PM50

Version 3.0

Power Module for DC, Brushless DC and AC Motors

TECHNOSOFT

DSP Motion Solutions

Technical Data

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PM50 v.3.0

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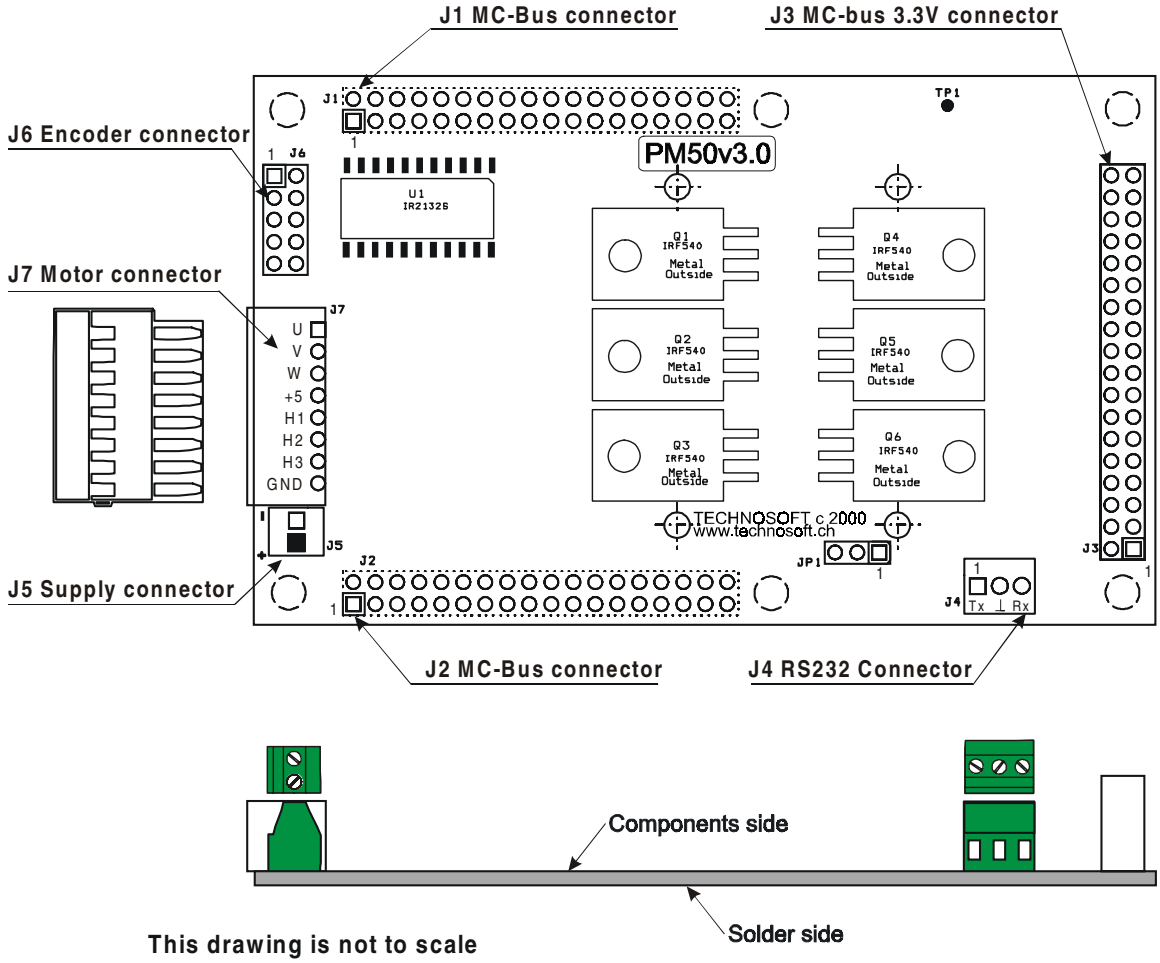
PM50 V3.0 power module technical data

Pm50 V3.0 was designed to work with both 5V and 3.3V I/O signal levels.
It may function with MSK240 / 243 boards using J1, J2 connectors (5V MC bus).
It may function with MSK2407 (without using adapter board LF 2407 Adapter) using **only** J3 connector (3.3V bus).

