AND8372/D

Current Range Switching using AMIS-3052x/ NCV7052x

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APPLICATION NOTE

Introduction

The AMIS–3052x/NCV7052x is a free programmable stepper motor driver operated by SPI. The device allows setting of several parameters, one of which is the motor peak current. Up to 32 different current values (from 30 mA to 1600 mA) can be selected.

In some applications, the user may be willing to reprogram the peak current during operation. For instance, a higher current can be applied during motion (*run current* or I_{RUN}), while after the motor is stopped, a significantly lower current (*hold current* or I_{HOLD}) might be sufficient to keep it at its final position. Because of the motor coils' inductance, care must be taken to avoid false failure detection when a relevant current reduction is needed.

This document explains how the current measurements are performed by the 52x and describes how peak current change can properly be managed.

Current Sensing: Hardware Description

A simplified diagram of the 52x H–bridge and current sensing circuitry is presented in **Figure 1**. The current sensing is performed internally, by measuring the voltage over the low side MOSFETs while they are in "ON" state. This measurement is used by a PWM current regulator. The pwm regulator is switching off the coil at the moment the *setpoint current* is reached. To achieve proper current regulation and overcurrent detection, accuracy in measurements is needed.

Since the 52x is capable to drive high output currents, the minimum *channel resistance* $R_{DS(on)}$ is kept low in order to reduce power dissipation in the device. At the other hand, when operating at low current levels, higher $R_{DS(on)}$ is used, in order to increase feedback signal amplitude, thus improving *signal to noise* (S/R) ratio.

In the 52x, the total low side channel resistance $R_{DS(on)LS}$ is dependent to the current setting. The selectable current settings are grouped in four *current ranges* (**Table 1**).

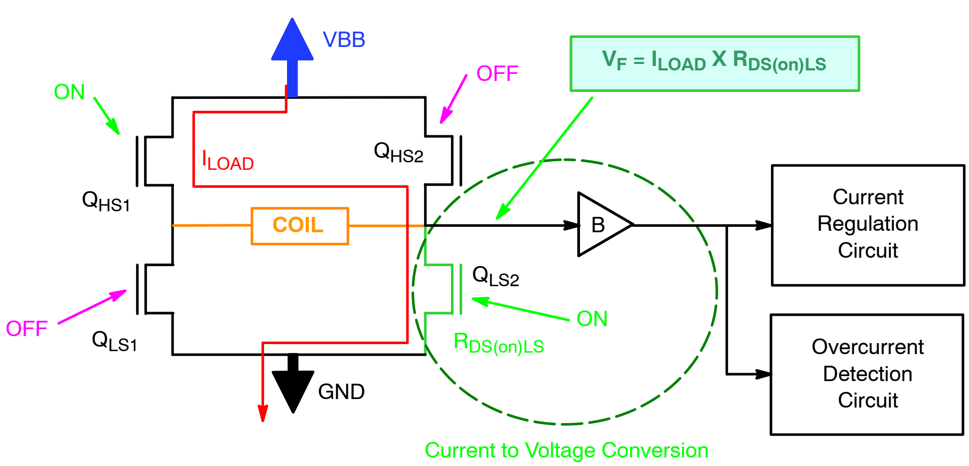

Figure 1. Current Measurement Performed by AMIS–3052x/NCV7052x on One of the Two Stator Windings

Table 1. ADAPTED $R_{DS(on)LS}$ TO CURRENT RANGES

Current Range	I_{RANGE} [mA]	$R_{DS(on)LS}$ [Ω] (TYPICAL VALUE)
(0)	30 .. 160	10
(1)	180 .. 325	5
(2)	365 .. 650	2.5
(3)	725 .. 1600	1.25

Coil Current Waveform and Voltage Feedback

Coil current is internally measured by means of the voltage drop over the low side MOSFETs:

$$V_F = I_{COIL} \times R_{DS(on)LS} \qquad \text{(eq. 1)}$$

Equation 1 shows Coil current feedback inside the 52x.

Due to the different $R_{DS(on)LS}$ values used in the 52x, any peak current reduction has to follow a special scheme to prevent false *overcurrent* detection.

To do so, $\mathbf{V_F}$ must always stay below the *overcurrent threshold voltage* $\mathbf{V_{Fth}}$, which is around **2.2 V**.

Figure 2 presents the coil current (as seen in the low side MOSFET) and the related feedback voltage, when a change to a lower level is commanded. Because of the motor coils' inductance, the current cannot instantaneously follow the new set point and a decaying phase is seen. This means a certain *settling time* has to elapse before current reaches the new value.

In particular, the slope of the decaying phase is characterized by a time constant $\boldsymbol{\tau = L / R}$, where L is the motor coil inductance and R is the total path resistance (MOSFETs' channel resistance + coil resistance). The coil current reaches the new commanded level in four or five time constants at most.

