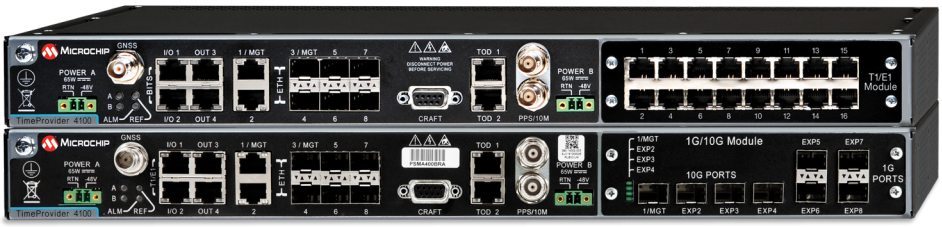
TimeProvider® 4100 Release 2.2

Precise Timing Grandmaster With Gateway Clock, High Accuracy and Redundancy

New 2.2 Version Highlights

- 2.2 introduces the following new capabilities
- Software Redundancy with a dual unit Active/Passive single IP address model
- Support for Multiband GNSS via a new upgraded GNSS internal module on every unit
- Support for expanded security with TACACS+ ,Radius authentication and enhanced SSHv2 profile option
- Support for a new "Super OCXO" oscillator option
- Numerous other enhancements for monitoring, ePRTC support, NTP, SyncE



Key Features

- IEEE 1588v2 Precision Time Protocol (PTP) grandmaster
- Redundancy via software mechanism using two units with health monitoring of Active and Stand-By devices
- SyncE including enhanced ESMC & eEEC
- NTP Reflector with highest capacity, NTP Daemon (NTPd) with MD5 authentication and NTP logs
- GNSS with multi-constellation support (GPS, GLONASS, BeiDou, QZSS and Galileo)—and SBAS support
- GNSS with multi-band L1/L2/E5B support
- Primary Reference Time Clock (PRTC) Class A and Class B
- Enhanced PRTC (ePRTC) ITU-T G.8272.1, 30 ns
- Reliable Fan less Passive Thermal Operation
- Oscillator options: mini OCXO, super 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× 1 PPS/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 multidomain 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 160,000 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 patented enhanced automatic asymmetry compensation over multiple network variations
- Security via enhanced SSH and TACACS+, Radius authentication
- Monitoring and measurement capabilities for phase (PTP) and legacy ports
- 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, Open RAN, 5G
- Ethernet backhaul networks, cable remote PHY
- High accuracy phase distribution over long-haul optical networks
- Migration from legacy synchronization (SONET/SDH) to Ethernet and 1588 PTP for Utilities, Transportation and Government markets

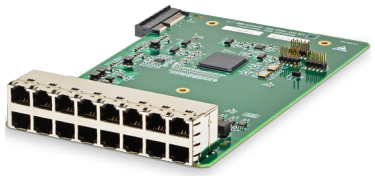
High Performance

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 160,000 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.

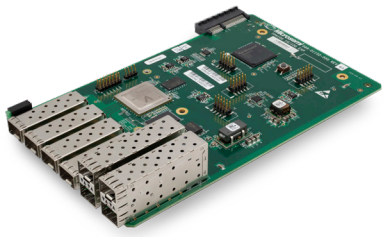
E1/T1 Expansion Module



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 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.

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 modules, one for E1/T1 expansion and one for 1G/10G fan-out expansion.

GNSS Support

Timeprovider 4100 includes a 72-channel GNSS receiver coupled with Microchip's patented active thermal compensation technology. TimeProvider 4100 GNSS satellite input provides flexible support for constellations of choice depending on the region. TimeProvider 4100 supports GPS, GLONASS, BeiDou, Galileo, QZSS and SBAS in its standard version. Per default TimeProvider 4100 is configured to support single band.

Starting with release 2.2, TimeProvider 4100 provides support for multiband with a new enhanced GNSS receiver.

Ionospheric conditions depend on time, season and solar activity. These Ionospheric conditions can lead to substantial errors (around 50ns in some typical cases) which need to be compensated. Leveraging a multi-band GNSS receiver allows to design software that can mitigate these errors conditions.

A multi-band receiver can also be leveraged to mitigate jamming if one frequency is being jammed, the other band can be used for continued operation.

