ETH-COMPACT

Ethernet CNC Motion Controller

User’s manual

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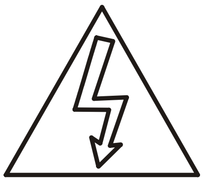
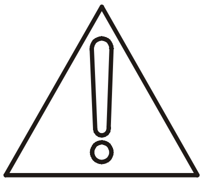
CONTENTS

SAFETY WARNINGS





When working with ETH-COMPACT motion controller there are dangers and risks that can lead to equipment damage and also injuries of people nearby.

For the installation procedure of ETH-COMPACT motion controller it is needed to have a high level of knowledge from the fields of electronics, computers and mechanics. It is also necessary to obey safety measures for work with high voltages and mechanical dangers caused by working with heavy, powerful machines.

Voltages above 50VDC can be lethal. If surrounding electronics works with voltages greater than 50VDC, apply prescribed measures for safe operation.

ETH-COMPACT motion controller should not be used in places where its failure could impose danger to people safety, great financial loss or any other loss.

When working with ETH-COMPACT motion controller it is required to use all necessary precaution measures.

It is recommended to achieve galvanic isolation of the work system from the computer (using opto-isolators or similar). All Audioms Automatika doo drives for step and DC servo motors has opto-isolators on STEP and DIR inputs so for that lines additional isolation is not needed. For other inputs and outputs, depending on equipment used, usage of additional opto-isolators can be necessary.

For usage of ETH-COMPACT motion controller it is required to have understanding of the whole system operation and as well to be aware of possible risks when working with tools and machines.

It is recommended to place ETH-COMPACT motion controller in a metal enclosure so that it is protected from external influences in case of strong electromagnetic radiation, too high temperature, humidity and similar.

It is necessary to obey safety standards like for example installation of EStop button, limit switches and similar.

It is not excluded possibility that this document contains errors. Thereby the manufacturer does not take responsibility for any damage caused by using ETH-COMPACT motion controllers and that is caused as a consequence of obeying or not obeying this user manual.

1 ETH-COMPACT Motion controller based on Ethernet connection

The motion controller is available in the form:

- ETH-COMPACT motion controller (Figure 1.1), and
- ETH-COMPACT-AL motion controller with aluminum angled bracked (Figure 1.2).

Figure 1.1 ETH-COMPACT motion controller

Figure 1.2 ETH-COMPACT-AL motion controller

The ETH-COMPACT motion controller with connector layout is given in Figure 1.3.

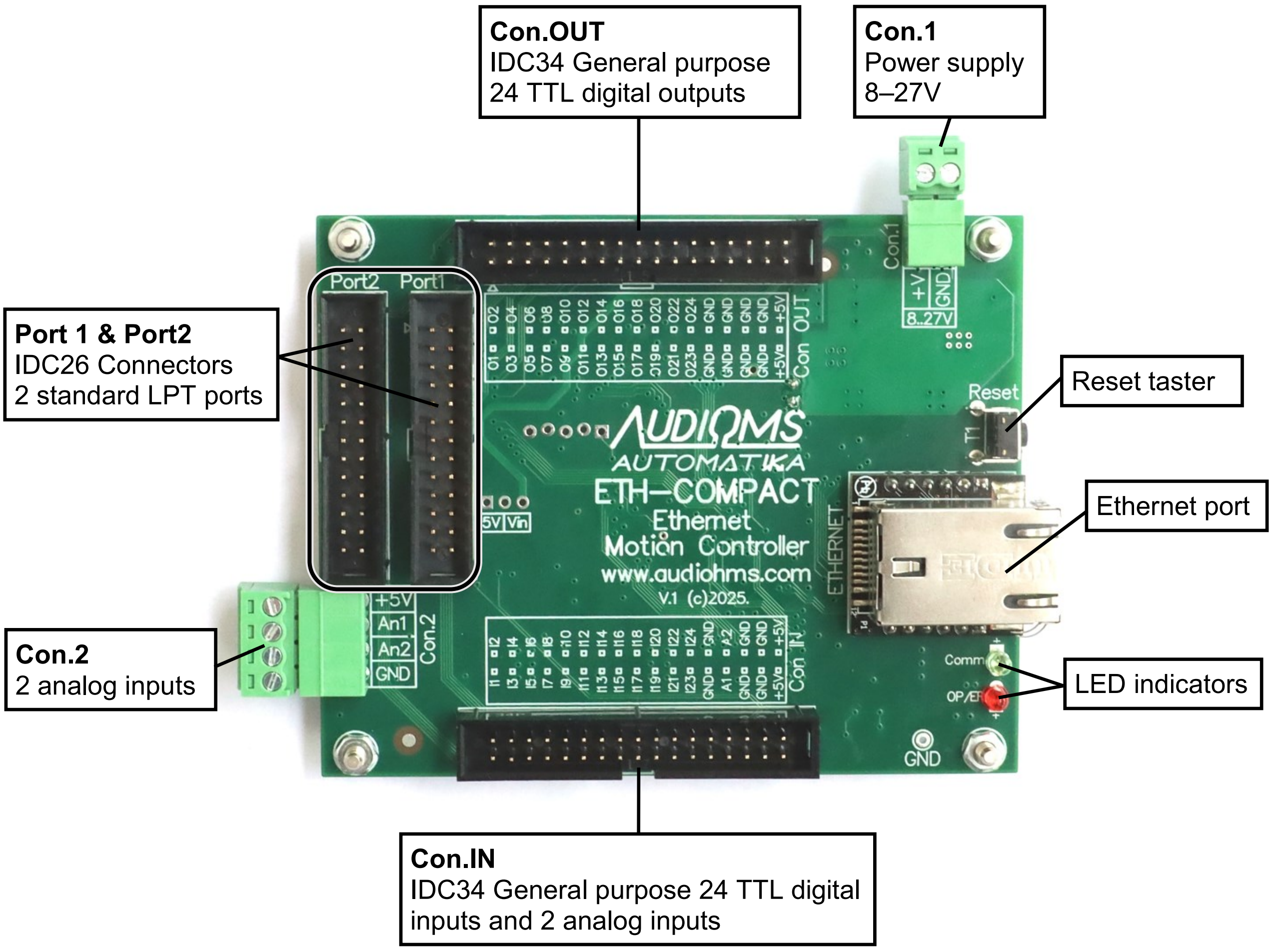


Figure 1.3 Connector ETH-COMPACT motion controller

1.1 DESCRIPTION

The ETH-COMPACT is a 6 axis high performance motion controller for CNC machines designed for use with popular Mach3 CNC control software in Windows XP, Vista, 7, 8, 8.1, 10 and 11 operating systems with 32-bit (x86) and 64-bit (x64) architectures. As an external controller, it brings various improvements in comparison to using Mach3 software with parallel port. ETH-MC motion controller does not require installation of Mach3 LPT driver.

The ETH-COMPACT motion controller is supported by the free software mikroCNC.

Motion controller ETH-COMPACT with its integrated 32-bit microcontroller takes over all real-time tasks that require precision timing. Therefore, computer CPU is less loaded, so that control software now can work on less powerful desktop, laptop, and even tablet computers.

The Ethernet connection with a computer is considered to be one of the most robust connection types, so it is suitable for application in difficult industrial conditions. It should be noted that wired Ethernet connection also features galvanic isolation between ETH-COMPACT motion controller and a PC computer.

Mach3 plugin contains integrated latest compatible firmware version, so in case that firmware has to be updated, this process is automatic and easy for the user.

1.2 Main features of ETH-COMPACT motion controller

- Ethernet 10/100 Mbit connection
- 4 leyer printed circuit board
- all jogging modes
- spindle PWM output, adjustable frequency 10 Hz – 200 kHz
- spindle index input, adjustable divider
- spindle step/dir axis
- spindle relays (M3, M4 and M5)
- coolant relays (M7, M8 and M9)
- ESTOP input
- MPG (encoder) inputs, all Mach3 MPG modes + hardware mode
- freely assignable functions to any of inputs and outputs
- adjustable active signal state (low/high) for all inputs and outputs
- homing/referencing (single axis and multiaxis)
- hardware limit switches
- softlimits
- limits override, auto/manual/external
- charge pump outputs, adjustable frequency (12.5 kHz and 5 kHz)
- slave axes
- probing function (G31)
- laser M10p1/M11p1, e5p1/e5p0 fast outputs (#1-6)
- laser PWM, power compensation (PWM duty cycle can change in relation to velocity of movement), adjustable arbitrary relation curve
- laser PWM, gate by M10/M11
- laser gray level (8-bit) engraving
- shuttle mode, adjustable acceleration time
- detailed adjustment for debouncing of all input signals
- offline mode
- threading on lathe using Mach3turn, G32, G76
- THC function (integrated and external controller support)
- THC advanced options (kerf detect, THC lock, low pass filter...)
- Backlash compensation

1.3 Other functions

With softlimits, slow zones are not adjustable, but width of these zones is automatically determined so that given criteria for maximum motor velocity and acceleration are obeyed for every axis separately.

1.4 Technical specifications

Function	Description
Connection with PC	Ethernet 10/100 MBit, TCP/IP - data buffer size of about 1 s for stable communication, Auto crossover detection
Number of axes	6 (including Spindle axis if Spindle axis is Step&Dir type)
Digital outputs	24 general purpose TTL digital outputs, maximum current on digital outputs 32 mA
Digital inputs	24 Schmitt trigger general purpose TTL digital inputs, Pull-up resistors 4.7 kΩ
Maximum STEP signal frequency	200 kHz or 100 kHz (adjustable in plugin)
STEP pulse width	2.5 µs (optional 5 µs)
PWM output frequency	10 Hz – 200 kHz
PWM duty cycle resolution	16-9 bits, depending on frequency; 16 bit for f ≤ 2kHz
Frequency of signal on Index input	≤ 10 kHz
Pulse width on Index input	≥ 100 ns
MPG/encoder input (x4) frequency	≤ 10 k steps/sec
Number of analog inputs	2
Analog input range	0–5 V, 10 bits
Number of Charge pump outputs	2
Charge pump frequency	12,5 kHz or 5 kHz
Power supply	8 – 27 VDC / 1 – 2 A (power consumption depends on attached peripherals)
Dimensions	91 mm x 115mm x 28 mm (ETH-COMPACT) 100 mm x 118 mm x 39 mm (ETH-COMPACT-AL)
Weight	~ 90 g (ETH-COMPACT) ~ 190 g (ETH-COMPACT-AL)

Index signal can be set on inputs 1-20

NOTE: Shown specifications are subject to change without prior notice

2 Installation

Below is a detailed description of the ETH-COMPACT motion controller installation.

NOTE: ETH-COMPACT motion controller does not require Mach3 LPT driver to be installed nor it uses this driver.

2.1 Plugin installation

NOTE: The ETH-COMPACT motion controller uses the same plugin as ETH-MCI motion controller.

To install ETH-COMPACT motion controller Mach3 plugin, copy supplied file **ethmci_drv.dll** to Mach3 plugins folder (usually "**c:\mach3\plugins**"). Then, start Mach3 and new plugin should be detected (Figure 2.1). Now choose **ETH-MCI-plugin** from displayed list of options. Also, optionally turn on option **Don't ask me this again** so that this choice is remembered and not displayed again on next Mach3 startup.

In case that this dialog for plugin selection is not shown, it is possible to initiate it using menu option **Function Cfg's\Reset Device Sel...**

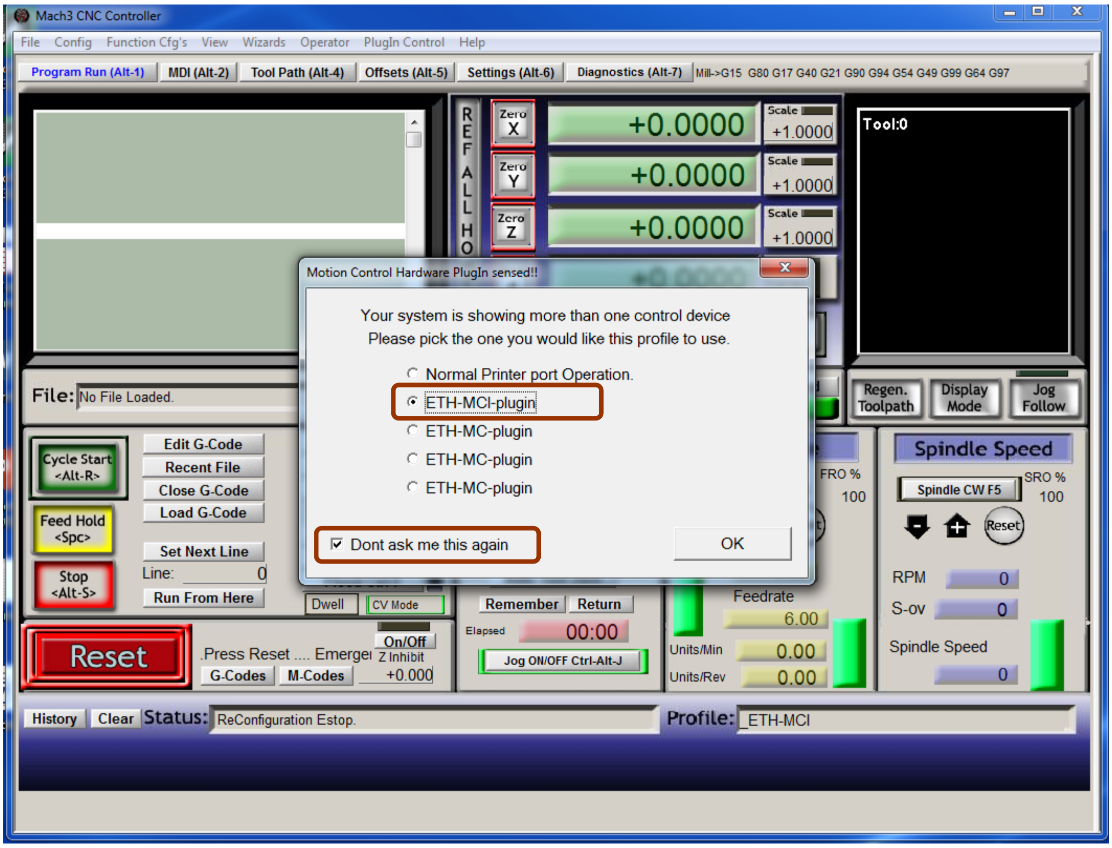


Figure 2.1 Plugin selection

Now it is required to setup network address for the controller that we are connecting with and that is done using configuration dialog Menu/PluginControl/ETH-MCI network setup (Figure 2.2). IP address of the ETH-COMPACT motion controller is stored in the EEPROM that is integrated on the controller and this address can be changed if needed by using special application (factory set IP address is 192.168.1.222).

Using dialog box (Figure 2.2) it is possible to enter known fixed IP address of the controller (option By IP address) or controller can be accessed via alias name in form ETH-MC-xxxxxx, where xxxxxx are six hexadecimal digits that represent unique identification number of the controller (option By alias name).

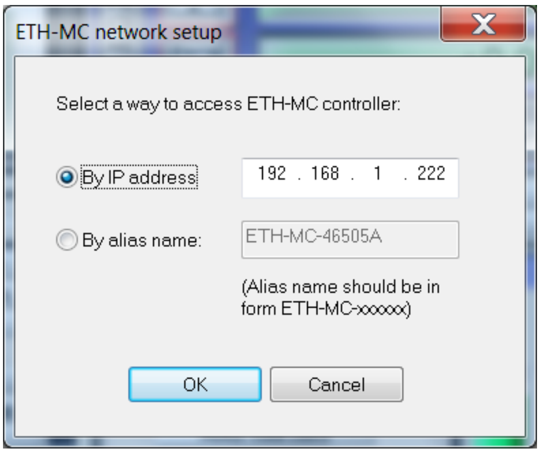


Figure 2.2 Setting up network communication in Mach3

2.2 Setting up network connection and connection to the computer

There are two possible options for connecting controller with PC computer:

a) Direct connection of the controller with PC computer using network (UTP) cable and
b) PC computer and controller are connected to the existing network via router.

a) Direct connection of the controller with PC computer using network cable

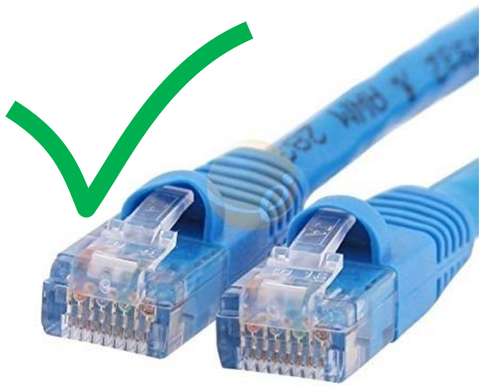
In this case network consists of only these two devices: PC computer and ETH-COMPACT motion controller.

NOTE: Described connection method is recommended for most secure operation and best communication performance.

Ethernet (network) cable that is used for connection of the network adapter on the PC computer and ETH-COMPACT motion controller does not need to be with crossed lines (crossover cable) because ETH-COMPACT motion controller has implemented automatic detection of the Ethernet port and needed mode of operation.

IMPORTANT NOTE: Ethernet module integrated on ETH-COMPACT motion controller provides galvanic isolation between computer and motion controller. Usage of shielded network cable (STP cable) is **NOT recommended** (Figure 2.3) because in that case galvanic isolation is lost, which in some cases can lead to damage of ETH-COMPACT motion controller and/or computer.

a)



b)

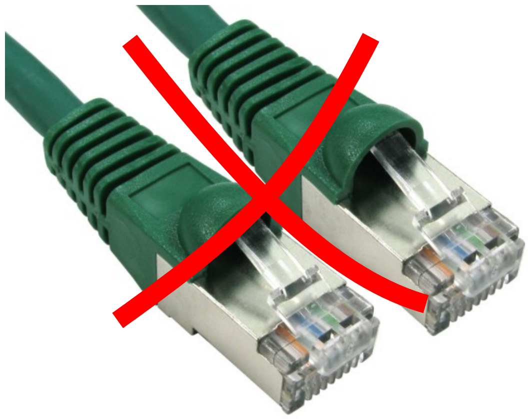


Figure 2.3 Network cable types, a) UTP cable (unshielded) and b) STP cable (shielded)

It is needed to manually specify fixed IP address of the computer and the other network parameters in windows system and that can be done in the following way.

1. Open **ControlPanel/Network and Sharing Center,** then choose **Change Adapter Settings**. In the shown list of network adapters, locate "**LocalAreaConnection**", right click on it, then choose "**Properties...**".

2. In the list of available protocols (Figure 2.4 left) locate "**Internet Protocol Version 4 (TCP/IPv4)".** Select it and then click **Properties.**

3. In dialog box (Figure 2.4 right) specify:

- IP address: for example 192.168.1.200 (it is important that only last digit is **NOT** the same as the last digit of the IP address of the ETH-COMPACT motion controller)
- Subnet mask: 255.255.255.0
- Default gateway: not relevant
- DNS servers are also not relevant.

4. Close all dialog boxes with OK.

Presented settings correspond to default settings of ETH-compact motion controller because its factory set IP address is 192.168.1.222 so it is located on the same subdomain (192.168.1.*).

