Application Note

Improve TLC59283 Control Loop Stability for Appliance Application

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ABSTRACT

TLC59283 is a 16-channel constant-current LED driver which is widely use in household appliances market. As the control and indication function has become increasingly rich and diverse, multi-board system is the one of main design to address this requirement. And with that, the parasitic parameters become larger with the increasing of the trace and cable length. This can change the loop characteristics, especially for the current sink control loop. The increased parasitic inductance can lead to loop stability issues, in some specific application conditions, the high frequency harmonic can be observed on current sink and external FETs. This paper explains the cause of the high frequency harmonic and ringing, and also provide the design to solve the issues.

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Trademarks

1 Introduction of Time-Multiplexing With TLC59283

TI proposed a scheme to realize time-multiplexing with TLC59283 if there are not enough I/Os in the system to control the transistor, a block diagram similar to Figure 1-1 can be used to drive 64 LEDs. TLC59283 uses eight PNP transistors to switch the common lines and forms a 8-multiplexing scheme. The eight transistors are controlled by the outputs of the TLC59283 so it reduces the I/O count. The more details can be seen in *Use TLC59283 for LED Indication with Better Brightness Uniformity, Smaller Size, and Ghosting Elimination*.

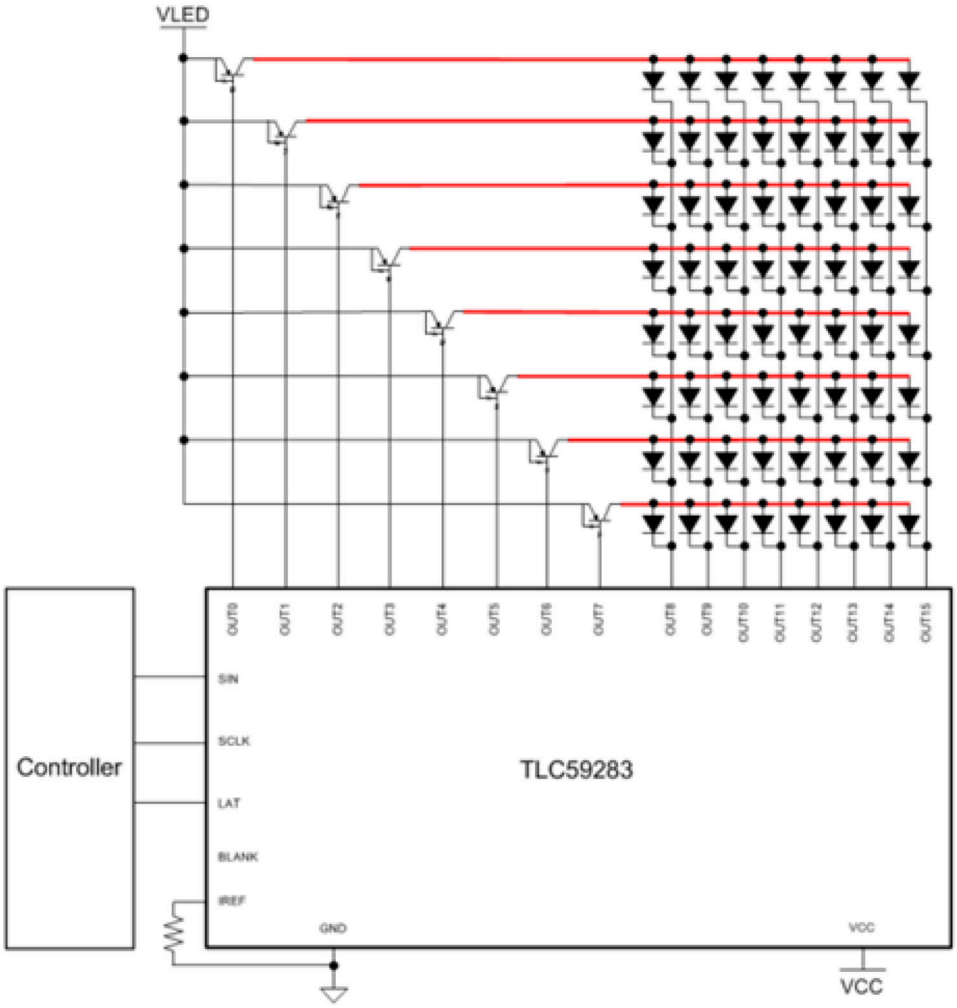

Figure 1-1. Time-Multiplexing Circuit Using TLC59283 With Less MCU I/Os

In the market of smart home appliances, the previous proposed scheme can cause output ringing since the leads are so long to result a relatively large parasitic inductance. This paper proposed a design for the ringing phenomenon and provided the result of simulation and bench test.

2 TLC59283 Ringing Simulation Assessment

The recommendation is to add capacitor in parallel at the output to reduce the output ringing. If possible, for best practices, connect a resistor in a series. Figure 2-1 shows the key parasitic inductance.

