Final Meeting

19th-20th May - Tres Cantos, Madrid

DIG-AC EMPIR JRP17RPT03

A digital traceability chain for AC voltage and current

WP2 - Wide Range Dynamic Digitizing

Technical approach, detailed activities, planning, deliverables, challenges & risks

Presenter: A. Sosso - INRIM

WP2 is about:

DIG-AC WP2: Wide Range Dynamic Digitizing

TARGET

Develop measurement systems employing **digital techniques** for **NMIs & Cal Labs** for the **practical realisation** of **step-up and step-down** procedures/scaling of electrical **current** and **voltage, starting from a Josephson standard**

STEPS

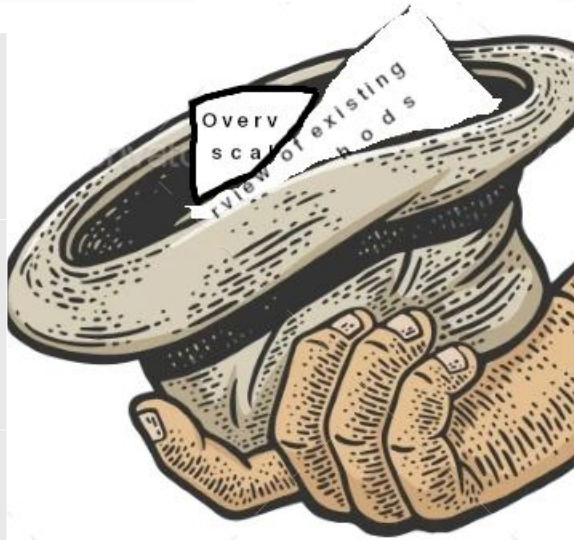
I) analysis of methods based on digital techniques for practical realisation of step-up and step-down procedures (Task 2.1);

II) study issues in interfacing digitisers in dynamic voltage scaling and in the measurement and scaling of currents (Task 2.2);

III) preparation of guidelines providing an integrated approach to scaling, digital techniques and quantum standards by combining digitisers with voltage dividers and current shunts (Task 2.3).

DIG-AC WP2: Wide Range Dynamic Digitizing

Activity Number	Activity Description
A2.1.1 M6	INRIM will coordinate a consultation with all partners to define a **set of criteria to classify methods for step-up and step-down** of voltages and currents using current shunts, voltage dividers and digitisers in terms of ranges covered by scaling, operating frequencies and other parameters, if applicable.
A2.1.2 M10	INRIM with assistance from all partners will **summarise the techniques in use for voltage scaling**, specifying the parameters defined in A2.1.1, and the analysis of amplitude and phase uncertainties. This activity will provide input to A2.1.5, A3.2.2, A3.2.3, A3.3.1 and A3.3.2.
A2.1.3 M10	INRIM with assistance from all partners will **summarise the techniques in use for current measurements and scaling**, specifying the parameters defined in A2.1.1, and the analysis of amplitude and phase uncertainties. This activity will provide input to A2.1.5.



DIG-AC WP2: Wide Range Dynamic Digitizing

- Completed document: "**Overview of scaling methods in use**" with a exhaustive overview of techniques in use in participants' labs

- Very simple **structure**

  VOLTAGE

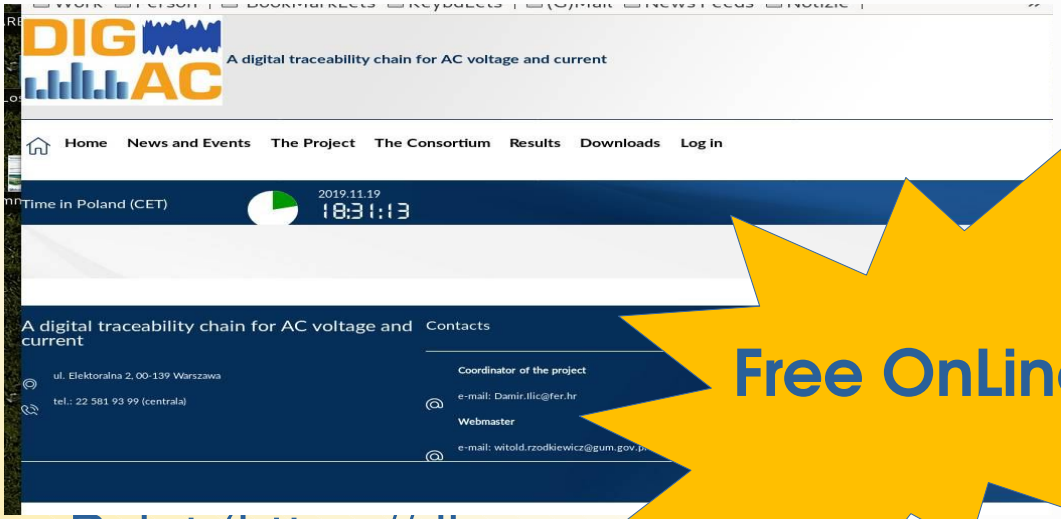
  STEP-UP

  STEP-DOWN

  CURRENT (SHUNTS)

  STEP-UP

  STEP-DOWN



- Available at the DIG-AC SharePoint (https://digac.gum.g[illegible]pl/)

DIG-AC WP2: Wide Range Dynamic Digitizing

Activity Number	Activity Description
A2.1.4 M6	INRIM with assistance from all partners will summarise the **techniques in use for direct digital voltage scaling** e.g. fast sampling using digital voltmeters + analysis of amplitude and phase uncertainties. This activity will provide input to A2.1.5, A3.2.2, A3.2.3, A3.3.1 and A3.3.2
A2.1.5 M10	INRIM in discussion with all partners will **analyse the results from A2.1.2 to A2.1.4 and provide a set of the most suited ranges and techniques for digital techniques for scaling both voltage and current.** Ranges will be selected considering impact and effectiveness of the quantum traceability obtained by scaling in the main applications. For currents the target considered to extend the traceability for shunts will be 1 A; voltage traceability will be targeted at 100 V; frequency range for both up to 1 kHz

