Journal of Nano- and Electronic Physics
Vol. 17 No 6, 06025(5pp) (2025)

Журнал нано- та електронної фізики
Том 17 № 6, 06025(5cc) (2025)

REGULAR ARTICLE

OPEN ACCESS

Design of Multi Coil Resonant Wireless Power Transmission for Office Communication Systems

Lala Bhaskar[1,*], Pradeep Kumar[1], Kishore Naik Mude[2]

[1] *Amity Institute of Information Technology, Amity University Uttar Pradesh, India*
[2] *Systec R&D, Porto, Portugal*

(Received 12 August 2025; revised manuscript received 15 December 2025; published online 19 December 2025)

Wireless Power Transfer (WPT) system consists of a transmitter connected to main power source causes a varying magnetic field, generating flux, due to which current is induced in the receiver coil. The design of coil parameters vary depends upon the application. Wireless charging of office communication systems is emerging technology worldwide which makes transfer power to the office communication devices like Laptops, Mobile Phones, Display Monitors, LED displays, Printers without using regular copper cable wires. The most popular method for wireless power transfer can be achieved by resonant inductive coupling. This paper focuses on the application of wireless power transfer from one source to multiple receiver loads. The idea is to power the basic need in office life, such as wireless laptop charging, wireless cell phone charging, wireless power transmission to printer. Mobile application in this paper defines as a mobile device or portable device that can be applied anywhere in office or at home. The motivation for this proposed model is to charge multiple mobile devices wirelessly. Traditional wired power solutions in office communication systems create clutter, reduce mobility, and limit scalability. Wireless power transmission (WPT) offers a promising alternative by eliminating cables and enabling flexible workspace arrangements. This study focuses on designing a multi-coil resonant WPT system.

Keywords: WPT (Wireless Power Transfer), Transmitter coil, Receiver coil, Charger, Finite element method (FEM).

DOI: 10.21272/jnep.17(6).06025 PACS number: 84.40.Qx

1. INTRODUCTION

In 1826, Andre- Marie Ampere showed that electric current produces a magnetic field. In 1830, Michael Faraday described the electromotive force that drives current in a conductor loop by a time-varying magnetic flux. [4] In 1864, J.C. Maxwell predicted the existence of radio waves and gave the concept of unified electricity and magnetism, called electromagnetism. Bolstered by Maxwell's theory, Heinrich Rudolf Hertz succeeded in showing experimental evidence of radio waves in 1888. The prediction and Evidence of the radio waves at the end of 19th century was the start of the wireless power transmission. [4] The need for instant practical sources for charging devices also increases from time to time, therefore one electrical source (transmitter) that can be used for multiple loads will be a great benefit [8, 13-16]. Inductive chargers are highly efficient, but the range is limited to only a few centimetres. Transmission coils require symmetry in shape and size and stringent alignment so that all magnetic flux created by transmission coil is received by acceptor coil. Multiple devices can be charged at once using resonant magnetic coupling. Transmitting and receiving coils resonate at fixed frequency which improves efficiency of transfer. Distance between these coils and their position with reference to one other is much more flexible because of loose coupling. Low coupling factors caused by increase in range or disturbance in coil alignment is made up for by high quality factor.

This paper focuses on the application of wireless power transfer from one source to multiple receiver loads. The idea is to power the basic need in office life, such as wireless laptop charging, wireless cell phone charging, wireless power transmission to printer. The mobile application in this paper defines as a mobile device or portable device that can be applied anywhere in the office or at home.

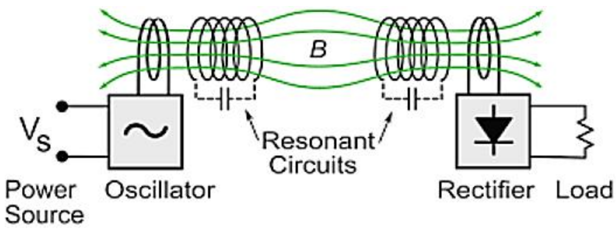


Fig. 1 – Power transmission by resonant inductive coupling

2. MISALIGNED COIL ANALYSIS

Grover developed a general method to calculate the mutual inductance between circular Filaments located at any position with respect to each other [4]. Using magnetic vector potential approach, the formulated model

