

Wireless Power Solution

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SECURE CONNECTIONS
FOR A SMARTER WORLD

Agenda

- Wireless Power Transfer
- Market Update
- NXP Focus
- 5-15W Solutions
- 65W Consumer Solution
- Industrial Solution
- Wireless Powere and NFC
- Wireless Power SW
- WPC Status

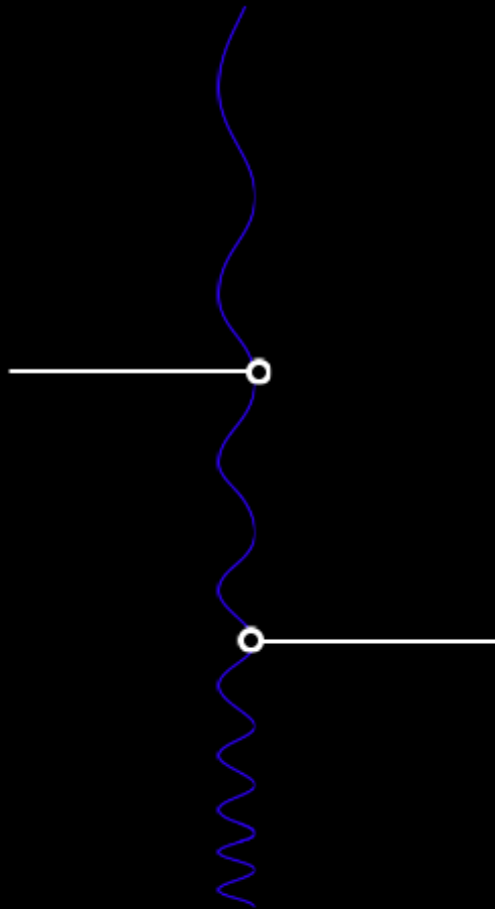
WIRELESS POWER TRANSFER METHODS



IT ALL STARTS WITH
A WAVE OF SOUND



It **VIBRATES**
the air so fast, you
can't hear it or feel it.



uBeam harnesses
energy from the
vibration.

The energy is then converted
into electricity, charging your
device.

ULTRASOUND

Almost 0% efficiency

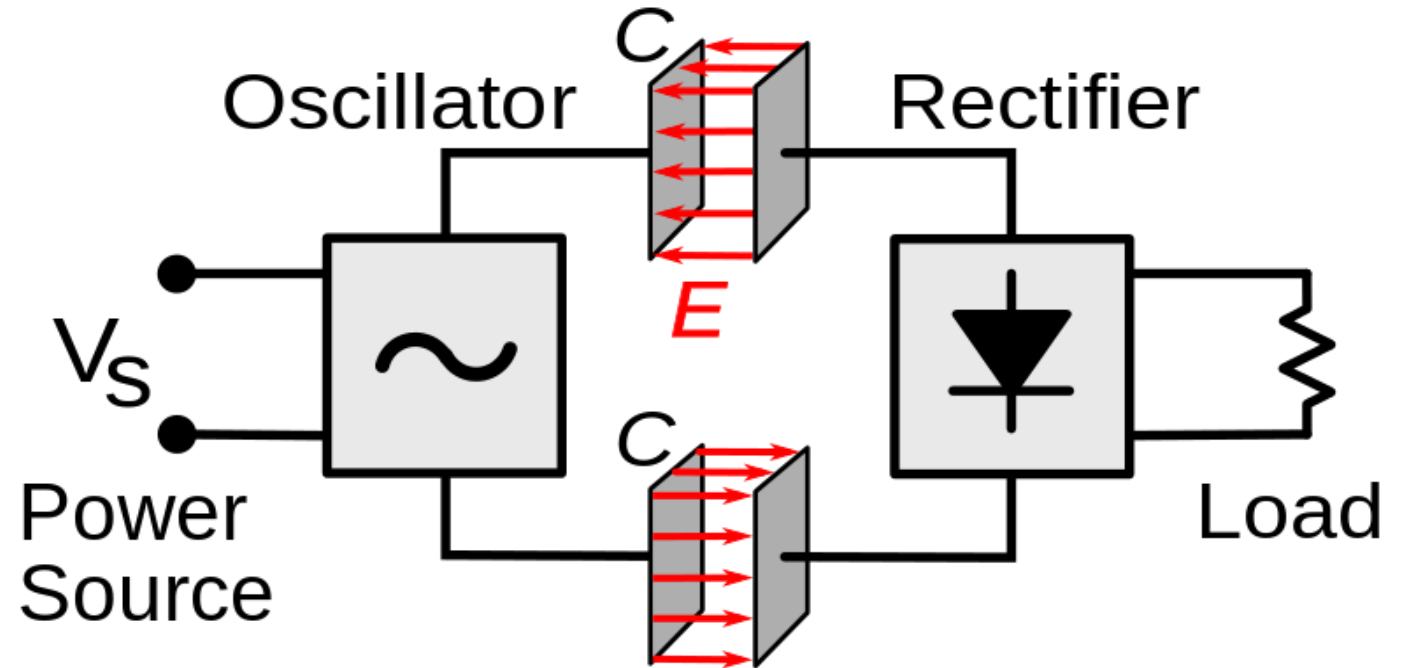
Not usable in real
environment

CAPACITIVE COUPLING

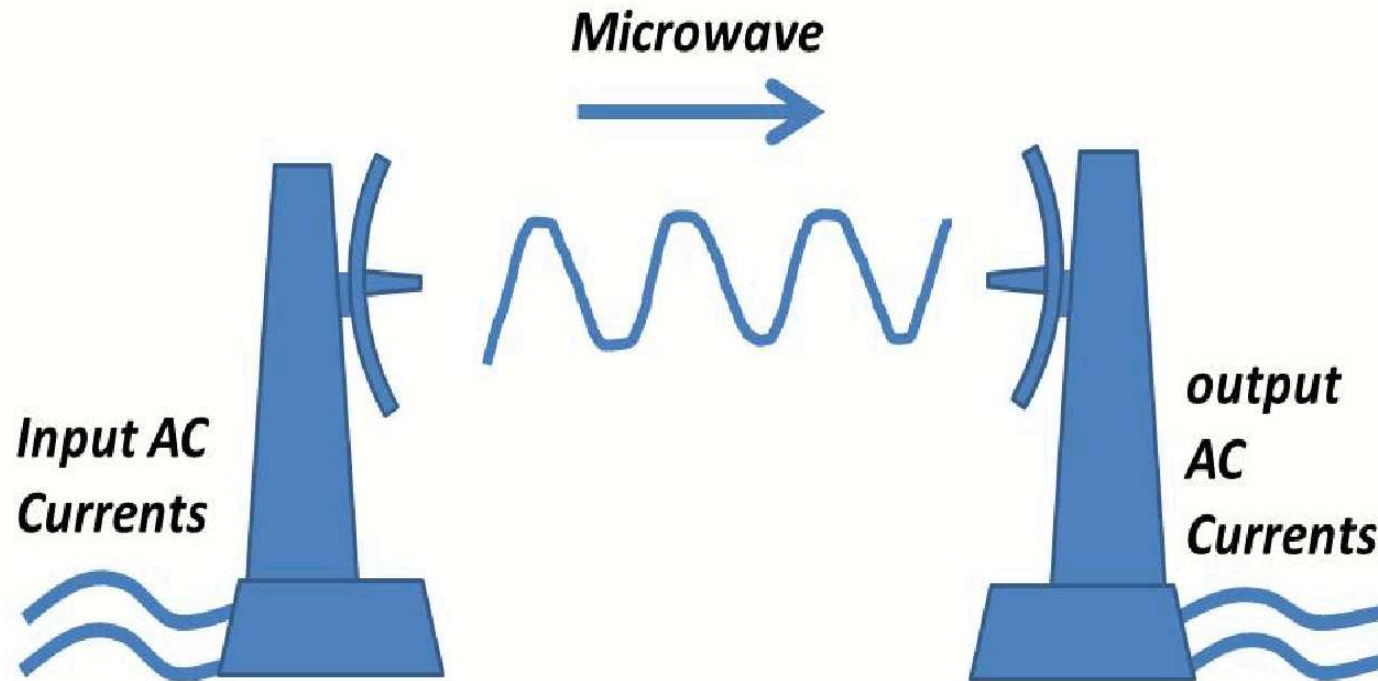
Extremely high voltage needed for 5W power transfer

High voltage transformer doesn't fit to mobile

Not usable in real environment



RF WIRELESS POWER



Long distance

Small efficiency

Dangerous – very strong field for 1W+ devices

Usable for mW power range

Not suitable for auto environment

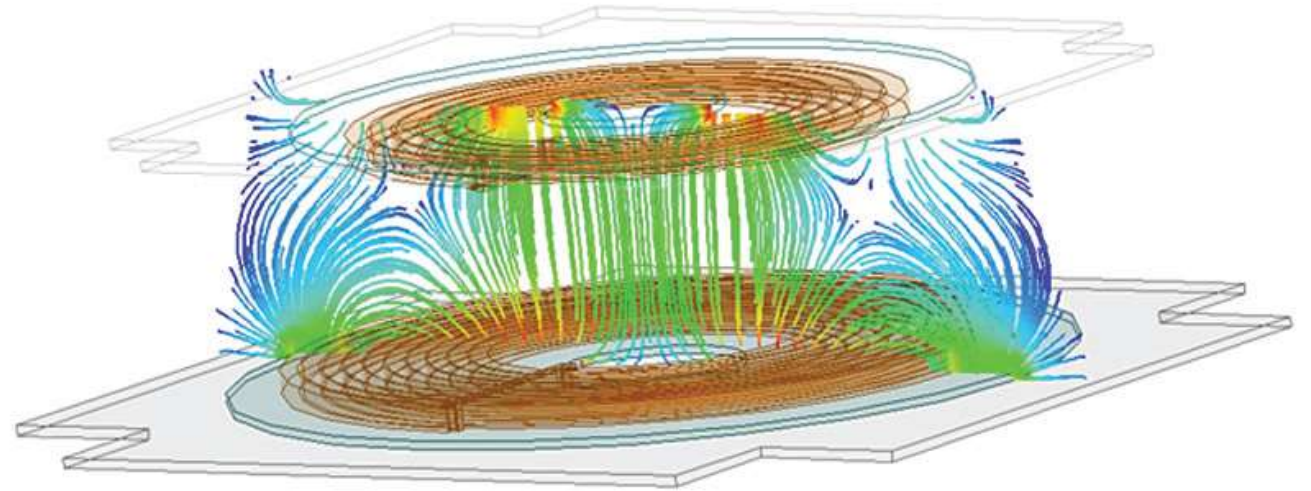
INDUCTIVE COUPLING – WINNER

Safe – closed field between TX and RX

High efficiency 60 – 94%

Big power range 1W – 20kW

Proven all environments
operation



Resonant principle – special case of inductive coupling

Wireless Power Converges on Qi standard



Before 2016

Competing standards stall industry adoption

pma
power matters alliance



2017

Automakers launch Qi based transmitters

Samsung and Apple launch Qi based phones

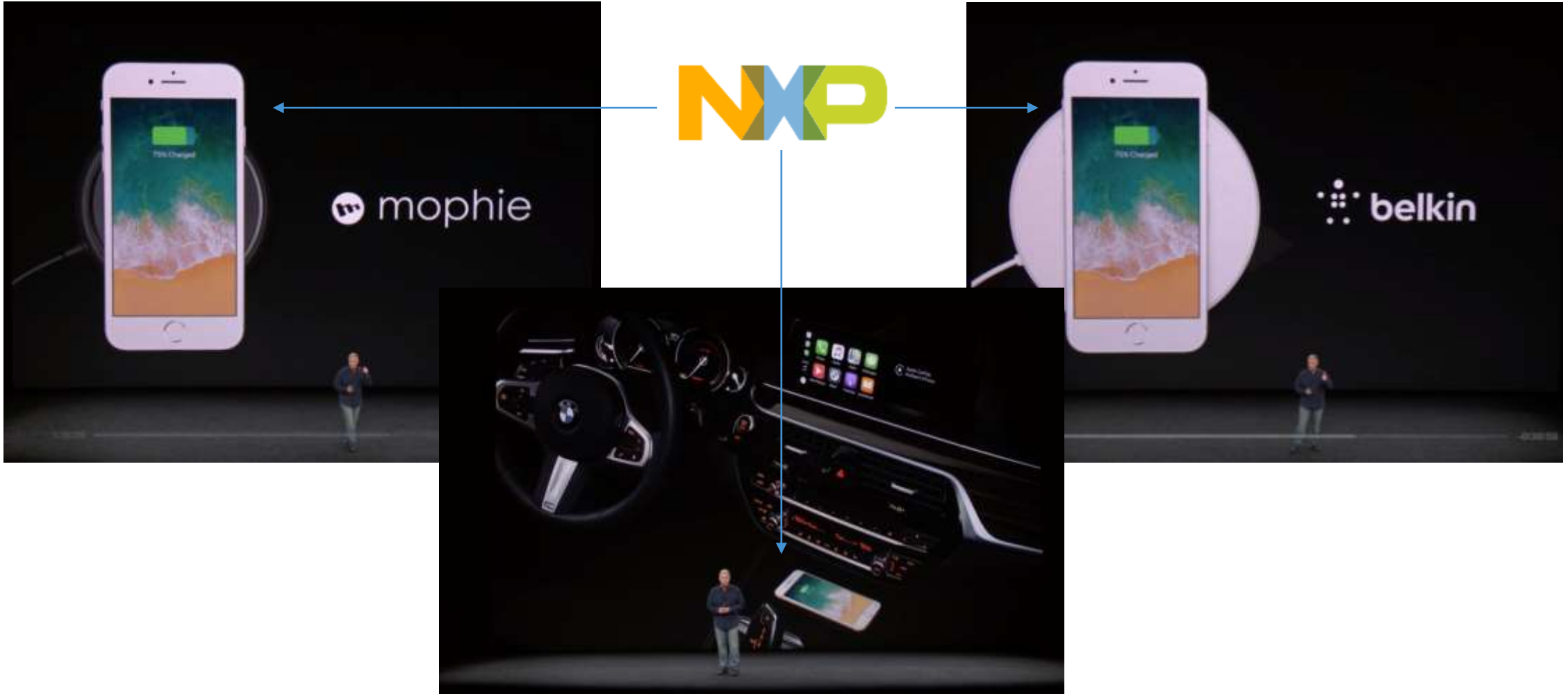
NOW

PowerMat (strongest support of PMA) joins Wireless Power Consortium to support Qi

No traction for A4WP

Qi*
Inductive coupling supporting 80 – 200kHz frequency and power levels from 2 – 2000W

*NFC direct charging complimentary to Qi for <2W



Wireless Power Market Growing into Different Applications

Growing (<2W)

- Hearables
- Wearables
- Health care and beauty aid



Growing (5-15W)

- Smart Phone Receivers
- Smart Phone Transmitters
- In-vehicle Charging



Ramping (30-90W)

- Consumer Charging Mats
- Portable Speakers
- Portable computing notebooks, tablets, etc.

