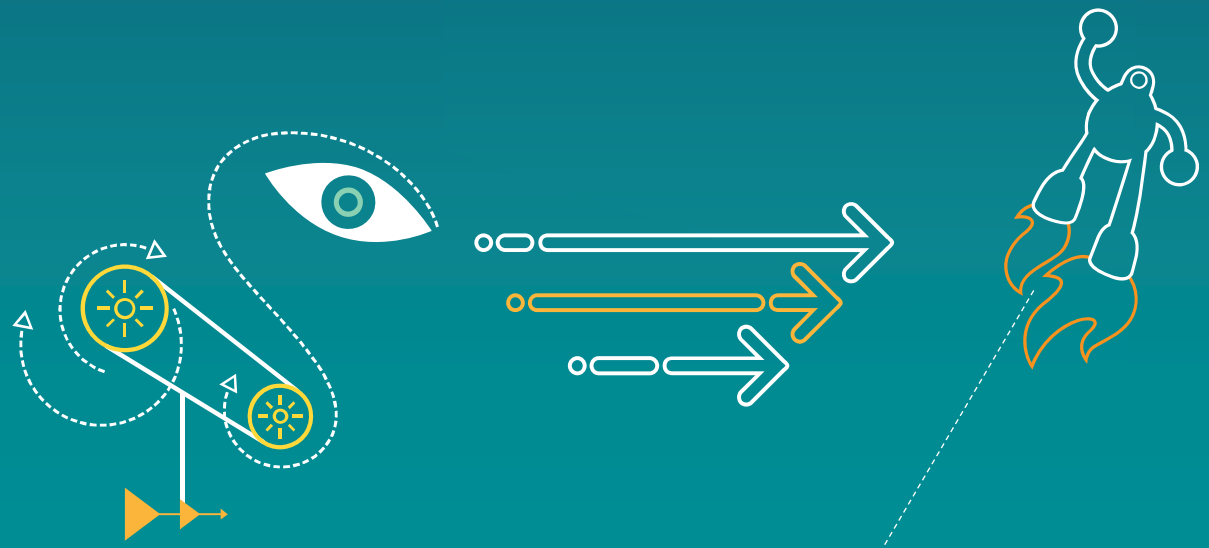
Francesco Carobolante
Vice President – Wireless Power Engineering
Qualcomm Technologies, Inc.

