Microstrip Antennas

Lecture 24
21.03.2014

Microstrip (Patch) Antenna

A metallic strip or patch mounted on a dielectric layer (substrate) which is supported by a ground plane

Rectangular Microstrip Antenna

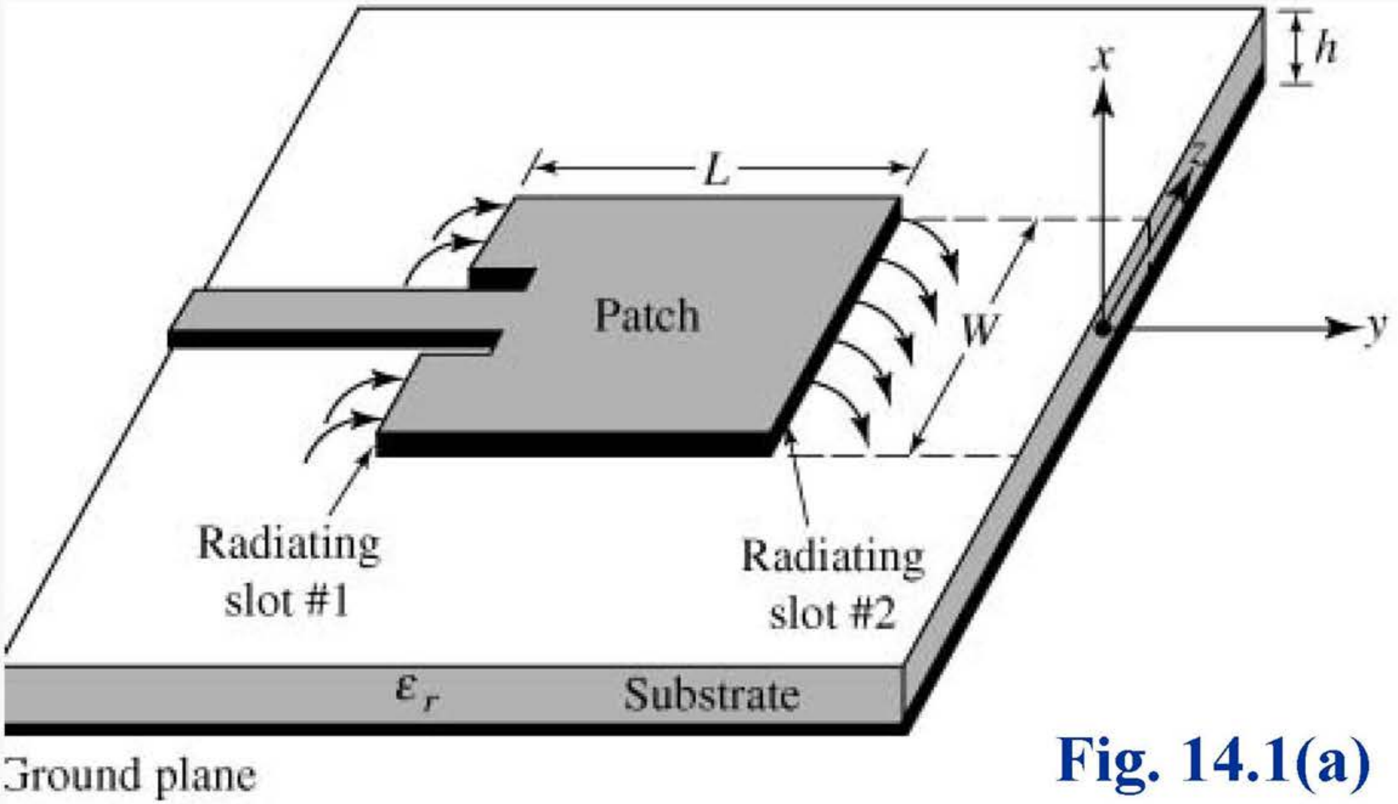


Fig. 14.1(a)

