



Energy Management: Enabling the IoT

Francesco Carobolante, Vice President
Qualcomm Technologies, Inc.

October 11, 2016

#whywait

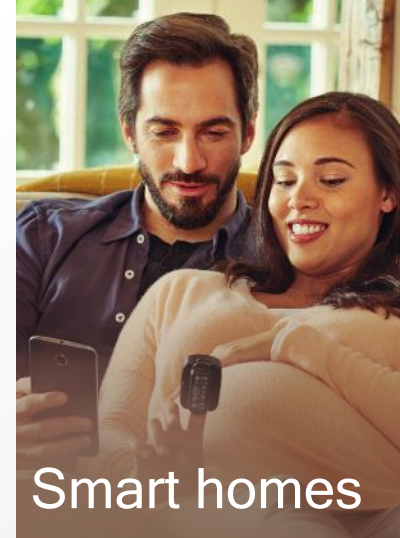


IoT

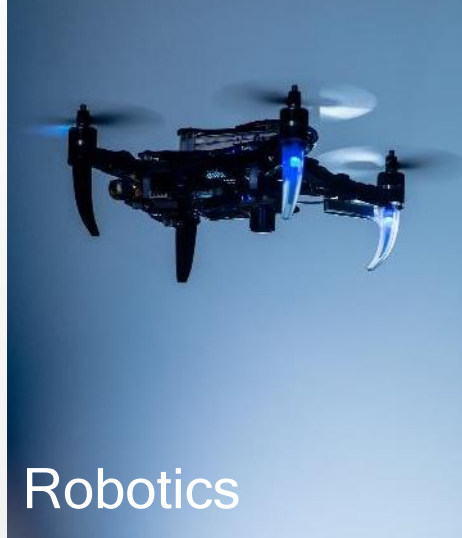
25B

permanently
connected things
by 2020*

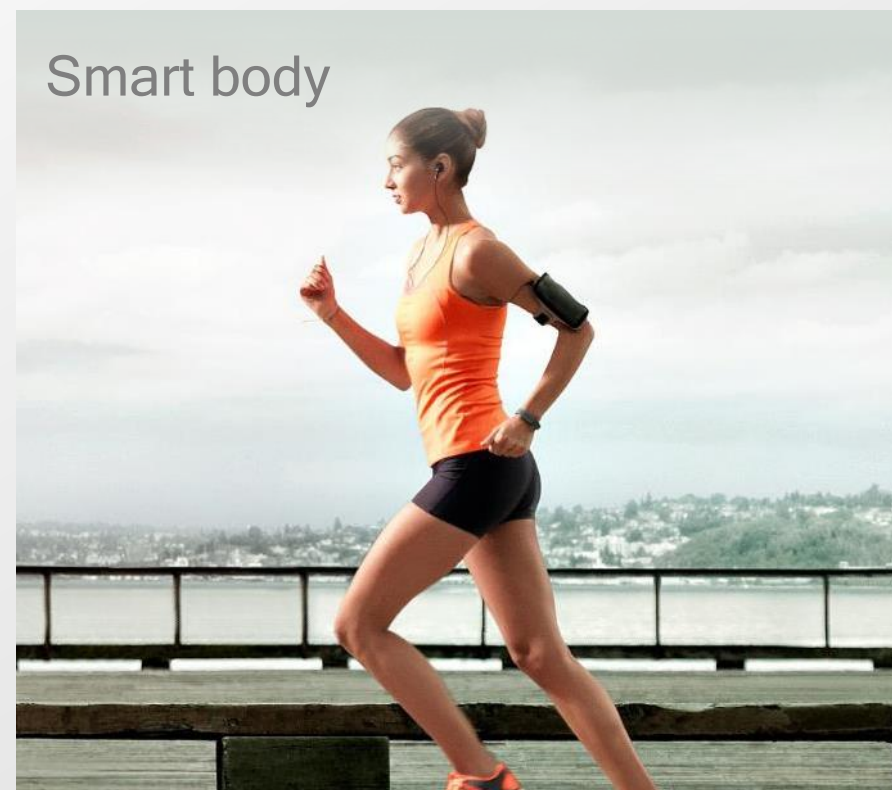
Smart
cities



Smart homes



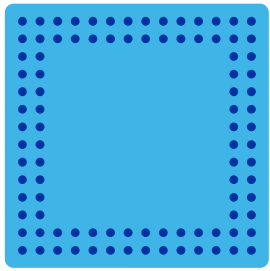
Robotics



Smart body

Fueling the needs of the Internet of Things

Most IoT devices share similar - but different - requirements



Thinner, lighter, sleeker

- Highly integrated
- 3D packaging



Ultra-long battery life

- Low power / high efficiency
- Platform optimizations
- Wireless charging



Always on, always sensing

- Low power sensing/processing
- End-to-end sensor optimizations



Always connected

- LTE and 3G
- Wi-Fi
- Bluetooth, BLE
- GNSS

Size matters!

