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Powercast Overview

Enabling products that eliminate Batteries or Battery Maintenance

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

SOLUTIONS FOR SENSORS AND THE IoT

- Wireless Power
- RF Energy Harvesting
- Power Management
RF Power Categories

Intentional
- Powercaster® & PowerSpot® Transmitters

Anticipated
- Wireless Power

Ambient
- RF Harvesting
- Unpredictable
Wireless Power
Intentionally broadcast Radio Frequency (RF) provides wireless power over distance

- Inches to over 100 feet depending on application
- Power from microwatts (µW) up to milliwatts (mW)

Controllable by Design
- Power Level
- Frequency
- Transmit Antenna Gain
- Receive Antenna Gain
- Number of Transmitters
- Distance
- Device Duty Cycle
- System Cost

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

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

\[ P_R = P_T \frac{G_T G_R \lambda^2}{(4\pi r^2)^2} \]

\[ 2 \times f \rightarrow \frac{1}{2} \lambda \rightarrow \frac{1}{4} P_R \quad \therefore G_R \uparrow 4 \rightarrow = P_R \]
Key Design Points

- US Bands: 915MHz, 2.4GHz, 5.8GHz
- Generally, the lower the frequency, the more throughput with omni-directional operation
- Receiving device size sets the lowest frequency
  - Game controller can fit a 915MHz dipole
  - Hearing aid, being small, would need 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
TX91501 Powercaster® TX

- On the market since 2010
- 915 MHz center frequency
- FCC and Industry Canada certified
- RoHS compliant
- DSSS modulation (power)
- ASK modulation (data)
- 1W or 3W EIRP
  - TX91501-1W-ID
  - TX91501-3W-ID
- Integrated antenna with 60° beam pattern
- Plug-and-play installation
- Powers virtually unlimited number of Powerharvester receivers
- Consumer desktop version pending FCC approval (¼ the size)

Power Jacks (2) – 5V
- Back – for tabletop placement
- Bottom – for wall mounting

Status Indicator LED
- Green – Transmitting
- Red – Fault Condition

WWW.SENSORSEXPO.COM
#SENSORS17
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

Reference Designs Available (Others available on request):
- **P1110** 915MHz high-efficiency continuous powering and recharging
- **P2110** 915MHz long-range pulsed powering and pulsed recharging
- **P2111** P2110 with enhanced sensitivity
- **P2120** 2.45GHz long-range pulsed powering and pulsed recharging
Powerharvester® Modules

- Modules allow easy deployment – RF in → DC out
- Provide high RF to DC conversion efficiency
- Power microcontrollers, sensors, electronics
- Designed for standard 50Ω antennas
- Support multiple frequency bands: 840-960MHz
- Based on Powercast PCC110 & PCC210 ICs

### P1110 Architecture

**Continuous Power Output**
- RF range: -5.0dBm to 20dBm
- Output voltage: 1.8V to 4.2V (configurable)
- Range of 3 meters or more

### P2110 Architecture

**Pulsed Power Output**
- RF range: -12dBm to 15dBm
- Output voltage: 2V to 5.5V (configurable and regulated)
- Range of 10 meters or more
Harvester Performance

P1110 - 915MHz, 3V

P2110 - 915MHz, 1.05V

Input Power (dBm)

RF-to-DC Conversion Efficiency (%)

Custom Designs
Harvesting sensitivities:
-25dBm with battery
-18dBm passive

Distance

Power

-12 -10 -8 -6 -4 -2 0 2 4 6 8 10 12 14 16 18 20
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
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

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

- Identification+
- Consumer Electronics (Recharging)
- Electronic Labeling
- Medical Sensors

- Access Control
- Advanced Packaging (Illumination)
- Process Monitoring (Wireless Sensors)
- Defense
Wirelessly Power Sensors

- Powercast enables a complete wireless infrastructure for wireless power and data

Network

Access Point (ZigBee, WiFi, etc)

Power Transmitter

Powercast-enabled Wireless Sensor
Temperature / Humidity / Motion / Light / etc
Bulk Trickle Charging

- Freedom of placement
- Eliminate wires and connectors
- Automatic/transparent charging
- Multiple battery types/chemistry
PowerSpot Recharging

Consumer Electronics Recharging Overnight When Not In Use

Computer peripherals
Hearing Aids
Headsets
Wearables
Tracking Devices
Other Devices

Consumer-Oriented PowerSpot® Transmitter
Small size and Low-cost
Added Capacity: 8 Hours

4W EIRP Transmitter

+55mAh

+27mAh

+15mAh

+355mAh

+96mAh

+47mAh

+26mAh

3.8V Li-Ion Battery
Added Capacity: 20 Hours

4W EIRP Transmitter

Desktop Recharging

+138mAh

+67mAh

+37mAh

+241mAh

+118mAh

+64mAh

+888mAh

6 in

1 ft

2 ft

3.8V Li-Ion Battery
RF Energy Harvesting
High-Function RFID Tags

UHF RFID Reader

- Identification
- Sensing
  - Temperature
  - Humidity
  - Light Level
  - Stress/Strain
  - Heart Rate
- Smart Packaging
  - Bi-Stable Display
  - Indications – LED, Audible
- Security
  - Biometrics and Encryption

Powercast provides >10X the power vs. traditional RFID
RFID Tag Power Needs

- Industrial Sensing
- Maintenance Tracking
- Manufacturing Operations

Enabled by Powercast

• Retail
• Supply Chain
• Medical

Power

ID Tag

Memory Tag

High-Function Tag

Sensors
Computation
Screen Update

Memory Access

ID read

• Retail
• Supply Chain
• Medical
UHF RFID Sensing

- EPC Class 1 Gen 2 & ISO/IEC 18000-6C compliant
- 10 meter read range
- High sensor accuracy – up to three sensors in a single tag
- “Find Tag” feature – enables locating one specific tag by illuminating an on-board LED
- Wide RF operating range: -17dBm to +20dBm
- Frequency range: 860MHz to 960MHz
- Compact and convenient hard case packaging
- Fast read rate

