SELECTING THE RIGHT INDUCTOR FOR DC-DC CONVERTERS USING REDEXPERT

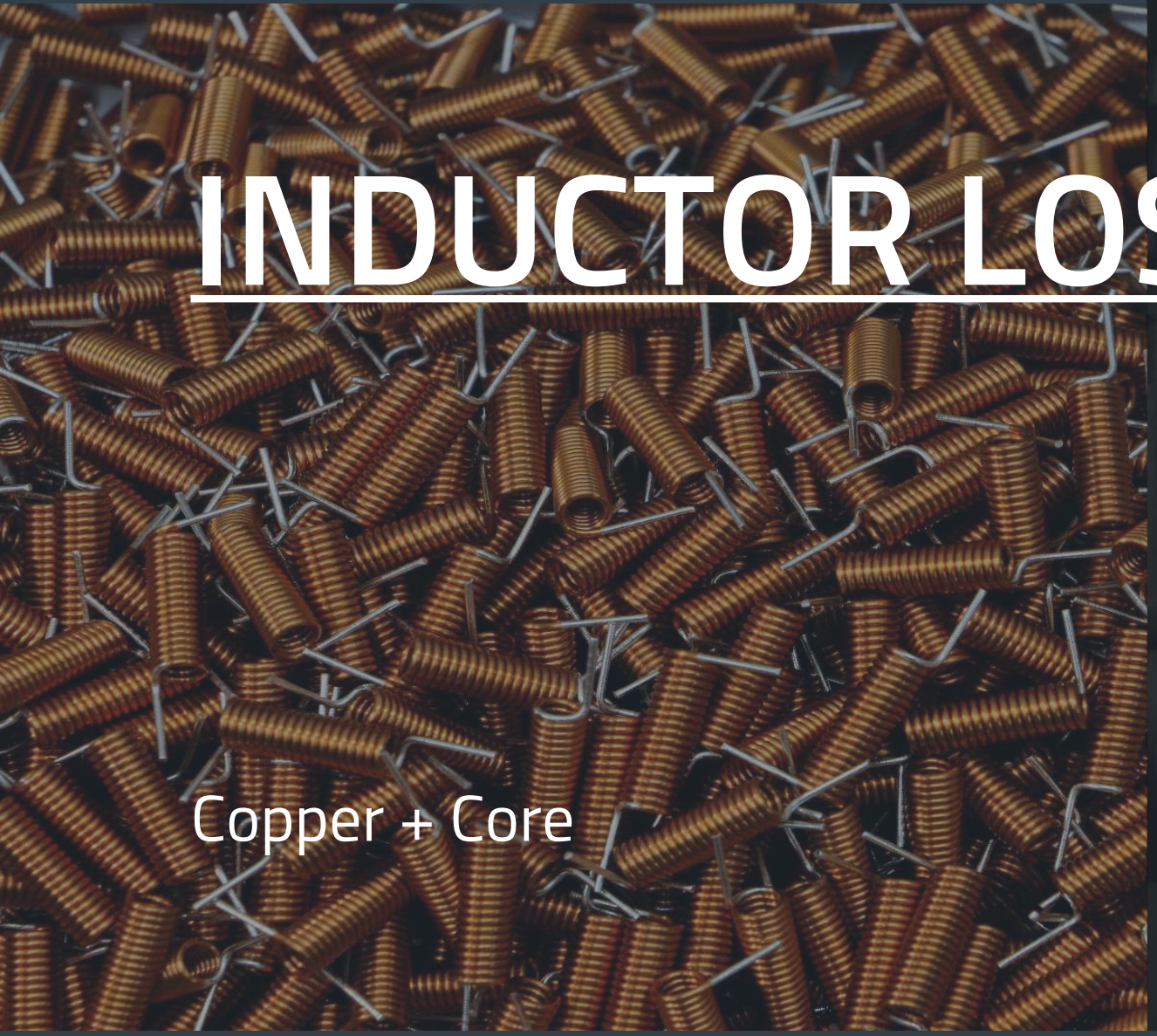
Ameer Elatrash – Technical Marketing Engineer

AGENDA

Selecting the right inductor using REDEXPERT

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

INDUCTOR LOSSES



Copper + Core

INDUCTOR LOSSES

Classification of Losses

- An inductor consists of two elements:
  - Copper.
  - Core.

- The power dissipation (losses) in an inductor are classified as:
  - Wire losses.
  - Core losses.

