SLG51003 Remote Sense Functionality
SLG51003

This application note describes the Remote Sense feature available in the SLG51003. This feature is used to compensate for parasitic parameters between the LDO1 output pin and the load in a circuit. It is especially relevant for high current applications when the connection to the load is far away from the IC connected by a narrow trace, or when flex wire connections are used, which can add parasitic resistance or inductance. In this application note, a typical use case is considered accompanied with a comparison of the voltage drop with and without remote sense mode being used in the circuit.

Contents

1. Table of Contents

Terms and Definitions

FPC - Flexible Printed Circuits

HP - High Performance

LDO - Low-Dropout Regulator

PMIC - Power Management Integrated Circuit

RS - Remote Sense

References

For related documents and software, please visit:

Power GreenPAK | Renesas

Download our free GreenPAK Designer software (Go Configure Software Hub) [1] to open the design file [2] and view the proposed circuit design. Use the GreenPAK development tools [3] to freeze the design into your own customized IC in a matter of minutes. Renesas Electronics provides a complete library of application notes [4] featuring design examples, as well as explanations of features and blocks within the Renesas IC.

[1] GreenPAK Go Configure Software Hub, Software Download and User Guide, Renesas Electronics

[2] AN-CM-405 SLG51003 Remote Sense Functionality.ppak, Design File, Renesas Electronics

[3] GreenPAK Development Tools, GreenPAK Development Tools Webpage, Renesas Electronics

[4] GreenPAK Application Notes, GreenPAK Application Notes Webpage, Renesas Electronics

[5] SLG51003V Datasheet, SLG51003V Datasheet, Renesas Electronics

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2. Introduction

When there is a significant voltage drop detected across long or high-resistance power supply lines, the SLG51003 with Remote Sense functionality can be used to compensate for the lower voltage. This can be achieved by sensing the voltage at the load, rather than directly at the LDO output, and ensuring that the correct voltage is received at the load. This is especially relevant in high current applications and in systems using flex cables that can add large parasitic parameters into the circuit.

3. Using SLG51003 in the Remote Sense Mode

Remote Sense mode can be utilized by LDO1 (LDO_HP) in the SLG51003 to regulate the voltage at the load side. In this mode, the GPIO1 pin is configured as an analog input to serve as the remote sense pin. GPIO1 should be connected to the load side that is being powered by LDO1. Because GPIO1 relies on V_{DDIO}, the V_{DDIO} voltage should be higher than the voltage at the LDO1 output. Load regulation performance depends on the parasitic parameters of the system and therefore the electrical specifications for LDO1 can be affected in remote sense mode operation.

Using Remote Sense mode on LDO1 can be especially useful in the following conditions:

- **Systems with long wires or FPC (Flexible Printed Circuit) connectors.**
  In applications where the load is physically far from the LDO, the wiring or traces can cause a voltage drop. Remote Sense compensates for this drop by adjusting the output voltage to maintain the required voltage level at the load site.
- **Systems with precision analog circuits.**
  For sensitive applications like data acquisition, even small variations in supply voltage can affect performance.
- **High current applications.**
  In circuits where large currents are drawn, significant voltage drops can occur within the distribution lines. Remote Sense ensures accurate voltage regulation at the load despite these drops.

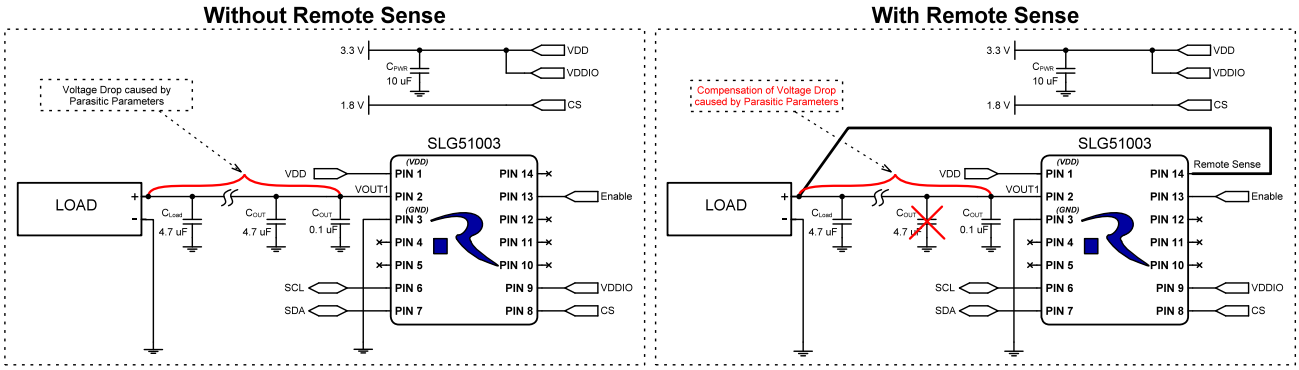

Figure 1: Typical SLG51003 application circuit without and with the use of the Remote Sense mode

