TPS61390 Boost Converter With Low APD Bias Voltage Ripple

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ABSTRACT

The APD bias voltage ripple should be very small to measure the photodiode current precisely. The power supply switching noise associated with the switching power supply can interfere with the photodiode DC measurement. This application report presents the TPS61390 boost converter, which has a very low APD bias voltage ripple.

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Trademarks

1 Introduction

The TPS61390 device is a fully-integrated boost converter with an 85-V FET to convert a low-input voltage to a higher voltage for biasing the APD. The TPS61390 device supports an input voltage ranging from 2.5 V to 5.5 V. The device operates at DCM mode even at the heavy load condition. The TPS61390 device integrates a high-side LDO to further decrease the APD bias voltage ripple. By proper design, the voltage ripple at the APD pin is only around one twentieth of the ripple at V_{out}.

This application report calculates and tests the TPS61390 output voltage ripple and the APD bias voltage ripple at different APD current condition. The tests were done on the TPS61390 evaluation board.

2 Device Calculation

Figure 1 shows the Inductor current waveform of the Boost converter at DCM mode.

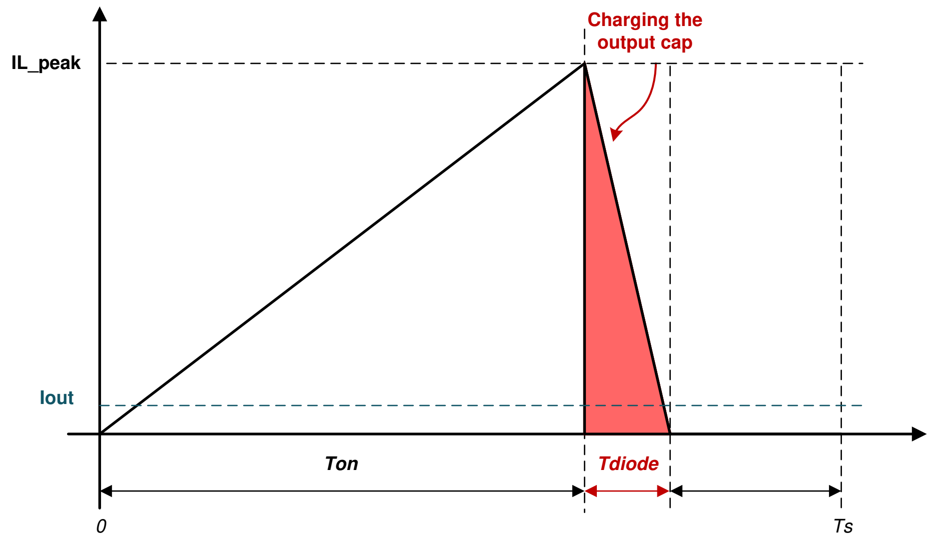

Figure 1. Inductor Current Waveform of the Boost Converter at DCM Mode

The duty cycle of the boost converter under DCM mode considering efficiency can be calculated by Equation 1:

$$D = \sqrt{\frac{\left(V_o^2 - V_o \times \eta \times V_{in}\right) \times 2 \times L}{R_o \times T_s \times \eta^2 \times V_{in}^2}} \tag{1}$$

So the peak inductor current can be calculated by Equation 2:

$$IL_{peak} = \frac{V_{in} \times D \times T_s}{L} \tag{2}$$

When the low side FET off, this peak inductor current will charge up the output capacitors with Equation 3:

$$\Delta V_{o\_charge} = \frac{\left(\frac{IL_{peak}}{2} - I_o\right) \times IL_{peak} \times L}{C_{out} \times \left(V_o - V_{in}\right)} \tag{3}$$

The ESR and the discharge during output rectifier diode off also contribute to the output ripple.

$$\Delta V_{o\_discharge} = \frac{I_o}{C_{out}} \times \left(T_s - \frac{IL_{peak} \times L}{V_o - V_{in}}\right) \tag{4}$$

$$\Delta V_{o\_ESR} = IL_{peak} \times ESR_{Cout} \tag{5}$$

When V_{in} = 3.3 V, V_o = 36 V, 140-mV output ripple voltage is obtained with 2-mA load current based on the TPS61390 evaluation board. The effective output capacitance is around 60 nF under 36-V DC bias. The test results are in accordance with the calculated result from the previous equations.

