

# Progress Report

## 22RPT02 – True8DIGIT Towards a true 8-digit digitiser

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05 Jun 2025



# Outline

- Introduction to True8DIGIT project
- Activity Overview
- Some results to date

## Quantum Voltmeter

DC – 100 kHzDC  
PerformanceNoise  $\approx 10^{-8}$   
Linearity  $\approx 10^{-8}$ 

- ☐ Best performance
- ☐ Cryogenic
- ☐ High Cost

Is there a need for a  
single range digitizer  
with better  
performance than the  
DMMs?

## Conventional Voltmeter



- ☐ Affordable cost
- ☐ Room temperature
- ☐ Multifunction

# A two-step approach

## Step 1 (Preparatory Research)

EPM Research Potential Project (22RPT02)

True8DIGIT “Towards a true 8 digit digitizer” Jun 2023- Jun 2026



## Step 2 (Implementation)

EPM Follow-on Project

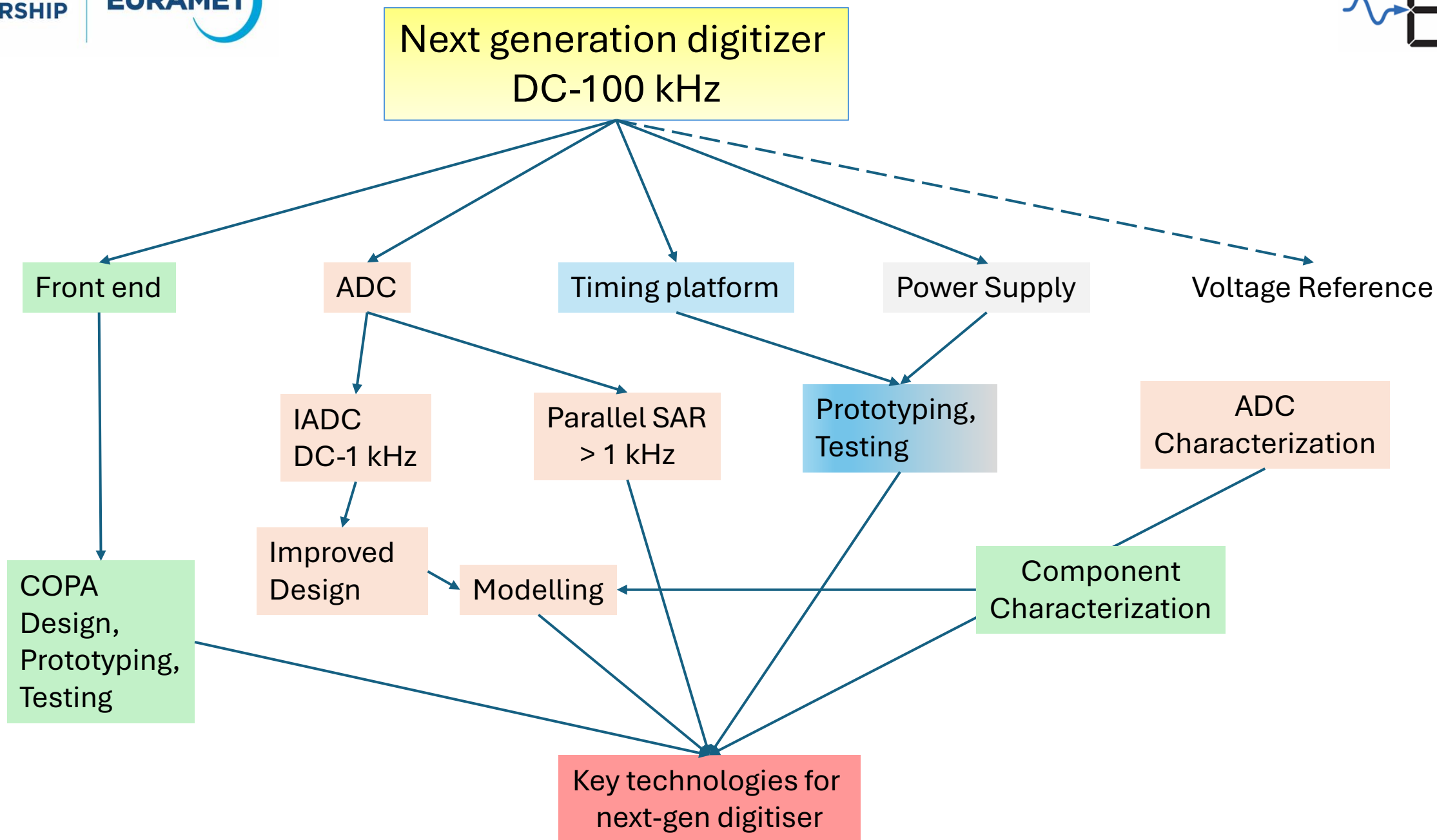
Next-generation digitiser for scientific and technological frontiers

