WIRELESS POWER TRANSFER – BASICS

WE CUT THE CORD

WPT TEAM

WÜRTH ELEKTRONIK MORE THAN YOU EXPECT

OH SO 20TH CENTURY.....

...YOU USE WIRELESS POWER TRANSFER EVERYDAY ALREADY

APPLICATION AREAS BESIDES CONSUMER PRODUCTS

Industrial

Automotive

https://youtu.be/GIrcPrzuPMM

Medical Technology

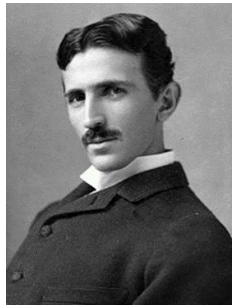
Furniture / Infrastructure

AGENDA

- Applications
- Technologies & Standards
- Coil Specific Considerations
- Würth Elektronik Products & Advantages

WIRELESS POWER TRANSFER HISTORY

1893 first wireless powered lightbulb N. Tesla



1980´s electrical toothbrush

2008 founding of Wireless Power Consortium (WPC) Qi Standard

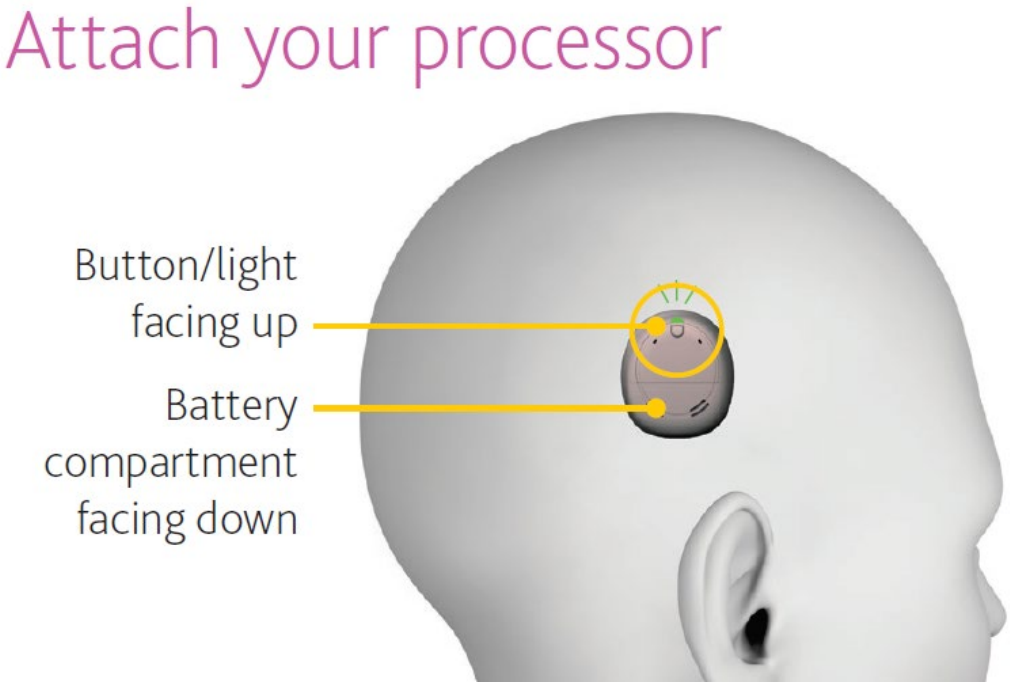
2011 first smart phones with integrated Qi receiver

