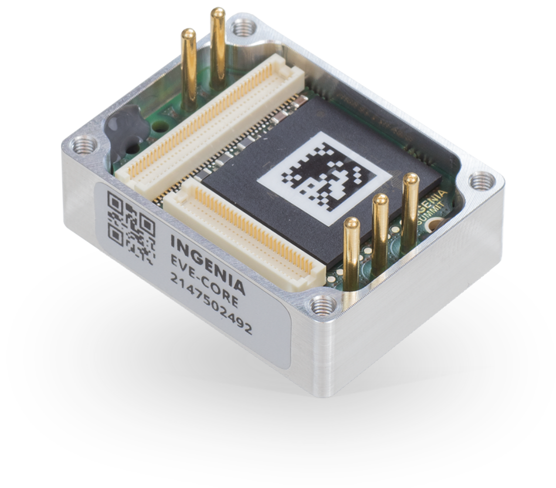
Everest CORE - Product manual



Edition 04/23/2021

For the most up to date information visit the online manual.

INGENIA-CAT S.L.

AVILA 124

08018 BARCELONA

INGENIA
passion for motion

1. Table of Contents

2. General Information

2.1. Manual revision history

Revision	Release Date	Changes
v1	12 Apr 2019	Initial version
v2	21 Feb 2020	Added safety-related indications.
v3	25 Aug 2020	Added chapter on Safe Torque Off Compliance with Everest CORE

For the most up to date information use the online Product Manual.

2.2. Disclaimers and limitations of liability

The information contained within this document contains proprietary information belonging to **INGENIA-CAT S.L.**

Such information is supplied solely for the purpose of assisting users of the product in its installation.

INGENIA-CAT S.L. rejects all liability for errors or omissions in the information or the product or in other documents mentioned in this document.

The text and graphics included in this document are for the purpose of illustration and reference only. The specifications on which they are based are subject to change without notice.

This document may contain technical or other types of inaccuracies. The information contained within this document is subject to change without notice and should not be construed as a commitment by **INGENIA-CAT S.L.**

INGENIA-CAT S.L. assumes no responsibility for any errors that may appear in this document.

Some countries do not allow the limitation or exclusion of liability for accidental or consequential damages, meaning that the limits or exclusions stated above may not be valid in some cases.

2.3. Contact

INGENIA-CAT S.L.
C/ Avila 124, 2-B
08018 Barcelona
Spain

Telephone: +34 932 917 682
E-mail: hello@ingeniamc.com
Web site: www.ingeniamc.com

3. Safety Information

3.1. For your safety

The instructions set out below must be **read carefully prior to the initial commissioning or installation** in order to raise awareness of potential risks and hazards, and to prevent injury to personnel and/or damage to property.

To ensure safety when operating this servo drive, it is mandatory to follow the procedures included in this manual. The information provided is intended to protect users and their working area when using the device, as well as other hardware that may be connected to it.

3.2. Warnings

Electric servo drives are dangerous: The following statements should be considered to avoid serious injury to individuals and/or damage to the equipment:

- Do not touch the power terminals of the device (supply and phases) as they can carry dangerously high voltages > 50 V.
- Never connect or disconnect the device while the power supply is ON to prevent danger to personnel, the formation of electric arcs, or unwanted electrical contacts.
- Disconnect the drive from all power sources before proceeding with any wiring change.
- The surface of the device may exceed 100 °C during operation and may cause severe burns to direct touch.
- After turning OFF and disconnecting all power sources from the equipment, wait at least 10 seconds before touching any parts of the controller, as it can remain electrically charged or hot.

3.3. Precautions

The following statements should be considered to avoid serious injury to those individuals performing the procedures and/or damage to the equipment:

- Always comply with the connection conditions and technical specifications. Especially regarding wire cross-section and grounding.
- Some components become electrically charged during and after operation.
- The power supply connected to this controller should comply with the parameters specified in this manual.
- When connecting this drive to an approved power source, do so through a line that is separate from any possible dangerous voltages, using the necessary insulation in accordance with safety standards.
- High-performance motion control equipment can move rapidly with very high forces. An unexpected motion may occur especially during product commissioning. Keep clear of any operational machinery and never touch them while they are working.
- Do not make any connections to any internal circuitry. Only connections to designated connectors are allowed.
- All service and maintenance must be performed by qualified personnel.
- Before turning on the drive, check that all safety precautions have been followed, as well as the installation procedures.

3.4. *Pour votre sécurité*

Les instructions ci-dessous ***doivent être lues attentivement avant la mise en service ou l'installation initiale*** *afin de sensibiliser aux risques et dangers potentiels et de prévenir les blessures aux personnes et/ou les dommages aux biens.*

Pour garantir la sécurité lors de l'utilisation de ce servomoteur, il est obligatoire de suivre les procédures incluses dans ce manuel. Les informations fournies sont destinées à protéger les utilisateurs et leur zone de travail lors de l'utilisation de l'appareil, ainsi que les autres matériels qui peuvent y être connectés.

3.4.1. *Avertissements*

Les servo-entraînements électriques sont dangereux *: Les déclarations suivantes doivent être prises en compte pour éviter des blessures graves aux personnes et/ou des dommages à l'équipement :*

- *Ne pas toucher les bornes d'alimentation de l'appareil (alimentation et phases) car elles peuvent véhiculer des tensions dangereusement élevées > 50 V.*
- *Ne jamais connecter ou déconnecter l'appareil lorsque l'alimentation est en marche afin d'éviter tout danger pour le personnel, la formation d'arcs électriques ou de contacts électriques indésirables.*
- *Déconnectez l'appareil de toutes les sources d'alimentation avant de procéder à tout changement de câblage.*
- *La surface de l'appareil peut dépasser 100 ºC pendant le fonctionnement et peut causer de graves brûlures au contact direct.*
- *Après avoir éteint et déconnecté toutes les sources d'alimentation de l'appareil, attendez au moins 10 secondes avant de toucher une partie quelconque de l'appareil, car il peut rester chargé électriquement ou être chaud.*

3.4.2. *Précautions*

Les déclarations suivantes doivent être prises en compte pour éviter des blessures graves aux personnes qui effectuent les procédures et/ou des dommages à l'équipement :

- *Respectez toujours les conditions de connexion et les spécifications techniques. En particulier en ce qui concerne la section des fils et la mise à la terre.*
- *Certains composants se chargent électriquement pendant et après le fonctionnement.*
- *L'alimentation électrique connectée à ce contrôleur doit être conforme aux paramètres spécifiés dans ce manuel.*
- *Lorsque vous connectez ce variateur à une source d'alimentation approuvée, faites-le par une ligne séparée de toute tension dangereuse éventuelle, en utilisant l'isolation nécessaire conformément aux normes de sécurité.*
- *Les équipements de control de mouvement à haute performance peuvent se déplacer rapidement avec des forces très élevées. Un mouvement inattendu peut se produire, notamment lors de la mise en service du produit. Restez à l'écart de toute machine opérationnelle et ne la touchez jamais pendant qu'elle fonctionne.*
- *N'effectuez aucune connexion à un circuit interne. Seules les connexions à des connecteurs désignés sont autorisées.*
- *Tous les travaux d'entretien et de maintenance doivent être effectués par un personnel qualifié.*
- *Avant de mettre le le contrôleur en marche, vérifiez que toutes les précautions de sécurité ont été prises, ainsi que les procédures d'installation.*

4. Product Description

Everest CORE is a high power, highly integrated, digital servo drive intended to be plugged or soldered to an application-specific daughter board. The drive features best-in-class energy efficiency thanks to its state of the art power stage, and can be easily configured with Ingenia's free software **MotionLab 3**.

Everest CORE can be interfaced by means of its proprietary SPI-based **Motion Control Bus** protocol.

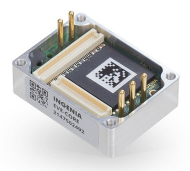
Main features:

- Ultra-small footprint
- Up to 80 V_{DC}, 45 A continuous
- Up to 99% efficiency
- Up to 50 kHz current loop, 25 kHz servo loops
- 10 kHz ~ 100 kHz PWM frequency
- 16 bit ADC with VGA for current sensing
- Supports Halls, Quadrature encoder, SSI and BiSS-C
- Up to 4 simultaneous feedback sources
- Full voltage, current and temperature protections

Typical applications:

- Collaborative robot joints
- Robotic exoskeletons
- Wearable robots
- AGVs
- UAVs
- Industrial highly integrated servomotors
- Smart motors
- Battery-powered and e-Mobility
- Low inductance motors

4.1. Part numbering

Product	Ordering part number	Communications	Environment	Status	Image
Everest CORE Pluggable servo drive with communication through proprietary **M**otion **C**ontrol **B**us protocol.	EVE-CORE	SPI	Industrial	PRODUCTION	
	EVE-CORE-E	SPI	Extended	IN-DESIGN	

For applications requiring a pluggable drive enabled with EtherCAT or CANopen, please see Everest NET.

For applications requiring a ready-to-go product, also enabled with EtherCAT or CANopen, please see Everest XCR.

