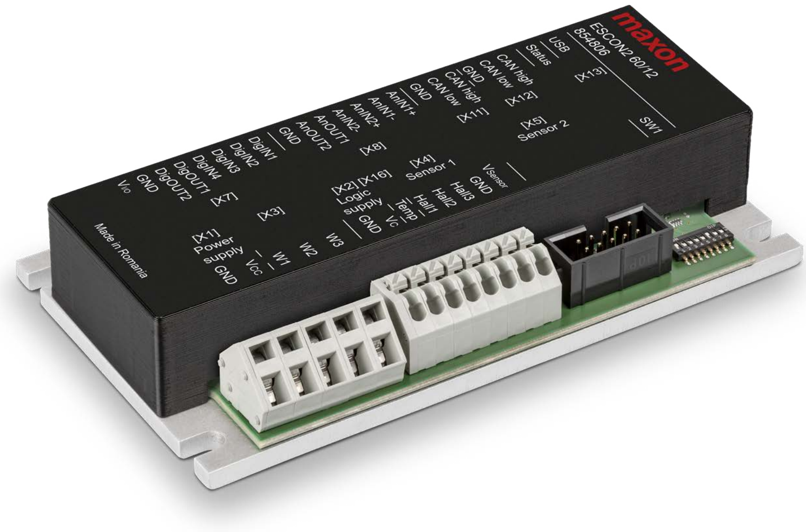
maxon

Servo Controller

ESCON2 60/12

Hardware Reference



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I/O

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READ THIS FIRST

These instructions are intended for qualified technical personnel. Prior commencing with any activities*…*

- *you must carefully read and understand this manual and*
- *you must follow the instructions given therein.*

The ESCON2 60/12 *is considered as partly completed machinery according to EU Directive 2006/42/EC, Article 2, Clause (g) and* ***are intended to be incorporated into or assembled with other machinery or other partly completed machinery or equipment****.*
Therefore, you must not put the device into service*,…*

- *unless you have made completely sure that the other machinery fully complies with the EU directive's requirements!*
- *unless the other machinery fulfills all relevant health and safety aspects!*
- *unless all respective interfaces have been established and fulfill the herein stated requirements!*

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1 ABOUT

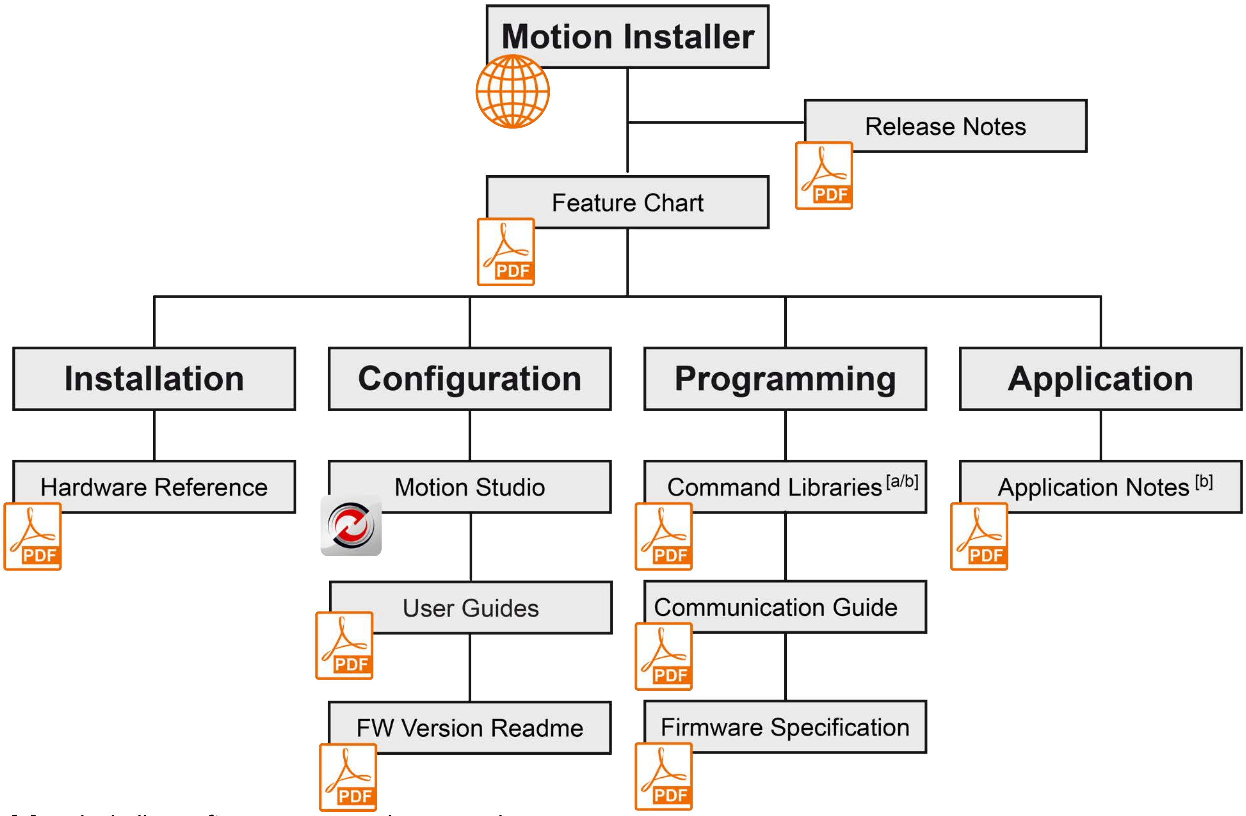
1.1 About this document

1.1.1 Intended purpose

This document familiarizes you with the ESCON2 60/12 Servo Controller. It describes the tasks for safe and proper installation and commissioning. Follow the instructions:

- to avoid dangerous situations,
- to keep installation and/or commissioning time at a minimum,
- to increase reliability and service life of the described equipment.

This document is part of a documentation set. It includes performance data, specifications, standards information, connection details, pin assignments, and wiring examples. The overview below shows the documentation hierarchy and how its parts are related:



[a] including software programming examples
[b] will be available with upcoming release

Figure 1-1 Documentation structure

Find the latest edition of this document, along with additional documentation and software for ESCON2 Servo Controller, at: http://escon.maxongroup.com

1.1.2 Target audience

This document is intended for trained and skilled personnel. It provides information on how to understand and perform the respective tasks and duties.

1.1.3 How to use

Follow these notations and codes throughout the document.

Notation	Meaning
ESCON2	stands for «ESCON2 Servo Controller»
«Abcd»	indicating a title or a name (such as of document, product, mode, etc.)
(n)	refers to an item (such as a part number, list items, etc.)
*****	refers to an internal value
➔	denotes “check”, “see”, “see also”, “take note of” or “go to”

Table 1-1 Notations used in this document

1.1.4 Symbols & signs

This document uses the following symbols and signs:

Type	Symbol	Meaning
Safety alert DANGER		Indicates an **imminent hazardous situation**. If not avoided, it **will result in death or serious injury.**
WARNING		Indicates a **potential hazardous situation**. If not avoided, it **can result in death or serious injury.**
CAUTION		Indicates a **probable hazardous situation** or calls the attention to unsafe practices. If not avoided, it **may result in injury.**
Prohibited action	(typical)	Indicates a dangerous action. Hence, **you must not!**
Mandatory action	(typical)	Indicates a mandatory action. Hence, **you must!**
Requirement, Note, Remark		Indicates an activity you must perform prior to continuing, or gives information on a particular point that must be observed.
Best practice		Indicates an advice or recommendation on the easiest and best way to further proceed.
Material Damage		Indicates information particular to possible damage of the equipment.

Table 1-2 Symbols and signs

1.1.5 Trademarks and brand names

For easier reading, the registered brand names below are not marked with their trademarks. Understand that these brands are protected by copyright and other intellectual property rights, even if trademarks are not shown later in this document.

Brand Name	Trademark Owner
Adobe® Reader®	© Adobe Systems Incorporated, San Jose, California, United States
Bel Fuse®	© Bel Fuse, Jersey City, New Jersey, United States
BiSS	© iC-Haus GmbH, Bodenheim, Germany
Bourns®	© Bourns, Inc., Riverside, California, United States
CANopen® CiA®	© CiA CAN in Automation e.V, Nuremberg, Germany
Panasonic®	© Panasonic Corporation, Kadoma, Ōsaka, Japan
Pulse®	© Pulse Electronics a YAGEO company, San Diego, CA, United States
Samtec®	© Samtec Europe GmbH, Germering, Germany
ST Microelectronics®	© STMicroelectronics SA, Plan-les-Ouates, France
Texas Instruments®	© Texas Instruments Inc., Dallas, Texas, United States
Vishay®	© Vishay Precision Group, Malvern, Pennsylvania, United States
Windows®	© Microsoft Corporation, Redmond, Washington, United States

Table 1-3 Brand names and trademark owners

1.1.6 Copyright

CCMC | ESCON2 60/12 Hardware Reference | Edition 2025-06 | DocID rel12875

1.2 About the device

The ESCON2 60/12 is a small, powerful 4-quadrant PWM Servo Controller. Its high power density allows flexible use for brushed DC motors and brushless EC (BLDC) motors up to 720 Watts. It supports various feedback options, such as Hall sensors, incremental encoders, and absolute sensors for many drive applications.

The device can operate with analog or digital set values. It can also operate as a slave node in a CANopen network. You can control the device through a USB port on a Windows workstation. The device has several analog and digital input and output functions. It uses spring clamps for fast and easy wiring.

The device uses advanced control technology. This includes field-oriented control (FOC) and acceleration or velocity feedforward. The control loop uses a high cycle rate to support precise motion control.

You can find the latest edition of this document on the Internet: ➔http://escon.maxongroup.com. This website also gives you access to related documents and software for ESCON2 servo controllers.

In addition, you can watch video tutorials in the ESCON video library. These tutorials show how to start with «Motion Studio». They also show how to set up communication interfaces and give helpful tips. Explore the video library on Vimeo: ➔https://vimeo.com/album/4646396

1.3 About the safety precautions

- Read and understand the note ➔«READ THIS FIRST»!
- Do not start any work unless you have the required skills ➔Chapter “1.1.2 Target audience” on page 1-5
- Refer to ➔Chapter “1.1.4 Symbols & signs” on page 1-6 to understand the symbols used.
- Follow all applicable health, safety, accident prevention, and environmental protection regulations for your country and work site.

DANGER

High voltage and/or electrical shock
Touching live wires can cause death or serious injuries.
- *Treat all power cables as live unless proven otherwise.*
- *Ensure neither end of the cable is connected to live power.*
- *Ensure the power source cannot be turned on while you work.*
- *Follow lock-out/tag-out procedures.*

Requirements
- *Install all devices and components according to local regulations.*
- *Electronic devices are not fail-safe. Install separate monitoring and safety equipment for each machine. If the machine has a failure, the drive system must go into a safe state and stay in this state. Possible failures include incorrect operation, failure of the control unit, failure of the cables, or other faults.*
- *Do not repair any components that maxon supplies.*

Electrostatic sensitive device (ESD)
- *Observe precautions for handling Electrostatic sensitive devices.*
- *Handle the device with care.*

2 SPECIFICATIONS

2.1 Technical data

ESCON2 60/12 (P/N 854806)		
Electrical data	Nominal power supply voltage V_{CC}	10…60 VDC
	Nominal logic supply voltage V_C	10…60 VDC
	Absolute supply voltage V_{min} / V_{max}	8 VDC / 62 VDC
	Output voltage (max.)	0.90 × V_{CC}
	Output current I_{cont} / I_{max} (< 5 s) [a]	12 A / 24 A
	Pulse Width Modulation (PWM) frequency	100 kHz
	Sampling rate PI current controller	50 kHz
	Sampling rate PI speed controller	10 kHz
	Sampling rate analog input	50 kHz
	Max. efficiency	97.5 % ➔Figure 2-3
	Max. speed DC motor	limited by max. permissible motor speed and max. output voltage (controller)
	Max. speed EC motor (FOC)	120'000 rpm (1 pole pair)
	Built-in motor choke per phase	22 µH / 12 A
Inputs & outputs	Sensor 1 Digital Hall sensor H1, H2, H3	0...24 VDC (internal pull-up)
	Sensor 2 (choice between multiple functions): • Digital incremental encoder • SSI absolute encoder [b] • BISS C absolute encoder [b] • High-speed digital inputs 1…2 • High-speed digital inputs 3…4 • High-speed digital output 1	 2-channel, EIA/RS422, max. 6.67 MHz 0.1...2 MHz (single-ended, configurable) 0.1...4 MHz (single-ended, configurable) EIA/RS422, max. 6.67 MHz Logic: 0...12 VDC, max. 6.25 MHz 3.3 VDC / I_L ≤ 24 mA / R_i = 75 Ω
	Digital Inputs 1...4	Logic: 0…30 VDC, inputs 1…2 PWM capable
	Digital Outputs 1...2	max. 36 VDC / I_L ≤ 500 mA (open drain with internal pull-up)
	Analog Inputs 1...2	Resolution 12-bit, ± 10 VDC (differential), 10 kHz
	Analog Outputs 1...2	Resolution 12-bit, ± 4 VDC (referenced to GND), 25 kHz
	Motor temperature sensor [b]	Resolution 12-bit, 0...3.3 VDC (internal pull-up)
Voltage outputs	Sensor supply voltage V_{Sensor}	5 VDC / I_L ≤ 145 mA
	Peripheral supply voltage $V_{Peripheral}$	-
Motor connections	DC motor	+ Motor, − Motor
	EC motor	Motor winding 1, Motor winding 2, Motor winding 3

Continued on next page.