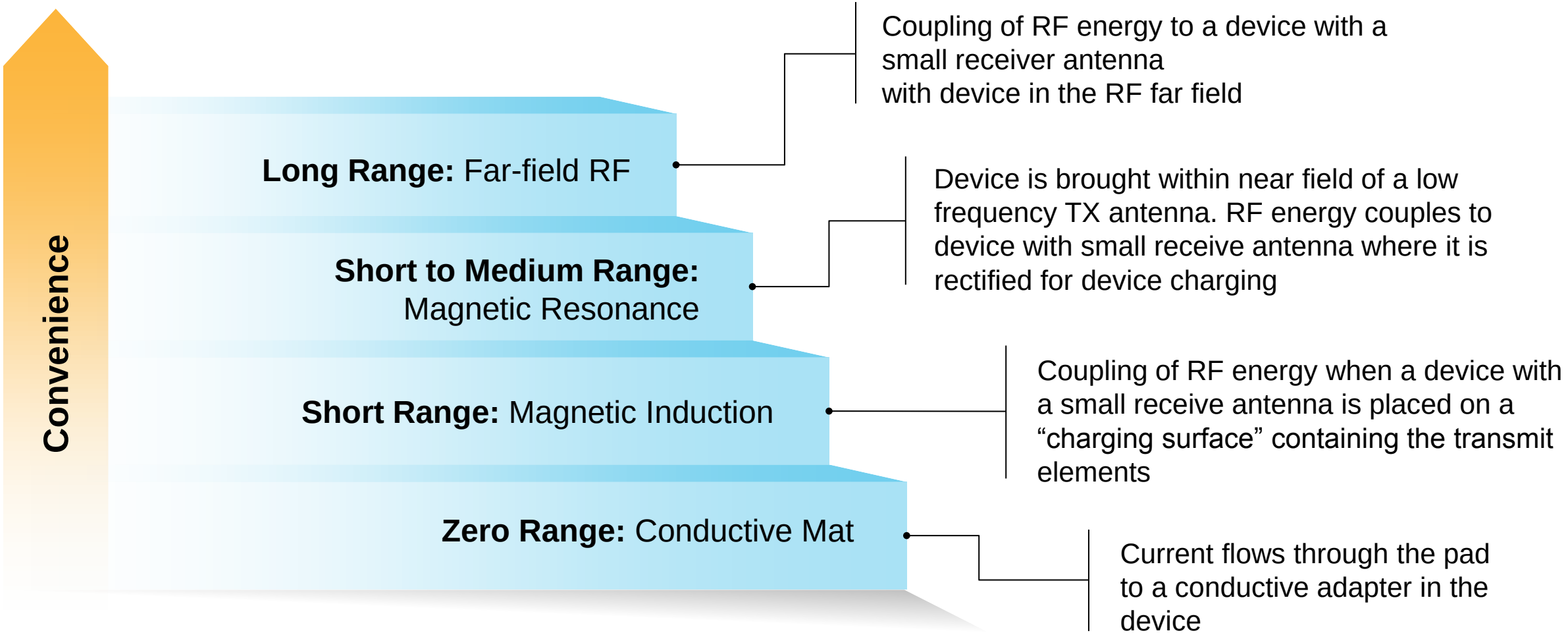
Wireless Charging by Magnetic Resonance

QUALCOMM®

ECTC 2014
Wireless Power Transfer Systems

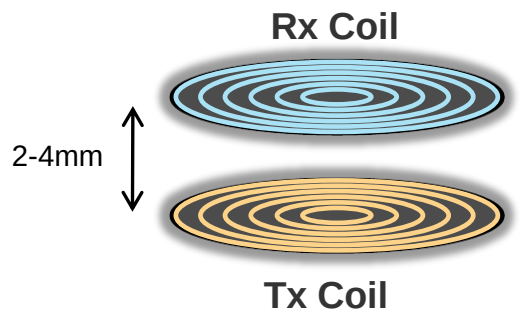


Wireless Charging Landscape



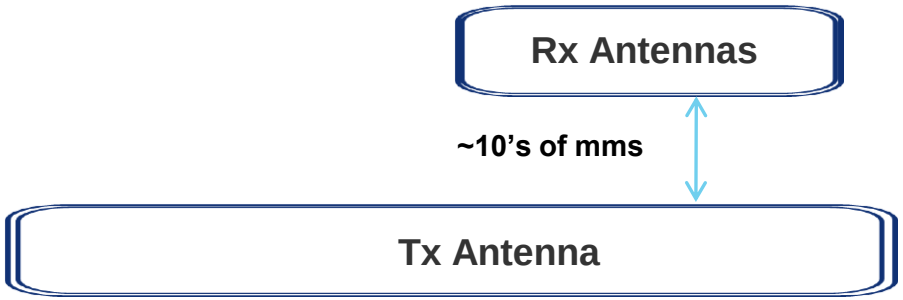
Magnetic Resonance vs. Inductive Solutions

Key Distinctions – Size, Separation and Orientation



Magnetic Induction (MI)

- 1:1 ratio of Tx to Rx coil
- Tx and Rx coils:
  - Are generally closely matched in size and shape
  - Are generally in close proximity to each other
  - Generally utilize magnets or other mechanism to maintain precise alignment



Magnetic Resonance (MR)

- Tx antennas are designed to create a CHARGING AREA or FIELD
- Allows devices to charge effectively even when Tx & Rx is separated by 10's mm
- Not impacted by coins, pens, and other metal objects
- Doesn't affect magnetic strip credit cards
- No precise alignment required of Rx to Tx
- Not just limited to desktop solutions

Freedom of Placement

Magnetic Induction (MI)

- MI solutions utilize positioning devices, such as magnets or physical constraints such as blocks or ‘posts’ to insure alignment.

- You cannot place the BT device on the tablet charging spot, and you can’t place the tablet on the smart phone spot and expect them to charge.

