can be achieved when the secondary coil is connected to the parallel capacitor compensation.

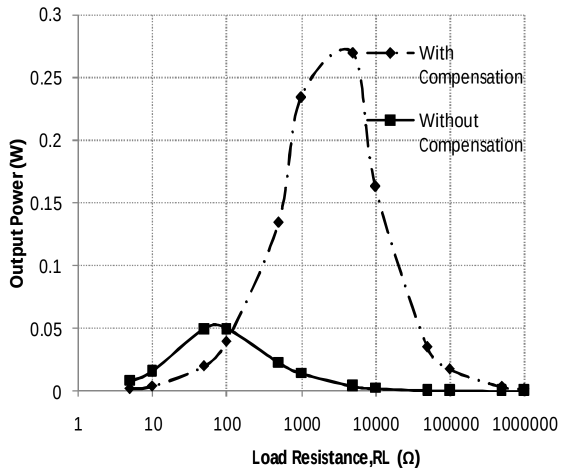

Fig. 13. Output Power vs. Load Resistance at 15mm Air Gap Distance

To be noted that the optimal load resistance, $R_{L\ (opt)}$ when current-fed parallel-tuned IPT system can be calculated as [13]:

$$R_{L(opt)} = (Q_2)^2 R_2(1 - k^2); \qquad (18)$$

when achieved maximum power transfer. Hence, based on Eq. (18), we obtain 10.1kΩ optimal load resistance that approximately similar to the experimental result. This optimal value only can be achieved when the IPT system met the resonant inductive coupling, which is k = 0.7 and quality factor at the secondary side, Q_2 is equal to

$$Q_2 = \frac{\omega_o L_2}{R_2}; \qquad (19)$$

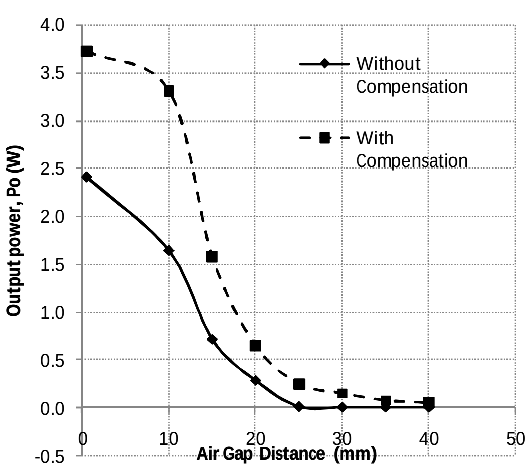

Fig. 14. Output Power vs. Air Gap Distance

From Fig. 14, the output power across 180Ω load resistance has slightly decreased when air gap distance become longer. It validated the theory that the strength of magnetic field becomes weak at longer air gap and cause a low output power of IPT system. The highest maximum output power is 3.7 W, which is occurred at 5mm coil separation. On the other hand, the maximum output power for the circuit without capacitor compensation is 2.4W. However, at the certain limit of the air gap distance, then, the output power is approximately to be a zero and remain constant . This is because, the secondary coil is does not receive the induced voltage from the first coil at that distances any more.

5 Conclusions

In this paper, the Class E converter circuit for inductive power transfer has been introduced at the primary circuit. On the other hand, the voltage doubler and Darlington circuit have been proposed at secondary circuit. The secondary capacitor compensation performance has also been studied. In regard to the best compensation method that yields a better efficiency, the parallel compensation seems give a better result than the serves one. Due to the leakage problem, the highest power that can be transmitted to the load at 15 mm air gap distance is 1.6W. Therefore, the intention future work that should be considered is to design a self-tuning Class E converter circuit to resolve that problem.

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References

[1] Jamal, N., S. Saat, and A. Shukor. *A study on performances of different compensation topologies for loosely coupled inductive power transfer system*. in *Control System, Computing and Engineering (ICCSCE), 2013 IEEE International Conference on*. 2013. IEEE.

[2] Bosshard, R., Badstubner, U., Kolar, J. W., & Stevanovic, I. *Comparative evaluation of control methods for inductive power transfer*. in *Renewable Energy Research and Applications (ICRERA), 2012 International Conference on*. 2012. IEEE.

[3] Sivakumar, S. and A. Eroglu. *Analysis of class-E based RF power amplifiers using harmonic modeling*. Circuits and Systems I:

Regular Papers, IEEE Transactions on, 2010. 57(1): p. 299-311.
[4] Sokal, N.O., *Class-E RF power amplifiers*. QEX Commun. Quart, 2001(204): p. 9-20.
[5] Liu, X., Ng, W. M., Lee, C. K., & Hui, S. R. *Optimal operation of contactless transformers with resonance in secondary circuits*. in *Applied Power Electronics Conference and Exposition, 2008. APEC 2008. Twenty-Third Annual IEEE*. 2008. IEEE.
[6] Kazimierczuk, M.K. and D. Czarkowski, *Resonant power converters*. 2012: John Wiley & Sons.
[7] Prasanth, V., *Wireless Power Transfer for E-Mobility*. Master of Science Thesis, Delf University of Technology, Faculty of Electrical Engineering, Mathematics and Computer Science, Electrical Power Processing, 2012.
[8] Minsheng, Y., Yaonan, W., Xizheng, Z., & Jianqi, L. *Analysis of Reflected Load Model for Inductively Coupled Power Transfer Systems*. in *Power and Energy Engineering Conference (APPEEC), 2010 Asia-Pacific*. 2010. IEEE.
[9] Thian, M. and V. Fusco, *Idealised operation of zero-voltage-switching series-L/parallel-tuned Class-E power amplifier*. IET circuits, devices & systems, 2008. 2(3): p. 337-346.
[10] Kazimierczuk, M. and K. Puczko, *Exact analysis of class E tuned power amplifier at any Q and switch duty cycle*. Circuits and Systems, IEEE Transactions on, 1987. 34(2): p. 149-159.
[11] Zhong, W., X. Liu, and S.R. Hui, *A novel single-layer winding array and receiver coil structure for contactless battery charging systems with free-positioning and localized charging features*. Industrial Electronics, IEEE Transactions on, 2011. 58(9): p. 4136-4144.
[12] Budhia, M., G.A. Covic, and J.T. Boys, *Design and optimization of circular magnetic structures for lumped inductive power transfer systems*. Power Electronics, IEEE Transactions on, 2011. 26(11): p. 3096-3108.
[13] Han, S. and D.D. Wentzloff. *Wireless power transfer using resonant inductive coupling for 3D integrated ICs*. in *3D Systems Integration Conference (3DIC), 2010 IEEE International*. 2010. IEEE.