Benha University | **June 2013 (تخلفات)**
High Institute of Technology | **Electrical Department**
Hospital Instrumentations (E472) | **4Th year (control)**
Dr.Wael Abdel-Rahman Mohamed | **Time: 3 Hrs**

Model Answer

Answer the following questions:

Question (1): [24 Marks]

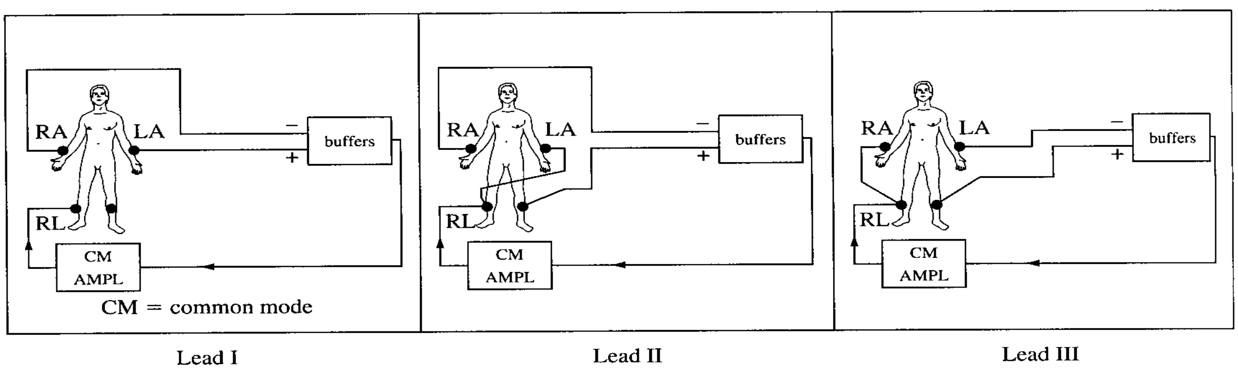
a) How do the unipolar limb leads differ from bipolar limb leads? (draw).

Bipolar Limb Leads: are those designated by Lead I, II, III which form Einthoven Triangle:

- Lead I = LA connection to noninverting amp. input and RA connecting to inverting amp. Input

- Lead II = LL connection to noninverting amp. input and RA connect to inverting input and LA shorted to RL

- Lead III = LL connected to noninverting input LA connected to inverting input



Unipolar Limb Leads= augmented limb leads: leads that look at composite potential from 3 limbs simultaneously where signal from 2 limbs are summed in a resistor network and then applied to an inverting amplifier input and the remaining limb electrode is applied to the non-inverting input

Lead aVR = RA connected to non-inverting input while LA and LL are summed at inverting input

augmented (amplified) Voltage for Right arm (aVR)

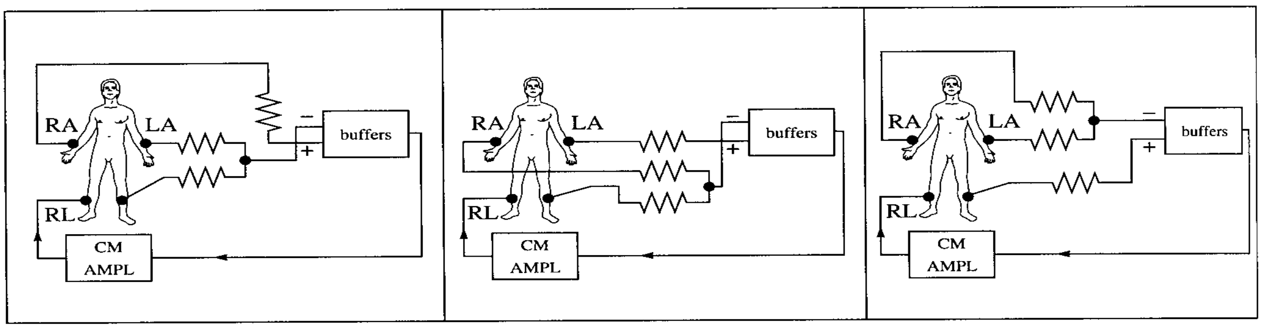
Lead aVL = LA connected to non-inverting input while RA and LL are summed at inverting input

augmented (amplified) Voltage for Left arm (aVL)

