MCST3601 – coolStep™

Introduction

One of the properties that differentiates stepper motors from other DC motors is the fact that the motor coil current is not depending on the load. That has the advantage for the user of stable and known motor behavior, since the heating of the latter is the same if the motor is stopped or if it drives high load. But this can also be considered as a drawback for low power application, when the user expects the motor consumption to be as low as possible when the load is low.
The coolStep™ feature brings a valuable solution taking advantages of the stepper motor intrinsic properties and adding the possibility to automatically decrease the current driven through the coils when the load is low.

coolStep™ operating principle

The coolStep™ feature works combined with stallGuard2™ function (see AN016). Using the back EMF, it evaluates the synchronism between the rotor and the electronic commutation:

- If the motor actuates a low load, both will be perfectly in phase.
- If the motor actuated a high load, the rotor might be slightly behind the electronics commutation. This effect is increased when the load reaches the maximal torque capability of the motor.

Thanks to this detection method, this allows minimizing the power dissipated inside the motor to the minimum required.

coolStep™ parametrization

Despite the empirical approach to use for tuning the stallGuard2™ feature, the following procedure will help you to identify faster the optimal parameters.
Before beginning coolStep™ parametrization, stallGuard2™ function has to be setup properly (see AN016).

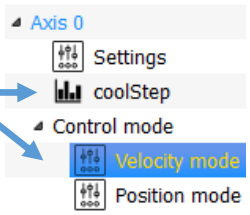
Please use the following procedure to setup coolStep™:

- Set the motor in nominal application condition. Nominal speed, current, temperature and load conditions shall be met.
- Tune coolStep™ parameters by setting the hysteresis and the current parameters, up to the automatic current adaptation point. Several iterations may be necessary.
- Increase progressively the load until the point where the current is automatically increased by the controller.
- Decrease progressively the load until the point where the current is automatically decreased by the controller.
- Check and validate the defined settings in the complete operational cycle of the application (temperature, speed, load, current).

The listed operations are fully detailed in the following points.

1. Motor nominal rotation setup

Before being able to setup coolStep™, stallGuard™ shall be fully parametrized (see AN016) and motor rotation has to be launched in the condition of the application (minimum load):



- Open the velocity mode and coolStep dialog boxes
- Setup the nominal velocity (values can be taken from shortcode)
- Click on “play” in the required direction to start rotation
- Check that the motor is rotating as expected

2. CoolStep Hysteresis setup

- During motor rotation, define Hysteresis properties from the CoolStep tab:
  - Tune Hysteresis start value to set the blue area just below the mean StallGuard value
  - Tune Hysteresis width value to define the StallGuard value range through which the current can vary
  - Set the current variation range by selecting the minimum value (½ or ¼ of the full current)
  - Set the current up/down steps speed (slow to fast)