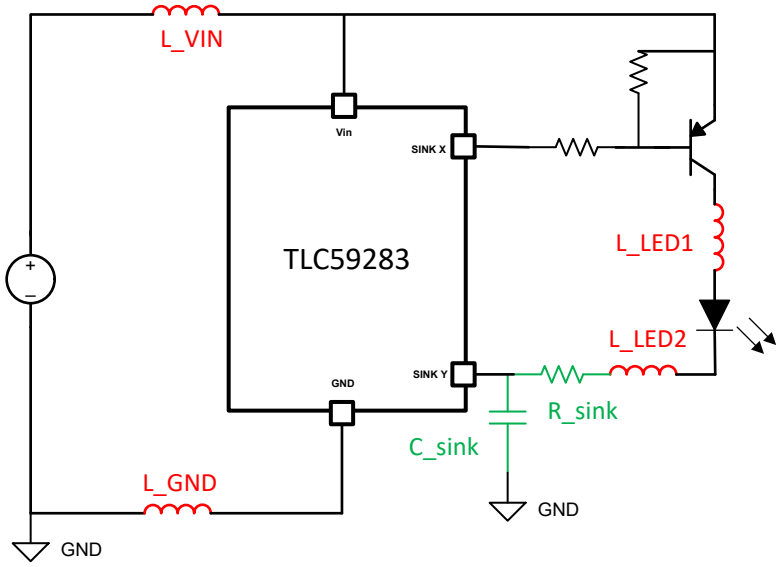

Figure 2-1. Key Parasitic Inductance

2.1 Small Parasitic Inductance of Vin and GND On-Board Without C_sink

Figure 2-2 is the simulation with ideal small parasitic inductance at the condition of L_VIN=20nH, L_GND=10nH, L_LED1=10nH, L_LED2=10nH, Vin=5 V.

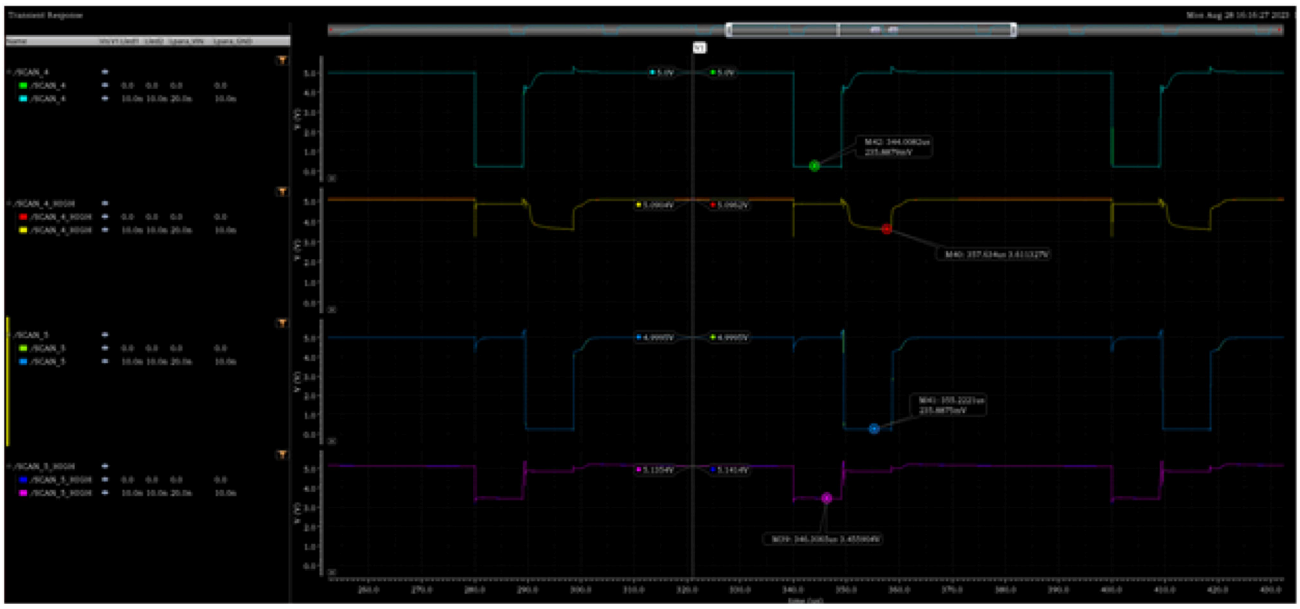

Figure 2-2. Small Parasitic Inductance of Vin and GND On-Board Without C_sink

2.1.1 Only Add L_LED1

Only add L_LED1, ringing starts to appear when L_LED1 > 610nH

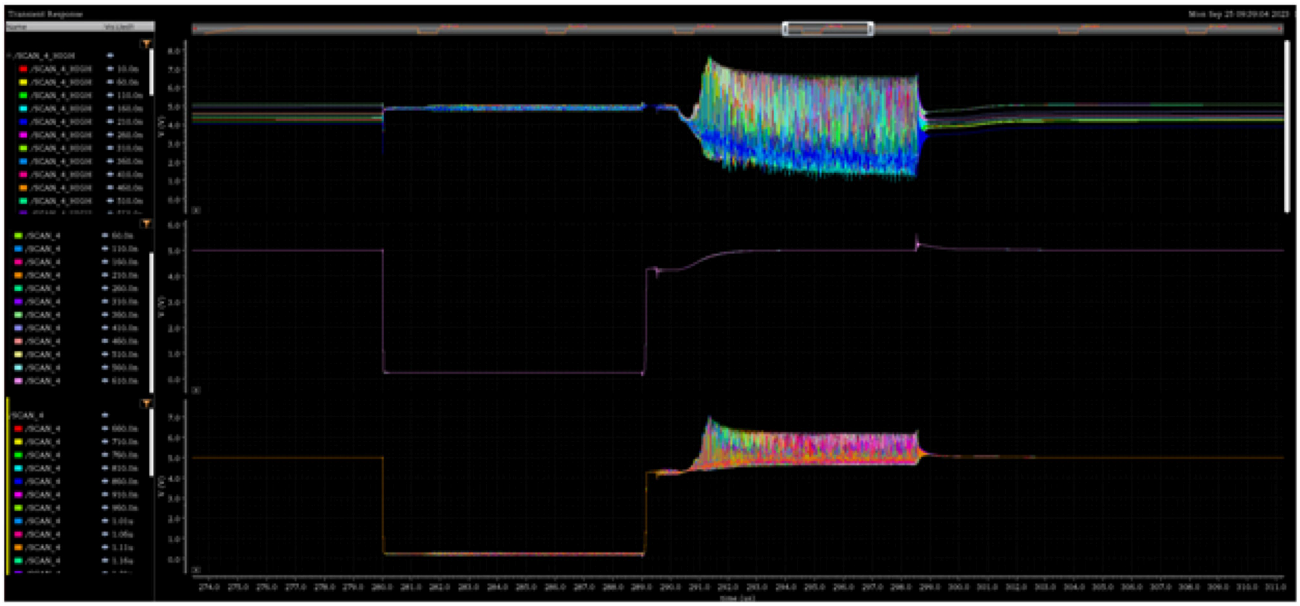

Figure 2-3. Only Add L_LED1 Without C_sink in Parasitic Inductance

2.1.2 Only Add L_LED2

Only add L_LED2, ringing starts to appear when L_LED2 > 560nH.

