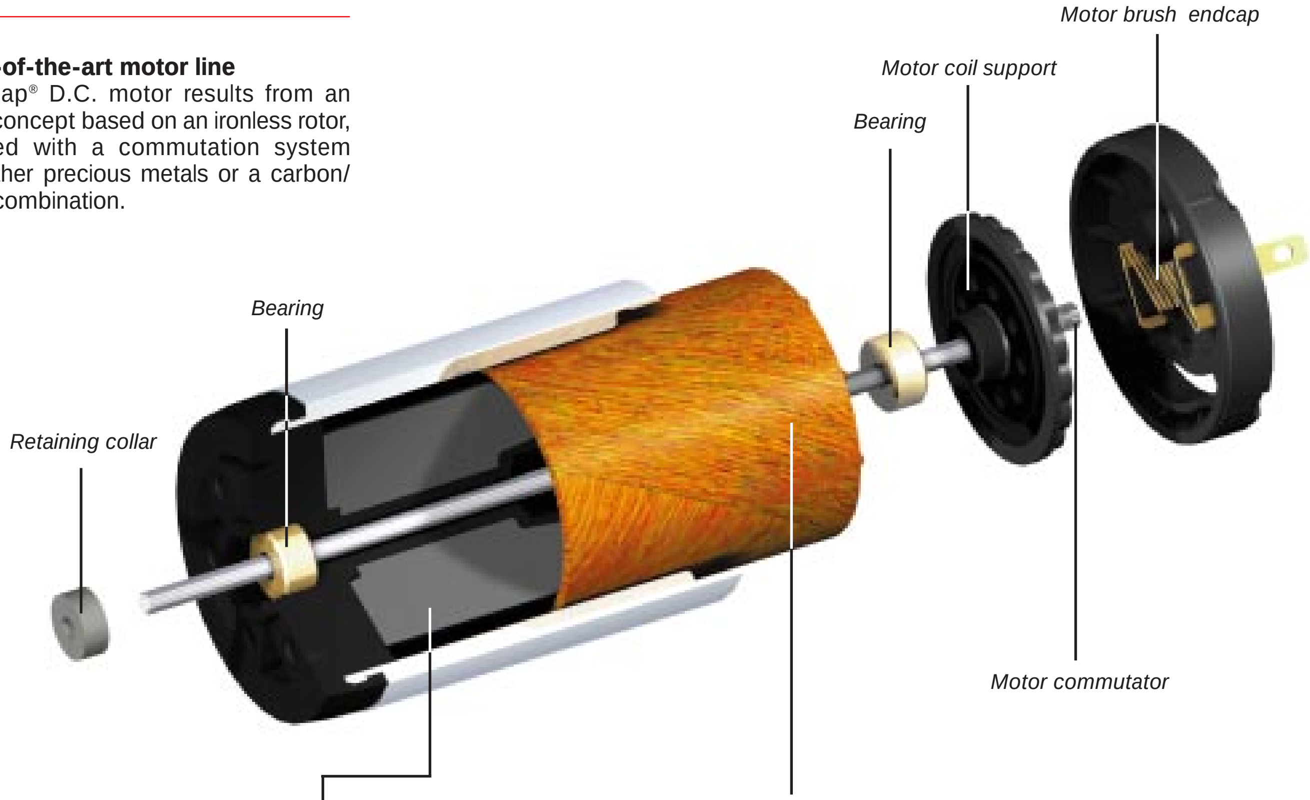
D.C. Motors

The ironless rotor motor technology

A state-of-the-art motor line
The escap® D.C. motor results from an original concept based on an ironless rotor, combined with a commutation system using either precious metals or a carbon/copper combination.



The stator
The stator part consists of a cylindrical two-pole permanent magnet, placed inside a steel tube closing the magnetic circuit. High quality rare earth or AlNiCo magnets ensure very high performance in a small envelope.

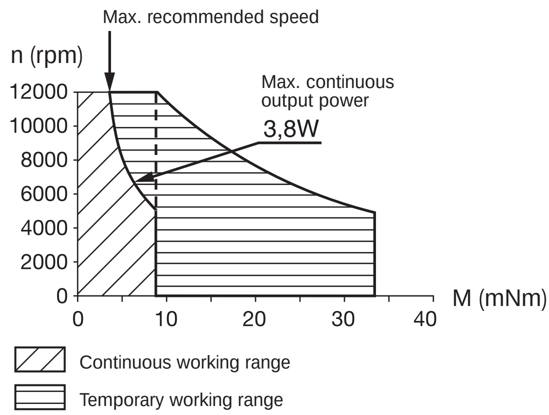
The rotor
The active rotor part simply consists of a cylindrical skew winding, requiring no iron core. As a result, rotor inertia is very low.
Unlike other D.C. motor technologies, due to the absence of iron there is no cogging and the rotor will stop in any position. There are also no iron losses, and the running speed depends only on the supply voltage and load torque.

