Continuous-Time CMOS Quantizer
For Ultra-Wideband Applications

Tuan Anh Vu
Nanoelectronics Group, Department of Informatics
University of Oslo, Norway
Email: anhtv@ifi.uio.no
1. Introduction
2. The proposed quantizer description
   • Amplifier stages
   • Threshold circuit
3. Simulated results
4. Conclusions
Outline

1. Introduction
2. The proposed quantizer description
   • Amplifier stages
   • Threshold circuit
3. Simulated results
4. Conclusions
Introduction (1)

The 1st version of the active echo
• Proposing a solution for continuous-time, high-gain quantizer suitable for ultra wideband applications.

• A bandwidth exceeding 10 GHz is feasible while maintaining sufficient DC gain for the thresholding operation.

• The proposed solution is designed in 90nm TSMC technology exploring resistive-feedback inverters and a single LC resonator at the input.
Outline

1. Introduction
2. The proposed quantizer description
   • Amplifier stages
   • Threshold circuit
3. Simulated results
4. Conclusions
The proposed quantizer block diagram
Amplifier stages (1)

- For increased bandwidth, strong feedback is applied sacrificing stage gain.
- Wider bandwidth is achieved at the expense of lower gain per stage by using low values of $R_f$.
Considering the inter-stage small signal model, the transfer function can be expressed as [7]:

$$\frac{V_{out}}{V_{in}} = \frac{-g_m R_T}{1 + sC_T R_T}$$

Where $R_T$ denotes $R_{f1} || R_{f2}$ and $C_T$ represent $C_1 + C_2$. $R_{f1} / R_{f2}$ and $C_1 / C_2$ denote equivalent resistors and capacitors contributed by previous and next stages, respectively.

Disadvantage of using resistive feedback\textsuperscript{[8]}

- Low gain
- Low output power
- Degraded noise figure

Multiple inductive-series peaking technique[7]

Splitting-load inductive peaking technique[11]

By locating a peaking inductor at the gate of nMOS of each inverter stage, the -3dB roll-off frequency can be boosted to higher frequencies.

Disadvantage of using peaking inductors

Area demanding
The proposed high-gain UWB amplifier

8 inverter stages
A resonant peak at the amplifier corner frequency can ‘pull up’ the gain, thus extending the bandwidth significantly.

- A single, small inductor (0.82 nH) is used for the LC resonator regardless of the number of amplifier stages.

- The LC resonator also acts as a high-pass filter at the input, shifting the bandwidth to higher frequencies suitable for the FCC approved UWB spectrum.
Bandwidth comparison among the designs

![Graph showing bandwidth comparison among different designs. The graph plots Gain [dB] against Frequency [GHz]. There are three lines representing 'Without inductor', 'Multiple peaking inductor', and 'Proposed LC resonator'. The proposed LC resonator has a wider bandwidth compared to the other two designs.](image-url)
Comparison with the state of the art

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>CMOS technology</td>
<td>0.18 μm</td>
<td>0.13 μm</td>
<td>90 nm</td>
</tr>
<tr>
<td>Supply voltage</td>
<td>1.8 V</td>
<td>1.3 V</td>
<td>1.2 V</td>
</tr>
<tr>
<td>Gain (dB)</td>
<td>61</td>
<td>13.2</td>
<td>70</td>
</tr>
<tr>
<td>-3 dB bandwidth</td>
<td>DC–7.2 GHz</td>
<td>DC–1.5 GHz</td>
<td>3.1 GHz–10.6 GHz</td>
</tr>
<tr>
<td>No. of stages</td>
<td>5</td>
<td>3</td>
<td>8</td>
</tr>
<tr>
<td>No. of inductors</td>
<td>8 (1.1 nH)</td>
<td>3 (2.4 nH, 2.4 nH, and 1.4 nH)</td>
<td>1 (0.82 nH)</td>
</tr>
</tbody>
</table>


Threshold circuit

Continuous-Time CMOS Quantizer for Ultra-Wideband Applications
Outline

1. Introduction
2. The proposed quantizer description
   • Amplifier stages
   • Threshold circuit
3. Simulated results
4. Conclusions
Simulated results (1)

• Simulated results of the quantizer for TSMC 90 nm CMOS technology are achieved using the CADENCE design environment.

• All components used for simulation are RF models provided by TSMC.
Simulated results (2)

Continuous-Time CMOS Quantizer for Ultra-Wideband Applications
Simulated results (3)

The performance of the threshold circuit

![Graph showing the relationship between threshold voltage and threshold current for a Continuous-Time CMOS Quantizer for Ultra-Wideband Applications.]
Simulated results (4)

Frequency response

Graph showing the frequency response of a Continuous-Time CMOS Quantizer for Ultra-Wideband Applications.
Simulated results (5)
Outline

1. Introduction

2. The proposed quantizer description
   • Amplifier stages
   • Threshold circuit

3. Simulated results

4. Conclusions
Conclusions

• Proposing a continuous-time, ultra wideband quantizer with tunable threshold level and high gain suitable for FCC UWB applications

• The -3 dB bandwidth covering the entire FCC UWB spectrum from 3.1 GHz to 10.6 GHz.

• A very high gain of approximately 70 dB.

• Area-efficient, single-inductor solution designed for TSMC 90 nm CMOS technology.
References

THANK YOU FOR YOUR ATTENTION!

Tuan Anh Vu
Nanoelectronics Group, Department of Informatics, University of Oslo, Norway
Email: anhtv@ifi.uio.no