CHIEFTEK PRECISION CO., LTD.

TC1-B Series Installation Guide

Ver. 2.0

Table of Contents

1. About this Guide

1.1. Safety Information

Please take the time to read this guide carefully to operate the TC1-B Driver correctly and safely. The information here helps you avoid risk and ensure safety while operating.
Please read this section carefully before installation.

Make sure all parts are grounded properly and ensure the electrical resistance with ground is low. Only qualified personnel can proceed with the installation. Professional knowledge of electronics, installation, testing, and motor operation is required for qualified persons.

There are sensitive electrical parts inside the TC1-B Driver. If the installation fails, or the driver encounters heavy hit or drop, the parts will be damaged. The TC1-B Driver should be kept away from highly-polluted condition or conductive objects. Make sure there is no static electricity and/or objects that might possess static electricity on an installer. To prevent accidents, make sure that all parts are properly tightened and that limit switch as well as safety switch is functional. Keep the pavement clean and the motor operation area empty.

1.1.1. Symbols

CAUTION
ISO 7000-0434 (2004-01)

Protective earth; protective ground
IEC 60417-5019 (2006-08)

WARNING, High voltage
IEC 60417-5036 (2002-10)

CAUTION, This surface can be hot
IEC 60417-5041 (2000-10)

1.1.2. Disclaimer

1. Information furnished by cpc is believed to be accurate and reliable. However, no responsibility is assumed by cpc for its use, nor for any infringements of patents or other rights of third parties which may result from its use. cpc doesn't grant any license under its patent rights, nor the rights of others.

2. In addition, cpc assumes no responsibility for any errors that may appear in this document and for any claims or damages arising from information contained in this document.

3. The product specified in this document has been developed, produced, tested and documented in accordance with the relevant standards. cpc is not responsible for damages, accidents, or injuries caused by any deviation from the configuration and installation described in this guide;

4. Furthermore, cpc is not responsible for the performance of new measurements or ensuring that regulatory requirements are met.

5. The product specified in this document is not assumed to be used in critical application including, but not limited to, medical equipment, transportation, aerospace and nuclear instruments, undersea equipment, power plant equipment, as well as disaster prevention and crime prevention equipment.

6. We reserve the right to modify our products, including its hardware and software design, in order to improve its design and/or performance. The information in this document is subject to change without notice and does not represent a commitment by cpc.

7. Specifications are subject to change without notice.

8. Performance specification beyond those specified by safety regulations are guaranteed by design and not subject to production test.

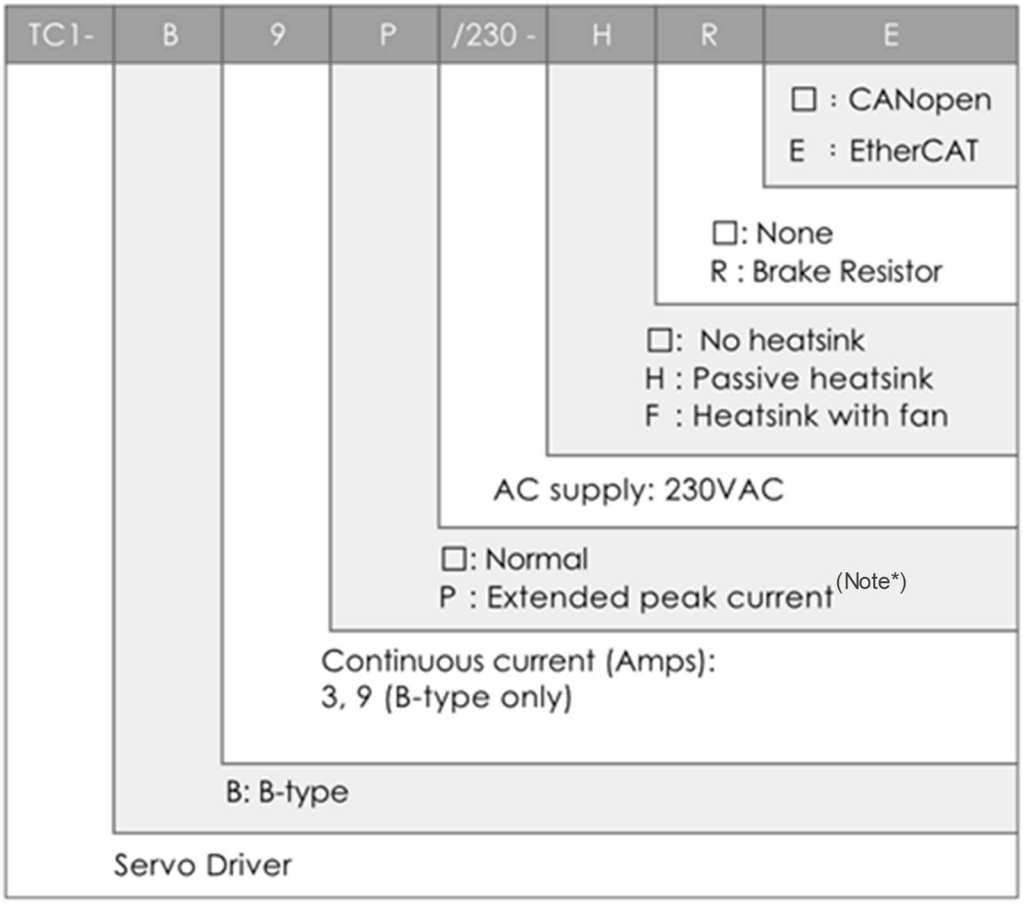
9. Customers should obtain the latest relevant information before placing orders and should verify that such information is current and complete.

10. cpc assumes no liability for applications assistance or customer product design. Customers are responsible for their products and applications using cpc products.

1.2. Revision History

Version	Date	Description	Remarks
1.0	Sep, 2017	Initial release	--
1.1	Oct, 2017	First revision	Amended and revised Ch. 3.3.
2.0	July, 2018	Second revision	1. Changed electrical circuit designs, see Ch. 3.12. 2. Changed pin-definitions of General (3.9), Controller (3.10), and Feedback ports (3.11). 3. Added a new feedback mechanism: Resolver. 4. More detailed circuit diagram of thermistor (2.11). 5. Added the section of Each Part of the Drive (3.1). 6. Added the picture indicating location of nameplate (3.1). 7. Added pin-definition of CANopen port and EtherCAT port (3.8).

1.3. Ordering Information



Note*: Current sensor with a wider input range is used at the cost of additional signal noise and reduced resolution. This arrangement is suitable for applications where the motor mostly operates in short, high current bursts.

1.4. Contact Us

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1.5. How to use this guide

To install and operate the cpc TC1-B drive correctly, you'd need to refer to this manual together with a set of cpc documents. Installation Guide is your first step; please read the safety instructions in the first chapter carefully and then the remaining chapters of installation instructions. See below:

- Chapter 3, Installation, provides step-by-step instructions for mounting, connecting and powering up the TC1-B driver.

- Chapter 4, Technical Specifications, lists all the driver rating and specifications.

Upon completing installation according to the instructions in this guide, your TC1-B driver should be successfully mounted and installed. Next, you'd need to consult the cpc GUI Software User Guide in order to configure and fine-tune the system for optimal performance.

2. Features

2.1. Driver Description

The TC1-Bxx/230 series servo drive is optimized for operating with linear Permanent Magnet Synchronous Motors (PMSM). It can operate in standalone configuration using an internal virtual scripting engine, can support external analog or pulse commands, and can be a part of a fieldbus network such as CAN supporting industry standard CANopen DS402 profile.

2.2. Current Loop

- Fully digital
- 12-bit current loop resolution
- 20 KHz working frequency
- Automatic and manual gain-tuning, to compensate for variations in the servo motors.
- Frequency response and time response testing
- Automatic Phasing

2.3. Auto Phase

- Sensorless
- Digital Hall—up to 20 KHz

2.4. Velocity Loop

- Fully digital
- 10 KHz working frequency
- Automatic and manual gain-tuning, to compensate for variations in the servo motors.
- Frequency response and time response testing
- Gain switch by condition of digital input, demand, feedback, error, and target reach.
- 3 sets of notch or low-pass filter

2.5. Position Loop

- Incremental Encoder—up to 20 Mega counts/s.
- Position Count Range— $-2^{31} \sim 2^{31}$

2.6. Command

- A/B Incremental command—up to 4 Mega Hz
- Pulse-direction command—up to 4 Mega Hz
- Up-down command—up to 2 Mega Hz
- Analog 10 V command to current, velocity or position

2.7. Gain Switch

- 3 sets of gain group
- Switching per digital input, demand, feedback, error, and target reach
- Controllable switching time.

2.8. Homing

- 31 kinds of standard method in CiA402.
- 5 kinds of special method for Homing with mechanical hard stop.

2.9. Filter

- Current Filter
- Velocity Filter
- Auxiliary Command Filter

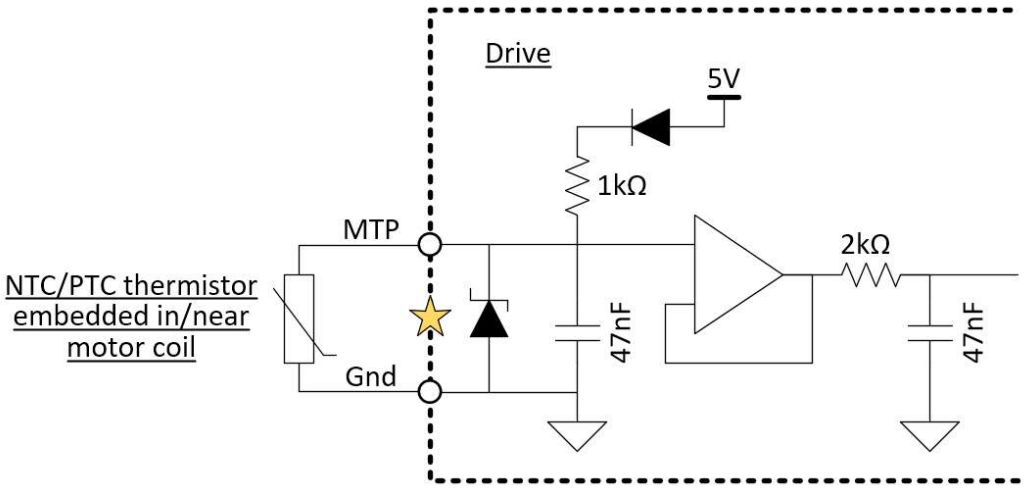
2.10. Script

- Point to point instruction up to 128 steps.
- 16k bytes script FLASH memory.
- User friendly interface
- Modular instructions

2.11. Motor Temperature Detecting

1. In order to detect the motor temperature *more accurately, the TC1-B series has included a 0~5V analog input to connect with the thermistor on the motor so as to know the **voltage** on the drive input. The UI will show users this monitored voltage. As thermistors vary, users will need to calculate the resistance (ohm) according to the voltage and then derive the corresponding temperature. Please see the circuit diagram and calculation formula below. (*: The TC1 series shows only temperature High/Low".)

<Equivalent Circuit Diagram>

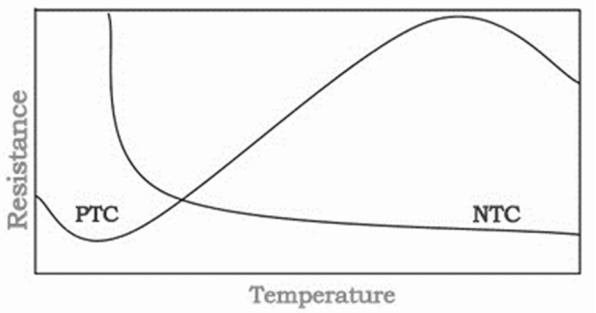


The formula to acquire the resistance (ohm) of place☆:
(The voltage of place☆ is known, monitored by the UI.)

$$V = \frac{5R}{R+1000} \quad , \quad R = \frac{1000V}{5-V}$$

2. You can choose preferred temperature curve in the UI software

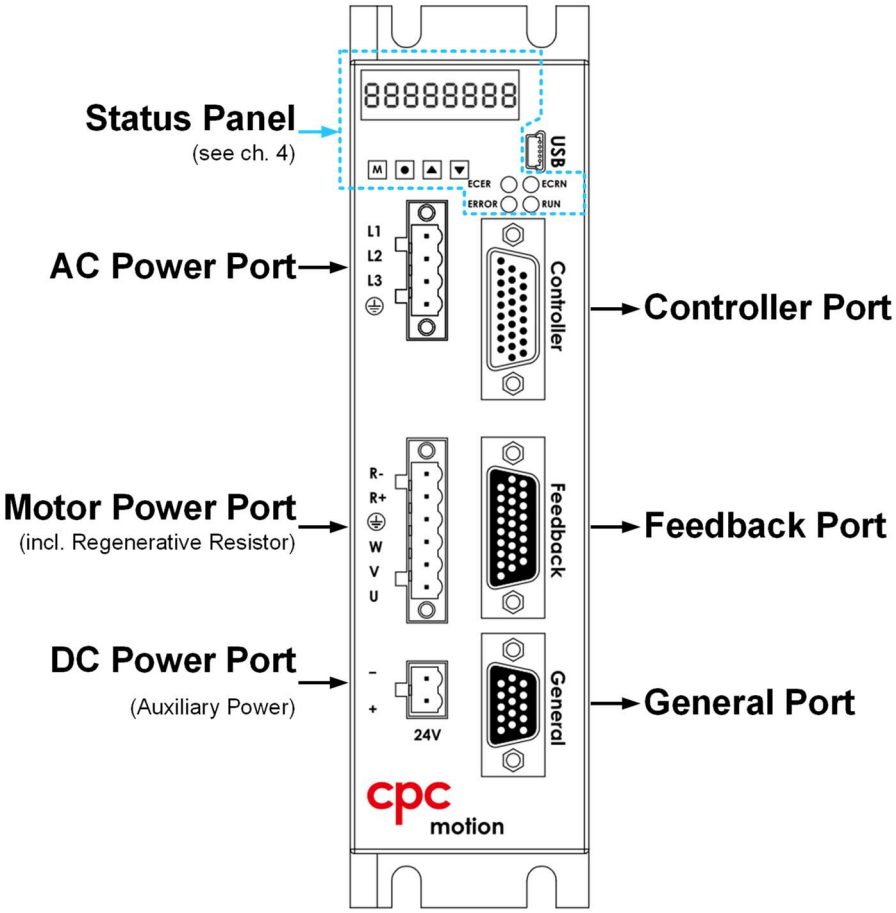
<Thermistor Diagram of Temperature & Resistance>



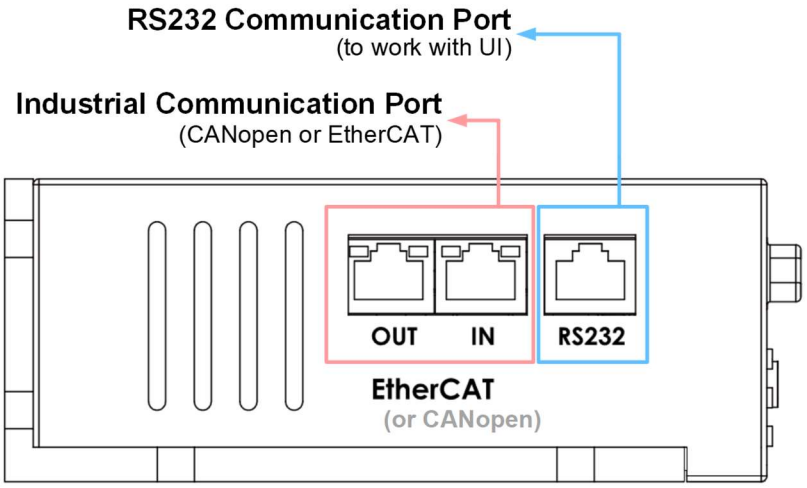
3. Installation

3.1. Each Part of the Drive

Front side



Lateral side

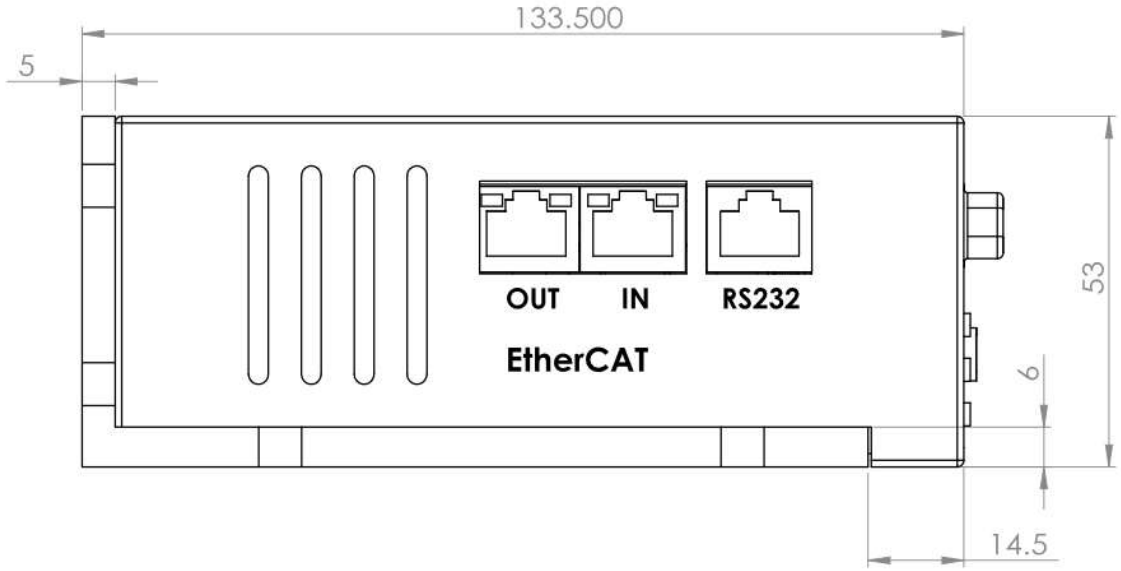


The location of nameplate sticker is as the picture below. You can check the Model description shown on sticker.

