POSSIBILITIES OF WIRELESS CHARGING FOR MULTI-PURPOSE ELECTRONIC SYSTEMS

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Abstract: This article describes possibilities of wireless charging (WC). One of the main application fields lies within small-size electronics and currently also the recharge electric vehicles (EV). Wireless Charging Station (WCS) is based on inductive power transmission (IPT) of electrical energy. The station is divided into a docking station and a charger. It includes invertor operating up to 108 kHz, a circular spiral coil on the receiving and transmitting side, rectifier with step-down converter and controllers. Wireless modules communicate in the ISM band with GFSK modulation, and are used for voltage and current monitoring in the charger, which can determine the insufficient position of the coils. This is also a way to enable accurate landing for unmanned aerial vehicles (UAV) instead of landing with camera and quick response (QR) code detection. Nevertheless, for precise guidance UAV towards station is necessary the global position system (GPS). The electromagnetic interference (EMI) in the shielded chamber was measured to give the idea about electromagnetic radiation.

Keywords: WC - wireless charging, IPT - inductive power transmission, EMI - electromagnetic interference, WPT- wireless power transfer

1 INTRODUCTION

Wireless charging is becoming a heavily evolved electrical engineering branch. Allowing users to seamlessly recharge mobile devices as easily as data are transmitted through the air [1-3]. The advantage of WPT is no use of charging connectors. Disadvantage is the number of components for charging increases. Nowadays current trend is resonant or inductive charging. Both methods use different electronics topologies to transfer energy. The resonance method carries the possibility of charging up to several tens of centimeters, while induction results in higher efficiency and lower interference.

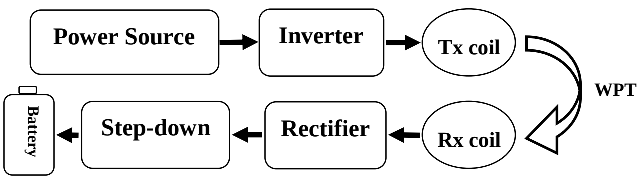

Figure 1: Basic schema of WCS

Figure 1 shows basic schema of WCS. The main source, a toroidal transformer, supplies the energy to the inverter connected as a double-acting source to power the transmitting coil. The WPT from the receiving coil proceeds towards the rectifier with Schottky diodes and then engages the step-down converter, which directly neighbors on the battery and the communication converter (having a 5 V output and 3.3 V operating voltage). Minor problem occurs with the transferring energy. Between coils is generated an electromagnetic field, which generates EMI. This may adversely affect the guidance and information systems and a serious error may occur in the electronic system. The station design is designed to charge low voltage and low power devices which can used Separated Extra Low Voltage (SELV).

2 MAGNETIC NEAR FIELD OF SINGLE LAYER SPIRAL COIL

The magnetic field moves from the inner radius of the coil to the outer radius and between the individual threads is blocked. The field thus grows along the top and bottom of the threads to a coherent state. At the outer edge of the coil there is a rapid reversal of the field and its polarity is changing rapidly. An important advantage is greater internal field strength and accurate centering for the WPT. Figure 2 shows the magnetic near field between turns of the coil model.

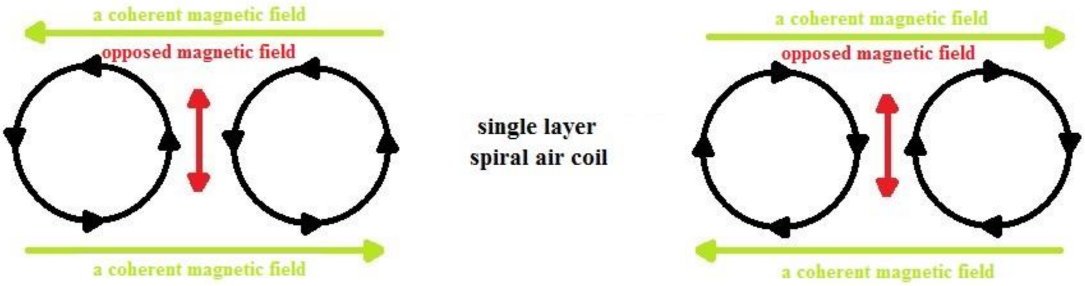

Figure 2: Magnetic near field of spiral air coil

3 WIRELESS TRANSMISSION

Experimental measurements were performed on 10 μH inductance coils [4]. The coils handle a theoretical maximum continuous current of 12 A. In Figure 3 are both coils. Power between them was measured depending on the altitude and misalignment. For the WPT letter *"z"* means altitude and the letter *"e"* means misalignment. The measurement was made for a load with a maximum transferred power of 52 W. Measured was rectified voltage and current from the transformer to the transmitting coil at the station. For receiving side was measured a rectified voltage and current depends on frequency.

