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New Selective Dual Band Microstrip Patch Antenna for WLAN

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Abstract:

A simple dual band coaxial fed microstrip patch antenna has been designed to meet the (IEEE 802.11n) standard (released Oct., 2009) for high speed Wireless Local Area Network (WLAN) to operate at (2.45 and 5.8 GHz). The position of the coaxial fed probe is chosen to provide the required matching for excitation of the dual resonance frequencies. The patch length is chosen to radiate at the lower frequency and with the help of a slot along the patch; the coupling provided resonance tuning for the higher frequency.

The patch was designed, simulated, fabricated and measured. There was a very good agreement between the measured and the simulated results.

Keywords:
Dual Band Microstrip antenna, Coaxial feeding, WLAN

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1. Introduction:

The demand for higher capacity of information in the wireless network systems leaded to the introduction of the dual usage of the (2.45 & 5.8 GHz) bands. The use of microstrip patch antennas to connect different network elements is present due to the advantages of microstrip physical and mechanical properties; such as light weight and thin profile, thus the use of microstrip patch dual-band antennas is becoming more interesting, (wide band antenna is not required for WLAN since it's selective for the proposed frequencies).

Whereas many papers suggested dual frequency response of a patch using either U shaped [1], E shaped [2] or monopole patch [3,4]; this paper introduces a simple microstrip patch antenna element configuration, small in size with acceptable return loss and radiation pattern over the required frequency bands (2.4-2.484 GHz) and (5.725–5.85 GHz).

2.Antenna Design:

In this paper, the probe feed position choice is based on the idea proposed in [5] where the probe feed impedance of a rectangular segment is obtained from the coupling impedance between the probe feed and another port.

This impedance is then simplified & used to locate the required position to obtain matching at the required two frequencies.

A rectangular patch antenna is shown in figure (1), where the effective length (a) for (2.45GHz), width (b) for (5.8 GHz) and the probe feed position (x_p, y_p) for matching need to be determined. The probe feed impedance for the rectangular patch antenna is given by:

$$Z_{pp} = j\omega\mu h\left(\begin{array}{l} -\dfrac{\cos ak + \cos(a-2x_p)}{2bk.\sin ak} + \\ \dfrac{b^2}{w_p^2\pi^3}\displaystyle\sum_{n=1}^{\infty}\left(\dfrac{\left\{\sin\left[\dfrac{n\pi}{b}\left(y_p+\dfrac{w_p}{2}\right)\right]-\sin\left[\dfrac{n\pi}{b}\left(y_p-\dfrac{w_p}{2}\right)\right]\right\}^2\left\{\cosh\left[\dfrac{a\pi}{b}\sqrt{n^2-\left(\dfrac{bk}{\pi}\right)^2}\right]+\cosh\left[\dfrac{(a-2x_p)\pi}{b}\sqrt{n^2-\left(\dfrac{bk}{\pi}\right)^2}\right]\right\}}{n^2\sqrt{n^2-\left(\dfrac{bk}{\pi}\right)^2}.\sinh\left[\dfrac{a\pi}{b}\sqrt{n^2-\left(\dfrac{bk}{\pi}\right)^2}\right]}\right)\end{array}\right)$$

Where; (W_p) port width, (k) propagation factor.

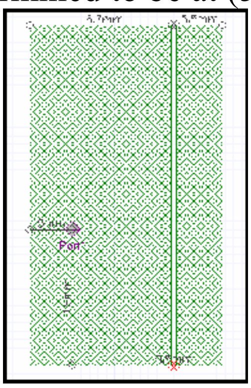
Thus; with the help of design equation of a microstrip patch antenna in [6], the dimensions of the patch and the probe feed location are determined.

