WIRELESS POWER TRANSFER – Choosing the Right Coils

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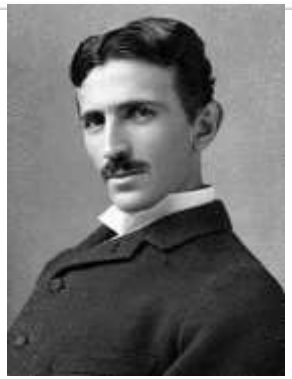
June, 2019

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

WIRELESS POWER CONSORTIUM

2011 first smart phones with integrated Qi receiver

2017 Apple joint WPC

2018 Wireless charging of EV´s

Applications

Application Areas besides Consumer Products

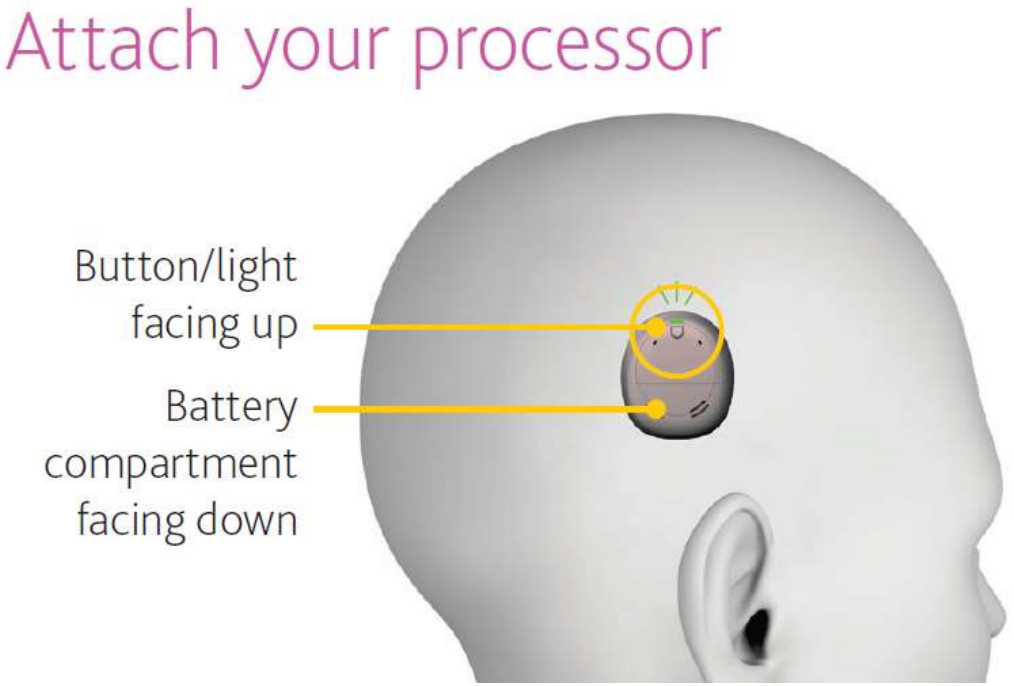
Industrial

Automotive

Medical Technology

Furniture / Infrastructure

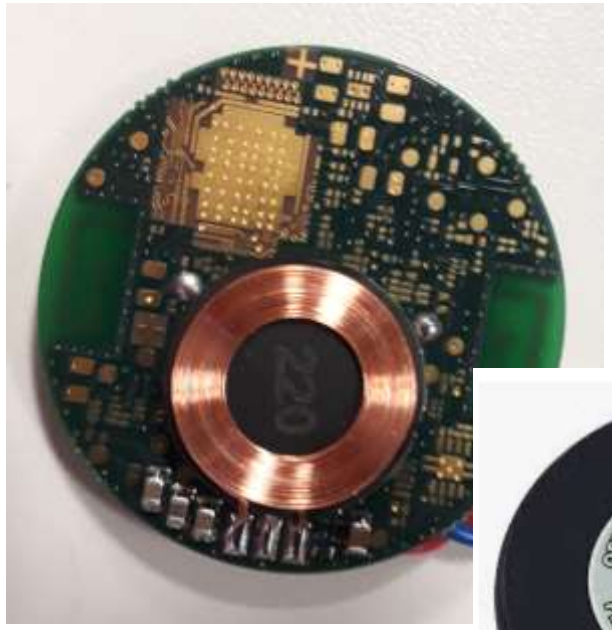
Applications of WE Customers

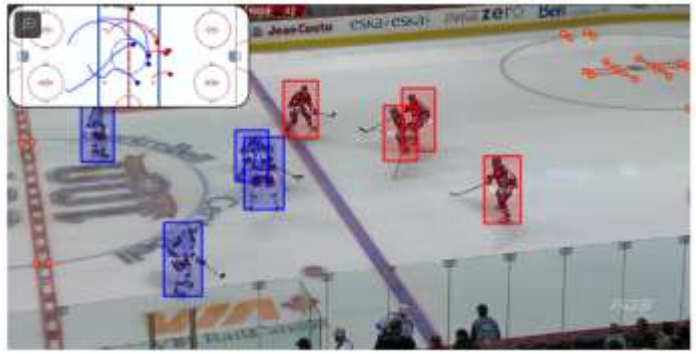


Applications of WE Customers

heinrichs weikamp gmbh
Charge diving computer

Jogmo World GmbH (Fraunhofer Institut Spin-off)





