

Data Sheet

# EM-PMI540-T4000

Electric machine, permanent magnet internal

## FEATURES

- Synchronous Reluctance assisted Permanent Magnet (SRPM) technology
- Extremely compact and robust aluminum frame structure
- Highest efficiency throughout the operation range on the market (~96 %)
- Liquid cooled with water-glycol mixture
- Low coolant flow required
- Allowed coolant temperature up to +65°C
- IP65 enclosure class to maximize reliability
- Multiple mounting possibilities



## GENERATOR SPECIFIC FEATURES

- Standard SAE flange mounting to match the diesel engine connection
- Wide selection of speed ratings allowing the generator to be selected to customer specific applications with various voltage requirements
- Can also be used as starter motor for the ICE

## MOTOR SPECIFIC FEATURES

- Extended speed and torque capabilities compared to standard PM motors from Danfoss reluctance assisted permanent magnet motor technology
- Motor structure is designed to be able to produce high starting torque: EM-PMI motor can produce instantly full torque to a non-rotating shaft
- Optimized speed range to meet the most common gear ratios used in heavy mobile machinery

## GENERAL

The machine is developed especially for demanding applications. It is smaller, lighter and more efficient than conventional products on the market.

## TYPICAL APPLICATIONS

- Generator for diesel-electric/serial hybrid applications
- Traction/propulsion motor
- Generator/Motor for parallel hybrid applications

## SPECIFICATIONS

General electrical properties	
Nominal voltage (line-to-line)	500 V <sub>AC</sub>
Voltage stress	IEC 60034-25:2009, Curve A: Without filters for motors up to 500 V <sub>AC</sub>
Nominal efficiency	96 %
Pole pair number	8
Power supply	Inverter fed
Nominal inverter switching frequency	8 kHz
Minimal inverter switching frequency	4 kHz (with limited speed 1.4 times nominal speed)
Maximum phase-to-phase peak-to-peak voltage without du/dt	1.5 kV
Maximum voltage rise time without du/dt	8 kV/μs

Basic information	
Machine type	Synchronous reluctance assisted permanent magnet
Frame material	Aluminum
Mounting direction	Only horizontal assembly (see user guide for details)
Mounting (IEC 60034-7)	IM1001-B3 (horizontal foot mounting) IM2001-B35-B3 (horizontal foot + flange mounting)
Standard flange D-end (SAE J617)	SAE ½ mating transmission housing
Standard shaft type D-end	Male cylindrical shaft, diameter 70 mm h7, contact length 130 mm
Standard flange N-end (SAE J617)	SAE ½ flywheel housing partly available for supporting structures (see dimension drawings)
Standard rotation direction	Clockwise (both directions possible)
Bearing type	Standard: 6216/C3 (with LGHP2 grease) +BIN option: D-end: 6216/C3 (with LGHP2 grease) N-end: 6216/C3VL0241 (with LGHP2 grease) +BIA option: 6216/C3VL0241 (with LGHP2 grease)
Protection class	IP65 Following best design principles
Duty type (IEC 60034-1)	S1/S9
Machine coating	Dark grey RAL7024
Altitude	Up to 4000 m, see Picture 2

Mechanical	
Total weight	950 kg (no options)
Moment of inertia	10.3 kgm <sup>2</sup>
Torsional stiffness of shaft drive end	18*10 <sup>5</sup> Nm/rad (130 mm from end of the D-end shaft)
Rotating mass	380 kg
Maximum static torque range on the shaft, max. 25000 cycles, R=0 (*)	9000 Nm
Maximum dynamic torque range on the shaft, max. 1e6 cycles, R=0 (*)	6000 Nm
Maximum allowed vibratory torque range, 1e9...1e10 cycles (*)	0.3 x nominal torque of machine
Maximum deceleration (fault stop)	1000 rad/s <sup>2</sup>

Dimensions	
Length (frame)	1040 mm
Height (frame)	665 mm

Cooling	
Cooling liquid	Plain water with appropriate corrosive inhibitor (max. 50 % corrosive inhibitor)
Cooling liquid corrosive inhibitor type	Ethylene glycol (Glysantin G48 recommended)
Cooling method (IEC 60034-6)	IC 71 W
Minimum cooling liquid flow	40 l/min
Coolant circuit capacity	4.4 l
Maximum operating pressure	2 bar
Pressure loss	0.9 bar with 40 l/min (+25°C coolant)
Nominal cooling liquid temperature	+65°C (derating required if exceeded), +40°C with +CL option
Minimum cooling liquid temperature	-20°C
Maximum cooling liquid temperature	+70°C

