



Development of a practical Johnson Noise Thermometer (JNT): latest progress

A joint project between Metrosol and NPL

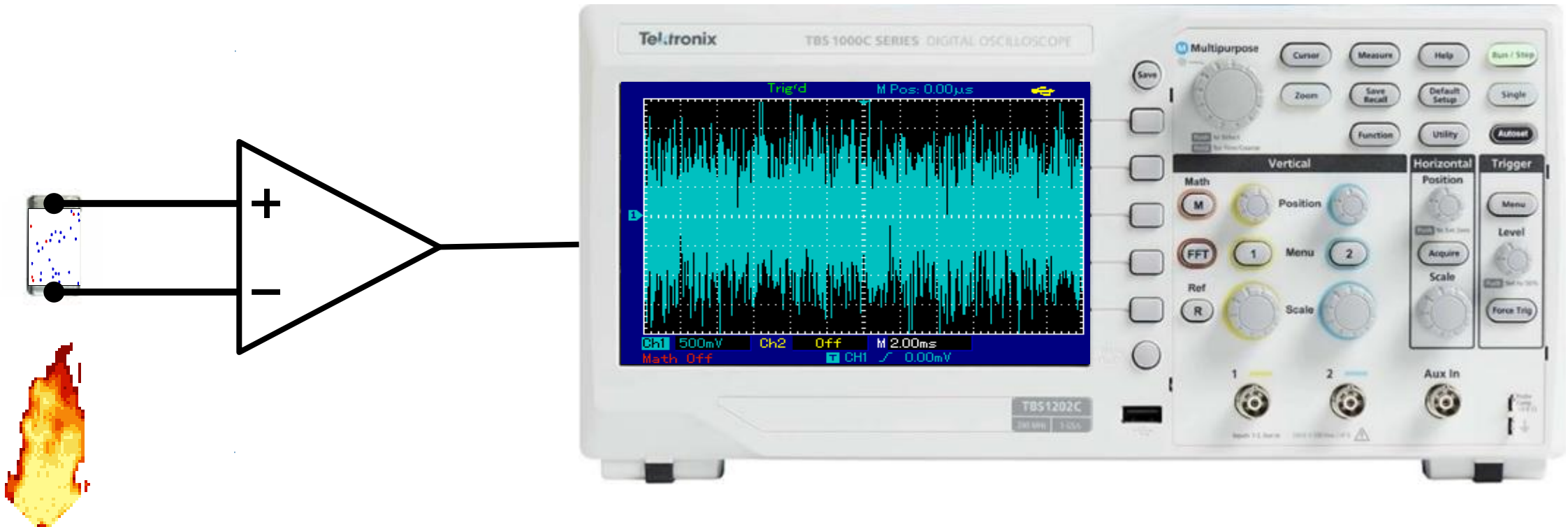
Paul Bramley - Metrosol Limited

1. Menu for today

- What is Johnson noise?
- Making a Johnson noise thermometer?
- Why use a JNT – what are the benefits?
- Progress towards the worlds first practical JNT for use in harsh industrial environments
- Next steps... do you want to join us?

