Current, Voltage, Power, and Temperature Monitoring

SLG47011V

Abstract

This white paper explores the advanced capabilities of the SLG47011V chip for measuring current, voltage, and power, highlighting the importance in leveraging its configurable logic and specialized features to meet the specific requirements of modern monitoring applications.

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1. Introduction

With the advancement of technology and the increasing complexity of electronic devices, the need for reliable and multifunctional monitoring of current, voltage, and power is becoming increasingly critical. Not only does obtaining instantaneous readings become particularly important, but also the ability to analyze the dynamics of the changes in these parameters over time as well. To solve such tasks, the optimal solution includes the use of configurable logic, which allows the creation of a flexible measurement system that can be tailored to specific application requirements. The implementation of such a measuring device based on the SLG47011V programmable logic chip makes it possible to combine data processing speed and functional flexibility in a single device, making this approach particularly attractive for solving modern engineering problems.

2. SLG47011V for Current, Voltage, and Power Monitoring

The SLG47011V stands out among other GreenPAK series chips due to its integration of several key blocks:

- A 14-bit SAR ADC capable of achieving speeds up to 2.35 Msps in 8-bit mode.
- A Programmable Gain Amplifier (PGA) which supports six amplifier configurations, with gain settings ranging from 1x to 64x, providing flexibility in analog signal processing.

- An integrated 12-bit DAC, operating at sampling rates of up to 333 ksps, which enables precise generation of analog output signals.
- Another notable feature is the hardware math unit (MathCore) which supports multiplication, addition, subtraction, and division operations, facilitating efficient data processing without the need to rely on external processors.
- Built-in dynamic memory for 4096 words

By utilizing these blocks, the SLG47011V becomes an ideal solution for monitoring current, voltage, power, and temperature. The use of these internal blocks reduce the number of required external components. For example, the built-in PGA block eliminates the need for an external differential amplifier for current measurements. Moreover, it provides additional advantages since this configurable block allows for flexible adjustment of its settings during the measurement process, including gain adjustment, which in turn increases the measurement range.

This combination of highly integrated analog and digital blocks within the SLG47011V significantly simplifies system design while enhancing functionality. The ability to perform measurements and process data within a single chip not only reduces the overall system complexity but also improves reliability by minimizing potential points of failure associated with using other external components. This level of integration, coupled with the flexibility of its programmable features, makes it particularly well-suited for creating compact and efficient monitoring solutions.

The configurable nature of this device makes it possible to dynamically adapt to the changing measurement requirements without any hardware modifications. This adaptability is especially valuable in applications where measurement conditions may vary significantly, enabling the system to maintain optimal performance across different operating scenarios.

