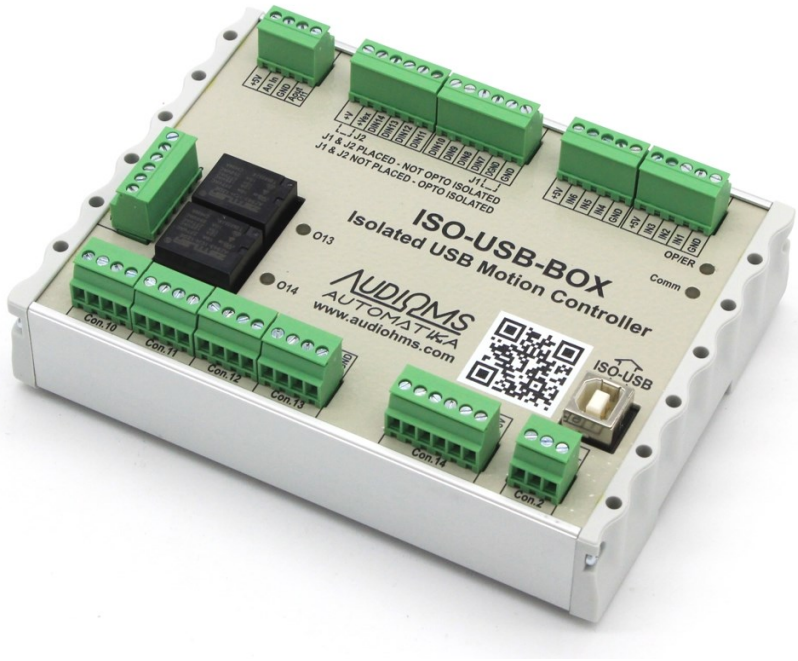
ISO-USB-BOX

Isolated USB Motion Controller



User's manual

AUDIOMS AUTOMATIKA

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1 Description

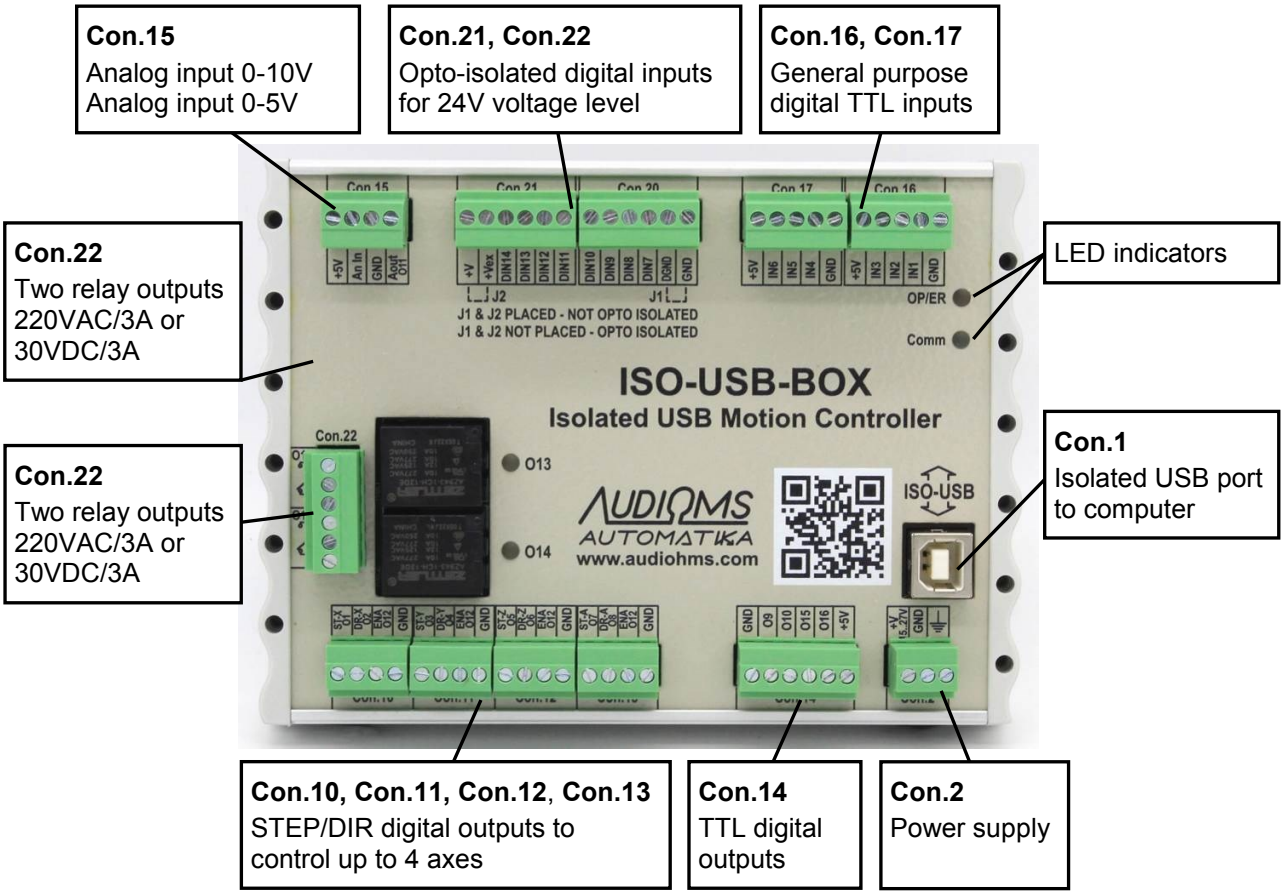


Figure 1.1 ISO-USB-BOX motion controller

ISO-USB-BOX is 6-axis motion controller 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. Motion controller features built in isolated USB port thus achieving galvanic isolation between the controller and PC computer that is used for control. This leads to significant reliability improvement of the control system in difficult industrial conditions.

Motion controller is enclosed in aluminum anodized case that can be mounted on standard holder (DIN rail) which enables easy installation of the motion controller into electric cabinet.

ISO-USB-BOX motion controller has:

- 16 digital outputs, including two relay outputs,
- 14 digital inputs, including 8 opto-isolated inputs for voltage levels of 24V and 6 TTL general purpose digital inputs,
- One analog output 0-10 V and
- One analog input 0-5 V.

Maximum step signal frequency is 250 kHz, optionally 125 kHz.

All inputs and outputs are accessible via detachable connectors, thus all peripherals can be easily connected to the ISO-USB-BOX motion controller.

Motion controller ISO-USB-BOX takes over all real-time tasks that require precision timing. Thus, computer CPU is less loaded, so that Mach3 now can work on less powerful desktop, laptop, and even tablet computers. Considering that controlling task does not need high performance computer, the price for complete control system can now by considerably reduced.

All digital inputs on ISO-USB-BOX motion controller are realized with Schmitt trigger digital input circuits, thereby significantly reducing the susceptibility to noise and interference.

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

2019. (Firmware v01.19 & Plugin v01.16) motion controllers ISO-USB-BOX and USB-MC use the same Mach3 plugin.

For connection of ISO-USB-BOX motion controller with PC, it is important to use high quality cable, as short as possible, preferably no longer that 1.5m. The motion controller is supplied with a high-quality 1m long USB cable with two ferrite cores.

NOTE: ISO-USB-BOX motion controller is NOT powered from USB port. For controller operation an external power supply 15-27 VDC / 250 mA is required.

1.1 Supported Mach3 functions

- all jogging modes
- spindle PWM out, 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 with deceleration for smooth stop
- 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 scale (8-bit) engraving
- shuttle mode, adjustable acceleration time
- detailed adjustment for debouncing of all input signals
- FRO, SRO or any DRO/Variable control using potentiometer or rotary encoder
- 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...) – **NEW**

1.2 Not supported

- 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.

2 Technical specifications

Function	Description
Communication with PC	Integrated isolated USB port. Data buffer of about 1 s for stable communication
Number of axes	6
Digital outputs	- 12 general purpose digital outputs - 1 PNP open collector output (for Enable line) - 1 digital output reserved for analog signal generation
Maximum current on digital outputs	32 mA
Relay outputs	2 relay outputs of NO type with capacity of 30 VDC / 3 A max. or 250 VDC / 3A max
Digital inputs	- 8 opto-isolated inputs for 24V signal levels - 6 Schmitt trigger general purpose digital inputs for TTL levels and with 4.7 kΩ pull-up resistors
Maximum STEP signal frequency	250 kHz (optional 125 kHz)
STEP pulse width	2 µs (optional 4 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	≤ 10k steps/sec
Number of analog outputs	1
Analog output range	0–5 V or 0–10 V
Number of analog inputs	1
Analog input range	0–5 V
Charge pump outputs	2
Charge pump frequency	12.5 kHz or 5 kHz
Power supply	15–27 VDC / 500 mA, recommended 1A
Mounting	to standard mounting holder - DIN rail
Dimensions	142 mm x 105 mm x 43 mm
Weight	~ 470 g

NOTE: Shown specifications are subject to change without prior notice

* PWM output signal can be assigned to the output pins 1-14 (O1-O14)

3 INSTALLATION

3.1 Driver installation

Connect ISO-USB-BOX motion controller to a free USB port on personal computer. In most cases, if Windows 7 or newer operating system is used, Windows will automatically find and install required drivers so that manual installation should not be needed. Otherwise, if Windows does not find drivers, it will ask for location on local computer to read it from. Drivers can be downloaded from www.audiohms.com site.

Note: ISO-USB-BOX motion controller does not require Mach3 LPT driver to be installed nor it uses this driver.

3.2 Plugin installation

Mach3 plugin contains integrated latest compatible version of firmware so in case that firmware has to be updated, this process is automatic and easy for user. Plugin can be downloaded from the www.audiohms.com site.

Note: Since the firmware version from June 2019. (Firmware v01.19 & Plugin v01.16) motion controllers ISO-USB-BOX and USB-MC use the same Mach3 plugin.

To install ISO-USB-BOX Mach3 plugin, copy supplied file **usbmc_drv.dll** to Mach3 plugins folder (usually "**c:\mach3\plugins**"). Then, start Mach3 and new plugin should be detected (Figure 3.1). Now choose **USB-MC-plugin** in displayed list of options. Also, optionally turn on option **Dont 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…**

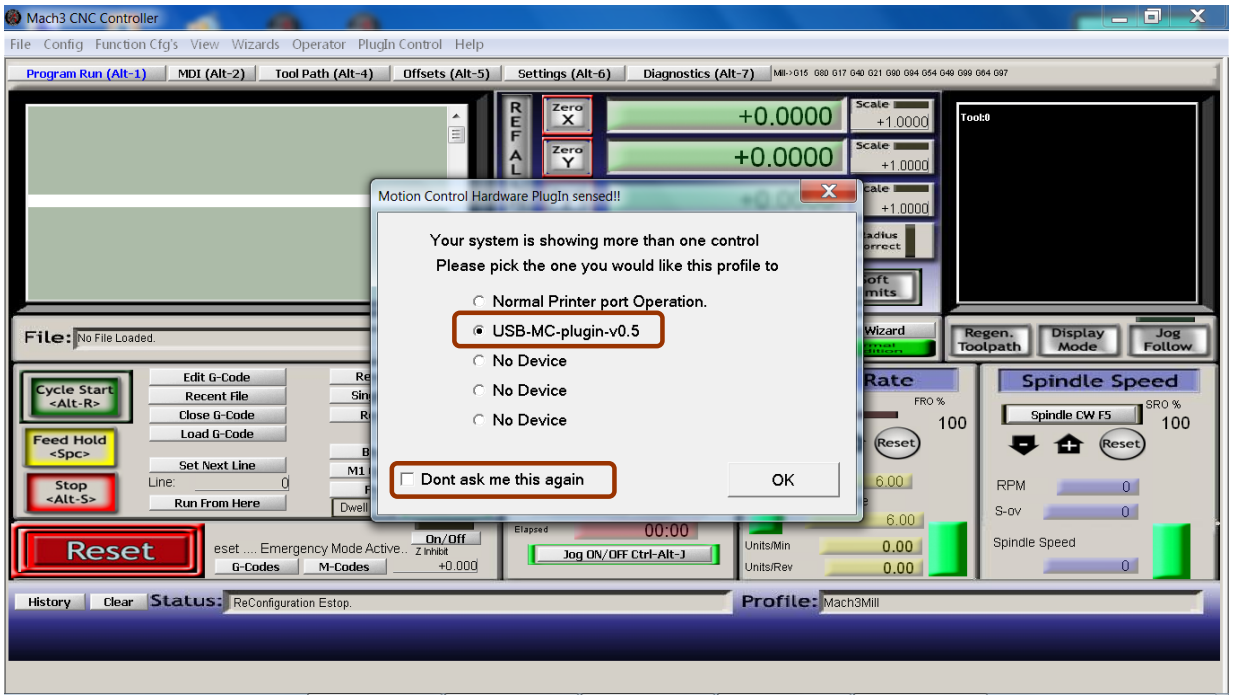


Figure 3.1 Plugin selection

Figure 3.2

On power-up, controller is in safe mode, that is, all outputs are in high impedance state (unconnected). Mode indicator LED on controller board is blinking slowly.

After clicking **RESET** button in Mach3, connection with controller is established and status like shown on Figure 3.2 is reported. Controller then enters normal operation mode, LED indicator on board stops blinking and lights continually.

If USB connection is lost for any reason, controller instantly enters safe mode. Then it is needed to investigate and eliminate cause of error and click RESET button to establish communication again.

Also, controller enters safe mode on all configuration changes and also on exiting Mach3 application.

3.3 Automatic firmware update

ISO-USB-BOX 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 3.3 will be shown. It is needed to click button **Yes** and wait for this process to be completed (Figure 3.4). Finally, result like on Figure 3.5 should be presented.

