SPIMD20

Integrated motor drive

Datasheet — production data

Features

- Advanced brushless motor control in a single module easy to piggyback to the motor
- Extremely compact dimensions: 165x60x26 mm, <0.5 kg weight
- Up to 2 kW power with 800 Vdc supply, on 100°C motor surface, can withstand peak of current up to 40 A
- Can operate on a motor surface temperature up to 100°C
- Integrated drive with real time connectivity via Ethernet-based fieldbus (i.e. EtherCAT®) and CANopen® DS402
- Safe torque off to disable IGBT drivers via hardware
- CAN bus hand-shaking channel
- RS232 interface for programming
- 2 Mb Flash memory aboard; also support removable Flash memory card.
- Supports position feedback both with resolver or digital encoder EnDat 2.2
- Motor current sensing with shunt sensors (2 phases)
- Vibration analysis and thermal sensing
- IP65 compliant
- Safe architecture to apply to most popular safety standards IEC61800-5-1
- EMI: IEC61800 - 3 / A11 and UL508C
- Up to 800 V_{DC} supply, auxiliary supply 18-48 V_{DC}
- RoHS compliant

Description

SPIMD20 is an integrated motor drive with real time connectivity enabling brushless motor manufacturers to create a proprietary motion control system based on a general purpose brick.

SPIMD20

This Shuttle version of the IMD is suitable for direct integration to the permanent magnet synchronous motor (i.e. 6 Nm torque) thanks to the reduced dimensions 165x60x26 mm. The Shuttle Drive™ is designed to operate on a motor with a surface temperature up to 100 °C. The IMD performs all motor driving required functions including speed, position and current loop execution, plus connectivity. Connection to the master is performed via real time ethernet fieldbus, including but not limited to EtherCAT® as per IEC61158. However, the IMD is an open and flexible platform to execute any other communication standard with the aboard FPGA (Altera Cyclone III type) and the two microprocessors STM32F103 series. A basic software package is available with SPIMD20. This software package includes PWM driving, current loop and speed loop execution; all the above being synchronized to the fieldbus.

Table 1. Device summary

Order code
SPIMD20

Contents

1 Main features

The SPIMD20 is the top level performing power drive system designed by STMicroelectronics in cooperation with ROBOX S.p.A. Coming in a very compact size and operating at very high temperature, the SPIMD20 is ideal for direct installation on a permanent magnet synchronous motor or nearby the motor.

The advantages of this system architecture are many, among them:

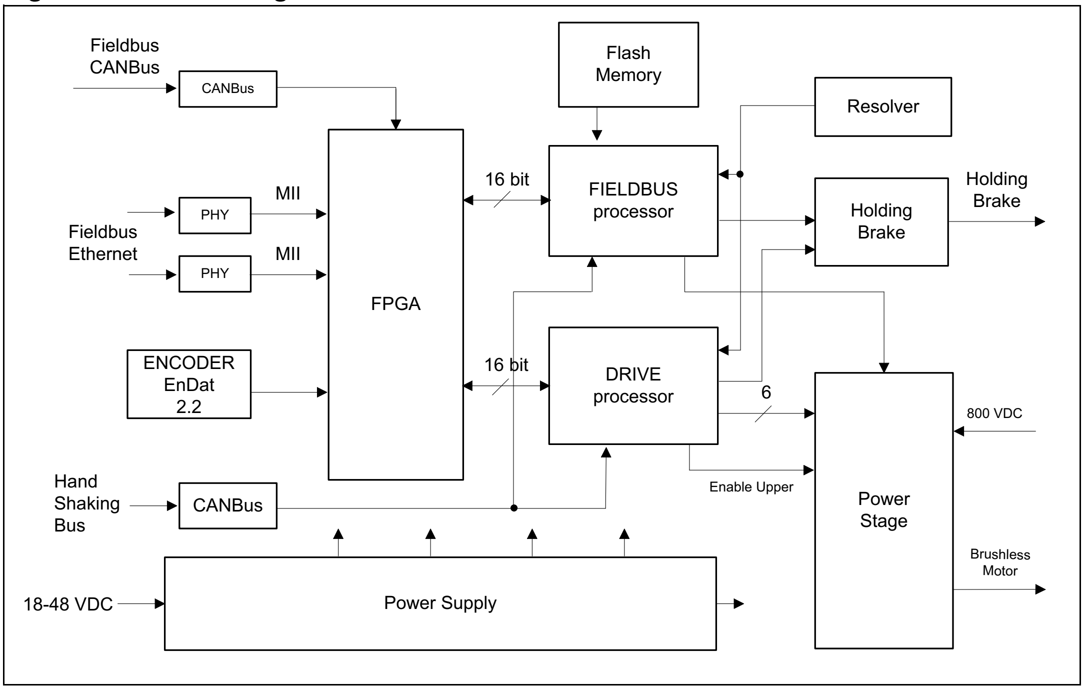
- SPIMD20 directly assembled to the motor permits a strong wiring reduction. The SPIMD20 just needs a DC power supply, a DC auxiliary supply, a fieldbus. All these connections can jump from one device to the other. The electrical cabinet will therefore result very compact.
- The distributed architecture allows faster designing and faster commissioning.
- The DC power supply shared between many SPIMD20s permits to realize sensible energy saving in a lot of applications.
- The fieldbus, Ethernet real-time, permits to make profit of all the advantages of flexible automation such as: recipes, fast switching among different previously saved menus, in-line behaviour optimization, centralized diagnostic and data logging. CANopen is optionally available in the development roadmap.
- A high performance FPGA Altera Cyclon III is available in the SPIMD20 to configure, among others, the Ethernet real-time bus according to your needs or preferences. The basic pack includes EtherCAT.
- Position read-out can be realized using the very popular resolver or other more performing devices such as EnDat 2.2 which are interfaced through the high performance FPGA. Different position transducers can be connected using their IP's.
- PWM driving is organized for operation at 4-8-16-32 kHz. All the devices connected to the same master are synchronized to the driving fieldbus. The synchronization involves position, speed, current loops and the PWM.
- A MEMS accelerometer permits to analyze the vibrations: abnormal behavior can be detected before a fatal crash occur
- An SPI channel is available to support a compact flash or similar device in order to store parameters, programs or other tools depending on the application.

