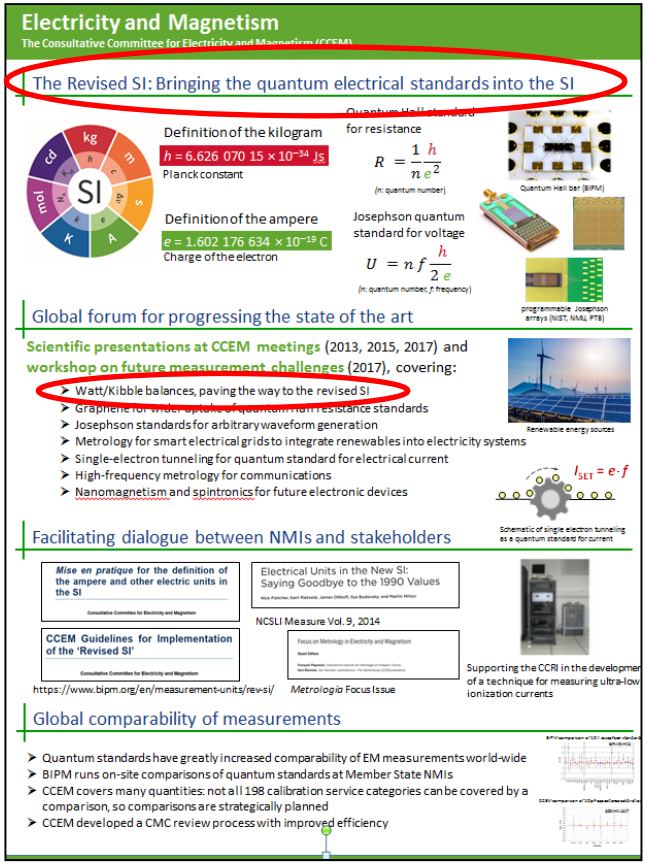
CCEM report to the CCU, 24th meeting, 2019

Gert Rietveld, CCEM president

Michael Stock, CCEM executive secretary

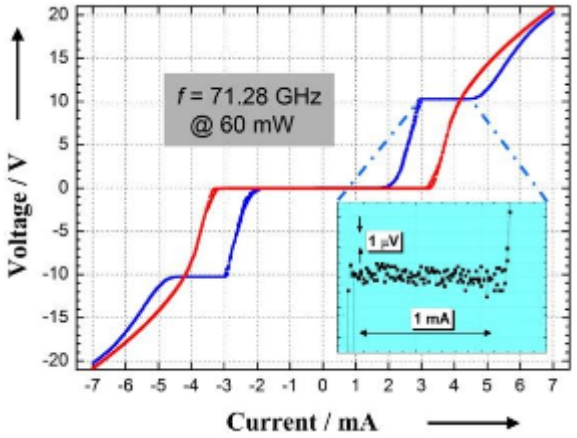
CCEM poster and CCEM President's presentation to the CGPM



www.bipm.org

Electrical quantum standards “brought into the SI”

Josephson voltage standard



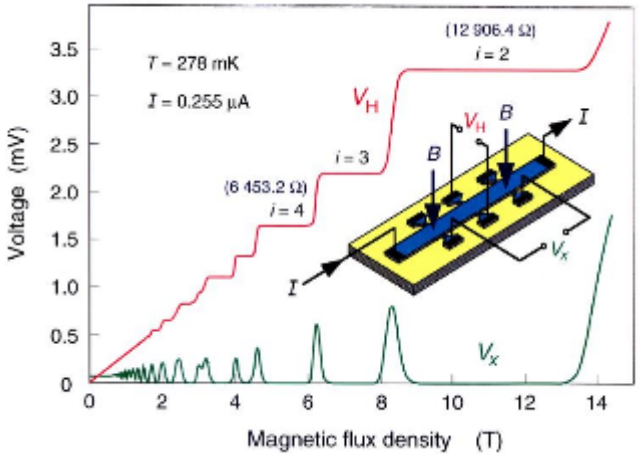
$$V = n \cdot (h/2e) \cdot f$$

K_{J-90}

$$R = (h/e^2) \cdot 1/n$$

R_{K-90}

Quantum Hall resistance standard



- Conventional values $K_{J\text{-}90}$ and $R_{K\text{-}90}$ used since 1990 -> parallel electric unit system
- Revised SI: K_J and R_K calculated from fixed numerical values of h and e

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$K_J = 2e/h$ = 483 597.848 416 984… GHz/V

$R_K = h/e^2$ = 25 812.807 459 3045… Ω

Implementing the revised SI

- When the 1990 values are replaced, small step changes are inevitable:
- The relative change from $K_{J\text{-}90}$ to K_J will be of the order 1×10^{-7}

  Voltage values will change by about **0.1 ppm**

  1 V before -> 1.000 000 1 V after

- The relative change from $R_{K\text{-}90}$ to R_K will be of the order 2×10^{-8}

  Resistance values will change by about **0.02 ppm**

  1 Ω before -> 1.000 000 02 Ω after

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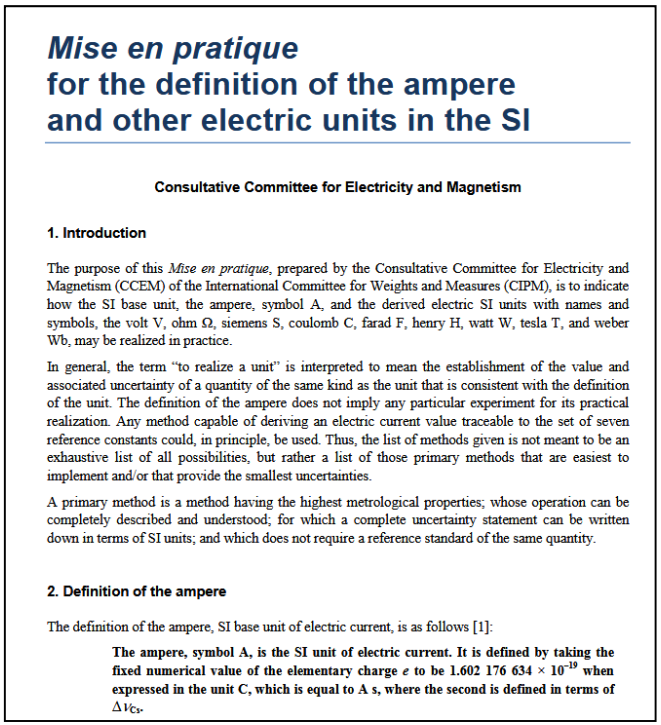
CCEM Guidance documents for stakeholders (NMIs, industry,…)

WG on the proposed modifications to the SI, WGSI, produced 2 essential documents:

- *Mise en pratique* for the ampere
- Implementation guidelines



Mise en pratique for the definition of the ampere and other electric units in the SI

Consultative Committee for Electricity and Magnetism

1. Introduction

The purpose of this *Mise en pratique*, prepared by the Consultative Committee for Electricity and Magnetism (CCEM) of the International Committee for Weights and Measures (CIPM), is to indicate how the SI base unit, the ampere, symbol A, and the derived electric SI units with names and symbols, the volt V, ohm Ω, siemens S, coulomb C, farad F, henry H, watt W, tesla T, and weber Wb, may be realized in practice.

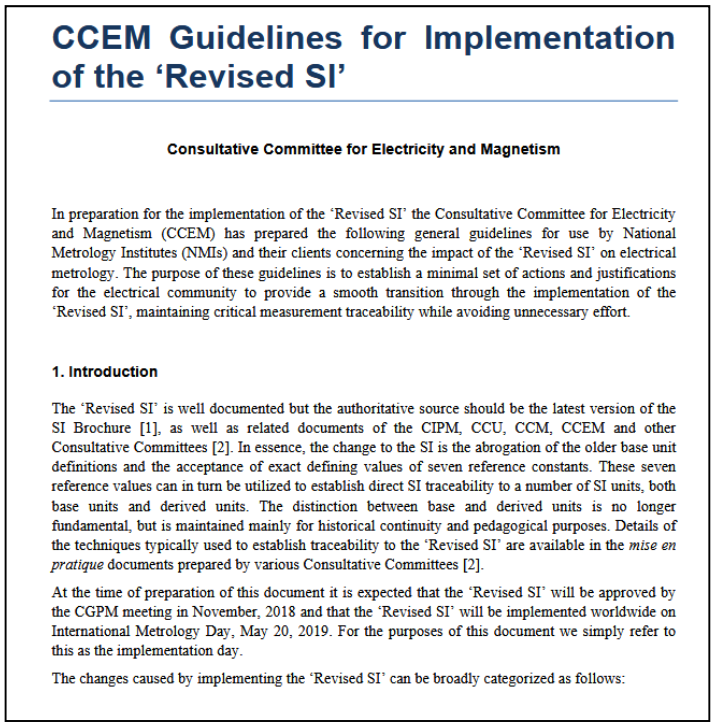
In general, the term "to realize a unit" is interpreted to mean the establishment of the value and associated uncertainty of a quantity of the same kind as the unit that is consistent with the definition of the unit. The definition of the ampere does not imply any particular experiment for its practical realization. Any method capable of deriving an electric current value traceable to the set of seven reference constants could, in principle, be used. Thus, the list of methods given is not meant to be an exhaustive list of all possibilities, but rather a list of those primary methods that are easiest to implement and/or that provide the smallest uncertainties.

A primary method is a method having the highest metrological properties; whose operation can be completely described and understood; for which a complete uncertainty statement can be written down in terms of SI units; and which does not require a reference standard of the same quantity.

2. Definition of the ampere

The definition of the ampere, SI base unit of electric current, is as follows [1]:

> **The ampere, symbol A, is the SI unit of electric current. It is defined by taking the fixed numerical value of the elementary charge e to be 1.602 176 634 × 10^{-19} when expressed in the unit C, which is equal to A s, where the second is defined in terms of $\Delta\nu_{Cs}$.**



CCEM Guidelines for Implementation of the 'Revised SI'

Consultative Committee for Electricity and Magnetism

In preparation for the implementation of the 'Revised SI' the Consultative Committee for Electricity and Magnetism (CCEM) has prepared the following general guidelines for use by National Metrology Institutes (NMIs) and their clients concerning the impact of the 'Revised SI' on electrical metrology. The purpose of these guidelines is to establish a minimal set of actions and justifications for the electrical community to provide a smooth transition through the implementation of the 'Revised SI', maintaining critical measurement traceability while avoiding unnecessary effort.

1. Introduction

The 'Revised SI' is well documented but the authoritative source should be the latest version of the SI Brochure [1], as well as related documents of the CIPM, CCU, CCM, CCEM and other Consultative Committees [2]. In essence, the change to the SI is the abrogation of the older base unit definitions and the acceptance of exact defining values of seven reference constants. These seven reference values can in turn be utilized to establish direct SI traceability to a number of SI units, both base units and derived units. The distinction between base and derived units is no longer fundamental, but is maintained mainly for historical continuity and pedagogical purposes. Details of the techniques typically used to establish traceability to the 'Revised SI' are available in the *mise en pratique* documents prepared by various Consultative Committees [2].

At the time of preparation of this document it is expected that the 'Revised SI' will be approved by the CGPM meeting in November, 2018 and that the 'Revised SI' will be implemented worldwide on International Metrology Day, May 20, 2019. For the purposes of this document we simply refer to this as the implementation day.

The changes caused by implementing the 'Revised SI' can be broadly categorized as follows:

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Changes in CCEM WG structure

As a consequence of the achieved redefinition, 2 WGs were closed:

- WGSI, which prepared guidance documents
- WGKG, which overlooked and coordinated the development of Kibble balances
  - KBs in future under the responsibility of Mass Community, CCM WGM
  - Technical discussions will take place at “Kibble Balances Technical Meetings” (KBTM)
  - “electrical metrology is a service provider”, but still has an important role to play
  - Regular reports from CCM WGM and KBTM at CCEM meetings

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