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

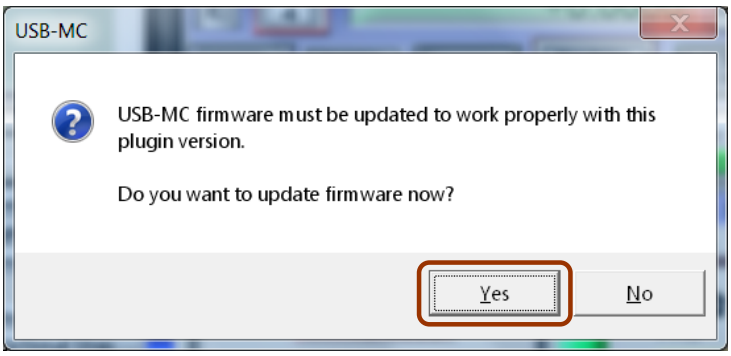


Figure 3.3

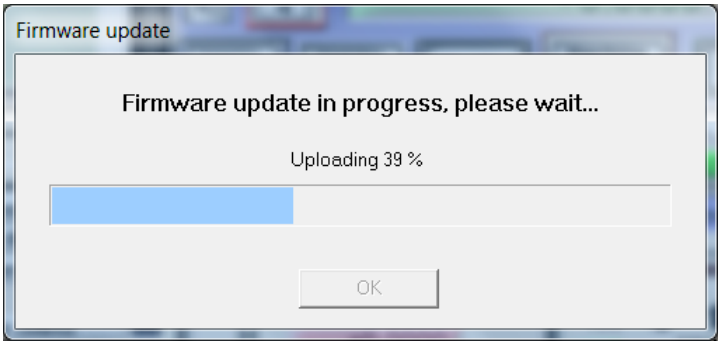


Figure 3.4

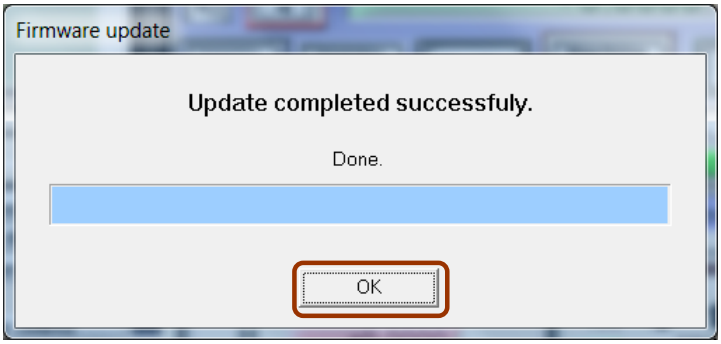


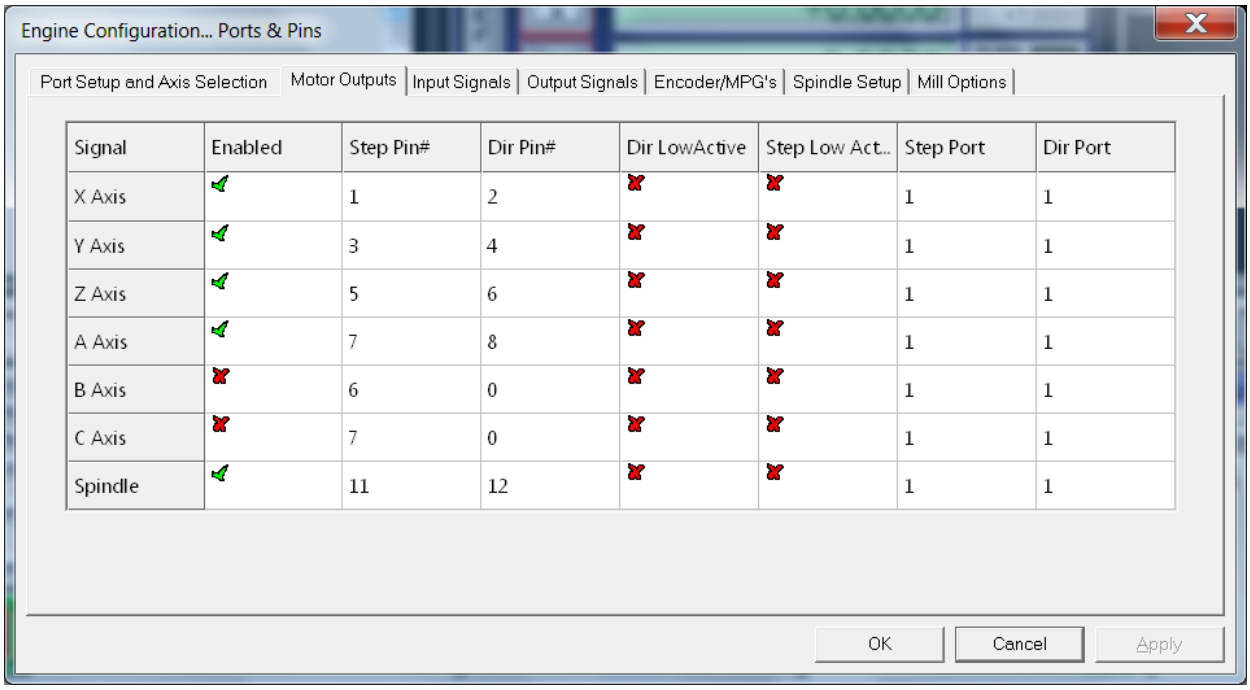
Figure 3.5

4 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 ISO-USB-BOX motion controller, can be adjusted via dialog box that is opened using menu option **Plugin Control/USB-MC Config….** Also, novelty is the status window that can be opened via **Plugin Control/USB-MC Status…**

4.1 Adjusting ports and pins via Ports & pins window

ISO-USB-BOX motion controller provides one digital input port with 14 pins and one digital output port with 16 pins. This pins can be remapped as desired, that is, can be assigned different functions that are needed for specific application (Figure 4.1).



Signal	Enabled	Step Pin#	Dir Pin#	Dir LowActive	Step Low Act..	Step Port	Dir Port
X Axis	✓	1	2	✗	✗	1	1
Y Axis	✓	3	4	✗	✗	1	1
Z Axis	✓	5	6	✗	✗	1	1
A Axis	✓	7	8	✗	✗	1	1
B Axis	✗	6	0	✗	✗	1	1
C Axis	✗	7	0	✗	✗	1	1
Spindle	✓	11	12	✗	✗	1	1

Figure 4.1 Ports and pins configuration

When using configuration dialogs like **Motor Outputs**, **Input Signals**, **Output Signals** etc. number 1 is always used for port number. Available pins on input port are numerated from 1 to 14. Similarly, output port pins are numerated from 1 to 16. ISO-USB-BOX motion controller will ignore any port number different from 1 and any pin number that is out of available range.

5 USB-MC configuration dialog

ISO-USB-BOX motion controller use the same configuration dialog as USB-MC motion controller. This dialog can be opened using menu option **Plugin Control/USB-MC Config…** (Figure 5.1).

5.1 General setup tab (Figure 5.1)

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.

IMPORTANT NOTE: Only output pins 1-14 can be used for PWM output (and not pins 15 and 16).

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.

5.1.2 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.

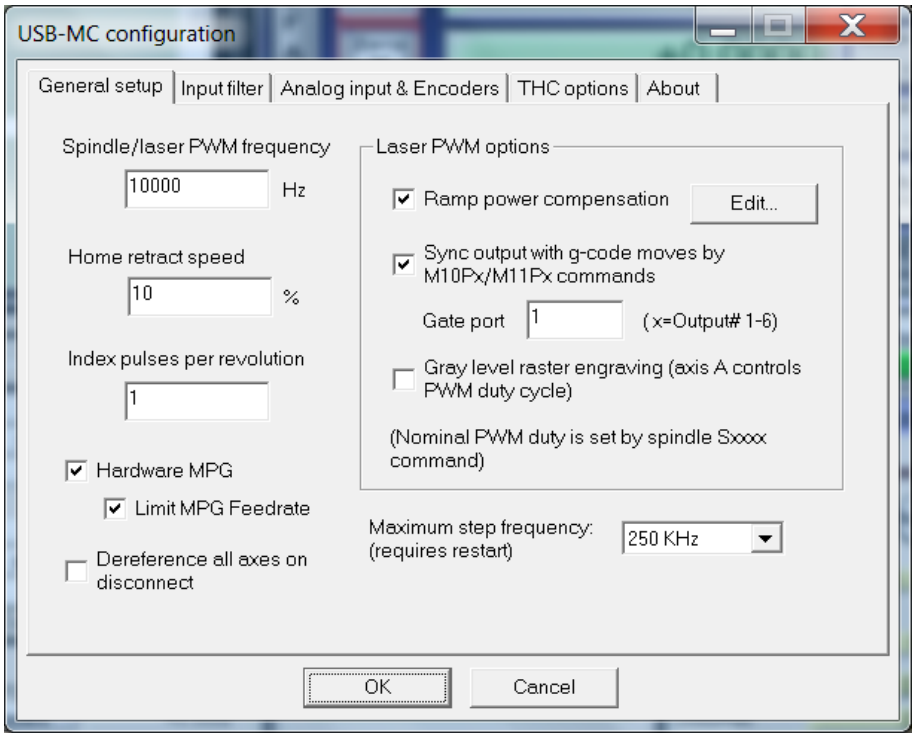


Figure 5.1 General setup

5.1.3 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).

5.1.4 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).

5.1.5 Maximum step frequency

Enables setting of maximum frequency for the generated step signals (Figure 5.1). Lower speed (125kHz, 4µs pulse width) is used in case when drivers/controllers that are being controlled are not fast enough for impulse width of 2µs that is required when using full speed (250kHz).

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.

5.1.6 Hardware MPG

If this option is turned on (Figure 5.1) ISO-USB-BOX 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 ISO-USB-BOX motion controller 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 ISO-USB-BOX 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).

5.1.7 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, M10px, M11px

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).

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 3ms 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).

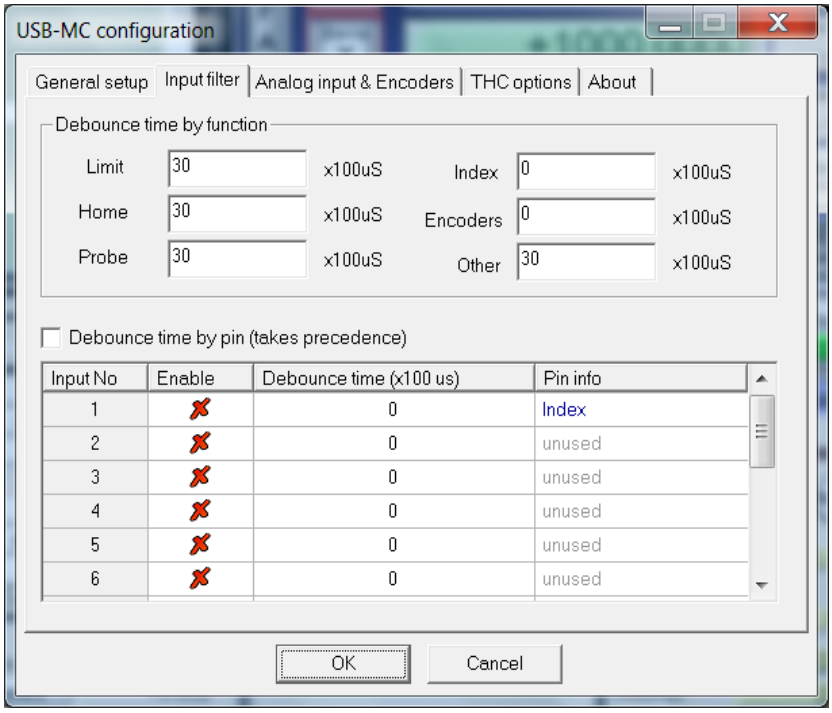


Figure 5.2 Input filter

5.3 Analog input & Encoders tab

ISO-USB-BOX motion controller offers one analog input, and in addition, enables simultaneous reading of two incremental encoders. Their functionality can be adjusted using this dialog (Figure 5.3).

5.3.1 Special function group

In the field on the left, 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 DROP** – similar to previous option, only in this case **ID** represents DROP field indicator.

When encoder is used, step increment for a variable is adjusted by setting detent value for the encoder used (see description in further text).

5.3.2 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.

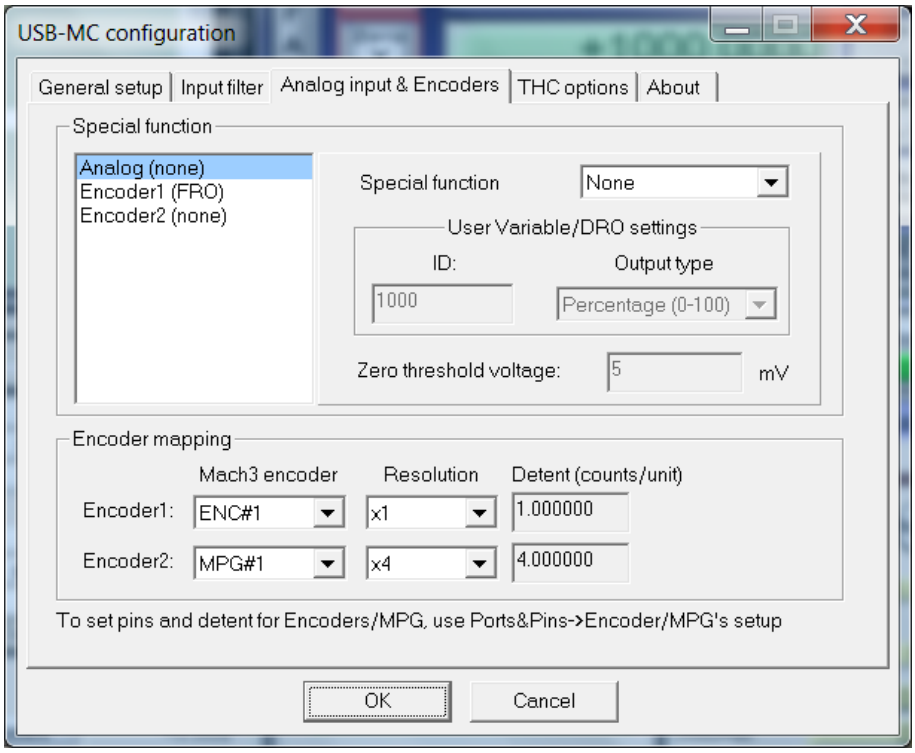


Figure 5.3 Analog input & encoders

5.3.3 Encoder mapping

ISO-USB-BOX motion controller supports simultaneous reading of two incremental encoders, including one from MPG device (Figure 5.3). Since Mach3 offers adjustments for total of seven encoder inputs, it is needed to map these two encoders to desired positions.

