



Model Answer

Answer the following questions with the aid of drawing and equations as possible.

Question (1): [15 Marks]

a) List the possible causes of the common mode voltage (CMV).

The common-mode voltage is comprised of two parts:

- 1) 50- or 60-Hz interferences.
- 2) DC electrode offset potential.
- 3) Any other voltage that may be applied to both electrodes simultaneously.

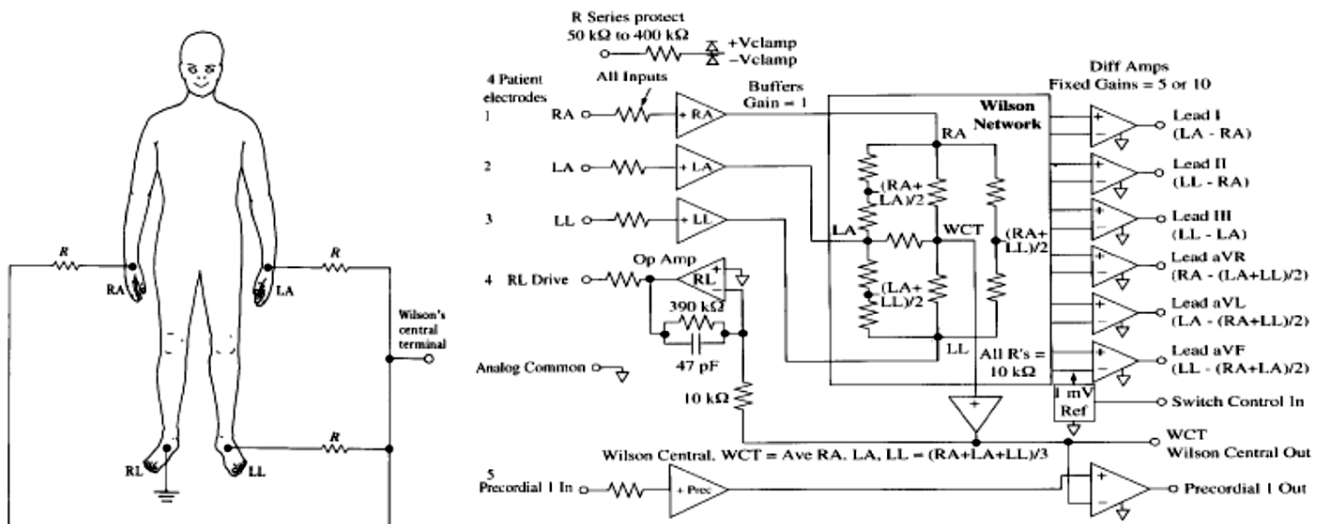
b) There are four general categories of pacemaker: asynchronous, demand, R-wave inhibited, and AV synchronized. Explain briefly each type and mention the difference between them.

See item 9-33-1 "Pacemaker classification" in your book

c) Mention three faults for the ECG machine and how to cure them.

See examples 8-1 & 8-2 & 8-3 for faults and troubleshooting.

d) What is meant by Wilson central terminal and Wilson network. Explain why Nelson network is used and what leads could be obtained from it.



Wilson Central Terminal:

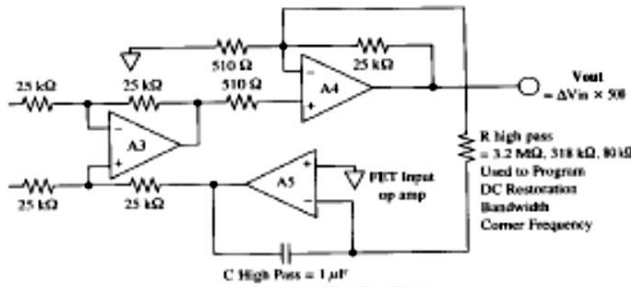
Configuration used with Unipolar Chest Leads where RA LA and LL are summed in resistor network and this is sent to the inverting input of an amplifier.

Wilson Network:

A *precision* resistor network (Wilson network) sums the various electrode voltages to achieve the standard voltages for the different ECG selections.

From Wilson network we get the limb leads (unipolar and bipolar) and the precordial lead with the Wilson central terminal which used to get the unipolar chest leads.

