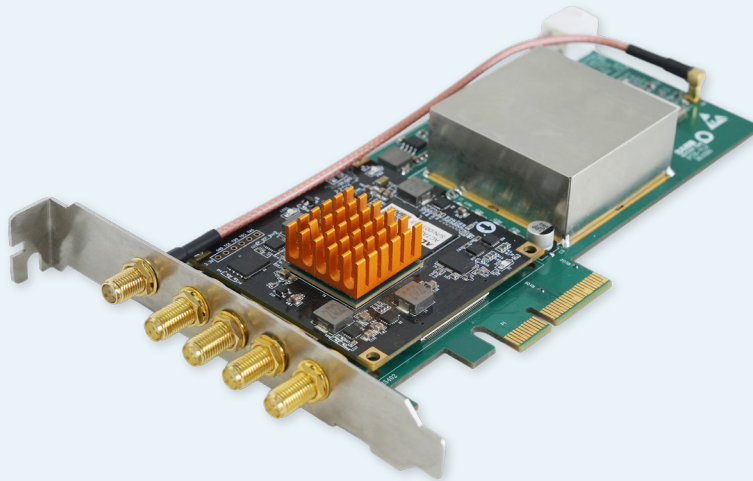


T221-C PCIe Timing Card

Standard PCIe card, GNSS timing, hardware PHC, PPS / 10 MHz / IRIG-B synchronization

Modern servers, industrial PCs, and edge computing platforms are now assuming critical roles in real-time data processing, network communication, event logging, and task scheduling. Such systems require not only precise timing but also a stable, traceable time reference capable of continuous operation following a reference interrupt. The T221-C PCIe Timing Card is a plug-in high-precision synchronization solution designed for computer systems. Leveraging the open-source technical architecture of the Time Appliances Project, it employs an FPGA to provide configurable local clocks, PPS and TOD synchronization, event timestamping, frequency measurement, and PCIe access capabilities, thereby delivering an independent hardware time reference to the host system.

The T221-C features an integrated u-blox LEA-M8T multi-constellation timing receiver and a high-stability slave clock, capable of converting GNSS time into stable 1PPS and 10MHz signals while maintaining temporal continuity even under satellite reference anomalies. Via the Linux time card driver, the board provides the host with PHC and PPS device interfaces, enabling the deployment of PTP master, slave, and boundary clock services using open-source software such as ptp4l, phc2sys, and chrony. The front panel includes a GNSS antenna and multiple SMA time/frequency interfaces, making this board suitable for time-sensitive applications in data centers, communications, power utilities, financial trading, broadcasting, scientific research measurements, and industrial control systems.



our advantages

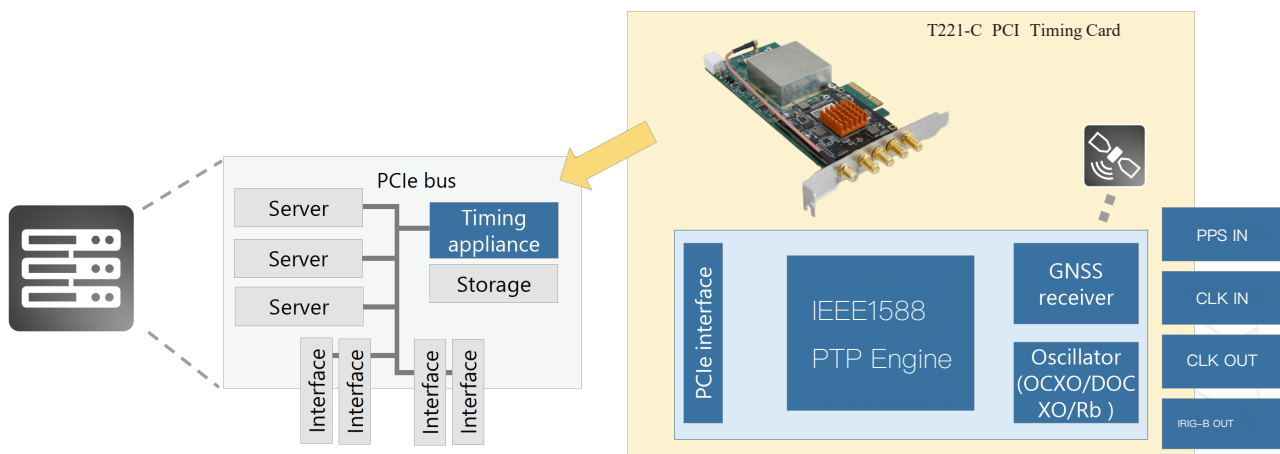
- ✓ **Open-source, evolvable technology architecture**
Implemented using an open-source FPGA, this solution features transparent interfaces, facilitating functional verification, firmware updates, and industry-specific customization, thereby reducing users' reliance on closed-off dedicated clock platforms.
- ✓ **Multi-Constellation GNSS Timing Solution**
Equipped with an integrated u-blox LEA-M8T timing receiver, it supports combined reception of GPS, Galileo, GLONASS, and BeiDou signals, and features fixed-point timing capability.
- ✓ **Flexible time-frequency interface**
Based on the open-source Time Card architecture, this solution supports GNSS antenna input and multiple SMA time-frequency interfaces, enabling the acquisition of signals such as PPS, 10 MHz, timestamps, and IRIG-B.
- ✓ **FPGA hardware time core**
Utilizing a Xilinx Artix-7 FPGA, it integrates hardware functionalities including adjustable clock, PPS generation and synchronization, TOD reception, event timestamping, frequency counting, and MSI interrupts.
- ✓ **High stability, local domestication, and timeliness**
Features a built-in high-stability temperature-stable crystal oscillator, supporting local clock acquisition and reference-free timekeeping, with frequency stability of $<3 \times 10^{-12}/1s$.
- ✓ **An open software and management ecosystem**
The Linux driver provides the system with /dev/ptpX PHC and /dev/ppsY interfaces, supports configuring the SMA interface via sysfs, and, when used in conjunction with linuxptp, enables system clock synchronization and monitoring.