Side View

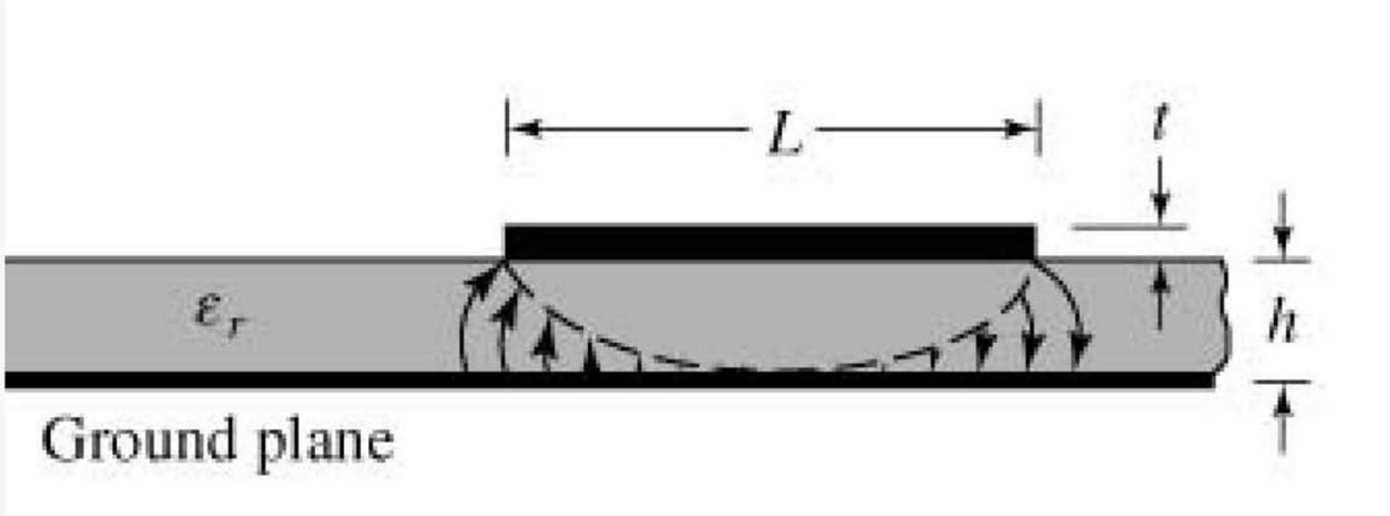


Fig. 14.1(b)

