



## EM-PMI375-T200

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, 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 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. 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, Curve A: Without filters for motors up to 500 V <sub>AC</sub>   |
| Nominal efficiency                   | 96 %  |
| Pole pair number                     | 6   |
| Power supply                         | Inverter fed.   |
| Nominal inverter switching frequency | 8 kHz   |
| Minimum 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                   | Can be used in any direction, 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 mating transmission housing   |
| Standard axle spline D-end           | DIN5480 W50x2x24x8f   |
| Standard Flange N-end (SAE J617)     | SAE 4, flywheel housing   |
| Bearing type                         | Standard: 6211-2RS1/C3WT<br>+BHS option: 6211/C3 (with LGHP2 grease)<br>+BIN option: D-end: 6211-2RS1/C3WT, N-end: 6211-2RS1/HC5C3WT<br>+BIA option: 6211-2RS1/HC5C3WT<br>+BHS+BIN options: D-end: 6211/C3 (with LGHP2 grease), N-end: 6211/HC5C3WT (with LGHP2 grease)<br>+BHS+BIA options: 6211/HC5C3 (with LGHP2 grease) |
| Standard rotation direction          | Clockwise (both directions possible)  |
| Protection class                     | IP65<br>IP67 available as option +IP67<br>Tests: 0.3 bar under pressure held for 120 seconds.<br>Pressure not allowed to drop under 0.25 bar  |
| Duty type (IEC 60034-1)              | S1/S9   |
| Standard color                       | Dark grey RAL7024 powder coating  |

### Mechanical

|  |  |
|--|--|
| Total weight   | 98 kg (no options)   |
| Moment of inertia  | 0.21 kgm <sup>2</sup>  |
| Torsional stiffness of shaft drive end                               |  |
| Rotating mass  | 26.5 kg  |
| Maximum static torque range on the shaft, max. 25000 cycles, R=0 (*) |  |
| Maximum dynamic torque range on the shaft, max. 1e6 cycles, R=0 (*)  |  |
| Maximum allowed vibratory torque range, 1e9...1e10 cycles (*)        |  |
| Maximum deceleration (fault stop)                                    |  |
| Maximum static torque on the shaft                                   | 3400 Nm  |
| Maximum dynamic torque on the shaft                                  | 2500 Nm  |
| Maximum deceleration (shaft braking)                                 | 6000 rad/s <sup>2</sup>  |
| Dimensions   |  |
| Length (frame)   | 278 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   | 0.8 l  |
| Maximum operating pressure   | 3 bar  |
| Pressure loss  | 0.4 bar with 20l/min (+25°C coolant)   |
| Nominal cooling liquid temperature                                   | +65°C (derating required if exceeded)  |
| Minimum cooling liquid temperature                                   | -20°C  |