3.2. Dimension

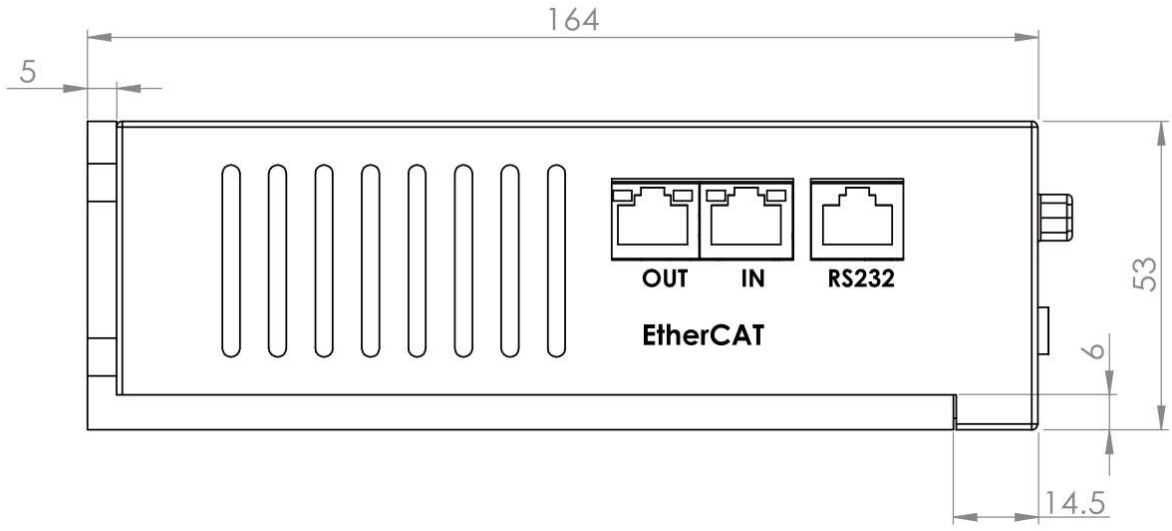
All dimension units in this manual are in mm. mm

3.2.1. 3A-type TC1-B Driver.



Unit: mm

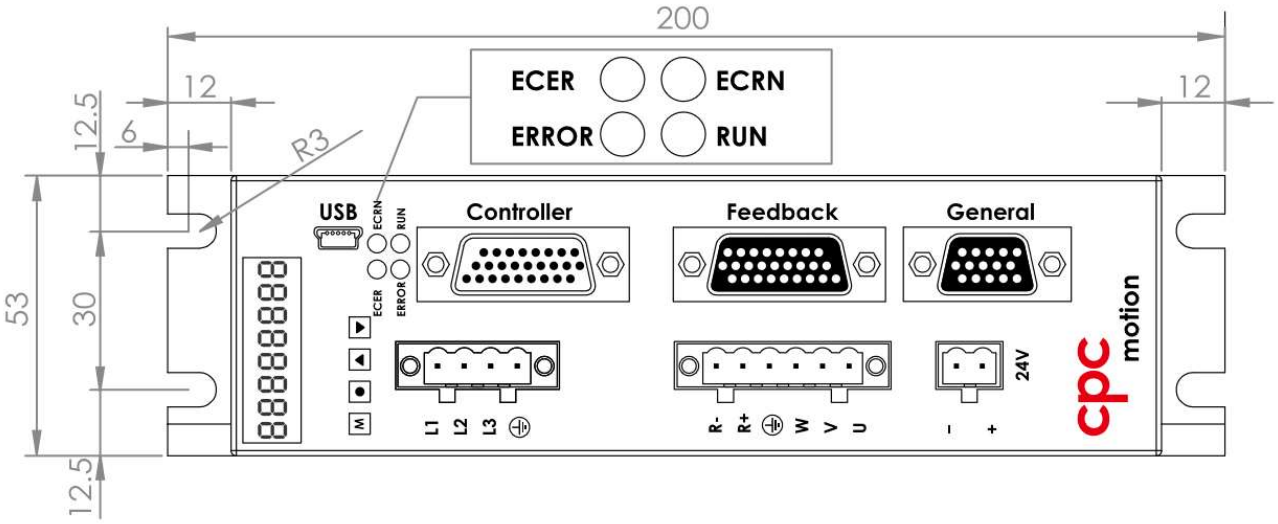
3.2.2. 9A-type TC1-B Driver.

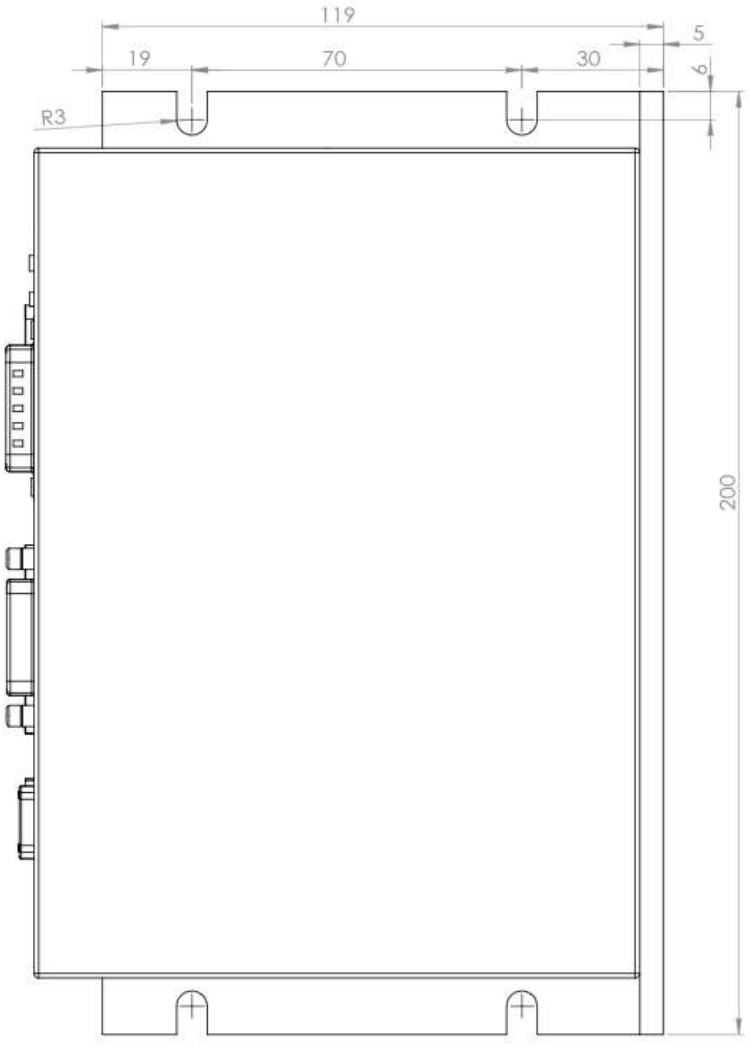


Unit: mm

3.3. Mounting

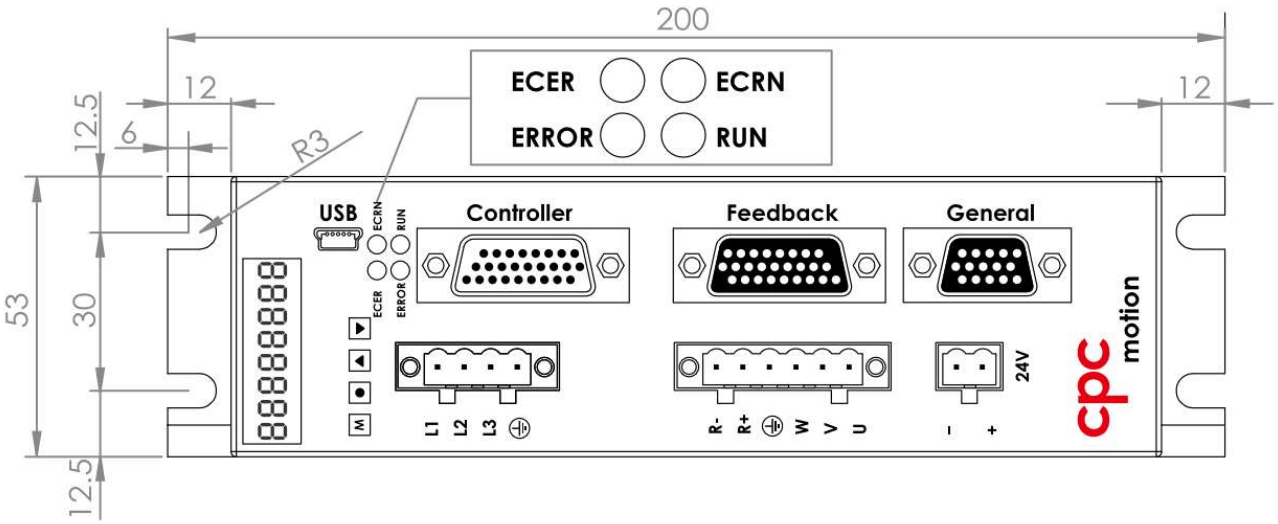
3.3.1. 3A-type TC1-B Driver



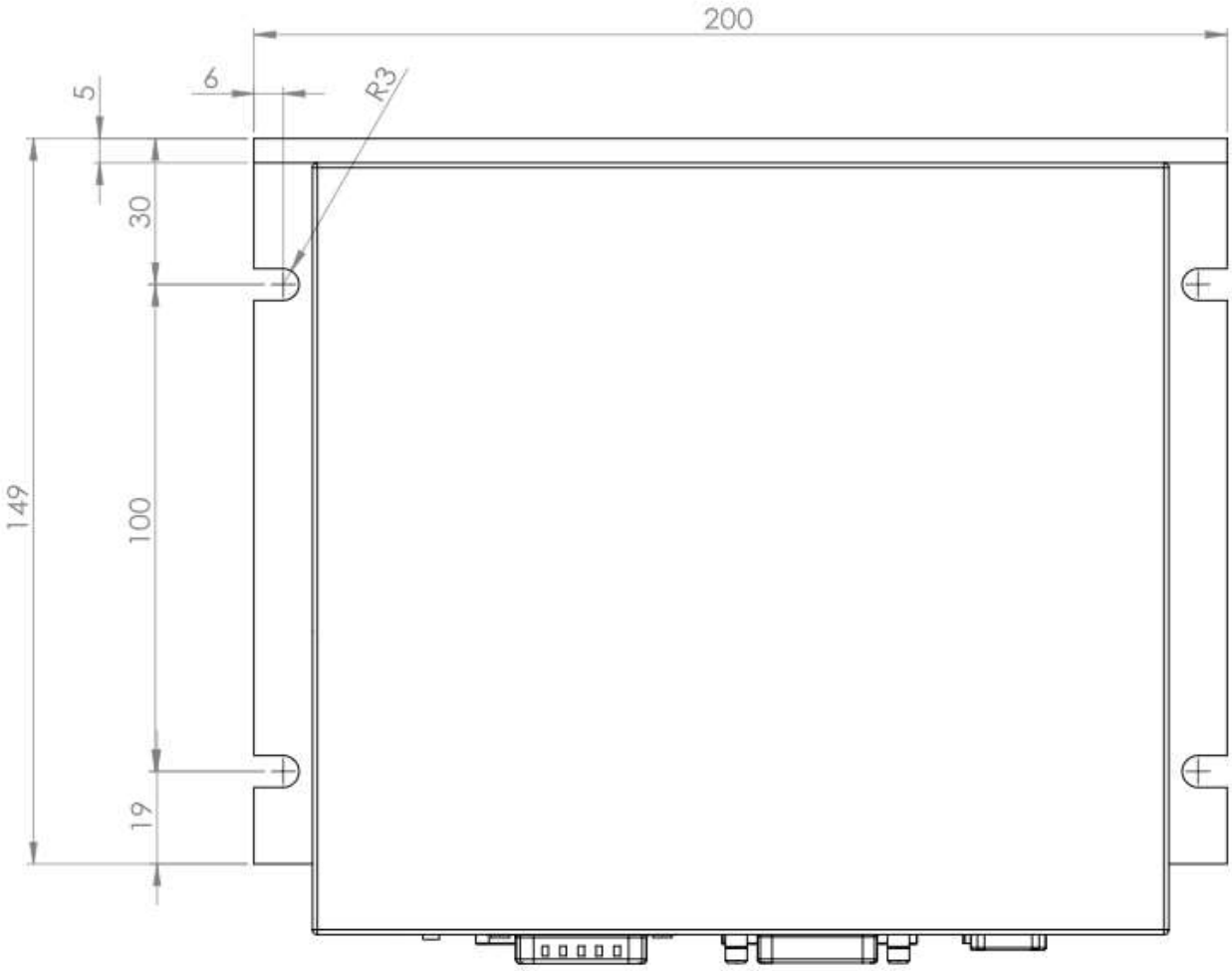


Unit: mm

3.3.2. 9A-type TC1-B Driver



The dimensions of this side are the same for both 3A-type and 9A-type TC1-B Driver.