Key Features - Integrated multi-constellation GNSS timing receiver - Integration of PHC and PPS hardware time references - Supports event time stamps and frequency measurement - Supports the calibration and timekeeping of local high-stability clocks - Supports 1PPS, 10 MHz, and B-code output - Integrate with the host software to build a PTP timing service	PCIe and FPGA Architecture - Xilinx Artix-7 FPGA - PCIe and AXI4-Lite Register Architectures - Support for MSI interrupt signaling - Supports adjustable local clocks and hardware timestamps; enables online upgrades for SPI Flash.	GNSS timing receiver - GPS, Galileo, GLONASS, Beidou - Supports concurrent reception from multiple constellations - Supports designated mode and Survey-in - Time pulse precision: ≤ 20 ns
Local Clock - Input reference: 1PPS, LVTTTL - Output power: 9–13 dBm - Frequency stability: $< 3 \times 10^{-12}$ @ 1s 1PPS accuracy: < 20 ns, typical: 15 ns 24-hour timing accuracy: < 10 μs	Time and Frequency Interface - SMA Input: External 1PPS or time/frequency reference input - SMA Output 1: 1PPS Output - SMA Output 2: 10 MHz output - SMA Output 3: IRIG-B time code output	PTP and System Software - Supports ptp4l and phc2sys - Supports host system time synchronization - Supports external event hardware timestamps - Supports SMA input/output software configuration

Application in networks

PCIe timing card

- It can be directly integrated into servers, industrial PCs, or edge computing platforms to provide the host system with an independent PHC, PPS, and high-stability frequency reference.
- Obtain the UTC reference via a GNSS receiver, and apply a desynchronization algorithm to calibrate the local 1PPS and 10 MHz clocks.
- In conjunction with the host network interface card and Linux PTP, it enables the deployment of a PTP master clock, slave clock, or boundary clock, thereby distributing precise time to network devices and time-sensitive applications.
- Through the 1PPS, 10MHz, and DCLS-B interfaces, time, frequency, and phase synchronization are provided to acquisition devices, communication modules, test instruments, and external timing devices.
- After the GNSS reference signal is interrupted, the high-stability local clock enters a timing maintenance state, ensuring the continuous operation of both the host time and the external synchronization signal.



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Should there be any changes to the product specifications, Nu will not issue separate notice.

timekeeping performance

	Clock	Aging / Day 30	Temperature stability
Standard OCXO	Standard punctual type	$\pm 5 \times 10^{-10}$	$\pm 50 \times 10^{-10}$
Ultra-high stability DOXO	High-stability environment type	$\pm 5 \times 10^{-11}$	$\pm 1 \times 10^{-11}$
Rubidium atomic clock	Punctual type	$\pm 8 \times 10^{-12}$	$\pm 5 \times 10^{-10}$

* Note: Effective daily aging is conducted one month after the equipment is energized.

	200nsec	400nsec	1 1usec	1 5usec	5usec	10usec	16ppb
StandardOCXO	1 hours	2 hours	4 hours	5 hours	8 hours	1 days	1 month
Ultra-high stability DOXO	5.5 hours	8.5hours	15 hours	18 hours	1.4 days	2 days	10 month
Rubidium atomic clock	12 hours	1days	3days	4days	8days	10days	5 years

* Note: The above values represent typical values (1σ confidence level) assuming a controlled temperature environment after the device has been powered on and GNSS72 locked for 1 hour. Due to the superior temperature stability of the High-Stability Environment Model, when significant temperature variations occur, the retention rate of the High-Stability Environment Model will exceed that of the rubidium clock.

application area

- Data centers and cloud computing infrastructure
- Communication Networks and Edge Computing
- Power Systems and Smart Grids
- Financial transactions and high-precision timestamps
- Professional Broadcasting and Audio-Video Synchronization
- Industrial Automation and Synchronous Data Acquisition
- Scientific research computing, metrological testing, and time-frequency alignment
- Radar, telemetry, and radio monitoring

B-DC output

- Route: Route 1;
- Interface: RS422;
- Frame format: IEEE Std 1344-1995/GJB 2991A-2008 compliant
- Configurable;Time zone: The time zone can be set from -12 to +12;Phase offset: -1024~1023 ns, configurable.

GNSSreceiver

- 72-channel u-blox M8 engine
GPS L1C/A, SBAS L1C/A, QZSS L1C/A, QZSS L1 SAIF,GLONASS L1OF, BeiDou B1, and Galileo E1B/C all support single-satellite timing mode (Single SV Timing).
- Supports advanced anti-jamming and anti-deception detection capabilities.
- Supports AI-based GNSS anomaly detection and NMS fusion monitoring capabilities.
- Capture time: ≤ 120s (cold start)
- Synchronization accuracy: ≤ 30 ns RMS

External antenna

- Users can configure antenna cable delay compensation.
- Antenna voltage: +3.3 VDC
- Antenna connector: SMA-F (50 Ω)

Physical and environmental parameters

- Power supply: 12VDC, powered via PCIe slot;
- Humidity: 95%, no condensation;
- Dimensions: X1; compatible with X4/X8/X16;
- Operating temperature: -40 °C to +60 °C;
- Storage temperature: -40 °C to +80 °C