IEM Call 2025



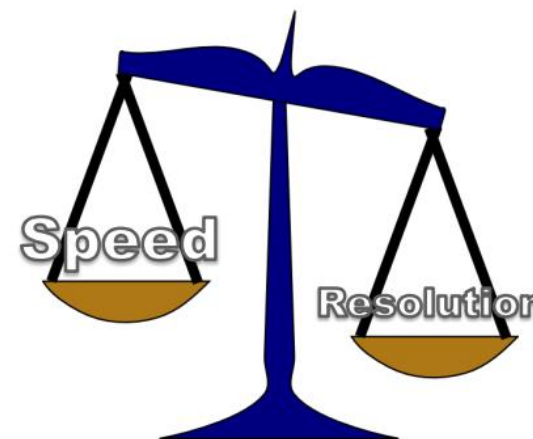
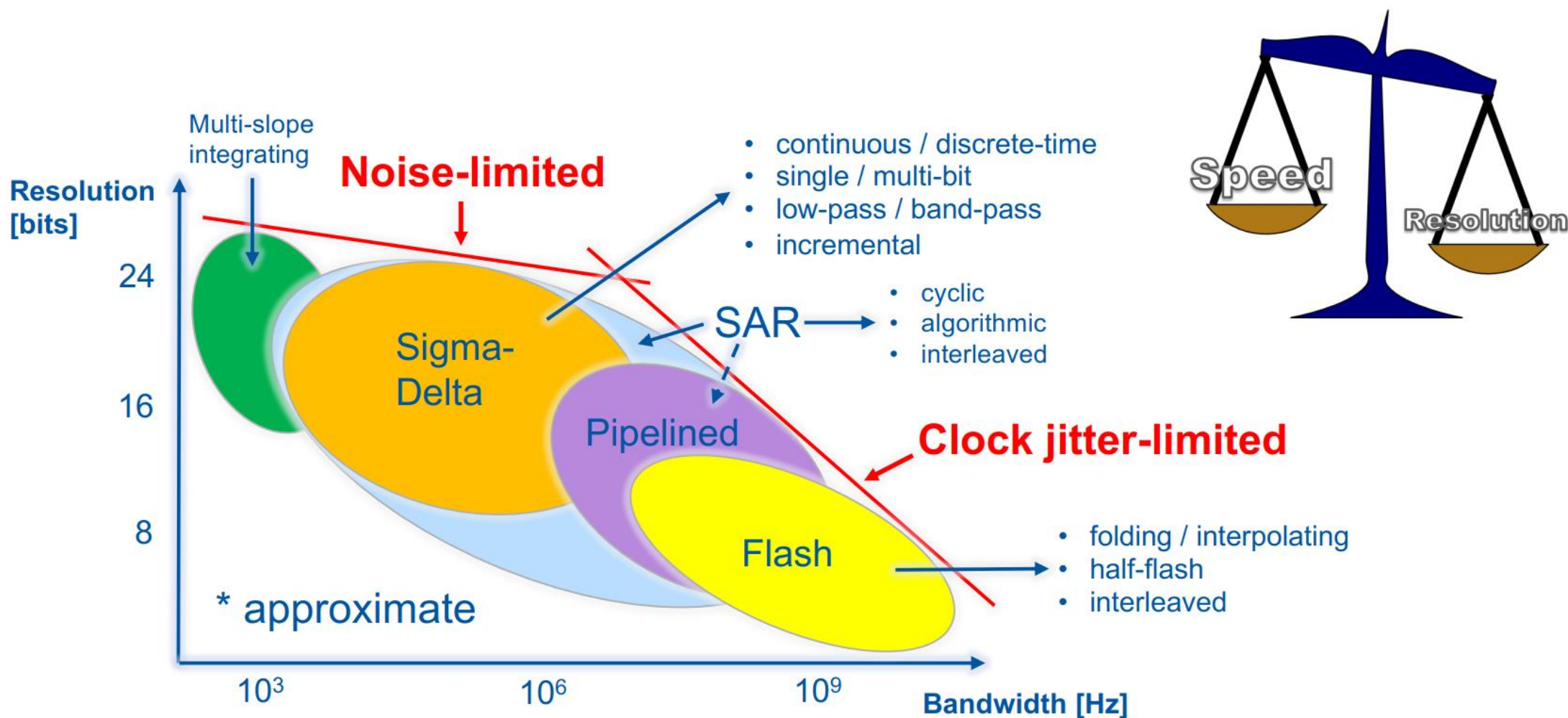
Industry Call 2026





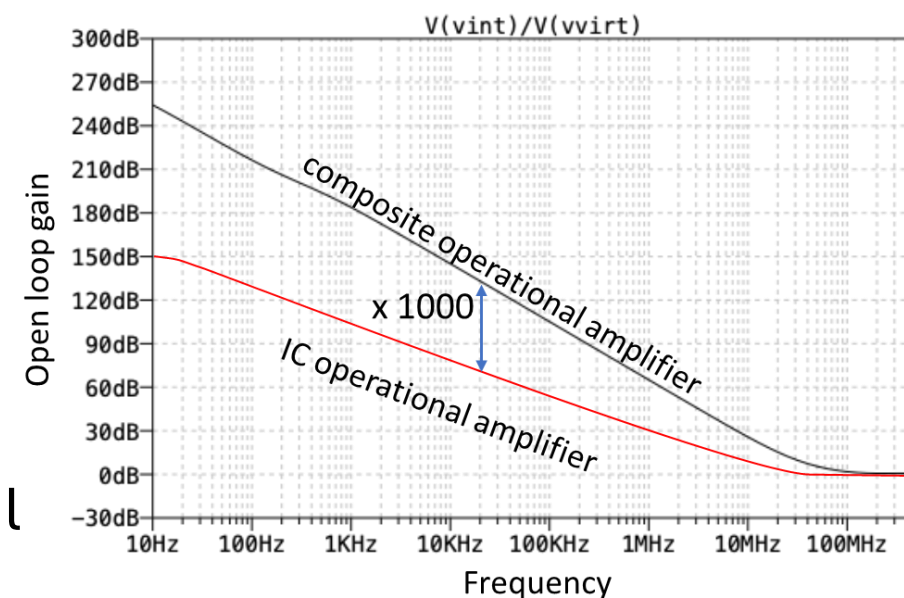
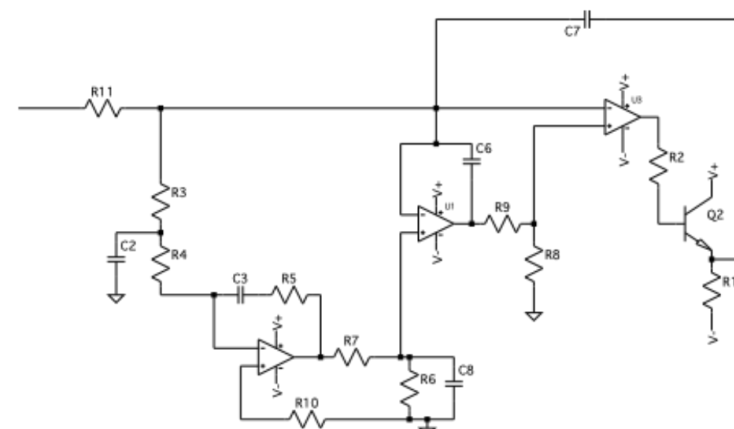


