Bandwidth Enhancement of Pin Shorted Triangular Patch Antenna with Circular Notch

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ABSTRACT
This paper presents the notch loading effect on the pin shorted equilateral triangular shaped microstrip antenna (ETMSA). The proposed antenna shows the dual band behavior due to pin shorting and also the effect of circular notch for bandwidth enhancement, with dual shorting pin. The proposed antenna providing enhanced impedance bandwidth of 13.42%.Also effect of different dielectric on the bandwidth performance has been studied. All the results have been carried out using MOM based IE3D simulation.

Keywords
ETMSA, shorting pin, dual band, circular notch.

1. INTRODUCTION
In modern wireless communication technology, the demand of compact low profile antenna is increasing significantly. To meet this requirement microstrip antenna has been proposed [1].However conventional microstrip antenna suffers from narrow bandwidth problem [2]. Several well-known methods used for improvement of bandwidth such as, use of thick substrate, different type of slotting like square-ring slot [3], U-type slot [4] etc. The stub loading is also effective bandwidth enhancement technique [5]. Various types of defective ground structuresare also used for bandwidth enhancement of MSA [6].The broad bandwidth can be achieved by using multiple stacked radiation patches with different length [7]. The main aim of this paper is to present the bandwidth enhancement of compact ETMSA using two shorting pin loading with a circular notch.

2. ANTENNA DESIGN AND SIMULATED RESULS
Basic parameters of ETMSA are ε_r=3.2; h=1.6 mm,tanδ =0.001 and length of each arm of ETMSA =20 mm is taken. The co-axial feed is at (0,0),Which shows the resonant frequency of 5.249GHz as shown in fig.1a and fig.1b.The percentage bandwidth is equal to 1% for -10dB return loss. The corresponding directive gain is shown infig.1c. The gain value is 6.806dbi (approx.).Simulation has been done by the method of moment based IE3D EM Design System (V: 14) simulator [8].

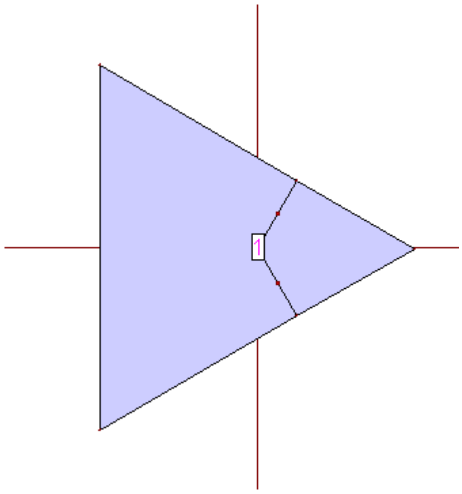

Figure 1a: IE3D Simulated View patch without pin shorting.

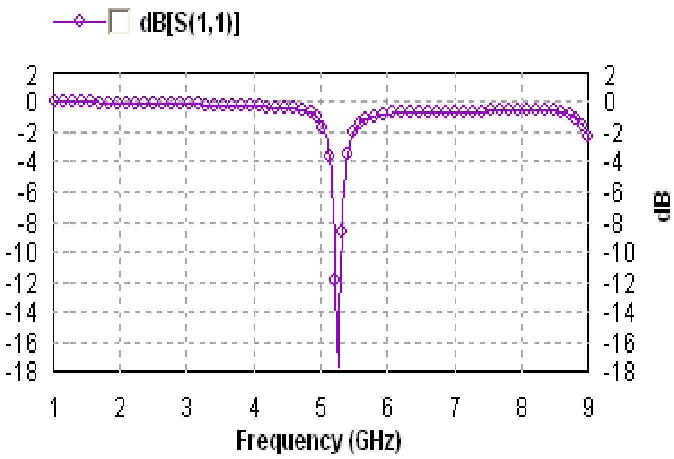

Figure 1b: Return Loss Performance.

