Benha University | **June 2013**
Benha Faculty of Engineering | **Electrical Department**
Hospital Instrumentations (E472) | **4Th year (control)**
Dr.Waleed Abdel Aziz Salem | **Time: 3 Hrs**

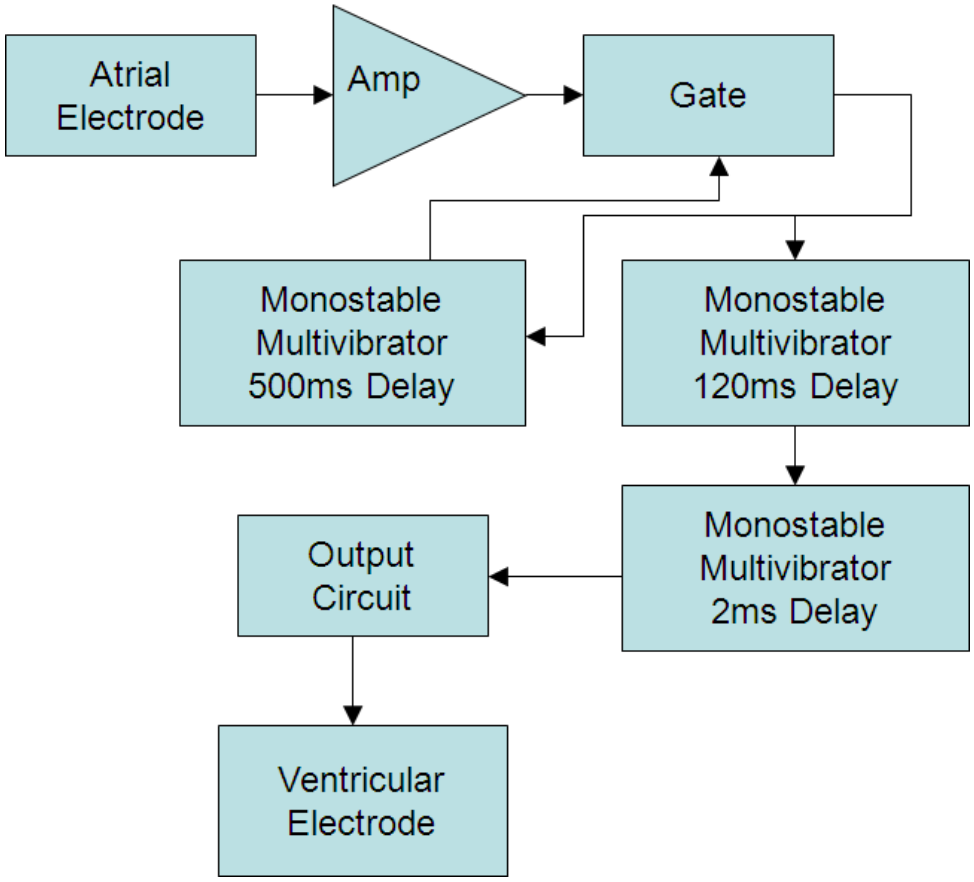
Answer the following questions.

Question (1): Complete (Write the answer only) [10 Marks]

a) The five electrodes used to make 12 lead ECG recording are connected to the patient's right arm, left arm, right leg, left leg, and Chest.
b) The frequency response of diagnostic ECG machine is from .05 to100 Hz.
c) Defibrillator protection in the input of bioelectric amplifiers uses Glow lamps, followed by series resistors and Zener diodes.
d) The frequency of an ultrasound signal in tissue is 19.7 MHz, if its velocity is 1500 m/s and the wavelength is 7.6×10^{-3} cm.
e) The EEG peak to peak signal amplitude is 1 to 100 µV & frequency range is 0.5 to 100 Hz.

