# Wireless Power ~~Charging~~
# Wireless Power Transfer


RF&Wireless

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# Content

- What is Wireless Power Charging?
- Wireless Power Consortium & QI Standard
- WE Offering
- Market Companions

# Consumer Motivators for Wireless Power Charging

- Not running out of power (prerequisit: certain infrastructure maturity )

- Speed of charging (fast power charging e.g. 80% in 30 min)

- Convenience
  - no wire
  - different devices on same power supply (like with µUSB chargers)
  - no need to carry a charger or spare battery

- Reliability (µUSB contact problems)

# How does Wireless Power Charging  work?

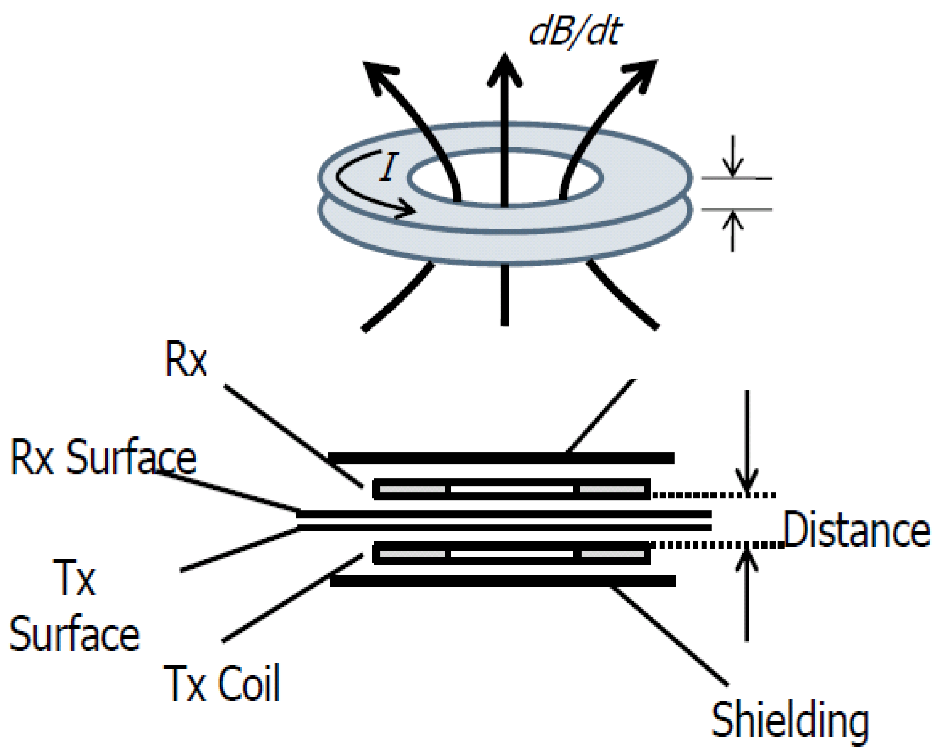
- Power transfers via inductive coupling at short distances (mm range)

- Transmitter (Tx) and Receiver (Rx) Coils are inductively coupled coils:

  AC current in Tx coil generates a magnetic field, which induces a voltage in Rx coil. Rx voltage may be used to power a mobile device or charge a battery