$$L = \frac{v_o}{2f\sqrt{\varepsilon_{reff}}}, \quad \frac{\Delta l}{\lambda} = 0.412\frac{(\varepsilon_{reff}+0.3)}{(\varepsilon_{reff}-0.258)}\frac{\left(\frac{w}{h}+0.264\right)}{\left(\frac{w}{h}+0.8\right)}, \quad \varepsilon_{reff} = \frac{(\varepsilon_r+1)}{2}+\frac{(\varepsilon_r-1)}{2}\left(1+\frac{12}{\left(\frac{w}{h}\right)}\right)^{-1/2}$$

Since the behavior of the dual band resonances is very sensitive to the feed position, especially for the higher resonating frequency; a slot is made dividing the patch element into two that is used to enhance the performance of the higher frequency via coupling. The slot width works as a fine-tuning to adjust the resonance at the required frequency. A comprehensive study for the position and slot width was done to achieve the optimum patch spacing and location. Results in figure (2) show the proposed widths that introduce best response at patch spacing equal (0.5 mm).

3. Microstrip Antenna Configuration:

The antenna system consists of two patches (16.7x40 mm) and (5.5x40 mm) with (0.5 mm) apart. Thus the overall dimensions us (22.7x40 mm). The antenna is made over a substrate of (2.54 mm) thick (RT/duroid 6010) with relative permittivity (10.2). The feeding point is determined to be at (5, 16 mm); as shown in figure (2).


(a)


(b)

Figure: *(1) (a) Configuration of the patch antenna (b) Fabricated structure*

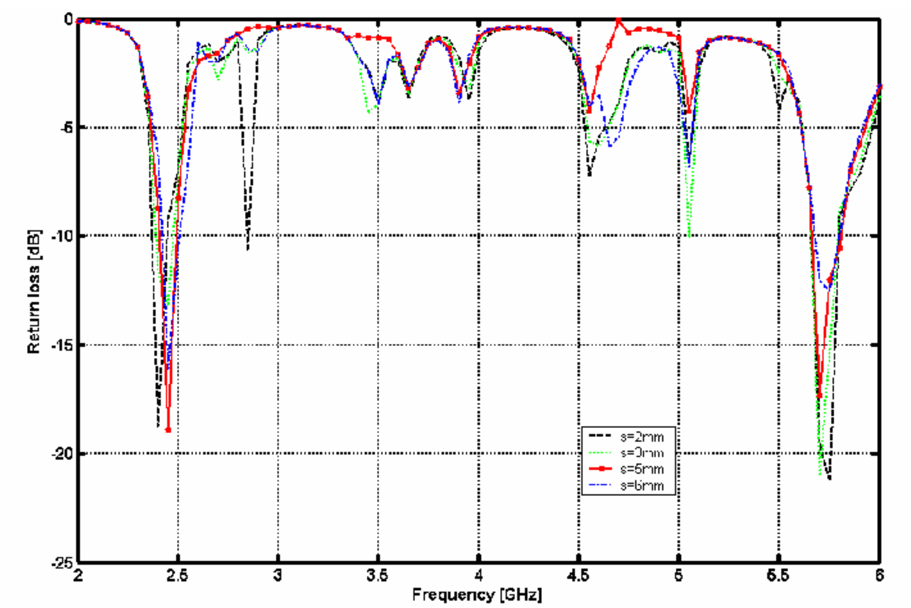


Figure: *(2) Optimization of spacing slot width*

The analysis of the structures was carried out using ANSOFT Designer software [7].
A prototype of the configuration has been fabricated using conventional photolithography printing circuit technique. The measurement is done using a HP 8510c vector network analyzer. The simulation results is compared to the measured data and shown in figure (3).
A return loss at the first resonance (2.45GHz) is about (-18.5dB) with a (90 MHz) that cover the entire bandwidth needed, while the second resonance (5.8GHz) has a return loss of (-17dB) with (115 MHz) bandwidth which is sufficiently acceptable.
The return loss over the rest of the entire band has been less than (-4 dB).