* Correspondence e-mail: lbhaskar1@amity.edu

Cite this article as: L. Bhaskar et al., *J. Nano- Electron. Phys.* 17 No 6, 06025 (2025) https://doi.org/10.21272/jnep.17(6).06025

for computing the mutual inductance between filamentary coils with both lateral and angular misalignments was obtained in [2]. As shown in Figure 2 there are two coils with parallel axis, so there is only lateral misalignment between them. The notations used in Figure 2 represent as Magnetic permeability of vacuum μ_0, Radius of secondary coil R_s, Radius of primary coil R_p, Separation distance between coils c, Lateral misalignment d, angle used for integration from primary coil ϕ, The mutual inductance when two coils are in parallel planes is given by

$$M = \frac{2\mu_0}{\pi}\sqrt{R_s R_p}\int_0^{\pi}\frac{\left(1-\frac{d}{R_s}\cos\Phi\right)\Psi(k)}{k\sqrt{V^3}}\,d\Phi \qquad (2.1)$$

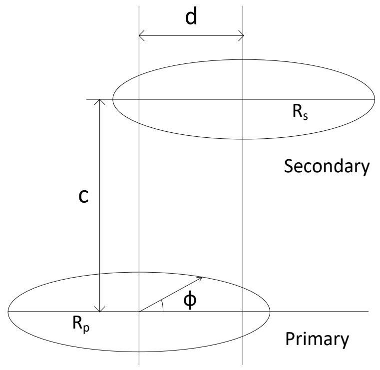


Fig. 2 – Two coils in parallel planes but misaligned

Using (2.1) for some values of the two-coil system (Table 1) as shown in Figure 2, mutual inductance and coupling coefficients are computed and plotted in Figure 3.

Table 1 – For some values of the two-coil system

S.No.	Measurement name	Value
1	Coil radius R_p	19 cm
2	Coil radius R_s	19 cm
3	Coil distance c	15 cm
4	Lateral displacement d	0 to 20 cm

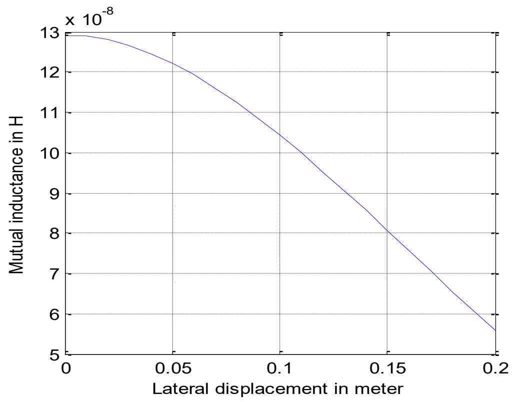


Fig. 3 – Mutual inductance variation

The peak value of M in Figure 3 is 0.1291 μH which is achieved when both coils are perfectly aligned, and this value is verified with the formula given in Grover's book [3]. To verify the nature of calculated mutual inductance, FEM study is carried on the two-coil system to find out mutual inductance with misaligned condition. A comparison of calculated and simulated output is shown in Table 2 and plotted in Figure 4. From figure 4 it is seen that there is a change in mutual inductance of about 4-10 % with a lateral displacement of 0.01m to 0.2m range.

Table 2 – A comparison of calculated and simulated output

Lateral Displacement	Calculated M (in H)	FEM value of M (in H)	% age difference
0	1.29E-07	1.2330E-07	4.50
0.01	1.29E-07	1.2302E-07	4.50
0.02	1.2796E-07	1.2218E-07	4.51
0.03	1.2655E-07	1.2078E-07	4.56
0.04	1.2462E-07	1.1887E-07	4.61
0.05	1.2220E-07	1.1645E-07	4.71
0.06	1.1933E-07	1.1361E-07	4.80
0.07	1.1606E-07	1.1037E-07	4.90
0.08	1.1243E-07	1.0676E-07	5.04
0.09	1.0848E-07	1.0281E-07	5.23
0.10	1.0427E-07	9.8600E-08	5.44
0.11	9.9831E-08	9.4160E-08	5.68
0.12	9.5213E-08	8.9620E-08	5.87
0.13	9.0452E-08	8.4850E-08	6.19
0.14	8.5585E-08	8.0090E-08	6.42
0.15	8.0644E-08	7.5150E-08	6.81
0.16	7.5660E-08	7.0300E-08	7.08
0.17	7.0661E-08	6.5190E-08	7.74
0.18	6.5672E-08	6.0270E-08	8.23
0.20	5.5820E-08	5.0430E-08	9.66

