WHITEPAPER

Wireless Charging: A Guide to the Qi Standard

www.infineon.com/OPTIGA-Trust-Charge

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Introduction

Our lives are becoming increasingly wireless, especially as our devices become more mobile. Data communications and connectivity have been wireless for some time but, until relatively recently, we have been required to plug our device into a wall outlet to replenish its power.

However, things are changing with millions of devices that are capable of being charged wirelessly shipping every year. Wireless charging consists of two separate parts (transmit and receive) and these must work seamlessly to give people the ability to charge their devices anywhere.

Standards such as Qi are enabling that different devices and chargers all work with each other, which is allowing the market to grow rapidly. The Qi standard has recently been revised to include the need for authentication between the transmitter and receiver to allow the proof of the transmitter's authenticity.

In this technical white paper, Infineon Technologies will look at the world of wireless charging and associated applications. It will then discuss how standards are evolving and the implications for transmitter design, as well as consider which devices will allow designers to meet these requirements.

2 Why is wireless charging important?

Many people have some form of mobile device, whether it is a smartphone, tablet, fitness device or something else. We are all very familiar with their ability to operate wirelessly, to connect to the Internet or to each other, and to transfer data/files/photos without needing a physical connection such as a cable. This delivers user convenience and has undoubtedly contributed to these devices' popularity.

However, when it comes to charging the device, the most common method remains to plug it into a fixed charger – either a wall outlet, or a 12V socket in a vehicle, or something similar. Compared to the freedom to transfer data wirelessly, this seems somewhat antiquated and inconvenient. However, the challenge of moving power across an air gap is quite different to moving data.

Recently, many devices (especially smartphones) have gained the ability to be charged wirelessly by simply placing them on a charging pad, and several standards have been developed to allow interoperability between devices from different manufacturers.

There are a number of advantages to this approach. Firstly, consumers will not need to dispose of old chargers when they get a new device, and secondly, there is no physical plug/socket connection which will ultimately wear and become unreliable.
Perhaps the greatest advantage to the user is convenience as simply putting the phone down (in the right place) initiates a charging cycle without the need to worry whether a USB-C, micro-USB or manufacturer-specific cable is needed.

Wireless charging is becoming available in public spaces such as airports as well as in hotel rooms, meaning that there is less need to remember a charger while travelling. Some furniture makers are now building charging pads invisibly into their furniture while others are marketing 'retrofit' kits to allow the functionality to be added to existing furniture. Increasingly, automakers are now providing dedicated charging pads in vehicles, allowing users to charge without wires while driving.

3 Adoption of wireless charging

The three wireless charging specifications addressing applications at different power levels are Qi (up to 15W), NFC (up to 1 W) and the AirFuel Alliance (up to 50W).