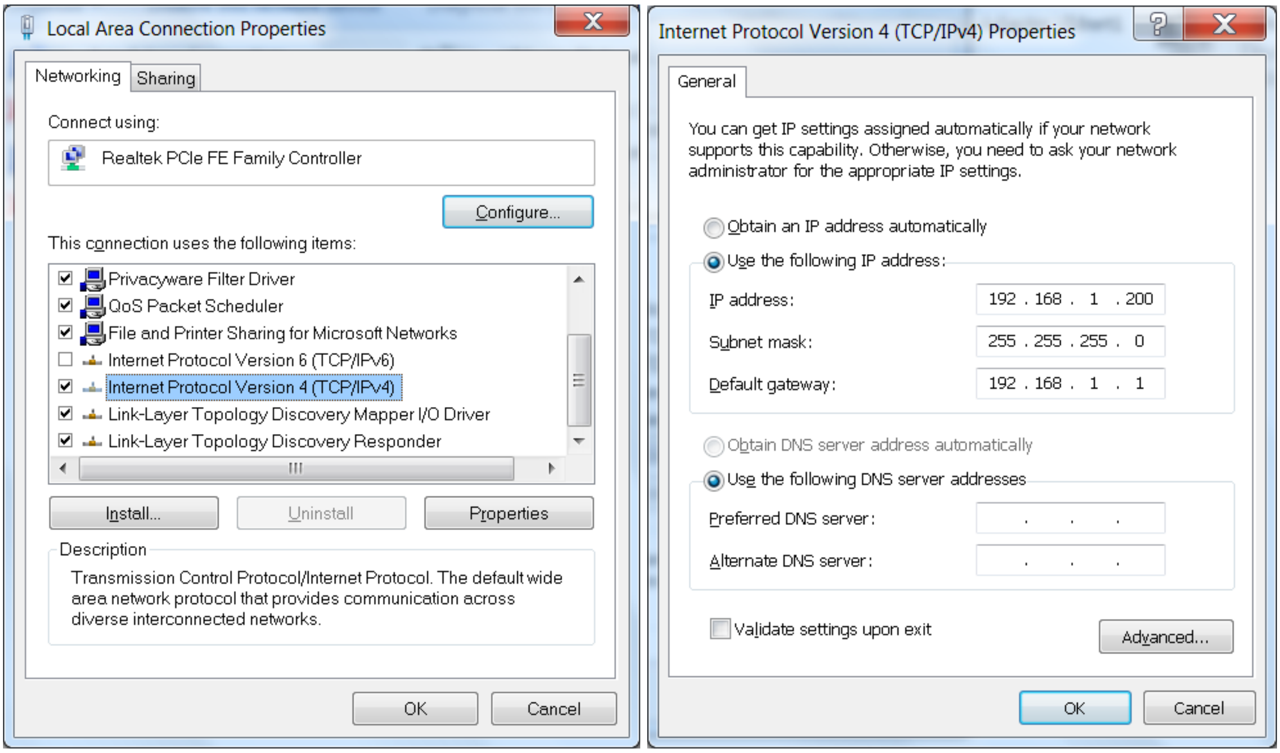


Figure 2.4 Setting up PC computer network parameters

b) If the controller is connected to an existing network

This connection method is used when we want to keep existing network infrastructure that PC computer is connected to. IP address of the PC computer is then already defined (or is obtained from the router like other network parameters, wired or via Wi-Fi) so we use existing settings and these parameters for the computer are not manually specified like mentioned above.

ETH-COMPACT motion controller is connected to an available router port using UTP cable and thus connected to the network in that way.

In this connection method we must adjust network parameters of ETH-COMPACT motion controller so that they correspond to the existing system. It is needed to use configuration software for ETH-COMPACT motion controller (see below) and adjust controller IP address to the address on the same subdomain as computer IP address (usually 192.168.1.x or 192.168.0.x, also possible to be 10.0.0.x). Subnet mask: 255.255.255.0.

Also, instead of manually setting parameters, it is possible to turn on the option to obtain IP address and other network settings automatically from the router by using DHCP protocol (Figure 2.5).

For manual setup of parameters it is needed to know network subdomain of the computer. This we can find via IP address or/and subnet mask. What is current IP address of the computer in the local network and the other network parameters can be obtained in the following way:

- In Windows click **Start** button and in the field that appears enter **cmd** and then press enter. This will open command interpreter,
- Then in the command line, enter: **ipconfig/all,** press enter and all present network adapters in the system and their settings will be listed.

NOTE: For the best performance and secure connection, wired network connection of the computer is recommended. Wi-Fi connection along the convenience unfortunately also brings possible problems with speed and latency variations. Because in the field of machine control, continuous fast and timely communication between computer and controller is required, some more severe cases of communication delay can be recognized as break of connection, which will lead to detain in work of machine that is being controlled.

2.3 Software for configuring network parameters of ETH-COPMACT motion controller

ETH-COMPACT motion controller keeps network parameters in its EEPROM. Figure 2.5 resents factory set values of these parameters and if needed these parameters can be changed and stored to EEPROM of ETH-COMPACT motion controller.
To begin work, ETH-COMPACT motion controller must be powered and it is needed that ETH-COMPACT controller and PC computer are both connected to the same network in any way.
Search network button is used to initiate search for all ETH-COMPACT controllers on the network. More precisely, PC computer broadcasts requests to all present network connections (UDP multicast protocol) and all ETH-COMPACT motion controllers that reply to identification request will be listed in the large field on the left side of dialog box. On the right side are shown current parameters for the selected device.

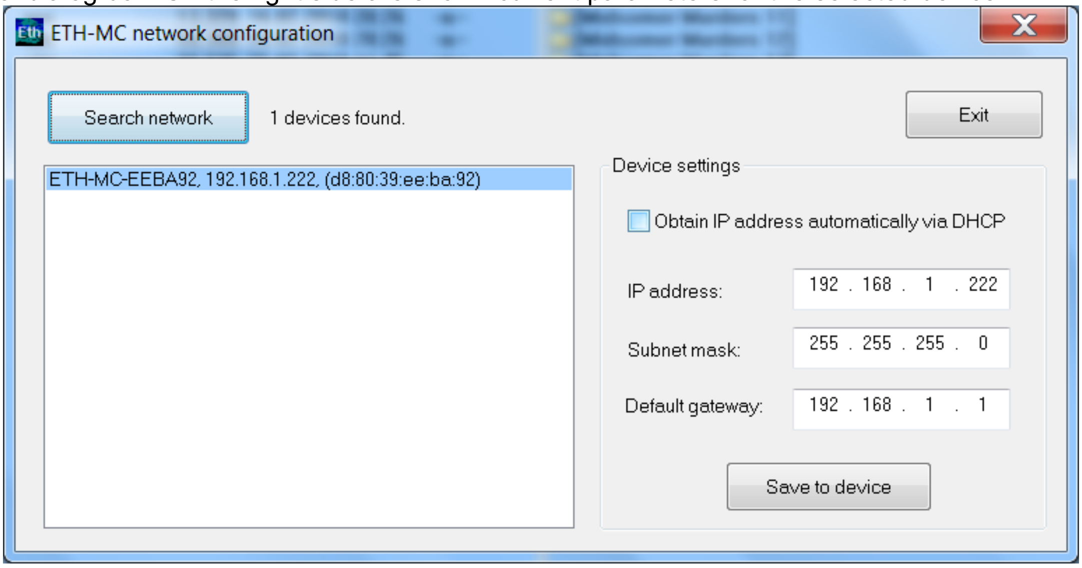


Figure 2.5 Software for configuring network parameters of the ETH-COMPACT motion controller

WARNING: Software should always be able to find all devices connected to the network no matter what network parameters have been set up, i.e. whether set network parameters are correct or not. Nevertheless, in some cases depending on existing network infrastructure, after adjusting controller parameters it can happen that device detection is not possible any more. In that case it is needed to reset controller network settings to factory set defaults. This can be performed using reset button on ETH-COMPACT motion controller.

2.4 Reset procedure for ETH-COMPACT motion controller

Press and hold Reset button until green LED indicator lights up (few seconds). Release Reset button, then power off and power controller back on.

2.5 Possible connection problems

In case that occasional break of connection occurs, especially in periods of non-activity, it is possible that Power saving for network card is turned on. Also, it may help fixing connection speed to 10/100 Mb instead of using Auto speed option in network settings.
On power up, controller is in so called safe mode, i.e. all outputs are in high impedance state (disconnected). Red LED indicator on the controller blinks slowly.
After clicking **RESET** button, connection with controller is established and status **Ethernet controller connected** is displayed (Figure 2.6). Then the controller enters normal work mode and red LED indicator on the controller stops blinking and lights continuously.

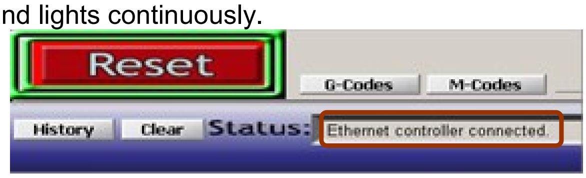


Figure 2.6

If network connection is lost for any reason, controller instantly goes to safe mode. Then it is needed to investigate and eliminate cause of the error and then click **RESET** button to establish communication again. Also, controller enters safe mode on all configuration changes and also on exiting Mach3 application.

3 Automatic firmware update

ETH-COMPACT plugin also contains needed firmware for the controller, thus upon establishing connection, if it is determined that firmware update is required, message like on Figure 3.1 will be shown. It is needed to click button Yes and wait for this process to be completed (Figure 3.2). Finally, result like on Figure 3.3 should be presented when firmware update procedure is finished successfully.

Current versions of the plugin and the firmware can be found on About window of the ETH-COMPACT configuration dialog.

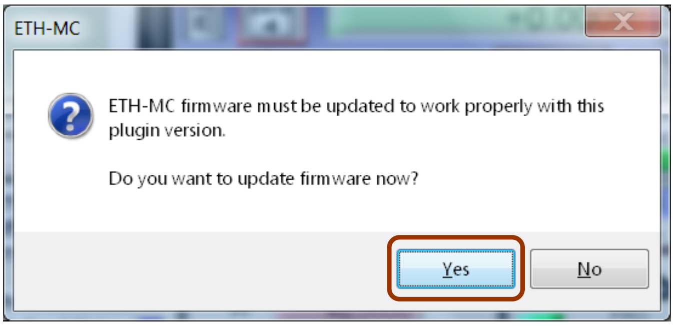


Figure 3.1

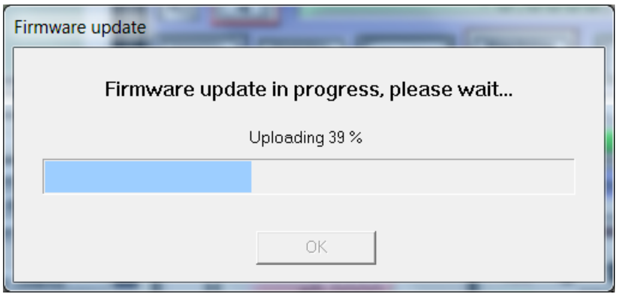


Figure 3.2

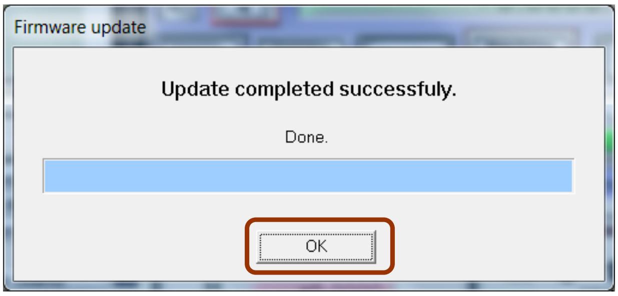


Figure 3.3

4 Mach3 software configuration

Most of configuration is done using existing dialogs for adjustments in Mach3 application, like **Ports and pins**, **General config** etc. just like when LPT driver is used. Some additional options, which are offered by ETH-COMPACT motion controller, can be adjusted via dialog box that is opened using the menu option **Plugin Control/ETH-MCI Config….** Also, novelty is the status window that can be opened via **Plugin Control/ETH-MCI Status…**

Status window will be displayed by choosing **Plugin Control/ETH-MCI Status…**

4.1 Adjusting ports and pins via Ports & pins window

ETH-COMPACT motion controller provides one digital input port with 24 pins and one digital output port with 24 pins. These pins can be remapped as desired, that is, can be assigned different functions that are needed for the specific application.

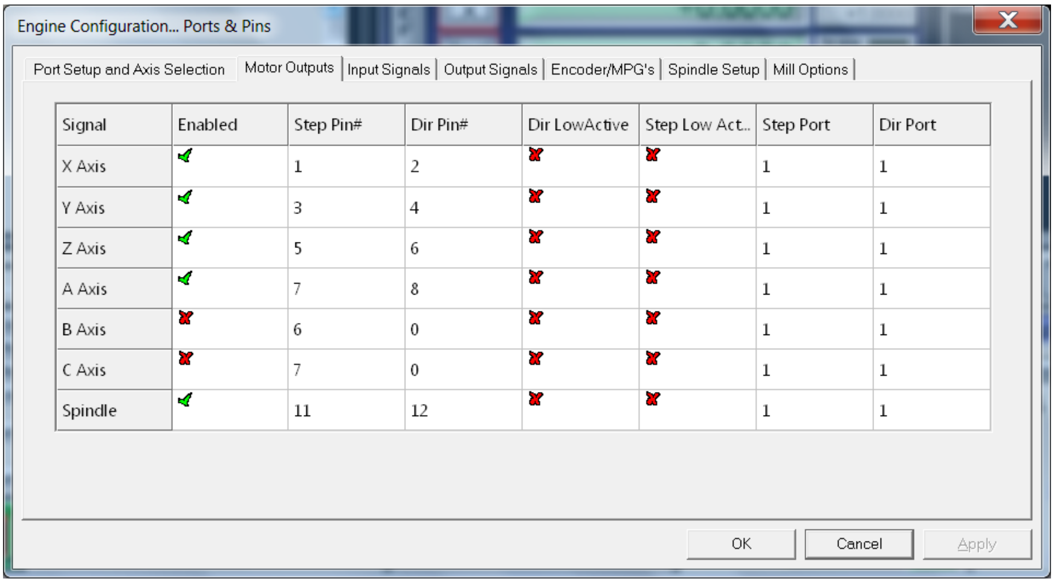


Figure 4.1 Ports and Pins configuration

When using configuration dialogs like **Motor Outputs**, **Input Signals**, **Output Signals** (Figure 4.1) etc. number 1 is always used for port number. Available pins on the input port are numerated from 1 to 24. Similarly, output port pins are also numerated from 1 to 24. ETH-COMPACT motion controller will ignore any port other then 1 and any pin that is set out of range.

5 ETH-COMPACT configuration dialog

This dialog can be opened using the menu option **Plugin Control/ETH-MCI Config…**

5.1 General setup tab

On the Figure 5.1 General setup tab is shown.

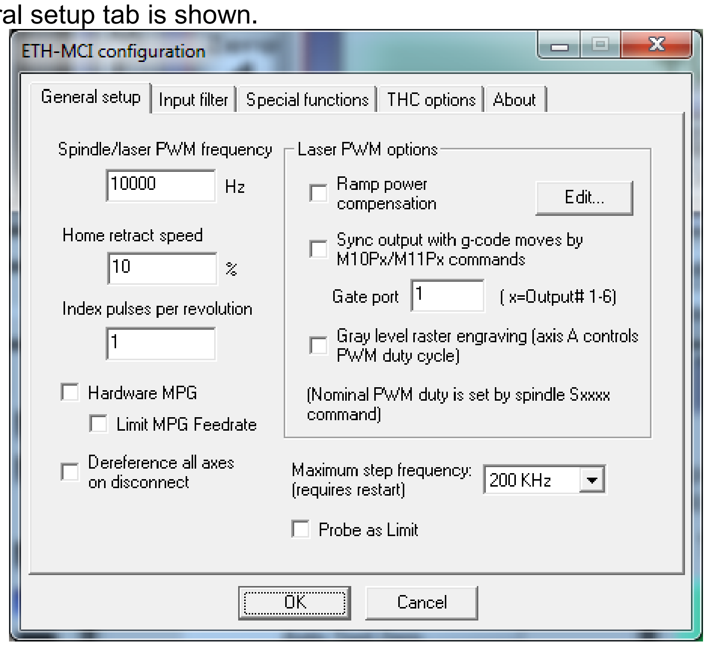


Figure 5.1 General setup tab

5.1.1 Spindle/laser PWM frequency

The frequency of PWM output signal that is used for spindle rpm control or for laser power control, can be adjusted in range 10-200000 Hz (Figure 5.1). Output pin for this purpose is selected via **Spindle axis** line in **Motor Outputs** window (Figure 4.1). Only adjustments for **Step** signal are used (**pin/low act/port**), and **Dir** field is not used for PWM output.

Also, in **Ports&pins/Spindle setup** window, in **Motor control** group, options **Use spindle motor** and **PWM control** should be turned on**. PWMBase Freq** in the same group, is not used.

Home retract speed

This is speed of retraction from a home switch given as a percentage of homing speed (Figure 5.1). In first phase of homing (referencing) operation for an axis, movement toward home switch is performed until the switch is activated.
Then, movement is performed in the opposite direction (retracting) until the switch deactivates and that position is used as a reference. Home retract speed should be low enough so that good referencing precision is achieved

Index pulses per revolution

Index input is used for detection of spindle rotational speed. It is common to use one pulse per revolution, but more than one can also be used (Figure 5.1).

Hardware MPG

If this option is **turned on** (Figure 5.1) ETH-COMPACT motion controller will use hardware MPG mode, that is, reading MPG inputs and generation of STEP/DIR output signals is done completely in hardware without need for communication with PC. This enables very fast response (low latency) and at the same time precise motor control. Configured motor parameters (maximum velocity, acceleration) are obeyed.
If this option is **turned off**, standard Mach3 modes are used for MPG operation. These options can be shown by pressing TAB key in Mach3. In this case ETH-COMPACT motion controller reads MPG input, sends current position to Mach3, and Mach3 then, according to selected MPG mode (Velocity only, Multi-Step...), generates appropriate commands for movements. These commands are then sent to ETH-COMPACT motion controller and executed.
In hardware mode just like in standard modes, **CycleJogStep** is used for setting movement step, and also most of all settings (MPG axis, detent...) are common.

Limit MPG feedrate

If this option is **turned on** (Figure 5.1), speed limit given with parameter **MPG Feedrate** is obeyed in hardware MPG mode. This parameter is located on MPG/Jog window (Figure 6.1).

Dereference all axes on disconnect

This option should be turned on if it is desired to dereference all axes in case of an error and break of connection with the controller (Figure 5.1).

5.1.2 Laser PWM options

Ramp power compensation

Laser power compensation (Figure 5.1) is used to overcome typical problem during laser engraving, and that is that depth/intensity of engraving depends on movement speed of the laser head. This is particularly visible on start and at the end of one engraving segment, where laser head slows down and stops, so unwanted black dots appear. To eliminate this phenomenon, laser power can be controlled using PWM so that PWM duty cycle is directly dependent on velocity of laser head. Thus, for example, if velocity is zero, PWM duty cycle will also be zero. As velocity increases, also is increased duty cycle that controls laser power. It is possible to configure an arbitrary relation curve.

Sync output with G-code moves by M10px, M11px commands

This option (Figure 5.1) enables that fast commands M10px and M11px, in addition to their primary function of setting state on output x (Output#1-6), at the same time can turn on/off PWM output. **Gate port** determines which output x controls PWM output in this way. So, for example, if command M11p3 is given and **gate port**=3, PWM output will be turned on.
Laser engraving requires much faster turn on/off of laser then it is possible to achieve using spindle commands (M3, M4, and M5). By using M10/M11 commands, laser turn on/off is also ideally synchronized with g-code execution. This is done in following way: when, for example, command M11p1 (turn on output 1) is executed in g-code program, initially nothing happens, but this "turn on output x" command is remembered as armed for execution. When next command for positioning (like G01 probably at the very next program line) is executed, then at the same moment when commanded movement begins, also given output is activated. The same logic applies for M11px (turn of output) command.

Gray level raster engraving

This option is used for laser engraving of raster images and 8-bit pallet is supported (256 shades of gray) (Figure 5.1). When this option is turned on A axis is used to control laser power i.e. given "movement" of A axis directly is translated to duty cycle of PWM output.
G-code should be generated from a bitmap image using one of the programs for that purpose. More details about this option and required settings in Mach3 for raster image engraving can be found in the separate document (USB-MC laser raster engraving).

