

Output Current Sensing

for the MC35XS3400 eXtreme Switch Device

1 Introduction

This application note relates to the output current sensing of 3rd generation Quad 35 mΩ device.

This application note presents the current sensing accuracy and the practical implementation of a calibration procedure to improve it.

Contents

1 Introduction	1
2 Scope	2
3 Selectable Current Sensing Overview	3
4 Calibration Practice	4
5 MCU Current Sense Monitoring	6
5.1 Current Sense Response Time	6
5.2 Synchronization of MCU Analog-to-Digital Conversion	7

3 Selectable Current Sensing Overview

The current sensing ratio can be adjusted according to the intended lamp wattage and operation mode. For example, the CSR0 and CSR1 ratios can be used to monitor the lamp current respectively during the steady state and in the inrush phase.

[Figure 2](#) presents the appropriate current sense ratio.

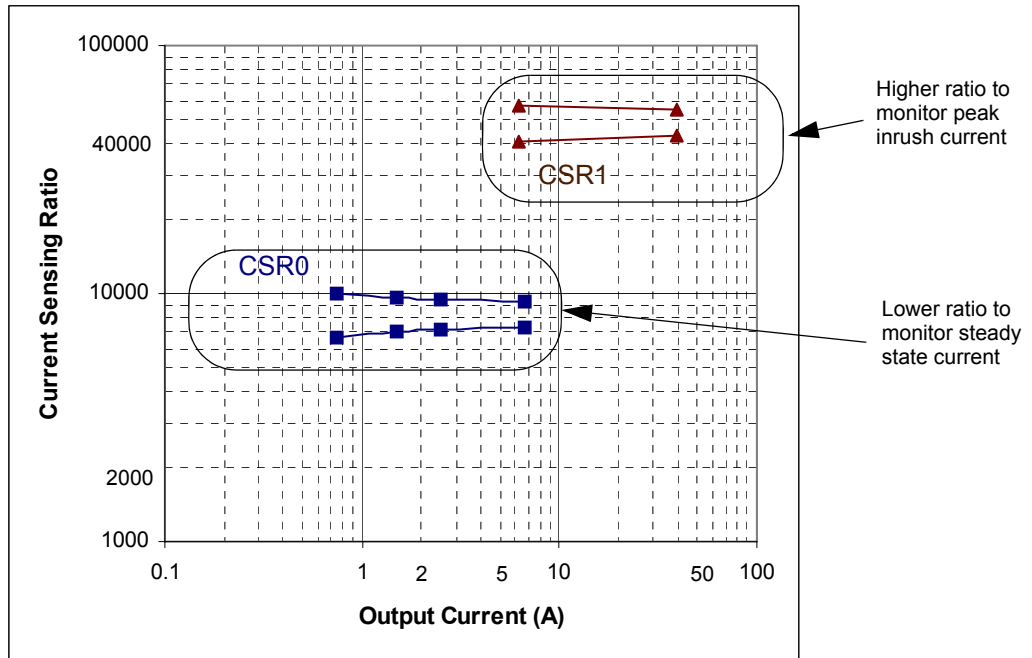


Figure 2. Current Sense Ratio in Function to Output Current Range

[Figure 3](#) describes the accuracy of the current sense as a function of the output current for the ambient temperature range [-40°C, 125°C] and battery voltage range [6.0 V, 20 V].

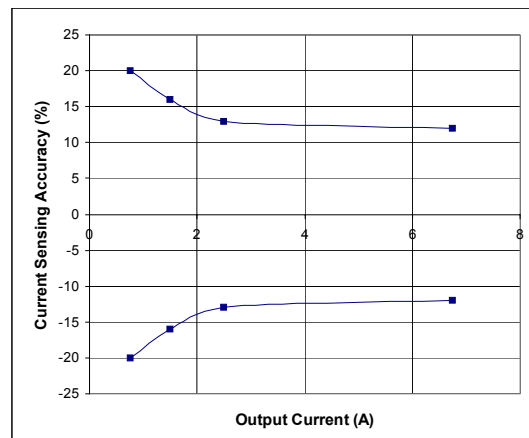


Figure 3. CSR0 Current Sense Variation

Based on statistical data analysis performed on two production lots (initial testing only), the effect of each contributor has been demonstrated for:

1. device to device deviation due to manufacturing
2. ambient temperature drift
3. battery voltage range

4 Calibration Practice

Calibration at a single point removes the device to device error contribution for that condition. Multiple calibration points remove variation at other conditions.