D.1. PM50 V3.0 - Connectors



Note:
1. The Wago 90° female connector for the motor (the external one) is supplied with the motor.
2. Connect the power supply (on J5 connector) before plug-in the MSK2407 DSP board into PM50V3.0.
3. Always MSK2407 DSP board should be on top of PM50V3.0.

D.2. Power Supply

J5 – Supply Connector

The PM50 v3.0 requires only one power supply: 9 – 36 V_{DC} for the motor. Other required voltages including $5V_{DC}$ for the internal logic are provided by on board power supplies directly from motor power supply.
The motor power supply is applied on the inverter DC-bus and must be adapted to the motor and application requirements. It should be able to absorb the energy generated during motor braking.

> **CAUTION** !
> **Be careful to correctly connect the power supplies polarities! Reverse polarities will damage the PM50 module!**

The PM50 v3.0 is equipped with a 2-pin 0.1" pitch screw-terminal connector for the supply. Its pin assignment is presented in Table D.1.

Table D.1. *J5 – Supply Connector: 2-pin 0.1" pitch screw-terminal connector*

Pin	Name	Type	Function
1	+MOT	I	9 - 36V power supply plus (+)
2	GND	I	9 - 36V power supply minus (-)

D.3. Power Stage Module

The PM50 v3.0 power module includes a 3-phase inverter, the protection circuits and the measurement circuits for the DC-bus voltage and the motor currents.

3-phase Inverter Command

The 3-phase inverter (see figure E.1) uses MOSFET transistors with switching frequency up to 50kHz. The PM50 v3.0 MC-bus interface includes 6 PWM command inputs (TTL/CMOS compatible) named $\overline{PWM1}$ to $\overline{PWM6}$ through which the control unit can drive each transistor of the inverter.
All PWM commands are active low.

- $\overline{PWM1}$, $\overline{PWM3}$, $\overline{PWM5}$ drive the upper transistors.
- $\overline{PWM2}$, $\overline{PWM4}$, $\overline{PWM6}$ drive the lower transistors.
- $\overline{PWM1}$ & $\overline{PWM2}$ drive phase A,
- $\overline{PWM3}$ & $\overline{PWM4}$ drive phase B,
- $\overline{PWM5}$ & $\overline{PWM6}$ drive phase C.

The control unit PWM commands should include a dead time of minimum 0.5µs for transistor's commutation.

Voltage input levels for PWM commands are 5V on J1 connector and 3.3V on J3 connector - direct compatible with MSK2407.

