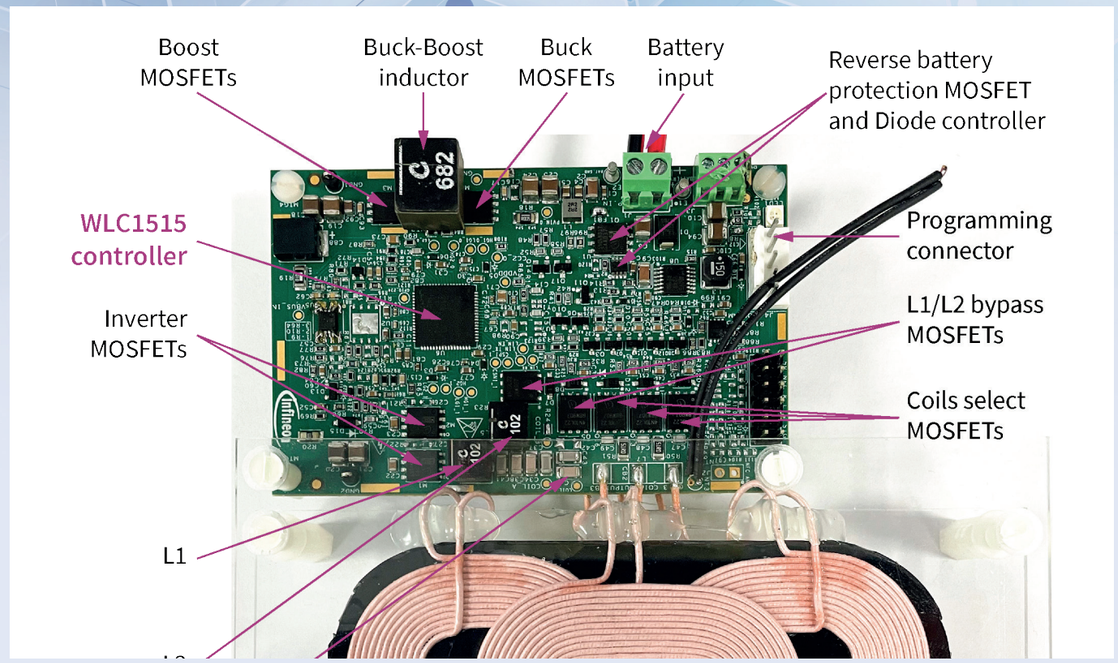


Automotive In-Cabin Wireless Charging Solution with Highly Integrated Controller

Key features, benefits, and application examples of Infineon's highly integrated WLC1515 wireless charging controller

By Subramanyam Sankaran, director of product marketing for USB Automotive Solutions at Infineon Technologies

INDUCTIVE CHARGING AND THE QI SPECIFICATION

Wireless charging technologies range from inductive, magnetic resonant, and capacitive to RF radiation, laser, acoustic, and other emerging ones. The inductive coupling technology is the frontrunner[1]; hence, its associated ***Qi standard*** is the most prevalent in wireless charging.

Inductive charging works based on Faraday's law, where an alternating current in the power transmitter (PTx) coil(s) generates an alternating magnetic field. This magnetic field is then mutually coupled to the power receiver (PRx) coil and transformed back into an alternating electrical current rectified for the DC load connected on the receiver side.

The ***Wireless Power Consortium (WPC)*** manages the respective specification release for this technology. Currently, at version 1.3.2, the new release of Qi specification clearly demonstrates the intent for safe, high-power (>5 W) wireless charging by adopting features such as enhanced foreign object detection (FOD), transmitter authentication with private key storage, and protocol features for better interoperability. The Baseline Power Profile (BPP) of the Qi specification limits the maximum delivered power to 5 W, while the Extended Power Profile (EPP) supports a power transfer of up to 15 W.

Powerful smartphones are enabled with fast wired charging over a ***USB-C interface***. The user experience of charging speed using Qi wireless power transfer is still evolving, paving the way for new solutions. This article introduces Infineon's first-generation ***wireless charging solution for automotive applications*** that integrates the latest Qi transmitter, DC/DC controller, gate drivers, sensing/protection peripherals, and configurable flash memory. Our programmable solution offers higher levels of flexibility along with the integration benefits, enabling designers to scale higher power levels and allow OEMs to offer differentiated features while remaining Qi-compatible.

