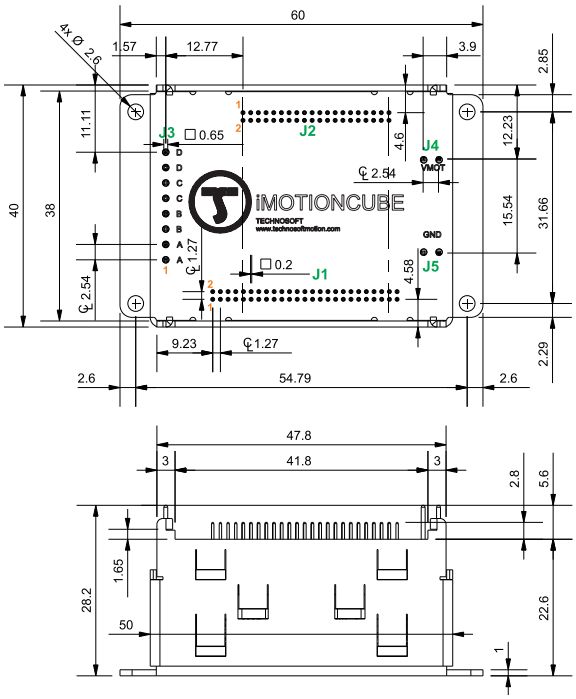

Motor – sensor configurations					
Sensor \ Motor	PMSM	BLDC	DC BRUSH	STEP (2-ph)	STEP (3-ph)
Incr. Encoder	✓		✓	✓	
Incr. Encoder + Hall	✓	✓			
Analog Sin/Cos encoder	✓				
Tacho			✓		
Open-loop (no sensor)				✓	✓

Mating connectors	
Connector	**Description**
J1	Socket 2x25 pins, 1.27x1.27mm pitch, square 0.40 mm pins
J2	Socket 2x20 pins, 1.27x1.27mm pitch, square 0.40 mm pins
J3	High-current socket 8 pins, 2.54 mm pitch, square 0.635 mm pins
J4, J5	High-current socket 2 pins, 2.54 mm pitch, square 0.635 mm pins

All dimensions are in mm.

Features

- Motion controller and drive in a single compact unit based on MotionChip ™ technology
- Universal solution for control of rotary and linear brushless, brushed and 2 or 3-phase step motors
- Advanced motion control capabilities (PVT,S-curve, electronic cam)
- Motor supply: 12-80V; Logic supply 12-36V
- Output current: 20A cont. (BLDC mode)*; 40A_{PEAK} , up to 125KHz PWM
- Feedback Devices (dual-loop support)

1st feedback devices supported:

- Incremental encoder interface (single ended or differential)
- Analogue sin/cos encoder interface (differential 1V_{pp})
- Digital Hall sensor interface (single ended and open collector)

2nd feedback devices supported:

- Incremental encoder interface (single ended)
- pulse & direction interface (single ended) for external (master) digital reference

- Separate ENABLE circuit: connect both ENA1 and ENA2 inputs to +24V, to allow motor PWM output operation
- 4 digital inputs, 5-36V, PNP/NPN programmable: 2 for limit switches, 2 general-purpose
- 4 digital outputs, 5-36V, 0.5A, NPN open-collector: Ready, Error, 2 general-purpose
- 2 analogue inputs: 12-bit, 0-5V: Reference, Feedback or general purpose
- RS-232 serial & dual RJ45 CAN connectors
- TMLCAN and CANopen (CiA 301 v4.2, CiA 305 v.2.2.13 and CiA 402 v3.0) protocols selectable by h/w axis ID pin inputs
- 127 h/w addresses in CANopen mode and 196 h/w addresses in TMLCAN mode
- 4k x 16 SRAM memory for data acquisition (default configuration) extendable up to 20k x 16
- 16k x16 E^2ROM to store setup data, TML motion programs, cam tables and other user data
- Operating ambient temperature: 0-40°C (over 40°C with derating)
- Programmable protections: short-circuit between motor phases and from motor phases to GND, over/under-voltage, over-current, I^2t, control error

* with external heat sink

Connector Description

	Pin	Name	Type	Description
J2	1..28	Reserved	-	Reserved
	29	CAN-Hi	I/O	CAN-Bus positive line (dominant high)
	30	Reserved	-	Reserved
	31	CAN-Lo	I/O	CAN-Bus negative line (dominant low)
	32	Reserved	-	Reserved
	33	+5V	O	+5V output power supply
	34	GND	-	Ground
	35..39	Reserved	-	Reserved
	40	GND	-	Ground