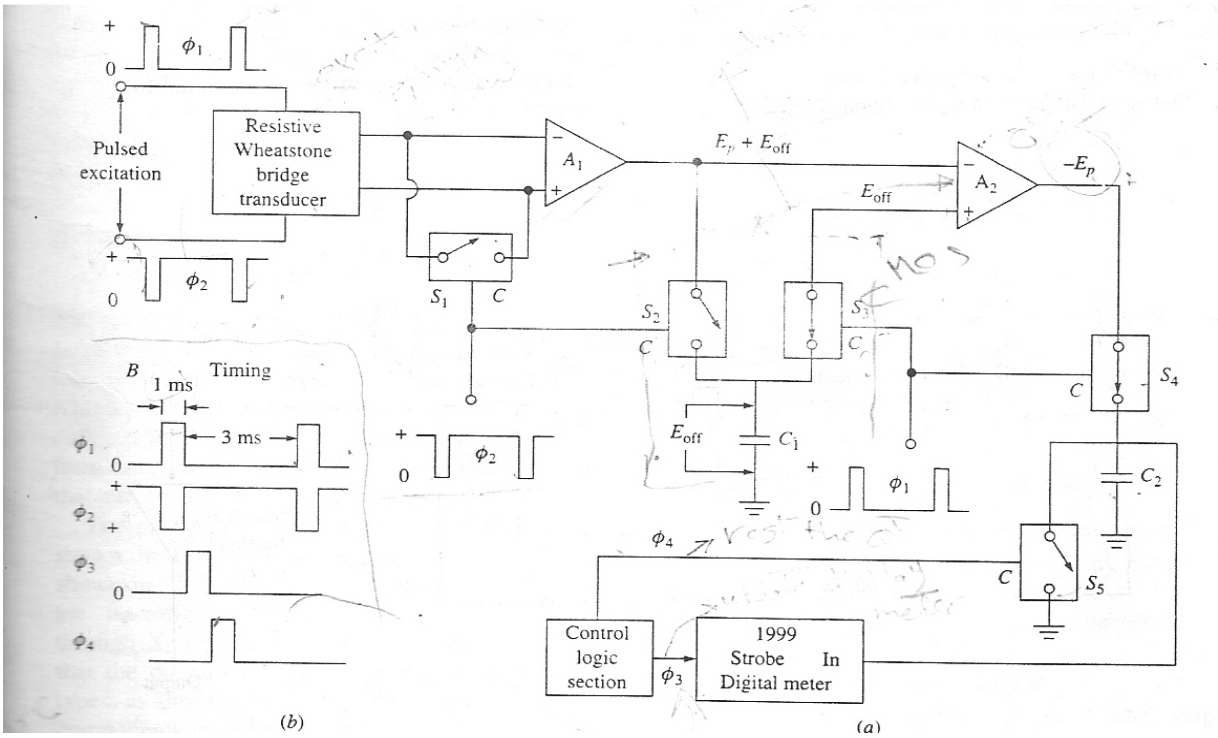
Question (2): [18 Marks]

a) Draw the atrial synchronous Pacemaker block diagram and explain its operation.



- **SA node firing triggers the pacemaker**
- **Delays are used to simulate natural delay from SA to AV node (120ms) and to create a refractory period (500ms)**
- **Output circuit controls ventricular contraction**
- **Combining the demand pacemaker with this design allows the device to let natural SA node firing to control the cardiac activity**

b) Draw the blood pressure pulse excitation amplifier circuit and explain its operation.