ESCON2 60/12 (P/N 854806)			
Communi-cation interfaces	CAN		Max. 1 Mbit/s
	RS232		-
	USB		12 Mbit/s (Full Speed)
Status indicators	Device status		Operation (green) Warning/Error (red)
Mechanical data	Dimensions (L × W × H)		116 × 67 × 24 mm
	Weight (approx.)		182 g
	Mounting		M3 screws
Environmen-tal conditions	Temperature	Operation	−30…+45 °C
		Extended range [c]	+45…+85 °C Derating approx. -0.30 A / °C ➔Figure 2-2
		Storage	−40…+85 °C
	Altitude [d]	Operation	0…500 m MSL
		Extended range [c]	Derating data available on reqest
	Humidity		5…90 % (condensation not permitted)

[a] The duration of the maximum output current depends on the electronics temperature and is limited automatically.
[b] The functionality will be available with a future firmware release.
[c] Operation within the extended range is permitted. However, a respective derating (declination of output current I_{cont}) as to the stated values will apply.
[d] Operating altitude in meters above Mean Sea Level, MSL.

Table 2-4 Technical data

2.2 Thermal data

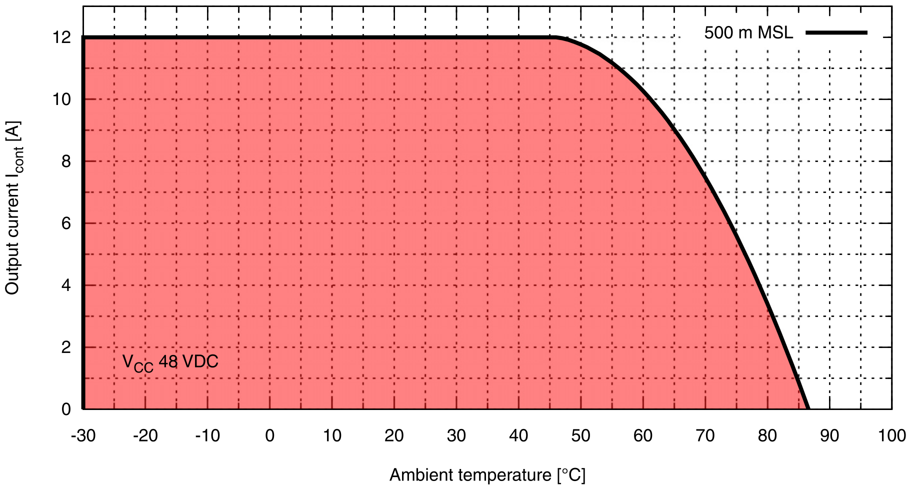
Mandatory operation within the specified limits

- *Operation within the specified thermal limits is mandatory.*
- *If the ambient temperature exceeds the specified limits, thermal overload can occur even at low output currents.*

2.2.1 Test setup for data collection

Unless stated otherwise, the thermal data was measured with the unit in an upright position. The unit was placed on holders with low thermal conductivity (floating in air).

2.2.2 Derating of output current (operation without additional heat sink)



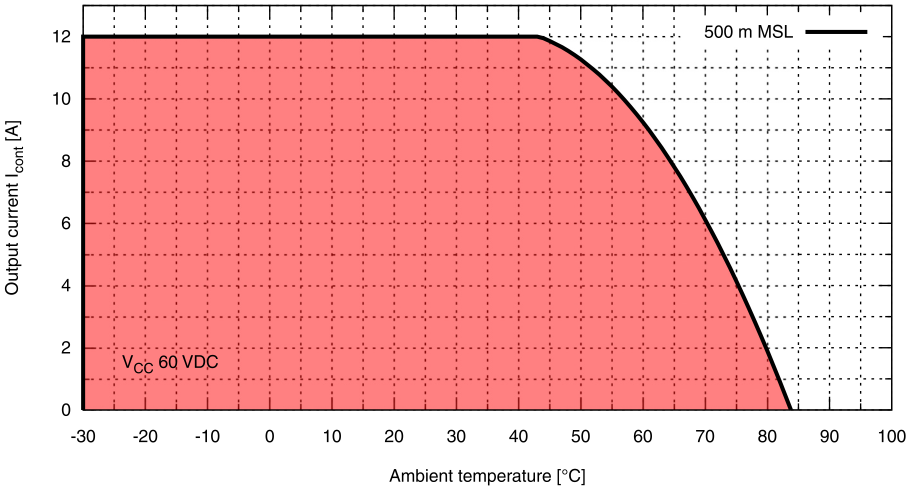


Figure 2-2 Derating of output current (operation without additional heatsink)

2.2.3 Power dissipation and efficiency

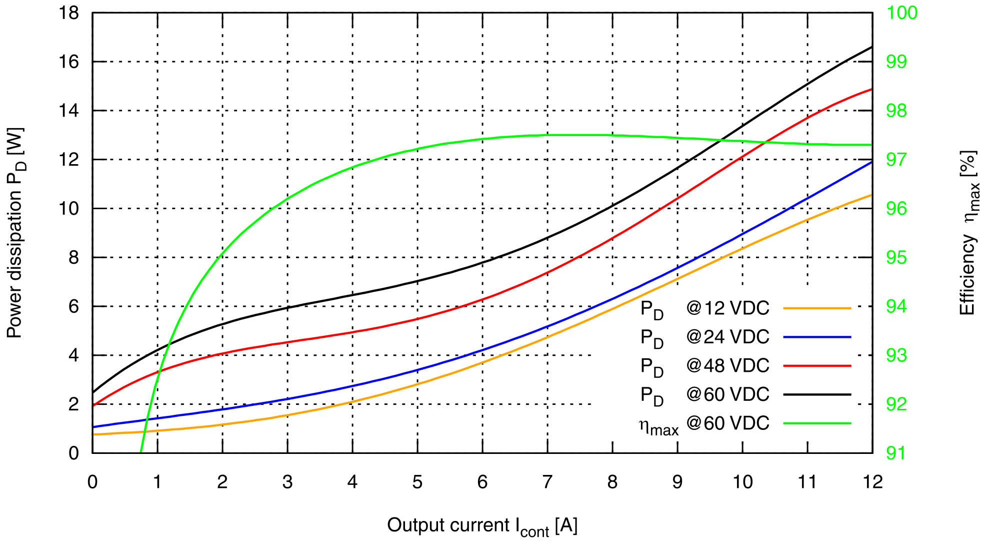


Figure 2-3 Power dissipation and efficiency

2.3 Limitations

Functionality		Switch-off threshold	Recovery threshold
Undervoltage		7.5 VDC	7.75 VDC
Overvoltage		65 VDC	64 VDC
Overcurrent		55.3 A	—
Thermal overload	logic	108 °C	98 °C
	power stage	100 °C	—

Table 2-5 Limitations

The device has a configurable output current limit and an overcurrent protection function. This protects the controller in case of a short circuit in a motor winding or a damaged power stage. The undervoltage, overvoltage, and thermal overload power stage protection limits are also configurable. For the thermal overload power stage protection, a linear derating of the maximum output current is implemented, which starts 10 °C below the switch-off threshold. For more information, see the «ESCON2 Firmware Specification».

2.4 Dimensional drawing

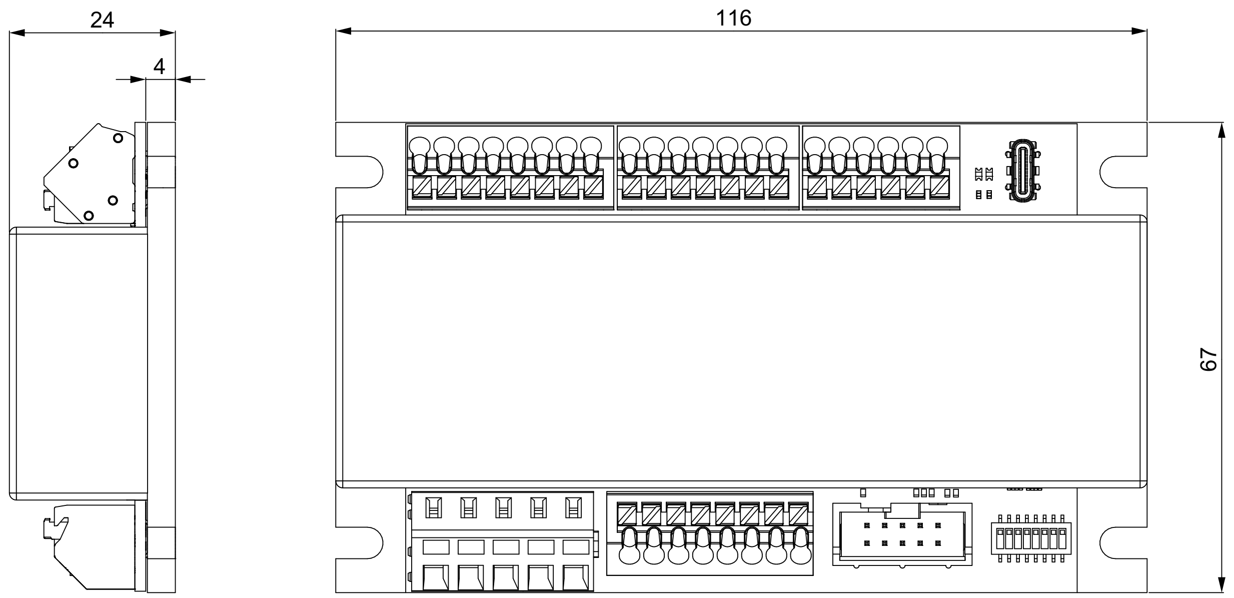


Figure 2-4 Dimensional drawing [mm]

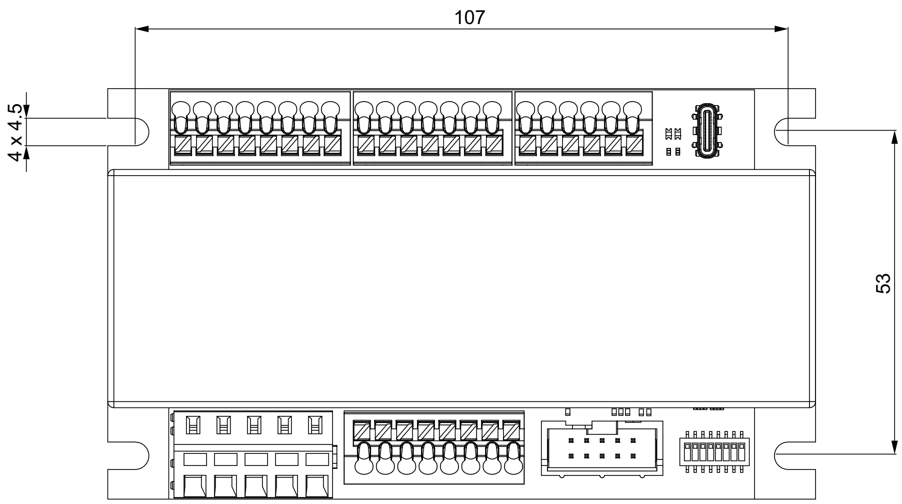


Figure 2-5 Dimensional drawing – Attachment points [mm]

2.5 Standards

The described device has been successfully tested for compliance with the standards listed below. Only the complete system (fully operational equipment with all components, such as the motor, servo controller, power supply unit, EMC filter, and cabling) can undergo an EMC test to ensure interference-free operation.

Important Notice
Compliance of the device with the mentioned standards does not guarantee compliance in the final, ready-to-operate setup. To achieve compliance for your operational system, you must perform EMC testing on the complete equipment as a whole.

Electromagnetic compatibility		
Generic	IEC/EN 61000-6-2	Immunity for industrial environments
	IEC/EN 61000-6-3	Emission standard for residential, commercial and light-industrial environments
Applied	IEC/EN 55022 (CISPR32)	Radio disturbance characteristics / radio interference
	IEC/EN 61000-4-3	Radiated, radio-frequency, electromagnetic field immunity test >10 V/m
	IEC/EN 61000-4-4	Electrical fast transient/burst immunity test ±2 kV
	IEC/EN 61000-4-6	Immunity to conducted disturbances, induced by radio-frequency fields 10 Vrms
	IEC/EN 61000-4-2	Immunity on electrostatic discharge (ESD) • 6 kV contact discharge or 8 kV air discharge

Others		
Environment	IEC/EN 60068-2-6	Environmental testing – Test Fc: Vibration (sinusoidal, 10…500 Hz, 20 m/s^2)
	MIL-STD-810F	Random transport (10…500 Hz up to 2.53 g_{rms})
Safety	UL File Number	Unassembled printed circuit boards: E207844
Reliability	MIL-HDBK-217F [a]	Reliability prediction of electronic equipment Environment: Ground, benign (GB) Ambient temperature: 298 K (25 °C) Component stress: In accordance with circuit diagram and nominal power Mean Time Between Failures (MTBF): on request

[a] The reliability calculation is based on MIL-HDBK-217F. Since component manufacturer data is more accurate, it has been used whenever possible.