In Figure 1, two circuits are shown: an application circuit without the remote sense pin on the left diagram and an application circuit with remote sense pin on the right. By using the circuit with remote sense mode, the voltage drop caused by parasitic parameters (inductance and resistance) on VOUT1 can be compensated for. Additionally, a large 4.7 µF capacitor can be removed near the IC, leaving only the small 0.1 µF capacitor in a 0201 package, which will help to reduce the solution cost and decrease the overall PCB area.

The following steps should be taken to enable the Remote Sense function for LDO1 with the SLG51003 Evaluation Board:

1. Connect the EVB (with the SLG51003) by USB cable to the PC.
2. Open the Go Configure Software Hub and choose the SLG1003 chip.
3. Open the LDO1 settings and enable the Remote Sense function, as shown in Figure 2.

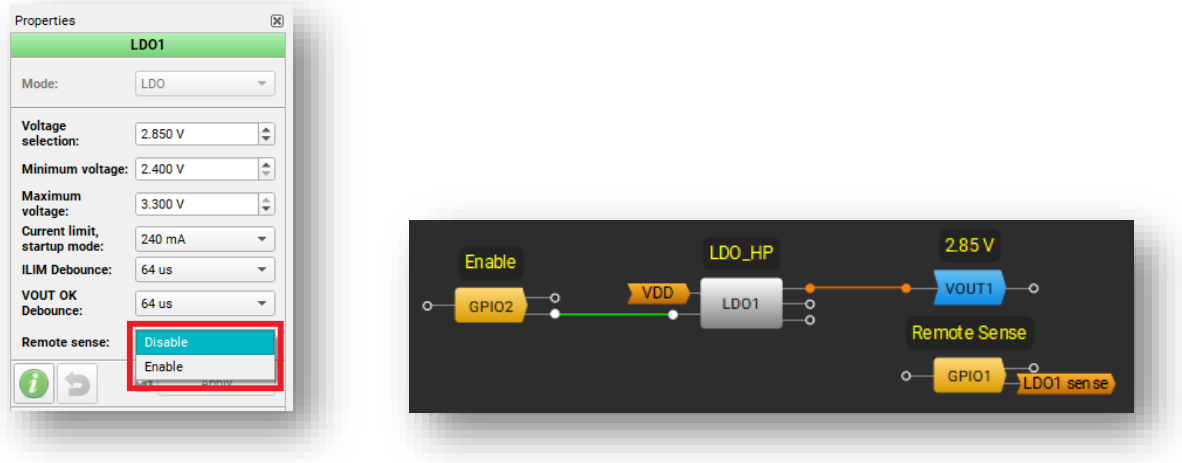

Figure 2: LDO1 settings in the Go Configure Software Hub to enable Remote Sense

4. Configure GPIO1 as an Analog Input. The V_{DDIO} power supply voltage in Remote Sense mode should be higher than VOUT1 but not higher than the V_{DD} voltage.

5. Connect GPIO1 to the load or any other point on the PCB where the VOUT1 voltage level needs to meet the application requirements and enable LDO1.

After configuration, the voltage near the load will be maintained with high accuracy, and any voltage drop detected between the IC and the load will be compensated for.

4. Typical Applications for the SLG51003 in Remote Sense Mode

4.1 FPC Connectors

One of the applications where using Remote Sense can be beneficial is in applications where FPC connectors are used. Flex wires can be used in various areas where compact, flexible, and reliable connections are needed. They can often be found in mobile devices to connect displays, touchscreens, cameras, and other components, often saving space and reducing weight.

