Freescale **Wireless Charging** Technology

APF-SHB-T1455

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Agenda

- Freescale Wireless Charger Solutions

- An easier way to design

  - FreeMASTER for wireless charger solutions

- New in Freescale Medium Power solutions

Freescale Wireless Charger Solutions

Wireless Charger Transmitter Segmentations 5W & 15W

Standalone

65% -> 20%

Less BOM

Lower Cost

Embedded

20% -> 45%

High performance

Less BOM

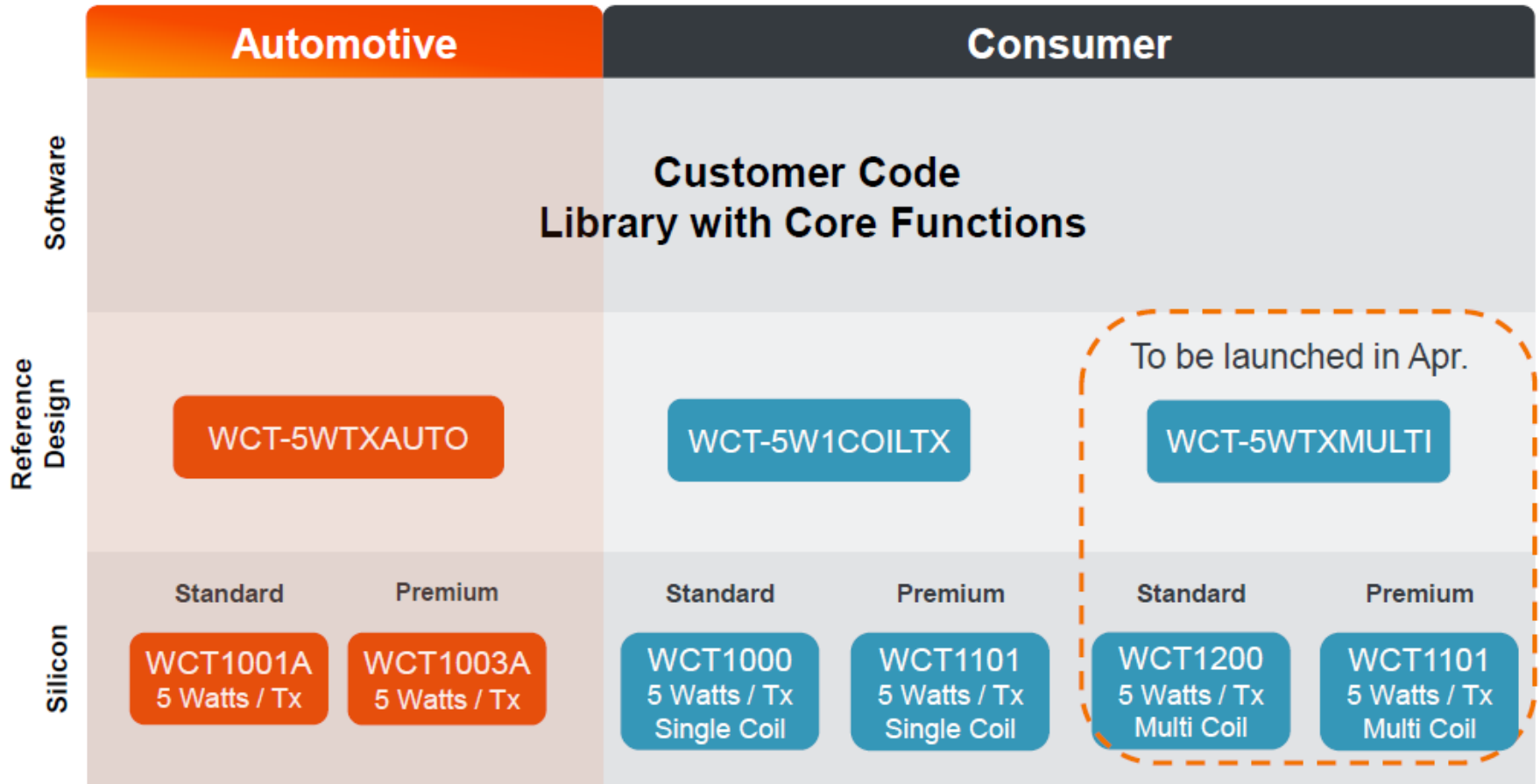## Model/Furniture
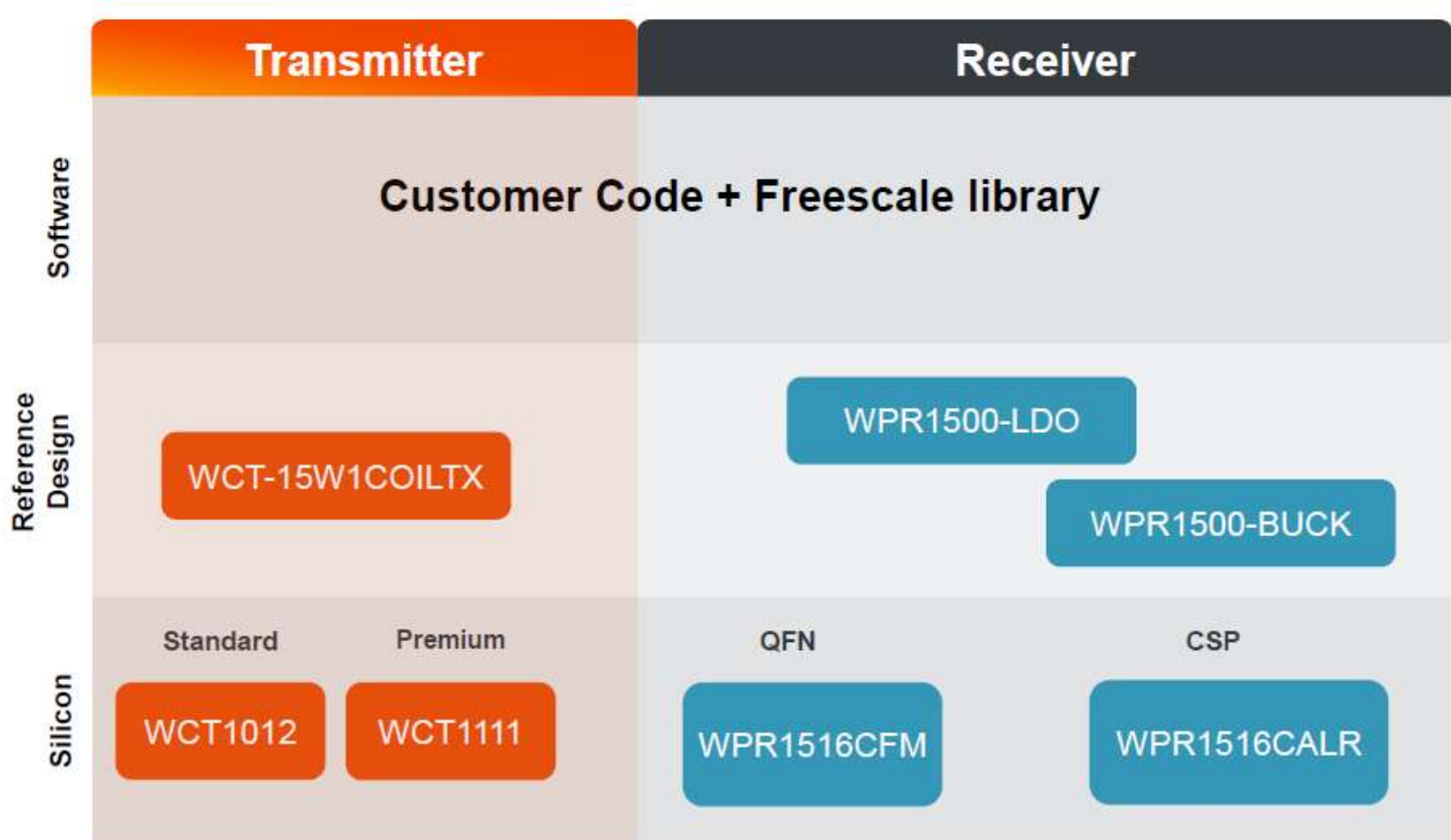
15% -> 35%

Design Flexibility

Lower Cost

"Wi-Fi for data & Wireless Charger for Power"

- 5W A11 / A13 / A28 from Freescale got Qi certification.
- 15W Tx which can be backward compatible to 5W will be the market requirement.
- WCT1000 can support all single coil type within WPC
- Reserved Multi-standard protocol capability like PMA

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Freescale Wireless Charging 5 Watt Tx Portfolio

	Automotive		Consumer			
Software			Customer Code Library with Core Functions			
Reference Design	WCT-5WTXAUTO		WCT-5W1COILTX		To be launched in Apr. WCT-5WTXMULTI	
Silicon	Standard WCT1001A 5 Watts / Tx	Premium WCT1003A 5 Watts / Tx	Standard WCT1000 5 Watts / Tx Single Coil	Premium WCT1101 5 Watts / Tx Single Coil	Standard WCT1200 5 Watts / Tx Multi Coil	Premium WCT1101 5 Watts / Tx Multi Coil

Freescale Wireless Charging 15 Watt Tx/Rx Portfolio

How to Choose

Part Number	Classification	Available Features for Now!	Remark
MWCT1000	Standard	WPC A11	5V single coil
MWCT1200	Standard	WPC A28	5V 3-coil
MWCT1101	Premium	WPC A11 WPC A11 + PMA WPC A11 + additional features WPC A28 WPC A28 + PMA WPC A28 + additional features	5V single coil 5V 3-coil
MWCT1001A *(AEC-Q100)*	Standard	WPC A13 + PMA	12V multi-coil
MWCT1003A *(AEC-Q100)*	Premium	WPC A13 + PMA + additional features (ex. NFC stack)	12V multi-coil
MWCT1012	Standard	WPC Medium Power Single coil	12V single-coil
MWCT1212	Standard	WPC Medium Power multiple coils	12V multi-coil
MWCT1111	Premium	WPC Medium Power Single coil WPC Medium Power multiple coils WPC Medium Power Single coil + additional features WPC Medium Power multiple coils + additional features	12V single-coil 12V multi-coil

| MWCT	Generation	Coil Config: 0 = Single 2 = Multi 1 = Premium	Power Class 0 = 5W 1 = MP	Memory 0 = 32 KB 1 = 64 KB 2 = 48 KB 3 = 256 KB	A: Auto Non: consumer

