TÜBİTAK

UME

17RPT03 DIG-AC

WP2: Task 2.2: Integration of scaling, digital techniques and quantum standards

Activity A2.2.6 : Evaluating Dividers' Performances Suitable to be Used for Waveform Scaling

19/05/2022

Madrid, Spain

Divider Requirements

High quality voltage scaling devices, which are:

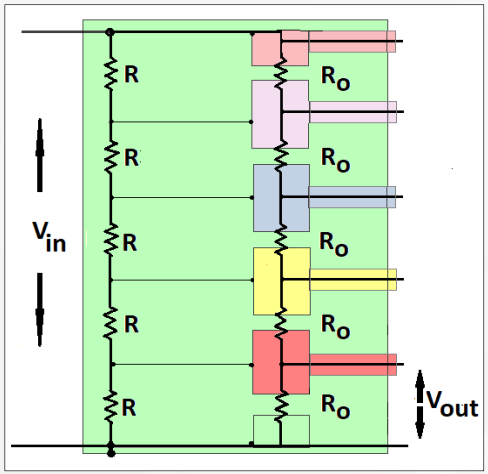
- Wide band,
- Linear
- Time invariant,
- Insensitive to environment conditions
- Low level dependant,

Traceability
Low Ratio measurement uncertainty
Behaviour under dynamic signals

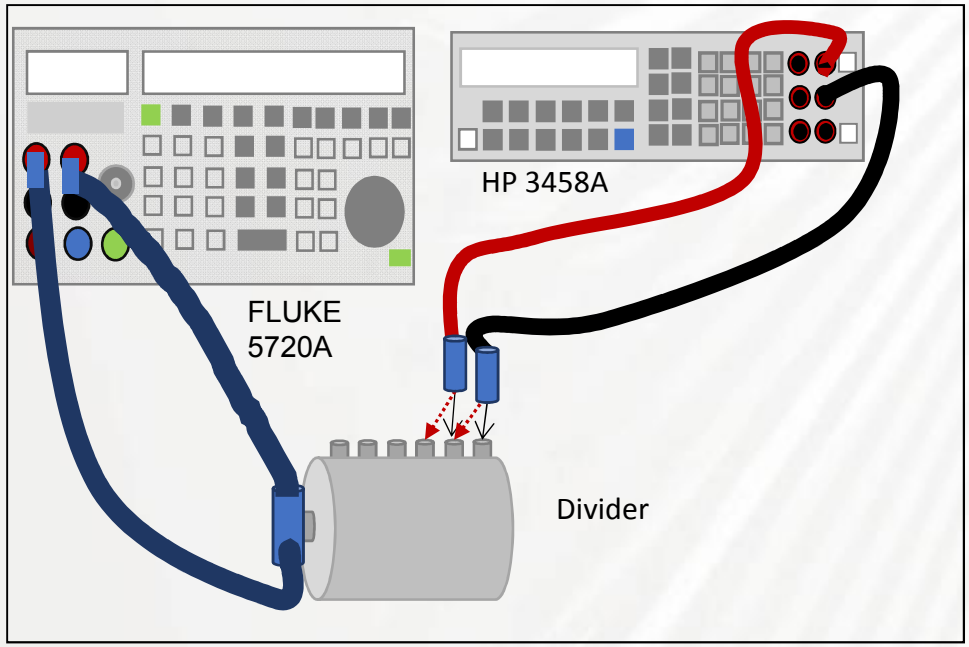
Types of Dividers for Voltage Scaling

- Voltage dividers for DC Voltage Scaling
  - Absolute Divider
  - Hamon divider
  - Low thermal voltage dividers
  - Kelvin Varley Voltage divider
- Voltage dividers for AC Voltage Scaling
  - Range resistor & cage AC-DC current shunts
  - Set of Dividers for Power Metrology
  - Inductive Voltage Dividers
  - New Type of Dividers

