Real-World Deployments of Remote Wireless Power in Wireless Sensor Networks and other Applications

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Enabling products that eliminate batteries or battery maintenance

- Founded in 2003
- Located in Pittsburgh, PA, USA
- 46 issued and 29 pending patents
- Products available since 2010
- Distributors: Arrow Electronics & Mouser Electronics

Solutions for sensors and the IoT

- RF Energy Harvesting
- Wireless Power
- Power Management
RF Wireless Power Markets

- Identification
- Consumer Electronics (recharging)
- Electronic Labeling
- Medical Sensors
- Advanced access control
- Process monitoring (Wireless sensors)
- Advanced packaging (illumination)

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Conference & Expo: June 27-28, 2018

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Market Segment Value Propositions

- **Industrial – Minimizes Operating Costs**
  - Eliminates cost to hard wire or replace batteries – e.g. wireless sensors
  - Eliminates service downtime caused by depleted batteries
  - Reduces battery handling and disposal

- **OEMs – Improved Product Design**
  - Product differentiation – eliminate wires, cables, connectors
  - Sealed devices – less expensive enclosures and manufacturing, waterproof
  - Reliability – improved durability, reduced product failures, eliminate ESD issues

- **Consumers – Convenience and Usability**
  - Placement flexibility – no charging mats
  - Untethered embedded power – eliminate wires, cables, connectors
  - Transparent charging – no user action required
RF Power Categories

Intentional
Wireless Power

Anticipated
RF Harvesting

Ambient
Unpredictable
Powerharvester® Chips

PCC110 – RF to DC Converter
- High conversion efficiency, up to 75%
- Converts low-level RF signals enabling long range applications
- RF operating range: -18dBm to +20dBm
- Frequency range: 10MHz to 6GHz
- Harvests from all modulation types
- Interoperable with numerous RF sources: Powercast TX91501 transmitter, RFID readers, Mobile Phones, Wi-Fi routers, etc.
- SC-70 package

PCC210 – Boost Converter
- High efficiency, up to 95%
- Operation down to 0.4V input
- Capable of 5.5V @ 50mA output
- Resistor settable output voltage
- SOT23-6 package
Key Design Points

- **US Bands**: 915MHz, 2.4GHz, 5.8GHz
- Generally, the lower the frequency, the more throughput with omnidirectional operation
- Receiving device size sets the lowest frequency
  - Game controller can fit a 915MHz dipole
  - Small hearing aids require 2.4GHz or 5.8GHz
- **Antenna design is critical**
  - Antenna loss has a direct impact on throughput
  - Electrically small antennas are possible but not always practical due to reduced bandwidth
- Point-to-point, point-to-multipoint beam steering antenna arrays are possible but with increased complexity comes increased cost
Does Frequency Matter?

- Power Density ($S$) is independent of frequency.
- Effective Area ($A_e$) of an antenna type decreases by frequency squared.
- But antenna size can be increased if the device allows, however larger antennas at higher frequencies become more directional.

$$S = \frac{P_T G_T(\theta_T, \phi_T)}{4\pi r^2} (1 - |\Gamma_T|^2)$$

$$A_e = \frac{G_R(\theta_R, \phi_R)\lambda^2}{4\pi} (1 - |\Gamma_R|^2) |\hat{p}_T \cdot \hat{p}_R|^2$$

What does this mean?

$$P_R = P_T \frac{G_T(\theta_T, \phi_T)G_R(\theta_R, \phi_R)\lambda^2}{(4\pi r)^2} (1 - |\Gamma_T|^2)(1 - |\Gamma_R|^2) |\hat{p}_T \cdot \hat{p}_R|^2$$

$$P_R = P_T \frac{G_TG_R\lambda^2}{(4\pi r)^2}$$

$$2xf \rightarrow \frac{1}{2}\lambda \rightarrow \frac{1}{4}P_R \quad \therefore \quad G_R \uparrow 4 \rightarrow = P_R$$
Technology Advantages