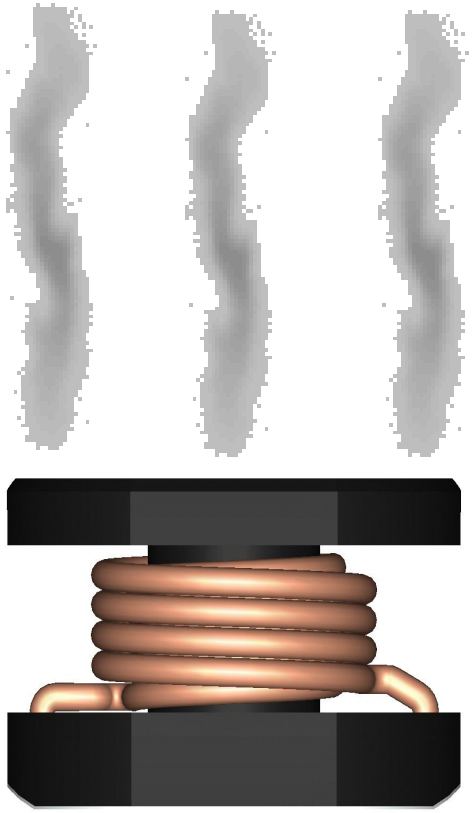
$$P_{total} = P_{core} + P_{copper}$$

INDUCTOR LOSSES

Self-Heating

- The inductors rise their own temperature when they drive current through them.
- It's important to not exceed the rated current of the inductor to avoid excessive over-heating.
- Reducing the losses of the inductor optimizes the efficiency of the circuit and reduces the workload of the cooling systems.

Ambient Temperature + Self-Heating (inductor)
= Temperature of Operation



COPPER LOSSES

Copper Losses

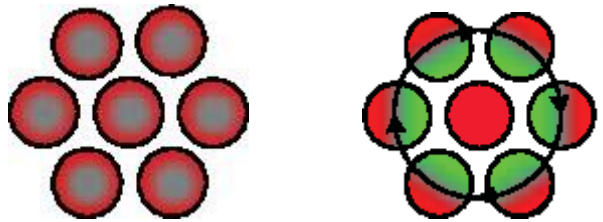
$$\text{Copper Losses} = P_{DC\_Copper} + P_{AC\_Copper}$$

- The copper losses are divided as:
  - DC losses.
  - AC losses.
- DC losses:
  - DC resistance of the conductive wire.
- AC losses:
  - Skin effect.
  - Proximity effect.

