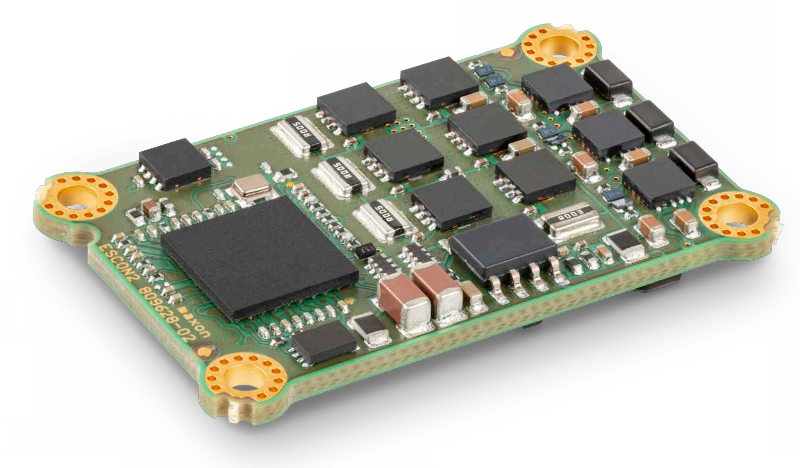
maxon

Servo Controller

ESCON2 Micro 60/5

Hardware Reference



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ESCON2 Micro 60/5 Servo Controller | P/N 809631
Hardware Reference
CCMC | Edition 2024-12 | DocID rel12663

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TABLE OF CONTENTS

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 Micro 60/5** 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

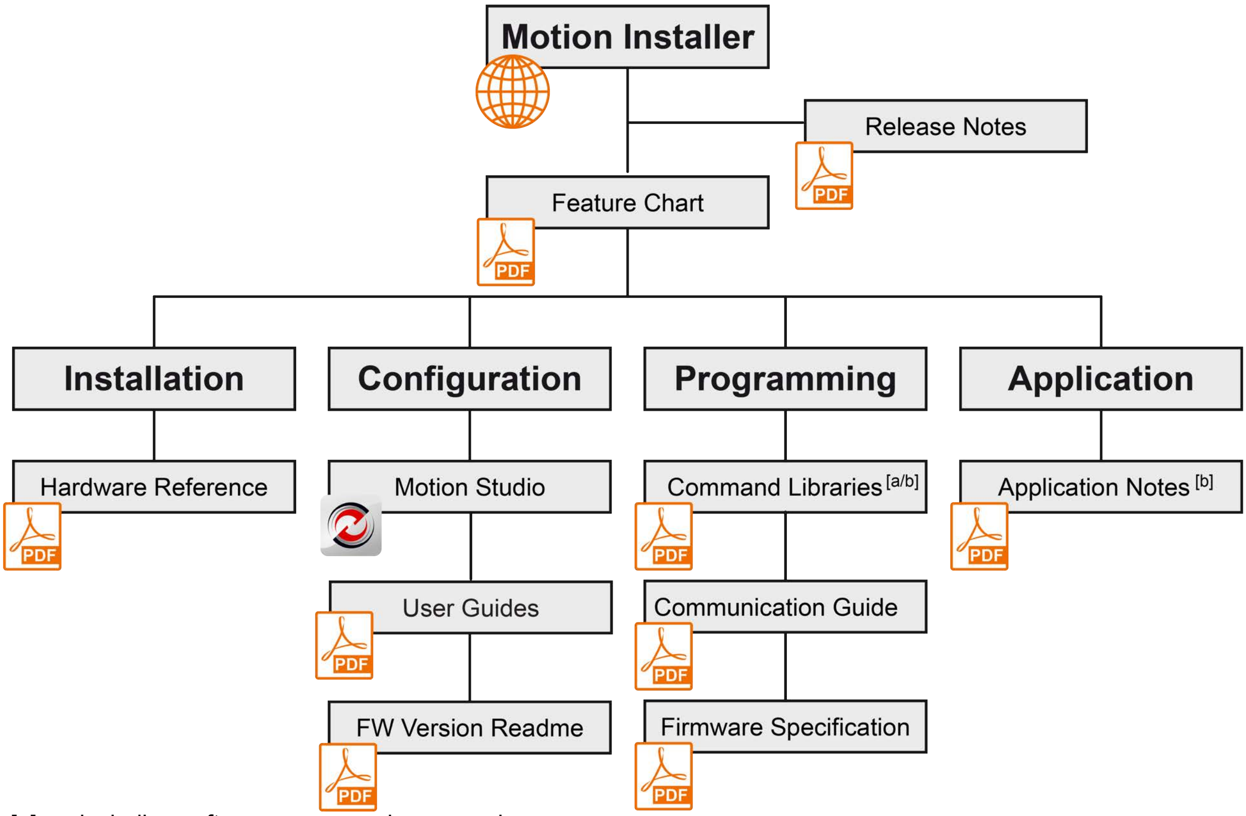
1.1 About this document

1.1.1 Intended purpose

This document familiarizes you with the ESCON2 Micro 60/5 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 Controllers, 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
ASSMANN WSW®	© ASSMANN WSW components GmbH, DE-Lüdenscheid
Adobe® Reader®	© Adobe Systems Incorporated, San Jose, CA, United States
BiSS	© iC-Haus GmbH, Bodenheim, Germany
CANopen® CiA®	© CiA CAN in Automation e.V, Nuremberg, Germany
Coilcraft®	© COILCRAFT INCORPORATED, ILLINOIS, United States
Comchip®	© Comchip, California, United States
Dialight®	© Dialight, New Jersey, United States
Diodes®	© Diodes is a registered trademark of Diodes Incorporated, United States
Global Connector Technology®	© GCT inc., Lawrence, Main, United States
Littelfuse®	© Littelfuse, Chicago, Illinois, United States
Nexperia®	© Nexperia, Nijmegen, Netherlands
onsemi®	© Onsemi, Scottsdale, Arizona, United States
Panasonic®	© Panasonic Corporation, Kadoma, Ōsaka, Japan
ROHM	© ROHM Co. Ltd., Ukyo-ku, Kyoto, Japan
Samtec®	© Samtec Europe GmbH, Germering, Germany
ST Microelectronics®	© STMicroelectronics SA, Plan-les-Ouates, France
Texas Instruments®	© Texas Instruments Incorporated, Dallas, Texas, United States
Toshiba®	© Toshiba Corporation, Minato, Tokyo, Japan
UCC ® (United Chemi-Con)	© United Chemi-Con, Rolling Meadows, Illinois, United States
Vishay®	© Vishay Precision Group, Malvern, Pennsylvania, United States
Windows®	© Microsoft Corporation, Redmond, Washington, United States
Würth Elektronik	© Würth Elektronik ICS GmbH & Co. KG, Niedernhall-Waldzimmern, Germany

Table 1-3 Brand names and trademark owners

1.1.6 Copyright

CCMC | ESCON2 Micro 60/5 Hardware Reference | Edition 2024-12 | DocID rel12663

1.2 About the device

The ESCON2 Micro 60/5 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 300 Watts. It supports various feedback options, such as Hall sensors, incremental encoders, and absolute sensors for many drive applications.

The device is designed to be controlled by analog and digital set values, or as a slave node in a CANopen network. You can also operate it via any USB or RS232 communication port of a Windows workstation. It has extensive analog and digital I/O functions.

It uses the latest technology, such as field-oriented control (FOC) and acceleration/velocity feed forward, with high control cycle rates for easy and advanced motion control.

The miniaturized OEM plug-in module integrates easily into complex applications. A suitable Evaluation Board, the ESCON2 EB Micro (P/N 809646), provides standard industry connector interfaces for commissioning and evaluation purposes.

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 “1.1.5 Trademarks and brand names” on page 1-7 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. Ensure any machine has independent monitoring and safety equipment. If the machine breaks down, is operated incorrectly, or if the control unit or cables fail, etc. the drive system must return to and stay in a safe mode.*
- *Do not repair any components supplied by maxon.*

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

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2 SPECIFICATIONS

2.1 Technical data

ESCON2 Micro 60/5 (P/N 809631)		
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.)	0.95 × V_{CC}
	Output current I_{cont} / I_{max} (< 4 s)	5 A / 15 A
	Pulse Width Modulation (PWM) frequency	50 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 2-5
	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	—
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 [a] • BISS C unidirectional absolute encoder [a] • 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 / R_i = 270 Ω
	Digital Inputs 1...4	Logic: 0…25 VDC, inputs 1…2 PWM capable
	Digital Outputs 1...2	3.3 VDC / R_i = 270 Ω, PWM capable
	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 [a]	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 $V_{Peripheral}$	3.3 VDC / I_L ≤ 20 mA (unprotected)
Motor connections	DC motor	+ Motor, − Motor
	EC motor	Motor winding 1, Motor winding 2, Motor winding 3

Continued on next page.

ESCON2 Micro 60/5 (P/N 809631)			
Communi-cation interfaces	CAN		Max. 1 Mbit/s
	RS232		Max. 115’200 bit/s, external transceiver required
	USB		12 Mbit/s (Full Speed)
Status indicators	Device status		external LEDs required
Mechanical data	Dimensions (L × W × H)		36.8 × 23.8 × 6.5 mm
	Weight (approx.)		6 g
	Mounting		Pluggable (using header) and M2 screws
Environmen-tal conditions	Temperature	Operation	−30…+50 °C
		Extended range [b]	+50…+70 °C Derating: approx. -0.227 A/°C ➔Figure 2-2 with additional heatsink: ➔Figure 2-3
		Storage	−40…+85 °C
	Altitude [c]	Operation	0…500 m MSL
		Extended range [b]	500...10'000 m MSL Derating ➔Figure 2-2
	Humidity		5…90 % (condensation not permitted)

[a] The functionality will be available with a future firmware release.
[b] Operation within the extended range is permitted. However, a respective derating (declination of output current I_{cont}) as to the stated values will apply.
[c] 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 otherwise specified, the thermal data has been obtained using the ESCON2 Micro 60/5 (P/N 809631) installed on the ESCON2 EB Micro (P/N 809646). For details, refer to ➔Chapter “4.1 Connection accessory - ready-to-use Evaluation Board” on page 4-41. The installation was performed using four screws to simulate mounting on a customer-specific motherboard. The assembly was oriented with the Evaluation Board connections facing upward and the Micro positioned at the bottom. It was placed on thermally poorly conductive supports, effectively floating in air.

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

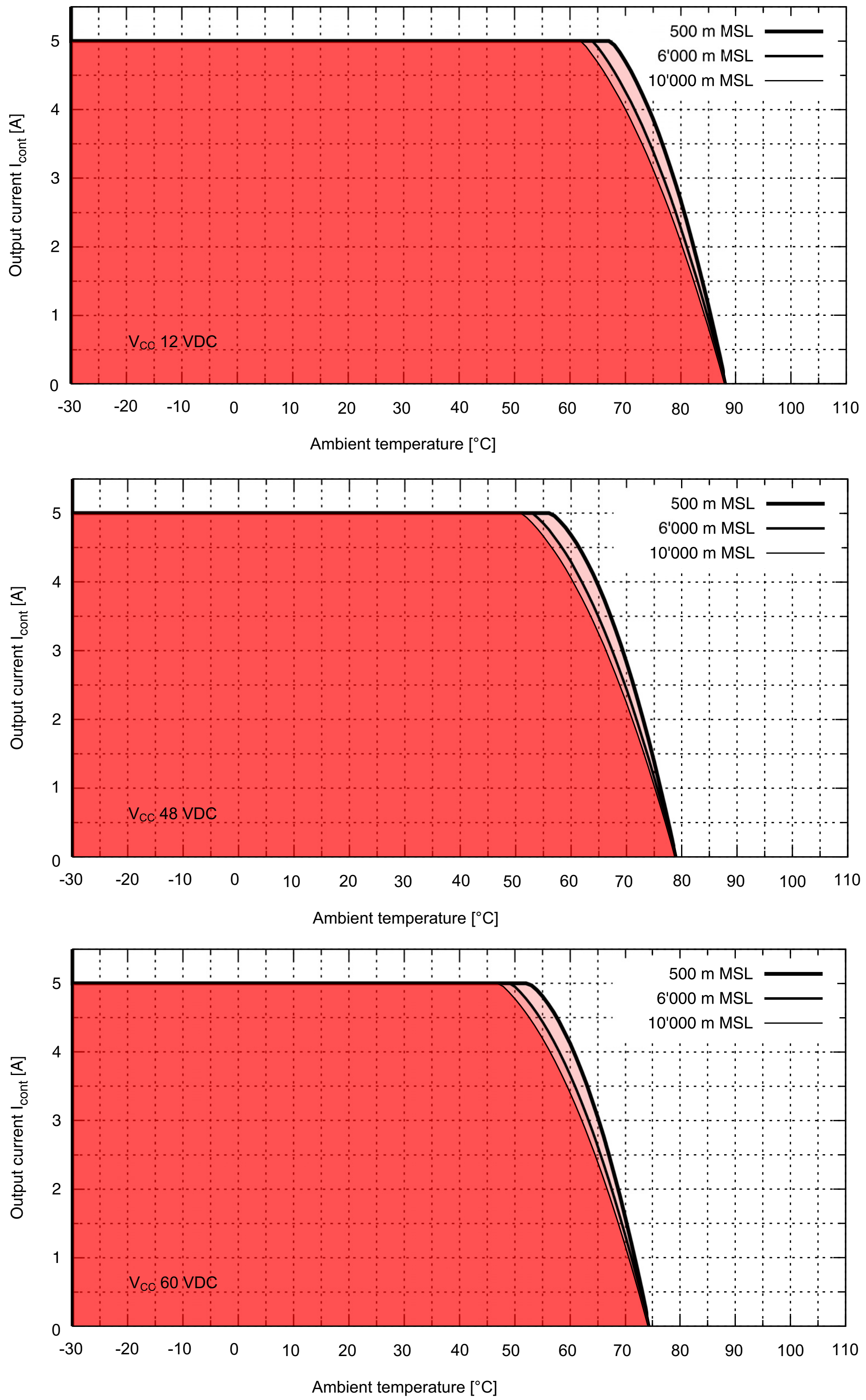


Figure 2-2 Derating of output current (operation without additional heatsink)

2.2.3 Operation with additional heatsink

During data collection in this chapter, the assembly was placed on its side. This position allows heat to flow upward from the additional heatsink, promoting effective passive cooling at the top.

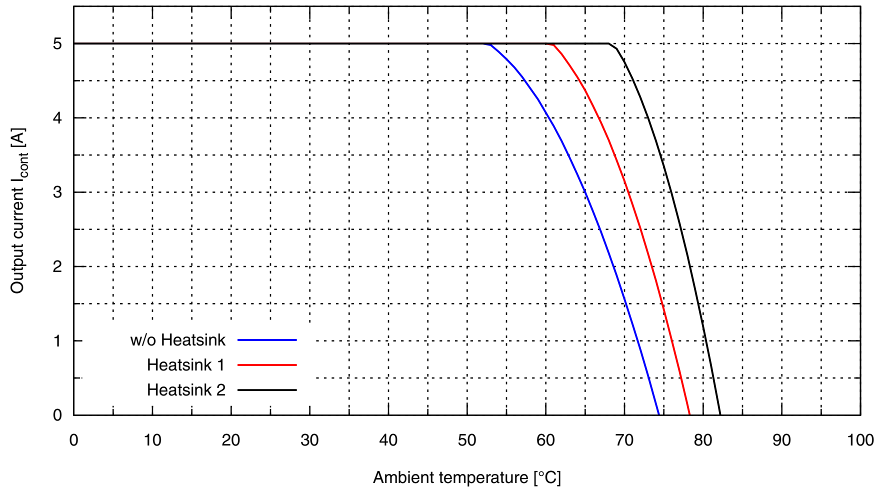


Figure 2-3 Extended operation @ V_{CC} 60 VDC with additional heatsink

Heatsink	Manufacturer	Type	Dimensions [mm]	Thermal resistance R_{th} [K/W]
1	Fischer Elektronik GmbH	SK 473 37,5 SA	37.5 × 27 × 6	19
2	Fischer Elektronik GmbH	SK 566 37,5 SA	37.5 × 27 × 22	6

Table 2-5 Heatsink – tested components

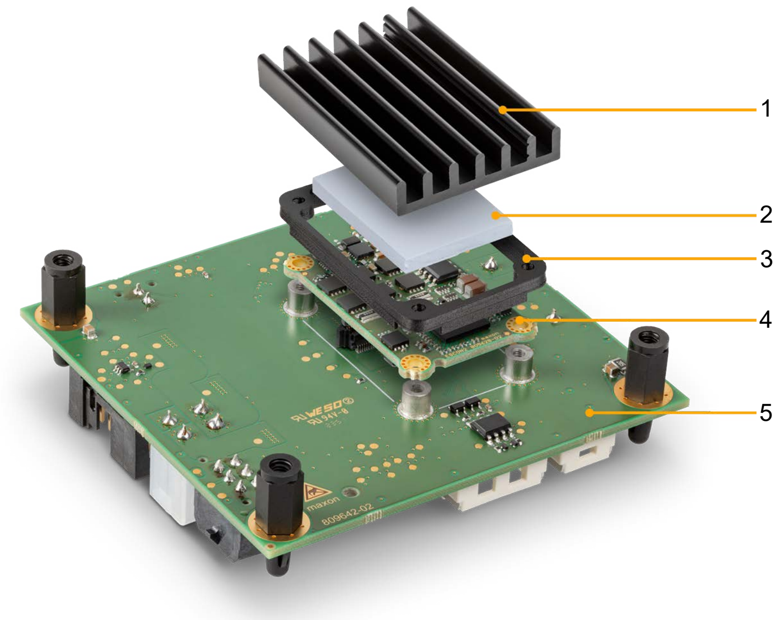
2.2.4 Thermal accessories

maxon offers the ESCON2 Micro 60/5 Thermal Accessory Kit (P/N 841890), consisting of a thermal pad and a mounting frame. Both fit the ESCON2 Micro 60/5 perfectly.

