bqTESLA™
Making Wireless Power a Reality!

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2Q-2011

Agenda

- Introduction to Wireless Power
- WPC – The Wireless Power Consortium
- bqTESLA™ Solutions
- Questions

Wireless Charging Technologies

Conductive Charging
(Wildcharge, Duracell)

RF Wireless Charging
(Powercast)

TI, Philips, Fulton, Convenient Power, Sanyo and more

Wireless Power Consortium

Palm, Powermat

Toothbrush, Witricity

Wireless Power Consortium (WPC)

Proprietary Solutions

Interoperability key to adoption

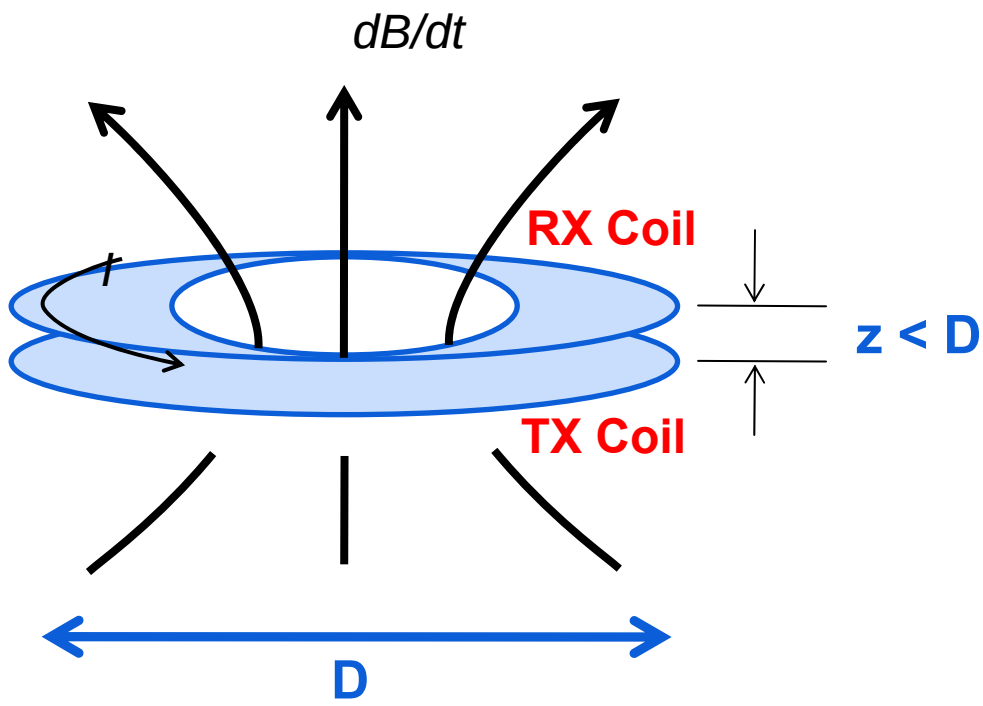
Power For A Wireless World

- Industry wide standard for delivering wireless power upto 5W
- Aimed to enable interoperability between various charging pads and portable devices
- Standard continues to gain traction with increasing list of members (80+)
- Compatible devices will be marked with a logo

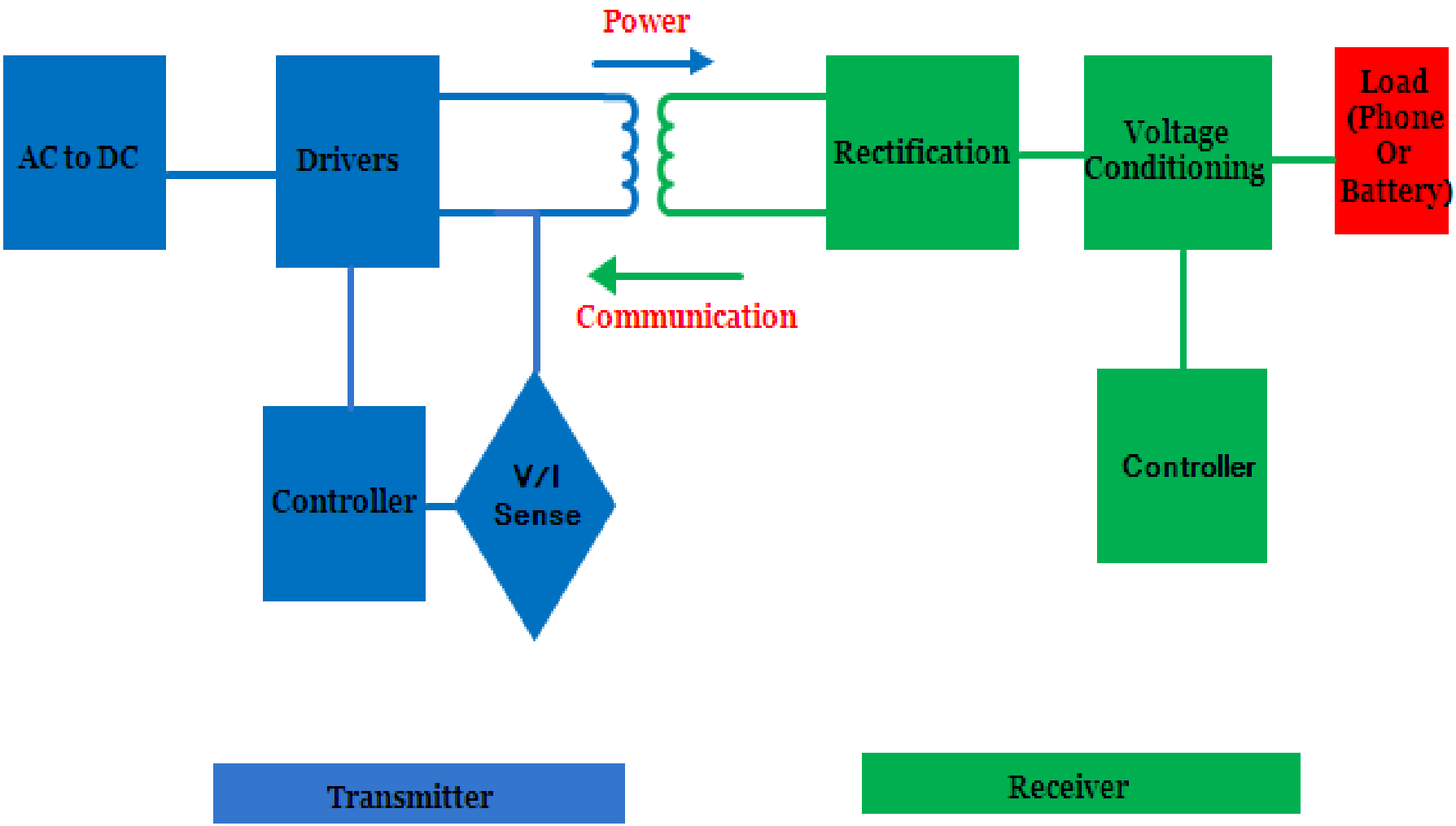
Broad Industry Support

Basics of Inductive Power Transfer

- Inductive power transfer works by coupling a magnetic field from primary to secondary
- Uncoupled field lines rotate around primary coil, don't represent loss as long as the field lines don't couple a parasitic load (eddy current loss)
- Reasonable efficiency can be achieved when the z-gap is less than the coil diameter



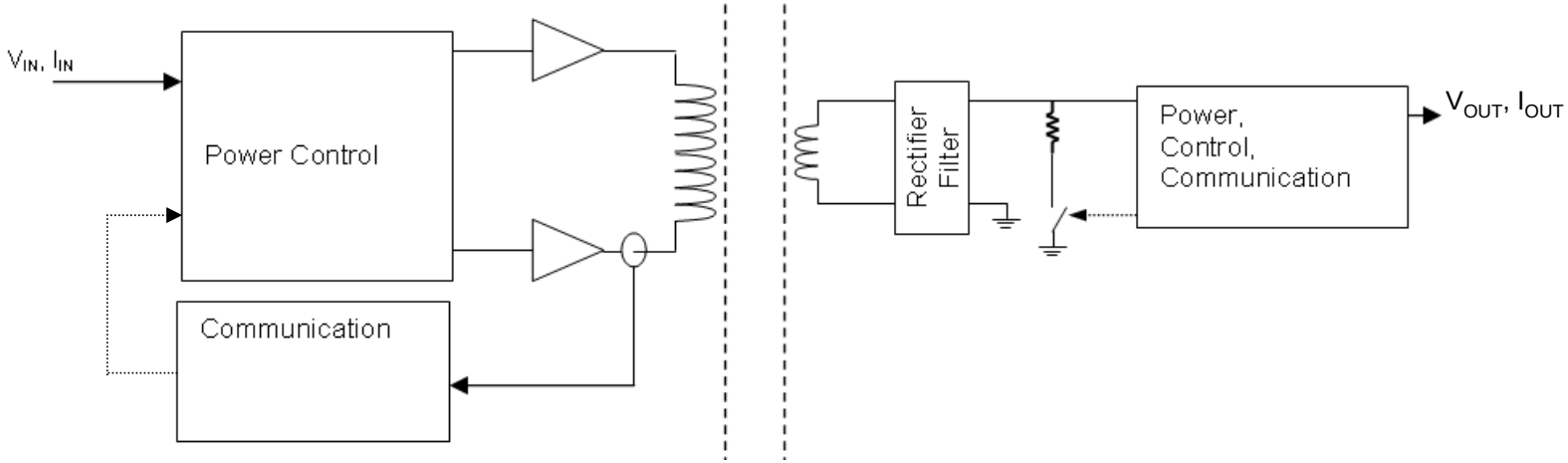
Typical Inductive Power System

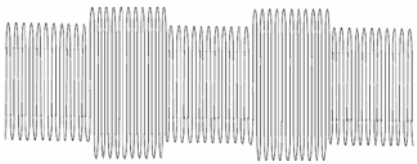


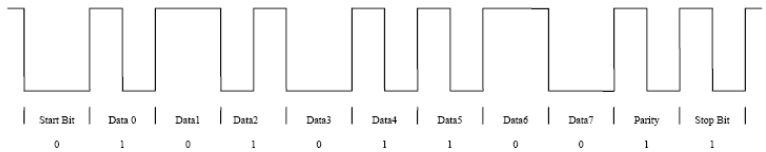
System Overview

- Power transmitted through shared magnetic field
  - Transmit coil creates magnetic field
  - Receive coil in proximity converts field into current
  - Shielding material on each side directs field to reduce stray field, increase efficiency, and increase positional freedom
- Power transferred only when needed
  - Transmitter waits until its field has been perturbed
  - Transmitter sends seek energy and waits for a digital response
  - If response is valid, power transfer begins
- Power transferred only at level needed
  - Receiver constantly monitors power received and delivered
  - Transmitter adjusts power sent based on receiver feedback
  - If feedback is lost, power transfer stops

