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Novel Method of Maximum Efficiency Tracking Control Scheme for Closed Loop Wireless Power Charging System Employing Series Resonant Tank

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Abstract-**A Maximum Efficiency Tracking Control Scheme For A Closed-Loop Wireless Power Charging (WPC) System For Wireless Charging Of Mobile Devices. CA novel control method is presented that exhibits substantially higher partial-load efficiency, while it also enables full control of the power semiconductor switching conditions. A closed-loop WPC system has a constant output voltage against coupling and load variations. A maximum efficiency tracking (MET) control scheme to achieve the highest possible efficiency. Therefore, the proposed WPC system satisfies both the requirements of a constant output voltage and high efficiency. The proposed control scheme determines the current of the transmitter based on the data received by the receiver via blue tooth.**

Index Terms **-** Wireless power transfer, maximum energy efficiency tracking

I. INTRODUCTION

wireless power transfer have extended to stationary and dynamic wireless charging of electric vehicles and trains In a critical review it has been pointed out that the use of “maximum energy efficiency” principle is more appropriate that “maximum power transfer” principle based on the impedance matching of the source impedance. The maximum energy efficiency operating point is dynamically changing with the load conditions the coupling coefficient and quality factor But for wireless power transfer applications, the load-dependent energy efficiency suggests that it is appropriate to tracking the maximum efficiency operating point for a dynamically changing load. Such high energy efficiency is in the context of the top region (say 10%) of the maximum energy efficiency range. In this paper, a method for maximum energy efficiency tracking (MEET) is explored and evaluated. Using the switched mode converter in the charging systems In a compensating scheme has been proposed to receiver module to emulate the optimal equivalent load condition dynamically, the proposed method ensures automatic MEET by searching for the minimum input power operating point for a given output power .The operating principle is demonstrated in a 2-coil wireless power transfer system designed to operate at the maximum energy efficiency principle.

II. OPTIMAL LOAD CONDITIONS FOR MAXIMUM ENERGY EFFICIENCY AND MAXIMUM POWER OPERATIONS

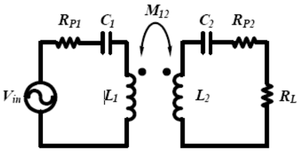

Fig 1: Circuit model of a two-coil WPT system

A simple 2-coil wireless power transfer (WPT) system with its equivalent circuit shown in Fig.1. Assuming that the power losses in the ferrite plates that shield the transmitter and receiver coils are negligible, the coupled circuit equations for the system are

$$(R_{P1} + jX_1)\mathbf{I}_1 + j\omega M_{12}\mathbf{I}_2 = \mathbf{V}_{in} \qquad (1)$$

$$j\omega M_{12}\mathbf{I}_1 + (R_{P2} + R_L + jX_2)\mathbf{I}_2 = \mathbf{0} \qquad (2)$$

w is the angular frequency of the operation; Xi (i=1, 2) is where the reactance ωLi-1/ (cu) of Resonator-i; I1 and I2 are the current vectors of the Resonator-1 and Resonant-2 respectively; RP1 and RP2 are the winding resistance of Resonant-1 and Resonant-2, respectively; C1 and C2 are the resonant capacitors of Resonant- 1 and Resonant-2, respectively; RL is the load resistance.

III. MAXIMUM ENERGY EFFICIENCY TRACKING (MEET)

A Two-Stage Output Power Circuit, I.E. Using A Front-End Ac-Dc Power Converter Followed By A Dc-Dc Power Converter, The Idea Applies To A Single-Stage Ac-Dc Power Converter. The Ac Input Voltage *VIN* On The Transmitter Side Is The Output Voltage Provided By A Power Inverter. Because A Resonator Is Used As The Transmitter, The Fundamental Component At The Resonant Frequency Is The Only Dominant Voltage Component.

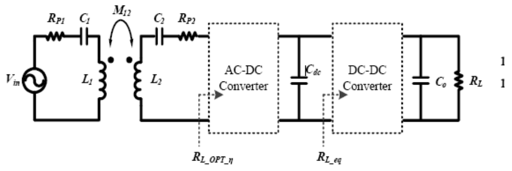

Fig 2: WPT System with AC-DC and DC-DC Converters

The Function of Approach is

1. Direct control at the optimal duty cycle based on load sensing; Determination of the optimal duty cycle based on a searching process.

