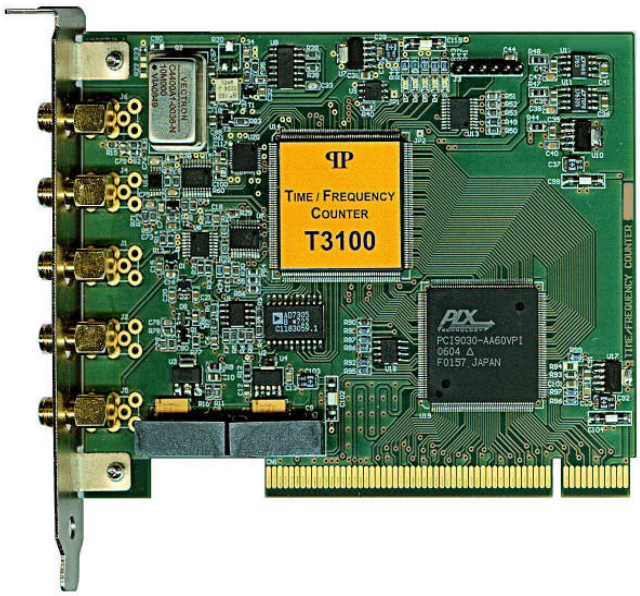
Time/Frequency Counter Model T3100(S)

High Performance Instrument with PCI Interface

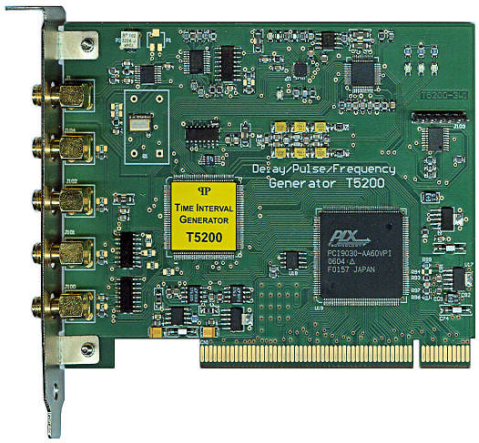
- Single PCI board for PC
- Time interval measurement range: 0 – 4400 seconds
- Precision (standard deviation) < 35 ps at time interval from 0 to 50 ms (OCXO)
- Frequency range up to 3.5 GHz
- Frequency sampling up to 2 MSa/s
- Measurement of Allan Deviation (ADEV)
- Measurement of Time Interval Error (TIE, MTIE), TDEV
- Totalize mode
- On-board automatic calibrator
- Selectable pulse edge and polarity
- Selectable input threshold level or automatic threshold search
- Comprehensive statistical data processing
- User-friendly software for Windows and DLL file for user's applications
- Export of data files for processing in other programs (*Stable32*, *MS Excel*)
- TCXO (T3100), OCXO (T3100S)



The T3100(S) Time/Frequency Counter occupies a single PCI slot in a PC and combines the picosecond precision of measurement with affordable cost and reliability for thorough industrial and scientific applications. The supplied software creates a user-friendly graphic interface and provides flexible control and display of the measurement data.

The heart of the instrument is a newly developed counter chip, which contains an interpolation time counter with two precise two-stage Time-to-Digital Converters, a FIFO memory which allows for high measurement rate, and a dedicated microcontroller. The counter T3100 has on-board a *Temperature-Compensated Crystal Oscillator* (TCXO), while the model T3100S contains an *Oven-Controlled Crystal Oscillator* (OCXO) which provides still higher accuracy and stability at reasonable cost.

Buy together with the precise
Time-Interval/Pulse/Frequency Generator T5200(S)
at a bargain price!



- Precisely controlled time interval between the leading edges of output pulses and the pulse width
- Time interval/width range: 10 ns – 10 seconds, 5 ps resolution
- Jitter: < 20 ps rms at time interval from 0 to 50 ms (OCXO)
- Internal trigger generator: 10 mHz to 1 MHz
- Frequency synthesizer: rectangular pulses with frequency variable from 0.1 Hz to 75 MHz
- Output pulses: positive, 2 V amplitude on 50 Ω load, rise- and fall time < 600 ps, selectable width (10, 20, 50, 100 ns) and polarity
- Clock generator: internal TCXO or OCXO (option S) or external 10 MHz reference clock
- User-friendly software for Windows