Parasitic elements reduction

Higher operating frequencies

Heterogeneous integration

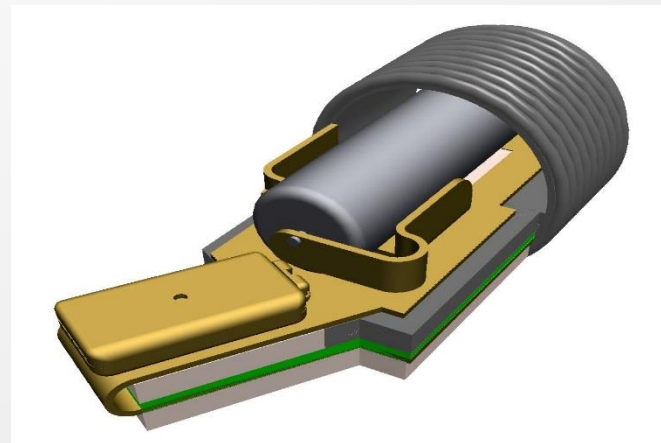
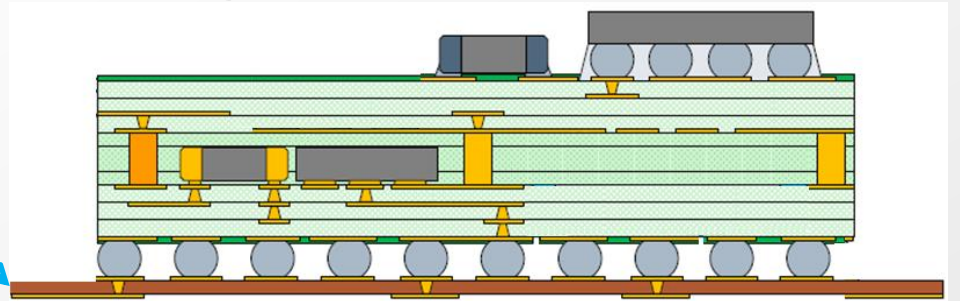
Printed Electronics

What about power density?

