Optical Sensor CHRocodile 2

Non-Contact Measurement for Distance and Layer Thickness

Protocol and Command Reference

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Chapter 1

CHRocodile Protocols

1.1 Introduction

Overview

The following chapter delineates the transfer of measurement data via the device's interfaces and the configuration of the device with the corresponding commands. The two underlying protocols are described, the dollar protocol and the packet protocol.

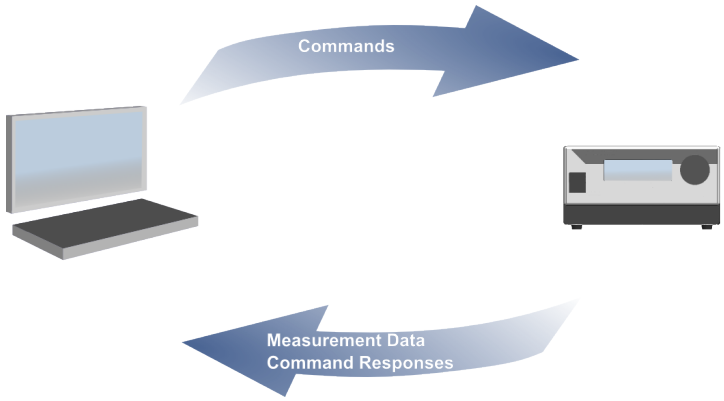
Characteristics

During normal operation, the device continuously sends data packets. There are two unique protocols for communication between the sensor and external clients, typically being PCs. One is the dollar protocol, which is also used by CHRocodile sensors of the first generation, and the other is the binary packet protocol. The following table compares the main characteristics of the two types of data transmission:

Dollar Protocol	Packet Protocol
• Available on TCP port 7890 and serial port	• Available only on TCP port 7891
• Economic result data transmission (2 bytes per measured value plus 2 bytes telegram header)	• Multi-client enabled
• Human readable command format, enabling setup and parameter adjustment with a simple terminal program.	• Multi-channel enabled (only on multi-channel devices)
• ASCII measurement output option, making the data output human readable on a simple terminal program.	• Simple packet structure with reasonable packet overhead
• Real-time data output over serial port	• Data packets, data format packets, command packets
	• Easily decodable
	• Easily extendable

Protocols similarities

In both protocols, commands are streamed up to the device and measurement data and command responses are streamed down to clients. The information (e.g., distance, thickness, intensity, etc.) included in the data stream can be chosen by the user with a command (SODX). The command responses are sent interleaved with data samples. These relationships are outlined in the following figure:



Protocols differences

Basically, the commands and the measured information available are identical on both protocols. However, there are some general differences and a few differences on individual commands. In the command reference, existing differences are mentioned for every affected command. For example, the command ULFW is supported by the packet protocol only.

Connection limitations

The maximum number of supported simultaneous connections is device specific.

Multi-channel devices

Those devices such as the CHRocodile MPS, CLS or DPS do not fully support the dollar protocol. Only the binary packet protocol is available for data transfer with those devices. However, the dollar protocol can be used for commands and parameter queries.

1.2 Dollar protocol

Overview

The dollar protocol got its name from the fact that every command begins with a dollar character. The $ character switches the CHRocodile into command receive mode.

In the dollar protocol, the format of the measurement data can be binary for optimal transmission speed ($BIN) or ASCII for easy readability ($ASC).

Interface

The dollar protocol is available on the Ethernet (TCP port 7890) and serial (RS422) interface.

Note: *If the dollar protocol is used with the serial interface, care has to be taken when choosing a combination of baud rate, sample rate, average, data format and selected output data that all data can be transmitted as the baudrate of the serial interface is far lower than that of the Ethernet interface.*

ASCII mode

In ASCII mode, the selected signals are transmitted as decimal number strings, separated by comma characters (,). A data telegram is concluded with a CR/LF (#13#10) character combination.

Binary mode

In binary mode a data telegram begins with a 2-byte synchronization sequence. The default sequence is #255,#255 (0xFF, 0xFF) but it can be customized by the $SSQ command. After the synchronization sequence the selected signals are sent either as 2-byte or 4-byte values, according to the selected format.

