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Performance of Ultra Reliable low Latency Communication (URLLC) in 5G Wireless Networks

***Abstract**. Recently, The research paper will focus on allowing URLLC services in order to estimate electric vehicle wireless charging (EVWC) which is become the most important topic due to the many advantages that can get from it such as lack of wires which tends to reduce the risk of wires that they get damaged at any time, saving time, simple and the car battery smaller than electric vehicle charge using wire, also it is considered one of the green technology applications where it tends to reduce the pollution in the world. This technology is one of the intelligent applications like smartphones wireless charging and still grow to make it a flexible dealing to allow all electric car charging wireless. In this research paper, a type of electric car (EC) has been discussed and designed a model of wireless electric vehicles charging to get a 5 kW charger then discussed the results.*

***Streszczenie.** Ostatnio, Artykuł badawczy skupi się na umożliwieniu usługom URLLC w celu oszacowania bezprzewodowego ładowania pojazdów elektrycznych (EVWC), co stało się najważniejszym tematem ze względu na wiele zalet, jakie można z niego uzyskać, takich jak brak przewodów, który zwykle zmniejsza ryzyko przewodów że ulegają uszkodzeniu w dowolnym momencie, oszczędzając czas, prosto i akumulator samochodowy mniejszy niż ładowanie pojazdu elektrycznego za pomocą drutu, jest również uważane za jedno z zastosowań zielonej technologii, w którym ma tendencję do zmniejszania zanieczyszczenia na świecie. Ta technologia jest jedną z inteligentnych aplikacji, takich jak bezprzewodowe ładowanie smartfonów i wciąż się rozwija, aby uczynić ją elastyczną, umożliwiającą bezprzewodowe ładowanie wszystkich samochodów elektrycznych. W tym artykule badawczym omówiono typ samochodu elektrycznego (EC) i zaprojektowano model bezprzewodowego ładowania pojazdów elektrycznych w celu uzyskania ładowarki o mocy 5 kW, a następnie omówiono wyniki. (**Wydajność ultra niezawodnej komunikacji o niskim opóźnieniu (URLLC) w sieciach bezprzewodowych) 5G**)*

Keywords: URLLC, EVWC, Electric car, Green Technology.
Słowa kluczowe: URLLC, EVWC, samochód elektryczny, zielona technologia.

Introduction

One of the main foundational elements of the world of 5G technologies is Ultra-Reliable Low-Latency Communications (URLLC). It is a key enabler for a variety of distinctive use cases in the fields of electronic manufacturing, energy transfer (such as wireless Electric cars), and transportation. Nowadays, URLLC for renewable technologies is popularly used to transfer power without cables on air gaps with various distances, and it is not considered a new technology but it has now been highlighted because of the evolution and development of life and the development of modern and complex devices that need technology for easy use as well as the exploitation of time [1-3]. Low latency characteristics will propel technologies like augmented reality to double-digit percent process improvements for hands-free order picking, machine maintenance, and remote service assistance (RSA). The introduction of higher industrial flexibility and human-machine collaboration (like autonomous driving characteristics) to adapt to both stable and erratic demand patterns will be made possible by URLLC. With all of this still to date many researchers and scientists are continuously developing this technique and experimenting to take advantage of its unique and easy features to suit life evolution and new applications, in recent years it has mainly been used in modern applications such as toothbrushes smartphones, electric vehicle, medical applications and so on [4-6], this is because of reliability, flexibility, safety features no need to use cables so can eliminate of the complexity of cables and devices harmful however WPT still grows till now. The basic principle of wireless power transfer is to transmit power on-air gap when a current flow in the primary coil a magnetic field is then generated which generate an alternating current in the secondary coil without using wires through. Electric vehicle (EV) charging is very popular now, at first electric car charging was by cables by plugging the charging cable in the electric car charging place [2], but now the science tries to charge car wireless without cables and the researchers try to apply this technique on all EV. Electric vehicle wireless charging system (EVWC) can be classified into three levels depending on power depending on the high power that can transmit to the receiver. Level1 uses a 120 V and transmits less than 1.4 KW which is considered the slowest way to charge, level2 charging uses a 208 - 240 V and transmits 3.7-7.7 Kw power, level 3 uses 480 V and transmits up to 50Kw which is the fastest level. Because the electricity in a car is DC so when charging car should convert the AC-DC before arrives at the battery [7-11].

Related Works

Wireless electric cars (WEC) are a key application of the initial 5G technology, which outlines the main stages of URLLC, additional 5G core network feature advancements supporting URLLC include the support for redundant transmission, dynamic division of the packet delay budget, and improvements to the session continuity mechanism. These are required to meet the URLLC standards for the end-to-end delay.