Wireless Power
Transfer antenna
embedded in the
Flex circuit



Integration for wearables



Hearing aid
prototype

Solving the Energy Equation

$$\int P_{in} * dt \geq \int (P_{conv} / \eta_{conv} + P_{comp} + P_{RF}) * dt$$

Efficient Energy Harvesting
and Power Conversion

High Density Energy
Storage

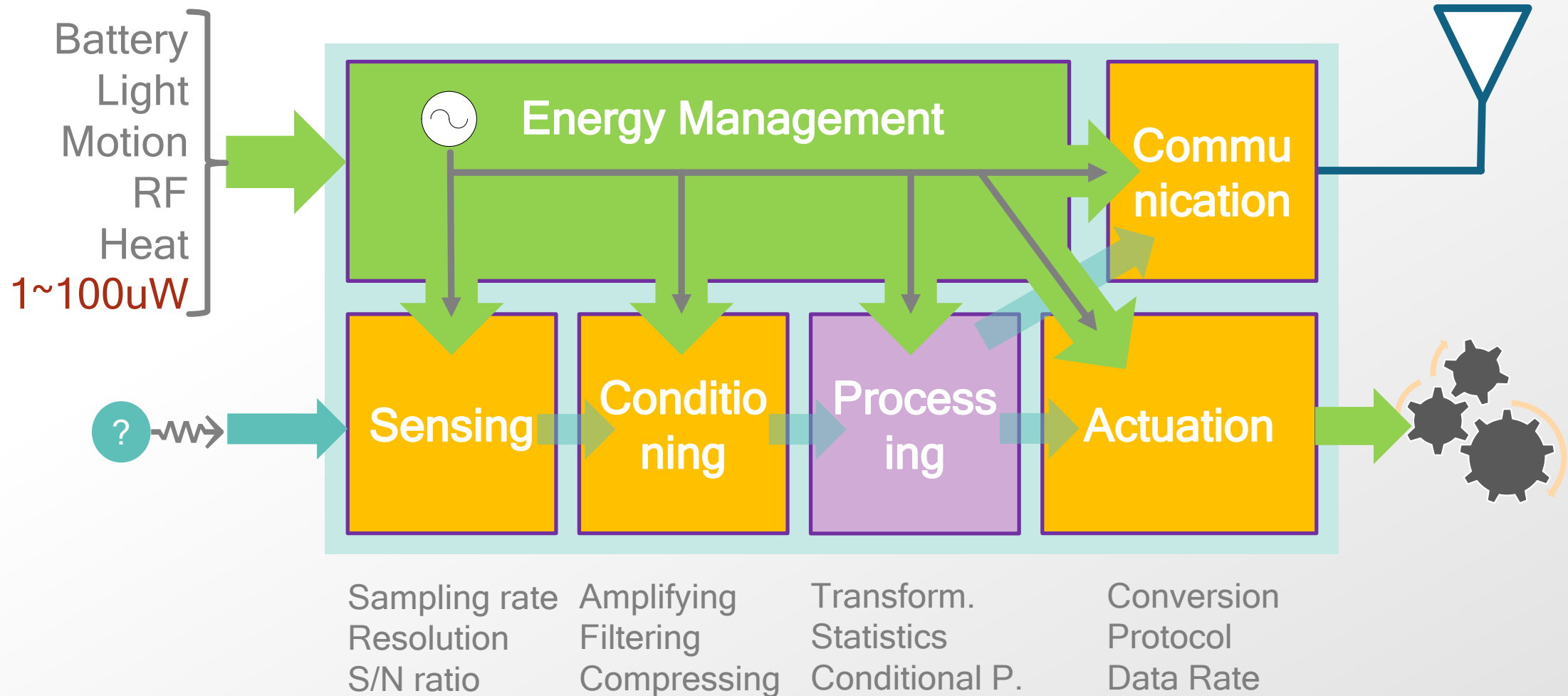
IoT Enablers

Ultra-low Power
Computing

Low Energy RF
Communication

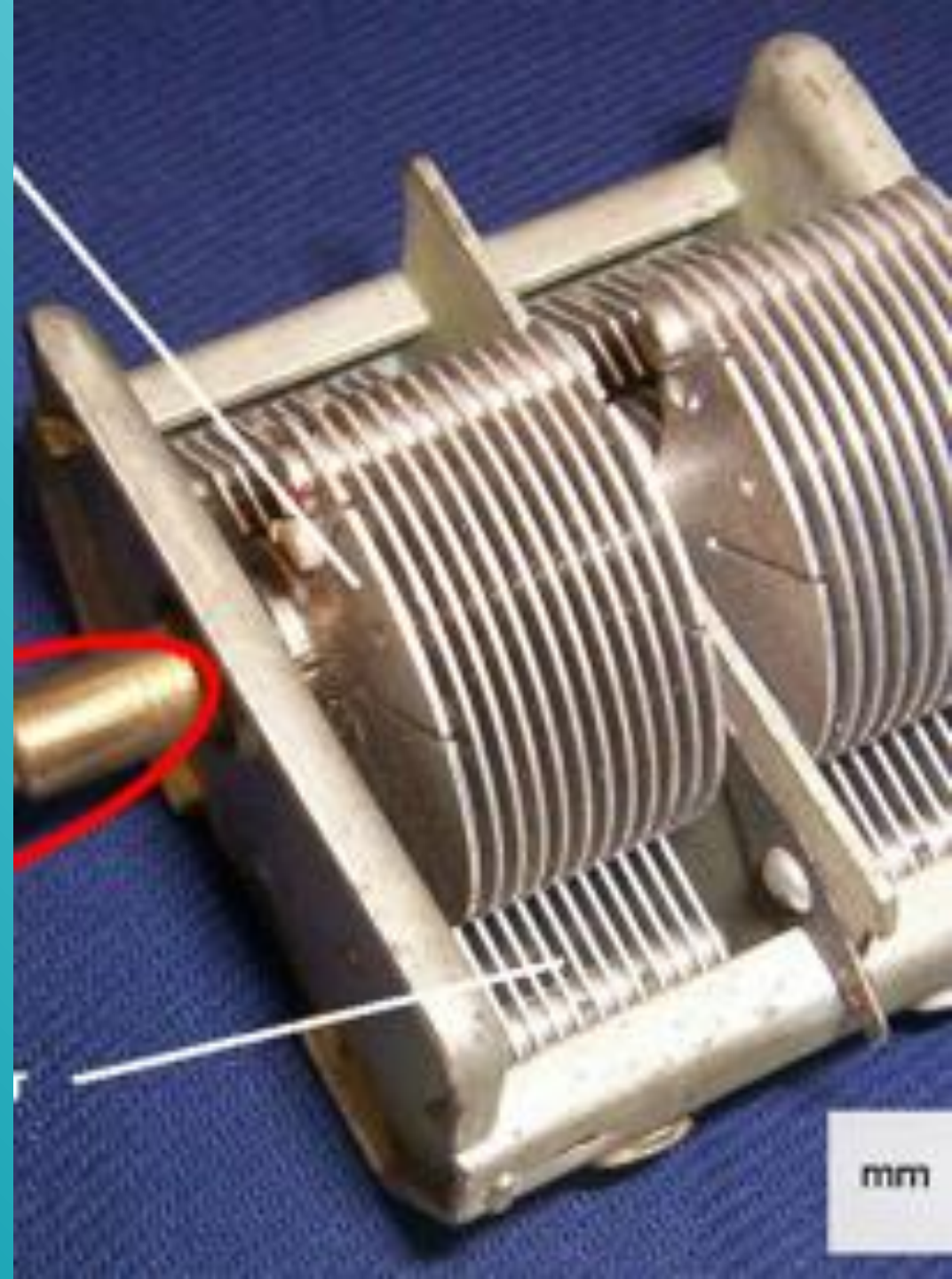
Block as well as system level optimizations are required