Unit: mm

3.4. Mechanical and Electrical Specifications

Specification			TC1-B Series		
Model No.			**TC1-B3/230**	**TC1-B9/230**	**TC1-B9P/230**
Input Power	Voltage and Phase		100 to 230 VAC 1 Ø	100 to 230 VAC 1 Ø or 3 Ø	
	DC Bus Peak Voltage [VDC]		390		
	Frequency [Hz]		50 to 60		
	Power Rating [W]		1125	3375	
Control Logic Power	Voltage Range [VDC]		24		
	Current [A]		> 0.5		
Output Power	Continuous Current [A]		**3** (2.12 RMS)	**9** (6.36 RMS) *Note 2	**9** (6.36 RMS) *Note 2
	Peak Current [A]		**9** (6.36 RMS)	**20** (14.14 RMS)	**30** (21.22 RMS) *Note 1
	Peak Current Time		2.5 seconds		
	Peak Power Output [kW]		1.3	4.4	6.6
	5 V Supply Current Output		0.5		
Encoder Input	Digital	Type	A/B Incremental (RS-422 signaling)		
		Work Frequency	Max. 20 Mega counts/s		
		Count Rage	Max. 2^{31} counts		
	Analog (sin/cos)	Amplitude	1 V_{P-P}		
		Work Frequency	Max. 100 kHz, 4096 Cnt/Period Interpolation		
	Absolute	Type	BiSS-C, Tamagawa, EnDat 2.2, SSI		
Encoder Output	Signal Type		RS-422		
	Work Frequency		Max. 20 Mega counts/s		
Feedback Position Error Mapping			Yes		
Regenerative Resistor	Active Voltage [VDC]		Default: 360		
	Stop Voltage [VDC]		Default: 350		
	Resistance [Ohm]		60 (optional)		
	Continuous dissipation [Watt]		100 (optional)		
	DC Bus Capacitance [uF]		540	1350	1350
	Pulse Braking Energy [Joule]		5000 (optional)		

Specification			TC1-B Series		
Model No.			**TC1-B3/230**	**TC1-B9/230**	**TC1-B9P/230**
	Braking Resistor Switch Cont. Current [A]		10	20	
Control Loop	Position Control	Loop Frequency	5 KHz		
		Trajectory Generator	Trapezoidal with S-curve filter		
		Counter Range	2,147,483,648 to 2,147,483,647 counts/second		
	Velocity Control	Loop Frequency	10 KHz		
		Output Filter	x3 (Low-pass or Notch)		
		Counter Range	2,147,483,648 to 2,147,483,647 counts/second		
	Current Control	Loop Frequency	20 KHz		
		Modulation	SVPWM		
Auxiliary Command Input	Position Mode	A/B Incremental	Max. 4 Mega counts/s		
		Pulse/Direction	Max. 4 Mega counts/s		
		CW/CCW	Max. 2 Mega counts/s		
		Analog Voltage	10 V		
	Velocity Mode	Analog Voltage	10 V		
	Current Mode	Analog Voltage	10 V		
DS 402 Operation Modes		**DS402**	PP, PV, PT, HM, CST, CSV, CSP		
Serial Bus			RS232		
Pulse Command Frequency	RS422		Max. 10 MHz		
	5V Single-end		Max. 1 MHz		
	24V Single-end		Max. 50 KHz		
Total Digital Inputs			x12 (5~24 V)		
Total Digital Outputs (open-collector)			x3 (24 V, 400 mA); x3 (24 V, 200 mA)		
High Speed Position Compare Output			x1 (RS422)		
Analog Input	Input Type		x1 (10 V single-end), x1 (10 V differential)		
	ADC Resolution		12 bit		

Specification		TC1-B Series		
Model No.		**TC1-B3/230**	**TC1-B9/230**	**TC1-B9P/230**
Autotuner		Current/Velocity/Position loop gain, motor phasing setup, sin/cos encoder calibration.		
Gain Switch Function		Yes		
Control Panel		x1 (8-digit LCD), x4 (push buttons)		
Software Protection		Dynamic brake, motor over-current, over/under-position, over-velocity. Virtual/physical position limit switch, missing hall signal, external fault trigger, following error.		
Hardware Protection		Drive over-temperature (analog), 5V output short circuit, motor over-temperature (analog).		
Dimensions (LxHxW)	[mm]	200 x 134 x 53	200 x 164 x 53	
Weight	[Kg]	1.2	1.6 (without optional heatsink)	
Application Environment	Operate Temperature	0˚C ~ 40˚C		
	Storage Temperature	-20˚C ~ 85˚C		
	Humidity	0~95%		
	Altitude	0~2000 m		
	Vibration	1 G		
	Protection Class	IP20		
Motor selection	1. Linear AC servo motor or Rotary AC servo motor.			
	2. Protective class I & Comply with IEC60034-1.			
	3. Refer output power mentioned above for your selection of servo drive.			
Note	Note 1: Current sensor with a wider input range is used at the cost of additional signal noise and reduced resolution. This arrangement is suitable for applications where the motor mostly operates in short, high current bursts.			
	Note 2: Additional heatsink required to ensure continuous operation at rated output.			

3.5. Recommended Selection of Wire Rod

Wiring of	Connection	Wire Diameter mm (AWG)
AC Input	L1, L2, L3	0.5 to 2 mm^2, 20 to 14 AWG
Auxiliary Power	24V+, 24V-	0.12 to 0.2 mm^2, 26 to 24 AWG
Motor	U, V, W	0.5 to 2 mm^2, 20 to 14 AWG
Protective Earth	PE	
Regenerative Resistor	R+, R-	0.5 to 2 mm^2, 20 to 14 AWG

This product can cause a.c. current in the protective earthing conductor. Where a residual current-operated protective (RCD) or monitoring (RCM) device is issued for protection in case of direct or indirect contact, only an RCD or RCM of Type B is allowed on the supply side of this product.

◆ **Recommended method of connection:**

(a) A fixed connection **and** :

- a cross-section of the protective earthing conductor of at least 10 mm^2 Cu or 16 mm^2 Al, or
- automatic disconnection of the supply in case of discontinuity of the protective earthing conductor; or
- provision of an additional terminal for a second protective earthing conductor of the same cross-sectional area as the original protective earthing conductor,

OR

(b) connection with an industrial connector according to IEC 60309 and a minimum protective earthing. Adequate strain relief shall be provided.

◆ **Marking for whole power drive system**

DANGER: Where an isolating device is not intended to interrupt load current, a warning shall state: DO NOT OPEN UNDER LOAD.

The following requirements apply to any supply isolating device which does not disconnect all sources of power to the PDS (power drive system)

(supply isolating device)

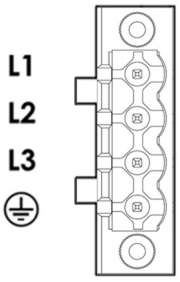
- If the isolating device is mounted in an equipment enclosure with the operating handle externally operable, a warning label shall be provided adjacent to the operating handle stating that it does not disconnect all power to the servo drive.
- Where a control circuit disconnector can be confused with power circuit disconnectors due to size or location, a warning label shall be provided adjacent to the operating handle of the control circuit disconnector stating that it does not disconnect all power to the servo drive.

3.6. Wiring of Driver Power

Ports on Driver:		**3A-type TC1-B Driver**	**9A-type TC1-B Driver**
Power Port(s)	AC power	4-pin with 5.0 mm pitch **DECA, ME060-50004**; its matching connector: DECA, MC101-50004.	
	24V DC power	2-pin with 5.0 mm pitch **DECA, ME300-50002**; its matching connector: DECA, MC100-50002.	
Motor Power Port		6-pin with 5.0 mm pitch **DECA, ME060-50006;** its matching connector: DECA, MC101-50006.	

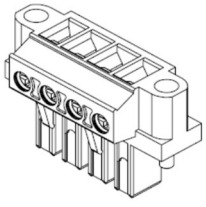
3.6.1. AC Power Wiring

- Driver side connector: DECA ME060-50004



For single phase model such as TC1-B3/230, L3 is internally unconnected. Connect Live and Neutral to **L** and **N** respectively.

- Matching connector: DECA MA101-50004

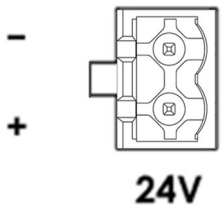


Vendor	Model number
DECA	MC101-50004

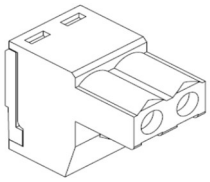
If screw flange is not needed, most 5.0 mm pitch Eurostyle plugs should match.

3.6.2. 24V DC Power Wiring

- Driver side connector: DECA ME030-50002



- Matching connector: DECA MA101-50004

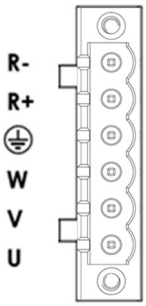


Vendor	Model number
DECA	MC100-50002

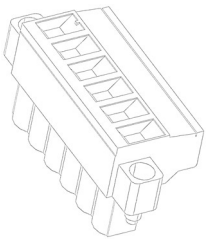
Most 5.0mm pitch Eurostyle plugs should match.

3.7. Wiring of Motor Power

- Driver side connector: DECA ME060-50006



- Matching connector:

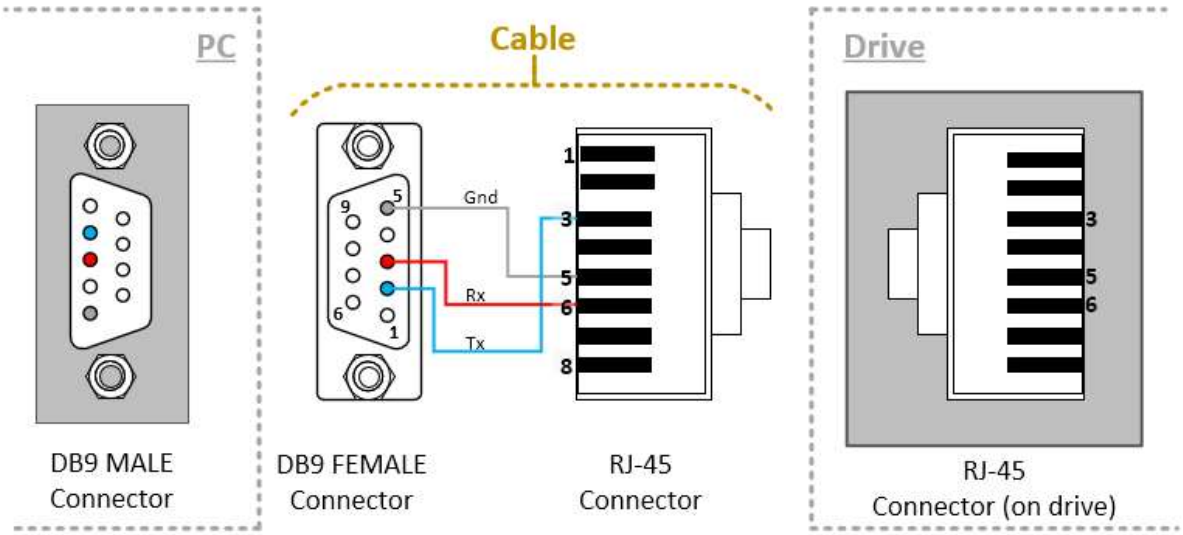


Vendor	Model number
DECA	MC101-50006

If screw flange is not needed, most 5.0 mm pitch Eurostyle plugs should match.

3.8. Communication Port Wiring

3.8.1. RS232 Cable



DB9 female connector of the communication cable (DB9)

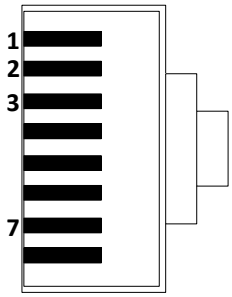
Pin#	Signal	Function
1	N/C	--
2	Tx	RS-232 transmit RS-232
3	Rx	RS-232 receive RS-232
4	N/C	--
5	GND	Ground
7, 8,9	N/C	--

RJ-45 connector of the communication cable (RJ-45)

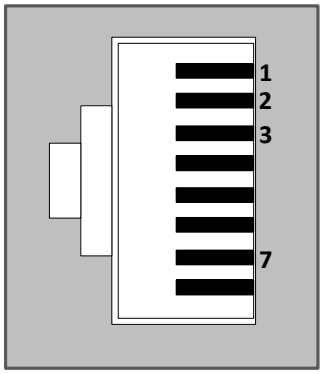
Pin#	Signal	Function
1, 2	N/C	--
3	Tx	RS-232 transmitRS-232
4	N/C	--
5	Gnd	Ground
6	Rx	RS-232 receiveRS-232
7, 8	N/C	--

3.8.2. CANopen

Using RJ-45 connectors on both sides of cable.



RJ-45
(Cable)



RJ-45
(Port on driver)

CANopen IN	
1	CANH
2	CANL
3	GND
4	--
5	--
6	--
7	GND
8	--

CANopen OUT	
1	CANH
2	CANL
3	GND
4	--
5	--
6	--
7	GND
8	--

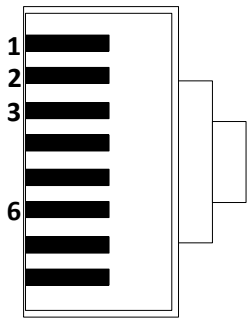
3.8.3. USB Cable

Mini USB

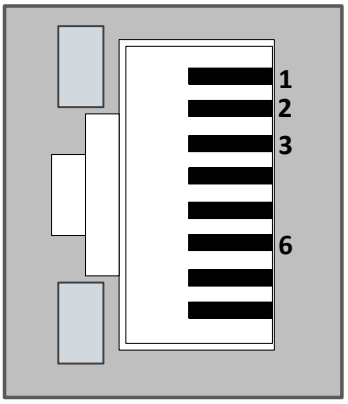
Mini USB Pin#	Signal	Function
1	VBUS	Power
2	D-	Data-
3	D+	Data+
4	--	--
5	GND	

3.8.4. EtherCAT OUT/IN (Optional)

Using RJ-45 connectors on both sides of cable. RJ45



RJ-45
(Cable)

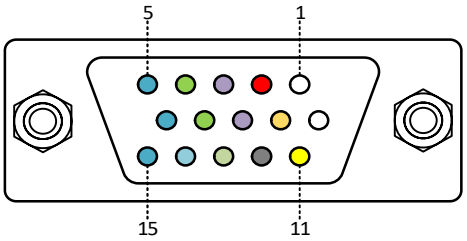


RJ-45
(Port on driver)

EtherCAT IN	
1	TX+
2	TX-
3	RX+
4	--
5	--
6	RX-
7	--
8	--

EtherCAT OUT	
1	TX+
2	TX-
3	RX+
4	--
5	--
6	RX-
7	--
8	--

3.9. General Port Wiring

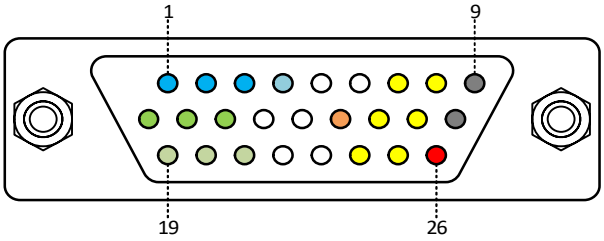


DB15 FEMALE connector of the Driver

Pin#	Signal	Function
1	AI-0-	Analog Input 0 LOW Input 0
2	5V	5V supply output
3	TrigOut+	Position trigger HIGH output
4	DO-A1	General purpose digital output
5	DI-A0	General purpose digital input
6	AI-0+	Analog Input 0 HIGH Input
7	AGnd	Analog ground
8	TrigOut-	Position trigger LOW output
9	DO-A0	General purpose digital output
10	DI-A1	General purpose digital input
11	AI-1	10V Analog input 1
12	Gnd	Ground
13	DO-ACOM	Digital output common
14	DI-ACOM	Digital input common
15	DI-A2	General purpose digital input

3.10. Controller Port Wiring

The pin-definitions of controller port vary according to the mode in use. The modes are: A/B mode, Step/Dir mode, and CW/CCW mode.