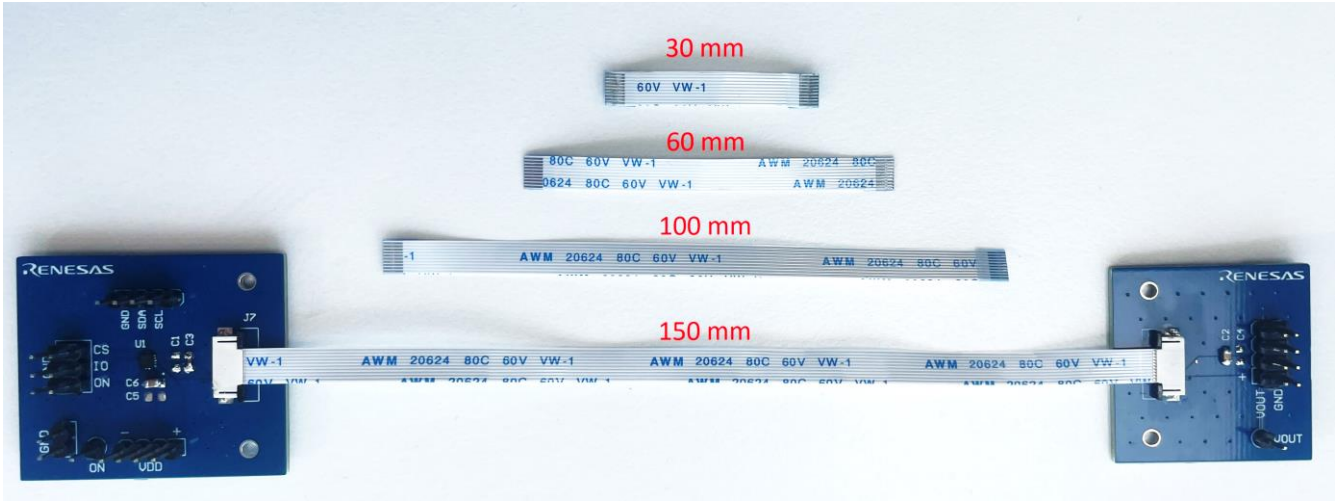

Figure 3: Bench setup for SLG51003 with FPC connectors and different wires.

In Figure 3, two boards are connected by a 150 mm (or 30/60/100 mm) length flexible flat cable through FPC connectors. On the left board, an SLG51003 with Remote Sense mode enabled is installed while the load and a 4.7 µF capacitor is located on the board on the right. The GPIO1 signal, being used as the Remote Sense is also connected near the load on the right.

The boards being used will test for voltage drop and then provide compensation with Remote Sense mode at different load currents. The input voltage of the SLG51003 is 3.3 V, and the output voltage is set to 2.85 V. The load is adjustable up to 475 mA. In the default LDO operating mode (without operating in Remote Sense mode) the output voltage drop can be observed by gradually increasing the load current.

In Remote Sense mode the voltage drop is compensated for at the VOUT pin while the load is located between GND and VOUT. Good GND polygons should be considered as well to minimize the impact of the voltage drop caused by GND. In Table 1, a comparison of the output voltage with and without the Remote Sense mode for 10 mA and 475 mA loads can be seen for each different wire length.

Table 1: Comparison of the voltage drop with/without Remote Sense pin at 475 mA load.

Wire Length	Trace Resistance	VOUT @ 10 mA without RS	VOUT @ 475 mA without RS	Voltage Drop without RS	VOUT @ 10 mA with RS	VOUT @ 475 mA with RS	Voltage Drop with RS
30 mm	67.6 mΩ	2.85 V	2.816 V	33.5 mV	2.853 V	2.847 V	6.2 mV
60 mm	98.8 mΩ	2.85 V	2.802 V	47.3 mV	2.853 V	2.844 V	9 mV
100 mm	144.8 mΩ	2.849 V	2.781 V	68 mV	2.853 V	2.839 V	13.9 mV
150 mm	202.7 mΩ	2.848 V	2.753 V	97.4 mV	2.853 V	2.833 V	19.6 mV