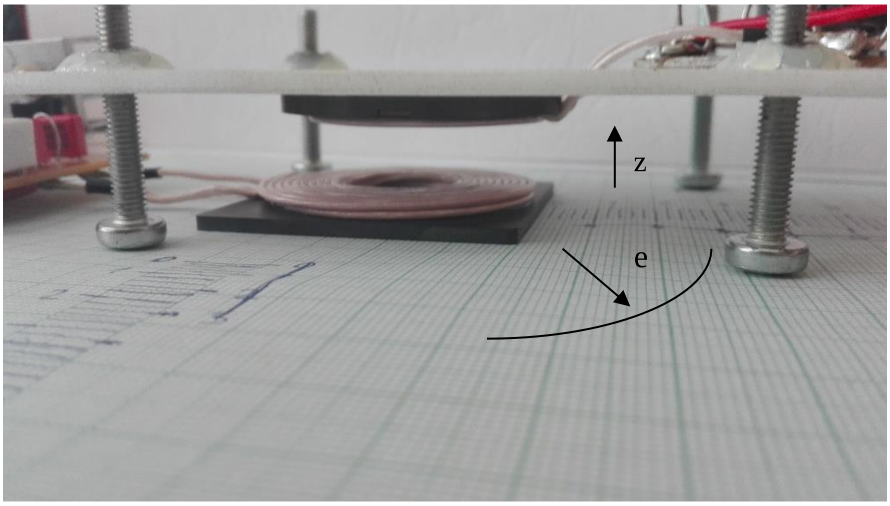

Figure 3: Measuring power dependence on altitude and misalignment.

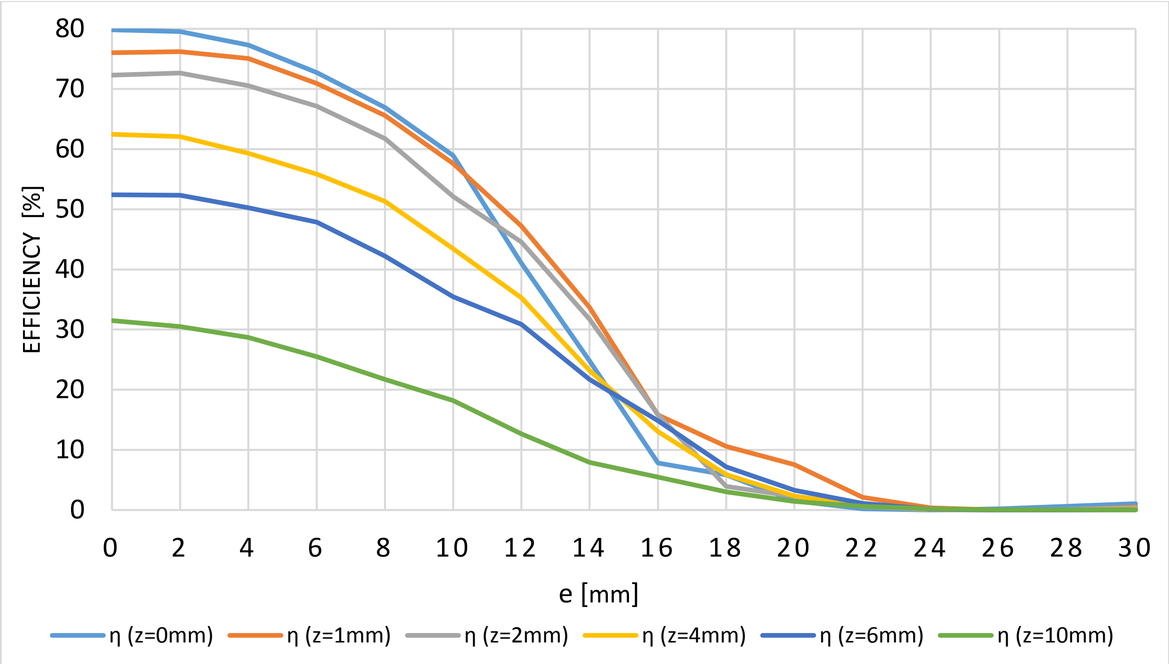

Figure 4: The dependence of the power efficiency of the inductive load transfer of 52 W on misalignment and altitude.

