

## SELECTING THE RIGHT INDUCTOR FOR DC-DC CONVERTERS USING REDEXPERT

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WURTH ELEKTRONIK MORE THAN YOU EXPECT

## **AGENDA**

Selecting the right inductor using REDEXPERT

- Power Inductor losses
- Demo Board Overview
- Live Demo using Thermal Camera



# INDUCTOR LOSSES

## Copper + Core

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*Ptotal* = *Pcore* + *Pcopper* 





#### **DC COPPER LOSSES**

#### **P** TOTAL = **P** COPPER + **P** CORE

Copper Losses = P DC\_Copper + P AC\_Copper

#### **DC Copper Losses**

Due to the DC resistance ( DCR) of the wire. Expressed as:  $P_{DC} = R_{DC} * l^2$ 

#### Can be Minimized by:

Using thicker wire Reducting number of turns









#### $\mathbf{P}$ TOTAL = $\mathbf{P}$ copper + $\mathbf{P}$ core

#### <u>Copper Losses = P DC\_Copper + P AC\_Copper</u>

#### **SKIN Effect**

As frequency increases, **AC current flows only on the outer surface** of the wire.

Reduces the effective conduction area  $\rightarrow$  **increases resistance** 







#### **Proximity Effect**

Additional current crowding due to nearby conductors carrying current in the same or opposite direction

Increases effective resistance and losses in bundled or closely spaced windings



#### Can be Minimized by:

Use flat wire or Litz wire to increase effective surface area and reduce AC resistance.



### **DESIGN TRADE OFFS**

Change	Effect on Losses	Side Effects
Thicker wire	↓ DC & AC copper losses	↑ physical size of the inductor
Fewer turns	↓ DC resistance	↓ inductance, ↑ core losses (to keep same <b>L</b> )
Flat wire	↓ AC losses (skin/proximity)	↑ cost and size



#### $\mathbf{P}$ TOTAL = $\mathbf{P}$ copper + $\mathbf{P}$ core

#### The core losses are classified in two parts:

Hysteresis losses Eddy currents

#### Hysteresis losses:

 Energy lost due to the changing magnetic energy in the core



#### **Eddy currents**

 Parasitic currents induced in the core – Energy lost





## HOW TO REDUCE CORE LOSSES

Reduce the ripple (Increase L) Reduce the switching frequency



Increase the size of the core

Change material



Change	Effect on Core Losses	Effect on Copper Losses	Other Impact
Bigger core	↓ Core losses	-	↑ Physical size of inductor
More turns (higher L)	$\downarrow$ Ripple $\rightarrow \downarrow$ Core losses	↑ Copper losses	
Change core material	↓ Core losses (better material)	_	









#### **BUCK DEMO KIT FOR REDEXPERT**

# Buck Demonstration Kit for **REDEXPERT**



#### TECHNICAL DATA: f<sub>w</sub>: 200 kHz ~ 2 MHz V\_: 4.5 V ~ 40 V

V<sub>our</sub>: 5V l<sub>our</sub>: 2A/3A peak

Order Code 988 141 Version 1.0





### **Buck Demo Kit for REDEXPERT**





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#### THE BOARD





#### TEST #1

**RED**EXPERT: Test condition 1

- V<sub>in</sub> = 19 V
- V<sub>out</sub> = 5 V
- I<sub>out</sub> = 0.5 A
- Frequency = 450 kHz
- $T_{iniziale} = 28^{\circ}C$

NE.

## REDEXPERT® THE WORLD'S MOST ACCURATE AC LOSS MODEL FOR INDUCTORS

#### BIL OF Maherials

14	Name .	Online Code	Velation	Properties	300
*	a	Montrorpation	3.814	Assembling Technology + 540° Calcontenter + 5 20° d* Assembling + 160° d* Margini + 1.50° mesi	1
3	(98)	40001204021	User	Assessming Partnoring - 3487 Constantions - 1.0010F Rated Voltage - 14.019 Register - 1.1010F	- 5
6	200	Paarkthaatra	1.57.94*	Indiactorica = 1.32 pH Paline Connect + 450,444 Fore + Ungle	1
3	(4)	Partyring	135,00	telapization + 3,30 per Instal Carneri + 1,00 a Type - 3triger	5





#### TEST #2

**RED**EXPERT: Test condition 2

- V<sub>in</sub> = 19 V
- V<sub>out</sub> = 5 V
- I<sub>out</sub> = 0.5 A
- Frequency = 2.2 MHz
- $T_{iniziale} = 28^{\circ}C$

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## REDEXPERT® THE WORLD'S MOST ACCURATE AC LOSS MODEL FOR INDUCTORS

#### BIT OF Maherials

14	(April 1)	Online Cardin	Velan	Properties	300
*	a	Montroposition	3.854	Assembling Technology + SAT Capacitation + 5 20 cd* Assemblings + 16,0 m Hanglin + 1,50 cm	1
3	(98)	400010001	UR94	Assessming Partnoring - 3487 Constantiance - 1.50104 Autori Visifagal - 74.819 Autori Visifagal - 74.819 Autori Visifagal - 74.819	5
6	200	Paarkthaatra	1.57.94*	Indiactorica = 1.30 gH Paling Connect + 450 gH Tone + Bright	1
3	148.1	Partyring	111.00	telapization + 3.30 per Reality Carnets' + 5.00 a Note + 30 ger	5





#### TEST #3

#### **RED**EXPERT: Test condition 3

- V<sub>in</sub> = 19 V
- V<sub>out</sub> = 5 V
- I<sub>out</sub> = 2 A
- Frequency = 2.2 MHz
- $T_{iniziale} = 28^{\circ}C$

#### 

NE.

## REDEXPERT® THE WORLD'S MOST ACCURATE AC LOSS MODEL FOR INDUCTORS

#### BIT OF Maherials

14	Name .	Online Code	Velation	Properties	300
*	æ	Montrorpation	3.814	Assembling Technology + 540° Calcontenter + 5 20° d* Assembling + 160° d* Margini + 1.50° mesi	1
3	(98)	40001204021	User	Assessming Partnoring - 3487 Constantions - 1.0010F Rated Voltage - 14.019 Register - 1.1010F	- 5
6	200	Paarkthaatra	1.57.94*	Indiactorica = 1.32 pH Paline Connect + 450,444 Fore + Ungle	1
3	(4)	Partyring	135,00	telapization + 3,30 per Instal Carneri + 1,00 a Type - 3triger	5