The endianess of the values depends on the signal bit width according to the table below (MSB: most significant byte, LSB: least significant byte):

Bit width	Endianess	Byte order
16 bit	Big endian	MSB, LSB
32 bit	Little endian	LSB, MSB

Example:
The command SODX 16640 (16-bit integer) creates a data stream with the following structure (big endian):
`0xFF,0xFF,PeakPos1 MSB,PeakPos1 LSB`

The command SODX 65 (32-bit integer) creates a data stream with the following structure (little endian):
`0xFF,0xFF,EncoderX LSB ...EncoderX MSB`

The length of a telegram can be calculated from the size of the selected data signals plus 2 bytes (synchronization sequence). As the synchronization sequence is not unique in the data flow (there might be signal values that equal the synchronization characters), the data client must apply a special technique in order to achieve (and maintain) telegram synchronization:

1. Stop the data flow by sending a command. After completion of the command the sequence ready [CR/LF] will be sent and the CHRocodile starts with a new telegram.
2. When the client does not receive the synchronization sequence at the expected place, synchronization is lost. In this (and only in this) case, it should wait for a new synchronization sequence. This will resynchronize the data flow in a few telegram cycles since the transmitted data words are usually changing and only the synchronization sequence is stable.

Command format

`$COMMAND <arg0> <arg1> ... <argn>[CR]`

Rules

Observe the following rules:

- Every command begins with “$” and is followed by at least three capital characters.
- The arguments have to be separated by a non-numeric character (preferably a whitespace, don’t use a comma as some parameters are in floating point format and the comma would be mistaken as decimal point).
- Most commands accept a question mark (“?”) as argument and then send back the current parameter setting as response.
- Commands which expect parameter values must be finished with a carriage return (#13) which is also echoed.
- Both in binary mode and in ASCII mode: All command argument and response values are in ASCII.

In the dollar protocol, every command must be preceded by a “$”-character and terminates with a carriage return (*CR*,\r, #13). At the reception of a “$”-character, the CHRocodile stops the sending of data telegrams at the next telegram boundary and the $ is echoed back. Between the “$”-character and the concluding *CR* all characters received by the device are immediately echoed back. Outside this command reception phase, no characters are echoed.
A command is composed of the leading 3 or 4 letter command name followed by a specific number of parameters. Commands may have optional parameters, which means that the last parameter(s) can be left away. Parameters must be separated by one (or more) space (#32) characters. Numerical parameters are given in human readable ASCII format, float values use a dot (.) as decimal separator.
Example: `$AAL 1 100.5`*`[CR]`*
When the device has completely received the command, the command is interpreted and a response is given. In the dollar protocol, the response always terminates with the string `ready\r\n`. After this termination, the sending of data telegrams is resumed.
Besides the concluding `ready\r\n`, most commands don’t have an additional dedicated response in the dollar protocol (there are exceptions, see the detailed command description). However, if the command is a query, there is a response that carries the queried information. Numerical values in responses are output in human readable ASCII format, float numbers use a dot (.) as decimal separator. If there is more than one response parameter, parameters are separated by a space (#32) character. The response always terminates with the string `ready\r\n`.

1.3 Binary packet protocol

Overview

This topic describes characteristics of the packet protocol and how communication between the CHRocodile device and the local network is carried out.

Interface

The packet protocol is available on the Ethernet interface. TCP port 7891 is used.

Byte order

The fields defined in the binary packet protocol are arranged in little endian order, i.e., the least significant byte is followed by more significant bytes.

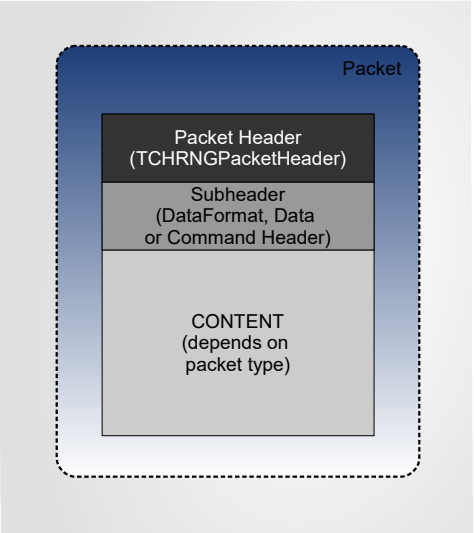
Packet types

The packet protocol currently has three different types of packets:

- Data packet
- Data format packet
- Command packet

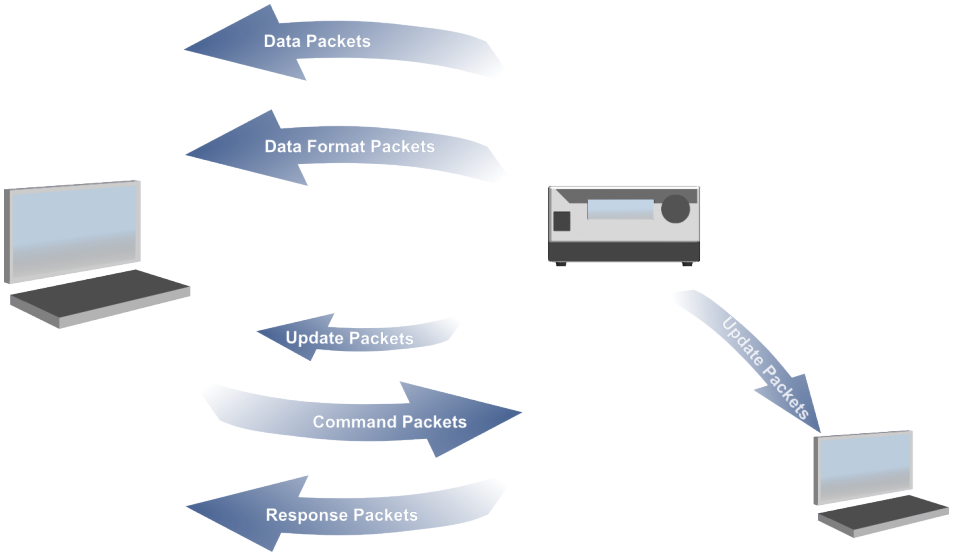
General structure

All data packets (command packets, data format packets and data packets) share the same general structure as shown in the following figure. C-like declarations of the related structures are given in the following sections.



Illustration

The following illustration describes how the different types of packets support communication between client and device:



Functions

The following table denotes the functions of the different types of packets:

Type	Function
Data packet	Contains signals (e.g., distance values, intensity, etc.)
Data format packet	Contains information about the structure of data packets, e.g., which data signals are included in which order, what type they have, how many bytes do they occupy, etc.
Command packet	Contains commands and associated arguments.
Response packet	Response of the device upon a command, can contain various flags (error, warning, etc.) indicating anomalies in the command processing. Structurally identical to command packets.
Update packet	Informs other clients about an internal state change of the device as result of a command. Structurally identical to command packets.

1.3.1 Packet header

Overview

All types of packets share a common main header at the beginning of the packet.

Packet header fields

The packet header contains:

- Magic Number (4 bytes): constant 0xAA55AA55, marks the beginning of the packet
- Packet Length (4 bytes, integer): length of a complete packet including its header, which is limited to 4096 bytes.
- Reserved (8 bytes): currently ignored, should be set to zero
- Packet Type (4 bytes): The type of the packet. There are currently 3 types:
  - `0x00444D43` (ASCII “CMD”) for command packet, including response and update packets.
  - `0x00544644` (ASCII “DFT”) for data format packet.
  - `0x00544144` (ASCII “DAT”) for data packet.

After the packet header, the packet data section follows. It contains the packet type specific subheader and the content.

Source code

In the following there is a listing of the structure and constants used in the packet header in the C language.

```
1
2     const u32 cMagicNumber = 0xAA55AA55;
3
4     enum class TCHRNGPacketType : u32 {
5         CommandTelegram     = 0x00444D43, //''CMD''
6         DataTelegram        = 0x00544144, //''DAT''
7         DataFormatTelegram  = 0x00544644, //''DFT''
8     };
9
10    struct TCHRNGPacketHeader {
11        u32 MagicNumber;
12        s32 PacketLength;
13        s32 Reserved1;
14        u32 Reserved2;
15        TCHRNGPacketType TelegramType;
16    };
```

1.3.2 Command packet definition

Overview

Command packets contain commands and associated arguments. They consist of the packet header and a command subheader, possibly followed by arguments. Commands are defined in terms of a 32 bit ID while parameters carry their type and their value. Supported types are (32 bit) integer, (single precision) float, string, char and blob (binary large object). The number of parameters that can be added to the command is merely limited by the maximum total size of a packet (currently 4096 bytes). Sending a command to the device from the client application basically means to send a command packet and wait for the echo / response to that packet. The command response packet has the same structure as the original command packet and usually contains all incoming arguments (possibly clipped or otherwise corrected) plus any additional parameters that might have been queried for.

Packet subheader

The command packet subheader includes:

- **Command** (4 bytes): three to four ASCII letters such as SODX
- **Destination filter ID** (4 bytes): will be reflected to client in the response packet.
- **Source filter ID** (4 bytes): will be reflected to client in the response packet.
- **Flags** (2 bytes). This field may contain a bitwise OR combination of any of the flags defined below:
  - `cCmdFlagQuery = 0x0001`
    This flag declares a parameter query. The sensor will respond with a command packet containing the current parameter value.
  - `cCmdFlagError = 0x8000`
    This flag is returned by the sensor in the command response in case of an error, i.e., if for any reason the command has not been executed. Additional information may be added as arguments.
  - `cCmdFlagWarning = 0x4000`
    Returned in the response packet in case the command has been executed, however, with possibly modified parametrization or other implications that the user has not expected. Additional information may be added as arguments.
  - `cCmdFlagUpdate = 0x2000`
    The device may send *“updates”*, i.e., command responses to the connected client whenever the current configuration / parametrization changes, e.g., due to some user action at the front panel or through another connection. The client will receive such packets *without* prior command packets. In such cases, the update flag will be set.
- **Reserved** (2 bytes)
- **Ticket** (2 bytes): The client attributes an arbitrary ticket number to a command packet. The response packet for the contained command will have the same ticket number. Thereby a command response packet can be unambiguously related to its originating command packet.
- **Arguments count** (2 bytes, integer): number of command arguments added behind this subheader

