European Metrology Research Programme

Delivering Impact

EURAMET

Transportable atomic clocks

Atomic timekeeping provides communication systems relaying information with very precise timestamping, and navigation systems with the ability to exactly pinpoint locations. The most accurate atomic clocks rely on expert staff maintaining complex operating conditions to ensure their performance. As applications requiring precise timekeeping increase, simpler yet highly accurate atomic clocks, suitable for use without expert supervision, are needed to supply the accuracy needed by industry and commerce.

Europe's National Measurement Institutes working together

The European Metrology Research Programme (EMRP) brings together National Measurement Institutes in 23 countries to address key measurement challenges at a European level. It supports collaborative research to ensure that measurement science meets the future needs of industry and wider society.

Challenge

Banks and internet companies need very accurate time and date stamps to send information and process high frequency transactions. As the technology used gets faster, greater timing precision is required. Atomic timekeeping, provided by National Measurement Institutes, supplies the highest timing accuracy, but these clocks are bulky and require very precise operating conditions and exceedingly low temperatures making them difficult to maintain. Technology and finance companies need on-site clocks that offer comparable levels of accuracy, but which are simpler to look after and operate.

Compact, and more portable, rubidium vapour clocks are being developed for industrial uses. In this type of atomic clock, lasers excite rubidium atoms under very tightly controlled temperature and magnetic conditions to produce and control the specific microwave frequencies used in timekeeping – the clocks 'ticks'. Variations in manufacturing processes can create very small changes to the clock's cavity that produces the microwaves, and hence can effect its performance. This makes a standardised frequency difficult to reliably reproduce between clocks from the same production process.

Reliable on-site atomic timekeeping has the potential to create innovations in financial transactions and internet based communications provided greater compactness and reliability can be achieved. Making clocks smaller, more robust and improving reliability will increase the spread of these highly accurate frequency standards.

Solution

The EMRP project *Compact and high-performing microwave clocks for industrial applications,* improved an existing prototype rubidium clock – the Rubiclock – to make it suitable for industrial applications.

The project made design changes to the clock's cavity, and improved understanding of how to make adjustments to its magnetic field and temperature. This allowed improved tuning of the frequency output, enabling greater optimisation of clock performance. Advances were validated against highly stable hydrogen maser atomic clocks.

The project's revised rubidium clock was further tested during zero-gravity flights in the earth's upper atmosphere. Removing gravity extends the clocks signal generation time, allowing more accurate confirmation of performance.

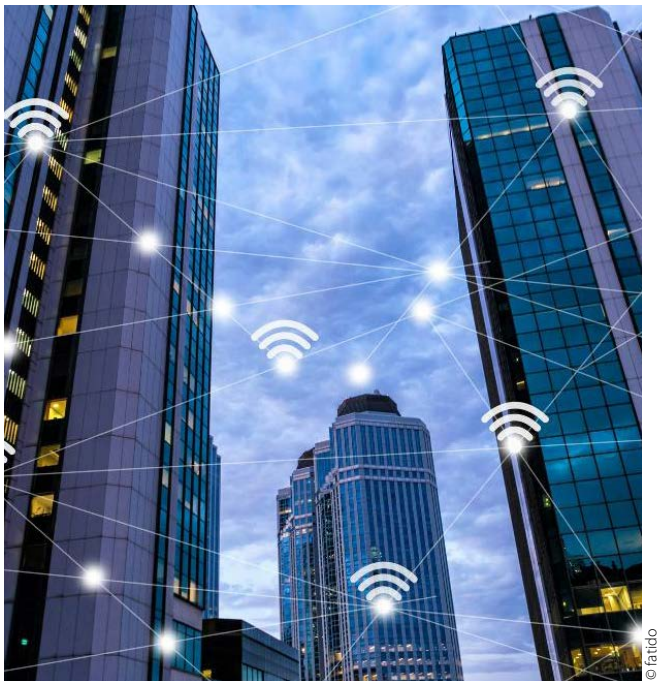
Impact

Muquans, a spinout company from the Institut d'Optique and Observatoire de Paris, built on Rubiclock technologies advanced in the project to develop and commercialise the clock for industrial applications. Project developments have enabled the Rubiclock's advanced prototype to be made more compact and provided better fine tuning for the clock's microwave cavity. This has significantly improved clock performance by reducing cavity size differences resulting from the manufacturing process. Now commercially available as the Muclock, it offers comparable on-site accuracy to NMI clocks, whilst being much more compact and easier to maintain.

Easy to use atomic clocks, such as the Muclock, will provide European financial, telecommunications, navigation and research organisations with accurate and reliable frequency and synchronisation tools for use in-house and on-site.

Compact, high-performance timing

The EMRP project *Compact and high-performing microwave clocks for industrial applications* investigated emerging clock technologies and designs with the potential to provide compact, highly accurate time and frequency references for next generation satellite navigation systems and industrial users. The project worked with three prototype atomic clock technologies and a Rubiclock to make them more compact, stable and suitable for use in space. This was made possible by an intensive and extensive collaboration between leading European atomic clock experts from National Measurement Institutes and academia. As a result of this project, atomic clock prototypes have been demonstrated that are suitable for commercialisation and will enable users to benefit from their own in-house time and frequency standards.



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EMRP
European Metrology Research Programme
Programme of EURAMET

The EMRP is jointly funded by the EMRP participating countries within EURAMET and the European Union

www.euramet.org/project-IND55

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