



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

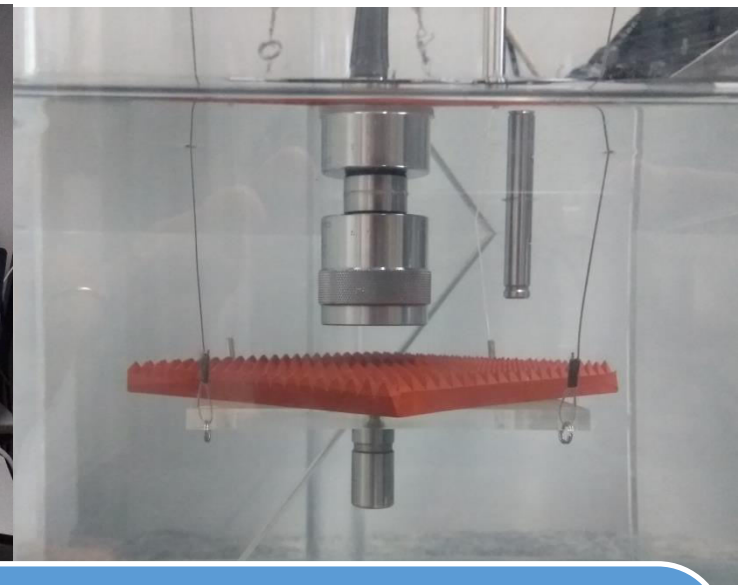
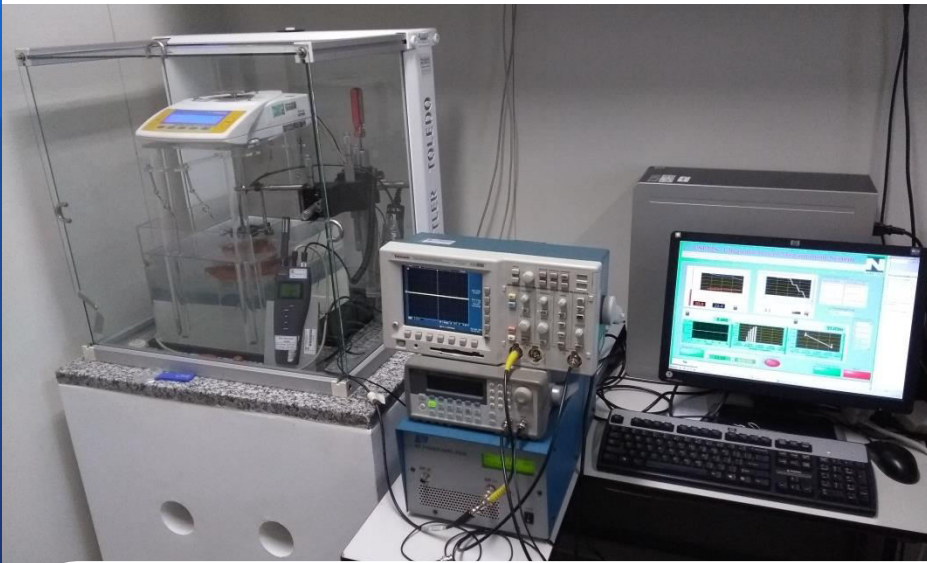
to show the capability to determine G of an ultrasonic transducer by measuring the total time-averaged ultrasonic power emitted for an applied RMS voltage

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, $\frac{1}{4}$ 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

USPMS - Ultrasonic Power Measurement System

(c) Laboratory of Ultrasound (Labus) / Division of Acoustics and Vibration Metrology (Diavi) / Directory of Scientific Metrology and Industrial Quality (Dimci) / National Institute of Metrology, Standardization, and Industrial Quality (Inmetro)
 Document of reference: NIT-LABUS-005 re 00 (Mai/2011). Software version: 00.00, released 20/Mai/2011. Maintenance due Dec/2012 or earlier.
 Previous versions: none

Setup
Checking input
Measurement
Power (results)
Radiation Conductance & Uncertainties
Variables

Instruments and General Parameters
VISA Names
Simulation
Scope, AWG & DMM

Instrumentation

Mass input
Sartorius CP2245

Signal output source
Agilent xxxxx

Source RMS voltage
Scope Tektronix xxxxx1

Waveform monitoring
Scope Tektronix xxxxx1

Temperature measurement (water)
Hygropalm (probe)

Temperature measurement (air)
Hygropalm (sensor)

Mains voltage
NI PXI-4071 (DMM)


