Study & Analysis of Multi-Band Microstrip Patch Antenna

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Abstract--- Microstrip patch antennas are increasing in popularity for use in wireless applications due to their low-profile structure, light weight and low cost. However, use of conventional Microstrip antennas is limited because of their poor gain, low bandwidth and polarization purity. There has been a lot of research in the past decade in this area. These techniques include use of Stacked Patch, slots and sorting pins, increasing the thickness of the patch, use of Square, circular and triangular patches with proper slits and antenna arrays. Various feeding techniques are also extensively studied to overcome these limitations. In this paper, study and analysis of Multi band frequency operation in single high performance Microstrip patch antenna using stacked patch configuration is presented.
Keywords: Microstrip Patch antenna, Stacked Patch, dual-polarized, Satellite communication, Mobile communication, Terrestrial communication.

I. INTRODUCTION

Microstrip patch antenna is widely considered to be suitable for many wireless applications, even though it usually has a narrow bandwidth. A system that is capable of exploiting the available wireless functionalities demand an antenna operating in Multi frequency bands. However, the coexistence of more antennas in a limited space generates the mutual coupling and has a negative effect on the performance of the system. A single antenna with multifunction and multiband operation can solve this problem effectively.[1]

Several broadbanding techniques for Microstrip antennas are widely known, prominent among them are the use of stacked patches or use of parasitic patches. The stacked patch antennas have multilayer structure consisting of several parasitic radiating elements placed one above the other.[2]

The presence of a parasitic patch immediately above the driven patch (referred to as a stacked patch) can have two effects depending on the design. One effect is that a second resonance is found in the S11 characteristics resulting from the resonant frequency of the second patch. There is a limit to the frequency difference between the two resonances if the parasitic patch relies on proximity coupling from the driven patch in order for it to be resonant.

The second effect is an increase in the bandwidth of the array. If the resonant frequency of the two patches is only slightly different, the antenna has effectively two overlapping resonances. This will have little change on the radiation pattern but changes the input impedance of the driven element significantly at the resonant frequency of the upper patch. Both techniques will increase the gain slightly due to the addition of a parasitic patch. Fig. 1 shows the structure of a simple stacked patch antenna. Note that the dielectric material lying between the upper and lower patches can be different from that between the lower patch and the ground plane.

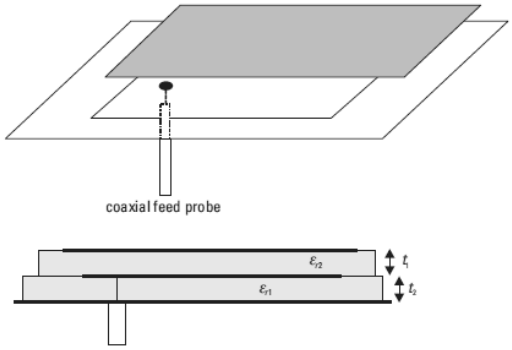

Fig. 1: Stacked Patch Configuration

There are two techniques for feeding a probe-fed stacked patch. One is to have the probe feeding the lower element, in which case the upper patch is generally larger than or the same size as the lower patch. The other involves feeding the upper patch through a cavity in the substrates and an access hole on the lower patch, in which case the upper patch is generally smaller than the lower patch, but may be slightly larger. The upper probe case is generally used for dual-frequency designs, where a large separation between the two frequencies is required. The coupling to the lower patch in this case is from the probe passing through the hole in the substrate and so both patches will be resonant and are not dependant on each other. The lower probe case is generally used for broadband patches. In this case, the coupling to the upper patch is caused by induced currents, and so the coupling is reduced as the difference between the resonant frequencies of the two patches increases.

II. LITERATURE SURVEY

A. Design of Single-Feed Dual-Frequency Patch Antenna for GPS and WLAN Applications [3]

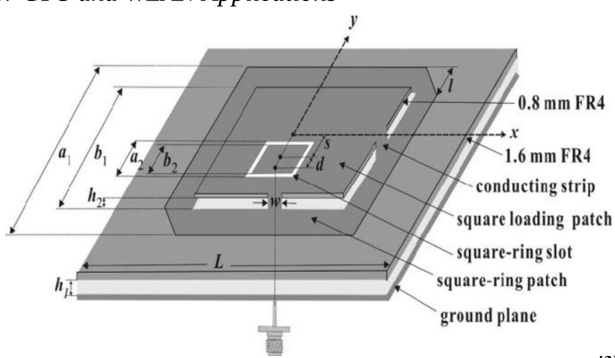

Fig. 2: Geometry of Dual band-frequency patch antenna[3]

In this paper, the antenna consists of two radiating elements which are arranged in a stacked structure(shown in fig. 2). One element is designed for GPS operation and it has Circular Polarization broadside radiation. The other element operates at the WLAN band and its radiation is Linear Polarization conical pattern. Moreover, the two elements can be simultaneously excited by a single feed.

The measured impedance bandwidth of GPS referred to 10 dB return loss, is from 1515 to 1630 MHz. The peak gain is around 7.5 dBic. The impedance bandwidth of WLAN referred to 10 dB return loss, is from 2360 to 2560 MHz include two coupled modes. The antenna can be applied to the wireless products which integrate satellite communication and terrestrial communication, such as GPS and WLAN.