Maximum step frequency

Enables setting of maximum frequency for the generated step signals (Figure 5.1). Lower speed (100 kHz, 5 µs pulse width) is used in case when drivers/controllers that are being controlled are not fast enough for impulse width of 2.5 µs that is required when using full speed (200 kHz).
After changing this parameter it is necessary to restart Mach3 for new setting to become in effect. Also, after the restart, it is needed to check in **MotorTuning** screen whether speed for any axis is set to a value greater than current maximum frequency permits and correct settings if needed.

5.2 Input Filter tab

Digital filtering (debouncing) is available for all inputs. **Input filter** window enables detailed debouncing adjustments (Figure 5.2). Debouncing time is specified in increments of 100 µs. For example, if value 30 is given, that means that 3 ms of stable state is needed on input for state to change from active to inactive or vice versa. If debounce time of 0 is given for an input, debouncing is turned off for that input. This is recommended in case we want maximum reading speed and we are sure that signal is clean (e.g. optical encoder). Debounce time can be adjusted for group of pins by function or for every pin separately (Figure 5.2).

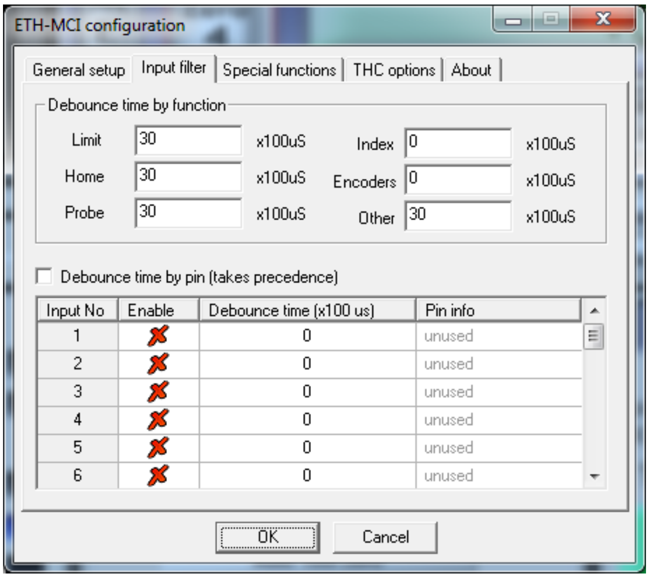


Figure 5.2 Input filter

5.3 Special functions tab

ETH-COMPACT motion controller offers two analog inputs, and in addition, enables simultaneous reading of two incremental encoders. Their functionality can be adjusted using this dialog (Figure 5.3).

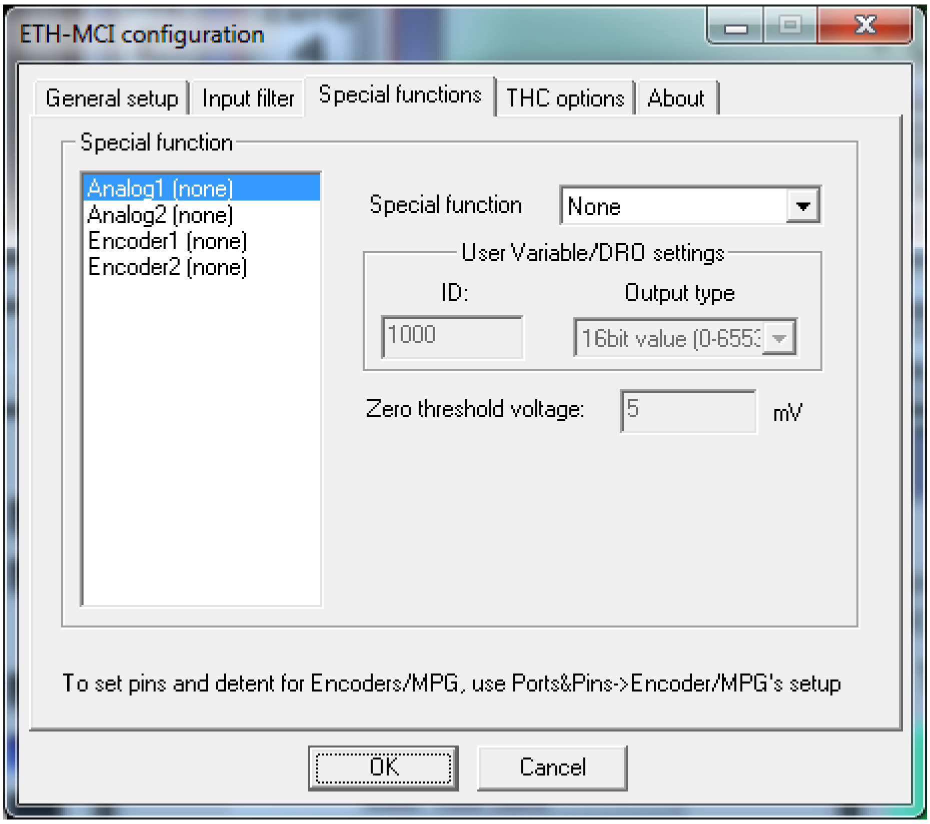


Figure 5.3 Special functions

5.3.1 Special function group

In the field on the left (Figure 5.3), available input signal sources are shown and in parentheses assigned function (if there is one). For the selected signal source, on the right side are shown parameters that can be adjusted.

For **Special function**, available options are:

- **None** – signal is not used for any special function.
- **FRO 0–250%** – feedrate override control.
- **SRO 0–250%** – spindle rate override control.
- **Set user variable** – read value is put in Mach3 internal variable so that it can be used for example from macro script or similar. **ID** represents identifier (address) of the variable. Type of output can be chosen to be 16-bit value (0–65535) or percentage (0-100%). Values of these variables can be monitored using Mach3 function **Operator/Geode Vary Monitor**.
- **Set user DRO** – similar to previous option, only in this case **ID** represents DRO field indicator.
- **THC Vnom (50-300V)** –nominal THC voltage control.

Detent (counts/unit)
When encoder is used for any function, the increment that is used for changing a variable is set by adjusting the detent value for that encoder. Detent represents a number of pulses from the encoder/MPG that constitutes one whole step.

Detent can be adjusted via Mach3 window **Config/Ports&Pins/Encoders/Mpg's** together with input ports and pins for encoders. Detent does not have to be a whole number, and also can be negative value if it is needed to change direction of rotation. Usually MPG is set to have detent value of 4 because 4 pulses are generated for one MPG step.

Zero threshold voltage – Voltage threshold adjustment for analog input, given in mV. Read value that is less or equal to this is considered to be zero.

5.3.2 Encoder mapping

ETH-COMPACT motion controller supports simultaneous reading of two incremental encoders (including one from MPG device). Mach3 offers adjustments for total of seven encoder inputs. ETH-MCI motion controller will enable operation of only first two encoders/MPGs encoders that are enabled in **Config/Ports&Pins/Encoders/Mpg's**.

5.3.3 THC options tab

THC (torch height control) function is used with plasma cutters for continuous regulation of plasma head vertical position above the material. In addition to support for external regulators, ETH-COMPACT motion controller also contains internal THC regulator that is possible to utilize by connecting appropriate voltage sensor (THC Sensor) to the analog input of the ETH-COMPACT motion controller.

ETH-COMPACT motion controller support:

- External THC Up/Down control (Figure 5.4 left),
- Internal THC control (Figure 5.4 right).

ETH-COMPACT motion controller offer many advanced THC option such as:

- kerf detect,
- anti-plunge option,
- THC lock from G-code etc.

More details about THC operation and settings in Mach3 related to this mode can be found in section (advanced controller options).

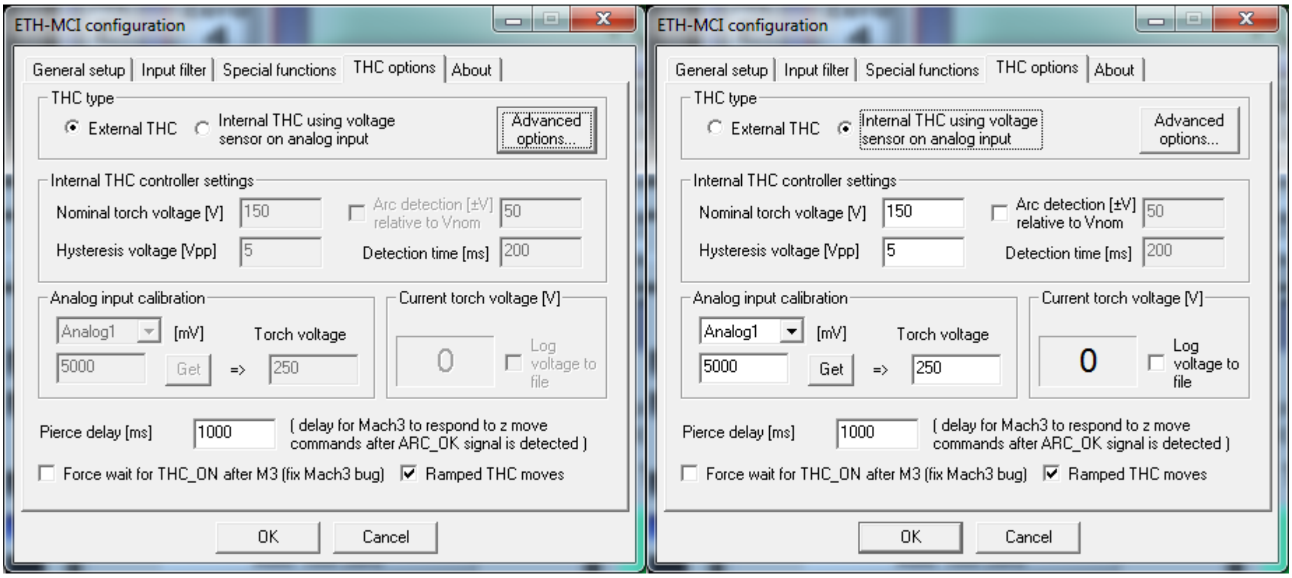


Figure 5.4 THC options

6 Shuttle mode

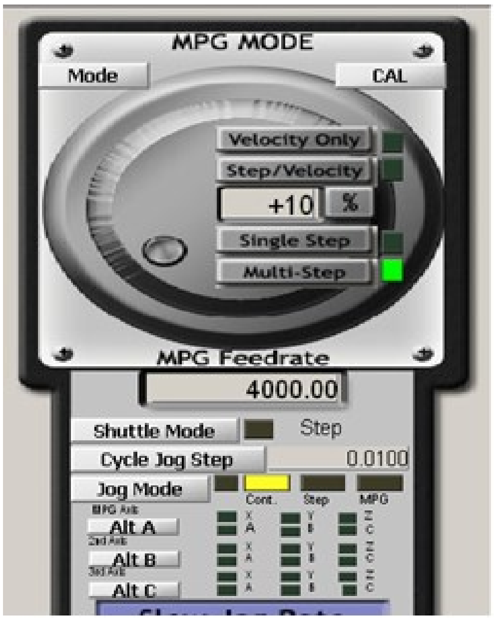


Figure 6.1

It is possible to use MPG also for Mach3 **shuttle mode**, that is, fine real-time control of execution speed of G-Code program (Figure 6.1). This function is performed completely in hardware and in this mode speed of turning MPG directly affects G-Code program execution speed.

Shuttle mode button can also be used as fast FeedHold, even if MPG is not connected or configured in the system. In this case, if shuttle mode is activated during G-code execution, movement on all axes slows down to complete stop.

By deactivating shuttle mode, movement on all axes is accelerated to reach the normal speed. This acceleration/deceleration can be adjusted using field **Shuttle Accel.** which can be found on Mach3 **General Config** dialog.

7 Status Window

Status window (Figure 7.1) displays current state of all input and output pins on ETH-COMPACT motion controller. Also, on the left side, current position of all 6 axes is shown, and on the right side, various status information for the controller. This window is floating above other windows and does not prevent normal usage of Mach3 controls.

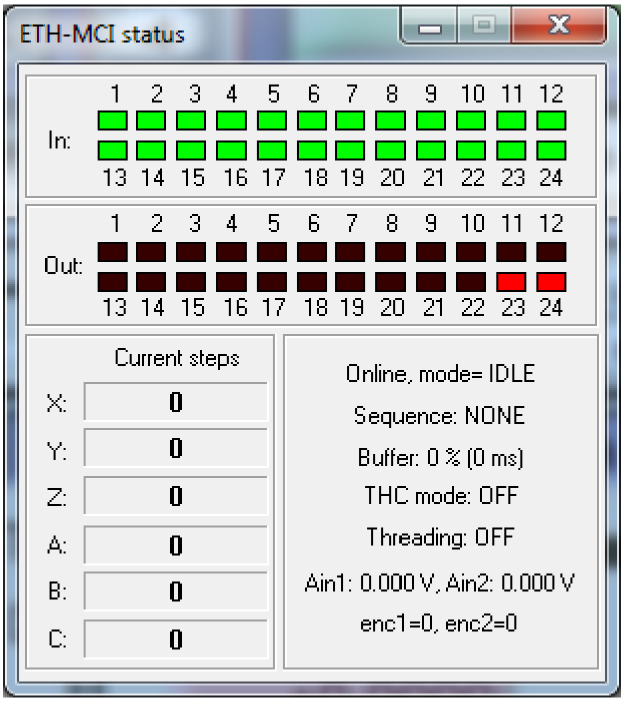


Figure 7.1 ETH-COMPACT status window

8 ETH-COMPACT motion controller dimensions

Figure 8.1 and Figure 8.2 shows ETH-COMPACT and ETH-COMPACT-AL motion controller's overall dimensions.

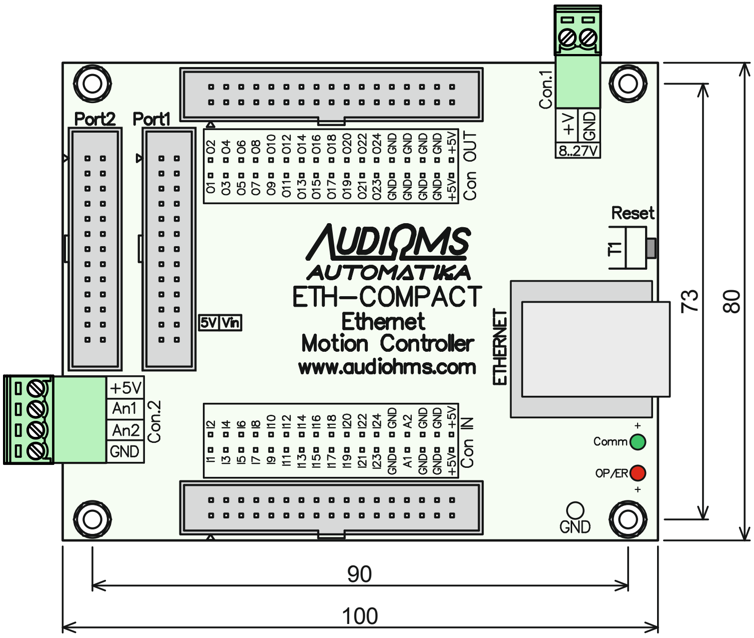


Figure 8.1 ETH-COMPACT Motion controller – dimensions

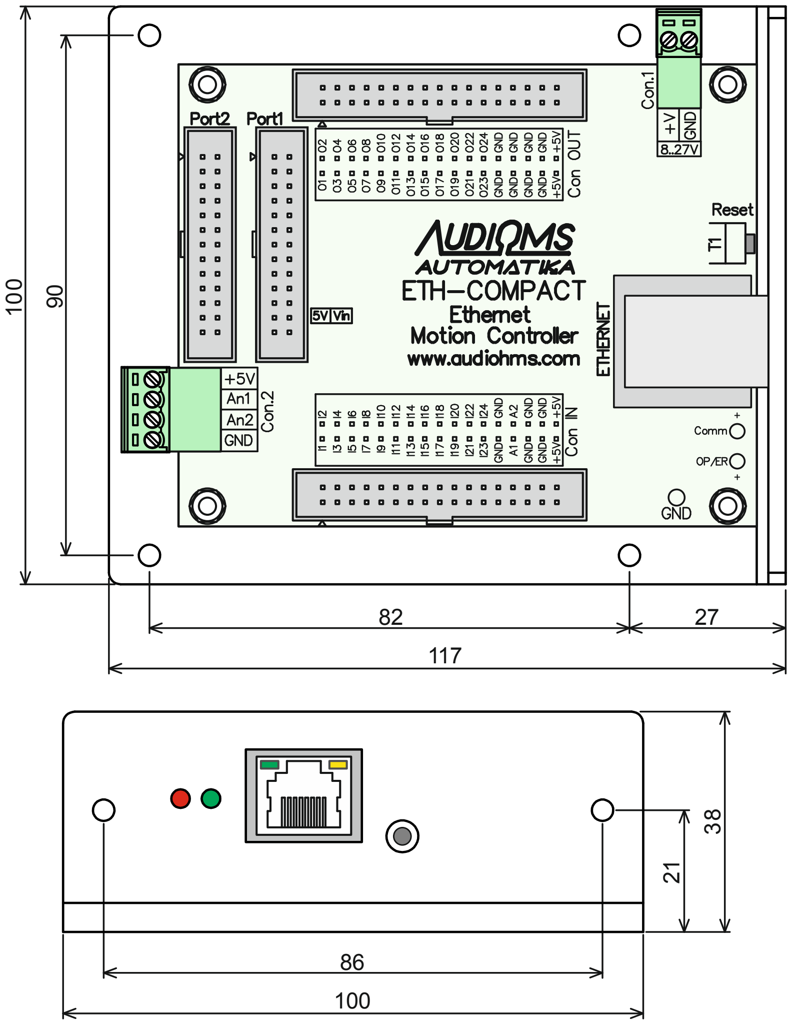


Figure 8.2 ETH-COMPACT-AL Motion controller – dimensions

9 Connection the ETH-COMPACT motion controller

9.1 Connecting the power source and connecting to the computer

The power supply of the ETH-COMPACT motion controller is supplied via the Con.1 connector and for that purpose it is necessary to provide a source in the range of 8 to 27VDC / 1-2 A (power consumption depends on attached peripherals).

A network (Ethernet) cable is used to connect to the computer, which is connected to the motion controller via the ETHERNET connector (Figure 9.1). See Chapter 2.2 for more details on configuring the Ethernet connection.

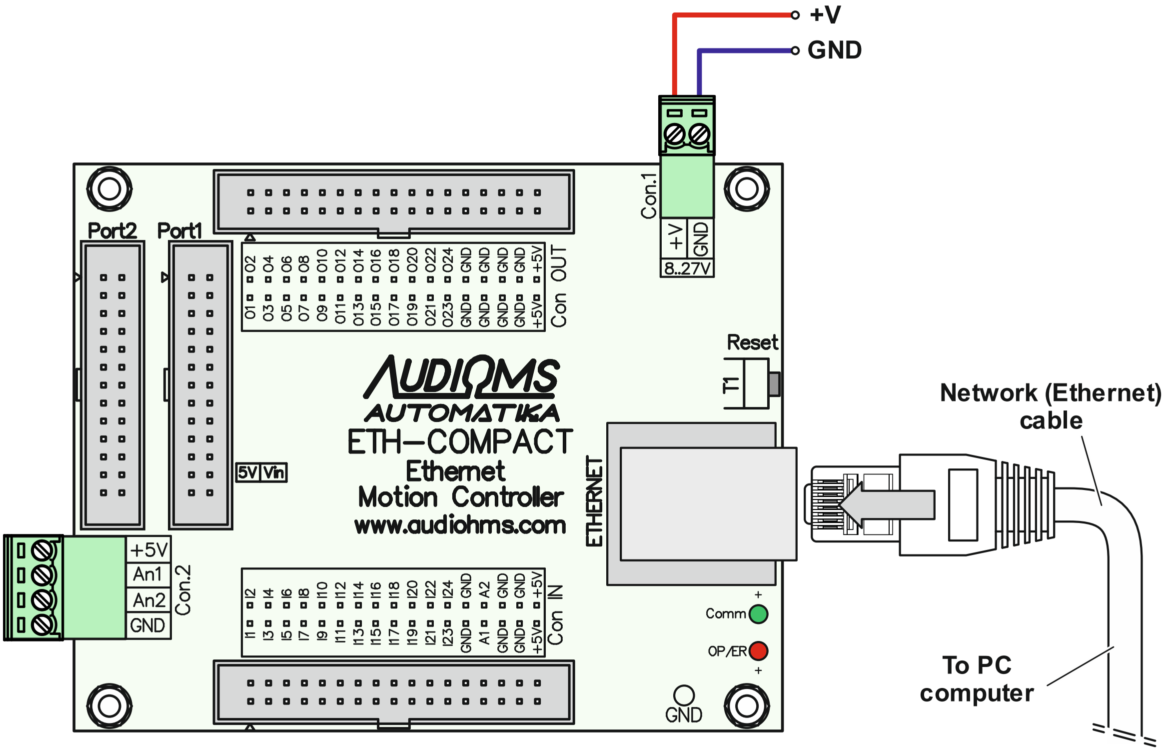


Figure 9.1

9.2 IDC connectors

ETH-COMPACT motion controller has 24 digital outputs, 24 digital inputs and two analog inputs. Digital inputs and outputs, as well as analog inputs, are available via the appropriate connectors located on the motion controller.

