Design And Analysis of Active Integrated Antenna(AIA) for WLAN Applications

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Abstract - *A new design of patch-slot-like microstrip active integrated antenna (AIA) is presented and discussed in this paper. The primary designed passive antenna is capable of supporting for WLAN bands at 2.45 GHz. The antenna with harmonic suppression capability is directly integrated with a amplifier to improved power added efficiency. The antenna is a microstrip patch with harmonic suppressing slits etched on it.The proposed passive patch antenna is integrated with a power amplifier (PA). The antenna has been designed on FR4 substrate dielectric constant 4.4 and thicknessh=1.53 mm & its dimension is 64.0 mm × 73.0 mm × 1.6 mm. The proposed antenna exhibits a much higher impedance bandwidth(2.30-2.66GHz) of about 15.33% (S11 < −10 dB) and the gain is about 3.4dB.The radiation pattern, return loss, VSWR and Bandwidth of the proposed antenna are described and simulated using HFSS software package.*

***Key Words*: microwave amplifiers; active integrated antenna slits, active components.**

1. INTRODUCTION

In recent years, the active integrated antenna (AIA) aspect has become a growing and developing research area which has absorbed a lot of attention toward itself. In one definition the AIA can be considered as an active microwave circuit which its input or output is terminated in free space rather than the conventional 50- terminations. The active device in an AIA can be of any kind such as transistors (three-terminal device) or resisters, inductors and any planar antennas such as microstrip patch or microstrip slot antennas can be used as the radiating element.
Active Integrated Antenna (AIA) is a direct integration between an antenna and an active circuit such as a power amplifier (PA), low noise amplifier (LNA), or an oscillator [1]. Such integration not only offers reduced circuit size by reducing parts of matching circuits, but also improves the performance of power amplifier when the antenna is designed to have harmonic suppressing capability[2] . The harmonic suppressing antenna has been designed from shorting pins , circular sector antennas , photonic band gap (PBG) structures , and defected ground[8]. While these designs show good improvement in power added efficiency (PAE), the design is relatively complicated. This paper presents a simple square antenna design that can be potentially modified to support both linear polarization and circular polarization for practical communication front-ends[6]. This architecture is easy to fabricate compared with the shorting pins structure. Symmetric geometry is another advantage which makes the antenna suitable for circular polarization applications in future[7].

1.1 ANTENNA DESIGN AND ANALYSIS

The dielectric chosen is FR4-epoxy substrate having relative permittivity of 4.4 and the thickness of 1.53mm. The dimension of patch is approximated by using basic design approach described for microstrip patch antenna as listed below:
Step 1: Calculation of Lambda (λ0)-
Lambda (λ0)=c/f=3x10^8/2.4x10^9
(λ0)=125mm at 2.4 GHz
Step 2: Calculation of monopole length (L)-
The frequency of operation of the patch antenna is determined by the length *L*.
The center frequency will be approximately given by:

$$f_c \approx \frac{c}{2L\sqrt{\varepsilon_r}}$$

$$L = \frac{C}{2fc\sqrt{\varepsilon_r}} \qquad \text{------------ (1)}$$

Where fc=is centre freq=2.4GHz
εr=4.4 and c=3x10^8
We get L=29mm
For Square patch L=W
So W=29mm
Step 3: Calculation of Length of feed (Li & Lo)-
Lin=Lo=lam/8*sqrt(4.4)=7.5mm
Step 2: Calculation of Length of feed (Lq)-
Lin=Lo=lam/4*sqrt(4.4)=14.5mm
Step 4: Calculation of Length of feed (Lm)-
Lm=lam/4*sqrt(4.4)=14.5mmy0=7mm
Step 5: Calculation of Feed length (L50)-
Feed length (L50)=lam/4*sqrt (4.4)
L50=14.5mm
Feed width calculate by using

$$Z_0 = \frac{60}{\sqrt{\varepsilon_r}} \ln\left(8\left(\frac{H}{W}\right) + 0.25\left(\frac{W}{H}\right)\right) \qquad \text{--------- (3)}$$

Hence,we get W=2.84mm.

1.2 *Active Integrated Circuit:*

For an active integrated antenna, the designed patch antenna should be directly connected to the amplifier's output as its load. Input impedance of the antenna can be used as a RLC load in HFSS simulation.
After designing the matching networks for input and output ports providing maximum gain while considering the amplifier's stability, the next part is DC bias circuit. This