- A basic software package is available with the SPIMD20. This software package includes:
  - torque speed position control
  - PWM driving 4-8-16-32 kHz
  - current loop closure 4-8-16 kHz (PI)
  - speed loop closure 1-2 kHz (PI)
  - position loop closure 1-2 kHz (P)
  - torque, speed, feed forward inputs provided
  - low pass or/and notch filters provided
  - All the above are synchronized to the fieldbus
  - Position transducers: resolver or encoder EnDat 2.2
  - EtherCat connectivity (CoE DSP402)
  - CANopen (DS301, DSP402) is also in the development roadmap
- Two powerful development environments are available:
  - IAR’s Embedded WorkBench to work at source code level (C, C++)
  - Robox’s RDE to work at system level, permitting debugging and performance optimization under real operating conditions.

A third one, QUARTUS II Altera development environment, should be used to implement other real time Ethernet standards or other digital transducers into the FPGA.

1.1 Block diagram

Figure 1. Block diagram



1.2 Safe torque off diagram

The module is equipped with four pins, available at JU1 and JU2 connectors, aimed to disable the IGBT drivers via hardware.

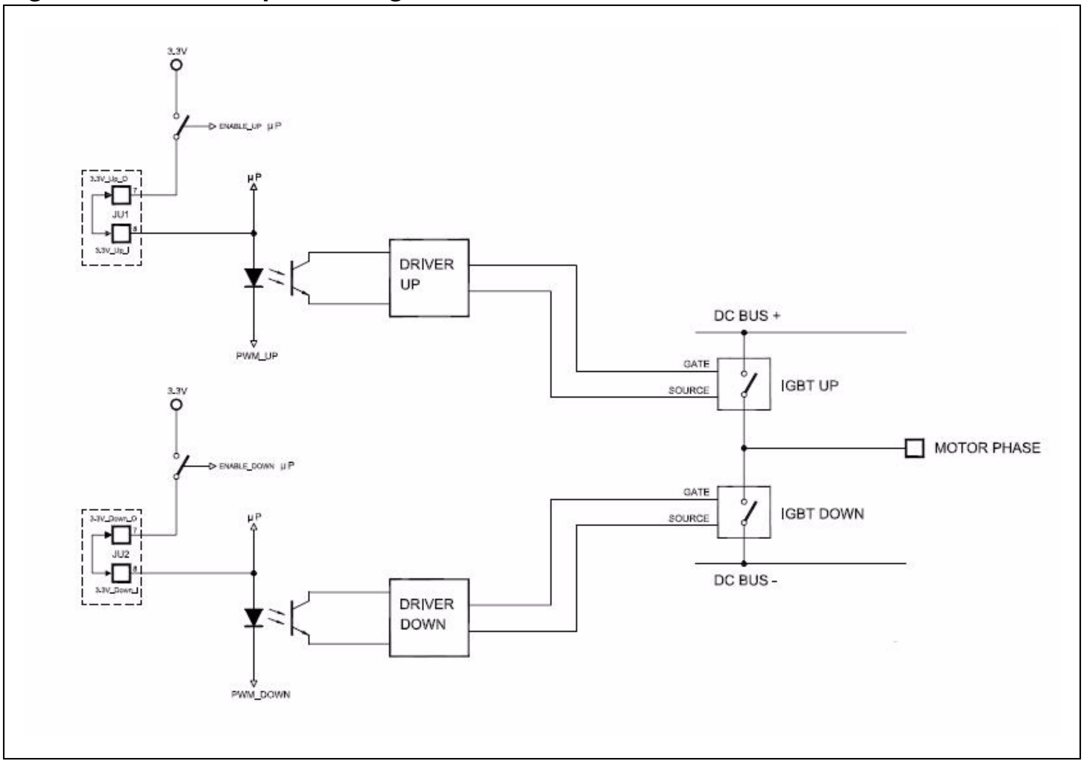
The schematic architecture is showed in *Figure 2.*