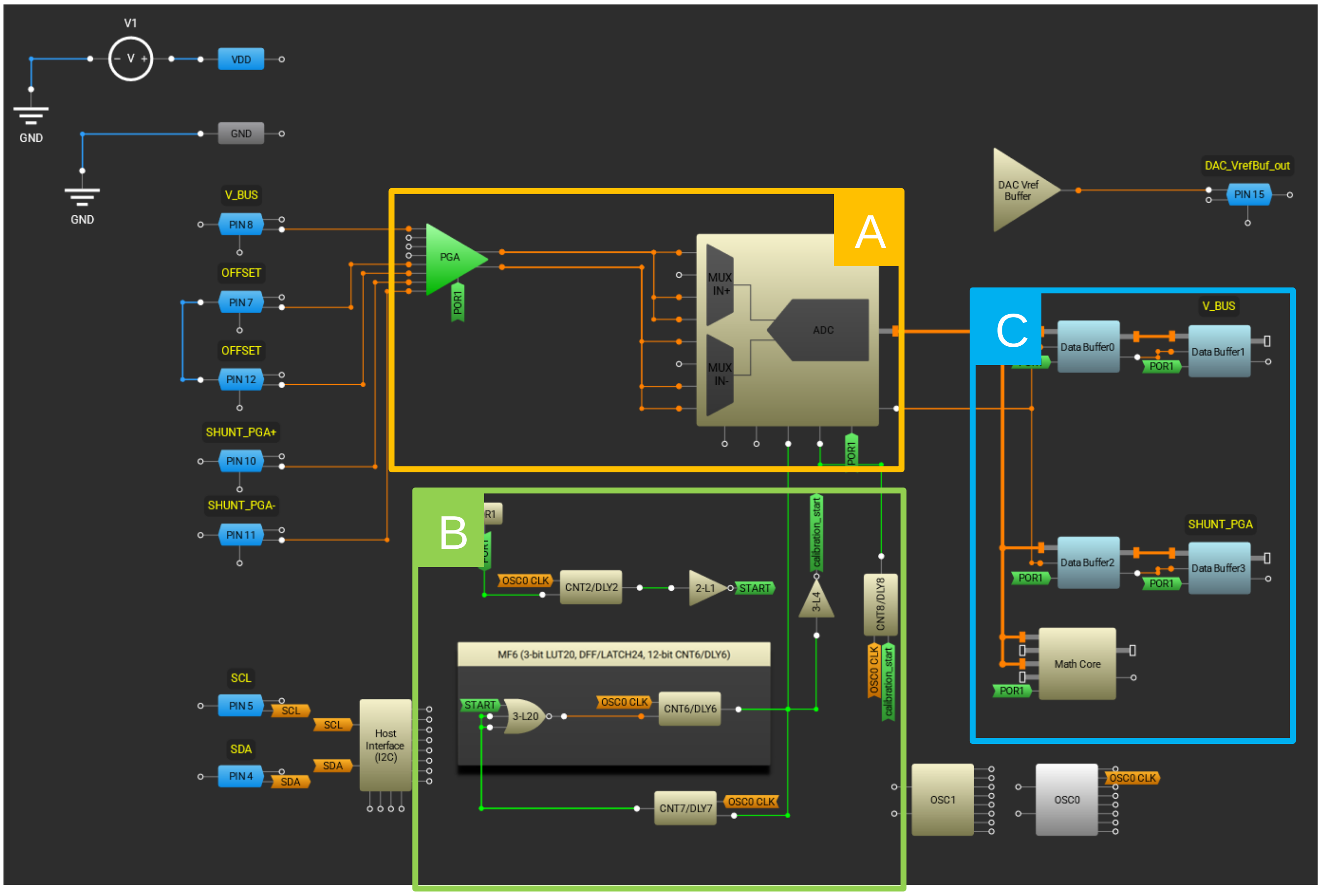

Figure 1. Typical design for Voltage, Current, Power measurement

This design shown in Figure 1 is intended to interface with an MCU via I²C and can be divided conceptually into the following blocks:

Block A: Responsible for digitizing incoming analog signals. Notably, the Programmable Gain Amplifier (PGA) can be reconfigured through I²C, allowing individual gain adjustment for each measurement channel based on the specific characteristics of the signals being measured.

Block B: Manages the ADC control logic, ensuring proper initiation of the ADC. The SLG47011V also offers offset compensation capabilities for differential measurements. This block oversees timing and the correct operation of offset compensation during current measurement.

Block C: Handles the storage and the processing of digitized data. Buffers 0 to 3 store digitized data (from the ADC) and function as filters by updating data based on a moving average principle. The MathCore performs power calculations by multiplying the digital outputs of the voltage and current.

The results from each Buffer can be read via I²C and subsequently displayed through the MCU, or connected to a computer to establish a monitoring system.

The solution shown in Figure 2 makes it possible to measure voltages up to 20 V and currents up to 4 A, provided that the PGA gain is switched via I2C depending on the current, namely: x32 for currents up to 1 A, x8 for currents from 1 A to 3 A, and x4 for 4 A.

Otherwise, this circuit can measure currents up to 1 A with a gain of x32. It is possible to reduce the gain to x16, thereby increasing the maximum measured current to 2 A. However, since the initial design is based on overwriting the gain via I^2C, it is important that the gain needs to be overwritten for both channel 3 (which is responsible for measuring the current) and channel 2, as it is responsible for calibrating the offset for channel 3.

