

News from TÜBİTAK UME

CCEM 2025

NEW FACILITIES/DEVELOPMENTS:

Voltage Laboratory (Contact: mehedin.arifovic@tubitak.gov.tr)

Two different methods for differential sampling measurements of AC Voltage using UME Programmable Josephson Voltage Standard (PJVS) were established and implemented. One by deleting step transition points and the other by combining two consecutive sampling periods with shifted phase.

A research on RF measurements at 4 K based on thermal transfer techniques and Josephson Arbitrary Waveform Synthesizer (JAWS) array is conducted. A new probe for coupling RF signals from room temperature to superconducting environment has been fabricated.

A feasibility study was conducted for the development of a new pulse pattern generator based on the RFSoc evaluation board and based on the results obtained, a EUREKA project named "PPG for Quantum Technologies" was proposed.

Within the scope of the BIPM-UME placement project, a researcher from INTI (Argentina) spent 3 months in the UME Voltage Laboratory working on the modelling of the digital twin of the UME PJVS and Digitizer measurement system. During the work, measurements were made by varying the parameters such as integration time, number of the steps in approximated signal, frequency, and a data-based digital twin model of the system was simulated.

Digital twins of the UME DC standard (Fluke 732B) were created using measurement data collected over a period of 25 years, using the LSTM deep learning algorithm.

Two new voltage dividers of ratio 10:1 V/V with improved AC-DC difference has been manufactured and tested.

Projects completed during this time period:

- 20FUN07 SuperQuant; Trustworthy Virtual Experiments and Digital Twins

Projects started or continued during this time period:

- 23NRM SBS Uncert; Support for standardization of sample-by-sample waveform uncertainty calculation
- EURAMET Project 1666; Study on Traceable Verification of AC Measurement Standard
- 23RPT01 WAC; Wideband AC quantum traceability
- 22DIT01/d02 VIDIT; Trustworthy Virtual Experiments and Digital Twins

Impedance Laboratory (Contact: enis.turhan@tubitak.gov.tr)

The Four-Terminal-Pair Digital Assisted Impedance Comparison Bridge was established at TÜBİTAK UME. Initially, the bridge was semi-automatic; now, fully automated measurement software has been completed and tested. Performance tests and characterization of the bridge are still ongoing.

The characterization of four reference resistors for the GULFMET.EM-K2 intercomparison at nominal values of 10 M Ω and 1 G Ω has been performed. The comparison measurements has begun.

A new partnership project, QuAHMET (Quantum Anomalous Hall Effect Materials and Devices for Metrology), began in June 2024. As part of this project, TÜBİTAK UME will perform CCC measurements on the samples produced.

TÜBİTAK UME participated in the BIPM.EM.K13.a and BIPM.EM.K13.b bilateral comparisons at nominal values of 1 Ω and 10 k Ω . Measurements at TÜBİTAK UME were conducted between November 2024 and February 2025. The reference standards will be sent to BIPM in March 2025.

Two new Quantum Hall samples have been supplied by PTB. Work on designing suitable sample holders for the QHR samples to be used in the cryogen-free system is still ongoing. Once the QHR system is completed, a bilateral QHR comparison with BIPM will be planned.

RF & Microwave Laboratory (Contact: erkan.danaci@tubitak.gov.tr)

The primary level RF power measurement system micro-calorimeter has been started to establish for millimetre-wave frequency up to 220 GHz in 2024.

The automatic absolute RF power measurement software developed by TÜBİTAK UME was proposed to be used in an EU-supported project (22RPT04 RFMicrowave II) and accepted. The software has deployed to eight different NMIs. This software provides features such as uncertainty calculation tools using the Law of Propagation and Monte Carlo Simulation Methods for absolute RF power measurement. In the same EU-supported project, a new calibration method for RF power sensor calibration with Vector Network Analyser (VNA) was offered, and project participants are working on further improving the method.