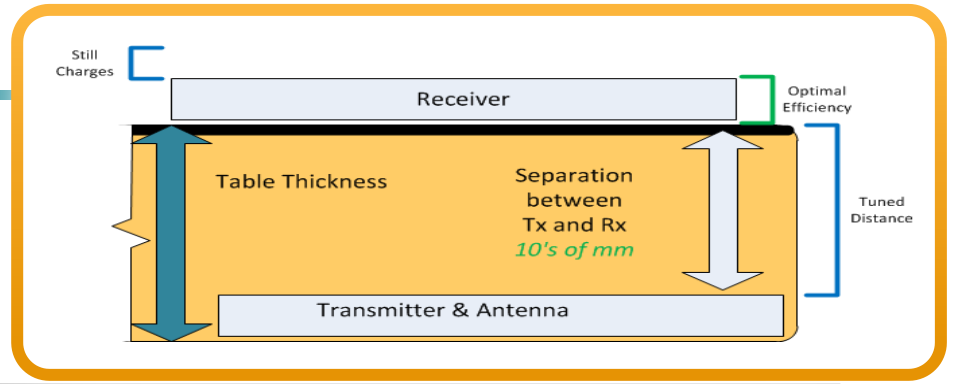
Freedom of Placement

Magnetic Resonance (MR)

- Flexible coupled solutions do NOT require any alignment devices

- One transmitter ‘field’ can charge BT, smart phones, and tablets.

Freedom of Design



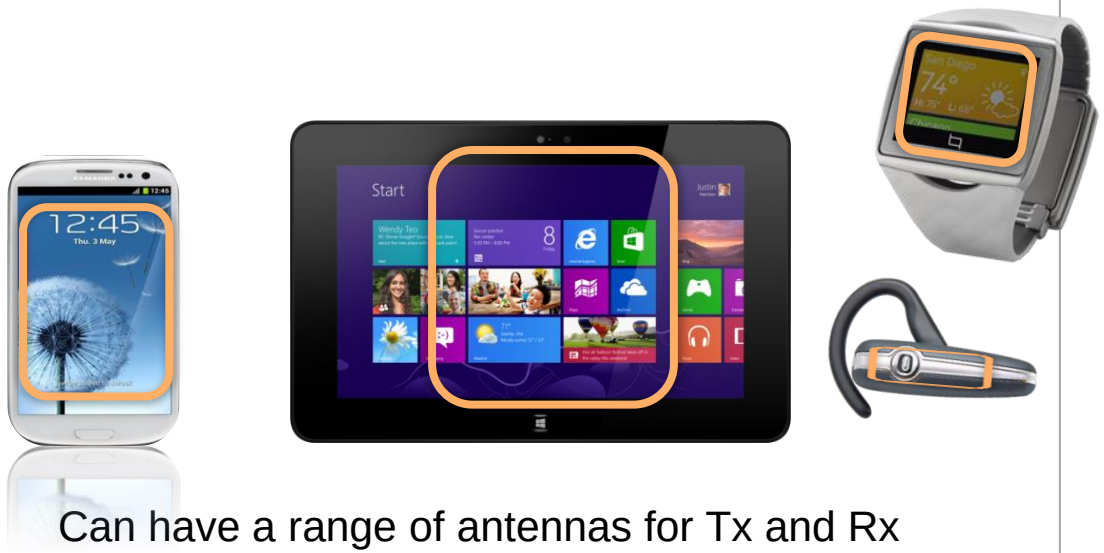
MI Systems

Each device requires a dedicated transmitter location where the coil size is reasonably matched in size or a multi-coil Transmitter is required

Must have Tx and Rx coils of comparable size and dedicated area for each device form factor

