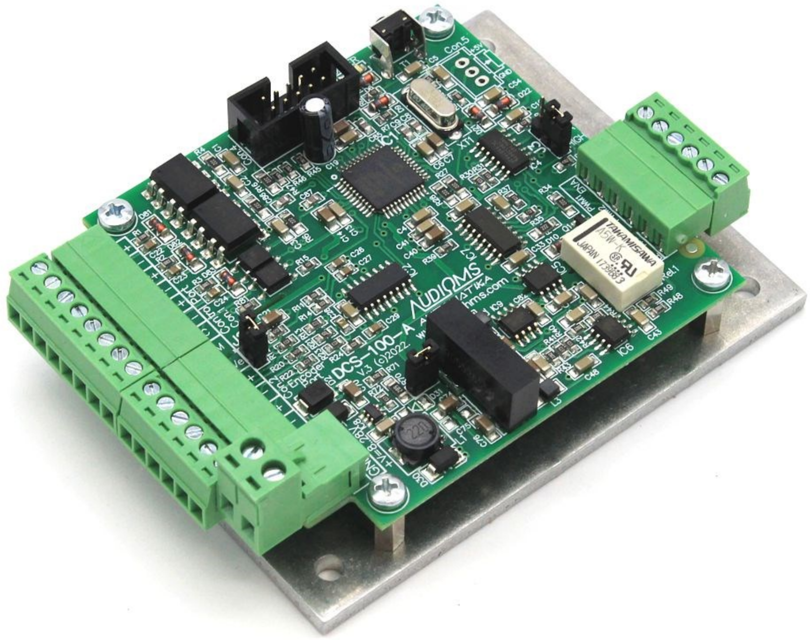
DCS-100-A

SERVO DRIVE WITH ANALOG OUTPUT ±10V



User's manual

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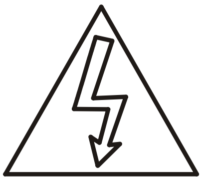
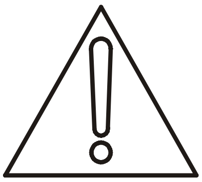
CONTENT

1 SAFETY WARNINGS





When working with the DCS-100-A servo drive, there are dangers and risks that can lead to damage to the equipment, as well as injuries to persons in the environment.

During the installation procedure of the DCS-100-A servo drive, it is necessary to have a high level of knowledge in the field of electronics, computer technology and mechanics. It is also necessary to observe safety measures when working with high voltage and mechanical hazards caused by working with heavy and dangerous machines.

Voltages over 50VDC can be danger of death.

The aluminum driver bracket must be properly grounded.

Use only galvanically isolated power supplies to power the DCS-100-A drive. The optoisolation distance between the input-output command lines and the control electronics on the driver's printed circuit board (PCB) is about 5 mm.

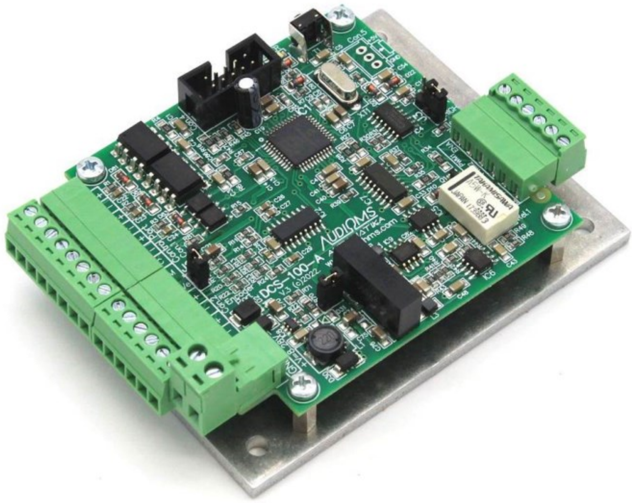
For an **Emergency stop**, it is recommended to disconnect the power supply lines of the DC servo motor and, if possible, engage the motor brake. In cases of danger to stop the servo motor, it is not recommended to use the opto-isolated ENABLE input.

The drive should not be used in places where its failure could lead to danger to human safety, large financial losses, or any other losses.

When working with the drive, use all necessary precautions.

The possibility that this document may contain errors is not excluded. At the same time, the manufacturer does not assume responsibility for any damage caused by the use of this driver, which occurred as a result of following or not following this user manual.

2 DESCRIPTION



DCS-100-A v.3 is microcontroller based drive with opto-isolated analog output ±10V. It is used to drive third party servo amplifiers. DCS-100-A is suitable for upgrading (retrofit) of CNC machines which has robust servo power amplifiers for AC or DC motors with analog input.

Drive is based on 16-bit microcontroller with implemented PID control algorithm. As the feedback of DC motor position an incremental encoder with phase-shifted square signal (quadrature encoder) is used. Encoder interface enables 1x, 2x and 4x encoder resolution.

Adjustment of all parameters is performed by using the configuration software ServoTune3.

The input control interface enables control via opto-isolated lines in next modes:

- STEP/DIR/ENABLE,
- CW/CCW/ENABLE,
- Encoder follower in 1x, 2x and 4x decoding, and
- Via analog input within the range 0–5 V with and without feedback.

Built-in soft start function enables DC motor 1s after power on in order to decrease power surge on start.

There is an opto-isolated digital output on drive, named Track Error which is activated if preset value of tracking error offset is exceeded. That output can be used for activation of external circuit for servo motor emergency stop.

Use power supply 8–24 VDC. Drive has reverse polarity protection.

2.1 Application

- CNC machines retrofit
- Coordinate tables
- Positioning
- Robots
- Education

3 SPECIFICATIONS

Type	Closed loop DC Servo drive with opto-isolated analog output ±10 V and PID control algorithm
Number of axis	1
Input control interface	Digital control modes via opto-isolated lines STEP/DIR/ENA, CW/CCW/ENA and Encoder follower (1x, 2x and 4x) Analog 0–5 V with and without feedback
Frequency of STEP command	< 600 kHz
Command line pulse width	> 0.5 µs
Command line current	~10 mA at 5 V
Output	Opto-isolated analog ±10 V
Auxiliary outputs	- Opto-isolated Tracking Error - Two inverted PWM signals (TTL) - Enable output (TTL)
Feedback	Incremental encoder with phase-shifted square signal
Incremental encoder resolution	×1, ×2 and ×4 multiplication, settable by configuration software
Incremental encoder power supply	Source on drive +5 VDC / 250 mA
Servo drive parameter set up	Via IDC10 connector and isolated programming interface IPI-USB
Power supply	8–24 VDC / 500 mA – reverse polarity protection
Dimensions (W x L x H)	102 mm x 77 mm x 31 mm
Weight	~150 g

NOTE: specifications are subject to change without notice

4 DRIVE APPEARANCE

DCS-100-A drive appearance and connectors locations are shown in Figure 4.1.

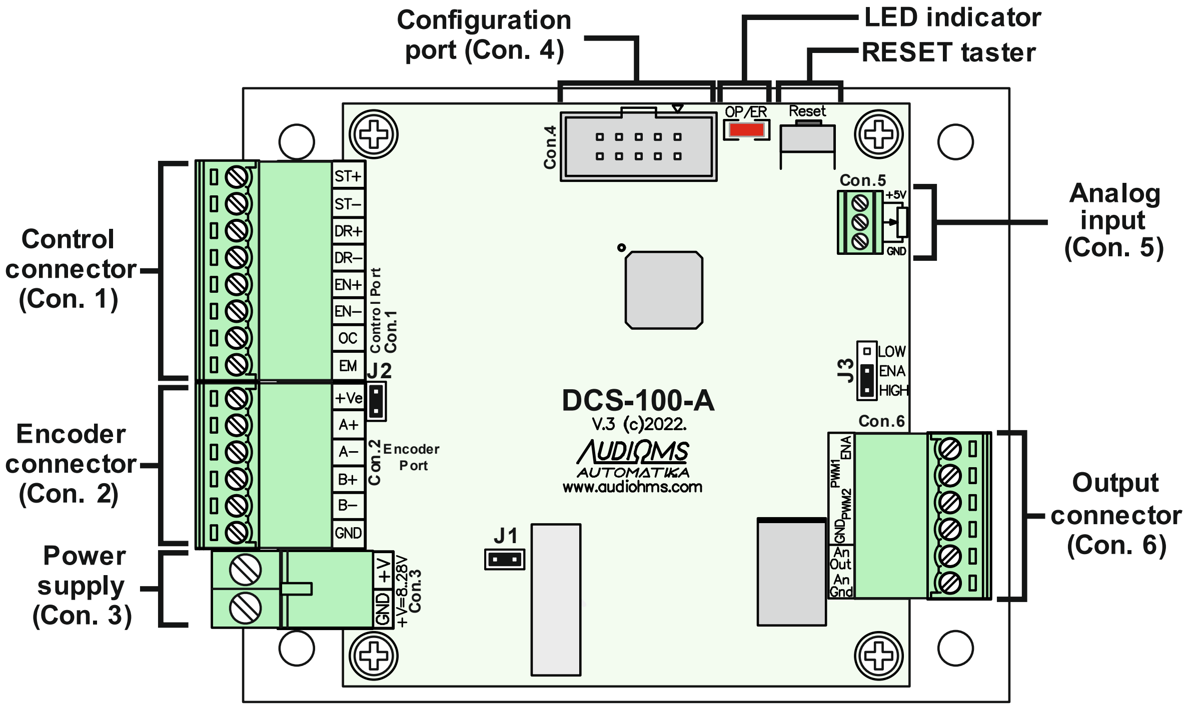


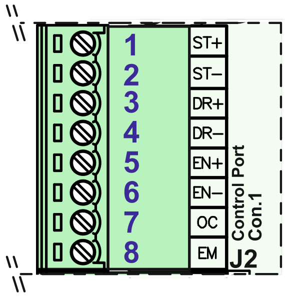
Figure 4.1 DCS-100-A drive appearance

4.1 Control connector

The digital control lines (STEP/DIR/ENA, CW/CCW/ENA or from the control incremental encoder) are connected via the 8-pin separable connector (control connector – Con.1). In addition, there is also a Tracking Error output on this connector, which is activated when the value of the tracking error offset is exceeded.

Table 4.1 gives a description of the pins on the Con.1 connector, while Figure 4.2 gives a simplified schematic of the servo drive DCS-100-A input section.

Table 4.1 Pins description of 8-pin control connector (Con.1)



Pin No.	Selected type of digital control			INPUT / OUTPUT
	STEP/DIR/ENABLE	CW/CCW/ENABLE	Encoder follower	
1	STEP +	CW +	A +	Input 1
2	STEP –	CW –	GND	
3	DIR +	CCW +	B +	Input 2
4	DIR –	CCW –	GND	
5	ENABLE +			Input 3
6	ENABLE –			
7	Error output (Tracking Error – open collector)			Output 1
8	Error output (emitter)			

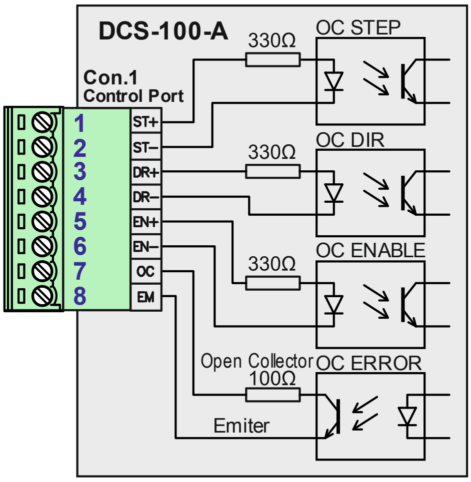


Figure 4.2 Schematic representation of opto-isolated inputs and outputs

At the input of the optocoupler for the STEP, DIR and ENABLE control signals there are 330 Ω resistors that limit the current of ~10 mA at a command voltage of 5 V (TTL logic level).

If the voltage level of the logic control commands is higher, then additional resistors should be placed on lines 1, 3 and 5 of the Con.1 connector to ensure that the current does not exceed 15 mA.

EXAMPLE: If a PLC with 24 V DC logic levels is used to control the DCS-100-A servo drive, then a 2.2 kΩ resistor must be placed in series on each of lines 1, 3 and 5 of the Con.1 connector.

It is necessary to note here that an external pull-up resistor must be placed on the Tracking Error line (Pin 7 on the Con.1 connector).

The optoisolation distance between the input-output command lines of the control connector and the control electronics on the driver's printed circuit board (PCB) is about 5 mm.

4.1.1 Connecting the control signal to the control connector

A servo driver with analog output DCS-100-A can be controlled with a full line of Audioms Automatika doo motion controllers.

Figure 4.3 gives the recommended way to connect an ETH-BOX motion controller with three (optionally possible to connect two to six) servo drivers. Outputs O1-O6 are used as STEP/DIR commands, while the ENA (Enable) output is common (O24). The Error output from all DCS-100-A servo drivers is common and is fed to the IN32 input of the ETH-BOX motion controller.

For more details on the ETH-BOX motion controller, refer to the user manual of the mentioned product.

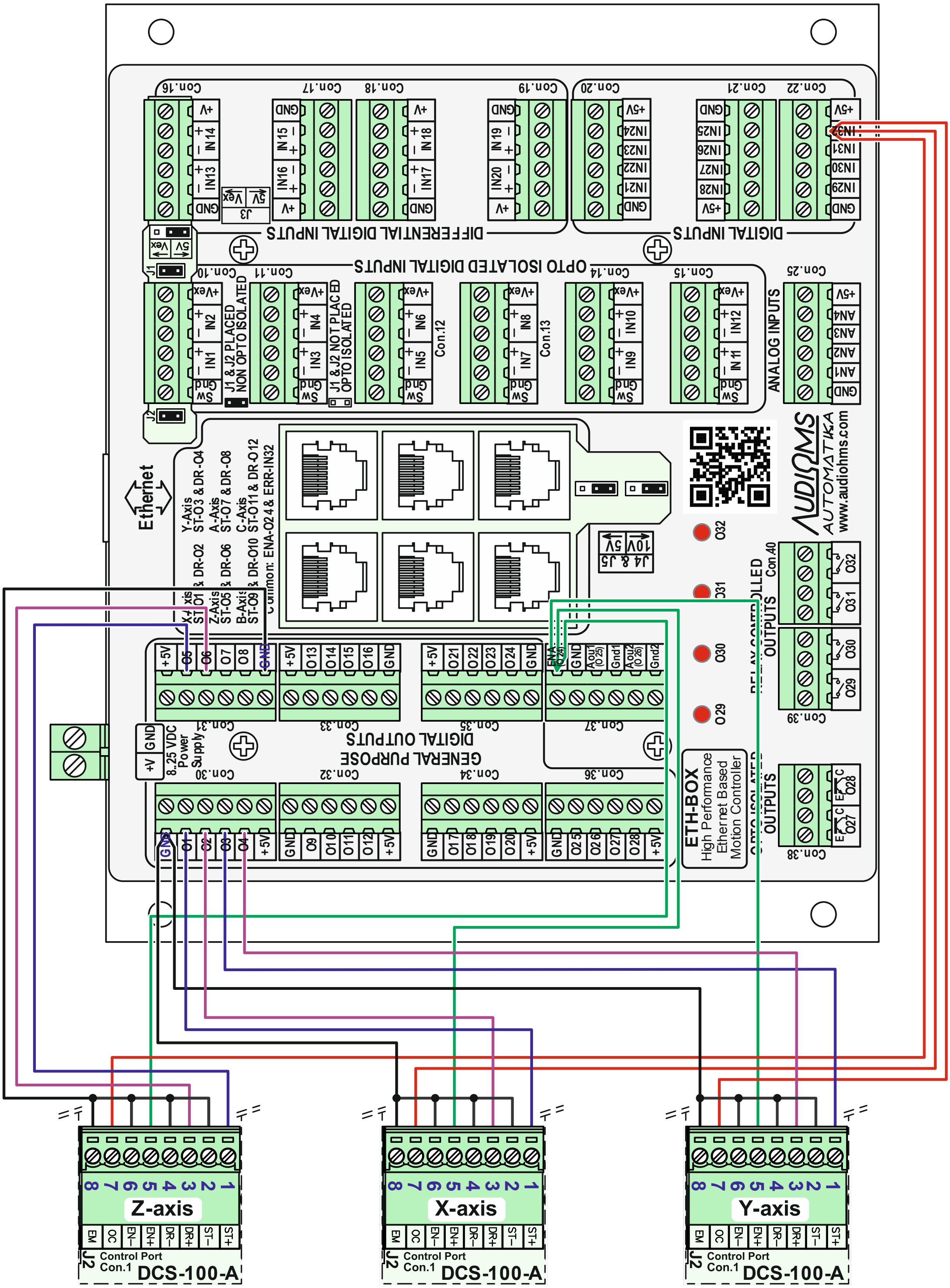


Figure 4.3 Control system with ETH-BOX motion controller

Figure 4.4 and Figure 4.5 give the recommended way to connect the ISO-USB-BOX motion controller, as well as the USB-MC motion controller and USB-UIO1 breakout board to four (optionally two to six) DC servo drivers DCS-100-A. Outputs O1-O8 are used as STEP/DIR commands, while the ENA (Enable) output is common (O12). The Error output from all servo drivers DCS-100-A is common and is fed to the IN5 input of the ISO-USB-BOX motion controller.