Specifications		
ESCON2 Micro 60/5 Thermal Pad	Dimensions (L × W × H)	26 × 19 × 2.54 mm
	Mounting	n/a (placed between controller and structure)
	Thermal conductivity	2.4 W/(mK)
ESCON2 Micro 60/5 Mounting Frame	Dimensions (L × W × H)	37.4 × 24.4 × 4.1 mm
	Mounting	4 holes ø2.2 mm

Table 2-6 Thermal accessories – specification

CAD files are available on the maxon website as part of the ESCON2 Micro 60/5 Thermal Accessoires Kit (P/N 841890).



1	Heatsink [a]	2	Thermal Pad
3	Mounting Frame	4	ESCON2 Micro 60/5
5	ESCON2 EB Micro		

[a] The heatsink is not part of the accessory kit and shown for illustration purposes only.

Figure 2-4 Assembly with thermal accessories

2.2.5 Power dissipation and efficiency

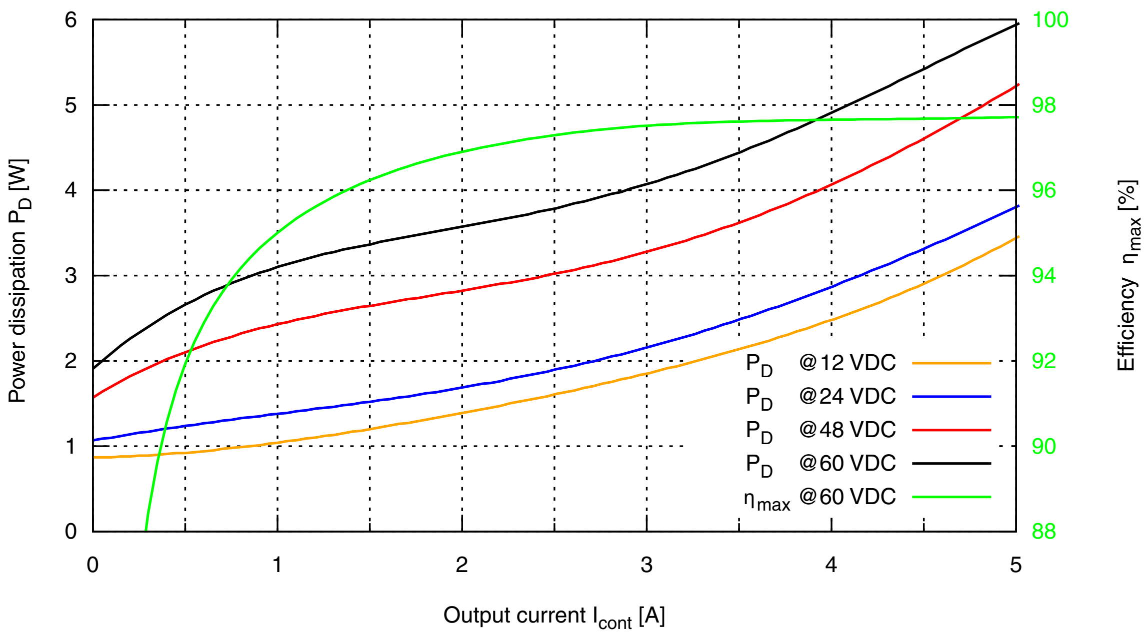


Figure 2-5 Power dissipation and efficiency

2.3 Limitations and protections

Functionality		Switch-off threshold	Recovery threshold
Undervoltage		7.5 VDC	7.75 VDC
Overvoltage		65 VDC	64 VDC
Thermal overload	logic	115 °C	105 °C
	power stage	100 °C	—

Table 2-7 Limitations and protections

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 more information, see the «ESCON2 Firmware Specification».

2.4 Dimensional drawing

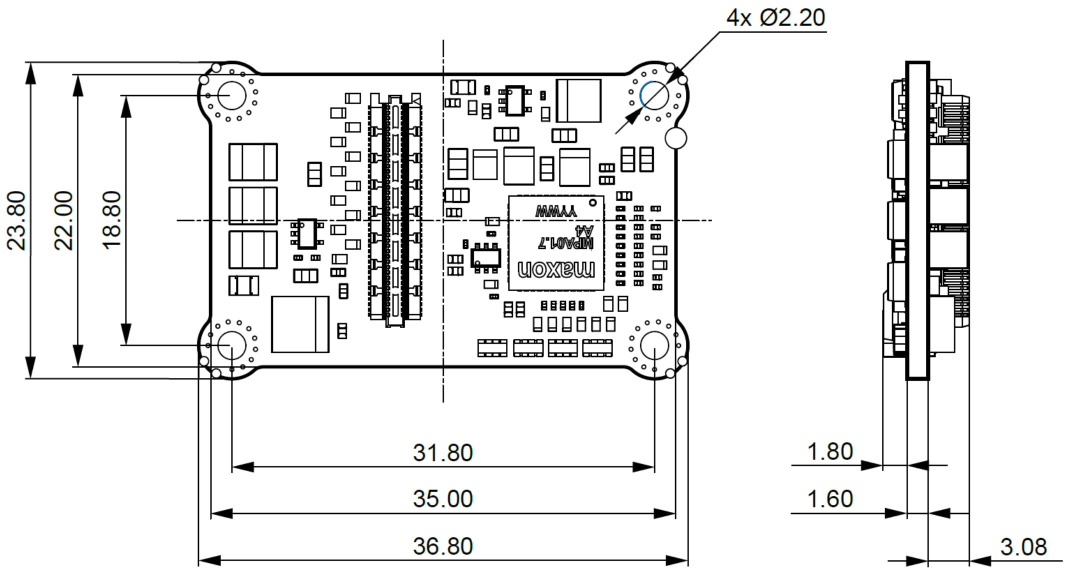


Figure 2-6 Dimensional drawing [mm]

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

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 board: 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): 347'202 hours

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

Table 2-8 Standards

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3 SETUP

IMPORTANT NOTICE: PREREQUISITES FOR INSTALLATION PERMISSION

The **ESCON2 Micro 60/5** 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 the 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. 5 A
  – short-time (acceleration) max. 15 A (< 4 s)

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

3.2 Pin assignment

For in-depth details on connections ➔Chapter “3.3 Connection specifications” on page 3-20.

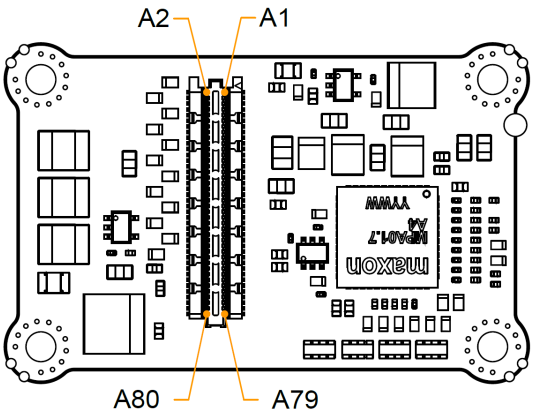

Figure 3-7 Pin assignment

Important Notice
How to read the following data
The column «Pin» refers to the socket pin number.
For example: ***A1...A3*** *means header A, pins 1 thru 3.*

Pin	Signal	Description
A1…A6 [a]	Motor winding 1	EC motor: Winding 1
	Motor (+M)	DC motor: Motor +
A7...A12 [a]	Motor winding 2	EC motor: Winding 2
	Motor (-M)	DC motor: Motor -
A13...A18 [a]	Motor winding 3	EC motor: Winding 3
	–	DC motor: DO NOT CONNECT
A19...A20	GND	Ground
A21	Hall sensor 1	Hall sensor 1 input
A22	Channel A	Digital incremental encoder channel A
	HsDigIN1	High-speed digital input 1
A23	Hall sensor 2	Hall sensor 2 input
A24	Channel A\	Digital incremental encoder channel A complement
	HsDigIN1\	High-speed digital input 1 complement
A25	Hall sensor 3	Hall sensor 3 input
A26	Channel B	Digital incremental encoder channel B
	HsDigIN2	High-speed digital input 2
A27	LED red	LED red (warning/error) signal
A28	Channel B\	Digital incremental encoder channel B complement
	HsDigIN2\	High-speed digital input 2 complement
A29	LED green	LED green (operation) signal
A30	Data	Data (SSI, BiSS C)
	HsDigIN4	High-speed digital input 4
A31	–	For maxon internal use. DO NOT CONNECT

Continued on next page.

Pin	Signal	Description
A32	HsDigIN3	High-speed digital input 3
A33	Clock	Clock (SSI, BiSS C)
	HsDigOUT1	High-speed digital output 1
A34	GND	Ground
A35	V_{Sensor}	Sensor supply voltage output (5 VDC / $I_L \leq$ 145 mA)
A36	AnIN1+	Analog input 1, positive signal
A37	DigIN1	Digital input 1
A38	AnIN1-	Analog input 1, negative signal
A39	DigIN2	Digital input 2
A40	AnIN2+	Analog input 2, positive signal
A41	DigIN3	Digital input 3
A42	AnIN2-	Analog input 2, negative signal
A43	DigIN4	Digital input 4
A44	AnOUT1	Analog output 1
A45	DigOUT1	Digital output 1
A46	AnOUT2	Analog output 2
A47	DigOUT2	Digital output 2
A48	MotorTemp	Motor temperature sensor input
A49	Auto bit rate	Automatic bit rate detection of CAN bus
A50	–	For maxon internal use. DO NOT CONNECT
A51	ID 1	CAN ID 1 (valence = 1)
A52	–	For maxon internal use. DO NOT CONNECT
A53	ID 2	CAN ID 2 (valence = 2)
A54	–	For maxon internal use. DO NOT CONNECT
A55	ID 3	CAN ID 3 (valence = 4)
A56	$V_{Peripheral}$	Peripheral components supply voltage output (3.3 VDC / IL ≤ 20 mA; unprotected
A57	ID 4	CAN ID 4 (valence = 8)
A58	GND	Ground
A59	ID 5	CAN ID 5 (valence = 16)
A60	V_{Bus}	USB supply voltage input (5 VDC)
A61	ID 6	CAN ID 6 (valence = 32)
A62	USB_D+	USB Data+ (twisted pair with USB Data-)
A63	GND	Ground
A64	USB_D-	USB Data- (twisted pair with USB Data+)
A65	CAN high	CAN bus high line
A66	GND	Ground
A67	CAN low	CAN bus low line
A68	DSP_TxD	Serial communication interface transmit (UART)
A69	GND	Ground
A70	DSP_RxD	Serial communication interface receive (UART)
A71	GND	Ground
A72	GND	Ground

Continued on next page.

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Pin	Signal	Description
A73	V_C	Logic supply voltage input (10...60 VDC)
A74	GND	Ground
A75	V_C	Logic supply voltage input (10...60 VDC)
A76 ... A80 [a]	V_{CC}	Power supply voltage input (10...60 VDC)

[a] Connect all pins in respect to the individual pin current rating.

Table 3-9 Pin assignment A1…A80

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 (➔see Page 5-59) that best suits your components.

Important Notice
How to read the following data
The column «Pin» refers to the socket pin number.
*For example: **A1...A3** means header A, pins 1 thru 3.*

3.3.1 Power supply

Pin	Signal	Description
A19/A20/ A71/A72/A74 [a]	GND	Ground
A76...A80 [a]	V_{CC}	Power supply voltage input (10...60 VDC)

[a] Connect all pins in respect to the individual pin current rating.

Table 3-10 Power supply – Pin assignment

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. 5 A • short-time (acceleration) max. 15 A (< 4 s)

Table 3-11 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 95 %*
- *Controller's max. voltage drop of 1 V @ 5 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:

$$V_{CC} \geq \left[\frac{U_N}{n_O} \cdot \left(n + \frac{\Delta n}{\Delta M} \cdot M\right) \cdot \frac{1}{0.95}\right] + 1[V]$$

3.3.2 Logic supply

Pin	Signal	Description
A71/A72/A74 [a]	GND	Ground
A73/A75 [a]	V_C	Logic supply voltage input (10...60 VDC)

[a] Connect all pins in respect to the individual pin current rating.

Table 3-12 Logic supply – Pin assignment

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 3-13 Logic supply requirements

3.3.3 Output voltages

Two output voltages are provided for the supply of external devices or as input voltage for I/Os. Typically:

- The sensor supply voltage (V_{Sensor}) is used for Hall sensors, encoders, high-speed digital inputs, digital I/Os, or an external RS232 transceiver.
- The peripheral supply voltage ($V_{Peripheral}$) is used for an external RS422 transceiver or other external devices.

Pin	Signal	Description
A34	GND	Ground
A35	V_{Sensor}	Sensor supply voltage output (5 VDC / I_L ≤ 145 mA)
A56	$V_{Peripheral}$	Peripheral components supply voltage output (3.3 VDC / I_L ≤ 20 mA; unprotected)
A58	GND	Ground

Table 3-14 Output voltages – Pin assignment

Unprotected voltage output $V_{Peripheral}$
The peripheral supply voltage output ($V_{Peripheral}$) is unprotected. Avoid any signals on this interface, as they can cause damage.

3.3.4 Motor

The controller is set to drive either an EC motor (BLDC, brushless DC motor) or a DC motor (brushed DC motor).

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

Pin	Signal	Description
A1...A6 [a]	Motor winding 1	Winding 1
A7...A12 [a]	Motor winding 2	Winding 2
A13...A18 [a]	Motor winding 3	Winding 3

[a] Connect all pins in respect to the individual pin current rating.

Table 3-15 EC motor – Pin assignment

Pin	Signal	Description
A1...A6 [a]	Motor (+M)	Motor +
A7...A12 [a]	Motor (-M)	Motor -
A13...A18	-	DO NOT CONNECT

[a] Connect all pins in respect to the individual pin current rating.

Table 3-16 DC motor – Pin assignment

3.3.5 Sensor 1 Hall sensor

Pin	Signal	Description
A21	Hall sensor 1	Hall sensor 1 input
A23	Hall sensor 2	Hall sensor 2 input
A25	Hall sensor 3	Hall sensor 3 input
A34	GND	Ground
A35	V_{Sensor}	Sensor supply voltage output (5 VDC / $I_L \leq$ 145 mA)

Table 3-17 Hall sensor – Pin assignment

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 “3.3.5 Sensor 1 Hall sensor” on page 3-22*
- *Incremental encoders ➔Chapter “3.3.6.1 Incremental encoder” on page 3-23*
- *SSI / BiSS C encoders ➔Chapter “3.3.6.2 SSI / BiSS C unidirectional absolute encoder (future release)” on page 3-26*
- *High-speed digital I/Os ➔Chapter “3.3.6.3 High-speed digital I/Os” on page 3-27*
- *Digital I/Os ➔Chapter “3.3.7 Digital I/Os” 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 3-18 Hall sensor specification

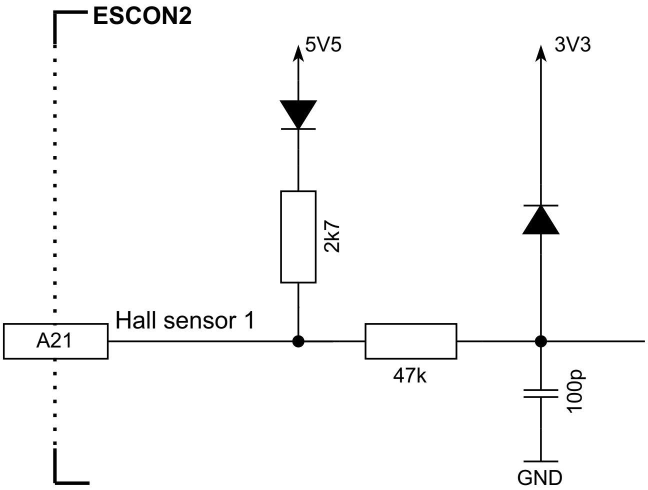

Figure 3-8 Hall sensor 1 input circuit (analogously valid for Hall sensors 2 & 3)

3.3.6 Sensor 2 Encoder / I/Os

You can connect additional sensors, either incremental encoders, serial encoders, or digital inputs and outputs. Only one sensor or function can be used at a time: either an incremental encoder, an absolute encoder, or high-speed digital I/Os.

