TimeProvider® 4100 Release 2.1

Precise Timing Grandmaster With Gateway Clock, PRTC-B and Virtual PRTC

New Versions Highlights

Release 2.1 builds upon release 2.0 by adding virtual PRTC (vPRTC) as well as PTP & NTP enhancements.

Virtual PRTC (vPRTC) is the ability to engineer a redundant distribution architecture for phase protection that delivers guaranteed PRTC precision (100ns) over an optical network deployment without dark fiber investments.

Release 2.1 also introduces NTPd with MD5 security in addition to NTPr.

NTPr & PTP Monitoring now supported on Expansion Module Ports.

Key Features

- IEEE 1588v2 Precision Time Protocol (PTP) grandmaster
- SyncE
- NTP Reflector with highest capacity and NTP Daemon (NTPd) adds NTP MD5 authentication
- GNSS (GPS, GLONASS, BeiDou, QZSS and Galileo)—and SBAS support
- Primary Reference Time Clock (PRTC) Class A and Class B
- Oscillator options—mini OCXO, OCXO and Rubidium (Rb)
- IPv6/IPv4 on all ports including Management (OAM)
- Standard base unit with 8 Ethernet ports, 4 E1/T1 ports, 1 craft port, 2 × 1PPS/ToD ports, 2 × 1PPS/10 MHz ports
- Optional internal expansion module with 16 E1/T1 ports for a total of 20 E1/T1 outputs per unit
- Optional internal expansion module with 4 SFP and 4 SFP+ for 10G support, 100M Fast Ethernet, and 1G fanout
- Support for multiple IEEE 1588v2 profiles per unit
- Support for: Management and Client and client or master
- Support for high-performance boundary clock with class C and D accuracy (New Operation Mode)
- High performance: 790 PTP unicast clients at 128 PPS and NTPr 20,000 tps per port, for a total of 180,000 tps per unit and NTPd at 500 tps on 3 ports for a total of 1,500 tps per unit
- Fully supports ITU-T profiles for phase synchronization: G.8275.1 and G.8275.2
- Fully supports ITU-T profiles for frequency synchronization: G.8265.1, Telecom 2008 and default
- ITU-T G.8273.4 APTS with enhanced automatic asymmetry compensation over multiple network variations
- Monitoring and measurement capabilities
- TimePictra® synchronization management system support

Benefits

- Sync solution for the mobile edge: 4G/LTE, cRAN, 5G
- Flexibility to leverage legacy and new investments
- Mitigates impact of backhaul noise, packet delay variation and asymmetry
- Preserves current MPLS network engineering

Applications

- LTE-FDD, LTE-TDD, LTE-A networks, CRAN, 5G
- Ethernet backhaul networks, cable remote PHY

Operation Modes

TimeProvider® 4100 is a device that can support multiple modes of operations. Release 1.0 introduced the Gateway Clock operation mode. Release 2.0 introduces the Single Domain High Performance Boundary Clock mode of operation. Release 2.1 introduces the Multi-Domain High Performance Boundary Clock mode of operation for a fully resilient PTP operation with two active boundary clock instances.

Each operation mode leverages a specific set of inputs as reference. In terms of outputs a fully featured multi-protocol grandmaster clock is available as well as monitoring of external timing inputs.

Gateway Clock Mode

TimeProvider 4100 is a gateway clock, a new class of synchronization product that accepts multiple inputs from Global Navigation Satellite Systems (GNSS), Synchronous Ethernet (SyncE), and 1588 PTP and E1/T1 digital transmission links, and distributes timing flows to multiple endpoints such as base stations. A gateway clock benefits from multiple layers of protection leveraging other assets in the core of the network.

TimeProvider 4100 is a best-in-class 1588 grandmaster complemented by extensive port fan-out for PTP, Network Time Protocol (NTP), SyncE, and legacy Building Integrated Timing Supplies (BITS). With multiple ports for current, legacy and future networks that can be connected to multiple base stations for 4G and 5G deployments, the device offers customers a cost-effective solution that can be easily adapted for a wide variety of use cases.

