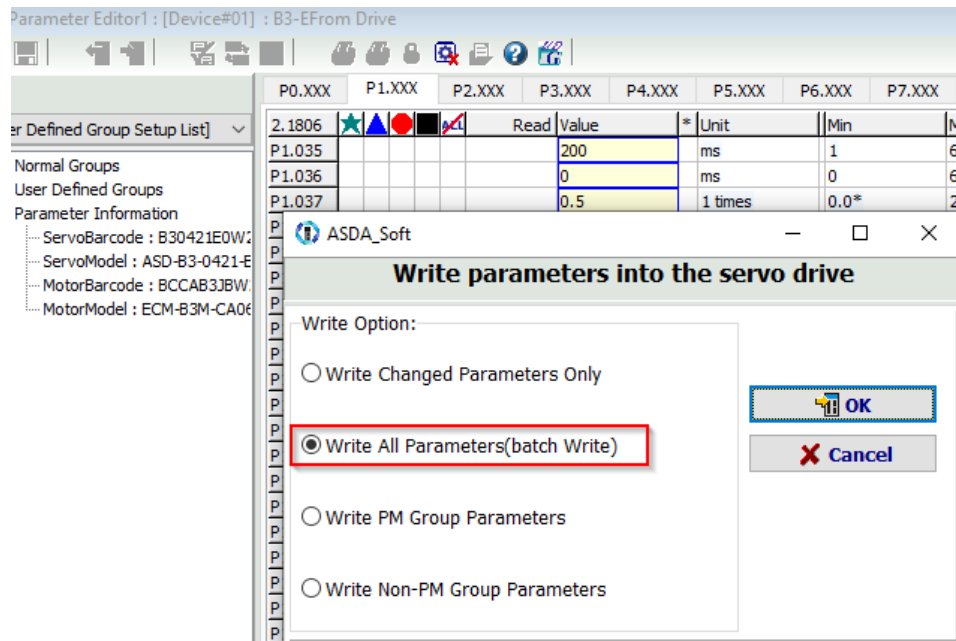
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## 8. Customer Stories

Here we present information provided by some customers how they solved any drive setup issue they encountered. We are extremely thankful to our customers who have shared their finding to help other users of EC01.

### *Tang K. Singapore.*

At the moment I am using Delta servo B3-E with a 400W motor equipped with an absolute encoder. Delta manual I am reading is “**DELTA\_IA-ASD\_ASDA-B3\_UM\_EN\_20210805**”. Section 11.1.3 has the EtherCAT information I am referring to in my email. When I was asking you why when my motor was enable, but not turning when clicking jog key in Mach4 it was due a very important step in my servo drive setup. When I finally got a setting that works for me by changing E-gear ratio I was still struggling because what ever worked for me no longer did after I power cycled my servo drive. In order to make my setup work again in Marh4 I had to use Delta software to batch write all my parameters into the servo drive every time I turn my servo on. Of course this is not the right way because I won't be using the delta software to run my CNC machine after the initial setup, so I kept searching the manual for answer.



As it turns out the very critical step that causes my problem is in section 11.1.3. I don't know why these parameters are made volatile in the servo drive by default. We have to change to non-volatile, else important settings for EtherCAT to work will be gone with each power cycle.

Such important information is buried in Delta's 700+ pages of manual, so I did not notice it until today.

### 11.1.3 Parameter settings of CANopen mode

Follow these instructions to connect the CANopen controller and the ASDA-B3 servo drive:

1. Set CANopen mode: set P1.001 to 0x0C.
2. Set node ID: set the range of P3.000 to 01h - 7Fh.
3. Set P3.001 to 0403h for baud rate as 1 Mbps (Z = 0: 125 Kbps; 1: 250 Kbps; 2: 500 Kbps; 3: 750 Kbps; 4: 1 Mbps).

4. It is suggested to set P3.012 to 0x0100 so the parameters in the following table are non-volatile.

| Variables during initialization | P3.012.Z = 0                          | P3.012.Z = 1 | Note                    |
|---------------------------------|---------------------------------------|--------------|-------------------------|
| P1.032                          | 0x0010                                | EEPROM       | -                       |
| P2.035                          | 50331648                              | EEPROM       | -                       |
| P1.047                          | 100                                   | EEPROM       | -                       |
| P1.049                          | 0                                     | EEPROM       | -                       |
| P1.038                          | 100                                   | EEPROM       | -                       |
| P6.001                          | 0                                     | EEPROM       | -                       |
| Acc (P1.034)                    | 200                                   | EEPROM       | Used in PV and PP modes |
| Dec (P1.034)                    | 200                                   | EEPROM       | Used in PV and PP modes |
| Torque slope (P1.034)           | 200                                   | EEPROM       | Used in PT mode         |
| P1.044                          | <del>1</del> 10000                    | EEPROM       | -                       |
| P1.045                          | 1                                     | EEPROM       | -                       |
| P1.055                          | Depending on the motor specifications | EEPROM       | -                       |
| P5.008                          | 2147483647                            | EEPROM       | -                       |
| P5.009                          | -2147483648                           | EEPROM       | -                       |

Very important step to follow to keep parameters the same after power down.

E-gear ratio. Change this default from 1 to 10000 for my motor to turn after enabling.

5. It is suggested to enable the dynamic brake function (P1.032 = 0x0000).

In summary, for Delta B3-E servo drive to work with EC01 the user has to change E-gear ratio from default 1 to 10000, and modify parameter P3.012 to 0x0000 to 0x0100. My setup has been tested several times by power cycling it and relaunch Mach4 and I am able to turn my motor without having to batch write parameters again using Delta software.