Data Sheet

EM-PMI375-T500

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, IP67 available as option
- 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_{AC}
Voltage stress	IEC 60034-25:2009, Curve A: Without filters for motors up to 500 V_{AC}
Nominal efficiency	96 %
Pole pair number	6
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	Can be used in all directions, see user guide for details. Greased for life bearings required.
Mounting (IEC 60034-7)	IM 3009-B5 (flange horizontal), IM 3019-V1 (flange and D-end down)
Standard flange D-end (SAE J617)	SAE 3 transmission housing
Standard axle spline D-end	DIN5480 W50x2x24x8f
Standard flange N-end (SAE J617)	SAE 4 flywheel housing
Standard rotation direction	Clockwise (both directions possible)
Bearing type	Standard: 6211-2RS1/C3WT +BHS option: 6211/C3 (with LGHP2 grease) +BIN option: D-end: 6211-2RS1/C3WT N-end: 6211-2RS1/HC5C3WT +BIA option: 6211-2RS1/HC5C3WT +BHS+BIN options: D-end: 6211/C3 (with LGHP2 grease) N-end: 6211/HC5C3WT (with LGHP2 grease) +BHS+BIA options: 6211/HC5C3 (with LGHP2 grease)
Protection class	IP65 IP67 available as option +IP67
Duty type (IEC 60034-1)	S1/S9
Machine coating	Dark grey RAL7024

Mechanical

Total weight	172 kg (no options)
Moment of inertia	0.46 kgm²
Torsional stiffness of shaft drive end	4*10^5 Nm/rad (from middle of the D-end spline to rotor air gap)
Rotating mass	52.5 kg

Maximum static torque range on the shaft, max. 25000 cycles, R=0 (*	3400 Nm
Maximum dynamic torque range on the shaft, max. 1e6 cycles, R=0 (*	2500 Nm
Maximum allowed vibratory torque range, 1e9...1e10 cycles (*	0.3 x nominal torque of machine
Maximum deceleration (fault stop)	6000 rad/s^2

Dimensions

Length (frame)	368 mm
Diameter (frame)	450 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	1.4 l
Maximum operating pressure	3 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 (F) / +110°C (H)
Maximum winding temperature	+175°C
Nominal ambient temperature	+65°C / +40°C with +CL option
Min. ambient temperature	-40°C
Nominal altitude (IEC 60034-1)	1000 m

Vibration & Shock tolerance

Mechanical vibration	5.9 G$_{RMS}$ ISO 16750-3 Test VII – Commercial vehicle, sprung masses – Table 12 Notes: Test duration 8h axis (two axes tested; radial and axial) Total spectral acceleration 5.91 G$_{RMS}$ Test done with EM-PMI375-T800 (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^2; –duration: 6 ms; –number of shocks: 10 per test direction Test done with EM-PMI375-T800 (with flange mounting)

Connections

Coolant connection	2 x G3/4 bore (see dimension drawing for details)
Cable direction	Standard cable direction towards D-end
HV cables	3 x 70 mm^2 max. (SINGLE winding model) 2 x 3 x 70 mm^2 max. (DUAL winding model)
HV cable glands	Pflitsch blueglobe TRI bg 225ms tri
HV cable recommended type	HUBER+SUHNER Radox Elastomer S, screened, single core, automotive cable (FHLR4GC13X) www.hubersuhner.com
HV cable lug size	35-8, 50-8, 70-8
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 www.druseidt.de
HV connection boxes	1 x 3 phase box (SINGLE winding model) 2 x 3 phase box (DUAL winding model)
LV connector	47 pin DEUTSCH HD34-24-47PE for resolver and temperature measurement https://www.te.com
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
LV connections (+LVB1 option)	Connection box with 2 x M25 cable glands (reserve 2 x plugged M16 threads available) and terminal block for LV connections. See Table 2
Angle/Speed sensor	Type: Externally excited SIN/COS resolver Pole pair number 6 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 (+HEAT1 option)	65 W 230 V$_{AC}$ single phase heater resistor
Heater connector (+HEAT1 option)	Hummel art no. 7651 0 51 01 D (combination of housing 7651 0 000 00 0, insert 7084 9 51 10 1 / 7084 9 51 12 1, crimp pins 7010 9 42 01 1) https://www.hummel.com
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 type	Hummel 7010 9 42 01 1
Heater connector 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	SeeTable 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 option)
29	Temperature 4, PT100 (N), windings (+TEMP4 option)
44	Temperature 5, PT100 (P), windings (+TEMP4 option)
43	Temperature 5, PT100 (N), windings (+TEMP4 option)
28	Temperature 6, PT100 (P), windings (+TEMP4 option)
16	Temperature 6, PT100 (N), windings (+TEMP4 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
37	Resolver, RES_COS_N, in-built non-contacting (additional resolver with +RES2 option)
24	Resolver, RES_COS_P, in-built non-contacting (additional resolver with +RES2 option)
23	Resolver, RES_SIN_N, in-built non-contacting (additional resolver with +RES2 option)
11	Resolver, RES_SIN_P, in-built non-contacting (additional resolver with +RES2 option)
9	Resolver, EXCN, in-built non-contacting (additional resolver with +RES2 option)
8	Resolver, EXCP, in-built non-contacting (additional resolver with +RES2 option)
4	Resolver, SHIELD/GROUND, in-built non-contacting (additional resolver with +RES2 option)

