Wireless charging: advanced technology delivers real benefits

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Power needs to catch up with data and become wireless to truly empower the latest generation of mobile devices. In this technical article, Infineon reviews the design challenges and standards that drive this new sector before looking at technologies that make this vital step possible.

Power is essential to every electronic device - that will never change. However the current approach of charging from a wall outlet is becoming obsolete. Charging needs to become more convenient for the user, they do not want to plug in the device but simply place it on a surface to charge. More than this, consumers want to be able to do this in public places such as airports, hotels, event venues, fast food chains and coffee shops, meaning that standardization needs to mature to drive universal compatibility. Somehow, designers have to find a way to re-invent current chargers to be able to deliver power through 'thin air'. The current switch mode power supply (SMPS) approach relies on a magnetically coupled transformer to change the voltage level and transfer power from the primary side to the secondary. In wireless, this transformer is split between the charger and the device. As the windings are separated (by the case thickness and air), the coupling is looser than with a normal SMPS. However, power can be transferred with unexpected efficiency with the correct magnetic design as the coils and coupling have a far greater impact on the overall performance than with an SMPS. Other than the magnetics, issues including efficiency, mechanical packaging, electromagnetic interference (EMI), thermal management and metallic foreign objects (such as coins and keys) create further challenges for designers.

As with many emerging technologies, multiple incompatible standards develop which stifle progress until a universal solution emerges. Wireless charging has two industry alliances and two standards. The Wireless Power Consortium (WPC) supports the Qi inductive standard that supports tightly coupled charging. Qi has become the mainstream standard, covering over 80% of all wireless charging receivers. The Power Matters Alliance (PMA) and the Alliance for Wireless Power (A4WP) were formed as separate organizations. PMA focused on tightly coupled inductive solutions whereas A4WP worked on loosely coupled resonant technology. PMA and A4WP merged and rebranded as the AirFuel Alliance (AFA).

Currently, there are three topologies for wireless charging, offering different advantages. Single-coil inductive is the simplest and most prevalent solution. Supported by Qi and AirFuel, this employs a single transmitter coil and requires exact and close positioning of the device and the transmitter, which precludes charging through surfaces. This approach can only charge a single device. Multi-coil enables intelligent systems that detect the coil closest to the device and direct the power accordingly. The broader charging field allows you more freedom in placing the device to be charged. AFA supports a resonant approach that relies on resonance between the transmitter and receiver to transfer energy far more efficiently. This approach charges multiple devices from a single coil and allows for a greater distance (up to 50mm) between the transmitter and receiver. This flexibility in positioning of the device gives a 'drop and go' experience with efficiencies up to 80%. Although an inductive solution can deliver more power in a precisely defined and controlled scenario, the resonant approach delivers an efficient energy transfer with higher placement freedom.

The resonant approach permits higher power ratings, allowing laptops or power tools to be charged wirelessly. The three key elements of a wireless charging solution are the adapter/charger, the transmitter and the receiver. The adapter is often separate and connected via a cable to the transmitter, although they could equally be combined. It powers the transmitter from the mains, usually with a regulated 5-20V DC. The transmitter contains a MOSFET-based bridge topology inverter to convert the DC power into an alternating magnetic field. A microcontroller and driver components provide flexibility and functionality.

There are two primary topologies used for resonant (AirFuel) applications, Class D and Class E. Class D offers an almost flat efficiency curve over a wide load range and is therefore

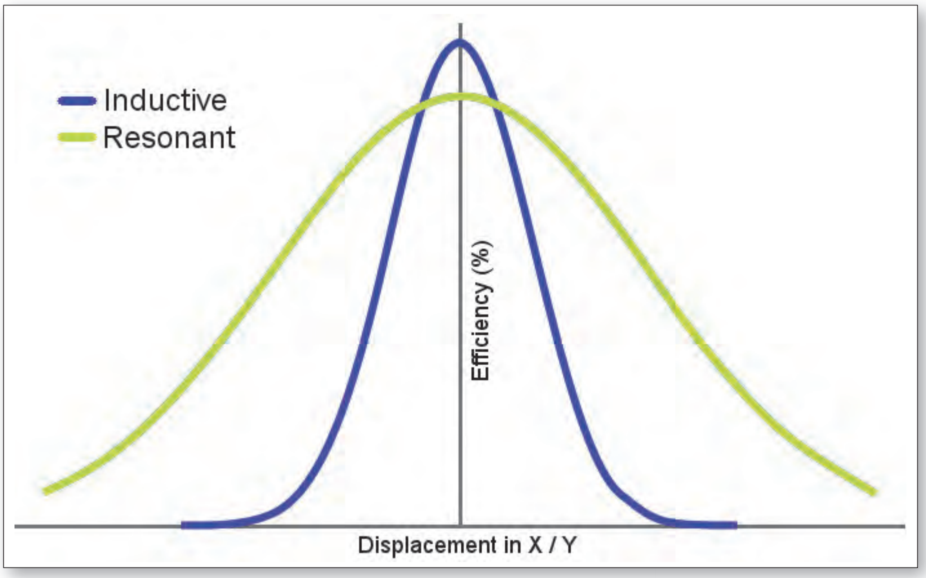

Figure 1. Comparison of efficiency vs displacement for inductive and resonant approaches