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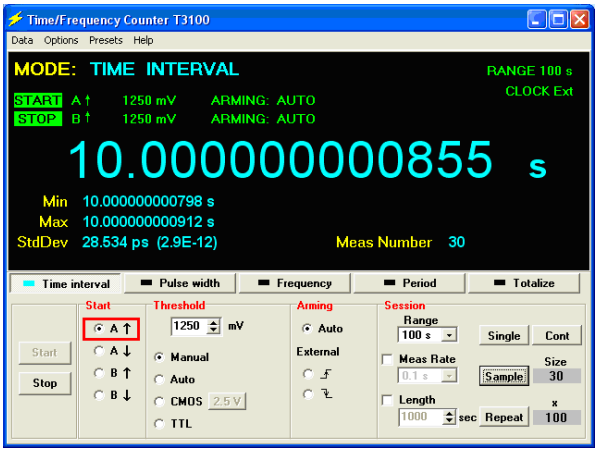
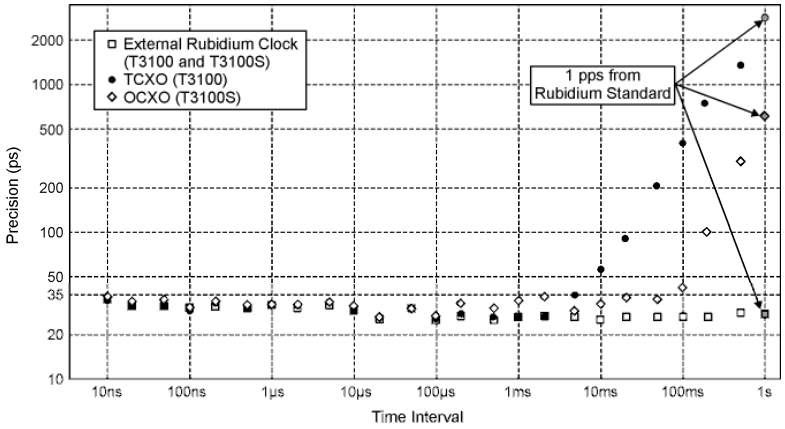


14-digit resolution in Time Interval mode



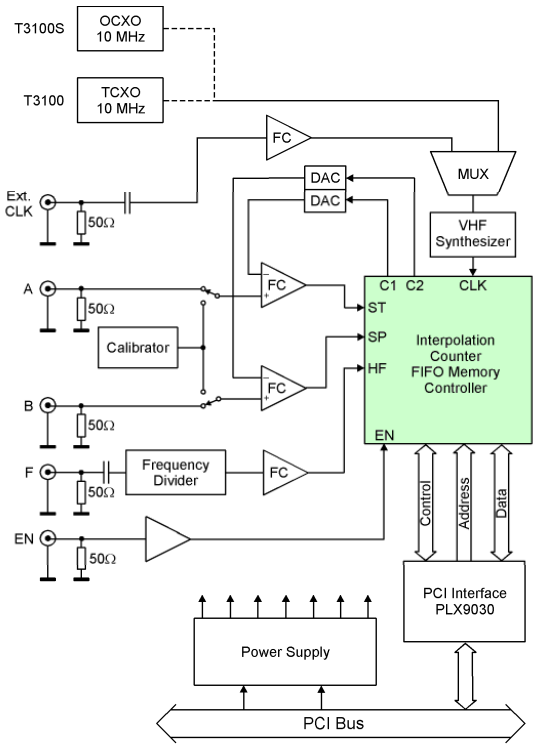
Precision (Standard Deviation of TI measurements)