AUTOMOTIVE WIRELESS CHARGING SOLUTION: IMPLEMENTATIONS

WLC1515: integrated buck-boost and inverter power stage

Infineon's ***WLC1515 transmitter controller IC**** is a highly integrated Qi-compliant wireless transmitter with an integrated DC/DC controller, ***gate drivers for MOSFETs***, and hardware-controlled protection features.

The WLC1515 uses the integrated buck-boost controller to generate the required bridge voltage to power the full-bridge inverter, which, in turn, supplies the PTx LC tank to deliver power to the PRx. The buck-boost converter supports an input voltage range of 4.5 V to 24 V.

The integrated gate drivers of the WLC1515 are designed to control a full-bridge or half-bridge inverter, depending on the Qi specification type and the operating scenario. The MP-A13 coil-based transmitter system shown in Figure 1 uses fixed-frequency variable-input voltage control for the inverter stage.

WLC1515 application use cases

The Qi-certified automotive wireless charging solution can be segmented into three spaces:

- Base model: This includes the WLC1515 and the ***OPTIGA™ Trust Charge device***.
- Mid-range model: This includes the base model with a ***PSoC™ microcontroller (MCU)*** to support the ***controller area network (CAN)*** bus interface of the vehicle with additional GPIOs.
- High-end model: This includes the base model with a ***TRAVEO™ T2G MCU*** to support the CAN bus, NFC, and AutoSAR.

The base model offers a Qi-certified solution with a ***local interconnect network (LIN)*** interface to communicate with the vehicle's board control module.

The mid-range model offers a Qi-certified solution with a supplement MCU (PSoC™) to support the CAN interface and GPIOs to support the fan and additional interfaces.

The high-end model offers a Qi-certified solution with a supplement MCU (TRAVEO™ T2G) to support AutoSAR compliance, CAN interface, NFC stack, and GPIOs to support the fan and additional interfaces.

Secure communication and authentication

The Qi EPP standard requires bidirectional in-band communication. The communication from PTx to PRx is based on a frequency shift keying (FSK) scheme implemented by the PTx, alternating the carrier-wave frequency. The communication from PRx to PTx is based on an amplitude shift keying (ASK) scheme created by modulating the load on the PRx side, causing a reflection to appear on the PTx, which is filtered and decoded.

The Qi 1.3.x specification mandates authentication for EPP power delivery greater than 5 W. It follows the public key cryptography that relies on a public and private key pair to encrypt and decrypt the content. The private key is the most sensitive secure credential and must be stored securely. The public key is typically a part of the binary certificate, and this certificate is transmitted to the recipient through the in-band communication medium.

According to the Qi specification, the PTx must securely host the product unit's private key in a storage subsystem for digital signature purposes. This private key is used to digitally sign the Challenge Authentication response from the power transmitter device. Our solution uses the ***OPTIGA™ Trust Charge device*** for this private key storage (Figure 1).[5]

* *Coming soon. For product availability or sample requests contact our **support***

