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 (prerequisite: 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

[Diagram of QI Standard System]
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


✓ 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/
Data transmission and signal processing

Closed loop – impedance modulation

- **Digital Signal Processing** is 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**

- **Coil with magnet**
- **Coil without magnet**
- **Dual coils**
- **Three coils**

**Moving coils**

**Coil arrays**

Source: TDK
The power of Qi

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

- Texas Instruments
- MediaTek
- ST Ericsson
- Freescale
- RRC
- Fulton
- PowerKiss
- Compal
- Sangfei

- LG
- Sony Ericsson
- Nokia
- Sanyo
- Samsung
- Panasonic
- Philips
- Motorola
- HTC
- Energizer

- PLDS
- Johnson Controls
- Ledgett & Platt

- SoftBank
- Orange

- NXP
- Nissho Iwai
- Compal
- Primax
- Convenient Power

- TÜV Rheinland
- ANSI
- CE

- EMS, ODM
- Testing and Certification
- Operators
- Consumer Brands
- Infrastructure
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

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Inductance</th>
<th>Q</th>
<th>Rated Current</th>
<th>Sat Current</th>
<th>RDC</th>
</tr>
</thead>
<tbody>
<tr>
<td>760308201</td>
<td>10µH</td>
<td>50</td>
<td>4.5A</td>
<td>8A</td>
<td>0.16Ohm</td>
</tr>
</tbody>
</table>

- Suggested by Texas Instruments for the use with the following Receiver 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

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<thead>
<tr>
<th>Part Number</th>
<th>Inductance</th>
<th>Q</th>
<th>Rated Current</th>
<th>Sat Current</th>
<th>RDC</th>
</tr>
</thead>
<tbody>
<tr>
<td>760308101</td>
<td>24μH</td>
<td>90</td>
<td>5.5A</td>
<td>10A</td>
<td>0.07Ohm</td>
</tr>
</tbody>
</table>
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)

<table>
<thead>
<tr>
<th>Type</th>
<th>Position</th>
<th>description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1, A5</td>
<td>guided (magnet)</td>
<td>single coil&lt;br&gt;coil dimensions: 43 x 2,1mm&lt;br&gt;variable frequency (105…205kHz)&lt;br&gt;A1: half-bridge, input voltage 19V&lt;br&gt;A5: full-bridge, input voltage 5V</td>
</tr>
<tr>
<td>A10, A11</td>
<td>guided (no magnet)</td>
<td>single coil&lt;br&gt;coil dimensions: 43 x 2,1mm&lt;br&gt;variable frequency (105…205kHz)&lt;br&gt;A10: half-bridge, input voltage 19V&lt;br&gt;A11: full-bridge, input voltage 5V</td>
</tr>
<tr>
<td>A2, A3</td>
<td>free</td>
<td>moving coil&lt;br&gt;coil dimensions: &lt;br&gt;A2: 40 x 2mm, A3: 33 x 1,8mm&lt;br&gt;full-bridge inverter, input voltage 3…12V&lt;br&gt;A2: fixed frequency (140kHz)&lt;br&gt;A3: variable frequency (105…140kHz)</td>
</tr>
<tr>
<td>A4</td>
<td>free</td>
<td>two coils&lt;br&gt;coil dimensions: 70 x 59 x 1,15mm&lt;br&gt;full-bridge inverter, input voltage 5…11V&lt;br&gt;variable frequency (110…180kHz)</td>
</tr>
<tr>
<td>A6</td>
<td>free</td>
<td>three coils&lt;br&gt;coil dimensions: 53,2 x 45,2 x 1,5mm&lt;br&gt;half-bridge inverter, input voltage 12V&lt;br&gt;variable frequency (115…205kHz)</td>
</tr>
</tbody>
</table>
## Basic power transmitter designs – Typ A transmitters (2)

<table>
<thead>
<tr>
<th>Type</th>
<th>Position</th>
<th>Description</th>
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<tbody>
<tr>
<td>A7</td>
<td>free</td>
<td>single coil</td>
</tr>
<tr>
<td>A8</td>
<td>free</td>
<td>single coil</td>
</tr>
<tr>
<td>A9</td>
<td>guided</td>
<td>single coil</td>
</tr>
</tbody>
</table>
## Basic power transmitter designs – Typ B transmitters

<table>
<thead>
<tr>
<th>Type</th>
<th>Position</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>B1</td>
<td>free</td>
<td>multi-coil array, coil dimensions: 28 x 0.6mm, 3-layer wire wound, half-bridge inverter, input voltage 0…20V, frequency fixed between 105…113kHz</td>
</tr>
<tr>
<td>B2</td>
<td>free</td>
<td>multi-coil array, based on 8-lyer PCB type primary coil array, coil dimensions: 31 x 0.6mm, half-bridge inverter, input voltage 0…20V, frequency fixed between 105…113kHz</td>
</tr>
<tr>
<td>B3</td>
<td>free</td>
<td>multi-coil array, hybrid PCB/wire wound coil structure (4-layer PCB + wire wound coil), full-bridge inverter, input voltage 12V, frequency fixed between 105…113kHz, variable phase angle of full-bridge inverter (0…180°)</td>
</tr>
<tr>
<td>B4</td>
<td>free</td>
<td>multi-coil array, Square shaped planar coils, 8-layer PCB or 3-layer wire wound (outer diameter 45mm) or hybrid PCB/wire wound, full-bridge inverter, input voltage 12V, frequency fixed between 105…113kHz, variable phase angle of full-bridge inverter (0…180°)</td>
</tr>
</tbody>
</table>
Evaluation Kit

A1-Standard: WE 760308101 with TI BQ500210

Evaluation Kit

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

www.we-online.com
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 \( Q = 100 \)
Thank you for your attention!