Table 2-6 Standards

3 SETUP

IMPORTANT NOTICE: PREREQUISITES FOR INSTALLATION PERMISSION

The **ESCON2 60/12** is considered partly completed machinery according to EU Directive 2006/42/EC, Article 2, Clause (g). **It is intended to be incorporated into or assembled with other machinery or partly completed** machinery or equipment.

WARNING

Risk of injury
Operating the device without full compliance of the surrounding system with EU Directive 2006/42/EC may cause serious injuries!

- *Do not operate the device unless you are certain that the other machinery fully complies with the EU directive's requirements.*
- *Do not operate the device, unless the other machinery fulfills all relevant health and safety aspects!*
- *Do not operate the device unless all respective interfaces have been established and fulfill the requirements stated in this document!*

CAUTION

Burn hazard
Hot surfaces can cause burns.

- *During operation, some parts of the device become very hot. Contact with these parts can burn your skin.*
- *Disconnect the power supply and secure it. Wait for the surface to cool before you do maintenance.*

3.1 Generally applicable rules

Maximum permitted supply voltage

- *Make sure that supply power is between 10…60 VDC.*
- *Supply voltages above 65 VDC or incorrect polarity will destroy the unit.*
- *The necessary output current depends on the load torque. The output current limits are:*
  – continuous max. 12 A
  – short-time (acceleration) max. 24 A (< 5 s)

Hot plugging the USB interface may cause hardware damage

If the USB interface is being hot-plugged (connecting while the power supply is on), the possibly high potential differences of the two power supplies of controller and PC/Notebook can lead to damaged hardware.

- *Avoid potential differences between the power supply of controller and PC/Notebook or, if possible, balance them.*
- *Insert the USB connector first, then switch on the power supply of the controller.*

Best practice

Keep the motor mechanically disconnected during the setup and adjustment phase.

3.2 Connections

For in-depth details on connections ➔Chapter “3.3 Connection specifications” on page 3-17.

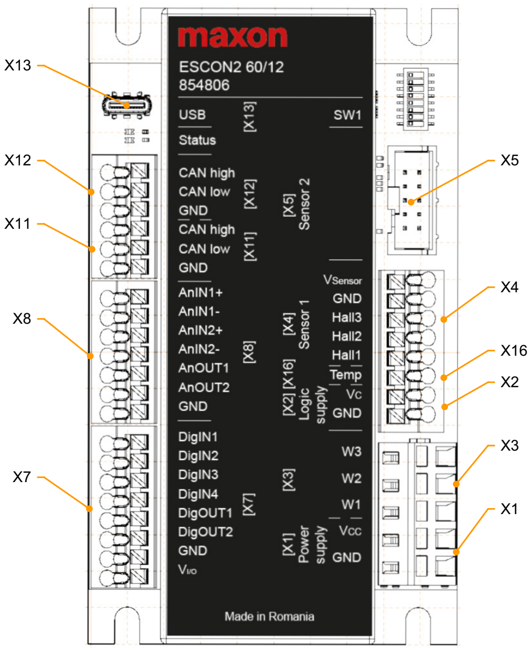


Figure 3-6 Connections

X1	Power supply ➔page 3-17
X2	Logic supply ➔page 3-19
X3	Motor ➔page 3-17
X4	Sensor 1 ➔page 3-19
X5	Sensor 2 ➔page 3-22
X7	Digital I/Os ➔page 3-30
X8	Analog I/Os ➔page 3-34
X11	CAN 1 ➔page 3-36
X12	CAN 2 ➔page 3-36
X13	USB ➔page 3-37
X16	Motor temperature sensor ➔page 3-19

3.3 Connection specifications

The actual connection depends on your drive system configuration and the type of motor you are using. Follow the description in the given order and choose the wiring diagram (➔as of page 4-43) that best suits your components.

How to read pin assignment tables

In the subsequent sections of the document, you will come across tables outlining the pin assignments. These tables provide information about the hardware connectors, their corresponding wired signals, the assigned pins, and details regarding the prefab cables that are available.

- *The initial column provides the pin numbers for the connectors.*
- *The second column specifies the pin numbers for the corresponding end (Head A) of the prefab cable.*
- *The third column describes the core color of the prefab cable.*
- *The fourth column indicates the pin numbers for the other end (Head B) of the prefab cable.*

3.3.1 Power supply (X1) | Motor windings (X3)

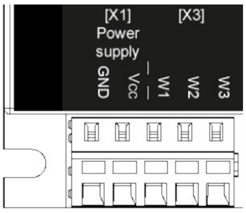


Figure 3-7 Power supply (X1), Motor windings connector (X3) | Connector

Pin	Signal	Description
X1 | GND	GND	Ground
X1 | V_{CC}	V_{CC}	Power supply voltage input (10...60 VDC)
X3 | W1	Motor winding 1 Motor (+M)	EC motor: Winding 1 DC motor: Motor +
X3 | W2	Motor winding 2 Motor (-M)	EC motor: Winding 2 DC motor: Motor -
X3 | W3	Motor winding 3 -	EC motor: Winding 3 DC motor: do not connect

Table 3-7 Power supply connector (X1), Motor winding (X3) | Pin assignment

Specification / Accessories	
Type	Spring clamp, MPN WKA500-05P
Suitable cables	Conductor cross section (solid and stranded) 0.2 … 2.5 mm^2, AWG 28-12 Conductor cross section flexible 0.25 … 1.5 mm^2
Stripping length	5...6 mm
Tools	Slotted screwdriver, size blade thickness 0.6 mm, width 3.5 mm

Table 3-8 Power supply (X1), Motor winding (X3) | Specification / Accessories

Best practice

Keep the motor mechanically disconnected during the setup and adjustment phase.

Power supply requirements	
Nominal output voltage V_{CC}	10…60 VDC
Absolute output voltage V_{CC}	min. 8 VDC / max. 62 VDC
Output current	Depending on load • continuous max. 12 A • short-time (acceleration) max. 24 A (< 5 s)

Table 3-9 Power supply requirements

1) Use the formula below to calculate the required voltage under load.
2) Choose a power supply according to the calculated voltage. Consider the following:
   a) During braking of the load, the power supply must buffer the recovered kinetic energy (e.g., in a capacitor).
   b) If using an electronically stabilized power supply, ensure the overcurrent protection circuit is inoperative within the operating range.

The formula already takes the following into account:
- *Maximum PWM duty cycle of 90 %*
- *Controller's max. voltage drop of 1 V @ 12 A*

KNOWN VALUES:
- Operating torque M [mNm]
- Operating speed n [rpm]
- Nominal motor voltage U_N [Volt]
- Motor no-load speed at U_N; n_O [rpm]
- Speed/torque gradient of the motor Δn/ΔM [rpm/mNm]

SOUGHT VALUE:
- Supply voltage V_{CC} [Volt]

SOLUTION:

$$V_{CC} \geq \left[\frac{U_N}{n_O} \cdot \left(n + \frac{\Delta n}{\Delta M} \cdot M\right) \cdot \frac{1}{0.9}\right] + 1\,[V]$$

3.3.2 Logic supply (X2) | Temperature (X16) | Hall Sensor (X4)

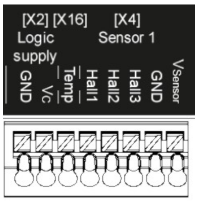


Figure 3-8 Logic supply (X2), Temperature (X16), Hall Sensor (X4) | Connectors

Pin	Signal	Description
X2 | GND	GND	Ground
X2 | V_C	V_C	Power supply voltage input (10...60 VDC)
X16 | Temp	MotorTemp	Motor temperature sensor input
X4 | Hall1	Hall sensor 1	Hall sensor 1 input
X4 | Hall2	Hall sensor 2	Hall sensor 2 input
X4 | Hall3	Hall sensor 3	Hall sensor 3 input
X4 | GND	GND	Ground
X4 | V_{Sensor}	V_{Sensor}	Sensor supply voltage output (5 VDC / I_L ≤ 145 mA)

Table 3-10 Logic supply (X2), Temperature (X16), Hall sensor (X4) connector | Pin assignment

Specification / Accessories	
Type	Push-in Design, Dinkle 0136-2008
Suitable cables	Conductor cross section solid 0.2 … 0.75 mm^2, AWG 28-16 Conductor cross section stranded 0.5 … 0.75 mm^2, AWG 28-16 Conductor cross section flexible 0.25 … 0.5 mm^2
Stripping length	8...9 mm
Tools	Slotted screwdriver, size blade thickness 0.4 mm, width 2.5 mm

Table 3-11 Logic supply (X2), Temperatur (X16), Hall Sensor (X4) | Specification /Accessories

Logic supply requirements	
Nominal output voltage V_C	10…60 VDC
Absolute output voltage V_C	min. 8 VDC / max. 62 VDC
Min. output power	P_C min. 3 W

Table 3-12 Logic supply requirements (X2)

Motor temperature sensor input	
Input voltage	0...3.3 VDC
Max. input voltage	+24 VDC
A/D converter	12-bit
Internal pull-up resistor	3.3 kΩ (referenced to 3.3 VDC)

Table 3-13 Motor temperature sensor (X16) – specifications

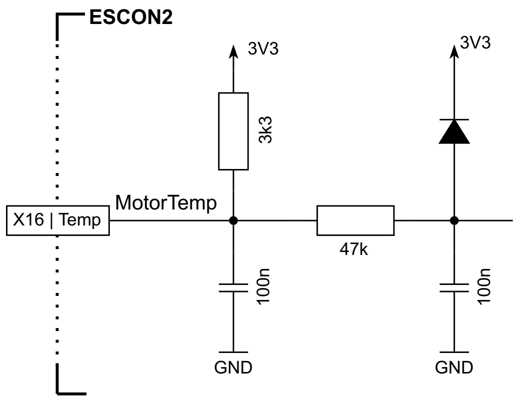


Figure 3-9 Motor temperature circuit (X16)

Important Notice

The maximum supply current of the sensor supply voltage output V_{Sensor} is in total 145 mA. It can be used for:

- *Hall sensors ➔Chapter "3.3.2 Logic supply (X2) | Temperature (X16) | Hall Sensor (X4)" on page 3-19*
- *Incremental encoders ➔Chapter "3.3.3.1 Incremental encoder" on page 3-23*
- *SSI / BiSS C encoders ➔Chapter "3.3.3.2 SSI / BiSS C unidirectional absolute encoder (future release)" on page 3-25*
- *High-speed digital I/Os ➔Chapter "3.3.4 Digital I/Os (X7)" on page 3-30*
- *Digital I/Os ➔Chapter "3.3.4 Digital I/Os (X7)" on page 3-30*
- *Other peripherals which need a 5 VDC supply.*

All currents resulting from parts connected to the sensor supply voltage output V_{Sensor} must not exceed 145 mA in total.

Hall sensor	
Sensor supply voltage output V_{Sensor}	5 VDC
Max. Hall sensor supply current	145 mA (➔refer to Important Notice)
Input voltage	0…24 VDC
Max. input voltage	24 VDC
Low-level input voltage	< 0.8 VDC
High-level input voltage	> 2.0 VDC
Internal pull-up resistor	2.7 kΩ (referenced to 5.45 VDC - 0.6 VDC)

Table 3-14 Hall sensor (X4) specification

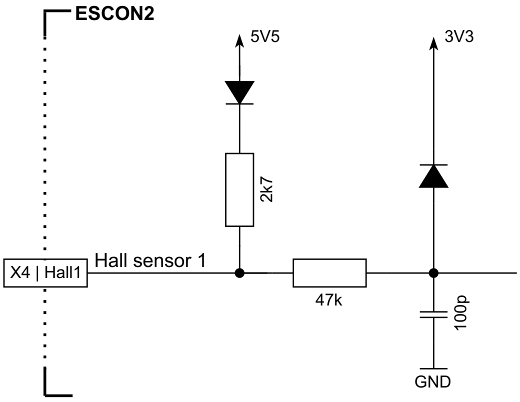


Figure 3-10 Hall sensor (X4) input circuit (analogously valid for Hall sensors 2 & 3)

3.3.3 Sensor 2 Encoder / I/Os (X5)

Additional sensors, both incremental and serial encoders, or digital inputs and outputs can be connected. Only one sensor/function can be used at a time, i.e. either an incremental encoder, or an absolute encoder, or high-speed digital I/Os.

