The EMPIR initiative is co-funded by the European Union's Horizon 2020 research and innovation programme and the EMPIR Participating States

TRACEABILITY CHAIN OF RF MEASUREMENTS

EMPIR 15RPT01 RFMICROWAVE

Dr. Erkan DANACI

TÜBİTAK UME

March, 2019
Turkey

Contents

SI and Derivated Units

RF Measurement Topics

Power Traceability Chain

Impedance Traceability Chain

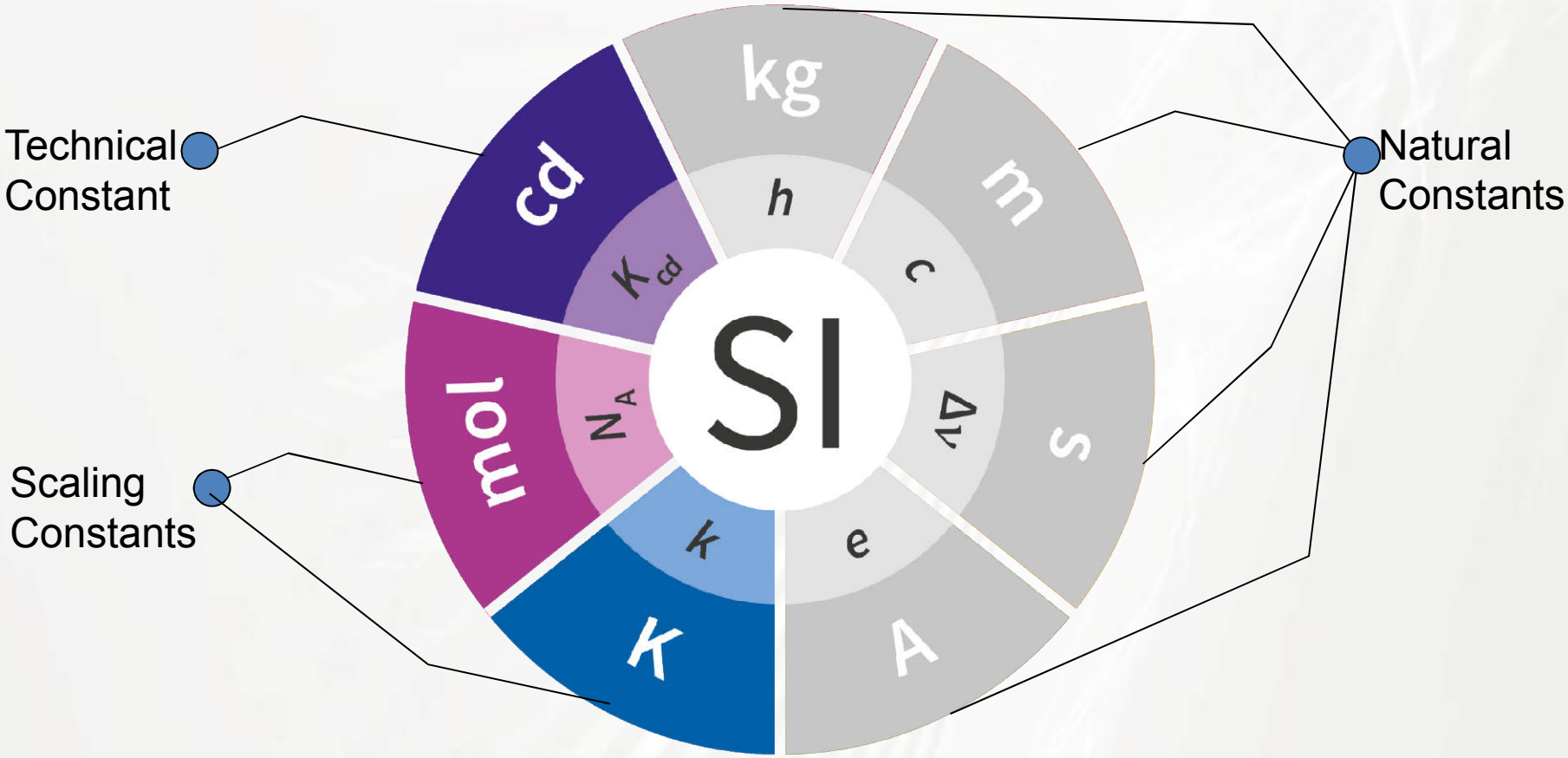
Attenuation Traceability Chain

Noise Traceability Chain

The Base Units of the SI

- Système International d'Unités (International System of Units)
- in 1960, SI Units were accepted in 11. CGPM
- 7 basic and so many derivated measurement quantities

