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ListTDC Event Recording System

1. Field of application

The ListTDC Event Recording System is mainly used in neutron scattering measurements with two dimensional position sensitive (PSD) detectors having delay line outputs. The basic mode of operation is **event recording**. Additionally, the unit accepts one (single) digital signal coming from a chopper or a T_0 signal source. It generates event record list data with two timestamps: high resolution absolute time and elapsed time from T_0 / chopper event. Data are 2D position coordinates or chopper / T_0 events. The unit is optimized to 2D monitor detector / beam profiler with **Time-of-Flight (TOF)** capability.

2. System description

Operation of a ListTDC Event Recording System needs 3 main hardware components:

a) **ListTDC Event Recorder Unit**
b) **Event Processor Unit**
c) **Spectrometer PC**

The system firmware / software components have also 3 main components according to the 3 hardware parts:

a) **ListTDC Event Recorder Firmware**

   It does not need any installation or setting.

b) **Event Processor Driver software** running in Event Processor Unit

   This server program performs the necessary signal processing by accepting and responding to requests or commands coming from Spectrometer PC.

c) **Spectrometer Application software** running in Spectrometer PC

   This is an application program for controlling the data acquisition, receiving and recording the list mode events. It contains a graphical user interface also with interactively starting and stopping the measurement and displaying instant 1D, 2D spectra.

An **Installation and Reference Guide documentation** is part of the delivery containing also the communication protocol and description of commands and data structures. All the software components are preinstalled in the delivered hardware units and also delivered on a pendrive.

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3. Description of hardware

3.1. ListTDC Event Recorder Unit

Housing: 2 unit width NIM module

Power connection: +6 V and GROUND of the NIM crate

Signal inputs:

- 5 front end detector signal inputs:
  - Start, StopX1, StopX2, StopY1, StopY2
  - LEMO connectors with NIM signal level
- 1 dedicated front end event input
  - single chopper input or T_0 input
  - LEMO connector with TTL signal level

Time to Digital Conversion:

- Finest internal time bin: 165 ps
- Time resolution used: separately configurable in X and Y direction
- Typical resolution: 1000*1000 pixels with time resolution 330 ps for both X and Y
- Maximal delay between Start and StopX1, StopX2, StopY1, StopY2: 5 microseconds
- Maximal count rate: 500 000 neutron events/sec
- Event recording absolute timestamp: 8 ns resolution, 30 days length

Data output communication: dedicated Gigabit Ethernet point-to-point connection

The ListTDC Event Recorder Unit gathers all the incoming chopper or T_0 events and the neutron events from the 2D PSD detector through a CFD unit as Start, StopX1, StopX2, StopY1 and StopY2 events. Each recorded elementary event source plus its high precision (165 ps) timestamp plus its absolute timestamp is sent to the Event Processor Unit.

3.2. Event Processor Unit

The Event Processor Unit receives the incoming chopper or T_0 and 2D PSD neutron elementary events through a dedicated peer-to-peer Gigabit Ethernet connection. It calculates the X-Y position of each single neutron event from the five (Start, StopX1, StopX2, StopY1, StopY2) elementary neutron events. The Event Processor Unit sends these neutron events and chopper or T_0 events together with their absolute and elapsed timestamps to a Spectrometer PC for further processing.

In addition, the neutron events are stored in a 2D X-Y intensity spectrum and in a 1D total_counts-elapsed_time spectrum. These spectra are available from the Spectrometer PC by sending commands.

The Event Processor unit takes care the data acquisition time: if the preset DAQ time value is exceeded it stops recording the incoming events.

Please use this Position Processor Unit "as is" and never install any computer program to this unit. Any software installation here will terminate the supplier's warranty obligation.