Once the pins 7 of JU1 and JU2 are respectively let opened versus the pins 8 of JU1 and JU2, the IGBT drivers are disabled.

If the pin 7 is shorted with the pin 8 on both the connectors JU1 and JU2, the module is properly working.

The current flowing on those connections is less than 5 mA.

Figure 2. Safe torque off diagram



2 General specifications

2.1 Ambient conditions

Table 2. Ambient conditions

Temperature	operation (*Ambient*)	0 … +40°C
	operation (*Motor*)	0 … +100°C
	operation (*Bottom Heatsink*)	0 … +100°C
	operation (*Top Heatsink*)	0 … +70°C
	storage	-30 … +70°C
	transportation	-25 … +70°C
Relative humidity	operation	5 … 95% (1)
	storage	5 … 95% (1)
	transportation	5 … 95% (1)
Altitude		4000mt
Protection degree		IP 65 & IP 67

1. Without ice and condensation

2.2 Vibrations and shocks

Table 3. Vibrations and shocks

Description	Test conditions	Value	Unit
Vibration sine: amplitude peak-peak	10…57Hz conforming to EN/IEC 60068-2-36	0.15 +/-15%	mm
Vibration sine: acceleration	57…150Hz conforming to EN/IEC 60068-2-6	1 +/-15%	g
Vibration noise (random) IEC 68-2-36	Frequency	20 … 150	Hz
	Spectral acceleration density, amplitude	0,005 ±3dB	g2/Hz
Vibration sine according to EN 60068-2-6 and EN 60068-2-37	10 … 2000Hz amplitude peak-peak	0.75	mm
	Acceleration at 10 … 2000Hz	5	g

3 Pin out description

Table 4. Pin description JU1/JU2

Name	JU1	JU2	Type	Description
PS_AUX+	1	1	Power in	Auxiliary input voltage 18 to 48Vdc
	2	-		
PS_AUX-	3	3		
	4	4		
POW_OK	-	2	INP-48V	Input power OK, PS_AUX- referred
IO_24V	5	-	Power out	24Vdc digital inputs feeding
IO_GND	6	-		
INP1	-	5	INP-24V	Dig. inputs, 24Vdc, IO_GND referred
INP2	-	6	INP-24V	
3.3V_UP_O	7	-	Safe torque off	Disable the IGBT drivers via hardware. If the pin 7 is shorted with the pin 8 on both the connectors JU1 and JU2, the module is properly working
3.3V_UP_I	8	-		
3.3V_DOWN_O	-	7		
3.3V_DOWN_I	-	8		
ETH1_TXD+	9	-	Ethernet	CH1 ethernet 10/100 IEEE 802.3
ETH1_TXD-	10	-		
ETH1_RXD+	11	-		
ETH1_RXD-	12	-		
ETH2_TXD+	13	-	Ethernet	CH2 ethernet 10/100 IEEE 802.3
ETH2_TXD-	14	-		
ETH2_RXD+	15	-		
ETH2_RXD-	16	-		
CANH	-	9	CanBus	Fieldbus CAN
CANL	-	10		
CAN_GND	-	11		
SB_GND	-	12	CanBus	Service bus
SB+	-	13		
SB-	-	14		
HBR_RLS#	-	15	INP-OD-3V3	Holding brake release
PB#	-	16	INP-OD-3V3	User push-button
EXT_FLASH#	-	17	INP-OD-3V3	Connect to GND to enable boot from external flash memory (type M25P16). External flash have to be connected to CRD_pins. (see next page) leave pin EXT_FLASH floating to enable boot from internal flash memory.

