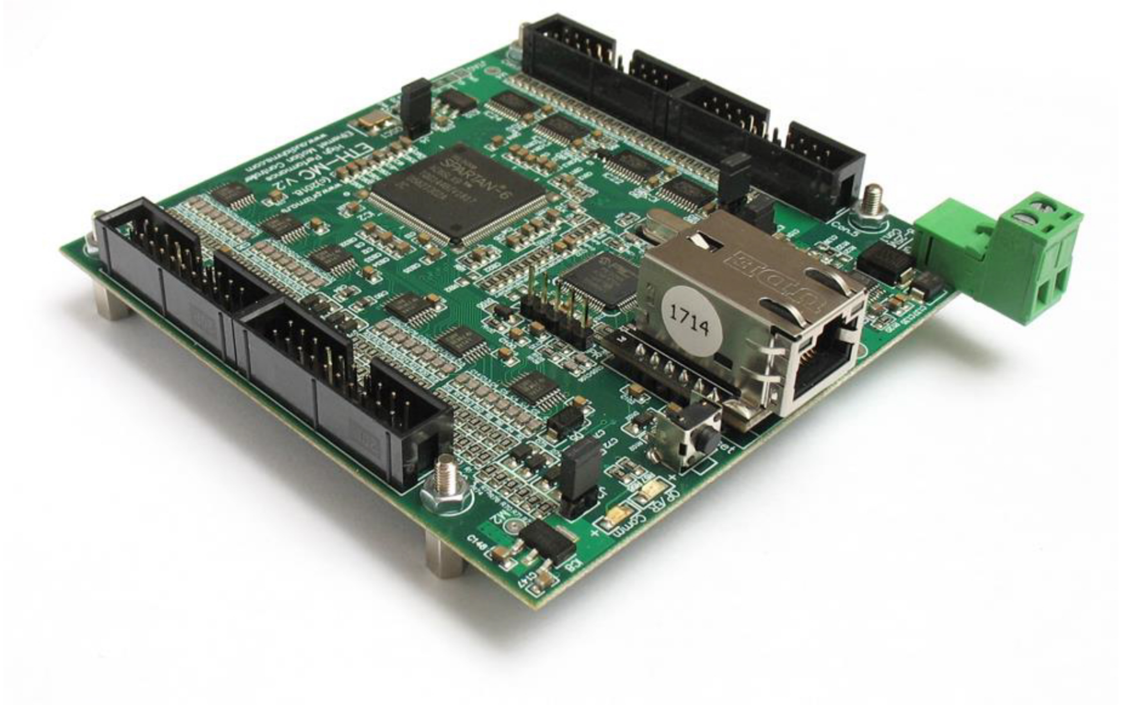
ETH motion card



User manual

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SAFETY WARNINGS

When working withETH motion cardler there are dangers and risks that can lead to equipment damage and also injuries of people nearby.

For the installation procedure of ETH motion card 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 motion card 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 motion card 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 Prizma drivers 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 motion card 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 motion card 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 motion card and that is caused as a consequence of obeying or not obeying this user manual.

1 ETH motion card based on Ethernet connection

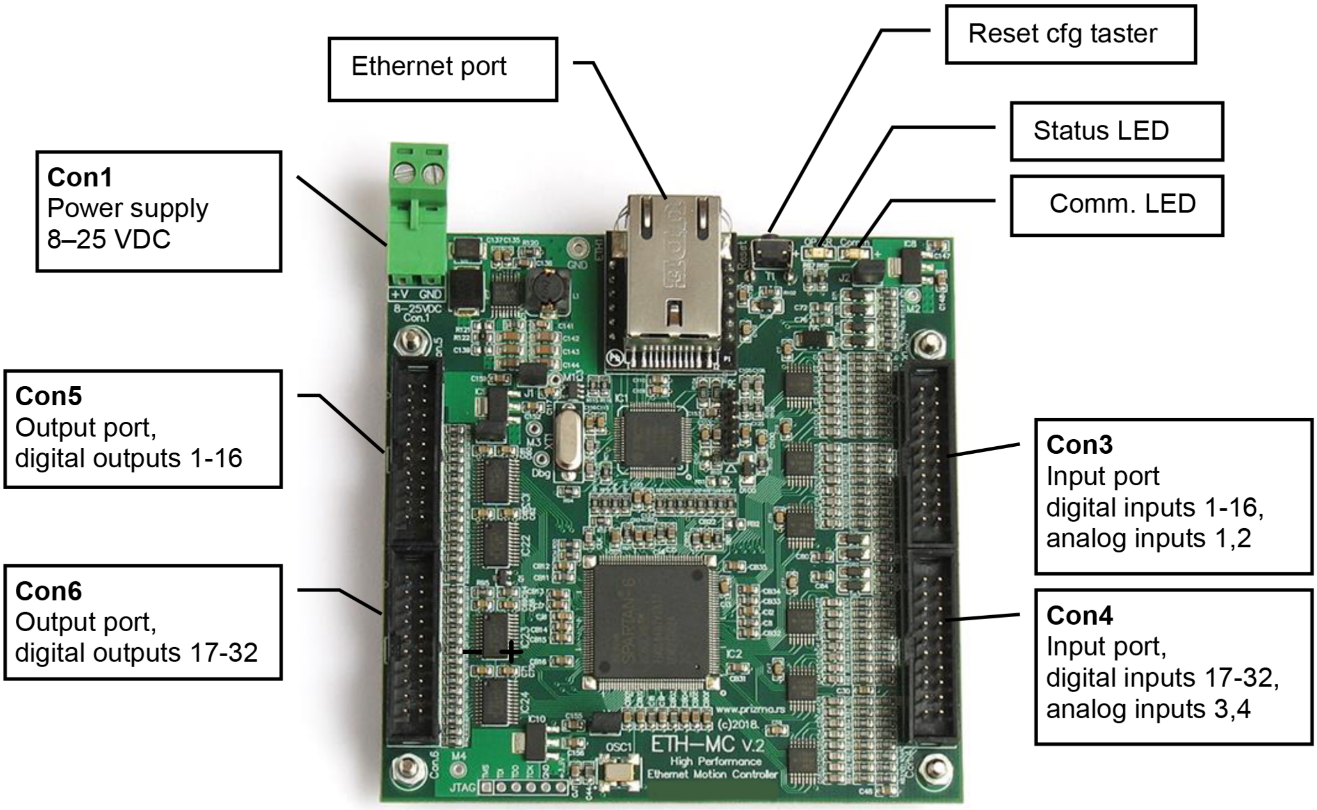

Figure 1.1 ETH motion card

1.1 Description

ETH motion card (Figure 1.1) is a high performance motion controller for CNC machines designed for use with popular Mach3 CNC control software in Windows XP, Vista, 7, 8, 8.1 and 10 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 motion card does not require installation of Mach3 LPT driver.
ETH motion card with its integrated 32-bit microcontroller and the powerful FPGA chip, takes over all real-time tasks that require precision timing. Therefore, computer CPU is less loaded, so that Mach3 now can work on less powerful desktop, laptop, and even tablet computers.

At the same time, much higher output frequency for the step signal (up to 5 MHz) is achieved and much better quality of the output signal than it is possible with parallel port regardless of performances of used computer.
A large number of functions have been added and many existing have been improved.