4.2. Specifications

4.2.1. Electrical and Power Specifications

Minimum DC bus supply voltage	8 V_{DC}
Maximum DC bus supply voltage	80 V_{DC} (continuous) 85 V_{DC} (peak 100 ms) Working at 80 V will require a stable power supply able to absorb any possible reinjection coming back from the driver.
Recommended power supply voltage range	12 V_{DC} ~ 72 V_{DC} This voltage range ensures a safety margin including power supply tolerances and regulation during acceleration and braking.
Internal drive DC bus capacitance	19 µF Note that EVE-CORE uses ceramic capacitors. The capacitance value varies with DC bias and temperature.
Logic supply voltage	4.9 V_{DC} ~ 5.1 V_{DC} A minimum of 500 mA should be provided. Higher current may be needed depending on the feedbacks used. Rise time of the 5 V supply must be between 2 ms and 10 ms to guarantee a proper initialisation.
Nominal phase continuous current	45 A @ 60 ºC Typically, 45 A can be obtained working at 48 V, 20 kHz with an appropriate cooling to keep case temperature under 60 ºC. On higher temperatures an automatic current derating will be applied to protect the system. See Thermal and Power Specifications below. For disambiguation on current definitions please see Disambiguation on current values and naming for Ingenia Drives.
Maximum phase peak current	60 A @ 1 sec Notice that peak current could be limited by an automatic current derating algorithm. In order to get 60 A, case temperature should be kept below 35 ºC.
Efficiency	Up to 99% @ 20 kHz, 80 V, 30 A

Maximum DC Bus voltage utilization	97.4% @ 10 kHz 94.8% @ 20 kHz 87% @ 50 kHz 74% @ 100 kHz Note 1: these values assume a Sinusoidal commutation. Trapezoidal commutation can reach even higher levels. Note 2: the absolute maximum DC bus utilization can only be achieved with no load connected. As soon as current is being delivered to the motor, small voltage drops in the switched elements will slightly decrease these utilization ratings.
Standby logic supply consumption	≤ 1 W Measured with commutation turned OFF.

4.2.2. Motion Control Specifications

Supported motor types	• Rotary brushless (SVPWM and Trapezoidal) • Rotary brushed (DC)
Power stage PWM frequency (configurable)	10 kHz, 20 kHz (default), 50 kHz & 100 kHz
Current sensing	3 phase, shunt based current sensing. 16 bit ADC resolution. Accuracy is ±2% full scale
Current sense resolution (configurable)	Current gain is configurable in 4 ranges: • 2.475 mA/count • 1.352 mA/count • 0.570 mA/count • 0.379 mA/count
Current sense ranges (configurable)	Current ranges for the 4 configurable current gains: • ±81.1 A • ±44.3 A • ±18.7 A • ±12.4 A
Max. Current loop frequency	50 kHz

Max. servo loops frequency (position, velocity & commutation)	25 kHz @ 50 kHz current loop

Feedbacks	• Digital Halls
	• Quadrature / Incremental encoder: Up to 2 at the same time.
	• Absolute Encoder: up to 2 at the same time, combining any of the following:
	    • BiSS-C (up to 2 in daisy chain topology)
	    • SSI
	All feedback inputs are single ended, 3.3 V logic levels.
	
	*Only a specific subset of absolute encoders are supported. Contact Ingenia for further information.

Supported target sources	Network communication (Motion Control Bus based on SPI)
Control modes	• Cyclic Synchronous Position • Cyclic Synchronous Velocity • Cyclic Synchronous Current • Profile Position (trapezoidal & s-curves) • Profile Velocity • Interpolated Position (P, PT, PVT) • Homing

4.2.3. Inputs/Outputs and Protections

Inputs and outputs	4 x non-isolated single-ended digital inputs - 3.3 V logic level. Can be configured as: • General purpose • Positive or negative homing switch • Positive or negative limit switch • Quick stop input 4 x non-isolated single-ended digital outputs - 3.3 V logic level, 3 mA max. sink / source current. Can be configured as: • General purpose • Operation enabled event flag • External shunt braking resistor driving signal 1 x ±3.3 V ,16-bit, differential analog input for load cells or torque sensors. Can be read by the Master to close a torque loop.
Shunt braking resistor output	Configurable over any of the digital outputs (see above). Enabling this function would require an external transistor or power driver.

Motor brake output	Dedicated, PWM capable, 3.3 V digital output for driving a mechanical brake. Turn-on and turn-off times are configurable. Enabling this function would require an external transistor or power driver.
Safe Torque OFF inputs	2 x dedicated, non-isolated STO digital inputs (3.3 V and 5 V tolerant).
Motor temperature input	1 x dedicated, 5 V, 12-bit, single-ended analog input for measuring motor temperature. NTC, PTC, RTD, Linear Voltage Sensors , Silicon Based Sensors and Switches are supported.

Protections	• Hardcoded / hardwired Drive protections:
	    • Automatic current derating on voltage, current and temperature
	    • Short-circuit Phase to DC bus
	    • Short-circuit Phase to Phase
	    • Short-circuit Phase to GND
	• Configurable protections:
	    • DC bus over-voltage
	    • DC bus under-voltage
	    • Drive over-temperature
	    • Drive under-temperature
	    • Motor over-temperature (requires external sensor)
	    • Current overload (I^2t). Configurable up to Drive limits
	    • Voltage mode over-current (with a closed current loop, protection effectiveness depends on the PID).
	• Motion Control protections:
	    • Halls sequence / combination error (Pending implementation)
	    • Limit switches
	    • Position following error
	    • Velocity / Position out of limits

4.2.4. Communication for Operation

MCB	Proprietary Motion Control Bus protocol based on SPI.

4.2.5. Environmental Specifications

Part number →	**Industrial** **(EVE-CORE)**	**Extended** **(EVE-CORE-E)**
Environmental test methods	IEC 60068-2	MIL-STD-810G

Case temperature (Operating)	-20 °C to +85 °C Check derating in Thermal and Power Specifications below.	-40 °C to +85 °C Check derating in Thermal and Power Specifications below.
Case temperature (Non-Operating)	-40 °C to +100 °C	-50 °C to +100 °C
Thermal Shock (Operating)	25 °C to 60 °C in 25 min	-40 °C to 70 °C within 3 min
Maximum Humidity (Operating)	up to 95%, non-condensing at 60 °C	up to 95%, non-condensing at 70 °C
Maximum Humidity (Non-Operating)	up to 95%, non-condensing at 85 °C	up to 95%, non-condensing at 85 °C
Altitude (Operating)	-400 m to 2000 m	
Vibration (Operating)	5 Hz to 500 Hz, 4/5 g	20 Hz to 2000 Hz, 14.6 g
Mechanical Shock (Operating)	±15g Half-sine 11 msec	±20g Half-sine 11 msec
Mechanical Shock (Non-Operating)	±15g Half-sine 11 msec	±40g Half-sine 11 msec
Isolation between aluminum case and live circuits	Basic insulation according to IEC 61800-5-1. > 200 MΩ. Measured between PE (case) and GND_P and +SUP and phases. Note: The drive includes 2 nF EMC capacitance between the power supply negative (GND_P) and the enclosure (PE).	

4.2.6. Reliability Specifications

MTBF	> 650.000 h Based on FIDES method for Standard Life Profile at 40 °C average. Other scenarios available on demand.

4.2.7. Mechanical Specifications

Aluminum case	Yes (connectors side open). Minimum wall thickness > 0.75 mm.
Horizontal dimensions	34.5 mm x 26 mm

Height	10.4 mm (case) 17 mm (including full length of the power pins)
Weight	16 gr

4.2.8. Compliance

Part number →	**Industrial** **(EVE-CORE)**	**Extended** **(EVE-CORE-E)**
EC Directives	**CE Marking** • **LVD:** Low voltage directive (2014/35/EU) • **EMC:** Electromagnetic Compatibility Directive (2014/30/EU) • **Safety:** Machinery Directive (2006/42/EC) • **RoHS 3:** Restriction of Hazardous Substances Directive (2011/65/UE + 2015/863/EU)	
Electromagnetic Compatibility Standard	**Electromagnetic Compatibility (EMC)** • IEC 61800-3:2017 • IEC 61000-6-2:2016	
Functional Safety Standard	**Safe Torque Off (STO)** • IEC 61800-5-2:2016 : **SIL3** • IEC 61508:2010 : **SIL3** • EN ISO 13849-1:2015 : **PLe** Cat. 3	
Safety Standard	**Safety** • UL 61800-5-1: Adjustable Speed Electrical Power Drive Systems - Safety Requirements - Electrical, Thermal and Energy • IEC/EN 61800-5-1: Adjustable speed electrical power drive systems - Safety requirements - Electrical, thermal and energy	

Environmental Test methods	**Environmental Testing** IEC 60068-2: • IEC 60068-2-1:2007: Test Ad, Cold • IEC 60068-2-2:2007: Test Be, Dry Heat • IEC 60068-2-38:2009: Test Z/AD, Composite temperature / humidity cyclic • IEC 60068-2-78:2012: Test Cab, Damp heat, steady state • IEC 60068-2-6:2007: Test Fc: Vibration (sinusoidal) • IEC 60068-2-27:2008: Test Ea: Shock	**Environmental Testing** MIL-STD-810G: • Test Method 501.5: High temperature • Test Method 502.5: Low Temperature • Test Method 503.5: Temperature Shock • Test Method 514.6: Vibration • Test Method 516.6: Shock • Test Method 507.5: Humidity

4.3. Thermal and Power Specifications

4.3.1. Standby power consumption

The following table shows the standby power consumption when the Everest power stage is disabled, no feedbacks or I/Os are connected. At this point the power consumption comes from the 5 V supply input only. The table also shows the "active standby" dc bus power consumption when the power stage is enabled, motor current is set to 0 and housing temperature is kept at 50 ºC.

