The primary measurement standard of ultrasonic power and radiation conductance at Inmetro

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Introduction

IEC 61161:2013 establishes methods to determine the ultrasonic power based on the measurement of the radiation force using a gravimetric balance

"A primary measurement set-up" means:

a measurement set-up that has taken part in an international key-comparison or another international comparison, organized by the CIPM/BIPM

The Laboratory of Ultrasound of Inmetro (Labus/Inmetro) took part of the key comparison CCAUV.U-K3.1

Introduction

Although the ultrasound power is the measurand of the key comparison, the CCAUV.U-K3.1 participants were asked to report the radiation conductance (*G*)

$$G = \frac{P}{V^2}$$

The goal

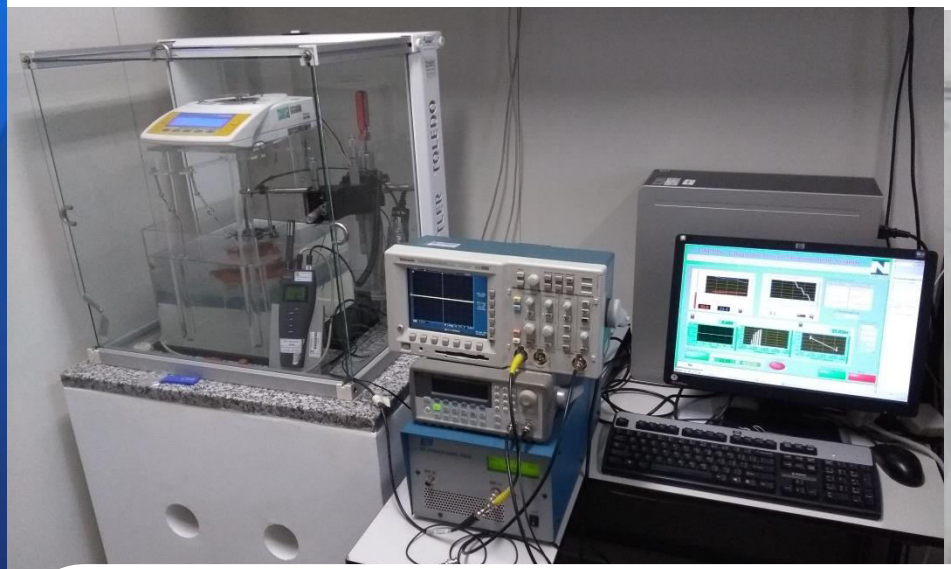
to show the capability to determine *G* of an ultrasonic transducer by measuring the total time-averaged ultrasonic power emitted for an applied RMS voltage

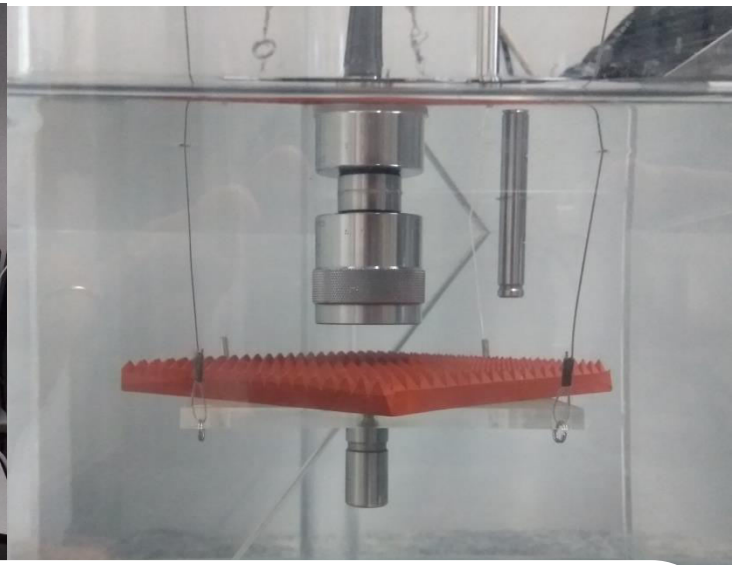
Labus/inmetro has also measured a own set of ultrasonic transducers in order to have reference measurement standards to perform periodic evaluation of the measurement system