DC losses

$$P_{loss\ (DC)} = I^2 \times R_{DC}$$

AC losses

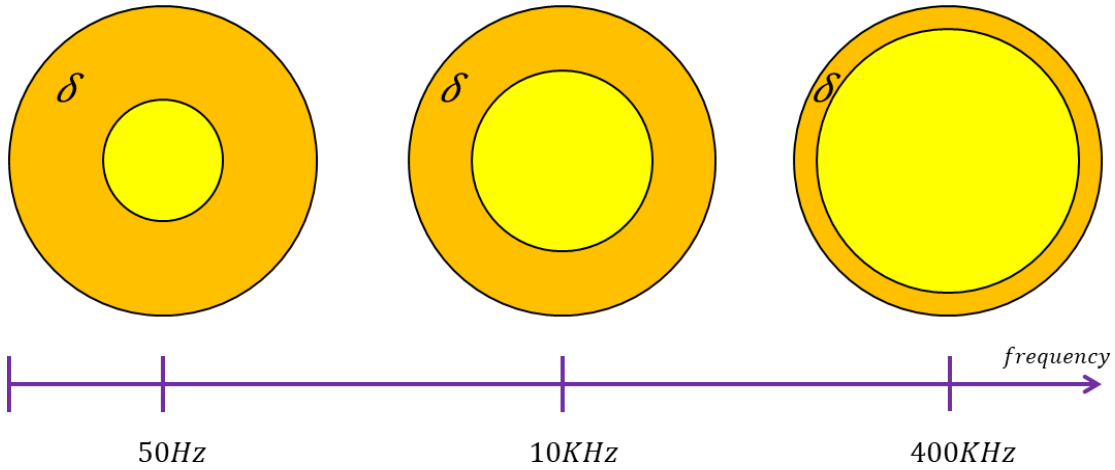


Skin effect / Proximity effect

COPPER LOSSES

Copper Losses – Skin Effect

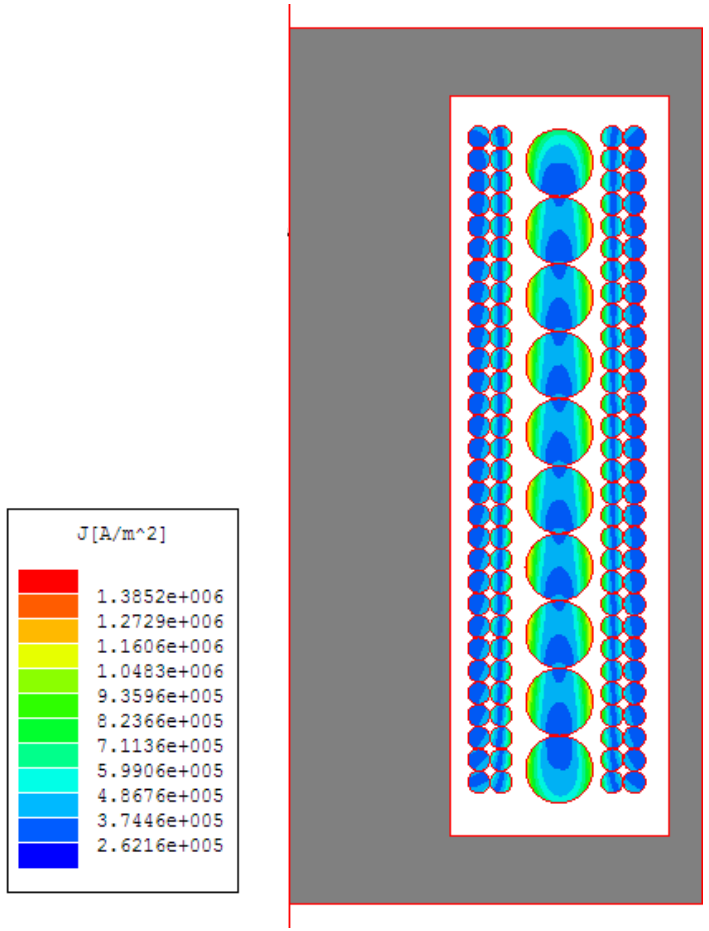
- It is a tendency for AC to flow on the outer surface of the conductor, wasting the effective area of the wire.
- The higher the frequency of the AC, the lower the surface area used for the current to flow through the wire, increasing the resistivity.



COPPER LOSSES

Copper Losses – Proximity Effect

- The current distribution is constricted into smaller regions, increasing the apparent resistance.
- This effect happens due to the magnetic field generated by the wire, thus influencing in the distribution of electric current flowing through the conductive wires nearby.



CORE LOSSES

Core Losses

$$P_{total} = P_{core} + P_{copper}$$

- The core losses are classified in two, both caused by AC:
  - 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.

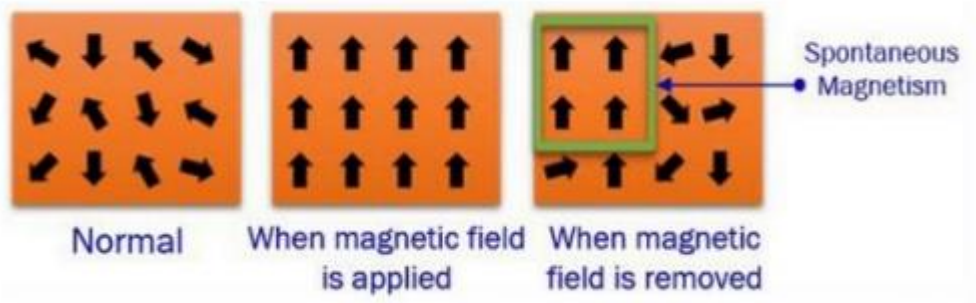
CORE LOSSES

Hysteresis losses

$$P_{total} = P_{core} + P_{copper}$$

- Hysteresis losses are caused by the magnetization and demagnetization of a core as current flows in reverse directions and it is released in the form of heat.

- The work done by the magnetization force against the internal friction of the core's molecules produces heat (energy lost).



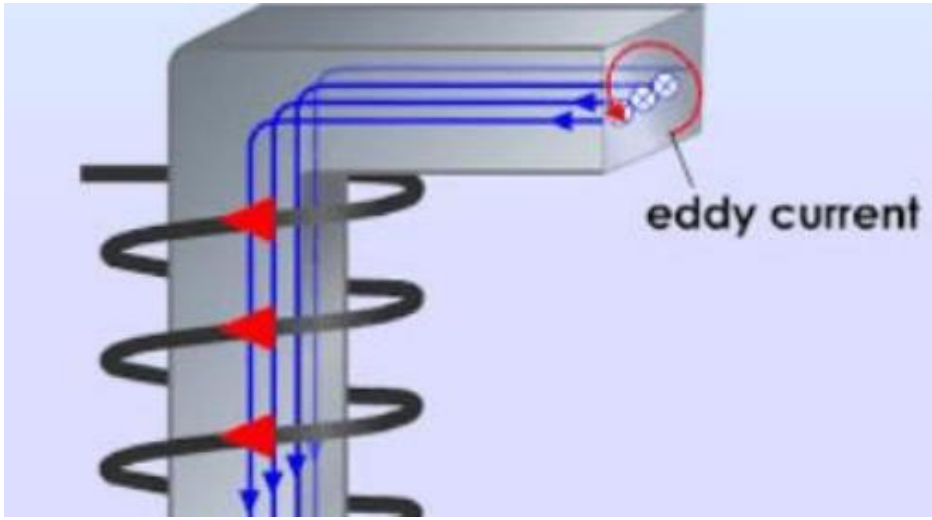
CORE LOSSES

Eddy Currents

$$P_{total} = P_{core} + P_{copper}$$

- The Eddy currents are induced in the core of the inductor due to the changing magnetic field produced by the inductor.

