

TimeProvider® 2700

Edge Grandmaster Clock



Features

- IEEE 1588-2008 Precision Time Protocol (PTP) grandmaster
- GNSS (GPS and GLONASS), Primary Reference Time Clock (PRTC)
- Mitigates impact of backhaul noise, packet delay variation, and asymmetry
- Multiple PTP profile support
- IPv4 and IPv6 PTP profile support
- Scalable PTP output capacity
- Gigabit Ethernet interfaces
- Synchronous Ethernet, input and output
- E1/T1, input or output (option)
- 10 MHz, PPS, and TOD output
- PTP input (option)
- DC or AC power models
- OCXO or rubidium holdover oscillator models
- Local and remote CLI, web interface, SNMP traps
- TimePictra Synchronization Management System support

Benefits

- Sync solution for the mobile network edge: 4G/LTE and small cells
- No change out or upgrade of network hardware
- Mitigates impact of backhaul noise, packet delay variation, and load asymmetry
- Synchronization protection for high network availability
- Preserves current MPLS network engineering

Applications

- LTE-FDD, LTE-TDD, LTE-A networks
- Ethernet backhaul networks

The Microsemi TimeProvider 2700 is an IEEE 1588 Precision Time Protocol (PTP) grandmaster scaled and optimized to enable deployment of small cells and meet the stringent phase timing and synchronization requirements of 4G/LTE networks. It is designed for deployment in networks with or without on-path timing support from PTP boundary clocks.

With an integrated GNSS receiver (GPS or GLONASS), TimeProvider 2700 meets applicable performance requirements of the ITU-T G.8272 standard for a Primary Reference Time Clock (PRTC). The TimeProvider 2700 offers the optional capability to accept PTP input and operate as an advanced gateway clock to complement and backup the GNSS signal. Additional output capabilities allow it to support legacy frequency timing applications, including E1/T1, 10 MHz, pulse per second (PPS), and time of day (TOD).

When deployed with Microsemi's TimePictra® Synchronization Management System, carriers can also benefit from superior monitoring information and management capabilities.

Edge Master Clocks

The continuing evolution of mobile network technologies has driven the need for increased accuracy and greater availability of timing and synchronization signals. At the same time, backhaul networks with high packet delay variation present timing jitter variation and asymmetry challenges that are difficult to solve with current solutions. Furthermore, deploying a GNSS receiver at every location is impractical, particularly in many small cell environments. Together, these issues create the need for a new overall synchronization distribution architecture for LTE networks.

Edge master clocks are PTP synchronization solutions designed for deployment in current networks by locating a grandmaster at or near the edge or by overlaying the network with advanced gateway clocks at planned locations. They enable mobile network transitions to include small cells, and they support the stringent LTE-TDD and LTE-A phase and time requirements without overhauling the current backhaul network. In frequency synchronized networks, edge master equipment can be deployed to eliminate timing issues caused by diverse technologies in the backhaul network, high packet delay environments, and asymmetry inherent in Carrier Ethernet networks.

The TimeProvider 2700 is a PTP grandmaster scaled for deployment at or near the edge of the backhaul network instead of closer to the network core. Also included in the edge master category, the TimeProvider 2300 is an advanced PTP boundary clock which can be deployed at select locations in the backhaul network to support precision time distribution to the mobile base stations. Together, edge master products enable synchronization distribution solutions that allow the mobile network to continue to evolve without retrofit of existing backhaul equipment and without changes to current network design or switching/routing policies.

