AN-2169 LMZ10501 and LMZ10500 SIMPLE SWITCHER® Nano Module Low Output Ripple Designs

ABSTRACT

The LMZ10501 and LMZ10500 SIMPLE SWITCHER nano modules are easy-to-use DC-DC solutions optimized for space-constrained applications. The LMZ10501 is capable of driving up to 1A load with excellent power conversion efficiency, line and load regulation. The LMZ10500 is a 650mA version module and is pin-to-pin compatible with the LMZ10501.

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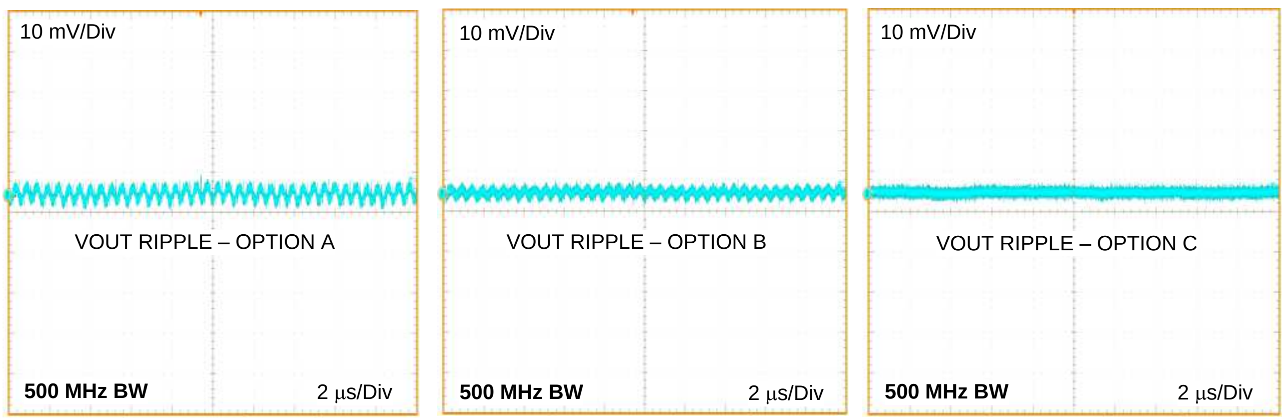
1 Introduction

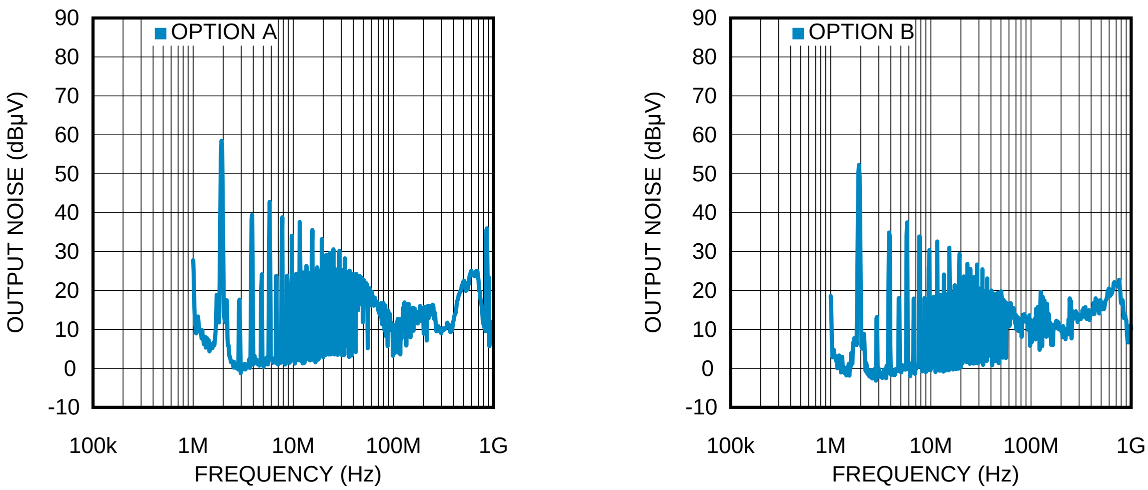
The LMZ10501 and LMZ10500 can deliver output voltage with exceptionally low output ripple. This application report demonstrates how to achieve output voltage ripple in the 4mV – 10mV pk-pk range. There are three different configurations that can be used, based on the application's ripple requirements: Section 3.1 is the default evaluation board configuration with 10mV pk-pk ripple, Section 3.2 achieves 6mV pk-pk of ripple, and Section 3.3 demonstrates ripple configuration at 4mV pk-pk. In addition, this document provides several tips and tricks on how to measure small amplitude ripple on a typical lab bench.