The input voltage is applied to the +V_BUS pin and is designed for a 4 V to 20 V voltage range.

Pins 7 and 8 must be connected together as they are responsible for the offset calibration.

Pin 16 (Sync) serves as a signal pin that controls when the MCU can access the SLG47011. Communication with the chip via I^2C is only possible when Pin 16 is LOW.

R3 is a shunt resistor from which the current is measured.

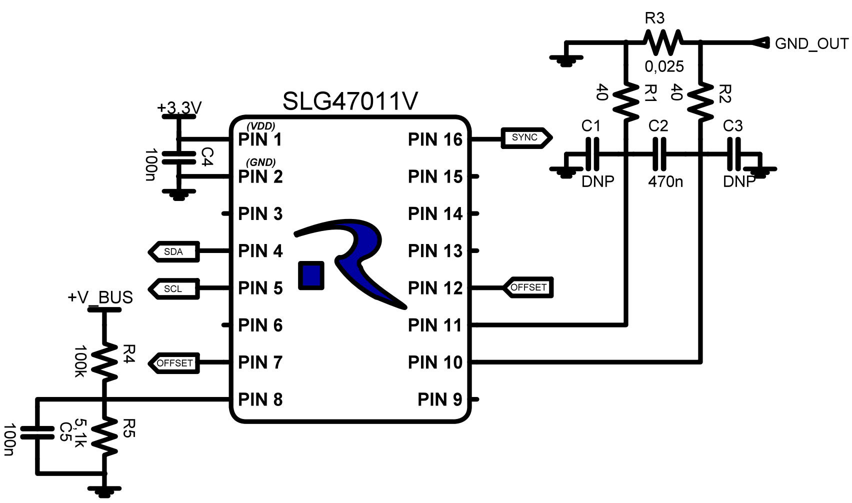

Figure 2. Typical application circuit.

The MathCore read data is converted using the following formula:

$$P = \frac{(2298537 \cdot M \cdot 2048)}{285212672000 \cdot G_e}$$

where:

- M – data read from MathCore
- G_e – gain of channel 3

It is also possible to read voltage and current values from Buffers 0 and 3, and they will be averaged in the same manner as the Buffer following the MathCore. However, since two buffers are connected in series for the current, 16 bytes are averaged over 14 bits.

The read voltage is converted using the following formula:

$$V_{bus} = \frac{(ADC_{Vbus}/2^N \cdot Vref)}{(R5/(R4 + R5))}$$

where:

- ADC_{Vbus} – data read from Buffer 1
- N – ADC resolution

The read current is converted using the following formula:

$$I = \frac{(ADC_{SHUNT}/2^N) \cdot Vref/2}{(R3/G_e)}$$

where:

- ADC_{SHUNT} – data read from Buffer 3

3. Demo Board Functional Description

One of the best demonstrations of the SLG47011V's voltage, current, and power measurement capabilities involves the use of SLG47011V Demo Board #1, which includes an MCU to read and display data from the SLG47011V in addition to all of the necessary additional components required for measurement. Three boards were tested for voltage and current measurement accuracy, the results of which are described in section 3.1.