Patches of Various Shapes

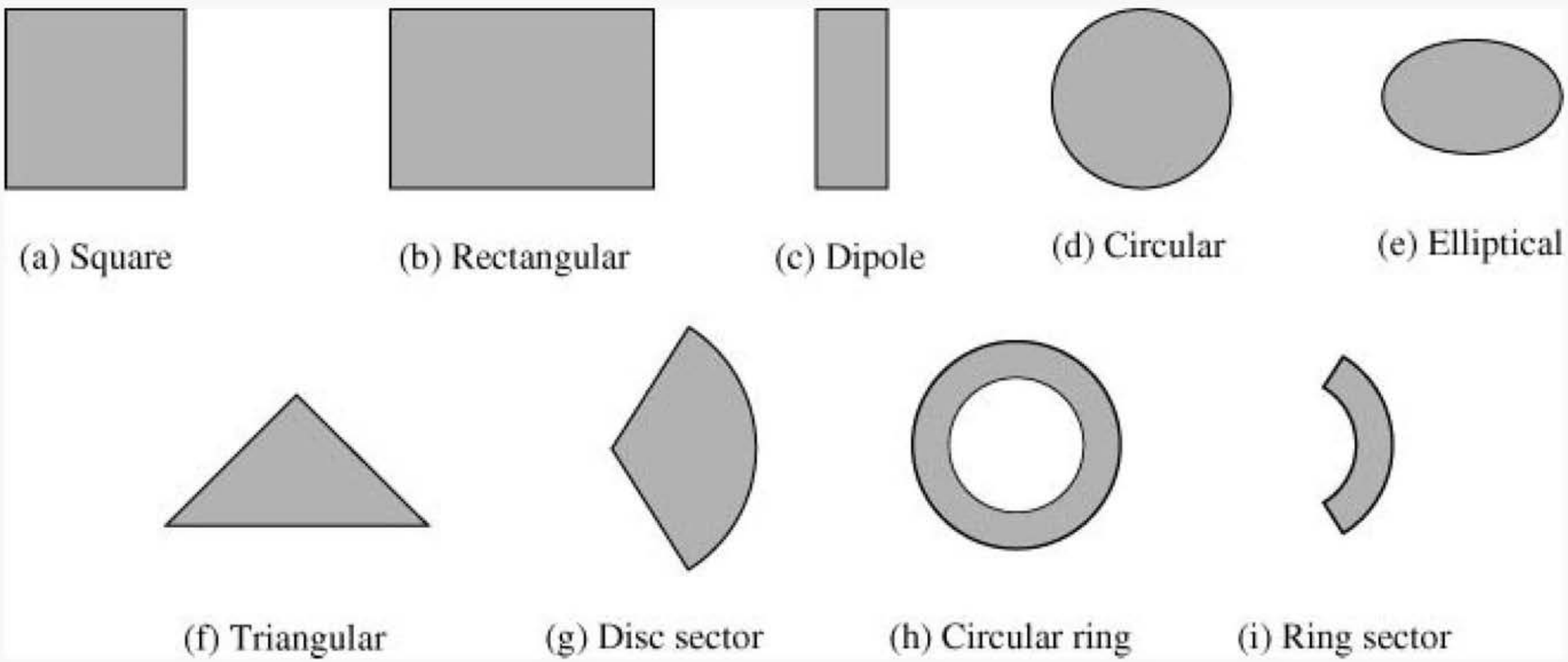


Fig. 14.2

Popular Feed Techniques

1. Microstrip line