Specifications

Functions	Time Interval (between two pulses at two inputs or pulses appearing consecutively at a single, common input), Period, Pulse Width, Frequency, Frequency Sampling, Allan Deviation, Time Interval Error (TIE), Maximum TIE (MTIE), Time Deviation (TDEV), Totalize
Statistics	Mean, Min and Max Values, Standard Deviation, Allan Deviation (frequency)
Graphics	Tables and plots of statistical distributions, display of frequency sampling in time domain to show possible frequency variation (Sampling mode)
Time Interval & Period	
Range	0 – 4400 seconds (Inputs **A** and **B**)
Resolution (LSB)	25 ps in single-shot measurements, may be reduced to 1 ps by averaging
Precision (*Standard Deviation*)	< 35 ps at time interval measured from 0 to 2 ms (TCXO – T3100) < 35 ps at time interval measured from 0 to 50 ms (OCXO – T3100S) < 35 ps at time interval measured from 0 to **1 second w**hen using an atomic clock as external reference clock $< 35/\sqrt{Sample\_Size}$ ps with averaging
Systematic Error	< ± (1 ns max + (Timebase Error x Interval) + Trigger Level Timing Error)
Range Limit (*Overflow*)	presettable: 1 s, 10 s, 100 s, 4400 s
Start Enable	internal (software) or external pulse (+1… +3 V) into 50 Ω (input **EN**)
Stop Disable	referred to Start, programmable in the range (1…999)·20 units, where the unit is selected as ns, µs, and ms
Dead Time	200 ns
Measurement Rate	$5 \cdot 10^6$ measurements per second maximum (when measuring zero time interval and storing data in internal FIFO memory), up to $4 \cdot 10^5$ measurements per second stored to memory in PC
Frequency & Period	
Range	Inputs **A** and **B**: 0.1 Hz to 200 MHz Sensitivity < 75 mV RMS typ. (0.01 to 200 MHz), Minimum slew rate: 10 V/µs Input **F**: 100 MHz to 3.5 GHz Sensitivity < -12 dBm (< 55 mV RMS) from 400 MHz to 3 GHz Sensitivity < - 3 dBm (< 160 mV RMS) from 100 MHz to 3.5 GHz
Gate Time	selected from 1 µs to 10 s (reciprocal method)
Measurement Rate	up to $8 \cdot 10^5$ measurements/sec (when measuring frequency in 1 µs gate and storing data in internal FIFO memory), up to $2.5 \cdot 10^5$ measurements/sec stored to memory in PC
Frequency Sampling	
Range	Inputs **A** and **B**: 1 to 200 MHz Input **F**: 100 MHz to 3.5 GHz
Sampling Rate	0.1, 0.2, 0.5, 1.0, 2.0 MSa/s
Totalize	
Range	0 to 10^{12} counts
Input frequency	max. 200 MHz
Gate Time	Internal: from 1 µs to 10 s, External arming (**EN**), Manual Start-Stop
Inputs A and B	Impedance: 50 Ω, DC coupled; SMA sockets Amplitude: within ± 4 V Pulse edge: selectable, rising or falling Threshold: manually adjustable from -4 V to +4 V with 40 mV resolution, or set automatically
Input EN	Impedance: 50 Ω, DC coupled; SMA socket Input pulses: standard TTL or min. +1 V referred to ground
Internal Clock Generator	**T3100:** 10 MHz TCXO, stability 0.5 ppm, (- 40 to +85 °C), ageing 1×10^{-6}/year **T3100S:** 10 MHz OCXO, stability 0.1 ppm, (-20 to +70 °C), ageing 1×10^{-8}/day*
External Clock Generator	10 MHz, sine or pulse, min. 100 mV on 50 Ω input impedance; SMA socket
Capacity of FIFO Memory	4 K measurements of time interval, 2.7 K measurements of frequency
Supplied Software	for *Windows*® XP/Vista/7, DLL file for other applications

*after 30 days of operation

Architecture



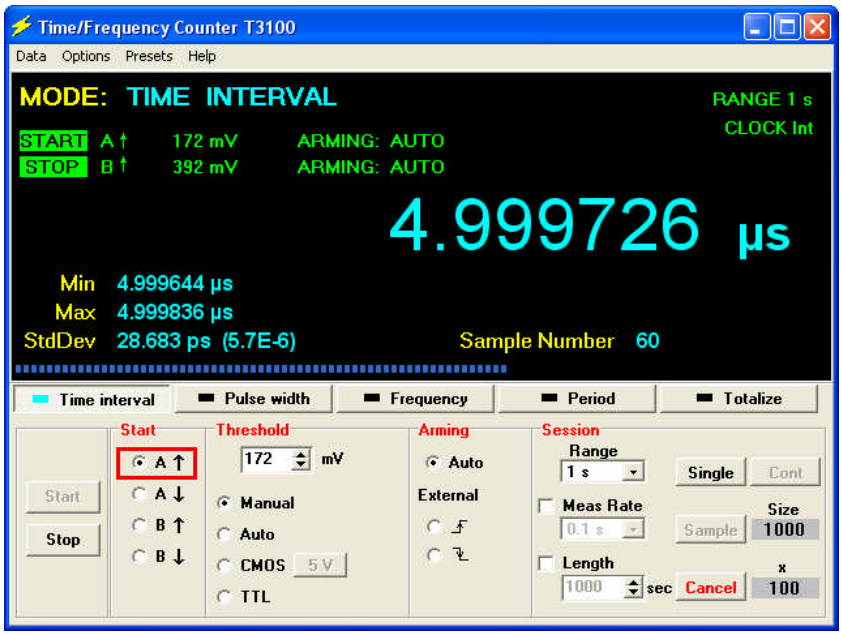
The main inputs for time-interval and frequency measurement are A and B. The fast comparators (FC) allow to select the required threshold level of the input pulses. The voltage levels are set by the corresponding Digital-to-Analog Converters (DAC) and can be adjusted manually on the virtual desktop or automatically by the software procedure.