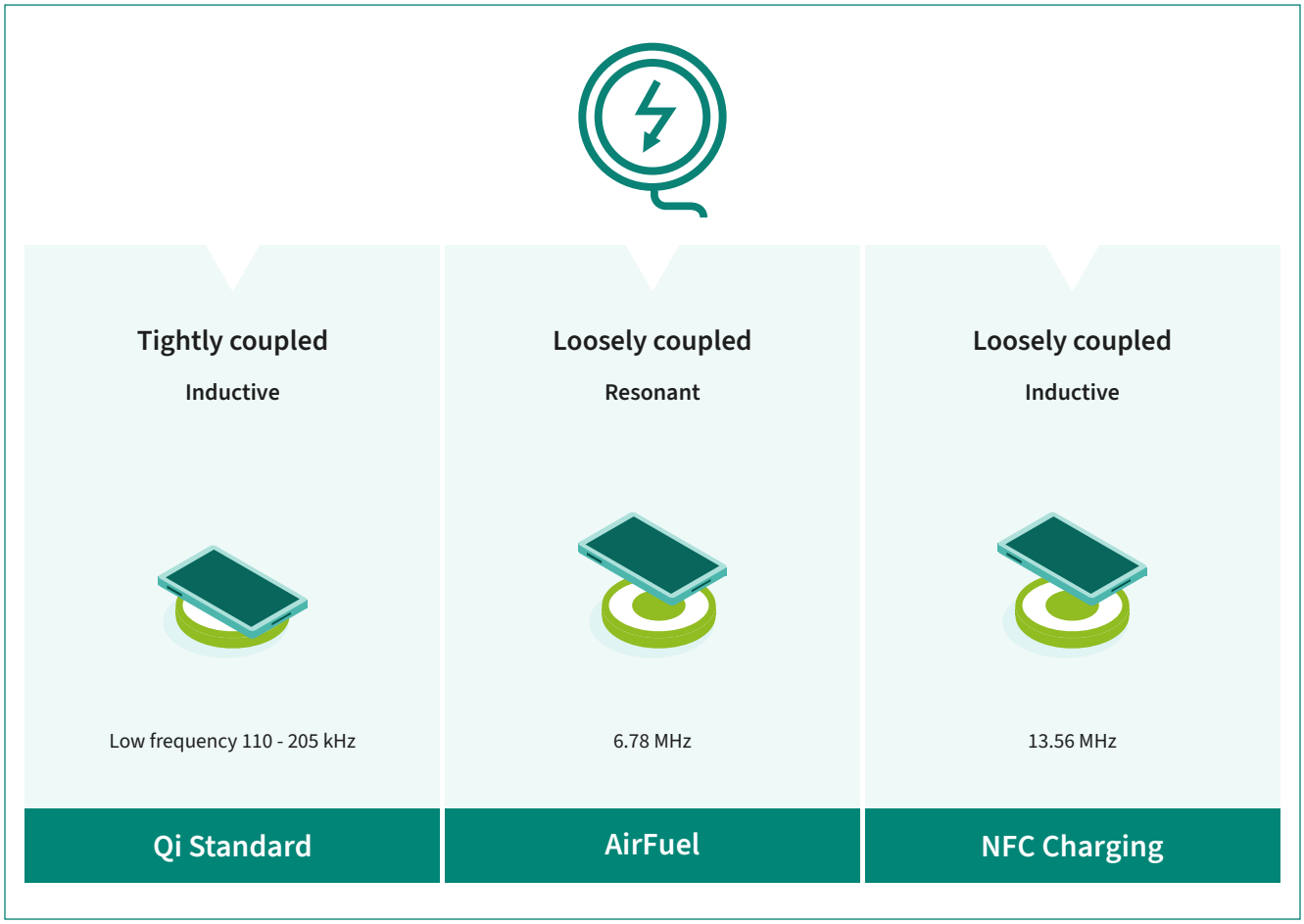

Figure 1 Qi, AirFuel and NFC Charging are the three main systems and standards for wireless chargin

Inductive charging is supported by the Qi standard, and it is here we will focus on in this white paper.

4 The Qi standard for wireless charging

The Qi standard is rapidly becoming the most widely adopted wireless charging standard. According to the latest market analysis by SAR Insight & Consulting, the market for tightly coupled inductive Tx is predicted to grow from ca. 300 million units in 2023 to over 1 billion units in 2028. Qi certified Tx account for the majority of this segment, which SAR projects will continue to dominate throughout the forecast.