	Pin	Name	Type	Description
J3	1,2	A/A+	O	Phase A for 3-ph motors, A+ for 2-ph steppers, Motor+ for DC brush motors
	3,4	B / A-	O	Phase B for 3-ph motors, A- for 2-ph steppers, Motor- for DC brush motors
	5,6	C / B+	O	Phase C for 3-ph motors, B+ for 2-ph steppers
	7,8	BR / B-	O	Brake resistor / Phase B- for step motors

	Pin	Name	Type	Description
J4	1,2	$+V_{MOT}$	I	Positive terminal of the motor supply

	Pin	Name	Type	Description
J5	1,2	GND	-	Negative return (ground) of the motor supply

Connector description

J1

Pin	Name	Type	Description
1	232RX	I	RS232 data reception
2	Enc1 A+/Sin1+	I	Incr. encoder # A+ diff. input, analogue encoder #1 Sin+ diff. input.
3	232TX	O	RS232 data transmission
4	Enc1 A-/Sin1-	I	Incr. encoder #1 A- diff. input, analogue encoder #1 Sin1- diff. input
5	AxisID 0	I	Axis ID / Address input #0. Analogue input, 0-5V
6	Enc1 B+/Cos1+	I	Incr. encoder # B+ diff. input, analogue encoder #1 Cos+ diff. input.
7	AxisID 1	I	Axis ID / Address input #1. Analogue input, 0-5V
8	ENC1B-/ Cos1-	I	Incr. encoder #1 B- diff. input, analogue encoder Cos1- diff. input
9	AxisID 2	I	Axis ID / Address input #2. Analogue input, 0-5V
10	Enc1 Z+	I	Incr. encoder #1 Z+ diff. input.
11	CAN-Hi	-	CAN-Bus positive line (dominant high)
12	Enc1 Z-	I	Incr. encoder Z- diff. input
13	CAN-Lo	-	CAN-Bus negative line (dominant low)
14	Hall1	I/O	Hall 1 sensor 5V digital input
15	ENA1	I	Enable circuit input1; connect ENA1&ENA2 to +24V to activate motor operation
16	Hall2	I/O	Hall 2 sensor 5V digital input
17	ENA2	I	Enable circuit input2; connect ENA1&ENA2 to +24V to activate motor operation
18	Hall3	I	Hall 3 sensor 5V digital input
19	Ref	I	Analogue input, 12-bit, 0-5V. Used to read an analog position, speed or torque reference, or as general purpose analogue input
20	Fdbk	I	Analogue input, 12-bit, 0-5V. Used to read an analogue position or speed feedback, or as general purpose analogue input
21	+Vlog	I	Positive terminal for logic supply 9-36V_{DC}
22	+5V_{OUT}	O	5V output supply. Max. 300mA for feedback sensors and I/Os
23	IN0	I	24V digital input #0, programmable NPN or PNP, general-purpose
24	OUT0	O	24 digital output #0, NPN, general-purpose
25	IN1	I	24V digital input #1, programmable NPN or PNP, general-purpose
26	OUT1	O	24V digital output #1, NPN, general-purpose
27	IN2/LSP	I	24V digital input #2, programmable NPN or PNP, positive limit switch
28	Out2/Error	O	24V digital output #2, NPN, drive error
29	In3/LSN	I	24V digital input #3, programmable NPN or PNP type, negative limit switch
30	Out3/Ready	O	24V digital output 3, NPN type, drive ready
31	TMOT	I	Motor temperature sensor input. Analogue input, 0-3.3V
32..34	Reserved	-	Reserved
35	GND	-	Ground
36	GND	-	Ground
37-40	Reserved	-	Reserved
41	Enc2 A	I	Incr. encoder #2 A digital input, 0-5V
42	SIN2	I	Analogue encoder #2 SIN input, 0-3.3V
43	Enc2 B	I	Incr. encoder #2 B digital input, 0-5V
44	COS2	I	Analogue encoder #2 COS input, 0-3.3V
45	Enc2 Z	I	Incr. encoder #2 Z digital input, 0-5V
46	+5Vout	O	5V output supply. Max. 300mA for feedback sensors and I/Os
47..50	Reserved	-	Reserved

Electrical characteristics

All parameters measured under the following conditions (unless otherwise specified):

- Tamb = 0…40ºC, VLOG = 24 VDC; VMOT = 80VDC
- Supplies start-up / shutdown sequence: -any-
- Load current (sinusoidal amplitude / continuous BLDC, DC, stepper) = 20A

