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**ECE 5317/6351**

**Microwave Engineering**

**Exam 2**

**Fall 2017**

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 provided. If you need more space, you may write on the backs of the pages.

**Problem 1 (30 pts.)**

An input transmission line having a characteristic impedance *Z*0 = 50 [Ω] splits off into three identical output transmission lines having characteristic impedance *Z*0 = 150 [Ω]. This represents a four-port system. On two of the ports (called ports 3 and 4) a load impedance of *ZL* = 50 [Ω] is placed at a distance that is one-fourth of a guided wavelength from the junction. This reduces the four-port system to a two-port system having ports 1 and 2.

Find the [*S*] matrix for this two-port system.



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**Problem 2 (20 pts.)**

A transmission line of characteristic impedance *Z*01 is connected to a one-port device (i.e., a load). The input reflection coefficient is called *S*11. The same device is then connected to a transmission line with a characteristic impedance *Z*02.The new input reflection coefficient is then called *S*11*new*.

Find *S*11*new* in terms of *Z*01,*Z*02, and*S*11.



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**Problem 3 (20 pts.)**

A nonmagnetic dielectric slab is shown below. (There is no ground plane, only free space above and below the slab.) There are four types of surface-wave modes that can propagate on the slab: TM*x*odd ,TM*x*even, TE*x*odd ,TE*x*even.

Use a TEN model to derive a transcendental equation for the wavenumber *kz* for the TE*x*odd andTM*x*even modes.

**Note:** Even and odd refer to the symmetry of the fields *Ey* and *Ez* about the center of the structure (*x* = 0) in the *x* direction.



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**Problem 4 (30 pts.)**

It is desired to match an incoming 50 [Ω] microstrip line to a 250 [Ω] microstrip line using a two-stage Chebyshev transformer as shown below. We want the magnitude of the reflection coefficient to stay below -20 dB in the passband.

a) Design the transformer by finding the characteristic impedances *Z*1 and *Z*2. Do not use the table in the Pozar book -- do the design by hand.

b) Determine the bandwidth of the transformer in percent.

c) Determine the (complex) input reflection coefficient at the center frequency of operation.

Substrate

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