Broadband Aperture Coupled Stacked Microstrip Antenna for Mobile Communications

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ABSTRACT

This paper presents a broadband aperture fed stacked patch antenna. The notable features of this feed configuration are wider bandwidth and the shielding of the radiation patch from the feed structure. Aperture-coupled microstrip feed uses two substrates separated by a common ground plane. The slot can be of any shape and size and these parameters are used to improve the bandwidth. The radiation of the open end of the feed line does not interfere with the radiation pattern of the patch because of the shielding effect of the ground plane. This also improves the polarization purity. A very significant bandwidth enhancement achieved (73%) by adding a reflector at the bottom of the aperture coupled stacked microstrip antenna. and by optimizing the antenna's dimensions, substrate materials and thickness, aperture dimensions and by positioning an aluminum foil at a particular angle as a reflector to stop the back radiation. The measured ultra-bandwidth found to be 73% at VSWR = 2.0 at 850 MHz. This antenna can find useful application in in-building mobile network coverage for CDMA and GSM frequencies.

Key Words: Microstrip antenna, Bandwidth, impedance, radiation pattern, matching, return loss

1. INTRODUCTION

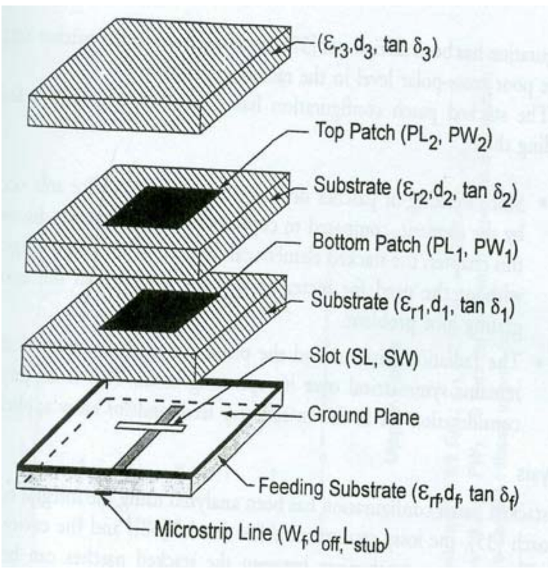
Microstrip antennas have several advantages compared to conventional microwave antennas. Some of the prime advantages are: light weight; low volume; thin profile, which can be made conformal; low fabrication cost; readily amenable to mass production; easily integrated with microwave integrated circuits etc. Microstrip antennas also have some limitations such as: narrow bandwidth; lower gain; lower power handling capability; excitation of surface waves; radiation from feeds and junctions etc.

Significant research has been pursued during the last two decades to increase the bandwidth [2-10] of the microstrip antennas. Design of wideband and dualband notched microstrip antennas were studied by Palit et al [2]. It is found that a properly designed notched patch can exhibit wideband and dualband operations. The two resonant frequencies are probably the results of the coupling between the main patch and the notch resonant frequencies. The maximum impedance bandwidths of 38% for band 1 and 27% for band 2 were achieved for coax-fed single notched patch. Palit et al [6] described a composite patch antenna to enhance bandwidth by adding a patch on top of the primary patch and another patch as a director in the right radiating side of the top one. It is found that the bandwidth is very sensitive to the gap between the main patch and the parasitic patch. The feed location is very important for good matching, which increases the bandwidth.

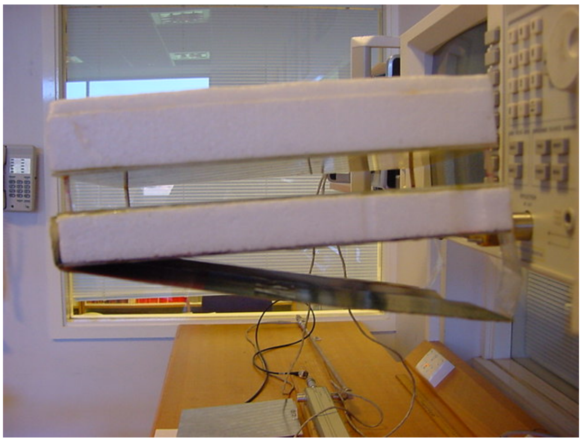
This paper presents a broadband aperture fed stacked patch antenna. The notable features of this feed configuration [1] are wider bandwidth and the shielding of the radiation patch from the feed structure. Aperture-coupled microstrip feed uses two substrates separated by a common ground plane. The slot can be of any shape and size and these parameters are used to improve the bandwidth. The radiation of the open end of the feed line does not interfere with the radiation pattern of the patch because of the shielding effect of the ground plane. This also improves the polarization purity. This paper shows a very significant bandwidth enhancement achieved (73%) by adding a reflector at the bottom of the aperture coupled stacked microstrip antenna.