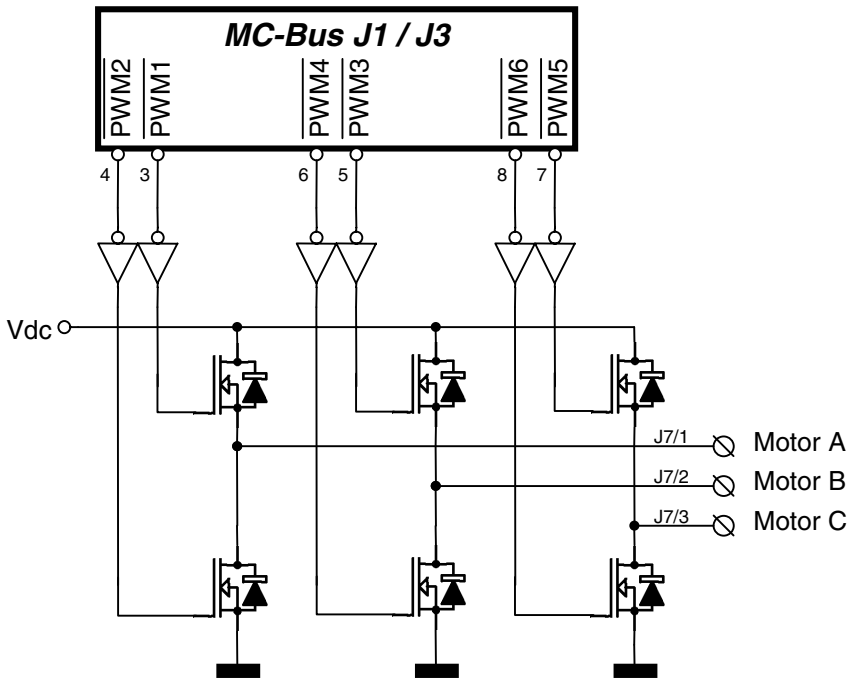


***Figure D.1**. 3-phase Inverter Control using PWM Command Inputs*

Protections. Error Signal

The PM50 v3.0 power stage includes protection circuits for: phase to phase short-circuit, over-current, over-voltage and accidental shutdown of logic supply (logic supply under-voltage). If any of these protections is triggered, the PM50 v3.0 sets low the MC-bus error signal $\overline{\text{PDPINT}}$ (open-collector signal) to sign this event to the control unit and the inverter transistors are turned off as long as the condition is maintained. If any low-leg motor current exceeds 7A for more than 10 ms, a $\overline{\text{PDPINT}}$ fault signal will occur. Short-term over-voltages having energy of less than 3J (47V $\times$ 5A $\times$ 12ms) will be clamped by an on-board 47V suppresser.

Current Measurement Interface

Using J1/J2 MC bus (5V)
The PM50 v3.0 measures the motor currents using shunts placed in the lower-legs of the inverter (see Figure D.2) using a current gain factor of 0.395V/A, which translates +/-6.33A currents into +/-2.5V voltages. These voltages are applied on the 5V J2 MC-bus analogue inputs IA, IB and IC with a 2.5V offset. Hence negative currents are measured between 2.5V to 5V and positive currents are measured between 0 and 2.5V. The midpoint 2.5V corresponds to a zero current.

Phase current [A] = (2.5V offset – voltage on analogue input [V]) / current gain [V/A]

Using J3 MC bus (3.3V)
The same current signals are translated from 0-5V level range in 0-3.3V level range using analog interface for J3 connector. In that case, the midpoint 1.66V corresponds to a zero current and the current gain factor is 0.26 V/A.

Phase current [A] = (1.66V offset – voltage on analogue input [V]) / current gain [V/A]

Remark: A negative current is defined as flowing from the lower transistor/diode to ground e.g. when the current exits from the motor. A positive current is defined as flowing from ground to the lower transistor/diode e.g. when the current enters in the motor. The motor phase currents can be computed with the formula:

WARNING: Be aware that the current measurement scheme, simple and cost-effective from the hardware point of view, requires some special care from the point of view of software implementation. Thus, for the three currents measurement scheme, the A/D conversion **MUST** be synchronised with the PWM command of the inverter transistors, to properly measure the currents on each phase of the motor.