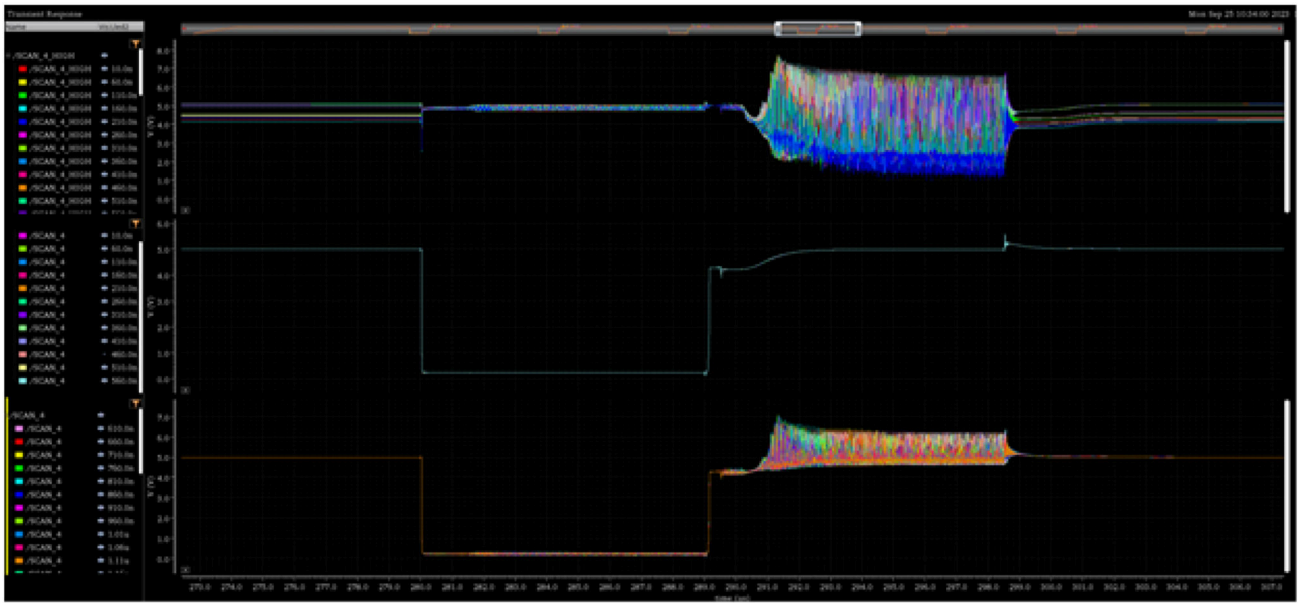

Figure 2-4. Only add L_LED2 without C_sink in Parasitic Inductance

2.2 Parasitic Inductance of Vin and GND On-Board With 4.7nF C_sink

2.2.1 L_LED1 Reach 3uH

The conditions are still at Vin=5V, L_VIN=20nH, L_GND=10nH, L_LED2=10nH, only add L_LED1, ringing does not appear even when L_LED1 reaches 3uH.

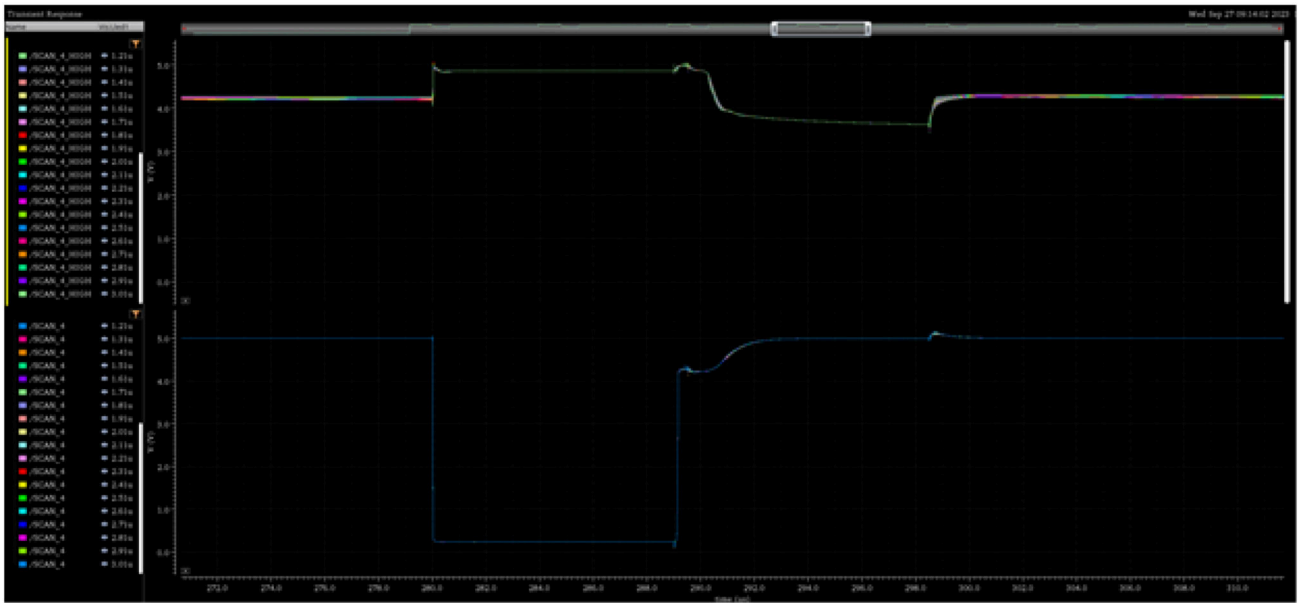

Figure 2-5. Only add L_LED1 with C_sink in Parasitic Inductance

2.2.2 L_LED2 Reach 3uH

The conditions are still at Vin=5 V, L_VIN=20nH, L_GND=10nH, L_LED2=10nH, only add L_LED1, ringing does not appear even when L_LED1 reaches 3uH.

