FIJI INSTITUTE OF TECHNOLOGY

SCHOOL OF ELECTRICAL & ELECTRONIC ENGINEERING

ADVANCED DIPLOMA IN ENGINEERING
(ELECTRICAL & ELECTRONICS)

EEE607 – ELECTRONIC TECHNOLOGY (TELECOMMUNICATION)

EXAMINATION

INSTRUCTIONS TO CANDIDATES

1. Candidates are reminded that they should have no books, notes, paper or other material in their possession unless their use is specifically permitted by "Instructions to Candidates" set out below.
2. Reading time is of 10 minutes duration.
3. Examination time is of 3 hours duration.
4. Write your candidate number at the top of each attached sheet.
5. Attempt ALL questions in Section A and Section B.
6. Each question carries a different mark.
7. A Formula & Facts sheet is attached.
8. The 74LS153 datasheet is on page 15.
9. A Table of Bessel Functions is on the page 16.
10. Non-Programmable Calculators may be used.
11. Cellphones are not allowed in the examination venue.

Formula & Facts Sheet

1. $dB = 10\log_{10}\left(\frac{P_o}{P_i}\right)$

2. Entropy $H = \sum_{i=1}^{n} P_{xi} I_{xi} = \sum_{i=1}^{n} P_{xi} \log_2 \left(\frac{1}{P_{xi}}\right)$

3. $C = B\log_2\left(1 + \frac{S}{N}\right)$ bps

4. $\frac{S}{N} = 10\log_{10}\left(\frac{S}{N}\right)$

5. ε_0 = Permittivity of Free Space = $\frac{1}{36\pi} \times 10^{-9}\, F/m = 8.842 \times 10^{-12}\, F/m$

6. μ_0 = Permeability of Free Space = $4\pi \times 10^{-7}$ *H/m*

7. c = Speed of Light = $\frac{1}{\sqrt{\mu_o \varepsilon_o}} = 3 \times 10^8\, m/s$

8. $$\underline{A} \times \underline{B} = (AB\sin\theta)a_n = \begin{vmatrix} a_X & a_Y & a_Z \\ A_X & A_Y & A_Z \\ B_X & B_Y & B_Z \end{vmatrix} = -\underline{B} \times \underline{A}$$

9. $$\nabla = \frac{\partial(\ )}{\partial x}\underline{i} + \frac{\partial(\ )}{\partial y}\underline{j} + \frac{\partial(\ )}{\partial z}\underline{k}$$
$$\therefore \nabla\phi = \frac{\partial \phi}{\partial x}\underline{i} + \frac{\partial \phi}{\partial y}\underline{j} + \frac{\partial \phi}{\partial z}\underline{k}$$

10. $$h_{11}I_1 + h_{12}V_2 = V_1$$
$$h_{21}I_1 + h_{22}V_2 = I_2$$

11. $V = \frac{q}{2\pi\varepsilon} \ln\left(\frac{b}{a}\right)$ V

12. $L = \frac{\mu_0}{2\pi}\ln\left(\frac{b}{a}\right)$ H/m

13. $C = \frac{2\pi\varepsilon}{\ln\left(\frac{b}{a}\right)}$ F/m

14. $Z_o = \frac{60}{\sqrt{\varepsilon_r}}\ln\left(\frac{D}{d}\right)$ Ω

15. $v = \frac{c}{\sqrt{\varepsilon_r}}$ m/s

16. $f(x) = a_0 + \sum_{n=1}^{\infty} \left(a_n \cos \frac{n\pi x}{L} + b_n \sin \frac{n\pi x}{L} \right)$

17. $cosAcosB = \frac{1}{2}[cos(A+B) + cos(A-B)]$

18. $sinAsinB = \frac{1}{2}[cos(A-B) - cos(A+B)]$

19. $cosAsinB = \frac{1}{2}[sin(A+B) - sin(A-B)]$

20. $sinAcosB = \frac{1}{2}[sin(A+B) + sin(A-B)]$

21. $(x+a)^n = \sum_{k=0}^{n} \binom{n}{k} x^k a^{n-k}$

22. $(1+x)^n = 1 + \frac{nx}{1!} + \frac{n(n-1)x^2}{2!} + \cdots$

SECTION A [10 Marks)