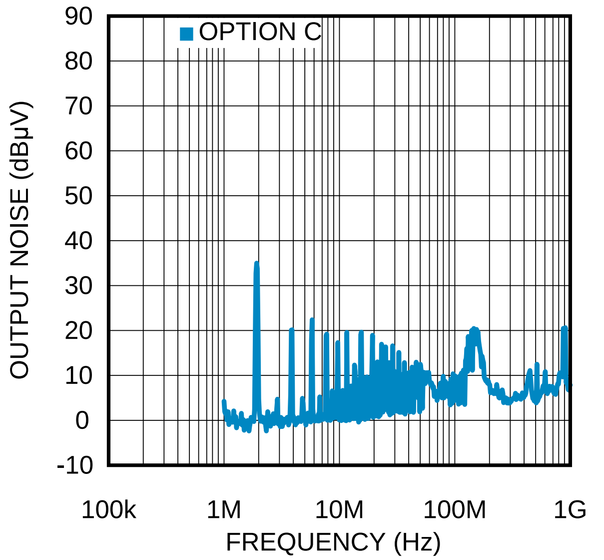
2 Board Specifications

- V_{IN} = 2.7V to 5.5V
- V_{OUT} = 1.8V
- 1A max load
- 2MHz switching frequency
- 4 layers PCB with 1oz copper
- 4.3 x 4.3 cm (1700 x 1700 mil) PCB size

3 Low Output Ripple Options







3.1 Output Ripple Option A

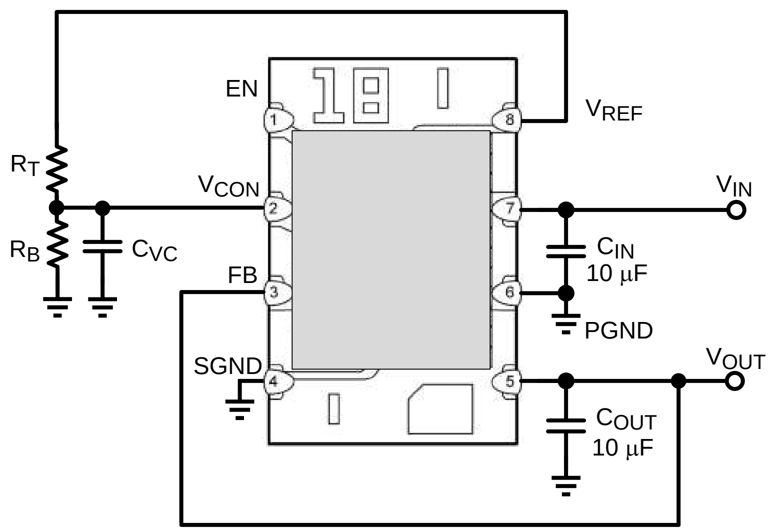


Figure 1. Schematic for Design A

Table 1. LMZ10501 and LMZ10500 Bill of Materials (BOM), V_{IN} = 2.7V to 5.5V, V_{OUT} = 1.8V, $I_{OUT\ (MAX)}$ = 1000mA / 650mA

