※ 考生請注意：本試題 ☑可 □不可 使用計算機

注意: Part 1 (填充題) 不必在答案卷上填寫計算過程，僅需將答案依題序在答案卷「第一頁」上明確填寫，務必標明格號，可自行製作適當表格填寫。

Part 1: 填充題 (50 分，每格 5 分)

1. The output of an FM modulator for the input signal 5cos(100t) is $s(t) = 10\cos(10^6 t + 40\sin(100t))$.
   (a) The instantaneous frequency of s(t) is ___(1)___.
   (b) The Carson's bandwidth of s(t) is ___(2)___.
   (c) The power of s(t) is ___(3)___.

2. The random process $W(t)$ is defined by $W(t) = X\cos(200\pi t + \theta) - Y\sin(500\pi t + \theta) + Z$, where X, Y and Z are zero-mean random variables with standard deviations 10, 8, and 5. Random variable θ is uniformly distributed over $(0, 2\pi)$. All these random variables are independent.
   (a) The ensemble average of $W(t)$ is ___(4)___.
   (b) The auto-correlation function of $W(t)$ is ___(5)___.
   (c) Determine and plot the two-sided power spectral density (PSD) of $W(t)$. ___(6)___

3. Consider the transmission of messages by using OQPSK (Offset QPSK or Staggered QPSK) modulation via an ideal bandpass channel with bandwidth = 50MHz. The channel's noise is AWGN with two-sided PSD = 10^{-10} W/Hz.
   (a) If the overall raised cosine channel spectrum is desired to avoid ISI, the transmitted data rate for roll-off factor α = 25% is ___(7)___.
   (b) If transmitted data rate = 10Mbps and required bit-error-rate P_b is 10^{-5}, the minimum received signal power (in dBm) for coherent detection of the OQPSK signals is ___(8)___.
   (Note that it is required E_b/N_0 = 12.6 dB for BFSK signal with coherent detection and $P_b = 10^{-5}$.)

4. A white signal with PSD = -26dBm/Hz passes through an ideal LPF of one-sided bandwidth = 10KHz. The filtered signal is then encoded by a DPCM (Differential PCM) with one-tap linear predictor ($x(n|n-1) = \alpha \cdot x(n-1)$). If the sampling rate R_s= 40KHz, the optimum prediction constant α is ___(9)___ and the corresponding prediction gain is ___(10)___.

(背面仍有題目,請繼續作答)

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Part 2: (50 分)

1. Consider the signal $x(t) = 100 \cdot \text{sinc}(100t)\cos(2\pi f_0 t)$, where $f_0 >> 100$.
   (a) Sketch the spectrum of $x(t)$. (5%)
   (b) Sketch the spectrum of $x_p(t) = x(t) + j\hat{x}(t)$, $\hat{x}(t)$ is the Hilbert transform of $x(t)$. (5%)
   (c) Sketch the complex envelope $\tilde{x}(t)$, where $x_p(t) = \tilde{x}(t) \cdot e^{j2\pi f_0 t}$, and also sketch its spectrum. (5%)

2. Consider an (n, k) binary code whose parity-check equations are

$$v_0 = u_0 + u_1 + u_2 + u_6 + u_7 + u_8 + u_{10}, \quad v_1 = u_0 + u_3 + u_4 + u_6 + u_7 + u_9 + u_{10},$$

$$v_2 = u_1 + u_3 + u_5 + u_6 + u_8 + u_9 + u_{10}, \quad v_3 = u_2 + u_4 + u_5 + u_7 + u_8 + u_9 + u_{10},$$

   where $\underline{u} = (u_0, u_1, u_2, \ldots, u_9, u_{10})$ is the message vector and $v_0 \sim v_3$ are parity-check digits.
   The codeword is $(v_0, v_1, v_2, v_3, u_0, u_1, u_2, u_3, u_4, u_5, u_6, u_7, u_8, u_9, u_{10})$.
   (a) Determine n, k, minimum distance, error-detecting capability and error-correcting capability of this code. (5%)
   (b) If message vector is $\underline{u}$ = (1 0 1 0 0 1 1 0 0 1 0), what is the encoded codeword? (5%)
   (c) If the received vector is (0 1 1 0 0 1 1 1 0 0 0 1 0 0 1), what is the decoded message? (5%)

3. The samples of a channel's impulse-response are $h_c(-2T) = -0.01$, $h_c(-T) = 0.1$, $h_c(0) = 1.0$, $h_c(T) = 0.2$, $h_c(2T) = -0.02$, and $h_c(kT) = 0$ for $k \neq -2, -1, 0, 1, 2$.
   (a) Determine the tap coefficients for a three-tap zero-forcing equalizer. (5%)
   (b) If the equalizer of (a) is used, determine the output samples of the overall impulse-response which combines channel and equalizer. (5%)

4. State and prove Nyquist's sampling theorem for baseband signals. (10%)