SI Units


Technical Constant
Natural Constants
Scaling Constants
SI
kg
m
s
A
K
mol
cd
h
c
Δν
e
k
N_A
K_cd

Defining constants

second, $\Delta\nu_{Cs}$
- Constant of nature. But we could have chosen other atoms

metre, $\Delta\nu_{Cs}, c$
- *c* appears to be a universal and fundamental constant of nature

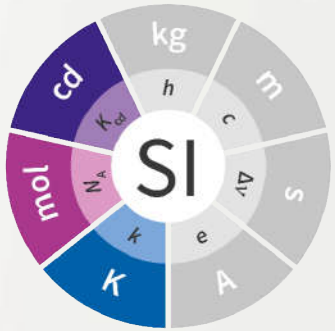
kilogram, $\Delta\nu_{Cs}, c, h$
- *h* appears to be a universal and fundamental constant of nature

ampere, $\Delta\nu_{Cs}, e$
- *e* appears to be a universal and fundamental constant of nature

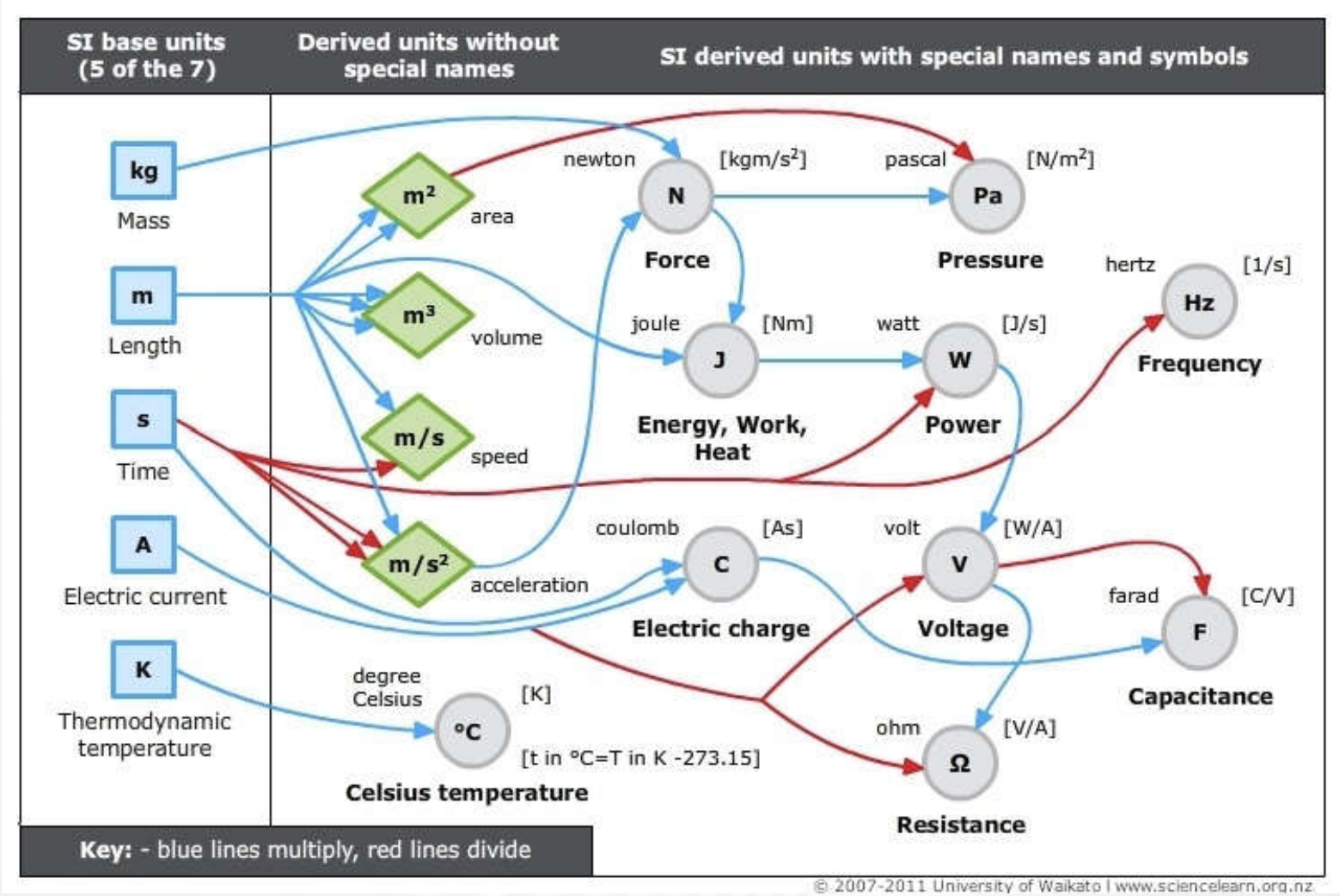
kelvin, k, $\Delta\nu_{Cs}, c, h$
- The Boltzmann, *k*, constant is a scaling constant

