

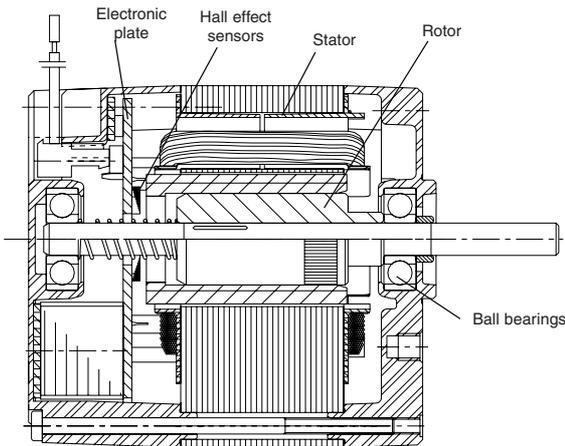
# Basic concepts

## Brushless motors and geared motors

### Principle

#### 1.1. Composition of the driving part:

Brushless motors comprise 3 main elements:



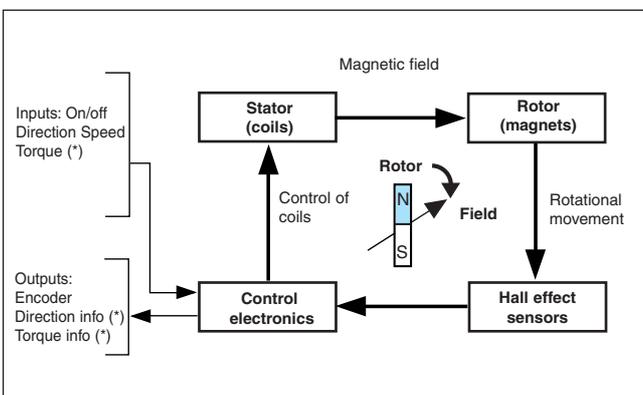
- A fixed part, the stator, which has three groups of coils, called the three phases of the motor. These coils operate as electromagnets and generate various orientations of magnetic field regularly distributed around the central shaft of the motor.

- A rotating part, the rotor, which has permanent magnets. Like the needle of a compass, these magnets permanently drive the rotor to align itself with the magnetic field of the stator. For optimum service life of the motor, the rotor is mounted on ball bearings.

- Three "Hall effect" magnetic sensors. These sensors provide information on the position of the rotor magnets at all times.

#### 1.2. The integrated control electronics:

**Crouzet brushless motors incorporate their control electronics as standard. The control electronics control the phases of the motor, regulate the speed and incorporate the encoder function.**



- The control electronics determine the position of the rotor using the Hall effect sensors. The electronics deduce from the sensors the orientation to give to the magnetic field of the stator. During rotation, they control the three coils to regularly adjust the orientation of the field to the position of the rotor, in order to drive it in the direction chosen by the user.

- By modulating the current in the coils, the electronics can accelerate or slow down the motor and thus regulate its speed. They can also orient the magnetic field in order to brake the movement of the rotor to bring it to a standstill.

- By limiting the current in the coils, the electronics can also limit the torque of the motor, and activate the corresponding output

- The electronics also generate the outputs of the built-in encoder using the Hall effect sensors.

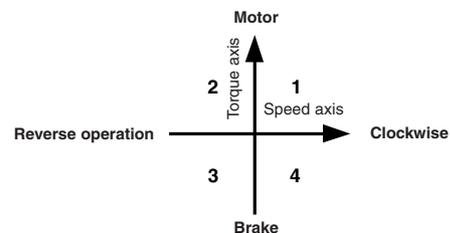
### Speed regulation

#### 2.1. What is 4-quadrant regulation?

The four zones of a torque/speed diagram are known as 'quadrants':

- A positive speed represents clockwise rotation, and a negative speed anti-clockwise

- A positive torque represents motor operation, and a negative torque brake operation.



1-quadrant regulation operates in a single direction of rotation, with no possibility of braking. In the event of overspeed, the regulator cuts off the current until the motor is braked by the load

The principle is identical for 2-quadrant regulation, but in both directions of rotation. This operating mode is offered as an option on Crouzet brushless motors, when required by a specific application.

4-quadrant regulation also operates in both directions of rotation, but also allows braking. In the event of overspeed, the motor is involved in the braking and the system quickly loses speed.

**All Crouzet brushless motors have 4-quadrant regulation as standard.**

## 2.2. Braking:

Braking means absorbing the energy of the mechanical system. There are several different types of braking, depending on the use made of this absorbed energy:

Regenerative braking converts the energy of the system into electrical current, which will be directed to the motor power supply.