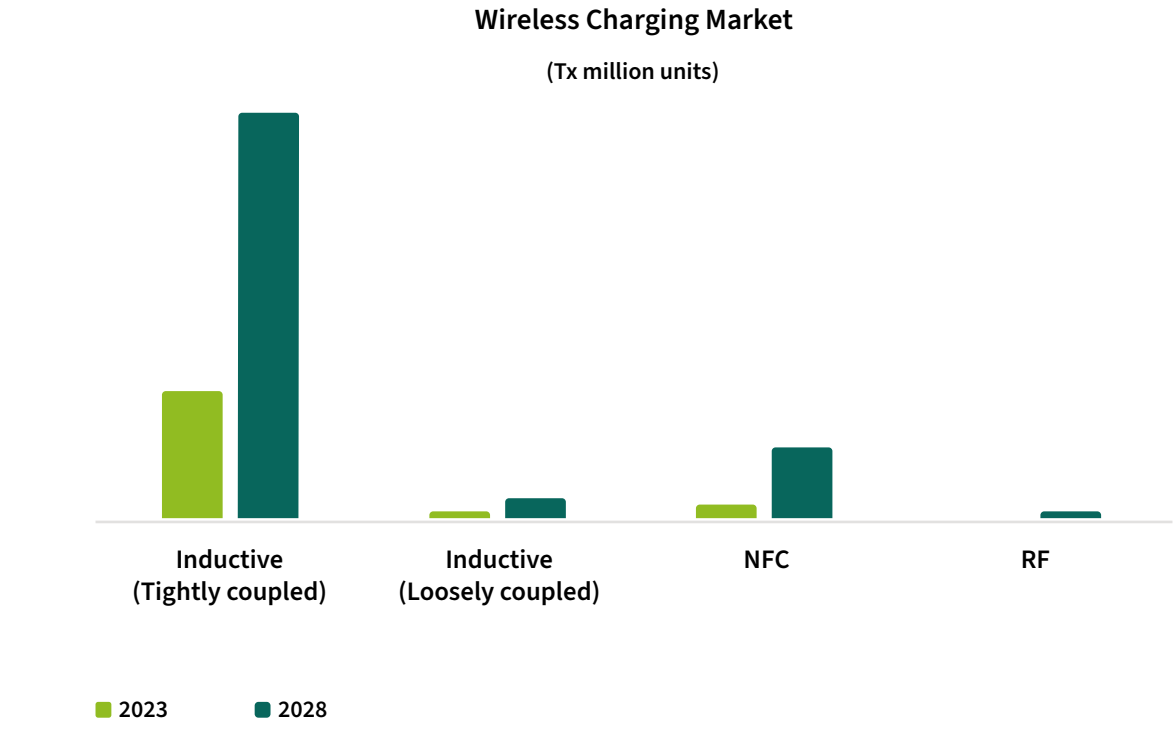

Image source: SAR Insight & Consulting – Wireless Power Technologies Service, June 2023

Figure 2 Inductive is, and will remain, the preferred approach for wireless charging

The Qi standard is a product of the Wireless Power Consortium (WPC) – an open, collaborative standards development group representing hundreds of member companies, including global smartphone market leaders, that collaborate for compatibility of wireless charging devices. WPC has developed a number of standards in the wireless charging area including the well-known Qi standard for smartphones and other mobile devices. Infineon is a member of WPC and, as such, contributes to the development of standards for wireless charging.

Today, the standard covers power levels up to 15 W, but there is a potential expansion to 60 W, thereby allowing devices such as laptops to be charged wirelessly.

The original Qi standard was published in 2009 covering low-power operation up to 5 W – this was later renamed as the ‘Baseline Power Profile’ (BPP).

