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International Centre for Radio Astronomy Research

SKA SYNCHRONISATION SYSTEM

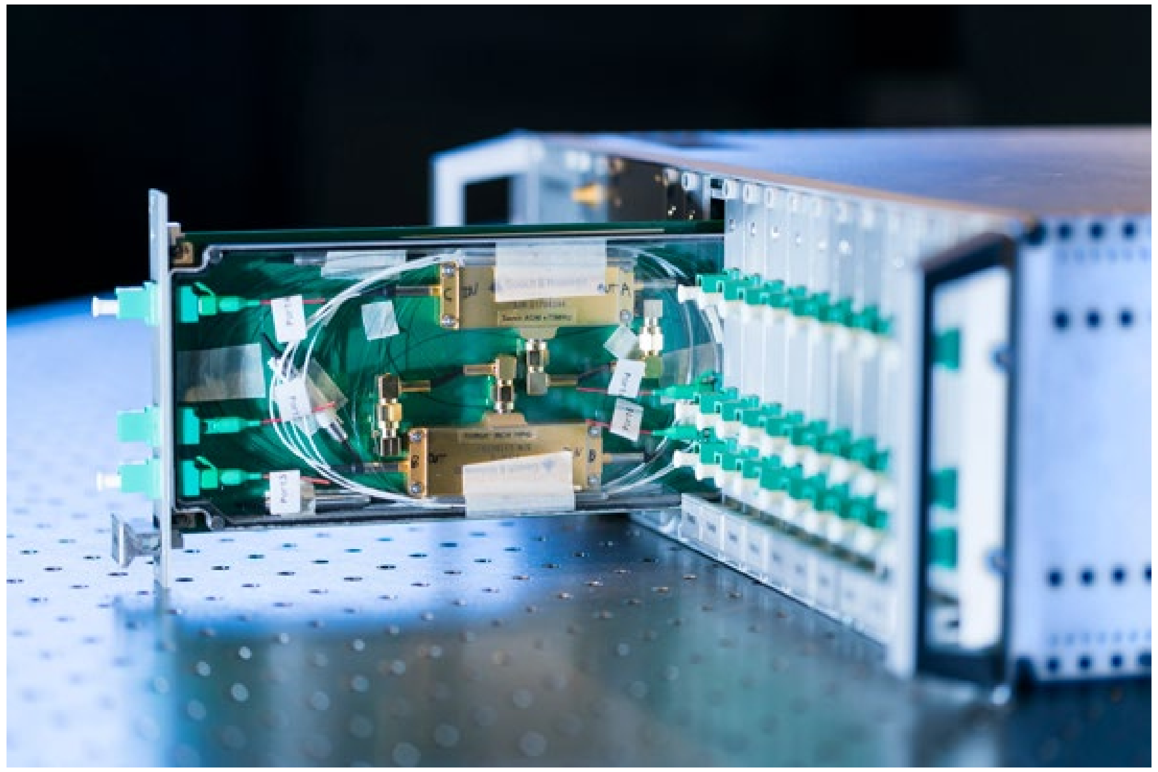
CASE STUDY

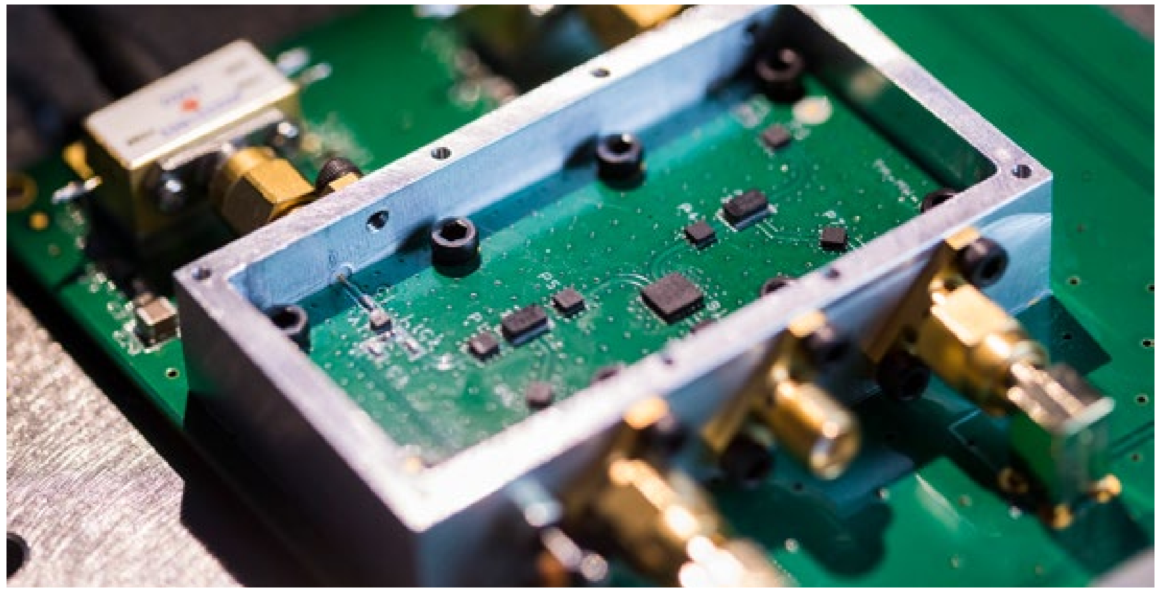
International Centre for Radio Astronomy Research

Curtin University

THE UNIVERSITY OF WESTERN AUSTRALIA

THE GOVERNMENT OF WESTERN AUSTRALIA





SKA SYNCHRONISATION SYSTEM

An optical fibre-based synchronisation system designed by ICRAR researchers was selected for the first phase of SKA-mid, the part of the Square Kilometre Array that will be built in South Africa in the coming years.

