Multichannel board for picosecond timing measurements of silicon sensors



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Outline

- Boards assembly.
- Base board.
- Sensor board.
- Simulation.
 - Frequency domain.
 - Time domain.
- Measurements.
 - Pulse response.
 - 3D sensors.
 - Noise.
 - Planar sensors.
- Conclusions.
- Future steps.



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Boards Assembly

Setup composed of a base board and a sensor board.

Sensor board is fully passive, with low noise and has temperature monitoring. It has compatibility with variety of sensor sizes, low material budget and easy alignment. Moreover, it is cheap.

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- Allows quick sensor test turn around.
- Allows group wire bonding.
- Possibility to use for other purposes. (IV, CV, ...).
- Base board is active with electronics for the signal amplification.

Front view



Side view



XUNTA DE GALICIA Interconnection





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Base boards design

- 16-channel readout board with integrated first and second stage.
- High Frequency SiGe technology (Infineon BFR840L3RHESD).
- High frequency design up to 12GHz.
- Low current (~220mA) for the full board (32 stages).
- Rogers 4350B (100 μm) for the high speed signals.
- Small packaging with 0201-size components for multichannel integration.
- Independent Shielding per channel.
- 18 mm x 18 mm central opening.
- 140 mm x 90 mm dimensions.
- Pre-assembled miniaturized coaxial edge connectors with panel-mounted SMA plugs.
- Vertical miniaturized coaxial plug connectors for sensor board (16 channels + HV/RTD).
- Keyed connectors with high life cycle.





First and second stage

Infineon	BFR840L3RHESD
G _{max}	26.5 dB
I _C max	35.0 mA
NF	0.5 dB
OIP3	17.0 dBm
OP1dB	4.0 dBm
V _{CEO} max	2.25 V
Frq. Range	Up to 12 GHz

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Sensor board

- Two types of designs. (15x15 mm and 5x5 mm central pad).
- 41 x 41 mm square shape.
- Rogers 4350B for the high speed signals.
- Connector area reinforce with 0.3 µm FR4.
- Under sensor pad thickness of 100 µm.
- Multiple drills design on the central pad to place different types and sensors sizes.
- 140 boards produced at Gacem.

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Back side



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Frequency domain simulation

- Initial frequency domain simulation to optimize the design for uniform response with frequency.
- No sharp gain change discontinuities.
- Gain ~70 for a two-stage configuration.
- Tested injecting a pulse of 300ps width and -10 mV amplitude. Readout with 10 GHz bandwidth scope and sampling rate of 50 Gsps.

S21 before freq. optimization

S21 after freq. optimization



Measurement Setup







Time domain simulation

- Spice time domain simulation using an ideal I source.
- Decreasing exponential pulse with time constant of 1 ns.

Before time optimization After time optimization

- Red output.
- Blue input.



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Red output. Blue input.

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Frequency measurement after time optimization





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Measurements

- Pulse response.
- 3D sensors using a Sr90 (4.15MBq).
 - 55 µm pitch.
- Noise using a 3D sensor and Sr90 (4.15MBq).
- Planar sensors (1 and 4 pixels) using a Sr90 (4.15MBq).
 - 50 μm, 100 μm, 200 μm, 300 μm thickness.

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Measurement Setup with source







Pulse response

- After the optimization in frequency and time.
- Tested injecting a pulse of 300ps width and -10 mV amplitude. Readout with 10 GHz bandwidth scope and sampling rate of 50 Gsps.
- Output fall time of 276 ps.

Measurement Setup for pulse response



Output signal



Input signal

3D sensors

CNM 3D sensors 55 um pitch.

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Used in: •





- Timing resolution and CCE of n-on-n silicon sensors with TCT setup Oscar David Ferrer Naval (CNM). 41st RD50.
- Timing performance of small cell 3D silicon detectors G. Kramberger, et al.
- Timing performance compatible with what was measure before.





Noise

- Measurement of the board output noise level with a 3D sensor.
- Noise RMS of 1.2 mV.

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EP R&D



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Planar sensors

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- Measurements of time response for different sensors thickness.
 - 50 μm, 100 μm, 200 μm, 300 μm.
- 4 sensors wirebonded per board in adjacent channels to measure board crosstalk.







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Planar sensors

Measurement example for the 100 µm sensor thick.





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Planar sensors: Crosstalk

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- No crosstalk observed between channels.
- One sensor connected in each oscilloscope channel.

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Conclusions

- Successful design, simulation and test of a platform for sensor characterization.
- Design of a 16 channels board to characterize single or multiple pixel sensors. Compact and versatile.
- Time and frequency domain studies for a better signal to noise ratio on the electronics.
- Measurement of the circuit pulse response.
- Test of planar and 3D sensors.



Future steps

- Test setup with collimated source for angle measurements & position scans.
- Test with laser.
- Cold test.
- Test 4x4 pixel matrix.
- Optimize to be used in the DUT of the <u>Timepix 4</u> <u>Telescope</u>.











Thanks







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Back up



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50 um sensor

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200 um sensor





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300 um sensor

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CV curves for 4 pixel planar sensors





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Crossstalk 300 um





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Crosstalk 200 um



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Crosstalk 100 um







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Crosstalk 50 um





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