Midterm #2 Solutions – EECS 145L Fall 2007

1.1

Platinum resistance thermometer	Thermistor
metal	semiconductor
R increases with increasing T	R decreases with increasing T
R increases linearly	R decreases exponentially
dR/dT relatively low	dR/dT relatively high
Increasing temperature deforms crystal lattice	Increasing T promotes electrons into conduction band
Operates at high temperature	Cannot operate at high temperature
Useful in corrosive conditions	Not useful in corrosive conditions

1.2

Incandescent lamp	Fluorescent lamp
Black body spectrum	Discrete emission wavelengths
Hot	Cool
Low energy efficiency	High energy efficiency
Light emitted by thermal agitation of electrons	Light emitted by electron transitions from one energy level to a lower level
Light emitted by a hot filament	Light emitted by a phosphor

1.3

PIN photodiode	LED
Converts light intensity into current	Converts current into light intensity
Light sensor	Light actuator
Low band gap (usually silicon)	Higher band gap (GaAs or GaInAs)
Uses current to voltage converter	Uses voltage controlled current driver
Sensitive to a wide range of wavelengths	Emits a narrow band of wavelengths

1.4

Peltier heat pump	Thermocouple
Semiconductor	Dissimilar metal wires
Converts electrical energy into a temperature difference	Converts a temperature difference into a voltage
Joule heating a factor (high current)	No Joule heating (very low current)
Requires a heat sink for effective cooling	Accuracy requires knowledge of temperature of reference junction

1.5

EMG	ECG
Produced by skeletal muscles	Produced by cardiac (heart) muscles
Multiple pulses at high rate (kHz) from many motor units	Large pulses generated during each heart beat
Signal processing requires amplification and rectification	Signal useable with only amplification
Can be altered by conscious thought (tensing muscles)	Cannot be directly controlled by conscious thought
Requires at least two electrodes	Standard ECG requires at least four electrodes

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2.1

- Disconnect hot and neutral connections whenever the current difference through them exceeds 5 mA, and until reset
- Provide a means for testing the circuit
- Provide a means for resetting the connections

[-2 points if both hot and neutral not disconnected from load]

[-3 points if circuit trip relays if currents exceed 5 mA rather than difference exceeds 5 mA]

[- 5 points for describing the circuit breaker]

[-1 point for omitting the test function requirement]

[-1 point for omitting the reset requirement]

2.2

- The hot and neutral wires are run through a transformer in opposite directions
- A mismatch in current generates a 60 Hz voltage in a secondary winding.
- That voltage is amplified and rectified
- When the rectified signal exceeds a threshold, a relay opens both hot and neutral wires
- A test pushbutton sends a current slightly higher than 5 mA through te transformer
- A reset button closes the relay to reconnect the hot and neutral wires

[-1 point if no differential transformer]

Note: the differential transformer is a more efficient way of determining the difference between two ac currents than by transforming each current into a voltage and subtracting the voltages

[-1 point if no amplification]

Note: the voltage drop across the primary coil is very small (mV). The threshold current of 5 mA will provide a volt-amp product that is only a few μW to the output coil. This is insufficient to latch open relays large enough to control 10A at 110 V, so amplification is needed.

[-1 point if no rectification]

Note: the output of the differential transformer is 60 Hz. This signal is rectified so that the electromagnets in the relays will pull in the direction that opens the switches.

[-2 points if no relays to open the hot and neutral conductors]

[-2 points off if no wire through the differential transformer to test the GFI]

[-1 point off if no button that mechanically resets the relays ("reset the circuit" does not imply a mechanical reset)]

3.1

A low-pass filter with a corner frequency $<< f$ will take the average of the square waves. This will result in a slow response time if f is low.

[-2 points for not indicating the corner frequency relative to f]

3.2

The square wave width w varies from 0 to $1/f$ and the average voltage produced by the circuit of 3.1 varies from 0 to 5 volts. V = 5 volts when $w = 1/f$, so V = (5 volts) wf.

An object as distance d will produce an echo that will be received after a time delay w

$2d = w$ (300 m/s) = V (300 m/s)/(5 volts)/f

V = 2 x (5 volts) df/(300 m/s) = df/(30 m/volt s).

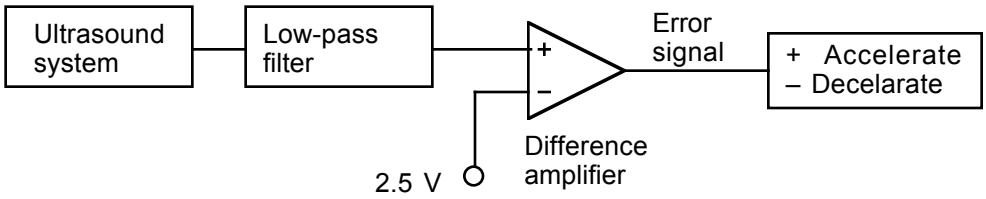
[-2 points for an equation where voltage is proportional to distance but no factor *f*/(30 m/volt s)]
[-4 points for an equation that does not show that voltage is proportional to distance]

3.3
The maximum value of d for f = 10 Hz is d = (5 volts)(30 m/volt s)/(10 Hz) = 15 m.
[-2 points for 7.5 m or 30 m]

Another approach is that the maximum width $w_{max} = 1/f = 1/10$ Hz $= 2d_{max} / (300m/s)$, and $d_{max} = 15$ m.

3.4
The desired distance 7.5 m corresponds to a voltage of 2.5 volts from the circuit of part 3.1. This determines the set point of a differential amplifier that produces the error signal. When the voltage is greater than 2.5 V, the vehicles are too far apart and the error signal is positive to increase the velocity. When the voltage is less than 2.5 V, the vehicles are too close and the error signal is negative to reduce the velocity.

[-7 points if there is no set point that corresponds to part **3.3**]



An alternative design uses a summing amplifier to take the difference between the average ultrasound ranging signal and the 2.5 V set point.

145L midterm #1 grade distribution:

Problem	
1	36.7 (3.9 rms) (40 max)
2	19.0 (4.8 rms) (24 max)
3	24.3 (8.3 rms) (36 max)

maximum score = 100
average score = 80.0 (12.8 rms)

30-39	1	
40-49	0	
50-59	0	
60-69	2	C+
70-79	9	B
80-89	6	B+
90-99	7	A
100	0	
	GPA 3.3	