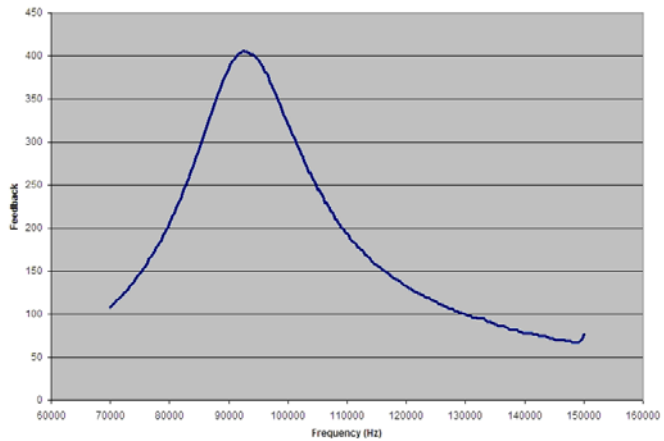
Communication





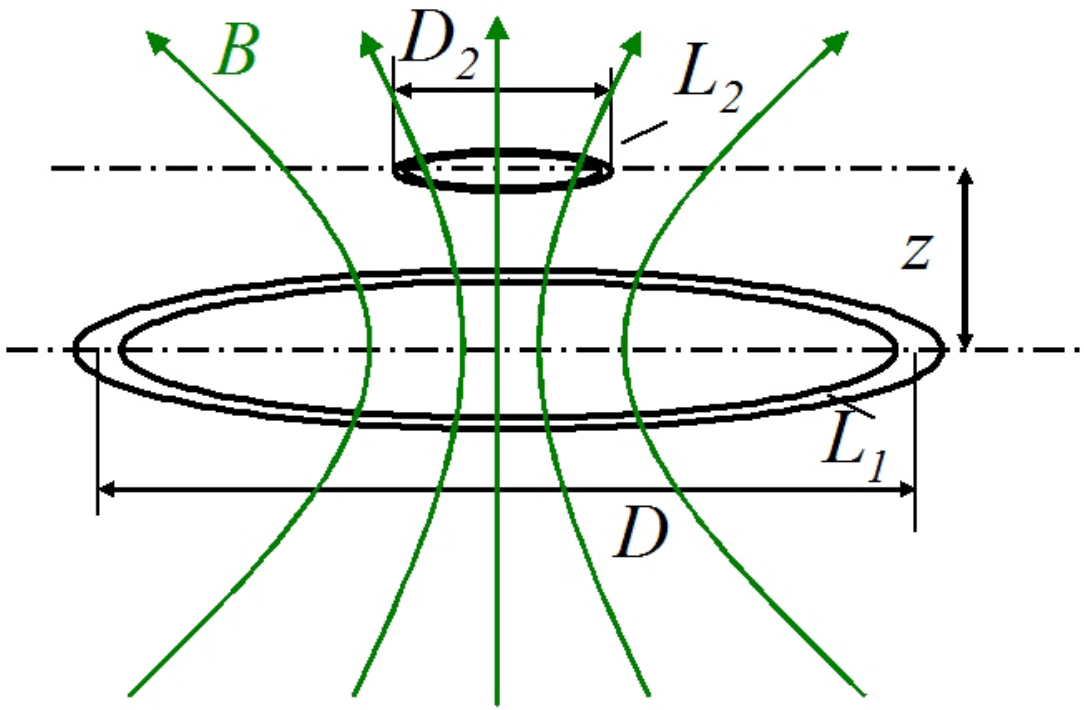


- **System operates near resonance for improved efficiency**
- **Power control by changing the frequency, moving along the resonance curve**
- **Modulation using the power transfer coils establishes the communications**
- **Feedback is transferred to the primary as error**

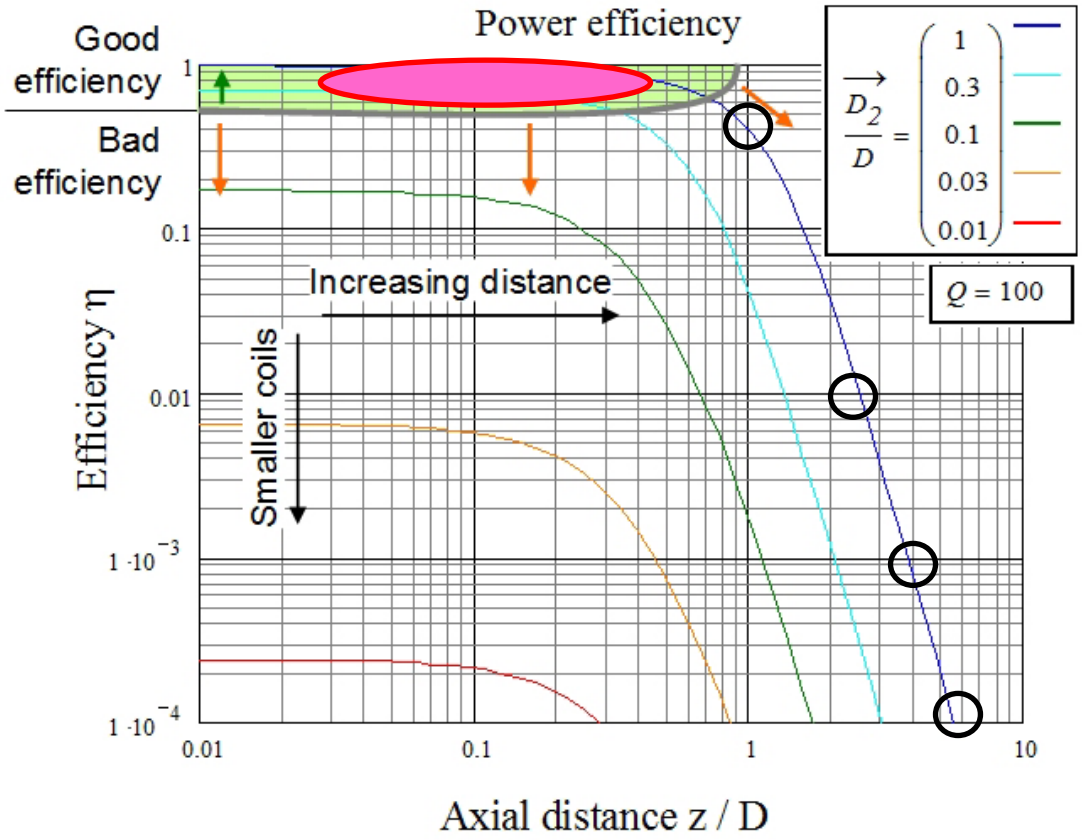


Efficiency Dependencies

- Distance (z) between coils
- Ratio of diameters (D_2 / D) of the two coils
- Q-factor (ratio of the inductance L to the resistance R)



Efficiency Is Good When Coils Are Less Than One Diameter Apart



- Qi operating distance
- 40% at 1 diameter
- 1% at 2.5 diameter
- 0.1% at 4 diameters
- 0.01% at 6 diameters

Market TAM Forecast Data

By Application

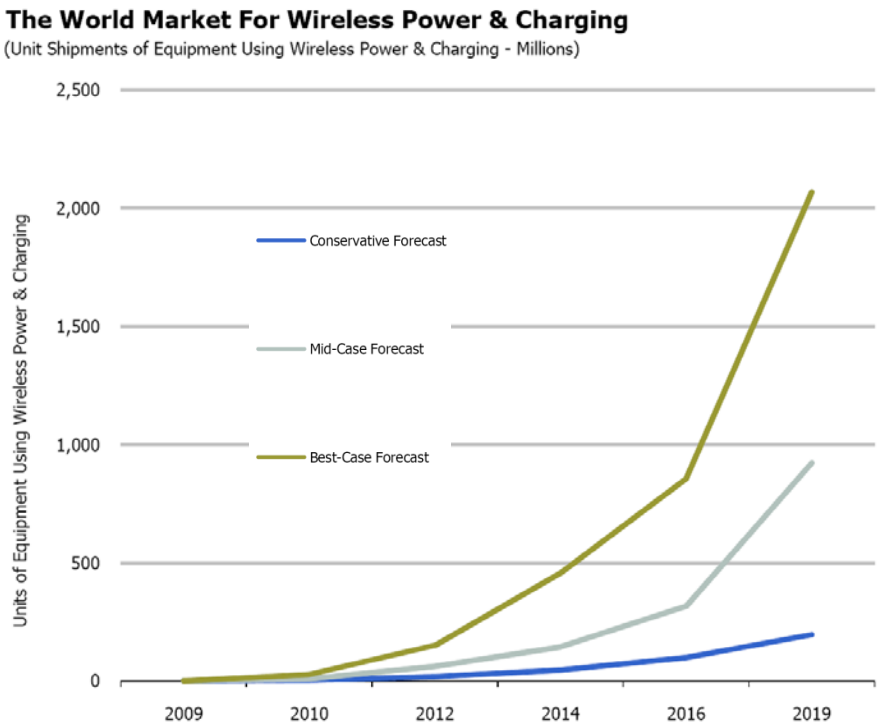
Millions of Units (2009 & 2019)