2. Probe (coaxial)
3. Aperture coupling
4. Proximity coupling

Microstrip Feed Line

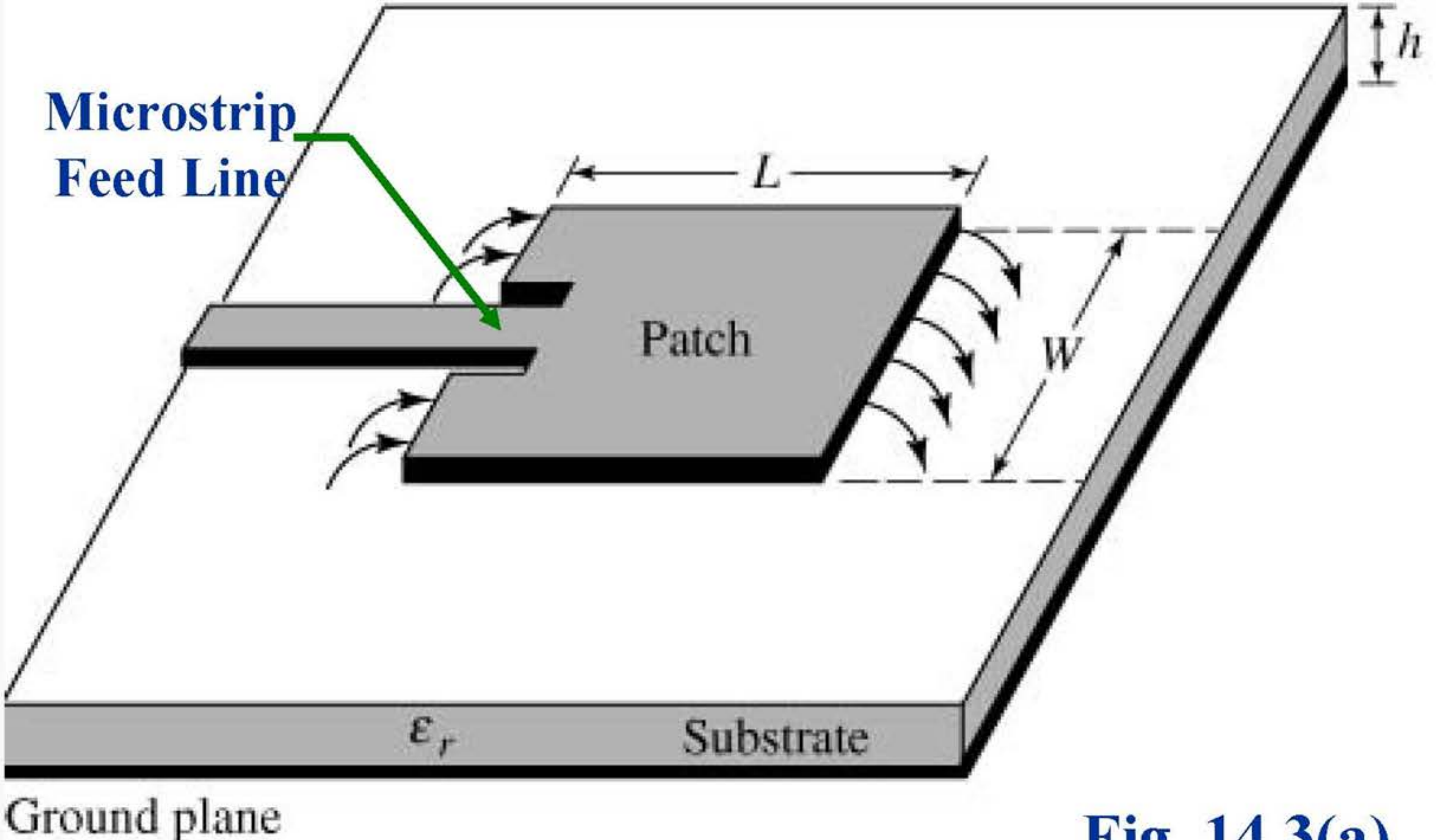