The CCEM.RF-K28.W- Effective efficiency of calibration factor of RF waveguide thermistor mounts (18 GHz to 26.5GHz) comparison measurements were performed in 2023, and its evaluation is awaited. The CCEM.RF-K5.d.C Coaxial scattering parameter measurements 2.4 mm line system (9 kHz - 50 GHz) comparison's first period measurements were performed in 2024. The EURAMET Project 1512 Effective Efficiency on coaxial RF thermistor mounts (10 MHz to 18 GHz) comparison piloted by TÜBİTAK UME was finalized.

An RF and Microwave Laboratory was established in Azerbaijan National Metrology Institute (AzMI) by TÜBİTAK UME. AzMI RF and Microwave Laboratory has the capability for absolute power measurement, RF power sensor calibration, and S parameter measurement up to 50 GHz.

EMPIR 20FUN07 SuperQuant and EMPIR 20IND03 FutureCom projects were completed. EPM 22RPT04 RFMicrowave II and EPM 23IND03 RF4 6G projects have been launched.

TÜBİTAK UME joined the EURAMET TC-IM Project 1448 DCC project. The first DCC-creating activities were started on scattering parameter calibrations.

High Voltage Laboratory (Contact: serkan.dedeoglu@tubitak.gov.tr)

International project “19NRM07-HV-com2: Support for standardisation of high voltage testing with composite and combined wave shapes”, is concerning the standardisation proposal about combined and composite measuring and testing systems. In the scope of this international project, 400 kV Universal (RCR) high voltage dividers was constructed and characterized by TÜBİTAK UME, PTB, VTT, LNE, LCOE and INRIM. The results of this characterization have been presented at CPEM 2023 in New Zealand. Another output of this project is to investigate and implement the composite and combined measurement software. The software with a special recorder has been performed and implemented for the combined and composite measurements. This project was completed at the end of April 2023.

Another international project is “23IND01 ENSURE: Electric Energy and Supply Reliability”. This project focuses on the metrology research necessary to support standardisation and the development of traceable tools for HV condition monitoring and fault detection as well as the means to ensure the reliable determination of losses in HV transformers and HV cables. At the end of this project, the capacitance and dissipation factor measurements of high voltage capacitors under high frequency will be made and their characterization will be done. This project started in June 2024. This project will be completed at the end of June 2027.

Power & Energy Laboratory (Contact: ozlem.yilmaz@tubitak.gov.tr)

Two new EPM projects began in June 2024 which are 23IND06 MET4EVCS “Metrology for electric vehicle charging systems” and 23IND01 ENSURE “Electric energy and supply reliability”. In the scope of 23IND06 project, TÜBİTAK UME has established calibration system for 'Fast Charging Stations' in the first 6 months of the project and has started responding to both domestic and international calibration requests. As part of the project, a portable measurement kit is being designed to perform on-site testing and analysis of charging stations. The project outputs will contribute to the revisions of OIML/WELMEC/TSE standards and the preparation of new regulations. In the scope of 23IND01 ENSURE, TÜBİTAK UME will develop test procedures and setups for the characterisation of the non-invasive non-optical current sensor, which will be used as a reference for the on-site calibration of the current transformers installed in MV and HV substations. The comparison of the non-invasive commercial/laboratory sensors will be performed considering both AC and distorted signals under fundamental and harmonics. In another work package of the project, the laboratory will support the determination of system requirements for the measurement of harmonic losses in power transformers, using knowledge from previous projects and on-site calibration experience.

EMPIR 19NRM05 was completed.

In 2024, the project entitled “Development of TEİAŞ Power and Energy Calibration Laboratory” was completed by TÜBİTAK UME successfully.

A bilateral comparison entitled "EURAMET.EM-S43 (EURAMET Project No: 1538) Bilateral Supplementary Comparison of High Voltage Transformer Measuring Systems" has been successfully completed. The final report has been published in the journal Metrologia. In this field of measurement, the laboratory has improved the CMC data. Furthermore, an international comparison titled “COOMET Project 859/TR/22 Supplementary Comparison of High Current Transformer Measuring Systems” was started with the participation of three metrology institutes. TÜBİTAK UME is the pilot institute for this comparison.