Dividers Suitable for Voltage Scaling at Accuracy of the Stability

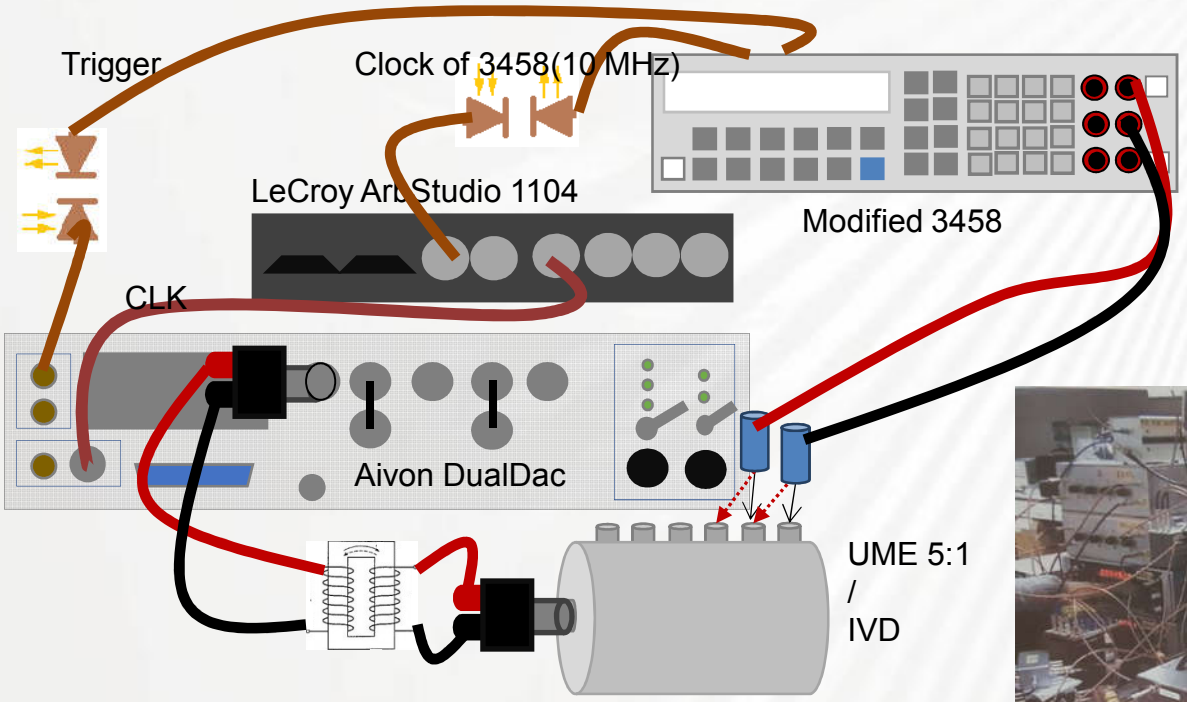


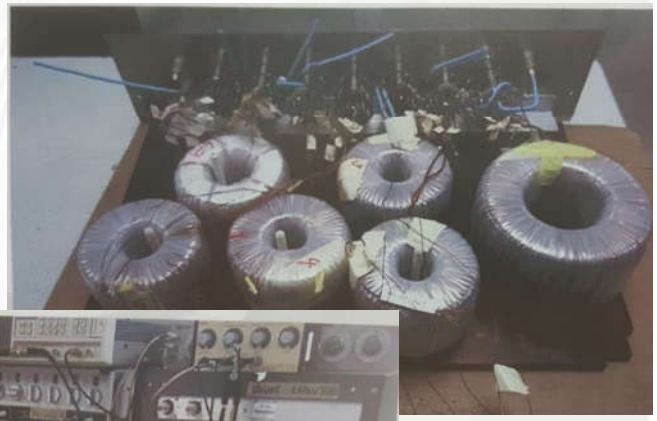
$$\frac{V_{in}}{V_{out}} = \frac{\sum_{i=1}^{N} V_i^{R_o}}{V_1^{R_o}}$$



Dividers Suitable for Voltage Scaling at Accuracy of the Stability Setup for Measuring Dynamic Ratio