TimeProvider 2700

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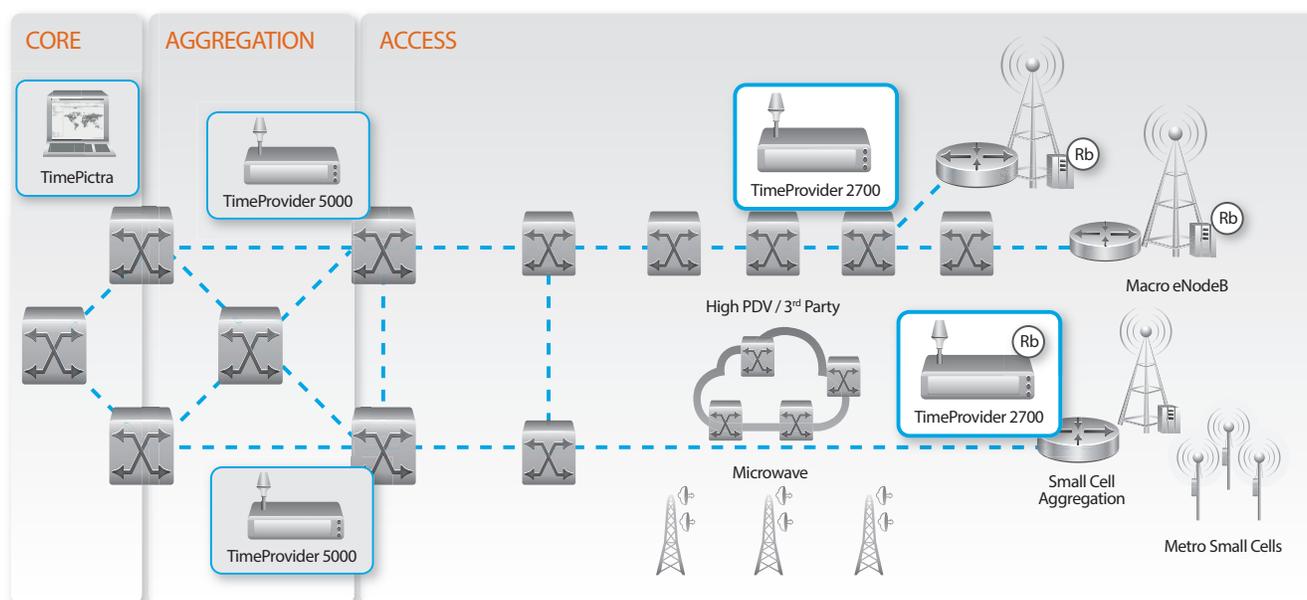
Meeting Stringent Synchronization Accuracy Requirements

Synchronization accuracy requirements have gone from relatively routine frequency specifications (16 ppb on the network side, 50 ppb for the air interface) to time and phase requirements as tight as $\pm 1.5 \mu\text{sec}$. GNSS/GPS receivers co-deployed or integrated into the mobile base stations are not always a feasible solution for either technical or economic reasons (satellite visibility and antenna deployment costs, for example). Primary Reference Time Clock performance, specified by ITU-T G.8272, meets the accuracy requirements using a GNSS signal (GPS or GLONASS) as a reference, and the IEEE 1588 PTP can deliver the needed accuracy under the right conditions. However, backhaul networks with many hops and asymmetric paths between the grandmaster and the PTP client; multiple transport technologies; or high packet delay variation due to loading or other issues cannot be sure to consistently meet the required specifications.

One solution is to upgrade the backhaul network for Synchronous Ethernet and include a PTP boundary clock in every transport element. This is the approach in ITU-T G.8275.1 with full timing on-path support from the network. This solution requires that

every network element between the grandmaster and the client support Synchronous Ethernet and include a boundary clock function—a solution that is not always feasible due to the high cost to upgrade a network or because the mobile carrier employs third-party networks for backhaul. Furthermore, operating at Ethernet Layer 2, G.8275.1 may obsolete or conflict with the current MPLS network design and provisioning policies of the backhaul network.

An alternate solution is to deploy an edge master class of product, using the approach proposed in G.8275.2. The following illustration depicts TimeProvider 2700 at or near the eNodeB locations. This deployment mitigates or eliminates issues introduced by the performance of the backhaul, and therefore, makes unnecessary the need to upgrade the entire backhaul network to include boundary clocks in every network element. Operating over existing networks at Layer 3, this solution also preserves current MPLS and other network provisioning policies and engineering practices, and it is compatible with and leverages previous investment in using the G.8265.1 profile for frequency synchronization.



Grandmaster at or Near the Edge

TimeProvider 2700 grandmasters are deployed in locations that ensure timing and synchronization at the base stations are within specification, mitigating asymmetry and eliminating issues that may result from noisy or third-party backhaul.

The TimeProvider 5000 PTP grandmaster provides an enhanced level of protection, enabling grandmasters at the edge of the network to hold synchronization for longer periods when GNSS signals are impaired. Rubidium oscillators, either in the base stations or the PTP grandmaster, also extend the holdover period. In the grandmaster, investment in the high-grade oscillator is leveraged across multiple base stations.