Electromagnetic Laboratory (Contact: bahadir.tektas@tubitak.gov.tr)

Within the scope of the EMP Project Development of RF and Microwave Capability II (22RPT04 RFMicrowave2), tapered cell measurement system (250 MHz-1GHz) was established for electric field probe calibrations. Validation and improvement studies of this system are ongoing.

Within the scope of the EMP Project Development of RF and Microwave Capability II (22RPT04 RFMicrowave2), μ TEM cell measurement system (50 MHz-1GHz) was established for electric field probe calibrations. Validation and improvement studies of this system are ongoing.

Within the scope of the EMP Project Development of RF and Microwave Capability II (22RPT04 RFMicrowave2), Helmholtz coil measurement system (1 MHz-10 MHz) was established for magnetic field probe calibrations. Validation and improvement studies of this system have been completed.

Within the scope of the EMP project titled “21NRM06 EMC-STD Metrology for emerging electromagnetic compatibility standards”, TÜBİTAK UME published 2 conference papers and a journal paper thorough the project. Also, a compact measurement device and a reference device has been constructed for measurements. This project is ongoing.

An international magnetic field probe calibration comparison titled “EURAMET.EM.RF-S46 (EURAMET Project No: 1538) Comparison of Magnetic Field Strength Measurements for Frequencies up to 30 MHz” has been completed and the final report has been published. TÜBİTAK UME was the pilot institute for the comparison.

Within the scope of the EMP Project Development of RF and Microwave Capability II (22RPT04 RFMicrowave2), Bilateral comparison of 30 MHz – 1 GHz open area test site antenna measurements between TÜRKİYE TÜBİTAK UME and SWEDEN RISE has been completed and draft report is ongoing. TÜBİTAK UME was the pilot institute for the comparison.

Within the scope of the EMP Project Development of RF and Microwave Capability II (22RPT04 RFMicrowave2), Comparison of 1 GHz – 40 GHz antenna factor measurements between TÜBİTAK UME, CMI and RISE has been completed and draft report is ongoing.

Within the scope of the EMP Project Development of RF and Microwave Capability II (22RPT04 RFMicrowave2), Comparison of 9 kHz – 30 MHz antenna factor (AF) for monopole antenna using equivalent capacitance substitution method (ECSM) has been completed and draft report is ongoing.

Magnetism Laboratory (Contact: huseyin.sozeri@tubitak.gov.tr)

International project 22HLT02 A4IM “Affordable low-field MRI reference system” supported by the EMPIR programme of the European Union’s and coordinated by PTB (Germany), started in June 2023. In this project TÜBİTAK UME contributed to WP1 “Reference MR scanner - hardware development, characterization and optimization” by constructing MR magnet made from permanent magnetic material in Halbach arrangement together with four RF power amplifiers (RFPA) and four gradient power amplifiers (GPA).

The national project conducted with Karadeniz Technical University about preparation of soft magnetic alloys used in high sensitive fluxgate magnetometers completed in 2023. Several ribbon type soft magnetic materials have been prepared by planar flow casting method. Characterization of several sensors produced using these ribbons was performed.

A joint project, between TÜBİTAK UME and Slovakia Academy of Science (SAS) on the preparation and design of space qualified magnetic sensors was completed. A set of magnetometer and torque rod was produced as an outcome of the project.

A joint project, between TÜBİTAK UME and Slovakia Academy of Science (SAS) entitled “New Material Based High Performance Magnetic Gradiometer Design” was supported and started in April 2024. A magnetic gradiometer will be constructed as an outcome of the project.

A national project entitled “Detection of magnetic anomalies in Ultra Low Frequency (ULF) range for an earthquake forecast by a novel design search coil magnetometer” and conducted with İnönü University was supported and started in Dec. 2023. A search coil magnetometer will be developed to trace magnetic field changes at frequencies below 5 Hz which could be signatures of impending earthquakes.