1. Modulation may be defined as
   (a) a process which involves the mixing of time and frequency.
   (b)a process whereby some characteristic of a carrier wave is varied in accordance with the instantaneous value of a modulating signal.
   (c)varying the amplitude with frequency
   (d)varying the carrier with time

2. Suppose $G(x) = x^5 + x^3 + x + 1$. How will this be represented in CRC binary format?
   (a) G(x) = 111111
   (b) G(x) = 101111
   (c) G(x) = 110011
   (d) G(x) = 101011

3. The decimal equivalent of the two's complement number 1001 1101 is
   (a) -9
   (b) -43
   (c) -99
   (d) -101

4. Attenuation, limited bandwidth, noise and delay distortion will affect the
   (a) signal in a medium
   (b) critical angle
   (c) sampling rate
   (d) parity

5. The sampling frequency of 33 kHz is being used to ensure a 10% tolerance from the effects of aliasing. The signal of interest is
   (a) 10 kHz
   (b) 15 kHz
   (c) 20 kHz
   (d) 30 kHz

6. The input power to a transmission system is 24 W. If the attenuation of -9 dB, the output power is
   a. 3 W
   b. 6 W
   c. 9 W
   d. 12 W

7. Since attenuation increases with frequency, the equipment that helps to reduce this effect is the
   (a) transducer
   (b) optical amplifier
   (c) equalizer
   (d) transponder

8. A transmitter has 3 amplifying stages in cascade with gains of -7 dB, -12 dB and 20 dB respectively. The total gain of the system is

   (a) 1 dB
   (b) 24 dB
   (c) -12 dB
   (d) 30 dB

9. An agreement between parties on how communication should take place is referred to as
   (a) parity
   (b) protocol
   (c) damage control
   (d) treaty

10. Telecom Fiji Ltd's broadband connection has a maximum capacity of
   (a) 1 Gbps
   (b) 20 Mbps
   (c) 60 Mbps
   (d) 100 Mbps

SECTION B . [100 Marks]

Attempt all questions.

QUESTION 1: MEDIA

(a) Figure 1 below shows an unshielded twisted pair cable of length 1 km connecting a 12 W source and an output amplifier of gain 9 dB, terminating at the load, R_L. The cable has the following properties: $Z_0 = 120\ \Omega$, $C = 48$ pF/m, attenuation = 0.064 dB/m and there is no reflection. Determine the output power, P_o.

[4 marks]

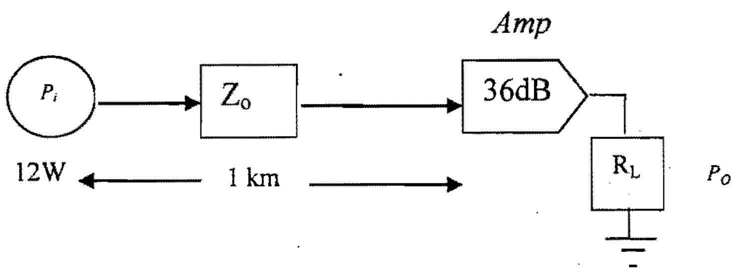


Figure 1: Unshielded Twisted Pair cable with Amplifier

(b) Refer to the Lossless Transmission Line in Figure 2 and the equations (1) and (2) which describe how *v* and *i* vary along a line.

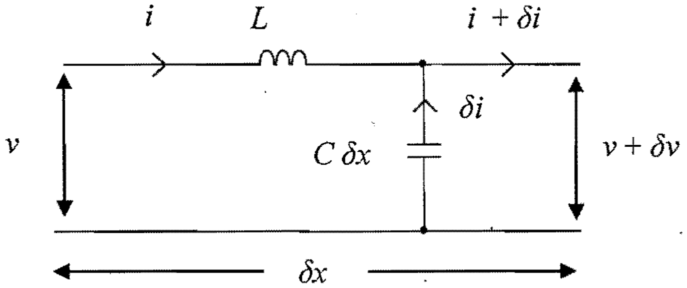


Figure 2: Lossless Transmission line

$$\delta v = -(L\delta x)\frac{\partial i}{\partial t}$$

$$\frac{\partial v}{\partial x} = -L\frac{\partial i}{\partial t} \quad \text{.................(1)}$$

$$\delta i = -\frac{\partial q}{\partial t} = -(C\delta x)\frac{\partial v}{\partial t}$$

$$\frac{\partial i}{\partial x} = -C\frac{\partial v}{\partial t} \quad \text{.................(2)}$$

