Stepper Motor Torque Basics Cheat Sheet

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Introduction

A stepper motor divides a full rotation into a number of equal steps. The motor's position can be caused to move and hold at one of these steps as long as the motor is carefully sized to the application in respect to torque and speed. Holding torque is a measurement of how much rotating force is required to force a stationary stepper motor shaft out of position. Holding torque (T) is the product of a motor's torque constant (KT) and the current (i) applied to the stator windings

$T = KTi$

Pulse Width Modulation (PWM) technology

In most applications, electronic drivers control stepper motors. They employ pulse width modulation (PWM) technology to monitor the stator current and apply the proper voltage to achieve the desired current and torque. When a motor is stationary, the driver only needs to use enough voltage to overcome the resistance of the stator coils (also known as motor phases). This is described by Ohm's law that calculates voltage as the current in amps multiplied by the resistance in ohms. If voltage increases, so does current, but if resistance increases, current reduces..

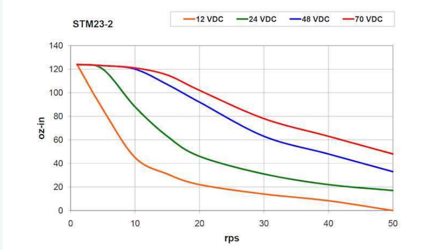
$V = iR$

To manage a heavier load

To manage a heavier load or accelerate faster requires more torque. However, the dynamic torque of a stepper motor decreases as speed increases because when a motor starts moving, it becomes a generator. As the rotor's magnetic field moves among the stator coils, a voltage appears on the motor terminals. The driver must apply an extra voltage to the motor to overcome this voltage, known as back EMF, which is a product of motor speed (w) and voltage constant (KE). Also, stator coils, like all coils, have inductance that resists the current change. As the stator current changes to keep the rotor turning, more voltage must be used to overcome inductance (L). The voltage equation for a motor in motion is:.

$V = KE\acute{\omega} + iR + L(di/dt)$

A PWM drive



A PWM driver will increase the voltage applied to the motor to keep the current and torque constant. At some speed, the power supply will not have enough voltage, and the motor current will begin to fall. The torque drops with the current. If using a higher voltage power supply, the dynamic torque remains flat to a higher speed (see Figure 1).

Sizing an application

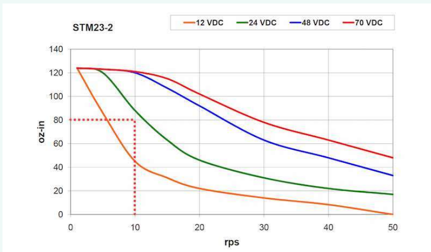
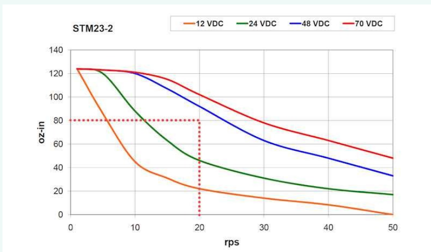


Figure 3: If an application requires 80 oz.-in. of torque up to 20 rps, the motor should use a 48-V power supply, as shown by the graph.The process of sizing an application involves calculating the required torque and speed range necessary to move the load. For example, if the application needed 80 oz.-in. of torque up to 10 revolutions/second (rps), this motor could use a 24-V power supply (see Figure 2)

Going Faster and Further



If we need to go farther and faster, one might accelerate to 80 oz.-in. at 20 rps. The motor would require a 48-V power supply (see Figure 3)