Lab:

LCR Meter

Now that you have built your inductor, characterize it using an LCR meter as follows: ← 39.1 μF real

36μF

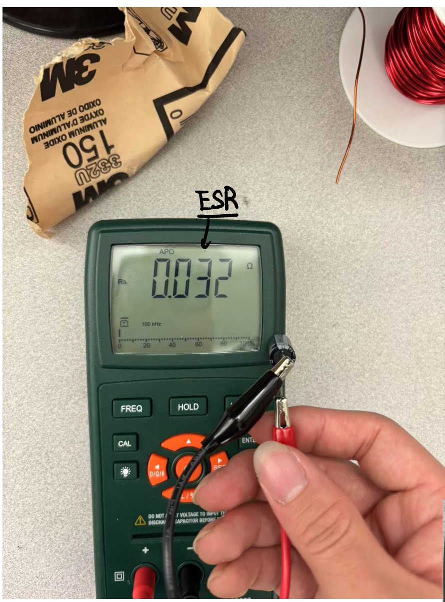
1. Measure your inductor's inductance at low frequency, and compare it to your design value. If your inductance measurement is significantly off, double check your inductance calculation and your shim stock thickness. The acceptable range for your characterized inductance is 100-110% the minimum value needed to meet the ripple specifications.

2. Measure your inductor's equivalent series resistance (ESR), and compare it to your design value.

3. Measure your inductor's inductance and ESR at 100 kHz, and compare these values to your low-frequency measurements.

Inductance

capacitance:



During Module 1, you simulated your buck converter considering only switch parasitics. Now, update the inductance and capacitances to their characterized values (i.e., your characterized inductance and capacitance fo the inductor and the electrolytic capacitor, respectively, and the manufacturer-provided capacitance of any MLCCs considering derating). Then, add parasitics (i.e., ESR) to each component as characterized at the appropriate frequency. Note: If you use several identical capacitors in parallel, you may combine their impedances in parallel (considering each to be an R-C branch) to form a single R-C branch.

Simulate your converter with both switch and passive component nonidealities, and determine the following for the nominal operating point and each corner operating point:

③ ① Cin not enough. ② datasheet.

1. The efficiency of your power converter. Compare this to the efficiency you measured in Module 1 considering only switch parasitics.
2. The power loss incurred by each of the passives, estimated via simulation. Compare this to the expected loss you calculated in the previous section.
3. The maximum ripples on i_L, v_{in}, and v_{out}. ⇐3
4. The rms current through any electrolytic capacitors.

characterized values: C: 100Hz: 0.032Ω ESR, 422.3μF; 100kHz: 8.18μF, 0.036Ω ✓

L: 100Hz: 38μH, 0.01Ω ESR ✓; 100kHz: 38.46H, 0.385Ω

we know that $\Delta i_L = 20\% \, i_L$ at nominal point.

$$\Delta i_L = 20\% \times \frac{100}{12} = \frac{20}{12} = \frac{5}{3}\text{ A} \qquad I_L = \frac{100}{12} = \frac{25}{3}\text{ A}.$$

$\Downarrow$

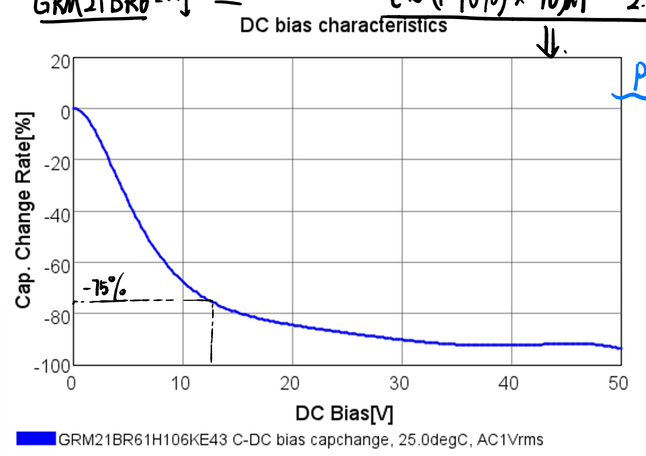
$$\Delta i_C \approx \Delta i_L = \frac{5}{3}\text{ A (peak-to peak)}.$$

$$\Delta i_{C\,RMS} = \frac{5}{6}\cdot\frac{1}{\sqrt{2}} = \frac{5}{6\sqrt{2}}\text{ (A)}$$

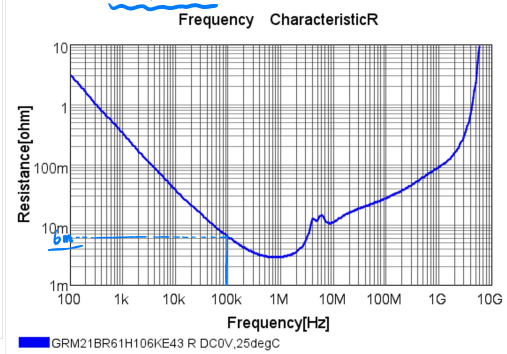
GRM21BR6...↓ = $C \approx (1-75\%) \times 10\mu F = 2.5\mu F$

$\Downarrow$

parallel x 2



ESR=6mΩ



1. The efficiency of your power converter. Compare this to the efficiency you measured in Module 1 considering only switch parasitics.