Best practice
For best performance and good resistance against electrical interference, ***we recommend using encoders with a line driver (differential scheme).*** *Otherwise, limitations may apply due to slow switching edges. Nevertheless, the controller supports both schemes – differential and single-ended (unsymmetrical).*

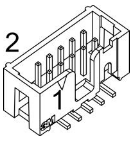


Figure 3-11 Sensor 2 connector X5

X5 Pin	Prefab cable Head A Pin	Prefab cable Cable color	Prefab cable Head B Pin	Signal	Description
1	1	brown	1	Data	Data (SSI, BiSS C)
				HsDigIN4	High-speed digital input 4
2	2	white	2	V_{Sensor}	Sensor supply voltage output (5 VDC / $I_L \leq$ 145 mA)
3	3	red	3	GND	Ground
4	4	white	4	Clock	Clock (SSI, BiSS C)
				HsDigOUT1	High-speed digital output 1
5	5	orange	5	Channel A\	Digital incremental encoder channel A complement
				HsDigIN1\	High-speed digital input 1 complement
6	6	white	6	Channel A	Digital incremental encoder channel A
				HsDigIN1	High-speed digital input 1
7	7	yellow	7	Channel B\	Digital incremental encoder channel B complement
				HsDigIN2\	High-speed digital input 2 complement
8	8	white	8	Channel B	Digital incremental encoder channel B
				HsDigIN2	High-speed digital input 2
9	9	green	9	–	not connected
10	10	white	10	HsDigIN3	High-speed digital input 3

Table 3-15 Sensor 2 connector X5 | Pin assignment

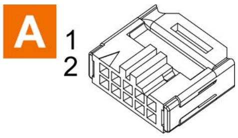
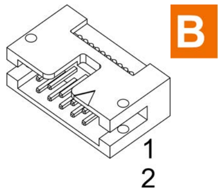
Encoder cable (275934)	
	
Cross-section	10 × AWG28, round-jacket, flat cable, pitch 1.27 mm
Length	3 m
Head A	DIN 41651 female, pitch 2.54 mm, 10 poles, with strain relief
Head B	DIN 41651 plug, pitch 2.54 mm, 10 poles, with strain relief

Table 3-16 Encoder cable

Important Notice

The maximum supply current of the sensor supply voltage output V_{Sensor} is in total 145 mA. It can be used for:

- *Hall sensors ➔Chapter “3.3.2 Logic supply (X2) | Temperature (X16) | Hall Sensor (X4)” on page 3-19*
- *Incremental encoders ➔Chapter “3.3.3.1 Incremental encoder” on page 3-23*
- *SSI / BiSS C encoders ➔Chapter “3.3.3.2 SSI / BiSS C unidirectional absolute encoder (future release)” on page 3-25*
- *High-speed digital I/Os ➔Chapter “3.3.4 Digital I/Os (X7)” on page 3-30*
- *Digital I/Os ➔Chapter “3.3.4 Digital I/Os (X7)” on page 3-30*
- *Other peripherals which need a 5 VDC supply.*

All currents resulting from parts connected to the sensor supply voltage output V_{Sensor} must not exceed 145 mA in total.

3.3.3.1 Incremental encoder

Digital incremental encoder (differential)	
Sensor supply voltage output V_{Sensor}	5 VDC
Max. sensor supply current	≤ 145 mA (➔refer to Important Notice)
Min. differential input voltage	± 200 mV
Max. input voltage	± 12 VDC
Line receiver (internal)	EIA/RS422 standard
Max. input frequency	6.67 MHz

Table 3-17 Differential digital incremental encoder specification

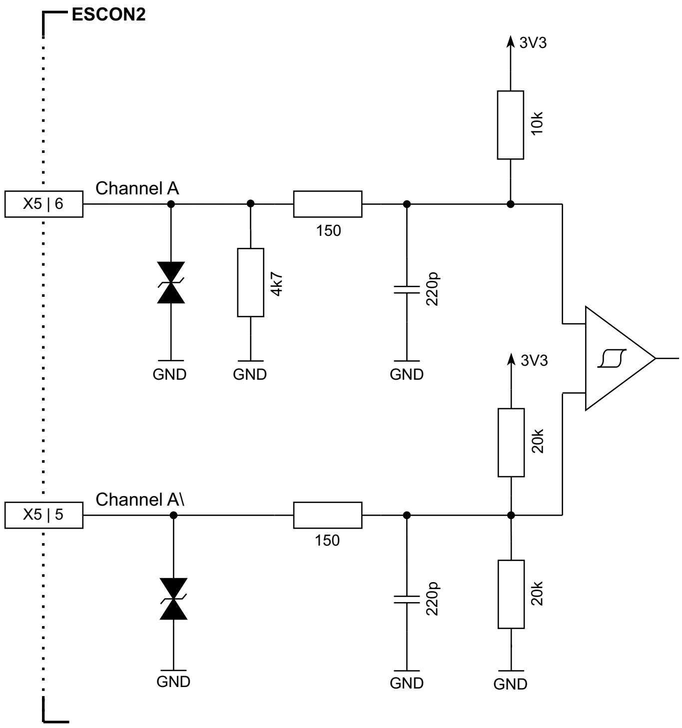


Figure 3-12 Digital incremental encoder input circuit Ch A “differential” (analogously valid for Ch B)

Digital incremental encoder (single-ended)		
Sensor supply voltage output V_{Sensor}		5 VDC
Max. sensor supply current		≤ 145 mA (➔refer to Important Notice)
Input voltage		0...5 VDC
Max. input voltage		± 12 VDC
Low-level input voltage		< 1 VDC
High-level input voltage		> 2.4 VDC
Input high current		I_{IH} = typically 1.3 mA @ 5 VDC
Input low current		I_{IL} = typically -0.36 mA @ 0 VDC
Max. input frequency	Push-pull	6.25 MHz
	Open collector	100 kHz (additional external 3k3 pull-up)

Table 3-18 Single-ended digital incremental encoder specification

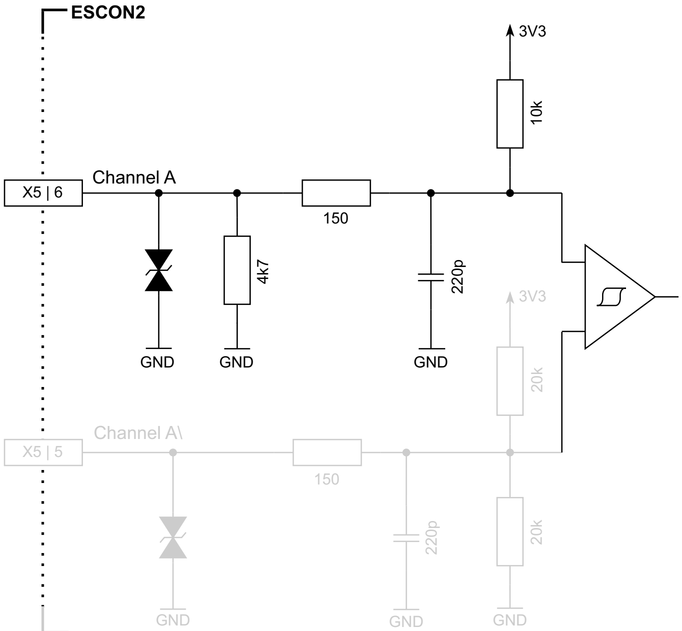


Figure 3-13 Digital incremental encoder input circuit Ch A “single-ended” (analogously valid for Ch B)

3.3.3.2 SSI / BiSS C unidirectional absolute encoder (future release)

The functionality will only be available with a future firmware release.

SSI / BiSS C unidirectional absolute encoder (single-ended)		
Sensor supply voltage output V_{Sensor}		5 VDC
Max. sensor supply current		≤ 145 mA (➔refer to Important Notice)
Clock frequency	SSI	0.1...2 MHz
	BiSS C	0.1...4 MHz

Table 3-19 SSI / BiSS C unidirectional absolute encoder specification

SSI / BiSS C unidirectional absolute encoder data channel	
Input voltage	0…5 VDC
Max. input voltage	± 12 VDC
Low-level input voltage	< 1.0 VDC
High-level input voltage	> 2.4 VDC
Input high current	I_{IH} = typically 0.34 mA @ 5 VDC (➔refer to Important Notice)
Input low current	I_{IL} = typically 0 mA @ 0 VDC (➔refer to Important Notice)
Max. input frequency	6.25 MHz
Total reaction time	< 1.5 ms

Table 3-20 Single-ended SSI / BiSS C unidirectional absolute encoder data channel specification

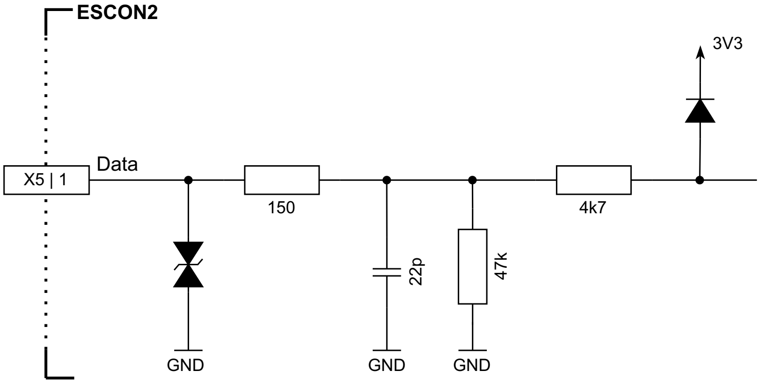


Figure 3-14 SSI absolute encoder data input (analogously valid for BiSS C)

SSI / BiSS C unidirectional absolute encoder clock channel		
Output voltage		3.3 VDC
Output resistance		47 Ω
Max. output current		24 mA
Clock frequency	SSI	0.1...2 MHz
	BiSS C	0.1...4 MHz

Table 3-21 Single-ended SSI / BiSS C unidirectional absolute encoder clock channel specification

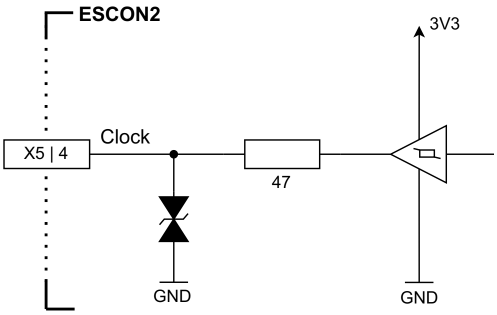


Figure 3-15 SSI absolute encoder clock output (analogously valid for BiSS C)

3.3.3.3 High-speed digital I/Os

Alternatively, the sensor 2 interface can be used for high-speed digital I/O operation.

For easier plug-and-play, use maxon's ribbon cable (P/N 354046) and adapter (P/N 262359) to connect the high-speed digital I/Os to a 10-pole screw terminal.

High-speed digital inputs 1…2 (differential)	
Max. input voltage	± 12 VDC
Min. differential input voltage	± 200 mV
Line receiver (internal)	EIA/RS422 standard
Max. input frequency	6.67 MHz
Total reaction time	< 1.5 ms

Table 3-22 Differential high-speed digital input specification

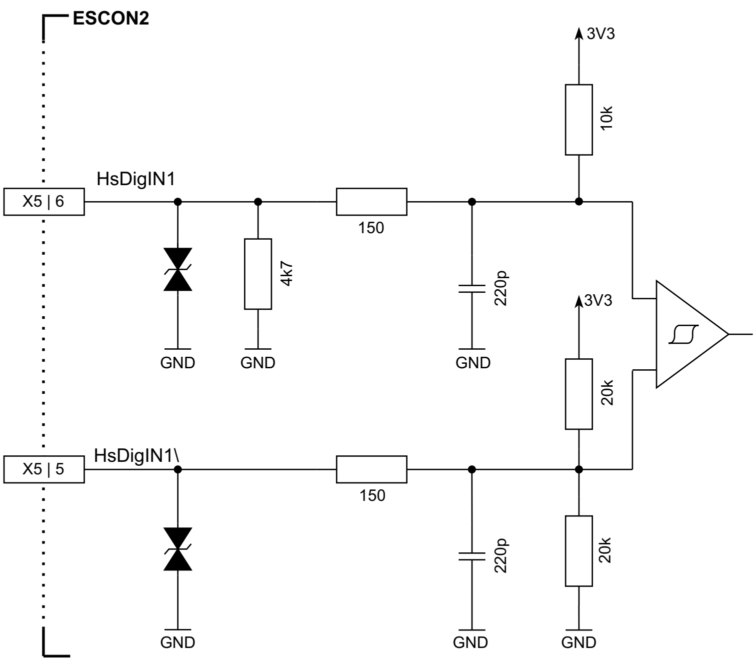


Figure 3-16 HsDigIN1 circuit “differential” (analogously valid for HsDigIN2)

High-speed digital inputs 1…4 (single-ended)		
Input voltage		0…5 VDC
Max. input voltage		± 12 VDC
Low-level input voltage		< 1.0 VDC
High-level input voltage		> 2.4 VDC
Input high current	HsDigIN1…3	I_{IH} = typically 1.3 mA @ 5 VDC (➔refer to Important Notice)
	HsDigIN4	I_{IH} = typically 0.34 mA @ 5 VDC (➔refer to Important Notice)
Input low current	HsDigIN1…3	I_{IL} = typically −0.36 mA @ 0 VDC (➔refer to Important Notice)
	HsDigIN4	I_{IL} = typically 0 mA @ 0 VDC (➔refer to Important Notice)
Max. input frequency		6.25 MHz
Total reaction time		< 1.5 ms