Power supply voltage	**Standby 5 V logic supply power consumption**	**Power stage DC bus consumption switching at 0 current**			
		10 kHz	**20 kHz**	**50 kHz**	**100 kHz**
12 V	0.90 W (logic supply consumption does not depend on bus voltage)	0.13 W	0.19 W	0.35 W	0.62 W
24 V		0.17 W	0.25 W	0.48 W	0.86 W
48 V		0.29 W	0.46 W	0.95 W	1.77 W
60 V		0.37 W	0.61 W	1.29 W	2.44 W
72 V		0.46 W	0.78 W	1.71 W	3.25 W

4.3.2. Thermal model

The Everest Core is designed to be mounted on a cooling plate or heatsink to achieve its maximum ratings. In order to calculate the heatsink requirements, the power dissipation can be estimated below.

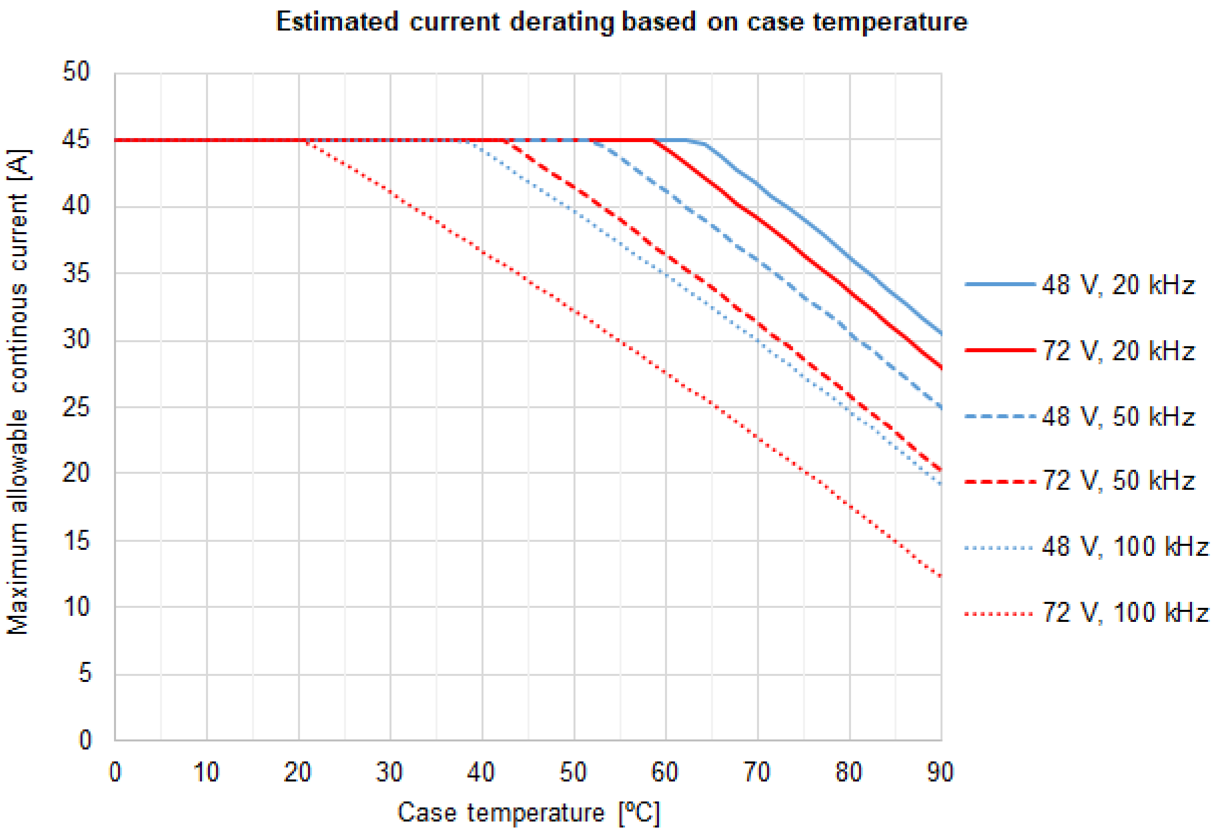
In some low power applications, the Everest can be NOT mounted to any heatsink. In this case its thermal resistance from housing/case to ambient $\mathbf{R_{th(h\text{-}a)}}$ can be estimated between 8 K/W, to 12 K/W assuming 10 cm clearance to allow air convection at sea level. A good thermal design of the PCB providing big thermal ground planes on the contact areas can greatly increase the heat dissipation and reduce $R_{th(h\text{-}a)}$ significantly.

4.3.3. Current derating

The following figure show the maximum motor phase current at different case temperatures and operating points. As can be seen lower temperature, bus voltage or PWM frequency allows higher current due to lower heat dissipation. For highest current, Everest can be configured at 10 kHz PWM frequency, however this may not be suitable for low inductance motors or acoustic noise sensitive applications. The graph expresses the achievable current including the derating algorithm that limits the current based operation conditions and the power stage temperature.

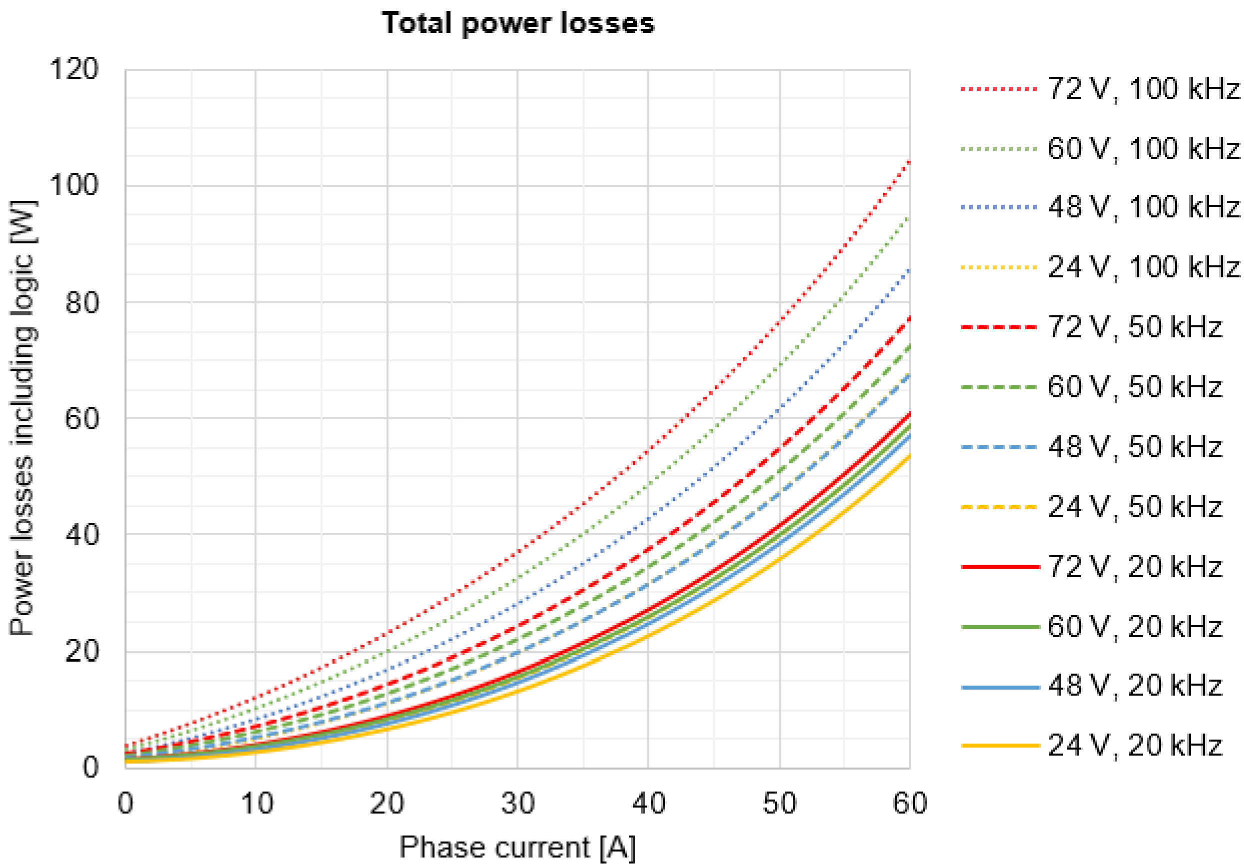
Notice that current is expressed in crest value for a 3 phase BLAC motor. For further clarifications and conversion to equivalent RMS values please refer to Disambiguation on current values and naming for Ingenia Drives.