DB25 MALE connector of the driver DB25

(See next page)

Pin#	Signal	Function		
		A/B/Z Mode	Step/Dir Mode	CW/CCW Mode
1	DI-C0	General purpose digital input		
2	DI-C1	General purpose digital input		
3	DI-C2	General purpose digital input		
4	DI-CCOM	Digital input common		
5	RZ+	----		
6	RZ-	----		
7	OZ+	Buffered RZ/EZ signal HIGH output		
8	OZ-	Buffered RZ/EZ signal LOW output		
9	Gnd	Ground		
10	DO-C0+	General purpose digital output (collector)		
11	DO-C1+	General purpose digital output (collector)		
12	DO-C2+	General purpose digital output (collector)		
13	RA+	Reference A HIGH input	**STEP+** STEP HIGH input	**CCW+** CCW HIGH input
14	RA-	Reference A LOW input	**STEP-** STEP LOW input	**CCW-** CCW LOW input
15	RCOM24V	Reference input 24V Common		
16	OB+	Buffered RB/EB signal HIGH output		
17	OB-	Buffered RB/EB signal LOW output		
18	Gnd	Ground		
19	DO-C0-	General purpose digital output (emitter)		
20	DO-C1-	General purpose digital output (emitter)		
21	DO-C2-	General purpose digital output (emitter)		
22	RB+	Reference B HIGH input	**DIR+** DIR HIGH input	**CW+** CW HIGH input
23	RB-	Reference B LOW input	**DIR-** DIR LOW input	**CW-** CW LOW input
24	OA+	Buffered RA/EA signal HIGH output		
25	OA-	Buffered RA/EA signal LOW output		
26	5V	5V supply output		

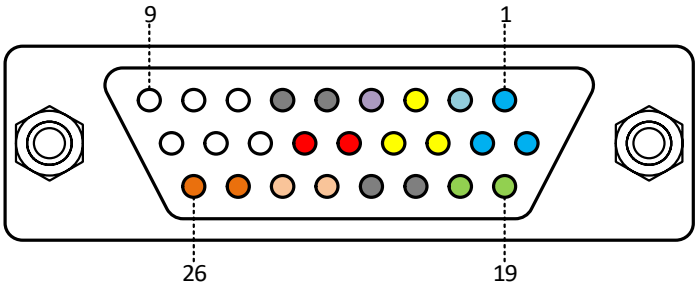
3.11. Feedback Port Wiring

The feedback cable is used to transfer data from the encoder to the driver.

The TC1-B series can accept the following types of feedback mechanism:

- A/B/Z-type encoder
- Analog sin/cos encoder
- Absolute encoder (EnDat encoder, BiSS-C encoder, Tamagawa, and Nikon encoder.)
- Resolver

Pin-definitions vary when wiring with different types of feedback device; see further information in subsequent chapters.



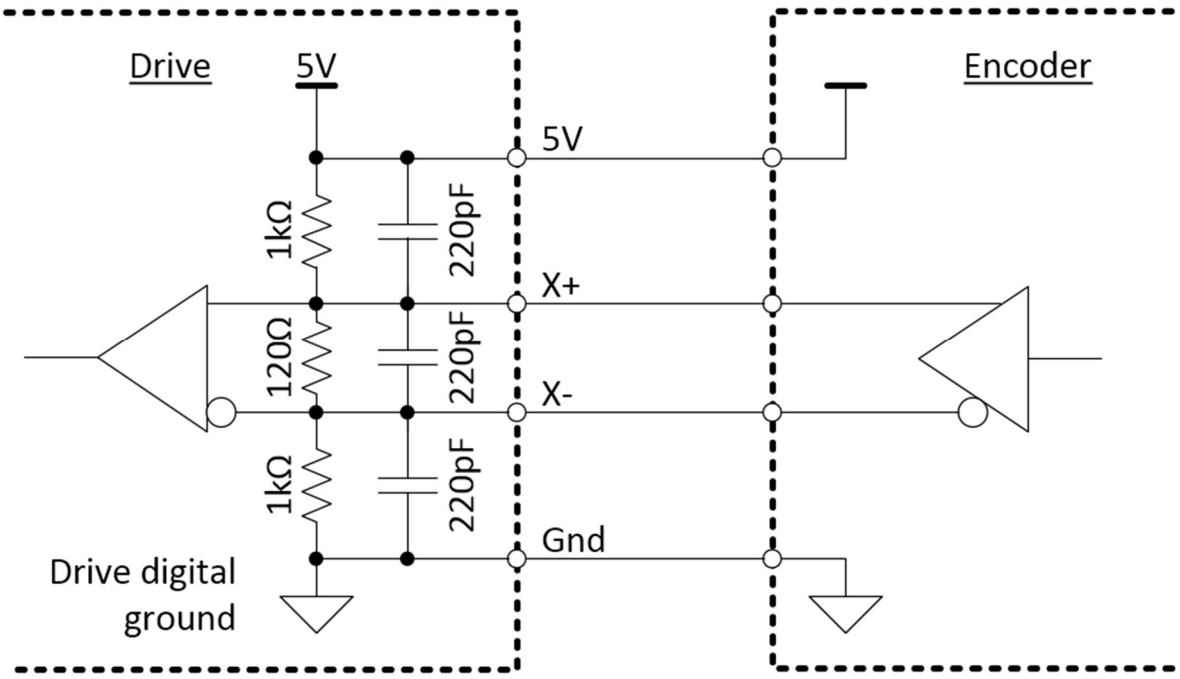
DB26 FEMALE connector of the drive.

<table>
<tr><th rowspan="2">Pin#</th><th rowspan="2">Signal</th><th colspan="5">Function</th></tr>
<tr><th>A/B/Z-type Encoder</th><th>Sin/cos Encoder</th><th>EnDat or BiSS-C Encoder</th><th>Resolver</th><th>Tamagawa / Nikon Encoder</th></tr>
<tr><td>1</td><td>DI-B4</td><td colspan="5">General purpose digital input</td></tr>
<tr><td>2</td><td>DI-BCOM</td><td colspan="5">Digital input common</td></tr>
<tr><td>3</td><td>DI-B1</td><td colspan="5">General purpose digital input (Hall B) (non-isolated)</td></tr>
<tr><td>4</td><td>MTP</td><td colspan="5">5V Analog input (MTP: Motor Temp. Protection)</td></tr>
<tr><td>5, 6</td><td>Gnd</td><td colspan="5">Ground</td></tr>
<tr><td>7</td><td>EZ+</td><td>Encoder Z+</td><td>Encoder Z+</td><td rowspan="3">No connect</td><td>No connect</td><td rowspan="3">No connect</td></tr>
<tr><td>8</td><td>EB+</td><td>Encoder B+</td><td>SIN+</td><td>S2</td></tr>
<tr><td>9</td><td>EA+</td><td>Encoder A+</td><td>COS+</td><td>S1</td></tr>
<tr><td>10</td><td>DI-B5</td><td colspan="5">General purpose digital input</td></tr>
<tr><td>11</td><td>DI-B3</td><td colspan="5">General purpose digital input</td></tr>
<tr><td>12</td><td>DI-B2</td><td colspan="5">General purpose digital input (Hall C) (non-isolated)</td></tr>
<tr><td>13</td><td>DI-B0</td><td colspan="5">General purpose digital input (Hall A) (non-isolated)</td></tr>
<tr><td>14, 15</td><td>5V</td><td colspan="5">5V supply output</td></tr>
<tr><td>16</td><td>EZ-</td><td>Encoder Z-</td><td>Encoder Z-</td><td rowspan="3">No connect</td><td>No connect</td><td rowspan="3">No connect</td></tr>
<tr><td>17</td><td>EB-</td><td>Encoder B-</td><td>SIN-</td><td>S4</td></tr>
<tr><td>18</td><td>EA-</td><td>Encoder A-</td><td>COS-</td><td>S3</td></tr>
<tr><td>19</td><td>DO-B0+</td><td colspan="5">General purpose digital output (collector)</td></tr>
<tr><td>20</td><td>DO-B0-</td><td colspan="5">General purpose digital output (emitter)</td></tr>
<tr><td>21, 22</td><td>Gnd</td><td colspan="5">Ground</td></tr>
<tr><td>23</td><td>DAT+</td><td rowspan="4">No connect</td><td rowspan="4">No connect</td><td>Data+</td><td rowspan="2">No connect</td><td>SD+ (Serial Data HIGH)</td></tr>
<tr><td>24</td><td>DAT-</td><td>Data-</td><td>SD- (Serial Data LOW)</td></tr>
<tr><td>25</td><td>CLK-</td><td>Clock-</td><td>R2</td><td rowspan="2">No connect</td></tr>
<tr><td>26</td><td>CLK+</td><td>Clock+</td><td>R1</td></tr>
</table>

DI-B0~B2 can be used as motor hall sensor input when hall source is set to **Feedback Port**.

3.12. I/O Pin Electrical Characteristics

3.12.1. Differential Input Equivalent Circuit of Feedback Port (A/B/Z Mode)



X: (X+, X-)
X = EZ, EB, EA

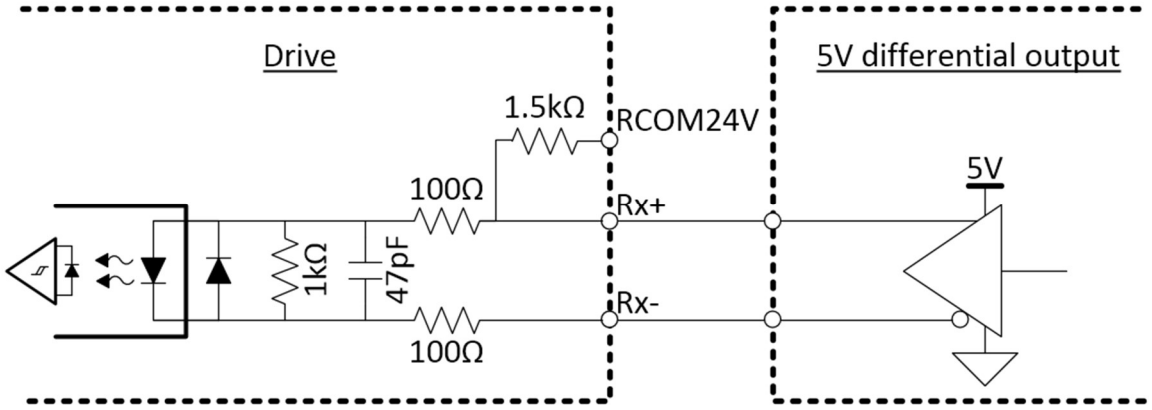
EA: (9, 18)
EB: (8, 17)
EZ: (7, 16)

3.12.2. Differential Input Equivalent Circuit of Controller Port (RA/RB/RZ)

There are 4 connection methods corresponding to different types of external signal.

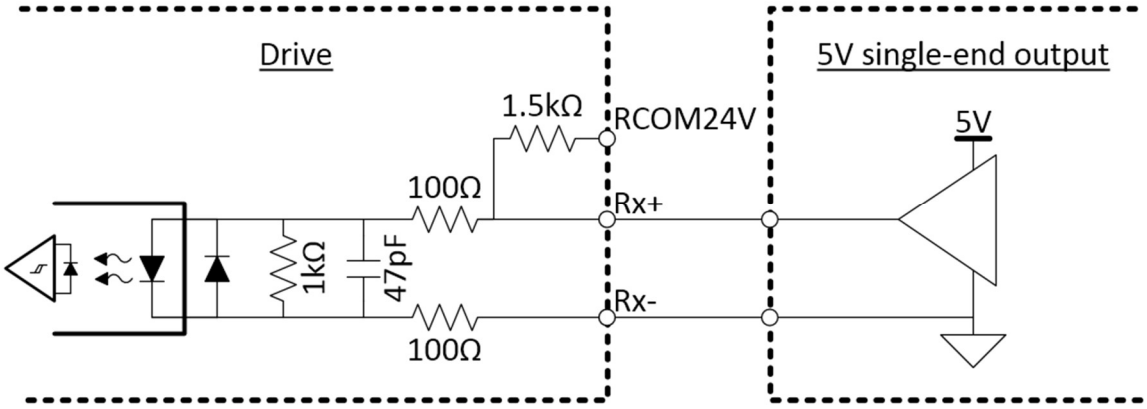
When connecting with:

(1) with external 5V differential signal



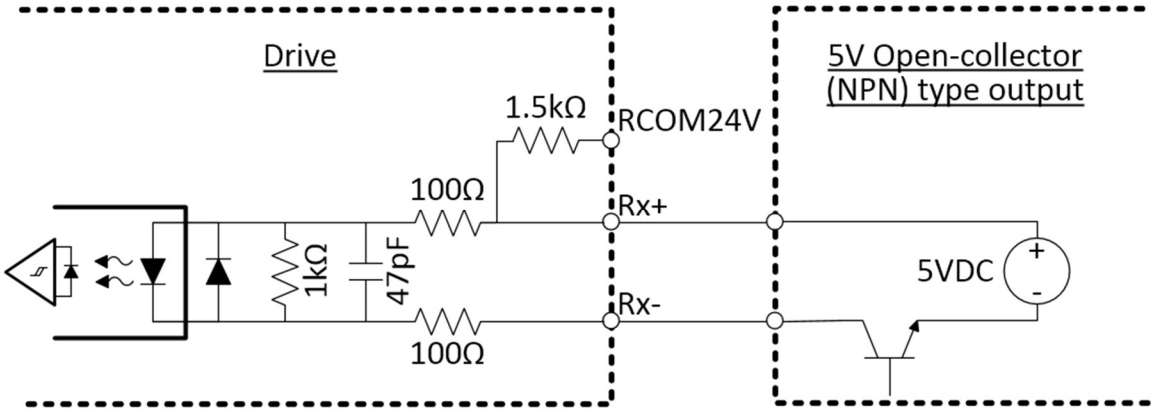
Rx: (Rx+, Rx-)
x = A, B, Z
RA: (13, 14)
RB: (22, 23)
RZ: (5, 6)

(2) with external 5V single-end signal



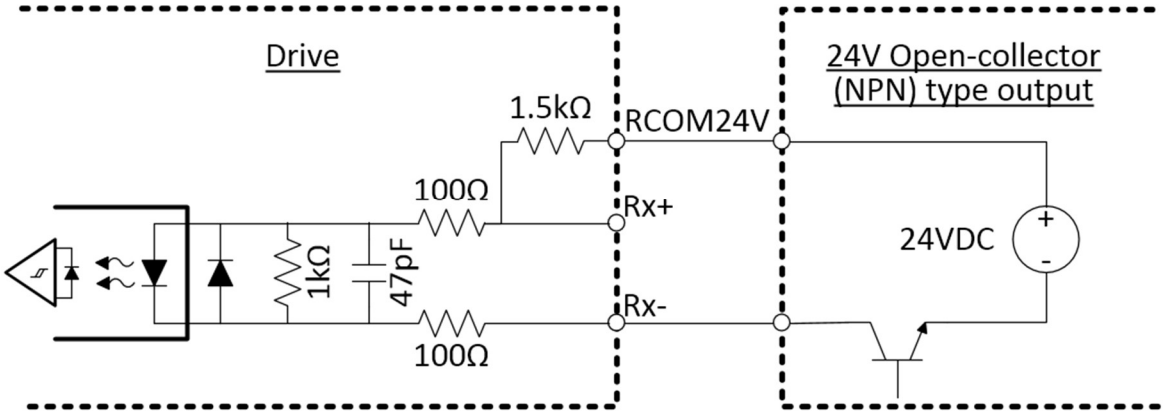
Rx: (Rx+, Rx-)
x = A, B, Z
RA: (13, 14)
RB: (22, 23)
RZ: (5, 6)

(3) with external 5V open-collector (NPN) signal



Rx: (Rx+, Rx-)
x = A, B, Z
RA: (13, 14)
RB: (22, 23)
RZ: (5, 6)