Objective

This work presents the result of a new complete set of radiation conductance measurements, performed with the Labus/Inmetro standard transducers set, which were compared with the results that had previously been achieved at the time of the key comparison CCAUV.U-K3.1

Material and Methods





Radiation force balance based on an absorber target

- Reservoir containing distilled and deionized water
- Calibrated analytical balance model CP224S (Sartorius, Germany)
- 5 degrees of freedom positioning system (Newport Corporation, USA)
- Support for the absorbing target
- Dissolved oxygen meter model XL40 (Accumet Instruments, Singapore)
- Thermo-hygrometer model Hygropalm 3 (Rotronic, Switzerland)
- Waveform generator 33250A (Agilent, USA)
- Oscilloscope TDS 3032B (Tektronix, USA)
- Power amplifier E&I (USA)

Material and Methods

Standard transducers (Panametrics, Olympus-NDT, USA) nominal diameter of 12.7 mm

- 1 MHz (model A303S); 2.25 MHz (model V306); 5 MHz (model V309); 7.5 MHz (model A320S); 10 MHz (model V311); 15 MHz (model A319S)

Temporal average output power (P) was measured (in watt) using the primary system radiation power measuring Labus/Inmetro according to IEC 61161:2013

Transducers were excited with sine waves in a continuous mode

Input voltage (V) was measured at the end of the transducer cable with the oscilloscope (measured in RMS volts)

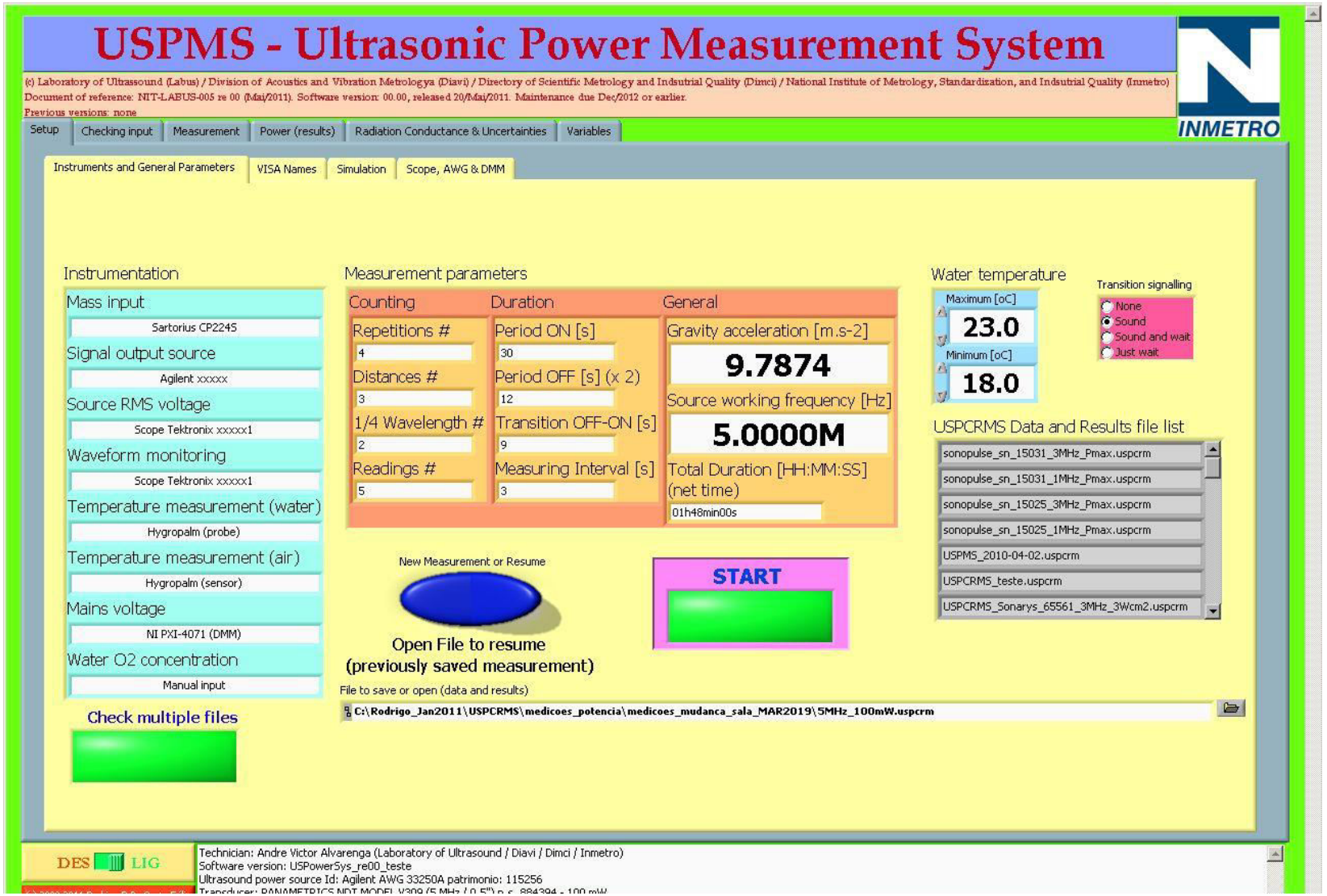
Measurements were taken at three different distances between the absorber target and the face of the transducer