# Comparison of ADC performance



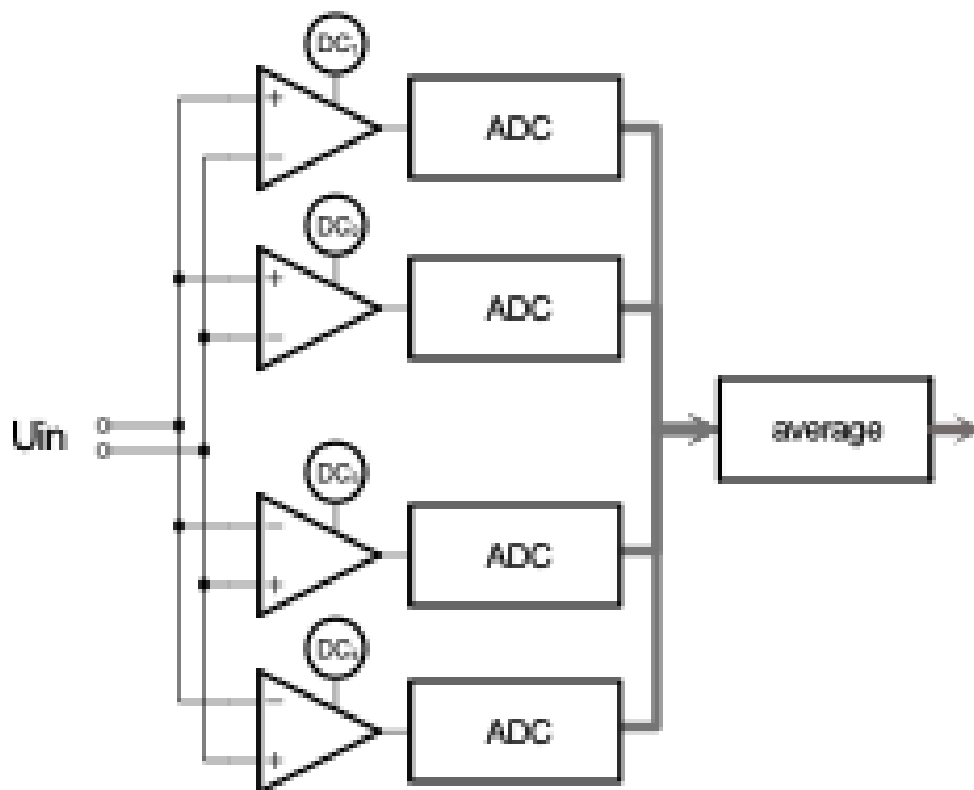
# An improved integrator for the IADC

- 3458A Integrator analysed
- New improved integrator design proposed
- Modelling predicts improved performance (against Keysight 3458A integrator)
- New integrator built and under test
- Selection of switches with low charge injection is vital

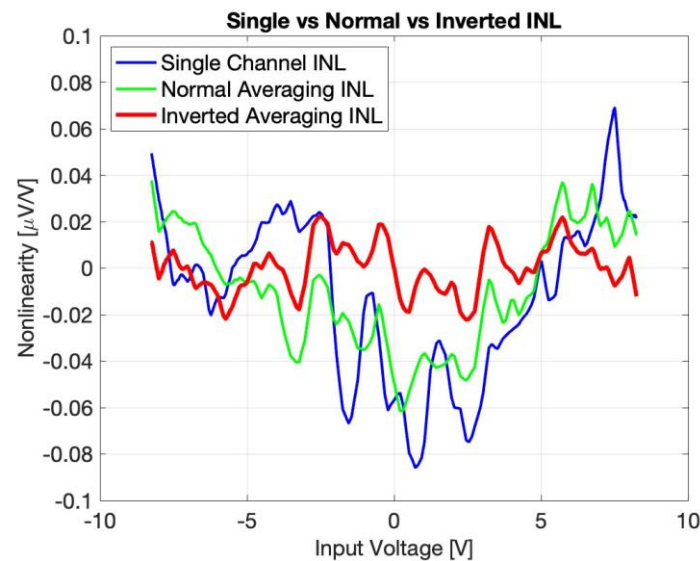
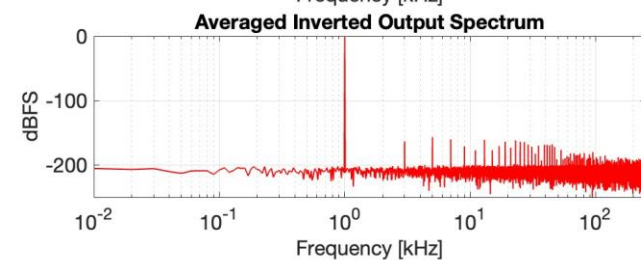
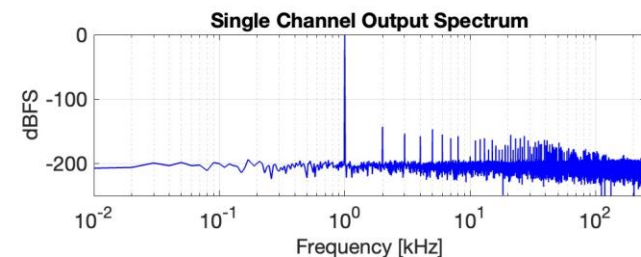