Water O2 concentration
Manual input

Check multiple files

Measurement parameters

Counting	Duration	General
Repetitions # 4	Period ON [s] 30	Gravity acceleration [m.s ⁻²] 9.7874
Distances # 3	Period OFF [s] (x 2) 12	
1/4 Wavelength # 2	Transition OFF-ON [s] 9	Source working frequency [Hz] 5.0000M
Readings # 5	Measuring Interval [s] 3	Total Duration [HH:MM:SS] (net time) 01h48min00s

New Measurement or Resume



Open File to resume
(previously saved measurement)

File to save or open (data and results)

Water temperature

Maximum [oC]
23.0

Minimum [oC]
18.0

Transition signalling

None


Sound

Sound and wait

Just wait

USPCRMS Data and Results file list

- sonopulse_sn_15031_3MHz_Pmax.uspcrm
- sonopulse_sn_15031_1MHz_Pmax.uspcrm
- sonopulse_sn_15025_3MHz_Pmax.uspcrm
- sonopulse_sn_15025_1MHz_Pmax.uspcrm
- USPMS_2010-04-02.uspcrm
- USPCRMS_teste.uspcrm
- USPCRMS_Sonarys_65561_3MHz_3Wcm2.uspcrm



START

DES LIG

Technician: Andre Victor Alvarenga (Laboratory of Ultrasound / Diavi / Dimci / Inmetro)
 Software version: USPowerSys_re00_teste
 Ultrasound power source Id: Agilent AWG 33250A patrimonio: 115256
 Transducer: PANAMETRICS MPT MODEL V300 (5 MHz / 0.5") n.º 884304 - 100 mW

USPMS - Ultrasonic Power Measurement System

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Setup | Checking input | Measurement | Power (results) | Radiation Conductance & Uncertainties | Variables

Position to show

Repetition #
4

Distance #
3

1/4 Wavelength #
2

Cycl

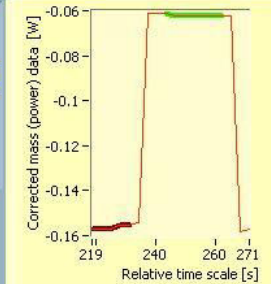
Initial ON
76

ON Per. OFF Per.

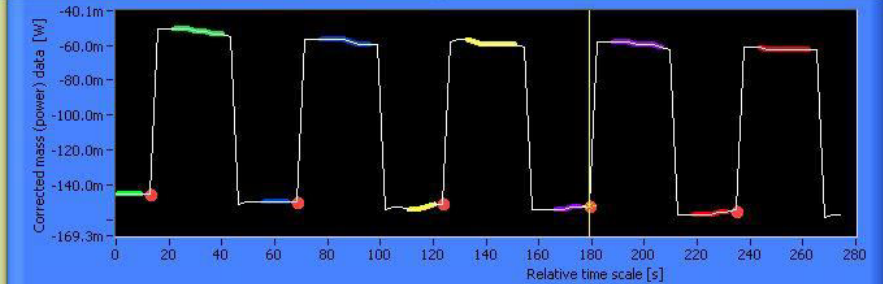
Initial Final
79 71

Final Final
86 76

Power Graph Zoom



Power Graph



Date and Time of Measurement quinta-feira, 11/abr/2019, 14h52min

Distance [mm]

20.00

Reading #

5

Power for different "Readings" [W] (defined "Wavelength" and "Distance")

Average Power [W]	Power St Deviation [W]	Set of power results [W]					
95.01m	1.28m	96.71m	95.46m	93.78m	95.43m	93.68m	0.000

Power for different "Wavelengths" [W] (defined "Distance")

Average Power [W]	Power St Deviation [W]	Set of power results [W]					
94.75m	368u	94.49m	95.01m	0.000	0.000	0.000	0.000

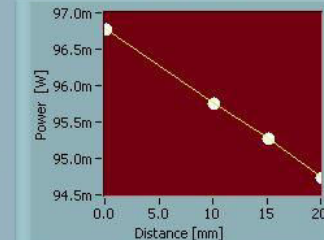
Power for different "Distances" [W] (same "Repetition")

Average Power [W]	Power St Deviation [W]	Set of power results [W]					
95.27m	509u	95.77m	95.28m	94.75m	0.000	0.000	0.000

Power for different "Repetitions" [W] (complete "Measurement")

Average Power [W]	Power St Deviation [W]	Set of power results [W]					
94.64m	1.65m	93.31m	96.68m	93.29m	95.27m	0.000	0.000

Power Graph (regression curve)



Power after regression [W] (within a Repetition)

96.79m

Average Power [W] (from regression)

