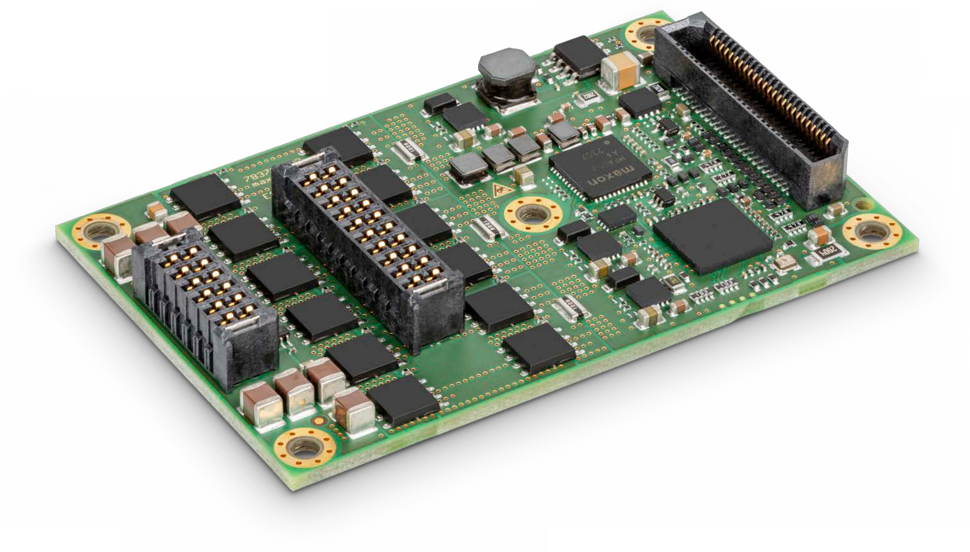
maxon

Servo Controller

ESCON2 Module 60/30

Hardware Reference



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ESCON2 Module 60/30 Servo Controller | P/N 783722
Hardware Reference
CCMC | Edition 2024-02 | DocID rel12220

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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 Module *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

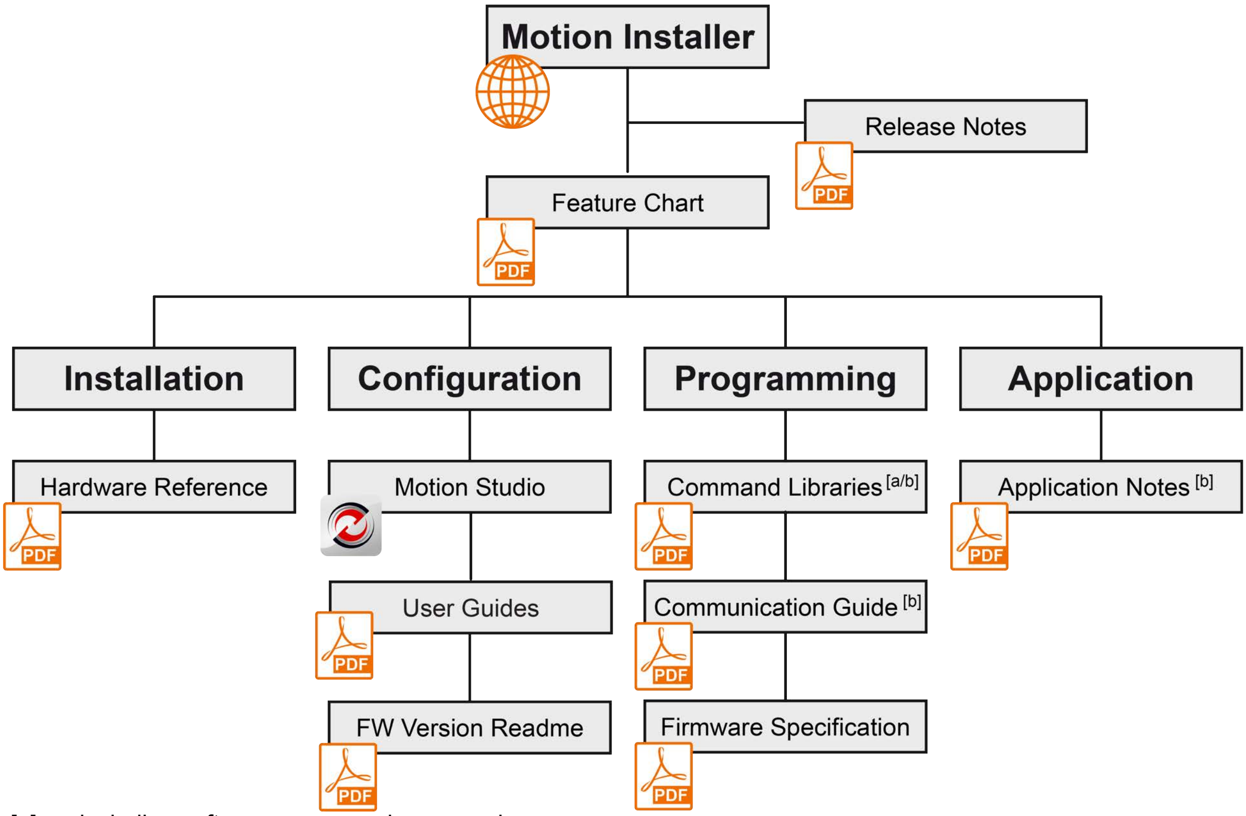
1.1 About this document

1.1.1 Intended purpose

The purpose of the present document is to familiarize you with the ESCON2 Module 60/30 Servo Controller. It will highlight the tasks for safe and adequate installation and/or commissioning. Follow the described 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.

The present document is part of a documentation set and contains performance data and specifications, information on fulfilled standards, details on connections and pin assignment, and wiring examples. The below overview shows the documentation hierarchy and the interrelationship of its individual parts:



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

Figure 1-1 Documentation structure

Find the latest edition of the present document as well as additional documentation and software for ESCON2 servo controllers on the Internet: http://escon.maxongroup.com

1.1.2 Target audience

The present document is intended for trained and skilled personnel. It conveys information on how to understand and fulfill the respective work and duties.

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1.1.3 How to use

Throughout the document, the following notations and codes will be used.

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 Notation used

1.1.4 Symbols & signs

In the course of the present document, the following symbols and signs will be used.

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 legibility, registered brand names are listed below and will not be further tagged with their respective trademark. It must be understood that the brands (the list below is not necessarily concluding) are protected by copyright and/or other intellectual property rights, even if their legal trademarks are omitted in the later course of this document.

Brand Name	Trademark Owner
Adobe® Reader®	© Adobe Systems Incorporated, USA-San Jose, CA
Bel Fuse®	© Bel Fuse (Jersey City, New Jersey, Vereinigte Staaten)
BiSS	© iC-Haus GmbH, DE-Bodenheim
Bourns®	© Bourns, Inc. (Riverside, Kalifornien, Vereinigte Staaten)
CANopen® CiA®	© CiA CAN in Automation e.V, DE-Nuremberg
Panasonic®	© Panasonic Holdings Corporation (Kadoma, Präfektur Ōsaka, Japan)
Pulse®	© Pulse Electronics a YAGEO company
Samtec®	© Samtec Inc. (520 Park East Blvd. New Albany, INDIANA UNITED STATES 47151)
ST Microelectronics®	© STMicroelectronics SA (Chem. du Champ-des-Filles 39, 1228 Plan-les-Ouates)
Texas Instruments®	© Texas Instruments Incorporated (Dallas, Texas)
Vishay®	© Vishay Precision Group (Malvern, Pennsylvania, Vereinigte Staaten)
Windows®	© Microsoft Corporation, USA-Redmond, WA

Table 1-3 Brand names and trademark owners

1.1.6 Copyright

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1.2 About the device

The ESCON2 Module 60/30 is a small-sized, powerful 4-quadrant PWM servo controller. Its high power density allows flexible use for brushed DC motors and brushless EC (BLDC) motors up to approximately 1’800 Watts with various feedback options, such as Hall sensors, incremental encoders as well as absolute sensors in a multitude of drive applications.

The device is specially designed to be commanded and controlled by analog and digital set values, as well as a slave node in a CANopen network. Additionally, the unit can be operated via any USB or RS232 communication port of a Windows workstation. It also features extensive analog and digital I/O functionality.

Latest technology, such as field-oriented control (FOC), acceleration/velocity feed forward, in combination with highest control cycle rates allow sophisticated, ease-of-use motion control.

The miniaturized OEM plug-in module can be seamlessly integrated in complex customer applications. A suitable connector board is available providing standard industry connector interfaces for commissioning, or installations where high integration is not necessary. The ESCON2 Module 60/30 (P/N 783722) together with the connector board ESCON2 CB 60/30 (P/N 783729) represent the ESCON2 Compact 60/30 (P/N 783734) which can be ordered as a preassembled unit directly from maxon.

1.3 About the safety precautions

- Make sure that you have read and understood the note ➔ «READ THIS FIRST»!
- Do not engage with any work unless you possess the stated 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 subsequently used indicators!
- You must observe any regulation applicable in the country and/or at the site of implementation with regard to health and safety/accident prevention and/or environmental protection!

DANGER

High voltage and/or electrical shock
Touching live wires causes death or serious injuries!

- *Consider any power cable as connected to live power, unless having proven the opposite!*
- *Make sure that neither end of cable is connected to live power!*
- *Make sure that power source cannot be engaged while work is in process!*
- *Obey lock-out/tag-out procedures!*
- *Make sure to securely lock any power engaging equipment against unintentional engagement and tag it with your name!*

Requirements

- *Make sure that all associated devices and components are installed according to local regulations.*
- *Be aware that, by principle, an electronic apparatus can not be considered fail-safe. Therefore, you must make sure that any machine/apparatus has been fitted with independent monitoring and safety equipment. If the machine/apparatus should break down, if it is operated incorrectly, if the control unit breaks down or if the cables break or get disconnected, etc., the complete drive system must return – and be kept – in a safe operating mode.*
- *Be aware that you are not entitled to perform any repair on components supplied by maxon.*

Electrostatic sensitive device (ESD)

- *Wear working cloth and use equipment in compliance with ESD protective measures.*
- *Handle device with extra care.*
- *Be aware that you are not entitled to perform any repair on components supplied by maxon.*

2 SPECIFICATIONS

2.1 Technical data

ESCON2 Module 60/30 (P/N 783722)		
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)	30 A / 60 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	98.5 % ➔ 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 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…30 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.

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ESCON2 Module 60/30 (P/N 783722)			
Communi-cation interfaces	CAN [a]		Max. 1 Mbit/s
	RS232 [a]		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 x W x H)		67 x 43 x 7.8 mm
	Weight (approx.)		19 g
	Mounting		Pluggable (using sockets) and M2.5 screws
Environmen-tal conditions	Temperature	Operation	−30…+25 °C
		Extended range [b]	+25…+75 °C Derating: approx. -0.506 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 stated thermal specifications is mandatory.*
- *Exceeding ambient temperatures beyond the specified limits can lead to thermal overload even at low output currents.*

2.2.1 Test setup for data collection

Unless otherwise stated, the thermal data has been generated using the ESCON2 Compact 60/30 (P/N 783734). This variant includes the Module along with the thermal accessories from ➔ Chapter “2.2.4 Thermal accessories” on page 2-12 and the connector board from ➔ Chapter “4.1 Connection accessory - ready-to-use connector board” on page 4-41. This configuration is intended to reproduce the mounting on a metal structure with a motherboard. The unit is positioned in an upright position (connections facing to the top) and is placed on thermally poorly conductive holders (floating in air).

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

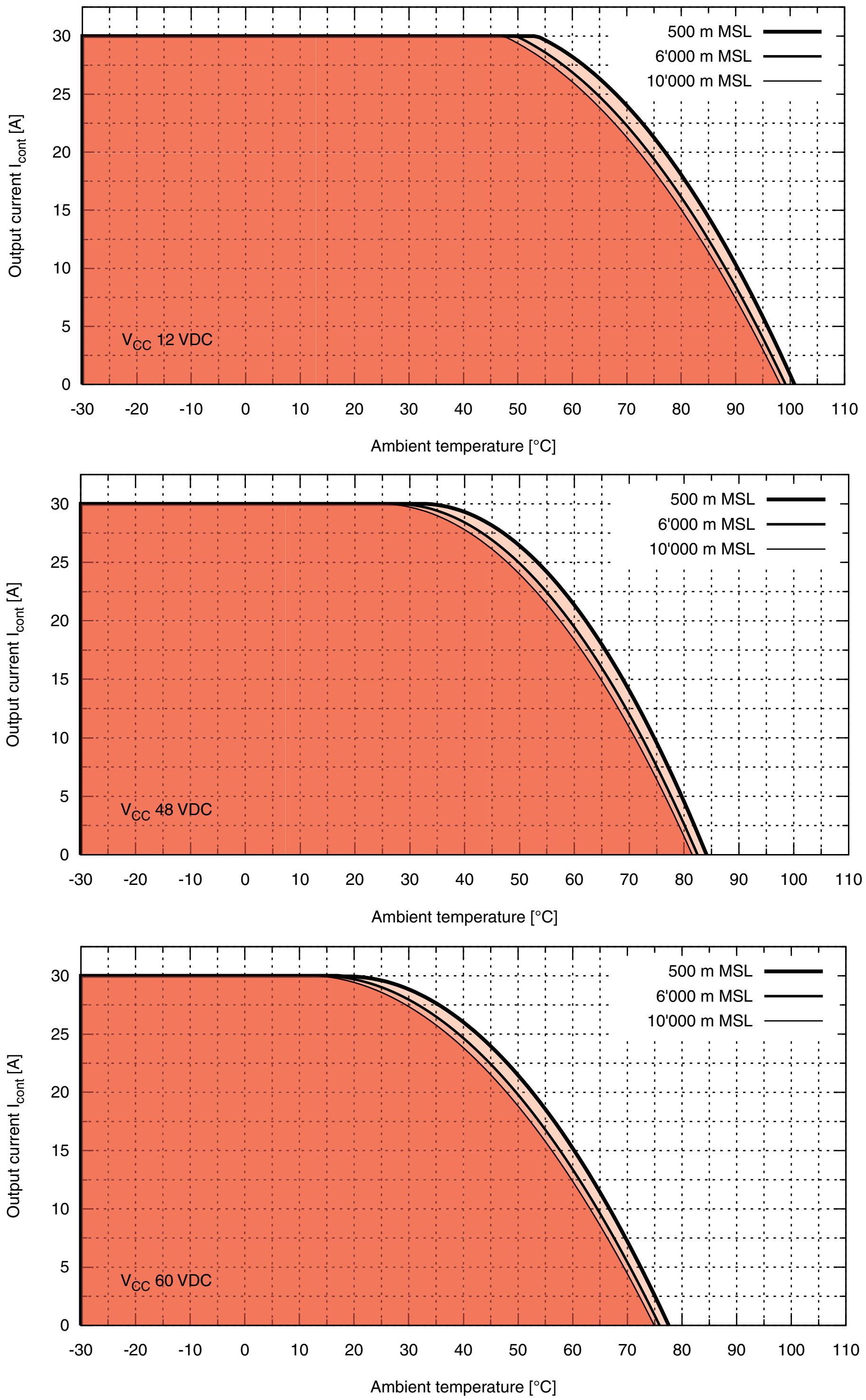

Figure 2-2 Derating of output current (operation without additional heatsink)

2.2.3 Operation with additional heatsink

In the process of data collection within this chapter, the unit was placed on its side. This positioning facilitates the upward flow of heat from the additional heatsink, thereby promoting effective passive cooling at the top.

