An introduction to the Wireless Power Consortium standard and TI's compliant solutions

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Introduction

Wireless power is beginning to show great potential in the consumer market. The ability to power an electronic device without the use of wires provides a convenient solution for the users of portable devices and also gives designers the ability to develop more creative answers to problems. This technology's benefits can be seen in the many portable devices, from cell phones to electric cars, that normally operate on battery power.

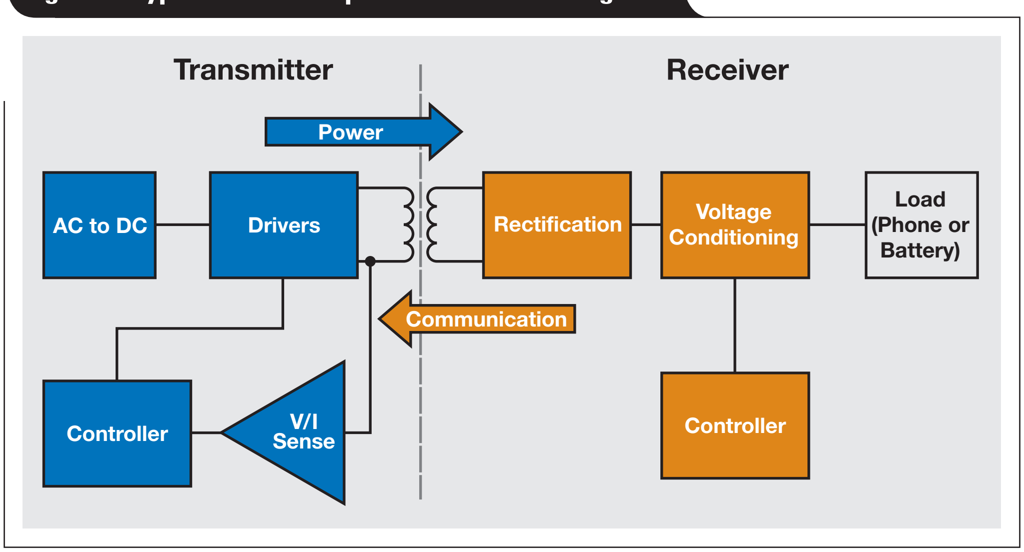
Inductive coupling is the method by which efficient and versatile wireless power can be achieved. For ease of use and the benefit of both designers and consumers, the Wireless Power Consortium (WPC) has developed a standard (see Reference 1) that creates interoperability between the device providing power (power transmitter, charging station) and the device receiving power (power receiver, portable device). Established in 2008, the WPC is a group of Asian, European, and American companies in diverse industries, including electronics manufacturers and original equipment manufacturers (OEMs). The WPC standard defines the type of inductive coupling (coil configuration) and the communications protocol to be used for low-power wireless devices. Any device operating under this standard will be able to pair with any other WPC-compliant device. One key benefit to this approach is that it makes use of the coils for communications between the power transmitter and the power receiver. See Figure 1 for a typical application diagram.

WPC standard for wireless power

Under the WPC standard, "low power" for wireless transfer means a draw of 0 to 5 W. Systems that fall within the scope of this standard are those that use inductive coupling between two planar coils to transfer power from the power transmitter to the power receiver. The distance between the two coils is typically 5 mm. Regulation of the output voltage is provided by a global digital control loop where the power receiver communicates with the power transmitter and requests more or less power. Communication is unidirectional from the power receiver to the power transmitter via backscatter modulation. In backscatter modulation, the power-receiver coil is loaded, changing the current draw at the power transmitter. These current changes are monitored and demodulated into the information required for the two devices to work together.

The WPC standard defines the three key areas of the system—the power transmitter that will supply power, the power receiver that will use the power, and the communications protocol between the two devices. These three areas are explored next.

Figure 1. Typical wireless-power functional diagram



Power transmitter

The direction of power transfer is always from the power transmitter to the power receiver. The key circuits of the power transmitter are the primary coil, used to transfer power to the power-receiver coil; the control unit for driving the primary coil; and the communications circuit for demodulating the voltage or current from the primary coil. Flexibility of the power-transmitter design is limited to provide consistent power and voltage levels to the power receiver.

The power receiver identifies itself to the power transmitter as a compliant device and also provides configuration information. Once the transmitter initiates power transfer, the power receiver sends error packets to the power transmitter requesting more or less power. The power transmitter stops supplying power upon receiving an "End Power" message, or if no packets are received for more than 1.25 seconds. While no power is being transmitted, the power transmitter enters a low-power standby mode.

The WPC specification allows for both fixed- and moving-coil configurations. A single fixed coil, referred to as type A1, is the solution that Texas Instruments (TI) supports.

The power transmitter, typically a flat surface upon which the user places the power receiver, is connected to the power source. The coils of a WPC-compliant device operate as a resonant half bridge on a 50% duty cycle, with a 19-VDC input (±1 V). If more or less power is needed at the power receiver, the frequency in the coil changes but stays between 110 and 205 kHz, depending on power demands.