Fig. 14.3(a)

Coaxial Feed Line

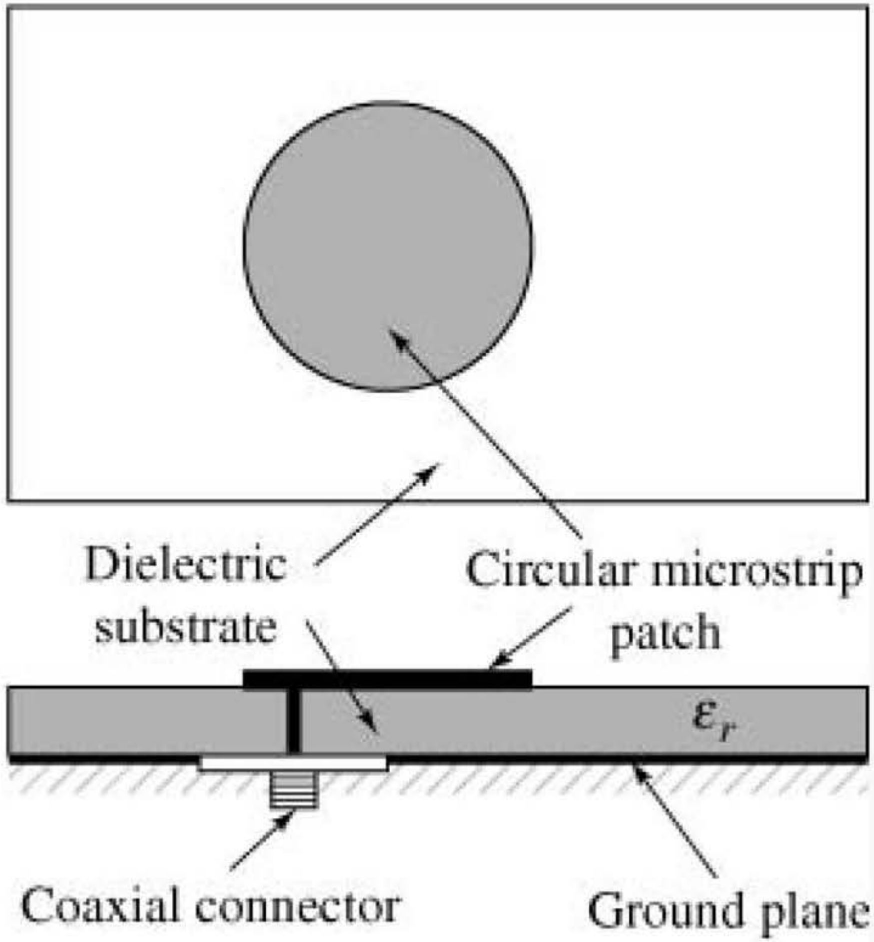


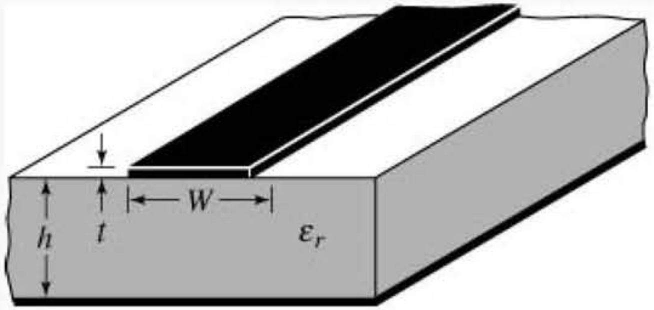
Fig. 14.3(b)