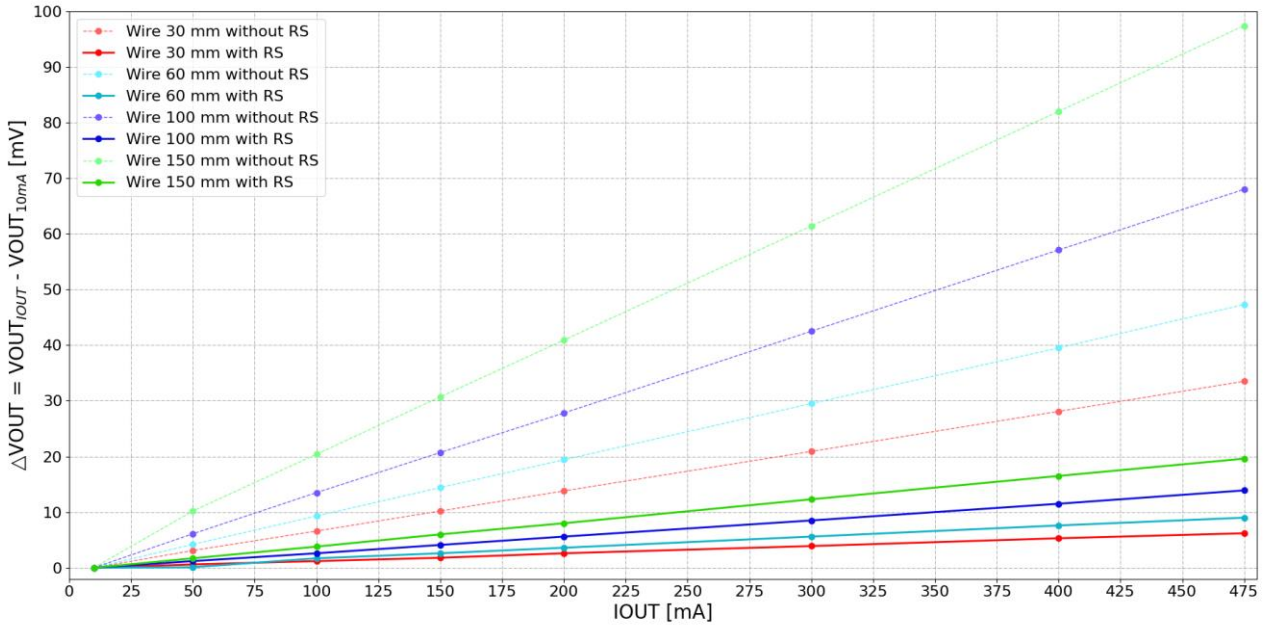

Figure 4: Voltage drop comparison on LDO1 with/without Remote Sense for different wire lengths

The voltage difference (ΔVOUT) on the load side is shown with (solid lines) and without (dashed lines) the Remote Sense mode is shown in Figure 4. The voltage difference is calculated as the difference between the voltage measured at 10 mA load and at other load current points and different wire lengths. It is clearly shown how remote sense compensates for voltage drop on the trace.

The SLG51003 can only compensate for the voltage drop on the LDO1 output trace. This means that parasitic parameters at GND can still affect the circuit and cause some voltage drop at the LDO1 output. Therefore, proper GND routing on the PCB is extremely important in these types of applications.

The results of load transient, startup current limit, and functional current limit tests for 30 mm wire length is shown in Figure 5 and Figure 6, Figure 7, and Figure 8 respectively.