All NHL teams will use in season 2019/2020 the new puck with this new technology

WIRELESS POWER CONSORTIUM

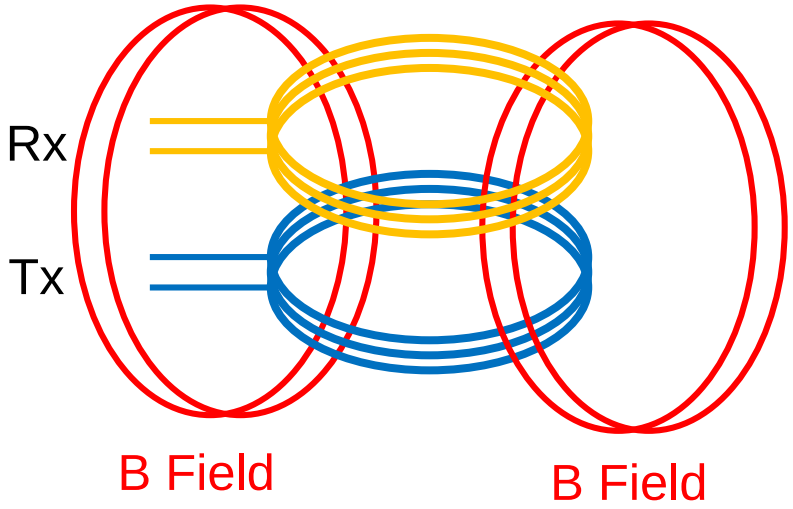
More power

60 – 200 Watt

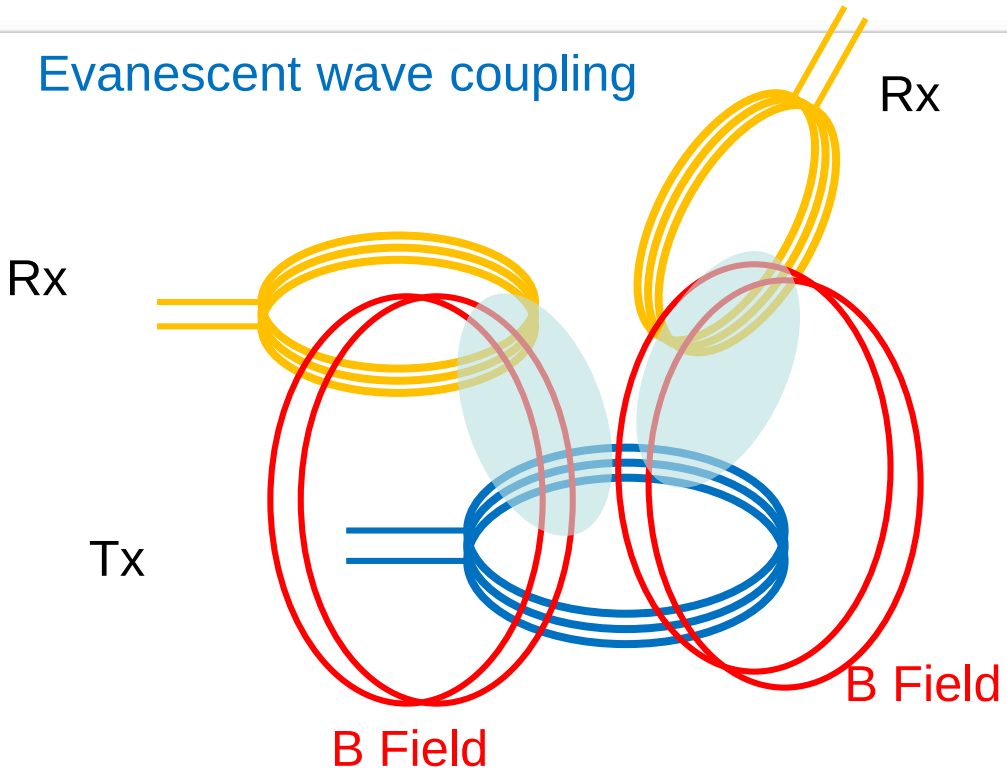
200 – 2400 Watt

Technologies and Standards

Inductive and Resonant Coupling

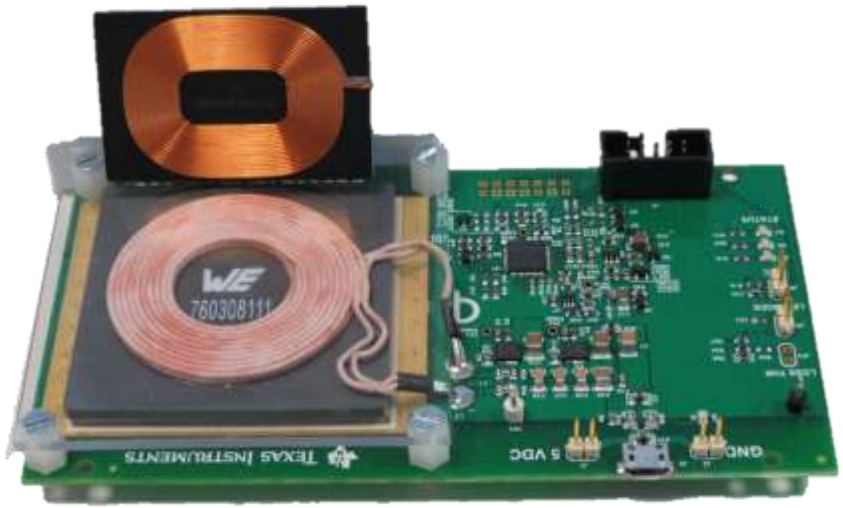


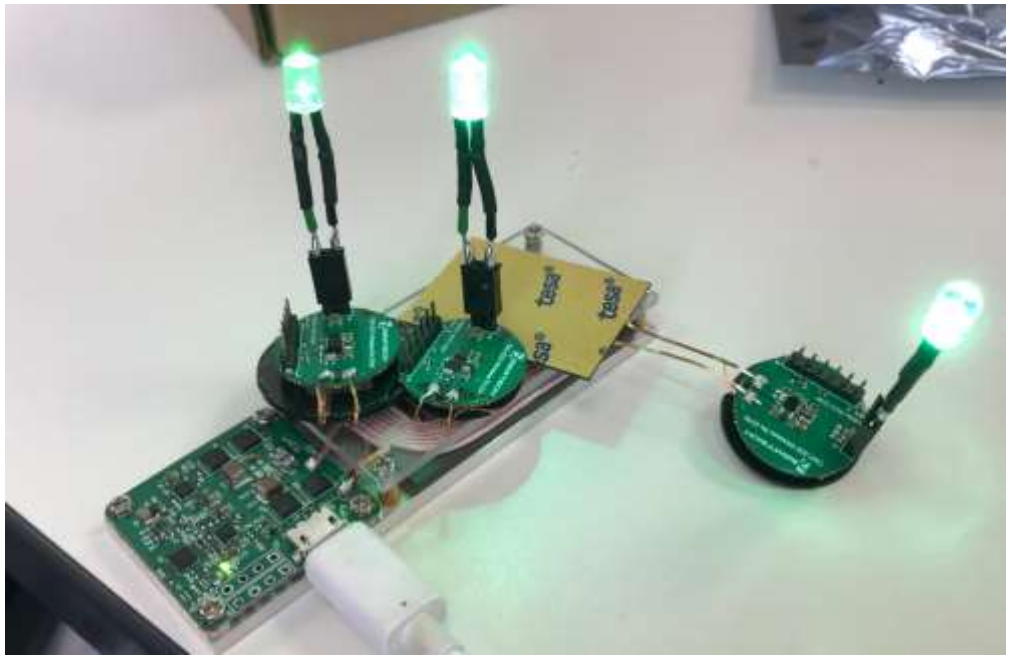
inductive power transfer



resonant power transfer

Examples





inductive power transfer

