
UNIVERSITI SAINS MALAYSIA

Second Semester Examination
Academic Session 2007/2008

April 2008

EEE 530 – COMMUNICATIONS CIRCUITS AND SYSTEMS

Duration: 3 hours

Please check that this examination paper consists of NINE pages of printed material and ONE page Appendix before you begin the examination.

This paper contains SIX questions.

Instructions: Answer FIVE (5) questions.

Answer to any question must start on a new page.

Distribution of marks for each question is given accordingly

All questions must be answered in English.

1. Double-sideband amplitude modulation consists of standard amplitude modulation AM and suppressed-carrier double sideband modulation SSB

(a) The unique property of AM is the envelope of the modulated carrier has the same shape as the message. Denoting the unmodulated carrier amplitude as $x(t)$, modulation by $x(t)$ produces the modulated envelope

$$A(t) = A_c [1 + \mu x(t)]$$

Discuss the AM signals and spectra and include the following information in your discussion. (modulation index μ , fourier transform, average transmitted power S_T , transmission bandwidth, AM spectrum, AM waveform)

(40%)

(b) **Proof** that by interpreting the average transmitted power as

$$S_T = P_c + 2P_{sb}$$

at least 50% of the total transmitted power resides in the carrier and thus conveys no message information. **How** does the wasted carrier power in amplitude modulation can be eliminated, state your answer?

(10%)

(c) The modulators and transmitters employs few methods to modulate DSB and SSB. Using Figure 1, explain briefly the system shown by the balanced modulator and phase shift method and state your assumption in your explanation if possible.

(50%)

2. (a) Using the Figure 2 shown below, explain these terms and state their equations appropriately

- (i) Mean value $\overline{v(t)}$
- (ii) Autocorrelation function $R_v(t_1, t_2)$
- (iii) Crosscorrelation function $R_{vw}(t_1, t_2)$
- (iv) Uncorellated $R_{vw}(t_1, t_2)$

(30%)

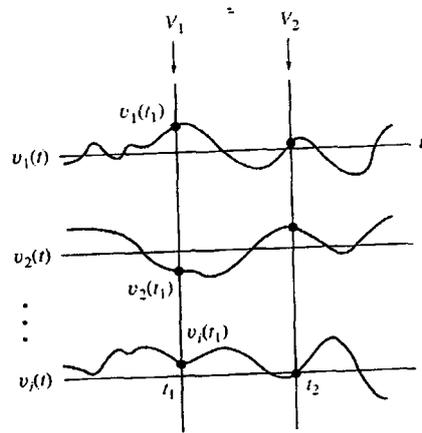


Figure 2

(b) The random variable X has a uniform distribution over $0 \leq x \leq 2$. Find

$\overline{v(t)}$, $R_v(t_1, t_2)$, and $\overline{v^2(t)}$ for the random process $v(t) = 6e^{-Xt}$

(20%)

- (c) The diagram shown in Figure 3 shows a simple analog signal baseband transmission. Explain the process from the arrival of average signal power source S_x to $S_D + N_D$ and produce the output using S_R (average received signal power), N_0 (source noise temperature) and W (message bandwidth).

(50%)

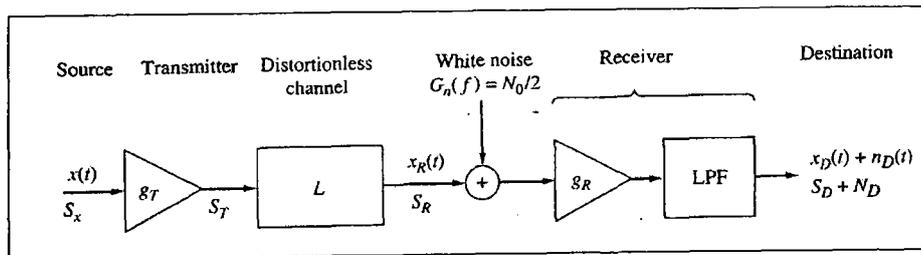


Figure 3

3. (a) Referring to Figure 4, a modulated signal $x_c(t)$ with receiver signal power $S_R = \overline{x_c^2}$, the additive noise at the receiver's input, total signal-plus-noise at the detector becomes $v(t) = x_c(t) + n(t)$ where $n(t)$ is the predetection noise (white noise). The filtered output of $n(t)$ has spectral density $G_n(f) = \frac{N_0}{2} |H_R(f)|^2$. Discuss the predetection signal-to-noise ratio $\left(\frac{S}{N}\right)_R$ and its relation with respect to signal-to-

noise ratio (relative to baseband) $\gamma \Delta = \frac{S_R}{N_0 B_T}$.

(50%)

- (b) In an ideal synchronous detector with DSB modulation, $v(t) = [A_c x(t) + n_i(t)] \cos \omega_c t - n_q(t) \sin \omega_c t$: Show that the destination signal-to-noise ratio is given as γ when $B_T = 2W$ and $S_R = A_c^2 S_x / 2$.