B. Single Feed Stacked Patch Circular Polarized Antenna for Triple Band GPS Receivers [4]

A novel design of a circular polarized Microstrip patch antenna for multiband is presented here. The antenna supports a triple band operation with good performance in GPS including L1 (1.575 GHz), L2 (1.227 GHz) and L5 (1.176 GHz).

The triple band operation has been obtained by using three patches stacked on top of each other as shown in fig.3. Slit cut and I-slot techniques have been implemented to achieve improved operational bandwidth and minimum axial ratio.

A single probe feed of 50 Ω input impedance is connected to the upper patch through via holes in the middle and lower patches while the middle and lower patches are excited through electromagnetic coupling. The via has contributed a capacitive coupling to negate the inductance effect due to the inner conductor of the probe. The use of slit on the edge of the lower patch introduces the dual orthogonal mode necessary for CP radiation pattern. Both the middle and upper patches are perturbed by corner truncation which produces near degenerated resonant mode resulting in circular polarization.

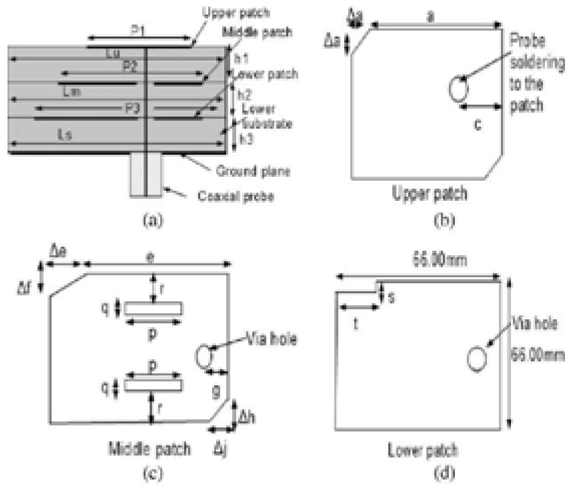

Fig. 3: Geometry of the proposed stacked patch CP antenna showing: (a) side view; (b) upper patch; (c) middle patch; and (d) lower patch. [4]

Moreover, the centres of the three patches are not aligned. It is kept so as to achieve the desired impedance matching in the required frequency bands. The slit in the lower patch and the corner truncation of the middle and upper patches play a key role in achieving an AR below 3 dB. Microstrip CP antennas usually suffer from poor AR because the resonance is degraded when singly fed or dual orthogonally fed with a nonisolated splitter. This problem has been overcome in this proposed antenna design through the use of symmetry I-slot in the middle patch.

The measured value of 10 dB impedance bandwidth for GPS L1, L2, and L5 frequency bands are 1.160–1.182 (2.0%), 1.214–1.232 (1.5%), and 1.568–1.598 GHz (2.0%), respectively. The simulated results appear to be 1.164–1.184 (1.7%), 1.219–1.242 (2.0%), and 1.550–1.590 GHz (2.5%) respectively as shown in fig. 4.

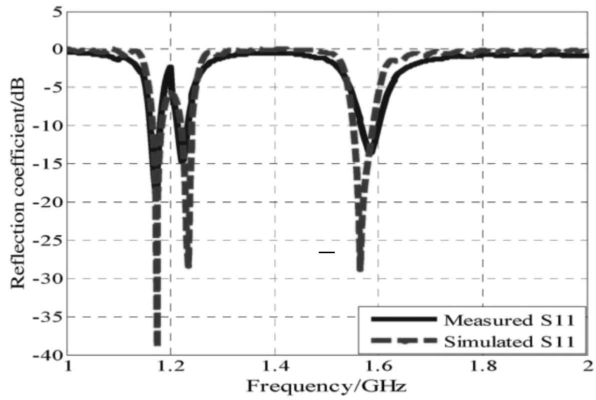

Fig. 4: Measured and simulated reflection coefficients of the proposed antenna.[4]

The simulated axial ratio at broadside direction (shown in Fig. 5) illustrates that the minimum axial ratio coincides with the resonant frequencies in the three bands. The ≤ 3 dB axial ratio bandwidth is 40 MHz (3.40%) in L5 frequency band, 10 MHz (0.81%) in L2 frequency band, and 13 MHz (0.83%) in L1 frequency band.

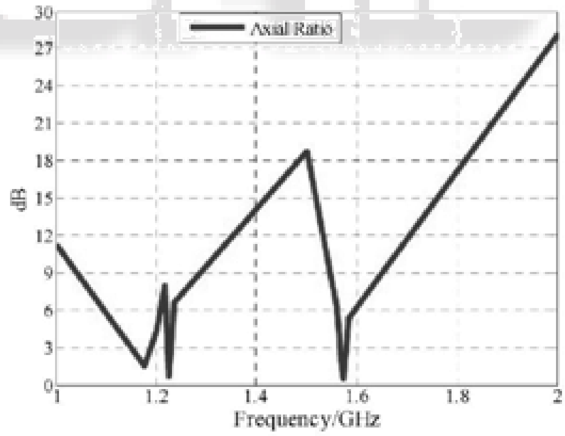

Fig. 5: Simulated axial ratio of the proposed antenna. [4]

Slit cut and I-slot techniques have been implemented to achieve improved operational bandwidth and minimum axial ratio. The broad beamwidth, low cross polarization and high gain of this antenna makes it suitable for the GPS applications.

