

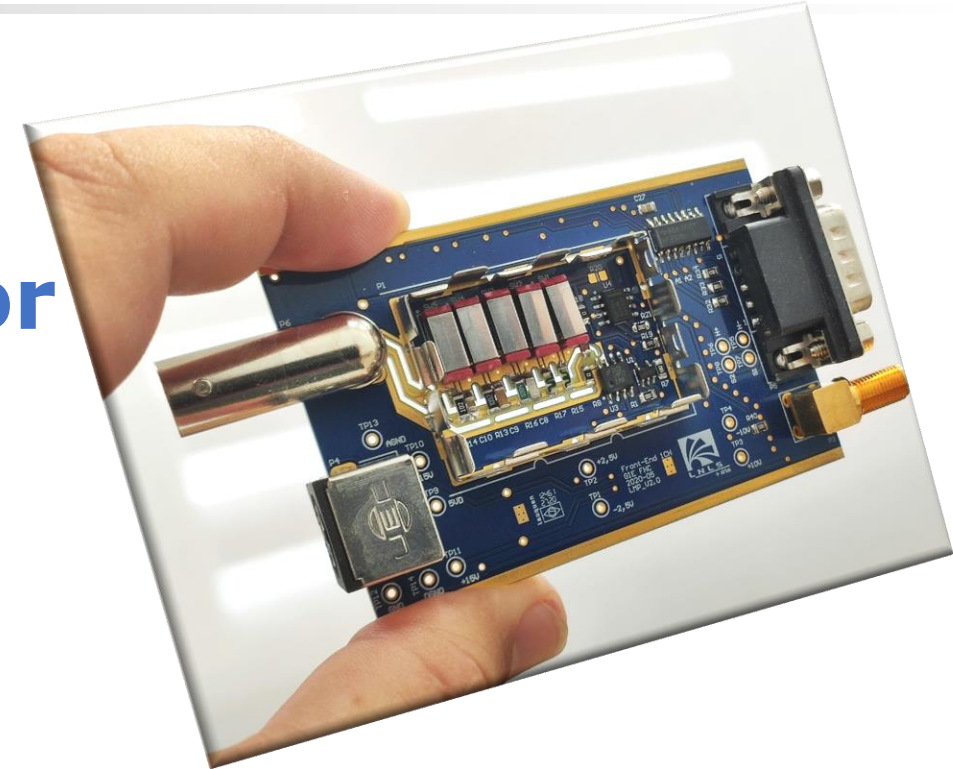
WEPAB330

A multirange Low Noise Transimpedance Amplifier for Sirius Beamlines

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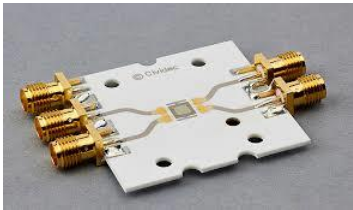
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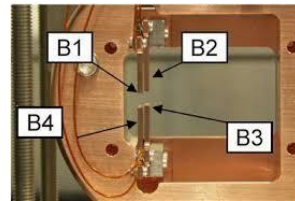


Low current measurements at Sirius beamlines

- Photodiodes;
- Ionization Chambers;
- Slits;
- Electron collectors;
- Beam position monitors
 - ✓ Blades, Wires, Diamond



