AN3395
Application note

Sensing resistor selection and usage in STC310x battery monitoring applications

Introduction

Voltage measurement and coulomb counting are the two most common methods used to implement battery monitoring for gas gauge applications. Although the use of voltage measurement has been a popular method, it does not produce the most accurate results. The STC310x series battery monitor ICs developed by STMicroelectronics combine the two methods into one integrated solution. It updates the battery State-of-Charge (SOC) at light load (relaxation/standby period) with the real battery Open-Circuit-Voltage (OCV) while using coulomb counting to track the battery capacity under heavy load to provide the most accurate SOC value under all application conditions.

In coulomb counting, the sensing resistor is used to measure the battery current. The specified maximum voltage drop on the sensing resistor is only 80 mV, thus it plays an important role in the gas gauge accuracy and merits careful attention. This document describes:

- the sensing resistor (Rcg) selection
- the Rcg power considerations
- the Rcg layout recommendations

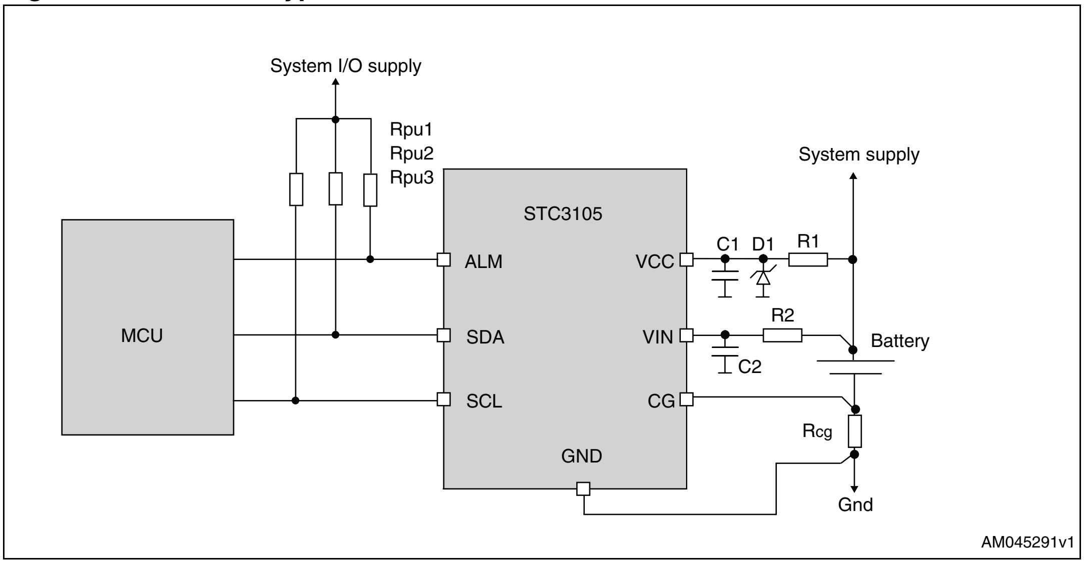
Contents

1 STC310x external components

Figure 1 illustrates the typical connections for a gas gauge application using the STC3105. The SDA, SCL and ALM (I/O0 in the STC3100) pins are open drain and require external pull-up resistors to either system I/O voltage or V_{CC} (pull up to battery voltage). The components shown in *Figure 1* connected to the V_{CC} and V_{IN} pins are used to provide additional ESD protection and input filtering, please refer to AN3064 for more information.

The resistor (Rcg) connected between the CG and GND pins is the sensing resistor. In order to obtain higher accuracy, refer to the following application guidelines.

Figure 1. STC3105 typical connections



2 Rcg resistance selection

The Rcg resistor is used to sense the current flowing "into" or "out of" the battery. The voltage drop on Rcg is input to the current measurement ADC through the CG pin. There are three common rules for the selection of the Rcg resistance:

1. Maximum peak current
2. Power rating
3. ADC code usage

2.1 Maximum peak current in the application

As specified in the datasheet (refer to the STC3105 or STC3100 datasheet), the voltage drop across the Rcg resistor (input voltage range on CG pin) must not exceed ±80 mV. That is Rcg x I_{PEAK} must be ≤ 80 mV. This gives a maximum limit for the Rcg resistor value in *Equation 1*.

Equation 1

$$Rcg(m\Omega) \leq \frac{80(mv)}{I_{PEAK}(A)}$$

2.2 Power rating of the resistor

The second step is to consider the power dissipation limit of the resistor as given in *Equation 2*. The power dissipation in the resistor must be kept within the power rating of the resistor calculated by:

Equation 2

Power dissipation = Rcg x I_{RMS}^2

Note: Must be less than the power rating of the resistor

However, it may be better to choose a smaller resistance value with a smaller power rating to:

- have a smaller PCB footprint and
- reduce the power loss in the resistor.