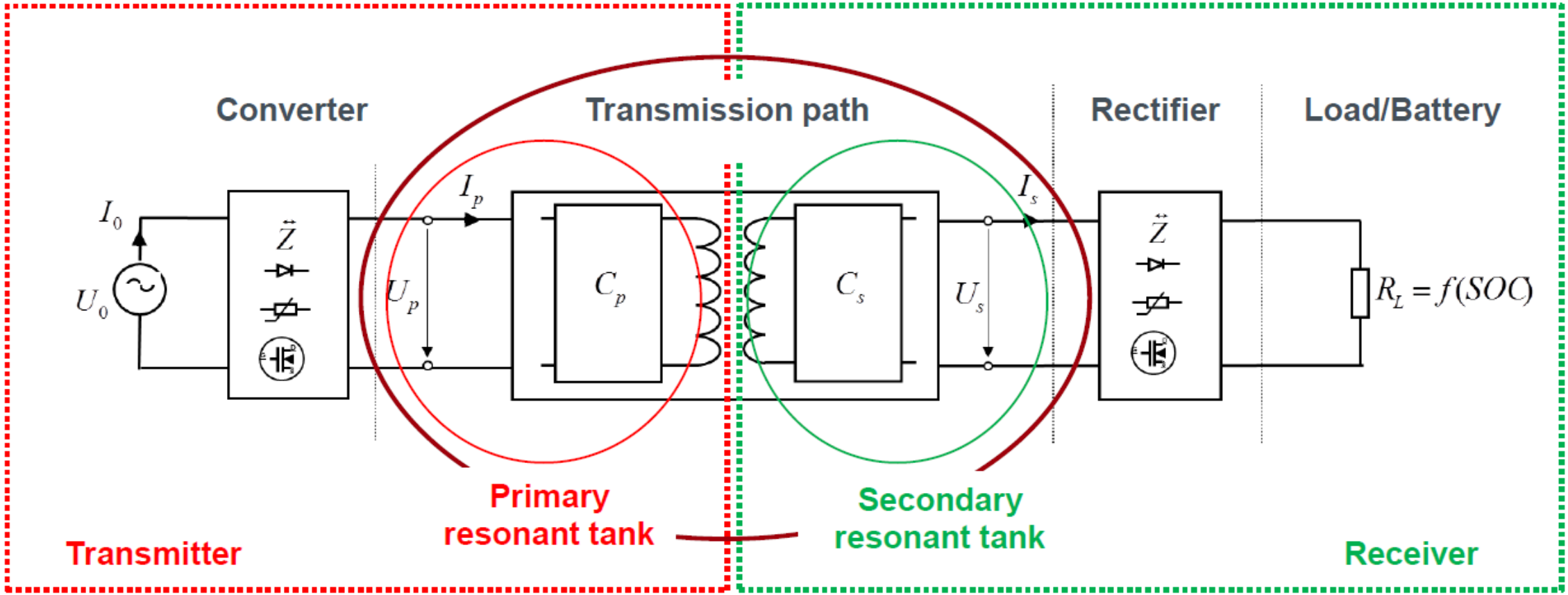
resonant power transfer

WIRELESS POWER Standards

- **Closely coupled**
  - Wireless Power Consortium (Qi)
    - Power transfer using resonant tank at very low frequency over short distances.
    - Resonant tank at 100 – 205 kHz.
    - 2009 “Low Power” 5W
    - 2016 Extended Power Profile 15W
    - higher power classes planned

- **Loosely coupled** (and closely coupled)
  - AirFuel Alliance
    - 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.

