

KRAFTRONICS

Definitions

Acceleration

A change in velocity as a function of time. Acceleration usually refers to increasing velocity, and deceleration to decreasing velocity.

Accuracy

A measure of the difference between expected position and actual position of a motor or mechanical system. Motor accuracy is usually specified as an angle representing the maximum deviation from expected position.

Ambient temperature

The temperature of the cooling medium, usually air, immediately surrounding the motor or another device.

Angular accuracy

The measure of shaft positioning accuracy on a servo or stepping motor.

Back EMF

The voltage generated when a permanent magnet motor is rotated. This voltage is proportional to motor speed and is present regardless of whether the motor winding(s) are energized or de-energized.

Bipolar chopper driver

A class of step motor driver which uses a switch mode (chopper) technique to control motor current and polarity. Bipolar indicates the capability of providing motor phase current of either polarity (+ or -).

Breakaway torque

The torque required to start a machine in motion. Almost always greater than the running torque.

Brushless motor

Class of motors that operate using electronic commutation of phase currents, rather than electromechanical (brush-type) commutation. Brushless motors typically have a permanent magnet rotor and a wound stator.

C-face mounting

A standard NEMA mounting design, where the mounting holes in the face are threaded to receive the mating mount.

Class B insulation

A NEMA insulation specification. Class B insulation is rated to an operating (internal) temperature of 130°C.

Class F insulation

A NEMA insulation specification. Class F insulation is rated to an operating (internal) temperature of 155°C

Class H insulation

A NEMA insulation specification. Class H insulation is rated to an operating (internal) temperature of 180°C.

Closed loop

A broadly applied term, relating to any system in which the output is measured and compared to the input. The output is then adjusted to reach the desired condition. In motion control, the term typically describes a system utilizing a velocity and/or position transducer to generate correction signals in relation to desired parameters.

Cogging (Cogging torque)

A term used to describe non-uniform angular velocity. Cogging appears as a jerkiness, especially at low speeds.

Commutation

1. A term which refers to the action of steering currents or voltages to the proper motor phases so as to produce optimum motor torque. In brush type motors, commutation is done electromechanically via the brushes and commutator. In brushless motors, commutation is done by the switching electronics using rotor position information obtained by Hall sensors, a Tachsyn, or a resolver.
2. Commutation of step motors is normally done open loop. Feedback from the motor is not required to hold rotor position precisely.

Continuous rated current (ICR) (Amperes)

The maximum allowable continuous current a motor can handle without exceeding the motor temperature limits

Continuous rated torque (TCR) (lb-in.)

The maximum allowable continuous torque a motor can handle without exceeding the motor temperature limits

Continuous stall current (ICS) (Amperes)

Amount of current applied to a motor (at locked rotor conditions), which results in rated temperature rise. Refer also to definition of "Continuous stall torque"

Continuous stall torque (TCS) (lb-in.)

The amount of torque at zero speed, which a motor can continuously deliver without exceeding its thermal rating. Determined by applying DC current through two windings with rotor locked, while monitoring temperature. Specified with motor windings at maximum rated temperature, with motor in 25 degrees C ambient, mounted to a heat sink. Refer to individual specs for heat sink size.

Controller

A term describing a functional block containing an amplifier, power supplies, and possibly position-control electronics for operating a servomotor or step motor.

Current at peak torque (IPK) (Amperes)

The amount of input current required to develop "peak torque". This is often outside the linear torque/current relationship.

Current, Rated

The maximum allowable continuous current a motor can handle without exceeding motor temperature limits.

D-flange mounting

This type of mount has clearance holes on the flange, and the mounting bolts stick out through the flange from the motor side. This mount is common in cases where the motor is integral to the machine.

Demag current

The current level at which the motor magnets will start to be demagnetized. This is an irreversible effect, which will alter the motor characteristics and degrade performance. Also known as peak current.

Detent torque

The maximum torque that can be applied to an unenergized step motor without causing continuous rotating motion.

DPBV - Dripproof Blower Ventilated

Type of motor cooled by blowing air through the inside of the motor using an attached blower.

Drive

An electronic device that controls torque, speed and/or position of an AC or brushless motor. Typically a feedback device is mounted on the motor for closed-loop control of current, velocity and position.

Driver

Electronics which convert step and direction inputs to high power currents and voltages to drive a step motor. The step motor driver is analogous to the servomotor amplifier's logic.