The webGUI on the TP4100 unit displays bar charts with the respective satellite signal values with all five constellations in parallel and dual frequencies.

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-inclass platform that associates connectivity to legacy networks as well as to the latest standards.

Starting with release 2.2, SyncE supports enhanced ESMC via extended QL TLV formats as per ITU-T G.8264 Amendment 1 (03/2018) Clause 11.3.1.2.

TimeProvider 4100 now supports enhanced SSM codes, cascaded eEECs add other extensions provided by the latest QL TLV format.

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.

Cascading of Units

TimeProvider 4100 is designed to enable cascading units for higher density applications and use cases. TimeProvider 4100 can leverage a sub-tenancy architecture whereby a client unit 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 client TimeProvider 4100 can simply feature a lower-cost oscillator without connectivity to GNSS. This architecture enables double the port count of the solution. In addition, units crossconnect and are connected to GPS, which enables a second reference when GNSS goes down.

Resilient Solution

TimeProvider 4100 uses a passively cooled design with no fans, 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 back up 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 an additional layer of protection, TimeProvider 4100 features optional oscillator upgrades for enhanced holdover performance.

TimeProvider 4100 also provides dual DC input for power redundancy and geographical network redundancy for failover.

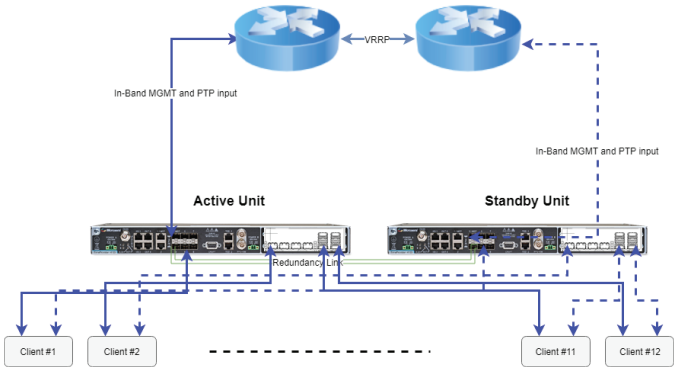
Redundancy

TimeProvider 4100 has introduced in release 2.2 a software redundancy capability which enables a cost-effective redundancy architecture that preserves flexibility, resiliency, and investment protection.

In this software redundancy schema, two units effectively act as a single coordinated system for high availability of Ethernet timing services. One unit is configured as "Active" while the second unit is set up as "Passive". Both hardware units need to be similar except for the oscillator grade which can be relaxed on the passive unit. License options need to be equivalent on both units.

Both units need to be connected via a direct fiber and additional RJ45 cable connection and co-located to a maximum of 100 meters.

Redundancy in release 2.2 is offered in Gateway-Clock Mode.



Use Case - Aggregation

Accuracy, i.e. the relative offset between the active and standby units, is lower than 5 ns relative to 1 PPS output on the active unit.

Single IP Management address is used.

Health metrics and check mechanisms ensure proper monitoring of units to trigger redundancy mechanism (switch over event).

Redundancy schema is non-revertive therefore manual intervention is required if the customer decides to switch back to original Active unit once back in operation.

Switch over of timing services is very performant, less than 3 seconds for any profiles (aside from G.8275.1) with recovery of the full list of connected clients. For G.8275.1 profile, switch over is performed in less than 0.375 seconds.

Legacy ports have different behaviors than ethernet. Squelch or Active-Active modes enable the customer to decide the behavior of the output ports to switch over or not depending on customer needs and redundancy strategy.

Security

SSH support as well as firewall features limit 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 done in the Hardware level.

New authentication mechanisms are now supported via TACACS+ and Radius. Support for up to 5 external servers (TACAS+ or Radius).

New SSH extensions introduce the concept of "secured profile" with a choice of security level via either CLI or TimePictra configuration to enable or disable high security mode.

Vulnerabilities documented via CVEs as well as cross-site scripting vulnerability have been addressed as well, see list in specification section.

Anti-Spoofing and Jamming

Timeprovider 4100 is designed to operate seamlessly with an upstream GNSS BlueSky firewall for best GNSS protection.

In addition, TimeProvider 4100 monitors received signals and performs consistency checks to detect possible attacks.