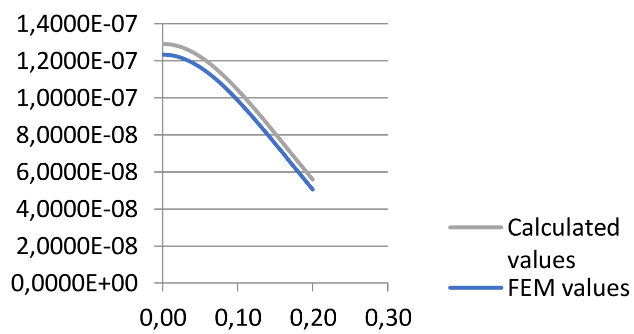
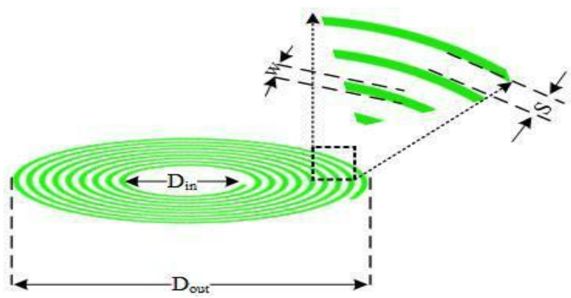


Fig. 4 – Mutual Inductance for calculated vs FEM values

3. DESIGN OF WPT SYSTEM

The design parameters for coil designing for the primary coil and secondary is based on Amended form of original Wheeler formula for an Archimedean spiral coil has been used to calculate the geometric parameters of the spiral coil from the estimated value of self – inductance.



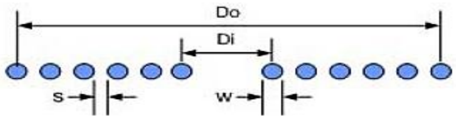


Fig. 5 – Archimedean spiral coil

A modified and more usable version of the Wheeler formula can be derived as

$$L = \frac{N^2(D_{out}+D_{in})^2}{8(15D_{out}-7D_{in})2.54}$$

$$D_{out} = D_{in} + 2w + (S + w)(2N - 1)$$

Where D_{out} = outer diameter; D_{in} = inner diameter, S = spacing between turns; w = diameter of the wire used.

Table 3 –Primary Coil Specifications

Primary Coil Specifications:	
Number of turns (N)	17
Inner diameter Din	50 mm
Wire diameter (w)	1.02 mm
Turn spacing (s)	1 mm
Outer diameter D_{out}	118.68 mm
Wire length (estimate)	4.5 m
Inductance L	28.29uH
Capacitance C	1.44 uF
Resonant frequency	25 KHz

The secondary load for multiple resonant pickup coils is calculated and are shown in Table 4. The electrical parameters were calculated for 20 V output with multiple loads as 50 W, 10W, 5 W at 25 kHz resonant frequency.

Figure 6 shows the Block diagram of WPT System. Alternating Current (AC) of 230 V with 50 Hz main power is stepped down to low voltage AC by conventional 50 Hz iron cored transformer which is then rectified by a bridge rectifier to develop Direct Current (DC) voltage. This DC voltage is again made to AC by a PWM inverter using MOSFETs and capacitors being switched at 25 KHz which is then fed to a resonating high frequency coil acting as primary of an air core transformer. Another matching resonating coil formed as secondary drives the load. Figure 7 shows the Block Diagram of Multi coil Resonant WPT Systems for 3 different loads.

Table 4 – Calculation of multi receiver secondary coil

Secondary Coil Parameters	for 50 W load	for 10 W load	for 5 W load
Number of turns	10	5	4
Wire diameter	1.02 mm	1.02 mm	1.02mm
Turn spacing	1 mm	1 mm	1 mm
Outer diameter	7.04 cm	4 cm	3.016 cm
Wire length (estimate)	1.58 m	047 m	0.28 m
Inductance	5.86 uH	0.95 uH	0.43 uH
Mutual Inductance	1.172 uH	0.19 uH	0.086 uH
Capacitance	6.96 uF	42.66 uF	94.25 uF
Resonant frequency	25 KHz	25 KHz	25 KHz
Resistor	8 ohms	40 ohms	80 ohms
Current	2.5 A	0.5 A	0.25 A