The standardized pulses from the comparator outputs are fed to the interpolation time counter. The counter can measure the time intervals in the range from 0 to 4400 seconds with a 25 ps resolution, or measure the frequency of input pulses up to 200 MHz. To increase that range a fast frequency divider enlarges the maximum frequency range to 3.5 GHz at the F input.

The counter T3100(S) was designed with two precise, two-stage interpolators integrated in the counter chip which contains also the FIFO memory, two correction look-up tables (LUTs) and a dedicated microcontroller.

The on-board calibration generator is used during the calibration routine to compensate the input time offset between the channels A and B, and to identify the transfer characteristics of two two-stage interpolators contained in the counter. The calibration pulses are applied through the solid-state relays to the inputs A and B simultaneously.

Measurement of Time Interval



The Start and Stop pulses are applied to the inputs A and B with selected edge (rising - ↑ or falling - ↓). The time interval can also be measured between the edges of two consecutive pulses appearing at a single input.

The Threshold at the inputs A and/or B may be set manually on any level between – 4 V and + 4 V, or may be set at the fixed TTL level (+1.5 V) or a selected CMOS level (+1.25 V, +1.65 V or +2.5 V). The "best" threshold level (in the middle of the amplitude) can also be adjusted automatically (Auto mode).

Input Arming is set by default in Auto mode, when the Start input is enabled after completing every measurement cycle and the Stop input is disabled until the Start pulse appears. In External mode the positive-going (⌐↑) or negative-going (↓¬) edge of the external arming pulse (Start Enable, EN) can be selected to perform a single *measurement session* preset in the windows Sample and Repeat.

To enable the STOP pulse (at the A or B input), an internal programmable counter can be utilized to set the needed STOP disable time (after the leading edge of the START pulse) over a range (1…999)·20 units, where the unit is selected as ns, µs, or ms.

In some practical cases, the Start pulse begins the measurement of time interval, but the Stop pulse does not appear. To avoid long waiting time for overflow in the nominal range (4400 seconds) you can lower the overflow limit by setting the maximum Range. You can select the values 1 s, 10 s, 100 s, or 4400 s. By default the Range equals 1 second. The selected range is also shown in the upper right corner of the display panel.

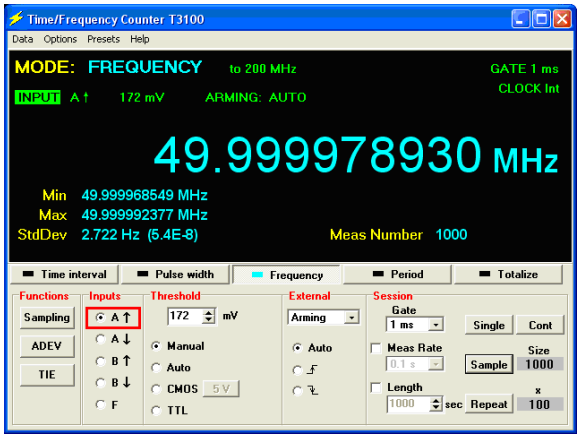
To achieve high versatility of the counter in many applications also the Length of the Session may be preset by ticking the mark (√) at the Length option and writing the desired value of the session length in the corresponding field.

Averaging is accomplished by execution of measurements in a preset Sample. For a Sample Size equal to n, the standard deviation of the resulting mean value is StdDev/√n. If StdDev = 30 ps and n = 100, then the standard deviation of the mean value is 50/10 = 3 ps.

The Pulse Width mode allows for measurement of pulse width of pulses applied to the input A or B. The polarity of pulses (active edges), threshold level, and measurement session are defined in the same way as in the Time Interval mode.

See the behavior of **precision versus time interval** (seldom presented by other manufacturers) shown on the previous page.

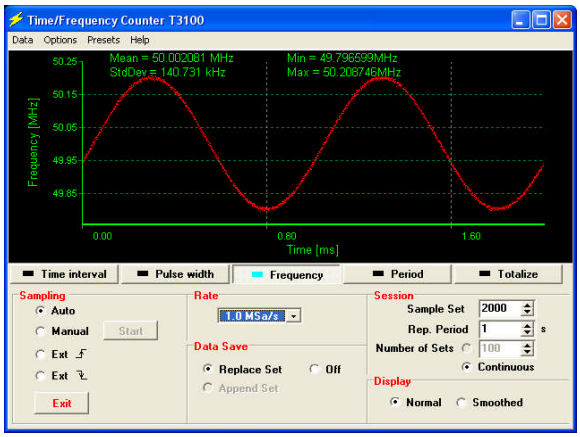
Measurement of Frequency



The inputs A and B can be used for frequency measurements (using reciprocal method) up to 200 MHz, while the input F accepts signals from 100 MHz up to 3.5 GHz.