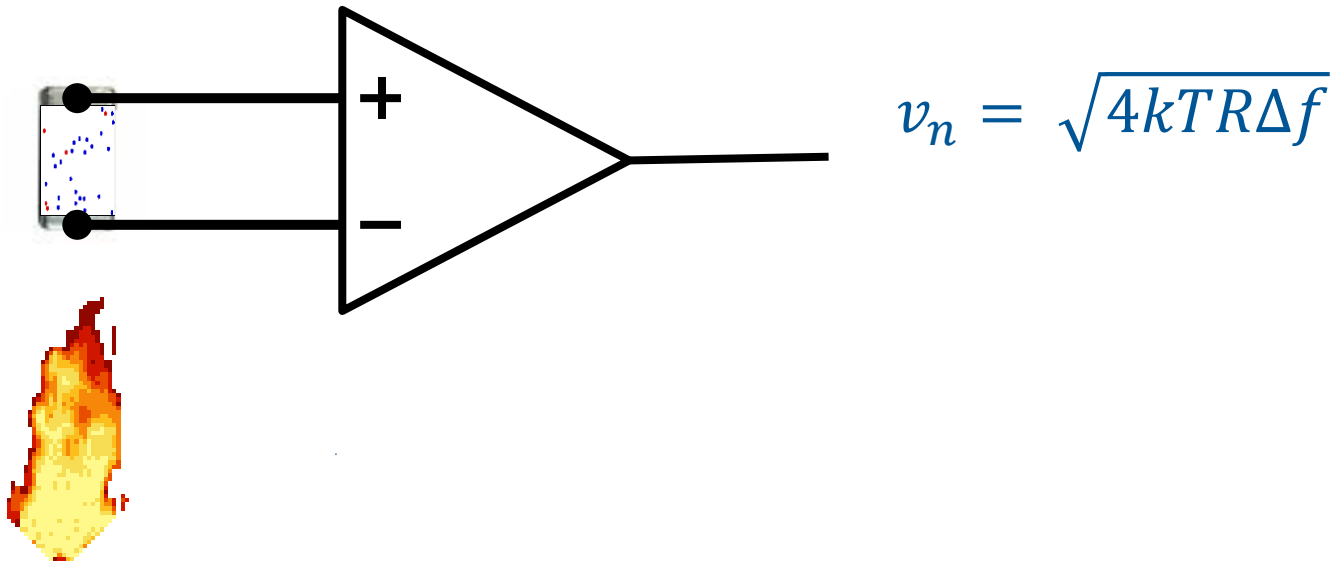


1. What Is Johnson Noise?



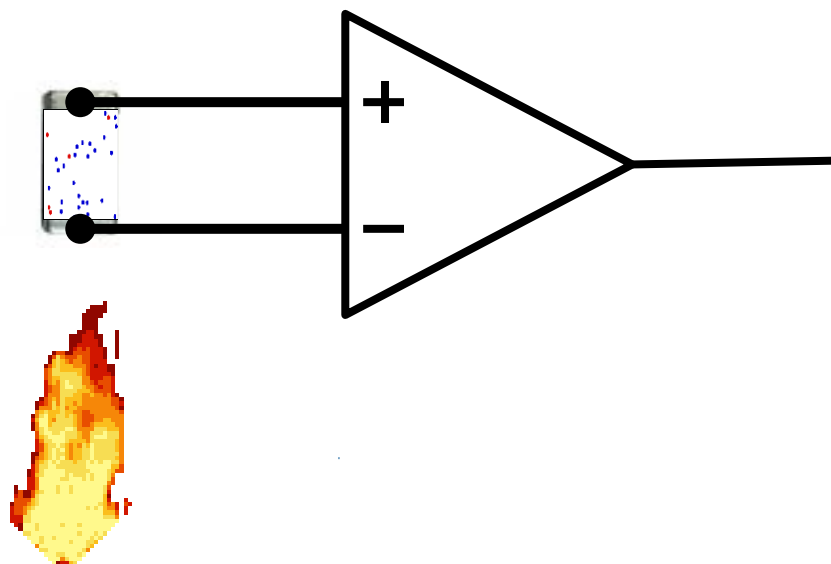
2. Making a Johnson Noise Thermometer

- JNTs use the Johnson-Nyquist equation



2. Making a Johnson Noise Thermometer

- JNTs use the Johnson-Nyquist equation



$$T = \frac{1}{4k} \left\{ \frac{v_n^2}{R\Delta f} \right\}$$

3. The benefits of a JNT



- Johnson Noise Thermometers **do not drift** (the electronics can!)

Places where replacement is a problem:

Space

Nuclear (power & waste storage)

Extended calibration intervals (lower cost):

Nuclear

Petrochemical

Metrology (standards)

Improved safety or process yield where drift is a problem

Power generation (nuclear, conventional thermal, aerospace/jet engines)