3.3. Spectrometer PC

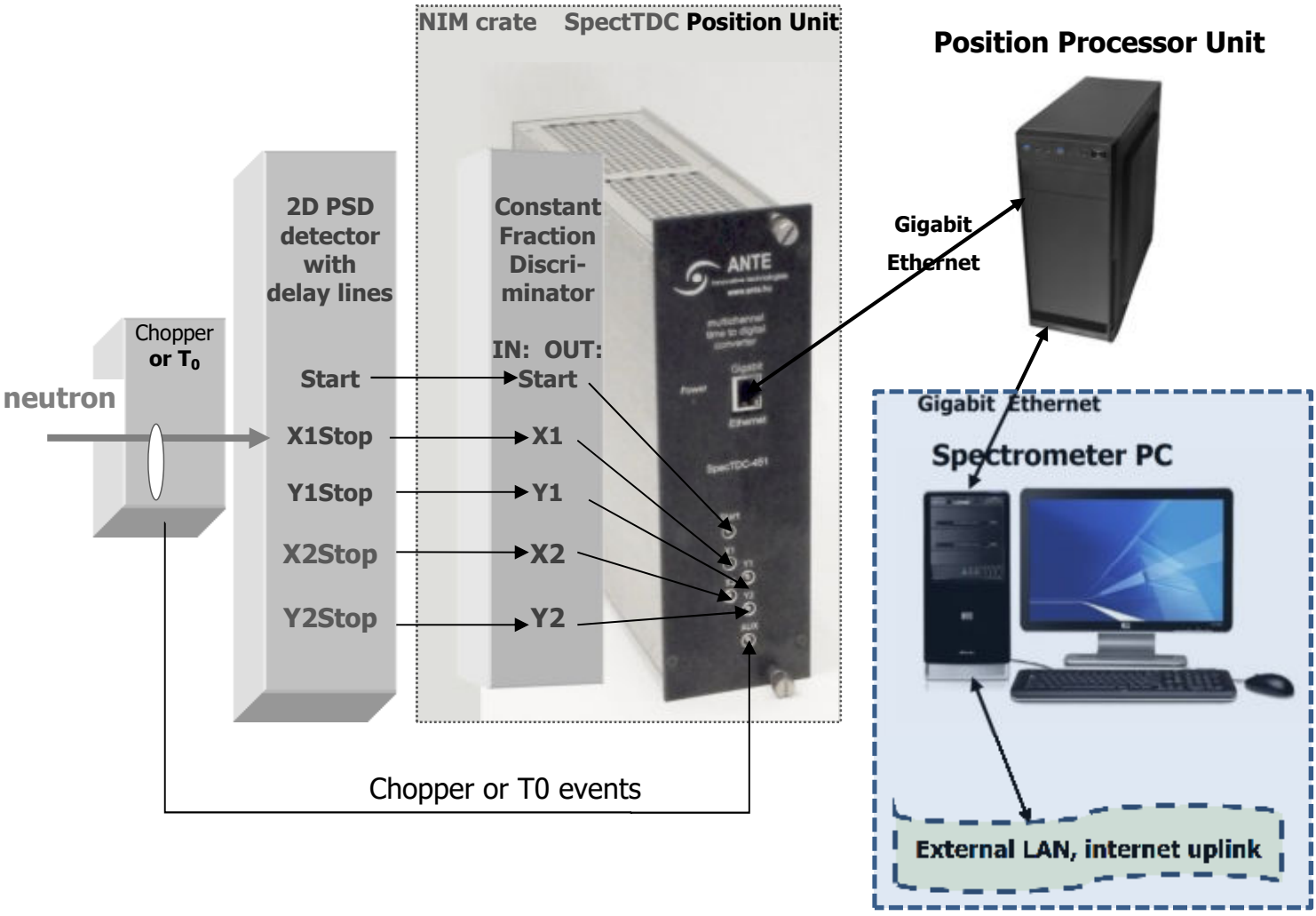
Such a PC or laptop is always necessary to make measurements. It controls the data collection process and it reads out the event (list mode) data records from the Event Processor Unit. Spectrometer PC can send several commands to Event Processor Unit for

- starting the event recording
- stopping the event recording
- checking the measurement status
- reading out the 2D X-Y intensity spectrum
- reading out the 1D total_counts - elapsed_time spectrum

Spectrometer PC has a graphical program for interactively handling the DAQ data.

You can use your own PC as Spectrometer PC. Of course, in this case you do not have the preinstalled application in your PC.

3.4. Hardware system build up



4. Description of software components

4.1. Firmware of ListTDC Event Recorder Unit

The firmware continuously pays attention to any new occurring events from the 2D PSD detector and the chopper or T_0 signal source. If a new event occurs it sends the event to the Event Processor Unit with the following parameters:

- Event source: Start, StopX1, StopX2, StopY1, StopY2 or T0 / chopper
- High precision (165 ps resolution) timestamp, for calculating the position
- Absolute timestamp: 8 ns resolution 32 bit length

The firmware fills the Ethernet packages optimally by taking care of timeouts also.

4.2. Event Processor Driver software

This driver program performs the necessary signal processing of all incoming events:

- It calculates a single neutron event and the X - Y detector position from the five elementary events: Start, StopX1, StopX2, StopY1 and StopY2.
- It calculates a common absolute timestamp (100 ns resolution, 48 bit length)
- It calculates the elapsed time from the last chopper / T_0 signal.
- It records all the events as neutron events and T_0 / chopper events

All the recorded events are sent to the Spectrometer PC.

In addition, it stores and continuously updates the following spectra:

- 2D X-Y intensity spectrum
- 1D TotalCounts-ElapsedTime spectrum

It works as a TCP/IP server program which accepts, performs and responds to commands and requests from the Spectrometer PC. The main accepted commands:

`StartDAQ` Start measurement and event acquisition
- Start N (start event acquisition until N millisec time)
- Example: `StartDAQ, Time=10000;`
- Response: `DAQStart;`

`StopDAQ;` Stop measurement (immediate stop)
- Response: DAQStop;

`GetStatus;` Status request
- Response: Status: Running;

`Get2DHistogram;` 2D spectrum request
- Response example: `Get2DHistogram, seq=20000000, dimx=600, dimy=600, sum=8, shiftx=-10, shifty=50, time=9000, bytelength=123456789, Histogram=`(binary data)`...;`

`Get1DHistogram;` 1D spectrum request
- Response example: `Get1DHistogram, seq=20000000, dim=1500, sum=4, time=9000, monitor=14567, bytelength=12345, Histogram=`(binary data)`...;`

`GetEvents;` Request for sending all occurring events
- Response: (Event records as identities, params, timestamps are sent)

4.3. Spectrometer Application software

This application software runs under Microsoft Windows 10 in a Spectrometer PC.