Encoder/MPG resolution

It is used to adjust incremental encoder resolution (Figure 5.3). Available options are x1 and x4. Option x4 off course gives best resolution and is appropriate e.g. for optical encoders. Option x1 gives basic encoder resolution, that is, one increment for one full cycle of state change on A and B lines. This option is appropriate for e.g. little mechanical, rotational encoders, for which we want for one detent to correspond to position change of 1 and not 4. Also, with mechanical encoders, there is possible effect of contacts bouncing which induces errors in position reading thus it is needed to set debouncing for encoder to an optimal value. The algorithm that is used for x1 reading option is fairly resistant to these problems so it is possible to set debouncing to zero when this option is used.

Detent (counts/unit)

Detent is number of pulses (increments) from encoder/MPG for one full movement step in Mach3. For MPG, this step is defined on MPG/Jog screen (Figure 6.1).
Detent value is, for better clarity, shown on this dialog, but 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 if it is needed to change direction of rotation.

Usually MPG is set to have detent value of 4 if encoder resolution x4 is chosen.

5.3.4 THC option 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, ISO-USB-BOX motion controller also contains internal THC regulator that is possible to utilize by connecting appropriate voltage sensor to the analog input of the ISO-USB-BOX motion controller.

More details about THC operation and Mach3 adjustments related to this mode can be found in the separate document (USB-MC THC operation).

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 ISO-USB-BOX 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.

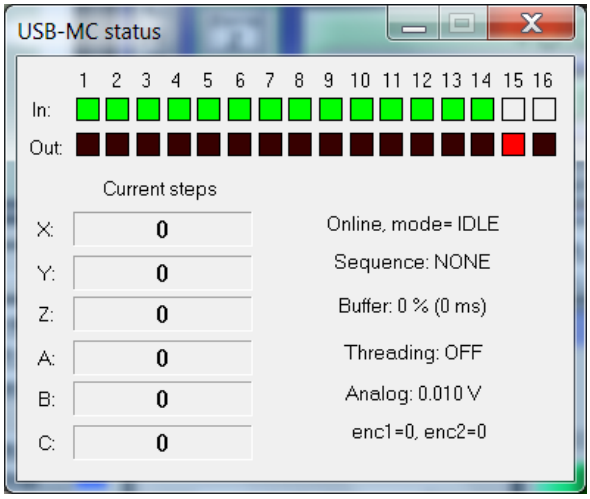


Figure 7.1 ISO-USB-BOX status window

8 Connecting ISO-USB-BOX motion controller into CNC system

In the following is given description of wiring ISO-USB-BOX motion controller into CNC control system.

8.1 Connection with computer and power supply for the ISO-USB-BOX motion controller

For powering ISO-USB-BOX motion controller it is required to provide external power supply 15-27 VDC/500 mA (recommended 1A) (Figure 8.1). **ISO-USB-BOX motion controller is NOT powered from USB port.**

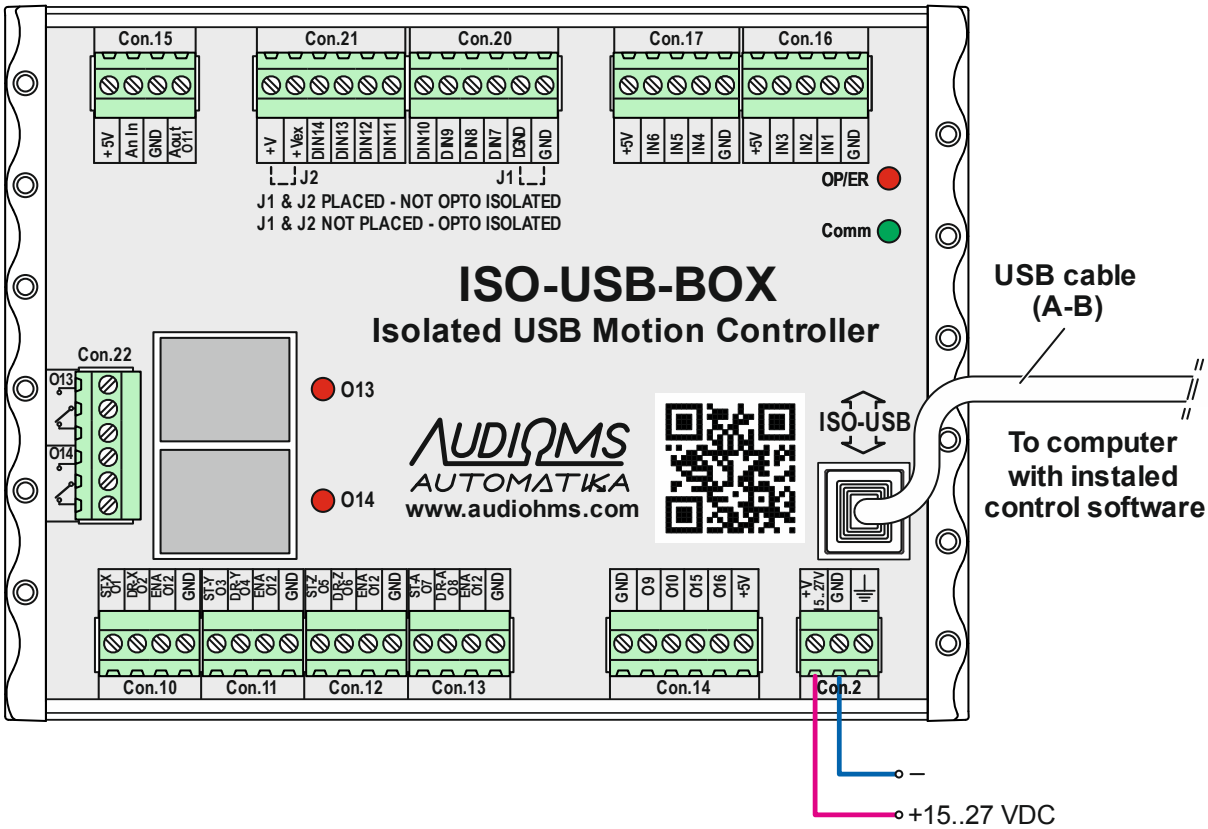


Figure 8.1 Connection with computer and connecting power supply to ISO-USB-BOX motion controller

For connecting ISO-USB-BOX motion controller to a computer type A-B USB cable is used (Figure 8.1).
A quality USB cable should be used, if possible no longer than 1.5 m. Usage of USB cable with ferrite noise suppression chokes is recommended (Figure 8.2). **The motion controller is supplied with a high-quality 1m long USB cable with two ferrite chokes.**

Figure 8.2 Type A-B USB cable with ferrite chokes

8.2 Connecting stepper motor drives to ISO-USB-BOX motion controller

ISO-USB-BOX can accept connection of up to 6 step motor drivers. Figure 8.3 shows recommended wiring principle for STEP/DIR/ENABLE command lines to four microstep stepper motor drivers MST-107.

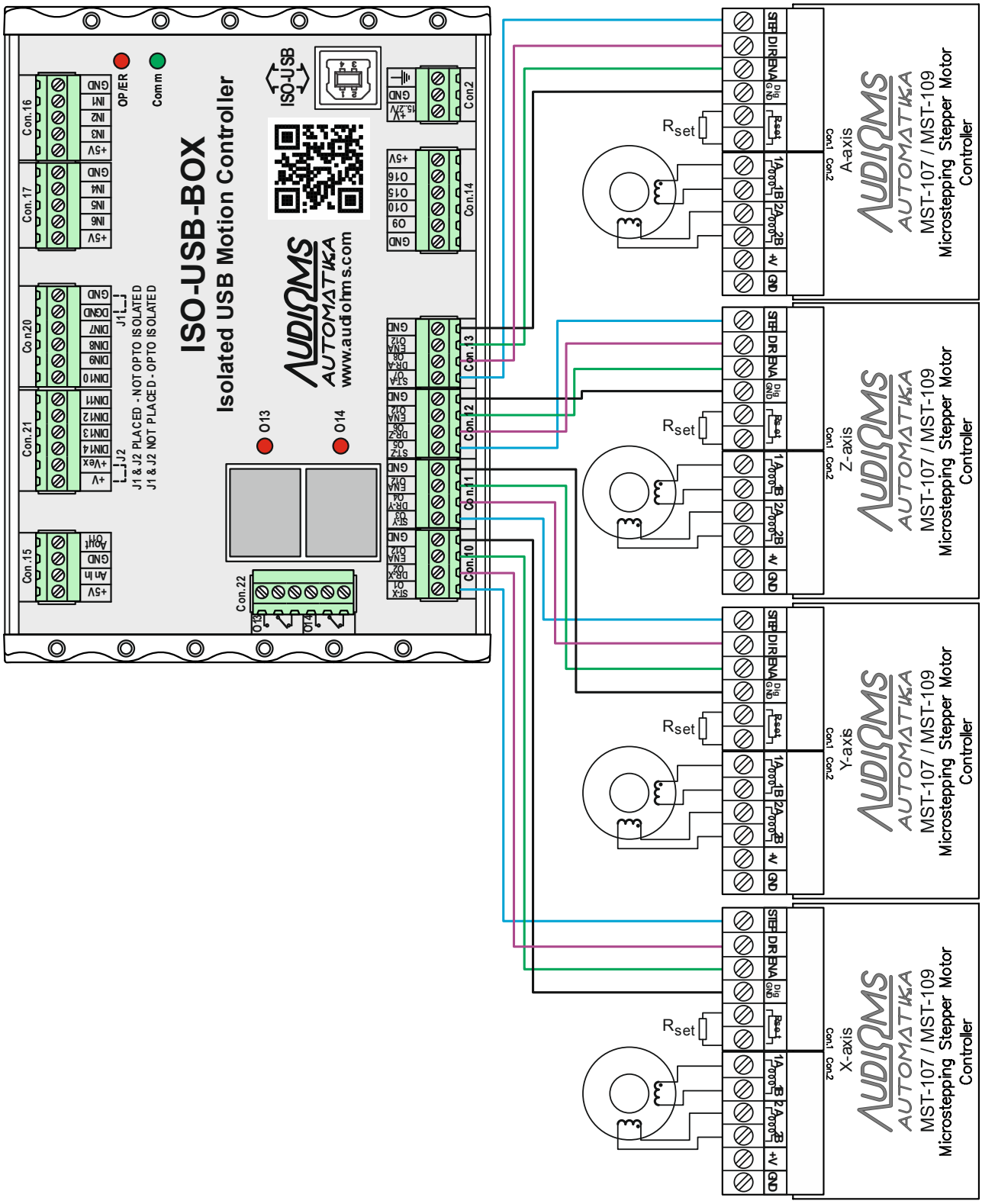


Figure 8.3 Connecting 4 microstep drivers MST-107 to ISO-USB-BOX motion controller

Optionally, ISO-USB-BOX motion controller can accept additional two axes that is two more microstep motor drivers MST-107 (Figure 8.4).

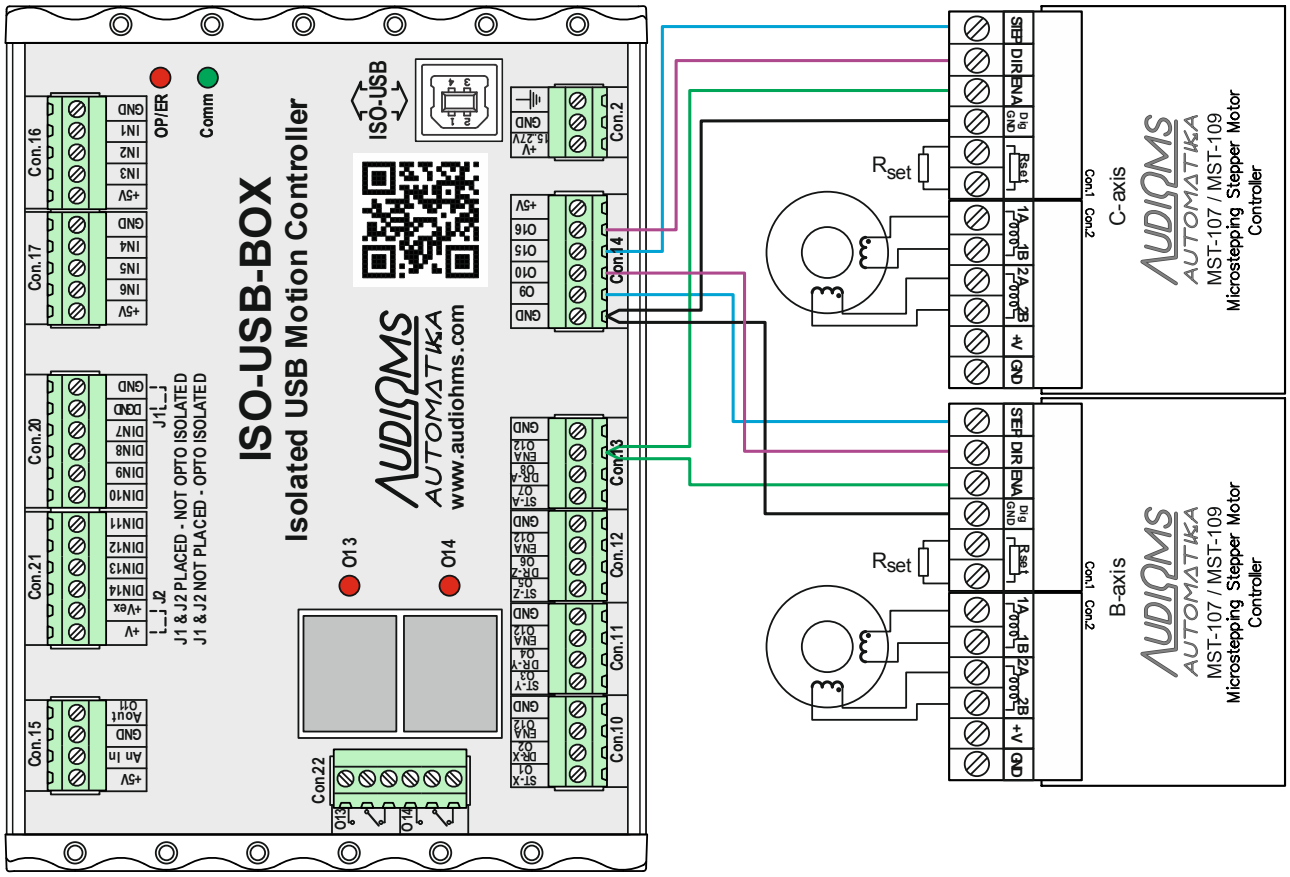


Figure 8.4 Optional connection of fifth and sixth axis

Common Enable output is available on connectors Con.10, Con.11, Con.12 and Con.13 and is labeled ENA O12. Enable output is realized using PNP transistor wired in open collector configuration and is activated by output O12. Maximum current for Enable output is 150 mA.