Duty cycle

For a repetitive cycle, the ratio of on time to total cycle time.

Duty cycle (%) = $[\text{On time} / (\text{On time} + \text{Off time})] \times 100\%$

Dynamic braking

A passive technique for stopping a permanent magnet brush or brushless motor. The motor windings are shorted together through a resistor which results in motor braking with an exponential decrease in speed.

Efficiency

The ratio of power output to power input.

Electrical time constant (te) (Seconds)

The time required for current to reach 63.2% of its final value for a fixed voltage level. Can be calculated from the relationship $t_e=L/R$ where L is inductance (henries) and R is resistance (ohms).

Encoder

A feedback device which converts mechanical motion into electronic signals. The most commonly used, rotary encoders, output digital pulses corresponding to incremental angular motion. For example, a 1000-line encoder produces 1000 pulses every mechanical revolution. The encoder consists of a glass or metal wheel with alternating transparent and opaque stripes, detected by optical sensors to produce the digital outputs.

Feedback

A signal which is transferred from the output back to the input for use in a closed loop system.

Ferrite

A type of permanent magnet consisting of ceramic compounds made up of oxides of iron, barium and strontium.

Form factor

The ratio of RMS current to average current. This number is a measure of the current ripple in a SCR or other switch-mode type of drive. Since motor heating is a function of RMS current while motor torque is a function of average current, a form factor greater than 1.00 means some fraction of motor current is producing heat but not torque.

Four quadrant

Refers to a motion system which can operate in all four quadrants; i.e., velocity in either direction and torque in either direction. This means that the motor can accelerate, run, and decelerate in either direction.

Friction

A resistance to motion caused by contact with a surface. Friction can be constant with varying speed (Coulomb friction) or proportional to speed (viscous friction).

Hall sensor

A feedback device which is used in a brushless servo system to provide information for the amplifier to electronically commutate the motor. The device uses a magnetized wheel and hall effect sensors to generate the commutation signals.

Holding torque

Sometimes called static torque, holding torque specifies the maximum external torque that can be applied to a stopped, energized motor without causing the rotor to rotate. Generally used as a figure of merit when comparing motors.

Horsepower

An index of the amount of work a machine or motor can perform. One horsepower is equal to 746 watts. Since power is equal to torque multiplied by speed, horsepower is a measure of a motor's torque and speed capability; e.g., a 1 HP motor will produce 36 lb-in. at 1,750 rpm.

Formula:

$$\text{HP} = \text{Torque (lb-in.)} \times \text{Speed (RPM)} / 63,025$$

or

$$\text{HP} = \text{Torque (lb-ft.)} \times \text{Speed (RPM)} / 5,252$$

or

$$\text{HP} = \text{Volts} \times \text{Amps} \times \text{Efficiency} / 746$$

Hybrid step motor

A motor designed to move in discrete increments of steps. The motor has a permanent magnet rotor and a wound stator. Such motors are brushless. Phase currents are commutated as a function of time to produce motion.

Idle current reduction

A step motor driver feature that reduce the phase current to the motor when no motor motion is commanded (idle condition) for a specified period of time. Idle current reduction reduces motor heating and allows high machine throughputs from a given motor.

Indexer

Electronics which convert high level motion commands from a host computer, PLC or operator panel into step and direction pulse streams for use by the step motor driver. Indexers can be broadly divided into two classes. A preset indexer typically accepts distance, velocity and ramp time inputs only. The more sophisticated programmable indexer is capable of complex motion control and includes program memory.

Inductance (L) (mH - millihenries line-to-line)

The electrical equivalent to mechanical inertia; that is, the property of a circuit, which has a tendency to resist current flow when no current is flowing, and when current is flowing has a tendency to maintain that current flow. Pacific Scientific measures inductance (line-to-line) with a bridge at 1000 Hz and with the rotor positioned so the back-EMF waveform is at the peak of the sinusoid.

Inductance (mutual)

Mutual inductance is the property that exists between two current carrying conductors or coils when magnetic lines of force from one link with those of the other.

Inertia

The property of an object to resist change in velocity unless acted upon by an outside force. Higher inertia objects require larger torques to accelerate and decelerate. Inertia is dependent upon the mass and shape of the object.

Inertial match

For most efficient operation, the system coupling ratio should be selected so that the reflected inertia of the load is equal to the rotor inertia of the motor.

Insulation Class

The rating assigned to the maximum temperature capability of the insulating components in a motor or other piece of equipment.