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 motion card 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 motion card

- Four layer circuit board, FPGA + 32-bit microcontroller
- Ethernet 10/100 Mbit connection
- Advanced smooth trajectory interpolation
- 6 axes + spindle axis, 5 MHz max. step signal frequency, adjustable pulse width
- Available axis output modes: step/dir, cw/ccw, quadrature
- 32 digital inputs, 5 V Schmitt triggers
- 32 digital outputs, 5 V TTL
- 4 analog inputs, 0-5 V
- 7 quadrature encoders reading at 12,5 MHz max, resolution multiplied by 4 in hardware
- All digital inputs and outputs freely remapable
- For all digital inputs and outputs adjustable active state (low/high)
- Hardware feedhold (instantaneous activation, no delay)
- Hardware MPG mode (real-time control, no latency) + all Mach3 MPG modes
- Synchronized motion generation using encoder as feedback (electronic gearing)
- Threading with lathe, encoder based (G32, G76) using Mach3turn;
  advanced, autonomous synchronized motion generation,
  no pullout delay at the end of a cut pass, successive G32 moves can be seamlessly joined in tapered threads...
- Rigid tapping using Spindle encoder as feedback, axis selection, forward/reverse speed adjustment etc.
- THC integrated controller with advanced precision PID regulator (closed loop 1 kHz) and classic Up/Down regulator (for usage with THC voltage sensor connected to one of the analog inputs)
- THC support for external Up/Down controller
- THC acceleration ramped moves, voltage sampling, anti-plunge support, arc detection...
- THC advanced option: Low pass filter, Kerf detect, THC lock from G-code, consumable status...
- Laser PWM output, fast M10/M11, eNp0/eNp1 port commands, PWM gate by M10/M11
- Laser power compensation, adjustable arbitrary curve relation to speed of motion
- Laser 8-bit gray level engraving
- Detailed setup for debouncing for all digital inputs and adjustable digital filters for encoder inputs
- SoftLimits
- Probing function (G31)
- Backlash compensation
- One standard PWM output (for spindle / laser) + two additional PWM outputs (10Hz – 200KHz)
- Shuttle mode, control using MPG or using potentiometer via analog input
- Slave axes
- Spindle index input, adjustable divider
- Charge pump output signals, adjustable frequency (12,5 kHz and 5 kHz)
- Offline mode
- Limits override, auto/manual/external
- Configurable special functions for control via analog inputs or encoders (FRO, SRO, Set User Variable, Set User DRO...)

1.3 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 + spindle axis
Number of digital outputs	32
Number of digital inputs	32
Maximum STEP signal frequency	5 MHz (adjustable from plugin for every axis)
STEP pulse width	50 % (or fixed, adjustable from plugin for every axis)
STEP signal output modes	Step&Dir / CW&CCW / Quadrature
PWM outputs	10 Hz – 200 kHz
PWM duty cycle resolution	16 bit
Frequency of signal on Index input	≤ 50 MHz
Pulse width on Index input	≥ 10 ns
MPG/encoders input (x4) frequency	≤ 12.5 M steps/sec
Digital inputs type	Schmitt trigger, 5 V, Pull-up resistors 4,7 kΩ
Digital outputs type	TTL, 5 V
Maximum current on digital outputs	32 mA
Number of analog inputs	4
Analog input range	0–5 V, 10 bits
Charge pump outputs	2
Charge pump frequency	12,5 kHz or 5 kHz
Power supply	8 – 25 VDC / 0,25 A – 1 A (current draw depends on connected peripherals)

NOTE: Shown specifications are subject to change without prior notice

1.4 Installation

Below is a detailed description of the ETH motion card installation.

Note: ETH motion card does not require Mach3 LPT driver to be installed nor is uses this driver.

1.4.1 Plugin installation

To install ETH-MC Mach3 plugin, copy supplied file **ethmc_drv.dll** to Mach3 plugins folder (usually "**c:\mach3\plugins**"). Then, start Mach3 and new plugin should be detected (Figure 1.2). Now choose **ETH-MC-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…**

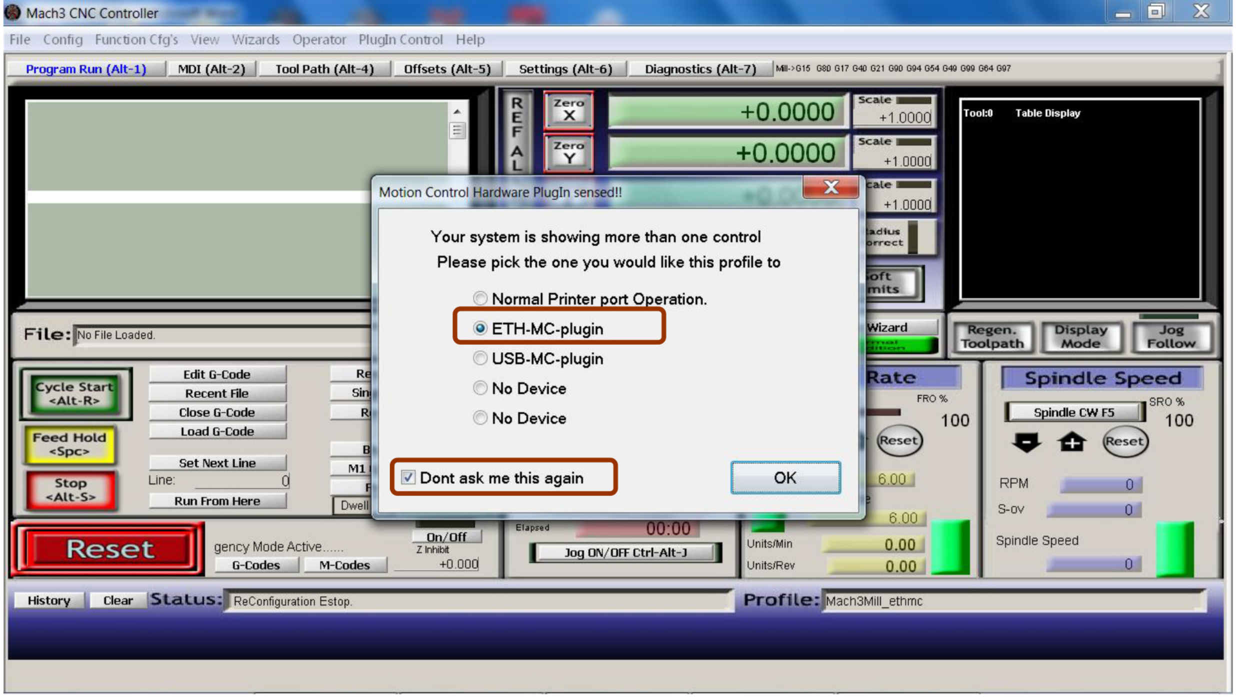

Figure 1.2 Plugin selection

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-MC network setup (Figure 1.3). IP address of the ETH-MC 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 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).

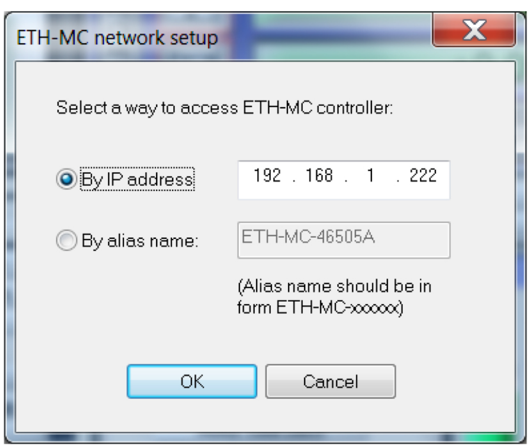

Figure 1.3 Setting up network communication in Mach3

1.4.2 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 motion card. **Described connection method is recommended for most secure operation and best communication performance**.

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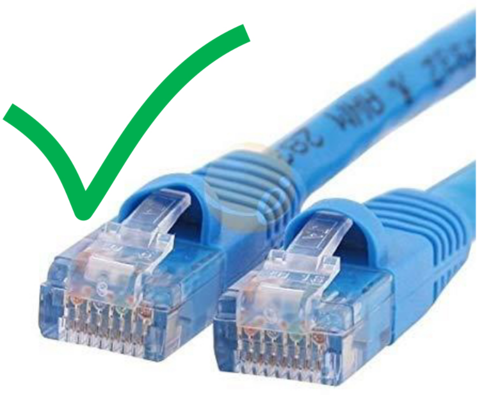
Ethernet (network) cable that is used for connection of the network adapter on the PC computer and ETH-MC motion controller does not need to be with crossed lines (crossover cable) because ETH motion card has implemented automatic detection of the Ethernet port and needed mode of operation.

IMPORTANT NOTE: Ethernet module integrated on ETH motion card provides galvanic isolation between computer and motion controller. Usage of shielded network cable (STP cable) is NOT recommended (Figure 1.4) because in that case galvanic isolation is lost, which in some cases can lead to damage of ETH motion card and/or computer.

a)



b)

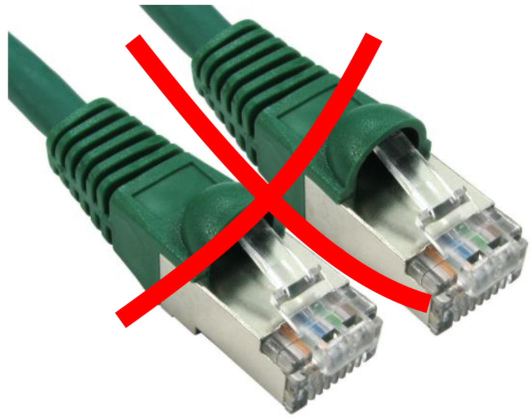


Figure 1.4 Network cable types, a) UTP cable (unshielded) and b) STP cable (shielded)

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...**".

