Application Report
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Achieving Changeable Holding Current of a DRV88x Stepper Motor Driver

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ABSTRACT

This document is provided as a supplement to the DRV88x stepper motor drivers using external V_{REF} to realize output current control (DRV8818, DRV8812, DRV8813, DRV8821, DRV8823, DRV8824, DRV8825, DRV8828, and DRV8829; hereafter in this document referred to as DRV88x). The application report details a method to provide the changeable holding current function for a stepper motor.

Contents

Figures

1 Introduction

In some applications, stepper motors are expected to stop at a particular position and hold that position until the next step input. To ensure the position is not moved, the holding torque should be stronger than the load. For those stepper motors whose mechanical holding function can't provide enough holding torque when facing heavy loads, extra holding current is necessary. This is called electric holding. Also, stepper motors can only be locked at a mechanical stepping angle (electric full step) when no current flows through windings during the holding state. For applications expecting to stop and restart at same position, electric holding is an ideal solution.

When performing electric holding, the stepper motor is still powered on in the holding state, there is a big current flowing through the windings. When the stepper motor stops, all the current turns into heat in the motor windings. Although a large holding current can generate enough torque to hold the load, it also produces high heat in the motor windings. In fact, the minimum current needed to hold the load is smaller than the current above. It is necessary to cut down the holding current to decrease the dissipation and meanwhile keep enough holding torque. So in a practical application, changeable holding current is preferred. For chips using external V_{REF} to realize output current (DRV8818, DRV8812, DRV8813, DRV8821, DRV8823, DRV8824, DRV8825, DRV8828, and DRV8829), the current of the motor windings is set by the external V_{REF} pin, and the holding current can be changed using an external circuit.

2 Current Regulation Principle

The current regulation of DRV88x chips is achieved by the external V_{REF}. Figure 1 depicts the typical analog block utilized to sample current information and disable the H-bridge accordingly.

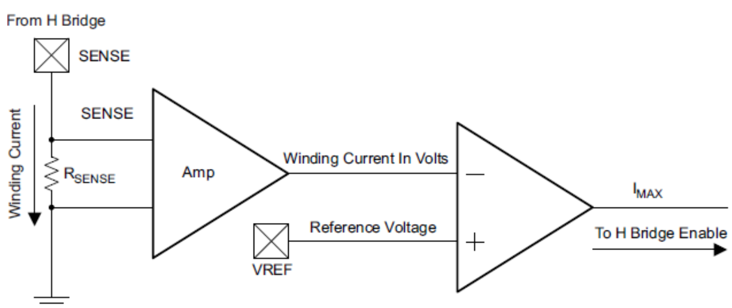

Figure 1. Current Regulation Analog Block

The current regulation block continuously monitors motor winding current by sampling the voltage across the SENSE resistor which is proportional with the winding current. The voltage is amplified and then compared against the reference voltage. When the amplified SENSE resistor voltage is greater than the reference voltage, this signifies winding current is larger than the target current. Then, the device’s logic disables the H-bridge and allows the current to decay through the internal structure. This process is repeated on a continuous basis thus obtaining a regulated current output.

The typical regulated current (I_{TRIP}) is in the form of:

$$I_{TRIP} = \frac{V_{REF}}{GAIN \times R_{SENSE}} \quad (1)$$

Where:

I_{TRIP} - the current regulation set point

V_{REF} - the analog reference voltage at the device’s V_{REF} input

GAIN - the internal amplifier gain

R_{SENSE} - the SENSE resistor in Ohms

3 Changeable Holding Current Circuit

The circuit in Figure 2 can realize changeable holding current function by using the CD74HC123. The CD74HC123 is a dual, retriggerable, monostable multivibrator, with reset. In this application, the input STEP comes from the step signal of the motor driver ICs, such as DRV8818. The output V_{REF} is applied to the V_{REF} pin of the motor driver ICs to achieve changeable holding current.

According to the principle of CD74HC123, when a pulse is applied to pin 1, there is a high output on pin 13, with a pulse width of $0.45\ R_X \times C_X$ starting at the falling edge of the signal on pin 1. When the signal frequency on pin 1 is bigger than $1 / (0.45\ R_X \times C_X)$, the high level on pin 13 maintains all the time. Figure 3 shows that by this time, the voltage on pin 13 stays high (Vcc), through a potential-divider network, an R4 × Vcc / (R4 + R2 // R3) output voltage is applied to the V_{REF} pin of the motor driver IC.