Table 8.1 gives list of recommended outputs for generation of STEP and DIR signals for controlling up to 6 axes. Output O12 is reserved for Enable signal.

Table 8.1 List of recommended outputs for controlling 6 axis

Axis	STEP (Output)	DIR (Output)	ENA (Output)
X	O1	O2	O12
Y	O3	O4	
Z	O5	O6	
A	O7	O8	
B	O9	O10	
C	O15	O16	

For powering ISO-USB-BOX motion controller and up to 4 microstep drivers MST-107 or MST-109 it is recommended to use power supply module with integrated motor break PSB-1 (Figure 8.5). More details about this power supply module and wiring instructions can be found in manual for this module.

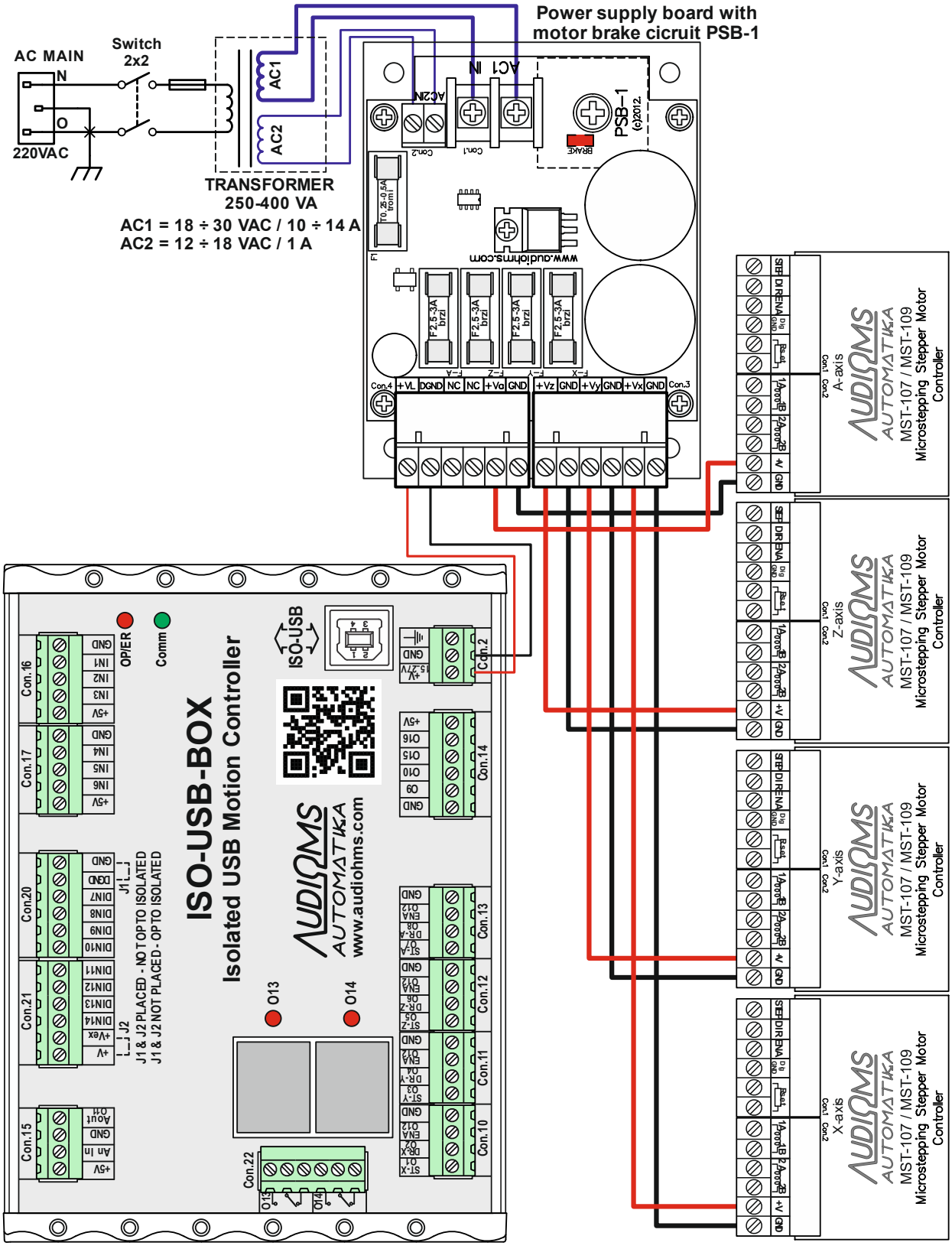


Figure 8.5

User can also provide his own power supply. In that case Figure 8.6 shows recommended scheme for connecting power supply for ISO-USB-BOX motion controller and up to 4 drivers MST-107. Power supply must provide two independent sources, one for powering ISO-USB-BOX motion controller (15–27 VDC / 500 mA) and the other one for powering stepper motor drivers MST-107 in range 20-40 VDC or in range from 20-55VDC for stepper motor drivers MST-109 (current for this power source depends of stepper motors used – review manual for microstep drivers MST-107 / MST-109).

On each +V power supply line, for each driver MST-107 or MST-109, it is recommended to use fast blow fuses that protect drivers in case of overload situation.

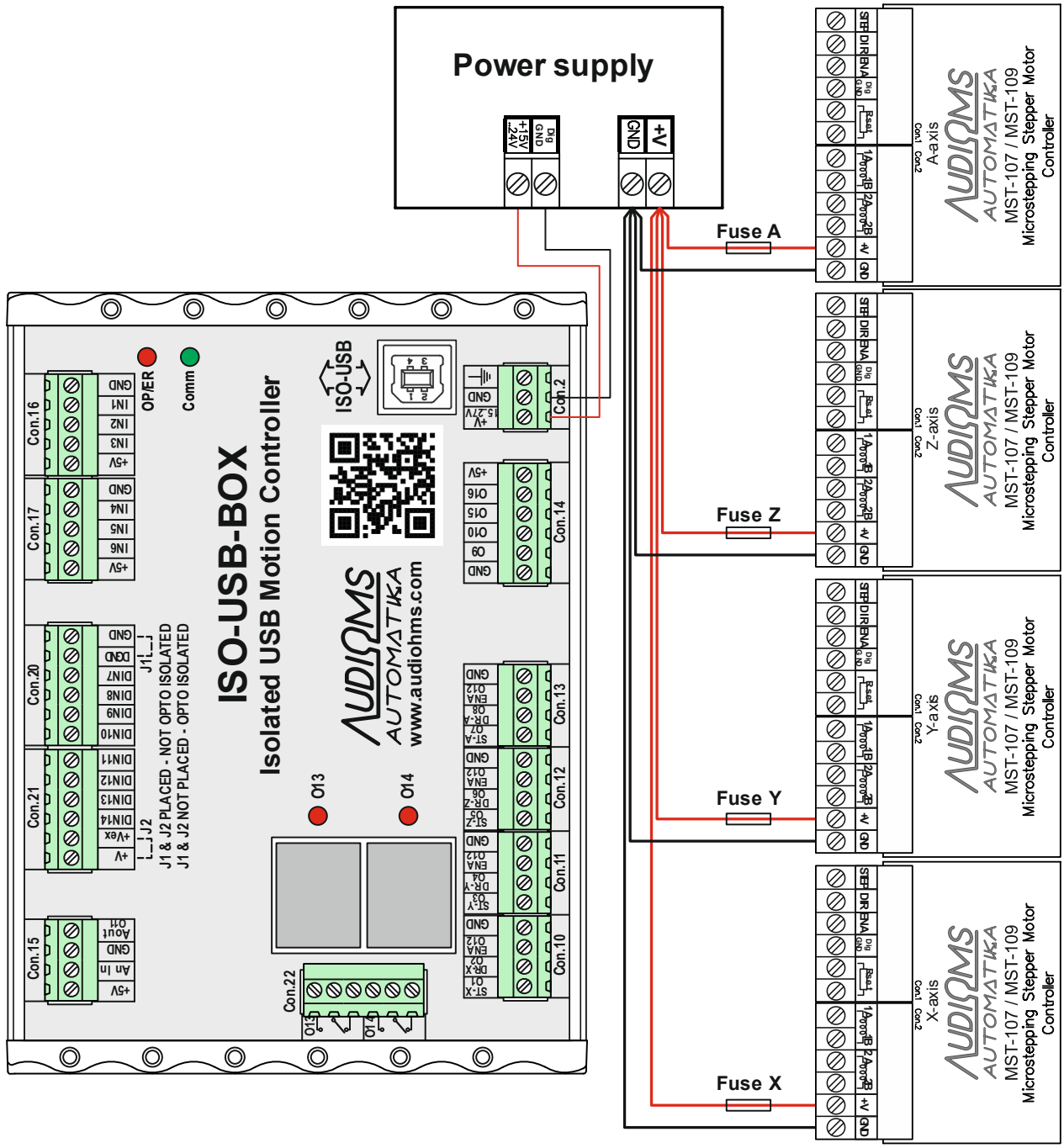


Figure 8.6

8.3 Connecting drives from other manufacturers to ISO-USB-BOX motion controller

Figure 8.7 shows recommended wiring scheme for connecting 4 drives from other manufacturers to ISO-USB-BOX motion controller. Used digital outputs on ISO-USB-BOX motion controllers are of TTL type. Drives from other manufacturers, regardless whether they are intended for stepper, DC servo or AC servo motors, usually have same or very similar input interface.

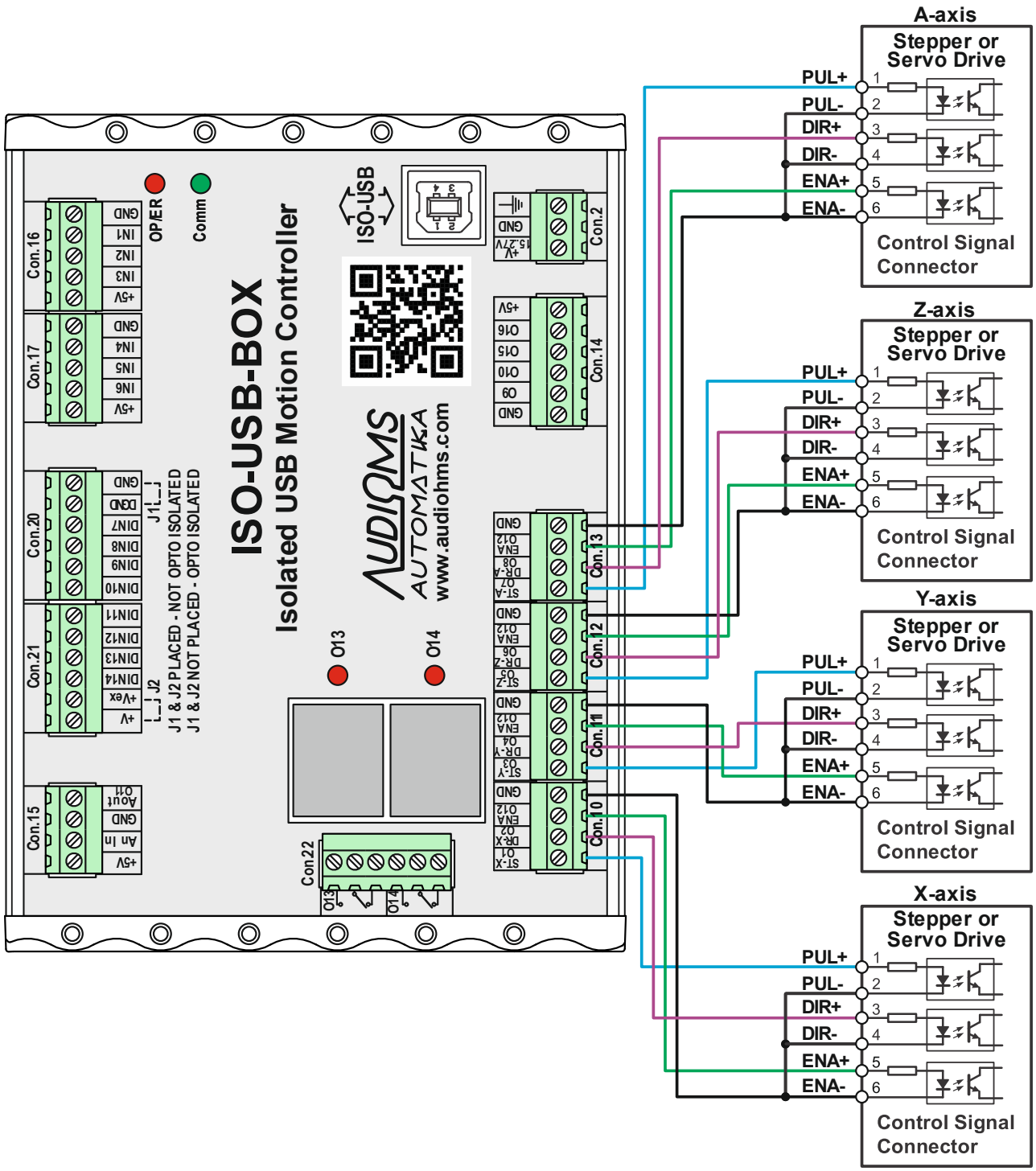


Figure 8.7

Optionally, it is possible to connect additional two axes i.e. additional two drives from other manufacturers to the ISO-USB-BOX motion controller (Figure 8.8).