How to Implement

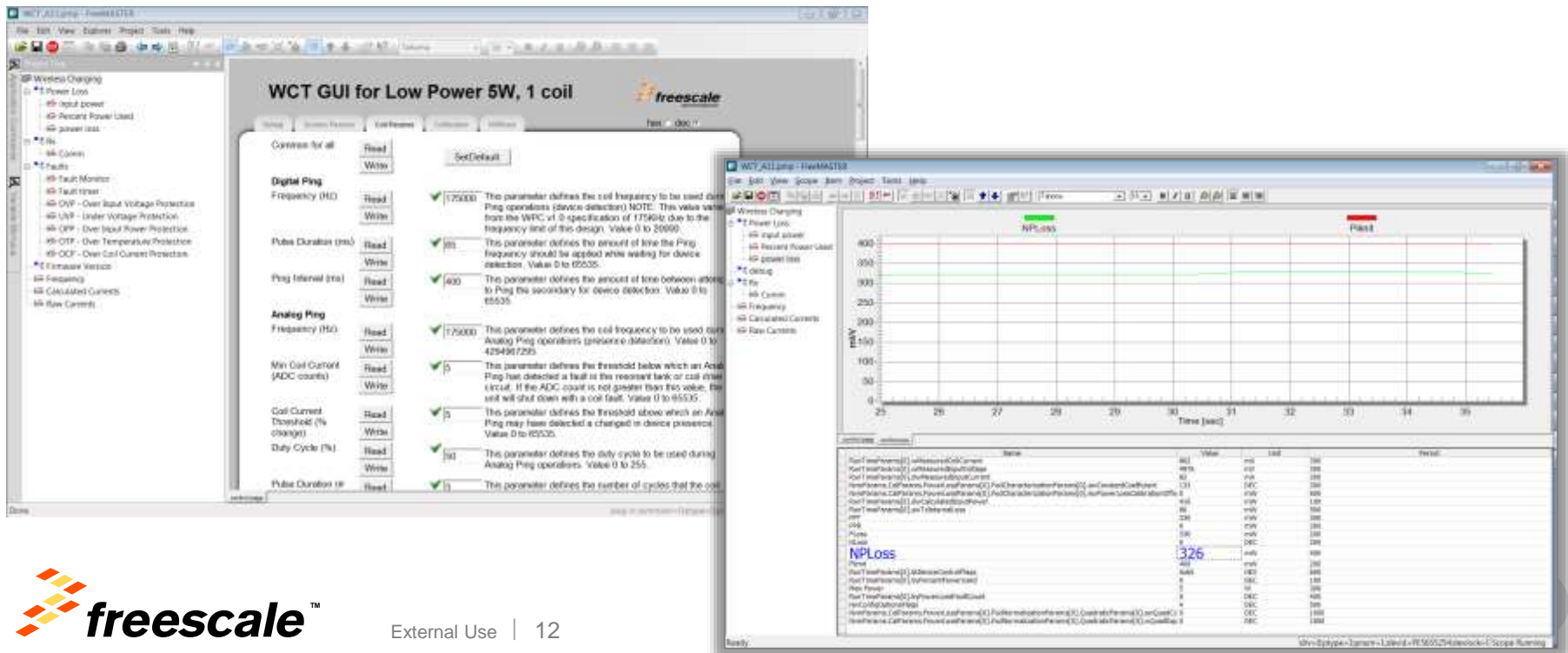|	Development / Verification	Production
Basic *Ready-to-Use*	**Freescale Reference Design** •Schematic, gerber, firmware package & application notes	**FreeMASTER** •PCBA Calibration •Function test **P&E Programmer**
Medium *(more than basic)*	**FreeMASTER** •Design, verification, tuning	
Superior *(more than medium)*	**Codewarrior / IAR / KEIL** •Add additional application code (with Freescale APIs) •Hardware interface configuration **Quick-start** Hardware interface configuration GUI tool	

FreeMASTER for Wireless Charging
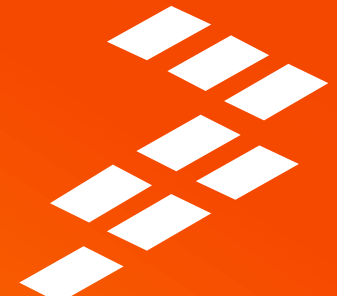
Developing Environment
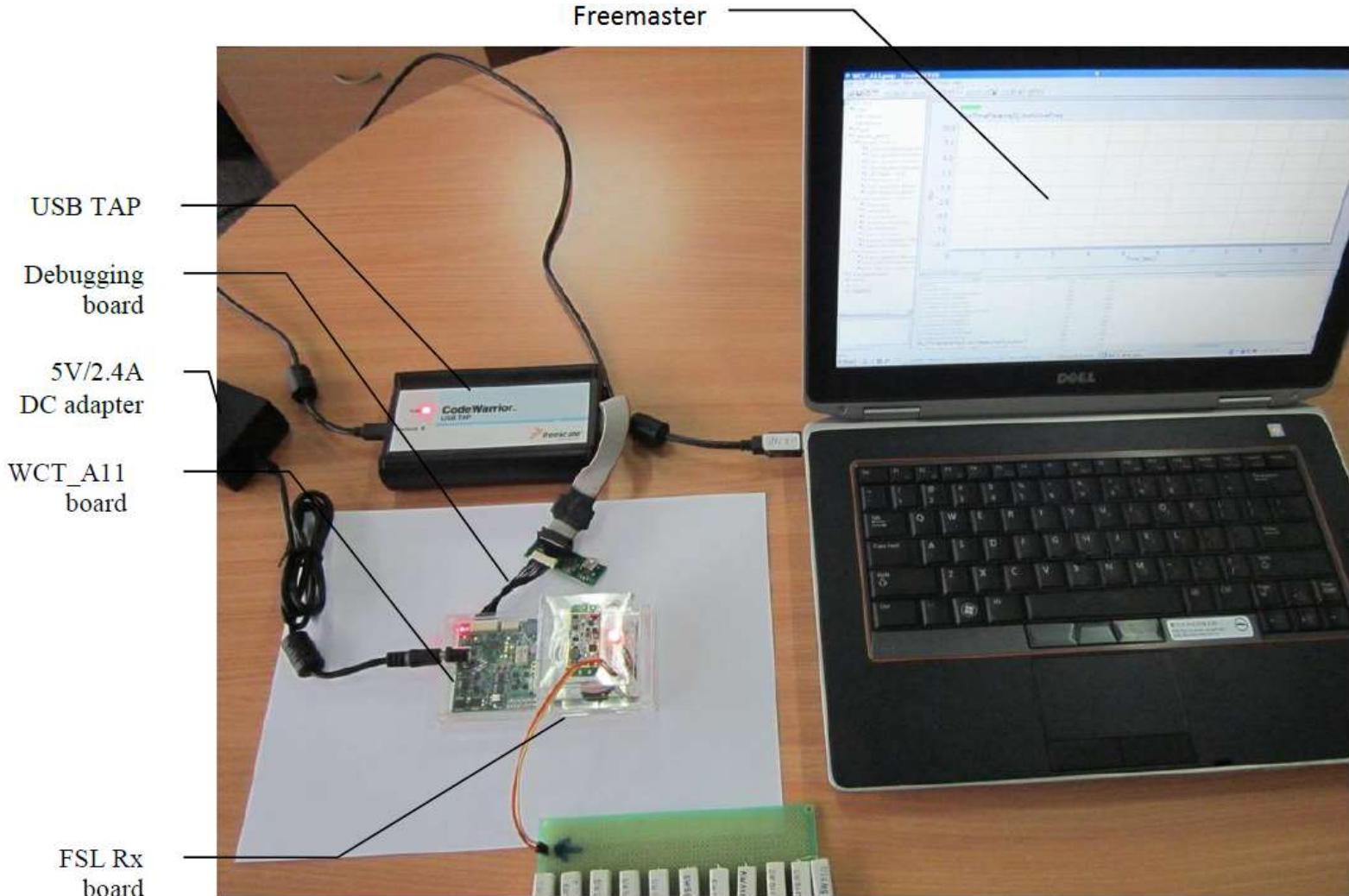
FreeMASTER for Wireless Charging

- FreeMASTER GUI is a real-time monitoring and user-friendly control tool for application development
  - **Monitoring:** real-time application variables monitoring
  - **Configuration**: view and change the application parameters
 - **Debug**: functions software simulation, calibrate the coefficients for analog signals sensing and FOD

New in WPC Medium Power

Difference to Low Power Tx

	LP TX	MP TX
Maximum Power	5W	15W
Communication	One-way (RX→TX)	Two-way (RX←→TX)
Negotiation	None	TX and RX negotiate to establish a more advanced power Xfer contract
Power Xfer Control Method	-Full bridge phase control -Full bridge frequency control	-Half bridge frequency control -Half bridge duty cycle control -Full bridge phase control -Full bridge frequency control

