University Bremerhaven

INSTITUTE FOR AUTOMATION AND ELECTRIAL ENG.

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Sample Test ES-MED ST-1

Time 120 minutes
– class documents allowed –

Name: ____________________ **Percent:** ____________

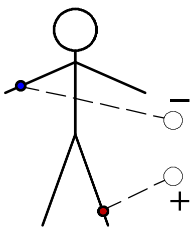
Matr. No.: ____________________ **Grade:** ____________

1	2	3	4	5		Σ

(1) Biosignal Chain

Components of a portable ECG device (one channel)

(1.1) Draw the block diagram of the complete device. Start with the following figure.



Note that the signal voltage is less than 5mV, the common mode DC offset is approx. 1.5V and 300mV small variable offset occurs.

(1.2) Witch filters (analog and digital) are required in your design?

(1.3) Which bit resolution is required for data processing. What is the dynamic range (in dB) does your solution provide?

(2) PLL for 800 Hz Frequency Tracking

A phased locked loop circuit to track frequencies in the 800 kHz range is required. For the reason of simplicity the design should be carried out *in continuous time*.

(2.1) Draw a complete block diagram of the PLL.

(2.2) Draw a complete structure for the controlled oscillator. The oscillator should have a frequency of 800 Hz when the input is zero. What are the initial conditions of the integrators.

(1) = 6	(2) = 6	(3) = 6	(4) = 6	(5) = 6					Σ = 30
1.0 ≥ 29	1.3 ≥ 27	1.7 ≥ 26	2.0 ≥ 24	2.3 ≥ 23	2.7 ≥ 21	3.0 ≥ 20	3.3 ≥ 18	3.7 ≥ 17	4.0 ≥ 15

(2.3) Design the lowpass (aperiodic 2. order IIR) for a suitable cutoff (corner) frequency.

(2.4) Assume that the amplitude of the frequency under measurement is 1, design the parameters of a PI controller. Choose ω_0 of the closed loop so that the lowpass filter can be ignored for PI controller design.

(3) Butterworth Highpass IIR filter

A Butterworth 3. order highpass filter for 10 Hz should be designed.

(3.1) Design the coefficients of a 10 Hz Butterworth lowpass filter.

(3.2) Convert the filter to a highpass filter. Give values of the coefficients.

(3.3) How could it be converted to a discrete filter? What is a suitable sampling frequency?

(4) 8-Tap Bandpass FIR Filter

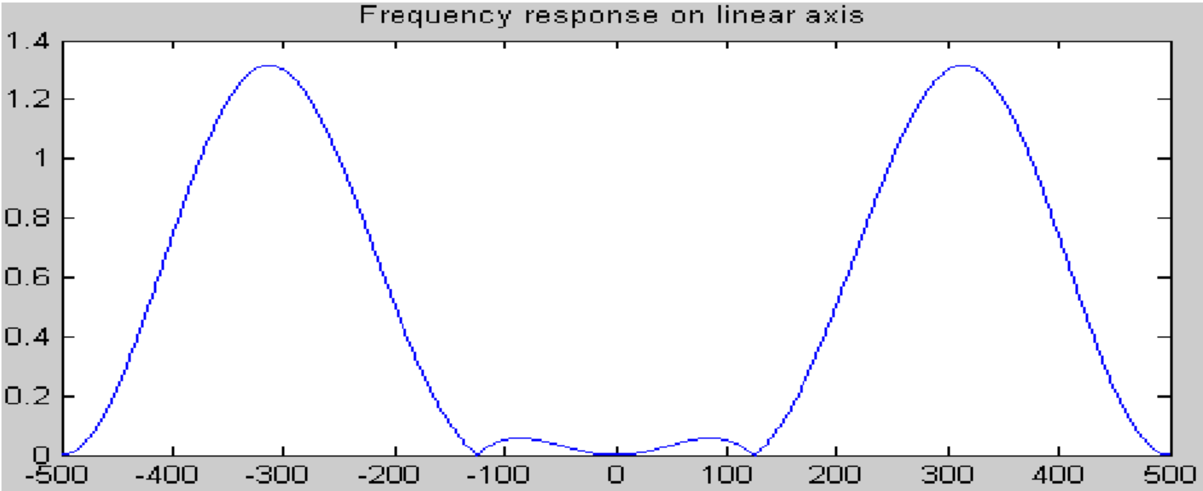
A discrete FIR bandpass filter for 300 Hz should be designed. The sampling frequency is 1 kHz.

(4.1) Design the FIR bandpass in frequency domain. Since 300 Hz is not exactly a discrete frequency use a reasonable approximation. Inverse FFT computation is not required.

(4.2) Assume the IFFT solution is $h^T(k) = [0.1768, -0.2500, -0.1768, 0.5000, -0.1768, -0.2500, 0.1768, 0.0000\,]$. What is the Filter transfer function?

(4.3) Calculate the step response and draw the plot of the step response. What value is the lim $\rightarrow \infty$? Why?

(4.4) Describe why the maximum in the frequency response is not exactly at 300 Hz and why the the gain is not equal to 1. How can a gain = 1 be achieved? Where are the transmission zeros located?



(4.5) Draw a block diagram of the filter with $\frac{1}{z}$ delay elements.

(4.6) How could you improve the filter characteristic?

(5) CORDIC Tangent Computation

CORDIC should be used for tangent computing in hardware

(5.1) Draw a block diagram how this is possible (with only multiplier, shift, adder blocks.

(5.2) Draw one CORDIC rotation cell and one CORDIC vectoring cell in detail.

(5.3) What are minimum and maximum values for tangent computation of 45° (with 10 stages)? You can assume that the word length is sufficiently large.