Table 1 Pin configuration of LV-connector

PIN	Description
1	Temperature 1, PT100 (P), windings
2	Temperature 1, PT100 (N), windings
3	Temperature 2, PT100 (P), windings
4	Temperature 2, PT100 (N), windings
5	Temperature 3, PT100 (P), windings
6	Temperature 3, PT100 (N), windings
7	Temperature 4, PT100 (P), windings (+TEMP4 option)
8	Temperature 4, PT100 (N), windings (+TEMP4 option)
9	Temperature 5, PT100 (P), windings (+TEMP4 option)
10	Temperature 5, PT100 (N), windings (+TEMP4 option)
11	Temperature 6, PT100 (P), windings (+TEMP4 option)
12	Temperature 6, PT100 (N), windings (+TEMP4 option)
16	Heater, phase, 230 V_{AC}
17	Heater, neutral
⏚	Heater, ground / protective earth, M4 screw inside connection box
⏚	General shielding, ground / protective earth, M4 screw inside connection box
18	Resolver, RES_COS_N, in-built non-contacting
19	Resolver, RES_COS_P, in-built non-contacting
20	Resolver, RES_SIN_N, in-built non-contacting
21	Resolver, RES_SIN_P, in-built non-contacting
22	Resolver, EXCN, in-built non-contacting
23	Resolver, EXCP, in-built non-contacting
24	Temperature, PT100 (P), bearings N-end (+BTMP1 option)
25	Temperature, PT100 (N), bearings N-end (+BTMP1 option)
NA	D-end bearing temperature sensor with separate connector (+BTMP1 option), see table below

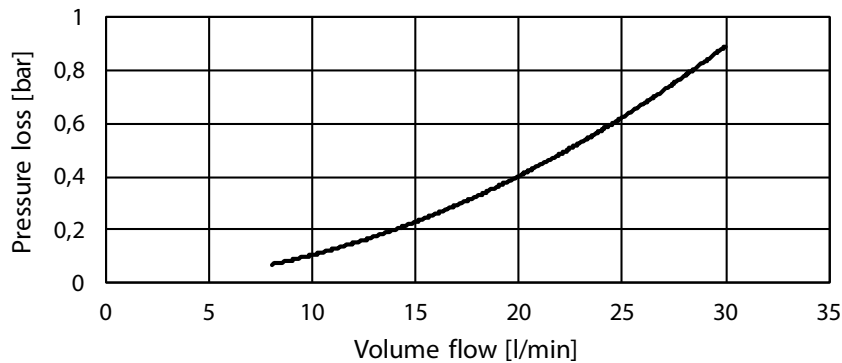Table 2 Pin configuration of LV connections (+LVB1 option)

PIN	Description
1	Phase, 230 V_{AC}
2	Neutral
⏚	Ground / protective earth
4	Reserve
5	Reserve

Table 3 Pin configuration of heater with connector

PIN	Description
1	PT100
2	PT100
3	PT100_GND
4	PT100_GND

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

PRESSURE LOSS VS COOLANT FLOW

Picture 1 Pressure loss vs coolant flow

MOTORS (temperature class F, maximum winding temperature +150°C, with +CL option)

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-PMI375-T500-1300	520	71	95	575	78	110	1300	2600	1480	N/A
EM-PMI375-T500-1800	511	96	121	560	106	132	1800	3600	1400	N/A
EM-PMI375-T500-2000	502	105	136	550	115	149	2000	4000	1200	N/A
EM-PMI375-T500-2300	497	120	156	543	125	168	2300	4000	1170	N/A
EM-PMI375-T500-2700	472	133	170	530	150	192	2700	4000	895	N/A
EM-PMI375-T500-3200	442	148	192	484	162	208	3200	4000	736	1038

(* Peak torque achieved with one 350A inverter
(** Peak torque achieved with two 350A inverters
(*** Mechanical maximum speed

GENERATORS (temperature class F, maximum winding temperature +150°C, with +CL option)

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-PMI375-T500-1300	82	74	94	0.91	95	83	109	0.87	1400	140	0.379
EM-PMI375-T500-1800	104	102	120	0.98	113	110	131	0.97	1900	190	0.284
EM-PMI375-T500-2000	116	110	135	0.94	129	120	148	0.93	2100	210	0.252
EM-PMI375-T500-2300	133	125	153	0.94	144	131	165	0.91	2300	240	0.217
EM-PMI375-T500-2700	145	138	169	0.95	164	155	191	0.94	2800	280	0.190
EM-PMI375-T500-3200	164	154	190	0.94	177	166	205	0.94	3300	330	0.158