Lead aVF = LL connected to non-inverting input while RA and LA are summed at inverting input

augmented (amplified) Voltage for Foot (aVF)

Unipolar limb leads

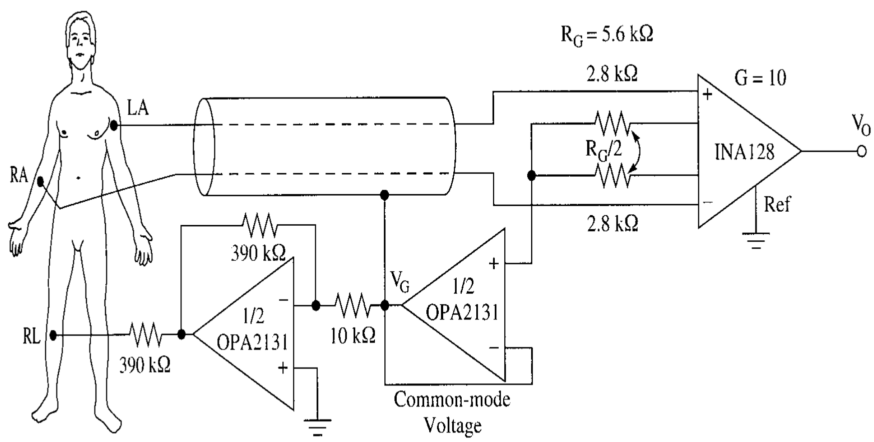


Lead aVR** Lead aVL** Lead aVF**

** Also known as "augmented" leads

b) What is meant by right leg drive and why it is used? (draw)

In most modern electrocardiographic systems, the patient is not grounded at all. Instead, the right-leg electrode is connected (as shown in Figure below) to the output of an auxiliary op amp. The common-mode voltage on the body is sensed by the two averaging resistors R_a, inverted, amplified, and fed back to the right leg. This negative feedback drives the common-mode voltage to a low value. The body's displacement current flows not to ground but rather to the op-amp output circuit. This reduces the interference as far as the ECG amplifier is concerned and effectively grounds the patient.

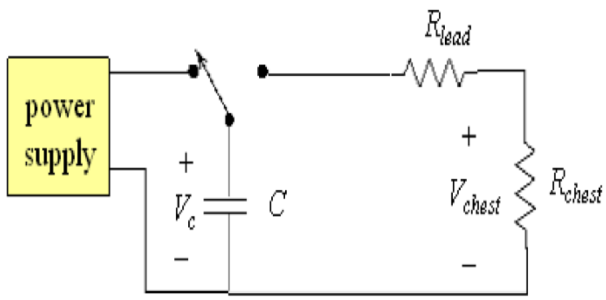


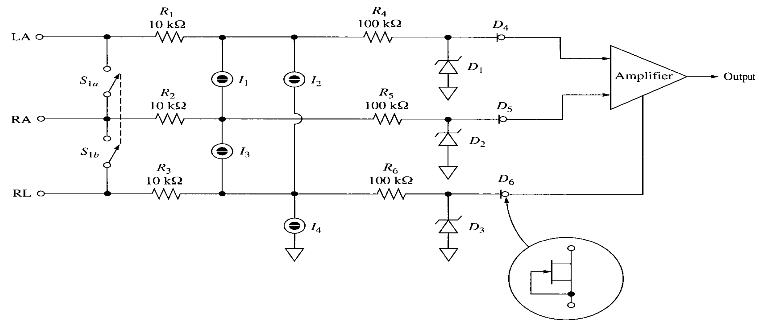
The circuit can also provide some electric safety. If an abnormally high voltage should appear between the patient and ground as a result of electric leakage or other cause, the auxiliary op amp in Figure below saturates. This effectively ungrounds the patient, because the amplifier can no longer drive the right leg. Now the parallel resistances R_f and R_o are between the patient and ground. They can be several mega-ohms in value—large enough to limit the current. These resistances do not protect the patient, however, because 120 V on the patient would break down the op-amp transistors of the ECG amplifier, and large currents would flow to ground.

c) Differentiate between the *defibrillator circuit* and the *defibrillator protection circuit* for the ECG amplifier. Suggest a defibrillator protection circuit that may be used with ECG amplifier. List two types of damage that can result from using defibrillator.

The defibrillator circuit is a high voltage impulse signal generator that is used to defibrillate the heart fibrillation problem.