PCT100 SPECIFIC FEATURES
- Completely battery-free wireless sensing
- Data accessible in user memory
- -40 to +85C operational temperature range

PCT200 SPECIFIC FEATURES
- Up to 1 month of battery life without recharging
- Battery is recharged using the RFID reader’s field (no wires to plug in, no batteries to change)
- Customizable data read times from 1 minute to 1 hour
- Stores maximum, minimum, and average values in user memory
- Read times and dates are available along with sensor data

Passive Sensing

Multiple Configurations

<table>
<thead>
<tr>
<th>Model</th>
<th>Sensor Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>PCT100-T</td>
<td>Temperature</td>
</tr>
<tr>
<td>PCT100-L</td>
<td>Light</td>
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<tr>
<td>PCT100-H</td>
<td>Humidity</td>
</tr>
<tr>
<td>PCT100-TL</td>
<td>Temperature and Light</td>
</tr>
<tr>
<td>PCT100-TH</td>
<td>Temperature and Humidity</td>
</tr>
<tr>
<td>PCT100-LH</td>
<td>Light and Humidity</td>
</tr>
<tr>
<td>PCT100-TLH</td>
<td>Temperature, Light and Humidity</td>
</tr>
<tr>
<td>PCT200-T</td>
<td>Temperature</td>
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</table>
Lifetime Power® Power Management Solutions
Ideal Industries and Powercast have partnered to provide Lifetime Power wireless sensor products for use in building automation applications.

Powercast continues to develop new products for Ideal.

Audacy lighting control system was selected for installation at Wrigley Field in Chicago, Sports Authority Field at Mile High, Petco Park, SFO Airport Terminal 1, UCLA, Universal Studios Orlando.

Audacy was voted Product of the Year ‘16 by EC&M magazine.

*Wireless Gateway*  
*Wireless Device*  
*25+ year battery life*  

*flexibility of wireless with the longevity of a wired system*
LIGHTING AND HVAC CONTROL

- Energy Optimization and Reporting
- Lighting Retrofit Savings 25% – 50%
- Advanced Lighting Controls Savings 20% – 40%
- Plug Load Control Savings 10% – 30%
- Wireless HVAC and Lighting Control Devices

CORPORATE ENERGY MANAGEMENT

- Portfolio-Wide Energy Management
- Benchmarking
- EnergyStar Certification
- Comparative Statistics
- Preventative Maintenance Programs

COMPREHENSIVE DEMAND RESPONSE

- Peak Load Shedding
- Capacity Management
- Demand Pricing Optimization
- Open ADR Certified
- Recurring Energy Revenue

HVAC INTEGRATION AND OPTIMIZATION

- Occupancy-Based Temperature Optimization
- Fault Detection and Prioritization
- Performance Monitoring Savings 25% - 50%
- Asset Management Tools
- Demand Control Ventilation
• Powercast and Compliance Innovations have partnered to produce Smart Auto Plates (SAP)
• USA version ready to enter drive trails in several states
• Cellular connectivity allows communication between the SAP and a custom compliance server
• E-paper display and unique power management enables greater than ten-year battery life
• Key features:
  – Battery powered (no wires)
  – Ruggedized case made from UV stabilized, abrasion/impact resistant plastic
  – Antenna diversity provides superior cellular coverage
  – IP67 rated waterproofing
Vikaura Screens, available in 4, 6, and 9.7 inch sizes, enable a smartphone, laptop, or other Bluetooth devices to post pictures and information to the screen using a unique app. The screen, unhindered by cords, can be placed anywhere and will last for years on the replaceable battery.

- Vikaura is a Powercast brand
- Full product design performed by Powercast
  - Industrial Design
  - Electrical & Mechanical Design
  - Embedded Firmware
  - iOS and Android App
- Shipping in August ‘17

App-driven screens that enable customization of your customer’s surroundings: Custom pictures, graphics, and targeted advertising
Arrester Temperature Monitoring System (ATMS)

- Arresters protect the most valuable assets in substations and there are virtually no indicators that the arrester is functioning or failing in a long term degrading scenario.
- Station arresters seldom fail, but when they do they cause an outage that can last for extended periods.
- There are currently no cost effective, reliable means for continuous, automatic monitoring of the health of a station class arrester on the market.
- Thermal imaging is used periodically to check the arresters.
- Or, costly manual meters are used.
ATMS monitors the health of an arrester by measuring its external temperature and compares it to other arresters in the same area.

- Wireless sensors transmit digital data as far as 100 feet to a gateway.
- Gateway is installed in the substation control room and transfers the temperature data via Ethernet or cellular means to a cloud database.
- Up to 100 sensors per gateway.
- 20-25 year battery lifetime.
- Sensors can be installed on a live arrester and are attached with aggressive industrial adhesive.

Diagram:
- Wireless Temp Sensor
- Cellular or Ethernet Gateway
- Web Based ArresterWorks Dashboard
- Database
Sensor Information
- Company Name: Utility ABC
- Substation Name: Tupalo 2
- Sensor Location: 230-27
- Number of Sensors: 3
- Arrester Types: Hubbell Polymer
- Days in Service: 15
- Max Delta to Date: .702 Deg F 6-4-17
- Arrester Status: Healthy
- Removal Prediction: None

ATMS Pilot
--- Arrester Temperatures ---

Delta Temperatures at Midnight for last 30 Days

Today's Temperatures for Sensors 10, 20, 30
Thank You
Visit us at Booth 943!

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