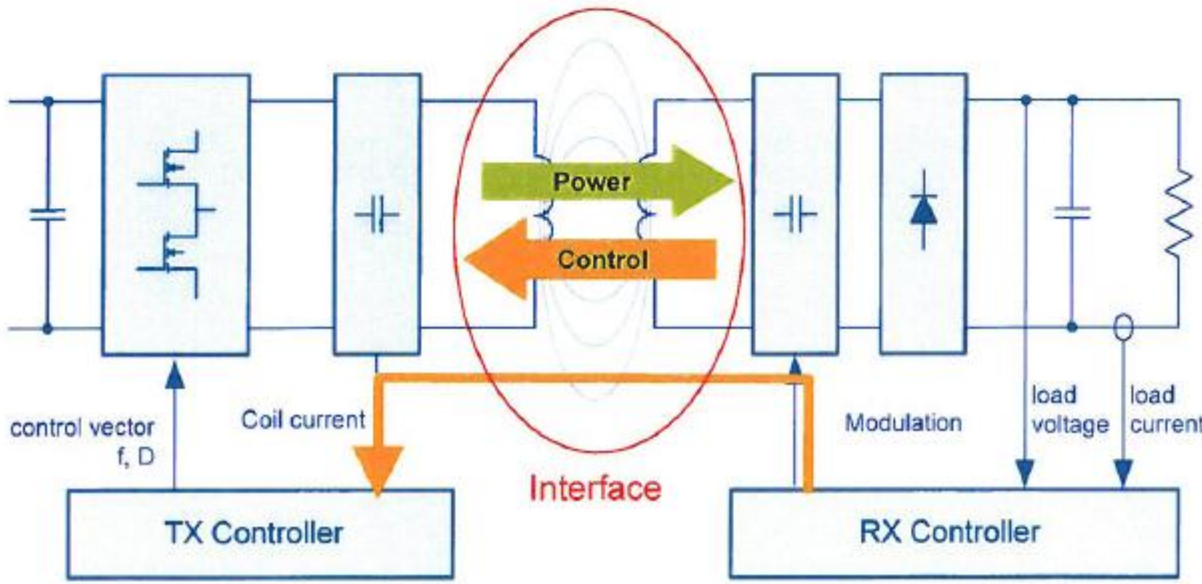
- Magnetic field concentrated in small volume between Tx / Rx

- Improve coupling effect between coils by:
  - ✓ matching coil size
  - ✓ flat surface between coil to keep distance small
  - ✓ shielding and aligning of coils



# QI Standard System Overview

- Base Station
  - Contains one or more transmitters
  - Transmitter provides power to receivers
- Mobile Device
  - Contains a receiver that provides power to a load or charges a battery
  - Receiver provides control information to transmitter
- The Qi standard is an interface specification
  - sets the minimum number of rules needed to guarantee compatibility of all Qi transmitters and Qi receivers
  - maximizes the design freedom for developers of transmitters and receivers



# Application – Mobile Devices

- **More convenience when using portable electronic devices**

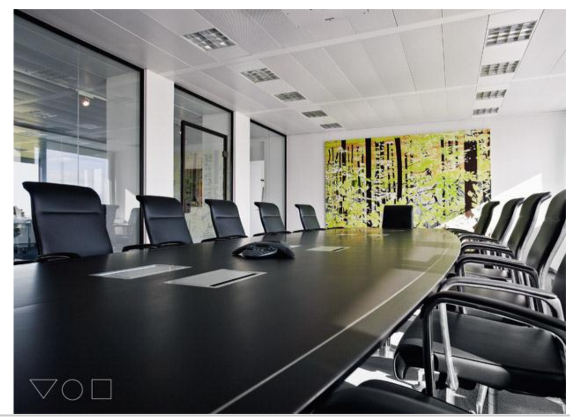
- **No need to carry multiple external power adaptors**


# Application - Furniture

Power supply integrated in desks, tables, appliances

Wireless power charging stations in:
- Desks in hotels, offices and homes
- Conference tables
- Restaurant & coffee shop
- Movie theaters
- etc.

Key success factor – Standardization
- Qi- Standard

# Application - Automotive

Use time in car for convenient charging

# Industry Accepted Standardization: Qi Standard

✓Standardization increases consumer confidence and demand

✓Qi “气” (Chee: “Vital Energy” in Asian Philosophy - An Intangible Flow of Power)

✓Industry standard developed by Wireless Power Consortium (WPC)

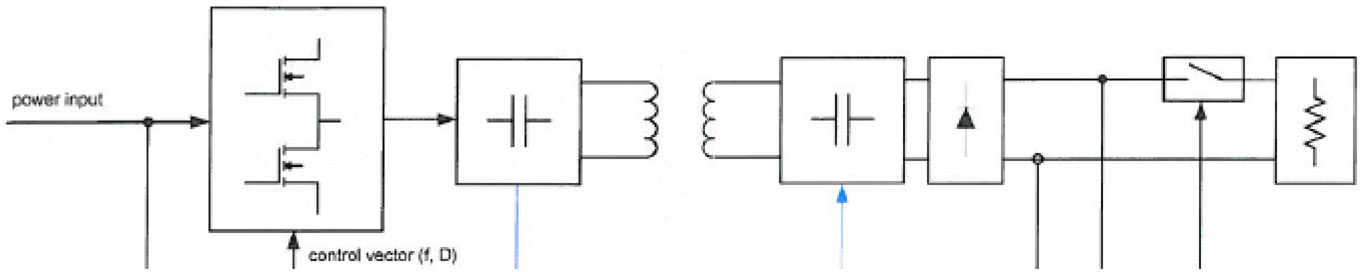
✓Rapid industry-wide adoption
(100+ Members)