When the stepper motor is in holding state, there will be no pulse on the STEP, the level on pin 1 will be low so the output voltage on pin 13 will be driven low (GND), hence the V_{REF} voltage becomes Vcc × (R2 // R4) / (R2 // R4 + R3), as shown in Figure 4. In this way, the holding current of the stepper motor can be set by choosing suitable resistors.

So the V_{REF} can be automatically changed when the stepper motor enters into holding state. Note: to get a good performance of normal operation, adjust the value of R_X and C_X based on a target STEP signal to achieve a constant high level on pin 13 when the stepper motor is in normal operation.

For example, if the frequency of the step signal is 1/15 Hz, that is, there are only four steps in one minute, then $1/15 > 1 / (0.45\ R_X \times C_X)$, so $R_X \times C_X$ must be larger than 33.3, so 10M can be selected for R_X, 10 µF can be selected for C_X.

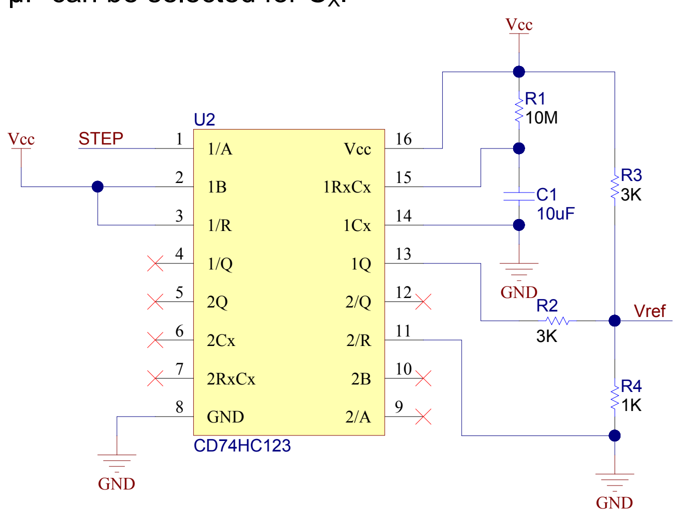

Figure 2. Changeable Holding Current Circuit

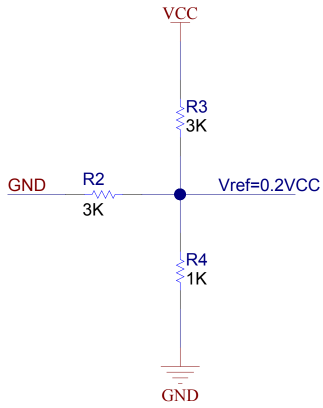

Figure 3. Output of Normal Operation

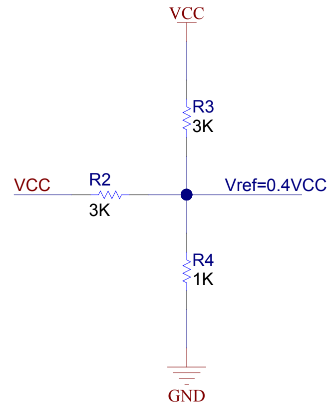

Figure 4. Output of Holding State

4 Application Example Based on DRV8818

This example is a total solution of a stepper motor with changeable holding current function using the DRV8818. When the stepper is in normal operation, the V_{REF} of DRV8818 is about 2 V, when the stepper enters into the holding state, the V_{REF} automatically drops down to 1 V. Figure 5 and Figure 6 show the test results.

Figure 5 and Figure 6 are the V_{REF} and STEP waveforms of two-operation state, Figure 5 is a normal operation waveform and Figure 6 is the holding-state waveform. It can be found that V_{REF} is cut down to half in holding state compared to the normal operation.

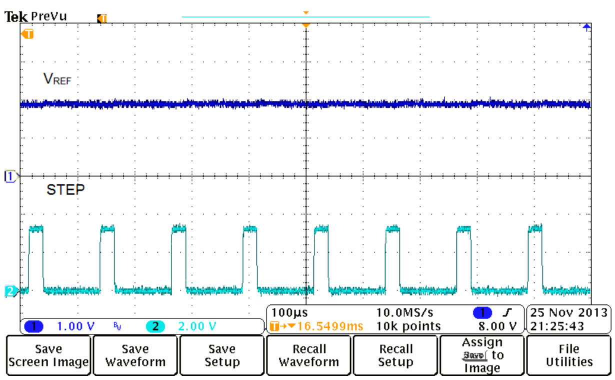

Figure 5. Normal Operation Waveform

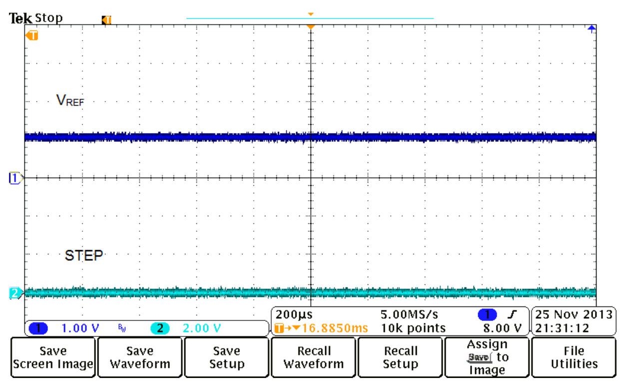

Figure 6. Holding State Waveform

Figure 7 shows the detailed schematic of the application example.