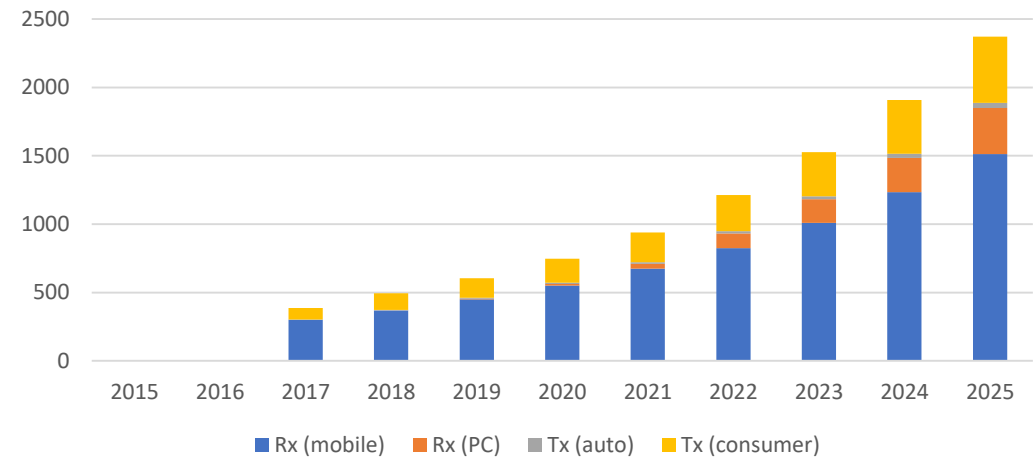


Longer-term (200-2000W)

- Kitchen Appliances
- Power Tools



Market Applications
(MUnits)



QI HOW IT WORKS



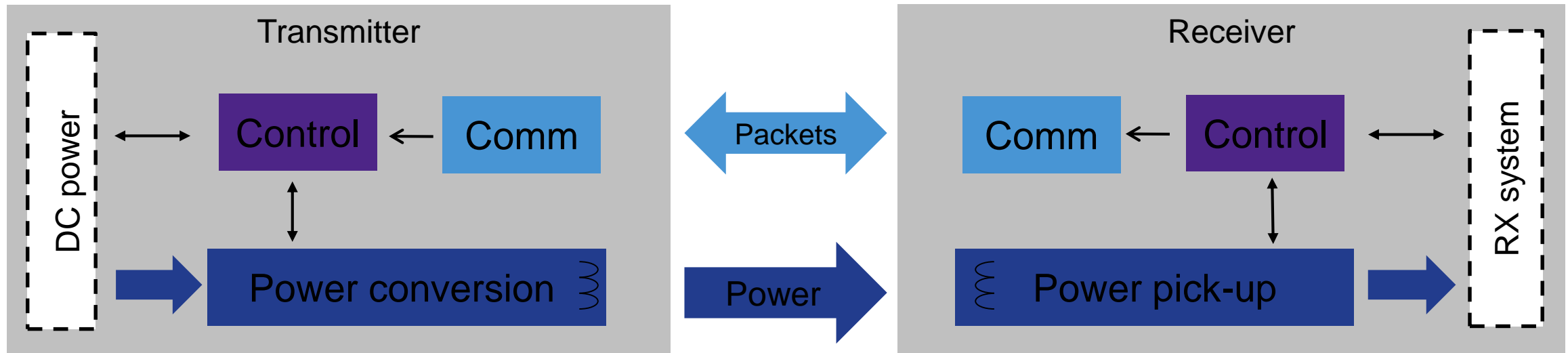
QI – HOW IT WORKS

Transmitter

- Providing desired power
 - According to control error message
- Adapt power by PID regulator
 - Desired control point (power)
 - Actual control point (power)

Receiver

- Controlling power level
- Sending control error message
- Calculate control error
 - Desired control point (power)
 - Actual control point (power)



QI – 5-15W COMMUNICATION

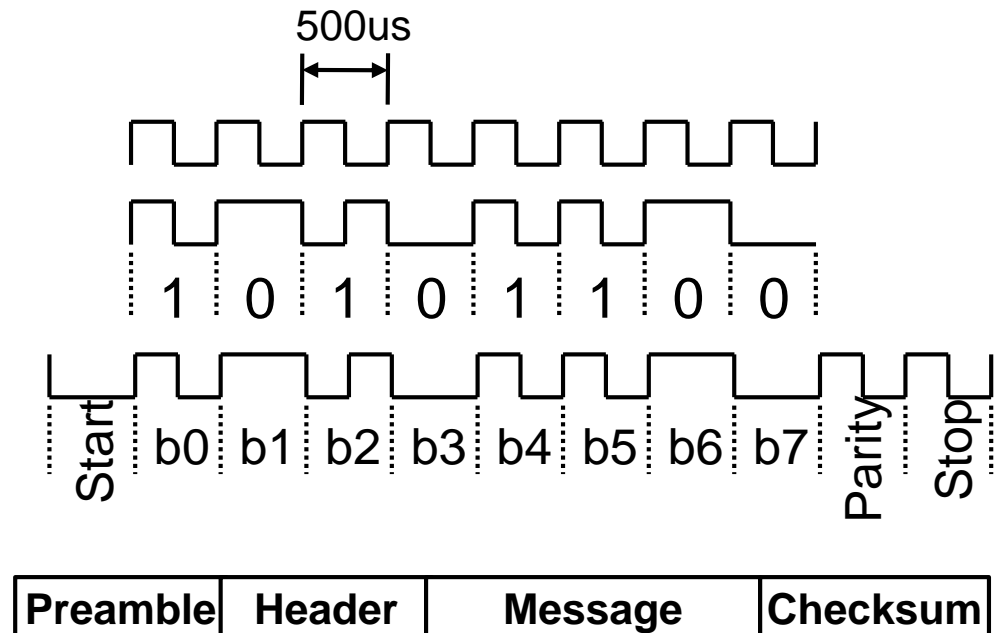
In-band communication

AM modulation for RX to TX comm

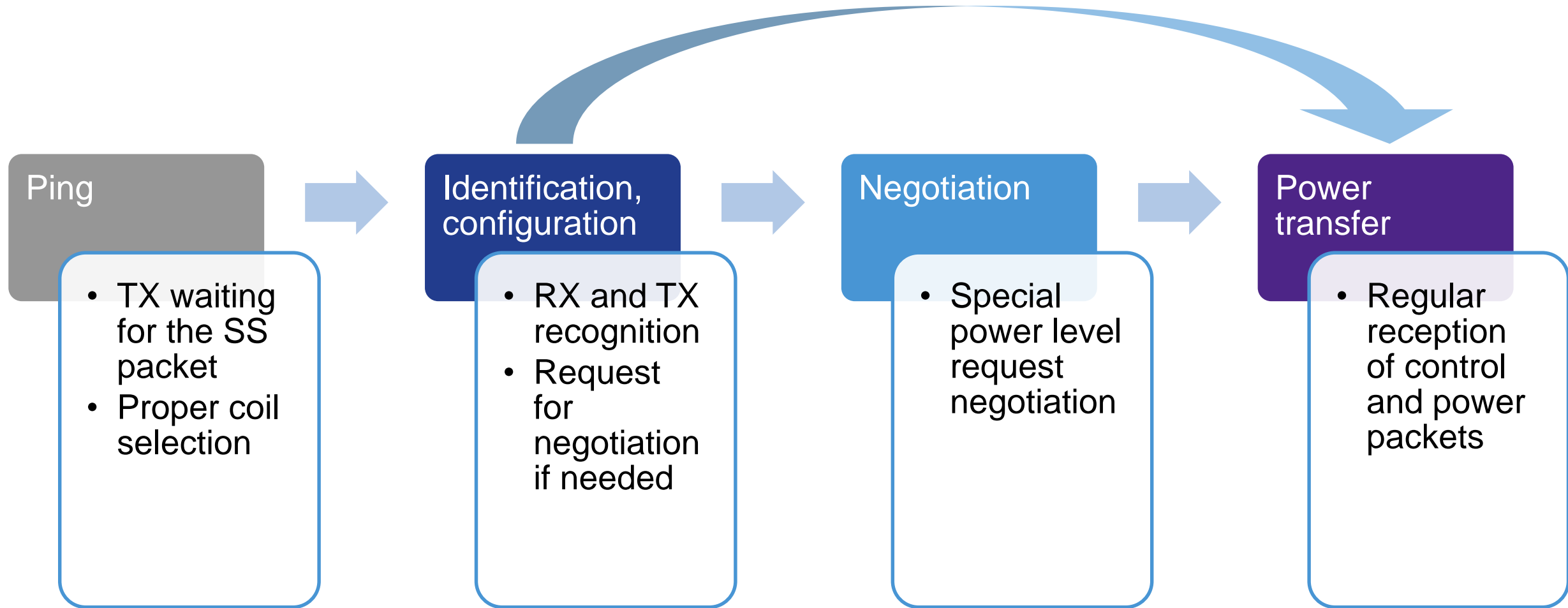
FM modulation for TX to RX comm

Message – 3 .. 30 Byte

Speed – 2 Kbps



QI – POWER TRANSFER INITIALISATION



Q1 – POWER CONTROL METHODS

Frequency control \longleftrightarrow

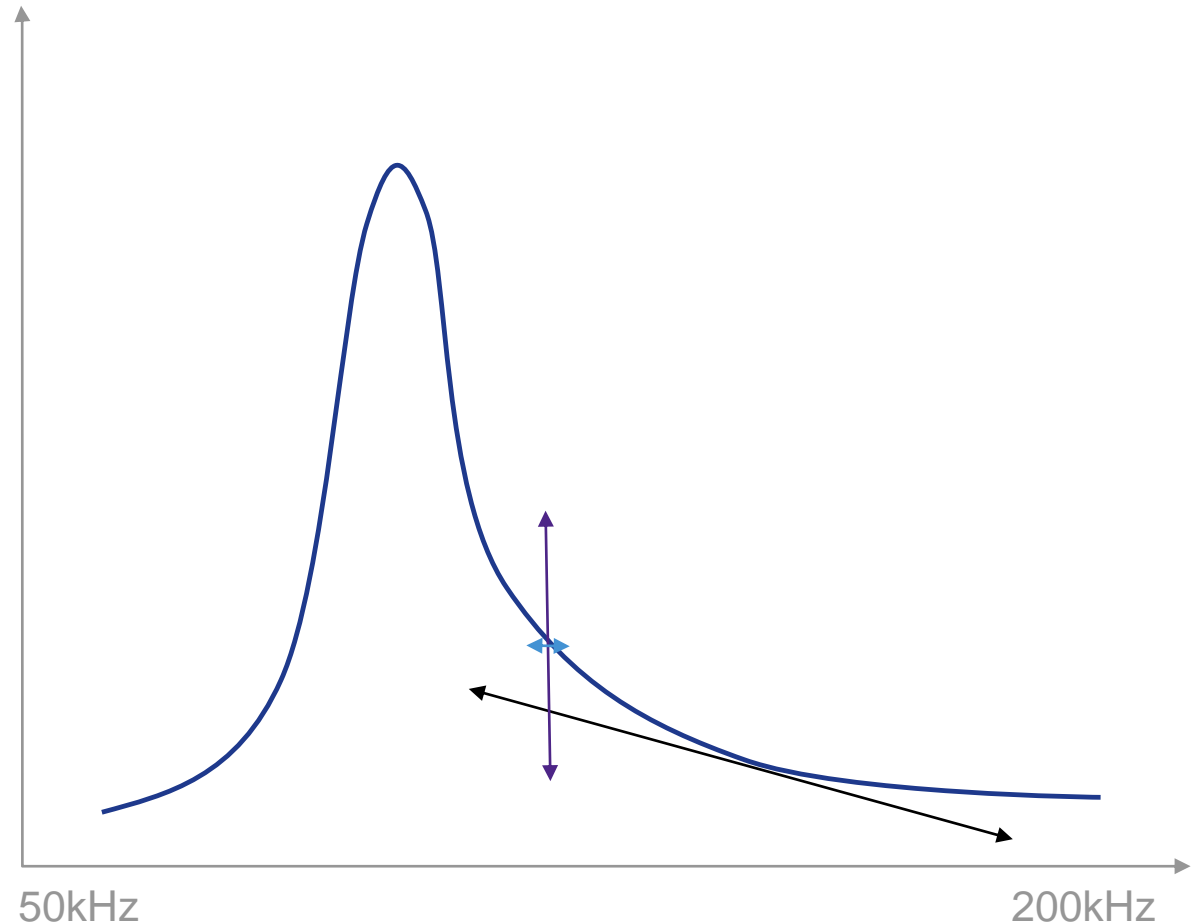
- Bad EMC
- Fixed voltage, duty cycle
- Most common in consumer designs

Duty cycle control \longleftrightarrow

- Bad EMC
- Fixed voltage, frequency

Rail voltage control \longleftrightarrow

- Good EMC
- Fixed duty cycle, frequency
- Automotive design



NXP FOCUS



CUTTING THE LAST CORD

NXP VISION FOR A WIRELESS FUTURE



Broad power level support, from <math><1\text{W}</math> to 200W:

Covering wearables, to PC peripherals, to smart phones, to tablets, 2-in-1s and notebooks
True power source operation where it matters



Multiple device charging, across power levels:

Charge smart phone while charging notebook
Single infrastructure investment supports range of devices



Broad spatial freedom in all directions:

Modular transmitter coil arrays to scale spatial freedom



Enhanced safety and security:

In application payment and ID card / tag protection
Anticounterfeit and OEM specific authentication



WPC Qi alignment:

Power delivery, communications and safety



NXP WIRELESS POWER INNOVATION

Driving WPC Specifications

- Steering Group Member
- Co-Chair – Specification Working Group
- **Co-Chair – Medium Power Working Group – leading 65W specification**
- Co-Chair – RFID Task Force
- Co-Chair – Communication Task Force
- Driving / Proposal Submission – Kitchen Working Group, Authentication Task Force, NFC Detection Task Force
- Largest span of end customer certified Qi transmitters
- Multiple transmitter types submitted to specification (adopted broadly in market by various suppliers)



Investing in Innovation

- Internal development and test labs
- NXP TX and RX solutions are **golden units in WPC specification**

Defacto Supplier for Customers with most Advanced Requirements

- Automotive in-vehicle – over **75% of the market**
- Extreme Accuracy Precise Frequency Control
- Ultra High Efficiency 65W for portable PCs
- Payment Card / RFID Tag Detection

