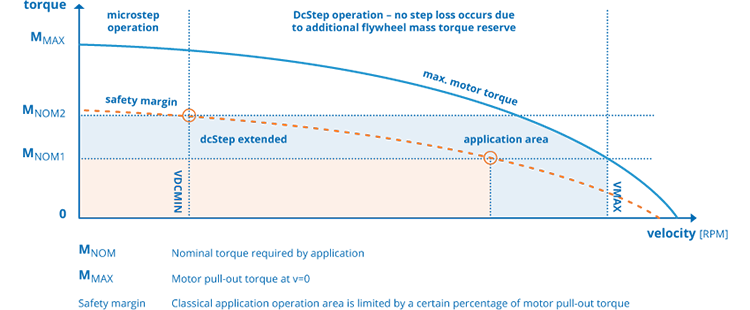
* **Standalone Driver:** Stand-Alone drivers are those drivers that tend not to adhere to the simple or advanced driver model. Such drivers include the Crystal Reports driver.
* **Step/Dir Interface**: A step/dir interface is a basic communication interface that uses two digital signals to run stepper motors:
* Step signal: A short impulse that tells the motor to take a step of a predetermined length
* Direction signal: Determines the direction of the movement, such as forward or backward
* **SpreadCycle™**: SpreadCycle is a chopper algorithm that's used to control stepper motors. It's a current-controlled algorithm that's designed to be high-precision, low-noise, low-resonance, and low-vibration. SpreadCycle automatically finds the best ratio between slow and fast decay to create the ideal fast decay for each cycle. It can also help to optimize motor settings for different velocities.
* **StealthChop™:** stealthChop is a voltage-controlled chopper principle in contrast to current controlled chopper principles like spreadCycle. This becomes visible when measuring the microstep current in series with the coil
* **Integrated Current Sense Option:** Current sensing in a stepper motor can help control the motor's torque or precisely set its position. It can also help detect fault conditions, such as a winding short, or determine the motor's load, or torque output.
* **DcStep™**: is a highly efficient stepper motor commutation scheme from Analog Devices, Inc. (ADI) Trinamic family, which aims to use most of the available output torque of a stepper motor at 80% of the maximum pull-out torque. Effectively, DcStep technology provides extra torque to match sudden increases in load resistance while uniquely maintaining position counter integrity.

DcStep technology closes the gap between fully featured closed-loop stepper drives and cost-efficient open-loop systems. Optimizing torque output with DcStep technology can help improve safety margins and ensure your applications reach the target position without losing a step.

How Does DcStep Technology Work?

Stepper motors are typically used with a safety margin of 40% to 50% of their maximum pull-out torque. This margin is needed to compensate for unforeseen load peaks, torque loss due to resonance, and aging of mechanical components in an open-loop system. Furthermore, stepper motors have a decreased torque at higher speeds caused by the specific dependency of rotor velocity and back-EMF.

To ensure a stepper motor doesn’t lose steps when the load becomes too high, this sensorless technology uses most of the available output torque at about 80% of the stepper motor. It gives the stepper a DC motor-like behavior if the load exceeds the motor output torque for the actual working point, automatically adapting the motor velocity to the actual motor load by moving along the shape of the stepper motor’s torque curve.



DcStep technology is used at middle and higher velocities where the back-EMF significantly affects motor coil current and maximum output torque. For a given setup and application, the stepper motor technology extends the motor’s functional area by either allowing for more torque output at the same velocity or by increasing the maximum velocity. This allows engineers to use more SWaP-effective stepper motors with the same results.

[Learn More About DcStep Technology and the DcStep Tuning Wizard](https://www.analog.com/en/resources/app-notes/an-003.html)

DcStep Technology Adds DC Motor Characteristics to Your Stepper Motor Drive:

While most open-loop stepper motor drives lose steps in an overload situation, DcStep drives reduce speed instead. The load-dependent speed control automatically adapts the velocity to the actual motor load and moves the motor as fast as possible without losing a step. By doing so, the drive can overcome the resistance from the heavy load situation and thereby maintain position counter integrity. This is similar to a DC motor behavior in terms of energy efficiency. DcStep features furthermore allow for autoramping by adapting the ramping profile to the real-time torque overload condition, making sure the target position is reached.

* **StallGuard2™**: StallGuard2™ High precision sensorless load measurement using the back EMF on the coils. Works with the SpreadCycle current control algorithm.
* **StallGuard4™:** StallGuard4™ High precision sensorless load measurement using the back EMF on the coils. Works with the StealthChop voltage control algorithm
* **CoolStep™:** CoolStep™ Load-adaptive automatic current scaling based on the load measurement via StallGuard2 or StallGuard4 adapting the required current to the load. Energy consumption can be reduced by as much as 75%.