Each function's energy requirement can be traded off against the others



Using Variable Reactances

A new approach to Power Management



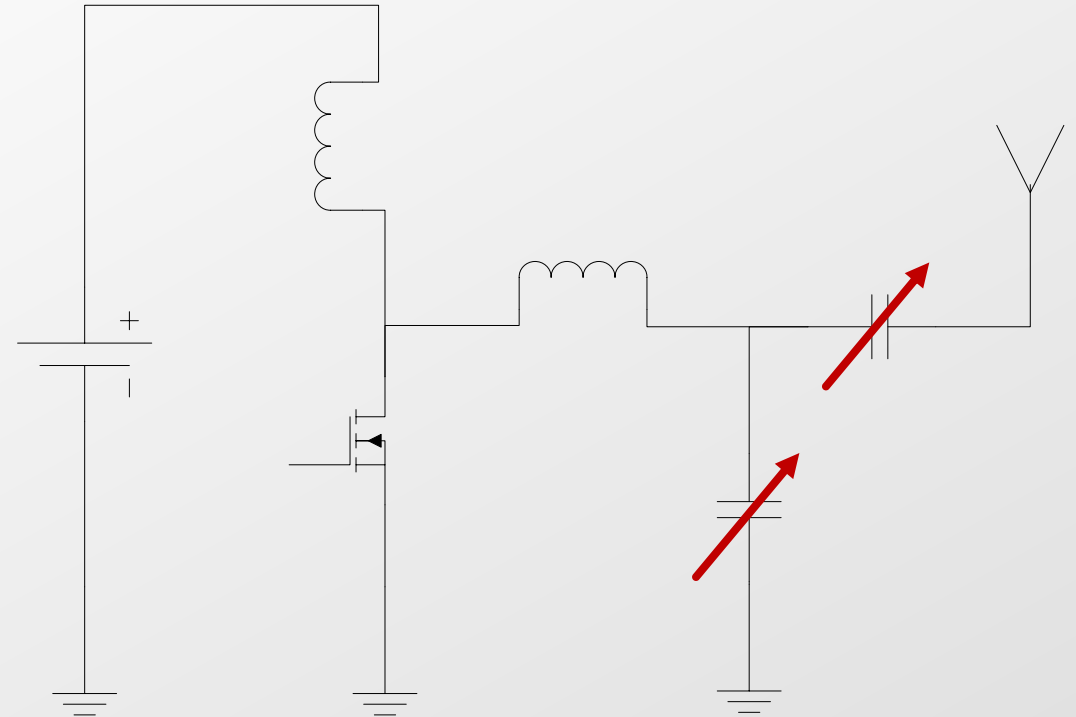
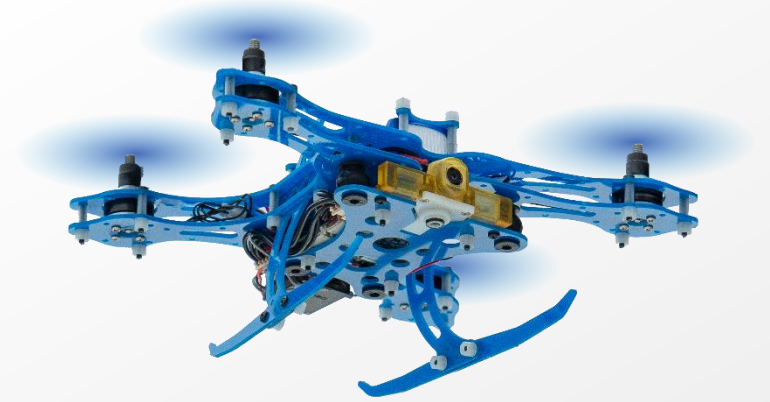
Tunable RF Front End for IoT

Reducing cost, increasing flexibility

Tuning for component tolerances
and frequency changes

Compensation of VSWR

Efficiency optimization of RF PA for
different power levels and load
changes



What about Resonant Power Conversion and Resonant Power Transfer?

Can we use tunable capacitors for:

Resonant Class D, E, EF or LLC converters

→ Tuning load resonance instead of frequency

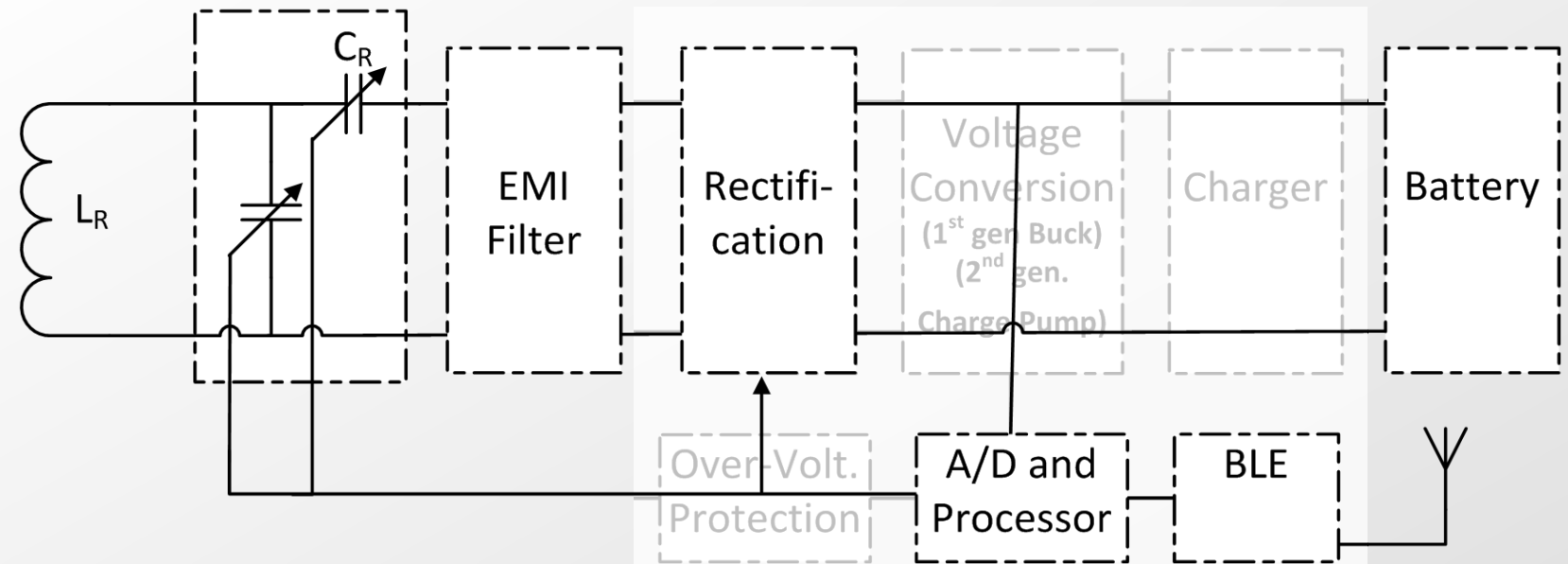
→ Tuning drain capacitance instead of duty-cycle or delay