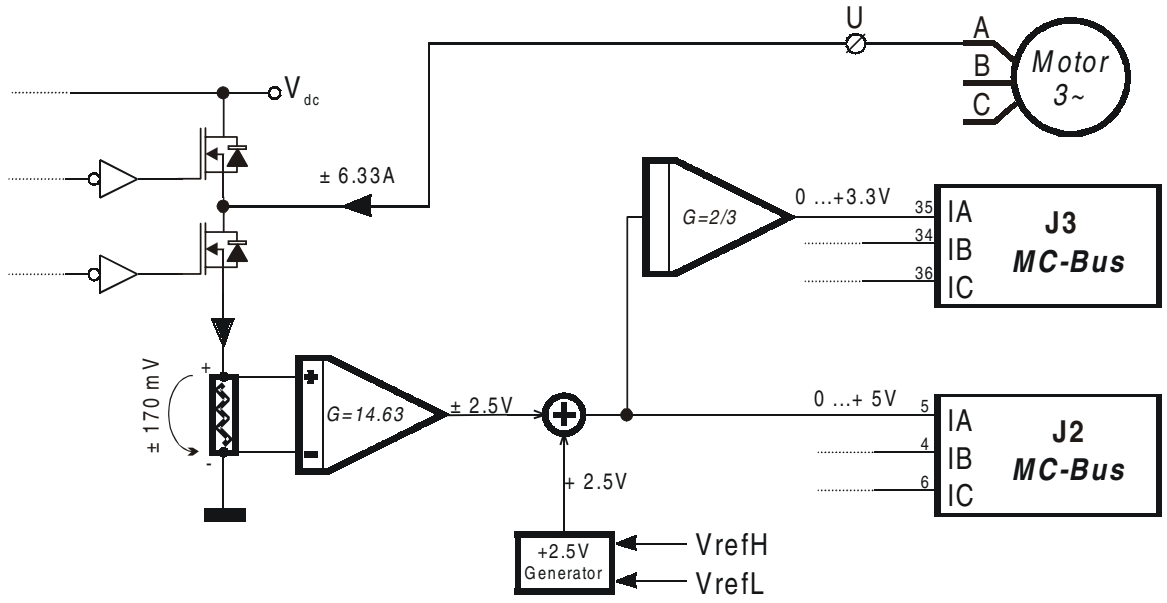


Figure D.2. *Current Measurement*

Motor Supply / DC-bus Voltage Measurement

The PM-50 v 3.0 includes a motor supply / DC-bus voltage feedback applied on the MC-bus analogue input named VDC. The gain factor is 0.0909. Hence, DC-bus voltages between 0 and 55V are translated into 0 to 5V at J2 connector / pin 3.
For 3.3V bus (J3), the gain factor is 0.0606. Hence, DC-bus voltages between 0 and 55V are translated into 0 to 3.3V at J3 connector / pin 33.

Please note that the 55V is only a computing value! Do not supply the board with more than 36V if your power supply can not absorb the energy produced during the braking stage of the motor (especially when the load has a high inertia). The PM50 V3.0 board has an internal protection (a Zener Diode of 47V, 1W)

The measurement scheme provides filtering with a cut-off frequency of 730 Hz in order to remove spurious switching noise generated by the on-board power stage.

D.4. Motor sensors

J7 – Motor and Hall Sensors Connector

The PM50 v3.0 is equipped with an 8-pin 0.1" pitch Wago 90° male connector for the motor. Its pin assignment is presented in Table D.2.

Table D.2. *J7 – Motor Connector: 8-pin 0.1" pitch Wago 90° male connector*

Pin	Name	Type	Function
1	U	O	Phase A for 3-phase motors
2	V	O	Phase B for 3-phase motors
3	W	O	Phase C for 3-phase motors
4	+5V	O	$+5V_{DC}$ for Hall sensors
5	HALL1	I	Hall 1
6	HALL2	I	Hall 2
7	HALL3	I	Hall 3
8	GND		Ground

The output level for Hall sensors is 0-5V – on the J2 connector, or 0-3.3V on J3 connector.

J6 – Encoder Connector

By default, the PM50 v3.0 is equipped with a 2x5 0.1" pitch header connector for the encoder. Its pin assignment is presented in Table D.3. The encoder connector can be configured from **SJ1** solder joint (placed on the solder side near J6 connector) to be compatible with API-Portescap A22 encoders or Hewlett Packard/Agilent HEDL65xx encoders. The **SJ1** solder joint must be:

- **ON** for HP HEDL65xx encoder type
- **OFF** for API-Portescap A22 encoder type (default)

Table D.3. *J6 – Encoder Connector (default): 2x5 0.1" pitch header connector*

Pin	Name	Type	Function
1	GND		Ground
2	+5V	O	Encoder supply
3	DIR		Connected to ground if SJ1 = ON (see note)
4	$\overline{\text{STBY}}$	I	Connected to +5V
5	-	n.c.	Not connected
6	A	I	Positive A for differential encoder or A for single-ended encoder
7	-	n.c.	Not connected
8	B	I	Positive B for differential encoder or B for single-ended encoder
9	-	n.c.	Not connected
10	Z	I	Positive Z for differential encoder or Z for single-ended encoder

On request, the PM50 v3.0 can also be equipped with a vertical (J666) or 90° (J66) 5-pin Molex connector for the encoder, which is compatible with all Hewlett Packard/Agilent HEDSxxxx single-ended TTL-compatible encoders. Table D.4 presents the pin assignment the for Molex connectors.

Table D.4. *J66 – Encoder Connector (alternate option): 5-pin Molex connector*

Pin	Name	Type	Function
1	GND		Ground
2	Z	I	Positive Z for differential encoder or Z for single-ended encoder
3	A	I	Positive A for differential encoder or A for single-ended encoder
4	+5V	O	Encoder sensor supply
5	B	I	Positive B for differential encoder or B for single-ended encoder

D.5. Communication

J4 – RS-232 Connector

The PM50 v3.0 power module includes an RS-232 connector. It can be used to pass the Rx232 and Tx232 signals to the control unit through the MC-bus interface. The PM50 v3.0 simply applies the signals from the RS-232 connector to the J2 MC-bus. The RS-232 transceiver should be on the control unit.

The PM50 v3.0 is equipped with a 3-pin 0.1" pitch screw-terminal connector for RS-232 link. Its pin assignment is presented in Table D.5.