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System Overview
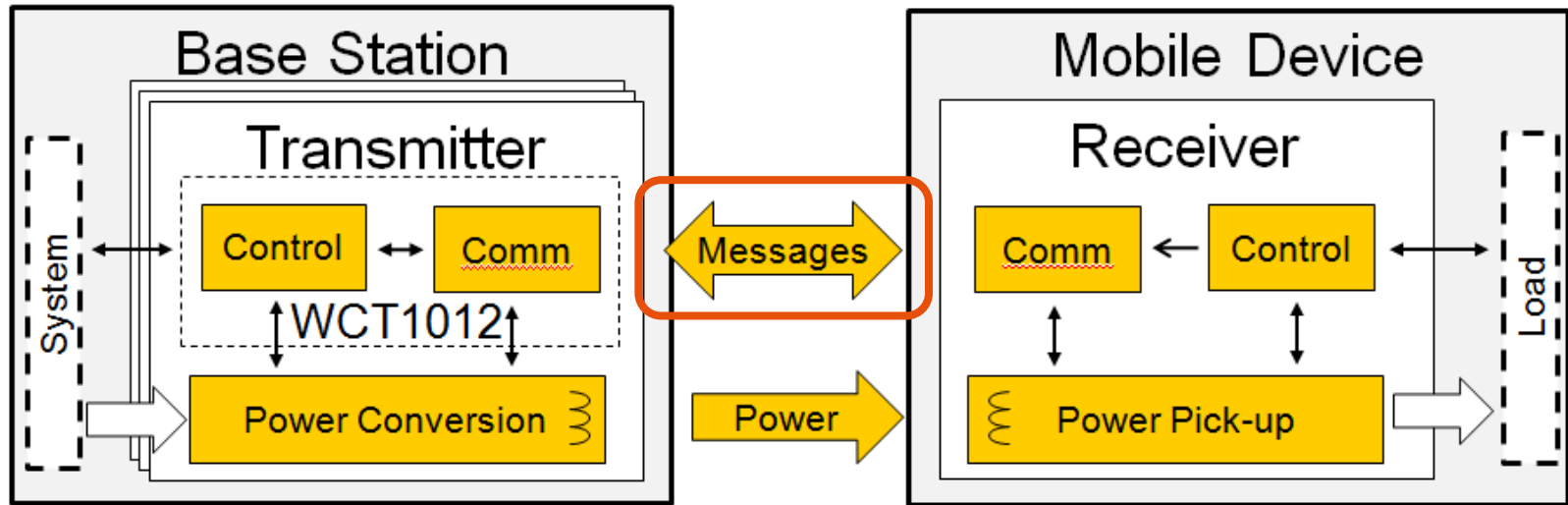
Transmitter(TX):
1) Receive control information from the receiver
2) Send negotiation information to the receiver
3) Adjust the desired operation point to meet the need of the receiver

Receiver(RX) :
1) Send messages to provide control information to the transmitter
2) Receive messages from TX
3) Control the power to the output load

State Machine

❖ *Start*

Transmitter provides signal and senses for presence of an object

❖ *Ping*

Receiver indicates its presence

❖ *Identification & Configuration*
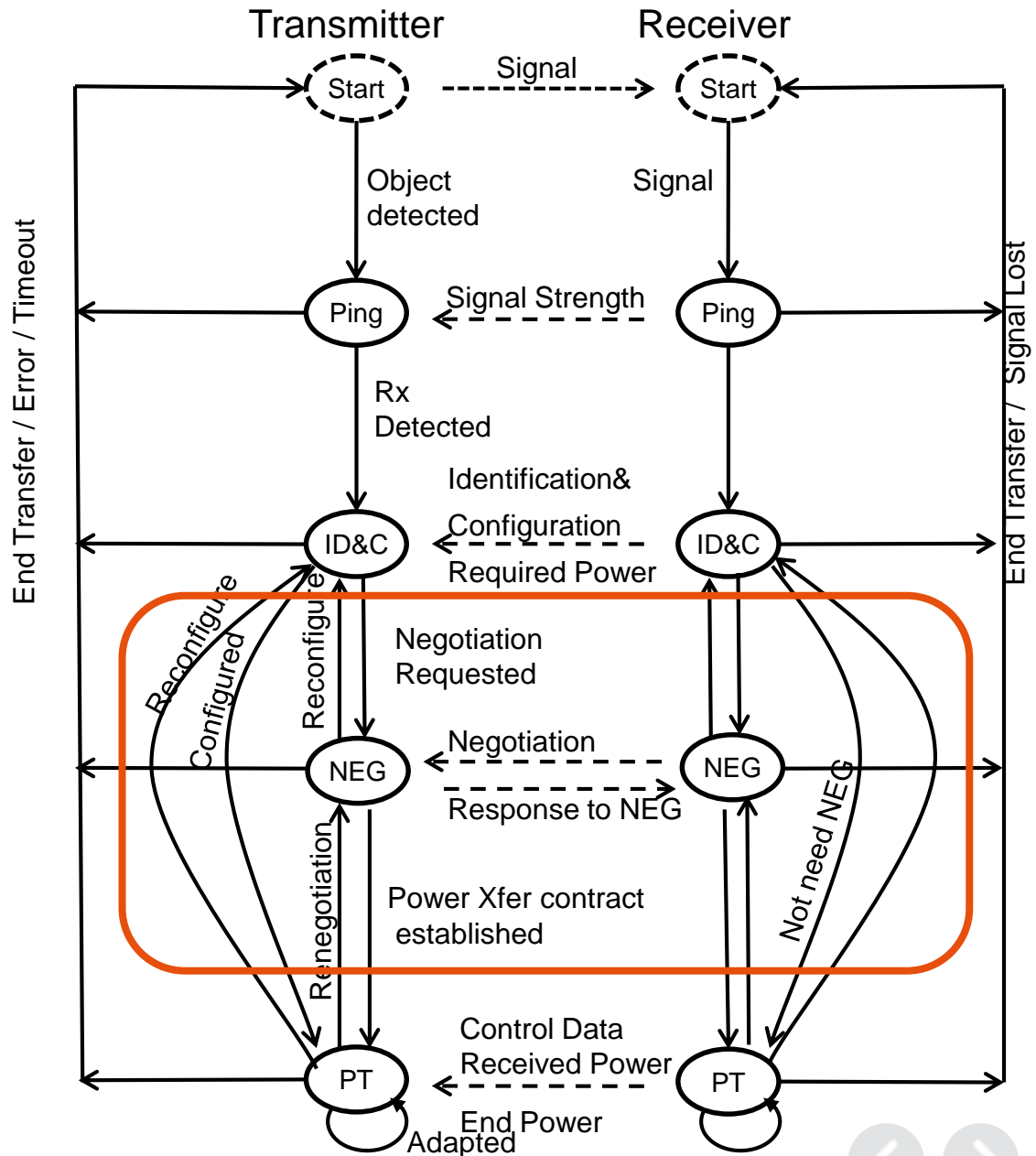
Receiver provides configuration information

❖ *Negotiation*

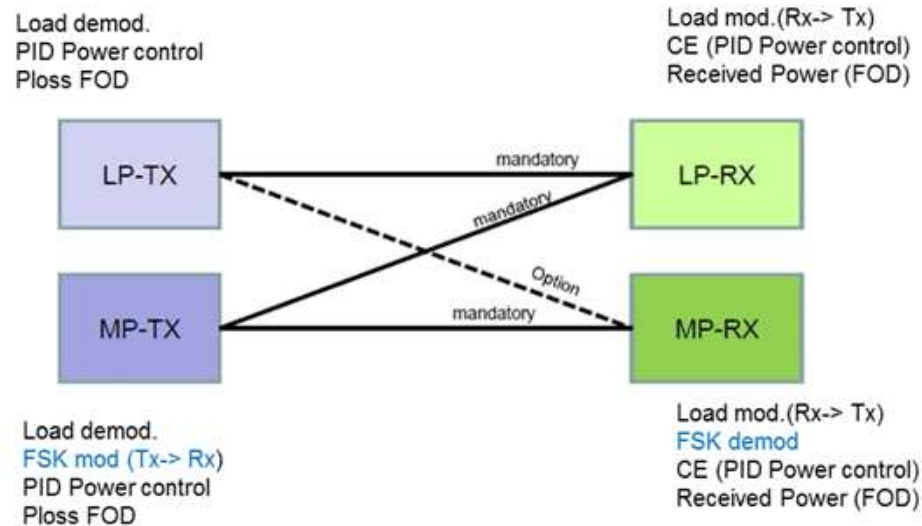Transmitter and Receiver negotiate to establish power transfer contract

❖ *Power Transfer*

Receiver output power and Transmitter adapts

Control types

MP Compatibility with LP

Load demod.
PID Power control
Ploss FOD

Load mod.(Rx-> Tx)
CE (PID Power control)
Received Power (FOD)

Load demod.
FSK mod (Tx-> Rx)
PID Power control
Ploss FOD

Load mod.(Rx-> Tx)
FSK demod
CE (PID Power control)
Received Power (FOD)

| Type	Input voltage(V)	Topology	Coils	Resonant L	Resonant Cap	Operating Frequency	Ping Parameter	Mark
MP-A1	19V	Half/Full Bridge	1	24uH	100nF	110K~205KHz	175K	
MP-A2	12V	Half/Full Bridge	1	10uH	247nF	110K~140KHz	140K	
MP-A3	2.5~11.5V	Full Bridge	1	10.1uH	251nF	110K~205KHz	12V,160k~180k	
MP-AX	**12V**	**Half/Full Bridge**	**1**	**8.9uH**	**276nF**	**110K~205KHz**	**175K**	**Freescale**

Communication Rx -> Tx

- ASK(Amplitude Shift Keying)

- Speed: 2 kbps

- 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)

