Design of Automotive Chargers
For WPC 1504

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Agenda

- Wireless Charging in Automotive
- Automotive Wireless Charging Challenges
- Automotive Wireless Transmitter Solution Design
- Wireless Charging Software Design
- Q&A
Wireless Charging in Car

- Toyota
- Honda
- Chrysler
- Audi’s Phone Box
Wireless Charging Challenges in Automotive

• **Foreign Object Detection:**
  Selective and qualitative detection of foreign objects around the system (metallic or magnetic objects) is of key importance due to their ability to absorb energy from the wireless power supply field in the form of heat (parasitic heating) and possibly become a hazard.

• **CE4A (Consumer Electronics for Automotive)**
  — No-Go for all automotive OEM’s:
    ▪ Radio AM/FM band (AM band)
    ▪ Remote t key (Most systems operate inside existing Qi frequency range)
    ▪ Capacitive switch
    ▪ Immobilizer
    ▪ NFC

  — Automotive key points:
    ▪ Environmental
    ▪ Harsh operating temperature ranges
    ▪ Humidity and spill protection
    ▪ Vibration profiles
    ▪ Thermal shock

• **Shielding effectiveness:**
  The shielding added under the primary and above the secondary is important for the safe operation of wireless power transfer. Without shielding, the magnetic field may interfere with the device or other objects; it may cause battery heating and may circulate current in metallic parts.
### Wireless charging Transmitter – A13 transmitter Litz Wire Coils

#### Key Features:

<table>
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<tr>
<th>Feature</th>
<th>Description</th>
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<tr>
<td>Compliant with Wireless Power Consortium (WPC) low power specifications</td>
<td>to support up to 5W power transfer</td>
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<td>Integrated digital demodulation</td>
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<td>Support free positioning multiple coils low power transmitter solutions</td>
<td>using fixed frequency PWM control</td>
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<td>Support both Resonance Shift and Power Loss FOD methods</td>
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<td>Support key FOB and AM band avoidance</td>
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<td>Low standby power consumption</td>
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<td>Automotive applications design</td>
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<td>Support PMA SR1 specifications</td>
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<td>AEC-Q100 grade 2 certification</td>
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<td>Voltage/current/temperature protection</td>
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<tr>
<td>Software based solution with Freescale embedded wireless charger</td>
<td>software libraries to provide maximum design freedom and product differentiation</td>
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<td>FreeMASTER GUI tool to enable customization and calibration</td>
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Got WPC Qi certification with WCT1001AVLH: 15010210HKG
Example of PCB type Coil (4 coils) –A33 Transmitter Type

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**Diagram Details:**
- **4th coil**
- **Inter1**
- **Shielc**

**Measurements:**
- \( d_{cc} = 105\mu m \)
- \( d_{ll} = 200\mu m \)
How Freescale Solution Fits for Automotive (1/3)

- Safety
  - Foreign object detection:
    - Support resonance shift method for FOD before power transfer
    - Support power loss method for FOD during power transfer
    - Additional coils temperature protection
How Freescale Solution Fits for Automotive (2/3)

• Harsh Environment
  – Alignment Aids
    ▪ Support wire-round type coils and PCB type coils
    ▪ Support multi-coil array for fee positioning alignment with large charging area
    ▪ Large z-gap up to 10mm
  – AEC-Q100 certified product
  – Comprehensive system fault protection: voltage/current/temperature protection

• Emissions/Interferences
  – Fixed operating frequency to reduce the emission for wide frequency band
  – KeyFOB/Radio Interference
    ▪ Support operating frequency drift to reduce the interference according to specific frequency band
  – NFC co-existance
    ▪ Partner with Melexis to provide NFC solution for co-existance with WPC
How Freescale Solution Fits for Automotive (3/3)

• Low standby power consumption
  - Support touch sensor for ultra low standby power consumption
  - Support analog PING with intermittent controller deep sleep for low standby power consumption

• Vehicle Interface
  - Support wide support voltage range from 9V to 16V
  - Ignition interface designed
  - CAN communication interface
    ▪ Support to add wireless charging into car network for better management
    ▪ Support software updating from HMI

• Productibility
  - Software based solution to easily provide automatic test feature during mass production and service
Analog demodulation in wireless charging

Hardware demodulation circuit

Coil current signal

TX Coil

Wireless Charging chipset
Digital demodulation in wireless charging
- Low cost and Flexible

<table>
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<th>Benefit</th>
<th>Tradeoff</th>
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<tbody>
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<td>BOM cost reduced</td>
<td>Sophisticated demodulation algorithms</td>
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<tr>
<td>PCB area reduced for more compatible applications</td>
<td>DSP processing required</td>
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Freescale Wireless Transmitter Software Structure

- The basic kernel functions of wireless charging is packed as library form.
- The add-on/customized functions are provided as API interfaces such as FOD, Touch sensor, CAN, NFC, IIC, indicator/buzzer etc.
- User is required to write his/her code for those user application code.
- Sample code projects will be provided for customer reference to speed the development time.
Wireless Transmitter State Machine

- **Selection**
  - RX removed
  - Retry time expires

- **Retry**
  - Set retry time according to error type

- **Ping**
  - No start bit and timeout

- **Iden and Config**
  - No packet and timeout
  - Error packet timeout
  - Error protection

- **Power transfer**
  - Close loop control
Software Development GUI Tool

Freescale wireless charging GUI tool is based on FreeMASTER, and provides:

- Configuration: System parameters, coil parameters and FOD parameters
- Calibration: Analog signal sensing coefficients, FOD algorithm coefficients
- Debugging: System real-time status and variables
WCT1000 / WCT1101* – Single Coil Transmitter IC

Hardware
- 100MHz core
- Support any 5W single coil type
- Run-time calibration capable
- Low-power (< 30mA PID loop current)
- 32QFN

Software
- Closed loop PID algorithm
- Foreign Object Detection
- Digital demodulation
- I2C for Touch Sense Interface (low power)

* WCT1101 - Premium
- Program memory available to build & customize application
- Additional IOs to expand platform capabilities (e.g. multi-channel charger, NFC, etc.)
- 64LQFP
WCT100xA – Automotive Transmitter

**Hardware**
- Automotive-specific transmit controller solutions
- Supports full H-bridge, multi-coil topology
- Standard option provides additional programmability and communications interfaces
- **Premium** option expands on flash and SRAM for expanded programmability
- Multi-protocol capable
- WCT1001A & WCT1003A pin-pin compatible in the 64LQFP package

**Software**
- Voltage control algorithm
- Foreign Object Detection
- Digital demodulation
Q & A