NXP WIRELESS POWER SOLUTIONS

LEADING THE WAY TO A WIRELESS FUTURE

Hardware

- Full Qi certified reference design
- Optimized BOM

Software

- Professional grade Qi certified library
- Customizable application / clean API

Support

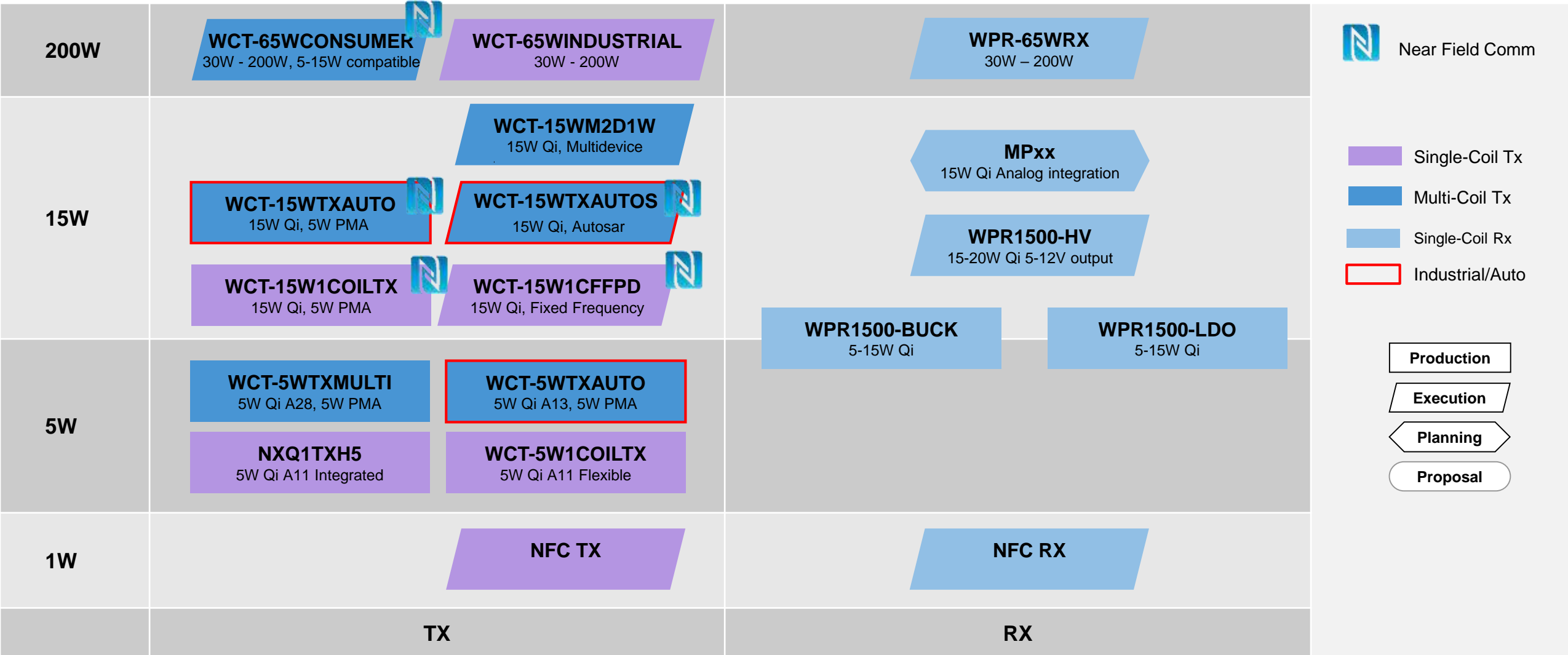
- Application Expertise
- On-site support up to production

Certification

- WPC consortium co-chair
- Up to date specification certifications

- Most comprehensive portfolio of Qi certified transmitter and receiver solutions in industry
- Most flexible solutions for wide range of end applications
- Fastest time to market

WIRELESS POWER SOLUTIONS PORTFOLIO



5-15W CONSUMER SOLUTIONS



WCT-15W1FFPD

15W iPhone Fast Charge Transmitter

Target Applications

- iPhone Fast Charging (7.5W), Samsung fast charging

Complete and Qi certified hardware and software solution

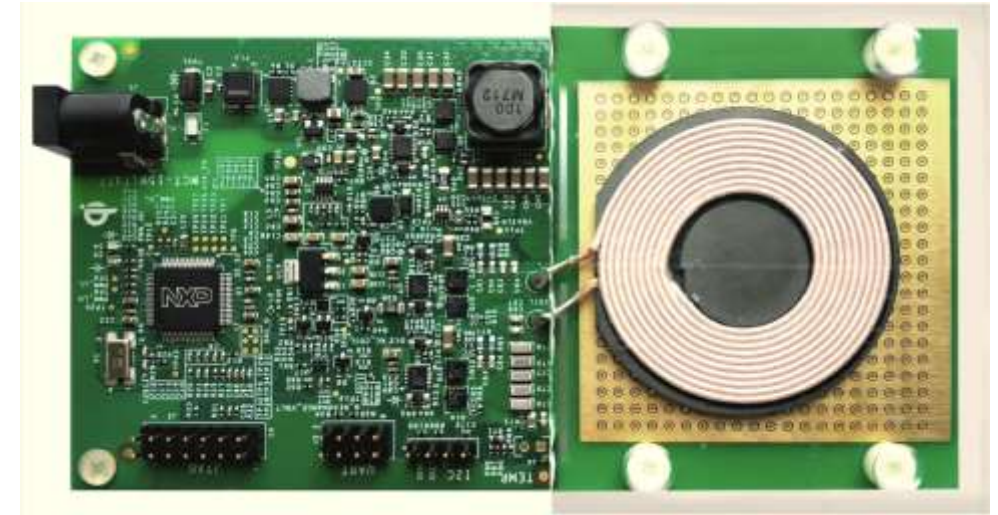
- Supports iPhone and Samsung Fast Charge, full 15W Qi
- Supports 1-n coils
- (Adding optional NFC card detection and USB PD supply)

Designed for consumer applications

- High accuracy fixed frequency design (EMC control)
- Cost optimized design

Use cases

- Standalone transmitter
- Monitor stand
- Docking station
- All-in-one
- Workstation



Belkin - BOOST↑UP™ Wireless Charging Pad for iPhone X, iPhone 8 Plus, iPhone 8



WIRELESS CHARGING OPTIMIZED FOR iPhone X, iPhone 8 PLUS, AND iPhone 8

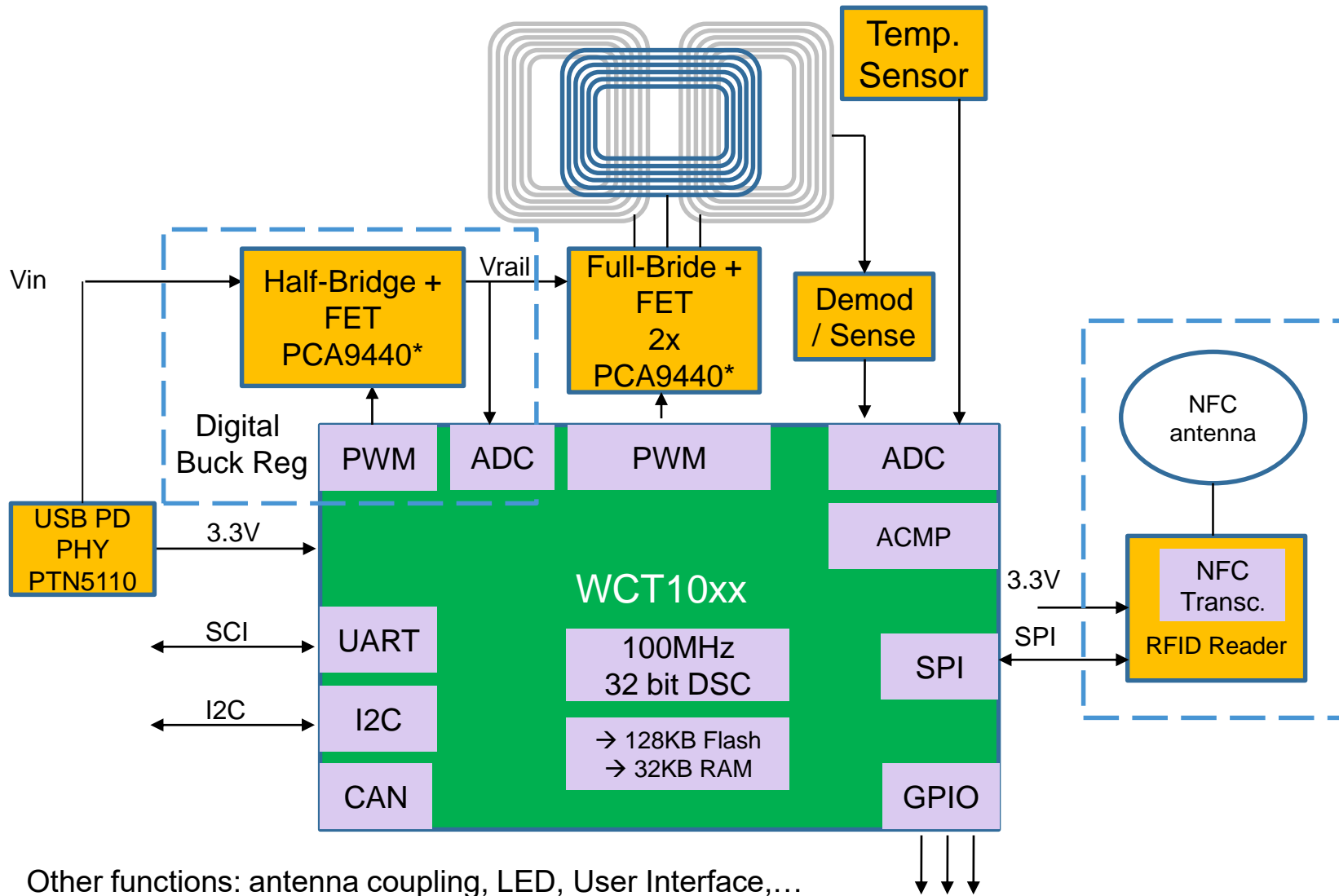
Unclutter your space and simplify charging with the BOOST↑UP Wireless Charging Pad. Belkin worked closely with Apple to engineer an efficient and high-speed charging pad for iPhone X, iPhone 8 Plus, and iPhone 8—just lay your phone onto the charging pad and go. There's no need to remove your iPhone X, iPhone 8 Plus, and iPhone 8 from its case when powering up, the BOOST↑UP Wireless Charging Pad can charge through most lightweight cases.

Made for: iPhone X, iPhone 8 Plus, and iPhone 8

<http://www.belkin.com/us/F7U027-Belkin/p/P-F7U027/>



MP-A11 EXAMPLE TRANSMITTER BLOCK DIAGRAM



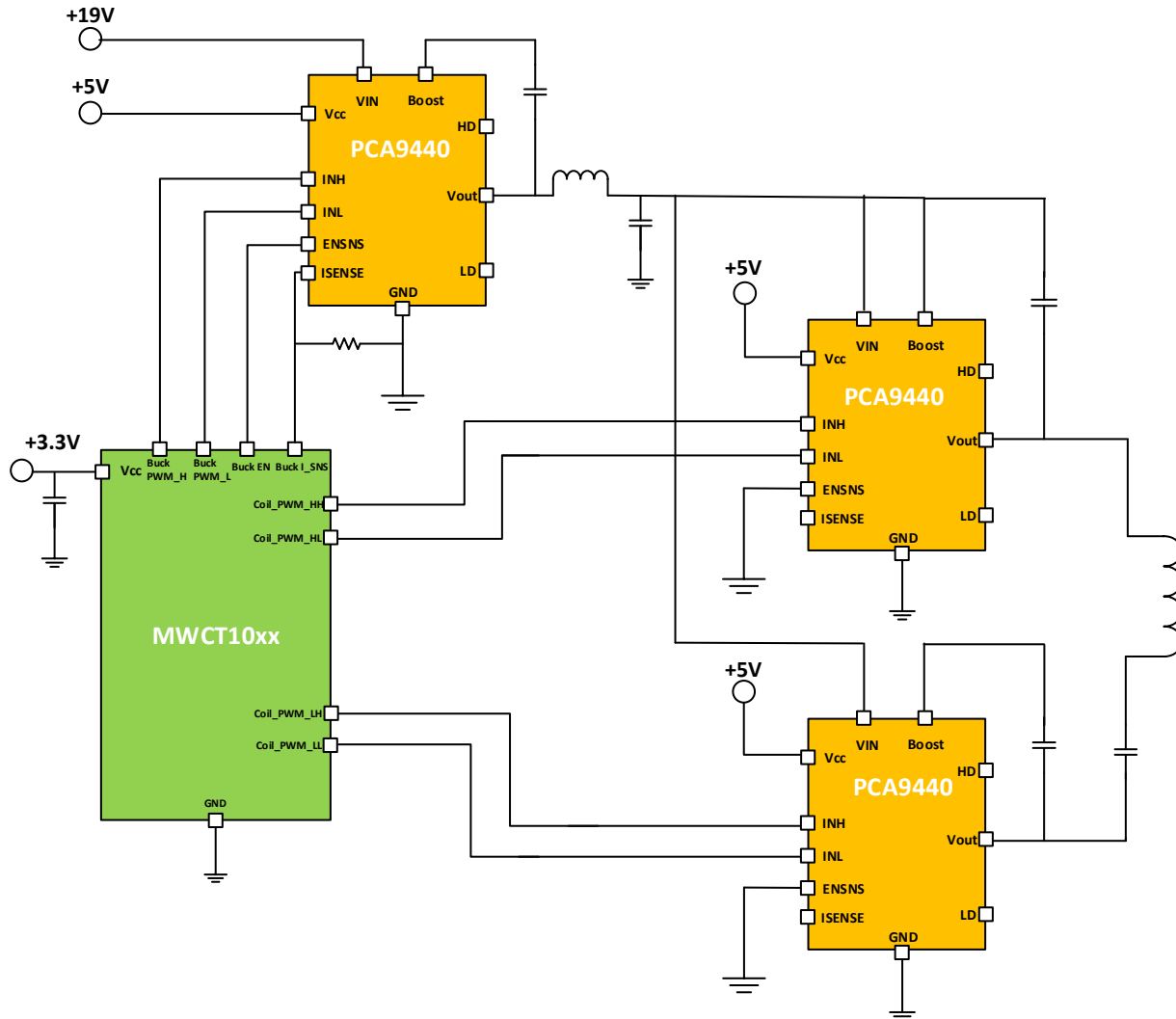
Other functions: antenna coupling, LED, User Interface,...

