Multi Mode Receiver Design

To Accelerate Wireless Power Market Adoption

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Wireless Power Solutions | MediaTek
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Today’s Wireless Power Ecosystems are Self Contained and Divided
Competing Ecosystems Create a Road Block to WW Wireless Power Adoption

But there is hope...

- Qi/PMA Dual mode products are just starting to emerge (e.g. SGS6)
- Qi/PMA/A4WP Multi mode receiver products are emerging (see tradeshow)
# Each Standard Has Benefits

<table>
<thead>
<tr>
<th>Feature/Benefit</th>
<th>Qi</th>
<th>PMA</th>
<th>A4WP</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Market maturity, lowest cost today</td>
<td>++</td>
<td>++</td>
<td></td>
<td>Qi &amp; PMA have been in the market for years, Qi has the highest volume</td>
</tr>
<tr>
<td>Coil Area (e.g. 5W Phones)</td>
<td>X</td>
<td>X</td>
<td>2-3X</td>
<td></td>
</tr>
<tr>
<td>Power control</td>
<td>IB</td>
<td>IB</td>
<td>BLE</td>
<td>IB = In Band, potentially lower cost</td>
</tr>
<tr>
<td>Efficiency</td>
<td>++</td>
<td>++</td>
<td>+</td>
<td>Due to tight coupling and frequency choice</td>
</tr>
<tr>
<td>EMI sensitivity</td>
<td>++</td>
<td>++</td>
<td>+</td>
<td>Tight coupling minimizes stray EMI</td>
</tr>
<tr>
<td>Freedom of placement</td>
<td>+</td>
<td>+</td>
<td>++</td>
<td>Loose coupling</td>
</tr>
<tr>
<td>Interoperability of different size coils / power levels</td>
<td>+</td>
<td>+</td>
<td>++</td>
<td>Loose coupling</td>
</tr>
<tr>
<td>Multiple device support</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>With a single Tx coil</td>
</tr>
<tr>
<td>Distance Charging</td>
<td>+</td>
<td>+</td>
<td>++</td>
<td>Low = ~5mm, High = ~45mm</td>
</tr>
<tr>
<td>Charging continuity in presence metals</td>
<td>+</td>
<td>+</td>
<td>++</td>
<td>Sensitivity to metals causes FOD schemes to interrupt or prevent charging</td>
</tr>
</tbody>
</table>

Based on standards Qi 1.1.2, PMA 1.0, A4WP 1.2
Essential Differences
Tightly Coupled (TC) vs Loosely Coupled (LC)

- All the Standards are “resonant”
- Higher Q resonance yields higher efficiency, especially at distance (i.e. LC)
- All WP system designers strive to minimize loss, and thus maximize Q
- Higher operation frequency generally helps to maximize Q
  • Inductor Q=ωL/R

\[ \eta = \frac{k^2 Q_1 Q_2}{\left(1 + \sqrt{1 + k^2 Q_1 Q_2}\right)^2} \]

n = efficiency
K = coupling
Q = quality factor of resonance
Use Case May Help Decide Tightly vs. Loosely Coupled

TC
- **1: 1**
- Ltd freedom
- **0.3 < k < 0.7**

LC
- **1: Many**
- Ext. freedom
- **k < 0.3**

- Higher Q cannot overcome the loss in k entirely, but many advantages can be had
  - Freedom of movement
  - Different coil sizes on Rx
  - Multi device support

- Can we build solutions that can take advantage of each standard? **YES**

3D Coil-Coil Efficiency
- **1mm Z gap**
- **Qi A6**
- **A4WP Class 3**
- DC-DC measured, electronic losses removed
### What Makes These Standards Different?

<table>
<thead>
<tr>
<th>Feature</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Comms Protocols</td>
<td>This is just a language. The essential algorithm for power transfer is similar</td>
</tr>
<tr>
<td>Power Transfer</td>
<td>Higher Q coils allow greater design flexibility with the same efficiency, but system operate on same principles</td>
</tr>
<tr>
<td>Operating Frequency</td>
<td>Qi &amp; PMA are of similar frequencies, and A4WP is a very different frequency</td>
</tr>
</tbody>
</table>
Frequency of Operation Does Create a Fence

Tightly Coupled LF

Low Frequency (LF) Ecosystem

Operating Frequency Fence

Loosely Coupled HF

High Frequency (HF) Ecosystem

100-300kHz

6.78 MHz

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We Can Use Frequency To Our Advantage

- Low cost approach w/single:
  - Coil
  - Matching network
  - Power path

- Matching circuit delivers power at the desired frequency
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**LF MI Mode**
- $Z_C > 1000 \, \Omega$
- $Z_L < 0.4 \, \Omega$

**HF MR Mode**
- $Z_C < 0.4 \, \Omega$
- $Z_L > 600 \, \Omega$

**Rx Case...**

![Diagram of an LC resonator with a rectifier and a current source](image)

**Graph:**
- $s_{21} (\text{dB})$
- Frequency (Hz): $100 \, \text{kHz}$, $6.78 \, \text{MHz}$

**Circuit Diagrams:**
- LF MI Mode
- HF MR Mode
Multi Mode Receiver Designs are Here

- Device, MT3188
  - In Mass Production

- Certification
  - WPC 1.1.2 → Mar, 2014
  - PMA 1.0 → Dec, 2014
  - A4WP 1.2 → Feb, 2015

See Kupiin sleeves at the Tradeshow!

KUPIIN

MediaTek MT3188 Multimode Rx
Multi Mode Transmitter Considerations

1:1 Transmitter
- Single coil option similar to Rx coil designs
- Multi TC coil offers freedom of placement for TC devices

1:Many Transmitter
- Freedom of placement for multiple devices
- Simplest option
- TC coils may de-tune LC coil
- May have user ‘dead’ spots for TC devices
- TC coils may de-tune LC coil
- High complexity
To Date Companies are Moving Towards Rx Implementations

- Companies have announced Rx solutions first including...
  - MediaTek MT3188
  - Broadcom BCM59350
  - IDT IDTP9700

- The infrastructure market is asking for multimode transmitters; none are announced
Summary

- Technology can support multi-frequency solutions for both transmitters and receivers; *receivers are simpler and will be sooner to market*

- Multi-frequency, multi-standard products are already emerging on the market. Let’s welcome them.

- *Multi-standard wireless power products can be a contemporary approach to promote world wide acceptance of wireless charging*

- *Use cases can be drive the best technology/standard choice*