  - Checksum (1 Byte)
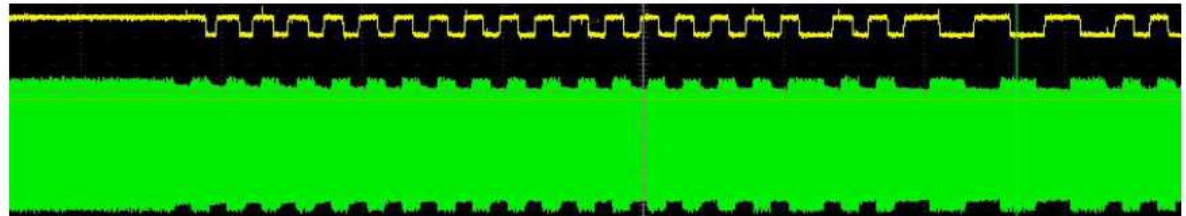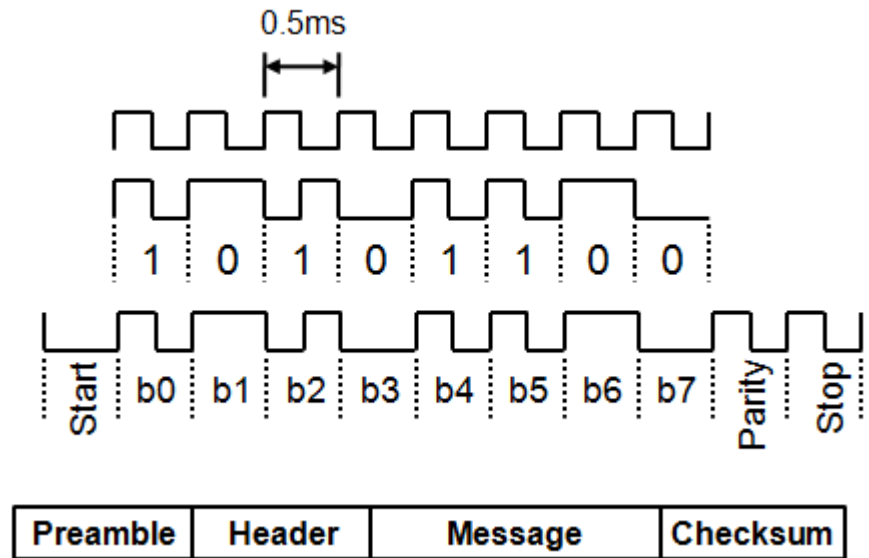
Communication Tx -> Rx

- Frequency Shift Keying (FSK)
- Speed: fop/512
- Bit-encoding: bi-phase
- Byte-encoding:
  - Patten message : 8 bits
  - Normal message: Start-bit, 8-bit data, parity-bit, stop-bit
- Packet structure
  - Header (1 Byte) : Indicates packet type and message length
  - Message (1 .. 27 Byte): identification and configuration information
  - Checksum (1 Byte)
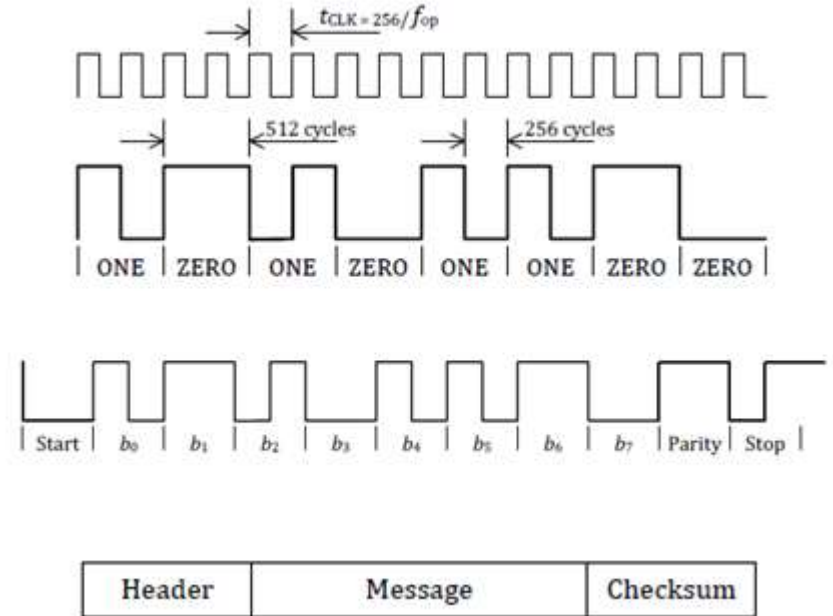
Full Qi Starting Wave (Example)

| No	Phase	Action
1	Ping	Rx -> Tx Signal Strength
2	IDE & Config	Rx -> Tx Identification Packet
3	IDE & Config	Rx -> Tx Configuration Packet
4	Negotiation	Tx -> Rx Ack Pattern
5	Negotiation	Rx -> Tx Require IDE data
6	Negotiation	Tx -> Rx Reply IDE data
7	Negotiation	Rx -> Tx Require CNFG data
8	Negotiation	Tx -> Rx Reply CNFG data
9	Negotiation	Rx -> Tx Required Guaranteed power
10	Negotiation	Tx -> Rx ACK Pattern
11	Negotiation	Rx -> Tx Require End Negotiation
12	Negotiation	Tx -> Rx ACK Pattern
13	Power Transfer	Rx -> Tx Control Error Packet
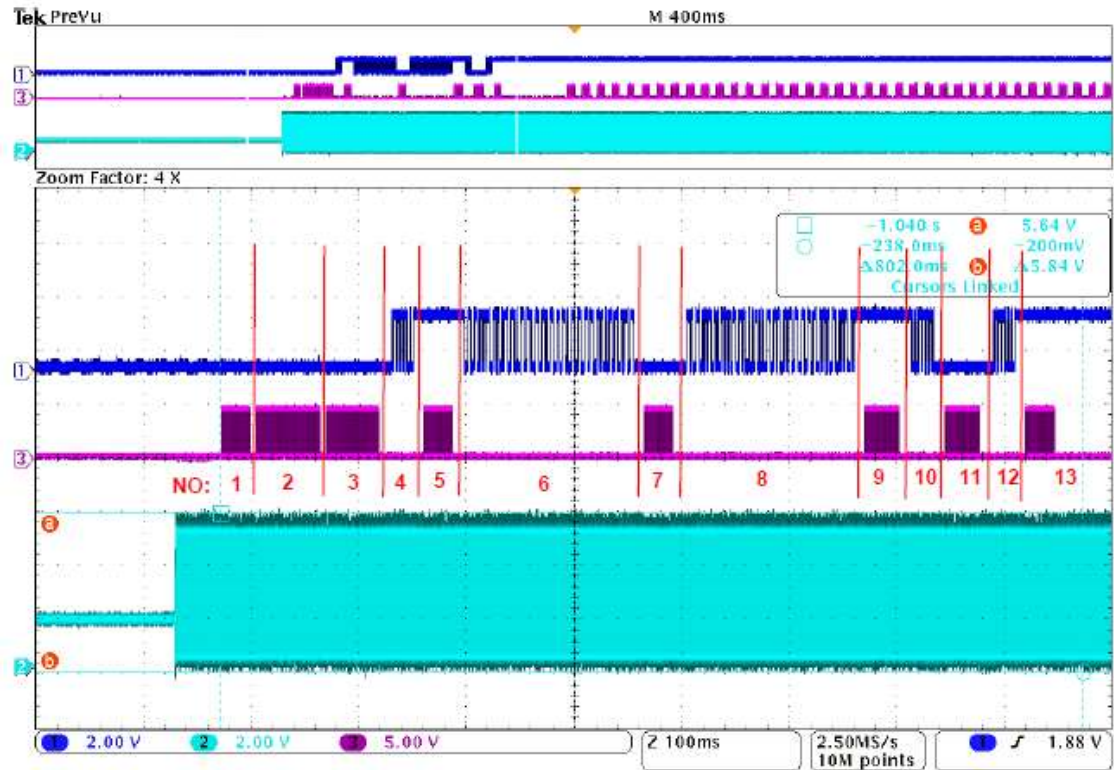
CH1: Tx -> Rx FSK Data
CH2: Rx -> Tx ASK Data
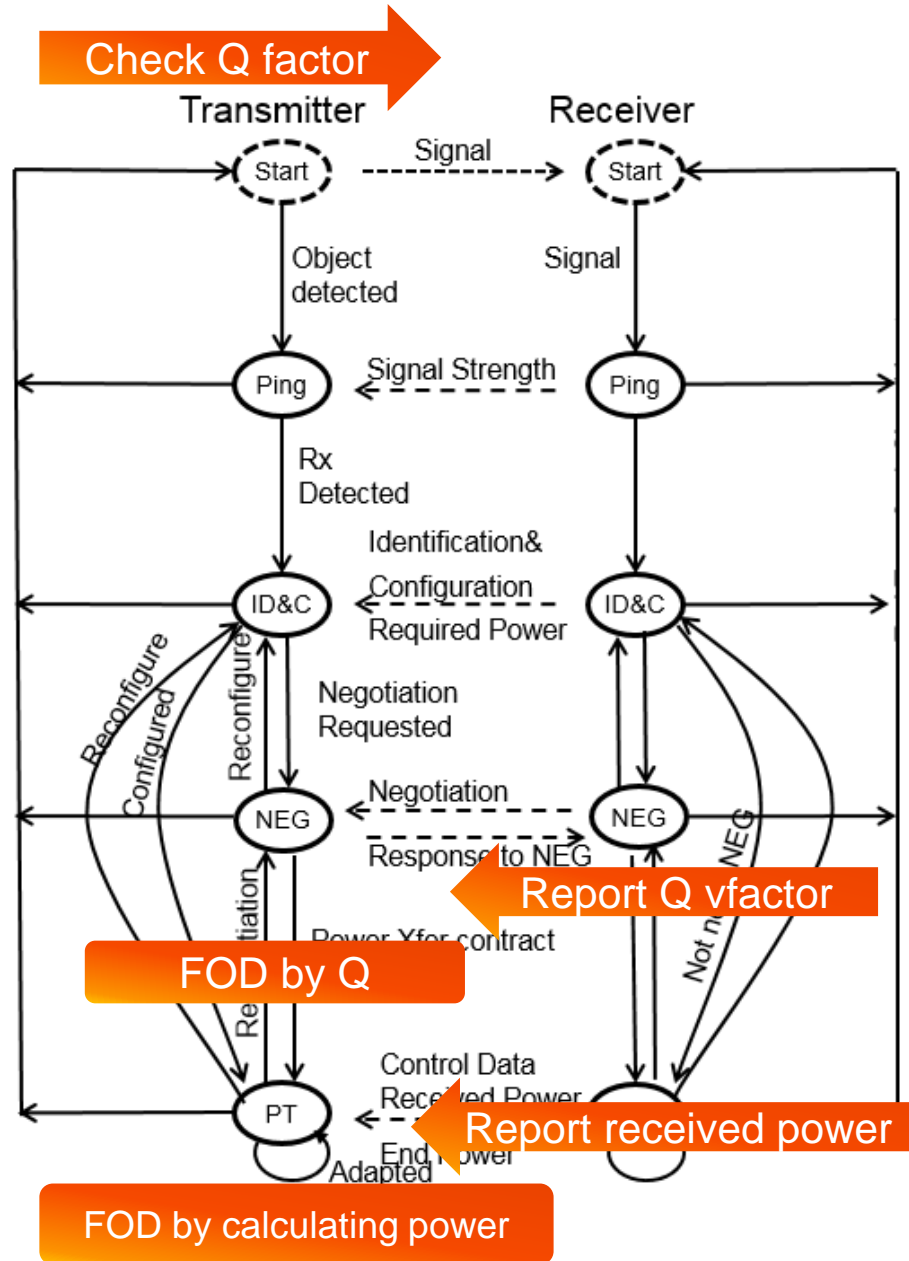CH3: ASK wave after demodulation circuit

