

Answer any 8 questions. Questions are equally weighted. Answer in the script book provided.

Question 1.

- (a) What are the name and symbol for the fundamental SI unit of luminous intensity?
- (b) Given one example each of a direct, an indirect, and a null measurement.
- (c) What kind of AC bridge is suitable for measuring:
 - (1) High-Q inductors?
 - (2) Capacitance?
 - (3) Low-Q inductors?

Question 2.

- (a) Give five properties of an ideal operational amplifier.
- (b) Draw the circuit for an op-amp differentiator.
- (c) In a differential op-amp:
 - (1) Define the input offset voltage.
 - (2) Why does a real op-amp have a nonzero input offset voltage?
 - (3) Why do its inputs have nonzero currents?

Question 3.

- (a) Name two applications of isolation amplifiers.
- (b) What is the unit for:
 - (1) noise specification?
 - (2) voltage drift?
- (c) Describe two (2) situations in which the effect of noise can be reduced. In each case, explain the noise reduction technique that you would use, and why it works.

Question 4.

- (a) Strain gauges:
 - (1) What is another name for the sensitivity S of a strain gauge?
 - (2) Write the formula for S in terms of the resistance R and the length L of a conductive bar under longitudinal compression.

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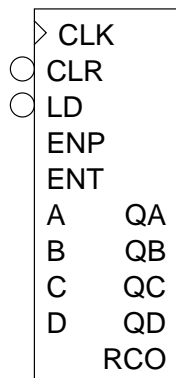
(b) Thermistors:

- (1) Write the formula for the resistance R of a thermistor as a function of *absolute* temperature T , coefficient β , reference temperature T_0 and reference resistance R_0 .
- (2) If a thermistor has a resistance of $300\text{ k}\Omega$ at 20 degrees *Celsius*, and a coefficient $\beta = 4000\text{ K}$, then at what temperature is its resistance equal to $280\text{ k}\Omega$?

(c) For a thermocouple, what is the name of the effect whereby a potential applied between the junctions generates a temperature gradient?

Question 5.

(a) In the 74LS163 (see following diagram), what is the function of the control inputs labelled CLK, CLR, LD, ENP and ENT, and what does it mean if the output RCO is high?

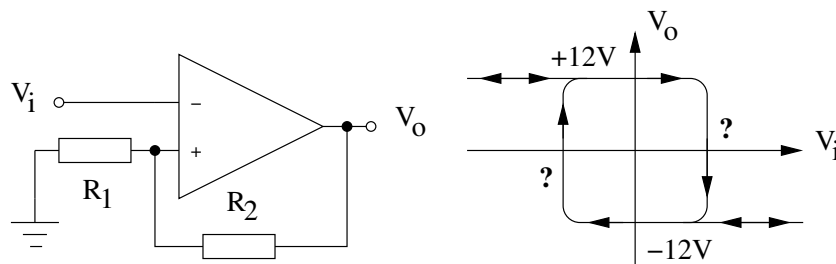


(b) Using a 74LS163, draw the circuit for a counter with counting sequence 4, 5, ..., 12.

(c) Using as many 74LS163 ICs as necessary, draw the circuit diagram for an eight-bit counter.

Question 6.

(a) For the simple Schmitt trigger in the next diagram, assume that the maximum and minimum output voltages are $+12\text{V}$ and -12V , and that $R_1 = 3\text{ k}\Omega$ and $R_2 = 6\text{ k}\Omega$. Calculate the input voltages at which the transitions occur.



(b) State the sampling theorem.

(c) An eight-bit DAC has a minimum voltage of zero volts (for the binary input zero) and a maximum voltage of 5.10V . What binary number produces the output voltage 3.20V ?

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Question 7.

- (a) Describe amplitude modulation (AM).
- (b) Describe frequency modulation (FM).
- (c) Quote the formula for the modulation index m of an FM system, and name all the variables in the formula.
- (d) Define the following terms:
 - (1) rise time;
 - (2) ringing.

Question 8.

- (a) Name the three (3) functional parts of a cathode-ray tube (CRT).
- (b) Give the formula relating the oscilloscope bandwidth BW to the rise time t_r .
- (c) Draw the waveform produced by a sweep generator. Label each of the sections and significant points of the waveform.
- (d) Name two (2) advantages of sampling oscilloscopes over standard oscilloscopes.

Question 9.

- (a) What is the approximate capacitance of a one metre (1 m) length of small-diameter coaxial cable?
- (b) If a CRO has an input impedance of $1\text{ M}\Omega$ in parallel with 30 pF , and is connected to 90 cm of coaxial cable to a signal generator producing a 1 MHz sine wave, then what is the capacitive impedance of the combination of CRO and cable?
- (c) If the signal generator in part (b) has a source impedance of $600\ \Omega$, then what is the ratio of the voltage measured by the CRO to the nominal voltage produced by the signal generator? (The nominal voltage may be taken as being the same as the signal generator's Thevenin equivalent voltage.)
- (d) What is the purpose of the variable capacitor in a times-ten probe?
- (e) What is flashover?

Question 10.

- (a) In a spectrum analyser, what is the function of the voltage controlled oscillator (VCO)?
- (b) Wave analysers are used to measure what three (3) types of quantity?
- (c) Define total harmonic distortion.
- (d) Describe how a distortion analyser works.
- (e) Name five (5) instruments contained in an audio analyser.

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Question 11.

- (a) Define frequency response.
- (b) What is intermodulation distortion?
- (c) Define slew rate.
- (d) Define full-power bandwidth.
- (e) Define input offset voltage.

Question 12.

- (a) State the formula for the total impedance of the RLC series resonant tank circuit.
- (b) Give the formula from the notes for the bandwidth of a tank circuit.
- (c) In a tuned transformer, there is a magnetic coupling between the primary and secondary windings.
 - (1) If this coupling is large, what effect does it have on the Q of the circuit?
 - (2) What happens to the frequency response curve if the coupling is very large?
- (d) What is a notch filter?

Question 13.

- (a) What company devised the ATE bus architecture on which the GPIB was based? What was their bus called?
- (b) Name the two GPIB data rates, and state how many kilobytes per second (kB/s) each operates at.
- (c) Of what does a minimal GPIB system consist?
- (d) What are the three (3) functions of a controller in a GPIB system?
- (e) Name four classes of commands or address codes used by the GPIB.

Question 14.

- (a) Name the three (3) classes of noise source given in the notes.
- (b) How does pink noise differ from white noise?
- (c) What causes shot noise?
- (d) Electrically coupled interference voltage increases with what four (4) quantities?
- (e) List four (4) everyday sources of electromagnetic interference.

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Question 15.

- (a) State the international standard color for each of the three (3) lines in an AC power cord.
- (b) Describe a situation that may give rise to a leakage current inside an instrument.
- (c) List four (4) possible causes of a ground loop.
- (d) Give a possible solution to the problem of crosstalk.

Question 16.

- (a) Name and describe two (2) properties of real amplifiers that give rise to distortion.
- (b) What is hiss noise?
- (c) If an electric shield has an opening in the shape of a cylinder with a diameter of 2 cm and a sleeve of length 8 cm, then what is the attenuation of an interference waveform of wavelength 60 cm that enters that opening? [Hint: $54.5(\frac{L}{\lambda_c})\sqrt{1 - \frac{\lambda_c^2}{\lambda^2}}$, where $\lambda_c = \pi r$.]
- (d) What might you use to eliminate the interference caused by the 50 Hz hum from the mains power?