Application Area	2009	2019	CAGR
Cell Phones	1.3	641.7	85.9%
Games Contollers	0.0	94.3	154.8%
Notebooks	0.0	34.8	137.6%
All Other Portable	0.0	82.7	127.5%
All Other Apps	0.1	69.5	87.5%
Total	**1.5**	**922.9**	**90.5%**

By Implementation

Millions of Units (2009 & 2019)

Supplier	2009	2019	CAGR
Aftermarket Receivers	1.5	331.0	72.0%
Integrated Receivers	0.0	591.9	238.0%
Others	**1.5**	**922.9**	**90.5%**



Inductive Charging - Power Levels

- Low Power : 0 to 5 Watts

- Medium Power : 5 to 125 Watts

- High Power

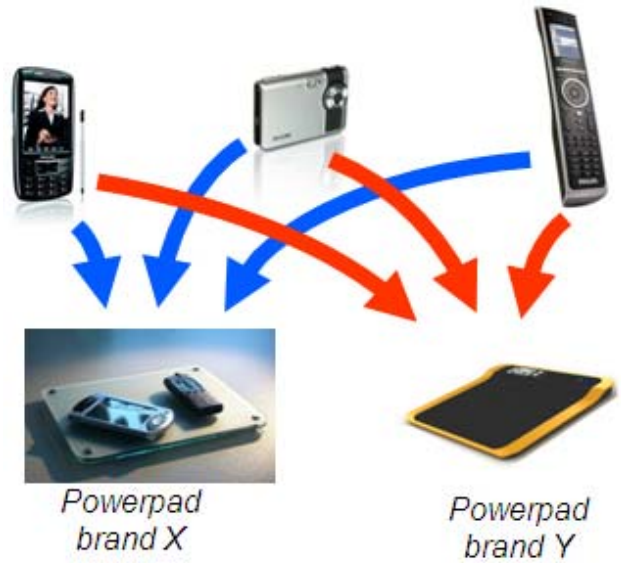
Battery Charge Management

Texas Instruments

Wireless Power Consortium - WPC

Wireless Power Consortium (WPC)

- http://www.wirelesspowerconsortium.com/
- WPC is the only industry standard that has released a specification for low power applications (<5W)
- Currently there are 81 members from various segments of the industry (As of Apr 2011)
- The standard aims to enable interoperability between various charging pads and portable devices
- All compatible devices will be marked with a logo
- The Consortium is now working towards a specification for Medium Power (upto 125W)



TI and WPC

- As members of the Steering and Specification Work groups, TI is actively involved in setting the industry standard and the vision of WPC

- In addition, we are also actively involved in the Promotional, Logo& Licensing and Regulatory Work groups

- TI has also established successful partnerships with various members to accelerate the adoption of WPC solutions into market and solve the technical challenges associated with this technology

Wireless Power Consortium – Members

A short list of members shown above

Qi Devices Announced in the Market

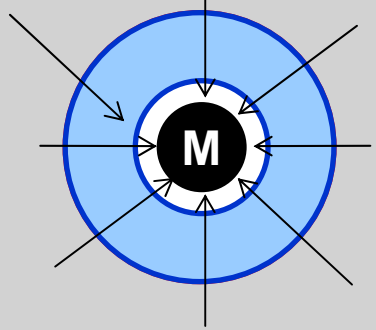
Sengfei's Phone & Charging Pad

LG Charging Pad

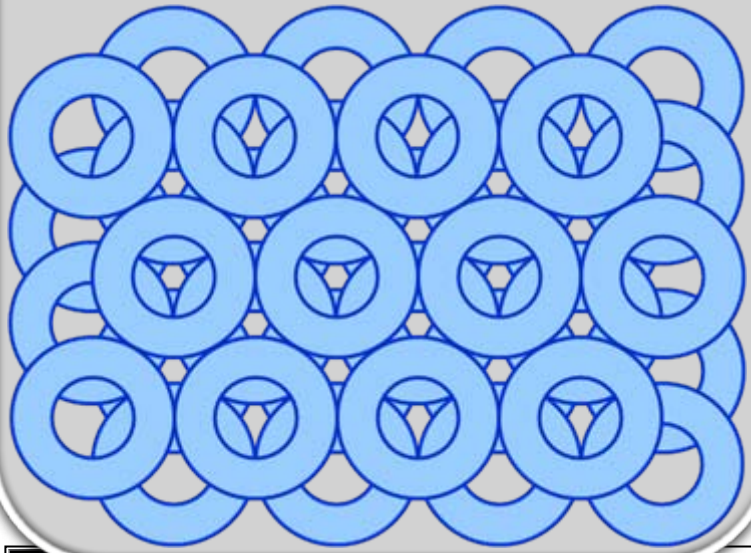
WPC Version 1.0 TX Design Freedom

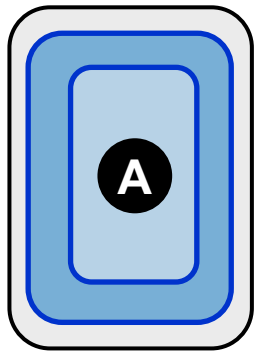
- Tactical feedback, or free positioning
- Alignment, or selection of coils
- Activation after detection

Guided Positioning
(**M**agnetic **A**ttraction)

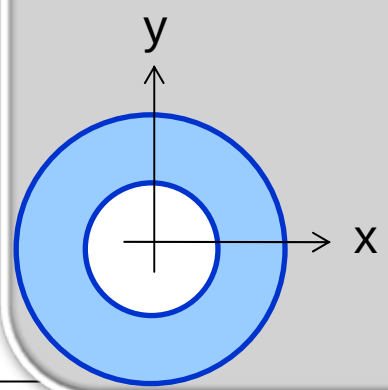


Free Positioning (Coil Array)





Free Positioning
(Moving Coil)



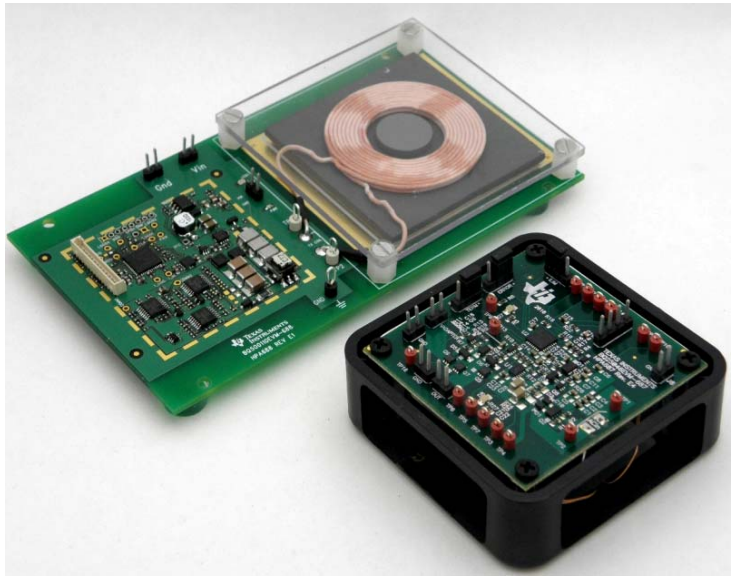
bqTESLA™ Solutions

bqTESLA™ Chipset

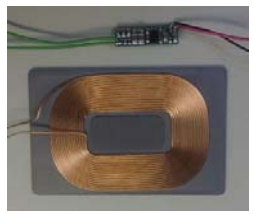
- TI is working on a two-pronged, parallel approach to provide WPC Compliant charging solutions
  - **Gen 1 solutions : Based on discrete components (Released in Nov 2010)**
  - **Gen2 solutions: Based on integrated solutions that will optimize performance, size and cost (Gen2 RX BQ51013 released in Apr 2011)**
- Solutions focused on WPC V1.0 Low Power Standard