FOD

- Pre-powerXfer FOD
  - Q factor detecting(not implemented yet)
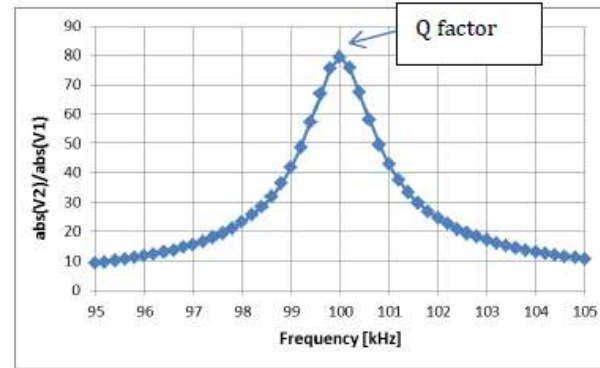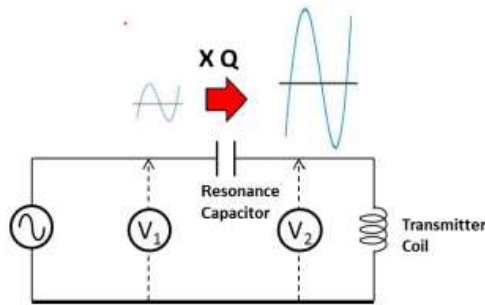
$$Q \overset{\text{def}}{=} 2\pi \times \frac{\text{Energy Stored}}{\text{Energy dissipated per cycle}} = 2\pi f_r \times \frac{\text{Energy Stored}}{\text{Power Loss}}.$$

- FOD during power Xfer
  - Auto calibration to improve on the accuracy of the power loss
 - Power loss calculation
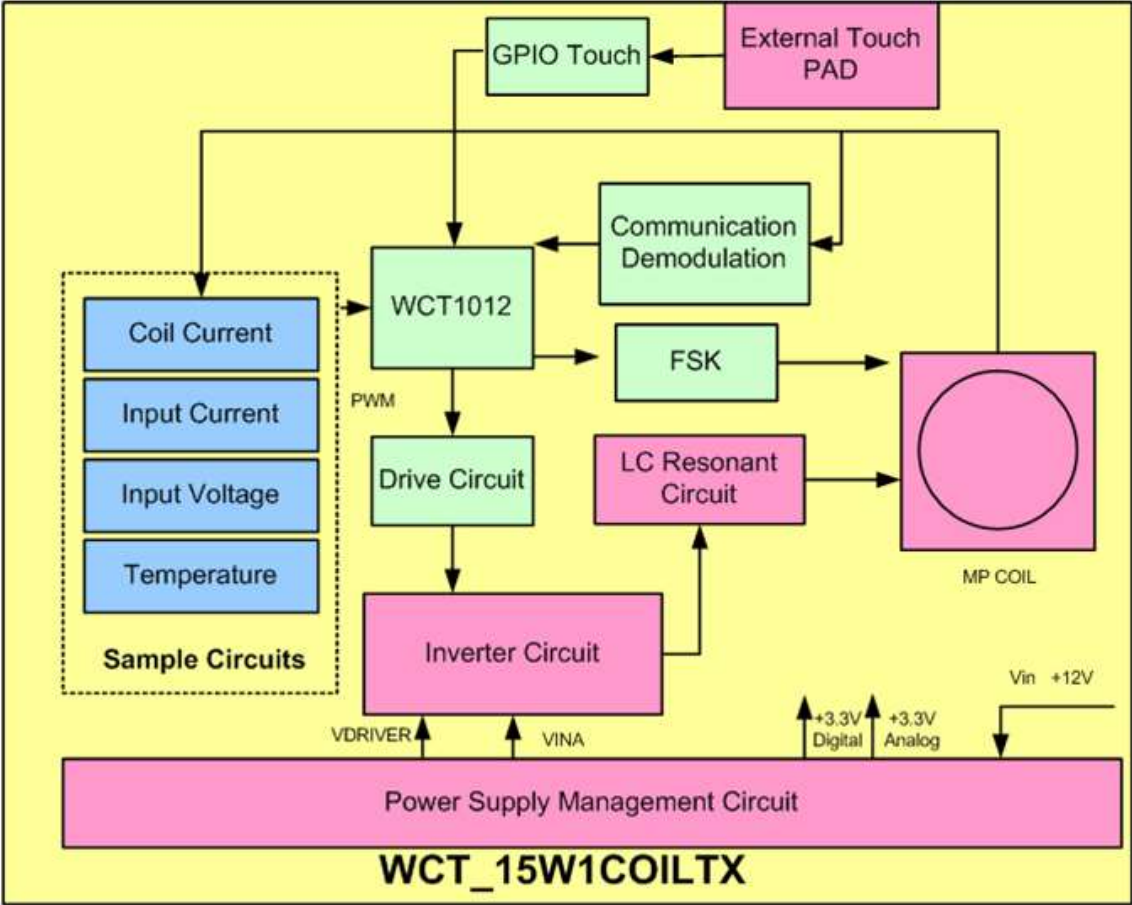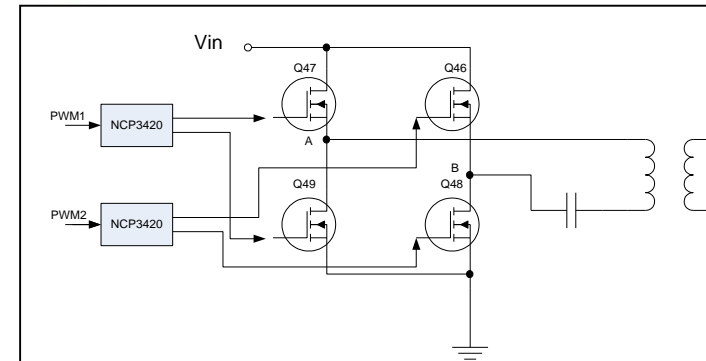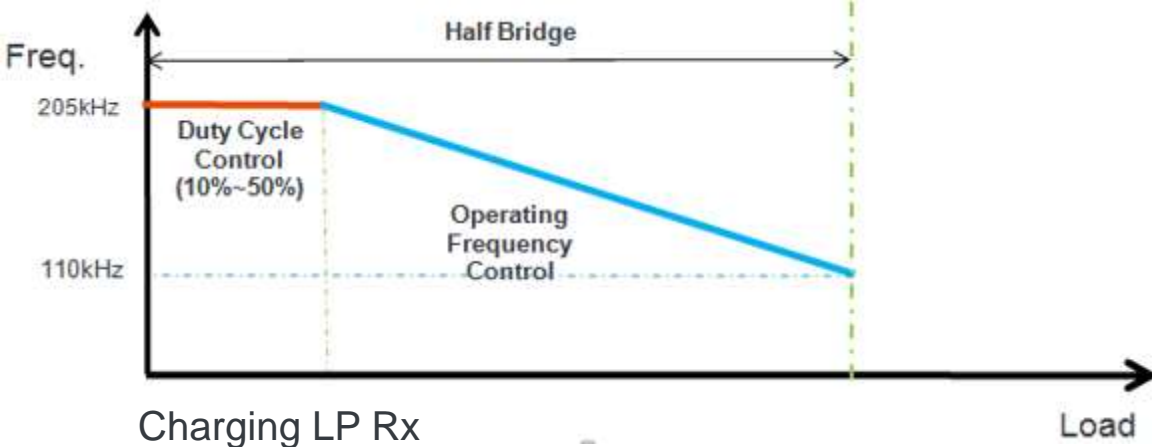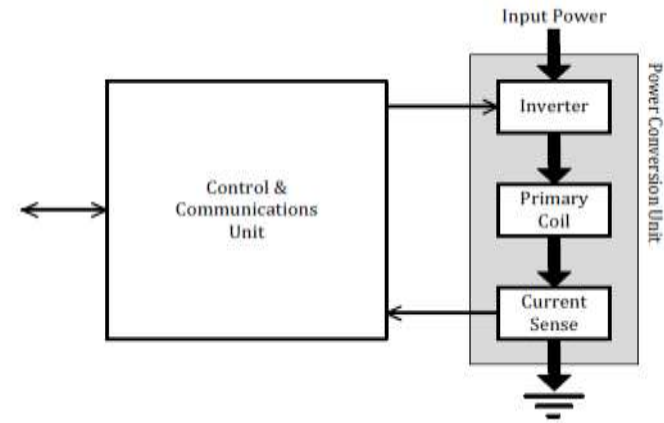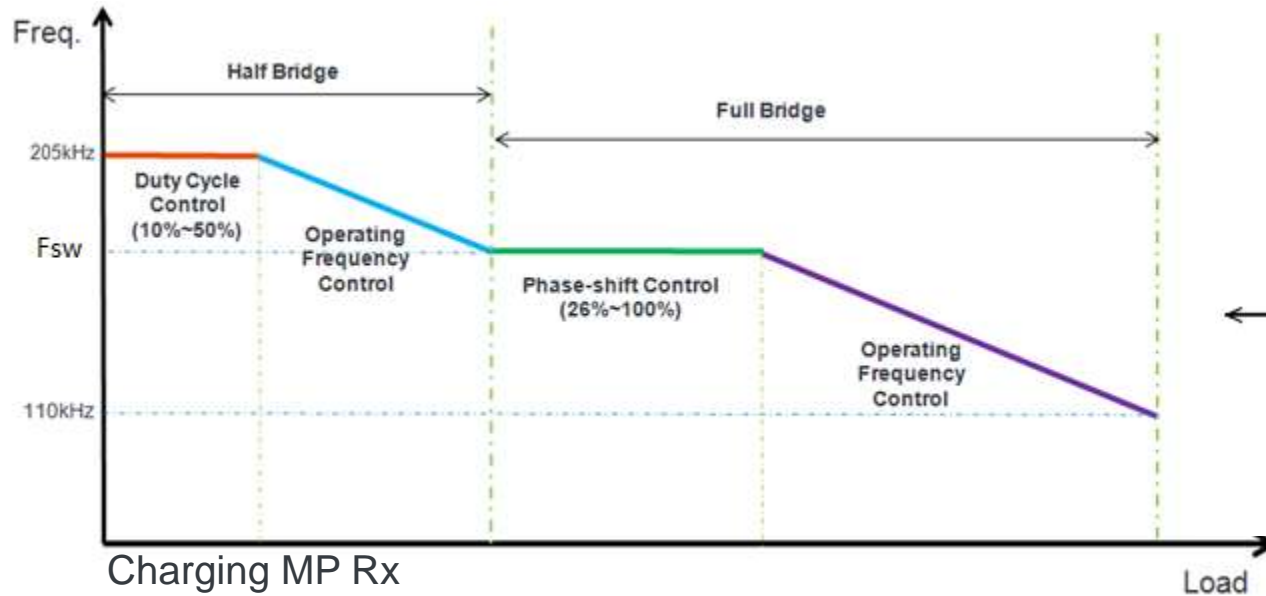
FOD in MP