2017 Apple join WPC

2018 Wireless charging of EV´s

Applications

APPLICATIONS OF WE CUSTOMERS



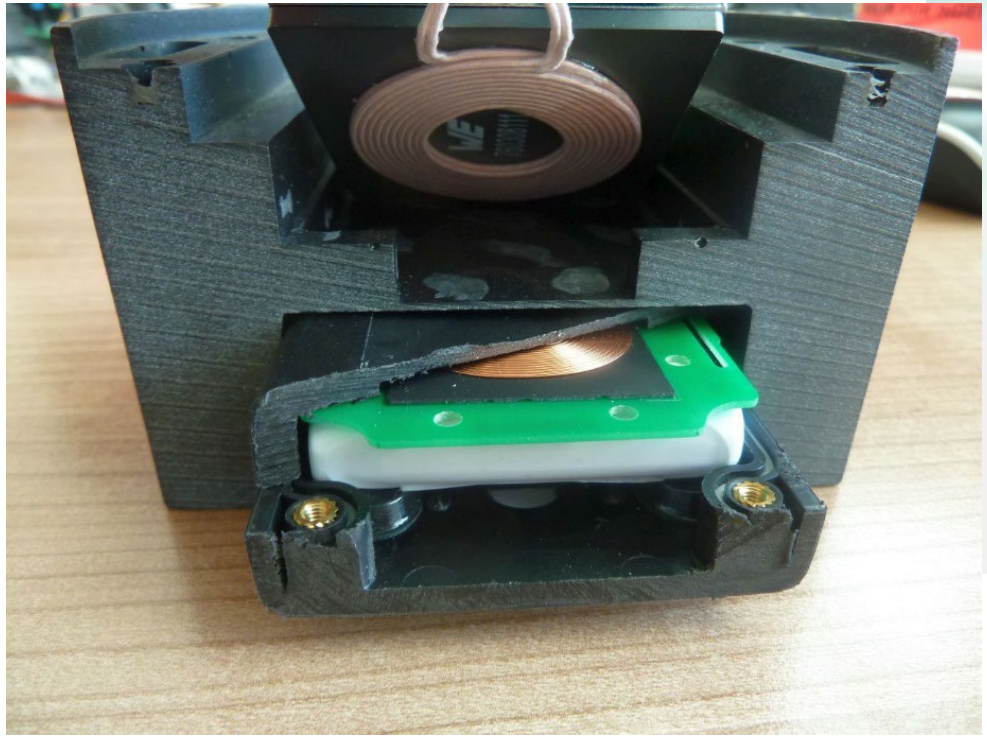
APPLICATIONS OF WE CUSTOMERS

Lower power medical devices: hearing aids, maternity healthcare

APPLICATIONS OF WE CUSTOMERS

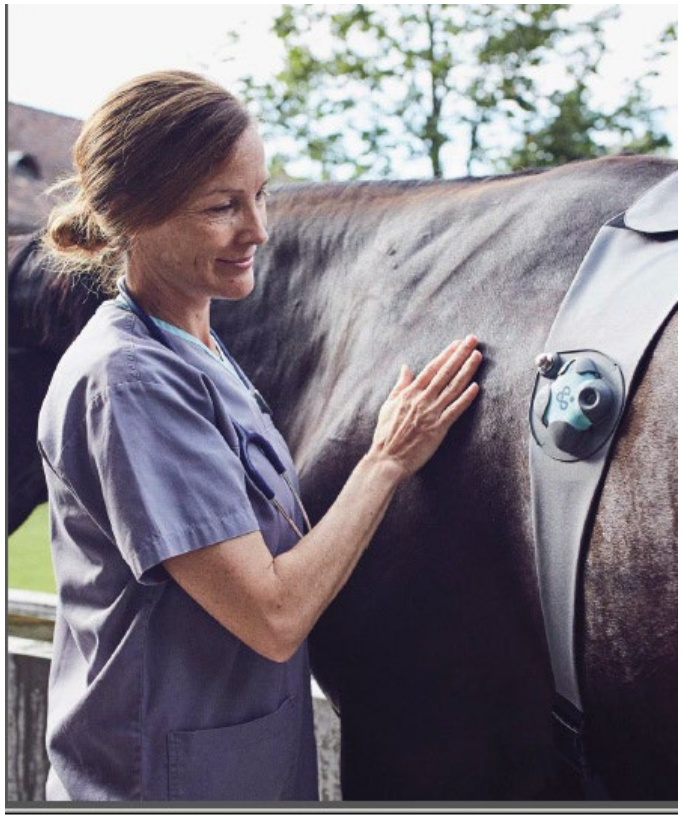
Schmitz & Söhne Germany

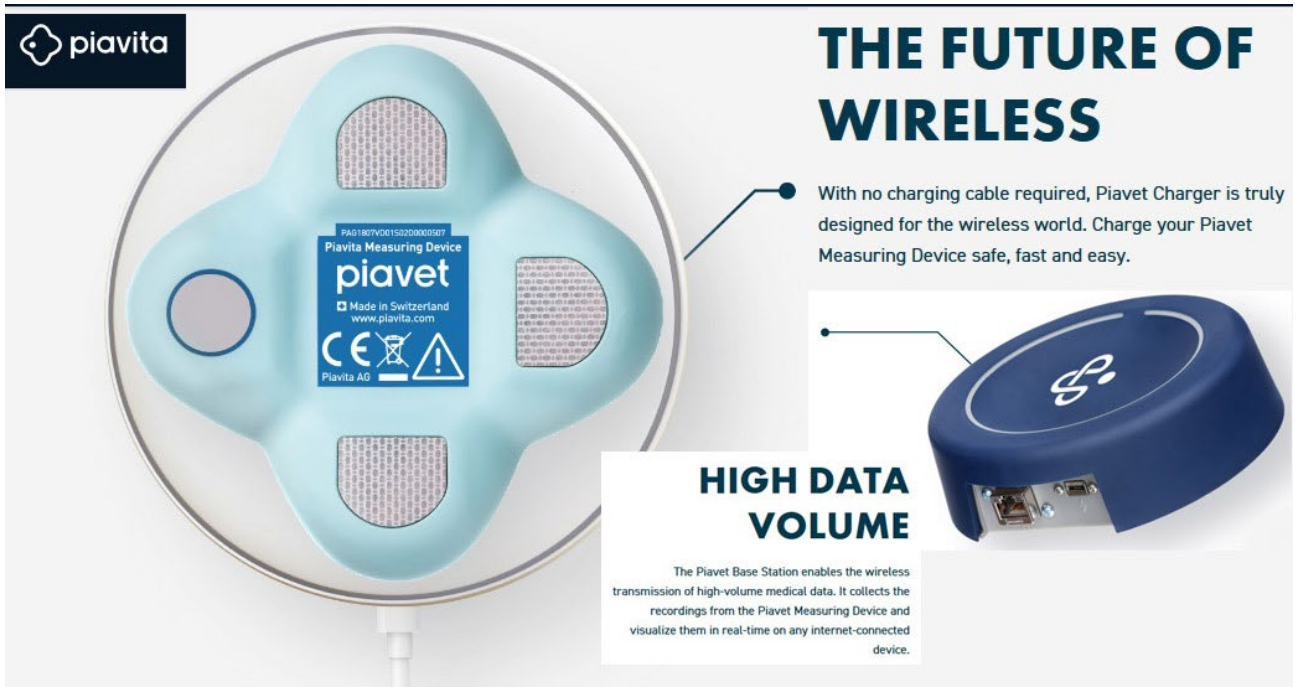
Remote control operating table



Power < 5W

APPLICATIONS OF WE CUSTOMERS





Power < 5W

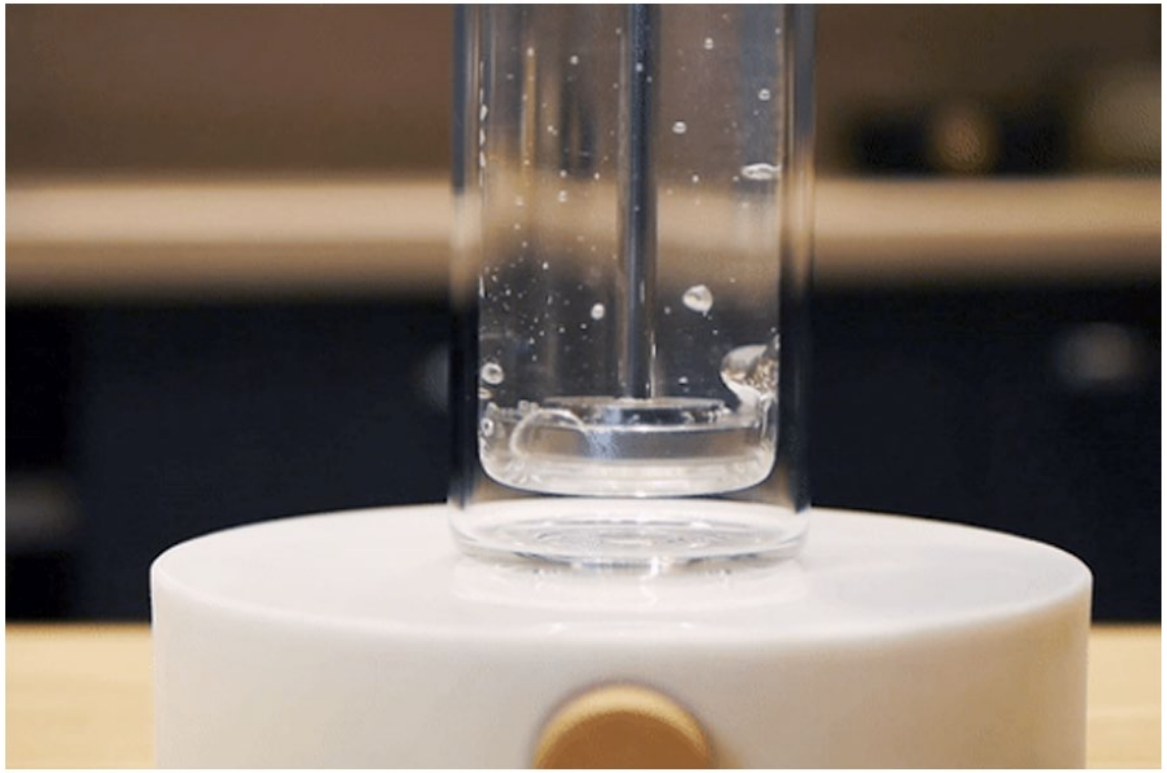
APPLICATIONS OF WE CUSTOMERS

Heinrichs Weikamp gmbh

Charge diving computer

Power < 5W

APPLICATIONS OF WE CUSTOMERS



WIRELESS POWER CONSORTIUM

More power

60 – 200 Watt

200 – 2400 Watt

17 February 2017

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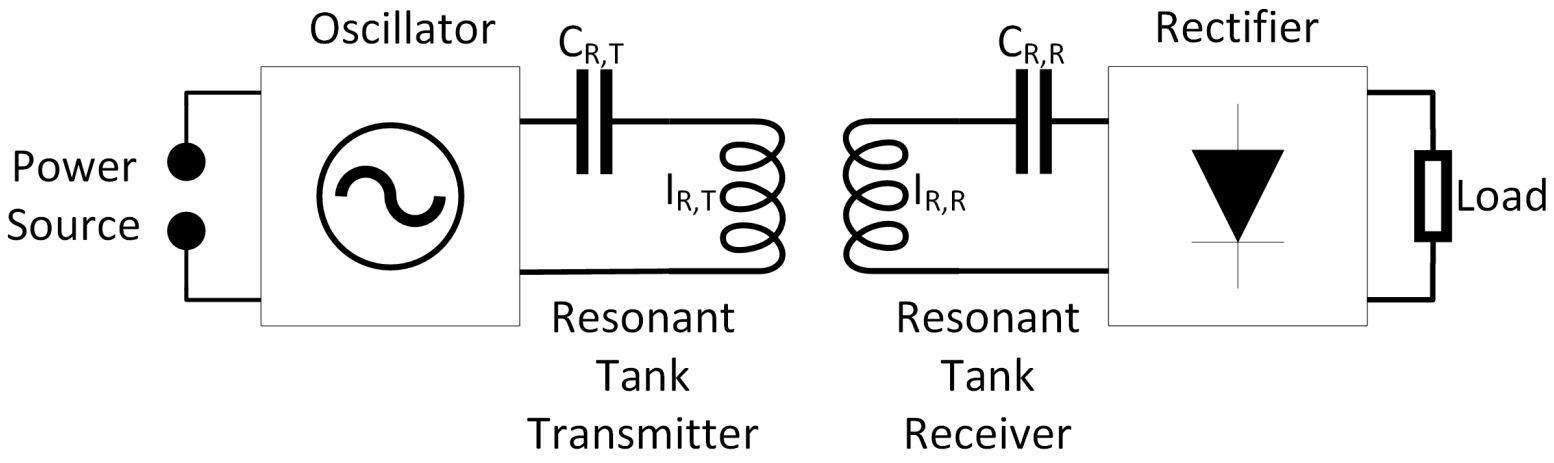
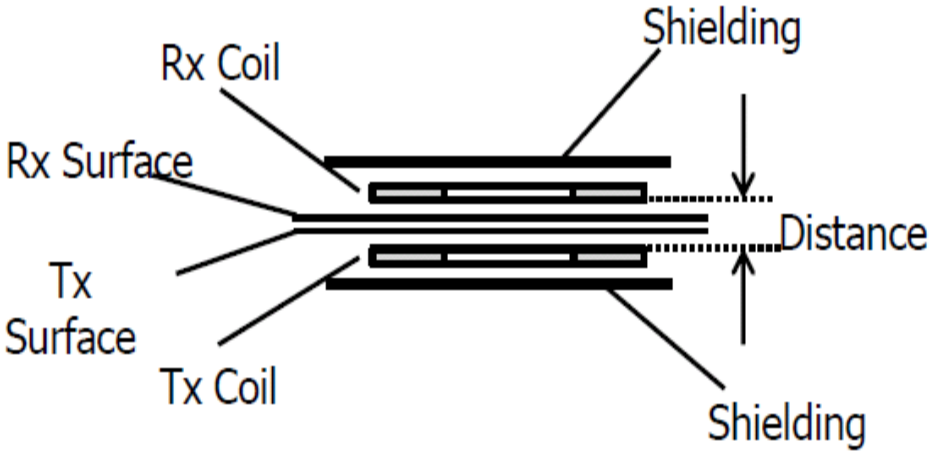
Technologies and Standards

HOW DOES WIRELESS POWER TRANSFER WORK?

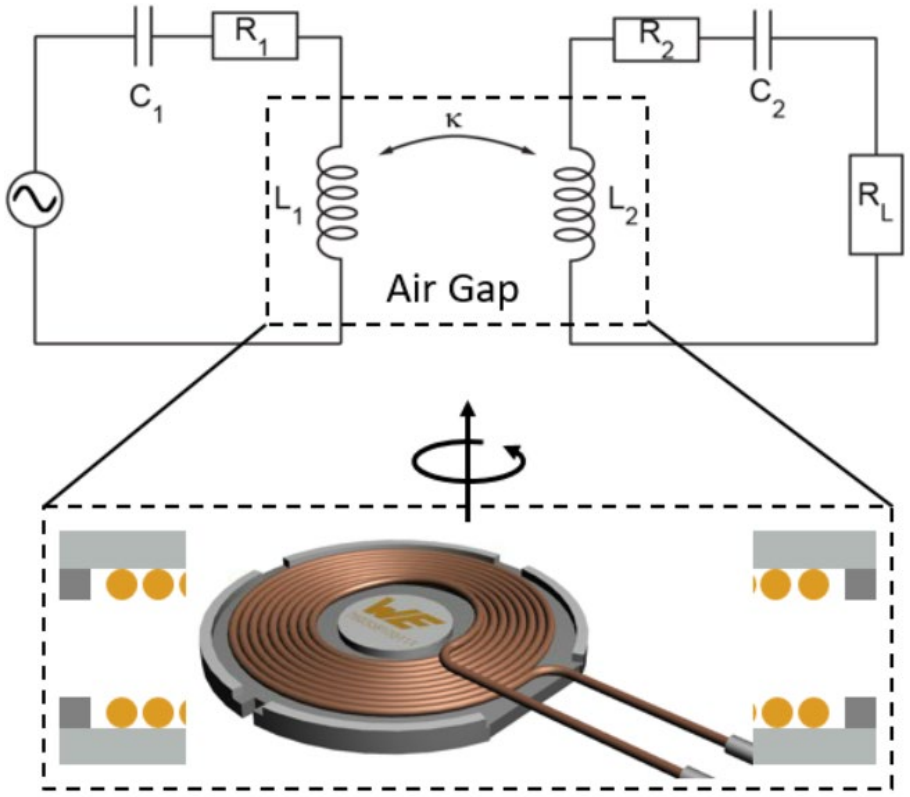


- Power transfers via inductive coupling at short distances (mm range)
- Transmitter (Tx) and Receiver (Rx) Coils are inductively coupled coils.
- Magnetic field concentrated in small volume between Tx / Rx



HOW DOES WIRELESS POWER TRANSFER WORK?