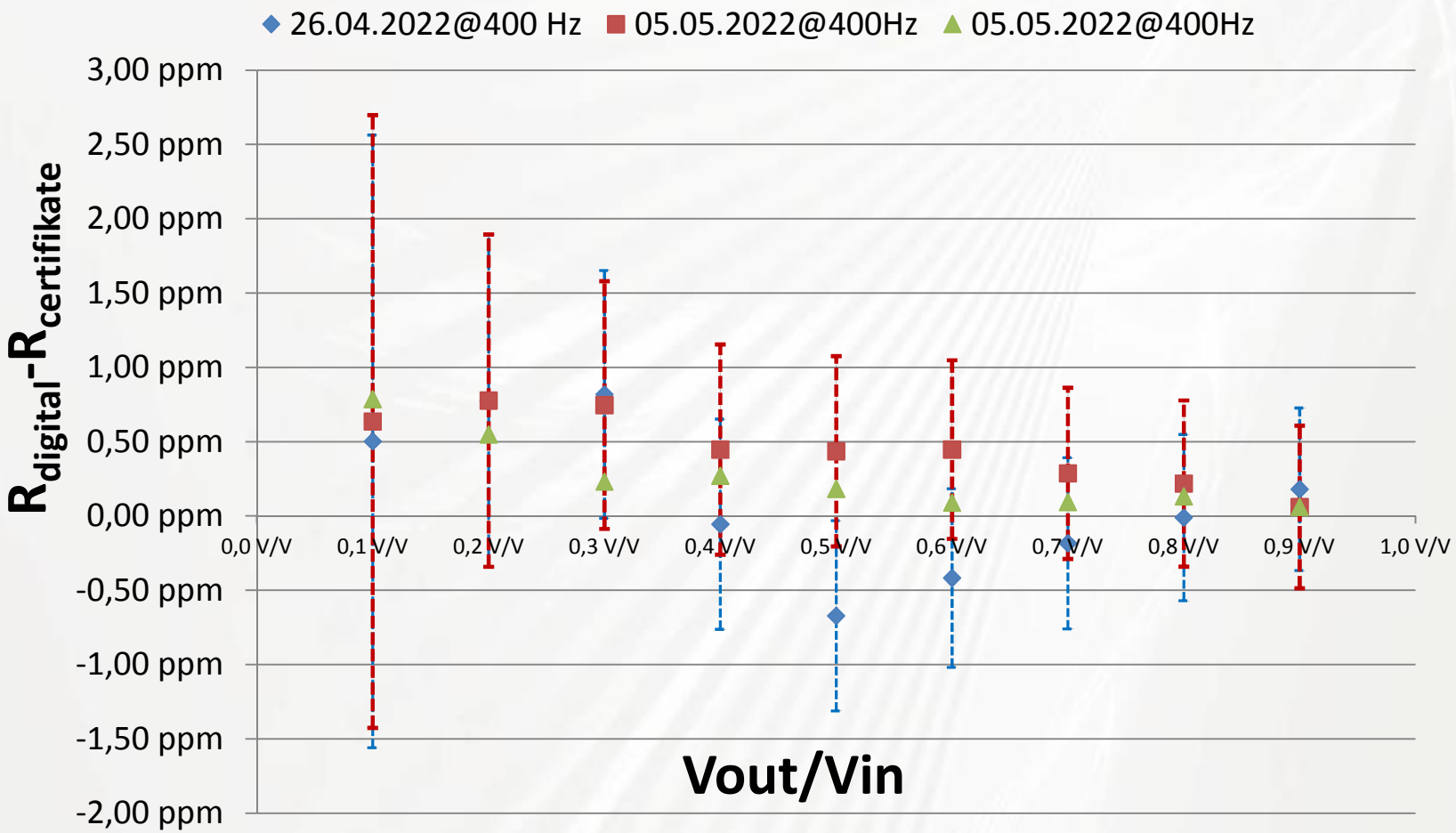
$$\frac{V_{in}}{V_{out}} = \frac{\sum_{i=1}^{N} V_i^{R_o}}{V_1^{R_o}}$$





