NAME (please print) ____

UNIVERSITY OF CALIFORNIA

College of Engineering
Department of Electrical Engineering and Computer Sciences

EECS 145L: Electronic Transducer Laboratory

FINAL EXAMINATION Fall 2001

You have three hours to work on the exam, which is to be taken closed book.
Calculators are OK, use equation sheet provided.
You will not receive full credit if you do not show your work. Use back side of sheet if necessary.
Total points = 200 out of 1000 for the course.

1 ______________ (60 max) 2 ______________ (90 max) 3 ______________ (50 max)

TOTAL _____________ (200 max)

COURSE GRADE SUMMARY

LAB REPORTS (500 points max):
[5 short reports (lowest grade dropped)- 100 points max]
[5 full reports (lowest grade dropped)-400 points max]

4 __________ 5 __________ 6 __________ 7 __________ 11 __________

12 __________ 13 __________ 14 __________ 15 __________ 16 __________

17 __________ 18 __________ 19 __________ 25 __________

LAB TOTAL ____________ (500 max)

LAB PARTICIPATION ____________ (100 max)

MID-TERM #1 ____________ (100 max)

MID-TERM #2 ____________ (100 max)

FINAL EXAM ____________ (200 max)

TOTAL COURSE GRADE ____________ (1000 max)

COURSE LETTER GRADE

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PROBLEM 1 (60 points)

In 50 words or less, describe the ***essential differences*** between the following pairs

1a (10 points) the **ideal operational amplifier** vs. the **ideal instrumentation amplifier**

1b (10 points) the **ground fault interrupter** vs. the **circuit breaker**

1c (10 points) the **thermocouple** vs. the **thermistor**

1d (10 points) **common mode gain** vs. **differential gain** (of an instrumentation amplifier)

1e (10 points) **photodiode** vs. **light-emitting diode**

1f (10 points) **strain** vs. **stress**

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PROBLEM 2 (90 points)

Design a system that converts sound into light for transmission down an optical fiber and then converts the optical signal back into sound.

Assume the following

1. You will use a microphone to convert the input sound into a differential electrical signal
2. You will use a light emitting diode to convert the electrical signal into an optical signal
3. You will use an optical fiber to conduct the optical signal
4. You will use a photodiode to convert the optical signal to an electrical signal
5. You will use a loudspeaker to convert the electrical signal into output sound
6. The microphone produces a maximum differential signal of 1 mV p-p (peak-to-peak) at the maximum sound intensity that you need to consider.
7. The microphone wires have 60 Hz electromagnetic pickup of 1 mV p-p common mode and zero differential mode.
8. The input signal to the light emitting diode can vary from 0 mA to 100 mA, and a forward voltage of 2 V is necessary for forward conduction.
9. The photodiode (on the output end of the optical fiber) produces 0 mA to 1 mA when the light emitting diode receives 0 mA to 100 mA input.
10. The speaker has an input impedance of 10 Ω.
11. Input offset voltage is zero for your amplifiers.

The design requirements are:

1. The 1-mV p-p 60 Hz electromagnetic common mode pickup at the microphone wires should produce less than 10 mV at the speaker.
2. For all frequencies from 20 Hz to 20,000 Hz (even 60 Hz), when the microphone produces a differential 0 mV to 1 mV p-p signal, your design should drive the loudspeaker with a proportional 0 V to 10 V p-p signal.

In your design, you should provide enough detail so that a skilled technician could be able to build it and understand how it works. Include any essential parameters, such as CMRR. You may use any circuit components used in the laboratory exercises or discussed in lecture, but keep it simple.

2a (15 points) Describe how a 0 mV differential microphone signal is processed by your design. Include the signal amplitude at each circuit element.

2b (25 points) Describe how a 1 mV p-p differential microphone signal is processed by your design. Include the signal amplitude at each circuit element.

2c (50 points) Sketch your circuit, including all necessary components. Label all components and signals

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PROBLEM 3 (50 points)

You have designed an electronic circuit that works fine on the bench, but fails miserably in an aircraft during test flights. Thinking that the temperature variations between 0°C and 40°C during the flights might be responsible for the failure, you go back to the lab and test your circuit at different temperatures. To your surprise, you find that your circuit can only operate between 15°C and 25°C.

Your next task is to ***design a temperature control system*** for your circuit, which can be operated on an aircraft in flight.

Assume the following:

- You have decided to mount the circuit in a small, thermally insulated box
- Since your circuit is small, you have decided to use a solid-state thermoelectric (Peltier) heat pump, rather than a larger, heavier mechanical heat pump (motor plus compressor).
- There is ample electrical power on the aircraft to operate your temperature control system

Design requirements:

- The temperature in the insulated box is to be kept in the range from 15°C to 25°C, despite external temperature variations from 10°C to 40°C.
- The above temperature must be maintained during flights lasting 18 hours.

You should only need components and concepts covered in EECS145L. Your designs will be graded on the basis of

- Meeting the design requirements
- Sufficient detail so that a skilled technician could build your design.
- Avoidance of unnecessary complexity (keep it simple)

3a (30 points) Sketch a block diagram of your design. Include and label all essential components and signals.

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3b (10 points) Describe the operation of your system when the temperature outside the box is 0°C. Provide enough detail to convince the other members of your design team that your design will work at 0°C.

3c (10 points) Describe the operation of your system when the temperature outside the box is 40°C. Provide enough detail to convince the other members of your design team that your design will work at 40°C.