ENGINEERING TOMORROW

Data Sheet

EM-PMI375-T1100-690V

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)	690 V_{AC}
Nominal efficiency	96 %
Pole pair number	6
Power supply	Inverter fed
Minimum inverter switching frequency	4 kHz
Maximum phase-to-phase peak-to-peak voltage without du/dt	2 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 W55x2x26x8a
Standard flange N-end (SAE J617)	SAE 4 flywheel housing
Standard rotation direction	Clockwise (both directions possible)
Bearing type	Standard: 6214/C3 (with LGHP2 grease) +BGL option: 6214-2RS1/C3WT +BIN option: D-end: 6214/C3 (with LGHP2 grease) N-end: 6214/HC5C3 (with LGHP2 grease) +BIA option: 6214/HC5C3WT (with LGHP2 grease) +BGL, +BIN options: D-end: 6214-2RS1/C3WT N-end: 6214-2RS1/HC5C3WT +BGL, +BIA options: 6214-2RS1/HC5C3
Protection class	IP65 IP67 available as option +IP67
Duty type (IEC 60034-1)	S1/S9
Machine coating	Dark grey RAL7024
Altitude	Up to 3000 m, see Picture 2

Mechanical	
Total weight	295 kg (no options)
Moment of inertia	0.99 kgm^2
Torsional stiffness of shaft drive end	7*10^5 Nm/rad (from middle of the D-end spline to rotor air gap)
Rotating mass	111 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)	2000 rad/s^2

Dimensions	
Length (frame)	548 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	2.8 l
Maximum operating pressure	3 bar
Pressure loss	0.4 bar with 20 l/min (+25°C coolant)
Nominal cooling liquid temperature	+65°C, +40°C with +CL option
Minimum cooling liquid temperature	-20°C
Maximum cooling liquid temperature	+65°C

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

Vibration & Shock tolerance	
Mechanical vibration	5.9 G_{RMS} ISO 16750-3:2003 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 16750-3:2003 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 2x plugged M16 threads available) and terminal block for LV connections. See Table 2
Anti-condensation heater (+HEAT1 option)	130 W 230 V_{AC} single phase heater resistor
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 %

Heater connector (+HEAT1 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) 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, 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	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 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, 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
37	Resolver, RES_COS_N, inbuilt non-contacting
24	Resolver, RES_COS_P, inbuilt non-contacting
23	Resolver, RES_SIN_N, inbuilt non-contacting
11	Resolver, RES_SIN_P, inbuilt non-contacting
9	Resolver, EXCN, inbuilt non-contacting
8	Resolver, EXCP, inbuilt non-contacting
4	Resolver, SHIELD/GROUND, inbuilt non-contacting

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, inbuilt non-contacting
19	Resolver, RES_COS_P, inbuilt non-contacting
20	Resolver, RES_SIN_N, inbuilt non-contacting
21	Resolver, RES_SIN_P, inbuilt non-contacting
22	Resolver, EXCN, inbuilt non-contacting
23	Resolver, EXCP, inbuilt 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)

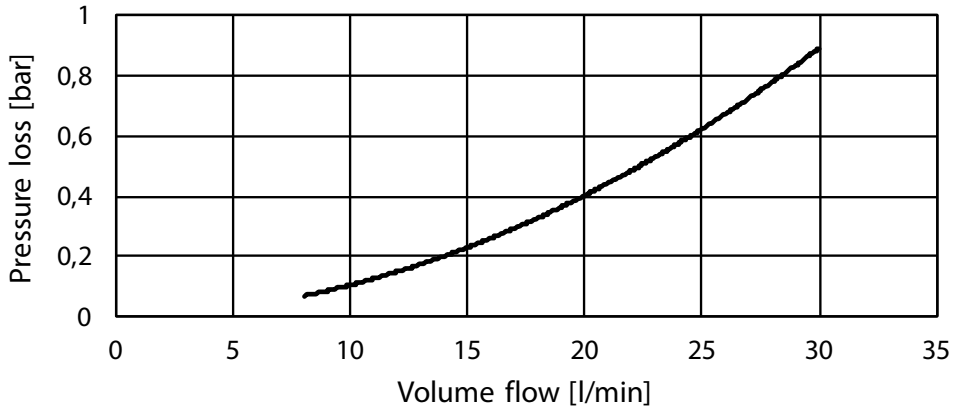
PIN	Description
1	Phase, 230 V_{AC}
2	Neutral
⏚	Ground / protective earth
4	Reserve
5	Reserve