Table 3-23 Single-ended high-speed digital input specification

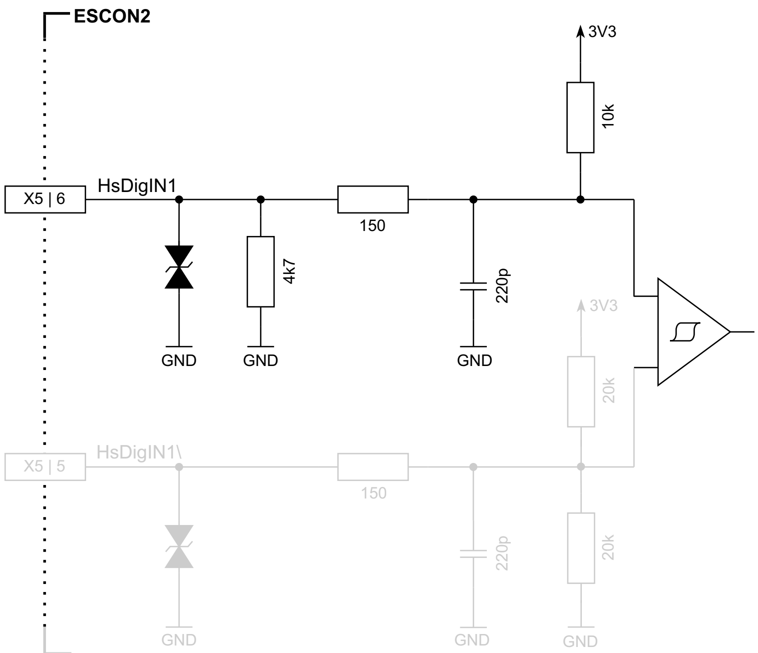


Figure 3-17 HsDigIN1 circuit “single-ended” (analogously valid for HsDigIN2…3)

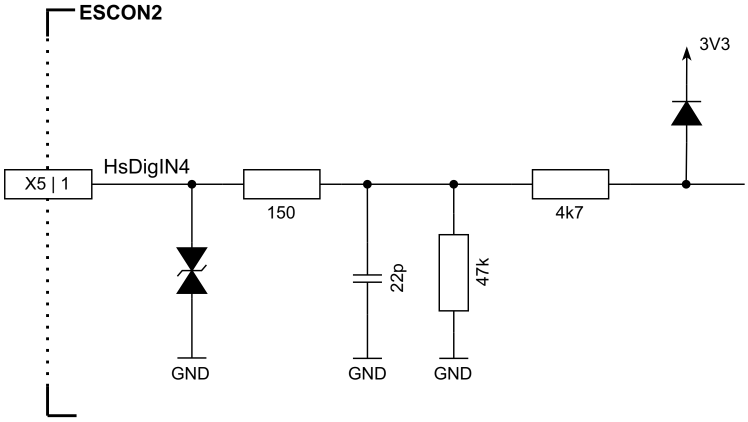


Figure 3-18 HsDigIN4 circuit “single-ended”

High-speed digital output 1	
Output voltage	3.3 VDC
Output resistance	47 Ω
Max. output current	24 mA
Max. output frequency	25 kHz

Table 3-24 High-speed digital output specification

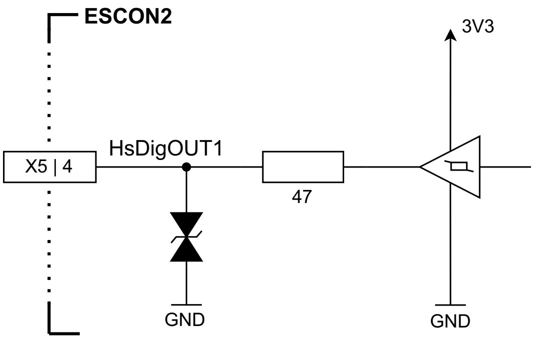


Figure 3-19 HsDigOUT1 circuit

3.3.4 Digital I/Os (X7)

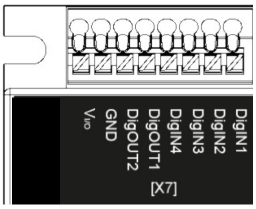


Figure 3-20 Digital I/Os connector X7

Pin	Signal	Description
X7 | DigIN1	DigIN1	Digital input 1
X7 | DigIN2	DigIN2	Digital input 2
X7 | DigIN3	DigIN3	Digital input 3
X7 | DigIN4	DigIN4	Digital input 4
X7 | DigOUT1	DigOUT1	Digital output 1
X7 | DigOUT2	DigOUT2	Digital output 2
X7 | GND	GND	Ground
X7 | $V_{I/O}$	$V_{I/O}$	$V_{I/O}$ = 5 VDC - 0.75 VDC = 4.25 VDC

Table 3-25 Digital I/O (X7) | Pin assignment

Specification / Accessories	
Type	Push-in Design, Dinkle 0136-2008
Suitable cables	Conductor cross section solid 0.2 … 0.75 mm^2, AWG 28-16 Conductor cross section stranded 0.5 … 0.75 mm^2, AWG 28-16 Conductor cross section flexible 0.25 … 0.5 mm^2
Stripping length	8...9 mm
Tools	Slotted screwdriver, size blade thickness 0.4 mm, width 2.5 mm

Table 3-26 Digital I/O (X7) | Specification/Accessories

Digital inputs 1…2	
Input voltage	0…30 VDC
Max. input voltage	±30 VDC
Low-level input voltage	< 0.8 VDC
High-level input voltage	> 2.1 VDC
Input resistance	typically 47 kΩ < 3.3 VDC typically 37 kΩ @ 5 VDC typically 25 kΩ @ 24 VDC
Input current at logic 1	typically 135 μA @ 5 VDC
Hardware switching delay	< 6 μs
Total reaction time	< 2.3 ms
PWM duty cycle (resolution)	10...90 % (0.1 %)
PWM frequency	50 Hz...10 kHz
PWM accuracy	typically +0.1 % absolute @ 50 Hz / 5 VDC typically +1.5 % absolute @ 10 kHz / 5 VDC

Table 3-27 Digital inputs 1...2 specification

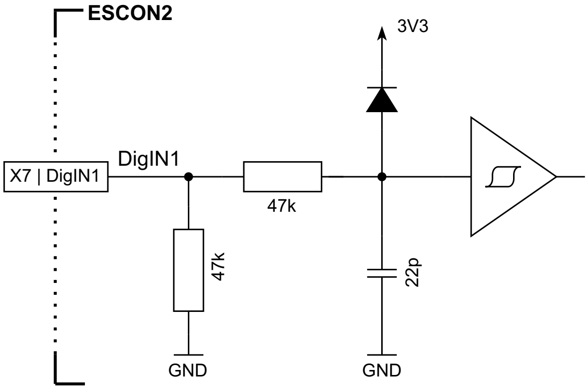


Figure 3-21 DigIN1 circuit (analogously valid for DigIN2)

Digital inputs 3…4	
Input voltage	0…30 VDC
Max. input voltage	±30 VDC
Low-level input voltage	< 0.8 VDC
High-level input voltage	> 2.1 VDC
Input resistance	typically 47 kΩ < 3.3 VDC typically 37 kΩ @ 5 VDC typically 25 kΩ @ 24 VDC
Input current at logic 1	typically 135 μA @ 5 VDC
Hardware switching delay	< 300 μs
Total reaction time	< 2.3 ms

Table 3-28 Digital inputs 3...4 specification

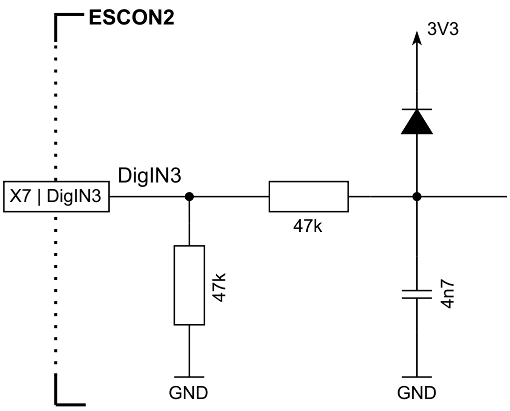


Figure 3-22 DigIN3 circuit (analogously valid for DigIN4)

Digital outputs 1…2 “sink”	
Max. input voltage	36 VDC
Max. load current	500 mA
Max. voltage drop	0.25 VDC @ 500 mA
Max. load inductance	100 mH @ 24 VDC; 500 mA with internal clamping typically 45 VDC
Max. output frequency	25 kHz

Table 3-29 Digital outputs specification – Sinks

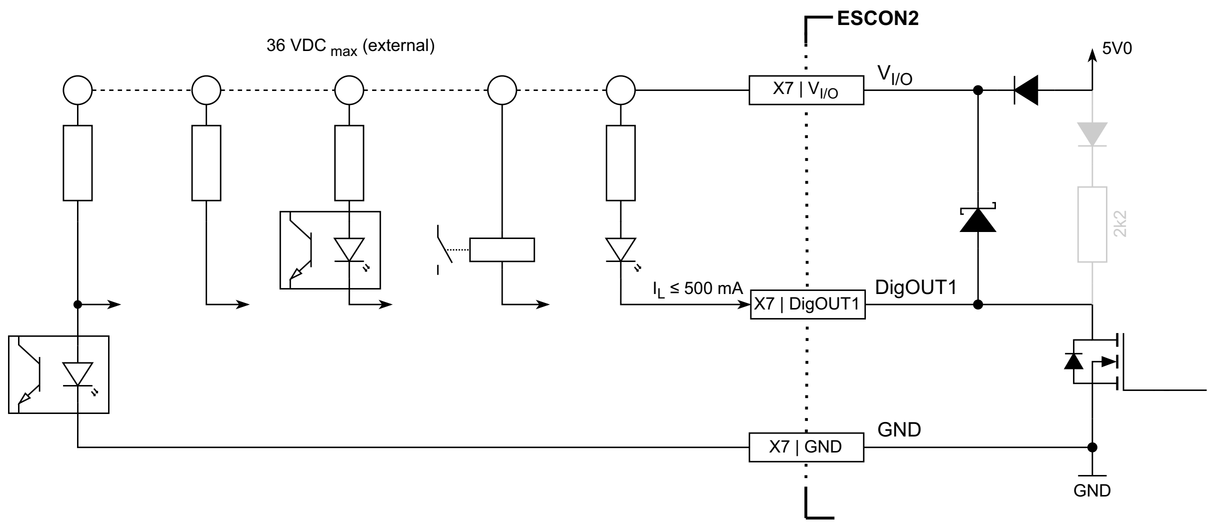


Figure 3-23 DigOUT1 “sinks” (analogously valid for DigOUT2)

Freewheeling diode for inductive loads
When utilizing the digital output load switch for the operation of inductive loads, such as relays, and $V_{I/O}$ is not used, it is essential to confirm the presence of a freewheeling diode to prevent potential harm to the hardware. If possible, install the freewheeling diode at the load.