✓Wurth Electronics is an official member of the WPC
http://www.wirelesspowerconsortium.com/member-list/

more than you expect

# Data transmission and signal processing

## Closed loop – impedance modulation




Communication Tx
Typ. 125kHz

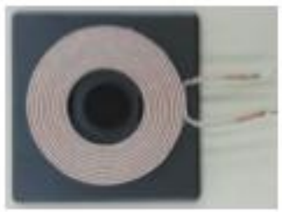
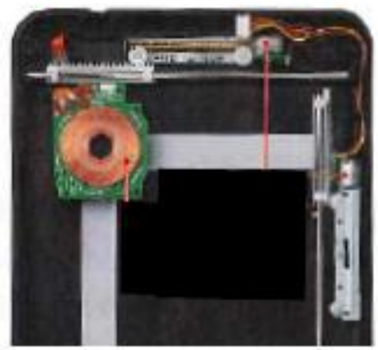
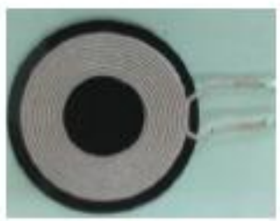
Communication Rx
Typ. 125kHz

- **Digital Signal Processing ist used for**
  - **Demodulation of data packet from power receiver**
  - **Calculation of active power for foreign object detection (FOD)**
  - **Closed-loop control of power transmission**
  - **Monitoring of overload and overtemperature**

- **Advantages:**
  - **Full digital solution for robust designs**
  - **Low parts count**
  - **Enables customization (e.g. I²C, CAN,…)**

- **Challenge to realize the features above with a MCU that meets cost and power consumption objectives**

