Ramp Parameter Setup for TMC429

Valid for TMC429 and TMC428

This application note describes the basic setup of the ramp generator parameters for velocity and acceleration. You learn to use the electronic gear shifting of the TMC429 for both, acceleration and velocity setting in order to cover a wide dynamic range without sacrificing resolution within the ramps.

A spreadsheet guides you through all steps (TMC429_ramp_setup.xls).

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1 Setting the Velocity

The target motion velocity is the basic setting for a motion controller. Its choice depends on the application, the motor type, and its load. The choice of microstep resolution additionally influences the required pulse frequencies for a certain RPM velocity. The basic TMC429 velocity parameter is *V_MAX*. It provides a 12 bit resolution. In order to cover a wider range, an additional parameter *PULSE_DIV* works as electronic gear shifting. It provides 14 gears by setting a value between 0 and 13. Each increment of *PULSE_DIV* halves the effective velocity. This way an overall velocity range corresponding to a 26 bit setting is achieved. The gear shifting parameter *PULSE_DIV* normally remains stable within an application or at least within each motion ramp.

Step for step instruction for setting up *V_MAX* and *PULSE_DIV*:

1. Imagine *V_MAX* = 2047. This is the maximum setting for *V_MAX*. For this value, *PULSE_DIV* needs to be determined, because this velocity will act as the upper limit possible during any motion sequence. Use the step frequency formula from the datasheet (copied below) to determine the lowest setting for *PULSE_DIV* giving a step frequency equal to or above your target.

2. Now, you have determined *PULSE_DIV* in a way, that you satisfy your desired maximum system velocity with *V_MAX* as high as possible, i.e. in the range 1024 to 2047. This way, you get the best resolution for the velocity setting (*V_ACTUAL*) of at least 1024 different velocity steps when accelerating from 0 to *V_MAX*. You can now determine the exact *V_MAX*.

$$R[Hz] = \frac{f_{CLK}[HZ] * V\_MAX}{2^{PULSE\_DIV} * 2048 * 32}$$

where

R[Hz] is the desired microstep rate, i.e. 200*16*1/s when operating a 1.8° motor with 16 microsteps at 1 rotation per second.

f_{CLK}[Hz] is the frequency of the external clock source feeding the TMC429, i.e. 16MHz.

V_MAX is in range 0 to 2047.

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2 Setting up the Acceleration Phase

The procedure for setting up the acceleration phase is very similar to the procedure for the velocity setting. The choice for the acceleration setting depends on the application, the motor type, and its load, especially dynamic load (flywheel load). A higher dynamic load requires a lower acceleration. The basic parameter is the acceleration setting *A_MAX*. It provides a 12 bit resolution. In order to cover a wider range, an additional parameter *RAMP_DIV* works as electronic gear shifting for the acceleration. It provides 14 gears by setting a value between 0 and 13. Each increment of *RAMP_DIV* halves the effective acceleration. This way an effective acceleration range corresponding to a 26 bit setting is achieved. The gear shifting parameter *RAMP_DIV* normally remains stable within an application or at least within each motion ramp. While the actual velocity *V_ACTUAL* is ramped from 0 to *V_MAX* and back to 0 for each complete motion ramp, *A_ACTUAL* normally is switched on to +*A_MAX* or -*A_MAX* for acceleration or deceleration. Due to this, the choice of *RAMP_DIV* is not critical.

Step for step instruction for setting up *A_MAX* and *RAMP_DIV*:

1. As a starting point, set *RAMP_DIV* equal to *PULSE_DIV*. This will allow relatively quick acceleration ramps. Imagine *A_MAX* at a medium setting, i.e. 250. For this value, use the acceleration formula from the datasheet (copied below) to determine the number of steps for acceleration from 0 to *V_MAX*. This will give you an idea on the extent of the acceleration ramp.

2. Now, you can increase (or decrease) *PULSE_DIV* until you satisfy your desired length of the acceleration ramp. This is best tested interactively in the application. Fine tuning is possible by modifying *A_MAX*. In case you end up with *RAMP_DIV* higher than *PULSE_DIV*+2, please make sure to choose *A_MAX* in a way, that the number of acceleration steps *S* does not exceed 2 Million, because the length of the deceleration ramp is limited by 2^{21}.

$$S = \frac{1}{2} * \frac{V\_MAX^2}{A\_MAX} * \frac{2^{RAMP\_DIV}}{2^{PULSE\_DIV}} \div 2^3$$

where

        S = number of steps during the linear acceleration phase from 0 to *V_MAX*
        A_MAX = linear acceleration setting
        V_MAX = velocity setting

3 Determining the Deceleration Settings

In order to allow the TMC429 to properly calculate automatic linear ramps, it requires the additional parameters *PMUL* and *PDIV*. These parameters depend on the settings for *A_MAX*, *RAMP_DIV* and *PULSE_DIV*.

1. Choose *PMUL* and *PDIV* in a way that the formula

$$\frac{A\_MAX}{128 * 2^{RAMP\_DIV - PULSE\_DIV}} = 0.99 * \frac{PMUL}{2^{3 + PDIV}}$$

becomes satisfied. This is easily done using the spreadsheet calculation or the algorithm from the TMC429 datasheet.

Value range for *PMUL*:   128… 255
Value range for *PDIV*:   one out of {0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13}

4 Overview

1. Set *V_MAX* = 2047. Determine *PULSE_DIV* to give a step frequency equal to or above your target.

$$R[Hz] = \frac{f_{CLK}[HZ] * V\_MAX}{2^{PULSE\_DIV} * 2048 * 32}$$

2. You can now determine the exact *V_MAX* to match your desired velocity.

3. As a starting point, set *RAMP_DIV* equal to *PULSE_DIV* and *A_MAX* at a medium setting, i.e. 250. Now, use the acceleration formula to determine the number of steps for acceleration from 0 to *V_MAX*. This will give you an idea on the extent of the acceleration ramp.

$$S = \frac{1}{2} * \frac{V\_MAX^2}{A\_MAX} * \frac{2^{RAMP\_DIV}}{2^{PULSE\_DIV}} \div 2^3$$

4. Now, you can increase (or decrease) *PULSE_DIV* until you satisfy your desired length of the acceleration ramp. Fine tuning the acceleration by modifying *A_MAX*.

5. Choose *PMUL* and *PDIV* in a way that the formula

$$\frac{A\_MAX}{128 * 2^{RAMP\_DIV - PULSE\_DIV}} = 0.99 * \frac{PMUL}{2^{3+PDIV}}$$

becomes satisfied. This is easily done using the spreadsheet calculation or the algorithm from the TMC429 datasheet.

5 Disclaimer

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6 Revision History

6.1 Document Revision

Version	Date	Author	Description
		BD – Bernhard Dwersteg	
1.00	2013-MAY-30	BD	Initial version

7 References

TMC429 datasheet, www.trinamic.com
TMC429 getting started manual, www.trinamic.com