

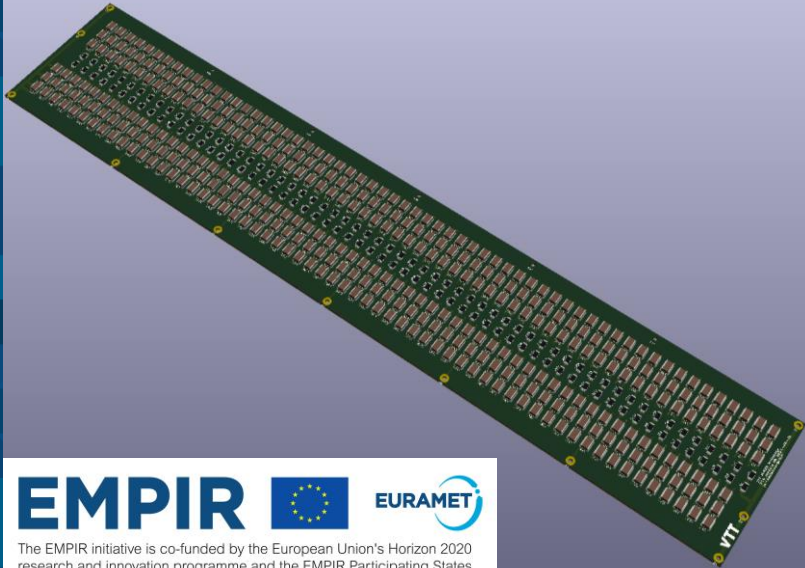
VTT

Workshop, 25th of April, 2023

19NRM07 HV-com²

WP2: Traceable reference systems

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EMPIR



EURAMET

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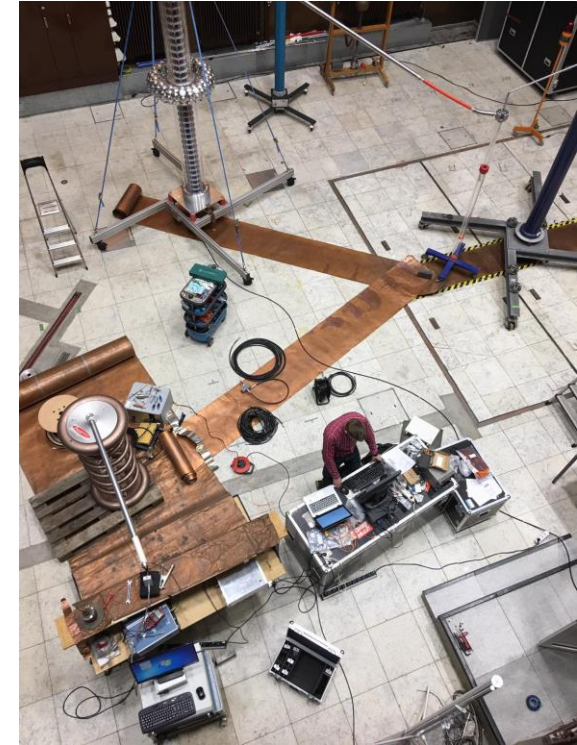
WP2 overview



Task 2.1: Design and construction of a **modular universal voltage divider**



Task 2.2: **Measurement campaign at PTB** to study the accuracy limits of the reference measurement systems that are used for measuring composite and combined waveforms



Task 2.1: Design and construction of a modular universal voltage divider

The aim of this task is to design and construct a modular universal voltage divider for use in the calibration of the measurement systems that have been designed for measuring composite and combined waveforms. The nominal voltage for one module is at least 100 kV. The divider will be designed so that the modules can be stacked for use with higher voltages. At least 3 additional modules will be built by different partners.