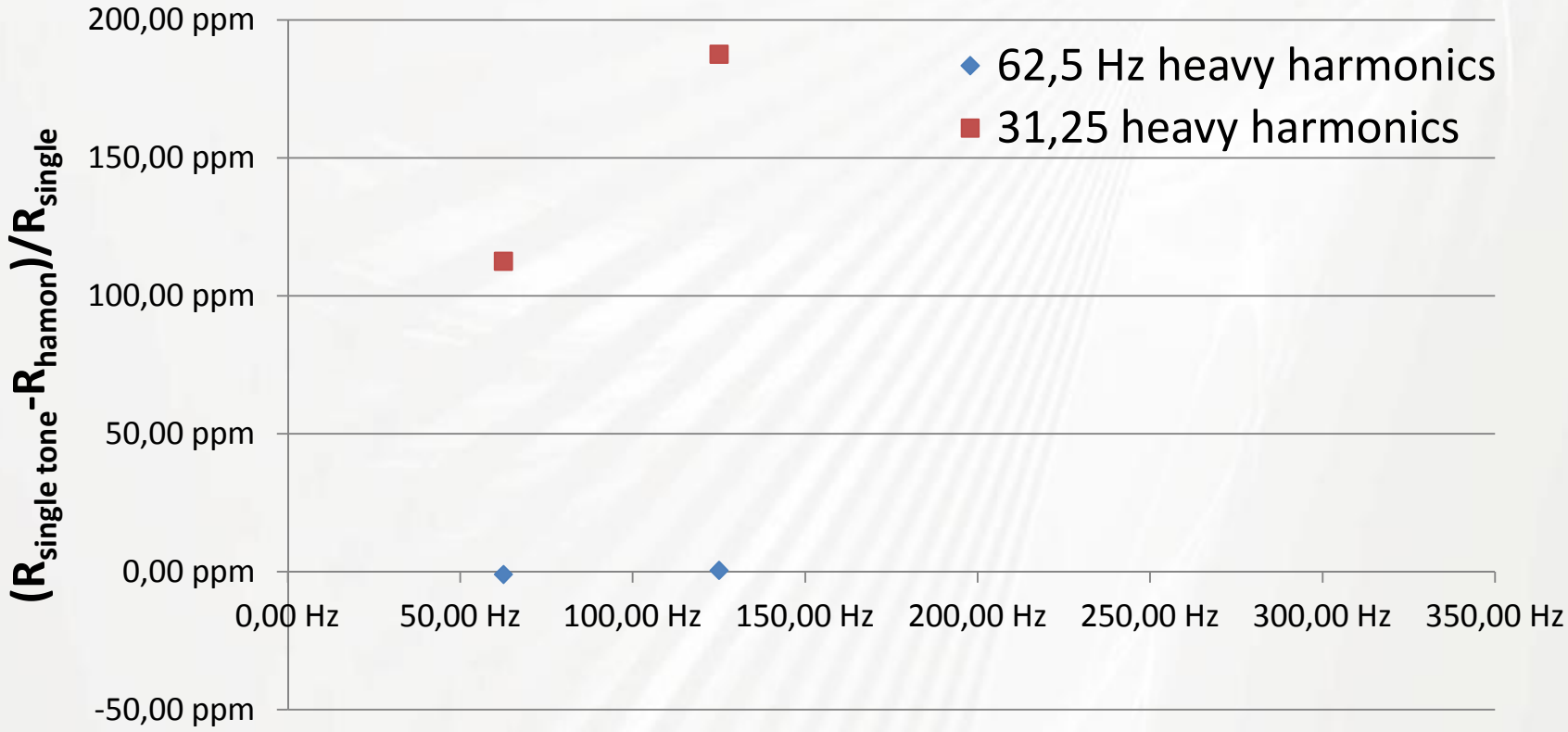
Calibrating Inductive Voltage Divider Using a Digital Method

Uncertainty bars are digital calibration's type A uncertainty combined with uncertainty declared in IVD's certificate according to classical methods