The TimePictra Synchronization Management System provides remote management of the synchronization equipment and visibility of all PTP clients.

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GNSS (GPS and GLONASS) and Small Cells

Integrated GNSS receivers are a viable alternative for timing of macro eNodeB equipment, though operations would still be jeopardized by the well-publicized vulnerabilities of GNSS systems, and so using network distributed synchronization at least for backup is considered best practice. Metro or public access small cells present new challenges for synchronization. They require stringent accuracy, but are often deployed in locations where adequate GNSS signal reception is not feasible (indoors, tunnels, and urban canyons, for example). TimeProvider 2700 is designed for cost-effective deployment at the small cell aggregation sites. From this location, most small cell backhaul links can support distribution of PTP timing to small cell base stations. Should the small cell backhaul links themselves include many hops or high packet delay variation (PDV), the problem can be solved by deploying an advanced boundary clock at selected small cell network nodes.

Protected Synchronization

As tight phase synchronization becomes more essential to the normal operation of the network (Inter-Cell Interference Coordination, for example) the negative impact of losing synchronization becomes more significant. The overall synchronization distribution architecture enabled by TimeProvider 2700 offers cost-effective ways to provide protection.

As shown in the previous illustration, it is likely that a centrally located, high-capacity PTP grandmaster is already in place to provide frequency synchronization through existing networks. Common practice includes deployment at multiple locations, allowing each grandmaster to provide backup for the others. The edge deployment of grandmasters can leverage this investment by incorporating a PTP client as an input to TimeProvider 2700. Now operating with PTP backup protection with automatic asymmetry compensation, the edge grandmasters can use the backhaul distributed synchronization to complement the GNSS input and extend the holdover period when satellite signals are impaired or lost due to natural, accidental, or malicious causes (antennas knocked down in storms, cables damaged, jammers and spoofing).

Rubidium oscillators provide another way to protect synchronization by delivering best-in-class holdover performance (phase timing of $\pm 1.5 \mu\text{sec}$ for up to 24 hours). Often seen as expensive upgrades for individual macro base stations, rubidium oscillators in the grandmaster are now more affordable as their cost is amortized across an entire cluster of small cells and co-located macro base stations.

TimeProvider 2700 Equipment

TimeProvider 2700 PTP grandmaster standard capabilities include either a GPS or GLONASS input, allowing it to fulfill the requirements as a Primary Reference Time Clock, as defined by the ITU-T G.8272 standard for phase and time synchronization, as well as G.811 for frequency reference. TimeProvider 2700 provides two gigabit Ethernet interfaces in a combo port configuration supporting use of either copper or optical

connections. Synchronous Ethernet is supported on the input and output ports. Multicast operations support substantially high client counts. Client capacity can be increased in the field with software license options. TimeProvider 2700 is available with either an OCXO or rubidium oscillator, each delivering a different level of phase and frequency holdover performance and allowing operators to better optimize their network SLAs. TimeProvider 2700 includes a programmable 10 MHz or 1 PPS BNC port and a PPS+TOD RS422 on an RJ45 connection. Models with either dual-DC or single-AC power input are available. Using passive cooling, TimeProvider 2700 has no fans.

TimeProvider 2700 Software License Options

Licensed software options for TimeProvider 2700 include:

Greater client capacity: PTP client capacity in deployed units can be increased with a simple licence key installation, allowing network engineers to design for capacity they need today and be protected for increased requirements in the future.

Concurrent GPS and GLONASS: The base configuration allows the choice of either the GPS or the GLONASS GNSS system for the primary reference signal. A software license option enables support for both GPS and GLONASS concurrently, providing a greater level of sync network protection against GPS jamming alone.

PTP input: Employing PTP distributed over the backhaul network provides a backup to GNSS, allowing the oscillator to hold accurate timing longer than otherwise possible. The PTP client option, enabling PTP backup protection, includes advanced algorithms that compensate for network asymmetry—particularly important for LTE-TDD and LTE-A networks with tight phase synchronization requirements.

E1/T1 input/output: The E1/T1 software option activates this port for use as either an input or output. As an input, the signal provides a frequency reference to the clock function. As an output, it can be used for synchronization of equipment using this established timing reference.

Default profile: Enables Layer 3 multicast capabilities for operation in additional network scenarios.

IPv6 PTP support: Allows the PTP ports to be configured as IPv4 or IPv6.