2.3 ADC code usage efficiency

The full scale voltage range of the ADC is designed for the input on the CG pin to reach ±80 mV (max). To make better use of the ADC performance, Rcg must not be too small: Rcg x I_{PEAK} must be > 40 mV for a reasonable ADC code usage.

2.4 Selection of Rcg (example)

Assume I_{PEAK} = 2.2 A and I_{RMS} = 1.5 A in a mobile phone.

According to *Equation 1*, the maximum limit of Rcg is obtained, that is Rcg < 36 mΩ.

Let's choose a 33 mΩ resistor.

Power rating = 33 mΩ x 1.5^2 A = 74 mW

Therefore, a 1/8 W (125 mW) resistor is sufficient, however, it is possible to use a 20 mΩ resistor that will only dissipate 45 mW instead of 74 mW.

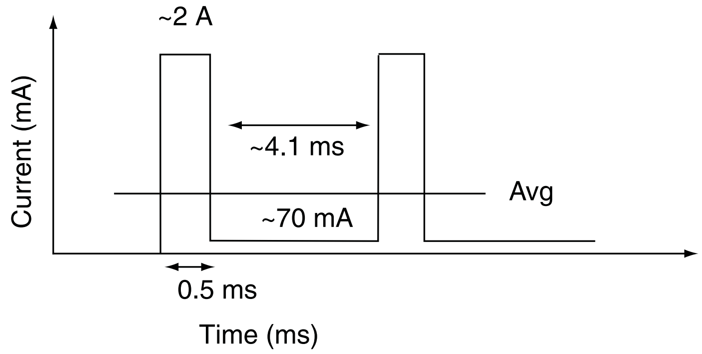
A 20 mΩ resistor is optimal because 20 mΩ x 2.2 A = 44 mV, which is acceptable in comparison with the full scale range of 80 mV.

3 Rcg power loss consideration

The power loss of the Rcg should be considered. Let's look at the worst case when the mobile phone is drawing current during continuous talk time.

Assuming a battery with capacity of 5.55 Wh (1500 mAh) and a 300 mA average current consumption (5 hours talk time), and assuming typical GSM load current waveform below in *Figure 2*:

Figure 2. Typical GSM load profile



For the power loss calculation we must consider RMS current, not average current:

Equation 3

$$I_{RMS} = \sqrt{\frac{2^2 \times 0.5 + 0.07^2 \times 4.1}{4.6}} = 0.66A$$

Equation 4

Power loss = Rcg x I_{RMS}^2 x talk time = 0.02 x 0.66^2 x 5 = 0.044 Wh

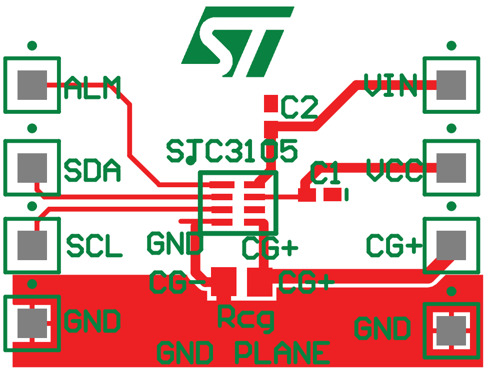
0.044 Wh equals 0.8% of battery capacity (5.55 Wh).

This is the worst case condition. If the device is not used in continuous talking mode but in mixed mode usage (with lower RMS power consumption), the power loss will be less and will not significantly affect the accuracy of the battery capacity measurement.

4 Rcg layout considerations

Figure 3 shows the recommended layout of the PCB for Rcg.