Table 4. Pin description JU1/JU2 (continued)

Name	JU1	JU2	Type	Description
LED1#	17	-	OUT-LO-3V3	User Led
LED2#	18	-	OUT-LO-3V3	
WS_SDA	-	18	BIDIR-3V3	I^2C line for WorkStation connection
WS_SCL	19	-	OUT-3V3	
JTMS	20	-	INP-3V3	JTAG software debug port
JTCK	21	-	INP-3V3	
JTDI	22	-	INP-3V3	
JTDO	23	-	OUT-3V3	
JTRST#	24	-	INP-LO-3V3	
JRESET#	25	-	INP-OD-3V3	
IO3#	-	19	BIDIR-OD-3V3	TTL digital I/O, GND referred External decoupling required
IO4#	-	20	BIDIR-OD-3V3	
3V3	-	21	Power out	3.3V power supply for outputs, LED and I^2C - 100mA max
GND	-	22		
CRD_CS#	-	23	OUT-LO-3V3	3.3V external flash. SPI Interface 50mA max.
CRD_CLK	-	24	OUT-3V3	
CRD_DI	-	25	OUT-3V3	
CRD_DO	-	26	INP-3V3	
CRD_VCC	-	27	Power out	
CRD_GND	-	28		
RS232_GND	26	-	RS232	RS232 full duplex connection
RS232_RXD	27	-		
RS232_TXD	28	-		

- INP-48 V: 48 V digital input, active high
- INP-24 V: 24 V digital input, active high
- INP-3V3: 3.3 V digital input, active high
- INP-LO-3V3: 3.3 V digital input, active low
- INP-OD-3V3: 3.3 V dig. input (Internal pull-up) to be connected to open-drain output
- OUT-3V3: 3.3 V digital output, push-pull active high
- OUT-LO-3V3: 3.3 V digital output, push-pull active low
- BIDIR-3V3: 3.3 V digital input/output
- BIDIR-OD-3V3: 3.3 V digital input/output (Internal Pull-up) to be connected to open-drain output

Table 5. Pin description JU3

Name	Pin	Type	Description
DC_BUS-	1	Power in	800VDC BusBar-
	2		
-	3	-	Position not loaded
DC_BUS+	4	Power in	800VDC BusBar+
	5		
-	6	-	Position not loaded
FE	7	Functional Earth	Connected to chassis and shield/FE pins of JU1, JU2, JM3,JM7, JM9, JM10 and JM11 connectors
	8		

Table 6. Pin description JM3

Name	Pin	Type	Description
TMOT-	1	Analog	Connection to PTC motor thermal probe (KTY84-130)
TMOT+	2	Analog	
-	3	-	N.C.
SHIELD	4	-	Connected to PE pins on JU3

Table 7. Pin description JM7

Name	Pin	Type	Description
PE	1	-	Connected to PE pins on JU3
DC_BUS-	2	Power	800VDC BusBar capacitor connection
PE	3	-	Connected to PE pins on JU3
DC_BUS+	4	Power	800VDC BusBar capacitor connection

Table 8. Pin description JM9

Name	Pin	Type	Description
PE	1	-	Connected to PE pins on JU3
	2		
	3		
MOTOR_U	4	Motor	Motor U phase
MOTOR_V	5	Motor	Motor V phase
MOTOR_W	6	Motor	Motor W phase

Table 9. Pin description JM10

Name	Pin	Type	Description
SHIELD	1	-	Connected to PE pins on JU3
-	2	-	-
HBR+	3	Brake	24VDC holding brake connection Current max 500mA
HBR-	4	Brake	

Table 10. Pin description JM11

Name	Pin	Type	Description
SHIELD	1	-	Connected to PE pins on JU3
	8		
ENC_GND	2	Power out	5V, 200mA max Encoder EnDat 2.2
ENC_5V	9		
ENC_CLK-	3	RS422	
ENC_CLK+	10		
ENC_DAT-	4	RS485	
ENC_DAT+	11		
RES_EXC-	5	Analog	Resolver
RES_EXC+	12		
RES_SIN-	6	Analog	
RES_SIN+	13		
RES_COS-	7	Analog	
RES_COS+	14		

4 Electrical characteristics

4.1 Absolute maximum ratings

Table 11. Absolute maximum ratings

Symbol	Parameter	Value	Unit
DC_BUS_MAX	MAX DC BusBar supply voltage (JU3 pin 1, 2, 4, 5)	850	V
DC_BUS_MIN	MIN DC BusBar supply voltage (JU3 pin 1, 2, 4, 5)	40	V
Pw_MAX	Max continuous power (Output current = 6A rms MAX)	2000	W
I_OUT_MAX	Max output current (RMS)	6	A
I_OUT	Max output current peak (200ms on 1.5s period)	17	A
PS_AUX	DC auxiliary supply voltage (JU1 pin 1-4 JU2 pin 1, 3, 4)	50	V
IO_24V	DC logic supply voltage (JU1 pin 5, 6)	28	V
Tstg	Storage temperature range	-30 … +70	°C

