Question 1.

(a) Given one example each of:

(i) a **direct**,

(ii) an **indirect**, and

(iii) a **null** measurement.

(b) *Name* the types of **AC bridge** suitable for measuring:

(i) High-Q inductors?

(ii) Capacitance?

(iii) Low-Q inductors?

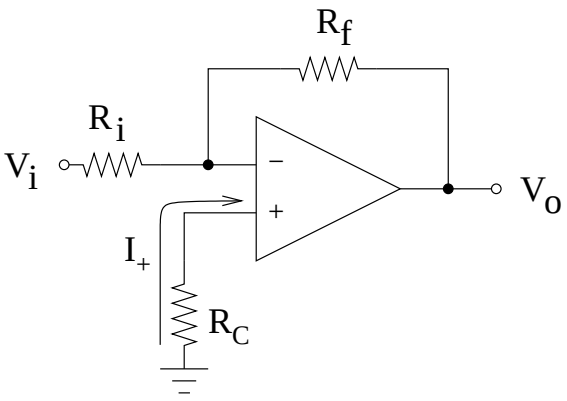
(iv) A wide range of Q values?

(c) If a **thermistor** has a resistance of R_0 = 300 kΩ at the reference temperature T_0 = 300 K (kelvin), and a temperature coefficient β = 4000 K, then at what **temperature** T is its resistance R = 280 kΩ? *(Hint*: see *formula sheet*.)

Question 2.

(a) What are five (5) properties of an **ideal** operational amplifier?

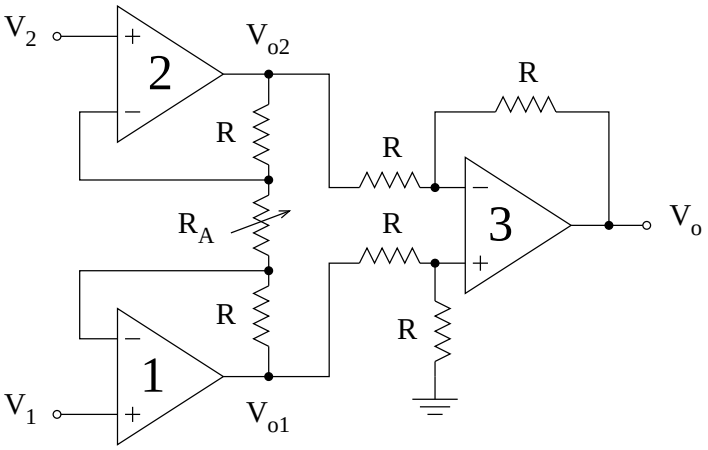
(b) The following circuit involves a **real** op-amp.



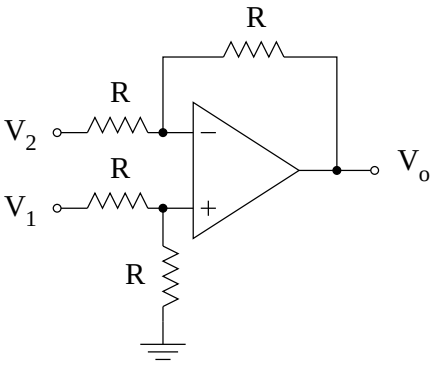
(i) What does the **compensation resistor** compensate for?

(ii) Given that $R_1 = 3\,k\Omega$ and $R_f = 6\,k\Omega$, what is a suitable value for R_C?

(c) The following is a design for an instrumentation amplifier.

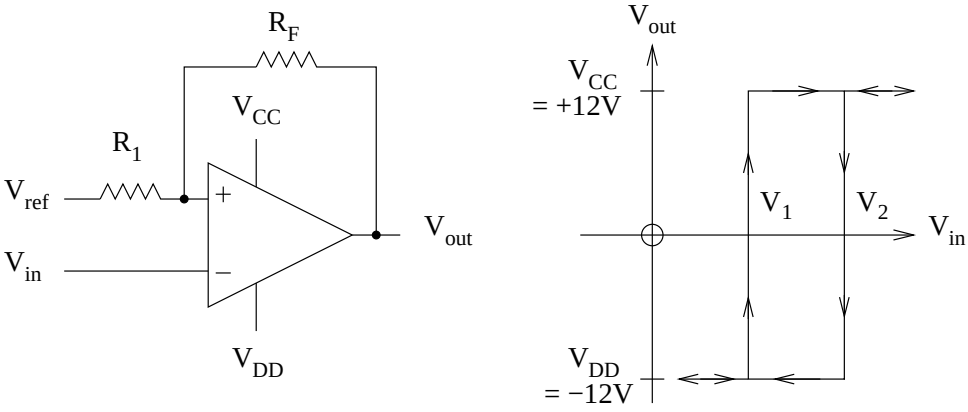


What are its **advantages** over the following simpler design?



Question 3.

(a) For the simple Schmitt trigger in the next diagram, assume that the maximum and minimum output voltages are +12V and -12V, that R_1 = 3 kΩ and R_F = 6 kΩ, and that V_{ref} = 2 V.



Calculate the input voltages V_1 and V_2 at which the transitions occur.

(b) A *ten*-bit (10-bit) Digital to Analog Converter (DAC) has a minimum output voltage of zero volts (for the binary input zero) and a maximum output voltage of 10.23 V. What ***binary* number** produces the output voltage 4.32 V?

(c) Compare the average speeds of these three types of Analog to Digital Converter as functions of *n* (the number of bits of output).

