# Microwave Wireless Power Transfer at Multiple Frequencies

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*Abstract* – **Microwave Wireless Power Transfer (WPT) Systems one of the alternatives to replace wired power transmission in the modern life nowadays. Directive radiation antenna is used in this system to make sure power transmitted in effective way through microwaves in a long range. This paper describing about the directional radiation microstrip rectangular patch is chosen as antenna to transmit power. The WPT system is created in multiple of frequencies without degrade any performance and can reduce the size of antenna.**

***Keyword – Microwave Wireless Power Transfer (MWPT), Directive Radiation Antenna, Microstrip Rectangular Patch Antenna.***

## I) INTRODUCTION

Wireless power transfer is a great potential system in our life nowadays. The usage of the electricity can be efficient with revolution of the electromagnetic wave power transmission. Without any physical medium or wired, electrical power is transferring from one point to others. WPT can be dividing by three main part (1) Transmission. (2) Reception. (3) Rectification. This paper shown the work on WPT based on radiation technique of antenna. Power will radiated in form of wave at certain frequencies in the transmission system and propagate through the air as a medium and receive at the receiver then rectified to DC as shown in Figure 1 [1].

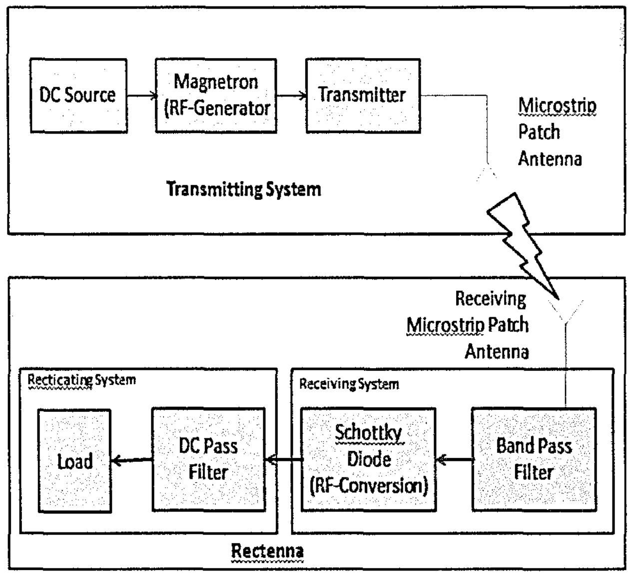


Figure 1: WPT block diagram

### A. *Transmission*

Transmitting system is delivery RF signal in form of microwave signal as shown in Figure 1. DC source will be converting to RF signal implemented by Magnetron and carry on using transmitter to microstrip patch antenna. A microstrip patch antenna with any possible shape and created by radiating patch on one side of substrate and grounding at the other side. Signal which carry power radiated in air as medium delivery to the receiver.

### B. *Reception*

Microwave power signal which delivered by transmitter will received at the receiving system.

Receiving system consist microstrip patch antenna in any shape and design as receiving antenna while band pass filter to remove distortion or harmonic. Receiving antenna will grab the all transmitted power from transmit antenna.

*C. Rectification*

Output from receiving antenna is heading to diode passed through the band pass filter. Impedance matching is required to get maximum power between filter and antenna [2].

1. Diode: It is act as conversion between microwaves to the DC in WPT system.
2. D.C Pass Filter: Output from Schottky diode is going through the DC pass filter which is the balance of microwave signal will be reflected again to the diode.

II) TRANSMITTING ANTENNA DESIGN

Microstrip patch antenna is directive radiation pattern antenna that is stacked with

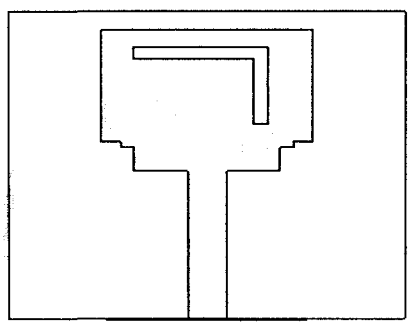

Figure 2: Single rectangular patch antenna

dielectric substrate and etched with a small size of feed line to suit with impedance matching as shown in Figure 2. Grounding will cover the rare surface of substrate.