Features

- Delivers full 15W to receiver
- Variable or (customizable) fixed frequency operation
- > 70% power transfer efficiency (low cost coils)
- Extra Accurate Foreign object detection
- Integrated USB PD Stack
- Optional NFC to support card detection
- Single- or Multi-Coil configuration options
- Improved EMI protection to meet various standards
- On-Chip Digital Buck regulator for decreased BoM cost
- Half-bridge driver with integrated current sensor

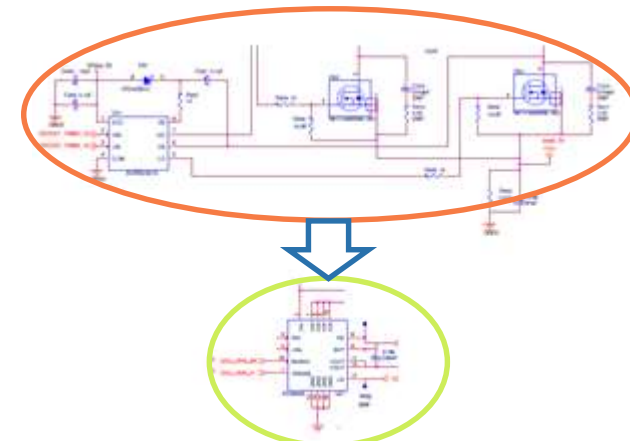
PCA9440

Half-Bridge Gate Driver with Dual Integrated Switches



Features

- 25V Input Voltage Rating
- 15mΩ Low RDSON for Better Thermal Performance and Efficiency
- Up to 5A Output Continuous Current
- Fully Integrated Dual-Switch
- Independently Controlled High-side and Low-side Gate Signal
- Estimated > 80% PCB Area Saving Comparing to Discrete Solution

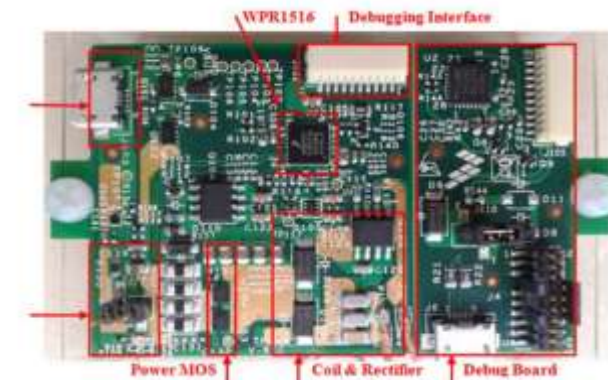
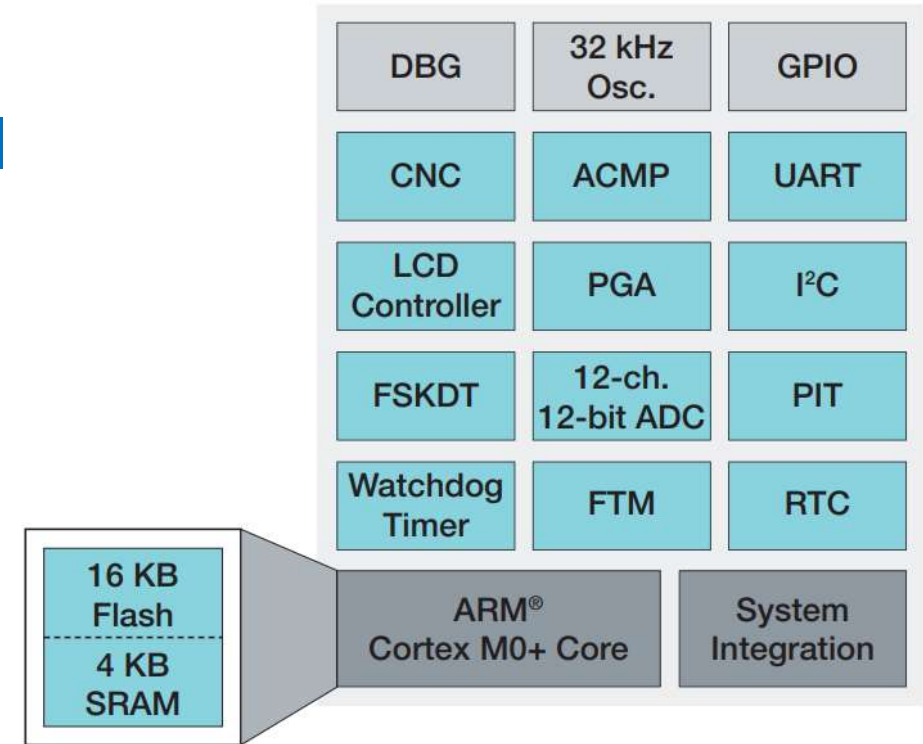


WPR1516 15W Qi RECEIVER

Programmable RX Enabling Optimize Thermal

Features

- 15W EPP Qi certified SW
- External rectifier – flexible design, allows optimization and synchronous rectifier implementation for extremely low thermals
- Input power (3.5V ~ 20V AC peak) from the transmitter via the receiver coil – integrated DC/DCs
- Output power up to 15 W
- Programmable output voltage 5-12V and charging profiles
- Programmable I2C interface
- High accuracy FOD – high precision ADC
- On-chip FSK demodulation
- On-chip overcurrent and overvoltage protections



WPR1500-LDO DEVELOPEMENT BOARD

Multi-Device Tx

15W Wireless Charging Transmitter Solution

Target Applications

- Simultaneous multiple Qi device charging

Complete and Qi certified hardware and software solution

- Supports iPhone and Samsung Fast Charge, full 15W Qi
- Charges upto four devices simultaneously
- (Adding NFC card detection and USB PD supply)

Easy to use

- Complete hardware and software solution – charges out of the box!
- Hardware design files



5W Integrated Single Coil Transmitter

NXQ1TZH5BD1401

- Integrates A5, A11, A12, & A16 WPC Qi V1.2 analog and digital functions for 5W System Specification
- No external OpAmp, filter, or biasing circuit needed
- Less than 10 external passive components required
- The NXQ1TXL5 is a lower-power, lower-cost option for <5W applications that do not require FOD
- Easy FOD Control for coil and caps
- Internal voltage and current measurement circuits
- On-chip analog and digital filters for robust ASK detection
- Low cost 32.768kHz external crystal for low power oscillator to achieve standby current of 15 μ A (typical); System Standby Power of 10mW (typ)
- Operates supply from 3.5V to 5.25V
- Small 5mm x 5mm HVQFN32 package
- Qi Certified



Reference Documents

- ▶ Application Note: [AN11775](#)
- ▶ User Manual: [UM10943](#)
- ▶ Board Layout Files: [Click Here](#)

- AVAILABLE

MP-A4 15W SINGLE COIL TRANSMITTER

WCT-15W1COILTX

Target Applications:

- Fast Mobile Charger, Tablet Charger

Features and Enablement:

- Variable frequency (reduced BOM)
- Compliant with the Qi v1.2.2 specification
- Integrated digital demodulation in chip
- Supports FOD based on quality factor (Q factor) change
- Supports FOD based on calibrated power loss accounting
- Supports Qi MP receiver with 15W output power capability
- Supports multiple types of RX modulation signals (AC capacitor, AC resistor, and DC resistor)
- 100MHz core frequency



• Availability & Certification:

- Available for demo and evaluation now!
- Qi Certificated

Quick Charge 4 Power Bank Solution

New Power Bank Design

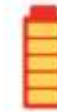
- Hi power delivery & High efficiency
- Wireless Charging supports iPhone&Samsung fast charge
- System support PD + PPS & QC4+
- Software integration includes: wireless power and battery management, PD stacks and more programable APIs



5 FOR 5



5 MINUTES
of charging gets you

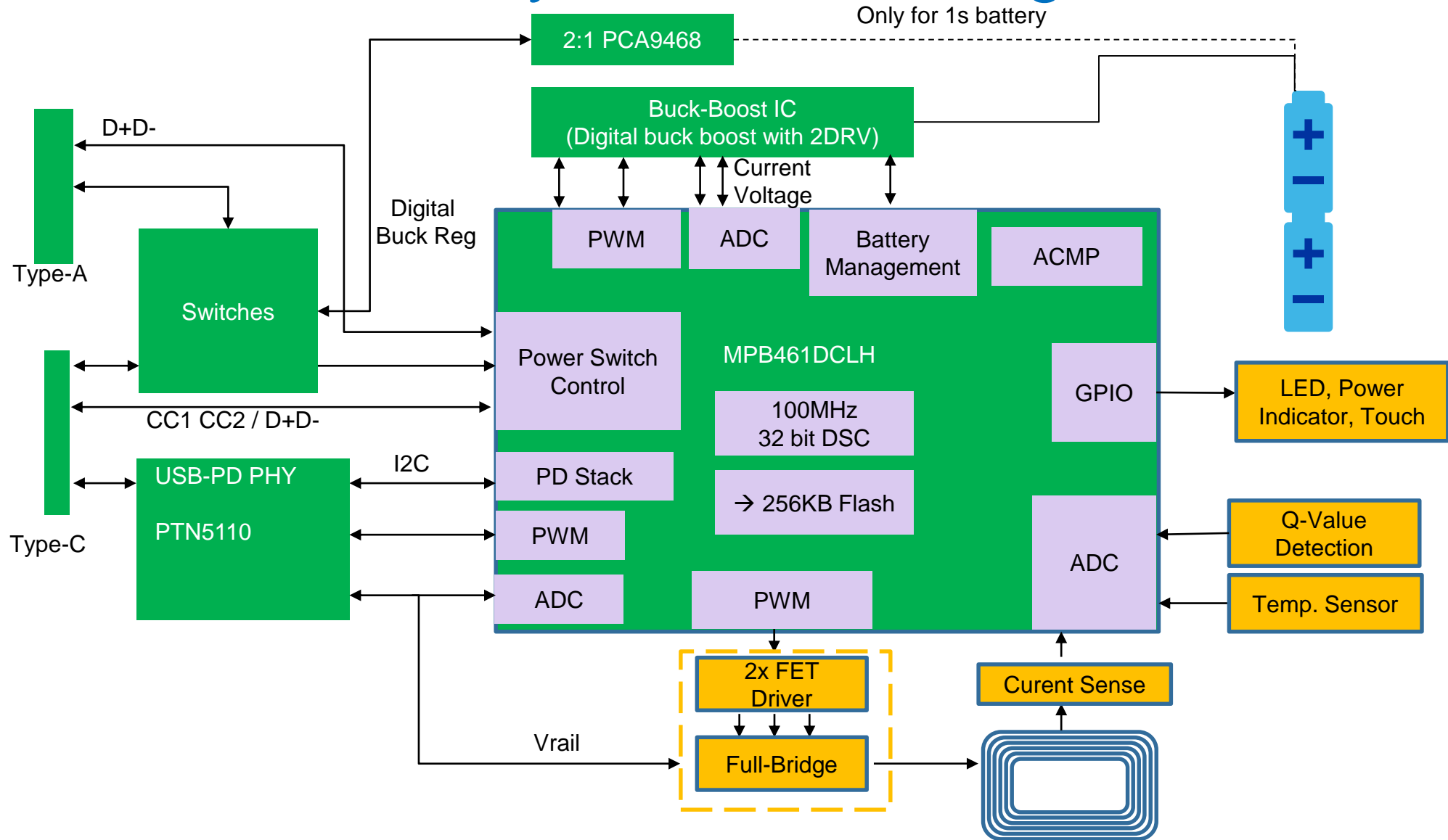


5 HOURS
of battery life

Key Features:

- Dual-way type C supports input & output
- Quick Charge for input and output, PD+PPS, QC2,QC3,QC4,
- 2S battery supported (capability~20000mAh), output >50W
- Integrated wireless 15W transmitter, support Samsung and Apple fast charge
- Digital control Buck-boost
- 2:1 Direct Charging with high efficiency around 98%
- One Control IC provides Buck boost, Charge, QC algorithm, PD communication and Wireless power managements

QC4+ Power Bank System Block Diagram



5-15W AUTOMOTIVE SOLUTION



5W and 15W Auto TX Solutions



- Free positioning (multi coil)
- On chip digital demodulation (reduced BOM)
- Fixed frequency Rail Voltage control (better EMC)
- Q-factor and Power Loss FOD methods
- Key FOB and AM band interference avoidance
- AEC-Q100 grade 2 certification
- Temperature sensing
- CAN, LIN interfaces
- NFC

WCT-15WTXAUTOS
15W Qi, Autosar

WCT-15WTXAUTO
15W Qi, 5W PMA

WCT-5WTXAUTO
5W Qi A13, 5W PMA



WCT-15WTXAUTO MP-A9

- 120-130kHz frequency range
- iPhone frequency supported
- Fast charging
- WPC golden unit
- Low cost black box solution
- **MWCT101xA**

WCT-15WTXAUTOS MP-A9

- 120-130kHz frequency range
- iPhone frequency supported
- Fast charging
- WPC golden unit
- AutoSAR, MCAL, ...
- No need for host controller
- **MWCT101xS**

WCT-5WTXAUTO A13

- 105-115kHz frequency range
- WPC golden unit
- **MWCT100xA**

NXP IN-VEHICLE WIRELESS POWER SUMMARY

MWCT101xS

Full AutoSAR SW compatibility

15W, Qi 1.2.4 (all topologies support)
iPhone fast charging frequency support
PCA9440 support

CAN-FD, LIN, UART, SPI, I2C, CSEc
512kB, 1024kB, 2048kB Flash
64kB, 128kB, 256kB RAM
64LQFP, 100LQFP, 144LQFP

MCAL, AutoSAR OS, ANFC, Touch,
Crypto CSEc, Safety SW, ...

MWCT1011A

Low-cost black box solution

15W, Qi 1.2.4 (all topologies support)
iPhone fast charging frequency support
PCA9440 support

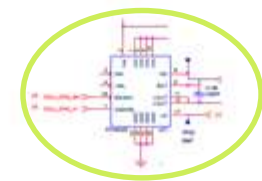
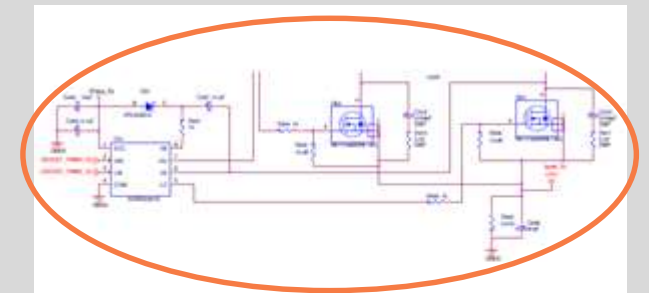
UART, SPI, I2C
64kB Flash / 16kB RAM
64LQFP

PCA9440 (MP81)

Integrated half-bridge

Optimized for 15W Qi TXs
12 -> 4 components BOM reduction

2x MOS-FET, 2x MOS-FET Driver,
Current sensing



Innovation & Standardization

Qi Steering Group member
Specification Working Group chair
RFID-TF, Comm-TF, MP-WG co-chair



Broad patent portfolio
Internal development and test labs

65W CONSUMR SOLUTION



65W CONSUMER SOLUTION OVERVIEW

First commercially available high-power wireless charging solution for notebooks and 2-in-1 tablets

- **Charging pad (transmitter):** Desktop or mounted below surface
- **Receiver:** Integrated into notebook or 2-in-1 keyboard
- **Certified Software:** Power delivery, communications and safety with complete bill of materials

Breakthrough Technology:

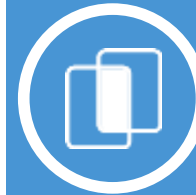
- Advanced control algorithms ensuring best efficiency
- Run-time monitoring of the best operating point
- No interference with other electronic systems
- Innovative hardware and system design solution
- Complete replacement of classic power cord and brick



65W High-Power Wireless Charging Receiver



5-15W Qi mobile phones support:
One mat to charge phone or laptop, extended Wireless Power ecosystem



Capable of fitting into the tightest industrial design constraints: <2mm in coil thickness, low component count