For more details on the ISO-USB-BOX motion controller, as well as the USB-MC motion controller and USB-UIO1 breakout board, refer to the user manual of the mentioned products.

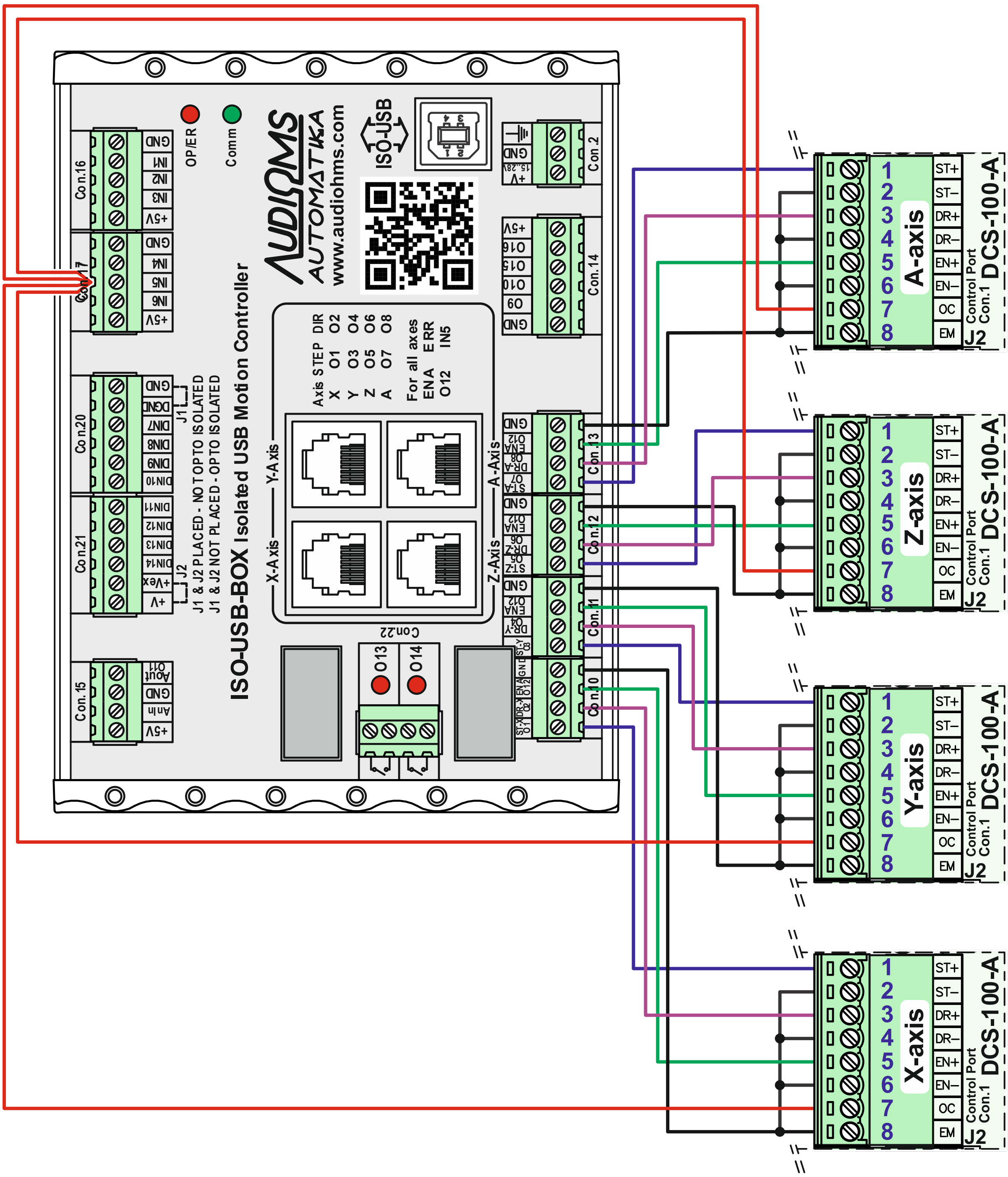


Figure 4.4 Control system with ISO-USB-BOX motion controller

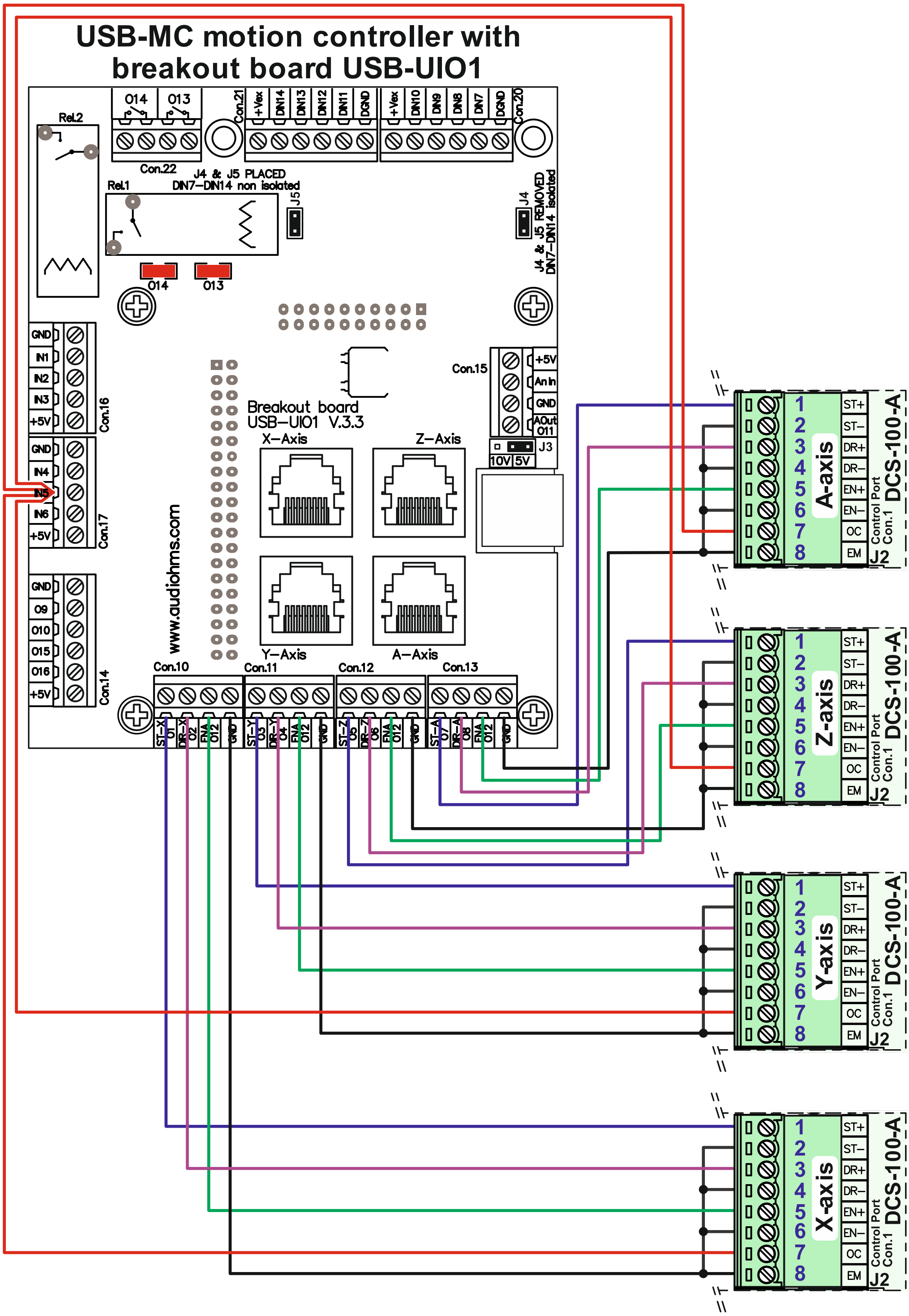


Figure 4.5 Control system with USB-MC motion controller and USB-UIO1 breakout board

Figure 4.6 gives the recommended way of connecting the breakout board IO3-R3 to four (optionally possible to connect two or three) DC servo drivers with analog output DCS-100-A. Outputs O2-O9 are used as STEP/DIR commands, while the ENA (Enable) output is common.

The Error output from all servo drivers DCS-100-A is common and is fed to input SW5 (IN5) of the breakout board IO3-R3 (shown by dashed lines).
For more details, refer to the breakout board IO3-R3 user manual.

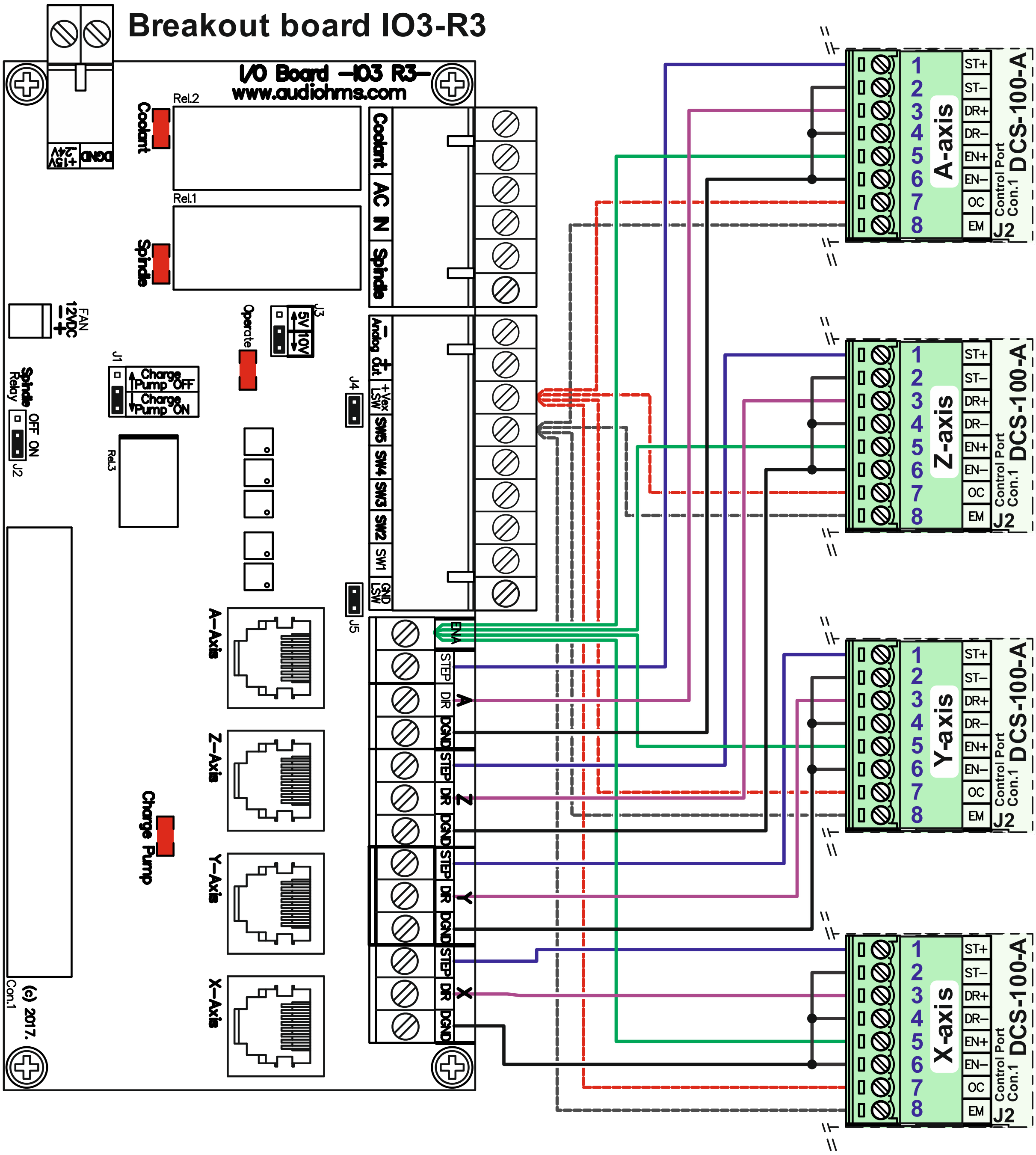


Figure 4.6 Control system with IO3-R3 breakout board

4.1.2 Servo driver control using PLC

A servo drive with an analog output DCS-100-A can also be controlled via a PLC that has the ability to generate the desired motion profiles. Connection is possible to both types of PLC, with outputs of the NPN type (Figure 4.7), as well as with outputs of the PNP type (Figure 4.8). It should be noted that the input interface (Control port) of the servo drive DCS-100-A can be configured to receive the following control modes:

- STEP/DIR,
- CW/CCW and
- via an incremental encoder (Encoder follower or Quadrature encoder).

PLCs generally have logic voltage levels of 24V on output, so it is necessary to add one resistor each to the STEP, DIR and ENABLE lines. Resistors R should be dimensioned so that the current on the STEP, DIR and ENABLE lines does not exceed 15 mA. In the case of a logic voltage level of 24V, the value of the resistor R (Figure 4.7 and Figure 4.8) should be 1.2–2.4 kΩ.