The graph in Figure 4 (for the WPT) shows that the inductive power transfer is most effective when the coils are misalignment to a maximum of 4 mm and the axial distance of 2 mm. The efficiency then decreases rapidly. But with a misalignment greater than 10 mm and a coil distance z = 2 mm, it's still better than 50%. Such efficiency is enough to start the charging process. The centering algorithm then increases efficiency. The charging power of the entire station with the consumption of all modules is 40 W.

4 EMI MEASURMENT

The WCS was measured in a shielded chamber at a distance of 3 m from the Bi-Logarithmic measuring antenna to the WCS. However, according to the general standard EN 50081, which includes residential areas and light industry, EMI is usually measured at 10 m [5]. The limit value for distance 3 m on the frequency range from 30 ÷ 230 MHz is 40 dBμV/m and for the frequency range 230 ÷ 1000 MHz it is 47 dBμV/m.

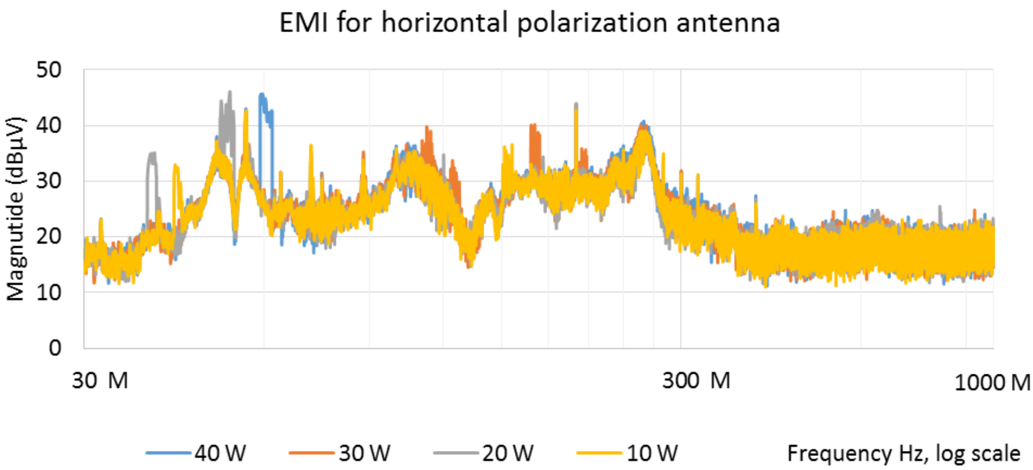

Figure 5: Measured EMI for different power rates with horizontal polarization antenna

The values in the graph ensure that the equipment or WCS does not interfere with the operation of other conventional electrical and electronic equipment. The largest radiation was measured for horizontal polarization as shown in Figure 5. An undesirable level of 45 dBμV occurs around the 60 MHz and 200 MHz frequencies with 20 and 40 W station power. The reason for the overlimit interference is the non-inclusion of a suitable EMI filter before tranformer and on the converter output.

5 SIMPLIFIED CHARGING FUNCTION

When the charging station is switched on, the microcontroller peripherals are initialized by a timer that is used for reading in the interrupt. The GPIO ports indicate the connection status of the station with the charger via LEDs. Other ports fold for opto-coupler switching to adjust feedback voltages. Next, the wireless module addresses and the Ethernet port of the Ethernet module are automatically set. The infinite loop is waiting for the connection to be established. If wireless modules are connected, a maximum of 50% duty cycle is set on the transmitter coil and data are awaited. The received data are copied to the data field from which it is then read out via the port to the website. If the connection is not established, the loop for excitation of the transmitter coil remains 15%, and the "unconnected" status is printed on the web pages and the program returns to an infinite loop as shown in the flowchart in Figure 6.