Terms and definition

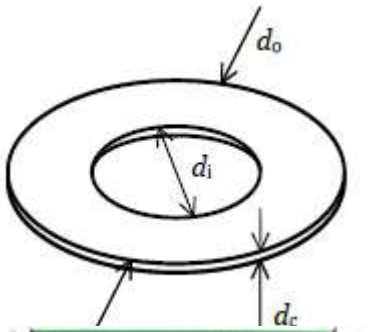


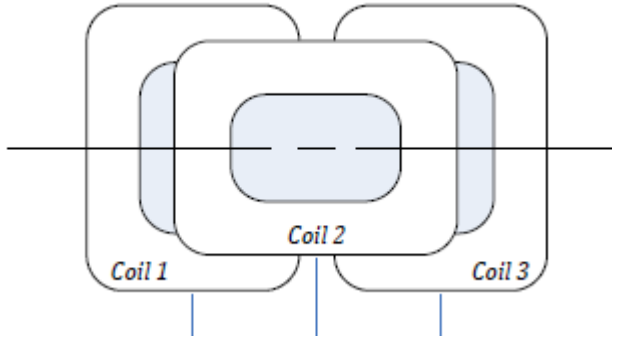
Coil Specific Considerations

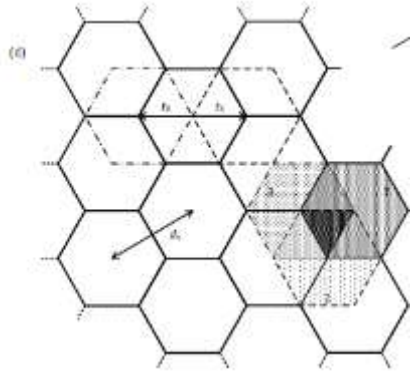
Coil System Requirements

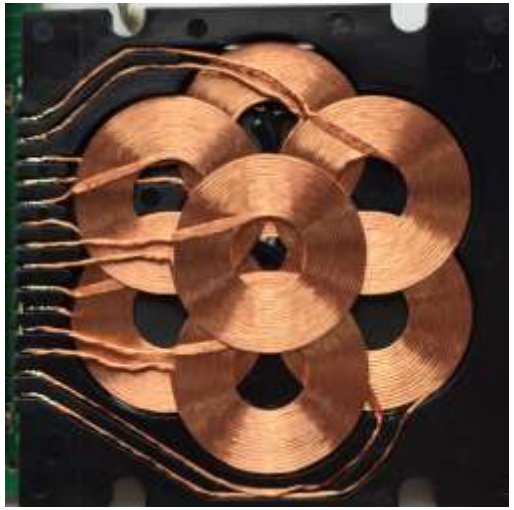
- Power level
- Available space within Rx device
- Distance between Tx and Rx
- Freedom of positioning Rx
- Electrical performance (efficiency, Q-factor, R_{DC}, shielding..)
- Price

Coil Types - Freedom of Positioning

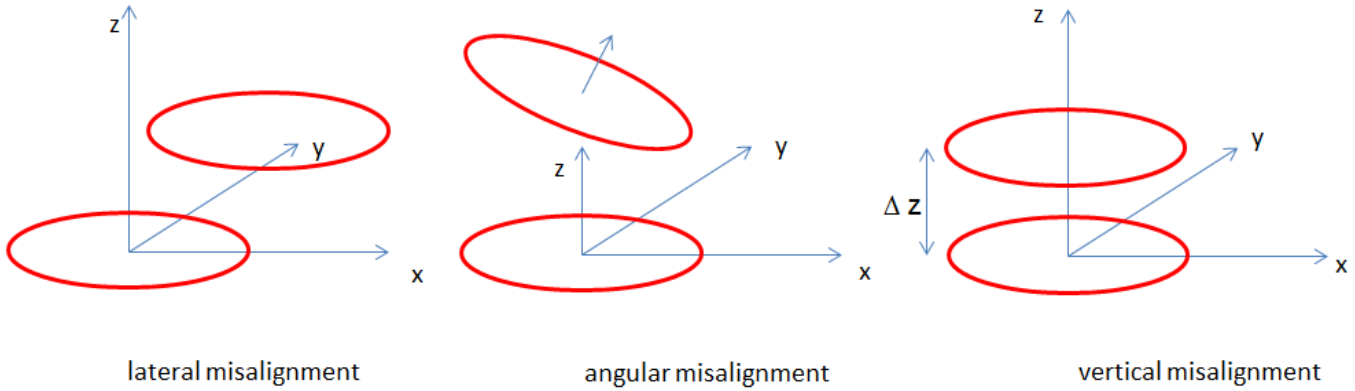








Coupling factor / alignment tolerances



lateral misalignment | angular misalignment | vertical misalignment

Good coupling and maximum energy transmission depends on

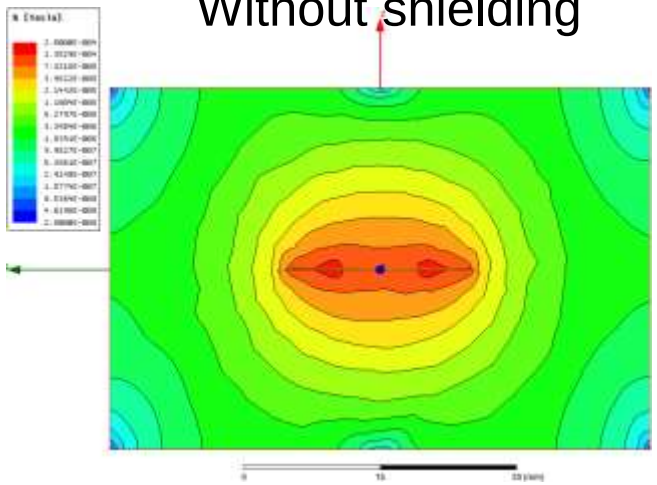
- size of the effective area of the receiver coil in the magnetic field
- the distance in the z direction