Temperature rating	
Insulation class (IEC 60034-1)	H (+180°C)
Temperature rise (IEC 60034-1)	+85°C / +110°C with +CL option
Maximum winding temperature	+150°C
Nominal ambient temperature	+65°C / +45°C with +CL option
Min. ambient temperature	-40°C

Connections	
Coolant connection	2 x G3/4 bore (see dimension drawing for details)
Cable direction	Cable direction fixed
HV cables	2 x 3 x 95 mm <sup>2</sup> max. 4 x 3 x 95 mm <sup>2</sup> max.
HV cable glands	Pflitsch blueglobe TRI bg 232ms tri
HV cable recommended type	HUBER+SUHNER Radox Elastomer S, screened, single core, automotive cable (FHLR4GC13X) <a href="http://www.hubersuhner.com">www.hubersuhner.com</a>
HV cable lug size	70-8, 95-8
Recommended cable lug	70 mm <sup>2</sup> : Druseidt with narrow flange 03906 95 mm <sup>2</sup> : Druseidt with narrow flange 03910 <a href="http://www.druseidt.de">www.druseidt.de</a>
HV connection boxes	2 x 3 phase box 4 x 3 phase box
LV connector	47 pin DEUTSCH HD34-24-47PE for resolver and temperature measurement <a href="https://www.te.com">https://www.te.com</a>
LV connector type	DEUTSCH HD34-24-47PE
LV connector pin type	Gold plated
LV mating connector type	DEUTSCH HD36-24-47SE or DEUTSCH HD36-24-47SE-059 (**)
LV mating connector pin type	DEUTSCH 0462-201-1631 DEUTSCH 0462-005-2031 Plug: DEUTSCH 0413-204-2005 (size 20) Plug: DEUTSCH 0413-003-1605 (size 16)
LV connector pin configuration	See Table 1

Angle/Speed sensor	Type: Externally excited SIN/COS resolver Pole pair number 8 Input 7 V Frequency 10 kHz Output 2 V +/- 0.2 V Input impedance 110 Ohm +/- 10 % Output impedance 330 Ohm +/- 15 %
Anti-condensation heater (+HEAT2 option)	2 x 130 W 230 V <sub>AC</sub> single phase heater resistor
Heater connector (+HEAT2 option)	Hummel art no. 7651 0 51 01 D (combination of housing 7651 0 00 00 0, insert 7084 9 51 10 1 / 7084 9 51 12 1, crimp pins 7010 9 42 01 1) <a href="https://www.hummel.com">https://www.hummel.com</a>
Heater mating connector	Hummel art no. 7550 6 51 02 D (combination of housing 7550 6 00 00 0, insert 7084 9 51 10 2 / 7084 9 51 12 2 and crimp socket 7010 9 42 00 2)
Heater connector pin configuration	See Table 2
Bearing temp. measurement connector type	4-pin M12 A coded male
Bearing temp. measurement mating type	4-pin M12 A coded female
Bearing temp. measurement connector pin configuration	See Table 3

(\* The values are based on structural analysis and they are not applicable to any marine class rules or requirements.

(\*\* Connector IP-rating of IP67 is reached only when connector mating part is installed and all unused pin holes are plugged in the connector mating part with the following plugs, depending on the hole size: DEUTSCH 0413-003-1605 (size 16) or DEUTSCH 0413-204-2005 (size 20). For further information, contact the connector manufacturer TE connectivity directly.

PIN	Description
47	Temperature 1, PT100 (P), windings
46	Temperature 1, PT100 (N), windings
33	Temperature 2, PT100 (P), windings
32	Temperature 2, PT100 (N), windings
45	Temperature 3, PT100 (P), windings
31	Temperature 3, PT100 (N), windings
30	Temperature 4, PT100 (P), windings
29	Temperature 4, PT100 (N), windings
44	Temperature 5, PT100 (P), windings
43	Temperature 5, PT100 (N), windings
28	Temperature 6, PT100 (P), windings
16	Temperature 6, PT100 (N), windings
42	Temperature 7, PT100 (P), windings (+TEMP4 option)
27	Temperature 7, PT100 (N), windings (+TEMP4 option)
15	Temperature 8, PT100, (P) windings (+TEMP4 option)
14	Temperature 8, PT100 (N), windings (+TEMP4 option)
40	Temperature 9, PT100 (P), windings (+TEMP4 option)
26	Temperature 9, PT100 (N), windings (+TEMP4 option)
41	Temperature 10, PT100 (P), windings (+TEMP4 option)
13	Temperature 10, PT100 (N), windings (+TEMP4 option)
39	Temperature 11, PT100 (P), windings (+TEMP4 option)
38	Temperature 11, PT100 (N), windings (+TEMP4 option)
25	Temperature 12, PT100 (P), windings (+TEMP4 option)
12	Temperature 12, PT100 (N), windings (+TEMP4 option)
35	Resolver, RES_COS_N, inbuilt non-contacting
20	Resolver, RES_COS_P, inbuilt non-contacting
36	Resolver, RES_SIN_N, inbuilt non-contacting
21	Resolver, RES_SIN_P, inbuilt non-contacting
22	Resolver, EXCN, inbuilt non-contacting
10	Resolver, EXCP, inbuilt non-contacting
34	Resolver, SHIELD/GROUND, inbuilt non-contacting

