PROJECT SPECIFICATIONS AND DETAILS

Goal: Design and implement (in MATLAB) a bandstop filter that meets the specifications given below while minimizing the hardware and energy requirements. In other words, you have to design the filter, choose the architecture, and the bit-widths of a fixed-point implementation.

Specifications:

Parameter	Value
Input sample rate, F_S	1 MHz
Pass-band edge	70 kHz, 170 kHz
Stop-band edges	90 kHz, 120 kHz
Minimum stop-band attenuation	40 dB
Maximum pass-band ripple	0.05 dB
Pass-band group delay variation	no requirement
Minimum output SNR (for -6dB full-scale sinusoidal input)	72 dB

Procedure and other notes:

1. Estimate the hardware and energy consumption in terms of the number of "basic" logic gates required according to the following approximate table. Furthermore, assume that each "basic" logic gate running at F_S, consumes a power P.

Arithmetic Block	Number of Logic Gates
n-bit Adder	4n
n-bit Multiplier	$2n^2$
n-bit Register	5n

2. You should design an IIR filter to meet the specifications. (You do NOT have to guarantee that phase is linear over the pass-band).

3. Grading will be according to the following rubric:

Accomplishment	Score
Correct filter design that meets specifications ● Rationale (why, how etc.) (50%) ● Quantitative arguments (50%)	20%
Correct implementation that meets specifications ● Rationale (why, how etc.) (50%) ● Quantitative arguments (50%)	20%
Correct demonstration of designed system's operation and that it meets specifications ● Frequency response, pole-zero plots, impulse response plots (with and without finite precision effects) (30%) ● Time-domain simulations showing SNR is greater than target (40%) ● Calculation of required hardware (20%) ● Executable MATLAB code (10%)	30%
Innovations in filter design to reduce hardware ● Description of your approach (60%) ● Quantitative arguments (40%)	15%
Innovations in filter implementation to reduce hardware ● Description of your approach (60%) ● Quantitative arguments (40%)	10%
Report (clarity, relevance etc.)	5%

4. It is very important that your design and implementation choices be motivated by well-conceived and well-articulated. The arguments should be quantitatively supported. For example, suppose you chose a 16-b word length for your filter implementation (as an example). You should present quantitative reasons behind your choice. Reasons such as "…MATLAB suggested 16-b…" or "…I tried several choices and this was the best.." are NOT valid.

SUBMISSION DETAILS:

1. Please submit MATLAB code that will design your filter and plot all relevant results e.g., frequency response plots, pole-zero plot, impulse response etc., all with and without quantization effects. **I will run your MATLAB code to evaluate it.** Do not forget proper labeling of your plots.
2. Please submit a report (no longer than four pages, single spacing, 12-point font) summarizing the design approach, rationale behind your design choices and a table of performance numbers. Show quantitative arguments in favor of your choices.

3. The deadline for the project submission is June 7, 2024 at 11:59 pm i.e. the last business day of the last week of instruction.
4. All submissions will be made on Gradescope.