# Simulation of Parallel ADC Operation

Parallel ADC operation simulated

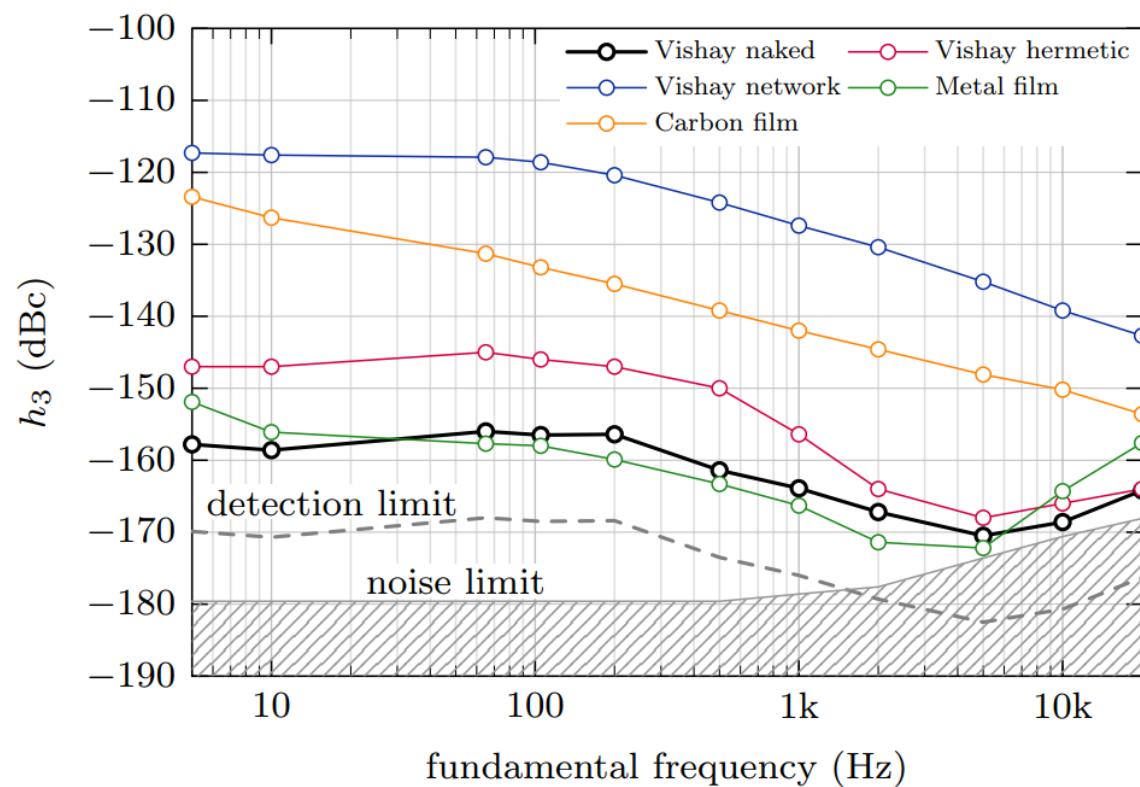
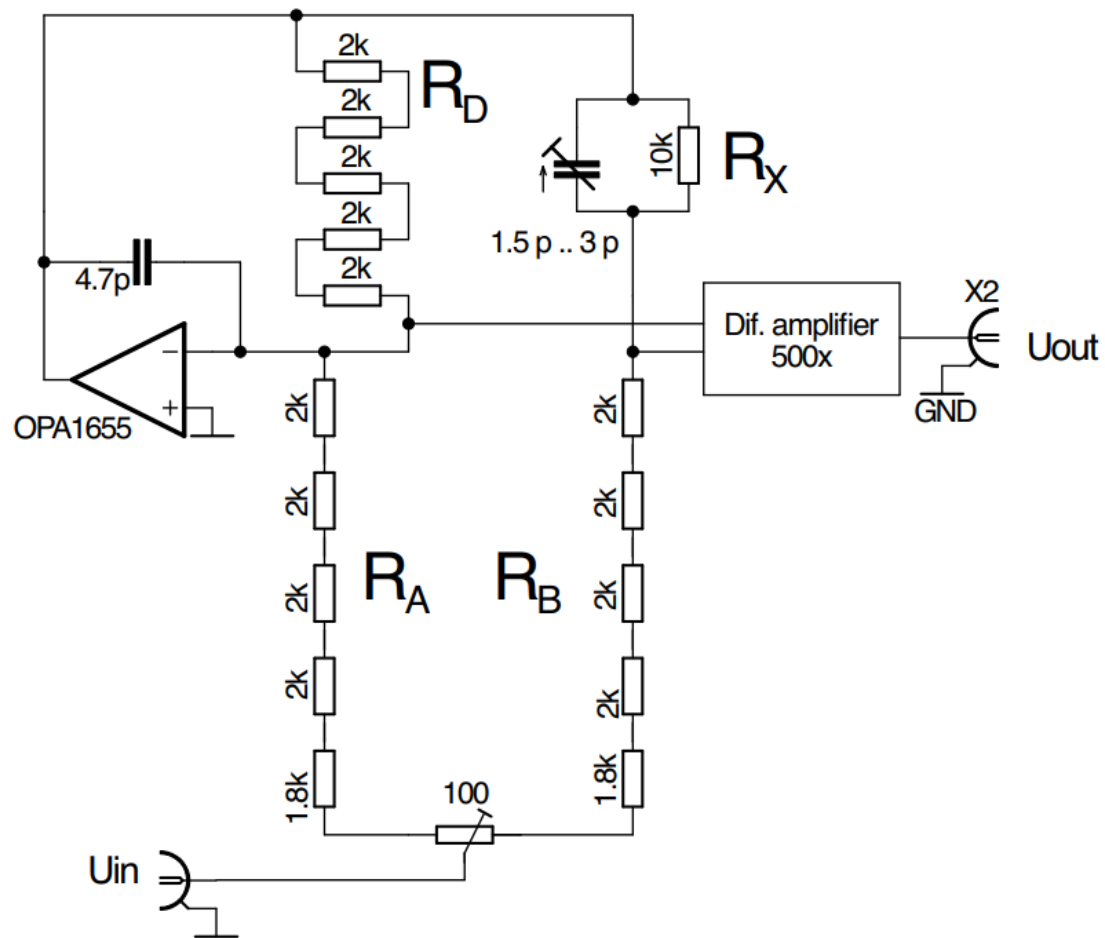


Measurements are underway



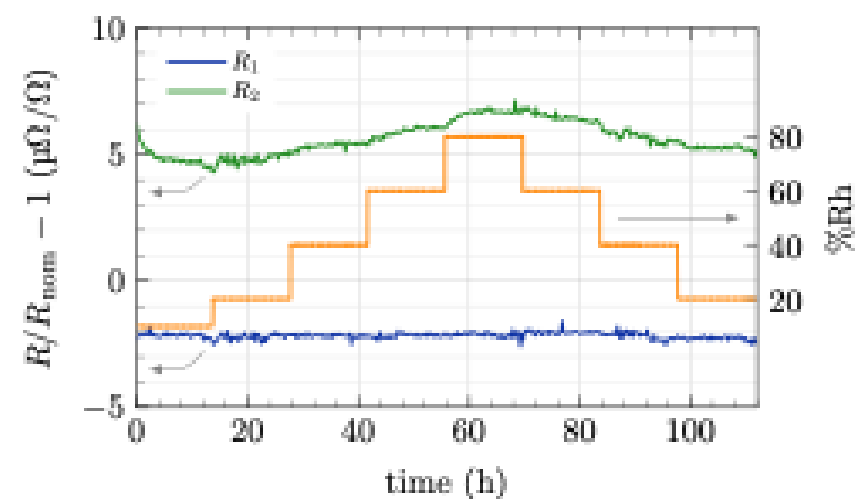
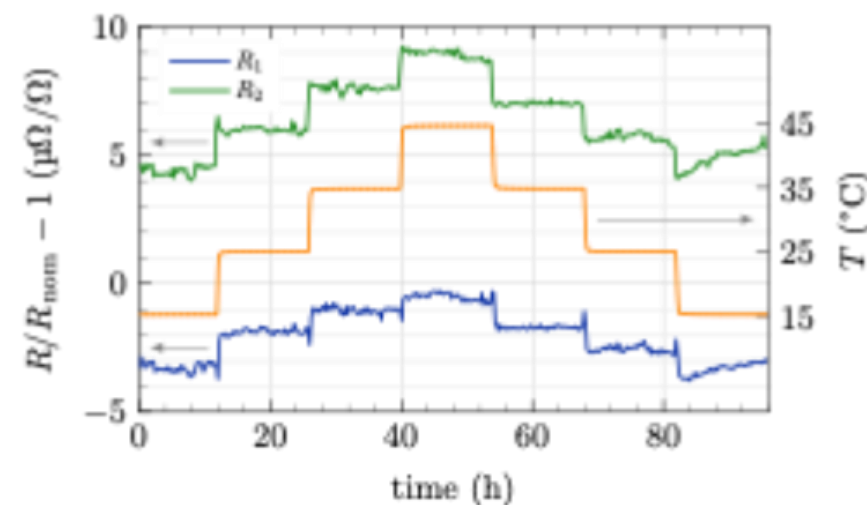


