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**ECE 5317/6351**

**Microwave Engineering**

**Exam 1**

**Fall 2015**

Instructions

1. This exam is open book and notes. Calculators and Smith chart tools (e.g. compasses and rulers) may be used. Laptops and any devices that may be used for communication are not allowed.
2. Please show *all of your work* and *write neatly* in order to receive credit. No credit will be given if the work required to obtain the solution is not shown, or if it is not easily readable.
3. Put all of your answers in terms of the parameters given in the problems, unless otherwise noted.
4. Include units with all numerical answers in order to receive full credit.
5. Perform all of your work on the paper and Smith charts provided. If you need more space, you may write on the backs of the pages.

**You will have a total of 80 minutes.**

**Problem 1**

A coaxial cable has a 50 Ω characteristic impedance. The radius of the shield is 0.25 cm. The radius of the solid inner wire is 0.075 cm. The solid inner wire is made of copper with a conductivity of 3.0 ×107 [S/m]. The outer shield is made of braided copper with an effective conductivity of 1.5 ×107 [S/m]. The filling material is Teflon, with a relative permittivity of  and a loss tangent of .

**Note: Please keep at least five significant figures in each of your answers below.**

a) Calculate the parameters (*R*, *L*, *G*, *C*) at 10 GHz.

b) Calculate the total attenuation at 10 GHz, in dB/m. Do this by using the formula for *γ* in terms of these four parameters.

c) Calculate the conductor attenuation at 10 GHz, in dB/m. Do this by using the formula for *γ* and making the appropriate assumption about which of the *RLGC* parameters you can neglect.

d) Calculate the conductor attenuation at 10 GHz, in dB/m. Do this by using the perturbation formula for *αc* .

e) Calculate the dielectric attenuation at 10 GHz, in dB/m. Do this by using the formula for *γ* and making the appropriate assumption about which of the *RLGC* parameters you can neglect.

f) Calculate the dielectric attenuation at 10 GHz, in dB/m. Do this by assuming that the mode is a perfect TEM mode if there is no conductor loss, and then using your knowledge of how *γ* is related to *k* for a TEM mode.

g) What is the maximum frequency at which the cable can be used, before higher-order waveguide modes begin to propagate?

**Room for additional work**

**Room for additional work**

**Problem 2**

A air-filled WR90 rectangular waveguide operating in the TE10 mode at 10 GHz has dimensions *a* = 2.29 cm, *b* = 1.02 cm. The waveguide feeds a horn antenna, as shown below. Measurements are taken, and it is found that the reflection coefficient at the end of the waveguide (*z* = 0) is Γ*L* = 0.2∠30o.

a) Calculate where to place an inductive iris in order to obtain a perfect match as seen on the waveguide looking from the left towards the iris. That is, determine the distance *d* from the end of the waveguide where the iris will be placed (use the smallest value of *d* possible). The iris is made from very thin sheets of metal running along the side walls of the waveguide. Use the Smith chart provided.

b) Determine the value of the reactance *X* (in Ω) that models the iris, when this reactance is placed in the TEN model of the system. Assume that the characteristic impedance of the TEN transmission line that models the waveguide is the same as the wave impedance of the TE10 mode in the waveguide. Use the Smith chart provided.

c) Draw the TEN model of the system, with all impedances (including the characteristic impedance, the iris impedance, and the load impedance) labeled and with numerical values given.

Top view



Incident TE10 wave



Horn

Iris



**Room for additional work**

**Room for additional work**





**Room for additional work**