Inductively coupled magnetic resonant system



- Frequency: kHz regime
- Distance: short range regime (e.g. 1-10mm)

Maximum Transmission Efficiency

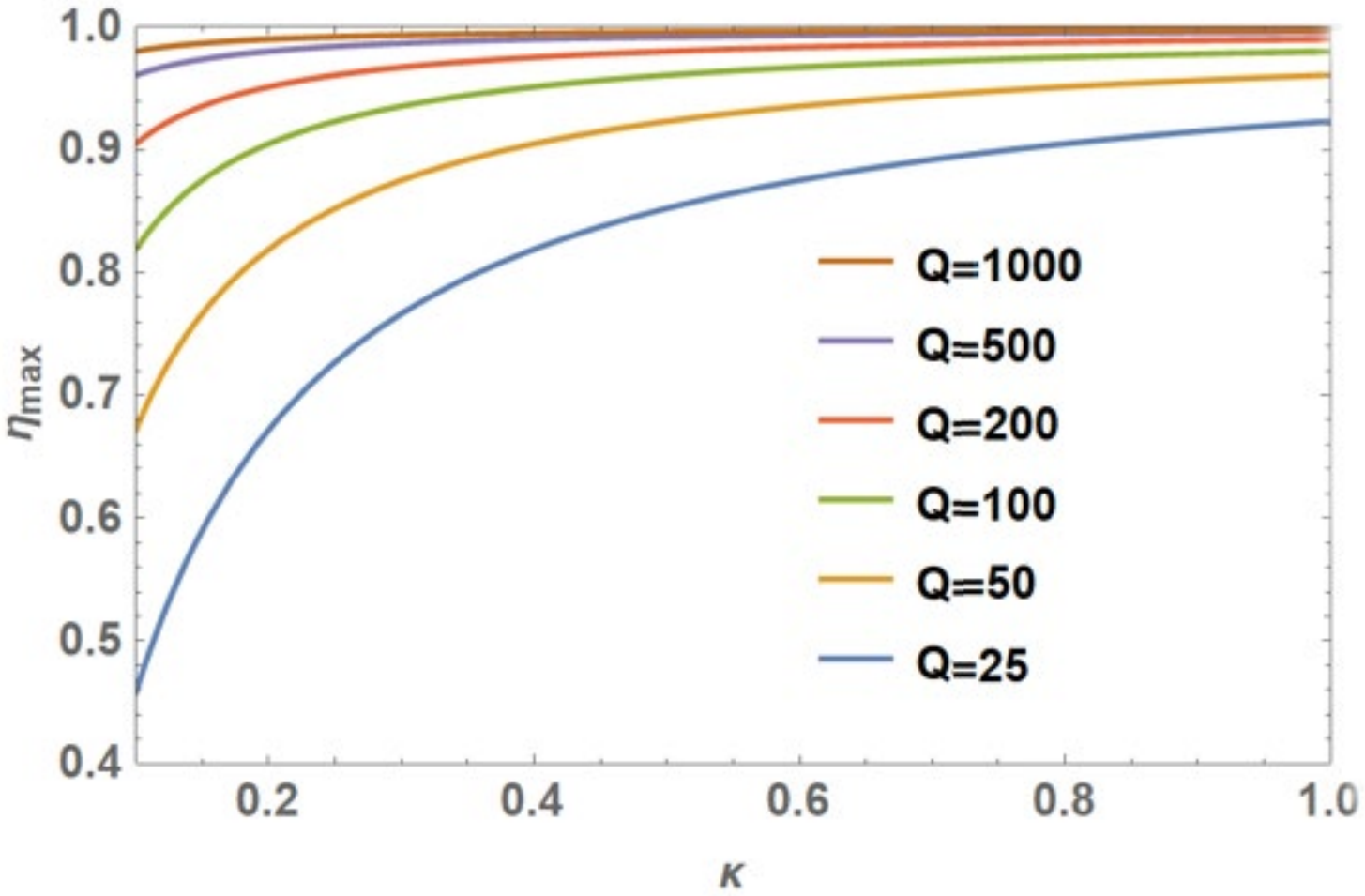
$$\eta_{\max} = \frac{\kappa^2 Q^2}{\left(1+\sqrt{1+\kappa^2 Q^2}\right)^2} \approx 1 - \frac{2}{\kappa Q}$$

high Q

κ
coupling factor

Q
quality factor

FIGURE OF MERIT FOR EFFICIENT POWER TRANSFER



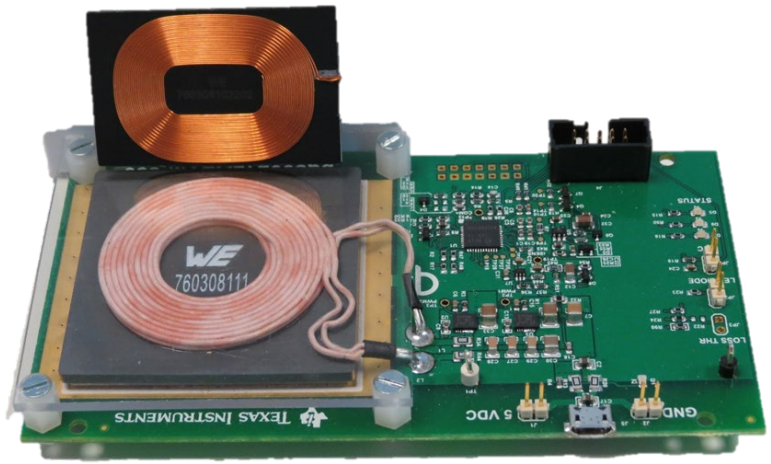
coupling κ is often limited by boundary conditions of the application

High Q coils allow

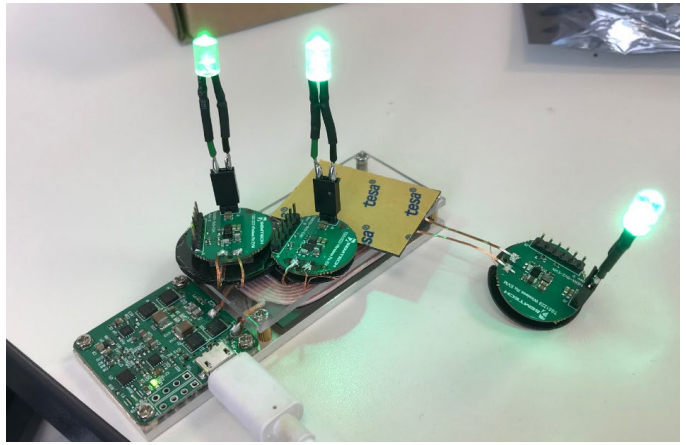
- long transfer distance
- higher freedom of positioning

$$\eta_{\max} = \frac{\kappa^2 Q^2}{\left(1+\sqrt{1+\kappa^2 Q^2}\right)^2} \approx 1 - \frac{2}{\kappa Q}$$

CLOSE-COUPLED INDUCTANCE



inductive power transfer



resonant power transfer

AirFuel™ Alliance

WIRELESS POWER STANDARDS

- **Loosely coupled**
  - AirFuel Alliance *(formed from Alliance for Wireless Power (A4WP) and the Power Matters Alliance (PMA)*
    - Power transfer based on resonant tank at very high frequency over longer distances (40mm)
    - Ability to charge multiple devices at same time
    - Resonant tank at 6.78MHz. (ISM Band)
    - Capability up to *30W systems
    - Under 50 products certified

SUCCESS FACTORS OF WIRELESS POWER TRANSFER

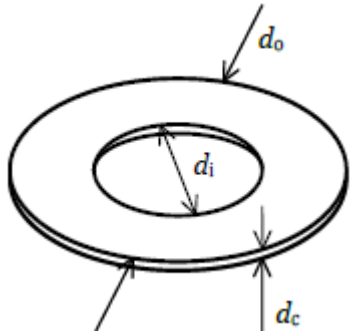
- No metal contacts
- Completely sealed devices
- Standard
- Interoperability
- Safety
- Convenience
- Integration in IoT

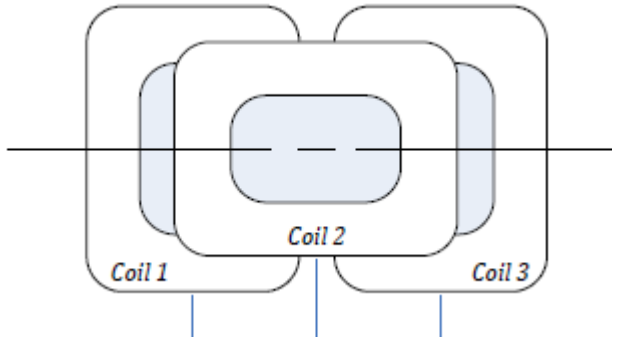
Coil specific considerations

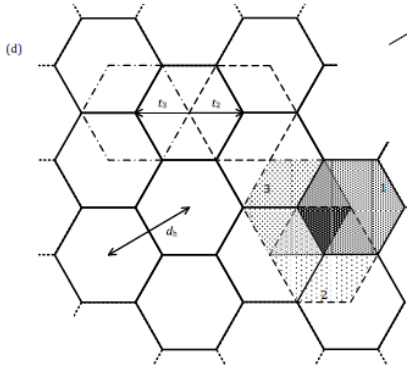
OPTIMIZING THE COIL – POINTS TO CONSIDER

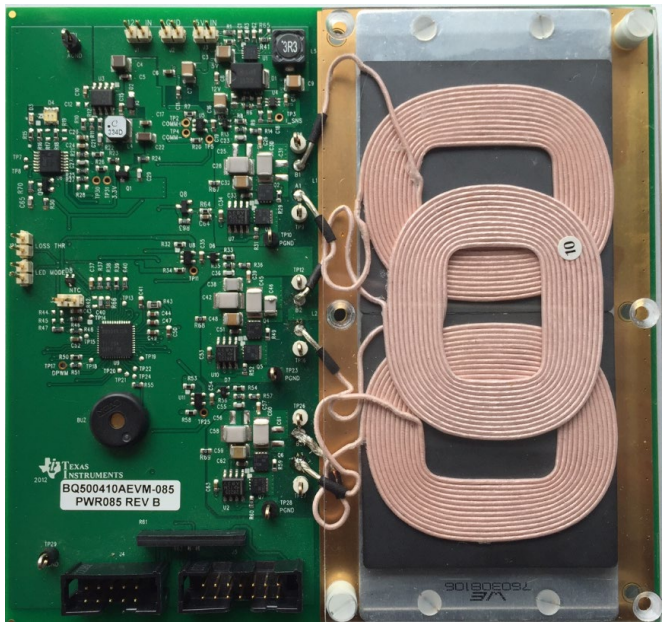
- Use the largest possible coil
- Keep the distance in the range of maximum efficiency
- Keep the misalignment minimal
- Choose the best matching coil combination
- Be aware of parameters which influence performance or cost (FoM, wire,..)