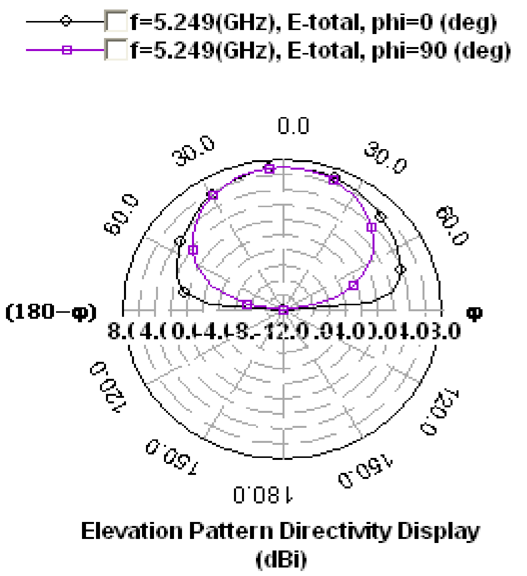

Figure 1c: Radiation pattern at f=5.249 GHz

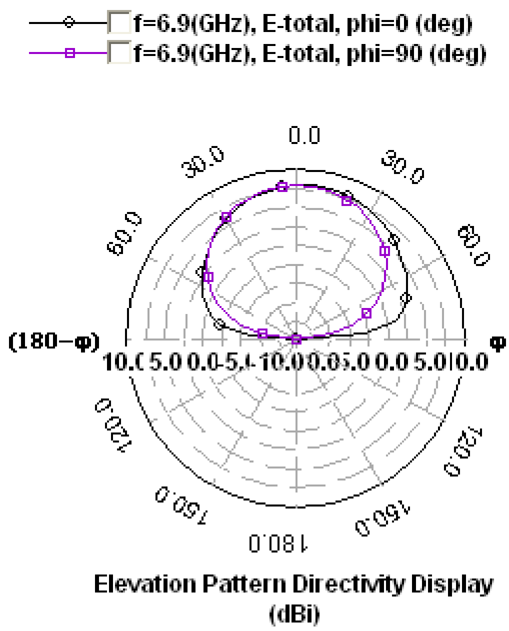

Figure 2c: Radiation pattern at f=6.9 GHz

2.1 EFFECT OF SINGLE PIN SHORTING

When Pin(P1) is shorted between vertex and co-axial feed point as shown in fig.2a.the resonant frequency shifted from 5.249GHz to 6.9GHz as shown in fig.2b.In proposed antenna the position of P1 from vertex is 1.65mm.The corresponding directive gain is 7.824dbi as shown in fig.2cAlso, the impedance bandwidth becomes higher (7.2%), as shown in table (1).

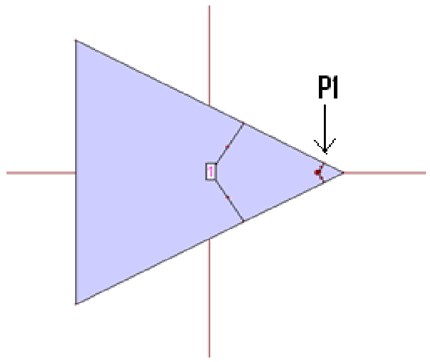

Figure 2a: Effect of single Pin shorting.

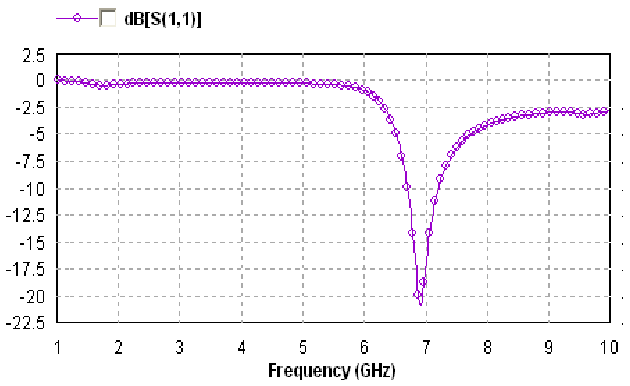

Figure 2b: Return Loss Performance for single pin shorting.