All digital inputs (In1 to In24) are Schmitt trigger general purpose TTL digital inputs with 4.7 kΩ pull-up resistors and with a passive low-pass filter with a cutoff frequency of 160 kHz. All digital inputs, as well as two analog inputs, are available via the 34-pin IDC connector marked as CON IN (Figure 9.2).
All digital outputs (Out1 to Out24) are general purpose TTL digital outputs and are available on the 34 pin connector marked as CON OUT (Figure 9.2).

The ETH-COMPACT motion controller has 2 ports that are compatible with systems that use a parallel port for control. Two parallel ports are available on the 26 pin IDC connectors labeled Port1 and Port2 on the motion controller (Figure 9.2).

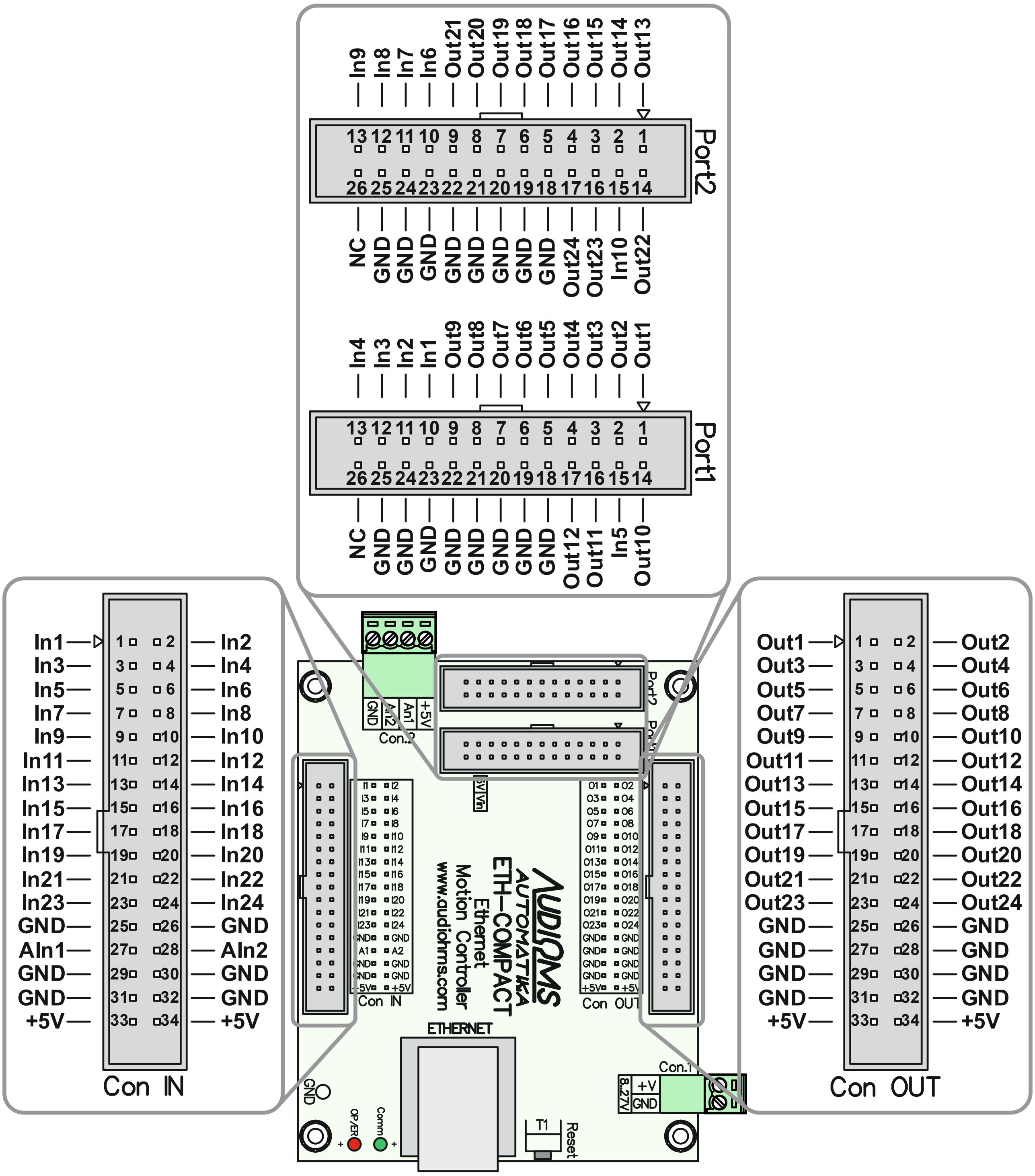


Figure 9.2 ETH-COMPACT motion controller connector position and pinout description

9.3 Analog inputs connector

ETH-COMPACT motion controller has two analog inputs with range 0-5 V and these are available on the connector Con.2 (Figure 9.3). Analog inputs are also available on the 34 pin IDC connector Con IN (Figure 9.2).

Analog inputs offer a possibility of connecting potentiometers, THC sensors and other sensors with analog outputs in order to realize some of the special functions (FRO, SRO, THC control, etc.).

Figure 9.3 shows the recommended way for connecting THC Sensor analog output to analog input An1 and recommended method for connecting potentiometer to the analog input An2. A detailed description of the Torch Height Control (THC) function suppoted by ETH-COMPACT motion controller is given in chapter 10.1.

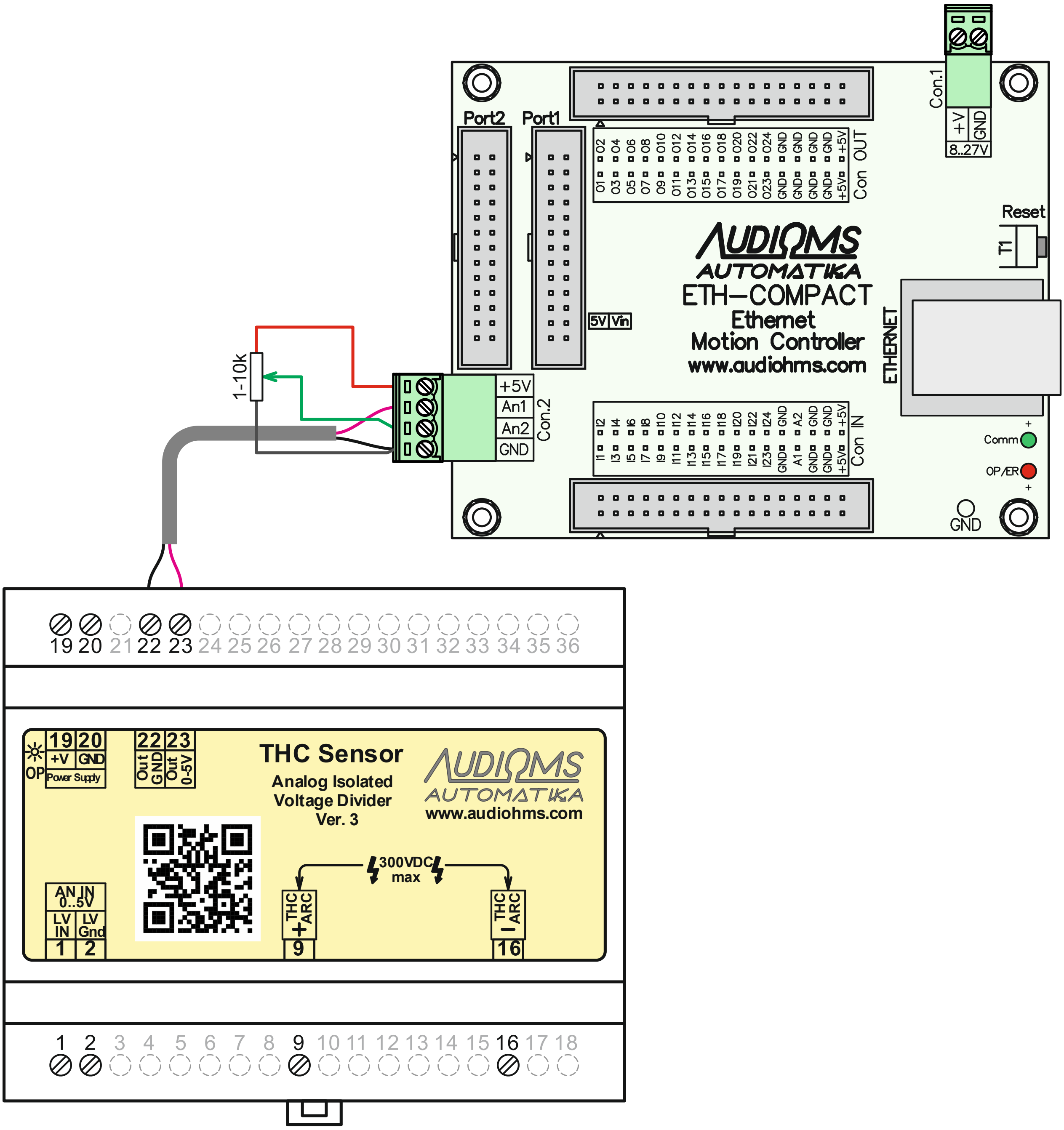


Figure 9.3 Connecting the sources of analog signal to the analog inputs; from THC sensor and from potentiometer

10 Setting up advanced options

ETH-COMPACT motion controller offer a large number of advanced options. This chapter describes some of the supported advanced options.

10.1 Torch Height Control – THC

Torch Height Control – THC (Figure 10.1) is a function used in plasma cutting machines to continuously regulate the height of the plasma head. It is necessary to ensure that a constant distance is maintained between the plasma head and the material being processed. The mentioned function is functionally similar with the Audioms Automatika doo ETH-COMPACT motion controller as when working with the LPT port, with numerous improvements and additional options. It should be noted that the THC function requires a licensed version of Mach3 (the demo version does not support THC mode of operation).

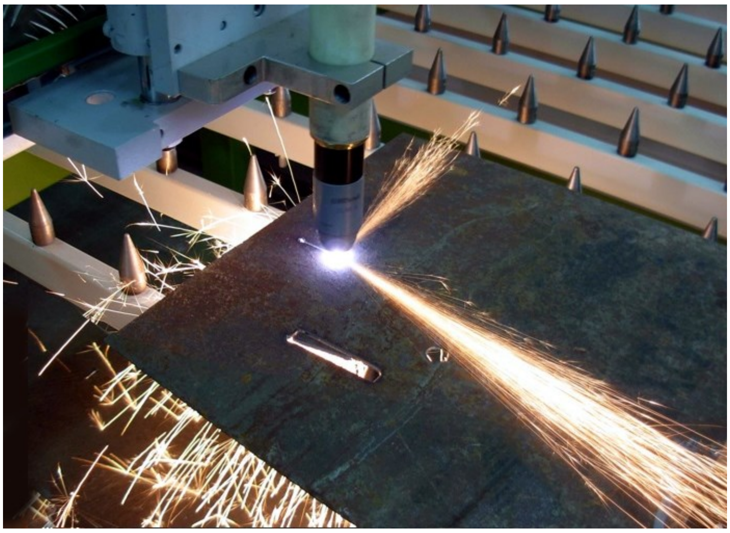


Figure 10.1 Plasma cutting process

Important features offered by the ETH-COMPACT motion controller:

- **Two options for THC control:**
  - support for external THC controllers,
  - internal THC classic Up/Down regulator (1 ms response).
- **Advanced options of the internal THC controller:**
  - kerf detect – tip saver,
  - disable of THC movement when the arc voltage is outside the valid range,
  - set nominal voltage from G-code via S command,
  - arc presence detection,
  - voltage sampling frequency 1 kHz,
  - adjustable low-pass voltage filter.
- **For internal and external regulator:**
  - THC enable/disable using G-code commands,
  - THC movement with acceleration/deceleration,
  - Anti-plunge option,
  - Manuel THC mode.
- **Customized Mach3 screen** with additional indicators and DRO fields.

The most popular way of regulating the torch height is by monitoring the voltage of the plasma arc as feedback, considering that the voltage on the arc is proportional to the length of the arc, i.e. height of the plasma head above the material. The THC controller raises or lowers the plasma head in order to achieve and maintain the set nominal value of the plasma arc voltage.

Traditionally with the Mach3, an external THC regulator is used which measures the arc voltage and via digital inputs requests the Mach3 to move the plasma head up or down.

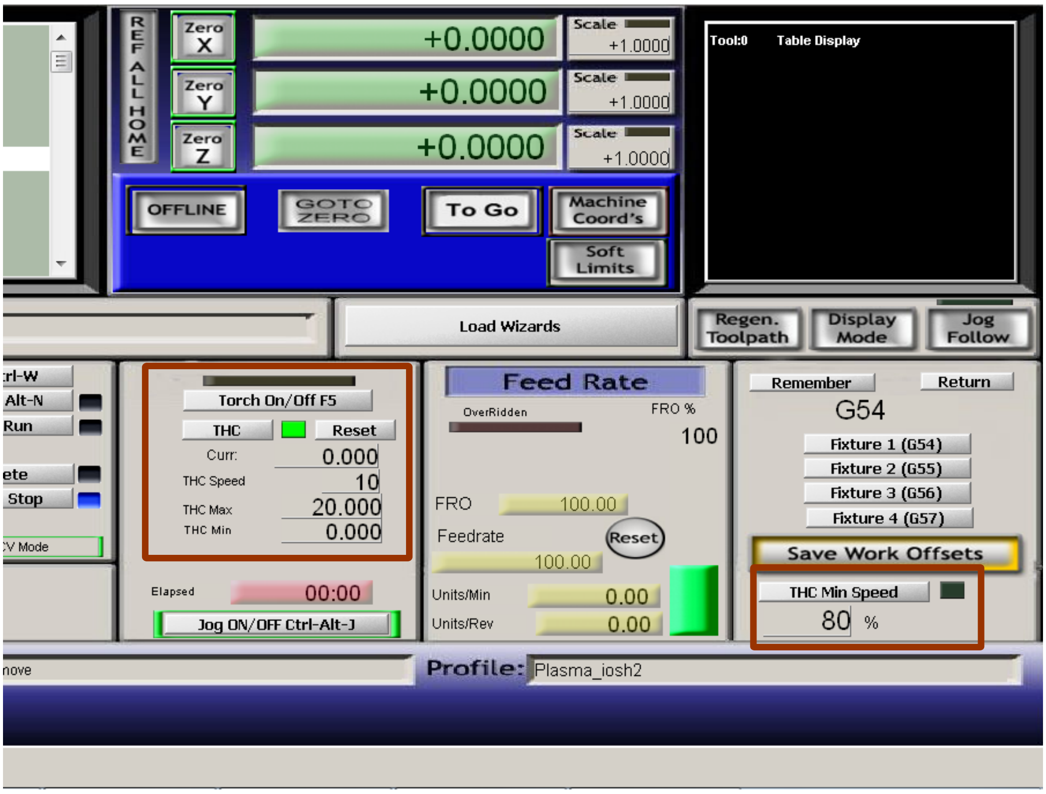


Figure 10.2 THC controls na Mach3 “Plasma.set“ ekranu

The novelty of the Audioms ETH-COMPACT motion controller is that, in addition to supporting work with an external THC controller, it has an integrated internal THC controller that can be used by connecting a suitable voltage sensor (for example THC Sensor) to the analog input of the Audioms ETH-COMPACT motion controller. The internal regulator also brings more advanced options for controlling THC regulation such as "kerf detect" and others. Fot both regulators, it is posible to disable/enable THC movement via commands from the G-code program, as well as manual mode of operation.

In the case of both internal and external THC controllers, all essential functions are performed autonomously within the hardware of the Audioms ETH-COMPACT motion controller so that a fast response of the controller is ensured.

In order for the THC-related controls to appear on the Mach3 main screen (Figure 10.2), it is necessary to:

- when starting the Mach3 program, select a plasma profile (such as the factory Plasma.xml) or
- load screen "plasma.set" into an existing profile via the menu option " View/Load screens...".

Short description of THC controls:

- Torch On/Off – button can be used to manually turn torch on/off. Usually this button is not used except for testing purposes, and the torch is controlled programmatically by G-code commands, usually M3 is used to turn torch on and M5 to turn it off.
- THC – turns on/off THC mode of operation. **THC mode must be turned on manually before the beginning of work so that ETH-COMPACT motion controller could correctly execute THC functions.** LED indicator near the button shows whether this mode is active (green rectangle).
- Reset button – resets to zero internal variable (Curr: field) that represents correction of vertical position (z axis) of the plasma torch. Current *z* position of the torch then becomes reference point for defined minimum and maximum of *z* correction.

- Curr field – displays current value of *z* position correction. At the moment of torch ignition, current *z* position is remembered as a reference, so THC Max and THC Min are defined in relation to this reference.
- THC Speed – field is used to specify vertical movement speed of plasma torch when regulation is performed. It is given as a percentage of the maximum speed of z axis that is defined in motor tuning adjustments. **ETH-COMPACT offers the option of THC movement without acceleration/deceleration, similarly as when working with an LPT port. In that case, the THC speed needs to be carefully adjusted to a lower value that will not cause stepper motor-based control systems to stall (step loss). On the other hand, if the ramping and deceleration motion option is used, too high a speed can cause the controller to oscillate, for example if the hysteresis zone is too narrow. Also, if too little acceleration is set for the Z axis, the reaction speed of the controller may be inadequate.**
- THC Min / THC Max – fields define minimum and maximum correction for z position of plasma torch in relation to the reference position.
- THC min speed – button enables anti-plunge option that prevents plasma torch from falling too low. This can happen if during cutting motion velocity in *x-y* plane drops significantly, for example at sharp corners of cutting contours, i.e. on rapid changes of moving direction. THC min speed is specified as a percentage of set feedrate. If speed in *x-y* plane drops below this value, Up/Down THC commands are ignored until speed rises again.

WARNING: It is recommended to avoid simultaneous z axis control by G-code and by THC Up/Down regulator, internal or external (when ARC_OK signal is active). ETH-COMPACT motion controller will in this case favor G-code z axis movement while Up/Down requests from THC regulator will be suspended. Nevertheless, because of sudden changes of motion type also motion speed and direction, stall of stepper motor that controls z axis is possible

Therefore it is advisable to correctly define a pause time period for the ETH-COMPACT motion controller in THC options/ Pierce delay (Figure 10.8) so that all G-code controlled movement of z axis is finished before enabling regulation performed by internal or external THC regulator.

Alternatively it is possible to specify appropriate pause time in external controller if it supports such an option. THC controllers usually offer the option to specify pause time from the torch ignition to the activation of Up/Down commands in order to prevent sudden drop of plasma torch head toward the material just after torch ignition. Namely, it is necessary to wait for arc voltage to fall to a normal value and stabilize.