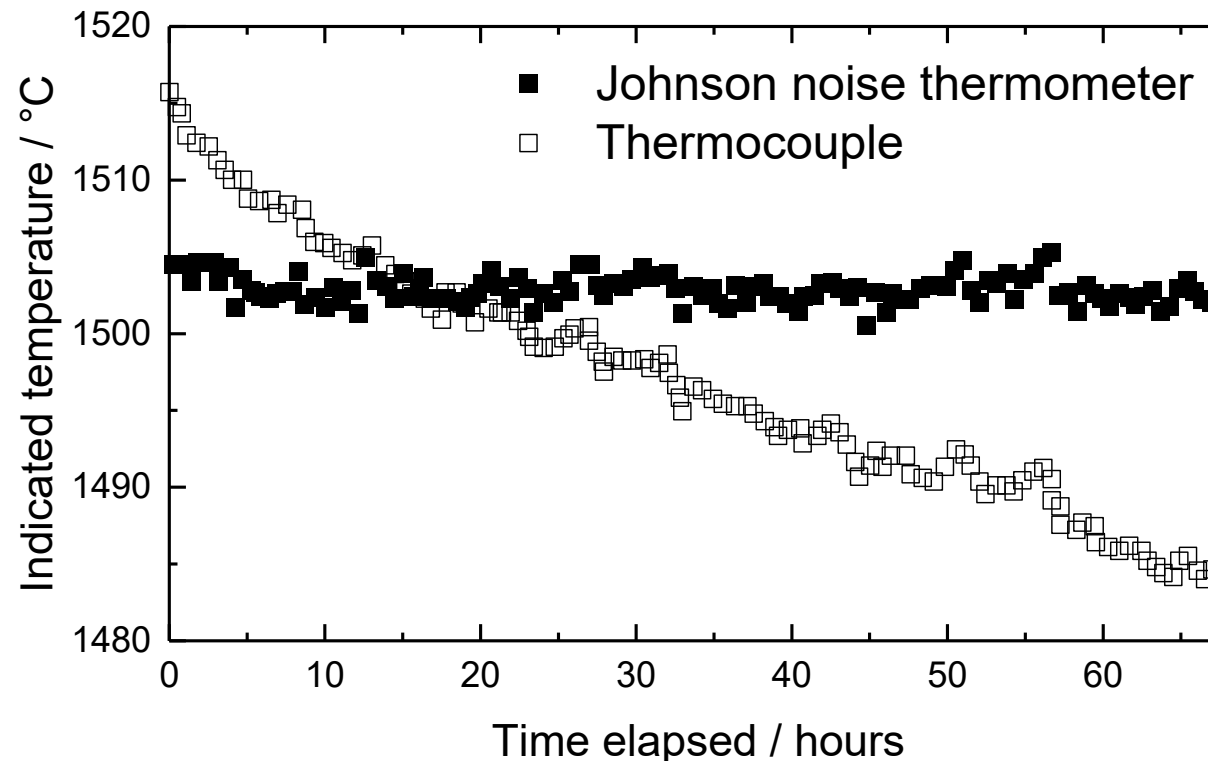
Aerospace – turbine blade manufacture

Ideal replacement for thermocouples in applications where their drift is a problem

- Traceable to electrical standards – **faster (lower cost) calibration**

4. Progress Towards a Practical JNT

- 2014: NPL proposed the joint development of a JNT to meet increasing demand for more stable thermometers in harsh industrial environments
- Best prior art was Brixy (1996):



4. Project “JNT1”

- JNT1 project (Oct 2015 – Mar2017), 2 outputs:

New concept in JNT (patented)

Proof-of-principle prototype

UNITED STATES PATENT AND TRADEMARK OFFICE

NOTICE OF ALLOWANCE AND FEES DUE

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UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 40
Washington, Virginia 22163-1400
www.uspto.gov

EXAMINER
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FIRST NAMED INVENTOR
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ATTORNEY DOCKET NO.
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\$3,000

DATE DUE
10/26/2020

THE APPLICATION IDENTIFIED ABOVE HAS BEEN EXAMINED AND IS ALLOWED FOR ISSUANCE AS A PATENT. PROSECUTION ON THE MERITS IS CLOSED. THIS NOTICE OF ALLOWANCE IS NOT A GRANT OF PATENT RIGHTS. THIS APPLICATION IS SUBJECT TO WITHDRAWAL FROM ISSUE AT THE INITIATIVE OF THE OFFICE OR UPON PETITION BY THE APPLICANT. SEE 37 CFR 1.313 AND MPEP 1308.

THE ISSUE FEE AND PUBLICATION FEE (IF REQUIRED) MUST BE PAID WITHIN THREE MONTHS FROM THE MAILING DATE OF THIS NOTICE OR THIS APPLICATION SHALL BE REGENERATED AS ABANDONED. THIS STATUTORY PERIOD CANNOT BE EXTENDED. SEE 35 U.S.C. 151. THE ISSUE FEE DUE INDICATED ABOVE DOES NOT REFLECT A CREDIT FOR ANY PREVIOUSLY PAID ISSUE FEE IN THIS APPLICATION. IF AN ISSUE FEE HAS PREVIOUSLY BEEN PAID IN THIS APPLICATION (AS SHOWN ABOVE), THE RETURN OF PART B OF THIS FORM WILL BE CONSIDERED A REQUEST TO REAPPLY THE PREVIOUSLY PAID ISSUE FEE TOWARD THE ISSUE FEE NOW DUE.

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I. Review the ENTITY STATUS shown above. If the ENTITY STATUS is shown as SMALL or MICRO, verify whether entitlement to that entity status still applies.

If the ENTITY STATUS is the same as shown above, on PART B - FEES/ISSUE, complete section number 5 titled "Change in Entity Status (from status indicated above)".

For purposes of this notice, small entity fees are 1/2 the amount of undiscounted fees, and micro entity fees are 1/2 the amount of small entity fees.

II. PART B - FEES/ISSUE TRANSMITTAL, or its equivalent, must be completed and returned to the United States Patent and Trademark Office (USPTO) with your ISSUE FEE and PUBLICATION FEE (if required). If you are charging the fee(s) to your deposit account, section "4a" of Part B - Fees/ISSUE TRANSMITTAL should be completed and an extra copy of the form should be submitted. If an equivalent of Part B is filed, a request to reapply a previously paid issue fee must be clearly made, and delays in processing may occur due to the difficulty in recognizing the paper as an equivalent of Part B.

