Introduction

The STSPIN220 is a stepper motor driver designed for portable applications thanks to the 3 x 3 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.
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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 \( V_{\text{Sth(ON)}} \), 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 \( t_{\text{MODEho}} \) after the latching event.

![Figure 1. Setting of the step resolution](image)

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

<table>
<thead>
<tr>
<th>Step resolution</th>
<th>MODE4/ DIR</th>
<th>MODE3/ STCK</th>
<th>MODE2</th>
<th>MODE1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full-step</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>½ step</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>¼ step</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>1/8th step</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>1/16th step</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>1/32nd step</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>1/64th step</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>1/128th step</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>1/256th step</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

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 µs (minimum $t_{\text{MODEsu}}$ time).
4. Set the STBY high. The MODEx configuration is now latched inside the device.
5. Wait for at least 100 µs (minimum $t_{\text{MODEho}}$ time).
6. Enable the power stage releasing the EN/FAULT input and start the operation.

Figure 2. Recommended power-up sequence (1/256th 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 → ½ step
  - MODE3/STCK = high and MODE4 = high → 1/8th step
  - MODE3/STCK = low and MODE4 = low → 1/128th step
  - MODE3/STCK = low and MODE4 = high → 1/256th step

- **SETUP 2** (MODE1 = low, MODE2 = high)
  - MODE3/STCK = low and MODE4 = high → ¼ step
  - MODE3/STCK = low and MODE4 = low → 1/32nd step
  - MODE3/STCK = high and MODE4 = high → 1/64th step
  - MODE3/STCK = high and MODE4 = low → 1/256th step

- **SETUP 3** (MODE1 = high, MODE2 = high)
  - MODE3/STCK = high and MODE4 = low → 1/8th step
  - MODE3/STCK = high and MODE4 = high → 1/16th step
  - MODE3/STCK = low and MODE4 = high → 1/64th step
  - MODE3/STCK = low and MODE4 = low → 1/256th step

![Figure 3. Recommended setups for microstepping applications](image.png)

**NOTE:** VDD is the logic supply voltage
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 ($I_{\text{peak}} = \frac{V_{\text{REF}}}{R_{\text{sense}}}$)

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°, 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>
<thead>
<tr>
<th>½ step</th>
<th>¼ step</th>
<th>1/8th step</th>
<th>1/16th step</th>
<th>1/32nd step</th>
<th>1/64th step</th>
<th>1/128th step</th>
<th>1/256th step</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>4</td>
<td>8</td>
<td>16</td>
<td>32</td>
<td>64</td>
<td>128</td>
</tr>
<tr>
<td>3</td>
<td>6</td>
<td>12</td>
<td>24</td>
<td>48</td>
<td>96</td>
<td>192</td>
<td>384</td>
</tr>
<tr>
<td>5</td>
<td>10</td>
<td>20</td>
<td>40</td>
<td>80</td>
<td>160</td>
<td>320</td>
<td>640</td>
</tr>
<tr>
<td>7</td>
<td>14</td>
<td>28</td>
<td>56</td>
<td>112</td>
<td>224</td>
<td>448</td>
<td>896</td>
</tr>
</tbody>
</table>

Table 2. Number of STCK pulses required to reach 45° position from the reset position
Figure 5. Switching to full-step (1/8th step microstepping)

Figure 6. Switching back to microstepping (1/8th step microstepping)
Switching to full-step on-the-fly

Figure 7. Switching to full-step (1/64th step microstepping)

Figure 8. Switching back to microstepping (1/64th step microstepping)
4 Revision history

Table 3. Document revision history

<table>
<thead>
<tr>
<th>Date</th>
<th>Revision</th>
<th>Changes</th>
</tr>
</thead>
<tbody>
<tr>
<td>18-Oct-2016</td>
<td>1</td>
<td>Initial release.</td>
</tr>
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</table>
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