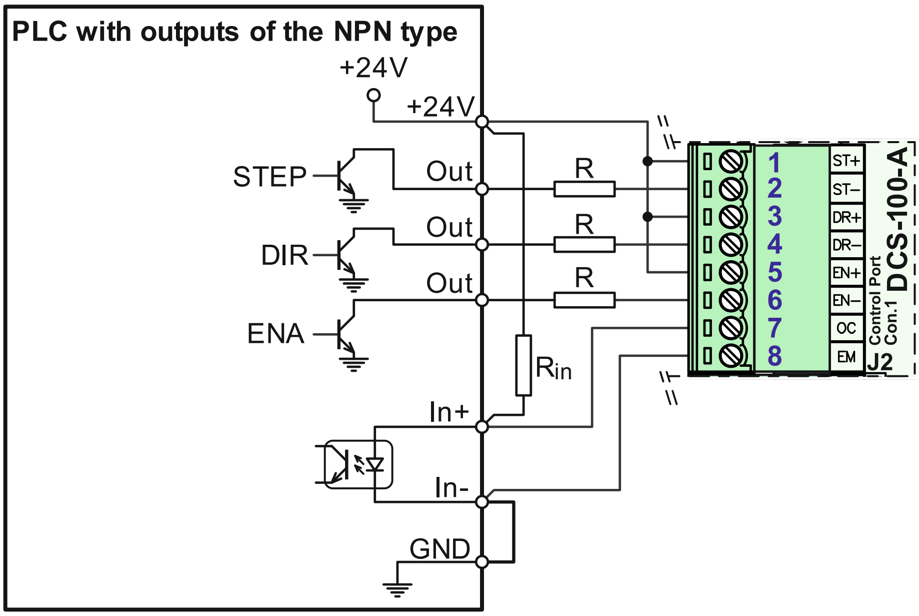


Figure 4.7 Connection to a PLC with NPN type outputs

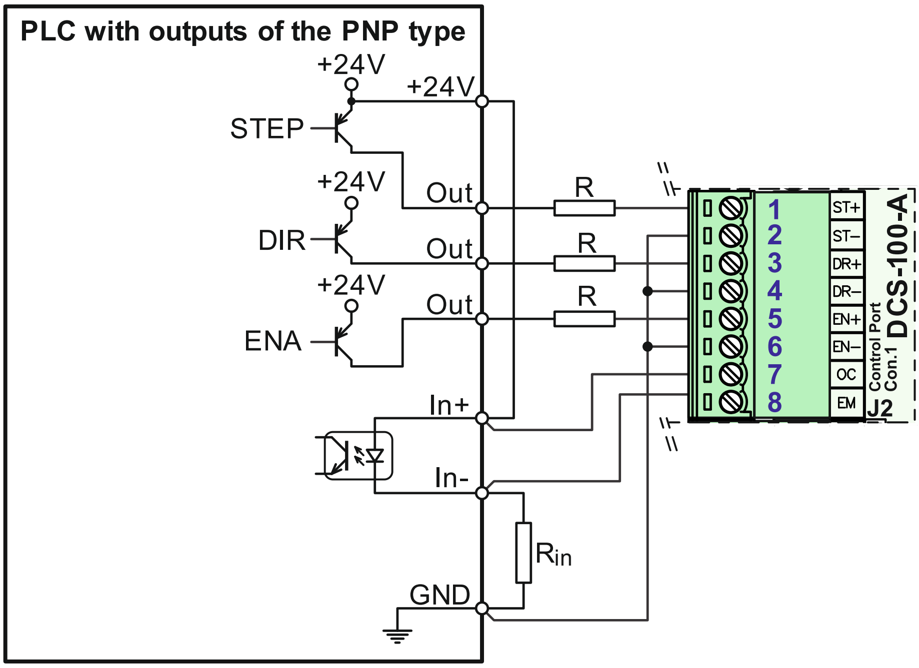


Figure 4.8 Connection to a PLC with PNP type outputs

Figure 4.7 and Figure 4.8 also show two options for connecting the opto-isolated digital output from the servo driver. The digital output from the servo driver displays the error status of the driver. Resistor R_{in} (Figure 4.7 and Figure 4.8) determines the current of the input diode on the optoisolator of the PLC; roughly, it can be in the range of 1.2–2.4 kΩ.

4.1.3 Control with an incremental encoder

In addition to STEP/DIR control, the input port of the servo driver DCS-100-A can be configured to receive CW/CCW as well as an encoder signal. Setting up the input interface is described in more detail in chapter 9.10.1.

Figure 4.9 gives a proposal for connecting a Manual Pulse Generator (MPG) as a control signal generator. In this case the incremental encoder is powered by an internal +5V power supply from the servo driver DCS-100-A available on Con.5.

NOTE: A 5V / 100mA power supply is available on the Con.5 connector.

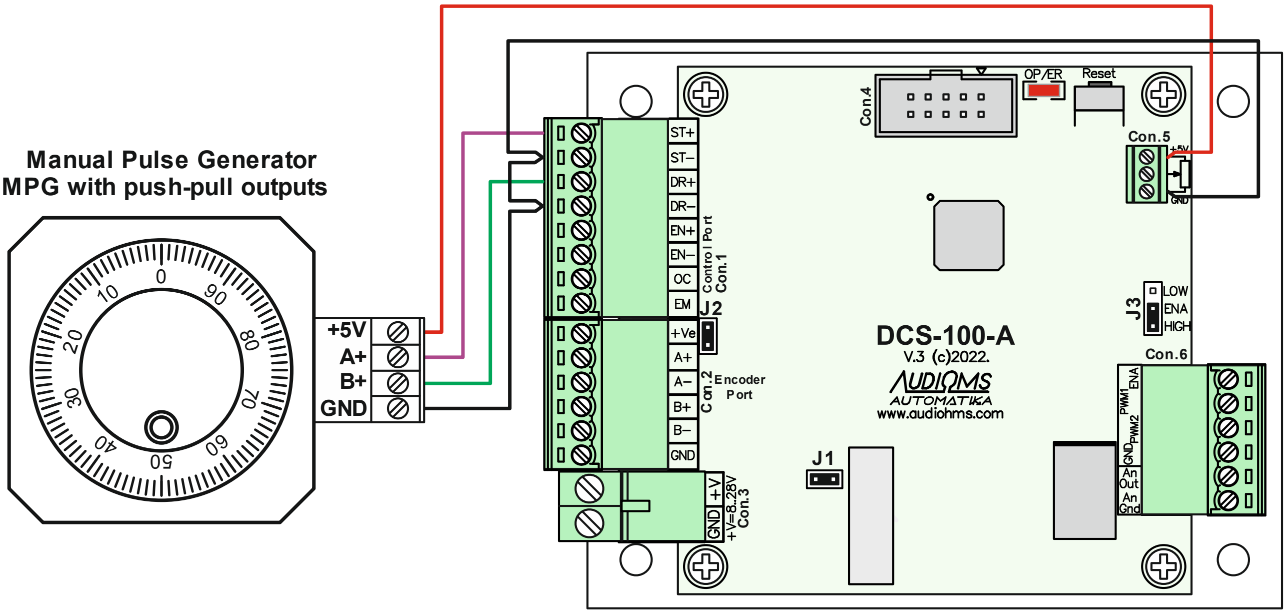
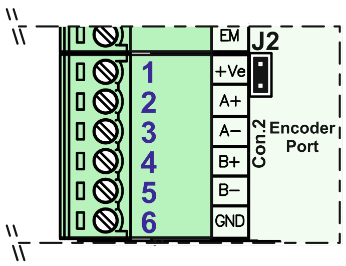


Figure 4.9 Controlling the DCS-100-A servo driver using an incremental encoder

4.2 Incremental encoder connector

For feedback by position, an incremental encoder is used, which is connected to the servo driver DCS-100-A via the encoder connector (Figure 4.1 – connector Con.2). Table 4.2 shows the pin function of this 6-pin connector.

Table 4.2 Description of the pins of the 6-pin encoder connector (Con.2)

	Pin No.	Name	Description	Function
	1	+Ve	Encoder power supply source 5 V / 250 mA max	Connecting an incremental encoder
	2	A+	A encoder channel input with pull-up resistor 4.7 kΩ to +Ve	
	3	A–	A\ encoder channel	
	4	B+	B encoder channel input with pull-up resistor 4.7 kΩ to +Ve	
	5	B–	B\ encoder channel	
	6	GND	GND – Encoder	

Use an incremental encoder with quadrature phase-shifted TTL outputs. On the driver DCS-100-A there is a power source for the incremental encoder +5 V / 250 mA max.

As feedback by position, it is recommended to use an incremental encoder with differential (complementary) outputs (A+, A-, B+ and B- outputs, Figure 4.10).

In order to reduce the impact of high-frequency electrical interference, it is recommended to use a shielded cable for the connection of the incremental encoder. The cable for connecting the incremental encoder should not be longer than the specific application requires.

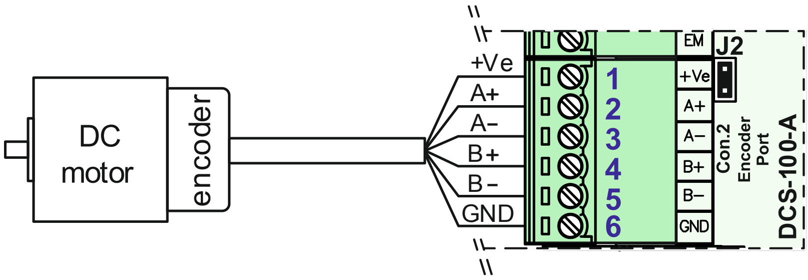


Figure 4.10 Connecting the incremental encoder with differential (complementary) outputs to the servo driver DCS-100-A

To connect an incremental encoder with single-ended outputs to the DCS-100-A servo driver, it is recommended to use the SED2 encoder interface (Figure 4.11). Encoder interface SED2 is a line driver that converts a single-ended input signals (A, B and Z) from an incremental encoder into differential (complementary) outputs (A+, A-, B+, B-, Z+ and Z-). A+, A-, B+ and B- outputs are used for DCS-100-A servo driver operation.

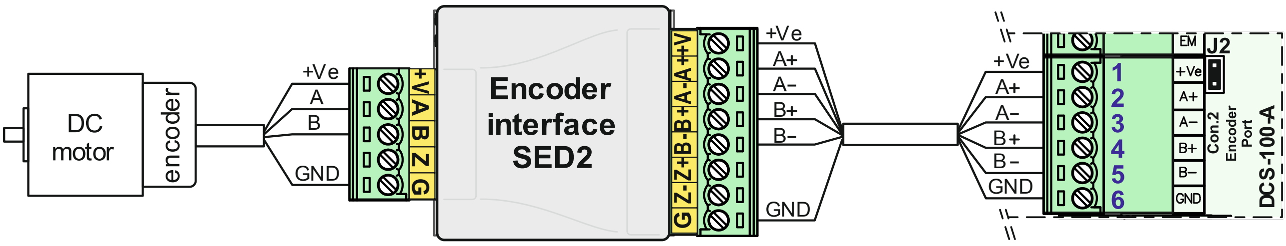


Figure 4.11 Connecting an incremental encoder with single-ended outputs to a DCS-100-A servo driver using the SED2 encoder interface – **recommended connection method**

An incremental encoder with single-ended outputs can be connected directly to the DCS-100-A servo driver (Figure 4.12).

NOTE: Connecting an incremental encoder with single-ended outputs to the DCS-100-A servo driver (Figure 4.12) is NOT RECOMMENDED FOR LONGER CABLE LENGTHS.

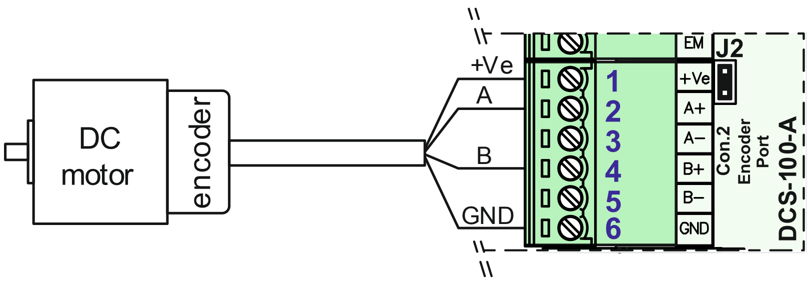


Figure 4.12 Connecting an incremental encoder with single-ended outputs to the DCS-100-A servo driver – **not recommended**

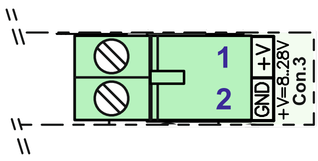
4.3 Power supply connector

The servo driver DCS-100-A is powered via connector Con.3 (see Figure 4.1 and Table 4.3).

The power source of the servo drive DCS-100-A should be 8–24 V DC / 500 mA or more. It is not necessary for this source to be stable, but it is sufficient that after rectification it is filtered by an electrolytic capacitor with a minimum capacitance of 470 μF to 1000 μF.

The DCS-100-A servo driver has reverse polarity protection.

Table 4.3 Description of the pins of the 2-pin connector Con.3

	Pin No.	Name	Description	Function
	1	+V	Power supply +8–24 V DC / 500 mA	Servo drive power supply
	2	GND	GND	

4.4 The configuration port

Setting the parameters of the DCS-100-A servo driver (PID controller constants, encoder resolution, tracking error offset, etc.) is done using the isolation programming interface IPI-USB and the ServoTune3 configuration software.

The isolation programming interface IPI-USB connects to the DCS-100-A servo driver via the configuration port labeled Con.4 (see Figure 4.1, 10-pin IDC connector).

4.5 Analog input

The servo driver DCS-100-A has the ability to be controlled via a voltage reference of 0–5 V which is applied to the analog input (see Figure 4.1, connector Con.5). A potentiometer with a nominal resistance of 1–10 kΩ can be directly connected to the analog input (Figure 4.13.a).

NOTE: A 5V / 100 mA power supply is available on the Con.5 connector.

Figure 4.13.b shows the generation of the speed profile of the motor by means of an external motion generator. The voltage at the output of the motion generator must not exceed 5 V DC.

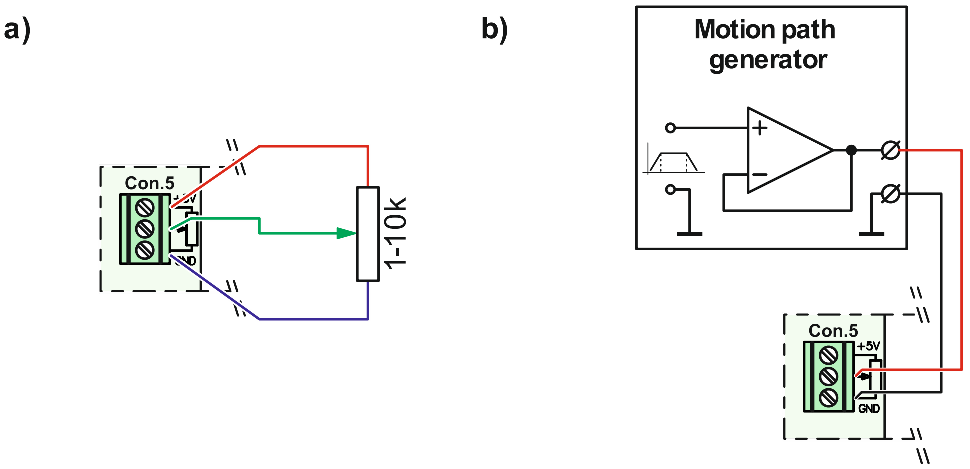
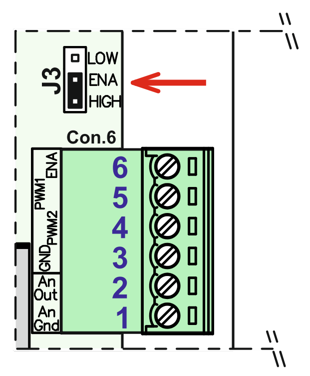


Figure 4.13 Generation of the voltage reference on the analog input of the ABD-A servo driver via, a) an external potentiometer and b) a motion path generator

4.6 Output connector

Analog output ±10 V, also the additional outputs PWM1, PWM2 and ENA, are located on connector Con.6 (see Figure 4.1, and Table 4.4).