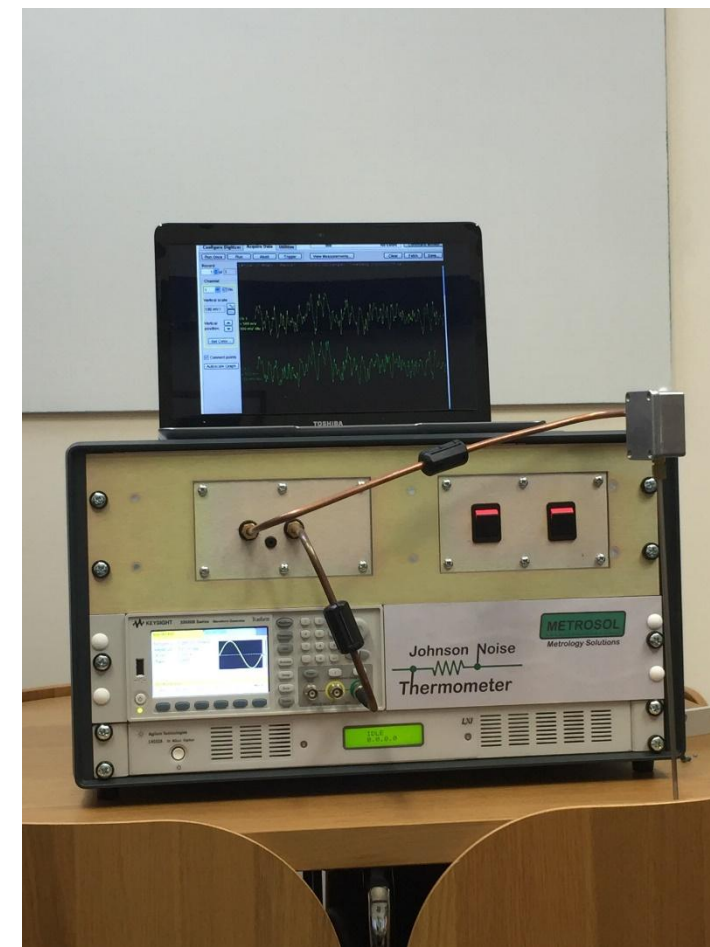
III. All communications regarding this application must give the application number. Please direct all communications prior to issuance to Mail Stop ISSUE FEE unless advised to the contrary.

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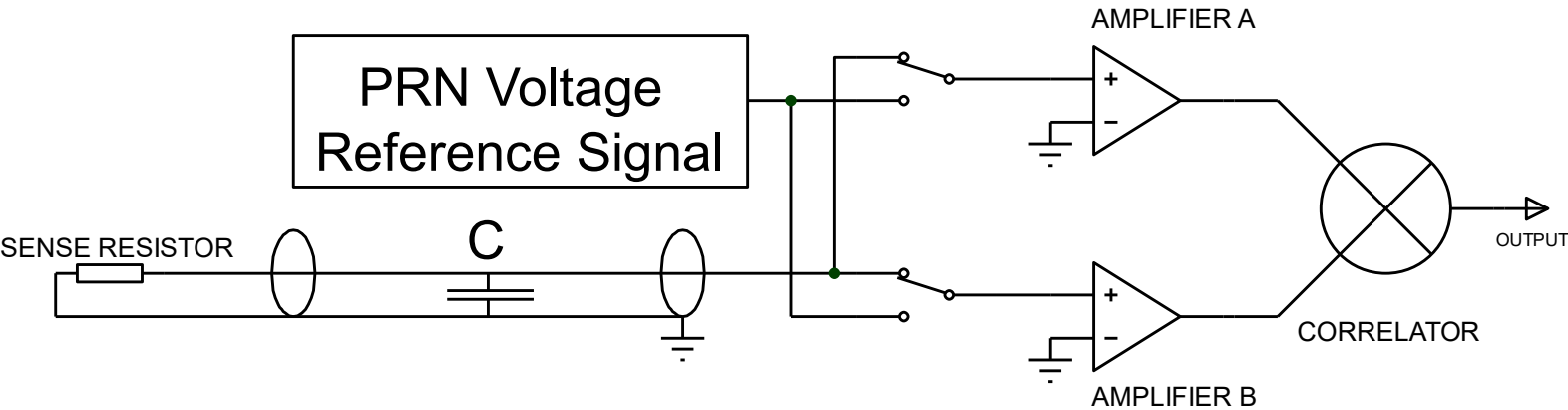
PTOL-45 (Rev. 02/11)

