7102100 Lääketieteellinen elektroniikka - Tentti 11.5.2005
7102100 Medical Electronics - Exam 11.5.2005

Voit vastata joko suomeksi tai englanniksi.

Answer briefly, max. two lines / question (1 point per question):

a) 1 kΩ resistance creates thermal noise of 4nV/√Hz. How much thermal noise is generated in 2kΩ resistance?
b) What does' guarding' mean when connected to circuit board or signal cable?
c) What does 'rail to rail' mean when connected to opamps?
d) Electrode currents should be balanced. Why?
e) What is a Holter recorder?
f) What happens to input bias current when opamp's temperature rises? What types of opamps are the most sensitive to temperature rise?

Design an ECG recording system for diagnostic high-quality ECG recording (12 points).

Pay attention to the following issues that are relevant with respect to the performance of the system:

the performance requirements of the ECG recording system,
the hospital environment where the medical device is intended to be used,
effective elimination of noise coupled to the recording system from noise sources that are external to the patient,
an ECG electrode and its connection to the skin,
the transfer of the ECG signal from the electrode to the electrocardiograph, and
an ECG amplifier that meets the international standard requirements (you can refer to Figure 2.).

Tehtävän 3a-b voit korvata harjoitusaktiivisuudesta saamillasi pisteillä. Voit myös vastata siihen, jolloin loppuarvostelussa huomioidaan parempi tulos.
Problem 3a-b can be replaced by the exercise activity points. You can also answer the problem, and the best result is taken into the account in the assessment of the exam.

3 a) (2 points)

In the circuit of Figure 1 $R_1 = 10$ kΩ , $R_2 = 300$ kΩ. Used opamp is OP27C in a room temperature. Determine the Rp and calculate error output voltage caused by input offsets. (See Datasheet)
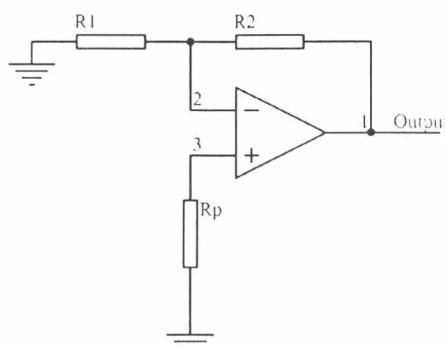

Figure 1

b) (4 points)

Determine the values of resistors and capacitors for instrumentation amplifier presented in Figure 2. so that all following characteristics are fulfilled:
    a. Amplification of 1st stage 50
    b. Amplification of 2nd stage 5
    c. Amplification of filter 1
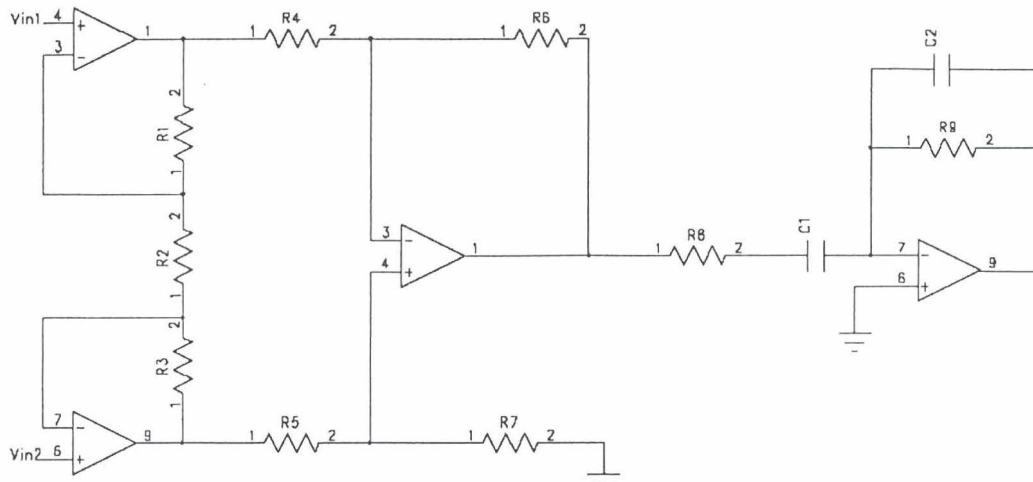   d. Filter frequency bandwidth 1 Hz- 150 Hz

Figure 2.

electrical characteristics at specified free-air temperature, $V_{CC\pm} = \pm15$ V (unless otherwise noted)

PARAMETER		TEST CONDITIONS	T_A†	OP27A, OP37A			OP27C, OP37C			UNIT
				MIN	TYP	MAX	MIN	TYP	MAX	
V_{IO}	Input offset voltage	$V_O = 0$, $V_{IC} = 0$ $R_S = 50\ \Omega$, See Note 3	25°C		10	25		30	100	µV
			Full range			60			300	
α_{VIO}	Average temperature coefficient of input offset voltage		Full range		0.2	0.6		0.4	1.8	µV/°C
	Long-term drift of input offset voltage	See Note 4			0.2	1		0.4	2	µV/mo
I_{IO}	Input offset current	$V_O = 0$, $V_{IC} = 0$	25°C		7	35		12	75	nA
			Full range			50			135	
I_{IB}	Input bias current	$V_O = 0$, $V_{IC} = 0$	25°C		±10	±40		±15	±80	nA
			Full range			±60			±150	