A coupling factor of 1 is ideal

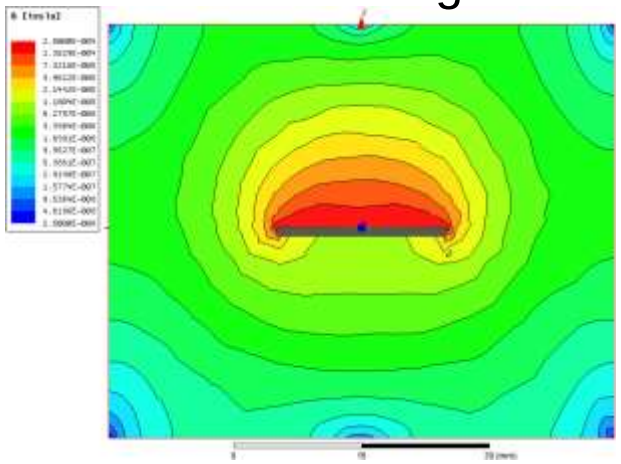
$$k = \frac{\phi_1}{\phi_{21}}$$

Improvement using ferromagnetic shielding

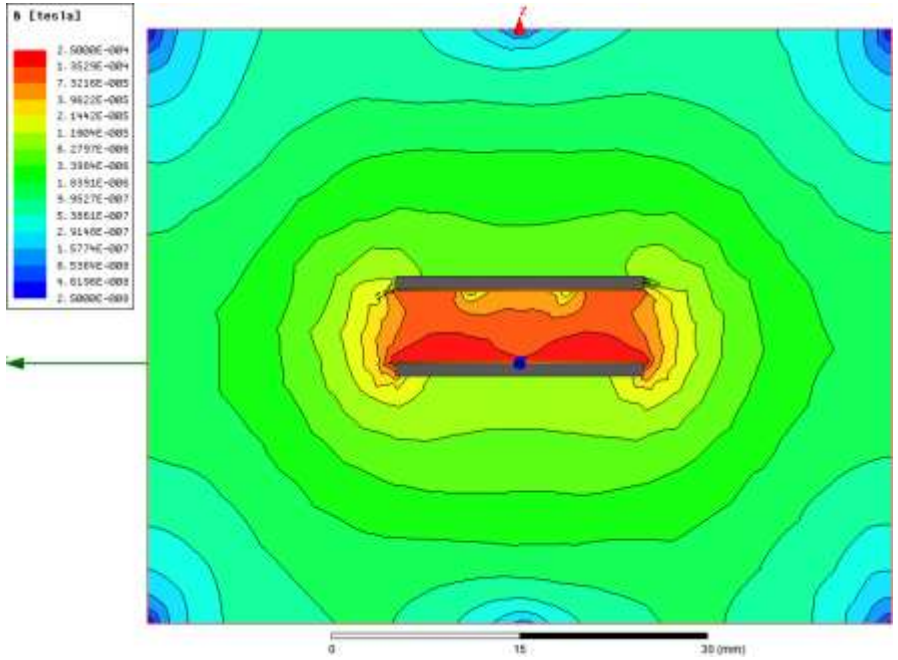
Without shielding



With shielding



Tx_Rx with shielding



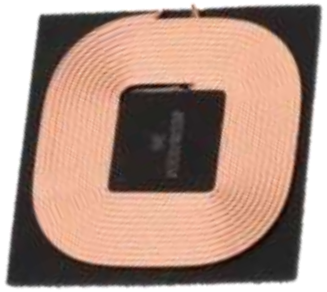
Coupling Factor k depending on Coil Size Ratio

- Tx/Rx coil size impacts coupling factor k
- ϕ is defined by current and coils diameter

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

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

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

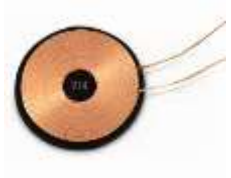
760 308 100 111 (A11)

k= 0.29
A_{Rx}/A_{Tx} = 1:6

760 308 101 214

760 308 101 104

k= 0.60
A_{Rx}/A_{Tx} = 1:1



760 308 101 214

Examples from ***WE*** Mix&Match and RedExpert

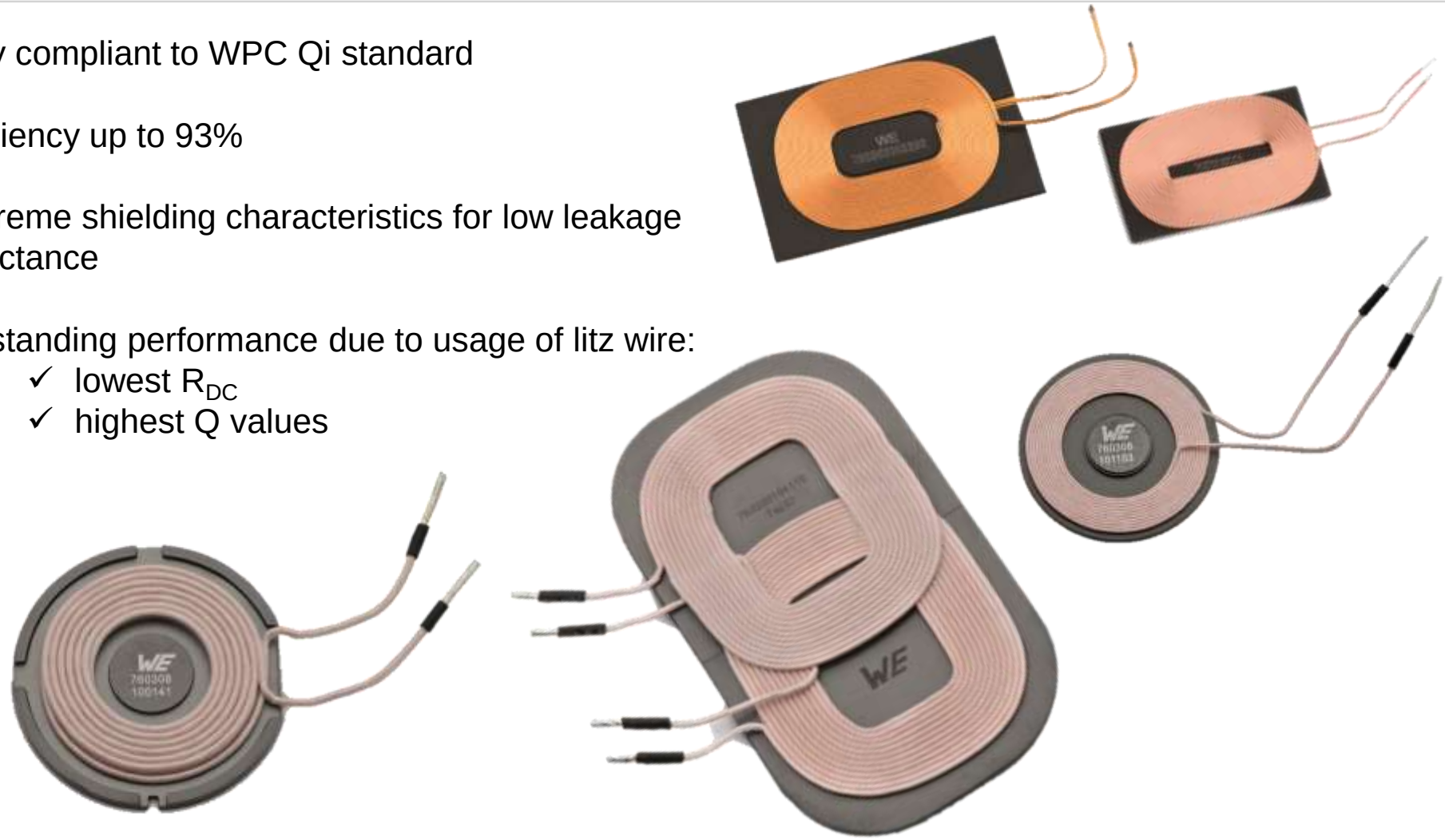
Receiver coils size is a key for success