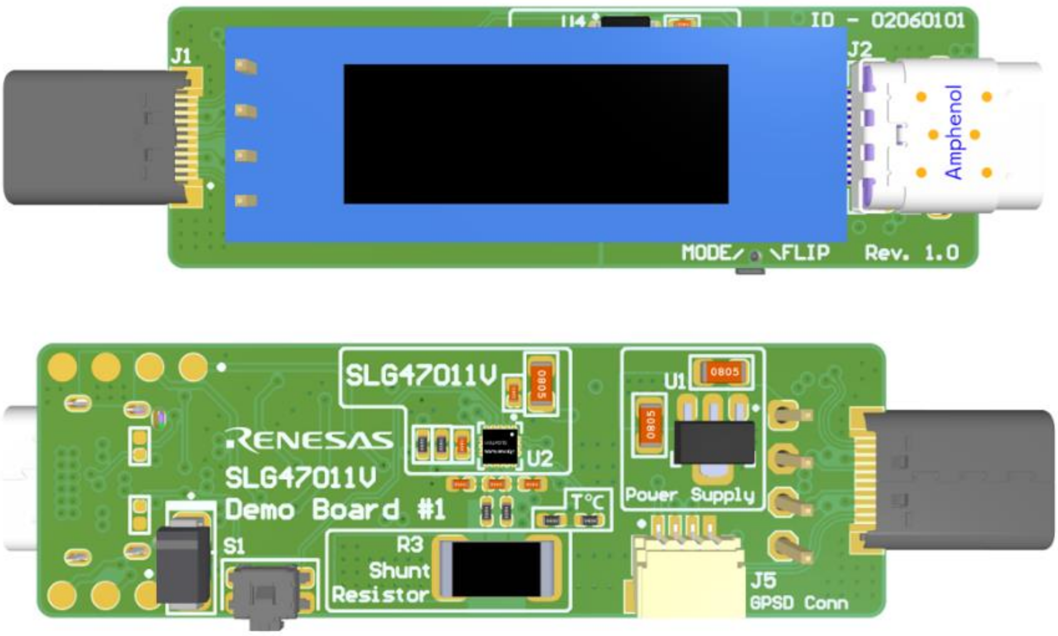

Figure 3. SLG47011V Demo Board #1

Features

- Power Delivery compatible (up to 28 V, 5 A)
- Voltage, Current, Power, and Temperature measurements
- Measurements in both directions (plug and receptacle connection)

- 128 x 32 OLED monochrome display

A simplified functional diagram is shown in Figure 4.

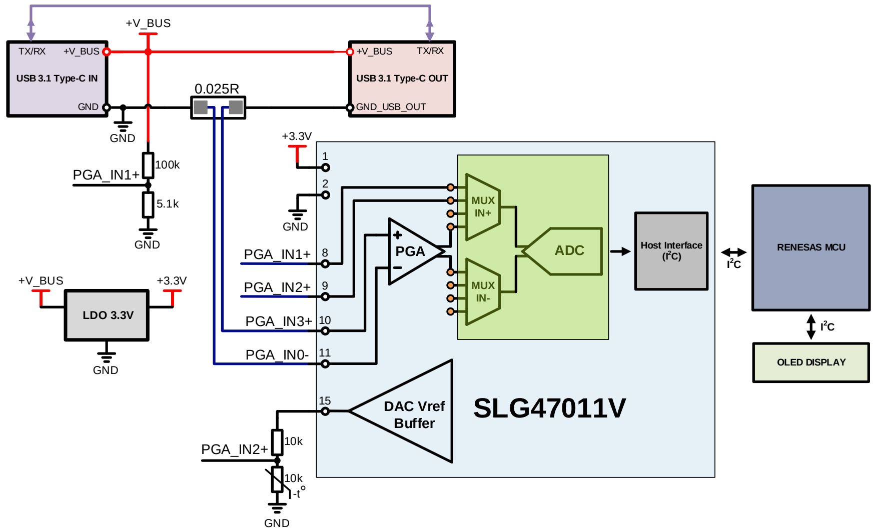

Figure 4. Functional Block Diagram of SLG47011V Demo Board #1 R1.0

3.1 Measurement Accuracy

Voltage and current measurements were performed on three different boards to gather statistics on accuracy (see Table 1 and Table 2).

Table 1: Voltage Measurements Data

Demo Board #1		Demo Board #2		Demo Board #3	
Applied Voltage [V]	Measured Voltage [V]	Applied Voltage [V]	Measured Voltage [V]	Applied Voltage [V]	Measured Voltage [V]
4.989	4.99	4.985	4.99	4.988	4.98
8.986	9.00	8.985	9.00	8.987	8.99
11.987	12.02	11.986	12.01	11.987	12.00
19.990	20.06	19.987	20.05	19.990	20.03