Table D.5. *J4 – RS-232 Connector (default): 3-pin 0.1" pitch screw-terminal connector*

Pin	Name	Type	Function
1	TxD	O	Data Transmission
2	GND		Ground
3	RxD	I	Data Reception

Note: Do not use this connector for serial communication when PM50 is used together with the MSK2407 DSP board. Use **only** the DB9 serial connector J8 from the MSK2407 DSP board.

D.6. Control Unit Interface (MC-Bus)

J1, J2, J3 – MC-Bus Connectors

The PM50 v3.0 power module receives the PWM command signals and sends the feedback and status signals to the control unit through two 2x18-pin 0.1" pitch MC-Bus connectors J1 and J2 for 5V levels or through J3 –for 3.3V levels.

Table D.6. *J1 – MC-bus connector*

Pin	Name	Type	Description
1	-reserved-	n.c.	Not connected on the PM50 v3.0
2	-reserved-	n.c.	
3	$\overline{\text{PWM1}}$	I	CU output. Active low command for the upper transistor, A-phase leg
4	$\overline{\text{PWM2}}$	I	CU output. Active low command for the lower transistor, A-phase leg
5	$\overline{\text{PWM3}}$	I	CU output. Active low command for the upper transistor, B-phase leg
6	$\overline{\text{PWM4}}$	I	CU output. Active low command for the lower transistor, B-phase leg
7	$\overline{\text{PWM5}}$	I	CU output. Active low command for the upper transistor, C-phase leg
8	$\overline{\text{PWM6}}$	I	CU output. Active low command for the lower transistor, C-phase leg
9	-reserved-	n.c.	Not connected on the PM50 v3.0
10	-reserved-	n.c.	Not connected on the PM50 v3.0
11	-reserved-	n.c.	Not connected on the PM50 v3.0
12	-reserved-	n.c.	Not connected on the PM50 v3.0
13	-reserved-	n.c.	Not connected on the PM50 v3.0
14	-reserved-	n.c.	Not connected on the PM50 v3.0
15	-reserved-	n.c.	Not connected on the PM50 v3.0
16	-reserved-	n.c.	Not connected on the PM50 v3.0
17	ENC-A	O	CU input. Encoder signal A from J6, J66 or J666
18	ENC-B	O	CU input. Encoder signal B from J6, J66 or J666
19	ENC-Z	O	CU input. Encoder signal Z (index/zero) from J6, J66 or J666
20	-reserved-	n.c.	Not connected on the PM50 v3.0
21	$\overline{\text{PDPINT}}$	O	CU input. Power stage error signal, driven by protection circuitry. Open-collector signal
22	-reserved-	n.c.	Not connected on the PM50 v3.0
23	-reserved-	n.c.	
24	-reserved-	n.c.	
25	$+5V_{DC}$	O	$+5V_{DC}$ output
26	DGND		Ground terminal. All digital signals are referenced to this signal
27	DGND		
28	DGND		
29	DGND		
30	-reserved-	n.c.	Not connected on the PM50 v3.0
31	-reserved-	n.c.	
32	-reserved-	n.c.	
33	-reserved-	n.c.	
34	-reserved-	n.c.	
35	-reserved-	n.c.	
36	-reserved-	n.c.	

I – input in PM50 v3.0, output from control unit
CU – control unit (MSK240/3/07 DSP board) connected through the MC-bus with PM50 v3.0
O – output from PM50 v3.0, input in CU