candela, $K_{cd}, \Delta\nu_{Cs}, h$
- The candela constant K_{cd} is a technical constant

mol, N_A
- The Avogadro constant N_A is a scaling constant

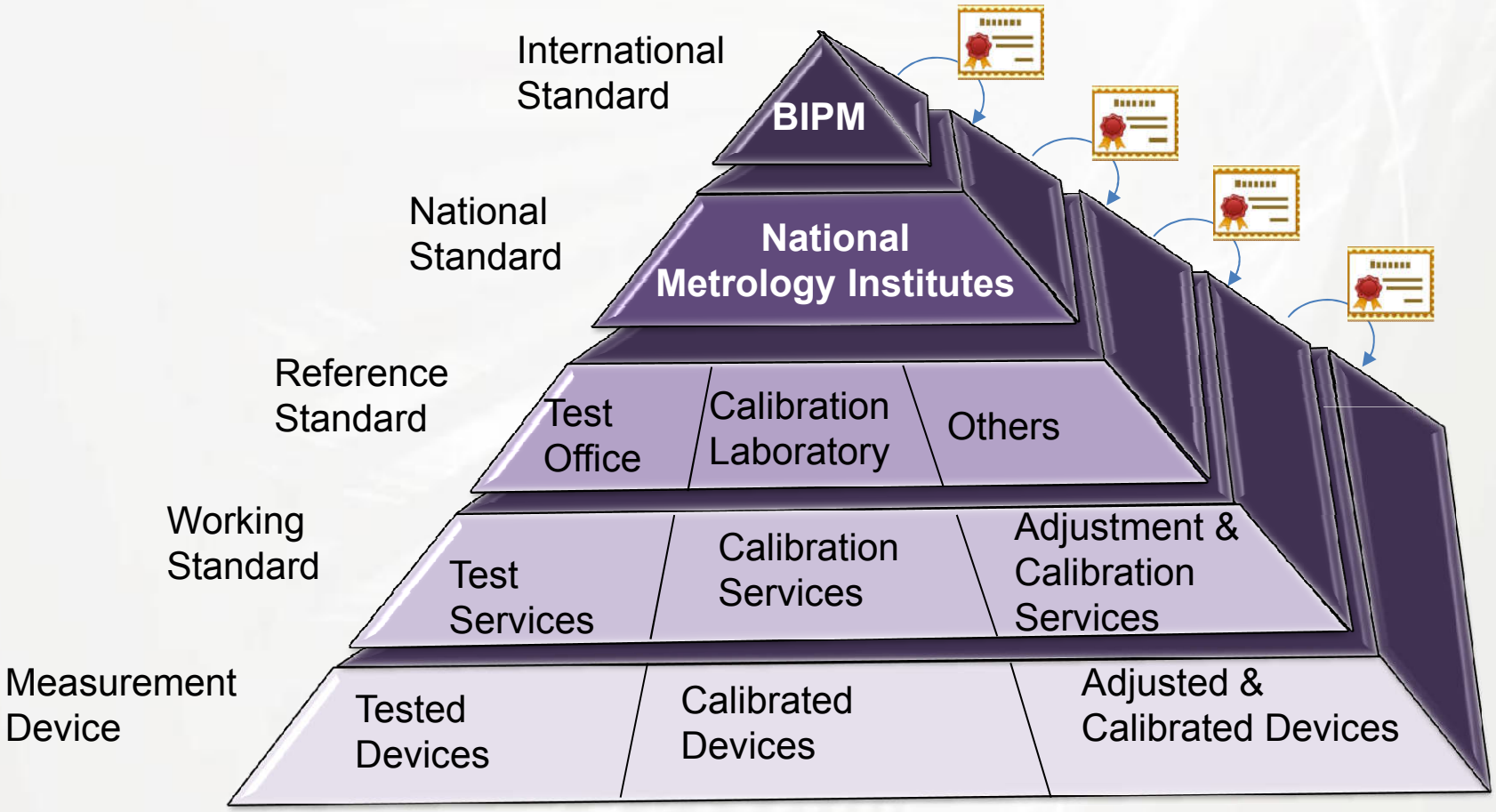


Derivated Units

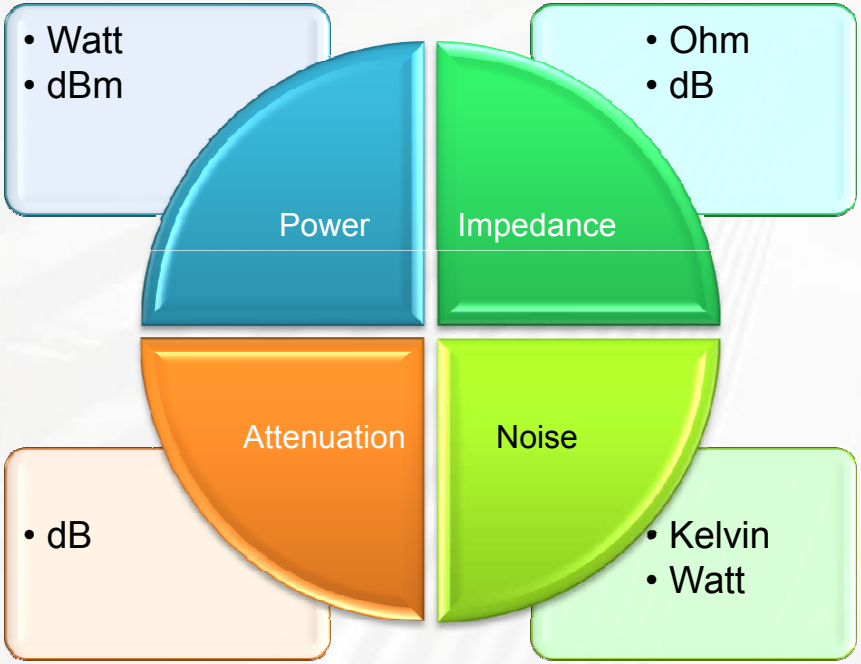


https://www.sciencelearn.org.nz/images/2299-relationship-between-units

Traceability Chain



RF Measurement Topics



RF Measurement Topics

	Main Topic	Sub Topic
1	Power	Power Powermeter Power Sensors Calibration Factor Effective Efficiency
2	Impedance	Impedance Reflection Coefficient Return Loss SWR
3	Attenuation	Attenuation Amplifier Transmission Coefficient Insertion Loss
4	Noise	Noise Source Radiometer

RF Measurement Topics

RF & Microwave Laboratories' Measurement Quantities & Unit

	Main Topic	Quantity	Unit
1	Power	Power/Powermeter Calibration Factor Effective Efficiency	Watt , dB, dBm - -
2	Impedance	Impedance Reflection Coefficient	Ohm -
		Return Loss SWR	dB -
3	Attenuation	Attenuation Amplifier Transmission Coefficient Insertion Loss	dB dB - dB
4	Noise	Noise	Kelvin, Watt