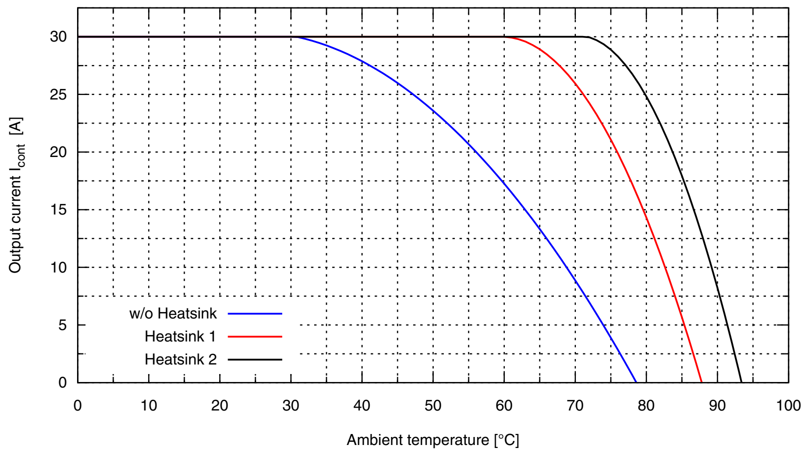

Figure 2-3 Extended operation @ V_{CC} 60 VDC with additional heatsink

Heatsink	Manufacturer	Type	Dimensions [mm]	Thermal resistance R_{th} [K/W]
1	Fischer Elektronik GmbH	SK 81 50 SA	50 × 100 × 15	3
2	Fischer Elektronik GmbH	SK 92 50 AL	50 × 100 × 40	1.75

Table 2-5 Heatsink – tested components

2.2.4 Thermal accessories

maxon offers a thermal pad and a heat spreader as accessories which both perfectly fit the ESCON2 Module 60/30.

Specifications		
ESCON2 Module 60/30 Thermal Pad (P/N 802197)	Dimensions (L × W × H)	67 × 43 × 0.23 mm
	Mounting	5 holes ø2.7 mm Hole pattern corresponds the ESCON2 Module 60/30 design ➔ Chapter “2.4 Dimensional drawing” on page 2-14
ESCON2 Module 60/30 Heat Spreader (P/N 816161)	Dimensions (L × W × H)	85 × 43 × 11 mm (with preinstalled threaded studs) Height/thickness without studs is 3 mm
	Mounting	4 slotted holes for M3 screws for mounting the heat spreader 4 threaded studs M2.5 and 1 threaded hole M2.5 for mounting the ESCON2 Module 60/30
	Material	Aluminum alloy

Table 2-6 Thermal accessories – specification

CAD files are available on the maxon website. Both components are used in the ready-to-connect unit ESCON2 Compact 60/30 (P/N 783734).

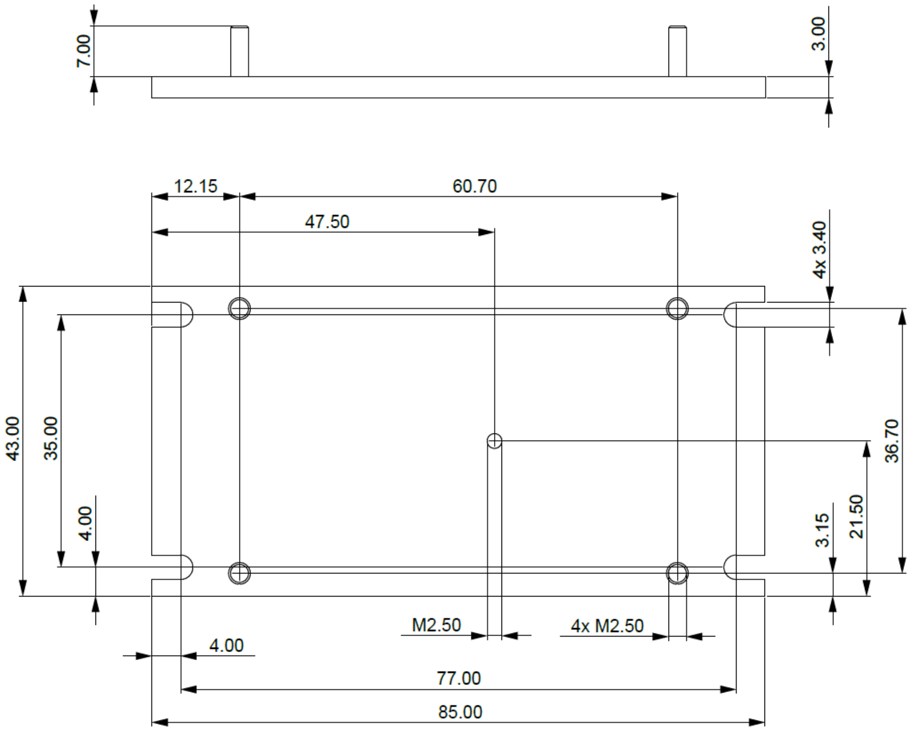

Figure 2-4 Heat spreader dimensional drawing [mm]

2.2.5 Power dissipation and efficiency

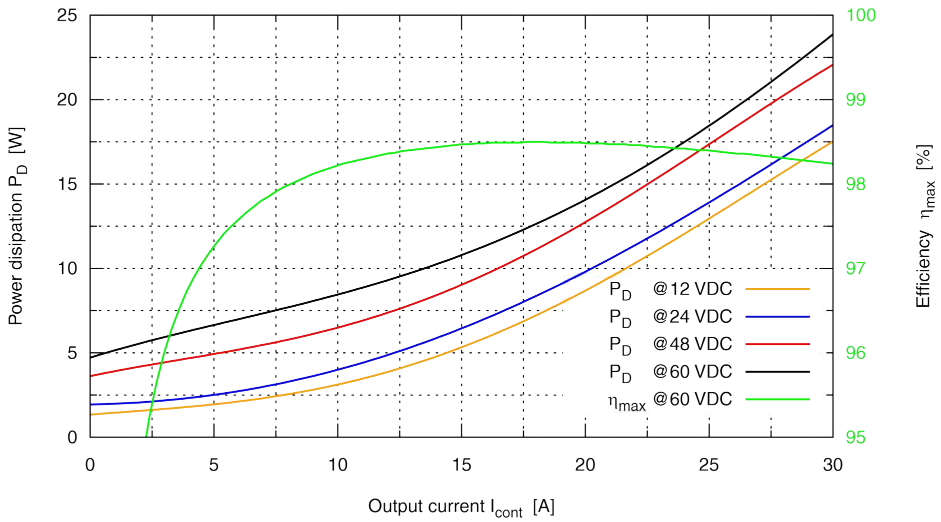

Figure 2-5 Power dissipation and efficiency

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	108 °C	98 °C
	power stage	110 °C	—

Table 2-7 Limitations and protections

Additionally, the device features a configurable output current limit and an overcurrent protection function that protects the controller in the event of a short circuit in a motor winding or a damaged power stage. The undervoltage, overvoltage and the thermal overload power stage protection limits are configurable. Further information can be found in the «ESCON2 Firmware Specification».

2.4 Dimensional drawing

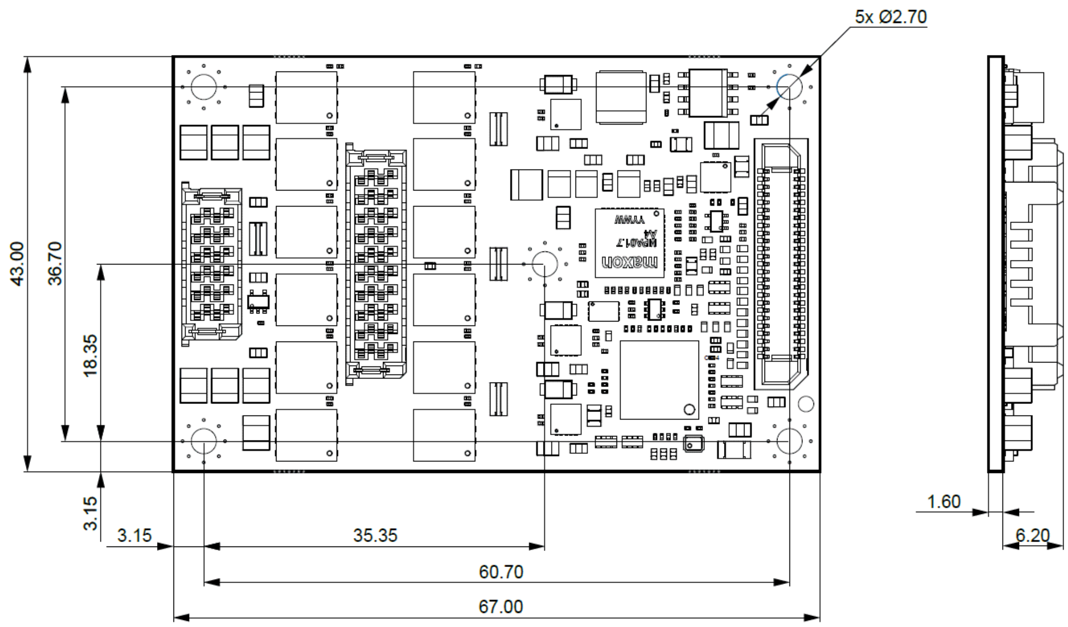

Figure 2-6 Dimensional drawing [mm]

2.5 Standards

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

Important Notice
The device's compliance with the mentioned standards does not imply its compliance within the final, ready to operate setup. In order to achieve compliance of your operational system, you must perform EMC testing of the involved 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): 317'416 hours

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

Table 2-8 Standards

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3 SETUP

IMPORTANT NOTICE: PREREQUISITES FOR PERMISSION TO COMMENCE INSTALLATION

The **ESCON2 Module** 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**.

WARNING

Risk of injury

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

- *Do not operate the device, unless you have made completely sure 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!*

3.1 Generally applicable rules

Maximal permitted supply voltage

- *Make sure that supply power is between 10…60 VDC.*
- *Supply voltages above 65 VDC, or wrong polarity will destroy the unit.*
- *Note that the necessary output current is depending on the load torque. Yet, the output current limits are as follows:*
  – continuous max. 30 A
  – short-time (acceleration) max. 60 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.

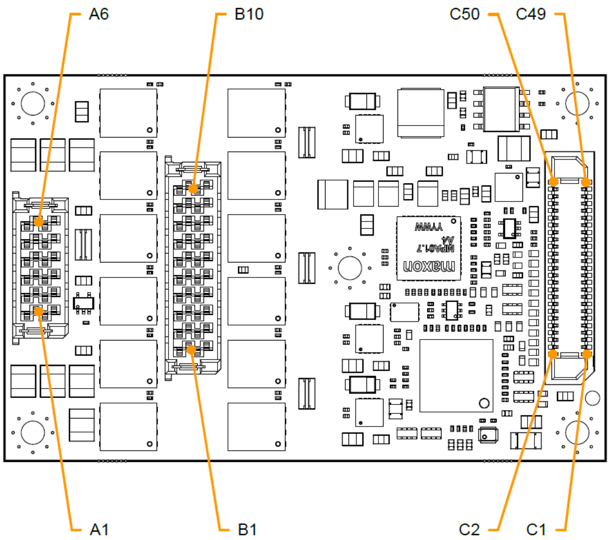

Figure 3-7 Pin assignment

Important Notice
How to read the following data
The column «Pin» refers to the socket pin number.
*Example: **B4...B7** means socket B, pins 4 thru 7.*

Pin	Signal	Description
A1…A3 [a]	GND	Ground
A4...A6 [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…A6

Pin	Signal	Description
B1…B3 [a]	Motor winding 1	EC motor: Winding 1
	Motor (+M)	DC motor: Motor +
B4...B7 [a]	Motor winding 2	EC motor: Winding 2
	Motor (-M)	DC motor: Motor -
B8...B10 [a]	Motor winding 3	EC motor: Winding 3
	-	DC motor: DO NOT CONNECT

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

Table 3-10 Pin assignment B1…B10

Pin	Signal	Description
C1	V_C	Logic supply voltage input (10...60 VDC)
C2	V_{Sensor}	Sensor supply voltage output (5 VDC / $I_L \leq$ 145 mA)
C3	GND	Ground
C4	Channel A	Digital incremental encoder channel A
	HsDigIN1	High-speed digital input 1
C5	Hall sensor 1	Hall sensor 1 input
C6	Channel A\	Digital incremental encoder channel A complement
	HsDigIN1\	High-speed digital input 1 complement
C7	Hall sensor 2	Hall sensor 2 input
C8	Channel B	Digital incremental encoder channel B
	HsDigIN2	High-speed digital input 2
C9	Hall sensor 3	Hall sensor 3 input
C10	Channel B\	Digital incremental encoder channel B complement
	HsDigIN2\	High-speed digital input 2 complement
C11	LED red	LED red (warning/error) signal
C12	Data	Data (SSI, BiSS C)
	HsDigIN4	High-speed digital input 4
C13	LED green	LED green (operation) signal
C14	HsDigIN3	High-speed digital input 3
C15	-	For maxon internal use. DO NOT CONNECT
C16	GND	Ground
C17	Clock	Clock (SSI, BiSS C)
	HsDigOUT1	High-speed digital output 1
C18	AnIN1+	Analog input 1, positive signal
C19	DigIN1	Digital input 1
C20	AnIN1-	Analog input 1, negative signal
C21	DigIN2	Digital input 2
C22	AnIN2+	Analog input 2, positive signal
C23	DigIN3	Digital input 3
C24	AnIN2-	Analog input 2, negative signal
C25	DigIN4	Digital input 4
C26	AnOUT1	Analog output 1
C27	DigOUT1	Digital output 1
C28	AnOUT2	Analog output 2
C29	DigOUT2	Digital output 2
C30	MotorTemp	Motor temperature sensor input
C31	Auto bit rate	Automatic bit rate detection of CAN bus
C32	-	For maxon internal use. DO NOT CONNECT
C33	ID 1	CAN ID 1 (valence = 1)
C34	-	For maxon internal use. DO NOT CONNECT
C35	ID 2	CAN ID 2 (valence = 2)
C36	-	For maxon internal use. DO NOT CONNECT

Continued on next page.

Pin	Signal	Description
C37	ID 3	CAN ID 3 (valence = 4)
C38	$V_{Peripheral}$	Peripheral components supply voltage output (3.3 VDC / $I_L \leq$ 20 mA; unprotected)
C39	ID 4	CAN ID 4 (valence = 8)
C40	GND	Ground
C41	ID 5	CAN ID 5 (valence = 16)
C42	V_{Bus}	USB supply voltage input (5 VDC)
C43	ID 6	CAN ID 6 (valence = 32)
C44	USB_D+	USB Data+ (twisted pair with USB Data-)
C45	GND	Ground
C46	USB_D-	USB Data- (twisted pair with USB Data+)
C47	CAN high	CAN bus high line
C48	DSP_TxD	Serial communication interface transmit (UART)
C49	CAN low	CAN bus low line
C50	DSP_RxD	Serial communication interface receive (UART)

Table 3-11 Pin assignment C1…C50

3.3 Connection specifications

The actual connection will depend on the overall configuration of your drive system and the type of motor you will be using. Follow the description in given order and choose the wiring diagram (➔as of Page 5-53) that best suits the components you are using.