In order to get a better result, dimension of microstrip patch antenna was calculated as follow:

$$W = \frac{c}{2f_r\sqrt{(\frac{\varepsilon_r+1}{2})}} \qquad (1)$$

$W$ = Width
$c$ = free space of velocity of light 3 x $10^8$
$fr$ = frequency operation
$\varepsilon_r$ = Dielectric constant

The calculation of the effectiveness dielectric constant ( $\varepsilon_{reff}$) can be determine after knowing the value of W for antenna design.

$$\varepsilon_{reff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}[1 + 12\frac{h}{W}]^{-\frac{1}{2}} \qquad (2)$$

$\varepsilon_r$ = dielectric constant
$h$ = height of dielectric substrate

By knowing the effectiveness dielectric constant, calculation for effective length can be calculated.

$$L_{eff} = \frac{c}{2\, f_r\sqrt{\varepsilon_{reff}}} \qquad (3)$$

The physical length of patch is shorter than the effective electrical length due to fringing effect. Because of that, the total changing length is:

$$\Delta L = 0.412h\frac{(\varepsilon_{reff}+0.3)(\frac{W}{h}+0.264)}{(\varepsilon_{reff}-0.258)(\frac{W}{h}+0.8)} \qquad (4)$$

So, the formula for actual length is

$$L = L_{eff} - 2\,\Delta L \qquad (5)$$

Location for feed,

$$X_f = \frac{L}{2\sqrt{\varepsilon_{reff}}} \qquad (6)$$

*A. Inverted L-Slot*

Theoretically putting L-slot at the antenna can improved the return loss at lower frequency under 10dBi.

*B. Bottom Notches*

Cutting notches at the bottom techniques are aimed to change the distance between the lower part of the planar with the ground plane in order to tune the capacitive coupling and wider impedance bandwidth can be achieved.

## III) SIMULATION AND RESULT

### *A. Dimension antenna*

The microstrip rectangular patch antenna was design with a fix dimension and small size of shape without degrades any performance of antenna [3]. Dimension of substrate (*Wsub x Lsub*) is 30mm x 26mm with 1.6mm of thickness and 4.7 of relative dielectric constant ($\varepsilon_r$) designed on FR4 lossy. Dimension of rectangular patch (*W x L*) is 16mm x 12mm is connected by feed line with 3mm width line that printed on the substrate. The other side of substrate is covered by the grounding. This antenna will be achieved by adding inverted L slot with 1mm gap spacing. In order to get a better return loss, optimize antenna with two notches is created as shown in Figure 2.

### *B. Impedance characteristics of antenna*

The simulation results obtained from CST software with desired frequency.

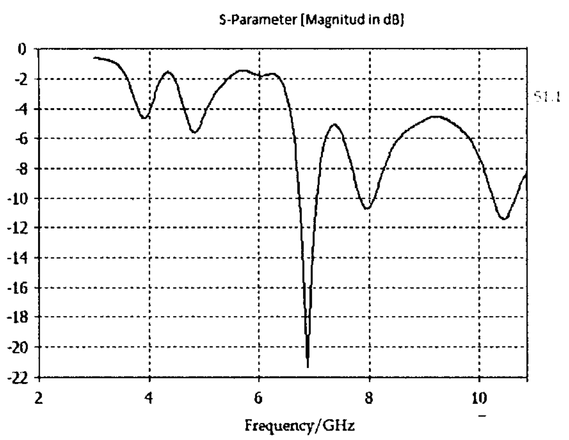


Figure 3: Simulation of return loss (S11)

Result $S_{11}$ vs frequency is shown in Figure 3. It has 50Ω input impedance. The return loss of the antenna at frequency 6.8GHz is respect at almost 21 dB. Mean this microstrip antenna really working at that frequency.

### *C. Farfield radiation pattern characteristic*

The antenna is created to operate at 6.8 GHz. The theoretical and simulated data are quite matching that covered under -10 dB [4]. The 3D radiation pattern for antenna is shown in Figure 4 and Figure 5 in polar view which is operating at 6.8GHz. The gain of antenna is 6.1dBi.

