Design and Simulations of 2D Planar Antenna for Dielectric Characterization of Biological Samples

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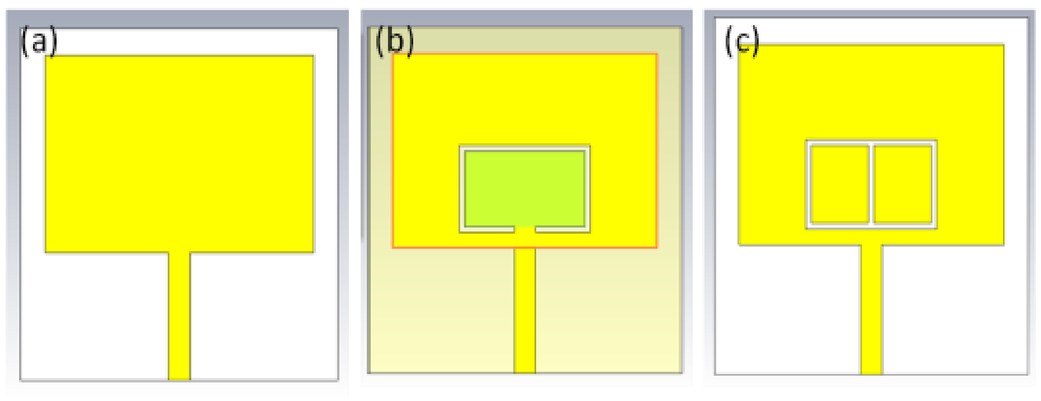
Introduction

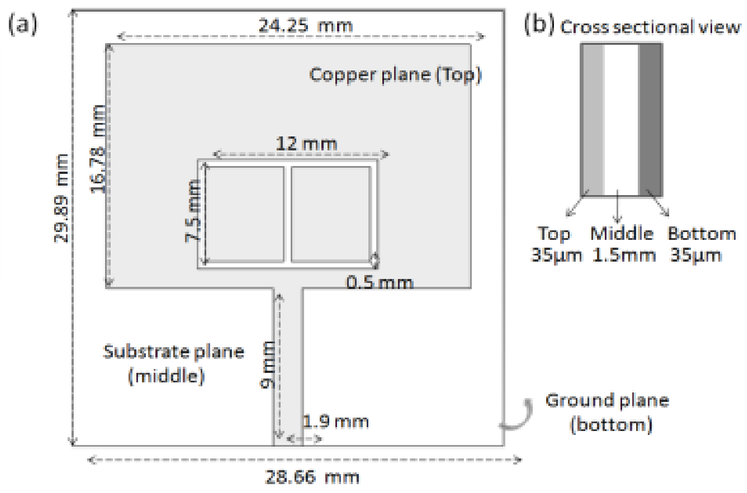
- Patch of the metal aligned above the ground plane
- Dielectric-based biosensor (resonates depending upon the physical properties of the biological tissues)
- Applications: Hyperthermia treatment, tumor detection, tissue characterization, and imaging [1-4]

Design parameters for patch antenna

Introducing the additional capacitance by cutting a small area surrounding the perimeter of a rectangle. This rectangle is then further divided in two small patches separated by a small gap.

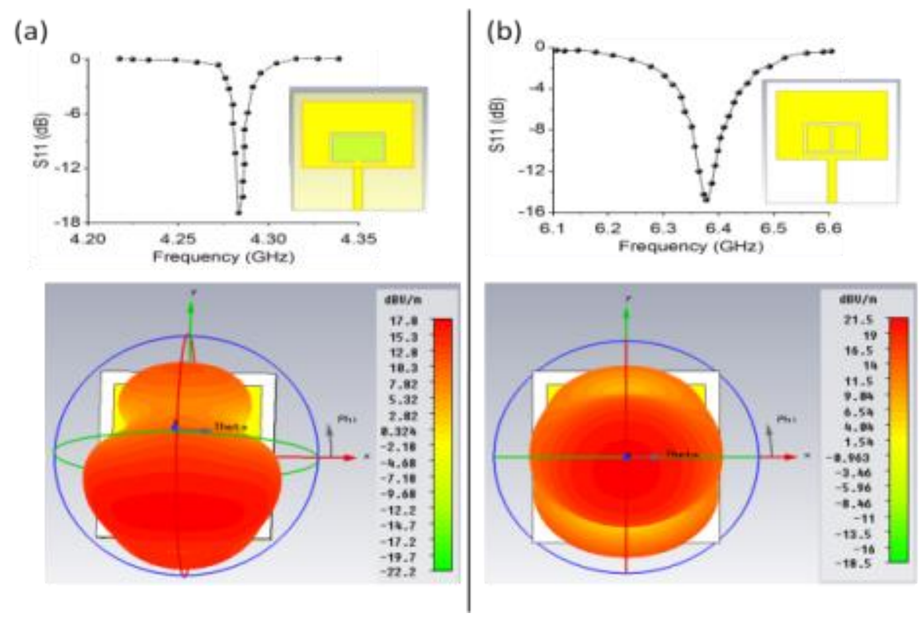


CST simulation of patch antenna (a) big patch (b) Introducing small patch inside big patch (c) Further introducing the cut for extra capacitance effect