***More*** *about* ***StallGuard™ & CoolStep™ added in pdf :*** *Parameterization of StallGuard2™ & CoolStep™*

* **Passive braking:** is a method used to hold the stepper motor in a fixed position without actively driving it with current. It relies on the inherent magnetic resistance of the motor's rotor to movement when the motor coils are not energized. The motor resists movement due to inherent magnetic resistance but does not consume power.

How it works: When the motor driver stops sending current to the motor coils, the motor's rotor resists movement due to the detent torque. This is the natural magnetic resistance provided by the permanent magnets in the motor.

Advantages:

- Energy-efficient because it does not require continuous current to hold the position.

- Simpler to implement compared to active braking methods.

Disadvantages:

- Less effective in holding position compared to active braking, especially under higher loads.

- May not be suitable for applications requiring precise positioning.

* **Freewheeling Mode:** allows the stepper motor to rotate freely without any resistance from the motor driver. The motor rotates freely without any electromagnetic resistance or power consumption.

How it works: In this mode, the motor driver completely disengages the motor coils, effectively making the motor act like a passive mechanical system. There is no electromagnetic resistance to rotation, and the rotor can spin freely.

Advantages:

- No energy consumption since the motor coils are not energized.

- Useful for applications where the motor needs to be easily moved by an external force when not powered.

Disadvantages:

- The motor cannot hold its position and will not resist external forces.

- Not suitable for applications requiring the motor to stay in a fixed position when not powered.

* **RDS(on)**: stands for "Resistance Drain-Source on-state." It is a measure of the electrical resistance between the drain and source terminals of a MOSFET when it is in the 'on' state (conducting state). Lower RDS(on) values indicate lower resistance, which means less power loss and more efficient operation.

**FEATURES AND BENEFITS**

TMC2100

* 2-phase stepper motors up to 2.0A coil current (2.5A peak)
* Standalone Driver Voltage Range 4.75… 46V DC
* Smooth Run 256 microsteps from 4 or 16 microsteps input (or from halfstepping, SpreadCycle only)
* **Step/Dir Interface** with microstep interpolation MicroPlyer™
* **StealthChop™** for quiet operation and smooth motion
* **SpreadCycle™** highly dynamic motor control chopper
* **Integrated Current Sense Option**
* **Standstill Current Reduction**
* **Full Protection & Diagnostics** (two outputs)
* Small Size 5x6mm2 QFN36 package or TQFP48 package

TMC2130

* 2-phase stepper motors up to 2.0A coil current (2.5A peak)
* Voltage Range 4.75… 46V DC
* Step/Dir Interface with microstep interpolation MicroPlyer™
* SPI Interface
* Highest Resolution 256 microsteps per full step
* StealthChop™ for extremely quiet operation and smooth motion
* SpreadCycle™ highly dynamic motor control chopper
* DcStep™ load dependent speed control
* StallGuard2™ high precision sensorless motor load detection
* CoolStep™ current control for energy savings up to 75%
* Integrated Current Sense Option
* Passive Braking and freewheeling mode
* Full Protection & Diagnostics
* Small Size 5x6mm2 QFN36 package or TQFP48 package

TMC2160

* 2-phase stepper motors from 1A to several 10A coil current
* Step/Dir Interface with microstep interpolation MicroPlyer™
* Voltage Range 8 … 60V DC
* SPI Interface
* Highest Resolution 256 microsteps per full step
* StealthChop2™ for quiet operation and smooth motion
* Resonance Dampening for mid-range resonances
* SpreadCycle™ highly dynamic motor control chopper
* DcStep™ load dependent speed control
* StallGuard2™ high precision sensorless motor load detection
* CoolStep™ current control for energy savings up to 75%
* Passive Braking and freewheeling mode
* Full Protection & Diagnostics
* Compact Size 7x7mm2 (body) TQFP48 package

TMC2208

* 2-phase stepper motors up to 2A coil current (peak)
* STEP/DIR Interface with 2, 4, 8, 16 or 32 microstep pin setting
* Smooth Running 256 microsteps by MicroPlyer™ interpolation
* StealthChop2™ silent motor operation
* SpreadCycle™ highly dynamic motor control chopper
* Low RDSon LS 280mΩ & HS 290mΩ (typ. at 25°C)
* Voltage Range 4.75… 36V DC
* Automatic Standby current reduction (option)
* Internal Sense Resistor option (no sense resistors required)
* Passive Braking and Freewheeling
* Single Wire UART & OTP for advanced configuration options
* Integrated Pulse Generator for standalone motion
* Full Protection & Diagnostics