(4) with external 24V open-collector (NPN) signal

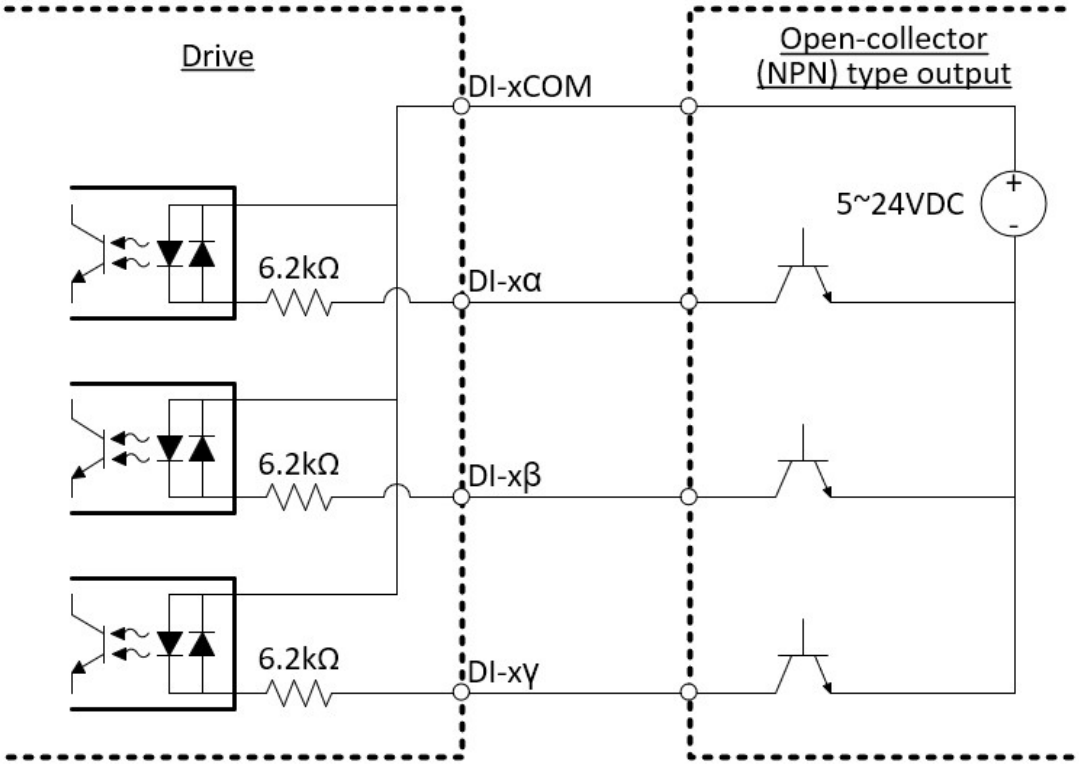


Rx: (Rx+, Rx-)
x = A, B, Z
RA: (13, 14)
RB: (22, 23)
RZ: (5, 6)

3.12.3. Digital Input up to 24V

All digital input pins of the TC1-B driver can accept up to 24V of digital command (while TC1 series can only accept up to 5V).

(1) **Isolated**



↑ **DI-xCOM, DI-xα/xβ/xγ:**

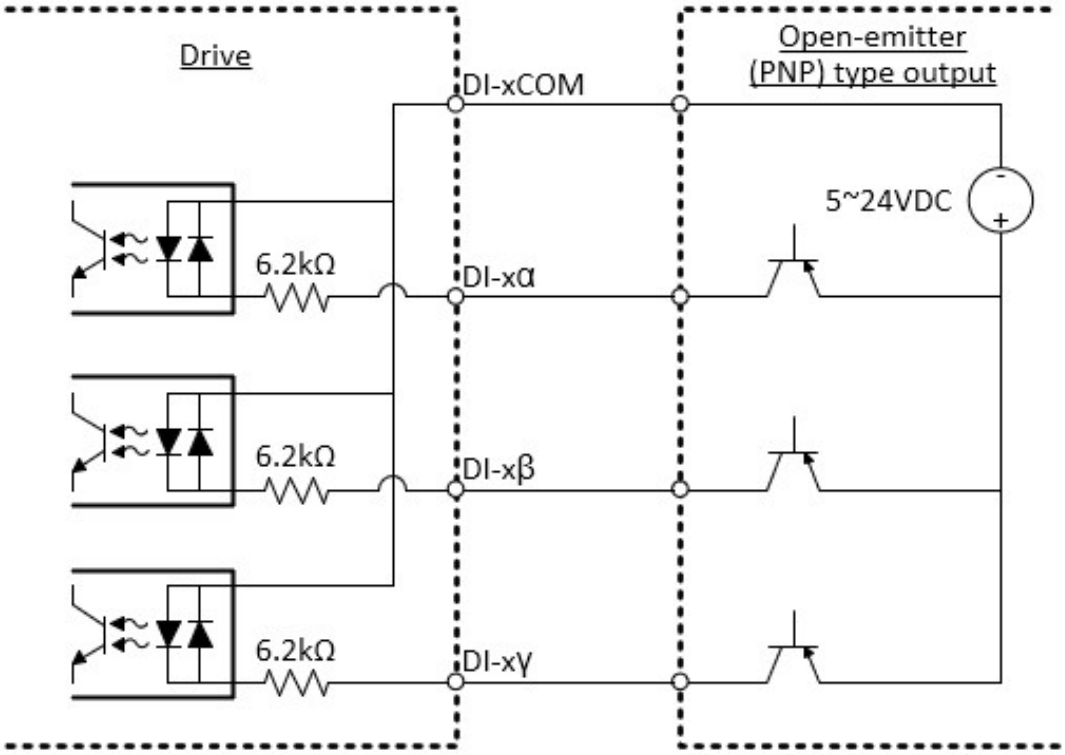
x = A, B, C

α / β / γ: serial numbers.

General port ➔ x = A; α / β / γ = 0, 1, 2. (ex: ACOM, A0, A1, A2)

Feedback port ➔ x = B; α / β / γ = 3, 4, 5.

Control port ➔ x = C; α / β / γ = 0, 1, 2.



↑ **DI-xCOM, DI-xα/xβ/xγ:**

x = A, B, C

α / β / γ: serial numbers.

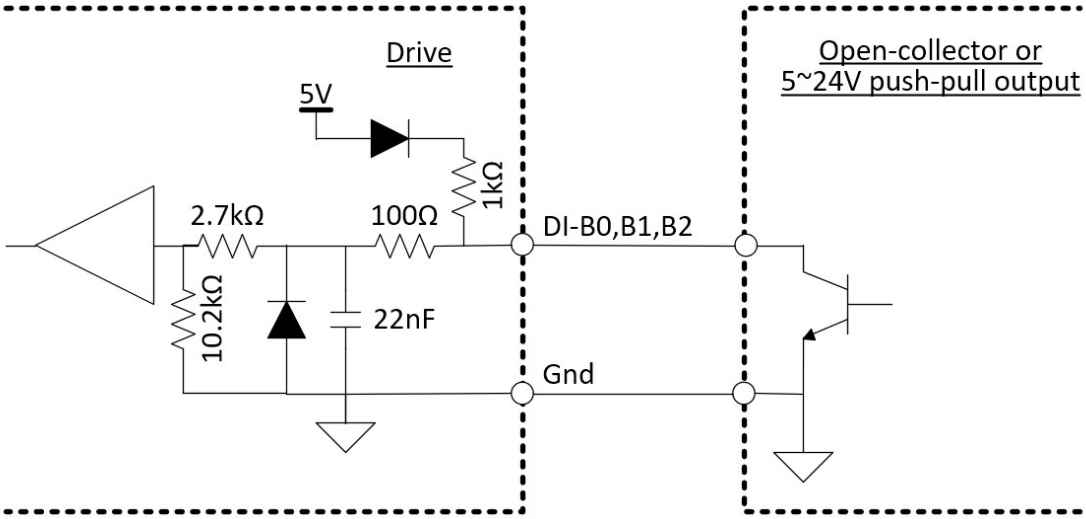
General port ➔ x = A; α / β / γ = 0, 1, 2. (ex: ACOM, A0, A1, A2)

Feedback port ➔ x = B; α / β / γ = 3, 4, 5.

Control port ➔ x = C; α / β / γ = 0, 1, 2.

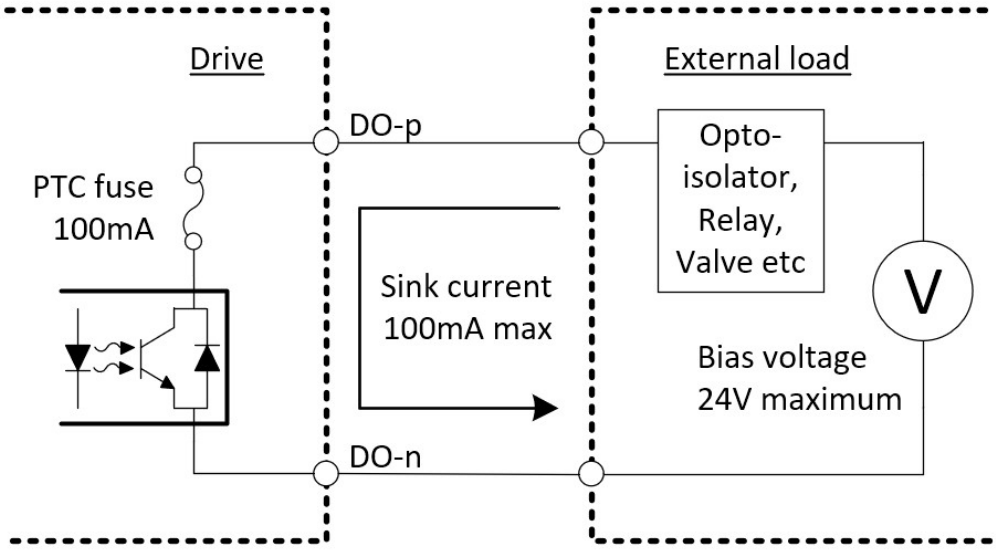
(2) Non-isolated

Mainly for the use of hall sensor.



3.12.4. Digital Output (Open-Collector)

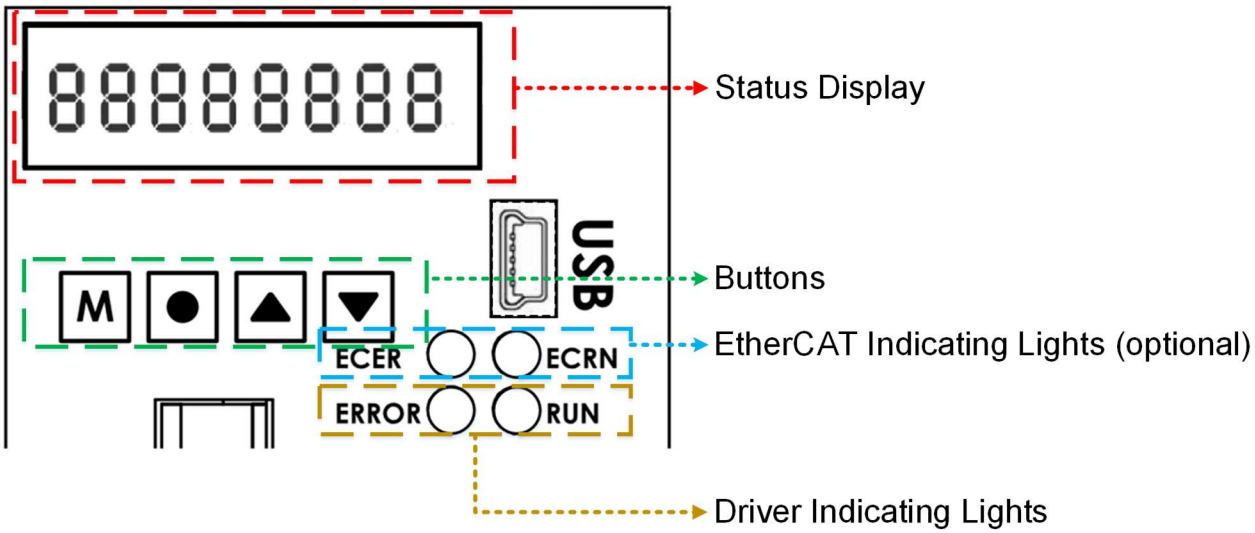
Maximum current allowed for DO: 100 mA.



Pin pair-up:

DO-p	DO-n
DO-A0, A1	DO-ACOM
DO-B0+	DO-B0-
DO-C0+	DO-C0-
DO-C1+	DO-C1-
DO-C2+	DO-C2-

4. Status Panel



4.1. Indicating Lights

4.1.1. Driver Indicating Lights

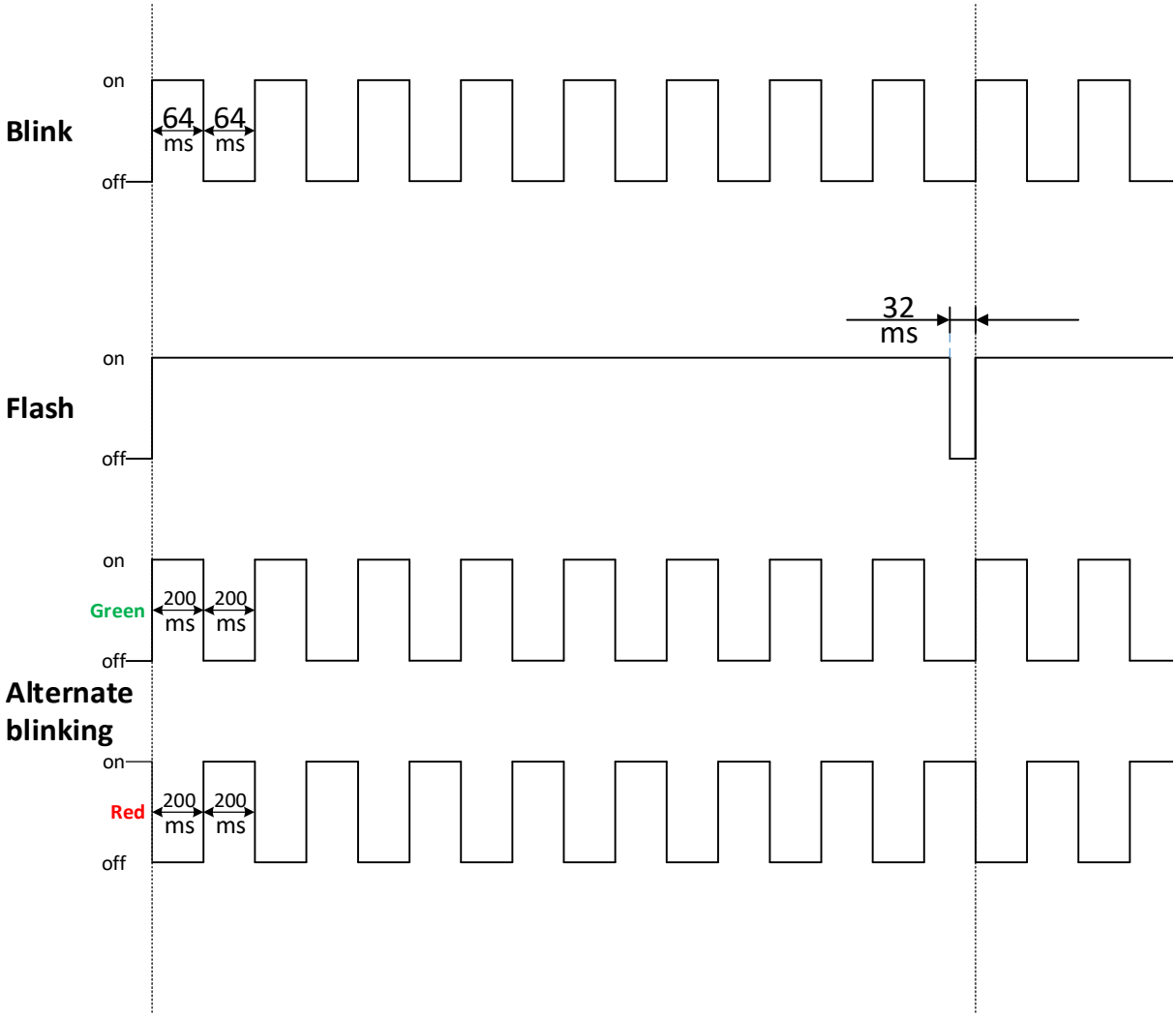
When observing the driver indicating lights, **check the green light first.**

4.1.1.1. Flashing rate of driver indicating light

When a driver indicating light keeps turning on and off, there are three possible states: **blink, flash** or **alternate blinking.**

- **Blink**:
  The light is on for 64 ms and off for 64 ms.
- **Flash**:
  The light is on for 480 ms and off for 32 ms.
- **Alternate blinking**:
  The green light and red light are taking turns to be on for 200 ms and off for 200 ms.