96.06m

Average for all Repetitions

Average Power [W]	Power St Deviation [W]
94.64m	1.65m

Inspect results at "Radiation Conductance & Uncertainties"



Go to "Measurement"



DES  LIG

Technician: Andre Victor Alvarenga (Laboratory of Ultrasound / Diavi / Dimci / Inmetro)
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 Transducer: PANAMETRICS NDT MODEL V300 (5 MHz / 0.5") p.e. 884394 - 100 mW

Measurement uncertainty

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Setup | Checking input | Measurement | Power (results) | Radiation Conductance & Uncertainties | Variables

Uncertainties sources

Balance	Target	Sound velocity	Gravity	Voltage
Calibration [%] IEC 61161 (7.2) 0.1	Imperfections [%] IEC 61161 (7.5) 0.5	Model [%] IEC 61161 (7.19) 0.1	Value [%] IEC 61161 (7.15) 0.001	Calibration [%] IEC 61161 (7.16) 1.1118
Linearity [%] IEC 61161 (7.3) 0.1	Misalignment [%] IEC 61161 (7.8, 7.9) 0.5	Temperature [%] IEC 61161 (7.10) 0.8	Resolution [%] IEC 61161 (7.15) 0.01	Resolution [%] IEC 61161 (7.16) 0.1
Resolution [mg] IEC 61161 (7.3) 0.1	Size [%] IEC 61161 (7.13) 0.5	Position [%] IEC 61161 (7.15) 0.5	Position [%] IEC 61161 (7.19) 0.01	Linearity [%] IEC 61161 (7.16) 0.1
Regression [mg] IEC 61161 (7.4) 1.00m				

Power

Power [W]	Uncertainty [W]	Uncertainty [%]	Degree of freedom	Coverage factor [95%]
96.06m	1.4m	1.5	417	1.97

Conductance Radiation

Average [S]	Uncertainty [S]	Uncertainty [%]	Degree of freedom	Coverage factor [95%]
5.391m	510u	9.5	4.91	2.78

Power Type A Uncertainty [W]

550u

Conductance Radiation Type A Uncertainty [S]

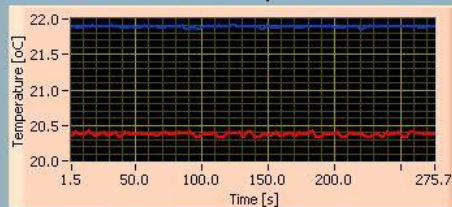
30u

4.1906 Average input voltage [V]

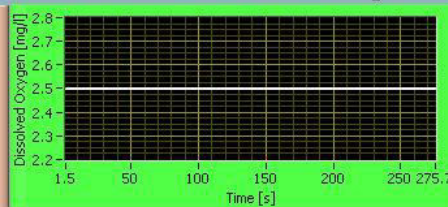
43.597m SD inout voltage [V]

4.183
4.228
4.132
4.219

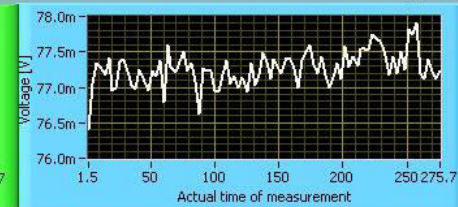
Measurement of Temperature



Measurement of Dissolved Oxygen



Measurement of Mains RMS voltage



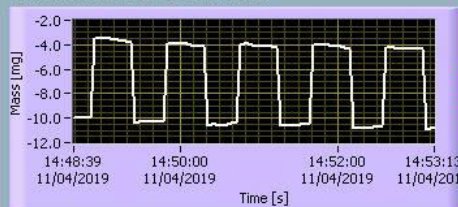
Position to show

Repetition #

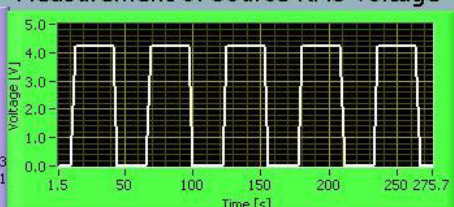
Distance #

1/4 Wavelength #

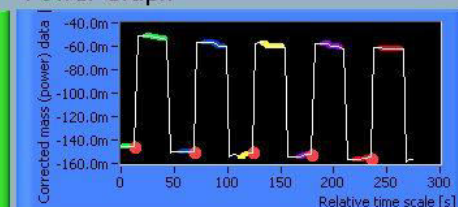
Measurement of Mass



Measurement of Source RMS voltage



Power Graph



Go back to "Power (results)"



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.

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AO SETOR PRODUTIVO.**



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