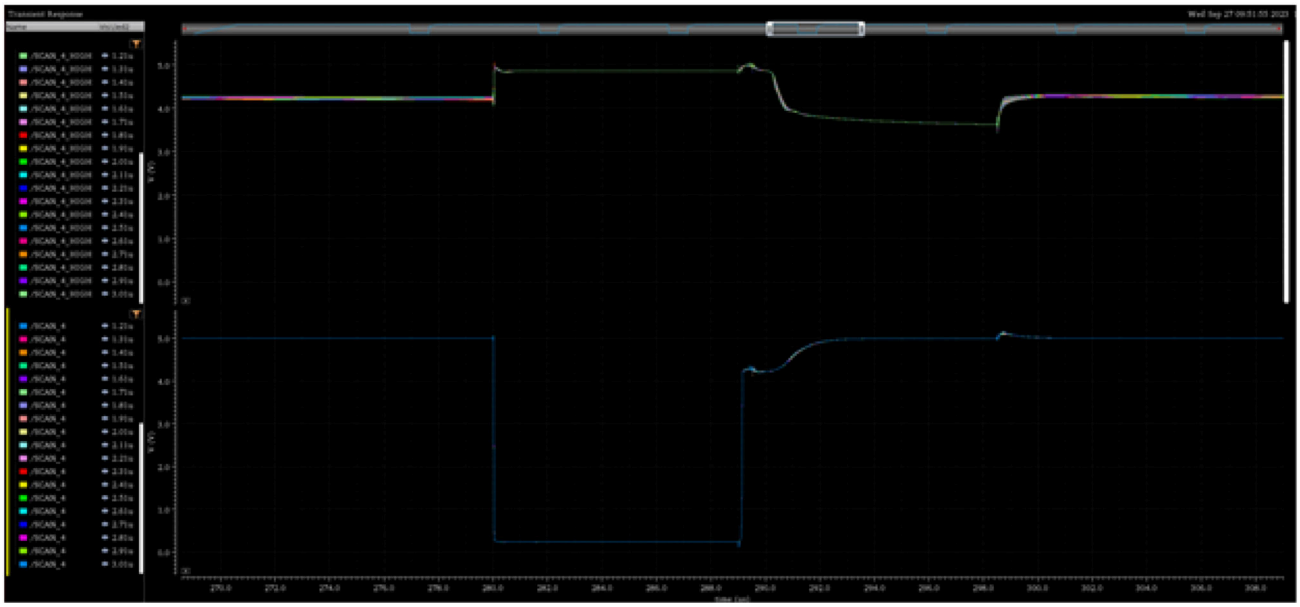

Figure 2-6. Only Add L_LED2 With C_sink in Parasitic Inductance

2.3 Parasitic Inductance of Vin and GND on Customer's Board Without C_sink

Vin=5V, L_VIN=100nH, L_GND=80nH, L_LED1=10nH, L_LED2=10nH

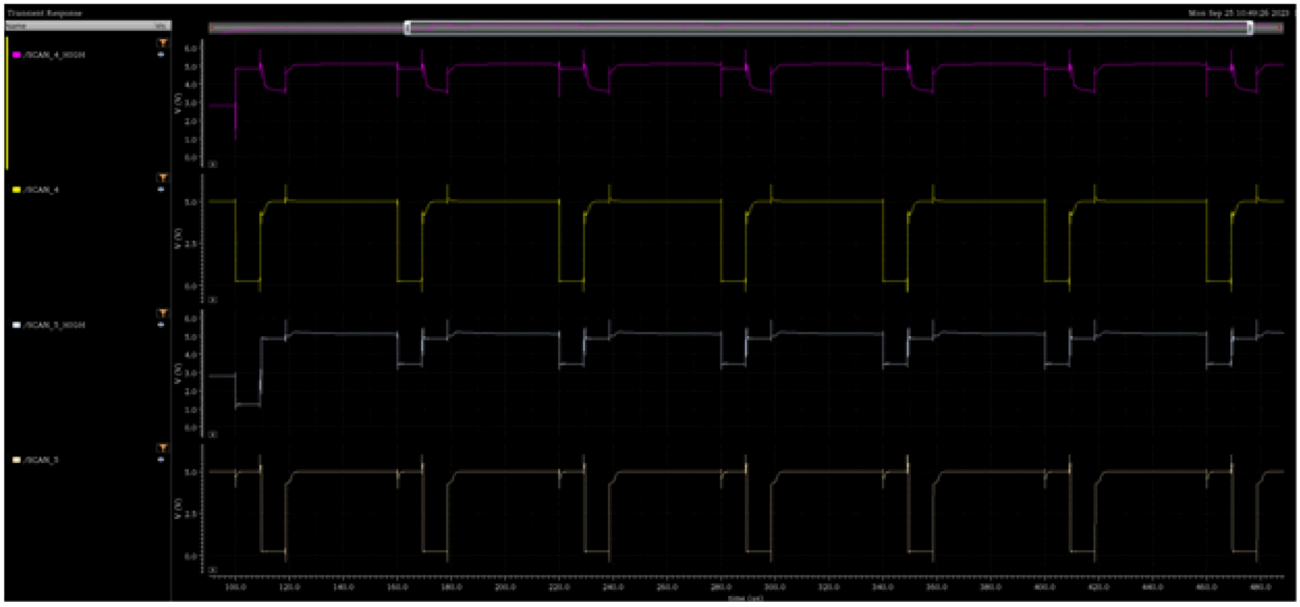

Figure 2-7. The parasitic inductance of Vin&GND on customer's board without C_sink