Cooling concerns eliminated: Operates At >90% power transfer efficiency



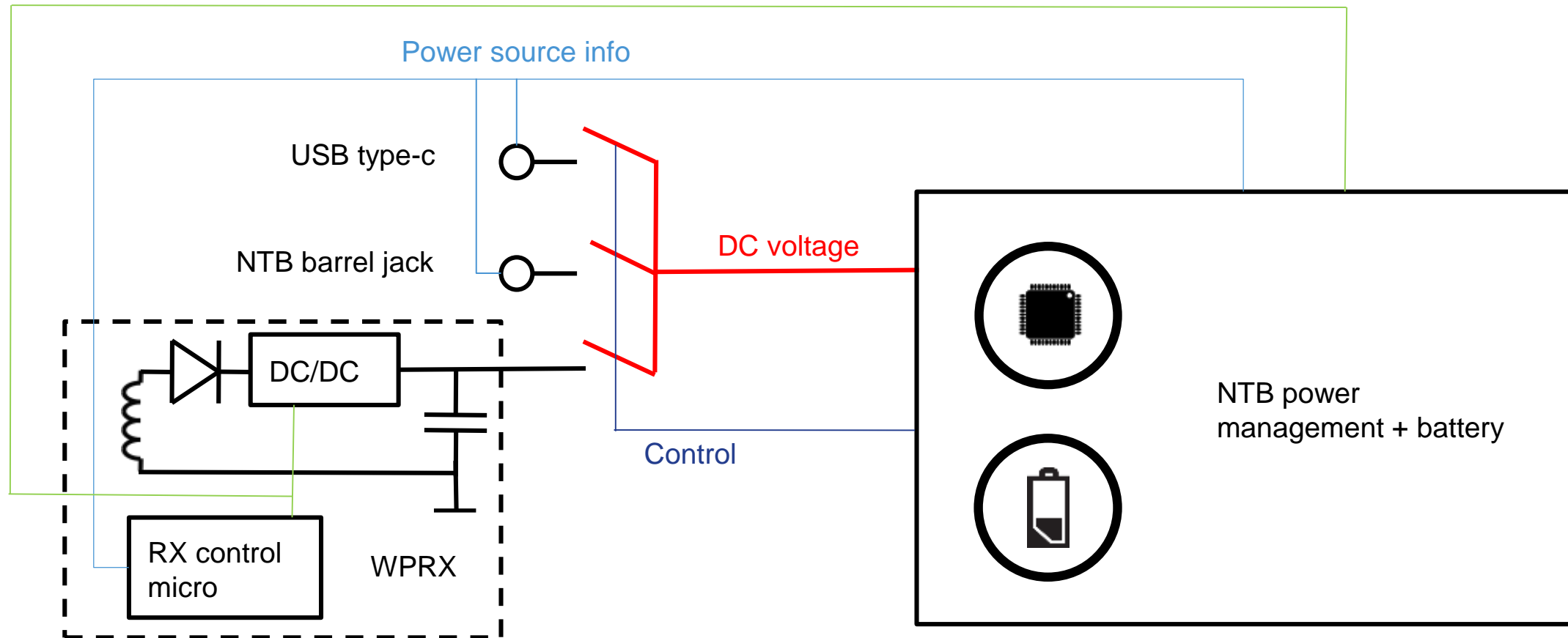
Broad spatial freedom in all directions: x-y plane, extended z-height

SHOWCASED AT CES 2018

WIRELESS POWER – NOT WIRELESS CHARGING

Voltage characteristic equal to USB-C PD and/or barrel connector **power source**

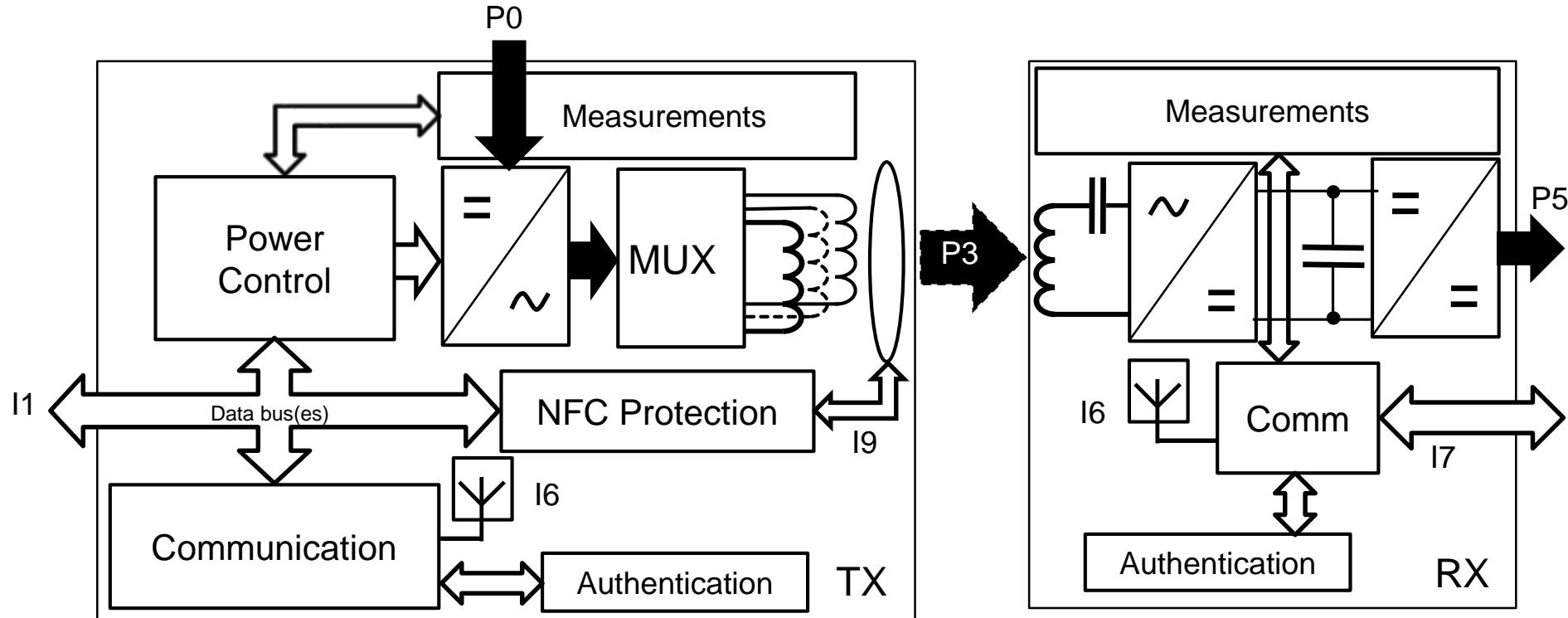
3.3/5V to power up system without battery involvement



65W WIRELESS POWER SOLUTION PARAMETERS

| | |
|--------------------------|--|
| Power: | 65W |
| Working frequency: | 100 – 145kHz |
| Rx – Tx gap (z): | 6 – 20mm |
| Free positioning (x/y): | 20/20mm (3 TX coils), unlimited (3+ TX coils) |
| High efficiency: | 80 – 85% (depends on displacement) |
| Communication: | BLE |
| Principle: | Resonant |
| Rx <-> EC communication: | I2C SMBus alike protocol |
| Safety: | NFC cards protection, conductive objects detection (FOD) |
| Security: | Authentication |
| FW updates: | TX & RX secure FW over the air updates through laptop OS |
| 5-15W compatibility: | 5-15W RX compatible with 65W TX |

65W CONSUMER SOLUTION BLOCK SCHEMATIC



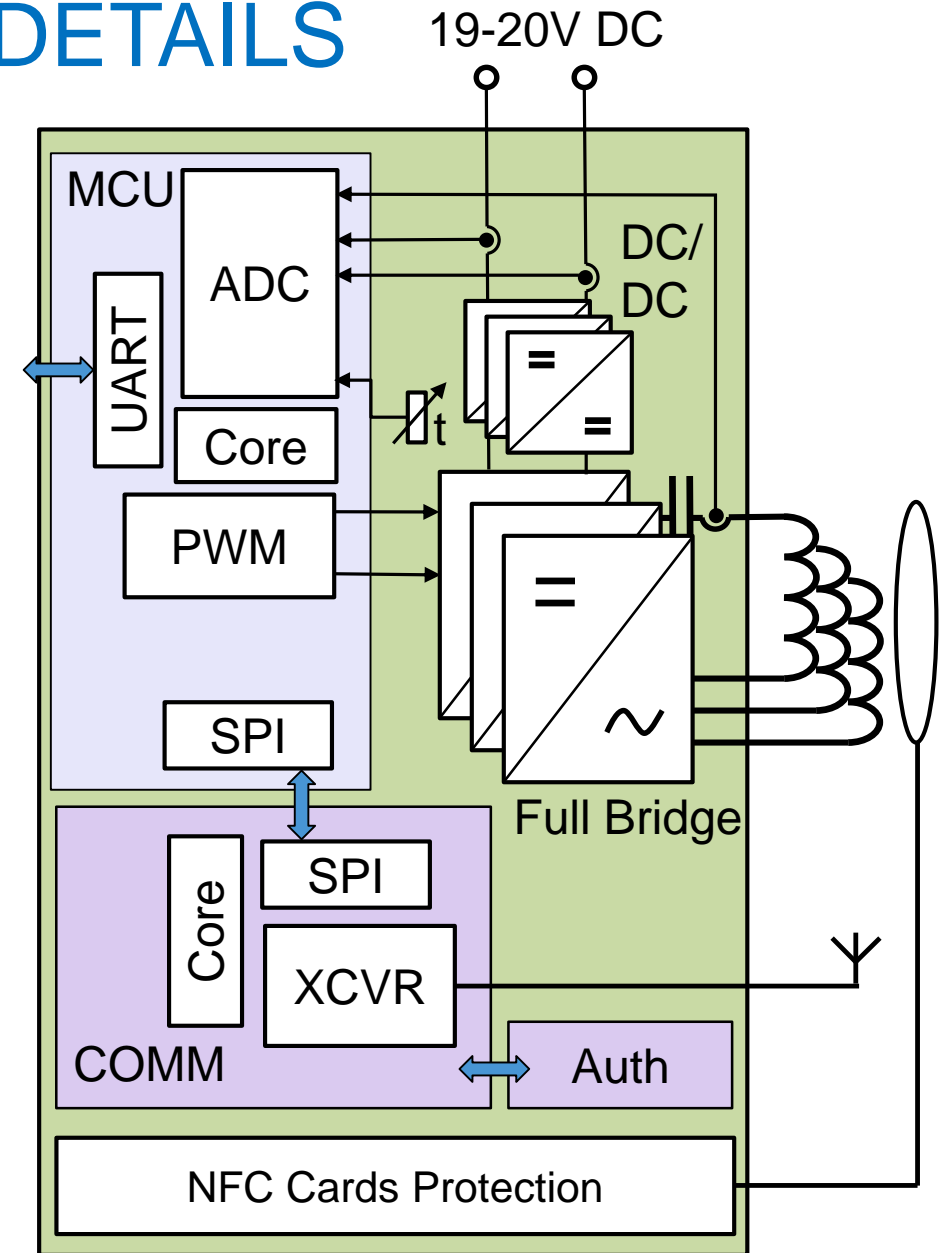
All blocks verified

- Communication (BLE)
- Power Control
- NFC Protection

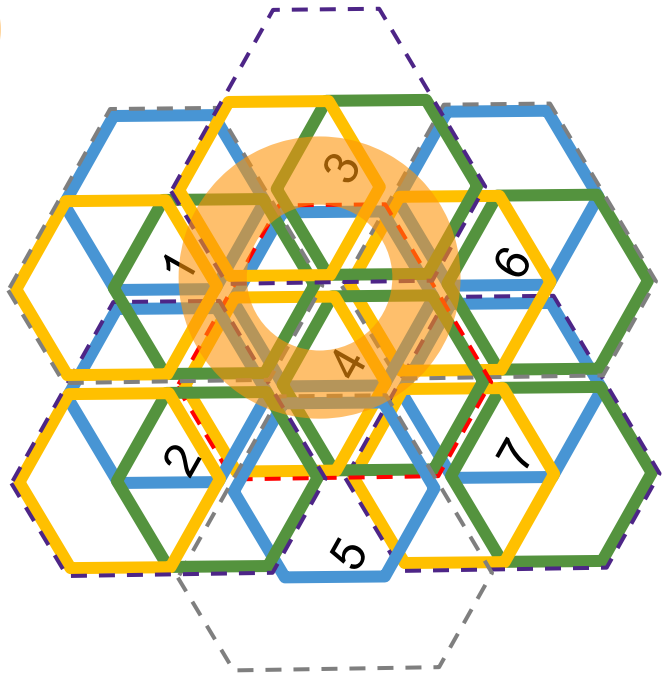
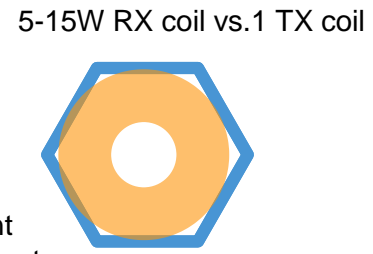
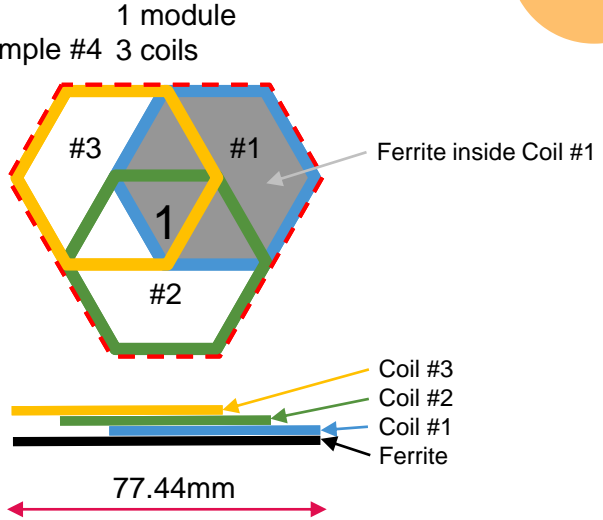
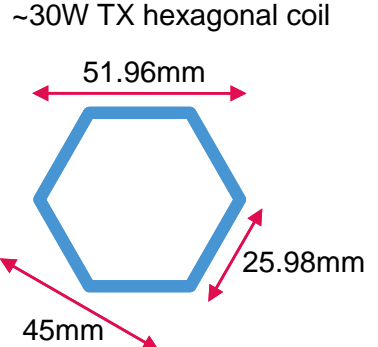
- I1 – User Interface
- I6 – BLE PRU<->PTU Communication
- I7 – I2C PRU<->Laptop Communication
- I9 – NFC Antenna Connection
- P0 – DC PTU Power Input
- P3 – AC 100-145kHz TX->RX Power Transfer
- P5 – DC PRU Power Output (Stable Voltage Source)

65W CONSUMER PTX TECHNICAL DETAILS

- Coils
 - 45mm coil diameter (based on 15W Qi PC0)
 - Standalone coil operating for 15W PC0
 - 3 coils operating for 65W PC1
- Power input
 - Input voltage: 19-20V DC nominal
 - Compatible with USB-C and standard power sources
 - 90W for 65W PRx output required – system can negotiate maximum output power based on adapter
- Power control
 - Rail voltage control
 - Operating frequency adjustment to keep resonance, best EMC and efficiency



HEXAGONAL MULTI-COIL DESIGN



Each hexagonal coil designed for 30W power transfer

Possibility to connect independent full bridge and current measurement to each coil