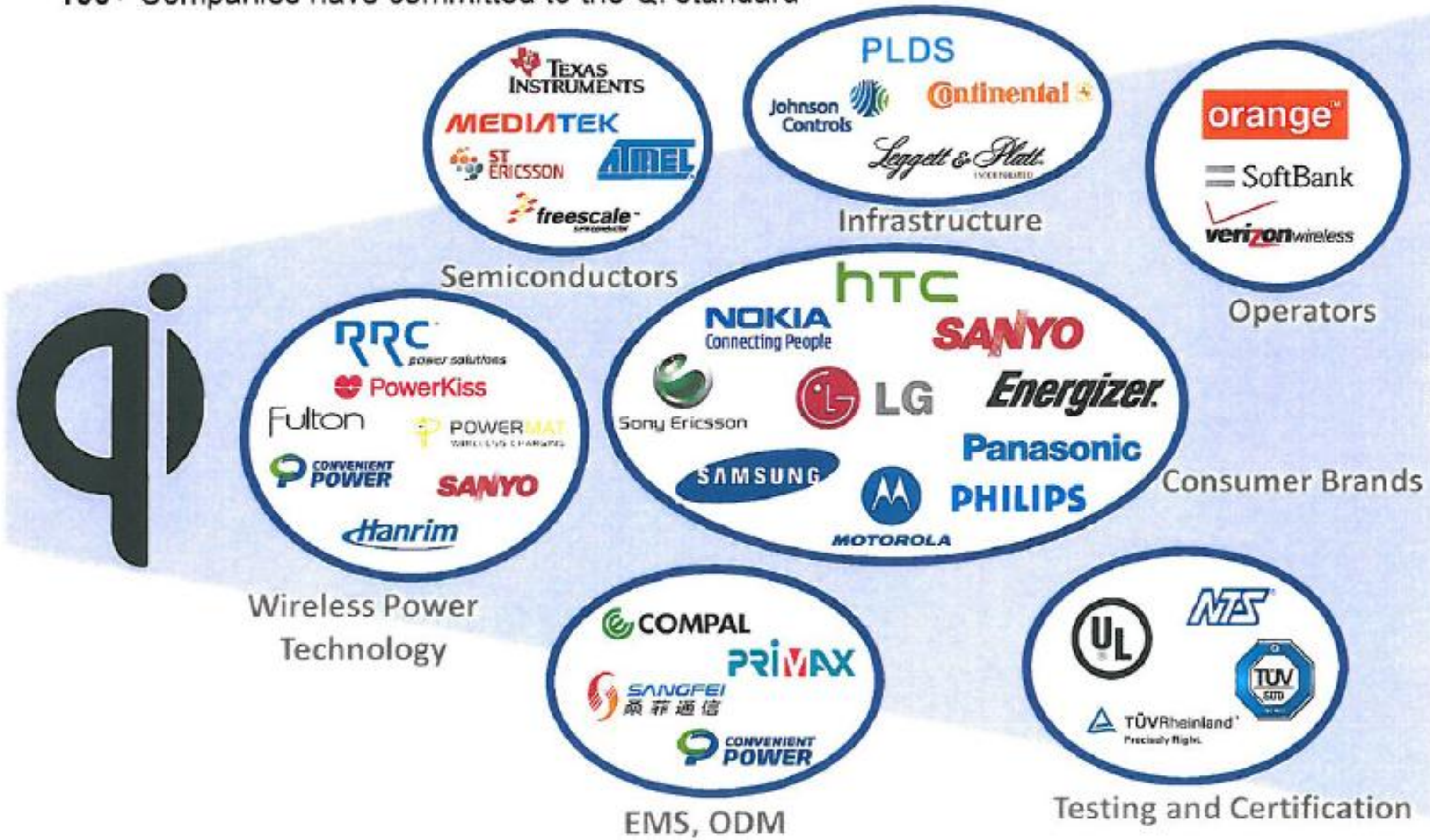
# Different types of Tx coils

| Single and multiple coils | Moving coils | Coil arrays |
| --- | --- | --- |
| Coil with magnet  |  |  |
| Coil without magnet  | |  |
|  Dual coils  Three coils | | |

Source:TDK

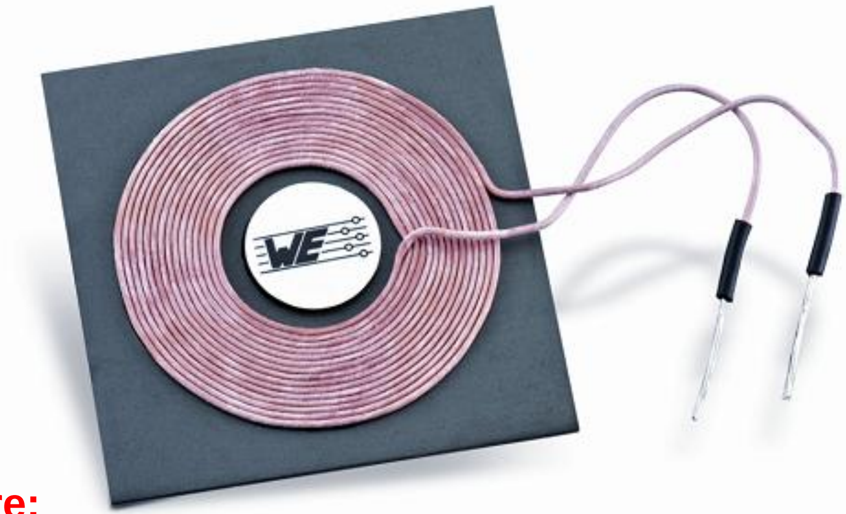
# The power of Qi

**Standardization Creates Ease of Use, Interoperability, for Consumers**
100+ Companies have committed to the Qi standard



# Wireless Power Coils WE-WPCC - Receiver 760 308 201

- Used as receiver coil in mobile devices with wireless charging function
- Fully compliant to WPC Qi standard
- Efficiency up to 75%
- Designed to fit to WE Transmitter Coil 760308101
- **Outstanding performance due to usage of litz wire:**
  - ✓ **lowest $R_{DC}$**
  - ✓ **highest Q values**



| Part Number | Inductance | Q | Rated Current | Sat Current | RDC |
|---|---|---|---|---|---|
| 760308201 | 10µH | 50 | 4.5A | 8A | 0.16Ohm |