circuit should be able to isolate the RF sections of the amplifer from the DC parts. It should be also able to deliver the required DC power with minimum dissipation as we are interested in an efficient design The width of this transmission line should be very narrow to increase its characteristic impedance and the length should be quarter wavelength at the frequency of the amplifier's operation.
On the other side of this narrow transmission line where the DC supply is connected, using some decoupling capacitors effectively short circuits all frequencies except the DC supply at that point. The quarter wavelength transmission line will transform the short circuit to an open circuit where it is connected to the amplifier's network. That means the input or output signals cannot propagate inside that part of the circuit and in this way the RF network is isolated from the DC circuit. Simplified schematic for Active integrated (RF and DC sections) are illustrated in Fig. 1. For an active antenna, the designed patch antenna should be directly connected to the amplifier's output as its load. Input impedance of the antenna can be used as a RLC load in HFSS simulation.
After designing the matching networks for input and output ports providing maximum gain while considering the amplifier's stability, the next part is DC bias circuit. This circuit should be able to isolate the RF sections of the amplifer from the DC parts. It should be also able to deliver the required DC power with minimum dissipation as we are interested in an efficient design The width of this transmission line should be very narrow to increase its characteristic impedance and the length should be quarter wavelength at the frequency of the amplifier's operation.
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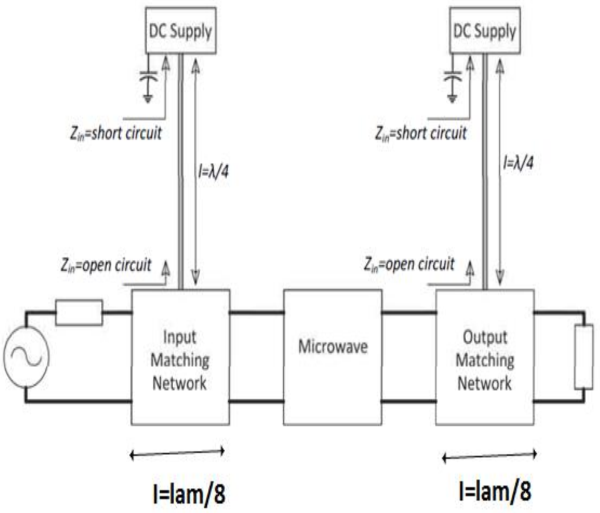

2. Comparison Table

Sr. No .	Results	Freq (GHz)	Return Loss (dB)	VSWR	BW MHz	Impedance
1.	Simulated Results	2.46	-16.55	1.34	300	52.2
2.	Measured Results	2.43	-33.43	1.03	320	51.1

3. ACTIVE INTEGRATED ANTENNA

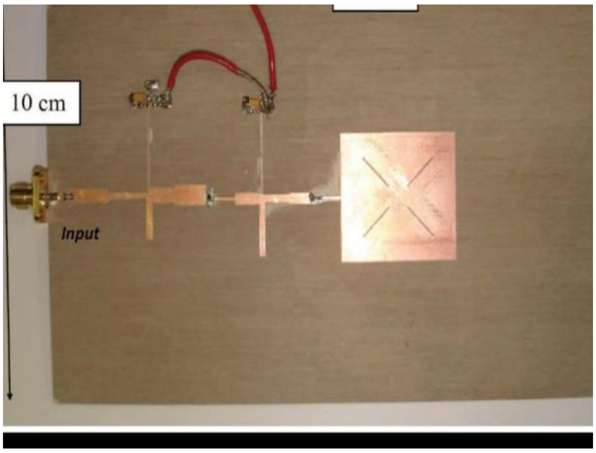

Fig.Fabricated active integrated antenna with harmonic suppression

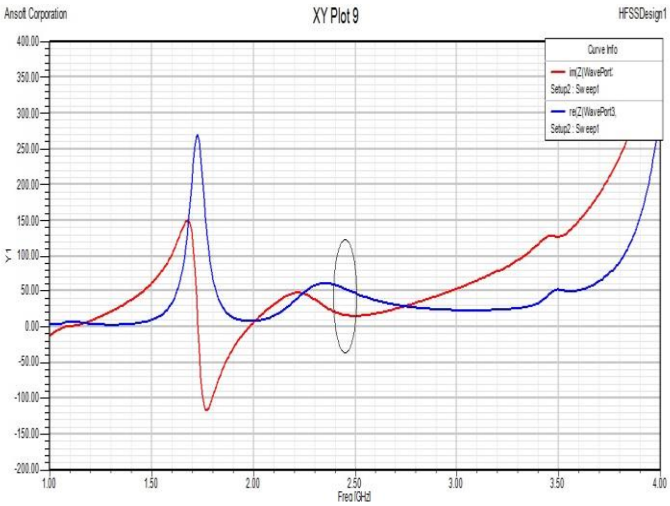

Fig.Input Impedance of antenna with Harmonic Suppression

CONCLUSION

In this paper, a new design of microstrip with slits active integrated antenna is proposed for WLAN applications. The simulated passive antenna has operating frequency bands at 2.46 GHz and improved bandwidth levels is obtained by utilizing active integrated amplifiers at its ports.

The simulated results for the proposed AIA reveal that it covers frequency bands of 2.30-2.66 GHz and with 3.4dB gain and bandwidth enhancement respectively in contrast to the simple passive antenna.

The measured and simulated results for both proposed passive and active antennas are in appropriate correlation and agreement, and the presented antenna can be used as a for WLAN applications.

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