3 TX coils running simultaneously to deliver 65W to PC1 RX coil

1 TX coil running independently to deliver 5-15W to PC0 RX coil



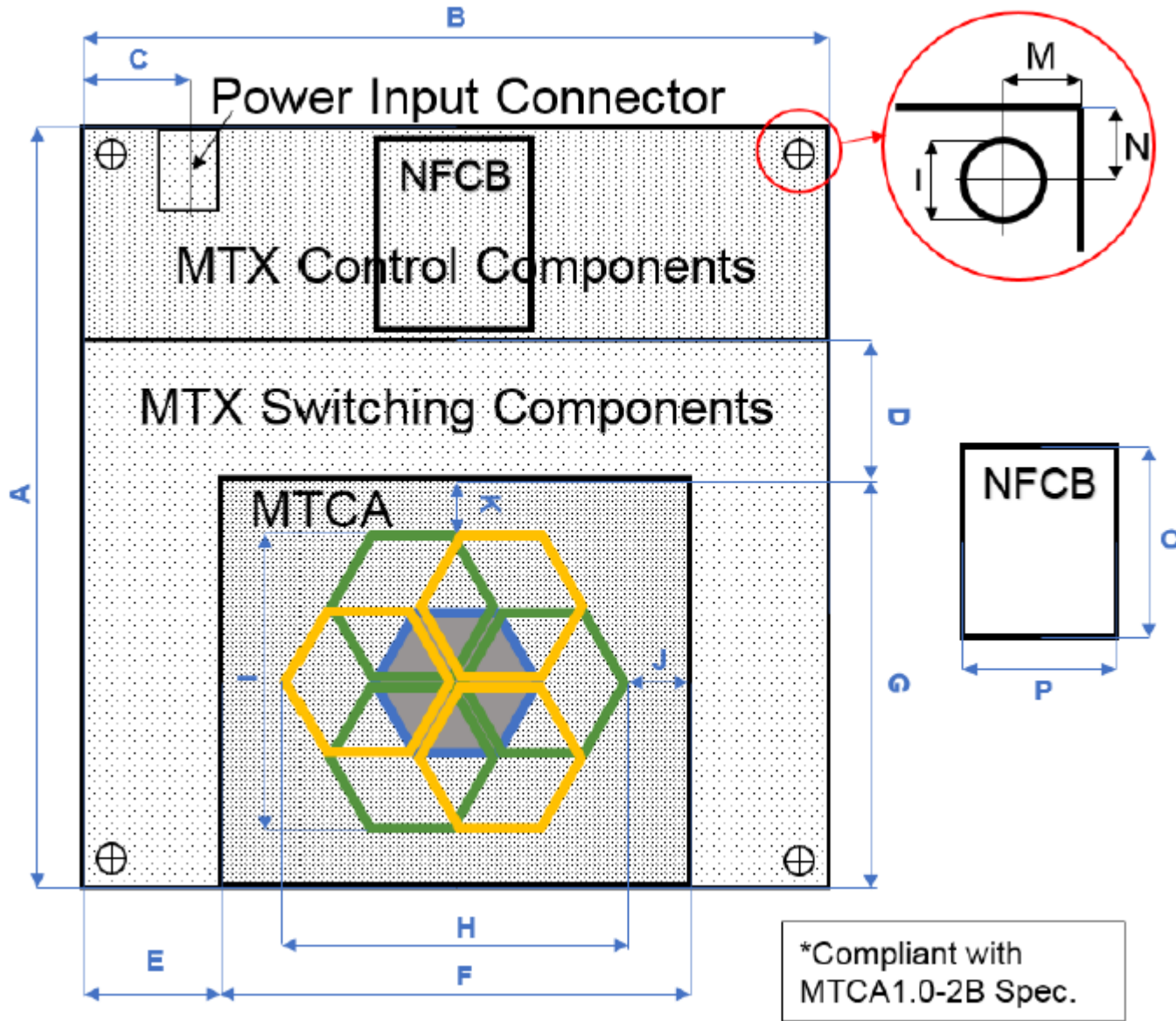
65-90W RX coil vs. 3 TX coils



7 modules
18 coils
Module 3 – only coils #2, #3
Module 5 – only coil #1

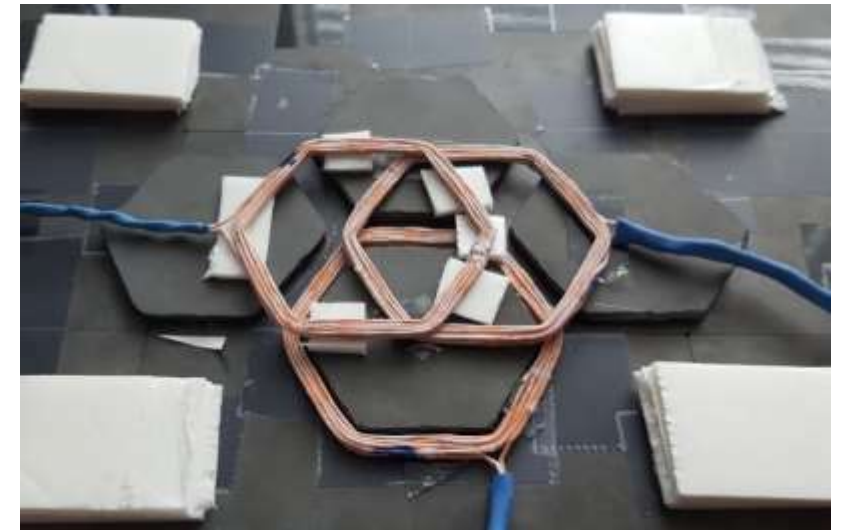


PTU Dimensions

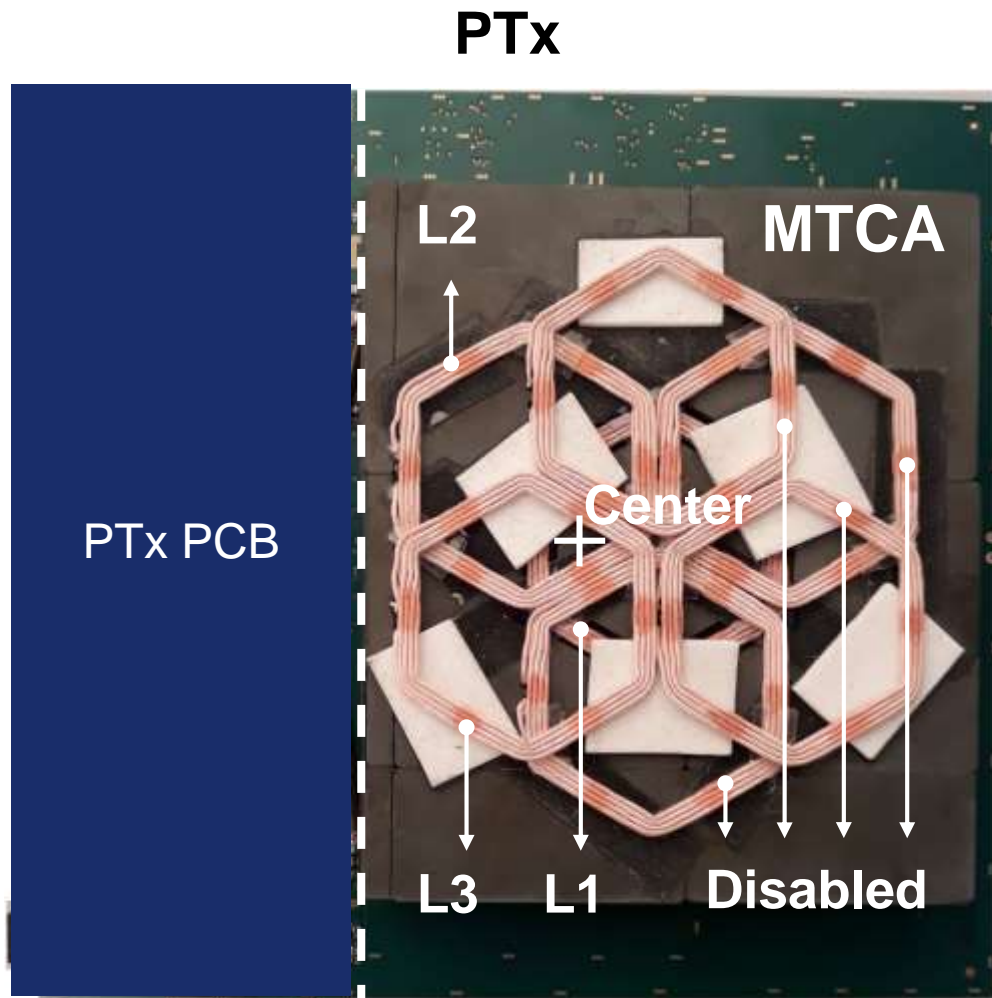


*Compliant with MTCA1.0-2B Spec.

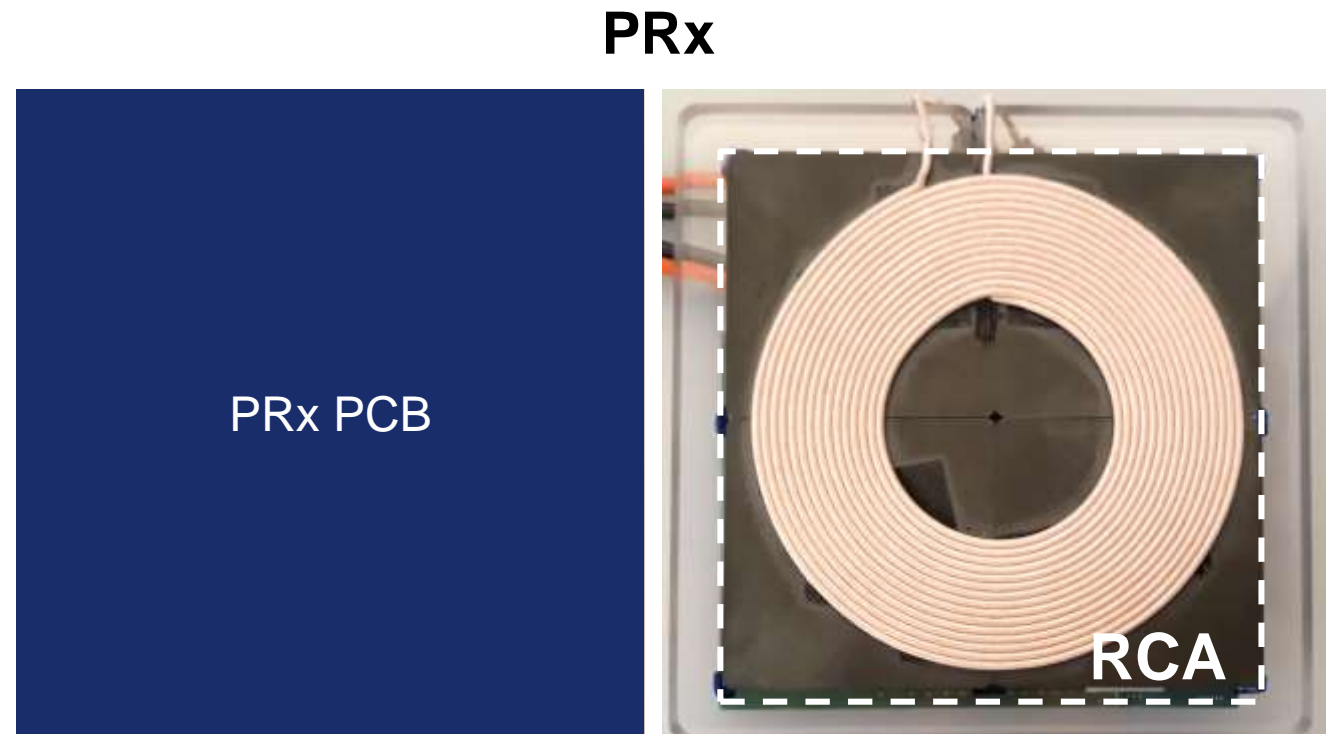
| Dimension | mm |
|-----------|-------|
| A | 180 |
| B | 190 |
| C | 13.7 |
| D | 8.0 |
| E | 33 |
| F* | 123.9 |
| G* | 110.0 |
| H* | 103.9 |
| I* | 90.0 |
| J* | 10.0 |
| K* | 10.0 |
| L | 3.0 |
| M | 3.6 |
| N | 3.6 |
| O | 54.1 |
| P | 37.3 |



System Overview



PTU – 170.0 x 180.0 x 13 mm



RX – 55.0 x 75.0 x 3.2 mm
RCA – 75.0 x 75.0 x 2.0 mm

INDUSTRIAL WIRELESS POWER



INDUSTRIAL WIRELESS POWER

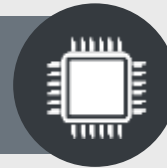
Vacuum cleaners, power tools, e-bikes, medical, cameras, ...



Complete system – Tx + Rx



In-house NXP technology



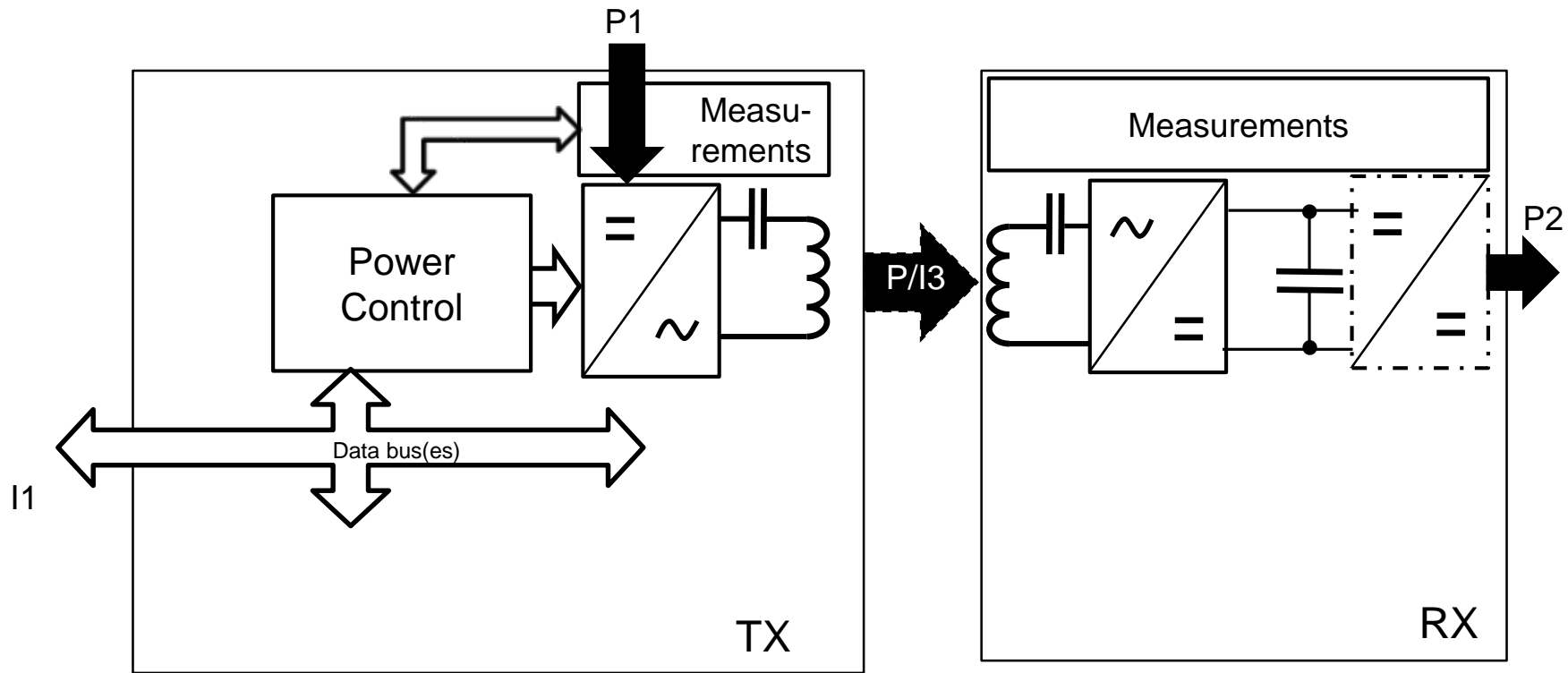
Future WPC compatibility



Customizable power level – 30W to 100W



15-25W INDUSTRIAL PTU & PRU Block Schematic



I1 – User Interface

I3 – In-Band PRU <-> PTU Communication

P1 – DC PTU Power Input

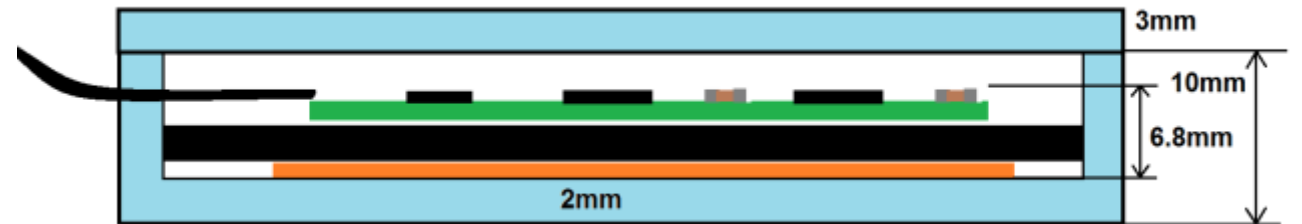
P3 – AC 100-145kHz TX -> RX Power Transfer

