

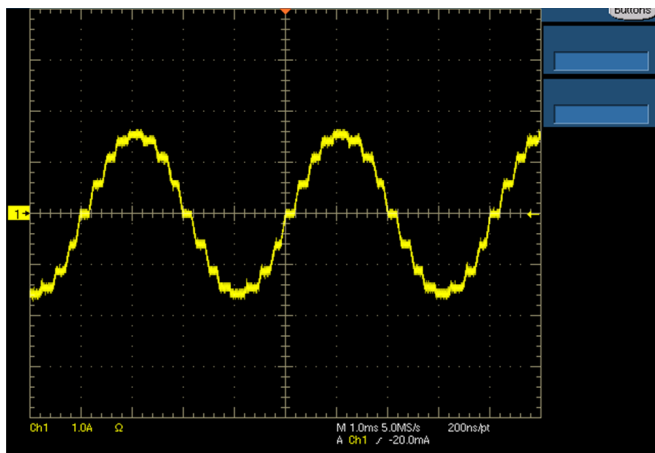
# Smart Tuning for Efficient Stepper Driving

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Many applications use stepper motors as a way to achieve low-cost mechanical positioning. A typical hybrid stepper motor has an angular step size of 1.8° per step. Using a technique called "microstepping", stepper motors can achieve more precise angular positioning of 1/4 to 1/256 that step size. By reducing the step size, microstepping helps to reduce noise and vibration in stepper motors by allowing the shaft to move more smoothly.

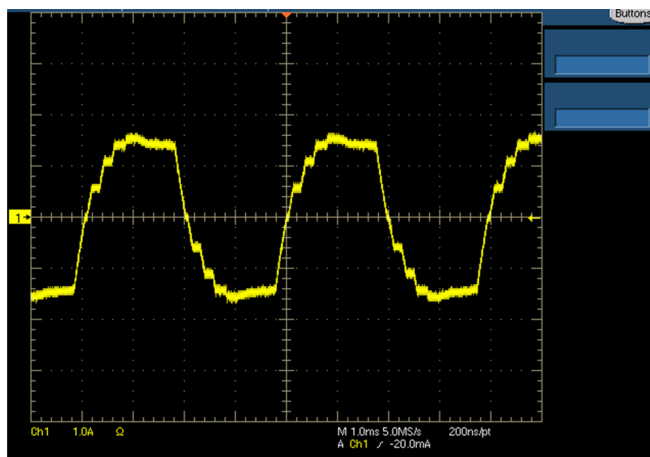
An integrated stepper driver must regulate the current through each of the two windings of a bipolar stepper motor to achieve microstepping. The magnetic fields of each winding pull the rotor in different directions and with different magnitudes create the intermediate positional steps when microstepping. As the stepper driver steps through the microstep levels, the currents it regulates in each winding form a sinewave shape as shown in Figure 1.



**Figure 1. Stepper current waveform running at 4,000 pulses per second using 1/4 microstepping and dynamic decay**

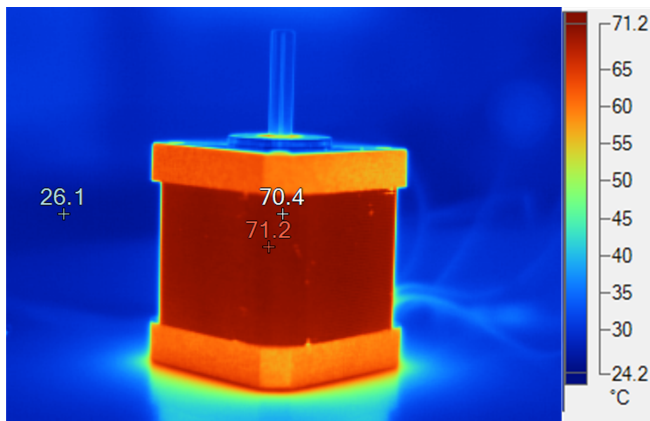
Integrated stepper drivers implement various current chopping techniques to regulate the current levels as these factors change. Stepper drivers often provide options to control the mixture of slow decay versus fast decay in the current chopping scheme. Stepper driver datasheets describe the details of the decay mode options they provide in their current chopping scheme.

However, factors such as winding inductance, resistance, back EMF, current level, and supply voltage impact how well the stepper driver can regulate the current for a chosen decay mode. Unfortunately, most stepper drivers only allow designers to choose a single fixed-decay setting when tuning their stepper motor. This can cause issues, especially as back EMF and current levels change while driving the stepper motor. Figure 2 shows a current waveform of a poorly tuned stepper with a fixed-decay setting.

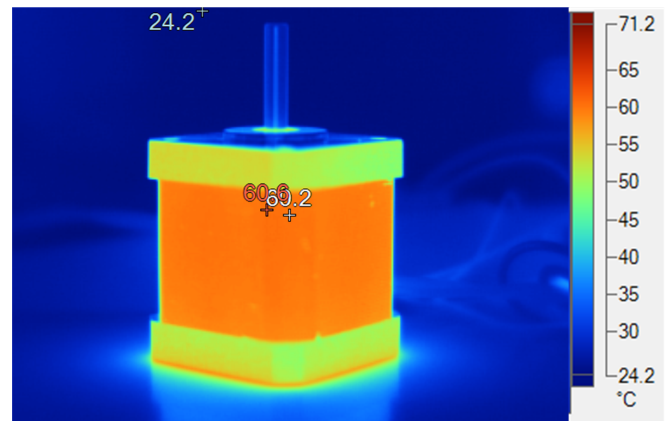


**Figure 2. Stepper current waveform running at 4,000 pulses per second using 1/4 microstepping and slow decay on increasing and decreasing steps**

In Figure 2, the high step rate causes back EMF of the motor to be significant, and slow decay is not sufficient to regulate the current during the decreasing steps. This results in excess current with respect to the desired sinusoidal profile. This excess current becomes wasted energy due to  $I^2R$  losses in the stepper windings. Figure 3 shows a thermal picture of the stepper motor running the slow-decay mode from Figure 2.



**Figure 3. Thermal image after one hour using 1/4 microstepping and slow decay on increasing and decreasing steps**



**Figure 4. Thermal image after one hour using 1/4 microstepping and dynamic decay on increasing and decreasing steps**

TI stepper drivers such as [DRV8886AT](#), [DRV8880](#), and [DRV8881](#) offer smart tuning settings to solve the problem of poorly chosen decay modes that result in poor tuning. These smart tuning current regulation schemes automatically adjust the decay modes and ripple current levels on a cycle-by-cycle basis during operation. TI's smart tuning features accommodate the changes in back EMF and current levels that occur during stepper driving. Smart tuning can also adapt the decay modes across motor supply voltages to accommodate multiple system variants. With smart tuning, the current is more tightly regulated, which wastes less energy in the motor. [Figure 4](#) shows the thermal picture of the same stepper motor using the dynamic decay setting from [Figure 1](#).

The temperature of the motor driven with dynamic decay is 11 °C lower. This indicates less wasted power due to resistive losses when using the dynamic decay setting. By using smart tuning settings like dynamic decay, system designers can increase their system efficiency and reduce thermal losses. This helps the system run cooler and more reliably overall.

**Table 1. Alternative Device Recommendations**

Device	Smart-tuning decay mode settings
<a href="#">DRV8886AT</a>	Dynamic decay and ripple control
<a href="#">DRV8881</a>	Dynamic decay
<a href="#">DRV8880</a>	Dynamic decay

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