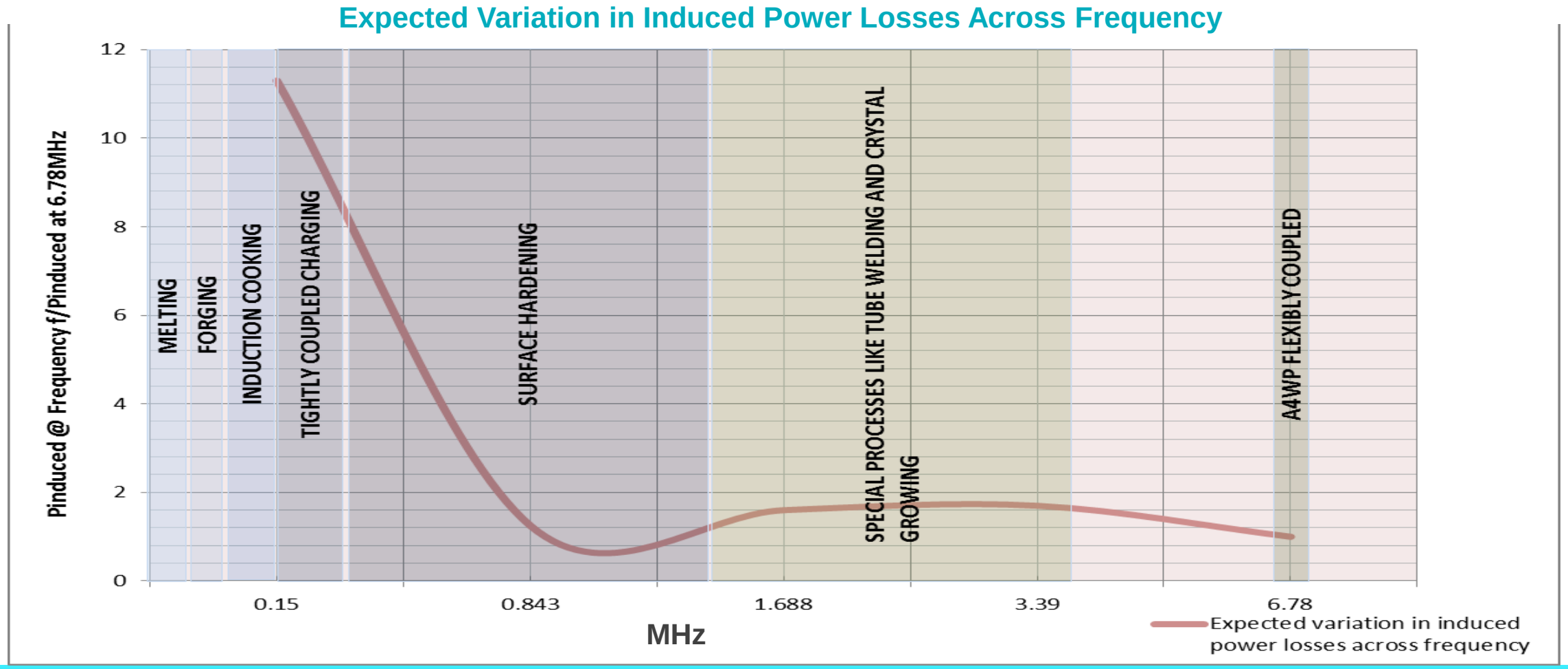
MR Systems

Each device can be placed anywhere on the transmitter



Can have a range of antennas for Tx and Rx therefore supporting form factors as small as Bluetooth headsets while still supporting smartphones, netbooks, etc.

