

IEEE Technical Committee on RFID Distinguished Lecture

Energy Harvesting: Extending the Battery Life of Mobile
Products

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Chair IEEE CRFID, Wi2Wi Inc.
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Bio – Will Lumpkins (Sanitate)



- VP of Engineering O & S Services <http://www.ons-services.com/>
- Lead Consultant for Wi2Wi Inc. (Wi-Fi/GPS/BT)
- Chair, IEEE Systems Man & Cybernetics Standards Committee
- Chair, IEEE Technical Committee on RFID
- IEEE Consumer Electronics Magazine Senior Editor
- IEEE Senior Member
- 20+ Years professional experience in the Consumer Electronics
BS University of New York
- Leader in Multi-disciplinary Science product development

Research Interests

- AI in Games, Haptic's (Tactile Response), Sensory Augmentation, Autonomous Mental Development, IoT, Automotive Technologies, Health Systems, Gaming Technologies, RFID, Energy Harvesting

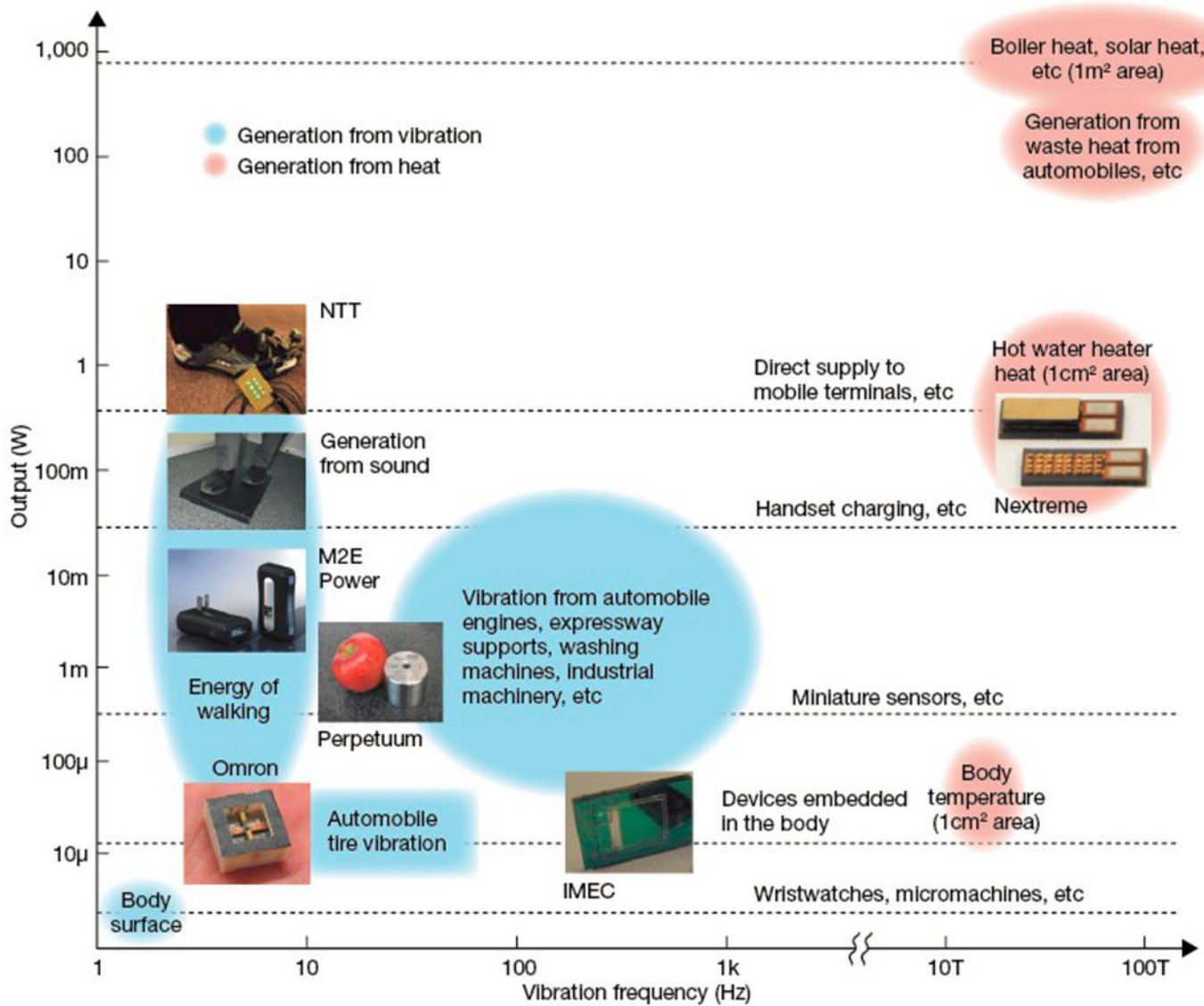
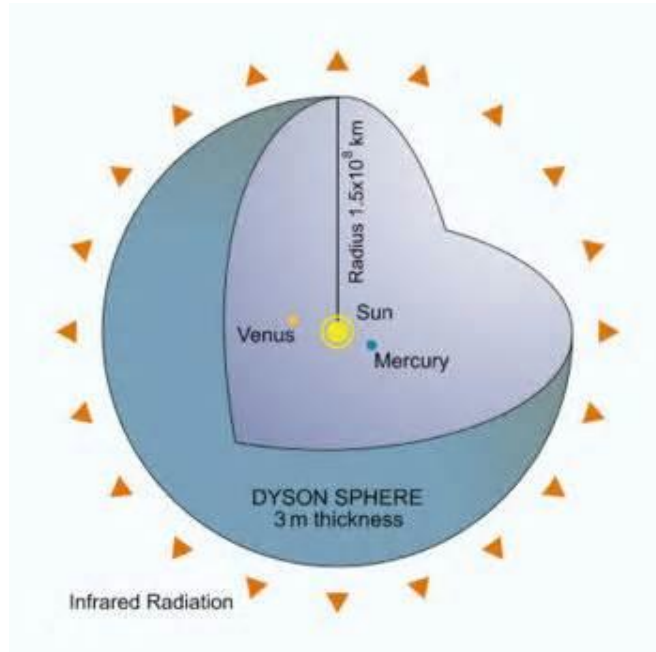


