5G Synchronisation Solutions

Technical Note

Introduction

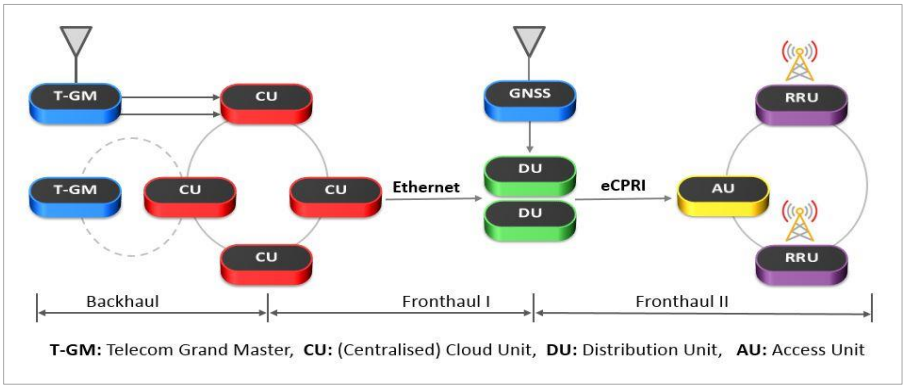
Traditional base station architectures have been centred around Base Band Units (BBU) and Remote Radio Units (RRU). Typically, the main functions for BBUs were network interfacing and base band signal processing. The radio unit - managed high-speed data conversion, power amplification, low noise amplification and other filtering and mixing required for cellular transmission and reception.

5G network topologies are evolving. Significant changes are occurring in radio technology as well as in connectivity between base band processing and radio functions. The functions are restructured as Central Units, Distribution Units, Access Units and Radio Units. Depending on the focussed application (eMBB – enhanced Mobile Broadband, uRLLC – ultra-Reliable Low Latency Communications or mMTC – massive Machine Type Communications) the functions are realised at various network levels.

5G Architectures

Synchronisation requirements are evolving for both 5G base stations and transport architectures. One architectural difference between traditional and new generation base stations, is the decoupling of BBUs and RRUs with front-haul networks.

Physical layer connectivity between the BBU/RRU, traditionally based on CPRI/OBSAI, is giving way to Ethernet or eCPRI based connectivity. Such connectivity not only provides flexible interconnection for the Base Band and Radio Units, but also provides higher data transfer speeds demanded by 5G architectures.



T-GM: Telecom Grand Master, **CU:** (Centralised) Cloud Unit, **DU:** Distribution Unit, **AU:** Access Unit

Packet Synchronisation in Radio Units

There are strict timing requirements between the air interfaces of adjacent base stations, as well as the BBU and the RRU of a single base station to enable advanced applications supported by 5G. The new BBU/RRU connectivity necessitates packet-based synchronisation techniques between the BBU and the RRU. The inherent Packet Delay Variation and low packet rate, requires clock recovery servo systems to have low bandwidth filtering and support from a high performance oscillator.

Rakon's 5G RRU solutions include ultra-stable TCXOs with industry leading performance. Rakon's new Neptune™ is an analogue TCXO achieving 50 ppb temperature stability – the first of its kind. It is available in industry standard footprints with lower power consumption than comparable solutions. The harsh environmental performances demanded by massive MIMO based outdoor radios include higher operating temperature ranges (up to 105 °C) and