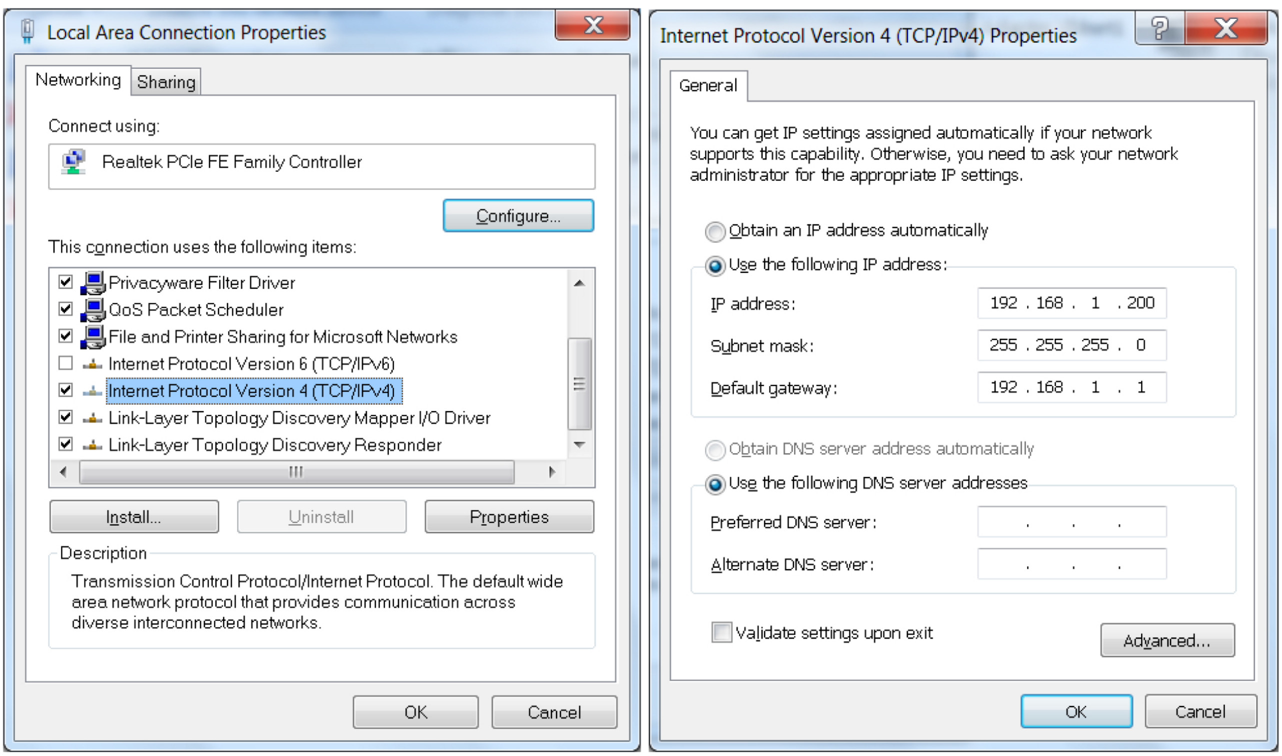


Figure 1.5 Setting up PC computer network parameters

2. In the list of available protocols (Figure 1.5 left) locate "**Internet Protocol Version 4 (TCP/IPv4)".** Select it and then click **Properties.**

3. In dialog box (Figure 1.5 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 motion card)
- 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 motion card because its factory set IP address is 192.168.1.222 so it is located on the same subdomain (192.168.1.*).

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 WiFi) so we use existing settings and these parameters for the computer are not manually specified like mentioned above.

ETH motion card 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 motion card so that they correspond to the existing system. It is needed to use configuration software for ETH motion card (see below) and adjust controller IP address to the address on the same subdomain as computer IP address (usually 192.18.1.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 1.6).

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.

1.5 Software for configuring network parameters of ETH motion card

keeps network parameters in its EEPROM. Figure 1.6 presents factory set values of these parameters and if needed these parameters can be changed and stored to EEPROM of ETH motion card.

To begin work, ETH motion card must be powered and it is needed that ETH motion card and PC computer are both connected to the same network in any way.

Search network button is used to initiate search for all ETH motion card on the network. More precisely, PC computer broadcasts requests to all present network connections (UDP multicast protocol) and all ETH-MC 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.

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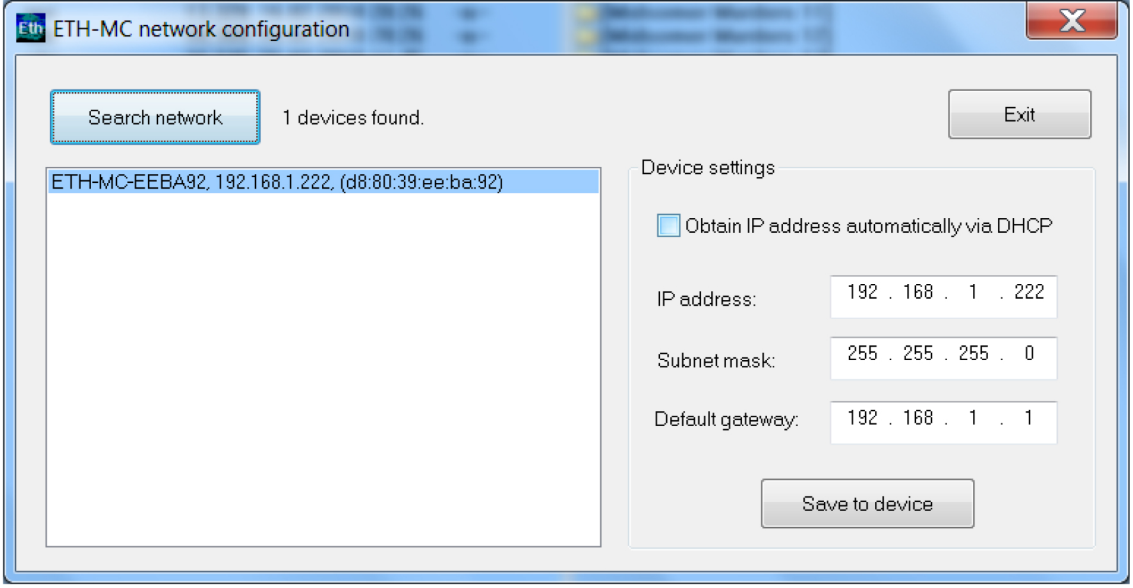

Figure 1.6 Software for configuring network parameters of the ETH motion card

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 motion card.

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

1.5.1 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.

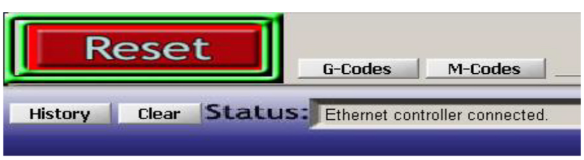

Figure 1.7

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 1.7). Then the controller enters normal work mode and red LED indicator on the controller stops blinking and lights continuously.

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.

1.6 Automatic firmware update

ETH-MC 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 1.8 will be shown. It is needed to click button **Yes** and wait for this process to be completed (Figure 1.9). Finally, result like on Figure 1.10 should be presented when firmware update procedure is finished successfully.

