

Data Sheet

# EM-PMI540-T2000

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	Horizontal or vertical assembly (see user guide for details)
Mounting (IEC 60034-7)	IM 3009-B5 (flange horizontal), IM 3019-V1 (flange vertical and D-end down), IM1009 - B3 (horizontal, foot mounting), IM2009 - B35 (horizontal, foot and flange mounting), IM2019 - V15 (vertical, foot and flange mounting, D-end down)
Standard flange D-end (SAE J617)	SAE ½ mating transmission housing
Standard axle spline D-end	DIN5480 W55x2x26x8a
Standard flange N-end (SAE J617)	SAE ½ flywheel housing partly available for supporting structures (see dimension drawing for details)
Standard rotation direction	Clockwise (both directions possible)
Bearing type	Standard: 6214/C3 (with LGHP2 grease) +BIN option: D-end: 6214/C3 (with LGHP2 grease) N-end: 6214/HC5C3 (with LGHP2 grease) +BIA option: 6214/HC5C3WT (with LGHP2 grease)
Protection class	IP65
Duty type (IEC 60034-1)	S1/S9
Machine coating	Dark grey RAL7024

Mechanical	
Total weight	490 kg (no options)
Moment of inertia	4.73 kgm <sup>2</sup>
Torsional stiffness of shaft drive end	5*10 <sup>^5</sup> Nm/rad (from middle of the D-end spline to rotor air gap)
Rotating mass	189 kg
Maximum static torque range on the shaft, max. 25000 cycles, R=0 (*)	6800 Nm
Maximum dynamic torque range on the shaft, max. 1e6 cycles, R=0 (*)	4000 Nm
Maximum allowed vibratory torque range, 1e9...1e10 cycles (*)	0.3 x nominal torque of machine
Maximum deceleration (fault stop)	825 rad/s <sup>2</sup>

Dimensions	
Length (frame)	598 mm
Diameter (frame)	648 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	20 l/min
Coolant circuit capacity	3.9 l
Maximum operating pressure	2 bar
Pressure loss	0.4 bar with 20 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
Maximum winding temperature	+150°C
Nominal ambient temperature	+65°C / +45°C with +CL option
Min. ambient temperature	-40°C
Nominal altitude (IEC 60034-1)	1000 m

Vibration & Shock tolerance	
Mechanical vibration	5.9 G <sub>RMS</sub> ISO 16750-3 Test VII – Commercial vehicle, sprung masses – Table 12 Notes: Test duration 8h per axis (two axes tested; radial and axial) Total spectral acceleration 5.91 G <sub>RMS</sub> Test done with EM-PMI540-T1500 (with flange mounting)
Mechanical shock	50 G ISO 16750-3 4.2.2 Test for devices on rigid points on the body and on the frame Notes: –acceleration: 500 m/s <sup>2</sup> ; –duration: 6 ms; –number of shocks: 10 per test direction Test done with EM-PMI540-T1500 (with flange mounting)

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.
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	50-8, 70-8, 95-8
Recommended cable lug	50 mm <sup>2</sup> : Druseidt with narrow flange 03903 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
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 %
LV connections (+LVB1 option)	Connection box with 2x M25 cable glands (reserve 2x plugged M16 threads available) and terminal block for LV connections. See Table 2
Anti-condensation heater (+HEAT1 option)	130 W 230 V <sub>AC</sub> single phase heater resistor
Heater connection (+HEAT1 option)	Pflitsch blueglobe TRI bg 212ms tri (M12) and terminal strip inside connection box <a href="https://www.pflitsch.de">https://www.pflitsch.de</a>
Heater terminal strip pin configuration	See Table 3
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 4