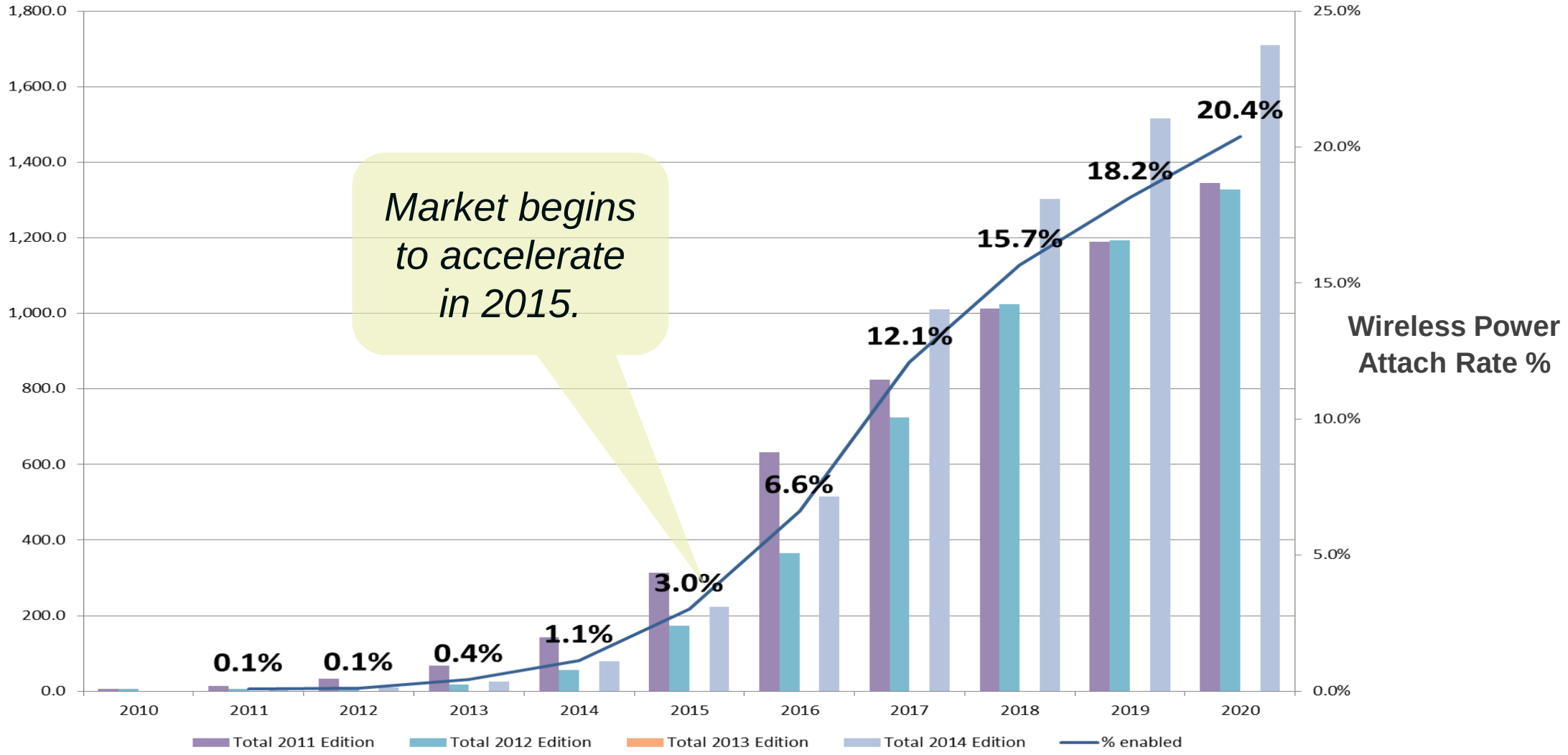
Ensuring Metal Objects in or Near the Field Do Not Have a Significant Temperature Rise



Wireless Charging Solutions Operating in the 100s of KHz Range Generate ~10x the Amount of Induced Power in Foreign Objects as That of 6.78 MHz Systems

