ENGINEERING TOMORROW

Data Sheet

EM-PMI540B-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
- IP67 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 be also 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. The design of these machines makes them 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	8
Power supply	Inverter fed
Nominal inverter switching frequency	8 kHz
Minimal inverter switching frequency	4 kHz (with 10 % derated performance)
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	Frame including coolant circuit: Aluminum 6063 Endshields: AlSi7Mg
Mounting direction	Horizontal or vertical assembly (V1, D-end shaft down) (see user guide for details)
Mounting (IEC 60034-7)	See Table 5
Standard flange D-end (SAE J617)	SAE ½ mating transmission housing
Standard shaft spline D-end	DIN 5480 W55x2x26x8f
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	IP67
Duty type (IEC 60034-1)	S1/S9
Machine coating	Coating is optional
Nominal altitude (IEC 60034-1)	Up to 4000 m (see Picture 1 for details)

Mechanical	
Total weight	547.6 kg (+/- 2 %, no options)
Moment of inertia	5.3 kgm^2
Torsional stiffness of shaft drive end	5*10^5 Nm/rad (from middle of the D-end spline to rotor air gap)
Rotating mass	213 kg
Maximum static torque range on the shaft, max. 25000 cycles, R=0 (*	5700 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^2

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

Dimensions	
Length (frame)	614 mm
Diameter (frame)	600 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	3.4 l
Maximum operating pressure	2 bar
Pressure loss	0.5 bar with 20 l/min (+25°C coolant) (see Picture 2 for details)
Nominal cooling liquid temperature	+65°C (derating required if exceeded)
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
Min. ambient temperature	-40°C

Vibration & Shock tolerance	
Mechanical vibration	3.19 G_{RMS} ISO 16750-3:2023 Test XVI - Hybrid-electric/fully electric commercial vehicle, sprung mass (vehicle body), large and heavy DUT Note: Flange mounting tested with two axes (radial and axial)
Mechanical shock	50 G ISO 16750-3:2023 4.2.2 Test for devices on rigid points on the body and on the frame Note: Flange mounting tested with two axes (radial and axial)

Connections	
Coolant connection	2 x G3/4 bore (see dimension drawing for details)
Cable direction	Cable direction fixed upwards
HV cables	2 x 3 x 95 mm^2 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) www.hubersuhner.com
HV cable lug size	35-8, 50-8, 70-8, 95-8
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

	95 mm²: Druseidt with narrow flange 03910 www.druseidt.de
HV connection boxes	2 x 3 phase box
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
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 80 +/- 16 Ohm Output impedance 380 +/- 76 Ohm
Anti-condensation heater (+HEAT1 option)	130 W 230 V_{AC} single phase heater resistors
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 art. no. 7010 9 42 01 1
Heater connector pin configuration	See Table 3
Bearing temp. measurement connector type	D-end: 4-pin M12 A coded male N-end: DEUTSCH HD34-24-47PE
Bearing temp. measurement mating type	D-end: 4-pin M12 A coded female N-end: DEUTSCH HD36-24-47SE or DEUTSCH HD36-24-47SE-059
Bearing temp. measurement connector pin configuration	See Table 1 and Table 4

(** 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.

