电感问题知多少，MPS论坛来揭晓

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(特别鸣谢 Sven Spohr)

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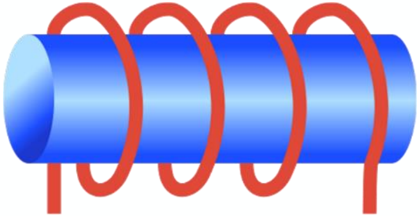
Introduction - What Is an Inductor?

Wire wounded in coil shape with or without core



What is the main task of the inductor?

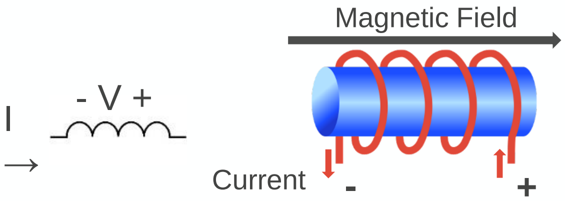
Opposes a change in current

$$V = L\frac{di}{dt}$$

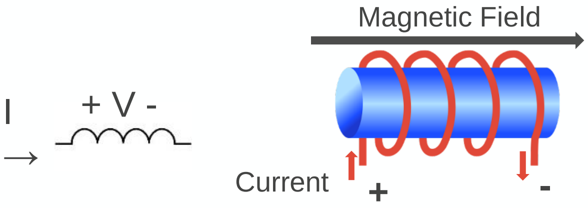
Inductors always have a voltage across them if there is change of current

I = constant V = 0

○ It opposes a change in current from a circuit
  - If current is increasing, inductors try to keep them from increasing

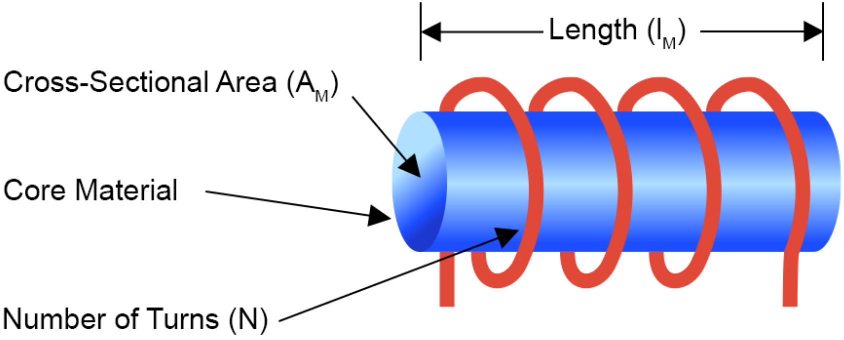


  - If current is decreasing, inductors try to keep them from decreasing



Inductance

$$L=\frac{\mu_o\mu_r A}{l}N^2$$



How to Increase Inductance:

μ ↑ Higher Permeability Core Material

l ↓ Reduce Effective Length of Core

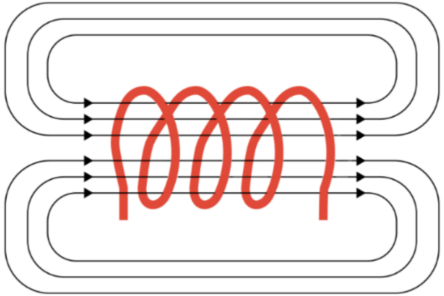
A ↑ Bigger Core Cross Sectional Area

N^2 ↑ Higher Number of Turns

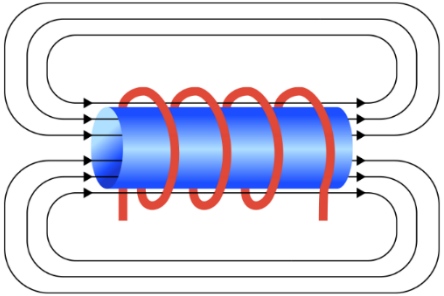
Balance Between Size, Weight, and Performance
Smallest Package Possible to Reduce Weight
Less Turns Possible to Reduce R_{DC}

Permeability

Material	Relative Permeability μ_r
Air	~1
Iron (FE-Based)	50 to 150
Nickel-Zinc	40 to 1500
Manganese-Zinc	300 to 20000



$$\vec{B} = \mu_o \vec{H}$$



$$\vec{B} = \mu_o \mu_r \vec{H}$$

The magnetic field remains the same

Magnetic flux concentration can intensify by using highly permeable core material

$$L = \frac{\mu_o \mu_r A}{l} N^2$$

Rated Current

Self-heating of the component caused by the wire's R_{DC}.

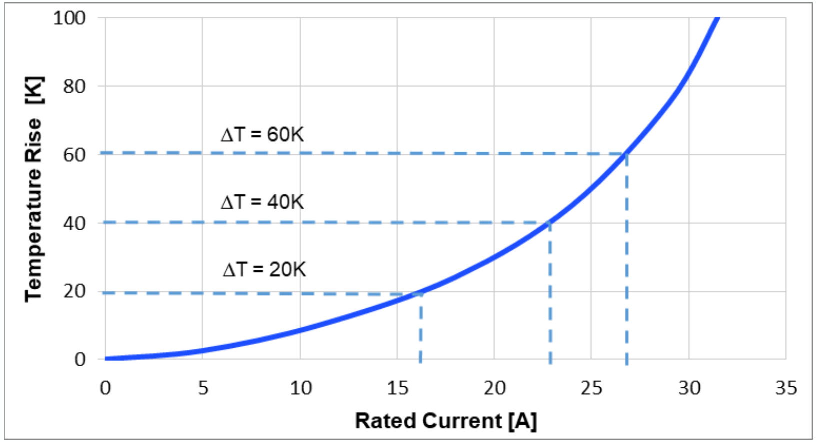
The temperature rise is not standard, and varies from manufacturer to manufacturer.

$T_{OP} = T_{AMB} + \Delta T$

T_{AMB}	Ambient Temp	-40 to 85°C / -40 to ?°C
ΔT	Temperature Rise (Self-Heating)	20K / 30K / 40K / ?K
T_{OP}	Operating Temperature	Max. Value Given in Datasheet

Don't exceed the maximum operating temperature T_{OP}

- At higher ambient temperatures, the ΔT (self-heating) should be adjusted
- Larger-sized component

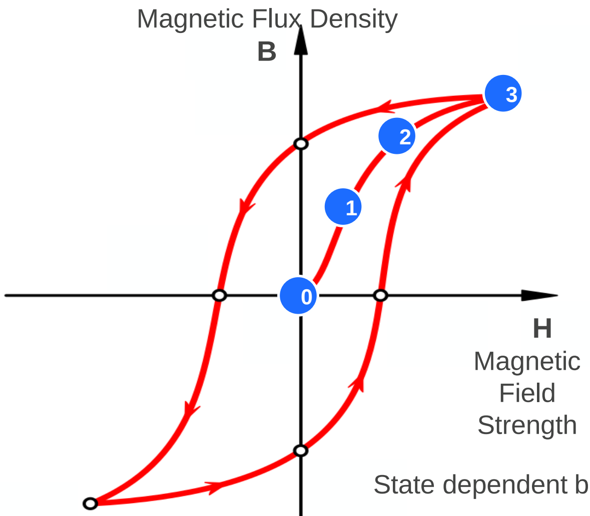


Saturation Current

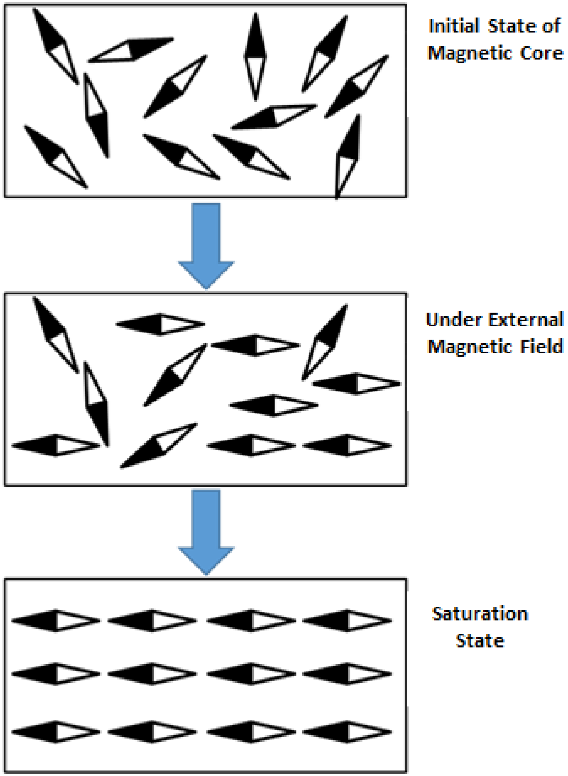
When the current is passed through the coil, the coil generates a magnetic field.

The magnetic core is magnetized by the field, and its internal magnetic domain rotates slowly.

When the magnetic core is completely magnetized, the direction of the magnetic domains becomes consistent with the magnetic field.

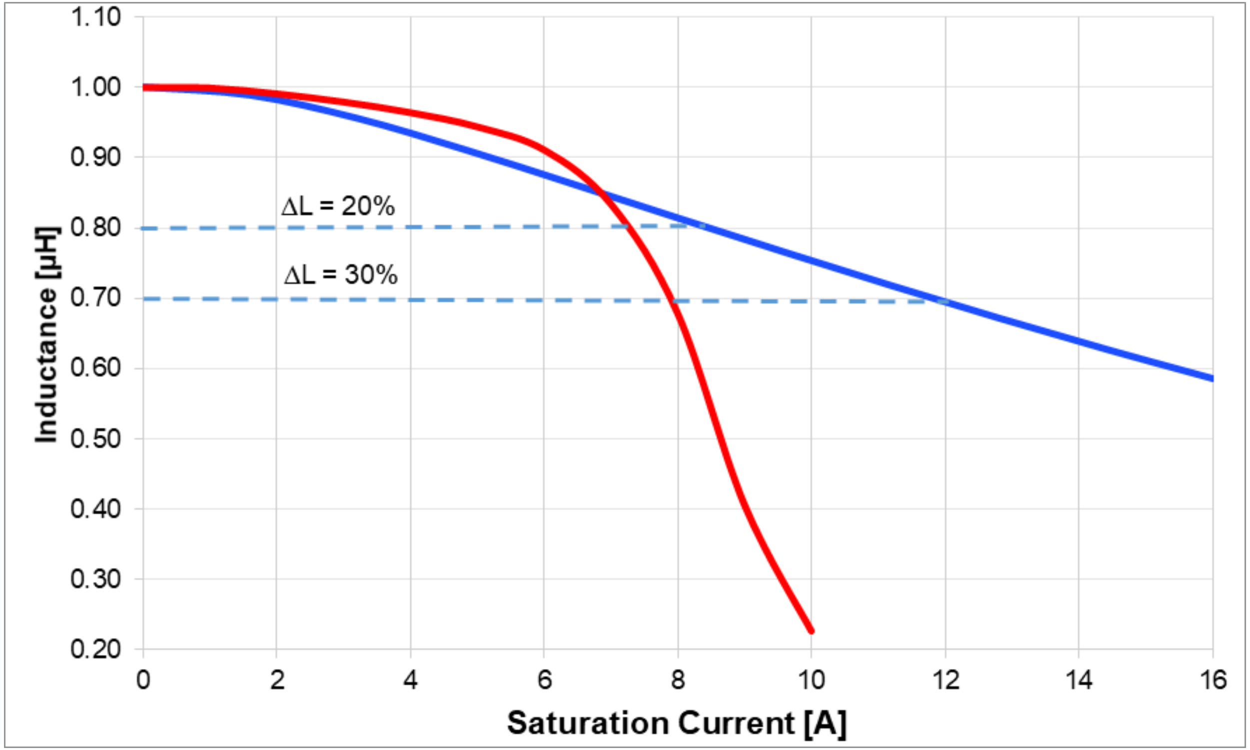


State dependent behavior B,H



Saturation Current

Inductance drops by 30% at the given current

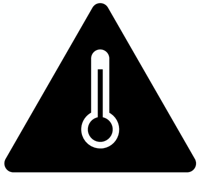


Losses

Copper Losses

DC loss

Heat dissipation of the inductor winding's R_{DC}

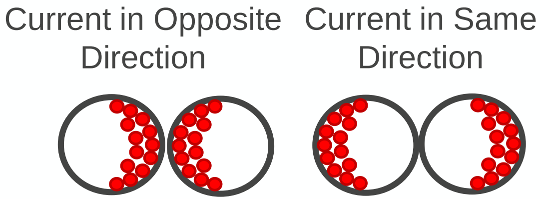


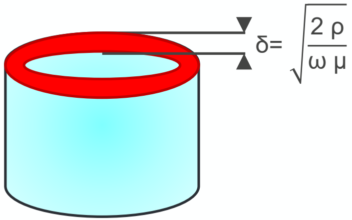
AC loss

Winding structure loss driven by the frequency

Proximity Effect

Skin Effect





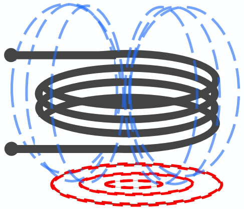
$$\delta = \sqrt{\frac{2\rho}{\omega\mu}}$$

