Thermal diagnostics for LTP

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Purpose:

In order to comply with mission top level science requirement,

$$S_{\Delta a}^{1/2}(\omega) = 3\times10^{-14}\left[1+\left(\frac{f}{3\ \mathrm{mHz}}\right)^2\right]\ \frac{m}{s^2}\mathrm{Hz}^{-1/2}\ , \qquad 1\ \mathrm{mHz} \le f \le 30\ \mathrm{mHz}$$

thermal stability must be below

$$S_T^{1/2} \le 10^{-4}\ \mathrm{K}/\sqrt{\mathrm{Hz}}\ , \qquad \text{same band}$$

Thermal diagnostics sensors must meet this

***Noise related problems*: JNF *and* SHE**

Johnson noise fluctuations have: $S_V^{1/2} = \sqrt{4k_B T\, R}$

and in terms of temperature, $S_T^{1/2} = \alpha^{-1}\sqrt{4k_B T / P}$

· To minimize *JNF* effect, large ❁*'s* and large *Power Excitation* are needed.

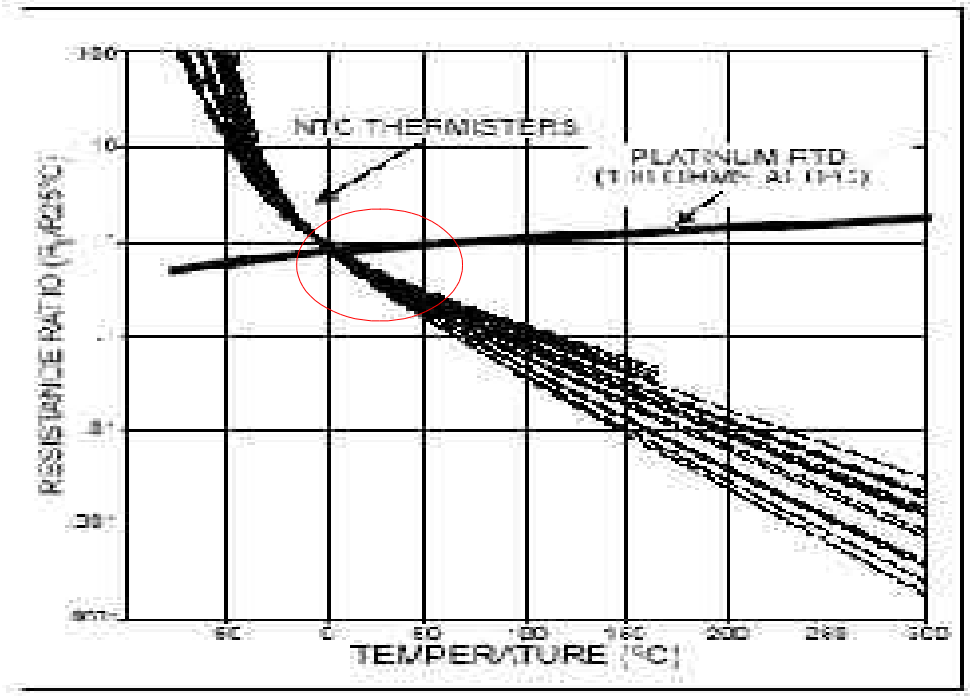
· Large *Power Excitation* causes *SHE* problems.

Assuming at *T=295 ºK,* $S_T^{1/2} = 10\mu K / \sqrt{\mathrm{Hz}}$

required power follows : $\begin{cases} P_{Pt-100} \geq 10\mu W \\ P_{10k\Omega-NTC} \geq 0.1\mu W \end{cases}$