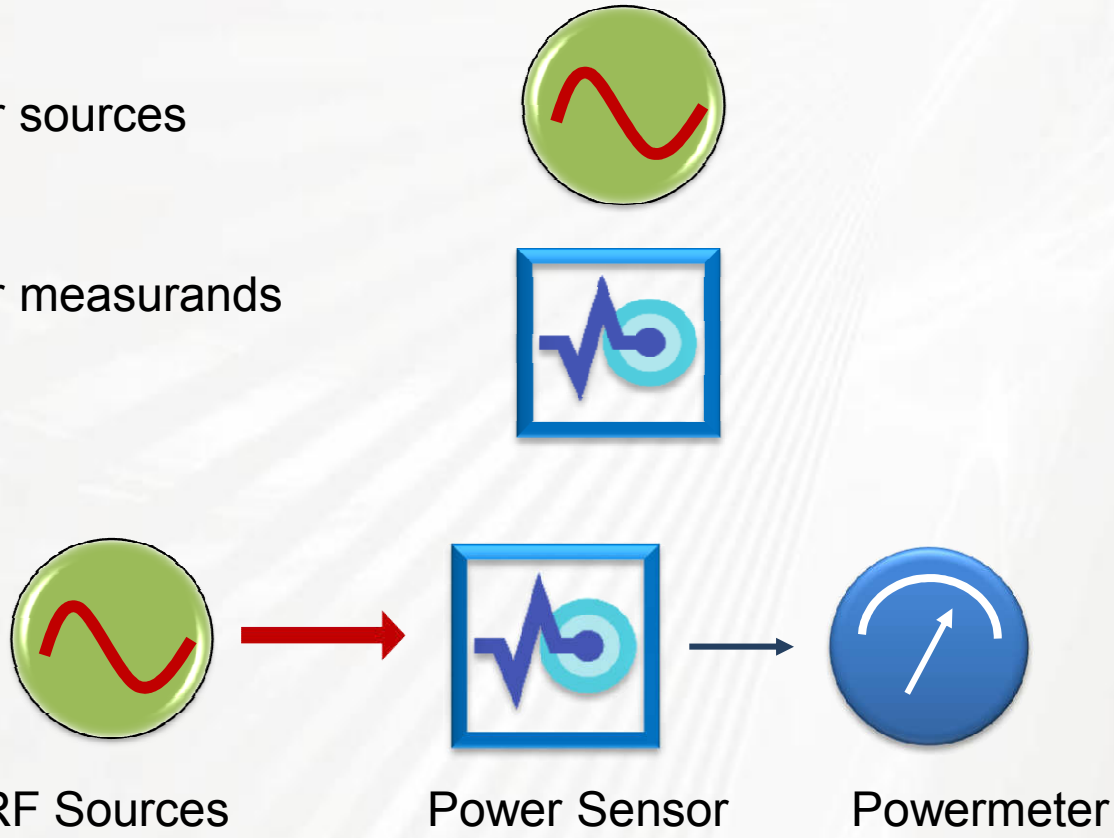
RF Measurement Topics

RF & Microwave Laboratories' Measurement Standards

	Measurement Topic	Primary Level Standards	Secondary Level Standards
1	Power	Microcalorimeter System	Power Sensors
2	Impedance	Airline	SNA VNA Terminations Special Measurement Setups
3	Attenuation	Piston Attenuator	SNA VNA Attenuators Special Measurement Setups
4	Noise	Noise Source	Radiometer