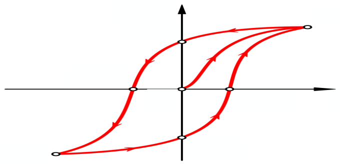
Core Losses

Magnetic material loss

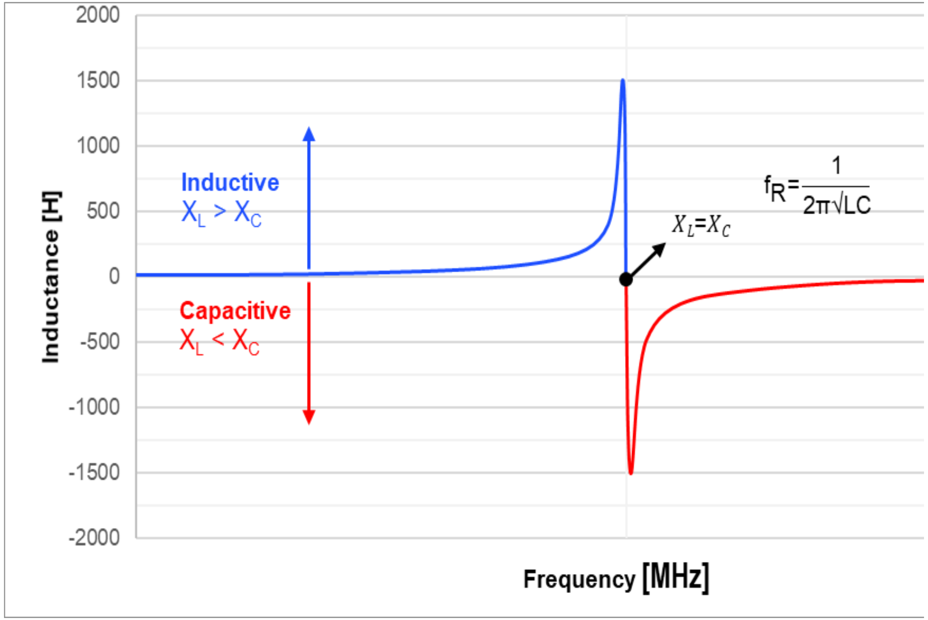
Eddy Currents

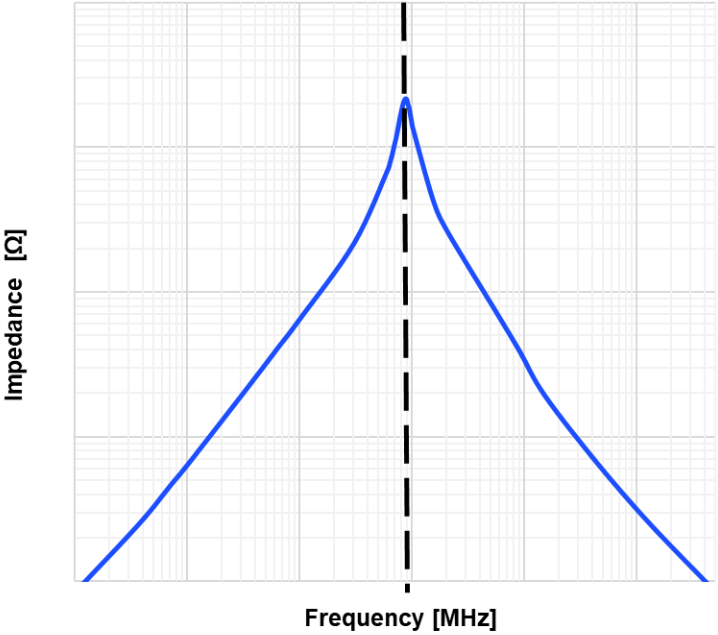
Hysteresis Loss





Resonant Frequency

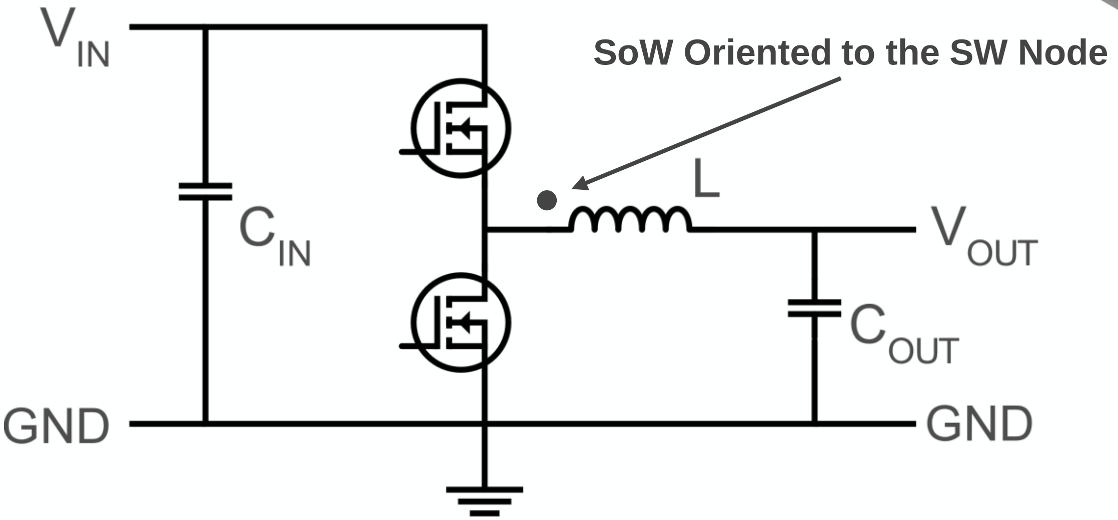




Self-resonant frequency needs to be much higher than the switching frequency

Start of Winding

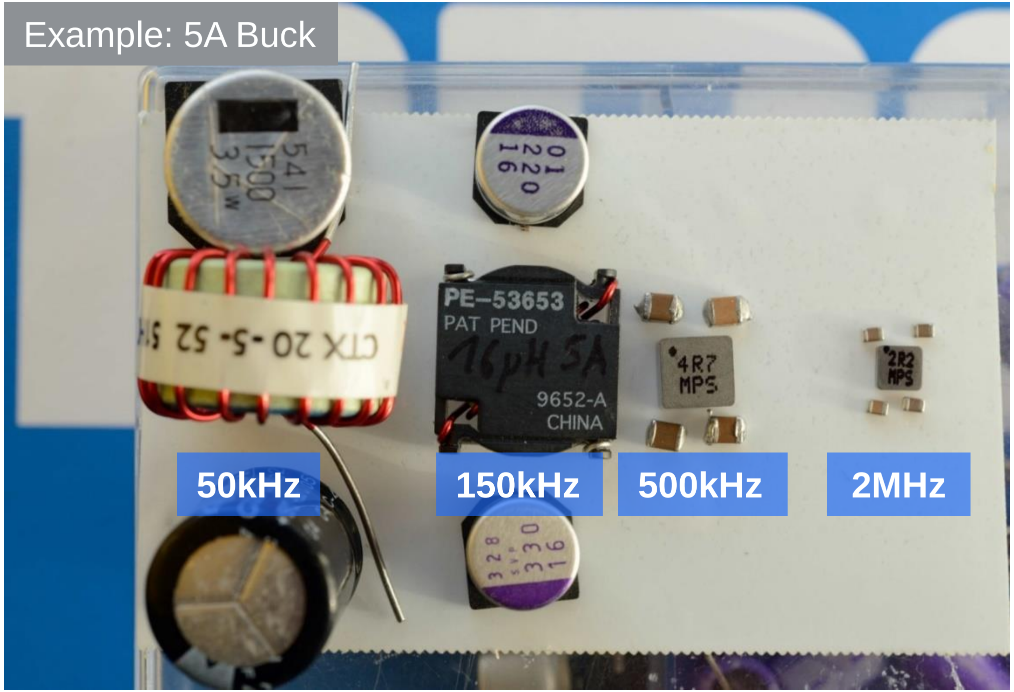
The converter switch node is close to the start of winding side

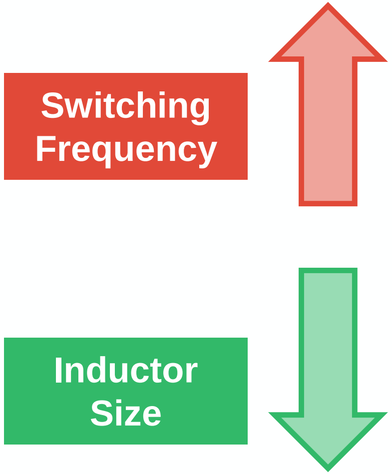


Selection of Inductor In DCDC

Inductor Selection – Different Switching Frequency

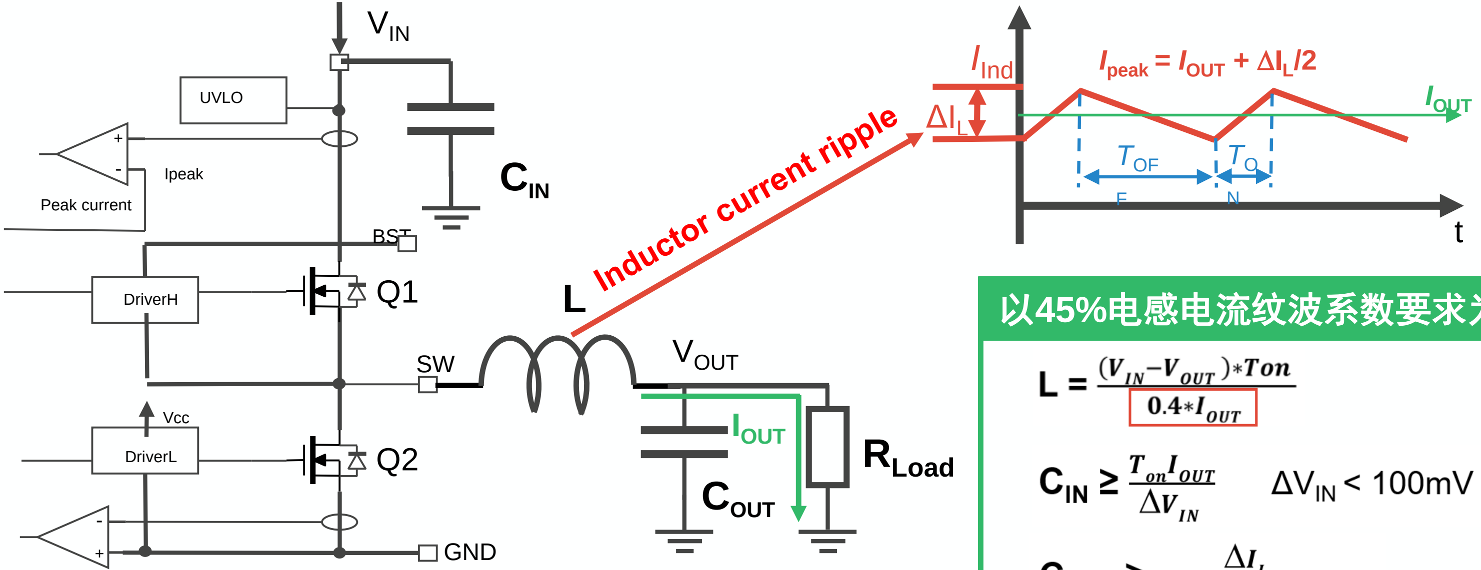
Switching frequency is a key factor to determine how much inductance you use.




Switching Frequency

Inductor Size

Inductor Selection – Current Ripple



以45%电感电流纹波系数要求为例，可得：

$$L = \frac{(V_{IN}-V_{OUT})*Ton}{\boxed{0.4*I_{OUT}}}$$

$$C_{IN} \geq \frac{T_{on}I_{OUT}}{\Delta V_{IN}} \qquad \Delta V_{IN} < 100\text{mV} \qquad \text{ESR} < \frac{\Delta V_{IN}}{I_{peak}}$$

$$C_{OUT} \geq \frac{\Delta I_L}{(8*F_{SW}*\Delta V_{OUT})}$$

$$\text{ESR} < \frac{\Delta V_{OUT}}{\Delta I_L}$$

V_{out} ripple:

$$\Delta V_{OUT} \sim \Delta I_L\,(\text{ESR} + 1/(8*F_{SW}*C_{OUT}))$$

关键设计指标:

- I_{OUT}
- ΔI_L
- ΔV_{IN}
- ΔV_{OUT}

$$\text{Q1 D.C. (Duty Cycle)} = \frac{V_{OUT}}{V_{IN}}$$

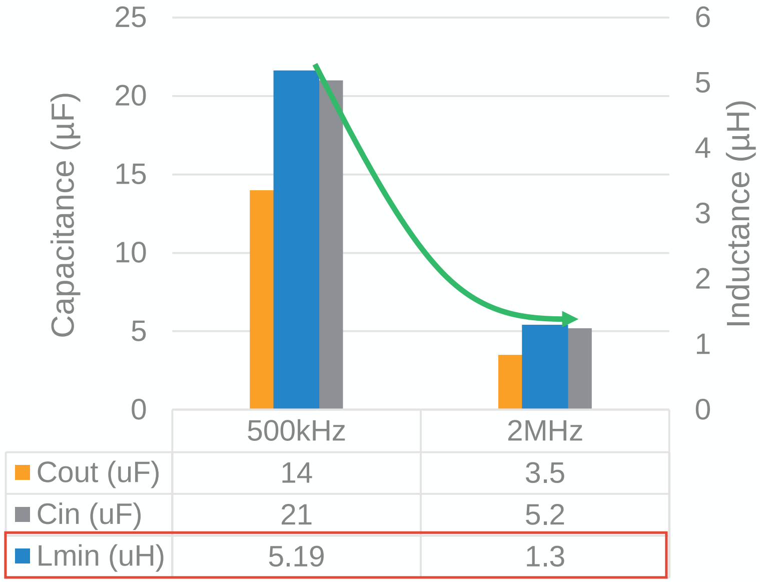
$$T_{ON} = \frac{D.C.}{F_{SW}}$$

Inductor Selection – Working Condition

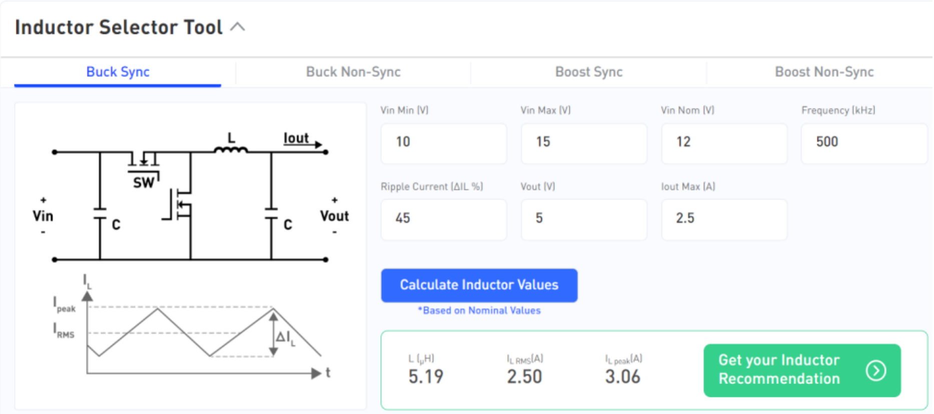
Design Example:

- 45% Inductor Ripple Current
- 20mV Peak-to-Peak Output Ripple
- With Fs=500kHz / 2MHz
- Vin=12V; Vout=5V @ 2.5A

Component Sizing
12V to 5V at 2.5A



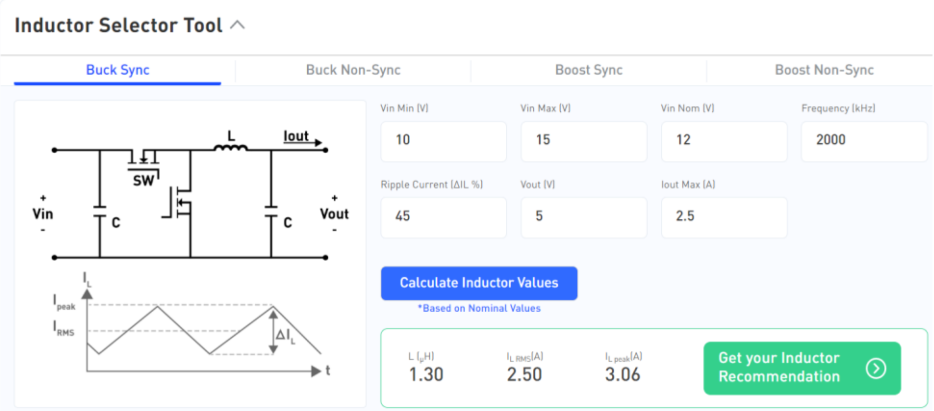
	500kHz	2MHz
Cout (uF)	14	3.5
Cin (uF)	21	5.2
Lmin (uH)	5.19	1.3



Vin Min (V): 10
Vin Max (V): 15
Vin Nom (V): 12
Frequency (kHz): 500
Ripple Current (ΔIL %): 45
Vout (V): 5
Iout Max (A): 2.5

*Based on Nominal Values

L (µH): 5.19
$I_{L\ RMS}$(A): 2.50
$I_{L\ peak}$(A): 3.06



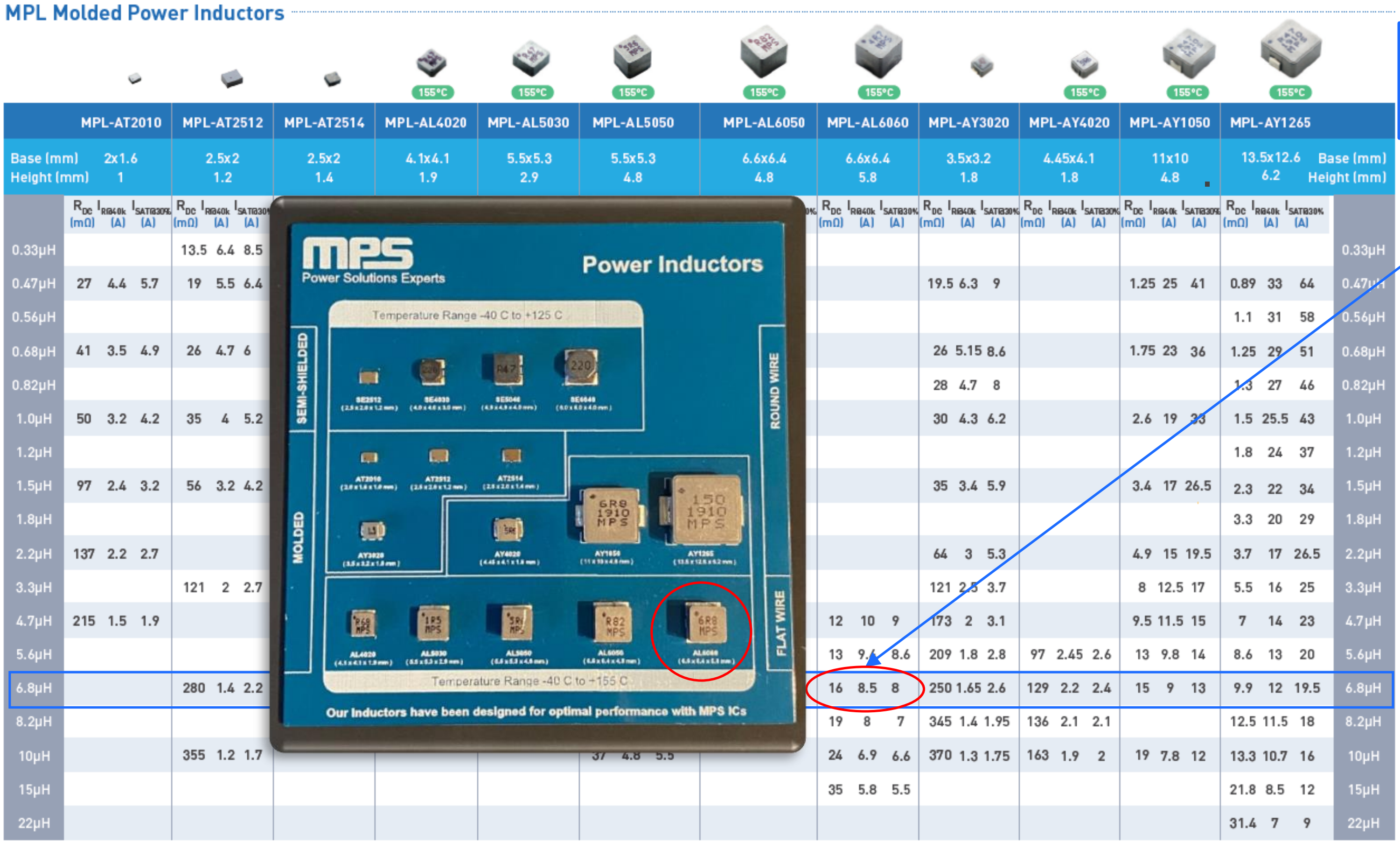
Vin Min (V): 10
Vin Max (V): 15
Vin Nom (V): 12
Frequency (kHz): 2000
Ripple Current (ΔIL %): 45
Vout (V): 5
Iout Max (A): 2.5