Peak Current Change: Suggested Scheme

The $\mathbf{R_{DS(on)LS}}$ value is increased when switching to lower current ranges. As a consequence of the current decay, a step in $\mathbf{V_F}$ will occur. Such a step can eventually trigger a fake over current condition, if the current range switching scheme shown in Figure 3 is not respected.

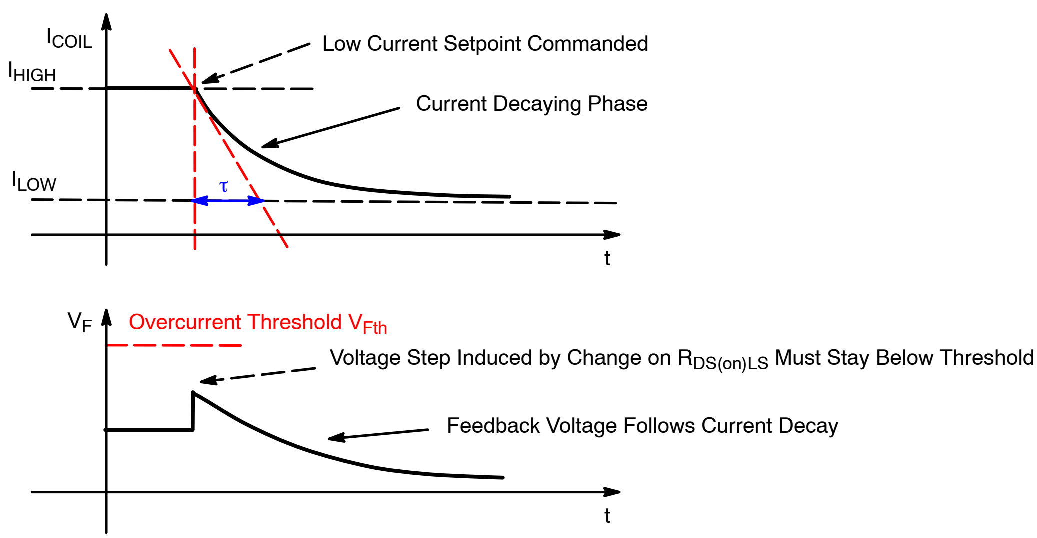

Figure 2. Coil Current Decay when Low Levels are Commanded

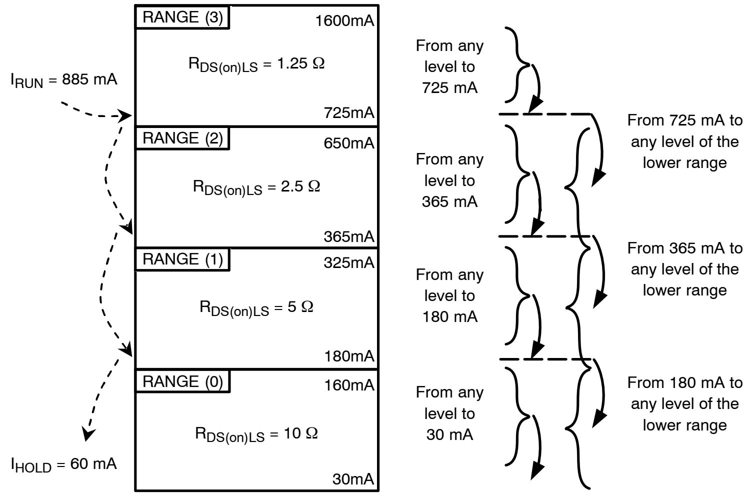

Figure 3. Suggested Current Level Switching with the 52x*

In the above picture, the text and arrows on the right depict the general rule, while the dotted arrows show an example, in which a current level change from $\mathbf{I_{RUN}}$ **= 885 mA** to $\mathbf{I_{HOLD}}$ **= 60 mA** is desired*:

1. I_{RUN} = 885 mA → I_{RUN_INT1} = 725 mA (RANGE 3);
2. I_{RUN_INT1} → I_{RUN_INT2} = 365 mA (RANGE 2);
3. I_{RUN_INT2} → I_{RUN_INT3} = 180 mA (RANGE 1);
4. I_{RUN_INT3} → I_{HOLD} = 60 mA (RANGE 0).

Referring to the scheme in **Figure 3**, it is advised to wait a minimum time of *three time constants* **τ** after each current setpoint change, before jumping to any succesive step. This allows current regulation to stabilize to a low enough level, preventing feedback voltage to rise over the threshold.

References

1. “Stepping Motor Physics”: Part 2 of “Stepping Motors” by Douglas W. Jones
2. Datasheet AMIS−30521/NCV70521 & AMIS−30522/NCV70522 products, http://www.onsemi.com

*The current levels shown are given as an example. Please refer to the latest datasheet revision for actual values.

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