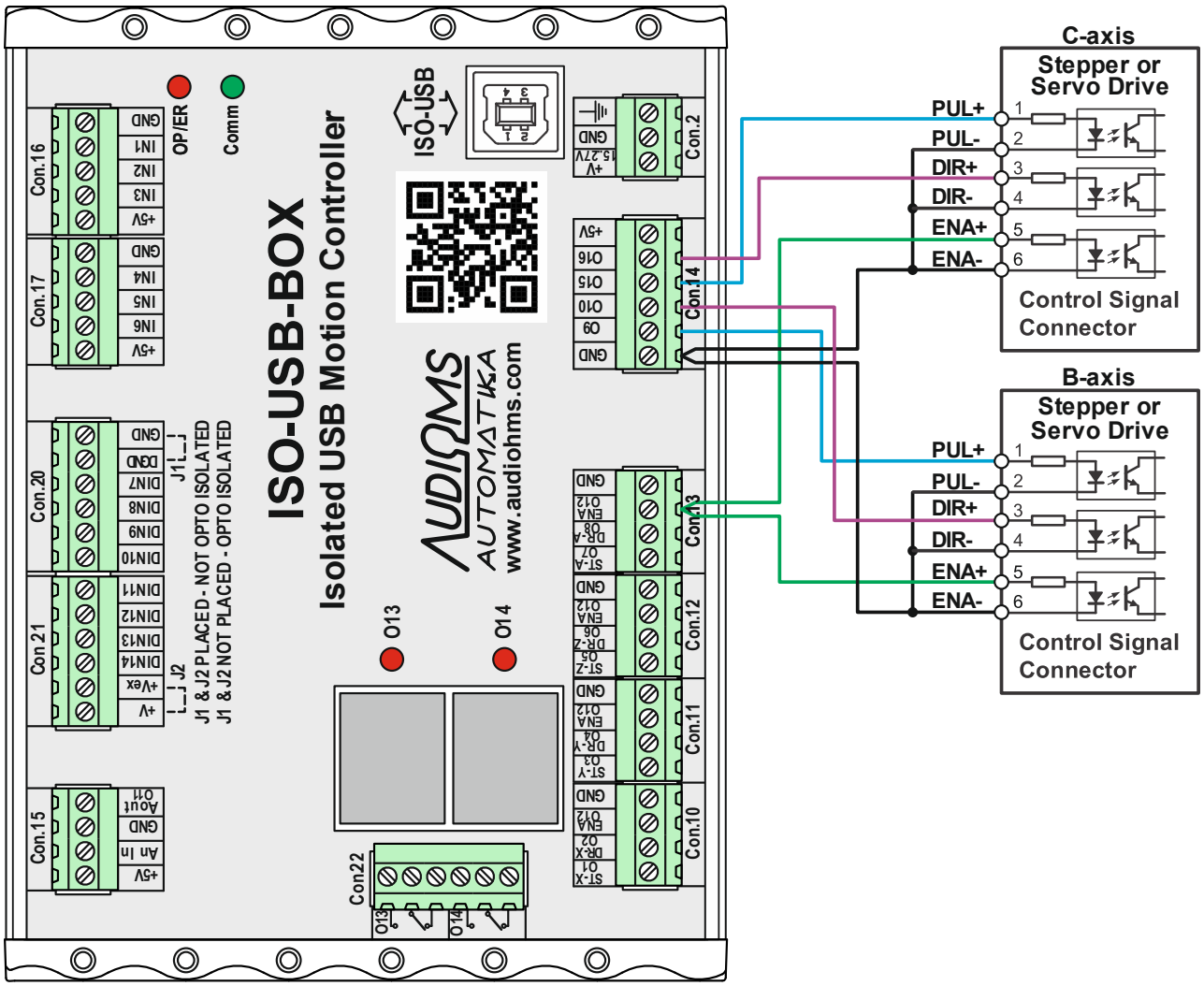


Figure 8.8

Table 8.1 lists recommended output choices for generation of STEP/DIR signals for controlling up to 6 axes. Output O12 is reserved for Enable signal.

Possible problems when connecting third-party drivers and suggestions for overcoming the problems.

- Drivers from other manufacturers often have relatively strong filters on the PUL (STEP) and DIR lines. In the event that the maximum frequency of STEP pulses on the ISO-USB-BOX motion controller is set to 250 kHz (with a STEP pulse width of 2 μs), it may happen that the third-party driver loses steps or does not detect STEP pulses at all. In that case, it is necessary to reduce the maximum frequency to 125 kHz in the ISO-USB-BOX (USB-MC) motion controller plugin, which also increases the STEP pulse width to 4 μs. **After changing the parameters, it is necessary to restart the control software in order for the settings to be activated.**

- Check if the third-party driver requires a falling or rising edge of the STEP control signal. Activate or deactivate the "**Step low active**" option in the control software as necessary.

- Some third-party drivers have inverted logic for the ENA (Enable) signal. The ISO-USB-BOX motion controller cannot provide the mentioned requirement and **in that case does not connect** the ENA+ and ENA- lines (Figure 8.1). **Then the drivers will always be active**.

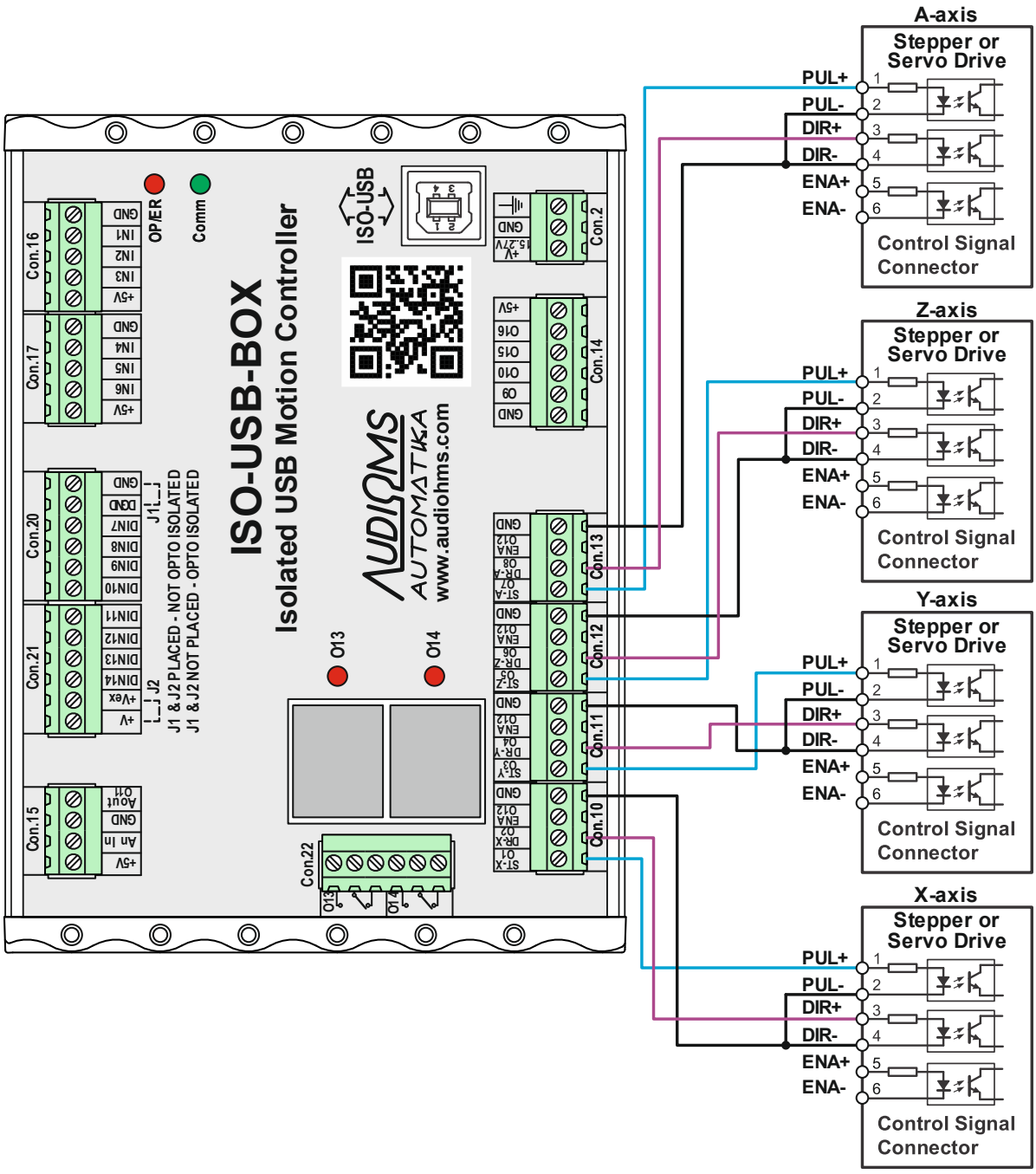


Figure 8.9 Connecting drivers from other manufacturers in case of inverted logic on the driver's ENA input

8.4 Connecting relay outputs

ISO-USB-BOX motion controller has integrated two relays with NO type contacts. Capacity for each relay is 30 VDC / 3 A max or 250 VDC / 3A max.

Figure 8.10 shows possible wiring scheme of relay outputs on ISO-USB-BOX motion controller. For currents that exceed 3A it is recommended to use external relays with higher nominal current or contactors and in that case these can be activated by relays on ISO-USB-BOX motion controller.

For activation of relay outputs digital outputs O13 and O14 are used and on ISO-USB-BOX motion controller there are indicators that show state of relay outputs.

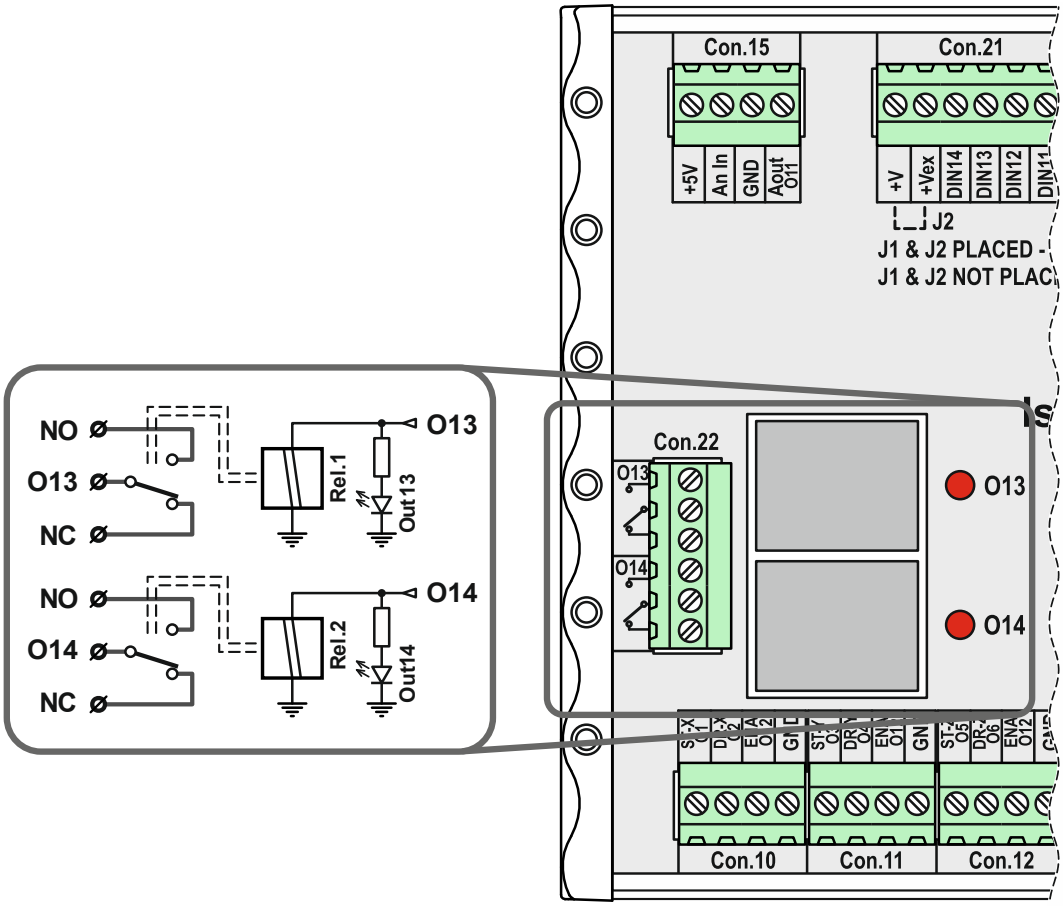


Figure 8.10 Relay outputs

8.5 Analog output on ISO-USB-BOX motion controller

Mach3 has the ability to generate a PWM (Pulse-width modulation) signal. PWM or pulse width modulation is a method of control where the frequency of the control signal does not change. What is changing is the signal / pause ratio, i.e. the signal width changes.