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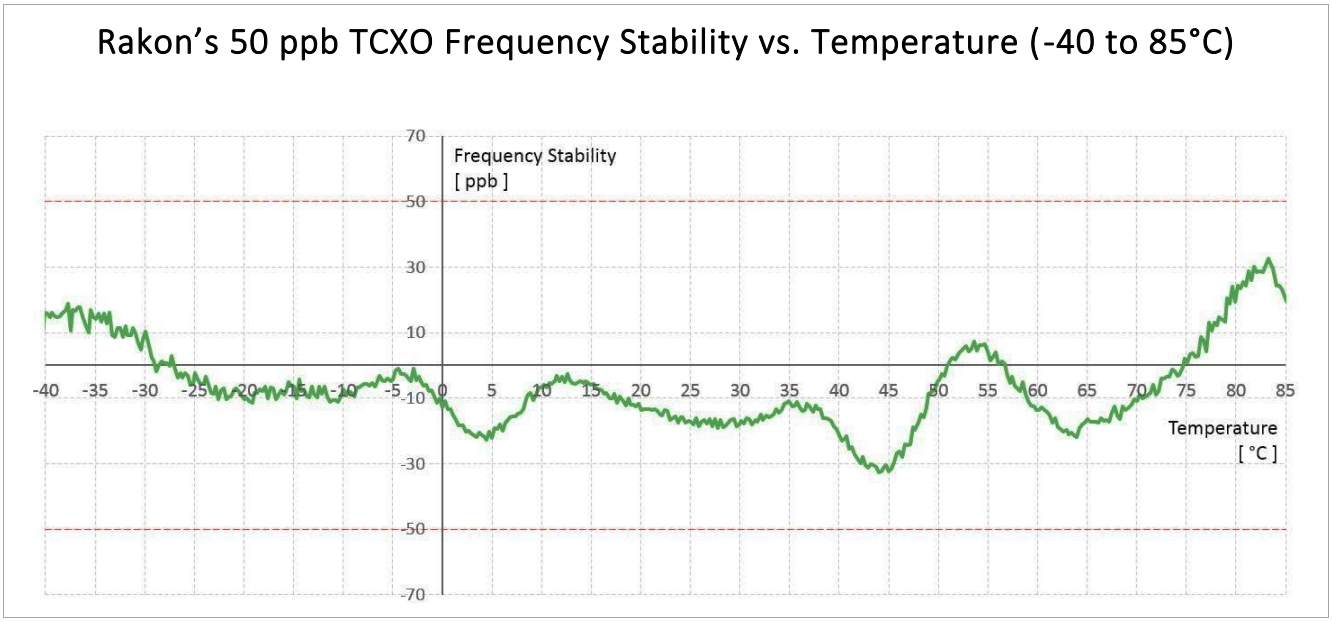
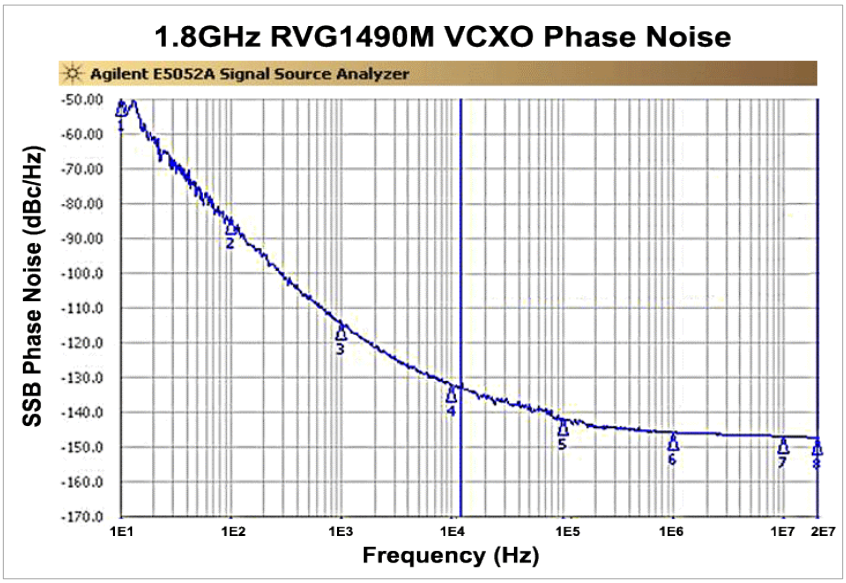
low *g*-sensitivity, which are addressed by the new family of TCXOs. Rakon TCXOs are also equipped with low temperature sensitivities (10 ppb/°C) to enable superior servo performance in transient environments.

For applications that require even higher temperature sensitivity performances (~1 ppb/°C), Rakon's ASIC based OCXOs are optimised for power, profile, reliability, and are available in a 9 x 7 mm footprint. The temperature stability of these devices are 10-50 ppb across -40 to 105°C.



GHz VCXOs for High Spectral Frequencies

5G spectral frequencies range from <1 – 100 GHz. Depending on the country of the Mobile Network Operator, common 5G trials are focussing on various spectral frequencies. Frequencies above the traditional 4G spectrum demand low phase noise reference clocks to support higher data rates based on higher QAM rates. Reference clock phase noise should be minimised, to reduce the phase noise contribution to Error Vector Magnitude (EVM) masks, enabling support of higher QAM rates and therefore increased throughput.



Rakon's GHz VCXOs (0.5 – 2.2 GHz) offer very low phase noise and jitter (~30 fs over a 12 kHz – 20 MHz bandwidth). These are ideal as high frequency reference clocks for high-speed data converters. They offer superior close in phase noise and temperature stability performance compared to other technologies. With various options for electrical output types such as sine, differential sine or LVPECL, these devices have flexible design options.