	Description	PIN	Option
Temperature 1	phase U1, main sensor, PT100 (P)	47	
	phase U1, main sensor, PT100 (N)	46	
Temperature 2	phase V1, main sensor, PT100 (P)	33	
	phase V1, main sensor, PT100 (N)	32	
Temperature 3	phase W1, main sensor, PT100 (P)	45	
	phase W1, main sensor, PT100 (N)	31	
Temperature 4	phase U2, main sensor, PT100 (P)	30	
	phase U2, main sensor, PT100 (N)	29	
Temperature 5	phase V2, main sensor, PT100 (P)	44	
	phase V2, main sensor, PT100 (N)	43	
Temperature 6	phase W2, main sensor, PT100 (P)	28	
	phase W2, main sensor, PT100 (N)	16	
Temperature 7	phase U1, spare sensor, PT100 (P)	42	+TEMP5
	phase U1, spare sensor, PT100 (N)	27	
Temperature 8	phase V1, spare sensor, PT100 (P)	15	+TEMP5
	phase V1, spare sensor, PT100 (N)	14	
Temperature 9	phase W1, spare sensor, PT100 (P)	40	+TEMP5
	phase W1, spare sensor, PT100 (N)	26	
Temperature 10	phase U2, spare sensor, PT100 (P)	41	+TEMP5
	phase U2, spare sensor, PT100 (N)	13	
Temperature 11	phase V2, spare sensor, PT100 (P)	39	+TEMP5
	phase V2, spare sensor, PT100 (N)	38	
Temperature 12	phase W2, spare sensor, PT100 (P)	25	+TEMP5
	phase W2, spare sensor, PT100 (N)	12	
Resolver COS	Resolver, RES_COS_N, Inbuilt non-contacting	35	
Resolver COS	Resolver, RES_COS_P, Inbuilt non-contacting	20	
Resolver SIN	Resolver, RES_SIN_N, Inbuilt non-contacting	36	
Resolver SIN	Resolver, RES_SIN_P, Inbuilt non-contacting	21	
Resolver EXCN	Resolver, EXCN, Inbuilt non-contacting	22	
Resolver EXCP	Resolver, EXCP, Inbuilt non-contacting	10	
Resolver shield	Resolver, SHIELD/GROUND, Inbuilt non-contacting	34	
Bearing temperature, sensor 1	PT100	2	
Bearing temperature, sensor 1	PT100_GND	18	
Bearing temperature, sensor 2	PT100	3	
Bearing temperature, sensor 2	PT100_GND	19	

Table 1 Pin configuration of LV-connector

Measurement	Description	PIN	Option
N-END			
HEAT	Heater, ground / protective earth	1 ⏚	+HEAT
HEAT	Heater, neutral	2	+HEAT
HEAT	Heater, phase, 230 V_{AC}	3	+HEAT
Resolver shield	Resolver, SHIELD/GROUND, Inbuilt non-contacting	4 ⏚	+RES1
Resolver COS	Resolver, RES_COS_N, Inbuilt non-contacting	5	+RES1
Resolver COS	Resolver, RES_COS_P, Inbuilt non-contacting	6	+RES1
Resolver SIN	Resolver, RES_SIN_N, Inbuilt non-contacting	7	+RES1
Resolver SIN	Resolver, RES_SIN_P, Inbuilt non-contacting	8	+RES1
Resolver EXCN	Resolver, EXCN, Inbuilt non-contacting	9	+RES1
Resolver EXCP	Resolver, EXCP, Inbuilt non-contacting	10	+RES1
Temperature 1	phase U1, main sensor, PT100 (P)	11	
	phase U1, main sensor, PT100 (N)	12	
Temperature 2	phase V1, main sensor, PT100 (P)	13	
	phase V1, main sensor, PT100 (N)	14	
Temperature 3	phase W1, main sensor, PT100 (P)	15	
	phase W1, main sensor, PT100 (N)	16	
Temperature 4	phase U2, main sensor, PT100 (P)	17	
	phase U2, main sensor, PT100 (N)	18	
Temperature 5	phase V2, main sensor, PT100 (P)	19	
	phase V2, main sensor, PT100 (N)	20	
Temperature 6	phase W2, main sensor, PT100 (P)	21	
	phase W2, main sensor, PT100 (N)	22	
Temperature 7	phase U1, spare sensor, PT100 (P)	23	+TEMP5
	phase U1, spare sensor, PT100 (N)	24	
Temperature 8	phase V1, spare sensor, PT100 (P)	25	+TEMP5
	phase V1, spare sensor, PT100 (N)	26	
Temperature 9	phase W1, spare sensor, PT100 (P)	27	+TEMP5
	phase W1, spare sensor, PT100 (N)	28	
Temperature 10	phase U2, spare sensor, PT100 (P)	29	+TEMP5
	phase U2, spare sensor, PT100 (N)	30	
Temperature 11	phase V2, spare sensor, PT100 (P)	31	+TEMP5
	phase V2, spare sensor, PT100 (N)	32	
Temperature 12	phase W2, spare sensor, PT100 (P)	33	+TEMP5
	phase W2, spare sensor, PT100 (N)	34	
TEMP	N/A	27	
TEMP	N/A	28	
TEMP	N/A	29	
TEMP	N/A	30	
TEMP	N/A	31	
TEMP	N/A	32	
TEMP	N/A	33	
TEMP	N/A	34	
TEMP	N/A	35	
TEMP	N/A	36	
TEMP	N/A	37	