- These currents end up dissipated as heat in the core of the inductor, which represents an energy loss.



LOSSES

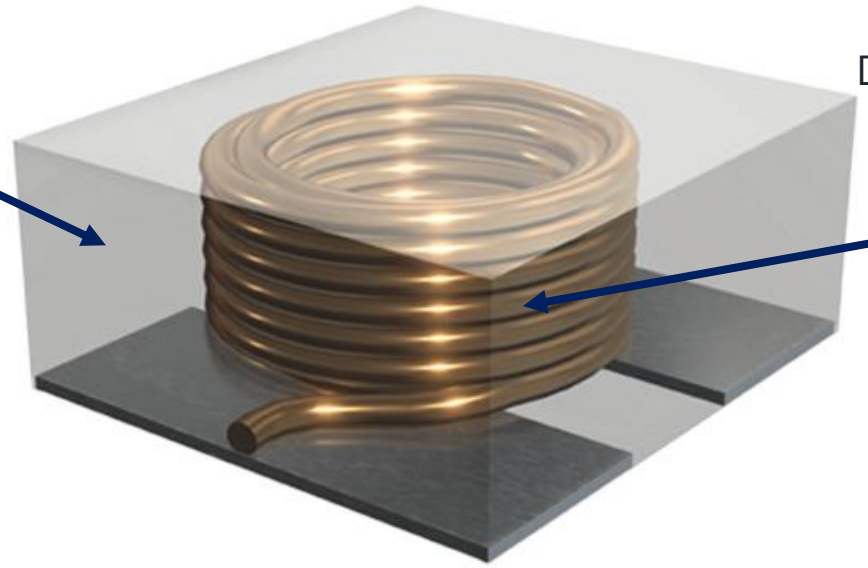
Losses Summary

$$P_{total} = P_{core} + P_{copper}$$

Core Losses

Hysteresis losses

Eddy current losses



Copper Losses

DC losses – depending on DC resistance of wire