DAQ Control Application

This application program component sends control commands to the Event Processor Driver running in the Event Processor Unit. This application program is delivered in both binary and source code form. By delivering the source code we would like to support you in preparing your own application for your special purposes, if necessary. If you order also a Spectrometer PC you can develop your own application using this Spectrometer PC. This means that - unlike in the Event Processor Unit - you can install your own or third party software also in this Spectrometer PC.

This DAQ Control Application software uses the communication protocol elements, commands as they were described in the previous point. It is suitable for

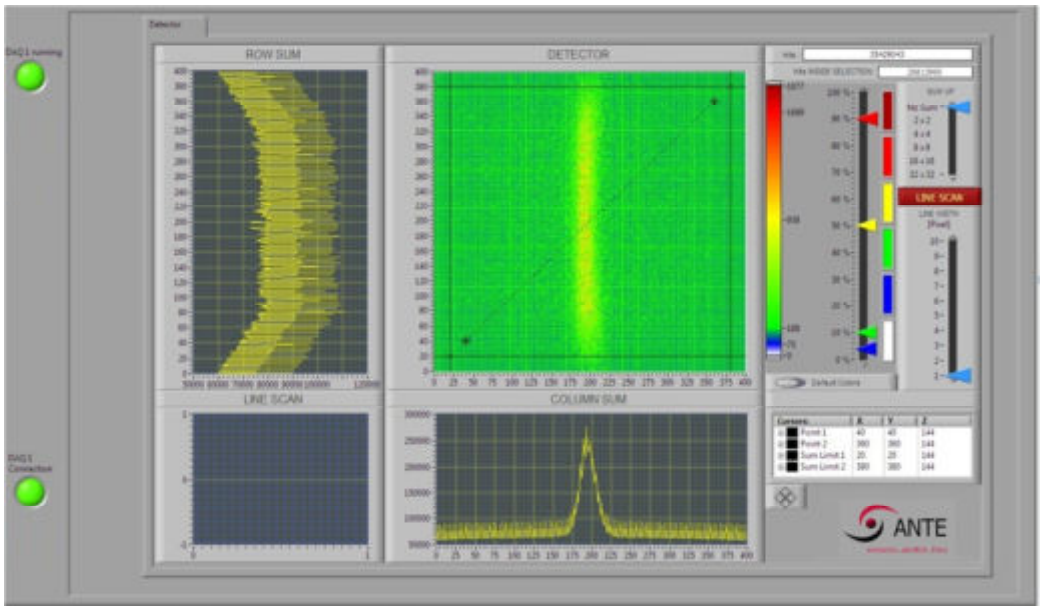
- starting and stopping the signal processing
- reading out the status of signal processing
- reading out the new event records

Detailed documentation of the communication protocol, description of commands is delivered together with the software.

Detector Display Application

This software part is delivered in compiled binary form. This graphical application software contains a complex program for

- interactively or continuously reading out the 2D X-Y – neutron intensity spectrum
- displaying the 2D spectrum
- interactively or continuously reading out the 1D TotalCounts-ElapsedTime spectrum
- displaying the 1D spectrum
- storing the actual spectrum
- continuously storing the incoming event records



You can separate your data acquisition control (by using the DAQ Control Application program) and displaying the collected X-Y spectrum or 1D TotalCounts-ElapsedTime (by using the Detector Display Application program). This means that

- ✓ you can start your data acquisition by using this DAQ Control Application program on one Spectrometer PC, and
- ✓ you can display the collected spectrum by using the Detector Display Application program on another Spectrometer PC at the same time.

Event recording in general

We deliver new generation equipments for neutron scattering measurements. The hardware units are equipped with software components also. All these units and modules are constructed to fully support the "event recording" mode of operation. This kind of the data acquisition means that every single event during the scattering measurement is recorded together with its parameters and with a high resolution timestamp. All these events are collected into an event list file. Typical events are:

1) neutron detection event and position from the detector

2a) Either chopper event

2b) Or Source Pulse (T_0) signal event

Event recording obviously provides the following benefits:

- It best suits to Time-of-Flight (TOF) measurements.
- User has the option to "replay" (revisit) the whole experiment later and to improve the primary data handling algorithm also.
- Revisiting the data is like replaying a film taken from several camera positions.
- You can reveal dynamic – time dependent – scattering effects also.