bqTESLA™ EVM kit

bqTesla100LP
Gen1 TX+ Gen1 RX

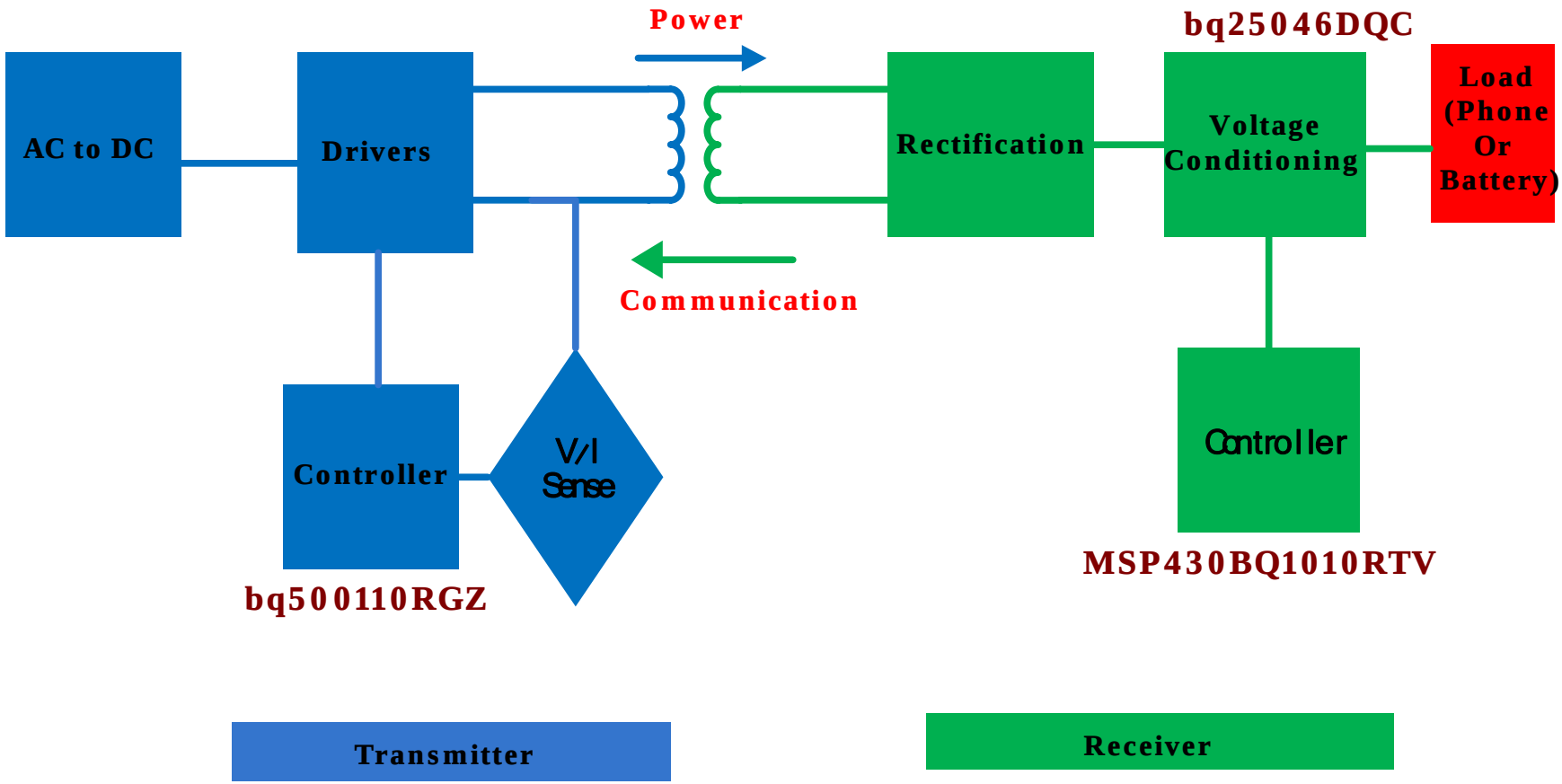


bqTesla150LP
Gen1 TX+ Gen2 RX (BQ51013)



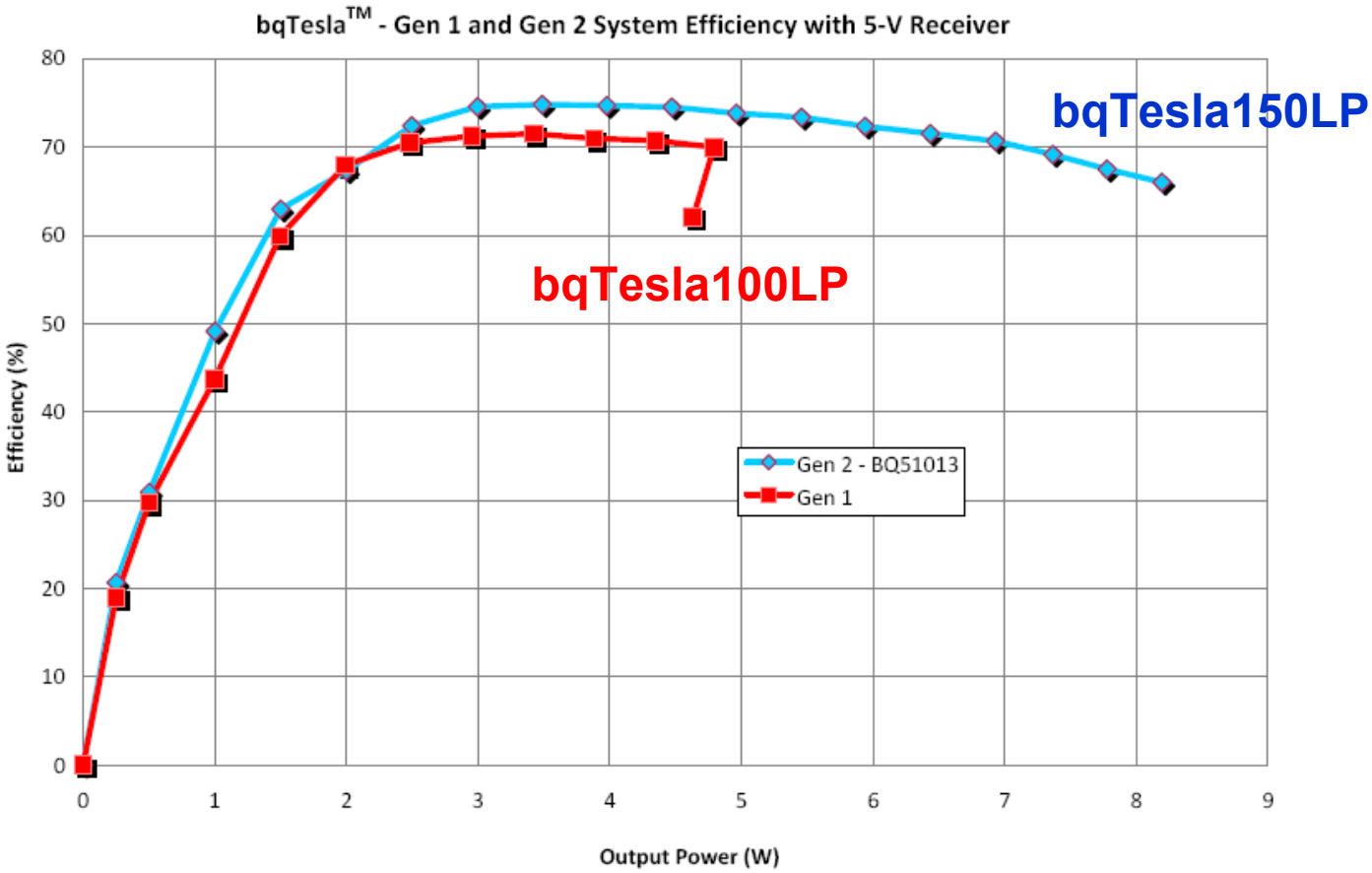
Gen2 RX 2.5W design
PCB 15x50x1.5mm3
BOM count 20
80% Area reduction vs Gen1 !!

bqTesla™: Discrete Solutions (Gen1)



bqTesla™ Eval Kit Efficiency

- Efficiency Curve – from 19V Vin TX to 5V Vout RX



Gen1 (TX+RX) BOM

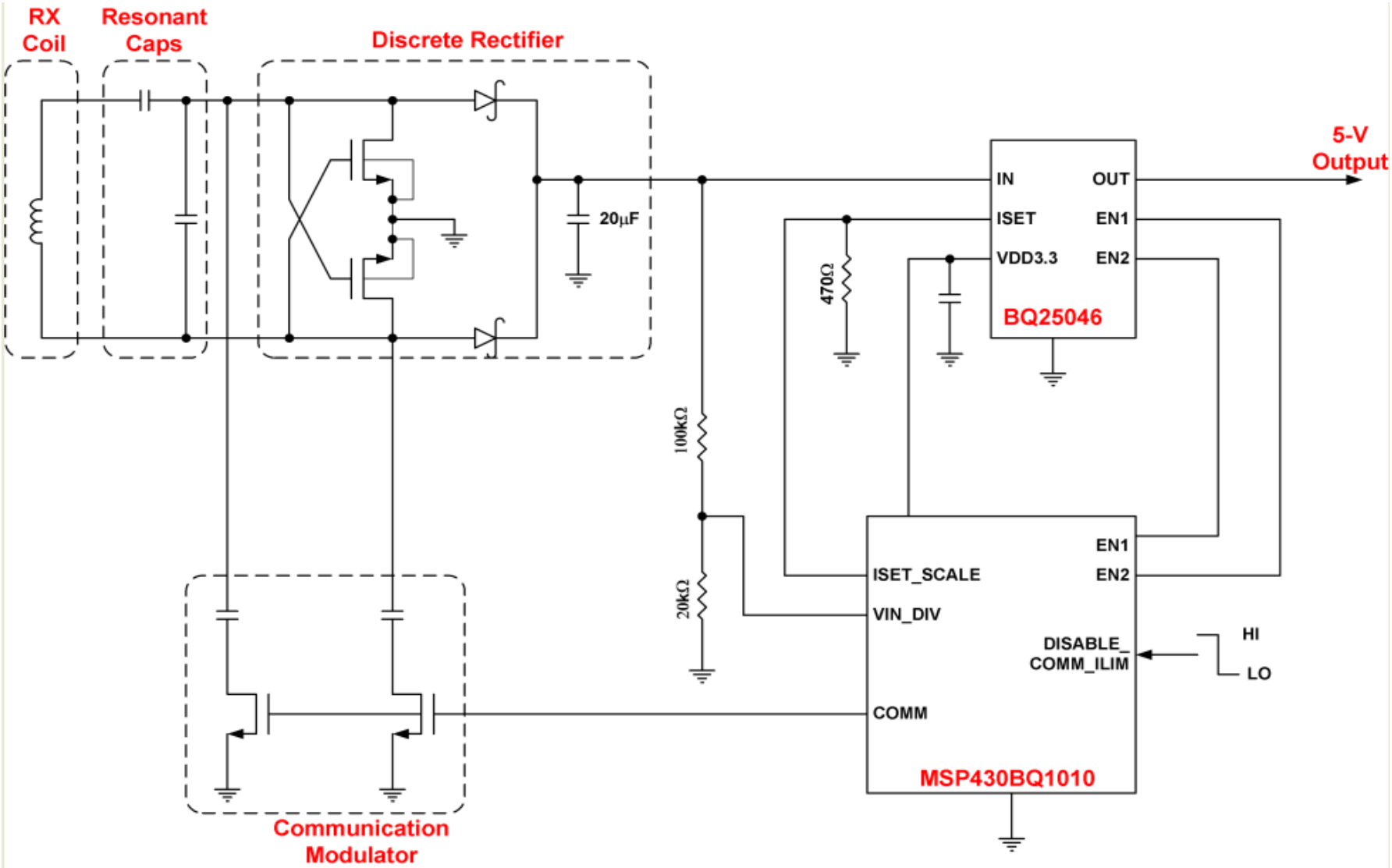
TX/RX	Qty	PART NUMBER
TX	1	TPS54231D
TX	1	INA214AIDCKT
TX	1	BQ500110
TX	1	TPS715A01DRBT
TX	1	TPS28225DRBR
TX	3	OPA4348AIPWR
TX	1	SN74LVC1G3157DCKR
TX	2	CSD17308Q3
RX	3	CSD25302Q2
RX	1	BQ25046DQC
RX	1	MSP430BQ1010RTV