As part of the new Multi-band GNSS support, two new indicators are introduced, for monitoring and protection against jamming.

The Automatic Gain Control (AGC) and the Continuous Wave values can lead to recommended mitigation and actions that are documented in the User Guide.

TimeProvider 4100 utilizes advanced algorithms that observe each signal and utilize knowledge linked the superior oscillator of the unit as compared to the GNSS receiver. The TP4100 can detect and mitigate abnormal subtle patterns and offer ultra-high protection of the output timescale.

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 CLI (command line interface) and TimePictra. A separate management port can be selected either as RJ-45 or as an SFP or SFP+ port. In-band management is also supported.

Internal logging, SNMP traps & alarms as well as LEDs provide additional insight into the status of the unit.

Configuration Changes made after an upgrade and before a reboot are now preserved starting in release 2.2. Support for NTP client and local time assures time alignment for system logs.

Monitoring

TimePictra is enabled to present monitoring results in an intuitive and useful manner, a WebGUI is also offered on the TimeProvider 4100 itself as user-friendly interface for monitoring results, measurements, and calculations.

- WebGUI-based real-time metric updates
- Graph any metric vs. user-configured thresholds
- Selectable generic alarm generation for any metrics that support thresholds
- 24-hour memory depth for time-based metric (new one is TIE)
- Simple download for every metric (compatible with TimeAnalyzer)
- 1 nanosecond resolution

The initial focus of the product has been on helping customers with phase deployments. Monitoring PTP traffic has been a primary focus with Time Error. 1PPS Monitoring is also available.

With release 2.2 monitoring has been expanded to also support legacy monitoring including E1/T1, SyncE, 10 Mhz Frequency Time Interval Error (TIE) monitoring is presented as MTIE for observation periods of 1s, 10s, 100s, 1000s, 10 000s and 100 000 seconds.

SyncE signal monitoring uses the same physical port as PTP monitoring.

NTPr and PTP Monitoring are also supported on the 1GE/10GE expansion Module Ports.

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

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, super OCXO and Rubidium upgrades.

TimeKeeping and Holdover

Typical Timekeeping in Holdover

Time Keeping	200 ns	400 ns	1.1 µs	1.5 µs	5 µs	10 µs
OCXO	4 hours	8 hours.	14.5 hours	16.5 hours	1.5 days	2 days
Super OCXO	11 hours	18 hours	43 hours	52 hours	4.4 days	6.6 days
MAC Laser Driven Rubidium	1 day	1.8 days	3.6 days	4.3 days	8 days	12 days

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.

Frequency	Aging after 30 days	Aging with learning	Temperature stability
OCXO	±6e-11 per day	±3e-11 per day	±4e-10
Super OCXO	±6e-11 per day	±3e-11 per day	±4e-10
MAC Rb	±1e-10 per month	±5e-11 per day	±3.5e-11

The TP4100 is assumed to be powered up for 3 weeks and locked to GNSS for 96 hours for aging with learning frequency performance category.

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, Super 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 Rubidium used by competitors.

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

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 introduced the Single Domain High-Performance Boundary Clock mode of operation. Release 2.1 introduced the Multi-Domain High Performance Boundary Clock mode of operation for a fully resilient PTP operation with two active boundary clock instances. Release 2.1.10 now introduces the enhanced PRTC as a new operation mode.

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, Time_of_Day (TOD) 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.

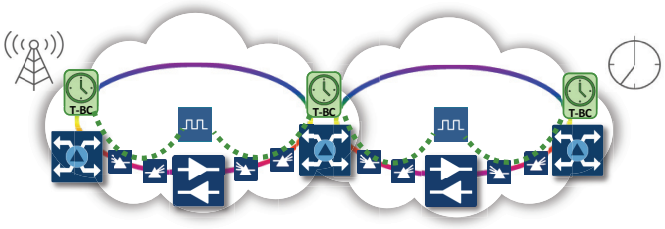
TimeProvider 4100 is a best-in-class 1588 grandmaster complemented by extensive port fan-out for PTP, Network Time Protocol (NTP), SyncE, and legacy Building Integrated Timing Supplies (BITS). With multiple ports for current,

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.