Arguments section

The command packet subheader is followed by the arguments section. Every argument starts with a type specifier defined as:

Type specifier	Type of command argument
0	integer (32 bit)
1	float (single precision)
2	string
3	char
4	blob (chunk of untyped, binary data)

The type specifier is followed by data formatted in a type-specific way.

For int, float and char parameters, the data directly follows the type specifier:

```
<Type Specifier(4 bytes)><Value(4 bytes)>
```

String and blob parameters do not have fixed length. Therefore, the length of the data is given in the first four bytes after the type specifier:

```
<Type Specifier><Str/Blob Length(4 bytes)><String/Blob Value(ASCII)>
```

For alignment reasons, the string or blob parameters must contain multiples of 4 bytes. If a string has a length of, say, nine, then three zeros must be added to the end to fill twelve bytes which are divisible by four. The real string/blob length is, as said, stored in the length field.

Multiple arguments may be concatenated to form the argument part of the command packet.

Response packet

Once the command packet has been received and processed completely, the device will respond with a command response packet. This response packet has the same format as the command packet and acts as a receipt for the command. Please note that:

- The response packet may not only contain the arguments set by the client, but also other parameters that reflect the state of the device.
- The ticket of the response packet is the same as the ticket of the command packet.

Update packet

Beside responding to the client that sent a command, the resulting internal change(s) will be communicated to all other connected clients using update packets. The only differences between those and the response packet are their update flags and their ticket number. While the response packet contains the original ticket number assigned by the issuing client and an unset update flag, the update packets will have their ticket number set to zero and their update flags set.

Source code

The types and constants involved in command packets are listed below:

```
1
2       struct TCHRCmdHeader {
3           TCHRCmd ID; // Three to four ASCII letters such as "SODX"
4           u32 DestFilterID;
5           u32 SourceFilterID;
6           u32 Flags: 16;
7           u32 Reserved: 16; //ignored, should be set to 0
8           u32 Ticket: 16; // arbitrary number, repeated in the response
9           u32 ArgsCount: 16; // The number of following arguments
10      };
11
12      struct TIntParam { // An integer argument
```

```
13          TParamType ParamType;
14          s32 Value;
15      };
16
17      struct TFloatParam { // A floating point argument
18          TParamType ParamType;
19          float Value;
20      };
21
22      struct TStringParam { // A string argument
23          TParamType ParamType;
24          u32 Length;
25          char[n] string_chars; // length n as given in length field
26          char[m] zeros; // additional zeros to fill multiple of four bytes
27      };
28
29      // A blob argument has the same structure as a string argument.
30      // A char argument is formatted like an integer argument.
```

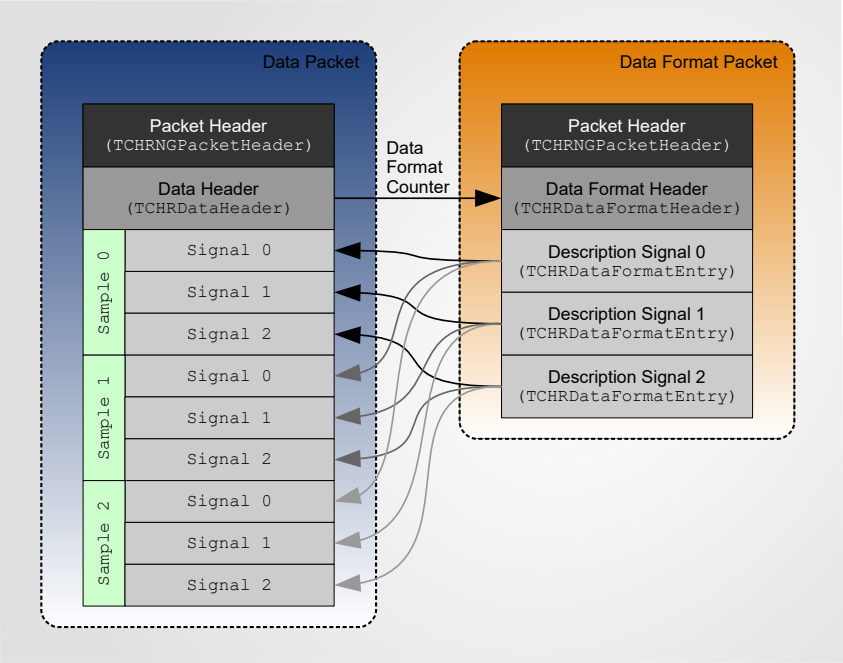
1.3.3 Data format packet definition

Overview

Data format packets contain information about the structure of data packets, e.g., which data signals are sent from the device to the client. For details about data packets please refer to next section. The signals definition contained in a data format packet is valid for all the following data packets until a new data format packet arrives.