Determine the second order partial differential equation forms of the following:

(i) 1st Telegrapher's Equation **[3 marks]**

(ii) 2nd Telegrapher's Equation **[3 marks]**

(c) Resolve for the maximum theoretical information (data) rate that can be achieved with a music system has a bandwidth of 15 kHz and a typical signal-to-noise ratio of 96 dB. Note the Shannon-Hartley law, $C = B\log_2\left(1+\frac{S}{N}\right)$.

[3 marks]

(d) Given the equivalent circuit of the Common Emitter amplifier in Figure 3, determine the small-signal equivalent circuit, with the transistor replaced by the *h*-parameter model. Reduce it to the Thevenin equivalent circuit. **[4 marks]**

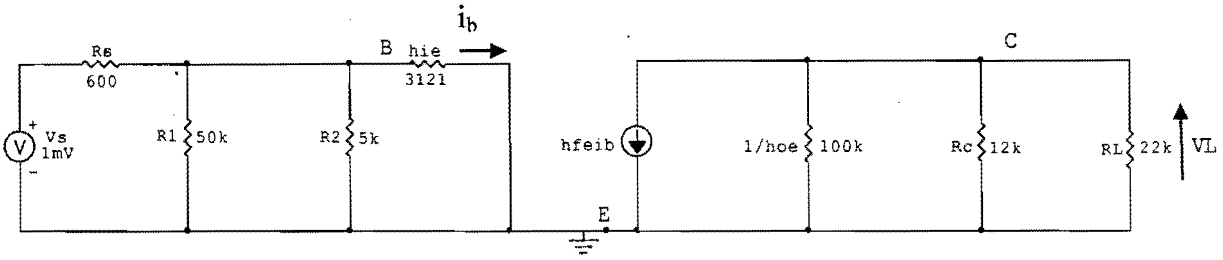


Figure 3: Common Emitter amplifier equivalent circuit

(e) Resolve for the Voltage Gains A_{vs} and A_v. **[3 marks]**

[TOTAL = 20 MARKS]

QUESTION 2: OSI; SERIAL COMMUNICATION

(a) Explain briefly on the reason for creating the OSI model. **[2 marks]**

(b) Describe what happens when data flows from the OSI model Application layer on the source computer. **[4 marks]**

(c) Explain what happens in data transmission via Asynchronous communication illustrated in the diagram following.

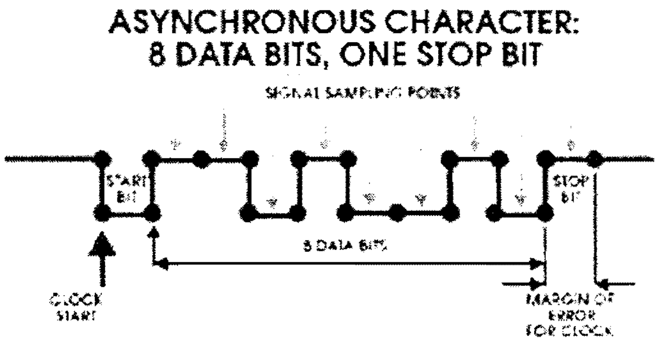


Figure 4: Asynchronous Character

[4 marks]

[TOTAL: 10 MARKS]

QUESTION 3: INFORMATION THEORY; NOISE

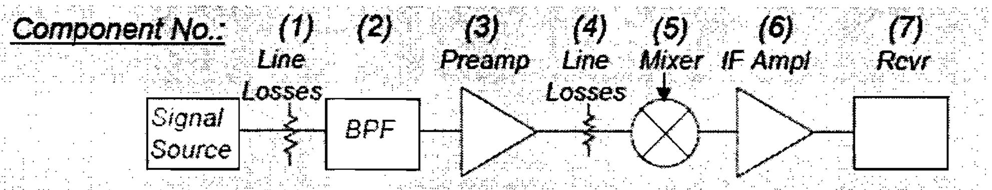
(a) Consider 2 messages with probabilities of 2/5 and 3/8. Determine the following:

(i) Information content of each message. **[2 marks]**

(ii) Entropy or the Average Information Content per message. **[2 marks]**

(b) Analyse the Cascaded system shown in Figure 5 and determine the total Noise Figure in the system knowing that in a cascaded system consisting of n devices,

$$F_{1-n} = F_1 + \frac{F_2 - 1}{G_1} + \frac{F_3 - 1}{G_1 G_2} + ... + \frac{F_n - 1}{G_1 G_2 ... G_{n-1}}$$



		(1)	(2)	(3)	(4)	(5)	(6)	(7)
G (dB)		-0.1	-0.3	20	-1	-6	30	
T, T_e°K	290	320	320		320	380		
F (dB)				3			1	15
G (Ratio)		0.977	0.933	100	0.794	0.25	1000	-
$G_{1\text{-}k}$ (Ratio)		0.977	0.912	91.15	72.38	18.17	18166	
F^* (Ratio)		1.026	1.079	2	1.286	4.906	1.259	31.62

Figure 5: A Cascaded system with Noise Figures

[6 marks]

[TOTAL = 10 MARKS]

QUESTION 4: MULTIPLEXING

Two mutually exclusive combinational logic control circuits are described by the Boolean functions, $f_1(C,B,A)=\sum_m(0,1,4,5,6,7)$ and $f_2=(C,B,A)=\sum_m(1,2,3,5)$. Realize the Boolean functions using each of the following procedures:

(a) Utilize the 74LS153 Dual 4-to-1 **Multiplexer** to implement the two functions where only one function is active at a time. Give explanations where appropriate. (Data sheet is given in the back).

[10 marks]

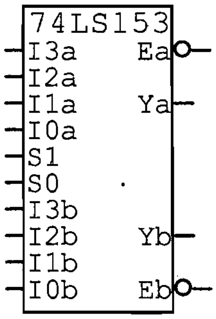


Figure 6: 74LS153 Dual 4-to-1 Mux

[TOTAL = 10 MARKS]

QUESTION 5: MODULATION

(a) The given signals are mixed (modulated) so that $v_c(t)$ is Amplitude Modulated by $v_m(t)$ signal: $v_m(t) = 3\cos(2\pi \times 1{,}000t)\,V$, $\quad v_c(t) = 120\cos(2\pi \times 10^6 t)\,V$.

Deduce the expression for the AM signal in the time domain, $s(t)$, given the trigonometric identity cosA cosB = ½(cos[A+B] + cos[A-B]). **[3 marks]**

The AM signal is,

$$s(t) = A_c[1 + \mu\cos(2\pi f_m t)]\cos(2\pi f_c t); \quad \mu = \frac{A_m}{A_c} = \frac{V_m}{V_c}$$

(b) An AM Superheterodyne receiver uses an IF frequency of 455 kHz. A radio station at 1200 kHz modulates its carrier with a maximum audio frequency of 9 kHz.

(i) What are the highest and lowest frequency components that are actually broadcast by the station? **[2 marks]**

(ii) What are the highest and lowest frequencies that must be passed without much loss by the receiver's IF amplifier to recover the original audio signal with full bandwidth? **[2 marks]**

(c) Design a block diagram representation of a Modulation system that will modulate a 2 MHz carrier signal with a 5 kHz audio signal to produce the difference of the 2 MHz and 5 kHz at the output. No other output signal is produced.

The components available to you are 3 crystal oscillators rated at 10 MHz, 12 MHz, and 20 MHz respectively. All types of filters are available, together with a signal generator with a maximum frequency of 800 KHz.

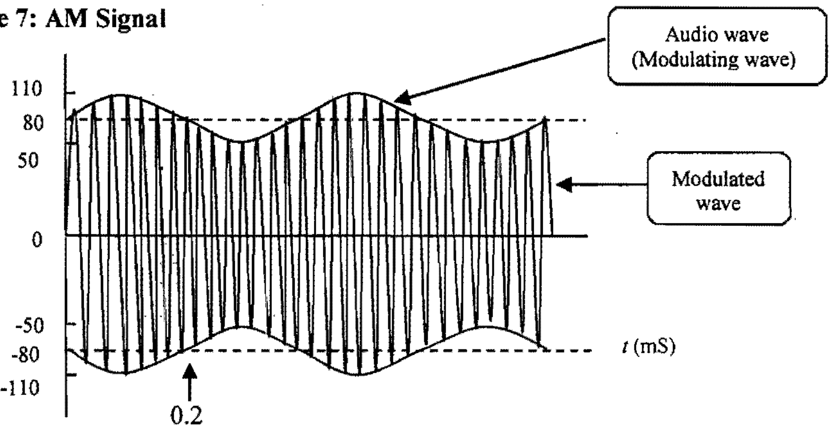
Assume that all the required power is connected to the system – you do NOT have to show the power connections. Label the diagram clearly. **[3 marks]**