# Bridge for non-linearity/distortion measurement of components down to -170 dBc



# Temperature & Resistance Sensitivities of Resistor Arrays

- ❑ 10 k $\Omega$ /10k $\Omega$  Foil Resistor Arrays
- ❑ Plastic packaging & hermetically sealed
- ❑ Relative TempCos: -0.05 to +0.14 K<sup>-1</sup>
- ❑ Slight humidity effect for plastic packages



# Measurement of the dielectric absorption of capacitors

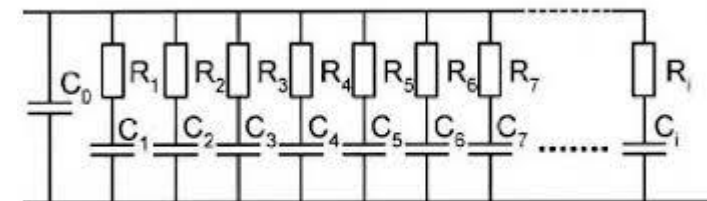
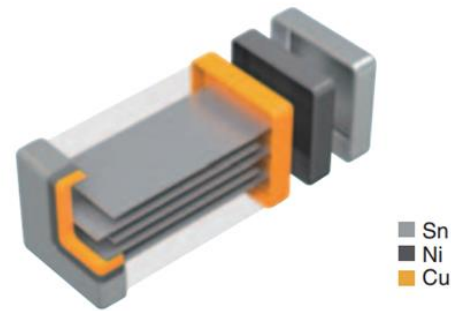
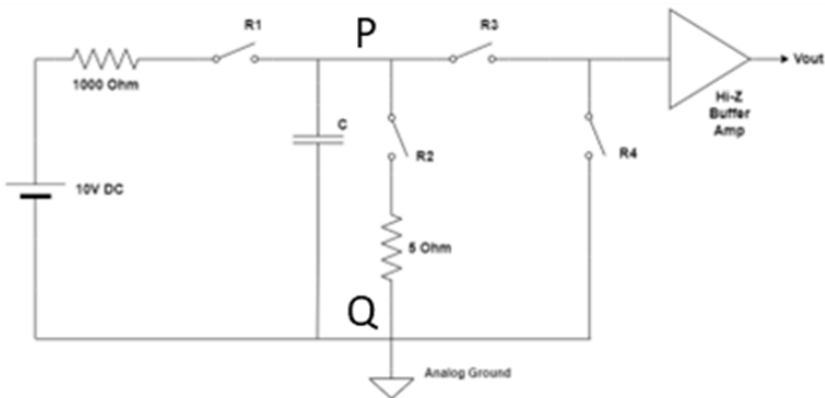
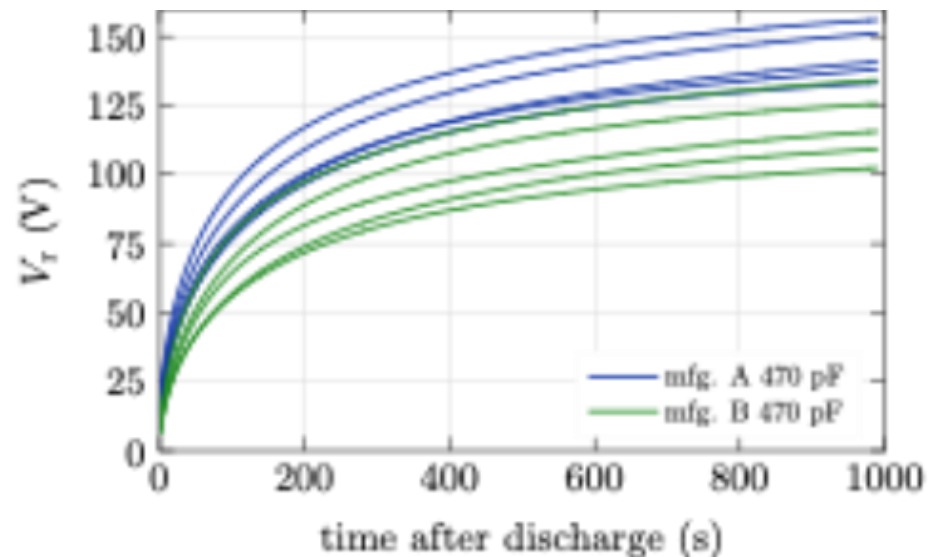