Digital outputs 1…2 “source”	
Output voltage	V_{Out} = 5 VDC − 0.75 VDC − (I_L × 2´200 Ω)
Max. load current	$I_L \leq 2$ mA

Table 3-30 Digital outputs specification – Sources

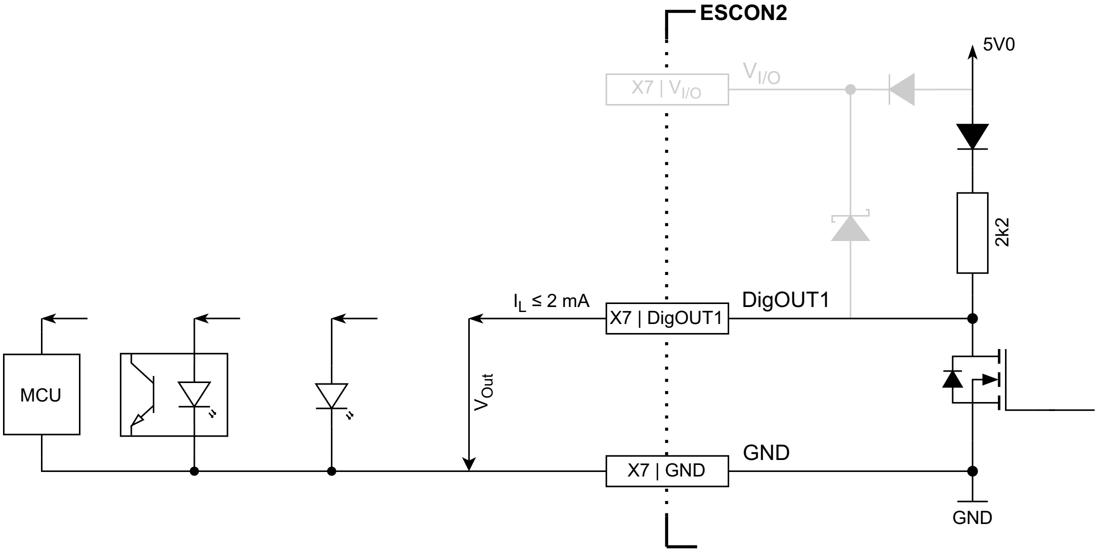


Figure 3-24 DigOUT1 “source” (analogously valid for DigOUT2)

3.3.5 Analog I/Os (X8)

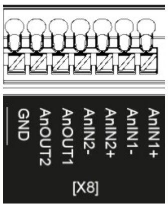


Figure 3-25 Analog I/Os connector X8

Pin	Signal	Description
X8 | AnIN1+	AnIN1+	Analog input 1 positive signal
X8 | AnIN1-	AnIN1-	Analog input 1 negative signal
X8 | AnIN2+	AnIN2+	Analog input 2 positive signal
X8 | AnIN2-	AnIN2-	Analog input 2 negative signal
X8 | AnOUT1	AnOUT1	Analog output 1
X8 | AnOUT2	AnOUT2	Analog output 2
X8 | GND	GND	Ground

Table 3-31 Analog I/O (X8) | Pin assignment

Specification / Accessories	
Type	Push-in Design, Dinkle 0136-2007
Suitable cables	Conductor cross section solid 0.2 … 0.75 mm^2, AWG 28-16 Conductor cross section stranded 0.5 … 0.75 mm^2, AWG 28-16 Conductor cross section flexible 0.25 … 0.5 mm^2
Stripping length	8...9 mm
Tools	Slotted screwdriver, size blade thickness 0.4 mm, width 2.5 mm

Table 3-32 Analog I/O (X8) | Specification/Accessories

Analog inputs 1…2		
Input voltage		±10 VDC (differential)
Max. input voltage		±24 VDC
Common mode voltage		−5…+10 VDC (referenced to GND)
Input resistance	differential	80 kΩ
	referenced to GND	65 kΩ
A/D converter		12-bit
Resolution		5.64 mV
Bandwidth		10 kHz

Table 3-33 Analog input specification

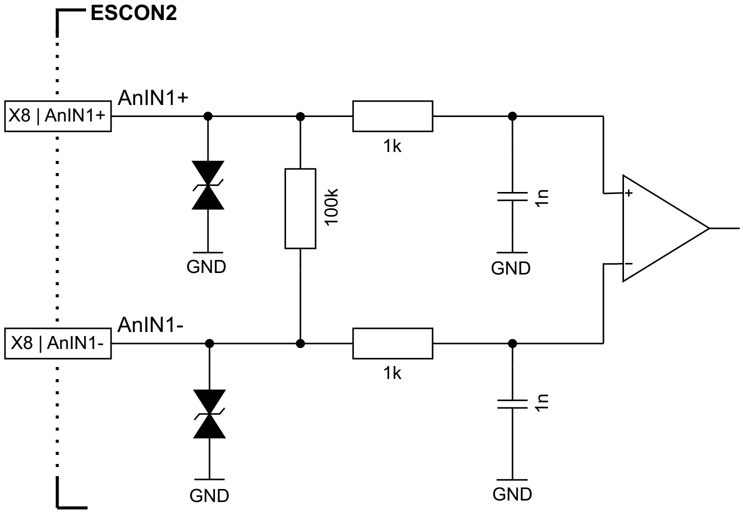


Figure 3-26 AnIN1 circuit (analogously valid for AnIN2)

Analog outputs 1…2	
Output voltage	±4 VDC
D/A converter	12-bit
Resolution	2.42 mV
Refresh rate	50 kHz
Analog bandwidth of output amplifier	25 kHz
Max. capacitive load	300 nF ***Note:*** *The increase rate is limited in proportion to the capacitive load (e.g. 5 V/ms @ 300 nF)*
Max. output current limit	1 mA

Table 3-34 Analog output specification

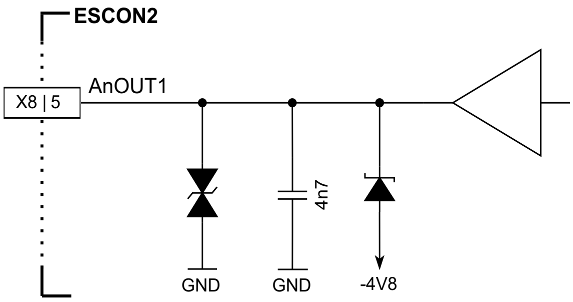


Figure 3-27 AnOUT1 circuit (analogously valid for AnOUT2)

3.3.6 CAN 1 (X11) & CAN 2 (X12)

The ESCON2 is specially designed to be commanded and controlled via a Controller Area Network (CAN), a highly efficient data bus common in all fields of automation and motion control. It is preferably used as a slave node in the CANopen network.

For the CAN configuration check ➔Chapter “3.4 DIP switch configuration (SW1)” on page 3-38.

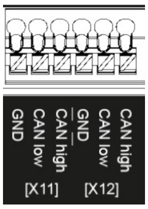


Figure 3-28 CAN 1 (X11) / CAN 2 (X12)

Pin	Signal	Description
X12 | CAN high	CAN high	CAN bus high line
X12 | CAN low	CAN low	CAN bus low line
X12 | GND	GND	Ground
X11 | CAN high	CAN high	CAN bus high line
X11 | CAN low	CAN low	CAN bus low line
X11 | GND	GND	Ground

Table 3-35 CAN 1 (X11) / CAN 2 (X12) | Pin assignment

Specification / Accessories	
Type	Push-in Design, Dinkle 0136-2007
Suitable cables	Conductor cross section solid 0.2 … 0.75 mm^2, AWG 28-16 Conductor cross section stranded 0.5 … 0.75 mm^2, AWG 28-16 Conductor cross section flexible 0.25 … 0.5 mm^2
Stripping length	8...9 mm
Tools	Slotted screwdriver, size blade thickness 0.4 mm, width 2.5 mm

Table 3-36 CAN 1 (X11) / CAN 2 (X12) | Specification/Accessories

CAN interface	
Standard	ISO 11898-2:2003
Max. bit rate	1 Mbit/s
Max. number of CAN nodes	31/127 (via hardware/software setting)
Protocol	CiA 301 version 4.2.0
Node-ID setting	By DIP switch or software

Table 3-37 CAN interface specification

Note

- *Consider the CAN master’s maximal bit rate.*
- *The standard bit rate setting (factory setting) is 1 Mbit/s.*
- *Use 120 Ω termination resistor at both ends of the CAN bus.*
- *For detailed CAN information see separate document ➔«ESCON2 Communication Guide».*

3.3.7 USB (X13)

Hot plugging the USB interface may cause hardware damage

If the USB interface is being hot-plugged (connecting while the power supply is on), the possibly high potential differences of the two power supplies of controller and PC/Notebook can lead to damaged hardware.

- *Avoid potential differences between the power supply of controller and PC/Notebook or, if possible, balance them.*
- *Insert the USB connector first, then switch on the power supply of the controller.*

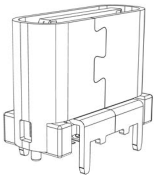


Figure 3-29 USB connector X13

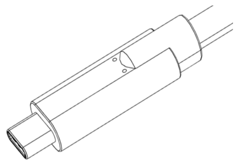
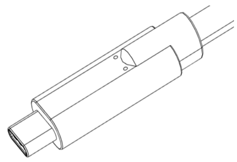
USB Type C - Type C cable (P/N 845854)	
A 	 B
USB standard	USB 3.2
Length	1.5 m
Head A	USB Type C
Head B	USB Type C

Table 3-38 USB Type C – Type C cable

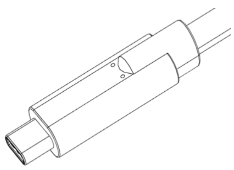
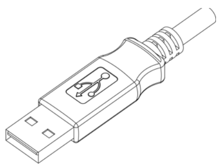
USB Type A - Type C cable (P/N 838461)	
A 	 B
USB standard	USB 2.0 / USB 3.0
Length	1.5 m
Head A	USB Type C
Head B	USB Type A

Table 3-39 USB Type A – Type C cable

USB	
Data signaling rate	12 Mbit/s (Full speed)
Max. bus supply voltage V_{Bus}	5.25 VDC
Max. DC data input voltage	−0.3…+3.8 VDC

Table 3-40 USB interface specification

3.4 DIP switch configuration (SW1)

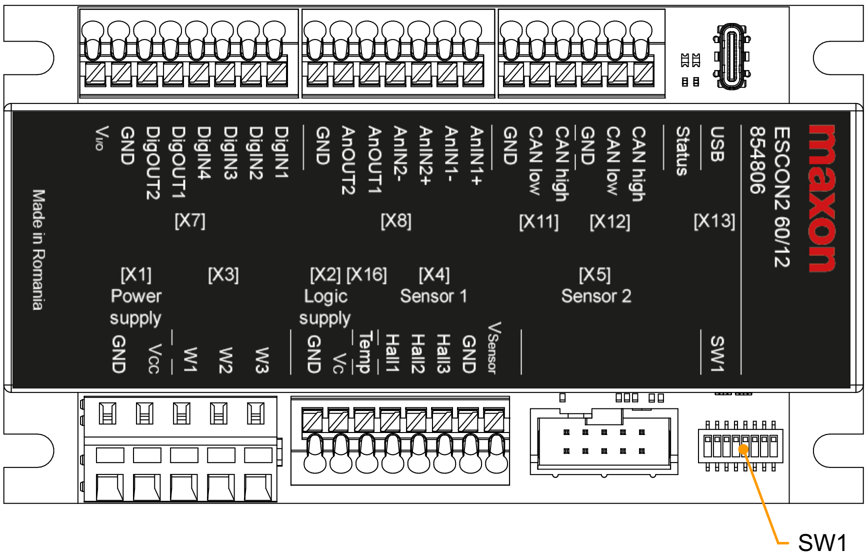


Figure 3-30 DIP switch SW1

3.4.1 CAN ID (Node-ID)

The device's identification (subsequently called "ID") can be set by means of DIP switches 1...5 or software using binary code.

Setting the ID by DIP switch SW1

- *DIP switches 6…8 do not have any impact on the ID.*

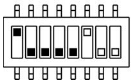
Setting	Switch	Binary Code	Valence
1 8  ON OFF (factory setting)	1	2^0	1
	2	2^1	2
	3	2^2	4
	4	2^3	8
	5	2^4	16

Table 3-41 DIP switch SW1 – Binary code values

Continued on next page.

The set ID can be observed by adding the valence of all activated switches. Use the following table as a (non-concluding) guide:

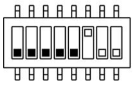
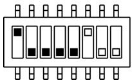
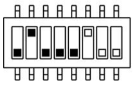
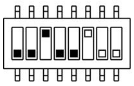
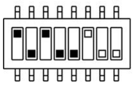
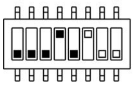
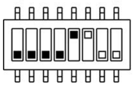
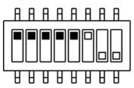
Setting	Switch					ID
	1	2	3	4	5	
1 8  ON OFF	0	0	0	0	0	–
1 8  ON OFF	**1**	0	0	0	0	1
1 8  ON OFF	0	**1**	0	0	0	2
1 8  ON OFF	0	0	**1**	0	0	4
1 8  ON OFF	**1**	0	**1**	0	0	5
1 8  ON OFF	0	0	0	**1**	0	8
1 8  ON OFF	0	0	0	0	**1**	16
1 8  ON OFF	**1**	**1**	**1**	**1**	**1**	31
0 = Switch “OFF” 1 = Switch “ON”						

Table 3-42 DIP switch SW1 – Examples

SETTING THE ID BY MEANS OF «MOTION STUDIO»

- The ID may be set by software (changing object 0x2000 «Node-ID», range 1…127).
- The ID set by software is valid if the ID is set to “0” (DIP switches 1...5 set to OFF).

3.4.2 CAN automatic bit rate detection

With this function, the CANopen interface can be put in a “listen only” mode. For further details see separate document ➔«ESCON2 Firmware Specification». Automatic bit rate detection is activated with DIP switch 6.

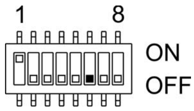
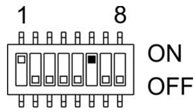
Switch	OFF	ON
6	 Automatic bit rate detection deactivated	 Automatic bit rate detection activated (factory setting)

Table 3-43 DIP switch SW1 – CAN automatic bit rate detection

3.4.3 CAN bus termination

A 120 Ω termination resistor can be "activated" with DIP switch 7.

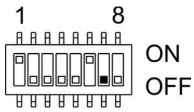
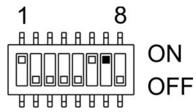
Switch	OFF	ON
7	 Without bus termination (factory setting)	 Bus termination with 120 Ω

Table 3-44 DIP switch SW1 – CAN bus termination

3.5 Status indicators

The ESCON2 features a set of LED indicators to display the device condition.