If an appropriate filter is placed on the TTL output on which the PWM signal is received, then the analog signal will be output at this filter. The voltage level of the analog signal depends on the signal / pause ratio. For example, if the signal width is 10% and the pause width is 90%, the analog output voltage will be 10% of the maximum voltage. This analog signal can be used as a control signal for regulating the spindle speed or for controlling one of the other peripherals on the machine.

ISO-USB-BOX motion controller has one analog output. Analog output Aout is available on connector Con. 15 (Figure 8.11). The control of the analog output Aout is done by generating a PWM signal on digital output O11.

Voltage level for analog output is factory preset to range 0-10 V. Optionally it is possible to set voltage level to range 0-5V (on special request).

NOTE: Negative output of analog output Aout (O11) is galvanically connected to the power supply ground of ISO-USB-BOX motion controller.

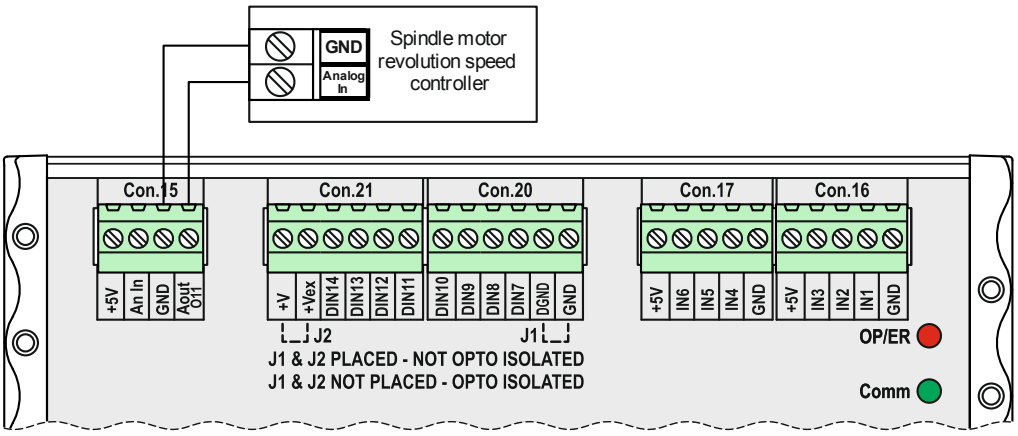


Figure 8.11 Analog output for controlling spindle motor revolution rate

8.6 Analog input on ISO-USB-BOX motion controller

ISO-USB-BOX motion controller has one analog input (An in) with range 0-5 V and it is available on the connector Con.15 (Figure 8.12).

Analog input offers the 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 8.12.a shows the recommended method for connecting potentiometer to the analog input An In, and Figure 8.12.b shows recommended way for connecting THC Sensor analog output to analog input An In. A detailed description of the Torch Height Control (THC) using ISO-USB-BOX is given in separate instruction manual.

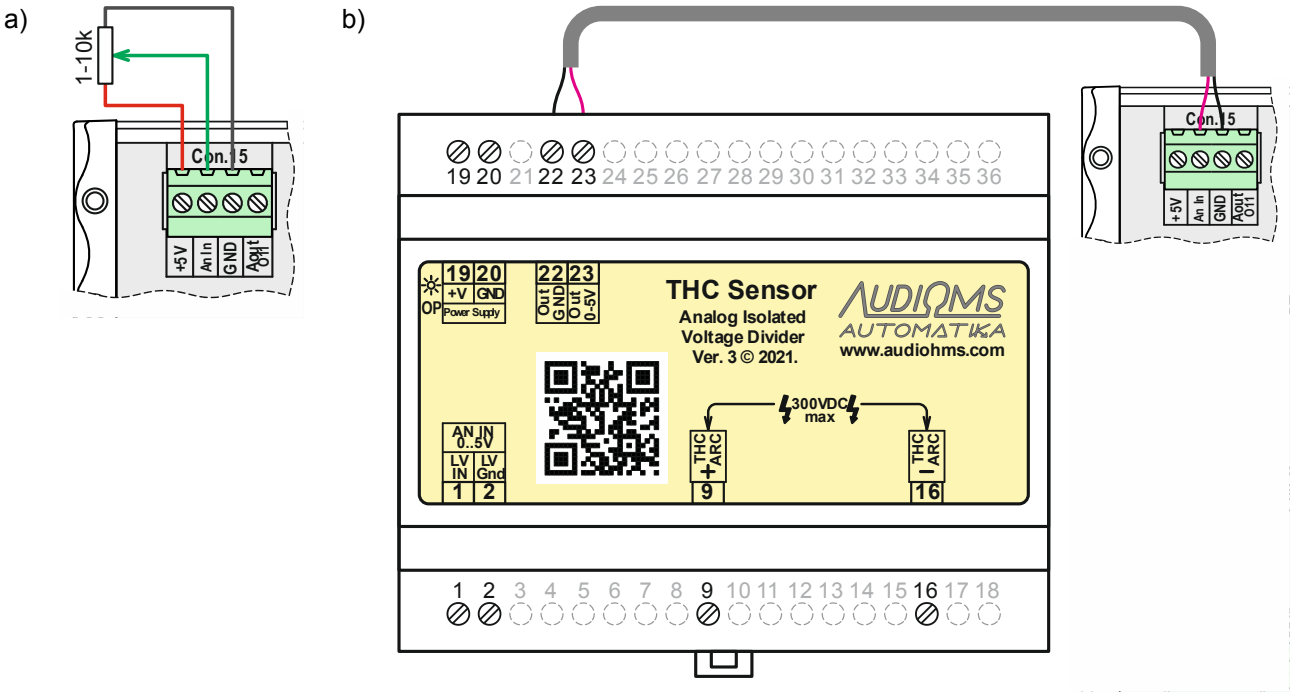


Figure 8.12 Connecting the source of analog signal to the analog input, a) using potentiometer and b) from THC sensor

8.7 Opto-isolated digital inputs

ISO-USB-BOX motion controller offers connection of signals to up to 8 digital inputs (DIN7-DIN14) of voltage level 24 VDC. These digital inputs are connected to connectors Con.20 and Con.21 (Figure 8.13). For level shifting the voltage levels from 24 VDC to 5 VDC optocouplers on-board are used.

NOTE: For the activation of digital inputs, for safety reasons it is recommended to use NC type of switches (Normally Closed).

There are two modes for wiring limit switches:

- non-isolated mode and
- opto-isolated mode.

In addition, Figure 8.13 shows the electric schematic of the input circuit for digital inputs DIN7-DIN14, as well as two modes for wiring limit switches (non-isolated mode and opto-isolated mode). Digital inputs DIN7-DIN14 has implemented passive low pass filter with 3.4 kHz cutoff frequency.

Digital inputs DIN7-DIN14 has common positive supply line (+Vex).

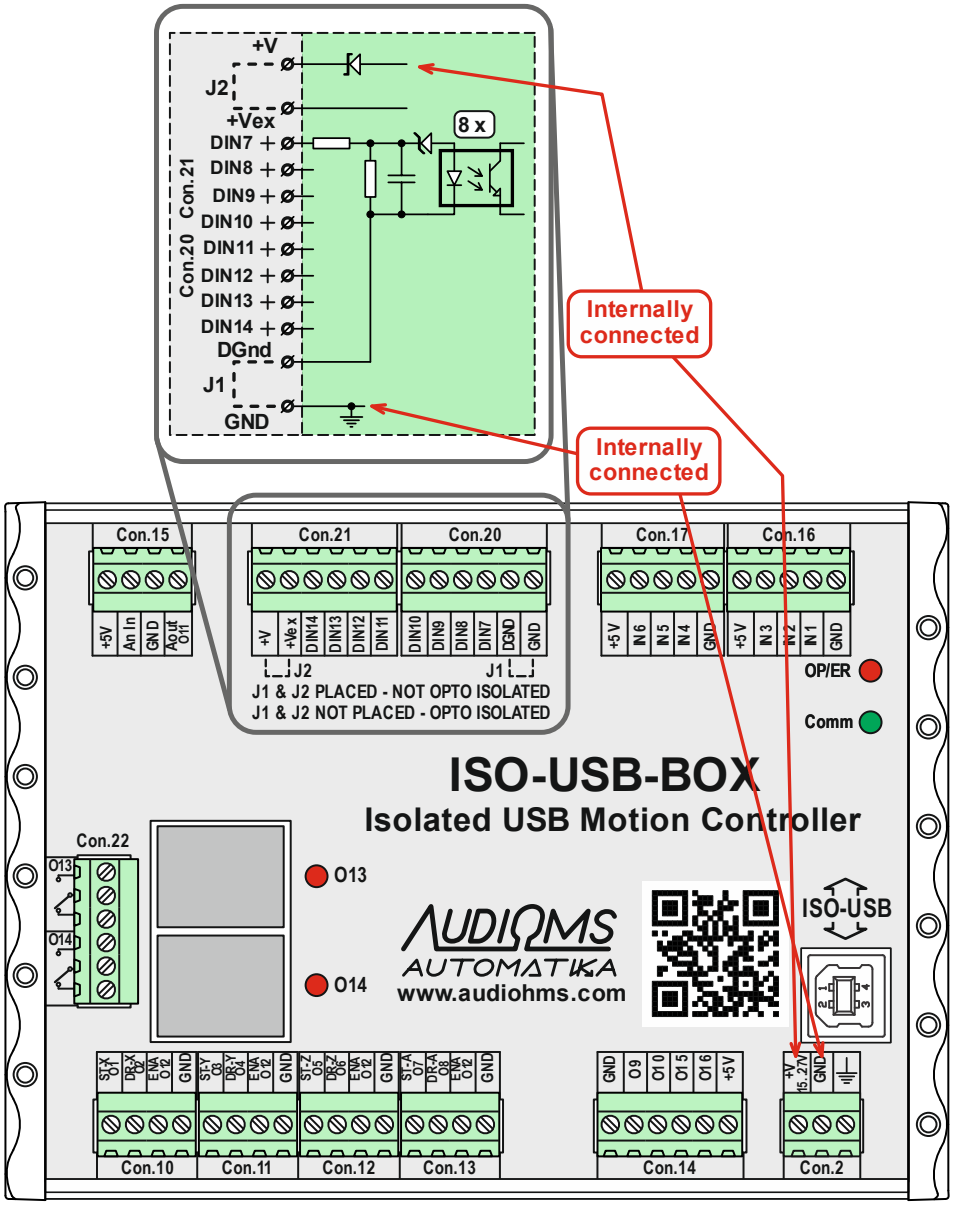


Figure 8.13 Location of opto-isolated digital inputs on the ISO-USB-BOX motion controller

8.7.1 Isolated mode for wiring limit switches to the opto-isolated inputs

Isolated mode for wiring limit switches to digital inputs DIN7-DIN14 implies using **additional power supply** with voltage in range of 15-25 VDC. Figure 8.14 shows connection of electro-mechanical switches,

while Figure 8.15 shows a possible way of connecting inductive switches to digital inputs DIN7-DIN14 in **isolated wiring mode**.

IMPORTANT NOTE: When connecting limit switches in **isolated mode** (Figure 8.14 and Figure 8.15) it is required to **remove jumpers from locations J1 and J2**.

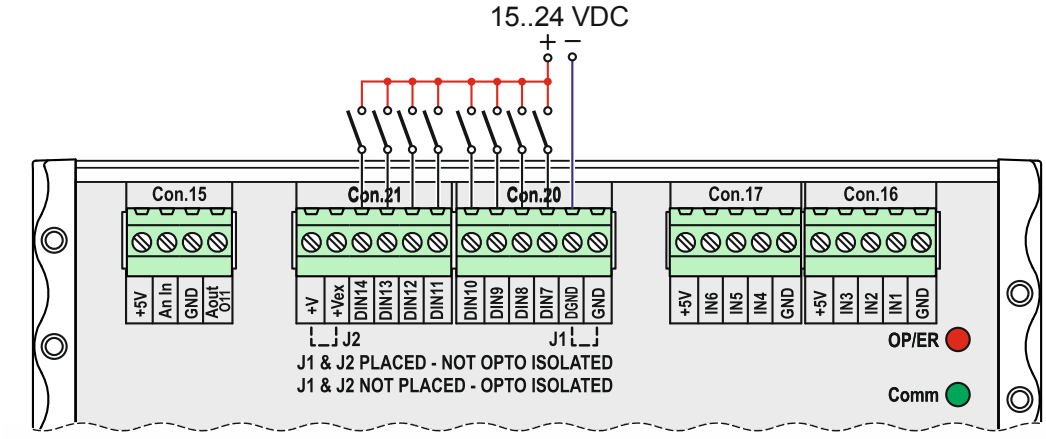


Figure 8.14 Isolated mode for wiring electro-mechanical type of limit switches

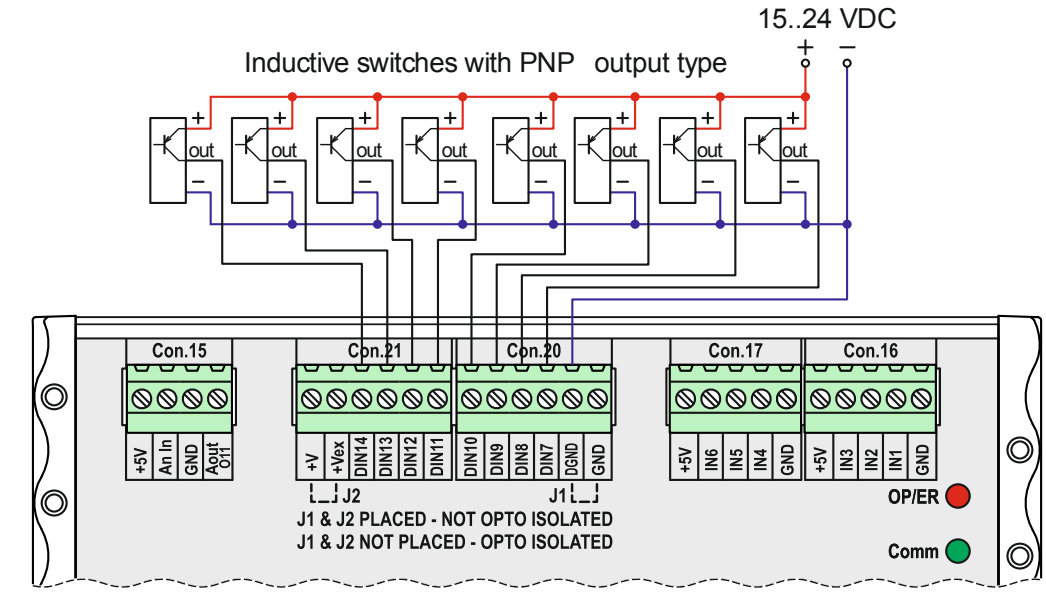


Figure 8.15 Isolated mode for wiring inductive type of limit switches

8.7.2 Non-isolated mode for wiring limit switches to the opto-isolated inputs

This mode implies usage of power supply of ISO-USB-BOX motion controller for activation of digital inputs DIN7-DIN14. In that case it is necessary for supply voltage of ISO-USB-BOX controller to be in recommended range (15-27 VDC). Figure 8.16 shows wiring of electro-mechanical switches, while Figure 8.17 shows a possible connection of inductive switches to digital inputs DIN7-DIN14 in non-isolated wiring mode.