Freescale MP Tx

System Features

- Compliant with WPC low power(5W) specification.
- Compliant with WPC Medium power (15W) specification Qi Medium Power v0.9 specification (Jan 2015)
- Integrated digital demodulation in chip
- Supports multiple types of RX modulation signals (AC capacitor, AC resistor and DC resistor)
- Supports two-way communication
- Supports Qi MP receiver with 5 V DC@3A output power capability
- Supports Qi LP receiver with 5 V DC@1A output power capability
- Super low standby power
- Supports switch between full bridge topology and half-bridge topology
- Supports frequency control, phase shift control and duty control algorithm
- LED for system status indication
- Input voltage, input current, and coil current sensing
- Supports debug console
- FreeMASTER GUI tool to enable customization and calibration
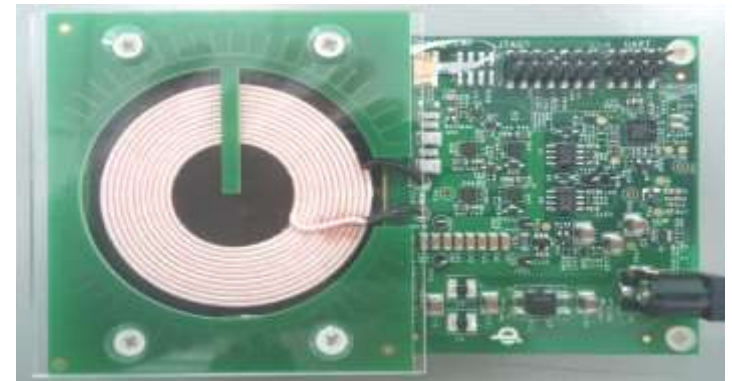
System Block Diagram

