# Mat Lab Simulation and Programming for Wireless Power Transfer through Concrete

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***Abstract:***-Wireless power transmission using circuits resonating at the frequency of 50 Hz and 60 Hz. The purpose of this research paper is to develop a matlab simulation and matlab programming for calculating efficiency and max efficiency of the system for transmitting electrical power through concrete walls. The transmission efficiency that considers the copper and core losses was derived through equivalent circuit analysis.

The transmission efficiency was found to be dependent on the shape of the magnet pole pieces. A transmission efficiency of 78.54%. And max efficiency of 76.57% for a load of 146.5 ohms for a rectangular shape magnet.

In this paper for two different frequencies, efficiency and max efficiency is calculated and tabulated along with the magnetic field distribution.

***Keywords:*** *wireless power transmission, mat lab, magnetic field distribution.*

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## I. INTRODUCTION

**T**HE ultimate goal of the present research is to develop a method to write a mat lab program for calculating the values of efficiency and maximum efficiency and simulation in mat lab for wireless power transfer through concrete. Since it is very difficult for manual calculation for analyzing different parameters of the circuit and for different frequency.

There are different methods of wireless power transmission (WPT): electromagnetic induction, magnetic resonance, and radio waves.

Since resonant energy transfer was first developed by the WiTricity project [2], there has been a great deal of research carried out using this and other approaches [3]–[5].

In the paper Wireless Power Transmission Through Concrete Using Circuits Resonating at utility Frequency of 60 Hz by Hiroki Ishida and Hiroto Furukawa , IEEE TRANSACTIONS ON POWER ELECTRONICS, VOL. 30, NO. 3, MARCH 2015, is calculated manually for the three different magnetic configuration.

In the present research paper, the efficiency of resonant power transmission through concrete is calculated at the utility frequency of 50 Hz and 60 Hz using mat lab programming, for three different magnet pole piece configurations. Mat lab simulation is also done along with magnetic field distribution programming.

## II. CIRCUIT DIAGRAM ANALYSIS

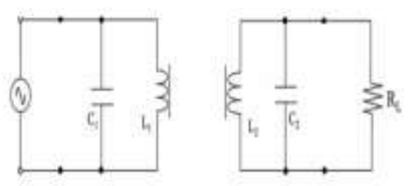


**Fig1 Circuit diagram for WPT**

Fig. 1 shows a circuit diagram of the WPT system.
The results presented in this paper, the secondary condenser $C_2$ was connected in parallel with the load

The equivalent circuit for that in Fig.1 is also simple, as shown in Fig. 6 Here, $r_1$ is the primary winding resistance, $jx_1$ is the primary leakage inductance, $-jx_{C1}$ is the primary capacitance, $r_2$ is the secondary winding resistance, $jx_2$ is the secondary leakage inductance, $-jx_{C2}$ is the secondary capacitance, $r_c$ is the core loss, $jx_L$ is the mutual inductance, and $R_L$ is the load resistance.

## III. MAT LAB SIMULATION

Simulation for the above circuit diagram is done by using the matlab simlink tools and input and output ware forms are shown in the fig 2-5