TEMP	N/A	38	
TEMP	N/A	39	
TEMP	N/A	40	
TEMP	N/A	41	
TEMP	N/A	42	
TEMP	N/A	43	
TEMP	N/A	44	
TEMP	N/A	45	
TEMP	N/A	46	
TEMP	N/A	47	
TEMP	N/A	48	
TEMP	N/A	49	
TEMP	N/A	50	
TEMP	N/A	51	
TEMP	N/A	52	
TEMP	N/A	53	
TEMP	N/A	54	
TEMP	N/A	55	
TEMP	N/A	56	
TEMP	N/A	57	
TEMP	N/A	58	
Bearing temperature, sensor 1	PT100	59	+BTMP
Bearing temperature, sensor 1	PT100_GND	60	+BTMP
Bearing temperature, sensor 2	PT100	61	+BTMP
Bearing temperature, sensor 2	PT100_GND	62	+BTMP
Reserve		63	
Reserve		64	
Reserve		65	
Reserve		66	
D-END 1/2			
Bearing temperature, sensor 1	PT100	74	+BTMP
Bearing temperature, sensor 1	PT100_GND	75	+BTMP
Bearing temperature, sensor 2	PT100	76	+BTMP
Bearing temperature, sensor 2	PT100_GND	77	+BTMP
D-END 2/2			
HEAT2	Heater 2, ground / protective earth	78	+HEAT2
HEAT2	Heater 2, neutral	79	+HEAT2
HEAT2	Heater 2, phase, 230 V_{AC}	80	+HEAT2

Table 2 Pin configuration of +LVB connection

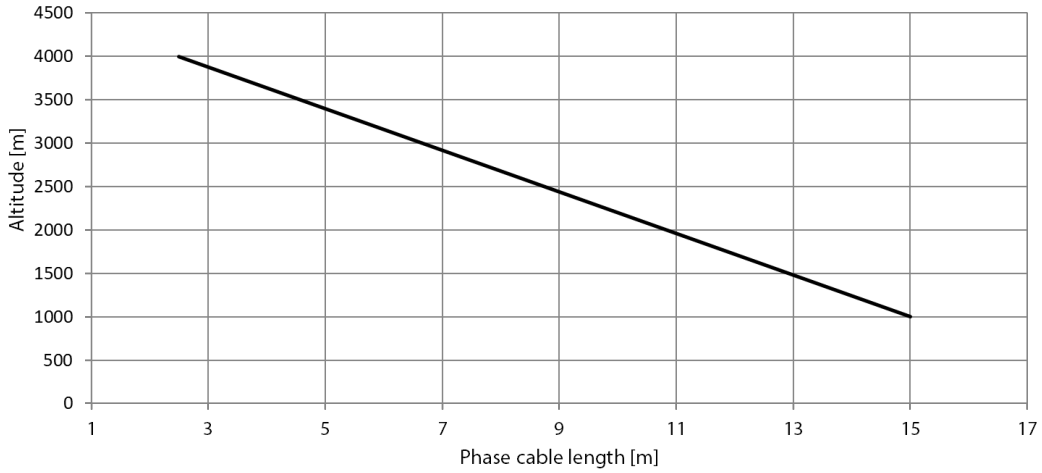
PIN	Description
1	Phase, 230 V_{AC}
2	Neutral
⏚	Ground/protective earth
4	Reserve
5	Reserve

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

PIN	Description
1	PT100, sensor 1
2	PT100_GND, sensor 1
3	PT100, sensor 2
4	PT100_GND, sensor 2

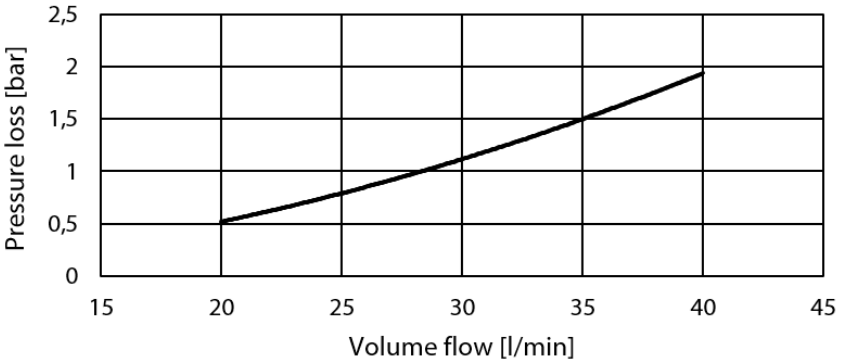
Table 4 Pin configuration of bearing temperature sensor connector (one two-wire PT100 sensor) in D-end