The defibrillator protection circuit is a circuit used to protect the ECG amplifier from damage when the defibrillator is used in patient with ECG leads connected.





Defibrillator Circuit Defibrillator protection circuit

Two types of damage that can result from using defibrillator are:

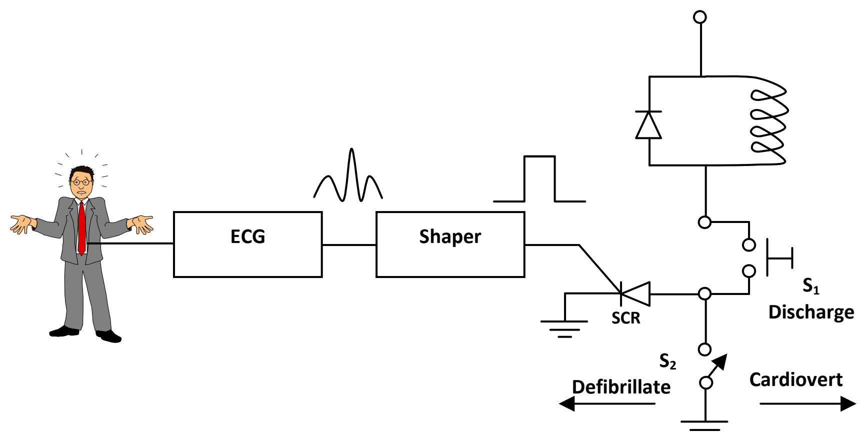
1) Damage for one terminal of the amplifier (the ECG signal is distorted).
2) Damage for both terminals of the amplifier (no ECG signal out).

d) There are four general categories of pacemaker: *asynchronous*, *demand*, *R-wave inhibited*, and *AV synchronized*. Explain briefly each type and mention the difference between them.
See item 9-33-1 "Pacemaker classification" in your text book.

Question (2): [10 Marks]

For the circuit shown:

a) Explain the function of the circuit and how does it work?
b) Explain the function of the block called shaper and what is inside that black box?



a) The circuit is used to select between defibrillation and cardioversion to be suitable for both atrial and ventricular fibrillation.

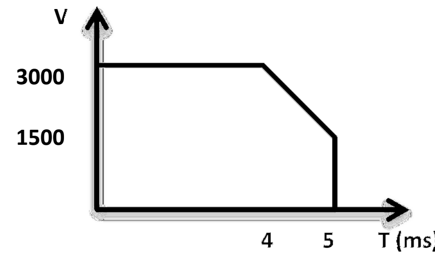
Defibrillator action:
When there is no ECG signal the switch S_2 is closed to select defibrillator and to make a path to the ground and when pressing the switch S_1 the shock is delivered to the patient.

Cardioverter action:
With the presence of the ECG signal, the shaper will detect the R-wave and use it to trigger the SCR that enables a second path to the ground when S_2 is opened and when the switch S1 is pressed the shock will be delivered only when the SCR is triggered to prevent delivering the shock during the T-wave which may convert the atrial fibrillation (if exist) into ventricular fibrillation.

b) The shaper is used to detect the presence of the R-wave of the ECG waveform and convert it into a square pulse delayed by 30 μs. the shaper box may contain a simple threshold detector (comparator) or a differentiator to differentiate between the R-wave and a bigger T-wave.

Question (3): [10 Marks]

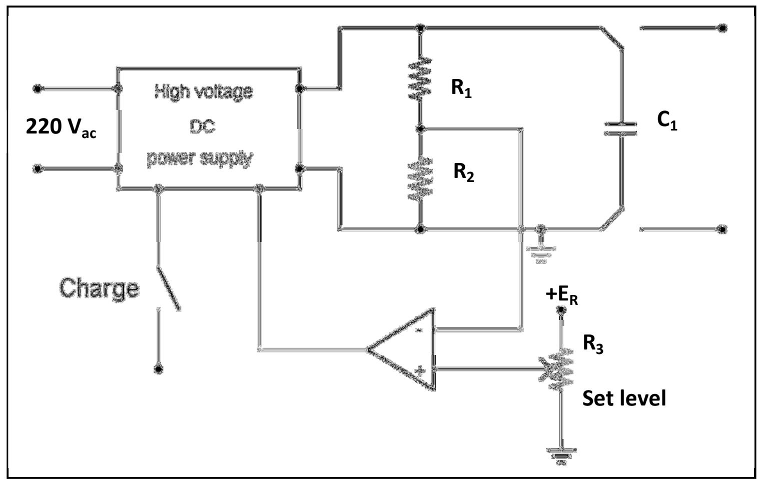
The voltage pulse delivered to defibrillator paddles attached to a patient is given in the shown figure. The thorax resistance RT= 50 Ω, what must be the skin-electrode resistance in order that 110 J of energy will be delivered to the thorax of the patient? Assume that RD= 10 Ω.