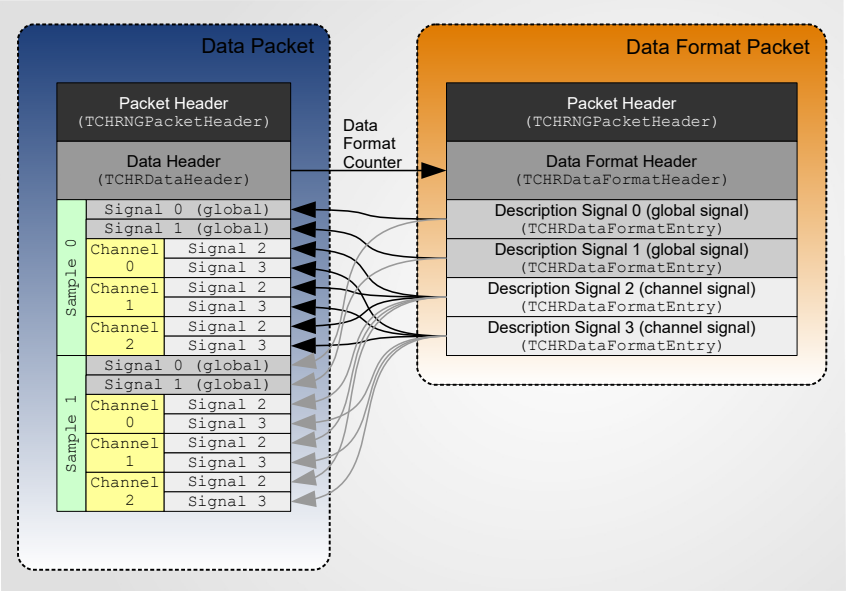
Single channel device

The relationship between a data format packet and a data packet is described in the following figure. As illustrated, a data packet contains one or more *samples*, each being a group of *signal values*:



Multi-channel device

The relationship between a data format packet and a data packet in a multi-channel device. Note that global signals are placed at the beginning, channel signals are placed behind:



Sample and signal

A sample is a collection of signal values simultaneously measured during one detector exposure.

A signal can be, e.g., the distance to the surface measured, some encoder value as latched during exposure, a time stamp or a peak intensity – whatever has been requested by the user by means of an SODX command. A complete list of available signals is given in Chapter 3.

We distinguish between global, channel signals (or measuring point related signals) and peak related signals. Global signals, like encoder positions or exposure time stamps are common for the whole sample, whereas the channel signals are individual for each channel of a multi-channel device. However, the set of transmitted channel signals is the same for all channels. The peak related signals represent different aspects of a measured peak, e.g., its value, its position in the spectrum, its median, etc.

Data packets contain this data with only a minimum of declarative overhead. Instead, all information is given in the data format packets which have to be sent only once by the sensor whenever the signal arrangement has been changed via the SODX command.

Packet subheader

The data format subheader consists of the following information:

- The data stream ID (4 bytes, integer), always set to one
- The data format counter (4 bytes, integer), which is incremented on any new data format packet. Each data packet contains the same data format counter value as the data format packet that describes it.
- The sample rate of the stream (samples per second, 4 bytes, float)
- The data signals count (4 bytes, integer), which declares how many *different* signals are included in a sample. One sample consists of one set of global signals (transmitted first) and then n (= number of channels) sets of channel signals. One data packet can contain multiple samples.

  In the example of the figure in Section 1.3.3 for multi-channel devices, the signals count is 4: 2 global signals and 2 channel signals. On the left of the data format packet we see a data packet that is built according to this data

format packet. It contains 2 samples. Each sample has 3 channels with 2 signals each. The signal sets of all channels are the same (here signal 2 and signal 3).

Signal description

The section after the data format subheader contains descriptions of every signal present in the data packets:

- The data type (1 byte), e.g., “integer” or “single precision float”
- Reserved (1 byte) – ignore this field
- The number of channels (2 bytes, integer) (“points”) in case of a multi-channel device, 1 otherwise
- The number of the first channel to be transferred (2 bytes, integer). Is zero unless otherwise configured.
- The signal ID (2 bytes, integer)

Requesting data

When the client is connected to the device, by default the device will not send any data to the client. The client has to first order data by sending an SODX command to the device. Such an SODX command contains a list of IDs of those signals requested by the client. Provided the requested signals are valid and available, the SODX command will be responded by an SODX response packet – followed by a data format packet based on the SODX command packet sent by the client. Note, however, that the binary packet protocol does not guarantee the order of signals to be the same as given in the SODX command. This guarantee is only given in the dollar protocol.