Technology Enablers of WEC

Firstly, in 5G communication systems, ultra reliable and low latency communication (URLLC) is an important essential service type that aims for scalability and dependability with low latency. This service is expected to consolidate into a crucial mMTC in the near future with new use cases, posing new design problems for wireless networks beyond 5G. Although a straightforward mixing of URLLC may be supported by standard network slicing, it is challenging to concurrently ensure the latency, scalability, and reliability requirements.

End-to-end latency is often influenced by network performance and the distance between the user equipment and the server. Each was enhanced to work with URLLC applications. There are three perspectives on 5G's technological enablers. First, in the 5G New Radio, the air interface has been adjusted for low latency utilizing flexible numerology to specify varied subcarrier spacing ranging from 15 kHz to 240 kHz, scheduling optimization for low latency by shortening scheduling intervals, or uplink grant-free transmission. Reliability is increased by lowering the likelihood of connection failure and increasing the robustness of control channels and HARQ [3]. Second, Network Slicing, a key component of the SA architecture of the 5G core network, enables the on-demand allocation of resources for users with various needs.

Principle of EVWPT Operation

Secondly, the technique of wireless charging is based on the Qi standard which is used commonly with smartphones. This can work with charging electric vehicles [2]. The principle of work is based on electromagnetic induction, where the transmitter (primary) coil in the transmitter unit and the receiver (secondary) coil are connected to the charging unit such as an electric car, when current passes through a primary coil a magnetic field is generated which induces a current in the secondary coil then connect it to the charging unit and wireless charging is obtained [8,9].

Proposed System

Fig.1 shows a block diagram of the WPT system the power source (AC) get from the park station is converted to a DC converter then to AC High frequency(HF) and supplied to the primary coil, then it creates a magnetic field transmitted to secondary coil and produces an AC power in the receiver coil, the important thing to obtain an efficient wireless charging is to maintain the resonant frequency(Fr) between transmitter and receiver coil, to do that, a compensation network added at both sides. After that AC power at the receiver, side is converted to DC and then fed to a battery through a control unit or Battery management system(BMS) [10-13].

Where Tx, Rx is a transmitter and receiver coil, respectively.

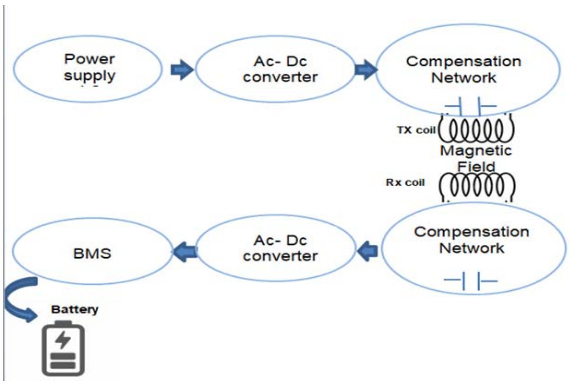

Fig.1. Schematic of dynamic wireless charging.

Wireless Electric Vehicle Charging

Electric vehicle (EV) charging is today an important topic because it tends to reduce the pollution emitted from unrenewable technologies and that is what the world tries to get [14]. Due to the development and the importance of this technique, the scientist tries to envelop ways to make it easy and less time charge so wireless charging systems for electric vehicles distinguish into two types [15].

- Static wireless charging (SWC).
- Dynamic wireless charging (DWC).

Static Wireless Charging

Static wireless charger means the car charging when it became static and in the park station specified for wireless car static (WCS) charging. The transmitter is put underneath the ground and the receiver is put underneath a car when needed to charge the car it needs to park a car on the specified station and align the transmitter and receiver then wait for charging. AC power level and distance affect charge time. Fig.2 shows the static wireless charging [16-19].

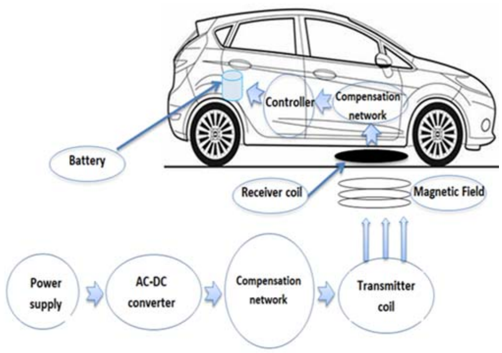

Fig.2. schematic of the static wireless charging system.

Dynamic Wireless Charging (DWC)

Dynamic wireless charging is considered a novel way of charging a car battery while it is in motion overpowering track, this technique depends on put a receiver coil underneath the car and many transmitter coils put beneath a specific road which is specified for charging not like static charge in one place, this technique saves time and no need for large energy stored which tend to reduce the weight of the vehicle/car [17,18]. This technique is now very popular and science try to improve it to become a better way for charging an electric car. Fig.3 shows the dynamic wireless charging system [19-22].