https://www.ifixit.com/Teardown/iPhone+8+Teardown/97481

WE Products

Würth Elektronik Wireless Power Coils WE-WPT

- Fully compliant to WPC Qi standard
- Efficiency up to 93%
- Supreme shielding characteristics for low leakage inductance
- Outstanding performance due to usage of litz wire:
  - ✓ lowest R_{DC}
  - ✓ highest Q values



WE Wireless Power Coils – 06/2019

32 Transmitter Coils

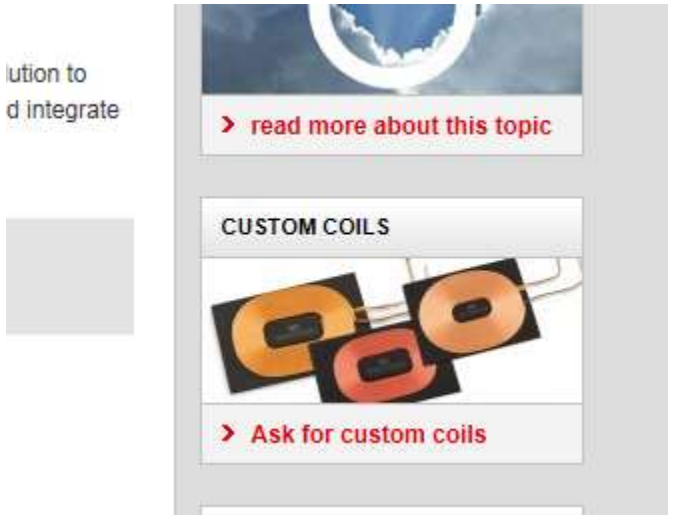
27 Receiver Coils

http://www.we-online.de/web/de/electronic_components/produkte_pb/demoboards/wireless_power/wireless_power_1.php

http://katalog.we-online.de/en/pbs/browse/Power_Magnetics/Wireless_Power_Transmission

Customer Specific Coils

- **Yes, we do ☺ ☺**
- **Use template on WPT website:**



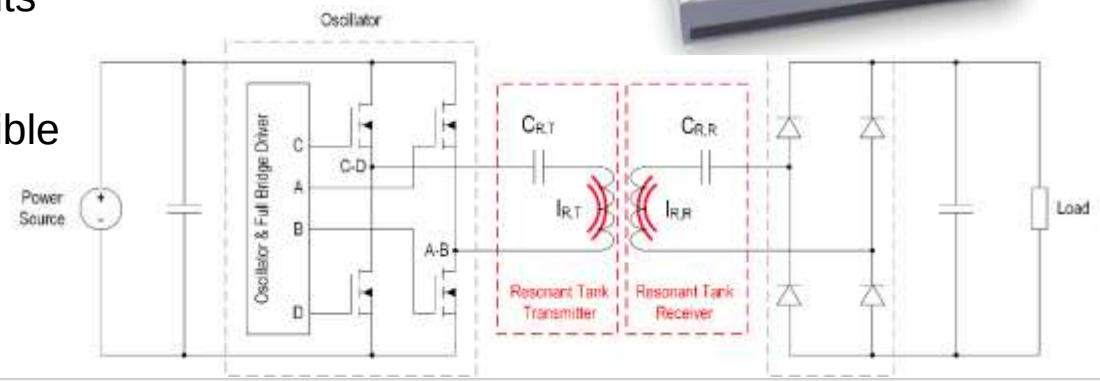
- http://www.we-online.de/web/en/electronic_components/produkte_pb/demoboards/wireless_power/wirelesspowercoilinquirysheet.php
- **MOQ: 5.000**