Figure 2: Dielectric absorption model

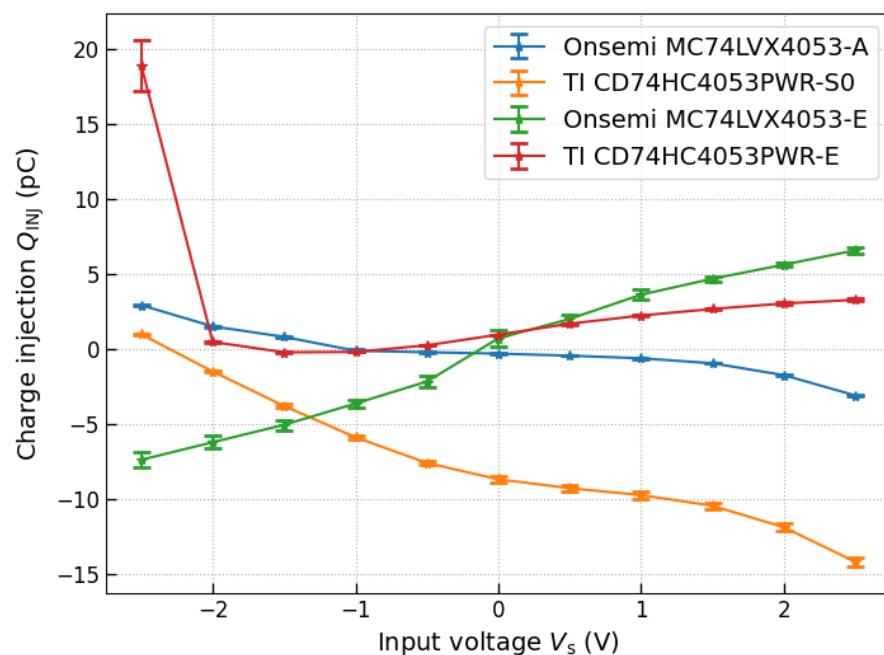
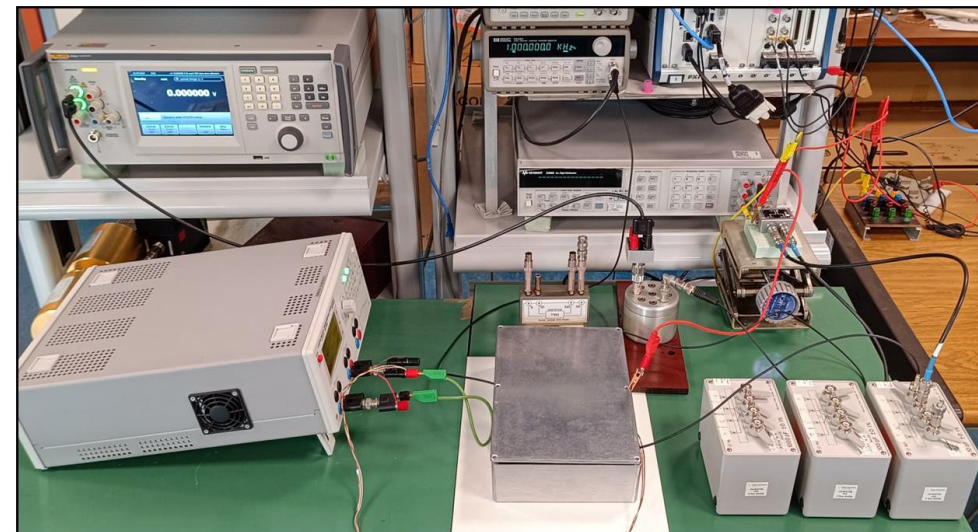
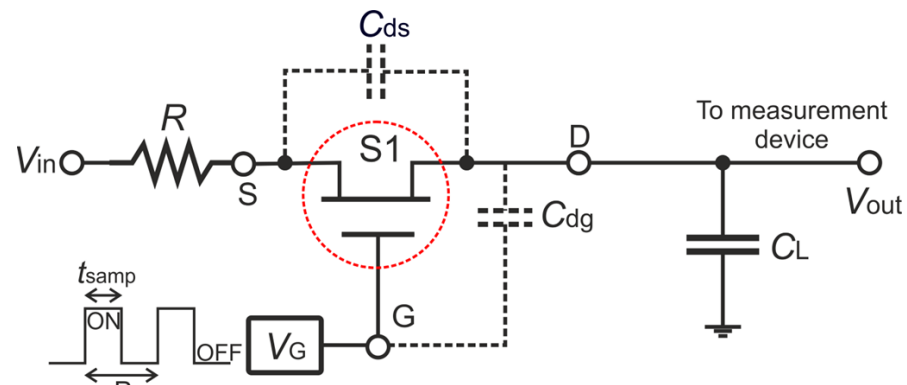
## Recovery voltage for 470pF ceramic CG0 Capacitors 5 samples from two different manufacturers



| Component Nr. | $R_i$ (T $\Omega$ ) | $C_i$ (pF) |
|---------------|---------------------|------------|
| 1             | 82.5                | 1.780      |
| 2             | 255.0               | 2.410      |
| 3             | 25.6                | 1.620      |
| 4             | 18.1                | 0.571      |
| 5             | 16.1                | 0.031      |



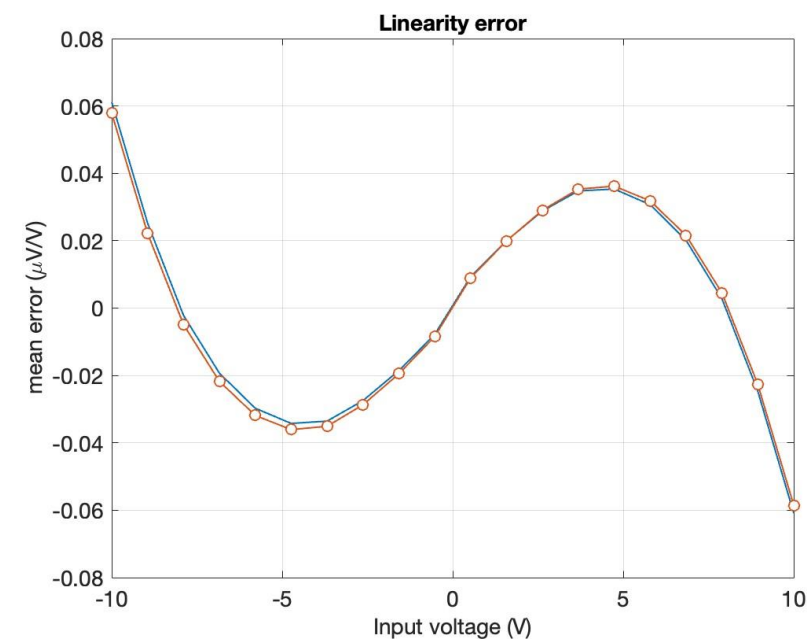
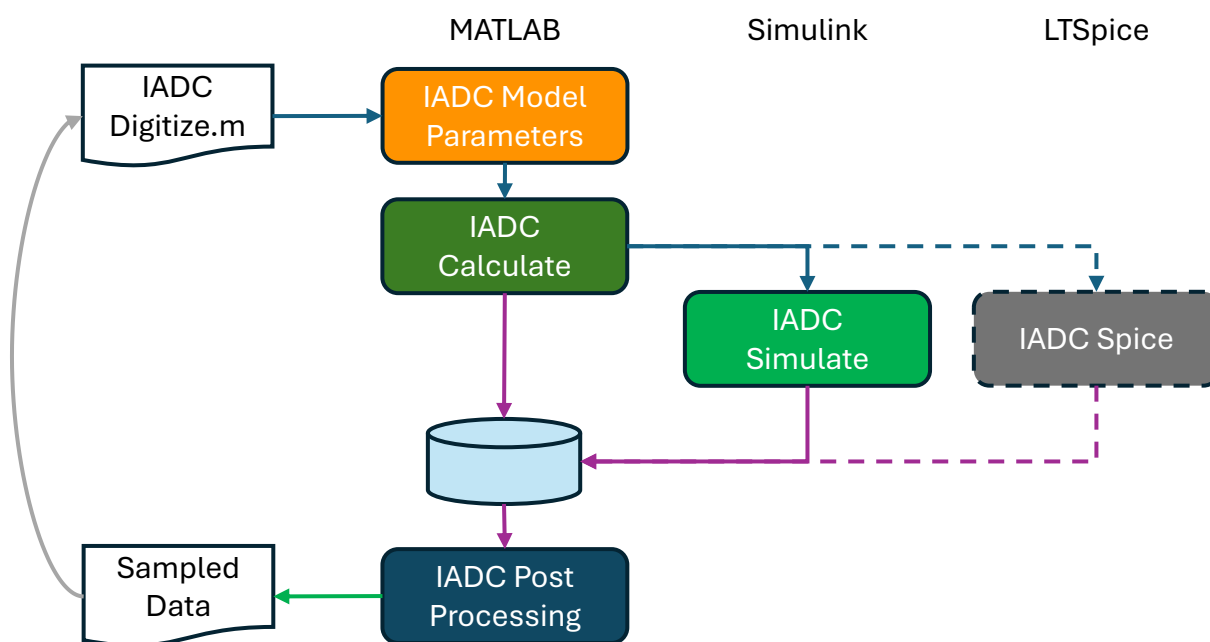
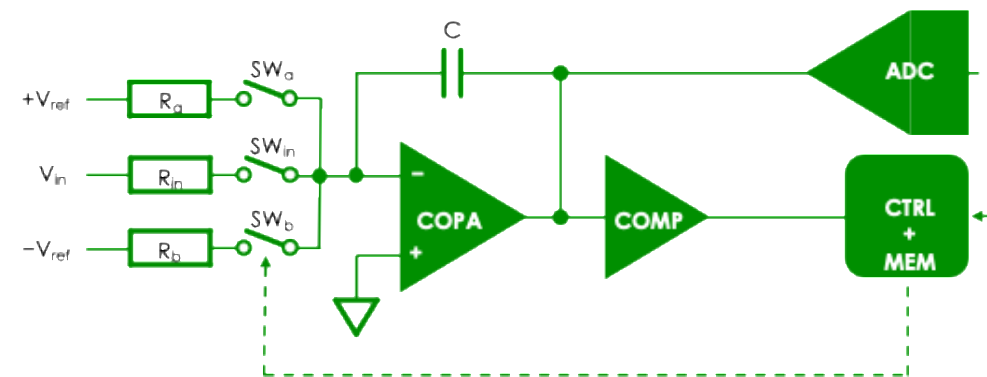
# Traceable Measurement of Charge Injection in CMOS Switches



