COLLEGE OF ENGINEERING & TECHNOLOGY

Department: Electronics and Communications Engineering
Lecturer: Associate Prof. Dr. Hussein H. M. Ghouz
Course: Microwave Technology
Course Code: EC546 **Time : 1 Hours**
Date : Sat., Dec., 13, 2014 **Total Marks : 20**

12th Exam (Fall-2014/2015)

Question No. 1: (6-Mark):

Design an Equal-ripple **3**-order bandpass filter with the following specifications: **(3-Mark)** *f_o=6.0 GHz, Z_o=50 **Ω**, bandwidth=2000 MHz, and Ripple=0.5dB.* The coefficients of **ER LP** proto-type filter is given by :**{ 1.000, 1.5963, 1.0967, 1.5963, 1.000}.** Select the proper method to implement the designed filter and then, sketch roughly its frequency response **(3-Mark)**

Question No. 2: (14-Mark):

(a) Discuss the different implantation methods of the most commonly used direction couplers in practice, then, define and explain: coupling factor, directivity, and isolation **(4-Mark)**

(b) A resistive T-junction power divider circuit has a ratio of "**a:b"** power division. Assume, the source impedance is $\mathbf{Z_s}$ and the characteristic impedance of each arm is $\mathbf{Z_o}$ ($\mathbf{Z_S > Z_o}$). Find the optimum series resistance values of each arm such that all ports are matched. Compute the magnitude and phase of the S-parameters and the power loss in this case **(5-Mark)**

(c) A single-hole waveguide directional coupler is designed to operate in dominant mode $\mathbf{TE_{10}}$. Assume rectangular waveguides are filled with a dielectric material of ε_r=10.0 and the desired coupling factor is **15.0** dB. The required output ports are as follows: **port#2**(through), **port#3** (isolated), and **port#4** (coupled). Assume, the waveguides cross section is axb=1.070x0.430cm^2**.** Select the correct frequency from the following frequencies to design the required directional coupler: **{f_o=3.0, f_o=6.0, f_o=22.0} GHz,** and then derived a closed form equations for location and radius of the hole aperture **(5-Mark)**

Bonus Question: (6-Mark additional to added to the 7th Grade):

A single section coupled line coupler with a coupling factor of 15 dB, a system impedance of **50** Ω, and a center frequency of **5** GHz, is desired to be realized on FR-4 substrate edge-coupled microstrip configuration, with ε_r**=4.4** and **d=1.6** mm. Find the necessary strip widths and separation using the Impedance-Table given below. Assume the voltage source is V_o**=10** volt peak-to-peak and the line lengths is **λ/4**, find the power at each port. Sketch roughly the directivity and the coupling from **4** to **6** GHz.

		Z_{oe} W/d				Z_{oe} S/d			
		54	57	60	63	54	57	60	63
Z_{oo}	40	2.0	1.9	1.8	1.7	0.05	0.06	0.07	0.08
	43	1.7	1.6	1.5	1.4	0.08	0.09	0.10	0.21
	46	1.5	1.5	1.4	1.3	0.10	0.15	0.20	0.25
	49	1.4	1.3	1.2	1.1	0.15	0.20	0.30	0.35
	51	1.3	1.2	1.1	1.0	0.20	0.25	0.28	0.38

P.T.O →

Formula Sheet

$$A_{10}^{+} = -jTr_o^3\left(T^{+}\sin^2(\pi S/a) - T^{o}\cos^2(\pi S/a)\right) \qquad T^{+} = \left(2\varepsilon/3 - 4\mu_o/3Z_{10}^2\right)$$

$$A_{10}^{-} = -jTr_o^3\left(T^{-}\sin^2(\pi S/a) - T^{o}\cos^2(\pi S/a)\right) \qquad T^{-} = \left(2\varepsilon/3 + 4\mu_o/3Z_{10}^2\right)$$

$$T = \omega A/P_{10} \qquad T^{o} = \left(4\pi^2\mu_o/Z_{10}^2\beta^2a^2\right) \qquad P_{10} = ab/Z_{10} \qquad k = \omega/\upsilon$$

$$k_{cmn} = \sqrt{(m\pi/a)^2 + (n\pi/b)^2} \qquad Z_{10} = k\eta/\beta \qquad \beta = \sqrt{k^2 - k_c^2}$$

$\varepsilon_o = 10^{-09}/(36x\pi)$ F/m $\qquad$ $\mu_o = 4\pi x10^{-07}$ H/m

Filter Type	Frequency Transformation	Impedance Scaling
LPF ↓ BPF	$L_k \longrightarrow L_k = L_k/(\omega_o\Delta)$, $C_k = \Delta/(\omega_o L_k)$	
	$C_k \longrightarrow L_k = \Delta/(\omega_o C_k)$, $C_k = C_k/(\omega_o\Delta)$	$L_k \longrightarrow L_kR_o$
	$\Delta = (\omega_2 - \omega_1)/\omega_o$	$C_k \longrightarrow C_k/R_o$
	$(1/\Delta)(\omega/\omega_o - \omega_o/\omega) \longrightarrow \omega$	