

Association of Professional Engineers of Ontario

Annual Examinations - 2002 (Spring)
98-Elec-A3

Communications

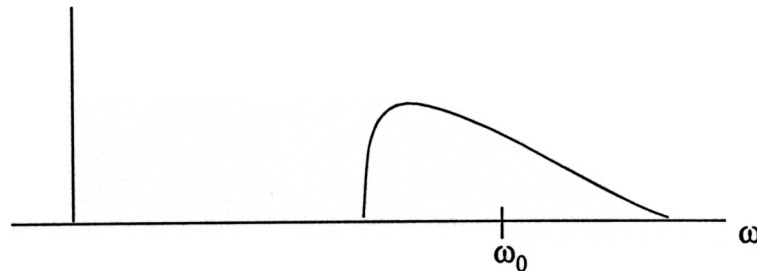
3 hours duration

Notes:

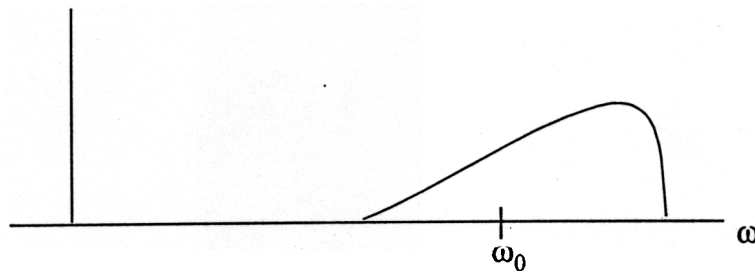
- 1) If doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer paper a clear statement of any assumption made.
- 2) "Closed-Book" - no aids other than a calculator (Casio FX-991 or Sharp EL-540) are permitted.
- 3) Any five questions constitute a complete paper. Only the first five questions as they appear in your answer book will be marked.
- 4) All questions are of equal value.

- 1) A signal $x(t) = A \cos(\omega_0 t)$ is passed through a half-wave amplifier and then input to a limiter. The limiter has a threshold k , where $0 < k < A$ (i.e. the output is equal to the input if the input is less than k and equal to k if the input is greater than k).
- Find the Fourier series of the signal at the output of the limiter.
 - What is the value of the limiter threshold k that maximizes the amplitude of the third harmonic.
 - If the limiter output is input to a low-pass filter with bandwidth $3.5\omega_0$ what is the average power at the output of the filter.

- 2) A real bandpass signal has center frequency ω_0 as shown in the following Figure (shown only for positive frequencies).

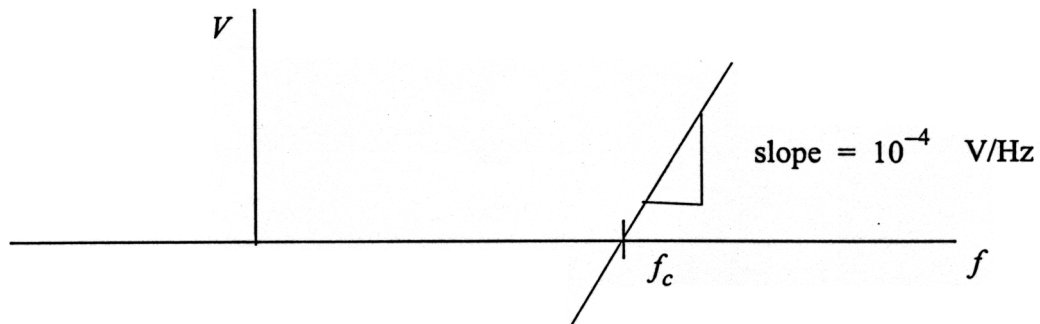


Give the block diagram of a system that transforms the above signal to a bandpass signal with the same carrier frequency but with a spectrum that is the mirror image about the carrier frequency (for positive frequencies), i.e. the spectrum is as follows (for positive frequencies)



- 3) A discrete time causal system is described by the following difference equation $y(n] = \frac{1}{2}y(n-1) + \frac{1}{4}y(n-2) + x(n)$, where $x(n)$ is the input to the system and $y(n)$ is the output.
- Sketch the block diagram for the system.
 - Give the transfer function of the system.
 - Find the impulse response for the system.

- 4) A VCO has the characteristics shown in the following Figure:



- a) If this VCO is used to implement an FM modulator, give an expression for the output of the FM modulator if the message signal is $m(t)$ and the modulator output power is equal to 10.
- b) Give the block diagram of a demodulator for the above FM signal.
- c) Give an approximate value for the bandwidth of the FM signal if the bandwidth and peak value of the message signal are 10 KHz and 2 V respectively.
- 5) A digital communication system supports a bit rate of 60 Kb/s. This system is used to transmit an analog signal by using PCM with uniform quantization. The reconstructed signal is to have an SNR of 30 dB. What is the maximum bandwidth of an analog signal that can be transmitted on this channel. (Assume that the signal is uniformly distributed in $[-V_m, V_m]$).
- 6) A double sideband modulator is implemented using a square-law device (i.e. a squarer). The carrier frequency is f_c and the bandwidth of the message signal is B . The carrier and message signals are input to an adder and the output of the adder is input to the squarer. Appropriate filters are used.
- a) Give the block diagram of the system including any appropriate filters.
- b) For a given carrier frequency f_c what is the maximum value of the bandwidth of the message signal that we can have.