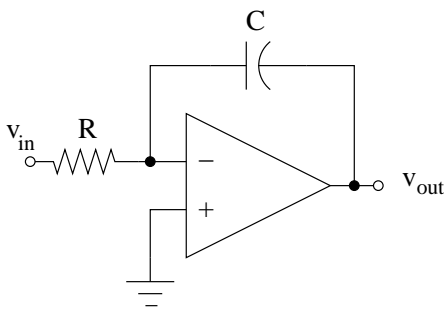


# 2001 ELE22EMI exam Solutions

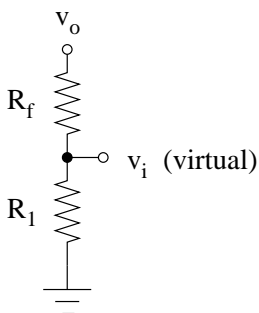
24th October 2004

## Question 1.

(a) Op-amp Integrator.



(b)



$$\frac{v_o}{v_i} = \frac{R_1 + R_f}{R_1} = 1 + \frac{R_f}{R_1}$$

## Question 2.

- (a) Three (3) of: phase, frequency, amplitude, rise time, shape, period.
- (b) Blanking prevents visible retrace.
- (c) ALT: sweep wave 1, then sweep wave 2.
- (d) CHOP: display a short segment of wave 1, then a short segment of wave 2.
- (e) Low frequencies  $\Rightarrow$  slow trace  $\Rightarrow$  CHOP mode better displays two waveforms.

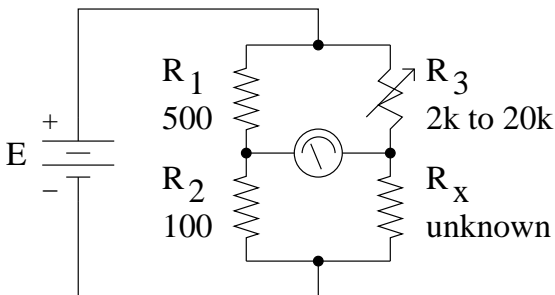
### Question 3.

- (a) Accuracy = closeness of *mean* measurement to *true* value.
- (b) Precision = variation between trials (of same measurement).
- (c) Repeatability = do repeated measurements on constant true value give same result?
- (d) Null measurement circuit: Wheatstone bridge.
- (e) Parallax reading error is caused by gap between scale and needle, in an analog meter.

### Question 4.

- (a) Schering bridge.

- (b)



- (c)

$$\frac{R_x}{R_3} = \frac{R_2}{R_1} = \frac{1}{5} \Rightarrow R_x = 400\Omega \rightarrow 4k\Omega.$$

- (d) p (pico).
- (e) Giga (G).

### Question 5.

- (a) AM: Amplitude (of carrier wave)  $\propto$ (time-varying) signal.
- (b) FM: Frequency (of carrier wave)  $\propto$ (time-varying) signal.
- (c) Multipath propagation: electromagnetic (EM) wave takes multiple distinct paths from same source to same destination.
- (d) Carrier wave determines frequency band of propagation; media differ in absorption of each frequency.
- (e) Walls may contain materials that absorb heavily at mobile phone frequencies.

### Question 6.

- (a)  $k$  = Boltzmann's constant =  $1.38 \times 10^{-23}$  J/K.
- (b)  $q$  = magnitude of electron charge =  $1.609 \times 10^{-19}$  Coulomb.
- (c)  $T$  is measured in Kelvin (K).
- (d) Diode.
- (e)  $V_T = \frac{k(273+27)}{q} = \frac{1.38 \times 10^{-23} \times 300}{1.609 \times 10^{-19}} = 2.57 \times 10^{-2} \text{V} = 25.7 \text{mV}.$

## Question 7.

(a) (i) In surgery or other biomedical use, to separate sensor from high current of power and ground; or (ii) for signal acquisition in high voltage circuits.

(b) Voltage drift = drift of output DC level caused by minor changes in the input circuit (usually due to slow temperature changes). Voltage drift is measured in  $\mu\text{V}/^\circ\text{C}$ .

(c) Common mode gain =  $\frac{v_o}{v_i}$  when  $v_i = v_+ = v_-$ .

(d) List any 5 real op-amp properties from:

- (1) finite gain
- (2) nonzero output impedance
- (3) finite input impedance
- (4) nonzero noise
- (5) finite bandwidth
- (6) offset current
- (7) offset voltage
- (8) nonlinearity for large output signals

(e) (i) CMRR degradation due to mismatched resistors. (ii) Low (and usually mismatched) input impedances.

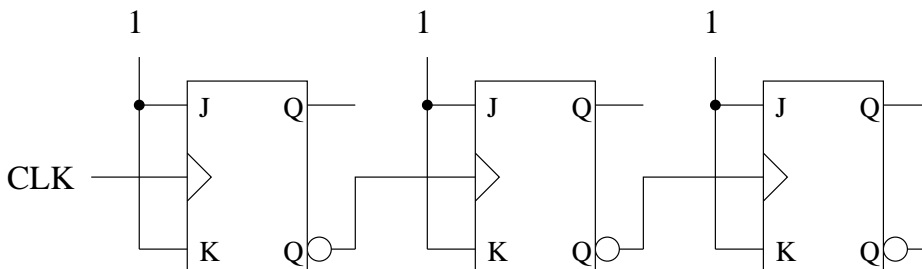
## Question 8.

(a) White noise: (i) Thermal; (ii) Shot.

(b) Pink noise: (i) Flicker; (ii) Burst.

(c) AC meters measure  $V_{RMS}$  of *sine* waves.

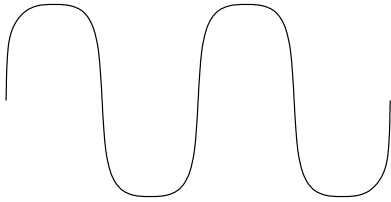
(d)



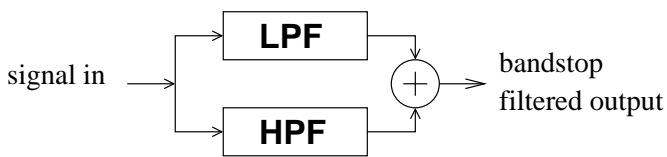
(e) Propagation delay  $\propto$  number of bits.

## Question 9.

- (a) Peltier effect: potential applied between the junctions generates a temperature gradient.
- (b) Sampling theorem: must sample a band-limited waveform at (at least) twice its maximum frequency in order to reconstruct it.
- (c) Sending a square wave into a low-pass filter may produce an output like this:



- (d) VCO's purpose in a spectrum analyser is to generate a sinusoid of frequency  $\propto$  voltage on horizontal plates (and thus  $\propto$  timebase).
- (e) Bandstop filter:



## Question 10.

- (a) Two sources of capacitive (electric) interference, such as:

- (1) Fluorescent lamps
- (2) Unconnected power sockets
- (3) Unconnect light sockets

- (b) GPIB standard's device classes:

- (1) Talker
- (2) Listener
- (3) Talker/Listener
- (4) Controller

- (c)

$$THD = \frac{E_h}{E} = \frac{V_{RMS}(U)}{V_{RMS}(T)}$$

where U = unwanted harmonics and T = amplifier's total output.

- (d)

$$Q = \frac{f_r}{B}$$

which is a dimensionless quantity.

- (e) High sweep rate can cause *ringing*.