Methods Of Analysis
(Models)

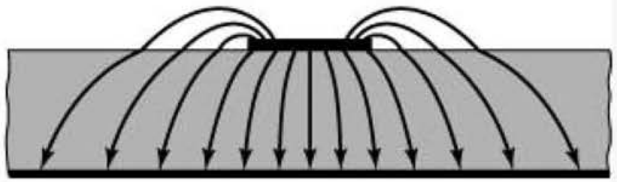
1. Transmission line model
2. Cavity model
3. Full-wave model
   a. Integral equation (MoM)
   B. Modal
   C. Finite-difference time-domain
   D. Finite element
   E. Others

Transmission-Line Model

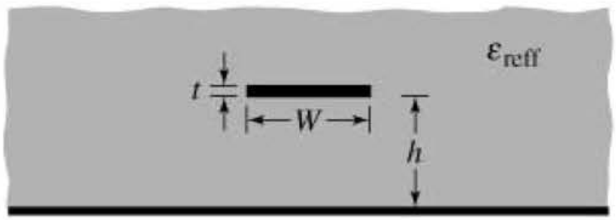
Effective Dielectric Constant For Microstrip Line



(a) Microstrip line



(b) Electric field lines



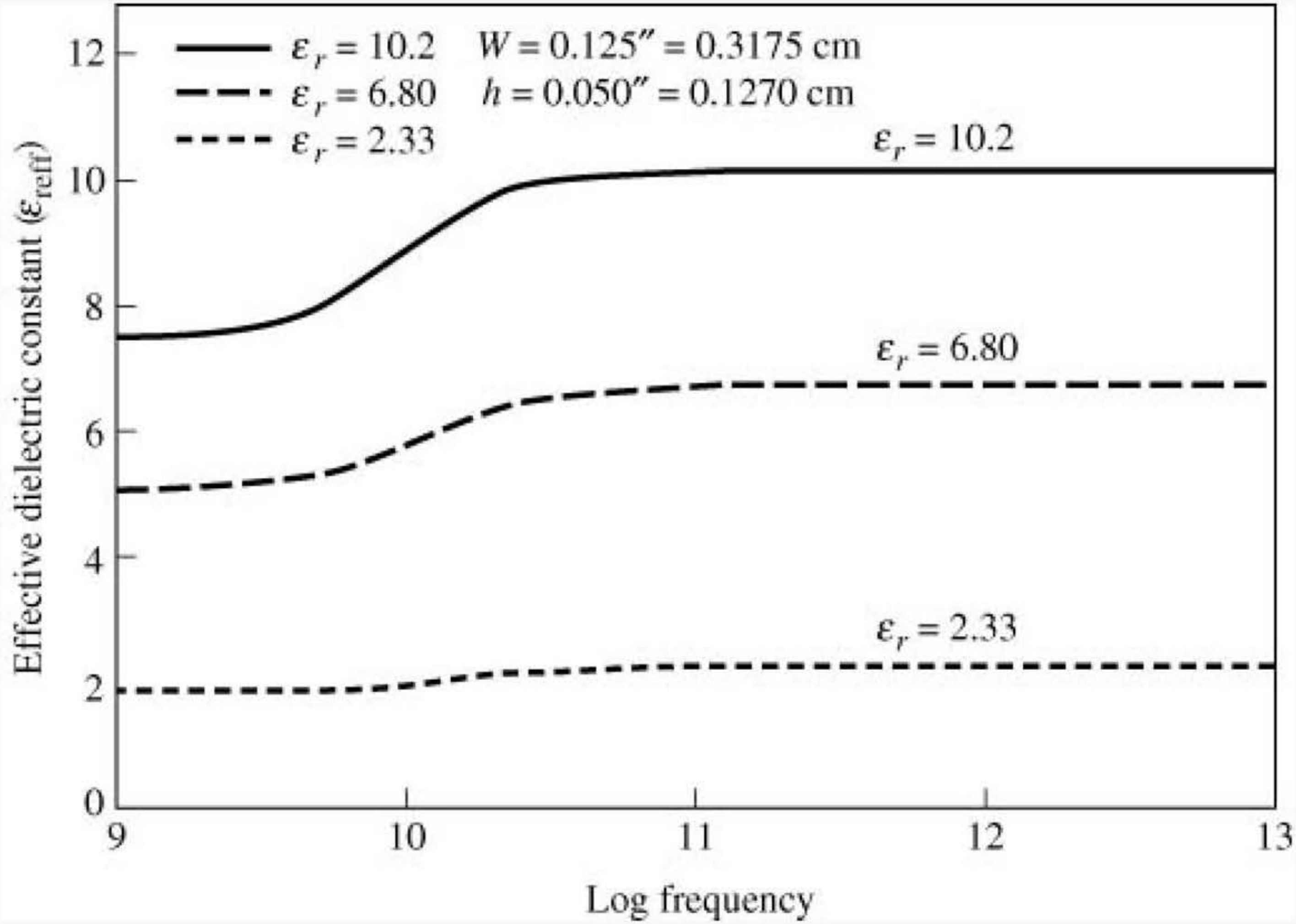
(c) Effective dielectric constant

Fig. 14.5

Effective Dielectric Constant

$W/h > 1$

$$\varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[1 + 12\frac{h}{W}\right]^{-1/2} \quad (14\text{-}1)$$



$\varepsilon_r = 10.2$ $W = 0.125'' = 0.3175$ cm
$\varepsilon_r = 6.80$ $h = 0.050'' = 0.1270$ cm
$\varepsilon_r = 2.33$
$\varepsilon_r = 10.2$
$\varepsilon_r = 6.80$
$\varepsilon_r = 2.33$
Effective dielectric constant ($\varepsilon_{\text{reff}}$)
Log frequency
0
2
4
6
8
10
12
9
10
11
12
13