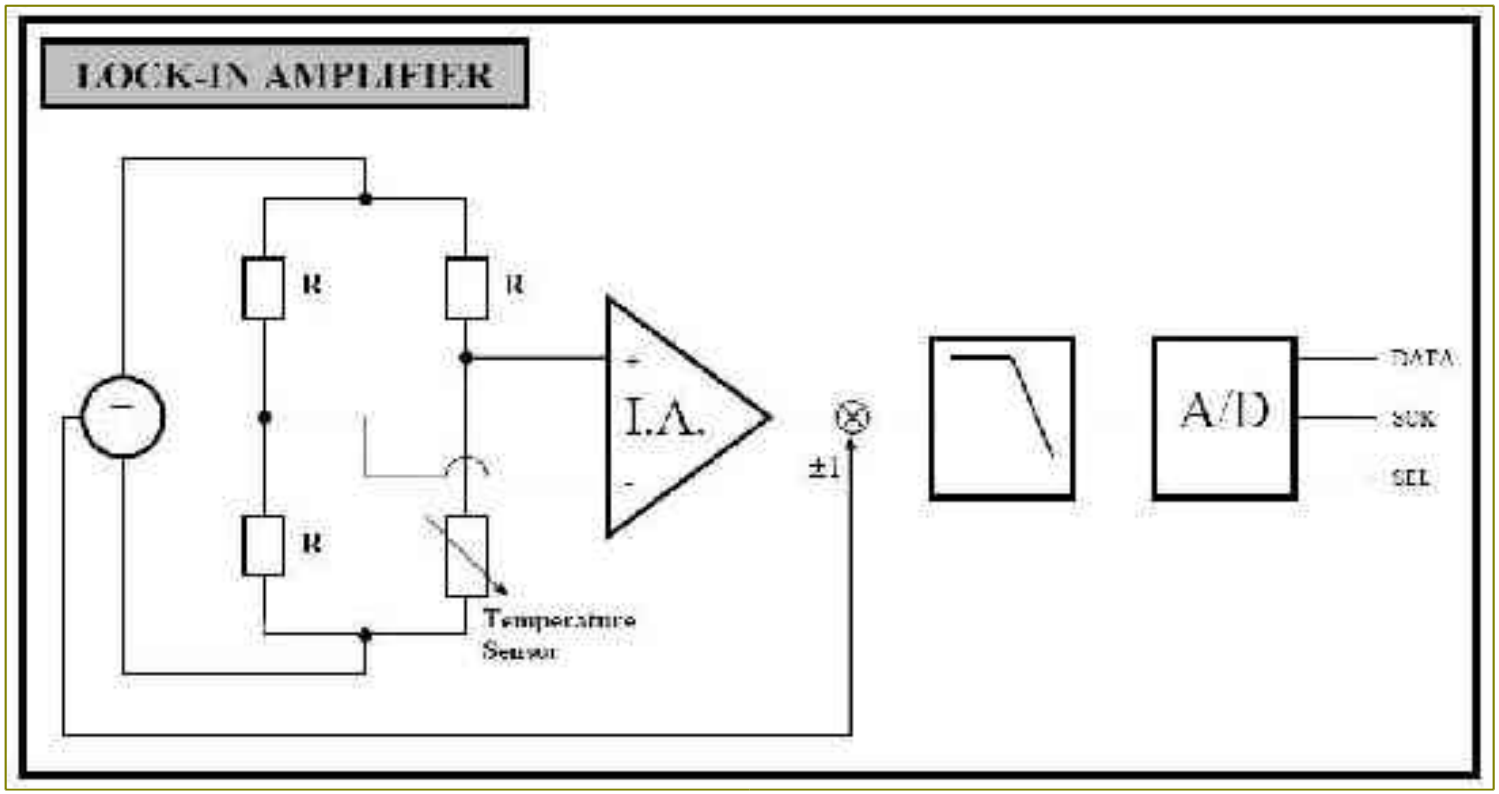
Thermal diagnostics

- Sensor choice: NTC & RTD will be tested

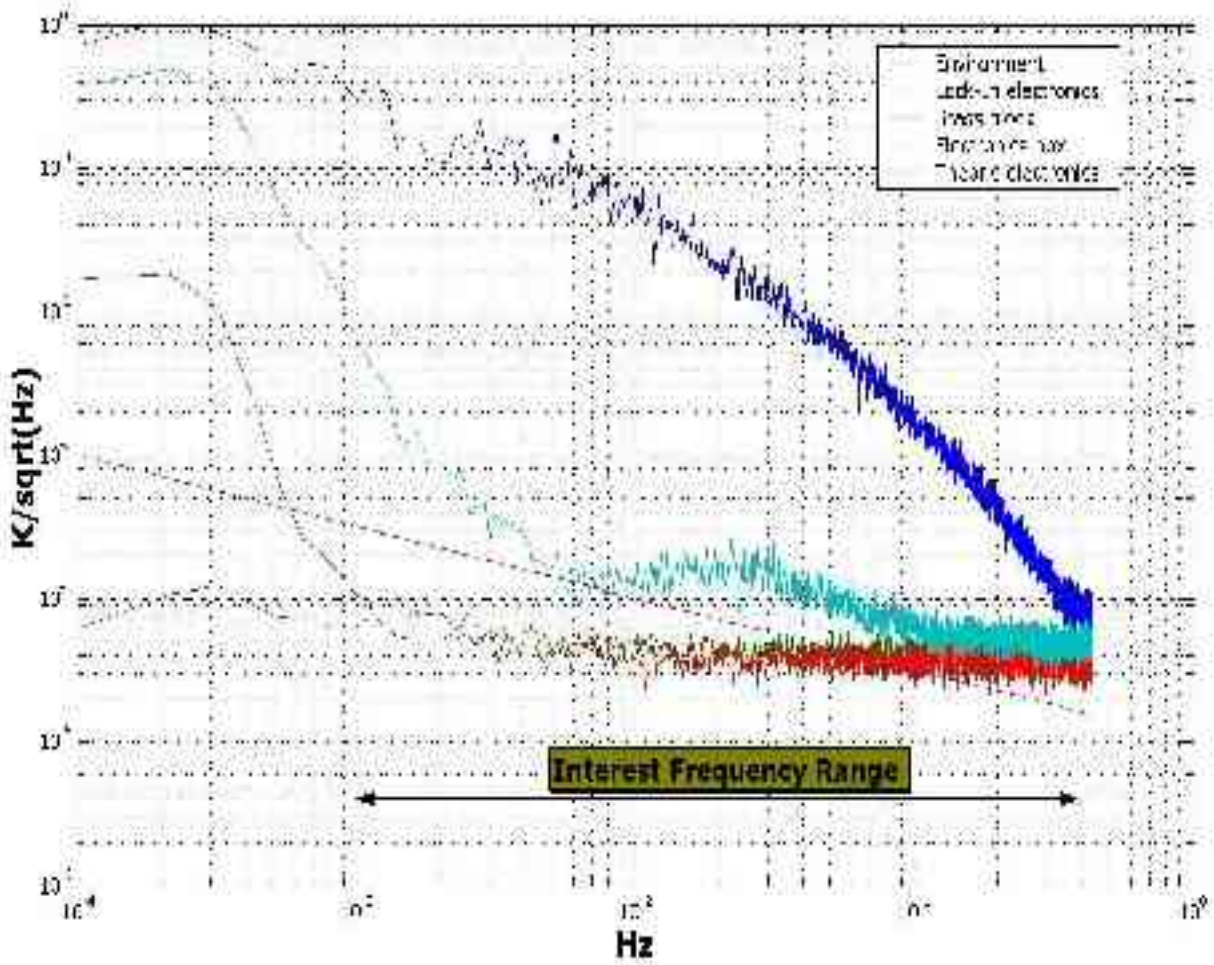


Thermal diagnostics

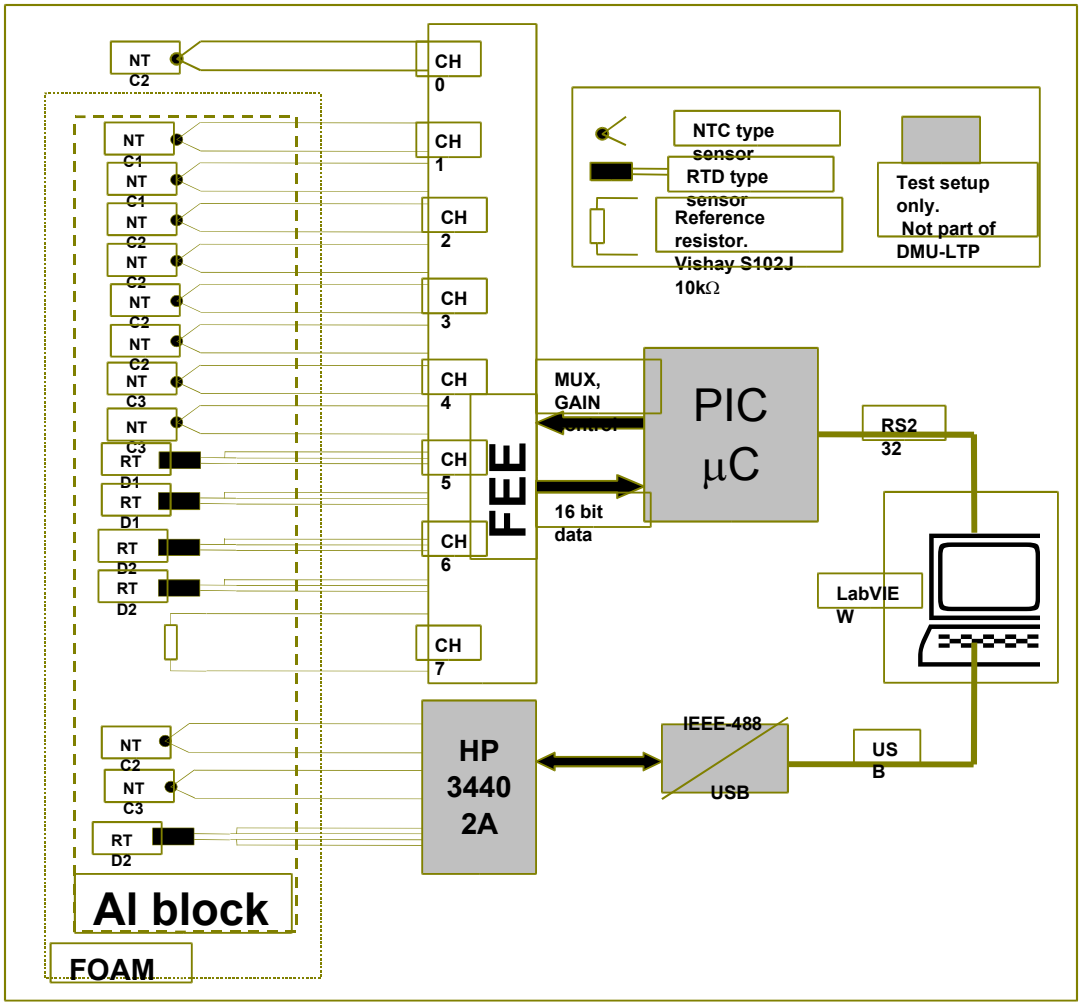