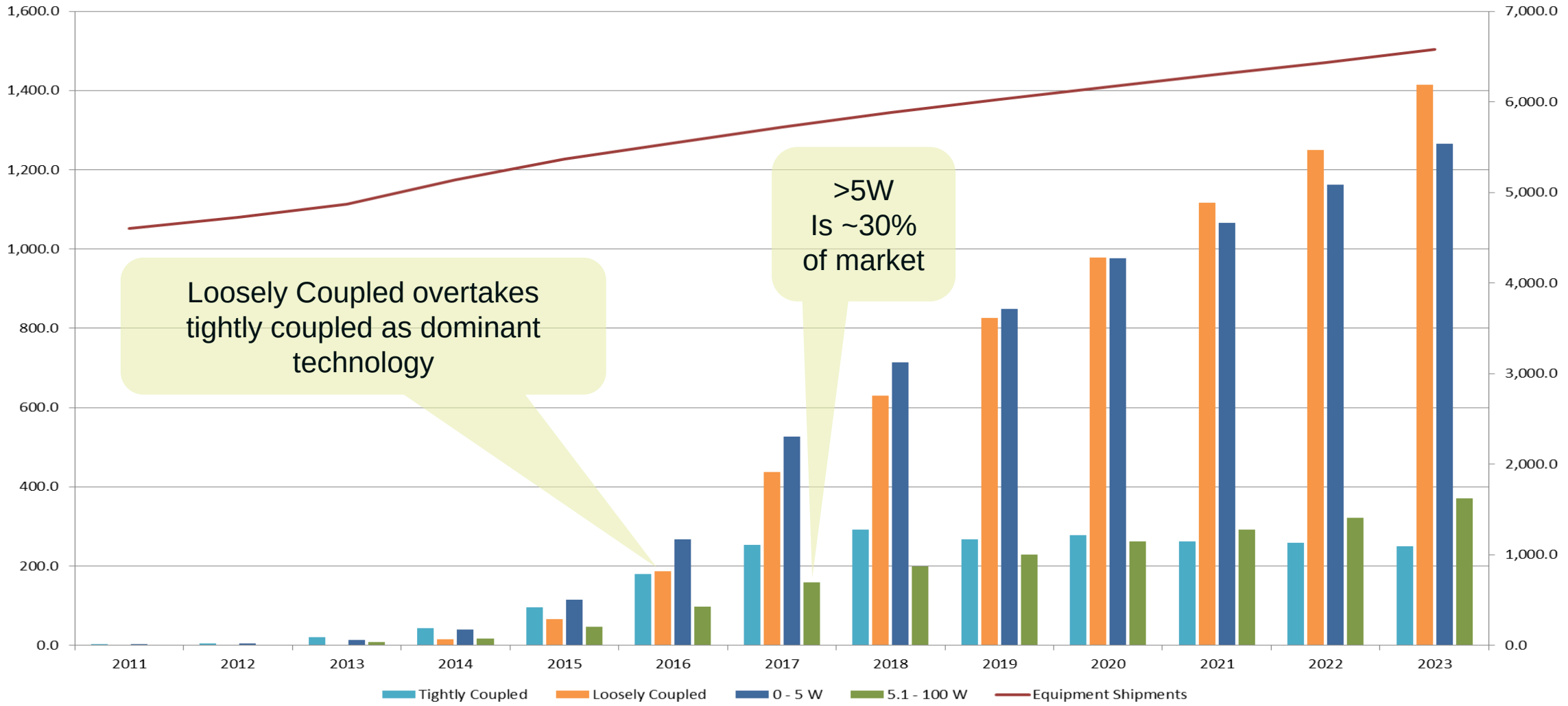
Total Market (Rx and Tx)