Virtual PRTC (vPRTC)

Up until recently the main source of precise time has been GPS and other similar regional constellations broadly known as GNSS. However, deployment of GNSS can be expensive given the increasing densification of end points. Operators are very motivated to find solutions where GNSS dependency is reduced or even eliminated at many locations.

Protecting the mobile network against GNSS disruption and distributing precise time over long distance for national coverage and protection requires a different time distribution architecture as well as performances in order to meet end-to-end budget for 5G needs.

This new architecture prescribes:

- to leverage the existing optical network (thus avoiding high cost draf fiber expenses)
- to use of a dedicated lambda in order to transport time in the most rapid manner to protect to the utmost level
- a redundant source of time that meets the highest performance in the form of enhanced PRTC (ePRTC) which can meet 30 ns performance and that uses a combination of Cesium and GNSS as source of time
- to have two directions for the flow of time, East and West, so that a redundant path be leveraged in case of any issues along the way from source to end point
- to have a chain of high precision multi-domain high performance boundary clocks (MD HP BC) that can meet the highest level of performance defined by the standards today (T-BC Class D 5 ns)

This virtual PRTC multi-domain architecture is the only solution today for an affordable, highly performant, state-of-the-art, redundant sub 5-nanosecond distribution of precise time over hundreds of miles.

Best-of-Breed Master Clock

TimeProvider 4100 is an industry-leading grandmaster clock with a base model that offers multiple PTP profiles per unit, supporting IEEE 1588v2 frequency profiles such as Telecom 2008, G.8265.1, as well as the latest phase profiles such as G.8275.1 and G.8275.2.

It supports SyncE input and output, and is built on a best-in-class platform that associates connectivity to legacy networks as well as to the latest standards.

TimeProvider 4100 is based on Microchip's newest platform as well as its latest packet engine generation. This provides the utmost flexibility to support multiple packet services in the box, to specify the service on each port (master, client, probe, NTP), and to select management and client service on either an RJ45 or an SFP port (depending on the network and preference). This flexibility enables operators to select and benefit from the number and types of ports and interfaces that are necessary to deploy and scale for specific use cases including 5G, cRAN and DOCSIS remote PHY, without compromising performance or features.

Primary Reference Time Clock

TimeProvider 4100 meets stringent precise time standards and complies with Primary Reference Time Clock (PRTC) Class A (100 ns) and Class B (40 ns), as well as the latest time and phase standards.

PRTC Class B Use Cases

- ±130 ns fronthaul - PRTC at DU, TE ±40 ns
- TSN network - remove extraneous source clock noise
- Smart city PNT - connected vehicles, fast UE detection

GNSS Support

The 72-channel GNSS receiver coupled with Microchip's patented active thermal compensation technology. With the time source provided through GNSS satellite input, it is essential to provide flexible support for constellations of choice depending on the region. TimeProvider 4100 supports GPS, GLONASS, BeiDou, Galileo, QZSS and SBAS in its standard version.

Flexible Architecture

A key aspect of TimeProvider 4100 is its rich base platform with support for PTP, NTP and legacy frequency timing applications. The clock features 4 BITS ports (E1/T1), 2 1PPS/ToD ports, 2 1PPS/10 MHz ports, 1 GNSS port and 1 craft port.

Complementing its standard advanced feature set, TimeProvider 4100 offers optional expansion modules based on customer needs and deployment scenarios. Flexibility is of the utmost importance for enabling operators to select appropriate package, options and interfaces for their respective use cases and deployment models. TimeProvider 4100 offers two optional both E1/T1 and 1G/10G modules.

TimeProvider 4100 can leverage a sub-tenancy architecture whereby a slave can subtend from a master using a ToD input/output. The master is connected to GNSS constellations and is recommended to be upgraded to the Rubidium atomic clock oscillator, whereas the slave TimeProvider 4100 can simply feature a lower-cost oscillator without connectivity to GNSS. This architecture enables double the port count of the solution.

Resilient Solution

TimeProvider 4100 is a fanless device, which minimizes the risks associated with rotation or moving parts. It also features passive heat sinks, which enables great scalability with SFP ports in the base chassis.