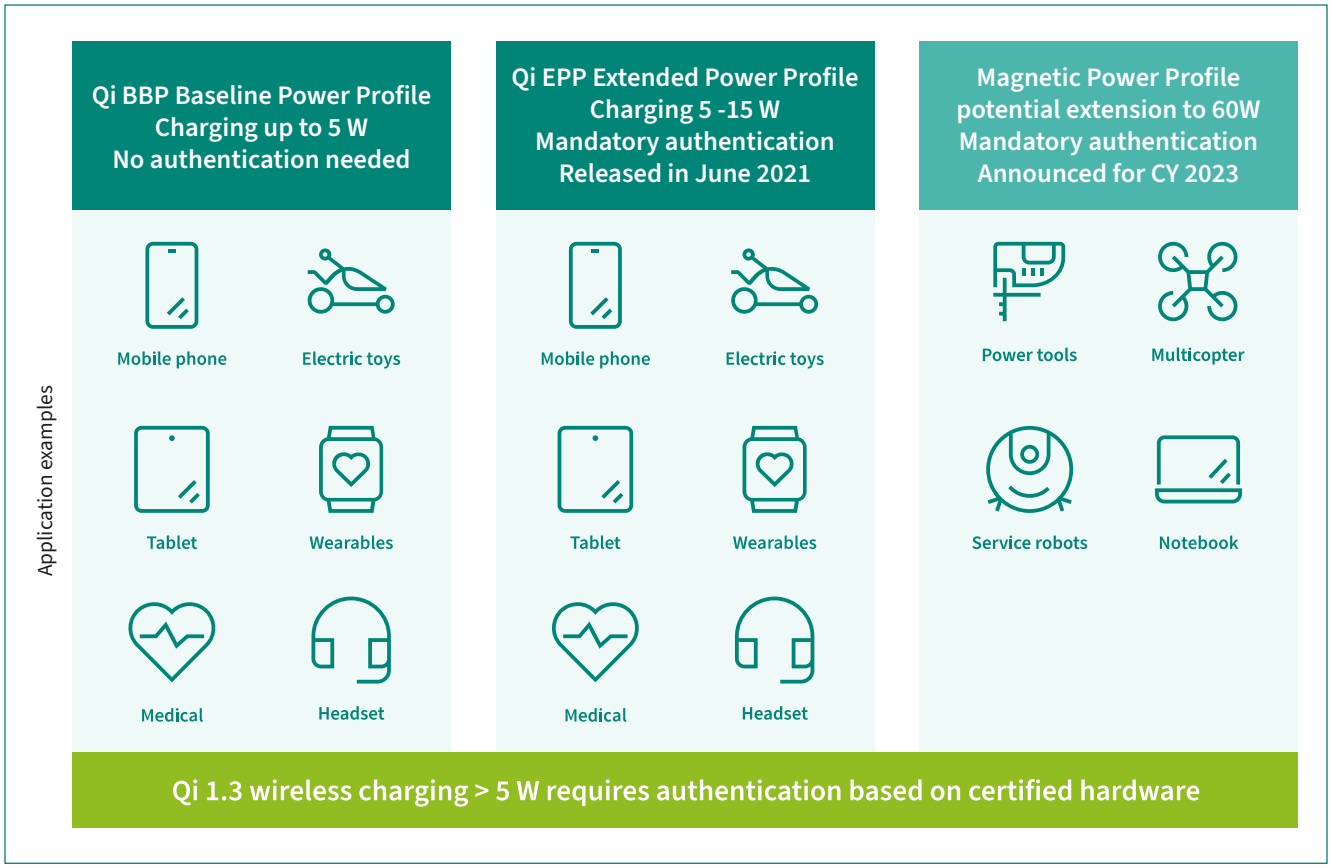

Figure 3 Qi currently covers up to 15W, with a potential extension to 60W

WPC incorporated a power increase up to 15 W into the specification and released the Extended Power Profile (EPP) in 2015 as version 1.2 of the standard. The standard was further updated in June 2021 to version 1.3 which included a number of significant changes.

Firstly, the standard was completely restructured into a total of 15 books, organized by theme and the language was improved in certain areas. More significantly, the foreign object detection (FOD) features and testing requirements were enhanced and a significant number of new compliance tests were introduced to test new features – as well as some existing features that were not previously tested.

The most significant change was the introduction of the need for authentication so that the power receiver that is embedded in the device being charged (smartphone, tablet etc.) can digitally verify whether the transmitter is trustworthy. This reduces the risk of damage to the device or user when charging with higher power levels as the device is only charged by a charger that was tested and approved by WPC.

While version 1.3 now provides seven options[1] for security evaluation and certification of a “Secure Storage Subsystem”, a manufacturer’s Certification Authority (CA) is only mandated to load WPC-related key and certificate material for one of the defined certifications.

Recently, the WPC has announced the release of the Qi 2 standard in 2023, which will incorporate a magnetic power profile into the Qi specification and thus ensure the compatibility with iPhones as well as Android and other devices. The specification will cover power levels up to 15 W, as the current 1.3 specification. The requirements for authentication will be the same as in Qi 1.3.

1 As of June 2023

5 Register of Qi products

To assure users that a device marketed as 'Qi-compliant' is genuinely compliant and not a forgery, WPC operates a rigorous testing program and register of approved devices. In order to be placed on the register (which now contains over 8000 approved devices) the product must be tested for compliance with the standard by one of eleven authorized test labs (ATLs). Then the device must be tested for its ability to interoperate with existing devices by a specialist interoperability testing center (IOC) of which there are currently two. This testing is designed for new products placed in the register to work well with all other products. Finally, the new product has to be checked for compliance with the latest version of the Qi standard.