**Fig 2 Mat Lab Simulation for Wireless Power Transfer**

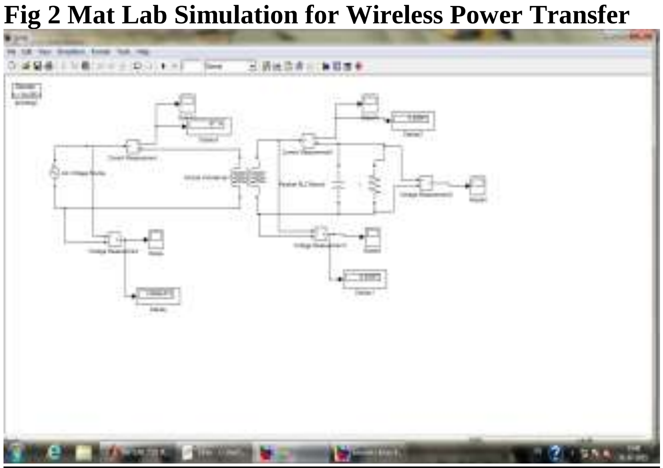


**Fig 3 INPUT VOLTAGE: 200v**

ISSN: 2321-8169
4869 - 4872

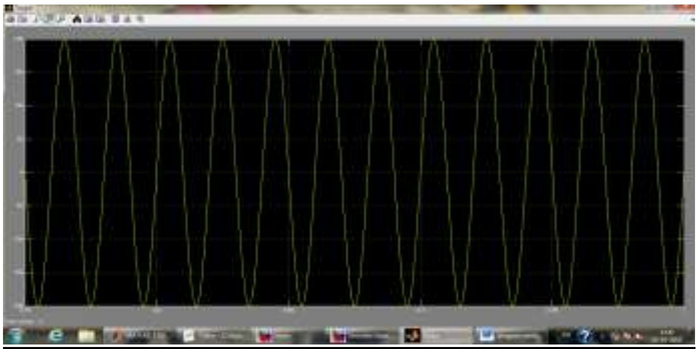


**Fig4 OUTPUT VOLTAGE:**

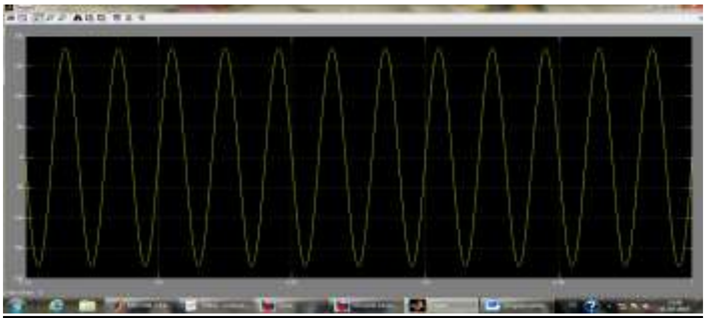
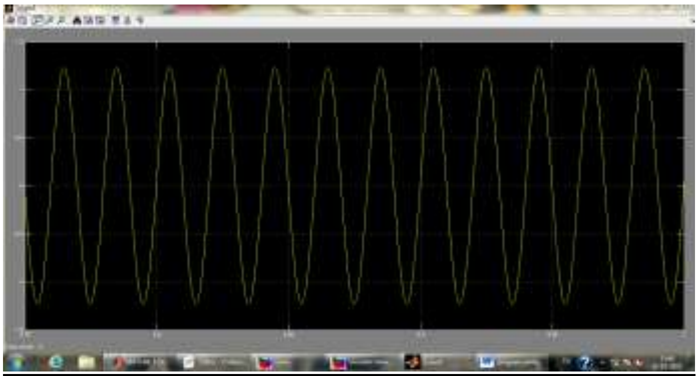


**Fig 5 OUTPUT CURRENT :( FOR LOAD OF 146.5 OHMS)**



## IV. EQUIVALENT CIRCUIT ANALYSIS

The equivalent circuit of the above circuit diagram (fig 1) is shown.

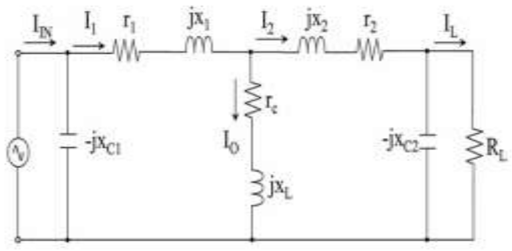



**Fig6.Equivalent circuit**

The equations corresponding to the above equivalent circuit is shown,
If C2 is connected,
$x_{C2} = 1/\omega_0 C_2 = x_L + x_2$ .