The output of the boost converter can be followed by an RC filter to further reduce the ripple. A 100-Ω, 0.1-µF RC filter is used on the TPS61390 evaluation board to reduce the voltage ripple at the MONIN pin. The TPS61390 device integrates a high-voltage LDO inside, and makes the APD bias voltage ripple at least 10 times smaller than that of the MONIN pin. Thus, the voltage ripple at the APD pin is only around one twentieth of the ripple at the output side. In the V_{in} = 3.3 V, V_o = 36 V, 2-mA APD current application, the APD bias voltage ripple is only around 7 mV.

3 Test Result

Figure 2 through Figure 5 show the APD bias voltage ripple under 48-V APD bias voltage. It is evident that the ripple voltage is very low, much less than 10-mV, even with 4-mA APD current.

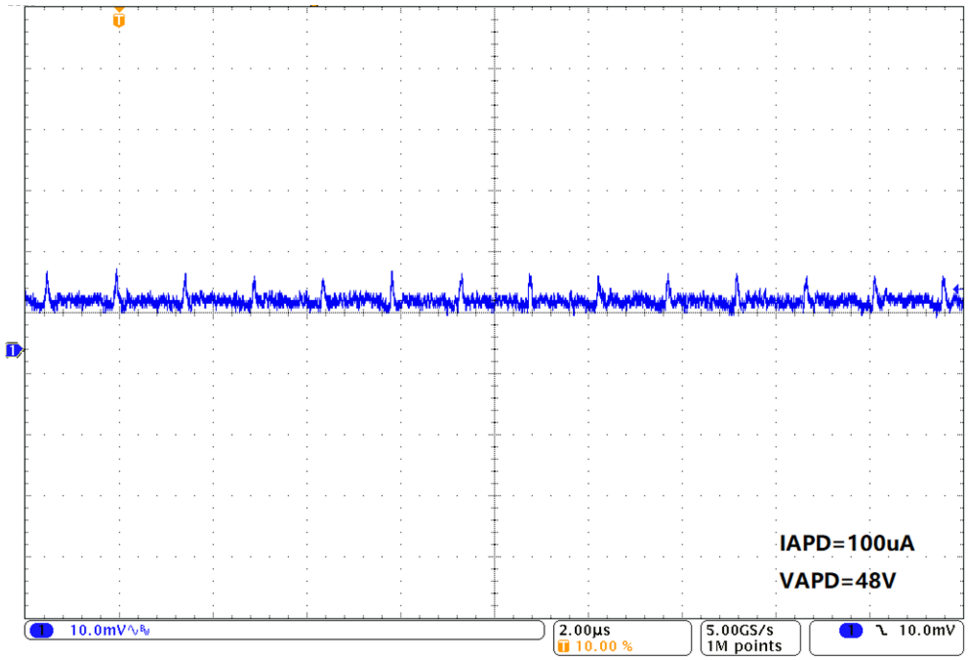

Figure 2. APD Bias Voltage Ripple at 100-µA APD Current (V_o = 48 V)