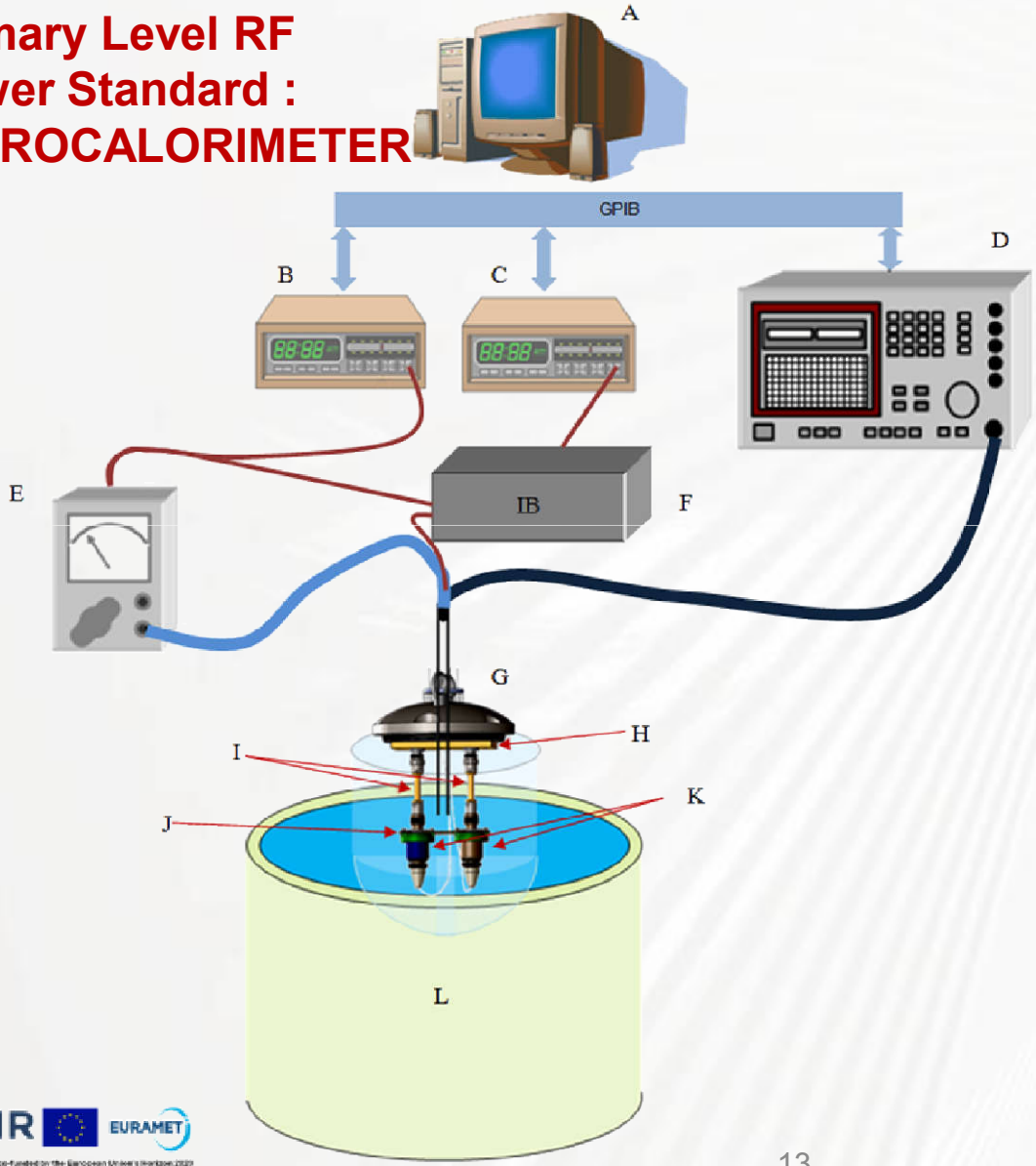
RF Power Traceability Chain

- RF power sources
- RF power measurands



RF Power Traceability Chain

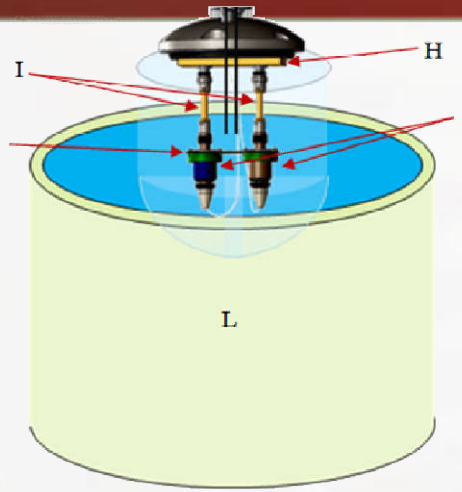
Primary Level RF Power Standard : MICROCALORIMETER

