Dept. of Electrical Eng.  
Faculty of Engineering  
Assiut University  
2nd Semester - 2014/2015  
Final Exam - May, 2015

All Programs  
Course: Electromagnetic Fields (2B)  
2nd year - bylaw: 2004  
Time: 3 Hours  
Marks: 50

- This exam measures ILOs no.: a2.1 & b6.3 & c4.1 & c4.2
- No. of pages: 4, No. of questions: 4
- Solve each question in the space that is provided for it.
- Smith chart is included. It should be returned with the exam.

\[
e=10^9/36\pi \quad \text{and} \quad \mu_0=4\pi \times 10^7, \quad \sigma_{\text{copper}}=5.7 \times 10^7
\]

**Answer all the following questions:**

**Question # 1 (8 points, 3 points for (a), and 5 points for (b)):**

(a) What is the frequency band, you think, that is suitable to practically use the regular waveguides? Why?

(b) Sketch the k-\(\omega\) diagrams of a parallel-plate waveguide separated by a dielectric slab of thickness \(b\) and constitutive parameters \(\mu, \varepsilon\) for TM\(_1\), TM\(_2\), and TM\(_3\) modes. Discuss
(i) how \(b\) and constitutive parameters affect the diagrams,
(ii) whether the same curves apply to TE modes.
Question # 2 (15 points, 5 points for (a), and 10 points for (b)):

(a) A standard air-filled S-band rectangular waveguide has dimensions a=7.21 cm, and b=3.4 cm. What mode types can be used to transmit electromagnetic waves having the following wavelengths?
   (i) \( \lambda = 10 \) cm
   (ii) \( \lambda = 5 \) cm.

(b) A TE_{10} wave at 10 GHz is the only mode propagating in a brass (\( \sigma_0=1.57 \times 10^7 \) S/m) rectangular waveguide with length \( a=1.5 \) cm. The guide is filled with nonmagnetic polyethylene of \( \varepsilon_r=2.25 \).

Determine,
(i) the guiding phase constant,
(ii) the guide wavelength,
(iii) the guide phase velocity,
(iv) the wave impedance of the guided mode,
(vi) the group velocity of the guided mode.
Question # 3 (14 points, 6 points for (a), and 8 points for (b)):

(a) For a dielectric-filled rectangular copper cavity resonator the \( \varepsilon_r = 2.4 \) and its dimension is \( a = 3.6 \text{ cm} \). The cavity supports only the dominant mode at frequency of 5 GHz.

(i) What is the length \( l \) of the cavity.

(ii) What is the quality factor of the cavity.

(b) A 6 GHz signal is to be transmitted inside a hollow circular waveguide. Determine the diameter of the waveguide such that its lowest cutoff frequency is 10% below this operating frequency. Is there any other mode can be transmitted in this waveguide?

Note that the roots of Bessel function are:

\[
\begin{array}{c|c|c}
\text{n=0} & \text{n=1} \\
2.405 & 3.832 \\
5.52 & 7.016 \\
\end{array}
\]

and for the derivative Bessel function the roots are:

\[
\begin{array}{c|c|c}
\text{n=0} & \text{n=1} \\
3.832 & 1.841 \\
7.016 & 5.331 \\
\end{array}
\]
Question # 4 (13 points, 3 points for (a) and 10 points for (b)):
(a) It is found that the attenuation on a 150 Ω distortionless two wire transmission line is 0.01 dB/m. The line has an inductance of 0.2 μH/m.
(i) Find the resistance, capacitance, and conductance per meter of the line.
(ii) Determine the percentage to which the amplitude of a voltage travelling wave on this line decreases in 1 km distance from the transmitting end.

(b) A 100 Ω lossless T.L. The reflection coefficient at the load is 0.6 < 60° and the first voltage maximum is found at 4 m from the load. Calculate using smith chart:
(i) The load impedance.
(ii) The reflection coefficient at a distance 10 m from the load.
(iii) The voltage standing wave ratio, S, on the line.
(iv) The input impedance at a distance 0.5 km from the load.
(v) The shortest distance from the load to put a matching short circuited stub.
(vi) The length of the stub.

End of the questions

Good Luck

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