

# Frequently Asked Questions

## No fuss, just wireless Wireless Charging for Electric Vehicles

### Technology

#### What is Wireless Electric Vehicle Charging?

Wireless Electric Vehicle Charging (WEVC), is a no fuss, simple solution for charging electric vehicles (EV) and plug-in hybrid electric vehicles (PHEV). WEVC technology uses magnetic resonance to couple power from a Base Charging Unit (BCU) to a Vehicle Charging Unit (VCU). Power is transferred to the VCU pad via magnetic coupling, and is used to charge the vehicle's batteries. Communications between the VCU and BCU ensures minimal impact on the grid.

#### What is the operating frequency?

Although the WEVC system can work at a range of frequencies in the Very Low Frequency or Low Frequency bands - typically below 300kHz - there is some debate as to the best frequency to use in automotive applications. Qualcomm Halo is participating in global standards discussions relating to many wireless charging topics including selection of optimal operating frequency for WEVC.

#### What is the status of the technology?

Many industrial applications have exploited wireless power transfer for factory automation and car assembly, for example. The breakthrough in wireless vehicle charging is the ability to transfer power efficiently, over large air gaps. This is important because it enables people to park their car without precise alignment while still charging the vehicle at high efficiency. Wireless charging is already working in multiple vehicles, in multiple trials, including most recently two Qualcomm Halo WEVC enabled Citroën C1 cars in

the government backed CABLED trial in the UK and in the Rolls Royce Phantom 102EX experimental electric vehicle that has been touring the world. Auto manufacturers are currently evaluating how best to incorporate wireless charging into their electric vehicle programs.

### Emissions

#### What international standards are relevant to WEVC?

Currently there are no agreed industry standards for WEVC. Qualcomm Halo is working in various EV industry-working groups on standards and regulatory compliance requirements.

#### What international regulations are relevant to WEVC?

The regulatory assessment of Qualcomm Halo ideas and inventions is normally performed early in the research and development cycle to determine: 1) Applicable worldwide regulations; 2) Technical requirements based on harmonized standards; and 3) Methodology for demonstrating compliance.

Qualcomm has a dedicated team of Regulatory Engineering experts with experience in simulation, design, test and regulatory certification ensuring our systems are designed with compliance in mind.

#### Does WEVC impact other electronics?

Qualcomm Halo WEVC systems are designed with the coexistence with other electronics in mind. This is accomplished through frequent and ongoing cooperation with infrastructure providers as well as the auto OEMs and their suppliers to ensure compatibility with infrastructure, electronics and vehicle and occupant electronics. Qualcomm Halo has a

dedicated team of Electromagnetic Compatibility (EMC) Engineering experts with experience in simulation, design and test.

#### Does WEVC interfere with medical devices?

Qualcomm Halo WEVC system designs are assessed for potential interference to implantable medical devices as well as home located medical devices that are becoming more common. Through this assessment applicable guidelines for control of medical devices near WEVC systems are provided.

#### Is the WEVC system powered up all the time?

The ground BCU remains off until a vehicle with a compatible VCU is in the correct proximity. The BCU and VCU communicate prior to charging to carry out authentication, validating usage, charging requirements and tariffs as needed. Once all the required authentication and checks are complete, charging can begin.

### Efficiency

#### How does efficiency compare to conductive plug-in systems?

The efficiency levels of the Qualcomm Halo WEVC system are comparable to plug-in or conductive charging systems. Transfer efficiency is over 97% across the air-gap and the DC-to-DC efficiency is over 90%.

#### How do charge times compare with conductive systems?

Charging times are dependent on the power rating of the charging system, e.g. 3.3kW versus 7kW, and the efficiency of the charging system. To some extent the battery management system can impact charging times especially when

balancing cells in a battery pack. Qualcomm Halo wireless charging times are comparable to conductive charging times in similar configurations.