(\* 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 (+TEMP4 +TEMP5 option)
29	Temperature 4, PT100 (N), windings (+TEMP4 +TEMP5 option)
44	Temperature 5, PT100 (P), windings (+TEMP4 +TEMP5 option)
43	Temperature 5, PT100 (N), windings (+TEMP4 +TEMP5 option)
28	Temperature 6, PT100 (P), windings (+TEMP4 +TEMP5 option)
16	Temperature 6, PT100 (N), windings (+TEMP4 +TEMP5 option)
42	Temperature 7, PT100 (P), windings (+TEMP5 option)
27	Temperature 7, PT100 (N), windings (+TEMP5 option)
15	Temperature 8, PT100, (P) windings (+TEMP5 option)
14	Temperature 8, PT100 (N), windings (+TEMP5 option)
40	Temperature 9, PT100 (P), windings (+TEMP5 option)
26	Temperature 9, PT100 (N), windings (+TEMP5 option)
41	Temperature 10, PT100 (P), windings (+TEMP5 option)
13	Temperature 10, PT100 (N), windings (+TEMP5 option)
39	Temperature 11, PT100 (P), windings (+TEMP5 option)
38	Temperature 11, PT100 (N), windings (+TEMP5 option)
25	Temperature 12, PT100 (P), windings (+TEMP5 option)
12	Temperature 12, PT100 (N), windings (+TEMP5 option)
35	Resolver, RES_COS_N, in-built non-contacting
20	Resolver, RES_COS_P, in-built non-contacting
36	Resolver, RES_SIN_N, in-built non-contacting
21	Resolver, RES_SIN_P, in-built non-contacting
22	Resolver, EXCN, in-built non-contacting
10	Resolver, EXCP, in-built non-contacting
34	Resolver, SHIELD/GROUND, in-built non-contacting

Table 1 Pin configuration of LV-connector

PIN	Description
1	Heater, phase, 230 V <sub>AC</sub>
2	Heater, neutral
⏚	Heater, ground / protective earth, M5 screw inside connection box
3	Reserve
4	Reserve
5	Temperature 1, PT100 (P), windings
6	Temperature 1, PT100 (N), windings
7	Temperature 2, PT100 (P), windings
8	Temperature 2, PT100 (N), windings
9	Temperature 3, PT100 (P), windings
10	Temperature 3, PT100 (N), windings

11	Temperature 4, PT100 (P), windings (+TEMP4 option)
12	Temperature 4, PT100 (N), windings (+TEMP4 option)
13	Temperature 5, PT100 (P), windings (+TEMP4 option)
14	Temperature 5, PT100 (N), windings (+TEMP4 option)
15	Temperature 6, PT100 (P), windings (+TEMP4 option)
16	Temperature 6, PT100 (N), windings (+TEMP4 option)
17	Temperature 7, PT100 (P), windings (+TEMP5 option)
18	Temperature 7, PT100 (N), windings (+TEMP5 option)
19	Temperature 8, PT100 (P), windings (+TEMP5 option)
20	Temperature 8, PT100 (N), windings (+TEMP5 option)
21	Temperature 9, PT100 (P), windings (+TEMP5 option)
22	Temperature 9, PT100 (N), windings (+TEMP5 option)
23	Temperature 10, PT100 (P), windings (+TEMP5 option)
24	Temperature 10, PT100 (N), windings (+TEMP5 option)
25	Temperature 11, PT100 (P), windings (+TEMP5 option)
26	Temperature 11, PT100 (N), windings (+TEMP5 option)
27	Temperature 12, PT100 (P), windings (+TEMP5 option)
28	Temperature 12, PT100 (N), windings (+TEMP5 option)
29	Resolver, RES_COS_P, in-built non-contacting (+RES1 option)
30	Resolver, RES_COS_N, in-built non-contacting (+RES1 option)
31	Resolver, RES_SIN_P, in-built non-contacting (+RES1 option)
32	Resolver, RES_SIN_N, in-built non-contacting (+RES1 option)
33	Resolver, EXCP, in-built non-contacting (+RES1 option)
34	Resolver, EXCN, in-built non-contacting (+RES1 option)
35	Resolver, SHIELD/GROUND, in-built non-contacting (+RES1 option)
36	Temperature, PT100 (P), bearings N-end (+BTMP1 option)
37	Temperature, PT100 (N), bearings N-end (+BTMP1 option)
38	Reserve
39	Reserve
NA	D-end bearing temperature sensor with separate connector (+BTMP1 option), see table below

Table 2 Pin configuration of LV connections (+LVB1 option)