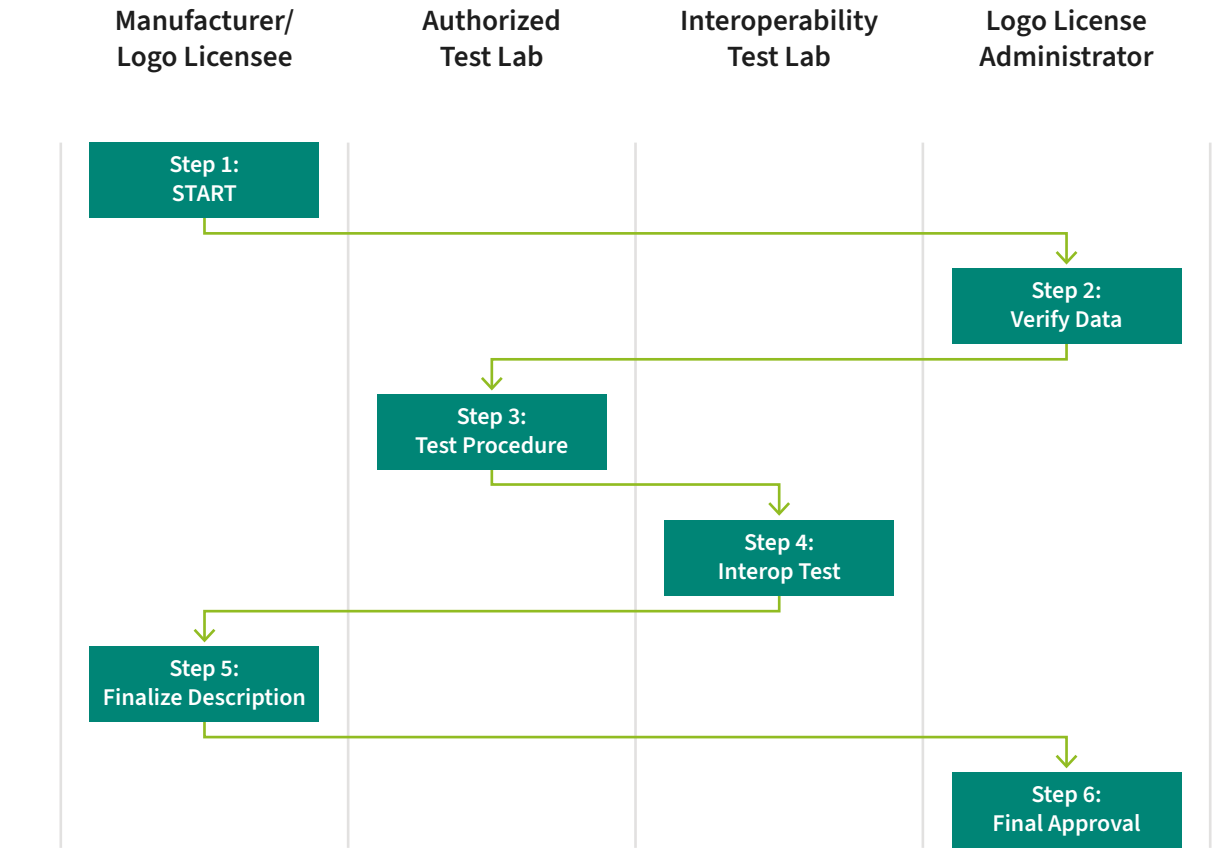

Image source: https://www.wirelesspowerconsortium.com/data/images/7/3/0/registration-procedure.jpg

Figure 4 There is a well-defined process for Qi device certification

6 Qi Certification Chain

Platform manufacturers wishing to become Power Transmitter Manufacturers (PTMG) must submit a request to become a member of the Qi Ecosystem of the WPC.

The PTMG (vendor) then expresses their intent to submit a product for certification to the WPC, which issues the PTMG a unique Power Transmitter Manufacturers Code and Qi ID. The vendor then contacts the WPC stating they have selected Infineon as the manufacturing Certificate Authority for their platform, listing the associated PTMC and Qi ID.

The customer provides the PTMC and Qi ID to Infineon, validating the PTMC and Qi ID with the WPC. Infineon then generates the appropriate certificates and sets up a certificate signing request to sign the manufacturing certificate with the WPC Root Certification Authority (CA). Once the signing ceremony is complete, Infineon generates a limited number of platform units for the customer to evaluate.

Evaluation involves verifying that the units are programmed correctly and meet all requirements. The platform manufacturer provides notification to Infineon that the validation units are acceptable.

The platform manufacturer completes WPC certification and validation testing, and once completed, the customer can request full production units and quantities from Infineon.

The manufacturer CA and WPC product unit certificate issued are securely stored in the OPTIGA™ Trust Charge security controller along with the Qi ID of the platform. Stringent measures are taken to prevent the leakage and modification of private information at the Common Criteria certified production site.

7 Benefits of Qi certification

Having a device certified as Qi-compliant offers a number of benefits to the manufacturer and consumer/user.
The user can trust that the device has been designed and tested to be compliant with the standard and to interoperate with other devices. This, in turn, shows them that it will be safe to use and will not damage devices that it is paired with.