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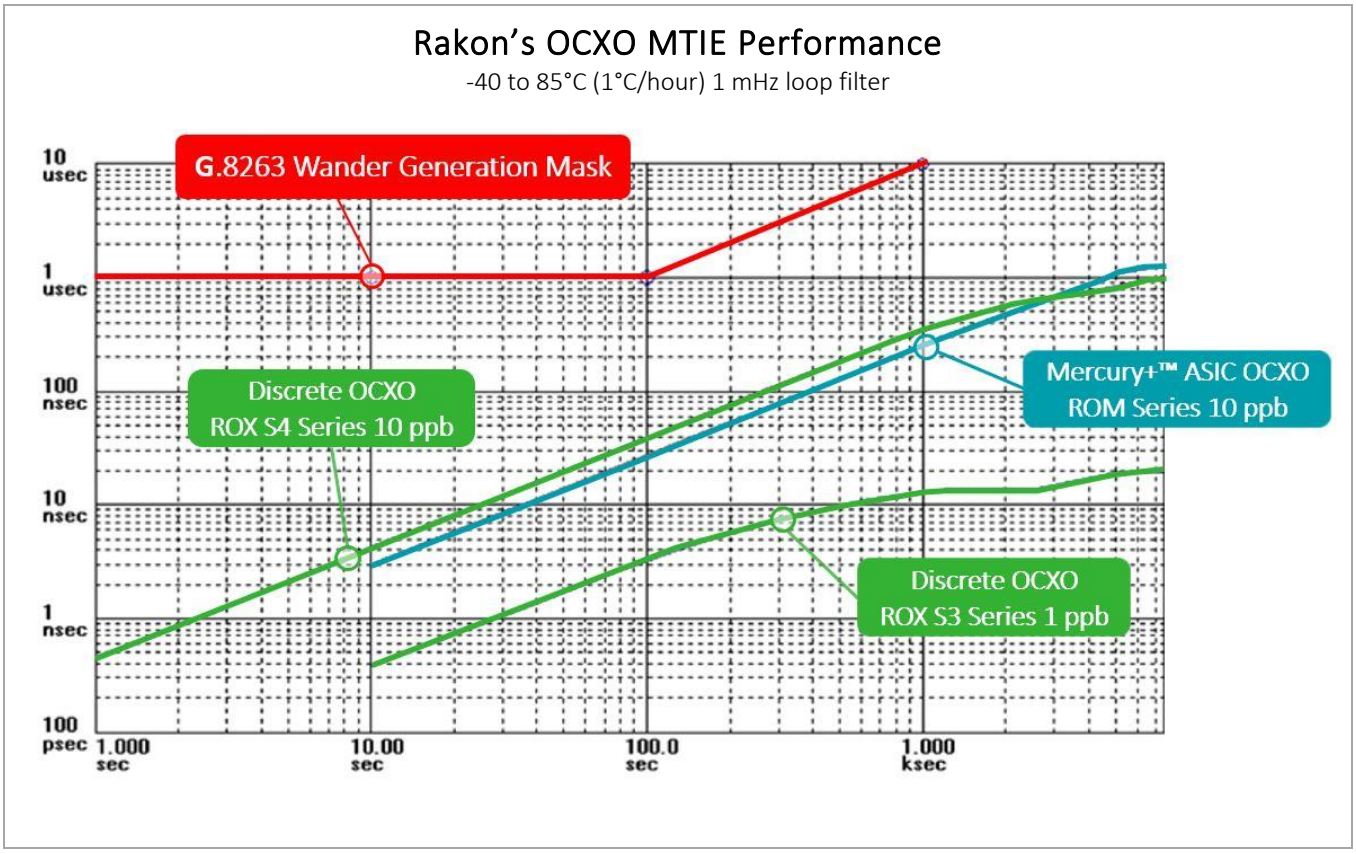
Front-Haul Synchronisation

CU/DU synchronisation replaces traditional BBU synchronisation options. With the development of new synchronisation standards, there are multiple synchronisation reference options; GNSS, IEEE 1588, SyncE and other external references. Reference oscillators support various servo technologies and medium holdover (1 – 8 hours) capabilities.

The requirements of 5G front-haul transport are still being defined. There are proposals to support ±130 ns time error for the entire front-haul from the time server to the base station with up to 20 transport element nodes in between. Assuming a 20 ns error at the GNSS based time server and 10 ns error at the base station, the individual node error is suggested to be 5 ns. To support such low time error, along with other system design requirements, a stable reference clock is required.

Rakon has a comprehensive range of OCXO capabilities including conventional, hybrid, and ultra-reliable ASIC-based OCXOs. Temperature stabilities of 1 – 50 ppb and ageing performance of 0.2 – 1 ppb/day are supported.