Control Algorithm

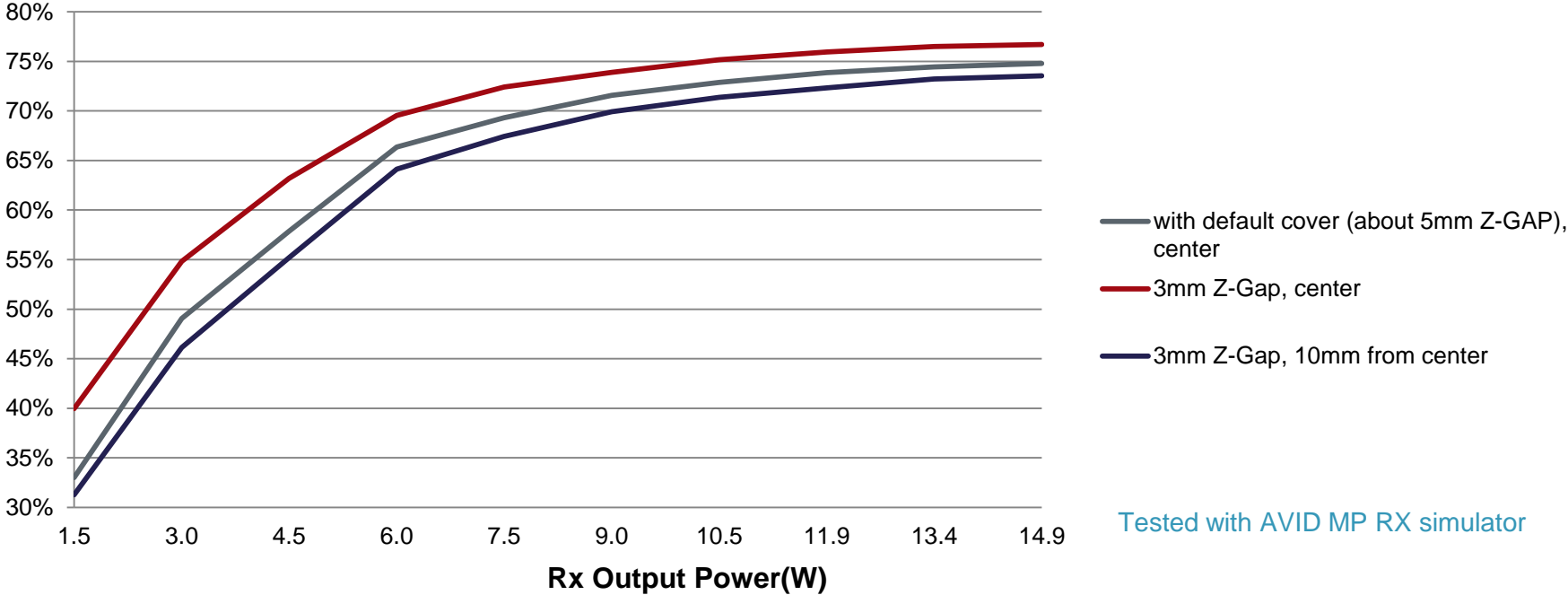Charging MP Rx

Charging LP Rx

Software Structure
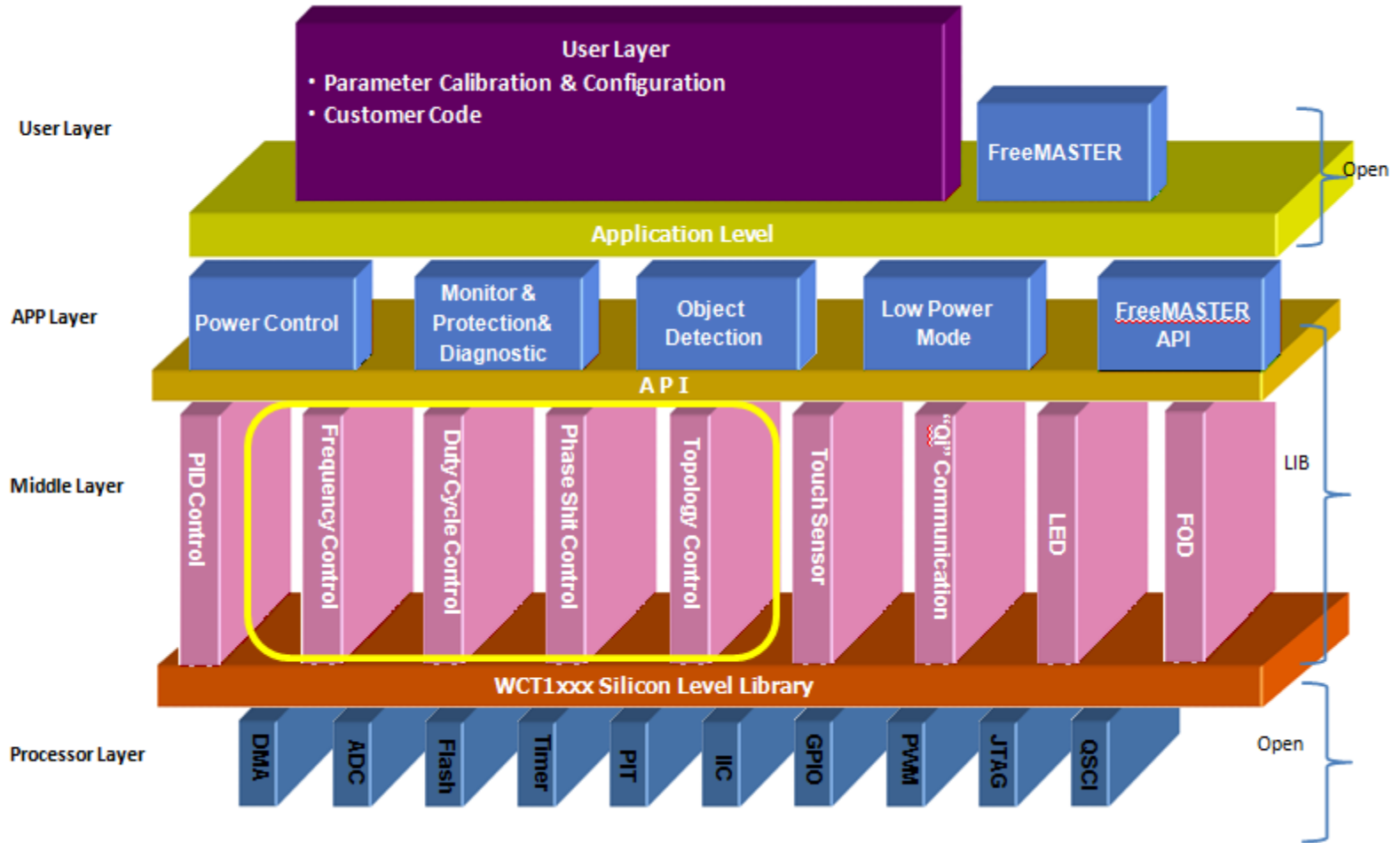
System Efficiency

WCT1012 15W MP V2.0 System Efficiency

Legend:
- with default cover (about 5mm Z-GAP), center
- 3mm Z-Gap, center
- 3mm Z-Gap, 10mm from center

Tested with AVID MP RX simulator

MP TX Controller - WCT1012

WCT1012 Main features:

- **DSC based on 32-bit 56800EX core**
  - Up to 100 MIPS at 100 MHz core frequency in fast mode
  - DSP and MCU functionality in a unified, C-efficient architecture
- **On-chip memory**
  - Up to 64 KB flash memory
  - Up to 8 KB data/program
- **Analog**
  - Two high-speed, 8-channel, 12-bit ADCs with dynamic x1, x2, and x4 programmable amplifier
  - Three analog comparators with integrated 6-bit DAC references
  - Two 12-bit digital-to-analog converter (DAC)
  - One eFlexPWM module with up to 12 PWM outputs, including 8 channels with highresolution NanoEdge placement
  - Timers, Clocks and operating characteristics is designed for Wireless charger application.
- **Package**
  - 32PIN QFN suitable for the compact dimension application.
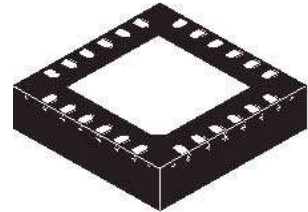
Freescale MP Rx

Freescale Medium Power Receiver Solution

WPR1500-LDO MPRX Wireless Charging Reference Design

WPR1500-BUCK MPRX Wireless Charging Reference Design

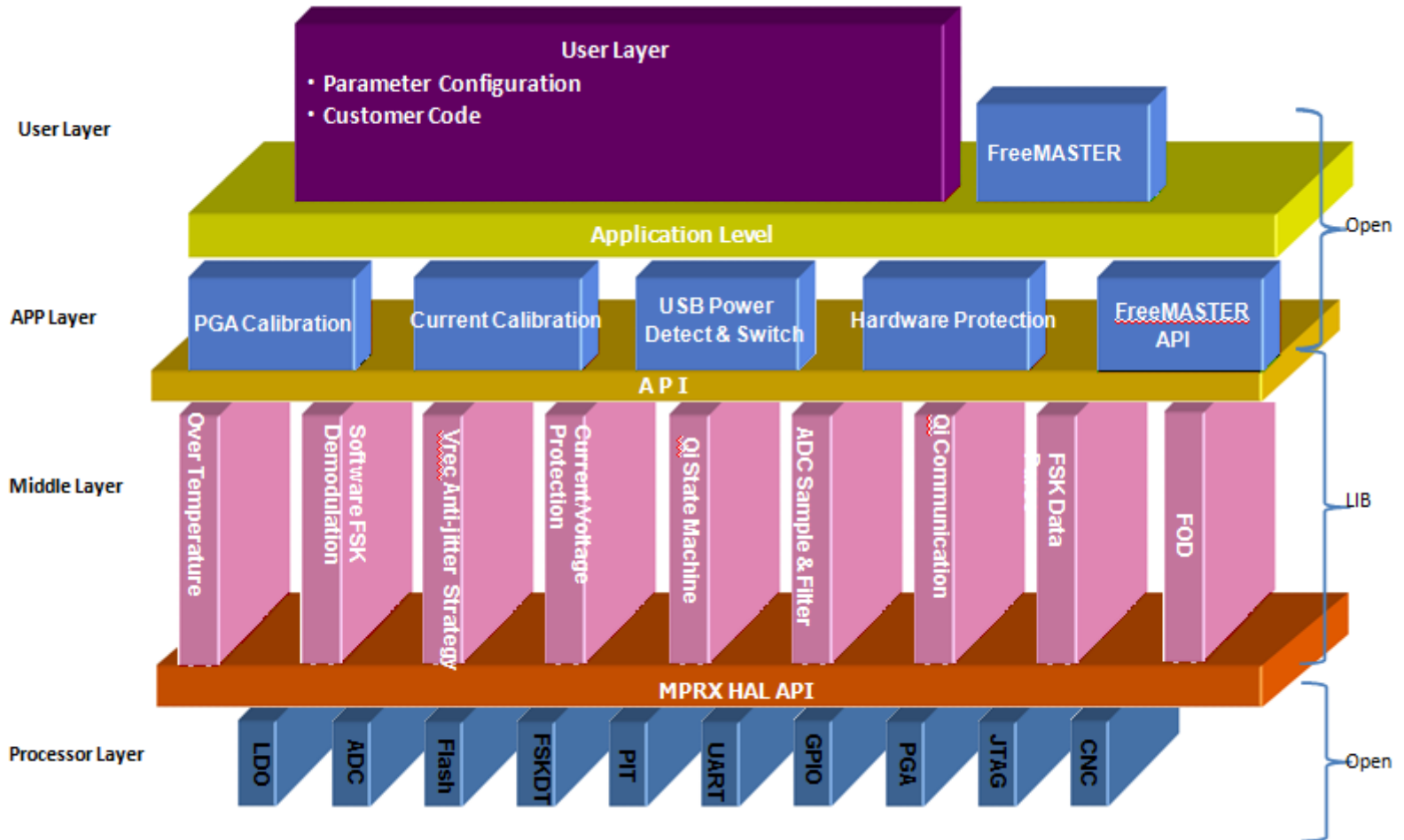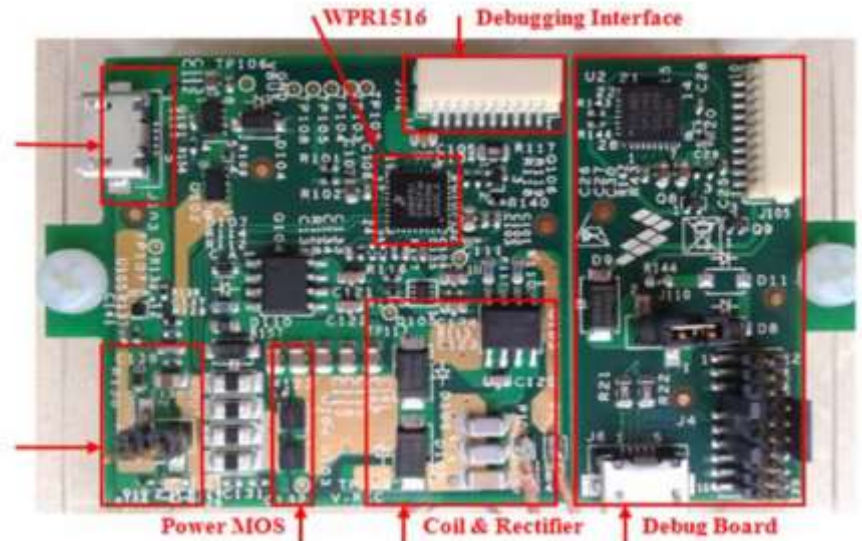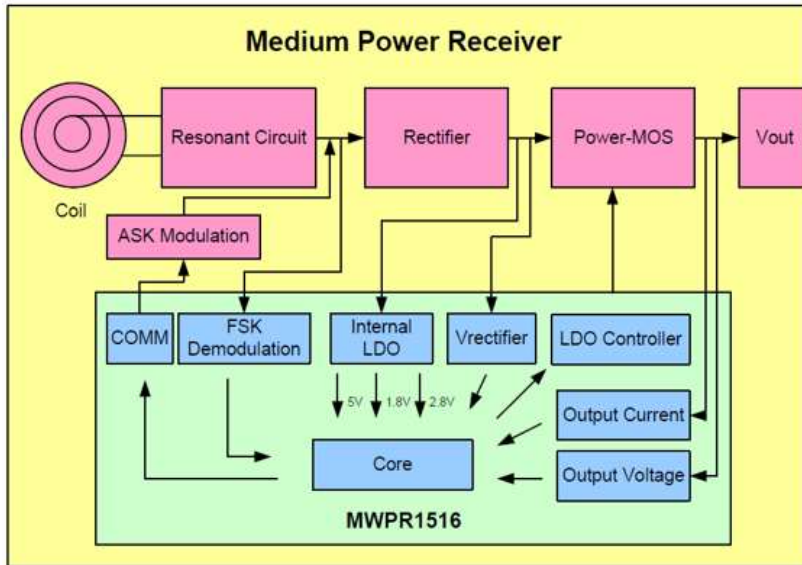| Key Features: |
| --- |
| Compliance with the medium power WPC Qi specification |
| Input power (3.5 V ~ 20 Vac peak) from the transmitter via the receiver coil |
| Output power of 15 W (5 V with LDO type, 5~12.6V with bulk type) |
| Power transfer efficiency exceed 75% |
| Support of FSK communication signals from the medium power transmitter |
| Hardware protection of rectifier voltage, output voltage and output current |
| Small PCB size (40 mm × 40 mm) |
| Open source reference solution with Freescale embedded wireless charger software libraries |
| USB/adapter power switcher to charge products with wire and wireless with priority |
| FreeMASTER tool to enable customization and calibration |

