Next generation of quantum voltage systems for wide range applications

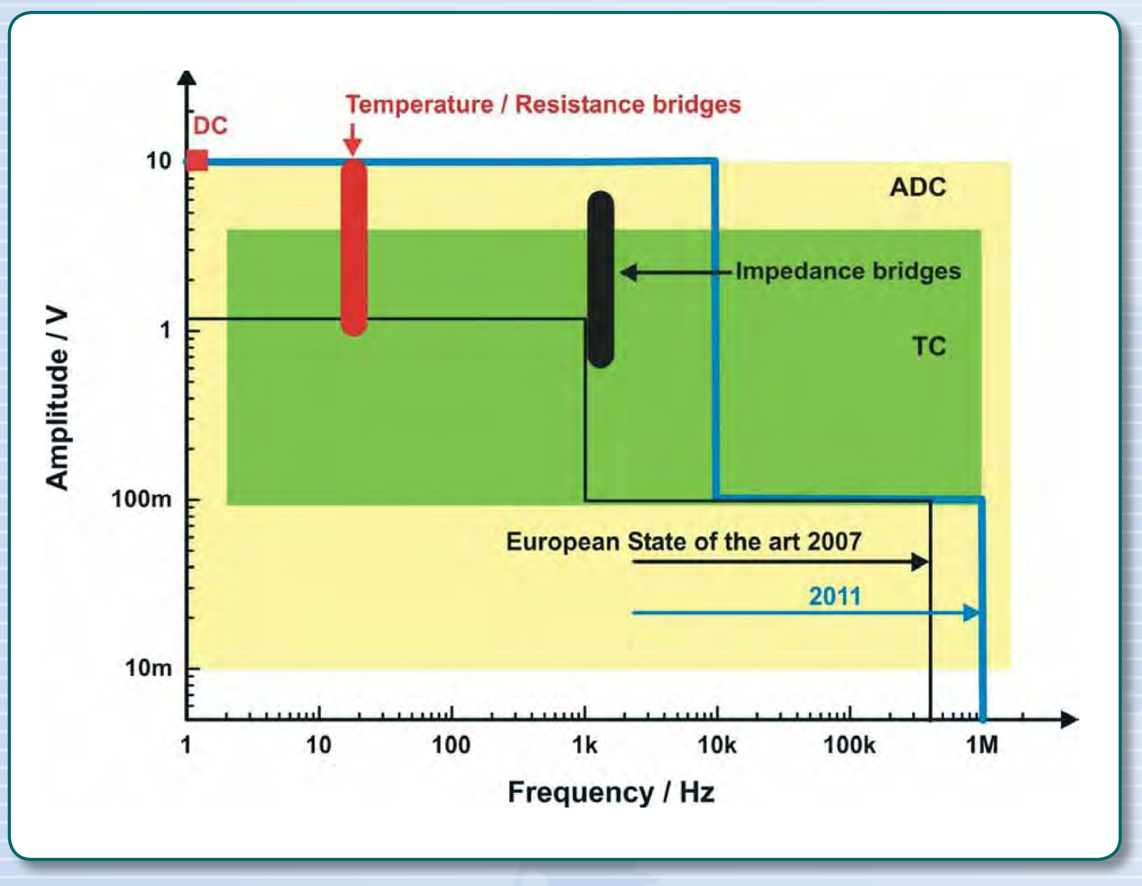
EURAMET
European Association of National Metrology Institutes

The need for the project

The use of microelectronic circuits in control systems in commercial devices is constantly increasing and is improving the performance and efficiency of mass-produced items.

However, the performance of a control system depends on the performance of electronic components (e.g. analogue to digital converters [ADCs] and digital to analogue converters [DACs]), and the performance of the components, in turn, depends on the performance of the electronic measurement equipment used to test them.

This project aimed to introduce quantum-based measurement systems into AC metrology, providing faster calibrations with lower uncertainties with the aim of supporting electronic measurement and test equipment used in research and development.



The voltage and frequency ranges addressed in this project. The coloured lines illustrate the most important frequency and voltage ranges of various AC applications.

Technical achievements

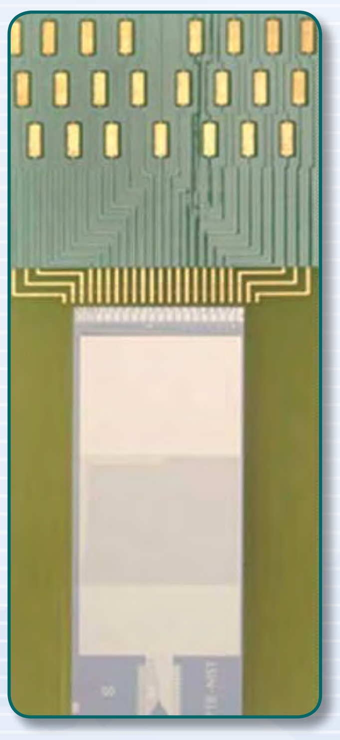
The project has extended the application area for Josephson based methods and produced much better Josephson Synthesizers (JoSys) and quantum-based voltage measurement systems.

A new technology based on a more robust barrier material, Nb_xSi_{1-x}, will be the new basis for Josephson array fabrication. The first wafers containing binary-divided 10-V Josephson series arrays, fabricated for 70-GHz operation and consisting of about 70,000 junctions, showed a good yield and wide constant-voltage steps with a width of around 1 mA.

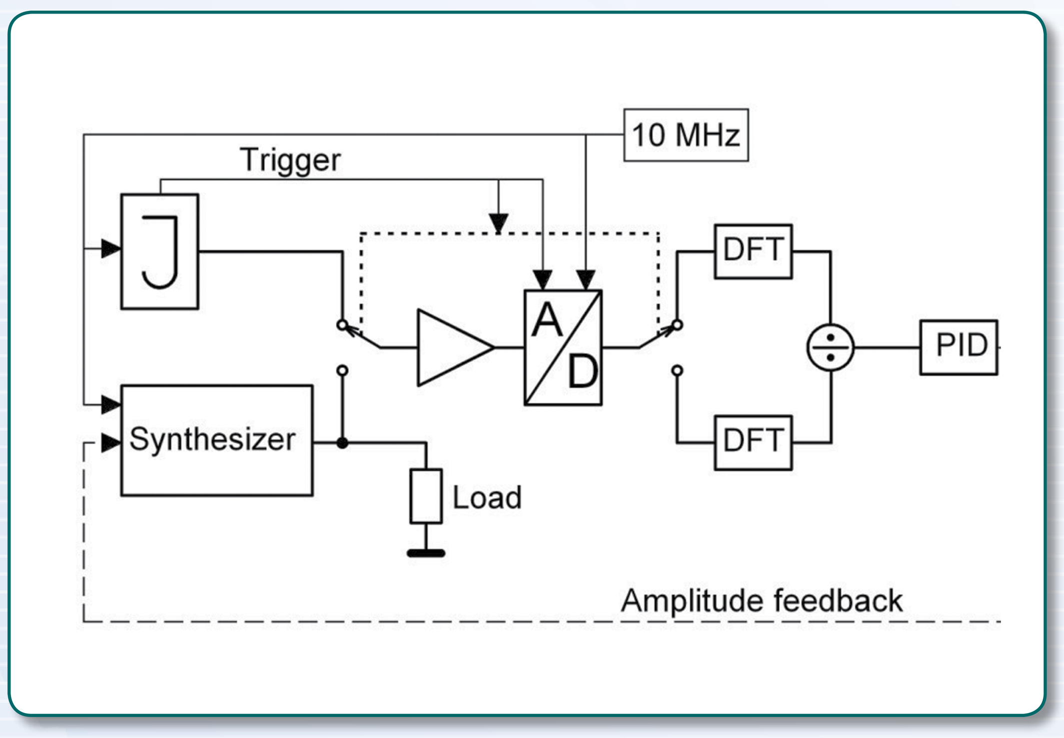
A Josephson voltage standard locked synthesizer (JoLoS) has been developed. The JoLoS with amplitude feedback can be used as a source to drive low impedance with an uncertainty below 1.5 µV/V, ranging from 100 mV to 1 V and 10 Hz to 1 kHz.

Differential sampling methods achieve uncertainties below 0.1 µV/V for frequencies up to 100 Hz in thermal converter measurements.

A flexible Josephson two-terminal-pair bridge method has been developed and shows at 10 kΩ uncertainties of a few parts in 10^8, comparable to those of conventional impedance bridges. The Josephson bridge can measure over a much wider frequency range, from 25 Hz up to 10 kHz and over a wider range of impedance ratios than conventional two-terminal-pair bridges.



◄ *10-V array based on Nb_xSi_{1-x}-SNS Josephson junctions.*



▲ *Schematic diagram of the Josephson voltage standard locked synthesizer (JoLoS).*

New generation quantum voltage systems

Established a new generation of quantum voltage systems for synthesizing and measuring waveforms - enabling numerous previously unavailable calibration methods based on an intrinsically stable quantum effect (i.e. the Josephson Effect).

Calibration of instruments

Established methods for the calibration of thermal converters, ADCs and DACs, inductive dividers, amplifiers, spectrum analysers, waveform generators, AC bridges and other instruments with a frequency dependent response.

Industrial testing

Carried out a successful on-site test in an industrial location, esz AG, Eichenau, Germany, which demonstrated the quality and robustness of quantum-based voltage standards. Two technology transfer projects in Germany have also started to make the new Nb_xSi_{1-x} fabrication process commercially available and two companies, Supracon and esz AG, have expressed an interest in this commercialisation.

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