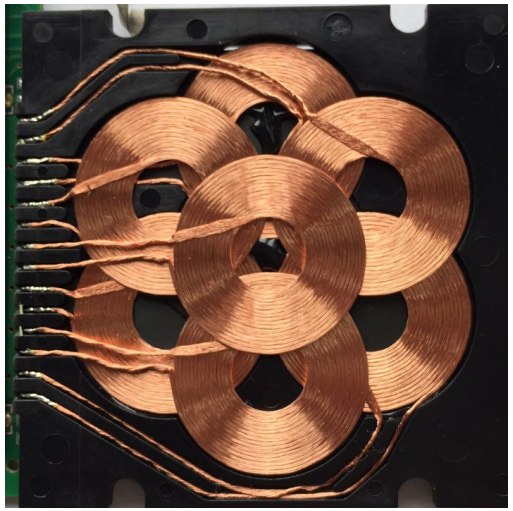
COIL TYPES - FREEDOM OF POSITIONING



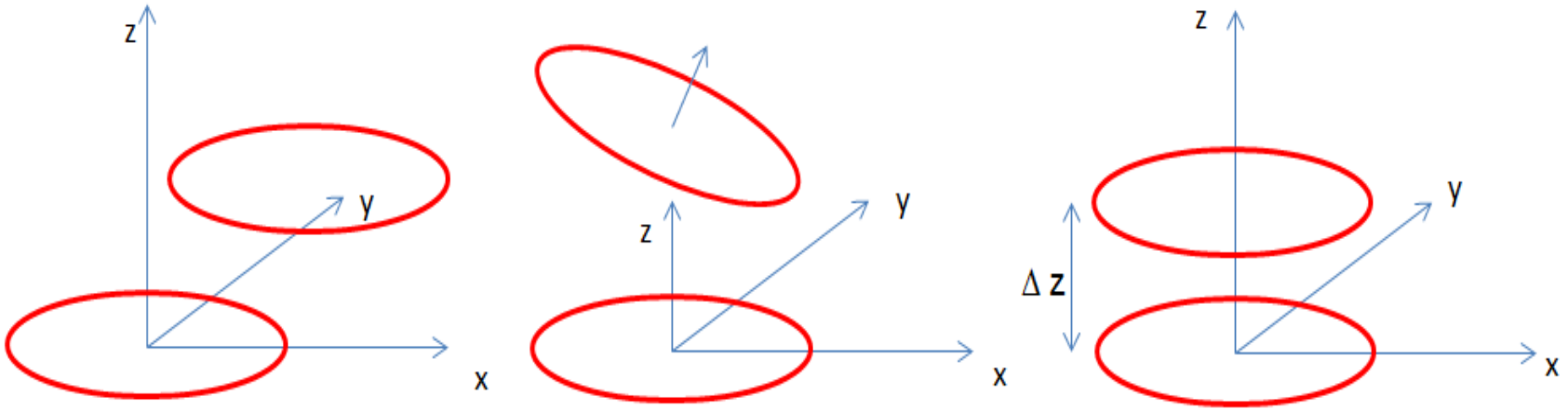








COUPLING FACTOR / ALIGNMENT TOLERANCES



lateral misalignment angular misalignment vertical misalignment

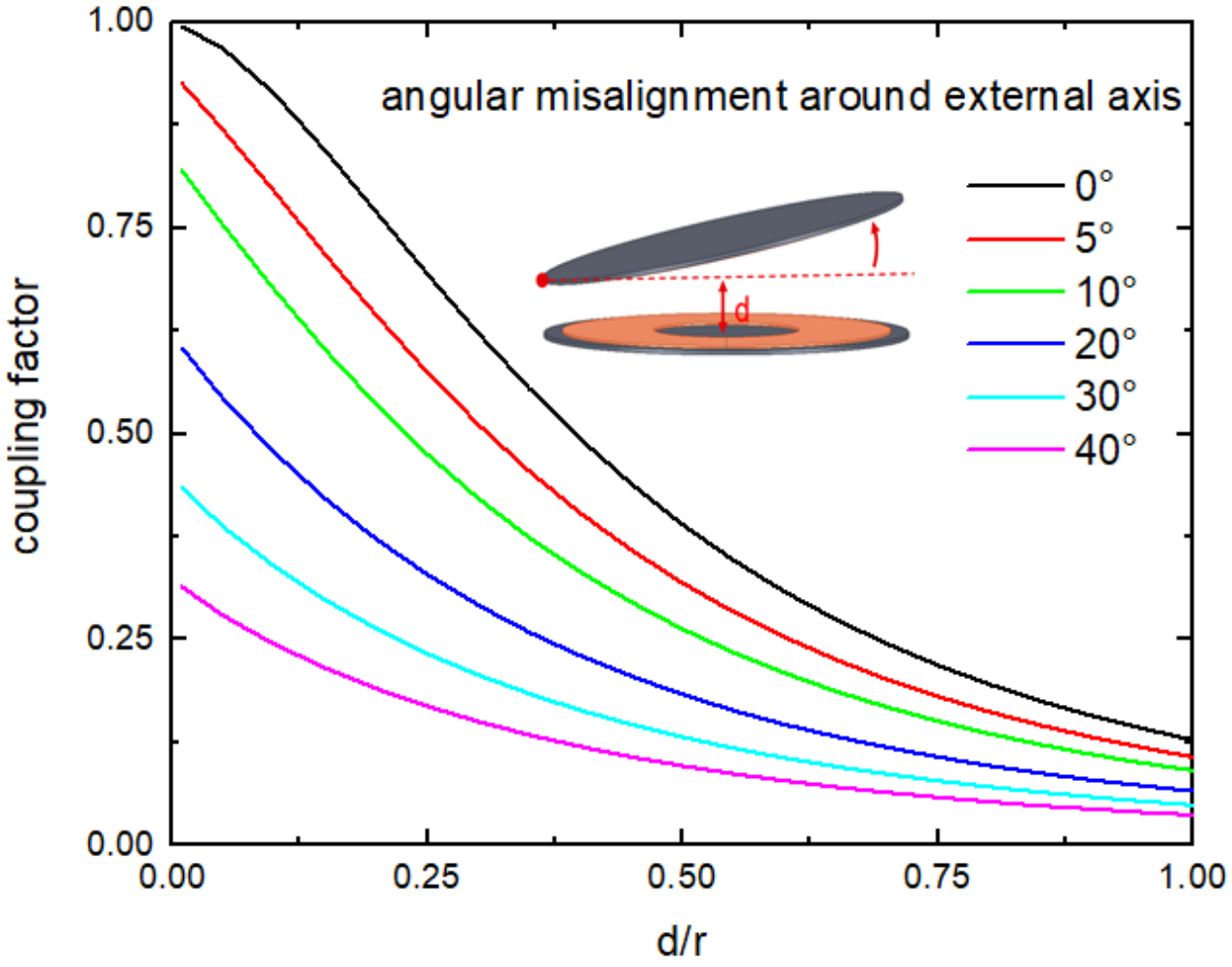
Good coupling and maximum energy transmission depends on

- size of the effective area of the receiver coil in the magnetic field
- the distance in the z direction