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

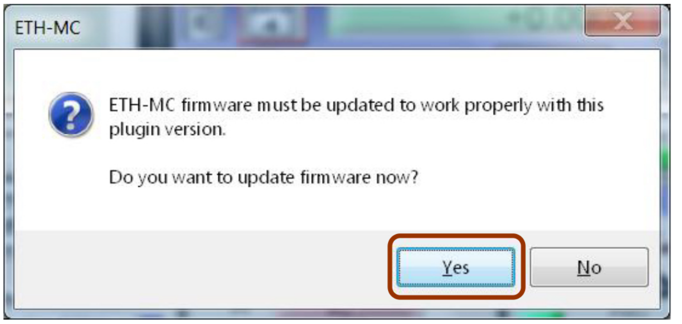

Figure 1.8

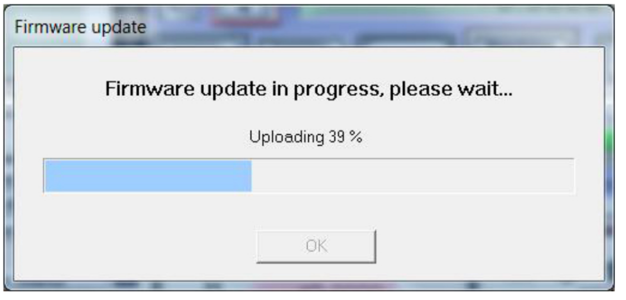

Figure 1.9

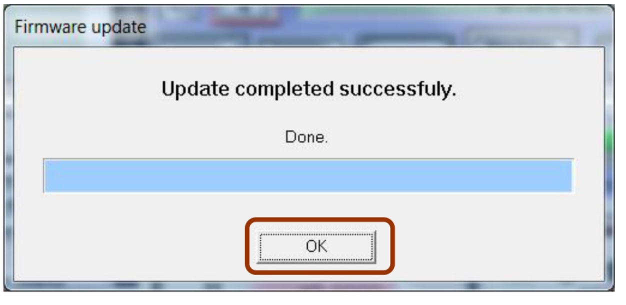

Figure 1.10

1.7 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 motion card, can be adjusted via dialog box that is opened using the menu option **Plugin Control/ETH-MC Config…**. Also, novelty is the status window that can be opened via **Plugin Control/ETH-MC Status…**

1.7.1 Adjusting ports and pins via Ports & pins window

ETH motion card provides one digital input port with 32 pins and one digital output port with 32 pins. These pins can be remapped as desired, that is, can be assigned different functions that are needed for the specific application.

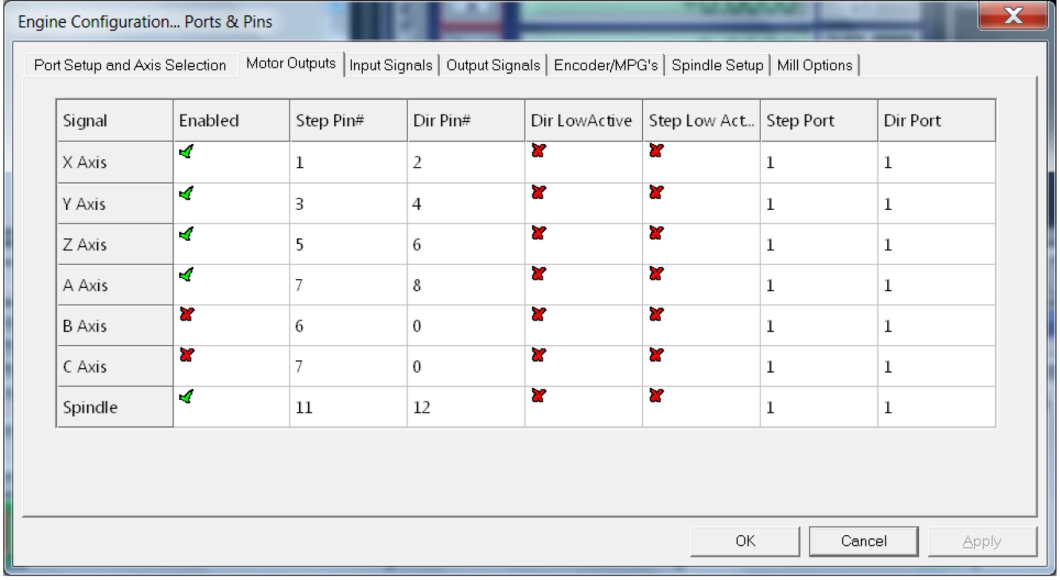

Figure 1.11 Ports and pins configuration

When using configuration dialogs like **Motor Outputs**, **Input Signals**, **Output Signals** (Figure 1.11) etc. number 1 is always used for port number. Available pins on the input port are numerated from 1 to 32. Similarly, output port pins are also numerated from 1 to 32. ETH motion card will ignore any port number different from 1 and any pin number that is out of available range.

When a breakout board (input/output card) is used, it is needed to refer to the card specifications for correct mapping of input and output pins.

1.8 ETH-MC configuration dialog

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

1.8.1 General setup tab

On the Figure 1.12 General setup tab is shown.

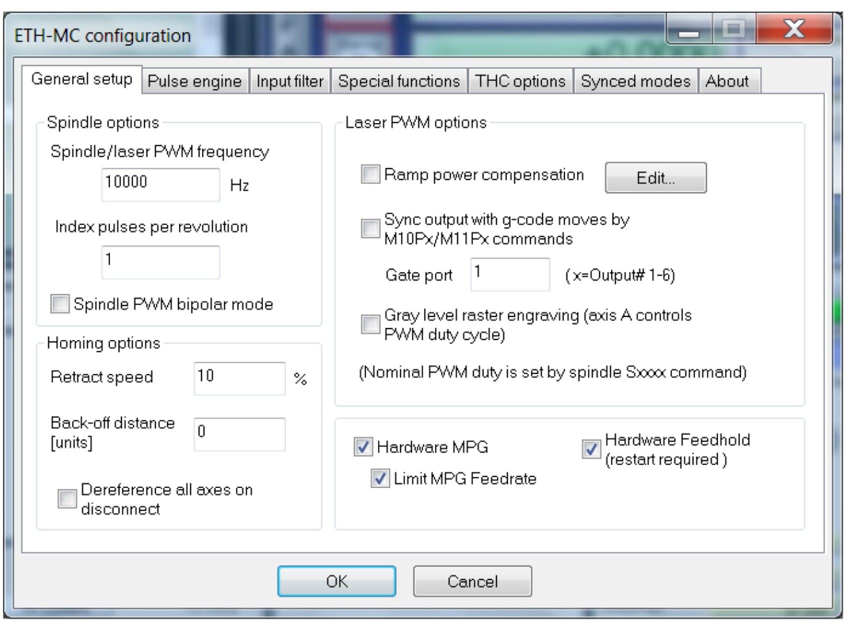

Figure 1.12 General setup tab

Spindle options

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 of 10-200000 Hz. Output pin for this purpose is selected via axis line in Motor Outputs window (Figure 1.11). 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.

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.

Spindle PWM bipolar mode

This options enables to control not only the rotation speed but also direction of the rotation. It is used when required by the controlled hardware. Namely, when this option is turned on, rotation speed of 0 RPM corresponds to 50% PWM duty cycle. Maximum rotation speed contra-clockwise is obtained by 0%, and clockwise by 100% PWM duty cycle. Rotation direction is controlled normally using M3 and M4 commands, and rotation speed via Sxxxx command from G-code.

Homing options

Home retract speed

This is speed of retraction from a home switch given as a percentage of homing speed. 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.

Back-off distance [units]

After an axis referencing is finished it is possible to back off from the home switch for the given distance.

Dereference all axes on disconnect

This option should be turned on when it is desired to dereference all axes in case of error or loss of communication with the controller.

Other options

Hardware MPG

If this option is **turned on** ETH motion card 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 motion card reads MPG input, sends current position to Mach3, and Mach3 then, according to selected MPG mode (Velocity only, Multi-Step...), and generates appropriate commands for movements. These commands are then sent to ETH motion card 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.

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Limit MPG feedrate

If this option is turned on, speed limit given with parameter **MPG Feedrate** is obeyed in hardware MPG mode. This parameter is located on MPG/Jog window (Figure 1.17).

Hardware Feedhold

This option enables to choose whether the feedhold function should be performed by Mach3 or by the ETH-MC motion controller completely autonomously.

If Mach3 internal function is chosen (turned off option Hardware feedhold), then when Feedhold button is pressed during the work, Mach3 plans stopping and starts sending appropriate movement commands to the controller. Stopping is controlled but there is a delay of about 1s from the moment when Feedhold button is pressed to the actual execution of the function after all previously planned motion is consumed from the motion buffer.

Hardware feedhold enables instant, controlled (with slowdown) stopping. It works by gradually slowing down the whole feed (all axes) to a complete stop. To continue working it is needed to press Cycle start button and then feed is accelerated up to the normal speed. Nevertheless, during the pause it is not possible to perform other functions like Jog axis unless first the STOP button is pressed. **However, pressing the STOP button during the pause will lead to loss of all movement data currently present in the movement buffer.**

Nevertheless, work can be resumed from approximately the same position. Namely, ETH motion card will after the STOP button is pressed, present the line that was executing when break occurred as a current line of execution and set this line as next (SetNextLine). This means that when Cycle start button is pressed afterwards, execution of the G-code will resume from this program line and starting from the current axes positions.