- 35kg & 70L
- -20 to +120°C

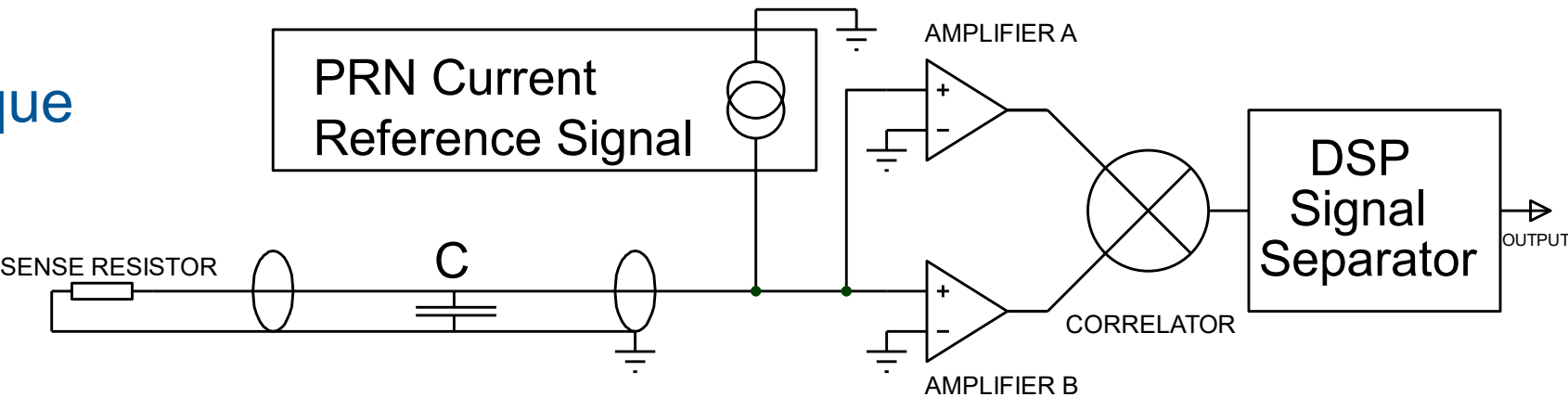


4. The New Technique:

Prior Art



New Technique



4. Project “JNT2”



- JNT2 project (Oct 2017 – Dec 2020)
- Turn this new technology into a fully engineered technology capable to realising a practical JNT

Develop all the required technologies

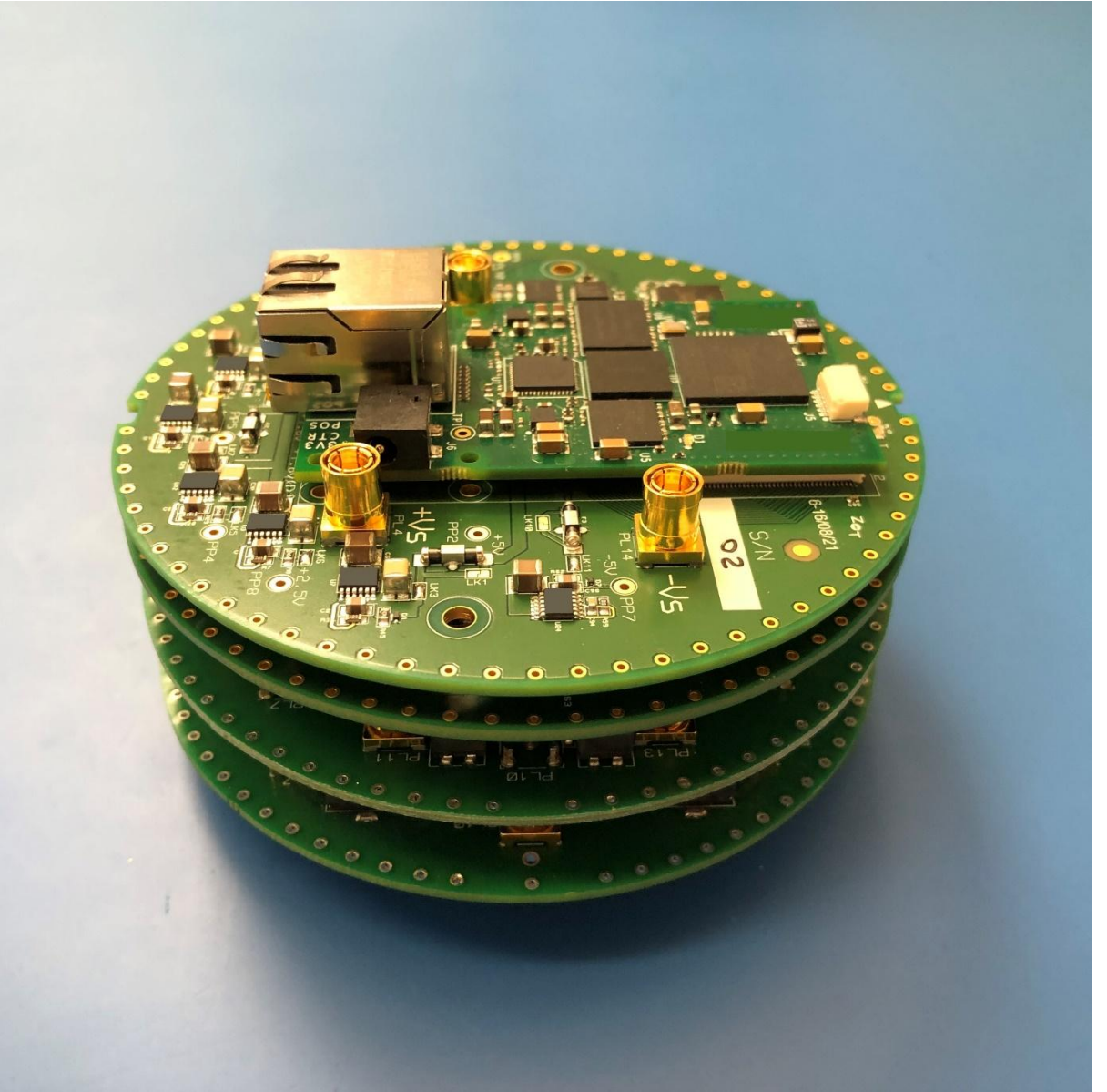
Achieve EMC: make it work in a harsh environment