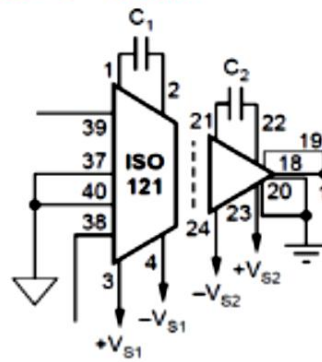
e) In the general block diagram of the ECG machine, explain the function and the internal construction of the "Baseline restoration" and "Isolation circuit" blocks.



A5 is the DC (Baseline) restorer

The DC restorer is an integrator circuit that is used to remove the DC offset voltage and restore the baseline for the ECG signal.

Isolation amplifiers used to isolate the patient completely from the high current in the circuit and also to prevent the current to get back to the patient where the circuit have to references; one of them is connected to the patient and this one have a very low current and the other one is connected to the chaises of the instrument and to the ground from the electric company and this one is totally isolated from the patient.



isolation amplifier

Question (2): [10 marks]

For the circuit shown:

a) Explain the function of the circuit and how does it work?

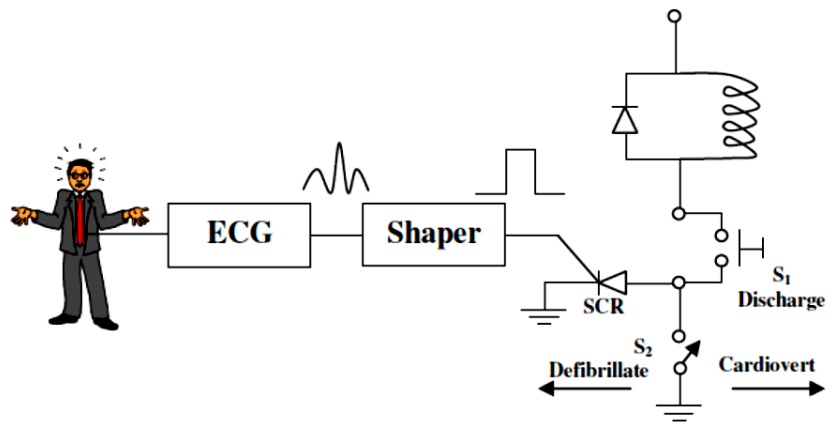
The circuit used to select between defibrillator and cardioverter.

Defibrillator action:

When there is no ECG signal the switch S₂ is closed to select defibrillator and to make a path to the ground and when pressing the switch S₁ 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 S₂ 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.



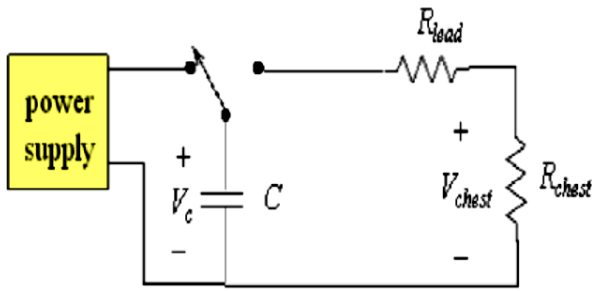
b) Explain the function of the block called shaper and what is inside that black box?

The shaper box contains a QRS detector with a time delay, this block detects the QRS using a threshold detector or a differentiator then the QRS is transformed into a square pulse. When the QRS is present, a signal from the output of the detector is passed through approximately 30 μS of delay and then presented to the SCR gate.

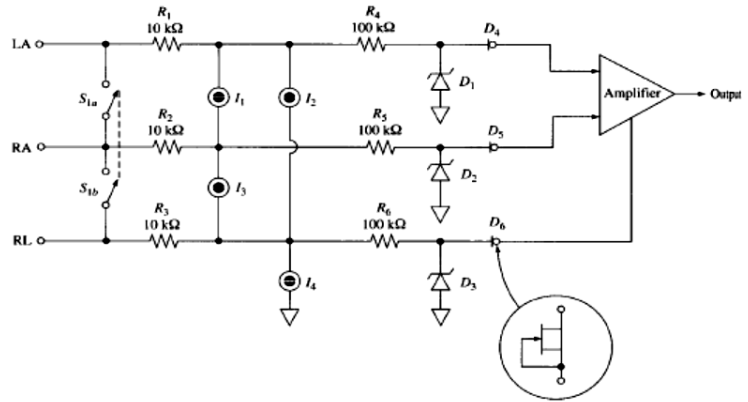
If the attendant is holding down the cardiovert switch, the SCR will trigger the defibrillator pulse generator. It then defibrillates the heart approximately 30 μS after the QRS.