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

MOTORS (temperature class F, maximum winding temperature +150℃, with nominal voltage 400 V$_{AC}$)

Type	Coolant temperature +40 °C					
	Cont. Torque [Nm]	Cont. Power [kW]	Nom. Current [A]	Nom. Speed [rpm]	Max. Speed [rpm] (*	Peak Torque [Nm]
EM-PMI375-T500-1300	625	65	108	1000	2600	1480
EM-PMI375-T500-1800	592	81	136	1300	3600	1400
EM-PMI375-T500-2000	586	92	156	1500	4000	1200
EM-PMI375-T500-2300	590	105	181	1700	4000	1170
EM-PMI375-T500-2700	555	116	196	2000	4000	895
EM-PMI375-T500-3200	541	136	228	2400	4000	736

(* Mechanical maximum speed

MOTORS (temperature class H, maximum winding temperature +175℃)

Type	Coolant temperature +65℃			Coolant temperature +40℃			Coolant temperature +40/+65℃			
	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-PMI375-T500-1300	560	76	103	607	83	114	1300	2600	1480	N/A
EM-PMI375-T500-1800	552	104	131	616	116	146	1800	3600	1400	N/A
EM-PMI375-T500-2000	550	115	150	596	125	164	2000	4000	1200	N/A
EM-PMI375-T500-2300	538	130	169	578	139	184	2300	4000	1170	N/A
EM-PMI375-T500-2700	524	148	190	585	165	215	2700	4000	895	N/A
EM-PMI375-T500-3200	473	158	207	539	181	233	3200	4000	736	1038

(* 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℃ is 1.5 minutes. The given values indicate typical duration and are not verified. In case more accurate values are required, cyclic dimensions are needed.

GENERATORS (temperature class H, maximum winding temperature +175℃)

Type	Coolant temperature +65℃				Coolant temperature +40℃				Coolant temperature +40/+65℃		
	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-PMI375-T500-1300	90	83	102	0.93	100	90	113	0.89	1500	150	0.379
EM-PMI375-T500-1800	113	110	130	0.97	126	124	145	0.98	2000	200	0.284
EM-PMI375-T500-2000	129	123	148	0.95	141	131	163	0.93	2100	210	0.252
EM-PMI375-T500-2300	144	134	166	0.93	158	146	181	0.93	2400	240	0.217
EM-PMI375-T500-2700	163	153	189	0.94	186	173	213	0.93	2800	280	0.190
EM-PMI375-T500-3200	177	166	204	0.94	199	185	230	0.93	3300	330	0.158

(* Back EMF for cold (+20℃) 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 name	Description
EM-PMI375-T500-1300	Standard 1300 rpm unit with standard options
EM-PMI375-T500-1300+BIN+RES1	Standard unit otherwise but with insulated bearing in N-end and resolver

Table 5 Product code examples

Variant	Code	Description	Additional information
High voltage connections	*	One 3 phase system	One connection box containing one 3 phase system with one M25 cable gland per phase
	-DUAL	Two galvanically isolated 3 phase systems	Two connection boxes each containing one 3 phase system with one M25 cable gland per phase. Available only for speed variant 3200 rpm
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	*	Flange	SAE 4 flywheel housing
	+NE2	Male shaft + Flange	DIN5480 W50x2x24x8f + SAE 4 flywheel housing
Bearing lubrication and mounting direction	*	Greased for life	Deep groove ball bearing, contact seal on both sides, any mounting direction (see user guide for details)
	+BHS	Grease lubricated	Deep groove ball bearing, open design, horizontal mounting direction (see user guide for details)
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
Protection class	*	Standard protection class	IP65 protection class
	+IP67	IP67 protection class	IP67 protection class, not available with +BHS option
Cable direction	*	Cable direction fixed	Cable direction towards D-end
	+CNE	Cable direction towards N-end	Cable direction towards N-end
Rotation sensor	*	None	No resolver
	+RES1	Resolver	In-built non contacting resolver, 6-pole pair
	+RES2	Double resolver	2 x In-built non contacting resolver, 6-pole pair
Side mounting	*	None	No side mounting holes available. In case side mounting holes are present, they are plugged by default.
	+SM1	Side mounting	12 x side mounting threaded holes M10x1.5. Plugged by default with M10x10, DIN 913, (ISO 4026), SET SCREW
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 (not available with +LVB1 option)

Bearing temperature sensors	*	None	
	+BTMP1	PT100 in bearings	Plug-in connector
Anti-condensation heaters	*	None	
	+HEAT1	One anti-condensation heater	230 V_{AC} / 65 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

Classified as Business