|                                    |  |   |   |
|------------------------------------|--|---|---|
| Maximum cooling liquid temperature | +70°C  | HV connection boxes                                   | 1 x 3 phase box   |
| Condensation dew point             | Please use anti-condensation heaters   | LV connector  | 47 pin DEUTSCH HD34-24-47PE for resolver and temperature measurement.   |
| Temperature rating                 |  | LV connector type                                     | DEUTSCH HD34-24-47PE  |
| Insulation class (IEC 60034-1)     | H (180°C)  | LV connector pin type                                 | Gold plated   |
| Temperature rise (IEC 60034-1)     | 85°C (F) / 110°C (H)   | LV mating connector type                              | DEUTSCH HD36-24-47SE or DEUTSCH HD36-24-47SE-059  |
| Maximum winding temperature        | 175°C  | LV mating connector pin type                          | DEUTSCH 0462-201-1631<br>DEUTSCH 0462-005-2031<br>Plug: DEUTSCH 0413-204-2005 (size 20)<br>Plug: DEUTSCH 0413-003-1605 (size 16)          |
| Nominal ambient temperature        | +65°C / +45°C with +CL option  |   |   |
| Min. ambient temperature           | -40°C  |   |   |
| Nominal altitude (IEC 60034-1)     | 1000 m   | LV connector pin configuration                        | See Table below   |
| Vibration & Shock tolerance        |  | 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 below |
| Mechanical vibration               | 5.9 G <sub>RMS</sub><br>ISO 16750-3<br>Test VII – Commercial vehicle, sprung masses – Table 12<br>Notes:<br>test duration 8h axis (two axes tested; radial and axial)<br>total spectral acceleration 5,91 grms<br>Test done with EM-PMI375-T800 (with flange mounting) | Anti-condensation heater (+HEAT1 option)              | 65 W 230 V <sub>AC</sub> single phase heater resistor (requires +LVB1 option)   |
|                                    |  | Heater connector (+HEAT1 option)                      | Hummel art. no. 7651 0 51 01 D  |
|                                    |  | Heater mating connector                               | Hummel art. no. 7550 6 51 02 D  |
| Mechanical shock                   | 50 G<br>ISO 16750-3<br>4.2.2 Test for devices on rigid points on the body and on the frame<br>Notes:<br>–acceleration: 500 m/s <sup>2</sup> ;<br>–duration: 6 ms;<br>–number of shocks: 10 per test direction.<br>Test done with EM-PMI375-T800 (with flange mounting) | Heater connector pin type                             | Hummel 7010 9 42 01 1   |
|                                    |  | Heater connector pin configuration                    | See Table below   |
|                                    |  | Bearing temp. measurement connector type              | 4-pin M12 A coded male  |
|                                    |  | Bearing temp. measurement mating type                 | 4-pin M12 A coded female  |
| Connections                        |  | Bearing temp. measurement connector pin configuration | See Table below   |
| Coolant connection                 | 2 x G3/4 bore  |   |   |
| Cable direction                    | Standard cable direction towards D-end   |   |   |
| HV cables                          | 3 x 70 mm <sup>2</sup> max.  |   | (* The values are based on structural analysis and they are not applicable to any marine class rules or requirements.                     |
| HV cable glands                    | Pflitsch blueglobe TRI bg 225ms tri  |   |   |
| HV cable                           | Recommended H+S Radox screened cable   |   |   |
| HV cable lug size                  | 35-8, 50-8, 70-8   |   |   |
| Recommended cable lug              | 35 mm <sup>2</sup> : Druseidt with narrow flange 03901<br>50 mm <sup>2</sup> : Druseidt with narrow flange 03903<br>70 mm <sup>2</sup> : Druseidt with narrow flange 03906   |   |   |

| 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)                                       |
| 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 <sub>AC</sub>   |
| 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)                       |

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

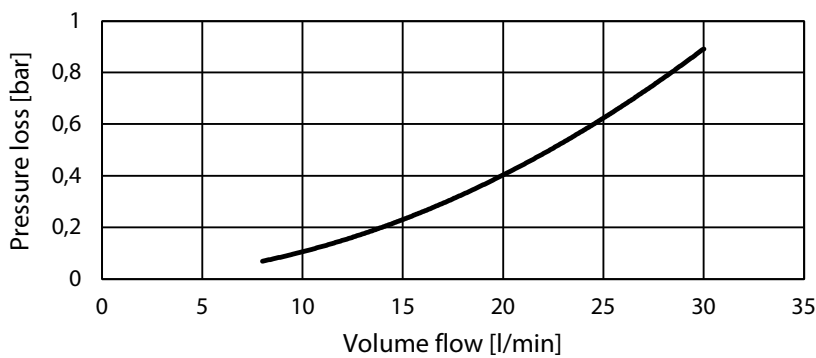
| PIN | Description                |
|-----|----------------------------|
| 1   | Phase, 230 V <sub>AC</sub> |
| 2   | Neutral                    |
| ⊥   | Ground / protective earth  |
| 4   | Reserve                    |
| 5   | Reserve                    |

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

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 (*) |
| EM-PMI375-T200-600  | 190                       | 12               | 16               | 210                       | 13               | 18               | 600                             | 1200             | 500                    |
| EM-PMI375-T200-1000 | 197                       | 21               | 28               | 213                       | 22               | 31               | 1000                            | 2000             | 500                    |
| EM-PMI375-T200-1400 | 186                       | 27               | 34               | 209                       | 31               | 39               | 1400                            | 2800             | 500                    |
| EM-PMI375-T200-1900 | 184                       | 37               | 51               | 203                       | 40               | 60               | 1900                            | 3800             | 500                    |
| EM-PMI375-T200-2600 | 170                       | 46               | 61               | 205                       | 56               | 73               | 2600                            | 4000             | 500                    |
| EM-PMI375-T200-3200 | 161                       | 54               | 72               | 189                       | 63               | 85               | 3200                            | 4000             | 500                    |

