EmDrive L30

PM-motor controller

Datasheet V2.5

ISO 9001:2000 certified

General

- Intended use:
  - Electric and hybrid powertrains (traction or auxiliary):
    - Automated Guided Vehicle (AGV)
    - Non-road mobile machinery
    - Material handling and warehouse logistic vehicles
    - Golf carts and utility vehicles
    - Scooters and two-wheelers
    - Glider planes (electric sustainer)
  - Electric pump for industrial, agriculture and construction machinery
- Design:
  - Automotive ready
  - Compact, cost-effective
  - Well suited for OEMs

Mechanical design

- Plastic molded enclosure, aluminum base plate (optional: integrated liquid cooling)
- IP protections class IP6K6 IP6K9K(pending) excluding screw terminals for motor phase and DC connection
- Conduction cooled capacitors for high continuous power ratting

Software motor control features

- Vector control (FOC) in 4 quadrant operations
- Torque and velocity control
- Advanced control algorithm for optimal power module usage and efficiency:
  - adjustable field weakening operation,
  - configurable MTPA (for IPMSM),
  - Sensorless operation, optional transition from sensored (low RPM) to sensor-less operation (at higher RPM)
  - Sensor-less operation at 0 RPM (only for IPMSM motors with sufficient saliency ratio)
  - Smooth start into rotating motor also in sensor-less mode.
- Supported motor types:
  - PMSM
  - IPMSM
  - BLDC
  - Induction (optional)

Motor sensors

- Supported rotor position sensors:
  - Absolute digital SSI encoder with RS422 interface
  - 5 V analogue SIN / COS with differential signals
  - Resolver
  - *Hall + index (with sinusoidal FOC control)*
  - Incremental A, B (optional for induction machines)

- 2 x temperature sensor input
  - Dual range
  - Supports PT100, PT1000, KTY84, KTY81, NTC 10k

Protection functions with linear de-rating

- Temperature sensing for motor current derating and alarms:
  - Motor thermal protection
  - Controller thermal protection (MOSFET, back plate and capacitor temperature monitoring)
  - Blocked rotor (stall) protection with real-time power semiconductor junction temperature calculation.
- Battery under/over voltage protection
- Continuous phase current protection – prevents prolonged operation at peak current.
- Instant protections mechanisms:
  - Phase overcurrent
  - Rotor angle sensor failure
  - DC link overvoltage
  - Communication fault detection
- Full self-check at power up

Functional safety automotive ISO 26262 ready solution

- ISO 26262 ready solution:
  - Safety certified CPU
  - Design follows best practices in gate driver, power supply and CAN modules
- Safety against hazards caused by unwanted torque:
  - Three level concept:
    - Level 1: torque control
    - Level 2: monitoring of produced torque
    - Level 3: Controller HW monitoring
    - Level 1 and Level 2 is running on independent cores

Functional safety machinery EN 13849 (optional)

  - Safe torque off (STO) PLd -. Implemented as safe digital input or Safe CANopen message
  - Safe Brake Control - stopping by immediate removal of power and activating electromagnetic brake) PLd -. Implemented as safe digital input or Safe CANopen message
  - Safe limited speed SLS and safe direction SDI – PL d – Limiting operation RPM and direction

Other functional safety standards considered in design (optional)

- ISO 25119 Agriculture
  - Target AgPL C for generation of unwanted torque
- Support for machine safety at higher layer. emDrive reports next values as safe messages to supervision system (PL b):
  - Actual RPM and direction
  - Value of external angle sensor (5 V sin/cos)

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Advanced diagnostic capabilities

- System for internal data acquisition and storage
- Fast data acquisition functionality – virtual oscilloscope (recording values every FOC cycle) with various trigger settings
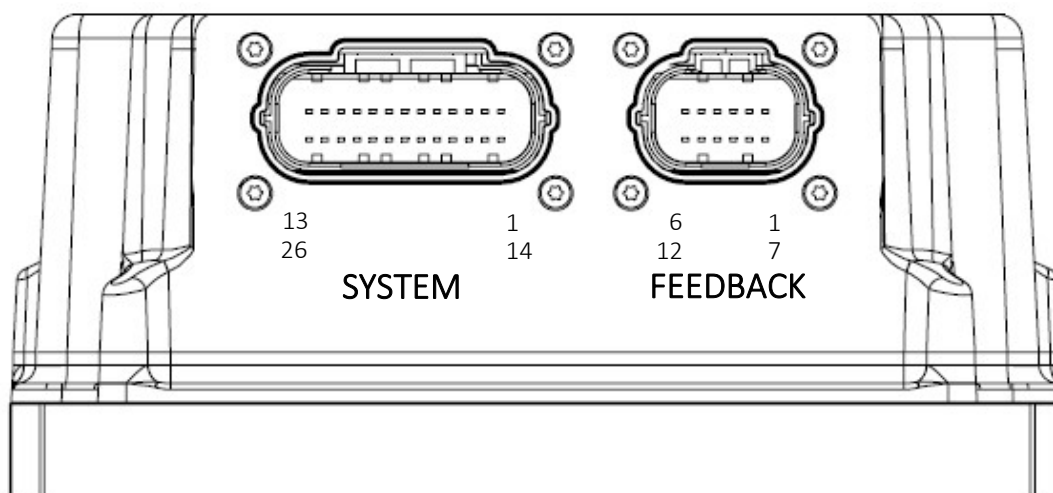
Communication protocol

