Endless Power
for
Always-On IoT and Wearable Devices

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Overview

- Introduction and concept
- Wireless charging ecosystem
- Practical implementations
- Future directions

The Problem

- More devices
  - More connected collecting/sharing data
    - Always on, and always “on the go”

- More ways to have battery anxiety
  - More and more devices to maintain
    - Greater problems when a device is off-line

“Today” Solutions

- Hard-wired devices with separate mains power
- Hard-wired devices with combined data-power (ex. USB)

More troubling…

- Battery operated devices requiring battery replacement
- Battery operated devices requiring periodic recharging
- Unserviceable battery operated devices
  - Especially sealed devices with no connector

Better solutions

- Hard-wired devices with combined data-power
  - Power over Ethernet (short-to-long distances)
    - Excellent IoT solution for large buildings, factories, etc.
      Fully integrates: phone, intercom, sensor networks, security
- Battery operated devices with continuous or ubiquitous access to a charging source
  - USB-C but the trend in phones, personal care devices, wearables, and medical devices is fully wireless data and exactly zero connectors
  - A better, better way: wireless power delivery

A Wireless Charging Ecosystem

- Standards based – any device works on any charger
  - Great user experience guaranteed by compliance testing!
  - Wireless eliminates connector/cable issues, especially in public infrastructure subject to damage/contamination
- Charging spots are everywhere:
  - Home (multiple locations)
  - Automotive
  - Office
  - Public infrastructure (everywhere)

Then a miracle happens…

- Battery anxiety diminishes because devices can be charged almost anywhere wirelessly
- Batteries can become smaller
- The ‘last connector’ will largely go extinct
  - No mechanical reliability issues
  - Products can be easily sealed against liquids, dust, gas
- Products will no longer be sold with power supplies !!!!

And even more surprising…

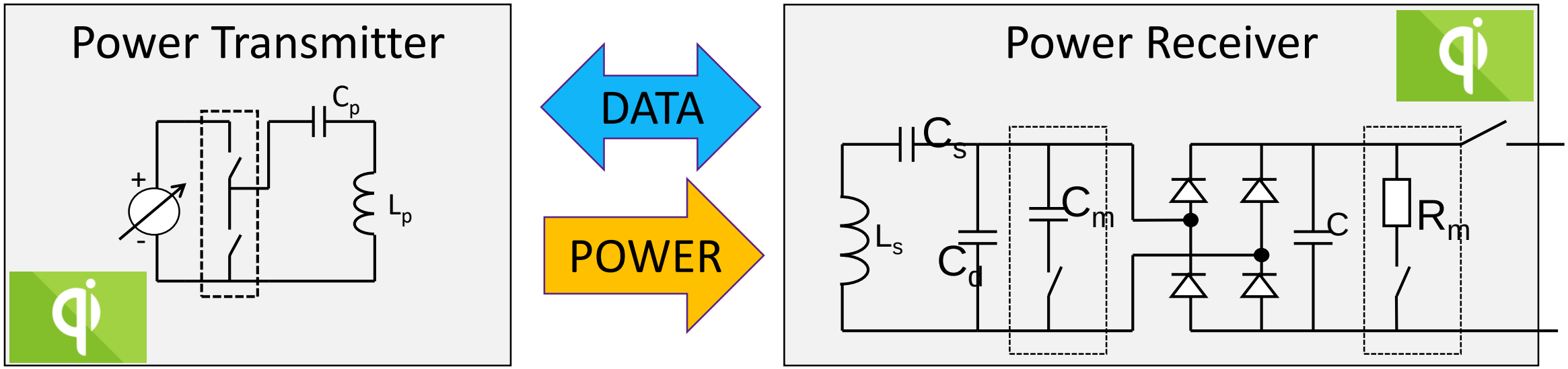
versus

Changes people's behaviors !

- "Fishers of wires" run their phone down to zero before recharging
  (And hence the short term market demand for "fast charging")
- "Drop and forget" users keep their phone topped off at 100% all the time !
- And how is it possible to choose the wrong micro-USB orientation way more than 50% of the time ???