- Front end electronics finished and ready for test:



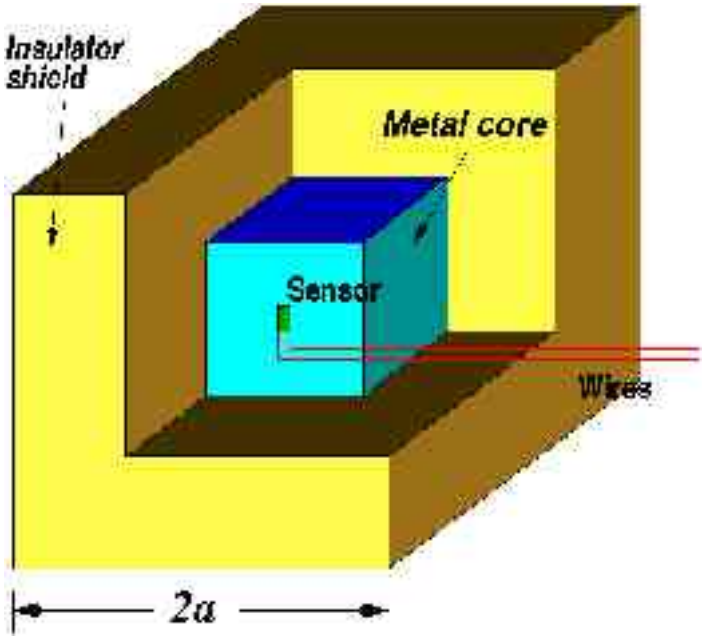
Thermal diagnostics



Thermal diagnostics



Test Philosophy



Thermal diagnostics

Mathematical model:

$$\rho\, c_p \frac{\partial}{\partial t} T(\mathbf{x},t) = \nabla \cdot \left[\kappa\, \nabla T(\mathbf{x},t)\right] \qquad T(\mathbf{x}=\mathbf{x_b},t) = T_0(\mathbf{x_b},t)$$

$$\mathring{T}(\mathbf{x},\omega) = \mathring{H}(\mathbf{x},\omega)\,\mathring{B}(\omega)$$