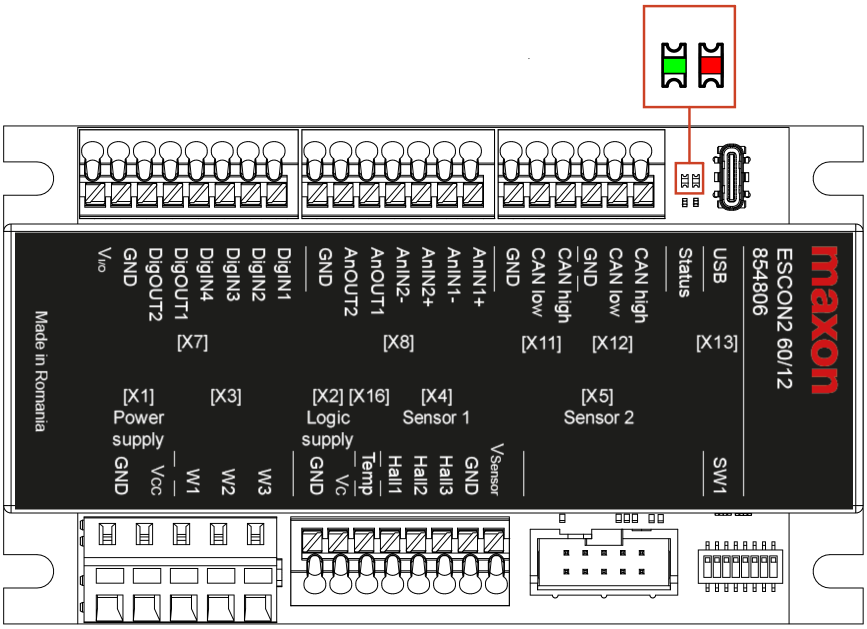


Figure 3-31 LEDs – Location

The LEDs display the actual status and possible warnings and errors of the ESCON2:

- Green LED shows the operation status
- Red LED indicates warnings and errors

LED		Warning / Error	Description
Green	**Red**		
Slow	OFF	No warning/error active.	Power stage is disabled. The ESCON2 is in status • Switch on disabled • Ready to switch on • Switched on
Slow	Slow	At least one warning is active.	
ON	OFF	No warning/error active.	Power stage is enabled. The ESCON2 is in status • Operation enabled • Quick stop active
ON	Slow	At least one warning is active.	
ON	ON	At least one error has occurred.	Power stage is enabled. The ESCON2 is in temporary status • Fault reaction active
OFF	ON	At least one error has occurred.	Power stage is disabled. The ESCON2 is in status • Fault
Flash	ON	n/a	Firmware update in progress or invalid application
Slow = LED is slowly blinking (0.5 s OFF, 0.5 s ON) Flash = LED is flashing (0.9 s OFF, 0.1 s ON)			

Table 3-45 Device status LEDs

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4 WIRING

This section provides wiring information for your setup. You can either use the consolidated wiring diagrams (see ➔Figure 4-33) featuring the full scope of interconnectivity and pin assignments, or you may use the connection overviews for either DC motor or EC (BLDC) motor to determine the wiring for your particular motor type and the appropriate feedback signals.

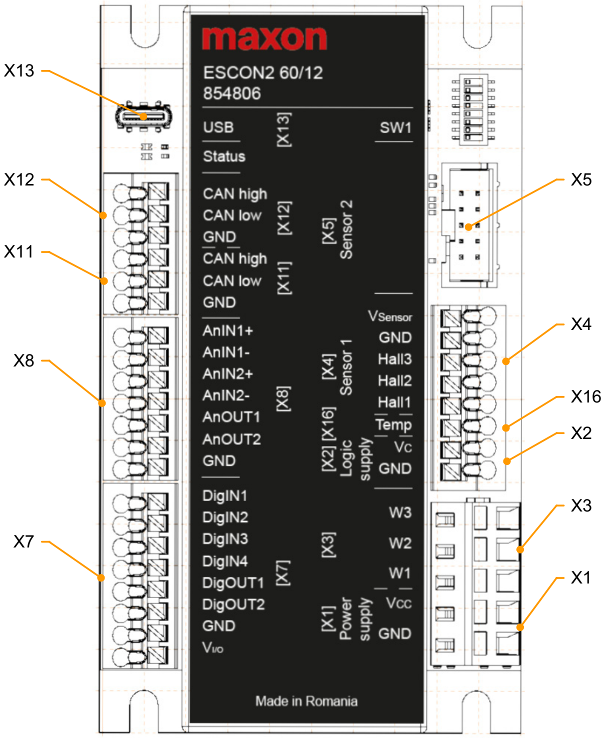

Figure 4-32 Interfaces – Designations and location

Signs and abbreviations used

The subsequent diagrams feature these signs and abbreviations:

- *«EC motor» stands for brushless EC motor (BLDC).*
- *Ground safety earth connection (optional).*

4.1 Possible combinations to connect a motor

The following tables show feasible ways to connect the motor with its respective feedback signals or possible combinations thereof. To find the wiring that best suits your setup, proceed as follows:

1) Decide on the type of motor you are using and go to the respective subsection;
For DC motor, see ➔Chapter “4.1.1 DC motor” on page 4-44 or
For EC (BLDC) motor, see ➔Chapter “4.1.2 EC (BLDC) motor” on page 4-44.
2) Connect the power supply and the logic supply as shown in the referenced figure.
3) Check-out the listing for the combination that best suits your setup. Pick the wiring method number and go to the respective table;
For DC motor see ➔Table 4-46,
For EC (BLDC) motor see ➔Table 4-47.
4) Pick the row with the corresponding wiring method # and refer to the listed figure(s) to find the relevant wiring information.

4.1.1 DC motor

Power supply

Power supply and optional logic supply . . . . .Figure 4-34

Motor & feedback signals

Without sensor . . . . .Method # DC1 [a]

Digital incremental encoder . . . . Method # DC2

SSI / BiSS C unidirectional absolute encoder . . . . .Method # DC3 [b]

Method #	Sensor 2		➔Figure(s)
	Digital incremental encoder	SSI / BiSS C unidirectional absolute encoder [b]	
DC1 [a]			4-34
DC2	✓		4-34 4-37
DC3 [b]		✓	4-34 4-38

[a] For method # DC1, only the operating mode current control can be used.
[b] The functionality will be available with a future firmware release.

Table 4-46 Possible combinations of feedback signals for DC motor

4.1.2 EC (BLDC) motor

Power supply

Power supply / DC motor . . . . .Figure 4-34

Power supply / EC (BLDC) motor. . . . . .Figure 4-35

Motor & feedback signals

Hall sensors . . . . Method # EC1

Hall sensors & Digital incremental encoder . . . . Method # EC2

Hall sensors & SSI / BiSS C unidirectional absolute encoder . . . . .Method # EC3 [a]

SSI / BiSS C unidirectional absolute encoder . . . . .Method # EC4 [a]

Method #	Sensor 1	Sensor 2		➔Figure(s)
	Hall sensors	Digital incremental encoder	SSI / BiSS C unidirectional absolute encoder [a]	
EC1	✓			4-35 4-36
EC2	✓	✓		4-35 4-36 4-37
EC3 [a]	✓		✓	4-35 4-36 4-37
EC4 [a]			✓	4-35 4-37

[a] The functionality will be available with a future firmware release.