Task 2.1: Design of universal divider

Activity number	Activity description	Partners (Lead in bold)
A2.1.1 M06	Using the information from A1.1.1, VTT will coordinate the design of the modular universal voltage divider. VTT, PTB, FFII, LNE, TUG, TUBITAK, INRIM, TAU, RISE and Haefely will participate in e.g. a brainstorming session at the kick-off meeting to agree on the main principles for the design of the modular universal voltage divider, and in web meetings to discuss and agree on details. Design documents, including e.g. a set of drawings and a component list, will be prepared.	VTT , PTB, FFII, LNE, TUG, TUBITAK, INRIM, TAU, RISE, Haefely

- PCB based design is ready
- Additional/modified designs by PTB, RISE, FFII, LNE, TUBITAK

→ Completed

Task 2.1: Construction of a prototype

The aim of this task is to design and construct a modular universal voltage divider for use in the calibration of the measurement systems that have been designed for measuring composite and combined waveforms. **The nominal voltage for one module is at least 100 kV.** The divider will be designed so that the modules can be stacked for use with higher voltages. At least 3 additional modules will be built by different partners.

Activity number	Activity description	Partners (Lead in bold)
A2.1.2 M11	PTB, with support from VTT and TUBITAK will construct one prototype module of the modular universal voltage divider considering the definitions from A1.1.2 and using the design documents from A2.1.1.	PTB , VTT, TUBITAK

- Building a PCB based prototype modules (4 x 100 kV) has been finished
- Additional/modified designs by PTB, RISE, FFII, LNE, TUBITAK

→ Completed

Task 2.1: Characterization of the prototype

Activity number	Activity description	Partners (Lead in bold)
A2.1.3 M13	VTT, with support from PTB, INRIM, TAU and TUBITAK, will characterise at least the scale factor and the step response of the prototype module of the modular universal voltage divider developed in A2.1.2. This characterisation will be performed at VTT or PTB. Based on the test report generated, VTT will review the design documents prepared in A2.1.1 and will update them, if needed. The prototype will then be redesigned and re-tested, if needed.	VTT , PTB, INRIM, TUBITAK, TAU

- VTT has performed AC, DC, LI, step response tests and provided a test report for partners

→ Completed

Task 2.1: Construction of additional modules

Activity number	Activity description	Partners (Lead in bold)
A2.1.4 M18	PTB will coordinate the building of at least 3 additional modules for use by interested partners, with support from some of the other partners from this activity (selected from: VTT, TUBITAK, INRIM, TAU, RISE, TUG, Haefely). The partners who will jointly build the at least 3 additional modules, for their own use, will be decided at the M9 (January 2021) meeting. The modules will be built according to the updated design documents prepared in A2.1.3.	PTB , VTT, TUBITAK, INRIM, TAU, RISE, TUG, Haefely

- First batch: 1x100 kV prototype + additional 3x100 kV PCB modules (VTT+PTB)
- Second batch: 6x100 kV (TAU+VTT)
- Separate orders: FFII 2x100 kV, TUBITAK + TUG are interested

→ Completed

Task 2.1: Characterization of additional modules

Activity number	Activity description	Partners (Lead in bold)
A2.1.5 M22	PTB, with support from VTT, INRIM, TAU, RISE and TUBITAK, will characterise the frequency response of the at least 3 additional modular universal voltage dividers that were built in A2.1.4 using the same procedures as in A2.1.3. The tests will be undertaken jointly at PTB, and test reports will be produced.	PTB , VTT, INRIM, TAU, RISE, TUBITAK

- VTT, TAU and PTB have characterized four 100 kV modules
- Characterization of second batch is under way

→ Completed

Task 2.1: Frequency response correction is not needed

Activity number	Activity description	Partners (Lead in bold)
A2.1.6 M22	If the frequency responses determined in A2.1.5 are not sufficient for the measurements, VTT, with support from TUBITAK and TUG, will correct the frequency response using convolution and deconvolution techniques. This activity will result in at least 3 functional additional modular universal voltage dividers (at least 4 in total).	VTT , TUBITAK, TUG

- Dynamic behavior has been good enough, and the software corrections are not needed

→ Completed

Task 2.2: Measurement campaign at PTB

The aim of this task is to study the accuracy limits of the reference measuring systems that are used for measuring composite and combined waveforms with a target amplitude uncertainty of less than 2 %. Commercial reference measuring systems and the new modular universal voltage divider (a traceable reference system), prepared in A2.1.1-A2.1.6, will be characterised using the new test setup developed in A2.2.2. The aim is to validate at least 3 modules, which were tested in A2.1.5, for use in reference systems.