TimeProvider 4100 supports Hybrid operation which allows frequency reference to come from one frequency only source (i.e. SyncE) and the time reference to come from another source (i.e. PTP).

High Performance Boundary Clock Mode

An optional license can enable High Performance Boundary Clock (HP BC) mode. High Performance refers to Class D (10 ns) and Class C (5 ns).



Optical Timing Channel

One single license can enable two different operation modes: either Single Domain or Multi-Domain HP BC (MD HP BC).

In MD HP BC, a typical architecture would be a horse shoe with enhanced PRTC at each end of the horse shoe serving as source of time to a chain of HP BC units providing PRTCA (100 ns) service to Gateway Clock units. This architecture is redundant as both directions of the horseshoe design can serve as backup in case of failure in one specific direction.

In initial release, focused on single domain HP BC, the “chromatic dispersion” calculator was designed for a single PTP client. This has been enhanced to support two PTP clients with respective fiber length fields. Two different “Chromatic Dispersion Offset” values can be calculated.

Enhanced PRTC (ePRTC) Mode

Mitigates Threat of GNSS Vulnerabilities

The threat of GNSS vulnerabilities has become real in that events (signal anomalies, regional disruptions, and even global outages) have already occurred. Governments across the globe are now asking their primary network infrastructure providers for a plan and solution for how they plan to defend against this serious threat. The TimeProvider 4100 ePRTC delivers a unique solution that goes far beyond mitigating the threat of GNSS and instead enables an operator to deploy an autonomous time source that is impervious to GNSS anomalies and outages.

Meets ITU-T G.8272.1

ITU-T G.8272.1 specifies the requirements for enhanced Primary Reference Time Clocks (ePRTCs). This recommendation describes more stringent output performance levels that will set the foundation for time, phase, and frequency for many years to come. Also described in G.8272.1 is the requirement for an ePRTC to have a frequency input that can be fed with an autonomous primary reference clock.

Enhanced PRTC is a new Operation Mode on the TimeProvider 4100 platform and enables an operator to configure a TimeProvider 4100 unit as an Enhanced PRTC (ePRTC) device which meets the 30 ns standard requirements.

Enhanced PRTC is a software upgrade, no need for new hardware. If the TimeProvider unit has been produced after July 2019, the unit has been calibrated at the factory to meet PRTC-A, PRTC-B and ePRTC. Thus, the unit can simply be upgraded to firmware release 2.1.10 to operate as Enhanced PRTC if configured accordingly.

The output signal generator of the TimeProvider 4100 ePRTC system provides several formats, including PTP, SyncE, 10 MHz, time-of-day (TOD), 1 PPS, and traditional timing formats such as E1.

Multiband Enhancements

TimeProvider 4100 takes advantage of multi-band GNSS support with metrics such as Peak TDEV noise which is reduced compared to single band.

Cesium Atomic Clock System – Flexibility and Choice

TimeProvider 4100 innovative and performant design and architecture enables to meet the ITU-T G.8272.1 30 ns requirement for ePRTC with either a standard Cesium such as Time Cesium 4400/4500 series or with a high performance.

Time Cesium 4x00 and CSIII have one 10 MHz output and one 5 MHz output. Starting with release 2.2 5 Mhz is now supported in addition to the existing 10 MHz signal. No additional configuration is required since TimeProvider 4100 can sense if the incoming frequency is 10 MHz or 5 MHz.

Cesium atomic clock system such as 5071A thus enabling the customer to select the right Cesium source system based on requirements and budget.

Ensemble

The Ensemble function is available when there are two cesium clocks connected to the system. The ensemble algorithm measures and compares the stability of the individual cesium clocks and uses these measurements to

produce a higher level of accuracy. Using two cesium clocks also provides operational advantages, as one of the cesium clocks can be removed from service while the system is in operation without any performance degradation. Dynamic weight for each of the Cesium based on the algorithm quality assessment for each clock. This "ePRTC Output Weight" metric is visible via CLI and via TimePictra.

Value Beyond the Standard – Fully Protected Time Scale

The TimeProvider 4100 ePRTC generates time by producing its own independent autonomous Time Scale. The Time Scale provides time, phase, and frequency that are aligned and calibrated to the GNSS signal over time. Using patented measurement algorithms, the ePRTC engine evaluates and measures its own autonomous time scale relative to GNSS. It then adjusts its Time Scale as needed, rather than following the GNSS time regardless of its accuracy. The ePRTC system's approach is to make the Time Scale become the autonomous master source of time, while the cesium clocks and GNSS help maintain the accuracy of the ePRTC Time Scale.