Table 1 Pin configuration of LV-connector

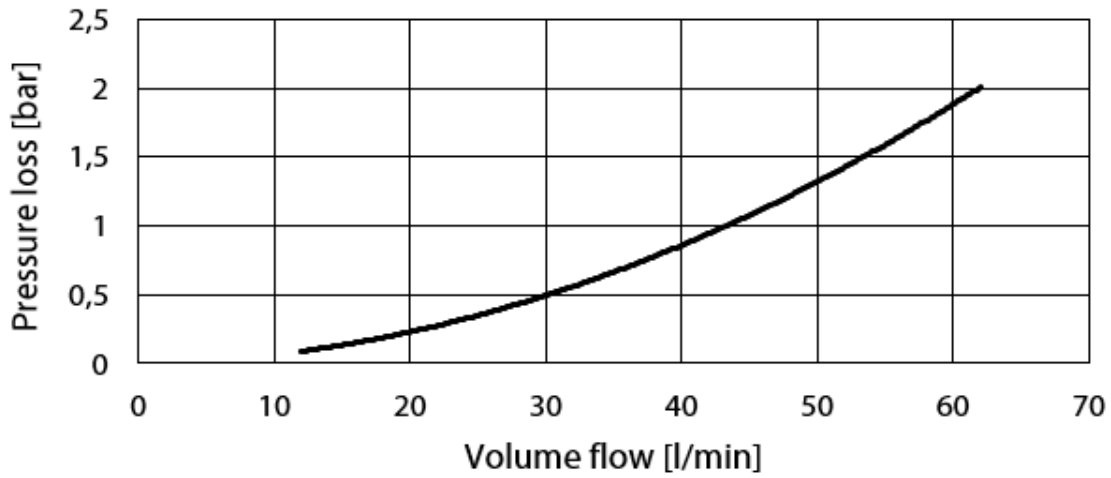
PIN	Description
1	Phase, 230 V <sub>AC</sub>
2	Neutral
⊥	Ground/protective earth
4	Reserve
5	Reserve

Table 2 Pin configuration of heater

PIN	Description
1	PT100
2	
3	PT100_GND
4	

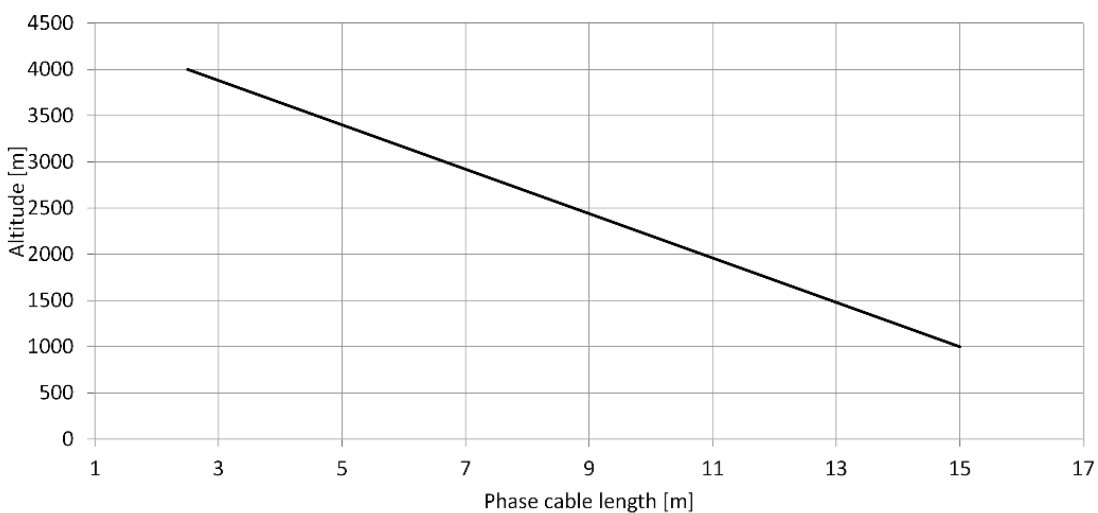
Table 3 Pin configuration of bearing temperature sensor connector (one sensor)