Question (3): [12 Marks] Draw only

a) Defibrillator circuit and defibrillator protection circuit.



Defibrillator Circuit



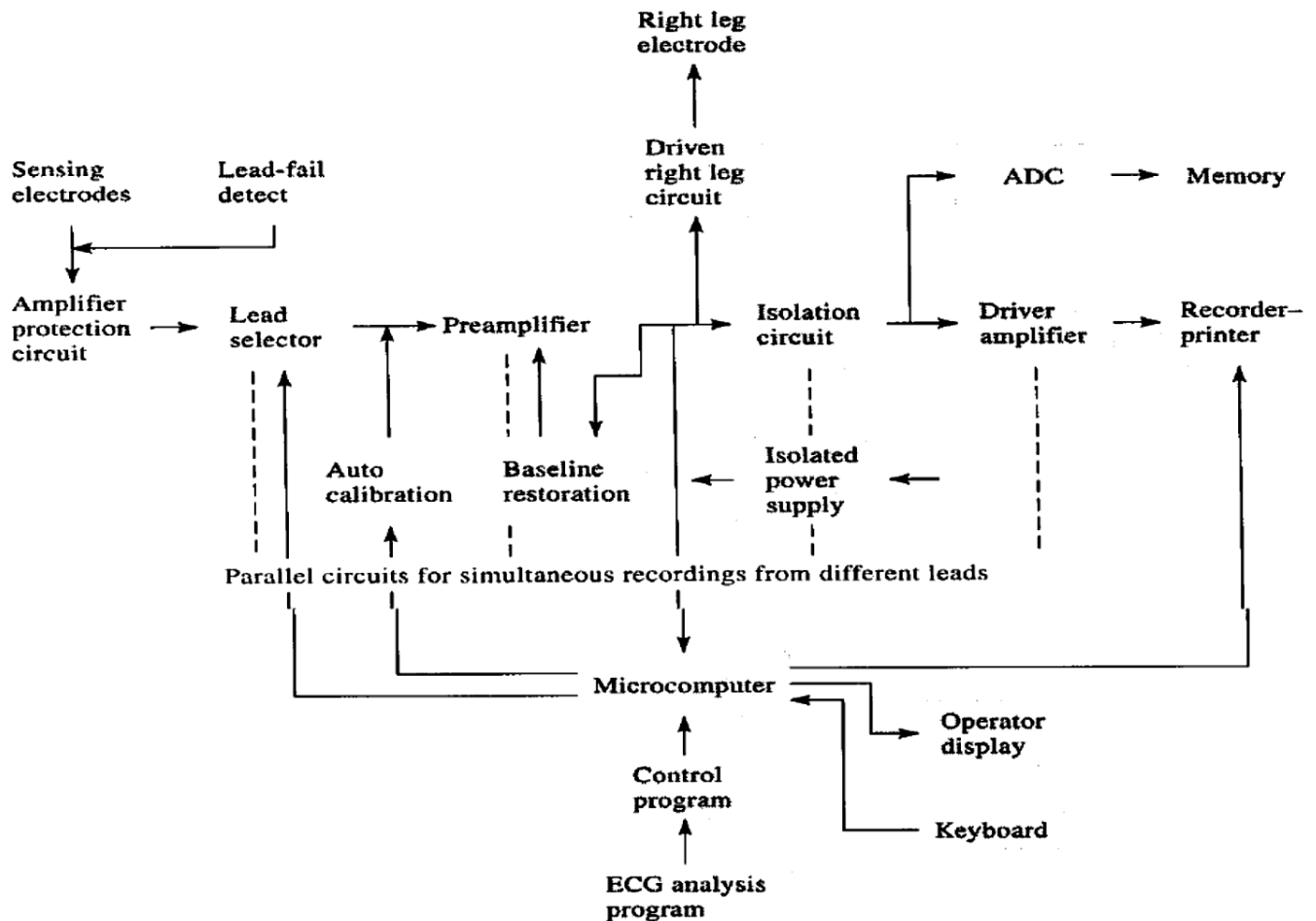
Defibrillator protection circuit

The protection circuit may be only the series resistors or the zener diodes or the neon glow lamps or the FET diodes.

b) ESU spark gap RF generator and ESU protection circuit.

