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University of the Witwatersrand, Johannesburg

Course or topic No(s)	ELEN3024
Course or topic name(s) Paper Number & title	Communication Fundamentals
Examination/Test* to be held during month(s) of (*delete as applicable)	September 2012
Year of Study (Art & Sciences leave blank)	Third
Degrees/Diplomas for which this course is prescribed (BSc (Eng) should indicate which branch)	B.Sc (Eng) Elec.
Faculty/ies presenting candidates	Engineering
Internal examiners and telephone number(s)	Dr. D.J.J. Versfeld x7212
External examiner(s)	Dr. K. Ouahada
Special materials required (graph/music/drawing paper) maps, diagrams, tables, computer cards, etc)	None
Time allowance	Course Nos: ELEN3024 — Hours: One
Instructions to candidates (Examiners may wish to use this space to indicate, inter alia, the contribution made by this examination or test towards the year mark, if appropriate)	Answer *ALL* questions. Type '2' Examination - Written A4 permitted. Show all working.

Internal Examiners or Heads of Department are requested to sign the declaration overleaf

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Note: Show all workings, complete with the necessary comments. Marks will be allocated for all working and logical reasoning and not just for the correct answer.

Question 1

Refer to Fig. 1. Assume that the input signal is $r(t) = A_c(1+a \cdot A_m \cos(2\pi f_m t))\cos(2\pi f_c t)$.

a.) Show how the circuit can be modelled using a block diagram, given that the switch is closed. Indicate all relevant components.

(5 marks)

b.) Give a mathematical expression for $m(t)$ when the switch is open. (You do not have to simplify the equation.)

(3 marks)

c.) Give a mathematical expression for $m(t)$ when the switch is closed.

(4 marks)

d.) Explain the significance of the signal $m(t)$ when the switch is closed.

(3 marks)

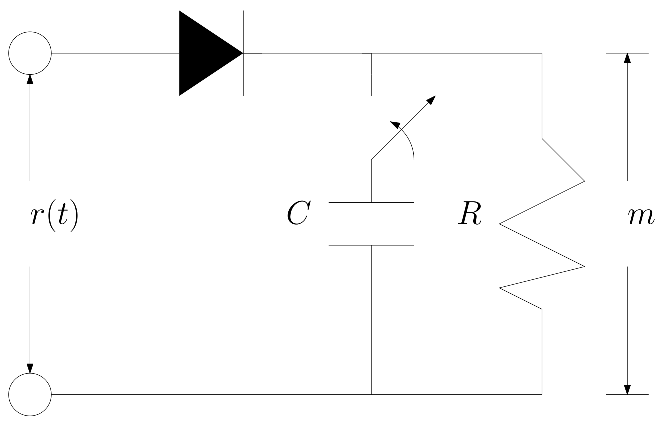

Figure 1: Receiver

(Total 15 marks)

Question 2

Using Euler's formula ($e^{ix} = \cos x + i \sin x$), show that

$$\cos x \cos y = \frac{1}{2}\left[\cos(x+y) + \cos(x-y)\right].$$

(Total 5 marks)

Question 3

The modulating signal into an FM modulator is

$$m(t) = 4.36 \cos 16\pi t.$$

The output of the FM modulator is

$$u(t) = 10 \cos \left[4000\pi t + 2\pi k_f \int_{-\infty}^{t} m(\tau) d\tau \right],$$

where $k_f = 10$.

(a) Determine and sketch the output spectrum showing the relative amplitudes of the side frequencies.

(5 marks)

(b) Determine the bandwidth.

(2 marks)

(c) Determine the approximate minimum bandwidth using Carsons rule.

(2 marks)

(d) Derive a general expression depicting the composite wave consisting of the various frequency components. (Your equation must show all significant frequency components.)

(3 marks)

(e) If the output of the FM modulator is passed through an ideal bandpass filter centered at $f_c = 2000$ Hz with a bandwidth of 66 Hz, determine the power of the frequency components at the output of the filter. What percentage of the transmitter power appears at the output of the bandpass filter?

(5 marks)

(f) Determine the maximum frequency-deviation for the system.

(2 marks)

(g) What is the effect on the bandwidth of the output signal $u(t)$, if both the amplitude A_m and frequency f_m of the message $m(t)$ are doubled?

(1 marks)

(Total 20 marks)

Question 4

A superheterodyne FM receiver operates in the frequency range of 88 - 108 MHz. The intermediate frequency (f_{IF}) and local oscillator frequencies (f_{LO}) are chosen such that $f_{IF} < f_{LO}$. We require that the image frequency f_c' fall outside of the 88 - 108 MHz region. Determine the minimum required f_{IF} and the range of variations in f_{LO}?

(Total 5 marks)

(Test Total 45 marks)

Table 1: Bessel functions of the first kind, $J_n(m)$

β	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	0.52	0.43	0.20	0.06	0.02									
2.5	-0.05	0.50	0.45	0.22	0.07	0.02	0.01								
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						
5.45	0	-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	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	0.25	0.14	-0.18	-0.27	-0.06	0.20	0.33	0.31	0.21	0.12	0.06	0.03	0.01	
10.0	-0.25	0.05	0.25	0.06	-0.22	-0.23	-0.01	0.22	0.32	0.29	0.21	0.12	0.06	0.03	0.01