4.2 Electrical data

4.2.1 Power supply

Table 12. Power supply

Symbol	Parameter	Test conditions	Value			Unit
			Min	Typ	Max	
DC_AUX	DC auxiliary supply voltage	Power In (JU1/JU2 pin 1-2)	18	24	48	V
DC_AUX_MAX_CUR	DC auxiliary current BRAKE connected	Vin (JU1/JU2 pin 1-2) = 18V, BRAKE connected			1.6	A
		Vin (JU1/JU2 pin 1-2) = 48V, BRAKE connected			0.8	A
	DC auxiliary current without BRAKE	Vin (JU1/JU2 pin 1-2) = 18V, without BRAKE			0.6	A
		Vin (JU1/JU2 pin 1-2) = 48V, without BRAKE			0.3	A
DC_Brake	24 V DC Brake connection	Current max 500mA (JM10 pin 3-4)	21.6	24	26.4	V
CRD_VCC	Analogue supply for external Flash	SPI max current 50mA (JU2 pin 27)	3.2	3.3	3.4	V
3V3	I^2C power supply	DC for Outputs, I2C & LEDs 100mA max JU2 pin 21	3.2	3.3	3.4	V
IO_24V	24 Vdc digital inputs feeding	100mA max JU1 pin 5-6	21.6	24	26.4	V

4.2.2 Power stage

Figure 3. Equivalent circuit

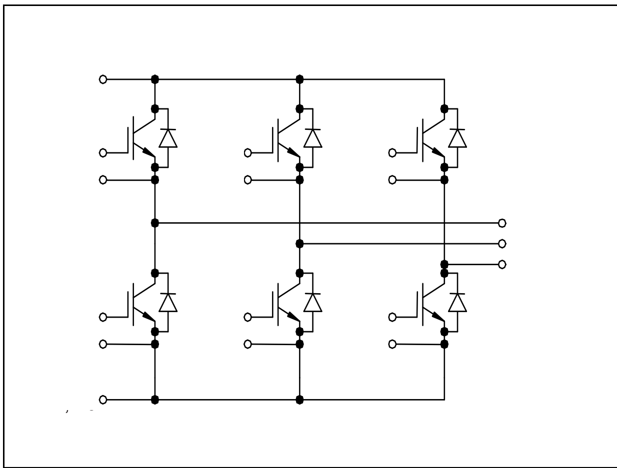


Figure 4. Test circuit for inductive load switching

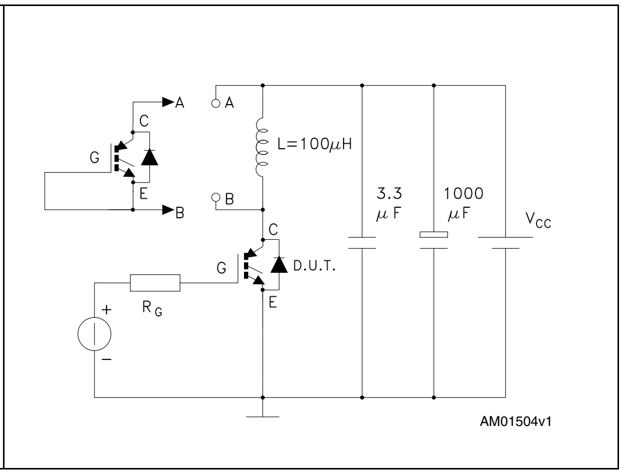


Table 13. IGBT

Symbol	Parameter	Test conditions	Value			Unit
			Min	Typ	Max	
$V_{CE(sat)}$	Collector-emitter saturation voltage	V_{GE}= 15V, I_C= 30A V_{GE}= 15V, I_C= 30A, T_j =125 °C	-	2.8 2.7	3.85	V
I_{CES}	Collector cut-off current (V_{GE} = 0)	V_{CE} =1200V V_{CE} =1200V, T_j=125 °C	-		500 10	µA mA
I_{GES}	Gate-emitter leakage current (V_{CE} = 0)	V_{GE} =± 20V	-		± 100	nA
$t_{d(on)}$	Turn-on delay time	V_{CC} = 960V, I_C = 30A R_G= 10Ω, V_{GE}= 15V, T_j= 125°C *see Figure 6*	-	45		ns
t_r	Current rise time		-	38		ns
$t_{d(off)}$	Turn-off delay time		-	420		ns
t_f	Current fall time		-	360		ns
E_{on} (1)	Turn-on switching losses		-	4.7		mJ
E_{off}	Turn-off switching losses		-	9.3		mJ
C_{ies}	Input capacitance	V_{CE} = 25V, f = 1MHz, V_{GE}=0	-	2577		pF
C_{oes}	Output capacitance		-	196		pF
C_{res}	Reverse transfer capacitance		-	39.5		pF
Q_g	Total gate charge	V_{CE} = 960V, I_C= 20A,V_{GE}=15V	-	126		nC