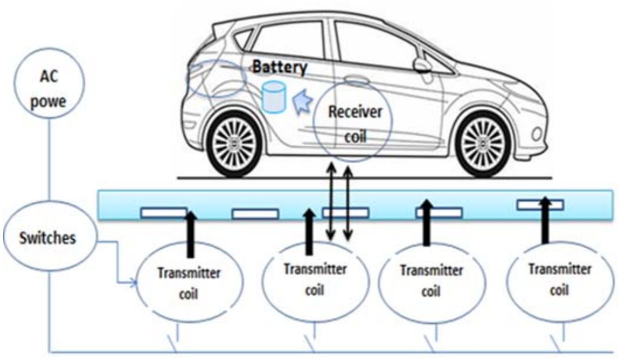

Fig. 3. Schematic of dynamic wireless charging.

Based on operating techniques Electric Vehicles wireless charging systems can be divided into four categories [23].

- Capacitive wireless charging system (CWC).
- Permanent magnetic gear wireless charging system (PMGWC).
- Inductive wireless charging system (IWC).
- Resonant inductive wireless charging system (RIWC).

Electric Car Wireless Charging (ECWC) System

The one of operating techniques electric vehicles wireless charging is Resonant Inductive Wireless Charging (RIWC) which can transmit energy at a high rate when the frequency becomes at resonance allowing it to transmit energy higher than IWC even if the magnetic field is weak. The maximum transfer power can get is When the primary and secondary coil is tuned which means the resonance frequency of two coils is a match, so to obtain a gain resonance frequency, compensation networks are added to the transmitter and receiver coils added compensation network on the transmitter and receiver side is better, Table.1 shows the comparison [24]. in terms of power transmitting and efficiency. For more information about the efficiency of magnetic resonance, more addition information about WPT can find it in [13].

Table.1 Comparison between power and efficiency Factors [24].

Factors	N-N	N-S	S-N	S-S
Power	Low	Low	High	High
Efficiency	Low	High	Small	High

Where N is no resonance, S the transmitter or receiver side is resonant, or both.

System Design

In this paper, a parameter of level 2 has been used in Simulink design in mat lab program where the parameters used are 85 kHz, 5kw. Where a resonance frequency 85 kHz specified (EVC), L1, and L2 value is 55 µH, 55 µH, respectively. Moreover, C1 and C2 value is 63.7nF, and 63.7nF respectively. These values made matched two coils.

DC power source is used in the proposed design and then converted to AC power to transmit to a secondary coil however the compensation circuit has an important part after that added a control system boost converter to make the output dc voltage high and reduce the output current.

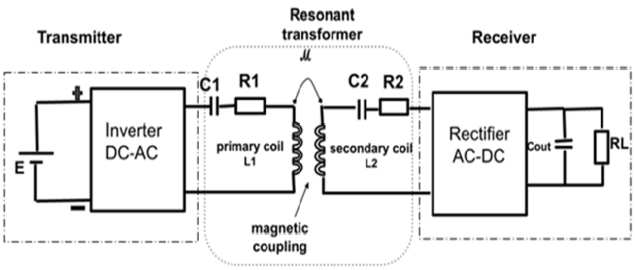

Fig. 4. Wireless Electric Car Charging System

The parameters of the design have been calculated by the equations below [12].

(1) $$Fr = \frac{1}{\sqrt{LC}}$$

(2) $$Ls = Qs\frac{R_L}{W}$$

(3) $$Lp = \frac{\mu^2}{LsK^2}$$

where Fr is resonance frequency, Qs is a quality factor and µ is mutual inductance.

Results and Discussions

The results are obtained by the Matlab program are shown below, Figure 5 (a) shows a square wave input voltage of 130 V on the transmitter side after putting the inverter whereas (b) shows the voltage and current on the secondary side after being transmitted wirelessly where can be noticed that the voltage is increased to 150 V with R load approximately 4.5Ω.

Figure 6 (a) shows the output Dc voltage 150 V for charging electric car and can notice the dc shape due to the rectifier which change AC to DC voltage the smoothing of curve due to capacitor added to rectifier load which is considered a smoothing capacitor to reduce or eliminate ripple voltage because battery need a dc voltage to charge, (b) shows the output current 33 A which is decrease from 50 A to 32 A. Where input power is blue colour and red colour is output power.

Figure 7 shows the input and output power where can be noticed there are little power losses in the circuit tend to reduce power from 5512 W to 5016 W where this loss is not considered a huge effect on system performance because any system suffers from power losses when transmitting power especially wireless.