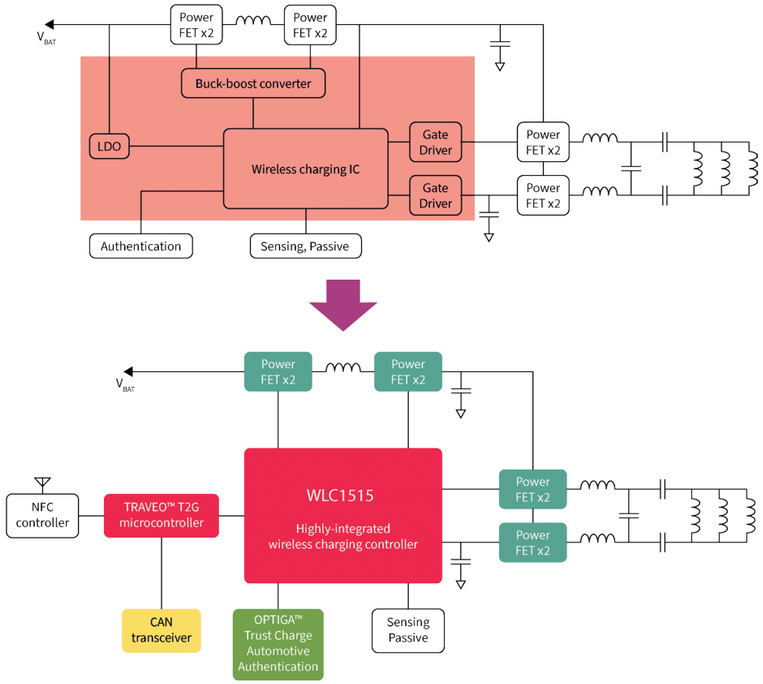


Figure 1: In-cabin wireless charging solution with WLC1515 (bottom) vs. a standard discrete solution (top)[4]

Foreign object detection

WLC1515 transmitter controller also supports enhanced FOD based on Q factor, resonance frequency, power loss, and overtemperature (if a thermistor is used) methods.

The Q factor and resonance frequency measurements are used for FOD before the power delivery phase. The PRx reports the Q factor and resonance-frequency reference values calibrated with a Qi-defined reference coil. The PTx compares the reported values with its measured values in situ to determine the presence of a foreign object. A scaling factor is used to convert the PRx-reported Q factor and resonance-frequency values to those equivalent to the reference transmitter coil and to accommodate measurement variations.

The power loss method is mainly used during the power transfer phase. The power loss FOD uses the PTx power measured at the buck output, which is fed to the inverter bridge. This PTx power is further adjusted by tuning FOD coefficients to account for inverter losses and friendly metal losses. After computing the calibrated PTx power, the result is compared against the latest PRx reported power value. An FOD event is logged if the difference between the calibrated PTx power and PRx power exceeds the P_{loss} threshold.

To prevent erroneous disconnects and improve user experience, WLC1515 uses an adaptive algorithm that distinguishes between real P_{loss} FOD versus P_{loss} arising from poorly coupled PRx. The FOD coefficients and the P_{loss} thresholds are fully configurable to adapt to the system design.

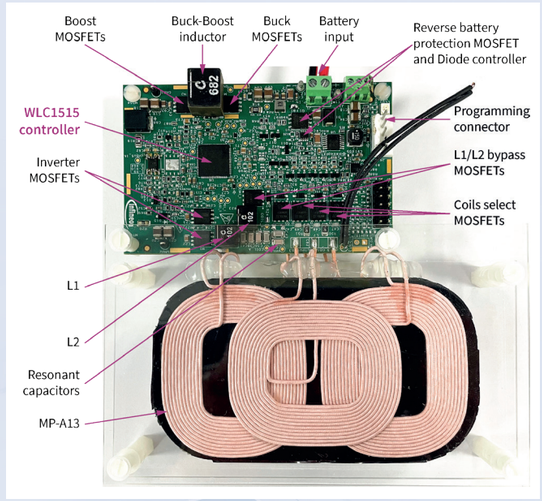


Figure 2: Key components of the WLC1515 solution demo board response of attenuation, input impedance, and output impedance

CONCLUSION

The past few years have seen very rapid development in the components and applications of smart charging technologies. While a great deal of focus has been on standardizing wired charging toward USB-C[8] to enable universal connectors, there is also a growing trend to make charging more pervasive and convenient for various user groups — this is the prime mover for wireless charging.

Our wireless charging solutions with Infineon's OPTIGA™ Trust Charge Authentication offer a compelling bill-of-materials value proposition to OEMs looking to develop Qi v1.3.2–compliant transmitters. The key features, such as adaptive FOD, support for proprietary protocols, DC/DC controller integration, and software libraries, make our platform unique and well-positioned to cater to proprietary as well as emerging Qi standards for inductive wireless charging.

Wireless charging solutions

Please scan the QR code and visit our ***wireless charging ICs website*** to explore how Infineon's WLC programmable solutions are able to offer the required flexibility to scale to higher power levels while remaining Qi-compatible.

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For More Information

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