Important Notice
How to read the following data
The column «Pin» refers to the socket pin number.
*Example: **B4...B7** means socket B, pins 4 thru 7.*

3.3.1 Power supply

Pin	Signal	Description
A1…A3 [a]	GND	Ground
A4...A6 [a]	V_{CC}	Power supply voltage input (10...60 VDC)

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

Table 3-12 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. 30 A • short-time (acceleration) max. 60 A (< 4 s)

Table 3-13 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. Thereby consider:
   a) During braking of the load, the power supply must be capable of buffering the recovered kinetic energy (for example, in a capacitor).
   b) If you are using an electronically stabilized power supply, make sure that the over current protection circuit is configured 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 @ 30 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
C1	V_C	Logic supply voltage input (10...60 VDC)
C3	GND	Ground

Table 3-14 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 3-15 Logic supply requirements

3.3.3 Output voltages

Two output voltages are provided for the supply of external devices or as an input voltage for I/Os. Typically, the sensor supply voltage V_{Sensor} is used for Hall sensors, encoder, high-speed digital inputs, digital I/Os or an external RS232 transceiver. The peripheral supply voltage $V_{Peripheral}$ may be used for an external RS422 transceiver or other external devices.

Pin	Signal	Description
C2	V_{Sensor}	Sensor supply voltage output (5 VDC / $I_L \leq$ 145 mA)
C3	GND	Ground
C38	$V_{Peripheral}$	Peripheral components supply voltage output (3.3 VDC / $I_L \leq$ 20 mA; unprotected)
C40	GND	Ground

Table 3-16 Output voltages – Pin assignment

Unprotected voltage output $V_{Peripheral}$
The peripheral supply voltage output $V_{Peripheral}$ is unprotected. Any signals on this interface must be avoided and can result in 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
B1...B3 [a]	Motor winding 1	Winding 1
B4...B7 [a]	Motor winding 2	Winding 2
B8...B10 [a]	Motor winding 3	Winding 3

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

Table 3-17 EC motor – Pin assignment

Pin	Signal	Description
B1...B3 [a]	Motor (+M)	Motor +
B4...B7 [a]	Motor (-M)	Motor -
B8...B10	-	DO NOT CONNECT

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

Table 3-18 DC motor – Pin assignment

3.3.5 Sensor 1 Hall sensor

Pin	Signal	Description
C2	V_{Sensor}	Sensor supply voltage output (5 VDC / $I_L \leq$ 145 mA)
C3	GND	Ground
C5	Hall sensor 1	Hall sensor 1 input
C7	Hall sensor 2	Hall sensor 2 input
C9	Hall sensor 3	Hall sensor 3 input

Table 3-19 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 3-23*
- *Incremental encoders ➔ Chapter "3.3.6.1 Incremental encoder" on page 3-24*
- *SSI / BiSS C encoders ➔ Chapter "3.3.6.2 SSI / BiSS C 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 3-28*
- *Digital I/Os ➔ Chapter "3.3.7 Digital I/Os" on page 3-31*
- *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 3-20 Hall sensor specification

maxon

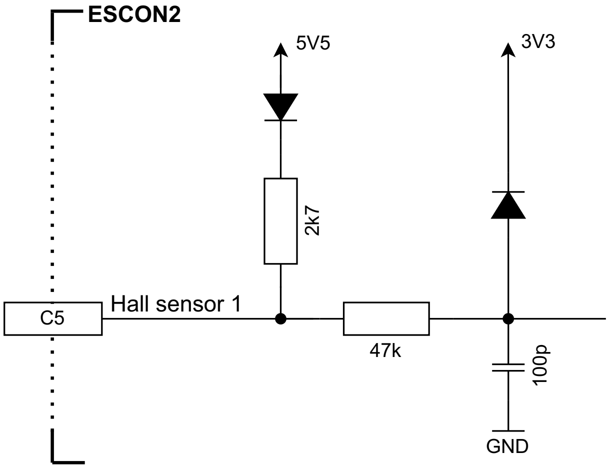

Figure 3-8 Hall sensor 1 input circuit (analogously valid for Hall sensors 2 & 3)

3.3.6 Sensor 2 Encoder / I/Os

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.

3.3.6.1 Incremental encoder

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).*

Pin	Signal	Description
C2	V_{Sensor}	Sensor supply voltage output (5 VDC / $I_L \leq 145$ mA)
C3	GND	Ground
C4	Channel A	Digital incremental encoder channel A
C6	Channel A\	Digital incremental encoder channel A complement
C8	Channel B	Digital incremental encoder channel B
C10	Channel B\	Digital incremental encoder channel B complement

Table 3-21 Incremental 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 3-23*
- *Incremental encoders ➔ Chapter "3.3.6.1 Incremental encoder" on page 3-24*
- *SSI / BiSS C encoders ➔ Chapter "3.3.6.2 SSI / BiSS C 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 3-28*
- *Digital I/Os ➔ Chapter "3.3.7 Digital I/Os" on page 3-31*
- *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 3-22 Differential digital incremental encoder specification

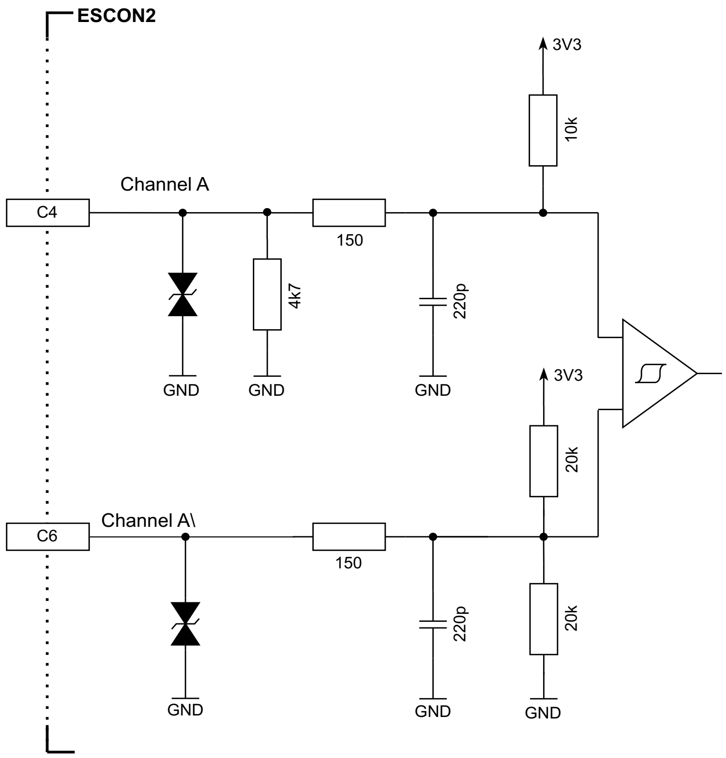

Figure 3-9 Digital incremental encoder input circuit Ch A “differential” (analogously valid for Ch B)

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 3-23 Single-ended digital incremental encoder specification

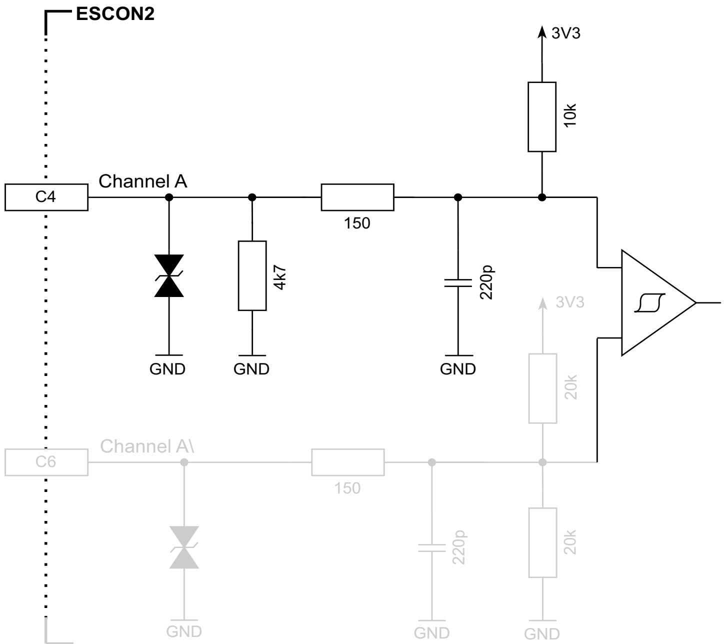

Figure 3-10 Digital incremental encoder input circuit Ch A “single-ended” (analogously valid for Ch B)

3.3.6.2 SSI / BiSS C 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 good resistance against electrical interference, ***we recommend using encoders with a line driver (differential scheme).*** *For this an external transceiver is required on the motherboard ➔ Chapter “4.2.8 RS422 transceiver for differential SSI, BiSS C or high-speed I/Os signals” on page 4-48.*

Pin	Signal	Description
C2	V_{Sensor}	Sensor supply voltage output (5 VDC / I_L ≤ 145 mA)
C3	GND	Ground
C12	Data	Data (SSI, BiSS C)
C17	Clock	Clock (SSI, BiSS C)

Table 3-24 SSI / BiSS C 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 3-23*
- *Incremental encoders ➔ Chapter “3.3.6.1 Incremental encoder” on page 3-24*
- *SSI / BiSS C encoders ➔ Chapter “3.3.6.2 SSI / BiSS C 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 3-28*
- *Digital I/Os ➔ Chapter “3.3.7 Digital I/Os” on page 3-31*
- *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 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 3-25 SSI / BiSS C absolute encoder specification

SSI / BiSS C 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 3-26 Single-ended SSI / BiSS C absolute encoder data channel specification

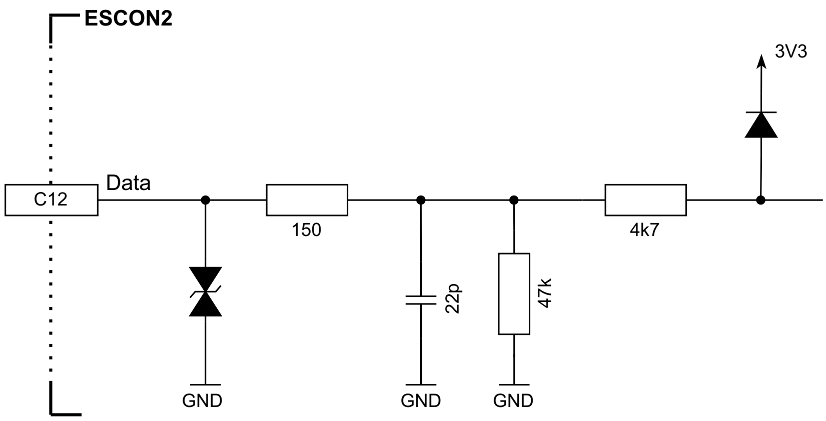

Figure 3-11 SSI absolute encoder data input (analogously valid for BiSS C)

SSI / BiSS C absolute encoder clock channel		
Output voltage		3.3 VDC
Output resistance		270 Ω
Clock frequency	SSI	0.1...2 MHz
	BiSS C	0.1...4 MHz

Table 3-27 Single-ended SSI / BiSS C absolute encoder clock channel specification

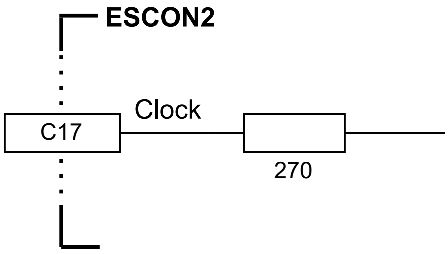

Figure 3-12 SSI absolute encoder clock output (analogously valid for BiSS C)

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
C2	V_{Sensor}	Sensor supply voltage output (5 VDC / $I_L \leq$ 145 mA)
C3	GND	Ground
C4	HsDigIN1	High-speed digital input 1
C6	HsDigIN1\	High-speed digital input 1 complement
C8	HsDigIN2	High-speed digital input 2
C10	HsDigIN2\	High-speed digital input 2 complement
C12	HsDigIN4	High-speed digital input 4
C14	HsDigIN3	High-speed digital input 3
C17	HsDigOUT1	High-speed digital output 1

Table 3-28 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 3-23*
- *Incremental encoders ➔ Chapter "3.3.6.1 Incremental encoder" on page 3-24*
- *SSI / BiSS C encoders ➔ Chapter "3.3.6.2 SSI / BiSS C 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 3-28*
- *Digital I/Os ➔ Chapter "3.3.7 Digital I/Os" on page 3-31*
- *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 3-29 Differential high-speed digital input specification

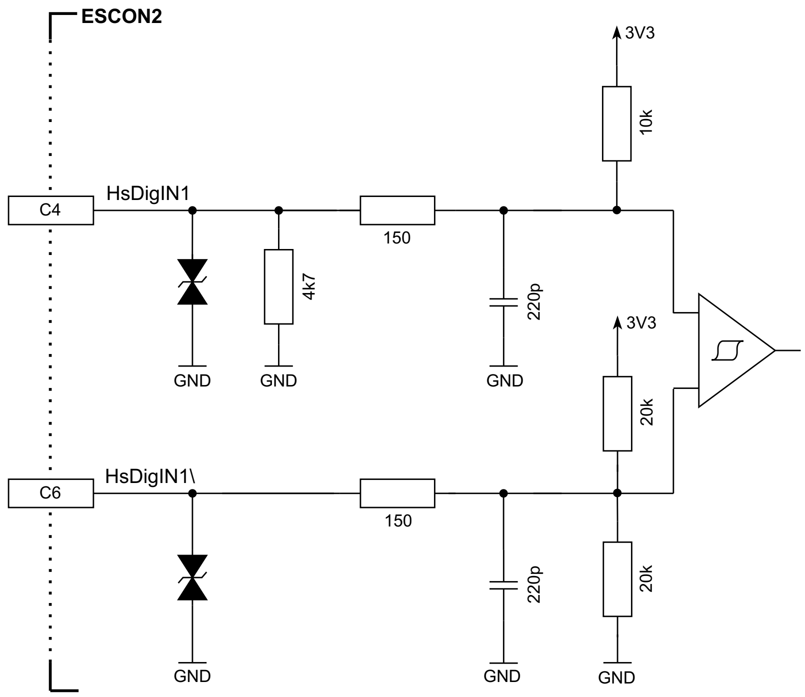

Figure 3-13 HsDigIN1 circuit “differential” (analogously valid for HsDigIN2)

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 3-30 Single-ended high-speed digital input specification