Figure 10.3 shows one possible procedure for initial positioning of the plasma torch and the arc ignition. It can be seen that in the beginning period a G-code movement along z axis is performed, first to position for the arc ignition, and then after the pierce, for the actual cutting. When this later positioning is finished, and after pierce_delay time delay has elapsed, Up/Down movements from THC regulator are enabled.

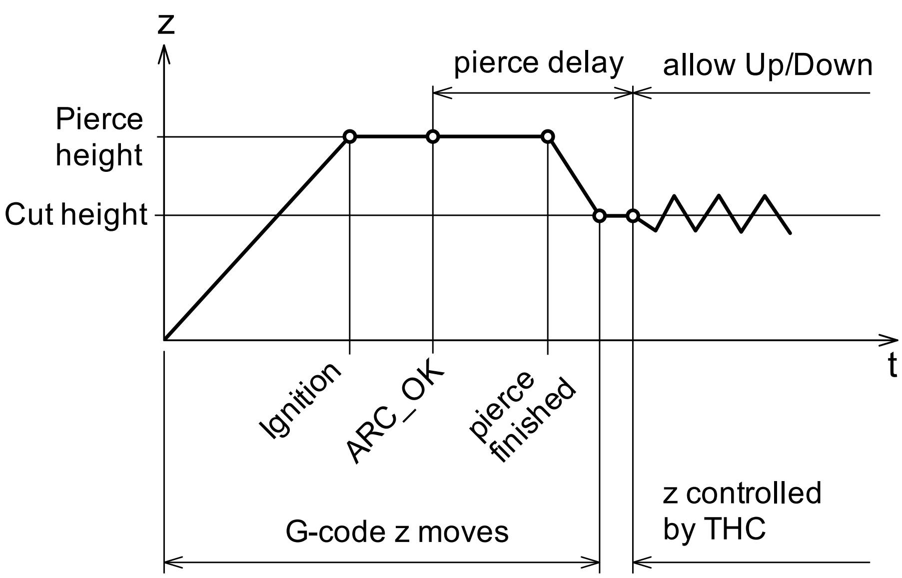


Figure 10.3 Example of plasma cutter operation

Ignition of the arc is initiated usually using M3 command which, for example, activates Output #1 signal that is connected to the plasma inverter.

ARC_OK (THC on) signal is sourced from the plasma inverter (or from external/internal THC controller) and indicates presence of the arc. Mach3 waits for this signal to continue program execution after arc ignition is commanded. If arc is lost at some time, then all movement is suspended until arc presence is detected again.

Figure 10.3 does not show initial search for the material i.e. zero z position. That function can be realized using PROBE or HOME G-code commands and for this it is required that machine supports some means to detect contact between the plasma torch and the material (floating head or ohmic sensor).

10.1.1 Configuration for operation with external THC regulator

An external THC controller (Proma Compact THC and similar) measures the voltage of the plasma arc and, depending on the set desired voltage of the plasma arc, generates a digital signal to raise or lower the plasma head. In addition, external THC regulators often generate a signal corresponding to the presence of a plasma arc. Figure 10.4 shows an example of connecting an external THC controller to a Gecko G540 control unit, while the G540 control unit is controlled by an ETH-COMPACT motion controller.

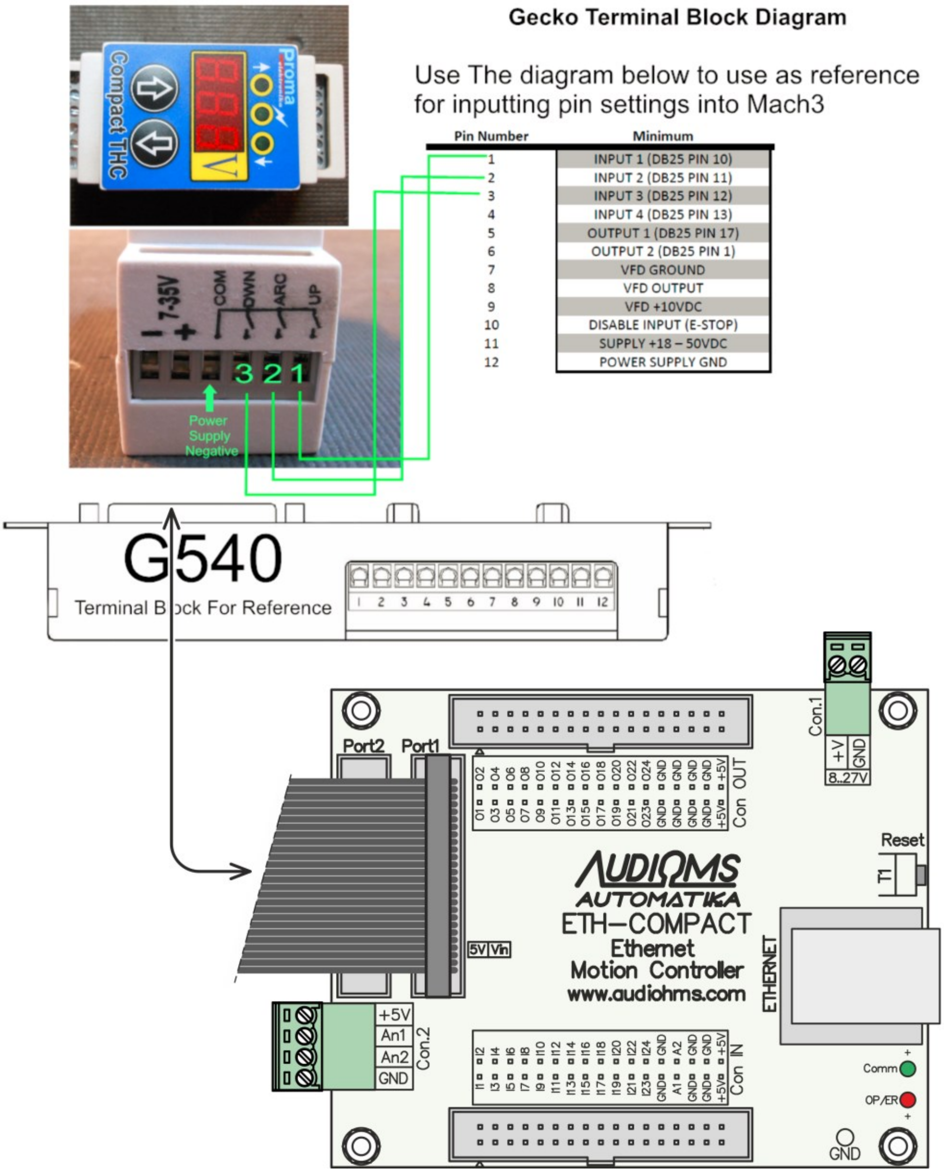


Figure 10.4 Example of connecting an external THC controller to the G540 control unit in combination with the ETH-COMPACT motion controller

For operation with external THC regulator it is required to setup port and pins for digital inputs THC On (ARC_OK), THC Up, THC Down (Figure 10.5).

THC On – signal name may be confusingly formulated and really means ARC_OK i.e. working arc is detected. This signal can be sourced from plasma inverter, external THC controller or a special current sensor installed for the purpose of arc detection.

Alternatively, it is possible to completely avoid usage of this ARC_OK signal and in that case it is required to open Mach3 dialog box Config/Ports and Pins/Mill Options and in THC options group to turn on the option Allow THC UP/DOWN Control even if not in THC mode. **In that way Mach3 is instructed not to wait for the ARC_OK signal when executing G-code, so after M3 command for the arc ignition, execution does not pause but instead it is continued immediately.**

If you instead use internal/external detection of ARC_OK signal then this option should be turned off (Allow THC UP/DOWN Control even if not in THC mode).

THC Up – command to move plasma torch up.

THC Down – command to move plasma torch down.

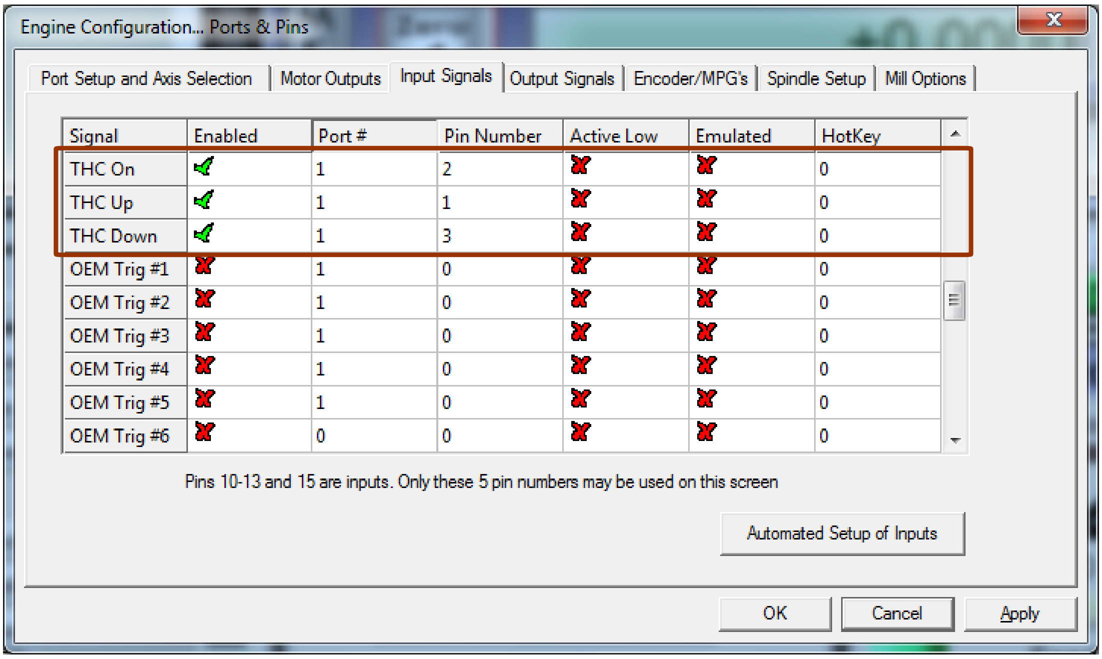


Figure 10.5 Configuration of THC input pins

NOTE: This example shows pin setup when G540 control unit is connected to Port 1, pins 1, 2 and 3 on ETH-COMPACT motion controller. For other cases of input-output hardware it is necessary to adjust pin numbers.

In addition, it is necessary to set up digital output that is used for the arc ignition that is controlled by command M3/M4. In example that is shown on figure 4, Output#1 has been chosen and for that signal, port and pin number has been set (Figure 10.7).

Optionally it is possible to set delay times that are introduced upon the torch turn on/off, shown in General parameters group on Figure 10.6. **This settings apply also to the internal regulator**.

In ETH-COMPACT configuration dialog that can be opened using menu option Plugin Control/ETH-MCI Config.../THC options (Figure 10.8) for THC type it is needed to select option External THC.

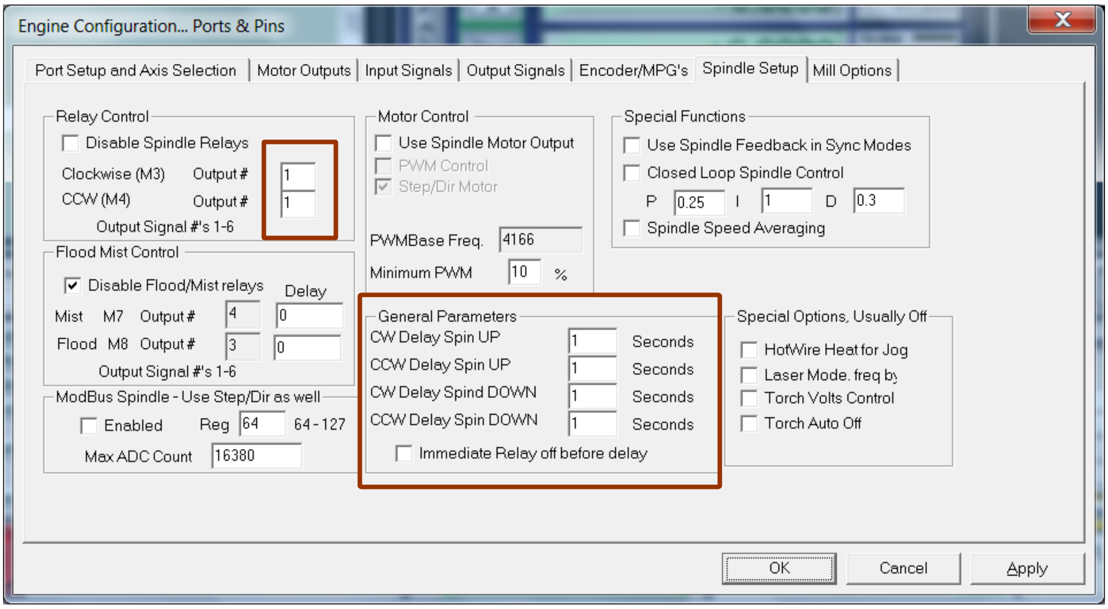


Figure 10.6 Setting up digital output signal for ignition of the plasma torch

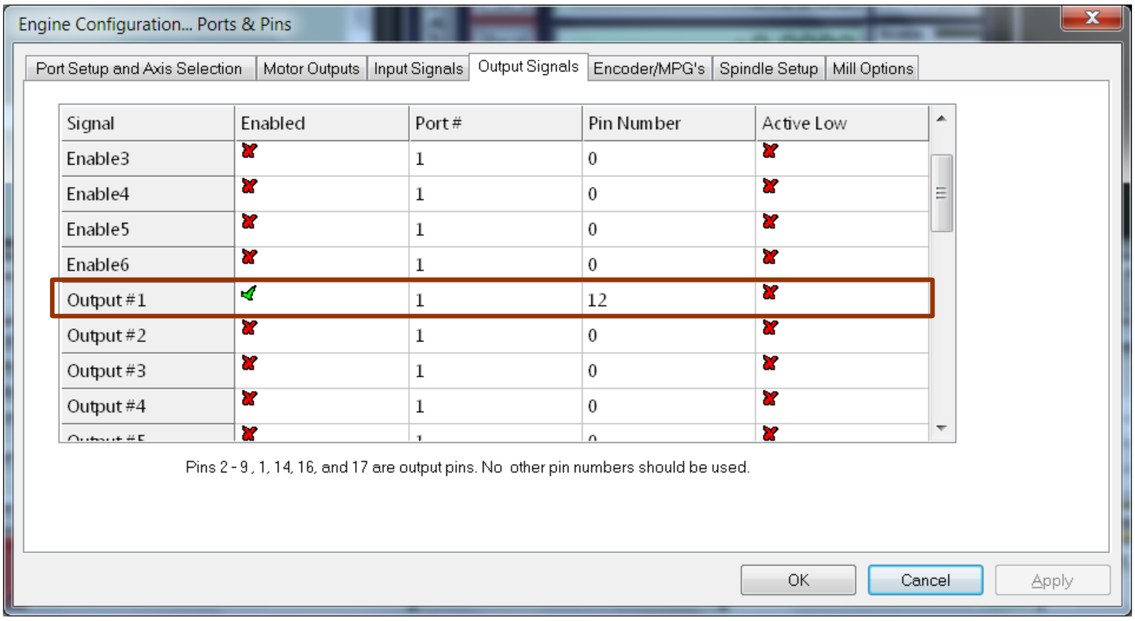


Figure 10.7 Setting up output pin for plasma torch ignition signal

NOTE: An example of setting the output pin when the relay output is set to output 12 is given.
For other cases of input-output hardware it is necessary to adjust pin number.

For both regulator types (internal and external) the following two options are available to setup:

Pierce delay - As already mentioned, this field defines the time delay from the moment when ARC_OK signal is detected to the moment of enabling Up/Down motion requested from THC regulator.

Usually M3 command for arc ignition is followed by G04 command that is used to wait for the pierce to be completed. After that, torch is positioned along *z* axis to cut height and cutting operation (moving in *x-y* plane) begins. Pierce delay parameter should be set so that THC motion is enabled only when all this mentioned steps are completed (Figure 10.3).

Force wait for THC_ON after M3 (fix Mach3 bug) - Mach3 has a bug (or at least illogical feature) regarding the order of operations after execution of M3 command for the arc ignition. Namely, as already mentioned, often after M3 command then follows G04 command for waiting to material pierce to be completed before continuing further code execution.

So, correct order of steps should be:

- execute M3 command,
- wait for ARC_OK signal,
- pause for G04 dwell time,
- continue execution.

How Mach3 really works:

- execute M3 command,
- immediately execute G04 dwell pause,
- wait for ARC_OK signal,
- continue execution.

The difference often goes unnoticed if after M3 is executed torch gets ignited very fast while dwell pause time is still in progress. But, if torch ignition takes longer so that ARC_OK signal appears later after the dwell pause, Mach3 then continues operation without any delay. Also, time needed for torch to ignite can vary (especially is longer for the first ignition), thus it is desirable for pierce pause (given via G04) to be measured from the moment of ARC_OK signal appearance.

To get over this problem an option is introduced to force waiting for ARC_OK signal first after M3 command issuance and only then continue further operation. This way the correct order of steps is achieved and also more precise timing for torch ignition sequence is achieved.

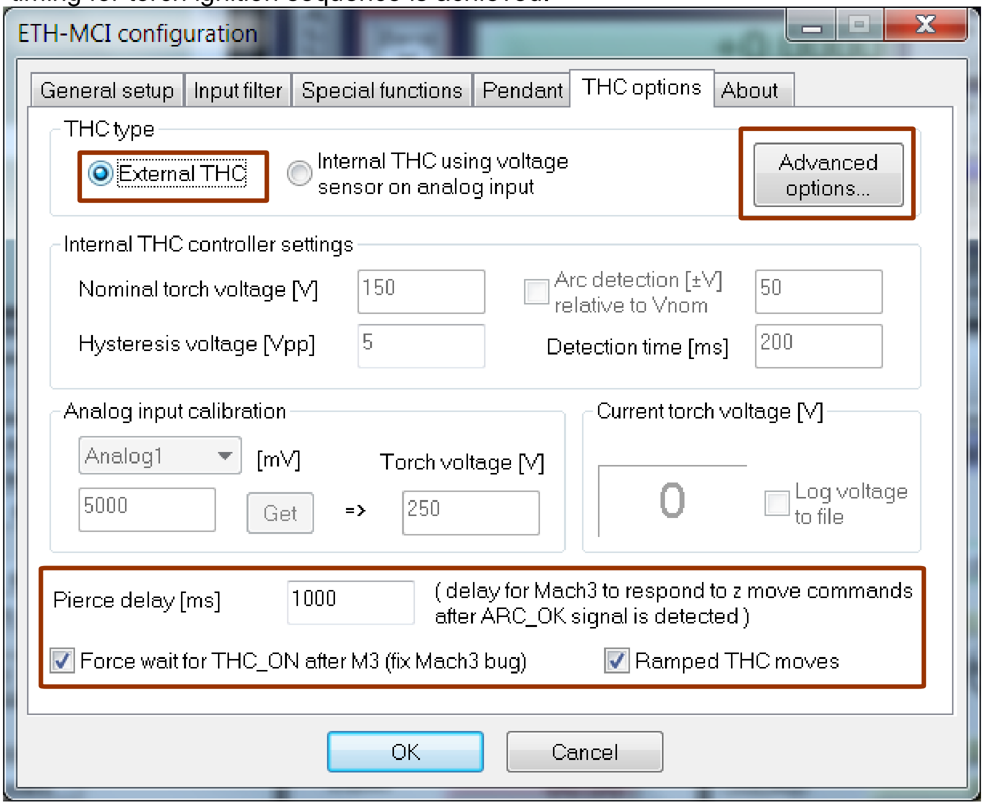


Figure 10.8 Dialog for configuring options when working with external THC regulator

10.1.2 Configuring the internal THC regulator

The internal THC regulator integrated in ETH-COMPACT motion controller replaces the function of external regulator and it is realized completely in hardware. For this function it is necessary to connect voltage signal from plasma inverter via special isolated interface (THC Sensor, Figure 10.11) to the analog input of ETH-COMPACT motion controller.