ALLOWED ALTITUDES VS PHASE CABLE LENGTH



Picture 1 Allowed altitudes vs phase cable length

PRESSURE LOSS VS COOLANT FLOW



Picture 2 Pressure loss vs coolant flow

Mounting				Shaft			IEC60034-7	
Horizontal/ Vertical	**Foot**	**Side/V**	**Flange**	**D-end**	**Dual-end**	**Spline**	**Code I**	**Code II**
H		☑	☑	☑		☑	B25	IM2401
		☑	☑		☑	☑	N/A	N/A
		☑		☑		☑	B20	IM1101
		☑			☑	☑	N/A	N/A
	☑		☑	☑		☑	B35	IM2001
	☑		☑		☑	☑	N/A	N/A
	☑			☑		☑	B3	IM1001
	☑				☑	☑	N/A	N/A
			☑	☑		☑	B5	IM3001
			☑		☑	☑	N/A	N/A
V		☑	☑	☑		☑	N/A	IM2411
		☑	☑		☑	☑	N/A	IM2412
		☑		☑		☑	N/A	IM1111
		☑			☑	☑	N/A	IM1112
	☑		☑	☑		☑	V15	IM2011
	☑		☑		☑	☑	N/A	IM2012
	☑			☑		☑	V5	IM1011
	☑				☑	☑	N/A	IM1012
			☑	☑		☑	V1	IM3011
			☑		☑	☑	N/A	IM3012

Table 5 Mounting method

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 *(b*
EM-PMI540B-T2000-700	2462	180	242	2716	199	267	700	1400	3700
EM-PMI540B-T2000-1000	2390	250	321	2570	269	344	1000	2000	3650
EM-PMI540B-T2000-1300	2303	313	413	2386	325	431	1300	2600	3650
EM-PMI540B-T2000-1700	2009	358	485	2276	405	543	1700	3400	2750
EM-PMI540B-T2000-2100	1919	422	569	2153	473	633	2100	4000 *(a*	2300

(a Mechanical maximum speed
(b Peak torque achieved with two 350A inverters

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_{AC} /rpm] *(c*
EM-PMI540B-T2000-700	211	201	241	0.95	233	221	266	0.95	800	107	0.714
EM-PMI540B-T2000-1000	279	269	320	0.97	297	285	342	0.96	1100	147	0.492
EM-PMI540B-T2000-1300	355	331	410	0.93	372	347	428	0.93	1400	186	0.363
EM-PMI540B-T2000-1700	436	413	506	0.95	466	440	538	0.94	1900	253	0.272
EM-PMI540B-T2000-2100	482	454	562	0.94	534	510	621	0.95	2300	307	0.227

(c 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-PMI540B-T2000-1700-DUAL	Standard 1700 rpm unit with standard options
EM-PMI540B-T2000-1700-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	1 x M32 cable gland per phase
Connection extension	*	None	1 x M32 cable gland per phase
	+CE1 (***	Double phase connections	Extended connection boxes with 2 x M32 cable glands per phase
Low voltage connections (signal and auxiliaries)	*	Low voltage connections done with connector	See Connections – section of the data sheet
	+LVB1	Low voltage connections done with connection box and terminal strip	D-end: LV connection box with 1 x M16 cable gland + terminal strips N-end: LV connection box with 1 x M25, 2 x M16 and 1 x M12 cable glands + terminal strips (see user guide for pinout)
N-end attachment	*	None	
	+NE4	Male shaft, no flange	DIN 5480 W55x2x26x8f
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	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 (two wire) in windings
	+TEMP5	Redundant temperature surveillance	12 x PT100 (two wire) in windings
Bearing temperature sensors	*	None	
	+BTMP1	PT100 in bearings	Plugin connector
Anti-condensation heaters	*	None	
	+HEAT1	One anti-condensation heater	230 V_{AC} /130 W (see user guide for more information)
Machine coating	*	None	
	+C5	High corrosion category	Dark grey RAL7024 Type of coating: Epoxy Minimum number of coats (MNOC): 2 Minimum nominal dry film thickness: 240 µm

(Standard option*
*(*** Option not currently launched. Standard delivery time extended.*

Table 7 Option list