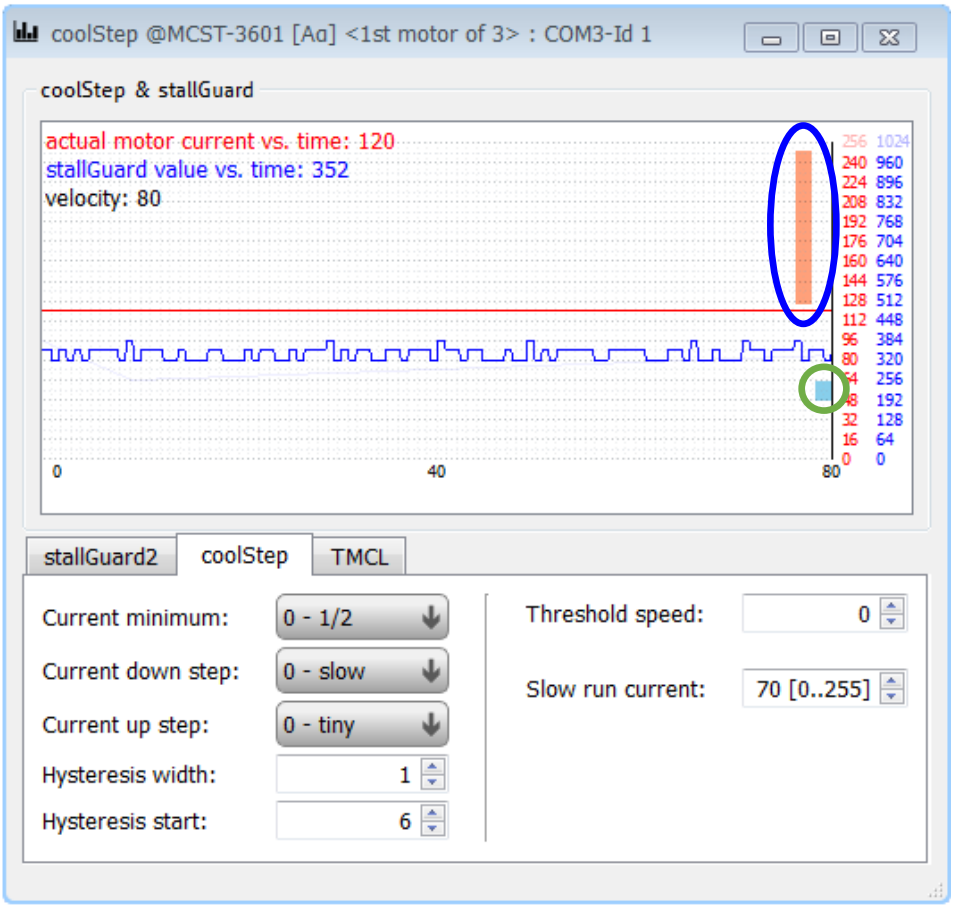


Figure 1: Hysteresis parameters setup

3. Motor load increase

- During motor rotation, increase progressively the load
- Check that when the load estimated by the StallGuard value reaches the range specified by the Hysteresis value, the current begins to increase. When the StallGuard value is below the Hysteresis range, the current shall reach its maximum value