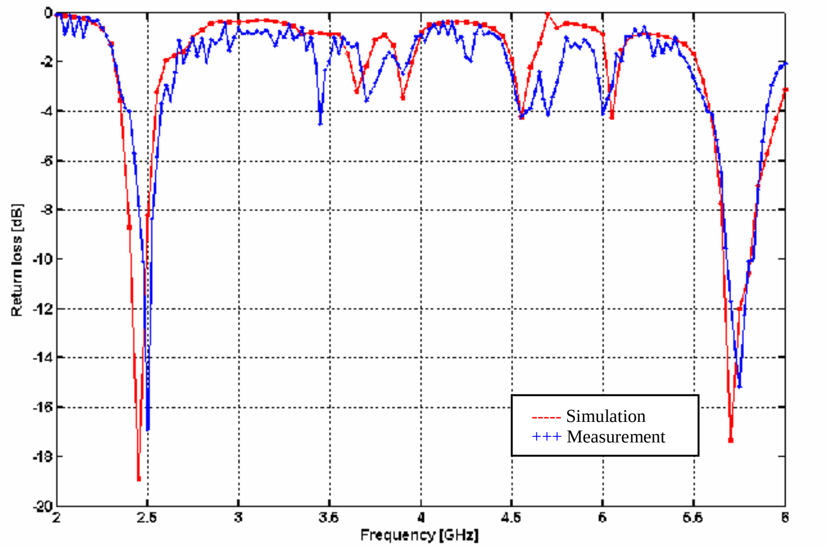


Figure: *(3) Simulation and measured results for dual band antenna*

In addition, the radiation patterns at the two center frequencies are shown in figure (4).

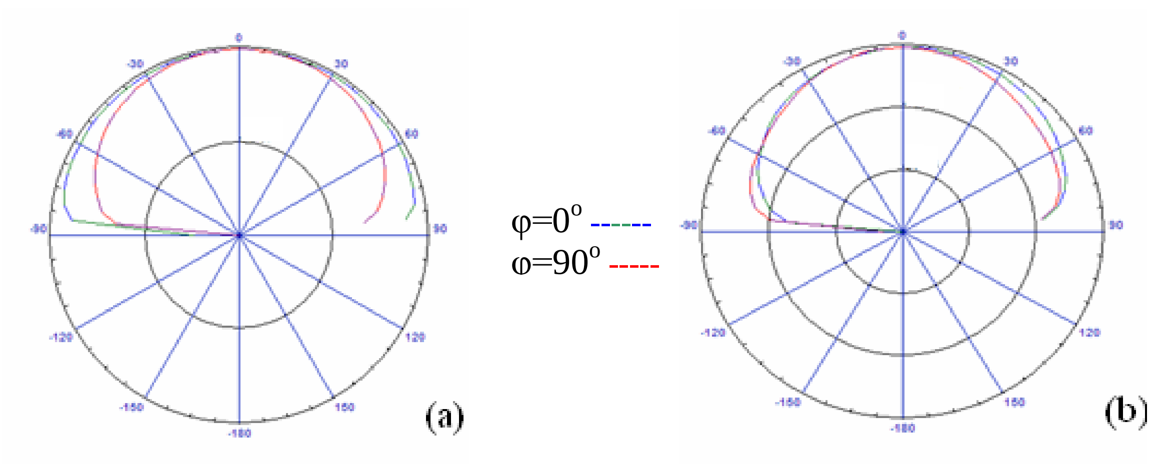


Figure: *(4) Polar pattern at (a) 2.45 GHz, (b) 5.8 GHz*

4. Conclusion:

A new selective dual band microstrip antenna element is presented. The element is simple in form, with coaxial feed probe and a slot to provide good matching for the proposed frequencies, a (-18.5dB, -17dB) return loss at the resonance frequencies with sufficient bandwidth are obtained while no more than (–4dB) is present along the whole frequency band. Good agreement between the analitical and experimental results shows that the fabricated and tested antenna can be used for WLAN systems.

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