2.3.1 Only Add L_LED1

Only add L_LED1, ringing starts to appear when L_LED1 > 370nH

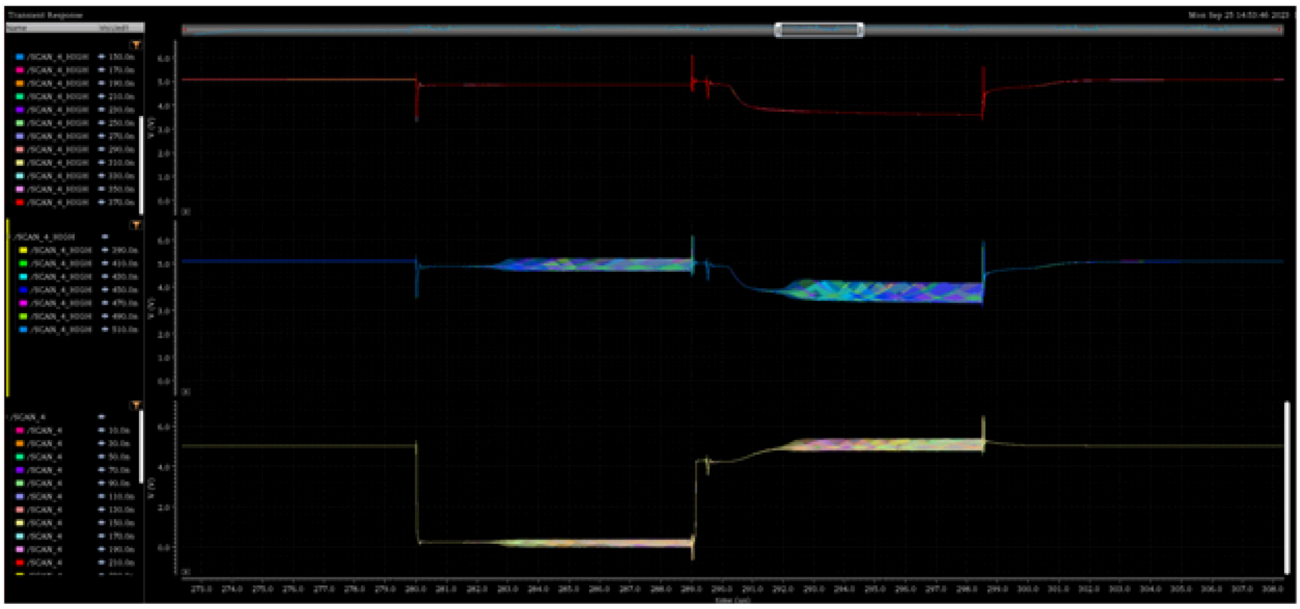

Figure 2-8. Only add L_LED1 on Customer's Board Without C_sink

2.3.2 Only Add L_LED2

Only add L_LED2, ringing starts to appear when L_LED2 > 370nH

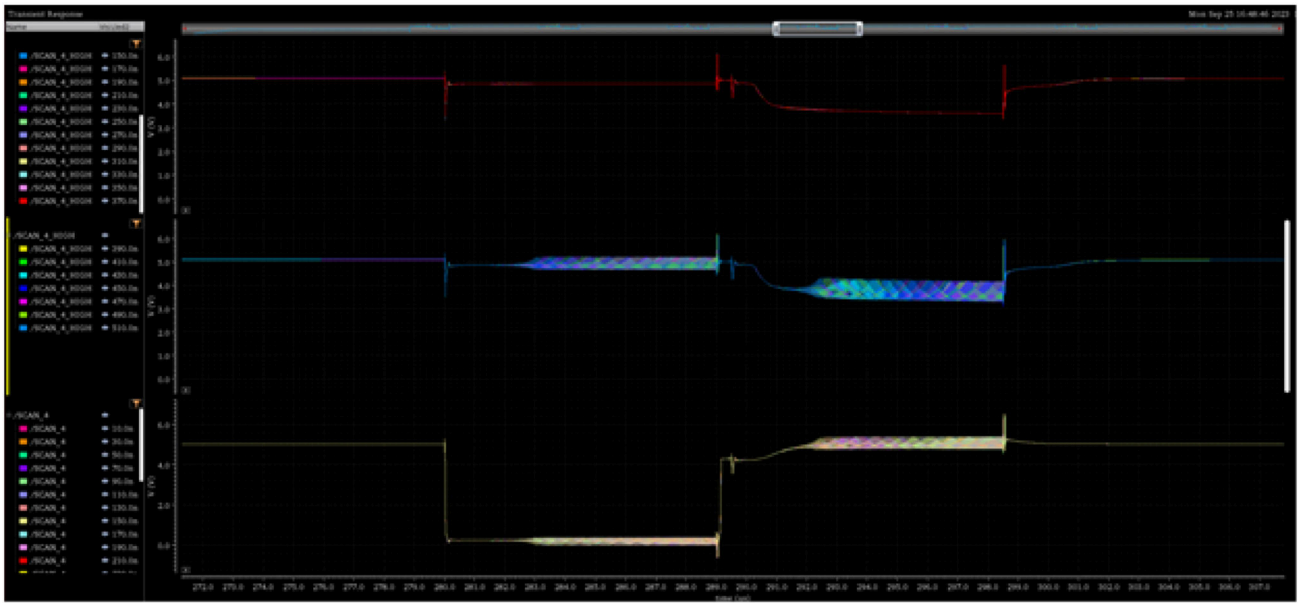

Figure 2-9. Only Add L_LED2 on Customer's Board Without C_sink

2.3.3 Add L_LED1 and L_LED2

Only L_LED1 and L_LED2 of the same values, ringing starts to appear when L_LED1 = L_LED2 = 200nH