## Alignment – Vertical and Lateral Tolerance

### What happens if the vertical gap is too large or small?

The Qualcomm Halo WEVC system manages alterations in the air gap automatically reducing power if needed to safeguard the integrity of the charging process. This also means that the system can compensate for different road clearance heights when the vehicle is fully laden.

### What happens if the BCU and VCU are not aligned?

Qualcomm Halo wireless charging systems are very tolerant to misalignment. The tolerance is managed up to an offset of 200mm in any direction to maintain efficiency, ensure adequate power is transferred and that system integrity is maintained. This tolerance is sufficient for the majority of parking situations. If the alignment exceeds the set tolerance of the system the amount of power transferred may reduce and beyond a specific set limit the system will power down to ensure compliance with regulatory requirements and industry standards.

## Physical Attributes

### What are the physical attributes of the system?

The BCU consists of a ground-based pad that can be surface mounted or buried a few centimeters under the ground. The BCU pad is connected to a remote AC power source with associated control and communications electronics. The BCU pad can be manufactured to various sizes depending on the power rating but is typically 766mm x 575mm x 28mm (30x23x1 inch) and weighs 20kg (44lbs). The VCU consists of the VCU pad and on-board control electronics. The VCU pad is smaller and lighter than the BCU pad, typically 350mm x 220mm x 22mm (14x8.5x0.87 inch) and 7kg (15.4lbs) in weight.

## Economics

### What will be the typical cost?

Cost of the WEVC components will be dependent on the specification required by each auto manufacturer. Qualcomm Halo's business model is to license our WEVC technology to multiple auto industry suppliers to ensure a competitive and dynamic market for wireless charging. These suppliers will set the market price for the BCU and the VCU equipment. We believe a vibrant and competitive supplier market will ensure competitive pricing.

## Commercial Model

### What is your business model?

Qualcomm Halo's business model is best described as horizontal with Research and Development (R&D) and technology transfer from our highly experienced engineering teams, ensuring that a broad range of licensees can be confident in the technology and products we provide.

This business model is highly collaborative and ensures that multiple companies can bring their own innovations to the industry while enabling eco-system participants to focus on their own core competencies, driving development of unique product features and total system capabilities.

### What strategic partners are Qualcomm Halo interested in?

Qualcomm Halo has years of experience in bringing new technologies to market, developing industry eco-systems and working with government, standards and regulatory bodies to accelerate new industries. We will partner and collaborate with multiple organizations across the entire spectrum of the industry.

### Will you license others to manufacture or manufacture yourself?

The Qualcomm Halo business model focuses on licensing our technology across multiple companies to create a large eco-system of suppliers who will manufacture WEVC systems. Some licensees may manufacture the whole system including BCU and VCU. Others may choose to manufacture components of the system. Qualcomm Halo is

initially manufacturing BCUs and VCUs for trials and customer pilot schemes while we build up our portfolio of licensees and develop the standards environment.

## Intellectual Property

### Is the Qualcomm Halo WEVC technology patented?

We hold patents across the total wireless charging system for both low power and high power applications – from watts to kilowatts.

## Market Opportunity

### Is there a market for wireless charging of EVs?

The feedback we have received from all segments of the EV industry is clear and unequivocal in support of WEVC. The interest is not only from existing auto industry participants, but from new entrants to this sector; companies who are looking at new power supply and infrastructure opportunities for example; retailers who want vandal proof EV charging solutions to encourage shoppers to visit; even city planners working to roll out city-wide EV charging infrastructure, but need to minimize visual impact and reduce street furniture.

## Credentials

### Do you see this a long-term business opportunity?

Qualcomm Halo have been investing in wireless power for many years and our business model has been successfully operating since 1985. In addition, we are exploiting 20 years of research into wireless power transfer by The University of Auckland. We see WEVC as a long-term business opportunity, and as a Fortune 500 company, Qualcomm has the resources and professional organization to drive the market and industry forward.

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