The local atomic clock is not used simply for holdover backup but for protection against real world GNSS events that happen during day to day "normal" tracking operation. TimeProvider 4100 ePRTC has the best protection decoupling in the market with full day of isolation to mitigate real world jamming and spoofing with unsurpassed detection of anomalous GNSS measurements.

The TimeProvider 4100 ePRTC does not simply lock to one atomic clock but actively and seamlessly lock to two clocks in a properly weighted timescale ensemble. For example, if one atomic clock degrades in performance TimeProvider 4100 ePRTC will gracefully de-weight it from influencing the outgoing time and frequency services.

We provide simple intuitive dashboard metrics on both our protection availability and timescale performance to support proactive management of the ePRTC in the customer's network.

Value Beyond the Standard – Holdover Gas Gauge

Our long-standing expertise in real life deployments leads us to understand that beyond day to day protection from GNSS issues, there is an equal need for assurance that the timescale will support the 14-day holdover requirement.

We maintain a simple dashboard estimate so you can know what the current time error accumulation is during holdover and how far they can go until empty.

Value Beyond the Standard – Commissioning our long-standing expertise in real life deployments leads us to understand the value proper installation of our ePRTC and very importantly the proper commissioning of TimeProvider 4100 ePRTC. Key installation aspects include GNSS antenna and cabling, initial survey-in period. Microchip and its channel partners are the experts who can assist you for all installation details that need to be properly accomplished to ensure years of unsurpassed service.

Value Beyond the Standard – Independence between 10 MHz and 1 PPS

At the heart of any clock, there is a need to provide corrections to the local oscillator to achieve the desired frequency and time services.

In some applications, the same correction is applied to frequency outputs (10 MHz) as the time outputs (PPS). There is a need to "over correct" frequency service to maintain time coherence with the 1pps. There is an implicit trade off that the over-correct-added-noise and potential degradation from the source of time is worth the coherence. On the other hand, for a Timescale in an ePRTC system, the need is to achieve both maximum stability and resiliency for the frequency services (10 MHz) and to not introduce "over correction" to steer the time. Basically, the frequency outputs are optimized for frequency and the time outputs are optimized for time.

Virtual PRTC (vPRTC) Architecture

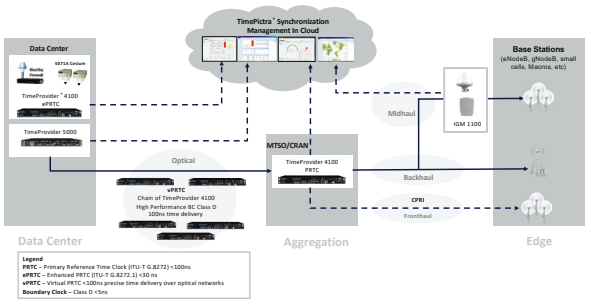
Up until recently the main source of precise time has been GPS and other similar regional constellations broadly known as GNSS. However, deployment of GNSS can be expensive given the increasing densification of end points. Operators are very motivated to find solutions where GNSS dependency is reduced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

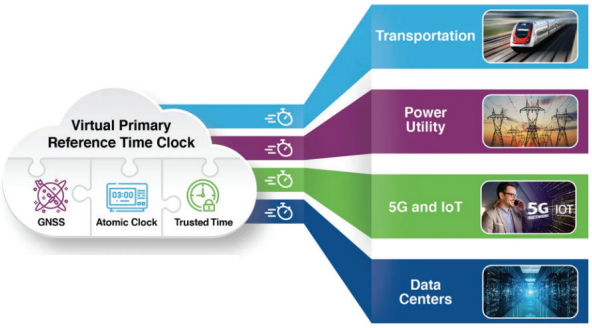
Protecting the mobile network against GNSS disruption and distributing precise time over long distance for national coverage and protection require a different time distribution architecture as well as performances to meet end-toend budget for 5G needs.

This new architecture prescribes:

- to leverage the existing optical network (thus avoiding high cost dark fiber expenses)
- to use of a dedicated lambda 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.