For each distance, ¼ wavelength offset measurements were taken

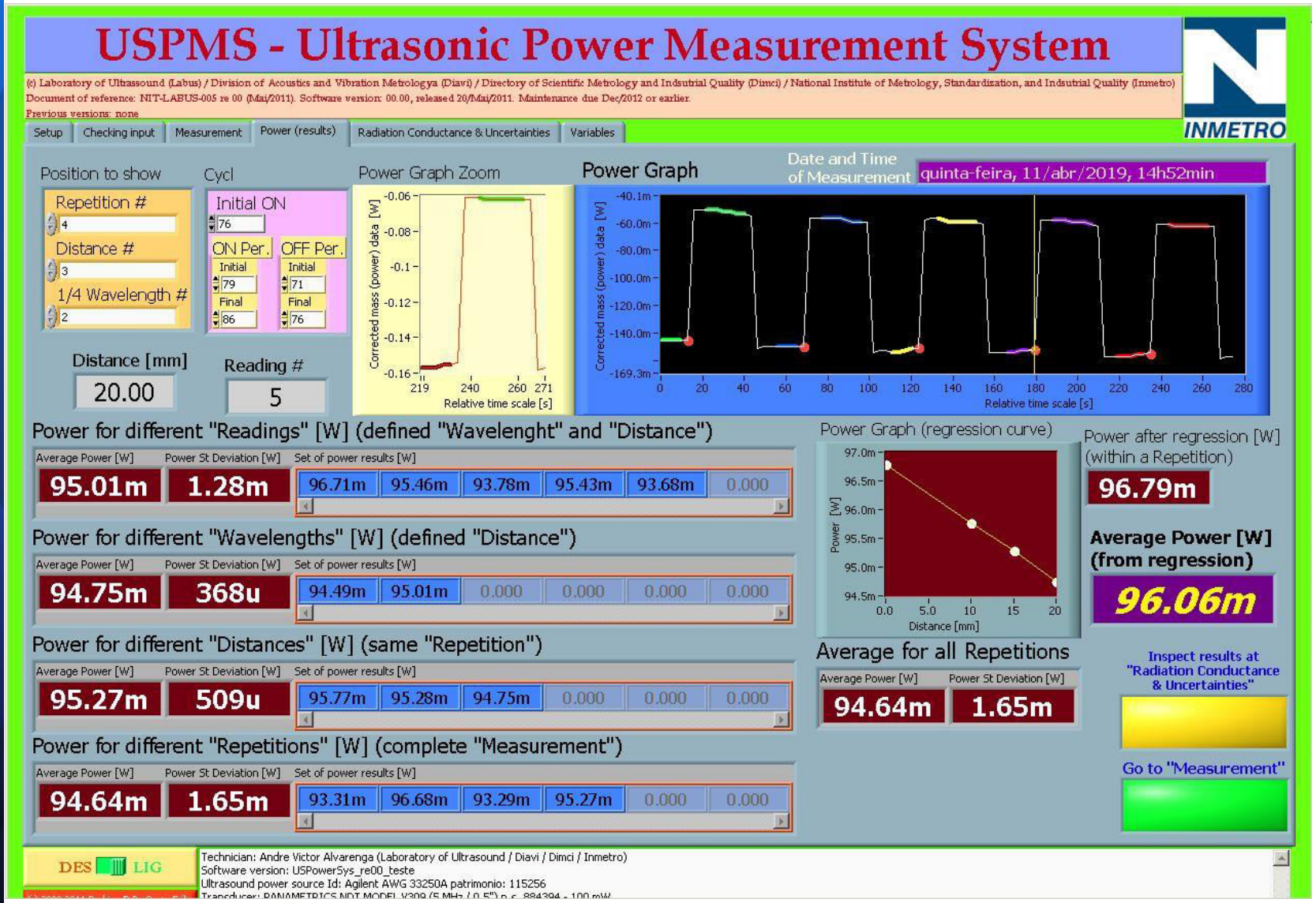
The final ultrasonic power was determined as the extrapolated power value for the zero distance between the target and the face of the transducer