For the manufacturer, the benefit comes from being able to access a wider market of customers. As educated consumers search for devices that are compliant with the Qi standard, being on the Qi register is a significant marketing tool that will lead to increased sales.

The extensive third-party testing means that there will be few (if any) issues that need to be supported and customers can expect to receive a device that does exactly what it is intended to – every time.

8 OPTIGA™ Trust Charge

Infineon offers OPTIGA™ Trust Charge as an authentication solution for wireless charging applications based upon Infineon's significant experience gained by shipping a huge number of security controllers over several decades. This high-end security controller is easily integrated into wireless chargers and complies with the authentication requirements of the Qi standard.

The device is based upon Common Criteria (CC) EAL6+ (high) certified hardware enabling it to prevent physical attacks on the device itself and providing high levels of trust that the keys or arbitrary data stored cannot be accessed by an unauthorized entity. In order to meet the WPC Qi 1.3 requirements OPTIGA™ Trust Charge provides secured storage for private keys and certificates as well as ECDSA P256 and SHA-256 hardware crypto engines that are used for fast and tamper resistant authentication.

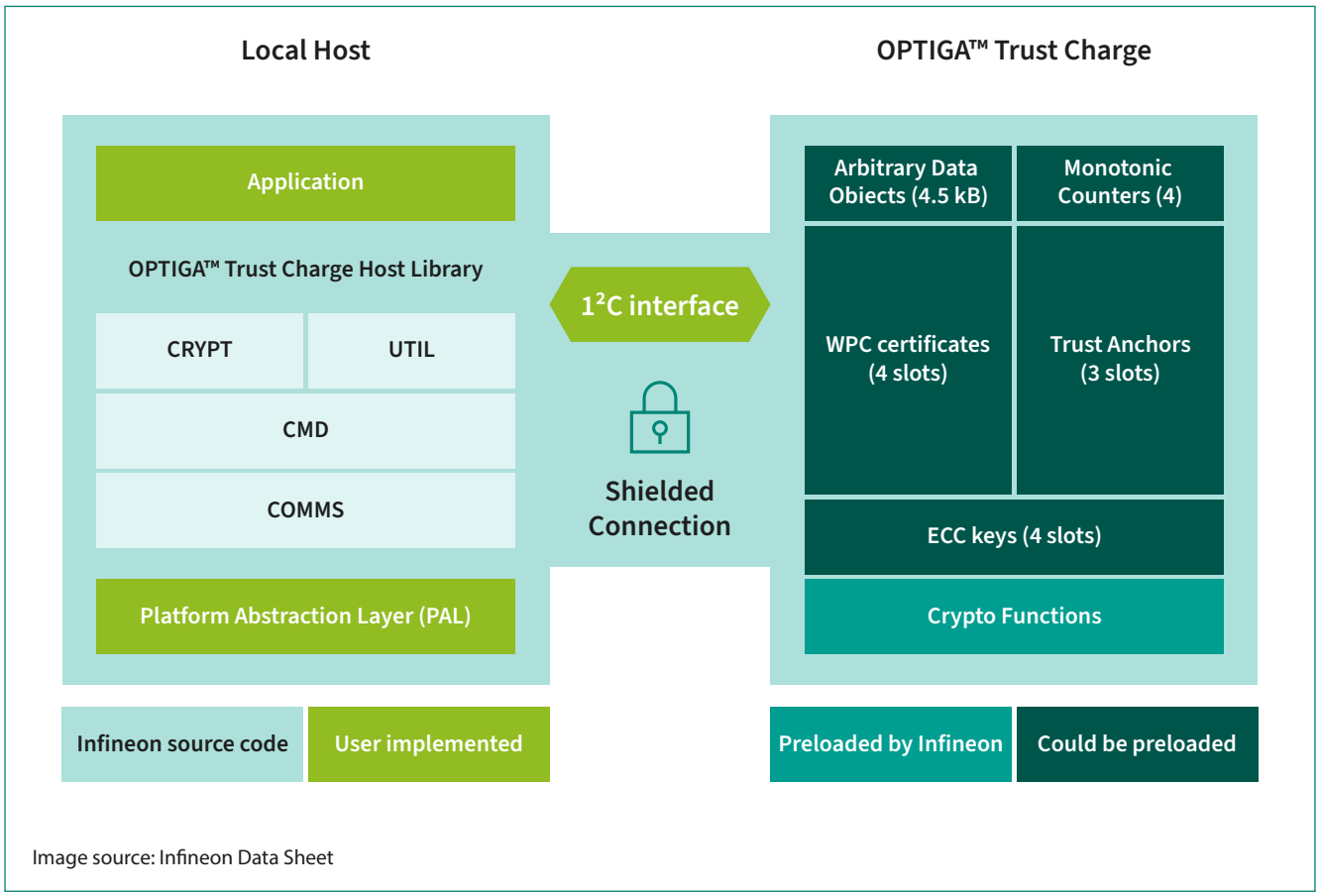

Figure 5 Block diagram of the OPTIGA™ Trust Charge security controller

The OPTIGA™ Trust Charge includes 10 kB user memories that can be used to store up to four WPC certificates and communication with a local host is performed via an I2C interface operating at speeds up to 1 MHz.

As a turnkey solution all customer-specific key/certificate material is pre-programmed by Infineon before devices are shipped, thereby reducing the resources needed for design, integration and deployment. The device also includes pre-programmed OS/application code that is locked and host-side modules that allow integration with the host microcontroller.

Devices are housed in a small (3 x 3 mm) PG-USON-10-2, -4 package and are able to operate over the temperature range -40°C to +105°C making them suitable for densely packed industrial applications. The product lifetime is 15 years, extending to 20 years for industrial automation and infrastructure applications.