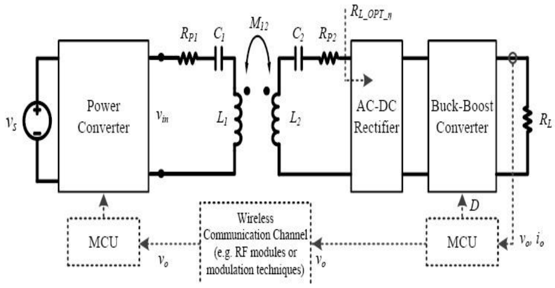

Fig 3: A two-winding WPT system with AC- DC and DC-DC converters.

1. An initial input AC voltage *Vin0* on the transmitter coil is applied. This voltage should

preferably be high enough for delivering enough power to a targeted load on the receiver side for a designated output voltage under all possible operating conditions.

2. The DC-DC converter on the receiver side automatically adjusts its duty cycle to generate the designated output voltage for a given load. This initial duty cycle is denoted $D0$.

3. The input power $Pin0$ to the transmitter coil is measured and recorded by the control unit on the primary side.

4. The input AC voltage Vin is then increased (or decreased) slightly (e.g. $\Delta Vin = 5\%Vin0$) to a new value $Vin1 = Vin0+\Delta Vin$ (or $Vin1 = Vin0- \Delta Vin$). Changing the input ac voltage to the transmitter coil on the primary side will change the input DC voltage of the DC-DC converter on the receiver side.

5. Once again, the DC-DC converter will be *forced* to regulate its duty cycle in order to regulate the output voltage. Now the duty cycle is denoted as $D1$.

6. The input power $Pin1$ to the Transmitter coil is measured and recorded.

7.Compare $Pin1$ and $Pin0$. If $Pin1$ is smaller than $Pin0$ (which means the energy efficiency of the system rises), then repeat step 4 and 5 until the input power stops decreasing. Then a minimum input power point or a maximum efficiency point is found. Otherwise, if $Pin1$ is larger than Pin0 *(* which means the energy efficiency of the system decreases), then the searching direction is reversed (i.e. apply $Vin1 = Vin0 - \Delta Vin$). Similarly, repeat step 4 and 5 until the input power stops decreasing and a maximum efficiency point is found.

8. The optimum operation point will be kept for a designated time interval, say *td*.

9. After this time interval *td*, a new searching process will start from this selected operating point in case that the load and/or the coupling $M12$ have varied.

The major difficulty in realizing the proposed system is to design the control for the DC-DC converter so that not only a steady operating point can be found for a given input voltage but also the maximum energy efficiency point can be successfully found by searching from the initial steady operating point. Details and explanations are provided in the following design example.

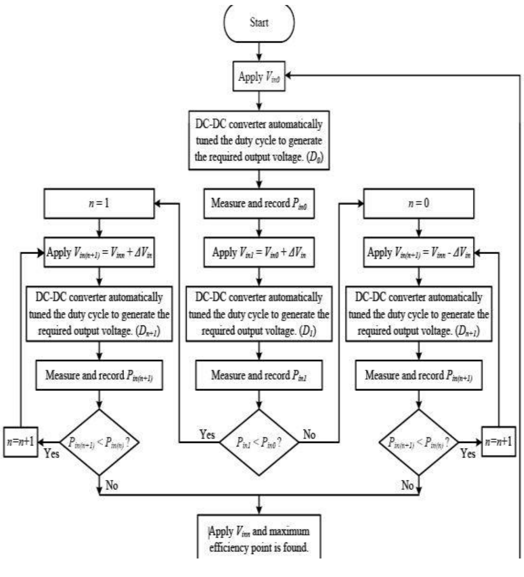

Fig 4: Flow Diagram

For rated load resistance RL = 2.5 Ω, the relationship between the duty cycle D of the buck-boost converter and the efficiency of the system (assuming all the converters are lossless) and the input voltage of the primary resonator (i.e. the output voltage of the power inverter) is shown in Fig. 9. The searching process of the maximum energy efficiency operating point is now illustrated with the aid of Fig. 9. The purple solid line in Fig. 9 represents the required Input voltage of the power inverter on the transmitter side in order to generate an output voltage of 2.5 V on the receiver side for a load resistance of 2.5 Ω. At D = 0.38, where is indicated with a vertical dotted line, input voltage required for an output power of 2.5W in this example is at its minimum value. The dotted line separates the system operating range into two regions. The relationships between the duty cycle and the output voltage (or output power) are opposite in these two regions. On the left side (D <.38), the output power increases as D increases (thereby a lower input voltage is required when D becomes larger). On the right side (D > 0.38), the output power decreases as D increases (thereby a higher input voltage is required when D becomes larger). It is important to note that, only the region where the maximum energy efficiency operating point exists should be used for MEET operation. In this example, the region on the right side of the dotted line should be chosen as the operating region. If 10V is used as the initial input voltage, the searching process based on Fig. 9 will allow the input voltage to change gradually to about 2.5V at which the energy efficiency is at its maximum of 69%. In Fig. 10, the efficiency is plotted against the input voltage of the primary resonator. One method to restrict the operation of the system within the right region is to restrict the duty cycle to be larger than 0.38.