Solved exactly in sheets.

Question (4): [8 Marks] For the circuit shown:

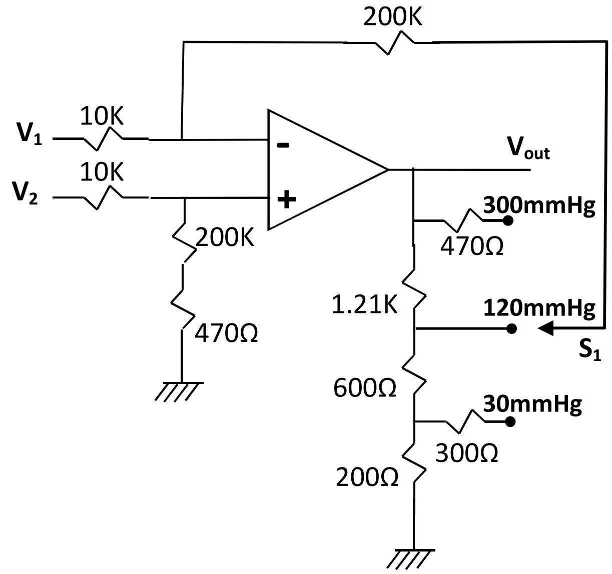
a) Explain the function of the circuit and how does it work?
b) Suggest another configuration to make the same function of this circuit.



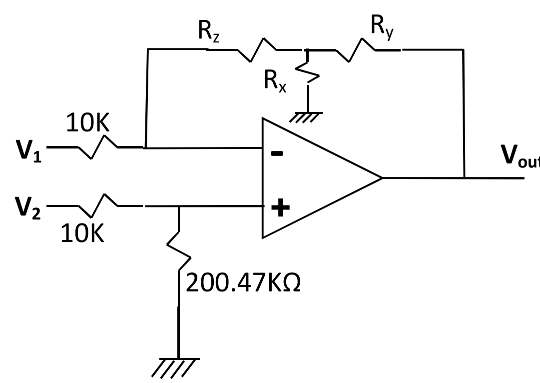
a) An approach to design a set level control circuit for the DC defibrillator. The DC output of the high voltage power supply is fixed. A voltage comparator will turn the supply on and off depending on the voltages applied to its inputs. One input of the comparator is connected to voltage divider R_1/R_2, which produces a low voltage sample of the high voltage applied to capacitor C. the other input of the comparator is connected to a potentiometer, when the operator selects an energy level, the voltage at the potentiometer wiper will represent the desired charge.
b) Another technique used a variac (variable autotransformer) in the primary of the high voltage transformer in the DC supply. The operator, then, is actually adjusting the high voltage DC supply when setting the energy level. The DC output voltage of the power supply is a function of the variac setting. When the charge button is pressed, AC power is applied to the transformer through variac. The capacitor will continue to charge until its voltage equal to the power supply voltage. When these two voltages are equal, the operator may discharge the defibrillator.

<u>Question (5):</u> [8 Marks]

In the circuit of the DC pressure amplifier, the pressure transducer is a resistive Wheatstone bridge strain gauge. Find the amplifier output voltage if the output from the bridge was $V_1 = 1.5\ V$ and $V_2 = 1.7\ V$ when using the 30mmHg range.



First redraw the circuit to be as shown



Where:

$R_z = 200\ K\Omega + 300\ \Omega$

$R_x = 200\ \Omega$

$R_y = 600\ \Omega + 1.21\ K\Omega$

Then solve for the voltages to find the relation between V_{out} and V_1 and V_2

$V_{out} = 40.21$ V. (the op-amp will saturate to its V_{cc} value)

$V_+ = V_- = 1.62$ V

$V_x = 4$ V. (at the point over R_x)

With best wishes