Quantity	Designator	Description	Case Size	Manufacturer	Manufacturer P/N
1	U1	SIMPLE SWITCHER Nano Module	SE08A	Texas Instruments	LMZ10501SE or LMZ10500SE
2	C_{IN}, C_{OUT}	10 µF, X5R, 10V	0805	KEMET	C0805C106K8PACTU
1	C_{VC}	1000 pF	0603	TDK	C1608C0G2A102J
1	R_B	82.5 kΩ	0603	Vishay-Dale	CRCW060382K5FKEA
1	R_T	187 kΩ	0603	Vishay-Dale	CRCW0603187KFKEA

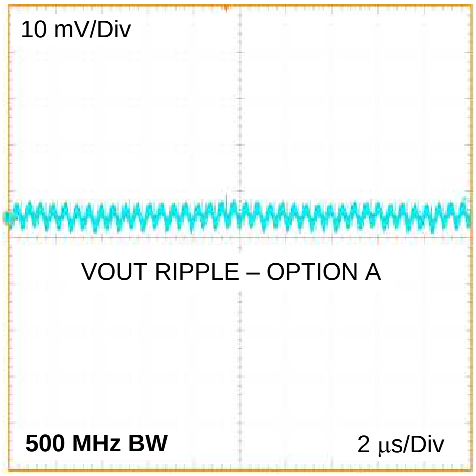


Figure 2. Output Voltage Ripple Design A
V_{IN} = 5V, I_{OUT} = 1A

3.2 Output Ripple Option B

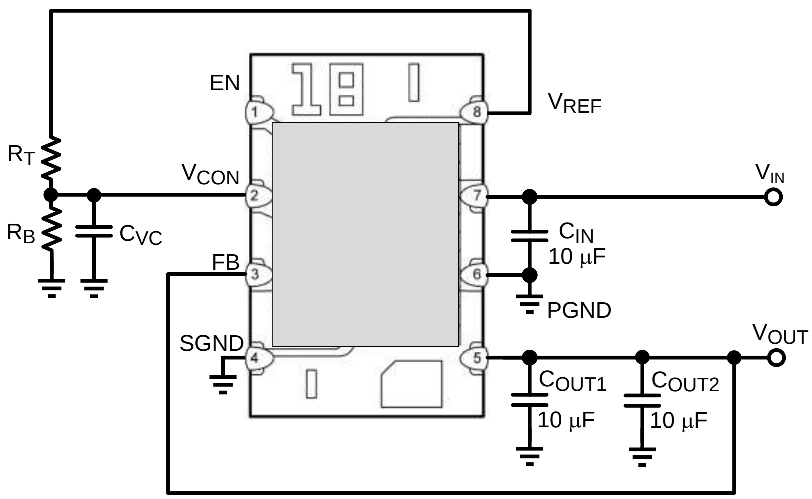


Figure 3. Schematic for Design B

Table 2. LMZ10501 and LMZ10500 Bill of Materials (BOM), V_{IN} = 2.7V to 5.5V, V_{OUT} = 1.8V, $I_{OUT\ (MAX)}$ = 1000mA / 650mA

Quantity	Designator	Description	Case Size	Manufacturer	Manufacturer P/N
1	U1	SIMPLE SWITCHER Nano Module	SE08A	Texas Instruments	LMZ10501SE or LMZ10500SE
3	C_{IN}, C_{OUT1}, C_{OUT2}	10 µF, X5R, 10V	0805	KEMET	C0805C106K8PACTU
1	C_{VC}	1000 pF	0603	TDK	C1608C0G2A102J
1	R_B	82.5 kΩ	0603	Vishay-Dale	CRCW060382K5FKEA
1	R_T	187 kΩ	0603	Vishay-Dale	CRCW0603187KFKEA