<Flashing Rate of Driver Indicating Light>



4.1.1.2. Meaning of driver Indicating light

Green (Run)	Red (Fault)	Description
Off	Off	Power off
	Blink	Fault active
	On	Fault (to be reset)
On	Off	Standby
	On	Motor is off, waiting for external enable
Blink	Off	Motor is on
	Flash	Executing phase-find or waiting for *delay time.
Flash	Off	Motor is off, and dynamic brake is active.
	Blink	Fault condition is active and dynamic brake is active.
	Flash	Motor is off, waiting for external enable; dynamic brake is active.
	On	Fault (to be reset), and dynamic brake is active.
Green/Red Alternate Blinking		■ Parameter is being saved to flash; OR ■ (for TC1-B series only): Driver is under bootload mode updating the firmware.

Note*: Motors activation delay time is 100 ms.

4.1.2. EtherCAT Indicating Light (Optional)

We follow the regulations written in Document: ETG.1300 S (R) V1.1.1 by EtherCAT Technology Group.

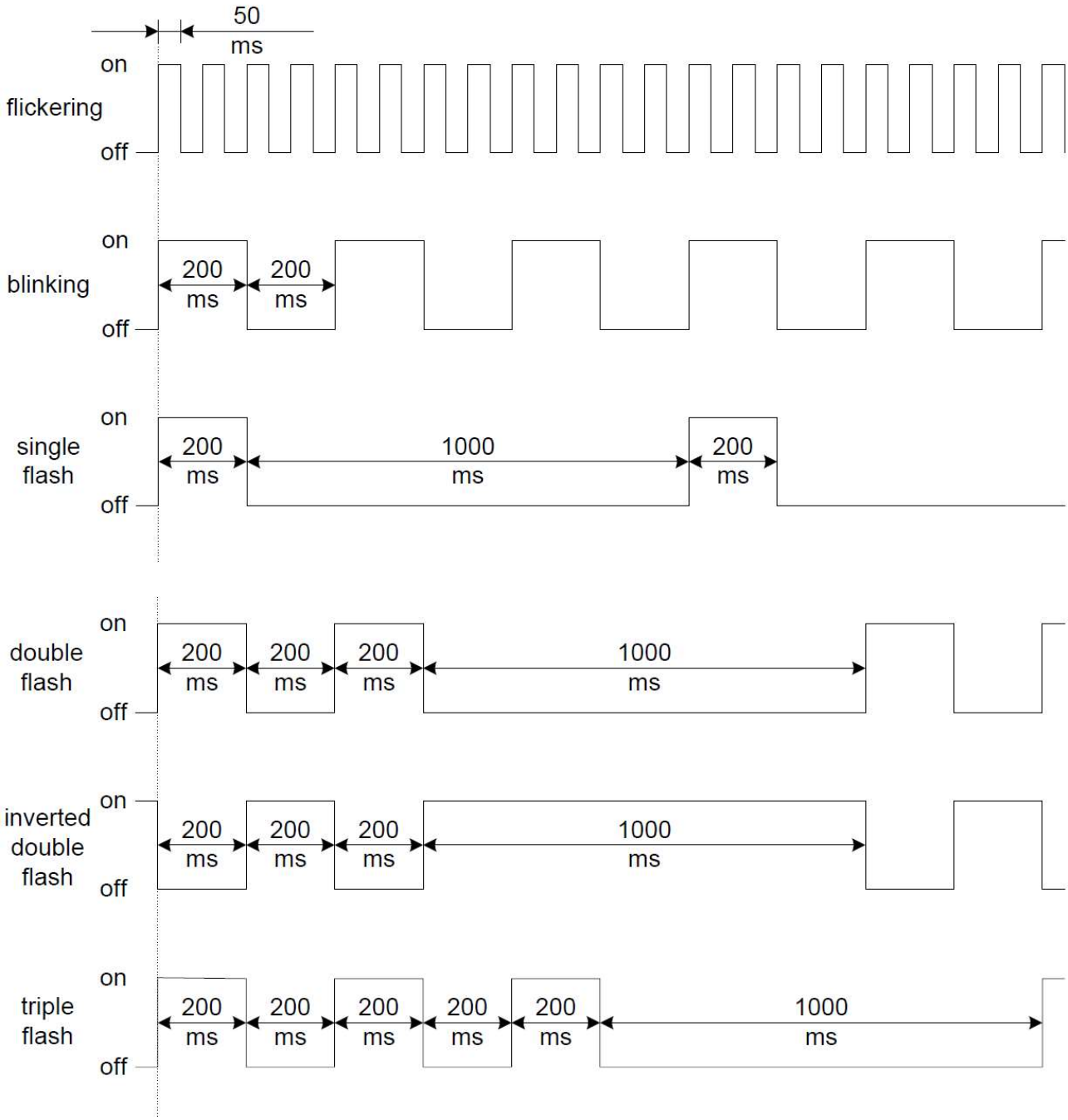
4.1.2.1. Flashing rate of EtherCAT indicating light

The indicating light (or indicator) states are defined in Table 1 and the flashing rates in Figure 1. The times listed shall be met with a tolerance of less than +/- 20%.

<Table 1>

Indicator states Definition	Definition
on	The indicator shall be constantly on.
off	The indicator shall be constantly off.
flickering	The indicator shall turn on and off iso-phase with a frequency of 10 Hz: on for 50 ms and off for 50 ms.
blinking	The indicator shall turn on and off iso-phase with a frequency of 2.5 Hz: on for 200 ms followed by off for 200 ms.
single flash	The indicator shall show one short flash (200 ms) followed by a long off phase (1000 ms).
double flash	The indicator shall show a sequence of two short flashes (200 ms), separated by an off phase (200 ms), and followed by a long off phase (1000 ms).
inverted double flash	The indicator shall show a sequence of two short off flashes (200 ms), separated by an on phase (200 ms), and followed by a long on phase (1000 ms).
triple flash	The indicator shall show a sequence of three short flashes (200 ms), separated by an off phase (200 ms), and followed by a long off phase (1000 ms).

<Figure 1: EtherCAT Indicator flashing rate>



4.1.2.2. RUN Indicator

The RUN indicator shows the status of the ESM.

1. LED: The color of the RUN indicator is green.
2. Labeling: The RUN indicator is labeled with **ECRN**.
3. States: The RUN indicator states are specified in Table 2.

<Table 2>

Indicator States	Slave State	Description
Off	INITIALISATION	The device is in state INIT
Blinking	PREOPERATIONAL	The device is in state PREOPERATIONAL
Single Flash	SAFEOPERATIONAL	The device is in state SAFEOPERATIONAL
On	OPERATIONAL	The device is in state OPERATIONAL
Flickering	INITIALISATION or BOOTSTRAP	The device is booting and has not yet entered the INIT state, or: The device is in state BOOTSTRAP. Firmware download operation in progress

4.1.2.3. ERROR Indicator

The ERROR indicator shows errors such as watchdog timeouts and unsolicited state changes due to local errors (e.g. input error).

1. LED: The color of the ERROR indicator is red.
2. Labelling: The ERR indicator is labeled with **ECER**.
3. States: The ERR indicator states are specified in Table 3.

<Table 3>

ERR State	Error Name	Description	Example
On	Application controller failure	An critical communication or application controller error has occurred	Application controller is not responding any more (PDI Watchdog Timeout detected by ESC)
Double Flash	Process Data Watchdog Timeout/ EtherCAT Watchdog Timeout	An application watchdog timeout has occurred.	Sync Manager Watchdog timeout
Single Flash	Local Error	Slave device application has changed the EtherCAT state autonomously, due to local error (see ETG.1000 part 6 EtherCAT State Machine). Error Indicator bit is set to 1 in AL Status register.	Device changes its EtherCAT state from Op to SafeOpError due to a synchronization error.
Blinking	Invalid Configuration	General Configuration Error	State change commanded by master is impossible due to register or object settings, or invalid hardware configuration (pin sharing violation detected by ESC)
Flickering	Booting Error	Booting Error was detected. INIT state reached, but Error Indicator bit is set to 1 in AL Status register, or	Checksum error in Application controller flash memory.
Off	No error	The EtherCAT communication of the device is in working condition	

4.2. Buttons and Status Display

- **Buttons**

Item	Descript
M	Menu
●	Enter
▲	Switch data source
▼	Switch data source

- **Status Display**

Data Source	Description	Unit
	Script Step Number	
	Current Auxiliary Command	0.1A
	Current Reference	0.1A
	Current Feedback	0.1A
	Velocity Auxiliary Command	cnt/s/1000
	Velocity Reference	cnt/s/1000
	Velocity Feedback	cnt/s/1000
	Position Auxiliary Command	cnt/1000
	Position Reference	cnt/1000
	Position Feedback **(Default)**	cnt/1000
	Position Error	cnt
	cpc internal use only	
		

5. Maintenance

5.1. General

DANGER: To prevent electric shock, disconnect the power supply before maintenance.

CAUTION: Any excessive adjustment could lead to a hazardous state of the servo drive.

Do not open this device for any inspection or maintenance. Contact customer service for any of the servicing.

When the TC1-B driver has an error such as over temperature, exceeding protection threshold, incorrect wiring, having difficulty accessing signals, etc.
The Error Log will record the time and code of errors when errors occur. If TC1-B driver shuts down due to errors, users can trace the causes of malfunction according the error log.

When the TC1-B driver detects multiple errors, its display will show the code of the last-found error. The rest of errors need to be checked via UI.

5.2. Troubleshooting

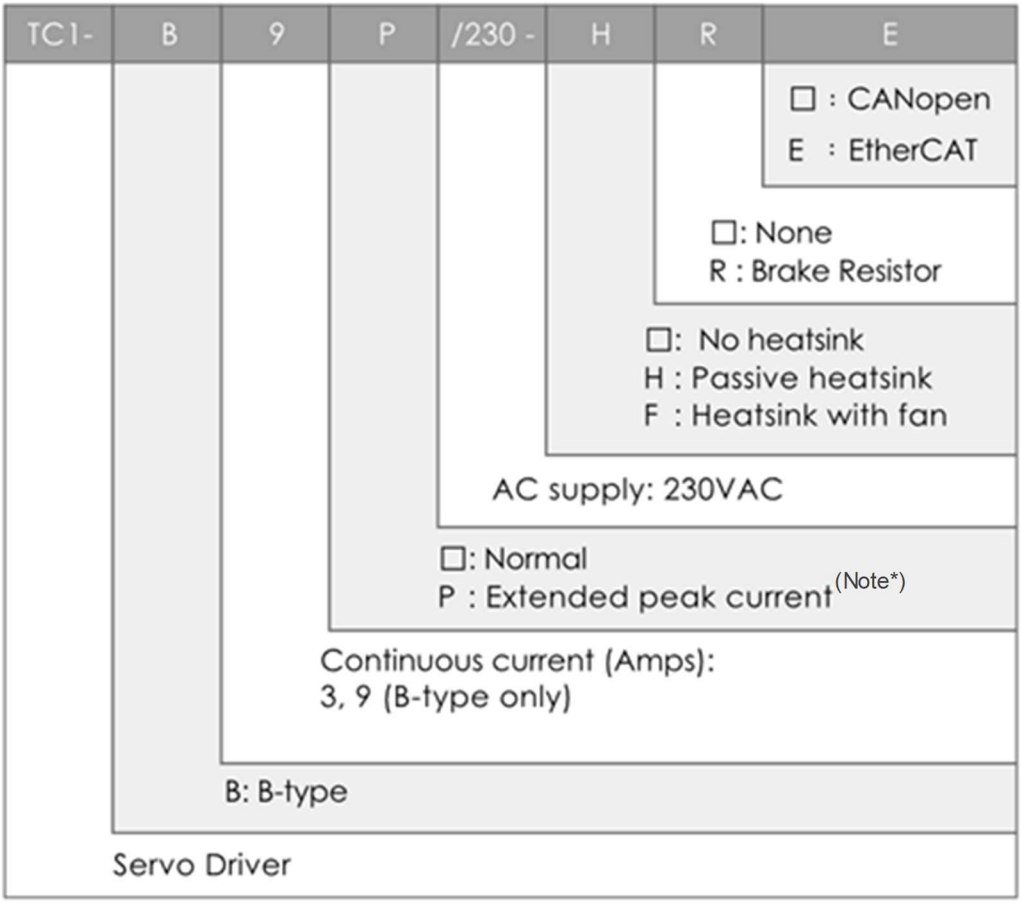
Error Code	Error Message	Description	Action Required
2220	ContinuousOverCurrent_DeviceInternal	Drivers internal power stage is short	Check for unstable current loop gain
2310	ContinuousOverCurrent_MotorSide	Motor current exceeds limit	Check for unstable current loop gain
E3210	DCLinkOverVoltage	Internal DC capacitor over limiting value (default is 375V)	1. Check external AC supply. AC 2. Consider adding additional regenerative braking resistor.
3220	DCLinkUnderVoltage	Internal DC capacitor under limiting value (default is 48V)	Check high voltage supply AC
4310	ExcessTemperatureDrive	Drivers internal temperature over safe limit	Improve environment cooling condition
4380	ExcessTemperatureMotor	Motors internal temperature over safe limit	Improve environment cooling condition
5520	ROM_EPROM	Factory calibration lost	Contact Customer Service
5530	EEPROM	Stored user parameters lost	Reload driver setting from file
7121	MotorBlocked	Motor stuck triggered	Check slide and guide or motor stuck setting.
7122	MotorErrorOrCommutationMalfunc	Something wrong during phase find.	Check 1.motor wiring. 2.Execute phase find again.
7305	IncrementalSensor1Fault	Encoder feedback signal error	Check encoder wiring or improve system noise

Error Code	Error Message	Description	Action Required
7306	IncrementalSensor2Fault	Auxiliary encoder signal transition error	Check controller wiring or improve system noise
8481	OverVelocityAbsolute	Motor velocity feedback over velocity protection limit.	Check motor operation or over-velocity protection setting.
8611	FollowingError	Motor position error satisfy the condition of following error.	Check 1. Motor operation and 2. The setting of Following Error Window/Timeout.
8682	PositionLimitMinimum	Motor position feedback over position protection limit.	Check motor operation or over-position protection setting.
8683	PositionLimitMaximum	Motor position feedback under position protection limit.	Check motor operation or under-position protection setting.
90F0	ExternalAlarmDigitalInput	External alarm triggered.	Check controller operation.
FF01	MainISROverload	CPU overload.	Contact Customer Service.
FF02	CurrentSensorU	Motor current sensor error	Reboot driver
FF03	CurrentSensorV	Motor current sensor error	Reboot driver
FF05	HallSensorCodeInvalid	Invalid hall sensor code detected	Check hall sensor configuration
FF07	MotorCtrlOpModeInvalid	The code of Operation Mode is invalid.	Check Operating Mode and wiring.
FF08	CommutationRequired	Attempting to activate motor without performing phase find first.	1. Check phase find setting. 2. Execute phase find again.

