VIAVI Solutions

TIMING and SYNCHRONIZATION

Vital for 5G-NR TDD Network Success

NEW USE CASES

5G Enables the Flexibility to Support:

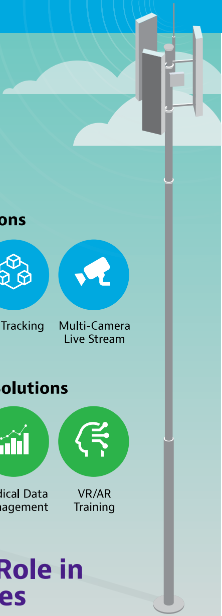
High Throughput
Enhanced Mobile Broadband (eMBB)

Low Latency
Ultra Reliable Low Latency Communications (URLLC)

High Connection Density
Massive Device Capacity

Stringent, Demanding Synchronization

THE CHALLENGES



5G is a Brave New World of Complexity with Much Stricter Requirements

Per ITU-T standards recommendation, both 5G-NR TDD and LTE-TDD networks need to be phase synchronized to limit the end-to-end time error to under 1.5μs.

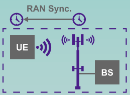
Industrial Automation

- Predictive Maintenance
- Strong Data Security
- Public Network

Automotive Solutions

- 3D Location
- Cloud Services
- Telemetrics

5G End-to-End Synchronization Use Cases



Event Solutions

- Drone Security
- 3D Tracking
- Multi-Camera Live Stream

Healthcare Solutions

- Online Consultations
- Medical Data Management
- VR/AR Training

Timing and Synchronization Play a Critical Role in Varied Network Configurations and Features

Frame Sync	**LTE/ 5G-NR TDD**	Slot Frame Coordination with Adjacent LTE or 5G	Signal Drift between Adjacent Cells	Poor Cell Performance (Capacity, Throughput, etc.).
Time Sync	**LTE/ 5G-NR /CoMP/OTDOA**	<1µs Relative OTA	RF Signal Coordination	Location Accuracy, Spectral Efficiency
Time Sync	**LTE/ 5G-NR TDD/ eCIC**	~1.5µs Absolute	Interference Management/ Coordination	Poor Performance, (Interference, Capacity, etc.)
Time Sync	**LTE/ 5G-NR/eMBMS/CA**	~3-5µs Absolute	Video Decoding Carrier Aggregation	Poor Video Quality and CA Failure, Low Throughput
Time Sync	**LTE/ 5G-NR FDD**	~10µs Absolute	Time Slot Alignment	Accessibility and Retainability

Frequency Synchronization = 500ppb Absolute

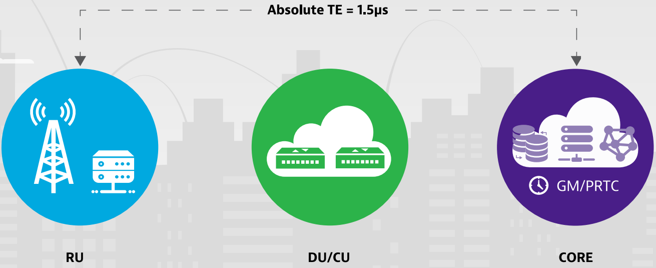
More

Stringent Synchronization

Less

5G Raises the Bar on Synchronization, Speed and Accuracy

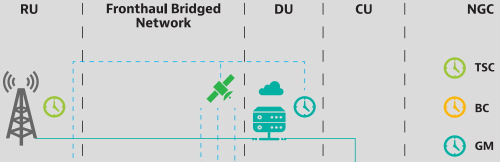
Regardless of RU, DU and CU location, Total Time Error between RU and the Grand Master cannot exceed 1.5µs.