DIG-AC WP2: Wide Range Dynamic Digitizing

- Completed document: "**Digital techniques for quantum-traceable ac scaling**" overviewing **digital** techniques in use
  - *Digital methods are very **effective** in **dc** but...*
  - *Just **a few attempts** up to now in **ac** (Metrosert, PTB, ..)*
  - *Results are promising especially for "not only V_{rms}" measurements*
  - *Further work needed to determine uncertainty budget and ultimate limitations of digital techniques*
- **10mA-1 A / 10mV-100 V / up to 1 kHz** most suited ranges for digitizing scaling ⟹ predicted ranges were substantially **confirmed**
- DIG-AC SharePoint?

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Activity Number	Activity description
A2.2.1 M14	INRIM: effect of **staircase signals** present at the output of Programmable Josephson Voltage Standards on voltage scaling using the techniques selected from A2.1.5.
A2.2.2 M16	CEM/INRIM: study the effect of **digitiser's instabilities** with time, temperature and frequency considering in particular the input impedance for the loading effect on dividers and shunts
A2.2.3 M18	Metrosert: **phase displacement of dividers and shunts** within the ranges selected in A2.1.5 in the audio frequency range in systems with two digital voltmeters, phase compensated and guarded voltage dividers, and coaxial current shunts CEM: phase displacement between the two DMMs
A2.2.4 M18	Metrosert/FER: application of **two digital voltmeters for direct digital determination of a voltage ratio** in the audio frequency range by simultaneous sampling
A2.2.5 M18	CEM: **digital counterpart of thermal-converter**-based step up of shunts using a calibrated combination of shunt and quantum-traceable digitizers
A2.2.6 M18	TUBITAK: **define dividers** for voltage calibration and **evaluate their performance** by measurements of the dividers for dynamic digital metrology
A2.2.7 M20	INRIM+CEM+Metrosert+TUBITAK: **outline an optimal system integration configuration** suitable to application at NMIs and calibration laboratories

DIG-AC WP2: Wide Range Dynamic Digitizing

- Results presented in deliverable D3 document (following slides)
- Several papers published / conferences / project reports

- *TÜBİTAK UME, "Report on the selection of three digitisers and their parameters.." 17RPT03 DIG-AC Project – Report D1*
- *A. Pokatilov et al., "Application of simultaneous sampling of two voltages for direct digital determination of a voltage ratio," DIG-AC Project, Internal Report, January 2022*
- *Y.A. Sanmamed, et. al: "Temperature influence on the establishment of a digital voltage reference", CPEM 2020 Digest, Denver, Colorado, 24-28 August 2020*
- *J.D. de Aguilar,et. al:"Characterization of an analog-to-digital converter frequency response by a JAWS", Meas. Science and Technology, 2019, vol. 30, No. 3, 035006,*
- *D. Peral,et. al: "Feasibility of a digital counterpart of thermal converter-based current step up", submitted to 25 th IMEKO TC4, September 2021*
- *J.R. Salinas et al., "Study of Keysight 3458A Temp Coeff for Different Aperture Times in DCV Sampling Mode", CPEM, 2018, pp.1-2*
- *D. Ilić,et.al: "Calibration of a precision current measurement system for high AC voltages using an AC Quantum Voltmeter" CPEM 2020, pp. 1-2*

_ _ _ maybe some are missing… sorry!

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Deliverable D3

Activty number	Activity description
A2.3.1 M30	Using input from A2.2.1, INRIM will write a **report** on the **effect of step approximated signals** on voltage scaling considering the most relevant techniques and providing an estimate of the related uncertainty.
A2.3.2 M30	Using input from A2.2.2, CEM will write a **report** about the **contribution of digitiser's instabilities with time, temperature, frequency and loading effect** of **input impedance** on **dividers** and **shunts Uncertainties** will be analysed and a solution for reducing effect on the scaling network will be developed.
A2.3.3 M30	Using input from A2.2.3, Metrosert with INRIM will write a **report** on the c**haracterisation of phase displacement of dividers and shunts** with two digital voltmeters, phase compensated and guarded voltage dividers, and coaxial current shunts.
A2.3.4 M30	Using input from A2.2.4, Metrosert with FER will write a **report** describing the **application of simultaneous sampling of two voltages** using **two digital voltmeters for direct digital determination of a voltage ratio** providing an estimate of the method's uncertainty.
A2.3.5 M30	Using input from A2.2.5, CEM will write a **report** on a **digital counterpart of thermal-converter-based step-up with** a calibrated combination of shunt/quantum-traceable digitiser
A2.3.6 M30	Using input from A2.2.6, TUBITAK will write a **report** on voltage scaling by evaluating the **performance of at least three types of dividers** for dynamic digital metrology aspects.
A2.3.7 M36	INRIM, with assistance from CEM, Metrosert and TUBITAK, will summarize results in guide lines for integration of digital techniques with quantum standards, suitable for use at NMIs and calibration laboratories,

Activity A2.3.7

Deliverable D3 : Guidelines on the development of scaling systems employing digital techniques for use at NMIs and calibration laboratories for the practical realisation of step-up and step-down procedures and scaling of electrical current and voltage

Partners
INRIM, CEM, Metrosert, Tubitak

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DIG-AC WP2: Wide Range Dynamic Digitizing

D3 document is a 25-pages report that summarizes all outcomes from DIG-AC WP2

Possible discussion in more detail on relevant points, questions, special interests...

Final Meeting

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