Signal sorting

In a data format packet and its corresponding data packet, all *global* signals (i.e., signals which appear only once per exposure for both single channel and multi-channel devices, such as exposure start time, exposure period and encoder values) are always placed at the beginning. The so-called “peak signals” (signals that are related to specific measurement peaks, e.g., “Distance 1 / 2 / 3” or “Intensity 1 / 2 / 3”) are placed behind the sample global signals. See the next section for the details of the arrangement of the data blocks.

Source code

```
struct TCHRDataFormatHeader {
    u32 DataStreamID;
    s32 DataFormatCounter;
    float SampleRate;
    s32 SignalsCount;
};
```

For each signal, one entry of type `TCHRDataFormatEntry` is added to the data format packet.

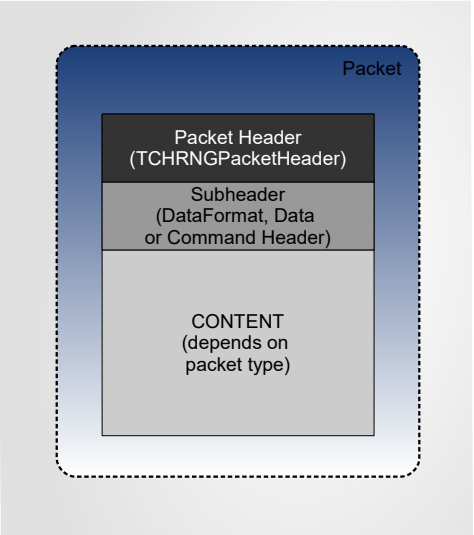
```
typedef enum {
    sitU8 = 0, //byte
    sitS8,     //signed char
    sitU16,    //unsigned 16bit
    sitS16,    //signed 16bit
    sitU32,    //unsigned 32bit
    sitS32,    //signed 32bit
    sitFloat   //single precision float
} TSignalType;

// Attention: the following definition uses bitfields
// in order to create a packed record
struct TCHRDataFormatEntry {
    TSignalType DataType: 8;
    u32 Reserve: 8;
    u32 PointCount: 16;
    u32 FirstPoint: 16;
    u32 SignalID: 16;
};
```

1.3.4 Data packet definition

Overview

As shown in the following figure, data packets consist of the general packet header, a data packet subheader, and the content (i.e., the data):



Packet subheader

The data packet subheader defines:

- Data stream ID (4 bytes, integer), always 0x1
- Data format counter (4 bytes, integer), so that the corresponding data format packet can be associated.
- Time stamp (8 bytes), the time stamp of the first sample inside the packet. It has the 32.32 bit fixed point format, where the most significant 32 bits represent the full seconds and the least significant 32 bits contain the fraction of one second. For example:

Time [s]	Representation in 32.32 fixed point format
1	0x0000 0001 0000 0000
1.5	0x0000 0001 8000 0000
2	0x0000 0002 0000 0000
2.00025	0x0000 0002 0010 624D

  Given a constant data rate, any other sample's time stamp can be calculated from this time stamp, the stream sample rate, and the index of the data sample inside the packet.
- Data row count (4 bytes, integer), the number of samples in this packet

Packet payload

The data packet subheader is followed by the actual data. In the data section, multiple samples may be placed, where each sample consists of (number of global signals + number of channels * number of channel signals) values. In the example of the figure in Section 1.3.3 for multi-channel devices, 8 values are transmitted per sample. Samples are transferred one after another. There is no padding (alignment filling with zeros) between the samples. However, in order to keep the total packet length a multiple of four, padding can occur at the end of a data packet.

Signal sorting

As mentioned earlier, data is ordered such that global signals (time stamps, encoder values etc.) are located at the beginning, followed by the channel signals.

For example, if signals 256 and 257 (which is Distance 1 and Intensity 1 in confocal mode) are requested for a *single channel device* (e.g., CHRocodile 2 S), then the data block will appear as:

```
<Signal Value 256><Signal Value 257>
```

If multiple samples are included in one single data packet, the data block may look like:

```
<Signal Value 256 - sample 1><Signal Value 257 - sample 1>
<Signal Value 256 - sample 2><Signal Value 257 - sample 2>
<Signal Value 256 - sample 3><Signal Value 257 - sample 3>
...
```

In case of a *multi-channel device* (e.g., CHRocodile CLS or MPS), if signals 256 and 257 are requested, the data block will appear as:

```
<Signal Value 256 of Channel 1><Signal Value 257 of Channel 1>
<Signal Value 256 of Channel 2><Signal Value 257 of Channel 2>
...
<Signal Value 256 of Channel 191><Signal Value 257 of Channel 191>
<Signal Value 256 of Channel 192><Signal Value 257 of Channel 192>
```

Note the pattern of the data values: values of signal 256 and 257 are given consecutively for each channel. In this example, only one sample is contained in the data packet.