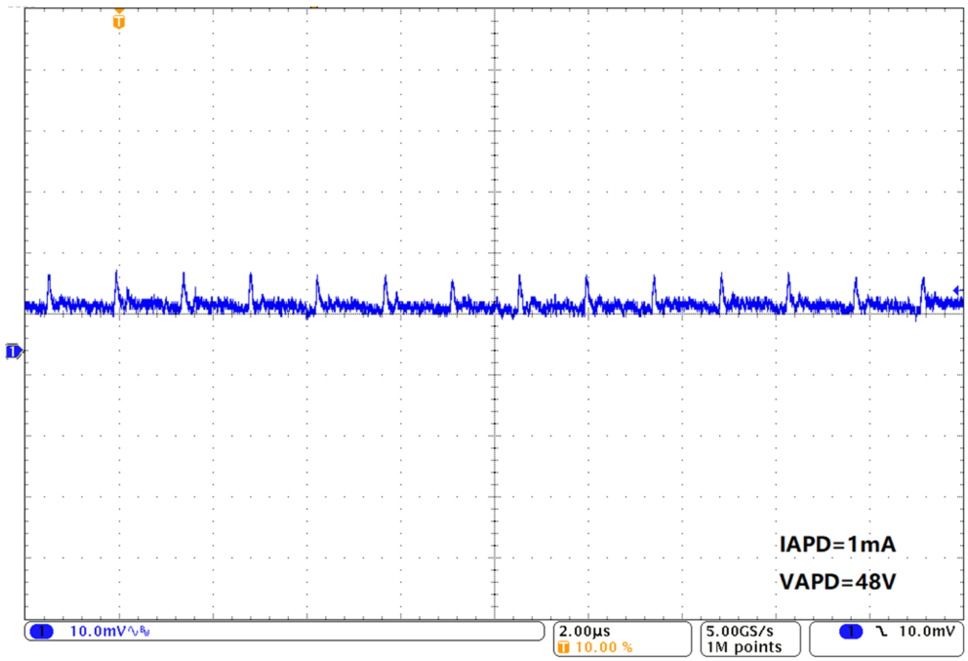

Figure 3. APD Bias Voltage Ripple at 1-mA APD Current (V_o = 48 V)

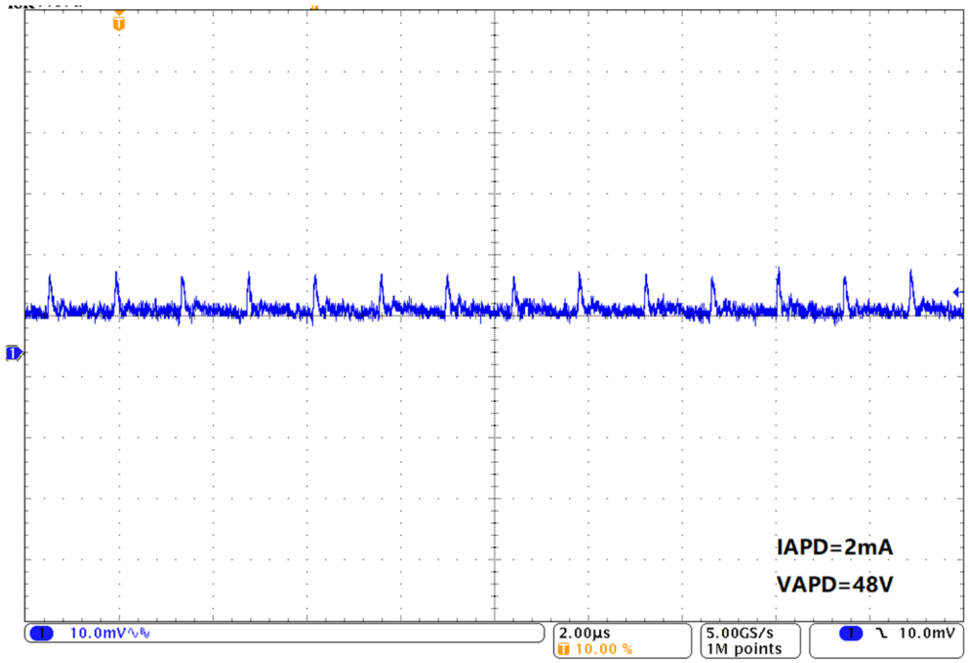

Figure 4. APD Bias Voltage Ripple at 2-mA APD Current (V_o = 48 V)