- High efficiency over a broad operating range
- Maintains efficiency with changes in:
  - Input power (changes in distance & orientation)
  - Battery voltage and recharging current (dead to fully charged)
  - Load resistance
- Over 850 MHz operating bandwidth
  - Essential for ambient energy harvesting
  - Easy scalability for geographic regions using different frequency bands
- Result ...
  - Horizontal solution
  - Better performance & more power
  - Simplified design-in
Harvester Performance

915 ISM
1.2 V
Harvester Performance

2.4 GHz ISM
1.2 V

Efficiency (%) vs. $P_{in}$ (dBm)

- 2400MHz
- 2450MHz
- 2500MHz
Real World Applications
High Function RFID Tags

- Identification
- Smart Packaging
  - Bi-Stable Display
  - Indications – LED, Audible
- Security
  - Biometrics and Encryption

Sensing
- Temperature
- Humidity
- Light Level
- Stress/Strain
- Heart Rate

Powercast provides >10x the power vs traditional RFID
Powercast enables a complete wireless infrastructure for power and data.
RFID Batteryless Price Tags

- Perpetual operation without batteries
- Instant updating of multiple tags from up to 2m
- Delayed updates up to 10m
- Configurable as hang tag or shelf-edge label
- Display remains constant after writing
  - No need for batteries
  - Powered by UHF
- Eco-friendly alternative to traditional paper price tags
- Available Q4
Smart/Illuminated Packaging

- Brand/product differentiator
- “Try me” without the need for power source or batteries
- Interactive
- Reusable
- Components take up less space than traditional smart packaging options
- Integrable as printed and flexible electronics
Wearables

- Wireless charging eliminates the need to remove the battery pack in wearables
- Flexible antennas allow for integration into any garment
- Applications
  - Safety gear
  - Athletic shirts with sensors
  - Heated garments
- Closet Recharging
Bulk Trickle Charging

- Freedom of placement
- Eliminate wires and connectors
- Automatic/transparent charging
- Multiple battery types/chemistry
PowerSpot® Consumer Electronics Charging

- Controllers and gaming accessories
- Headphones and headsets
- Wearables
- Computer peripherals
- E-paper displays
- Hearing aids and small personal medical devices
- Smart cards
PowerSpot® Entertainment Stand Recharging
PowerSpot® Countertop Recharging
PowerSpot® Desktop Recharging
Multiple PowerSpot® Transmitters Allow Convenient Charging Throughout the Home
Headphones Retrofit

Sony XB950B1 Extra Bass wireless Bluetooth headphones

Shown at CES 2018
Initial Use Case Data

- **Use Case**
  - Product is used during the day
  - At night, the product is placed on a desk or countertop near the PowerSpot transmitter to recharge

- **Assuming:**
  - 4 hours of use per day
  - 12 hours of PowerSpot recharging per day

- **Result:**
  - At 6 inches or less, Sony XB950B1 headphones never need to be plugged in again
  - At 2-3 inches, fully recharge overnight (570mAh Battery)
Technical Update

- **Design**
  - The design was updated and the antenna was further optimized for the application

- **Assuming:**
  - 4 hours of use per day
  - 12 hours of PowerSpot recharging per day

- **Result:**
  - At 12 inches or less, Sony XB950B1 headphones never need to be plugged in again
  - At 3 inches or less, fully recharge overnight (570mAh Battery)
Xbox Controller Retrofit

- Utilizes Powerharvester chip
- Compatible with PowerSpot

Battery pack installed

Wirelessly rechargeable retrofit battery pack

Shown at CES 2018
Expanding the Market

PCC114  Powerharvester RF to DC Converter Chip

- 7x smaller, 20x less volume than PCC110
  Footprint: 1mm x 0.6mm x 0.3mm
- Enables wireless energy harvesting in virtually any device
Future Applications

- Hearing aids
- Smart cards
- Consumer Electronics
- Other small medical devices

The PCC114 Powerharvester can harvest energy from an anticipated RF source such as an NFC POS reader.
Thank You
Visit us at Booth 940!

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