Mechanical time constant (tm) (Seconds)

In a simple first order system, the time required for the motor's speed to attain 63.2% of its final value for a fixed voltage level. Can be calculated from:

where:

J is inertia in lb-in./s²

R is resistance in ohms

KT is torque constant in lb-in./amp.

8.87 is a conversion factor

tM is calculated in seconds

Microstepping

An electronic technique for increasing a step motor's position resolution and velocity smoothness by appropriately scaling the phase currents. Microstepping is also a technique used to reduce or eliminate the effects of system resonance at low speeds.

Mid-range instability

A phenomenon in which a step motor can fall out of synchronism due to a loss of torque at mid-range speeds. The torque loss is due to the interaction of the motor's electrical characteristics and the driver's electronics. Some drivers have circuitry to eliminate or reduce the effects of mid-range instability.

NEMA - National Electrical Manufacturer's Association

Acronym for an organization which sets standards for motors and other industrial electrical equipment.

Neodymium iron boron

A type of rare-earth permanent magnet material.

NTC - Negative Temperature Coefficient

A negative temperature coefficient thermistor is used to detect and protect a motor winding from exceeding its maximum temperature rating. Resistance of the device decreases with an increase in temperature.

Open-loop

A system in which there is no feedback. Motor motion is expected to faithfully follow the input command. Stepping motor systems are an example of open-loop control.

Overload capacity

The ability of a drive to withstand currents above its continuous rating. It is defined by NEMA as 150% of the rated full-load current for "standard industrial DC motors" for one minute.

Peak torque (Tpk) (lb-in.)

The maximum torque a brushless motor can deliver for short periods of time. Operating PacTorq motors above the maximum torque value can cause demagnetization of the rare-earth magnets. This is an irreversible effect that will alter the motor characteristics and degrade performance. This is also known as peak current.

Not to be confused with system peak torque, which is often determined by amplifier peak current limitations, where peak current is typically two times continuous current.

Poles

Refers to the number of magnetic poles arranged on the rotor of the brushless motor. Unlike an AC motor, the number of poles has no direct relationship to the base speed of the motor.

Power

1. The rate at which work is done. In motion control, power is equal to torque multiplied by speed.
2. The rate of doing work or expending energy. It may be written as: Power (watts) = force x distance/ time. Expressed in electrical terms it is voltage x current = power (watts)

Power factor

Ratio of true power (kW) to apparent power (kVA).

PTC - Positive Temperature Coefficient

A positive temperature coefficient thermistor is used to detect and protect a motor winding from exceeding its maximum temperature rating. Resistance of the device increases with an increase in temperature.

Pull-out torque

The maximum friction load, at a particular inertial load, that can be applied to the shaft of a synchronous motor (running at constant speed) and not cause it to lose synchronism.

Pulse rate

The frequency of the step pulses applied to a step motor driver. The pulse rate, multiplied by the resolution of the motor/driver combination (in steps per revolution), yields the rotational speed in revolutions per second.

Pulse Width Modulation (PWM)

1. A PWM controller (amplifier) switches DC supply voltage on and off at fixed frequencies. The length of the on/off interval or voltage waveform is variable.
2. Pulse width modulation (PWM), describes a switch-mode (as opposed to linear) control technique used in amplifiers and drivers to control motor voltage and current. PWM offers greatly improved efficiency compared to linear techniques.

Regeneration

The action during motor braking, in which the motor acts as a generator and takes kinetic energy from the load, converts it to electrical energy, and returns it to the amplifier.

Repeatability

The degree to which a parameter such as position or velocity can be duplicated.

Resistance, Hot (RH)(Ohms line-to-line)

The motor's terminal resistance value specified at the hot winding temperature, which is at the motor's maximum rated temperature.

Resolution

The smallest increment into which a parameter can be broken down. For example, a 1000 line encoder has a resolution of 1/1000 of a revolution.

Resolver

An electromagnetic feedback device which converts angular shaft position into analog signals. These signals can be processed in various ways, such as with an RDC (resolver-to-digital converter) to produce digital position information. There are two basic types of resolvers; transmitter and receiver. A transmitter-type is designed for rotor primary excitation and stator secondary outputs. Position is determined by the ratio of the sine output amplitude to cosine output amplitude. A receiver-type is designed for stator primary excitations and rotor secondary output. Position is determined by the phase shift between the rotor output signal and one of the primary excitation signals.