IMPORTANT NOTE: When connecting limit switches in **non-isolated mode** (Figure 8.16 and Figure 8.17) it is required to **set jumpers into positions J1 and J2**.

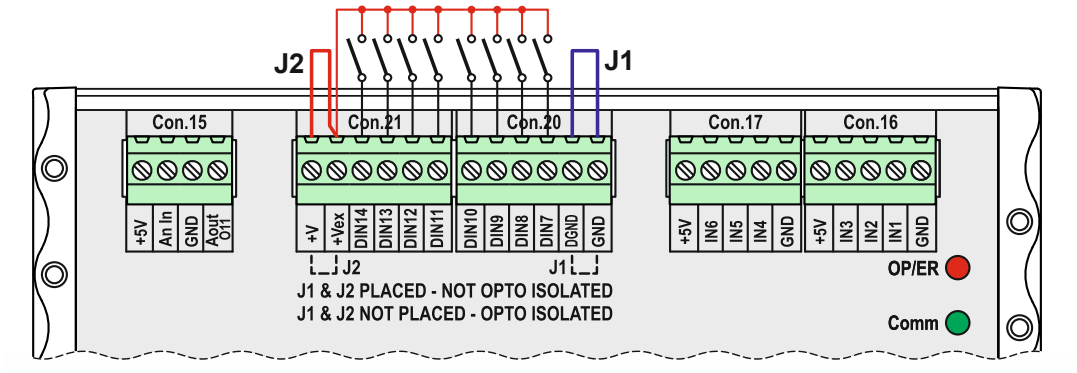


Figure 8.16 Non-isolated mode for wiring limit switches of electro-mechanical type

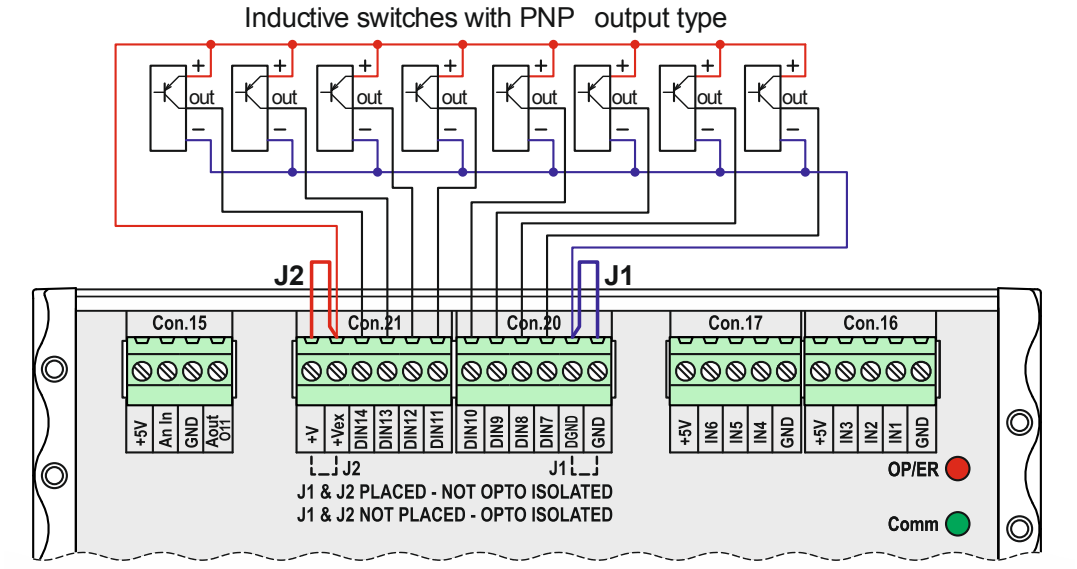


Figure 8.17 Non-isolated mode for wiring limit switches of inductive type

8.7.3 Connection of inductive switches of the NPN type

IMPORTANT NOTE: The ISO-USB-BOX motion controller is designed to work with PNP type inductive switches. With the installation of additional resistors, it is possible to use inductive switches of the NPN type.

NPN type inductive switches can be connected in:

- Uninsulated mode and
- Opto-isolated mode.

Figure 8.18 gives a recommended connection scheme of inductive switches with NPN-type outputs to a ISO-USB-BOX motion controller in opto-isolated mode. In this case, it is necessary to provide an additional power source of 24VDC to power the inductive switches. A resistor with a value of 1x2/1W to 1x5/1W must be placed on each of the DIN7..DIN14 input lines that are in use (Figure 8.18).

IMPORTANT NOTE: When connecting the limit switches, as shown in Figure 8.18, it is necessary that there are NO JUMPERS in positions J4 and J5. In this way, galvanic isolation of the power supply of the limit switches in positions from DIN7 to DIN14 and the power supply of the USB motion controller is ensured.

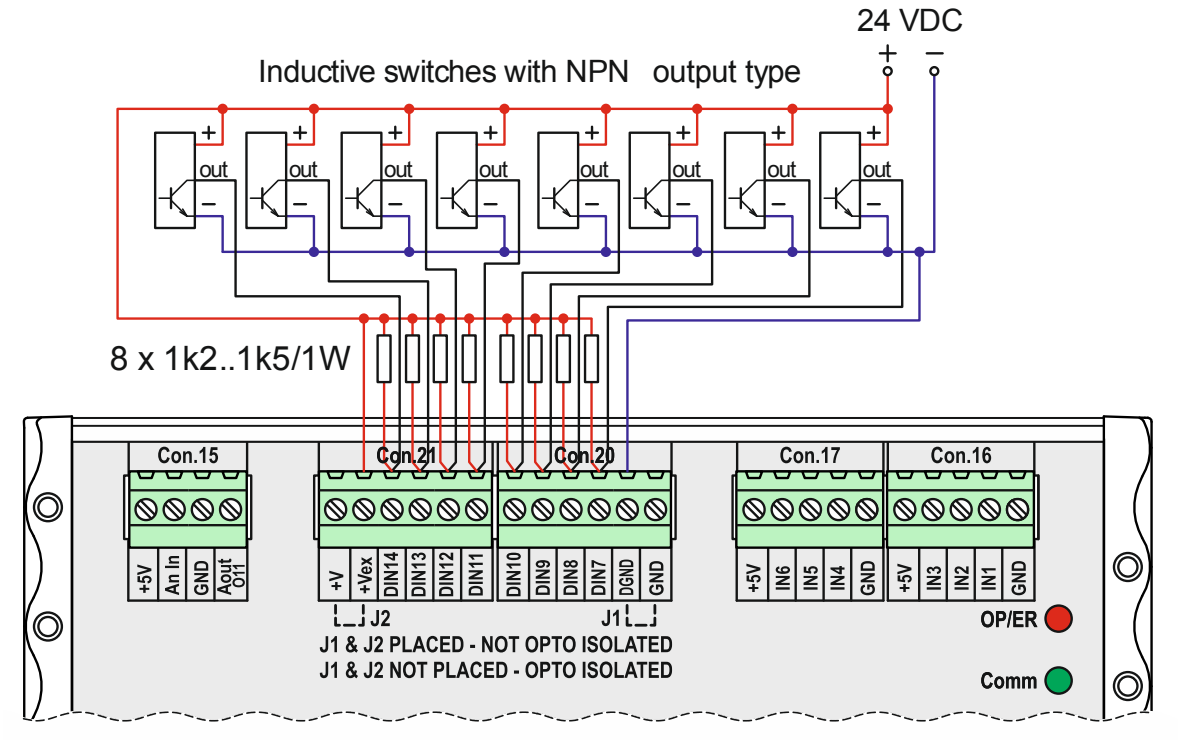


Figure 8.18 Connection of inductive NPN type limit switches in opto-isolated mode

Figure 8.19 shows the connection diagram for the case of the **non-isolated mode** of connection of limit switches for the case of using inductive switches with NPN-type outputs. A resistor with a value of 1x2/1W to 1x5/1W must be placed on each of the input lines DIN7..DIN14 that is in use (Figure 8.19).

IMPORTANT NOTE: When connecting the limit switches, as shown in Figure 8.19, jumpers MUST BE INSTALLED in positions J4 and J5. In this way, for the operation of limit switches from DIN7 to DIN14, the power supplied to the 3-pin connector Con.2 located on the ISO-USB-BOX motion controller is used.

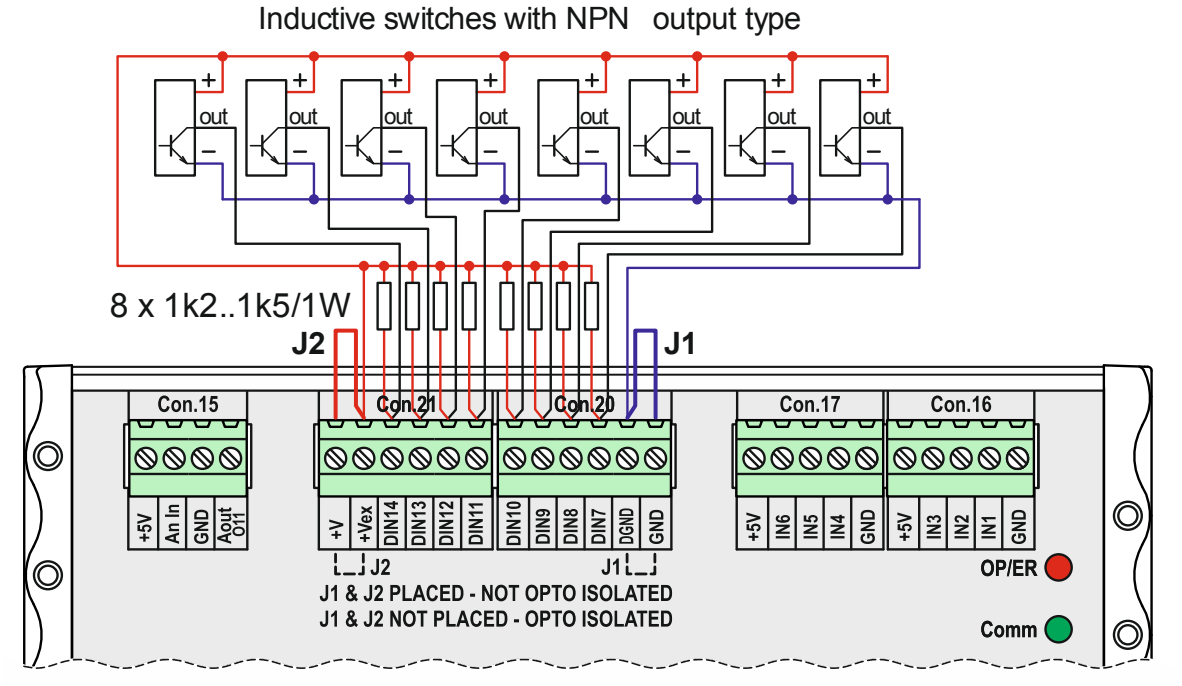


Figure 8.19 Connection of inductive NPN type limit switches in non-isolated mode

8.7.4 Connecting the cutting tool height measuring system

One useful option with modern CNC control systems is to measure cutting tool height across the Z axis (Auto Tool Height). This is done with the G31 function (Probe function). The **AutoToolZero** macro is also often used. The specified macro internally calls G31 for probing and then adjusts the Z offset, ie. resets the Z coordinate.

Measuring the length of the tool, i.e. setting the offset along the Z axis, can be done in several ways. In the following text, the two most commonly used measurement methods will be described.

The first way is by using a special measuring tool (Figure 8.20). When the tool touches the upper surface of the measuring tool, a switch is activated as a signal to the control system that contact has occurred. In this case, the switch leads are not in electrical contact with the metal parts of the measuring tool, so the signal generated is isolated from the metal parts of the machine. The described method is also the recommended method of calibration.

The second way to measure the length of the tool along the Z axis is by using a metal plate of known thickness or some simple measuring tool (Figure 8.21). There is an electrical insulating material on the underside of the measuring tool to electrically isolate the measuring tool from the machine. In this case, the switch consists of the aforementioned measuring tool (or accessory) and the tool itself, which is placed in the chuck of the machine. In this way, the metal parts of the machine are in direct electrical connection with the control electronics. **With this method of measurement, it is very important to take care of electrical connection of the measurement system in order to avoid problems and damage to the measurement system**.