2. The power loss incurred by each of the passives, estimated via simulation. Compare this to the expected loss you calculated in the previous section.

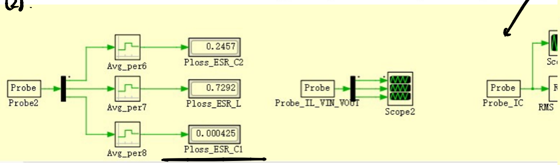
3. The maximum ripples on i_L, v_{in}, and v_{out}.

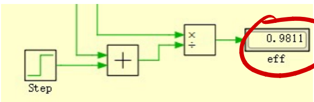
4. The rms current through any electrolytic capacitors.

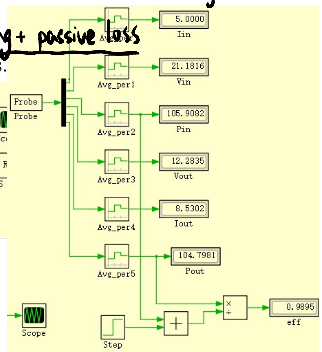
switching loss in Module 1

Switching + passive loss

(2).







For the loss: $P_{cin} = I_{crms}^2 \cdot ESR_{cin}$

$$= \Delta i_L \cdot \frac{1}{\sqrt{2}} \cdot \frac{1}{D} \cdot ESR_{cin}$$

$$= \frac{5}{3} \times \frac{1}{\sqrt{2}} \times \frac{1}{0.6} \times 0.036$$

parallel x3

$$\approx 0.0707$$

$P_{cin\_3} = 3 \cdot P_{cin} = 0.2121.$ ← by hand

0.2457 ← by simulation

higher because of ripples.

$P_L = I_{rms}^2 \cdot ESR_L$

$$= \left(\frac{100}{12}\right)^2 \times 0.01$$

$$\approx 0.6944$$ ← by hand

$$= 0.7292$$ ← by simulation

$P_{cout} = \Delta i_L \cdot \frac{1}{\sqrt{2}} \times ESR_{cin}$

$$= \frac{5}{3} \times \frac{1}{\sqrt{2}} \times 0.006$$

$$= 0.0071$$

$P_{cout\_2} = 2P_{cout} = 0.0142.$

0.004 simulation.

higher because ignore C ripples.

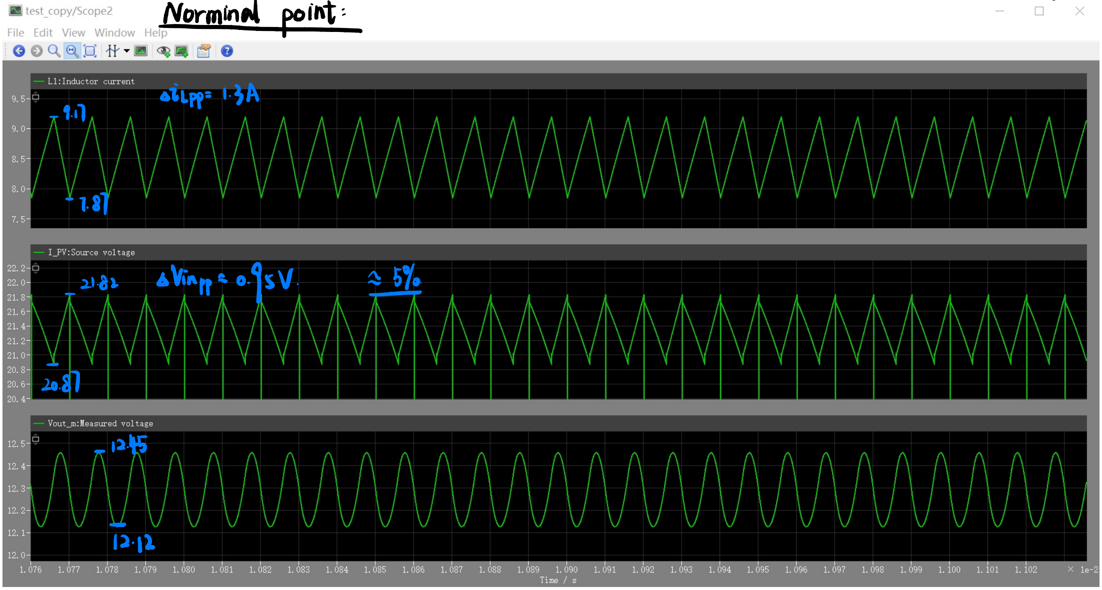
Efficiency:

P = 100W.	Vin = 16V:	98.14%
P = 100W	Vin = 24V:	98.10%
P = 50W.	Vin = 16V	98.87%
P = 50W	Vin = 24V	98.82%