$$k = \frac{M}{\sqrt{L1 \cdot L2}}$$

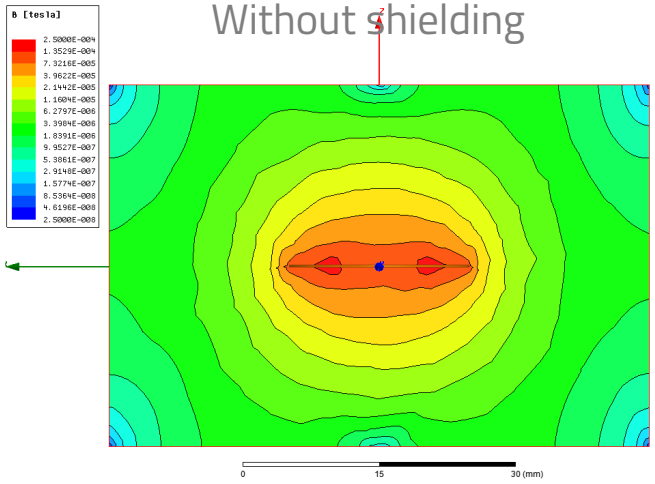
A coupling factor of 1 is ideal

3D FEMM ANALYSIS OF WPT MODEL-ANGULAR MISALIGNMENT

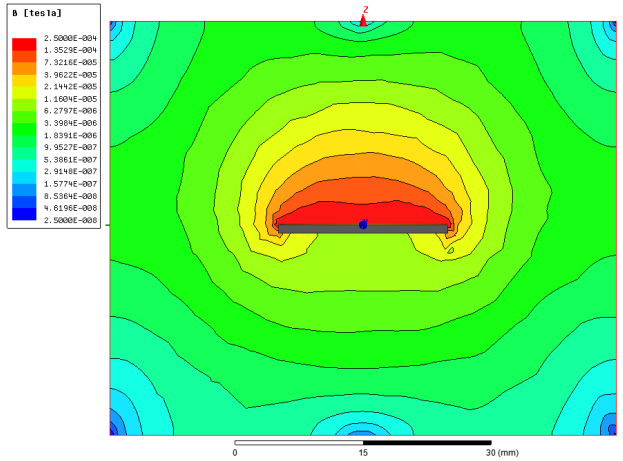


IMPROVEMENT USING FERROMAGNETIC SHIELDING

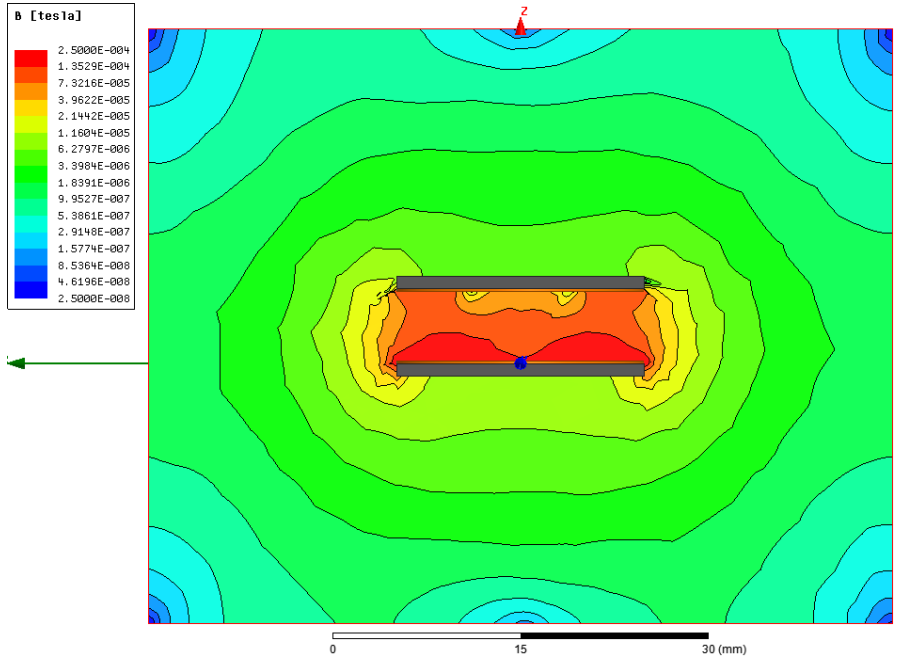
Without shielding



With shielding



Tx_Rx with shielding



COUPLING FACTOR K DEPENDING ON COIL SIZE RATIO

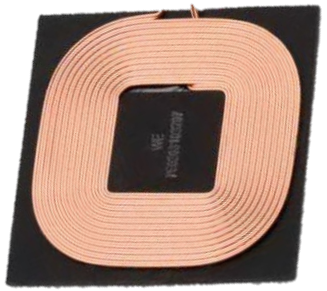
- Tx/Rx coil size impacts coupling factor k

$$k = \frac{\phi_1}{\phi_{21}}$$

$$\Phi_{21} = B_1 A_2 = \left(\frac{\mu_0 I_1}{2R_1}\right)\pi R_2^2 = \frac{\mu_0 \pi I_1 R_2^2}{2R_1}$$

k= 0.81

A_{Rx}/A_{Tx} = 1:1

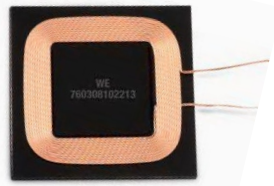


k= 0.75

A_{Rx}/A_{Tx} = 1:1.1

k= 0.61

A_{Rx}/A_{Tx} = 1:2



Examples from *WE* Mix&Match and RedExpert

TX/RX SIZE RATIO IMPACT

760 308 100 111 (A11)

k= 0.29

A_{Rx}/A_{Tx} = 1:6

760 308 101 104

k= 0.60

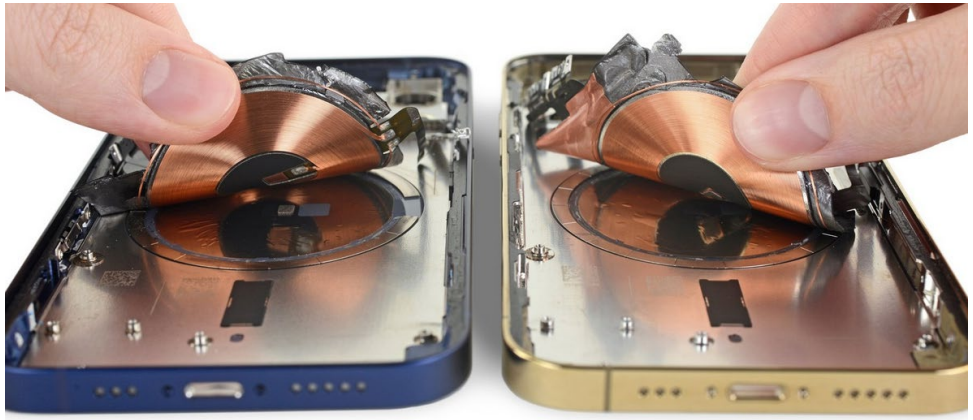
A_{Rx}/A_{Tx} = 1:1

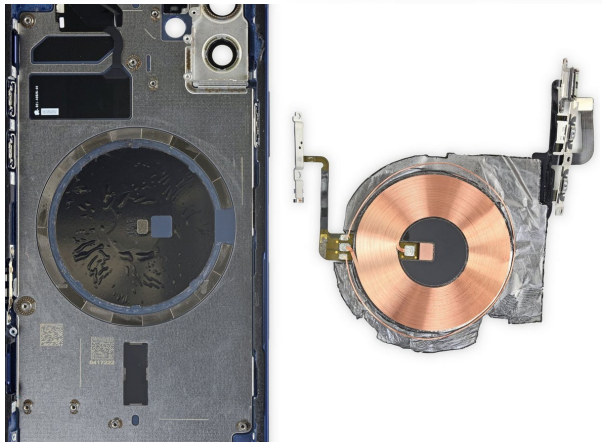
760 308 101 214

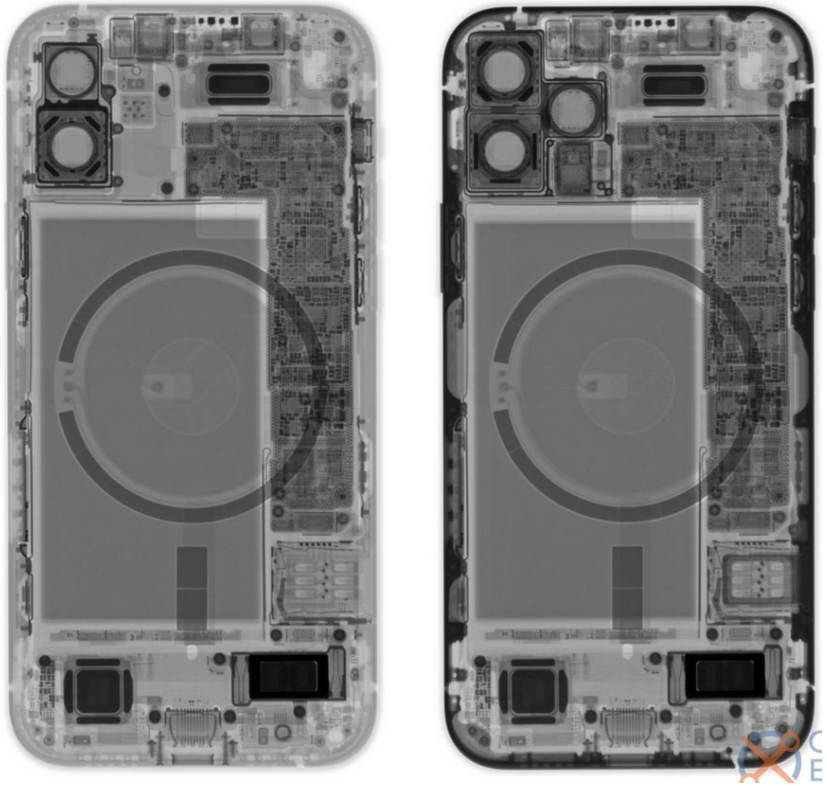
760 308 101 214

RECEIVER COILS SIZE IS A KEY FOR SUCCESS

Applications







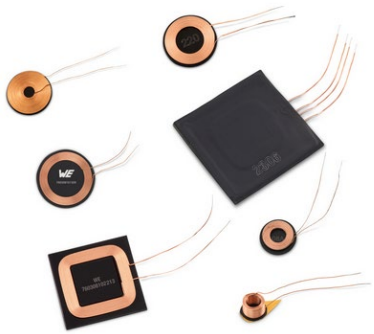
https://de.ifixit.com/Teardown/iPhone+12+und+12+Pro+Teardown/137669