Variance From Previous Edition - Revenue



Source: *The World Market for Wireless Power - 2014 Edition.* IHS

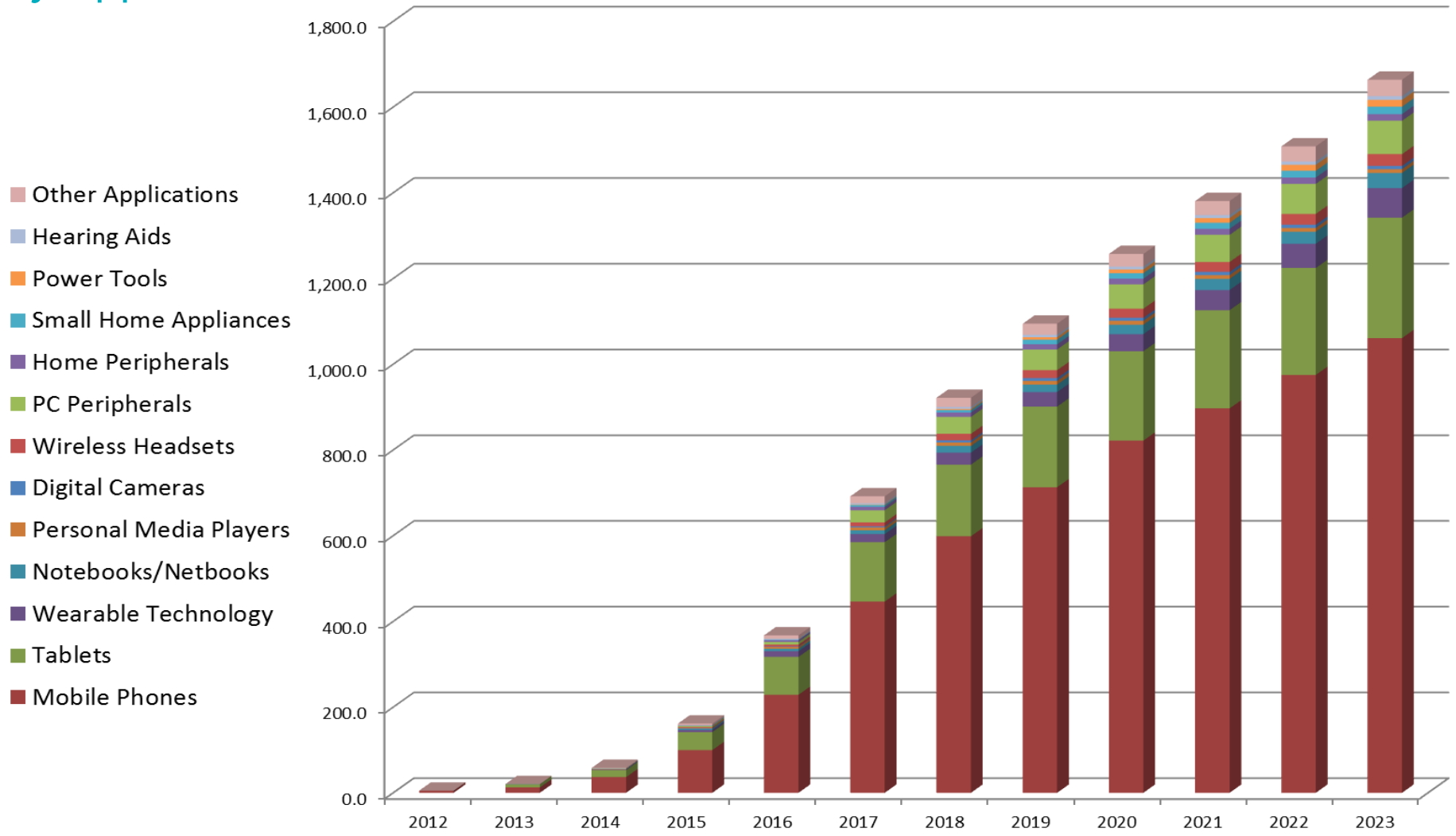
Transition To Loosely Coupled Begins in 2015



Source: *The World Market for Wireless Power - 2014 Edition.* IHS

Wireless Power Receivers

Volumes by Application



Source: *The World Market for Wireless Power - 2014 Edition.* IHS

Quick comparison of the Alliances

	A4WP	PMA	WPC
Consumer Brand	Rezence		Qi
When Established	5/2012	2012	12/2008
Number of Members	101	~70	~210
Technology Type Promoted	Resonant (MR)	Magnetic Induction (MI)	Magnetic Induction(MI)
Specification Release	2012	2009	2010
First Product Launch	NA	2009	2010
Frequency of power transfer	6.78MHz	Variable 80~300KHz	~205KHz
# of devices charged simultaneously	2, 3, more	1	1
Type of devices supported	Currently up to 22W	Limited to 5W or less	Limited to 5W or less
Signaling method	**OOB – BLE 2.4GHz**	**IB**	**IB**
System Efficiency	50-65%	70+% 1:1	~70% - 1:1 designs, ~60% - coil arrays
Specification Requires EMI/EMC Compliance	Yes	No	No
# of potential generated network harmonics	<9	100's	100's
Device heating or Foreign Object Concerns	No	Yes, deploys FOD	Yes, deploys FOD

rezence
Alliance for Wireless Power

Membership

101 MEMBERS

As of June 2, 2014

A4WP Latest Developments

Alliance for Wireless Power Unveils Rezence™ Brand

rezence
Alliance for Wireless Power

Rezence Named Digital Trends Best of CES 2014 Award Finalist (Top 5!)

