## AN4923 <br> Application note

## STSPIN220: step-mode selection and on-the-fly switching to full-step <br> Enrico Poli

## Introduction

The STSPIN220 is a stepper motor driver designed for portable applications thanks to the $3 \times 3 \mathrm{~mm}$ package and the standby consumption below 80 nA .

The integrated sequencer can provide a resolution up to 256 microsteps, but it is always possible to switch to the full-step operation on-the-fly.
This document describes how to select the step resolution and manage the switch between the microstep and full-step operation.

## Contents

1 Selecting step resolution ..... 3
2 Recommended power-up sequence and setups ..... 5
2.1 Half-step and microstepping applications ..... 6
2.2 Full-step applications ..... 7
3 Switching to full-step on-the-fly ..... 8
4 Revision history ..... 11

## 1 Selecting step resolution

The resolution of the integrated microstepping sequencer is selected through the following digital inputs:

- MODE1
- MODE2
- MODE3/STCK
- MODE4/DIR

The value of these inputs is latched at the power-up, i.e. when the supply voltage rises above the turn-on threshold $\left(\mathrm{V}_{\mathrm{Sth}(\mathrm{ON})}\right)$, or at the rising edge of the standby input (Figure 1). In both cases, the logic signals must remain asserted for a time greater than $t_{\text {MODEsu }}$ before the latching event and $\mathrm{t}_{\text {MODEho }}$ after the latching event.

Figure 1. Setting of the step resolution


After the configuration is set, the logic inputs change functionalities as listed below:

- MODE1 and MODE2 force the device to the full-step mode as described in Section 3 on page 8.
- MODE3/STCK is the step-clock input
- MODE4/DIR is the direction input

The correspondence between the MODEx logic inputs and the step resolutions is listed in Table 1.

Table 1. Step resolution configuration inputs

| Step resolution | MODE4/ DIR | MODE3/ STCK | MODE2 | MODE1 |
| :---: | :---: | :---: | :---: | :---: |
| Full-step | 0 | 0 | 0 | 0 |
| $1 / 2$ step | 0 | 1 | 0 | 1 |
| $1 / 4$ step | 1 | 0 | 1 | 0 |
| $1 / 8^{\text {th }}$ step | 0 | 1 | 1 | 1 |
|  | 1 | 1 | 0 | 1 |
| $1 / 16^{\text {th }}$ step | 1 | 1 | 1 | 1 |
| $1 / 32^{\text {nd }}$ step | 0 | 0 | 1 | 0 |
|  | 1 | 0 | $0^{(1)}$ | $0^{(1)}$ |
| $1 / 64^{\text {th }}$ step | 1 | 0 | 1 | 1 |
|  | 1 | 1 | 1 | 0 |
| $1 / 128^{\text {th }}$ step | 0 | 0 | 0 | 1 |
|  | 0 | 1 | $0^{(1)}$ | $0{ }^{(1)}$ |
| $1 / 256^{\text {th }}$ step | 0 | 0 | 1 | 1 |
|  | 0 | 1 | 1 | 0 |
|  | 1 | 0 | 0 | 1 |
|  | 1 | 1 | $0^{(1)}$ | $0^{(1)}$ |

1. Keeping the MODE1 and MODE2 inputs low after the step resolution configuration forces the full-step mode instead of the selected configuration. See Section 2.2 for the details.

## 2 Recommended power-up sequence and setups

The recommended power-up sequence is following:

1. Power-up the device applying the VS supply voltage but keeping both STBY and EN/FAULT inputs low.
2. Set the MODEx inputs according to the target step resolution (see Table 1).
3. Wait for at least $1 \mu \mathrm{~s}$ (minimum $\mathrm{t}_{\text {MODEsu }}$ time).
4. Set the STBY high. The MODEx configuration is now latched inside the device.
5. Wait for at least $100 \mu \mathrm{~s}$ (minimum $\mathrm{t}_{\text {MODEho }}$ time).
6. Enable the power stage releasing the EN/FAULT input and start the operation.

Figure 2. Recommended power-up sequence $\left(1 / 256^{\text {th }}\right.$ step case)


### 2.1 Half-step and microstepping applications

The recommended setups for the microstepping operation are shown in Figure 3; for the full-step application refer to Section 2.2.

Each setup allows operating with different step resolutions according to the MODE3/STCK and MODE4/DIR values applied during the power-up sequence:

- SETUP 1 (MODE1 = high, MODE2 = low)
- MODE3/STCK $=$ high and MODE4 $=$ low $\rightarrow 1 / 2$ step
- MODE3/STCK $=$ high and MODE4 $=$ high $\rightarrow 1 / 8^{\text {th }}$ step
- MODE3/STCK = low and MODE4 = low $\rightarrow 1 / 128^{\text {th }}$ step
- MODE3/STCK $=$ low and MODE4 $=$ high $\rightarrow 1 / 256^{\text {th }}$ step
- SETUP 2 (MODE1 = low, MODE2 = high)
- MODE3/STCK = low and MODE4 $=$ high $\rightarrow 1 / 4$ step
- MODE3/STCK = low and MODE4 = low $\rightarrow 1 / 32^{\text {nd }}$ step
- MODE3/STCK $=$ high and MODE4 $=$ high $\rightarrow 1 / 64^{\text {th }}$ step
- MODE3/STCK $=$ high and MODE4 $=$ low $\rightarrow 1 / 256^{\text {th }}$ step
- SETUP 3 (MODE1 = high, MODE2 = high)
- MODE3/STCK $=$ high and MODE4 $=$ low $\rightarrow 1 / 8^{\text {th }}$ step
- MODE3/STCK $=$ high and MODE4 $=$ high $\rightarrow 1 / 16^{\text {th }}$ step
- MODE3/STCK = low and MODE4 $=$ high $\rightarrow 1 / 64^{\text {th }}$ step
- MODE3/STCK = low and MODE4 = low $\rightarrow 1 / 256^{\text {th }}$ step

Figure 3. Recommended setups for microstepping applications


### 2.2 Full-step applications

If the device is used in an application only requiring the full-step operation, the MODE1 and MODE2 inputs can be shorted to ground.

In this way, whatever are the values of the MODE3/STCK and MODE4/DIR during the power-up sequence, the device always operates in the full-step.

Figure 4. Recommended setup for full-step applications


## 3 Switching to full-step on-the-fly

The STSPIN220 device has the possibility to switch to the full-step resolution on-the-fly forcing low both the MODE1 and MODE2 inputs. Thanks to this feature, the application can take all the advantages of a high resolution microstepping (smoothness and precision) at low speeds without incurring in the respective limitations when the high speed operation is required (lower torque and high step-clock frequency).

Switching from the microstepping to the full-step:

- The counter of the sequencer is increased of one full-step at each STCK rising edge
- The target current is increased up to the peak value ( $\left.\mathrm{I}_{\text {peak }}=\mathrm{V}_{\mathrm{REF}} / \mathrm{R}_{\text {sense }}\right)$

In order to make the switching between the microstepping and full-step operation smoother and safer possible, synchronization with the microstepping sequence is required. The switching between the two modes should be performed when the electrical position is a multiple of $45^{\circ}$, i.e. when the phase currents of the stepper motor are equal in the module (see from Figure 5 to Figure 8). This way, even if the current increases from $I_{\text {peak }} / \sqrt{ } 2$ to $I_{\text {peak }}$, the electrical and mechanical positions are unchanged. Table 2 lists the number of STCK pulses required to reach the recommended switching position starting from the reset state.

Table 2. Number of STCK pulses required to reach $45^{\circ}$ position from the reset position

| $\mathbf{1} / \mathbf{2}^{\text {step }}$ | $\mathbf{1}_{\mathbf{4}} \boldsymbol{\text { step }}$ | $\mathbf{1 / 8}^{\text {th }}$ step | $\mathbf{1 / 1 6}^{\text {th }}$ step | $\mathbf{1 / 3 2}^{\text {nd }}$ step | $\mathbf{1 / 6 4}^{\text {th }} \boldsymbol{s t e p}$ | $\mathbf{1 / 1 2 8}^{\text {th }}$ step | $\mathbf{1 / 2 5 6}^{\text {th }}$ step |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 1 | 2 | 4 | 8 | 16 | 32 | 64 | 128 |
| 3 | 6 | 12 | 24 | 48 | 96 | 192 | 384 |
| 5 | 10 | 20 | 40 | 80 | 160 | 320 | 640 |
| 7 | 14 | 28 | 56 | 112 | 224 | 448 | 896 |

Figure 5. Switching to full-step ( $1 / 8^{\text {th }}$ step microstepping)


Figure 6. Switching back to microstepping (1/8 ${ }^{\text {th }}$ step microstepping)


Figure 7. Switching to full-step ( $1 / 64^{\text {th }}$ step microstepping)


Figure 8. Switching back to microstepping (1/64 ${ }^{\text {th }}$ step microstepping)


## 4 Revision history

Table 3. Document revision history

| Date | Revision | Changes |
| :---: | :---: | :--- |
| 18-Oct-2016 | 1 | Initial release. |

## IMPORTANT NOTICE - PLEASE READ CAREFULLY

STMicroelectronics NV and its subsidiaries ("ST") reserve the right to make changes, corrections, enhancements, modifications, and improvements to ST products and/or to this document at any time without notice. Purchasers should obtain the latest relevant information on ST products before placing orders. ST products are sold pursuant to ST's terms and conditions of sale in place at the time of order acknowledgement.

Purchasers are solely responsible for the choice, selection, and use of ST products and ST assumes no liability for application assistance or the design of Purchasers' products.

No license, express or implied, to any intellectual property right is granted by ST herein.

Resale of ST products with provisions different from the information set forth herein shall void any warranty granted by ST for such product.

ST and the ST logo are trademarks of ST. All other product or service names are the property of their respective owners.

Information in this document supersedes and replaces information previously supplied in any prior versions of this document.

$$
\text { © } 2016 \text { STMicroelectronics - All rights reserved }
$$