Note:

$$\gamma = \left(\frac{S}{N} \right)_D = \frac{S_R}{N_o \omega}$$

(20%)

- (c) - Discuss the situation when signal-to-noise ratio is called threshold effect and show that the threshold level using the *Rayleigh function*

$$P(A_c \geq A_n) = 0.99 \text{ requires that } \left(\frac{S}{N} \right)_{Rth} = 4 \ln 10 \approx 10 .$$

$$P(A_n > a) = e^{-a^2 / 2N_R}$$

Note: the *Rayleigh equation* shows the probability that A_n exceeds some specified value a .

(30%)

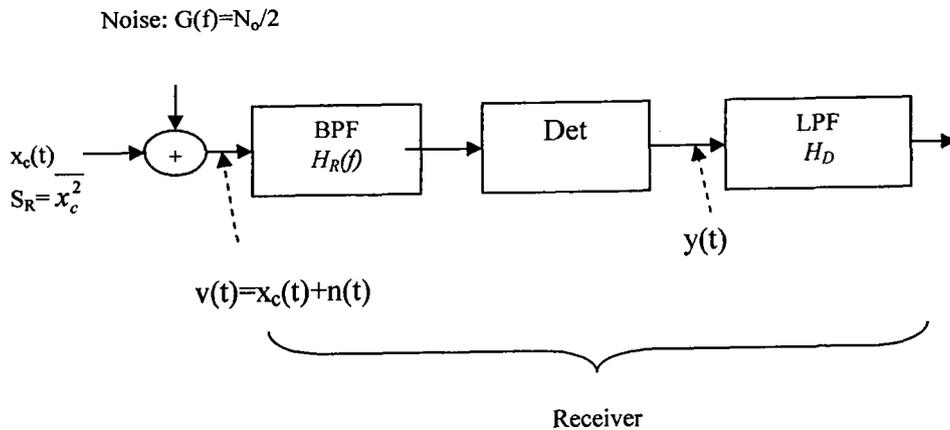


Figure 4: Model of CW communication system with noise

4. (a) Describe 2 type of receivers and give their advantages and disadvantages including their applications.

(20%)

- (b) A double-sided signal of the form $V_{RF}(t) = V_U \cos(\omega_{LO} + \omega_{IF})t + V_L \cos(\omega_{LO} - \omega_{IF})t$ is applied to a mixer with an LO voltage given by $v_{LO}(t) = \cos 2\pi f_{LO}t$ where at one side is shifted by 90° as shown in Figure 4 below. The patch antenna gives 0 phase shift at one output port and 180° at the other. Derive the output of the mixer after low pass filtering and after combination at the IF coupler.

(50%)

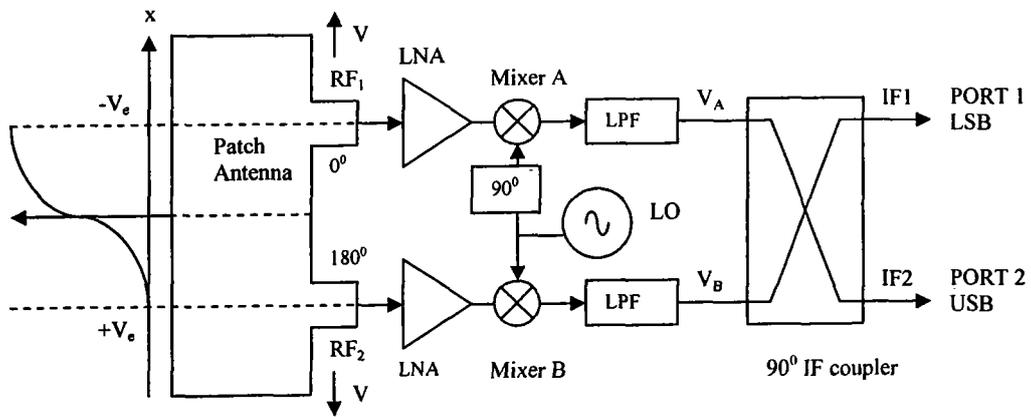


Figure 4

- (c) The percent modulation of an AM wave changes from 40%-60%. Originally the power content at the carrier frequency was 900W. Determine the power content at the carrier frequency and within each of the sidebands after the percent modulation has risen to 60%

(30%)

5. (a) In a Colpitts oscillator, C_1 and C_2 are shunted by transistor and stray capacitances. An additional capacitance slightly alters the frequency of oscillation. Figure 5(a) below shows how the oscillating frequency can be made nearly independent of the transistor and stray capacitances. An additional capacitor C_3 has been added to the tank circuit. This capacitor is much smaller than either C_1 and C_2 . As a result, the equivalent tank capacitance is approximately equal to C_3 . This type of oscillator is known as a Clapp oscillator. If C_3 is adjusted to 10.57 pF, calculate the following:

- (i) the feedback fraction, B
- (ii) f_{osc} , oscillating frequency
- (iii) X_{C1} , X_{C2} , X_{C3} and X_L
- (iv) X_T of the L1C2C3 branch