Along with application notes, data sheets and other technical support materials, Infineon also offers an OPTIGA™ Trust Charge evaluation kit to demonstrate the functionalities and capabilities of the security controller in wireless charging authentication.

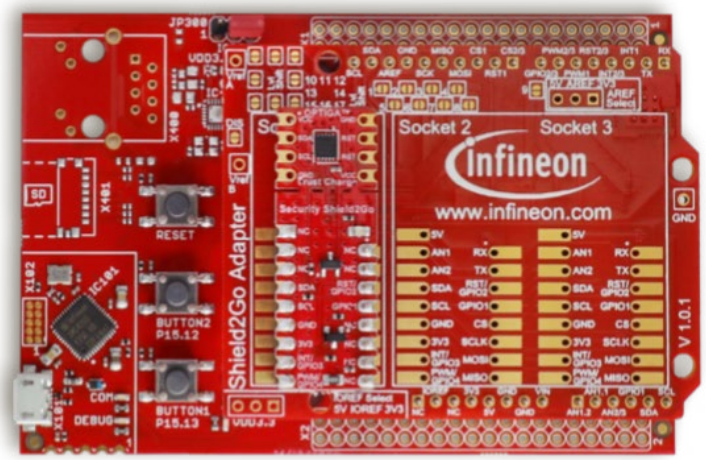

Figure 6 Infineon's evaluation kit speeds up the process of designing authentication for wireless charging

The evaluation kit includes an OPTIGA™ Trust Charge device while open-source code allows for easy integration. The kit combines the authentication solution with a powerful Infineon microcontroller, the XMC4700. Users can connect the kit and explore the solution through the shielded I2C interface. Host software and further application guides can be downloaded from GitHub. The kit is suitable for direct design-in or to create a reference design for a bespoke wireless charging application. Infineon also has a reference design for a complete wireless charging transmitter, which includes all necessary components, a configurable software which supports the Qi protocol, as well as other proprietary protocols and it is Qi certified.

Summary

Wireless charging promises much for the future – convenient charging for devices and less waste through the removal of the need for the small chargers that are supplied with almost every smartphone, tablet and other device.

The inductive approach has become the most popular and is predicted to remain so into the future. Defined by the WPC through their Qi standard, the technology is evolving to encompass higher power levels, allowing more device types (such as laptops) to be charged wirelessly. One of the most significant changes in the 1.3 version of the standard is the requirement for authentication before charging at power levels above 5 W. This allows the user to trust that a genuine, WPC approved (and therefore safe) charger is being used. The standard continues to evolve to promote interoperability and safety. With the release of the new Qi 2 standard in 2023, further growth is expected in the use of Qi wireless charging across different ecosystems.

Infineon has extensive experience in this area having shipped billions of security controllers over three decades. Their OPTIGA™ Trust Charge device provides authentication and security for Qi charging in multiple applications.

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