Task 2.2: Preparation of existing dividers

Activity number	Activity description	Partners (Lead in bold)
A2.2.1 M14	Selected partners from this activity (FFII, LNE, INRIM, PTB, TUG) will characterise a total of 2-4 of their existing voltage dividers in their own labs in preparation for the measurement campaign. This work will be coordinated by FFII and the partners who will perform the characterisation will be decided at the kick-off meeting. The characterisation will include the preparation of uncertainty budget(s) for at least 2 test wave shapes with consideration of the definitions from A1.1.2.	FFII , LNE, INRIM, PTB, TUG

- Dividers: RISE, PTB, FFII

→ Completed

Task 2.2: Preparation of voltage generation setups

Activity number	Activity description	Partners (Lead in bold)
A2.2.2 M12	PTB, with support from VTT and TUBITAK, will design setups for the generation and measurement of both combined and composite wave shapes with voltages up to 300 kV to be used in the measurement comparison campaign (A2.2.5). Therefore, two high voltage generating circuits, one for impulses, and one for HVAC/HVDC, will be combined using coupling components (e.g. a spark gap, capacitor or resistor). Specifications, e.g. the wave shapes and the voltage levels of the individual voltage shapes, for the setup will be prepared by PTB, with support from VTT.	PTB , VTT, TUBITAK

- PTB prepared a working setup up to 300 kV

→ Completed

Task 2.2: Characterization of stacked modular divider

Activity number	Activity description	Partners (Lead in bold)
A2.2.3 M24	PTB, RISE and VTT will jointly characterise the entire modular universal voltage divider (comprising at least 3 modules) that was developed in A2.1.1-A2.1.6 in preparation for the measurement comparison campaign. This characterisation will include preparing uncertainty budget(s) for at least 2 test wave shapes.	PTB , RISE, VTT

- 2x100 kV at VTT
- 2x100 kV at TAU, Master's thesis, Simon Boonants, TAU
- **4x100 kV at PTB, used also in WP3 comparison**

→ Completed

Task 2.2: Comparison plan

Activity number	Activity description	Partners (Lead in bold)
A2.2.4 M26	VTT, with support from PTB, TUBITAK, INRIM, TAU, FFII and LNE, will prepare a plan for the measurement comparison campaign for studying the accuracy limits of the reference measurement systems that are used for measuring composite and combined waveforms. The plan will take into account the definitions proposed in A1.1.3. The measurement comparison campaign will include reference measurement systems for HVAC, HVDC and impulse voltages, which will be provided by PTB and VTT.	VTT , PTB, TUBITAK, INRIM, TAU, FFII, LNE

- Preliminary plan was prepared in May 2022

→ Completed

Task 2.2: Comparison campaign

Activity number	Activity description	Partners (Lead in bold)
A2.2.5 M27	A measurement comparison campaign will be arranged by PTB at PTB based on the plan from A2.2.4, the setup from A2.2.2, and the characterisation results from A2.2.1 and A2.2.3. At least VTT, FFII and RISE will join PTB for the measurement comparison campaign. The measurement comparison campaign at PTB will study the accuracy limits of the reference measurement systems that are used for measuring composite and combined waveforms with a target amplitude uncertainty of less than 2 %.	PTB , VTT, FFII RISE