TMC2209

* 2-phase stepper motors up to 2.8A coil current (peak), 2A RMS
* STEP/DIR Interface with 8, 16, 32 or 64 microstep pin setting Smooth Running 256 microsteps by MicroPlyer™ interpolation
* StealthChop2™ silent motor operation
* SpreadCycle™ highly dynamic motor control chopper
* StallGuard4™ load and stall detection for StealthChop
* CoolStep™ current control for energy savings up to 75%
* Low RDSon, Low Heat-Up LS 170mΩ & HS 170mΩ (typ. at 25°C)
* Voltage Range 4.75… 29V DC
* Low Power Standby to fit standby energy regulations
* Internal Sense Resistor option (no sense resistors required)
* Passive Braking, Freewheeling, and automatic power down
* Single Wire UART & OTP for advanced configuration options
* Integrated Pulse Generator for standalone motion
* Full Protection & Diagnostics
* Compact QFN package with large heat slug

TMC2225

* 2-phase stepper motors up to 2A coil current (peak)
* STEP/DIR Interface with 4, 8, 16 or 32 microstep pin setting Smooth Running 256 microsteps by MicroPlyer™ interpolation
* StealthChop2™ silent motor operation
* SpreadCycle™ highly dynamic motor control chopper
* Pin Selection for chopper scheme
* Low RDSon LS 280mΩ & HS 290mΩ (typ. at 25°C)
* Voltage Range 4.75… 36V DC
* Automatic Standby current reduction (option)
* Internal Sense Resistor option (no sense resistors required)
* Passive Braking and Freewheeling
* Single Wire UART & OTP for advanced configuration options
* Integrated Pulse Generator for standalone motion
* Full Protection & Diagnostics
* HTSSOP package for best thermal resistance

TMC2226

* 2-phase stepper motors up to 2.8A coil current (peak), 2A RMS
* STEP/DIR Interface with 8, 16, 32 or 64 microstep pin setting Smooth Running 256 microsteps by MicroPlyer™ interpolation
* StealthChop2™ silent motor operation
* SpreadCycle™ highly dynamic motor control chopper
* StallGuard4™ load and stall detection for StealthChop
* CoolStep™ current control for energy savings up to 75%
* Low RDSon, Low Heat-Up LS 170mΩ & HS 170mΩ (typ. at 25°C)
* Voltage Range 4.75… 29V DC
* Low Power Standby to fit standby energy regulations
* Internal Sense Resistor option (no sense resistors required)
* Passive Braking, Freewheeling, and automatic power down
* Single Wire UART & OTP for advanced configuration options
* Integrated Pulse Generator for standalone motion
* Full Protection & Diagnostics
* Thermally optimized HTSSOP package for optical inspection

TMC2660

* Drive Capability up to 4A motor current
* Voltage up to 30V DC
* Highest Resolution up to 256 microsteps per full step
* Compact Size 10x10mm QFP-44 package
* Low Power Dissipation very low RDSON & sync. rectification
* EMI-optimized programmable slope
* Protection & Diagnostics short to GND, overtemperature & undervoltage, overcurrent and short to VS (TMC2660C only)
* StallGuard2™ high precision sensorless motor load detection
* CoolStep™ load dependent current control saves up to 75%
* MicroPlyer™ 256 microstep smoothness with 1/16 step input.
* SpreadCycle™ high-precision chopper for best current sine wave form and zero crossing
* Improved Silent Motor operation (TMC2660C only)
* Stand Alone option (TMC2660C only)

TMC5130A

* 2-phase stepper motors up to 2A coil current (2.5A peak)
* Voltage Range 4.75… 46V DC
* Motion Controller with sixPoint™ ramp
* Step/Dir Interface with microstep interpolation MicroPlyer™
* SPI & Single Wire UART
* Encoder Interface and 2x Ref.-Switch Input
* Highest Resolution 256 microsteps per full step
* StealthChop™ for extremely quiet operation and smooth motion
* SpreadCycle™ highly dynamic motor control chopper
* DcStep™ load dependent speed control
* StallGuard2™ high precision sensorless motor load detection
* CoolStep™ current control for energy savings up to 75%
* Integrated Current Sense Option
* Passive Braking and freewheeling mode
* Full Protection & Diagnostics
* Compact Size 7x7mm2 TQFP48 package

TMC5160

* 2-phase stepper motors from 1 to several 10A coil current
* Motion Controller with SixPoint™ ramp
* Step/Dir Interface with microstep interpolation MicroPlyer™
* Voltage Range 8 … 60V DC
* SPI & Single Wire UART
* Encoder Interface and 2x Ref.-Switch Input
* Highest Resolution 256 microsteps per full step
* StealthChop2™ for quiet operation and smooth motion Resonance Dampening for mid-range resonances
* SpreadCycle™ highly dynamic motor control chopper
* DcStep™ load dependent speed control
* StallGuard2™ high precision sensorless motor load detection
* CoolStep™ current control for energy savings up to 75%
* Passive Braking and freewheeling mode
* Full Protection & Diagnostics
* Compact Size 7x7mm2 (body) TQFP48 package / 8x8mm² QFN