Fig. 14.6

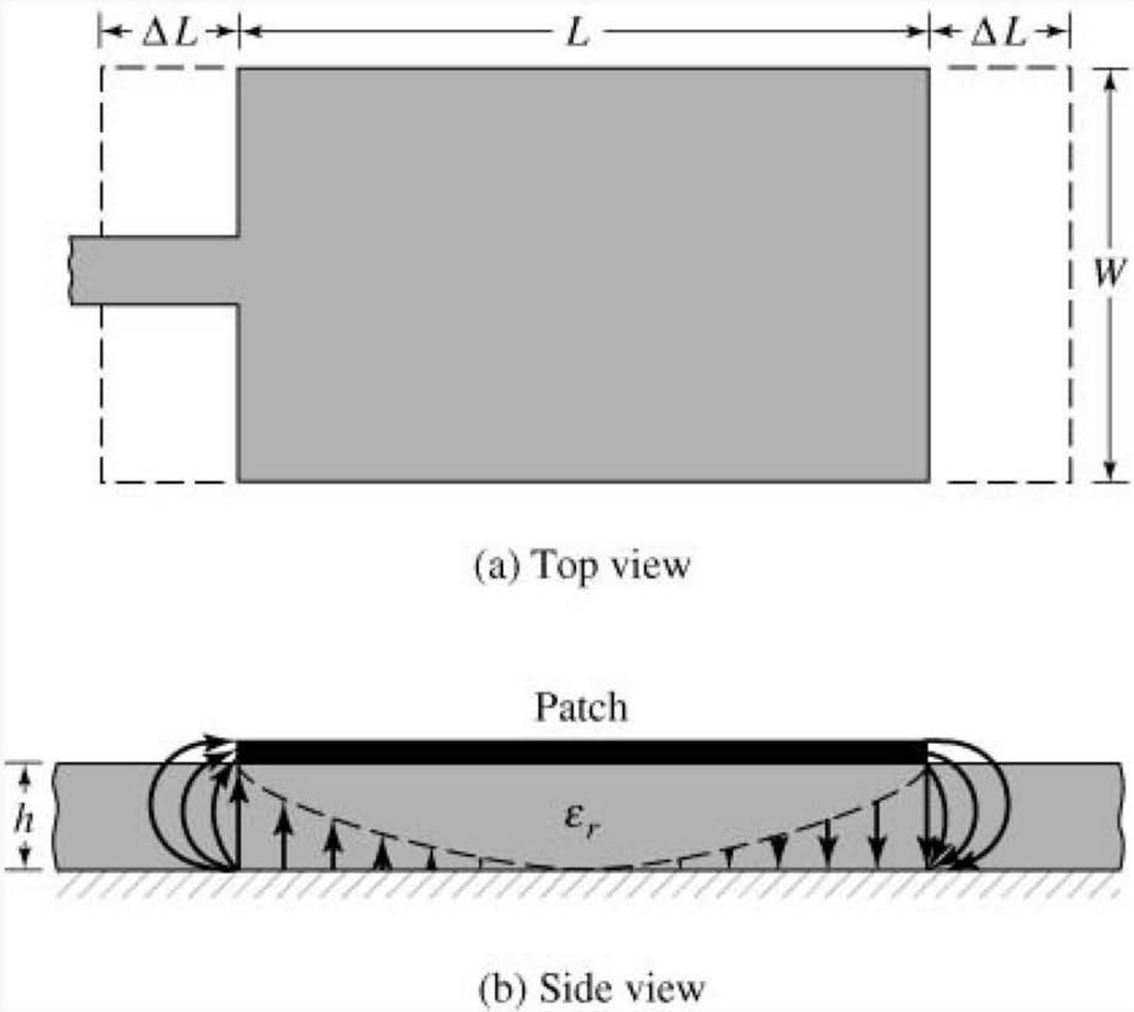


Fig. 14.7

$$\frac{\Delta L}{h} = 0.412 \frac{(\varepsilon_{reff} + 0.3)\left(\frac{W}{h} + 0.264\right)}{(\varepsilon_{reff} - 0.258)\left(\frac{W}{h} + 0.8\right)} \quad (14\text{-}2)$$

$$(f_{rc})_{010} = \frac{v_0 / \sqrt{\varepsilon_{reff}}}{2[L + 2\Delta L]} = g \frac{v_0 / \sqrt{\varepsilon_r}}{2L}$$

g = fringe factor (length reduction factor)

The resonant frequency with no fringing is given by

$$(f_r)_{010} = \frac{v_o}{2L\sqrt{\varepsilon_r}} \quad (14\text{-}4)$$

Because of fringing, the effective distance between the radiating edges seems longer than L by an amount of Δl at each edge. This causes the actual resonant frequency to be slightly less than f_{ro} by a factor q. Thus

Fringe factor

$$(f_{rc}) = \frac{v_o}{2(L+2\Delta L)\sqrt{\varepsilon_{reff}}} = q\frac{v_o}{2L\sqrt{\varepsilon_r}} \quad (14\text{-}5)$$