To ensure a proper performance of Everest XCR, the **case temperature should be held always below 85 ºC (T_{c-max} = 85 ºC).**



4.3.4. Heat dissipation and heatsink calculation

Following figure show the total power losses at different operating points. This includes logic supply which is an important contributor at low loads. As can be seen, lower PWM frequency and voltage leads to lower power losses.



Please, use the following procedure to determine the required heatsink:

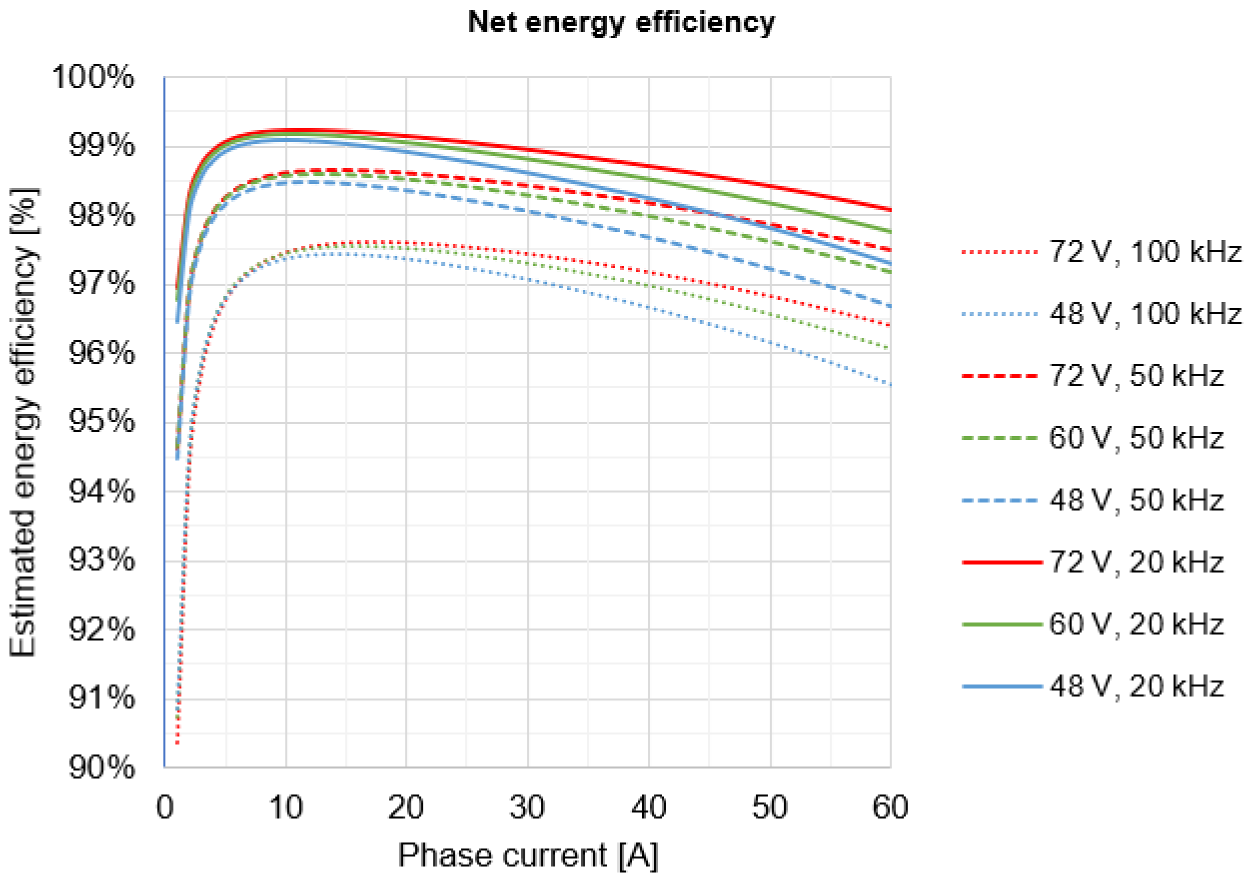
1. Based on the voltage & continuous (averaged) current required by your application and Current derating graph determine the Case temperature $\mathbf{T_c}$. Remember that Case temperature must be always below 85 °C (T_c < 85 °C)
    a. For example: If the application requires 30 A @ 72 V (20 kHz) the T_c will be 85 °C
2. Based on the voltage & continuous current required by your application and Power losses graph determine the generated Power Losses $\mathbf{P_L}$ to be dissipated.
    a. For example: If the application requires 30 A @ 72 V (20 kHz) the P_L will be 25 W
3. Determine the Thermal impedance of the used thermal sheet $\mathbf{R_{th(c\text{-}h)}}$
    a. For example, a thermal sheet TGX-150-150-0.5-0, which has an estimated thermal impedance of $R_{th(c\text{-}h)}$ = 0.2 K/W
4. Based on the ambient temperature and using the following formula determine the maximum thermal impedance to air of the required heatsink $\mathbf{R_{th(h\text{-}a)}}$

$$R_{th(h-a)} \leq \frac{T_c + P_L \cdot R_{th(c-h)} - T_a}{P_L}$$

    a. For example: If the application requires 30 A @ 72 V (20 kHz) working at T_a = 25 °C and we use a thermal sheet with $R_{th(c\text{-}h)}$ = 0.2 K/W the required thermal impedance of the heatsink will be $R_{th(h\text{-}a)}$ = 2.6 K/W

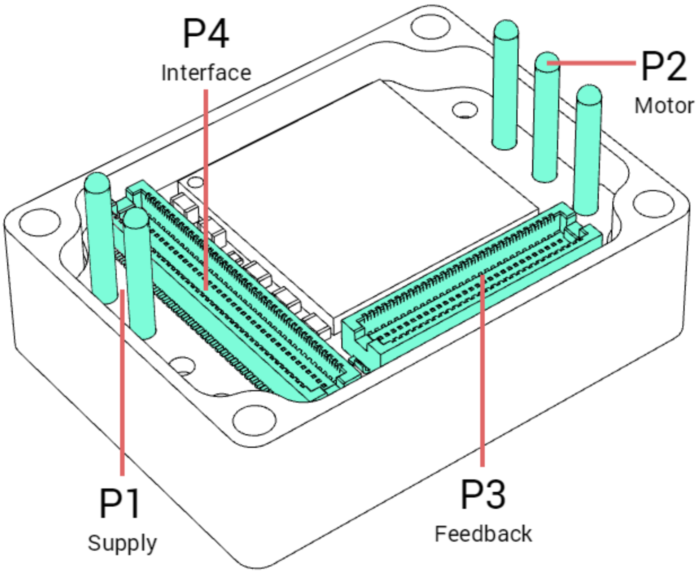
4.3.5. Energy efficiency

The following graph shows the **net energy efficiency including logic** for various operation points assuming 50°C case temperature and maximum output power. Very high efficiencies > 99% can be achieved at 10 kHz or 20 kHz PWM frequencies.

