OVERVIEW OF WIRELESS POWER AND DATA COMMUNICATION

Charlie Wu
Senior Principle Engineer
System and Architecture
NXP Semiconductors
Agenda

• Wireless Power Data Exchange and Software Architecture

• What are WPID and NFC?

• Wireless Power Data Communication - Network Architecture
How Qi Wireless Power Works

• Main application
  – Battery charging, or other suitable loads
  – For wide range of battery powered devices
    ▪ Mobile phone, camera, mp3 player, headset, drills, surgical tools,…

• Thousands Watt of power delivery

• Power transfer via magnetic induction
  – Loosely coupled transformer
  – At short distance (a few Centimeters)
System Overview

- **Base Station**
  - Contains one, or more transmitters
  - Transmitter provides power to receiver

- **Receiver**
  - Contains a receiver that provides power to a load (e.g. a battery)
  - Receiver provides control information via transmitter
System Overview (Power Conversion)

- Power Conversion Unit converts electrical power to wireless power signal
- Power Pickup Unit converts wireless power signal to electrical power
System Overview (Control)

- Receiver controls the power to the output load
  - To the need of the electronics device (required power)
  - To the desired operation point (e.g. output current, voltage)
- Transmitter adapts power transfer
  - To the need of the receiver (required power)
  - To the desired operation point (e.g. primary coil current)
System Overview (Communication)

- Receiver sends/receives messages
  - To provide control and device information to the transmitter by load modulation on the power signal
  - From transmitter by de-modulation of the frequency modulation on the power signal
- Transmitter receives/replies messages
  - About power control and device information from the receiver by de-modulation of load modulation
  - To provide information of transmitter and networking messages to the receiver by frequency modulation on the power signal
Communication (Data Format)

• Bit-encoding: bi-phase
• Byte encoding:
  Start-bit, 8-bit data, parity-bit, stop-bit
• Packet Structure
  – Preamble (>= 11bit)
  – Header (1 Byte)
    ▪ Indicates packet type and message length
  – Message (1 .. 27 Byte)
    ▪ One complete message per packet
    ▪ Payload for control
  – Checksum (1 Byte)
Power Transfer Control

Transmitter
• Interpret desired control point from
  • Control error message
  • Actual control point
• Adapt power towards zero difference between
  • Desired control point
  • Actual control point
• Relay the message between Receiver and Host

Receiver
• Calculate control error
  = difference between
  • Desired control point
  • Actual control point
• Communicate control error message
• Relay the message between transmitter and load

Host

Power Conversion

Desired
Interpret

Adapt

Actual

Power Pick-up

Power and message

Load

Control Error
Message

Control Error

Desired

Actual

Calculate
Qi Wireless Charging System State Machine

*CM: calibration mode
Baseline Power Profile Transmitter State Machine

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

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

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

- **Iden and Config**
  - Error packet timeout
  - Error protection

- **Power transfer**
  - Close loop control
Software Benefits on Power Transmitter

- Much greater product differentiation and design flexibility by adding new features without any hardware change
  - Multi-mode solution extension
  - Specs upgrading
  - Cost saving with DDM
  - New features such as object detection by analog PING, RX quick removing detection, input power/temperature limiting etc.

- Store operational data for diagnostic and record keeping
- Firmware updating for product sustaining
- Flexible communication capabilities for smart management, connecting with Wifi, BT, NFC etc. modules
- Project portability, shorter R&D cycle, fewer turns of board prototyping
- IP protection and technology differentiation
Software Benefits on Power Receiver

- Much greater product differentiation and design flexibility by adding new features without any hardware change
  - Multi-mode solution extension
  - Specs upgrading
  - New features such as fast charging protocol, flexible power profile etc.
- Store operational data for diagnostic and record keeping
- Firmware updating for product sustaining
- Project portability, shorter R&D cycle, fewer turns of board prototyping
- IP protection and technology differentiation
What is Wireless Power Identification (WPID)

A unique identification assigned to a wireless charging receiver device

- Assigned by IEEE
- Identify itself to the Power Transmitter by sending a unique identification number during as part of the power-up sequence
- Contains two data packs
  - Three Most Significant bytes plus Two CRC bytes
  - Three Least Significant Bytes plus Two CRC bytes
- WPC WP Identification Packet
Purpose of WPID

• Enable the data exchange between receivers and cloud system
• Allow infrastructure companies have the ability to track customer preferences and buying habits
• Enables pay for charge applications
1. If TX supports Negotiation phase, then goes to Negotiation phase and sends initial ACK to RX; otherwise, enters Power Transfer phase directly.

2. When getting the first WPID packet (0x54), TX should:
   a. Replies ACK if the packet received correctly, goes to step 3;
   b. Replies ND if the packet is not defined, then goes to step 4;
   c. Replies NAK if CRC is not correct, then waits for RX to re-send this packet (0x54); TX should accumulate the retry counter; if the counter is larger than 3, TX should revert to Selection phase.

3. Gets the second WPID packet (0x55) and checks if the packet received correctly
   a. If correct, sends ACK, stores the WPID for later process, and goes to step 4;
   b. Replies NAK if CRC is not correct, then waits for RX to re-sends this packet (0x55); TX should accumulate the retry counter; if the counter is larger than 3, TX should revert to Selection phase.

4. Continues to negotiate other parameters

1. If RX gets ACK from TX, enters Negotiation phase; otherwise goes to Power Transfer phase.

2. RX sends the first WPID packet (0x54)
   a. If TX responds ACK, goes to step 3;
   b. If TX responds ND, goes to step 4;
   c. If TX responds NAK or RX doesn’t receive response, RX should re-send this packet again (0x54).

3. RX sends the second WPID packet (0x55)
   a. If TX responds ACK, goes to step 4 to continue negotiating other parameters;
   b. If response is NAK, re-send this WPID packet (0x55).

4. Continues to negotiate other parameters
What is NFC?

Near Field Communication is a short-range wireless connectivity technology *standard*, designed for *intuitive* and *simple* communication between *two* electronic devices.
Out band Communication using NFC

Receiver
- Rectifier
- NFC

Base Station
- Transmitter
  - HomePlug
  - Ethernet
  - WiFi

To LAN
Data Stream Basic Purpose

• Base stations (Transmitters) play the interface to be able to interface to a wide variety of PHY interfaces
  ▪ Ethernet
  ▪ Zigbee
  ▪ WiFi
  ▪ Blue Tooth
  ▪ NFC
• Enable the data exchange between receivers and cloud system via above PHY interfaces
  ▪ Reporting of usage
  ▪ Policy setting
  ▪ Admission control
• Allow the conditional charging in public installation
• Allow remotely controlling and monitoring status of charging battery in industrial applications, such as surgical tools
Wireless Power Network Architecture

Location A
RX1
TX1
RX2
TX2
RX3
TX3
Base Station Gateway

Location B
RX1
TX1
RX2
TX2
RX3
TX3
Base Station Gateway

Location C
RX1
TX1
RX2
TX2
RX3
TX3
Base Station Gateway

Cloud Service

Wireless Power Device Makers

Wireless Power Service Providers

Parental Control

Wireless Power
Device Makers

Wireless Power
Service Providers

Parental Control

Cloud Service