Range:
Picoampere to
Milliampere



- UVX (our old machine)
 - ✓ 18 beamlines
 - ✓ ~ 30 devices

- SIRIUS
 - ✓ 14 beamlines (Phase 1A and 1B)
 - ✓ ~200 devices



**Decision for in-house development:
A Multirange Low Noise
Transimpedance Amplifiers**



Standard Acquisition
Hardware



Benchmark: SR570

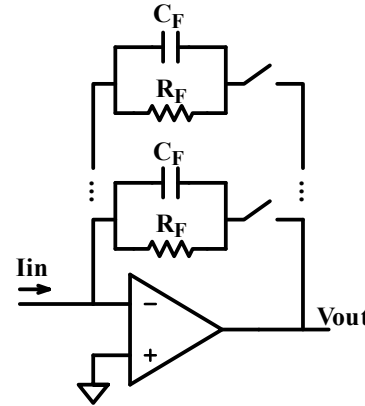


US\$ 3.000

In-house specification

Parameters	Value
Input Channels	1
Input Connectors	BNC or TRIAX
Full-scale ranges	500pA to 7.3mA (5 SCALES)
Input Current Polarity	Bipolar
Output Voltage	±5V
Bandwidth	10 Hz at 100pA/V scale 1 kHz for Other scales
RMS Noise	10 fA/√Hz (max) @100pA/V, 1Hz
Size	80x54x23mm
Gain Error	10% (max) @100pA/V scale
Drift	250ppm @100pA/V scale
Accuracy	±10% @100pA/V scale

Circuit Topology



Common error sources

- Surface leakage
- Triboelectric effect
- EMI e RFI (effective shielding needed)
- Electrostatic coupling
- Temperature variation
- Humidity
- Dirty
- Cosmic rays (<pA Range)