The whole procedure was repeated 4 times

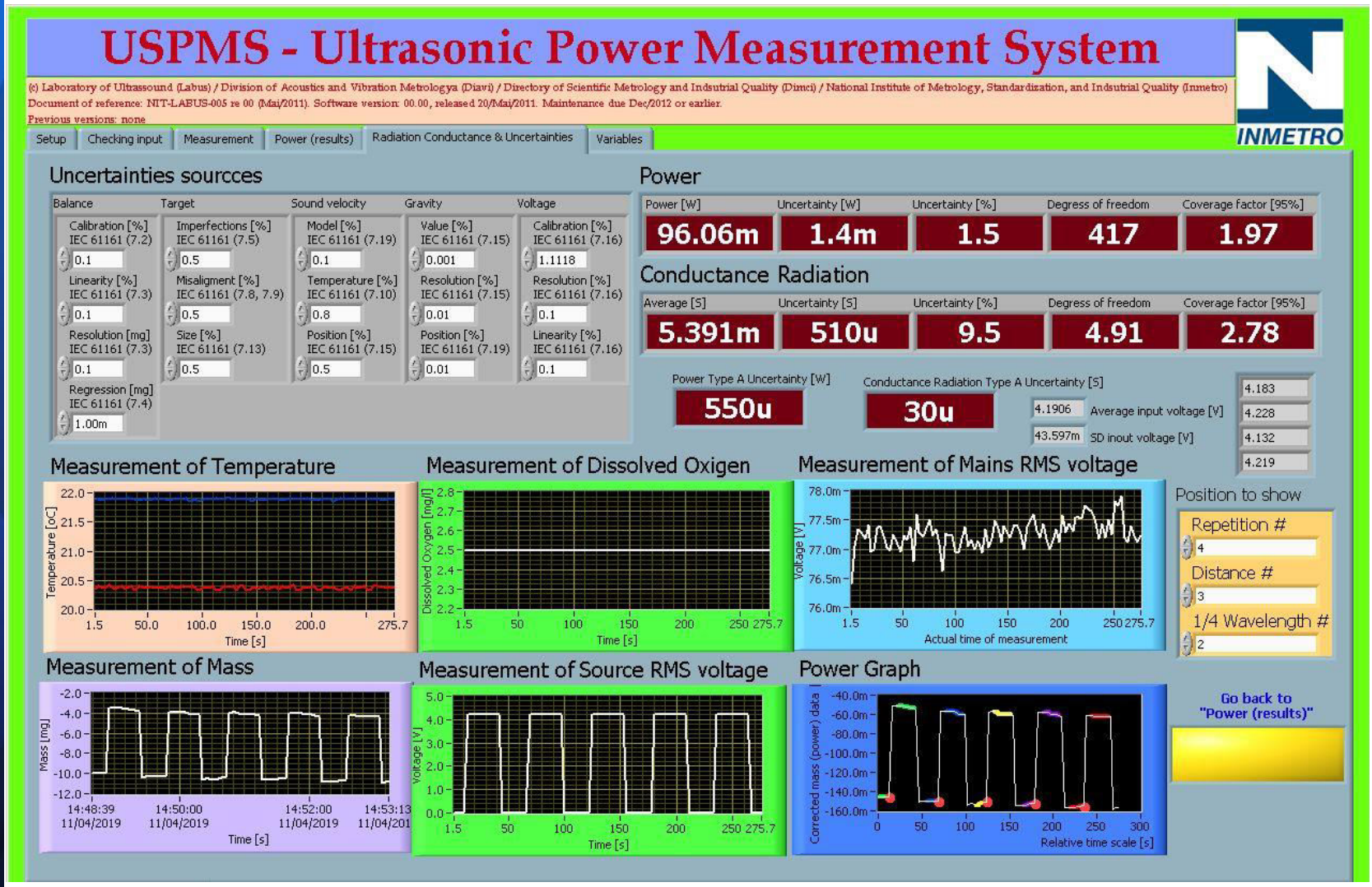
Measurement software



Measurement software



Measurement uncertainty



Results

Serial number	Frequency [MHz]	DEC/2014				APR/2019				EN
		Vin [V]	P [mW]	G [mS]	U [mS]	Vin [V]	P [mW]	G [mS]	U [mS]	
851953	1	3.57	9.27	0.727	0.046	3.50	8.99	0.733	0.083	0.06
		11.38	99.82	0.771	0.016	11.04	93.82	0.770	0.030	0.01
		35.90	1006.00	0.781	0.0058	25.65	514.70	0.782	0.027	0.06

Serial number	Frequency [MHz]	DEC/2014				APR/2019				EN
		Vin [V]	P [mW]	G [mS]	U [mS]	Vin [V]	P [mW]	G [mS]	U [mS]	
536444	2	4.40	10.99	0.568	0.058	4.29	10.84	0.588	0.057	0.24
		13.69	110.30	0.589	0.024	13.23	105.20	0.601	0.021	0.39
		39.20	994.35	0.647	0.086	25.46	400.30	0.617	0.027	0.33

Serial number	Frequency [MHz]	DEC/2014				APR/2019				EN
		Vin [V]	P [mW]	G [mS]	U [mS]	Vin [V]	P [mW]	G [mS]	U [mS]	
884394	5	1.27	8.86	5.47	0.30	1.26	8.61	5.46	0.61	0.02
		4.25	99.60	5.51	0.16	4.19	96.06	5.47	0.20	0.17
		9.23	464.50	5.452	0.088	9.20	462.30	5.46	0.15	0.07

Results

Serial number	Frequency [MHz]	DEC/2014				APR/2019				EN
		Vin [V]	P [mW]	G [mS]	U [mS]	Vin [V]	P [mW]	G [mS]	U [mS]	
535099	7	2.36	9.90	1.77	0.20	2.24	8.66	1.72	0.22	0.17
		7.37	97.48	1.794	0.056	7.31	96.51	1.808	0.054	0.18
857470	10	1.61	10.45	4.05	0.54	1.50	8.25	3.69	0.46	0.52
		4.88	91.73	3.86	0.19	4.64	81.15	3.76	0.23	0.32
540390	15	7.64	107.25	**1.84**	0.11	7.48	67.80	**1.21**	0.048	**5.05**

Conclusion

Based on the normalized error values, one can conclude:

- The power measurement system in Labus/Inmetro continues to provide results statistically comparable to those obtained when the system was implemented at the time of participation in CCAUV key comparison
- The dissonant result is that obtained with the 15 MHz transducer, which showed a significant reduction of its radiation conductance value
- Further tests have shown that 15 MHz-transducer has lost sensitivity, and it is not a reliable standard transducer.

NOSSA MISSÃO

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