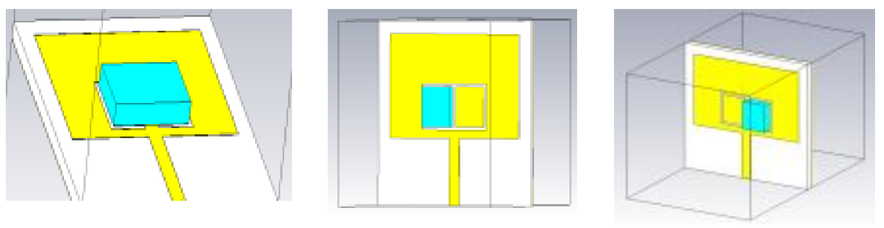
Design of patch antenna (a) Top view (b) Cross sectional view

Results and Discussions

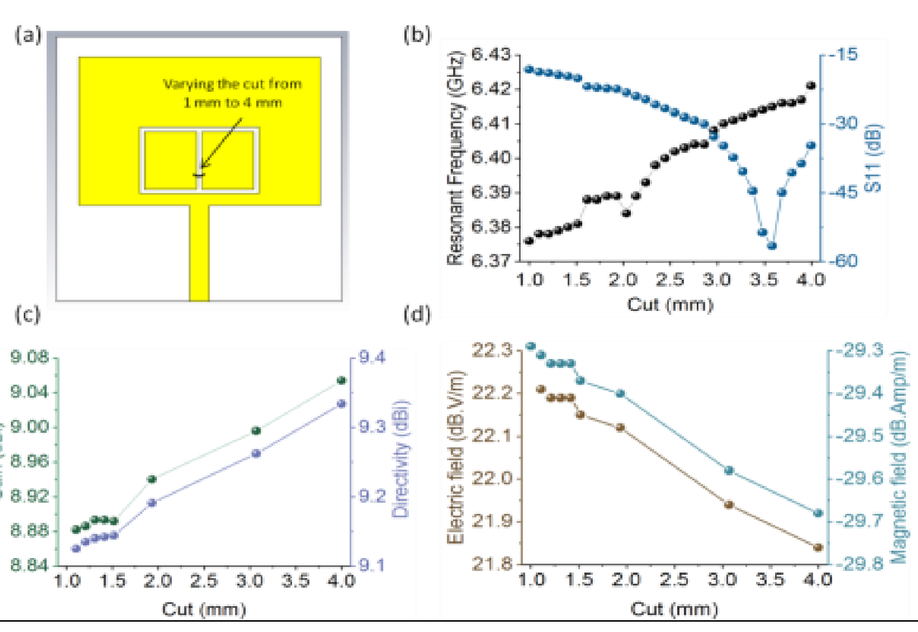


The radiation field of patch antennas can be increased by introducing extra capacitance in the patch.

Resonant Frequency (R.F.), Return Loss (R.L.) and Frequency Shift (F.S.) by loading samples.



				Single Patch			Dual Patch					
				Sample Loading			Left Side loading			Right Side Loading		
No	Samples	εr	σ	R.F.	R.L.	F.S	R.F.	R.L.	F.S	R.F.	R.L.	F.S.
1	Empty	-	-	4.283	-17.145	0	6.376	-14.856	0	6.376	-14.856	0
2	Skin tissue	35	3.9	4.238	-8.860	44.3	6.321	-10.082	55	6.321	-10.085	55
3	Water	78	10^{-6}	4.225	-10.892	57.6	6.290	-12.473	86	6.290	-12.455	86
4	Tooth	9	1.2	4.246	-24.325	36.3	6.329	-13.740	47	6.329	-13.740	47
5	Tongue tissue	47	5.5	4.235	-14.681	48	6.311	-11.231	65	6.311	-11.230	65
6	Bile tissue	63	7.5	4.231	-10.733	52	6.304	-9.857	72	6.304	-9.857	72
7	Blood tissue	52	6.8	4.236	-11.128	46.4	6.310	-10.826	66	6.309	-10.836	67
8	Brain tissue	39	5.2	4.236	-11.128	46.4	6.314	-11.452	62	6.314	-11.452	62
9	Fat tissue	10	8.7	4.246	-27.325	36.4	6.320	-10.393	56	6.320	-10.385	56
10	Lung tissue	18	2.2	4.243	-23.588	40	6.323	-12.199	53	6.323	-12.200	53
11	Reproductive tissue	38	4.5	4.236	-19.820	46.4	6.314	-11.626	62	6.314	-11.626	62



- Tooth and Fat have the difference of 1 unit of dielectric constant, the frequency shift measured in D3 was 9 MHz as compared to D2 which showed a shift of only 0.1 MHz frequency.
- Frequency and S11 shift of left and right sections were nearly same.
- Cut enhances the sensitivity of patch towards dielectric properties of biological samples, which makes it an apt design for biological sample characterization.

Outcomes* : *Even loading the sample separately on the two sections, the frequency shift and return loss appear symmetric, the proposed antennae can be used as an alternative to the bulky cavity perturbation technique in which device handling and the sample position are some limitations. Furthermore, validation of the results with fabricated antenna will play crucial role in bio-sensing.

References:

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