THE TECHNOLOGY

Timing and Synchronization Configuration Options

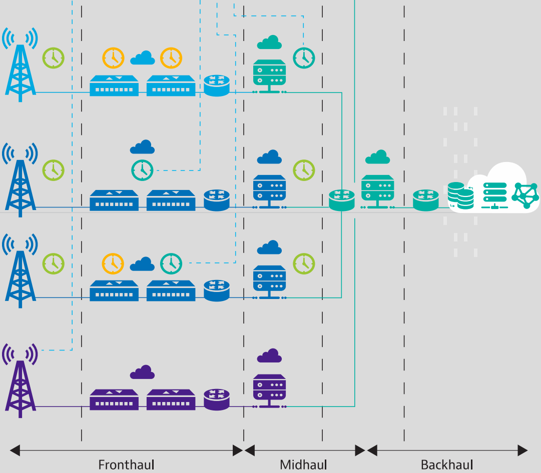
- Timing from DU to RU via point-to-point topology
- DU is PTP GM Clock
- RU is PTP Slave Clock
- No Ethernet switches



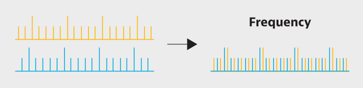
- Timing from DU to RU with one or more Ethernet switches
- DU is a PTP GM Clock
- Ethernet switches must be either Boundary Clocks (BC) or Transparent Clocks (TC)
- RU is a PTP Slave Clock

- Timing from GM to both DU and RU
- One or more Ethernet switches are present in the fronthaul network
- DU is a PTP Slave Clock
- RU is a PTP Slave Clock

- Local time source (typically a GNSS receiver) integrated into the RU
- Ethernet network between DU and RU is unreliable
- PTP is not used

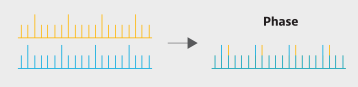


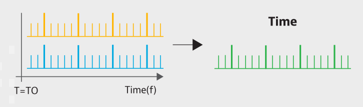
Forms of Synchronization



Frequency — Two clocks that are aligned in terms of their repeating interval (i.e., frequency) but not in terms of phase or time.

Phase — Two clocks that are aligned in terms of their repeating interval (i.e., frequency), and also phase (a one-second interval), but without a common time origin.





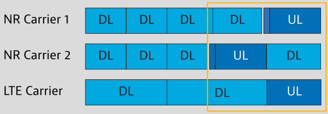
Time — Two clocks that are aligned in terms of their repeating interval (i.e., frequency), their phase (a one-second interval), and sharing a common time origin.

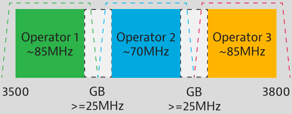
Frame — A compatible frame structure to avoid simultaneous UL/DL transmission, which determines a specific DL/UL transmission ratio and frame length.

Getting Interference Out...Better Performance In

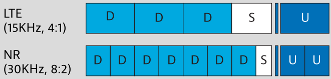
Without Synchronization

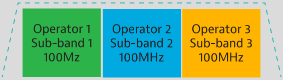
Interference





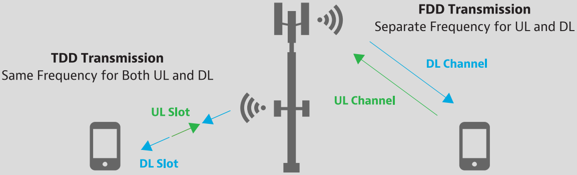
With Synchronization





Both Uplink and Downlink are on the Same Frequency

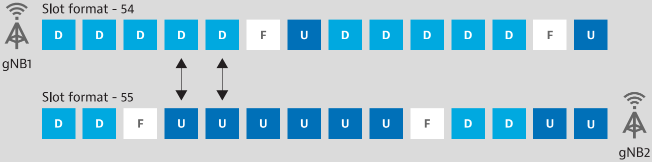
Because TTD has uplink and downlink transmission sharing the same frequency, there is a much greater likelihood of interference.



A Matter of Filling the Right Slots

Just like LTE, 5G radio frames have a fixed duration of 10ms. Each radio frame contains ten 1ms subframes. How it differs from LTE is that in 5G-NR, subcarrier spacing changes the number of slots and symbols per subframes.