The total impedance for the circuit in the absence of $C_1$ can be written as, hence the values of resistance components $r_1$, $r_2$, and $r_c$ are sufficiently small compared to the reactance components, they are neglected

$Z = (x_L/ x_L + x_2)^2 R_L + j(x_L x_1 + x_1 x_2 + x_2 x_L/ x_L + x_2).$

When $C_1$ is connected, the imaginary Part of $Z$ *becomes* zero it is given by,

$x_{C1} = 1/\omega_0 C_1$
$=((x_L / x_L + x_2)^2 R_L)^2/ (x_L x_1 + x_1 x_2 + x_2 x_L/ x_L + x_2 )+ (x_L x_1 + x_1 x_2 + x_2 x_L/ x_L + x_2)$

The efficiency of the system is calculated by using the equation,

$$\eta = \frac{R_L}{R_L + r_1 a^2 + r_2\left\{1+\left(\frac{R_L}{x_{c1}}\right)^2\right\} + r_c\left\{a^2+1+\left(\frac{R_L}{x_{c1}}\right)^2 - 2a\sqrt{1+\left(\frac{R_L}{x_{c1}}\right)^2}\cos\theta\right\}}$$

The maximum equation by considering the quality factor is calculated as,

$$\eta_{\max} \approx \frac{1}{1 + \frac{2}{k\sqrt{Q_1 Q_2}} + \frac{2r_x(k+k^{-1}-1)}{r_2 Q_2}}.$$

## V. MAT LAB PROGRAMMING

The mat lab program is written for the equivalent circuit to find the efficiency and max efficiency for different frequency and different values of magnetic configuration

```
clc
clear all
% input data for the wireless power transfer through concert.
v=input('input voltage in volts V=');
f=input(' frequency in HZ F =');
x1=input('reactance of pri.winding in ohms X1 =');
x2=input('reactance of sec.winding in ohms X2 =');
xL=input('reactance of magnatic circuit  in ohms XL  =');
xc1=input('capacitance reactance of pri.winding side in ohms XC1=');
%xc2=input('capacitance reactance of sec.winding side in ohms XC2=');
r1=input('resistance of pri.winding in ohms r1 =');
r2=input('resistance of sec.winding in ohms r2 =');
rc=input('resistance of magnatic circuit in ohms rc =');
RL=input('load resistance of  in ohms RL =');
xc2=(xL+x2);
w0=2*pi*f;
c2=(1/(w0*xc2));
c1=(1/(w0*xc1));
B=0;
if c1==B
 z=((xL/(xL+x2))^2*RL)+j*((xL*x1+x1*x2+x2*xL)/(xL+x2));
fprintf('\nthe value of z when C1=0 is =%f%+fiohms',real(z),imag(z));
end
if c1~=B

z=(((xL/(xL+x2))^2*RL)^2)/((xL*x1+x1*x2+x2*xL)/(xL+x2))+((xL*x1+x1*x2+x2*xL)/(xL+x2));
fprintf('\n the value of z when C1~=0 is =%f%ohms',real(z));
end
turnsratio=1;
% to find effeiency of he system.
k=input('\n Turns Ratio=');
if k==turnsratio
```