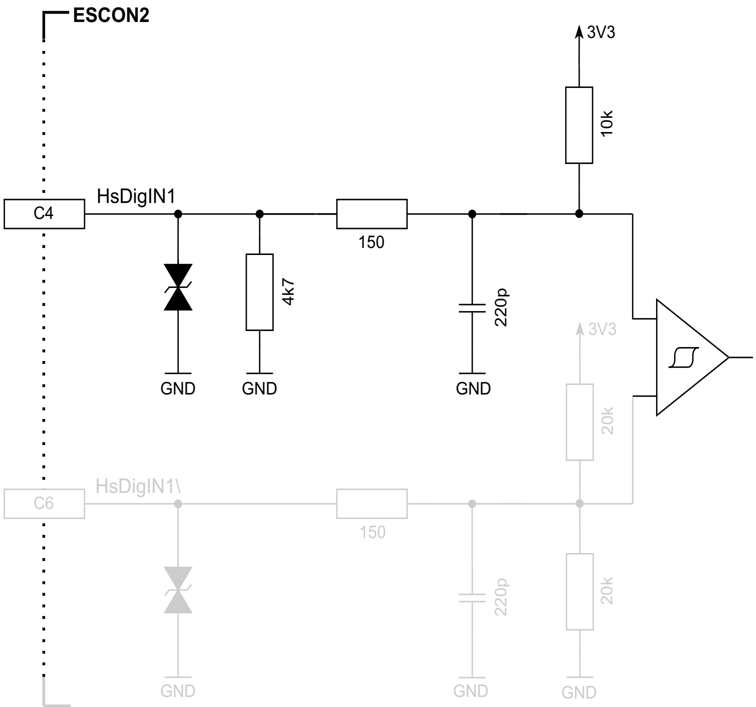

Figure 3-14 HsDigIN1 circuit “single-ended” (analogously valid for HsDigIN2…3)

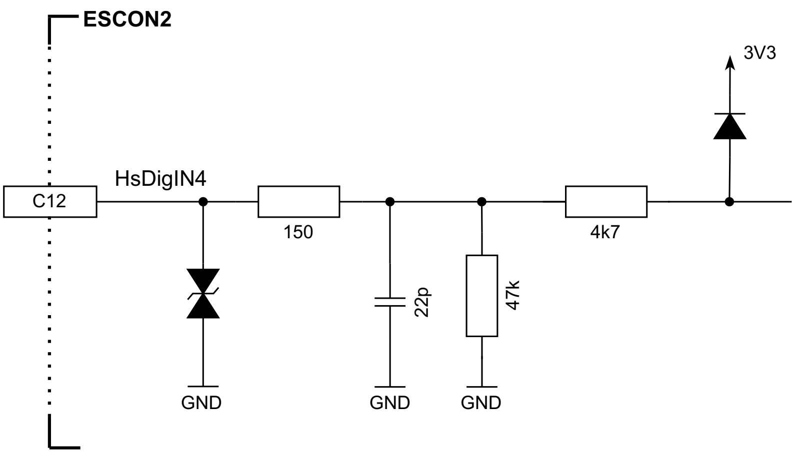

Figure 3-15 HsDigIN4 circuit “single-ended”

High-speed digital output 1	
Output voltage	3.3 VDC
Output resistance	270 Ω
Max. output frequency	25 kHz

Table 3-31 High-speed digital output specification

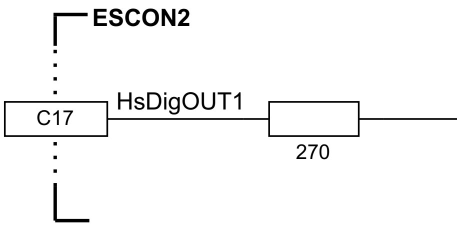

Figure 3-16 HsDigOUT1 circuit

3.3.7 Digital I/Os

Pin	Signal	Description
C2	V_{Sensor}	Sensor supply voltage output (5 VDC / $I_L \le 145$ mA)
C16	GND	Ground
C19	DigIN1	Digital input 1
C21	DigIN2	Digital input 2
C23	DigIN3	Digital input 3
C25	DigIN4	Digital input 4
C27	DigOUT1	Digital output 1
C29	DigOUT2	Digital output 2

Table 3-32 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 3-23*
- *Incremental encoders ➔ Chapter “3.3.6.1 Incremental encoder” on page 3-24*
- *SSI / BiSS C encoders ➔ Chapter “3.3.6.2 SSI / BiSS C 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 3-28*
- *Digital I/Os ➔ Chapter “3.3.7 Digital I/Os” on page 3-31*
- *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…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 3-33 Digital inputs 1...2 specification

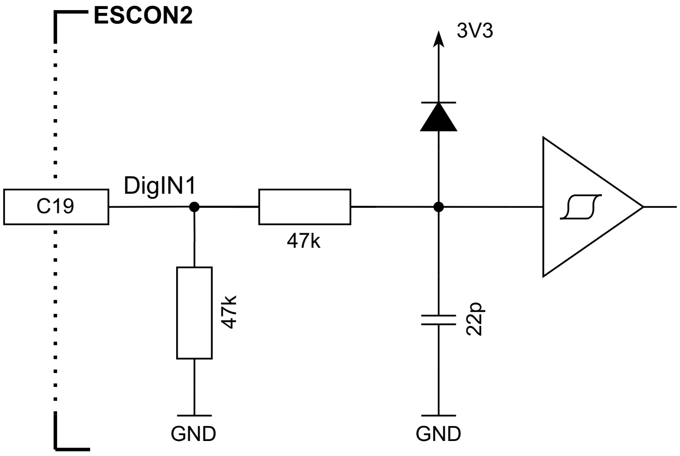

Figure 3-17	DigIN1 circuit (analogously valid for DigIN2)

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 3-34	Digital inputs 3...4 specification

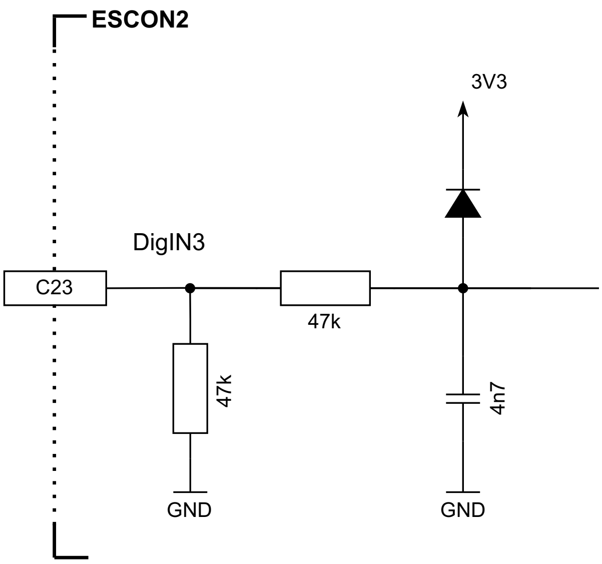

Figure 3-18	DigIN3 circuit (analogously valid for DigIN4)

Digital outputs 1…2	
Output voltage	3.3 VDC
Output resistance	270 Ω
Max. output frequency	25 kHz

Table 3-35 Digital output specification

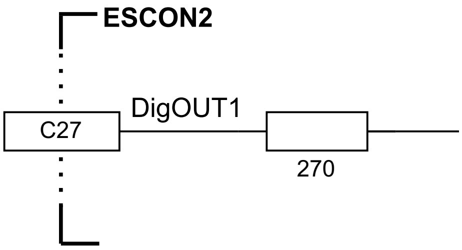

Figure 3-19 DigOUT1 circuit (analogously valid for DigOUT2)

For connecting devices that require a larger output current, an external load switch can be utilized on the motherboard ➔ Chapter “4.2.9 Digital outputs load switch” on page 4-48.

3.3.8 Analog I/Os

Pin	Signal	Description
C16	GND	Ground
C18	AnIN1+	Analog input 1, positive signal
C20	AnIN1−	Analog input 1, negative signal
C22	AnIN2+	Analog input 2, positive signal
C24	AnIN2−	Analog input 2, negative signal
C26	AnOUT1	Analog output 1
C28	AnOUT2	Analog output 2
C30	MotorTemp	Motor temperature sensor input

Table 3-36 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 3-37 Analog input specification

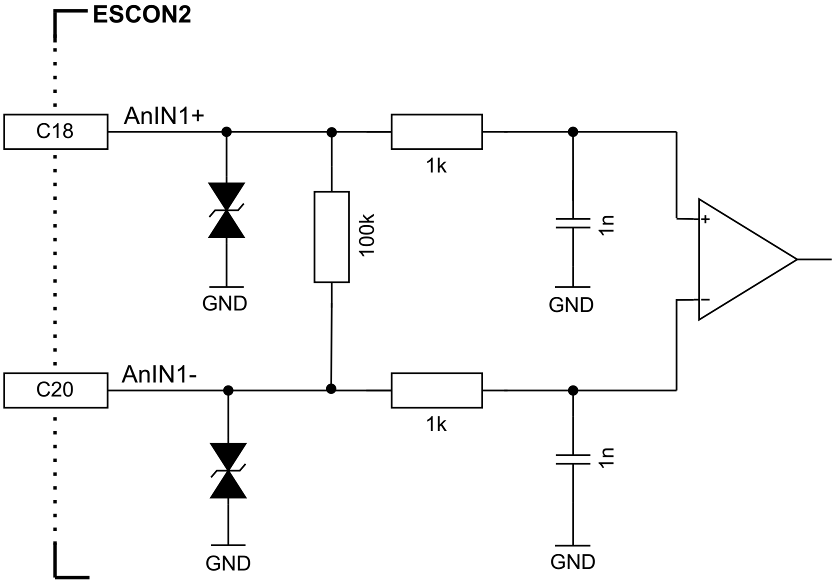

Figure 3-20 AnIN1 circuit (analogously valid for AnIN2)

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 3-38 Analog output specification

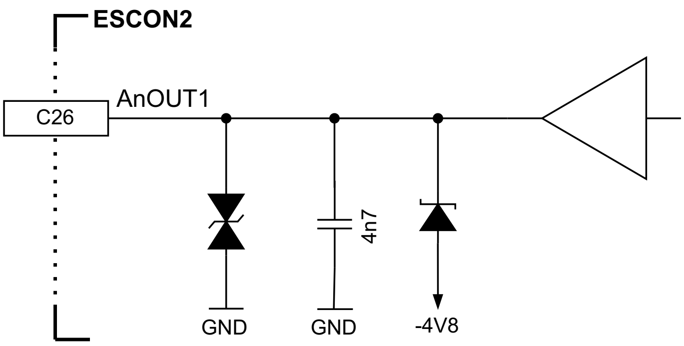

Figure 3-21 AnOUT1 circuit (analogously valid for AnOUT2)

3.3.9 CAN (future release)

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

3.3.9.1 Interface

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

Pin	Signal	Description
C45	GND	Ground
C47	CAN high	CAN bus high line
C49	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.*

3.3.9.2 Configuration

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

Pin	Signal	Description	Binary Code	Valence
C31	Auto bit rate	Automatic bit rate detection of CAN bus	-	-
C33	ID 1	CAN ID 1	2^0	1
C35	ID 2	CAN ID 2	2^1	2
C37	ID 3	CAN ID 3	2^2	4
C39	ID 4	CAN ID 4	2^3	8
C40	GND	Ground	-	-
C41	ID 5	CAN ID 5	2^4	16
C43	ID 6	CAN ID 6	2^5	32
C45	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

3.3.10 Serial Communication Interface (SCI) / RS232 (future release)

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

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 Mbit/s.*

Pin	Signal	Description
C48	DSP_TxD	Serial communication interface transmit (UART)
C50	DSP_RxD	Serial communication interface receive (UART)

Table 3-45 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	270 Ω
Max. bit rate	115‘200 bit/s
Data format	NRZ (non-return-to-zero)

Table 3-46 SCI specification

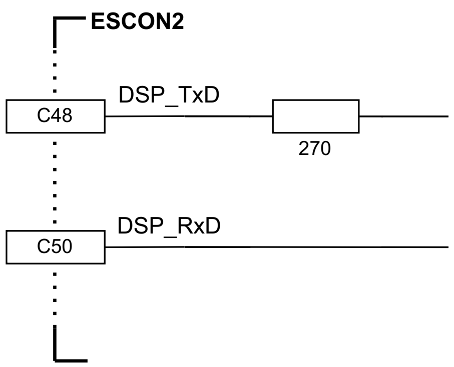

Figure 3-22 SCI circuit

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
C42	1	V_{BUS}	USB supply voltage input 5 VDC
C44	3	USB_D+	USB Data+ (twisted pair with USB Data−)
C45	4	GND	USB Ground
C46	2	USB_D−	USB Data− (twisted pair with USB Data+)

Table 3-47 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 3-48 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
C30	MotorTemp	Motor temperature sensor input
C40	GND	Ground

Table 3-49 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 3-50 Motor temperature sensor – specifications

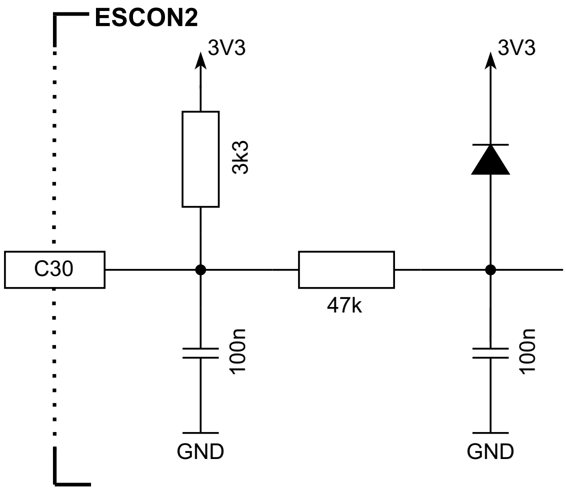

Figure 3-23 Motor temperature circuit

3.4 Status indicators

The ESCON2 Module 60/30 provides two output signals to display the actual operation status and possible warnings and errors of the device with LEDs. A set of green and red LED is recommended:

- 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 3-51 Device Status LEDs

Pin	Signal	Description
C11	LED red	LED red (warning/error) signal
C13	LED green	LED green (operation) signal

Table 3-52 Device status outputs - Pin assignment

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

Table 3-53 Device status output specification

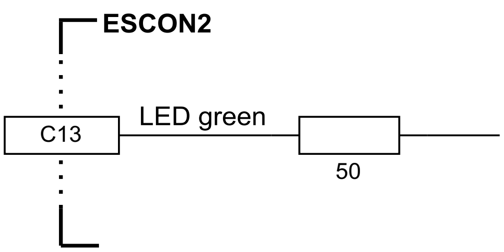

Figure 3-24 LED green circuit (analogously valid for LED red)

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4 MOTHERBOARD DESIGN GUIDE

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

Instead of designing an own motherboard, consider to use the connector board as described in ➔ Chapter 4.1 Connection accessory - ready-to-use connector board.

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 make any claim to completeness, 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 for this point.
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 connector board

With the ESCON2 CB 60/30 (P/N 783729), maxon offers a ready-to-use connector board which perfectly fits the Module. This board provides industrial connectors with which the maxon prefab cables can be used. Together with the thermal accessories from ➔ Chapter “2.2.4 Thermal accessories” on page 2-12 it forms the ready-to-connect version ESCON2 Compact 60/30 (P/N 783734). For further information refer to the hardware reference of the Compact.

