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Veloce X-STEP O-RAN

Veloce X-STEP optimizes O-RAN interoperability and conformance

Benefits

- Quad-link 10/25GBASE-R HW designed for 5G Fronthaul test and monitoring
- O-DU emulation for O-RAN interoperability testing on C/U/S/M-planes
- Nanosecond accuracy in C/U/S-plane timing measurements
- C/U-plane Rx window monitoring according to air interface timings
- Auto-detection of antenna carrier parameters and bandwidths
- Covers all sync topologies C1 to C4 with PTP master/slave, SyncE/SSM and GPS
- Ready-made IOT profiles with support for Cat A and B radios with LTE and 5G NR
- Bridged mode for M-plane services, including DHCP, SFTP and NETCONF

Summary

Veloce™ X-STEP™ is a smart, highly SW-based fiber-optic test system intended for the verification of 5G radios, distributed units, and Fronthaul network components. In addition to the nanosecond-level accuracy of Veloce X-STEP, its patented architecture allows full configurability of transmitted data and detailed visibility into received data, both reaching the level of individual data and control characters, as necessary. Along with the introduction of eCPRI and O-RAN in its wide protocol portfolio, Veloce X-STEP became the choice for the testing and development of O-RAN based 5G Fronthaul devices and networks. Veloce X-STEP can operate as a monitor to O-RAN C/U/S/M-plane traffic in quality and interoperability assurance, or as an emulator of the O-DU or O-RU, generating O-RAN traffic for the other part. Multi-link support in Veloce X-STEP significantly increases the testing efficiency and allows synchronized captures from separate fibers.

Capabilities

Accuracy

A key challenge in packet-based Fronthaul systems is the timing of control and user-plane packets so that antenna symbols reach the radio at the right time. High-precision timestamps in Veloce X-STEP-recorded O-RAN data captures allow accurate Tx/Rx window monitoring in the O-RAN Fronthaul domain.

The Veloce X-STEP architecture relies on customized hardware and accelerators tailored for transmitting and receiving Ethernet/O-RAN packets in a byte-accurate fashion, at a nanosecond level of precision. Packet timings are coupled with air interface slots and symbols via auxiliary signaling from a precision RTC clock or GPS, which makes it possible to inspect packet timings related to the transmission and reception time windows of each symbol.

Figure 1: Rx window monitoring results as a timeline of captured C/U-plane packets.

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Figure 2: Ready-made O-RAN IOT Profiles for Rx window monitoring needs.

Veloce X-STEP has built-in support for O-RAN Inter-Op Test (IOT) Profiles for TDD and FDD radios to be used as the basis for Rx window monitoring. Users can select any of the predefined IOT Profiles to get started with or create a profile of their own to match custom timing requirements of their radio.

Protocol layers
Veloce X-STEP users enjoy full configurability in terms of every protocol layer involved, from Ethernet to all fields in O-RAN section and extension headers.

Users can inject and detect link, transport and radio application layer errors and receive key performance indicators (KPI) metrics from each layer.

Byte-accurate transmission and reception are key in establishing deterministic test scenarios and detecting any kind of error occurring in the Fronthaul link. Users can have access to view or modify protocol data even down in the XGMII level, as needed. This facilitates detailed error injection/detection and high-precision timing analysis.

User plane
Veloce X-STEP O-RAN protocol support follows the O-RAN WG4 CUS specification version 5.0. Veloce X-STEP supports SCS schemes in the range of 15 to 240 kHz, and all TDD slot/symbol and PRACH configurations defined in the 3GPP 5G NR physical layer spec.

Functional split options 7-2 and 7-3 (O-RAN radio categories A and B) are supported. The maximum channel bandwidth is 400 MHz for an mmWave O-RU, as currently limited by 3GPP.

The mapping of LTE or 5G NR payload into O-RAN U-plane packets is based on an intuitive TDD pattern builder and frequency-domain IQ payload files with configurable FFT sizes and guard bands. Data sections scale from slots and symbols to resource blocks. Application-layer fragmentation and jumbo frames are supported, along with 802.1Q Virtual LAN tagging selectable on an antenna stream basis.

Figure 3: Timing analysis summary on a symbol and packet level.

Control plane
Veloce X-STEP O-RAN protocol implementation pays special attention to the fine-tuning of C-plane message timings. RTC messages can be carefully timed according to slot or symbol boundaries with the required T_CP advance values of the O-RU, while taking the 3GPP 5G NR slot formats into account in terms of idle and active symbols.

Users can also choose to leave C-plane out for the early SW integration phases or choose to combine multiple sections and section extensions into one C-plane message to stretch the capabilities of the radio and, for instance, build complex beamforming scenarios.