- ❑ Measurement Resolution  $\approx 1$  pC
- ❑ Type A Std. Uncertainty : 10 – 70 fC
- ❑ Temperature Dependence: 3%-6% (15 - 40°C)

# A comprehensive IADC model simulator

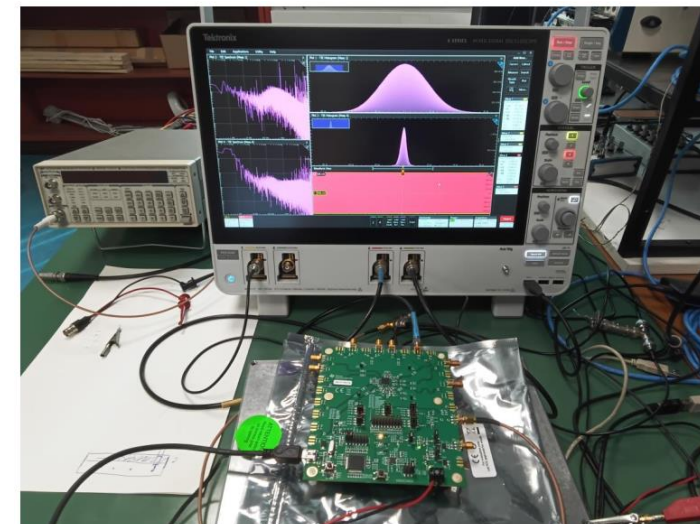
- ❑ - capacitor voltage dependence and dielectric absorption
- ❑ - resistor voltage dependence and self heating
- ❑ - switch charge injection and time jitter
- ❑ - COPA imperfections
- ❑ - and more



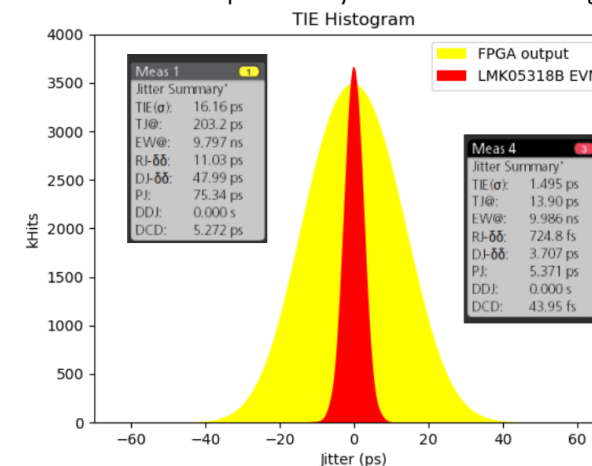


# Proposed Timing Platform

- ❑ 10 MHz and 100 MHz Synchronization Signals
- ❑ Galvanically Isolated
- ❑ Ultra-low jitter ( $< 5$  ps)
- ❑ Traceable measurement of jitter, delay and stability



