maxon EC motor iron-cored winding
Technology – short and to the point

Characteristics of **maxon EC flat motors** and **EC-i motors**
- Brushless DC motor
- Long service life
- Flat design for when space is limited
- Comparatively high inertia
- Motor characteristics may vary from the strongly linear behaviour
- Hall sensor signals utilizable for simple speed and position control
- Winding with iron core and several teeth per phase in the stator
- Low detent torque
- Good heat dissipation, high overload capacity
- Multipole Neodymium permanent magnet
- Smaller commutation steps

Characteristics of **maxon EC flat motors**
- Attractive price/performance ratio
- High torques due to external, multipole rotor
- Excellent heat dissipation at higher speeds thanks to open design
- Speeds of up to 20 000 rpm rotor with 1 pole pair

Characteristics of the **maxon EC-i** program
- Highly dynamic due to internal, multipole rotor
- Mechanical time constants below 3 ms
- High torque density
- Speeds of up to 15 000 rpm

Bearings and service life

The long service life of the brushless design can only be properly exploited by using preloaded ball bearings.
- Bearings designed for tens of thousands of hours
- Service life is affected by maximum speed, residual imbalance and bearing load

Programm

- **EC flat motor**
- **with Hall sensors**
- **sensorless**
- **with integrated electronics**

1. Flange
2. Housing
3. Laminated steel stack
4. Winding
5. Permanent magnet
6. Shaft
7. Print with Hall sensors
8. Ball bearing
9. Spring (bearing preload)

Electronical commutation

Block commutation
Rotor position is reported by three built-in Hall sensors which deliver six different signal combinations per commutation sequence. The three phases are powered in six different conducting phases in line with this sensor information. The current and voltage curves are block-shaped. The switching position of every electronic commutation lies symmetrically around the respective torque maximum.

Properties of block commutation
- Relatively simple and favorably priced electronics
- Controlled motor start-up
- High starting torques and accelerations possible
- The data of the maxon EC motors are determined with block commutation.

Possible applications
- Highly dynamic servo drives
- Start/stop operation
- Positioning tasks

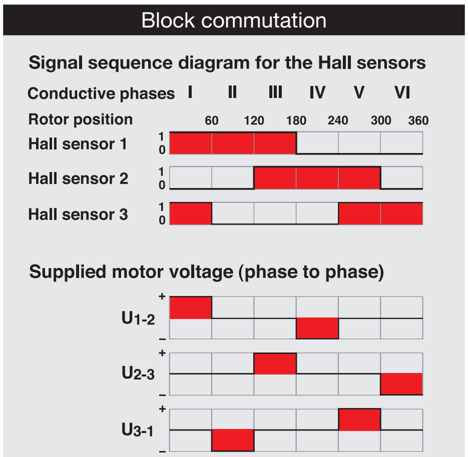
Sensorless block commutation
The rotor position is determined using the progression of the induced voltage. The electronics evaluate the zero crossing of the induced voltage (EMF) and commute the motor current after a speed dependent pause (30° after EMF zero crossing).
The amplitude of the induced voltage is dependent on the speed. When stalled or at low speed, the voltage signal is too small and the zero crossing cannot be detected precisely. This is why special algorithms are required for starting (similar to stepper motor control). To allow EC motors to be commuted without sensors in a Δ arrangement, a virtual star point is usually created in the electronics.

Properties of sensorless commutation
- No defined start-up
- Not suitable for low speeds
- Not suitable for dynamic applications

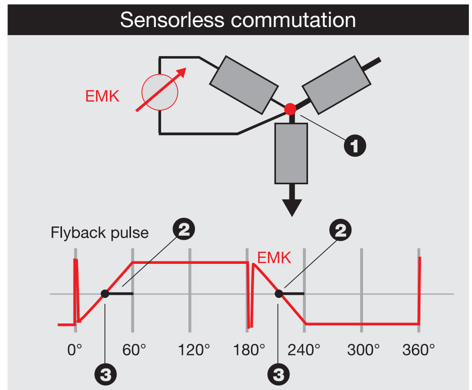
Possible applications
- Continuous operation at higher speeds
- Fans, pumps

Legend
The commutation angle is based on the length of a full commutation sequence (360°e). The length of a commutation interval is therefore 60°e.
The values of the shaft position can be calculated from the commutation angle divided by the number of pole pairs.

