

Doctorate Entry Examination (D-LMD – 2015/2016)

12/10/2015

Major: Telecommunications and Computer Engineering

Note: Answer only one topic (Topic 1 or Topic 2)

Topic 1: Communication System Engineering	Version: B	Time Duration: 2h:00
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Exercise 1: (5 points)

- a) The impulse response of a linear phase FIR filter starts at the values:

$$h[0] = 0.25, h[1] = -0.5, h[2] = 0.75.$$

For each of the four filter types, find the coefficients of the smallest order FIR filter that satisfies this condition.

- b) What is the main difference between the DFT of a signal and its discrete-time Fourier transform?
c) Find the 12-point discrete Fourier transform (DFT) of the following sequence:

$$x[n] = \sin\left[\frac{\pi}{3}n\right] \cos\left[\frac{2\pi}{3}n\right]$$

Exercise 2: (5 points)

Consider the polynomial of degree 4 over GF[2]: $p(x) = p_0 + p_1x + p_2x^2 + p_3x^3 + p_4x^4$. In this problem, we are going to find all the degree four irreducible polynomials.

- 1) From the degree and the fact that neither 0 nor 1 is a root, show that we must have

$$p_0 = 1 \quad ; \quad p_4 = 1 \quad ; \quad p_1 + p_2 + p_3 = 1$$

- 2) Consider the polynomials $q(x)$ and $r(x)$ of degree two and one respectively and the irreducible polynomial of degree two $x^2 + x + 1$. From $p(x) = (x^2 + x + 1)q(x) + r(x)$, show that the polynomial $r(x) = r_0 + r_1x$ must satisfy:

$$r_0 = 1 + p_2 + p_3$$

$$r_1 = 1 + p_1 + p_2$$

- 3) In order for $p(x)$ to be irreducible, we must have $r(x) \neq 0$. Deduce the three irreducible polynomials of degree four.

Exercise 3: (5 points)

Consider a lossless transmission line with characteristic impedance $Z_0 = 50 \Omega$ terminated with a load equivalent to a 60Ω resistor and an inductor with inductance X_L . If the voltage standing wave ratio in the line is $\rho = 3$:

- Determine the load inductance reactance X_L .
- Find the reflection coefficient at a distance $\frac{\lambda}{8}$ from the load; with λ being the wavelength in the line.
- Find the minimum distance, as a function of λ , from the load at which the line impedance is resistive. What is the value of that resistance?

$\frac{2}{4}$

Exercise 4: (5 points)

A plane wave of 50 MHz frequency with electric field amplitude of 50 V/m traveling in air is normally incident upon a perfect conductor with $\epsilon_r = 1$, $\mu_r = 1$, and $\sigma = 2.78 \cdot 10^{-3} \text{ S/m}$.

Find,

- The reflection coefficient.
- The average power densities of the incident and reflected waves.
- The maximum amplitude of the total electric field in the air medium.

Note: $\epsilon_0 \cong [36 \pi \times 10^9]^{-1} \text{ F/m}$ and $\mu_0 = 4 \pi \times 10^{-7} \text{ H/m}$