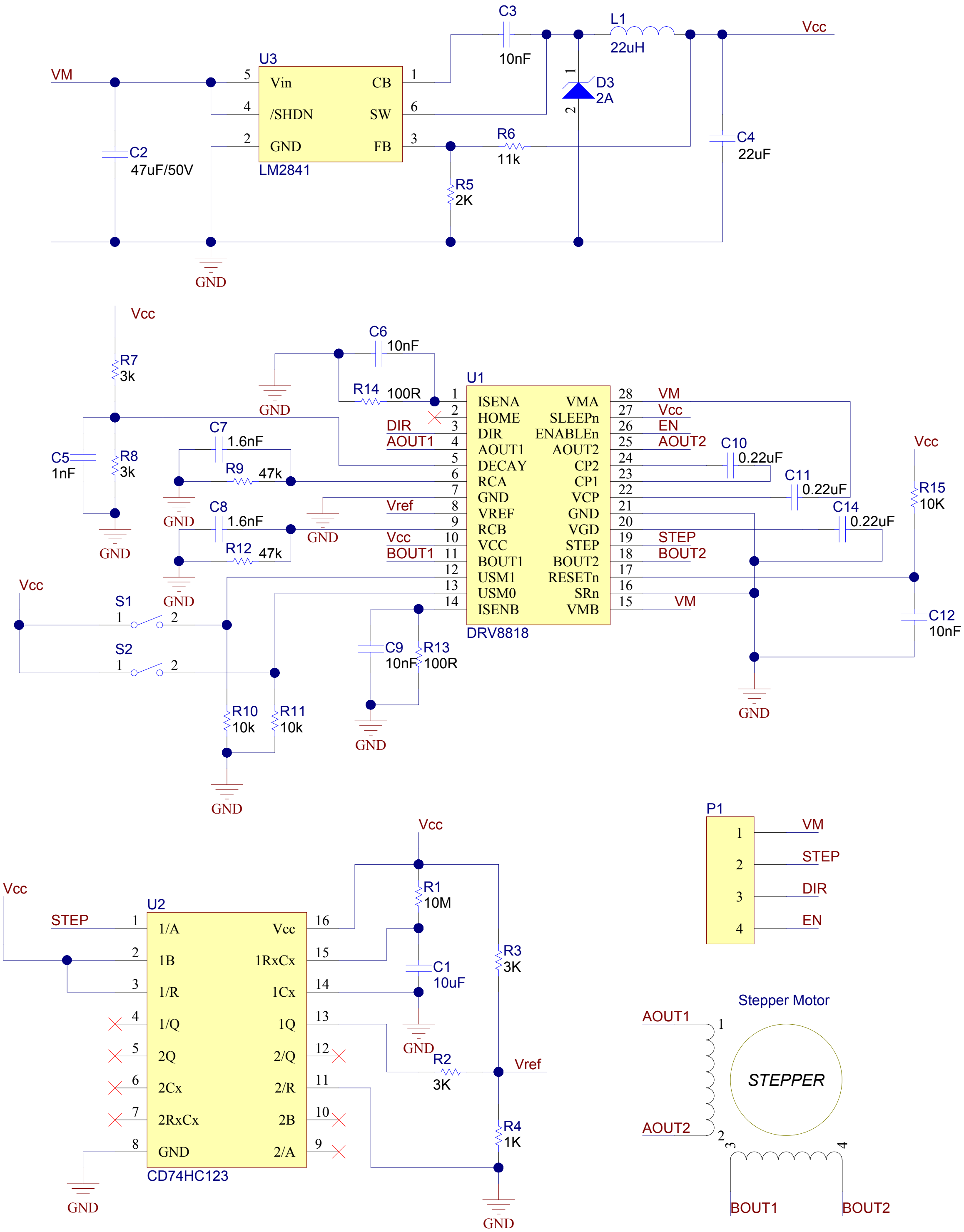

Figure 7. Schematic Application Example Based on DRV8818