Gen1 Solutions

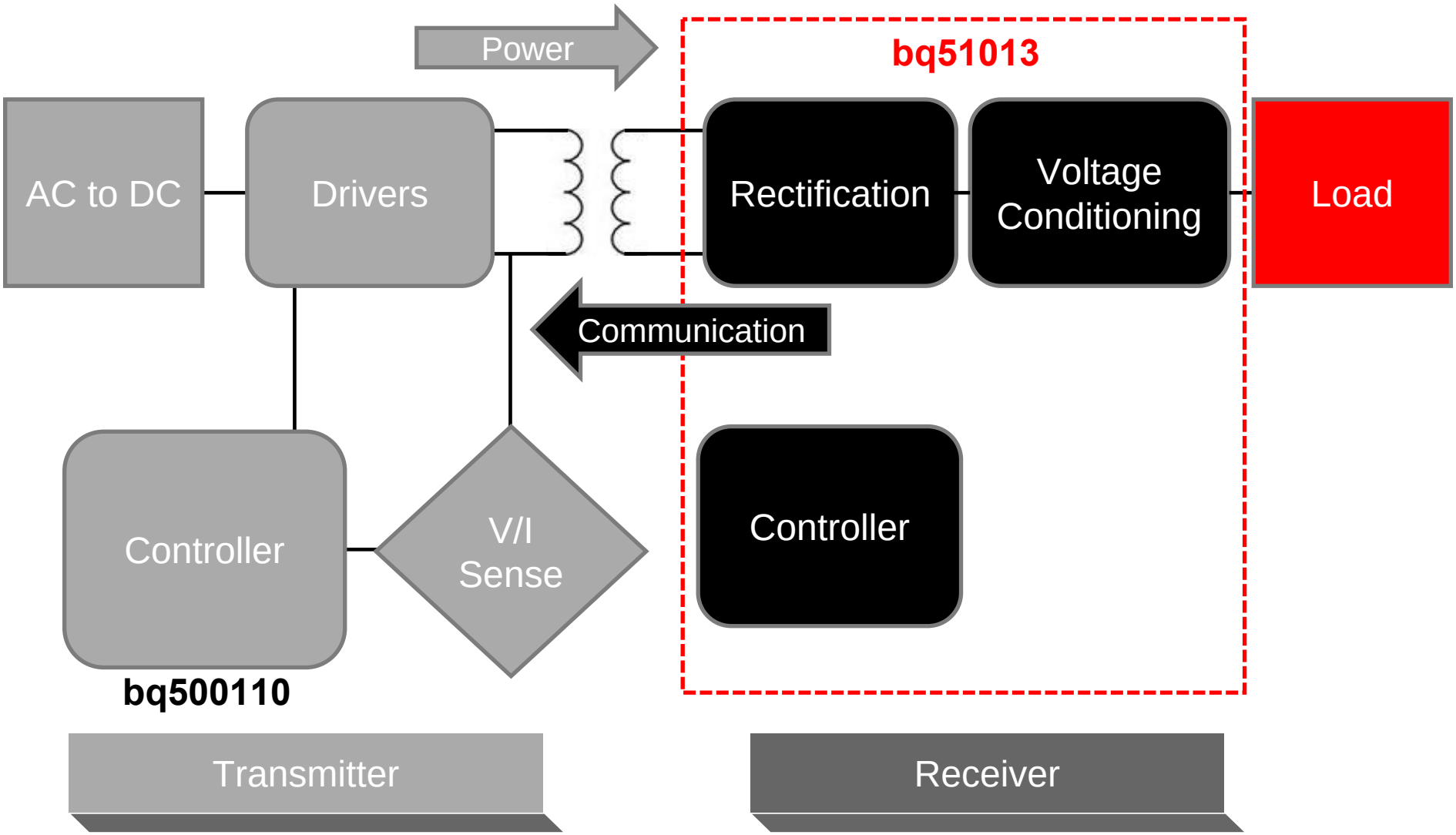
	Transmitter	Receiver
Schematics	Adobe Acrobat Document	Adobe Acrobat Document
Solution Size	52.5x45.7x7	22x16x1.7
# of Components	147	52
Magnetics	WPC v1.0	Customized

bqTESLA™ RX

Rx – Gen1 Power Supply Solution

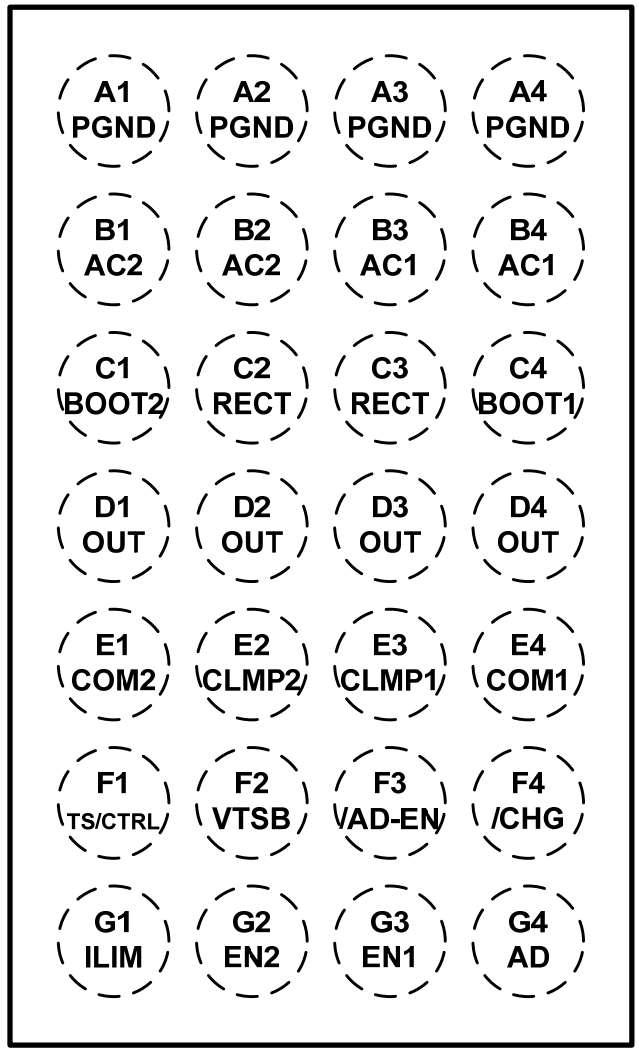


bqTESLA150LP:
Reciever Integration 80% PCB Area Savings vs. ‘100LP



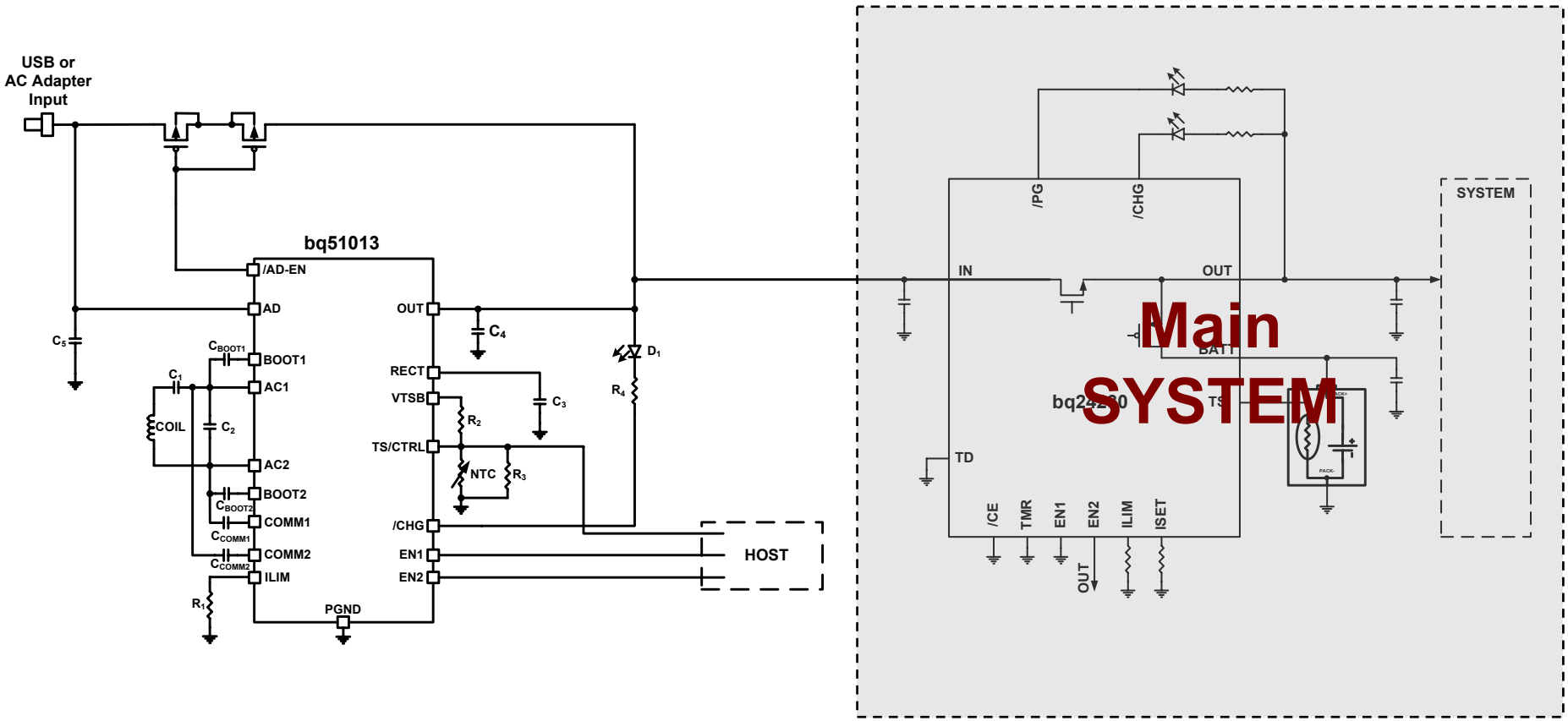
bq5101X — Fully Integrated Linear Charger and Wireless Power Supply