*Based on Nominal Values

L (µH): 1.30
$I_{L\ RMS}$(A): 2.50
$I_{L\ peak}$(A): 3.06

https://www.monolithicpower.com/en/inductor-selector-tool

Inductor Selection – MPS Inductor Flyer



MPL Molded Power Inductors

	MPL-AT2010			MPL-AT2512			MPL-AT2514			MPL-AL4020			MPL-AL5030			MPL-AL5050		
Base (mm)	2x1.6			2.5x2			2.5x2			4.1x4.1			5.5x5.3			5.5x5.3		
Height (mm)	1			1.2			1.4			1.9			2.9			4.8		
	R_{DC} (mΩ)	$I_{R@40k}$ (A)	$I_{SAT@30\%}$ (A)	R_{DC} (mΩ)	$I_{R@40k}$ (A)	$I_{SAT@30\%}$ (A)												
0.33µH				13.5	6.4	8.5												
0.47µH	27	4.4	5.7	19	5.5	6.4												
0.56µH																		
0.68µH	41	3.5	4.9	26	4.7	6												
0.82µH																		
1.0µH	50	3.2	4.2	35	4	5.2												
1.2µH																		
1.5µH	97	2.4	3.2	56	3.2	4.2												
1.8µH																		
2.2µH	137	2.2	2.7															
3.3µH				121	2	2.7												
4.7µH	215	1.5	1.9															
5.6µH																		
6.8µH				280	1.4	2.2												
8.2µH																		
10µH				355	1.2	1.7										37	4.8	5.5
15µH																		
22µH																		

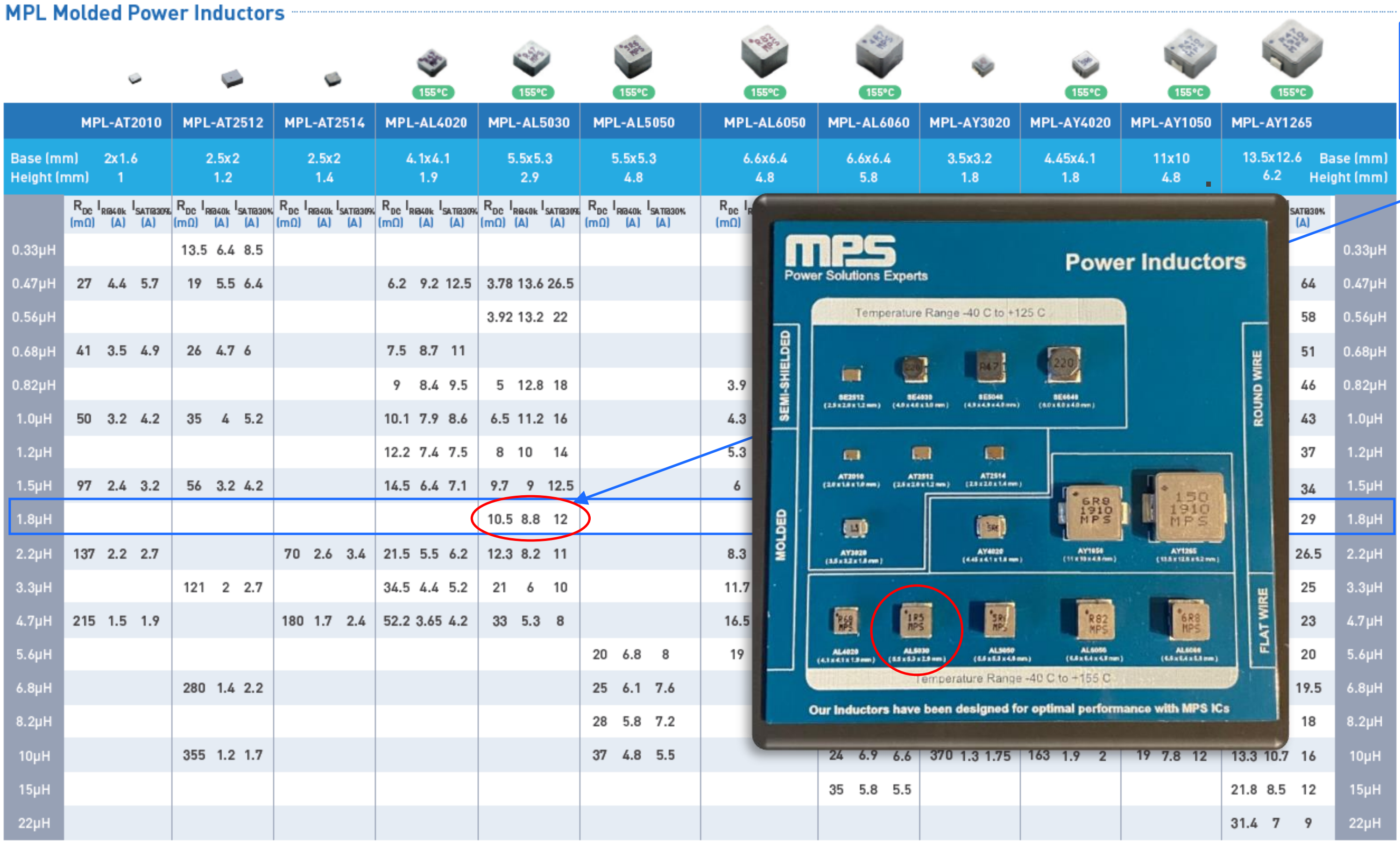
	MPL-AL6050			MPL-AL6060			MPL-AY3020			MPL-AY4020			MPL-AY1050			MPL-AY1265			
	6.6x6.4			6.6x6.4			3.5x3.2			4.45x4.1			11x10			13.5x12.6			Base (mm)
	4.8			5.8			1.8			1.8			4.8			6.2			Height (mm)
				R_{DC} (mΩ)	$I_{R@40k}$ (A)	$I_{SAT@30\%}$ (A)	R_{DC} (mΩ)	$I_{R@40k}$ (A)	$I_{SAT@30\%}$ (A)	R_{DC} (mΩ)	$I_{R@40k}$ (A)	$I_{SAT@30\%}$ (A)	R_{DC} (mΩ)	$I_{R@40k}$ (A)	$I_{SAT@30\%}$ (A)	R_{DC} (mΩ)	$I_{R@40k}$ (A)	$I_{SAT@30\%}$ (A)	
0.33µH																			0.33µH
0.47µH							19.5	6.3	9				1.25	25	41	0.89	33	64	0.47µH
0.56µH																1.1	31	58	0.56µH
0.68µH							26	5.15	8.6				1.75	23	36	1.25	29	51	0.68µH
0.82µH							28	4.7	8							1.3	27	46	0.82µH
1.0µH							30	4.3	6.2				2.6	19	33	1.5	25.5	43	1.0µH
1.2µH																1.8	24	37	1.2µH
1.5µH							35	3.4	5.9				3.4	17	26.5	2.3	22	34	1.5µH
1.8µH																3.3	20	29	1.8µH
2.2µH							64	3	5.3				4.9	15	19.5	3.7	17	26.5	2.2µH
3.3µH							121	2.5	3.7				8	12.5	17	5.5	16	25	3.3µH
4.7µH				12	10	9	173	2	3.1				9.5	11.5	15	7	14	23	4.7µH
5.6µH				13	9.4	8.6	209	1.8	2.8	97	2.45	2.6	13	9.8	14	8.6	13	20	5.6µH
6.8µH				16	8.5	8	250	1.65	2.6	129	2.2	2.4	15	9	13	9.9	12	19.5	6.8µH
8.2µH				19	8	7	345	1.4	1.95	136	2.1	2.1				12.5	11.5	18	8.2µH
10µH				24	6.9	6.6	370	1.3	1.75	163	1.9	2	19	7.8	12	13.3	10.7	16	10µH
15µH				35	5.8	5.5										21.8	8.5	12	15µH
22µH																31.4	7	9	22µH

Example

6.8µH / 8.5A

https://www.monolithicpower.com/en/support/product-literature.html

Inductor Selection – MPS Inductor Flyer



MPL Molded Power Inductors

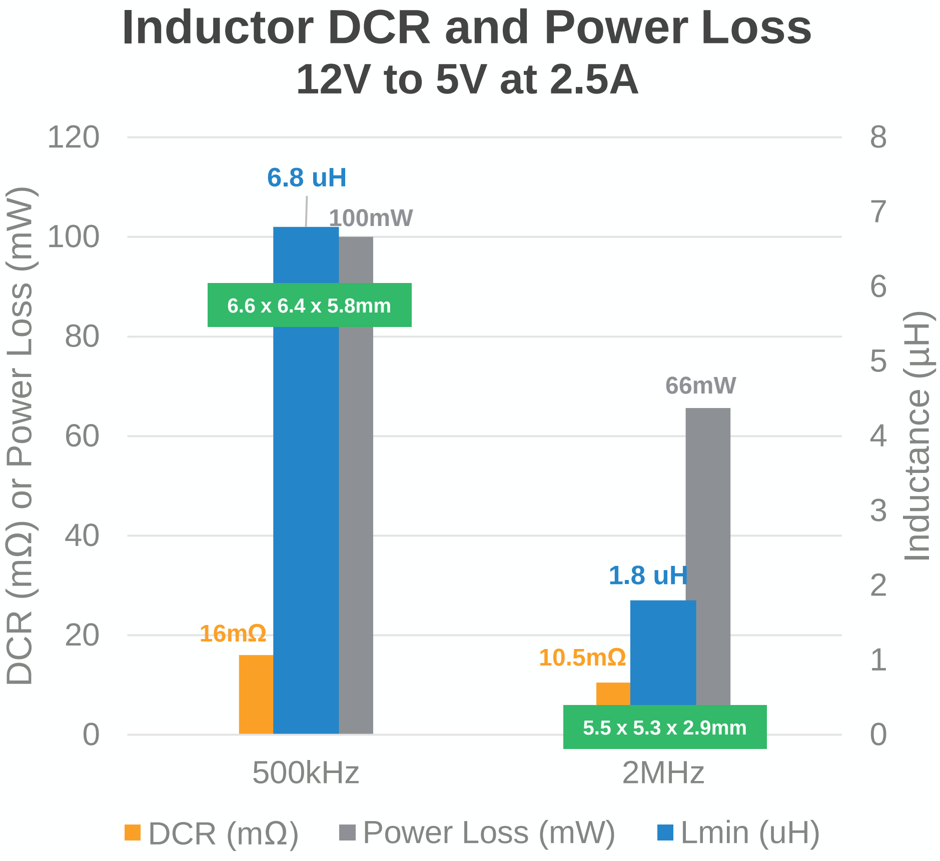
	MPL-AT2010			MPL-AT2512			MPL-AT2514			MPL-AL4020			MPL-AL5030			MPL-AL5050			MPL-AL6050			MPL-AL6060			MPL-AY3020			MPL-AY4020			MPL-AY1050			MPL-AY1265			
										155°C			155°C			155°C			155°C			155°C						155°C			155°C			155°C			
Base (mm)	2x1.6			2.5x2			2.5x2			4.1x4.1			5.5x5.3			5.5x5.3			6.6x6.4			6.6x6.4			3.5x3.2			4.45x4.1			11x10			13.5x12.6			Base (mm)
Height (mm)	1			1.2			1.4			1.9			2.9			4.8			4.8			5.8			1.8			1.8			4.8			6.2			Height (mm)
	R_{DC} (mΩ)	$I_{R@40k}$ (A)	$I_{SAT@30\%}$ (A)	R_{DC} (mΩ)	$I_{R@40k}$ (A)	$I_{SAT@30\%}$ (A)	R_{DC} (mΩ)	$I_{R@40k}$ (A)	$I_{SAT@30\%}$ (A)	R_{DC} (mΩ)	$I_{R@40k}$ (A)	$I_{SAT@30\%}$ (A)	R_{DC} (mΩ)	$I_{R@40k}$ (A)	$I_{SAT@30\%}$ (A)	R_{DC} (mΩ)	$I_{R@40k}$ (A)	$I_{SAT@30\%}$ (A)	R_{DC} (mΩ)																	$I_{SAT@30\%}$ (A)	
0.33µH				13.5	6.4	8.5																															0.33µH
0.47µH	27	4.4	5.7	19	5.5	6.4				6.2	9.2	12.5	3.78	13.6	26.5																					64	0.47µH
0.56µH													3.92	13.2	22																					58	0.56µH
0.68µH	41	3.5	4.9	26	4.7	6				7.5	8.7	11																								51	0.68µH
0.82µH										9	8.4	9.5	5	12.8	18				3.9																	46	0.82µH
1.0µH	50	3.2	4.2	35	4	5.2				10.1	7.9	8.6	6.5	11.2	16				4.3																	43	1.0µH
1.2µH										12.2	7.4	7.5	8	10	14				5.3																	37	1.2µH
1.5µH	97	2.4	3.2	56	3.2	4.2				14.5	6.4	7.1	9.7	9	12.5				6																	34	1.5µH
1.8µH													10.5	8.8	12																					29	1.8µH
2.2µH	137	2.2	2.7				70	2.6	3.4	21.5	5.5	6.2	12.3	8.2	11				8.3																	26.5	2.2µH
3.3µH				121	2	2.7				34.5	4.4	5.2	21	6	10				11.7																	25	3.3µH
4.7µH	215	1.5	1.9				180	1.7	2.4	52.2	3.65	4.2	33	5.3	8				16.5																	23	4.7µH
5.6µH																20	6.8	8	19																	20	5.6µH
6.8µH				280	1.4	2.2										25	6.1	7.6																		19.5	6.8µH
8.2µH																28	5.8	7.2																		18	8.2µH
10µH				355	1.2	1.7										37	4.8	5.5				24	6.9	6.6	370	1.3	1.75	163	1.9	2	19	7.8	12	13.3	10.7	16	10µH
15µH																						35	5.8	5.5										21.8	8.5	12	15µH
22µH																																		31.4	7	9	22µH

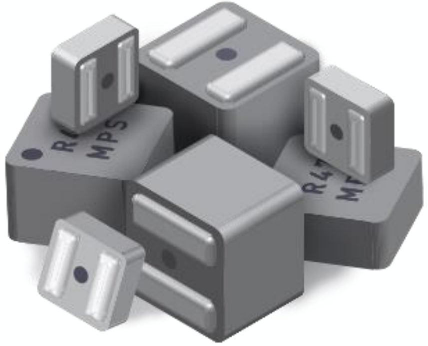
Example

1.8µH / 8.8A

https://www.monolithicpower.com/en/support/product-literature.html

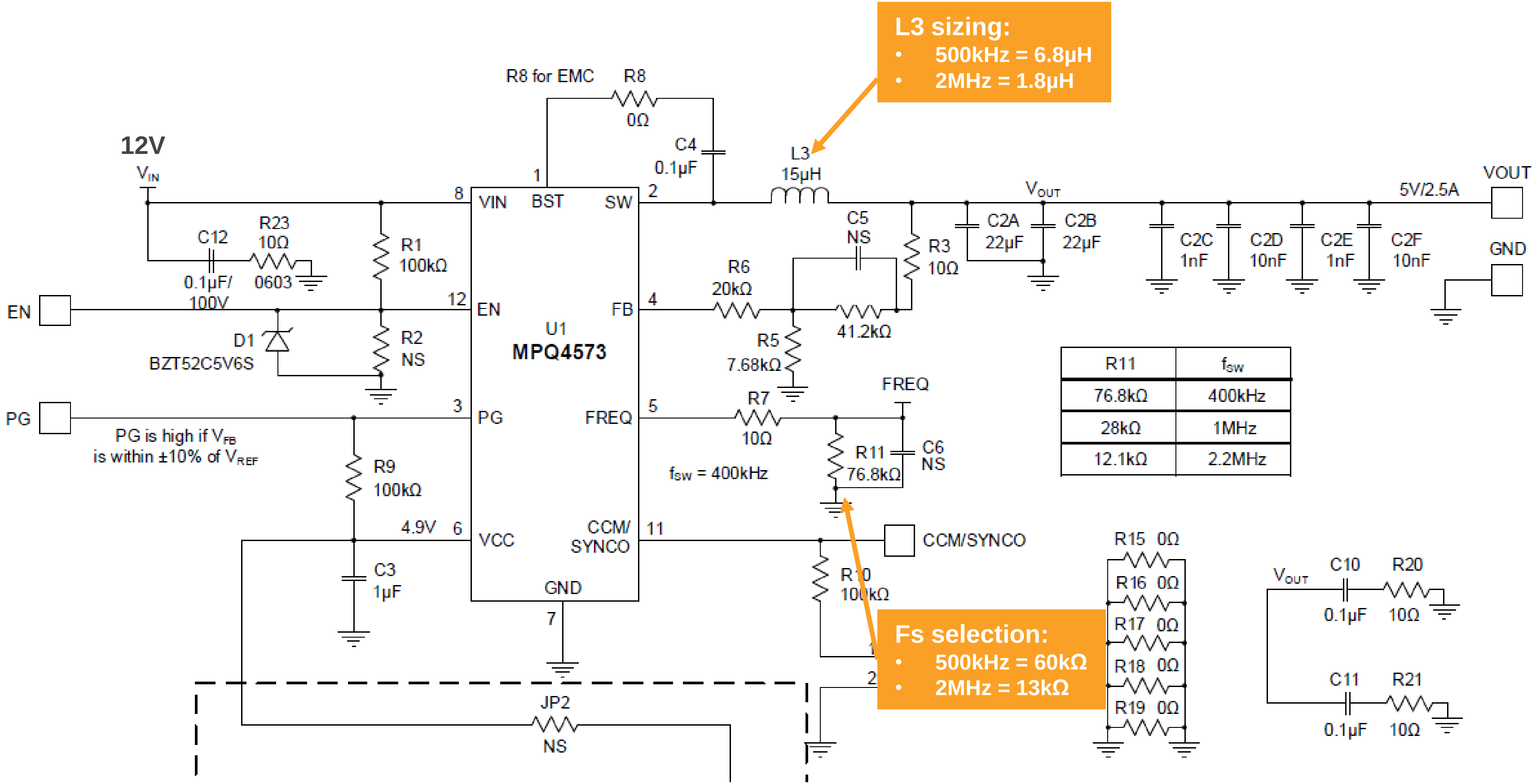
Inductor Selection – MPL-AL Series





- **MPL-AL (Low-Resistance Molded Inductors)**
  - **Start of Winding Indication**
  - **Flat Wire Construction**
  - **Lowest DCR**
  - High Performance
  - High Saturation Current
  - Soft Saturation
  - Stable over Temperature
  - Max Operating Temperature: 155˚C
  - Sizes: 4020 / 5030 / 5050 / 6050 / 6060