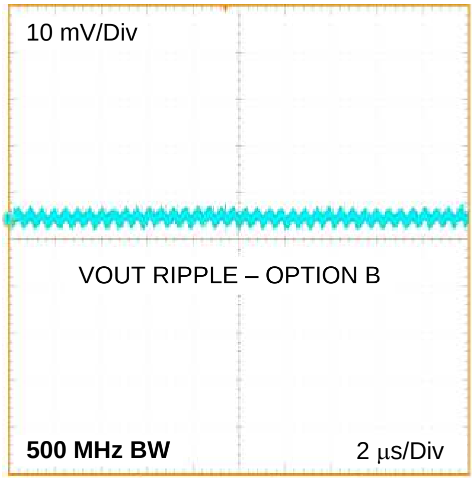


Figure 4. Output Voltage Ripple Design B
V_{IN} = 5V, I_{OUT} = 1A

3.3 Output Ripple Option C

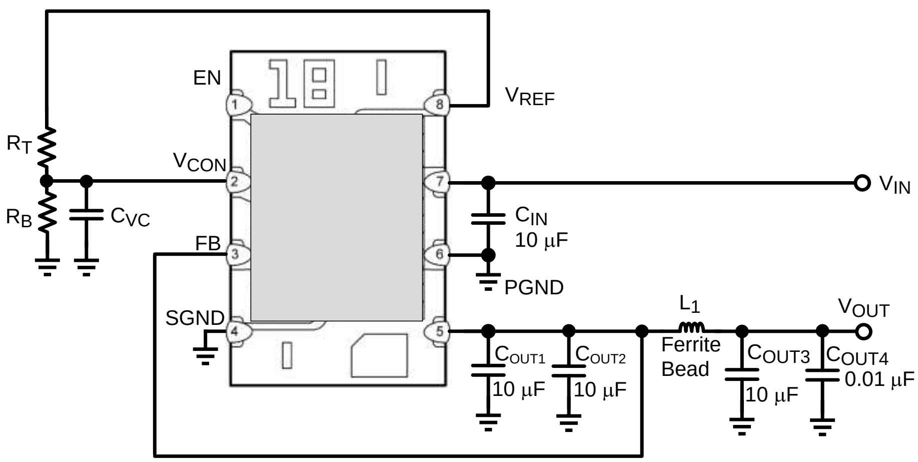


Figure 5. Schematic for Design C

Table 3. LMZ10501 and LMZ10500 Bill of Materials (BOM), V_{IN} = 2.7V to 5.5V, V_{OUT} = 1.8V, $I_{OUT\ (MAX)}$ = 1000mA / 650mA

Quantity	Designator	Description	Case Size	Manufacturer	Manufacturer P/N
1	U1	SIMPLE SWITCHER Nano Module	SE08A	Texas Instruments	LMZ10501SE or LMZ10500SE
4	C_{IN}, C_{OUT1}, C_{OUT2}, C_{OUT3}	10 µF, X5R, 10V	0805	KEMET	C0805C106K8PACTU
1	C_{OUT4}	0.01 µF	0805	Johanson Dielectrics Inc	500R15W103KV4T
1	C_{VC}	1000 pF	0603	TDK	C1608C0G2A102J
1	L_1	100Ω at 100MHz Ferrite bead	0805	TDK	MPZ2012S101A
1	R_B	82.5 kΩ	0603	Vishay-Dale	CRCW060382K5FKEA
1	R_T	187 kΩ	0603	Vishay-Dale	CRCW0603187KFKEA