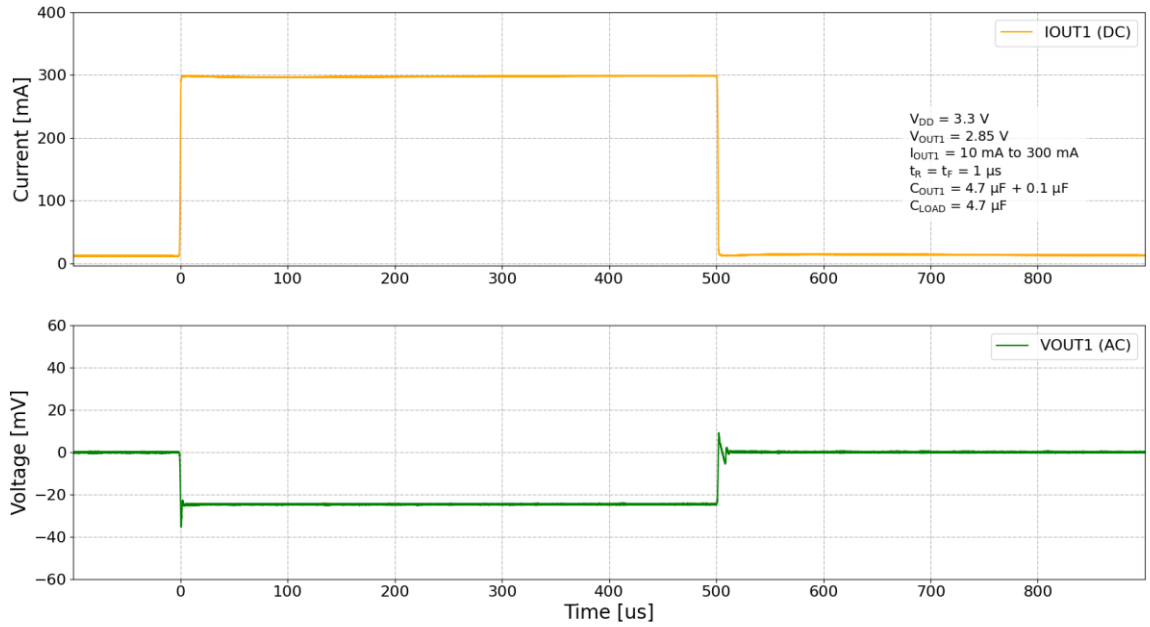

Figure 5: LDO1 Load Transient without Remote Sense

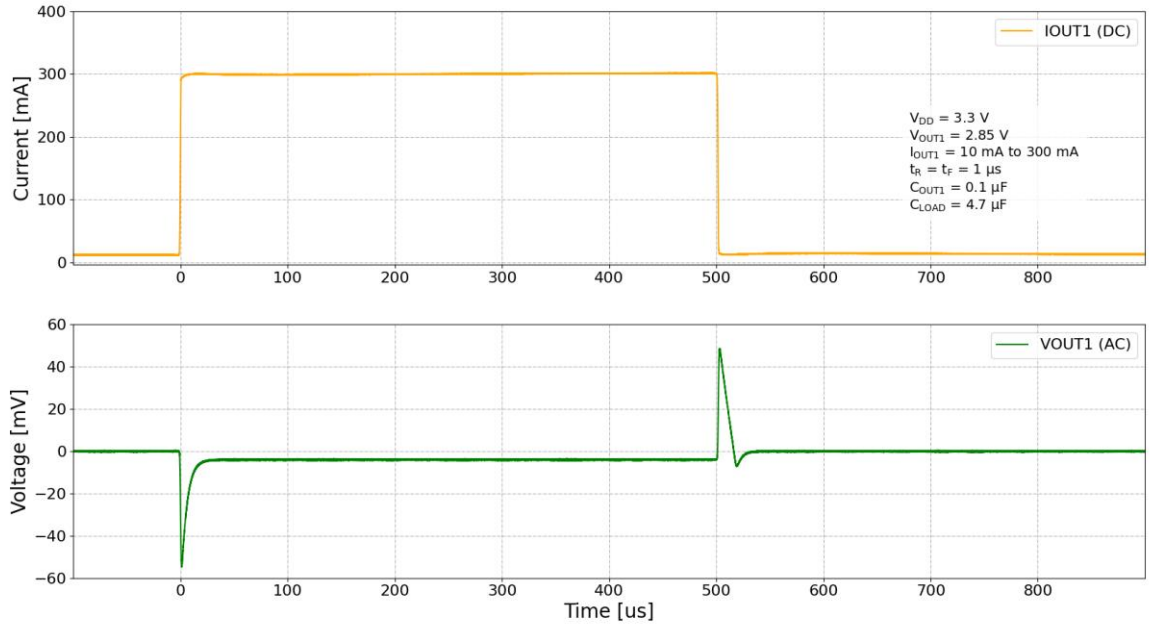

Figure 6: LDO1 Load Transient with Remote Sense

In Figure 5 and Figure 6 the results of the Load Transient tests are shown. This test assesses how quickly and accurately the LDO can stabilize its output voltage when the load current rapidly increases or decreases.

During the test, a controlled, fast-switching load is applied to the LDO, which simulates real-world scenarios where the connected load might fluctuate rapidly. Based on the figures above, it can be observed that when the remote sense pin mode is enabled, voltage spikes are larger than without using remote sense pin mode, but the voltage drop is much lower once the current is stabilized.