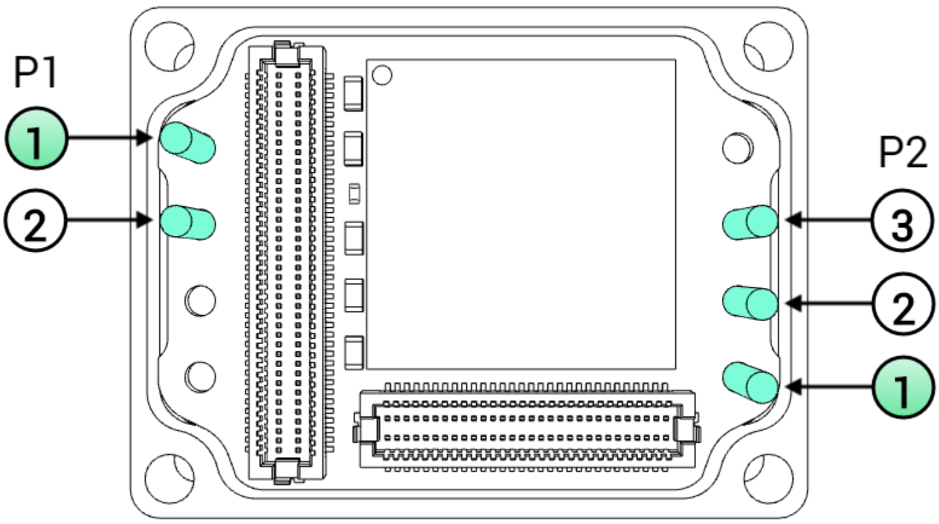


5. Pinout

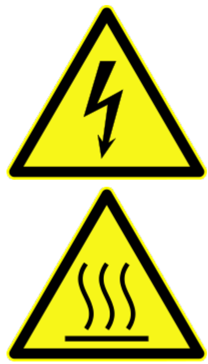
5.1. Connectors Overview



5.2. P1 and P2 Power pins



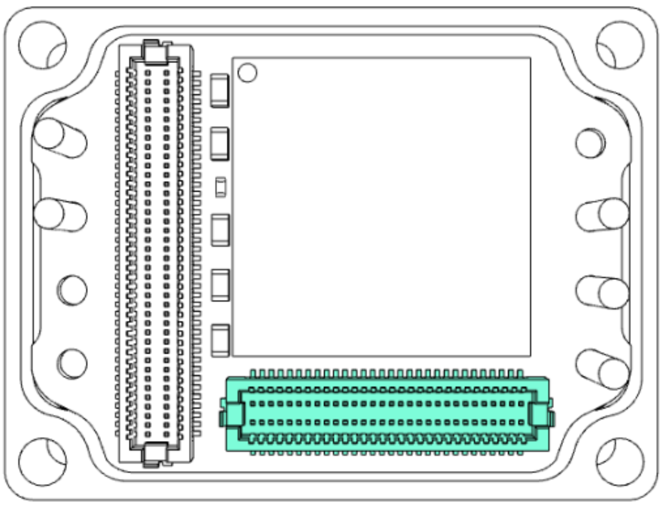
P1 Supply Power pins				
Pin	**Name**	**Type**	**Function**	**WARNING, POWER TERMINALS!**
1	POW_SUP	Power	Power supply positive (DC bus).	 Power pins can have high voltages > 50 V, always respect clearance and creepage requirements (Typ > 0.25 mm)! Dimension PCB traces and connectors according to the current of the application!
2	GND_P		Power supply negative (Power Ground).	
Chassis	PE		Protective Earth connected to driver housing and fixing M2.5 threads.	Ensure basic insulation (Min > 0.5 mm) between protective earth and other live circuits.

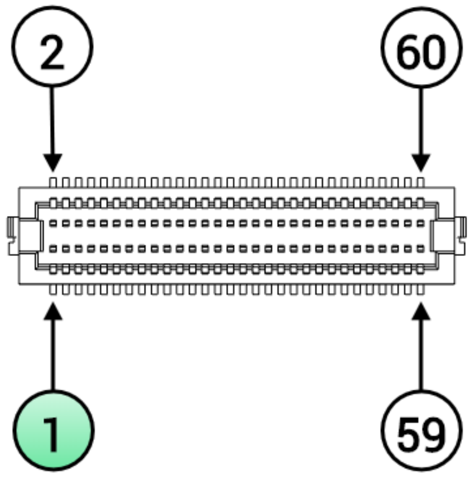
P2 Motor Power pins				
Pin	**Name**	**Type**	**Function**	**WARNING, POWER TERMINALS!**
1	PH_A	Power	Motor phase A for 3-phase motors, positive for DC motors.	 Power pins can have high voltages > 50 V, always respect clearance and creepage requirements (Typ > 0.25 mm)! Dimension PCB traces and connectors according to the current of the application!
2	PH_B		Motor phase B for 3-phase motors, negative for DC motors.	
3	PH_C		Motor phase C for 3-phase motors (do not connect for DC motors).	
Chassis	PE		Protective Earth connected to driver housing and fixing M2.5 threads.	Ensure basic insulation (Min > 0.5 mm) between protective earth and other live circuits.

Everest CORE connector	Recommended mating contact	Description
	Up to 11.2 A_{RMS} rated motors	
Ø 1.52 mm, 4 mm pitch, gold plated power pins.		Beryllium copper TH pin receptacle. Gold plated.
	Mill-Max 9372-0-15-15-23-27-10-0	
	> 11.2 A_{RMS} rated motors	
	Direct solder to PCB. TH pad with min. hole Ø 1.63 mm. Ensure PCB track are wide enough to withstand the target current.	

5.3. P3 Feedback connector

The pinout of the Feedback connector is exactly the same for for Everest CORE (EVE_CORE) and **Everest NET** (EVE_NET) although **the position of the connector is different**.





P3 Feedback connector							
#	Signal name	Description	Type	#	Signal name	Description	Type

1	GND_A	Analog Ground. Internally connected to GND_D using a ferrite bead. Do not connect in your board if analog signals are not used. If analog signals are used, do not connect to GND_D directly, use a ferrite bead or 1 Ω resistor in between. Use the GND_A as the reference ground for your analog circuits.	Power	**2**	GND_A	Analog Ground. Internally connected to GND_D using a ferrite bead. Do not connect in your board if analog signals are not used. If analog signals are used, do not connect to GND_D directly, use a ferrite bead or 1 Ω resistor in between. Use the GND_A as the reference ground for your analog circuits.	Power
3	DNC	Reserved. Do not connect (leave floating).	-	**4**	AN1_P	Analog input for torque sensing.	16 bit differential analog input
5	DNC			**6**	AN1_N		
7	DNC			**8**	DNC	Reserved. Do not connect (leave floating).	-
9	DNC			**10**	DNC		
11	DNC			**12**	DNC		
13	MOTOR_TEMP	Motor temperature sensor input. 0 V to 5 V level high impedance input.	12 bit single-ended analog input	**14**	DNC		
15	GND_D	Digital signal Ground.	Power	**16**	NC	Internally not connected. Recommended to leave them unconnected.	
17	HALL_1	Digital hall 1.	Input, 3.3 V level single ended.	**18**	NC		

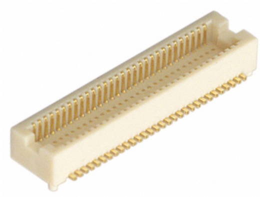
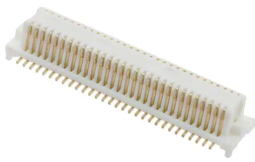
19	HALL_2	Digital hall 2.		**20**	GND_A	Analog Ground. Internally connected to GND_D using a ferrite bead. Do not connect in your board if analog signals are not used. If analog signals are used, do not connect to GND_D directly, use a ferrite bead or 1 Ω resistor in between. Use the GND_A as the reference ground for your analog circuits.	Power
21	HALL_3	Digital hall 3.		**22**	GND_D	Digital signal Ground.	
23	CLL	Reserved. Must be tied or pulled-down to GND_D.	-	**24**	DIG_ENC_1A	Digital encoder 1 A.	Input, 3.3 V level single ended.
25	CHL	Reserved. Must be tied or pulled-up to 3.3 V.		**26**	DIG_ENC_1B	Digital encoder 1 B.	
27	CLL	Reserved. Must be tied or pulled-down to GND_D.		**28**	DIG_ENC_1Z	Digital encoder 1 Index.	
29	CHL	Reserved. Must be tied or pulled-up to 3.3 V.		**30**	DIG_ENC_2A	Digital encoder 2 A.	

31	DNC	Reserved. Do not connect (leave floating).		**32**	DIG_ENC_2B	Digital encoder 2 B.	
33	DNC			**34**	DIG_ENC_2Z	Digital encoder 2 Index.	
35	DNC			**36**	GND_D	Digital signal Ground.	Power
37	DNC			**38**	ABSENC1_CLK	Clock output for Absolute Encoder 1.	Output
39	DNC			**40**	ABSENC1_DATA	Data input for Absolute Encoder 1 (supports SSI or up to 2 BiSS-C encoders connected in daisy chain topology).	Input
41	DNC			**42**	DNC	Reserved. Do not connect (leave floating).	-
43	DNC			**44**	GND_D	Digital signal Ground.	Power
45	DNC			**46**	DNC	Reserved. Do not connect (leave floating).	-
47	DNC			**48**	DNC		
49	DNC			**50**	DNC		
51	DNC			**52**	DNC		
53	DNC			**54**	DNC		
55	DNC			**56**	DNC		
57	DNC			**58**	DNC		
59	GND_D	Digital signal Ground.	Power	**60**	GND_D	Digital signal Ground.	Power

Notes and naming conventions:

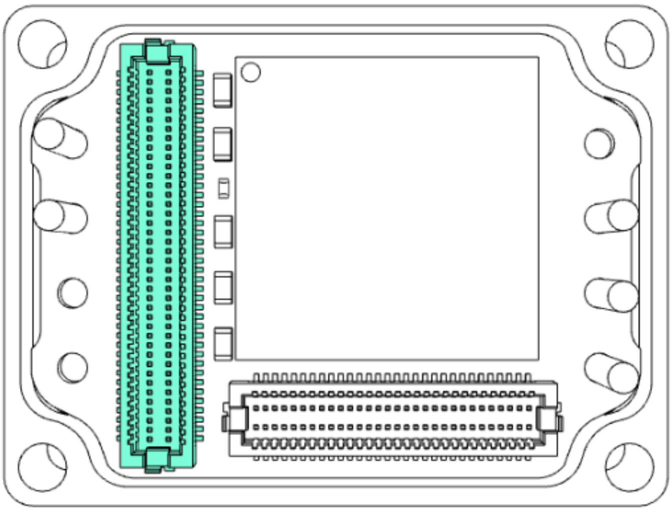
- All pins are tolerant to 3.3 V unless otherwise noted.
- Unused digital outputs should be left unconnected.
- Unused digital inputs should be connected to GND_D.