Table D.7. *J2 – MC-bus connector*

Pin	Name	Type	Description
1	-reserved-	n.c.	Not connected on the PM50 v3.0
2	-reserved-	n.c.	
3	VDC	O	CU analog input. Value of the motor supply / DC-bus voltage. Gain factor is 91mV/V
4	IB	O	CU analog input. Value of current in B-phase inverter lower leg, upper shifted with 2.5V. Gain factor is 0.395V/A
5	IA	O	CU analog input. Value of current in A-phase inverter lower leg, upper shifted with 2.5V. Gain factor is 0.395V/A
6	IC	O	CU analog input. Value of current in C-phase inverter lower leg, upper shifted with 2.5V. Gain factor is 0.395V/A
7	$V_{REF}LO$	O	Analogue ground. Separated from DGND. The connection between these two signals must be done on the CU
8	$+5V_A$	I	Analogue reference. CU must provide the $+5V_A$. Half of this value represents the upper shift for bipolar signals. Typical expected value is +5V, allowed range is +4.75…5.25V.Current drawn by PM50 v3.0 is under 0.5 mA
9	DGND		Ground terminal. All digital signals are referenced to this signal
10	DGND		
11	Hall 1	O	CU input. HALL1 signal from J7 connector. TTL signal (0-5V)
12	-reserved-	n.c.	Not connected on the PM50 v3.0
13	Hall 2	O	CU input. HALL2 signal from J7 connector. TTL signal (0-5V)
14	Hall 3	O	CU input. HALL3 signal from J7 connector. TTL signal (0-5V)
15	DGND		Ground terminal. All digital signals are referenced to this signal
16	-reserved-	n.c.	Not connected on the PM50 v3.0
17	Rx232	O	CU RS-232 input linked directly to J4 connector pin 3
18	Tx232	I	CU RS-232 output, linked directly to J4 connector pin 1
19	-reserved-	n.c.	Not connected on the PM50 v3.0
20	-reserved-	n.c.	
21	$+5V_{DC}$	O	$+5V_{DC}$ output
22	$+5V_{DC}$	O	
23	-reserved-	n.c.	Not connected on the PM50 v3.0
24	-reserved-	n.c.	Not connected on the PM50 v3.0
25	-reserved-	n.c.	Not connected on the PM50 v3.0
26	-reserved-	n.c.	Not connected on the PM50 v3.0
27	-reserved-	n.c.	Not connected on the PM50 v3.0
28	-reserved-	n.c.	Not connected on the PM50 v3.0
29	-reserved-	n.c.	Not connected on the PM50 v3.0
30	-reserved-	n.c.	Not connected on the PM50 v3.0
31	In	O	CU input. Provides JP1 position: 1 logic -> JP1 =1-2, 0 logic -> JP1=2-3
32	-reserved-	n.c.	Not connected on the PM50 v3.0
33	-reserved-	n.c.	Not connected on the PM50 v3.0
34	-reserved-	n.c.	Not connected on the PM50 v3.0
35	-reserved-	n.c.	Not connected on the PM50 v3.0
36	-reserved-	n.c.	Not connected on the PM50 v3.0

Table D.8. *J3 – 3.3V-bus connector*

Pin	Name	Type	Description
1	+3.3V	I	+3.3V Power supply input
2	+3.3V	I	
3	PWM1	I[1]	CU[2] output. Active low command for the upper transistor, A-phase leg
4	PWM2	I	CU output. Active low command for the lower transistor, A-phase leg
5	PWM3	I	CU output. Active low command for the upper transistor, B-phase leg
6	PWM4	I	CU output. Active low command for the lower transistor, B-phase leg
7	PWM5	I	CU output. Active low command for the upper transistor, C-phase leg
8	PWM6	I	CU output. Active low command for the lower transistor, C-phase leg
9	-	n.c.	Not connected on the PM50 v3.0
10	T2PWM/ T2CMP	O	3.3V level translated output Hall1 from J7 connector.
11	TDIRA/ IOPB6	O	3.3V level translated output Hall2 from J7 connector.
12	TCLKINA/ IOPB7	O	3.3V level translated output Hall3 from J7 connector.
13	CAP1/QEP1	O	Output QEPA. Encoder signal A from J6, J66 or J666. 3.3V level translated
14	CAP2/QEP2	O	Output QEPA. Encoder signal A from J6, J66 or J666. 3.3V level translated
15	CAP3/IOPA5	O	Output QEPZ. Encoder signal A from J6, J66 or J666. 3.3V level translated
16	#PDPINTA	O	CU input. Power stage error signal, driven by protection circuitry. Open-collector signal .
17	-	n.c.	Not connected on the PM50 v3.0
18	-	n.c.	
19	SPISIMO	n.c.	
20	SPISOMI	n.c.	
21	SPICLK	n.c.	
22	SPISTE	n.c.	
23	GND		Ground terminal. All digital signals are referenced to this signal.
24	GND		
25	+5V	O	$+5V_{DC}$ from internal power suply .Connected to J1, J2, J3 connectors. Max. output current : 0.5A.
26	+5V		
27	VREFHI	n.c.	Not connected on the PM50 v3.0
28	VREFLO		Analog ground terminal. Separated from DGND. The connection between these two signals must be done on the CU.
29	ADCIN00	n.c.	Not connected on the PM50 v3.0
30	ADCIN01	n.c.	
31	ADCIN02	n.c.	
32	ADCIN03	n.c.	
33	ADCIN04	O	CU analog input for 3.3V. Value of the motor supply / DC-bus voltage. Gain factor is 60.6 mV/V
34	ADCIN05	O	CU analog input for 3.3V. Value of current in B-phase inverter lower leg, upper shifted with 1.66V. Gain factor is 0.263 V/A
35	ADCIN06	O	CU analog input for 3.3V. Value of current in A-phase inverter lower leg, upper shifted with 1.66V. Gain factor is 0.263 V/A
36	ADCIN07	O	CU analog input for 3.3V. Value of current in C-phase inverter lower leg, upper shifted with 1.66V. Gain factor is 0.263 V/A