Fig 1 Wide Range of Outputs from 10 μ W to 1kW Heat as a type of vibration in the broad definition. Diagram shows outputs and vibration frequencies possible with existing technology for generation from vibration and heat. Generation from heat is expected to achieve 5W per cm² of area, or 1kW per m². Systems using turbines are the most effective in generation from vibration. There is a positive correlation between generating device size and output.

<http://techon.nikkeibp.co.jp/article/HONSHI/20090127/164650/>

Dyson Sphere

- A Dyson sphere is a hypothetical mega structure originally described by Freeman Dyson in 1959; such a “sphere” would be a system of orbiting solar-powered satellites meant to completely encompass a star and capture most or all of its energy output, which would be directed back to the destination planet, presumably Earth.



Energy Harvesting or Wireless Charging or Wireless Power

- Wireless Charging: Limited mobility, limited range, infrastructure charges
- Wireless Power: limited extended range
- Energy Harvesting: “Free power”, limited extended range 50% Efficiency
- Tesla Power: Still a “Pipe Dream” but we are getting closer.

RF Energy Harvesting Concerns

- Multi-Path Distortion
 - Won't this eliminate Multi-path?
- Efficiency
 - It is only 50% efficient, LDO's are 96%
- Loading source
 - In Power lines, the more load increases current generation

Old Energy Harvesting Table

Energy-Harvesting Sources Today			
Energy Source	Characteristics	Efficiency	Harvested Power
Light	Outdoor Indoor	10~24%	100 mW/cm ² 100 μW/cm ²
Thermal	Human Industrial	~0.1% ~3%	60 μW/cm ² ~1-10 mW/cm ²
Vibration	~Hz–human ~kHz–machines	25~50%	~4 μW/cm ³ ~800 μW/cm ³
RF	GSM 900 MHz WiFi	~50%	0.1 μW/cm ² 0.001 μW/cm ²

Courtesy of Texas Instruments

RF Energy Harvesting Measured Distances

- The minimal RF input power required for sensor node operation was -18 dBm (15.8 μ W). Using a 6 dBi receive antenna, the most sensitive RF harvester was shown to operate at a distance of 10.4 km from a 1 MW UHF television broadcast transmitter, and over 200 m from a cellular base transceiver station.



A Wireless Sensing Platform Utilizing Ambient RF Energy

Aaron N. Parks, Alanson P. Sample, Yi Zhao, Joshua R. Smith

Electrical Engineering Department and Computer Science and Engineering Department University of Washington, Seattle, USA-98195

Energy Harvesting (Applications)

Low Hanging Fruit: 1pA ~ 50 mA

- Battery-free wireless sensors
- - Industrial Monitoring
- - Smart Grid
- - Structural Health Monitoring
- - Defense
- - Building automation
- - Agriculture
- - Oil & Gas
- - Location-aware services
- - Wireless trigger
- - Low power electronics
- - Toys

Using a UHF RFID reader, a RF harvesting circuit can be used to power a microcontroller (MCU) and additional sensors (strain, vibration, etc). The MCU can communicate to NXP's UCODE RFID chip via the I2C interface, and the tag ID and data can be read through the RFID reader. The result: One infrastructure for communications and power, no batteries, reliable operation.

Energy Harvesting (Applications)

Holy Grail (Hard to Reach Fruit) 500ma ~ 6.5 Amp+

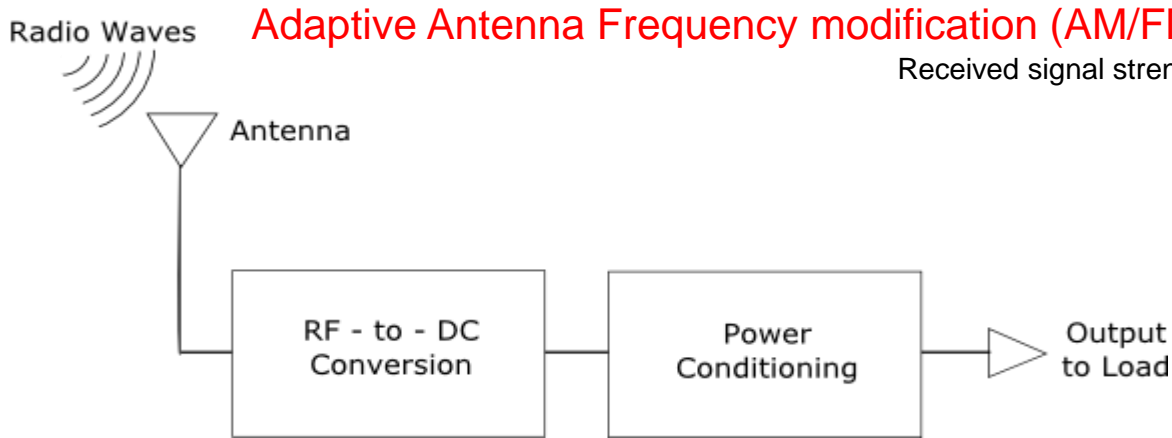
- Cell Phone
- Tablets
- Laptops
- Automotive (Electric vehicles)
- UAV (Drones)

Energy Harvesting (Applications)

Mid-Range Goals 50mA ~ 500mA

- Cell Phone (battery life extenders)
- Tablets (battery life extenders)
- Mice/Keyboards (input control devices/UI)
- In-Home phones
- Limited LED lighting
- Toys

Energy Harvesting-Tesla's Dream realized-Sort of...