- From the 27th of June until the 8th of July, 2022

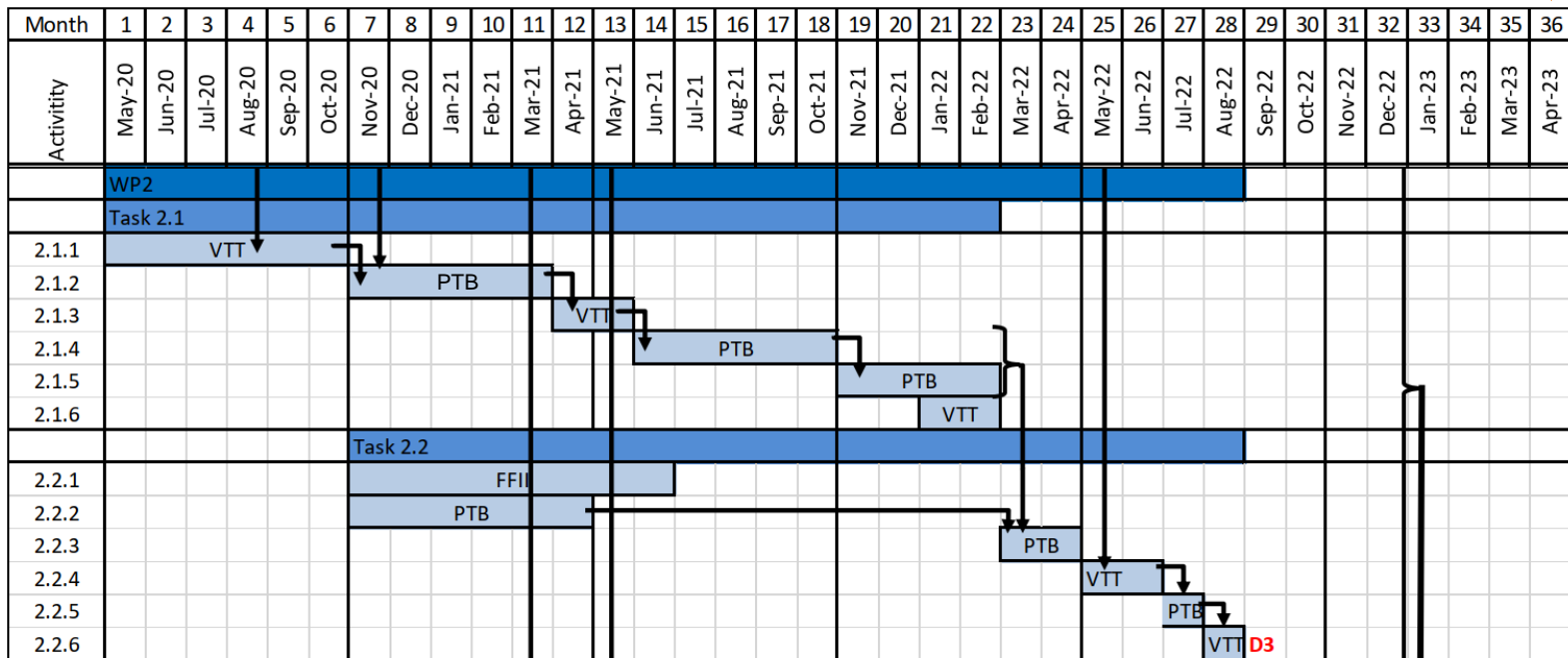
→ Completed

Task 2.2: Deliverable: test report

Activity number	Activity description	Partners (Lead in bold)
A2.2.6 M28	<p>Based on the outcomes of A2.2.3 and A2.2.5, VTT, with support from PTB, TUBITAK, INRIM, TAU, RISE, TUG, FFII and LNE, will prepare a test report on the performance of the modular universal divider and on the results of the measurement comparison campaign at PTB.</p> <p>Once agreed by the consortium, the coordinator on behalf of VTT, PTB, TUBITAK, INRIM, TAU, RISE, TUG, FFII and LNE will then submit the test report to EURAMET as D3: 'Test report on the performance of the modular universal divider and on the results of the measurement campaign at PTB. The target amplitude uncertainty of the divider is < 2 %. The measurement comparison campaign at PTB will study the accuracy limits of the reference measurement systems that are used for measuring composite and combined waveforms'.</p>	VTT , PTB, TUBITAK, INRIM, TAU, RISE, TUG, FFII, LNE

- Draft available, to be completed in May 2023

WP2 overview – Gantt chart



WP2 deliverable (needs final touch, M37...)

Relevant objective (Activity delivering the deliverable)	Deliverable number	Deliverable description	Deliverable type	Partners (Lead in bold)	Delivery date
3 (A2.2.6)	D3	Test report on the performance of the modular universal divider and on the results of the measurement campaign at PTB. The target amplitude uncertainty of the divider is < 2 %. The measurement comparison campaign at PTB will study the accuracy limits of the reference measurement systems that are used for measuring composite and combined waveforms	Test report	VTT , PTB, TUBITAK, INRIM, TAU, RISE, TUG, FFII, LNE	Aug 2022 (M28)





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