

Data Sheet

EM-PMI540-T1500

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 plain water or water/glycol mixture
- Low coolant flow required
- Allowed coolant temperature up to +65°C
- IP65 enclosure class to maximize reliability
- Multiple mounting possibilities

**GENERAL**

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

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 be also used as starter motor for the ICE

TYPICAL APPLICATIONS

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

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

SPECIFICATIONS

General electrical properties

Nominal voltage (line to line)	500 V _{AC}
Voltage stress	IEC 60034-25, Curve A: Without filters for motors up to 500 V _{AC}
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)

Basic information

Machine type	Synchronous reluctance assisted permanent magnet
Frame material	Aluminum
Mounting direction	Horizontal or vertical assembly (V1, D-end shaft down), 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
Axle spline N-end	See option list option +NE4 Note: Also D-end axle length changes from 80mm to 100mm with this option
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)
Standard rotation direction	Clockwise (both directions possible)
Protection class	IP65 Tests: 0.3 bar under pressure held for 120 seconds. Pressure not allowed to drop under 0.1 bar
Duty type (IEC 60034-1)	S1/S9

Standard color Dark grey RAL7024 powder coating

Mechanical

Total weight	390 kg (no options)
Moment of inertia	3.45 kgm ²
Torsional stiffness of shaft drive end	6*10 ⁵ Nm/rad (from middle of the d-end spline to rotor air gap)
Rotating mass	140 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)	1050 rad/s ²

Dimensions

Length (frame)	531 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 20l/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

Condensation dew point	Please use anti-condensation heaters	HV cable lug size	35-8, 50-8, 70-8, 95-8
Temperature rating		Recommended cable lug	35 mm ² : Druseidt with narrow flange 03901 50 mm ² : Druseidt with narrow flange 03903 70 mm ² : Druseidt with narrow flange 03906 95 mm ² : Druseidt with narrow flange 03910
Insulation class (IEC 60034-1)	H (180°C)		
Temperature rise (IEC 60034-1)	85°C		
Maximum winding temperature	150°C	HV connection boxes	2 x 3 phase box
Nominal ambient temperature	+65°C / +45°C with +CL option	LV connector	47 pin DEUTSCH HD34-24-47PE for resolver and temperature measurement.
Min. ambient temperature	-40°C	LV connector type	DEUTSCH HD34-24-47PE
Nominal altitude (IEC 60034-1)	1000 m	LV connector pin type	Gold plated
Vibration & Shock tolerance		LV mating connector type	DEUTSCH HD36-24-47SE or DEUTSCH HD36-24-47SE-059
Mechanical vibration	5.9 G _{RMS} ISO 16750-3 Test VII – Commercial vehicle, sprung masses – Table 12 Notes: test duration 8h per each axis (two axes tested; radial and axial) total spectral acceleration 5.91 G _{RMS} Test done with EM-PMI540-T1500 (with flange mounting)	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)
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 ² ; –duration: 6 ms; –number of shocks: 10 per test direction. Test done with EM-PMI540-T1500 (with flange mounting)	LV connector pin configuration	See Table below
Connections		Anti-condensation heater (+HEAT1 option)	130 W 230 V _{AC} single phase heater resistor
Coolant connection	2 x G3/4 bore	Heater connection (+HEAT1 option)	Pflitsch blueglobe mstri212 (M12) and terminal strip inside connection box
Cable direction	Cable direction fixed	Heater terminal strip pin configuration	See Table below
HV cables	2 x 3 x 95 mm ² max.	Bearing temp. measurement connector type	4-pin M12 A coded male
HV cable glands	Pflitsch blueglobe TRI bg 232ms tri	Bearing temp. measurement mating type	4-pin M12 A coded female
HV cable	Recommended H+S Radox screened cable	Bearing temp. measurement connector pin configuration	See Table below

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

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 _{AC}
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 2

Table 3 Pin configuration of LV connections (+LVB1 option)

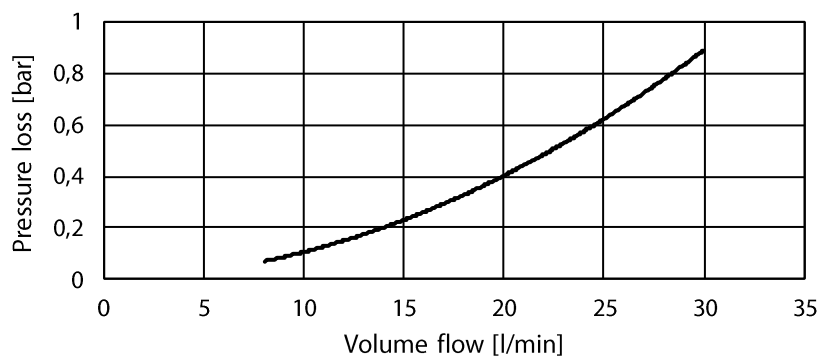
PIN	Description
1	Phase, 230 V _{AC} / Neutral
2	Phase, 230 V _{AC} / Neutral
⏏	Ground/protective earth, M5 screw connection inside connection box

Table 4 Pin configuration of heater (pin configuration does not matter)

PIN	Description
1	PT100
2	
3	
4	PT100_GND

Table 5 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-T1500-700	1619	119	154	1810	133	176	700	1400	2600	-
EM-PMI540-T1500-1200	1580	199	269	1716	216	293	1200	2400	2110	2600
EM-PMI540-T1500-1400	1553	228	325	1723	253	358	1400	2800	1695	2600
EM-PMI540-T1500-1600	1452	243	342	1662	278	391	1600	3200	1500	2600
EM-PMI540-T1500-1800	1455	274	376	1606	303	413	1800	3600	1359	2600
EM-PMI540-T1500-2100	1381	304	411	1542	339	454	2100	4000	1118	2500
EM-PMI540-T1500-2400	1322	332	458	1510	380	522	2400	4000	1012	2135

(* Peak torque achieved with one (350A) inverter

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

The maximum allowed peak torque duration at stator winding starting temperature +90°C is 5.5 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 _{AC} /rpm] (***)
EM-PMI540-T1500-700	137	131	153	0.96	155	147	175	0.95	800	106.7	0.713
EM-PMI540-T1500-1200	232	221	268	0.95	254	241	291	0.95	1400	187	0.389
EM-PMI540-T1500-1400	277	255	321	0.92	308	282	356	0.92	1600	213	0.324
EM-PMI540-T1500-1600	292	267	338	0.91	336	302	358	0.90	1800	240	0.291
EM-PMI540-T1500-1800	321	300	372	0.94	354	330	409	0.93	2000	267	0.259
EM-PMI540-T1500-2100	349	329	405	0.94	388	364	450	0.94	2300	307	0.238
EM-PMI540-T1500-2400	378	349	441	0.92	443	409	516	0.92	2600	347	0.194

(*** 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-T1500-1600-DUAL	Standard 1600 rpm unit with standard options
EM-PMI540-T1500-1600-DUAL+BIN	Standard unit with insulated bearing in N-end

Table 6 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
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
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
N-end attachment	*	None	
	+NE4	Male shaft, no flange	DIN5480 W55x2x26x8a, D-end axle length increases from 80mm to 100mm with +NE4 option
Foot mounting	*	None	
	+FM1	Foot	Foot mounting, shaft height 315mm
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 _{AC} / 130 W
Marine classification	*	No marine classification	
	+CL1		ABS American Bureau of Shipping
	+CL2		BV Bureau Veritas
	+CL3		DNV
	+CL4		LR Lloyd's Register
	+CL5		RINA

(* 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 7 Option list

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