Operating Conditions		**Min.**	**Typ.**	**Max.**	**Units**
Ambient temperature[1]		0		+40	ºC
Ambient humidity	Non-condensing	0		90	%Rh
Altitude / pressure[2]	Altitude (vs. sea level)	-0.1	0 ÷ 2	2	Km
	Ambient Pressure	0 [2]	0.75 ÷ 1	10.0	atm
Storage Conditions		**Min.**	**Typ.**	**Max.**	**Units**
Ambient temperature		-40		+85	ºC
Ambient humidity	Non-condensing	0		100	%Rh
Ambient Pressure		0		10.0	atm
Mechanical Mounting		**Min.**	**Typ.**	**Max.**	**Units**
Airflow		natural convection[3], closed box			
Environmental Characteristics		**Min.**	**Typ.**	**Max.**	**Units**
Size (Length x Width x Height)	Without mating connectors	60 x 40 x 28.2			mm
		~2.36 x 1.58 x 1.11			inch
Weight	Without mating connectors	45			g
Power dissipation	Idle (no load)		3.6		W
	Operating		11		
Efficiency			98		%
Cleaning agents	Dry cleaning is recommended	Only Water- or Alcohol- based			
Protection degree	According to IEC60529, UL508	IP20			-

Logic Supply Input (+V_{LOG})			**Min.**	**Typ.**	**Max.**	**Units**
Supply voltage	Nominal values		9		36	V_{DC}
	Absolute maximum values, drive operating but outside guaranteed parameters		8		40	V_{DC}
	Absolute maximum values, surge (duration ≤ 10ms) †		-1		+45	V
Supply current	No Load on Digital Outputs	+V_{LOG} = 9V		300		mA
		+V_{LOG} = 12V		250		
		+V_{LOG} = 24V		150		
		+V_{LOG} = 36V		100		

[1] Operating temperature can be extended up to **+65ºC** with reduced current and power ratings.
[2] iMOTIONCUBE can be operated in vacuum (no altitude restriction), but at altitudes over 2,500m, current and power rating are reduced due to thermal dissipation efficiency.
[3] It is recommended to mount the iMOTIONCUBE on a metallic support using the provided mounting holes, for better reliability and reduced de-rating due to heat dissipation

Motor Supply Input (+V_{MOT})			**Min.**	**Typ.**	**Max.**	**Units**
Supply voltage	Nominal values		12	80	90	V_{DC}
	Absolute maximum values, drive operating but outside guaranteed parameters		11		94	V_{DC}
	Absolute maximum values, surge (duration ≤ 10ms)[†]		-1		95	V
Supply current	Idle			1	5	mA
	Operating		-40	±20	+40	A
	Absolute maximum value, short-circuit condition (duration ≤ 10ms)[†]				45	A
Motor Outputs (A/A+, B/A-, C/B+, BR/B-)			**Min.**	**Typ.**	**Max.**	**Units**
Nominal output current, continuous	for DC brushed, steppers and BLDC motors with Hall-based trapezoidal control				20	A
	for PMSM motors with FOC sinusoidal control (sinusoidal amplitude value)				20	
	for PMSM motors with FOC sinusoidal control (sinusoidal effective value)				14.2	
Motor output current, peak	maximum 10s		-40		+40	A
Short-circuit protection threshold	measurement range				±45	A
Short-circuit protection delay			5	10		µs
On-state voltage drop	Nominal output current; including typical mating connector contact resistance			±0.3	±0.5	V
Off-state leakage current				±0.5	±1	mA
Motor inductance (phase-to-phase)	Recommended value, for current ripple max. ±5% of full range; +V_{MOT} = 80 V	F_{PWM}				µH
		20 kHz	330			
		40 kHz	150			
		60 kHz	120			
		80 kHz	80			
		100 kHz	60			
	Minimum value, limited by short-circuit protection; +V_{MOT} = 80 V	20 kHz	120			µH
		40 kHz	40			
		60 kHz	30			
		80 kHz	15			
		100 kHz	8			
Motor electrical time-constant (L/R)	Recommended value for ±5% current measure-ment error	20 kHz	250			µs
		40 kHz	125			
		60 kHz	100			
		80 kHz	63			
		100 kHz	50			
Current measurement	FS = Full Scale accuracy			±5	±8	%FS
Digital Hall Inputs (Hall1, Hall2, Hall3)			**Min.**	**Typ.**	**Max.**	**Units**
Mode compliance			TTL / CMOS / Open-collector			
Default state	Input floating (wiring disconnected)		Logic HIGH			
Input voltage	Logic "LOW"			0	0.8	V
	Logic "HIGH"		1.8			
	Floating voltage (not connected)			4.5		
	Absolute maximum, surge (duration ≤ 1S)[†]		-10		+15	
Input current	Logic "LOW"; Pull to GND			5	3	mA
	Logic "HIGH"; Internal 1KΩ pull-up to +5		0	0	0	
Minimum pulse width			2			µs
ESD protection	Human body model		±5			kV