Apart from batteries, most commercially available power supplies do not accept this type of current feedback (they are known as 'non-reversible'). It is therefore necessary to ensure that the directed current can be consumed by another device, without which the power supply may be damaged. This braking mode is offered as an option on Crouzet brushless motors, but must be used with caution.

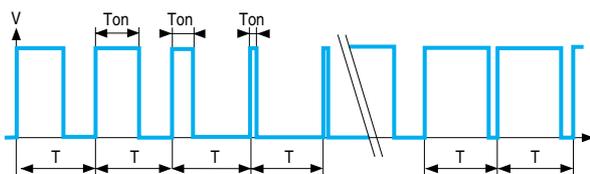
Crouzet brushless motors have braking 'without energy rejection' as standard. This means that on braking the kinetic energy of the system is converted into heat inside the motor itself, with no feedback to the power supply. This is the most suitable type of braking for most applications.

However, if there is prolonged braking, the heat that is generated may trip the thermal protection of the motor. For high inertia applications, or operation as a generator, PLEASE CONSULT CROUZET. Depending on the circumstances, our specialists will advise you to select either 2-quadrant regulation, or braking with energy rejection.

## 2.3. Control by PWM

PWM (Pulse Width Modulation) control is a method of indicating the speed setpoint to the motor. A PWM control motor should be chosen in the following cases:

- Control by CROUZET Millenium II logic controllers (see MOTOMATE information)
- Control by PLC with PWM outputs
- Control by digital control system



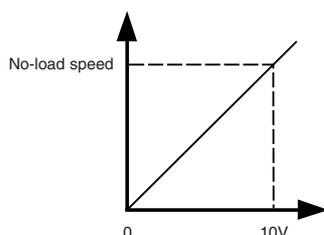
PWM control consists of pulse trains of fixed frequency (Period "T") but variable width ("Ton" period of the pulse). The speed setpoint depends on the Ton/T ratio. However it is independent of the voltage or frequency of the pulses, within the limits of the stated specifications.

Ton/T = 0%	Speed setpoint = 0
Ton/T = 100%	Speed setpoint = No-load speed of the motor
Ton/T = 50%	Speed setpoint = No-load speed of the motor/2

## 2.4. Control by 0-10V

0-10V voltage control is the other method of indicating the speed setpoint to the motor. A 0-10V input motor should be chosen in the following cases:

- Control by potentiometer
- Control by PLC with analogue converter outputs
- Control by analogue control system



In this type of control, the speed setpoint depends on the voltage U at the speed setpoint input:

U = 0	Speed setpoint = 0
U = 10V	Speed setpoint = No-load speed of the motor
U = 5V	Speed setpoint = No-load speed of the motor/2

## Torque limiting (\*)

### 3.1. Operation

Torque limiting is used to deliberately check the motor at certain moments in the operation of a system:

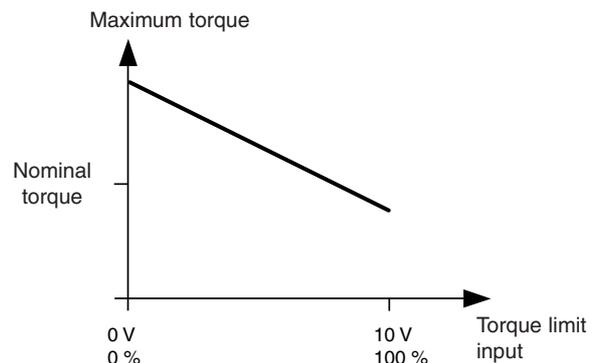
- If there is a risk of encountering an end stop or jamming, to prevent damage to the system
- To maintain a force when the system is at an end stop
- To control the tension of an element located between two moving motor

### 3.2. Torque limiting input (\*)

This input can be controlled in 0-10V and in PWM, whatever type of speed control is selected (Input impedance 16 k ohms. Minimum PWM voltage 12 volts.

Frequency range 150 Hz - 1 kHz

- When the input is at 0 or not connected, the motor delivers up to 140% of its nominal torque
- When the input is at maximum (100% PWM or 10V), the motor delivers around 30% of its nominal torque



When the torque limit is reached, the motor does not follow its speed setpoint, but maintains a constant torque equal to this limit, as long as its speed remains below the setpoint.

### 3.3. Limit reached alert output (\*)

This output is at logic state 1 when the torque limit is reached.

IMPORTANT: This output is PNP type. Consult the wiring diagrams and the precautions for use of this output in the motor specifications.

## Built-in protection

### 4.1. 30 watt motors

If the motor locks when it is controlled, a protection system cuts off the power after a few seconds.

The motor can only restart when the On input changes to 0 then 1.

### 4.2. 80 watt motors

A temperature sensor incorporated in the motor switches the motor to safety mode when the temperature exceeds a value which may damage it. When the trigger temperature is reached, the power is cut off, which causes the motor to stop.