3.3.6.1 Incremental encoder

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

Pin	Signal	Description
A22	Channel A	Digital incremental encoder channel A
A24	Channel A\	Digital incremental encoder channel A complement
A26	Channel B	Digital incremental encoder channel B
A28	Channel B\	Digital incremental encoder channel B complement
A34	GND	Ground
A35	V_{Sensor}	Sensor supply voltage output (5 VDC / $I_L \leq$ 145 mA)

Table 3-19 Incremental encoder – Pin assignment

maxon

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 “3.3.5 Sensor 1 Hall sensor” on page 3-22*
- *Incremental encoders ➔Chapter “3.3.6.1 Incremental encoder” on page 3-23*
- *SSI / BiSS C encoders ➔Chapter “3.3.6.2 SSI / BiSS C unidirectional absolute encoder (future release)” on page 3-26*
- *High-speed digital I/Os ➔Chapter “3.3.6.3 High-speed digital I/Os” on page 3-27*
- *Digital I/Os ➔Chapter “3.3.7 Digital I/Os” 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.

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 3-20 Differential digital incremental encoder specification

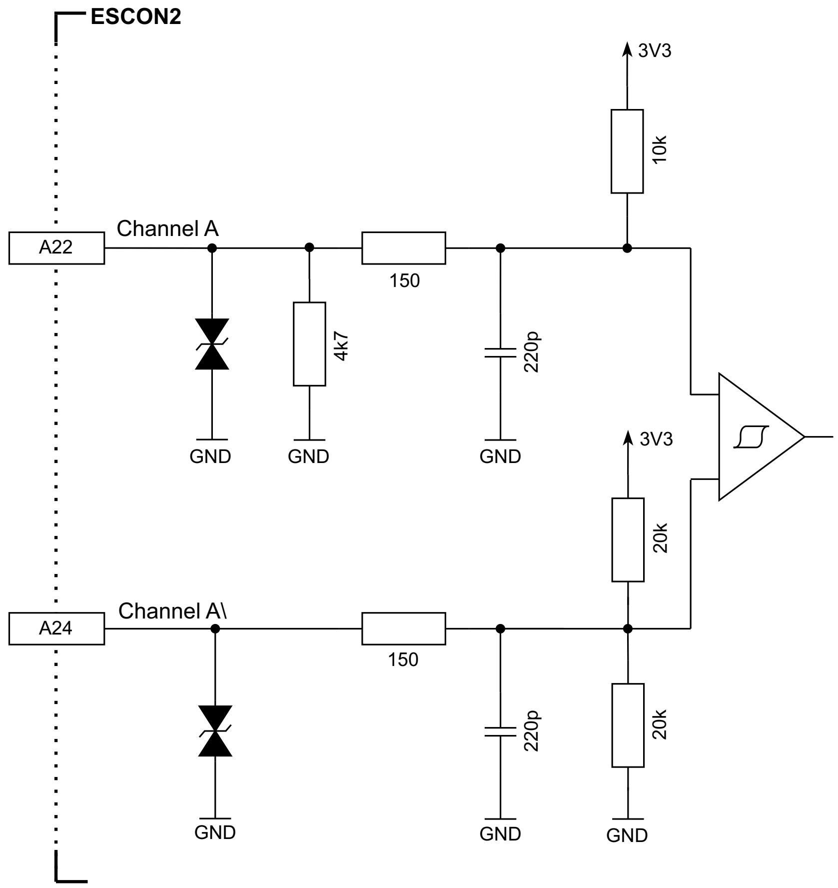

Figure 3-9 Digital incremental encoder input circuit Ch A “differential” (analogously valid for Ch B)

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 3-21 Single-ended digital incremental encoder specification

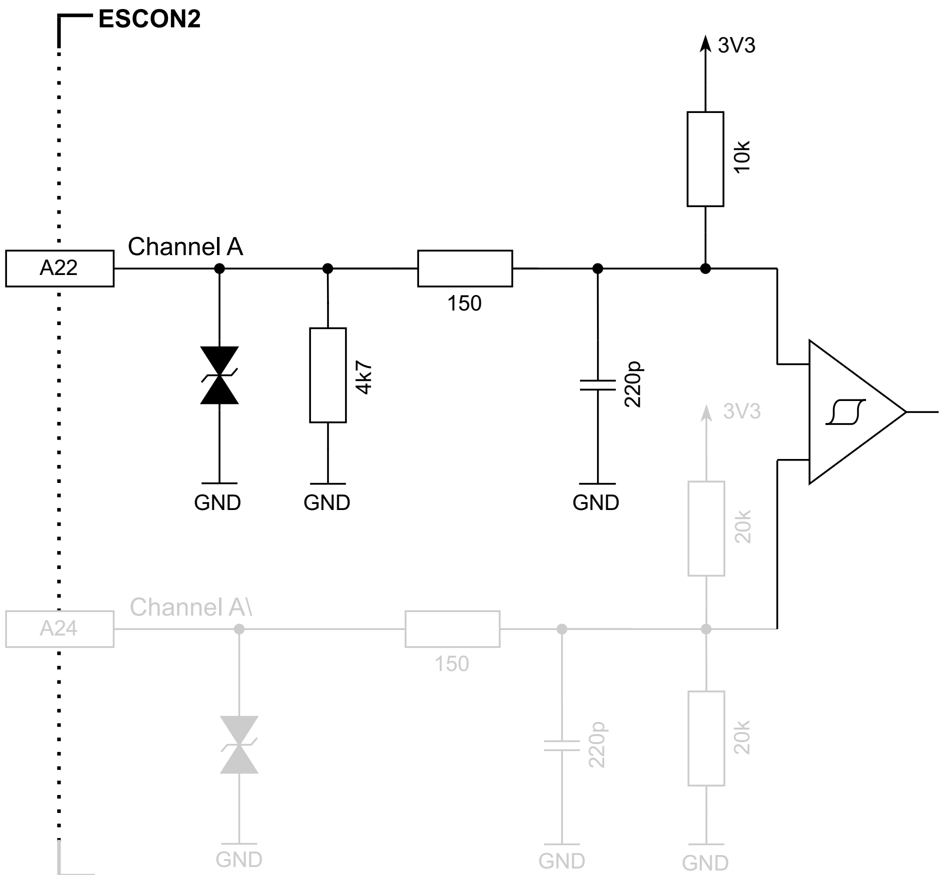

Figure 3-10 Digital incremental encoder input circuit Ch A “single-ended” (analogously valid for Ch B)

maxon

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

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

Best practice
For cable lengths over 30 cm and for best performance and resistance against electrical interference, ***use encoders with a line driver (differential scheme)****. This requires an external transceiver on the motherboard (see ➔Chapter “4.2.8 RS422 transceiver for differential SSI, BiSS C or high-speed I/Os signals” on page 4-48).*

Pin	Signal	Description
A30	Data	Data (SSI, BiSS C)
A33	Clock	Clock (SSI, BiSS C)
A34	GND	Ground
A35	V_{Sensor}	Sensor supply voltage output (5 VDC / I_L ≤ 145 mA)

Table 3-22 SSI / BiSS C unidirectional absolute encoder – Pin assignment

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 “3.3.5 Sensor 1 Hall sensor” on page 3-22*
- *Incremental encoders ➔Chapter “3.3.6.1 Incremental encoder” on page 3-23*
- *SSI / BiSS C encoders ➔Chapter “3.3.6.2 SSI / BiSS C unidirectional absolute encoder (future release)” on page 3-26*
- *High-speed digital I/Os ➔Chapter “3.3.6.3 High-speed digital I/Os” on page 3-27*
- *Digital I/Os ➔Chapter “3.3.7 Digital I/Os” 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.

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 3-23 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 3-24 Single-ended SSI / BiSS C unidirectional absolute encoder data channel specification

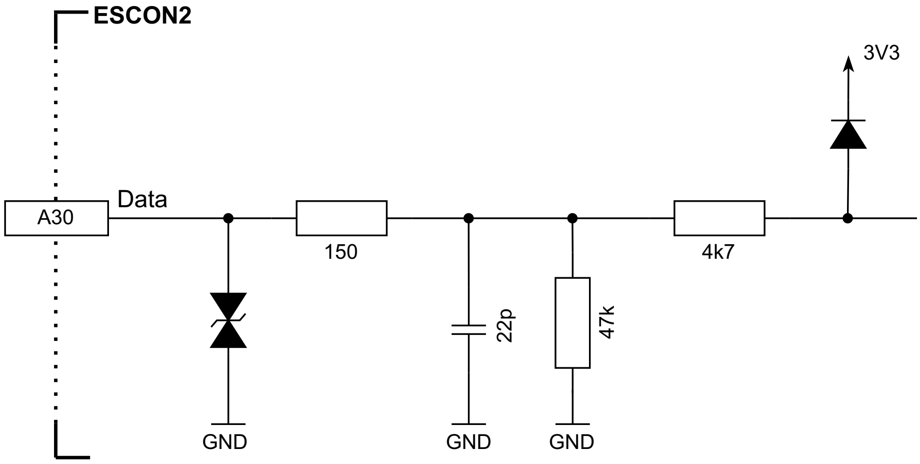

Figure 3-11 SSI absolute encoder data input (analogously valid for BiSS C)

SSI / BiSS C unidirectional absolute encoder clock channel		
Output voltage		3.3 VDC
Output resistance	Total	270 Ω (220 Ω + 50 Ω)
	Processor internal	50 Ω
Clock frequency	SSI	0.1...2 MHz
	BiSS C	0.1...4 MHz

Table 3-25 Single-ended SSI / BiSS C unidirectional absolute encoder clock channel specification

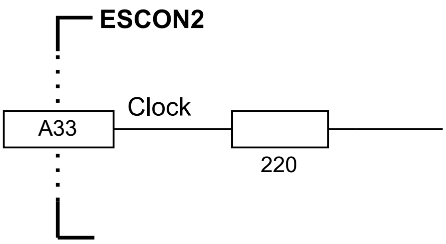

Figure 3-12 SSI absolute encoder clock output (analogously valid for BiSS C)

3.3.6.3 High-speed digital I/Os

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

Pin	Signal	Description
A22	HsDigIN1	High-speed digital input 1
A24	HsDigIN1\	High-speed digital input 1 complement
A26	HsDigIN2	High-speed digital input 2
A28	HsDigIN2\	High-speed digital input 2 complement
A30	HsDigIN4	High-speed digital input 4
A32	HsDigIN3	High-speed digital input 3
A33	HsDigOUT1	High-speed digital output 1
A34	GND	Ground
A35	V_{Sensor}	Sensor supply voltage output (5 VDC / I_L ≤ 145 mA)

Table 3-26 High-speed digital I/Os – Pin assignment

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 "3.3.5 Sensor 1 Hall sensor" on page 3-22*
- *Incremental encoders ➔Chapter "3.3.6.1 Incremental encoder" on page 3-23*
- *SSI / BiSS C encoders ➔Chapter "3.3.6.2 SSI / BiSS C unidirectional absolute encoder (future release)" on page 3-26*
- *High-speed digital I/Os ➔Chapter "3.3.6.3 High-speed digital I/Os" on page 3-27*
- *Digital I/Os ➔Chapter "3.3.7 Digital I/Os" 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.

High-speed digital input 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 3-27 Differential high-speed digital input specification

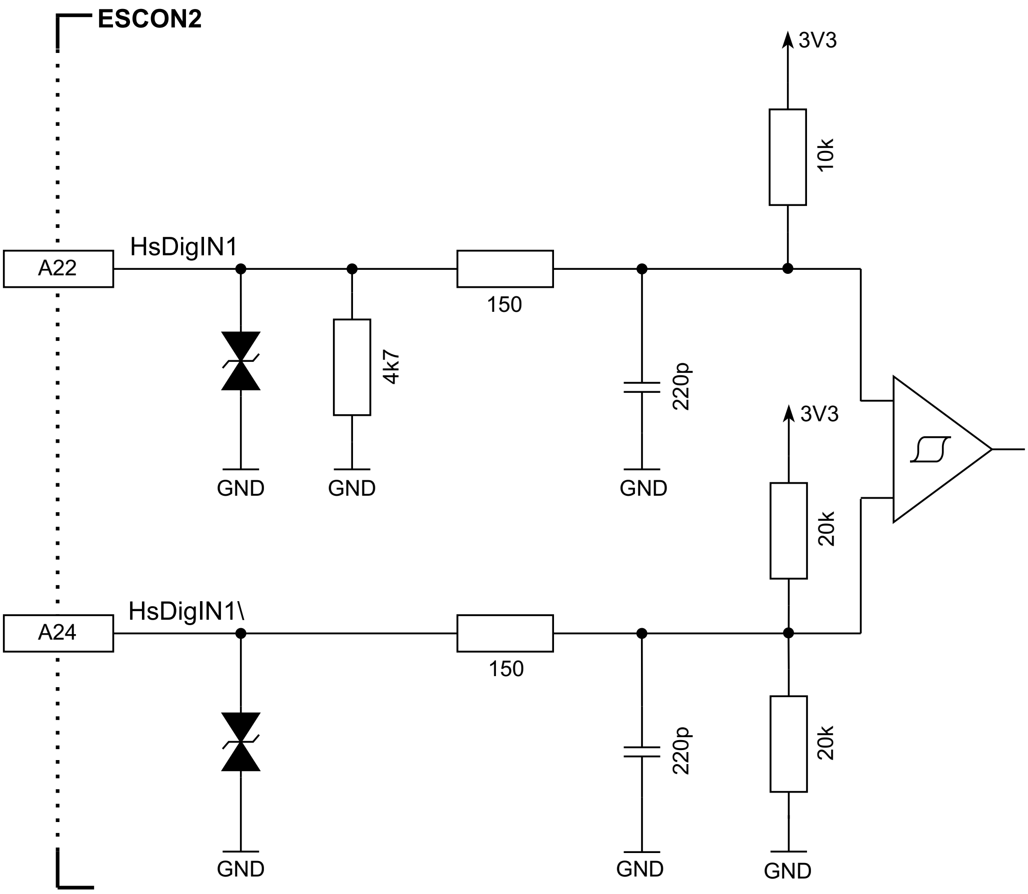

Figure 3-13 HsDigIN1 circuit "differential" (analogously valid for HsDigIN2)

High-speed digital input 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 3-28 Single-ended high-speed digital input specification

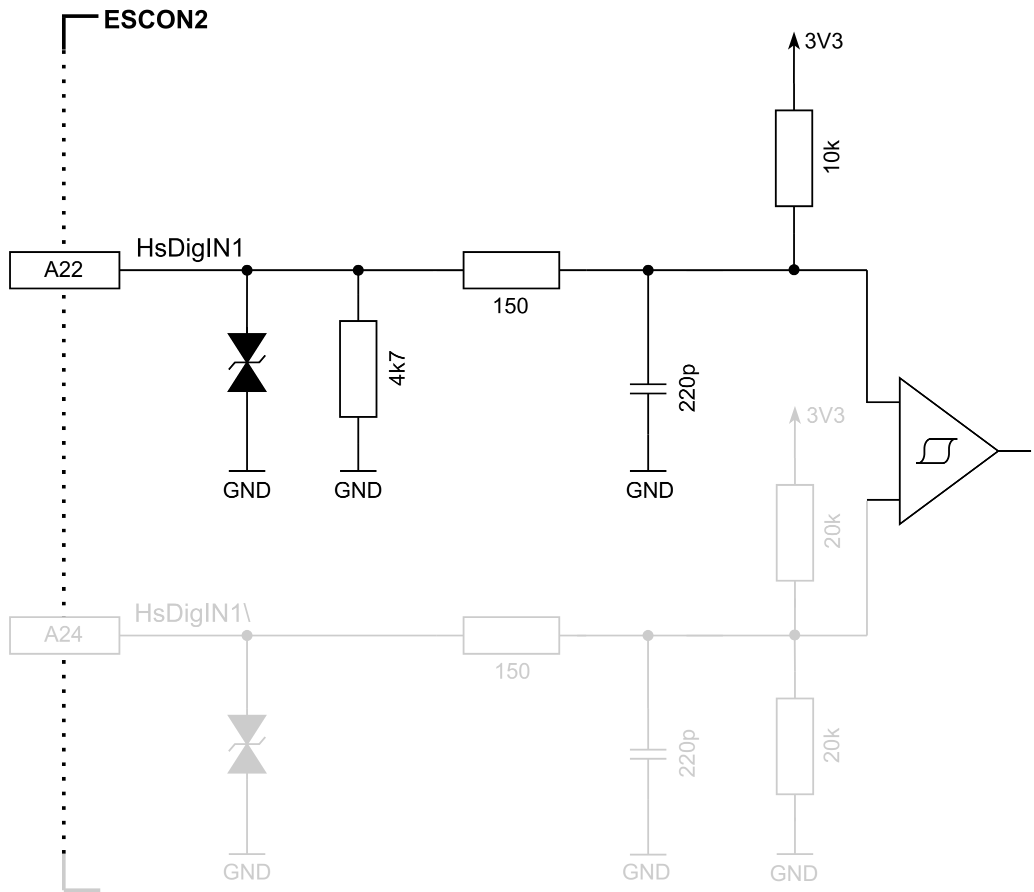

Figure 3-14 HsDigIN1 circuit “single-ended” (analogously valid for HsDigIN2…3)