1. Eon is the turn-on losses when a typical diode is used in the test circuit in *Figure 6*.

Table 14. Diodes

Symbol	Parameter	Test conditions	Value			Unit
			Min	Typ	Max	
V_F (1)	Forward voltage drop	I_F = 8A T_j = 25°C	-		2.2	V
		I_F = 8A T_j = 125°C	-	1.3	2.0	
I_{RM}	Reverse recovery current	I_F = 8A, d_{IF}/d_t = -200A/µs, V_R = 600V, T_j = 125°C	-	14	21	A
t_{rr}	Reverse recovery time	I_F = 1A, d_{IF}/d_t = -100A/µs, V_R = 30V, T_j = 25°C	-	50	70	ns

1. Pulse test: tp = 380 µs, δ < 2 %
To evaluate the conduction losses use the following equation: P = 1.5 x $I_{F(AV)}$ + 0.05 IF ² (RMS)

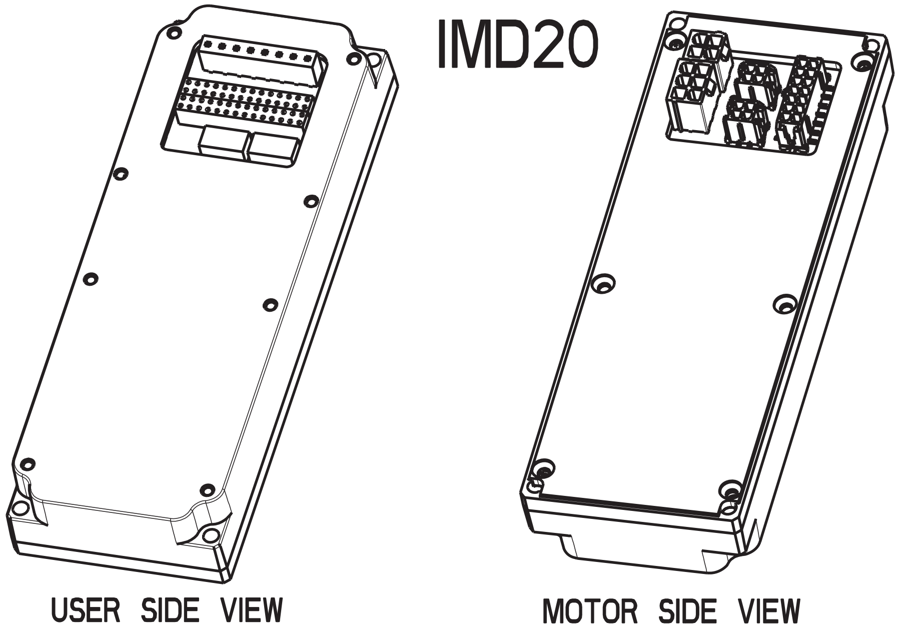
Table 15. Thermal resistance

Symbol	Parameter	Test conditions	Value			Unit
			Min	Typ	Max	
$R_{th(j-c)}$	Thermal resistance	IGBT	-	-	0.42	°C/W
$R_{th(j-c)}$		Diode	-	-	0.52	°C/W
$R_{th(CH)}$		Module with heatsink compound	-	-	TBD	°C/W

5 Mechanical dimensions

5.1 Mechanical data (dimensions in mm)

Figure 5. Mechanical data (dimensions in mm)



CONNECTORS					
JU1	PRECI-DIP	PN 803-87-028-65-001101	JM7	MOLEX	MINIFIT PN. 39288040
JU2	PRECI-DIP	PN. 803-87-028-65-001101	JM9	MOLEX	MINIFIT PN. 39288060
JU3	SAMTEC	PN. ASP-140487-01	JM10	MOLEX	MICROFIT PN. 430450420
JM3	MOLEX	MICROFIT PN. 430450420	JM11	MOLEX	MICROFIT PN. 430451420

