HRM-TDC High Resolution Timing Module

DATASHEET

USB-Controlled, High Resolution Timing Module

SensL's HRM-TDC is a portable, highly functional timing system providing flexible, easy-to-use timing functions. The HRM-TDC has four channels, each with 27ps timing resolution and a maximum data rate of 4.5MHz over high-speed USB 2.0 to the host computer. The system also comes equipped with 16 general-purpose, user-configurable I/O ports and a programmable LVTTL clock output.

The HRM-TDC system architecture combines a high performance timing module with a high end FPGA, on-board memory and a high speed USB 2.0 interface. The FPGA is the heart of the system and controls all aspects of operation in addition to performing commands from the external host computer. It uses a proprietary communication protocol for communication with the host PC running either the SensL Integrated Environment (SIE), or the users own application built using the SensL DLL. The SIE, DLL and LabView drivers are provided for the system.

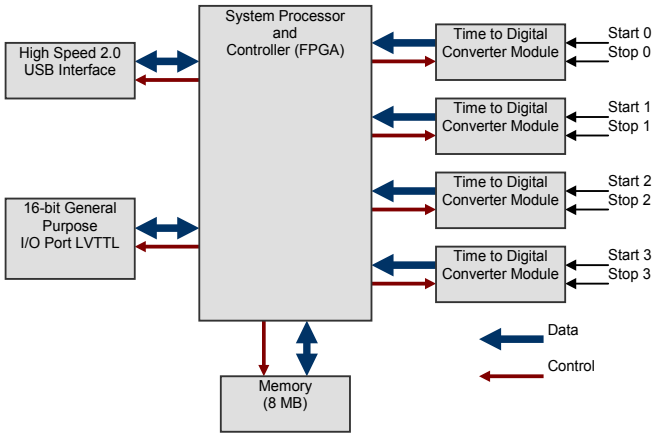
GENERAL SPECIFICATIONS

Number of channels	4
Connectors	SMA
Input voltage level	LVTTL (5V TTL tolerant)
START/STOP channels input impedance	51kΩ
Min. input pulse width	1.5ns
Modes	Single- and Multi-stop [1]
Internal Memory	8MB fast SRAM
Memory format	Dual ported linear or dual ported FIFO (mode dependent)
Readout during operation	Fully dual-ported memory (no stop start operation required)
Multi module operation	Depends on USB capability of PC
Programmable clock	LVTTL 50Ω SMA output up to 100MHz
I/O control	16 fully programmable LVTTL I/O ports
PC Requirements	Windows 7 or XP SP2, Min. 1.5 GHz and 5MB RAM and high-speed USB
PC Interface	High speed USB 2.0
Software	SensL Integrated Environment (SIE) and DLL drivers
Dimensions	164mm x 96mm x 34mm
Weight	680g
Power	+5V @ 0.65 A
Temperature	Operating: 0°C to +50°C Storage: -20°C to +70°C

TIMING SPECIFICATIONS

Resolution	27ps (LSB), 66ps (RMS)
Dead time	190ns
Saturated count rate	4.5MHz [2]
Usable count rate [3]	9MHz
Burst rates [4]	100MHz
Macro timing resolution (LSB) [5]	5ns
Maximum timing range	143μs
Differential Non Linearity	<±1 LSB

1) Single- and Multi-stop modes can be used in a variety of ways to produce four commonly used timing modes, as described in the sections below.
2) For a single channel. This rate is shared between all channels.
3) Useful count rate is the maximum count rate without loss of greater than 50%
4) Mode dependent
5) Time elapsed during an experiment, from the first START signal.



The architecture of the SensL HRM-TDC

TIMING MODES

The flexibility of the HRM-TDC allows it to be used in a variety of modes. Below are examples of SIE software utilizes the START and STOP signals in different ways to cater for different applications

SINGLE-STOP HISTOGRAM

Histogram modes use consecutive memory locations to store counts that represent successive timing values (Fig.1a). These memory locations or time bins are incremented based on the result of a time measurement between a START and the first STOP received. This is repeated to build up a histogram in memory showing the distribution of first events (STOPs) following a START input. This process is illustrated in Fig.1b and Fig.1c, and an example data set is shown in Fig.1d. Data is saved in .CSV format. This mode is also referred to as 'TCSPC mode', due to its application in Time Correlated Single Photon Counting.