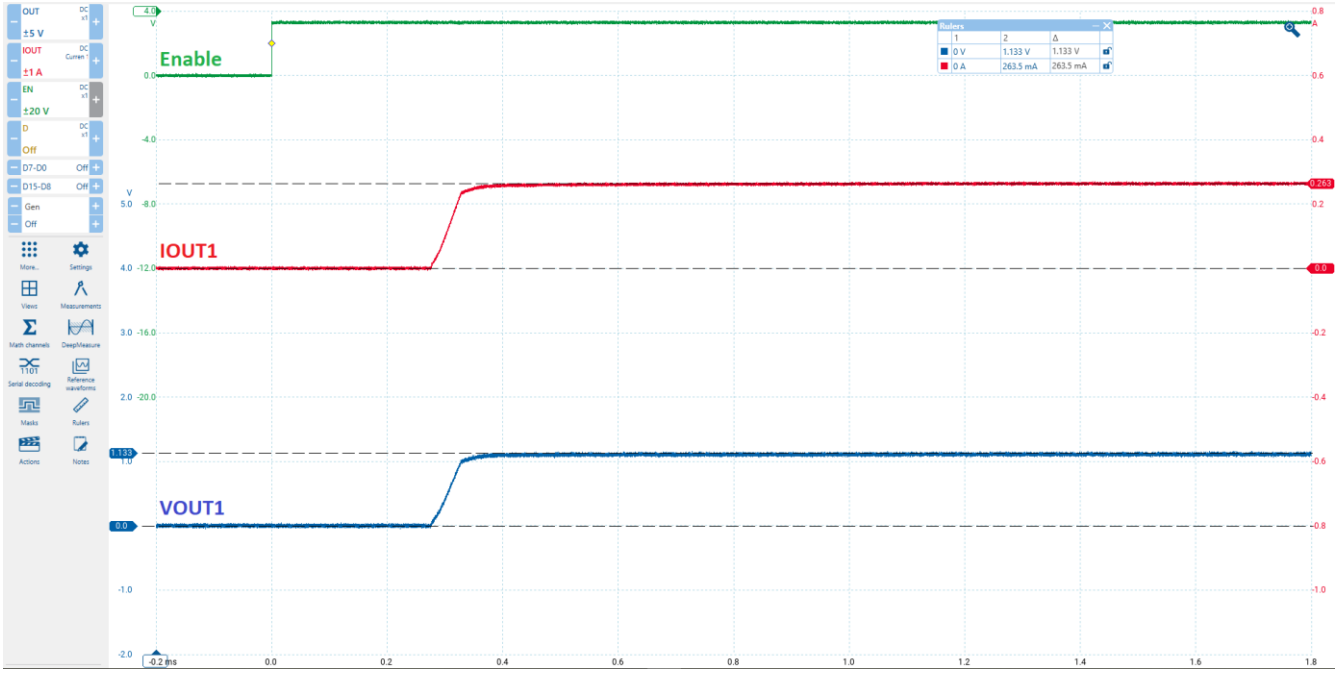

Figure 7: LDO1 Startup Current Protection with Remote Sense Mode

In Figure 7, the results of the Startup Current Limit operation is shown. A load with a current (~270 mA resistive load) exceeding the chip's configured startup limit is applied to VOUT1 and subsequently, LDO1 is enabled. The startup current limit for LDO1 is configured to 240 mA.

