TIDA-00736 Universal Stepper Motor Driver

Design Overview

This design achieves a universal high performance stepper driver which is capable of up to 1/256 micro stepping and 0.5A to 5A, 12V to 36V wide operation range. This solution can ideally work with most bipolar steppers and diversified industrial applications.

Design Resources

- **TIDA-00736** Design Folder
- **DRV8711** Product Folder
- **MSP430G2202** Product Folder
- **TLV70433** Product Folder
- **CSD18531Q5A** Product Folder

Design Features

- Wide and selectable current level from 0.5A to 5A
- Selectable micro-stepping from Full to 1/256
- Wide operation range from 12V to 36V
- Wide adaption to different stepper motors
- Standard ISO industrial inputs interface
- Full protections

Featured Applications

- Factory automation
- Textile industry
- CNC equipment
- Machine tools
- Robots

1. Introduction

This design achieves a universal high performance stepper driver. With the on-board MCU SPI configuration to DRV8711, it achieves up to 1/256 selectable micro-stepping level and 0.5A to 5A selectable peak current level. The supply voltage can be from 12V to 36V. With optimized decay parameters setting, this solution can ideally work with most bipolar steppers and diversified industrial
applications. Optocoupler isolation for inputs signal is included. Also full protections are provided, such as outputs short, over current, and over temperature.

2. Hardware Block Diagram

As shown in figure 1, a low cost MCU MSP430G2202 is used as a dedicated configuration device for DRV8711. The 5V LDO of DRV8711 is fully utilized for the power supply of the MCU and ISO devices. The output MOSFET CSD18531Q5A has very low RDSON down to 4.6 mohm which is able to driving high current with only on-board copper dissipation. An 8-position bit switch is used to change the micro-stepping mode and current level.

![Figure 1. Hardware block diagram](image)

3. Parameters and Settings

To give the best current regulation and driving performance, the parameters of DRV8711 are optimized with lot of tests on most commonly used bipolar steppers. The following parameters are recommended for DRV8711 for most stepper and its applications. For more info about decay mode and settings, we can check the datasheet of DRV8711 and the following application notes.


<table>
<thead>
<tr>
<th>Items</th>
<th>Example Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DTIME</td>
<td>400ns</td>
<td></td>
</tr>
<tr>
<td>ISGAIN</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>MODE</td>
<td>-</td>
<td>Set as needed</td>
</tr>
<tr>
<td>TORQUE</td>
<td>-</td>
<td>Set as needed</td>
</tr>
</tbody>
</table>
The on-board bit switch is configured as below table. ('X' means arbitrary)

<table>
<thead>
<tr>
<th>Bit switch states [BIT7~BIT0]</th>
<th>Micro-Stepping mode</th>
<th>Current level (PEAK, RMS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>xxxx 0000</td>
<td>Full</td>
<td></td>
</tr>
<tr>
<td>xxxx 0001</td>
<td>1/2</td>
<td></td>
</tr>
<tr>
<td>xxxx 0010</td>
<td>1/4</td>
<td></td>
</tr>
<tr>
<td>xxxx 0011</td>
<td>1/8</td>
<td></td>
</tr>
<tr>
<td>xxxx 0100</td>
<td>1/16</td>
<td></td>
</tr>
<tr>
<td>xxxx 0101</td>
<td>1/32</td>
<td></td>
</tr>
<tr>
<td>xxxx 0110</td>
<td>1/64</td>
<td></td>
</tr>
<tr>
<td>xxxx 0111</td>
<td>1/128</td>
<td></td>
</tr>
<tr>
<td>xxxx 1000</td>
<td>1/256</td>
<td></td>
</tr>
<tr>
<td>0001 xxxx</td>
<td></td>
<td>1.4A, 1.0A</td>
</tr>
<tr>
<td>0010 xxxx</td>
<td></td>
<td>2.1A, 1.5A</td>
</tr>
<tr>
<td>0011 xxxx</td>
<td></td>
<td>2.8A, 2.0A</td>
</tr>
<tr>
<td>0100 xxxx</td>
<td></td>
<td>3.5A, 2.5A</td>
</tr>
<tr>
<td>0101 xxxx</td>
<td></td>
<td>4.2A, 3.0A</td>
</tr>
<tr>
<td>0110 xxxx</td>
<td></td>
<td>4.9A, 3.5A</td>
</tr>
<tr>
<td>0111 xxxx</td>
<td></td>
<td>5.7A, 4.0A</td>
</tr>
</tbody>
</table>

4. Software Flow Chart

Figure 2 shows the basic flow chart of the MSP430G2202. The MCU reads the bit switch status all the time and updates the registers of DRV8711 online when it is changed. In this reference design, the SPI function is achieved by GPIO and running at ~250 kHz clock frequency. So any low cost MCU with basic GPIO functions can finish the task properly.
5. **Lab Test Data**

As shown in the following picture, two different current/power level steppers were used to generate the test waveforms.

Figure 4 to figure 12 shows the phase current waveforms at different micro-stepping mode of motor #1. Figure 13 to figure 21 shows the current waveforms with motor #2. Figure 22 to figure 24 shows the waveforms changing online with the bit switch changing. 24V VM supply is used. (Green: Phase current; yellow: STEP input)
Figure 4. Motor #1 Peak 2A (RMS 1.43A) at Full step

Figure 5. Motor #1 Peak 2A (RMS 1.43A) at Half step
Figure 6. Motor #1 Peak 2A(RMS1.43A) at 1/4 micro-stepping

Figure 7. Motor #1 Peak 2A(RMS1.43A) at 1/8 micro-stepping
Figure 8. Motor #1 Peak 2A(RMS1.43A) at 1/16 micro-stepping

Figure 9. Motor #1 Peak 2A(RMS1.43A) at 1/32 micro-stepping
Figure 10. Motor #1 Peak 2A(RMS1.43A) at 1/64 micro-stepping

Figure 11. Motor #1 Peak 2A(RMS1.43A) at 1/128 micro-stepping
Figure 12. Motor #1 Peak 2A (RMS 1.43A) at 1/256 micro-stepping

Figure 13. Motor #2 Peak 4.5A (RMS 3.2A) at Full step
Figure 14. Motor #2 Peak 4.5A(RMS3.2A) at Half step

Figure 15. Motor #2 Peak 4.5A(RMS3.2A) at 1/4 micro-stepping
Figure 16. Motor #2 Peak 4.5A (RMS 3.2A) at 1/8 micro-stepping

Figure 17. Motor #2 Peak 4.5A (RMS 3.2A) at 1/16 micro-stepping
Figure 18. Motor #2 Peak 4.5A (RMS 3.2A) at 1/32 micro-stepping

Figure 19. Motor #2 Peak 4.5A (RMS 3.2A) at 1/64 micro-stepping
Figure 20. Motor #2 Peak 4.5A (RMS 3.2A) at 1/128 micro-stepping

Figure 21. Motor #2 Peak 4.5A (RMS 3.2A) at 1/256 micro-stepping
Figure 22. Motor #2 online change from Full to 1/16 micro-stepping

Figure 23. Motor #2 online change from 1/16 to 1/128 micro-stepping
Figure 24. Motor #2 online current level changing
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