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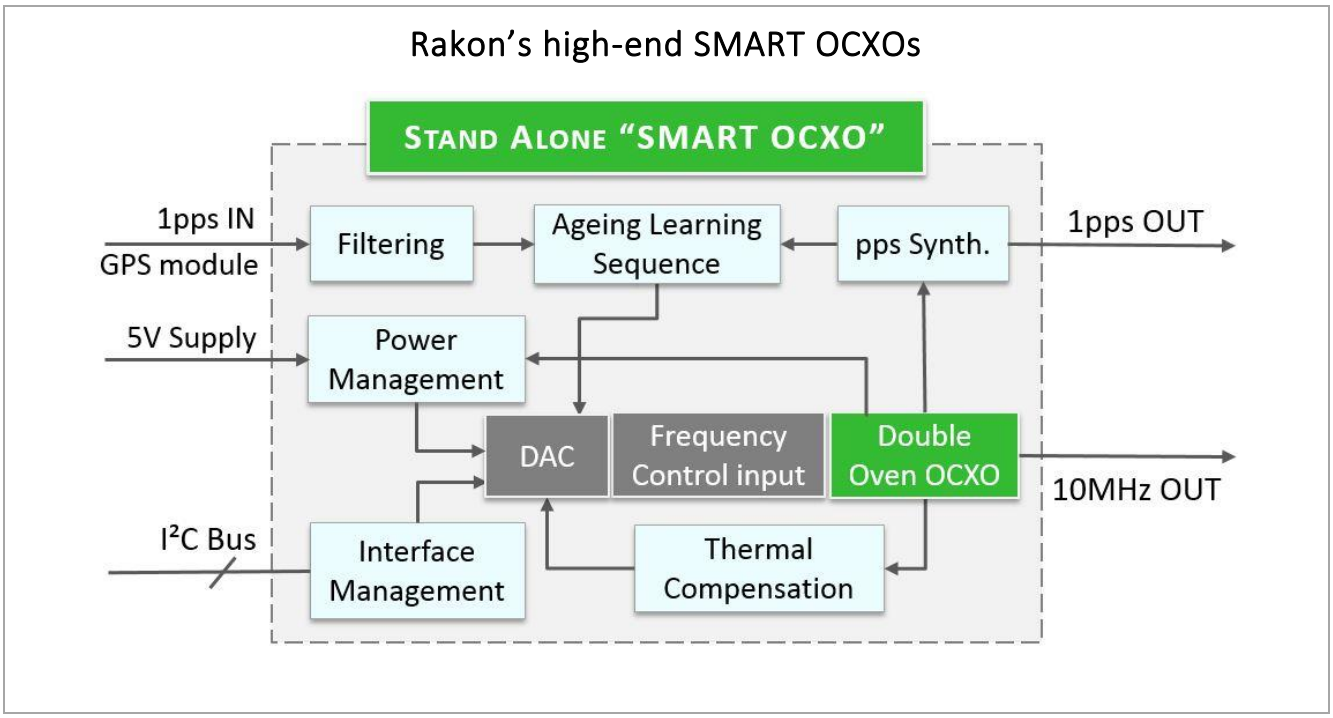
Long Holdover OCXOs for BBUs/Telecom Grand Master Clocks

Traditionally, the core of the network has high-end long holdover Grand Master clocks supported by atomic references. With the flattening of the synchronisation hierarchy, Grand Master clocks are moving towards the Access of the network. There are “edge”, “mini” and “integrated” Grand Masters offering GNSS connectivity backed up by PTP/SyncE and limited holdover capabilities.

Rakon’s high-end SMART OCXOs and standalone 1 pps modules offer long holdover (1.5 µs over 12 – 48 hours) performance to support such Grand Master designs. The 1 pps clock input into the solution is used for ageing compensation, therefore guaranteeing phase error on defined temperature excursions, when used with an industry standard GNSS modules.



Conclusion

Synchronisation architectures are evolving. The requirements for 5G will impact multiple layers of the network, driving synchronisation requirements across the board. Depending on the advanced application requirements in 5G, Rakon has a full range of solutions that meet the challenges of synchronisation across the Core, Access, Edge networks, Back-haul, CU/DUs, Front-haul and the RRUs.

Rakon product ranges include Crystals, SAW filters, XOs, VCXOs, TCXOs, Ultra-Stable TCXOs, ASIC-based OCXOs, Discrete OCXOs, OCSOs, Modules and Digital subsystems.

For further information, or support details, please contact us at: sales@rakon.com

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