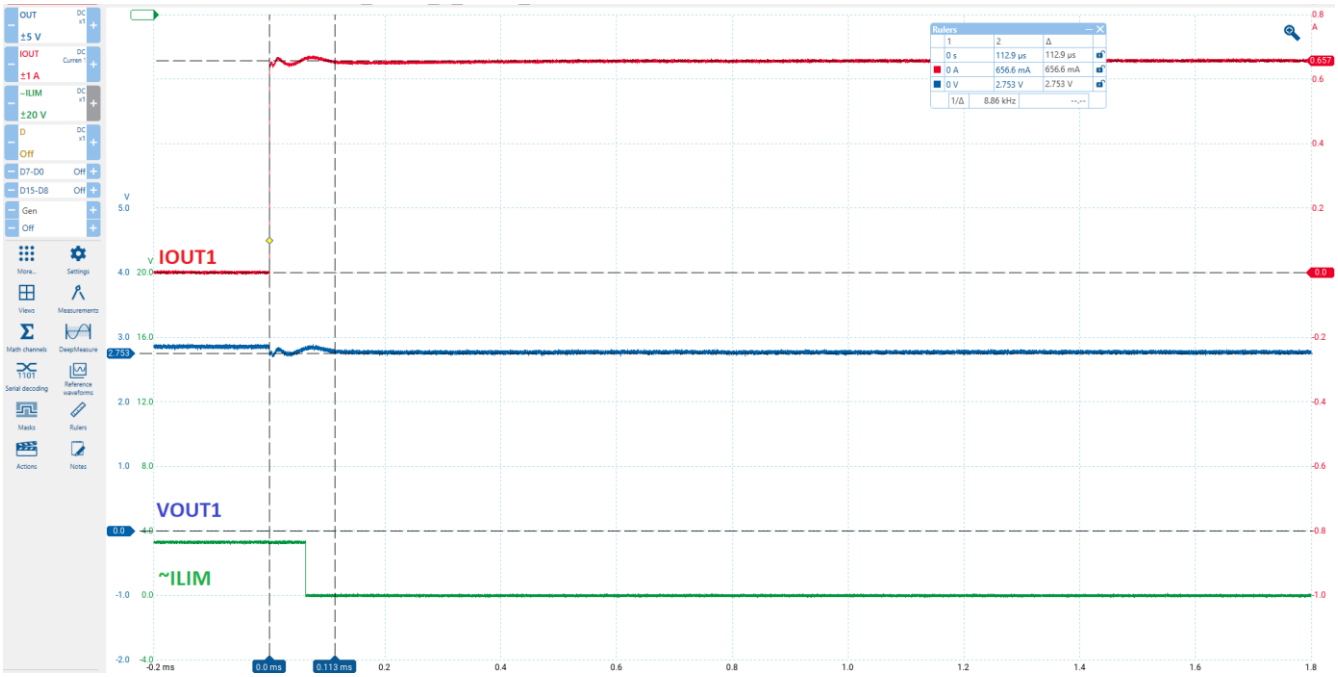

Figure 8: Operating waveform of LDO1 Functional Current Protection with Remote Sense Mode

In Figure 8 the results of the Functional Current Limit operation is shown. LDO1 is enabled and after that a load with a current (~690 mA) exceeding the chip's current limit is applied to VOUT1.

4.2 Boards with Long Traces

Another use case for using Remote Sense mode is when the load is located far from the IC on the PCB. At higher currents, the voltage drop becomes more noticeable depending on the VOUT trace length, width, and copper area being used.

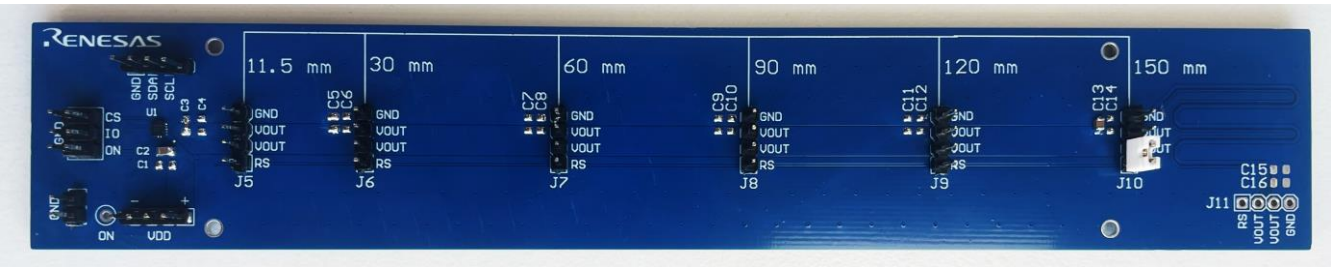

Figure 9: Bench setup for SLG51003 with long trace board

In Figure 9, a test board with different trace lengths is shown. The SLG41003 is configured with the same settings as in the previous test setup with the FPC boards.

Table 2: Comparison of the voltage drop with/without Remote Sense pin at 475 mA load for a Board with long traces.