Table: 1

Pin effect	fc (GHz)	Return loss (dB)	% B.W. (GHz)
Without Pin	5.25	-16.17	1
With single Pin P1	6.9	-20.67	7.2

2.2 EFFECT OF TWO PIN SHORTING

Shorting an additional Pin (P2) nearer to any of the other vertex (other than P1) results in dual band effect as shown in fig.3a. The two resonant frequencies are 6.03GHz and 7.238GHz as shown in fig.3b.The dual band effect can be produced either by LHCP (left hand circular polarization) or RHCP (right hand circular polarization).Both structure produced almost same return loss performance. The corresponding directive gain for both the resonant frequencies is shown in fig.3c and fig.3d.and comparison is done in table (2).Therefore it can be concluded that dual band can be achieved by using dual pin shorting near the vertices. Where one pin must be shorted on the same axis as of the axis of feed point.

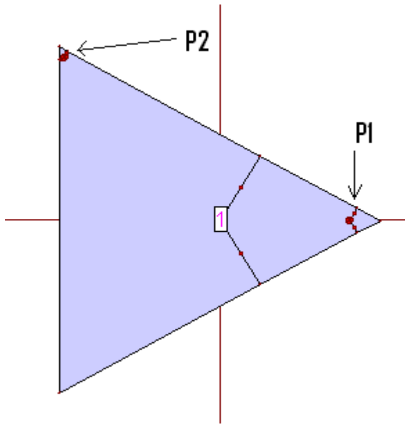

Figure 3a: Effect of dual Pin shorting.

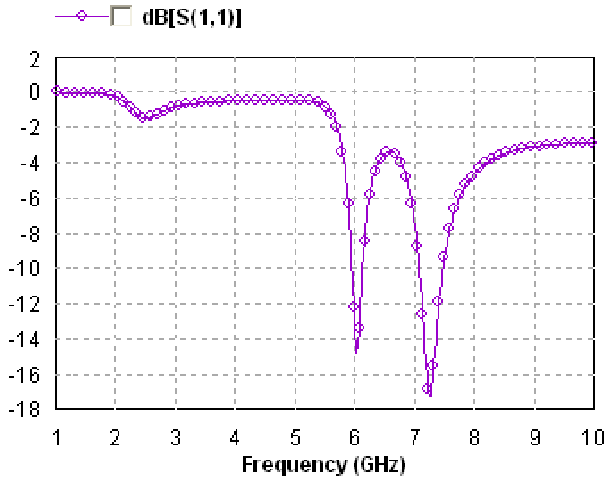

Figure 3b: Return Loss Performance for two pin shorting.

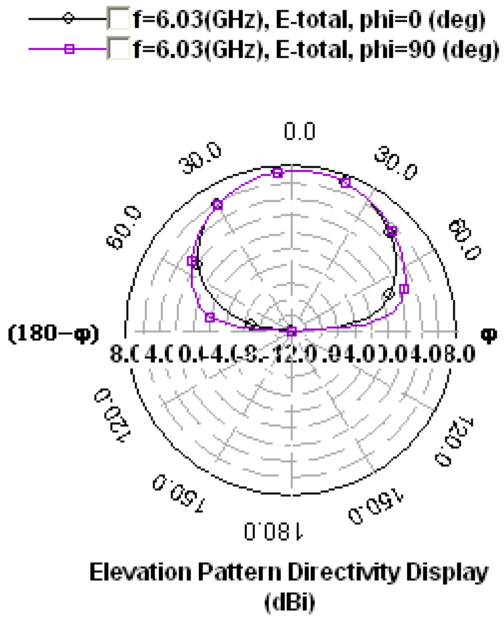

Figure3.c: Radiation pattern at f_1=6.03 GHz. (For two pin shorting).