Deployment of 4G/LTE networks and small cells present new technical and economic issues for network planners and engineers. A major challenge is to meet stringent timing requirements over backhaul paths that were not originally designed to deliver synchronization at the level of accuracy needed. Upgrading the backhaul network or deploying GNSS receivers at every base station and small cell is often not possible for technical or economic reasons. A new type of synchronization equipment is needed: the TimeProvider 2700 PTP Grandmaster enables synchronization architectures that are more feasible for many network scenarios.

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Specifications

GNSS Receiver

- 32-channel GNSS L1 receiver
- Choice of either GPS: 1575.42 MHz or GLONASS: 1601.5 MHz, software configurable
- Connector to antenna: SMA (f)
- Impedance: 50 Ω
- Voltage to antenna: 5 VDC

Interfaces

- 1 AC power model, IEC 60320 C14 socket
- 1 DC power model, dual $-48 V_{DC}$ terminal block
- 1 Reset button
- 1 RS232 serial console port, (57,600 bps), DB9
- 1 Gigabit Ethernet management port
 - Shielded RJ45, 100/1000BASE-T Ethernet
- 2 Gigabit Ethernet: PTP/SyncE input and output combo ports support:
 - Shielded RJ45, 100/1000BASE-T Ethernet
 - SFP (optical), 1000BASE-X
- One combo port is reserved for use as a PTP output (master) and the other combo port is reserved for use as an optional PTP input (client)
- 1 E1 or T1 input or output, software configurable, shielded RJ45 (option)
 - G.703/9, G.823/G.824 sync interface compliance
- 1 Time of Day (TOD) output port, RS422 data (9600 Baud) with pulse per second (PPS) signal, shielded RJ45
- 1 10 MHz or 1PPS output port, BNC (f)
- 1 L1 GNSS input port, SMA (f), 50 Ω
- 2 Grounding lugs

IEEE 1588-2008 PTP Support

- PTP output client capacity: 8 in basic models, expandable to 512
- Up to 128 messages per second per unicast client at full client capacity
- One-step and two-step clock
- PTP profiles
 - ITU-T G.8265.1
 - Telecom-2008
 - ITU-T G.8275.1
 - ITU-T G.8275.2
 - Ethernet-Default Profile (Layer 2 multicast, IEEE 1588-2008 Annex F)
 - Default Profile (Layer 3 multicast, IEEE 1588-2008) (optional)
- VLAN (802.1Q, 802.1p), up to 64 unique VLANs
- Best Master Clock Algorithm (BMCA)

IEEE 1588-2008 PTP Input (Optional Licensed Feature)

- PTP profiles
 - ITU-T G.8265.1
 - Telecom 2008
 - ITU-T G.8275.1
 - ITU-T G.8275.2
- Automatic asymmetry compensation
- Multi-sync function uses both PTP input and a frequency input (SyncE or E1/T1). All configurable using reference priority or reference quality.

Time and Frequency Accuracy

- When tracking and locked to GNSS, time is within 100 ns of UTC (conforms to ITU-T G.8272 sec. 6 for PRTC).
- When tracking and locked to GNSS, or to a Cesium PRC, frequency is G.811 frequency accuracy.

Holdover Performance

Oscillator	Phase $\pm 1.5 \mu\text{sec}$	Phase 5 μsec	Phase 10 μsec	Freq 16ppb
OCXO	1 hour	4 hours	12 hours	1 month
Rubidium	24 hours	3 days	5 days	5 years

Holdover values are approximate and assume operation at constant temperature; no initial frequency or phase offset; and that the unit has been powered on for 2 weeks and locked to GNSS for three consecutive days.

Synchronous Ethernet

- SyncE can be used as a frequency input or generated as an output (as a master).
- Conforms to relevant sections ITU-T G.8261, G.8262, and G.8264 Ethernet Synchronization Message Channel (ESMC)

Network Support

- IPv4 management port
- HTTP/HTTPS/SSL
- ICMP (RFC 792)
- DHCP Client (RFC2131)
- IEEE 1588-2008 PTP (IPv4 or IPv6)
- IEEE 802.1Q, 802.1p VLAN filtering/tagging
- DSCP