The guidelines of the following chapters are based on the design of the CB.

4.2 Requirements for components of third-party suppliers

Best practice
For references and recommended components consult ➔Table 4-54.

4.2.1 Terminal headers

For implementation of a motherboard for the Module, three terminal headers are required.

4.2.2 Power supply voltage

To protect the Module, using an external circuit breaker, a TVS diode, and a capacitor in the voltage supply cirquit is recommended.

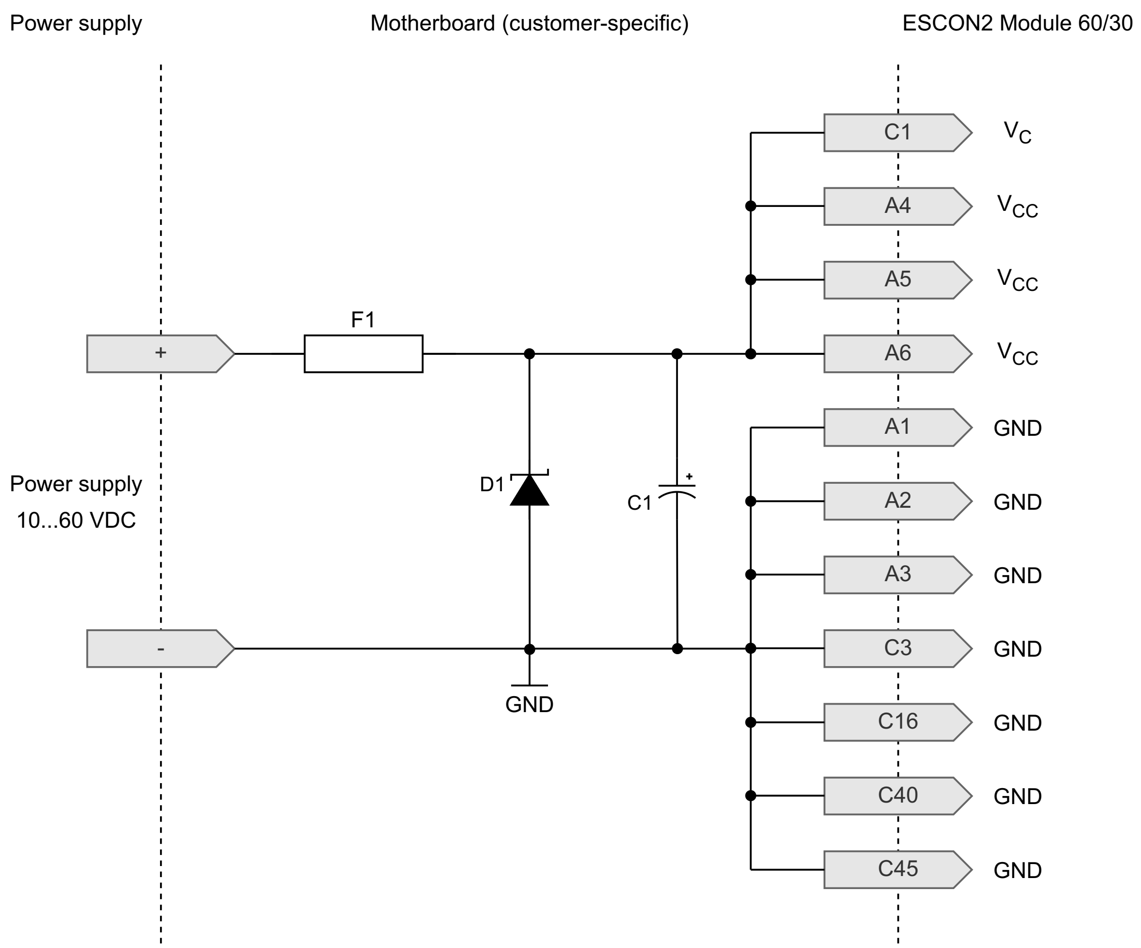

Figure 4-25 Wiring of power supply

Input Fuse (F1)

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

Capacitor (C1)

The function of the Module does not necessarily require the use of an external capacitor. Nevertheless, to further reduce voltage ripple or to buffer feedback currents (typically present during motor deceleration), an electrolytic capacitor (C1) can be connected to the voltage supply line. Use of an electrolytic capacitor is also recommended to avoid oscillations caused by supply cable inductance or by the Module’s built-in capacitors that 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 to connect a TVS (transient voltage suppressor) diode (D1) to the voltage supply line.

4.2.3 Logic supply voltage

The Module features a logic supply voltage input. Its voltage range is 10…60 VDC and must be either sourced separately or by the power supply voltage. The following figure provides an example of a separate logic supply.

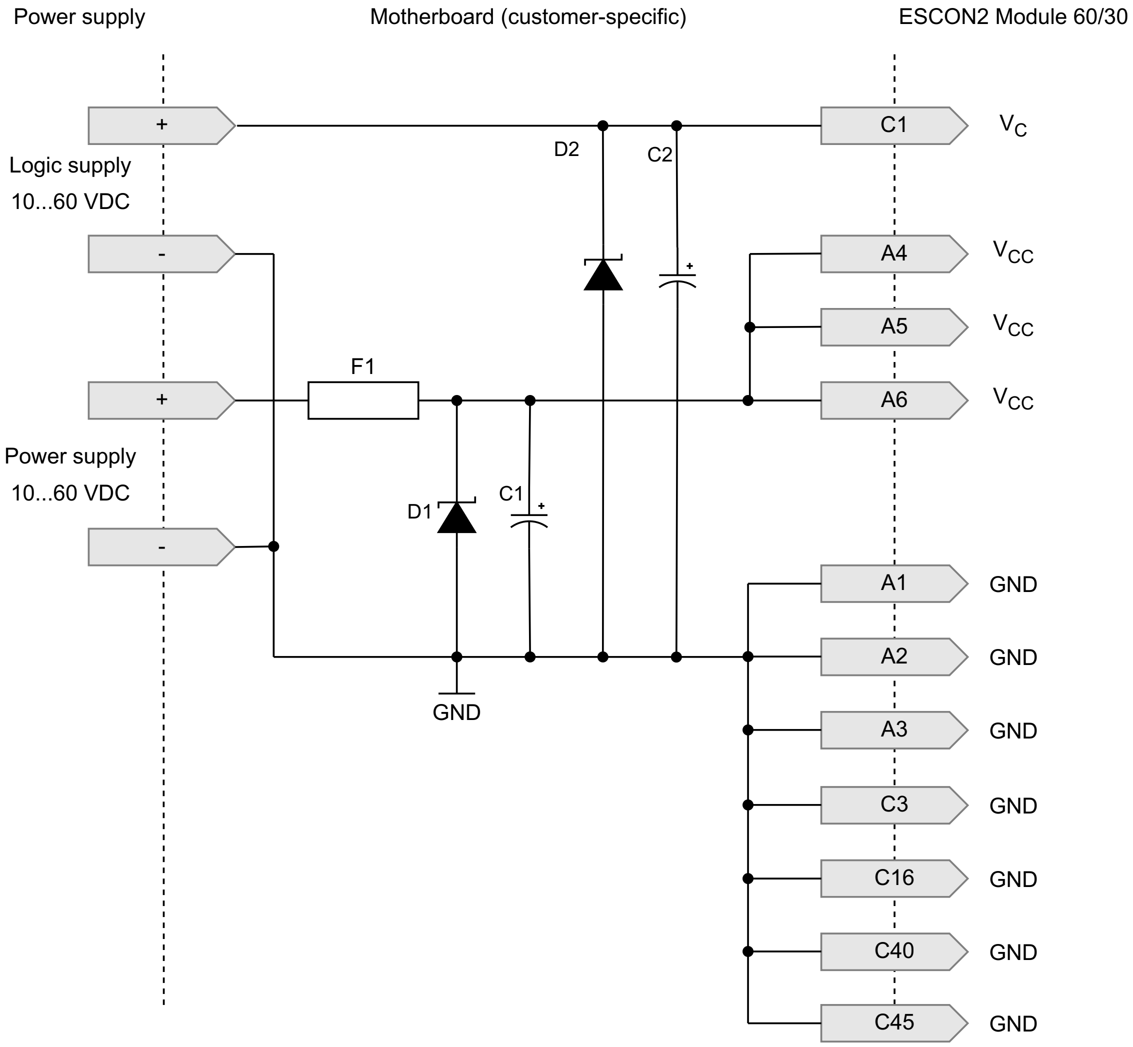

Figure 4-26 Wiring of logic supply

Capacitor (C2)

Use an electrolytic capacitor (C2) if the logic supply is sourced separately. This will avoid oscillations caused by supply cable inductance or the Module's built-in capacitors that could lead to a voltage overshoot at power plug-in.

TVS Diode (D2)

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

4.2.4 Motor chokes

The Module is not equipped with internal motor chokes.
The majority of motors and applications do not require additional chokes. However, in case of high supply voltage with very low terminal inductance, the ripple of the motor current can reach an unacceptably high value. This causes the motor to heat up unnecessarily and causes instable 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. Nevertheless, the use of chokes in combination with additional filter components can be useful to reduce the emission of electromagnetic interference.

An additional choke must feature electromagnetic shielding, an adequate saturation current, minimal losses, and a nominal current greater than the continuous current of the motor. The below wiring example refers to an additional inductance of 470 nH. If a different additional inductance is required, also the filter components must be adapted accordingly. Should you need further help with the filter design, contact maxon Support at ➔http://support.maxongroup.com.

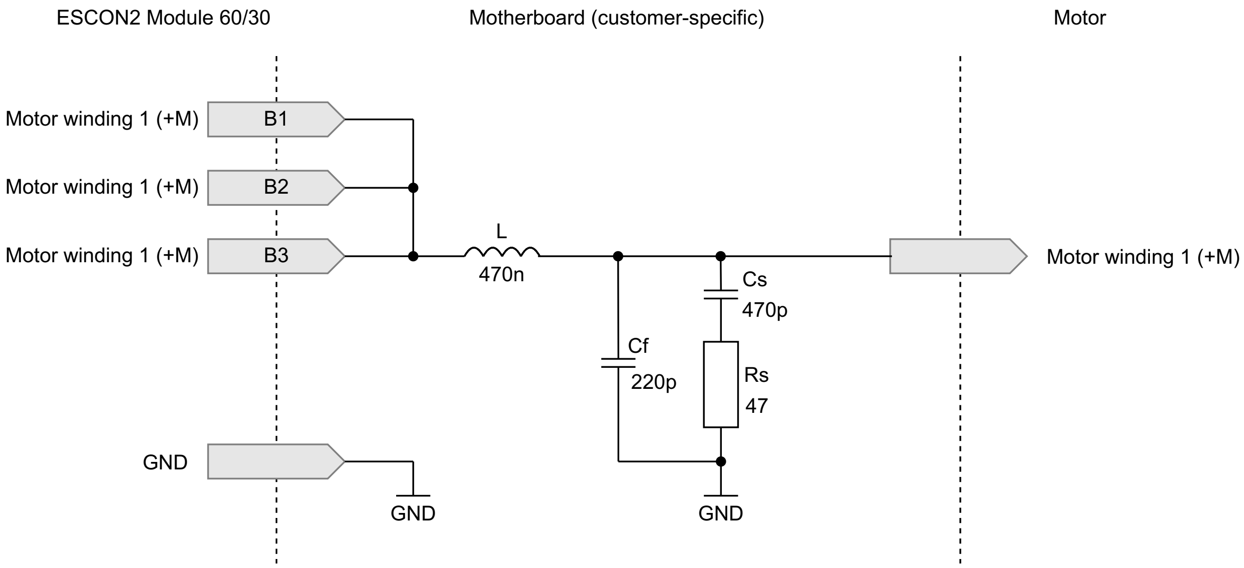

Figure 4-27 Wiring of motor winding 1 (analogously valid for motor winding 2 & 3)

4.2.5 USB interface

Use of an USB-C connector is recommended. In any case, if the USB interface is used, TVS diodes shall be installed for protection against overvoltage transients.

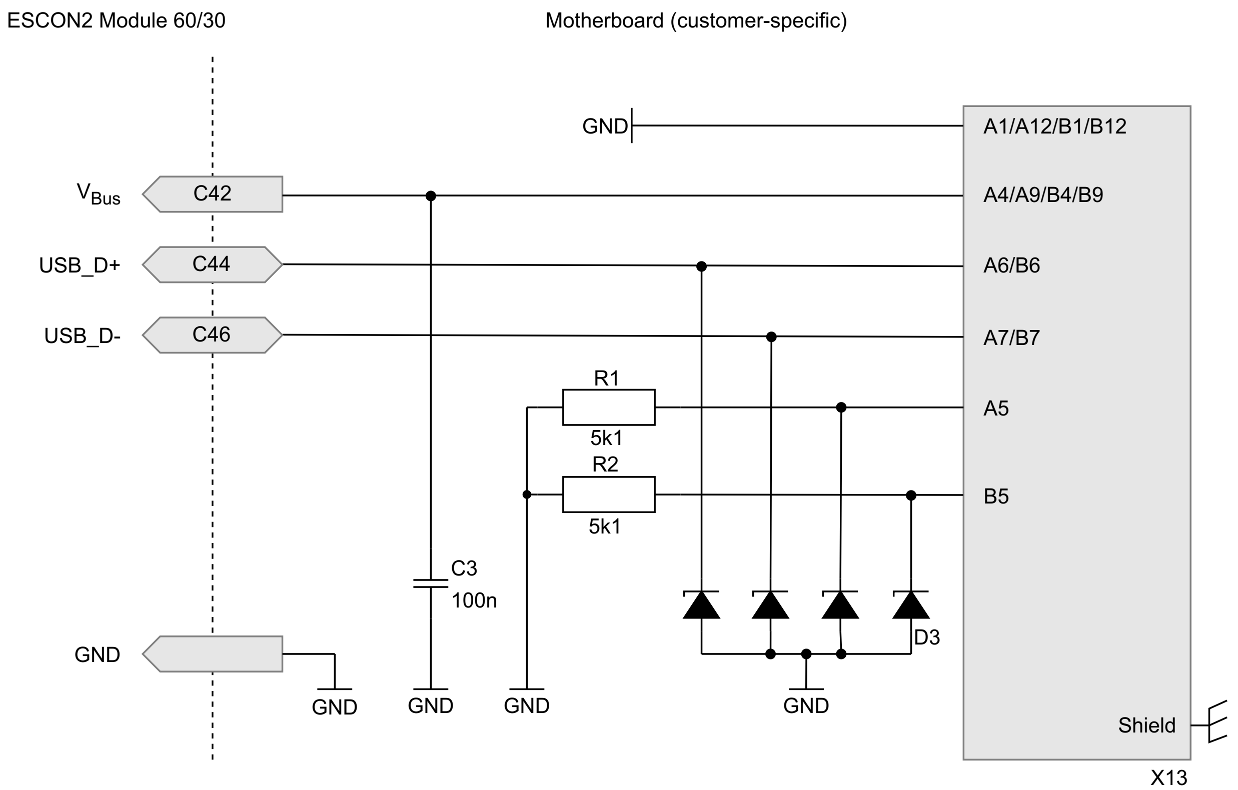

Figure 4-28 Wiring of USB-C connector

4.2.6 CAN interface

The device's CAN ID (Node-ID) and automatic bit rate detection can be configured by hardware. Furthermore, a bus termination is necessary on both ends of the bus line.