AC-losses – dep. on winding structure

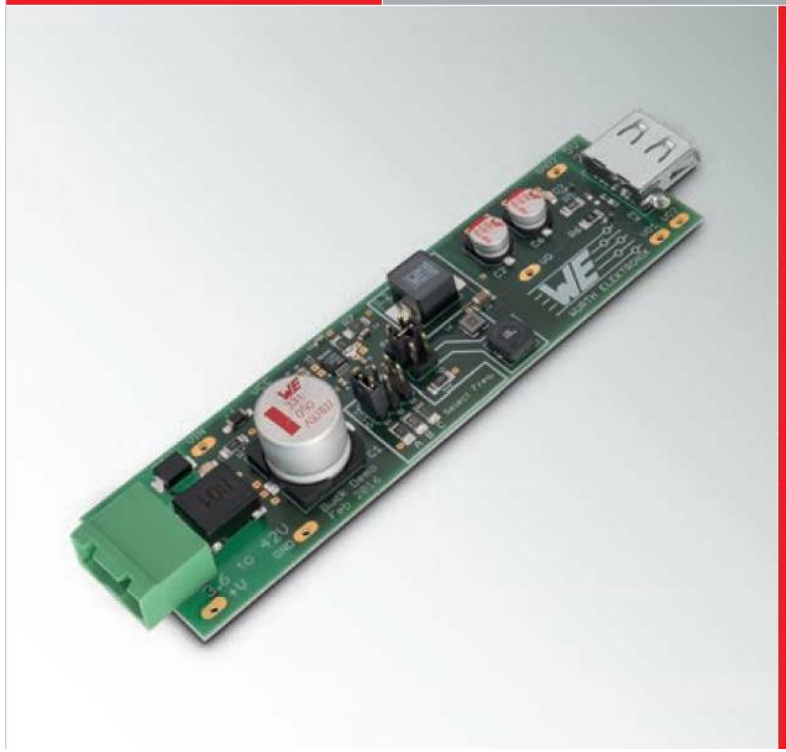
Skin-Effect

Proximity-Effect

BUCK DEMO KIT
+ RED EXPERT

BUCK DEMO KIT FOR REDEXPERT

Buck Demonstration Kit for REDEXPERT



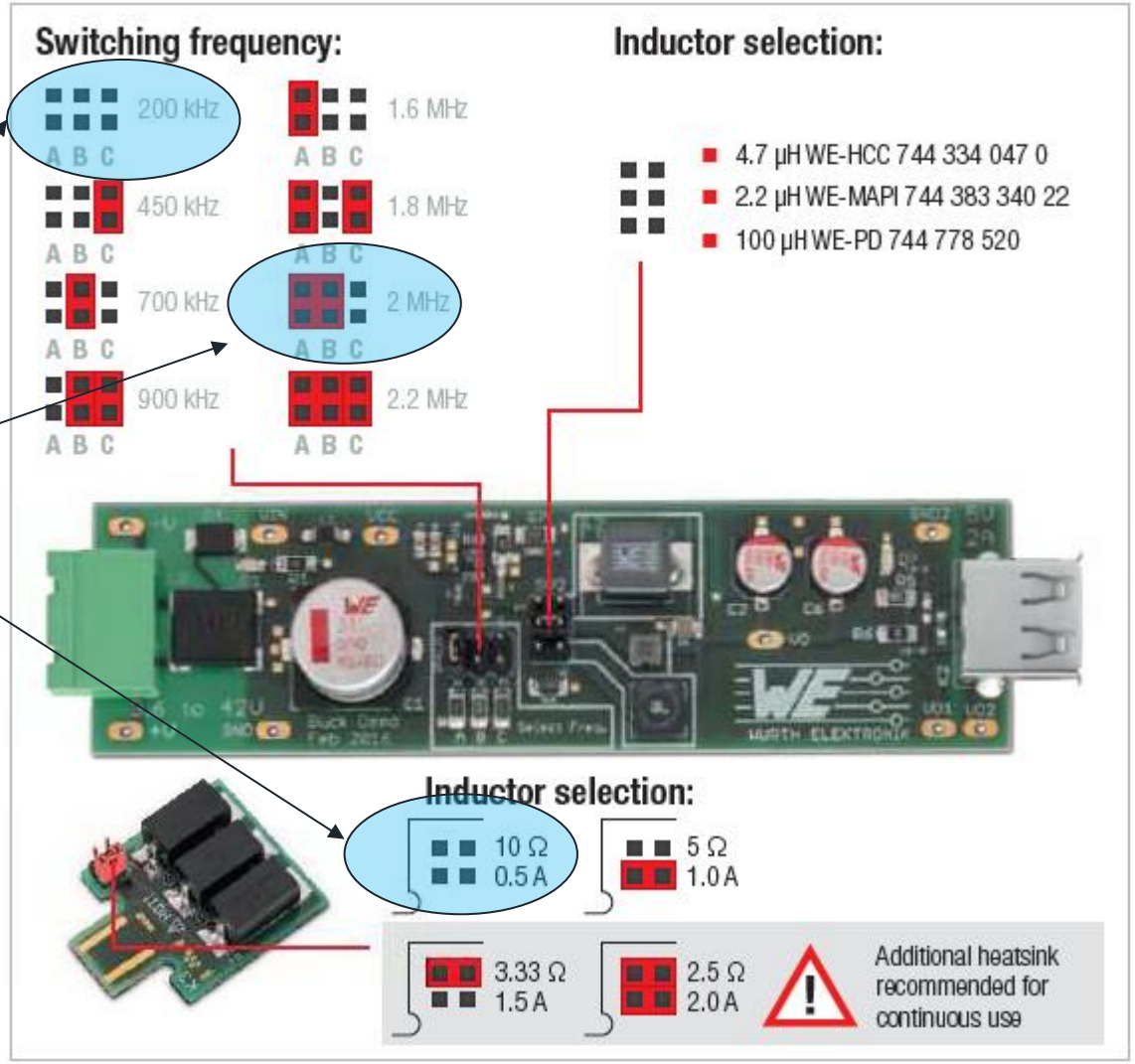
TECHNICAL DATA:

f_{SW}:	200 kHz ~ 2 MHz
V_{IN}:	4.5 V ~ 40 V
V_{OUT}:	5 V
I_{OUT}:	2 A / 3 A peak