Digital Inputs (IN0, IN1, IN2/LSP, IN3/LSN,)[1]			**Min.**	**Typ.**	**Max.**	**Units**
Mode compliance			PNP			
Default state	Input floating (wiring disconnected)		Logic LOW			
Input voltage	Logic "LOW"		-10	0	2.2	V
	Logic "HIGH"		6.3		36	
	Floating voltage (not connected)			0		
	Absolute maximum, continuous		-10		+39	
	Absolute maximum, surge (duration ≤ 1S)[†]		-20		+40	
Input current	Logic "LOW"; pulled to GND			0		mA
	Logic "HIGH"			6	8	

Mode compliance			NPN			
Default state	Input floating (wiring disconnected)		Logic HIGH			
Input voltage	Logic "LOW"		-10		2.2	V
	Logic "HIGH"		6.3		36	
	Floating voltage (not connected)			Vlog-1		
	Absolute maximum, continuous		-10		+36	
	Absolute maximum, surge (duration ≤ 1S)[†]		-20		+40	
Input current	Logic "LOW"; Pulled to GND			6	8	mA
	Logic "HIGH"; Pulled to +24V			0		

Input frequency			0		150	kHz
Minimum pulse			3.3			µs
ESD protection	Human body model		±2			kV
Digital Outputs (OUT0, OUT1, OUT2/Error, OUT3/ Ready)			**Min.**	**Typ.**	**Max.**	**Units**
Mode compliance	All outputs (OUT0, OUT1, OUT2/Error, OUT3/Ready)		NPN 24V			
Default state	Not supplied (+V_{LOG} floating or to GND)		High-Z (floating)			
	Immediately after power-up	OUT0, OUT1	Logic "HIGH"			
		OUT2/Error, OUT3/ Ready	Logic "LOW"			
	Normal operation	OUT0, OUT1, OUT2/Error	Logic "HIGH"			
		OUT3/Ready	Logic "LOW"			
Output voltage	Logic "LOW"; output current = 0.5A				0.8	V
	Logic "HIGH", external load to +V_{LOG}			V_{LOG}		
	Absolute maximum, continuous		-0.5		36V	
Output current	Logic "LOW", sink current, continuous				0.5	A
	Logic "HIGH", leakage current; external load to +V_{LOG}; V_{OUT} = V_{LOG} max = 39V				0.2	mA
Minimum pulse width			2			µs
ESD protection	Human body model		±2			kV

