Student Name: _____________________
Student ID #: ______________________
(Last 4 digits only)

EE4330 Section 001
Fundamentals of Telecommunications Systems

INSTRUCTOR: Dr. K. R. Rao

Fall 2006, Test 2
Thursday, 2 November 2006

11:00 am – 12:20 pm (1 Hour and 20 minutes)

INSTRUCTIONS:

1. Closed books and closed notes.
2. Any additional information required is attached to the test, you can only use the four-page cheat sheet handout.
3. Choose only one answer from the options given, and show all your work.
4. Please print your name and last four digits of your ID.
(Q1) Determine the basic block components (i), (ii), and (iii) of the given PLL (Phase-Locked Loop) operation diagram in Fig. 1,

\[
A \sin(\omega t + \theta_i) \rightarrow (i) \rightarrow (ii) \rightarrow e_c(t) \leftarrow (iii) \leftarrow B \cos(\omega t + \theta_o)
\]

where \(\otimes\) is multiplier and \(\oplus\) is adder

(i) , (ii) , (iii)

A. \(\otimes\) , VCO , Loop filter
B. \(\otimes\) , Loop filter, VCO
C. \(\oplus\) , VCO , Loop filter
D. \(\oplus\) , Loop filter, VCO

Fig. 1.

(Q2) Which is TRUE about the PLL?

A. Loop filter in PLL is a low-pass filter.
B. PLL tracks the phase and frequency of the carrier component of the received signal.
C. Both A and B are correct.
D. None of the above.

(Q3) What is/are the applications of PLL?

A. FM demodulator
B. Frequency divider
C. Frequency multiplier
D. All of the above
(Q4) Superheterodyne receiver in Fig. 2, is designed to receive the frequency band 540 kHz to 1300 kHz with IF frequency 260 kHz. Receiver frequency converter uses UP-conversion. Determine the range of frequencies generated by local oscillator for this receiver.

**Fig. 2.**

A. 800 to 1560 kHz  
B. 800 to 1040 kHz  
C. 280 to 1040 kHz  
D. 280 to 1560 kHz

(Q5) From (Q4), find image frequency, given an incoming RF signal with carrier frequency 1000 kHz. Image frequency is the carrier frequency of the interfering signal.

A. 1000 kHz  
B. 1260 kHz  
C. 1520 kHz  
D. None of the above
(Q6) Given message signal \( m(t) \),

![Diagram](image_url)

Determine the function names in blank blocks (i) and (ii) of Fig. 3.

(i) A. Integrator, Differentiator  
B. Integrator, PLL  
C. Differentiator, Integrator  
D. Differentiator, PLL

(ii) A.  
B.  
C.  
D.  

(Fig. 3.)

(Q7) Find the instantaneous phase deviation (in radians) of an angle modulated signal \( x(t) \), where \( x(t) = \cos[1000\pi t + \sin(2t) - 2\cos(\pi t)] \), given \( \cos(1000\pi t) \) is the carrier.

A. \( \sin(2t) - 2\cos(\pi t) \)  
B. \( 2\cos(2t) - 2\pi\sin(\pi t) \)  
C. \( \frac{1}{\pi}\cos(2t) + \sin(\pi t) \)  
D. \( \frac{1}{2\pi}\sin(2t) + \frac{1}{\pi}\cos(\pi t) \)

(Q8) From (Q7), find the instantaneous frequency deviation (in Hz).

A. \( \sin(2t) - 2\cos(\pi t) \)  
B. \( 2\cos(2t) - 2\pi\sin(\pi t) \)  
C. \( \frac{1}{\pi}\cos(2t) + \sin(\pi t) \)  
D. \( \frac{1}{2\pi}\sin(2t) + \frac{1}{\pi}\cos(\pi t) \)
(Q9) Given an FM signal \( y(t) = 5 \cos[10^6 \cdot \pi t + 2 \sin(3000 \pi t)] \), and \( 5 \cos(10^6 \cdot \pi t) \) is the carrier. Find the peak frequency deviation (in kHz).

A. 1 kHz  
B. 3 kHz  
C. 6 kHz  
D. 1000 kHz

(Q10) From (Q9), find the modulation index, given the bandwidth of message signal is 1.5 kHz.

A. 0.5  
B. 1  
C. 2  
D. 4

(Q11) From (Q9) and (Q10) estimate the bandwidth (in kHz) of this FM signal using Carson’s rule.

A. 3 kHz  
B. 6 kHz  
C. 9 kHz  
D. 18 kHz

(Q12) Message signal \( m(t) = 10 \sin(20 \pi t) \) is frequency modulated by a carrier, \( 20 \cos(1000 \pi t) \). Find the FM signal, given \( k_f = 0.1 \)

A. \( 20 \cos[1000 \pi t + \sin(20 \pi t)] \)  
B. \( 20 \cos[1000 \pi t + 20 \pi \cos(20 \pi t)] \)  
C. \( 20 \cos[1000 \pi t + 100 \sin(20 \pi t)] \)  
D. \( 20 \cos[1000 \pi t - \frac{1}{20 \pi} \cos(20 \pi t)] \)

(Q13) From (Q12), determine the average power of the FM signal.