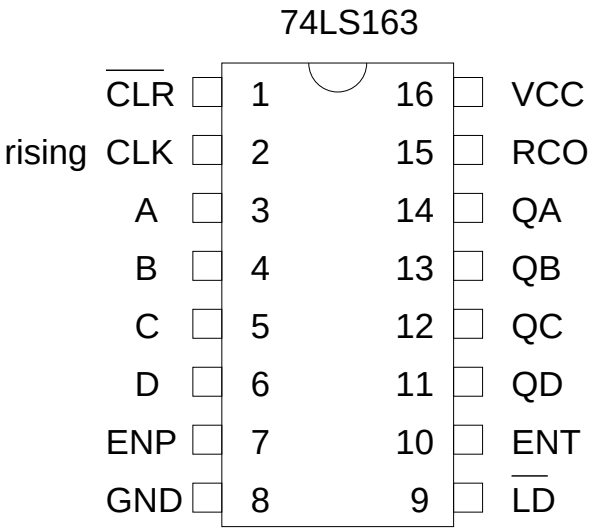
(i) Ramp ADC.

(ii) Successive Approximation ADC.

(iii) Flash ADC.

Question 4.

(a) A 74LS163 counter has the following pinout diagram,



Using a 74LS163 and any logic gates that may be required, **design** a counter that produces the repeating sequence 0, . . . , 9.

(b) Give three (3) advantages of **automated test equipment** (ATE).

(c) For the **general purpose interface bus** (GPIB):

(i) What are the four (4) kinds of devices in the GPIB?

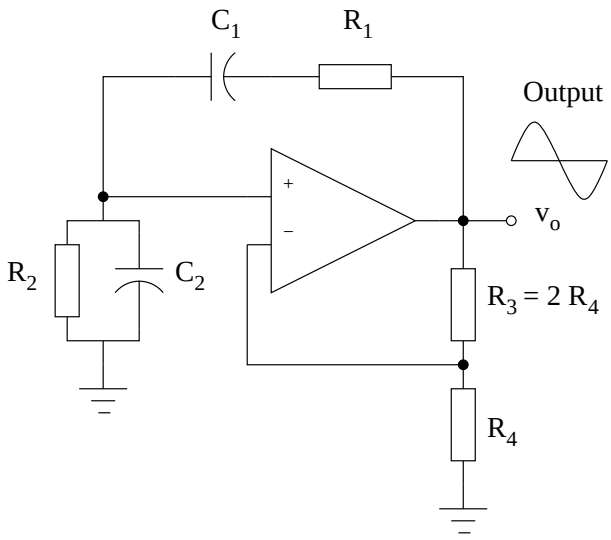
(ii) Of which two (2) types of devices does a minimal GPIB system consist?

(iii) What are the three (3) functions of a **controller**?

(iv) Give the two (2) GPIB data rates, in kilobytes per second.

Question 5.

(a) Here is an oscillator circuit:



What type of oscillator is it?

(b) For a pulse waveform, define the following terms:

(i) Rise Time,
(ii) Pulse Width,
(iii) Overshoot,
(iv) Ringing.

(c) In the operation of a frequency counter, describe the role of each of these four signals:

(i) Time Base output,
(ii) Reset,
(iii) Strobe,
(iv) Main Gate Flip-Flop output.

Question 6.

(a) **Draw** the *time-base* waveform produced by a **sweep generator**. **Label** each of the *sections* and *significant points* of the waveform.

(b) Suppose a CRO has an input impedance of 1 MΩ in parallel with 30 pF, and is connected to 90 cm of coaxial cable (with a capacitance of 100 pF per metre) to a signal generator producing a 1 MHz sine wave.

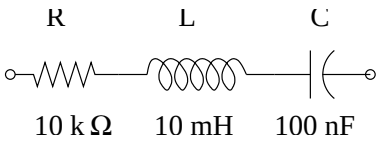
(i) Draw an **equivalent circuit** (using resistors and capacitors) for the signal generator, coaxial cable, and CRO input.
(ii) What is the **capacitive impedance** of the combination of CRO input and cable?
(iii) If the signal generator has a source impedance of 560Ω, then what is the **ratio** of the voltage measured by the CRO *divided by* the signal generator's Thevenin voltage?

(c) What is a **voltage controlled oscillator** (VCO)?

Question 7.

(a) Define **total harmonic distortion** (THD).

(b) **Calculate** the total (complex) **impedance** of this RLC series resonant tank circuit at an angular frequency of 1000 radians per second:



(c) In a **tuned transformer**, there is a magnetic coupling between the primary and secondary windings.

(i) If this coupling is large, what effect does it have on the Q of the circuit?

(ii) What happens to the shape of the frequency response curve if the coupling is very large?

Question 8.

(a) What is the **effective thermal noise bandwidth** Δf of a 1 kΩ resistor with 5 V_{rms} across its terminals at a temperature of 300 K? (*Hint*: see formula sheet.)

(b) **Electrically** coupled interference voltage increases with what four (4) quantities?

(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*: see formula sheet.)

Formulas

$0\,^{o}\mathrm{C} = 273\,\mathrm{K}$

$\mathrm{k} = 1.38 \times 10^{-23}\,\mathrm{W/\ Hz/\ K}$

Attenuation = $54.5\,(L/\lambda_c)\,\sqrt{1-(\lambda_c/\lambda)^2}$, where $\lambda_c = \pi r$

$\mathrm{P} = 4\mathrm{kT}.\Delta f$

$v_{\mathrm{RMS}}^2 = \mathrm{PR}$

END.