Inductor Selection – Example On MPQ4573 Demo



R11	f_{SW}
76.8kΩ	400kHz
28kΩ	1MHz
12.1kΩ	2.2MHz

L3 sizing:
- 500kHz = 6.8μH
- 2MHz = 1.8μH

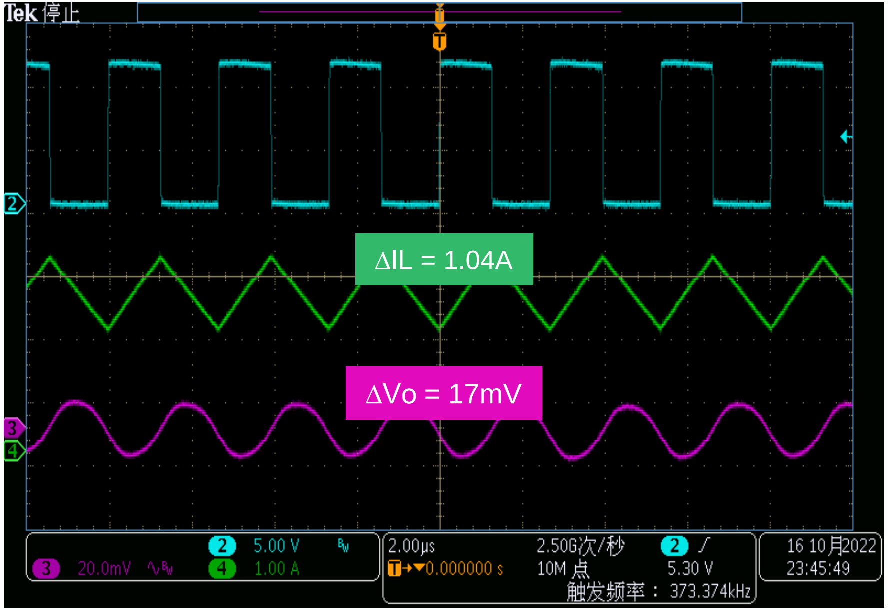
Fs selection:
- 500kHz = 60kΩ
- 2MHz = 13kΩ

Inductor Selection – 500kHz Waveforms

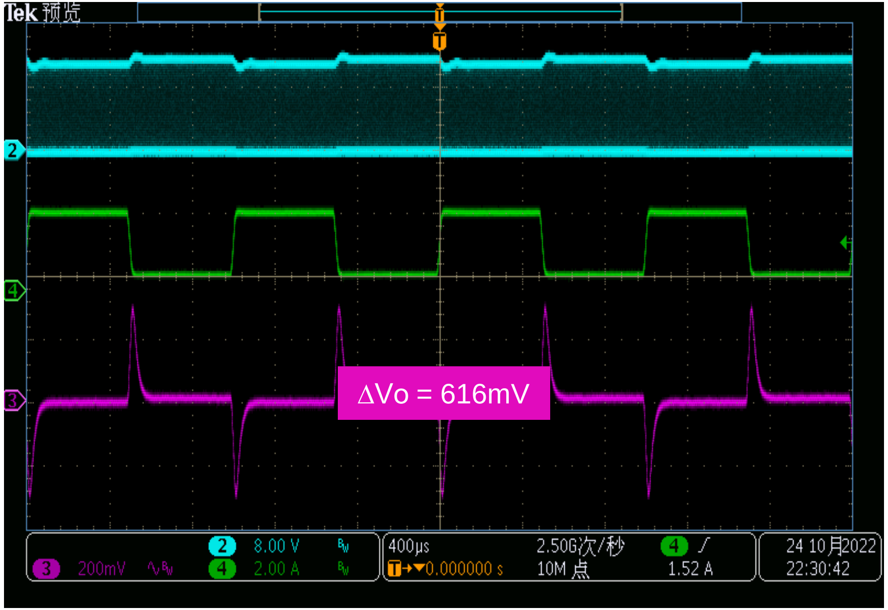
测试条件：12V to 5V @ 2.5A

- L = 6.8 µH (16mOhm)
- 89.74% Efficiency
- ΔIL=1.04A (42%)

Transient can be optimized with more Cout / Compensation.



Load=2.5A

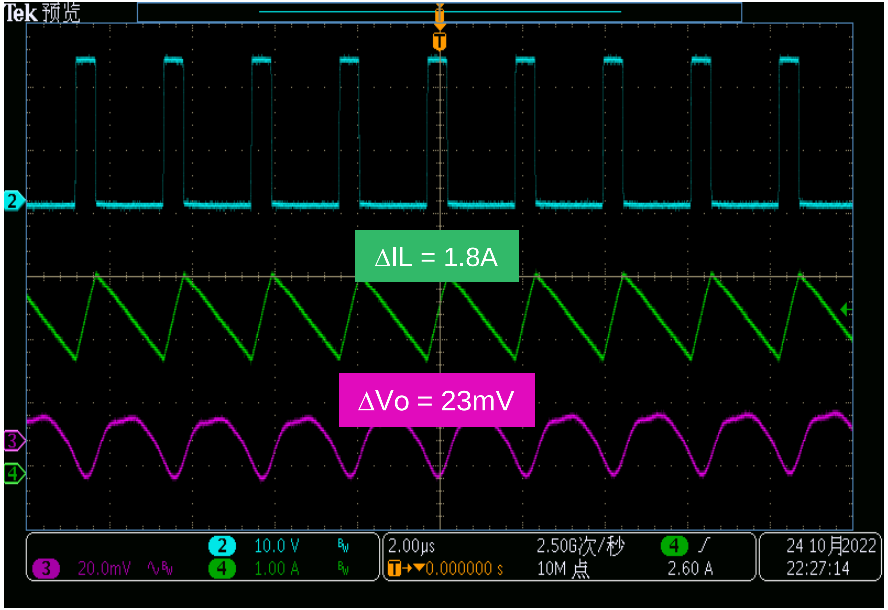


Transient=0.5A to 2.5A

Inductor Selection – 500kHz Waveforms

测试条件：24V to 5V @ 2.5A

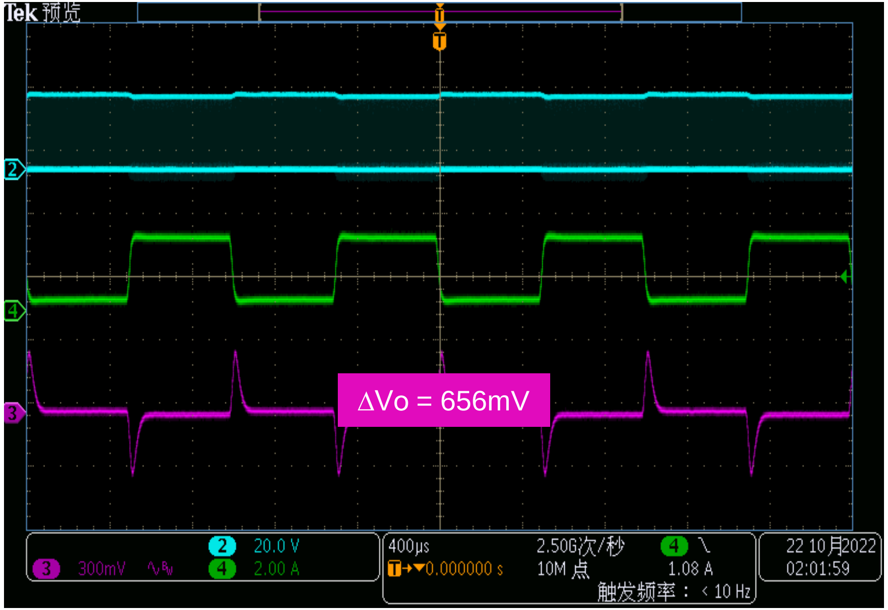
- L = 6.8 µH (16mOhm)
- ΔIL=1.125A (45%)
- Real ΔIL=1.8A (72%)



ΔIL = 1.8A

ΔVo = 23mV

Load=2.5A



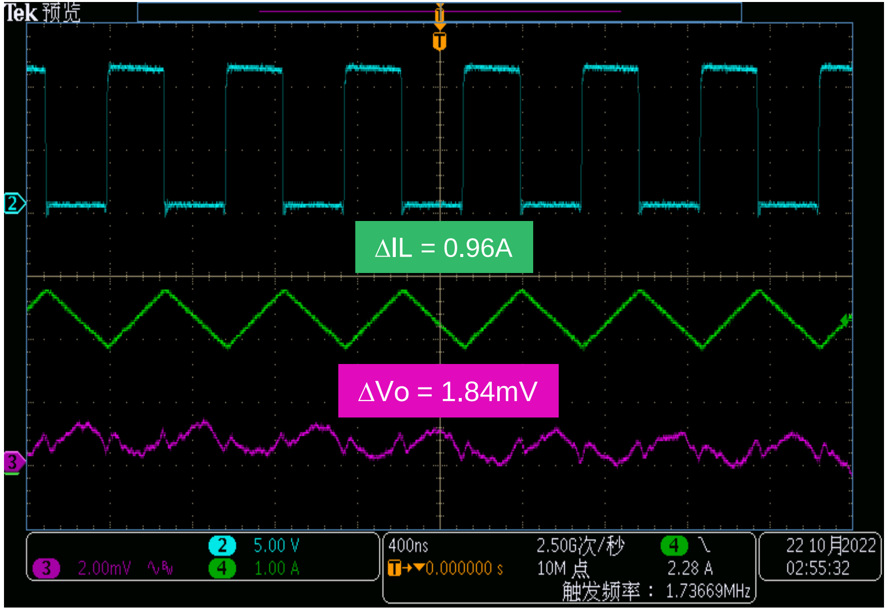
ΔVo = 656mV

Transient=0.5A to 2.5A

Inductor Selection – 2MHz Waveforms

测试条件：12V to 5V @ 2.5A

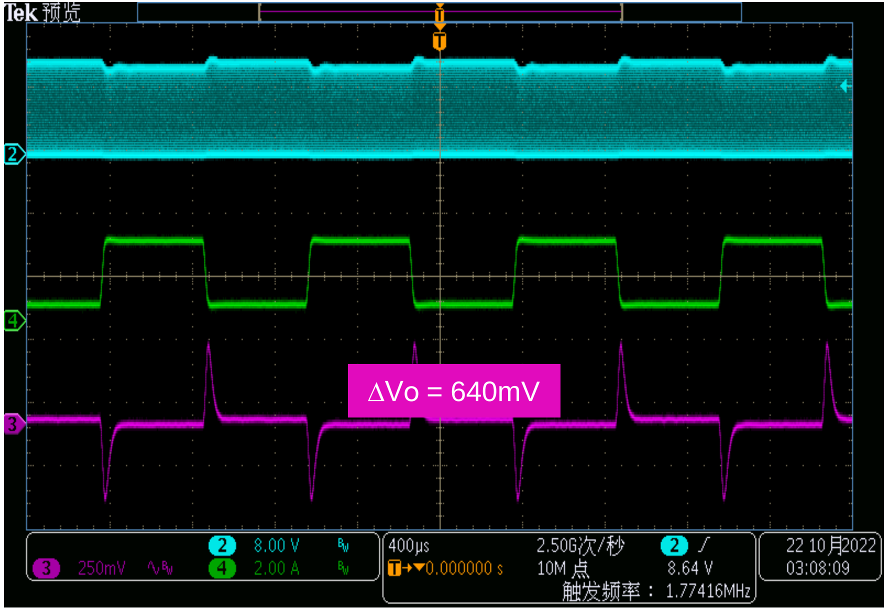
- L = 1.8 µH (10.5mOhm)
- 83.82% Efficiency
- ΔIL=0.96A (38%)



ΔIL = 0.96A

ΔVo = 1.84mV

Load=2.5A



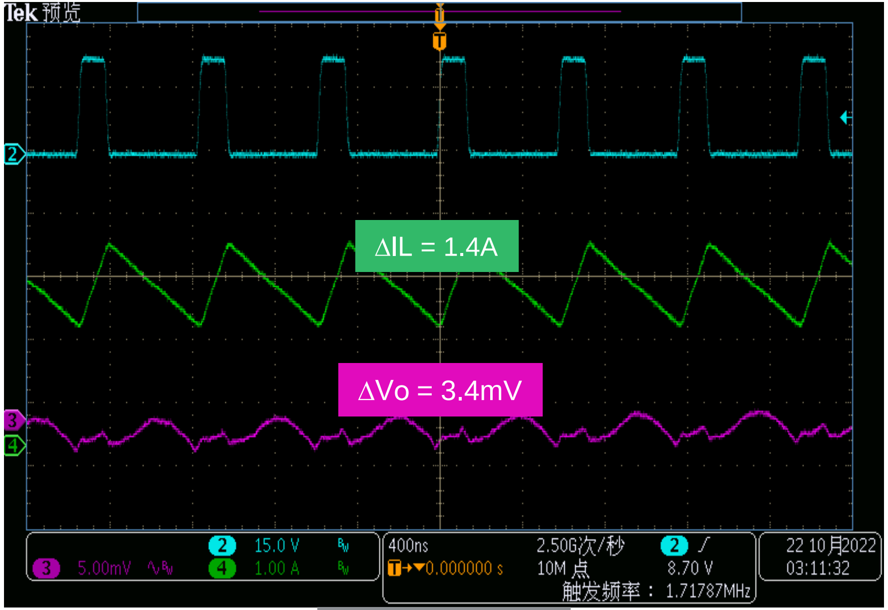
ΔVo = 640mV

Transient=0.5A to 2.5A

Inductor Selection – 2MHz Waveforms

测试条件：24V to 5V @ 2.5A

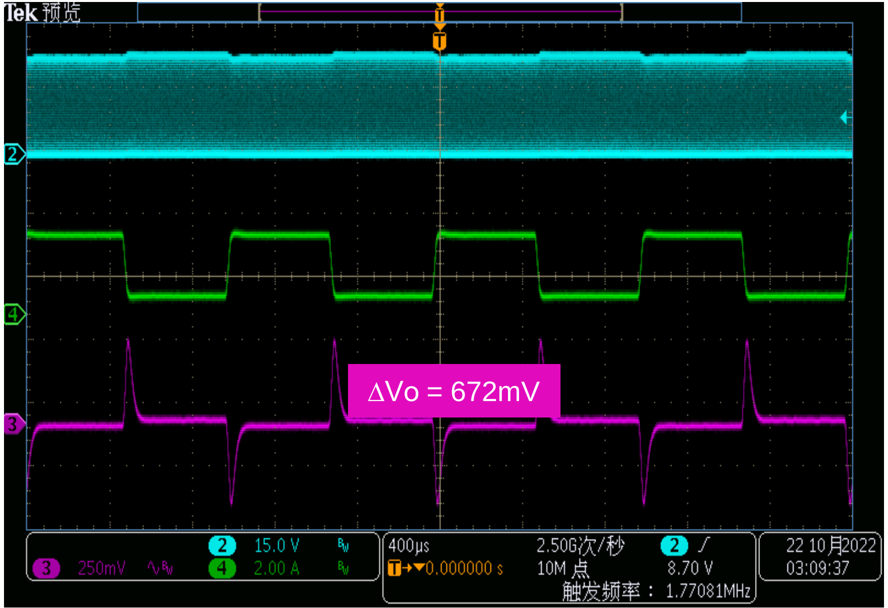
- L = 1.8 µH (10.5mOhm)
- ΔIL=1.125A (45%)
- Real ΔIL=1.4A (56%)