Reduce size (1L & 1kg)

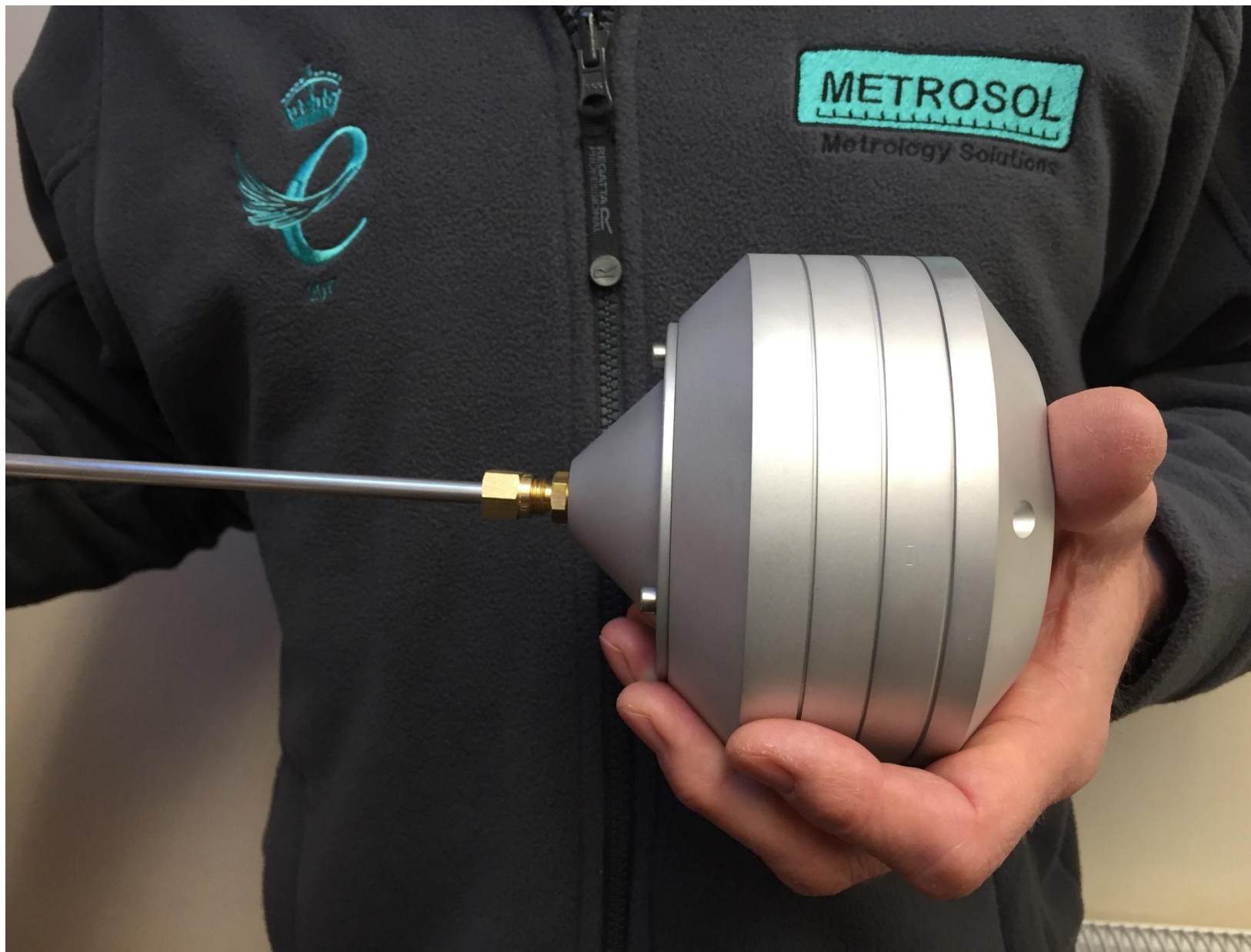
Work over a range of interest (0-1000°C)

The image displays four circular printed circuit boards (PCBs) for the MET09-03-01 ISS-D, arranged in a 2x2 grid. Each board is populated with various electronic components, including integrated circuits, resistors, capacitors, and connectors. The boards are labeled with their part number, revision, and serial number (S/N).