- Integrated Synchronous Rectifier
- Fully integrated digital control
- Supports 20V max input voltage
- Multiple configurations to support
  - Power Supply
  - Direct Charge (Li Ion)
- Over-voltage (Vrect) and over-current protection
- Efficient current limit mode
- Thermal shutdown
- NTC sense pin
- 3.0 x 1.8 mm 28-ball WCSP package



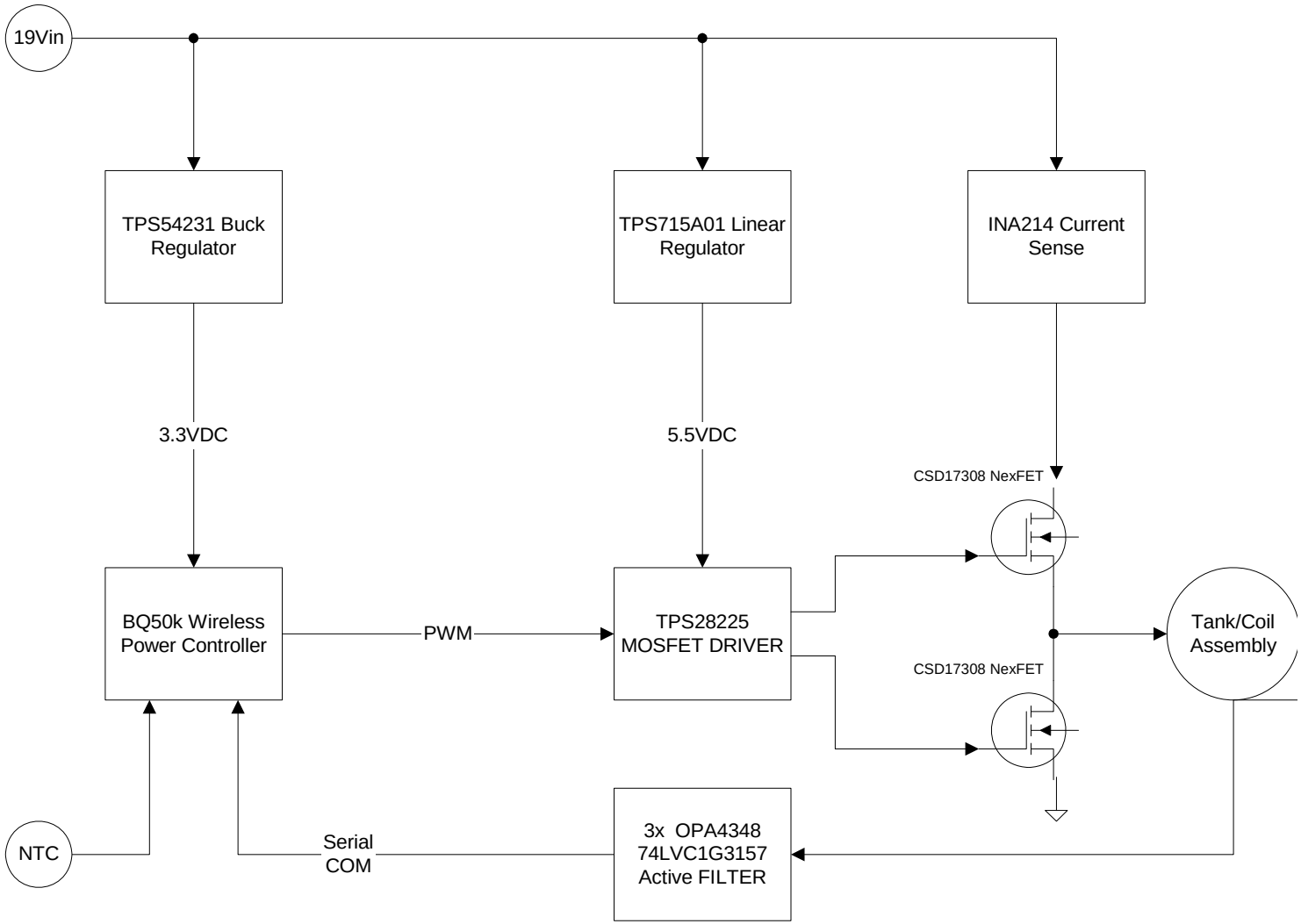
bq51013 – General 5V Power Supply

- bq51013 automatically selects between AC and wireless input power
- When wireless power is active, IC communicates with the primary to regulate the secondary voltage to 5V. bq51013 acts as a Power Supply to deliver 5-V to the VIN pin of the system charger



bqTESLA™ TX

GEN1: TX System Diagram

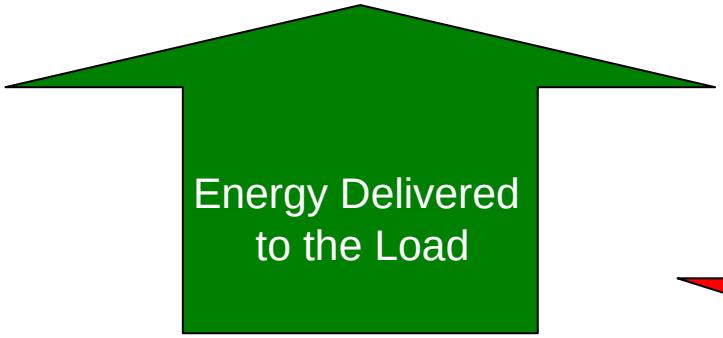


Tx Safety Protections

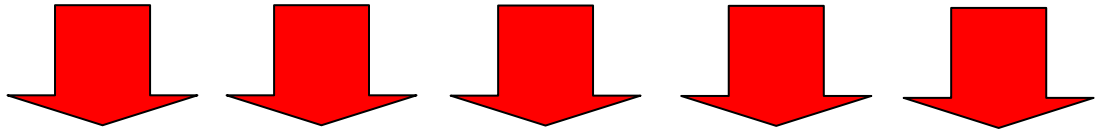
- Parasitic Loss Detection
- Thermal Protection
- Max Output Power – 10W
- Max Coil Current – 3A
- Wall Adapter over-current Protections

Parasitic Object Detection based on Loss Reconciliation During Power Transfer

Rx Side

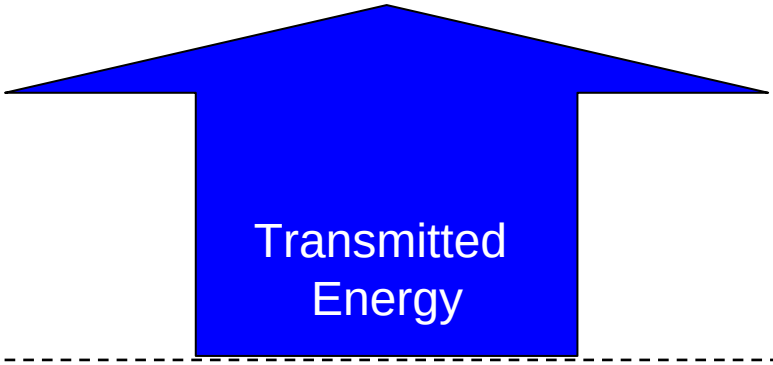


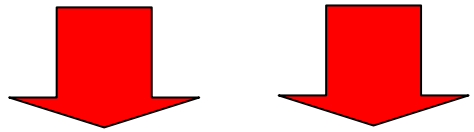
1) Conductive Losses in Rx Coil and Rectifiers
2) Rx Shield Magnetizing Losses
3) Eddie Current Losses in Friendly Metal Objects
4) Energy spent in Control Circuits
5) Energy Lost in Foreign Metals



This Approach Requires Significant Knowledge Of Energy Transfer Intricacies

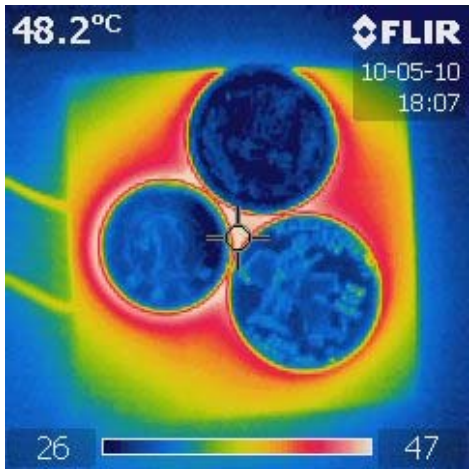
Tx Side: Energy Delivered to Tx Power Circuit