ΔIL = 1.4A

ΔVo = 3.4mV

Load=2.5A



ΔVo = 672mV

Transient=0.5A to 2.5A

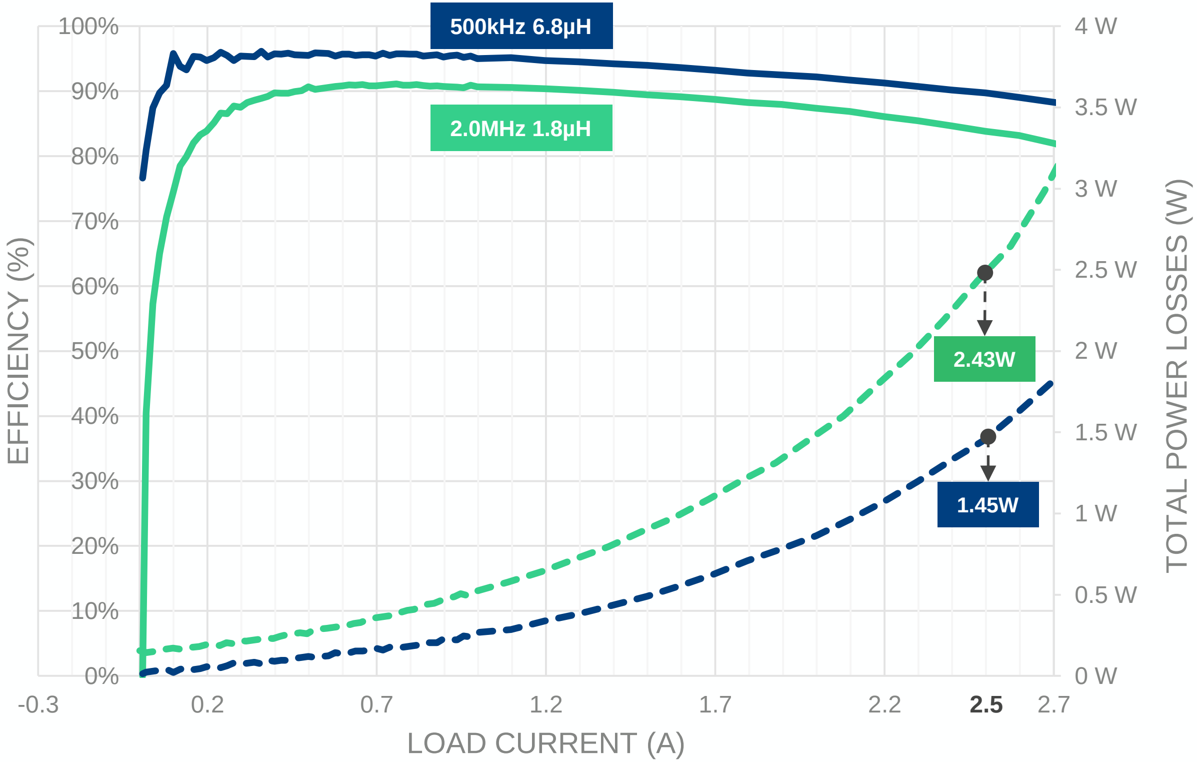
Inductor Selection – Efficiency Curve

Efficiency Curve of MPQ4573
(60V, 2.5A sync Buck - 250mΩ/45mΩ $R_{DS(ON)}$)

- Calculation shows highest DCR loss in coil for 500kHz setup
- Real world **500kHz efficiency is higher** because of less **switch transition losses**

Example:
How to losses split up?
1.45W (500kHz@2.5A):

- ✓ IC-FET R_{ON}: 823mW
- ✓ Coil DCR: 100mW
- ✓ Transition losses and IC supply losses: 134mW
- ✓ Others (Core + AC Winding + EMI Filter): 290mW



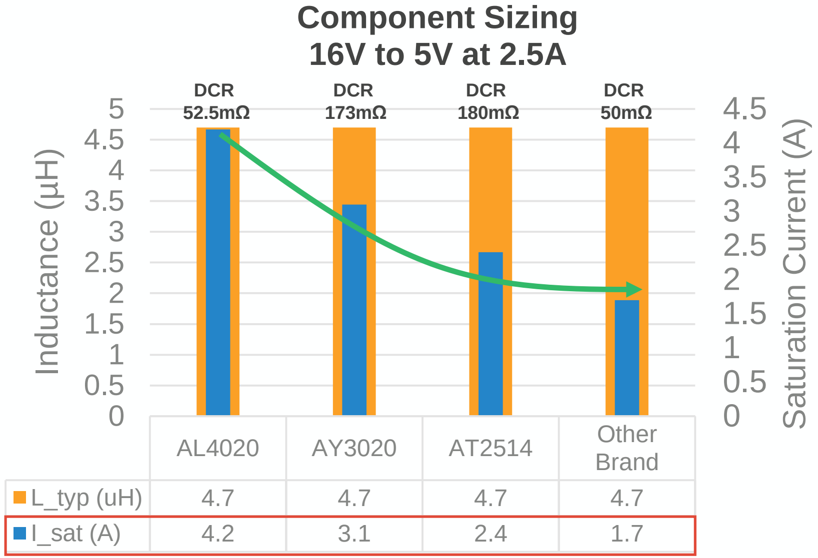
Pain Points of Inductor Using

Saturation Current

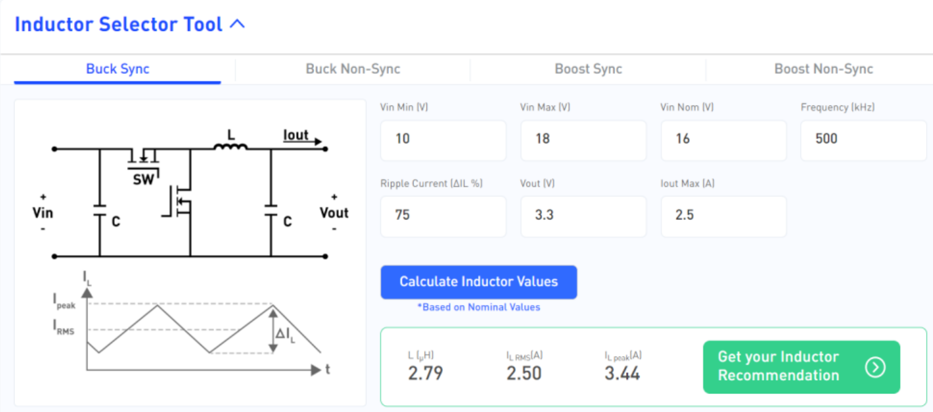
Inductor Saturation Current

Design Example (MVQ4573 Demo Board):

- 75% Inductor Ripple Current
- With Fs=500kHz
- Vin=16V; Vout=5V @ 2.5A



	AL4020	AY3020	AT2514	Other Brand
🟧 L_typ (uH)	4.7	4.7	4.7	4.7
🟦 I_sat (A)	4.2	3.1	2.4	1.7

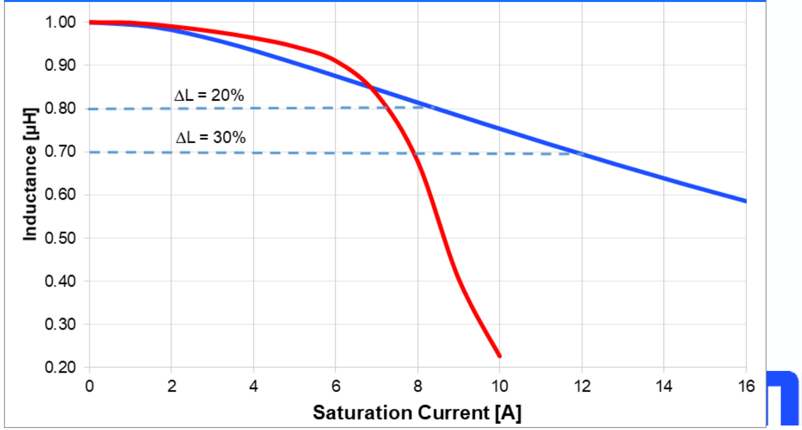


Vin Min (V): 10
Vin Max (V): 18
Vin Nom (V): 16
Frequency (kHz): 500
Ripple Current (ΔIL %): 75
Vout (V): 3.3
Iout Max (A): 2.5

*Based on Nominal Values

L (µH): 2.79
$I_{L\ RMS}$(A): 2.50
$I_{L\ peak}$(A): 3.44

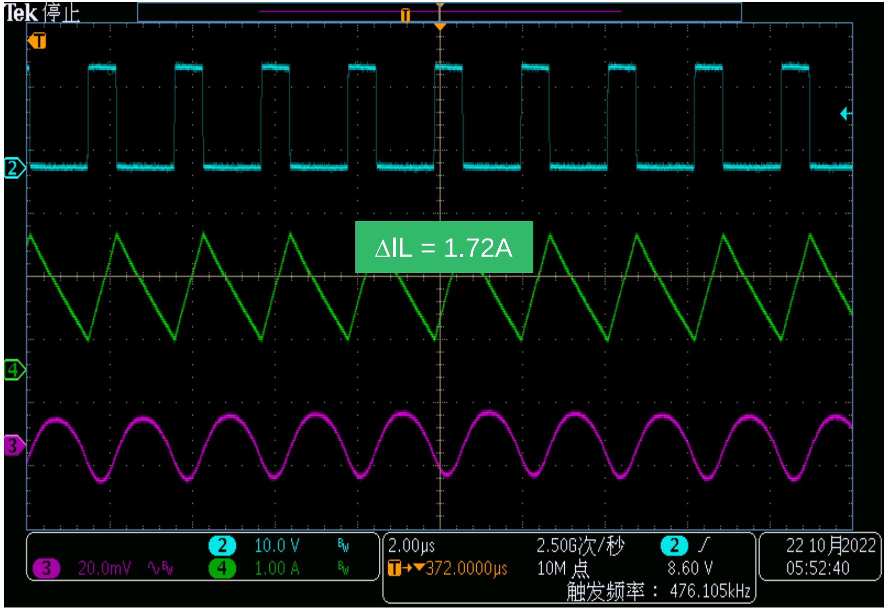
Inductance drops by 30% at the given current



Current Ripple Comparison – AL4020

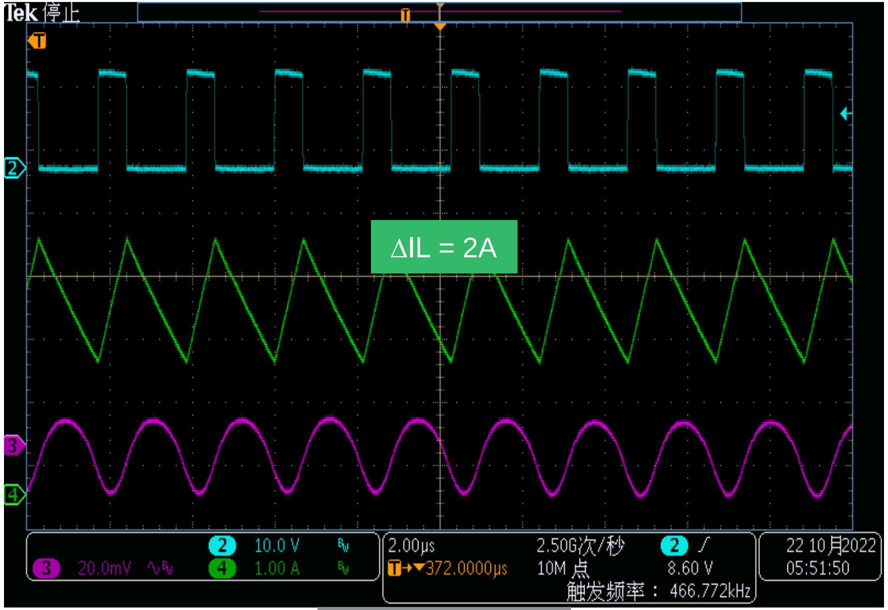
Test Condition： 16V to 5V

- L = 4.7 µH (52.5mOhm)
- I_Sat=4.2A
- OCP Threshold: 2.9A (11% ripple change)



ΔIL = 1.72A

Load=1.25A



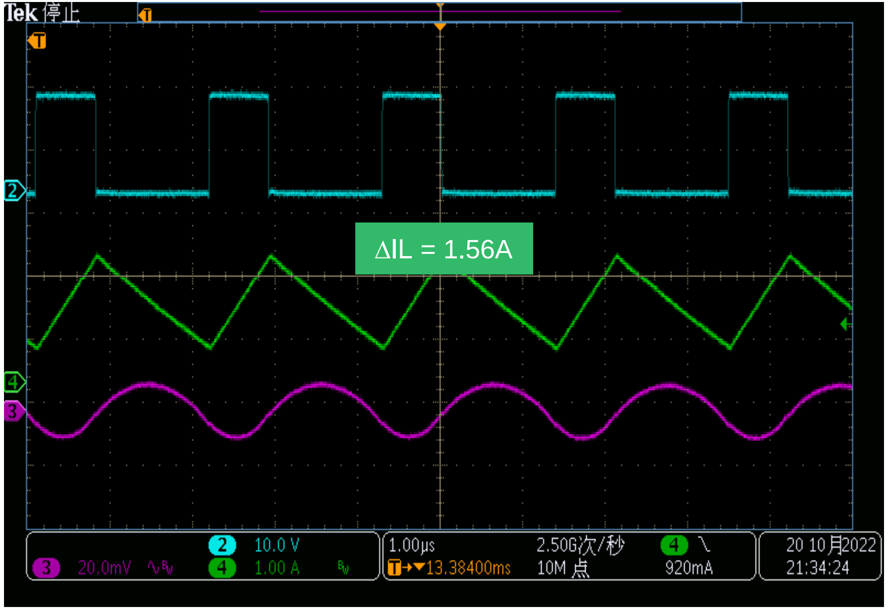
ΔIL = 2A

Load=2.9A

Current Ripple Comparison – AY3020

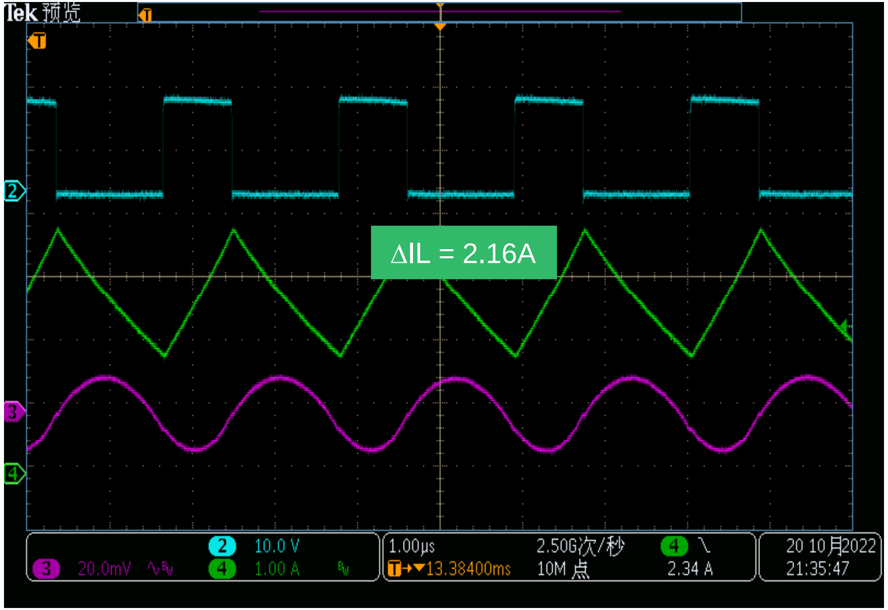
Test Condition： 16V to 5V

- L = 4.7 µH (173mOhm)
- I_Sat=3.1A
- OCP Threshold: 2.8A (24% ripple change)