A. 50 Watts  
B. 200 Watts  
C. 1.8 kWatts  
D. 5 kWatts
(Q14) PM signal with modulating signal \( m(t) \) is **NBPM**, when,

A. \( |k_p m(t)| << 1 \)
B. \( |k_p m(t)| >> 1 \)
C. \( |k_p m(t)| = 1 \)
D. None of the above

(Q15) Output signal of the following modulating scheme in Fig. 4, is

(\( m(t) \) goes through DSB-SC modulator, then \( k_p \) is multiplied, addition, \( \pi/2 \) and \( A \cos(\omega_c t) \) are added, followed by output)

A. DSB-SC  
B. NBFM  
C. NBPM  
D. None of the above

(Q16) NBPM signal is given by \( x_{NBPM}(t) = [\cos(2000 t) - 0.01 \cos(20 t) \cdot \sin(2000 t)] \).  
Where \( k_p = 0.01 \), message signal \( \cos(20 t) \) has bandwidth 20 rad/sec, carrier frequency is 2000 rad/sec.  
Determine the bandwidth of NBPM signal in rad/sec.  

Hint: NBPM signal is similar to AM signal \( [A + m(t)] \cos(\omega_c t) \).

A. 10 rad/sec  
B. 40 rad/sec  
C. 2000 rad/sec  
D. 4000 rad/sec
(Q17) Given Bessel function table of \( J_n(\beta_1) \), where \( \beta_1 \) is a constant.

<table>
<thead>
<tr>
<th>( n )</th>
<th>( J_n(\beta_1) )</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>L</td>
</tr>
<tr>
<td>1</td>
<td>M</td>
</tr>
<tr>
<td>2</td>
<td>N</td>
</tr>
<tr>
<td>3</td>
<td>P</td>
</tr>
</tbody>
</table>

Determine the value of \( \sum_{n=2}^{3} J_n^2(\beta_1) \)

A. \( L^2 \)
B. \( L^2 + 2N^2 \)
C. \( L^2 + M^2 + N^2 \)
D. \( L^2 + 2M^2 + 2N^2 \)

(Q18) Which is typical application of wide-band FM,

A. Satellite receiver systems
B. Data communications systems
C. Wireless broadcasting
D. All of the above

(Q19) The amplitude variations of the angle modulated carrier can be eliminated by a,

A. Band pass limiter
B. Band pass filter
C. Differentiator
D. DC blocker

(Q20) What is the main purpose of using PDE (preemphasis-deemphasis) in FM broadcasting?

A. To attenuate the lower frequency components of the message signal.
B. To reduce interference by channel noise at higher frequencies.
C. To reduce the bandwidth of the modulated signal.
D. None of the above.
class Notes, Ch 4 part 2 pp. 41

class Notes, Ch 4 part 2 pp. 41

class Notes, Ch 4 part 2 pp. 42

\[ f_{IO} = f_{RF} + \frac{v_p}{v_{down}} f_{iF} = [540, 1300] + 260 = [800, 1560] \]

class Notes, Ch 4 part 2 pp. 50-51, eqs 3.51, fig 3.19

Image frequency for up-conversion is \( \omega_{RF} + 2\omega_{IF} \)

for down-conversion is \( \omega_{RF} - 2\omega_{IF} \)

This case is up-conversion.

Hence Image frequency is \( 1000 + (2 \times 260) = 1520 \) kHz

Class Notes, Ch 5 part 1 pp. 5-1

\[ x(t) = \cos (\Phi + \Phi_m) \]

Instantaneous phase deviation = \( \Phi_m \)

Frequency deviation (Hz) = \( \frac{1}{2\pi} \frac{d}{dt} \Phi_m = \frac{1}{2\pi} \frac{d}{dt} (\sin 2t - 2\cos nt) \)

Peak frequency deviation (Hz) = \( \max | \text{Frequency deviation (Hz)} | \)

= \( \max | \frac{1}{2\pi} \frac{d}{dt} (2 \sin 3000nt) | \) = 3 kHz

FM modulation index \( \beta = \frac{\text{Peak frequency deviation (Hz)}}{\text{Message Signal Bandwidth (Hz)}} = \frac{3 \text{kHz}}{1.5 \text{kHz}} = 2 \)
11 C Carson’s Rule, $B_{WF} = 2(\text{Peak freq dev} + \text{Message BW}) = 2(\beta + 1) \text{Message BW} = 2(3k + 1.5k) = 2(2+1)1.5k = 9 \text{kHz}$

12 D $\Psi_{FM}(t) = 20 \cos \left[ 1000 \pi t \left( \frac{1}{20\pi} \cos(20\pi t) \right) \right]$

13 B $P_{WF} = \frac{20^2}{2} = 200 \text{ Watts}$

14 A Class Notes, Ch5 part 1, pp. 5-7, Textbook pp. 216

15 C Class Notes, Ch5 part 1, pp. 5-7, Fig. 5.6

16 B $x_{NPBM}(t) = \cos 2000t - 0.01 \cos 20t \sin 2000t$

17 D $\sum_{n=-2}^{2} J_n^2(\beta_i) = J_2^2(\beta_i) + J_1^2(\beta_i) + J_0^2(\beta_i) + J_1^2(\beta_i) + J_2^2(\beta_i) = N^2 + (-M)^2 + L^2 + (M)^2 + N^2 = L^2 + 2M^2 + 2N^2$

18 D Class Notes, Ch5 part 1 after page 5-17a

19 A Textbook pp. 234

20 B Textbook pp. 243