Table 3 Pin configuration of heater with connector

PIN	Description
1	PT100
2	
3	PT100_GND
4	

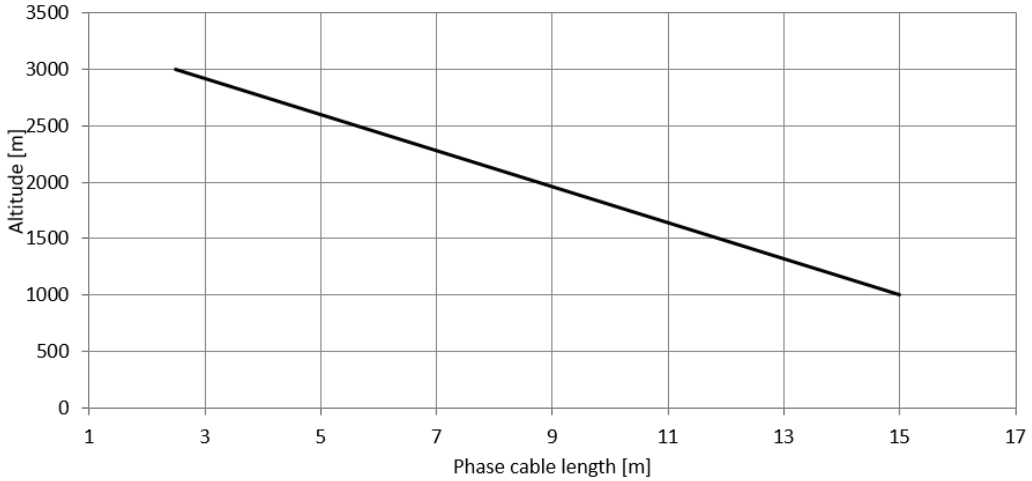
Table 4 Pin configuration of bearing temperature sensor connector (one sensor)

PRESSURE LOSS VS COOLANT FLOW



Picture 1 Pressure loss vs coolant flow

ALTITUDE DERATING



Picture 2 Altitude derating

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

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 *(a*	Peak torque DUAL *(b*	Volt/ speed ratio [V_{AC}/ rpm] *(c*
EM-PMI375-T1100-690V-1600	979	164	165	1076	180	181	1600	2400	1259	2522	0.462
EM-PMI375-T1100-690V-2200	859	198	190	967	223	216	2200	3100	943	1891	0.347
EM-PMI375-T1100-690V-2500	745	195	190	873	229	221	2500	3600	837	1680	0.308

(a Peak torque achieved with one 210A inverter
(b Peak torque achieved with two 210A inverters
(c Back EMF for cold (+20°C)

The maximum allowed peak torque duration at stator winding starting temperature +90°C is 2 minutes. The given values indicate typical duration and are not verified. In case more accurate values are required, cyclic dimensions are needed.

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-PMI375-T1100-690V-1600	1600 rpm unit with standard options
EM-PMI375-T1100-690V-1600+BIN+RES1	1600 rpm unit with insulated bearing in N-end and resolver

Table 5 Product code examples

Variant	**Code**	**Description**	**Additional information**
High voltage connections	*	One three-phase system	One connection box containing one three-phase system with one M25 cable gland per phase, total of 3 pcs M25 cable glands
	-DUAL	Two galvanically isolated three-phase systems	Two connection boxes each containing one three-phase system with one M25 cable gland per phase, total of 6 pcs M25 cable glands
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 (not available with +TEMP5 option)
N-end attachment	*	Flange	SAE 4 flywheel housing
	+NE2	Male shaft + Flange	DIN5480 W55x2x26x8a + SAE 4 flywheel housing
Bearing lubrication and mounting direction	*	Grease lubricated	Deep groove ball bearing, open design. Horizontal mounting direction (see user guide for details)
	+BGL	Greased for life	Deep groove ball bearing, non-contact seal on both sides. Any mounting direction (see user guide for details) Maximum speed 3400 rpm
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
Protection class	*	Standard protection class	IP65 protection class
	+IP67	IP67 protection class	IP67 protection class (only available with +BGL 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	Inbuilt 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} / 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