ΔIL = 1.56A

Load=1.25A



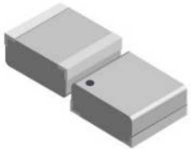
ΔIL = 2.16A

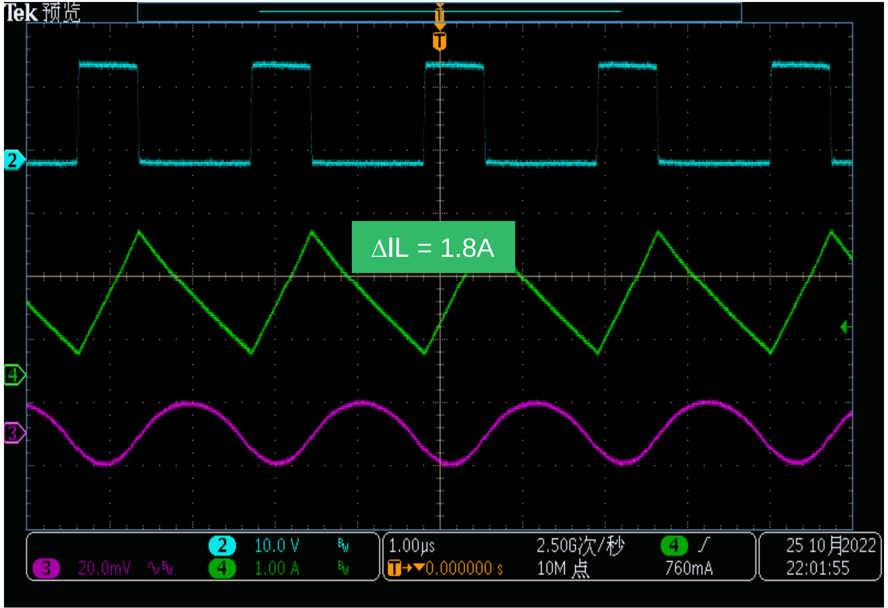
Load=2.8A

Current Ripple Comparison – AT2514

Test Condition： 16V to 5V

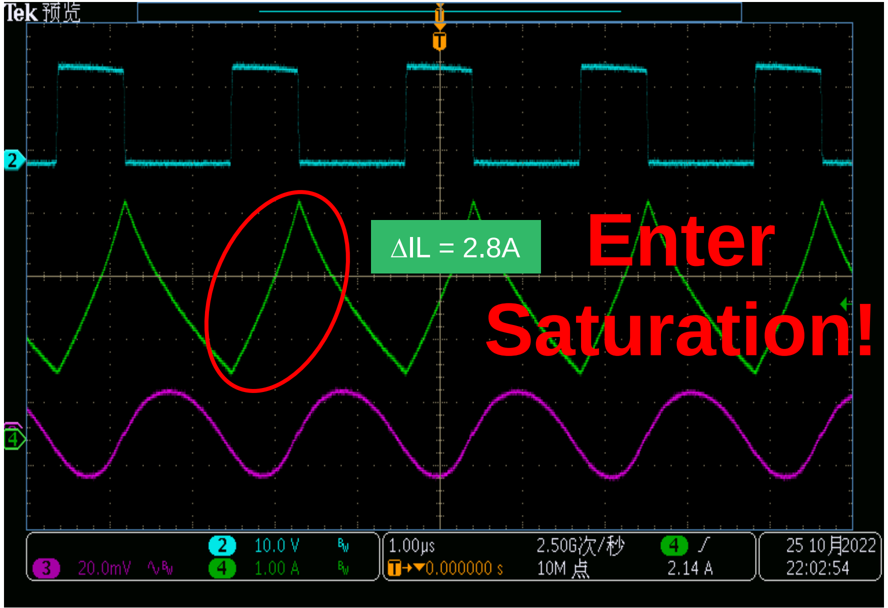
- L = 4.7 µH (180mOhm)
- I_Sat=2.4A
- OCP Threshold: 2.8A (40% ripple change)





ΔIL = 1.8A

Load=1.25A



ΔIL = 2.8A

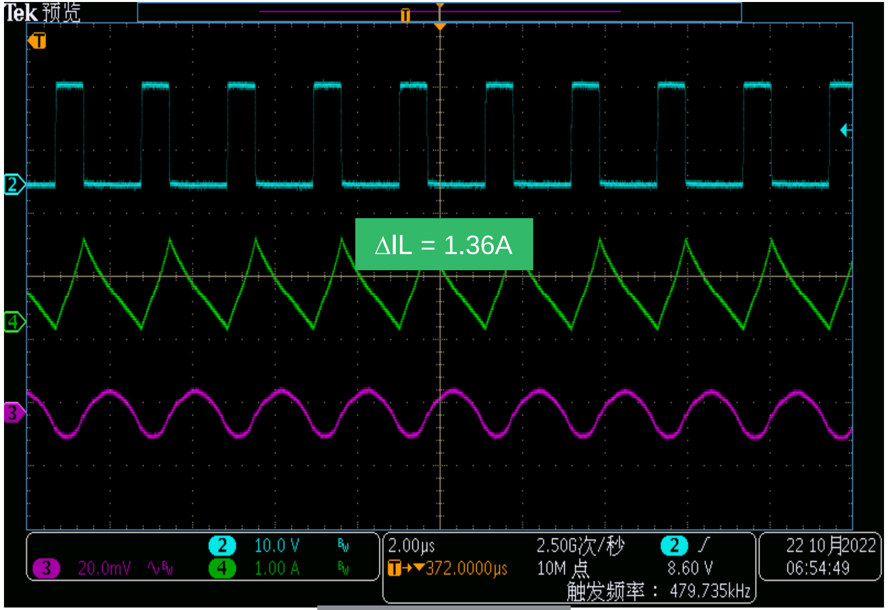
Enter Saturation!

Load=2.2A

Current Ripple Comparison – Other Brand

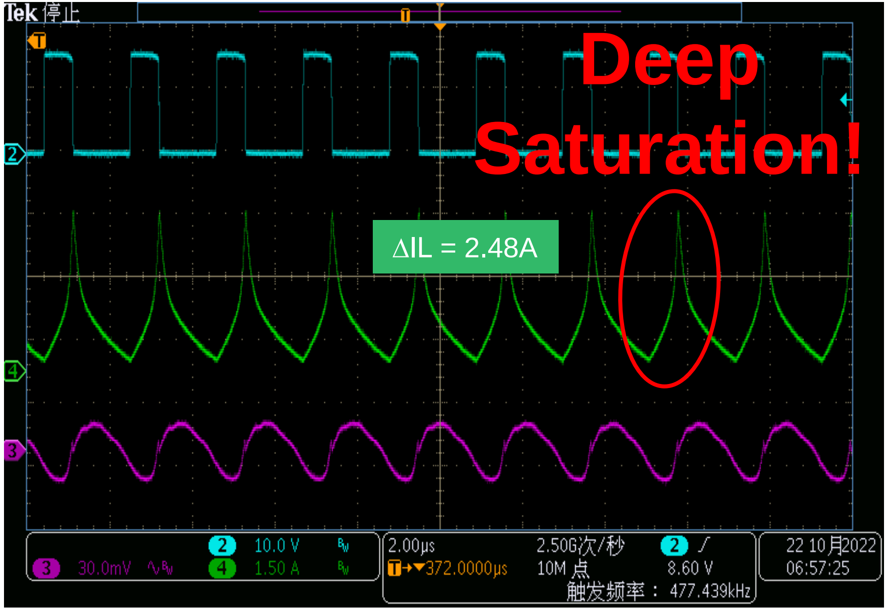
Test Condition： 16V to 5V

- L = 4.7 µH (50mOhm)
- I_Sat=1.7A
- OCP Threshold: 1.1A



ΔIL = 1.36A

Load=0.5A



Deep Saturation!

ΔIL = 2.48A

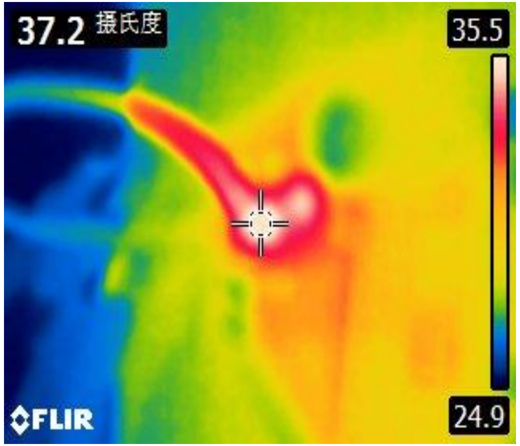
Load=1.1A

Saturation Condition: Thermal Rising

Test Condition： 16V to 5V

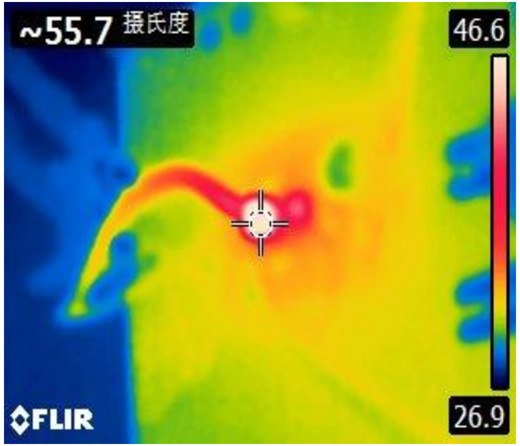
- L = 4.7 µH (AL4020 & Other Brand)
- Ambient temperature: 26℃

MPL-AL4020



Load=1.1A

Other Brand



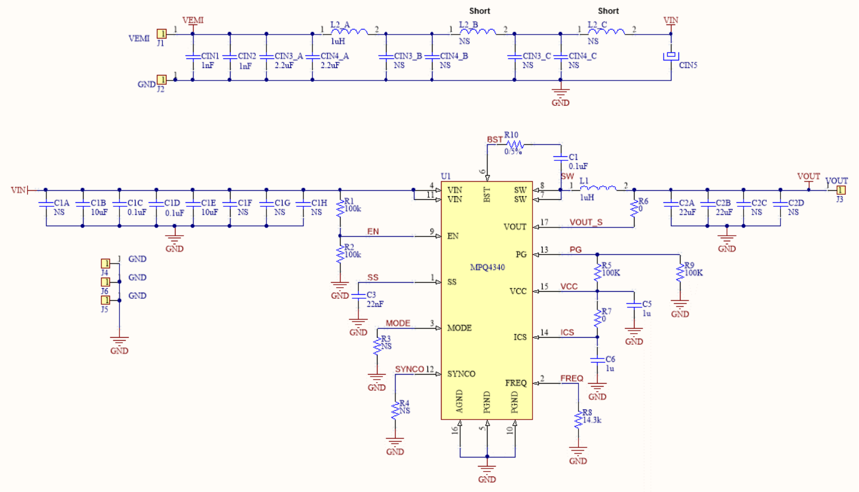
Load=1.1A

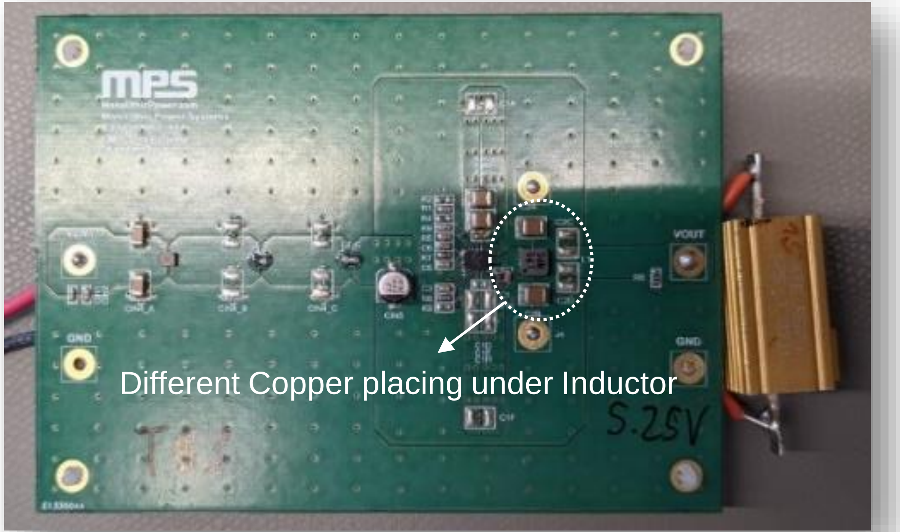
Pain Points of Inductor Using

Impact of EMI

Copper Under The Inductor

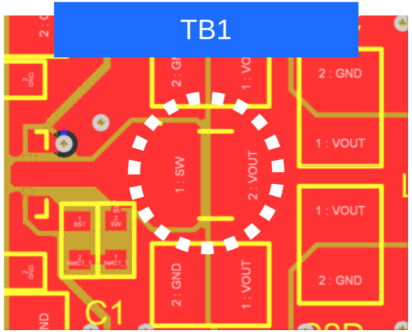
Standard Reference Schematics



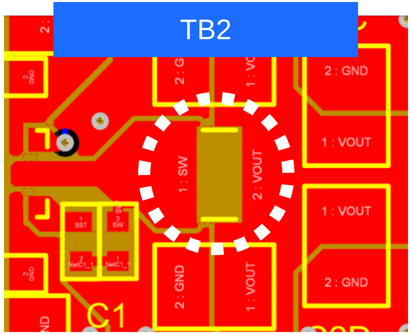


Different Copper placing under Inductor

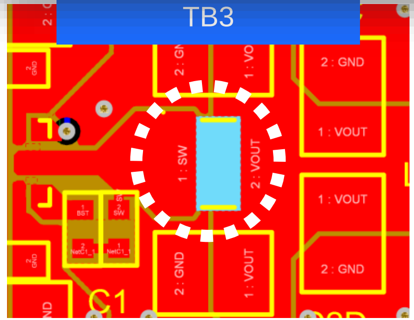
TB1



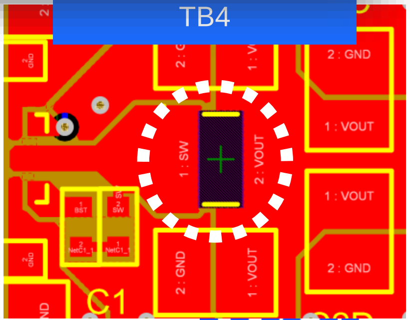
TB2



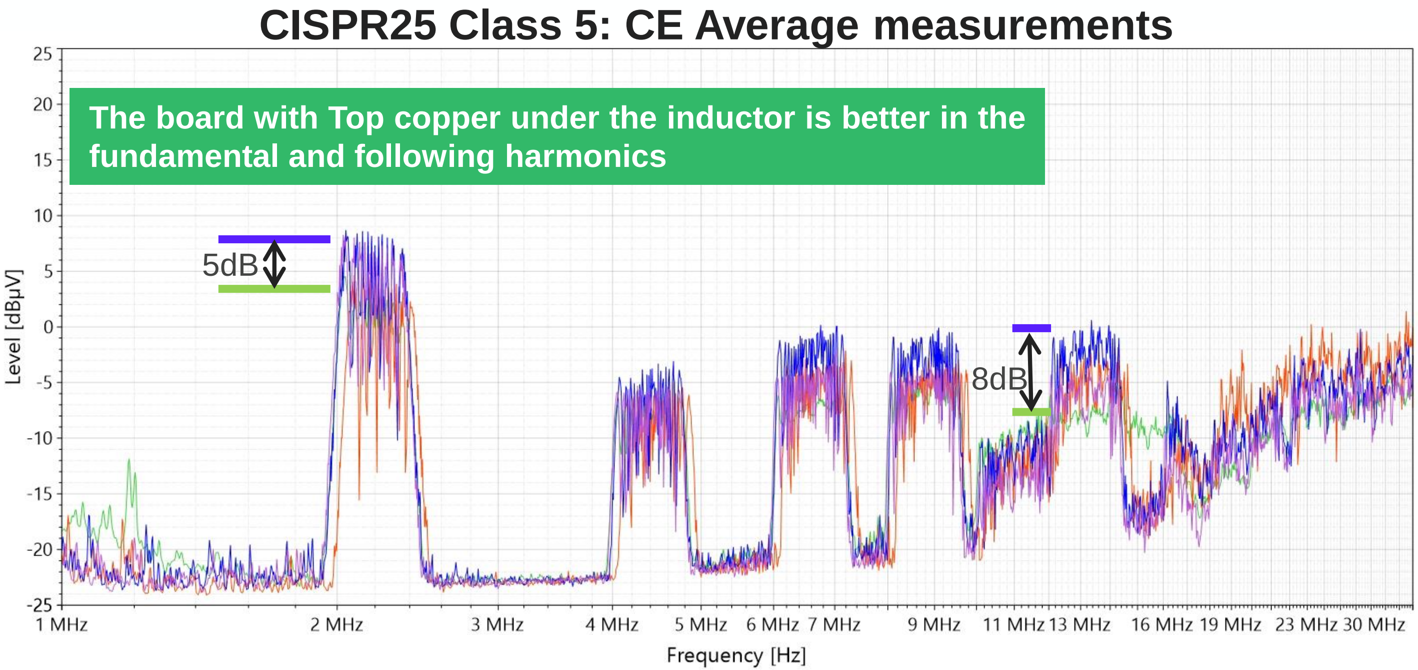
TB3



TB4



Copper Under The Inductor: Test results



The board with Top copper under the inductor is better in the fundamental and following harmonics

