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University of the Witwatersrand, Johannesburg

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| Course or topic No(s) | ELEN3024 |
| Course or topic name(s)<br>Paper Number & title | Communication Fundamentals |
| Examination/Test* to be held during month(s) of<br>(*delete as applicable) | September 2011 |
| Year of Study<br>(Art & Sciences leave blank) | Third |
| Degrees/Diplomas for which this course is prescribed<br>(BSc (Eng) should indicate which branch) | B.Sc (Eng) Elec. |
| Faculty/ies presenting candidates | Engineering |
| Internal examiners and telephone number(s) | Mr. DJJ Versfeld x7212 |
| External examiner(s) | Dr. Ouhada |
| 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.<br>Type '2' Examination. |

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.

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## Question 1

The output when no modulation is applied to an AM Double Sideband Full Carrier modulator is a 750 kHz carrier with amplitude of 25V. When the modulating input of 10 kHz is applied, it is of sufficient amplitude to cause a change in the output wave of ± 6V. Determine:

(a) Upper and lower side frequencies.

(b) Modulation coefficient.

(c) Peak amplitude of the modulated carrier and the upper and lower side frequency voltages.

(d) Expression for the modulated carrier.

(e) Sketch the output spectrum.

(f) Sketch the output signal.

( Total 10 marks)

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## Question 2

Consider AM Double Sideband Full Carrier modulation.

(a) Show that the total power $P_t$ is given by $P_t = P_c\left(1 + \frac{\mu^2}{2}\right)$, where $P_c$ is the power of the unmodulated carrier. Assume that the average power dissipated in a load by a sinusoidal wave is $P = \frac{(0.707V)^2}{R}$, where $V$ is the amplitude of the sinusoidal wave and $R$ is the load resistance.

(b) Determine the maximum carrier, upper, lower, and total sideband power for an unmodulated carrier power $P_c = 2.5$ kW.

( Total 10 marks)

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## Question 3

For an FM modulator with modulation index $\beta = 2$, modulating signal $v_m(t) = V_m\cos(2\pi 2000t)$ $(V)$, and an unmodulated carrier $v_c(t) = 8\cos(2\pi 800kt)$ $(V)$,

(a) Determine the number of sets of significant sidebands.

(b) Determine their amplitudes in volts.

(c) Sketch the frequency spectrum showing the relative amplitudes of the side frequencies.

(d) Determine the bandwidth.

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

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

(g) Fig. 1 depicts a superheterodyne receiver for an FM wave. Sketch the spectrum of the input signals to each component depicted in Fig. 1, when the FM wave described above is used as input. The following assumptions can be made:

- The intermediate frequency is 50 KHz, and high-side injection can be assumed, i.e., the frequency produced by the local oscillator is always greater than the carrier frequency.
- Assume that the channel bandwidth is the same as the bandwidth of the system (calculated in Question 2.b) and no guard bands (on either side) is needed.

For this setup, identify the image frequency and also specify the cutoff frequencies of the IF section.

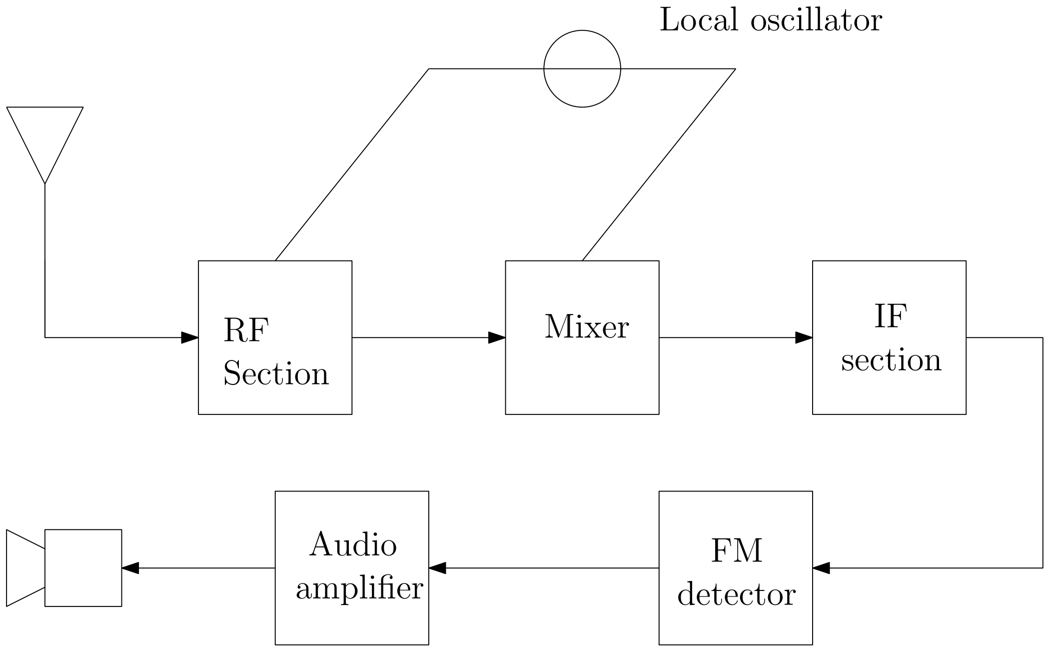


Figure 1: Receiver

( Total 20 marks)

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( Test Total 40 marks)

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

| $\beta$ | $J_0$ | $J_1$ | $J_2$ | $J_3$ | $J_4$ | $J_5$ | $J_6$ | $J_7$ | $J_8$ | $J_9$ | $J_{10}$ | $J_{11}$ | $J_{12}$ | $J_{13}$ | $J_{14}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 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 |