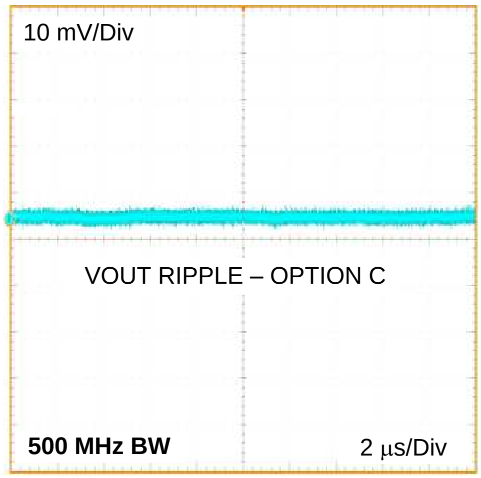


Figure 6. Output Voltage Ripple Design C
V_{IN} = 5V, I_{OUT} = 1A

4 Tips and Tricks for Output Ripple Measurements

Taking proper output ripple measurements can be challenging. It is important to have a probe with a small ground loop to avoid picking up noise. One way to take a proper measurement is shown in Figure 7. The 10x oscilloscope probe on the left has its ground wire forming a large loop which acts as an antenna and picks up noise. Such measurements will show high spikes on the oscilloscope screen. It is possible to improve this measurement by reducing the area of the ground loop. This is done by using a piece of bare wire and wrapping it around the scope probe's ground like shown in Figure 7. The probe is then inserted in hollow turret points mounted across the output capacitor. This 10x probe is adequate for measuring noise down to the 10mV range.

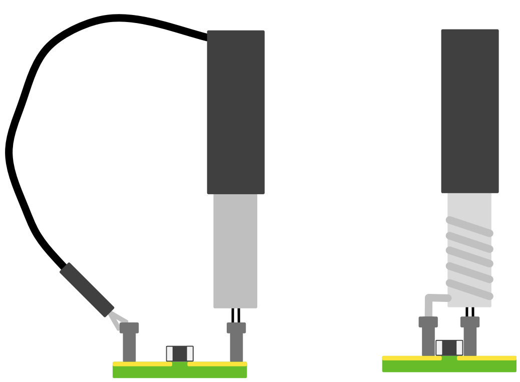


Figure 7. Oscilloscope 10X Probe

A simple, custom made 1x probe can be used for measurements under 10mV. This probe is shown below in Figure 8. A piece of coaxial cable is laid flat against the board and soldered directly to the output capacitor of the switching regulator. The coaxial cable then connects to a small board which has a series 0.1µF AC coupling (DC blocking) capacitor. The other end of the coupling capacitor board connects to a coaxial cable which connects to an external 50Ω termination on the scope channel. One can also use the internal 50Ω termination on the scope. The measurements for the three designs in this application report were taken using a probe like the one shown in . The AC coupling capacitor and the 50Ω termination form a high pass filter with a cutoff frequency at 1 / (2πRC). In this case, the capacitor is 0.1µF which results in a cutoff frequency at 31.8kHz. Since the switching frequency of the regulator in the three designs is at 2MHz, this cutoff frequency is suitable for output ripple measurements.

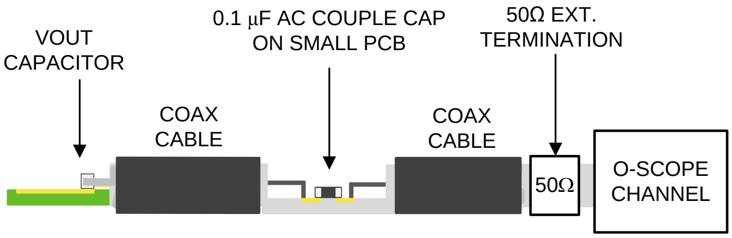


Figure 8. Custom 1X Low Noise Probe Diagram

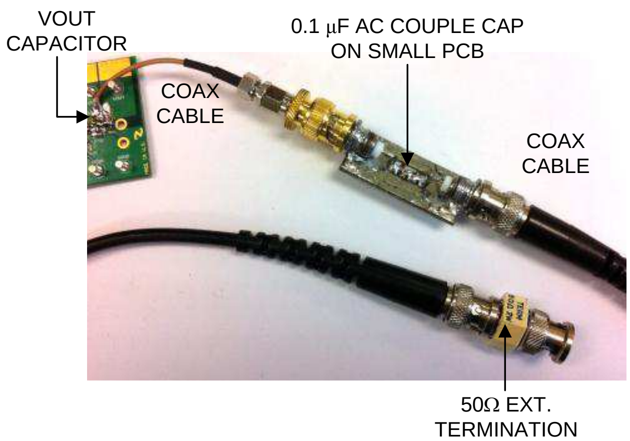


Figure 9. Custom 1X Low Noise Probe Picture