Antenna Theory & Design

Homework. 14

11.2-2) A square microstrip patch with $L = W = 4.02cm$ is printed on an 0.159-cm thick substrate with $\varepsilon_r = 2.55$. Find the resonant frequency, input impedance at resonance for an edge feed and the bandwidth.

Sol:) Given $L = W = 4.02cm$

and $\varepsilon_r = 2.55$

thickness $t = 0.159cm$

We know that $\lambda = \frac{\sqrt{\varepsilon_r} L}{0.49}$

$$= \frac{\sqrt{2.55}(4.02) \times 10^{-2}}{0.49}$$

$$= 0.131m$$

So $f = \frac{c}{\lambda}$

$$= \frac{3.8 \times 10^8}{0.131}$$

$$f = 2.9 GHz$$

Input impedance is given by

$$Z_A = \frac{90 \varepsilon_r^2}{\varepsilon_r - 1} \left(\frac{L}{W}\right)^2$$

$$= 90 \frac{2.55^2}{(2.55-1)} \left(\frac{4.02}{4.02}\right)$$

$$Z_A = 377.56\Omega$$

Input impedance $Z_A = 377.56\Omega$

Band width $$B = 3.77 \frac{\varepsilon_r - 1}{\varepsilon_r^2} \frac{W}{L} \frac{t}{\lambda}$$

$$= 3.77 \left[\frac{2.55-1}{2.55^2}\right]\left[\frac{4.02}{4.02}\right]\left[\frac{0.159 \times 10^{-2}}{0.131}\right]$$

$$= 0.011 = 11.2\%$$

11.2-4) Calculate the length of rectangular patch at resonance at 3GHz for substrate of dielectric constant 2.2 and variable thickness from 0.001 to 0.05λ. The patch width is a half-wavelength. Do this twice for two levels of approximation in (11-1) and (11-2). Compare using graph

Sol) $f = 3GHz$

$\varepsilon_r = 2.2$

$t = 0.001\lambda$ to 0.05λ

$W = \frac{\lambda}{2}$

$L = 0.49 \frac{\lambda}{\sqrt{\varepsilon_r}}$

$= 0.49 \frac{(0.1)}{\sqrt{2.2}}$

$= 0.033$ mt $\longrightarrow$ (11-1)

$\varepsilon_{re} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left(1 + \frac{10t}{W}\right)^{-0.5}$

$= \frac{2.2+1}{2} + \frac{2.2-1}{2}\left(1 + \frac{10 \times 0.05(0.1)}{\frac{(0.1)}{2}}\right)^{-0.5}$

$= 2.03$

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

$= 0.412 \frac{(2.03 + 0.3)(0.1 + 0.264)\ 0.05 \times 0.1}{(2.03 - 0.258)(0.1 + 0.8)}$

$= 1.06 \times 10^{-3}$

$= 0.0012$

$L = 0.5 \frac{\lambda}{\sqrt{\varepsilon_r}} - 2\Delta L$

$= 0.5 \frac{0.1}{\sqrt{2.2}} - 2(1.06 \times 10^{-3}) = 0.031$ mt — (11-2)

11.2-5) An edge-fed rectangular ($W = 1.5L$) microstrip patch antenna has a substrate of thickness 0.01λ.

a) Vary dielectric constant to find the value which gives highest bandwidth and state values of ε_r and B using these values

b) Calculate path length and width at resonant frequency of 3GHz

c) Calculate input impedance

Sol $W = 1.5L$; $t = 0.01\lambda$

$$B.W = 3.77 \frac{\varepsilon_r - 1}{\varepsilon_r^2} \frac{W}{L} \frac{t}{\lambda}$$

$$= 3.77 \frac{\varepsilon_r - 1}{\varepsilon_r^2} \frac{1.5L}{L} \frac{0.01\lambda}{\lambda}$$

$$= 0.056 \frac{\varepsilon_r - 1}{\varepsilon_r^2}$$

when $\varepsilon_r = 1.8$; $B.W = 0.257$

$\varepsilon_r = 1.9$; $B.W = 0.259$

$\varepsilon_r = 2$; $B.W = 0.2599$

$\varepsilon_r = 2.1$; $B.W = 0.2499$

$\varepsilon_r = 2.2$; $B.W = 0.2497$

when $\varepsilon_r = 2$; B.W is high

$$B.W = 3.77 \times 0.2599 \times 1.5 \times 0.1$$

$$= 0.0146$$

$$= 1.4\%$$

b) $L = ?$ $W = ?$

$f = 3GHz$

So $\lambda = \frac{c}{f}$

$$\lambda = 0.1$$

$$W = \frac{\lambda}{2}\left[\frac{\varepsilon_r + 1}{2}\right]^{-0.5}$$

$$= \frac{0.1}{2}\left[\frac{2+1}{2}\right]^{-0.5}$$

$$= 4.03cm$$

$$L = \frac{4.03}{1.5} = 2.74cm$$

c) $$Z_a = 90 \frac{\varepsilon_r^2}{\varepsilon_r - 1}\left(\frac{L}{W}\right)^2$$

~~$= 90 \frac{4}{4-1}\left(\frac{1}{1.5}\right)^2$~~

$$= 90 \frac{4}{4-1}\left(\frac{L}{W}\right)^2$$

$$Z_a = 160\Omega$$