[1] I – input in PM50 v3.0, output from control unit
[2] CU – control unit (MSK2407 DSP board) connected through the MC-bus with PM50 v3.0

JP1 - Jumper

The PM50 v3.0 power module provides one jumper JP1 whose position determines the level of the digital input In connected to the J1/J2 MC-Bus:

- JP1 = 1-2, In signal is high (1 logic)
- JP2 = 2-3, In signal is low (0 logic)

MSK2407 DSP board does not use this signal. It was maintained to comply with other control unit devices.

D.7. PM50 v3.0 - Electrical Specifications

Parameter	Conditions	Min.	Typ.	Max.	Units
DC Input Power					
Motor supply		9		36	V
Motor supply current				2.1	Arms
Motor supply current				6.33	Apeak
DC Output supply					
Output current on +5V supply to MC Bus J1,J2,J3	For CU		0.5	0.75	A
Output Power					
Voltage	set by external PWM control	0		36	Vrms
Nominal Motor Power	V_{in}=36V, f_{pwm}=20kHz, T_A=40°C			75	W
Nominal Motor Current	T_A=40°C			1.7	Arms
Overload Motor Current	V_{in}=36V, nominal full load current, f_{pwm}=20kHz, 0.1 sec. Duration			6.33	Apeak
PWM frequency		0.1	20	100	kHz
Inverter output dead band	Measured at inverter outputs using PWM commands with dead time of 0.5 µs, T_A = 25ºC		0.2		µs
Protections					
Output current trip level	T_C = 25ºC			7	Apeak
Over-voltage trip level		44	47	50	V
Under-voltage trip level	Referring to internal +12V supply, derived from logic supply (+5V)	10		11	V
Short circuit shutdown time	Output terminals shorted (U,V,W)		0.5		ms

Inputs from +5V MC-BUS J1, J2

PWM dead band command	Measured at MC-BUS pins, over operating ambient temperature	0.2	0.5		µs
High level input voltage	TTL compatible	2			V
Low level input voltage	TTL compatible			0.8	V
High level input current	Compatible with open-collector outputs	0		0	mA
Low level input current				2	mA

+3.3V Inputs from J3

PWM dead band command	Measured at MC-BUS pins, over operating ambient temperature	0.2	0.5		µs
High level input voltage	3.3V compatible	2		3.6	V
Low level input voltage	3.3V compatible			0.8	V

Analog Outputs

Gain of 3 motor currents feedback	Low-side leg inverter current / 5V bus		0.395		V/A
	Low-side leg inverter current / 3.3V bus		0.26		
Offset of 3 motor currents feedback on 5V MC Bus	to 5V MC-BUS J1, J2	2.375	2.5	2.625	V
	to 3.3V connector J3	1.65	1.66	1.67	V
Cut-off frequency of 3 motor currents feedback			400		KHz
DC bus voltage feedback gain	5V bus		90.9		mV/V_{BUS}
	3.3V bus		60.6		mV/V_{BUS}
Cut-off frequency of DC bus voltage			730		Hz
Setting time of the 3 motor currents feedback	10% accuracy: 5V bus			1	us
	10% accuracy: 3.3V bus			1.1	us

Digital Outputs to 5V MC-BUS J1, J2

High level output voltage for Mon/User MC-BUS pin J2/31	Direct link to +5V logic supply		5		V
Low level output voltage for Mon/User MC-BUS pin J2/31	Direct link to ground		0		V
High level output voltage for other signals on MC-BUS J1,J2		2			V
Low level output voltages for other signals on MC-BUS				0.8	V