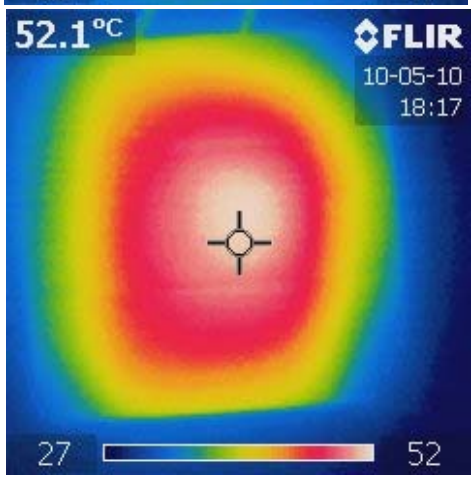




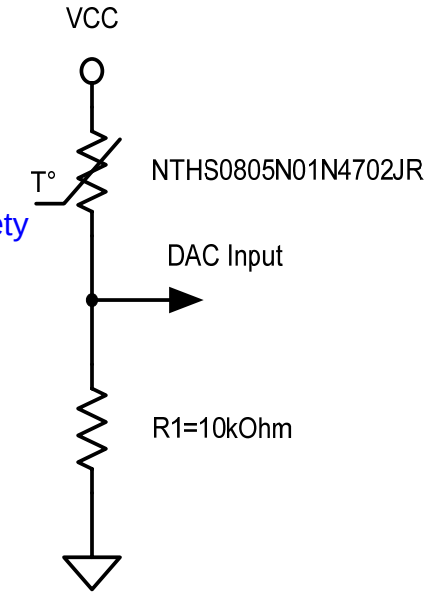
1) Conductive Losses in Tx Coil & FETs
2) TX Shield Magnetizing Losses

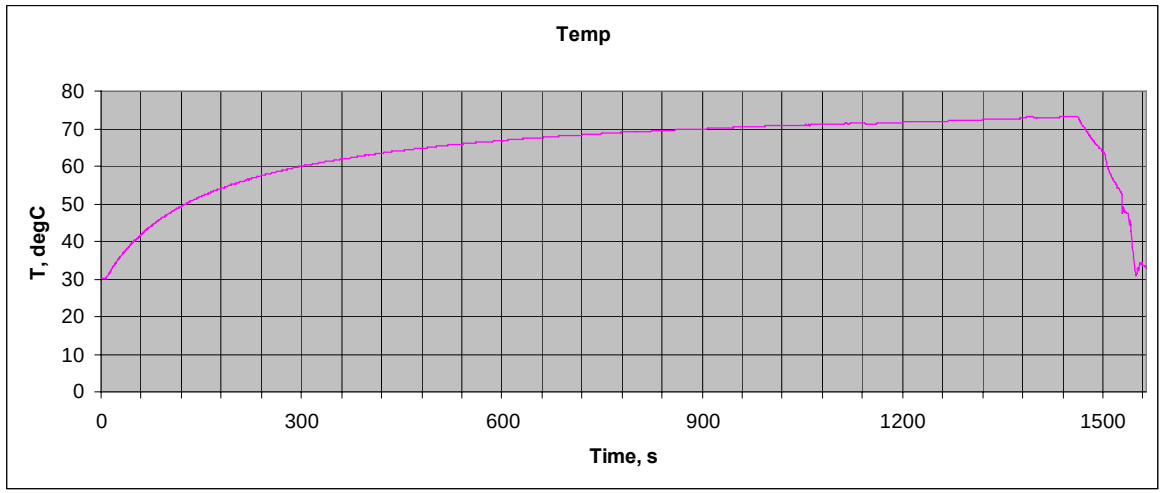
bq500110 Thermal Protection



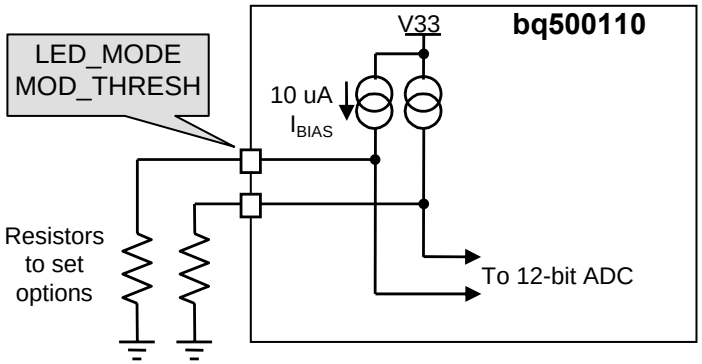


- Active surface temperature monitor provides additional safety protection
- OVT Action:
  - fixed threshold; variable R1 to set trip point (the decided upon approach)
  - every 1 s reading





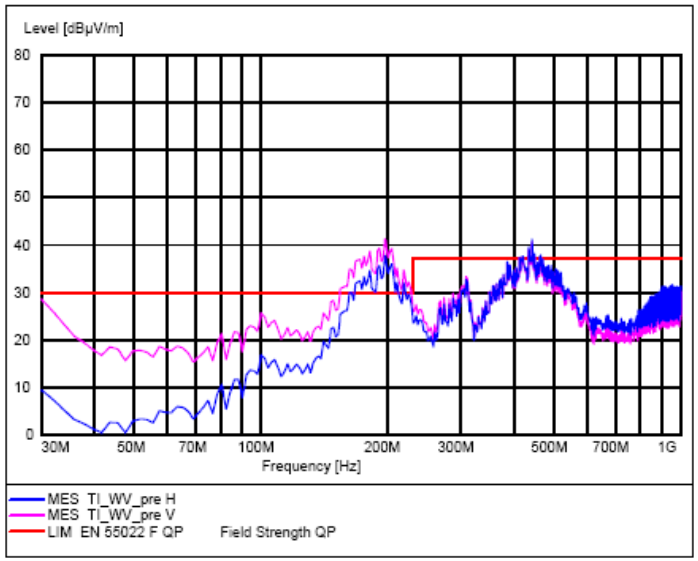
Programming LED mode an PLD Threshold



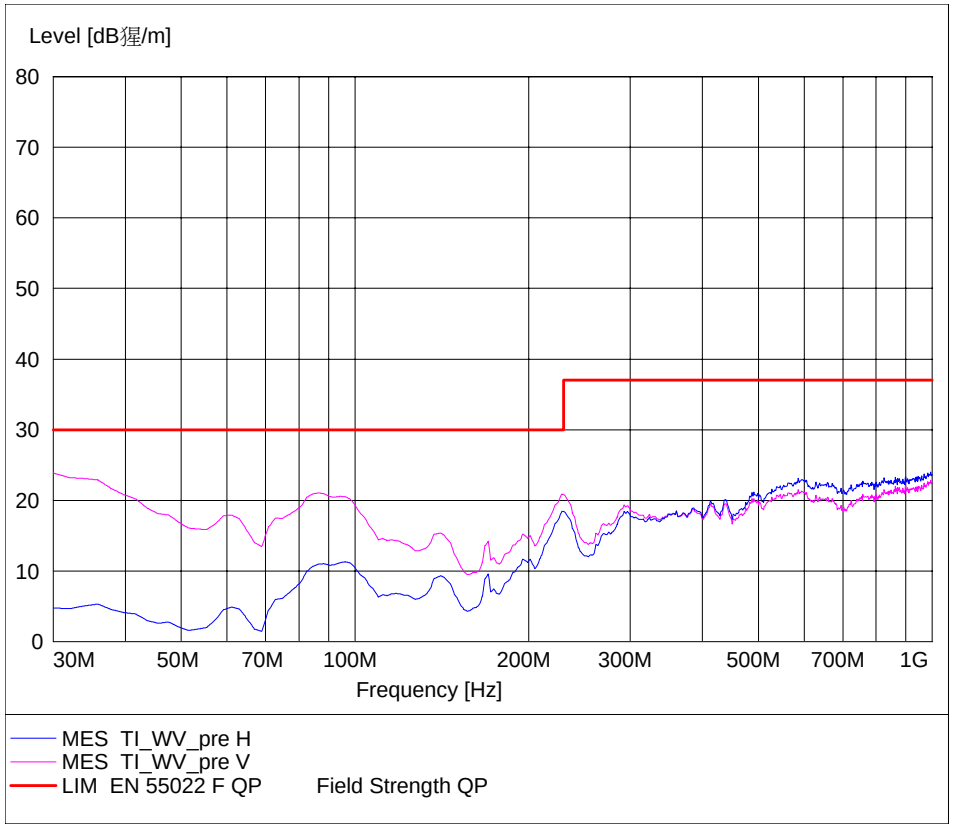
Bin number	RESISTANCE (kΩ)
13	open
12	205
11	178
10	154
9	133
8	115
7	100
6	86.6
5	75
4	64.9
3	56.2
2	48.7
1	42.2
invalid / disable	ground

EMI Considerations

CISPR22 Not Intended Transmissions



Not Optimized EVM



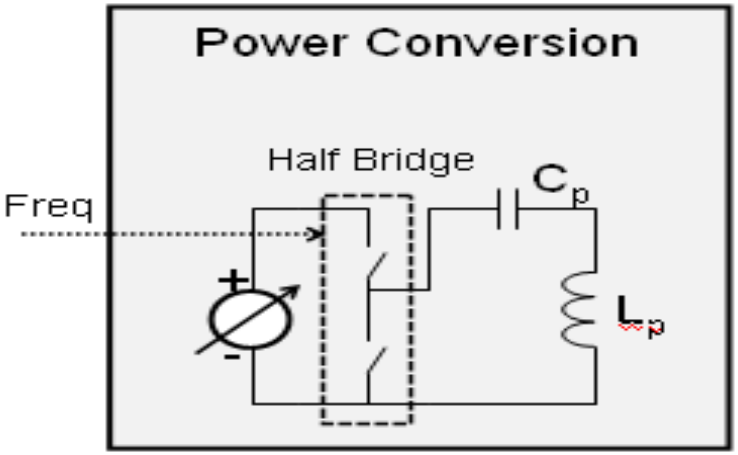
Improved TI EVM

Summary

- NDA Requirement
  - **Only need for un-RTP product information**
- bqTesla EVM kits
  - **http://focus.ti.com/docs/toolsw/folders/print/bqtesla100lp.html**
  - **Search “bqTesla” in eStore**
- Contact
  - **Asia : Silvan Ho, silvan_ho@ti.com**
- WPC website
  - **http://www.wirelesspowerconsortium.com/**

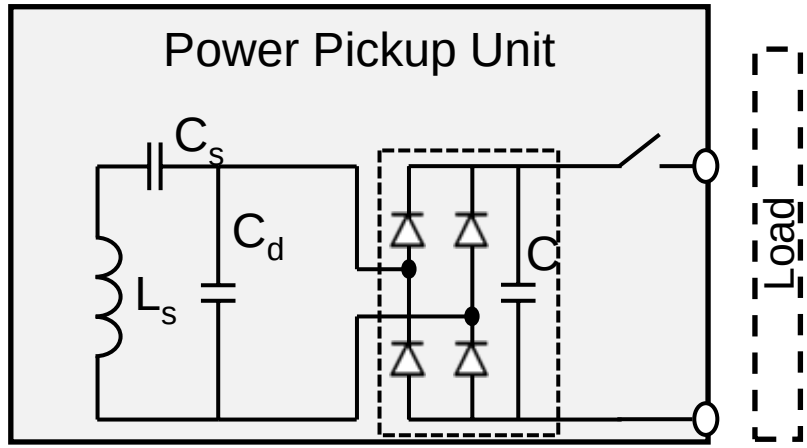
Questions …….