2. APERTURE FED STACKED PATCH ANTENNA

Fig. 1 shows the schematic diagram of the designed aperture fed stacked patch antenna. The size of the lower patch is slightly different from that of the upper patch to obtain a slightly different resonant frequency. Various parameters such as substrate thick nesses d_1 and d_2, dielectric constants ε_{r1} and ε_{r2}, patch sizes and feed location were adjusted to optimize the bandwidth. The stacked patch configuration has been designed and analyzed using Ensemble- a software package based on method of moment and the lossy transmission line model. Fig. 1 shows our designed antenna having two resonant patches that are different in size, with the lower patch fed by a microstrip line through a resonant slot in the common ground plane. The basic feature of this structure is that each of the three resonators (two patches and the slot) has its own impedance loop. There is also mutual coupling among these resonances. The resonator parameters are adjusted to bring the impedance loops closer to each other. The substrate thickness and the dielectric constant between the resonators are also varied to adjust the mutual coupling between them resulting in a wider bandwidth.



(a) An exploded view [9]



(b) Designed antenna structure with measurement set up

Fig. 1 Aperture coupled stacked Microstrip antenna

3. ANTENNA PERFORMANCE

The dimensions of the patches and the slots were optimized. Figs. 2-5 show the changes in input impedance as functions of antenna parameters. It is found that change of the lower patch size is very critical which contributes to both mutual resonances with the aperture below and the upper patch and therefore affects the size of both the loops as found in the figs. 2-5.

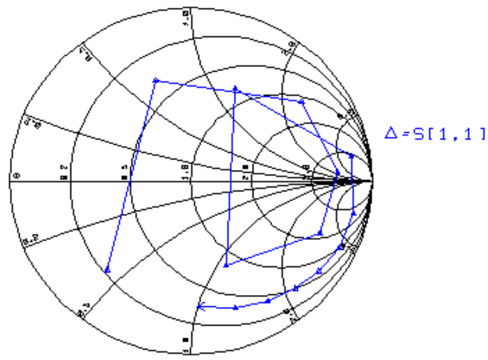


Fig 2: SL = 118.5 mm, SW = 5.0 mm, L_{stub} = 20.0 mm, ε_{rf} = 4.4, d_f = 1.6 mm, ε_{r1} = 2.54, d_1 = 40.0 mm, ε_{r2} = 1.0, d_2 = 30.0 mm, ε_{r3} = 2.54, d_3 = 30.0 mm PL_1 = 88.6 mm, PW_1 = 88.6 mm, PL_2 = 167.6 mm, and PW_2 = 167.6 mm.

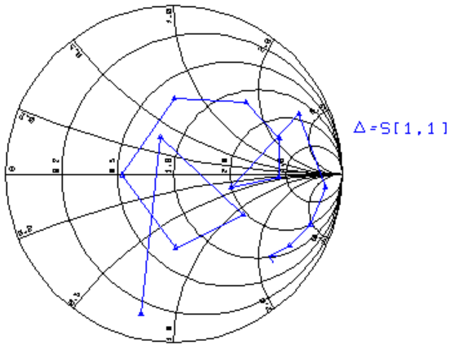


Fig 3: SL = 98.6 mm, SW = 5.0 mm,
L_{stub} = 20.0 mm, ε_{rf} = 4.4, d_f = 1.6 mm,
ε_{r1} = 2.54, d_1 = 10.0 mm, ε_{r2} = 1.0,
d_2 = 5.0 mm, ε_{r3} = 2.54, d_3 = 30.0 mm
PL_1 = 97.6 mm, PW_1 = 118.6 mm,
PL_2 = 97.6 mm, and PW_2 = 117.6 mm.

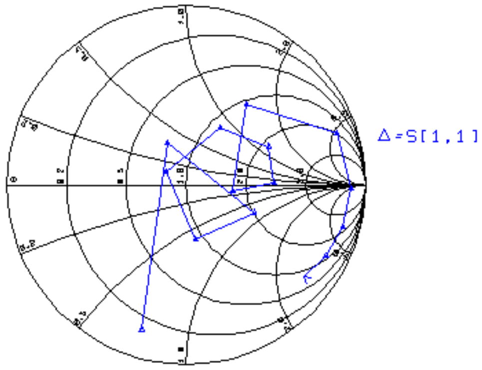


Fig 4: SL = 98.6 mm, SW = 5.0 mm,
L_{stub} = 20.0 mm, ε_{rf} = 4.4, d_f = 1.6 mm,
ε_{r1} = 2.54, d_1 = 20.0 mm, ε_{r2} = 1.0,
d_2 = 10.0 mm, ε_{r3} = 2.54, d_3 = 30.0 mm
PL_1 = 97.6 mm, PW_1 = 108.6 mm,
PL_2 = 97.6 mm, and PW_2 = 132.6 mm.