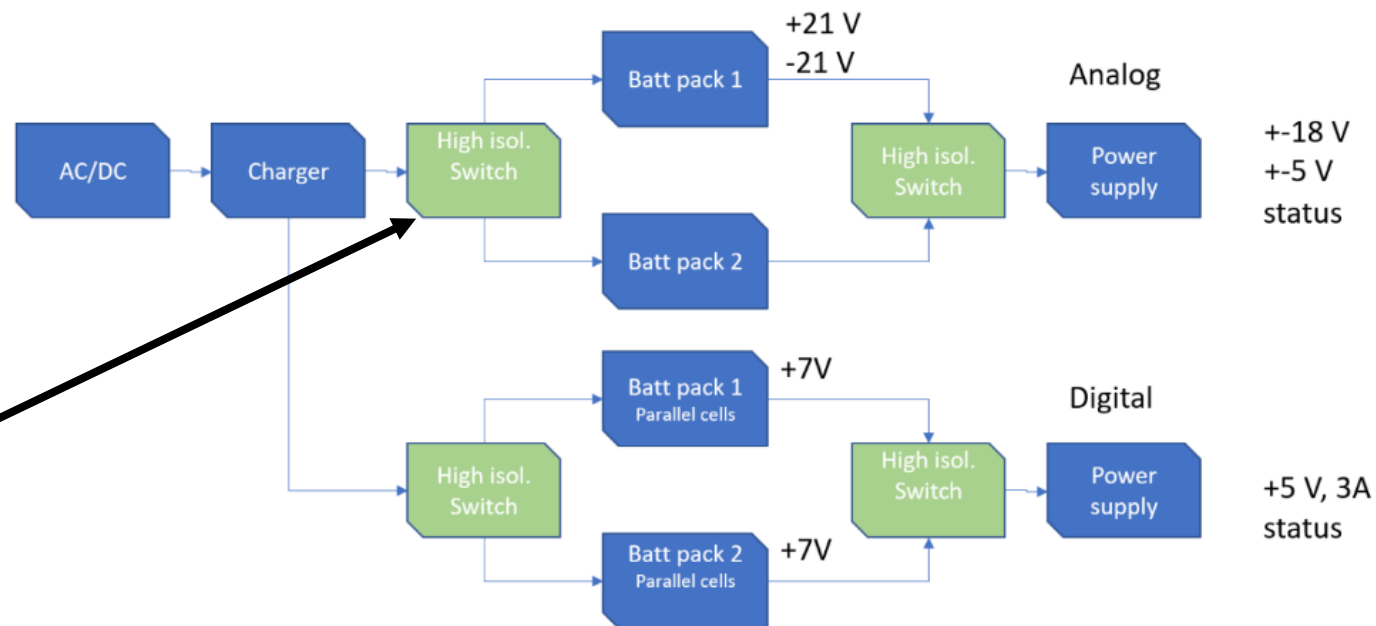
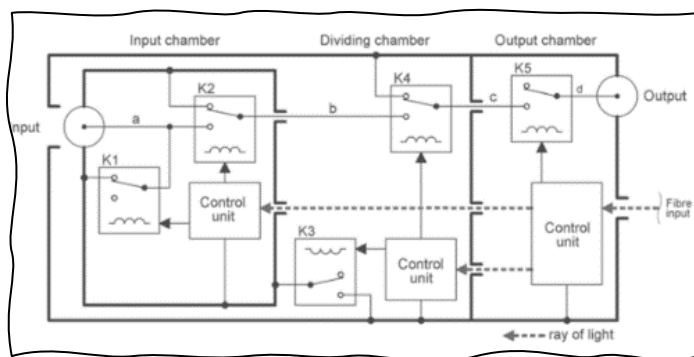
Jitter measurement preliminary results on 100 MHz signal



# Ultra-low Noise Power Supply

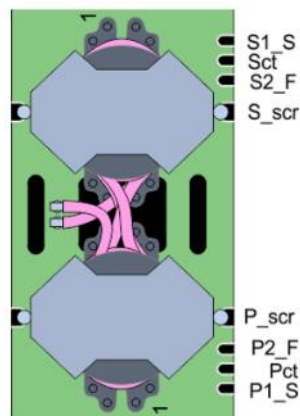
## Switched battery based

Total mains isolation  
Continuous operation



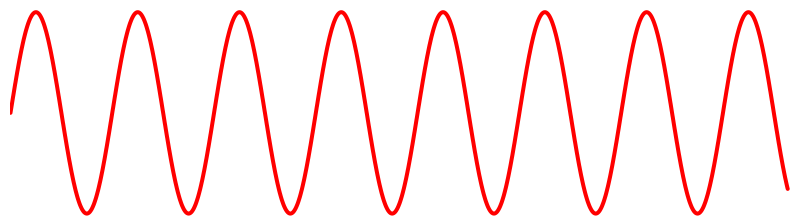
## DC-DC converter based

Very high mains isolation  
Isolation  $> 20 \text{ G}\Omega$ ,  $< 12 \text{ pF}$   
AC CMI  $< 5 \text{ nA}$

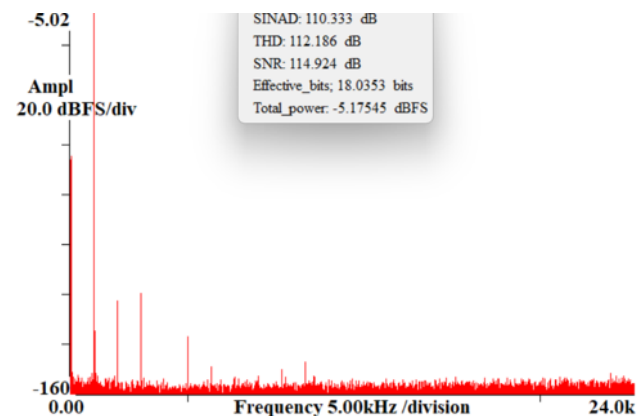
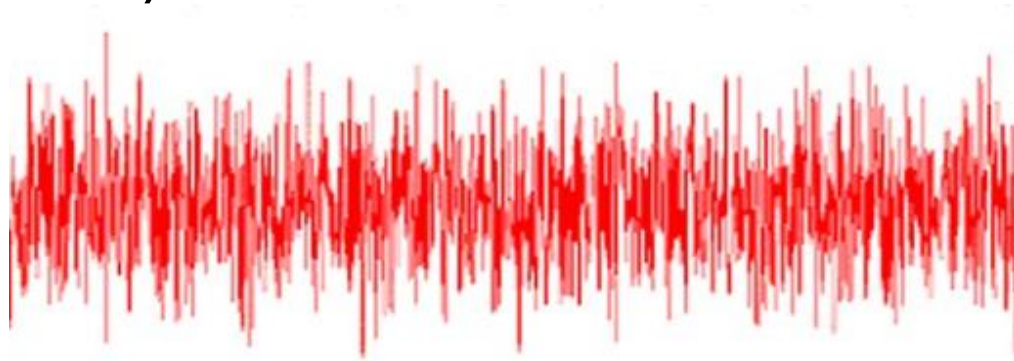


# Dynamic measurement of ADC non-linearity

Sine sources with ultra-low THD are used to test and characterise digitiser non-linearity



Multi-tone testing successfully performed on Audio Precision APx555 (24 bit DAC)



See Belcher R.A. et al. I2MTC 2024 Conference Proceedings

With our current research we are exploring possible areas of improvement, underpinning a successor project to design and test a real digitizer with sub-ppm performance.



*Collaborators: Janascard, Metron Design, Jaromir Sukuba*

- Stakeholders and collaborators are welcome to join the current project
- We plan to submit a proposal for a follow-on project for IND 2026 Call

# Questions?

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Rado Lapuh [rado.Lapuh@gmail.com](mailto:rado.Lapuh@gmail.com) (Science leader)

**Project website**

<https://true8digit.eu/>

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