GLASGOW COLLEGE UESTC

Exam paper

Communications Principles and Systems (UESTC3018)

Date: 3rd Jan. 2020
Time: 14:30-16:30

Attempt all PARTS. Total 100 marks

Use one answer sheet for each of the questions in this exam.
Show all work on the answer sheet.

Make sure that your University of Glasgow and UESTC Student Identification Numbers are on all answer sheets.

An electronic calculator may be used provided that it does not allow text storage or display, or graphical display.

All graphs should be clearly labelled and sufficiently large so that all elements are easy to read.

The numbers in square brackets in the right-hand margin indicate the marks allotted to the part of the question against which the mark is shown. These marks are for guidance only.

FORMULAE SHEET IS PROVIDED AT THE END OF PAPER

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Q1 (a) Sketch the block diagrams of analogue and digital communication systems demonstrating the major components of both. [10]

(b) Discuss the roles of modulation in analogue and digital communications demonstrating the similarities and differences between them. [5]

(c) Consider the passband signal

$$u_p(t) = A\,\mathrm{sinc}(Wt)\sin[2\pi ft + \phi], \text{ where } f > W/2.$$

i) Derive the baseband form of $u_p(t)$. [5]

ii) Determine the bandwidth of $u_p(t)$. [5]

Q2 Consider the message signal

$$m(t) = A\cos(2\pi f_m t + \phi)$$

and its DSB-SC modulated form

$$u_p(t) = m(t)\cos(2\pi f_c t), \text{ where } f_c > f_m.$$

(a) Determine the real parts $\mathrm{Re}[U_{LSB}(f)]$, $\mathrm{Re}[U_{USB}(f)]$ and imaginary parts $\mathrm{Im}[U_{LSB}(f)]$, $\mathrm{Im}[U_{USB}(f)]$ of the LSB and USB spectra of $u_p(t)$, $U_{LSB}(f)$ and $U_{USB}(f)$, respectively. [10]

(b) Derive the time domain expressions for the LSB and USB signals. [5]

(c) If $v_p(t)$ is the filtered version of $u_p(t)$, by employing a low pass filter with cut-off frequency $f_c - 0.5 f_m$, find the modulation format arisen from $v_p(t)$.[5]

(d) The conventional AM signal

$$u_{AM}(t) = 10\cos(2\pi f_c t) + m(t)\cos(2\pi f_c t)$$

is passed through an envelope detector. Can the message signal $m(t)$ be accurately recovered? [5]

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Q3 (a) Consider the FM signal

$$u(t) = 10\cos[1000\pi t + \cos(2\pi t)]$$

where t is in ms. Find an approximate value for the bandwidth of $u(t)$. [10]

(b) Consider the linearized first-order PLL system, i.e., with loop filter transfer function $G(s) = 1$, in which the input exhibits a frequency jump of $\Delta f = 1$ MHz.

i) Calculate the loop gain K such that the steady state error is at most 10 degrees. [10]

ii) Determine whether we can rectify the steady state error to become 0 degrees. [5]

Q4 Consider the modulating baseband signal

$$p(t) = \text{sinc}(Wt)$$

(a) Provide mathematical formulas and sketch the constellation diagrams for the following passband modulation techniques:

i) QPSK, [5]

ii) 32-QAM with rectangular constellation. [5]

(b) Determine the number of QPSK techniques contained in the 32-QAM and provide their respective mathematical formulas. [5]

(c) If we want to achieve a 120 Mbps data rate without intersymbol interference using 64-QAM, what should the value of W be? [10]

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FORMULAE SHEET

Common Functions

- Sinc Function: $\mathrm{sinc}(x) = \dfrac{\sin(\pi x)}{\pi x}$

- Indicator Function: $I_{[a,b]}(x) = \begin{cases} 1, & a \le x \le b \\ 0, & otherwise \end{cases}$

- Step Function: $u(x) = \begin{cases} 1, & x \ge 0 \\ 0, & otherwise \end{cases}$

Fourier and Inverse Fourier Transforms

Definitions

- Fourier Transform (FT): $S(f) = \int_{-\infty}^{\infty} s(t) e^{-j2\pi ft} dt$

- Inverse Fourier Transform (IFT): $s(t) = \int_{-\infty}^{\infty} S(f) e^{j2\pi ft} df$

- Notation: $s(t) \leftrightarrow S(f)$

Properties

- Time Shifting: $s(t - t_0) \leftrightarrow S(f) e^{-j2\pi f t_0}$

- Frequency Shifting: $s(t) e^{j2\pi f_0 t} \leftrightarrow S(f - f_0)$

- Modulation (cosine): $s(t)\cos(2\pi f_c t) \leftrightarrow \dfrac{1}{2}[S(f - f_c) + S(f + f_c)]$

- Modulation (sine): $s(t)\sin(2\pi f_c t) \leftrightarrow \dfrac{1}{2j}[S(f - f_c) - S(f + f_c)]$

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Pairs

- $\delta(t - t_0) \leftrightarrow e^{-j2\pi f t_0}$
- $e^{j2\pi f_0 t} \leftrightarrow \delta(f - f_0)$
- $W\,\mathrm{sinc}(Wt) \leftrightarrow I_{[-W/2, W/2]}(f)$
- $I_{[-T/2, T/2]}(t) \leftrightarrow T\,\mathrm{sinc}(Tf)$
- $\cos(2\pi f_c t) \leftrightarrow \frac{1}{2}[\delta(f - f_c) + \delta(f + f_c)]$
- $\sin(2\pi f_c t) \leftrightarrow \frac{1}{2j}[\delta(f - f_c) - \delta(f + f_c)]$

Laplace Transforms

- Definition: $G(s) = \int_0^{\infty} g(t) e^{-st} dt$
- Notation: $g(t) \;\square\; G(s)$
- Integration Property: $\int_0^t g(\tau) d\tau \;\square\; \frac{1}{s} G(s)$
- Step Function: $u(t) \;\square\; 1/s$, $\mathrm{Re}(s) > 0$
- Final Value Theorem: $\lim_{t \to \infty} g(t) = \lim_{s \to 0} [sG(s)]$

End of question paper