- CAN 2.0, CANOpen protocol (DSP402 compatible)
- CAN FD support – possible extension of CANOpen to CANOpenFD (optional)
- XCP support for automotive applications (optional)
- Crypted Firmware upgrade over CAN
- secondary CAN interface (optional)

Housing

- Aluminum base plate with plastic enclosure and plastic cover for contacts
- Dimensions (Width x Length x Height)
    - o LIQUID COOLED: 165 x 200 x 91 mm; weight 2,3 kg
- IP protections class IP6K9K except motor phase and DC connection

LV connectors

- System connector JAE 26 pin
    - o Mating connector housing 26 pin
        - ▪ Manufacturer Part No.: 656-MX23A26SF1 (housing), 656-MX23A26XF1 (front cap)
    - o Mating connector pins
        - ▪ Manufacturer Part No.: 656-M23S05K351
- Motor feedback JAE 12 pin
    - o Mating connector housing 12 pin:
        - ▪ Manufacturer Part No.: 656-MX23A12SF1 (housing), 656-MX23A12XF1 (front cap)
    - o Mating connector pins:
        - ▪ Manufacturer Part No.: 656-M23S05K351
- IP6K9K rating

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Pinout – SYSTEM connector

PIN No.	PIN No.	DESIGNATION	DESCRIPTION	COMMENT
1		GND 1	Logic power supply Ground terminal 1	
	14	VDD 1	Logic power supply Vcc terminal 1	Input range 9 – 63 V_{DC}
2		GND 2	Logic power supply Ground terminal 2	
	15	VDD 2	Logic power supply Vcc terminal 2	Input range 9 – 63 V_{DC}
3		AIN BRAKE 1	General purpose analogue input 1	Range 0 – 5.4V Bandwidth -3dB 100 Hz
	16	ACC 1	Accelerator wiper 1	
4		AIN GND	General purpose analogue ground	
	17	AIN SUPPLY	General purpose analogue supply 5V (50 mA)	
5		AIN BRAKE 2	General purpose analogue input 2	Range 0 – 5.4V Bandwidth -3dB 100 Hz
	18	ACC 2	Accelerator wiper 2	Range 0 – 5.4V Bandwidth -3dB 100 Hz
6		SHIELD	Shield for all signals	
	19	CAN H	CAN High	
7		CAN TERM	CAN bus 120 Ω termination	To enable termination, connect to CAN Low
	20	CAN L	CAN Low	
8		DI 6	Digital input 6	Threshold: positive 7.1 V negative 3.1 V
	21	CAN 2H / RS232 Rx	CAN2 High RS232 Receive (optional)	
9		DI 7	Digital input 7	Threshold: positive 7.1 V negative 3.1 V
	22	CAN 2L / RS232 Tx	CAN2 Low RS232 Transmit (optional)	
10		LS 2	Digital output 2; low side switch 2	I_{nom} = 1,25 A, I_{lim} = 1.5 A, f_{PWM_MAX} = 1kHz
	23	DI 1	Digital input 1 / STO 1 (optional)	Threshold: positive 7.1 V negative 3.1 V Safe Torque off OSSD 1 input (Optional)
11		DI 5	Digital input 5	Threshold: positive 7.1 V negative 3.1 V
	24	DI 3	Digital input 3	
12		DI 4	Digital input 4	
	25	DI 2	Digital input 2 / STO 2 (optional)	Threshold: positive 7.1 V negative 3.1 V Safe Torque off OSSD 2 input (Optional)
13		LS 3	Digital output 3; low side switch 3	I_{nom} = 1,25 A, I_{lim} = 1.5 A, f_{PWM_MAX} = 1kHz
	26	LS 4	Digital output 4; low side switch 4	I_{nom} = 1,25 A, I_{lim} = 1.5 A, f_{PWM_MAX} = 1kHz