TB1: Copper under L

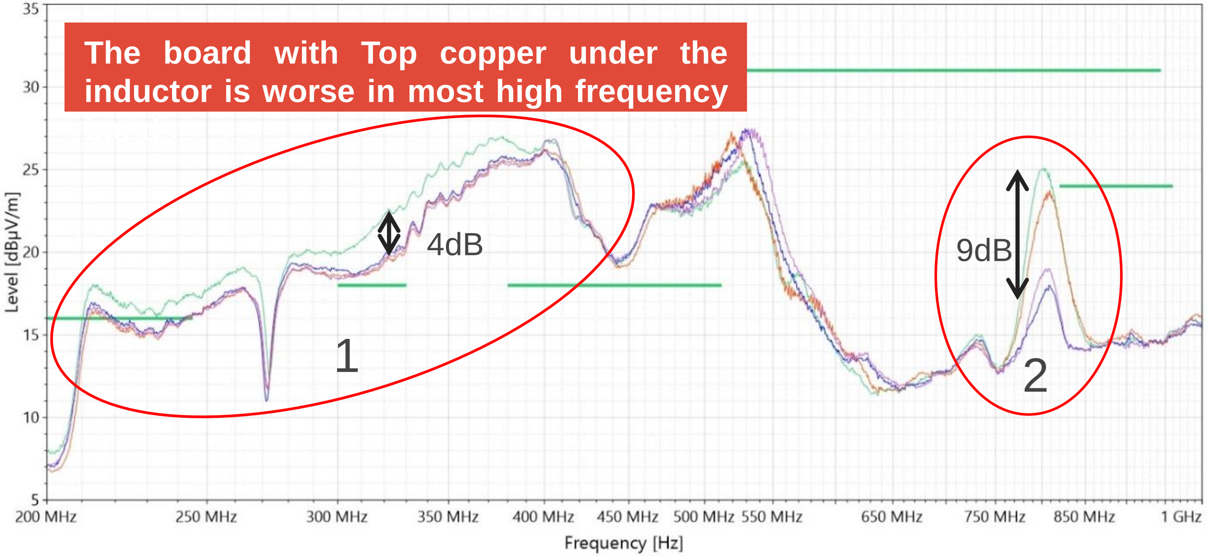
TB2: Removing Top copper

TB3: Removing Internal and Top copper

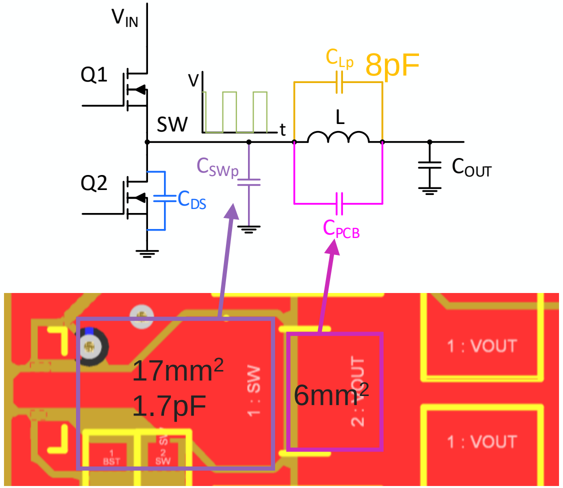
TB4: Removing all copper

Copper Under The Inductor: Test results

CISPR25 Class 5: RE Log Average measurements



The board with Top copper under the inductor is worse in most high frequency



The copper area under the inductor in top layer is Vout. The eddy currents are induced there. The Parasitic Capacitance between SW and Vout is increased by this extra area.

TB1: Copper under L

TB2: Removing Top copper

TB3: Removing Internal and Top copper

TB4: Removing all copper

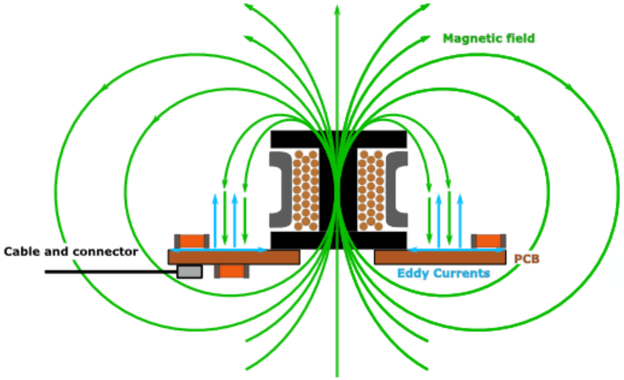
Copper Under The Inductor: Conclusion

The magnetic fields emitted by the inductor create eddy currents when they hit perpendicular to a conductor.

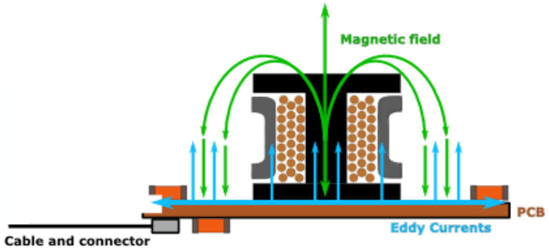
These eddy currents create losses in the form of heat and reduce the effective inductance. However, the eddy currents also generate magnetic fields which oppose the inductor’s one.

By placing copper under the inductor, most magnetic field is captured and converted to eddy currents so the emissions are lower.

PCB with window in Cu under coil

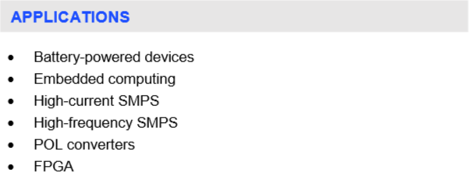


PCB with no window in Cu under coil



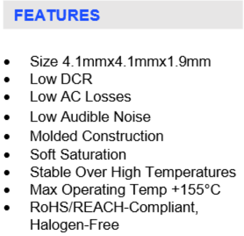
Shielded & Semi-Shielded Inductor

Changed the standard molded inductor used in all other test MPL-AL4020-1R0 to the semi-shielded MPL-SE4030-1R0



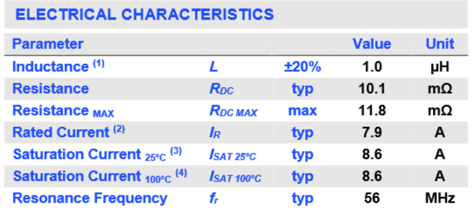
APPLICATIONS

- Battery-powered devices
- Embedded computing
- High-current SMPS
- High-frequency SMPS
- POL converters
- FPGA



FEATURES

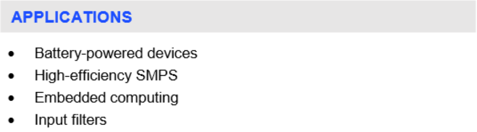
- Size 4.1mmx4.1mmx1.9mm
- Low DCR
- Low AC Losses
- Low Audible Noise
- Molded Construction
- Soft Saturation
- Stable Over High Temperatures
- Max Operating Temp +155°C
- RoHS/REACH-Compliant, Halogen-Free



ELECTRICAL CHARACTERISTICS

Parameter			Value	Unit
Inductance (1)	L	±20%	1.0	µH
Resistance	R_{DC}	typ	10.1	mΩ
Resistance $_{MAX}$	$R_{DC\ MAX}$	max	11.8	mΩ
Rated Current (2)	I_R	typ	7.9	A
Saturation Current $_{25°C}$ (3)	$I_{SAT\ 25°C}$	typ	8.6	A
Saturation Current $_{100°C}$ (4)	$I_{SAT\ 100°C}$	typ	8.6	A
Resonance Frequency	f_r	typ	56	MHz

Cp=8pF

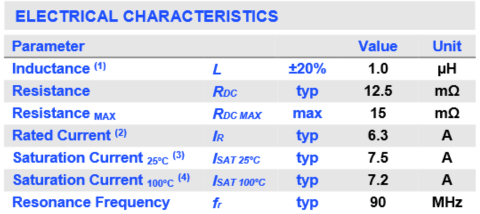


APPLICATIONS

- Battery-powered devices
- High-efficiency SMPS
- Embedded computing
- Input filters

FEATURES

- Size 4mmx4mmx3mm
- Semi-Shielded Construction
- Low DCR
- Low Stray Field
- Max Operating Temp +125°C
- RoHS/REACH-Compliant, Halogen-Free



ELECTRICAL CHARACTERISTICS

Parameter			Value	Unit
Inductance (1)	L	±20%	1.0	µH
Resistance	R_{DC}	typ	12.5	mΩ
Resistance $_{MAX}$	$R_{DC\ MAX}$	max	15	mΩ
Rated Current (2)	I_R	typ	6.3	A
Saturation Current $_{25°C}$ (3)	$I_{SAT\ 25°C}$	typ	7.5	A
Saturation Current $_{100°C}$ (4)	$I_{SAT\ 100°C}$	typ	7.2	A
Resonance Frequency	f_r	typ	90	MHz

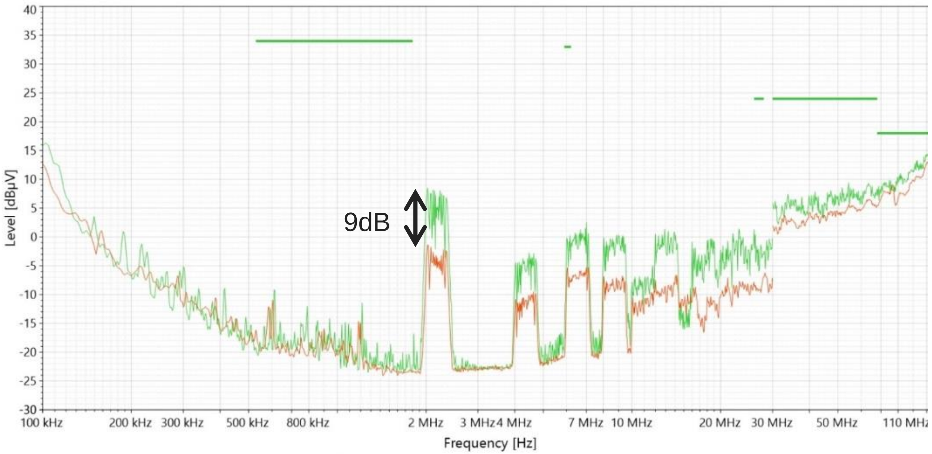
Cp=3pF

Shielded & Semi-Shielded Inductor: Test Results

Molded Inductor

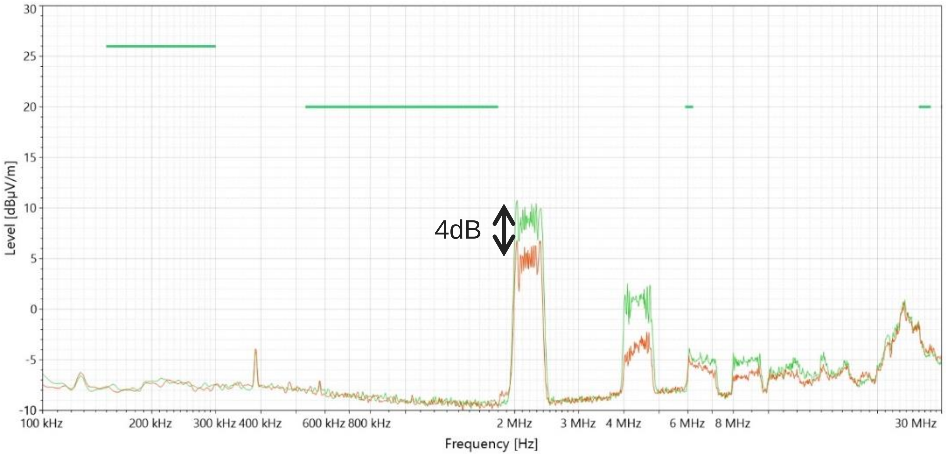
Semi-Shielded Inductor

CISPR25 Class 5: CE Average measurements



The semi-shielded inductor is much better at low frequency and helps at the FM band.

CISPR25 Class 5: Monopole Average measurements



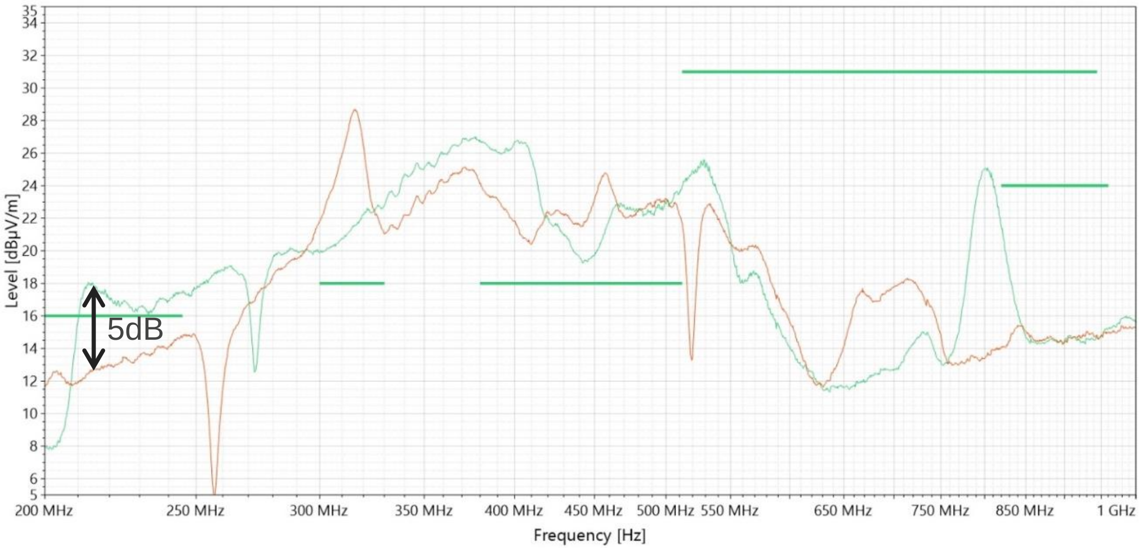
The semi-shielded inductor emits less E-field.

Shielded & Semi-Shielded Inductor: Test Results

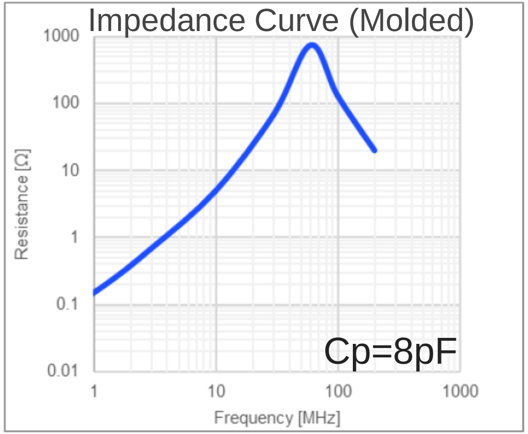
Molded Inductor

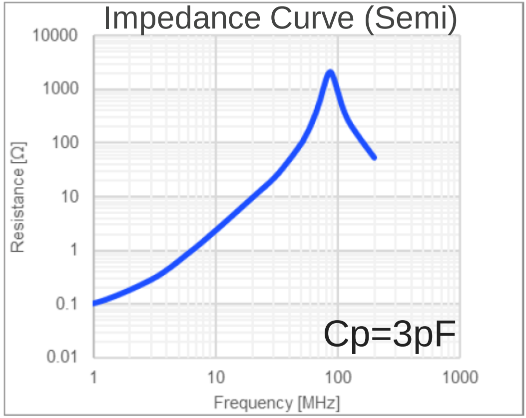
Semi-Shielded Inductor

CISPR25 Class 5: RE Log Average measurements (vertical)



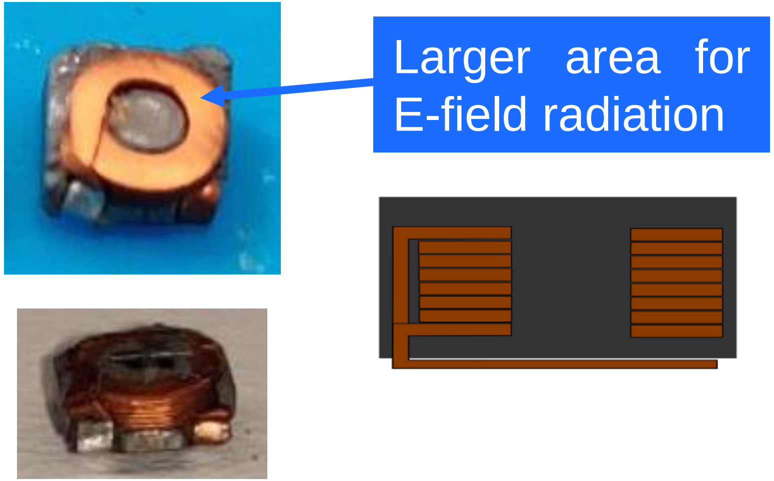
Overall the semi-shielded looks better except for the resonance at 320MHz.