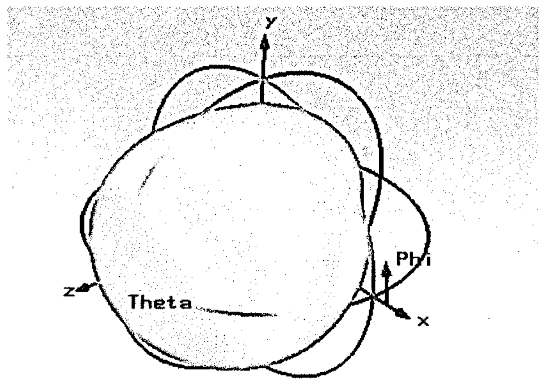


Figure 4: 3D radiation pattern microstrip patch antenna

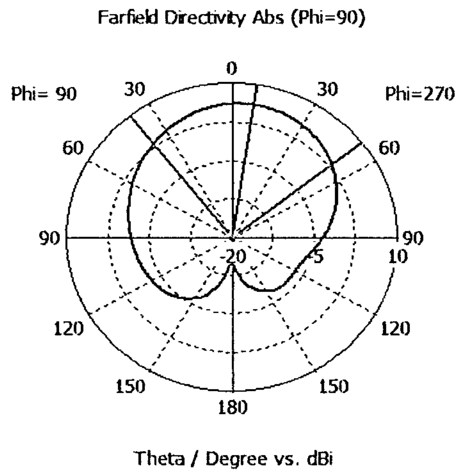


Figure 5: Radiation pattern In polar view

### *D. Antenna performance with uniform flat lens.*

A WPT system was designed by using two same kind of microstrip antenna that put with uniform inverted facing patch as shown in Figure 6 by 10mm distance.

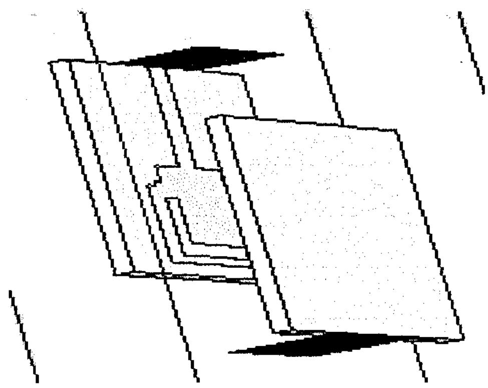

Figure 6: Microstrip with uniform flat lens.

The return loss of WPT is shown in Figure 7 which is two frequency that operate under -10 dB and 2.7 dBi gain.

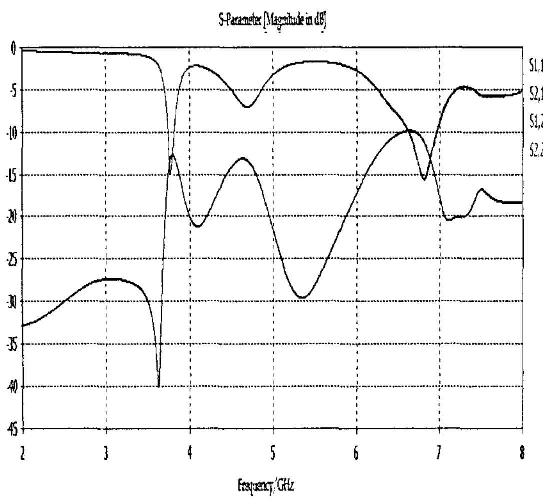


Figure 7:Simulation of return loss with uniform flat lens

## IV) CONCLUSION

A microstrip patch antenna with inverted L slot and 2 notch etched by feed line and FR4 lossy as substrate has been proposed in WPT system on this paper. Two similarity of antenna has been design in this system separately by a certain distance to transfer power.

Based on simulation, antenna is operating on two frequency 3.78 GHz and 6.8 GHz. Hence, the proposed antenna is really suitable for usage of wireless power transfer in multiple frequencies.

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