NOTE: **More about THC Sensor can be found on website www.audiohms.com**

THC type – it is required to select option Internal THC using voltage sensor on analog input (as shown in Figure 10.9).

Nominal torch voltage [V] – desired arc voltage i.e. nominal voltage value.

Hysteresis voltage [Vpp] – voltage hysteresis, peak-to-peak.

Arc detection [±V] relative to Vnom – option for arc presence detection (activates ARC_OK signal) that works by monitoring the arc voltage. The first parameter that should be specified is voltage margin in positive and negative directions in relation to the nominal value (V_d on Figure 10.10), and second parameter Detection time (T_d), is time interval for the detection. Namely, it is required for the arc voltage to stay during this defined time period inside given voltage range to consider that arc is established and ARC_OK signal is then activated.

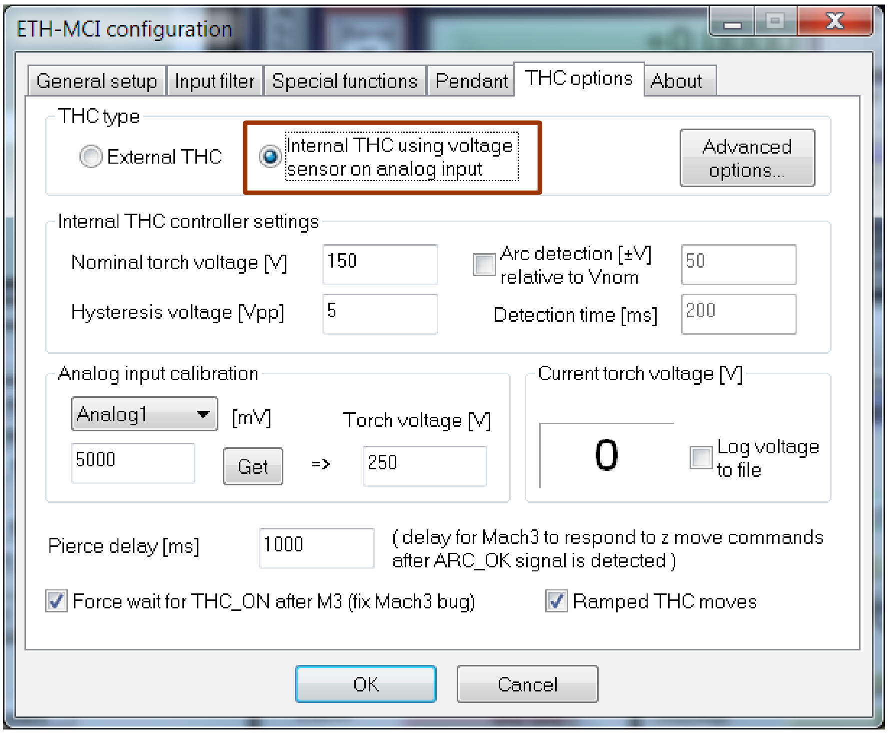


Figure 10.9 Dialog for configuring THC options when working with internal THC regulator

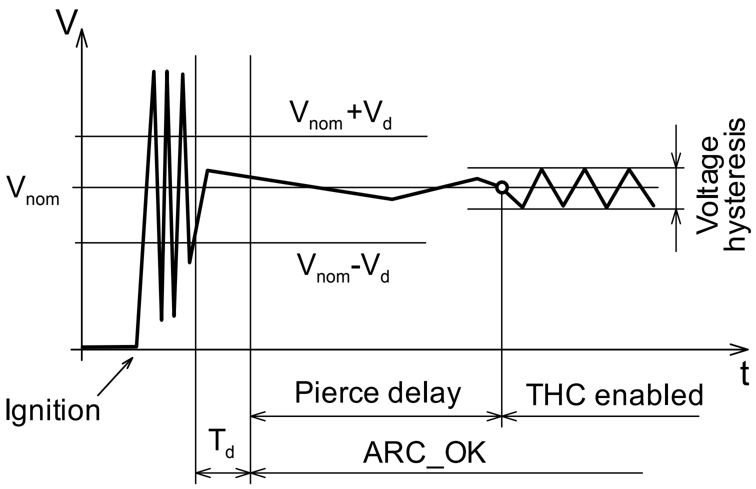


Figure 10.10 Plasma torch arc detection procedure

This option is useful if there is no possibility of bringing in an external ARC_OK signal and **in that case it is needed to turn off THC_ON signal in Ports&Pins settings (Figure 10.5) because ARC_OK signal is internally generated.**

On the other hand, if that possibility exists, it is required to setup digital input for this signal in the same way like when using external THC regulator (Figure 10.5).

NOTE: As already mentioned in external regulator section, it is possible to completely avoid usage of this ARC_OK signal and in that case it is required to open Mach3 dialog box Config/Ports and Pins/Mill Options and in THC options group to turn on the option Allow THC UP/DOWN Control even if not in THC mode. **In that way Mach3 is instructed not to wait for the ARC_OK signal when executing G-code, so after M3 command for the arc ignition, execution does not pause but instead it is continued immediately.**
In other words, **if internal/external detection of ARC_OK signal is used then this option should be turned off** (Allow THC UP/DOWN Control even if not in THC mode).

Input calibration

Interface that is used to connect plasma system to ETH-COMPACT motion controller has a certain voltage transfer ratio, i.e. high voltage that is present on plasma system side is downscaled to a voltage level that is appropriate for reading by ETH-COMPACT motion controller. This transfer ratio (voltage divider) is 50:1 on Audiohms plasma interface (optionally 1:1). THC sensor appearance is shown on Figure 10.11.

Figure 10.11 THC Sensor

So, to ensure correct calculation of arc voltage from a voltage reading on the analog input, it is necessary to perform a calibration. That can be done by providing one pair of values input-output. Transfer ratio 50:1 is related to default setting: 5000mV–250V (i.e. 5 V – 250 V).
Some plasma inverters have integrated voltage divider feature so that they offer lower voltage output signal (usually 0-5V) that is proportional to the plasma arc voltage. In that case it is possible to utilize voltage input 1:1 that is located on THC sensor (Figure 10.11).

Field Torch voltage [V] on the right side should, after the calibration, shows the correct value of current arc voltage.

Analog input - a selector that enables selection of the analog input to which the output from the THC Sensor is connected.

NOTE: The analog input used to monitor the voltage from the THC sensor should not have any function assigned via the Special functions dialog.

Analog input [mV] – voltage value read from the analog input. Maximum is 5V. This field can be populated manually or by pressing Get button in which case a current voltage value read from the analog input is taken.

Torch voltage [V] – plasma arc voltage that corresponds to previously specified voltage on the analog input.

IMPORTANT NOTE: When using the internal THC regulator, the THC Up and THC Down signals in the Ports & Pins dialog (Figure 10.5) must be OFF. In the case of using an internal regulator, these signals are internally generated by the internal THC regulator.
Also, if the plasma generator does not have the possibility to signal the ignition of the arc, then the THC On (ArcOK) signal should be turned OFF in the Ports & Pins dialog.

Digital output that initiates plasma torch ignition is setup the same way like it is done when using external controller (Figure 10.6 and Figure 10.7).

Also, as already mentioned, options Pierce Delay and Force wait for THC_ON after M3 (fix Mach3 bug) also apply to the internal regulator (these options are explained in external regulator section of this setup guide).

Connecting the THC Sensor to the ETH-COMPACT motion controller

Figure 10.12 gives the recommended connection method in the case of using a 1:50 input on the THC Sensor. The analog output from the THC Sensor is connected to the analog input An1 located on the connector Con.2 on the ETH-COMPACT motion controller (Figure 10.12).

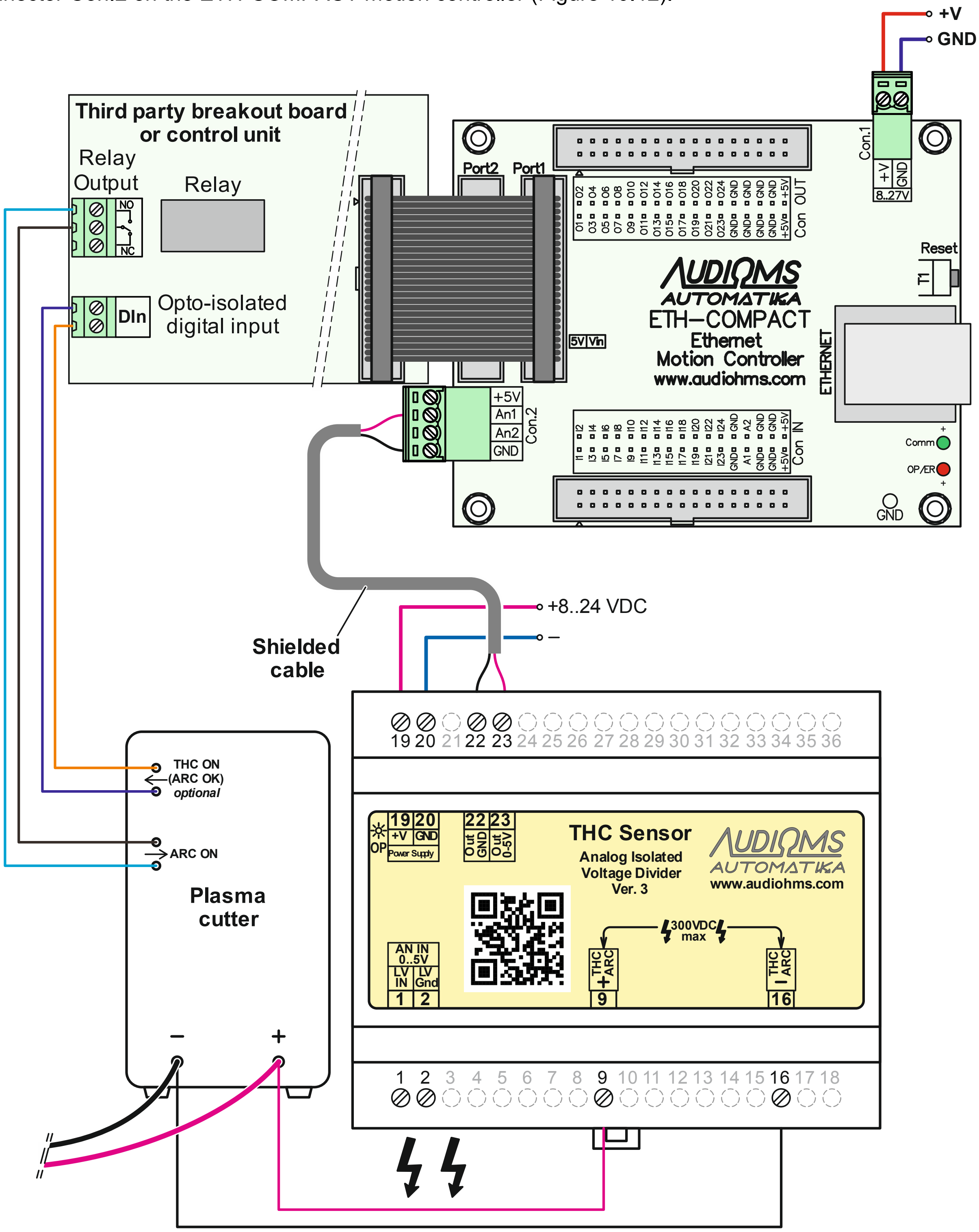


Figure 10.12 Connecting the THC Sensor to the ETH-COMPACT motion controller in the case when a high-voltage input of up to 250 V (300 V max) is used, i.e. a transmission ratio of 1:50

During the operation of the plasma aggregate, especially during the establishment of the arc, the presence of short-term pulses of voltage levels up to 1 kV (and even a couple of kV) is possible. For high-voltage lines (which connect to the THC ARC+ and THC ARC- terminals of the THC Sensor), use cables with insulation designed for the mentioned voltage levels. Considering that the high-voltage line is a source of major interferences, it should be as short as possible.

The relay output from the customized breakout board connected to the ETH-COMPACT motion controller (Figure 10.12) is used to activate the input on the plasma generator (ARC ON) to turn on the plasma arc.

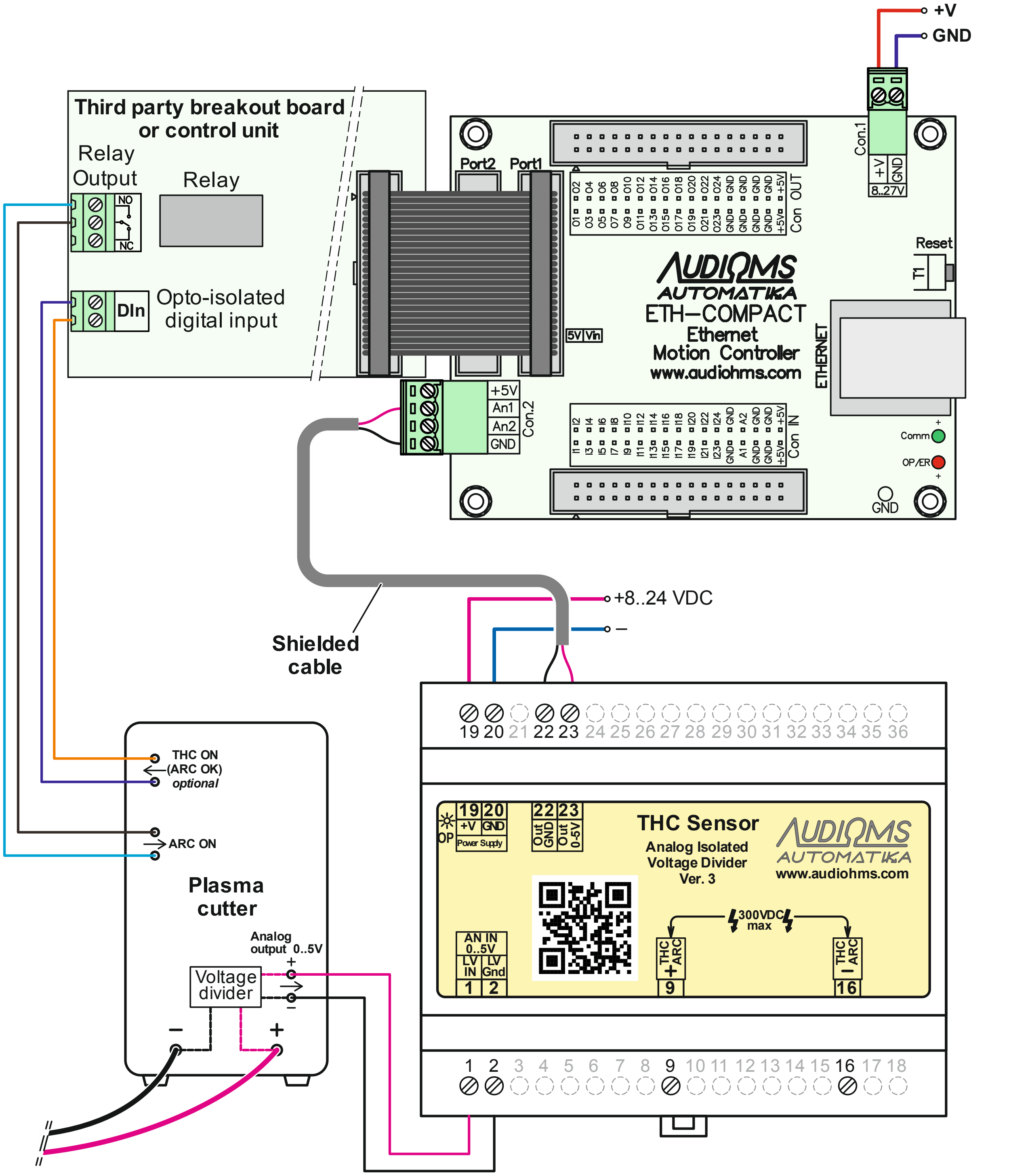


Figure 10.13 Connecting the THC Sensor to the ETH-COMPACT motion controller in the case when a low-voltage input of up to 5 V is used, i.e. a transmission ratio of 1:1

Some plasma generators have an output called THC ON (ARC OK) which is activated when a plasma arc is established. The THC ON (ARC OK) output can be connected to one of the opto-isolated digital inputs of the customized breakout board that is connected to the ETH-COMPACT motion controller (Figure 10.12).

On the market, it is possible to find plasma aggregates that have internally built-in voltage dividers, so that the analog output for torch height regulation is of a lower voltage level. Figure 10.13 gives the recommended way of connecting the THC sensor to the ETH-COMPACT motion controller in case the voltage level of the Plasma aggregate is 0-5 VDC. The analog output from the THC Sensor is connected to the analog input An1 located on the connector Con.2 on the ETH-COMPACT motion controller (Figure 10.13). Take care that the voltage level at the voltage input of the THC sensor with a transmission ratio of 1:1 should not exceed the level of 10 VDC, while the linear range is for input voltage levels up to 5 VDC.

Figure 10.14 and Figure 10.15 provide a basic wiring diagram of the ETH-COMPACT motion controller, the THC Sensor and the G540 control unit when using the internal THC controller.

Figure 10.14 shows the case when **the plasma cutter does not have a built-in voltage divider** and then uses the high-voltage input on the THC Sensor, which is available at terminals 9 and 16.

Figure 10.15 shows the case where **the plasma cutter has a built-in voltage divider** and then the low-voltage input on the THC Sensor that is available at terminals 1 and 2 is used.