How about completely re-thinking an architecture...

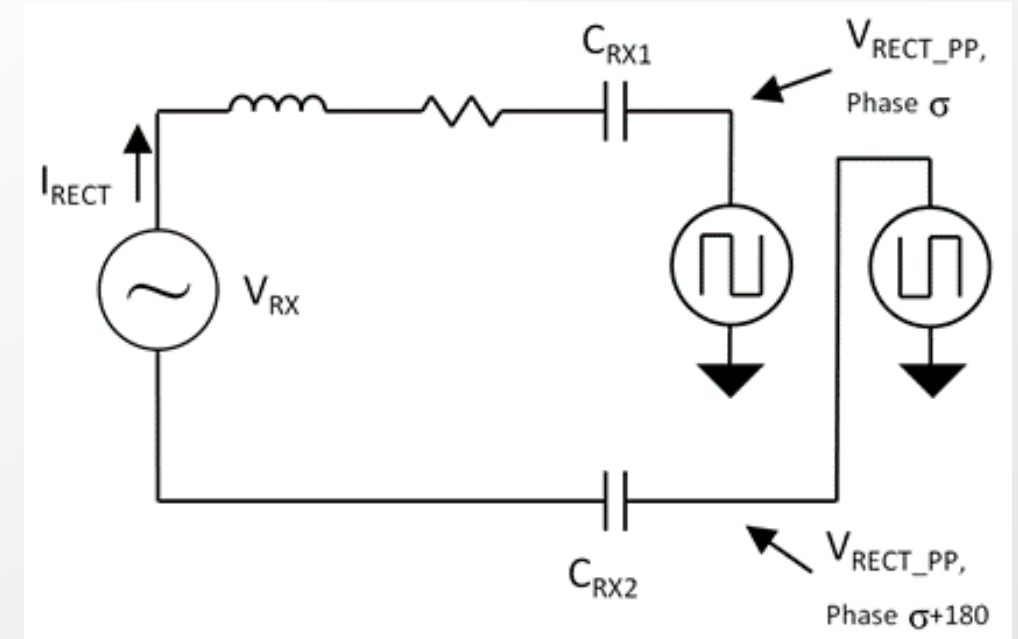
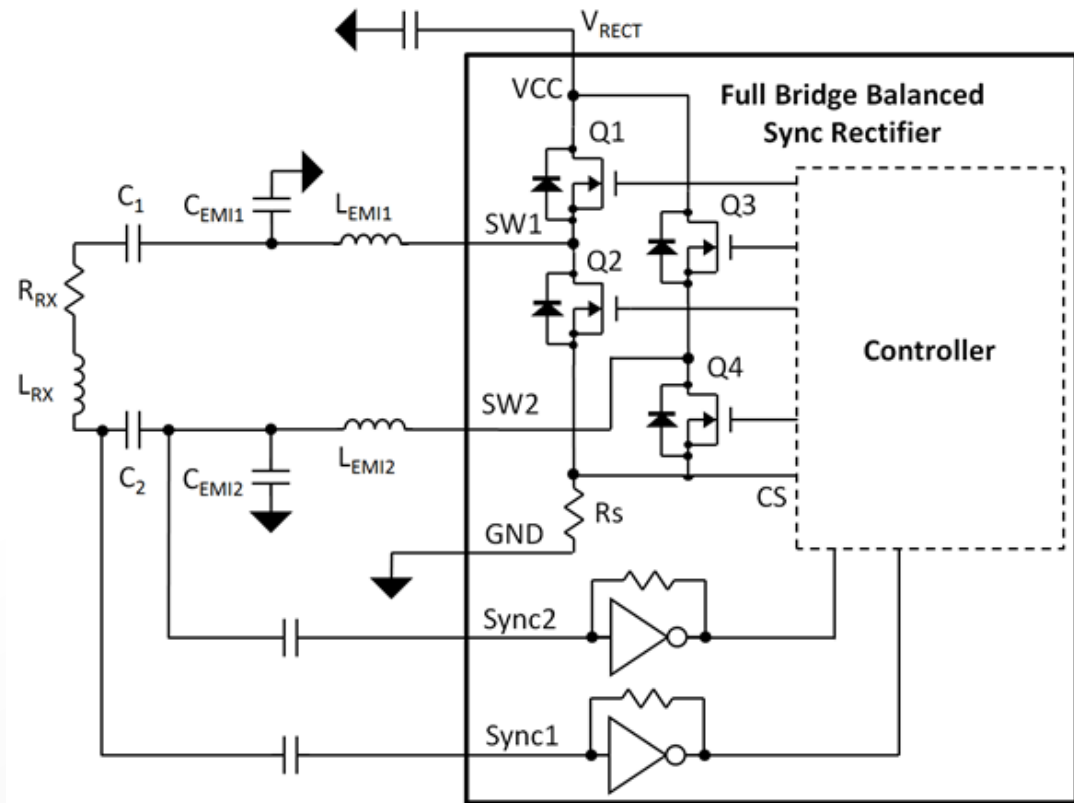
RF Energy transfer