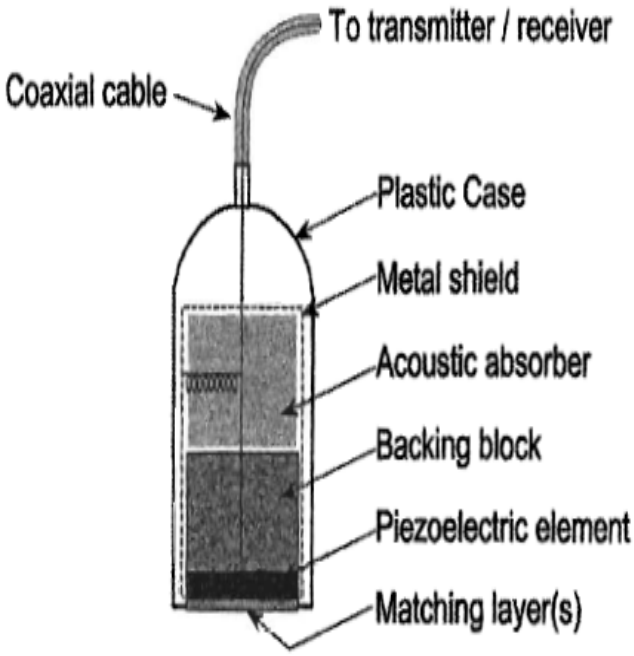


1- the excitation signal is a biphasic short duration pulse (duration on 1ms)
2- A1 is a dc pressure amplifier & A2 is a unity gain summation stage
3- Switches S1 to S5 are CMOS electronic switches which close when control line is high
4- All circuit action is controlled by 4 phases
-phase Φ1 & Φ2 excite the transducer & operate the drift cancellation (offset volt due to thermal changes)
- Φ3 update the display meter
- Φ1 reset the circuit
5- the transducer is excited only when Φ1 is high and Φ2 is low at all other times the transducer is not excited

c) Explain the function for each part of ultrasound transducer construction.

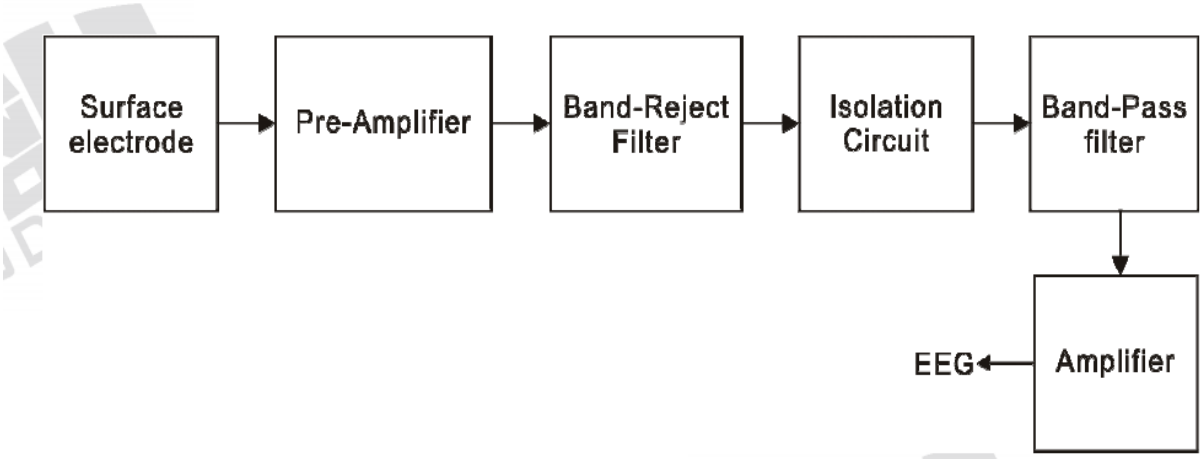
1- **Piezoelectric Element** change in shape of the crystal increases and decreases the pressure in front of the transducer, thus producing ultrasound waves When the crystal is subjected to pressure changes by the returning ultrasound echoes, the pressure changes are converted back into electrical energy signals
2- **Damping Block** composed of epoxy resin impregnated with tungsten bonded to the back of the elements to reduce the # of cycles in the pulse

-The damping block absorbs the backward directed ultrasound energy and attenuates stray ultrasound signals from the housing
-It also dampens (ring-down) the transducer vibration to create an ultrasound pulse with a short spatial pulse length, which is necessary to preserve detail along the beam axis (axial resolution)



3- **Matching Layer** A matching layer of material is placed on the front surface of the transducer to improve the efficiency of energy transmission into the patient
4- **Insulating Case** Plastic or metal casing around transducer
Protects: Keeps outside interference/electrical noise from entering Protects the transducer's components
5- **Wiring** Carries electrical pulse to the crystal
Transmits voltage from the receiving crystal back to the US unit

d) Draw the block diagram of **EEG** and list the function of each block.



Block diagram of EEG measurement circuit.

The surface electrodes are used to measure the pretty weak α wave that is induced By stimulating the eye with light. If the eyes open or close, an arrhythmic α wave will show up

Pre-amplifier with a gain of 50 is used as the preamplifier for picking up the unipolar component of EEG signals.
The band-reject filter is a filter for reject the un needed bandwidth.

the isolation circuit is to isolate the signal and line power source, and can be

implemented by using either an optical or voltage-transformed method.