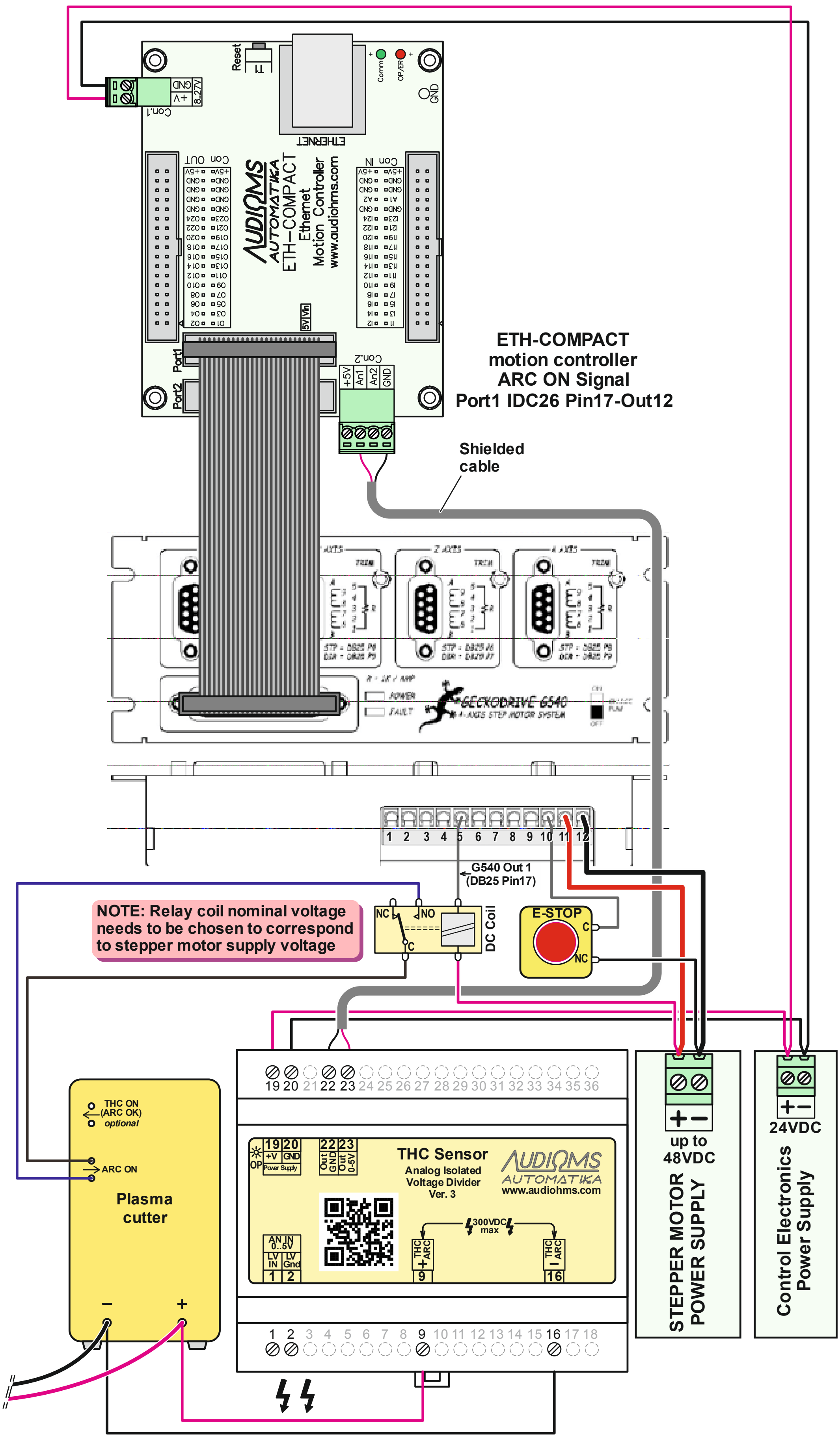


Figure 10.14 Connection diagram in the case when **the plasma cutter does not have a built-in voltage divider**

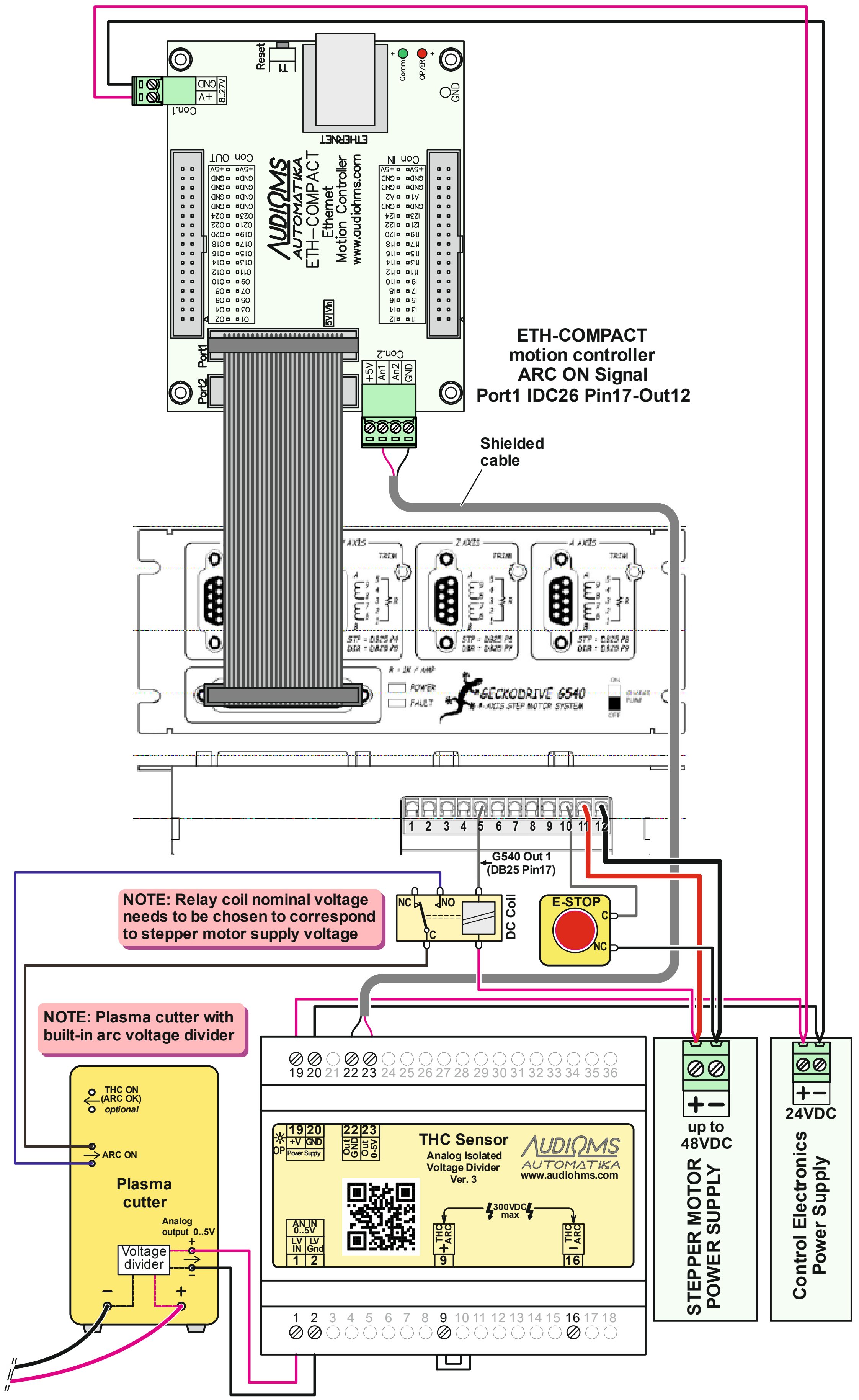


Figure 10.15 Connection diagram in the case when **the plasma cutter has a built-in voltage divider**

Advanced THC options

First three options (Figure 10.16) are related to monitoring the torch voltage thus they are only available when using analog THC Sensor (Figure 10.11) and internal regulator.

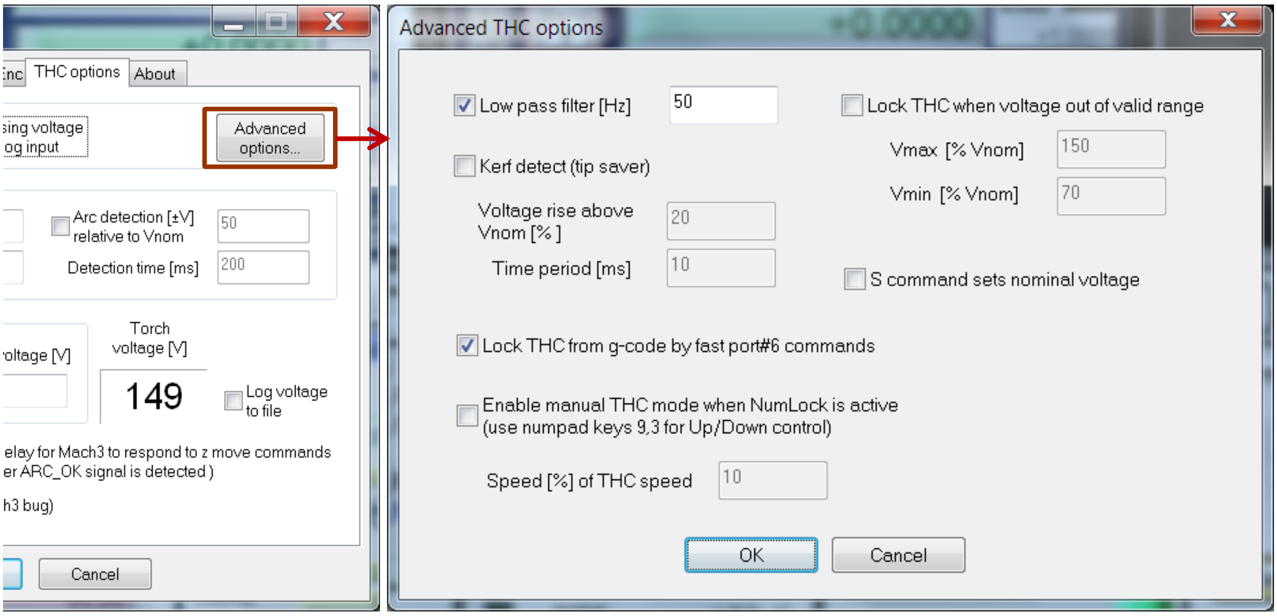


Figure 10.16 Advanced THC options

- Low pass filter [Hz] – Arc voltage signal that is monitored by THC controller can have a considerable noise present. Analog sensor (Figure 10.11) has embedded filter for noise suppression, but further filtering may be needed.

  Low pass filter is used to suppress frequencies above specified frequency. Lower this filter frequency is specified, better will be noise suppression, but at the same time bigger is slowdown of regulator reaction to the real signal changes.

- Kerf detect (tip saver) – When torch head crosses already cut path (kerf) or any other void in material, when crossing the void arc is lengthened, sparsed and is closed via near-by material edges. That leads to arc voltage rise, so THC controller reacts by lowering the torch and in worst case torch head can crash in the material.

  To prevent this problem an option is introduced to detect kerf crossing and to disable THC movements during the crossing time. THC movement is allowed again only when torch voltage drops to a normal value.

  Kerf detection works by monitoring the arc voltage and is looking for the fast voltage rise.

  Parameters to specify:
  - Voltage rise above Vnom [%] – Arc voltage rise above specified nominal value (in percent). If lower value is given (like few %) detection sensitivity is higher, but false detection can happed because of the present noise or other normal voltage variations. On the other hand, if too high value is specified, kerf may not be detected or may not be detected fast enough.
  - Time period [ms] – detection time period. Voltage rise must be fast enough to happen inside this time period to be detected as kerf crossing. In other words, if lower value is specified for time period (for example 5 ms), and voltage change (rise) is slow, then in this case this will not be recognized as kerf crossing.

    It should be noted that Low pass filter if enabled (previous option described) suppresses fast voltage changes when filter frequency is set lower. In that case for kerf detection to work properly it is needed to enlarge detection time or to specify higher filter frequency.

- Lock THC when voltage out of valid range – this option is used to disable THC movements if arc voltage is out of range. That can happen as mentioned when crossing kerf or other void in work material or for example when torch is moved out of the material bounds.
  Zadaju se:
  - Vmax [%Vnom] – upper arc voltage limit as a percent of the nominal voltage,
  - Vmin [%Vnom] – lower arc voltage limit as a percent of the nominal voltage.

- S command sets Voltage – When this option is turned on, the S command from the G-code (which is normally used to set the spindle speed) sets the nominal plasma arc voltage.

- Lock THC from g-code by fast port#6 commands – it is often desirable to temporarily disable THC movements by commands from G-code. Examples for this are for instance when cutting small holes, when during the cutting, pieces of the material drop down and leave a void, also when cutting traces with sharp corners where movement in *X-Y* plane is slowed down and that leads to lowering of the plasma torch etc.

  For this purpose are chosen the fast commands for output port control (originally intended for laser applications). This control type has a few good properties: commands are fast so there is no delay in execution, continuity of CV (*Constant Velocity*) movement is preserved so these commands can be issued in the middle of cut trace and are ideally synchronized with G-code axes movements.

  When this option is enabled, fast commands for port 6 control are interpreted as THC movement lock or unlock commands. Signal Output#6, namely corresponding port and pin in Mach3 settings (Ports & Pins) **does not need to be setup** for this commands to work properly.

  Specifically, commands are:
  ```
  E6p1 (disable THC motion)
  E6p0 (enable THC motion)
  ```

  Popular CAM programs that are used for plasma cutting support generating THC enable/disable commands in G-code according to previously defined criteria.

  This option works with both THC controllers, internal and external.

  NATICE:

  It should be reminded about the feature of these fast port commands that, strictly speaking, **they are executed at the start of next G-code motion in the program**. For example, if G-code similar to this everything is clear:
  ```
  G1X100
  E6P1
  G1X200
  ```

  But in the following G-code program THC motion will be disabled only at fourth program line which is not obvious at first glance:
  ```
  G1X100
  E6P1
  G04 P1
  G1X200
  ```

  Nevertheless, when this kind of behavior is not desirable it can easily be overcame by inserting any kind of motion of any axis just after command E6P1 in this case.

- Enable manual THC mode when NumLock is active – this option enables manual THC mode that is used for manual control of the plasma torch height. Namely, regardless of selected THC regulator, sometimes it is useful to temporarily take manual control. This may be the case for example for experimental determination of optimal height of the plasma torch during the cutting process. Manual mode can be activated at any time by pressing the NumLock key on numeric pad part of the keyboard. During the time while manual mode is active, THC automatic control is suspended and torch head can be moved up or down by pressing keys 9 and 3 on numeric part of the keyboard.

By pressing NumLock key again, manual THC mode is deactivated and automatic regulation takes over control over the torch height.
In manual mode, motion control is enabled even if there is currently active THC lock by some of the lock related THC options, and also the presence of the arc does not have to be detected.

- Speed [%] of THC speed – this field enables specifying the speed of movement in manual THC mode. Speed is given as a percent of the specified THC speed (field THC Speed on Mach3 main screen).

Custom plasma screen set

For a more comprehensive display of options and status indicators that are used in THC mode with ETH-COMPACT motion controller, it is possible to load a custom made screen set. This screen is a modified version of the original Mach3 Plasma.set screen.
Five new LED indicators (ArcOK, Up, Down, Lock, Manual) have been added to the main plasma control group, and they show current state of corresponding signals and modes of operation (Figure 10.17). Lock indicator is active when THC motion is disabled (during pierce delay pause, during anti-dive or by advanced options kerf detect, voltage out of valid range, or from G-code by appropriate commands).

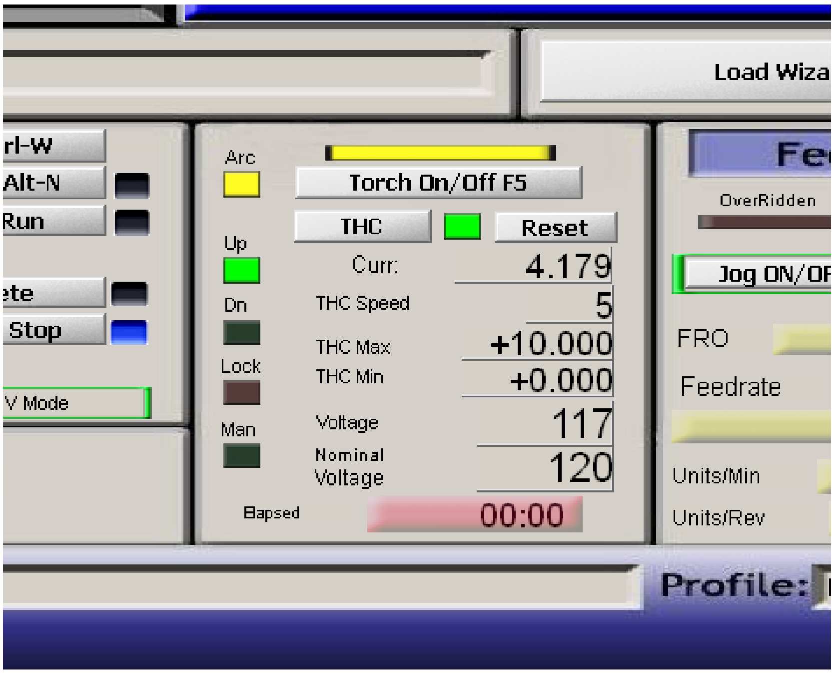


Figure 10.17 Mach3 screen set customized for THC mode when using ETH-COMPACT motion controller

Manual THC mode indicator flashes when this mode is active.

Also added are the fields that display current and nominal value of the torch voltage. These two fields are specific for the internal THC regulator of ETH-COMPACT motion controller. Nominal voltage can be specified by directly editing this field (in addition to using THC dialog of ETH-COMPACT motion controller shown on Figure 10.9).

Sometimes it is necessary to enter a negative value in the field THC Min, and that is not possible when using the original plasma.set screen. In this modified version that also has been enabled.

Custom screen set is available for download from www.audiohms.com site on the page that describes ETH-COMPACT motion controller.

10.1.3 Practical considerations and examples of THC cutting

Searching for material

This procedure is not specific to ETH-COMPACT motion controller, i.e. it is the same as when working with parallel port, but it is given here for completeness of the manual.

Searching for material, i.e. adjusting initial z position before the arc ignition, can be performed in two ways:

- using probe function (G31) or
- using home (G28.1) function of Mach3

If G31 method is used, it is needed to setup floating head as Probe input signal in Ports&Pins settings of Mach3, and then CAM postprocessor should generate a G-code like this:

```
G31 Z-100 F50    (probing downwards with speed 50 mm/min)
G92 Z-0.1        (set current position as Z=-0.1)
G00 Z5.0         (continue work, go to arc ignition height)
```

In case that G28.1 method is used, it is needed to setup z axis homing to be performed downwards and floating head should be setup to generate home signal for z axis (acting as a home switch).

In that case CAM postprocessor should generate G-code like this:

```
G28.1 Z0.50      (homing Z axis via point Z=0.5)
G92 Z-0.1        (set Z=-0.1)
G00 Z5.0         (continue work)
```

Example G-code for plasma cutting using THC

```
G0 X0Y50         (go to appropriate X,Y position)
G31 Z-100 F50    (probing downwards with speed 50 mm/min)
G92 Z-0.1        (adjust Z offset so that current position becomes Z=-0.1)
G0 Z5.0          (go to Z height for the arc ignition)
M3                    (command for the arc ignition, Mach3 waits for ARC_OK to
continue execution)
G4 P0.5          (dwell time 0.5s, wait for material pierce to complete)
G0 Z2.0          (go to cut height)
F1000            (feedrate = 1000 mm/min)
G2 X100 Y50 R50 (cutting the first part of the circle; when elapses pierce_delay
time that is measured from the moment of ARC_OK signal appearance, then THC
Up/Down regulation is enabled)
G2 X0 Y50 R50    (cutting second part of the circle)
M5               (turn off the arc)
M30              (end of program)
```

In the first part of the code searching for material is performed using G31 method, then torch is moved to ignition height. After M3 command for arc ignition, appearance of ARC_OK signal is waited (it is recommended to turn on option Force wait for THC_ON after M3 (fix Mach3 bug) in THC options of ETH-COMPACT motion controller).

When ARC_OK signal is recognized Mach3 continues execution of G-code and next command is G4 i.e. pause for 0.5s until material pierce is completed. At the same time, from the moment when ARC_OK signal is recognized, pierce delay time elapses (time delay to enable THC up/down regulation). This time period should be adjusted so that THC regulation is enabled only after pierce of material is completed and cutting of the material has been stared.

Manual control of plasma torch height by using emulated inputs

Sometimes it is useful to manually (using keyboard keys) control up/down motion of the plasma torch. Besides the manual THC mode offered by ETH-COMPACT controller, this is also possible to realize by using emulated inputs.

Mach3 offers a possibility for input signals (including also THC Up and THC Down) to be emulated by keyboard. These signals should be selected as Emulated and assigned a keys (HotKey) for manual control (Figure 10.5).

For this simulated control to work, THC function requires that:

- in ETH-COMPACT configuration (Figure 10.8) for THC type it is selected External THC mode because otherwise, if internal THC regulator is active, signals Up/Down are generated internally,

- THC mode is turned on (using THC button on the main screen),

- arc ignition is initiated either manually clicking the button Torch On/Off F5 or by M3 command from G-code,

- ARC_OK (THC_ON) input signal is detected. After this signal is activated, defined time period (pierce delay) is waited and then Up/Down motion is enabled.

  Alternatively, if this signal is not used, it is necessary to turn on option Menu/Config/PortsAndPins/MillOptions/Allow THC UP/DOWN Control even... In that case, right after the arc ignition is initiated, it is considered that arc is present and no further waiting for the arc is performed.

- Turned off the option THC Min Speed on the main screen in the lower right corner (Figure 10.2). This option (so called anti-dive) is used to disable THC regulation when feedrate in x-y plane drops bellow certain specified speed (set as a percent of maximum speed). So, to enable THC Up/Down motion also in the still state, it is needed to turn this option off.

10.1.4 Frequently asked questions

- ***THC regulation works, but constant up-down motion in regular rhythm is present, why is this happening?***
  This is regulator oscillation that can happen if too high speed of THC motion is specified (THC Speed) or, when using internal regulator, too small voltage hysteresis (difference between maximum and minimum voltage) is specified.