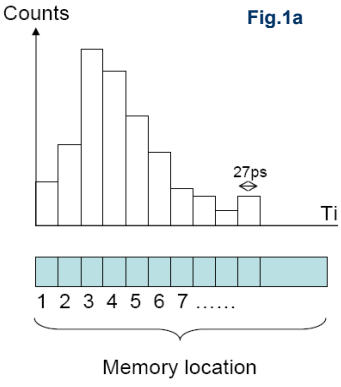


Fig.1a

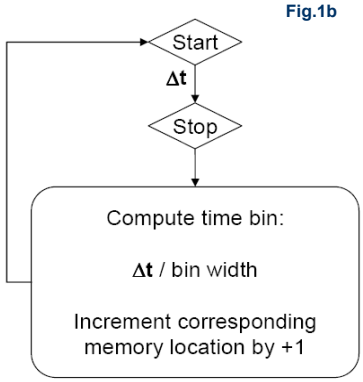


Fig.1b

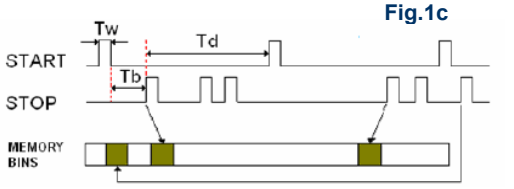


Fig.1c

Tw	Min. START or STOP input pulse width	1.5ns
Td	Dead Time (time to process event)	190ns
Tb	LSB (Min. histogram bin size)	27ps

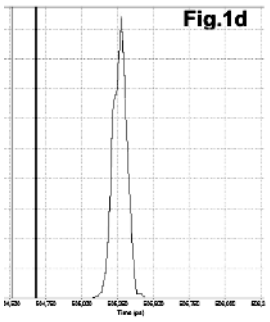


Fig.1d

MULTI-STOP HISTOGRAM

In this mode, all STOP events following a given START are measured and their corresponding time bins in the histogram incremented. The following START input will reset the timer and the following STOP events will be recorded until another START is received. The process is illustrated in Fig2.a and Fig.2b below. This is repeated to build up a histogram in memory, which is stored as in Fig.1a. Data is saved in .CSV format. This mode is also referred to as Multiscaler or Counter mode.

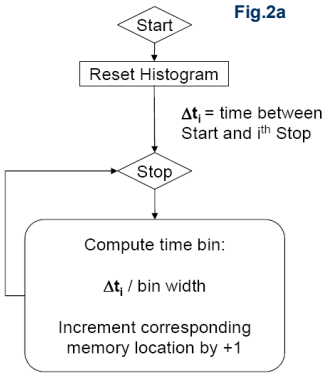


Fig.2a

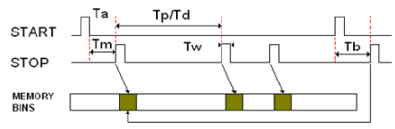


Fig.2b

Tw	Min. START or STOP input pulse width	1.5ns
Td	Dead Time (time to process event) *	190ns
Tb	LSB (Min. histogram bin size)	27ps
Tp	Min. time between STOPs*	5.5ns
Tm	Minimum time from START to first STOP	5.2ns

* Although the time to process an event is 190ns, burst rates in excess of 100MHz are possible owing to a 256-deep FIFO. The average rate should not exceed ~5MHz.

SINGLE-STOP FIFO

FIFO modes continually record the timing of events and save the results in consecutive locations in memory as shown in Fig.3a. When the last location in memory is filled, if not commanded to STOP, the module continues to record data starting at the beginning of memory again. The host PC, via the USB interface, keeps up in time with the module, reading the data from memory to a file in the host computer. Hence the memory can be regarded as a very large FIFO. Providing the host PC can keep up with the module, timing data can be recorded indefinitely.

In this mode the module carries out the Single-STOP process as described previously and illustrated below in Fig.3b and Fig.3c. However, along with the timing of the Single-STOP, a MACRO time (the time during the experiment that this measurement is made) is also recorded. Both times are recorded in the FIFO. An example of the data recorded is shown below in Fig.3d. Data is saved in .CSV format. This mode is also referred to as 'FIFO – TCSPC (with Macro Time)' due to its application in Time Correlated Single Photon Counting. The data can be saved as a .CSV file.