An experiment was done on low output current values. The relative CSR0 deviation based on only two calibration points per output was performed on two production lots. Between each calibration point, the linear regression was used for measuring CSNS analog current feedback high precision. [Figure 4](#) and [Figure 5](#) present the statistical results at 5 Sigma for battery voltage range from 9.0 to 16 V.

[Table 1](#) summarizes the accuracy at 1.0 A output current. There is a possibility of using the analog temperature feedback feature of the device to distinguish low a temperature range (-40°C to +25°C) and a high temperature range (+25°C to +125°C).

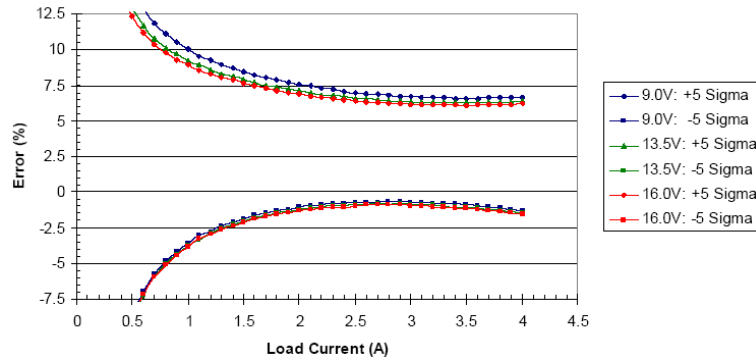
Table 1. Current Recopy Accuracy at 1.0 A Output Current

Without Calibration	With Calibration at 85°C only		
	Two Calibration Points		
from -40degC to 125degC	at -40degC	at 25degC	at 125degC
+17%, -17%	+10%, -3.0%	+6.0%, -2.4%	+3.0%, -3.5%

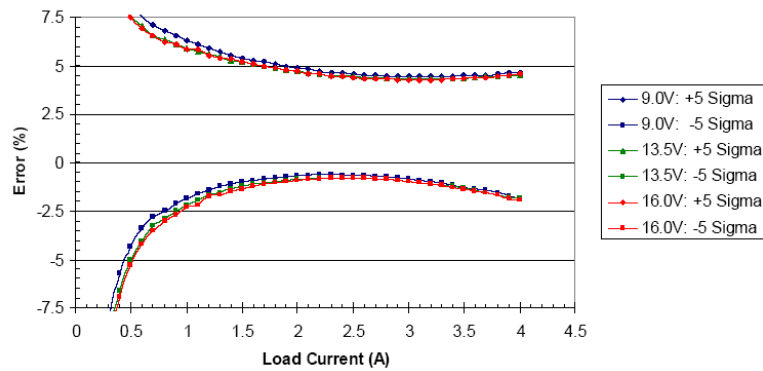
Note: Those results do not take into account the errors in the MCU and external sense resistor connected to the CSNS terminal.

Two calibration points at 85°C were 0.7 A and 2.0 A for $V_{PWR} = 13.5\text{ V}$:

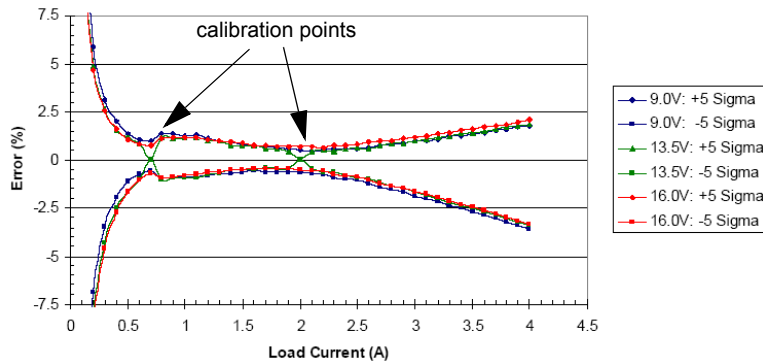
$T_A = -40^\circ\text{C}$



$T_A = 25^\circ\text{C}$



$T_A = 85^\circ\text{C}$



$T_A = 125^\circ\text{C}$

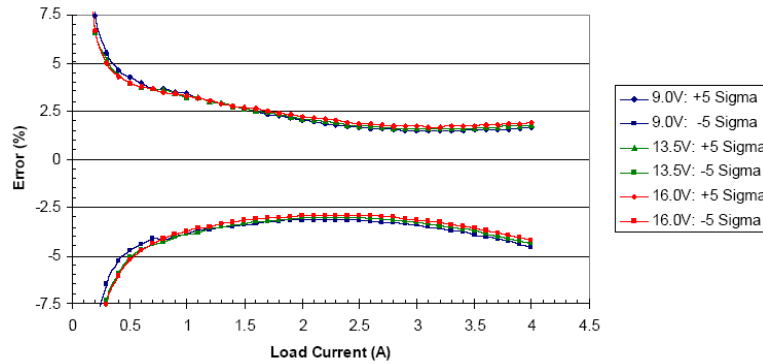


Figure 4. Calibrated CSR0 Current Sense Variation

5 MCU Current Sense Monitoring

5.1 Current Sense Response Time

Figure 5 describes the dynamic response of the current sensing function:

- 140 μsec . typical ($t_{\text{DLY(ON)}} + t_{\text{CSNS(VAL)}}$) after the turn-on command coming from the IN pin or SPI command, the current recopy is within +/-5% of the final value, whatever the battery voltage and the output current values,
- The CSNS output typically lags 5.0 μsec ($t_{\text{CSNS(SET)}}$) behind the actual selected output current.

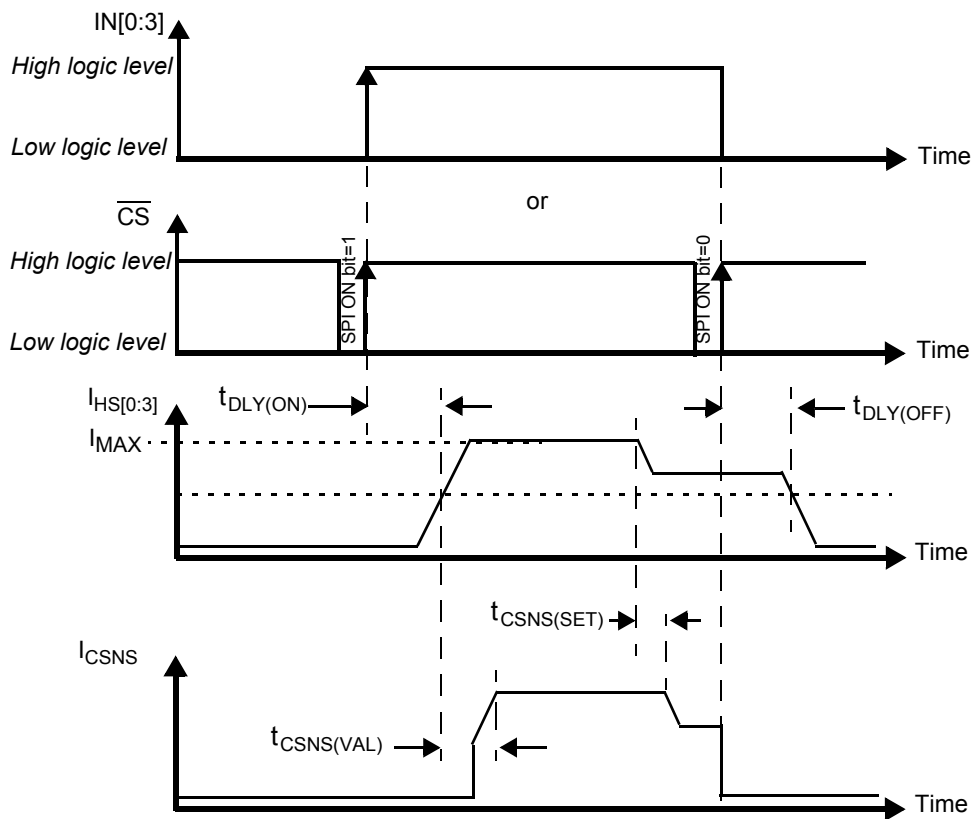


Figure 5. Current Sensing Time Delays

The current recopy transient response fulfills to 3.0% duty cycle of 200 Hz PWM output switching, with the default slew rate (4.0% duty-cycle for 400Hz PWM frequency with fast slew-rate selected).

5.2 Synchronization of MCU Analog-to-Digital Conversion

In many medium and high end microcontrollers, as in the Freescale's MC9S12XE, the Analog-to-Digital (A/D) converter includes features combining interrupt generation and data acquisition.

Either an external control signal (ETRIGx) or the CSNS signal may be used to trigger the A/D conversion, by first generating an interrupt and then sampling the analog value after the defined delay time. By using this feature, polling of the analog value at the CSNS pin can be avoided, thus alleviating microcontroller overhead, and reducing average power consumption.

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