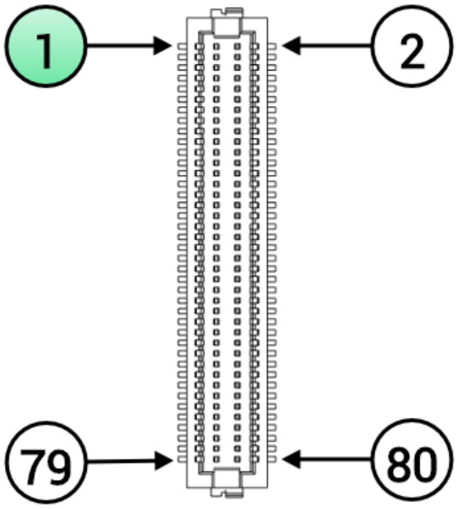
- Unused analog inputs should be connected to 1.65V_REF.
- "_P" and "_N" indicates positive and negative of differential signals
- "\" Indicates inverted (active low) signal
- "NC" means Not Connected. Pins marked with NC can be tied to GND or 3.3 V, but best practice is to leave them unconnected.
- "DNC" means Do Not Connect. Pins marked with DNC must not be tied to any driving voltage, including GND or 3.3 V.
- "CLL" means Connect to Low Level. Pins marked with CLL must be tied or pulled-down to 0 V.
- "CHL" means Connect to High Level. Pins marked with CHL must be tied or pulled-up to 3.3 V.

Manufacturer	Everest CORE connector	Required mating connector	Description
Hirose Electric			60-pin mezzanine stacking board connector. 0.5 mm pitch. Center strip, gold-plated surface mount contacts. 3 mm stacking height. Hirose DF12 connectors operation and storage temperature when mounted is -45°C to 125°C.
	DF12(3.0)-60DP-0.5V(86)	DF12(3.0)-60DS-0.5V(86)	

5.4. P4 Everest CORE Interface connector

Although using the same physical connector as Everest NET (EVE-NET), position and pinout is different in Everest CORE (EVE-CORE).





P4 Everest CORE Interface connector							
#	Signal name	Description	Type	#	Signal name	Description	Type

1	GND_D	Digital signal Ground.	Power	**2**	GND_D	Digital signal Ground.	Power
3	5V_D	5 V, 300 mA continuous logic supply input. Must be low ripple and ensure ±2% regulation tolerance or less. It is advised to connect all four 5V_D pins. It is recommended to provide at least 500 mA input current if pins 9 or 10 (3.3V_D) are used to drive external circuits. The rise time of the 5 V supply must be between 2 ms and 10 ms to guarantee a proper initialization.	Power input	**4**	5V_D	5 V, 300 mA continuous logic supply input. Must be low ripple and ensure ±2% regulation tolerance or less. It is recommended to connect all four 5V_D pins. It is advised to provide at least 500 mA input current if pins 9 or 10 (3.3V_D) are used to drive external circuits. The rise time of the 5 V supply must be between 2 ms and 10 ms to guarantee a proper initialization.	Power input
5	5V_D			**6**	5V_D		
7	GND_D	Digital signal Ground.	Power	**8**	GND_D	Digital signal Ground.	Power
9	3.3V_D	3.3 V, 250 mA max. output to supply peripherals. An excessive current demand on this pin could cause failure or even permanent damage to the Everest CORE.	Power output	**10**	3.3V_D	3.3 V, 250 mA max. output to supply peripherals. An excessive current demand on this pin could cause failure or even permanent damage to the Everest CORE.	Power output
11	GND_D	Digital signal Ground.	Power	**12**	GND_D	Digital signal Ground.	Power
13	GND_D			**14**	MCB_SPI_MISO	Motion Control Bus, Master input Slave output	Output
15	GND_D			**16**	MCB_SPI_MOSI	Motion Control Bus, Master output Slave input	Input
17	GND_D			**18**	\MCB_SPI_CS	Motion Control Bus, Chip Select input	
19	GND_D			**20**	MCB_SPI_CLK	Motion Control Bus, Clock input	
21	GND_D			**22**	MCB_SYNC0	Motion Control Bus, synchronization signal 0	
23	GND_D			**24**	MCB_SYNC1	Motion Control Bus, synchronization signal 1. It is strongly suggested to pull-up this signal to 3.3V with a 10 kΩ resistor.	Output
25	GND_D			**26**	MCB_IRQ	Motion Control Bus, interrupt request output. Add a pull-down resistor 10 kΩ to this pin.	

27	GND_D			**28**	DNC	Reserved. Do not connect (leave floating).	-
29	NC	Internally not connected. Recommended to leave them unconnected.	-	**30**	GND_D	Digital signal Ground.	Power
31	NC			**32**	GND_D		
33	\STO1	Safe Torque Off input 1 (non-isolated). Both \STO1 and \STO2 must be high-level (3.3 V and 5 V level compatible) to allow operation of the motor. Holding different logic states (STO1 ≠ STO2) for more than 1s will cause a latching fault.	Input	**34**	\STO2	Safe Torque Off input 2 (non-isolated). Both \STO1 and \STO2 must be high-level (3.3 V and 5 V level compatible) to allow operation of the motor. Holding different logic states (STO1 ≠ STO2) for more than 1s will cause a latching fault.	Input
35	DNC	Reserved. Do not connect (leave floating).	-	**36**	DNC	Reserved. Do not connect (leave floating).	-
37	FAULT_SIGNAL	Fault state signalling output. Can directly drive a (typically) red LED anode at 3.3 V up to 3 mA.	Output	**38**	\HW_RESET	Everest CORE reset input. Keeps the motion controller disabled with low power consumption. A minimum low-level pulse of 100 µs is needed for resetting Everest CORE. 2 kΩ pull-up to 3.3 V is internally included.	Input
39	GND_D	Digital signal Ground.	Power	**40**	DNC	Reserved. Do not connect (leave floating).	-
41	\EXT_FAULT	External fault input. Could be configured to force the Everest CORE state-machine to the Fault state (motor will be stopped) when the pin is driven to 0 V. Includes an internal weak pull-up, although external pull-up to 3.3 V is advised.	Input	**42**	PWM_BRAKE	PWM output for driving a mechanical brake. Configurable up to 20 kHz. High logic level indicates the motor is free to move and brake is released. Add a 10 kΩ ~ 47 kΩ pull-down resistor to this pin to ensure the brake is always on the safe state during boot-up or reset situations when this pin might be in high impedance.	Output
43	GPO4	Digital Output 4.	Output	**44**	DNC	Reserved. Do not connect (leave floating).	-
45	DNC	Reserved. Do not connect (leave floating).	-	**46**	DNC		
47	GPI1	Digital Input 1.	Input	**48**	DNC		
49	GPI2	Digital Input 2.		**50**	ABSENC2_CLK	Clock output for Absolute Encoder 2.	Output

51	ABSENC2_DATA	Data input for Absolute Encoder 2 (supports SSI only)		**52**	DNC	Reserved. Do not connect (leave floating).	-
53	GPI3	Digital Input 3.		**54**	DNC		
55	GPO1	Digital Output 1.	Output	**56**	GPO2	Digital Output 2.	Output
57	GPO3	Digital Output 3.		**58**	GPI4	Digital Input 4.	Input
59	GND_D	Digital signal Ground.	Power	**60**	GND_D	Digital signal Ground.	Power
61	DNC	Reserved. Do not connect (leave floating).	-	**62**	DNC	Reserved. Do not connect (leave floating).	-
63	DNC			**64**	DNC		
65	DNC			**66**	DNC		
67	GND_D	Digital signal Ground.	Power	**68**	GND_D	Digital signal Ground.	Power
69	NC	Internally not connected. Recommended to leave them unconnected.	-	**70**	NC	Internally not connected. Recommended to leave them unconnected.	-
71	NC			**72**	NC		
73	NC			**74**	NC		
75	1.65V_REF	1.65 V voltage reference output with sink/source capability up to ±10 mA. An excessive current demand or noise coupled to this pin can cause a loss of performance or even malfunction of Everest CORE: route by following the best layout practices.	Power output	**76**	NC		
77	3.3V_REF	3.3 V voltage reference output with sink/source capability up to ±10 mA. An excessive current demand or noise coupled to this pin can cause a loss of performance or even malfunction of Everest CORE: route by following the best layout practices.		**78**	DNC	Reserved. Do not connect (leave floating).	

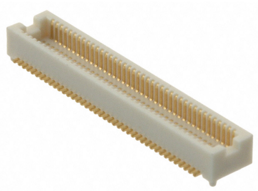
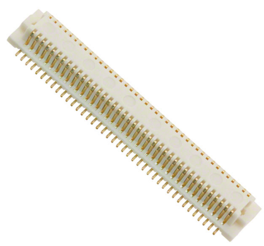
79	GND_A	Analog Ground. Internally connected to GND_D using a ferrite bead. Do not connect in your board if analog signals are not used. If analog signals are used, do not connect to GND_D directly, use a ferrite bead or 1 Ω resistor in between. Use the GND_A as the reference ground for your analog circuits.	Power	**80**	GND_A	Analog Ground. Internally connected to GND_D using a ferrite bead. Do not connect in your board if analog signals are not used. If analog signals are used, do not connect to GND_D directly, use a ferrite bead or 1 Ω resistor in between. Use the GND_A as the reference ground for your analog circuits.	Power

Notes and naming conventions:

- All pins are tolerant to 3.3 V unless otherwise noted.
- Unused digital outputs should be left unconnected.
- Unused digital inputs should be connected to GND_D.
- Unused analog inputs should be connected to 1.65V_REF.
- "_P" and "_N" indicates positive and negative of differential signals
- "\" Indicates inverted (active low) signal
- "NC" means Not Connected. Pins marked with NC can be tied to GND or 3.3 V, but best practice is to leave them unconnected.
- "DNC" means Do Not Connect. Pins marked with DNC must not be tied to any driving voltage, including GND or 3.3 V.