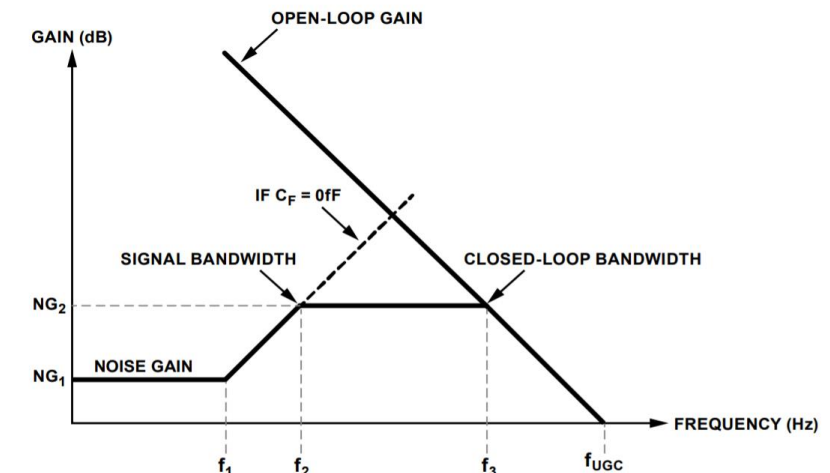
Theoretical analysis

$$V_{out} = -R_F I_{in}$$

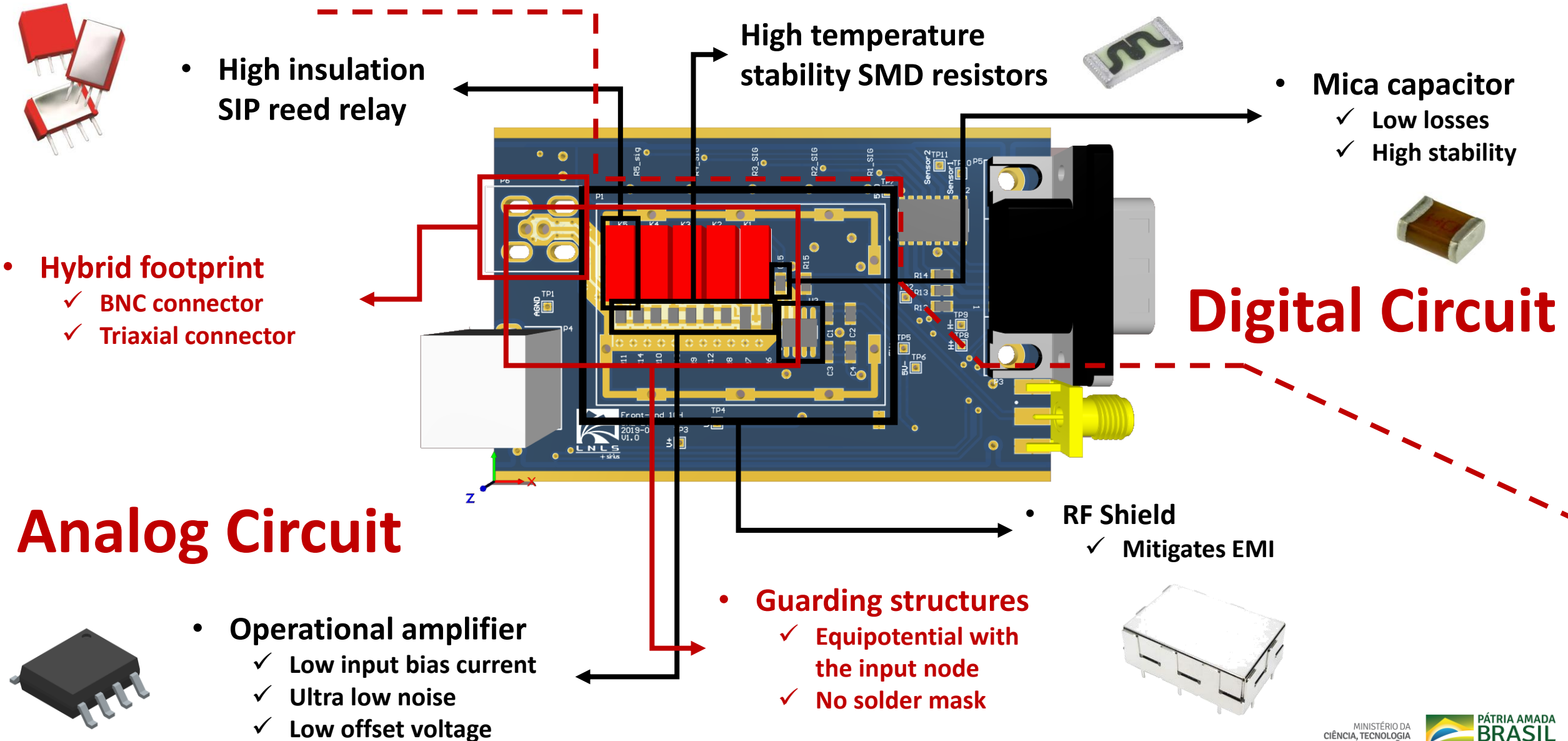
$$f_{cutoff} = \frac{1}{2\pi R_F C_F}$$