Table 4.4 Description of pins (terminals) on connector Con. 6



Pin No.	Name	Description	Function
6	ENA	ENA (Enable) output	PWM and ENA outputs that can be used to control drivers that require this type of control signal. They are not galvanically isolated from the supply ground with Con.3
5	PWM1	PWM1 output	
4	PWM2	PWM2 output	
3	GND	GND for digital outputs	
2	AOut	Analog output ±10 V	Analog output ±10 V Galvanically isolated from the supply ground with Con.3
1	AGND	GND for analog output	

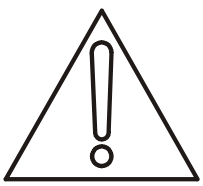
NOTE: The ground of analog output AGND and the ground of additional digital outputs GND are galvanically isolated.

Jumper J3 defines whether the ENA output (Table 4.4, Pin No. 6 on connector Con.6) will have positive logic (jumper J3 HIGH position) or negative (inverted) logic (jumper J3 LOW position). The position of jumper J3 is marked with a red arrow (Table 4.4).

5 Connecting the servo driver

Recommended procedure for connecting DC servo drive with analog output DCS-100-A to analog servo drives (power amplifiers) from third party manufacturers, consists of following steps.

5.1 Step 1



IMPORTANT NOTE: BEFORE TESTING THE DRIVERS OF OTHER MANUFACTURERS, IT IS NECESSARY TO DISCONNECT THE SERVO MOTOR WITH THE REMAINDER OF THE TRANSMISSION ON THE MACHINE. THE SPEED OF THE SERVO MOTOR CAN BE UNCONTROLLED AND CAN POTENTIALLY BE A SAFETY HAZARD. THE ROTATION OF THE SERVO MOTOR MUST NOT AFFECT THE MOVEMENT OF OTHER MOVING PARTS ON THE MACHINE.

LIFE-DANGEROUS VOLTAGE LEVELS MAY BE PRESENT WITH DRIVERS FROM OTHER MANUFACTURERS.

Figure 5.1 provides a recommended schematic for testing a third-party analog servo driver (amplifier). Two 9V batteries and one potentiometer are required. Before applying power to the third-party analog servo driver, apply a voltage of 0V to the analog input (adjust with a potentiometer).

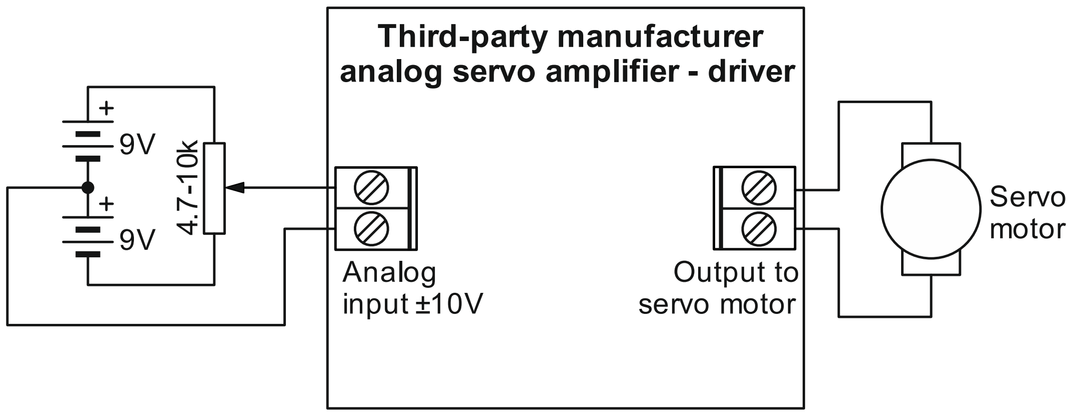


Figure 5.1 Testing analog servo driver from a third-party manufacturer

After supplying voltage to the third-party analog servo driver, gently turn the potentiometer handle to one side and then to the other side and check if the servo motor follows these changes.

Thus, the third-party analog servo driver of other manufacturers is ready for further connections with the servo driver with analog output DCS-100-A.

5.2 Step 2

Connect the incremental encoder to the servo driver with analog output DCS-100-A as shown in chapter 4.2.

Power the DCS-100-A driver through the power connector (Con.3). Using a voltmeter, check the voltage at the output of the DCS-100-A servo driver, i.e. voltage on pins 1 and 2 of connector Con.6. This voltage should be in the range of ±10 mV, which is also the DC offset of the DCS-100-A servo driver. Then turn the shaft of the incremental encoder by hand, whereby the voltage at the output of the DC servo driver DCS-100-A should follow the angle of rotation, i.e. it should be proportional to the angle of rotation of the incremental encoder (provided that only the P parameter of the PID controller is set). The maximum voltage at the DCS-100-A servo driver output is ±10.3 V. During this check, a tracking error may occur – see chapter 8.

After the checks described in this and the previous step, you can start connecting the entire control system.

5.3 Step 3

Figure 5.2 and Figure 5.3 gives the recommended way of connecting a servo driver with analog output DCS-100-A and a third-party analog servo driver.

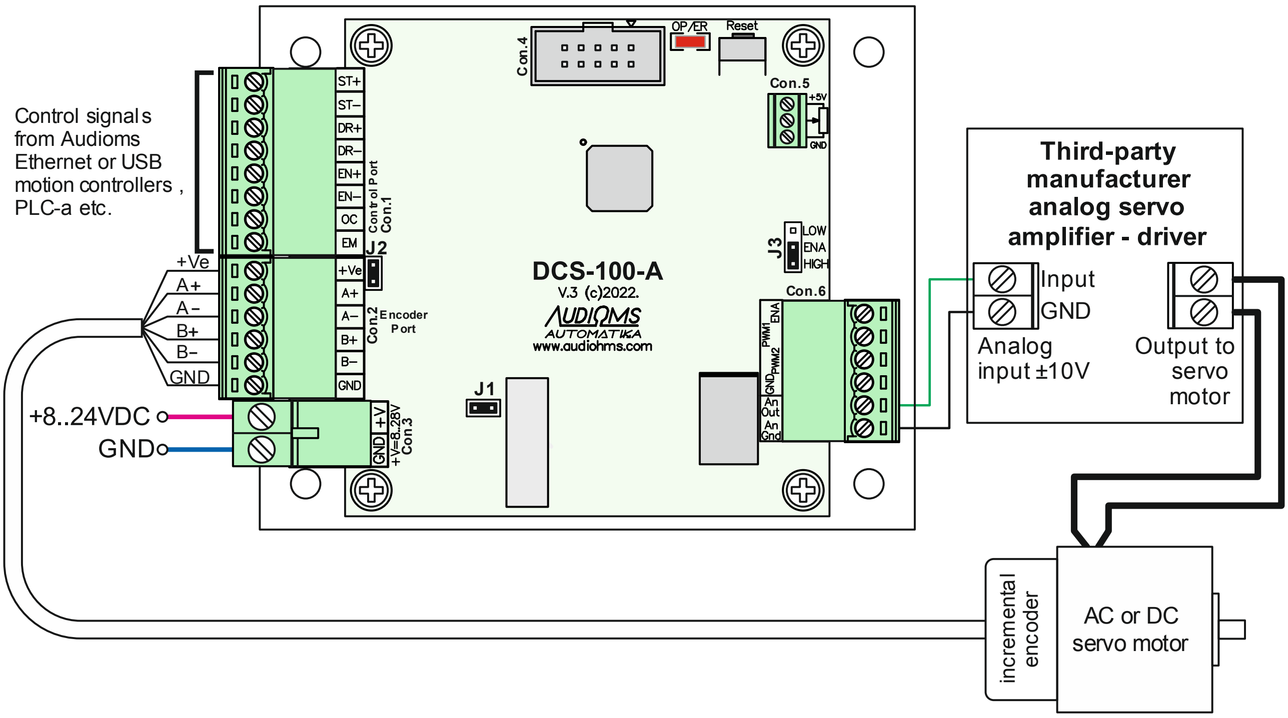


Figure 5.2 Connecting a servo driver with analog output DCS-100-A to a system for the case of an incremental encoder with differential outputs

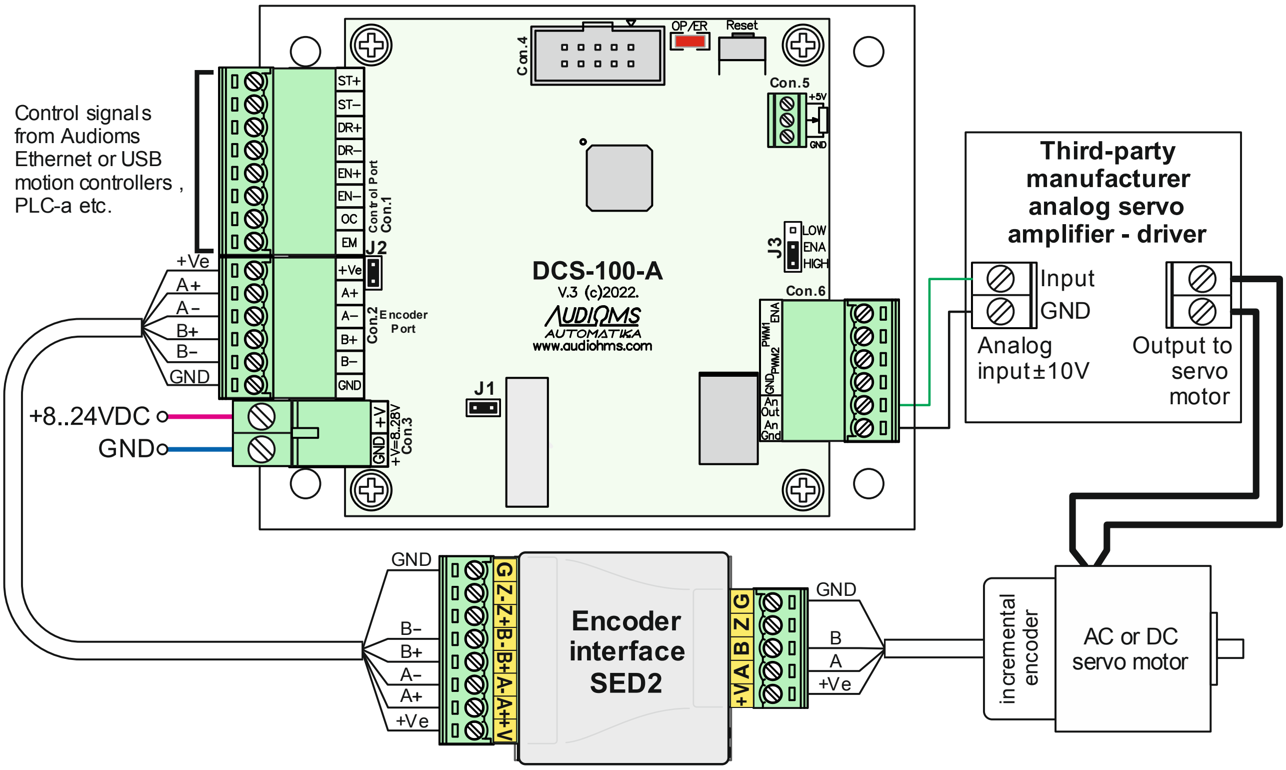


Figure 5.3 Connecting a servo driver with analog output DCS-100-A to a system for the case of an incremental encoder with unbalanced outputs

After applying power to the system (Figure 5.2), if everything is well connected, the servo motor shaft should remain in the position it was in. When attempting to move the servo motor shaft out of its equilibrium position, the system should return the shaft to a position that approximates the starting position (or resist the position change). If the servo motor shaft rotates several times and the Error tracking error is activated (see error codes in chapter 8), it means that the position of the phases on the incremental encoder needs to be replaced. Figure 5.4 shows the phase reversal in the case of an incremental encoder with differential outputs, while Figure 5.5 shows the phase reversal if an incremental encoder with single-ended outputs is used.

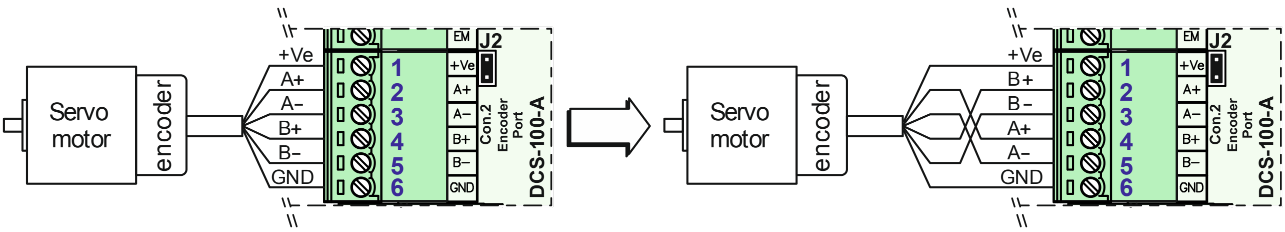


Figure 5.4 Replacement of incremental encoder phase positions with differential outputs

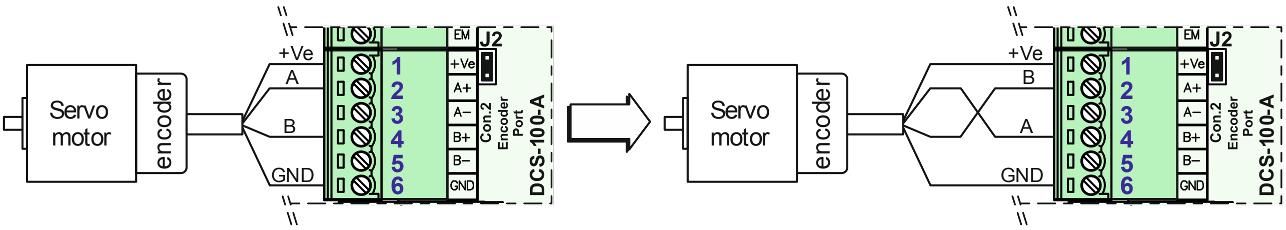


Figure 5.5 Replacement of incremental encoder phase positions with single-ended outputs

5.4 Step 4

Adjust the PID controller parameters of the DCS-100-A servo driver as explained in the ServoTune3 parameter setting software section of the user manual (Chapter 10).

6 CONNECTING INCREMENTAL ENCODERS THAT REQUIRE HIGHER SUPPLY VOLTAGE THAN +5 VDC TO THE DCS-100-A SERVO DRIVER

The DCS-100-A servo driver via the encoder connector (Con.3) provides a supply voltage of +5 VDC to power the incremental encoder. On the market, it is often possible to find incremental encoders that have a wider supply voltage range (up to 24 VDC).