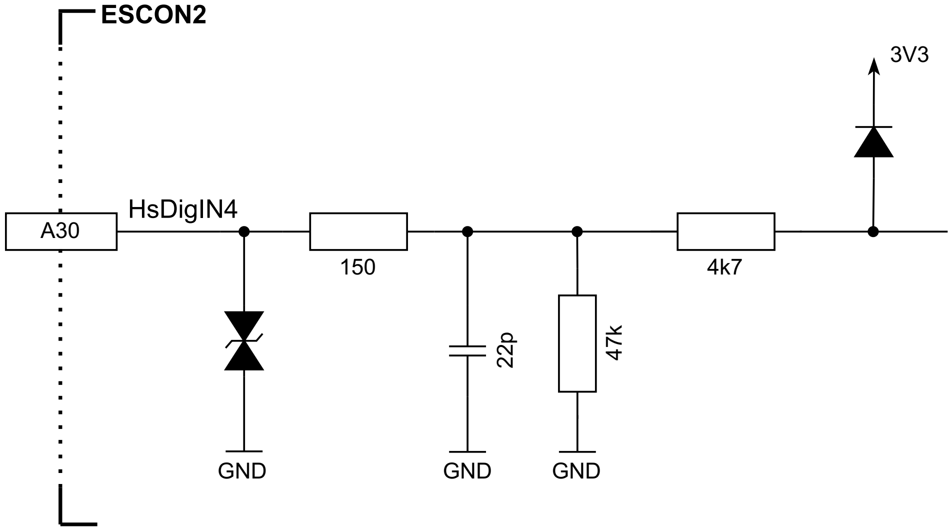

Figure 3-15 HsDigIN4 circuit “single-ended”

High-speed digital output 1		
Output voltage		3.3 VDC
Output resistance	Total	270 Ω (220 Ω + 50 Ω)
	Processor internal	50 Ω
Max. output frequency		25 kHz

Table 3-29 High-speed digital output specification

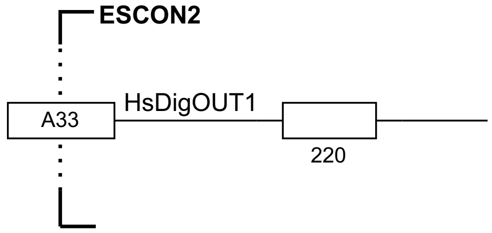

Figure 3-16 HsDigOUT1 circuit

3.3.7 Digital I/Os

Pin	Signal	Description
A34	GND	Ground
A35	V_{Sensor}	Sensor supply voltage output (5 VDC / I_L ≤ 145 mA)
A37	DigIN1	Digital input 1
A39	DigIN2	Digital input 2
A41	DigIN3	Digital input 3
A43	DigIN4	Digital input 4
A45	DigOUT1	Digital output 1
A47	DigOUT2	Digital output 2

Table 3-30 Digital I/Os – Pin assignment

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 "3.3.5 Sensor 1 Hall sensor" on page 3-22*
- *Incremental encoders ➔Chapter "3.3.6.1 Incremental encoder" on page 3-23*
- *SSI / BiSS C encoders ➔Chapter "3.3.6.2 SSI / BiSS C unidirectional absolute encoder (future release)" on page 3-26*
- *High-speed digital I/Os ➔Chapter "3.3.6.3 High-speed digital I/Os" on page 3-27*
- *Digital I/Os ➔Chapter "3.3.7 Digital I/Os" 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.

Digital inputs 1…2	
Input voltage	0…25 VDC
Max. input voltage	±25 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 3-31 Digital inputs 1...2 specification

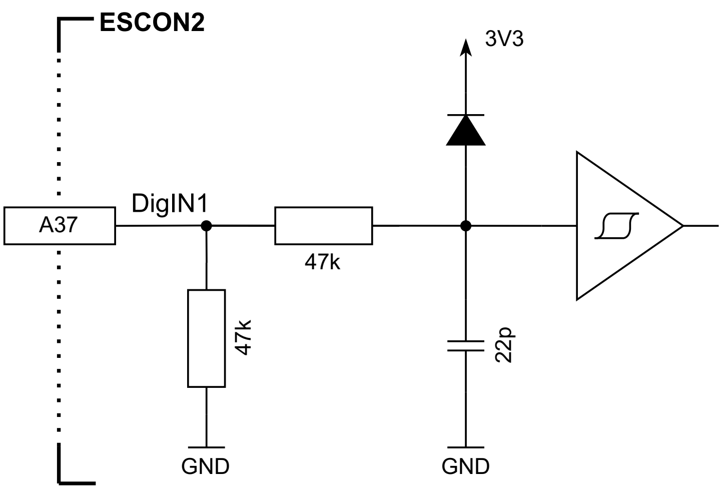

Figure 3-17 DigIN1 circuit (analogously valid for DigIN2)

Digital inputs 3…4	
Input voltage	0…25 VDC
Max. input voltage	±25 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 3-32 Digital inputs 3...4 specification

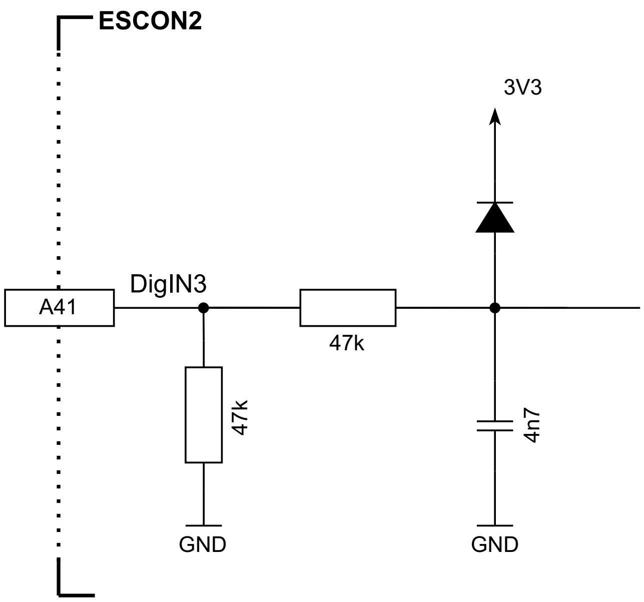

Figure 3-18 DigIN3 circuit (analogously valid for DigIN4)

Digital outputs 1…2		
Output voltage		3.3 VDC
Output resistance	Total	270 Ω (220 Ω + 50 Ω)
	Processor internal	50 Ω
Max. output frequency		25 kHz

Table 3-33 Digital output specification

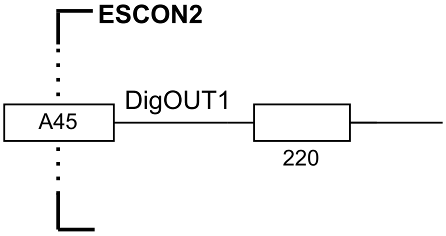

Figure 3-19 DigOUT1 circuit (analogously valid for DigOUT2)

For connecting devices that require a larger output current, use an external load switch on the motherbaord (see ➔Chapter “4.2.9 Digital outputs load switch” on page 4-52).

3.3.8 Analog I/Os

Pin	Signal	Description
A34	GND	Ground
A36	AnIN1+	Analog input 1, positive signal
A38	AnIN1−	Analog input 1, negative signal
A40	AnIN2+	Analog input 2, positive signal
A42	AnIN2−	Analog input 2, negative signal
A44	AnOUT1	Analog output 1
A46	AnOUT2	Analog output 2
A48	MotorTemp	Motor temperature sensor input

Table 3-34 Analog I/O – Pin assignment

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 3-35 Analog input specification

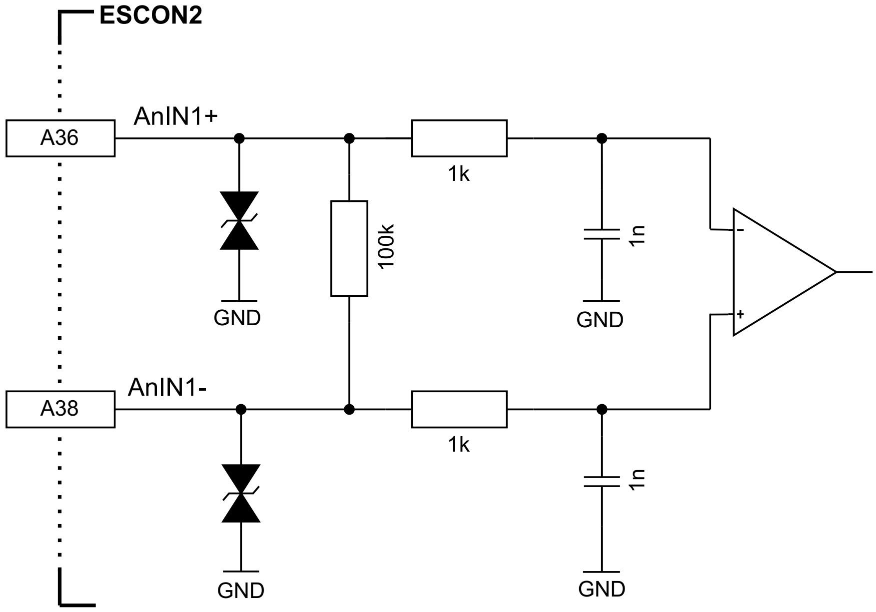

Figure 3-20 AnIN1 circuit (analogously valid for AnIN2)

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 3-36 Analog output specification

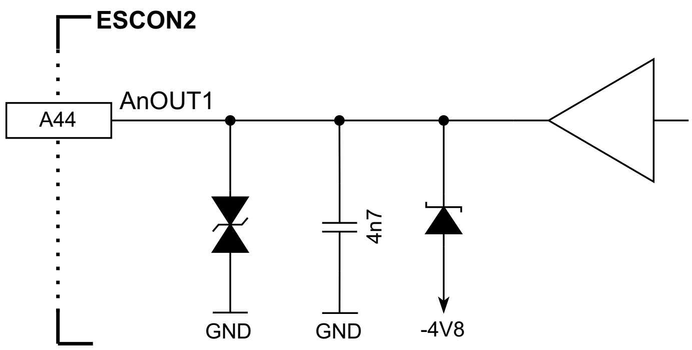

Figure 3-21 AnOUT1 circuit (analogously valid for AnOUT2)

3.3.9 Serial Communication Interface (SCI) / RS232

The SCI is a two-wire asynchronous serial port, commonly known as a UART. It supports digital communication between the CPU and other asynchronous peripherals that use the standard non-return-to-zero (NRZ) format.

A common use of the SCI is to build an RS232 interface by wiring it to an RS232 transceiver.

Bit rate setting
- *Consider the master’s maximal bit rate.*
- *The standard bit rate setting (factory setting) is 115‘200 bit/s.*

Pin	Signal	Description
A68	DSP_TxD	Serial communication interface transmit (UART)
A70	DSP_RxD	Serial communication interface receive (UART)

Table 3-37 SCI – Pin assignment

Serial Communication Interface (SCI)		
Input voltage		0...3.3 VDC
Max. input voltage		5 VDC
High-level input voltage		> 1.8 VDC
Low-level input voltage		< 1 VDC
High-level output voltage		> 2.4 VDC
Low-level output voltage		< 0.4 VDC
Series resistance transmit	Total	270 Ω (220 Ω + 50 Ω)
	Processor internal	50 Ω
Max. bit rate		115‘200 bit/s
Data format		NRZ (non-return-to-zero)

Table 3-38 SCI specification

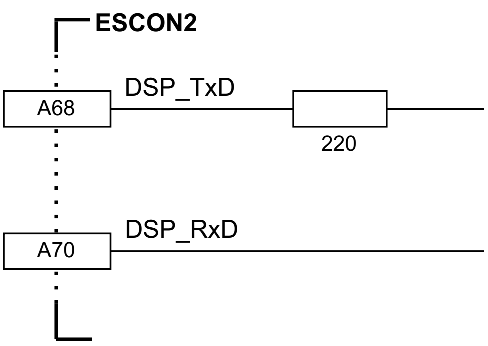

Figure 3-22 SCI circuit

3.3.10 CAN

3.3.10.1 Interface

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.

Pin	Signal	Description
A65	CAN high	CAN bus high line
A66	GND	Ground
A67	CAN low	CAN bus low line

Table 3-39 CAN – Pin assignment

CAN interface	
Standard	ISO 11898-2:2003
Max. bit rate	1 Mbit/s
Max. number of CAN nodes	63/127 (via hardware/software setting)
Protocol	CiA 301 version 4.2.0
Node-ID setting	By external wiring or software

Table 3-40 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».*

3.3.10.2 Configuration

The device’s identification (ID) can be set by hardware (external wiring) or software using binary code:

Pin	Signal	Description	Binary Code	Valence
A49	Auto bit rate	Automatic bit rate detection of CAN bus	-	-
A51	ID 1	CAN ID 1	2^0	1
A53	ID 2	CAN ID 2	2^1	2
A55	ID 3	CAN ID 3	2^2	4
A57	ID 4	CAN ID 4	2^3	8
A58	GND	Ground	-	-
A59	ID 5	CAN ID 5	2^4	16
A61	ID 6	CAN ID 6	2^5	32
A63	GND	Ground	-	-

Table 3-41 CAN Auto bit rate / ID – Pin assignment

CAN ID	
Logic 1	connected to GND
Logic 0	not connected

Table 3-42 CAN ID specification

The set ID can be observed by adding the valences of all inputs connected externally to GND. Use the following table as a (non-concluding) guide:

CAN ID						ID
1	**2**	**3**	**4**	**5**	**6**	
0	0	0	0	0	0	–
1	0	0	0	0	0	1
0	**1**	0	0	0	0	2
0	0	**1**	0	0	0	4
1	0	**1**	0	0	0	5
0	0	0	**1**	0	0	8
0	0	0	0	**1**	0	16
0	0	0	0	0	**1**	32
1	**1**	**1**	**1**	**1**	**1**	63
0 = ID input line not connected	1 = ID input line externally connected to GND					

Table 3-43 ID – 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” (none of the ID input lines connected).

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 when the input line is externally connected to GND.

Bit rate detection	
Logic 1	connected to GND
Logic 0	not connected

Table 3-44 Bit rate detection specification

3.3.11 USB

USB potential differences may cause hardware damage

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.*
- *Always establish physical USB connection first before switching on the power supply of the controller.*

Pin	PC's USB Terminal	Signal	Description
A60	1	V_{BUS}	USB supply voltage input 5 VDC
A62	3	USB_D+	USB Data+ (twisted pair with USB Data−)
A63	4	GND	USB Ground
A64	2	USB_D−	USB Data− (twisted pair with USB Data+)

Table 3-45 USB – Pin assignment

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 3-46 USB interface specification

3.3.12 Motor temperature sensor (future release)

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

Pin	Signal	Description
A48	MotorTemp	Motor temperature sensor input
A58	GND	Ground

Table 3-47 Motor temperature sensor – Pin assignment

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 3-48 Motor temperature sensor – specifications

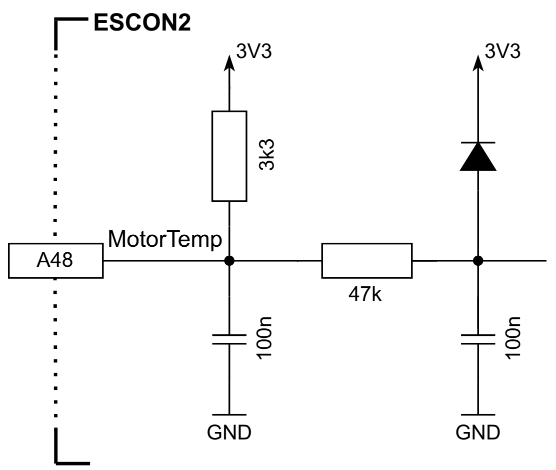

Figure 3-23 Motor temperature circuit

3.4 Status indicators

The ESCON2 Micro 60/5 provides two output signals to display the actual operation status and possible warnings and errors using LEDs. A set of green and red LEDs is recommended:

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

<table>
<tr><th colspan="2">LED</th><th rowspan="2">Warning / Error</th><th rowspan="2">Description</th></tr>
<tr><th>Green</th><th>Red</th></tr>
<tr><td>Slow</td><td>OFF</td><td>No warning/error active.</td><td rowspan="2">Power stage is disabled. The ESCON2 is in status
• Switch on disabled
• Ready to switch on
• Switched on</td></tr>
<tr><td>Slow</td><td>Slow</td><td>At least one warning is active.</td></tr>
<tr><td>ON</td><td>OFF</td><td>No warning/error active.</td><td rowspan="2">Power stage is enabled. The ESCON2 is in status
• Operation enabled
• Quick stop active</td></tr>
<tr><td>ON</td><td>Slow</td><td>At least one warning is active.</td></tr>
<tr><td>ON</td><td>ON</td><td>At least one error has occurred.</td><td>Power stage is enabled. The ESCON2 is in temporary status
• Fault reaction active</td></tr>
<tr><td>OFF</td><td>ON</td><td>At least one error has occurred.</td><td>Power stage is disabled. The ESCON2 is in status
• Fault</td></tr>
<tr><td>Flash</td><td>ON</td><td>n/a</td><td>Firmware update in progress or invalid application</td></tr>
<tr><td colspan="4">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)</td></tr>
</table>

Table 3-49 Device Status LEDs

Pin	Signal	Description
A27	LED red	LED red (warning/error) signal
A29	LED green	LED green (operation) signal

Table 3-50 Device status outputs - Pin assignment

Device status outputs	
Output voltage	3.3 VDC
Output resistance	50 Ω
Max. load current	5 mA

Table 3-51 Device status output specification

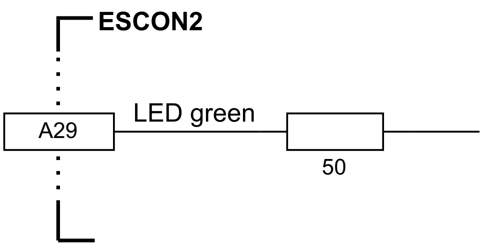

Figure 3-24 LED green circuit (analogously valid for LED red)

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4 MOTHERBOARD DESIGN GUIDE

The «Motherboard Design Guide» provides helpful information on integrating the Micro on a printed circuit board. It contains recommendations for the motherboard layout, specifies required external components, pin assignments, and provides connection examples.