Changing this options requires restarting Mach3 application so that new setting comes to be in effect.

Laser PWM options

Ramp power compensation

Laser power compensation 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, M10px, M11px

This option 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, 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 raster pictures engraving and 8-bit grayscale palette is supported, i.e. 256 shades of gray (from complete black to complete white). When this option is turned on, axis A is used to control laser power, namely commanded "movement" of A axis controls PWM output duty cycle.

G-code needs to be generated from the bitmap picture by using one of the software made for that purpose. More closely about this option and required Mach3 settings for laser raster picture engraving can be found in separate document (Laser raster engraving).

1.8.2 Pulse Engine tab

This dialog box (Figure 1.13) enables setting for every individual axis: output mode, maximum step signal frequency, and impulse width.

Axis output mode

It is possible to select one of the following modes of control pulses generation:

- **Step/Dir**, pulse on the first digital output (Step) executes one step and state on the second output (Dir) defines the direction of movement,
- **CW/CCW**, pulse on the first digital output (CW) causes movement in the clockwise direction, and pulse on the other output (CCW) causes movement in the opposite direction,
- **Quadrature**, encoder type output, A and B outputs feature phase shift of 90° like with incremental encoders.

Max step frequency [kHz]

Enables setting of the maximum frequency of the generated step output signals. This frequency should be set to the maximum value that is allowed by the controlled hardware (motor drivers etc.).

After changing this parameter it is required to restart Mach3 so that new settings comes into effect. Also it is needed after restart to check in MotorTuning if velocity for any axis is set to a higher value than that is possible by the new maximum frequency and correct the settings if needed.

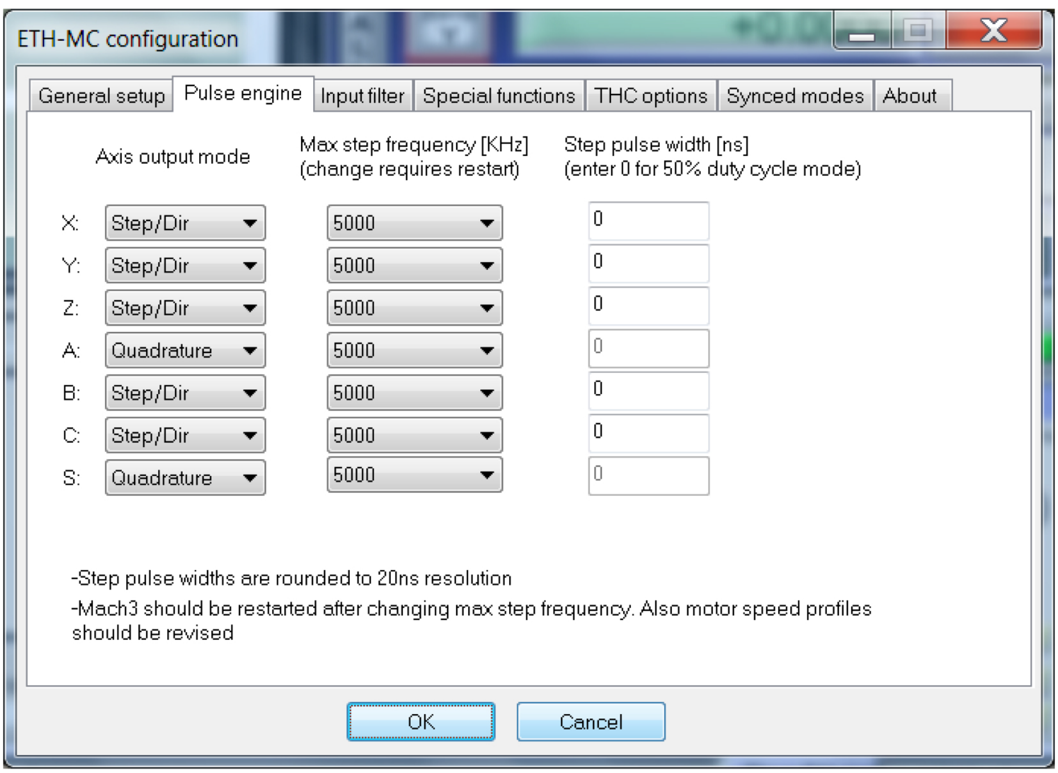


Figure 1.13 Pulse Engine tab

Step pulse width [ns]

Enables adjusting pulse width for the output step signals. It is possible to enter:

- value in nanoseconds [ns] or
- value 0 which activates 50% duty cycle mode.

Pulse width adjustment is used for Step/Dir and CW/CCW output modes.

1.8.3 Input Filter tab

Digital filtering (debouncing) is possible for all inputs. **Input filter** window enables detailed setup of the filtering. Debounce time is given in microseconds (µs). For example, if value 3000 is specified, that means that 3ms of stable signal state is needed on input for signal state to be changed from active to inactive or vice versa. If time 0 is entered for an input, filtering is turned off for that input. This is recommended when maximum reading speed is desired and it is certain that signal is clean, free of noise (e.g. optical encoder).

Debounce time can be specified (Figure 1.14) for:

- the group of pins by function or
- for every pin individually.

Dialog box content can be scrolled by using the slider on the right side or by using mouse wheel.

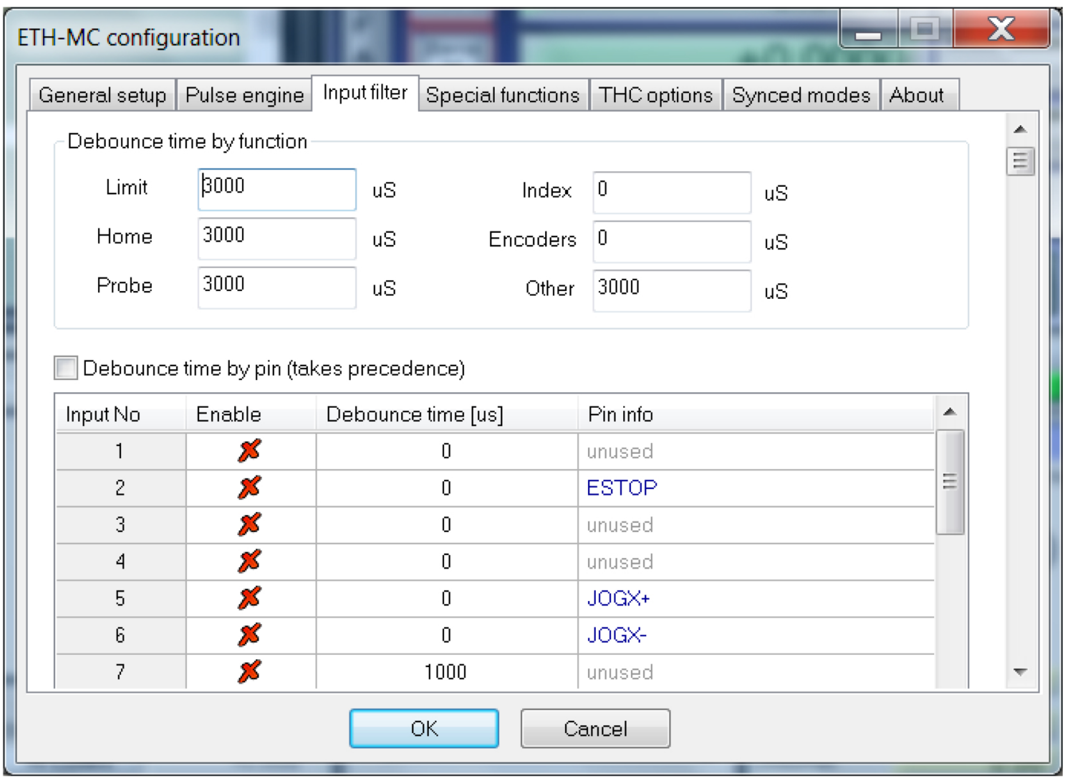


Figure 1.14 Input filter

In the bottom of the dialog box (Figure 1.15) is located group of fields for adjusting encoder digital filters. Filters can be adjusted to values in range from 1.04 to 6.25 MHz. If digital filter for encoder is turned on, debouncing for appropriate digital inputs that belong to that encoder will be disabled. In other words, encoder filter has priority over debouncing filters.