Table 2: Current Measurements Data

Demo Board #1		Demo Board #2		Demo Board #3	
Applied Current [A]	Measured Current [A]	Applied Current [A]	Measured Current [A]	Applied Current [A]	Measured Current [A]
0.1	0.098	0.100	0.098	0.100	0.099
0.3	0.302	0.300	0.302	0.300	0.302
0.5	0.503	0.500	0.504	0.500	0.499
1	1.010	1.000	1.002	1.000	1.006
3	3.039	3.000	3.018	3.000	3.030

4. SLG47011V Customization Features

As mentioned previously, the SLG47011V is a configurable logic IC, which allows for the implementation of advanced features such as watchdog functionality, overvoltage/overtemperature protection, among others, unlike other chips typically used in electrical parameter monitoring systems.

This enhanced design is utilized for the application note (AN-CM-375 Voltage, Current, Power, and Temperature Monitor).

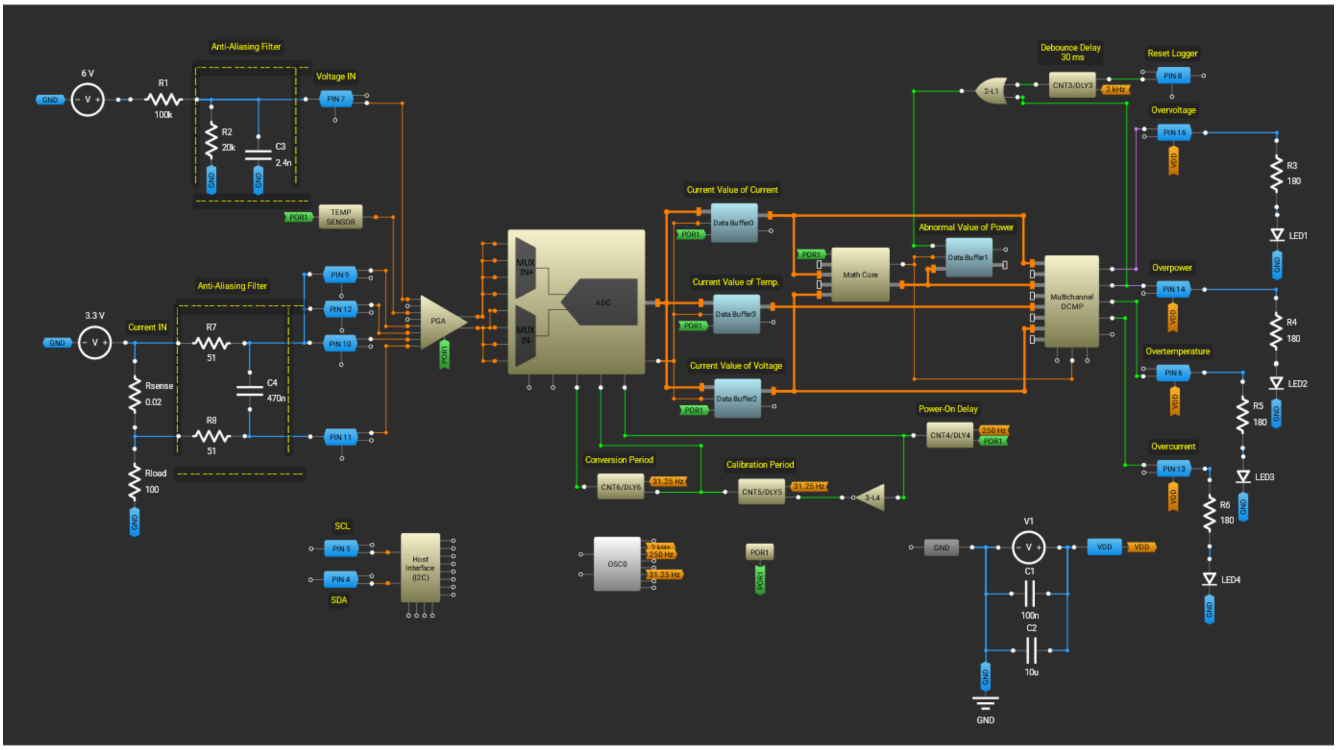

Figure 5. Design with OVP, OCP, and OTP features

This configuration not only allows for making simple measurements but also includes fault detection for the measured signals and outputs a fault signal externally as needed.