For configuration of a given ID, CAN ID 1 through CAN ID 6 must be connected to GND, as applicable (➔ Chapter "3.3.9.2 Configuration" on page 3-35). To activate the automatic bit rate detection, (C31) Auto bit rate must be connected to GND.

Alternatively, software setting can be used to adjust the parameters if the pins for the automated bit rate detection and CAN IDs are left open. If necessary, (C47) CAN high and (C49) CAN low can be linked 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.

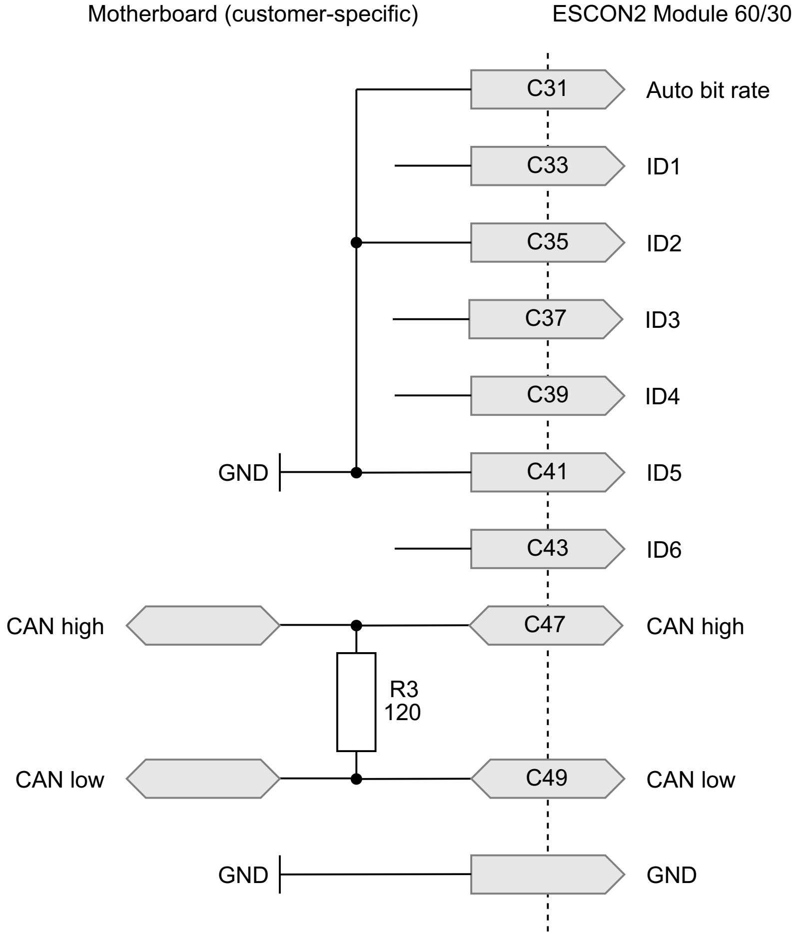

Figure 4-29 Wiring of CAN interface

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

4.2.7 RS232 interface

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.

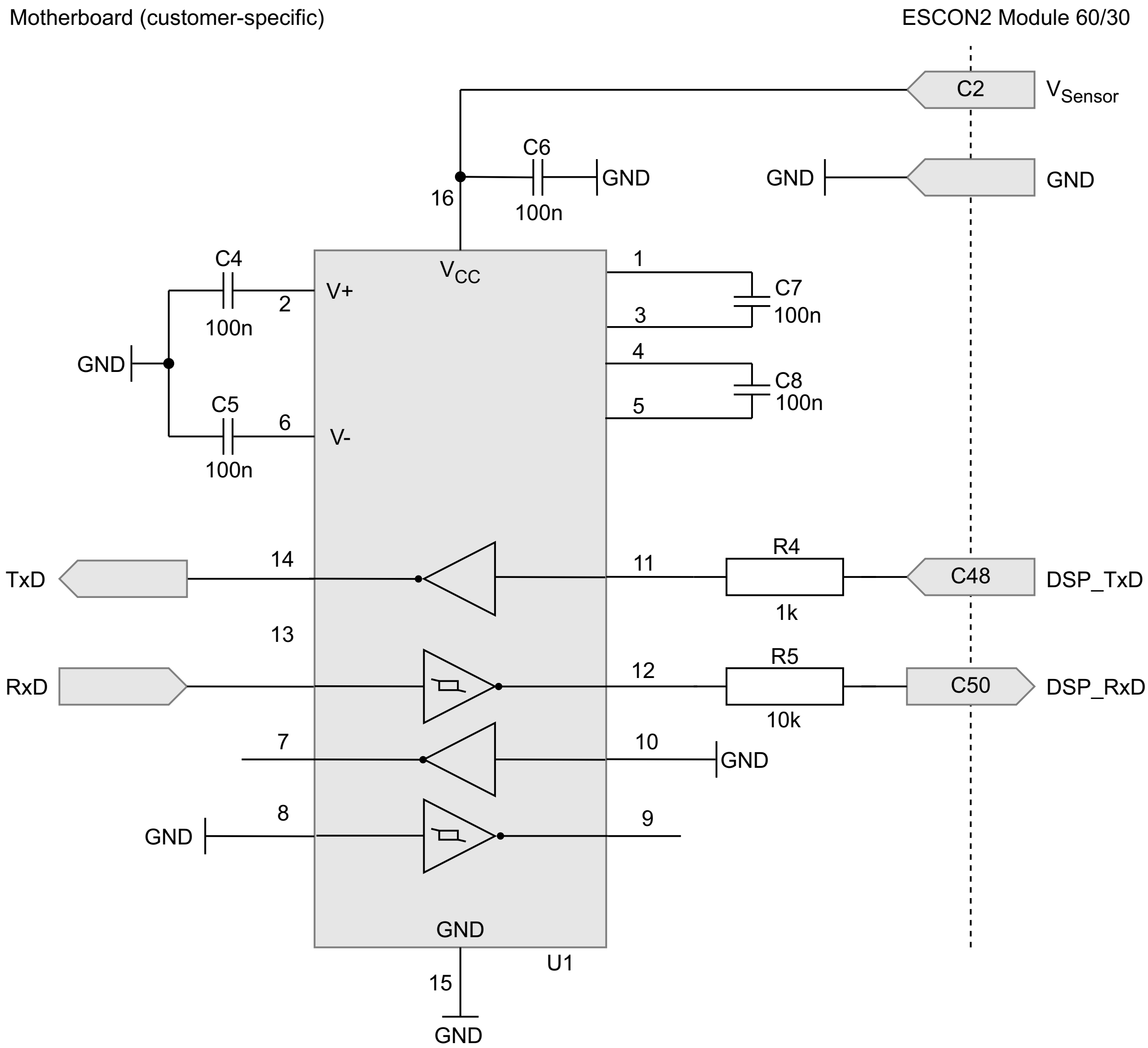

Figure 4-30 Wiring of RS232 interface

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 if you want to utilize the SSI / BiSS C 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.

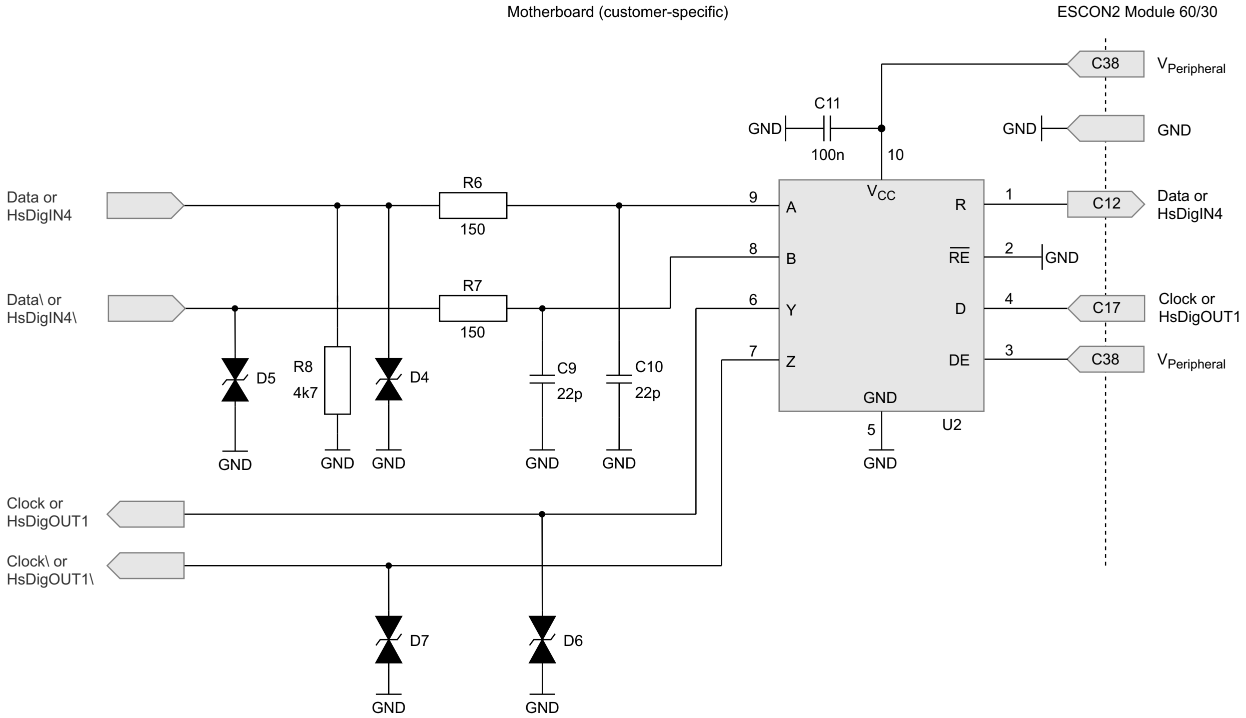

Figure 4-31 Wiring of RS422 transceiver

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. For the given circuitry example, the external load must be supplied with a maximum supply 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 just used for signal processing.

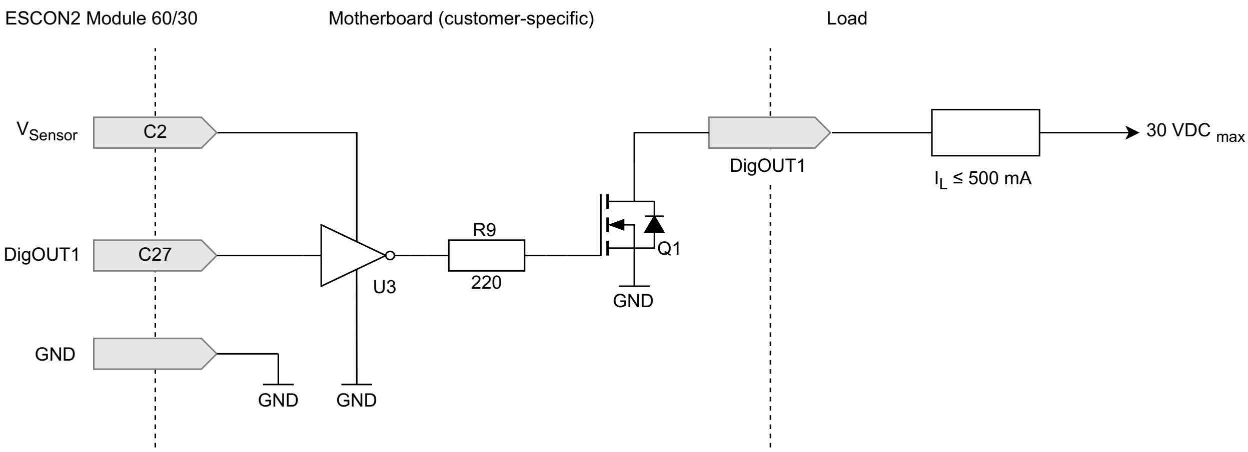

Figure 4-32 Wiring of digital output 1 load switch (analogously valid for digital output 2)

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. The freewheeling diode should be installed at the load, if possible.

4.2.10 LEDs for device status indication

A set of green and red LEDs can be installed on the motherboard to indicate the device status. The green LED shall be used for the operation status and the red LED for indication of warnings and errors. For further information refer to ➔ Chapter “3.4 Status indicators” on page 3-39

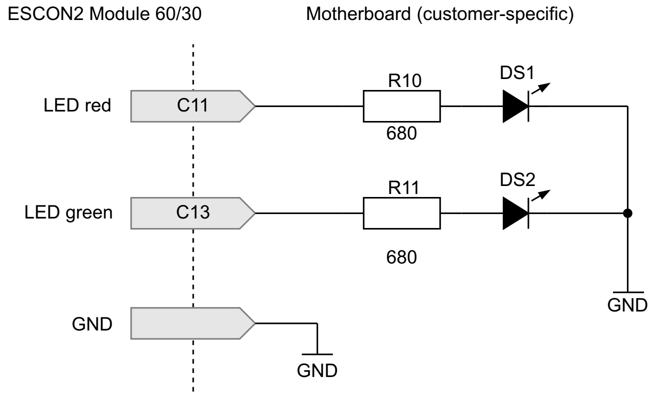

Figure 4-33 Wiring of LEDs for device status indication

4.2.11 Recommended components and manufacturers

Recommended components	
Header	
Terminal header	**6 poles:** • Samtec UMPT-06-07.5-L-V-S-W-TR • Samtec UMPT-06-07.5-S-V-S-W-TR **10 poles:** • Samtec UMPT-10-07.5-L-V-S-W-TR • Samtec UMPT-10-07.5-S-V-S-W-TR **2×25 poles:** • Samtec ERM8-025-08.0-L-DV-TR • Samtec ERM8-025-08.0-S-DV-TR
Power supply voltage	
Fuse (F1)	**40 A, 1’000 A^2s** • Bel Fuse 0678H9400-02 • Bourns SF-3812F4000T-2
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 however, the ripple current may reach I_{cont} / 2. Use capacitors with rated voltage ≥ 80 VDC and adequate ripple current to avoid overheat or lifetime reduction. Remark: If there is an excessive amount of reversed energy present (for example during deceleration of loads with a high inertia or during a vertical movement downwards), there might be the need to add an additional capacitor with a much higher capacity (for example up to 10'000…47'000 µF) and/ or to add a brake chopper, for example maxon DSR 70/30 (P/N 235811). **Example for C1 worst-case dimensioning:** I_{cont} = 30 A, I_{cont} / 2 = 15 A → 10 × capacitor with 22 µF, 80 VDC, 1'550 mA RMS • Panasonic EEHZA1K220P • Vishay MAL218297701E3 • UCC HHXB800ARA220MHA0G Choosing capacitors where the rated ripple current is higher than required will improve the components lifetime.
TVS diode (D1)	**V_R 60 VDC, V_C 96.8 VDC** • SMAJ60A

maxon

Recommended components	
Logic supply voltage	
Capacitor (C2)	To avoid voltage overshoot at power plug-in with a separately sourced logic supply, use an electrolytic capacitor covering 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** • SMAJ60A
Motor filter	
Motor choke (L)	**470 nH, rated current $I_{RMS} \geq I_{cont}$ / $I_{sat} \geq I_{peak}$, construction shielded** • Bourns SRP1245A-R47M • Vishay IHLP5050EZERR47M01 • Pulse PA4346.471ANLT
Filter capacitor (C_F)	**220 pF, 100 VDC**
Snubber resistor (R_S)	**47 Ω, 1 %, 0.250 W**
Snubber capacitor (C_S)	**470 pF, 100 VDC**
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
Resistor (R4)	**1 kΩ, 1 %, 0.0625 W**
Resistor (R5)	**10 kΩ, 1 %, 0.0625 W**
Capacitor (C4…C8)	**100 nF, 16 VDC**
RS422 transceiver	
Transceiver (U2)	**Full-duplex line driver and receiver with ESD protection** • Texas Instruments THVD1452DGSR • Texas Instruments SN65HVD76DGSR • Texas Instruments SN65HVD1476DGSR
Resistor (R6, R7)	**150 Ω, 1 %, 0.0625 W**
Resistor (R8)	**4.7 kΩ, 1 %, 0.0625 W**

Recommended components	
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 (R9)	**220 Ω, 1 %, 0.0625 W**
LEDs for device status indication	
Resistor (R10, R11)	**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 4-54 Motherboard design guide – Recommended components

4.3 Design guidelines

The following instructions are intended to serve as an aid when designing an application-specific motherboard and ensures the correct and reliable integration of the Module.

