**Definitions for EC-Motors**

All information is based on the measuring conditions mentioned below. The values mentioned are typical values for the design in question and are also subject to the tolerances included in the specification drawings. Unless otherwise stated, the supplements and safety notes contained in the relevant manual and/or in the specification drawings must be kept at all times.

**Nominal Voltage** $U_{BN}$ [V DC]

The DC voltage that is applied to the commutation electronics as a system supply voltage. All nominal values listed in the technical tables of the individual motors refer to this voltage. The system can, however, be operated at other voltages within limits defined at the lower end by the reliability of the electronic components at low voltages and at the higher end by the mechanical speed limitations of the motor and ability of the electronic components to survive the high voltages and currents. For motors with integrated operating electronics, the permissible operating voltage range is determined by the electronics. The permissible range referring to these motors is in brackets. The ripple of the supply voltage should not exceed 10 % as a higher ripple has a negative influence on the operating efficiency.

**Nominal Speed** $n_{N}$ [min⁻¹]

The speed at which the motor may be operated continuously while delivering nominal torque at an ambient temperature of 40 °C and nominal output torque. It is an operating point on the max. motor curve based on an ideal electronics with neglectable losses. When using an electronics with non-neglectable losses or with PWM-pulsing, the nominal speed that can be achieved is reduced accordingly when the supply voltage remains constant.

**Nominal Torque** $M_{N}$ [mNm]

The torque that the motor can deliver continuously at an ambient temperature of 40 °C and nominal speed.

**Nominal Current** $I_{BN}$ [A]

The current that is drawn from the system supply when the motor delivers nominal torque at nominal speed. The actual current that creates the torque is the current that flows in the motor lads, (Nominal current effective in the supply = $I_{Neff}$) it is generated by the operating electronics as output current. Due to the influence of the operating electronics in use (operating efficiency of the electronics and PWM pulsing), a certain deviation to the nominal current from the system supply is possible.

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**Motor Supply**

- Main Supply
- Transformer
- System Voltage
- Motor Supply
- Commutation sequences

\[
\begin{align*}
U_{BN} - I_{BN} - I_{BL} - P_{Inc} \\
I_{load} - I_{max} - I_{offset} \\
R_s - L_r - U_{max} \\
(P_{min} - P_{max})
\end{align*}
\]

The illustrated curves are idealized representations based on the figures in the tables.
Nominal output power $P_N$ [W]
The product of the nominal torque and nominal angular velocity. When calculating this value, the tolerances of the individual values contained in the specification data sheets must be considered. For the electromagnetic design of the motor the determination of the rated operating point is based on the fact that the nominal output power is close the maximum output power of the motor.

$$P_N = M_N \cdot \omega_N = \frac{\pi}{30} n_N \cdot M_N$$

Free-running Speed $n_L$ [min⁻¹]
The speed that is achieved with nominal voltage and unloaded motor. It is usually proportional to the connected system supply voltage. The free-running speed that is theoretically possible can be limited by the mechanical speed limit.

Free-running current $I_{BL}$ [A]
Is established with nominal voltage and unloaded motor; is largely influenced by the bearing friction.

Permanent stall Torque $M_{B0}$ [mNm]
Is the maximum permissible torque with which the motor may be permanently loaded when the rotor is locked.

Permissible eff. stall current $I_{B0}$ [A]
Is the maximum permissible current which at a stalled motor is allowed to flow into the motor lead as an effective value. In case of customer-specific operating electronics, this value must be adhered to in case of blocking to avoid overloading the motor.

Permissible permanent input power at stall $P_{B0}$ [W]
Is the voltage-independent maximum permissible output ($P = UxI$) that is allowed to be removed from the direct voltage source at a standstill. This value must also be adhered to when ebm-papst operating electronics are used by the user to avoid overloading the motor.

Permissible peak Torque
short-term $M_{B0}$ [mNm]
Is the torque which the motor can usually deliver in a short time.

Permissible peak Current, motor lead $I_{B0}$ [A]
Is the current that must flow in to the motor lead as a peak value to achieve the short-time peak torque. Based on the natural motor curve, this value usually applies to the speed 0 when the motor is started up. In specific cases, however, a correspondingly lower demagnetization current can be the basis for this limit value in which case this value must not be exceeded.

Induced Voltage $U_{B0}$ [V/1000 min⁻¹]
Maximum value of the induced voltage between two motor leads at 1000 min⁻¹. It is a dimension for the electromagnetic utilization of the motor. The values mentioned in the technical data refer to an ambient temperature of 25 °C.

Terminal Resistance $R_v$ [Ohm]
The winding resistance that is measured at 20 °C between any two of three winding terminations.

Terminal Inductance $L_v$ [mH]
The average inductance that is measured at 20 °C between any two of three winding terminations using a sinusoidal wave measuring frequency of 1 kHz.
**Definitions for EC-Motors**

**Rotor moment of inertia $J_R$ [kgm$^2 \times 10^{-6}$]**
The mass moment of inertia of the rotor and necessary dimension for the dynamic characteristics of the motor.