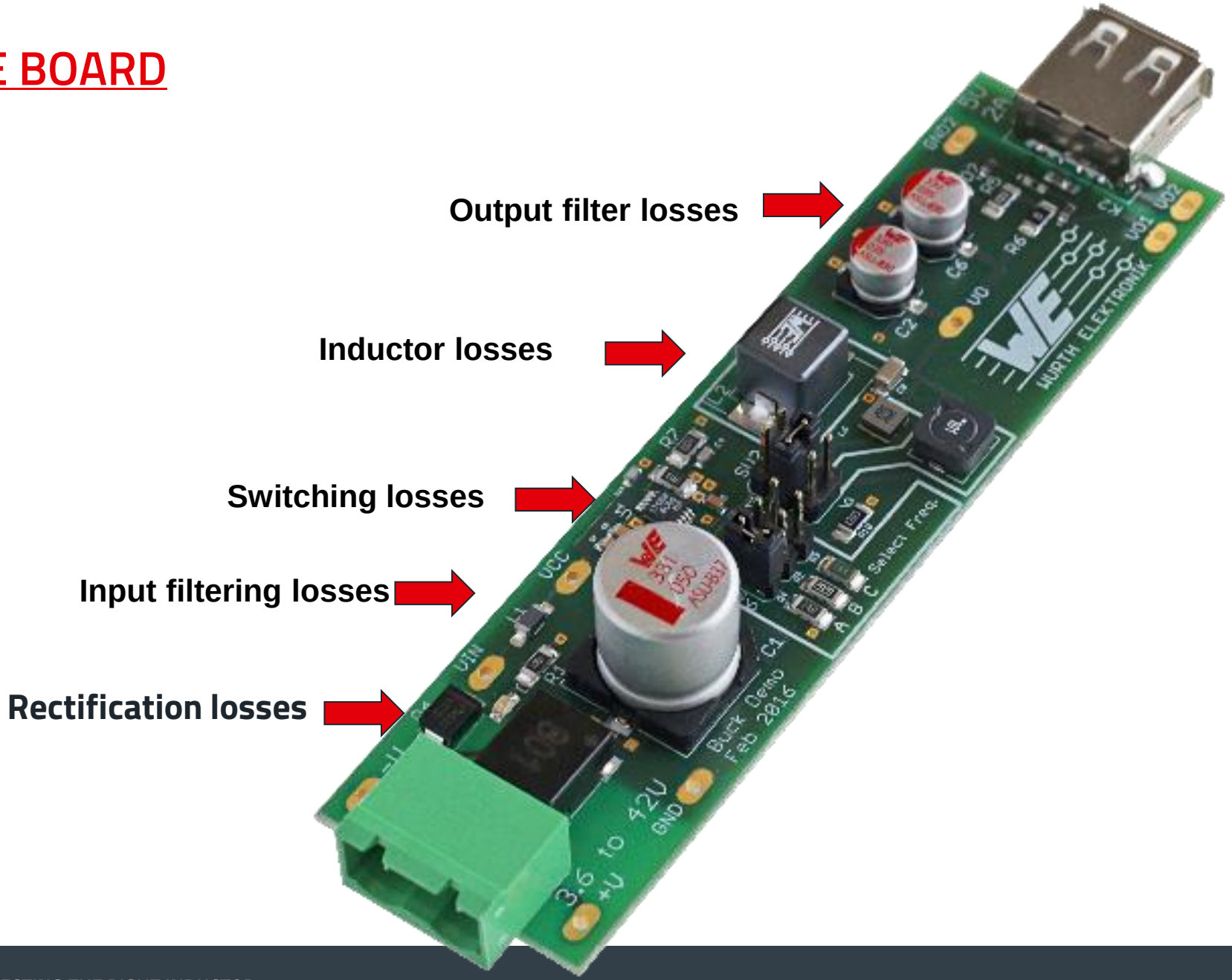
Order Code 988 141
Version 1.0

BUCK DEMO KIT FOR REDEXPERT

Test Conditions



THE BOARD

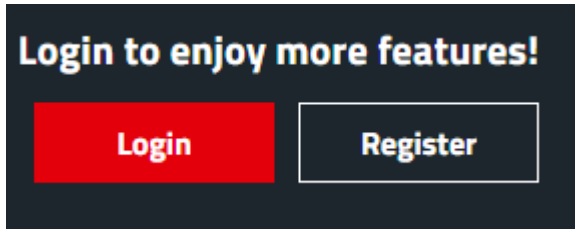

Output filter losses
Inductor losses
Switching losses
Input filtering losses
Rectification losses
WÜRTH ELEKTRONIK
Select Freq
Buck Demo
Feb 2016
3.6 to 42V
+U
GND