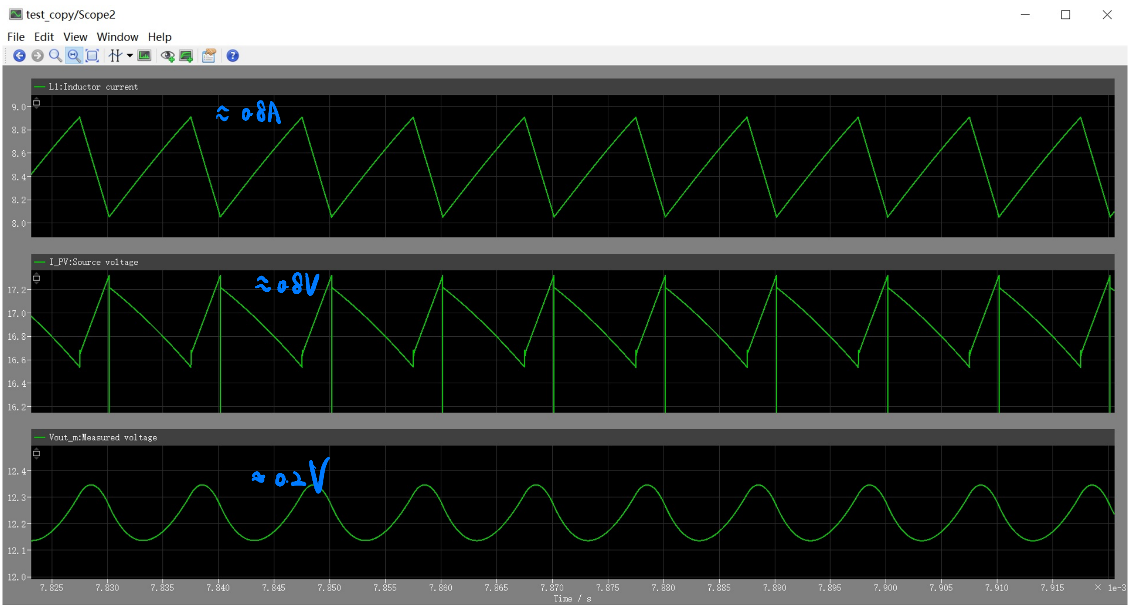
(3).

why strikes?

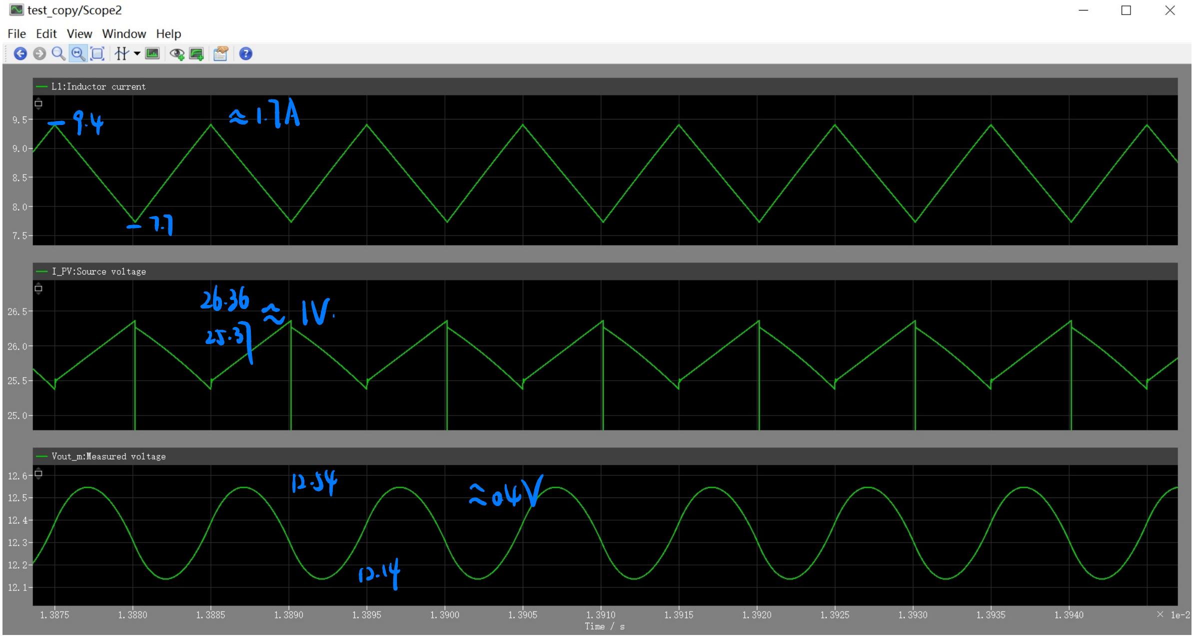
Norminal point:



P=100W. Vin=16V:



P=100W. Vin=24V. (worst-case)



(4).