Design Procedure

1. Specify: ε_r, f_r, h/λ_o
2. Determine: W, L

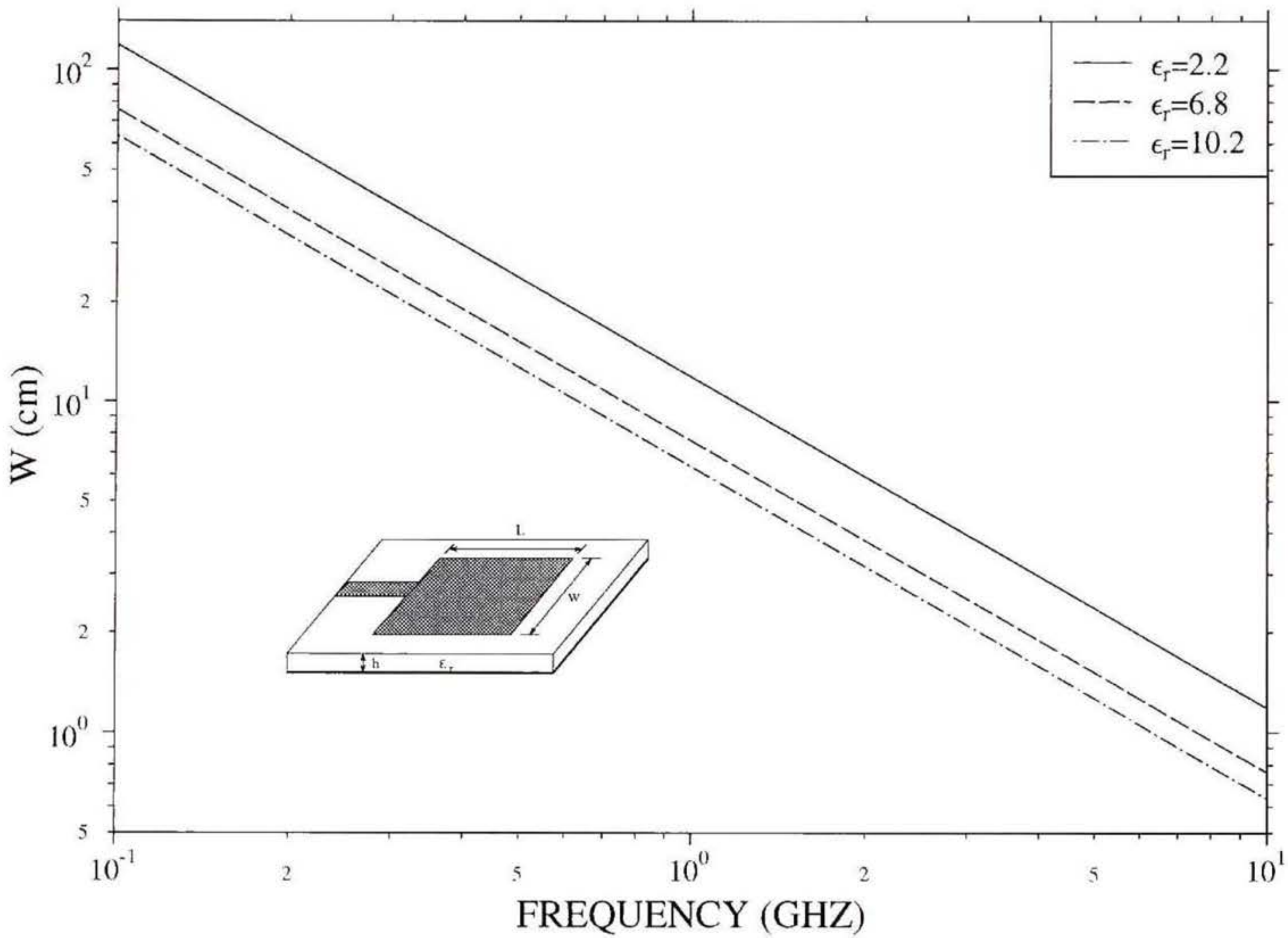
   A. Determine W:

   For an efficient radiator, a practical width which leads to good radiation efficiencies is

$$W = \frac{\upsilon_o}{2 f_r} \sqrt{\frac{2}{\varepsilon_r + 1}} \qquad (14\text{-}6)$$

Plots of W (in cm) as a function of frequency are shown in the attached figure.

Element Width vs. Frequency for Different Dieletric Substrates



B. Determine L:

once W is known, and the effective dielectric constant and length extension have been computer, the

$$L = \frac{\upsilon_o}{2 f_r \sqrt{\varepsilon_{reff}}} - 2\Delta L \qquad (14\text{-}7)$$

Plots of L (in cm) vs. frequency are shown in the attached figure.

Example 14.1:

Given: Duroid (ε_r=2.2), h=0.0625"= 0.1588cm (RT/5880), f_r=10 GHz

Solution:

$$W = \frac{v_0}{2f_r}\sqrt{\frac{2}{\varepsilon_r+1}} = \frac{3\times10^{10}}{2\times10^{10}}\sqrt{\frac{2}{2.2+1}} = 1.186\ cm$$

$$= 1.186\ cm = 0.467\ inches$$

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

$$= \frac{2.2+1}{2} + \frac{2.2-1}{2}\left[1+12\left(\frac{0.062}{0.467}\right)\right]^{-1/2} = 1.9726$$

$$\frac{\Delta L}{h} = 0.412 \frac{(1.972+0.3)\left(\frac{1.186}{0.1588}+0.264\right)}{(1.972-0.258)\left(\frac{1.186}{0.1588}+0.8\right)}$$

$$= 0.412\left(\frac{17.7178}{14.2865}\right) = 0.511$$

$$\Delta L = 0.511(0.1588) = 0.081\ cm\ (0.032\ in)$$

$$L_e = \frac{\lambda}{2} - 2\Delta L = \frac{30}{2(10)\sqrt{1.972}} - 2(0.081) = 0.906\ cm = 0.357\ in$$

$$L_e = L + 2\Delta L = \frac{\lambda}{2} = 1.068\ cm = 0.421\ in$$