Release 15 version of 3GPP 38.213 has defined 56 slot formats, each of which is a predefined pattern of downlink/flexible/uplink symbols during one slot. Service providers can use these different formats to flexibly accommodate different types of service. QoS issues may arise when two networks offering different types of service are located next to each other. Though they may be synchronized in time, interference can result if their slot formats are not synchronized.



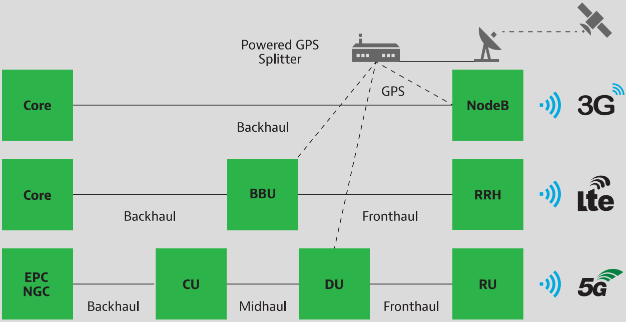
Slot format - 54
D D D D D F U D D D D D F U

Slot format - 55
D D F U U U U U U F D D U U

5G Network Topology Changes

CPRI, (a synchronous fronthaul interface) which is the technology used today for LTE, may not be practical for all 5G use cases. CPRI enforces stringent delay requirements which are well-suited for centralization, but can cause difficulties with bandwidth and node flexibility.

CPRI is not very efficient in terms of statistical multiplexing and cannot scale to the demands of 5G, especially for massive MIMO and larger bandwidth increments. The required bandwidth and antennas in a 5G scenario would push the CPRI bandwidth above 100Gbps. That is why the scalability of Ethernet is better-suited for fronthaul and midhaul applications.


Powered GPS Splitter

GPS

Core
Backhaul
NodeB
3G

Core
Backhaul
BBU
Fronthaul
RRH
lte

EPC NGC
Backhaul
CU
Midhaul
DU
Fronthaul
RU
5G

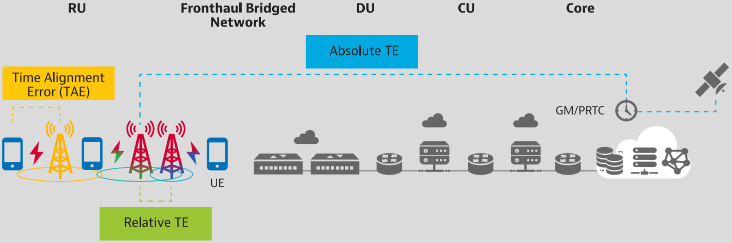
THE POTENTIAL ERRORS

Time and Time Alignment Errors

Time Alignment Error is the time difference between two antenna ports, measured over the air using GPS or a common timing source as a reference. GPS receivers have historically been the most common time synchronization source for cell sites, but they may not be cost-effective for 5G.

Relative Time Error is the time difference between inputs into two radio units. Relative TE requirements are essential for advanced features including carrier aggregation, MIMO, CoMP, and location-based services.

Absolute Time Error is the time difference between a node and PRTC which is the Grand Master time reference. It can be measured using the precision timing protocol (PTP) for a 5G-NR TDD system; ITU-T recommends 1.1 microseconds up to the access point.


RU
Fronthaul Bridged Network
DU
CU
Core

Absolute TE

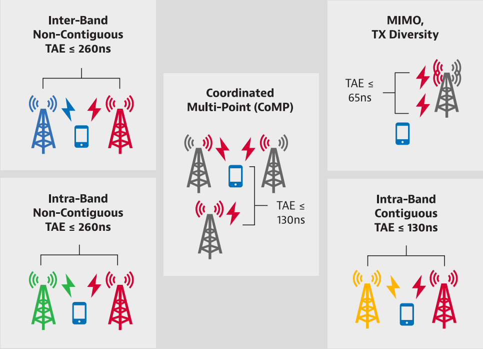
Time Alignment Error (TAE)