- Suggested by Texas Instruments for the use with the following Reciever ICs
  bq51013AEVM-764 ; bq51013AEVM-765 ; bq51013EVM-725

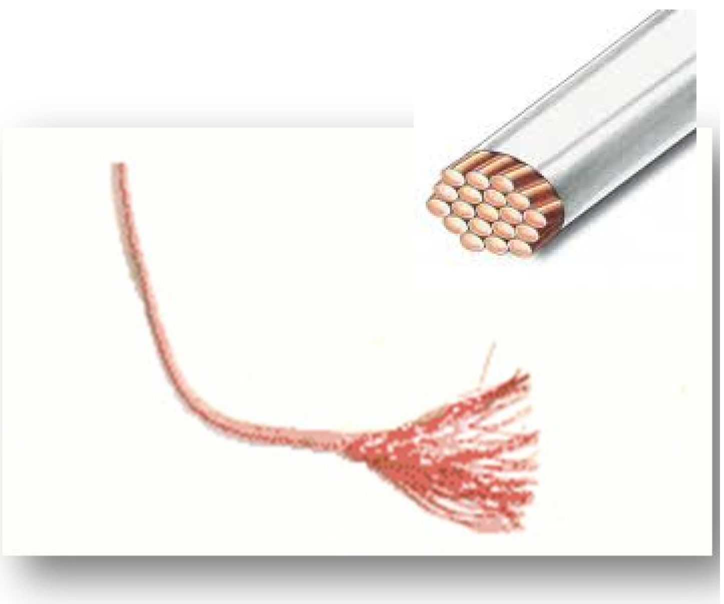
# Wireless Power Coils WE-WPCC - Transmitter 760 308 101

- Used as transmitter coil in power supplies for wireless charging
- Fully compliant to WPC Qi standard
- Efficiency up to 75%
- Designed to fit to WE Receiver Coil 760308201
- Supreme shielding characteristics for low leakage inductance
- **Outstanding performance due to usage of litz wire:**
  - ✓ **lowest $R_{DC}$**
  - ✓ **highest Q values**


| Part Number | Inductance | Q | Rated Current | Sat Current | RDC |
|---|---|---|---|---|---|
| 760308101 | 24µH | 90 | 5.5A | 10A | 0.07Ohm |

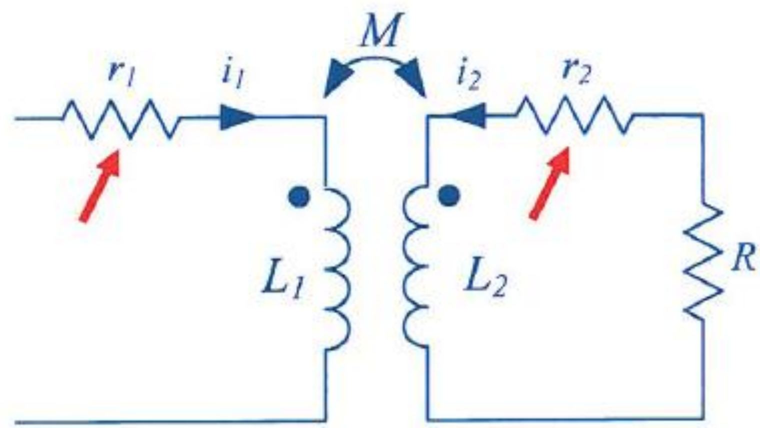
# Why do we use litz wire ?