Motion Control Bus

Everest CORE can be controlled as a slave by means of its proprietary **Motion Control Bus** (MCB). Check how in the **Summit Series Reference Manual**.

Manufacturer	Everest CORE connector	Required mating connector	Description
Hirose Electric			80-pin mezzanine stacking board connector. 0.5 mm pitch. Center strip, gold-plated surface mount contacts. 3 mm stacking height. Hirose DF12 connectors operation and storage temperature when mounted is -45°C to 125°C.
	DF12(3.0)-80DP-0.5V(86)	DF12(3.0)-80DS-0.5V(86)	

6. Safe Torque Off (STO)

The Safe Torque Off (STO) is a functional safety system that prevents motor torque in an emergency event while Everest CORE remains connected to the power supply. When STO is activated, the power stage is disabled by hardware and the drive power transistors are disconnected, no matter what control or firmware does. The motor shaft will slow down until it stops under inertia and frictional forces. Although not common, in the event of a failure of the power stage during an STO situation, the maximum expected motor movement with torque can be up to 180º electrical degrees. The system must be designed to avoid any hazard in this situation.

If the STO inputs are not energized, the transistors of the power stage are turned off and an STO fault is notified. In order to activate the power stage, and therefore allow the motor operation, the two STO inputs must be energized (high level, typically 5V). STO inputs should not be confused with a digital input configured as enable input, because enable input is firmware controlled and does not guarantee intrinsic safety as it can be reconfigured by a user.

In order to ensure redundancy and safety, the Everest CORE includes 2 separate STO inputs that must be activated or deactivated simultaneously (maximum 1.4 s mismatch). A difference of state between \STO1 and \STO2 inputs will be interpreted as an abnormal situation after 1.4 s the drive will be latched in a fault state. **A power supply reset is necessary to remove this STO abnormal error.**

Since Everest CORE is apluggable module intended for being integrated on an electronic interface board, **it requires some external electronic compoments to fulfil the safety requirements:**

- An **external overvoltage protection (or equivalent) is required to limit STO input voltage.**
- **Input current limiter** to avoid system destruction in case of internal fault. The current limit can be implemented with a resistor in series.
- **Input low-state must be guaranteed by means of a pull-down resistor** or equivalent (active output). Otherwise, safety function fault tolerance and reaction times, won't be fulfilled.

6.1. Safety Function Specifications

Safety Function Specification	Value	
Standards compliance	**Targeted standards (certification pending):** • IEC 61800-5-2:2016 • IEC 61508:2010 • EN ISO 13849-1:2015	
Safety function	Safe Torque Off (STO)	
Safety relevant parameters according to IEC 61508:2010 ***(certification pending)***	Safety integrity level	SIL3
	PFH	1.22×10^{-12} 1/h
	SFF	> 99 % (High)

Safety Function Specification	Value	
Safety relevant parameters according to EN ISO 13849-1:2015 ***(certification pending)***	PL	e
	Category	3
	DC	99% High
	MTTFd	≥ 100 years (High)
Safety Function Reaction Time	t < 4.8 ms The Safety Function Reaction time is measured as the time since one of the STO inputs (STO1 or STO2) goes below 0.8 V and the STO function actuates (power transistors deactivated).	
Fault Reaction Time	t< 4.8 ms The worst-case fault reaction time is on the event of an Abnormal STO.	
High-demand mode	The EUC (Equipment Under Control) is considered as a high-demand or continuous demand mode system.	
Mission Time	The mission time of the EUC is of 20 years.	
Diagnostic Time Interval	In order to guarantee the correct operation of the safety functions, the user has to check the STO function regularly, performing an STO External Diagnostic Test (see further information below). The diagnostic test interval is defined as a minimum of 1 activation per 3 months.	

6.2. Integration Requirements

Integration Requirement	Value	
STO Interface electrical characteristics	Input pins	\STO1 and \STO2
	Number of independent channels	2
	Type of Inputs	Digital inputs with ESD protection. Maximum nominal Voltage 7V. Maximum voltage in case of an external overvoltage fault 12 V.

	Mandatory External Requirements	▪ Input current limit (in case of internal short-circuit) = 50 mA ▪ Resistive pull-down of maximum 7.5 kΩ or equivalent (active output with 660 µA min current sink capability). ▪ Overvoltage protection on \STO signals, limiting to 12V in case of external fault.
	Maximum input LOW level (VIL)	0.8 V (below this value the STO is ACTIVE, no torque can be applied to the motor)
	Minimum Input HIGH level (VIH)	2.5 V (above this value the STO input is inactive, torque can be applied to the motor)
	Maximum absolute ratings	7 V max nominal voltage; 12V maximum failure voltage
	Input current (externally limited)	50 mA
	ESD capability	IEC 61000-4-2 (ESD) ± 15 kV (air), ± 8 kV (contact)
STO Interface timing characteristics	STO activation time (Safety function Reaction Time)	t < 4.8 ms
	STO deactivation time	t < 2ms
	Minimum, non-detected STO short pulse	t < 400 µs The Safety controller can transmit short pulses to STOx inputs for diagnostics purposes. These pulses will be ignored by the safety circuit and will not stop the power stage but can be read from firmware for system diagnostics, see: Drive protections Register 0x51A.
	Abnormal STO diagnostic time	≤ 4.8 ms (Activation STO)
	Abnormal STO latching time	1.4 s ~ 3.4 s (Latching state, permanent activation of STO until power reset)
	Power supply diagnostic time	3.3 V over-voltage 200 ns
Logic Supply Voltage Range	5 V ± 3% (range from 4.85 V to 5.15 V; maximum failure voltage 26.4 V). During the overvoltage fault system becomes unoperational, but safety function is maintained.	
Power Supply Voltage Range [1]	48 V SELV (range from 8V to 60V; maximum failure voltage 60 V)	
Motor Type	STO safety function is only considered when the drive is controlling **three-phase permanent magnet synchronous rotating motors.** STO does not apply to DC brush motors.	

Uncontrolled Motor Movement	**Uncontrolled Motor Movement** In the event of a failure in the power stage, **the motor shaft may rotate up to 180° electrical degrees.** It is responsibility of the customer to prevent any hazards related ot this unexpected motor movement.	
Environmental Conditions for STO	Pollution degree	Pollution degree 2 with an IP54 enclosure installation.
	Over-voltage category	II
	Altitude	< 2000 m above sea level.
Temperature range for STO [2]	Operating Temperature	-20°C to 50 °C
	Storage Temperature	-40°C to 100°C
Diagnostics	Internal power supply voltage monitors. Differences between STO1 and STO2 cause abnormal fault. After 1.4 s a hardware latching condition disables the drive until power cycling. Status of STO1, STO2, STO_REPORT, ABNORMAL_FAULT, and SUPPLY_FAULT can be read from the communications. **STO firmware notification** A STO stop is notified to the motion controller and creates a fault that can be read externally from any communication interface, however, STO operation is totally independent and decoupled from control or firmware.	
EMC	The interface board must meet the following EMC standards: • IEC 61800-3:2017 • IEC 61000-6-2:2016 To fulfill the EMC requirements the use of the following elements is required: Input EMI filter. Recommended: TE Connectivity 30EMC6 or equivalent. Motor phases ferrite cable core. Recommended : 28B0773-050 or equivalent. Properly grounded aluminum enclosure. See grounding recommendations for further information.	

Environmental	The interface board must meet the following environmental standards: • IEC 60068-2-1:2007 • IEC 60068-2-2:2007 • IEC 60068-2-38:2009 • IEC 60068-2-78:2012 • IEC 60068-2-6:2007 • IEC 60068-2-27:2008

1: Although the drive can operate in a wider range of voltages as can be seen in Product Description, the system cannot be considered safe outside this range.

2: The drive can operate outside this temperature range as indicated in the Product Description, however, the system cannot be considered safe as the system reliability and safety margins would not meet the standards.

6.3. STO External Diagnostic Test

The operation of the STO diagnostic circuits must be verified at least once per 3 months. The following procedure details a method to verify the correct operation of the STO diagnostic circuits. Note that it is responsibility of the customer to prevent any hazards related to motor movement during this proof test.

The procedure requires the Everest CORE to be connected to a brushless motor.

Procedure Step	Action
1	Power on the Everest CORE with STO1 = low, STO2 = low.
2	Try to perform a "Motor Enable" (using Motionlab 3 or network commands).
3	Verify that the power stage is not enabled by software (a fault should appear) or by hardware (checking the Motor phases voltage with a multimeter).
4	Provide STO1 = high, STO2 = low. Remain in this state more than 3.4 seconds.
5	Try to perform a "Motor Enable" (using Motionlab 3 or network commands).
6	Verify that the power stage is not enabled by software (a fault should appear) or by hardware (checking the Motor phases voltage with a multimeter).
7	Provide STO1 = high, STO2 = high.
9	Try to perform a "Motor Enable" (using Motionlab 3 or network commands).
10	Verify that the power stage is not enabled by software (a fault should appear) or by hardware (checking the Motor phases voltage with a multimeter).
11	Shut-down Everest CORE supply and remain in this state for more than 10 seconds.
12	Power on the Everest CORE with STO1= low, STO2 = high. Remain in this state more than 3.4 seconds.

