ATMX150RHA building blocks

May 25th 2021
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About Weeroc

• French Start-up company issued from IN2P3
  IN2P3 : French National Institute for Nuclear Physics and Particle Physics
• Created February 2012 → 9-year old
• ISO9001 certified
• Missions :
  – Microelectronics engineers → We design & sell ASICs
  – Embedded system engineers → We integrate our ASICs in systems
  – Application engineers → We support our customer building products with our ASICs
Weeroc Activity & Expertise

Design and sell Analogue & mixed microelectronics ASIC to read-out photodetectors and particle detectors and for radhard application

- Radhard design
- Low-noise, low power, analogue and mixed signal circuits
- Particle detection
Weeroc offer: application fields

- Aerospace Industry
- Homeland Security
- Scientific Instrumentation
- Medical Imaging
- Nuclear Industry
Project Framework

→ Build an analog/mixed IP library in spece-qualified ATMX150RHA technology to reduce risk in complex mixed signal design.

• Mini-circuit foundry funded by CNES
• Test of the mini-circuit funded by CNES

Block list based on end-user need assessment.
Work continuation of previous talk (AMICSA Leuven June 2018)
Test Vehicle Presentation

- Three small test vehicles including:
  - A high-bandwidth 5V / 500MHz analogue CMOS switch in a quad-switch configuration & 8→1 multiplexor
  - A 10b ADC with internal bandgap (2 configs), internal linear regulator
High bandwidth switch

- A high-speed CMOS switch with low latency
- Design of small test vehicle to ensure low bonding inductor

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
<th>Meas</th>
</tr>
</thead>
<tbody>
<tr>
<td>$R_{ON}$</td>
<td>20</td>
<td>20</td>
<td>0</td>
<td>Ohm</td>
<td>12</td>
</tr>
<tr>
<td>Commuting latency ON &amp; OFF</td>
<td>20</td>
<td>20</td>
<td>8,6</td>
<td>ns</td>
<td>8,6</td>
</tr>
<tr>
<td>3dB bandwidth</td>
<td>500</td>
<td>500</td>
<td>509,5</td>
<td>MHz</td>
<td>509,5</td>
</tr>
<tr>
<td>crosstalk</td>
<td>60</td>
<td>60</td>
<td>&gt;60</td>
<td>dB</td>
<td>&gt;60</td>
</tr>
</tbody>
</table>
Electrical & temperature performances

Transmission

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Frequency (MHz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>-40°C</td>
<td>-8.00</td>
</tr>
<tr>
<td>70°C</td>
<td>-2.00</td>
</tr>
<tr>
<td>20°C</td>
<td>0.00</td>
</tr>
</tbody>
</table>

R_on Switch (Ohms)

- RSW -30°
- RSW 125°

Isolation

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Frequency (MHz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>20°C</td>
<td>-80.00</td>
</tr>
<tr>
<td>70°C</td>
<td>-70.00</td>
</tr>
<tr>
<td>-40°C</td>
<td>-60.00</td>
</tr>
</tbody>
</table>

Crosstalk

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Frequency (MHz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>20°C</td>
<td>-100.00</td>
</tr>
<tr>
<td>70°C</td>
<td>-90.00</td>
</tr>
<tr>
<td>-40°C</td>
<td>-80.00</td>
</tr>
</tbody>
</table>
Switch : Radiation Measurement
10b ADC

- A 10-bit 10-MSPS full asynchronous SAR ADC

<table>
<thead>
<tr>
<th>Measure</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unité</th>
<th>Meas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Missing code</td>
<td>None</td>
<td></td>
<td></td>
<td></td>
<td>Missing code at MSB</td>
</tr>
<tr>
<td>Gain error</td>
<td>1%</td>
<td>FSR</td>
<td></td>
<td></td>
<td>4.4%</td>
</tr>
<tr>
<td>Offset</td>
<td></td>
<td>1%</td>
<td>FSR</td>
<td></td>
<td>2.2%</td>
</tr>
<tr>
<td>INL</td>
<td>-1</td>
<td>1</td>
<td>LSB</td>
<td></td>
<td>-5 à 5</td>
</tr>
<tr>
<td>DNL</td>
<td>-1</td>
<td>1</td>
<td>LSB</td>
<td></td>
<td>-0.7 à 3</td>
</tr>
<tr>
<td>Sampling Rate</td>
<td>10</td>
<td>MHz</td>
<td></td>
<td></td>
<td>14</td>
</tr>
</tbody>
</table>
10b ADC electrical & temperature performances
10b ADC: Radiation Measurement

The graph shows the evolution of the INL value (%) and the DNL MAX ADC (LSB) for different ASICs under varying radiation levels (0kRad, 20kRad, 40kRad, 60kRad, 80kRad, 100kRad, Annealing 1, Annealing 2) and annealing states (OFF, 100OFF, 140OFF). The INL value (%) is represented on the left y-axis, while the DNL MAX ADC (LSB) is represented on the right y-axis. The x-axis represents the evolution of irradiation.
Bandgaps

- Two different approaches of bandgaps:
  - One low silicon occupancy with trimmable features
  - One mismatch optimized not trimmable

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unité</th>
<th>Meas BG1</th>
<th>Meas BG2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output deviation from -40° to 125°C</td>
<td>1,5 mV</td>
<td>7</td>
<td>10,5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output deviation from -3V to 3,6V</td>
<td>1,8 mV</td>
<td>0,75</td>
<td>1,61</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bandgap voltage</td>
<td>1,25 V</td>
<td>1,251</td>
<td>1,22 to 1,3</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Bandgap1 electrical & temperature performance

Vref = f(Vdd)

Measurement
Monte Carlo simulation

DC standard deviation @ 300 K = 760 μV
Bandgap 1: irradiation measurement

Tension en fonction de l'étape d'irradiation

Evolution de l'irradiation

- ASIC REF
- ASIC4ON
- ASIC5ON
- ASIC6ON
- ASIC7ON
- ASIC9ON
- ASIC1OFF
- ASIC12OFF
- ASIC14OFF
- ASIC15OFF
Bandgap2 electrical & temperature performance

Vbg2 versus trimming code

Vbg2 with default trimming (minimum)

Vbg2min dispersion
Bandgap2 : irradiation measurement
Conclusion

• Several IP block has been designed and prototyped in ATMX150RHA technology
• These blocks has been tested and are in (or close to) specifications
• Bandgap are drifting by 100mV (8%) during lifecycle, to be included in EOL simulations
• Some blocks to be used in upcoming Weeroc design.
Thank you
Thank you
Thank you