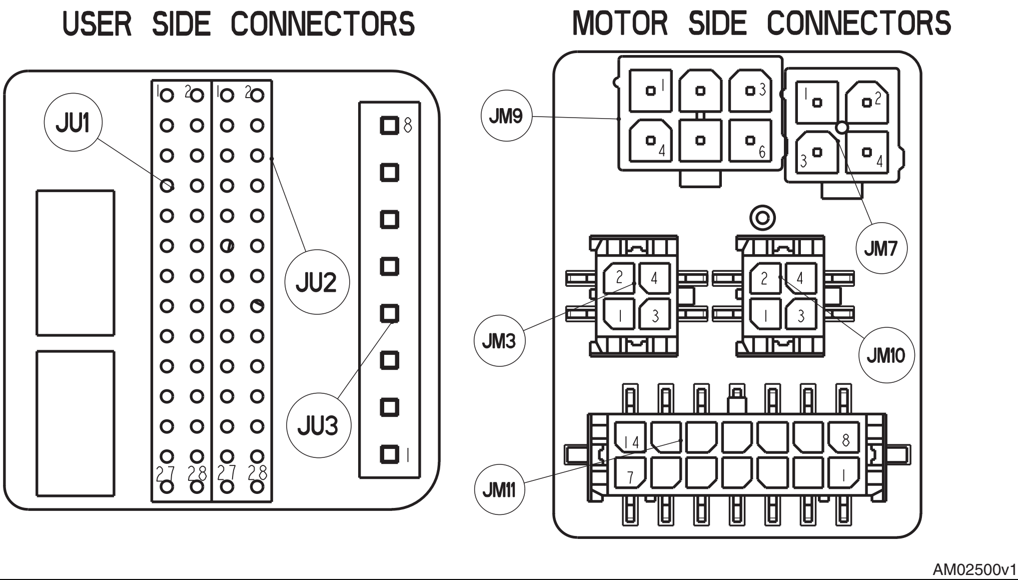
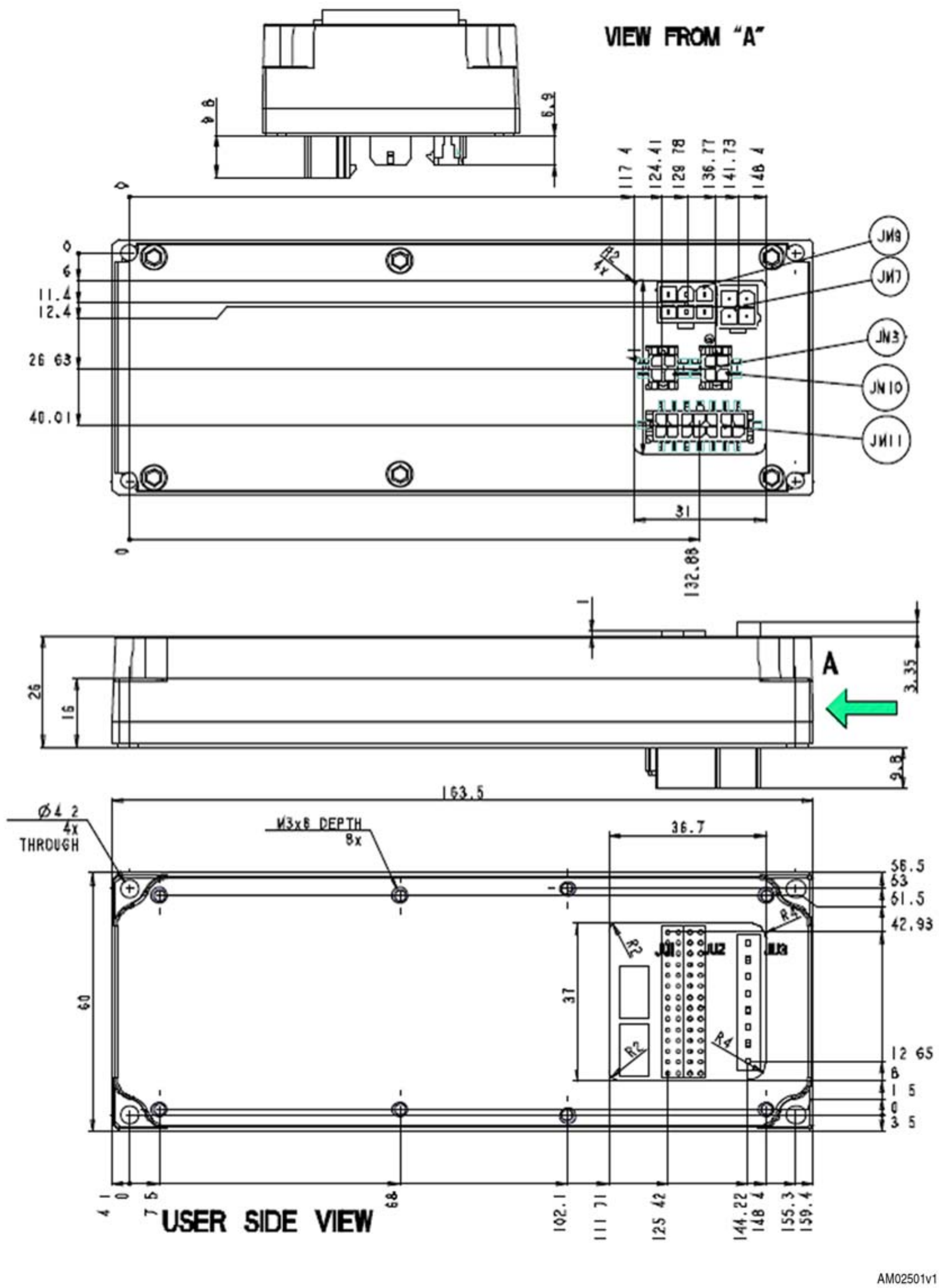