Near Field or Far Field, for fixed and mobile applications

Overcoming the variability of signal strength
with highly resonant systems and tunable elements
that eliminate DC-DC conversion (and their magnetic elements)

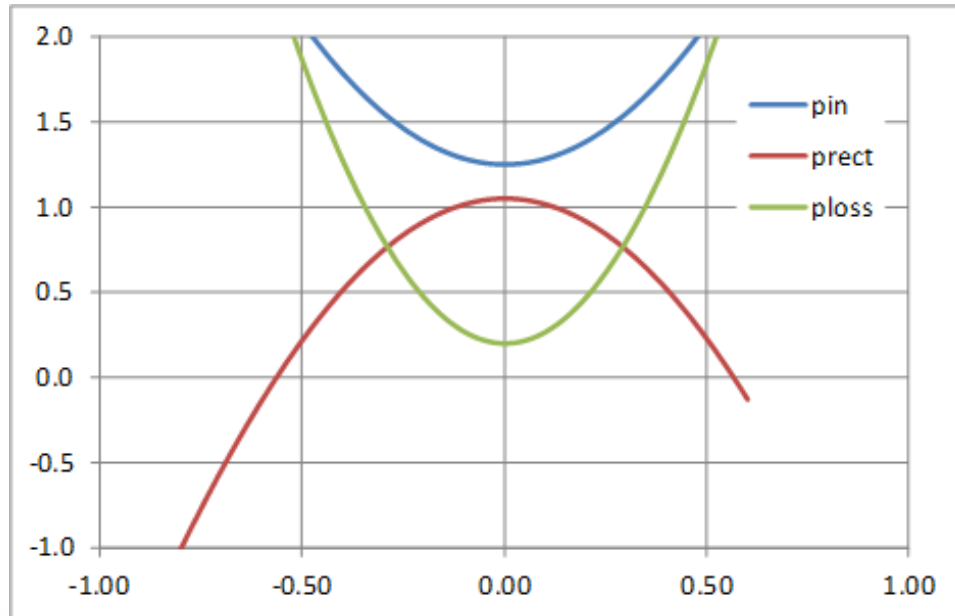


Controlling the phase angle of the synchronous rectifier

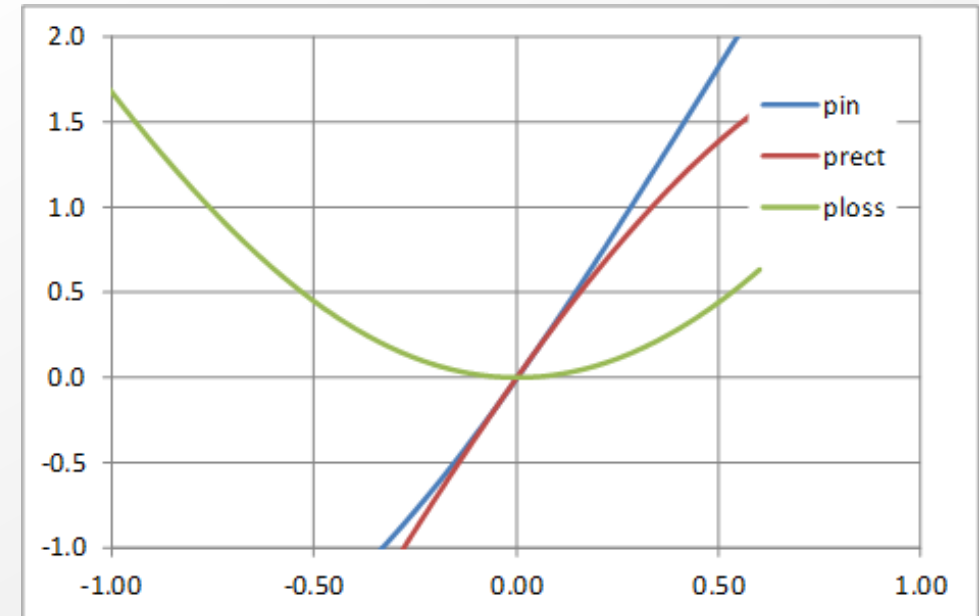


Simplified model for analysis

...but it works only if you can control the residual reactance
If tuned, the series resonant LC can provide the appropriate impedance