Block commutation



Sensorless commutation



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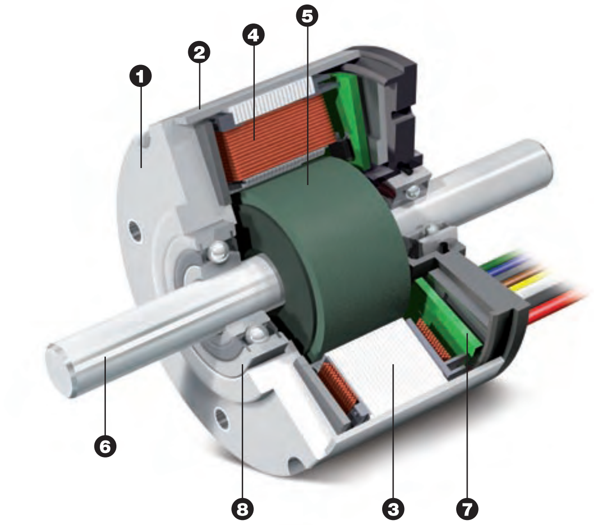
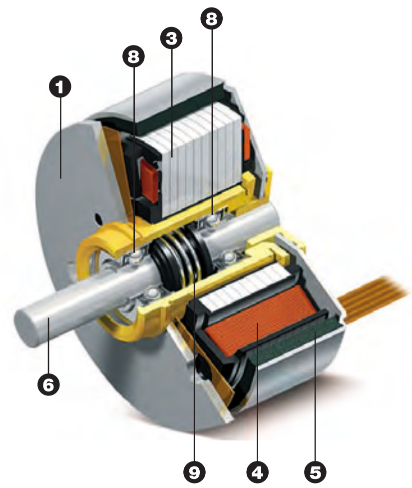




Hall sensor circuit

Winding arrangement

Sinusoidal commutation
Sinusoidal commutation for EC motors with slotted winding is basically possible, provided that an encoder can be mounted. The main benefit of sinusoidal commutation – the smooth operation – only comes into play to a limited degree due to the detent.

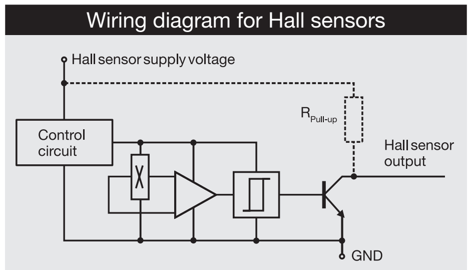
Integrated electronics

For motors with integrated electronics, the electronic commutation (mostly block commutation with Hall sensors) is built in. A speed controller and other functionalities can also be implemented.

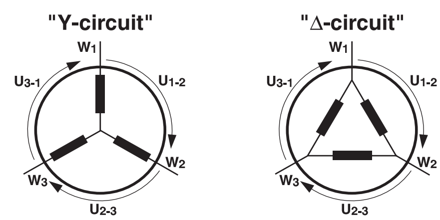
Features
– Simple operation with DC voltage
– Fewer connections than with the EC motor
– No additional electronics required
– Output power reductions possible due to less space for power electronics

The open collector output of Hall sensors does not normally have its own pull-up resistance, as this is integral in maxon controllers. Any exceptions are specifically mentioned in the relevant motor data sheets.

Wiring diagram for Hall sensors



The winding is divided into 3 partial windings which have several stator teeth each. The partial windings can be connected in two different manners - “Y” or “Δ”. This changes the speed and torque inversely proportional by the factor $\sqrt{3}$.
However, the winding arrangement does not play a decisive role in the selection of the motor. It is important that the motor-specific parameters (speed and torque constants) are line with requirements. Flat motors and EC-i are normally “Y”-circuited.



The maximum permissible winding temperature is 125°C. (EC-i 155°C).

For further explanations, please see page 151 or “The Design of High-Precision Microdrives” by Dr. Urs Kafader.

Legend
❶ Star point
❷ Time delay 30°
❸ Zero crossing of EMF