$$v_{total_n} = \sqrt{v_{v_n}^2 + v_{i_n}^2 + v_{R_F_n}^2}$$

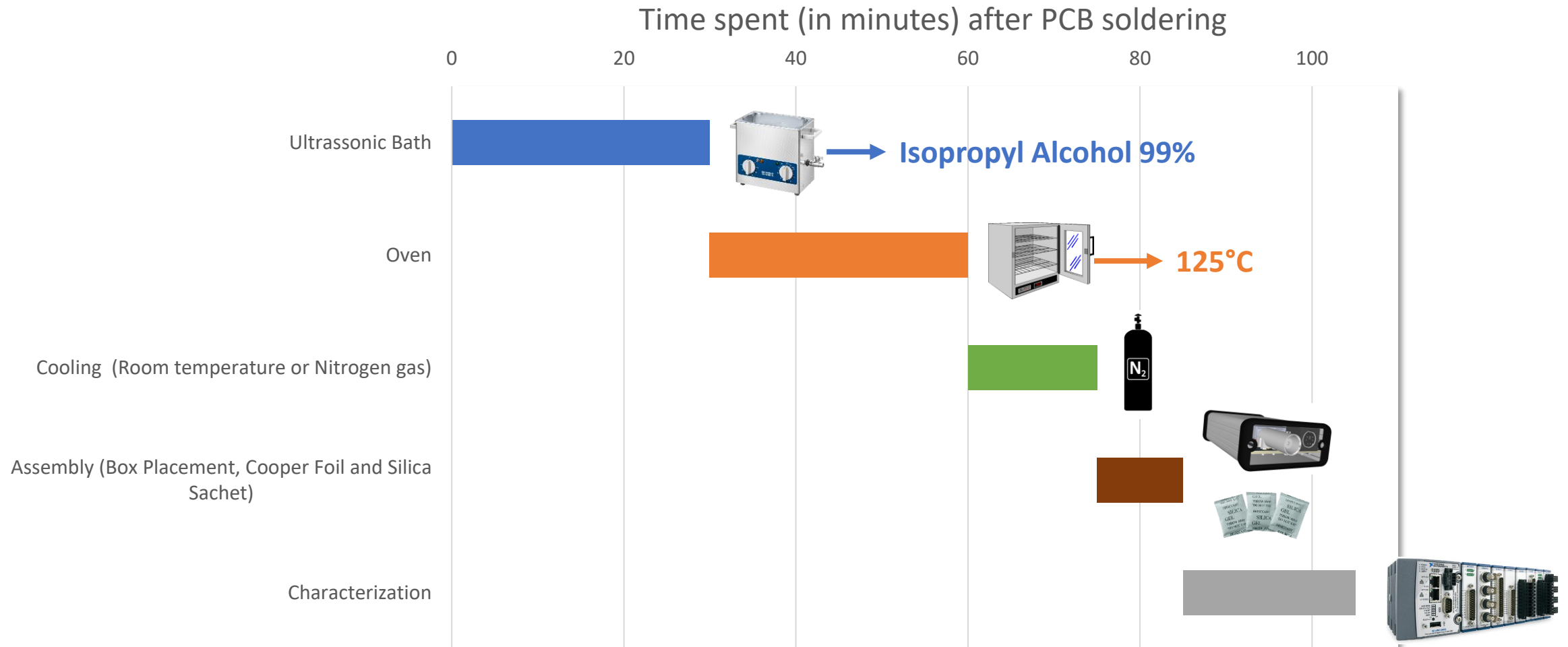
$$v_{johnson} = \sqrt{4k_B T R_F \Delta f}$$