The band-pass filter is a filter for a signal with bandwidth from 1 to 20 Hz.

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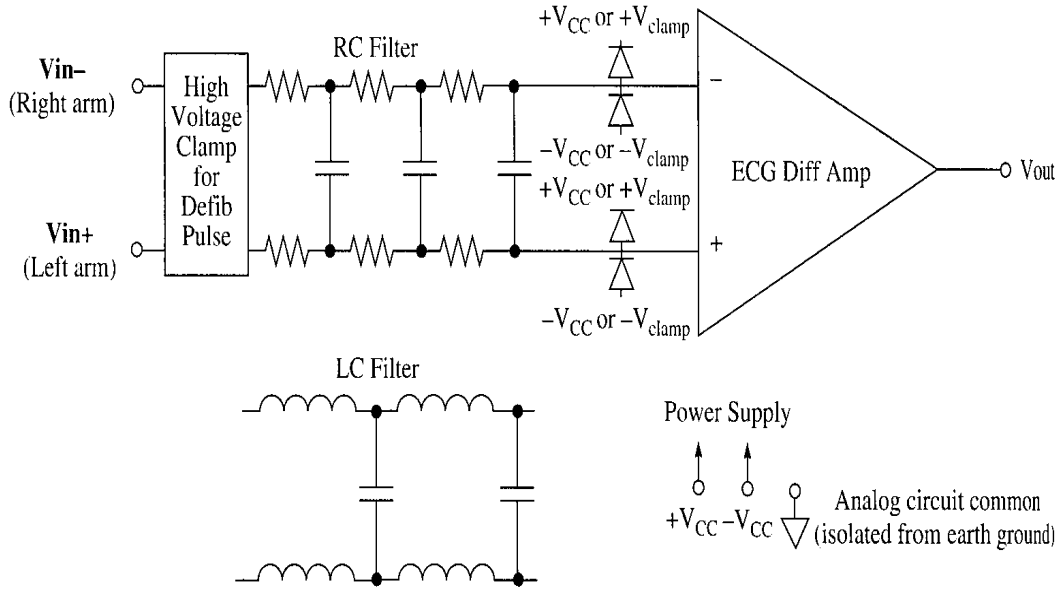
The amplifier with an amplification factor of 1000 (max) can magnify the weak signal that passes through the filter

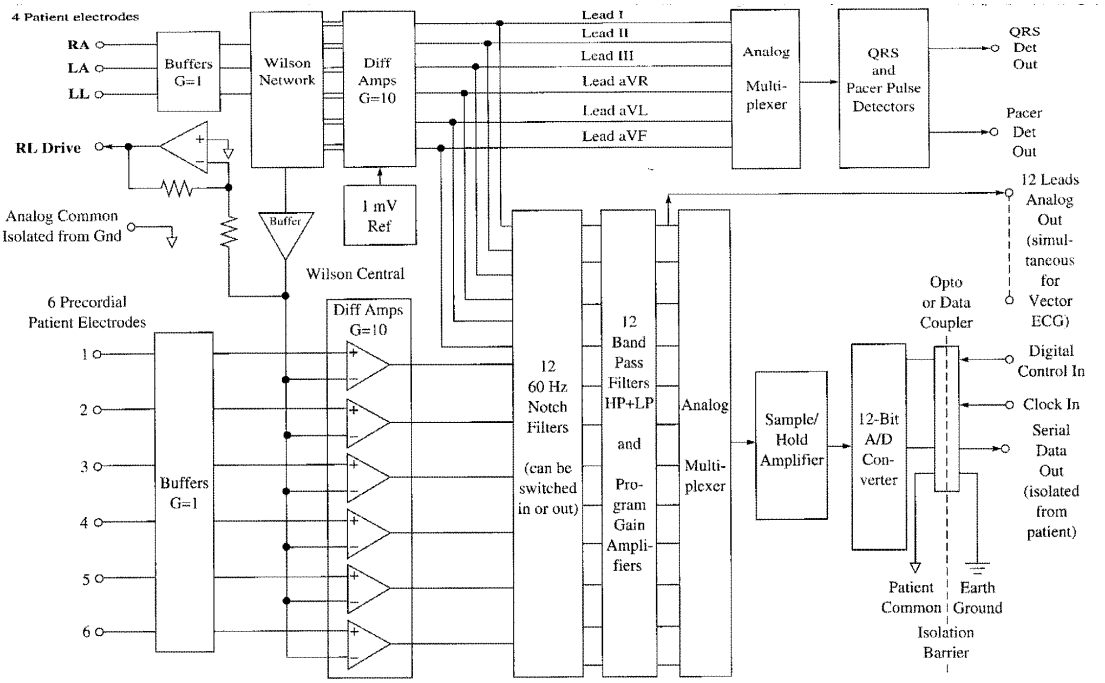
Question (3): *Draw only* [12 Marks]