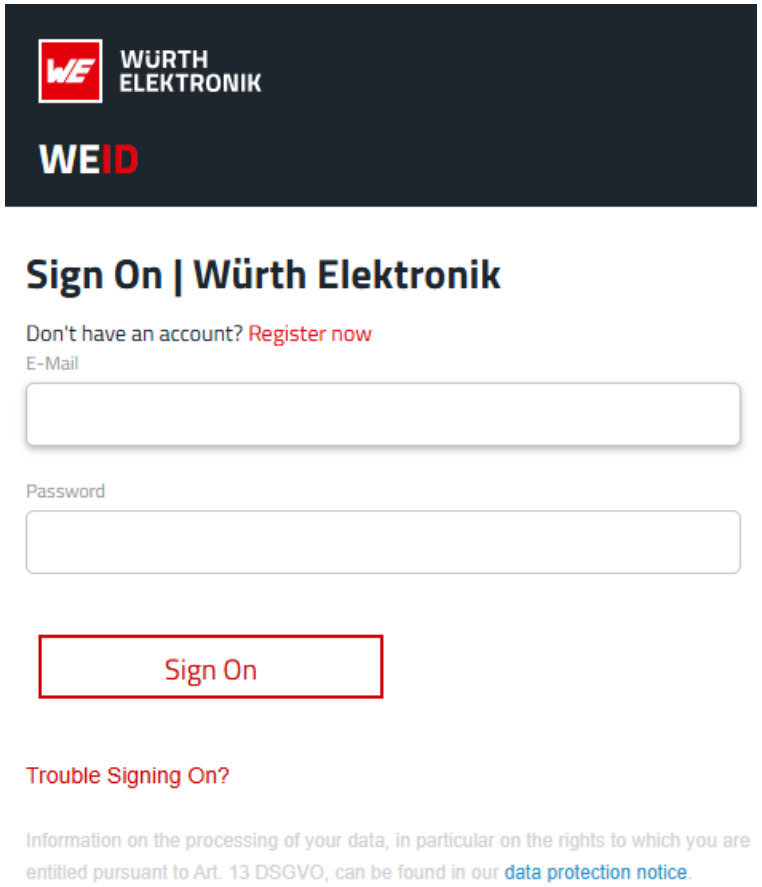
REDEXPERT

Sign up

- The sign up is free of charge.
- With an account you can get additional benefits such as:
  - Free samples
  - Request a quote
  - Manipulate the markers of the graphs.
  - Get precise data from the graphs.
- Your email will be used just to receive confirmations of samples orders and quotes. No marketing.

redexpert.we-online.com



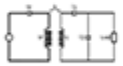


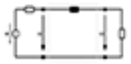
REDEXPERT

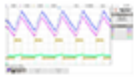
Design Tools


EMI Filter Designer


MagI³C Power Module Designer


Resonance Tank Calculation for Wireless Power


Filter Circuits ›


DC/DC Converter ›


Wireless Connectivity and Sensors ›


Capacitor lifetime calculator


Optoelectronics ›


Power Magnetics ›

Product selection


EMC Components ›

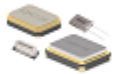

Power Inductors and Magnetics ›


MagI³C Power Products


Signal & Communications ›


Capacitors & Resistors ›


Optoelectronics ›


Quartz Crystals & Oscillators ›


EMC Shielding & Grounding ›

REDEXPERT

DC-DC Convert Topologies

- REDEXPERT counts with a simulator that calculates the inductor that meets in the requirements of the converter.

- You can simulate the following DC-DC converters:
  - Buck
  - Boost
  - Sepic

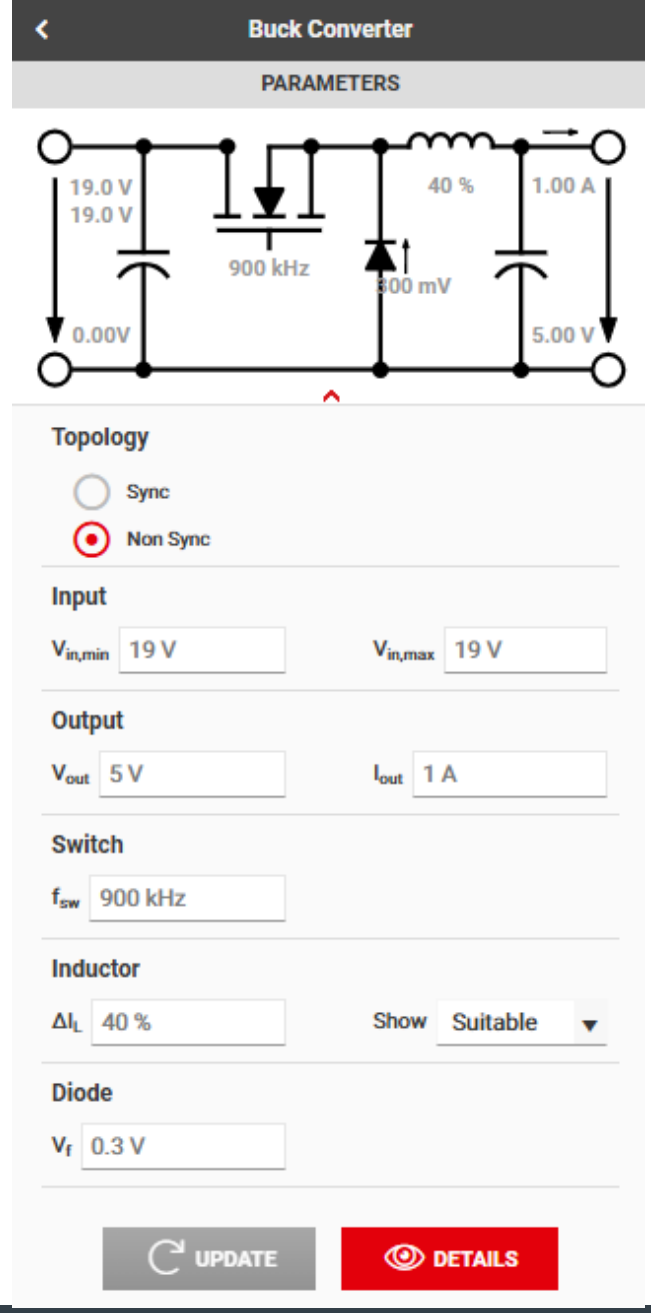
- Once the parameters of the inductor are calculated, a list of inductors is displayed to let you choose the one that best fits in your application.