If an incremental encoder with differential outputs (A+, A-, B+ and B-) is used that requires a supply voltage higher than +5VDC, then it is necessary to connect the control system as shown in Figure 6.1. **IMPORTANT: JUMPER J2 MUST BE REMOVED FROM THE DRIVER. In this way, the +5VDC supply line that goes from the DCS-100-A servo driver to the encoder connector (Con.3) is interrupted.**

The power supply of the incremental encoder is now provided by using an additional wire connecting the positive supply line of the DCS-100-A servo driver (pin +V from the connector Con.1) and the line +Vd from the Encoder connector (Con.2). **This establish power supply to the incremental encoder directly from the power line of the DCS-100-A servo driver.**

NOTE: In this case, the recommended DCS-100-A servo driver supply voltage is in the range of +8VDC to +22VDC (maximum up to +24VDC). Exceeding the maximum supply voltage of +24V can permanently damage the input part of the incremental encoder position reading circuit on the DCS100-A servo driver.

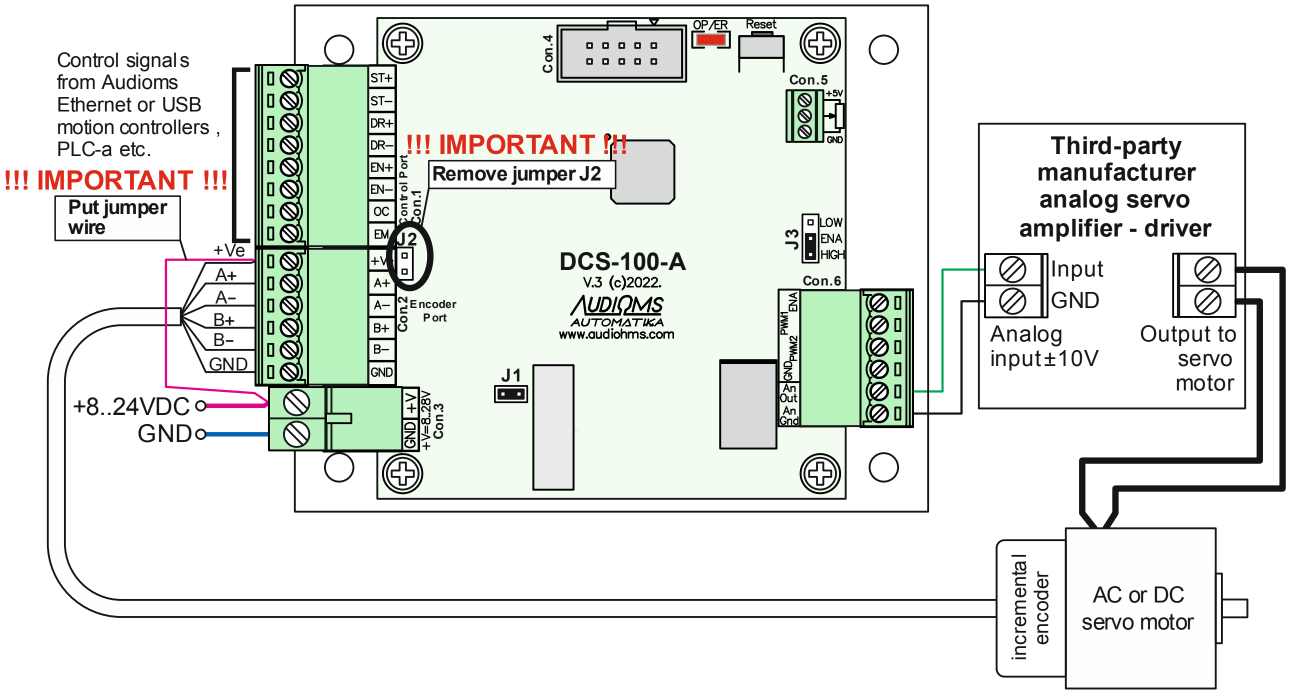


Figure 6.1 Connecting a servo driver with analog output DCS-100-A to a system for the case of an incremental encoder with differential outputs that requires a supply voltage higher than +5VDC

If an incremental encoder with single ended outputs (A and B) is used that requires a supply voltage higher than +5VDC, then it is necessary to connect the control system as shown in Figure 6.2. **IMPORTANT: JUMPER J2 MUST BE REMOVED FROM THE DRIVER. In this way, the +5VDC supply line that goes from the DCS-100-A servo driver to the encoder connector (Con.3) is disconnected.**

Powering the incremental encoder is now provided using an additional wire connecting the positive power supply line of the DCS-100-A servo driver (pin +V from the Con.1 connector) and the +Vd line from the

Encoder connector (Con.2). **This establish power supply to the incremental encoder directly from the power line of the DCS-100-A servo driver.**

NOTE: In this case, the recommended DCS-100-A servo driver supply voltage is in the range of +8VDC to +22VDC (maximum up to +24VDC). Exceeding the maximum supply voltage of +24V can permanently damage the input part of the incremental encoder position reading circuit on the DCS100-A servo driver.

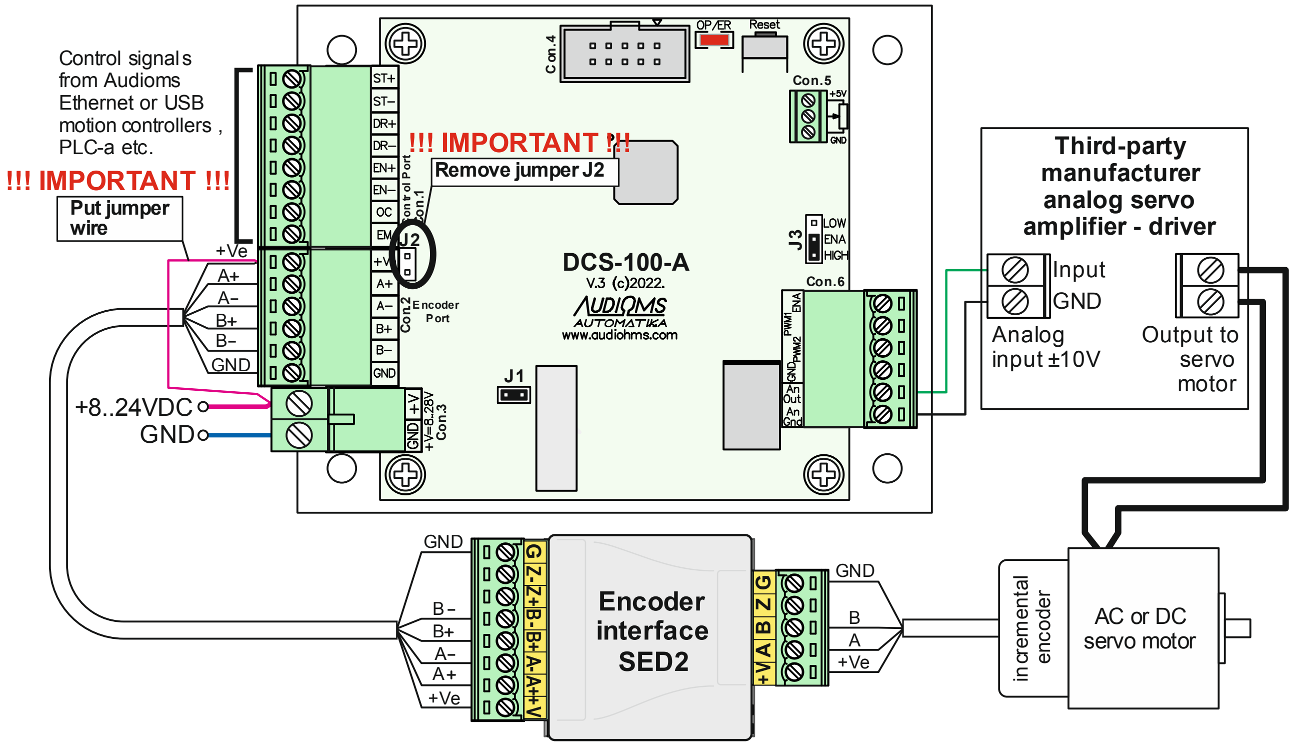


Figure 6.2 Connecting a servo driver with analog output DCS-100-A to a system for the case of an incremental encoder with single ended outputs that requires a supply voltage higher than +5VDC

7 RESET TASTER

The RESET button is located between the configuration port Con.4 and the analog input connector Con.5 (Figure 4.1). By pressing the RESET key, it is possible to clear the current error of the servo driver with analog output DCS-100-A.

In addition, by pressing the RESET button, the analog output is disabled, that is, the output relay connects the analog output to the ground of the analog output.

8 LED INDICATORS

The driver features a multi-purpose red OP/ER LED indicator that indicates the various states the analog output servo driver DCS-100-A is currently in (Table 8.1).

Table 8.1 Description of the states shown by **OP/ER** LED multi-purpose indicator

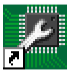
OP/ER	Description	
○	Servo drive control circuit is not powered – LED off	
●	Drive ready to work – ENABLE	
1 x ☀	Drive ready to work – DISABLE	
Errors	**Description**	**How to clear error**
2 x ☀	Tracking error	- Increase value of Error offset - Push RESET taster
3 x ☀	Incremental encoder error	- Check condition of incremental encoder and its cable - Turn off encoder error detection - Push RESET taster
7 x ☀	Microcontroller error	- Push RESET taster - Contact authorized service provider

WARRANTY

Manufacturer guarantees that all DC servo drives with analog output DCS-100-A are in good working order on delivery. All drives DCS-100-A are tested before shipping. Supply voltage that exceeds maximum allowed value, faulty incremental encoders, incorrectly connected or faulty DC servo motors, strong electromagnetic fields (in proximity to contractor) and similar, can damage the drive.

9 ServoTune3 – User's manual

ServoTune3 configuration software is used to set the driver parameters (Figure 9.1). The software consists of one file (ServoTune3.exe) and for its installation it is necessary to copy the file to the desired folder on the computer. To adjust the parameters of the DCS-100-A analog output DC servo driver, use ServoTune3 software version 3.09 or later.

ServoTune3 configuration software  works under Windows XP, Vista, 7, 8, 10 and 11 operating systems.

ServoTune3 software enables:

- Setting the constants of the PID regulator,
- Automatic adjustment of the PID controller
- Setting the multiplication of the resolution of the incremental encoder,
- Setting the step multiplier,
- Enable/disable the driver,
- Setting the number of steps to record the response of the DC motor to the step function and display the response diagram of the position of the servo motor,
- Setting the Tracking error offset value,
- Reading the current value of the position of the servo motor,
- Recording of a log file with values of set positions, current errors and current values of the current through the servo motor,
- Choice of input interface type (STEP/DIR/ENA, CW/CCW/ENA, encoder 1x, 2x or 4x or analog input with and without feedback),
- Choice of PWM frequency,
- Setting the digital filter options for the incremental encoder input,
- Setting the maximum current through the servo motor, etc.

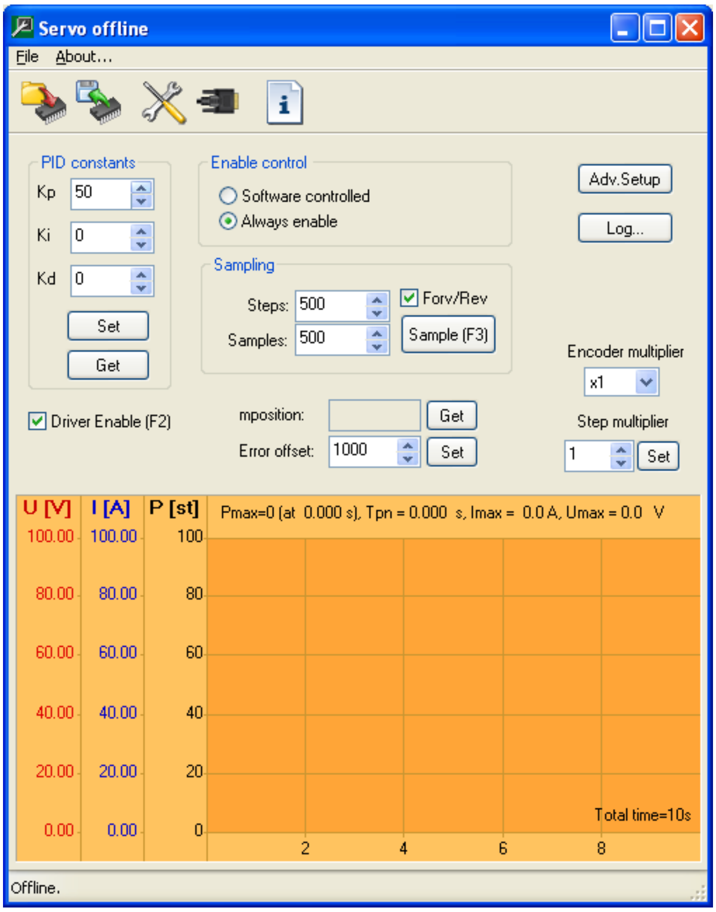
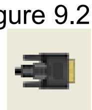


Figure 9.1 ServoTune3

NOTE: ServoTune3 software is used to adjust the operating parameters of the driver DCS-100-A. The software is not intended for servo motor control.

9.1 Selection of COM port

The connection between the ServoTune3 software and the PC with the DCS-100-A driver is realized via the IPI-USB programming interface. The parameters for the COM port are set via the dialog shown in Figure 9.2, which can be reached by selecting the option **File -> Communication setup** or by pressing the icon . Set the serial number of the COM port to which the programming interface is connected, as well as the desired baud rate. If the Save to EEPROM checker is active, the set baud rate value will be recorded in the EEPROM of the DCS-100-A driver microcontroller.

NOTE: The "This is Bluetooth port" field should be left unchecked if using the IPI-USB programming interface.

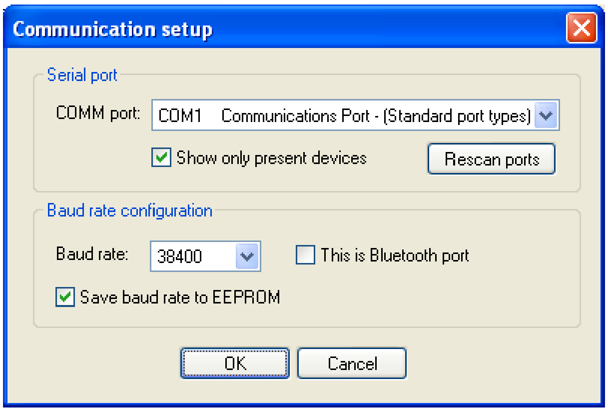


Figure 9.2 Communication setup dialog

If everything is set well at the top of the ServoTune3 application, the inscription that the driver is online with the firmware version will appear (Figure 9.3). All parameters will be read from the driver and will be written in the corresponding fields.

Figure 9.3

In the event that communication with the driver is not established, after starting the ServoTune3 software, a warning dialog will appear (Figure 8.4) and **servo offline** status on the main window as shown in Figure 9.1.

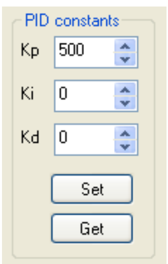
Figure 9.4 Error when opening the COM port

This error (Figure 9.4) occurs when the parameters (COM port number and baud rate) are not set correctly or when the programming interface is not connected to the driver.

In some cases, communication with the driver may be interrupted and it is necessary to exit the ServoTune3 software, reset the driver by pressing the RESET button and restart the ServoTune3 software.