C. Stacked-Patch Dual Polarized Antenna for Triple-Band Handheld Terminals[5]

In this paper, design of a stacked patch antenna for triple-band dual polarized is proposed.. The antenna supports a triple-band operation with good performance in GPS bands L1 (1.575 GHz) & L2 (1.227 GHz) and GSM Band (1.8 GHz) with frequency bands (shown in fig. 6).

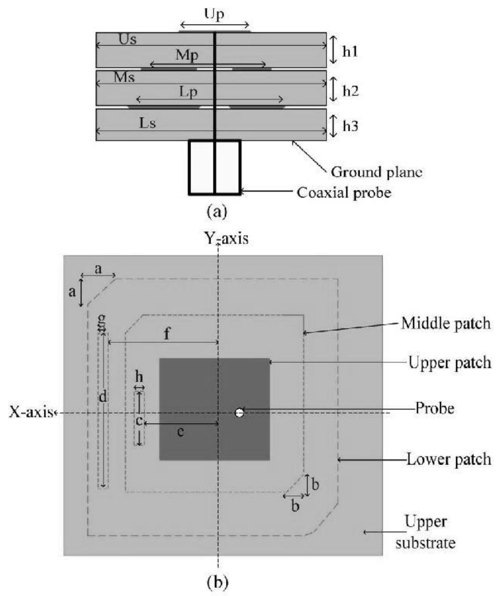

Fig. 6: Geometry of Triple Band-frequency patch antenna [5]

The GPS performance in both L1 and L2 bands has a circular polarization (CP) with a broadside radiation, pattern while a linear polarization (LP) is achieved in GSM 1800 band.

The integration of GPS L1 and L2 bands with terrestrial wireless communication networks such as Global System for Mobile Communications (GSM 1800) can boost the dissemination of data from the information sources and the transaction stations. Prompt evaluation with accuracy in timing and position can be obtained by such terminal users.

This antenna can work effectively in the mobile communication products that integrate satellite and terrestrial communications, such as GPS L1, L2 and GSM. The measured minus 10 dB impedance bandwidth in the GPS L1 and L2 bands are 1.215–1.241 GHz (26 MHz) and 1.560–1.598 GHz (38 MHz) respectively; while the measured minus 6 dB impedance band-width at GSM 1800 band is 1.771–1.846 GHz (75 MHz) as shown in fig. 7(a). The measured and simulated axial ratio of the proposed antenna is presented in Fig. 7(b). The $\leq$ 3 dB axial ratio bandwidth at GPS L1 and L2 frequency band is 1.6% (1.220–1.240 GHz) and 0.8% (1568–1.580 GHz) respectively.

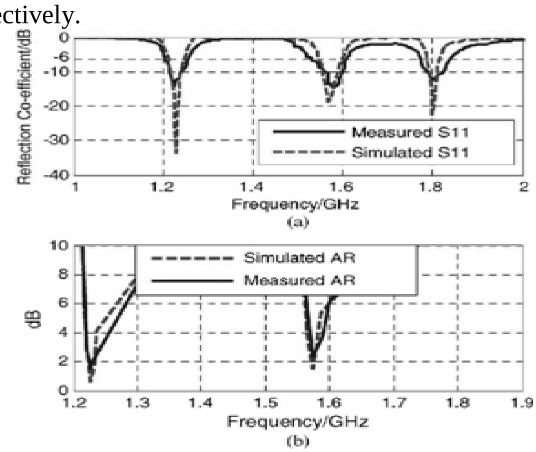

Fig. 7: Measured and simulated reflection coefficient and axial ratio of the pro-posed antenna: (a) measured and simulated reflection coefficient and (b) measured and simulated axial ratio.[5]

Good circular polarization with a broadside radiation Pattern is achieved at the lower and middle bands, respectively, while a better linear polarized conical radiation pattern with low cross polarization is achieved at the upper operating frequency. The antenna can easily meet the required CP bandwidth of 2 MHz for the GPS L1 and L2 bands, while it provides a 6-dB impedance bandwidth of 75 MHz for the GSM 1800 band. Therefore, this antenna can work effectively in the mobile communication products that integrate satellite and terrestrial communications, such as GPS L1, L2 and GSM.

III. CONCLUSIONS

From this literature review we reach out to the conclusion that stacked patch configuration effectively used in Multi-Band antenna and overcome the effect of narrow bandwidth and provide high performance. So from this we have proposed antenna that will support a triple band operation that will operate in GPS L1 band, GSM band and WLAN frequency bands. And we will also try to maintain high performance like high gain, broad bandwidth, improved beamwidth and Low cross polarization making it suitable for GPS, GSM and WLAN Applications.

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