The low winding inductance and constant improvements of the quality of the brushgear materials, combined with a system for Reduction of the Electro-Erosion (the REE® system which is covered by a patent), all result in a reduction of the electrical wear by a theoretical 75%. Thus lifetime is significantly increased.

Features
The technological features of escap® ironless rotor D.C. motors lead to distinct advantages for high performance drive and servo systems. Low friction, low starting voltage, absence of iron losses, high efficiency, good thermal dissipation, linear torque-speed function: all these factors facilitate their use and simplify the servo loop. These motors offer optimum solutions for all battery-powered equipment where efficiency is a major concern, and for incremental motion systems where the low rotor inertia allows for exceptional acceleration.

The Rotafente™ copper-graphite commutation system
For applications requiring high continuous and peak torques, where high current densities have to be commutated and power stages such as choppers are used, escap® D.C. motors with the Rotafente® commutation system provide the optimal solution.

Operating range
Definition
The speed-torque diagram indicates the maximum recommended values of speed n, torque M and power P for both continuous and intermittent operation.



Within this range, the maximum ON-time has to be determined with regard to the thermal limits of the unit.

D.C. Servomotors

Principles of operation

Reference to the chart reveals useful performance information valid for all escap® servomotors.
It shows speed n, current I, output power P and efficiency η plotted against torque M for a given supply voltage U. Torque M is a function of the current I and the torque constant k (expressed in Nm/A). The motor develops its maximum torque M_s at stall (n=0), when the current is maximum and determined only by the supply voltage U and the rotor resistance R:

$I_s = U/R$

$M_s = I_s \cdot k$

With increasing speed, an increasing back-EMF E is induced in the armature which tends to reduce the current:

$$I = \frac{U - E}{R}$$

The value of E is the product of angular speed ω (expressed in rad/s) and the torque constant (expressed in V/rad/s=Vs=Nm/A):

$E = k\omega$

Thus, the supply voltage splits into two parts: RI, necessary to establish the current I in the armature, which generates the torque M, and kω to overcome the induced voltage, in order to generate the speed ω:

$U = RI + k\omega$

No-load speed n_0 is a function of the supply voltage and is reached when E becomes almost equal to U; no-load current I_0 is a function of friction torque:

$$n_0 = \frac{U - RI_0}{k} \cdot \frac{30}{\pi} \qquad \text{(rpm)}$$

Power output P is the product of angular speed ω and torque M ($P = M \cdot \omega$); for a given voltage it reaches its maximum P_{max} at half the stall torque M_s, where efficiency is close to 50%. The maximum continuous output power is defined by an hyperbola delimiting the continuous and intermittent operation ranges.

Efficiency η is the mechanical to electrical power ratio ($\eta = P_m / P_{el}$). Maximum efficiency η_{max} occurs at relatively high speed. Its value depends upon the ratio of stall torque and friction torque and thus is a function of the supply voltage:

$$\eta_{max} = \left(1 - \sqrt{\frac{I_0}{I_d}}\right)^2$$

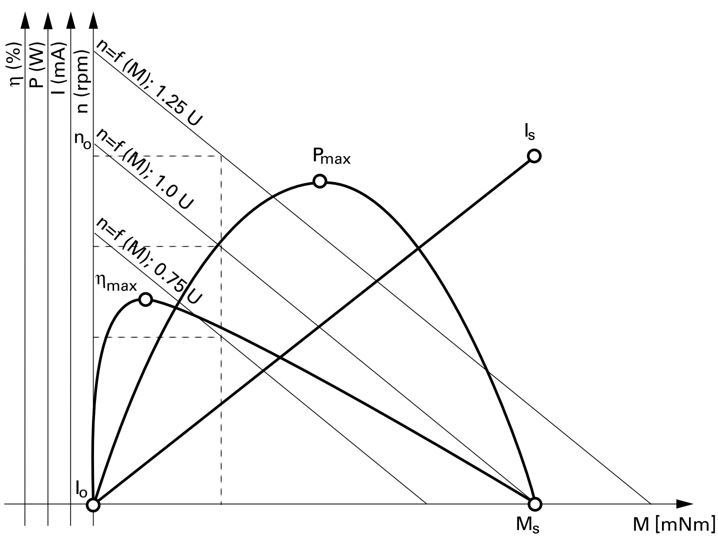
The maximum continuous torque depends upon dissipated power (I^2R), its maximum value is determined by:

$$M_{max} = k \sqrt{\frac{P_{diss}}{R_{max}}} = k \cdot I_{max}$$

$$= k \sqrt{\frac{T_{max} - T_{amb}}{R_{max} \cdot R_{th}}}$$

where T_{max} is the maximum tolerated armature temperature, T_{amb} is the ambient temperature, R_{max} is the rotor resistance at temperature T_{max} and R_{th} is the total thermal resistance (rotor-body-ambient).
At a given torque M, increasing or decreasing the supply voltage will increase or decrease the speed. The speed-torque function varies proportionally to the supply voltage U.

The «Think escap®» publications are available for those who want further information.



D.C. Servomotors

Definition of characteristics

Drawings

Unspecified tolerances are ±0.2 mm. Terminals or lead wires have no fixed exit relative to the mounting holes position. With motor-tacho units the relative position of motor cable and tacho cable is unspecified.