Fig.3a

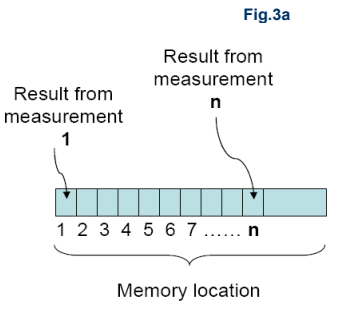


Fig.3b

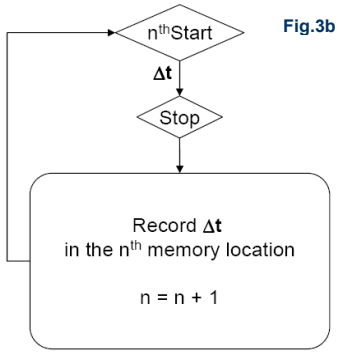
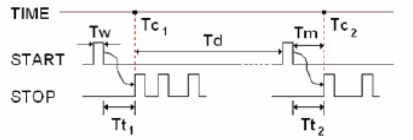


Fig.3c



Tw	Min. START or STOP input pulse width	1.5ns
Td	Dead Time (time to process event)	190ns
Tt	LSB (timing resolution)	27ps
Tc	Macro time LSB (time during experiment)	5ns
Tm	Minimum time from START to first STOP	5.2ns

Fig.3d

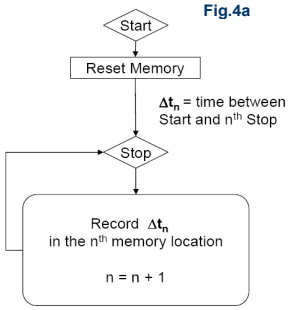
	A	B	C	D
	Tag #	Channel	Macro tag	Micro tag
1	0	0	197	18712
2	1	0	397	18713
3	2	0	597	18713
4	3	0	797	18714
5	4	0	997	18714
6	5	0	1197	18714
7	6	0	1397	18712
8	7	0	1597	18714
9	8	0	1797	18712
10	9	0	1997	18710
11	10	0	2197	18712
12	11	0	2397	18711
13	12	0	2597	18709

MULTI-STOP FIFO

Using this option the process is started with a single START pulse. The module will then fill the memory with time tags defining the time of each STOP event with relation to the initial single START pulse. Any further START inputs will be ignored. This mode is illustrated below in Fig.4a and Fig.4b and is also referred to as 'Time Tagging'. Data is saved as a .CSV file.

There is a further 'Re-Sync' option within this mode that uses a 250KHz clock output from the module as the START input. The clock continuously re-synchronizes the module to eliminate long term drift between channels. This is the preferred method when it is required to compare the data from more than one channel.

Fig.4a



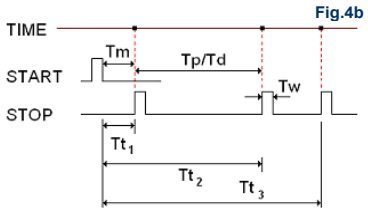
- Option 1: Free Running:

  Once acquisition started it carries on indefinitely

- Option 2: Re-Synch

  Acquisition is re-started at a rate of 250kHz.

Fig.4b



Tw	Min. START or STOP input pulse width	1.5ns
Td	Dead Time (time to process event)	190ns
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Tp	Min. time between STOPs	5.5ns
Tm	Minimum time from START to first STOP	5.2ns

* Although the time to process an event is 190ns, burst rates in excess of 100MHz are possible owing to a 256-deep FIFO. The average rate should not exceed ~5MHz.

Fig.4c

	A	B	C	D
1	Tag #	Channel	Macrotime	Microtime
2	0	0	0	18684
3	1	0	0	55740
4	2	0	0	92796
5	3	0	0	129852
6	4	0	0	166907
7	5	0	0	203958
8	6	0	0	241012
9	7	0	0	278066
10	8	0	0	315120
11	9	0	0	352173
12	10	0	0	389227
13	11	0	0	426280
14	12	0	0	463331

16 I/O PORTS

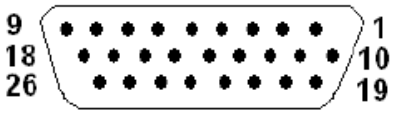
In certain experiments it is required that a timing measurement be repeated for a series of different external situations, such as sample location, illumination conditions etc. To facilitate this, it is possible to systematically divide the available system memory into sections, each section being used to store the data from one particular point of interest (experiment point) in the experiment field. (The concept only applies to Histogramming modes). The 16 programmable I/O ports can operate either as outputs to control external equipment or as inputs to allow external equipment to define the data to be processed.

Inputs

In this mode the external equipment will change the states of the ports that will in turn define the memory position for processing.