9.2 Setting the constants of the PID controller

The DCS-100-A driver is based on a 16-bit RISC microcontroller in which a PID control algorithm is incorporated. The setting of these constants is done in the fields shown in the table below.

	Name	Description	Minimum	Maximum	Default
	Kp	Proportional constant	0	32768	50
	Ki	Integral constant	0	32768	0
	Kd	Differential constant	0	32768	0

Pressing the **Get** button will read the values for Kp, Ki and Kd from the EEPROM. In order to write new values in the EEPROM of the microcontroller, which were previously written in the corresponding fields, it is necessary to press the **Set** button.

NOTE: When setting the PID constants, take all precautionary measures because the servo motor-mechanics system of the machine may oscillate.

9.3 Setting the resolution multiplier of the incremental encoder

The driver DCS-100-A has the possibility of software adjustment of the resolution multiplier of the incremental encoder (resolution multiplication). Thus, with incremental encoders that have a relatively small number of pulses per revolution, it is possible to obtain 2 or 4 times higher resolution.

Enc: x1	Name	Description	Values
	Enc	Multiplication of the resolution of an incremental encoder	x1, x2 i x4

EXAMPLE:

An incremental encoder with a resolution of 500PPR (pulses per revolution) will have:

- 500PPR when multiplying the resolution of the incremental encoder 1x,
- 500PPR x 2 = 1000PPR when multiplying the resolution of the incremental encoder 2x and
- 500PPR x 4 = 2000PPR when multiplying the resolution of the incremental encoder 4x.

9.4 Setting the step multiplier

The step multiplier indicates how many steps the servo motor will take for each pulse per STEP command line. This parameter is useful in the event that a high-resolution incremental encoder is used, and the STEP command generator does not have the ability to generate pulses with a sufficiently high frequency.

Step multiplier 1 Set	Name	Description	Minimum	Maximum	Default
	Step multiplier	STEP command multiplier	1	50	1

In order to write the desired value of the step multiplier into the EEPROM, press the **Set** button.

NOTE: Larger values for the Step Multiplier can result in “choppy” motion, especially at low servo motor speeds.

9.5 Programming the enable input of the driver DCS-100-A

The DCS-100-A driver enable input programming options are given in the table below.

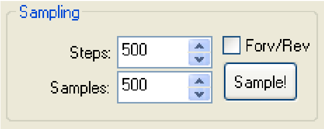
	Name	Possible choice
Enable control Software controlled Always enable	Enable control	**Software controlled** – in this mode, the ENABLE input on the Control connector Con.1 (Figure 4.1) is active. If there is an ENABLE logic “high” at the input, the driver is active and will execute the commands coming to it from the STEP and DIR command lines. If there is a logical zero at the ENABLE input, then the driver is inactive, STEP and DIR commands are not executed; the voltage at the analog output of the DCS-100-A driver will be zero (it will be blocked by the output relay). **Always enable** – in this mode, the ENABLE input on the control connector Con.1 (Figure 4.1) is not functional. The driver is always active (enabled).

The driver's ENABLE mode can be selected from the ServoTune3 software during parameter setting. Changing the state of this checker can also be done by pressing the function key F2.

Driver Enable (F2)	Name	Description	Possible choice
	Driver Enable	Driver Enable	ENABLE – selected DISABLE – not selected

9.6 Recording the response of the servo motor to the step function

In order to adjust the parameters of the PID controller as easily as possible, the ServoTune3 software provides the ability to record the response of the servo motor and the mechanics to which it is connected to the step function. In addition, it is possible to specify a certain number of steps without recording the response to the step function.

	Name	Description	Parameters		Min	Max
			Name	Description		
	Sampling	Response recording	Steps	Number of steps	1	32767*
			Samples	Number of points on the diagram	1	32767
	Steps	Step response without recording	Steps	Number of steps	1	32767*

*** The maximum value of the number of steps (Steps) should be smaller than the set value of the tracking error offset (Error offset). Otherwise, a tracking error will appear and the servo motor will be DISABLED. The tracking error is reset by pressing the RESET button or by turning off the DCS-100-A servo driver power supply.**

Activating the corresponding function is done by pressing the **Sample** or **Run** button.

By pressing the **Sample** button, or by pressing the function key F3, the servo motor will perform the set number of steps (**Steps**). By activating the **For/Rev** checker each time the **Sample** command is activated, the servo motor will perform the set number of steps alternately to one side and then to the other side.

After the execution of the **Sample** command, the response diagrams of the position of the servo motor to the step function will be drawn (Figure 9.5).

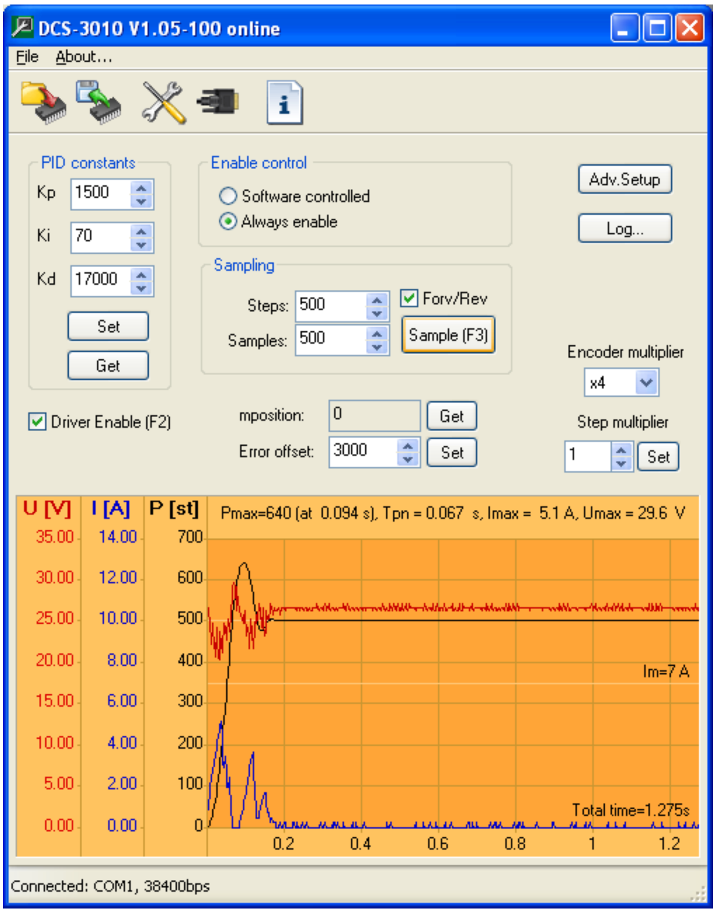


Figure 9.5

The recorded values of servo motor position, supply voltage and current through the servo motor will be saved in a file called `odziv.dat` located in the same folder where the ServoTune software is located. Below is a part of the `odziv.dat` file.

```
% ****** ServoTune sampling output ********
% Date and time: 07.12.2023 07:27:39
%  Time[s]   Position Current[mA]  Voltage[V]
  0.000000         0         244      26.63
  0.001500         1         488      27.12
  0.004000         9        1220      26.13
  0.006500        26        1464      24.65
  0.009000        48        1953      25.15
  0.011500        76        2441      22.19
  0.014000       111        2685      24.65
  0.016500       152        2685      23.67
  0.019000       200        3173      22.68
  0.021500       254        3417      20.71
  0.024500       315        3906      24.16
  0.027000       396        4150      22.68
  0.029500       471        4394      20.71
  0.032000       553        4638      20.21
```

The first column of the file is the time, the second column is the current position of the servo motor, the third column is the value of the current through the servo motor in milliamps (mA) (the values are not appropriate in the case of a DCS-100-A servo driver) and the fourth column is the change in the supply voltage of the DC motor in volts (V) (values are not appropriate in case of DCS-100-A servo driver). Values from the response.dat file can be easily loaded into software for drawing diagrams (Excel, Octave, MATLAB, etc.).

9.7 Setting the tracking error offset value

Setting the tracking error offset can be done by entering the desired value in the field called Error offset.

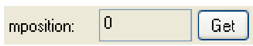
	Name	Description	Minimum	Maximum	Recommend
	Error offset	Tracking Error offset	0	32767	More than 10

In order to write the desired value of the tracking error offset into the EEPROM, it is necessary to press the **Set** button.

If the difference between the set point and the current position of the servo motor exceeds the set tracking error offset value, the Tracking Error output (on the Control port) will be activated, the **OP/ER** indicator will indicate Tracking error and the servo motor will be DISABLED. The tracking error offset error is reset by pressing the RESET button or by turning off the power supply of the DCS-100-A servo driver

9.8 Reading the current position of the servo motor

Reading the current position of the servo motor, or position of the incremental encoder (mposition) is obtained by pressing the **Get** button.

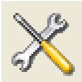
	Name	Description
	mposition	The current position of the servo motor

9.9 Saving and loading the configuration

Once set, the configuration can be saved as a configuration file by selecting **File -> Save config...** or by pressing the button .

Likewise, the configuration file with all settings can be loaded into the DCS-100-A servo driver by selecting **File -> Load config...** or by pressing the button .

9.10 Advanced Setup

By pressing the button **Adv. Setup** (Figure 9.6) or the icon  displays a dialog with a selection of options for advanced settings (Figure 9.7).

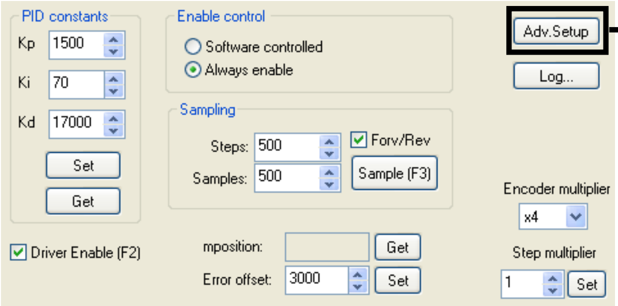


Figure 9.6

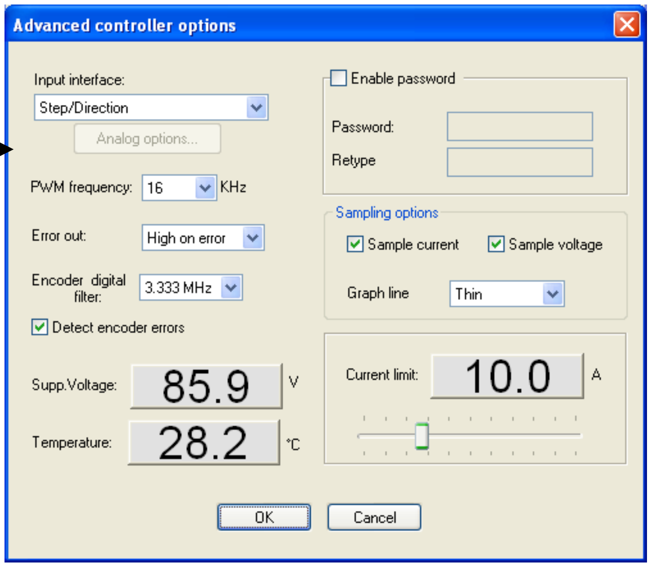


Figure 9.7

Advanced settings include a selection of options:

- input interface,
- PWM frequency,
- logical level at the Error output in the event of an error,
- digital filter at the input for the incremental encoder,
- incremental encoder error detection,
- protection of the set parameters with a password,
- selection of parameters to be displayed on the main diagram and
- DC motor maximum current (not available for DCS-100-A servo driver).

In order to write any of the above values into the EEPROM of the microcontroller, it is necessary to press the OK button (Figure 9.7).

9.10.1 Input interface

Servo motor control is done via 3 command lines available on connector Con.1. The first two command lines are named STEP/DIR in this manual, while the third is ENABLE (Figure 4.2 and Table 4.1). The input interface option provides the possibility to choose the control mode via the three command lines mentioned above, or via the analog input in the following modes:

- Step/Direction ie. STEP/DIR/ENABLE,
- StepUp/StepDown ie. CW/CCW/ENABLE,
- Enkoder x1 /ENABLE,
- Enkoder x2 /ENABLE,
- Enkoder x4 /ENABLE,
- Analog input with feedback (Analog with FB) and
- Analog input without feedback (Analog without FB).

NOTE: Encoder 1x, 2x and 4x input interface configurations have not been thoroughly tested.

The driver has the ability to control the servo motor via a voltage signal of 0–5V which is fed to the analog input (Figure 4.1, Con.4). It is possible to directly connect a potentiometer with a nominal resistance of 1–10kΩ (Figure 4.13.a) or a motion path generator (Figure 4.13.b) to the analog input. See chapter 4.5 of this manual.

If one of the options with analog input is selected, the **Analog option...** button will become active and after its activation, one of the dialogs will appear, as shown in Figure 9.8.

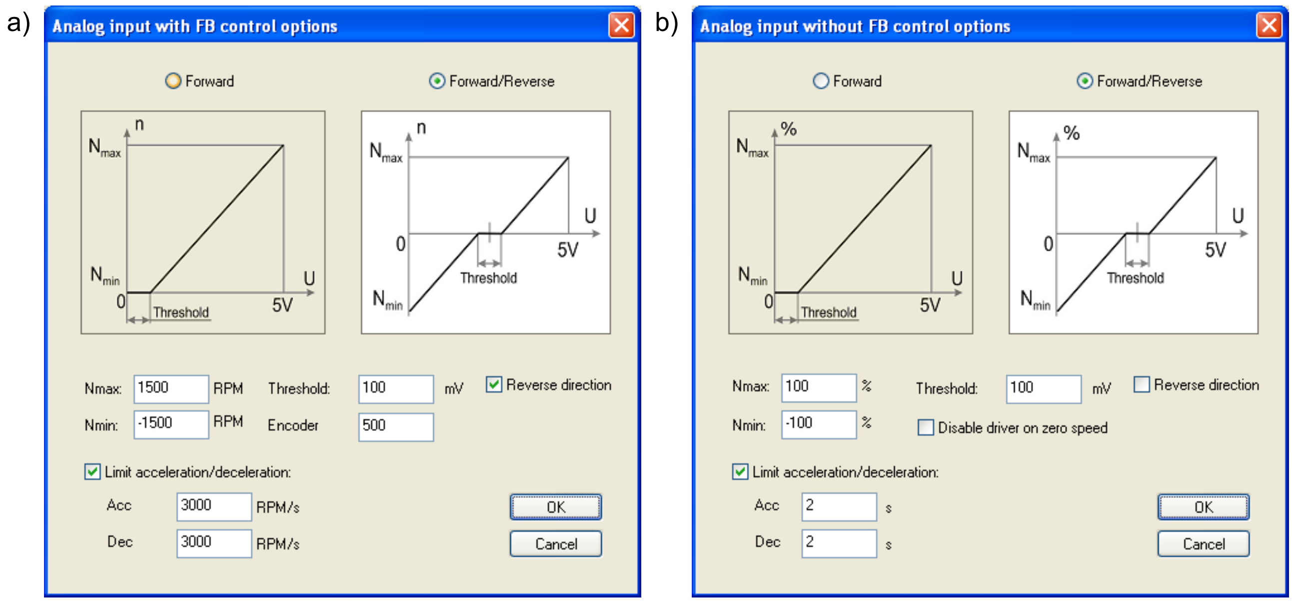


Figure 9.8 Dialog for setting parameters, a) analog input with feedback and b) analog input without feedback

The dialog for setting analog input parameters provides a choice:

- One or two directions of rotation of the DC motor (Forward or Forward/Reverse),
- Changing the direction of protection of the DC motor (Reverse direction),
- Maximum Nmax and minimum Nmin number of revolutions.
  - In the case of selecting an analog input with feedback (Analog with FB), the values of Nmax and Nmin are in revolutions per minute (RPM).
  - In the case of selecting an analog input without feedback (Analog without FB), the values of Nmax and Nmin are given as a percentage (%) in relation to the supply voltage of the DC motor.
- Width of the inactive zone (Threshold) expressed in mV.
- Number of lines of the incremental encoder (Encoder) in case of selection of analog input with feedback (Analog with FB).
- DC motor disabling options in case the set speed is equal to zero in case of analog input selection without feedback (Analog without FB).
- Acceleration (Acc) and deceleration (Dec) parameters of the DC motor (Limit acceleration/deceleration).
  - In case of selection of analog input with feedback (Analog with FB) Acc and Dec values are in revolutions per minute per second (RPM/s).
  - In case of selection of analog input without feedback (Analog without FB) the values of Acc and Dec are in seconds (s).

