2.4 GHz Antenna Design

To calculate the **resonant frequency** of a rectangular microstrip patch antenna, the fundamental frequency *f*0 can be determined using the equation:

where:

2*L εr*

*f*0 = *c*

 *c* = speed of light in vacuum (3 × 108m/s)

 *L* = length of the patch

 *εr* = eﬀective dielectric constant of the substrate

To **design a 2.4 GHz microstrip patch antenna**, follow these steps:

### Determine the Width (*W* )

The width of the patch is given by:

*W* = *c*

2*f*0 (*εr* + 1)/2

where:

 *f*0 = 2.4 GHz

 *εr* = dielectric constant of the substrate

### Determine the Eﬀective Dielectric Constant (*εeff* )

The eﬀective dielectric constant accounts for the fringing ﬁelds:

where:

*W*

*εeff*

= *εr* + 1

# 2

+ *εr* − 1

# 2

(1 + 12 *h* )

−1/2

 *h* = height of the substrate

### Calculate the Eﬀective Length (*Leff* )

The eﬀective length of the patch is:

## c

*εeff*

*Leff*

= 2*f*0

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### Compute the Length Extension (Δ*L*)

Due to the fringing eﬀect, the actual length diﬀers from the eﬀective length:

Δ*L* = 0.412*h* (*εeff* + 0.3)(*W* /*h* + 0.264)

(*εeff* − 0.258)(*W* /*h* + 0.8)

### Calculate the Actual Length (*L*)

*L* = *Leff* − 2Δ*L*

### Example Calculation for FR4 Substrate (*εr*

#### Width:

= 4.4**,** *h* = 1.6 **mm)**

# 3 × 108

*W* =

2 × 2.4 × 109 × (4.4 + 1)/2

# = 38.02 mm

#### Eﬀective Dielectric Constant:

* 1. **Eﬀective Length:**

*εeff*

# = 4.08

#### Length Extension:

* 1. **Final Length:**

*Leff* =

3 × 108

Δ*L* = 0.99 mm

2 × 2.4 × 109 × 4.08

= 29.77 mm

*L* = *Leff* − 2Δ*L* = 27.79 mm

Thus, for a **2.4 GHz microstrip antenna** with an **FR4 substrate**, the rectangular dimensions would be:

 **Width** ≈ **38 mm ** **Length** ≈ **28 mm**

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