Quantum Metrology Laboratory (Contact: gokce.ozbay@tubitak.gov.tr)

Clean-room facilities for nano-device manufacturing has been established in Quantum Metrology building. It is a ISO-6 clean room with ISO-9 laboratories where the thin film manufacturing systems are located. The sample loading interfaces has been established from ISO-6 rooms into the deposition systems, themselves. A system dedicated to superconducting materials has been set-up. The aim is to manufacture Josephson Junctions for Voltage Metrology and Single Photon Detectors for sensitive light detection. A second system with magnetron sputtering and e-beam evaporation capabilities has been built with the goal of sensitive magnetic field sensors, pressure sensors and bio-detection. Chemical Vapor Deposition systems are being installed for 1-diamond manufacturing for color-center engineered magnetic field and pressure sensors; 2-SiN and SiOx manufacturing for single-electron transistors for current metrology.

Two dilution refrigerators were installed for Quantum Hall and other Quantum measurements.

Projects on microwave characterization has been completed: EMPIR 20FUN07 SuperQuant and EMPIR 20IND03 FutureCom. Both involved microwave characterization at low temperatures (the former at mK temperatures) and analysis of aging on microwave properties.

Projects on resistance metrology: 20FUN03 COMET and 20FUN06 MEMQuD were completed.

A new partnership project, QuAHMET (Quantum Anomalous Hall Effect Materials and Devices for Metrology), began in June 2024. As part of this project, TÜBİTAK UME will characterize new type of materials for resistance metrology, specifically magnetic topological insulators that display Quantum

Anomalous Hall Effect. UME will perform CCC measurements on the devices made from these materials and elaborate on further use of these materials for resistance metrology.

A EUREKA project on diamond color center engineering has been accepted. A bilateral project on magnetic tunnel junction based field sensors with JAPAN Institute for Materials Science has started.

Digitalization Working Group (Contact: erkan.danaci@tubitak.gov.tr)

TÜBİTAK UME Digital Working Group's (DWG) was created in 2023. A pilot digitalization project named Digital Metrology Pilot Project (DMPP) was determined to be one of DWG's activities. Objectives, strategies, and the anticipated impact of the DMPP over the next five years were determined in 2023 by DWG.

The objectives of the TÜBİTAK UME DMPP are determined as given below:

- Transferring Metrological Scientific Outputs to Digital Media (Objective 1),
- Creating the Digital Calibration Certificate (DCC) and Digital Test Reports (DTR) and Sharing them on a digital platform (Objective 2),
- Creating smart Calibration Systems with Digital Measurement Device Twins (Objective 3).

The TÜBİTAK UME DMPP signifies a crucial step towards modernizing metrology practices in Türkiye. With a roadmap, well-defined objectives, and the collaborative efforts of the DWG, the pilot project is ready to bring about a positive transformation in the precision and efficiency of metrological areas.

TÜBİTAK UME joined to digital related R&D projects such as EPM 22DIT01 ViDiT “Trustworthy virtual experiments and digital twins”, EPM 22RPT04 RFMicrowave II “Development on microwave infrastructure II”, and EURAMET TC-IM Project 1448 “Development of digital calibration certificates” in 2023 and 2024.

The first DCC-creating activities were started on scattering parameter calibrations at the RF and Microwave Laboratory in 2024.

TÜBİTAK UME started to announce the first manifestos on the establishment of Türkiye's Digital Quality Infrastructure in 2024.