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



Qi Medium Power 15W Development Kit with bi-directional data transfer

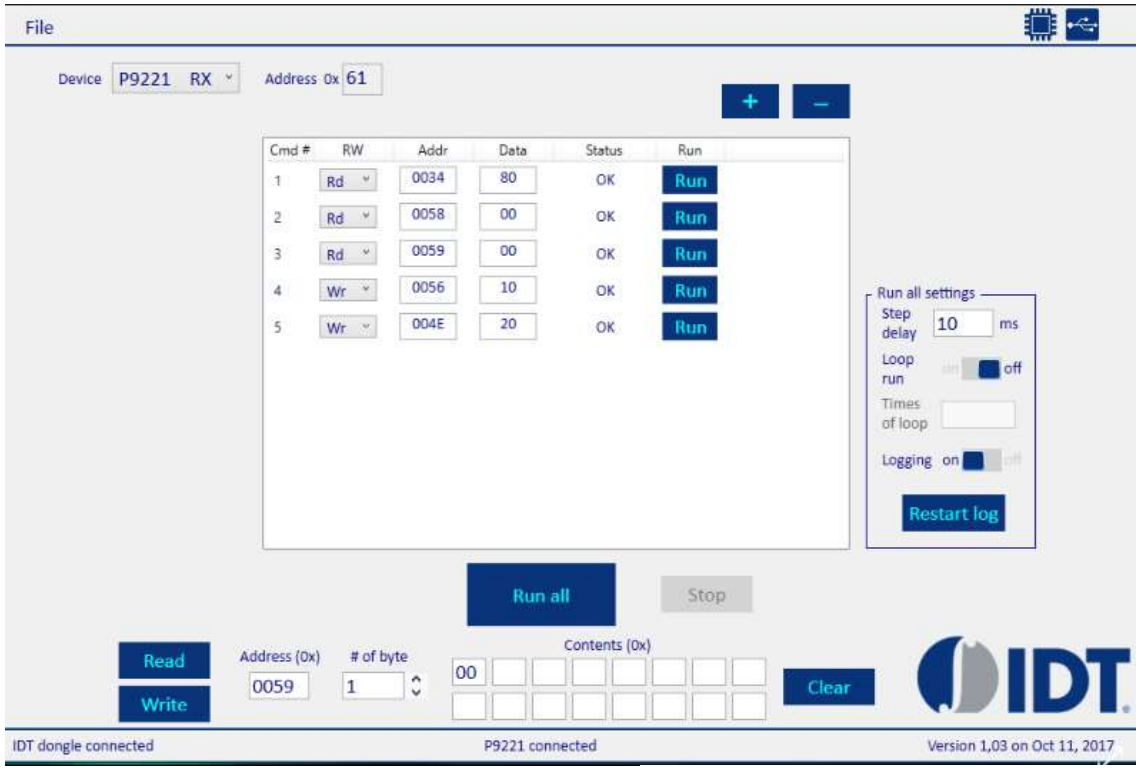
Transmitter 15W Qi ver. 1.2.3
Receiver 15W

Part No: 760308MP2

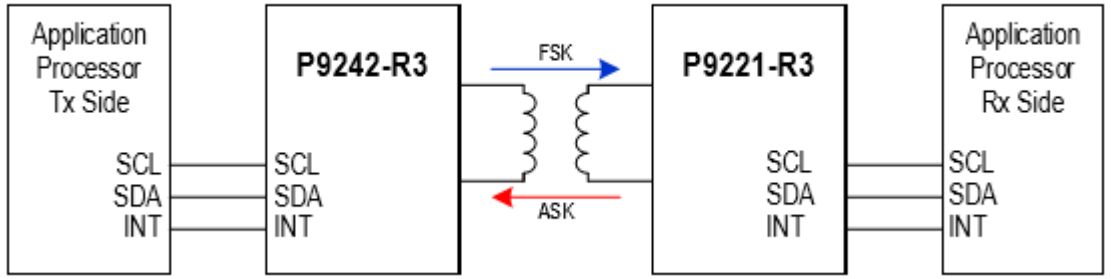
Website: 15W - IDT

Website: Pre-Order

Qi Medium Power 15W Development Kit with bi-directional data transfer (2)



The bi-directional data communication channel enables users to authenticate a wirelessly charged receiver device with a specific charging transmitter base or to transfer system data without any additional hardware



Information Material

Wireless Power Transfer Website

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

Mix and Match for Wireless Power Coil

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

Innovator award winning

Mix and Match für Wireless Power Spulen

Ihr Tool zum Finden der optimalen Spulenkombination für Ihre Wireless Power Anwendungen.

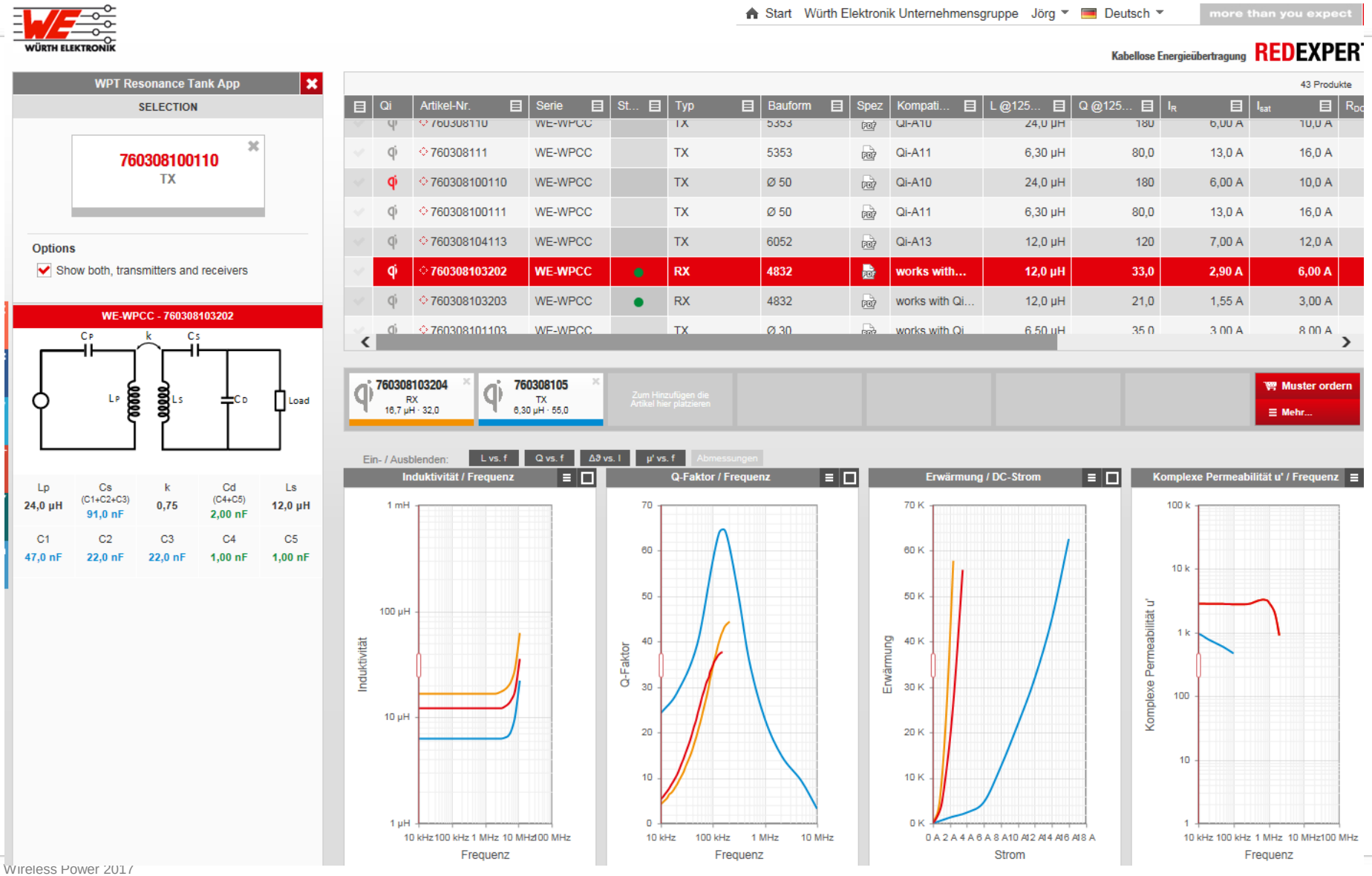
Durch Klick auf den ausgewählten Punkt werden Sie direkt auf unsere Online-Simulationssoftware REDEXPERT weitergeleitet und erhalten detaillierte Informationen zum ausgewählten Spulenpaar.

