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SCRUTINY OF LOSS TANGENT CONSEQUENCE ON PATCH RADIO WIRE PIECE

Vemulapalli Venkataramana*, VaddeArunaRai
Department of Computer Engineering, Eritrea Institute of Technology, Mai nefhi, Asmara, Eritrea
Department of Electronics and Communication Engineering, Eritrea Institute of Technology, Mai nefhi, Asmara, Eritrea

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ABSTRACT
The determination of legitimate substrate material is prime vital errand in smaller scale strip patch radio wire plan. Since the restrictions of miniaturized scale strip radio wire, for example, low increase, low effectiveness and exceptional yield misfortune can overcome by selecting legitimate substrate materials, since permittivity of substrate is basic parameter in controlling band width, proficiency, and radiation example of patch receiving wire. However, the substrate materials have two fundamental properties, for example, dielectric consistent and misfortune digression. Present paper thorough investigation of different dielectric materials of same permittivity at various misfortune digressions and its impact on radiation attributes of rectangular patch reception apparatus are examined. Results, for example, reverberation recurrence, transmission capacity, pick up, return misfortune, information and impedance are exhibited.

KEYWORD: dielectric constant, patch, loss tangent.

INTRODUCTION
Generally a dielectric substrate is defined by its two prime parameters one is its permittivity (It describes the materials with high polarizability) and another is loss tangent (It explains the dissipation of electromagnetic energy), $^{\varepsilon}=\varepsilon_r\varepsilon_0(1\text{-JTan}\delta)$. Loss tangent includes dielectric damping loss and conductivity loss of material and it is a frequency dependant. For a material with conductor loss and dielectric damping loss can be given as [1]

$$\begin{aligned}\nabla \times \overline{H} &= j\omega\overline{D} + \overline{J}_c \\ &= j\omega\epsilon\overline{E} + \sigma\overline{E} \\ &= j\omega\epsilon'\overline{E} + (\omega\epsilon'' + \sigma)\overline{E} \\ &= j\omega(\epsilon' - j\epsilon'' - j\frac{\sigma}{\omega})\overline{E} \\ &= j\omega[\epsilon' - j(\epsilon'' + \frac{\sigma}{\omega})]\overline{E}\end{aligned}$$

The imaginary part of above equation explains loss of material. Including dielectric damping loss (ϵ''), and the conductive loss (σ/ω).[2].

$$\begin{aligned}\nabla \times \overline{H} &= j\omega[\epsilon' - j(\epsilon'' + \frac{\sigma}{\omega})]\overline{E} \\ &= j[\omega\epsilon' - j(\omega\epsilon'' + \sigma]\overline{E}\end{aligned}$$

In microwave engineering the materials are defined with complex permittivity

$$\begin{aligned} \epsilon &= \epsilon' - j(\epsilon'' + \frac{\sigma}{\omega}) \\ &= \epsilon'[1 - j(\frac{\omega\epsilon'' + \sigma}{\omega\epsilon'})] \\ &= \epsilon'[1 - j\tan\delta] \end{aligned}$$

for loss less materials there is no loss tangent (Tanδ=0) then the permittivity is real ($\varepsilon=\varepsilon_r\varepsilon_0$)[3]. The structure of rectangular micro strip antenna in its simplest form consisting of sandwich of two conducting layers separated by single thin dielectric substrate is considered, where lower conductor function as ground plane and upper conductor function as radiator. Larger ground plane gives better performance but makes the antenna size bigger[4]. This structure is excited with coaxial feed. At resonate frequency of 1.7616GHz. Present paper different dielectric materials of same permittivity with different loss tangent were considered. Height of substrate 1.56mm taken common for all simulations [5].

MICROSTRIP PATCH ANTENNA DESIGN

The structure of rectangular patch antenna consists of dielectric substrate backed with optically plannar reflecting metal ground plane, on other side consists of radiating element.