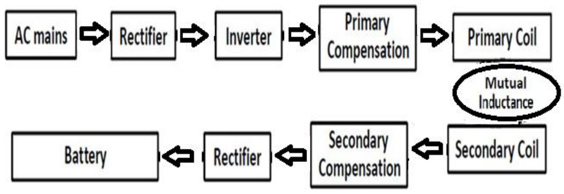


Fig. 6 – Block diagram of WPT system

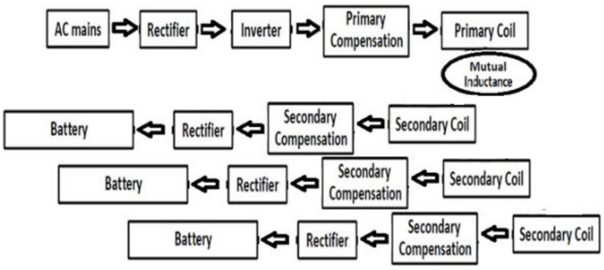


Fig. 7 –Block diagram of multi coil resonant WPT systems

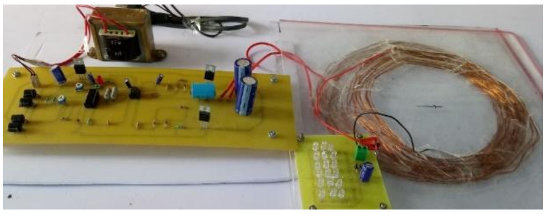


Fig. 8 – Design of WPT System for 50 W load

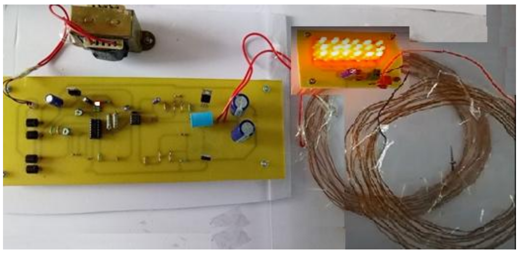


Fig. 9 –Power Transmission for misaligned coils

Fig. 10 – WPT system for 5 W-10 W load

Fig. 11 – Design of Receiver coil for 5 W

Figure 8 shows the design of a wireless power transfer system for charging electronic gadgets. The proposed design able to charge the mobile devices wirelessly. The distance between primary and secondary coil varies from 5 mm to 100 mm. The power received in secondary coil able to charge the mobile electronic gadgets. Figure 9 shows the output power received in misaligned secondary coil up to the distance of 100 mm. The maximum power transferred is 45.6 W. Figure 10 shows the output power received in perfectly aligned secondary coil is 10 watts with respect to distance 15 mm having 92 efficiency. The secondary coils shown in Figure 10 and Figure 11 can be able to receive power of 10 W, 5 W when perfectly aligned with primary coil shown in Figure 8. The power received in secondary coils is in the range of 5 W-45 W and is best suited for charging portable electronic devices.

3.1 Comparison Between Existing Models with Proposed Model

A comparison of the performance of this system with previously published work in terms of PTE, power delivered to loads (PDL) and spatial freedom is given in Table 5. Typically, efficiency is quoted as "DC-to-DC", with input power measured at the PTU amplifier input and output power measured at the PRU rectifier output.

Table 5 – Comparison of WPT systems with PDL < 10 W and increased spatial freedom

	[15]	[16]	[17]	[18]	[19]	Proposed work
Device type	Implantable sensor	Hearing aid	Test structures, open air	Mobile phone	Smart watch+ Mobile phone	Mobile, Smart phone
Max PDL	2.4mW	28mW	275 mW	3 W	1W + 5W	5W-10W
Max PTE	24%	28%	37%	60%	48%	92%
PTE terminal	DC-to-DC	DC-to-DC	coil-to-coil	DC-to-DC	DC-to-reg. 5V	DC-DC
Spatial Freedom	20 cm distance	360^0 inside bowl	Axially aligned, 1.1 coil diameter spacing	Planar charging surface, 32x22 cm^2	360^0 cylindrical charging surfaces	Planar charging surface, along with in the range of 15mm

Table 6 provides a comparison of the wireless charging systems in terms of source power, frequency, and effective charging distance. In the proposed model the receiver coil sizes are minimized so that it can fit in with the mobile or smart phone.

Table 6 – Comparison of wireless charging system in terms of source power, frequency, distance

System	Source Power	Frequency	Effective Charging Distance
RAV Power	7.5 W	110-205 KHz	8 mm
Duracell Power-mat	18 W	235-275 KHz	5 mm
Energizer Qi	22 W	110-205 KHz	11 mm
Writicity WiT-2000M	12 W	6.78 MHz	20 mm
UW Prototype	30 W	13.56 MHz	100 mm
Proposed Model	50 W	25 KHz	100 mm

4. CONCLUSION

The design of wireless power transmission system to full fill the requirement of office communication is successful to charge the electronic gadgets. In the present research work the transmission distance will be increased to some centimeters and the magnitude of power will reach about 5 to 50 Watts without creating harmful radiation in the surrounding ambient. The proposed model can meet the application of wireless power transfer from one source to multiple receivers such as to power the basic need in office communications, such as wireless laptop charging, wireless cell phone charging, wireless power transmission to printer.