9.10.2 PWM frequency

This option provides the possibility to adjust the frequency of the output PWM signal:

- 10 kHz,
- 12 kHz,
- 14 kHz,
- 16 kHz (default value for DCS-3010),
- 18 kHz,
- 20 kHz and
- 32 kHz (default value for DCS-100-A).

9.10.3 Logical level at the Error output in the case of an error

The selection of the logic level in the case of one of the errors on the Error output is given in the table below.

	Name	Possible choices – Description
	Error out	**High on error** – In the case of an error, the Error output will be a logical unit **Low on error** – In the case of an error, the Error output will be logical zero **Always low** – The Error output will always have a logical zero regardless of the existence of an error

9.10.4 Digital filter for incremental encoder

The settings of the digital filter for the input of the incremental encoder are made by selecting its upper frequency, namely:

- Switched of digital filter (Turn OFF),
- Filter frequency 6.667 MHz,
- Filter frequency 3.333 MHz (default),
- Filter frequency 1.667 MHz,
- Filter frequency 416.7 kHz,
- Filter frequency 208.3 kHz,
- Filter frequency 104.2 kHz,
- Filter frequency 52.1 kHz and
- Filter frequency 26.0 kHz.

The digital filtering option of the incremental encoder signal can be useful in an environment with strong electromagnetic interference that can lead to errors in the incremental encoder position reading.

NOTE: Filter frequencies of 1.667 MHz, as well as lower filter frequencies (more aggressive filtering) can potentially result in loss of position from the incremental encoder.

9.10.5 Incremental encoder error detection

If this option is enabled, the driver software checks whether there is a level change on both encoder inputs. If this is not the case, the output stage will be disabled and the OP/ER LED indicator will indicate an error of the incremental encoder.

NOTE: In some cases this error may be triggered even though the incremental encoder is working properly. Check experimentally for a specific case.

9.10.6 Reading servo motor supply voltage and driver temperature (not for DCS-100-A)

The reading of servo motor supply voltage and servo driver temperature in °C is not available for the DCS-100-A driver (Figure 9.9).

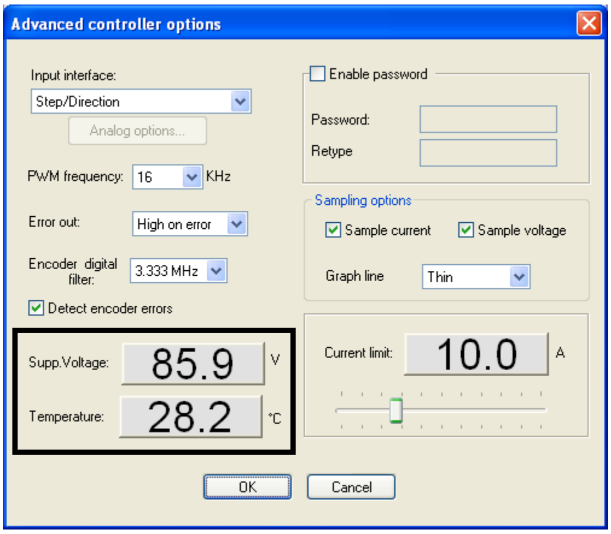


Figure 9.9 Boxed fields are not available on the DCS-100-A driver

9.10.7 Entering the password

The ServoTune3 software provides the possibility of entering a security code in order to prevent unauthorized changes to the set parameters of the DCS-100-A servo driver.

In order to activate this option, it is necessary to select the checker **Enable password** (Figure 9.10), which makes the fields **Password** and **Retype** active and it is then possible to enter the desired password. When the code is entered, a dialog (Figure 9.11) for entering the security code will appear every time the ServoTune3 software is started and the connection with the driver is established, which becomes a condition for accessing the set parameters.

NOTE: Keep the password in a safe place.

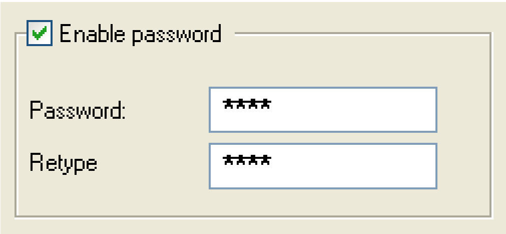


Figure 9.10 Dialog for entering the password

Figure 9.11 Dialog for entering the password when starting the ServoTune3 software

9.10.8 Selection of main diagram options

In the part of the dialog for advanced settings Advanced setup (Figure 9.12) (Sampling options) select:

Which of the parameters will be displayed on the main diagram and

The thickness of the lines with which the diagrams will be drawn (Thin, Medium and Thick).

With the DCS-100-A servo driver, there is no need to draw a diagram of the current and voltage changes on the servo motor because these values are not measured.

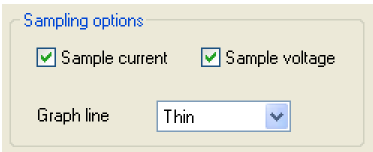


Figure 9.12

9.10.9 Setting the maximum servo motor current (not for DCS-100-A)

The maximum current of the servo motor is adjusted via the slider shown in Figure 9.13. The above option is not available for the DCS-100-A servo driver.

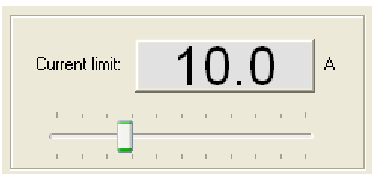


Figure 9.13

9.10.10 Recording the LOG file

The recording of a log file with values of set positions, current errors, current values of current and voltage on the servo motor is activated by pressing the **Log** button (Figure 9.14), which opens the Logging dialog (Figure 9.15).

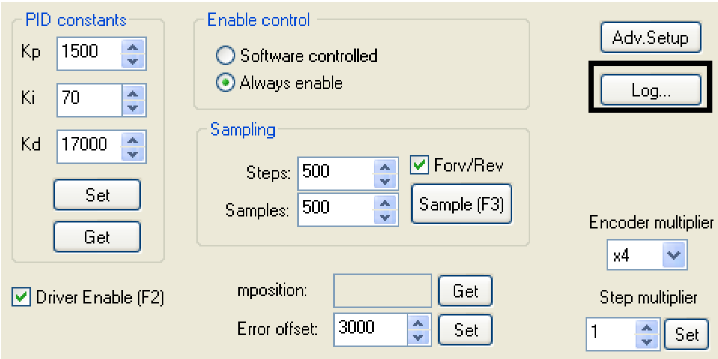


Figure 9.14 Log key position

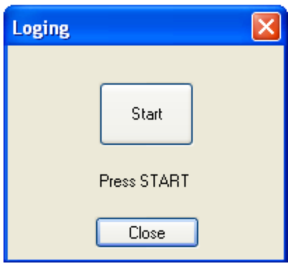


Figure 9.15 Log dialog

The start of log file recording is activated by pressing the Start button, and recording is stopped by pressing this button again. The data will be saved in a file called `servo.log` located in the same folder as the ServoTune3 software. Below is a small part of the `servo.log` file.

```
% *********** ServoTune log output file ************
% Date and time: 07.12.2023 19:00:05
%  Time[s]    Position  PosDiff Current[mA] Voltage[V]
  0.020960        -401         0          0      98.23
  0.023580        -401         0          0      98.23
  0.025676        -401         0          0      98.23
  0.027772        -401         0          0      97.78
  0.029868        -401         0          0      98.23
  0.032488        -401         0          0      98.23
  0.034584        -401         0          0      98.89
  0.036680        -400         1          0      98.23
  0.000000        -396         5          0      98.23
  0.001572        -386        13          0      98.23
  0.003668        -373        20          0      97.78
  0.005764        -349        32        119      97.02
  0.007860        -325        39        833      95.45
  0.009956        -296        44       1310      94.02
  0.012576        -263        39       1905      93.25
  0.014672        -226        38       2381      92.15
```

Thereby:

- The First column is time in seconds,
- The Second column is the set position of the DC motor,
- The Third column is the positioning error (tracking error), or the difference between the setpoint and the current position of the DC servo motor expressed in steps,
- The Fourth column represents the value of the current through the DC motor in mA (not for DCS-100-A) and
- The Fifth column is the DC motor supply voltage in V (not for DCS-100-A)

The values from the file `servo.log` can be easily loaded into some of the software for drawing diagrams (Excel, Octave, MATLAB, etc.).

Figure 9.16 gives an example of a servo motor position change diagram from one record of the `servo.log` file.

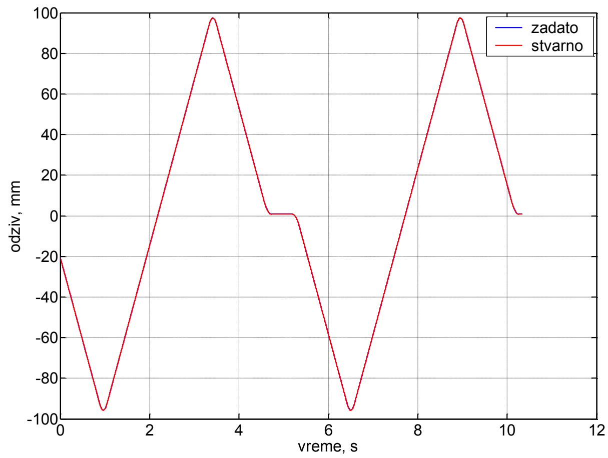


Figure 9.16 Diagram of the change of setpoint and actual position of the DC servo motor

10 PROCEDURE FOR ADJUSTING THE CONSTANTS OF THE PID REGULATOR

NOTE: When setting the constants of the PID controller, take all precautions because oscillation of the machine's servo motor-mechanics system may occur.

The constant values of the PID controller depend on:

- Characteristics of the DC motor (moment of inertia, supply voltage, maximum current, etc.),
- Material characteristics of the mechanics to which the DC motor is connected (mass, damping, etc.),
- Resolutions of the incremental encoder mounted on the DC motor and
- Set multiplications of the resolution of the incremental encoder (x1, x2 or x4).

Once set, the PID controller constants are only valid for that configuration. If there is a change in the configuration (some of the parameters mentioned above), it is necessary to reset the PID constants.

NOTE: During the adjustment of the constants of the PID controller, do not change the multiplication of the resolution of the incremental encoder.

10.1 Example of setting PID controller constants

The following is a description of the procedure for setting the constants of the PID controller. The resolution of the incremental encoder in this case was 500PPR, the multiplication of the resolution of the incremental encoder is x4, so the total resolution of the incremental encoder was 2000PPR.

STEP 1: The initial value of the PID constant is:

- Kp = 50,
- Kd = 0 and
- Ki = 0.

Slowly increase the constant Kp until a response similar to that shown in Figure 10.1 is obtained.

STEP 2: Increase the Kd constant until the system response "settles down" (Figure 10.2). The constant Kd can be significantly higher than the constant Kp.

STEP 3: Gradually increase the constants Kp and Ki until the response is similar to Figure 10.3. It should be noted here that the Ki constant is much smaller compared to the other two constants.

Repeat steps 2 and 3 until the DC motor shaft behaves as if the motor is "locked". In addition, check the engine in operation on the machine at various operating speeds (there must be no oscillations and tremors during operation).

STEP 4: Figure 10.4 gives the final values of the PID controller constants and the motor response.

The values of the PID constants set in this way must be checked during machine operation and corrected if necessary.