CAUTION

Dangerous Action
Errors in implementing the design can result in serious Injury!
- *Designing a printed circuit board requires special skills and knowledge and may only be performed by electronic developers!*
- *This quick guide is only intended as an aid. It does not claim to be complete and will not automatically result in a functional component.*

Get help
If you are not trained in the design and development of printed circuit boards, you will need additional support. maxon will be happy to provide you with a quote for designing and manufacturing a motherboard for your specific application.

4.1 Connection accessory - ready-to-use Evaluation Board

The ESCON2 EB Micro (P/N 809646) is a ready-to-use Evaluation Board provided by maxon, specifically designed for seamless integration with the Micro. This Evaluation Board features industrial connectors compatible with maxon prefab cables, making it ideal for commissioning and evaluation purposes. For comprehensive details, refer to the hardware reference for the Evaluation Board (EB).

The guidelines in the following chapters are based on the design of this EB.

4.2 Requirements for components of third-party suppliers

Best practice
For references and recommended components consult ➔Table 4-52.

4.2.1 Terminal sockets

To implement a motherboard for the Micro, one terminal socket is required.

4.2.2 Power supply voltage

To protect the Micro, it is recommended to use an external circuit breaker, a TVS diode, and a capacitor in the voltage supply circuit.

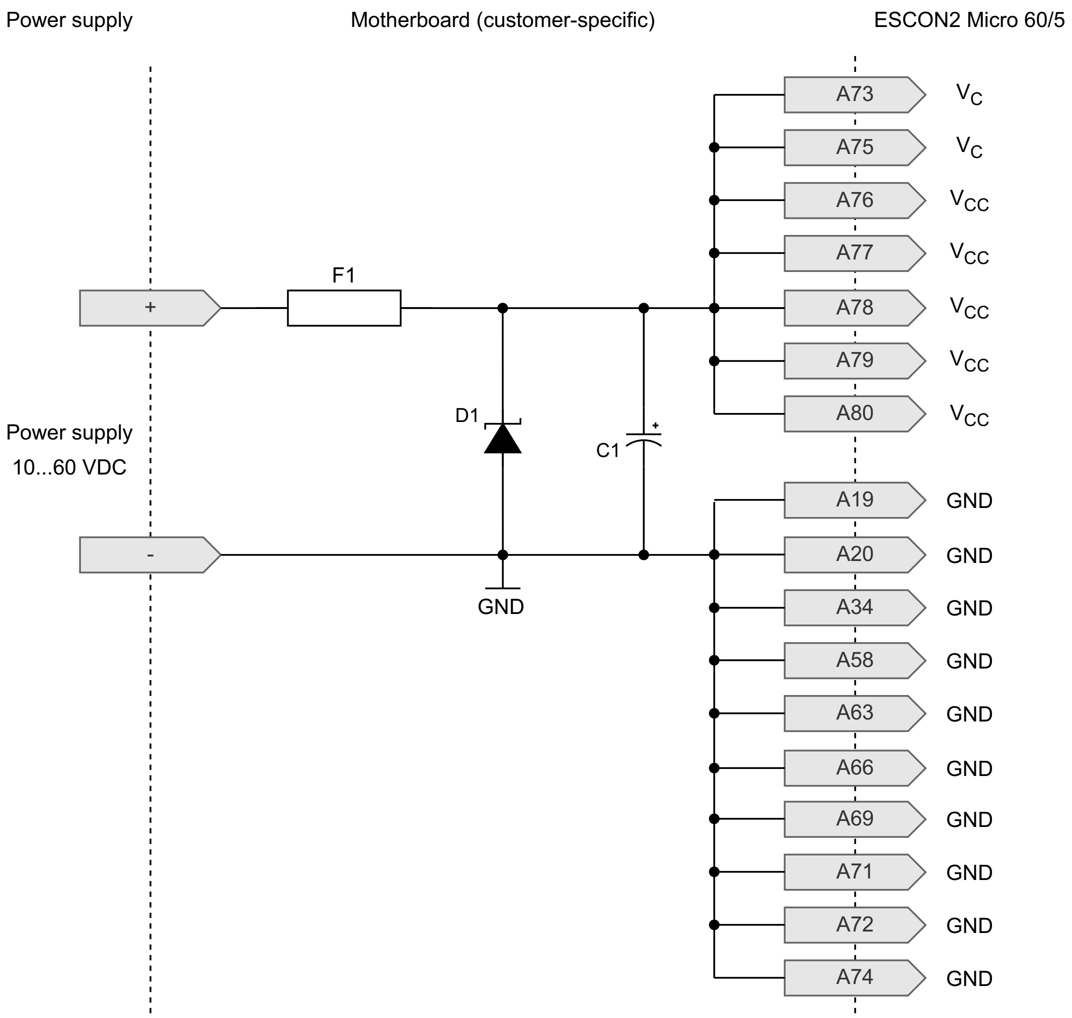

Figure 4-25 Wiring of power supply

Input Fuse (F1)

An input fuse (F1) is necessary in order to provide reverse polarity protection. Together with a unipolar TVS diode (D1), this prevents current from flowing in the wrong direction.

Capacitor (C1)

The function of the Micro does not necessarily require the use of an external capacitor. However, to further reduce voltage ripple or buffer feedback currents (typically present during motor deceleration), an electrolytic capacitor (C1) can be connected to the voltage supply line. Using an electrolytic capacitor is also recommended to avoid oscillations caused by supply cable inductance or the Micro’s built-in capacitors, which could lead to a voltage overshoot at power plug-in.

TVS Diode (D1)

To protect against overvoltage resulting from voltage transients (short voltage spikes), we recommend connecting a TVS (transient voltage suppressor) diode (D1) to the voltage supply line.

4.2.3 Logic supply voltage

The Micro features a logic supply voltage input with a voltage range of 10...60 VDC. This voltage must be sourced either separately or from the power supply voltage. The following figure provides an example of a separate logic supply.

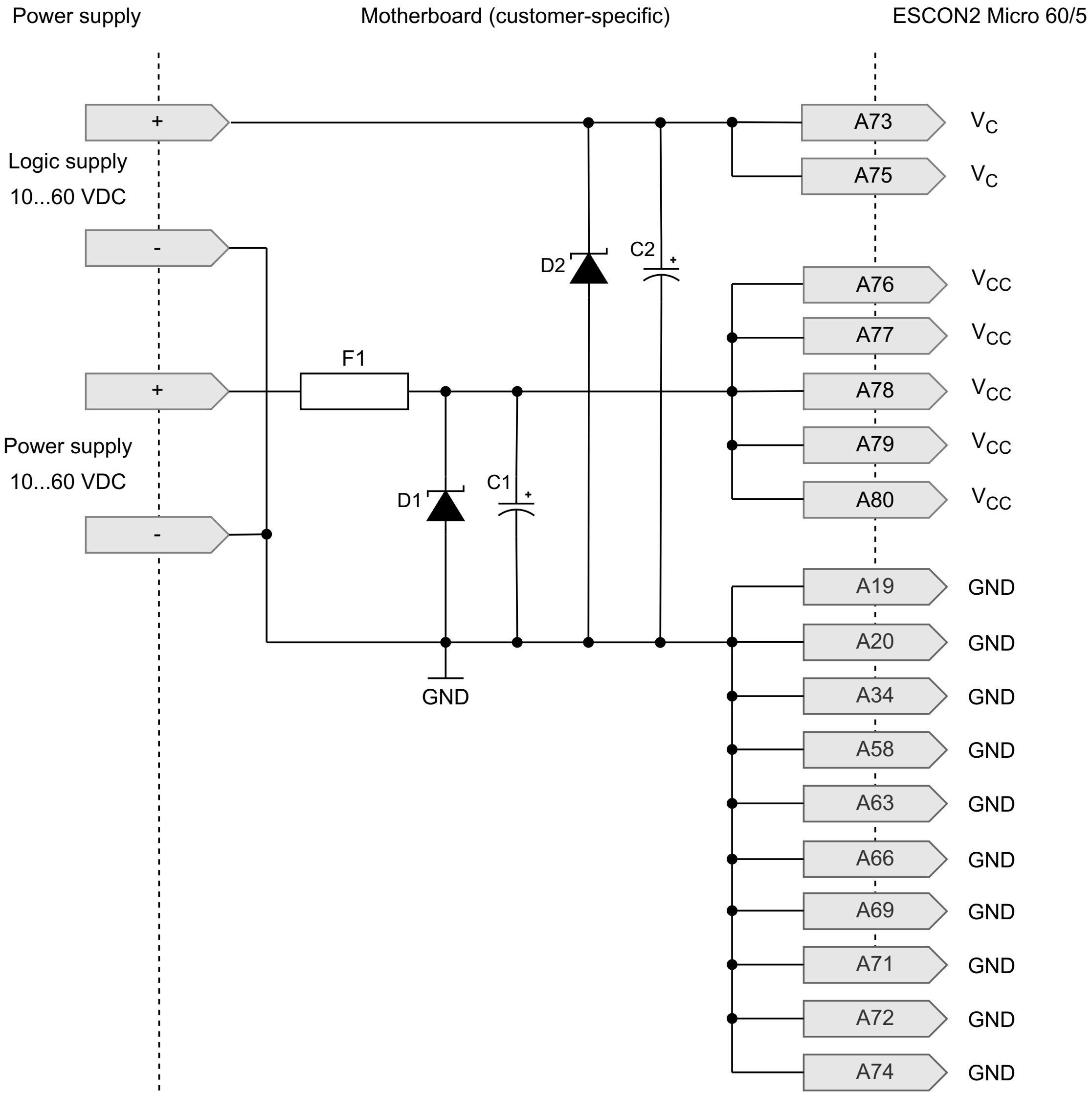

Figure 4-26 Wiring of logic supply

Capacitor (C2)

If the logic supply is sourced separately, use an electrolytic capacitor (C2). This will avoid oscillations caused by supply cable inductance or the Micro’s built-in capacitors, which could lead to a voltage overshoot at power plug-in.

TVS Diode (D2)

If the logic supply voltage is sourced separately, connect a TVS (transient voltage suppressor) diode (D2) at the logic supply voltage input to protect the Micro against overvoltage resulting from voltage transients (short voltage spikes).

4.2.4 Motor chokes

The Micro is not equipped with internal motor chokes.
Most motors and applications do not require additional chokes. However, in cases of high supply voltage with very low terminal inductance, the ripple of the motor current can reach an unacceptably high value. This can cause the motor to heat up unnecessarily and result in unstable control behavior. The minimum terminal inductance required per phase can be calculated using the following formula:

$$L_{Phase} \geq \frac{1}{2} \cdot \left(\frac{V_{CC}}{6 \cdot f_{PWM} \cdot I_N} - (0.3 \cdot L_{Motor})\right)$$

$L_{Phase}[H]$	Additional external inductance per phase
$V_{CC}[V]$	Operating voltage V_{CC}
$f_{PWM}[Hz]$	Switching frequency of the power stage = 50’000 Hz
$I_N[A]$	Nominal current of the motor (➔line 6 in the maxon catalog)
$L_{Motor}[H]$	Terminal inductance of the motor (➔line 11 in the maxon catalog)

If the result of the calculation is negative, no additional chokes are necessary. However, using chokes with additional filter components can be beneficial for reducing electromagnetic interference emissions.

An additional choke must have electromagnetic shielding, an adequate saturation current, minimal losses, and a nominal current greater than the motor's continuous current. The wiring example below refers to an additional inductance of 15 µH. If a different inductance is required, the filter components must also be adjusted accordingly. For further help with filter design, contact maxon Support at ➔http://support.maxongroup.com.

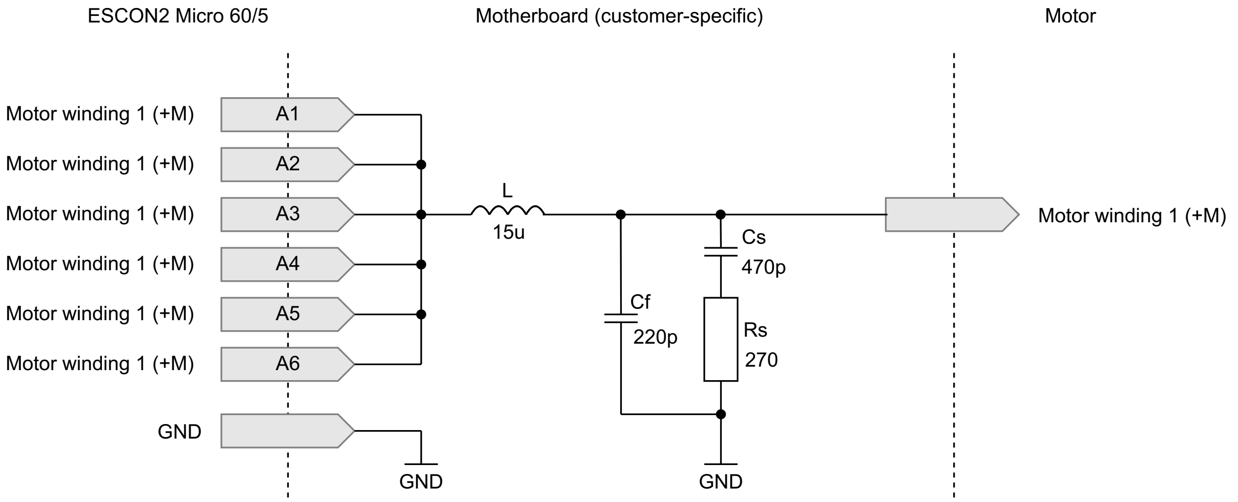

Figure 4-27 Wiring of motor winding 1 (analogously valid for motor winding 2 & 3)

4.2.5 USB interface

Use of an USB-C connector is recommended. If the USB interface is used, integrate TVS diodes for protection against overvoltage transients.

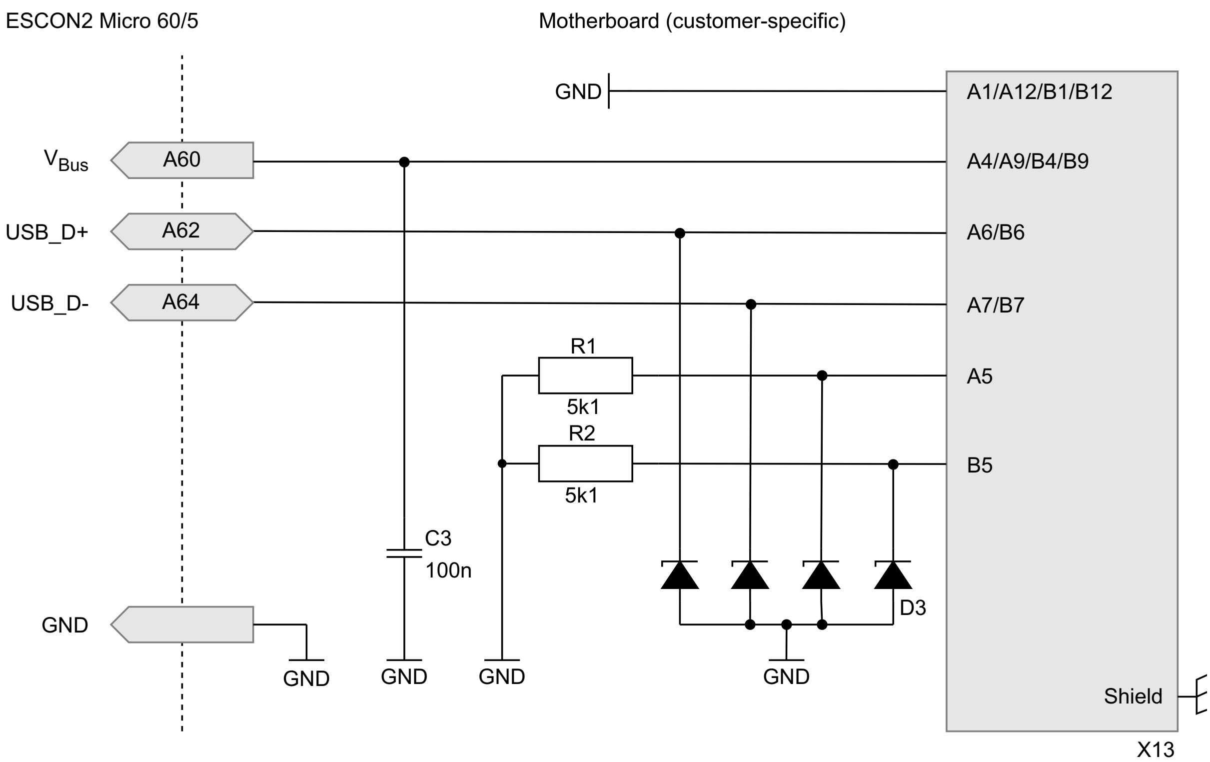

Figure 4-28 Wiring of USB-C connector

4.2.6 CAN interface

You must install a bus termination at both ends of the bus line.