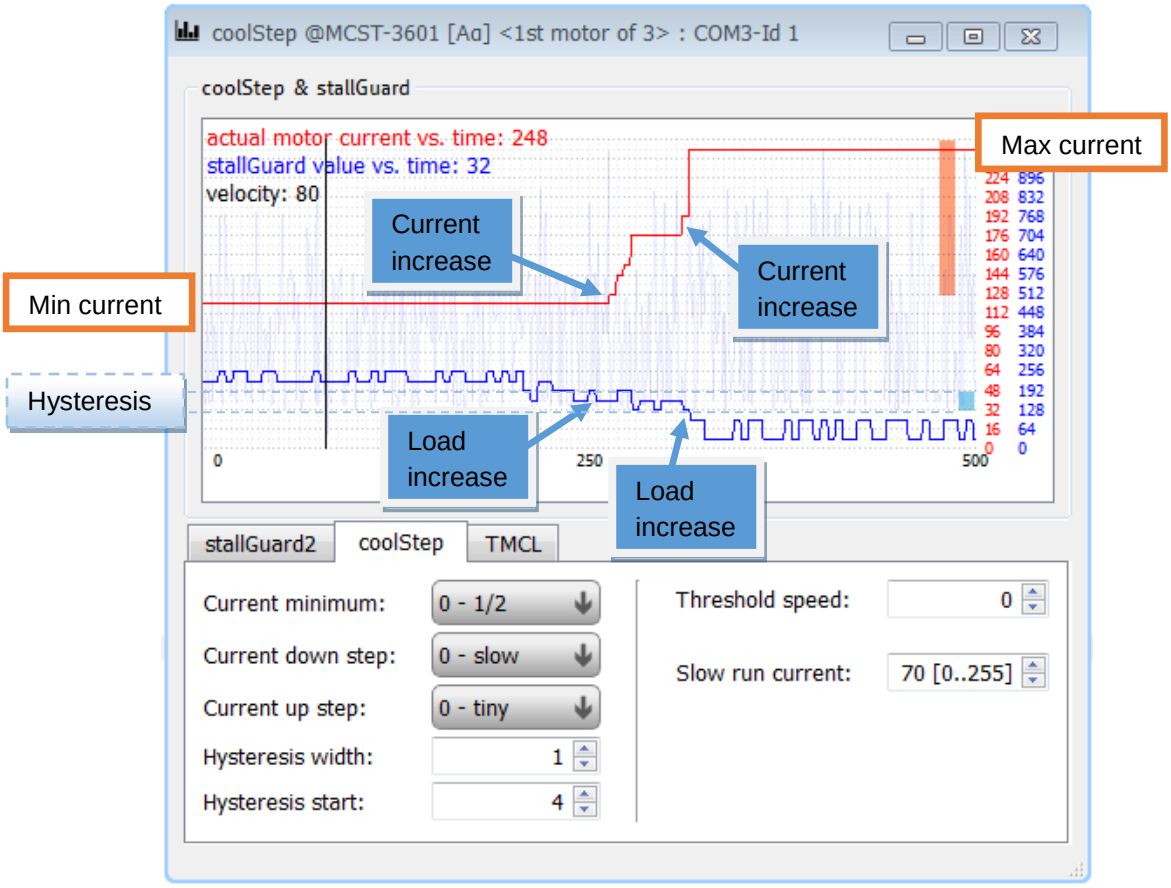


Figure 2: Load increase sequence

The example plot shows that at the first load increase step (detected by the stallGuard2™ value change), the current rises up to a first stable point (defined by the Hysteris range). When the load is increased again (up to a level that makes the stallGuard2™ value fall below the Hysteresis range), the current rises up to its maximal value.

The load values shall correspond to the expected application load range, and the user shall check that the current variations are adapted to compensate the load increase. If not, the motor would stall when the load increases.

If necessary, readjust hysteresis and current values to optimize the controller behaviour.

4. Motor load decrease

- During motor rotation with maximum load, decrease progressively the load.
- Check that when the load estimated by the stallGuard2™ value reaches the range specified by the Hysteresis value, the current begins to decrease. When the stallGuard2™ value is above the Hysteresis range, the current shall reach its minimum value