Procedure Step	Action
13	Try to perform a "Motor Enable" (using Motionlab 3 or network commands).
14	Verify that the power stage is not enabled by software (a fault should appear) or by hardware (checking the Motor phases voltage with a multimeter).
15	Provide STO1 = high, STO2 = high.
17	Try to perform a "Motor Enable" (using Motionlab 3 or network commands).
18	Verify that the power stage is not enabled by software (a fault should appear) or by hardware (checking the Motor phases voltage with a multimeter).
19	Shut-down Everest CORE supply and remain in this state for more than 10 seconds.
20	Power on the Everest CORE with STO1= high, STO2 = high.
21	Try to perform a "Motor Enable" (using Motionlab 3 or network commands).
22	Verify that the power stage can be enabled, allowing motor rotation. Do it by software (system should enter in motor enable state) or by hardware (checking the Motor phases voltage with a multimeter).

6.4. STO Operation States

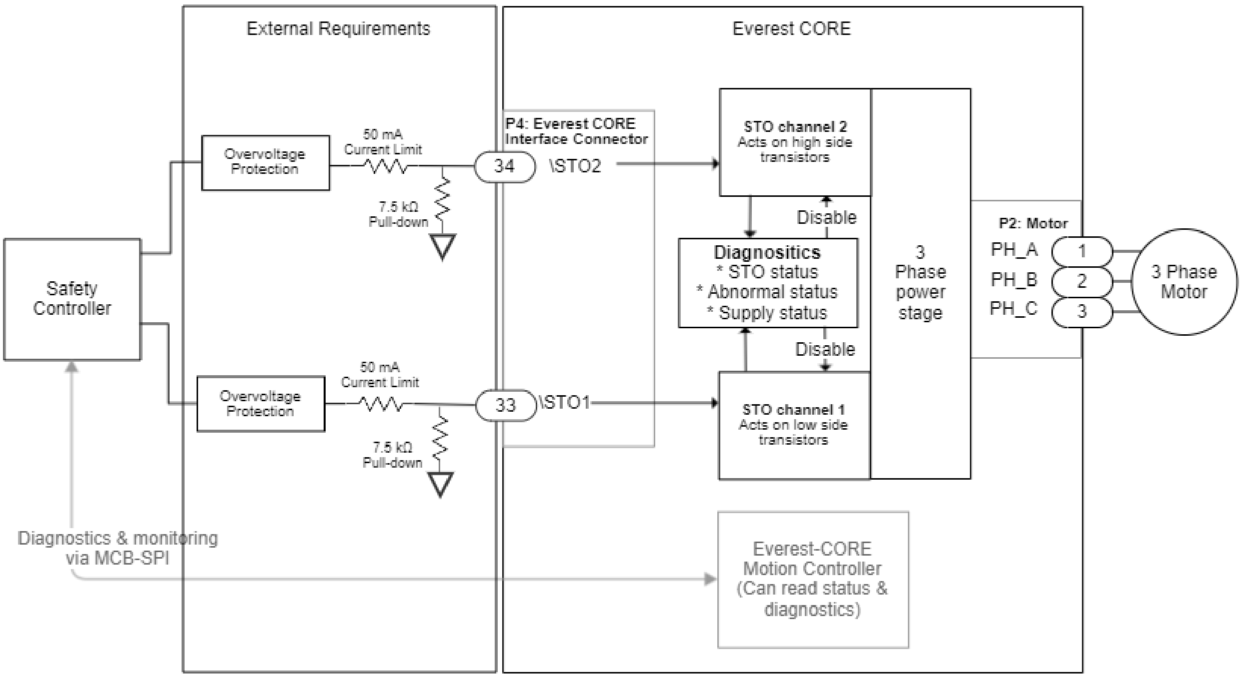
The truth table of the STO inputs is shown next indicating the different states of the system:

Mode	State	STO1 status / level		STO2 status / level		Power stage status	STO report bit status	STO abnormal fault	State description
Normal operation	**STO Enabled** (No torque to the motor)	0	< 0.8 V	0	< 0.8 V	OFF	0	0	The system logic is powered, but the STO function is activated. Therefore, no torque can be applied to the motor. STO trip is reported to the MCU and to the safety circuitry. This is intended safe torque off with dual-channel operation.

Mode	State	STO1 status / level		STO2 status / level		Power stage status	STO report bit status	STO abnormal fault	State description
	Torque enabled (STO inactive)	1	> 2.5 V	1	> 2.5 V	Can be enabled	1	0	The STO function is deactivated, and torque can be provided to the motor. The motor can run under firmware control. This is the normal operation state.
Abnormal operation	**Abnormal STO**	0	< 0.8 V	1	> 2.5 V	OFF	0	1	If any issue is detected on the dual-channel STO function (their state is different for a long period of time), an abnormal fault is active can be reported. This state avoids the application of torque to the motor. If this persists for > 1.4 s ~ 3.4 s the STO will lock in FAULT state. To reset this fault a power cycle is needed.
		1	> 2.5 V	0	< 0.8 V	OFF	0	1	
	Abnormal STO Latched	x	-	x	-	OFF	NOR (STO1, STO2)	1	After >1.4 s ~ 3.4 s of abnormal STO active, the driver will stay in this state until the power supply cycle.
	Abnormal Supply	x	x	x	x	OFF	x	x	If a voltage out of the limits is detected on the internal logic voltages, the system is conducted to a safe state, similar to power-off. Only if the safe logic voltages are recovered (usually after reparation or restart), the system can return to any other state.

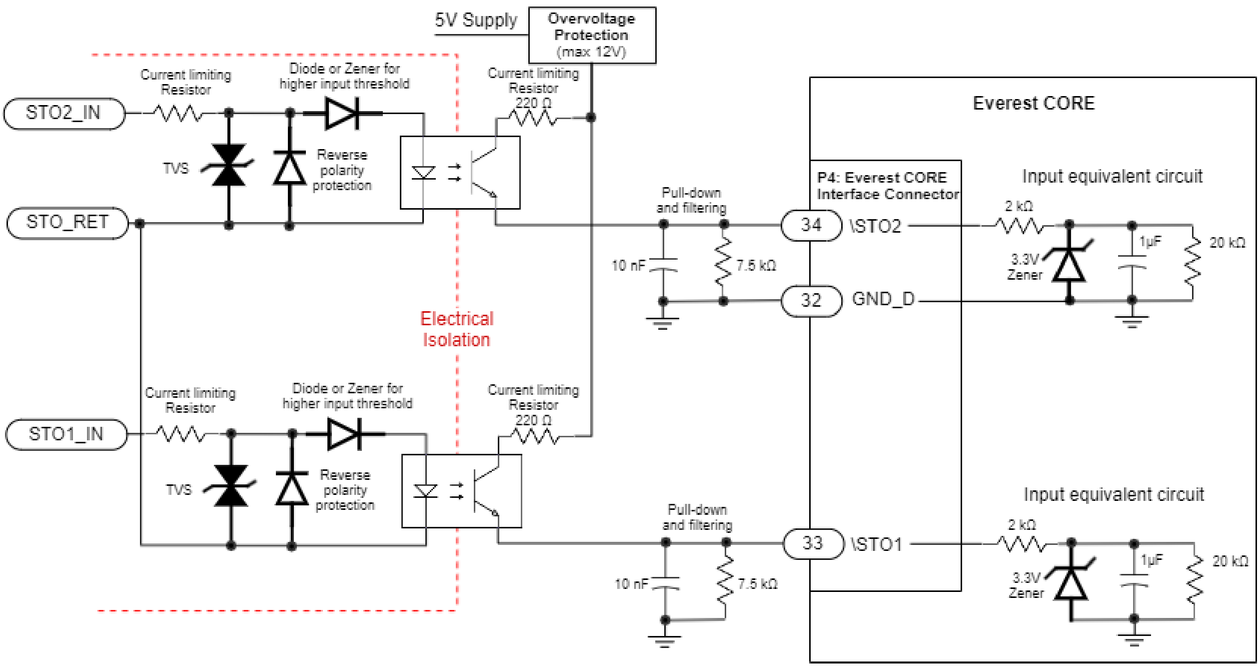
6.5. STO Inputs External Requirements

The following diagram summarizes the external requirements for the STO inputs.



6.6. Typical Interface Circuit

The following diagram shows a suggested circuit interface for the STO inputs.



STO1 and STO2 signals should always change at the same time with a maximum of 1.4 s mismatch. This is necessary to have 2 channel redundancy and allow diagnostics, as a mismatch will cause an abnormal fault.

7. Dimensions

All dimensions are in **mm**. All tolerances **≤ ±0.2 mm**

3D Model

For further detail, download the STEP model.