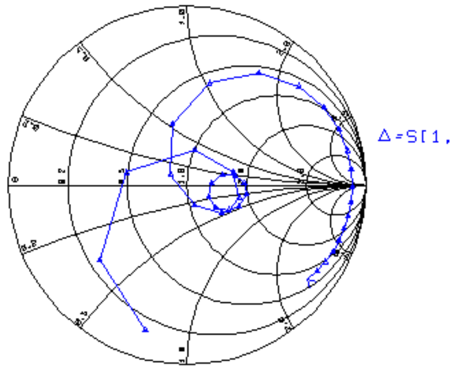


Fig 5: SL = 98.6 mm, SW = 5.0 mm,
L_{stub} = 20.0 mm, ε_{rf} = 4.4, d_f = 1.6 mm,
ε_{r1} = 2.54, d_1 = 20.0 mm, ε_{r2} = 1.0,
d_2 = 10.0 mm, ε_{r3} = 2.54, d_3 = 30.0 mm
PL_1 = 97.6 mm, PW_1 = 108.6 mm,
PL_2 = 97.6 mm, and PW_2 = 132.6 mm.

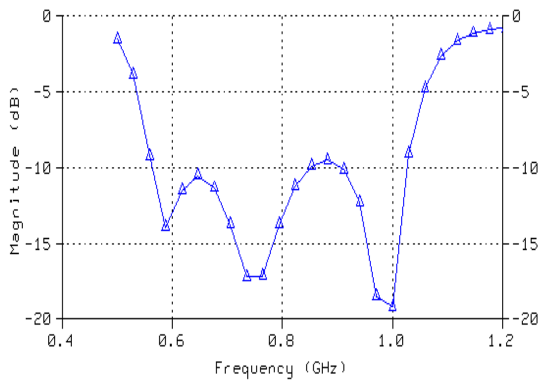


Fig. 6 Return loss as a function of frequency

Fig. 5 represents a proper balance between the two mutual resonances and therefore yields maximum bandwidth with respect to patch size and aperture size. Fig. 6 shows a theoretical return loss as a function of frequency. Maximum theoretical bandwidth at VSWR= 2 is found to be 59% at 800 MHz. Fig. 7 shows measured VSWR vs. frequency for the designed stacked microstrip antenna with an aluminum foil as the reflector at the bottom of the antenna to stop the back radiation. The optimum measured bandwidth of 73% at VSWR = 2.0 has been achieved with the reflector positioned at an angle of 14^{o} to the horizontal plane of the antenna which is considered to be a breakthrough in enhancing the bandwidth of a microstrip antenna.

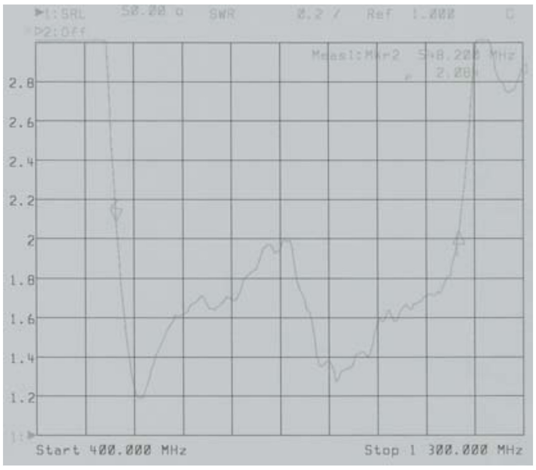


Fig. 7 Measured VSWR as a function of frequency

4. CONCLUSION

The analysis and design of an aperture coupled stacked microstrip antenna has been made and reported in this paper. A significant breakthrough in bandwidth enhancement has been achieved by optimizing the antenna's dimensions, substrate materials and thickness, aperture dimensions and by positioning an aluminum foil at a particular angle as a reflector to stop the back radiation. The measured ultra-bandwidth found to be 73% at VSWR = 2.0 at 850 MHz. This antenna can find useful application in in-building mobile network coverage for CDMA and GSM frequencies.

5. REFERENCES

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