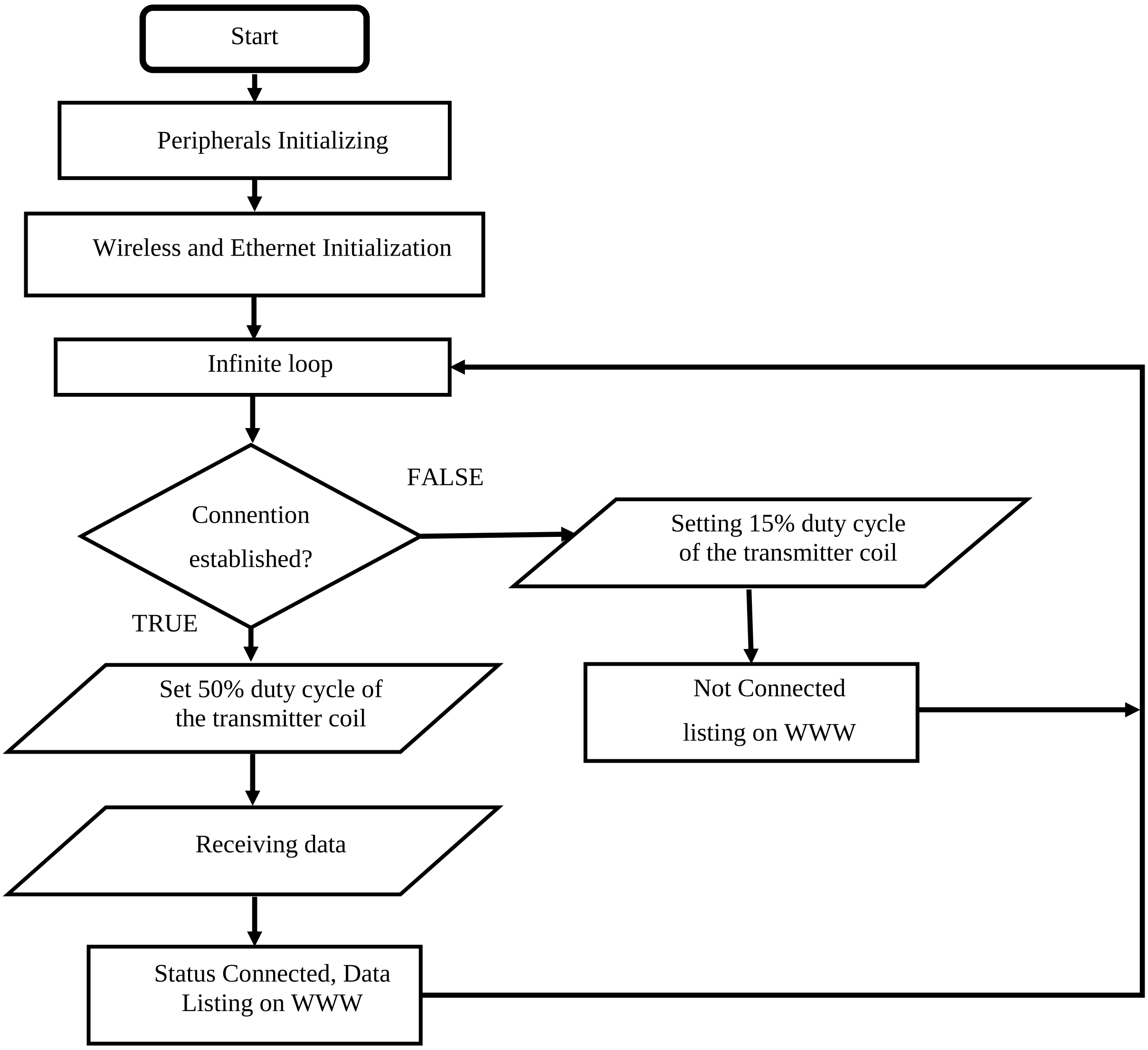

Figure 6: Flowchart for charging status

6 CONCLUSION

The goal for this article was to discuss and describe the WCS charger with a total useful power of 40 W for multipurpose electronic systems. Efficiency of Wireless power transfer (WPT) is 80 % for the exact coil misalignment. With a drop on all elements, the efficiency of the entire station is 68%. Efficiency can be enhanced by adding active measuring elements to topologies. The charger is versatile for devices with a low input voltage to 16.4 V. The field around flat spiral coils has been described, which transmits power with good efficiency even at 10 mm eccentricity. The station had EMI over-limit values in two frequency areas for horizontal polarization of the measurement antenna. Interference can be eliminated with a suitable EMI filter. The EMI was measured for vertical and horizontal polarization of the antenna and for two WCS angles and 4 different outputs. The solution contains a station where it is possible to monitor the transmitted power and the charger, which can be installed on a drone or a mobile robot. This eliminates the need to maintain contacts and offers the ability to charge in different environments.

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