REFERENCES

1. A.O. Amos, H. Ykandar, A. Yasser, D. Karim, *AFRICON* (2013).
2. S.I. Babic, F. Sirois, C. Akyel, *Prog. Electromagn. Res. M* **8**, 15 (2009).
3. E.B. Rosa, F.W. Grover, *Scientific Papers of the Bureau of Standards*, No. 169, Third Edition, Dec.1916.
4. F.W. Grover, *Proc. IRE* **32** No 10, 620 (1944).
5. Z. Luo, X. Wei, *IEEE Trans. Industrial Electron.* **65**, 331 (2018).
6. M.G.L. Roes, J.L. Duarte, M.A.M. Hendrix, E.A. Lomonova, *IEEE Trans. Industrial Electron.* **60** No 1, 242 (2013).
7. Y. Hu, X. Zhang, J. Yang, Q. Jiang, *IEEE Trans. Ultrason. Ferroelectr. Freq. Control* **50** No 7, 773 (2003).
8. S. Sasaki, K. Tanaka, K. Maki, *Proc. IEEE* **101** No 6, 1438 (2013).
9. Lala Bhaskar, Pradeep Kumar, Kishore Naik Mude, *IOP Conf. Ser.: Earth Environ. Sci.* **785**, 012001 (2021).
10. N. Tesla, *Proc. IEEE* **87** No 7, 1282 (1999).
11. S.Y.R. Hui, *IEEE Power Electron. Mag.* **3** No 1, 14 (2016).
12. Lala Bhaskar, Pradeep Kumar, Kishore Naik Mude, *1st Int. Conf. Adv. Inf. Technol. (ICAIT)*, 522 (2019).
13. Lala Bhaskar, Pradeep Kumar, Kishore Naik Mude, *Int. J. Innovat. Technol. Explor. Eng. (IJITEE)* **8** No 9S, 533 (2019).
14. Kunwar Aditya, Sheldon S. Williamson, *IEEE Trans. Industrial Electron.* **66** No 5, 3973 (2019).
15. P. Cong, M Suster, N Chaimanonart, D Young, *Sensors*, 1670 (2009).
16. J. Kim, D. Kim, K. Kim, Y. Park, *Proc. IEEE WPTC*, 60 (2014).
17. M. Kiani, et al., *IEEE Trans. Biomed. Circuits Syst.* **5** No 6, 579 (2011).
18. J. Choi, et al., *Proc. 42nd European Microwave Conf.*, 916 (2012).
19. Ron-Chi Kuo, Patrick Riehl, Anand Satyamoorthy, William Plumb, Philip Tustin, Jenshan Lin, *2015 IEEE Wireless Power Transfer Conference (WPTC)* (2015).

Проектування багатокотушкової резонансної бездротової передачі енергії для офісних комунікаційних систем

Lala Bhaskar[1], Pradeep Kumar[1], Kishore Naik Mude[2]

[1] *Amity Institute of Information Technology, Amity University Uttar Pradesh, India*
[2] *Systec R&D, Porto, Portugal*

Система бездротової передачі енергії (БПЖ) складається з передавача, підключеного до основного джерела живлення, який створює змінне магнітне поле, генеруючи магнітний потік, через який у приймальній котушці індукується струм. Конструкція параметрів котушки залежить від застосування. Бездротова зарядка офісних комунікаційних систем – це нова технологія у світі, яка дозволяє передавати енергію на офісні комунікаційні пристрої, такі як ноутбуки, мобільні телефони, монітори, світлодіодні дисплеї, принтери, без використання звичайних мідних кабельних проводів. Найпопулярніший метод бездротової передачі енергії може бути досягнутий за допомогою резонансного індуктивного зв'язку. Ця стаття зосереджена на застосуванні бездротової передачі енергії від одного джерела до кількох приймальних навантажень. Ідея полягає в тому, щоб задовольнити основні потреби офісного життя, такі як бездротова зарядка ноутбуків, бездротова зарядка мобільних телефонів, бездротова передача енергії на принтер. Мобільне застосування в цій статті визначається як мобільний або портативний пристрій, який можна застосовувати будь-де в офісі або вдома. Метою цієї запропонованої моделі є бездротова зарядка кількох мобільних пристроїв. Традиційні дротові рішення для живлення в офісних комунікаційних системах створюють безлад, зменшують мобільність та обмежують масштабованість. Бездротова передача енергії (БПЖ) пропонує перспективну альтернативу, усуваючи кабелі та забезпечуючи гнучке розташування робочого простору. Це дослідження зосереджено на проектуванні багатокотушкової резонансної системи бездротового транспортера (БПТ).

Ключові слова: БПЕ (бездротова передача енергії), Котушка передавача, Котушка приймача, Зарядний пристрій, Метод скінченних елементів (МСЕ).