The device's CAN ID (Node-ID) and automatic bit rate detection can be configured by hardware. To configure a given ID, connect CAN ID 1 through CAN ID 6 to GND as applicable (see ➔Chapter “3.3.9.2 Configuration” on page 3-37). To activate automatic bit rate detection, connect (C31) Auto bit rate to GND.

Alternatively, software settings can be used to adjust the parameters if the pins for automatic bit rate detection and CAN IDs are left open. If necessary, link (C47) CAN high and (C49) CAN low to a 120 Ω bus termination resistor.

The following example shows a wiring with CAN ID = 18, automatic bit rate detection activated and a 120 Ω bus termination resistor.

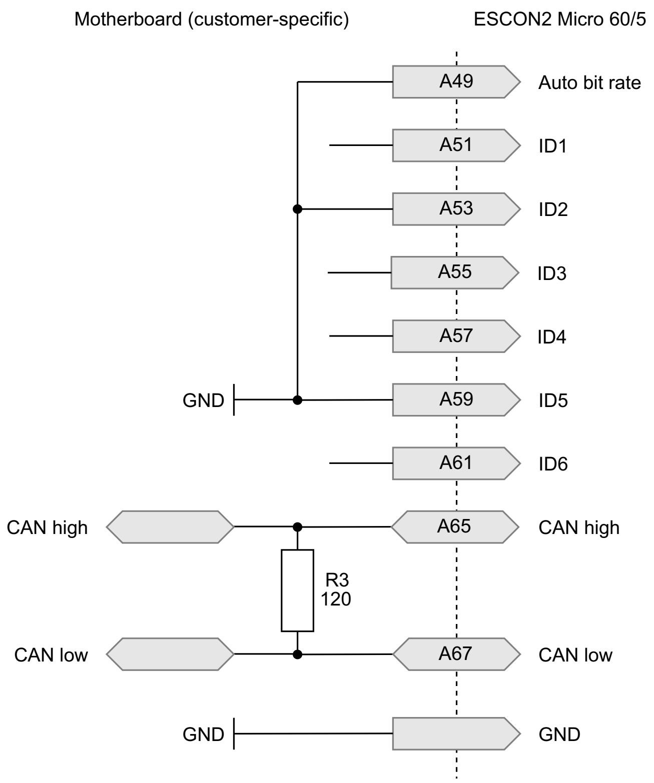

Figure 4-29 Wiring of CAN interface

If the CAN settings need to be variable, a DIP switch could be used, instead of fixed connections.

4.2.7 RS232 interface

To use the serial communication interface with an external RS232 master, an additional RS232 transceiver (line driver/receiver) is necessary on the motherboard. For board-level operation, the serial interface can be used for direct connection.

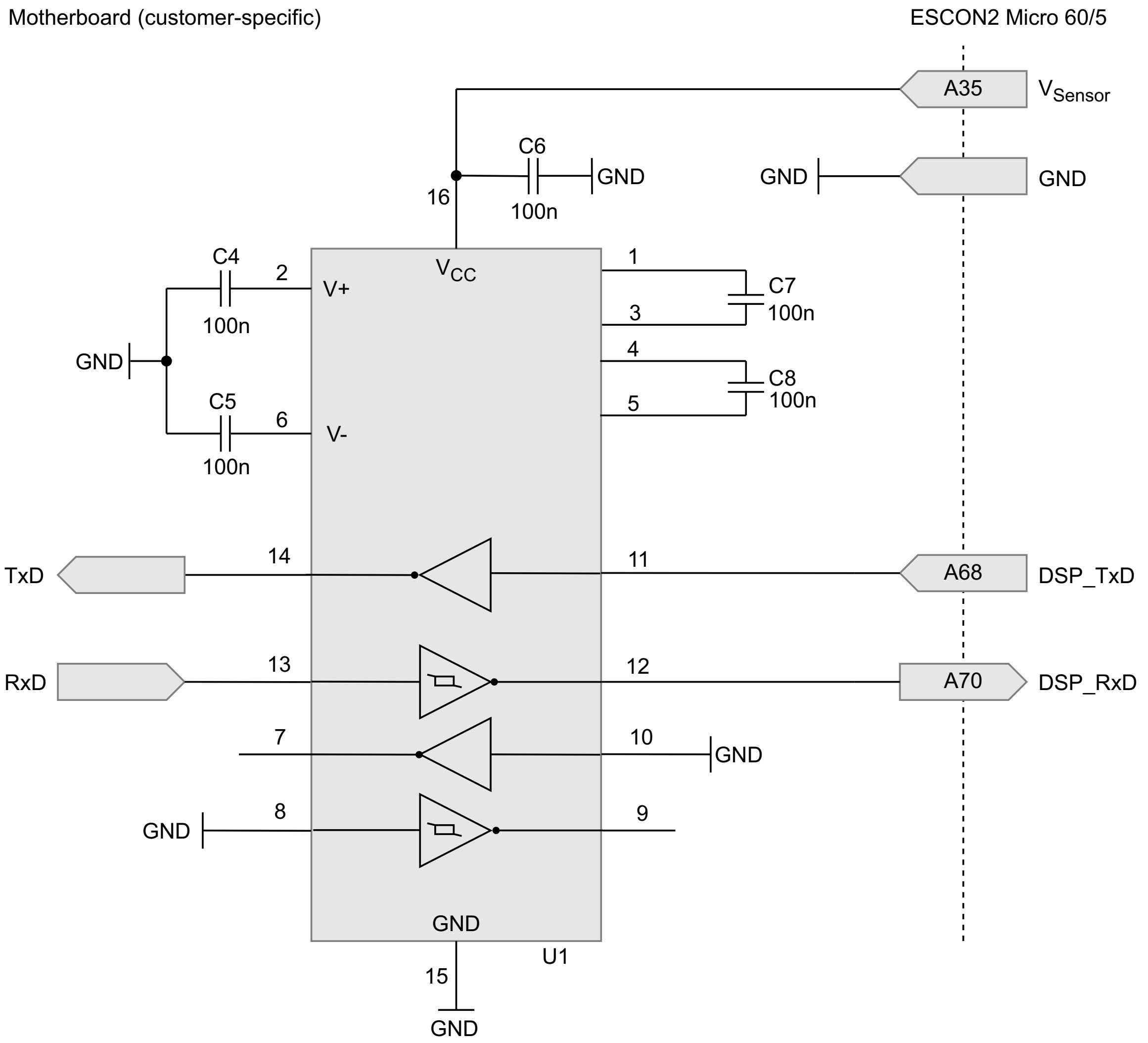

Figure 4-30 Wiring of RS232 interface

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4.2.8 RS422 transceiver for differential SSI, BiSS C or high-speed I/Os signals

An external RS422 transceiver (line driver/receiver) is required for cable lengths over 30 cm or to utilize the SSI / BiSS C unidirectional absolute encoder or high-speed digital I/Os with differential signals. In the wiring example below, the TVS diodes act as safeguards against overvoltage transients.

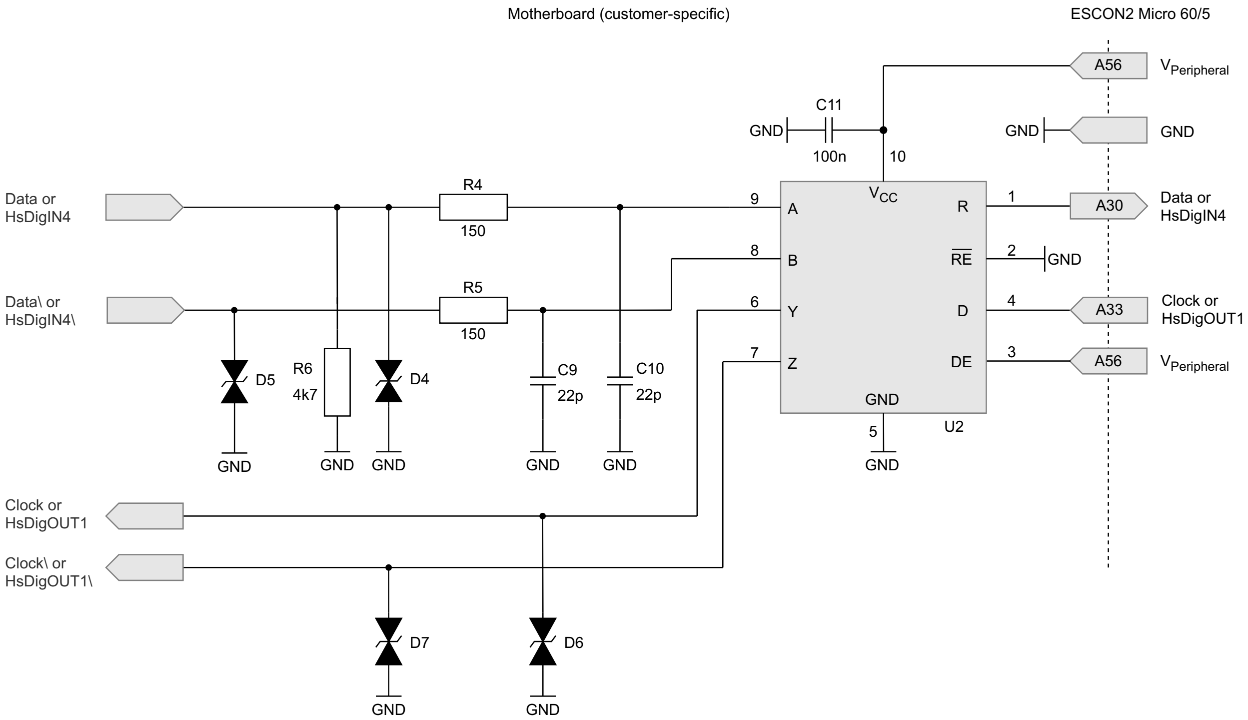

Figure 4-31 Wiring of RS422 transceiver

4.2.9 Digital outputs load switch

The digital outputs can be equipped with a load switch to connect devices requiring a larger output current. In the given circuitry example, the external load must be supplied with a maximum voltage of 30 VDC, and the load current (I_L) must not exceed 500 mA. This circuitry is not necessary if the digital output signals are only used for signal processing.

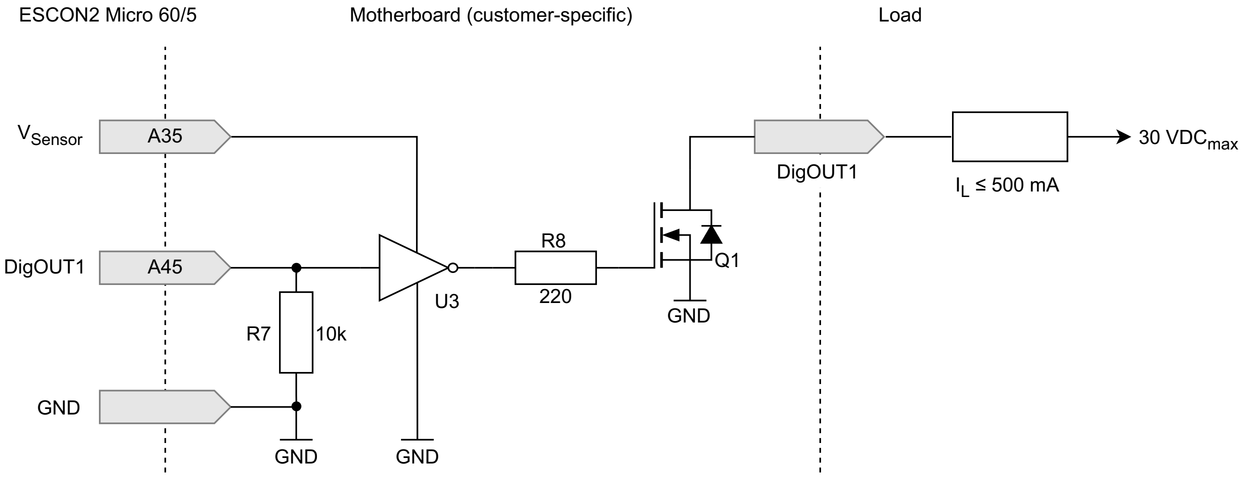

Figure 4-32 Wiring of digital output 1 load switch (analogously valid for digital output 2)

Freewheeling diode for inductive loads
When utilizing the digital output load switch for the operation of inductive loads, such as relays, 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.

4.2.10 LEDs for device status indication

A set of green and red LEDs can be integrated on the motherboard to indicate the device status. The green LED should be used for the operation status, and the red LED should be used for indicating warnings and errors. For further information, refer to ➔Chapter “3.4 Status indicators” on page 3-41.

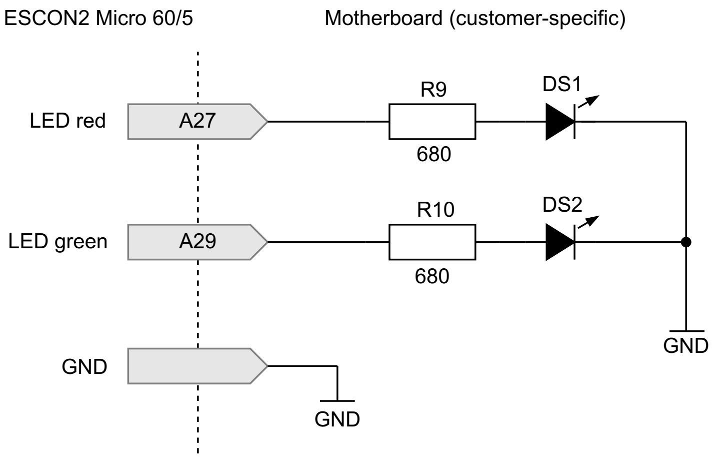

Figure 4-33 Wiring of LEDs for device status indication

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4.2.11 Recommended components and manufacturers

Recommended components	
Socket	
Terminal socket	**80 poles:** • Samtec SS4-40-3.00-L-D-K-TR
Power supply voltage	
Fuse (F1)	**10 A, 26.46 A^2s** • Littelfuse 0157010.DR
Capacitor (C1)	The ripple current load for C1 depends on the motor's operating point and the power supply output capacity. Under worst-case conditions, the ripple current may reach I_{cont} / 2. Use capacitors with a rated voltage ≥ 80 VDC and adequate ripple current to avoid overheating or reducing the lifetime of the capacitors. **Remark:** If there is an excessive amount of reversed energy (e.g., during deceleration of loads with high inertia or during downward vertical movement), you may need to add an additional capacitor with much higher capacity (e.g., up to 10,000…47,000 µF) and/or a brake chopper, such as the maxon DSR 70/30 (P/N 235811). **Example for C1 worst-case dimensioning:** I_{cont} = 5 A, I_{cont} / 2 = 2.5 A → 2 × capacitor with 22 µF, 80 VDC, 1'550 mA RMS • Panasonic EEHZA1K220P • Vishay MAL218297701E3 • UCC HHXB800ARA220MHA0G Choosing capacitors with a rated ripple current higher than required will improve the component's lifetime.
TVS diode (D1)	**V_R 60 VDC, V_C 96.8 VDC** • SMAJ60A
Logic supply voltage	
Capacitor (C2)	To avoid voltage overshoot at power plug-in with a separately sourced logic supply, use an electrolytic capacitor that meets the following requirements: **33 µF or 47 µF, 80 VDC, at least 265 mA RMS** • Panasonic EEHZA1K330P • Panasonic EEHZA1K470P
TVS diode (D2)	**V_R 60 VDC, V_C 96.8 VDC** • SMF60A
Motor filter	
Motor choke (L)	**15 uH, rated current I_{RMS} ≥ I_{cont} / I_{sat} ≥ I_{peak}, construction shielded** • Würth Elektronik 7447709150 • Coilcraft MSS1210-153MED
Filter capacitor (C_F)	**220 pF, 100 VDC**
Snubber resistor (R_S)	**270 Ω, 1 %, 0.250 W**
Snubber capacitor (C_S)	**470 pF, 100 VDC**

Continued on next page.