RF Power Harvesting

Battery management

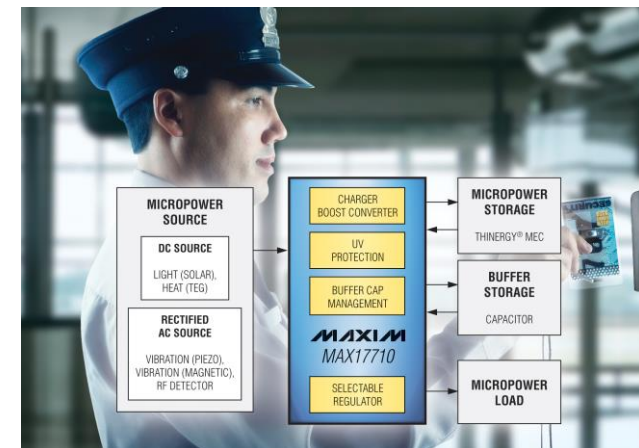
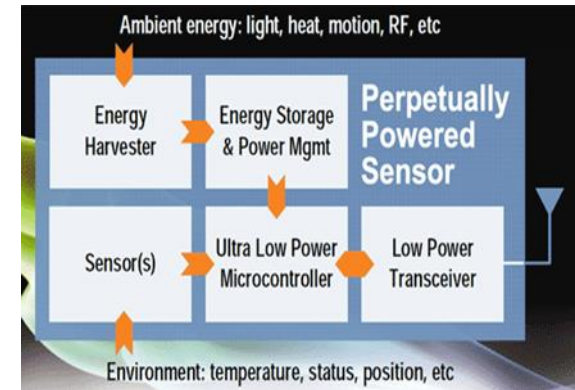
Maxim 17710 (Power Conditioning)

P2110 Power harvester™ Receiver
915 MHz (902-928MHz)

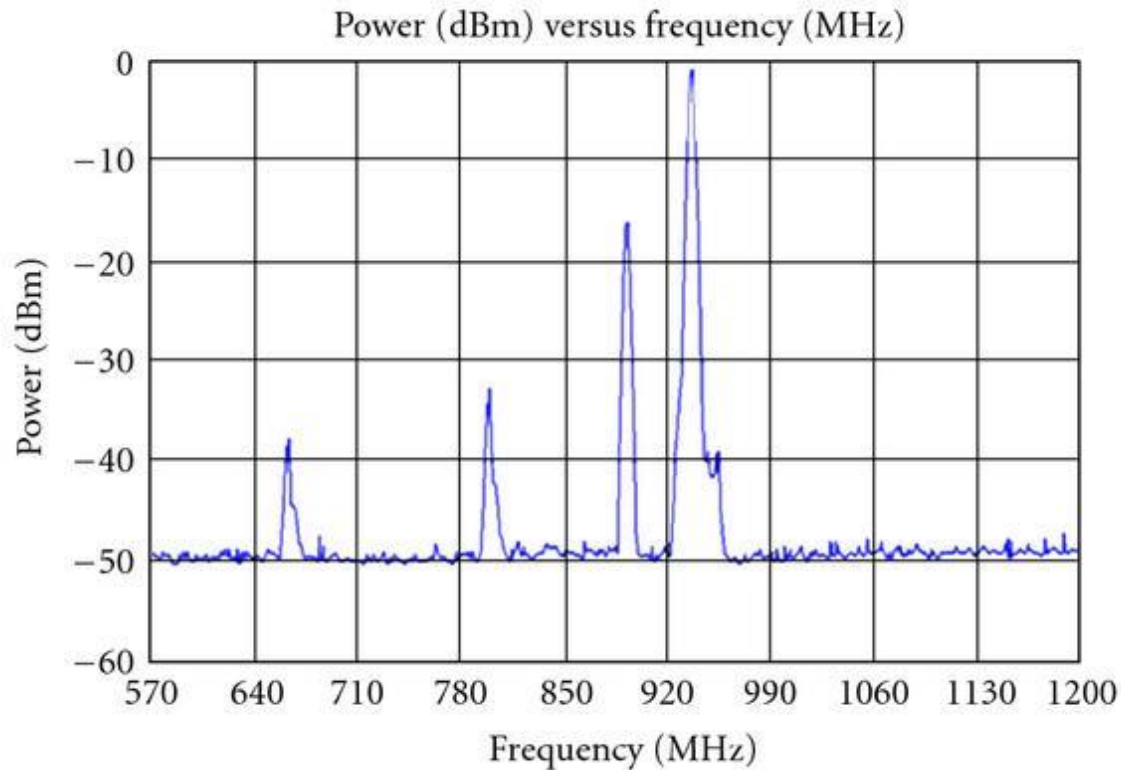
“With current RF sensitivity of the P2110 ... receiver at -11dBm, powering devices or charging batteries at distances of 40-45 feet from a 3W transmitter is easily achieved Improving the RF sensitivity allows for RF-to-DC power conversion at greater distances from an RF energy source. However, as the range increases the available power and rate of charge decreases.” Harry Ostaffe, VP of Marketing and Business Development, Powercast Corporation