Pinout – FEEDBACK connector

PIN No.	PIN No.	FUNCTION 1 SSI	FUNCTION 2 RESOLVER	FUNCTION 3 SIN/COS	FUNCTION 4 HALL / ENCONDER*
1		Temperature GND	Temperature GND	Temperature GND	Temperature GND
	7	Motor temperature 1	Motor temperature 1	Motor temperature 1	Motor temperature 1
2		Sensor feedback GND	Resolver EXC. -	Sensor feedback GND	Sensor feedback GND
	8	Motor temperature 2	Motor temperature 2	Motor temperature 2	Motor temperature 2
3		Feedback 5V supply 200mA	Resolver EXC. +	Feedback 5V supply 200mA	Feedback 5V supply 200mA
	9	SSI Data+ (RS422)	Resolver SIN +	SIN +	HALL input 1 / Enc A
4		Feedback Shield	Feedback Shield	Feedback Shield	Feedback Shield
	10	SSI Data- (RS422)	Resolver SIN -	SIN -	HALL input 2 / Enc B
5		High side switch HS (I_{nom} = 3 A, I_{lim} = 3.3 A, f_{PWM_MAX} = 1kHz)			
	11	SSI Clock+ (RS422)	Resolver COS +	COS +	HALL input 3
6		Low side switch LS1 (I_{nom} = 3 A, I_{lim} = 3.3 A, f_{PWM_MAX} = 1kHz)			
	12	SSI Clock – (RS422)	Resolver COS -	COS -	HALL input 4 / Enc Z

* Optional for induction motor

Insulation

- 1.5 kV (1 min DC) between case and rest of electronic
- 500 V (1 min DC) between power terminals and control terminals

Environment

- -40 °C to 85°C operation
- Base plate or inlet coolant temperature 60°C without derating
- IP69k
- Vibration ISO16750-3, Test IV, Passenger car, sprung masses (vehicle body)
- Shock ISO16750-3, chapter 4.2.2, 500m/s2, 6ms half sine
- Free fall ISO16750-3, chapter 4.3, 1m
- Operation altitude 2000 m (DC voltage deration above)

Specifications – target data

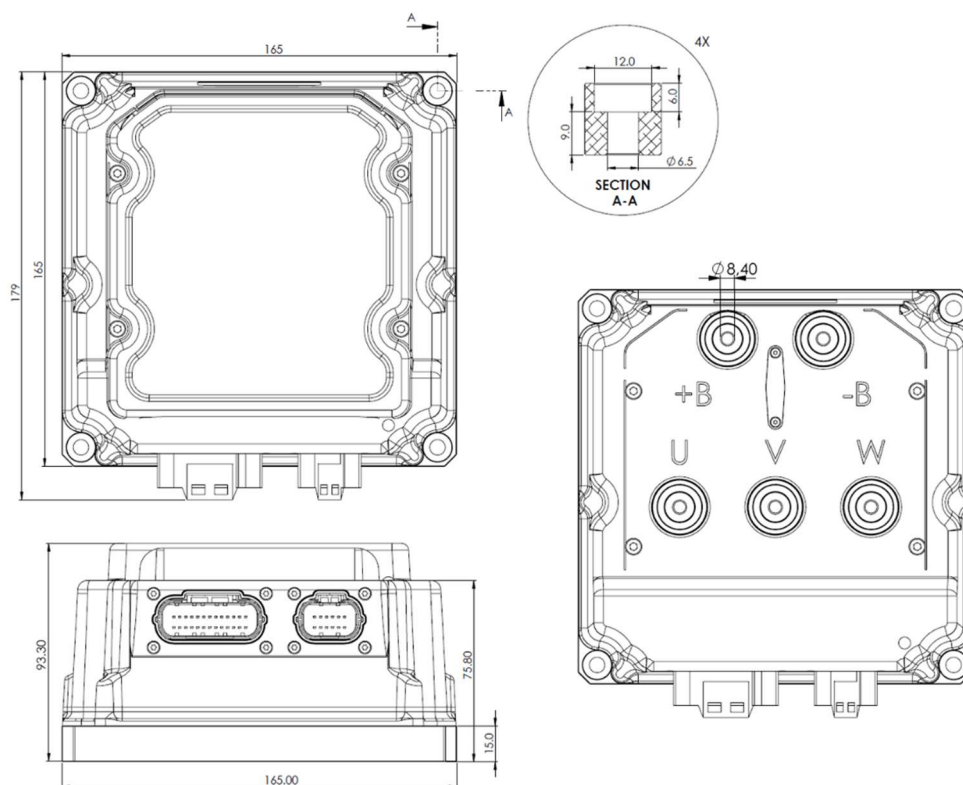|				unit
Electrical data				
Version	EmDrive L30 450/60	EmDrive L30 300/120	EmDrive L30 450/120 (var.02)	
Output continuous current	450	300	450	A_{RMS}
Output maximum peak current	650 (1 min)	450 (1 min)	650 (1 min)	A_{RMS}
Input DC link voltage operating range	12 - 63	12 - 120	12-120	V_{DC}
Input DC link capacitance	18	5,64	5,64	mF
Low voltage supply range	9 to 63			V_{DC}
Low voltage supply current consumption (Ignition current)	2,5			A
Switching frequency	16 kHz (optionally adjustable)			kHz
Operating ambient temperature**	-40 to 85			°C

* Depends on load and cooling.
** Base plate temperature < 60 °C

Certification

- EMC Automotive: UNECE R10

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Dimensions – Air cooled

Dimensions – Liquid cooled