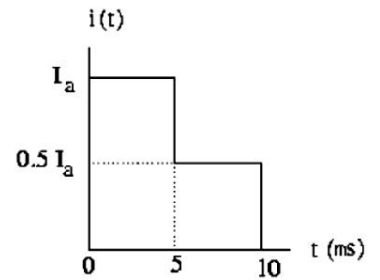
Draw the circuit in Fig.18.2 (spark gap RF generator) and the ESU protection circuit may be an RC or LC filter banks (Fig.8.8) in your text book.

The general block diagram of a basic ECG machine.



Question (4): [10 Marks]

- 1) A defibrillation current pulse $i(t)$ is shown. Assume that this pulse is to deliver 300 J energy to a 100Ω load. Determine I_a



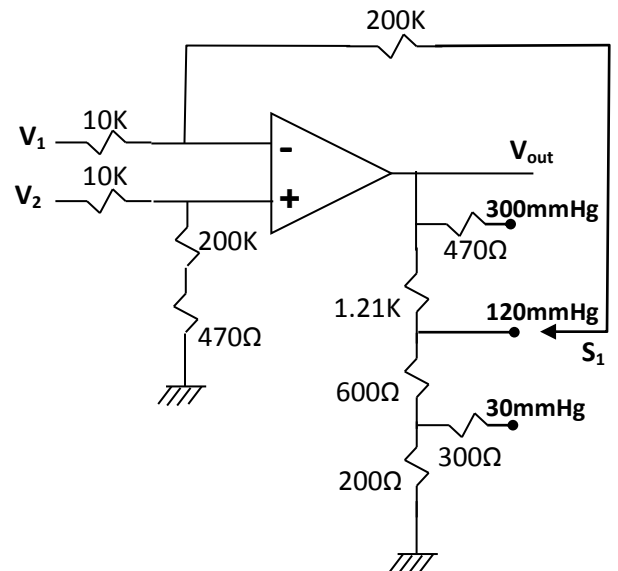
$$\begin{aligned}
 W &= \int p(t) \cdot dt = \int_0^{10\text{ms}} 100 i(t)^2 dt \\
 &= 100 \left[\int_0^{5\text{ms}} I_a^2 dt + \int_{5\text{ms}}^{10\text{ms}} (0,5 I_a)^2 dt \right] \\
 &= 100 \left[I_a^2 \cdot 5 \times 10^{-3} + 0,25 I_a^2 (10 \times 10^{-3} - 5 \times 10^{-3}) \right] \\
 &= 100 \times 6,25 \times 10^{-3} I_a^2 = 300 \\
 I_a^2 &= 480 \quad \rightarrow \quad I_a = \boxed{21,9\text{A}}
 \end{aligned}$$

- 2) 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 $V_1 = 1.5\text{ V}$ and $V_2 = 1.7\text{ V}$ when the input pressure was 140mmHg.

Take care that the applied pressure is 140 mmHg

Then you **must** select the 300 mmHg range

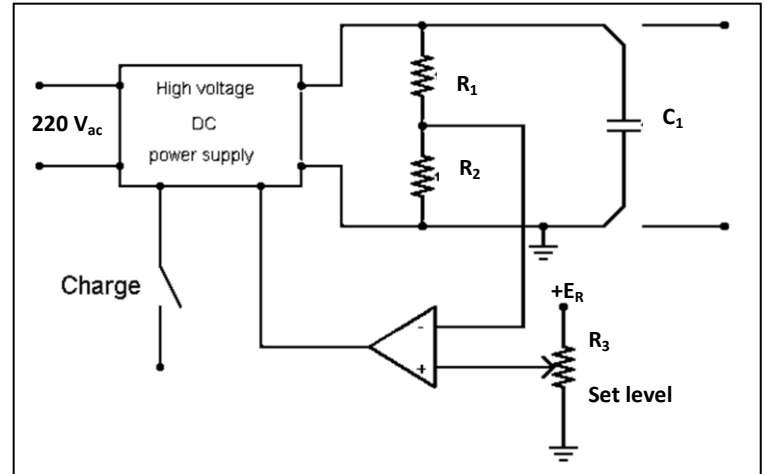
$$V_o = [(200\text{K} + 470) / 10\text{K}] (V_2 - V_1) = 20.047 \times 0.2 = \underline{\underline{4.0094\text{ V}}}$$



Question (5): [13 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.

With best wishes