**Thermal resistance $R_{th}$ [K/W]**
A substitutional resistance at normal rating that results from the difference between the winding temperature and the ambient temperature in relation to the overall power loss. Electronic loss is taken into consideration with motors that have integrated electronics.

**Direction of rotation**
Reversible for all 3-phase motors. Single-phase motors are only designed for one direction of rotation. The direction of rotation refers to the flange side of the motor shaft (A-side viewed on the motor shaft). In case the usable torque of the external rotor motor is delivered on the rotor side (B-side), the direction of rotation refers to the rotor (viewed on the rotor).

**Protection class**
Information on the protection class complies with the valid Standard EN 60 034-5.
It describes protection against foreign particles (Point 1) and water (Point 2).

**Permissible ambient temperature range $T_U$ [°C]**
Defines the minimum and maximum permissible ambient temperature to which the mentioned performance values apply when the motor is in operation. Other ambient temperatures are possible but should be given special consideration as e.g. higher ambient temperatures result in a reduction of output power.
The permissible winding temperature in the motor (115 °C for insulation Class E, as per EN 60 034-1) should not be exceeded.

**Motor mass $m$ [kg]**
Weight of the delivered unit without additional units or packaging.
Special definitions for 1-phase motors

**Average starting Torque** \( M_{\text{av}} \) [mNm]
Mean value of the torque, measured during a motor revolution generated by the maximum starting current (only for 1-phase reluctance motors).

**Max. starting Current** \( I_{\text{max}} \) [A]
The current that is drawn from the DC voltage source as the system supply current when the motor is switched on at nominal voltage (only for 1-phase reluctance motors).

Special definitions for motor series

**VARIODRIVE Compact with integrated operating electronics**

**Max. reverse Voltage** [V DC]
When the braking function is activated via the control inputs A / B and when the set value step change is negative, the Compact motor operates in controlled braking mode. In this operating state, the large part of the braking energy is feedback to the intermediate circuit until the max. reverse voltage is reached and the electronics prevent a further increase beyond this value by chopped braking. This behaviour should be given special consideration when selecting the system supply.

Set value input

Speed setting via a special DC low voltage interface (0 ... 10 V DC). Depending on the design, this voltage range is equivalent to a speed range of 0 ... 4,000 min\(^{-1}\) and / or 0 ... 10,000 min\(^{-1}\). The minimum possible speed value (with limited control performance) is approx. 50 ... 100 min\(^{-1}\) depending on the design.

**Recommended speed range** [min\(^{-1}\)]
Speed control range within which the speed control accuracy stipulated in the system specification is complied with.

Function for motor protection at stall

At speeds < 100 min\(^{-1}\) a locked rotor protection function is activated to thermally protect the motor. This function together with the stipulated cycle times \( T_{\text{on}} / T_{\text{off}} \) prevents overloading the motor and simultaneously attempts to re-start the motor at regular intervals.

**Average starting Torque** [mNm]
Is the average torque that can be delivered over a short time when the motor is started based on the electromagnetic motor characteristics and the set current limitation.
Definitions for EC-Motors

Motor selection

For selecting the suitable motor and / or the correct size of motor, the determination of the effective torque plays the major role in preventing the motor from becoming thermally overloaded during operation.

Effective Torque $M_{\text{eff}}$ [mNm]

The effective torque equivalent to continuous operation (operating mode S1) is determined according to the following form:

$$M_{\text{eff}} = \sqrt{\frac{M_A^2 \cdot t_A + M_B^2 \cdot t_B + M_{\text{Br}}^2 \cdot t_{\text{Br}}}{t_A + t_B + t_{\text{Br}} + t_{\text{St}}}}$$

- $M_A$: Starting torque
- $M_B$: Load torque
- $t_A$: Acceleration time
- $t_B$: Load period
- $t_{\text{Br}}$: Braking time
- $t_{\text{St}}$: Standstill time
- $M_{\text{Br}}$: Braking torque
- $M_{\text{St}}$: Standstill torque

At an ambient temperature of 40 °C this effective torque must not be greater than the nominal torque $M_N$ listed in the catalogue for the selected motor.

For intermittent operation (operating mode S3 with $t_r$ = relative on period) the following permissible load moment applies:

$$M_L = M_N \cdot \sqrt{\frac{100}{t_r}}$$

System selection

When selecting a motor and operating for a drive system, consideration should be given to the fact that the values permitted for the motor should not be exceeded by the electronics.

Measuring conditions

Operation of motors using reference electronics “ebm-papst Motor Tester 112-200; 70 V / 20 A” at an ambient temperature of max. 40 °C and a motor temperature of 20 °C when attached (thermally conductive) to a free-standing steel plate of the following size:

- VARIO DRIVE, ECA (up to 45.30), BG, ECI:
  - Steel plate 105 x 105 x 10 mm
- ECA (from 70.10), ebm:
  - Steel plate 140 x 120 x 20 mm

Subject to technical alterations.

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