NOVA SCHOOL OF
SCIENCE & TECHNOLOGY

MEEC/MIEEC

Analog Integrated Circuits

2nd Order Single-bit Sigma Delta Modulator

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Contents

List of Figures

List of Tables

1 Template

Table 1: Anti-Aliasing Filter Specifications and Achieved Performance

Specification	**Target**	**2nd-Order Butterworth**	**3rd-Order Butterworth**
Pass-band ripple $A_{\max}$ (dB)	≤ 0.5	0.5	0.5
Stop-band attenuation $A_{\min}$ (dB)	≥ 80	90	90
Pass-band edge f_p (kHz)	20	20	20
Stop-band edge f'_s (MHz)[1]	4.62	4.62	4.62
Transition ratio f'_s/f_p	231	231	231
Filter order N	—	2 (chosen)	3 (strict)
Theoretical in-band group delay[2] (μs)	—	7.9	11.8

Figure 1: Logo da Nova FCT

$$\begin{cases} R(283,15) = 1,998 \cdot 10^4\ \Omega \\ R(298,15) = 10^4\ \Omega \\ R(313,15) = 0,5282 \cdot 10^4\ \Omega \end{cases} \Leftrightarrow \begin{cases} A = 1,3092 \cdot 10^{-3} \\ B = 2,1439 \cdot 10^{-4} \\ C = 9,6600 \cdot 10^{-8} \end{cases} \tag{1}$$

Listing 1: Matlab code example

```
Fdz
printf('Polos: ');
PlFdz
%figure(3);
pzmap(Fdz);
%figure(4);
step(Fdz);
```

[1]First stop-band edge equals $f_s - f_p$, where f_s is the modulator sampling frequency (4.64 MHz).
[2]Approximate group delay evaluated at ω_p for a Butterworth LPF: $\tau_g \approx N/(2\pi f_p)$.

- item 1

  ...

- item n

1. Butterworth
2. Chebyshev
3. Elliptic
4. Bessel

   In the application in study, the group delay is a critical factor because the ECG signal is a time-domain signal, and the phase distortion can lead to a misinterpretation of the signal. So it is safe to say that the Bessel filter is the best choice for this application.

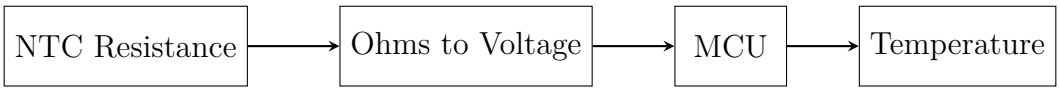

Figure 2: NTC's block diagram

Referece like this [?]