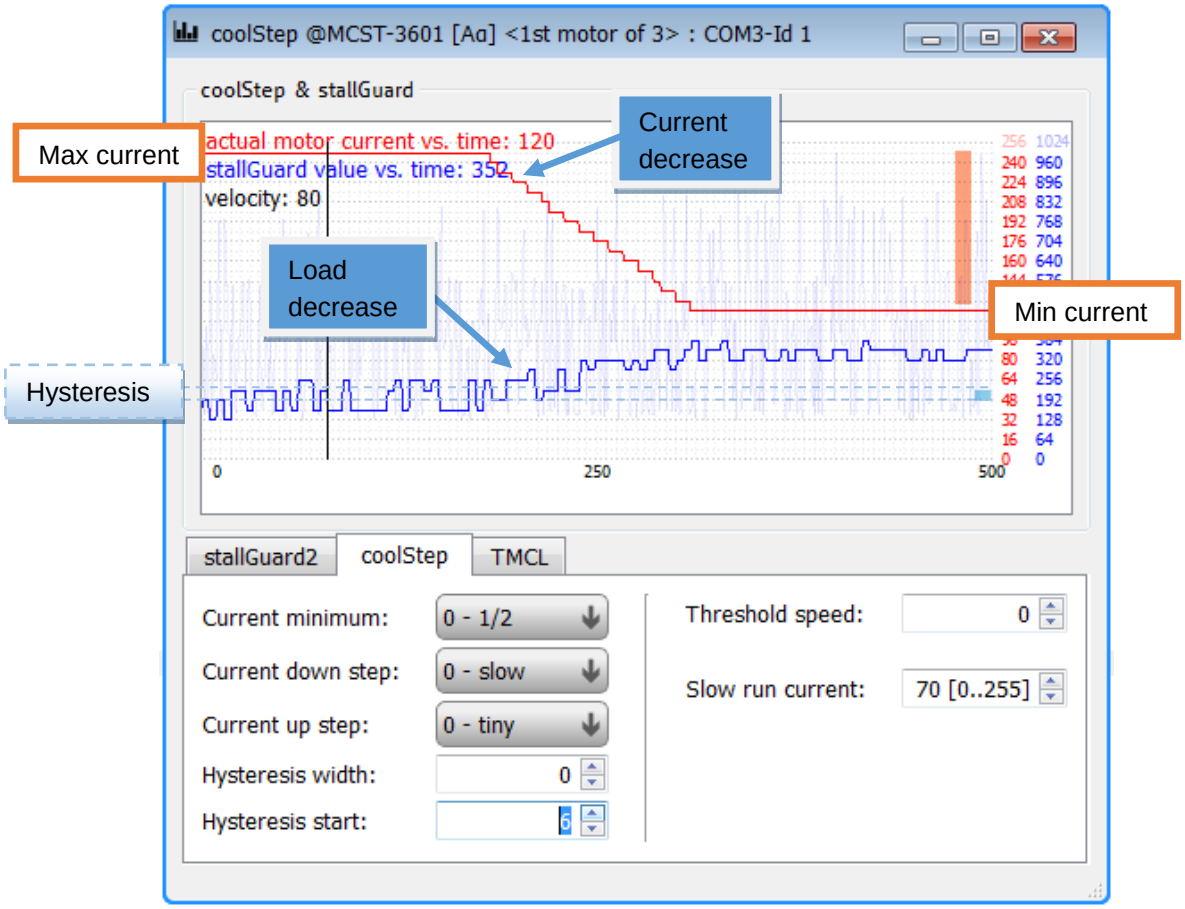


Figure 3: Load decrease sequence

The example plot shows that when the load decreases (detected by the stallGuard2™ value change), the current falls down progressively to its minimum value (defined by the Hysteris range).

The user shall check that the minimum current value is sufficient to drive the lowest load condition of the application. If not, the motor would stall when the current reaches its minimum value. For this reason, for most of the applications, it is recommanded to set the munimum current value to ½ of the full current instead of ¼ of the full current.

If necessary, readjust hysteresis and current values to optimize the controller behaviour.

5. Setup verification and validation

After the complete coolStep™ parametrization and tuning, shorts tests can be done to verify and validate that coolStep™ function is working properly. The following cases can be simulated for the validation:

- **Motor rotation through nominal load range:**
  During motor rotation, vary speed, current, acceleration, load, temperature (if possible) of the motor inside the nominal working range of the application. Check that the motor never stalls in all the situations, and that the current is properly adapted by the system.

- **Fast load variation:**
  Try to vary the load faster (but according to the realistic worst case scenario of the application), in order to check that the coolStep™ features reacts promptly enough to compensate variations.

coolStep™ function usage

The coolStep™ functions can be used through several ways, according to the user preferences and needs. When the coolStep™ parameters are defined, they can be introduced in user code.

Include coolStep™ Parameters in processor code:

When the stallGuard2™ and coolStep™ features are fully setup and validated through the dedicated interface windows, the parameters can be integrated in the processor code, using the “Copy to TMCL creator” button from TMCL tab, as illustrated by the following screenshot:

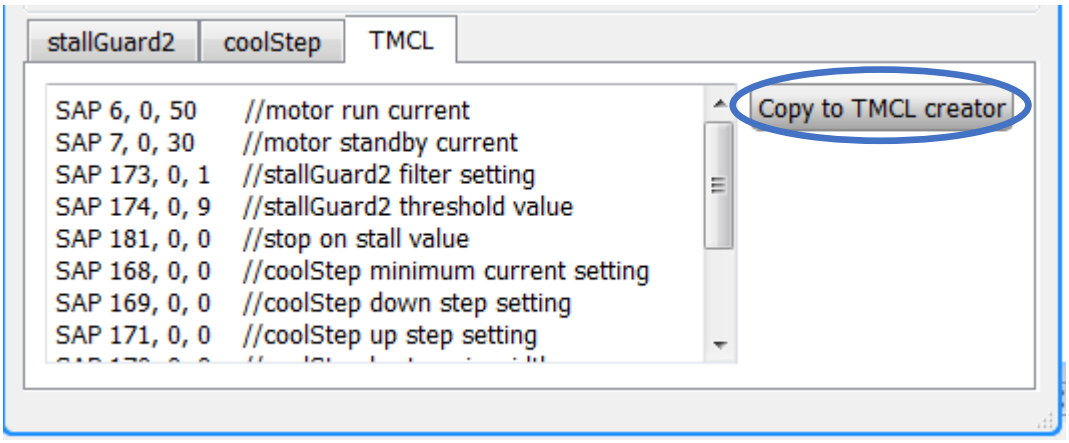


Figure 4: Copy StallGuard/CoolStep parameters to processor code

This setup code can be added at the beginning of the user program, with all the others microprocessor set-up functions.

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