It can only restart when the temperature has fallen below the restart temperature and the On input has changed to 0 then 1.

## Direction and on/off controls

### Input logic table

On	Direction	Speed	Action
0	X	X	Braking and stop
1	X	0	Braking and stop
1	1	V	Clockwise direction at speed V
1	0	V	Anti-clockwise direction at speed V

On and Direction inputs:

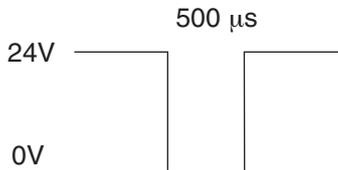
- Input impedance: 60 Ω
- Logic state 0: < 2V
- Logic state 1: > 4V

## Built-in encoder

The built-in encoder supplies fixed width pulses each time a Hall effect sensor switches. These pulses can be counted to ascertain the speed and position of the motor, or filtered to obtain an analogue signal proportional to the speed.

The additional direction of rotation (\*) output is used to determine the direction of count of the pulses.

IMPORTANT: These outputs are NPN or PNP type depending on the version. Consult the wiring diagrams and the precautions for use of these outputs in the motor specifications.



## Safety

Crouzet BRUSHLESS DC motors are designed and manufactured to be integrated into appliances or machines which meet, for example, the specifications of the machine standard: EN 60335-1 (IEC 335-1, "Safety of household and similar electrical appliances").

The integration of Crouzet DC motors into appliances or machines should generally take account of the following motor characteristics:

- no earth connection
- "simple isolation" motors
- protection index: IP54
- insulation system class: B (120 °C)
- Vibration: EN 60068.2.6: 5G from 55 Hz to 500 Hz/0.35 mm peak to peak from 10 Hz to 55 Hz
- Shock: IEC 60068.2.27: 1/2 sine 50G for 11 ms

### European low voltage directive 73/23/EEC of 19/02/73:

Crouzet DC motors and geared motors are outside the scope of this directive (LVD 73/23/EEC applies to voltages over 75 volts DC).

### IMPORTANT

#### ■ Product operation:

To ensure correct operation of Brushless actuators, it is advisable to take account of all the necessary installation and wiring precautions.

#### ■ Product characteristics:

The stated nominal operating characteristics correspond to the voltage-torque-speed characteristics which permit continuous operation, at an ambient temperature of 40 °C. Above these operating conditions, only intermittent duty cycles will be possible: without exception, where extreme conditions prevail, all checks should be performed by the customer in the real-life context of the application to ensure safe operation. For operation in non-nominal conditions:

-> available on request

#### ■ Product usage:

- If these products are being used in very specific operating conditions:
- food and beverage (eg: non-continuous, rectified)
  - ambient atmosphere (extreme temperatures and vibrations, significant relative humidity, explosive or confined atmosphere, etc)
  - other (use as load, sudden stalling, severe operating cycle, etc):
- > available on request

## EMC compatibility

On request, Crouzet will provide the EMC characteristics of the various types of product.

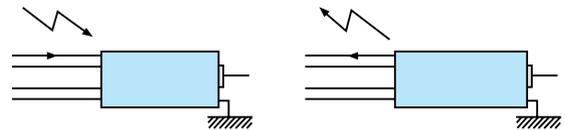
**European directive 89/336/EEC of 03/05/89**, "electromagnetic compatibility":

DC motors and geared motors which are components designed for professionals to be incorporated in more complex devices, and not for end users, are excluded from the scope of this directive.

**However, conscious of the potential customer difficulties concerning problems connected with electromagnetic compatibility, Crouzet has designed its products to meet the requirements of the standards: for example EN 55011 Gr. 1 class B (medical) and also EN 55022, class B (data processing) in terms of emitted electromagnetic interference, in addition to standards connected with immunity:**

IEC 1000- 4 -2/3/4/5/6/8

#### ■ Wiring precautions



For EMC conformity:

- The motor should be connected to earth via its front flange.
- The length of the wires is 0.5 m max.

(\*) Note: Functions marked with an asterisk are only available on the 80 watt versions. If they are required on 30 watt motors, please consult Crouzet.

#### ■ Electromagnetic compatibility:

##### Emission

- Conducted emissions: EN 55022/11G1 class B
- Radiated emissions: EN 55022/11G1 class B

##### Immunity

- Electrostatic discharges: EN 61000-4-2 Level 3
- Electromagnetic fields: EN 61000-4-3 level 3
- Pulse trains: EN 61000-4-4 level 3
- Shock waves: EN 61000-4-5 level 2
- Radio frequency: EN 61000-4-6 level 3
- Magnetic field: EN 61000-4-8 level 4
- Voltage dips: EN 61000-4-29

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