[1] The digital inputs are software selectable as PNP or NPN

Encoder#1 Inputs (A/A+, A-, B/B+, B-, Z/Z+, Z)		**Min.**	**Typ.**	**Max.**	**Units**
Single-ended mode compliance	Leave negative inputs disconnected	TTL / CMOS / Open-collector			
Input voltage, single-ended mode A/A+, B/B+	Logic "LOW"			1.6	V
	Logic "HIGH"	1.8			
	Floating voltage (not connected)		4.5		
Input voltage, single-ended mode Z/Z+	Logic "LOW"			1.2	V
	Logic "HIGH"	1.4			
	Floating voltage (not connected)		4.7		
Input current, single-ended mode A/A+, B/B+, Z/Z+	Logic "LOW"; Pull to GND		2.5	3	mA
	Logic "HIGH"; Internal 2.2KΩ pull-up to +5	0	0	0	
Differential mode compliance	For full RS422 compliance, see [1]	TIA/EIA-422-A			
Input voltage, differential mode	Hysteresis	±0.06	±0.1	±0.2	V
	Common-mode range (A+ to GND, etc.)	-7		+7	
Input impedance, differential	A+ to A-, B+ to B-	4.2	4.7		kΩ
	Z+ to Z-	6.1	7.2		
Input frequency	Single-ended mode, Open-collector / NPN	0		5	MHz
	Differential mode, or Single-ended driven by push-pull (TTL / CMOS)	0		10	MHz
Minimum pulse width	Single-ended mode, Open-collector / NPN	1			µs
	Differential mode, or Single-ended driven by push-pull (TTL / CMOS)	50			ns
Input voltage, any pin to GND	Absolute maximum values, continuous	-7		+7	V
	Absolute maximum, surge (duration ≤ 1S) †	-11		+14	
ESD protection	Human body model	±2			kV
Encoder#2 Inputs (A2, B2, Z2)		**Min.**	**Typ.**	**Max.**	**Units**
Single-ended mode compliance		TTL / CMOS / Open-collector			
Input voltage, single-ended mode A2, B2, Z2	Logic "LOW"			0.8	V
	Logic "HIGH"	2			
Input current, single-ended mode A2, B2, Z2	Logic "LOW"			0.1	mA
	Logic "HIGH"			0.1	
Sin-Cos Encoder Inputs (Sin+, Sin-, Cos+, Cos-)[1]		**Min.**	**Typ.**	**Max.**	**Units**
Input voltage, differential	Sin+ to Sin-, Cos+ to Cos-		1	1.25	V_{PP}
Input voltage, any pin to GND	Operational range	-1	2.5	4	V
	Absolute maximum values, continuous	-7		+7	
	Absolute maximum, surge (duration ≤ 1S) †	-11		+14	
Input impedance	Differential, Sin+ to Sin-, Cos+ to Cos-	4.2	4.7		KΩ
	Common-mode, to GND		2.2		KΩ
Resolution with interpolation	Software selectable, for one sine/cosine period	2		10	bits
Frequency	Sin-Cos interpolation	0		450	KHz
	Quadrature, no interpolation	0		10	MHz
ESD protection	Human body model	±2			KV

Enable circuit (ENA1, ENA2)		**Min.**	**Typ.**	**Max.**	**Units**
Enable function		Disables motor power when either ENA1 or ENA2 is disconnected from the power source			
Mode compliance		PNP			
Default state	Input floating (wiring disconnected)	Logic LOW			
Input voltage	Logic "LOW"	-10		2.2	V
	Logic "HIGH"	6.3		36	
	Absolute maximum, continuous	-10		+39	
Input current	Logic "LOW"; pulled to GND		0		mA
	Logic "HIGH", pulled to +Vlog		9	13	
Pulse duration	Ignored low-high-low			1	ms
	Ignored high-low-high			1.5	
	Accepted pulse	tbd			
Fault reaction time	From internal fault detection to register DER bit 14 =1 and OUT2/Error high-to-low			tbd	ms
ESD protection	Human body model	±2			kV
Analog 0…5V Inputs (REF, FDBK)		**Min.**	**Typ.**	**Max.**	**Units**
Input voltage	Operational range	0		4.95	V
	Absolute maximum values, continuous	-12		+18	
	Absolute maximum, surge (duration ≤ 1S) †			±36	
Input impedance	To GND		8		KΩ
Resolution		12			bits
Integral linearity				±2	bits
Offset error			±2	±10	bits
Gain error			±1%	±3%	% FS[2]
Bandwidth (-3dB)	Software selectable	0		1	KHz
ESD protection	Human body model	±2			KV
RS-232		**Min.**	**Typ.**	**Max.**	**Units**
Compliance		TIA/EIA-232-C			
Bit rate	Software selectable	9600		115200	Baud
Short-circuit	232TX short to GND	Guaranteed			
ESD protection	Human body model	±2			KV
CAN-Bus		**Min.**	**Typ.**	**Max.**	**Units**
Compliance		ISO11898, CiA-301v4.2 & 402v3.0			
Bit rate	Software selectable	125		1000	Kbps
Bus length	1Mbps			25	m
	500Kbps			100	
	≤ 250Kbps			250	
Resistor	Between CAN-Hi, CAN-Lo	none on-board			
Node addressing	Strapping option (AxisID0,1,2)	1 ÷ 127 (CANopen); 1-195 & 255 (TMLCAN)			-
ESD protection	Human body model	±15			kV
Supply Output (+5V)		**Min.**	**Typ.**	**Max.**	**Units**
Output voltage	Current sourced = 500mA	4.8	5	5.2	V
Output current		600	650		mA
Short-circuit		NOT protected			
Over-voltage		NOT protected			
ESD protection	Human body model	±2			KV

† Stresses beyond values listed under "absolute maximum ratings" may cause permanent damage to the device. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

[1] For full RS-422 compliance, 120Ω termination resistors must be connected across the differential pairs, as close as possible to the drive input pins.

[2] "FS" stands for "Full Scale"