Power receiver

The power receiver is typically a portable device. The key circuits of the power receiver are the secondary coil, used to receive power from the power-transmitter coil; the rectification circuit, used to convert AC to DC; the power-conditioning circuit, which buffers the unregulated DC into regulated DC; and the communications circuit, which modulates the signal to the secondary coil. The power receiver is responsible for all communications of its authentication and power requirements, as the power transmitter is only a "listener."

While design of the power transmitter is restricted to keep it WPC-compliant, much more freedom is permitted for designing the power receiver. The coil dimension of the power receiver can be adjusted to meet the device's form factor. The coil voltage at the power receiver is full-wave rectified, with a typical efficiency of 70% for a 5-V, 500-mA output. Because communication between the two devices is unidirectional, the WPC selected the power receiver to be the "talker." Inductive power transfer works by coupling a magnetic field from primary to secondary coils. Uncoupled field lines rotate around the primary coil and do not represent loss as long as the field lines don't couple a parasitic load (for example, eddy-current loss in metal).

Communications protocol

The communications protocol includes analog and digital pinging; identification and configuration; and power transfer. A typical start-up sequence that occurs when a power receiver is placed on a power transmitter proceeds as follows:

1. An analog ping from the power transmitter detects the presence of an object.
2. A digital ping from the power transmitter is a longer version of the analog ping and gives the power receiver time to reply with a signal-strength packet. If the signal-strength packet is valid, the power transmitter keeps power on the coil and proceeds to the next phase.
3. During the identification and configuration phase, the power receiver sends packets that identify it and that provide configuration and setup information to the power transmitter.
4. In the power-transfer phase, the power receiver sends control error packets to the power transmitter to increase or decrease the power supply. These packets are sent approximately every 250 ms during normal operation or every 32 ms during large signal changes. Also during normal operation, the power transmitter sends power packets every 5 seconds.
5. To end the power transfer, the power receiver sends an "End Power" message or sends no communications for 1.25 seconds. Either of these events places the power transmitter in a low-power state.

TI's WPC-compliant solutions

TI is a founding member of the WPC and has taken an active role in developing a robust wireless-power specification. TI has developed reliable solutions for both a power receiver and a power transmitter in the form of three newly developed ICs. The power receiver uses the MSP430bq1010 and bq25046 devices. The power transmitter is based on the bq500110, which supports type A1 (single-coil) configurations. Both receiver and transmitter ICs are designed to be interoperable with other WPC-compliant solutions.

The MSP430bq1010 in the power receiver handles all of the logic functions and communications. The onboard analog-to-digital converters monitor the levels of voltage into and current out of the bq25046. The bq25046 provides load-current information to the MSP430bq1010, which then uses this information to control the power transmitter's operating point. The bq25046 provides a low-current, 3.3-V low-dropout regulator (LDO) to power the MSP430bq1010 and logic circuit, while a larger 5.0-V LDO is capable of providing up to 1 A of current to the main output.

The power-transmitter solution is provided with the bq500110. This device demodulates and decodes serial data from the power receiver. The control circuits first certify that the power receiver is indeed a WPC-compliant device, then configure the power transmitter accordingly.

TI's BQTESLA100LP EVM kit combines separate transmitter and receiver designs into a single kit that includes mechanical packaging. This kit can be used for evaluation of the ICs or as a design example. The WPC has certified that both the power-transmitter and the power-receiver solutions meet the Version 1.0 specification. No software is required to operate the EVM, which needs only a 19-V input. The EVM kit's output will be 5 V at up to 1 A. The transmitter EVM includes multiple LED options for visual indication of power-transmission status. Also, two buzzer options provide audio indication of the start of power transfer.

Conclusion

The WPC standard is a set of guidelines that allows manufacturers to develop solutions with the confidence that their components will mesh with a variety of other WPC-certified components designed for inductive power transfer.

References

For more information related to this article, you can download an Acrobat® Reader® file at www.ti.com/lit/*litnumber* and replace "*litnumber*" with the **TI Lit. #** for the materials listed below.

Document Title	TI Lit. #
1. Wireless Power Consortium. "System Description Wireless Power Transfer, Vol. 1, Part 1," Version 1.0 [Online]. Available: http://www.wirelesspowerconsortium.com/downloads/wireless-power-specification-part-1.html	—
2. "Wireless Power Transmitter Manager," bq500110 Data Sheet	slusae0
3. "1.1A, Single-Input 5-V Power Supply IC for Wireless Power Applications," bq25046 Data Sheet	slusa83
4. "Wireless Receiver-Side Communication and Power Monitoring IC for Wireless Power," MSP430bq1010 Data Sheet	slas696
5. "bq500110EVM-688 Evaluation Module," User's Guide	slvu429a
6. "bq25046EVM-687 Evaluation Module," User's Guide	slvu420

Related Web sites

www.ti.com/wirelesspower

www.ti.com/sc/device/*partnumber*

Replace *partnumber* with bq25046, bq500110, or MSP430bq1010

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