Recommended components	
USB interface	
USB connector (X13)	**USB Type C, vertical** • ASSMANN WSW AUSB1-DFN-HSR4 • Global Connector Technology USB4115-03-C • Würth Elektronik 632722110112
Resistor (R1, R2)	**5.1 kΩ, 1 %, 0.0625 W**
Capacitor (C3)	**100 nF, 50 VDC**
TVS diode (D3)	**Quadruple ESD protection diode, V_R 5 VDC, V_C 10 VDC** • Nexperia PESD5V0L4UG • onsemi NSQA6V8AW5T2G • Toshiba DF5A6.8LFU
CAN interface	
Resistor (R3)	**120 Ω, 1 %, 0.125 W**
RS232 interface	
Transceiver (U1)	**Dual line driver and receiver with ESD protection** • Texas Instruments MAX202IPW • ST Microelectronics ST202EBTR
Capacitor (C4…C8)	**100 nF, 16 VDC**
Differential absolute encoder or high-speed I/O signals	
Transceiver (U2)	**Full-duplex line driver and receiver with ESD protection** • Texas Instruments THVD1452DGSR • Texas Instruments SN65HVD76DGSR • Texas Instruments SN65HVD1476DGSR
Resistor (R4, R5)	**150 Ω, 1 %, 0.0625 W**
Resistor (R6)	**4.7 kΩ, 1 %, 0.0625 W**
Capacitor (C9, C10)	**22 pF**
Capacitor (C11)	**100 nF**
TVS diode (D4…D7)	**ESD protection diode, V_R 12 VDC, V_C 22 VDC** • Comchip CPDQC12VE-HF • Diodes D12V0L1B2LP-7B • Littelfuse SPHV12-01ETG-C
Digital outputs load switch	
Inverter (U3)	**Inverter gate** • Diodes 74AHCT1G04SE-7 • Nexperia 74AHCT1G04GW • Texas Instruments SN74AHCT1G04DCKR
Transistor (Q1)	**Fully autoprotected power MOSFET (dual)** • STMicroelectronics VNS1NV04DPTR-E
Resistor (R7)	**10 kΩ, 1 %, 0.0625 W**
Resistor (R8)	**220 Ω, 1 %, 0.0625 W**

Continued on next page.

Recommended components	
LEDs for device status indication	
Resistor (R9, R10)	**680 Ω, 1 %, 0.0625 W**
LED (DS1)	**LED red** • Dialight 599-0010-007F • Vishay TLMS1100-GS15 • ROHM SML-D15UWT86C
LED (DS2)	**LED green** • Dialight 598-8070-107F • Vishay TLMG1100-GS15 • ROHM SML-D15MWT86C

Table 4-52 Motherboard design guide – Recommended components

4.3 Design guidelines

The following instructions serve as an aid when designing an application-specific motherboard and ensure the correct and reliable integration of the Micro.

While designing a motherboard, consider the following characteristics:

- Pin assignment (➔page 3-18)
- Technical data (➔page 2-9) and dimensional drawing (➔page 2-14)

4.3.1 Ground

All ground connections (GND) should be internally connected to the Micro (equal potential). It is customary to equip the motherboard with a ground plane. You should connect all ground connections to the voltage supply ground via wide conductive tracks.

Pin	Signal	Description
A19, A20	GND	Ground
A58, A63, A66, A69, A71...A74	GND	Ground

Table 4-53 Motherboard design guide – Grounding

If an earth potential is in place or required, you should connect the ground plane to the earth potential via one or more capacitors and one resistor. It is recommended to use ceramic capacitors with 10 nF and a minimum of 100 VDC and a resistor with 2 MΩ.

4.3.2 Layout

Guidelines for the layout of the motherboard:

- Connect terminal socket pins (A76), (A77), (A78), (A79), and (A80) for nominal power supply voltage (V_{CC}) to the fuse via wide conductive tracks.
- Connect terminal socket pins (A19), (A20), (A34), (A58), (A63), (A66), (A69), (A71), (A72), and (A74) for GND (ground) to the operating voltage ground via wide conductive tracks.
- The width of the conductive tracks and the copper coating thickness of the conductors for supply voltage and motor depend on the current required in your application. A minimum track width of 3 mm (118 mil) and a minimum copper coating thickness of 35 µm are recommended. The track width can be achieved using multilayer designs with distributed tracks.

4.3.3 SMT footprint

The figure below shows the footprint on the motherboard for the recommended terminal socket (see ➔Table 4-52 on page 4-52). This footprint can also be downloaded from the manufacturer's webpage. The hole pattern shown corresponds to that of the ESCON2 Micro 60/5.

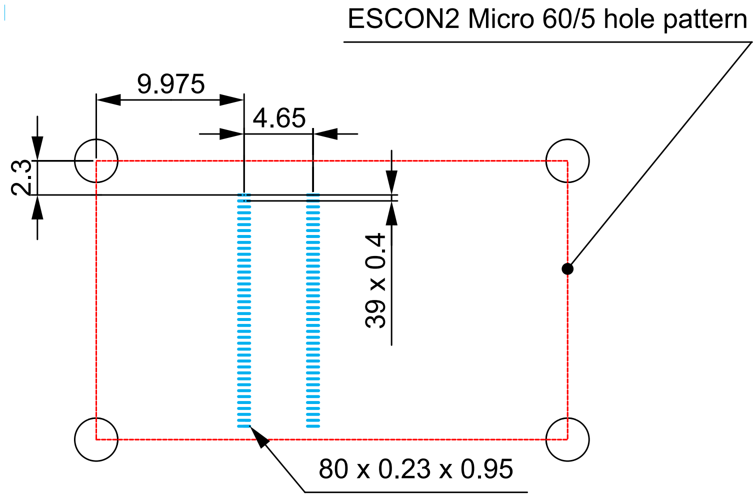

Figure 4-34 SMT footprint [mm] – Top view

4.3.4 Mounting of the Micro

The motherboard must support mounting the Micro using its four mounting holes, which are surrounded by GND circular rings. Utilize electrically and thermally conductive mounting materials to reduce the electrical load on the GND pins (see ➔ Table 4-53 on page 4-52) and to enhance heat dissipation of the Micro. Ensure the mounting points on the motherboard establish a connection between the mounting parts and the motherboard's ground plane.

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5 WIRING

This section provides wiring information for your setup. You can either use the consolidated wiring diagrams (see ➔Figure 5-36) 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.

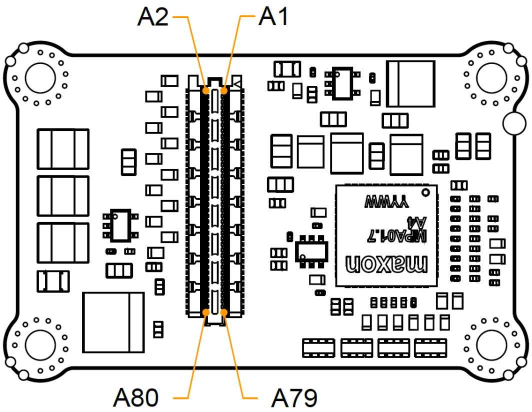

Figure 5-35 Interfaces – Designations

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).*

5.1 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 “5.1.1 DC motor” on page 5-56 or
For EC (BLDC) motor, see ➔Chapter “5.1.2 EC (BLDC) motor” on page 5-56.
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 5-54,
For EC (BLDC) motor see ➔Table 5-55.
4) Pick the row with the corresponding wiring method number and refer to the listed figure(s) to find the relevant wiring information.

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5.1.1 DC motor

Power supply

Power supply and logic supply . . . . Figure 5-37 / Figure 5-38

Motor & feedback signals

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

Digital incremental encoder . . . . Method # DC2

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

Method #	Sensor 2		➔Figure(s)
	Digital incremental encoder	SSI / BiSS C unidirectional absolute encoder [b]	
DC1 [a]			5-39
DC2	✓		5-39 5-42
DC3 [b]		✓	5-39 5-43

[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 5-54 Possible combinations of feedback signals for DC motor

5.1.2 EC (BLDC) motor

Power supply

Power supply and logic supply . . . . Figure 5-37 / Figure 5-38

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	✓			5-40 5-41
EC2	✓	✓		5-40 5-41 5-42
EC3 [a]	✓		✓	5-40 5-41 5-43
EC4 [a]			✓	5-40 5-43

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

Table 5-55 Possible combinations of feedback signals for EC (BLDC) motor

5.2 Main wiring diagram

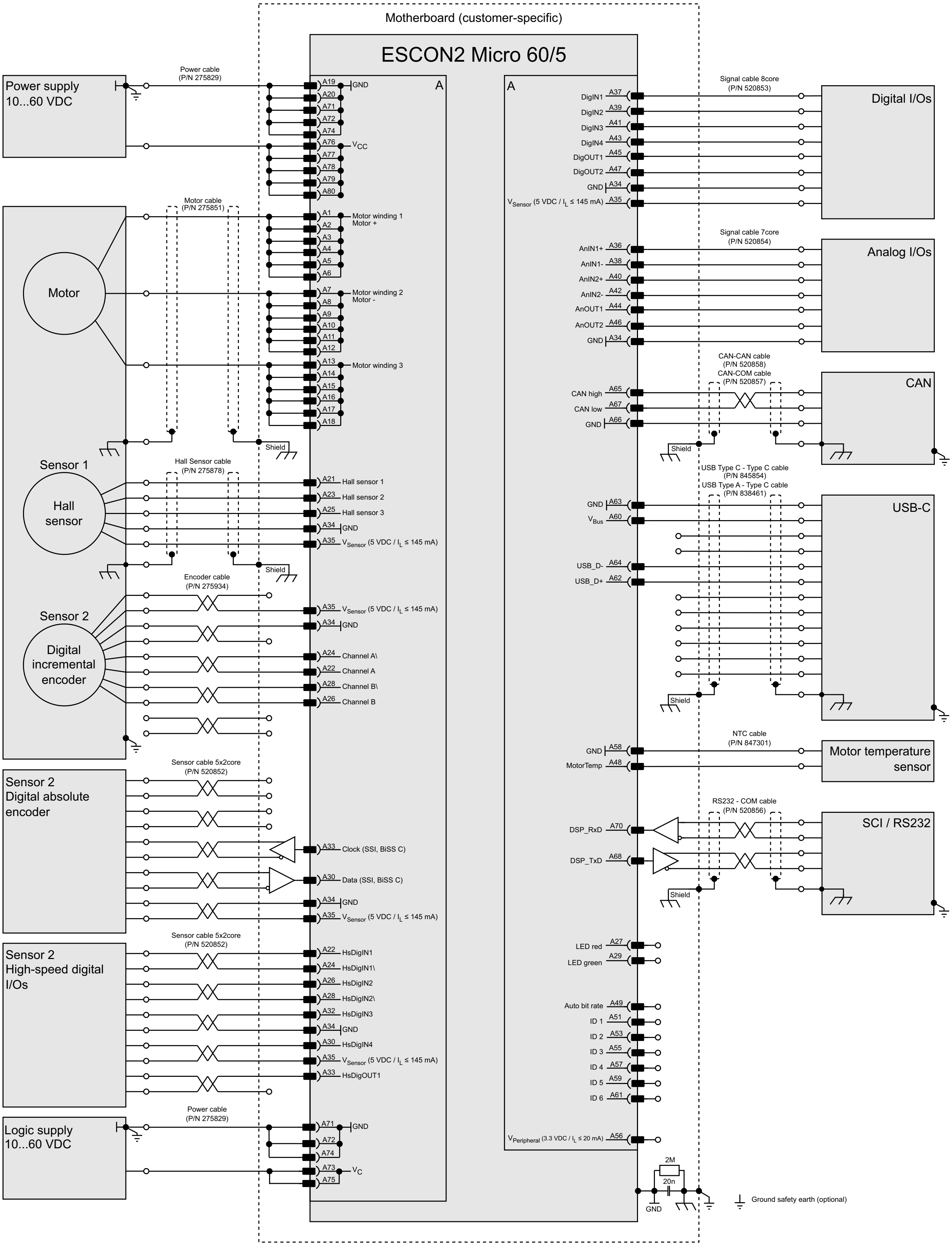

Figure 5-36 Main wiring diagram

5.3 Cabling

Utilize maxon's prefab cable assemblies to streamline your setup process. These ready-to-use cables can significantly reduce commissioning time. Refer to the table below for a list of compatible prefab cables and the corresponding connectors needed for motherboard installation.

For detailed information on these prefab cables, visit maxon's website and use the part number to access more information.

Prefab cable assembly				Required connector on motherboard (or similar)
Designation	**Part Number**	**For connection of external device Head B**	**For connection on motherboard Head A**	
Power cable	275829	Wire end sleeves 0.75 mm^2	Molex Mini-Fit Jr., 2 poles (39012020)	Molex Mini-Fit Jr., 2 poles (39281023)
Motor cable	275851	Wire end sleeves 0.75 mm^2	Molex Mini-Fit Jr., 4 poles (39012040)	Molex Mini-Fit Jr., 4 poles (39281043)
Hall Sensor cable	275878	Wire end sleeves 0.14 mm^2	Molex Micro-Fit 3.0, 6 poles (430250600)	Molex Micro-Fit 3.0, 6 poles (430450612)
Encoder cable	275934	DIN 41651 plug, pitch 2.54 mm, 10 poles	DIN 41651 female, pitch 2.54 mm, 10 poles	Amphenol ICC (52601-S10-8TLF)
Sensor cable 5x2core (for absolute encoder or high-speed digital I/Os)	520852	Wire end sleeves 0.14 mm^2	Molex CLIK-Mate, 10 poles (5031491000)	Molex CLIK-Mate, 10 poles (5031481090)
Signal cable 8core (for digital I/Os)	520853	Wire end sleeves 0.14 mm^2	Molex CLIK-Mate, 8 poles (5025780800)	Molex CLIK-Mate, 8 poles (5025840860)
Signal cable 7core (for analog I/Os)	520854	Wire end sleeves 0.14 mm^2	Molex CLIK-Mate, 7 poles (5025780700)	Molex CLIK-Mate, 7 poles (5025840760)
CAN-CAN cable	520858	Molex CLIK-Mate, 4 poles (5025780400)	Molex CLIK-Mate, 4 poles (5025780400)	Molex CLIK-Mate, 4 poles (5025840470)
CAN-COM cable	520857	Female D-Sub connector DIN 41652, 9 poles	Molex CLIK-Mate, 4 poles (5025780400)	Molex CLIK-Mate, 4 poles (5025840470)
USB Type C – Type C cable	845854	USB Type C connector	USB Type C connector	Würth Elektronik (632722110112)
USB Type A – Type C cable	838461	USB Type A connector	USB Type C connector	Würth Elektronik (632722110112)
NTC cable	847301	Wire end sleeves 0.5 mm^2	Molex Micro-Fit 3.0, 2 poles (430250200)	Molex Micro-Fit 3.0, 2 poles (430450212)
RS232 – COM cable	520856	Female D-Sub connector DIN 41652, 9 poles	Molex CLIK-Mate, 5 poles (5025780500)	Molex CLIK-Mate, 5 poles (5031750500)

Table 5-56 Prefab maxon cables

5.4 Excerpts

Depending on the connections, additional components are required to be installed on the motherboard. Detailed information can be found in ➔Chapter “4.2 Requirements for components of third-party suppliers” on page 4-43.

5.4.1 Power supply

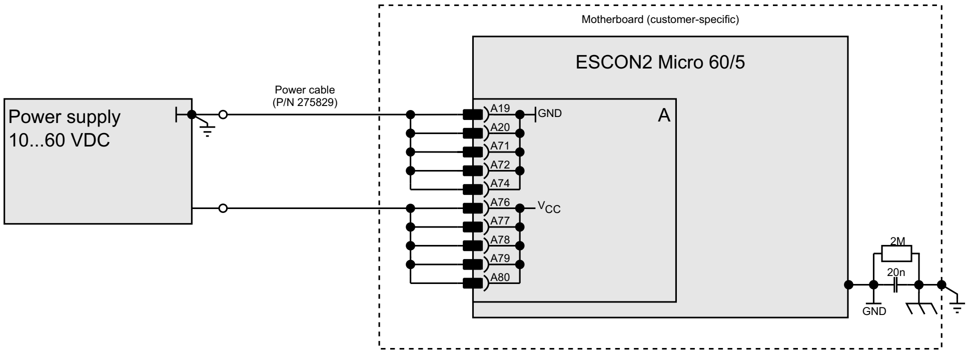

Figure 5-37 Power supply

For additional components that are recommended for installation on the motherboard refer to ➔Chapter “4.2.2 Power supply voltage” on page 4-42.

5.4.2 Logic supply

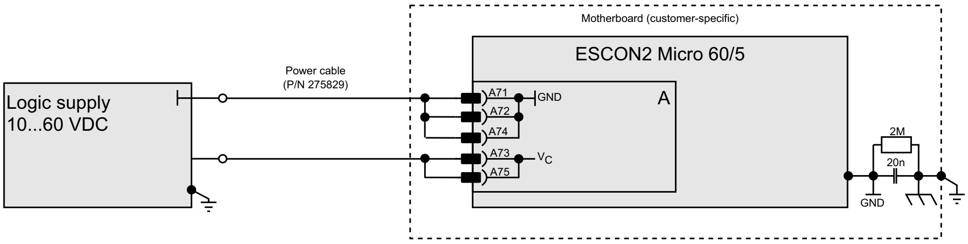

Figure 5-38 Logic supply

For additional components that are recommended for installation on the motherboard refer to ➔Chapter “4.2.3 Logic supply voltage” on page 4-43.