Adaptive Antenna Frequency modification (AM/FM ~ 80GHz) RSSI AGC

Received signal strength indication Automatic Gain Control



GSM Power Levels



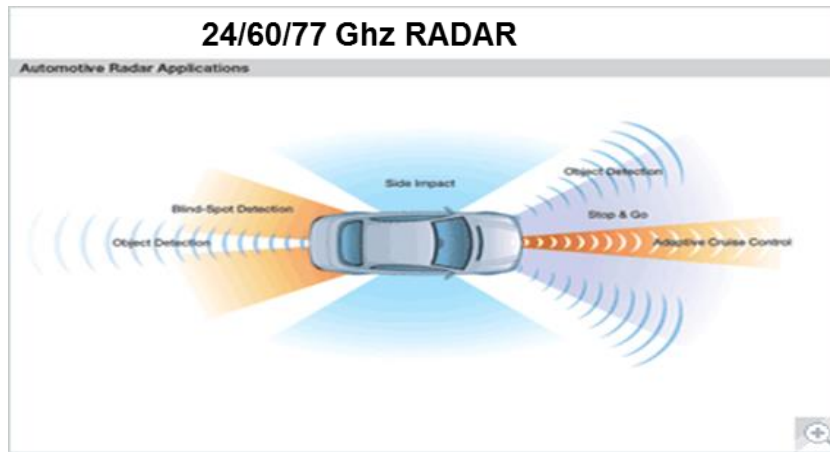
- To inspect the RF signal level of a low density spectrum, measurements were conducted using a spectrum analyzer (Rohde & Schwarz FSP) and a dipole antenna.
- ¹ Active and Passive Electronic Components Volume 2010 (2010), Article ID 591640, 7 pages

Investigation of RF Signal Energy Harvesting

[Soudeh Heydari Nasab](#), [Mohamed Asefi](#), [Lutfi Albasha](#), and [Naser Qaddoumi](#)

IEEE Standards – Vehicle Networking

Power Field Source: 2.4/5/60/77/80Ghs



Courtesy of freescale www.freescale.com

- **IEEE 802.11ac** tm – Multi-MIMO 500Mbits to 6.9Gbits
- IEEE 802.11p-DSRC/WAVE
- IEEE 1602.

- **IEEE 802.15.4** tm – IEEE 802.15.4 is a standard which specifies the physical layer and media access control for low-rate wireless personal area networks (LR-WPANS). It is the basis for the ZigBee, ISA100.11a, WirelessHART, and MiWi specifications, each of which further extends the standard by developing the upper layers which are not defined

Future RFID Gaming Systems

- Energy Harvesting
- E-Passport/NFC

RFID Community

- E-Newsletter-Looking for Editor
- Like a SIG, Open to all No-IEEE membership required