Resonance

Oscillatory behavior caused by mechanical limitations.

Restart torque

The maximum friction load, at a particular inertial load, that can be applied to the shaft of a synchronous motor without causing it to lose synchronism when accelerating to a constant speed from standstill.

Ringling

Oscillation of a system following a sudden change in state.

RMS Current - Root Mean Square Current

In an intermittent duty cycle application, the RMS current is equal to the value of steady state current which would produce the equivalent motor heating over a period of time.

RMS Torque - Root Mean Square Torque.

In an intermittent duty cycle application, the RMS torque is equal to the value of steady state torque which would produce the equivalent motor heating over a period of time.

Rotor

The moving part of the motor, consisting of the shaft and magnets. These magnets are analogous to the field winding of a brush-type DC motor.

Settling time

The time required for a parameter to stop oscillating or ringing and reach its final value.

Shock loading

A load that produces extremely high peak torques for very short durations. This type of load is associated with conveyerized grinding, crushing and separation processes.

Speed

Describes the linear or rotational velocity of a motor or other object in motion.

Stall Torque

The amount of torque developed with voltage applied and shaft locked, or not rotating. Also known as locked-rotor torque.

Stator

The non-moving part of the motor. Specifically, it is the iron core with the wire winding in it that is pressed into the frame shell. The winding pattern determines the voltage constant of the motor.

Step angle

The angular distance the shaft rotates upon receipt of a single step command.

Stiffness

The ability to resist movement induced by an applied torque. Stiffness is often specified as a torque displacement curve, indicating the amount a motor shaft will rotate upon application of a known external force when stopped.

Synchronism

A motor rotating at a speed corresponding correctly to the applied step pulse frequency is said to be in synchronism. Load torques in excess of the motor's capacity (rated torque) will cause a loss of synchronism. This condition is not damaging to a step motor.

TENV - Totally Enclosed Non-Ventilated

Acronym describing a type of motor enclosure, which has no outside air going into it. It is cooled only by convection to the frame, which is usually finned.

Thermal protection

A thermal sensing device mounted to the motor to protect it from overheating. This is accomplished by disconnecting the motor phases from the drive in an over temperature condition.

Thermal resistance (Rth) (°C/watt)

An indication of how effectively a unit rids itself of heat; a measure of temperature rise per watts lost. In Pacific Scientific literature, it is the specified value from the motor windings to the ambient, under locked rotor conditions.

Thermal time constant (tth) (minutes)

The time required for a motor to attain 63.2% of its final temperature for a fixed power input.

Thermostat

A temperature sensitive pilot duty device mounted on the interior of the motor to protect it from overheating.

Torque

A measure of angular force which produces rotational motion. This force is defined by a linear force multiplied by a radius; e.g. lb-in. Torque is an important parameter of any motion control system. Formula:
Torque (lb-ft.) = 5,250 x HP/RPM

Torque Constant (KT = lb-ft./A)

An expression of the relationship between input current and output torque. For each ampere of current, a fixed amount of torque is produced.

Torque-to-inertia ratio

Defined as the motor's holding torque divided by the inertia of its rotor. The higher the ratio, the higher a motor's maximum acceleration capability will be.

Unipolar driver

A step motor driver configuration that uses a unipolar power supply and is capable of driving phase current in only one direction. The motor phase winding must be center tapped (6 or 8 lead) to operate with a unipolar driver. The center tap is used instead of providing the current reversal of a bipolar driver.

Velocity

The change in position as a function of time. Velocity has both a magnitude and sign.

Viscous Damping (KDV) (lb-in./kRPM)

Inherent losses are present in all motors which result in lower torque delivered at the output shaft than developed at the rotor. Losses which are proportional to speed (i.e. speed dependent terms such as windage, friction, eddy current) are related through the motor's "viscous damping" constant, measured as the slope of the damping curve.

Voltage constant (KE) (V/kRPM peak, line-to-line)

May also be termed back-EMF constant. When a motor is operated, it generates a voltage proportional to speed, but opposing the applied voltage. The shape of the voltage waveform depends upon the specific motor design. For example, in a brushless motor, the waveshape may be trapezoidal or sinusoidal in nature. All Pacific Scientific brushless motor designs have a sinusoidal voltage constant. For a sine waveform, the voltage constant can be measured from line-to-neutral or line-to-line and expressed as a peak value or "RMS" value.

Watt

One horsepower equals 746 watts.



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