WE Products

WE WIRELESS POWER COILS

Broadest portfolio of wireless power coils: in total 65

Receiver coils



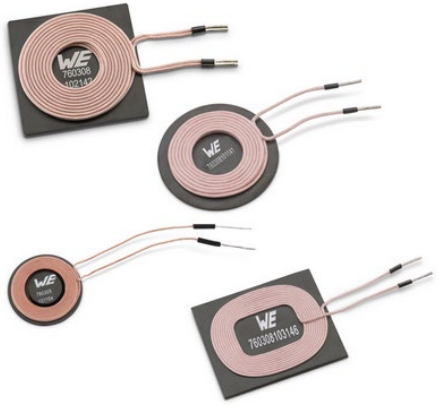
24 coils

Size: 6 – 48 mm

Power: 5 – 80 W

Magnet wire

Transmitter coils



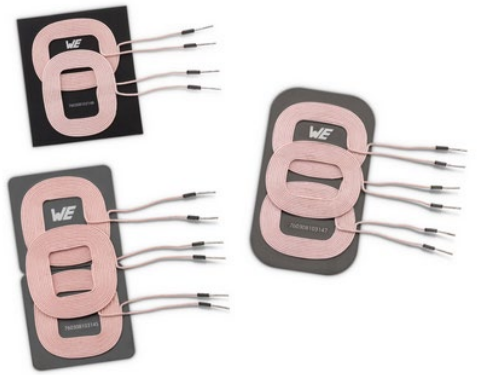
28 coils

Size: 20 – 75 mm

Power: 40 – 400 W

Litz wire

Array coils



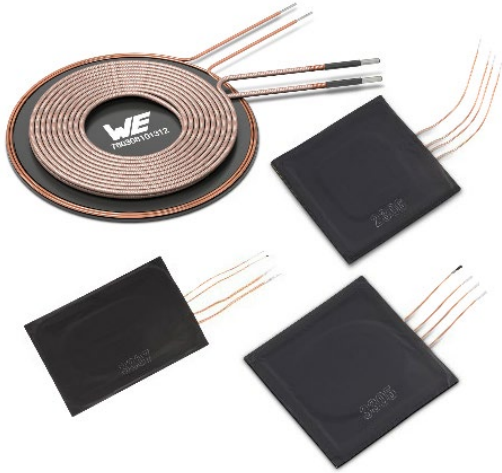
8 coils

Size: 71 – 130 mm

Power: 150 W

Litz wire

WPT / NFC coils



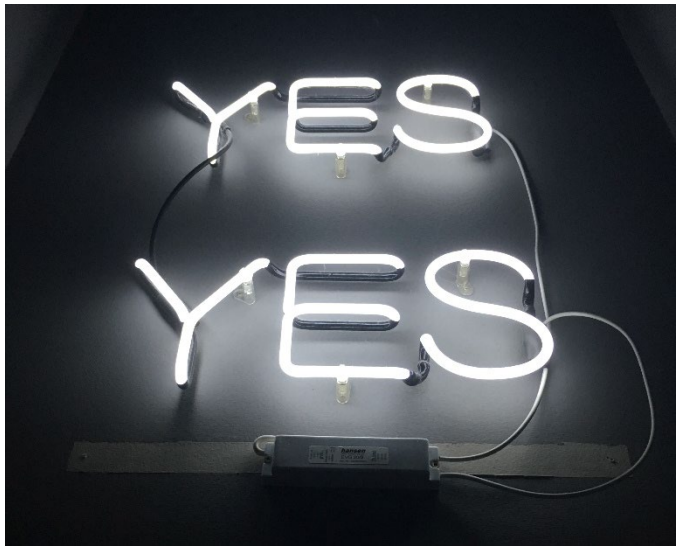
5 coils

Size: 40 – 65 mm

Power: 20 – 100 W

Magnet / Litz wire

CUSTOMER SPECIFIC COILS



Use template on WPT website: **Wireless Power Coil Inquiry Sheet** MOQ: 5.000

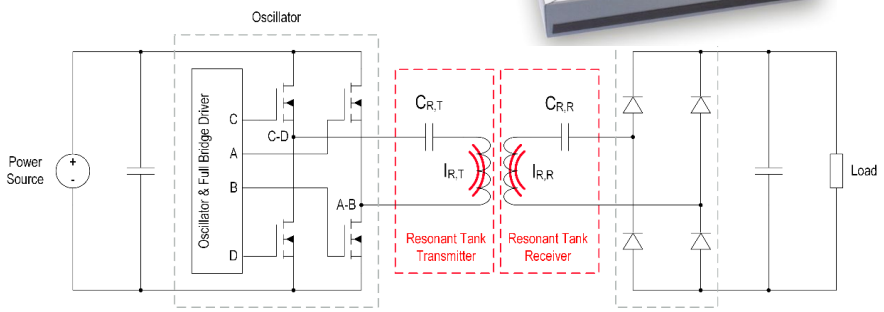
NEW 200W WPT solution with data transfer

www.we-online.com/wirelesspower/200WKit

- The current profile is almost sinusoidal
- By changing the resonance frequency the output voltage can be regulated
- It is scalable from low to high power (10 W – 10kW)
- The MOSFETs switch close to the zero crossover point (ZVS)

  → efficiency > 90%
- It is scalable for many different voltages/currents
- Data transfer from receiver to transmitter possible

www.we-online.de/ANP070



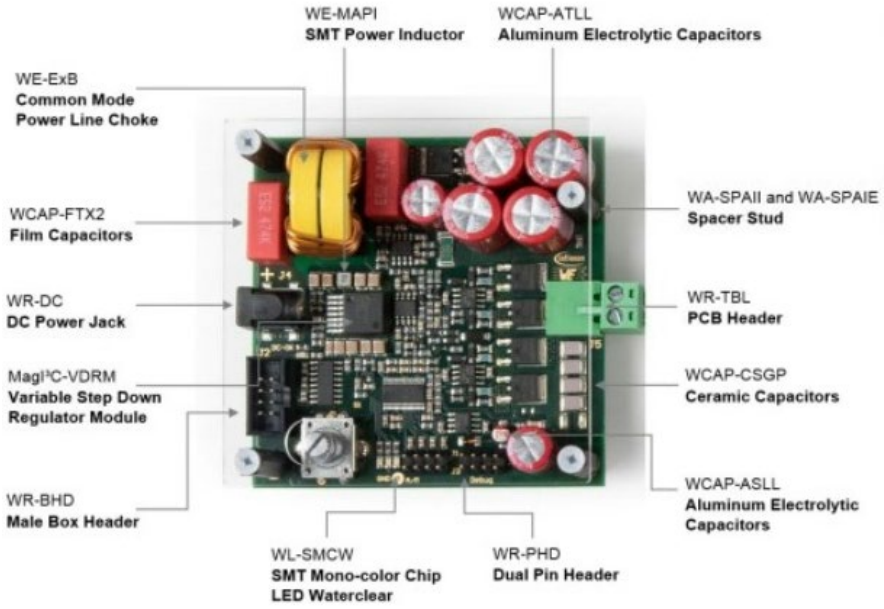
NEW 200W WPT solution with data transfer

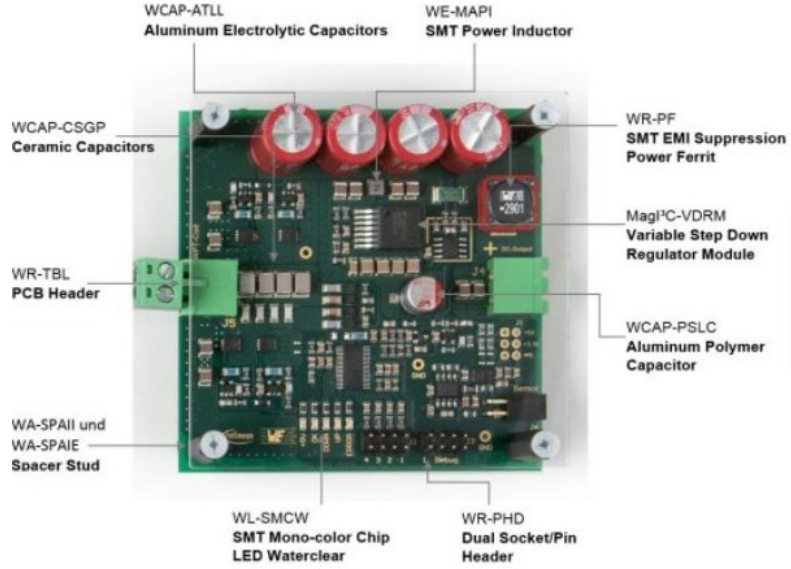
www.we-online.com/wirelesspower/200WKit

Power input

Power output

WE-WPCC
Wireless Power Transfer Coils



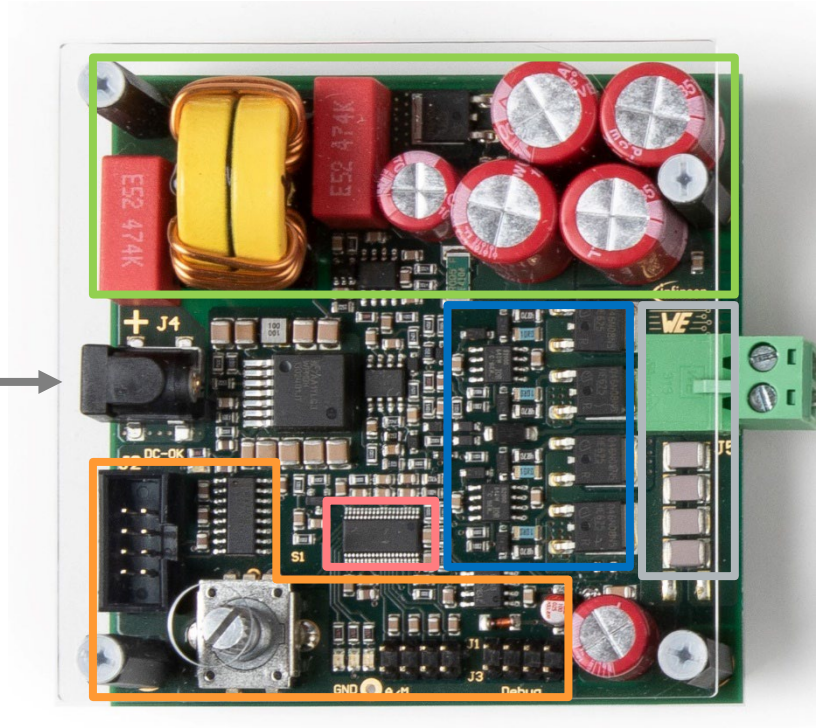


NEW 200W WPT solution with data transfer

www.we-online.com/wirelesspower/200WKit

Input power 200 W:

- Input voltage 19…24 V
- Input current 10 A max.