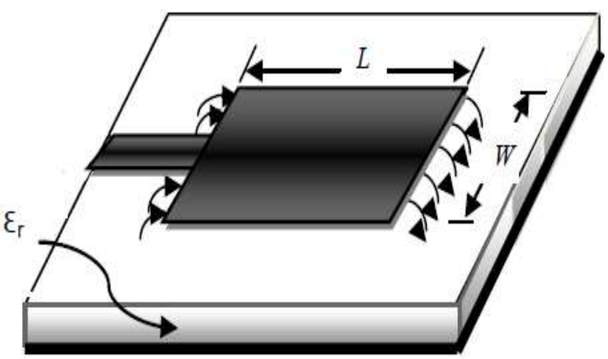

Fig1 :Rectangular Patch Antenna

The length of patch (L) is about $\lambda_g/2$ (λ_g is effective wave length) and substrate height(h) is of order of $\lambda_g/20$[6].Due to very small space between radiating element and ground plane main power is radiated towards broad side. The fringing fields effectively increase the length (ΔL) of patch need to be accounted in determine resonance frequency [7].

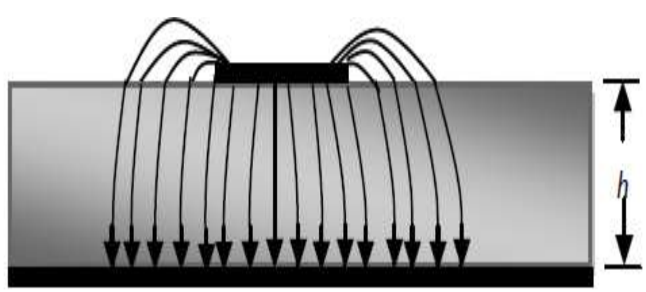

Fig2 : Electrical Field Lines(Side View)

The most commonly used design equations of antenna

a) Effective dielectric constant

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$$\varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[1 + 12\frac{h}{W}\right]^{\frac{1}{2}}$$

b) Length extension is

$$\Delta L = 0.412h\frac{(\varepsilon_{reff} + 0.3)\left(\frac{W}{h} + 0.264\right)}{(\varepsilon_{reff} - 0.258)\left(\frac{W}{h} + 0.8\right)}$$

c) Effective Length

$$L_{eff} = \frac{c}{2f_o\sqrt{\varepsilon_{reff}}}$$

d) Actual length of patch

$$L = L_{eff} - 2\Delta L$$

e) Patch width

$$W = \frac{c}{2f_o\sqrt{\frac{(\varepsilon_r + 1)}{2}}}$$

f) Ground plane dimensions

$$L_g = 6h + L$$

$$W_g = 6h + W$$

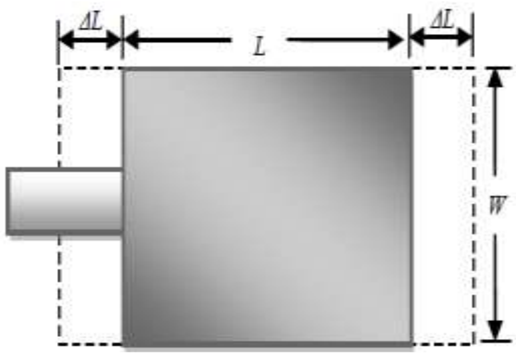

Fig3 : Physical & Effective Lengths of Patch

Co-Axial Probe Feed

This is a common feed technique here outer conductor is connected to ground plane and the inner conductor of co-axial connector is extends through dielectric and soldered to patch. Inner conductor of co-axial cable transfers the power from strip line to microstrip antenna from slot in the ground plane. Placing of feed position is important in order to have best matching with input impedance. Here a fee is applied at (0mm, 9.2mm). It provides narrow bandwidth performance and it is difficult to design for thick substrate. [8]

Dielectric Materials: Present paper I have considered different dielectric materials with same permittivity and different loss tangent are listed below.