A Practical Piece of the Puzzle

- Qi standards based wireless power delivery system
  - Short vertical distance (typically <1cm) magnetic inductive coupling
  - Uses partially resonant coupling for optimum power transfer
  - Good solution for cell phones, wearables, and many other IoT devices
  - Supports low bandwidth (~500bps) bi-directional data transfer

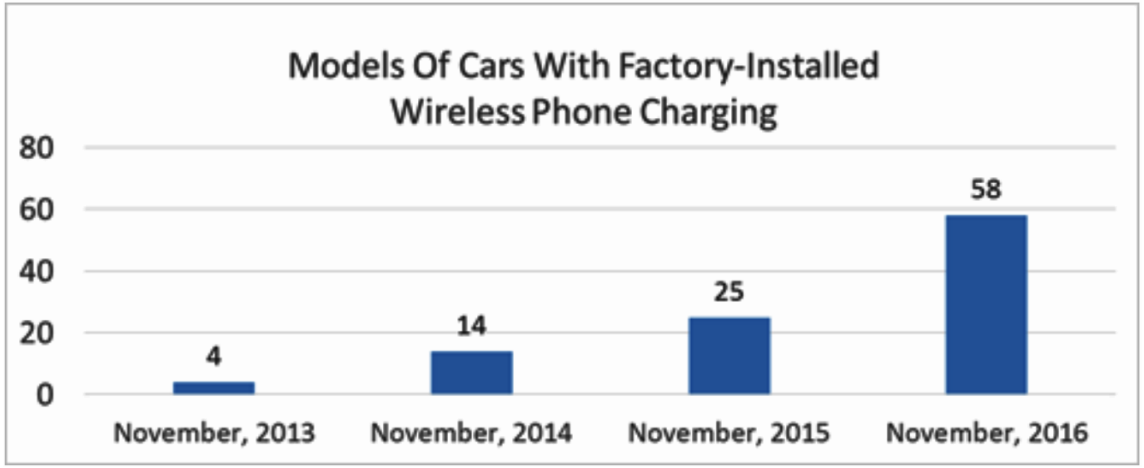


Qi Is a Robust, Widely Deployed Standard

- A wide range of compliant Qi products are here today
  - Adopted by Apple, Samsung, LG, etc. for phones/wearables
  - Reasonably efficient and very cost effective
  - Migrating into other wearables and other consumer products
  - Extensible to smaller devices and multiple concurrent devices
  - Extensible to much greater than present 15-Watt limitation
- And data, too !
  - Qi supports low bit rate (~500bps) bidirectional data transfer
  - Can eliminate costly, troublesome radios in various cases
  - Charger base can link IoT device to/from wider area networks

Practical, here today, standard

- Overwhelmingly dominant standard
  - 2017: 325 million receivers, 75 million transmitters
  - With Apple adoption, growth rate is explosive
  - Projected 1000+ million units by 2020
  - Already cost effective and commoditizing quickly
  - Nearly all traditionally slow auto makers have adopted Qi



Other applications

- Power and data delivery to door/window sensors and actuators
  - No cables through hinges, across moving parts
- Power and data delivery to inaccessible areas, pressure vessels, medical applications, wet/hot/cold areas
  - Avoids seals, breaks in surfaces, bonding incompatible materials, etc.
  - Safe, low voltage, and minimally interacting with biologics, hazardous materials, explosive mixtures, etc.
- All of the above could, or already do use Qi technology directly or low cost derivatives thereof

What about long distance power delivery?

- Radio, ultrasound, light, and highly resonant inductive systems are all being looked at, but seem far off in the future as an ecosystem solution
- So far, practical for milliwatts/microwatts at a distance
- Limitations and unknowns
  - Safety issues / concerns
  - Emissions and radio interference issues
  - Efficiency and cost issues
- However, potentially ideal for certain sensor networks, etc. which require only tiny amounts of average power

Where this is going…

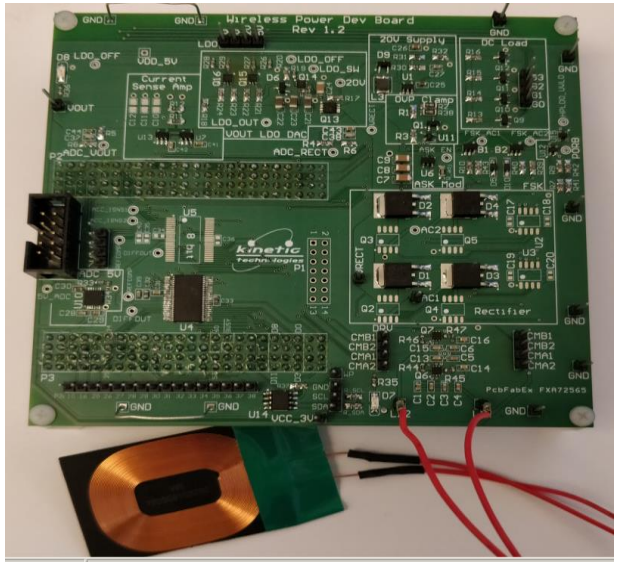
One standard to rule them all

(mostly true - and everybody wins)

The Role of the IC Company

- Driver of commercialization and commoditization
  - When the cost and business opportunity make sense !

Many Experts
$$$$$$$$
Months or Years



1 Engineer
< US$1.00
Hours or Days

Thank you