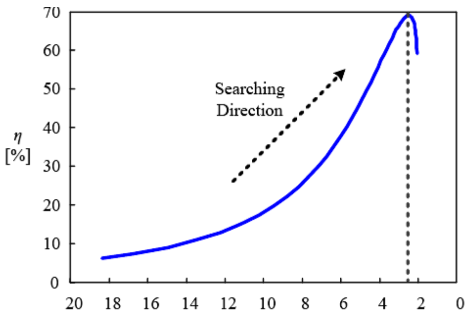

Fig 5. Efficiency variation as the input voltage

However, on the right region of the dotted line the output DC voltage of the output converter (which is proportional to the power) increases as decreases. This output voltage and duty cycle relationship is opposite to the voltage gain characteristic of a standard buck-boost converter, i.e. equation (17) which indicates that the output voltage increases with increasing duty cycle. One method to implement the required control characteristics is to use the complement of the duty cycle, i.e. D'=1-D as shown in Fig. 11. This can be practically achieved by using an inverter gate to invert the gate signal for the buck-boost converter. Instead of feeding D to the gate drive as normally implies

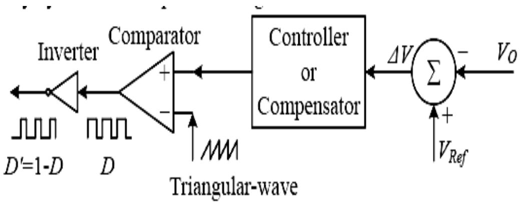

Fig 6: Control loop for DC-DC converter operating on the right region

Alternatively, a standard buck-boost converter could be used (without using the complement of the duty cycle) if one can adjust the minimum input voltage point to the left of the maximum efficiency point. Operating frequency or (ii) tuning the natural resonant frequency of the transmitter by adjusting the value of the compensating capacitor (*C1*). However, for the first method (i), the maximum efficiency of the system will be degraded due to non-zero impedance *X2*. For the second method (ii), the VA requirement of the power source increases due to non-zero

IV. CONCLUSION

A maximum energy efficiency tracking method is presented in this paper with the support of an analysis and the experimental verification of a 2-coil WPT system. The basic principle is to search for the minimum input power for any given output power. By keeping the equivalent load resistance of the receiver circuit to the optimal value through the closed- loop control of the power converter within the receiver module, maximum energy efficiency tracking can be achieved by searching for the minimum input power. Another advantage of this method is that it does not need any wireless communications between the transmitter and the receiver circuits, making it attractive in practical applications. The proposed method has been successfully tested under the situations of weak and strong magnetic coupling. Besides the differences due to the omission of the core losses and the inverter losses, the simulated and measured energy efficiency curves exhibit the same trends in both cases.

REFERENCES

[1] A.W. Green and J.T. Boys, “10 kHz inductively coupled power transfer-concept and control,” in Proc. ICPE-VSD, 1994, pp. 694– 699

[2] G.A.J. Elliott, J.T. Boys, and A.W. Green, “Magnetically coupled systems for power transfer to electric vehicles”, in Proc. 1995 International Conference on Power Electronics and Drive Systems, vol. 2, 1995, pp. 797– 801

[3] G.A. Civic and J.T. Boys, “Modern Trends in Inductive Power Transfer for Transportation Applications,” IEEE Journal of Emerging and Selected Topics in Power Electronics, vol. 1, no. 1, pp. 28–41, Mar. 2013.

[4] G.A. Civic and J.T. Boys, “Inductive Power Transfer,” Proc. IEEE, vol. 101, no. 6, pp. 1276–1289, Jun. 2013

[5] B. Choi, J. No, H. Cha, T. An, and S. Choi, “Design and implementation of low-profile contactless battery charger using planar printed circuit board windings as energy transfer device,” IEEE Trans. Ind. Electron., vol. 51, no. 1, pp. 140–147, Feb. 2004.