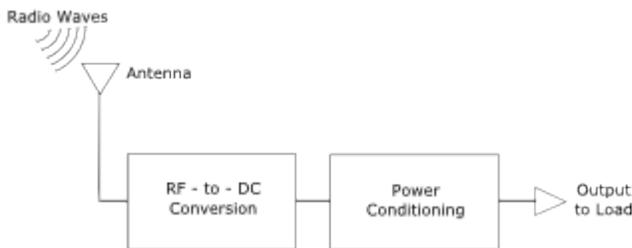


RF-based Wireless Charging and Energy Harvesting Enables New Applications and Improves Product Design

By Harry Ostaffe, VP of Marketing and Business Development, Powercast Corporation

RF energy is currently broadcasted from billions of radio transmitters around the world, including mobile telephones, handheld radios, mobile base stations, and television/ radio broadcast stations. The ability to **harvest RF energy**, from ambient or dedicated sources, enables **wireless charging** of low-power devices and has resulting benefits to product design, usability, and reliability. Battery-based systems can be trickled charged to eliminate battery replacement or extend the operating life of systems using disposable batteries. Battery-free devices can be designed to operate upon demand or when sufficient charge is accumulated. In both cases, these devices can be free of connectors, cables, and battery access panels, and have freedom of placement and mobility during charging and usage.

Energy Sources



The obvious appeal of **harvesting ambient RF energy** is that it is essentially “free” energy. The number of radio transmitters, especially for mobile base stations and handsets, continues to increase. ABI Research and iSupply estimate the number of mobile phone subscriptions has recently surpassed 5 billion, and the ITU estimates there are over 1 billion subscriptions for mobile broadband. Mobile phones represent a large source of transmitters from which

to harvest RF energy, and will potentially enable users to provide power-on-demand for a variety of close range sensing applications. Also, consider the number of WiFi routers and wireless end devices such as laptops. In some urban environments, it is possible to literally detect hundreds of WiFi access points from a single location. At short range, such as within the same room, it is possible to harvest a tiny amount of energy from a typical WiFi router transmitting at a power level of 50 to 100 mW. For longer-range operation, larger antennas with higher gain are needed for practical harvesting of **RF energy** from mobile base stations and broadcast radio towers. In 2005, Powercast demonstrated ambient RF energy harvesting at 1.5 miles (~2.4 km) from a small, 5-kW AM radio station.

RF energy can be broadcasted in unlicensed bands such as 868MHz, 915MHz, 2.4GHz, and 5.8GHz when more power or more predictable energy is needed than what is available from ambient sources. At 915MHz, government regulations limit the output power of radios using unlicensed frequency bands to 4W effective isotropic radiated power (EIRP), as in the case of radio-frequency- identification (RFID) interrogators. As a comparison, earlier generations of mobile phones based on analog technology had maximum transmission power of 3.6W, and Powercast’s TX91501 transmitter that sends power and data is 3W.

RF Harvesting Receivers

RF energy harvesting devices, such as **Powercast’s Powerharvester®** receivers, convert RF energy into DC power. These components are easily added to circuit board designs and work with standard or custom 50-ohm antennas. With current RF sensitivity of the **P2110 Powerharvester** receiver at -11dBm, powering devices or charging batteries at distances of 40-45 feet from a 3W transmitter is easily achieved and can be verified with Powercast’s **development kits**. 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.

An important performance aspect of an RF energy harvester is the ability to maintain RF-to-DC conversion efficiency over a wide range of operating conditions, including variations of input power and output load resistance. For example, **Powercast's RF energy-harvesting** components do not require additional energy-consuming circuitry for maximum power point tracking (MPPT) as is required with other energy-harvesting technologies. Powercast's components maintain high RF-to-DC conversion efficiency over a wide operating range that enables scalability across applications and devices. RF energy-harvesting circuits that can accommodate multi-band or wideband frequency ranges, and automatic frequency tuning, will further increase the power output, potentially expand mobility options, and simplify installation.

Typical Applications

RF energy can be used to charge or operate a wide range of low-power devices. At close range to a low-power transmitter, this energy can be used to trickle charge a number of devices including GPS or RLTS tracking tags, wearable medical sensors, and consumer electronics such as e-book readers and headsets. At longer range the power can be used for battery-based or battery-free remote sensors for HVAC control and building automation, structural monitoring, and industrial control. Depending on the power requirements and system operation, power can be sent continuously, on a scheduled basis, or on-demand. In large-scale sensors deployments significant labor cost avoidance is possible by eliminating the future maintenance efforts to replace batteries.

Available power from a 3W transmitter will be low milliwatts within a few feet and tens of microwatts at around 40 feet. This amount of power is best used for devices with low-power consumption and long or frequent charge cycles. Typically, devices that operate for weeks, months, or years on a single set of batteries are good candidates for being **wirelessly** recharged by **RF energy**. In some applications simply augmenting the battery life or offsetting the sleep current of a microcontroller is enough to justify adding RF-based wireless power and energy harvesting technology.

A network of transmitters can be positioned in a facility to provide **wireless power** on a room-by-room basis, or for a many-to-many charging topology. Mobile phones can be used as portable power sources for a number of **battery-free wireless** devices. Imagine a mobile phone powering a battery-less, body-worn sensor that sends data to the phone via a commonly used protocol such as Wi-Fi, Bluetooth, or ZigBee. This data can be displayed locally on the handset or transmitted by the phone to a monitoring service. Powercast has already demonstrated this application using ambient RF energy from an iPhone (see video to right).

Improved Product Design

Products with **embedded wireless power** technology can be sealed from environmental conditions such as moisture and from user access. In addition, connectors and cables can be eliminated. Product reliability and lifecycle can be significantly improved as a result. When in range of a suitable RF source, charging is automatic and transparent to the end-user which provides increased convenience of use. With Powercast's components, multiple battery chemistries and charge voltages can be supported which allows for maximum power storage flexibility.

Conclusion

Ambient radio waves are universally present over an ever-increasing range of frequencies and power levels, especially in highly populated urban areas. These **radio waves** represent a unique and widely available source of energy if it can be effectively and efficiently harvested. The growing number of **wireless**

transmitters is naturally resulting in increased **RF power** density and availability. Dedicated power transmitters further enable engineered and predictable wireless power solutions. With continued decreases in the power consumption of electronic components, increased sensitivity of passive receivers for **RF harvesting**, and improved performance of low-leakage **energy storage** devices, the applications for **wire-free charging** by means of RF-based wireless power and energy harvesting will continue to grow.

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