TimeProvider 4100 features layered protection and accepts PTP input with Microchip's enhanced asymmetry compensation to provide best-in-class Assisted Partial Timing Support (APTS) to backup the GNSS signal by correcting for up to 32 network path or behavior variations. APTS is a key technology that accounts for high packet delay variation, timing jitter variation and asymmetry challenges. As a second layer of protection, TimeProvider 4100 features optional oscillator upgrades for enhanced holdover performance.

Additional output capabilities enable support of legacy frequency timing applications, including E1/ T1, 10 MHz, PPS and ToD. TimeProvider 4100 also provides dual DC input for power redundancy and geographical network redundancy for failover.

Management

When deployed with Microchip's TimePictra synchronization management system, carriers can also benefit from superior monitoring information and management capabilities. TimeProvider 4100 features full FCAPS capabilities using TimePictra. Internal logging and SNMP are supported as well as security capabilities using SSH and firewall features. A separate management port can be selected either as RJ-45 or as an SFP port. In-band management is also supported.

In terms of monitoring, the focus is on helping customers with phase deployments. Monitoring PTP traffic is a primary focus with Time Error. 1PPS Monitoring is also available. A WebGUI is offered as user-friendly user interface for monitoring results, measurements and calculations. In 2.1 NTPr & PTP Monitoring are now supported on Expansion Module Ports.

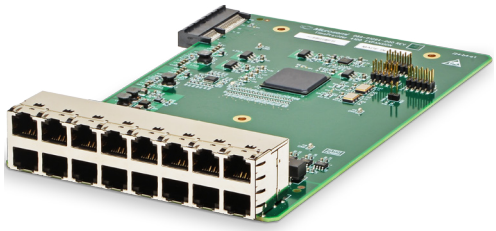
High Performance

High performance is another standard core attribute of TimeProvider 4100, which can support 790 PTP IEEE 1588v2 clients at the highest packet rate (128 PPS). Similarly, NTP support is achieved at a high performance either with NTPr at of 20,000 tps per port, for a total of 180,000 tps per unit due to utilization of hardware time stamping or with NTPd at 500 tps on 3 ports for a total NTPd performance of 1,500 tps per unit.

Optional Expansion Modules

TimeProvider 4100 provides the necessary flexibility to add internal expansion modules for various capabilities. The expansion module is an optional upgrade to the base unit.

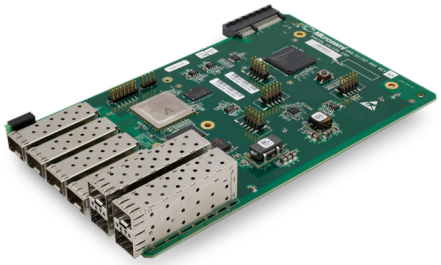
E1/T1 Expansion Module



The E1/T1 internal module with 16 E1/T1 ports brings the unit to a total maximum of 20 E1/T1 ports (4 in base and 16 in expansion module).

For needs beyond 40 E1/T1 ports, TimeProvider 4100 unit can be connected to an SSU or BITS system as a master reference with full PRC traceability.

1GE/10GE Expansion Module



The new 1GE/100M/10GE expansion module provides 1GE fanout and 10GE support. The module features 4 SFP and 4 SFP+ ports to enable a combination of 4 100M and 4 1GE ports, or 8 1GE ports, or a combination of 4 1GE ports and 4 10GE ports. As networks evolve, 10GE has become more prevalent, so this internal fanout capability is critical to connect to newer network elements.

Cascading of Units

TimeProvider 4100 is designed to enable cascading units for higher density applications and use cases.

This deployment provides additional flexibility because there is no need for GPS on the second unit—it is a sub-tenant of first unit, from which it inherits its reference via ToD port for instance. In addition, both units cross-connect and are connected to GPS, which enables a second reference when GNSS goes down.

World-Class Oscillator Options Improve Holdover Accuracy and Save Valuable Time

The standard TimeProvider 4100 is equipped with a crystal oscillator that keeps the TimeProvider 4100 accurate to nanoseconds when tracking GNSS. However, if GNSS connectivity is lost, and the server is placed in holdover, the oscillator will begin to drift, impacting timing accuracy. Upgrading the oscillator significantly improves the holdover accuracy. For example, consider the drift rates listed in the following table for the OCXO and Rubidium upgrades.