Figure 6. Mechanical data (dimensions in mm) continued



5.1.1 Technical specifications for surface coupling

IMD module can be coupled with a plane surface finished with characteristics detailed below:

Table 16. Technical specifications for surface coupling

Parameter	Value
Roughness	3.2 Ra
Planarity	0.1 mm
Max coupling torque on fixing screws	3 N/m

5.2 The basic software package

A basic software package is available on request, at source level. This software package is written in C language (not C++) by Robox and is supplied AS IS.

The comments are in English. It was developed using the IAR's Embedded WorkBench development tool.

In the design workspace each processor, the fieldbus processor and the drive processor, has its own project. The interface between them is defined in some common files.

The fieldbus processor main tasks are:

- building up of the whole system at power on
- communication handling with the external master fieldbus according to the EtherCat CoE profile (Ecat sync mode or Distributed clock mode)
- information exchange with the drive processor through the dual port ram implemented into the FPGA
- handling of the I^2C port to get application parameters
- holding brake management

The drive processor main tasks are:

- PWM driving performed at the same frequency of the current loop or at double frequency (4-8-16-32 kHz).
- current loop closure (4-8-16 kHz). The control algorithm is PI
- speed loop closure (1-2 kHz). The control algorithm is PI
- position loop closure (1-2 kHz). The control algorithm is P

The system is able to work in torque control or in speed control or in position control.

The feed forward inputs are provided for the two inner loops. The PWM driving, and the loops closure, are synchronized to the external master fieldbus sync event.

- DC bus reading
  An optically coupled reading of the DC bus voltage allows its monitoring. Moreover the gains of the current loop are independent from the DC bus level.
- Filtering:
  3 optional 2nd order filter stages (LowPass/Notch) can be activated on SpeedReference

3 optional 2nd order filter stages (LowPass/Notch) can be activated on TorqueReference.
Triple sampling on the resolver reading is provided

- Position or time capture on the two digital inputs
- Self tuning
  a complete self tuning procedure is available. It includes:
  - motor characteristics (correct wiring, number of motor and transducer poles)
  - current loop gains
  - speed loop gains
  - EnDat offset position read-out and storage in the e2prom
  - resolver adjustment (amplitude, sample phase, position offset and alarm threshold)
- Self test
  built-in self test allowing to generate square or synusoidal waveforms on the speed or torque reference with adjustable frequency, amplitude, offset and TT cycle.

A complete library to access all the involved peripherals is included.

The EtherCAT® entries manual of the basic software package is available at Robox on request.

5.3 Safety characteristics and connection requirements

The IMD module is designed to comply with the IEC61800-5-1 norms, applicable to the D.C. drive systems connected to the line voltage up to 800 V D.C.

The earthing connections are intended as TN or TT having the voltage between phase and Earth 300 V r.m.s. maximum.

In case this voltage is higher than 300 V r.m.s. the user shall provide the system with protective device (varistor, voltage discharger, etc.) in order to reduce the impulse voltage to 2500 V max.

The P.E. connections, available at JU3 pins 7, 8 and/or JM9 pins 1, 2, 3 shall be connected to the protective bonding before supplying the system.

⚠ Please note that Earth leakage current is > 3.5 mA. Automatic disconnection of thesupply in case of discontinuity of the protective conductor must be provided.

5.4 Installation and user's manual

For installation on a system or motor please ask end user.

Specifications for surface coupling can be find in this document section *Section 5.1.1*.

5.5 Maintenance

The IMD module doesn't require maintenance. In case of failure module is not repairable and have to be replaced.

6 Revision history

Table 17. Document revision history

Date	Revision	Changes
31-May-2010	1	First release
26-Jan-2011	2	Updated coverpage, *Table 4 on page 8* Added *Section 1.2 on page 6*
25-Jul-2012	3	Updated *Table 5 on page 10* and *Table 11 on page 12*.

Please Read Carefully: