

Event Timer A032-ET



Manual

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NOTICES

SAFETY

Warning. Dangerous voltages, capable of causing death, are present in the A032-ET hardware. Use extreme caution whenever the device cover is removed.

Line voltage. The A032-ET hardware operates from 100 to 240 V nominal ac power source. Verify that your power source complies this condition.

Power cord. The A032-ET is supplied with the detachable, three-wire power cord for connection to the power source and to a protective ground. Always use an outlet, which has a properly connected protective ground.

PREPARATION FOR USE

Warning. The A032-ET needs careful handling and should be served by skilled specialists. Especially be careful to the A032-ET hardware interconnection since incorrect handling can damage the device.

Necessarily read this Manual over before any initial actions with the instrument. Feel free to ask (E-mail: artyukh@edi.lv) if you will have any troubles concerning the A032-ET application.

The A032-ET hardware contains a complicated finely adjusted electronic circuit. Do not remove the device cover without special necessity to protect this circuit from any careless handling.

Hardware connection to PC. The A032-ET is supplied with the detachable connecting cable for hardware connection to the PC parallel port. Always use this cable to ensure the A032-ET reliable operation.

Hardware connection to other instruments. Carefully read part 3.2 of this Manual to define in details all requirements to the signals that you will use in your application. The instrument may lose the specified precision or even be damaged if operated with unforeseen signals.

WARRANTY

The A032-ET hardware is warranted to be free from any hidden defects in material and workmanship for one year from the date of purchase. During this warranty period the Manufacturer repairs the device at no charge or replaces it with a new one. The Manufacturer does not assume responsibility for any damages of the instrument caused by incorrect user handling.

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1. Overview

The Event Timer A032-ET is a computer-based instrument that precisely measures the times when events (input pulse comings) occur. The A032-ET can be used for various applications where picosecond-precision wide-range and high-speed timing measurements are especially needed. First and foremost the A032-ET is designed for applications related to Satellite Laser Ranging, although it can be also well suitable for other applications (such as time-of-flight spectrometry).

There are two currently available options of the A032-ET, which use the same specialized hardware but differ by the software. These options provide alternatively two basic kinds of measurement:

The option A032.1 provides continuous (gapless) measurement of events at high (up to 10 KHz) mean measurement rate, allowing bursts of the rate up to 16 MHz. This option is well suitable to measure the overlapped time intervals between Start and Stop events that come at the separate inputs (either *A* or *B*) of the Event Timer in any order. Specifically this is the case of advanced Satellite Laser Ranging at KHz repetition rate. In such applications the Event Timer is well competitive as compared with the highest-performance event timers currently available.

The option A032.2 provides cyclical measurement of events that come at the separate inputs of the ET-device in the strict order: in every cycle at first the Event Timer measures a single Start event coming at the input *A*, and then - a user-defined number of Stop events (up to 12,000) coming at the input *B*. The Stop events are measured within internal online programmable gate. Specifically this is the case of conventional Satellite Laser Ranging where the measured Start-Stop time intervals do not exceed the repetition period of Start events. In such applications the A032.2 considerably surpasses possibilities of the traditional time interval counters in both precision and functionality.

The A032-ET interacts with user's application programs via the network, providing overall remote control and remote applications in multi-user mode. Owing to employing a novel measurement method, the A032-ET offers high performance characteristics, using compact and relatively inexpensive specialized hardware. As a result the A032-ET combined with user-made or custom-made application program can be used to create various top-quality and reasonably priced timing systems.

A032-ET main features:

- Two inputs *A* and *B* for the events being measured
- Time-tag marking specifying the input (either *A* or *B*) that provides the measured event
- Output data presentation as time-tags synchronized to real-time clock
- FIFO depth up to 12,000 time-tags
- Two software options supporting different order of event incoming
- 16 MHz maximum measurement rate
- Up to 10 KHz mean rate of continuous (gapless) measurement (the A032.1 option)
- Up to 500 Hz cycle repetition rate (the A032.2 option)
- Internal online programmable gating with 10 ns LSD (the A032.2 option)
- Remote control and timing data transfer via the TCP/IP network
- Self-calibration and precision testing

Summary of specifications

Inputs (BNC):	INPUT A INPUT B GATE IN SYNC IN TRIG IN REF IN	NIM pulse (falling edge; >5 ns width)* NIM pulse (falling edge; >5 ns width)* NIM pulse (high level) TTL pulse (rising edge, 1 pps) TTL pulse (rising edge) 10 MHz (>0.5 V p-p)
Output (BNC):	TEST OUT	NIM pulse indicating the gate delay (the A032.2 option)
Single-shot RMS resolution**		<10 ps
Dead time		60 ns
Non-linearity error		<1 ps (<3-5 ps for time intervals less than 100 ns)
Offset temperature stability		<0.5 ps/°C after warm-up
Warm-up time		2 hours
FIFO depth		12,000 time-tags
Measurement rate***	A032.1 option A032.2 option	up to 10 KHz continuously up to 500 Hz cycle repetition rate
Triggering		external or internal (programmable)
Time-base		commonly external; internal (+/-10 ppm) – for optional use
Stop pulse gating	A032.1 option A032.2 option	only external also internal (10 ns LSD, 60 ns to 167 ms range) online programmable via network
Control		fully remote control from a user program via the network
Application interface		over TCP/IP
Hardware interface		via PC parallel port supporting EPP mode
Software		MS-Windows based
Accessory software		DEMO application software for both of the options
Hardware dimension, weight		375x60x233 mm (desktop); 3.0 kg
Power supply		100-240 VAC

* To support the specified precision it is necessary to provide the falling time < 2 ns/V and the pulse width <50 ns

** The resolution is specified for the case of using external high-stable time-base

*** The actual rate may depend on the PC performance and its extraneous load

Delivery content

The A032-ET is delivered as a specialized desktop hardware with two detachable cables for connecting this hardware to PC and power supply, and a distribution disc. The disc contains:

- A032.1-S1 software supporting the A032.1 timer option
- A032.2-S2 software supporting the A032.2 timer option
- A031.1-C1 software supporting DEMO subsystem for the A032.1 timer option
- A032.2-C2 software supporting DEMO subsystem for the A032.2 timer option
- This Manual

Optionally the same distribution disc may contain some other additionally ordered programs (such as A032-ET Sample Program). Both the hardware and the CD are marked with the same unique number and only in this case are compatible for further usage. Delivery content also includes test results specifying the actual precision characteristics of the delivered Event Timer.

2. Main features of the Event Timer

2.1. Architecture

Like most of the virtual instruments, the A032-ET performs its measurement functions partly by hardware means and partly by software means. The measurement software provides interfacing with a user program via TCP/IP network on the basis of well-known “Client/Server” scheme (Fig.1). The user program can control the A032-ET via this interface and receive measurement data from for further specific-application processing. This is not quite the usual way as compared to another ways of connecting devices to user’s PC (such as parallel ports, serial ports and USB). However the network connection offers capacities that are inaccessible for the most of conventional connections, especially in the case of designing distributed timing systems. At the same time the network interface based on TCP/IP standards is quite get-at-able for users as almost all Software Development Kits contain the library with the required TCP functions.

In terms of the Client/Server architecture the A032-ET can be considered as combination of a specialised timing device (subsequently referred to as ET-device), and a specialised Server (subsequently referred to as ET-server) dedicated both to managing the ET-device and processing the timing data obtained from it (Fig.1). In this case the ET-client is a PC on which user runs his application, using the specific ET-server resources via network. Note that in many cases a single PC under MS-Windows can serve as both the ET-server and the ET-client although use of a separate PC for the ET-server is preferable to achieve the highest operating speed.

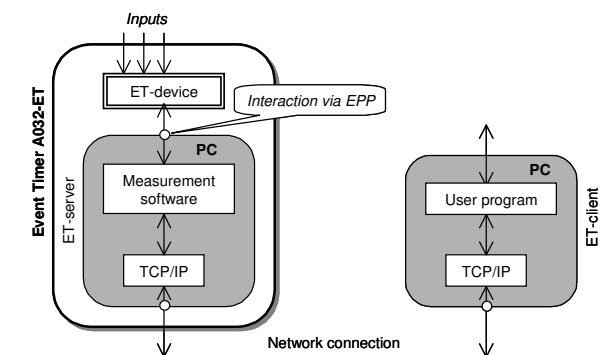


Fig.1. Network architecture of the Event Timer

The ET-device is compatible with different options of the ET-server software, providing different modes of the timer operation. Currently two kinds of ET-server software are available, specifying the option (either A032.1 or A032.2) of the Event Timer A032-ET as a whole. Any of these options can be used alternatively depending on the current user task.

2.2. Principles of operation

The A032-ET performs the measurement of input events in two stages. At first, the ET-device transforms every input event into single 80-bit timing data block (subsequently referred to as TD-block) and sequentially accumulates such TD-blocks in a buffer FIFO memory. Each TD-block contains the rough data (39 bits) and interpolating data (40 bits) about the time of event incoming, as well as one-bit mark specifying the input (either **A** or **B**) providing the measured event. Note that the interpolating data are presented initially in an intermediate redundant form and needs further an additional processing by the ET-server.

The used unconventional method of time interpolation supports both high precision and high speed. Specifically, using 100 MHz internal clocks it provides each single measurement with <10 ps RMS resolution during 60 ns only. This gives the maximum available rate of event timing (up to filling the FIFO memory) about 16 MHz. At this rate the used FIFO memory is able to accumulate up to 12,000 TD-blocks. On the other hand, each TD-block defines the time-tag in 1.5 hour range, meaning that the time intervals between adjacent events can be so long.

At the next stage the ET-server takes out TD-blocks from the FIFO memory and processes them to obtain the corresponding time-tags in a unified form. Further these time-tags are sent to the ET-client via network. To achieve the best precision, processing of TD-block takes into account the actual physical characteristics of time interpolation under actual operating conditions of the ET-device; these characteristics are defined through so called scaling (calibration) procedure before the measurement.

The ET-device is flexibly controllable and, in particular, allows writing TD-blocks in the FIFO memory and reading of them by the ET-server in different modes depending on the event timer option:

The A032.1 option provides continuous (gapless) event measurement during practically unlimited time. To do that, the ET-device continuously accumulates TD-blocks in FIFO memory in order of measured event incoming. Concurrently with this process, the ET-server continuously monitors the current state of the FIFO memory with some user-defined period T_M to detect the state when the amount M of TD-blocks exceeds the user-selectable value (204, 102, 50, or 25 TD-blocks). The rest of the FIFO memory capacity is used to damp possible bursts of input event intensity.

When the specified FIFO state is detected, the ET-server takes out M TD-blocks from the ET-device, processes them and sends the corresponding time-tags to the ET-client (Fig.2). Such procedure is being cyclically repeated. In this way continuous event registration goes together with cyclical timing data processing and sending the time-tags to the ET-client via TCP interface.

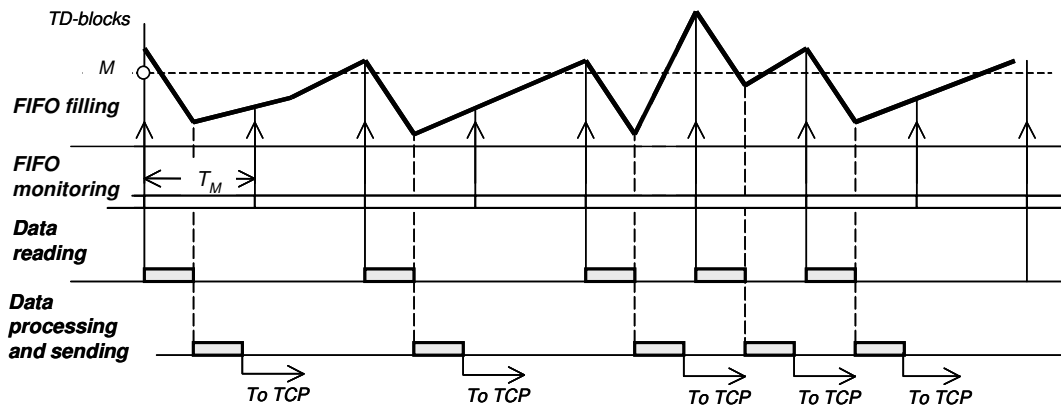


Fig.2. Schematic time diagram, illustrating process of data reading from the ET-device

The maximum available mean rate of such continuous measurement is limited mainly by the available reading and processing speed of the TD-block by PC of the ET-server. Typically (although it may depend on the actual performance of the PC) the total time of reading and processing of the single TD-block is about 0.1 ms, resulting in maximum mean measurement rate about 10 KHz.

In any specific application the monitoring period T_M and the amount M of TD-blocks can be adapted to the expected mean rate R of event measurement to avoid FIFO memory overflow. Generally the period T_M has to be defined so that it is a little less than the mean time M/R of accumulating M TD-blocks in the FIFO memory in view of the rate R . For example, if $R=10$ KHz and $M=204$, the period T_M should be less than the time $M/R=20.4$ ms. The minimum allowable value of T_M is 10 ms.

Note that the values $M=204$ and $T_M=15-20$ ms are applicable for any rate $R<10$ KHz of continuous measurement. However, when the actual rate is much lower than 10 KHz, the accumulation time of TD-blocks before being read by the ET-server can be too large,

resulting in too large delay of receiving the first time-tags by the ET-client. In some cases this may cause unwanted problems with real-time operation of the ET-client. In such cases it is recommended to decrease the M value as far as possible. For example, if $R=0.5$ KHz and $M=25$, the time $M/R=50$ ms and period T_M may be about 45 ms.

The A032.2 option provides cyclical measurement of events that come at the separate inputs of the ET-device in a strict order. Specifically, in the beginning of each cycle the Event Timer measures a single Start-event coming at the **Input A** of the ET-device, and only then - a number of Stop-events (up to 12,000) coming at the **Input B** (Fig.3). The Stop-events are registered over internal gate. The gate delay T_{Dj} is programmable by the ET-client in a wide range with 10 ns LSD resolution.

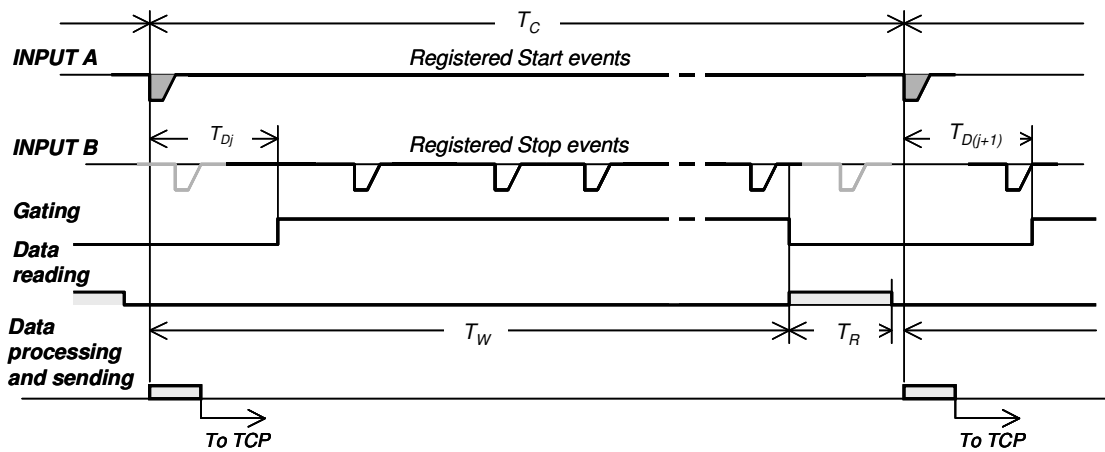


Fig.3. Time diagram illustrating the measurement provided by the A031.2 option

Unlike the A032.1 option, in this case the ET-device at first accumulates TD-blocks in the FIFO memory during some user-defined waiting period T_W , starting from Start-event registration. During this time the ET-server processes TD-blocks read out from the ET-device in previous cycle, and sends the corresponding time-tags to the ET-client. Then the ET-server interrupts the event registration, reads the currently accumulated TD-blocks and allows starting the next similar cycle. In any case the amount of TD-blocks read by the ET-server does not exceed the user-defined value M (from 1 to 12,000). The waiting period T_W can be defined in a wide range with a 1 ms step.

During the waiting period T_W the ET-server can receive a command from the ET-client to restart the measurement with modified gate delay. In this case the next measurement cycle will be performed with a new gate delay. For example, the restart command containing a modified gating parameter can be cyclically sent by the ET-client in response to each received batch of timing data. In this way online cycle-to-cycle controllable gating is possible. However it should be taken into account that the TCP/IP network may produce some unexpected delays for real-time data exchange, resulting in episodic loss of synchronism in such interactive operation at high (more than tens of Hz) repetition rate of measurement cycles.

The minimum available cycle duration T_C is defined by time period of data processing (that should be less than the waiting period T_W) and time period T_R of data reading. Total time of these operations depends on the amount of TD-blocks that the ET-server reads and processes. The time additionally needed for network interactions depends on the network performance and its actual load. These things should be taken into account to choose the parameters T_W and M so that they are well matched with the specific measurement conditions.

Generally the A032.2 option is oriented mainly to applications with cycle repetition rate up to tens of Hz (this is the case of conventional Satellite Laser Ranging). But if the M value is not too large (<10) the cycle repetition rate up to hundreds of Hz is quite practicable. In any case it is recommended to define the waiting period T_W as large as possible in view of the expected rate of Start-event repetition.

2.3. Typical precision characteristics

2.3.1. Resolution

The A032-ET provides measurement results with 1 ps LSD resolution. However the standard deviation of the time interval between measured events (so called RMS resolution) usually is much greater and characterizes the practicable measurement precision more adequately (Fig.4).

The RMS resolution of the A032-ET is surely better than 10 ps in unlimited measurement range, except the measurement of very small (close to the “dead time”) time intervals. Only in this limited range the damping transient of timer recovery can noticeably affect the RMS resolution (Fig.5).

The A032-ET supports the best RMS resolution after calibration on condition that the operating temperature does not noticeably vary ($< \pm 5^\circ\text{C}$) during following measurements. Although decrease of precision under time-varying operating conditions is not too essential, it is recommended to repeat calibration before any long-term measurement.

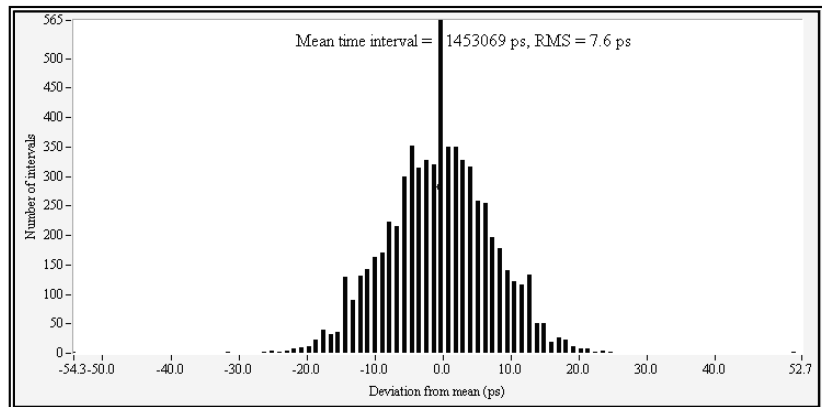


Fig.4. Histogram of time intervals between adjacent periodic events

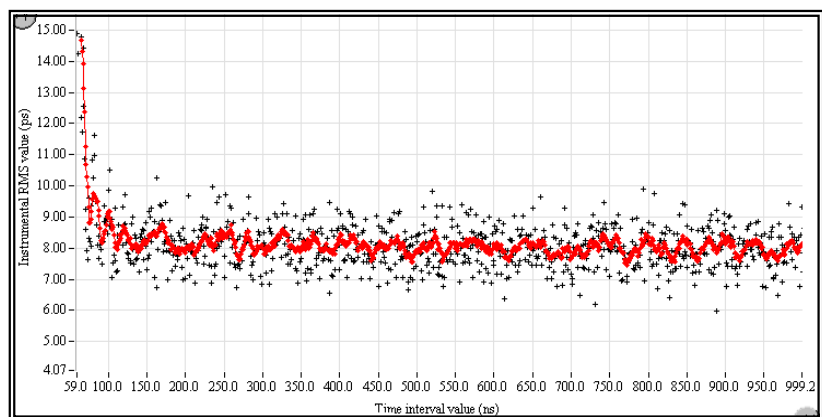


Fig.5. RMS resolution vs. time interval between adjacent events

2.3.2. Non-linearity error

By definition the non-linearity error is a systematic measurement error that depends on the value of time interval between measured adjacent events.

For the A032-ET the non-linearity error is so small that to exactly detect it experimentally on the background of random errors is extremely difficult. It is safe to say that the non-linearity

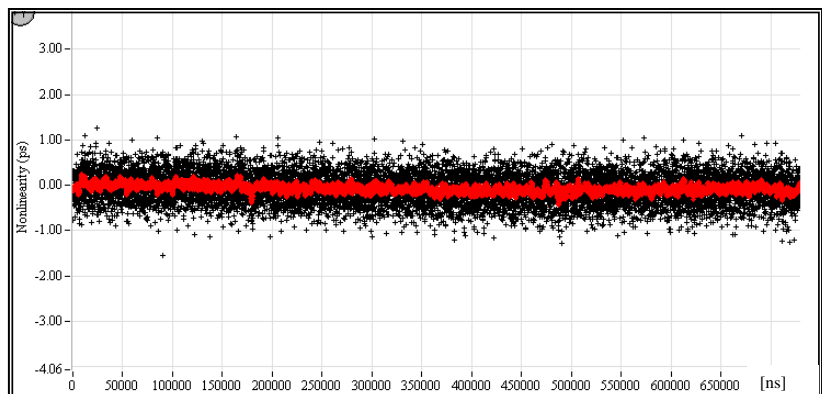


Fig.6. Non-linearity error vs. time interval

error surely does not exceed 1 ps at least for time intervals greater than 100 ns (Fig.6). For the measurement of smaller (less than 100 ns) time intervals, the damping transient of timer recovery may produce some noticeable non-linearity error in this range. But even in this case the non-linearity error typically does not exceed 3-5 ps.

2.3.3. Offset drift

There is some additive, internally produced offset in time interval measurement if the Start-event and Stop-event are provided by the different inputs (A and B) of the ET-device. This offset is caused by a difference between propagation delays of input signals to the single input of common measurement block. Generally these delays are temperature dependent and a slight drift of offset under time-varying operating conditions is possible.

As can be seen in Fig.8, the offset has noticeable drifts (about 2 ps) only directly after ET-device power-up when temperature inside the case rose from 20 to 40 °C approx. Thus, it may be roughly concluded that the temperature coefficient of the offset variation does not exceed 0.1 ps/°C.

For time interval measurements through any single input of the ET-device, the offset drift is caused by the absolute drift of the corresponding propagation delay during measured time interval and may be noticeable only for large (a few seconds and more) time intervals.

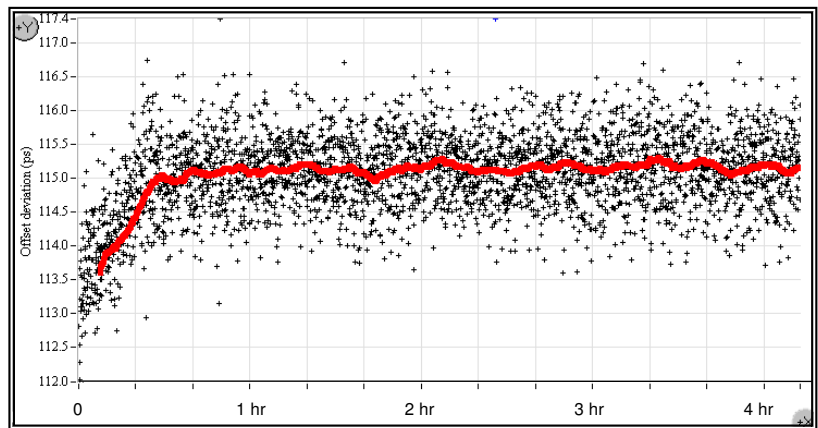


Fig.8. Offset drift during 4.2 hr after hardware power-up

2.3.4. Time-base error

The actual value of reference frequency and its stability directly affect the measurement error. Basically the A032-ET is oriented to using external high-performance sources of reference frequency (such as GPS Time and Frequency Standards) and only for this case the specified precision is guaranteed. Although self-contained operation using own clock source (± 10 ppm) is available.

2.4. Controlling the Event Timer

The A032-ET operation is fully controlled by the ET-client via TCP/IP network. For this reason it is very important to understand exactly all protocol procedures concerning such control.

As the A032-ET is a multi-user resource, an ET-client should establish a Session with the ET-server before any other interactions. In this way, the ET-client captures the A032-ET for exclusive use, up to the Session break.

The control procedures available during the Session are clarified below descriptively. More exactly these procedures are described in ANNEX A. To learn more details of implementing the protocol procedures in a user program you may additionally examine the DEMO software (see ANNEX B and ANNEX C).

There are four preparatory procedures:

- Scaling (calibration)

- Time synchronization
- Time monitoring
- Setting

and one basic procedure:

- Measurement.

In many respects the above procedures are similar for both options but some differ in essential details. So they are described below separately for each option.

2.4.1. Control procedures for the A032.1 option

Scaling. This procedure provides adaptation of the Event Timer to the actual operating conditions to achieve the best available measurement precision. The procedure includes statistical identification of the ET-device physical characteristics under current operating conditions (mainly – under temperature conditions), modification of the processing parameters in view of the identified characteristics, and self-estimation of actual measurement precision offered after the scaling has been performed. The self-estimation is based on measurement of an internal test signal and uses a special approach to exclude the influence of test signal jitter on the estimation result.

Additionally the procedure includes checking of presence of the external 10 MHz reference signal. It is supposed that such signal is provided basically by a high-stable source (such as GPS frequency standard). If the reference signal is not found, the ET-device still is able for operating, using automatically connected internal clock source (100 MHz/10 ppm VCXO).

After completing the scaling procedure the ET-server sends to the ET-client an estimate of actual precision that is offered for the following measurement, and info concerning the external 10 MHz reference signal. Typically the estimate of actual precision (RMS resolution) should be surely better than 10 ps.

Normally the scaling procedure lasts about 10 seconds. It may be repeated by the ET-client at any instant, for example, with the aim to check once more the offered precision of measurement or refresh the previous scaling result if the operating conditions were varied.

Time synchronization. This procedure, as well as the next procedure of time monitoring, can be performed only if the ET-device receives 1 pps sync pulses from an external source (such as Time and Frequency GPS standard). If this condition cannot be supported, both of the mentioned procedures can be omitted. In this case the Event Timer will be able for further operating but output time-tags will not be synchronized to the real-time clock.

The procedure provides synchronization of the timer's clock with both real-time clock of the server PC and 1 pps sync pulses. Synchronization is possible if during 10 sec at least 4 sequential sync pulses are stable so that deviation of time intervals between these pulses from 1 s does not exceed 100 ns. This is an ordinary requirement for the most of high-performance Time and Frequency standards.

When the procedure is completed, the ET-server sends to the ET-client the data concerning the time of synchronization. Besides, this data simply indicates that the procedure was completed successfully.

Note that successful time synchronization may become incorrect if during 1.5 hours after performing it the Event Timer has not been used either for the measurement or time monitoring (see below). To avoid this case it is recommended to activate the time monitoring during long pauses between measurements or repeat the procedure directly before the next measurement.

Time monitoring. Using this procedure, the ET-client can receive a sequence of time-tags corresponding to incoming the 1 pps sync pulses. In other words, the ET-client can see the real time provided by the timer's clock to use that for various purposes, for example, to check correctness of the time synchronization by comparing the timer's clock with any other available real-time clock. In the case of successful previous time synchronization all time-tags should be multiple to 1 sec approx.

The ET-client can end this procedure at any instant by sending the command STOP to the ET-server.

Setting. Using this procedure the ET-client defines the main parameters of the measurements. There are 4 separate parameters to be set:

1. Time correction (user-definable positive or negative integer of seconds). As compared to the time-tags provided after the time synchronization, further this value will be added to the every time-tag before sending of it to the ET-client. This allows correcting the time provided by the timer's clock.
2. Triggering (either external or internal). In the case of external triggering the start of a measurement will be additionally synchronized by an external pulse at the input **TRIG IN** of the ET-device; in the case of internal triggering the measurement will be enabled directly by the ET-client, without additional synchronization.
3. Amount M of TD-blocks (user-selectable: 204, 102, 50 or 25). This is the amount of TD-blocks, which the ET-server cyclically takes out from the ET-device, processes and sends to the ET-client.
4. Monitoring period T_M (user-definable from 10 ms with 1 ms step). This is a time period defining how often the ET-server checks the ET-device to detect the defined amount of TD- blocks in the FIFO memory.

Measurement. Using this procedure the ET-client starts the measurement with parameters set before. During the measurement the ET-server cyclically sends the batch of M time-tags to the ET-client. Each time-tag is presented by two integers: *data0* and *data1*, specifying the time instant in the range 24 hours with 1 ps LSD resolution. Sign of the *data0* defines the input of the ET-device providing the event. To calculate the event time from {*data0*, *data1*} the following simple expression is used:

$$time[i] = (data0) \times 327680 + (data1)/1000 \text{ [ns]}$$

where possible negative sign of the *data0* is set aside. Note that the size of batch received by the ET-client can differ from the size of batch sent by the ET-server. Generally the TCP/IP protocol affords both splitting and merging the batch of data blocks to send it by the sequential packets depending on the actual network performance and load. This should be taken into account for the specific data processing by the ET-client.

There is one more parameter user-defined at the starting (or restarting) of measurement. This parameter is transferred to the ET-server directly with the command START and defines the period of a NIM pulse sequence generated at the **TEST OUT** output of the ET-device. This additional feature is beyond the standard application of the A032.1 timer option and can be used optionally.

The ET-client can end the measurement procedure at any moment by sending the command STOP to the ET-server.

2.4.2. Control procedures for the A032.2 option

The above three procedures "Scaling", "Time synchronization" and "Time monitoring" are fully identical for both of the options of ET-server. However the procedures "Setting" and

“Measurement” for the A032.2 option differ in some essential details; they are described below.

Setting. As well as for the A032.1 option, there are 4 parameters to be set:

1. Time correction (user-definable positive or negative integer of seconds). As compared to the time-tags provided after the time synchronization, further this value will be added to the every time-tag before sending of it to the ET-client.
2. Triggering (either external or internal). In the case of external triggering the enabling of every measurement cycle will be synchronized by an external pulse at the input **TRIG IN** of the ET-device; in the case of internal triggering each next cycle will be enabled directly after the end of the previous one.
3. Amount M of TD-blocks (user-definable from 1 to 12,000). This is the maximum allowable amount of TD-blocks, which the ET-server will read from the ET-device after the waiting period to process them and send the time-tags to the ET-client.
4. Waiting time T_M (user-definable from 0 to 30 s with 1 ms step). This is a time period, starting from the Start-event, after which the ET-server stops the event registration and reads the accumulated TD-blocks from the ET-device.

Measurement. The ET-client starts the measurement with parameters set before. During the measurement the ET-server cyclically sends to the ET-Client the time-tags obtained in every measurement cycle. As for the A032.1 option, each time-tag is presented by two integers: *data0* and *data1*. Sign of the *data0* defines the input of the ET-device providing the measured event (Start-event or Stop-event).

There is one more important user-defined parameter at starting (or restarting) of the measurement. This parameter defines the gating delay from the Start-event only after which the Stop-events can be registered. It is supposed that the gating delay can be modified cycle-to-cycle by restarting the measurement by the ET-client.

The gating delay can be defined in the range from 60 ns to 167,772 ms approx. with a 10 ns step. It is generated fully digitally on the basis of 100 MHz internal clocks and, correspondingly, has uncertainty up to ± 5 ns. Just in case, the NIM pulses at the **TEST OUT** output of the ET-device will indicate beginning of each gate. For example, these pulses can directly simulate a sequence of Stop pulses to test the timer’s operation under time-varying online re-programmable gating (see ANNEX C).

The ET-client can end the measurement procedure at any instant by sending the STOP command to the ET-server.

3. Preparing the A032-ET for operation

3.1. Structure

As mentioned, the A032-ET is configured as the specialized ET-device connected to PC of the ET-server via parallel port supporting EPP mode, and to external signal sources (Fig.9). To provide the best measurement accuracy and full functionality the A032-ET should be combined with an external high-performance source of 10 MHz reference frequency and 1 pps sync pulses (such as GPS Time and Frequency Standard). Although the user program can be executed on the same PC, it is recommended to use a separate PC for the ET-server if high-speed timer operation is especially needed.

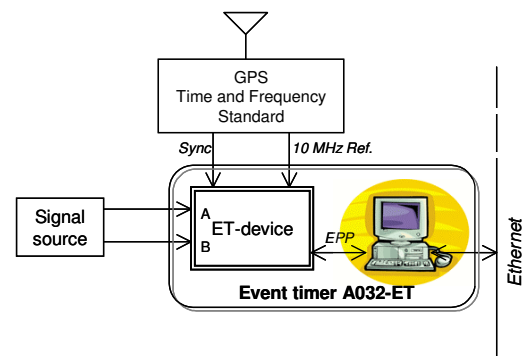


Fig.9. Typical structure of the A032-ET

3.2. ET-device

The ET-device is a desktop apparatus that contains the following connectors for wire connections with external signal sources and with PC of the ET-server:

On the front panel (Fig.10):

INPUT A and **INPUT B** (BNC connectors, 50 Ohm impedance) - two electrically identical inputs of the events to be measured. Each event should be represented by a falling edge of a NIM-standard Fast Negative Logic Signals (fall time: <2 ns, width: 5 to 50 ns; the pulses having greater width are acceptable but not recommended in view of possible channel-to-channel crosstalk). The ET-device identifies which input provided the pulse that was time-tagged. For the option A032.1 the input pulses are logically equal. For the option A032.2 the **INPUT A** provides Start-events and the **INPUT B** – Stop-events. The LEDs located above indicate physical presence of these signals.

GATE IN (BNC connector, 50 Ohm impedance) – input of the NIM pulses that define a time window where the events at the **INPUT B** will be registered by the ET-device (can be used optionally). High level of these pulses (or leaving the input **GATE IN** disconnected) opens the input **B**.

EXT REF (BNC connector, 50 Ohm impedance) – input of the external reference frequency (10 MHz, >0.5 V p-p). Maximum offset of this frequency (including the offset caused by long-term deviation) should not exceed ± 5 KHz. The external reference replaces the internal reference automatically after connecting. Located on the front panel LED “**EXT REF**” indicates the presence of the external reference.

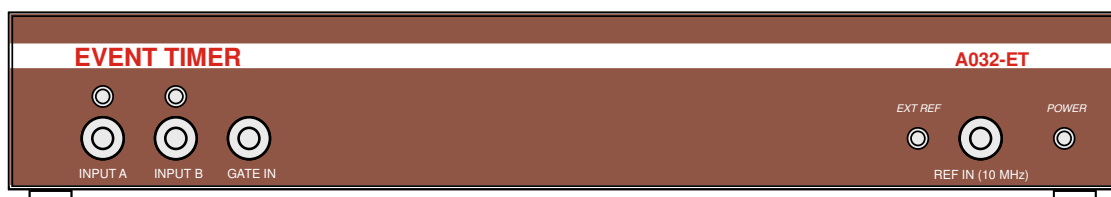


Fig. 10. Front panel of the ET-device

On the rear panel (Fig.11):

SYNC IN (BNC connector, 50 Ohm impedance) – input of TTL sync pulses that define the real time incrementing by 1 sec. (Note. It is supposed that both the reference signal and the synch 1 pps pulses are mutually synchronized).

TRIG IN (BNC connector, 50 Ohm impedance) - input of the TTL pulse that defines an external start of current measurement (can be used optionally).

PARALLEL PORT (DB-25 connector) – connection to the PC parallel port. To avoid eventual problems it is recommended to use only the provided cable for this connection.

AUX (DB-9 connector) – provides auxiliary signals (currently not for user's use).

TEST OUT (BNC connector) – provides NIM signal for optional use. Specific kind of this signal depends on the timer's option.

AUX OUT (BNC connector) – provides auxiliary signals (currently not for user's use).

AC 100-240 V – connector for device powering.

POWER – switch for power On/Off (LED on the front panel indicates when power is On).

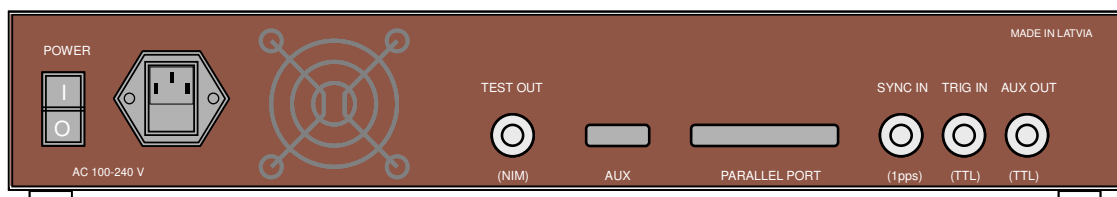


Fig. 11. Rear panel of the ET-device

The ET-device doesn't need any manual controls (except Power On/Off), can operate for long time in environment with temperature range from 10 to 50 °C. It should be warmed up after power-up during 1 hour approx. to support the specified precision and long-term stability of the measurement. For highest-accuracy applications it is recommended to place the ET-device inside a closed box to damp the environment temperature variation.

3.3. Requirement to PC supporting the ET-server software

The PC supporting exclusively the ET-server should conform to the following requirements:

- Pentium-III 800 MHz or faster processor
- Windows 9x, 2000 or XP installed
- video adapter and monitor supporting at least 800x600 pixel @ 256 color mode
- PC Parallel Port supporting EPP mode (Enhanced Parallel Port)
- Ethernet Card supporting TCP/IP standards
- at least 64MB of RAM
- free hard disc space at least 10 MB

3.4. A032.1(2) software installation

To install A032.1 (or A032.2) Software, run *Setup.exe* program from the distribution disc's corresponding directory – A032Server1 (or A032Server2) – and follow the instructions on screen. Note that CD serial number (#032xx) must be identical to serial number of the ET-device. The program allows you to change the directory where the software will be installed. By default, the installation directory will be:

“c:\Program Files\A032ET Server 1” for option 1 and
“c:\Program Files\A032ET Server 2” for option 2.

After the successful installation the working directory should contain the following files:

A032Server.exe – executable program;
Server.uir – user interface resource file;
Param.cnf – ASCII file with port and network addresses;
MasterSc.bin – file with scaling and settings;
CorMicro.bin – device-specific binary files .

**The device-specific binary files are valid only for the specific ET-device being delivered.*

All these files are obligatory. Absence or corruption of any file can crash the ET-server software. The only file that can be corrected (but carefully and only in the right part of assigning) is the ASCII file *Param.cnf*. This file defines two essential parameters for starting the ET-server software:

EPP PORT = Parallel Port address, to which the ET-device is connected (in decimal);
TCP PORT = TCP Port, under which the ET-server will be declared in the network.

ET-server program defines its own network address after the start and writes it to the file *Param.cnf* :

ADDRESS = network address of PC supporting ET-server.

ET-client software must use this network address and TCP Port for successful interaction with the ET-server.

For convenience, you can place a shortcut to the executable program on your desktop. Double clicking the shortcut or *A032Server.exe* icon in the working directory starts the Server software.

When the program is started, the ET-server control panel appears (Fig.12). This panel will indicate an actual state of the Event Timer in process of its further operation under network

control from the ET-client. Click on the **HELP** button opens the message panel with short information about the A032-ET, control panel button functions and LED meaning. Click on the **QUIT** button stops all processes and closes the ET-server program.

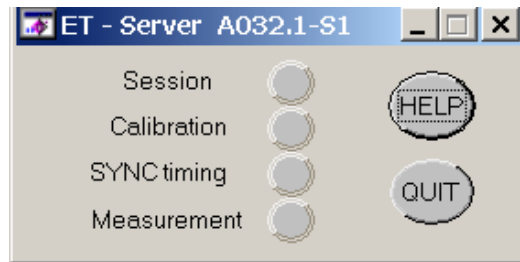
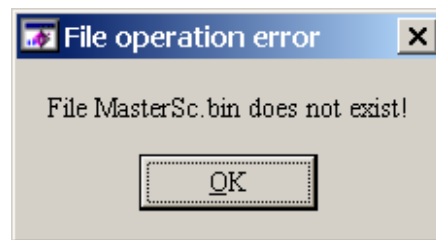


Fig.12. Indicating panel of the A032.1

If the required files are absent or corrupted, the corresponding meaningful message appears. For example, the message



means, that you must click “OK” button to quit the program, find or restore the necessary file *MasterSc.bin* from the distribution disk and restart the program.

After the start, ET-server program creates a special file *LogError.txt* to log all incorrect operations in interaction with the ET-client. All records are in ASCII format and contain date and time of fixed incorrectness and explanatory information. The file is truncated at each start of program.

To uninstall A032.1(2) Software you should use the standard MS-Windows function “Add or Remove Programs”.

If the Event Timer A032-ET as a whole has been properly configured and ET-server software correctly installed, it should be available for further use. However, some application software will be needed to check that. For this purpose you can use the DEMO software that is delivered with the Event Timer.

The “DEMO subsystem A032.1-C1” (see ANNEX B) can operate with the A032.1 option, and the “DEMO subsystem A032.2-C2” (see ANNEX C) - with the A032.2 option. These subsystems provide analysis of time intervals between adjacent events measured by the A032-ET and include all controlling procedures available for corresponding options. Probably, you may use these DEMO subsystems not only for timer checking but also for your other needs.

Note. The A032-ET is a special-purpose device designed and delivered only on special request implying that the customer agrees with particular methods used for its tests and specifications. Certain modifications and additions for the A032-ET providing special user requirements are available on agreement basis. E-mail for contacts: artukh@edi.lv

Interaction procedures for the Event Timer A032-ET

1. Introduction

The ET-server software is running under MS-Windows, and for proper operation needs WINSOCK.DLL library. Normally the vendors deliver it together with Ethernet card (or with any other network interface card you are using to run TCP/IP) and drivers. The library provides support of a platform-independent interface to reliable, byte-stream oriented network connection capabilities of TCP/IP. Through this interface the ET-client, having the same interface with TCP/IP, can control the Event Timer and receive the measurement data from it for further processing.

The following TCP functions are described in transcriptions used in LabWindows/CVI (C for Virtual Instruments) Software Development Kit. The same functions defined in other Development Kits may differ by transcription, parameter ordering and may have additional parameters.

To start interaction with the ET-server the ET-client should primarily establish the Session with the ET-server. To do that, the ET-client, knowing *network_address* (IP address) and unique *port_number* of the ET-server, connects to it using the function:

ConnectToTCPServer(*session_handle*, *port_number*, *network_address*, ...).

If the TCP/IP network is providing connection with the ET-server, the last responds to such connection by rejection or confirmation in Session establishment. In the case of rejection the ET-server responds by data packet that includes the application data and data concerning the cause of rejection, and disconnects from the ET-client. In the case of confirmation the ET-server responds by data packet that includes the application data with the acknowledgement of Session establishment and values of previously defined parameters.

After Session establishing the ET-client can interact with the ET-server using two functions:

ClientTCPWrite (*session_handle*, *Client_data*, *Client_data_Size*, *wait_time*);

ClientTCPRead (*session_handle*, *Server_data*, *Server_data_Size*, *wait_time*).

Specific content of *Client_data* and *Server_data* defines the further ET-server action and its response respectively. Specifically, the ET-client sends some *Client_data* to activate the required operation of the ET-server. These data contain a command defining the operation that should be activated in the ET-server and, possibly, some parameters of this operation. The ET-server responds to such activation by *Server_data* containing the result of command execution.

To end all interactions with the ET-Server the ET-Client breaks the Session using the function:

DisconnectFromTCPServer (*session_handle*).

This action interrupts any current operation at the ET-server and makes it accessible for new Session with any other similar ET-client.

Note that the above TCP functions are written in transcriptions used in LabWindows/CVI (C for Virtual Instruments) Software Development Kit. The same functions defined in other Development Kits may differ by transcription, parameter ordering and may have additional parameters.

The following description specifies in more details the content of application data for each of the procedures mentioned in Part 2.4 of the A032-ET Manual. For convenience the bytes in data blocks are grouped in quaternaries and in the following description are presented as four byte integer numbers.

2. Interaction procedures for the A032.1 option

2.1. Session establishment

ET-client actions	TCP/IP	ET-server actions
<p>To establish the Session the ET-client uses ConnectToTCPServer (<i>sCl</i>, <i>pNumb</i>, <i>nAddress</i>,...)*</p> <p>and waits response from the ET-server</p> <p>ClientTCPRead(<i>sCl</i>, {<i>sOld</i>, <i>err</i>}, 8, <i>t</i>) where <i>sCl</i> – session handle defined at the client side; <i>sOld</i> – session handle defined at the server side; <i>err</i> – negative number, meaning that Session is impossible now, and the ET-Server will immediately disconnect**;</p> <p>disconnection for (<i>sCl</i>)</p> <p>ClientTCPRead(<i>sCl</i>, { <i>sNew</i>, <i>par1</i>, <i>par2</i>, <i>par3</i>, <i>par4</i>}, 20, <i>t</i>) where <i>sNew</i> – session handle defined at the server side; <i>par1</i>..<i>par4</i> – parameters' values, which have been set earlier***.</p>	<p>>></p> <p><<</p> <p><<</p> <p><<</p>	<p>connection for {<i>sNew</i>}</p> <p>If the ET-server already has Session <i>sOld</i> with another ET-client, it responds with the message: ServerTCPWrite(<i>sNew</i>, {<i>sOld</i>,<i>err</i>},8,<i>t</i>)</p> <p>and disconnects from the ET-client:</p> <p>DisconnectTCPClient (<i>sNew</i>);</p> <p>In other case the ET-server confirms the Session establishment with the message: ServerTCPWrite(<i>sNew</i>, {<i>sNew</i>, <i>par1</i>, <i>par2</i>, <i>par3</i>, <i>par4</i>}, 20, <i>t</i>)</p>

* The *pNumb* (TCP port opened by the ET-server) and *nAddress* (IP address of the ET-Server PC) can be read in PARAM.CNF file in the working directory of the ET-server PC.

** Description of the error codes is presented in Part 4 of this Annex.

*** Meaning of the parameters is clarified in Part 2.5 of this ANNEX.

2.2. Scaling

ET-client actions	TCP/IP	ET-server actions
<p>To start this procedure, the ET-client issues ClientTCPWrite (<i>sCl</i>,{444}, 4, <i>t</i>)</p> <p>and waits response from the ET-server</p> <p>ClientTCPRead(<i>sCl</i>, {444, <i>ref</i>, <i>xxx</i>}, 12, <i>t</i>) where <i>ref</i> = 0, – if the external reference is found; 1, – if it is not found; <i>xxx</i> = <i>X</i> * 100.</p> <p>ClientTCPRead(<i>sCl</i>, {444, <i>err</i>}, 8, <i>t</i>) where <i>err</i> – negative number indicating the reason of unsuccessful scaling.</p>	<p>>></p> <p><<</p> <p><<</p>	<p>ServerTCPRead(<i>sNew</i>, {444}, 4, <i>t</i>) The ET-Server defines the current characteristics of the ET-device, estimates actual precision <i>X</i>, checks the external 10 MHz reference. Then the ET-server responds with the message*: ServerTCPWrite(<i>sNew</i>, {444, <i>ref</i>, <i>xxx</i>}, 12, <i>t</i>)</p> <p>If there were problems, the ET-server replies with the message:</p> <p>ServerTCPWrite(<i>sNew</i>, {444, <i>err</i>}, 8, <i>t</i>)</p>

* Normally delay of the response is about 10 sec. If the ET-device is not connected to the relevant Parallel Port the response will come immediately, but in the case of more complicate problems the delay may be up to 30 sec.

2.3. Time synchronization

ET-client actions	TCP/IP	ET-server actions
<p>To start synchronization, the ET-client issues ClientTCPWrite ($sCl, \{222\}, 4, t$)</p> <p>and waits response from the ET-server</p>	>>	<p>ServerTCPRead($sNew, \{222\}, 4, t$)</p> <p>The ET-server monitors the timing of 1 pps sync pulses; if the intervals between them conform to the specified stability ($1s \pm 100\text{ ns}$) the ET-server performs clock synchronization and responds with the message :</p>
<p>ClientTCPRead($sCl, \{222, sTime\}, 8, t$)</p> <p>where $sTime$ – ET-server real-time [sec];</p>	<<	<p>ServerTCPWrite($sNew, \{222, sTime\}, 8, t$)</p> <p>If there were problems the ET-server replies with the message:</p>
<p>ClientTCPRead($sCl, \{222, err\}, 8, t$)</p> <p>where err – negative number indicating the reason of unsuccessful synchronization.</p>	<<	<p>ServerTCPWrite($sNew, \{222, err\}, 8, t$)</p>

* Normally the delay of response is about 5 sec. If there are problems with stability of the 1 pps sync pulse the procedure may last more than 10 sec and then the ET-server responds by failure code. In the cases of other problems the delay of response may be less.

2.4. Time monitoring

ET-client actions	TCP/IP	ET-server actions
To start procedure, the ET-client issues ClientTCPWrite (<i>sCl</i> , { 227 , 4, <i>t</i> })	>>	ServerTCPRead (<i>sNew</i> , { 227 , 4, <i>t</i>) The ET-server measures the instants of the 1 pps sync pulses incoming and promptly sends the current timing result to the ET-client:
ClientTCPRead (<i>sCl</i> , { 227 , <i>sec</i> , <i>frac</i> }, 12, <i>t</i>)	<<	ServerTCPWrite (<i>sNew</i> , { 227 , <i>sec</i> , <i>frac</i> }, 12, <i>t</i>)
...	<<	...
...	<<	...
ClientTCPRead (<i>sCl</i> , { 227 , <i>sec</i> , <i>frac</i> }, 12, <i>t</i>)	<<	ServerTCPWrite (<i>sNew</i> , { 227 , <i>sec</i> , <i>frac</i> }, 12, <i>t</i>)
where <i>sec</i> – integral part of the current server time [sec]; <i>frac</i> – integer number presented by the first eight digits of the fractional part.		... up to the receiving any other command from the ET-client.
ClientTCPRead (<i>sCl</i> , { 227 , <i>err</i> }, 8, <i>t</i>)	<<	In case of failures, the ET-server responds with the message: ServerTCPWrite (<i>sNew</i> , { 227 , <i>err</i> }, 8, <i>t</i>)
where <i>err</i> – negative number indicating the reason of unsuccessful 1 pps sync pulse timing.		

2.5. Setting

ET-client actions	TCP/IP	ET-server actions
<p>To send measurement parameters, the ET-client issues ClientTCPWrite (<i>sCl</i>, {777, <i>par1</i>, <i>par2</i>, <i>par3</i>, <i>par4</i>}, 20, <i>t</i>) where <i>par1</i>..<i>par4</i> – parameters*;</p> <p>ClientTCPRead(<i>sCl</i>, {777, <i>bSize</i>}, 8, <i>t</i>)</p> <p>where <i>bSize</i> – size of data blocks (in bytes), which will be sent cyclically during measurement;</p> <p>ClientTCPRead(<i>sCl</i>, {777, <i>err</i>}, 8, <i>t</i>)</p> <p>where <i>err</i> – negative number, indicating the reason of unsuccessful setting; the digit position is in direct relation with parameter number;</p>	<p>>></p> <p><<</p> <p><<</p>	<p>ServerTCPRead(<i>sNew</i>, {777, <i>par1</i>, <i>par2</i>, <i>par3</i>, <i>par4</i>}, 20, <i>t</i>)</p> <p>The ET-server checks the conformance of all parameters. If they are valid, the ET-server replaces the previous parameters by the new ones and responds with the message: ServerTCPWrite(<i>sNew</i>, {777, <i>bSize</i>}, 8, <i>t</i>)</p> <p>If the parameters are abnormal, the ET-server responds by the message: ServerTCPWrite(<i>sNew</i>, {777, <i>err</i>}, 8, <i>t</i>)</p>

* Meaning of the parameters and their allowable values (see also Part 2.4 of A032-ET Manual):

- par1* – time correction in sec (may be positive or negative). This value will be added to the every time-tag before sending of it to the ET-client to correct the time provided by the timer's clock.
- par2* – either external (= 4) or internal (= 2) triggering of measurement. In the case of external triggering start of measurement will be synchronized by an external pulse at the input TRIG IN of the ET-device; in the case of internal triggering the measurement will be enabled directly by the START command.
- par3* – amount of the accumulated TD-blocks (each TD-block contains the timing data about a single event) that will be detected and taken out by the ET-server from the ET-device during periodic checking of its current state. There are four possible amounts of these TD-blocks depending on the *par3* value:
 - = 0 – corresponds to 25 TD-blocks.
 - = 1 – corresponds to 50 TD-blocks;
 - = 2 – corresponds to 102 TD-blocks;
 - = 3 – corresponds to 204 TD-blocks;
- par4* – time period (in ms) defining how often the ET-server will check the ET-device to detect the preset amount of the accumulated TD-blocks. This period should not be less than 10 ms. See Part 2.2 of the Manual to correctly specify the value of both *par3* and *par4* under specific measurement conditions.

2.6. Measurement

ET-client actions	TCP/IP	ET-server actions
<p>To start the measurement, the ET-client issues START command</p> <p>ClientTCPWrite (<i>sCl</i>, {999, <i>par7</i>}, 8, <i>t</i>)</p> <p>where</p> <p><i>par7</i> – number defining periodicity of the pulses at the TEST OUT output of the ET-device; this number may be from 6 to 16777218, corresponding to the period from 60 to 167772180 ns.</p> <p>ClientTCPRead(<i>sCl</i>, {...{<i>data0</i>, <i>data1</i>}_{<i>i</i>} ...}, <i>bSize</i>^{***}, <i>t</i>)</p> <p>where</p> <p><i>bSize</i> – size of data blocks (in bytes), which has been defined in the setting procedure (see A032-ET Manual, part 2.4.1).</p>	<p>>></p> <p><<</p>	<p>ServerTCPRead(<i>sNew</i>, {999, <i>par7</i>}, 8, <i>t</i>)</p> <p>The ET-server starts the measurement and additionally provides generation of periodic pulse sequence by the ET-device. During the measurement ET-server cyclically sends time-tags in the data block[*]:</p> <p>ServerTCPWrite(<i>sNew</i>, {...{<i>data0</i>, <i>data1</i>}_{<i>i</i>} ...}, <i>bSize</i>, <i>t</i>)</p>

* The data block includes the data specifying time-tags; their amount in single block is defined by *par3*.

** Pair of *data1* and *data0* defines both the time-tag and the input (either A or B) providing the measured event. If *data0* is a negative number the event has been provided by the INPUT A of the ET-device; otherwise – by the INPUT B. To calculate time-tag from {*data0*, *data1*}_{*i*} for the event with ordering number *i* the following expression is used (negative *data0* should be converted to positive):

$$time[i] = data0 * 327680 + data1 / 1000 \text{ (in nanoseconds).}$$

data1 must always be positive number. Negative number indicates the failure of the Event Timer. In this case *data0* is the last event number. Description of such negative numbers is presented in Part 4 of this Annex.

*** Compared to the size of data block sent by the ET-server, the size of the data block received by the ET-client may vary depending on the actual network performance and load. Generally the TCP/IP protocol affords both splitting and merging the data block to send it by sequential packets. This should be taken into account for the specific data processing.

The measurement, as well as the time monitoring, is related with cyclical sending/receiving of the timing data. This continuous process can be aborted by any command, including the Session break. But it is preferable to use the dedicated STOP command for this purpose:

ET-client actions	TCP/IP	ET-server actions
<p>To stop the measurement, the ET-client issues STOP command</p> <p>ClientTCPWrite (<i>sCl</i>, {111}, 4, <i>t</i>)</p>	<p>>></p>	<p>ServerTCPRead(<i>sNew</i>, {111}, 4, <i>t</i>)</p>

3. Interaction procedures for the A032.2 option

3.1. Session establishment

For the A032.2 option this procedure is the same as for A032.1 option (see part 2.1).

3.2. Scaling

For the A032.2 option this procedure is the same as for A032.1 option (see part 2.2).

3.3. Time synchronization

For the A032.2 option this procedure is the same as for A032.1 option (see part 2.3).

3.4. Time monitoring

For the A032.2 option this procedure is the same as for A032.1 option (see part 2.4).

3.5. Setting

ET-client actions	TCP/IP	ET-server actions
<p>To send measurement parameters, the ET-client issues ClientTCPWrite (<i>sCl</i>, {777, <i>par1</i>, <i>par2</i>, <i>par6</i>, <i>par5</i>}, 20, <i>t</i>) where <i>par1</i>, <i>par2</i>, <i>par5</i>, <i>par6</i> – parameters*;</p>	>>	<p>ServerTCPRead(<i>sNew</i>, {777, <i>par1</i>, <i>par2</i>, <i>par6</i>, <i>par5</i>}, 20, <i>t</i>)</p> <p>The ET-server checks the conformance of all parameters. If they are valid, the ET-server replaces the previous parameters by the new ones and responds with the message:</p>
<p>ClientTCPRead(<i>sCl</i>, {777, <i>bSize</i>}, 8, <i>t</i>)</p> <p>where <i>bSize</i> – size of data blocks (in bytes), which will be sent cyclically during measurement;</p>	<<	<p>ServerTCPWrite(<i>sNew</i>, {777, <i>bSize</i>}, 8, <i>t</i>)</p>
<p>ClientTCPRead(<i>sCl</i>, {777, <i>err</i>}, 8, <i>t</i>)</p> <p>where <i>err</i> – negative number, indicating the reason of unsuccessful setting; the digit position is in direct relation with parameter number;</p>	<<	<p>If the parameters are invalid, the ET-server responds by the message: ServerTCPWrite(<i>sNew</i>, {777, <i>err</i>}, 8, <i>t</i>)</p>

* Meaning of the parameters and their allowable values (see also Part 2.4 of A032-ET Manual):

- par1* – time correction in sec (may be positive or negative). This value will be added to the every time-tag before sending of it to the ET-client to correct the time provided by the timer's clock.
- par2* – either external (= 4) or internal (= 2) triggering of measurement cycle. In the case of external triggering the enabling of every measurement cycle will be synchronized by an external pulse at the input TRIG IN of the ET-device; in the case of internal triggering each next cycle will be enabled directly after previous cycle ending.
- par6* – amount of TD-blocks (from 1 to 12,000). This is the maximum amount of TD-blocks, which the ET-server will read from the ET-device in every cycle at the end of the waiting period.

par5 – waiting period (in ms). This is the time period, starting from the Start-event coming, after which the ET-server stops the event registration and reads the accumulated TD-blocks from the ET-device.

3.6. Measurement

ET-client actions	TCP/IP	ET-server actions
<p>To start (or restart) the measurement, the ET-client issues START command</p> <p>ClientTCPWrite (<i>sCl</i>, {999, <i>par8</i>}, 8, <i>t</i>)</p> <p>where</p> <p><i>par8</i> – number defining the gating delay, starting from Start-event coming; the number may be from 6 to 16777220, resulting in the delay value from 60 to 167772220 ns.</p> <p>ClientTCPRead(<i>sCl</i>, {...{<i>data0</i>, <i>data1</i>}_{<i>i</i>} ...}, <i>bSize</i>^{***}, <i>t</i>)</p> <p>where</p> <p><i>bSize</i> – size of data blocks (in bytes), which has been defined in the setting procedure (see A032-ET Manual, part 2.4.2).</p>	<p>>></p> <p><<</p>	<p>ServerTCPRead(<i>sNew</i>, {999, <i>par8</i>}, 8, <i>t</i>)</p> <p>The ET-server sets the gating delay defined by the <i>par8</i> and permits the measurement. During the measurement the ET-server cyclically sends time-tags in the data block :</p> <p>ServerTCPWrite(<i>sNew</i>, {...{<i>data0</i>, <i>data1</i>}_{<i>i</i>} ... }, <i>bSize</i>, <i>t</i>)</p>

* The data block includes timing data specifying the time-tags; their maximum amount in every data block is defined by *par6* (see 3.5).

** Pair of *data1* and *data0* defines both the time-tag and the input (either A or B) providing the measured event. If the *data0* is negative number the event has been provided by the INPUT A of the ET-device; otherwise – by the INPUT B. To calculate time-tag from {*data0*, *data1*}_{*i*} for the event with ordering number *i* the following expression is used (negative *data0* should be converted to positive):

$$time[i] = data0 * 327680 + data1 / 1000 \text{ (in nanoseconds).}$$

The *data1* must be always positive number. Negative number indicates the failure of the Event Timer. In this case the *data0* is the last event number. Description of such negative numbers is presented in part 4 of this Annex.

*** Compared to the size of data block sent by the ET-server, the size of the data block received by the ET-client may vary (but not more than that which has been defined in the setting procedure) depending on the actual network performance and load. Generally the TCP/IP protocol affords both splitting and merging the data block to send it by the sequential packets. This should be taken into account for the specific data processing.

The measurement, as well as the time monitoring, is related with cyclical sending/receiving of the timing data. This continuous process can be aborted by any command, including the Session break. But it is preferable to use the dedicated STOP command for this purpose:

ET-client actions	TCP/IP	ET-server actions
<p>To stop the measurement the ET-client issues STOP command</p> <p>ClientTCPWrite (<i>sCl</i>, {111}, 4, <i>t</i>)</p>	<p>>></p>	<p>ServerTCPRead(<i>sNew</i>, {111}, 4, <i>t</i>)</p>

4. Error codes

err code	Problem explanation
-10	The ET-device is inaccessible
-20	The failure of interface with the ET-device; check the specified port address and protocol
-30	The failure of the ET-device or interface with it (bad timing data)
-40	Waiting time for Start pulse was more than 30 sec
-80	The 1 pps sync pulses are not found
-90	The synchronization cannot be done, because the intervals between 1 pps sync pulses are incorrect
-1000	Currently there is a Session with another ET-Client
-xxxxx7	Time correction parameter is out of permitted range from –10800 to +10800 (± 3 hours)
-xxxx7x	Triggering parameter is invalid; there are two permitted values: 4 and 2
-xxx7xx	The buffer size value is out of permitted range; there are four possible values: 0, 1, 2, 3.
-xx7xxx	The time period of the ET-device memory checking is out of permitted range (from 10 ms to 30000 ms)
-x7xxxx	The waiting period is out of permitted range (from 1 to 30000 ms)
-7xxxxx	The number of Stop events is out of permitted range (from 1 to 12000)

DEMO subsystem A032.1-C1**1. Introduction**

Any specific timing system based on the Event Timer A032-ET includes an application subsystem (ET-client) that provides timing data processing required for user tasks (Fig.B-1). The A032.1-C1 represents an example of such subsystem compatible with the A032.1 option. It provides an analysis of time intervals between events measured continuously. Specifically the A032.1-C1 displays these time intervals in process of timing data receiving, calculates statistics for user-selectable part of them, provides data filing in any from two offered formats. However, the A032.1-C1 is intended more to check the timer's features and illustrate how a program for any other application may be written than to use it directly for real applications. Accordingly the A032.1-C1 uses all protocol procedures of interaction with the ET-server to illustrate their action by a real example.

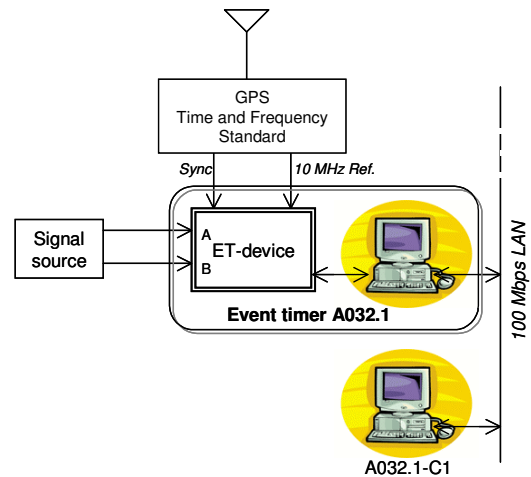


Fig.B-1. Typical structure of the distributed timing system

The A032.1-C1 software is written in C language for LabWindows/CVI ver.6.0 that provides convenient Graphic User Interface (GUI), TCP/IP functions, functions for statistical processing and many other useful facilities. Functions for GUI and user activities through GUI panel controls (numeric and buttons) are platform dependent and directly related with an application specific. These functions may be simply replaced by user or Distribution Kit specific functions. TCP/IP functions are identical for all Distribution Kits; all other functions use the standard C operators and can be compiled in any Development Kit for C or converted to other languages. The program sources are fully commented.

2. Software installation

The A032.1-C1 software can be installed either on separate PC under MS-Windows or commonly with the A032.1-ET Server software. The first is preferable to obtain the best overall performance. To install the A032.1-C1 software, run the program \A032Client1\Setup.exe from the distribution disk and follow the instructions on screen. Setup program allows you to change the directory where the software will be installed.

After the successful installation the working directory should contain the next files:

APPClient.exe – executable program;
APPClient.uir – user interface resource file;
Param_cl.cnf – ASCII file with port and network addresses;

All these files are obligatory. Absence or corruption of any file can crash the A032.1-C1 software work. The only file, which can be corrected, is the ASCII file *Param_cl.cnf*. This file defines for starting the ET-client software three parameters:

ADDRESS = network address of PC acting as ET-server (IP address);
TCP PORT = TCP Port for interactions with the ET-server software;
POINTS NUMBER = number of events accumulated in working arrays.

First two parameters are defined in corresponding configuration file for ET-server program and must be the same. The last parameter is the size of dynamically allocated arrays, in which all timing data are stored for next processing and saving. Any text editor can be used to correct the corresponding parameter values in the configuration file.

For convenience, you can place a shortcut to the executable program *APPClient.exe* on your desktop. Double click the shortcut or *APPClient.exe* icon in the working directory starts the ET-client software. When started, the program opens a main control panel “DEMO Subsystem A032.1-C1” (Fig.B-2).

To uninstall A032.1-C1 Software you should use the standard MS-Windows function “Add or Remove Programs”.

3. Control panels of the A032.1-C1

The main control panel of the A032.1-C1 (Fig.B-2) provides mainly the functions related with the measurement On/Off, presentation and filing of the measurement results. However before any measuring some preparatory procedures should be performed. Click the button SERVER to call out an accessory panel “ET-Server A032.1 Control” (Fig.B-3), which provides the Session establishment and the preparatory procedures (“Scaling”, “Time synchronization”, “Time monitoring”, “Setting”) for the following measurements.

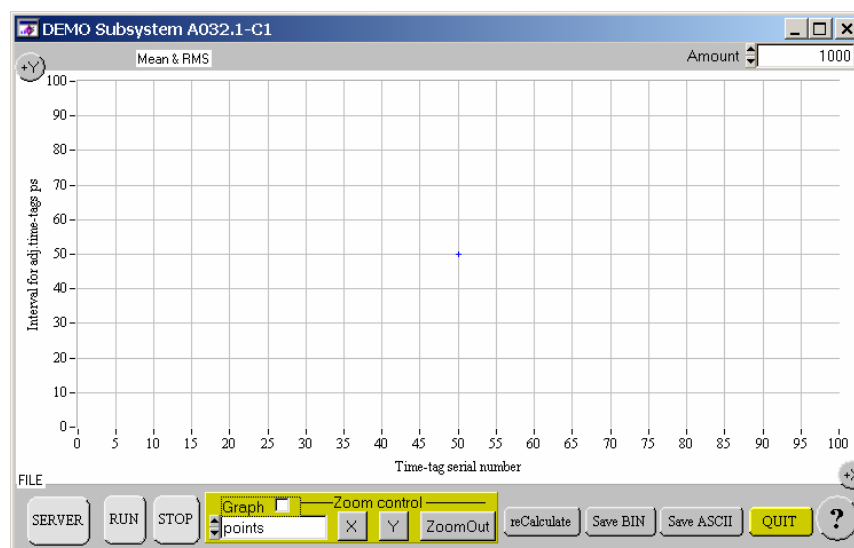


Fig.B-2. The A032.1-C1 main control panel

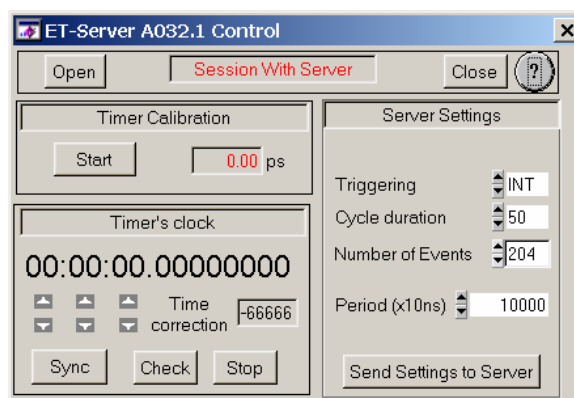


Fig.B-3. The A032.1-C1 accessory panel

3.1. Accessory panel

The accessory panel (Fig.B-3) contains four dedicated sub-panels titled according to their basic functions:

- Session with Server
- Timer Calibration
- Timer's clock
- Server Setting

3.1.1. Session with Server. This sub-panel provides the Session establishing. This is the first action that must be made before any other activities. Clicking the button **Open** initiates the TCP/IP connection to the predefined ET-Server. If the ET-Server is in action and is free from other Sessions the Session has to be established. In this case the title "Session with Server" changes in colour from red into black. In other cases the message indicating the reason of reject appears. Clicking the button **Close** closes the earlier established Session and makes the ET-server available for any other ET-client.

3.1.2. Timer calibration. This sub-panel provides functions corresponding to the procedure "Scaling". Click the button **Start** to activate this procedure, resulting in correction of parameters for data processing in view of current operating conditions. At the end of the procedure a self-estimation of the timer's expected precision is performed.

In case of successful calibration a currently offered timer's precision (RMS) appears. Normally this precision should be surely less than 10 ps and is written in black. In other cases the message indicating the reasons of calibration impossibility appears, and RMS value remains written in red.

The procedure should be necessarily made after warming up (about 1 hr) of the ET-device and if the operating conditions have been essentially changed in temperature (± 5 °C approx.). Without timely executing of this procedure the measurement error can increase.

3.1.3. Timer's Clock. This sub-panel provides synchronization of the timer's clock with the sync 1 pps pulses from an external source and PC clock, monitoring of the timer's clock and epoch time correction if desired. The mentioned procedures are not compulsory in online application of this subsystem, but the synchronization can be useful if you want to get the synchronized time-tags for their further offline processing.

Clicking the button **Synch** activates the procedure "Time synchronization", resulting in displaying of time when this synchronization has been performed. In the case of command reject the message indicating the reasons of such rejection appears.

Clicking the button **Check** activates the procedure "Time monitoring", resulting in displaying the timer's clock. The clock's readouts can be manually corrected at will. In this case the number of seconds in correction is displayed and further will be sent to the ET-sever as setting parameters. In the case of command reject the message indicating the reasons of such rejection appears.

Click the button **Stop** to interrupt the procedure "Time monitoring" and go to the next procedure.

3.1.4. Server setting. This sub-panel provides setting the parameters for further measurement in accordance with the values in control fields:

Triggering: either INT (internal) or EXT (external)

Cycle duration [ms] (is adequate to the period of ET-device monitoring)

Number of Events (is adequate to the amount of TD-blocks that will be read from the ET-device)

Period (x10 ns) defines the period of test pulses that will be generated at the TEST OUT connector of the ET-device.

Let's remember that the Cycle duration and Number of Events should be set in view of expected mean rate of event incoming. Generally the values Cycle duration = 15 ms and Number of Events = 204 are acceptable for any rate but can be non-optimal for the specific case.

Clicking the button **Send Settings to Server** leads to sending the first three setting parameters and the previously defined time correction value (see above) to the ET-server. In the case of success the measurement with preset parameters becomes possible. The fourth setting parameter (Period) will be send separately, directly by the command to start measurement. In the case of setting command reject the message indicating the reasons of such rejection appears.

If the ET-server is set and the Session remains open you can start the measurement using the main control panel.

3.2. Main control panel

Clicking the button **RUN** starts the measurement with earlier preset parameters. In this case the A032.1-C1 cyclically receives the batches of time-tags, calculates the time intervals between all adjacent time-tags and displays these intervals versus time-tag serial numbers. Once pressed the button becomes inaccessible up to the measurement stopping.

The measurement will be stopped either automatically when the preset amount of time intervals (see the numeric control at the upper right corner of the panel) is reached or manually by clicking the button **STOP** at any moment. Generally the Event Timer A032-ET in itself does not limit the total amount of measured events but the A032.1-C1 software limits this amount up to certain value user-defined in configuration file *Param_cl.cnf*. This value should be defined depending on the available PC resources because all received data has to be stored in the working memory for further processing and saving.

The main control panel provides also following user-controlled procedures related with data displaying:

“Graph” – ring control to choose one of six graph styles; the control is possible only after measurement ending and acts on the displayed data.

Check box at right of title “Graph” – if it is initially checked all points which reflect the time intervals from every Start event to the next nearest Stop event will be displayed in blue colour after measurement ending to separate them from time intervals between any other pairs of adjacent events.

X toggle button - its suppressing allows to zoom in the plot for X-axis. If zoom is made after the measurement is stopped, the zoomed area is defined by left and right sides of zooming rectangle; if zoom is made during the measurement, the only left side of the zooming rectangle defines the zoomed area.

Y toggle button - its suppressing allows to zoom in the plot for Y-axis. Such zoom can be made at any time; the zoomed Y-axis size remains the same up to the next zoom changing.

If **X** or/and **Y** are suppressed you may press and hold the mouse left button and drag the mouse to draw rectangles; the inner area of the last rectangle will be zoomed after the mouse button is released.

There are additional controls for zooming at the ends of the graph X-axis and Y-axis:

+X round button – each click decreases the left value and increases the right value of the X-axis on quarter;

+Y round button – each click decreases the bottom value and increases the upper value of the Y-axis on quarter.

ZoomOut – click this button to release the **X** and **Y** buttons and set: the Y-axis sizes to the maximal and minimal values of registered time intervals; the X-axis from 0 to the last interval number. The mouse right click executes the zoom out only for Y-axis and does not affect on X-axis and **X** and **Y** buttons. Both zoom out operations can be made at any time.

reCalculate – click this button to calculate Mean value and RMS deviation for time intervals in zoomed area; the upper information string will show the calculating results. This operation restricts the maximum and minimum of Y-axis by the maximal and minimal visible time intervals.

Save BINARY – click this button to save the timing data in binary format for events, which conform to the currently visible time intervals. The number of events should be greater than 100.

Save ASCII – click this button to save the timing data in ASCII format for events, which conform to the currently visible time intervals. The number of events should be greater than 10.

The buttons for data saving are accessible only after measurement ending. In both saving operations the Window Select File menu appears and allows setting a name of saved file; the name of file will appear in the bottom information string.

QUIT - click this button to close the program.

4. Example of measurement with the A032.1-C1

In this example a signal source generates two periodic sequences of test pulses that come at the inputs **A** and **B** of the ET-device so that a group of 1023 periodic Stop pulses follows after each periodic Start pulse.

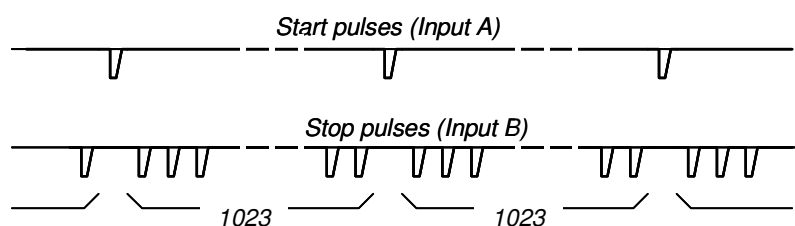


Fig. B-4.

The total rate of incoming the input pulses exceeds 10 KHz. Such pulse sequences are formed on the basis of low-jittered crystal clock oscillator to check the available measurement precision as well.

After performing of all preparatory procedures:

Open Session,
Timer Calibration,
Synchronization of Timer's clock,
Server Setting

the accessory panel has the appearance shown in Fig.B-5. As indicated, the timer suggests the measurement RMS resolution about 6.9 ps (this estimate may differ from the actual one by +/-10% approx.). The server setting is adapted to the highest-speed operation. Under these conditions the measurement of about 50,000 input events results in three separate fractions of time intervals between adjacent events (Fig.B-6).

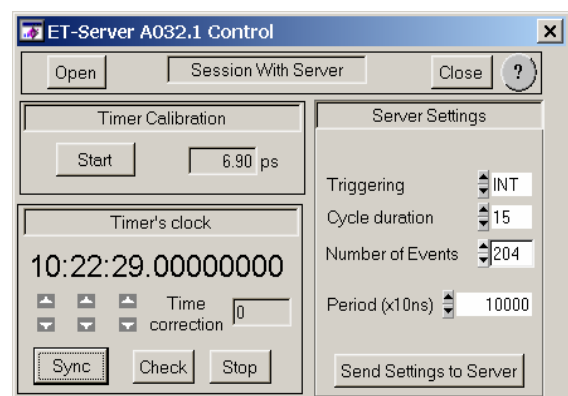


Fig.B-5.

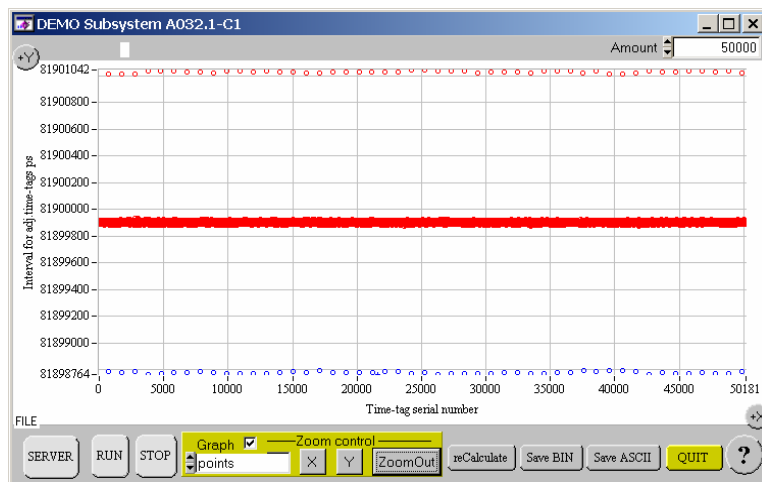


Fig.B-6.

The upper fraction corresponds to time intervals between adjacent Stop and Start pulses, the central fraction – between adjacent Stop pulses and the bottom fraction – between adjacent Start and Stop pulses (they are coloured in blue). This indicates that each Start pulse is located between adjacent Stop pulses with some (about 1 ns) asymmetry. Note that there are not any unexpected time intervals that could indicate possible gaps in the continuous measurement.

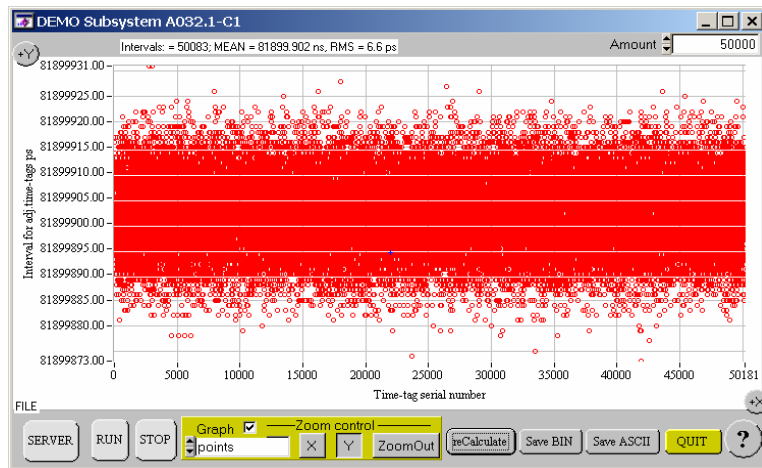


Fig.B-7.

Using zoom for Y-axis one can see each fraction of time intervals separately and calculate its basic statistics. For example, Fig.B-7 shows the central fraction of “Stop-Stop” time intervals. Mean and RMS deviation of these time intervals are 81,899.902 ns and 6.6 ps respectively. This indicates that the own jitter of test signal is negligible small as compared to the predicted measurement resolution, and the actual timer resolution even better than the predicted one.

As for “Start-Stop” time intervals (the bottom fraction in Fig.B-6), mean and RMS deviation of them are 81,898.778 ns and 7.1 ps respectively. In other words, the actual asymmetry of Start pulses location is 1.124 ns and absolute instability of their periodicity is a little greater than that for the Stop pulses.

Thus, as one can see, the A032.1 option used in the above measurement really supports gapless event measurement at rate 12.210 KHz with RMS resolution better than 7 ps. Note that these characteristics are much better than that indicated in specifications as typical ones. On the other hand, the A032.1-C1 subsystem combined with this timer option results in complete timing system that can provide versatile analysis of pulse sequences with picosecond resolution.

DEMO subsystem A032.2-C2

1. Introduction

Any specific timing system based on the Event Timer A032 includes an application subsystem (ET-client) that provides timing data processing required for user tasks (Fig.C-1). The A032.2-C2 represents an example of such subsystem compatible with the A032.2 timer's option. It provides an analysis of time intervals between the adjacent events measured cyclically over internal gating. Specifically the A032.2-C2 displays these time intervals in process of timing data receiving, calculates statistics for user-selectable part of them, provides data saving in desired formats. However, the A032.2-C2 is intended more to check the timer's features and illustrate how a program for any other applications may be written than to use it for real tasks. Accordingly the A032.2-C2 uses all protocol procedures of interaction with the ET-server to illustrate their action by a real example.

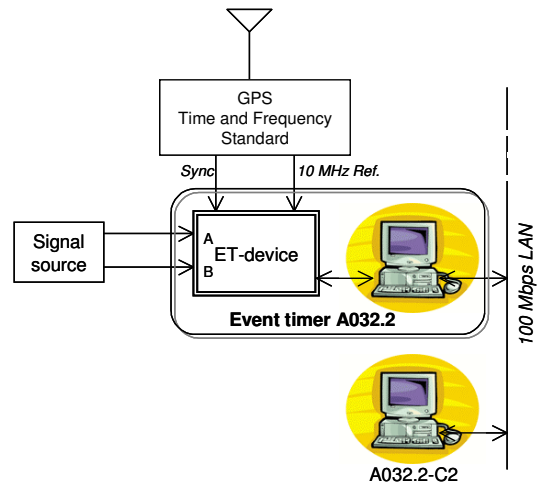


Fig.C-1. Typical structure of the timing system

The A032.2-C1 software is written in C language for LabWindows/CVI ver.6.0 that provides convenient Graphic User Interface (GUI), TCP/IP functions, functions for statistical processing and many other useful facilities. Functions for GUI and user activities through GUI panel controls (numeric and buttons) are platform dependent and directly related with an application specific. These functions may be simply replaced by user or Distribution Kit specific functions. TCP/IP functions are identical in all Distribution Kits, and all other functions use the standard C operators and can be compiled in any Development Kit for C or converted to other languages. The program sources are fully commented.

2. Software installation

The A032.2-C2 software can be installed either on separate PC under MC-Windows or commonly with the A032.2-ET Server software. The first is preferable to obtain the best overall performance. To install the A032.2-C2 software, run the program \A032Client2\Setup.exe from the distribution disk and follow the instructions on screen. Setup program allows you to change the directory where the software will be installed.

After the successful installation the working directory should contain the next files:

APPClient.exe – executable program;
APPClient.uir – user interface resource file;
Param_cl.cnf – ASCII file with port and network addresses;

All these files are obligatory. Absence or corruption of any file can crash the A032.2-C2 software work. The only file, which can be corrected, is the ASCII file *Param_cl.cnf*. This file defines for starting ET-client software three parameters:

ADDRESS = network address of PC acting as ET-server (IP address);
TCP PORT = TCP Port for interactions with the ET-server software;
POINTS NUMBER = number of events accumulated in working arrays.

First two parameters are defined in corresponding configuration file for ET-server program and must be the same. The last parameter is the size of dynamically allocated arrays, in which all timing data are stored for the next processing and saving. Any text editor can be used for correction of corresponding parameter values in the configuration file.

For convenience, you can place a shortcut to the executable program *APPClient.exe* on your desktop. Double click the shortcut or *APPClient.exe* icon in the working directory starts the ET-client software. When started, the program opens a main control panel “*DEMO Subsystem A032.2-C2*” (Fig.C-2).

To uninstall A032.2-C2 Software you should use the standard MS-Windows function “Add or Remove Programs”.

3. Control panels of the A032.2-C2

The main control panel of the A032.2-C2 (Fig.C-2) provides mainly the functions related with the measurement On/Off, presentation and filing of the measurement results. However before any measuring the preparatory procedures should be performed. Click the button **SERVER** calls out an accessory panel “*ET-Server A032.2 Control*” (Fig.C-3), which provides the Session establishment and the preparatory procedures (“Scaling”, “Time synchronization”, “Time monitoring”, “Setting”) for the following measurements.

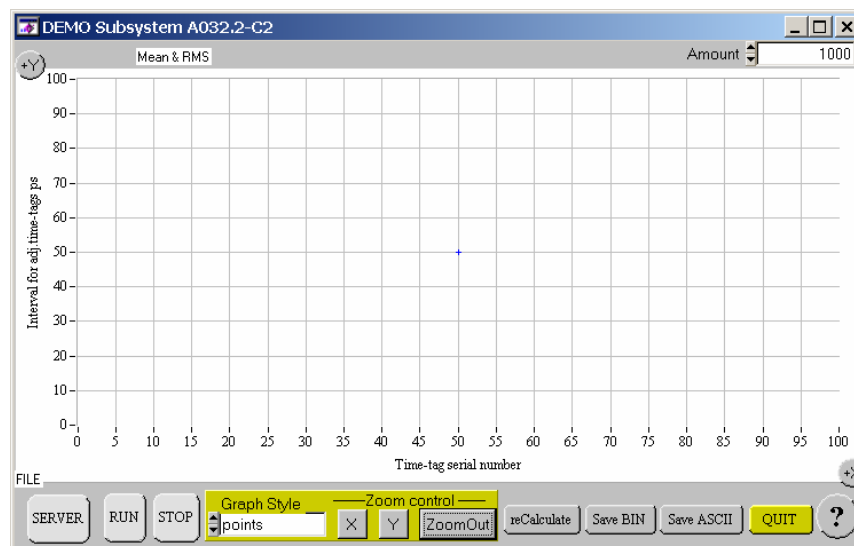


Fig.C-2. The A032.2-C2 main control panel

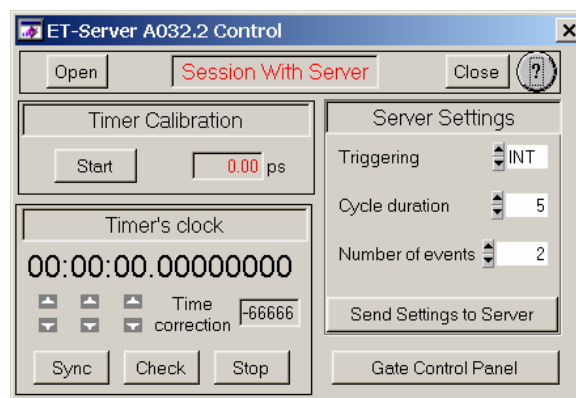


Fig.C-3. The A032.2-C2 accessory panel

3.1. Accessory panel

The accessory panel (Fig.C-3) contains four separate sub-panels titled in conformity with their basic functions:

- Session with Server
- Timer Calibration
- Timer's clock
- Server Setting

and separate button **Gate control Panel** which is used to demonstrate online programmability of the gating delay during specific measurement.

3.1.1. Session with Server. This sub-panel provides the Session establishing. This is the first action that should be made before any other activities. Clicking the button **Open** initiates the TCP/IP connection to the predefined ET-Server. If the ET-Server is in action and is free from other Sessions the Session has to be established. In this case the title "Session with Server" changes in colour from red into black. In other cases the message indicating the reason of reject appears. Click the button **Close** closes the earlier established Session and makes the ET-server available for any other ET-client.

3.1.2. Timer calibration. This sub-panel provides functions corresponding to the procedure "Scaling". Click the button **Start** to activate this procedure, resulting in correction of parameters for data processing in view of current operating conditions. At the end of the procedure a self-estimation of the timer's expected precision is performed.

In case of successful calibration a currently offered timer's precision (RMS) appears. Normally this precision should be surely less than 10 ps and is written in black. In other cases the message indicating the reasons of calibration impossibility appears and RMS value stays remains written in red.

The procedure should be necessarily made after warming up (about 1 hr) of the ET-device and if the operating conditions have been essentially changed in temperature (± 5 °C approx.). Without timely executing of this procedure the measurement error can increase.

3.1.3. Timer's Clock. This sub-panel provides synchronization of the timer's clock with the sync 1 pps pulses from an external source and PC clock, monitoring of the timer's clock and epoch time correction if desired. The mentioned procedures are not compulsory in online application of this subsystem, but the synchronization can be useful if you want to get the synchronized time-tags for their further offline processing.

Clicking the button **Synch** activates the procedure "Time synchronization", resulting in displaying of time when this synchronization has been performed. In the case of command reject the message indicating the reasons of such rejection appears.

Clicking the button **Check** activates the procedure "Time monitoring", resulting in displaying the timer's clock. The clock's readouts can be manually corrected at will. In this case the number of seconds in correction is displayed and further will be sent to the ET-sever as setting parameters. In the case of command reject the message indicating the reasons of such rejection appears.

Click the button **Stop to** interrupt the procedure "Time monitoring" and go to the next procedure.

3.1.4. Server setting. This sub-panel provides setting of the parameters for thereafter started measurement procedures in accordance with the values in control fields:

Triggering: either INT (internal) or EXT (external)

Cycle duration [ms] (is adequate to the waiting time T_M , part 2.4.2 of the Manual)

Number of Events (is adequate to the maximum amount M of TD-blocks that can be accumulated in one cycle, part 2.4.2 of the Manual)

Let's remember that the Cycle duration and Number of Events should be set in view of expected rate of Start-event incoming.

Clicking the button **Send Setting to Server** leads to sending the setting parameters and the previously defined correcting value (see above) to the ET-server.

3.1.5. Gate control panel. To demonstrate possibilities of online gate delay control, the A032.2-C2 generates the gate delay values in form of periodic triangle function with user-definable range and incrementing step. Clicking the button **Gate control panel** brings about a panel providing a setting for such values generation (Fig.C-4).

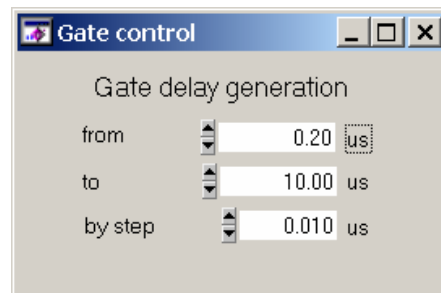


Fig.C-4. Gate control panel

A new value is generated at each Start event and represents a parameter in the start command (see ANNEX A, part 3.6). This parameter acts for every measurement cycle as long as new start command with other parameter will come. During the measurement the A032.2-C2 repeats the start command after acceptance of each data batch. In more details the gate delay control is illustrated by an example (see Part 4.2 of this Annex).

If the ET-server is set and the Session remains open you can start the measurement using the main control panel.

3.2. Main control panel

Click the button **RUN** starts the measurement with earlier preset parameters. In this case the A032.2-C2 cyclically receives the batch of time-tags, extract Start-events from the batch, generates new gate delay and restarts measurement with it. After that A032.2-C2 calculates the time intervals between all adjacent time-tags and displays these intervals versus time-tag serial numbers. The interval between Start event and following Stop event is coloured in blue, but all others in red. Button **RUN** remains accessible and can be clicked to restart the measurement with modified parameters of gate delay control.

The measurement will be stopped either automatically when the preset amount of time intervals (see the numeric control at the upper right corner of the panel) is reached or manually by clicking the button **STOP** at any moment. Generally the Event Timer A032-ET in itself does not limit the total amount of measured events but the A032.2-C2 software limits this amount up to certain value user-defined in configuration file *Param.cl.cnf*. This value should be defined depending on the available PC resources because all received data has to be stored in the working memory for further processing and saving.

The main control panel provides also following user-controlled procedures related with data displaying:

“Graph” – ring control to choose one of six graph styles; the control is possible only after the measurements stops, and acts on the displayed data.

X toggle button - its suppressing allows to zoom in the plot for X-axis. If zoom is made after the measurement is stopped, the zoomed area is defined by left and right sides of zooming rectangle; if zoom is made during the measurement, the only left side of the zooming rectangle defines the zoomed area.

Y toggle button - its suppressing allows to zoom in the plot for Y-axis. Such zoom can be made at any time; the zoomed Y-axis size remains the same up to the next zoom changing.

If **X** or/and **Y** are suppressed you may press and hold the mouse left button and drag the mouse to draw rectangles; the inner area of the last rectangle will be zoomed after the mouse button is released.

There are additional controls for zooming at the ends of the graph X-axis and Y-axis:

+X round button – each click decreases the left value and increases the right value of the X-axis on quarter;

+Y round button – each click decreases the bottom value and increases the upper value of the Y-axis on quarter.

ZoomOut – click this button to release the **X** and **Y** buttons and set: the Y-axis sizes to the maximal and minimal values of registered time intervals; the X-axis from 0 to the last interval number. The mouse right click executes the zoom out only for Y-axis and does not affect on X-axis and **X** and **Y** buttons. Both zoom out operations can be made at any time.

reCalculate – click this button to calculate Mean value and RMS deviation for time intervals in zoomed area; the upper information string will show the calculating results. This operation restricts the maximum and minimum of Y-axis by the maximal and minimal visible time intervals.

Save BINARY – click this button to save the timing data in binary format for events, which conform to the currently visible time intervals. The number of events should be greater than 100.

Save ASCII – click this button to save the timing data in ASCII format for events, which conform to the currently visible time intervals. The number of events should be greater than 10.

The buttons for data saving are accessible only after measurement ending. In both saving operations the Window Select File menu appears and allows setting a name of saved file; the name of file will appear in the bottom information string.

QUIT - click this button to close the program.

4. Examples of measurement with the A032.2-C2

4.1. Measurement under constant gate delay

In this example two independent pulse signal generators are used to provide Start pulses and Stop pulses at the corresponding inputs of the ET-device. Start pulses are generated at ~320 Hz repetition rate, and Stop pulses – at 86,440 KHz repetition rate. So in this case a group of about 268 periodic Stop pulses follows after each Start pulse, but only first five Stop pulses will be registered in each measurement cycle. In this case the time interval between each Start pulse and nearest Stop pulse will be variable as opposed to the time intervals between adjacent Stop pulses that are formed on the basis of low-jittered crystal clock oscillator. The gate delay will be set as a constant value.

After performing of all preparatory procedures the accessory panel has the appearance shown in Fig.C-4. As shown, the event timer suggests the measurement RMS resolution about 7 ps. The server setting is adapted to the highest-speed operation (waiting time is zero); 6 events (including Start event) will be measured in each cycle.

The gate delay control is defined on the own panel (Fig. C-5). The gate delay is set to 1.5 μ s and the increment step is set to zero to avoid in this way the delay variation.

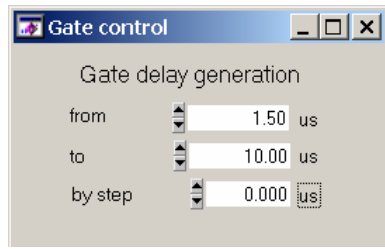


Fig.C-5

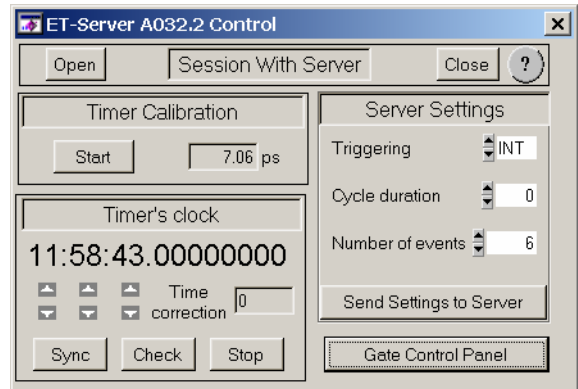


Fig.C-4.

Under these conditions the measurement of about 10,000 input events during 1667 sequential cycles results in two separate fractions of time intervals between all pairs of adjacent events. Zoom in for X-axis makes it possible to see these fractions in more details and separate the “Start-Stop” intervals (coloured in blue) from other ones (Fig. C-6).

The upper fraction corresponds to “Stop-Start” time intervals (they are near to the period 3.1 ms of cycle repetition) and the bottom fraction – to “Start-Stop” and “Stop-Stop” time intervals that are much smaller. Note that there are no any unexpected larger time intervals that could indicate skips of some measurement cycles.

Zoom in for Y-axis allows seeing every fraction of time intervals with better time resolution and calculating their basic statistics. Specifically, Fig.C-7 shows that “Start-Stop” time intervals are variable as compared to the much more stable “Stop-Stop” time intervals (as was expected). Mean and RMS deviation of the “Stop-Stop” time intervals is about 11,568.7 ns and 8.9 ps respectively.

Thus, the above measurement exemplifies that the A032-ET really supports multi-stopped measurement at 320 Hz cycle repetition rate with RMS resolution surely better than 10 ps. Actually the cycle repetition rate can be much higher.

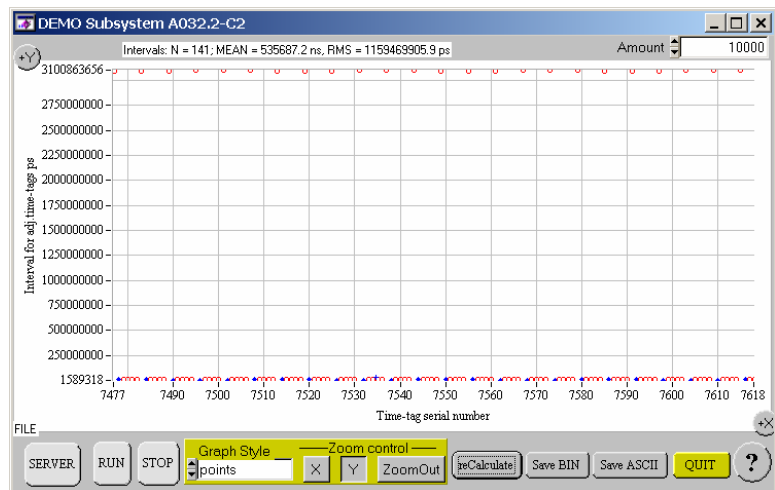


Fig.C-6

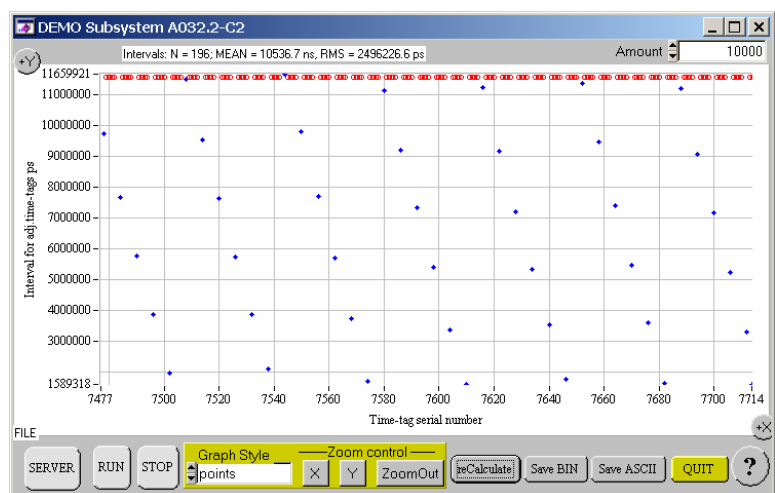


Fig.C-7

4.2. Measurement under variable gating

This example demonstrates the speed abilities of online re-programming the gate delay. As compared to the previous example, in this case the output TEST OUT of the ET-device indicating the gate delay is connected via 3-m coaxial cable to the INPUT B (as Stop pulses) to measure and display the values of this delay under different measurement conditions.

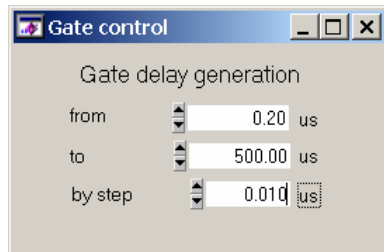


Fig.C-8

Setting the parameters for controlling the gate delay is shown in Fig. C-8. This setting means that the control data will define the gate delay that first should rise from 200 to 500,00 ns with 10 ns increment in each cycle and next fall down with the same speed. In fact we shall measure only initial (rising) part of these delays.

The A032.2-C2 always restarts the measurement in response to the every batch of data received from ET-server, and through this action attempts to define a new gate delay value for each next measurement cycle. However the TCP/IP network may produce some unexpected delays for real-time data exchanging, resulting in troubles for such interactive operation at high rate of measurement cycle repetition. Specifically, in this case the control data can be delivered later than the ET-server starts the corresponding cycle. What is more, these data may consist of a few separate data blocks addressed to both the past cycles and the current cycle. When the A032.2-C2 restarts the measurement, it takes into account only the latest data concerning the gate delay, omitting out-dated ones. In these cases some gaps in the delay gate control appear.

Fig. C-9 illustrates this effect for the case of measurement at 500 Hz cycle repetition rate. As can be seen, there are many repeated gaps in gate delay control. Thus, the measurement under variable gating at high cycle repetition rate is possible but with certain limitations concerning the rate of gate delay modifying.

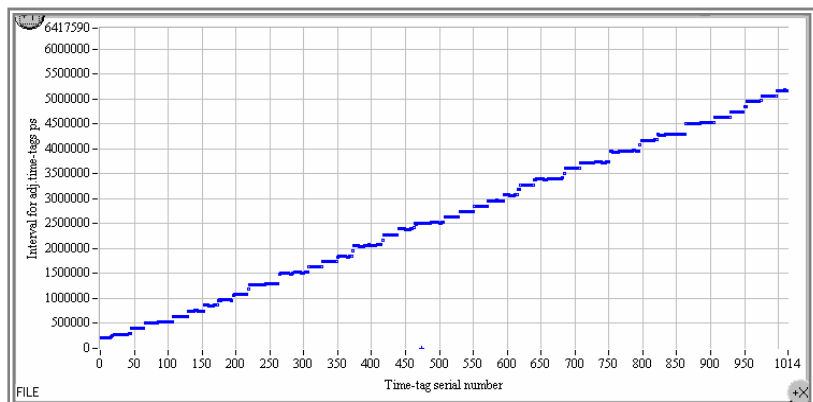


Fig.C-9

When cycle repetition rate is not so high, gapless online control for gate delay is quite possible. Fig. C-10 illustrates such ability for 40 Hz cycle repetition rate. In this case there are no any gaps in delay control.

However in each specific case the highest available rate of gapless control may depend on the various things, e.g., the actual performance and charge of PC. It is recommended to reproduce similar measurement under specific user's conditions with the aim to evaluate the actually available maximum rate of gapless gate delay control.

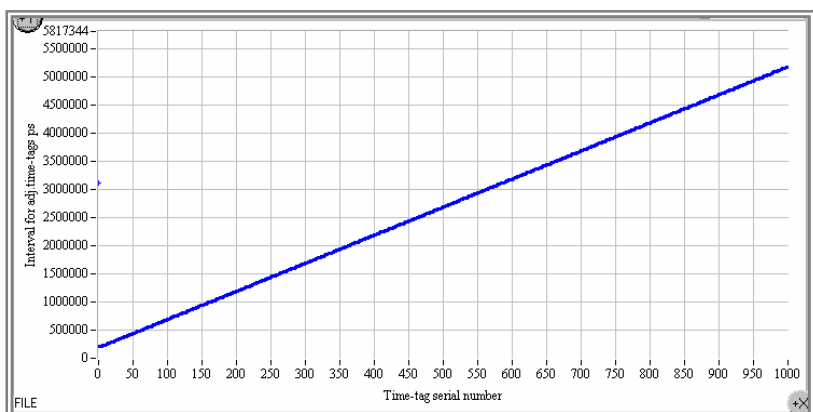


Fig.C-10