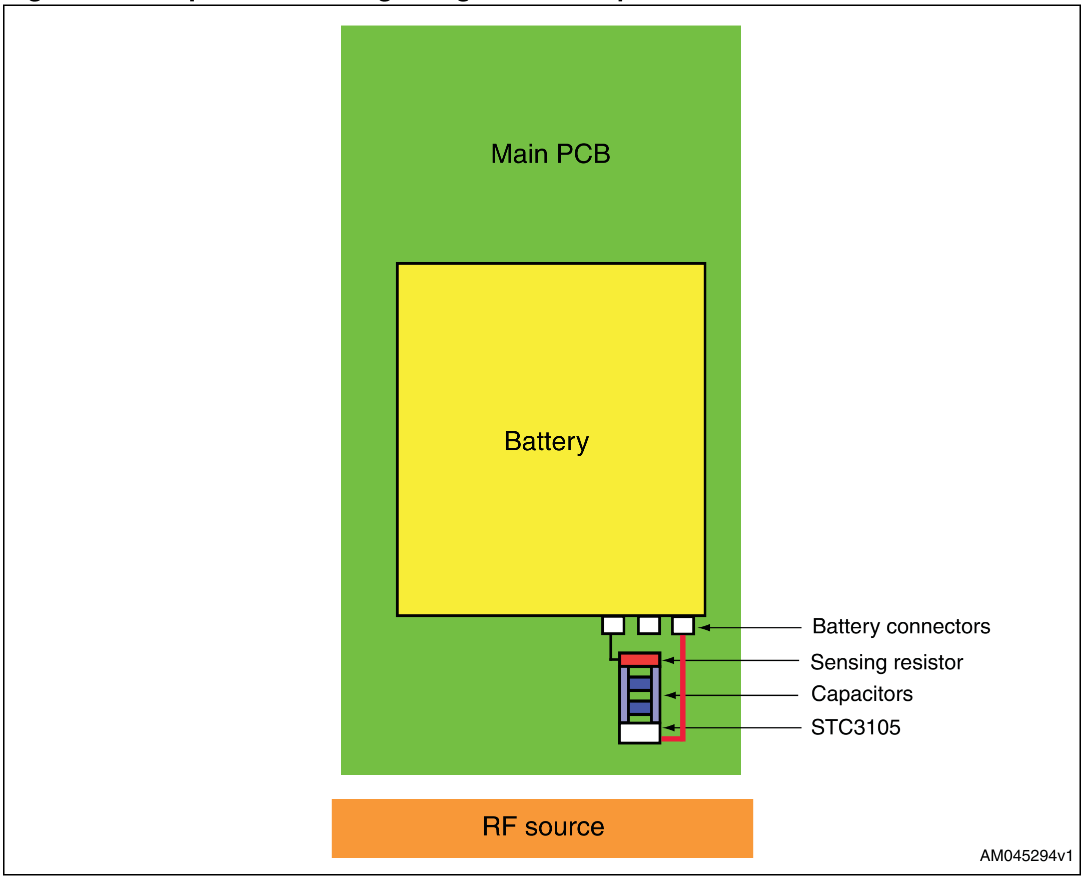
Figure 3. Rcg recommended layout with the STC3105



In order to obtain the most accurate SOC estimation, follow these recommendations:

1. **Place Rcg as close as possible to the CG pin.**
   The STC3105 measures the battery current by sensing the voltage between the CG and GND pin. Between these two pins are two PCB traces and Rcg. Any voltage drop on the traces will directly add error to the measurement. The shorter the traces are, the better the accuracy of the measurement obtained.
2. **The STC3105 GND pin should be connected directly to a terminal of Rcg (CG– in *Figure 3*), not through the ground plane.** This Rcg terminal (CG– in *Figure 3*) should be connected to the ground plane on the PCB.
   This connection avoids the occurrence of high current through Rcg to the voltage potential on the STC3105 GND pin. Any ground disturbances will directly affect the accuracy of the current measurement and therefore the SOC estimation.
3. **If the STC3105 is on a PCB near RF components, special care should be taken to avoid ground disturbance by the RF interference.**
   The user can simply connect two high-frequency ceramic capacitors in parallel with Rcg to minimize the RF effect, if needed. The capacitance should be selected based on the frequencies which produce the highest RF disturbance. For example, 15 pF (ex. Murata 15 pF, part code: GQM2195C2A150GB01) and 68 pF (ex. Murata 68 pF, part code: GQM1885C1H680GB01) can be selected to avoid the disturbances from 1.8 GHz and 900 MHz (strongest RF power in a cell phone). This is illustrated in *Figure 4 on page 8*.

Figure 4. Capacitive filtering using ceramic capacitors



5 Conclusion

This document provides guidance to the user for the selection, the power consumption consideration and the layout of the sensing resistor used with the STC310x battery monitor for gas gauge applications. In most applications, 33 mΩ or 20 mΩ resistance is preferred to avoid power consumption concerns. With regards to PCB layout, the sensing resistor should be positioned as close to the STC310x as possible and the two terminals of Rcg directly connected to the CG and GND pins of the STC310x. The sensing resistor should be connected to the PCB ground plane. In the event of RF frequency exposure, capacitive filtering should be implemented by the parallel placement of high-frequency ceramic capacitors to avoid the disturbance of the GND pin of the STC310x for more accurate SOC measurement.

6 Revision history

Table 1. Document revision history

Date	Revision	Changes
05-Dec-2011	1	Initial release.