5.4.3 DC motor

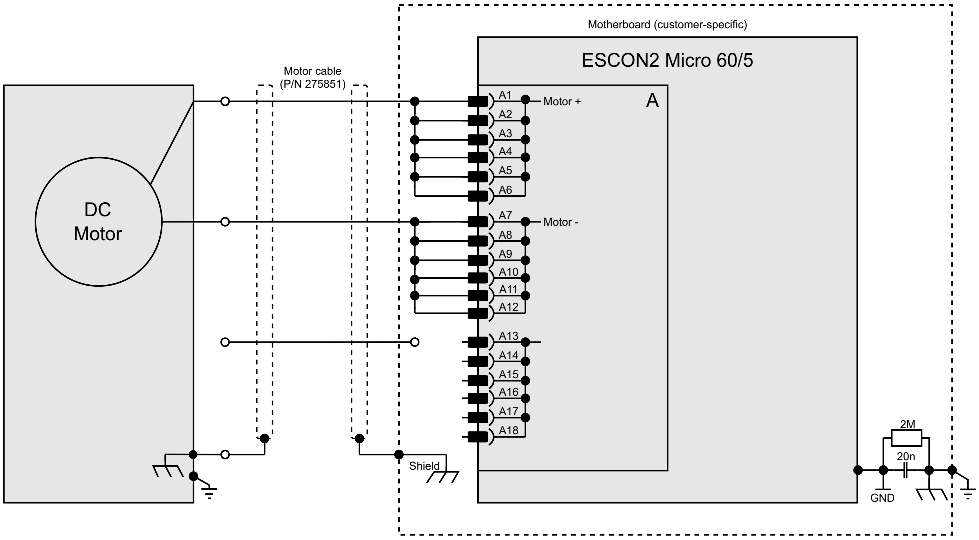

Figure 5-39 DC motor

For additional components that are recommended for installation on the motherboard refer to ➔Chapter “4.2.4 Motor chokes” on page 4-44.

5.4.4 EC (BLDC) motor

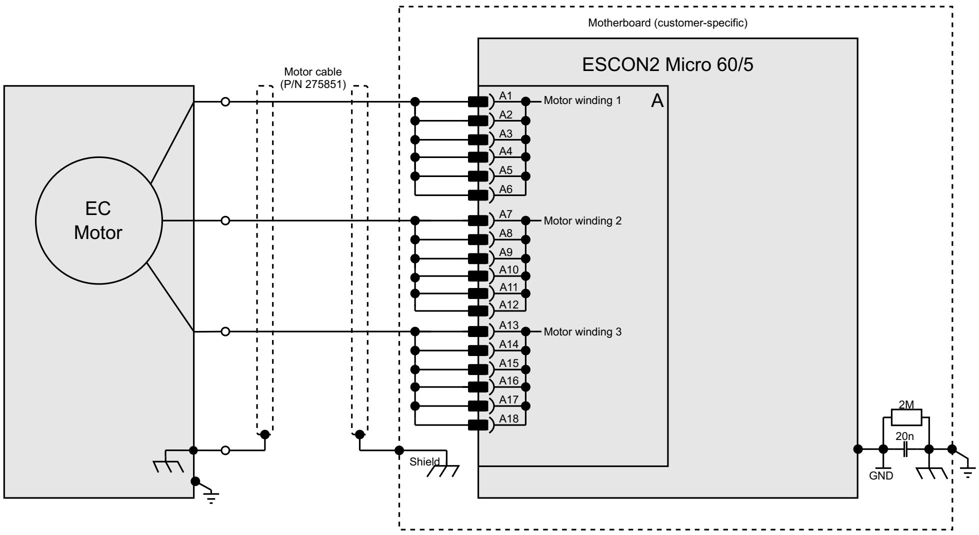

Figure 5-40 EC (BLDC) motor

For additional components that are recommended for installation on the motherboard refer to ➔Chapter “4.2.4 Motor chokes” on page 4-44.

5.4.5 Sensor 1 Hall sensor

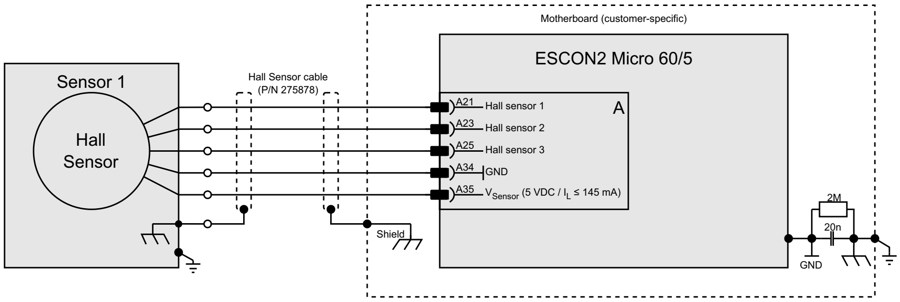

Figure 5-41 Sensor 1 Hall sensor

5.4.6 Sensor 2 Encoder / I/Os

5.4.6.1 Digital incremental encoder

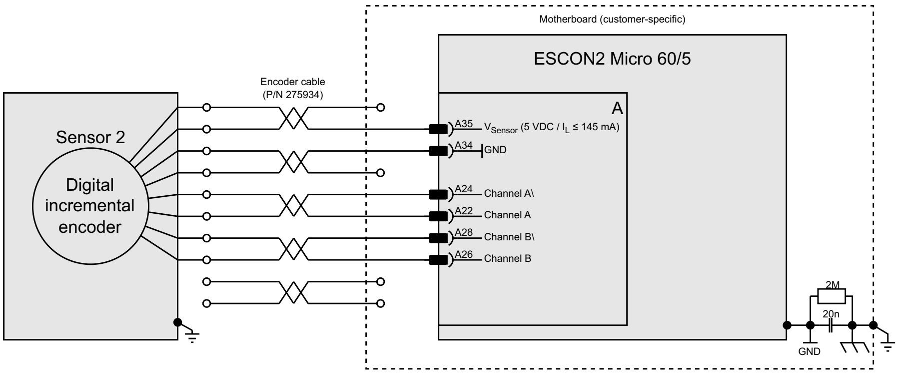

Figure 5-42 Digital incremental encoder

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

5.4.6.2 SSI / BiSS C unidirectional absolute encoder

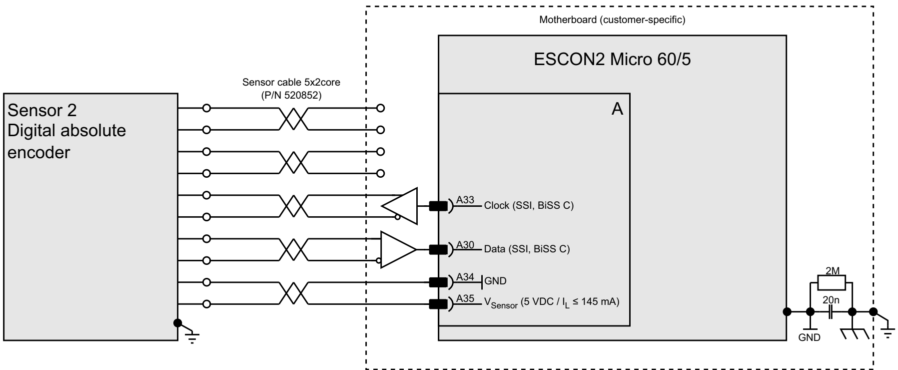

Figure 5-43 SSI / BiSS C unidirectional absolute encoder

An additional RS422 transceiver (line driver/receiver) is required on the motherboard for cable lengths over 30 cm or if differential signals shall be used. A wiring example is provided in ➔Chapter “4.2.8 RS422 transceiver for differential SSI, BiSS C or high-speed I/Os signals” on page 4-48.

This interface can handle a digital incremental encoder, an SSI/BiSS C digital unidirectional absolute encoder, or high-speed digital I/Os. Only one of these three functions can be used at a time.

5.4.6.3 High-speed digital I/Os

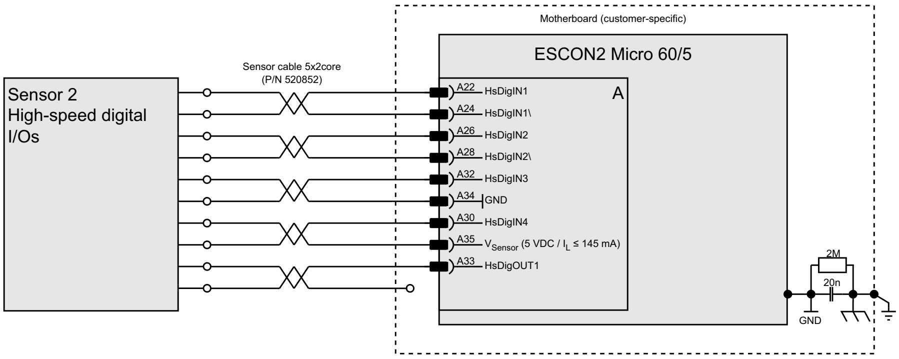

Figure 5-44 High-speed digital I/Os

An additional RS422 transceiver (line driver/receiver) is required on the motherboard if differential signals shall be used for HSDigIN3, HSDigIN4 or HSDigOUT1. A wiring example is provided in ➔Chapter "4.2.8 RS422 transceiver for differential SSI, BiSS C or high-speed I/Os signals" on page 4-48.

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

5.4.7 Digital I/Os

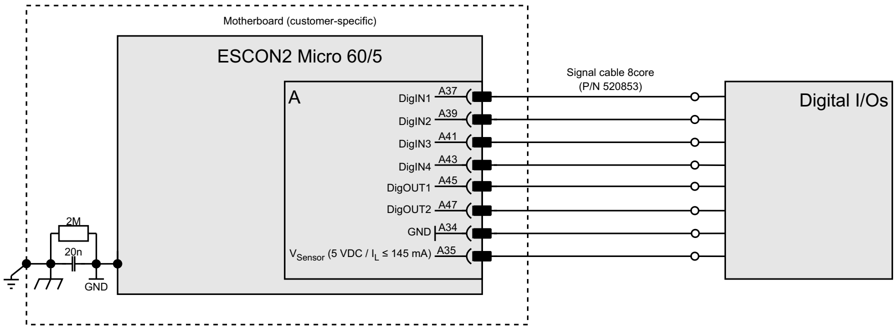

Figure 5-45 Digital I/Os

5.4.8 Analog I/Os

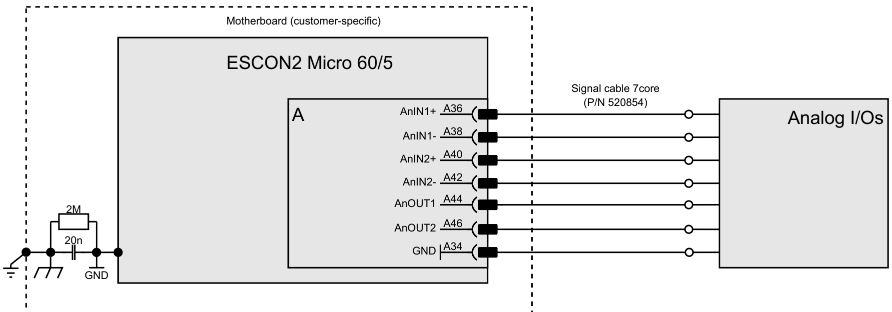

Figure 5-46 Analog I/Os

5.4.9 SCI / RS232

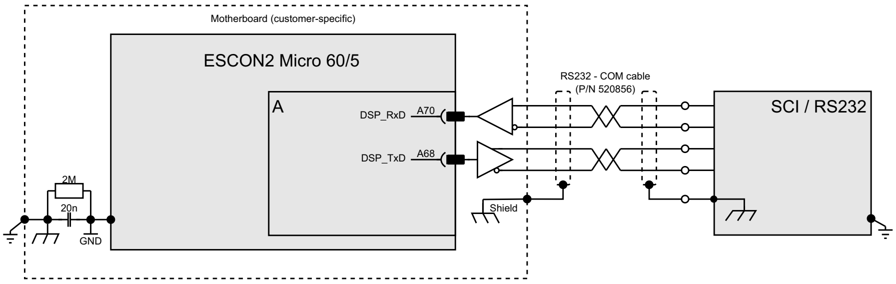

Figure 5-47 SCI / RS232

An additional RS232 transceiver (line driver/receiver) is necessary on the motherboard to use the serial communication interface with an external RS232 master. For board level operation, the serial interface can be used for direct connection. A wiring example is provided in ➔Chapter “4.2.7 RS232 interface” on page 4-47.

5.4.10 CAN

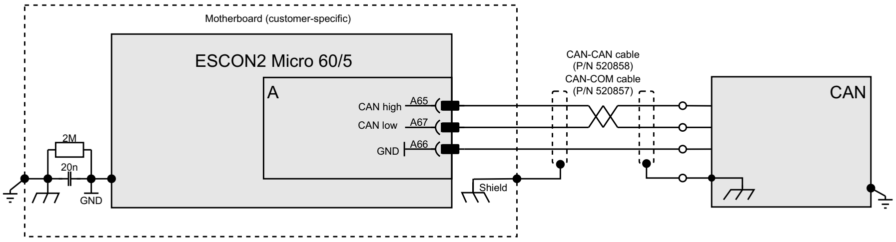

Figure 5-48 CAN

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

5.4.11 USB

5.4.11.1 USB-C

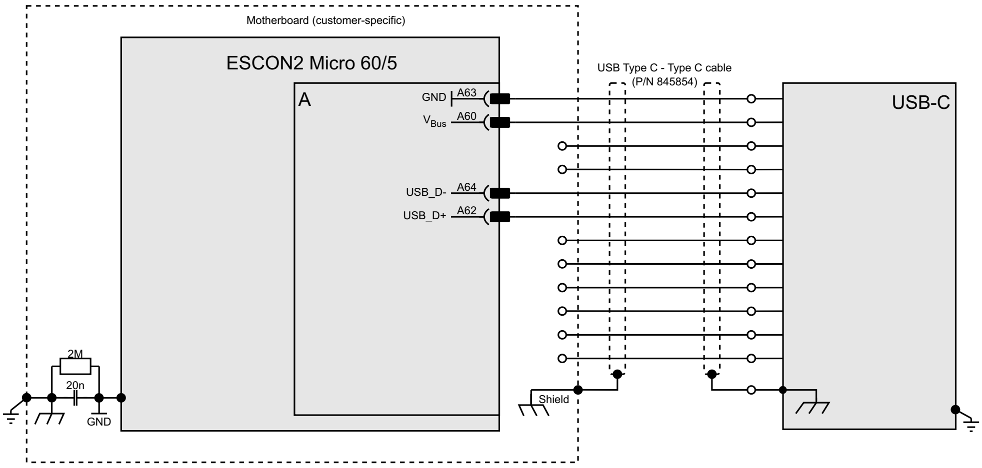

Figure 5-49 USB-C

The wiring above considers the installation of an USB-C connector on the motherboard. Such a connector is required if the prefab cable shall be used. A wiring example is provided in ➔Chapter “4.2.5 USB interface” on page 4-45.

5.4.11.2 USB-A

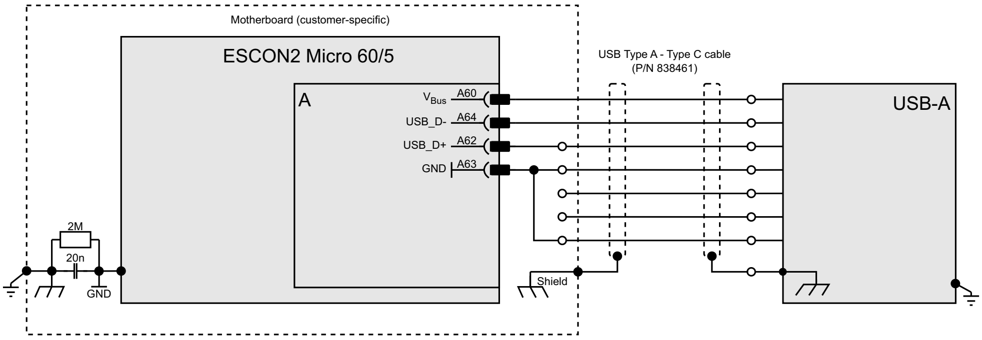

Figure 5-50 USB-A

The wiring above considers the installation of an USB-C connector on the motherboard. Such a connector is required if the prefab cable shall be used. A wiring example is provided in ➔Chapter “4.2.5 USB interface” on page 4-45.

5.4.12 Motor temperature sensor (future release)

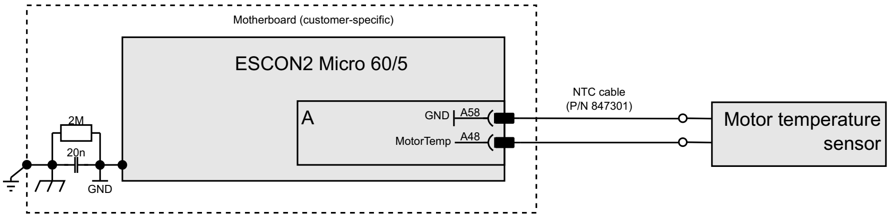

Figure 5-51 Motor temperature sensor

LIST OF FIGURES

LIST OF TABLES

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INDEX

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