- Higher Q-factor,  which results in a higher efficiency
- Less frequency dependent eddy currents, equal to less AC - resistance
- Less DC resistance



**Accounting for losses**

Winding loss modeled using equivalent series resistances (ESR)

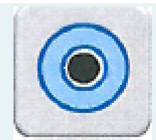
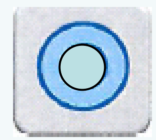
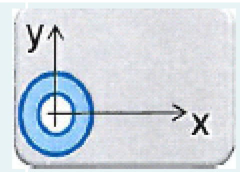
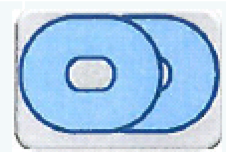
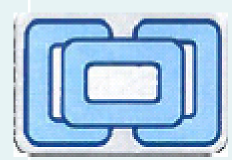



Equivalent series resistances (ESR) to consider power losses due to

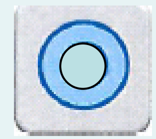
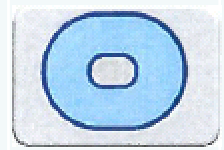
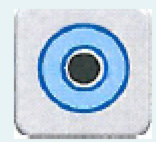
- DC resistance of a single coil
- Losses caused by eddy currents flowing in a single coil (frequency dependent)

Based on this definition the ESR is independent of the magnetic coupling

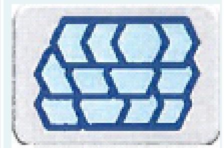
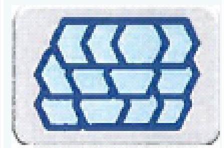
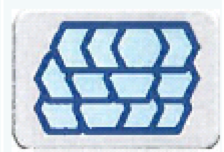
# Basic power transmitter designs – Typ A transmitters (1)

| Type | Position | | description | | |
|---|---|---|---|---|---|
| A1, A5 | guided (magnet) | single coil | coil dimensions: 43 x 2,1mm<br>variable frequency (105…205kHz)<br>A1: half-bridge, input voltage 19V<br>A5: full-bridge, input voltage 5V |  | |
| A10, A11 | guided (no magnet) | single coil | coil dimensions: 43 x 2,1mm<br>variable frequency (105…205kHz)<br>A10: half-bridge, input voltage 19V<br>A11: full-bridge, input voltage 5V |  | |
| A2, A3 | free | moving coil | coil dimensions:<br>A2: 40 x 2mm, A3: 33 x 1,8mm<br>full-bridge inverter, input voltage 3…12V<br>A2: fixed frequency (140kHz)<br>A3_ variable frequency (105…140kHz) |   | |
| A4 | free | two coils | coil dimensions: 70 x 59 x 1,15mm<br>full-bridge inverter, input voltage 5…11V<br>variable frequency (110…180kHz) |  | |
| A6 | free | three coils | coil dimensions: 53,2 x 45,2 x 1,5mm<br>half-bridge inverter, input voltage 12V<br>variable frequency (115…205kHz) |  | |

# Basic power transmitter designs – Typ A transmitters (2)

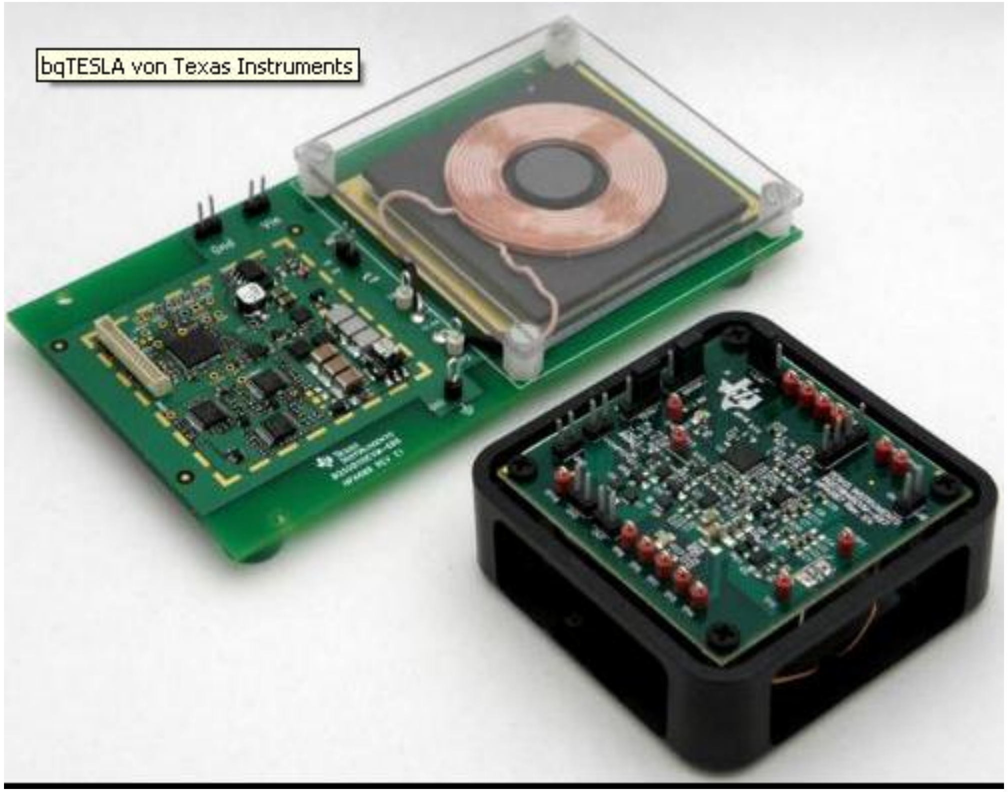
| Type | Position | | description | | |
|---|---|---|---|---|---|
| A7 | free | single coil | coil dimensions: 39 x 1,9mm<br>full-brigde inverter, variable input voltage 3…12V<br>frequency fixed betreen 105…140kHz<br>(140kHz recommended) |  | |
| A8 | free | single coil | coil dimensions: 39 x 1,9mm<br>full-brigde inverter, variable input voltage 5…11V<br>variable frequency 110…180kHz |  | |
| A9 | guided | single coil | coil dimensions: 43 x 2,1mm<br>full-brigde inverter, variable input voltage 2…15V<br>frequency fixed betreen 105…115kHz<br>(110kHz recommended) |  | |