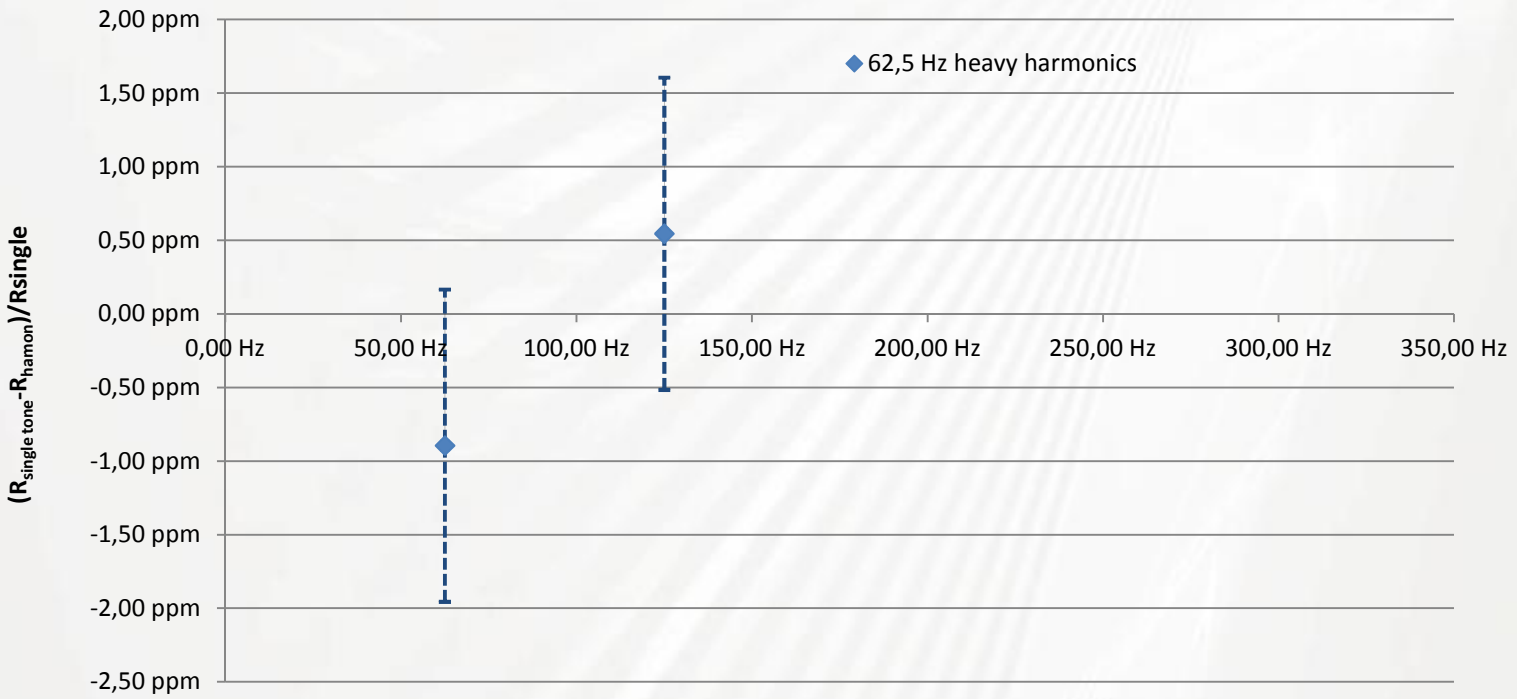


Comparison of ratios measured under single tone and heavy harmonics voltages

Harmonics are five times of the fundamental frequency with equal amplitudes



- If the voltage of the harmonic content is less than **saturation coefficient multiplied by the frequency** IVD Ratio may be constant under multi harmonics