P2 – DC PRU Power Output (Stable 20V Voltage Source)



25W System Description

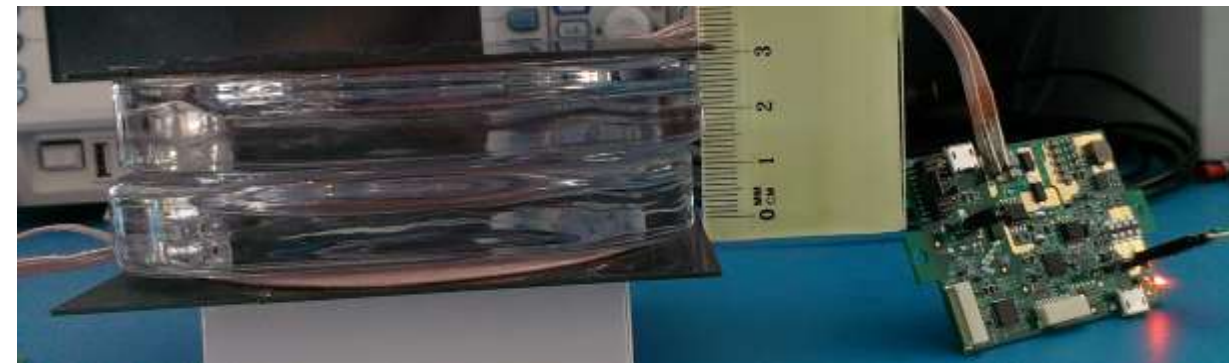
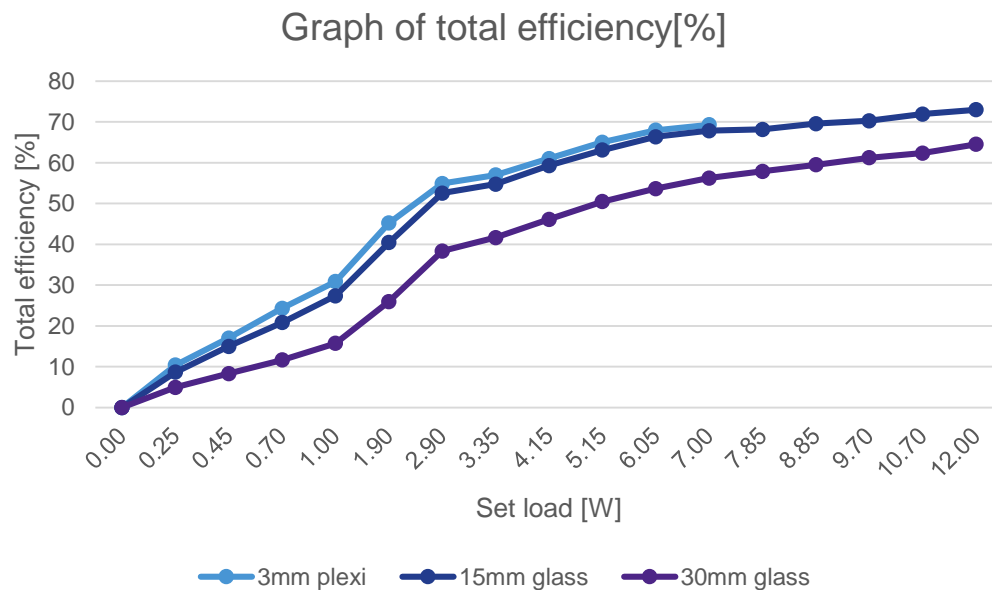
- Input power: 19V/1.5A
- Output power: 10-12V/2.8A
- Efficiency: >60%
- Maximum distance: 35mm
- Total thickness (Coil,ferit,PCB): 6.8mm



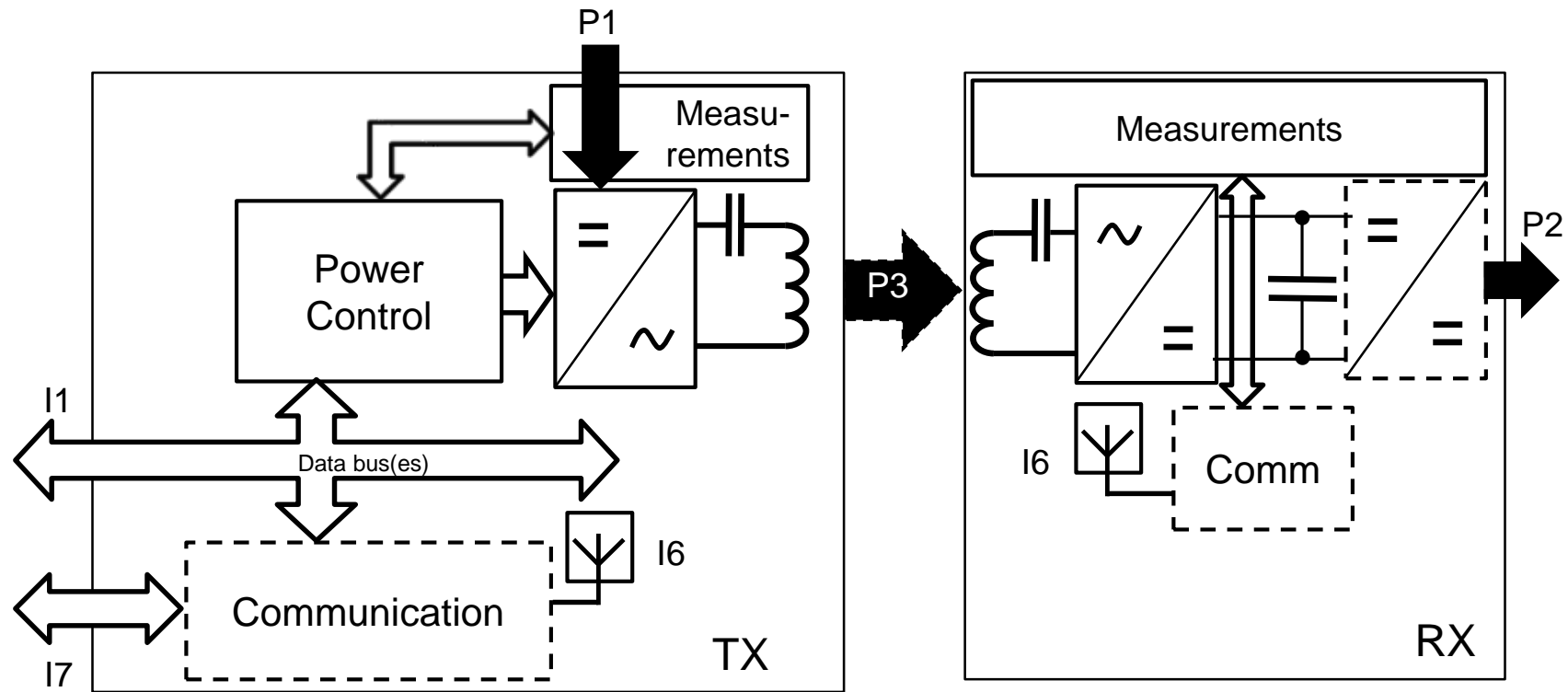
15-20W Industrial Wireless Power System

Commercial / Residential through Window Power Transfer

- Working z-gap: 3-35mm
- Max Output power: 15W+
- Environment: Glass, Air, Plexi



60W INDUSTRIAL PTU & PRU Block Schematic



I1 – User Interface

I6 – BLE PRU <-> PTU Communication

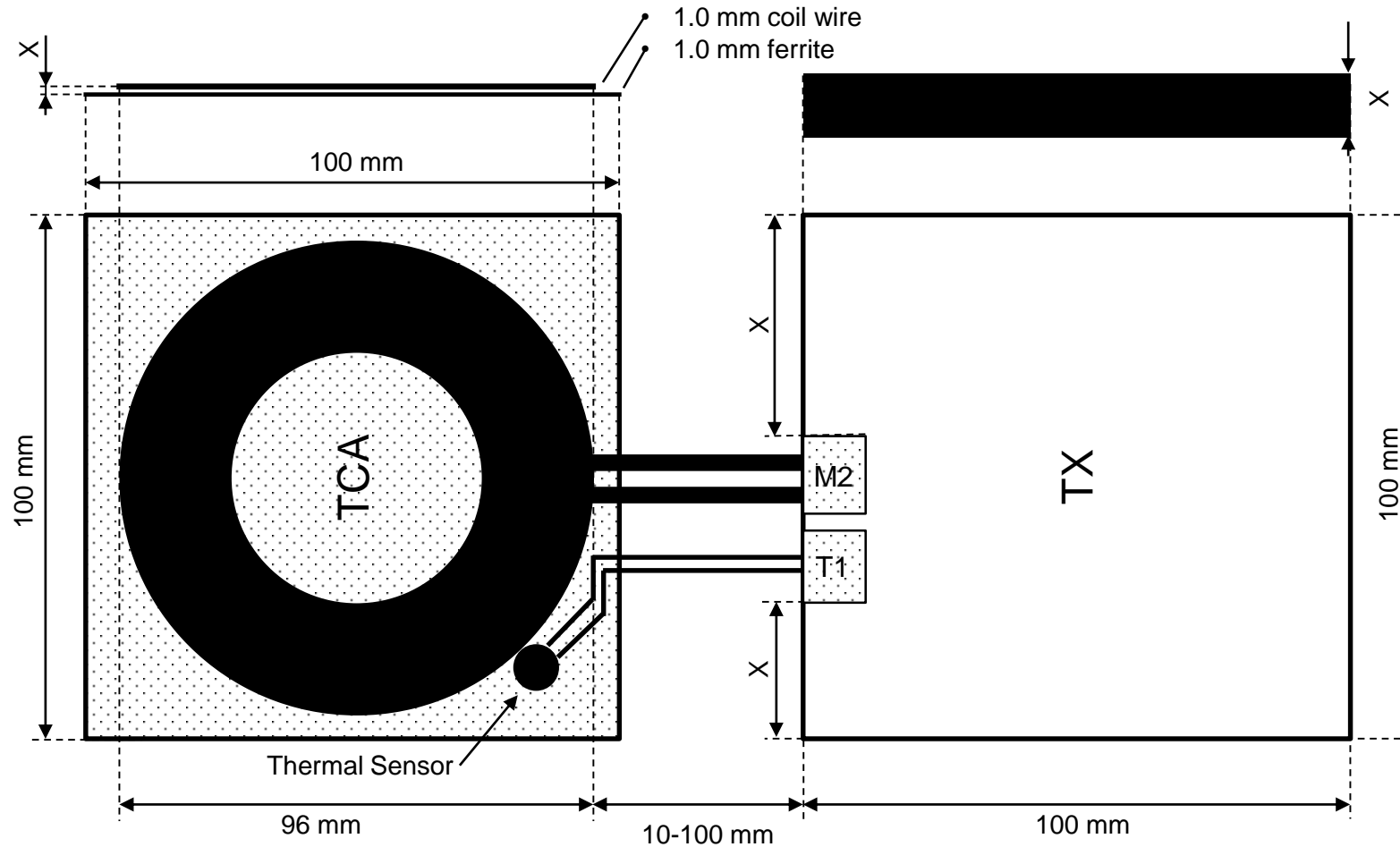
I7 – I2C (EEC) PTU <-> Industrial System Communication

P1 – DC PTU Power Input

P3 – AC 100-145kHz TX -> RX Power Transfer

P2 – DC PRU Power Output (Stable 20V Voltage Source)

65W INDUSTRIAL PTU TX & TCA Dimensions



WIRELESS POWER AND NFC



WIRELESS CHARGING & NFC TAG CONFLICT

NFC TAG can be damaged during power transfer if NFC tag is placed between TX and RX coils



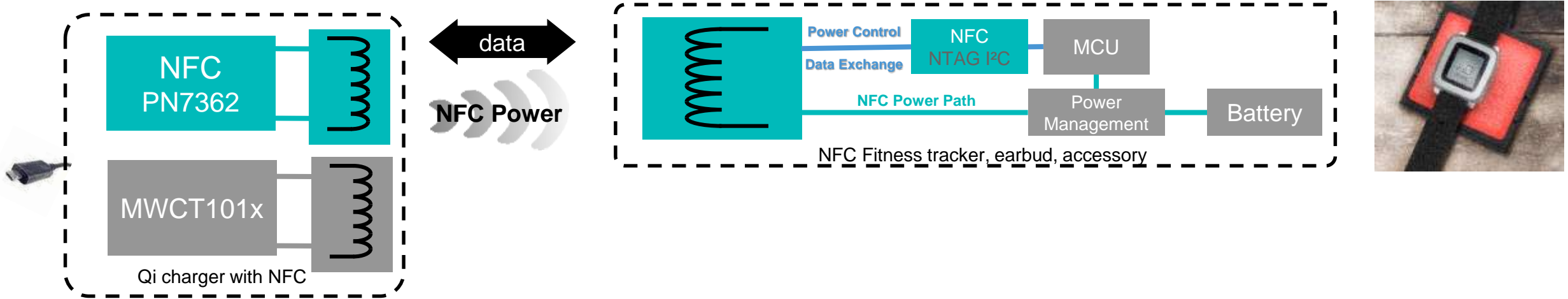
DAMAGE PREVENTION: NFC TAG detection during and before charging



ADDING <1W CHARGING TO Qi TRANSMITTER

NFC in Qi transmitters can directly charge a fitness tracker, earbuds or any other small battery driven accessory

Support broadest range of device from single Transmitter (<1W to 15W)



Fitness trackers to be charged are identified via NFC forum specific wireless charging capability container in NDEF message. In accordance with NFC forum wireless charging standard.