REDEXPERT

Parameters

- Once the topology is selected, the following parameters are required:
  - Input and output voltages.
  - Output current.
  - Frequency of operation.
  - Inductor ripple current (Delta IL)
  - Diode's voltage.

- REDEXPERT not only shows the inductors that meet the requirements, it also estimates their losses.

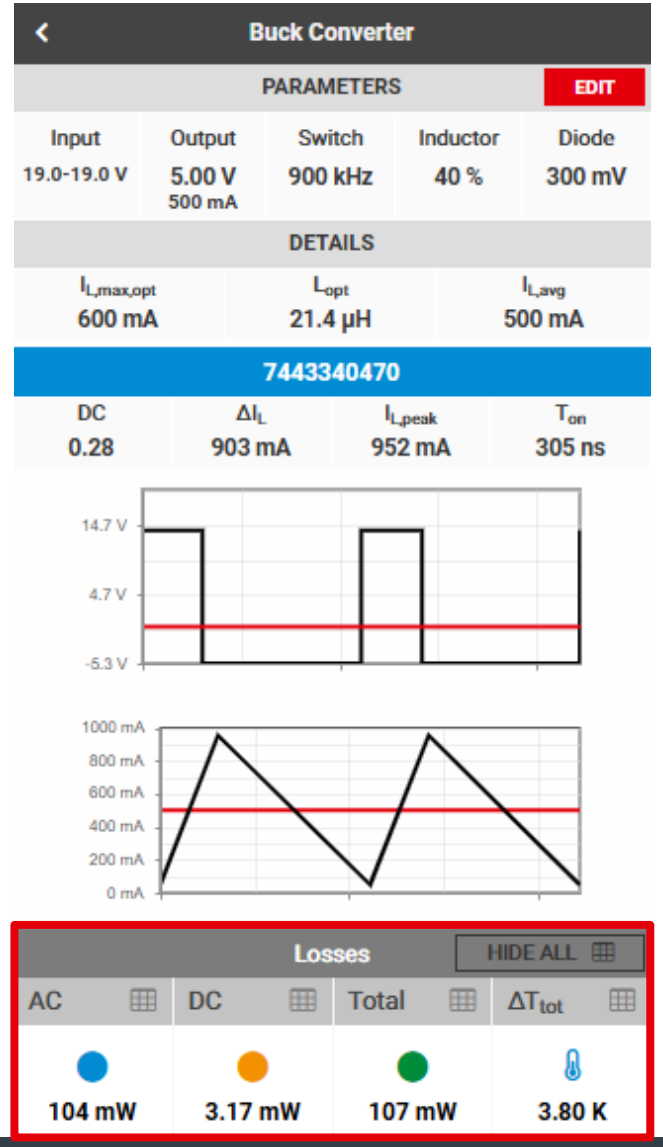


REDEXPERT

Losses

- REDEXPERT shows graphs of the voltage drop in the inductor as well as the behavior of the current flowing through it.

- In terms of losses, REDEXPERT shows the following data:
  - AC losses.
  - DC losses.
  - Total losses.
  - Self-Heating.



TEST #1

REDEXPERT: Test condition 1

- V_{in} = 12 V
- V_{out} = 5 V
- I_{out} = 0.5 A
- Frequency = 200 kHz
- $T_{iniziale}$ = 24 °C

TEST #2

REDEXPERT: Test condition 2

- V_{in} = 12 V
- V_{out} = 5 V
- I_{out} = 0.5 A
- Frequency = 2 MHz
- $T_{iniziale}$ = 24 °C

CLOSING

Questions?