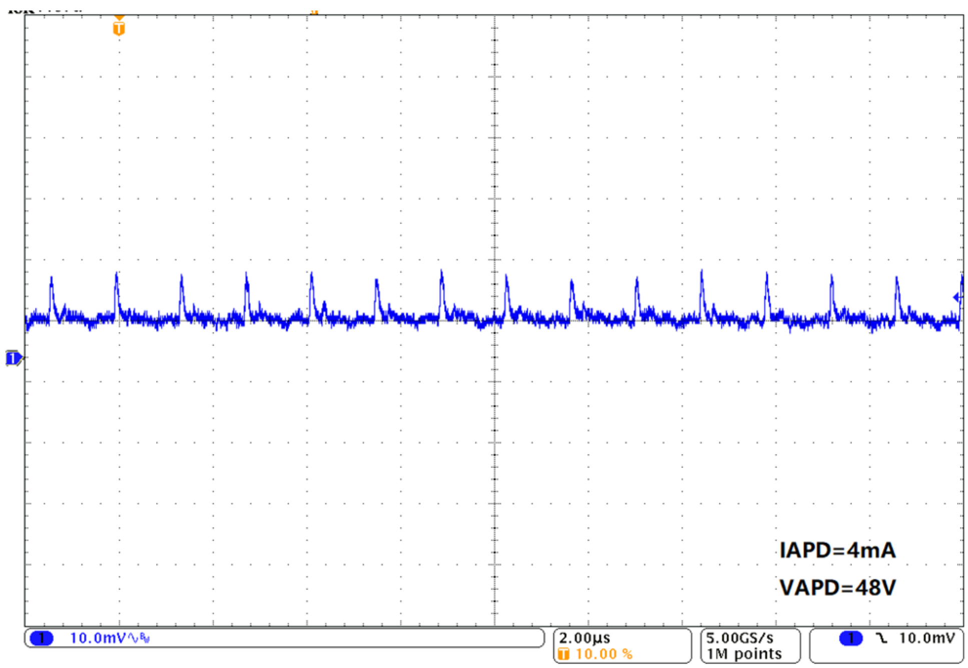

Figure 5. APD Bias Voltage Ripple at 4-mA APD Current (V_o = 48 V)

Figure 6 shows the boost stage output voltage ripple under 36-V APD bias voltage and 2-mA APD current. The boost stage output ripple is around 140 mV, which is quite high.

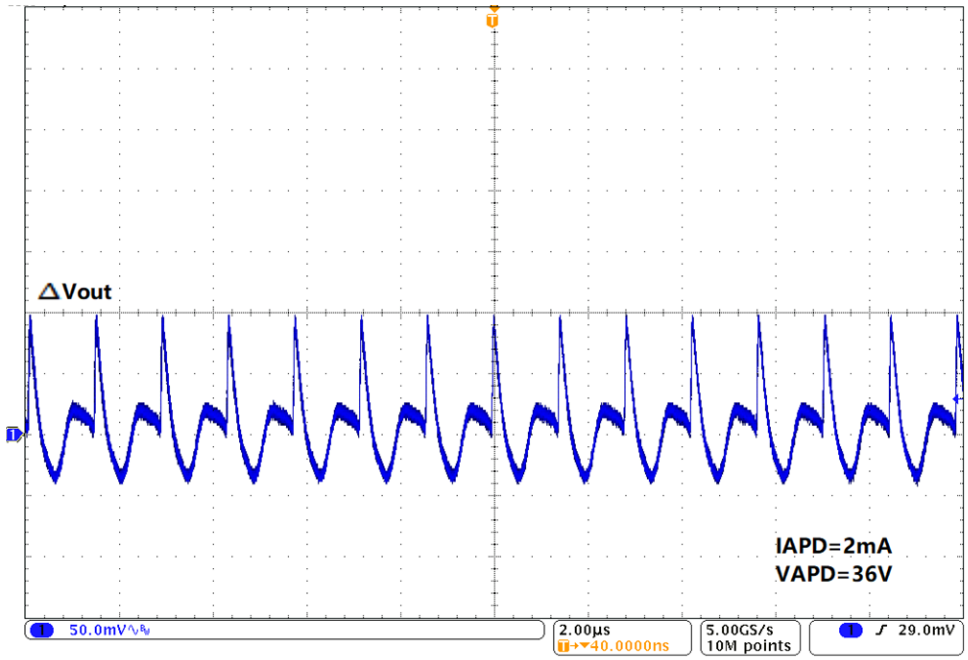

Figure 6. Output Voltage Ripple at 2-mA APD Current (V_o = 36 V)

Figure 7 and Figure 8 show the APD bias voltage ripple under 36-V APD bias voltage. The ripple voltage is very low, only around 5 mV with 2-mA APD current.