PARTICIPATION of TÜBİTAK UME in ILCs/PTs

Type of ILC/PT	Field/subfield	Pilot lab or provider of ILC/PT	Identification of ILC/PT	Parameters/ range of measurements	Status	Evaluation criterion	Result
EURAMET supplementary comparison	EM/Resistance	RISE	EURAMET.EM-S47	DC resistance: 2 GΩ Voltage: up to 200 kV	Draft A report in progress	degrees of equivalence	-
GULFMET key comparison	EM/Resistance	EMI	GULFMET.EM-K2	Resistance: 10 MΩ and 1 GΩ	Measurements in progress	degrees of equivalence	
EURAMET key comparison	EM/AC Power	VSL	EURAMET.EM-K5.2018	AC power: 120 V & 240 V, 5 A, 53 Hz, PF: 0 - 1	Draft A report in progress	degrees of equivalence	-
Multilateral ILC	EM/High voltage and current	TÜBİTAK UME	COOMET Project 859/TR/22	Primary current: 10 A, 50 A, 100 A, 500 A, 1500 A Secondary current: 5 A Frequency: 50 Hz	Measurements in progress	degrees of equivalence	-
EURAMET supplementary comparison	EM/High voltage and current: Lightning impulse voltage	RISE	EURAMET.EM-S36	Apparent charge and rise time of internal step voltage pulse	Draft B report	degrees of equivalence	CMCs supported (New/modified CMCs will be submitted)
EURAMET supplementary comparison	EM/High voltage and current	RISE	EURAMET.EM-S46	High Voltage DC Ratio: 20000	Draft A report in progress	degrees of equivalence	-
CIPM key comparison	EM/Radio frequencies	NIM	CCEM.RF-K28.W	RF power from 18 GHz to 26.5 GHz in rectangular waveguide	Draft A report in progress	degrees of equivalence	-
CIPM key comparison	EM/Radio frequencies	METAS	CCEM.RF-K5.d.C	Scattering parameters in 2.4 mm coaxial line (9 kHz - 50 GHz)	Measurements in progress	degrees of equivalence	-

Type of ILC/PT	Field/subfield	Pilot lab or provider of ILC/PT	Identification of ILC/PT	Parameters/ range of measurements	Status	Evaluation criterion	Result
CIPM key comparison	EM/Radio frequencies	NMIJ	CCEM.RF-K5.c.CL	Scattering Coefficients 100 MHz – 33 GHz 3.5 mm connector	Draft B Report circulated	degrees of equivalence	Passed
CIPM key comparison	EM/Radio frequencies	NMIJ	CCEM.RF-K26	Attenuation at 18 GHz, 26.5 GHz and 40 GHz using a step attenuator	Approved for equivalence	degrees of equivalence	Passed (New CMCs will be submitted)
EURAMET supplementary comparison	EM/Radio frequencies	TÜBİTAK UME	EURAMET.EM.RF-S46 (EURAMET Project 1538)	Correction Factor (dB): 53 Hz, 400 Hz, 10 kHz, 100 kHz, 300 kHz, 500 kHz, 5 MHz, 10 MHz, 20 MHz, 30 MHz	Approved	degrees of equivalence	Passed
Bilateral ILC	EM/Radio frequencies	TÜBİTAK UME	22RPT04 RFMicrowave2 project	Antenna Factor 30 MHz – 1 GHz	Draft A Report in progress	degrees of equivalence	-
Multilateral ILC	EM/Radio frequencies	RISE	22RPT04 RFMicrowave2 project	Antenna Factor 1 GHz – 40 GHz	Draft A Report in progress	degrees of equivalence	-
Multilateral ILC	EM/Radio frequencies	RISE	22RPT04 RFMicrowave2 project	Antenna Factor 9 kHz – 30 MHz	Draft A Report in progress	degrees of equivalence	-
Multilateral ILC	EM/Radio frequencies	TÜBİTAK UME	EURAMET Project 1512	Effective Efficiency Frequency range: 10 MHz to 18 GHz	Draft B report	degree of equivalence	Passed
Bilateral ILC	EM/Radio frequencies	TÜBİTAK UME	TÜBİTAK UME, CSIR NPLI	Calibration Factor up to 18 GHz, Coaxial	Draft B report in progress	degrees of equivalence	-

SCI PAPERS AND PROCEEDINGS:

Voltage

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High Voltage

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RF & Microwave

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