6. Model Variations

- Please refer to **chapter 1.3** (ordering information) about variations (P, H, F, R, and E) and also **chapter 6** for how to select the model you need. In addition, we offer optional accessories (**chapter 7**) such as Noise Filter Board and Ferrite Choke. When placing orders, please specify your requirements.

  Note:
  The variations of **P, H,** and **F** are for the **9A-type** TC1-B Driver ONLY**.**



- **Please see the Summary Table below for quick understanding.**

<Summary Table>

<table>
<tr><th></th><th>TC1-B3/230</th><th colspan="3">TC1-B9/230</th></tr>
<tr><td>User's needed continuous current for application</td><td>3 A</td><td>3 A</td><td>6 A</td><td>9 A</td></tr>
<tr><td rowspan="2">and the

corresponding Heatsink Type</td><td rowspan="2">N/A</td><td rowspan="2">N/A</td><td>H type</td><td>F type</td></tr>
<tr><td>Factory-installed
  </td><td>Factory-installed
  </td></tr>
<tr><td rowspan="2">Regenerative Resistor</td><td>Optional</td><td colspan="2">Optional</td></tr>
<tr><td>Installed by users</td><td>Installed by users</td><td>Factory-installed
  </td></tr>
</table>

6.1. **P**: Extended Peak Current (for 9A-type TC1-B Driver only)

The peak current function is for the 9A-type TC1-B Driver only; the peak current can reach 30 A.

Specification				
Model No.			**TC1-B9/230**	**TC1-B9P/230**
Output Power	Continuous Current	[A]	**9** (6.36 RMS)	**9** (6.36 RMS)
	Peak Current	[A]	**20** (14.14 RMS)	**30** (21.22 RMS)
	Peak Current Time		2.5 seconds	

6.2. Heatsink (for 9A-type TC1-B Driver only)

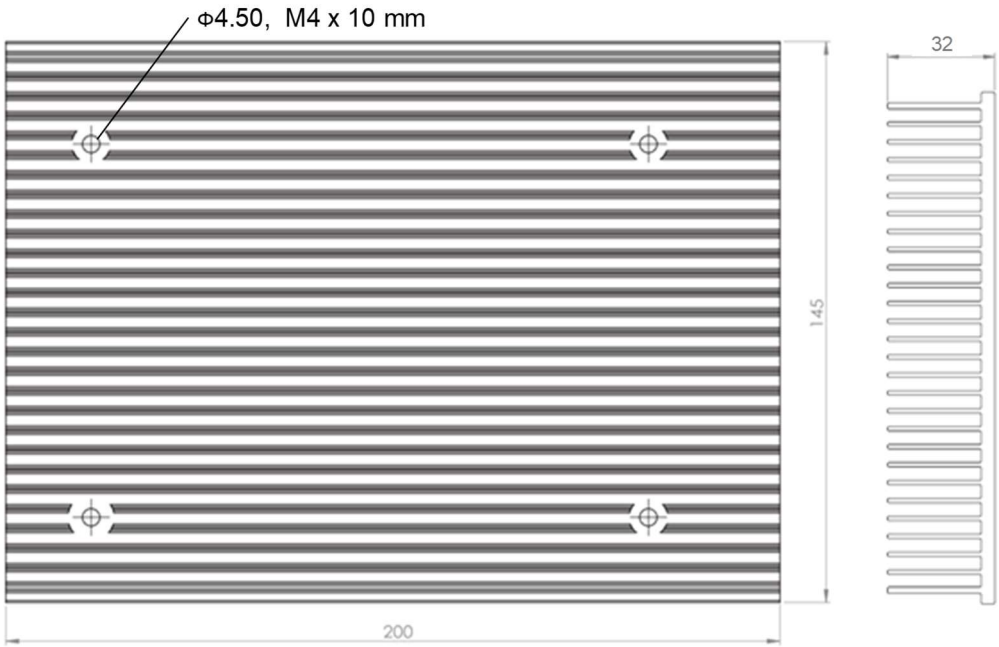
Note: Heatsink options are **for the 9-A type driver only.** There are H and F types.

6.2.1. **H**: Passive heatsink (for 9A-type TC1-B Driver only)

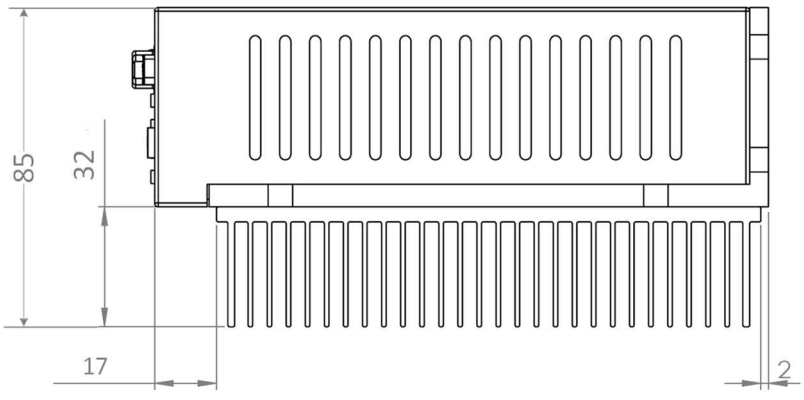
1. For 9A-type TC1-B Drivers only. 9 ATC1-B
2. **If a continuous current of 6 A is needed**, users need to equip this type of passive heatsink.
3. This passive heatsink will be installed by cpc before shipment.

6.2.1.1. Dimensions of H-heatsink

(1) H-heatsink:



(2) H-heatsink with the driver:



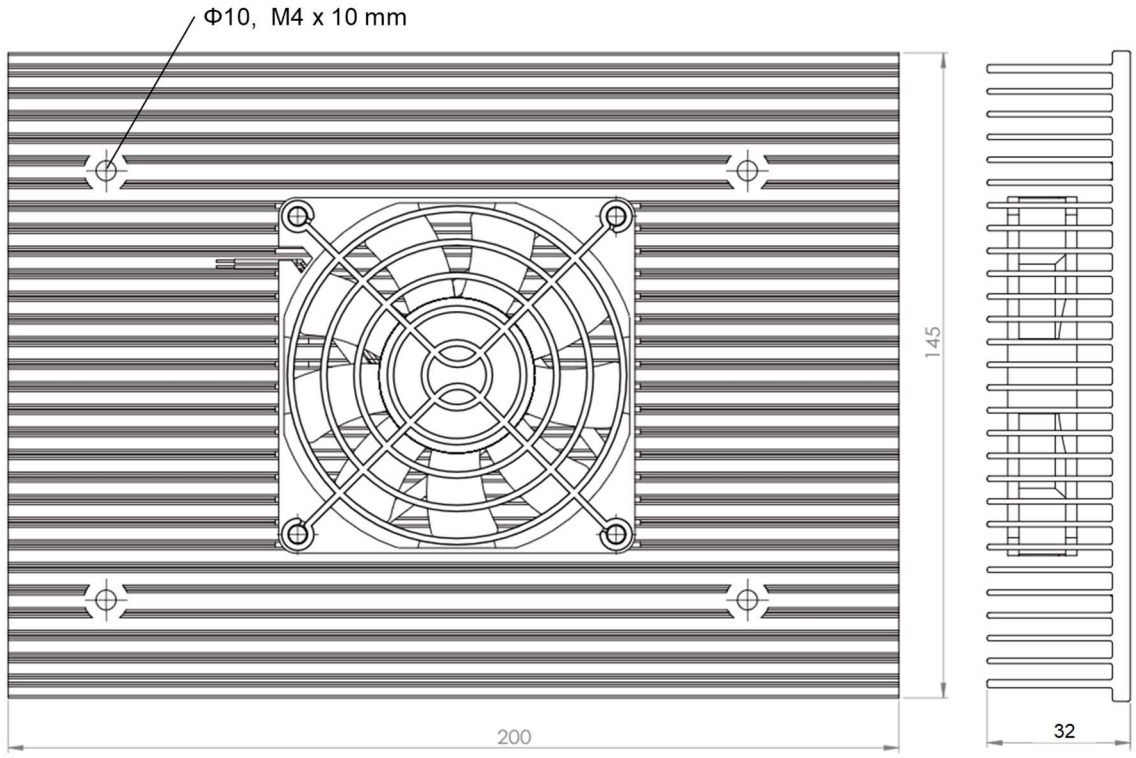
Unit: mm

6.2.2. **F**: Heatsink with fan (for 9A-type TC1-B Driver)

1. For 9A-type TC1-B Drivers only.
2. **If a continuous current of 9 A is needed**, users need to equip this passive heatsink with fan.
3. Passive heatsink with fan will be installed by cpc before shipment.

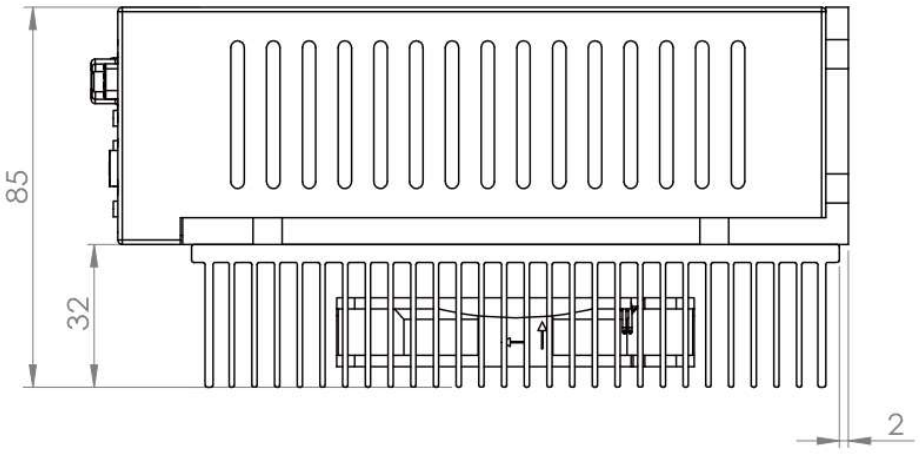
6.2.2.1. Dimensions of F-heatsink

(1) F-heatsink:



Unit: mm

(2) F-heatsink with the driver:



Unit: mm

6.3. **R**: Regenerative Resistor

Both the 3A-type and the 9A-type TC1-B Driver can work with the regenerative resistor.

A. To work with the 3A-type TC1-B Driver:

Users will need to install the regenerative resistor by themselves.

B. To work with the 9A-type TC1-B Driver

1. Without heatsink:

   Users will need to install the regenerative resistor by themselves.

2. With heatsink

   (a) H-heatsink (to satisfy continuous current of 6 A):

   Users will need to install the regenerative resistor by themselves.

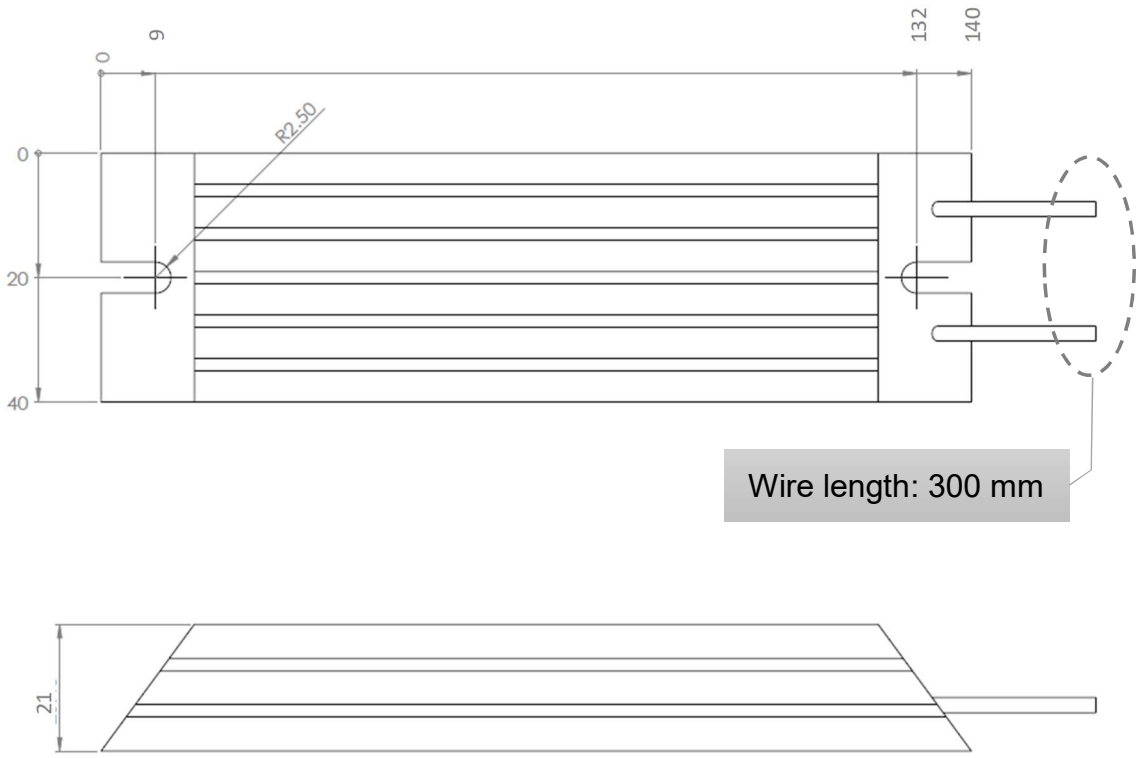
   (b) F-heatsink (to satisfy continuous current of 9 A):

   The regenerative resistor will be embedded in the heatsink for the 9A-type TC1-B Driver; cpc will embed it before shipment. **See Ch. 6.3.1, (2).**

Please refer to the Summary Table in chapter 6 introduction.