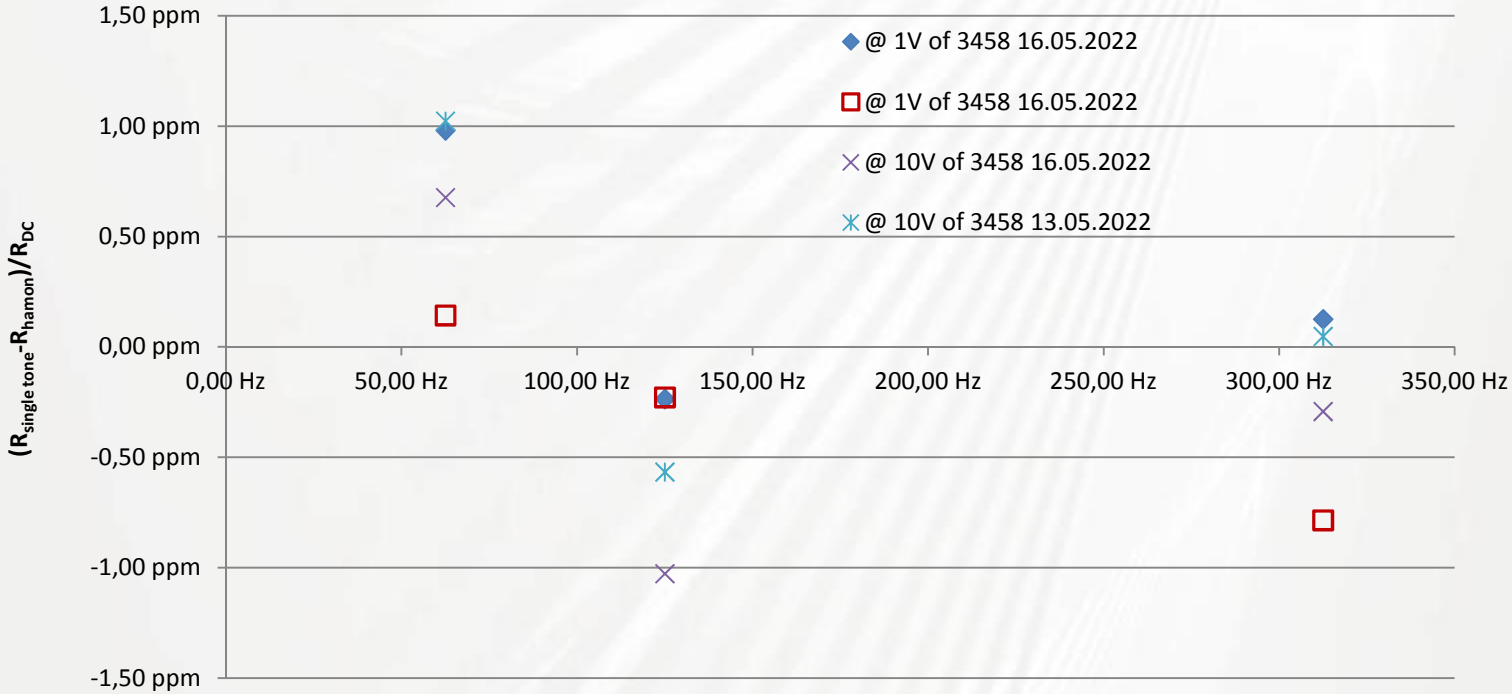


Calibrating Resistive Voltage Divider Using a Digital Method

Comparison with sampling wattmeter

R_{DSWM}-$R_{VOLTAGE}$ (@62.5 Hz ;5V)	$U(R_{DSWM})$ (@62.5 Hz ;5V)	$U(R_{VOLTAGE})$ (@62.5 Hz ;5V)	D	En
-0,40 ppm	2,00 ppm	0,50 ppm	2,06 ppm	-0,2