Dielectric Loss Tangent:

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Table I

Material Name	Permittivity	Loss Tangent
Rubber_hard	3	0
Roger RO3003	3	0.0013
Arlon AD300A	3	0.002
Neltec NH 9300	3	0.0023
Rogers Ultralam 1300	3	0.003

Numerical Design:

The proposed co-axial feed rectangular micro strip patch antenna operating at 1.7616GHz having physical dimensions of radiating patch length L=47.4mm along Y-axis, width W=56.5mm along X-axis (here width of patch is maintained higher than length because of wider operating band width). The co-axial feed is provided at 0mm, 9.2mm along X,Y-axis respectively. The substrate height is 1.56mm

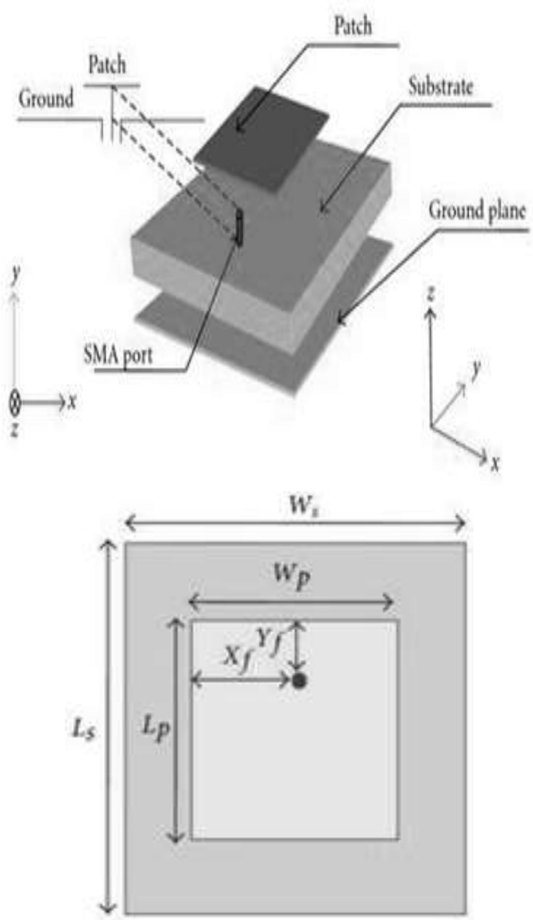

Fig 4: Coaxial feed microstrip antenna

SIMULATION SETUP

The Ansoft HFSS software is utilized here for execution of current proposal of coaxial feed rectangular microstrip antenna. And results of return loss, gain and band width were presented

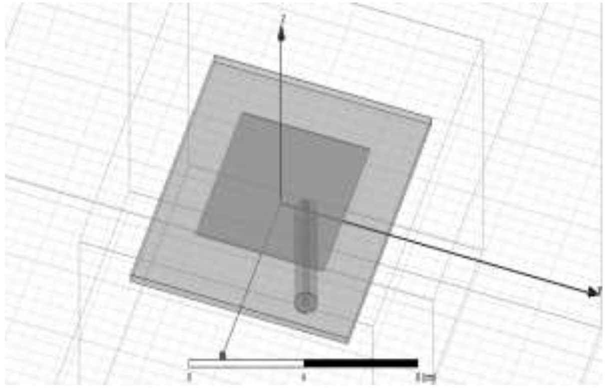

Fig 5: Simulated Antenna Model

RESULTS & DISCUSSION

Return loss: According to maximum power transfer theorems, maximum amount of power will be transferred when there is a perfect matching between input and output. if load is mismatched the whole power is not delivered to load and there is a return of power that is called loss, since this loss is returned hence is called return loss is -20log$|\Gamma|$. Where Γ is reflection coefficient. The response of magnitude of S11 verses frequency curve clearly explains return loss

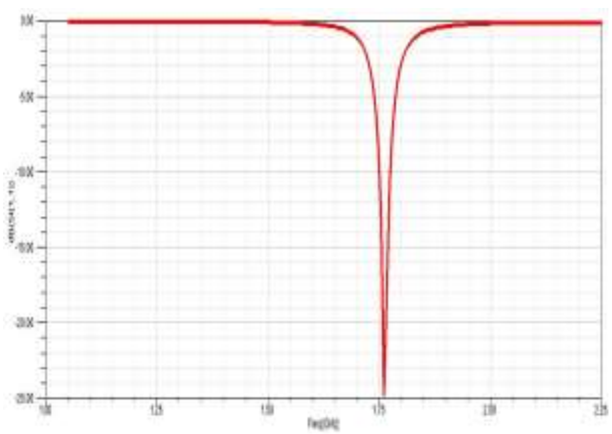

Fig 6 : Return loss

Return Loss:
Table II

Substrate	Return loss	Operating Frequency(GHz)
Rubber_hard	-18.1618	1.7616
Roger RO3003	-20.9417	1.7616
Arlon AD300A	-22.5992	1.7616
Neltec NH 9300	-23.3269	1.7616
Rogers Ultralam 1300	-24.8394	1.7616

One thing we can say that as the loss tangent of dielectric material increases the return loss value also decreasing. Indicates more amount of power is forwarded and very less amount of power is reflected back.