[TOTAL = 10 MARKS]

QUESTION 6: AMPLITUDE MODULATION; FREQUENCY MODULATION [20 MARKS]

(a) Refer to the AM signal shown whose carrier angular frequency ω_c is $10^6\pi$ rad/s. The transmitted power is 2.8 kW.

Figure 7: AM Signal



(i) Derive the equation for the audio signal. **[2 marks]**

(ii) Find the equation of the carrier signal. **[2 marks]**

(iii) Determine the actual equation of the AM signal in Figure 3 given the general equation for the AM signal below.

$$s(t) = E_c\left[1+\left(\frac{E_m}{E_c}\right)\cos(\omega_m t)\cos(\omega_c t)\right] = E_c\cos(\omega_c t)+\frac{mE_c}{2}\cos(\omega_c t+\omega_m t)+\frac{mE_c}{2}\cos(\omega_c t-\omega_m t)$$

[2 marks]

(iv) Analyse the system to find the power content of the carrier and each of the sidebands. **[3 marks]**

(b) Consider an FM signal with a maximum deviation of 32 kHz, which is modulated with an audio frequency of 4 kHz.

(i) Resolve the required bandwidth using the Bessel Functions table. **[3 marks]**

(ii) Use Carson's rule to determine the required bandwidth. **[2 marks]**

(c) An FM signal is represented by $v_c(t) = 960\sin\left(8.4\times10^{8}t + 5\sin 2\pi\times 4000t\right)$.
Determine the following:

(i) Carrier frequency, f_c, and modulating frequency, f_m. **[2 marks]**

(ii) Modulation Index, m_f, and Maximum frequency deviation Δf_c. **[2 marks]**

(iii) The FM power transmitted if the antenna resistance is 8 Ω. **[2 marks]**

[TOTAL = 20 MARKS]

QUESTION 7: ERROR CORRECTION & DETECTION; PARITY

(a) The data, M(x) = 1100 1001, is transmitted over the PSTN while P(x) = 10 1110 is the Check Pattern. The Cyclic Redundancy Check method is used to detect any error in transmission of data

(i) Derive the Frame Check Sequence (FCS) and the Transmitted Data **[4 marks]**

(ii) Briefly describe how CRC checks for error in the received data. **[2 marks]**

(b) Determine the Even Parity and the Odd Parity bit for the following data:

(i) 110 1000 **[2 marks]**

(ii) 110 0000 **[2 marks]**

[TOTAL = 10 MARKS]

QUESTION 8: FOURIER SERIES

A periodic current waveform is given by, $i(t) = \begin{cases} 20, & 0 \le t < 2 \\ 0, & 2 \le t < 4 \end{cases}$ **Amps, and** $i(t+4) = i(t)$.

(a) Sketch 3 periods of the function i*(t)* and label clearly. **[2 marks]**

(b) Determine the coefficients a_o, a_n, and b_n. **[4 marks]**

(c) Synthesize the first 4 terms of the Fourier series of *v(t).* **[4 marks]**

[TOTAL = 10 MARKS]

[THE END]

Table 1: Datasheet for the 74LS153 Dual 4-to-1 Multiplexer

FAIRCHILD
SEMICONDUCTOR™

August 1986
Revised March 2000

DM74LS153
Dual 1-of-4 Line Data Selectors/Multiplexers

General Description

Each of these data selectors/multiplexers contains inverters and drivers to supply fully complementary, on-chip, binary decoding data selection to the AND-OR-invert gates. Separate strobe inputs are provided for each of the two four-line sections.