Bei Auswahl der Artikelnummern erfolgt eine Weiterleitung zum jeweiligen Produkt in unserem Online-Katalog.

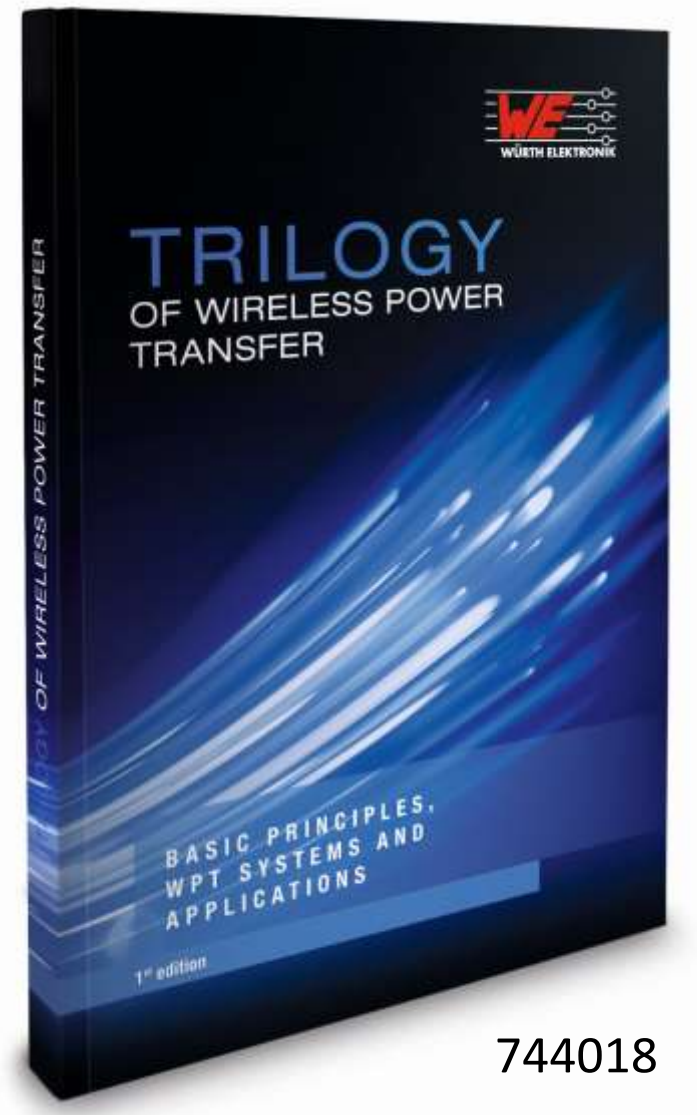
	Receiver																						
	760 308 201	760 308 103 202	760 308 103 203	760 308 103 204	760 308 103 205	760 308 103 206	760 308 102 207	760 308 101 208	760 308 101 208A	760 308 102 210	760 308 103 211	760 308 102 212	760 308 102 213	760 308 101 214	760 308 103 215	760 308 101 216	760 308 101 217	760 308 101 219	760 308 101 220	760 308 101 303	760 308 103 305	760 308 102 306	760 308 103 307
760 308 101 Qi-A1 / 19 V	✓	✓	✓	✓	✓	✗	✓	✗	✗	✓	✓	✗	→	→	✓	✗	✗	✗	✗	→	✓	✓	✗
760 308 105 Qi-A5 / 5 V	✓	✓	✓	✓	✓	✗	✓	✗	✗	✓	✓	✗	✓	✓	✓	✗	✗	✗	✗	✓	✓	✓	→
760 308 106 Qi-A6 / 12 V	✓	✓	✓	✓	✓	✗	✓	✗	✗	✓	✓	✗	✓	✓	✓	✗	✗	✗	✗	→	✓	✓	✗
760 308 110 Qi-A10 / 19 V	✓	✓	✓	✓	✓	✓	✓	✗	✗	✓	✓	✓	✓	✓	✓	✗	✗	✗	✗	→	✓	✓	✓

REDEXPERT for Wireless Power Coil

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



New! Trilogy of Wireless Power Transfer



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Thank you