Typical Timekeeping in Holdover

Oscillator	200 ns	400 ns	1.1 µs	1.5 µs	5 µs	10 µs
OCXO	4 hrs	8 hrs	14 hrs	16 hrs	1.5 days	2 days
MAC Laser Driven Rubidium	1 day	1.8 day	3.5 day	4 day	8 day	12 day

Note: The above are typical (1 Sigma Confidence) values, and include initial phase and frequency errors. Assume a benign temperature environment. Assume TP4100 is powered up for 3 weeks and locked to GNSS for 96 hours.

The value of the upgraded oscillator is that if the GNSS signal is lost, TimeProvider 4100 can continue to serve very accurate PTP and NTP services, allowing plenty of time to correct the problem with no degradation or disruption in time synchronization accuracy.

The TimeProvider 4100 base unit comes with a mini OCXO. This provides the necessary flexibility to select the OCXO or Rubidium model depending on deployment needs.

It is crucial to understand that at the high-end, Rubidium oscillators are unequalled for telecom applications and it is extremely important to be aware of the design differences between models in the marketplace.

Small Form Factor Rubidium Oscillator

Not all Rubidium oscillators are equal and there are strong arguments in favor of Rubidium over OCXOs. Microchip's miniature Rubidium clocks each have a unique physics package based on the Coherent Population Trapping (CPT) atomic clock. It consumes less power and has wide-spectrum temperature operation and longer life cycles than legacy lamp-based Rubidiums used by competitors.

Rubidium clocks have much shorter lock times than OCXOs: 24 hours after power-up versus 2 to 5 weeks. This differentiation alone is a tremendous reason for using Rubidium-based units over OCXO-based units.

Specifications

Mechanical

- Size: 1 RU
- 1.73 in. (44 mm) (H) × 17.24 in. (438 mm) (W) × 9.30 in. (237 mm) (D), or 10.07 in. (256 mm) (D) including connectors on faceplate
- 1.75 in. (H) × 17.5 in. (19 in. with handle bracket) (W) × 9.5 in. (10.5 in with BNC connector)
- Rack mounts: 19-inch and 23-inch options with rack adapter sold separately
- Weight: 8 pounds (10 pounds with shipping box)

Power

- DC power models:
  dual-power feeds, –38.4 VDC to –72 VDC
- Power consumption:
  - OCXO model with DC supply:
    28 Watts (max), 20 Watts (typical)
  - Rubidium model with DC supply:
    =35 Watts (max), 28 Watts (typical)

Oscillator

- Standard oscillator: mini OCXO
- Oscillator upgrade options: OCXO and Rubidium

GNSS

- Constellations: GPS, GLONASS, BeiDou, QZSS and Galileo
- SBAS support

PTP Client (PTP Input)

- 1 PTP client or 2 PTP clients in MD-HP-BC mode of operation
- Profiles: Telecom-2008, ITU-T G.8265.1, ITU-T G.8275.1, and ITU-T G.8275.2
- BMCA (IEEE1588 v2), alternate BMCA (ITU-T G.8275.1/2) and G-BMCA 1.0 (Global Best Master Clock Algorithm)

Timing Services

- Profiles: Ethernet default, Telecom-2008, ITU-T G.8265.1, ITU-T G.8275.1, ITU-T G.8275.2 and default (IPv4)
- Multiple PTP profiles support per box
- NTPr v4 and v6 and NTPd with MD5 security
- NTP or PTP support per port
- Main unit: total of 8 ports can operate in parallel with any packet engine services
- Management is possible in-band or out-of-band from ports ETH1, ETH3 or EXP1
- MGT port is capable of PTP client and NTPd timing service as well
- Ports 2, 4–8, and EXP1–8 can operate as packet engine services (PTP GM, NTP, PTP probe)
- PTP client timing service can be set on any **one** of the ports or ETH7 and ETH8 ports **together** in MD-HP-BC operation mode.
- Maintains ITU-T G8271.1 400ns GMC holdover specification for up to 43 hours
- Maintains performance levels for a period of time until technicians can reestablish GNSS or fix the disruption
- Several levels of oscillators (hold 200 ns for full day) to enable remediation. Maintains ITU-T G8271.1 400ns GMC holdover specification for up to 43 hours
- ITU-T G.8273.4 APTS with enhanced automatic asymmetry compensation providing extended phase alignment protection for up to 32 network variations
- Configurable bridging time
- Geographical redundancy through network topology and failover