Mechanical

- Size: 1 RU
- Height: 1.73 in. (44 mm)
- Width: 17.24 in. (438 mm)
- Depth: 9.30 in. (237 mm); 10.07 in. (256 mm) with connectors on faceplate
- Rack mounts: 19 in. and 23 in. options
- Weight: AC power models: 7.6 lbs (3.5 kg)
DC power models: 8.1 lbs (3.7 kg)

Environmental

- Acoustic noise level: 0 dBA (negligible due to passive cooling)
- Operating temperature
 - OCXO models: -40°C to 65°C , cold start at -20°C
 - Rubidium models: -5°C to 55°C
- Storage temperature: -40°C to 70°C
- Relative humidity: 5% to 95%

Power

- DC power models: dual power feeds, $-38.4 V_{DC}$ to $-72 V_{DC}$
- AC power models: 90 V_{AC} to 264 V_{AC}, 50/60 Hz
- Power consumption
 - OCXO model with DC supply: 20 W (max), 17 W (typical)
 - Rubidium model with DC supply: 28 W (max), 20 W (typical)
 - OCXO model with AC supply: 43 W (max), 37 W (typical)
 - Rubidium model with AC supply: 60 W (max), 43 W (typical)

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EMC Compliance

- FCC Part 15 (Class A)
- AS/NZS CISPR22 (Class A)
- EN55022 (Class A)
- KN55022 (Class A)
- ICES 003 (Class A)
- VCCI (Class A)
- EU 2004/108/EC Electromagnetic Compatibility Directive
- EN 300 386 Telecommunications Network Equipment (EMC)

EMC Immunity

- EN55024 (Class A)
- KN55024 (Class A)
 - EN-61000-4-2 ESD
 - EN-61000-4-3 radiated immunity
 - EN-61000-4-4 EFT
 - EN-61000-4-5 surge
 - EN-61000-4-6 low frequency common immunity
 - EN-61000-3-2 power line harmonics
 - EN-61000-3-3 voltage fluctuations/flicker
 - EN-61000-4-11 voltage dips and sags

Safety Compliance

- UL/CSA 60950-1 (2nd edition)
- CAN/CSA-C22.2 No. 60950-1 (2nd edition)
- IEC 60950-1 CB Scheme (2nd edition)
- EN60950-1 (2nd edition)
- CE mark

Environmental Compliance

- EN300-019-2-3, Class T3.2
- ETSI EN 300 019-2-2 (1999): Transportation, Class T2.3
- ETSI EN 300 019-2-1 (2000): Storage, Class T1.2
- RoHS (6 of 6)

Network Equipment Building System

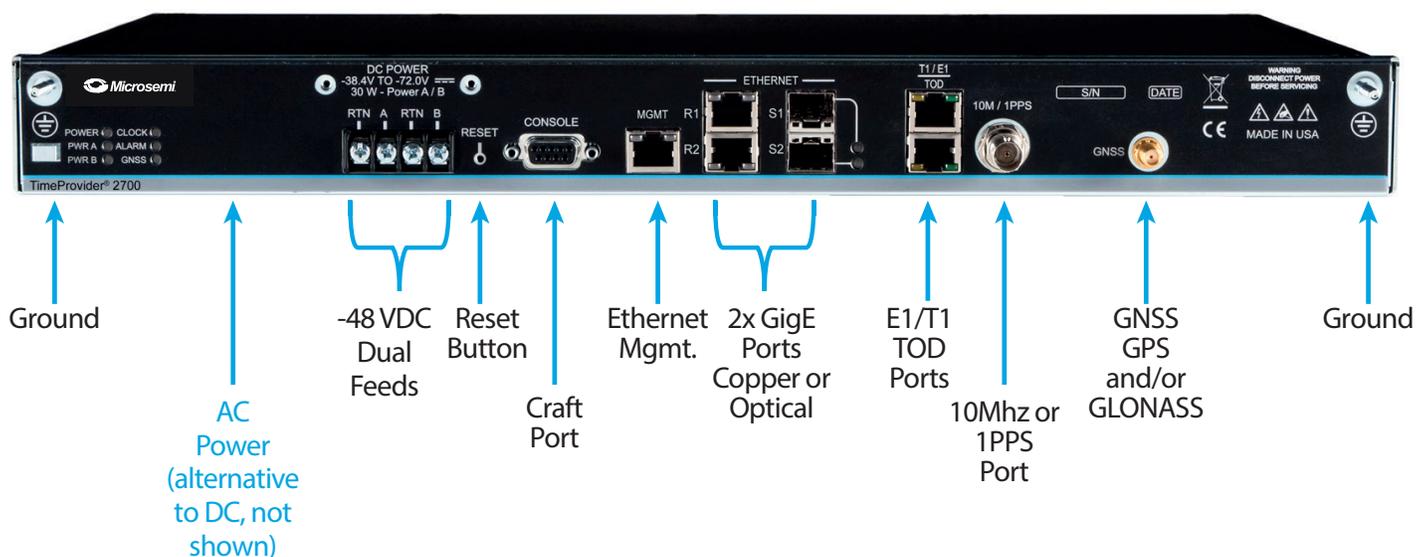
- NEBS Level 3 (when following deployment guidelines as specified in the user manual), GR-1089