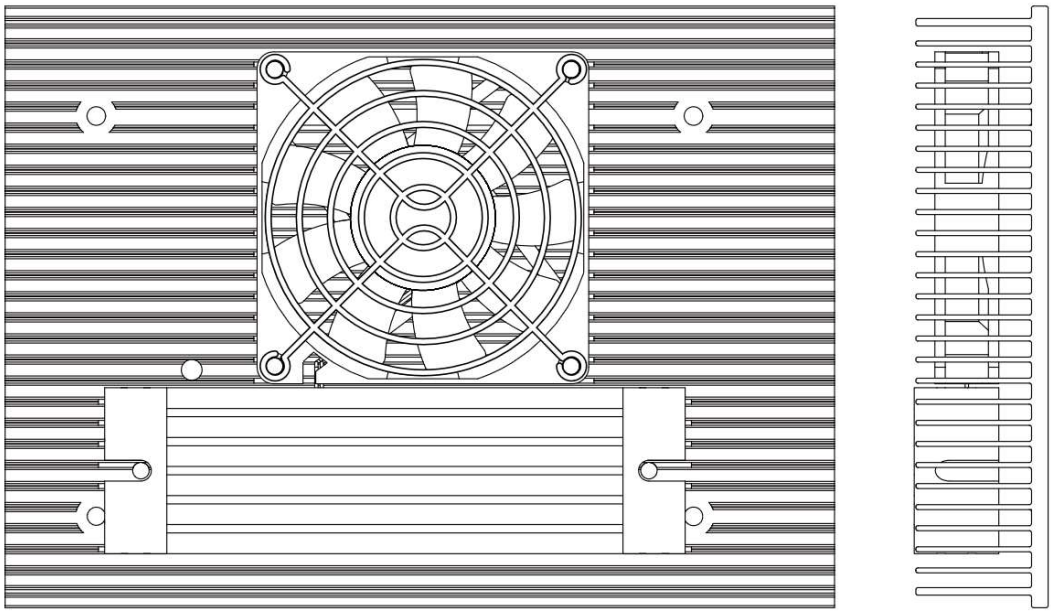
6.3.1. Dimensions of Regenerative Resistor

(1) Regenerative resistor:



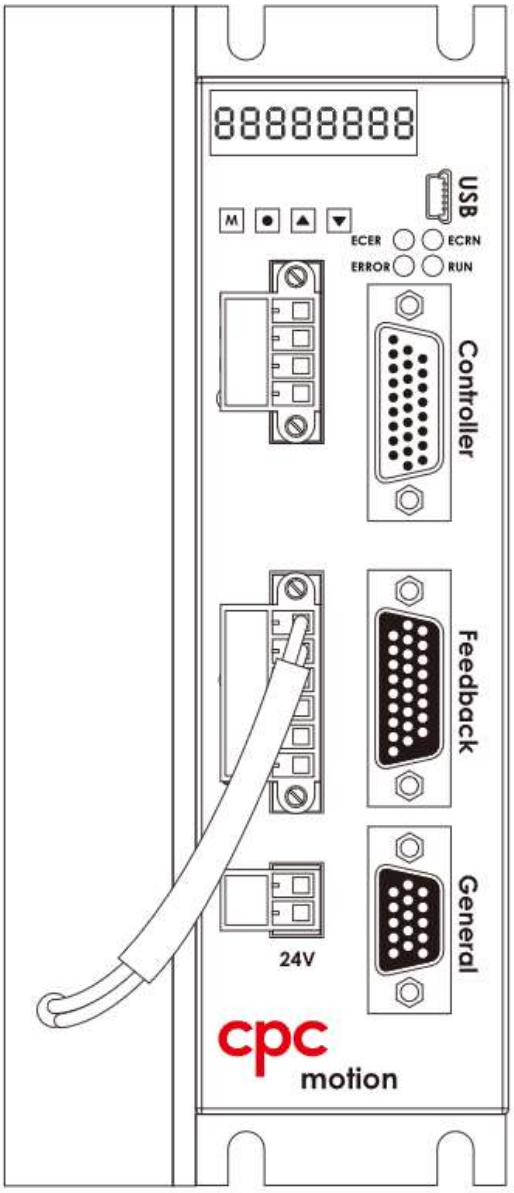
(2) Regenerative resistor embedded in the F-heatsink:

Side view



Unit: mm

Front view



Unit: mm

6.4. **E**: EtherCAT

Users can equip either CANopen, which is the cpc standard, or EtherCAT interface on TC1-B Drivers.

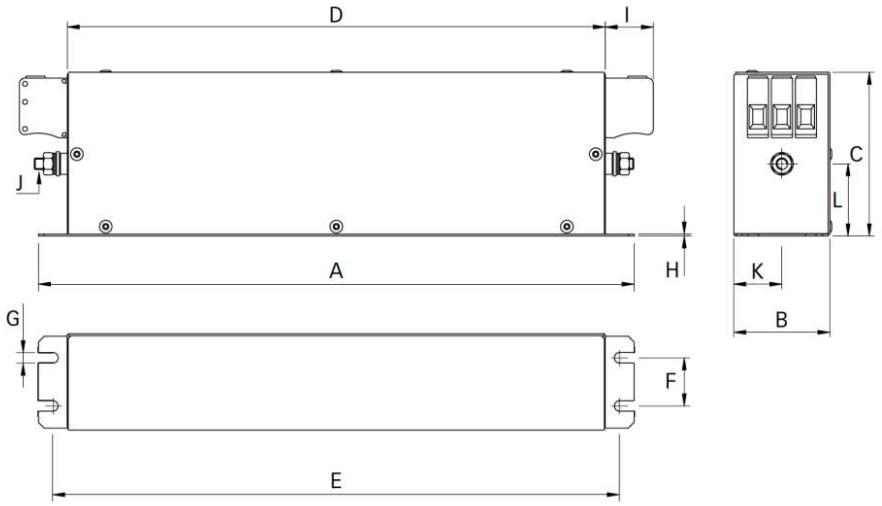
7. Optional Accessories

7.1. AC Power Filter

This AC power filter is made by SCHAFFNER.

The 3A-type and the 9A-type TC1-B Driver use the SCHAFFNER FN3258-7-45 (7 Amperes).

7.1.1. Dimensions of AC Power Filter



Dimensions

	7 A
A	190
B	40
C	70
D	160
E	180
F	20
G	4.5
H	1
I	22
J	M5
K	20
L2	29.5

Unit: mm

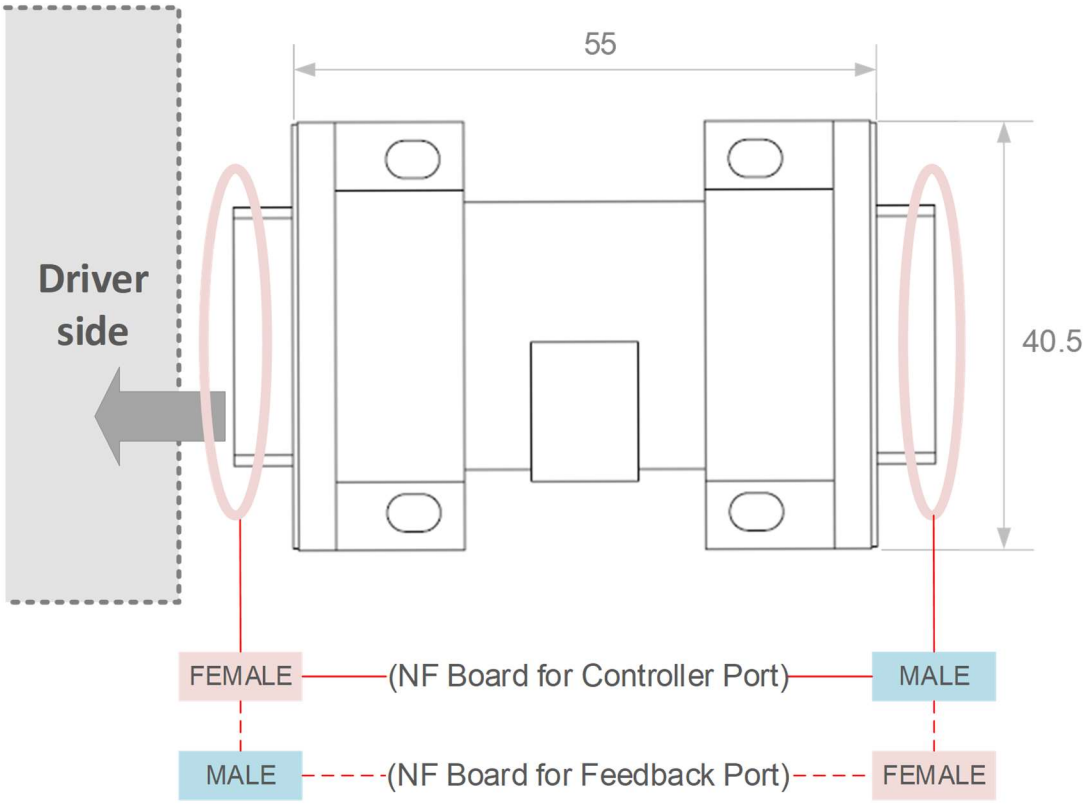
For further product information please visit the official website of SCHAFFNER.

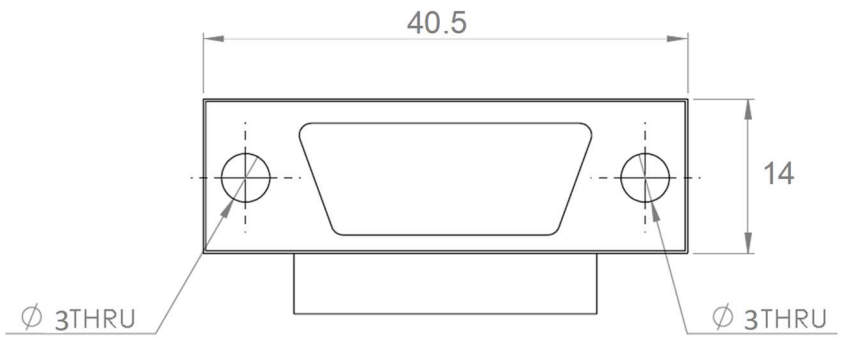
7.2. Noise Filter Board for TC1-B Driver

Noise Filter Board* (NF board) helps to shield from the noise from signal cables. Please insert NF boards to the corresponding ports respectively.

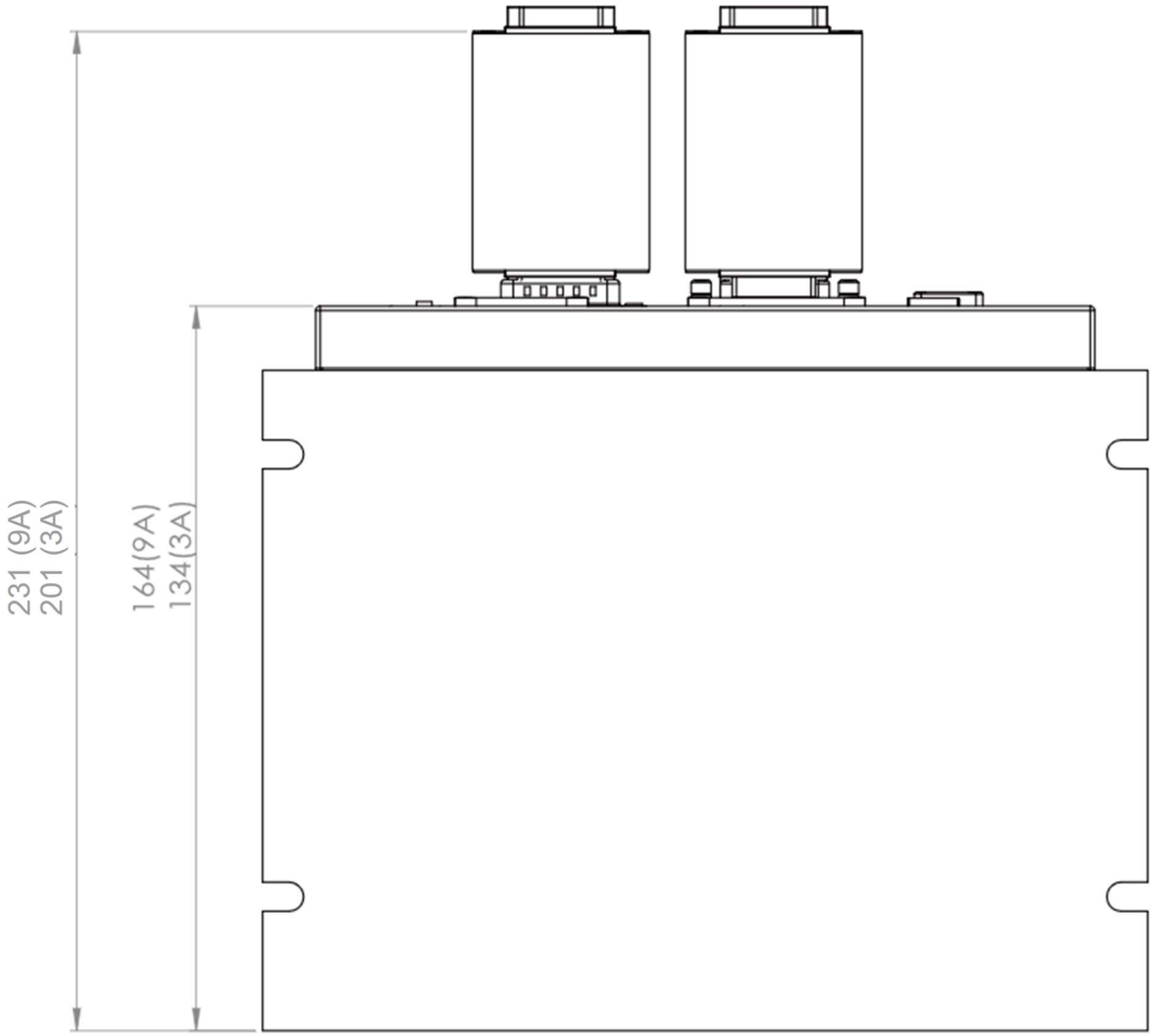
(*: Present version is 0.3)

7.2.1. Dimensions of NF Board (stand-alone / assembly)





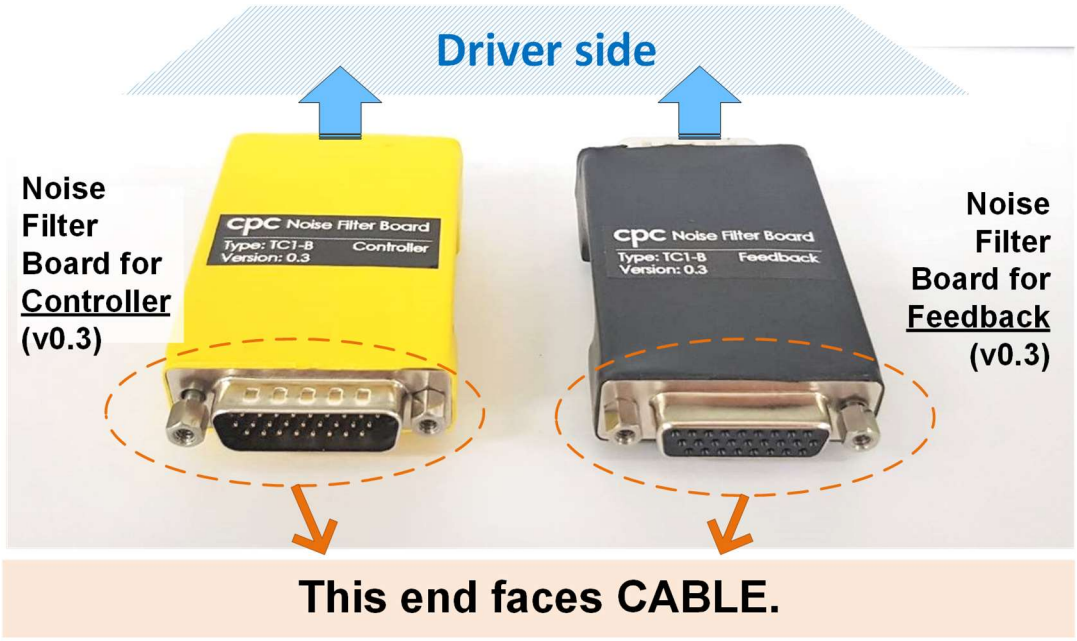
Unit: mm



Unit: mm

7.2.2. Assembly Direction and Steps

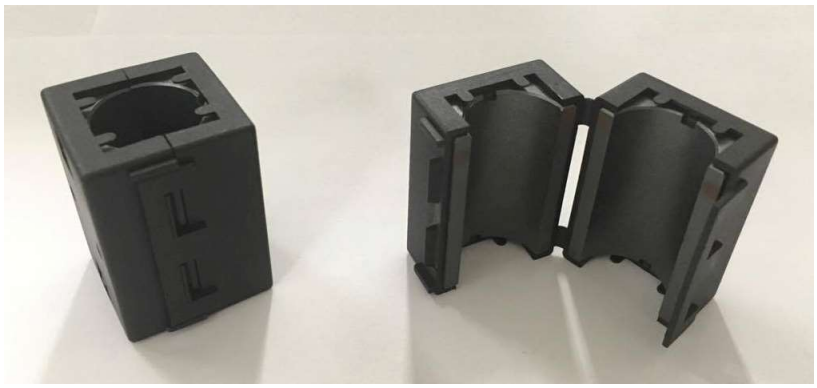
- When assembling, pay attention to the correct direction.



- Assembly Step: (take Feedback as example)
  (1) Insert the NF Board for Feedback into the feedback port and tighten the copper pillars **at the same time**.
  (2) Connect with signal cable.

7.3. Ferrite Choke

A ferrite choke helps to shield from the external noise.



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