Figure 8.20

Figure 8.21

The ISO-USB-BOX motion controller provides the possibility of connecting digital inputs that work at 24V, whereby the said inputs are opto-isolated. The mentioned inputs have a positive power supply line as common, so Figure 8.22 gives the recommended way of connecting the measurement system. In the given example, tool height measurment is performed via the digital input DIN7.

In order to ensure the opto-isolated mode of operation, an additional 24VDC power supply is required. Also, it is very important that there are no jumpers on positions J4 and J5 (Figure 8.22).

Pay attention to the additional resistor R in the circuit of the measurement system, which should have a resistor of 1k2 to 1k5 and a power of 1W (Figure 8.22).

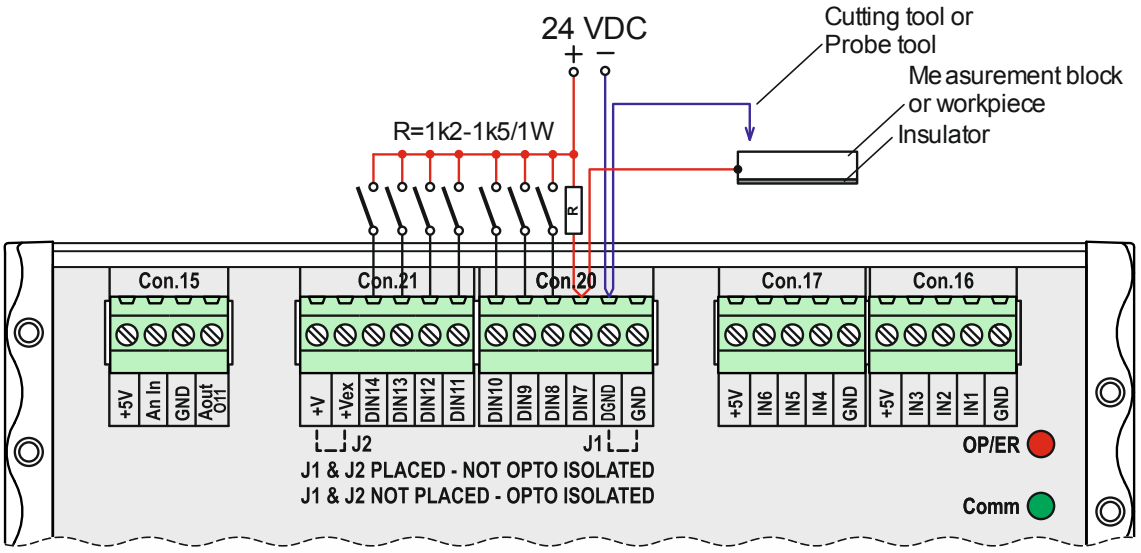


Figure 8.22

8.8 General purpose digital inputs

ISO-USB-BOX motion controller offers six general purpose TTL digital inputs which are accessible via connectors Con.16 and Con.17. These are labeled as IN1 to IN6 (Figure 8.23) and have integrated 4.7 kΩ pull-up resistors. Digital input IN5 is used for **Error** signal from connectors for controlling DC servo drivers (connectors labeled as X-Axis, Y-Axis, Z-Axis and A-Axis).

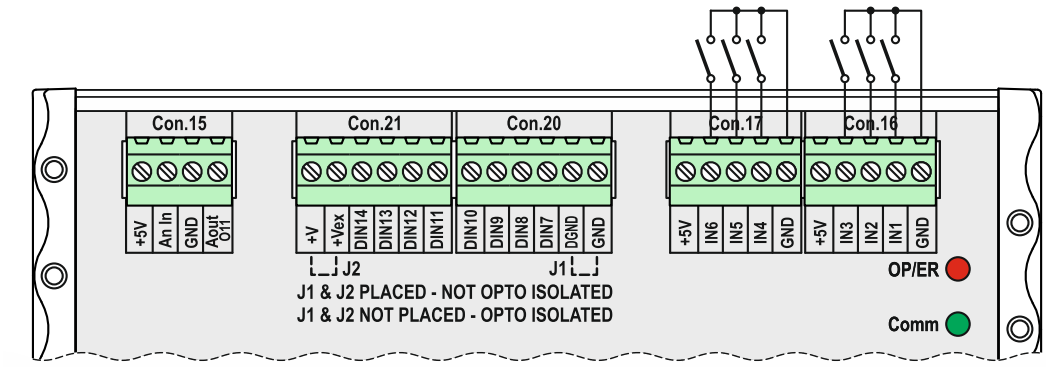


Figure 8.23 Position of general purpose digital inputs

8.8.1 Connecting an incremental encoder to a ISO-USB-BOX motion controller

The ISO-USB-BOX motion controller plugin provides the option to select a number of special functions. One of them is reading the incremental encoder in order to change one of the parameters during the execution of the G code.

Figure 8.24 gives the appearance of a rotary incremental encoder of the mechanical type, as well as a schematic representation of its connection to a ISO-USB-BOX motion controller.

In this case (Figure 8.24), the incremental encoder is connected to ground GND, as well as to general-purpose digital inputs IN1 and IN2. All general-purpose digital inputs have built-in 4.7k pull-up resistors.

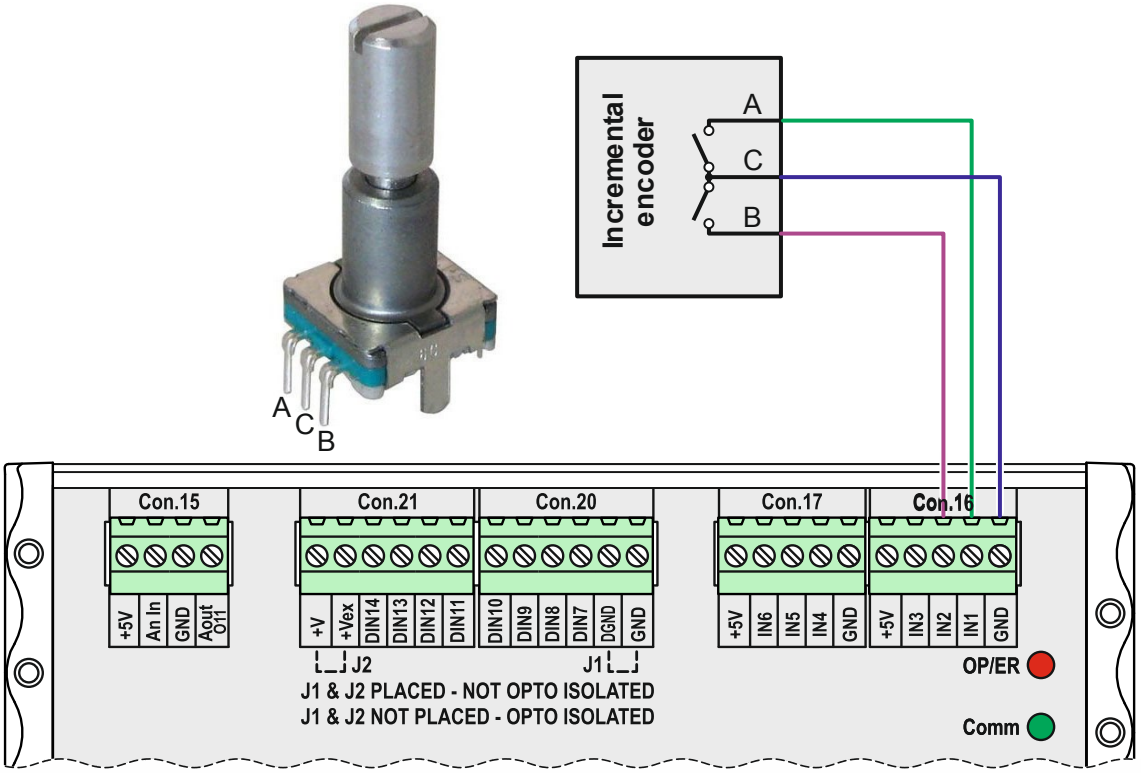


Figure 8.24

8.8.2 Example application of an incremental encoder: Control of the THC nominal voltage

The plug-in for the ISO-USB-BOX motion controller has support for the THC internal regulator, where it is possible to change the value of the THC nominal voltage via an incremental encoder within the special functions. In the considered example (Figure 8.25) this special function (**THC Vnom (50-300V)**) is assigned to the first encoder (Encoder1).

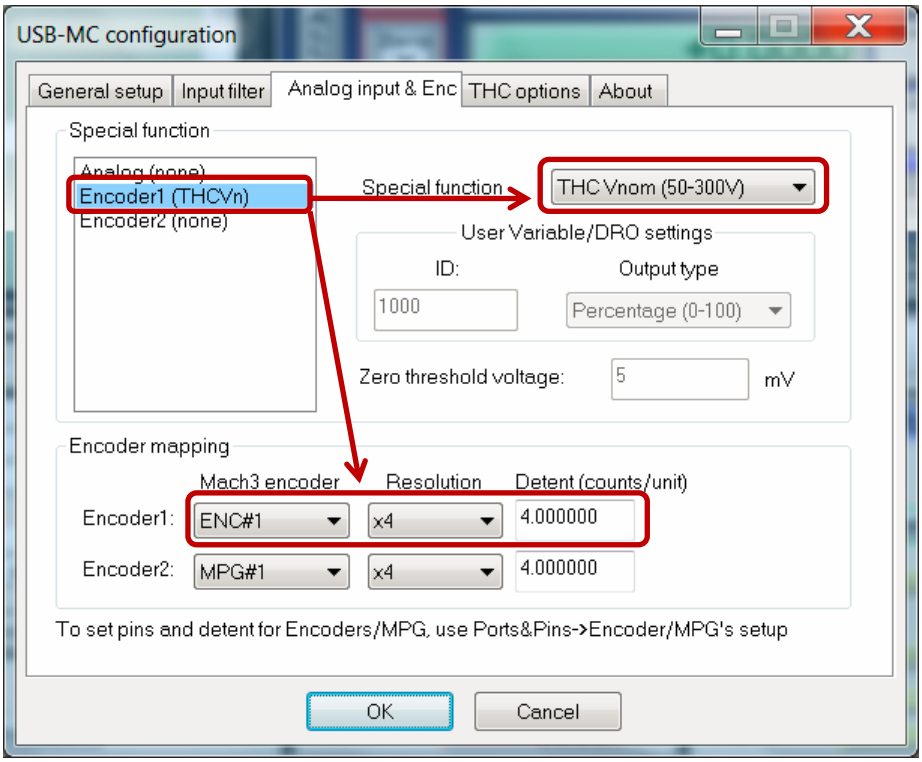


Figure 8.25

8.9 General purpose digital outputs

ISO-USB-BOX motion controller also has 4 TTL digital outputs for general purpose. These are marked as O9, O10, O15 and O16 and are available on connector Con.14 (Figure 8.26).

General purpose digital outputs can be used for generation of STEP/DIR signals for additional axes (fifth and sixth axis) (Figure 8.4 and Figure 8.8), for activation of external relays etc.

NOTE: PWM signal cannot be configured to outputs O15 and O16.

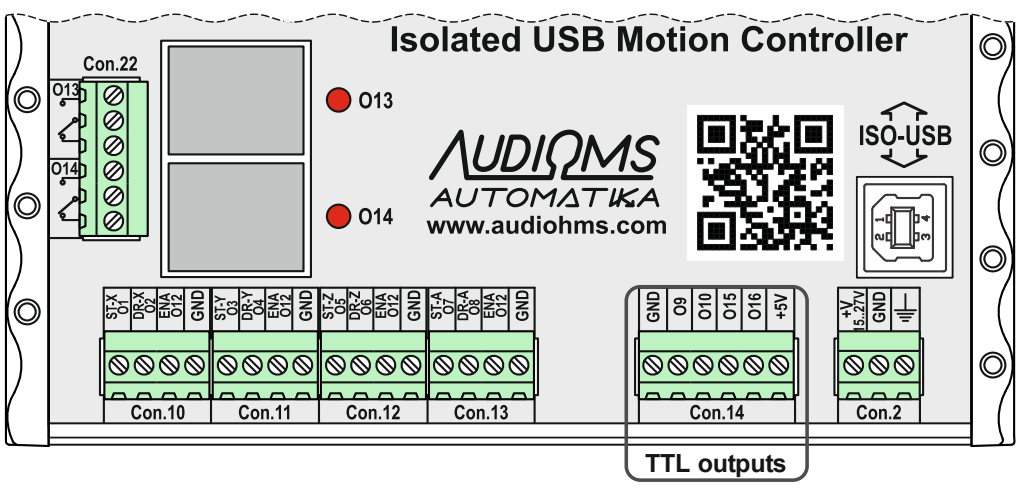


Figure 8.26 Location of general purpose digital outputs

9 LED indicators

9.1 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

9.2 Comm LED

Lights when there is a communication with computer.

10 Safety recommendations

- It is highly recommended to enforce galvanic isolation between work environment and PC (using opto-isolators and similar).
- All Audioms Automatika doo drives for stepper and DC servo motors have built-in opto-couplers on STEP and DIR inputs thus for these lines additional isolation is not needed. For other inputs and outputs, and depending on used equipment, it may be needed to use additional opto-isolators.
- Usage of ISO-USB-BOX motion controller requires knowledge and understanding of operation of complete work system, also awareness of possible risks of working with machines and tools.
- It is advisable to place ISO-USB-BOX motion controller in metal enclosure so that it is protected from external influences in presence of strong electromagnetic field, very high temperature, moisture, and similar.
- It is necessary to comply with safety standards like installation of EStop button, limit switches and similar.

DOCUMENT REVISION:

- Ver. 1.0, July 2021, Initial version
- Ver. 1.1, July 2022, Minor revisions
- Ver. 1.21, November 2023, New photos for ISO-USB-BOX motion controller
- Ver. 2.0, June 2024, A redesigned version of the ISO-USB-BOX V.3 motion controller