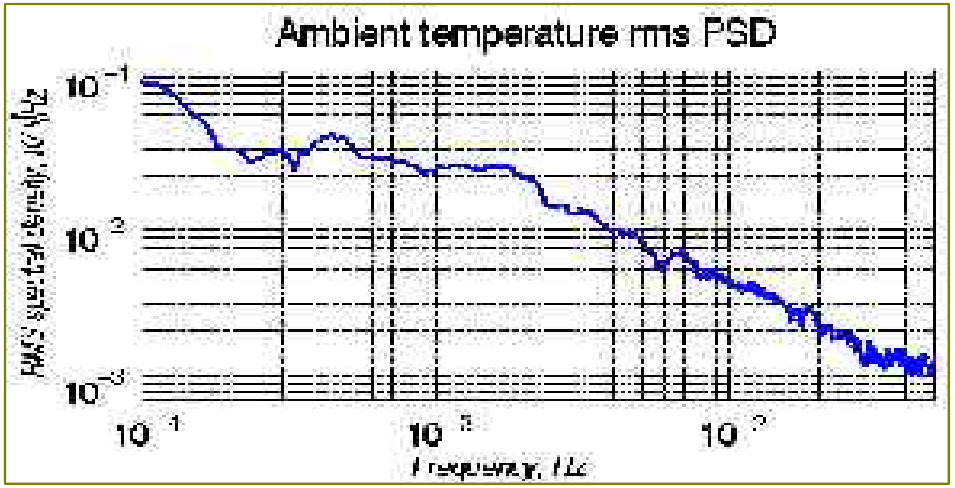
$$\mathring{H}(\mathbf{x},\omega) = \sum_{n=1}^{\infty} Q_{n0}\, R_{n0}(r)\, \frac{1}{1+i\omega\tau_{n0}}$$

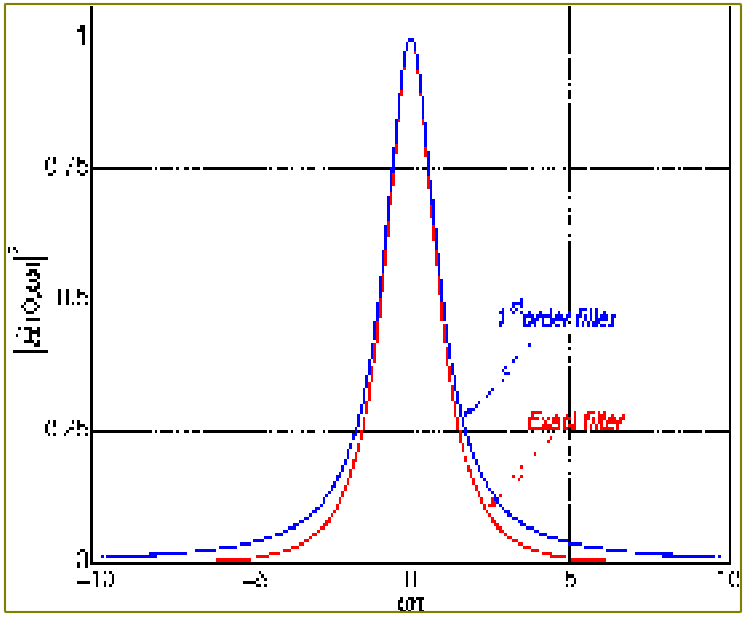
$$\mathring{H}_{\text{1st-order}}(\omega) = \frac{1}{1+i\omega\tau_{10}}$$

Thermal diagnostics

Defined goal: 5×10^{-6} K/Hz$^{1/2}$

at 1 mHz





	Aluminum	Polyurethane	τ_{10}	$S_T^{1/2}$
# 1	12.5 cm	22.5 cm	142 000	9 x 10^{-6}
# 2	12.5 cm	32.5 cm	200 000	7 x 10^{-6}
# 3	15 cm	25 cm	185 000	7 x 10^{-6}
# 4	15 cm	50 cm	330 000	4 x 10^{-6}

Summary

- Procurement of thermal insulator underway
- *This week* will be in place (*NTE*)
- Electronic equipment being shipped to test site (*NTE*)
- Aluminum drill and sensor placement will be done
- Test documentation essentially ready
- Test expected before August

LISA-5, 12-July-2004 NTE clean room