a) ESU protection circuit.



b) The internal circuit design of automatic blood pressure measurement device with **operational amplifier**.
Solved in the lecture

c) The Block diagram of **Entire ECG Circuit**.



d) The beam profile of ultrasound transducer & write the equations for each field and angle.

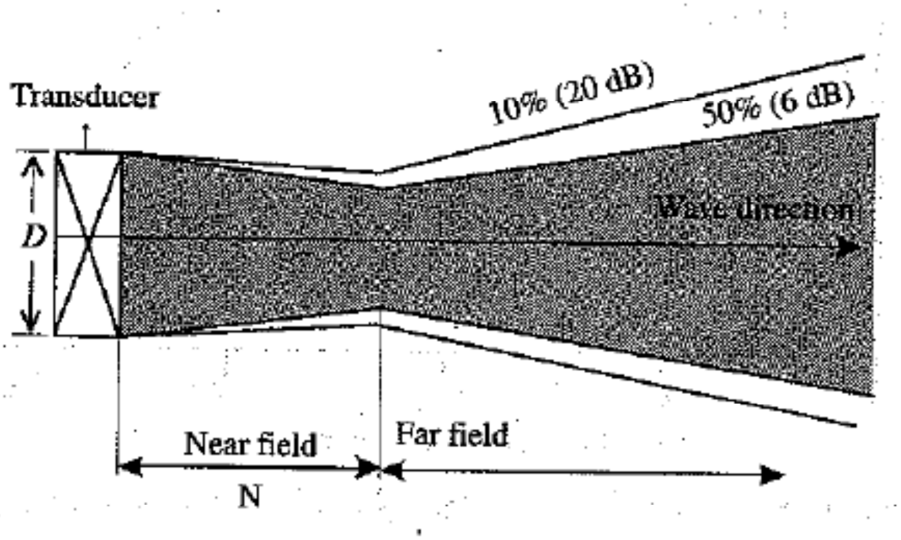
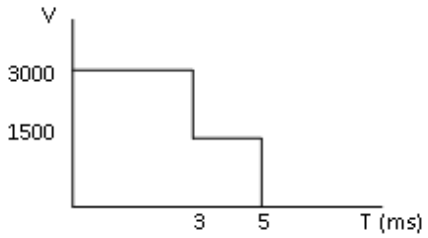


Fig. 3.29 Beam profile of a transducer

- Near Field: $d \le \frac{D^2}{4\lambda}$
- Far Field: $d > \frac{D^2}{4\lambda}$
- Beam spreading angle: $\theta = \frac{1.2\lambda}{D}$

Question (4): [10 Marks]

1) 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 R_D= 10 Ω.



Solved exactly in the sheet

2) For the circuit in **Fig. (1)**, if the whetstone bridge excitation voltage equal 12 volt, pressure sensor resistance R1=20 Ω, R2=R4= 1000Ω, R3= 100 Ω and the selected pressure range at 300 mmHg, determine the output circuit voltage & determine the setting voltage (Vof) of the zero adjustment potentiometer to compensate for -2 V offset voltage at the input. (Set the value of the gain potentiometer to 70 kΩ).

Solved exactly in the lecture

Question (5): *For the circuit in Fig. (2):* [10 Marks]

a) Explain the function of the circuit.