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 Module (equal potential). It is customary to equip the motherboard with a ground plane. All ground connections should be connected to the voltage supply ground via wide conductive tracks.

Pin	Signal	Description
A1…A3	GND	Ground
C3, C16, C40, C45	GND	Ground

Table 4-55 Motherboard design guide – Grounding

If an earth potential is in place or required, the ground plane should be connected to the earth potential via one or more capacitors. The use of ceramic capacitors with 10 nF and min. 100 VDC is recommended.

4.3.2 Layout

Guidelines for the layout of the motherboard:

- Terminal header pins (A4), (A5) and (A6) for nominal power supply voltage V_{CC} should be connected to the fuse via wide conductive tracks.
- Terminal header pins (A1), (A2), (A3), (C3), (C16), (C40) and (C45) for GND (ground) should be connected with 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 40 mm (1'575 mil) and a minimum copper coating thickness of 35 µm are recommended. The track width can be realized by using multilayer designs with distributed tracks.

4.3.3 SMT footprint

The below figure shows the footprints on the motherboard of the recommended terminal headers, see ➔Table 4-54 on page 4-51, which can be downloaded from the manufacturer's webpage. The hole pattern shown corresponds to that of the ESCON2 Module 60/30.

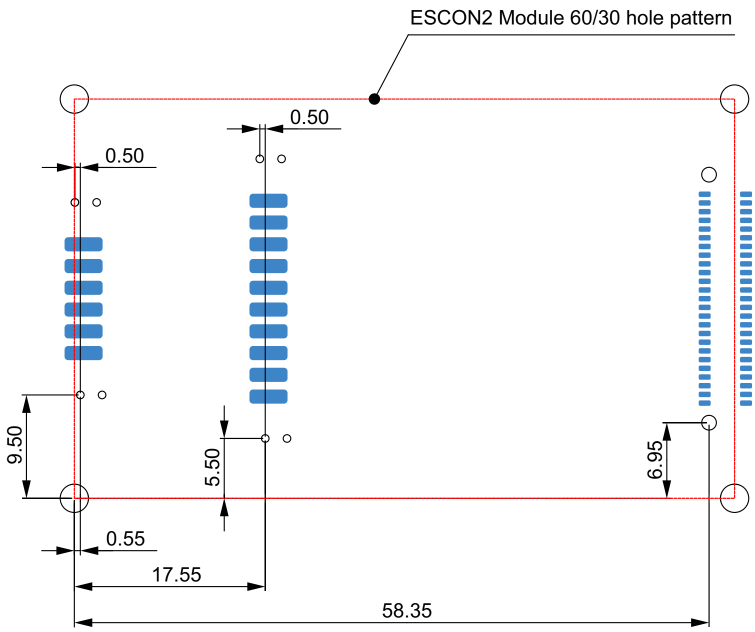

Figure 4-34 SMT footprint [mm] – Top view

5 WIRING

In this section you will find the wiring information for the setup you are using. You can either use the consolidated wiring diagrams (➔Figure 5-36) featuring the full scope of interconnectivity and pin assignment. Or you may wish to use the connection overviews for either DC motor or EC (BLDC) motor that will assist you in determining the wiring for your particular motor type and the appropriate feedback signals.

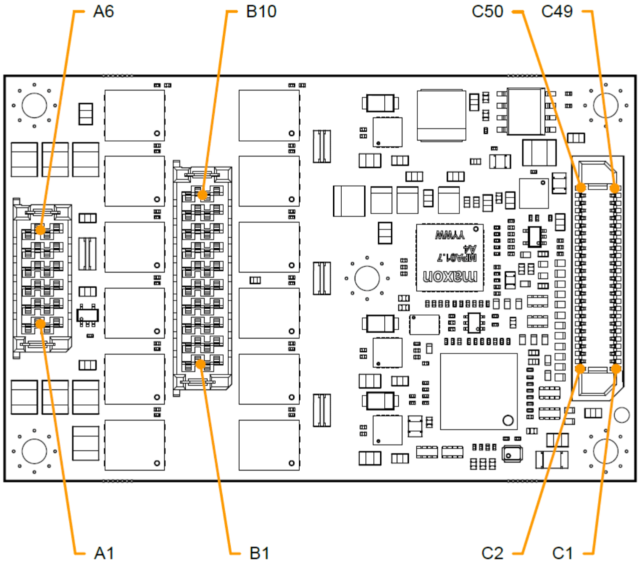

Figure 5-35 Interfaces – Designations

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 on how 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; ➔Chapter “5.1.1 DC motor” on page 5-54 or ➔Chapter “5.1.2 EC (BLDC) motor” on page 5-54.
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 # and go to the respective table; for DC motor see ➔Table 5-56, for EC (BLDC) motor see ➔Table 5-57.
4) Pick the row with the corresponding wiring method # and refer to the listed figure(s) to find the relevant wiring information.

Continued on next page.

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 absolute encoder. . . . . Method # DC3

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

[a] For method # DC1, only the operating mode current control can be used.

Table 5-56 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 absolute encoder . . . . .Method # EC3 [a]

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

Method #	Sensor 1	Sensor 2		➔Figure(s)
	Hall sensors	Digital incremental encoder	SSI / BiSS C 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 5-57 Possible combinations of feedback signals for EC (BLDC) motor

5.2 Main wiring diagram

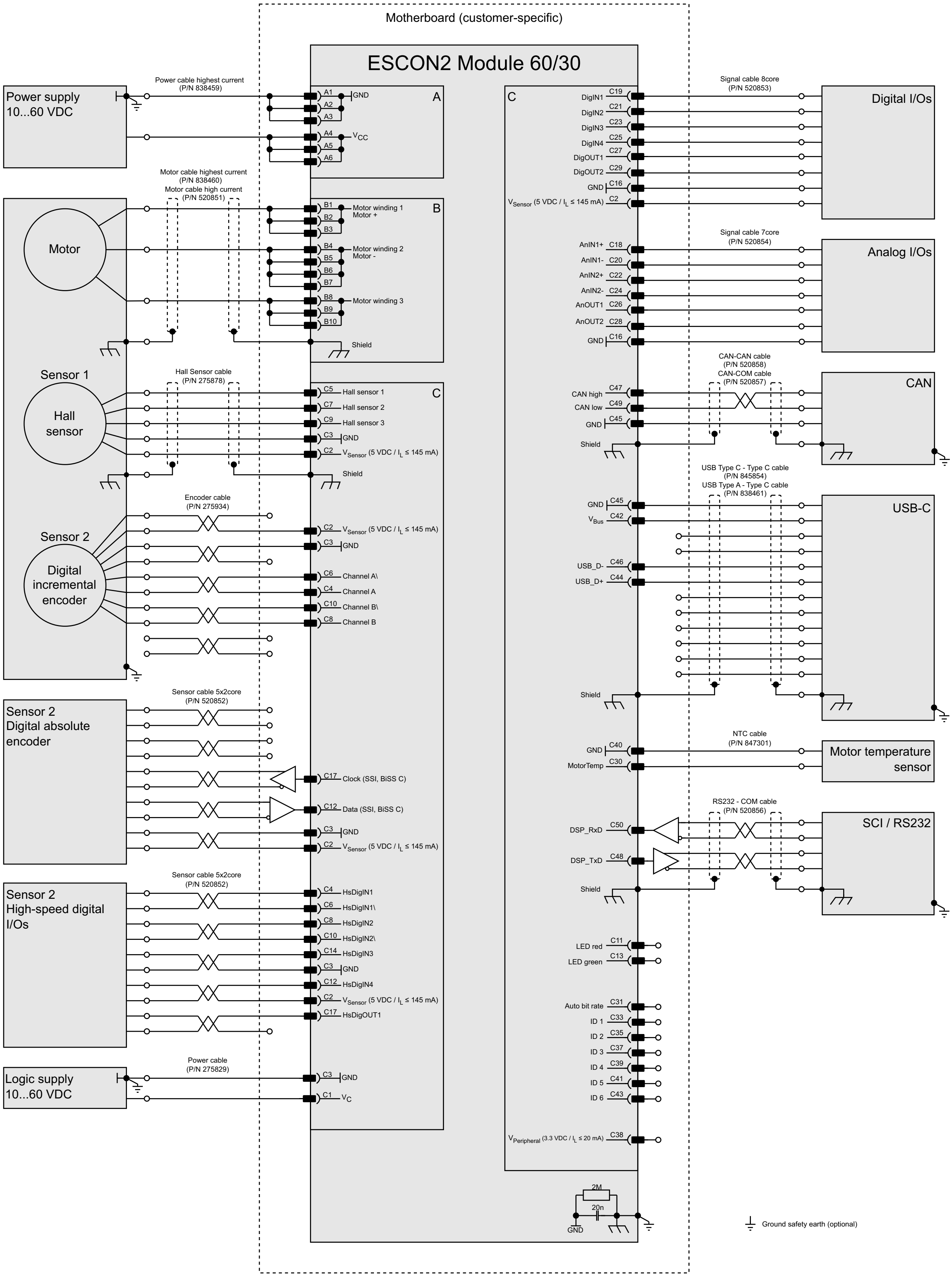

Figure 5-36 Main wiring diagram

5.3 Cabling

Utilize maxon's prefab cable assemblies to streamline your setup process. These cables are ready-to-use parts and 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 a deeper dive into these prefab cables, check out maxon's website using the part number for detailed 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 highest current (for power supply)	838459	Wire end sleeves 4 mm^2	Molex Mini-Fit Sr., 2 poles (428160212)	Molex Mini-Fit Sr., 2 poles (428192214)
Power cable (for separate logic supply)	275829	Wire end sleeves 0.75 mm^2	Molex Mini-Fit Jr., 2 poles (39012020)	Molex Mini-Fit Jr., 2 poles (39281023)
Motor cable highest current (for currents higher than 20 A)	838460	Wire end sleeves 4 mm^2	Molex Mini-Fit Sr., 3 poles (428160312)	Molex Mini-Fit Sr., 3 poles (428193214)
Motor cable high current (for currents up to 20 A)	520851	Wire end sleeves 2.5 mm^2	Molex Mega-Fit, 4 poles (1716920104)	Molex Mega-Fit, 4 poles (1720650204)
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 5-58 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 4-41.

5.4.1 Power supply

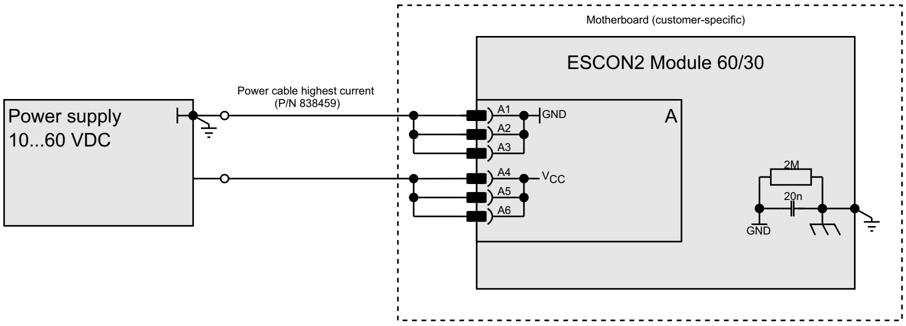

Figure 5-37 Power supply

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

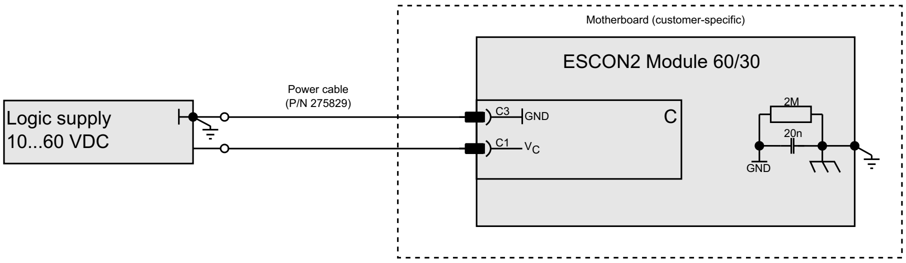

Figure 5-38 Logic supply

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

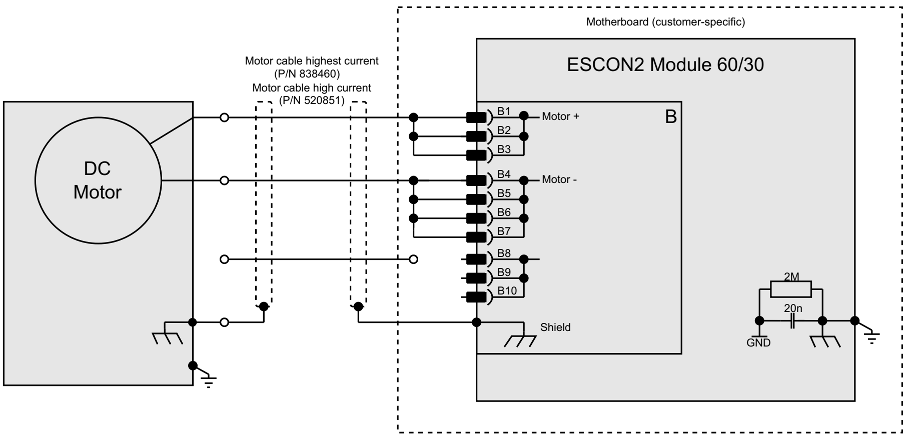

Figure 5-39 DC motor

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

The "Motor cable high current" (P/N 520851) can be used for currents up to 20 A. For higher currents, the "Motor cable highest current" (P/N 838460) must be used.