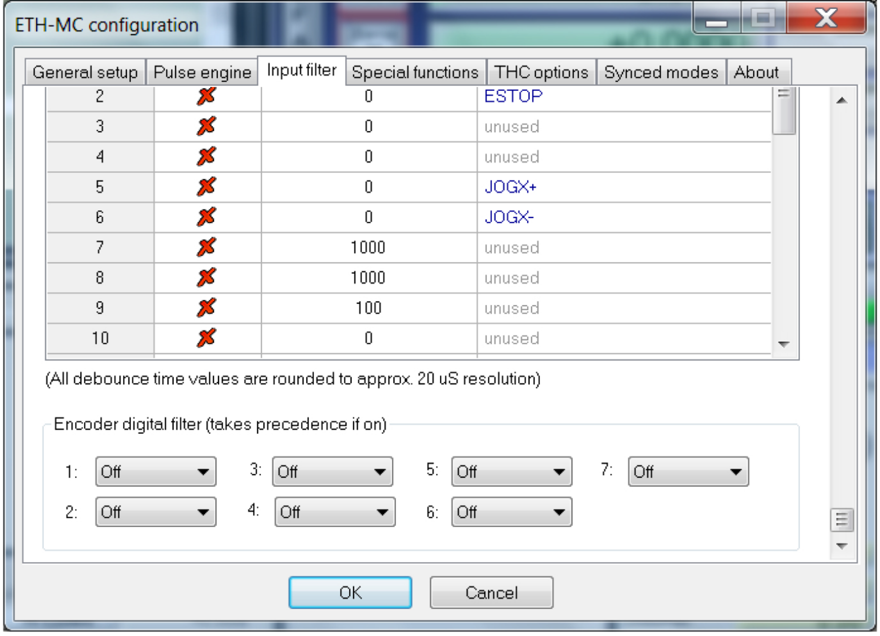


Figure 1.15 Encoder digital filters

1.8.4 Special functions tab

ETH motion card offers four analog inputs and also enables simultaneous reading of seven incremental encoders. Variety of functions can be assigned to these inputs and that can be configured using this dialog box (Figure 1.16).

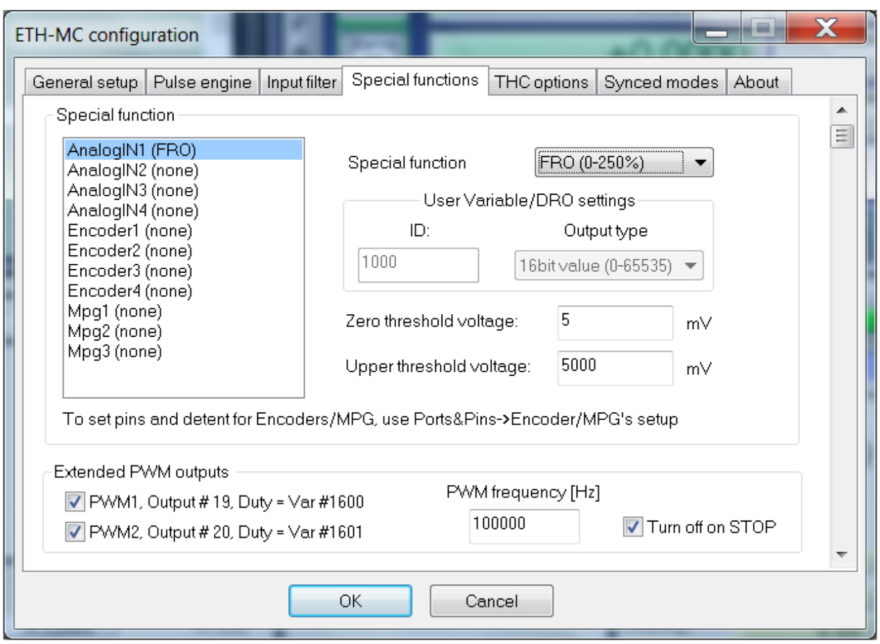


Figure 1.16 Analog input & encoders

Special function group

The area on the left side shows available signal sources and in parentheses assigned function (if there is any). For the selected input source, on the right sight are shown available parameters that can be set.

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

- **None –** signal is not used for special function.

- **FRO 0–250%** - feedrate override control.
- **SRO 0–250%** - spindle rate override control.
- **Set user variable –** read value is transferred to the specified inter Mach3 variable so that it can be used for example from a macro script or similar. **ID** represents identification (address) of the variable. It is possible to choose output type: 16-bit value (0-65535) or percentage (0-100%).
  Values of these variables can be monitored by using Mach3 function **Operator/GCode Var Monitor**.
- **Set user DRO** – similar to the previous option, but in this case **ID** represents identification of the DRO field.
- **Shuttle control –** control execution speed of G-code program.

When encoder is used for a function, then the step for incrementing that function variable is adjusted by changing detent value for the encoder. Detent represents the number of pulses from encoder/MPG for one complete step.

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

Zero threshold voltage – Is used for adjusting voltage threshold in mV for analog inputs. Acquired value from the input that is equal or lower than threshold value is considered zero.

Upper threshold voltage – This field enables to specify the maximum voltage on analog input in mV (default value is 5000 mV). Acquired voltage value on the analog input higher or equal to this threshold corresponds to maximum value of the variable that is controlled.

This dialog box also enables adjusting the options for pendant operation (more detail in section **Error! Reference source not found.**).

Shuttle mode

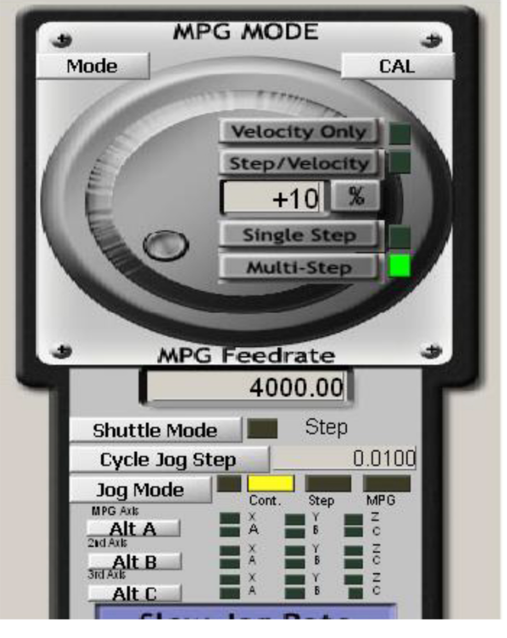


Figure 1.17

MPG or one of the analog inputs can be also used for Mach3 **shuttle mode**, (Figure 1.17) i.e. fine and real-time control of G-code program execution speed. This function is realized completely in hardware so that MPG rotation speed directly controls execution speed of the G-code program.

Shuttle mode button can also be used as fast FeedHold function even if there is no MPG in the system. In this case if Shuttle mode is activated during the execution of the g-code program, motion of all axes is gradually slowed down to complete stop.

When Shuttle mode is deactivated, motion of all axes is accelerated to resume to the original normal speed. This acceleration/deceleration can be adjusted by the field **Shuttle Accel.** which is located in the Mach3 **General Config** dialog.

Extended PWM outputs

Besides the standard PWM output that is used in Mach3 to control Spindle or laser, ETH motion card offers additional two PWM outputs that can be used for an arbitrary purpose.

PWM1 and PWM2 signals are generated on outputs Output#19 and Output#20 respectively. Port and pins for these pins should be set in **Config/Ports&pins/Output Signals** Mach3 window.

Pulse width for these PWM outputs can be set from G-code program by direct value assignment to the G-code variables #1600 and #1601. Value that is given in percent (0-100) does not have to be a whole number.

1.8.5 THC options tab

THC (torch height control) function is used for plasma cutting machines for continual regulation of the plasma torch height.

Beside the support for an external regulator, ETH motion card also has two integrated THC regulators (Figure 1.18) which can be utilized by connecting appropriate voltage sensor (THC Sensor) to one of the analog inputs of the ETH motion card (Figure 1.16).

ETH motion card supports the following regulation types:

- External THC regulator,
- Internal THC Up/Down regulator and
- Internal THC PID regulator.

ETH motion card offers a large number of options that enable a top quality control such as:

- servo regulation loop (PID regulator),
- voltage sampling for automatic voltage adjustment,
- kerf detect,
- anti-plunge options,
- THC lock from G-code etc.

In more detail about THC operation mode and Mach3 adjustments related to this mode can be found in section 3.2 (advanced controller options).