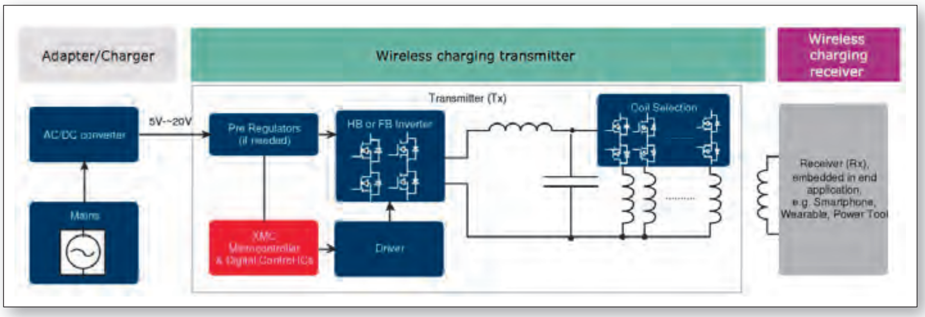

Figure 2. Typical wireless charging systems consist of three main elements.

suited to general-purpose wireless charging stations, such as those found in public places where a wide variety of devices could be charged. Class D is suitable for a wide range of power levels. In contrast to the Class D topology, Class E is optimized for a particular design point and, at this point, will show greater efficiency. However, the Class E efficiency falls off more rapidly away from this point. Thus this topology is best suited to high power and for 1:1 charging of a specific device that is either charged close to target power or not charged at all. The BOM costs associated with Class E are very similar but tend to be slightly lower than those of Class D. The Infineon product range includes an extensive suite of solutions for wireless charging transmitters and chargers that give designers the ability to use components and subsystems with known compatibility. Central to the transmitter design is a microcontroller for system control and intelligence. The Infineon XMC range includes the XMC1400 and XMC4400 that are suited for wireless charging via Class D and E topologies. The MOSFETs are directly driven by EiceDRIVER gate drivers that translate the microcontroller signals. Class D uses the new 2EDL71 and Class E uses the established 1EDN. The company is well known for their extensive MOSFET range. Designers are presented with significant choice of package size as well as RDS(ON) and Qg and voltage classes from 30V to 250V. As such, designers are able to design wireless chargers with the same base technology at multiple power levels. Class D or E power inverters (as well as synchronous rectification topologies) are best served by OptiMOS technology and CoolMOS devices are very suitable for ACDC adapters. Infineon also offers a range of flyback controllers for the power adapters that work well alongside the CoolSET integrated IC and power stage.

Apart from the technical challenges, designers are being required to bring new designs to fruition in ever-shortening timescales. To support this, a test board for a Class D transmitter was developed that allows designers to get a head start in designing wireless charging solutions. Designers that want to evaluate the performance of Infineon MOSFETs in a Class D configuration power amplifier will find the board a very valuable resource. The board comprises two half-bridges formed from two 80V 2x2 Infineon MOSFETs (IRL80HS120) as well as related drivers making prototyping a simple task. Users can evaluate either single-ended configurations (only one half-bridge is active) or differential configurations (both half-bridges are active), making the switch between the two easy. Users can rely on the embedded 6.78 MHz oscillator or use an external pin and BNC connector to inject other frequencies from a waveform generator. Everything needed for zero voltage switching (ZVS) power solutions are included with the board. There is even an on-board linear regulator to supply the board logic with a stable supply voltage. If a wireless charging capable receiver device is available then a complete wireless charging design can be created using the second BNC connector to connect and evaluate external transmitting coils for wireless power transfer.

Many consumers consider that the ability to wirelessly charge mobile devices is long overdue. The recent consolidation and advancements of the relevant standards has played a large part in moving towards a truly wireless society. Leading semiconductor companies, such as Infineon, have brought their broad strengths in power and magnetic design to bear on finding solutions. Drawing on their extensive experience of microcontrollers, MOSFETs and drivers they now offer a fully integrated solution with components that have demonstrated compatibility. Beyond this, Infineon is also releasing valuable design tools such as their Class D test board that allows designers to rapidly prototype and evaluate wireless charging systems. ■

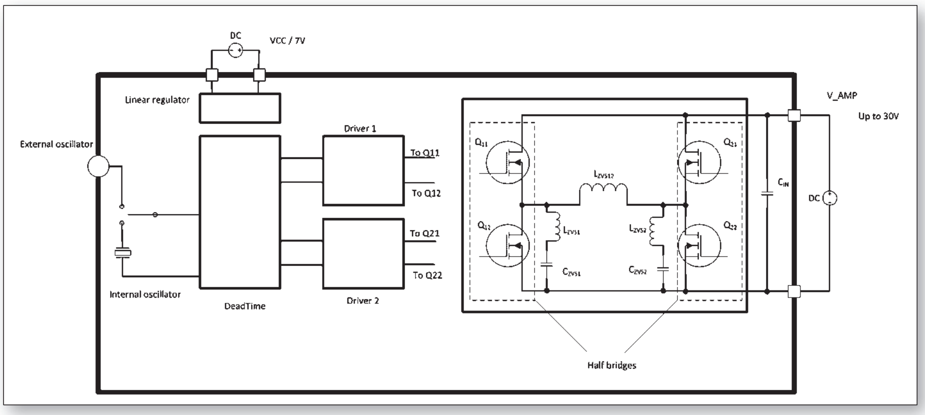

Figure 3. Simplified block diagram of the Class D test board