EE-711 Millimeter Wave Electronics

Spring 2004

Homework #1
Design of a resonator using microstrip line

Due Thursday, April 8, 2004

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1. The following parameters are used for the substrate and metal strip line:

**Substrate:**
Dielectric constant: 9.6; Tangent (δ): 0.005; Substrate thickness: 20 mil; Center freq: 14GHz

**Metal strip line:**
Metal line thickness: 0.15 mil; Conductivity: $4.1 \times 10^7 \text{ S/m}$

2. Simulation procedure and results

A) Gap coupled resonator

By introducing a gap between the resonator and a microstrip line, we can couple a microwave signal to the resonator. 5 um gap is used to start with.

Step A1: use LineCalc to get approximate microstrip line width and length (as in fig.1)

![LineCalc Result](image)

Step A2: We can draw the microstrip line in the schematic (as in fig. 2a).

Step A3: By using Simulate -> Tuning …, we adjust the microstrip line length from 161.512 mil (from LineCalc) to 153.512 mil.
Step A4: Get the 3 dB from fig. 3

The -3 dB bandwidth can be calculated from the markers in fig. 3.

\[ BW(3dB) = \omega_2 - \omega_1 = 2\pi \cdot \Delta f = 2 \times 3.14 \times 16 \times 10^9 \text{ Hz} = 1 \times 10^9 \text{ Hz} \]
B) Increase the gap and observe the response of the resonator

Sweep the gap from 0 um to 300 um, with step of 50 um, we can clearly see it will undergo undercoupled, critical coupling and overcoupled region (fig. 4)

At $\text{Gap} = 130 \text{ um}$ and $L = 153.992$ mil, we reach critical coupling, which will give very sharp resonance (fig. 5).
C) **Add another coupled line at the other end and observe what happened with the changes in the coupling gap.**

Sweep the gap between another coupled line and the microstrip line from 0 um to 300 um, with step of 50 um, we can clearly see that as the gap increase, the coupling will decrease (fig. 6).

![Graphs showing input reflection, reverse transmission, forward transmission, and output reflection coefficients](image)

**Fig. 6**

D) **Double the resonator width**

As shown in fig. 7, the red line is the forward transmission response after the microstrip line width is doubled and the blue line is the response without any change.

There is not much difference between these two plots. But the center frequencies of both traces are shifted to lower frequency due to added load. We do some adjustment to the length of microstrip line to get center frequency back to 14 GHz (fig. 8).
E) Simulate the system with momentum

By updating the plot in layout (change the term to microstrip line and port), we can get the layout and simulate with Momentum. From intuition, we think the double width one will radiate because of impedance mismatch. The single width one may also radiate a little because the
frequency is high. Some results are given below (fig. 9-12). But I lack some theoretical background to explain this.

![Graphs showing S-Params simulation (single width)](image)

**Fig. 9** S-Params simulation (single width)

**Power**

![Graphs showing 2D radiation pattern (single width)](image)

**Fig. 10** 2D radiation pattern (single width)
Fig. 11  S-Params simulation (double width)

Fig. 12  2D radiation pattern (double width)