Synchronization plane
For time synchronization, Veloce X-STEP supports the ITU-T G.8275.1 profile of the IEEE 1588-2008, precision time protocol v2, in master and slave directions for operation in all O-RAN clock topologies, namely C1 through C4. ITU-T G.8262, synchronous Ethernet, is used for frequency locking. G.8264, sync status messaging (SSM), can be used to distribute clock quality information.

A precision real-time clock or global navigation satellite system can also be used for establishing air frame synchronization. O-RAN system frame numbering scheme is also covered, so that the frame ID counter is derived from PTP timestamp.

Management plane
For the M-plane, X-STEP provides standard protocols such as DHCP, SSH and SFTP for handling the initialization sequence of an O-RAN Radio. A NETCONF client can be installed in the Veloce X-STEP Linux OS for standard or vendor-specific M-plane implementations.

Intelligent analytics
In an O-RAN interoperability test lab, it is often unclear what to expect from a Fronthaul link configuration. For that reason, Veloce X-STEP provides sophisticated O-RAN analytics features to automatically detect link and antenna configuration and display eAxC parameters, such as subcarrier spacing and the bandwidth of each antenna carrier.

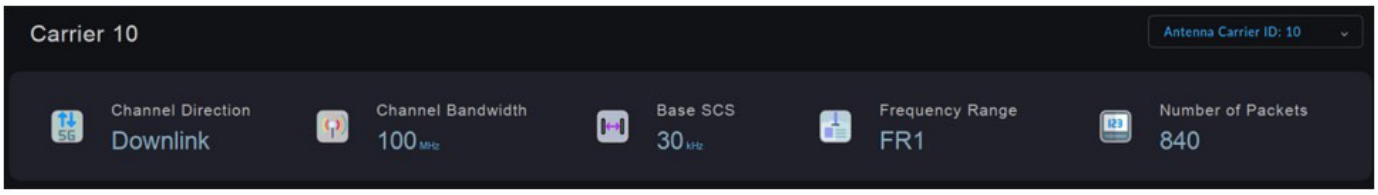

Figure 4: Overview of an automatically detected antenna carrier.

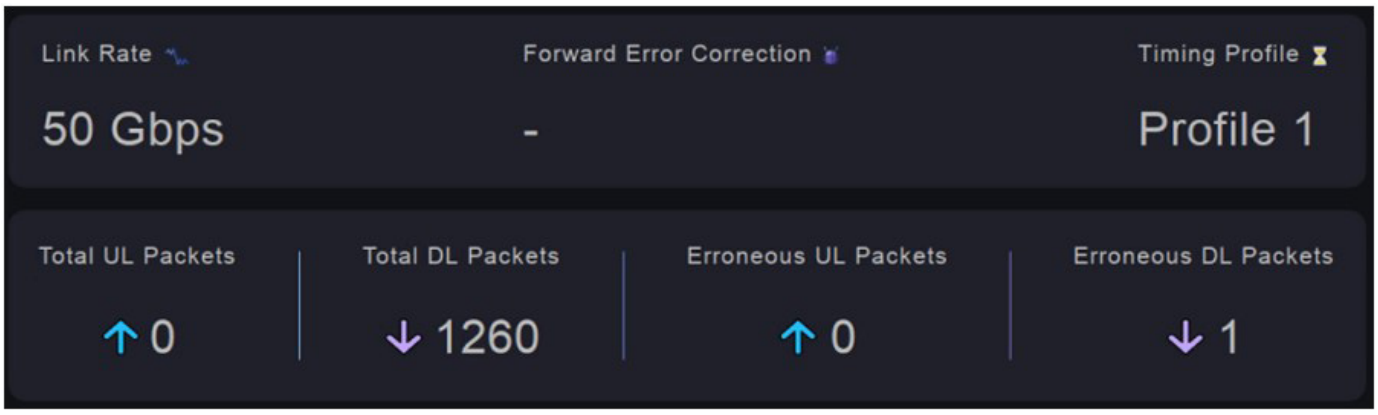

Figure 5: Summary of a 50 Gbps O-RAN link emulated in Veloce X-STEP.

Figure 6: Link utilization as the function of capture time.

Summary

With its unique O-RAN test capabilities, Veloce X-STEP ensures accurate protocol implementation and packet timings and, as a result, full interoperability between Fronthaul devices. Getting equipment to work reliably as part of a Fronthaul system is essential to the success of equipment manufacturers and the whole O-RAN community.

Siemens Digital Industries Software
siemens.com/software

Americas +1 314 264 8499
Europe +44 (0) 1276 413200
Asia-Pacific +852 2230 3333

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