Features

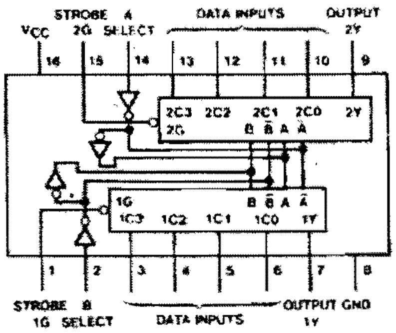
- Permits multiplexing from N lines to 1 line
- Performs at parallel-to-serial conversion
- Strobe (enable) line provided for cascading (N lines to n lines)
- High fan-out, low impedance, totem pole outputs
- Typical average propagation delay times
  - From data 14 ns
  - From strobe 19 ns
  - From select 22 ns
- Typical power dissipation 31 mW

Ordering Code:

Order Number	Package Number	Package Description
DM74LS153M	M16A	16-Lead Small Outline Integrated Circuit (SOIC), JEDEC MS-012, 0.150 Narrow
DM74LS153N	N16E	16-Lead Plastic Dual-In-Line Package (PDIP), JEDEC MS-001, 0.300 Wide

Devices also available in Tape and Reel. Specify by appending the suffix letter "X" to the ordering code.

Connection Diagram



Function Table

Select Inputs		Data Inputs				Strobe	Output
B	A	C0	C1	C2	C3	G	Y
X	X	X	X	X	X	H	L
L	L	L	X	X	X	L	L
L	L	H	X	X	X	L	H
L	H	X	L	X	X	L	L
L	H	X	H	X	X	L	H
H	L	X	X	L	X	L	L
H	L	X	X	H	X	L	H
H	H	X	X	X	L	L	L
H	H	X	X	X	H	L	H

Select inputs A and B are common to both sections.
H = HIGH Level
L = LOW Level
X = Don't Care

 DS006393 www.fairchildsemi.com

Table 2: BESSEL FUNCTIONS

x	n														
(m_f)	J_0	J_1	J_2	J_3	J_4	J_5	J_6	J_7	J_8	J_9	J_{10}	J_{11}	J_{12}	J_{13}	J_{14}
0.00	1.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.25	0.98	0.12	-	-	-	-	-	-	-	-	-	-	-	-	-
0.5	0.94	0.24	0.03	-	-	-	-	-	-	-	-	-	-	-	-
1.0	0.77	0.44	0.11	0.02	-	-	-	-	-	-	-	-	-	-	-
1.5	0.51	0.56	0.23	0.06	0.01	-	-	-	-	-	-	-	-	-	-
2.0	0.22	0.58	0.35	0.13	0.03	-	-	-	-	-	-	-	-	-	-
2.4	0.00	0.52	0.43	0.20	0.06	-	-	-	-	-	-	-	-	-	-
2.5	-0.05	0.50	0.45	0.22	0.07	0.02	-	-	-	-	-	-	-	-	-
3.0	-0.26	0.34	0.49	0.31	0.13	0.04	0.01	-	-	-	-	-	-	-	-
4.0	-0.40	-0.07	0.36	0.43	0.28	0.13	0.05	0.02	-	-	-	-	-	-	-
5.0	-0.18	-0.33	0.05	0.36	0.39	0.26	0.13	0.05	0.02	-	-	-	-	-	-
5.5	0.00	-0.34	-0.12	0.26	0.40	0.32	0.19	0.09	0.03	0.01	-	-	-	-	-
6.0	0.15	-0.28	-0.24	0.11	0.36	0.36	0.25	0.13	0.06	0.02	-	-	-	-	-
7.0	0.30	0.00	-0.30	-0.17	0.16	0.35	0.34	0.23	0.13	0.06	0.02	-	-	-	-
8.0	0.17	0.23	-0.11	-0.29	-0.10	0.19	0.34	0.32	0.22	0.13	0.06	0.03	-	-	-
8.65	0.00	0.27	0.06	-0.24	-0.23	0.03	0.26	0.34	0.28	0.18	0.10	0.05	0.02	-	-
9.0	-0.09	0.24	0.14	-0.18	-0.27	-0.06	0.20	0.33	0.30	0.21	0.12	0.06	0.03	0.01	-
10.0	-0.25	0.04	0.25	0.06	-0.22	-0.23	-0.01	0.22	0.31	0.29	0.20	0.12	0.06	0.03	0.01

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