Connections

Most standard motor types have solder terminals. Soldering should be done quickly and at sufficient temperature (3 s, 350°C) in order to avoid overheating. Some motors and tachos are equipped with lead wires of 150 mm length and 0.14 mm^2 cross section. The motor rotates clockwise (viewed from the shaft end) when the red wire or + terminal is connected to positive. The motor may be operated in both directions and in any mounting position.
With a tacho rotating clockwise (viewed from the shaft end), the + terminal, or white lead, carries the positive.

MEASURED VALUES

1. Measuring voltage
Supply voltage at which the characteristics have been measured (at 20/25°C).

2. No-load speed
Speed of the unloaded motor, it is proportional to the supply voltage. Tolerance is ±8%, it is slightly higher for very small motors having a diameter <13 mm.

3. Stall torque
Torque developed at the moment of applying the supply voltage. The tolerance could exceed ±8% due to tolerance accumulation.

4. Average no-load current
Current of the unloaded motor at no-load speed. It represents the friction losses of the standard motor at that speed. Tolerance is about ±50%, and still more at low temperatures.

5. Typical starting voltage
The majority of motors (without load) will start to rotate at between 0.5 and 2 times the typical value.

MAXIMUM VALUES

The values of lines **6.** (max. continuous current), **7.** (max. continuous torque) and **8.** (max. angular acceleration) are recommended for usual operating conditions regarding thermal environment and peak current.

INTRINSIC PARAMETERS

9. Back-EMF constant
Voltage induced at a motor speed of 1000 rpm. The tolerance is ±8%.

10. Torque constant
Indicates the torque developed for a current of 1 A, as well as the EMF induced at an angular velocity of 1 rad/s. The tolerance is ±8%.

11. Terminal resistance
Value measured with the coil at 20/25°C (70/80°F). It includes the resistance of the commutation system, and it rises at a rate of 0.4%/°C. Tolerance is ±8% (±12% with graphite brushes). Depending on the rotor stall position, a brush could short-circuit two of the commutator segments and cause a lower reading.

12. Motor regulation
By dividing the motor resistance R by the square of the torque constant k, the motor regulation R/k^2 is obtained. It represents the slope of the speed-torque curve, i.e. the change in speed caused by a change of the load torque. A smaller value indicates that the motor will dissipate less power to provide a given torque, and therefore has a higher efficiency when transforming electrical energy into mechanical energy. The tolerance could exceed the nominal ±8% due to tolerance accumulation.

13. Rotor inductance
Measured with a frequency of 1 kHz at the terminals of the stalled motor. The value gives an order of magnitude.

14. Rotor inertia
Order of magnitude of the rotor inertia which depends mainly on the mass of copper rotating.

15. Mechanical time constant
It is the product of motor regulation (R/k^2) and rotor inertia J. It describes the motor physically taking into account electrical (R), magnetic (k) and mechanical (J) parameters. It is the time needed by the motor to reach 63% of its no-load speed or of its final speed in view of the voltage and load conditions. The tolerance may reach ±20% due to tolerance accumulation.

THERMAL PARAMETERS

16., 17. Thermal time constant
Order of magnitude of the time required by the rotor (or stator) to reach 63% of the temperature rise corresponding to a given constant power dissipation.

18., 19. Thermal resistance
Gives the armature temperature rise with respect to the body, or body to ambient, respectively, for a power dissipation of 1 W. These values are order of magnitudes, measured under unfavourable conditions. With measuring methods reflecting more common operating conditions, values which are 10 to 50% lower may be obtained.

OTHER PARAMETERS

Viscous torque constant
Gives the increase of losses proportional to speed. With ironless rotor motors viscous losses are very small, thanks to the absence of iron losses. Their viscous losses include windage losses in the airgap and the braking torque generated by short-circuiting the coils during commutation, as well as bearing friction.

Radial play

It is measured at 1 mm from the motor circlip.

Temperature

All specified values are measured at a temperature of 20/25°C (70/80°F)

Motor life

It depends upon several application parameters and in particular on speed and torque. It is limited by mechanical wear and by the electroerosion of the commutation system. Most of the motors are equipped with the REE® system in order to reduce electroerosion. Our engineers will be pleased to estimate lifetime figures for your specific application.
Certain product characteristics are subject to variations over the motor life. A statistic control following well defined procedures is made during numerous life tests.

Standard test of D.C. motors

100% test:

1. No-load speed ± 8%.
2. No-load current: ≤ 150% of the average value.
3. Direction of rotation.
4. Terminal resistance: ± 8%, with precious metal brushes.
5. Starting voltage: ≤ 200% of the average value.
6. Commutation signal: In the case of a precious metal system the signal delivers exact information about the motor quality.
7. Axial shaft play: With sleeve bearings it is set to a value between 50 and 150 µm.
8. Running noise: A measure does not make sense since noise depends largely on the application conditions. Nevertheless, from each lot samples are tested subjectively.