- ***ARC_OK signal is activated right after M3 command for the arc ignition is executed, instead of waiting for the real recognition of this input signal***.
  Option Menu/Config/PortsAndPins/MillOptions/Allow THC UP/DOWN Control even not in THC mode... is turned on. This option, as the matter of fact, is indeed used to avoid usage of ARC_OK signal.

- ***THC regulator does not react on occurrence of some of the input signals (Up, Down, THC On/ARC_OK).***
  It should be verified that inputs in Ports&Pins settings are properly setup, also that option Emulated is not selected for that signals.

- ***Mach3 during the G-code execution after the arc ignition by M3 command, does not correctly wait specified G04 dwell pause time.***
  It is needed to turn on the option Force wait for THC_ON after M3 (fix Mach3 bug) on ETH-COMPACT THC configuration dialog.
  Also check if time is given in seconds or milliseconds, i.e. according to the setting in Mach3 (Menu/GeneralConfig/G04 Dwell in ms).

- ***Z axis motion range is limited and is insufficient for proper THC regulation***.
  It is needed to correctly setup fields THC Min and THC Max on Mach3 main screen. Also check if specified SoftLimts for Z axis are limiting the movement range. Furthermore, it is possible that Z axis is not properly calibrated, so check in Menu/Config/MotorTuning dialog whether field steps per unit is set to a correct value.

10.2 MPG (manual pulse generator) pendant operation

ETH-COMPACT motion controller supports connecting MPG pendant (Figure 10.18) for controlling CNC machine, i.e. enables standard operations that these pendants offer.

It is supported:

- by pressing Enable button MPG operation is enabled, i.e. MPG mode is activated,
- selecting axis that should be controlled (maximum 6 axes),
- selecting step for MPG (maximum 4 positions),
- ESTOP button on pendant,
- LED indicator of activity,
- for axes 4, 5 and 6 it is possible to assign alternative functions (Shuttle, FRO, SRO, THCV).

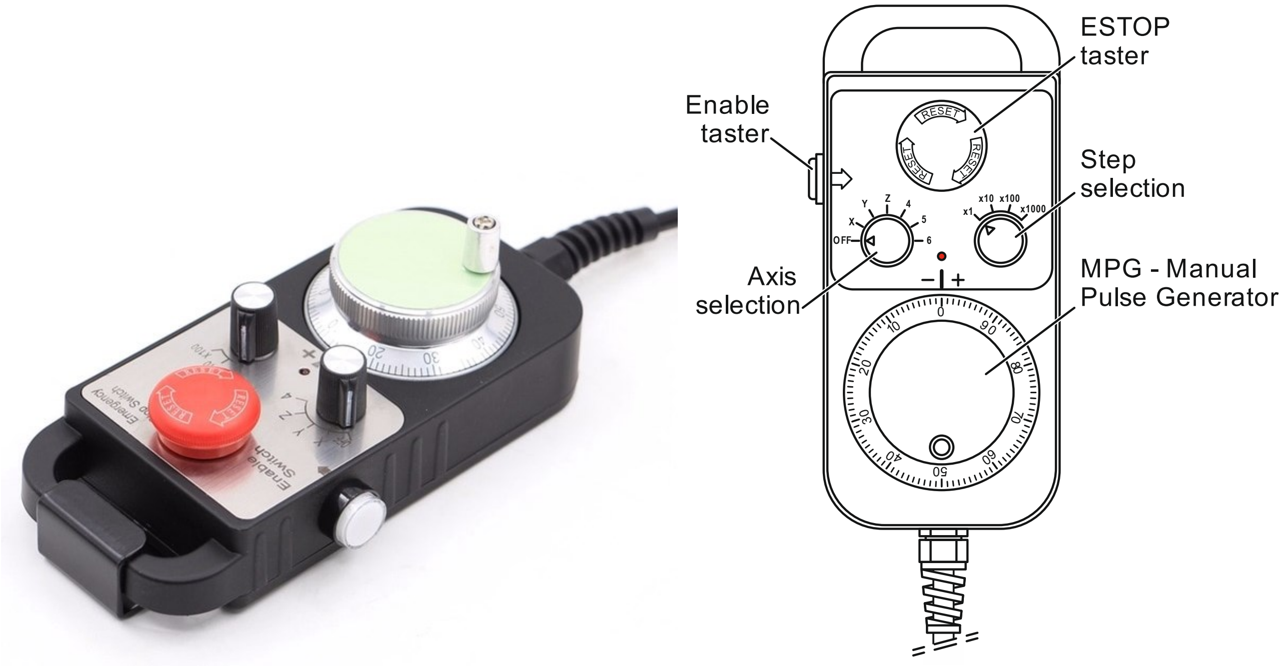


Figure 10.18 Pendant for CNC machine control

Mentioned pendants are usually realized in a way that it is required to press Enable taster (located on the right side Figure 10.18) for pendant operation to be enabled (this does not apply to ESTOP button which is always enabled).

By pressing Enable button MPG jog mode is automatically entered and by releasing this button MPG jog mode is deactivated. For axes 4, 5 and 6 if an alternative functions (Shuttle, FRO, SRO) is selected, pressing Enable button activates that selected function and releasing this button deactivates selected function mode.

NOTE: To connect the pendant to the ETH-COMPACT motion controller, a custom breakout board is required.

Options for pendant functions can be adjusted using ETH-COMPACT configuration dialog box. Options for Pendant are located in the Pendant tab (Figure 10.19).

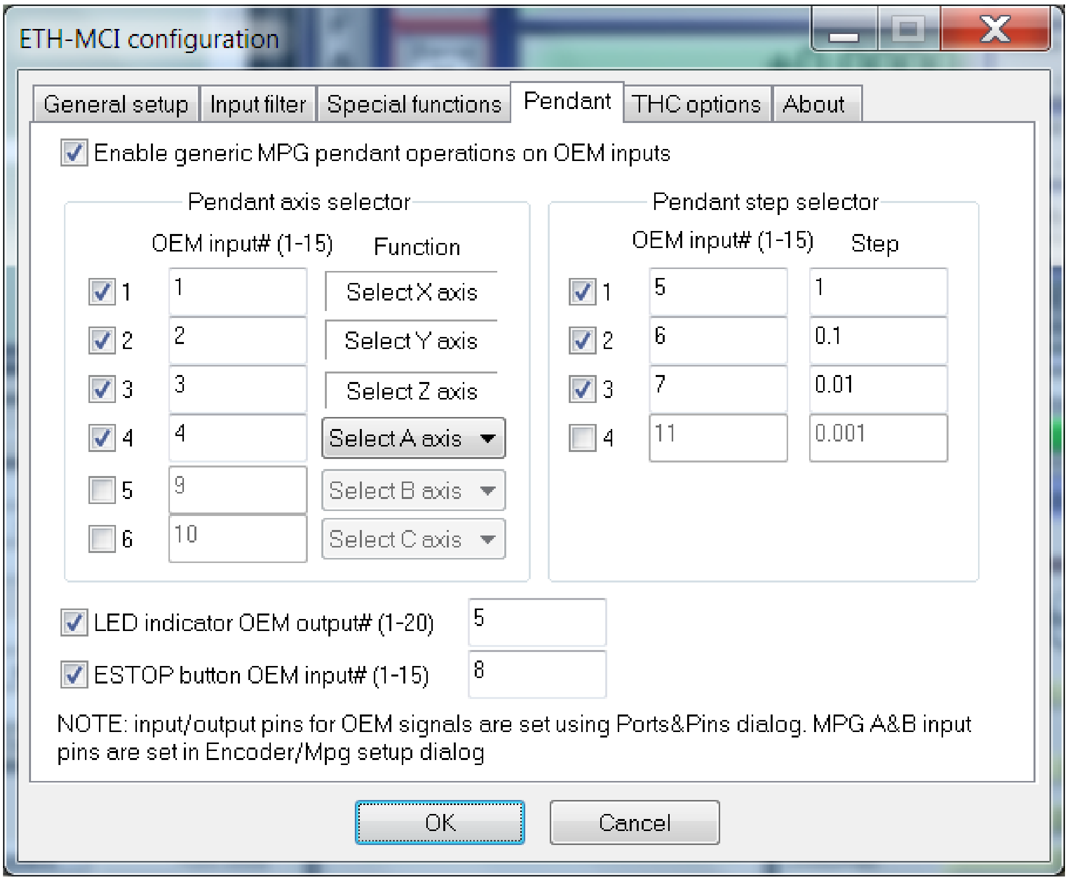


Figure 10.19 An example setup of functions for pendant with 4 positions for axis selector switch and 3 positions for step selector switch

Mach3 OEM input signals are used for reading current states of selector switches and the other pendant controls. More closely, state of mentioned signals is used regardless of the way they are activated (normally via digital inputs or alternatively set by some other plugin, script or similar).

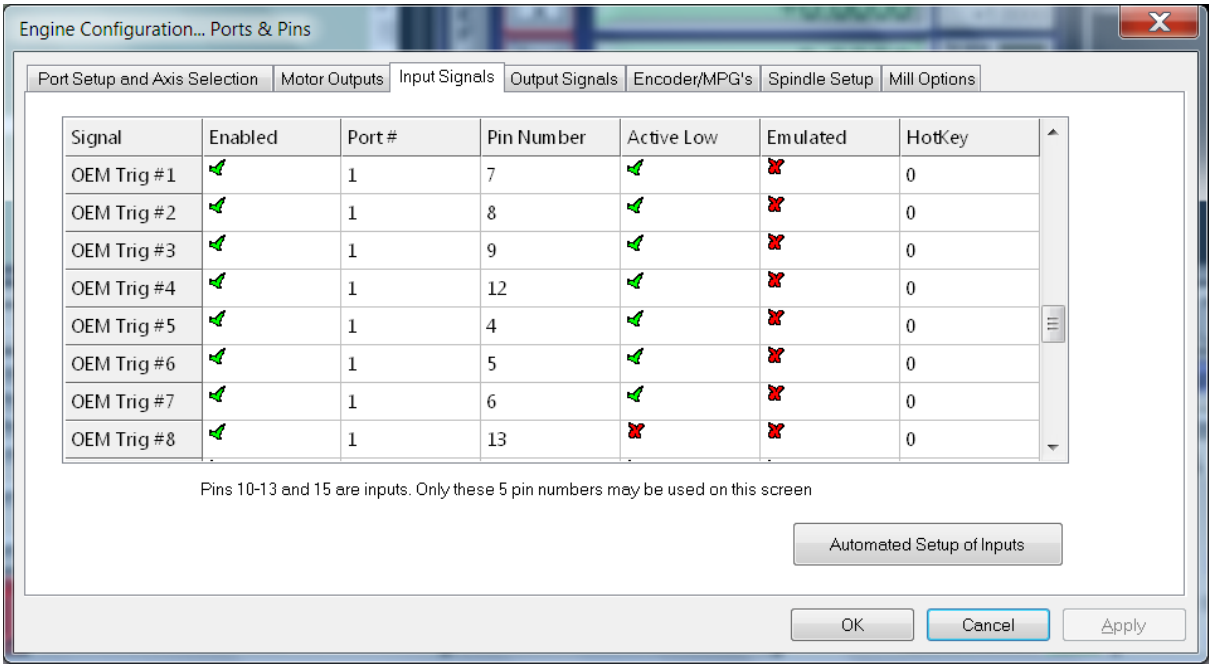


Figure 10.20 Example of setting up input pins for OEM input signals that are used for pendant functionality

Available options (Figure 10.19) are:

- Enable generic MPG pendant operations on OEM inputs – Activates/deactivates pendant operations.
- Pendant axis selector – enables setting up the functionality of the axis selector. Maximum of 6 switch positions are supported. Using OEM input# field it is possible (if needed) to change which OEM input signals are used for each switch position. Pin and port for digital inputs for these OEM signals can be set up using Mach3 Ports&Pins input configuration dialog (Figure 10.20).

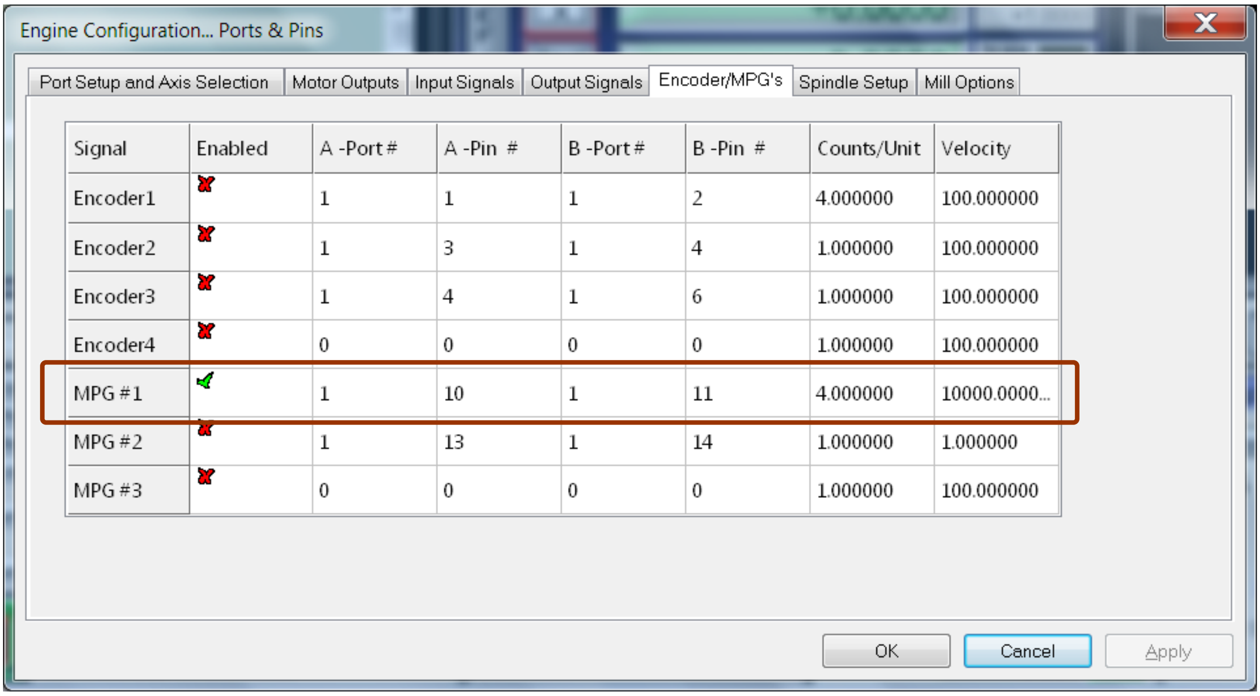
  As already mentioned, for positions 4, 5 and 6 it is possible to setup following functions:
  - Shuttle mode activation (controlling the speed of G-code execution by turning MPG wheel),
  - FRO (Feedrate override 0-250%),
  - SRO (Spindle rate override 0-250%),
  - THC Vnom (set nominal THC voltage, 50-300V).

- Pendant step selector – this option group enables setting up pendant step selector (Figure 10.19). Maximally 4 positions are supported for step selector. OEM input# and Step fields enable setting up OEM input and step value for each position.

- LED indicator OEM output# (1-20) – if pendant has LED indicator it is possible to use it by connecting it to a free digital output. LED indicator lights up when pendant is active.

- ESTOP button OEM input# (1-15) – if pendant has ESTOP button it is possible to use it by turning this option on

For setting up MPG (Manual Pulse Generator) Encoder/MPG's (Figure 10.21) dialog is used. It is needed to turn on MPG1 and set pin and port for A and B inputs as well as other required fields. For detent value (counts/unit) it is needed to enter a number of pulses that MPG generates when moved for one mark (usually 4 pulses).



Signal	Enabled	A -Port #	A -Pin #	B -Port #	B -Pin #	Counts/Unit	Velocity
Encoder1	✗	1	1	1	2	4.000000	100.000000
Encoder2	✗	1	3	1	4	1.000000	100.000000
Encoder3	✗	1	4	1	6	1.000000	100.000000
Encoder4	✗	0	0	0	0	1.000000	100.000000
MPG #1	✓	1	10	1	11	4.000000	10000.0000...
MPG #2	✗	1	13	1	14	1.000000	1.000000
MPG #3	✗	0	0	0	0	1.000000	100.000000

Figure 10.21 An example setting for case when A and B MPG lines are connected via digital inputs 10 and 11

NOTE: For the best performance it is recommended to enable option Hardware MPG in General Setup tab of ETH-COMPACT motion controller configuration dialog. In that case controller autonomously reads MPG position and controls axis position without any need for communication with PC computer.

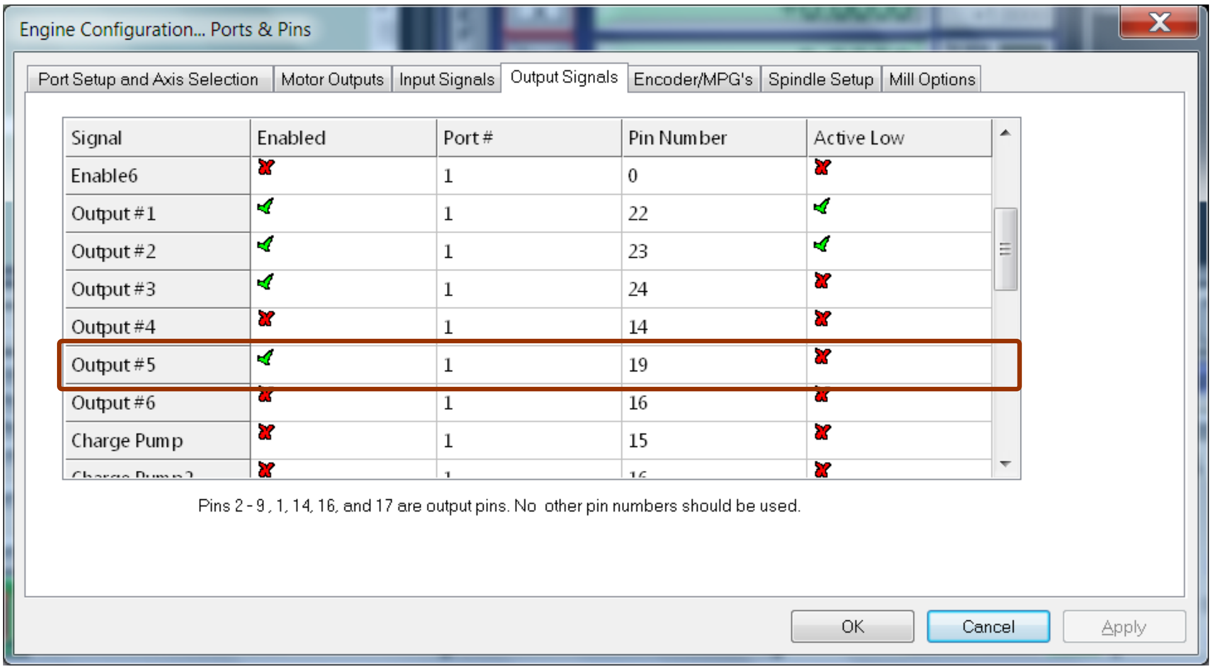


Figure 10.22 An example setting for case when pendant LED indicator is connected to output pin 19

Some MPG pendants have an LED indicator that shows whether the pendant is active. Figure 10.22 gives an example of setting a digital output that activates an LED indicator.

11 LED indicators

11.1 OP/ER – Status LED

Does not light up	Controller is not powered
Blinking slow	Controller is in safe mode (outputs are in high impedance state)
Constantly lights	Established connection with computer, controller is in idle mode (ready for work)
Blinking fast	A command (jog, G-code) is currently being executed
1 short blink	An error is detected (e.g. limit switch activated, ESTOP or similar). For error type look at Mach3 status line

11.2 Comm LED

Lights when there is a communication with computer.

DOCUMENT REVISION:

- Ver. 1.0, May 2025, Preliminary version
- Ver. 1.1, August 2025, Added wiring diagrams in Figure 10.14 and Figure 10.15 for internal THC regulator