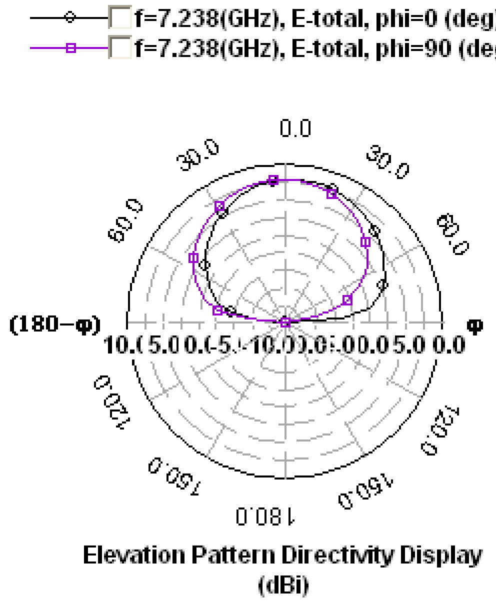

Figure3.d: Radiation pattern at f_2=7.238 GHz. (For two pin shorting).

Table: 2

Circular polarization	f_1(GHz)	% B.W(GHz)	f_2(GHz)	% B.W.(GHz)
LHCP	6.03	2.8	7.238	5.3
RHCP	5.98	2.85	7.2	5.32

2.3 EFFECT OF TWO PIN SHORTING WITH A CIRCULAR NOTCH

A circular notch is inserted in between two pin shorted vertices. The proposed length of circular notch (L) is given as (λ/4) < L< (λ /2). So for the proposed antenna, L=13.23 mm is taken as shown in fig.4a.With circular notch loading, the enhanced bandwidth of 13.42% with Centre frequency (f_c) of 6.98GHz is produced, as shown in fig.4b and table (3).The primary resonant frequency (f_1) is 6.631GHz and the secondary resonant frequency (f_2) is 7.1398GHz.The corresponding directive gain is shown in fig.4c, 4d and 4e.No bandwidth enhancement is observed when the values of "L" lie outside the above defined boundary.

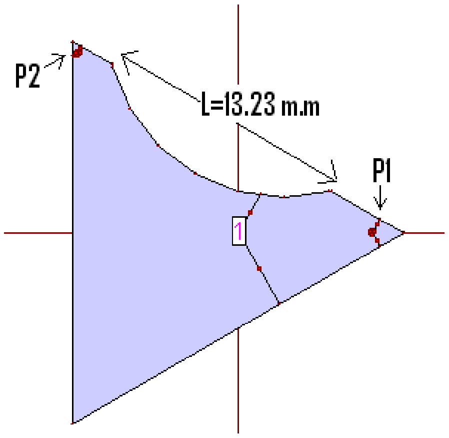

Figure 4a: Effect of two Pin shorting with a circular notch.

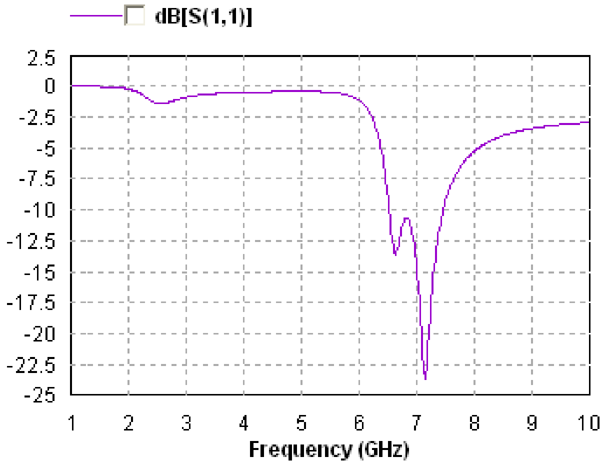

Figure 4b: Return Loss Performance for two pin shorting with a circular notch.