ECG amplifier with common mode voltage cancelation via right leg driven and dc offset voltage cancelation via the use of a DC restorator.

b) Calculate the gain values for the buffers stage, differential amplifier stage,the out Amplifier stage and Cutoff Freq. of the filter.

Stage 1 V1=(1+(2*100,000/20,000))= 11
Stage 2 V2=(50,000/50,000)=1
Stage 3 V3=(1+(25,000/510)=50
Total Gain=V1*V2*V3=11*50*1= 550

- ***Diagnostic Mode*** (most time) where

RC = $1x10^{-6}$F*$3.2x10^{6}$Ω = 3.2 sec
Cutoff Freq = 1/(2πRC) = 0.05Hz

- ***Monitor Mode*** (medium time) where

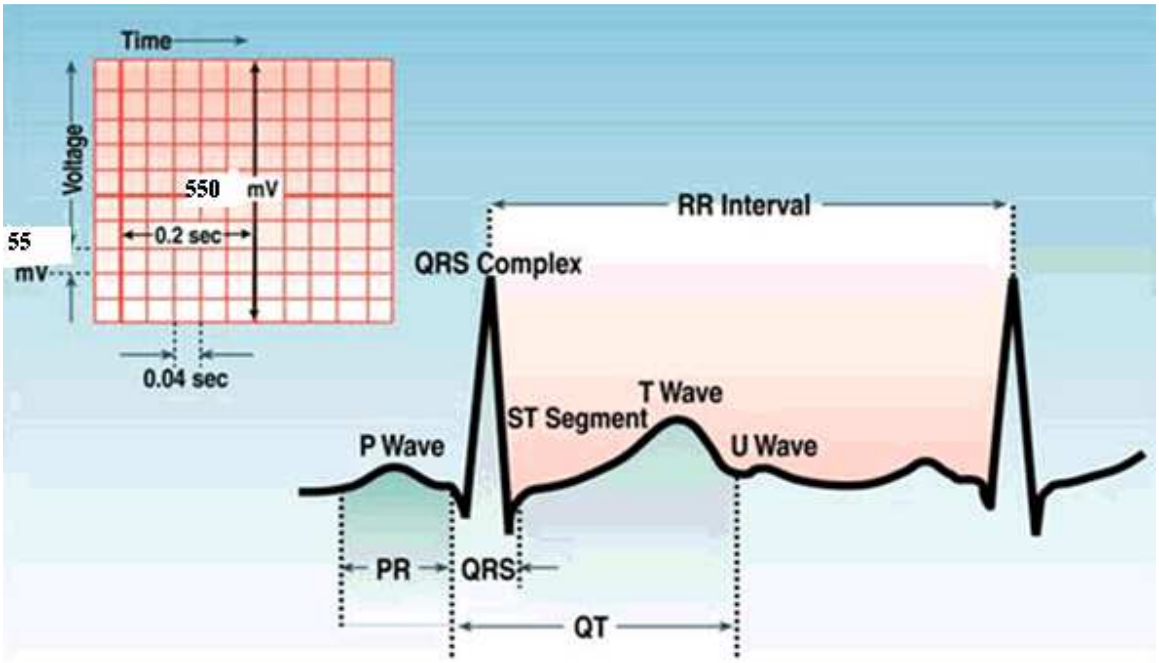
RC = $1x10^{-6}$F*$318x10^{3}$Ω = 0.318 sec
Cutoff Freq = 1/(2πRC) = 0.5Hz

- ***Quick Restore*** (least time) where

RC = $1x10^{-6}$F*$80x10^{3}$Ω = 0.08 sec
Cutoff Freq = 1/(2πRC) = 2Hz

c) Draw the output voltage if the input was 1 mVp-p ECG wave form + 300 mV dc offset.
[Mention the effect of using the integrator A5]

The 300 mV dc offset voltage is canceled via the dc restorator and the 1 mV will be amplified with the gain of 550 (which is the total gain of the circuit) and give an output of 500 mV (0.55 V) peak-to-peak.


Time
Voltage
550 mV
0.2 sec
55
mV
0.04 sec
RR Interval
QRS Complex
T Wave
ST Segment
P Wave
U Wave
PR
QRS
QT