Time to digital converter - TDC1
by S-Fifteen Instruments

1 Features

- 4 independent inputs
- 2 ns timing resolution
- <200 ps timing jitter
- 10 MHz maximum count rate
- No intrinsic deadtime
- Small form factor

Applications: Ultra-sensitive fluorescence measurements, Environmental analysis, Biomedical devices, Quantum key distribution

2 General Description

The TDC1 is a combined moderate-speed counter and timestamping/timetagging device for processing electrical pulses in four independent inputs. It can accept a wide range of standardized signal standards including (NIM and TTL) and is completely powered from a USB2 connection. The internal clock source can be disciplined by an external 10 MHz timing reference for precise absolute timing.

In counting mode, the device has 4 independent counters registering events on each of the four inputs, and 4 counting coincidence events between 4 pairs of inputs that register counts for a selectable integration time from 1ms to 65s. In timetag mode, the device registers the absolute time of the leading edge every signal event (pulse) at any of the input lines with a resolution of 2ns together with the logical state of all four input lines. This allows to identify complex detector patterns with a single device.

The TDC1 is bundled with open source scripts in Python and C to perform data collection and visualize real time counts and coincidences.

3 Specifications

Table 1: Device Specifications

Signal Inputs	
Impedance	50 Ohm (default) and 1 kOhm (selectable by jumpers)
Input Standards	TTL, NIM, custom (positive or negative pulses with a trigger level between -3.3V and +3.3V)
Minimal Pulse Width	2 ns
Minimal Pulse Separation	2 ns
Connector	LEMO00 size coaxial connector (optional: SMA)
Absolute Maximum Input Amplitude	± 4.2V
Clock Reference	
External Reference Frequency	10 MHz nominal (accepts 9...11 MHz)
External Reference Amplitude	100 mVpp min, 2.3 Vpp max
Clock Selection	Automatic or Manual
Internal Clock Accuracy	<50 ppm, temperature drift TBD
Counter Mode Parameters	
Maximal count rate	80 MHz in each channel
Integration time	1 ms to 65535 ms in steps of 1 ms
Pairwise Coincidences	Ch1-Ch3/Ch1-Ch4/Ch2-Ch3/Ch2-Ch4
Timestamp Mode Parameters	
Timing Resolution	2 ns
Timestamp Bits	32 (27 timing, 1 rollover, 4 channel bits)
Timing Jitter	<200 ps (nominal)
Maximal Event rate	<3 Mevents/s average, <250 Mevents/s in bursts of <512 events
Dead time between events	None
Interface	
Host Connection	USB CDC ACM class / virtual com port (no device driver necessary)
Data Format	Text or binary
Physical Parameters	
Size (W x L x H)	85 mm x 46 mm x 22 mm
Weight	150 g
Power Consumption	<0.5 W (100 mA from USB bus)

4 Software Control Commands

Send plain-text commands terminated/separated by newline/cr or semicolon via the virtual COM port. An eventual reply comes terminated with cr+lf. The commands are case-insensitive.

Table 2: List of serial commands/queries available on the detector

Command	Description
*IDN?	Returns device identifier
*RST	Resets device
TIME <value>	Set the gate time to <value> in msec. Default is 1000, minimum is 1, max 65535.
TIME?	Returns the current gate time.
COUNTS?	Triggers a counting window, and replies with the number of detected events as a list of space-separated integers.
ABORT	Stops current counting cycle.
SINGLES	Return only singles (mode 0).
PAIRS	Return singles and pairs (mode 1).
TIMESTAMP	Returns timestamps as packed binary patterns (mode 3).
MODE?	Returns device counting mode.
TTL	Process TTL inputs (threshold +1.6V, positive edge)
NIM	Process NIM inputs (threshold -0.5V, negative edge).
LEVEL?	Returns input threshold voltage and polarity (POS or NEG).
REFCLK <value>	Sets the reference clock source, where <value> is 0 for autoselect, 1 to force external reference, and 2 to force the internal reference. In auto mode, an external clock is considered acceptable if 9 MHz<f<11 MHz.
REFCLK?	Queries the current reference clock setting (reply is 0, 1 or 2).
ECLOCK?	Queries external clock status. returns 1 if an external clock with a frequency 9...11 MHzis detected, or 0 otherwise.
POS <value>, NEG <value>	Sets input to detect positive or negative edges at a given threshold <value> (range -3.3...+3.3 V).
HELP	Print help text.

4.1 Python Library for S-Fifteen Instruments

A python class encapsulating all serial commands can be found on `https://github.com/s-fifteen-instruments/pyS15`. To install the library follow the instructions on GitHub.

Here a code example to count events for 1 second, and return the output from all four channels:

```
from S15lib.instruments import TimeStampTDC1
counter = TimeStampTDC1('/dev/serial/by-id/usb-S-Fifteen_Instruments_USB_Counter_TDC1-0017-if00')
[counts_ch1,counts_ch2,counts_ch3,counts_ch4] = counter.get_counts()
```

Note that the exact device path depends on the serial number of the device, and the operating system (Windows, Mac or Linux).