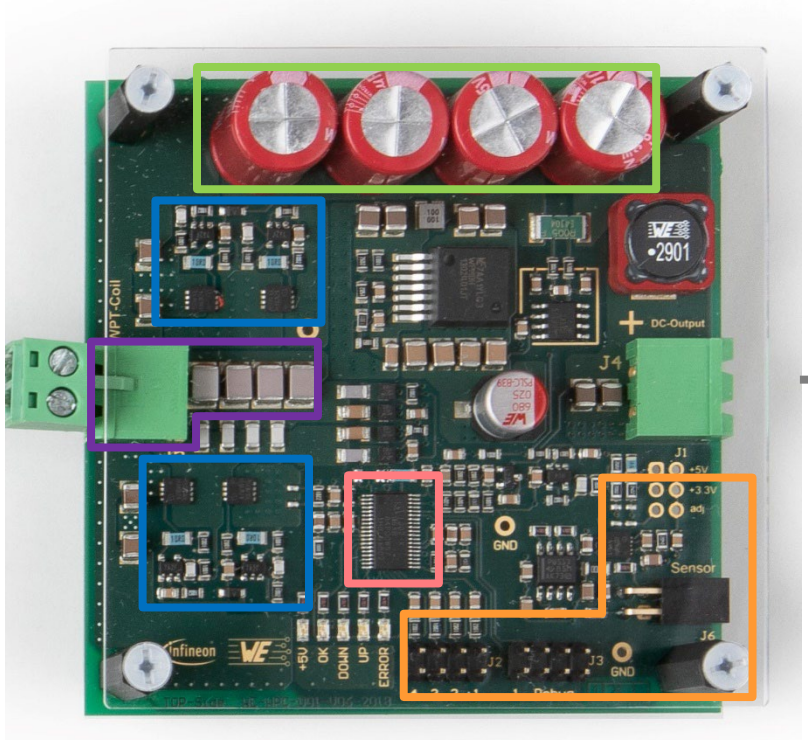
→ Transmitter coil

- Structures for EMC protection, signal filtering
- Resonant tank: series resonant circuit for better magnetic coupling between the two coils → better efficiency, wider transmission range
- XMC controller to control all signals (PWM, LEDs, RS232, Debug, Encoder, operating mode and other internal signals)
- Full Bridge circuit and bridge control: transformation of DC current to AC current
- Interfaces: RS232 (e.g. display board), debug, operating mode (man./auto.), incremental encoder

NEW 200W WPT solution with data transfer

www.we-online.com/wirelesspower/200WKit

Receiver coil →



→ Output power 200 W:

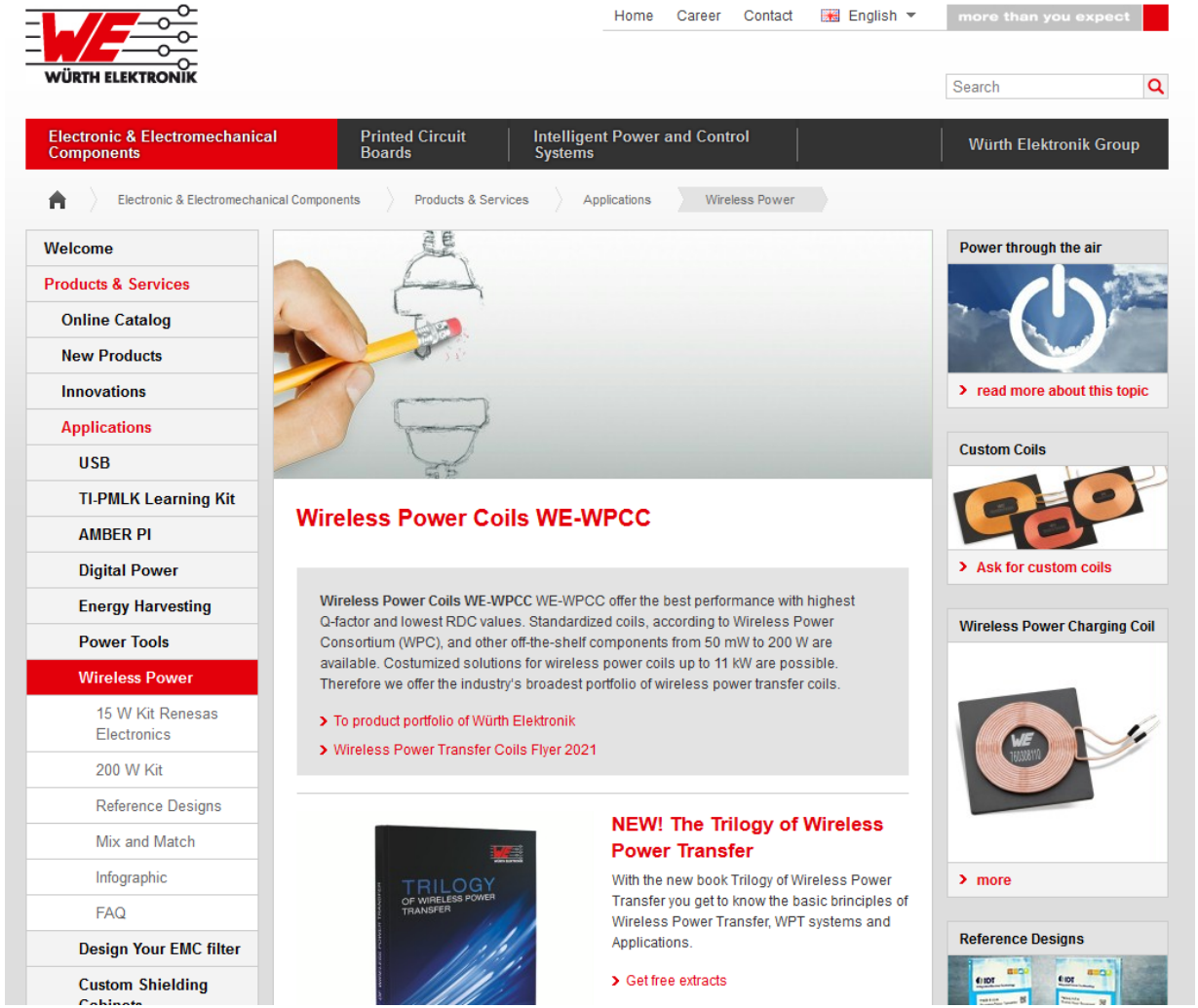
- Output voltage 19 V
- Output current 10 A max.

- Smooting capacitors for a stable output voltage
- Resonant tank: series resonant circuit for better magnetic coupling between the two coils → better efficiency, wider transmission range
- XMC controller to control all signals (PWM, LEDs, I²C, Debug and other internal signals)
- Active rectifier: transformation of AC current to DC current
- Interfaces: I²C (e.g. temperature sensor), debug, interface to define