Scalability

- 790 PTP clients at 128 PPS per box in unicast
- NTPr up to 20,000 tps per port, for a total of 180,000 tps per unit
- NTPd up to 500 per port up to 3 ports for a total of 1,500 tps per unit

Licensing

- Base unicast client count of 64 clients and software upgrade options through licensing to 128, 256, 512 and 790 clients at 128 packets per second
- High Performance Boundary Clock license
- NTP license

Management

- Separate management port from other traffic (such as PTP grandmaster, NTP server and more)
- In-band management (from PTP client interface)
- IPv4 or IPv6 support for management traffic
- FCAPS on Microchip TimePictra platform
- Internal log
- SNMP traps (v2 and v3)
- CLI through SSHv2
- WebGUI through HTTPS for Performance Monitoring

Security

- Firewall limits specific protocols such as SNMP, SSH, ICMP and more
- Avoid traffic port denial of service scenarios including sync and announce packet receptions for GM port in HW level

Class of Service (CoS) and VLANs

- Up to 256 VLANs for PTP master, both for IPv4 and IPv6
- 1 VLAN for management
- Total number of VLANs is 260 per system (256 PTP master, 2 PTP client, 1 management and 1 spare)

Time and Frequency Accuracy

- PRTC: fully compliant with ITU-T G.8272
- L1 calibrated PRTC Class B (40 ns)
- Designed with ToD input that is fully compliant with Microchip's TimeSource® ePRTC system
- Frequency accuracy: conforms with ITU-T G.811
- Multi-domain high performance boundary clock (MD HP BC) function with G.8273.2 performance [Class C and D (<10 ns and <5 ns)]

Monitoring

- 1PPS measurement (two channels)
- PTP Packet probing and monitoring with threshold level
- Presentation of network accuracy with all available data through local web GUI
- NTPr & PTP Monitoring now supported on Expansion Module Ports

Synchronous Ethernet (SyncE)

- SyncE can be used as a frequency input and 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)
- Automatic SyncE switchover feature in MD-HP-BC mode. SyncE switchover between ports

Physical Interfaces

- 2 × Gigabit Ethernet—Shielded RJ45, 100/1000 BaseT Ethernet
- 6 × Gigabit Ethernet SFP cages—ports support either:
  - SFP (optical), 1000 BaseX
  - SFP (electrical), 1000 BaseT
- 4 x E1/T1: 2 × input/output ports + 2x output ports over balanced RJ48c connectors, 120 Ω/100 Ω impedance
- Optional expansion module: 16 × E1/T1 output ports over balanced RJ48c connectors, 120 Ω/100 Ω impedance
- Optional expansion module: 4xSFP and 4xSFP+ for 10G support and 1GE or 100M optical fan out
- 2 × 10 MHz/1PPS input/output ports over single-ended BNC connectors, 50 Ω impedance.
- 2 × ToD/1PPS input/output over RS-422 RJ45 connectors, 100 Ω impedance
- ToD formats : ITU-T G.8271, China Mobile V2, NTP4
- Support for bidirectional SFPs

Network Support

- IPv4 and IPv6 (PTP and management)
- HTTP/HTTPS/SSL
- ICMP (RFC 792)
- DHCP client (RFC2131)
- IEEE 1588v2 PTP
- IEEE 802.1Q, 802.1p VLAN filtering/tagging
- DSCP
- SSHv2
- SNMPv2, SNMPv3
- NTPv3, NTPv4

Regulatory and Environmental Requirements

Environmental

- Acoustic noise level: 0 dBA
- Operating temperature: –5°C to 55°C for Rb
  –5°C to 65°C for mini OCXO and OCXO
- Storage temperature: –40°C to 70°C
- Relative humidity: 5% to 90% non-condensing, 100% with condensation