5.4.4 EC (BLDC) motor

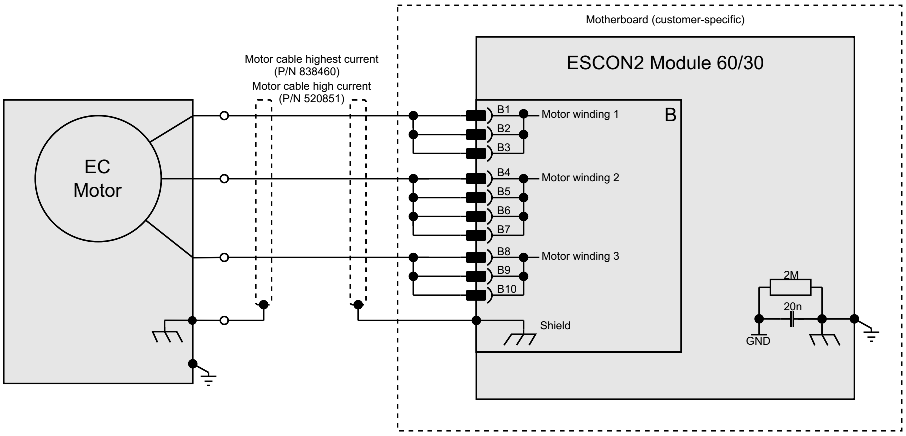

Figure 5-40 EC (BLDC) motor

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

The "Motor cable high current" (P/N 520851) can be used for currents up to 20 A. For higher currents, the "Motor cable highest current" (P/N 838460) must be used.

5.4.5 Sensor 1 Hall sensor

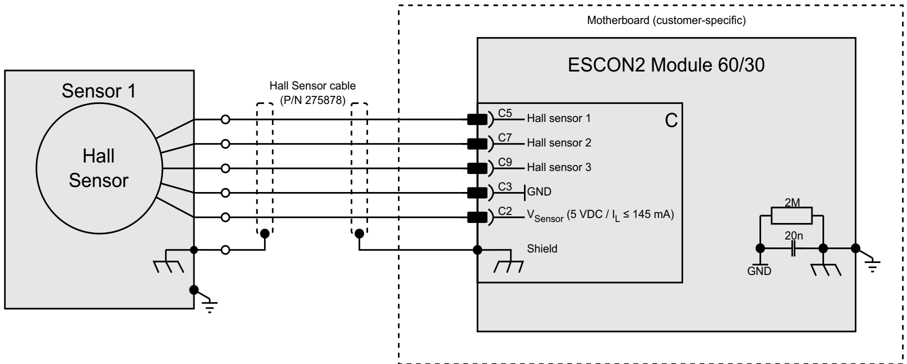

Figure 5-41 Sensor 1 Hall sensor

5.4.6 Sensor 2 Encoder / I/Os

5.4.6.1 Digital incremental encoder

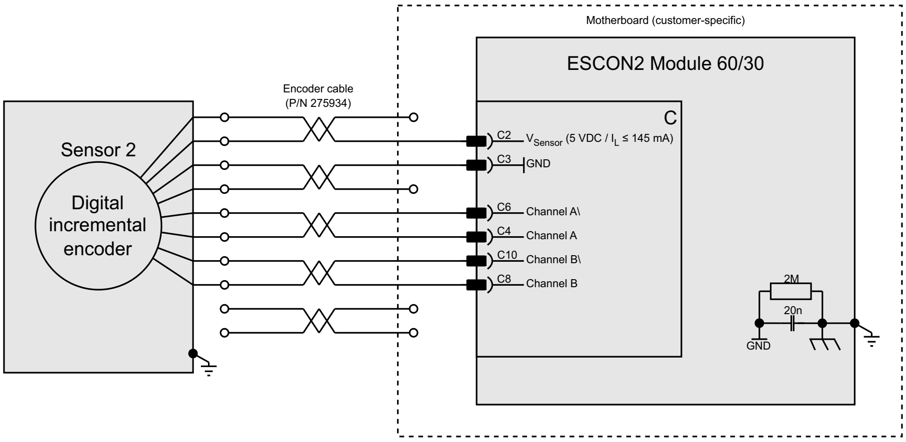

Figure 5-42 Digital incremental encoder

This interface can handle a digital incremental encoder, an SSI / BiSS C digital 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 absolute encoder (future release)

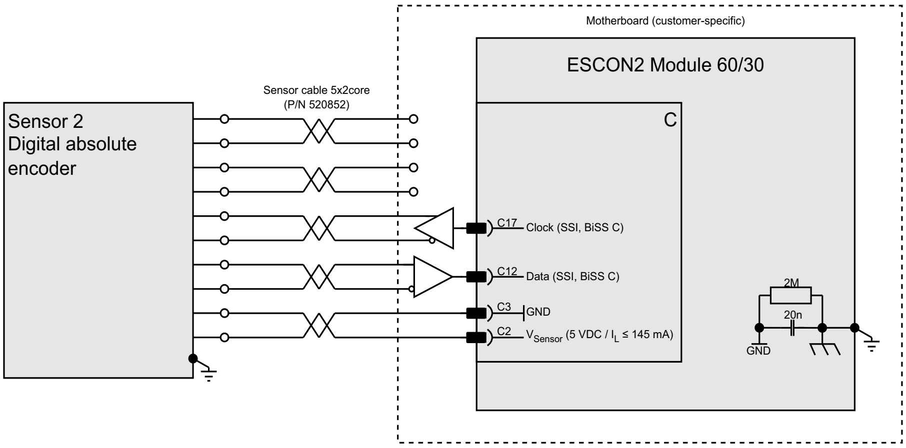

Figure 5-43 SSI / BiSS C absolute encoder

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 absolute encoder or high-speed digital I/O's. Only one out of these three functions can be used at the same time.

5.4.6.3 High-speed digital I/Os

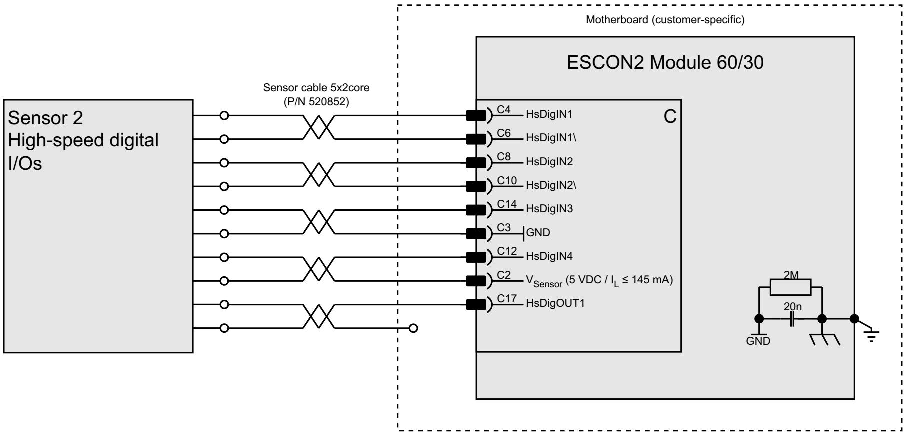

Figure 5-44 High-speed digital I/Os

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 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

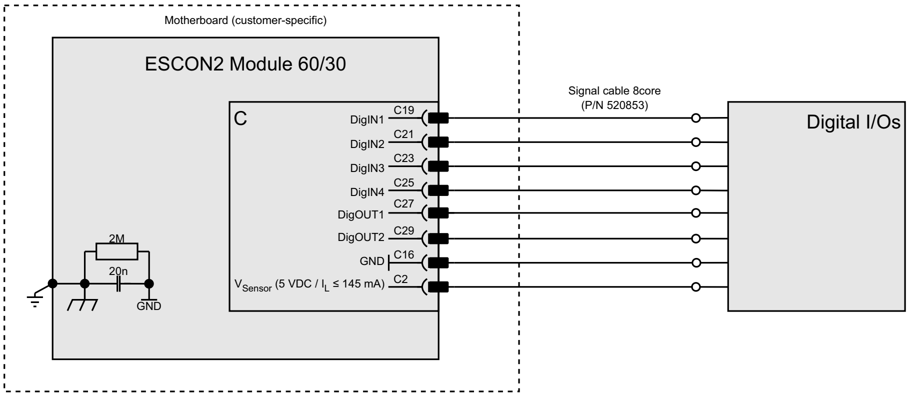

Figure 5-45 Digital I/Os

5.4.8 Analog I/Os

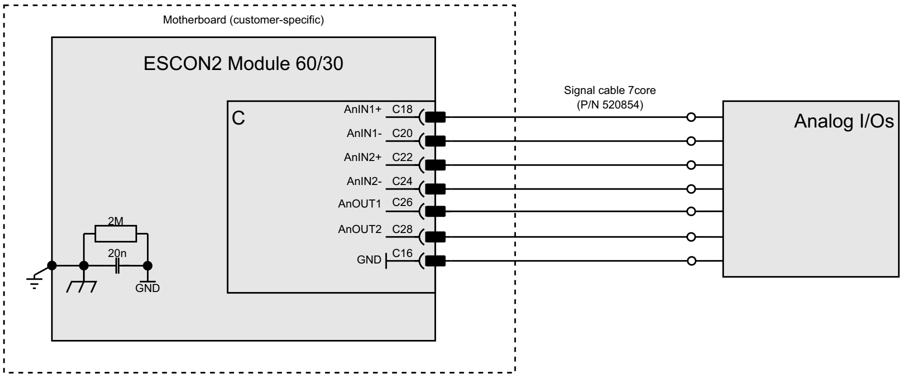

Figure 5-46 Analog I/Os

5.4.9 CAN (future release)

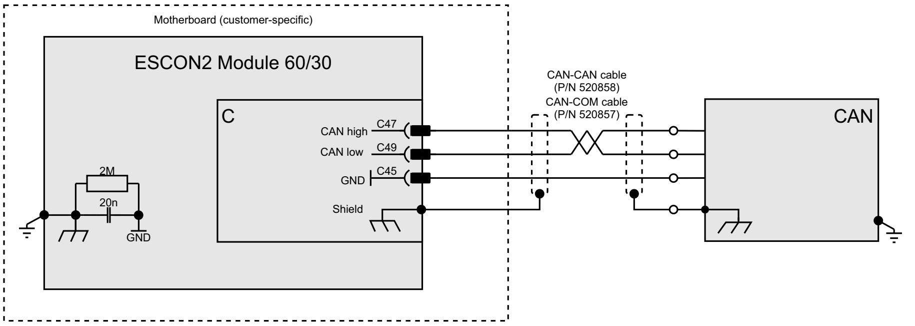

Figure 5-47 CAN

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

5.4.10 SCI / RS232 (future release)

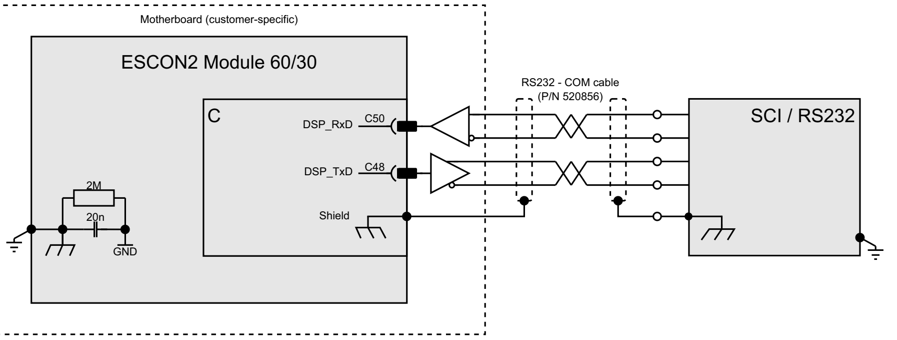

Figure 5-48 SCI / RS232

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.

5.4.11 USB

5.4.11.1 USB-C

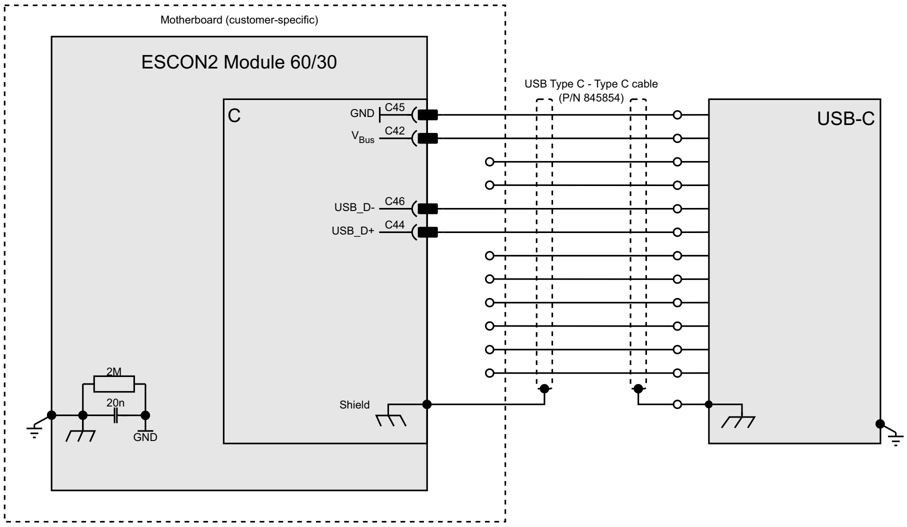

Figure 5-49 USB-C

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

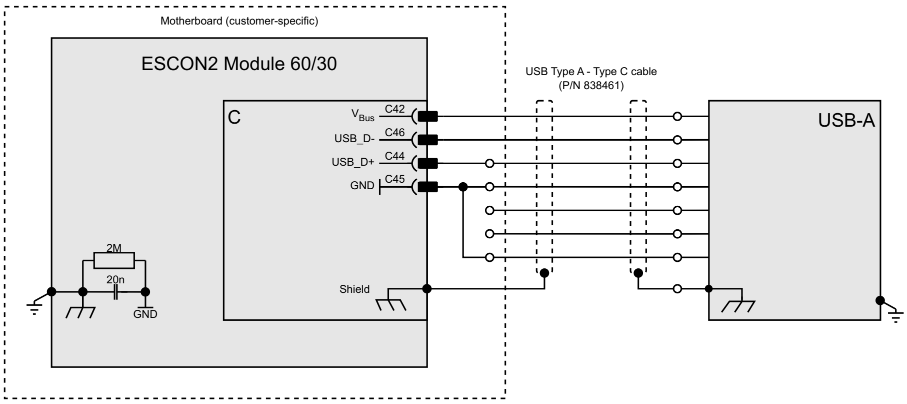

Figure 5-50 USB-A

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)

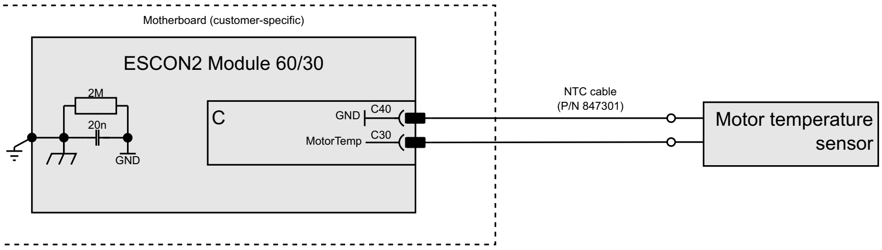

Figure 5-51 Motor temperature sensor

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