ISSN: 2321-8169
4869 - 4872

```
alpha=(xL+x2)/xL;
   IL=v/RL;
   I1=alpha*IL;
   I2=IL*(sqrt(1+(RL/xc2)^2));
   I0=I1-I2;
   pf=xc2/(RL^2+xc2^2);
%I0^2=IL^2*(alpha^2+(1+(RL/xc2)^2)-
2*alpha*sqrt(1+(RL/xc2)^2*pf);

eff=RL/((RL+r1*alpha^2+r2*(1+(RL/xc2)^2))+rc*(alpha^2+1+(R
L/xc2)^2-2*alpha*sqrt(1+(RL/xc2)^2*pf)));
   eff1=eff*100;
fprintf('\n the efficiency of the system =%f%',eff1);
end
% to find the maximum of the system.
effmax=1/(1+(2*r2/xc2)*sqrt(alpha^2*(r1/r2)+1)+(rc*(alpha^2*(1
+(r1/r2)))-
2*alpha*sqrt(alpha^2*(r1/r2)+2*pf+2)/(xc2*sqrt(alpha^2*(r1/r2)+
1))));
effmax1=effmax*100;
fprintf('\n the maximum effeciency of the system =%f%',effmax1);
L1=w0*x1;
L2=w0*x2;
%Q1=(w0*L1)/r1;
%Q2=(w0*L2)/r2;
%L1=input('\n inductance of the pri. coil in  henry=');
%L2=input('\n inductance of the sec. coil in  henry=');
Q1=input ('\n quality factor in the primary side=');
Q2=input ('\n quality factor in the secondary side=');
% to find the max Eff. when quality factor is considered.
M=(xL/(xL+x2))*L2
k1=M/(sqrt(L1*L2))
effmax2=1/((1+(2*r2/xc2)*sqrt((1/k1^2)*(Q1/Q2)+1)+(rc*(alpha^
2+2+1/k1^2)*(Q2/Q1))-
2*alpha*sqrt((1/k^2)*(Q2/Q1)+2*pf)/(xc2*sqrt((1/k^2)*(Q2/Q1)+
1))));
effma=effmax2*100;
fprintf('\n the maximum effeciency of the system =%f%',effma);
% to check the condition.
greaterthanone=(1/k1^1)*(Q1/Q2);
fprintf('\n the above condition is true under any
condition=%f%',greaterthanone);
% to find max.eff. when quality factor  is considered
maxeff_QF=1/(1+(2/(k1*sqrt(Q1*Q2)))+(2*rc*(k1+(1/k1)-
1)/(r2*Q2)));
maxeff=maxeff_QF*100;
fprintf('\n the maximum effeciency of the system with quality
factor =%f%',maxeff);
% the conclussion of the above program.
fprintf('\n -------------------THE CONCLUSION OF ABOVE
RESULTS------------');
fprintf('\n a larger value of the product of k and q yields high eff.');
fprintf('\n a larger value of the product of r2 and Q2 yields high
eff.');
fprintf('\n copper losses and core losses increases with decreasing
k1.');
```

**Specified parameters for 5o Hz and 6o Hz.**

| | Rectangular | Double flare | Single flare |
|---|---|---|---|
| $X_1$-ohms | 23.8 | 27.6 | 40.3 |
| $X_2$-ohms | 25.7 | 28.1 | 41.5 |
| $X_L$-ohms | 7.83 | 11.0 | 23.1 |
| $X_{c1}$-ohms | 31.2 | 35.4 | 53.1 |
| $X_{c2}$-ohms | 33.2 | 35.4 | 57.4 |
| $r_c$-ohms | 0.46 | 0.50 | 0.60 |
| $R_L$-ohms | 146.5 | 159.2 | 173.6 |
| $r_1$-ohms | 0.68 | 0.68 | 0.74 |
| $r_2$-ohms | 0.69 | 0.68 | 0.78 |
| $Q_1$ | 40.0 | 45.3 | 61.1 |
| $Q_2$ | 42.4 | 46.7 | 58.0 |

**Output values at 5o Hz.**

| | Rectangular | Double flare | Single flare |
|---|---|---|---|
| efficiency | 78.54 | 83.24 | 90.33 |
| Max efficiency | 76.57 | 80.54 | 87.04 |

## VI. CONCLUSION

From the above program it is very easy for calculating the efficiency and maximum efficiency of the wireless power transfer through concrete for different parameters.

A large *Q* factor is difficult at low frequencies, which is the reason why low-frequency approaches have not been used until now. From the above results the total transmission efficiency into consideration, and concluded that the utility frequency of 50 Hz or 60 Hz is best. However, using the frequency, a model can also be designed for different frequencies in which power can be
transferred efficiently, even through a concrete plate. A working system of this type is expected to find applications in disaster-struck areas where batteries can be charged through WPT for robots.

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