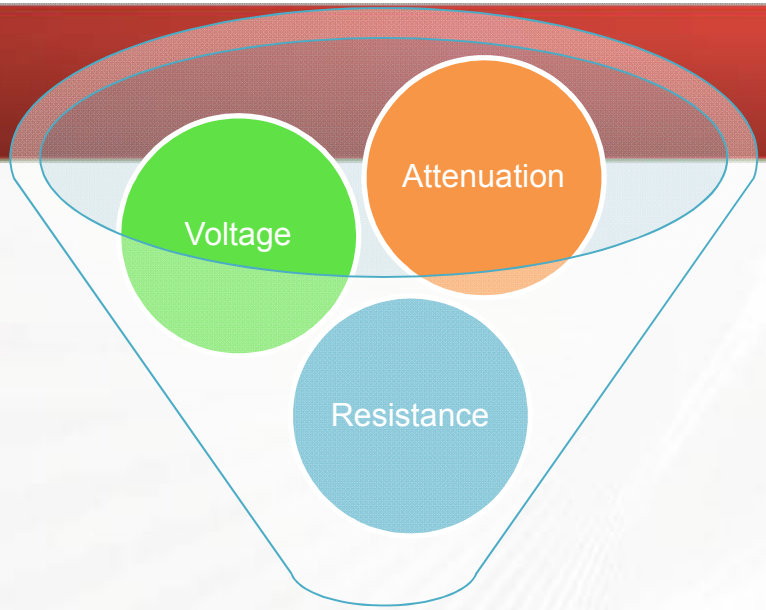


Microcalorimeter System

A. PC,
B. Voltmeter,
C. Nano voltmeter,
D. RF Signal Source,
E. Powermeter,
F. Connection Box,
G. Microcalorimeter head/body,
H. Heat Absorber,
I. Thin Line (2 pieces),
J. Thermopile,
K. Thermistor Mount (2 pieces),
L. Water pool

RF Power Traceability Chain





Volt, Ohm, dB

Microcalorimeter

Thermistor Mount

Effective Effieincy

Power Sensor

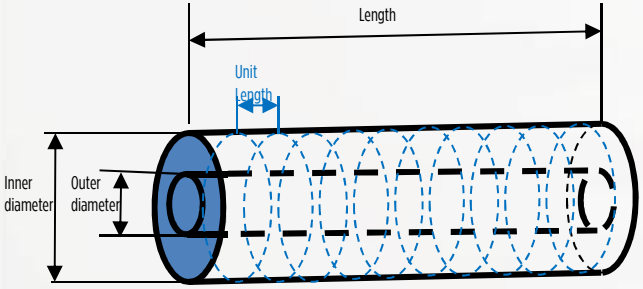
Calibration Factor

RF Power

Watt

RF Power Traceability

Impedance Traceability Chain

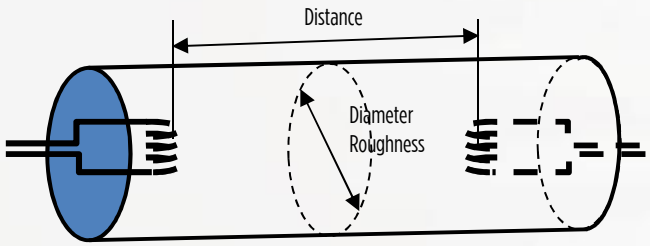


Dimension, Material Parameters — meter

Airline — Reflection Coefficient

Impedance — Ohm

Attenutation Traceability Chain

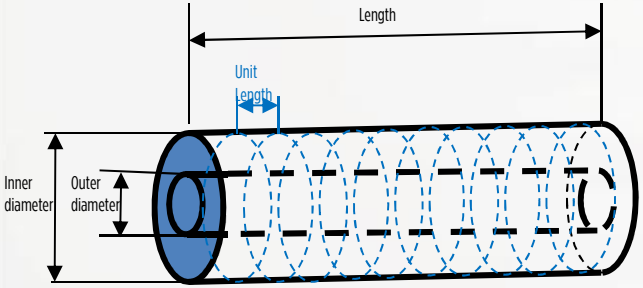


Dimension, Material Parameters — meter

Piston Attenuator — Transmission Coefficient

Attenuation — dB

S Parameter (Impedance & Attenutation) Traceability Chain



Dimension

Airline

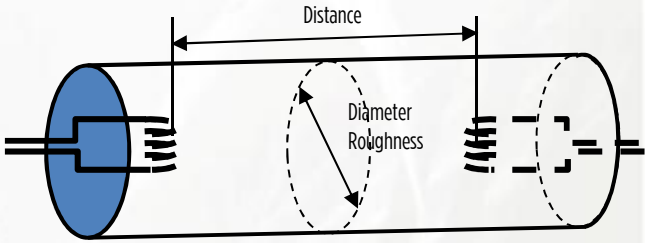
Impedance

Dimension

Piston Attenuator

Attenuation

VNA Traceability



EMPIR EURAMET
The EMPIR initiative is co-funded by the European Union's Horizon 2020 research and innovation programme and the EMPIR Participating States

RFMICROWAVE

Noise Traceability Chain

Temperature, Power — Kelvin, Watt

Noise Source — Kelvin

Noise — Kelvin

The EMPIR initiative is co-funded by the European Union's Horizon 2020 research and innovation programme and the EMPIR Participating States

15RPT01 RFMicrowave
Development of RF and Microwave Metrology Capability

Thanks for attention!