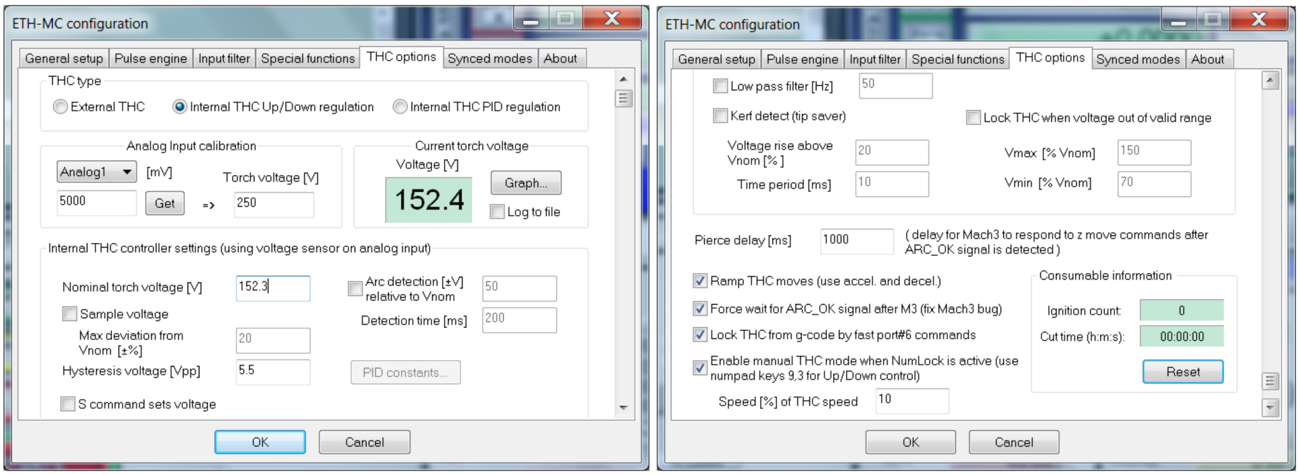


Figure 1.18 THC options

1.8.6 Synced modes tab

ETH motion card supports advanced real-time synchronized motion (Figure 1.19).

Namely, for some processing operation (such as threading on lathe or tapping into the holes) motion of some axes has to be precisely synchronized to a master axis, e.g. spindle axis that can freely rotate and during the work it can change rotation speed and even rotation direction. This master axis that is the reference for synchronization, must have installed incremental encoder that is used as a current position sensor.

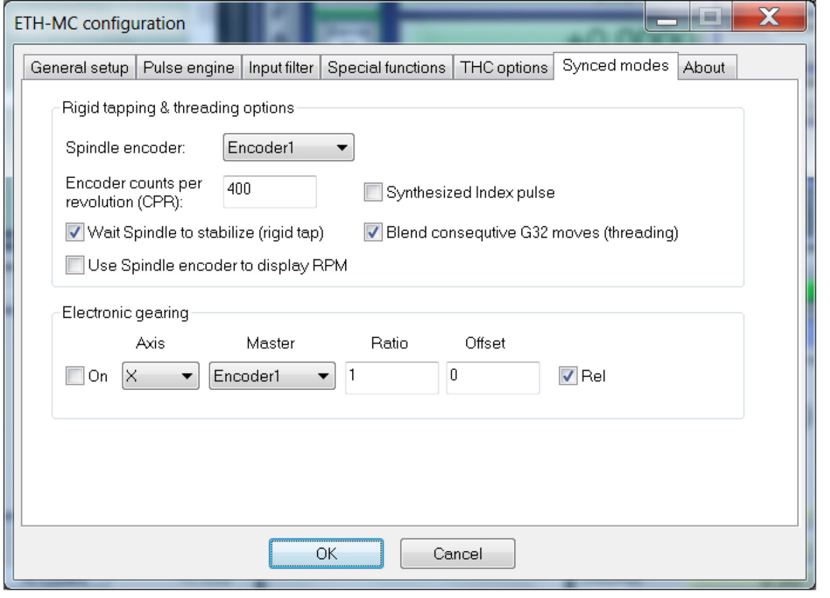


Figure 1.19

For **thread cutting** (functions G32, G76) ETH motion card has much improved algorithm in comparison to the standard Mach function. ETH-MC uses its own, autonomously generated linear motion that follows spindle rotation and as a feedback it uses an incremental encoder.

Rigid tapping is the function that Mach3 originally does not offer (does not support related G-code command). ETH motion card however enables also this advanced function and it is done by calling the appropriate macro.

Electronic gearing enables for one axis movement to be tied to another axis that has encoder as position feedback. Transfer ratio can be adjusted to an arbitrary number.

1.9 Status window

Status window (Figure 1.20) shows the current state of input and output pins of the ETH motion card. Also, on the left side position for all 6 axis is shown, in the middle area different controller statuses and on the right the current state of analog inputs and encoder positions are shown. Status window can "float" above other windows and does not prevent normal usage of Mach3 controls.

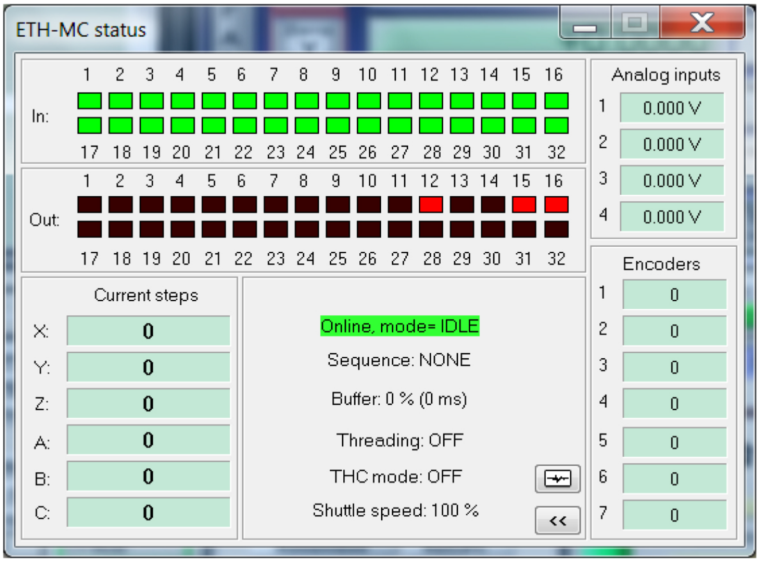


Figure 1.20 ETH-MC status window

1.10 ETH motion card wiring and input/output connectors pinout

For operation of ETH motion card it is needed to provide power supply with voltage in range from 8 to 25VDC (Figure 1.21). Current consumption of ETH motion card depends on supply voltage and also on the current draw of connected peripherals and can be up to 2A. Typically in most cases current draw will be less than 500mA.

For example, if power supply has voltage of 24 VDC, ETH motion card alone has current draw of about 100 mA.

Communication with PC computer is done via network (Ethernet) cable. More about the connection with computer can be found in section 1.4.2.

Peripherals can be connected to the ETH motion card using the connectors Con.3, Con.4, Con.5 and Con.6 (Figure 1.21).

Pinouts for connectors Con.3, Con.4, Con.5 and Con.6 (Figure 1.22) are given in tables 1.1, 1.2, 1.3 and 1.4.

General purpose digital inputs are marked with labels from IN1 to IN32 and are all of Schmitt trigger type, with voltage level of 5V. All inputs have 4k7 pull-up resistor.

General purpose digital outputs are marked with labels from O1 to O32. All digital outputs have TTL voltage levels.

Analog inputs are marked with labels from AN-IN1 to AN-IN4.