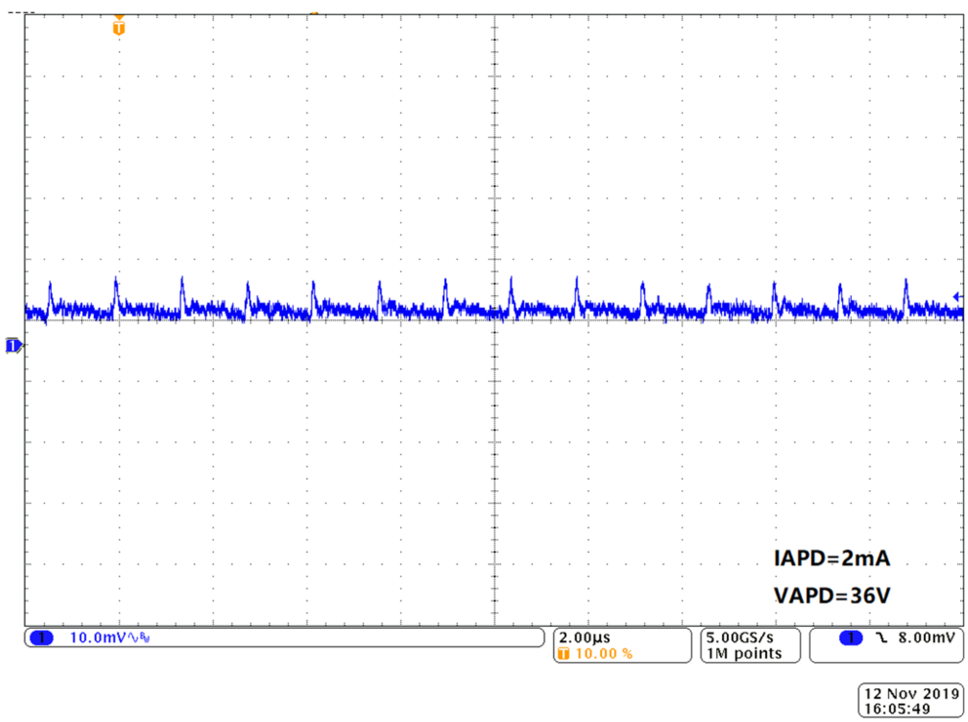

Figure 7. APD Bias Voltage Ripple at 2-mA APD Current (V_o = 36 V)

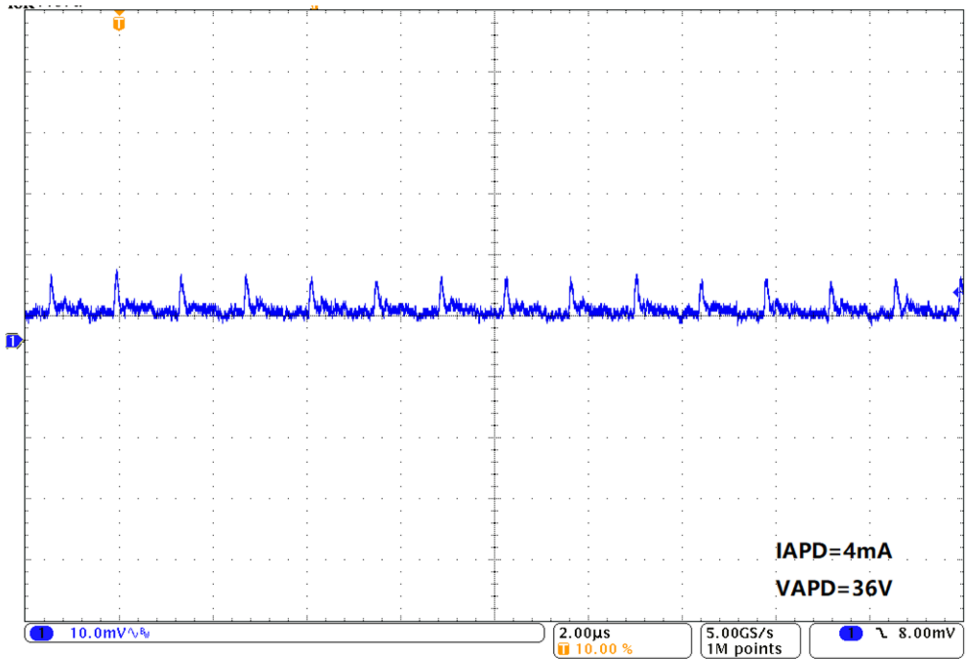

Figure 8. APD Bias Voltage Ripple at 4-mA APD Current (V_o = 36 V)

4 Summary

This application report describes why the TPS61390 boost converter can achieve a very small APD bias voltage ripple. A 100-Ω, 0.1-µF RC filter connects between the output and the MONIN pin can help to filter the output voltage ripple. An integrated high side LDO followed by the MONIN pin can further decrease the voltage ripple. So the APD bias voltage ripple is only around one twentieth of the output voltage ripple.

5 References

- Texas Instruments, *TPS61390 85-V_{OUT} Boost Converter With Current Mirror and Sample / Hold Data Sheet*
- Texas Instruments, *TPS61391 85-V_{OUT} Boost Converter with Current Mirror Integrated Data Sheet*