Table 4-47 Possible combinations of feedback signals for EC (BLDC) motor

4.2 Main wiring diagram

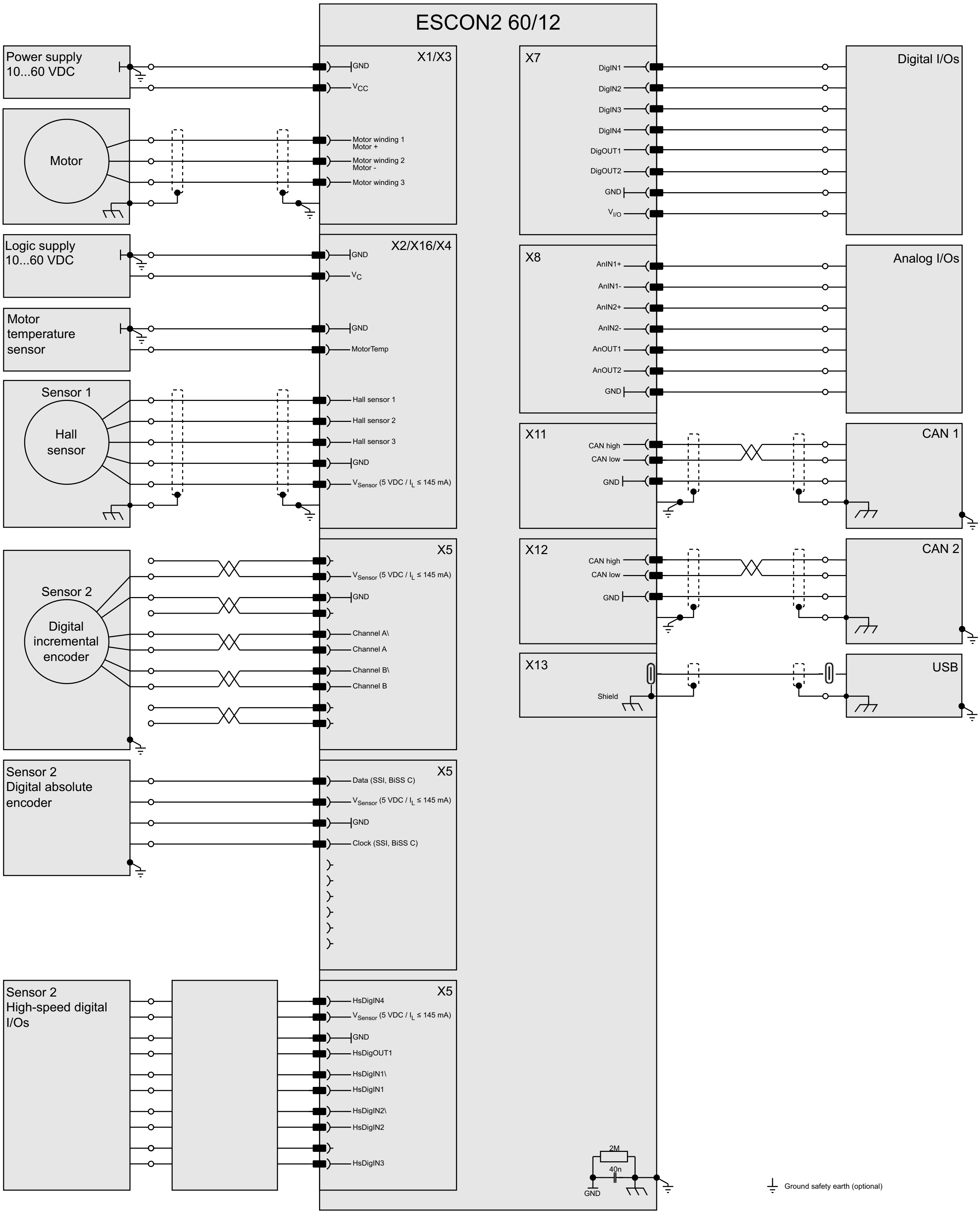

Figure 4-33 Main wiring diagram

4.3 Excerpts

4.3.1 Power supply / DC motor

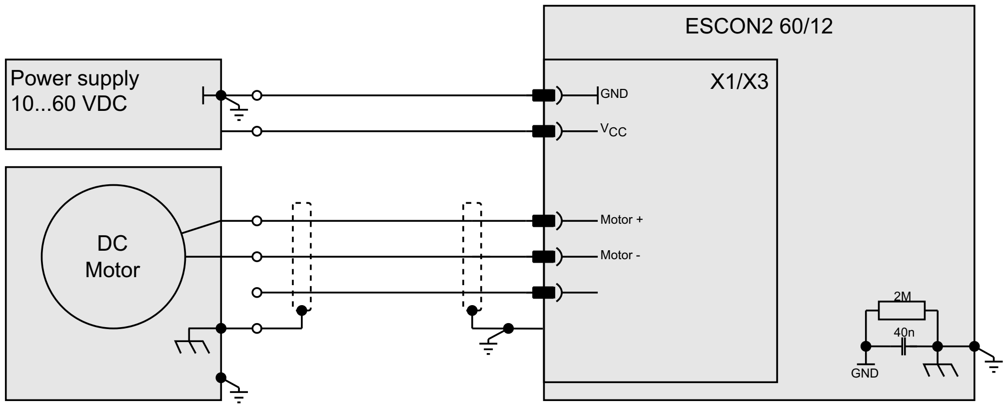

Figure 4-34 Power supply / DC motor

4.3.2 Power supply / EC (BLDC) motor

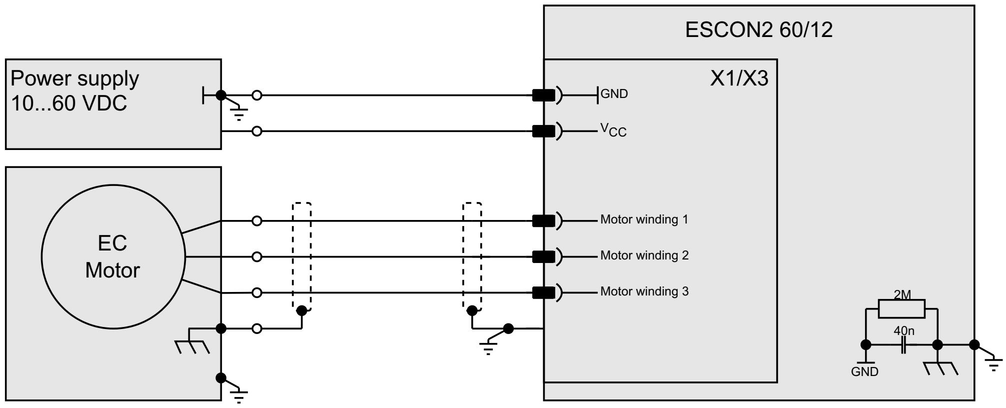

Figure 4-35 Power supply / EC (BLDC) motor

4.3.3 Logic supply / Temperature / Hall sensor

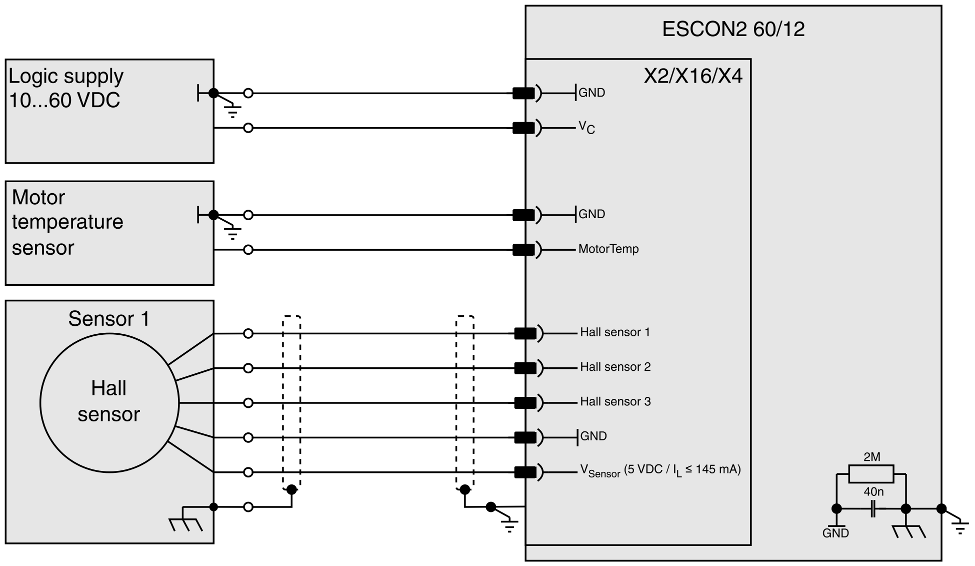

Figure 4-36 Logic supply / Temperature / Hall sensor

4.3.4 Sensor 2 Encoder / I/Os

4.3.4.1 Digital incremental encoder

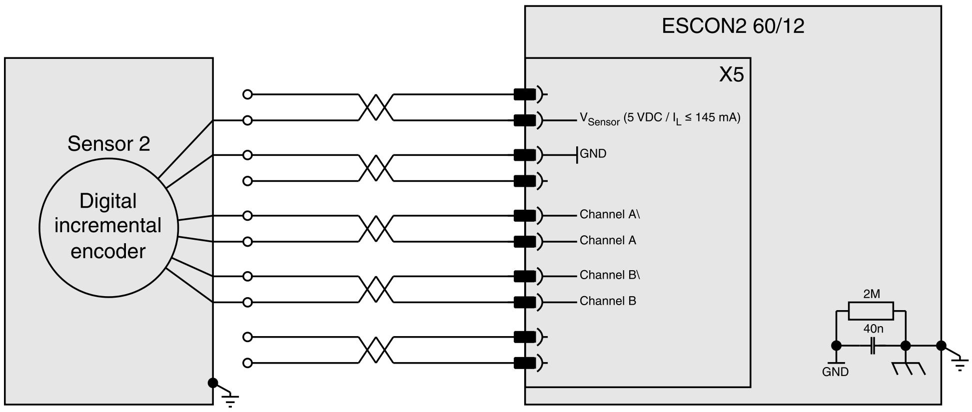

Figure 4-37 Digital incremental encoder

4.3.4.2 SSI / BiSS C unidirectional absolute encoder (future release)

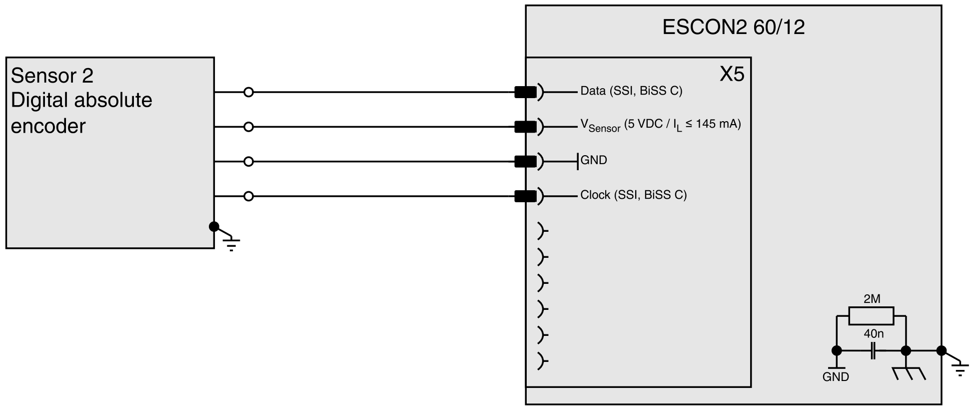

Figure 4-38 SSI / BiSS C unidirectional absolute encoder

This interface can handle a digital incremental encoder, an SSI / BiSS C digital absolute encoder or high-speed digital I/O's. Only one out of these three functions can be used at the same time.

4.3.4.3 High-speed digital I/Os

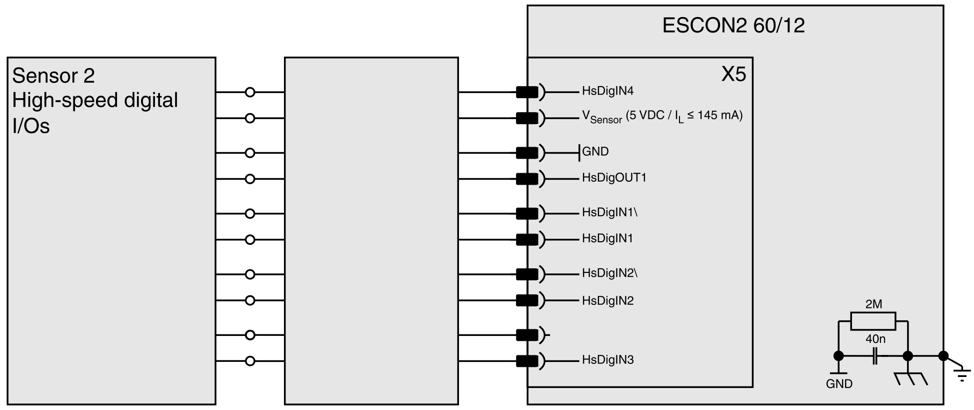

Figure 4-39 High-speed digital I/Os

This interface can handle a digital incremental encoder, an SSI / BiSS C digital absolute encoder or high-speed digital I/O's. Only one out of these three functions can be used at the same time.

4.3.5 Digital I/Os

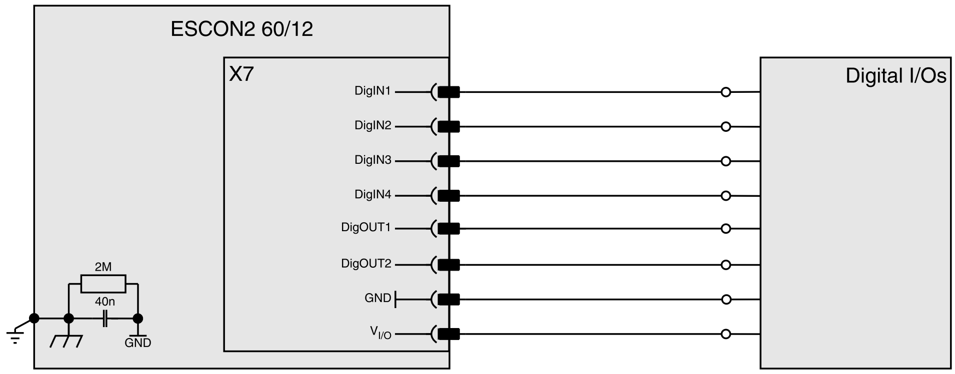

Figure 4-40 Digital I/Os

4.3.6 Analog I/Os

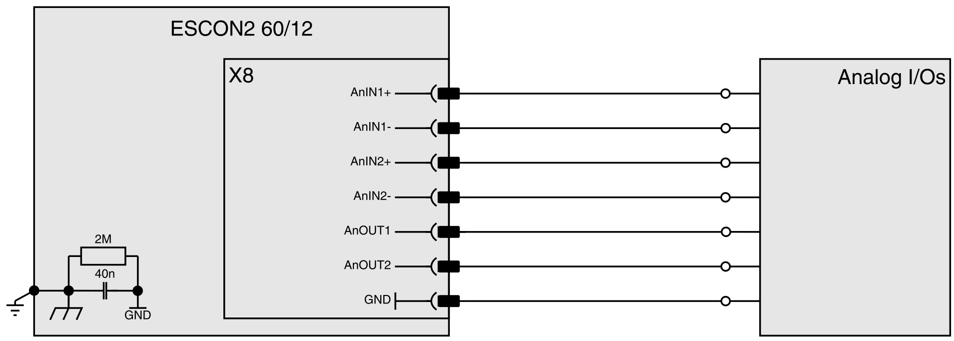

Figure 4-41 Analog I/Os

4.3.7 CAN

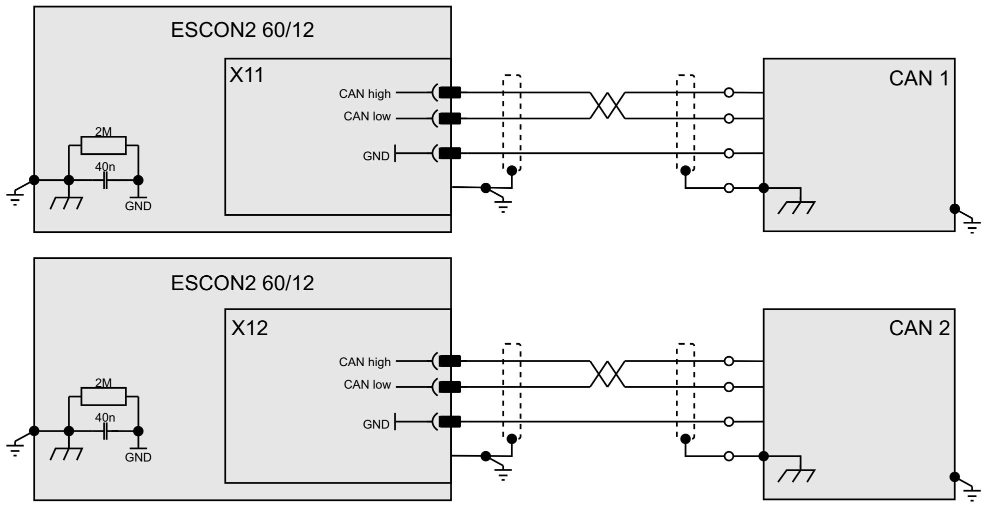

Figure 4-42 CAN

Depending on the preferred interface, one of the two prefab CAN cables can be used.

4.3.8 USB

4.3.8.1 USB-C

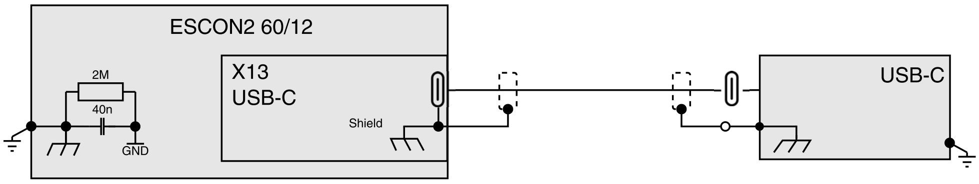

Figure 4-43 USB-C

4.3.8.2 USB-A

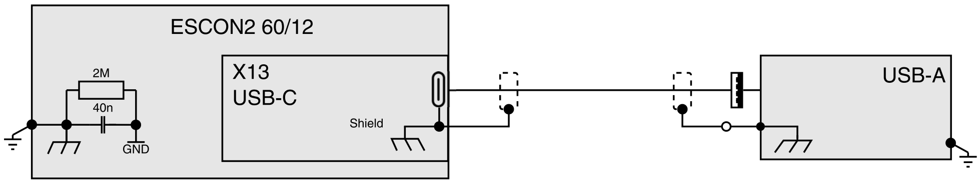

Figure 4-44 USB-A

LIST OF FIGURES

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