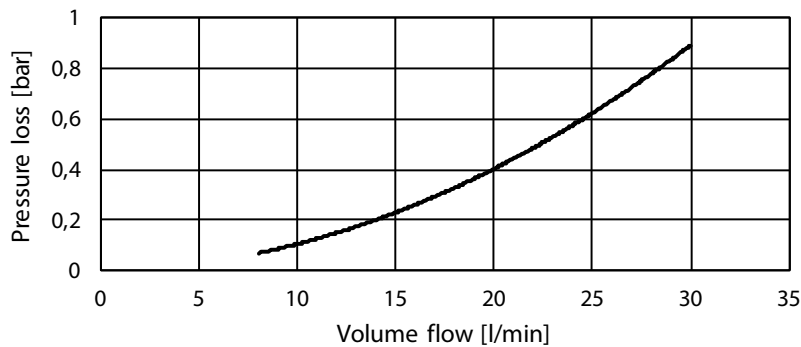
PIN	Description
1	Phase, 230 V <sub>AC</sub> / Neutral
2	Phase, 230 V <sub>AC</sub> / Neutral
⏚	Ground/protective earth, M5 screw connection inside connection box

Table 3 Pin configuration of heater (pin configuration does not matter)

PIN	Description
1	PT100
2	
3	PT100_GND
4	

Table 4 Pin configuration of bearing temperature sensor connector (one sensor)

## PRESSURE LOSS VS COOLANT FLOW



Picture 1 Pressure loss vs coolant flow

## 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 SINGLE (*)	Peak torque DUAL (**)
EM-PMI540-T2000-700	2462	180	242	2716	199	267	700	1400	3400	3700
EM-PMI540-T2000-1000	2390	250	321	2570	269	344	1000	2000	2500	3650
EM-PMI540-T2000-1300	2303	313	413	2386	325	431	1300	2600	1930	3650
EM-PMI540-T2000-1700	2009	358	485	2276	405	543	1700	3400	1400	2750
EM-PMI540-T2000-2100	1919	422	569	2153	473	633	2100	4000	1150	2300

(\* Peak torque achieved with one 350A inverter

(\*\* Peak torque achieved with two 350A inverters

(\*\*\* Mechanical maximum speed

The maximum allowed peak torque duration at stator winding starting temperature +90°C is 6.5 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] (*)
EM-PMI540-T2000-700	211	201	241	0.95	233	221	266	0.95	800	107	0.714
EM-PMI540-T2000-1000	279	269	320	0.97	297	285	342	0.96	1100	147	0.492
EM-PMI540-T2000-1300	355	331	410	0.93	372	347	428	0.93	1400	186	0.363
EM-PMI540-T2000-1700	436	413	506	0.95	466	440	538	0.94	1900	253	0.272
EM-PMI540-T2000-2100	482	454	562	0.94	534	510	621	0.95	2300	307	0.227

(\* 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-T2000-1700-DUAL	Standard 1700 rpm unit with standard options
EM-PMI540-T2000-1700-DUAL+BIN	Standard unit with insulated bearing in N-end

Table 5 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
Connection extension	*	None	Two connection boxes each containing one 3 phase system with one M32 cable gland per phase
	+CE1	Double phase connections	Extended connection boxes with two M32 cable glands per phase
Low voltage connections	*	Low voltage connections done with connector	DEUTSCH HD34-24-47PE connector for LV connections
	+LVB1	Low voltage connections done with connection box and terminal strip	Connection box with 2x M25 cable glands (reserve 2x plugged M16 threads available) and terminal block for LV connections
N-end attachment	*	None	
	+NE4	Male shaft, no flange	DIN5480 W55x2x26x8a
Foot mounting	*	None	
	+FM1	Foot	Foot mounting, shaft height 315 mm
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	In-built grounding ring
Rotation sensor	*	None	No resolver
	+RES1	Resolver	In-built non contacting resolver, 8-pole pair
Winding temperature sensors (**)	*	Temperature surveillance	3 x PT100 (two wire) in windings
	+TEMP4	Redundant temperature surveillance	6 x PT100 (two wire) in windings
	+TEMP5	Redundant temperature surveillance	12 x PT100 (two wire) in windings
Bearing temperature sensors	*	None	
	+BTMP1	PT100 in bearings	Plug-in connector
Anti-condensation heaters	*	None	
	+HEAT1	One anti-condensation heater	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 6 Option list

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