Information Material

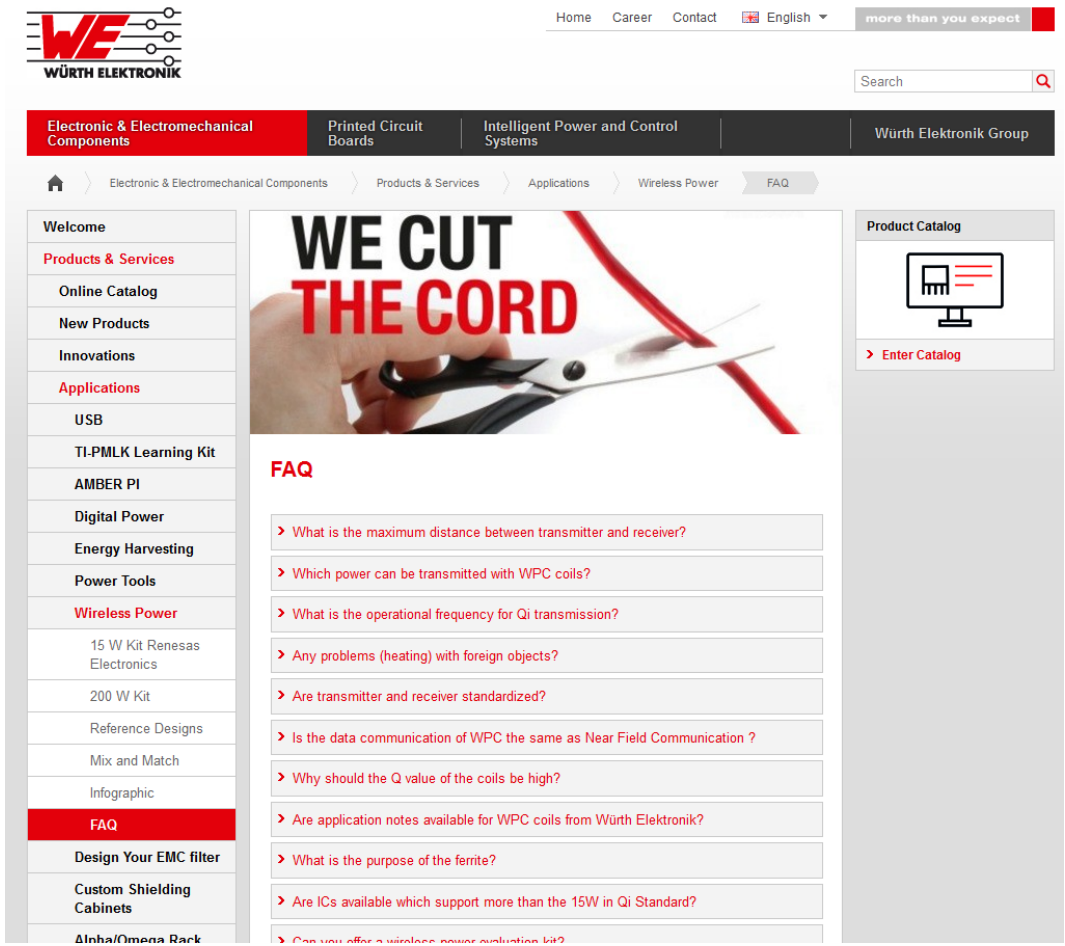
WIRELESS POWER TRANSFER WEBSITE

HTTP://WWW.WE-ONLINE.COM/WIRELESSPOWER



FAQ - HOTLINE

- http://www.we-online.com/wirelesspower/faq

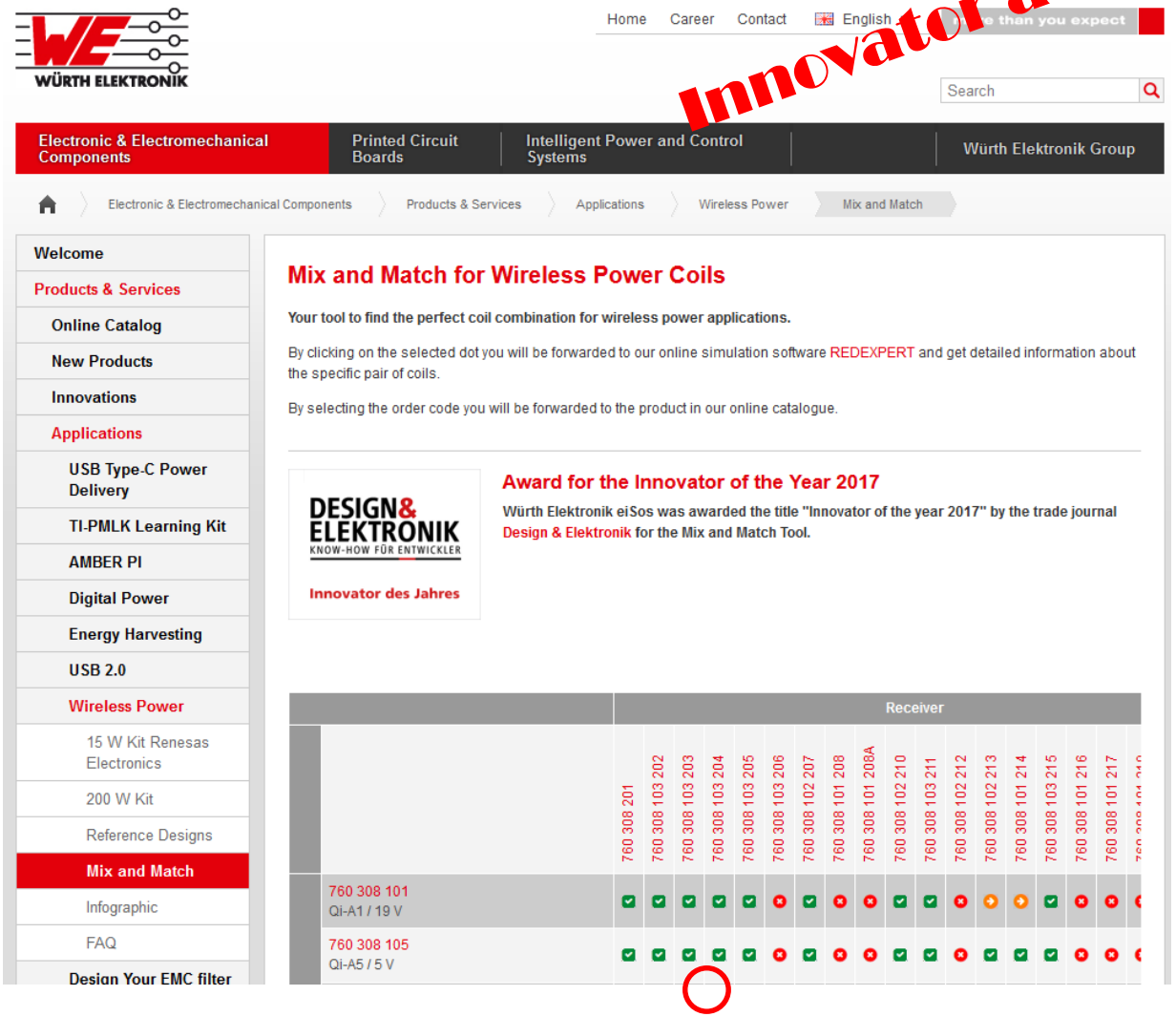


Other requests to wirelesspower@we-online.com

MIX AND MATCH FOR WIRELESS POWER COIL

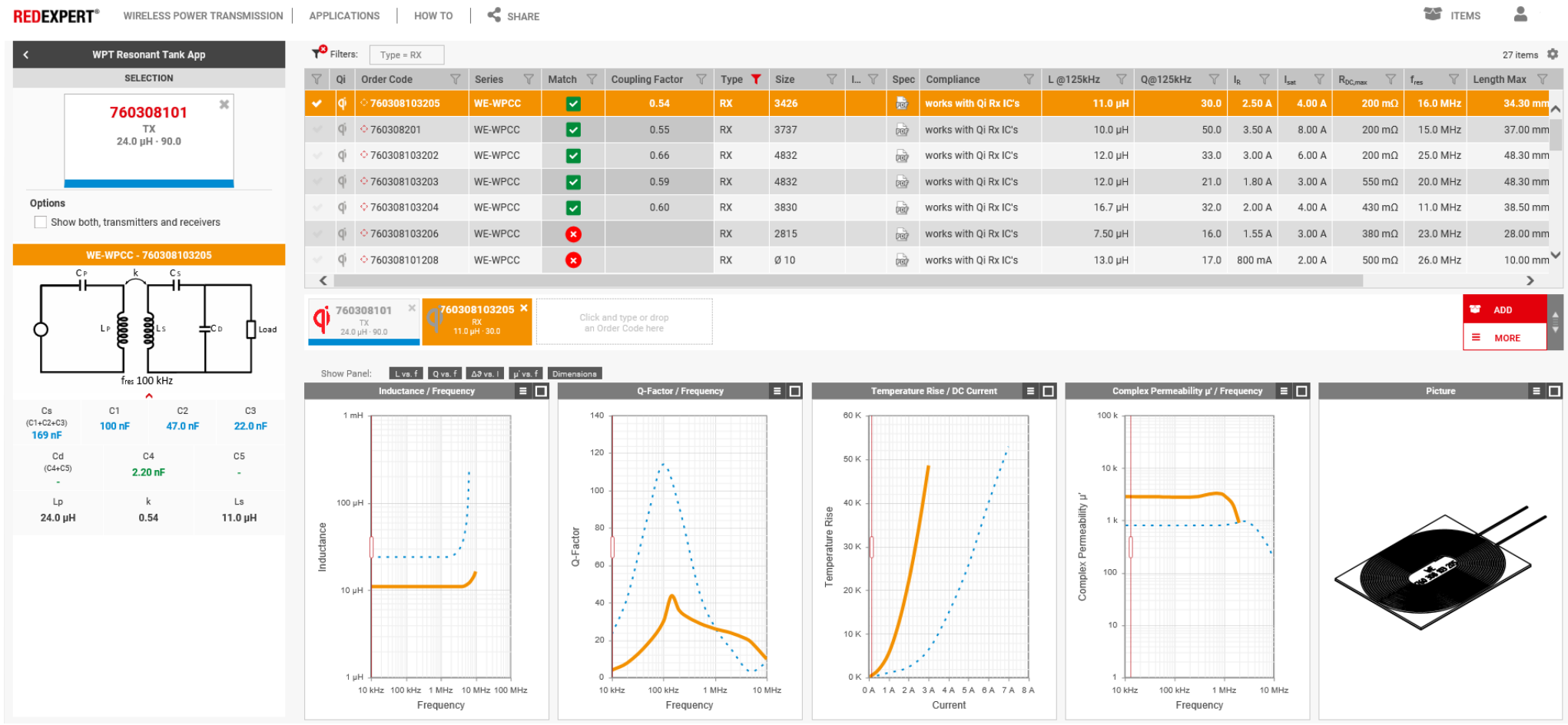
http://www.we-online.de/wirelesspower/mixandmatch

Innovator award winning

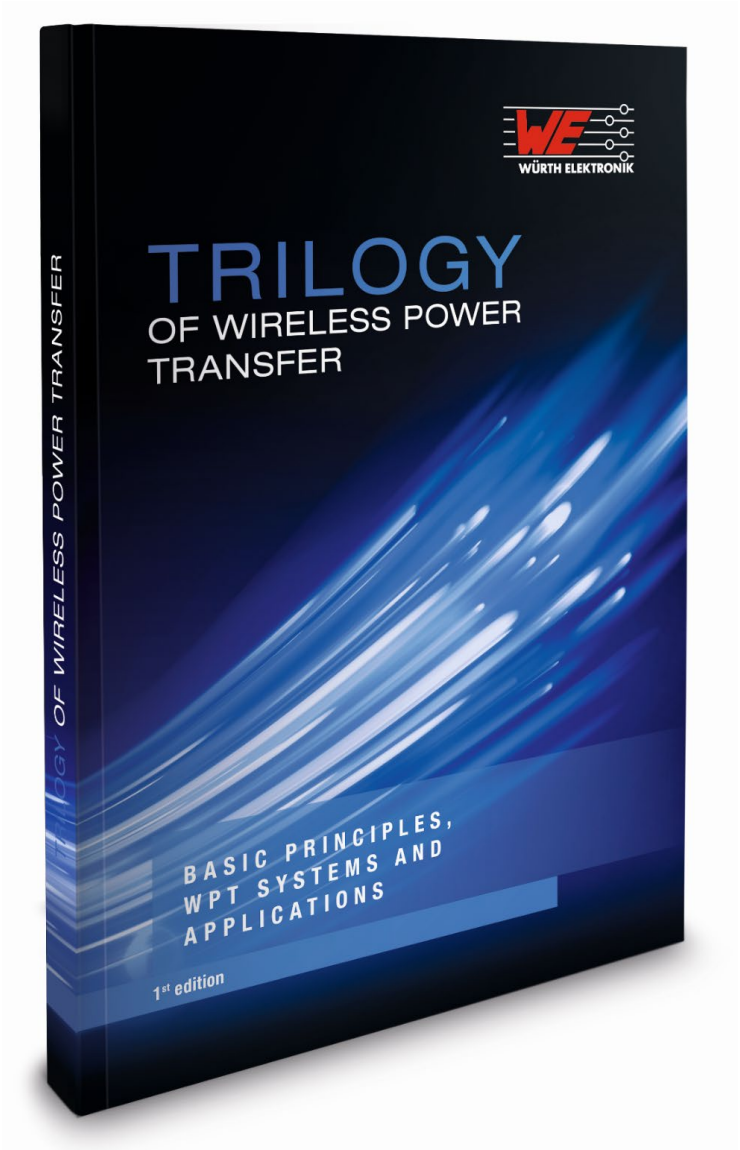


REDEXPERT FOR WIRELESS POWER COIL

https://www.we-online.com/redexpert/wirelesspower



NEW! TRILOGY OF WIRELESS POWER TRANSFER



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ARGUMENTS TO USE WPT

- *WE* have the broadest publicly available portfolio of wireless power coils
- *WE* do customer specific coils
- *WE* have a high performance / quality product line
- *WE* have a high volume product line
- *WE* have supporting tools (Mix&Match, Red Expert, Trilogy)

Over to you….

wirelesspower@we-online.com