# Basic power transmitter designs – Typ B transmitters

| Type | Position | | description | | |
|---|---|---|---|---|---|
| B1 | free | multi-coil array | coil dimensions: 28 x 0,6mm, 3-layer wire wound,<br>half-bridge inverter, input voltage 0…20V<br>frequency fixed between 105…113kHz |  | |
| B2 | free | multi-coil array | based on 8-lyer PCB type primary coil array<br>coil dimensions: 31 x 0,6mm<br>half-bridge inverter, input voltage 0…20V<br>frequency fixed between 105…113kHz |  | |
| B3 | free | multi-coil array | hybrid PCB/wire wound coil structure<br>(4-layer PCB + wire wound coil)<br>full-bridge inverter, input voltage 12V<br>frequency fixed between 105…113kHz<br>variable phase angle of full-bridge inverter<br>(0…180°) |  | |
| B4 | free | multi-coil array | Square shaped planar coils, 8-layer PCB or 3-layer wire wound (outer diameter 45mm) or hybrid PCB/wire wound<br>full-bridge inverter, input voltage 12V,<br>frequency fixed between 105…113kHz<br>variable phase angle of full-bridge inverter<br>(0…180°) |  | |

# Evaluation Kit

## A1-Standard: WE 760308101 with TI BQ500210

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http://www.ti.com/lit/ug/sluu911/sluu911.pdf
http://www.ti.com/lit/ug/slvu447a/slvu447a.pdf

IDT Integrated Device Technology

# Evaluation Kit

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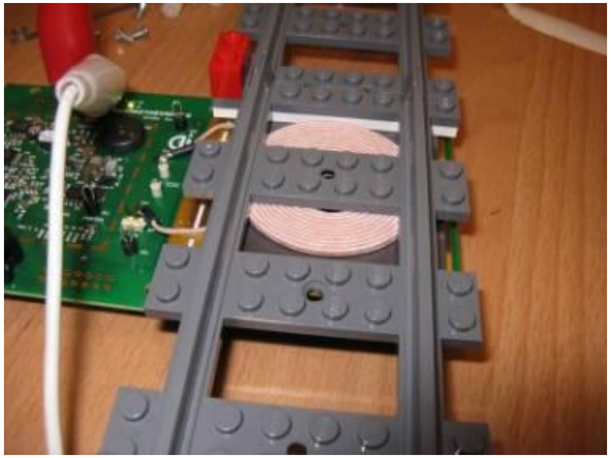
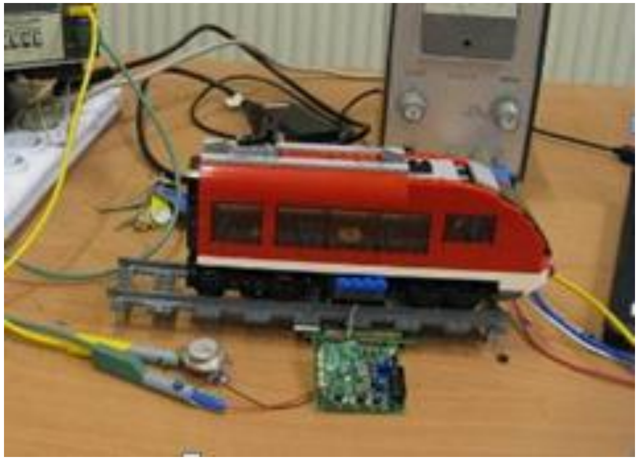
## IDTP9030 Evaluation Kit Contents