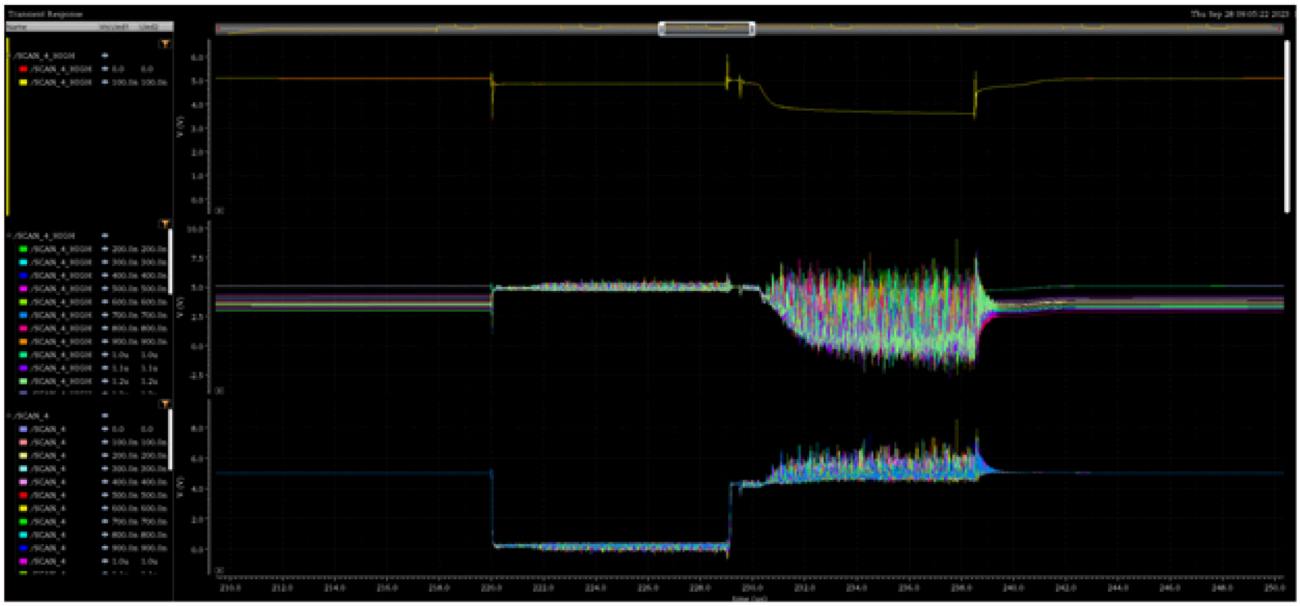

Figure 2-10. Add L_LED1 and L_LED2 on Customer's Board Without C_sink

2.4 Parasitic Inductance of Vin and GND on Customer's Board With 4.7nF C_sink

Vin=5V, L_VIN=100nH, L_GND=80nH, add L_LED1 and L_LED2 of the same values, ringing does not appear even when L_LED1 and L_LED2 reaches 3uH.

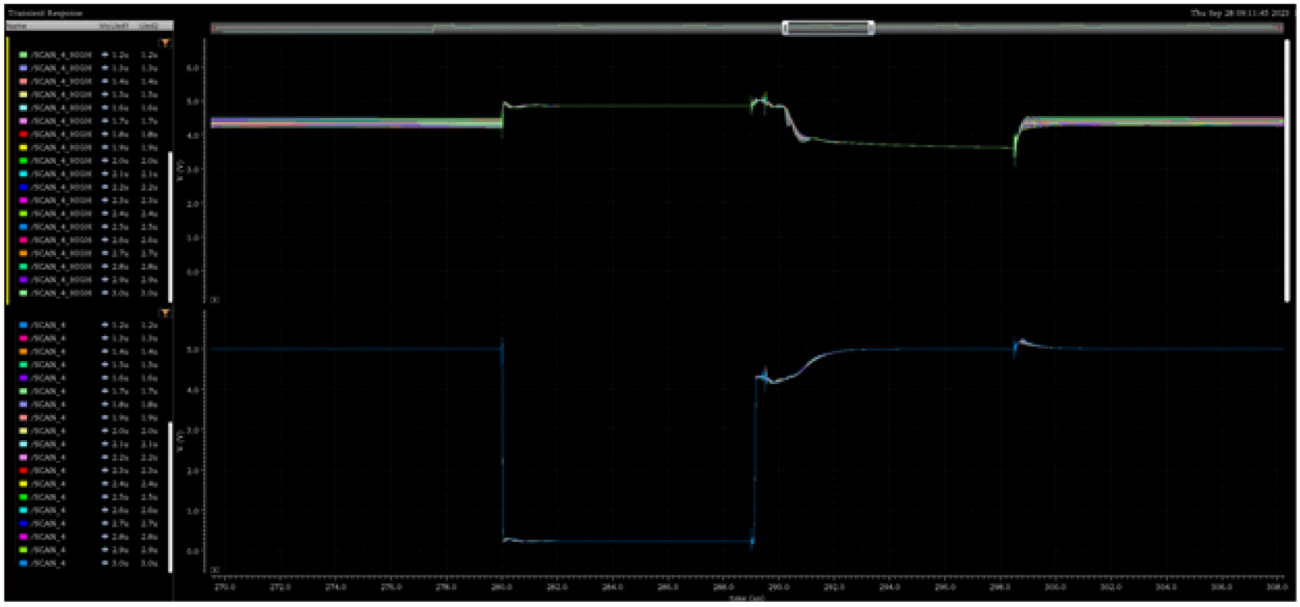

Figure 2-11. Parasitic Inductance of Vin and GND on Customer's Board with C_sink

3 TLC59283 Ringing Bench Assessment

A long-term external light board was used to simulate the situation where the parasitic inductance is relatively large on the EVM board. Then, the waveform were captured with and without the RC filter circuit.