Wire Length	Trace Resistance	VOUT @ 10mA without RS	VOUT @ 475 mA without RS	Voltage Drop without RS	VOUT @ 10mA with RS	VOUT @ 475 mA with RS	Voltage Drop with RS
30 mm	27.7 mOhm	2.851 V	2.838 V	13.3 mV	2.851 V	2.845 V	6.3 mV
60 mm	33.1 mOhm	2.851 V	2.835 V	15.8 mV	2.851 V	2.845 V	6.3 mV
150 mm	48.3 mOhm	2.851 V	2.828 V	23.2 mV	2.851 V	2.845 V	6.3 mV

Table 2 shows that as the trace length increases, the voltage drop across the load also increases. At the maximum current of 475 mA, the voltage may sag by several millivolts, but the difference can be compensated for thanks to the remote sense mode function. Only the GND trace resistance on the board will have an impact on the voltage drop in this case. The output voltage drop when using remote sense mode is the same for each of the given distances and is significantly smaller than without the use of this function.

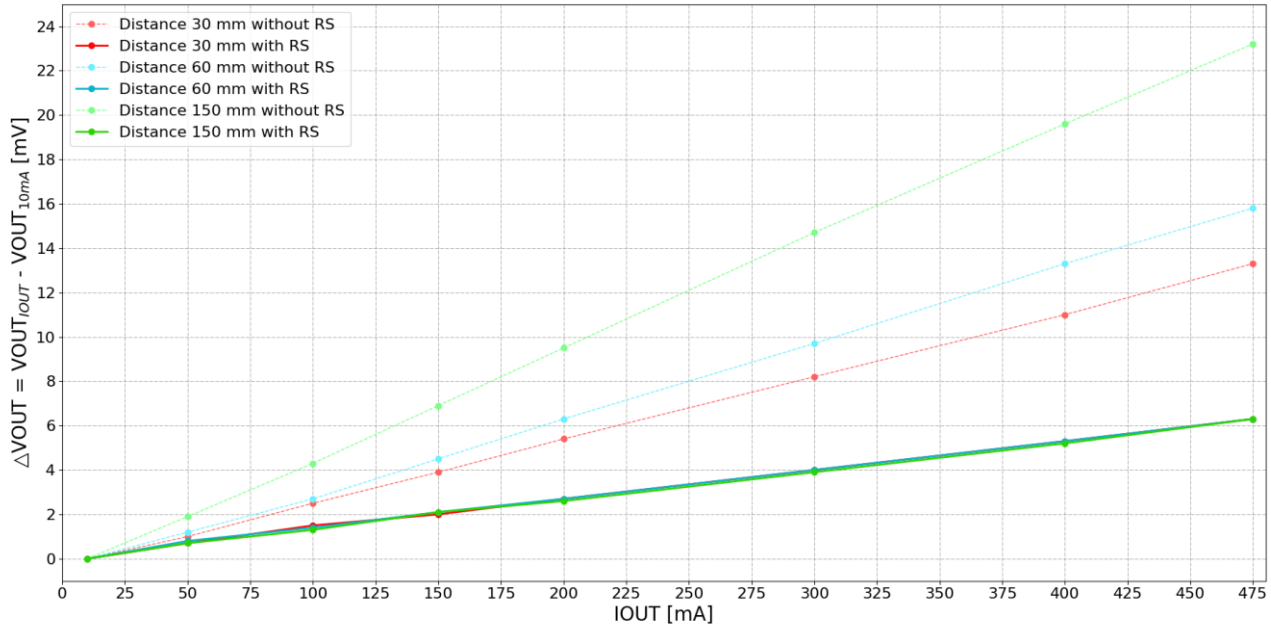

Figure 10: LDO1 Comparison of the voltage drop with/without Remote Sense for different trace distances

The voltage difference (ΔVOUT) on the load side, calculated as a difference between the voltage at 10 mA load and other load current points and different lengths on the PCB, with and without the Remote Sense mode is shown in Figure 10. It clearly indicates that the Remote Sense mode successfully compensates for the voltage drop on the trace.

5. Conclusions

Remote Sense mode is an additional option in the high performance LDO with high PSRR and low noise (LDO1) in the SLG51003. This feature is designed to improve the accuracy of the output voltage across the load, and it can be enabled or disabled in the LDO configuration settings. Load regulation performance also depends on the parasitic parameters of the system, and the electrical specifications for LDO1 can be affected in remote sense mode operation.

The SLG51003 also provides additional Power GreenPAK features, such as I^2C support, GPIOs, configurability, status and event indicators, and sequencing. Furthermore, the device's flexibility makes it possible for customers to use it for a variety of project applications and still be able to meet their different respective requirements. The accompanying design file used in this example can be modified and customized for different needs and requirements.

6. Revision History

Revision	Date	Description
1.00	Mar 11, 2024	Initial Version

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