The long distances between SKA antennas means radio waves from the sky will arrive at each antenna at different times. With thousands of antennas spread over continental scales, one of the most complex technical challenges for the SKA is to synchronise the incoming signals with extreme precision before they're combined by the SKA's supercomputers.

> "The extreme accuracy of this technology could have all sorts of applications beyond discovering stars and galaxies from the early Universe."

"Given the scale of the SKA, this is an engineering problem that hadn't really been faced before by any astronomical observatory and we need to achieve a precision better than five parts in a trillion," said André Van Es, the SaDT Engineering Project Manager supervising the consortium's work for the SKA Organisation.

To achieve this level of precision or "coherence" across the array, the SKA requires a synchronisation distribution system that suppresses these fibre fluctuations in real time.

"The performance required is less than 2% coherence loss. Bearing in mind a 1% loss is equivalent to losing 2 dishes or antenna stations, it's crucial that we get this right for the telescopes to be effective," said SKAO timing domain specialist Rodrigo Olguin.

While optical fibres are incredibly stable and suited to transport data, mechanical stresses and thermal changes also affect the fibre, degrading the stability of the transmitted signals over long distances.

The reference signals sent by the synchronisation distribution system travel to each antenna using the optical fibre network also used for transporting astronomical data to the SKA's central computer. The system then takes into account the mechanical stresses and thermal changes in the fibre and corrects the timing difference to make sure all signals coming from the antennas are digitised synchronously with a precision better than five parts in a trillion.

"Our SKA frequency synchronisation system continuously measures changes in the fibre link and applies corrections in real-time with fluctuations of no more than five parts in one-hundred trillion over a 1-second period", said lead designer, Dr Sascha Schediwy from ICRAR and The University of Western Australia (UWA).

The system has been extensively tested in a laboratory setting with signals transmitted over metropolitan fibre links and fibre spools. In the field, the system has been tested on 186 km of overhead fibre at the South African SKA-mid telescope site, and astronomical verification conducted with the Australia Telescope Compact Array.

"A clock relying on a signal of that stability would only gain or lose a second after 600,000 years and field tests have shown our system to be performing between 100 and 10,000 times better than what's required for the SKA," said Dr Schediwy.

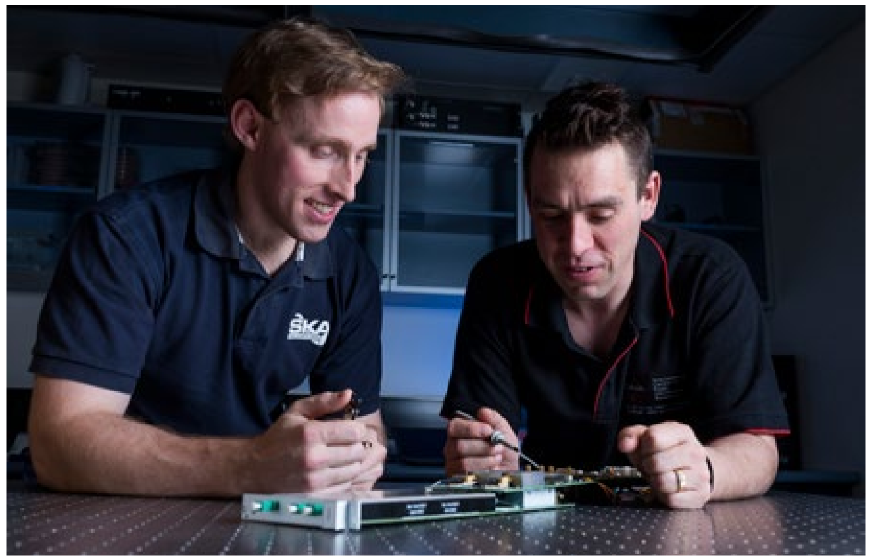
"Working with the SKA-mid telescope is an enormous technological challenge, with the higher frequency of the transmitted signals requiring extreme levels of stabilisation precision," he said.

"The system needs to be deployed on 197 independent fibre links with distances up to 175 km—the longest of which will be mounted on overhead poles. This means that the noise caused by the environment is a thousand times that of a buried fibre."

Australian SKA project director David Luchetti said the extreme accuracy of this technology could have all sorts of applications beyond discovering stars and galaxies from the early Universe.

"Astronomy is constantly pushing the boundaries in fields like precision timing, imaging and big data management, leading to new technologies like more advanced medical imaging," he said.

"At the time of invention, we often don't fully appreciate the extent to which these technologies can change lives and boost the economy."



Left Sascha Schediwy and David Gozzard with components of their SKA-mid phase synchronisation system Transmitter Module. Credit: ICRAR.

Top A close-up of the high-precision electronic microwave-frequency mixing circuitry—a crucial part of every SKA-mid Transmitter Module. Credit: ICRAR.

Top Left A Sub-Rack enclosure used to hold 16 of the 197 Transmitter Modules for the SKA-mid phase synchronisation system. One prototype Transmitter Module is shown partly extended from the front of the enclosure, revealing details of the system's critical fibre-optic components. Credit: ICRAR.