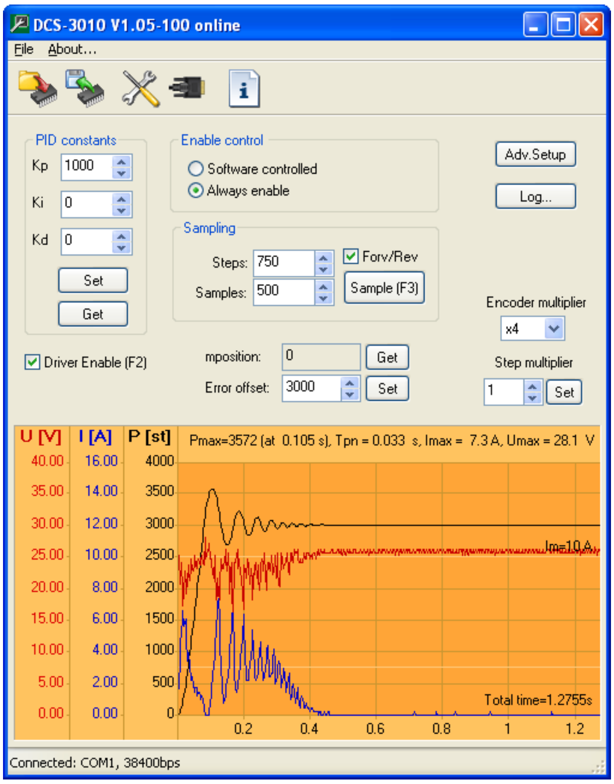


Figure 10.1

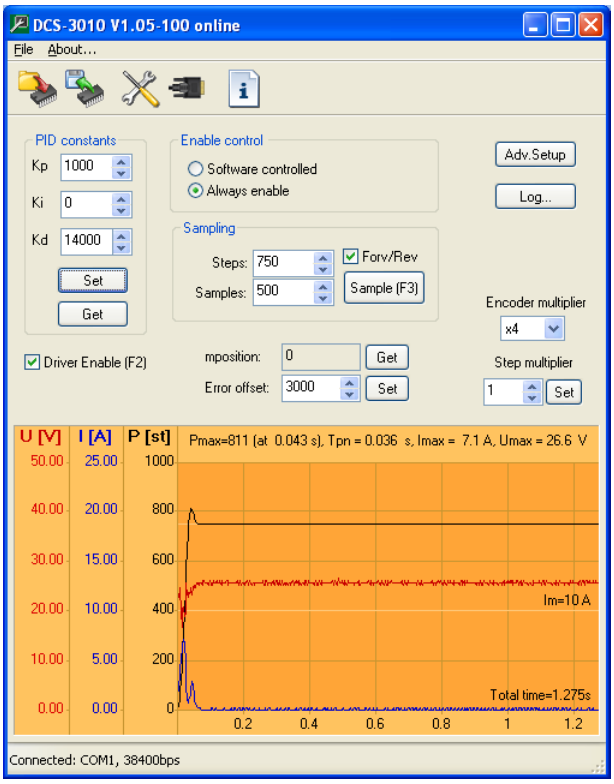


Figure 10.2

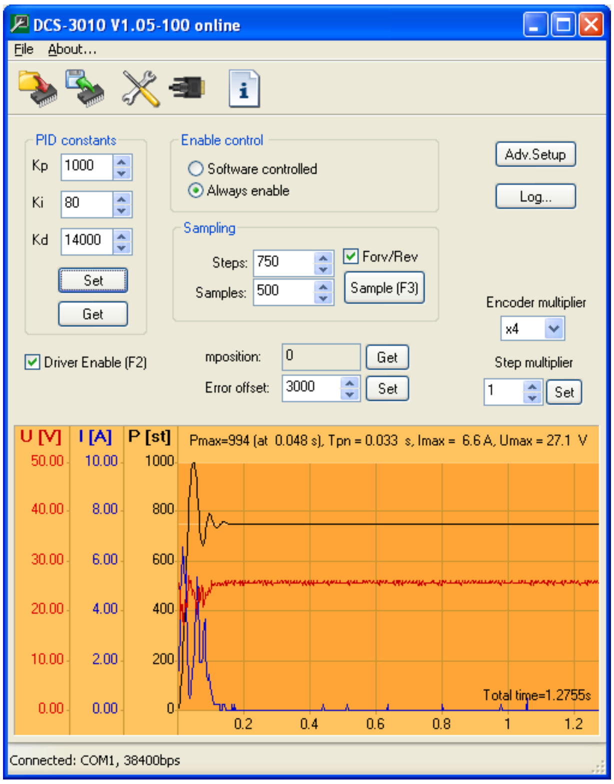


Figure 10.3

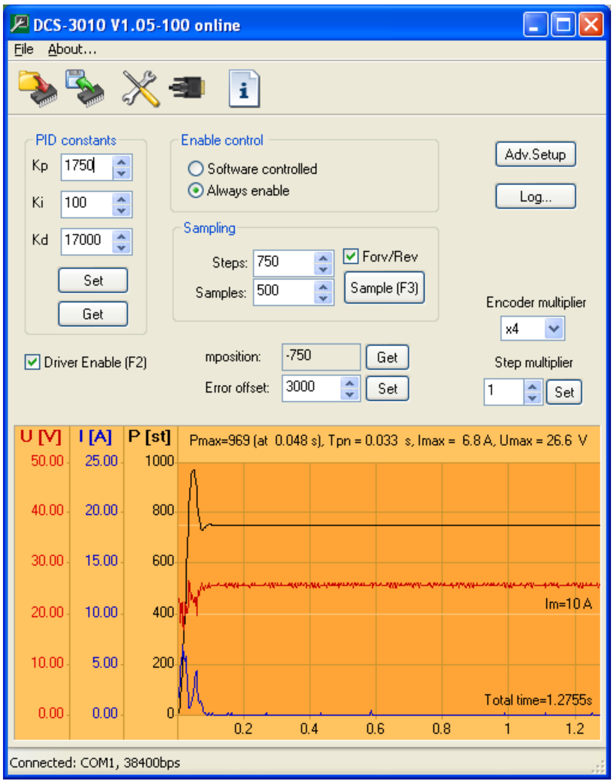


Figure 10.4

10.2 Automatic adjustment of PID parameters

The option of automatic determination and adjustment of PID parameters is available from ServoTune3 software version v3.07. The dialog for automatic setting of PID parameters is accessed by pressing the **AutoPID** (Figure 10.5) button. After that, a warning dialog will appear (Figure 10.6).

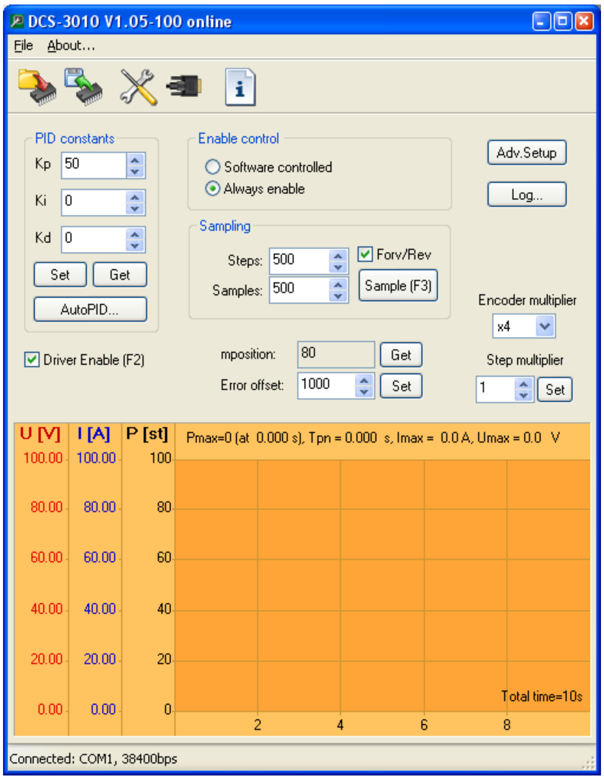


Figure 10.5

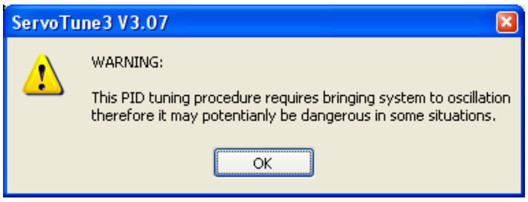


Figure 10.6

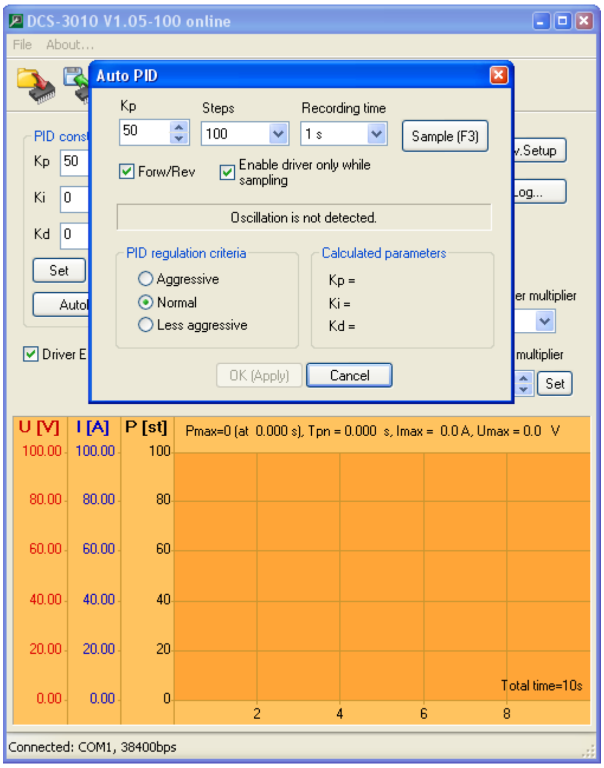


Figure 10.7

NOTE: The procedure of automatically determining and setting the constants of the PID regulator implies bringing the servo driver – servo motor system and the mechanics of the machine into an unstable state, that is, it is necessary for the mentioned system to oscillate.
The procedure of automatic setting of PID parameters is carried out by the user at his own risk.

Within the **AutoPID** dialog (Figure 10.7), it is possible to set the following parameters:

- The proportional constant **Kp**.
- The number of **Steps** that defines the bounce function. The pull-down menu provides the possibility to choose previously defined values for the number of steps, namely: 100, 150, 200, 250, 300, 400, 500, 750 and 1000. Choose the value of the number of steps that corresponds approximately to 5-10% of the number of steps that is required for the DC motor to make a full revolution.
  EXAMPLE: The incremental encoder has 500PPR and the Encoder multiplier x4 option is selected. In this case, it takes 500 x 4 = 2000 steps for the DC motor to make a full revolution. Recommended values for Steps would be 100, 150, or 200.
- **Recording time** that can be selected via the pull-down menu: 1s, 2s, 3s, 4s and 5s. Considering that during the recording of the system response, it is necessary to bring the system into a state of oscillation, it is recommended that this time be as short as possible.
- Alternating the direction of rotation of the servo motor when recording the jump function (**Forw/Rev** option). It is recommended that this option be active.
- **Enable driver only while sampling** option. It is recommended that this option be active.

The procedure for determining the constants of the PID controller implies a gradual increase in the constant **Kp**. Every time the Kp constant changes, the **Sample (F3)** button or the F3 function key must be pressed to record the system response. The parameter **Kp** is increased gradually and carefully until the system oscillation occurs, as shown in Figure 10.8, Figure 10.9 and Figure 10.10. Here it is important to note that these images do not show all the steps during the gradual increase of the **Kp** parameter.

The ServoTune3 software will recognize that the system has oscillated, as shown in Figure 10.10 (**Oscillation is detected...**) and will suggest the PID regulator constants **Kp**, **Ki** and **Kd** depending on the set criteria for PID regulation. It is possible to choose the following criteria:

- **Aggressive**,
- **Normal** or
- **Less aggressive**.

By pressing the **OK (Apply)** button, the calculated PID parameters will be written into the EEPROM of the DCS-100-A driver microcontroller.

Check the behavior of the servo motor with the parameters of the PID controller calculated in this way (Figure 10.11). If necessary, manually fine-tune the parameters of the PID controller.

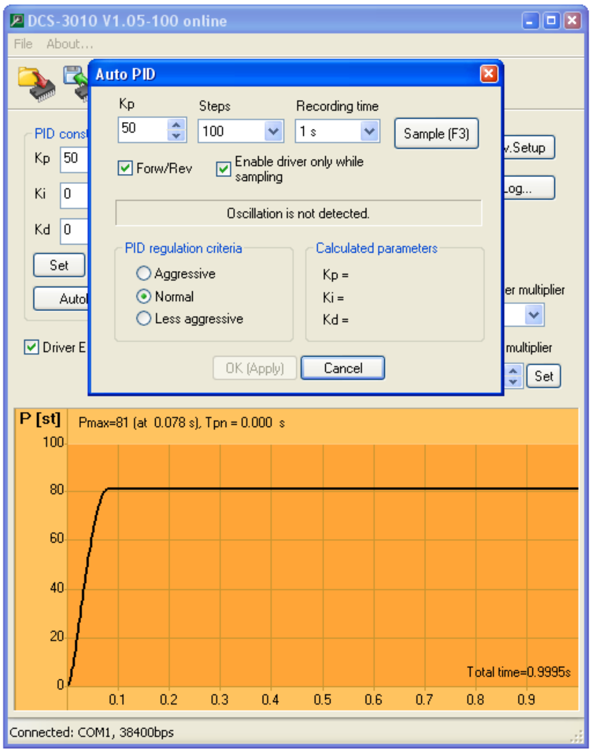


Figure 10.8

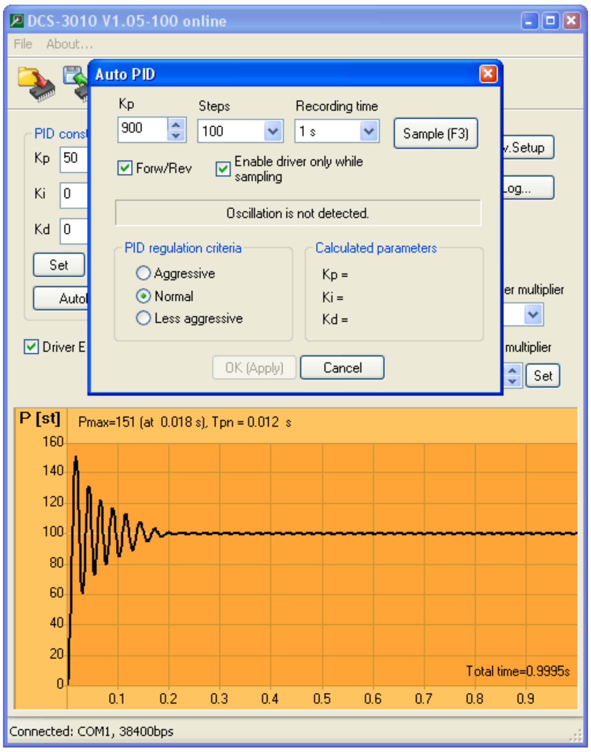


Figure 10.9

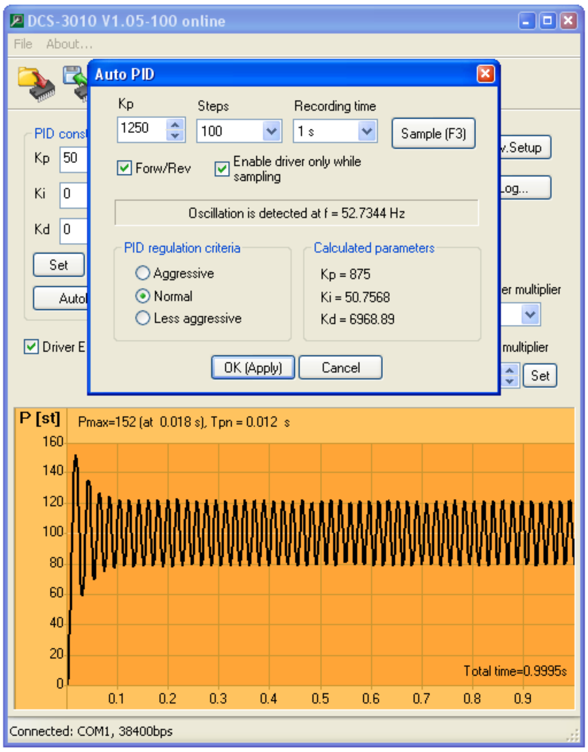


Figure 10.10

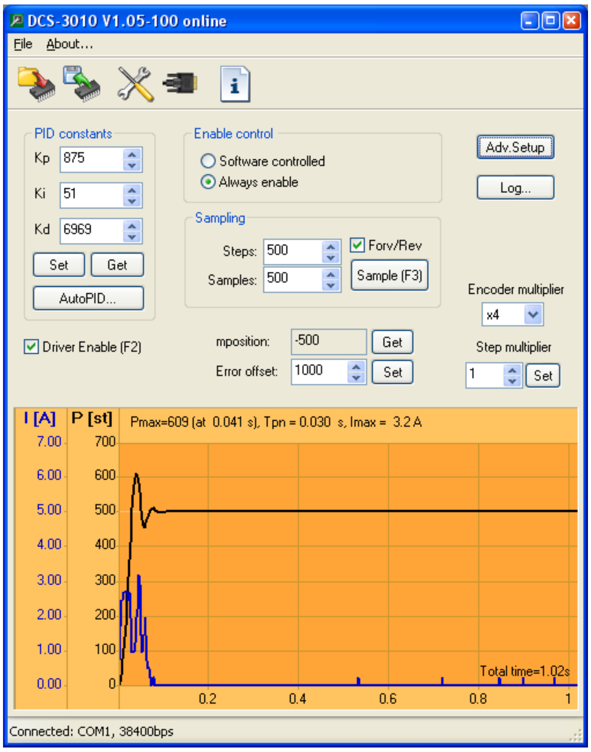


Figure 10.11

DOCUMENT REVISION:

- Ver. 1.0, June 2016, Initial version
- Ver. 1.1, November 2020, Minor revision
- Ver. 2.0, February 2024, New hardware version DCS-100-A V.3 and change of manual accordingly
- Ver. 2.1, May 2024, Updated schematic diagram of incremental encoder connection with encoder interface SED2. Added chapter 6. Minor revisions