- Top Left Board:** Labeled "MET09-03-01 ISS-D", "2.060218", and "S/N 02". It features a central microcontroller (U1) and several peripheral components.
- Top Right Board:** Labeled "MET09-03-01 ISS-D", "2.060218", and "S/N 02". It features a central microcontroller (U1) and several peripheral components.
- Bottom Left Board:** Labeled "MET09-03-01 ISS-D", "2.060218", and "S/N 04". It features a central microcontroller (U1) and several peripheral components.
- Bottom Right Board:** Labeled "MET09-03-01 ISS-D", "2.060218", and "S/N 34". It features a central microcontroller (U1) and several peripheral components.



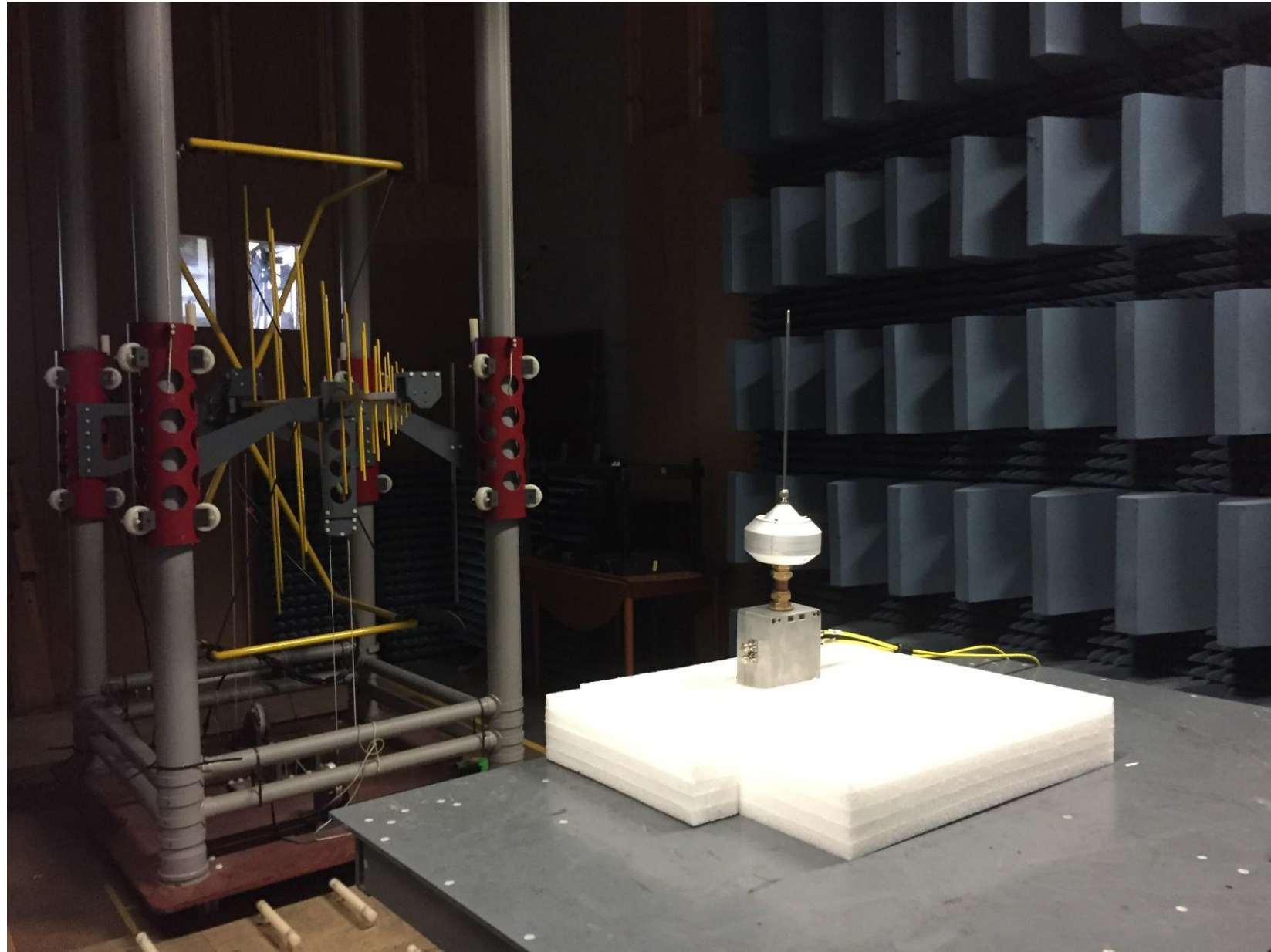
4. JNT2: Weight Loss Programme



4. JNT2: EMC Achieved (a key milestone)

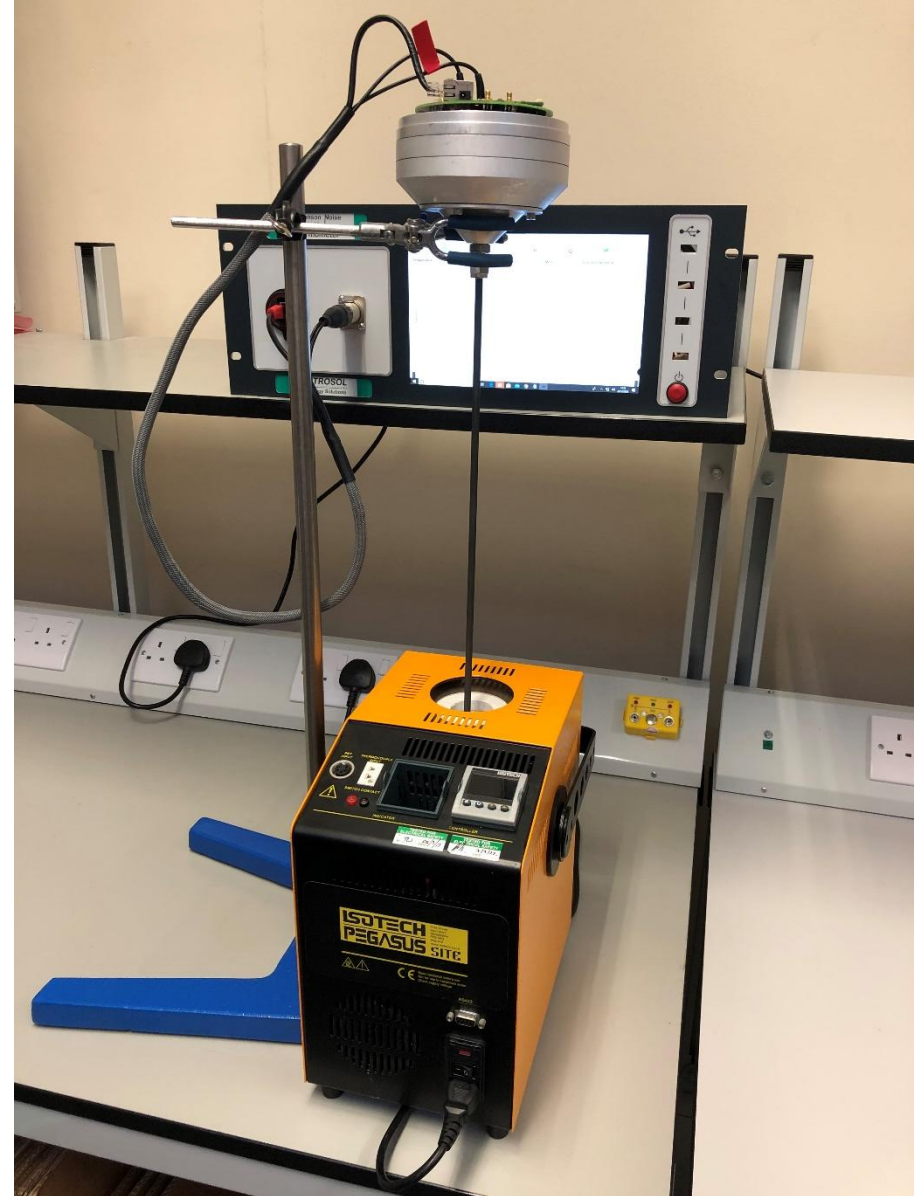


10Vm^{-1}
Heavy Industrial Limit



4. Project “JNT2”

- Standard Deviations:
0.36°C @ 20°C
1.1°C @ 1,000°C
- Rice’s Equation Limit:
0.12°C @ 20°C
0.53°C @ 1,000°C
(for 1MHz BW & 5.9s)



4. Project “JNT3”

- JNT3 project (Jan 2021 – Dec 2021)
- Characterise and optimise all parts of the measurement system to create a realistic specification & uncertainty budget
- ADC 
- DAC 
- Calibration signal injection network 

5. Project “JNT4”



- Anticipated JNT4 project (Jan 2022+)
- By end of 2021 we will have all the technology to create a practical JNT for us in harsh industrial environments
- What sort of JNT do we design first?
(Metrology/industrial, temperature range, features, interface: Ethernet, USB, RS232, HART, Fieldbus, 4-20mA)
- If you are interested in engaging in order to influence the first JNT contact paul.bramley@metrosol.co.uk

www.johnson-noise-thermometer.com

<https://www.facebook.com/johnsonnoisethermometer/>

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