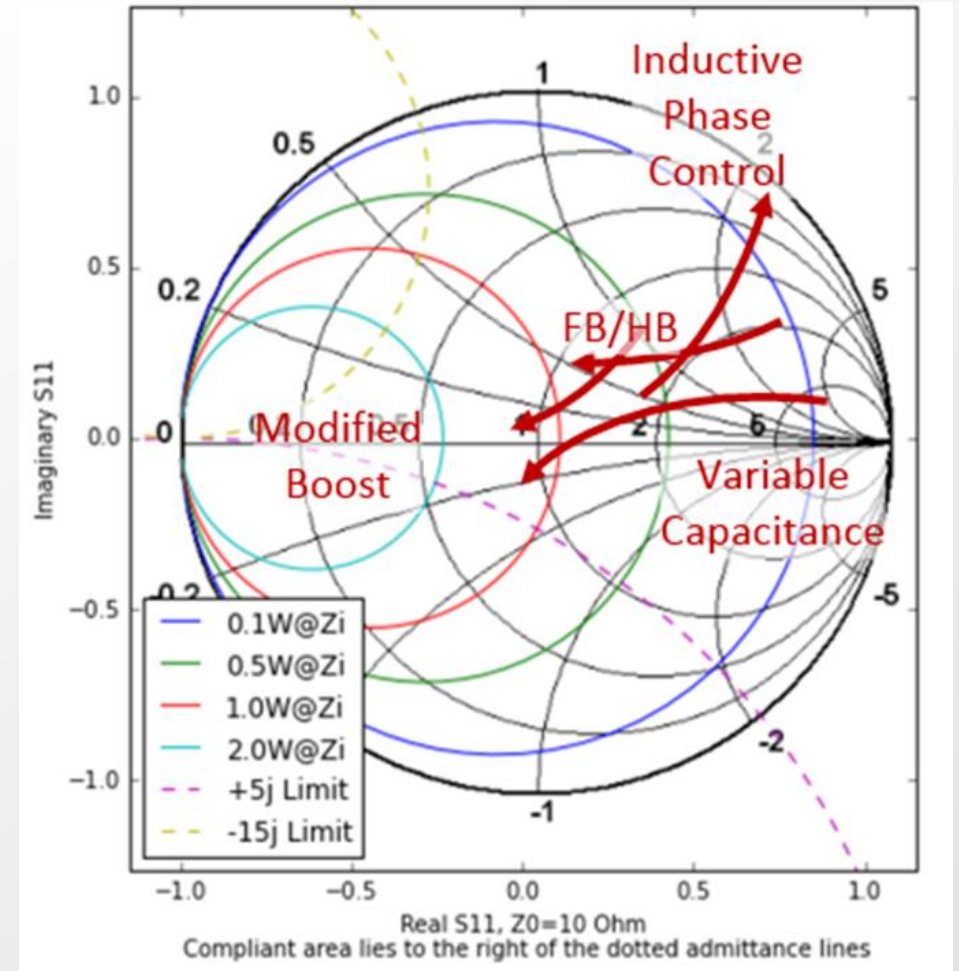
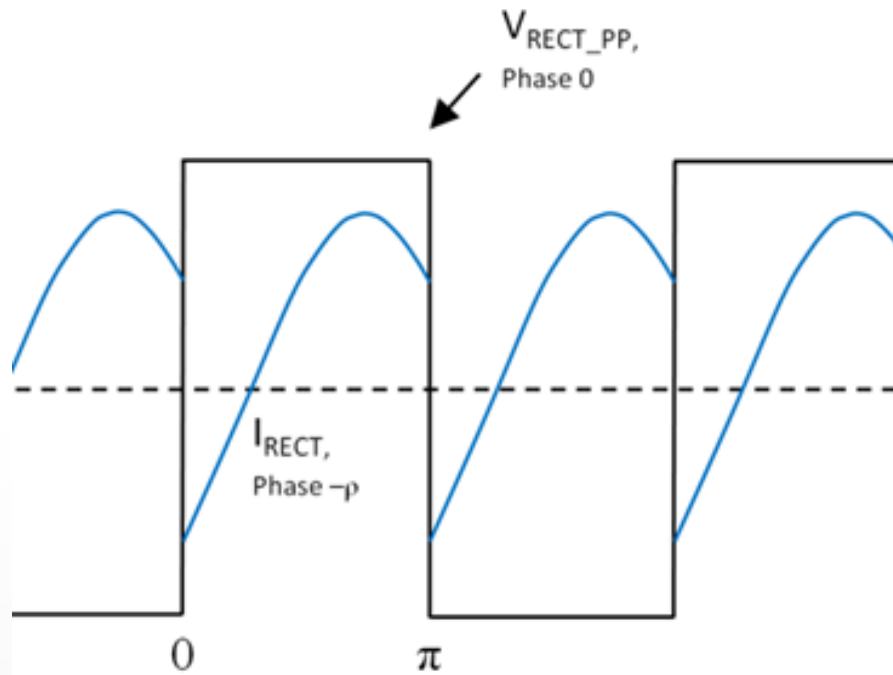
Coupling impedance tuned to zero reactance.
Under these conditions phase adjustments modestly affect load power but at significant efficiency penalty in losses



Tuning the reactance significantly modifies the power curves where phase adjustments effectively modulate transfer. Under these conditions it is possible to regulate power transfer from 0 to 1W, with moderate power loss.

