GLASGOW COLLEGE UESTC

Exam paper

Communications Principles and Systems (UESTC3018)

Date: 26th Dec. 2018
Time: 09:30-11:30 am

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 [25]

A) Design the block diagrams of analog and digital communication systems showing interactions of their major components. [10]

B) From the designs of A), justify the prevalence of digital communications by analyzing the major differences of the block diagrams. [5]

C) Consider the passband signal

$$u_p(t) = \sin c(2t)\cos(100\pi t)$$

where t is in *msec*.

i) Determine the carrier frequency and derive the baseband form of $u_p(t)$. [5]

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

Q2 [25]

A) Consider the message signal

$$m(t) = 2\cos[2\pi t + (\pi / 4)]$$

and its DSB-SC modulated form

$$u_p(t) = m(t)\cos(400\pi t)$$

where t is in *msec*.

i) Determine and plot the spectrum $|U_p(f)|$ of $u_p(t)$. [5]

ii) If $v_p(t)$ is the filtered version of $u_p(t)$ by employing a high pass filter with cut-off frequency *200 kHz*, determine and plot the spectrum $|V_p(f)|$ of $v_p(t)$. Characterize and justify the modulation format arisen from $v_p(t)$. [10]

B) Consider the message signal $m(t)$ with spectrum

$$M(f) = I_{[-2,2]}(f)$$

and the DSB-SC signal

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$$u_p(t) = 10m(t)\cos(300\pi t).$$

Frequency f is in *kHz*.

i) Determine and plot the spectrum $|U_p(f)|$ of $u_p(t)$. [5]

ii) The signal $u_p(t)$ is passed through an envelope detector. Determine the output signal of the envelope detector and analyze whether accurate detection is possible. [5]

Q3 [25]

A) Consider the angle modulated signal

$$u(t) = A\cos[2\pi f_c t + 4\pi \operatorname{sinc}(2t)].$$

Determine the time domain forms of the message signals in the cases of analog FM and PM. [10]

B) Consider the linearized first-order PLL model ($G(s)=1$), in which the input exhibits a constant frequency jump of $\Delta f = 1\ kHz$. Determine the loop gain K such that the steady state error is at most 5 degrees. [15]

Q4 [25]

Consider the modulating baseband signal to be defined as

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

A) Provide mathematical formulas and design the constellation diagrams for the following passband modulation techniques: 4ASK with equal distances between adjacent signals and antipodal signaling, QPSK, 8QAM with rectangular constellation. [15]

B) Determine W in order to have 40 *Mbps* data rate using 16QAM. [10]

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FORMULAE SHEET

➢ Common Functions

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

- 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**

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

➢**Laplace and Inverse Laplace Transforms**

- Notation: $g(t)$ € $G(s)$
- Integration: $\int_0^t g(t)d\tau$ € $\frac{1}{s}G(s)$
- Step Function: $u(t)$ € $1/\mathrm{s}$
- Final Value Theorem: $\lim_{t\to\infty} g(t) = \lim_{s\to 0} sG(s)$

End of question paper