(a)

(b)

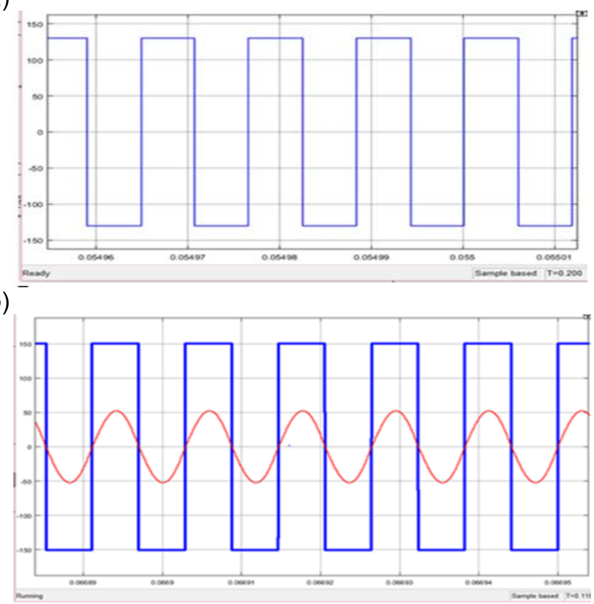

Fig. 5. (a) Voltage on the primary side after inverter, (b) Voltage and current on the secondary side

(a)

(b)

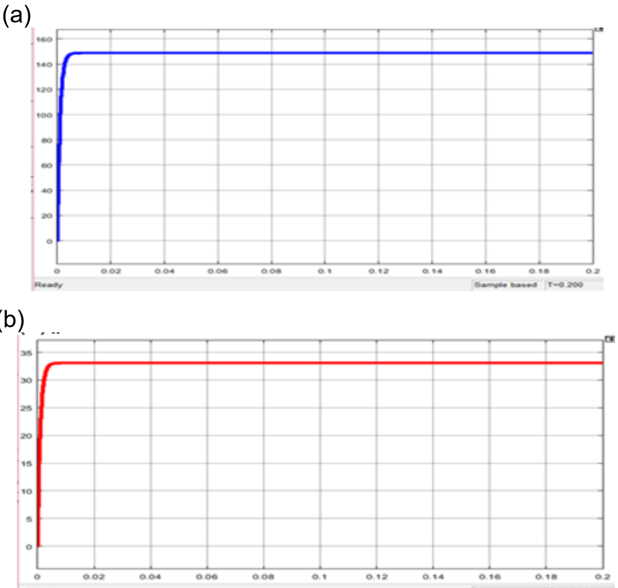

Fig. 6. (a) output voltage after the rectifier, (b) output current after rectifier.

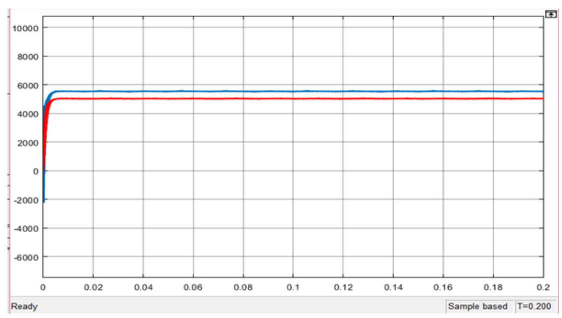

Fig 7. Results between input and output power

Figures (5 -7) shows how the parameter can affect power transmission and the importance of adding some parameters such as inverter, rectifier, and also inductance which is considered a one of the core design parameter where the inverter converts the Dc input to Ac which is needed in transmitting, a rectifier converts the Ac to Dc voltage and current with the load capacitance made a smoothing to the output I and V curve which is that what is need to charging the car battery.

Conclusions

Applications for vehicles must offer complete connection with 99.9999% availability, security, and ultra-responsiveness with a latency of no more than one millisecond. In that situation, the uRLLC task is to operate huge data in real-time for a sizable number of applications and devices with the best dependability and the smallest latency. The existence of uRLLC with regard to vehicle applications poses an ever-evolving problem for system design to accommodate several uses at the same time. Recently, electric vehicles or electric car wireless charging ECWC is a main important topic, and have been noticed that charging wireless is become possible and can develop more because of its many advantages such as time-saving, eliminating cables and damages that will make at using a cable, and reduce polluted which is the important problem the world suffers from it. This research paper has presented an overview of static and dynamic electric car wireless charging and shows the simulation results in Matlab program the voltage and power transmitted wirelessly to charging the battery and obtains from design approximately 5Kw output which is considered an acceptable value to charging the battery of the electric car.

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