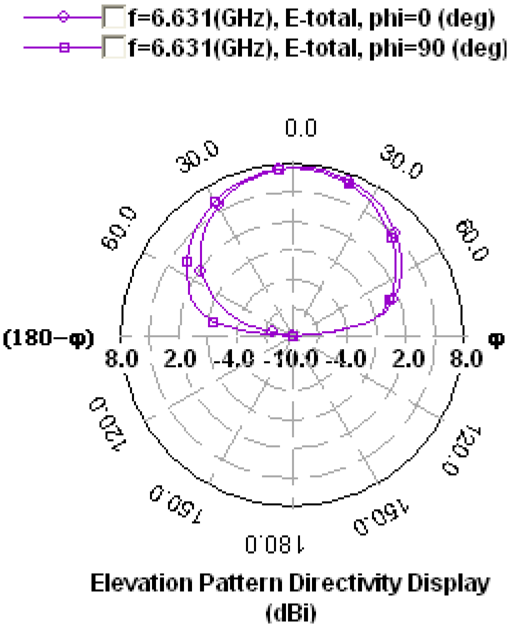

Figure4.c: Radiation pattern at f_1=6.631 GHz. (For two pin shorting with a circular notch).

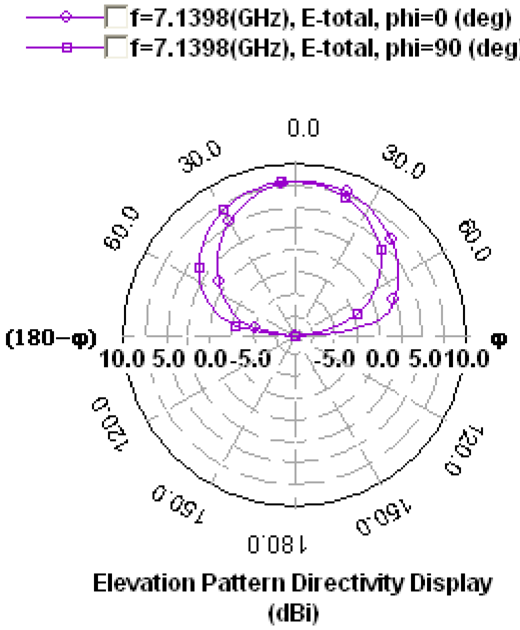

Figure4.d: Radiation pattern at f_2=7.1398 GHz. (For two pin shorting with a circular notch).

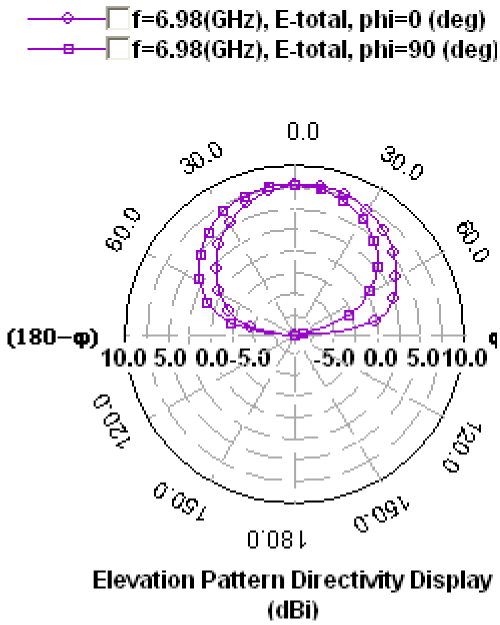

Figure4.e: Radiation pattern at f_c=6.98 GHz. (For two pin shorting with a circular notch).