Another feature is the ability to measure the current on a copper pad (refer to AN-CM-394 Current Sensing with Cu Trace).

In addition to the standard offset compensation available through the Memory Table and MathCore, it is also possible to measure current with the ability to compensate for temperature drift as well.

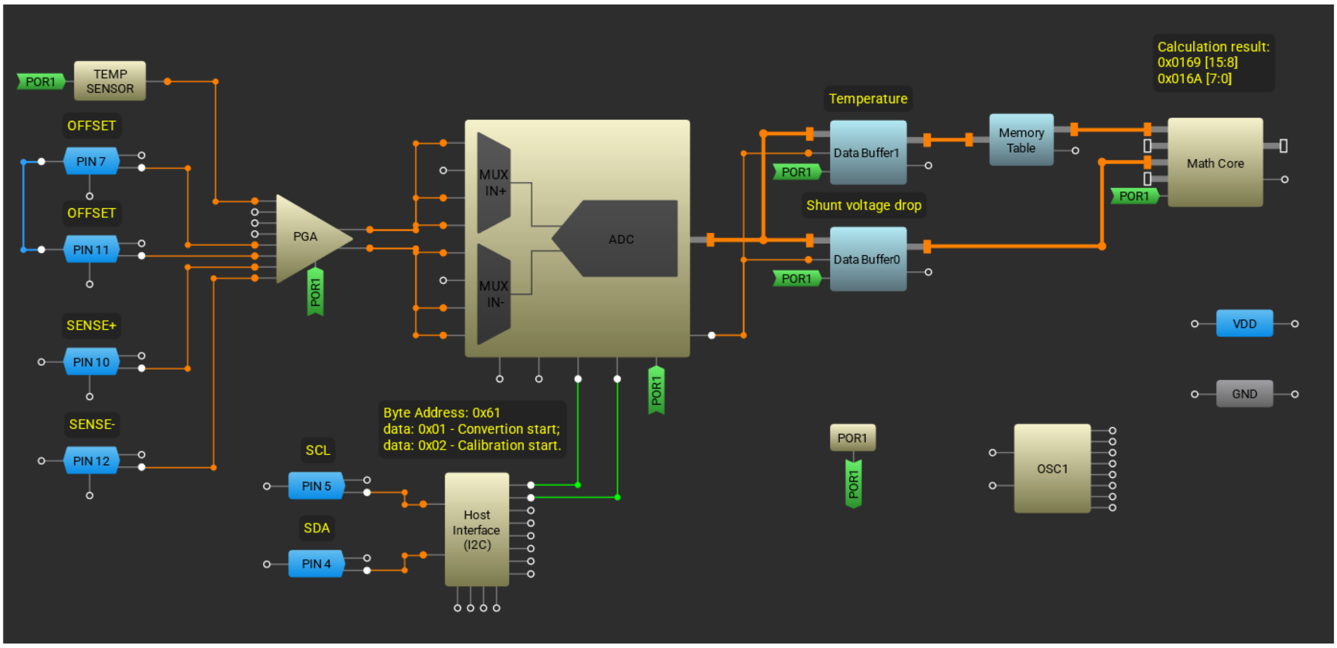

Figure 6. Design with Compensation for Temperature Drift

5. Conclusions

The SLG47011V chip stands out as a versatile and efficient solution for current, voltage, and power measurement applications. Its configurable logic, combined with its advanced features such as offset compensation, temperature drift correction, and fault detection, makes it a robust choice for modern monitoring systems. The possibility of integrating additional functions like watchdog timers and overvoltage/overtemperature protection into designs further enhances its flexibility and reliability.

By leveraging its programmability and high level of integration, the SLG47011V provides a cost-effective and scalable platform for designing sophisticated monitoring solutions, enabling precise measurements and providing real-time signal analysis across a wide range of applications.

6. Revision History

Revision	Date	Description
1.00	April, 2025	Initial release