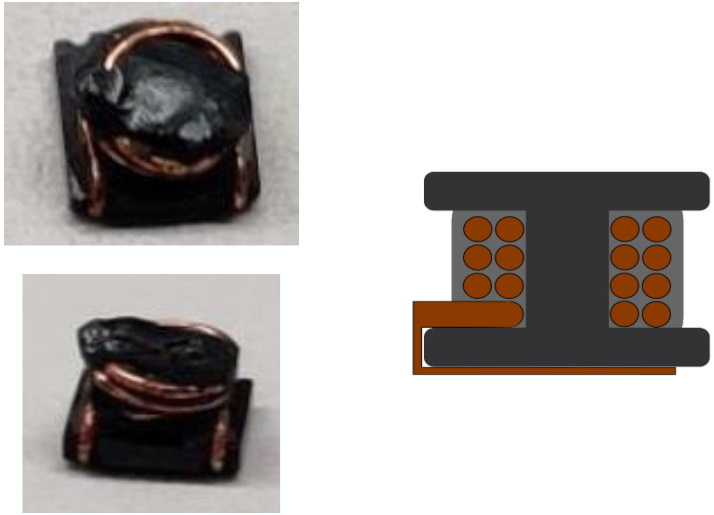


Shielded Inductor: Conclusion

Shielded inductors are not always having better EMI performance compared to non-shielded or *semi-shielded inductors.* Each design is unique, you have to test in the early stages and evaluate which components are best. Not all inductors are built equal.


Larger area for E-field radiation

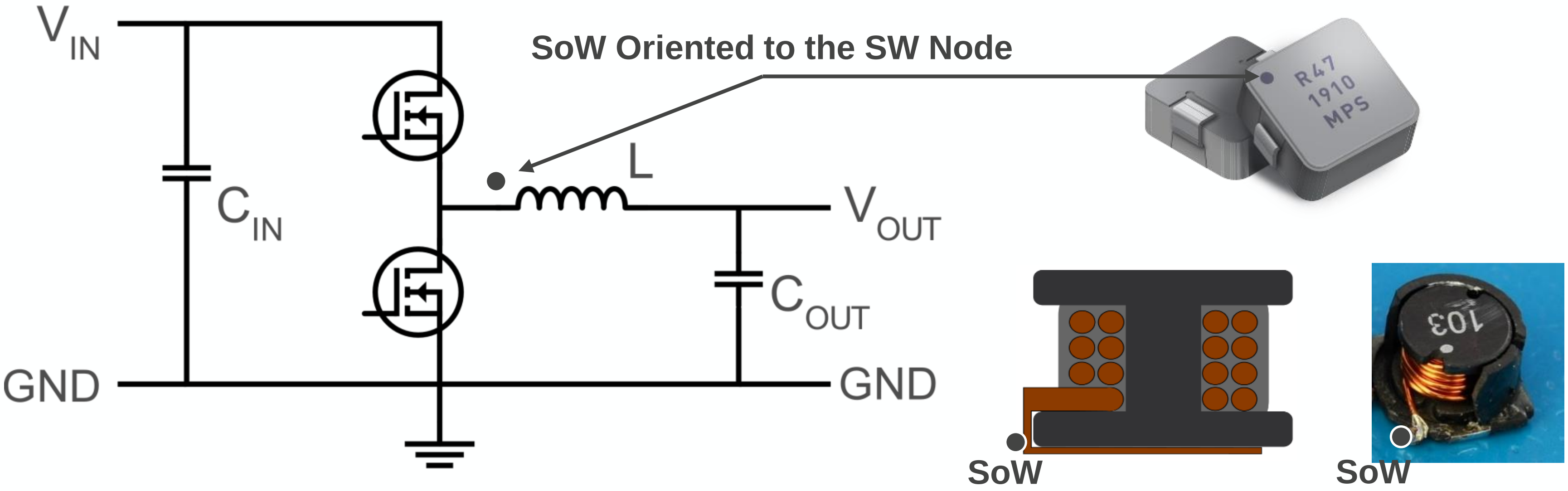
Shielded (molded)



Semi-Shielded (epoxy coating)

Orientation of Inductor (Start of Winding)

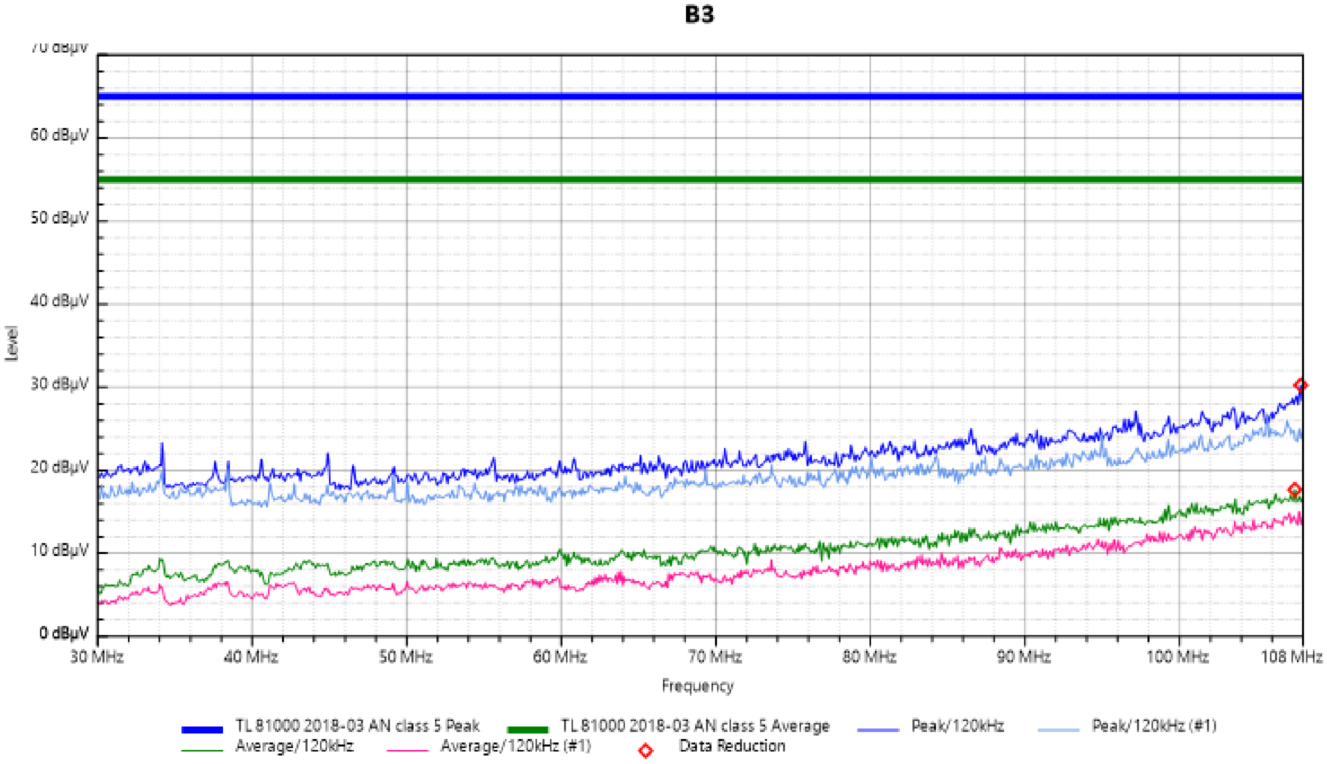
The converter switch node is close to the start of winding (SoW) side.


SoW Oriented to the SW Node

- Avoids audible noise from harmonics
- Reduces emissions caused by the inductor

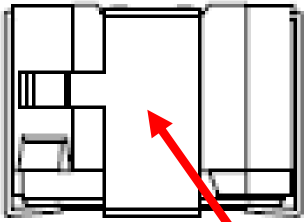
Orientation of Inductor - XAL5030 1µH in Both Directions

Start of Winding at SW is 2-3dB better



Orientation of Inductor (Start of Winding)

4.5mm Height

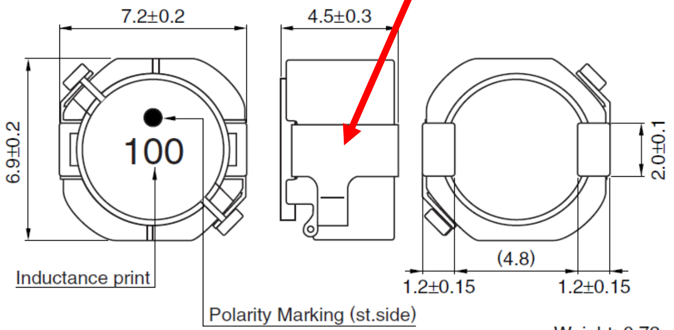


Contact metal acts as antenna for
E-field from SW-node dV/dt

End of Winding side
Contact metal with two
clip into airgap for
mechanical robustness

Even if SoW is at
SW, plate will cause
trouble

SHAPES AND DIMENSIONS

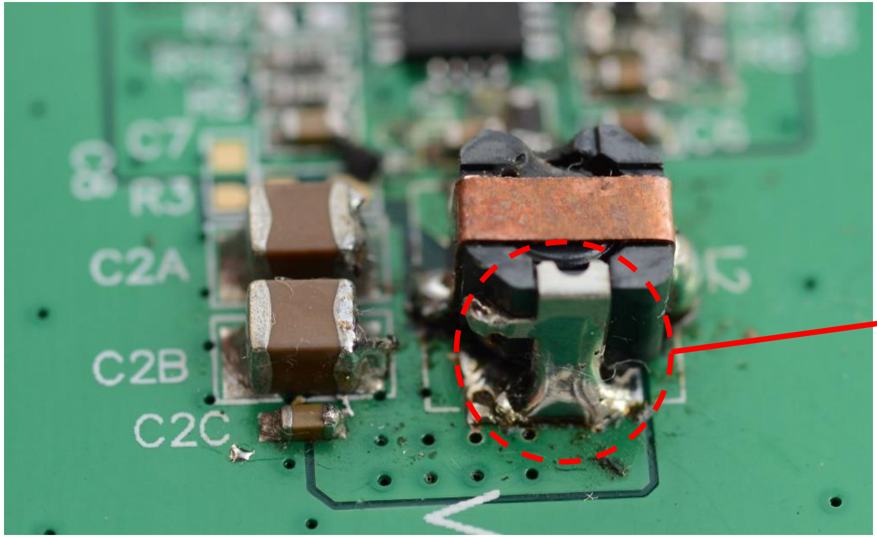


Weight: 0.72g

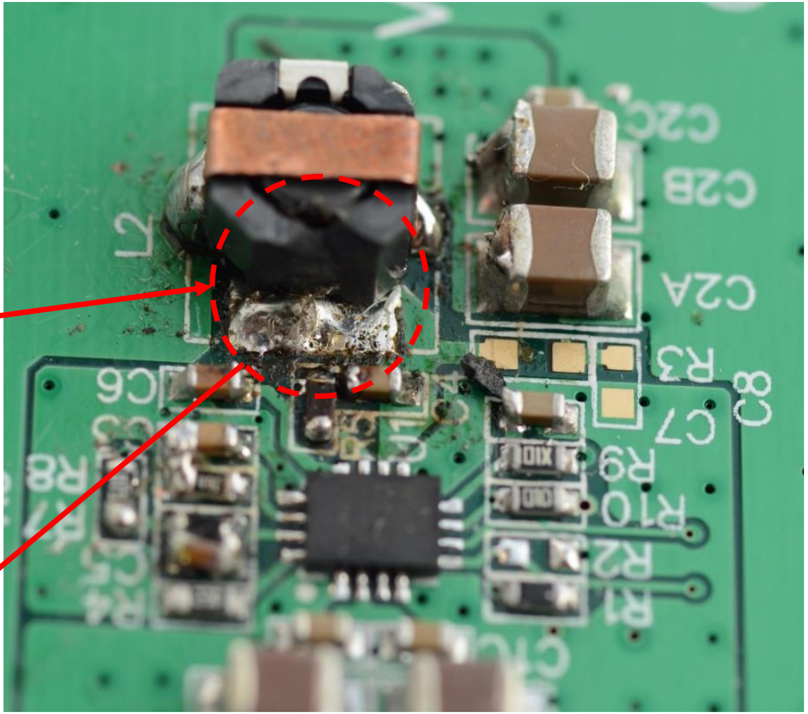
Dimensions in mm

Example Drawings from Murata, TDK and ABC

Orientation of Inductor (Start of Winding)

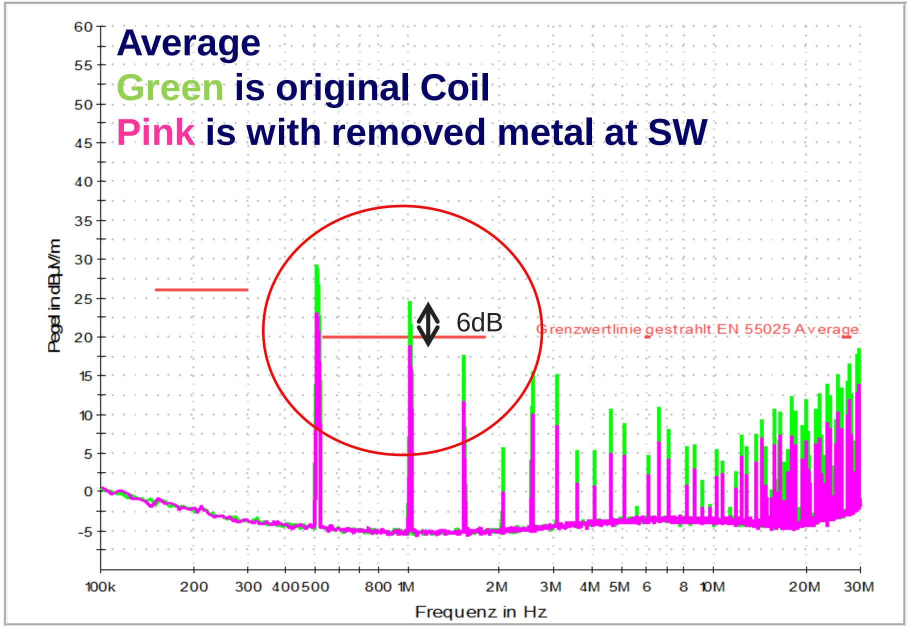


SW-node contact plate removed:

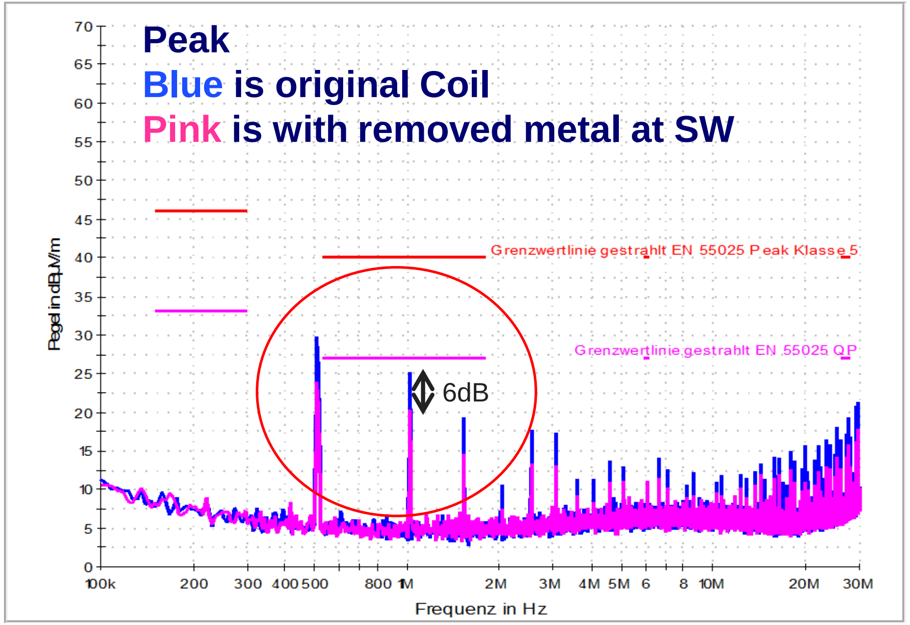


4.5mm height contact plate act as E-Field antenna for SW-node high dV/dt.
Optimum coil should have SW-contact at the bottom.

Orientation of Inductor (Start of Winding)



Average
Green is original Coil
Pink is with removed metal at SW



Peak
Blue is original Coil
Pink is with removed metal at SW

SW-node contact plate removed:
Winding soldered directly to PCB.
6 dB lower emissions at 1MHz
In Monopole Antenna Test

Conclusions

- **Inductor**
    - An Inductor Reacts to Current Changes
    - Stores Induced Electric Energy as Magnetic Energy
    - Inductance Depends on the Core Material Characteristics and Number of Turns
    - Rated Current & Saturation Current
    - SoW Orientation.

- **Inductance Selection**
    - Topology Determined.
    - Design Target: Current Ripple, Voltage Ripple.
    - Worst Case Working Condition: Input Voltage Range, OCP & SCP.

- **Influence of EMI**
    - Copper Under Inductor.
    - Shielded Inductor / Inductor Structure – Smaller Size Preferred.
    - Place SoW At DCDC SW Terminal.

Q&A

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