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Software Structure

WPR1500-LDO

Medium Power Receiver
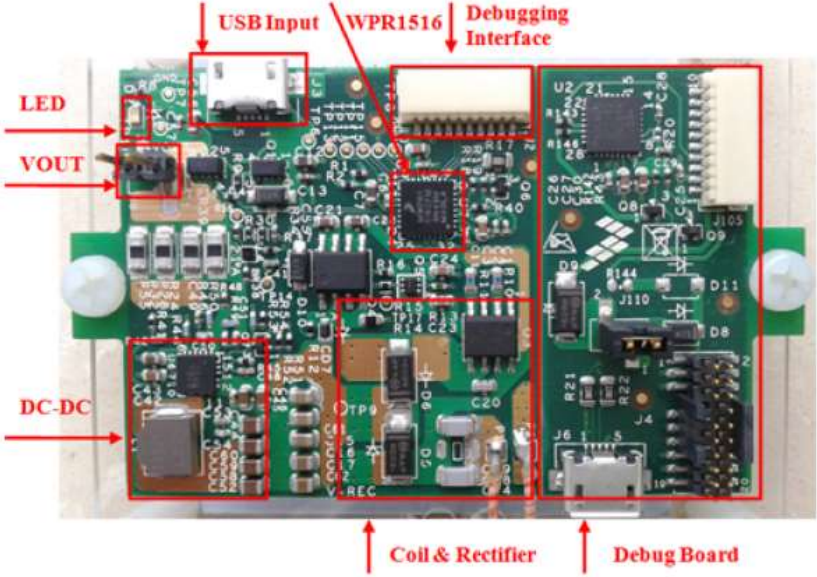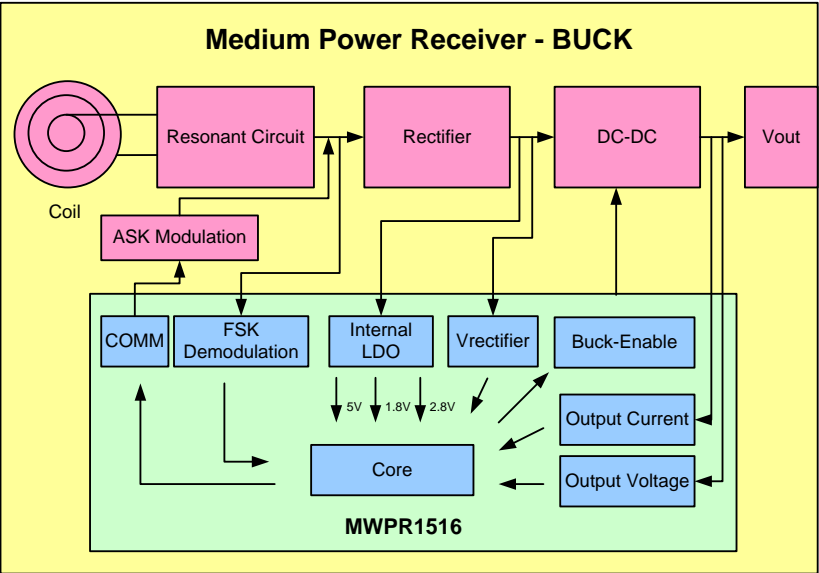

Features:

High integrated LDO with less external components

Extreme low BOM cost

Small PCB size

Doesn't need external DC-DC chip and relative circuits

WPR1500-BUCK

Medium Power Receiver - BUCK

- Coil
- Resonant Circuit
- Rectifier
- DC-DC
- Vout
- ASK Modulation
- COMM
- FSK Demodulation
- Internal LDO
- Vrectifier
- Buck-Enable
- 5V 1.8V 2.8V
- Output Current
- Core
- Output Voltage

MWPR1516

- USB Input
- WPR1516
- Debugging Interface
- LED
- VOUT
- DC-DC
- Coil & Rectifier
- Debug Board

Advantage:

Efficiency performance is better, can reach 75% with FSL MPTX.

Can be easy optimized to working at 12.6V/1.2A, 9V/1.67A

Small current enduring diode and MOS for rectifier

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VREC Control Strategy

- Purpose
  - Improve Power Transfer Efficiency
  - Make the system startup more reliable
  - Make the system more stable

Medium Power LDO VREC Control

Current	VREC	ERROR Limitation
<=50mA	11.5V	60
<=100mA	9V	50
<=200mA	8V	40
<=300mA	6.5V	30
<=300mA	5.9V	25
<=500mA	5.6V	20
>500mA	5.15V	15

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Protection
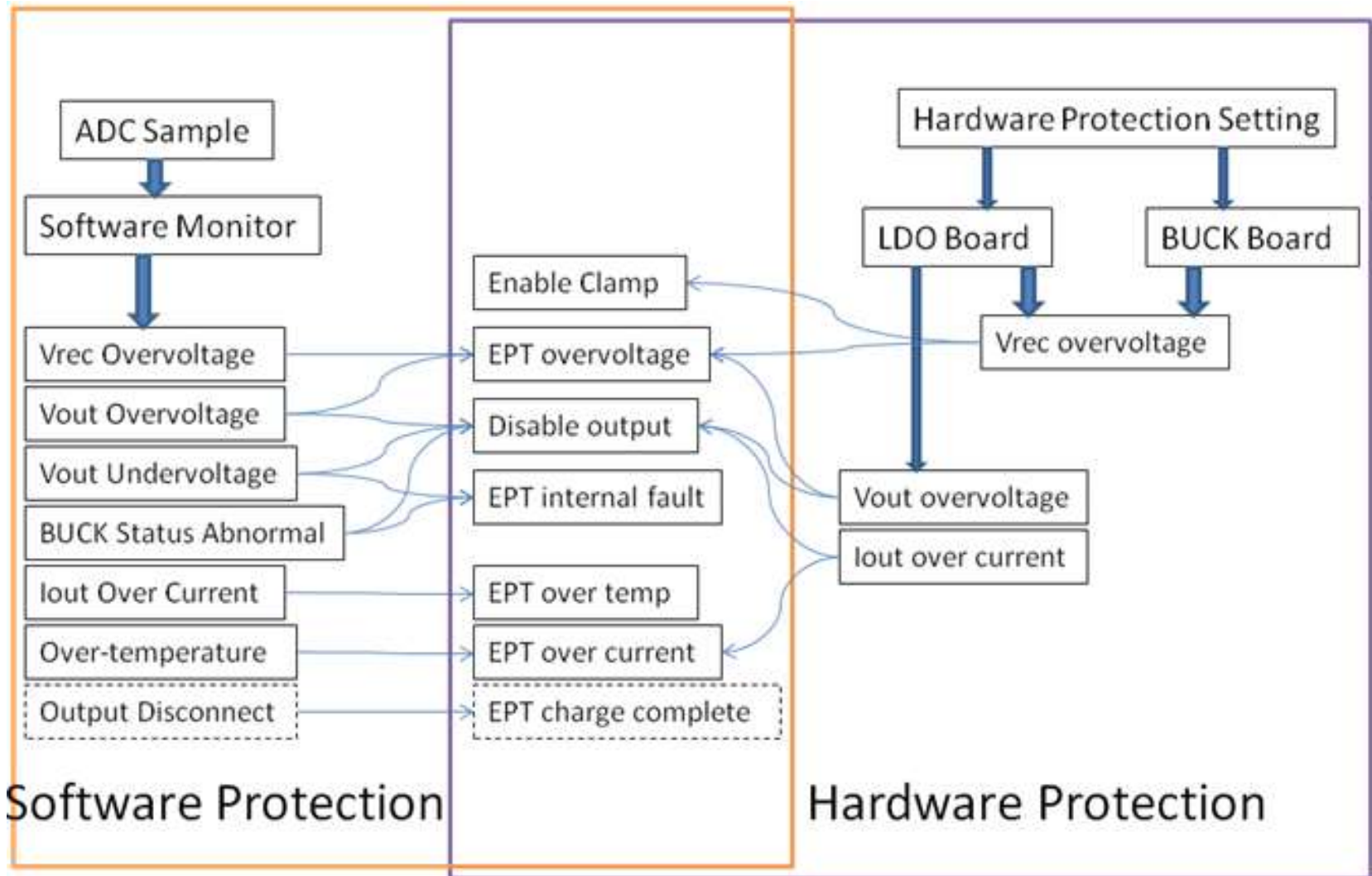
MP RX Controller - WPR1516

24 MHZ Cortex M0+ core , 16KB Flash, 4KBRAM, ASSP with Freescale's UHV technology.

Features:
Flash based ASSP with ARM core provides most popular development ecosystem
Flexibility to support wide DC input voltage of 3.5-20V
Architecture defined based on WPC MPWG Qi specification
Specially designed FSKDT and CNC model ease the MPWG bi-directional communication development
Provide alternative packages to meet either easier manufacturing, or saving PCB space
Easy-to-use debug and configuration tools to speed up product development

Package Offering:

Samples Part Number	Max. Freq.	Pin Count	Package	Size	Ready
PWPR1516CFM	Rx	32	QFN32	5x5x0.65	Now
PWPR1516CAL	Rx	36	WLCSP	3.1x3x0.6	Now

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