Comparison of ratios measured under single tone and heavy harmonics voltages



Divider Summary for Voltage Metrology

Divider Summary for Voltage Metrology	**Wide band?** (AC-DC difference<50 ppm @(0 Hz – 1kHz))	**Time invariant?**	**Insensitive to environment conditions ?**	**Have low level dependence ?**	**Traceability**	**Estimated Ratio Uncertainty** (0 Hz-400 Hz @ 100 V)
Absolute Divider	No	Yes	Yes	Yes	Self calibration	<0.5 µV/V
Hamon resistance	No	Yes	Yes	Yes	Self calibration	<0.5 µV/V
Kelvin Varley	No	Yes	Yes	No	Self calibration	2.5 µV/V-0.25 µV/V
Range resistor & AC-DC current shunts	Yes	No	No (47 ppm/°C)	Yes	Sampling voltmeter calibration + step-up / DC+AC-DC tranester &Step-up	> 47 µV/V
Set of Dividers for Power Metrology	Yes	Yes	Yes	Yes	Sampling voltmeter calibration+Step-up	2 µV/V-6 µV/V
Inductive Voltage Dividers	No (not suitable @DC and low frequencies)	Yes	Yes	Yes	Self calibration	<0.75 µV/V
UME 5:1 (50 V/10V)	Yes (<50 ppm @ 20 kHz)	Yes	Yes	Yes	Self calibration	<0.75 µV/V
UME 10:1 (100 V/10V)	Yes (<50 ppm @ 5 kHz)	Yes	Yes	Yes	Step-up	3.5 µV/V
UME 100:1 (400 V/4V)	No (<50 ppm @ 400 Hz)	Yes	Yes	Yes	Step-up	4.5 µV/V
UME 101:1 (190 V / 1.88 V)	Yes (<50 ppm @ 100 kHz)	Yes	Yes	Yes	Step-up	4.5 µV/V

- **Suggestion for a Setup for Primary AC Voltage Calibration Enabling Voltage Divider**

- The new dissemination road for AC sources can be accomplished by maintaining a stable digital AC source and AC ratio device similar as in DC voltage metrology.

- New stable digital AC sources are emerging and they are suitable for direct calibration to quantum standards

- The differential measurement setup will be suitable for reducing loading errors of ratio device and digital AC source. Many measurements in various voltage and frequency pairs are necessary to investigate the ranges and their corresponding uncertainty of this traceability road.
- Many measurements and setups should be tried

Thank you for your attention!

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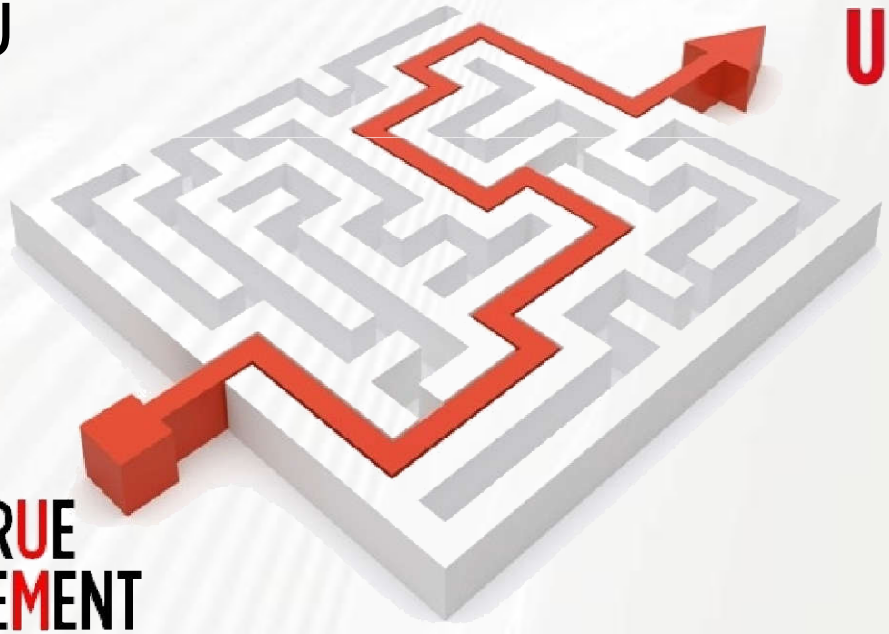
Naylan KANATOĞLU



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MEASUREMENT
EXCELLENCE