(50%)

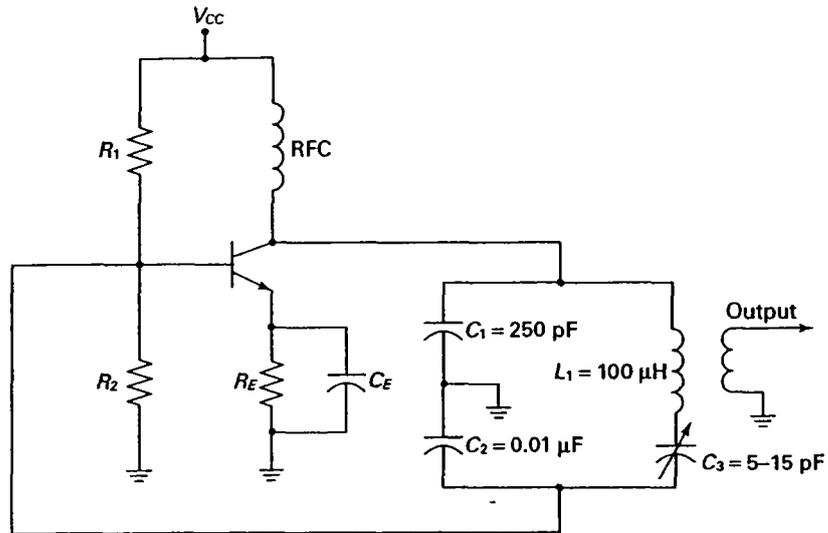


Figure 5(a)

(b) In Figure 5(b) below assume N is variable between 50 and 75. Calculate.

- (i) $f_{0(min)}$
- (ii) $f_{0(max)}$
- (iii) f_{CH}

The variables have their usual meaning.

(30%)

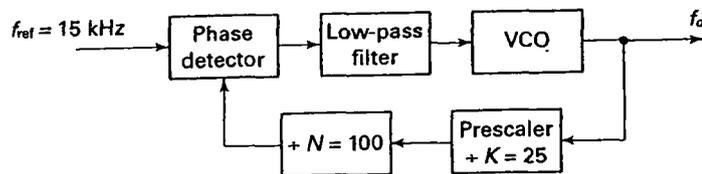


Figure 5(b)

- (c) Explain in details the operations of PLL (phase lock-loop) and its applications.

(20%)

6. (a) What is the difference between directive gain and directivity? What can you conclude if the directivity of an antenna is unity?

(10%)

- (b) An electric dipole of length 40 cm is situated in free space. If the maximum value of the current is 35 A and its frequency is 50 MHz. Determine:

- (i) The electric and magnetic fields in the far zone
- (ii) The average power density
- (iii) The radiation resistance

(40%)

- (c) Sketch the field pattern in the xy-plane of a 10 elements, Hertzian dipole, linear array when the spacing between the elements is $\lambda/4$ and the phase shift is 90° .

(25%)

- (d) A 9 GHz tracking radar is tracking a 0.02 m^2 target at a range of 100 km. If the gain of the common transmitting and receiving antenna is 45 dB and the transmitter power is 1 MW, find the received signal P_R in dBm.

(25%)

E dan H fields:

$$\vec{H} = \frac{j\beta I l}{4\pi r} \sin \theta e^{-j\beta r} \vec{a}_\phi$$

$$\vec{E} = \eta \vec{H}$$

$$\eta = 120\pi, \beta = \frac{\omega}{c}$$

$$\text{Power density, } \vec{S} = \frac{1}{2} [\vec{E} \times \vec{H}]$$

$$\text{Radiated power, } P_{rad} = \frac{\eta}{12\pi} \beta^2 l^2 I^2$$

Antena tatasusunan (array):

$$E_p = \frac{E_0}{\sqrt{n}} [1 + e^{j\theta} + e^{j2\theta} + \dots + e^{j(n-1)\theta}]$$

$$[1 + e^{j\theta} + e^{j2\theta} + \dots + e^{j(n-1)\theta}] = \frac{\sin(\frac{n\theta}{2})}{\sin(\theta/2)}$$

$$\theta = \frac{2\pi d \cos \phi}{\lambda} \pm \alpha$$

$$E_p = \sqrt{2} E_0 \cos\left(\frac{\theta + \alpha}{2}\right) \text{ untuk 2 elemen}$$

Normalized array:

$$F(\psi) = \frac{\sin(n\psi/2)}{\sin(\psi/2)}$$

$$\alpha = \beta d \cos \phi$$

$$\text{Null point: } \psi = \pm \frac{2p\pi}{n} \quad p=1,2,3$$

$$\text{Maximum point: } \psi = \pm \frac{(2q+1)\pi}{n} \quad q=1,2,3,\dots$$

$$\text{Max. amplitude: } = \frac{n}{1.5\pi}$$

$$\text{Radar equation: } P_R = \frac{P_T G^2 \lambda^2 \sigma}{(4\pi)^3 R^4}$$