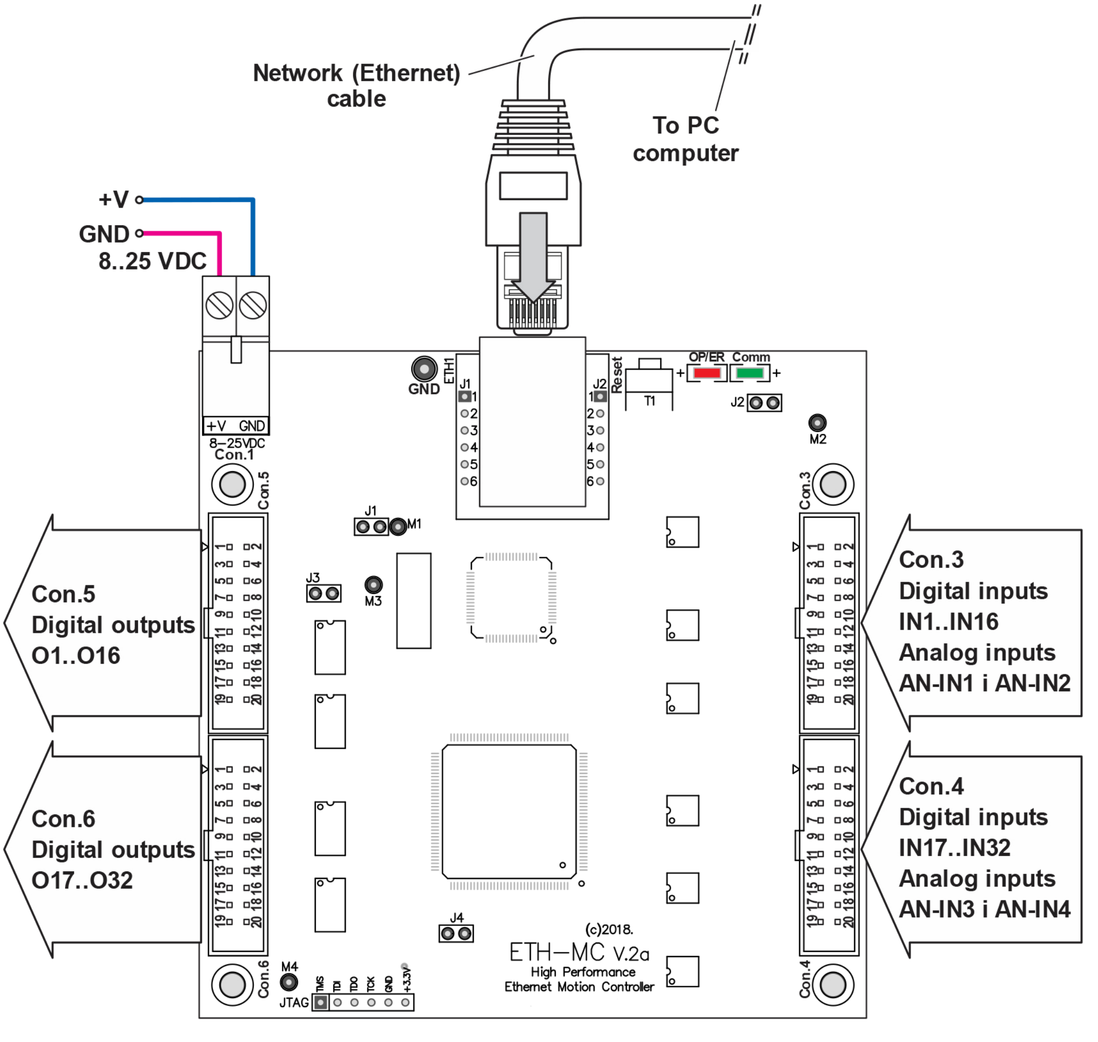


Figure 1.21 Connecting the ETH motion card

Table 1.1 Pinout of the connector Con.3

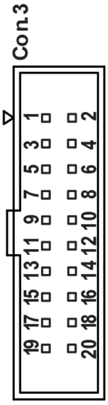
Pin	Name		Name	Pin
1	GND		+5 V	2
3	IN1		IN2	4
5	IN3		IN4	6
7	IN5		IN6	8
9	IN7		IN8	10
11	IN9		IN10	12
13	IN11		IN12	14
15	IN13		IN14	16
17	IN15		IN16	18
19	AN-IN1		AN-IN2	20

Table 1.2 Pinout of the connector Con.4

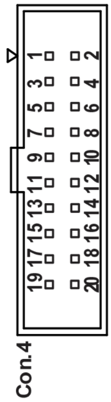
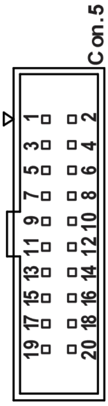
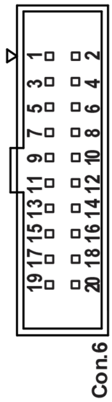
Pin	Name		Name	Pin
1	GND		+5 V	2
3	IN17		IN18	4
5	IN19		IN20	6
7	IN21		IN22	8
9	IN23		IN24	10
11	IN25		IN26	12
13	IN27		IN28	14
15	IN29		IN30	16
17	IN31		IN32	18
19	AN-IN3		AN-IN4	20

Table 1.3 Pinout of the connector Con.5

Pin	Name		Name	Pin
1	+V[1)]		+5 V	2
3	O1		O2	4
5	O3		O4	6
7	O5		O6	8
9	O7		O8	10
11	O9		O10	12
13	O11		O12	14
15	O13		O14	16
17	O15		O16	18
19	GND		+3,3 V	20

[1)] Supply voltage for ETH motion card

Table 1.4 Pinout of the connector Con.6

Pin	Name		Name	Pin
1	+V[1)]		+5 V	2
3	O17		O18	4
5	O19		O20	6
7	O21		O22	8
9	O23		O24	10
11	O25		O26	12
13	O27		O28	14
15	O29		O30	16
17	O31		O32	18
19	GND		+3,3 V	20

[1)] Supply voltage for ETH motion card

1.11 ETH motion card dimensions

Figure 1.22 shows outside dimensions and dimensions important for the installation of the ETH motion card.

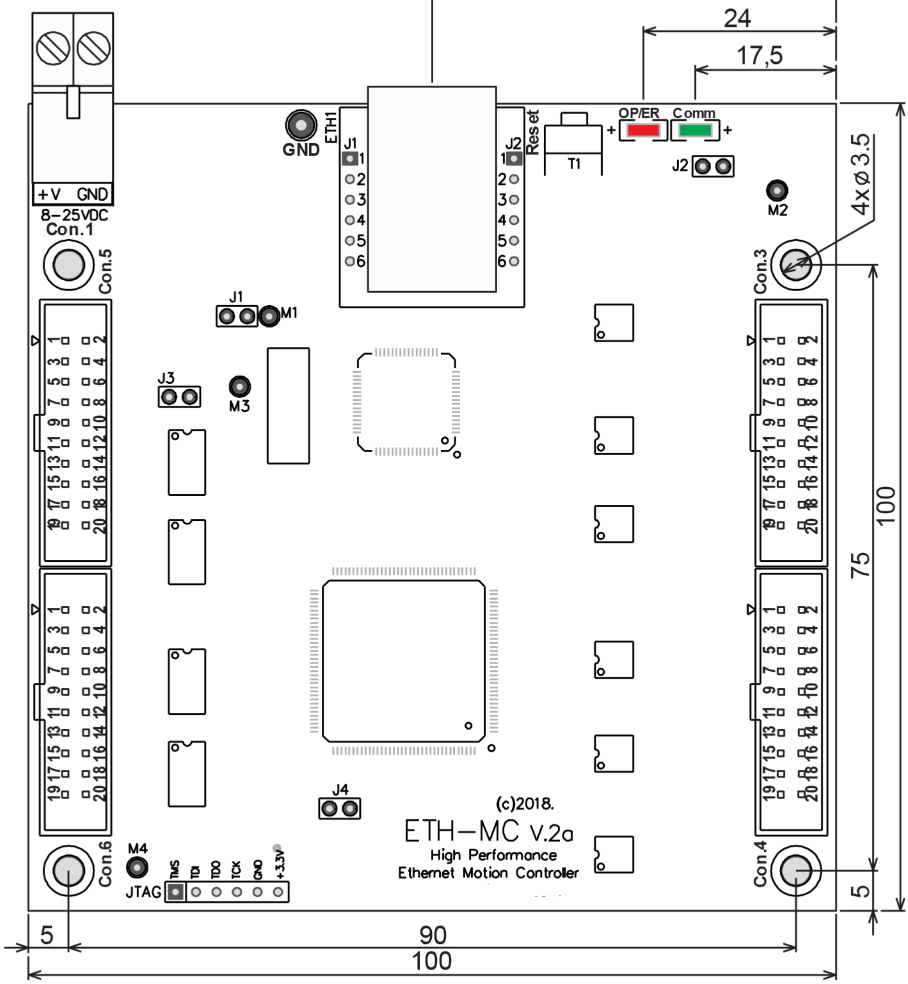


Figure 1.22 Outside dimensions of the ETH motion card

DOCUMENT REVISION:

- Ver. 1.0, March 2019., Initial preliminary version
- Ver. 1.1, June 2019., Updated part for ETH motion card