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Oscilloscope function

.Oscilloscope function

.General information

The oscilloscope function can be used to record drive-internal and external status variables (parameter contents). This function can be effectively used both for initial commissioning and debugging. Its functionality can be compared to that of an 8-channel oscilloscope.

The total scope of the oscilloscope function is divided into the following function blocks:

- **Measured value recording**
  It is possible to record 8 channels at the same time, the signals being selected by configuring signal selection lists (IDN lists).
- **Configuration (basic settings)**
  The control/status block determines the basic functions (start/stop, time resolution, size of memory, operation mode). The current state (state diagram) of the oscilloscope is continuously transmitted to the higher-level control.
- **Trigger function**
  Besides extensive trigger functions, the drive provides the possibility of triggering at different signals and events in the drive.

.Features

The oscilloscope function is characterized by the following features:

- **Measured value recording**
  - Up to 8 channels with up to 8192 measured values each (the total should not exceed 32,768 measured values)
  - Time resolution to be freely selected in steps of the position controller clock (see ↘ “ctrlX DRIVE clock rates ”)
  - Signal selection by indicating the IDN of the respective parameter
- **Configuration (basic settings)**
  - Multiple-channel display in ctrlX DRIVE Engineering
  - More than 100 different measuring and trigger signals (cf. P-0-0149)
  - Via symbol-based patch variables, up to 4 variables can be recorded
  - Extended oscilloscope function using 2 patch functions
  - Extended oscilloscope function using 2 average value filters for display
- **Trigger function**
  - Trigger signal selection by indicating the parameter IDN
  - Internal trigger or external trigger
  - External trigger with trigger offset determination for synchronizing multiple-axis measurements
  - Unit of trigger level adjusting to trigger signal selection
  - Possibility of triggering at internal memory contents with patch signal
  - Possibility of triggering to variable with symbol-based patch signal
  - Time stamp for trigger time is mapped to parameter "P-0-0035.0.1, Oscilloscope: Trigger time".

.Additional information and details

.General information on the oscilloscope function

.Sequence of a measurement (state diagram)

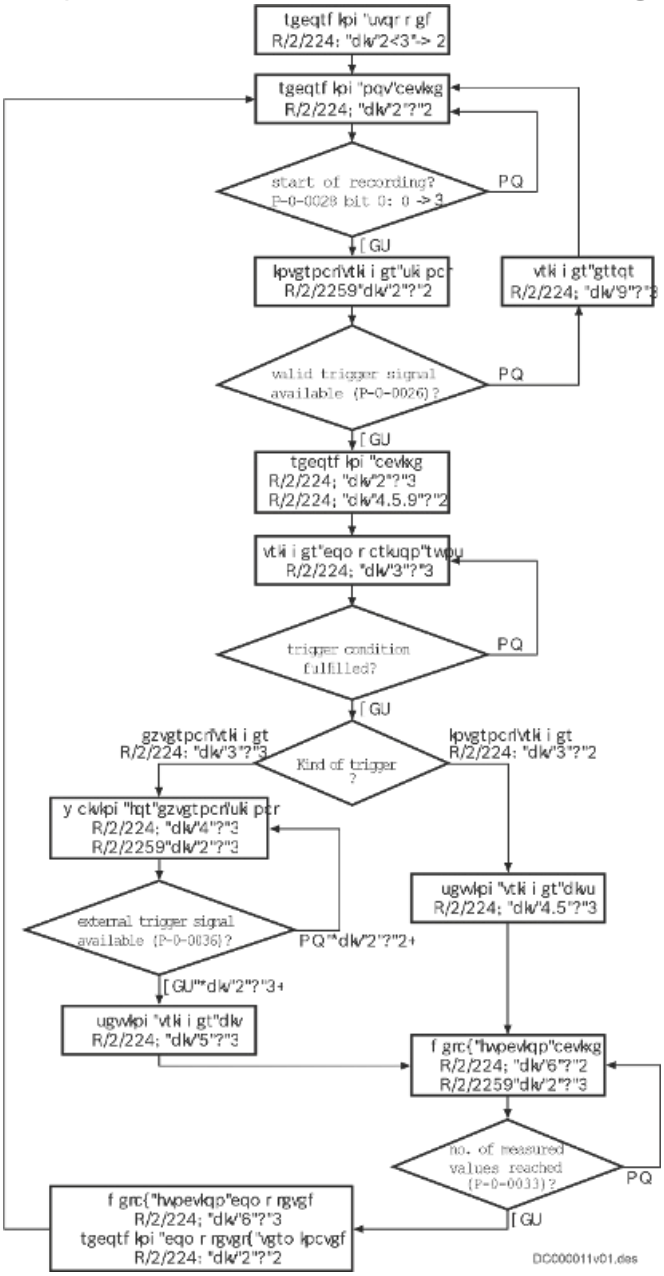

Fig. 350: State diagram of oscilloscope function

.Configuring the measured value channels

A measured value channel is configured by inputting the IDN of the desired parameter in the respective signal selection parameter:

- P-0-0023, Oscilloscope: Signal selection 1
- P-0-0024, Oscilloscope: Signal selection 2
- P-0-0147, Oscilloscope: Signal selection 3
- P-0-0148, Oscilloscope: Signal selection 4
- P-0-0270, Oscilloscope: Signal selection 5
- P-0-0271, Oscilloscope: Signal selection 6
- P-0-0272, Oscilloscope: Signal selection 7
- P-0-0273, Oscilloscope: Signal selection 8

.Signal selection list (P-0-0149)

All IDNs contained in parameter "P-0-0149, Oscilloscope: Signal selection list" can be entered.

P-0-0149 contains all parameters that can be used as trigger signal (P-0-0026) or as measuring signal (P-0-0023, P-0-0024, P-0-0147, P-0-0148, P-0-0270, P-0-0271, P-0-0272, P-0-0273). By reading P-0-0149, the higher-level control can detect the signals that can be recorded in the drive.

Currently, all cyclically configurable parameters (> 100) are included in the list!

.Example of signal selection

Example of the signal selection of the oscilloscope function:

- "S-0-0051, Position feedback value of encoder 1“ is selected as the signal to be recorded
- Position feedback value of encoder 1 (S-0-0051) is written to parameter "P-0-0023, Oscilloscope: Signal selection 1"

→ If the requirements have been complied with, the actual position value of axis 1 is recorded in the oscilloscope and transmitted to the higher-level control.

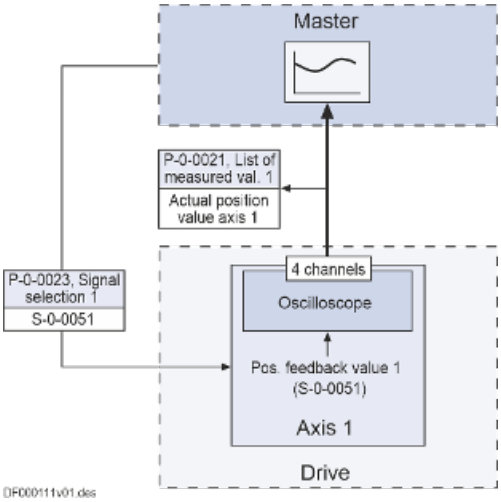

Fig. 351: Example of signal selection

.Extended oscilloscope function (patch function)

Apart from recording parameter contents via the oscilloscope function, the drive provides the option to record internal signals, i.e. memory addresses (patch function).

Using the patch function is only possible with the information on the structure of the internal data memory. Therefore, this function can only be used effectively by the development staff of the ctrlX DRIVE firmware.

See also ↘ “Patch function ”

.Extended oscilloscope function (symbol-based patch function)

Besides the recording of parameter contents via the oscilloscope function, the drive provides the option to record symbol-based variables (symbol-based patch function). See also ↘ “Patch function ”

.Activating the oscilloscope function

The oscilloscope function is activated/deactivated using the parameter "P-0-0028, Oscilloscope: Control word".

P-0-0028, bit 0:

- Bit 0 = 1 → starting a measurement
- Bit 0 = 0 → stopping a measurement

Setting bit 0 in P-0-0028 activates the oscilloscope function, i.e. the recording of measured values of the selected signal starts. The oscilloscope function waits for the selected trigger edge or level to occur. At detection of a valid edge the measured values keep being written to the measured value memory until the number of measured values defined in

"P-0-0033, Oscilloscope: Number of measured values after trigger event" has been reached (delay function).

For synchronous measurement of multiple axes or devices, it is required to synchronously set the start bit in the axes or the device.

After the defined number of measured values has been recorded, the "delay function completed" bit (bit 4) is set in parameter "P-0-0029, Oscilloscope: Status word". Now, the recording is complete and automatically terminated. Bit 0 in parameter P-0-0028 is reset and the list of measured values can be read.

Depending on the parameterization of the size of memory, the time resolution, the number of measured values after trigger event and the point of time the trigger event occurs, the entire measured value memory for the current measurement is not always written.

.Trigger function

.Trigger signal selection

The drive provides extensive and flexible triggering options.

.Triggering at standard signals

The trigger signal is selected in "P-0-0026, Oscilloscope: Trigger signal selection" by directly inputting parameter IDNs. Only IDNs are allowed that are contained in the list "P-0-0149, Oscilloscope: Signal selection list".

If there is no valid trigger signal available when the oscilloscope function is activated, bit 7 for "trigger error" is set in parameter "P-0-0029, Oscilloscope: Status word".

"P-0-0026, Oscilloscope: Trigger signal selection" determines which signal is monitored with regard to the parameterized edge reversal or threshold value.

.Triggering at any signal

Besides the triggering of parameter contents, the drive provides the possibility of recording any internal signal, i.e. memory addresses (patch function).

Using the patch function is only possible with the information on the structure of the internal data memory. Therefore, this function can only be used effectively by the development staff of the ctrlX DRIVE firmware.

.Patch function

In order to trigger at internal signals (memory address contents), configure the "P-0-0485, Patch function 1, display" or

"P-0-0491, Patch function 2, display" parameter in P-0-0026.

Furthermore, triggering to a variable in a symbol-based way is possible.

See also ↘ “Patch function ”

.Internal or external trigger

Select the trigger type in parameter "P-0-0028, Oscilloscope: Control word".

P-0-0028, bit 1:

- Bit 1 = 0 → Internal trigger without offset measurement
- Bit 1 = 1 → External trigger with offset measurement

.Trigger event

The trigger event is the moment when trigger signal (P-0-0026) and trigger level (P-0-0027) are matching, taking the determined trigger edge into account (P-0-0030). When the trigger event occurs, the internal trigger is released.

.Internal trigger (without offset measurement)

If "internal trigger" is selected (P-0-0028; bit 1 = 0), the external trigger source (P-0-0036, bit 0) is not taken into account. Until the trigger event is reached, the current state of the "signal/trigger level" comparison is displayed in "P-0-0029, Oscilloscope: Status word".

When the trigger event has been reached, the "internal trigger event" bit is set in parameter "P-0-0029, Oscilloscope: Status word" and recording is continued until the defined number of measured values after trigger event (P-0-0033) has been reached. Only then the "Delay function completed" bit is set (P-0-0029; bit 4). Setting this bit completes the entire recording. Independent of the trigger source, the bit indicates the end of the recording.

In case of an internal trigger source, the "Trigger function completed" status bit (P-0-0029, bit 3) is set simultaneously with the bit for "Internal trigger event" (P-0-0029, bit 2) (see state diagram).

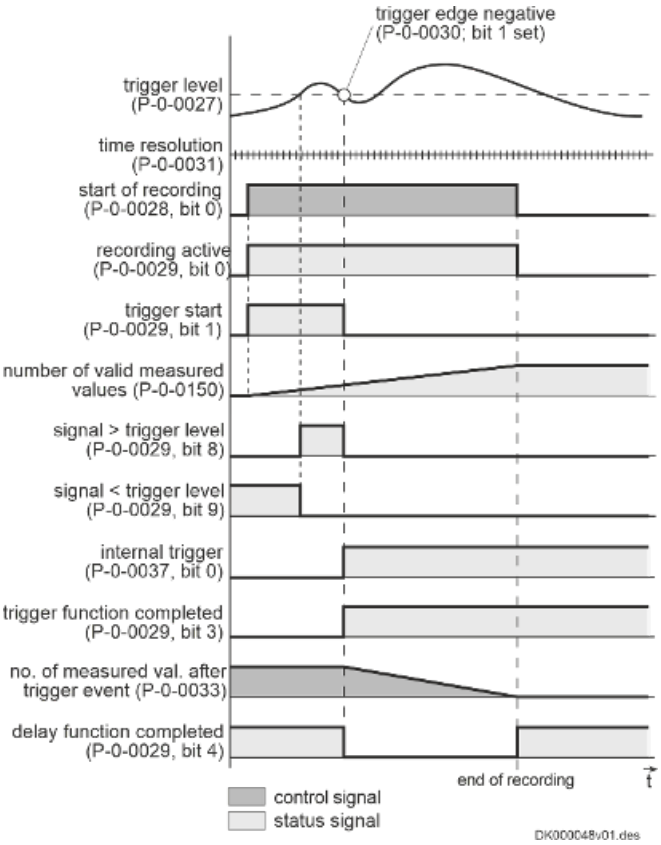

Fig. 352: Internal trigger without offset measurement (P-0-0028; bit 1 = 0)

Parameterizing P-0-0036 (external trigger signal) in "P-0-0026, Oscilloscope: Trigger signal selection" allows the internal trigger function to be triggered by the external trigger input.

.External trigger with offset measurement

In case of trigger type "External trigger with offset measurement" (P-0-0028, bit 1 = 1), the internal and external trigger are used for the triggering axis.

When "External trigger" has been selected, the behavior, until the internal trigger event has been reached, corresponds to the behavior for the case when trigger source "Internal trigger" has been selected. Until the external trigger signal occurs (P-0-0036; bit 0), the trigger offset between both trigger events is determined and displayed in parameter P-0-0035. Then the "Trigger function completed" bit (P-0-0029; bit 3) bit is set in the status word. The rest of the sequence is the same as in the case of internal trigger source without offset measurement.

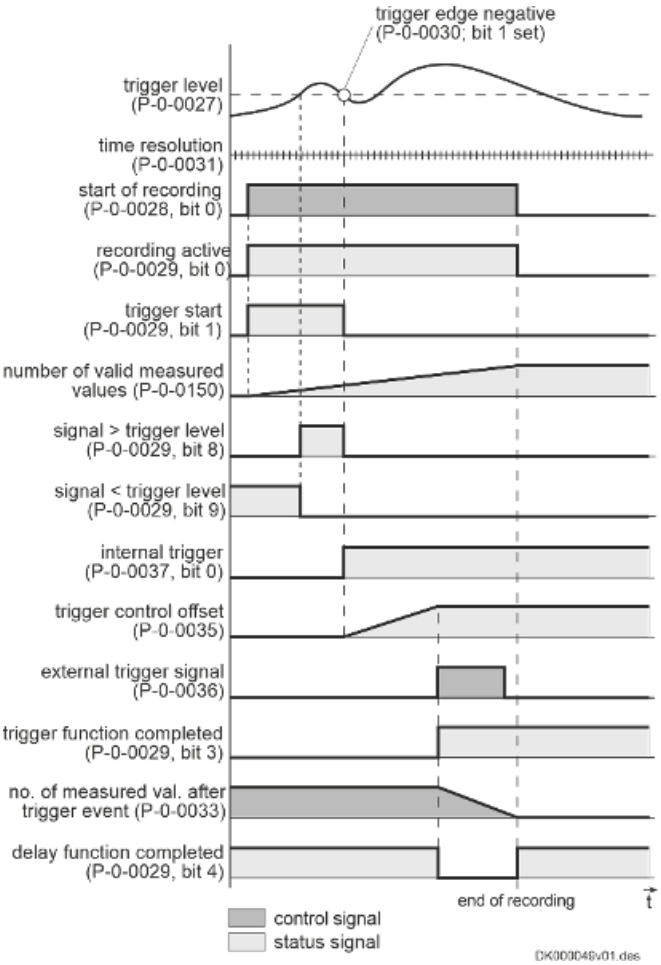

Fig. 353: External trigger with offset measurement (P-0-0028; bit 1 = 1)

The use of the external trigger source with trigger offset determination is described in section ↘ “Synchronizing the measuring signals of multiple axes” (see below).

.Selecting the trigger edges

.Trigger edge (P-0-0030)

In the parameter "P-0-0030, Oscilloscope: Trigger edge", it is possible to set the edge of the trigger signal at which the internal trigger is released. The following options are available:

- Triggering at the **positive** edge
  Triggering is applied at the transition "less than or equal to → greater than".
- Triggering at the **negative** edge
  Triggering is applied at the transition "greater than or equal to → less than".

- Triggering at **both** edges
  Triggering is applied at the transition "less than/equal to → greater than" and "greater than/equal to → less than".
- Triggering when trigger signal **equals** trigger level

Even if both edges have been enabled, the trigger only starts if the value is exceeded or fallen below. The trigger is not released in the event of parity.

See parameter description "P-0-0030, Oscilloscope: Trigger edge"

.Setting the trigger delay

.Trigger delay function

Via "P-0-0033, Oscilloscope: Number of measured values after trigger event" it is possible to reach a trigger delay independent of the preset trigger source (external/internal). For this purpose, the number of measured values that is to be recorded after the respective trigger event is set in parameter P-0-0033.

It is also possible to record measured values before the trigger event occurs (trigger delay function of an oscilloscope).

No data lying after the trigger event are recorded if "0" is input in P-0-0033. The trigger event is the last value in the list of measured values. If the value of the parameter P-0-0032 is input, no measured values lying before the trigger event are recorded. The trigger event is the first value in the list of measured values. The trigger event is thus counted, too. In other words, if P-0-0033 has the value "0" or "1", the trigger event is the last value in the list of measured values.

If the time until the trigger event is too short, it can sporadically happen that the measured value lists are not completely filled (in extreme cases, only one value if P-0-0033 has the value "0").

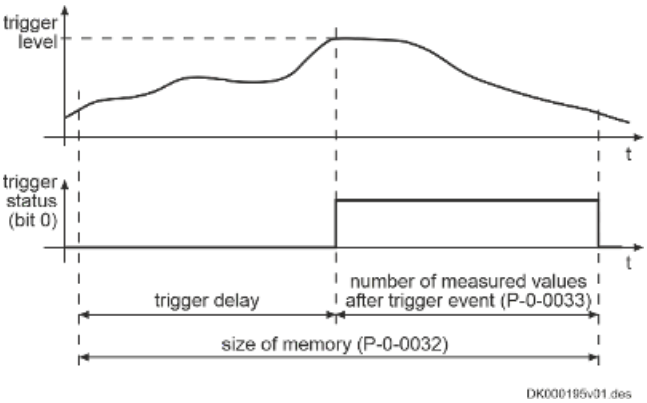

Fig. 354: Trigger delay: Number of measured values after trigger event

.Extended trigger functions

.Trigger mask (P-0-0025)

With the parameter "P-0-0025, Oscilloscope: Trigger mask", it is possible to trigger to certain events. For trigger signals with "binary", "hexadecimal" or "decimal" display formats, it is possible to mask the trigger signal and the trigger level to trigger to certain events. With the parameter "P-0-0025, Oscilloscope: Trigger mask", a mask for the trigger signal is specified. This mask is used to mask both the measured signal value and the trigger value that was set, for the purpose of comparison. The mask that was set is ignored in the case of the display value "Float".

If the mask has the value "0" or "0xFFFFFFFF", the mask is ignored. Only values unequal to "0" or "0xFFFFFFFF" are useful values and are used as trigger mask.

.Trigger level (P-0-0027)

The trigger level can be freely set via parameter "P-0-0027, Oscilloscope: Trigger level", the attribute, unit etc. being adjusted to the selected trigger signal.

See parameter description "P-0-0027, Oscilloscope: Trigger level"

.Manual trigger

As a manual trigger, parameter P-0-0136 should be used since parameter P-0-0036 is also used for multi-device measurement. It is cyclically configured and can no longer be written by the user. Note: Depending on the edge configuration, exceeding/falling below signalizes the trigger event (not reaching of the level). See ↘ “Selecting the trigger edges ” .

.Trigger time

When the system time has been set, it is possible to read out the system time at the moment of triggering via "P-0-0035.0.1, Oscilloscope: Trigger time". This way, it is possible to establish the trigger time retrospectively. This can be a useful function if monitoring is configured and the user wants to see when the trigger event occurred. It can be displayed as an additional information in ctrlX DRIVE Engineering.

The system time is specified in Sercos time format (IEC 61588). As not all field buses support 8-byte parameters, the time is transmitted in an array with 2*32 bit. As data is basically transmitted in Little Endian, the first element includes the system time (fine) and the second element includes the system time (coarse) according to "S-0-1305.0.2 System time (fine)" and "S-0-1305.0.3, System time (coarse)".

The parameter "P-0-0035.0.1" can be used to synchronize measurements if e.g.

- a simultaneous measurement on the PC and in the drive is to be carried out. For this purpose, the system time of the drive has to be synchronized beforehand with the system time of the PC connected via ctrlX DRIVE Engineering.
- Simultaneous measurement in multiple drives
- Synchronization of Diagnostic Trace

.Including persistent storage

All configuration values of the oscilloscope are saved persistently, depending on the selected storage mode. Either

- when changing the value if the storage mode in "S-0-0269, Storage mode" has been set to non-volatile or
- by executing the command "S-0-0264, C2200 Backup working memory procedure command".

If the configuration values of the oscilloscope were saved persistently, this configuration can be used when booting up the drive for an automatically activated measurement. To do this, the value of "P-0-0028, Oscilloscope: Control word" is always backed up upon voltage failure. This means, if the oscilloscope is active in the control word when switching the device off, the oscilloscope is still active when the device is switched on. After initializing the parameter system, the measurement is started. Measuring signals that cannot be configured during booting, are ignored in the measurement. Ignored measuring signals do not have any list elements. The lists are blank.

.Synchronizing the measuring signals of multiple axes

The parameter "P-0-0035, Oszilloskop: Trigger control offset" contains the number of measured values between the occurrence of the internal trigger event (P-0-0029; bit 2) and the external trigger event (P-0-0036; bit 0).

.Trigger control offset (P-0-0035)

The transmission of the trigger event of the triggering axis causes a delay between the detection of the trigger event and the release of the trigger. This offset is measured by the triggering axis and stored in parameter "P-0-0035, Oscilloscope: Trigger control offset". A time-correct display of the signals of several drives can be guaranteed by taking this parameter into account for the visualization of the measured values.

The higher-level control has to initiate the transmission of the trigger. For this purpose, the internal trigger signal has to be distributed to all involved axes in parameter "P-0-0037, Oscilloscope: Internal trigger signal" of the triggering axis in the form of a real-time bit as external trigger signal "P-0-0036, Oscilloscope: External trigger signal".

See also above ↘ “Internal or external trigger ”

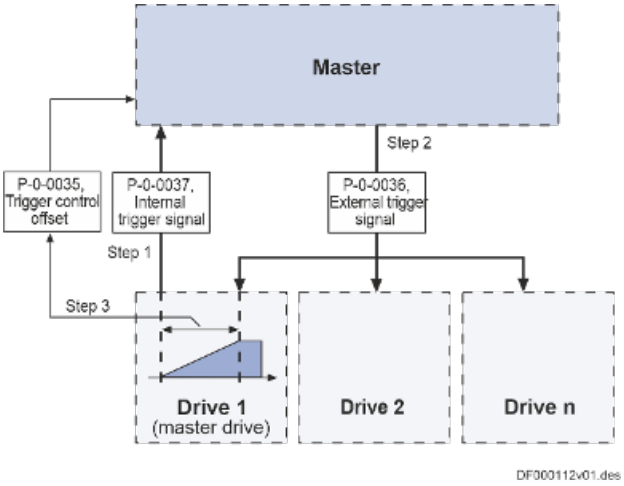

Fig. 355: Application for trigger source "External" with determination of trigger offset

The value in parameter P-0-0035 can be used by the higher-level control for synchronizing the measuring signals of multiple axes with the internal trigger event of the triggering axis.

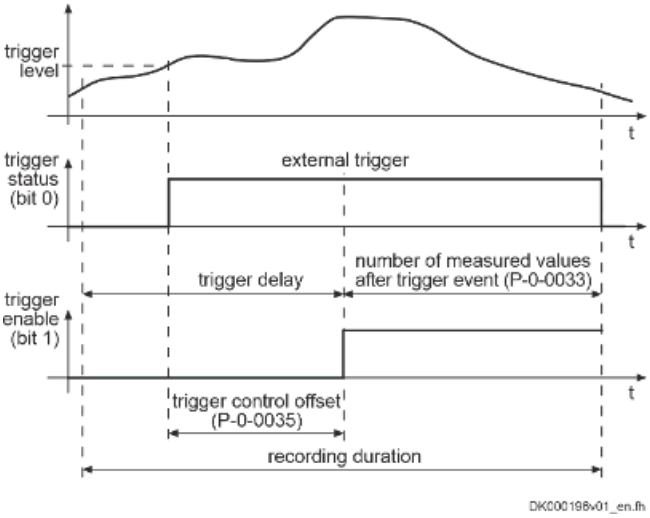

Fig. 356: Trigger control offset

.Status of internal trigger (P-0-0037)

Upon successful comparison of trigger signal and trigger condition, bit 0 is set in parameter "P-0-0037, Oscilloscope: Internal trigger signal" (trigger status), but the trigger is not released. Thus, the higher-level control can simultaneously signal the trigger event via the real-time status bits and real-time control bits to multiple drives and to release the trigger.

.External trigger signal (P-0-0036)

"P-0-0036, Oscilloscope: External trigger signal" can be parameterized as real-time control information, both in the real-time channel of the interface and as hardware input. This allows triggering at external signals that are preset using

- the master communication of the higher-level control

- or -

- an analog or digital input.

.Multi-device measurement in CCD group

Requirements for multi-device measurement in a CCD group:

- CCD is active and in phase 4.
- In the CCD master, synchronous master communication is active.
  Without synchronous master communication in the master, the time resolution has to be equal to the position controller clock cycle to get synchronous measurement.
- "P-0-0031, Oscilloscope: Time resolution" must not exceed the Sercos cycle time.
- The real-time control bits are correctly configured in the CCD master and the CCD slaves (this is done by ctrlX DRIVE Engineering).

.Parameterizing the oscilloscope function

.Recording duration

The recording duration is determined according to the following relationship:

$$t_A = (P\text{-}0\text{-}0031) \times (P\text{-}0\text{-}0032)$$

Fig. 357: Determining the recording duration

t_A	Recording duration (in µs)
P-0-0031	Oscilloscope: Time resolution
P-0-0032	Oscilloscope: Size of memory

Via "P-0-0032, Oscilloscope: Size of memory", the number of measured values is determined. The maximum allowed number of measured values depends on the number of used channels. The available measured value memory comprises 32768 measured values. Since the maximum size of memory of a measured value list can comprise 8192 measured values, the configurable size of memory is reduced if more than 4 channels are used.

.Parameterizing the selection of measured values

For the oscilloscope function, it is possible to select 4 signals that are defined by the IDNs of their respective parameters and assigned to the following parameters:

- P-0-0023, Oscilloscope: Signal selection 1
- P-0-0024, Oscilloscope: Signal selection 2
- P-0-0147, Oscilloscope: Signal selection 3
- P-0-0148, Oscilloscope: Signal selection 4
- P-0-0270, Oscilloscope: Signal selection 5
- P-0-0271, Oscilloscope: Signal selection 6
- P-0-0272, Oscilloscope: Signal selection 7
- P-0-0273, Oscilloscope: Signal selection 8

Only such parameter IDNs are allowed that are contained in the list parameter "P-0-0149, Oscilloscope: Signal selection list".

The selected signal (parameter IDN) defines the unit of the data stored in the list of measured values.

.Parameterizing the trigger function

See above ↘ “Trigger function ”

.Parameterizing time resolution and size of memory

The recording range or the recording duration can be adjusted to the measurement requirements via the following parameters:

- P-0-0031, Oscilloscope: Time resolution
- P-0-0032, Oscilloscope: Size of memory

.Size of memory of oscilloscope function

Via "P-0-0032, Oscilloscope: Size of memory", the number of measured values is determined. A maximum of 8192 measured values per channel can be recorded.

.Time resolution of oscilloscope function

Via "P-0-0031, Oscilloscope: Time resolution", the time intervals, in which the measured values are recorded, are determined (sampling rate). It is possible to select the time resolution on the time base of the position controller clock (T_{osci} = N x $T_{A\_position}$; N = 1, 2, 3, 4, ...).

The position controller cycle time depends on the control performance. The control performance in turn depends on the hardware design of the controller and the setting in parameter P-0-0556.

For the possible times please see ↘ “ctrlX DRIVE clock rates ”).

.Diagnostic and status messages

.Status of the oscilloscope function

The parameter "P-0-0029, Oscilloscope: Status word" shows the current state of the oscilloscope function.

P-0-0029 contains, for example, status information on:

- Start/end of recording
- Trigger function
- State of trigger signal
- Delay function

See also parameter description "P-0-0029, Oscilloscope: Status word"

Via parameter "P-0-0037, Oscilloscope: Internal trigger signal", the higher-level control is informed about the status of the internal trigger. This parameter can be parameterized as real-time status information, both in the real-time channel of the interface and as hardware output.

.Displaying the number of valid measured values

After a measurement, the parameter "P-0-0150, Oscilloscope: Number of valid measured values" displays the number of measured values in the ring buffer. If the ring buffer was completely filled with the length specified in parameter "P-0-0032, Oscilloscope: Size of memory", the size of memory is displayed in this parameter.

See also description of parameter "P-0-0150, Oscilloscope: Number of valid measured values"

.Trend mode

The trend mode allows for recording of up to 8 channels in a cyclic mode. The values are managed in a buffer memory and cyclically called. ctrlX DRIVE Engineering can read this memory and display it continuously. Since it is not necessarily an equidistant measurement, measured values are sometimes missing, e.g. due to a slow connection. These values are represented accordingly in the graphics.

To allow the trend mode to be used, the system time has to be activated. This time base is used to unequivocally assign the corresponding measuring points to a point in time.

The time resolution can only be set and signals can only be selected if the trend mode has been switched off. Only times that are multiples of the minimum time that can be selected are allowed as time resolutions. If another value is entered, it is rounded down to the next possible value. Signal selection is done using the previous parameters.

The trend mode is activated by setting P-0-0020, bit 5. The mode of the "conventional" oscilloscope cannot be used in parallel. Trend recording is then activated via P-0-0028, bit 0. The trend also signals the activity in P-0-0029, bit 0.

.Parameters involved

.Parameters involved

- P-0-0020, Oscilloscope: Operation mode
- P-0-0136, Oscilloscope: Manual trigger signal

Control/status:

- P-0-0028, Oscilloscope: Control word
- P-0-0029, Oscilloscope: Status word
- P-0-0031, Oscilloscope: Time resolution
- P-0-0032, Oscilloscope: Size of memory
- P-0-0149, Oscilloscope: Signal selection list
- P-0-0150, Oscilloscope: Number of valid measured values

Measuring channels:

- P-0-0021, Oscilloscope: List of measured values 1
- P-0-0022, Oscilloscope: List of measured values 2
- P-0-0023, Oscilloscope: Signal selection 1
- P-0-0024, Oscilloscope: Signal selection 2
- P-0-0145, Oscilloscope: List of measured values 3
- P-0-0146, Oscilloscope: List of measured values 4
- P-0-0147, Oscilloscope: Signal selection 3
- P-0-0148, Oscilloscope: Signal selection 4
- P-0-0274, Oscilloscope: List of measured values 5
- P-0-0275, Oscilloscope: List of measured values 6
- P-0-0270, Oscilloscope: Signal selection 5
- P-0-0271, Oscilloscope: Signal selection 6
- P-0-0276, Oscilloscope: List of measured values 7
- P-0-0277, Oscilloscope: List of measured values 8
- P-0-0272, Oscilloscope: Signal selection 7
- P-0-0273, Oscilloscope: Signal selection 8

Trigger function:

- P-0-0025, Oscilloscope: Trigger mask
- P-0-0026, Oscilloscope: Trigger signal selection
- P-0-0027, Oscilloscope: Trigger level
- P-0-0030, Oscilloscope: Trigger edge
- P-0-0033, Oscilloscope: Number of measured values after trigger event
- P-0-0035, Oscilloscope: Trigger control offset
- P-0-0036, Oscilloscope: External trigger signal
- P-0-0037, Oscilloscope: Internal trigger signal