GM/PRTC

UE

Relative TE

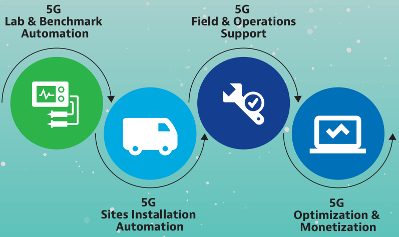
- 🟧 Low Frequency Band: Carrier 1
- 🟩 Low Frequency Band: Carrier 2
- 🟦 High Frequency Band
- ▨ Inter-Band Non-Contiguous TAE ≤ 260ns
- ▨ Intra-Band Non-Contiguous TAE ≤ 260ns
- ▨ Intra-Band Contiguous TAE ≤ 130ns


Inter-Band Non-Contiguous TAE ≤ 260ns
Intra-Band Non-Contiguous TAE ≤ 260ns
Coordinated Multi-Point (CoMP)
TAE ≤ 130ns
MIMO, TX Diversity
TAE ≤ 65ns
Intra-Band Contiguous TAE ≤ 130ns

THE ROLE OF TEST AND MEASUREMENT

From Lab to Field to Assurance, Testing is Essential Through Every Stage of the 5G Lifecycle

Testing and assuring with VIAVI means connecting and communicating point-to-point, engineer-to-engineer. There's technical timing and synchronization enhancing your network's performance, and there's the human timing and synchronization that goes into every VIAVI and client relationship.


5G Lab & Benchmark Automation
5G Field & Operations Support
5G Sites Installation Automation
5G Optimization & Monetization

As a leader in test and measurement, VIAVI offers the most comprehensive Timing & Synchronization validation solutions and is currently the only provider offering such testing for 5G TDD deployment.

THE SOLUTIONS

The VIAVI T-BERD®/MTS-5800-100G along with OneAdvisor 800 Wireless can perform all required timing and synchronization tests for all types of 5G networks. They measure throughput, delay, packet jitter, timing, and frame synchronization to ensure backhaul, midhaul, fronthaul, and air interface meet designed network specifications.

Applications include:

GPS Signal/Satellite Coverage Test
It is important to check GPS signal stability and suitability for the GPS antenna location at the time of installation, and periodically after installation as conditions around the site may change. The VIAVI T-BERD/MTS-5800 tests GPS signals using an integrated GPS receiver and provides the number of visible satellites, signal strengths and satellite lines of sight.

PTP Timing Error Test
Using two VIAVI portables (either a T-BERD/MTS or OneAdvisor 800 Wireless), one of which works as a PTP slave, an engineer can check connectivity to the PTP grand-master and determine if the timing error is within requirements.

Frequency and Time Error Validation
Using a VIAVI OneAdvisor 800 Wireless, an RF engineer or technician can quickly validate over-the-air frequency and time errors, ensuring synchronization conforms to the +/- 1.5µs vs UTC. This can be tested for the adjacent channel network as well.

5G-NR Frame Format Validation
To prevent intercell interference between adjacent networks, validating an adjacent network's conformity to the agreed slot and frame formats is critical. Using a OneAdvisor 800 Wireless, service providers can easily validate frame format for multiple operators through over the air measurements.

Synchronization Issue Resolution in the Field
Service providers experiencing RF performance issues—handover failure, poor throughput, compromised QoS, and lower accessibility and retainability—can work with VIAVI engineers using the OneAdvisor 800 Wireless with NSA Signal Analysis to conduct over-the-air tests that quickly troubleshoot, pinpoint and resolve synchronization problems.

Network Timing and Synchronization
The field-optimized Timing Expansion Module Version 2 (TEM V2) helps network operators maintain precise synchronization by delivering industry-leading accuracy to field portable timing and synchronization measurements.

T-BERD/MTS-5800-100G

OneAdvisor 800 Wireless

Timing Expansion Module V2

VIAVI

Application Note

5G Timing and Synchronization Handbook for TDD Deployment

Read the **Timing and Synchronization Handbook** and visit **VIAVI** online for more 5G insights on timing and synchronization in TDD networks.

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