EMC Compliance Under Directive 2014/30/EU and 2014/53/EU (RTT&E)

Emmisions

- FCC Part 15 (Class A)
- ICES 003 (Class A)
- VCCI (Class A)
- EN 300 386 Telecommunications Network Equipment (EMC)
  - CISPR32
  - EN55032
  - KN32
- RED (Radio Equipment Directive) - 2014/53/EU
  - EN 301 489
  - EN 303 413

Immunity

- EN55024 (Class A)
- KN35 (Class A)
  - EN/KN-61000-4-2 ESD
  - EN/KN-61000-4-3 radiated immunity
  - EN/KN-61000-4-4 EFT
  - EN/KN-61000-4-5 surge
  - EN/KN-61000-4-6 low frequency common immunity

Safety Compliance

- UL 62368-1
- CAN/CSA-22.2 No. 62368-1
- IEC 62368-1
- EN 62368-1
- Safety Directive 2014/35/EU
  - CE mark

Environmental Compliance

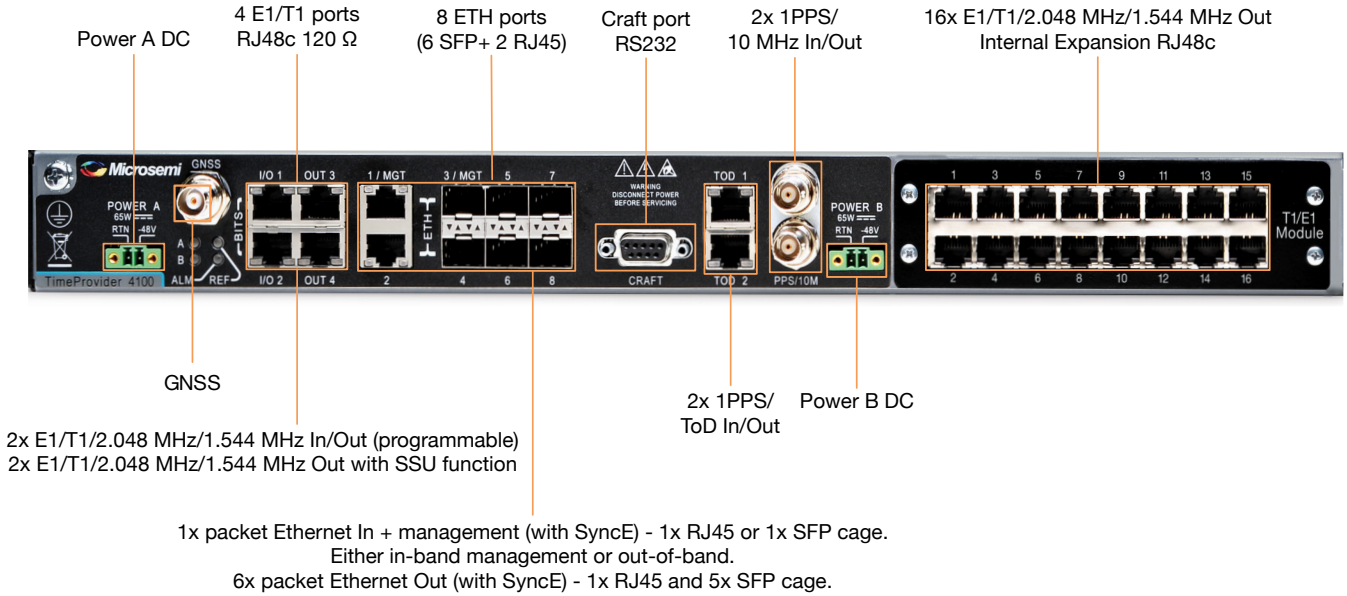
- EN300-019-2-3, Class T3.2
- ETSI EN 300 019-2-2 (1999) – Transportation, Class T2.3
- ETSI EN 300 019-2-1 (2000) – Storage, Class T1.2
- GR-63
- RoHS (6 of 6)

Network Equipment Building System

- NEBS Level 3*, GR-1089

**When following deployment guidelines as specified in the user manual*

TimeProvider 4100 Physical Outline



TimeProvider 4100 with 10G Module Physical Outline