A4WP Announces First Rezence Products Following Launch of Global Certification Program

4 companies have certified product:

- Samsung
- Qualcomm
- Gill Electronics
- Samsung Electro-Mechanics

Alliance for Wireless Power and Power Matters Alliance Join Forces

pma
Power Matters Alliance

Overcoming the Hurdles to Drive Wireless Power into the Mainstream

rezence
Alliance for Wireless Power

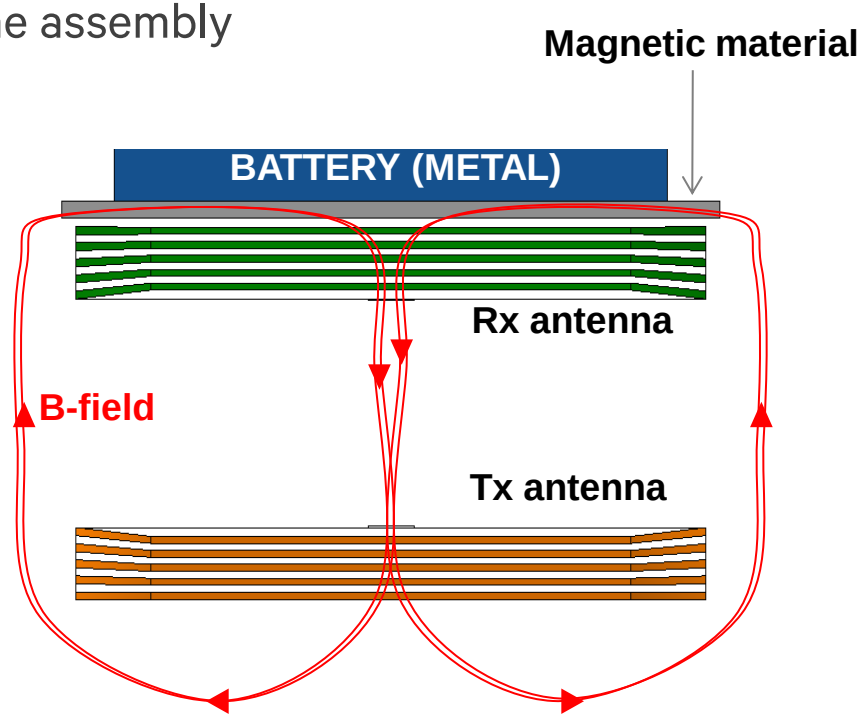
Meets **User Case** Requirements	Delivers Spatial Freedom (Simultaneously meeting X/Y **and** Z)	✓
	Simultaneous charging of multiple devices from a single specification	✓
	Simultaneous charging of multiple device types from a single specification	✓
Meets **Regulatory** Requirements	ICNIRP	✓
	FCC Part 15/18	✓
	CISPR 11	✓
Meets **Standardization** Requirements	Rezence brand launch by A4WP provides certification of products for interoperability and safety	✓
Meets **Commercial Readiness** Requirements	Charge Time, Touch and Battery Temperature Requirements	✓
	Mobile Phone Coexistence	✓
	Minimal temperature rise in foreign objects in or near the field	✓

Technology challenges

What it takes to operate at 6.78MHz

- Ferrite and antenna structures trade-off: thickness vs. permeability
  - Magnetic reluctance is given by $R = \frac{l}{\mu w t}$, where μ is the permeability of the material
  - Hysteresis losses (given by μ"), which contribute to heating of the assembly
  - Complex permeability: $\mu = \mu' - j\mu''$
  - Magnetic loss tangent $\tan\delta = \frac{\mu''}{\mu'}$

Quantity	Existing	Desirable
μ'_r	100-200	>200
μ''_r	1-5	<1
t (mm)	0.4-0.75	≤0.3



Electronic components' challenges

- Transmitter: High efficiency, resonant Power Amplifiers from 10 to 50+ Watts
  - Low average dissipation, but large instantaneous power loss when off-resonance
  - GaN shows some advantage, but dynamic conditions and thermal capacitance are a challenge
- Receiver: Rectification at 6.78MHz
  - Challenges: high efficiency, low EMI generation
  - Synchronous rectification presents some advantages but high voltage required and power dissipation challenge integration
- EMI filters:
  - Low losses at 6.78MHz and high rejection at the harmonics and all the way to LTE and WWAN bands

Wireless Power Integration opportunities

- Integration of Wireless Power and NFC antennas
- Integration of antenna structure in Wearables
- Integration in SiP

Thank you

QUALCOMM Technologies, Incorporated, 5775 Morehouse Drive, San Diego, CA 92121-1714