Management and Security

- SNMP v2c, v3 traps
- SYSLOG
- CLI, local (serial) and remote (telnet/SSH)
- Web interface (HTTP/HTTPS)
- Multi-level user access
- Ability to disable management interfaces
- Remote software upgrade and rollback
- TimePictra® Management System (purchased separately)

Models and Options

- TimeProvider 2700 edge grandmaster clock
 - 8 PTP client capacity, upgradable
 - Rack mount ears and screws
- Power supply models: AC or DC
- Oscillator models: OCXO or Rubidium
- SW license options
 - PTP client capacity expansion options
 - PTP Input license
 - IPv6 support for PTP ports
 - Enable E1/T1 port
 - Enable concurrent GPS and GLONASS
 - Enable PTP default profile (Layer 3 multicast)
- Hardware accessories (not included)
 - AC power cords
 - Ethernet optical SFP transceivers
 - GNSS antenna and cable kits



TimeProvider 2700 Physical Outline

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Packet Delay Variation (PDV) and Asymmetry

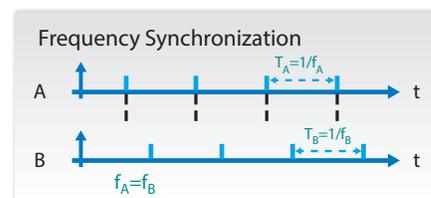
Timing and synchronization, fundamental in all mobile networks, is even more critical as small cells are added and networks evolve to LTE-TDD and LTE-A technologies. Backhaul network performance can dramatically impact PTP timing accuracy, and thereby the mobile network itself—affecting service quality and customer satisfaction.

The problem is packet delay variation (PDV), which represents the change in latency from packet to packet. Packet delay itself has no effect on the accuracy of the clock, as constant delay would allow an accurate time offset calculation by the PTP client. Variable delay, however, induces noise in the PTP client's perception of the time at the master, which can result in variation in time calculations based on the time stamps in the PTP packets.

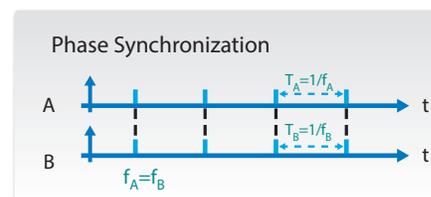
Delay can vary as PTP packets are processed, buffered, and queued along with the payload traffic through the network switches and routers, and it tends to be correlated to network load that can be highly asymmetric in nature. As the amount of traffic in the network increases, the delay variation is also likely to increase. Asymmetry is also introduced by the physical topology of the network as packets travel different and changing paths in the upstream and downstream directions.

Time accuracy is affected by both the magnitude of this variation and how effective the client is at removing this noise. TimeProvider 2700 incorporates Microsemi's advanced PTP client technology and a high-quality reference oscillator. With a GNSS reference, advanced algorithms effectively filter this noise, allowing the timing signal at the base station to remain within specification.

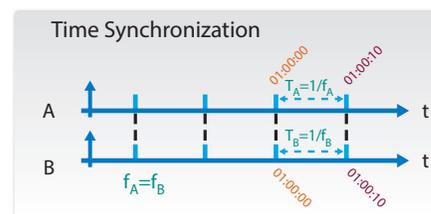
Frequency, Phase, and Time Synchronization



Leading edge of the pulses are at same pace, but not at the identical moment.



Leading edge of the pulses are at the identical moment.



Leading edge of the pulses are at the identical moment and identical time.



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