High Efficiency and Simplified Design of Wireless Charging System

Hooky Lin (林富祈)
Aug. 31, 2017
Challenge of Wireless Charging Application

• Wireless charging is facing the challenge that users have experienced the convenience of rapid charging through various “wire” fast charging technology.
• The thermal issue is turning out to be critical in handheld and wearable devices with lots of components filled in the compact case especially when higher power delivery is required.
• WPC portfolio accounts several dozen of transmitter types.
• System integrators have great level of flexibility addressing practical wireless power implementations.
AGENDA

- Overview of Wireless Charging System.
- Efficiency Variants.
- Example and Data of Transmitter Efficiency Optimization.
- Receiver Optimization for Handheld/Wearable Devices.
- RT3181A as Universal Transmitter Building Block
- Simplified Design Examples of Transmitter System.
- Handheld/Wearable Wireless Power Receivers.
- Summary
Overview of Wireless Charging System – Efficiency

Transmitter
- DC Input
- VPA Control
- MOSFET DR. MOS
- MCU/Driver System Controller
- Cs
- Transmitter Coil

Receiver
- RX System Controller
- Rectifier
- LDO or Buck
- DC-DC Stage
- Switching Charger
- Linear Charger
- Battery

Charger
- DC-DC Stage
- Inverter AC-DC Stage
- Filter/LC Matching
- TX-RX Coil Coupling
- RX LC Matching
- Full-Syn. Rectifier
- DC-DC Stage
- Charger Stage

η = 90% - 98%
Efficiency Variants

**TX Side**
- Inverter MOSFET/Dr. MOS stage: Low $R_{DS(ON)}$ and low switching loss MOFSET.
- Matching Capacitor: Low ESR, accurate and temperature-compensating capacitor such as C0G instead of X7R.
- Coil: High electrical resistivity/high permeability of magnetic (ferrite) sheet and thick enough or PCB underneath far away from coil. /Low DC resistance Litz wire coil.

**RX Side**
- Coil: high coupling factor against TX coil and low resistance. (Litz wire is better but its thickness is critical especially for handheld devices)
- Matching Capacitor: Low ESR, accurate and temperature-compensating capacitor such as C0G. (The capacitance of C0G is generally not enough for WPC wireless power application)
- Rectifier: Synchronized full bridge rectifier with low switching/conduction/driving losses.
- DC-DC stage: keep the LDO drop out as low as possible or bypass switching charger.
WPC BPP-A11 DC-DC Efficiency

Efficiency Variants:
-- Matching circuit capacitor
-- Inverter MOSFET
-- TX coil
WPC EPP MP-A5 DC-DC Efficiency

WPC MP-A5 EPP TX/RX DC-DC Efficiency

WPC MP-A5 EPP TX/RX DC-DC Efficiency
RX Optimization for Handheld/Wearable Device

Thermal budget estimation:
Battery charging power - 10W
The power losses
(a) Receiver : 0.84W
(b) Switching charger: 1.11W

Thermal dissipation of the device is critical especially for the compact device such as smartphone and wearable device.

VRECT voltage is able to be tracked according to battery charging current and voltage for optimizing its efficiency.
What Wireless Power Transmitter is Made Of

• Typical WPTX takes DC input
  • Regulates it down to power control circuitry
  • The MCU controls all TX functions
  • Interface chips demodulate RX feedback signals.
  • The Power Amplifier converts DC voltage to square wave AC that energizes the resonant network.
  • The resonant network drives sine wave current through TX coil.
  • All these functions in many cases are done by the individual discrete components making TX design complex and expensive.
RT3181A – Universal Single Chip WPC TX Inverter

• RT3181A Does:
  • Regulates DC input down to power control circuitry and PA
  • Incorporates MCU that controls all TX functions and digitally processes RX feedback signals
  • Incorporates Power Amplifier that converts DC voltage to the square-wave AC voltage that energizes the resonant network
  • Supports two FOD methods – before power transfer and during power transfer
  • Controls LED indicators and buzzers
  • Reduces TX BOM by more than 50%

Integrating Most of WPTX Functions into a Single IC Provides Highly Functional and Economical WPTX Solution
WPC Transmitter Examples

- **RT3181A**
  - Support WPC BPP & EPP
  - Configurable Internal PA or External PA
  - Package, 6x6 QFN48
WPC BPP TX Application - A6/A19

- **A6 (3 coil)**
  - External selection FET
  - High efficiency by 2 HB parallel operation.
  - Optional Boost controller for 5V input

- **A19 (2 coil)**
  - Simple BOM
  - Trade off of BOM cost and charging area
  - Optional Boost controller for 5V input
Thin TX Design

Conventional Design

Coil Wire Extension

Remote Drive
Example of Remote Drive™ TX

• Why Remote Drive™
  • For very thin TX Pad design (~2mm), TX Attached on the table edge, no need to drill the hole
  • Separate the heat in TX, versus the conventional design, TX PCB underneath the coil.
  • Prototype base on A11, can also apply to MP-A5 and other TX type
  • Module Supplier : Kupiin
Example of MP-A5 TX Module Design

- MP-A5 Coil Module Design based on RT3181A
  - WPC EPP 15W Certified.
  - 4L PCB Ref design

---

**Diagram:**

- **RT3181A**: Buck Controller
- **Dr MOS RT9682A**: MP-A5
- **12V IN**: Input voltage
- **HB/Dr MOS DRV**: High-Bandwidth Dr M.O.S controller

---

**Components:**

- **Buck Controller**: RT3181A
- **Dr MOS**: RT9682A
- **MP-A5 (EPP)**: Integration diagram with 12V IN and various components.
Handheld/Wearable Receiver Solution

- **WPC base Handheld/Wearable Solution**
  - RX : RT1652/RT1653, Voltage source or Direct Charge to battery for efficiency optimization.
  - TX : RT3181A with mini-A11 coil
  - Coil and PCB : minimized for low power application.

- **Module Supplier**
  - Luxshare/ICT
  - Contact : Jefferson Lin, Email : Jefferson.Lin@luxshare-ict.com

The power losses of linear/switching charger could be saved!!

VRECT voltage tracks the battery status of Pre-charge/CC/CV mode for best efficiency
SUMMARY

• Simplify your next wireless power product design.
• Choose Qi SOC transmitters for system BOM reduced.
• Choose battery charger integrated for RX thermal enhanced.
• Look for these part numbers.

<table>
<thead>
<tr>
<th></th>
<th>TX</th>
<th>RX</th>
</tr>
</thead>
<tbody>
<tr>
<td>WPC BPP</td>
<td>RT3181A</td>
<td>RT1650</td>
</tr>
<tr>
<td></td>
<td>- A11</td>
<td>RT1652</td>
</tr>
<tr>
<td></td>
<td>- A6/A19</td>
<td></td>
</tr>
<tr>
<td>WPC EPP</td>
<td>RT3181A</td>
<td>RT3180W</td>
</tr>
<tr>
<td></td>
<td>- MPA5</td>
<td>RT1653</td>
</tr>
</tbody>
</table>

http://www.richtek.com/
RICHTEK
your power partner.

thank you.