ECE5320/6322 Midterm III December 3, 2006

Name Key

You may use your portfolio and a calculator but no textbook.

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$a = .12$, $b = .01$

1. (25 points) A waveguide has inner dimensions 12 x 1 cm. Find the cutoff frequencies of the first four modes, and specify which modes these are.

$$f_c = \frac{c}{2\pi}\sqrt{\left(\frac{m\pi}{a}\right)^2 + \left(\frac{n\pi}{b}\right)^2}$$

$$f_{c\,TE_{10}} = \frac{3\times10^8}{2\pi}\sqrt{\left(\frac{\pi}{12\text{cm}}\right)^2} = 1.25\text{ GHz} \quad \#1$$

$$TE_{20} = \frac{3\times10^8}{2\pi}\sqrt{\left(\frac{2\pi}{.12}\right)^2} = 2.5\text{ GHz} \quad \#2$$

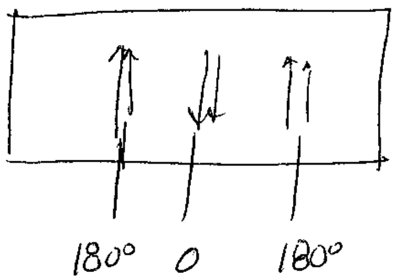
$$TE_{30} = \frac{3\times10^8}{2\pi}\sqrt{\left(\frac{3\pi}{.12}\right)^2} = 3.75\text{ GHz} \quad \#3$$

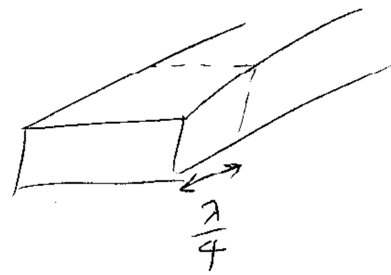
$$TE_{40} = \frac{3\times10^8}{2\pi}\sqrt{\left(\frac{4\pi}{.12}\right)^2} = 5.0\text{ GHz} \quad \#4$$

$$TE/TM_{11} = \frac{c}{2\pi}\sqrt{\left(\frac{\pi}{.12}\right)^2 + \left(\frac{\pi}{.01}\right)^2} = 15.05\text{ GHz}$$

2. (25 points) (a) Sketch and describe a method of feeding the TE_{30} mode in a waveguide. Be sure to show where the feed point(s) are, what their orientation is (sketch and/or describe), and what their relative magnitudes and phases are. (b) Repeat for the TM_{11} mode. (These modes do NOT need to be fed simultaneously.)

(a)

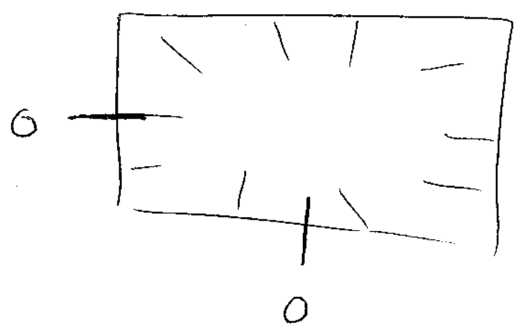




3 coaxial probe feeds

be sure $f > f_{c_{30}}$

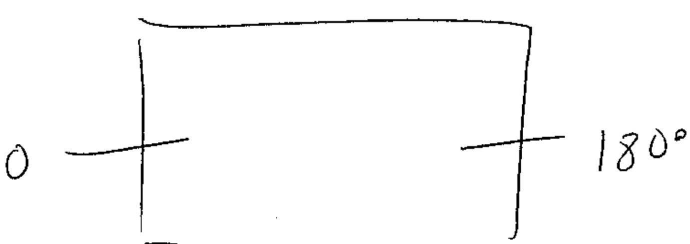
(b)



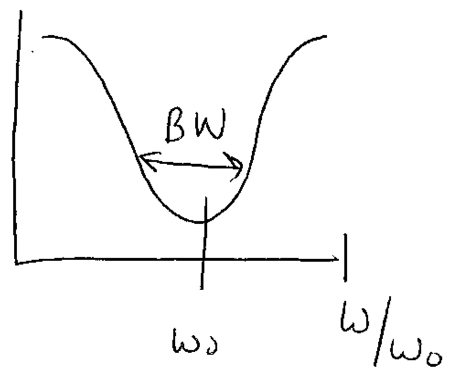
2 coaxial probe feeds

Be sure $f > f_{c_{11}}$

or



3. (25 points) Design a series resonant circuit that has a center frequency of 1 MHz and a bandwidth of 0.1 MHz.



$$\frac{1}{Q} = \frac{BW}{}$$

↑ This is normalized Bandwidth BW/ω_o

$$Q = \frac{1}{(0.1\,mHz / 1\,mHz)}$$

mistakes here (−3) → $Q = 10$ = unloaded Q

$$\omega_o = \frac{1}{\sqrt{LC}} = 2\pi(1\times10^6\,Hz) = \frac{1}{\sqrt{LC}}$$

choose $L = 1\mu H$, purchaseable value

$$C = \frac{1}{L\omega_o^2} = \frac{1}{(1\times10^{-6})(2\pi\times10^6)^2} = 25nF$$

$$R = \frac{\omega_o L}{Q} = \frac{(2\pi\times10^6)(1\times10^{-6})}{10} = 0.628\,\Omega$$

4. (25 points) The human torso acts like a resonant cavity at some frequencies. At resonance, the electric and magnetic fields reflect back and forth in the body many, many times before they are fully absorbed by the body and die away. The stored electric energy is proportional to the square of the electric field, and the stored magnetic energy is proportional to the square of the magnetic field.

At resonance, what can you say about the relative values of these two sources of stored energy?

They are equal

Given what you know about resonance, what is a "high Q cavity"?

A cavity with high Q & lots of reflections as a result

Give an example of one such "high Q cavity" in your practical experience.

Microwave Oven

Laser Cavity

Music Reverb chamber

Maybe the head, or body, given what is described above

Any others ...?