3.1 Bench Test Without R_sink and C_sink

Figure 3-1. Bench Test Without R_sink and C_sink

3.2 Bench Test With 1nF C_sink

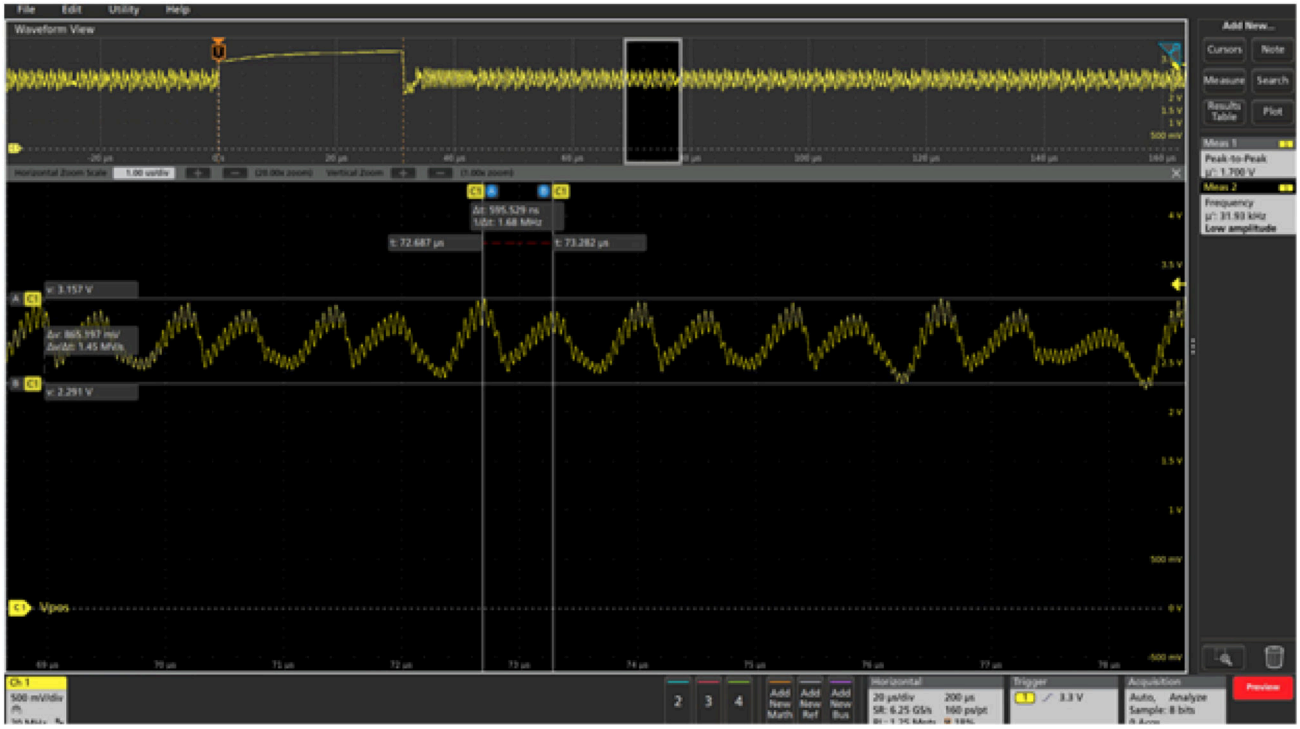

Figure 3-2. Bench Test With 1nF C_sink

3.3 Bench Test With 10nF C_sink

Figure 3-3. Bench Test With 10nF C_sink

3.4 Bench Test With 150 Ω R_sink

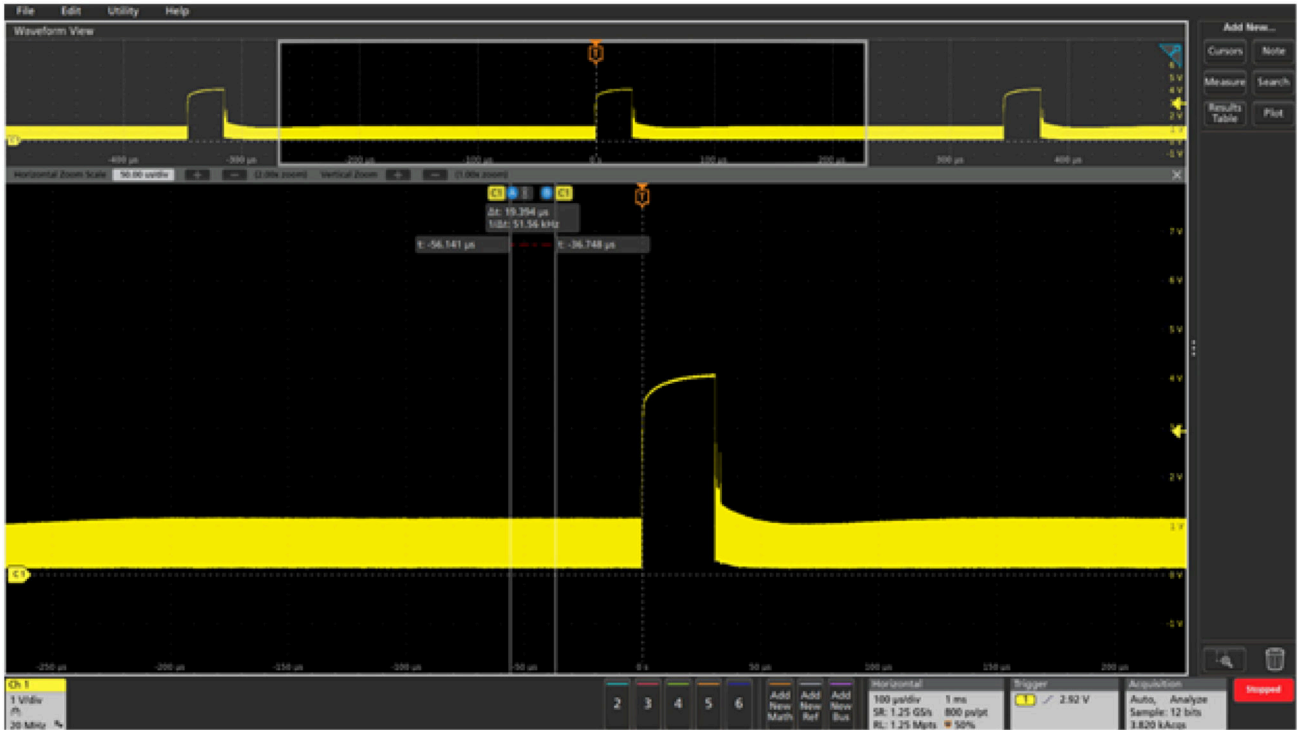

Figure 3-4. Bench Test With 150 Ω R_sink

3.4.1 Bench Test With 10nF C_sink and 150 Ω R_sink

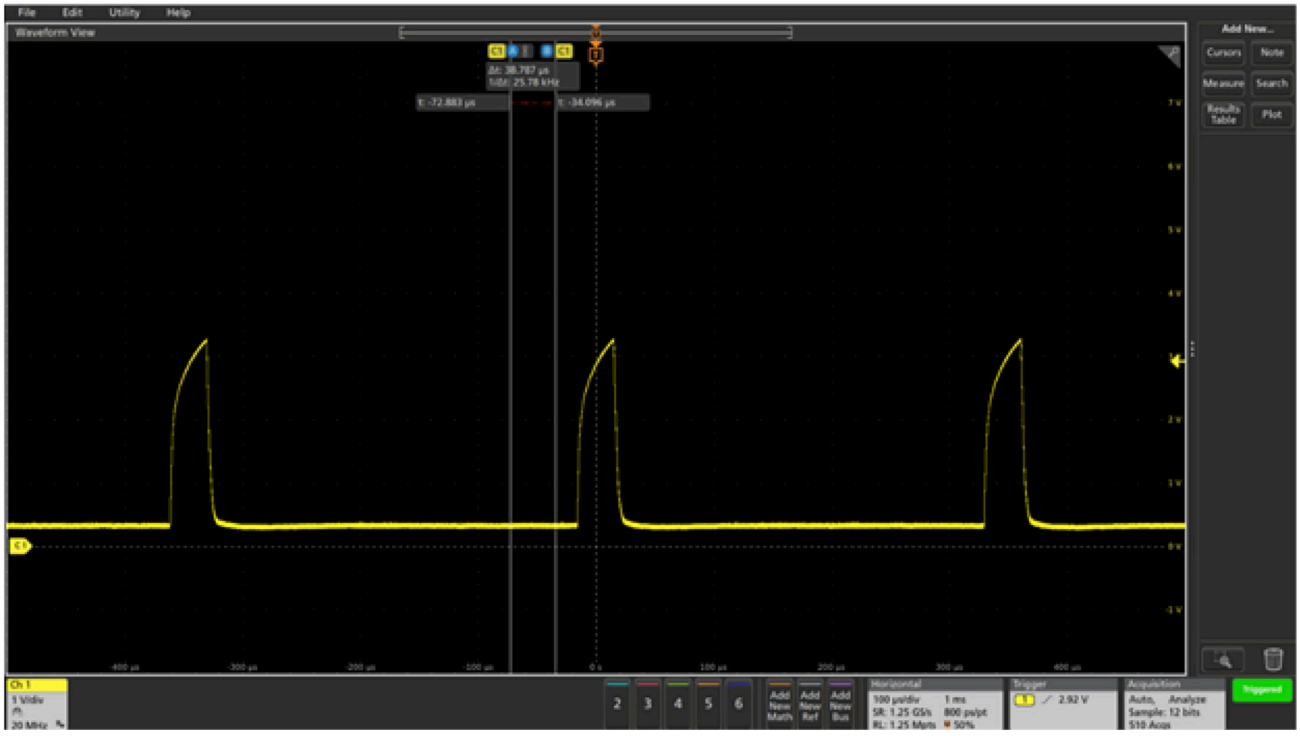

Figure 3-5. Bench Test With 10nF C_sink and 150 Ω R_sink

4 Calculation of Resistor Value in RC Circuit

Usually, the value of the series resistor is determined by the setting current. The voltage dropped on the output pin needs to satisfy the requirement minimum headroom voltage.

We assume the minimum headroom voltage of output is 0.5 V. Therefore, the calculation needs to

$$V_o = V_{LED} - V_d - V_f - I_{set}{}^*R > 0.5\text{V} \quad (1)$$

V_o	The output voltage
V_{LED}	The voltage of VLED
V_d	The voltage dropped on the BJT
V_f	The forward voltage of LED
I_{set}	The setting current
R	The value of series resistor

5 Summary

A relatively larger parasitic inductance does cause TLC59283 output ringing, but this can be solved by adding an RC circuit. We recommend to connect a 10 nF capacitor in parallel and connect a resistor in series with the output. The value of series resistor can be referred below calculation.

6 References

- Texas Instruments, *TLC59283, 16-Channel, Constant-Current LED Driver with Pre-Charge FET*, data sheet.
- Texas Instruments, *Use TLC59283 for LED Indication with Better Brightness*, data sheet.

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