- Evaluation board
- JM60 Programming Dongle
- USB type A to micro-USB type B cable
- IDTP9030-EVAL Evaluation Board Manual
- Universal AC to 19V DC Power Adapter
- WPC "Qi" Compatible RX Energizer Sleeve
- CD containing:
  - IDTP9030 control software tool
  - IDT USB Device Driver
  - Reference layout Gerber Files
  - Reference layout Cadence Allegro board files
  - Electronic copy of IDTP9030-EVAL manual


# Playing Around – The Blog





http://www.element14.com/community/groups/wireless-power-solution

# Frequently Asked Questions (1)

**What is the operational frequency for QI transmission?**

the transmitter operates in a range of 100 – 205 kHz

**Can you transmit with an A6 (3 coils) transmitter more energy than with a A5 or A11?**

No, the reason for 3 coils is only to increase the area for optimal coupling

# Frequently Asked Questions (2)

**What is the distance range between transmitter and receiver coils?**

„the closer – the better“. Recommendation is to stay between 8 -12 mm
larger distance leads to inferior energy transfer
WPC is talking about an increase of the distance in a specification update

**Why should the Q value of the coils be high?**

The better the Q value is, the larger the distance can be between the transmitter and receiver coils

$$M = \sqrt{(k \cdot QTx \cdot QRx)}$$

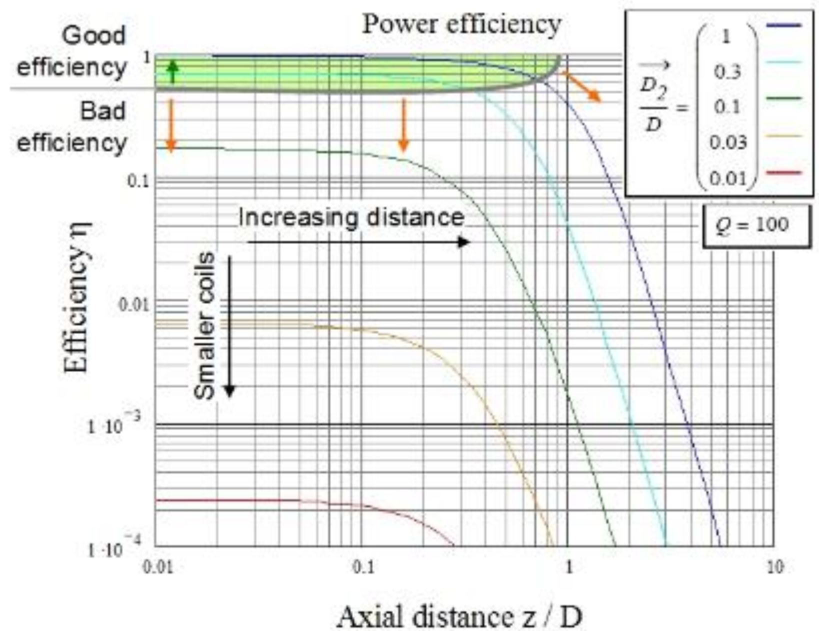



*Figure 2 Power efficiency for an inductive power transfer system consisting of loop inductors in dependence on their axial distance z with size ratio as parameter. Calculated for a quality factor of Q = 100*

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# Thank you for your attention!