Period In this mode the measurements are performed in a similar fashion as in the Frequency mode.

Totalize In this mode the input pulses are counted within a preset time gate. The duration of the gate may be selected in the Gate window as 1 µs, 10 µs, 100 µs, 1 ms, 10 ms, 100 ms, 1 s, and 10 s, or not set (Gate Open). For each gate the number of counted pulses is displayed and the respective Mean Frequency in pulses per second.

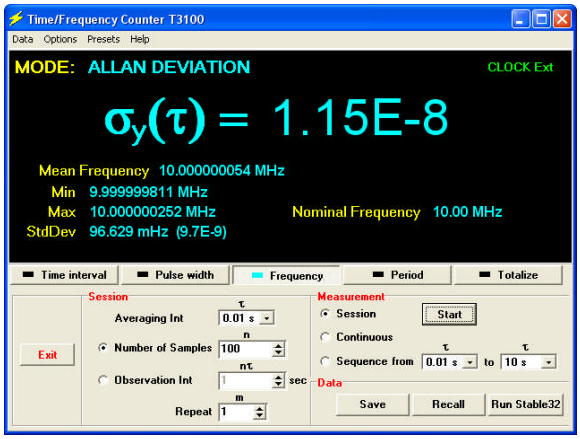


Frequency sampling

The sampling mode allows for discovering a frequency variation or modulation (needed or not) of the measured signal. Thanks to the short dead time of the counter, the frequency sampling can be performed at an internally generated rate ranging from 100 kSa/s up to 2 MSa/s.

The lowest value of the sampled frequency depends on the selected sampling rate. The lowest sampling rate results in a minimum random error, while the highest sampling rate allows for maximum resolution to observe rapid changes in the sampled frequency.

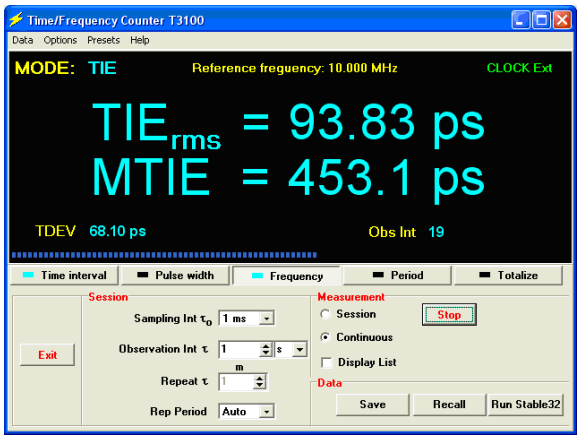
◄ The screen snapshot was obtained for a 50 MHz signal from the HP8648 signal generator, with a 1 kHz frequency modulation.



Allan Deviation

A commonly used measure of the short-time stability of periodic signals is the *Allan Deviation* (ADEV). The counter T3100 has built-in this feature.

The measurements may also be performed in the Sequence mode, where the results are displayed in the list form and as a graph, for a sequence of observation intervals with different values of τ. The $\sigma_y(\tau)$ measurement begins with a value of τ selected from a predefined set and ends with another selected value of τ. The resulting data sequence is displayed in the real time on the screen.



Measurement of frequency wander – Time Interval Error (TIE) and Maximum TIE (MTIE)

Wander usually results from the frequency offset or changes in cable delay due to temperature variation and can lead to data slips in communication systems. To guarantee network synchronization quality, the wander should be kept within the secure limits defined in respective standards. An important parameter characterizing the wander is the *Time Interval Error* (TIE). The maximum value of TIE (MTIE), computed from an array of TIE data, can characterize the frequency offsets and phase transients of a tested signal to obtain a clear view of quality of relevant electronic apparatus or systems.

The resulting data may also be arranged on display in the list form or as a graph. In addition, the *Time Deviation* (TDEV) is computed.

Storing and processing of measurement data

The measurement results are first stored in the FIFO memory and then transmitted to PC and stored in a file located on the hard disk or another nonvolatile memory. The names of respective files and folders are conveniently arranged for easy reviewing and identification of measurement sessions.