Bandwidth: It can be defined as the range of frequencies over which gain is constant. In software simulation this value is taken at intersecting point s of -10db line and return loss curve.

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Band Width:
Table III

Substrate	Band width (MHz)	Operating Frequency(GHz)
Rubber_hard	22.5	1.7616
Roger RO3003	22.5	1.7616
Arlon AD300A	22.5	1.7616
Neltec NH 9300	22.5	1.7616
Rogers Ultralam 1300	22.5	1.7616

The loss tangent of substrate does not effect the operating bandwidth of antenna.

Impedance: Here only one impedance diagram is shown which indicates all the substrate materials have same impedance, means loss tangent is not affected the impedance.

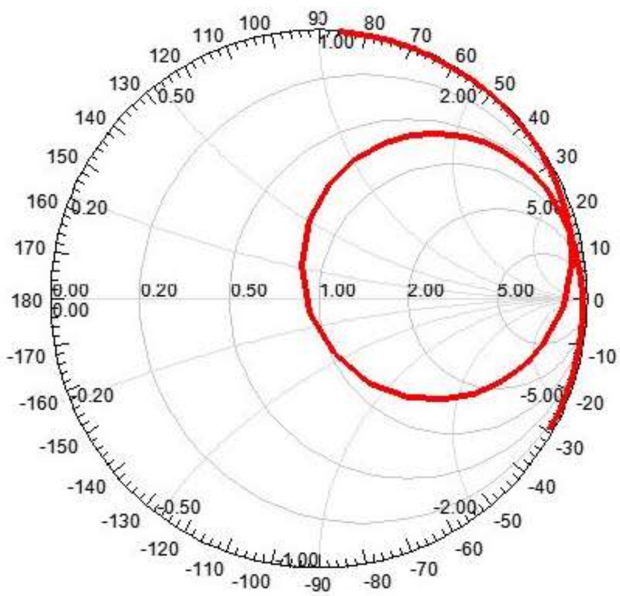

Fig 7: Impedance

Gain: Pick up clarifies figure of value of reception apparatus which joins recieving wire's directivity and electrical effectiveness. Since reception apparatus is a latent gadget the increase can't be measured specifically. Increase is a measure of force emanated per unit surface territory by the test receiving wire in a provided guidance at a discretionary separation, to speculative isotropic radio wire.

Antenna Parameters
Tabe IV

Parameter/Substrate	***Rubber Hard***	***Roger RO3003***	***Arlon AD300A***	***Neltec NH 9300***	***Rogers Ultima 1300***
Max U	0.0040633 (w/sr)	0.0037989 (w/sr)	0.0036672	0.0036126	0.0034885
Peak Directivity	5.231	5.2288	5.2285	5.2284	5.2276
Peak Gain	5.2428	4.864	4.6823	4.6082	4.443

Peak Realized Gain	5.1571	4.8216	4.6544	4.5851	4.4276
Radiated Power	0.0097641	0.0091301	0.008814	0.008683	0.008386
Accepted Power	0.0097394	0.0098149	0.0098422	0.0098515	0.009867
Incident Power	0.0099012	0.0099012	0.0099012	0.0099012	0.0099012
Radiation Efficiency	1.0023	0.93023	0.89553	0.88139	0.84991
FBR	26.57	26.57	26.573	26.577	26.432

By careful observation of antenna parameters given in above table, the antenna parameters (such as gain, directivity and radiation efficiency) are decreasing as the loss tangent of substrate material is increasing.

CONCLUSION

The dielectric materials give mechanical quality to fix reception apparatus outline. To have successful radiation qualities it is ideal to consider a dielectric material with a low misfortune digression. Yet, misfortune digression won't influence the working band width.

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