WIRELESS POWER SW



WIRELESS POWER SOFTWARE

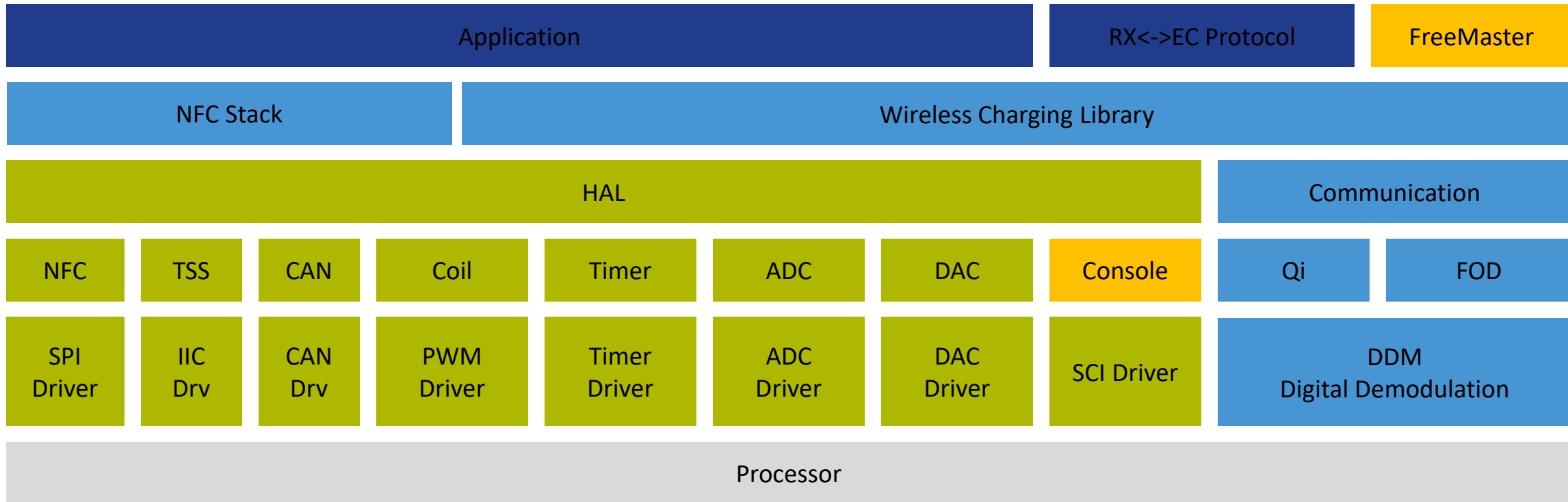
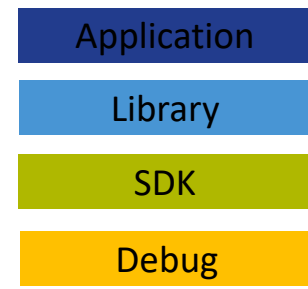
Qi certified library

- Advanced algorithms (NXP IP)
- Qi state machine

Fully customizable application

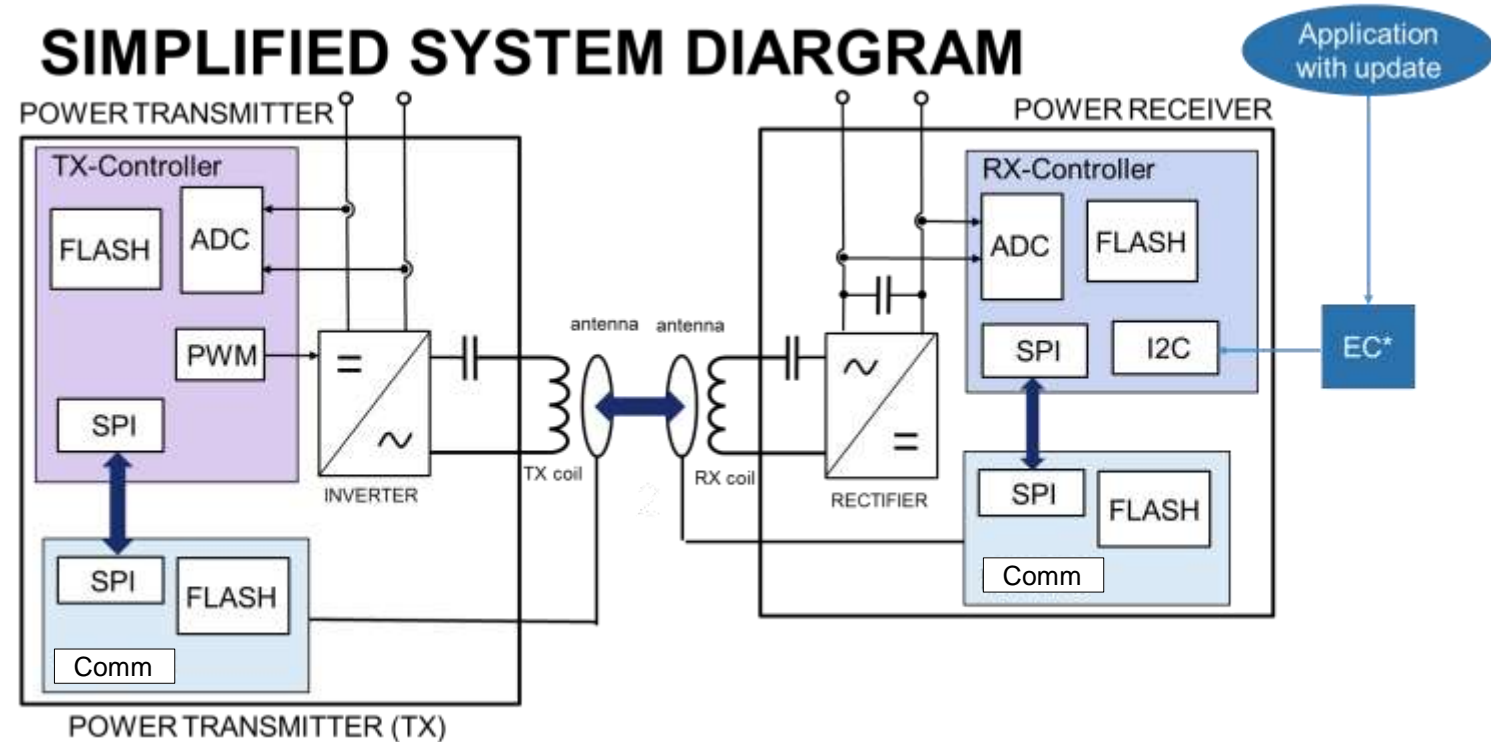
RX<->EC SM-BUS protocol

NFC Stack



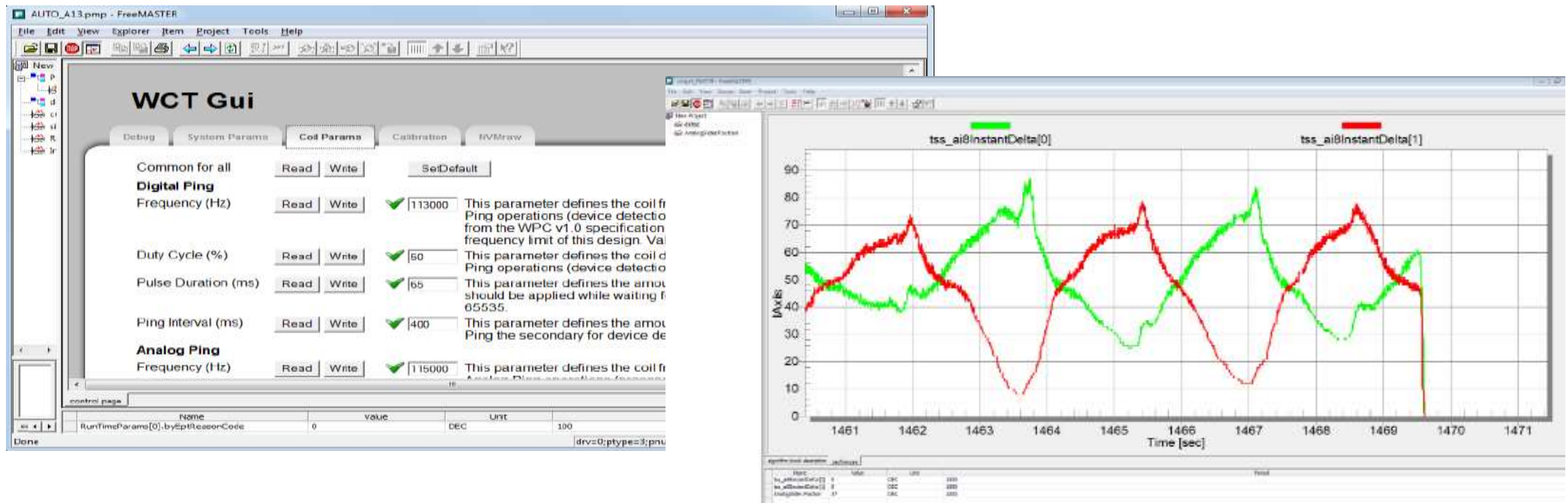
IN APPLICATION FIRMWARE UPDATES

- Ability to update firmware in both power receiver and transmitter MCU from Application interface
- All updates contain sha256 hash - signature is checked prior booting to application to validate its integrity
- Ability to revert back to older version of SW is supported



SOFTWARE DEVELOPMENT VISUALIZATION – GUI

- NXP 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



WPC SPECIFICATION PROGRESS



Wireless Power Consortium 30-100W Specification Progress

- Alliance of 6 companies
 - Joint proposals to move specification forward



LG



- Architecture group was established
 - Dell, HP, Nok9, Schosche
- Spec drafting approved
- Test/benchmark PRx definition in progress
- BLE vs. NFC communication TF under SG
- New WPC governance model in progress
- Separation of Consumer Mobile/Laptops Ecosystem and Industrial Simple Battery Charging

VISION



NXP WIRELESS POWER WORLD VISION

Everything works on the same pad (wearable, mobile, laptop)

Enhanced freedom of positioning

Multidevice charging



30W – 200W

Laptops, Power Tools,
Home Appliances

5 - 15W

Smart Phones

<1W

Hearing aids, wearables



Partner - NuCurrent



Wireless charging with NXP and NuCurrent



Charging without the cord

NXP's excellent wireless power iCs provide the basis for an outstanding wireless power experience. Transmitter and receiver antennas (coils) are critical to power transfer and NuCurrent, an NXP partner, is the leader in this technology.



Growing marketplace need

Now commonplace in mobile phones, wireless charging is advancing rapidly into new product categories and is becoming a key differentiating product feature. Sensors, Wearables, Smarthome



Successful wireless power – Fast!

Getting to market fast is critical and NXP and NuCurrent help get you there. As an NXP Approved Engineering Consultant, NuCurrent brings world-class modeling and simulation, along with NuIQ technology to accelerate your designs



Wireless power experts available to support your product development

- Experts in Wireless Power systems design = successful product launches
- Standards-based wireless power or proprietary systems

Innovators in wireless power and wireless charging

Faster time-to-market and products with the best user experiences

- Patented coil assemblies, which are the thinnest, highest-performance, and lowest-heat in the industry
- Turn-key modules, multi-coil arrays, control software and services
- Hyper-accurate system simulation tools to optimize performance and reduce hardware spins

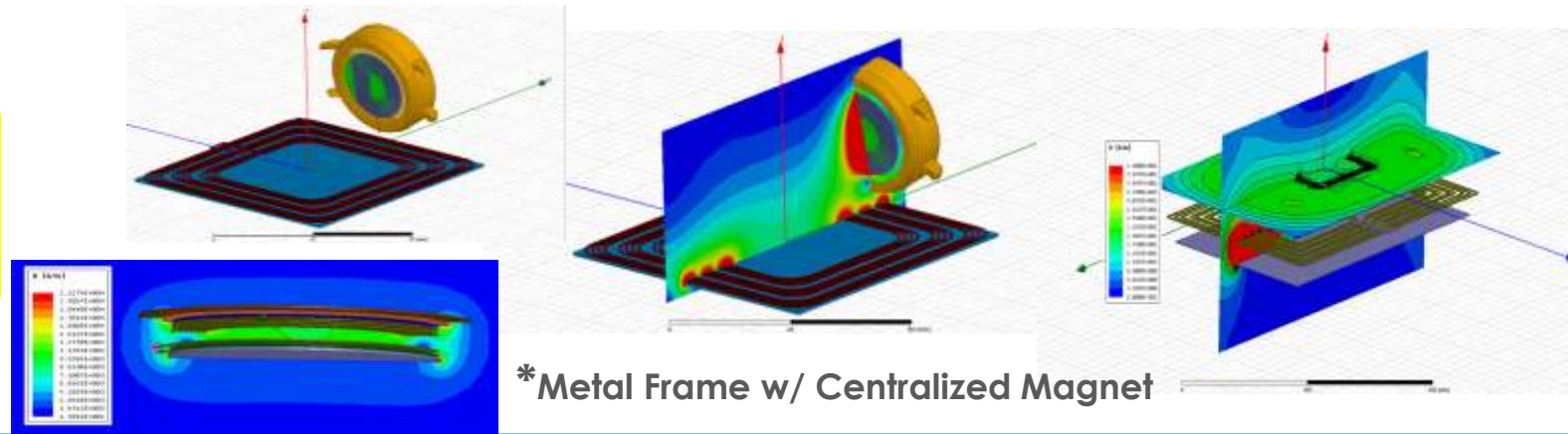
World-class products and services

NuCurrent is an Approved Engineering Consultant with NXP



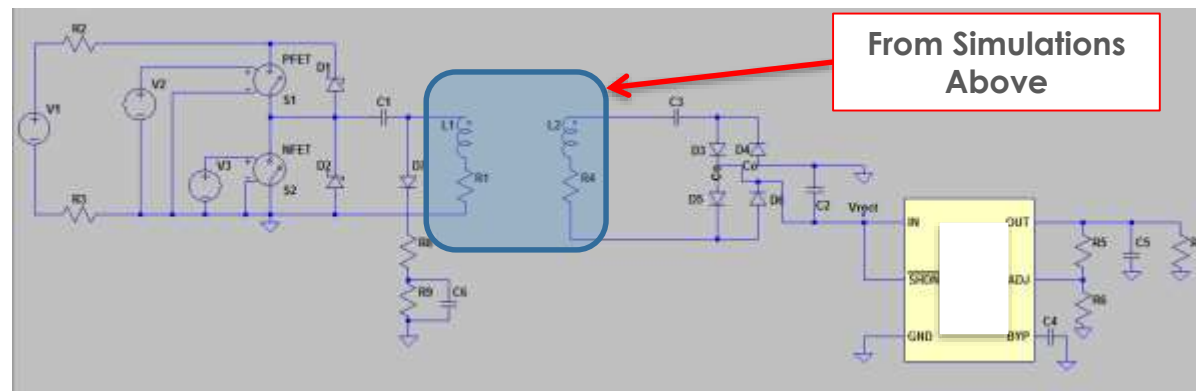
Environmental Modeling: Theory to Actual Product Accurate. Non-Iterative Builds. Seamless Integration.

Magnetics Simulation & Design



- ✓ Fastest Turnaround
- ✓ Design Confidence
- ✓ Fewer Builds Needed

Board Design & Simulation

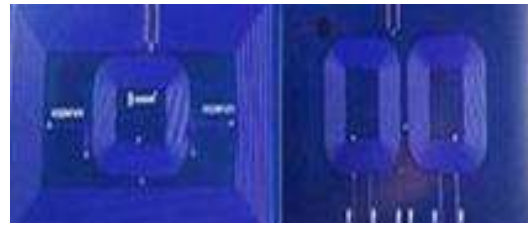


Broad Portfolio to Suit Customer Needs

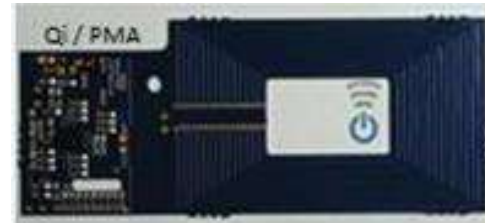
- Meeting the customer where they need us...



Tx & Rx Coils & Resonators



Integrated Multi-Coil Arrays



Active Rx & Tx Modules



Systems & Software



SECURE CONNECTIONS
FOR A SMARTER WORLD

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