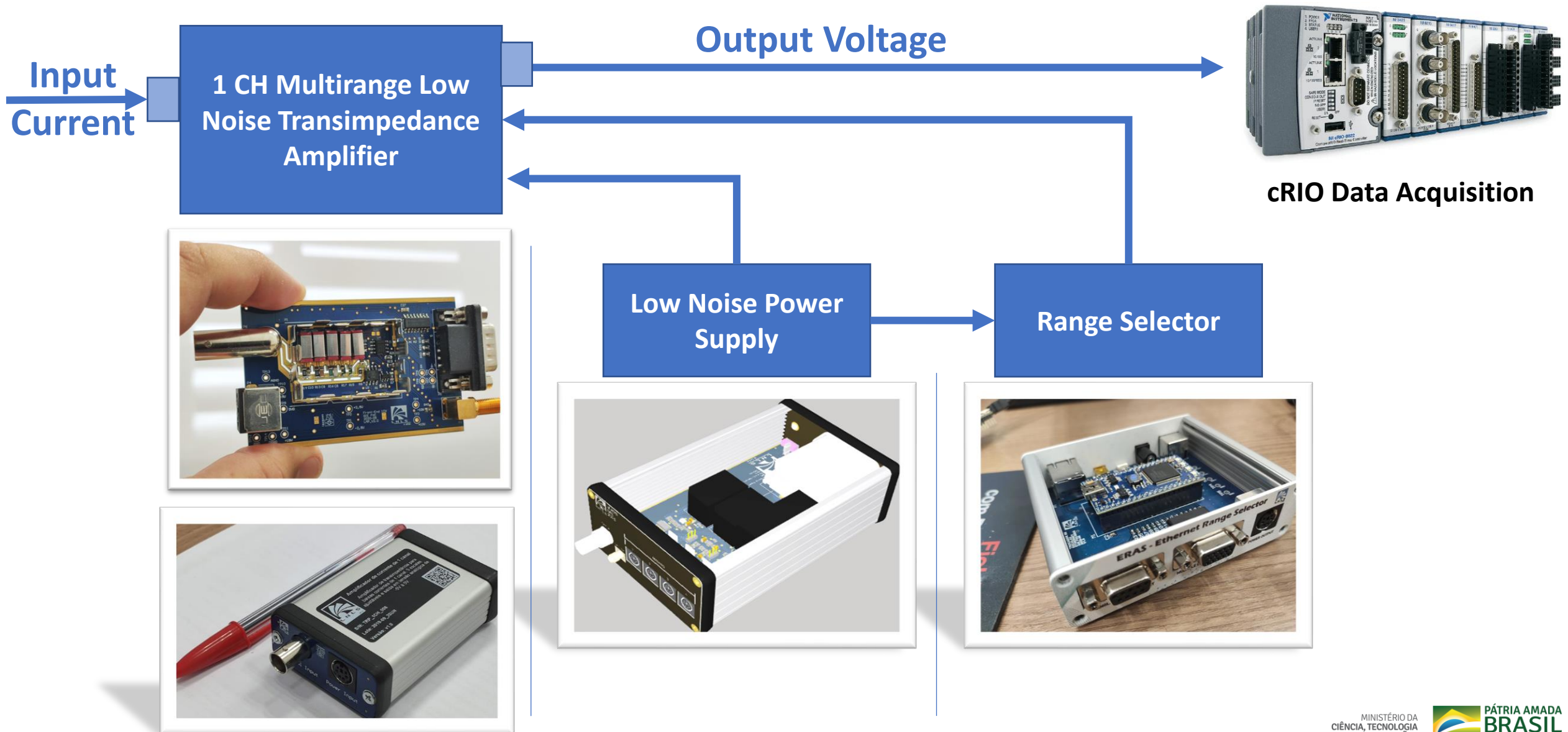
Component selection and hardware design



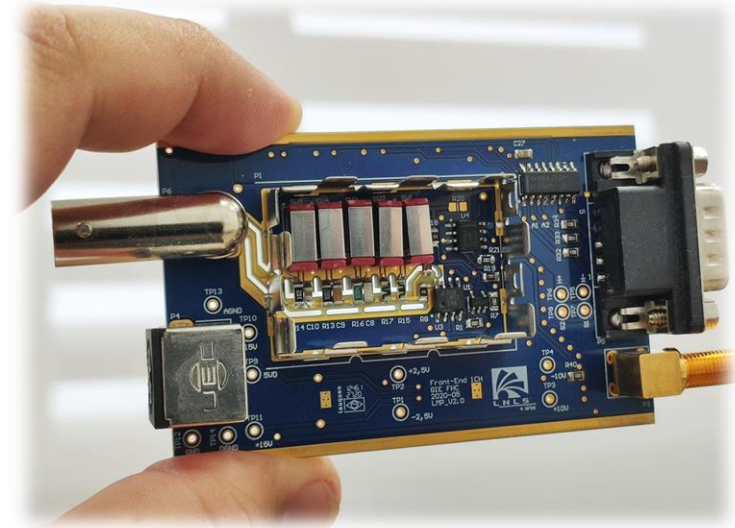
Cleaning process



Installation Diagram



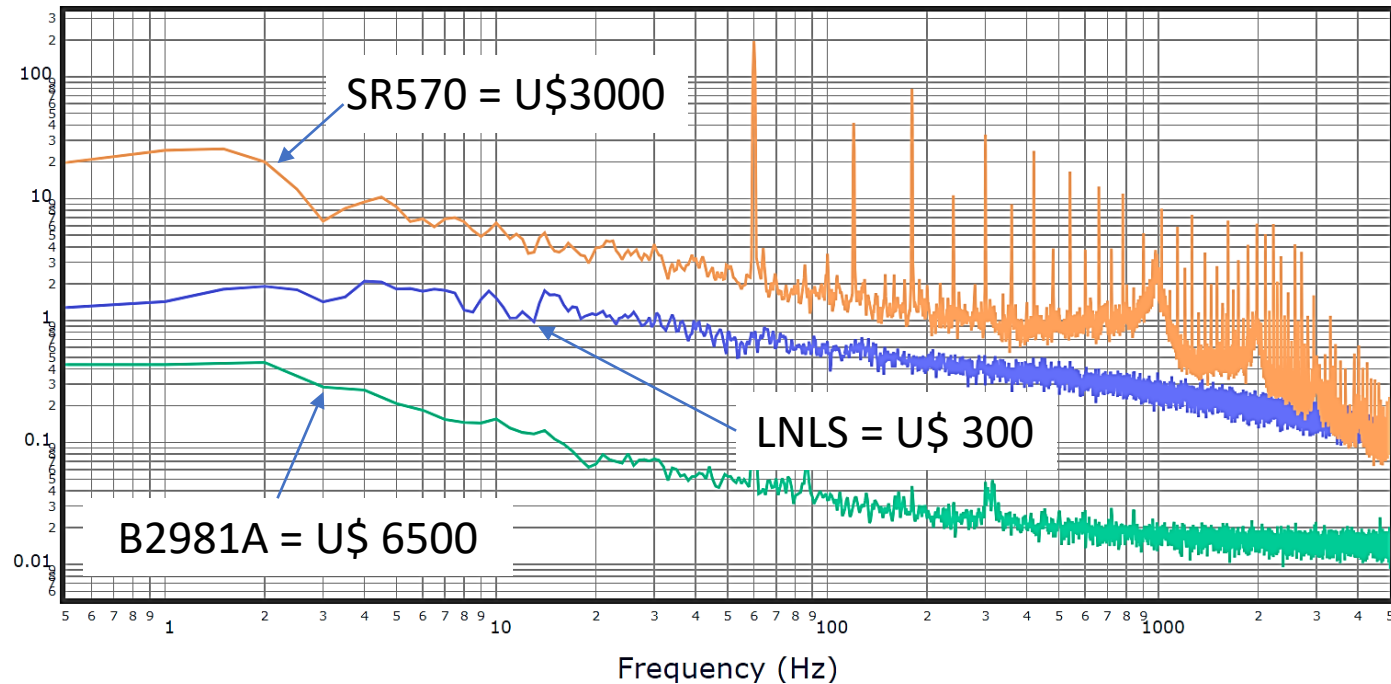
Results: Noise Comparison



Unit Cost (fab. Brasil) = U\$ 300

RMS Current Noise Spectral Density (fA/sqrt(Hz))

RMS Current PSD - 100.00pA/V Sensitivity



- Device
- LNL-1CH
 - Keithley-6514
 - Keysight-B2981A
 - LNL-AD549
 - Stanford-SR570
 - LNL-4CH-ADA
 - NI9239 noise floor
 - AD7177 noise floor
 - NI9215 noise floor

Conclusions

- *The first units were developed successfully. For low bandwidth applications, the noise performance is comparable to expansive well-known commercial bench equipment;*
- *A number of error sources can have serious impacts on low current measurements. The right component choice and all the strategies adopted to make a proper guarding, shielding and PCB layout showed to be effective to reduce static and dynamic errors;*
- *The cleaning process showed to be an indispensable process, specially for the most sensible range: the offset voltage after the cleaning process, on average, reduced three orders of magnitude;*
- *For the first fourteen beamlines, we have produced around 75 units. Due to increase number of devices for low current monitoring, the in-house development is more cost-effective solution.*
- *Besides the low noise amplifier, we also have developed an ultra low noise power supply and an ethernet range selector to the fully integration on the beamline's control system;*

Future plans

- *To fulfill the Sirius beamlines applications other devices must be developed in a near future, such as a 4-channel digital picoammeter (with integrated ADCs and ethernet interface) and a single scale amplifier with a high dynamic range ;*

Thank you for your attention!



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E INOVAÇÕES



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