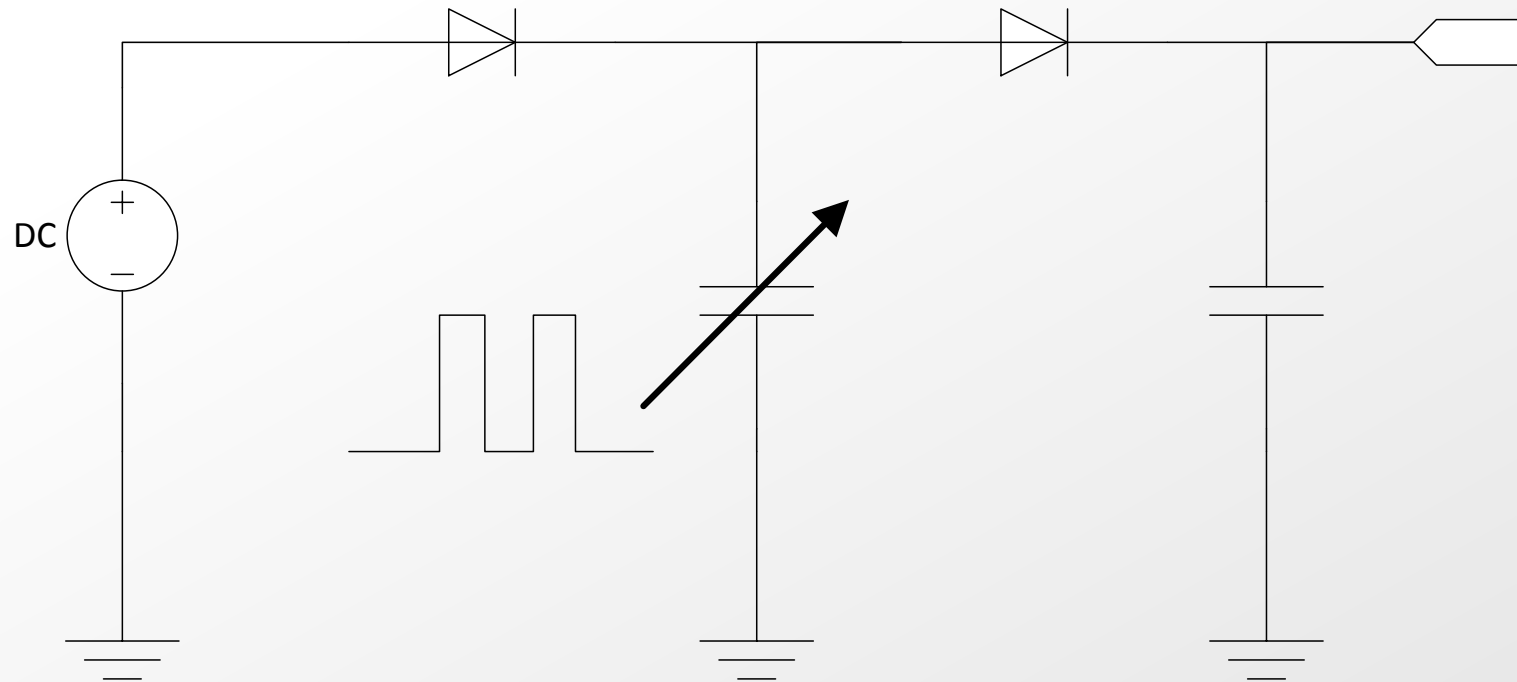
Buck and Boost operations

Combining reactance and phase changes



...by the way, perpetual motion is not yet achievable

This does not work!



Thank you

Follow us on:    

For more information, visit us at:

www.qualcomm.com & www.qualcomm.com/blog

Nothing in these materials is an offer to sell any of the components or devices referenced herein.

©2016 Qualcomm Technologies, Inc. and/or its affiliated companies. All Rights Reserved.

Qualcomm, Snapdragon and DragonBoard are trademarks of Qualcomm Incorporated, registered in the United States and other countries. Snapdragon Flight is a trademark of Qualcomm Incorporated. Other products and brand names may be trademarks or registered trademarks of their respective owners.

References in this presentation to “Qualcomm” may mean Qualcomm Incorporated, Qualcomm Technologies, Inc., and/or other subsidiaries or business units within the Qualcomm corporate structure, as applicable. Qualcomm Incorporated includes Qualcomm’s licensing business, QTL, and the vast majority of its patent portfolio. Qualcomm Technologies, Inc., a wholly-owned subsidiary of Qualcomm Incorporated, operates, along with its subsidiaries, substantially all of Qualcomm’s engineering, research and development functions, and substantially all of its product and services businesses, including its semiconductor business, QCT.