Table: 3

f_1(GHz)	f_2(GHz)	fc(GHz)	% B.W.(GHz)	Return loss for f_1 (dB)	Return loss for f2 (dB)
6.631	7.1398	6.98	13.42	-13.8	-22.94

3. THE EFFECT OF DIFFERENT DIELECTRICS ON THE BANDWIDTH PERFORMANCE

The proposed structure is tested on different available dielectric material. The percentage bandwidth degraded sharply for higher value of dielectric constant(ε_r) as thichness(h) is increased as shown in fig.5a.It is also observed that for ε_r=3.2,the %B.W. is almost contant w.r.t thickness.Therefore in the proposed antenna the dielectric constant of substrate is taken as ε_r=3.2.

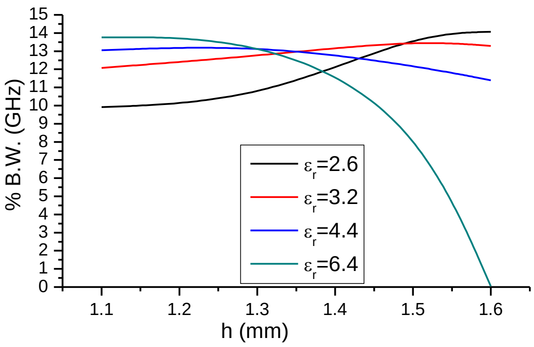

Figure5.a:%B.W vs. thickness plot for different value of dielectric constant.

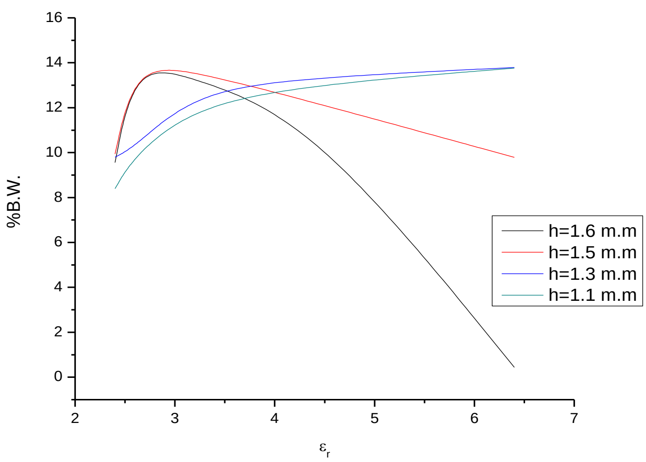

Figure5.b:%B.W vs. relative permittivity plot for different value of substrate thickness.

4. DIRECTIVITY

For the proposed antenna the sufficient directivity (in dBi) can be achieved in between the utilized bandwidth from 6GHz to 8.5GHz with maximum directivity of 7.85dBi at 7.4GHz as shown in fig.6.

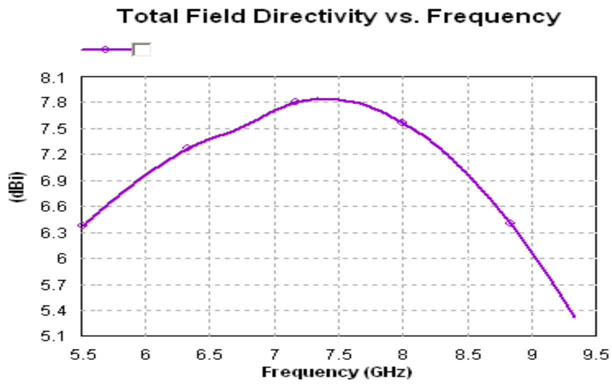

Figure6: Directivity vs. frequency plot for two pin shorted antenna with circular notch.

5. CONCLUSION

The simulation carried out on the new proposed antenna. The two pin shorting effect produces dual band and the notch loading along with the two shorting pins results in enhanced bandwidth performance. Bandwidth performance of this antenna is also examined for various antenna parameters such as substrate thickness and substrate permittivity. It is concluded that for higher value of permittivity the percentage bandwidth significantly decreases with increasing thickness.

6. REFERENCES

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