Transmitter



- Primary coil (Lp) + serial resonance capacitor (Cp)
- Inverter: e.g. half bridge
- Controlled by e.g. frequency or voltage

Receiver

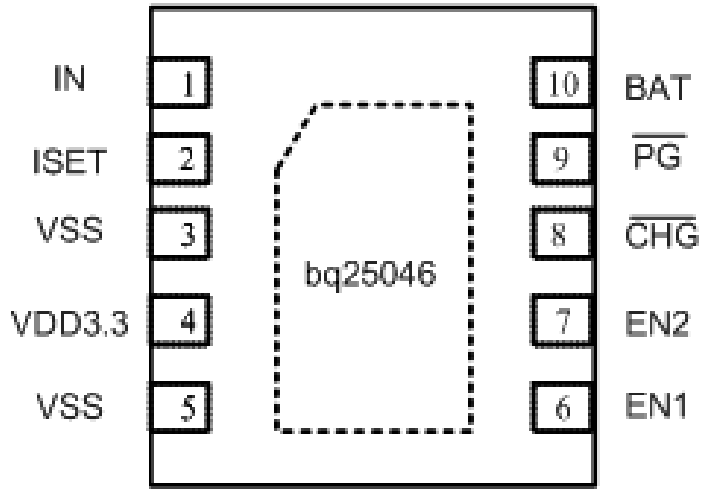


- Secondary coil (L_s)
- Serial resonance capacitor (C_s) for efficient power transfer
- Parallel resonance capacitor (C_d) for detection purposes
- Rectifier: full bridge (diode, or switched) + capacitor
- Output switch for (dis-)connecting the load

bq25046: 1.5A,Single-Input, Wireless Receiver Power Supply with 15mA LDO

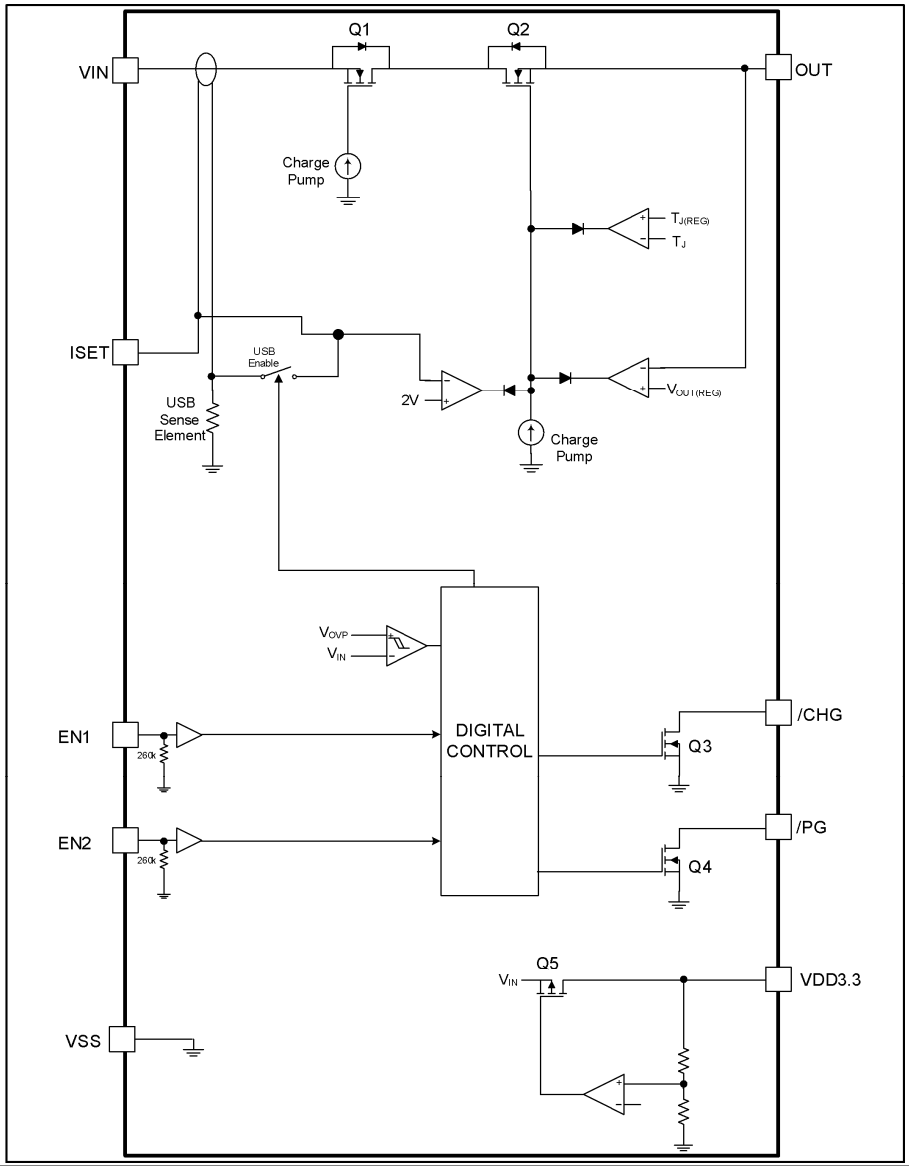
Features

- 30V input rating, with 15V Over-Voltage Protection (OVP) threshold
- Integrated charge current sense for contactless power transfer efficiency monitoring
- 3.3V, 15mA integrated low dropout linear regulator (VDD3.3) supplies power to MSP430BQ1010 directly
- 2% Output Voltage Regulation
- Pin selectable 100mA and 500mA current limit enables robust communication at any output current level
- Soft-Start feature to reduce inrush current
- Status Indication – Power Good (/PG) and Output Enabled (/CHG)
- Available in small 2mm x 3mm DFN-10 package



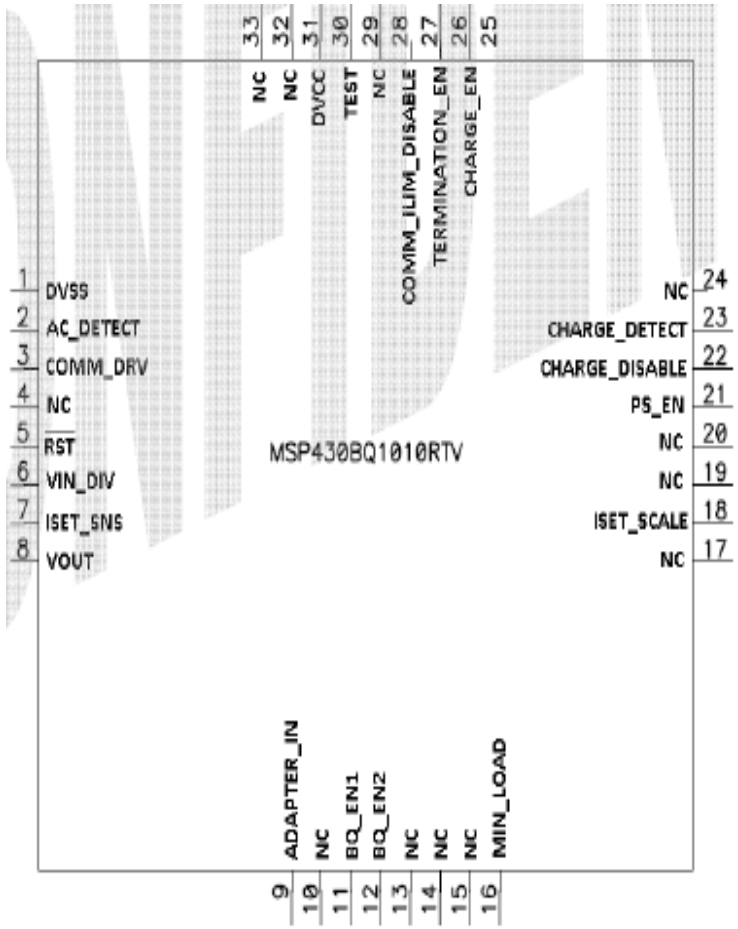
10-pin 2mm x 3mm DFN

bq25046 Block Diagram



MSP430BQ1010

- Enables contactless power solution
- Communication & voltage/current monitoring
- WPC-compliant communication protocol
- Optional contactless power transfer termination
- Fixed function device - No software development required
- 5.0 x 5.0 x 0.75mm 32-pin RTV (QFN) package



bq500110 Wireless Tx Controller

- Intelligent Control of the Power Transfer between Base Station and Mobile Device
- Conforms to the Wireless Power Consortium (WPC) Wireless Power Transfer v1.0 Specification
- Demodulates and Decodes WPC Complaint Message Packets from the Power receiving device over the same wireless link that transfers electrical power
- Implements closed-loop Power Transfer PID control by modulating frequency of the voltage on the transmitting coil
- Half-bridge NFET power stage
- 3 Digital I/O Pins
- Input Voltage of 19V
- 7x7 48 pin QFN Package (Pb Free, RoHS Compliant)