### PRESSURE LOSS VS COOLANT FLOW



Picture 1 Pressure loss vs coolant flow

### ALLOWED ALTITUDES VS PHASE CABLE LENGTH



Picture 2 Allowed altitudes vs phase cable length

## MOTORS

Type	Coolant temperature +65°C			Coolant temperature +40°C			Coolant temperature +40 / +65°C			
	Cont. Torque [Nm]	Cont. Power [kW]	Nom. Current [A]	Cont. Torque [Nm]	Cont. Power [kW]	Nom. Current [A]	Nom. speed [rpm]	Max. speed [rpm]	Peak torque DUAL (a)	Peak torque QUAD (b)
EM-PMI540-T4000-1200	4229	531	716	4692	590	790	1200	2000 (c)	4158	5930
EM-PMI540-T4000-1600	4183	701	954	4639	777	1058	1600	2000 (c)	3062	5930

(a) Peak torque achieved with two 350A inverters

(b) Peak torque achieved with four 350A inverters

(c) Mechanical maximum speed

The maximum allowed peak torque duration at stator winding starting temperature +90°C is 10.5 minutes. The given values indicate typical duration and are not verified. In case more accurate values are required, cyclic dimensions are needed.

## GENERATORS

Type	Coolant temperature +65°C				Coolant temperature +40°C				Coolant temperature +40 / +65°C		
	Apparent power [kVA]	Cont. power [kW]	Nom. Current [A]	Power factor	Apparent power [kVA]	Cont. Power [kW]	Nom. Current [A]	Power factor	Nom. speed [rpm]	Nom. Freq. [Hz]	Volt / speed ratio [V <sub>AC</sub> /rpm] (d)
EM-PMI540-T4000-1200	609	589	705	0.97	674	648	779	0.96	1400	187	0.416
EM-PMI540-T4000-1600	809	759	942	0.94	896	831	1040	0.93	1800	240	0.290

(d) Back EMF for cold (+20°C) generator

## PRODUCT CODE AND OPTIONS

Use product code including all needed options for ordering. Standard options are not given with the code as they are selected by default if a non-standard option is not selected. Standard options are indicated by a star (\*).

Product code	Description
EM-PMI540-T4000-1600-DUAL	Standard 1600 rpm unit with standard options
EM-PMI540-T4000-1600-DUAL+BIA+RES1	Standard unit otherwise but with isolated bearings and resolver

Table 4 Product code examples

Variant	Code	Description	Additional information
High voltage connections	-DUAL	Two galvanically isolated 3 phase systems	Two connection boxes each containing one 3 phase system with one M32 cable gland per phase
	-QUAD	Four galvanically isolated 3 phase systems	Four connection boxes each containing one 3 phase system with one M32 cable gland per phase
Bearing insulation	*	Non-insulated bearings	Non-insulated bearings
	+BIN	Insulated bearing in N-end	Insulated bearing in N-end
	+BIA	Insulated bearing in both ends	Insulated bearing in both ends
Shaft grounding	*	None	
	+SG1	D-end shaft grounding	Inbuilt grounding ring
Rotation sensor	*	None	No resolver
	+RES1	Resolver	Inbuilt non-contacting resolver, 8-pole pair
Winding temperature sensors (**)	*	Temperature surveillance	6 x PT100 in windings
	+TEMP4	Redundant temperature surveillance	12 x PT100 in windings
Bearing temperature sensors	*	None	
	+BTMP1	PT100 in bearings	Plug-in connector
Anti-condensation heaters	*	None	
	+HEAT2	Two anti-condensation heaters	2 x 230 V <sub>AC</sub> / 130 W (see user guide for more information)
Marine classification	*	No marine classification	
	+CL1		ABS American Bureau of Shipping
	+CL2		BV Bureau Veritas
	+CL3		DNV
	+CL4		LR Lloyd's Register
	+CL5		RINA
	+CL6		CCS China Classification Society

(\* Standard option

(\*\* Winding temperature sensors are for stator winding. The selection of high voltage connections does not have an influence on the quantity of PT100 elements.

Table 5 Option list

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