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

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/rpm] (***) |
| EM-PMI375-T200-600  | 15                        | 15               | 16               | 0.97         | 17                        | 16               | 18               | 0.96         | 700                             | 70              | 0.833                           |
| EM-PMI375-T200-1000 | 25                        | 24               | 27               | 0.97         | 27                        | 26               | 30               | 0.96         | 1200                            | 120             | 0.5                             |
| EM-PMI375-T200-1400 | 31                        | 31               | 33               | 0.98         | 36                        | 35               | 38               | 0.97         | 1600                            | 160             | 0.365                           |
| EM-PMI375-T200-1900 | 44                        | 39               | 50               | 0.90         | 53                        | 45               | 60               | 0.85         | 2200                            | 220             | 0.269                           |
| EM-PMI375-T200-2600 | 52                        | 49               | 60               | 0.94         | 63                        | 59               | 72               | 0.93         | 2700                            | 270             | 0.182                           |
| EM-PMI375-T200-3200 | 59                        | 55               | 71               | 0.92         | 74                        | 67               | 84               | 0.9          | 3300                            | 330             | 0.148                           |

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

MOTORS (temperature class H, maximum winding temperature 175 °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 (*) |
| EM-PMI375-T200-600  | 209                       | 13               | 18               | 228                       | 14               | 19               | 600                             | 1200             | 500                    |
| EM-PMI375-T200-1000 | 213                       | 22               | 31               | 243                       | 25               | 35               | 1000                            | 2000             | 500                    |
| EM-PMI375-T200-1400 | 209                       | 31               | 39               | 231                       | 34               | 43               | 1400                            | 2800             | 500                    |
| EM-PMI375-T200-1900 | 208                       | 41               | 62               | 214                       | 43               | 63               | 1900                            | 3800             | 500                    |
| EM-PMI375-T200-2600 | 191                       | 52               | 68               | 212                       | 58               | 76               | 2600                            | 4000             | 500                    |
| EM-PMI375-T200-3200 | 189                       | 63               | 86               | 212                       | 71               | 96               | 3200                            | 4000             | 500                    |

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

The maximum allowed peak torque duration at stator winding starting temperature +90°C is 1 minute. 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 °C)

| 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/rpm] (***) |
| EM-PMI375-T200-600  | 17                        | 16               | 18               | 0.96         | 19                        | 18               | 19               | 0.95         | 700                             | 70              | 0.833                           |
| EM-PMI375-T200-1000 | 27                        | 26               | 31               | 0.96         | 32                        | 30               | 34               | 0.94         | 1200                            | 120             | 0.5                             |
| EM-PMI375-T200-1400 | 36                        | 35               | 38               | 0.97         | 36                        | 35               | 42               | 0.97         | 1600                            | 160             | 0.365                           |
| EM-PMI375-T200-1900 | 54                        | 46               | 61               | 0.85         | 53                        | 45               | 62               | 0.85         | 2200                            | 220             | 0.269                           |
| EM-PMI375-T200-2600 | 59                        | 55               | 67               | 0.94         | 66                        | 61               | 76               | 0.93         | 2700                            | 270             | 0.182                           |
| EM-PMI375-T200-3200 | 74                        | 67               | 84               | 0.90         | 83                        | 74               | 95               | 0.90         | 3300                            | 330             | 0.148                           |

(\*\*\* 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-PMI375-T200-2600          | Standard 2600 rpm unit with standard options                             |
| EM-PMI375-T200-2600+BIN+RES1 | Standard unit otherwise but with insulated bearing in N-end and resolver |