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
- Optional Rubidium Miniature Atomic Clock (MAC)
- Oscillator upgrade options: OCXO, super OCXO, and Rubidium

GNSS

- Multi-Constellations: GPS, GLONASS, BeiDou, QZSS and Galileo
- SBAS Support
- Multi-band support
- GPS L1/L2C
- Galileo E1/E5b
- Glonass L1/L2
- BeiDou B1I/B2I
- QZSS L1/L2C

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
- G.8275.1 PTP master profile on 10GE expansion module is sourced from main unit packet engine per default
- PTP Client list for all ports including 10GE expansion module
- NTPr v4 and v6 and NTPd with MD5 security
- NTP client mode for setting log files – NTPv4&v3 (RFC5905) – up to 10 HMAC keys – MD5, SHA224, SHA256, SHA512, RC4 – status in CLI and TimePictra – 3 NTP servers (configurable)
- 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

TimeKeeping and Holdover

- Maintains ITU-T G8271.1 400ns GMC holdover specification for up to 43 hours
- Maintains performance levels for a period 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 G8271.1 400 ns GMC holdover specification for up to 43 hours
- ITU-T G.8273.4 APTS with enhanced patented automatic asymmetry compensation providing extended phase alignment protection for up to 32 network variations
- Configurable bridging time
- Geographical redundancy through network topology and failover

Enhanced Primary Reference Time Clock

- ePRTC ITU-T G.8272.1 30 ns accuracy with support for both 10Mhz or 5Mhz input from Cesium Clock. Time reference inputs can be GNSS, ToD-1 and ToD-2. Frequency Reference inputs can be GNSS, PPS10M-1 and PPS10M-2. Other references such as 1pps for monitoring only.

- ePRTC ensembling – use of dual Cesium feeds in parallel
- ePRTC default bridging period: 14 days, configurable from 5 days to 80 days
- Provides autonomous time scale for time, phase and frequency that operates even without GNSS availability
- Exceeds requirements as defined by ITU G.8272.1
- Operates with one or two Cesium clock inputs
- PTP 1588 grandmaster or integration to external grandmasters such as TimeProvider 5000 and TimeProvider 4100
- Meets standard with either standard Cesium or HighPerformance Cesium source systems
- Time Error in locked mode: Accuracy to within 30 ns or better when verified against the applicable primary time standard (such as UTC)
- Wander in locked mode: better than MTIE and TDEV masks as defined by G.8272.1
- Holdover over 14 Days: Meets and exceeds 100ns or better when verified against the applicable primary time standard (such as UTC)
- Holdover gas gauge
- Intuitive dashboard metrics

Scalability

- 790 PTP clients at 128 PPS per box in unicast
- NTPr up to 20,000 tps per port, for a total of 160,000 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
- Multicast GNSS operation license
- Enhanced PRTC (ePRTC) 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
- Support for TACACS+ authentication. Maximum 5 external TACACS+ servers. NSS (Name Service Switch). Configuration via SSH or TimePictra.
- Support for Radius authentication. Maximum 5 external Radius servers. Configuration via SSH or TimePictra.
- Vulnerabilities fixed in TimeProvider 4100:
  - CVE-2019-15921
  - CVE-2019-15916
  - CVE-2019-10639
  - CVE-2018-20856
  - CVE-2019-8912
  - CVE-2019-11477/11478/11479
  - CVE-2019-5599
  - CVE-2020-11868
  - Cross-site scripting
  - High Security profile for secured mode configuration (SSH extensions)
- SSH High security Profile:
  - KexAlgorithms curve25519-sha256@libssh.org,diffie-hellman-group-exchange-sha256
  - Ciphers chacha20-poly1305@openssh.com,aes256-gcm@openssh.com,aes128-gcm@openssh.com,aes256-ctr,aes192-ctr,aes128-ctr
  - MACs hmac-sha2-512-etm@openssh.com,hmac-sha2-256-etm@openssh.com,hmac-sha2-512, hmac-sha2-256/etc/ssh/moduli: remove all lines with moduli < 2047 bit