Digital Outputs to 3.3V BUS J3

High level output voltages		2		3.6	V
Low level output voltages				0.8	V

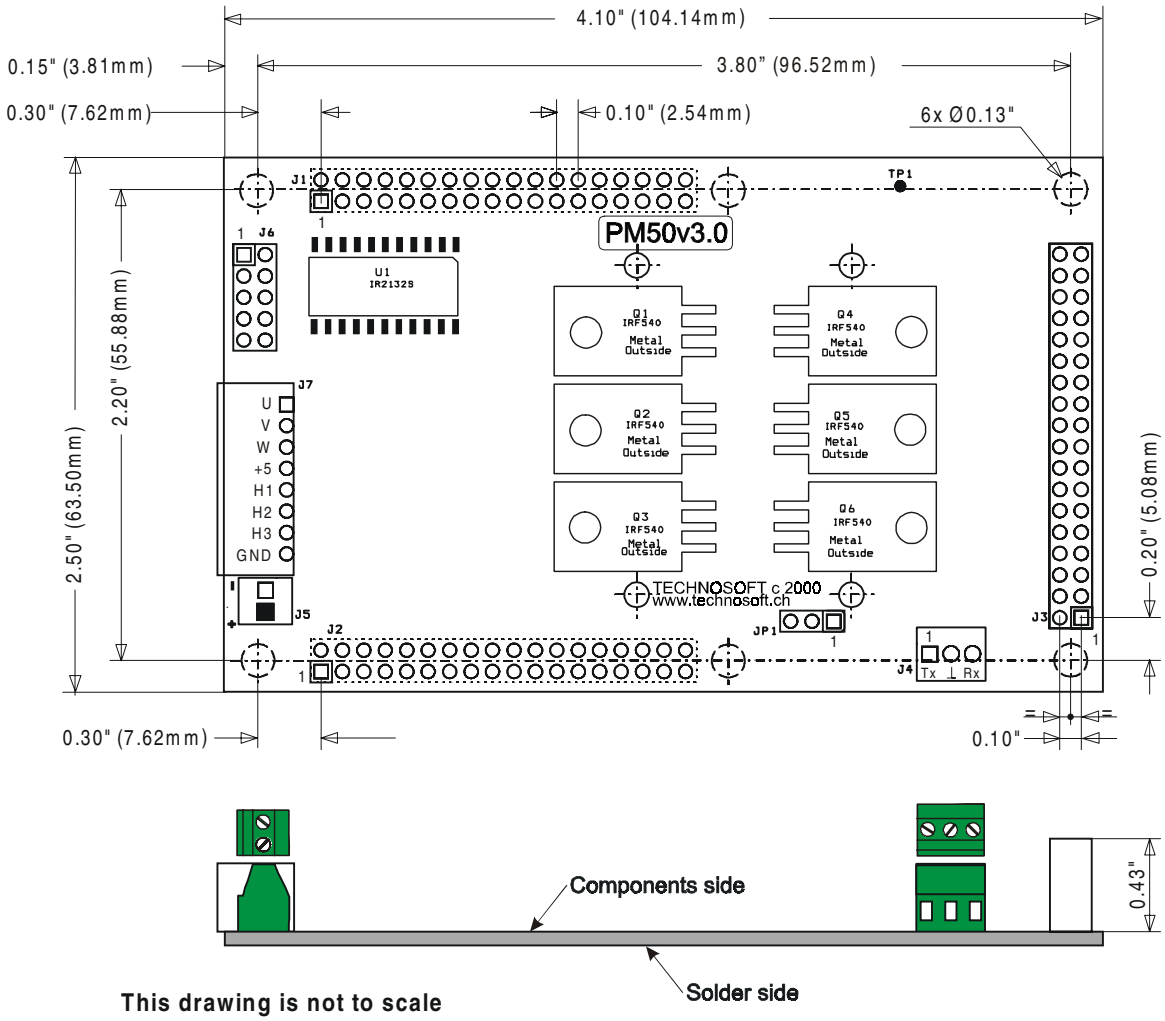
Hall Inputs from motor connector

High level input current	Pull-up resistor to +5V	0		0	mA
Low level input current				1.2	mA

System Environment

Ambient Operating Temp.	90%RH max. (non-condensing)	0		55	ºC

D.8. PM50 v3.0 – Mechanical Drawings



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