Table 5 Product code examples

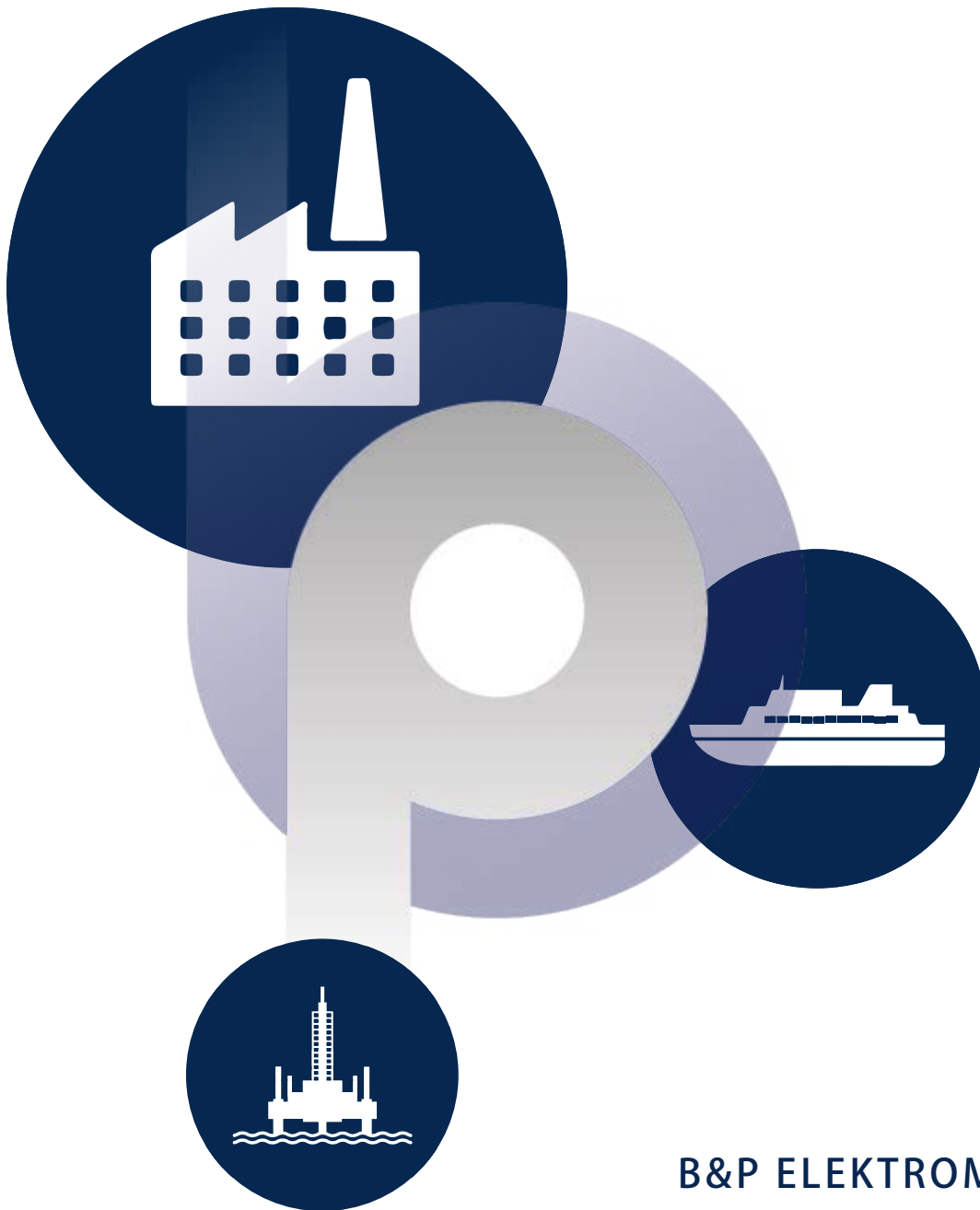
| Variant                                    | Code   | Description   | Additional information   |
|--|--------|---|--|
| Low voltage connections                    | *      | Low voltage connections done with connector                         | DEUTSCH HD34-24-47PE connector for LV connections  |
|  | +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  |
| Winding temperature sensors (**)           | *      | Temperature surveillance  | 3 x PT100 (two wire) in windings   |
|  | +TEMP4 | Redundant temperature surveillance                                  | 6 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> / 65 W   |
| Marine classification                      | *      | No marine classification  |  |
|  | +CL1   |   | ABS American Bureau of Shipping  |
|  | +CL2   |   | BV Bureau Veritas  |
|  | +CL3   |   | DNV GL DNV GL AS   |
|  | +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 6 Option list

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