Redundancy

- Software solution
- 2-unit act as single coordinated system (Active/Passive)
- Direct fiber and RJ45 connections, less than 100 meters between redundant pair units
- Accuracy: <5ns relative to 1PPS output of Active unit
- ETH4 & ETH2 redundancy links
- Unique IP address
- Non-revertive schema
- Heartbeat message exchange and Clock State Sync
- Very performant switch over: <0.375s for G.8275.1; <3s for all other timing profiles
- “Squelch” or “On” modes for legacy ports

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

- Presentation of network accuracy with all available data through local web GUI
- 4 channel measurements
- PTP Packet probing and monitoring with threshold level
- 1PPS measurement (two channels)
- 10 MHz measurement (two channels)
- E1/T1 measurement (two channels)
- Frequency Time Interval Error (TIE) and MTIE
- MTIE thresholds and alarms support
- SyncE monitoring on same physical port as PTP
- Up to 2 SyncE inputs
- Monitoring resolution ≤1 ns and accuracy ≤2 ns
- Jitter & Wander measurements comply with ITU-T O.172/O.174 for frequency
- Monitoring sample frequency of 40Hz for up to 100,000 seconds
- 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
- Extended QL TLV format as per ITU-T G.8264 Amendment 1 (03/2018) clause 11.3.1.1 including enhanced SSM Codes

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
- 4x 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
- Support for G.703 for all physical interfaces including ToD/E1/T1/10MHz

Network Support

- DHCP
- 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, OCXO and Super OCXO
- Storage temperature: –40°C to 70°C
- Relative humidity: 5% to 90% non-condensing, 100% with condensation
- 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)

Emissions

- 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 (Criteria A)
- KN35 (Criteria 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 conducted immunity

Safety Compliance

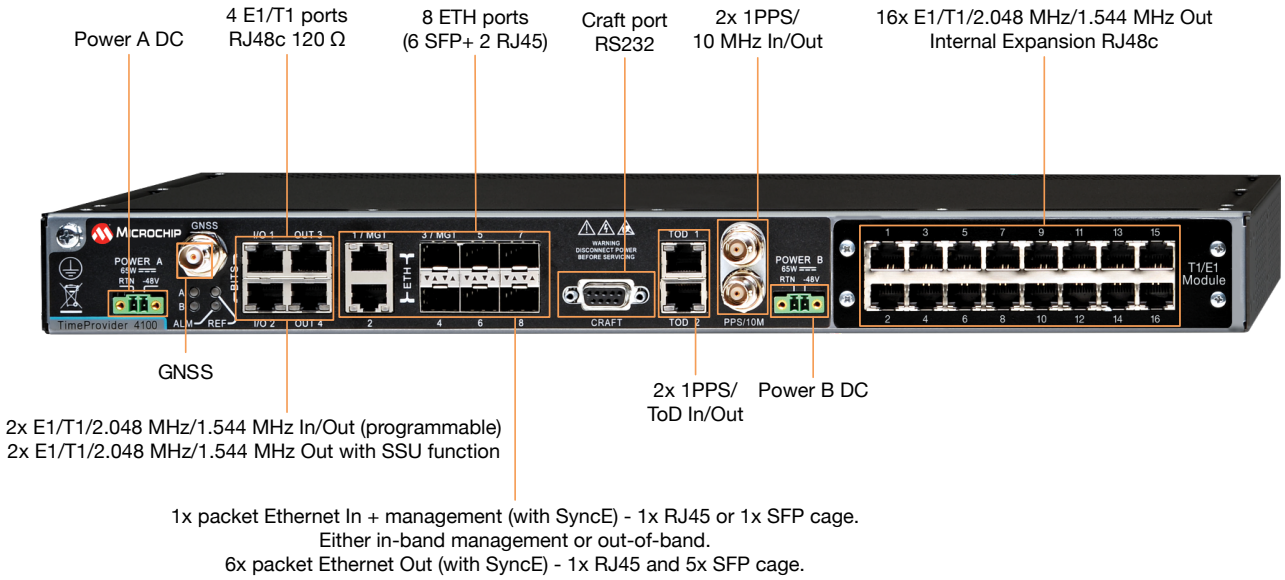
- UL 62368-1
- CAN/CSA-22.2 No. 62368-1
- IEC 62368-1
- EN 62368-1
- Safety Directive 2014/35/EU
- CE mark

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