Outputs

In this mode the external equipment will be controlled through the port. The SIE enables the user to configure the number of experiment points, the number of time bins per experiment point - and hence the depth of each bin, the sequence in which the experiment points are followed, and the configuration of the I/Os that correspond to each data point. It is also possible to configure delays between each data point, the trigger type and any trigger delays. Examples of such interfacing equipment include: x/y stepper motor drivers or scanning mirrors - for location control, multiplexer - for addressing individual sensors in a sensor array (PMTs or photon courting detectors), monochromator - for changing the illumination light wavelength or looking at different emission wavelengths.



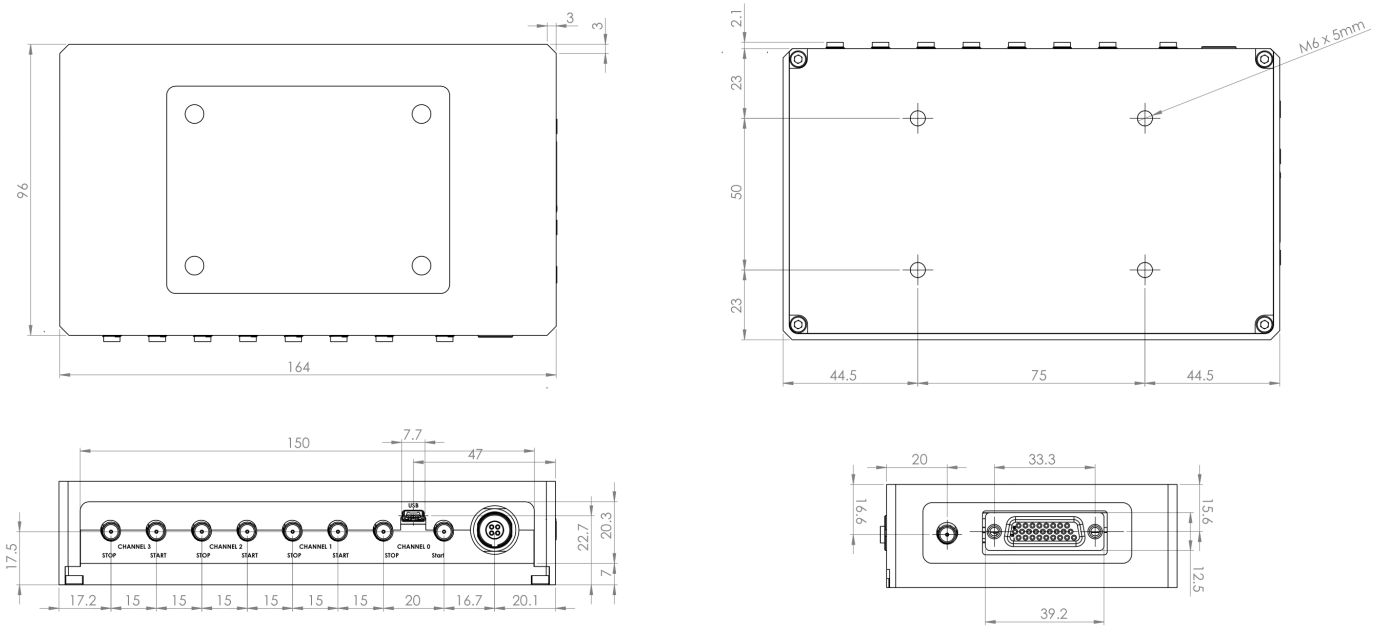
Pins 1 to 16:	I/O ports 0 to 15 respectively
Pin 17:	Test clock signal ENABLE (LO to disable test clocks
Pin 18 to 22:	Test clock signals (outputs)
Pin 23, 24:	+5v
Pin 25, 26:	Ground

Allocation of the I/O pins

SOFTWARE

The SIE is a user interface that facilitates the HRM-TDC set-up and control, as well as providing timing data display and management. While the interface provides an extensive range of operating modes and measurement processes, it does not fully cover all of the features present within the HRM-TDC module. The HRM-TDC DLL provides a set of functions that will allow full control of the HRM-TDC for all features. For complex experiments that require control beyond the scope of the SIE, it is expected that the user will write their own real-time application utilizing the various functions in this DLL. The DLL functions are compatible with C, C++, Visual Basic and Labview drivers are also provided, that act as wrappers for the DLL functions. It should be noted that the SIE is only guaranteed to work on Windows XP SP2 and Windows 7.

SCHEMATICS (All dimensions in mm)



An OEM version of the HRM-TDC is available. For the relevant schematics please contact SensL

ORDERING INFORMATION

Product Code	Description
HRM-TDC	4-Channel, High-Resolution Timing Module with 27ps LSB, SIE software, DLLs and LabVIEW drivers

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All specifications are subject to change without notice