Source code

Below is the data packet header declaration.

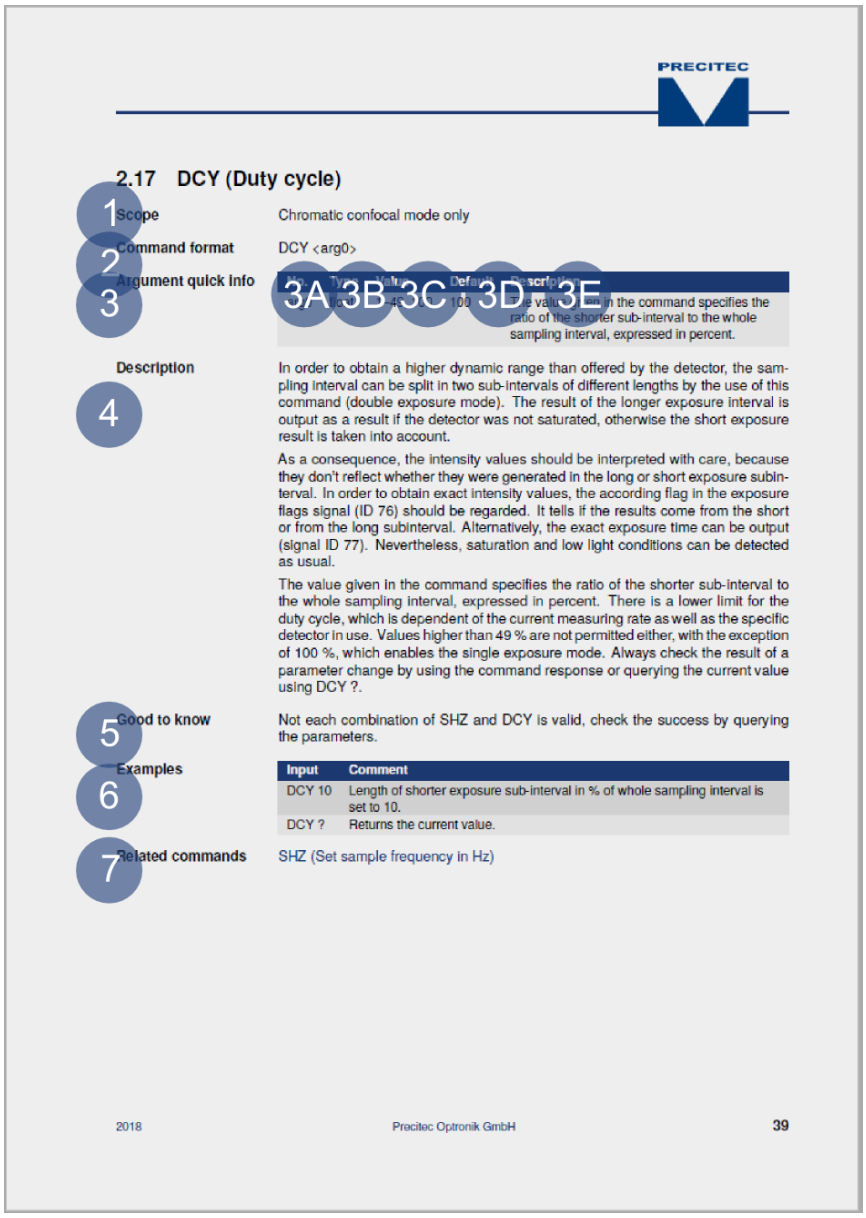
```
1
2     struct TCHRDataHeader {
3         u32 DataStreamID;       //always zero
4         s32 DataFormatCounter; //refers to respective data format packet
5         u64 TimeStamp;          //Exposure start time of first exposure
6         s32 DataRowCount;       //Number of samples contained in this packet
7     };
```

Chapter 2

CHRocodile Commands

How to read the Command Reference

Illustration The following figure indicates the different blocks in the Command Reference:



Description

The following table describes each block in detail:

No.	Criterion	Explanation
1	Scope	Scope of command, e.g., limitation to certain modes or communication protocols
2	Command format	Short form of command with associated arguments. Arguments are listed in angle brackets. Optional arguments are additionally enclosed in square brackets.
3	Argument quick info	Info table on command with the following information (3A–3E):
3A	No.	Argument index
3B	Type	Specifies data type of the corresponding argument: int: abbreviation for integer float: abbreviation for floating point number str: abbreviation for string blob: binary large object
3C	Value	Accepted values of the corresponding argument. Two numerical values separated by "–" denote a range, values separated by commas define a fixed set of possibilities for a value. A type name followed by "[]" denotes an array of that type.
3D	Default	Default value. This value will be set when using the SFD command. Note: The default values do not necessarily correspond to the as-delivered settings.
3E	Description	Description of argument
4	Description	Detailed description of command
5	Good to know	Tips and hints when dealing with the command
6	Examples	Examples of good practice to explain the functionality of command
7	Related commands	Links to related commands

Value range and type

The following table describes notations of valid parameter values:

Notation	Explanation
a–b	Values between a and b are valid.
a, b, d	Only parameter values of a, b and d are valid.
full range	No limitation of parameter values
u8, u16, u32	Unsigned integers that are 8, 16 or 32 bits wide
s8, s16, s32	Signed integers that are 8, 16 or 32 bits wide
float	Floating point numbers according to IEEE 754 (single precision)
s16[]	Array of signed 16 bit integers

2.1 AAL (Auto adapt light source)

Command format

AAL <arg0> [<arg1>]

Argument quick info

No.	Type	Value	Default	Description
arg0	int	0, 1	0	Enables / disables auto adapt mode
arg1	float	Packet protocol: 0–100	33	Packet protocol: Only needed if <arg0> = 1: desired detector level in % saturation level (0–100), 33 is recommended
arg1	int	Dollar protocol: 0–255	84	Dollar protocol: Only needed if <arg0> = 1: desired detector level in % of saturation level (0–255), 84 is recommended

Description

An algorithm tries to keep the level of the detector signal at the given level by constantly adapting the exposure time. The setpoint value is entered as fraction of the saturation level of the detector by the second parameter. If the second parameter is not specified, the device keeps its current setting.
There is a historic difference in the range scaling of the second parameter between the dollar protocol and the packet protocol: On the packet protocol, the setpoint value is given as a percentage of the saturation level in float format (0–100 %). On the dollar protocol, the setpoint value is given as an integer in the range from 0–255.

Good to know

- The auto adapt mode is disabled by the LAI command.

Examples

Input	Comment
AAL 1 50	Activates auto adapt light source, set target saturation level to 50 %.
AAL 0	Deactivates auto adapt light source.
AAL ?	Returns the current value(s).

Related commands

LAI (Lamp intensity)

2.2 ABE (Abbe number)

Command format

ABE <arg0> ...

Argument quick info

No.	Type	Value	Default	Description
arg0	float	0–500	0	Abbe number of layer 1
arg1	float	0–500	0	Abbe number of layer 2
...	...	...	0	As many as number of layers (NOP -1)

Description

Sets Abbe number to achieve a correct thickness measure by modeling the dependency of the refractive index on the wavelength (dispersion). A low Abbe number means a strong dispersion, a high number means little dispersion. A value of 0 codes zero dispersion (constant refractive index for all wavelengths).

The Abbe number on a certain layer only takes effect, if SRT..0.. is selected (no preloaded index table) for the corresponding layer. You should give as many Abbe numbers as there are layers to be measured, which is (number of peaks - 1).

The reply of the query includes Abbe numbers of all layers even though not all are used according to the setting of NOP.

Good to know

ABE 0 on a certain layer disables dispersion correction for that layer.

Examples

Input	Comment
ABE 0 155 32.5	Sets the Abbe numbers for three layers.
ABE ?	Returns the current value(s).

Related commands

NOP (Number of peaks)
SRI (Set refractive indices)
SRT (Set refractive index table)

2.3 ALI (Aiming laser intensity)

Command format

ALI <arg0>

Argument quick info

No.	Type	Value	Default	Description
arg0	int	0–255	255	255: Maximum intensity of the aiming laser 0: Turns off the aiming laser completely.

Description

Sets the intensity of the pilot/aiming laser.

Good to know

This command is only relevant for devices with a pilot/aiming laser installed.

Examples

Input	Comment
ALI ?	Queries for current aiming laser intensity.
ALI 100	Sets the aiming laser to 100.

2.4 ANAM (Analog output mode)

Command format ANAM <arg0>

Argument quick info

No.	Type	Value	Default	Description
arg0	int	0, 1	0	0: Voltage output (-10–10 V) with internal reference 1: Voltage output with LVDT mode

Description The analog outputs support voltage output with an internal reference or LVDT mode. The same type will be used on both outputs. It is selected with the ANAM command.

Related commands ANAX (Analog output function, extended)

2.5 ANAX (Analog output function, extended)

Command format

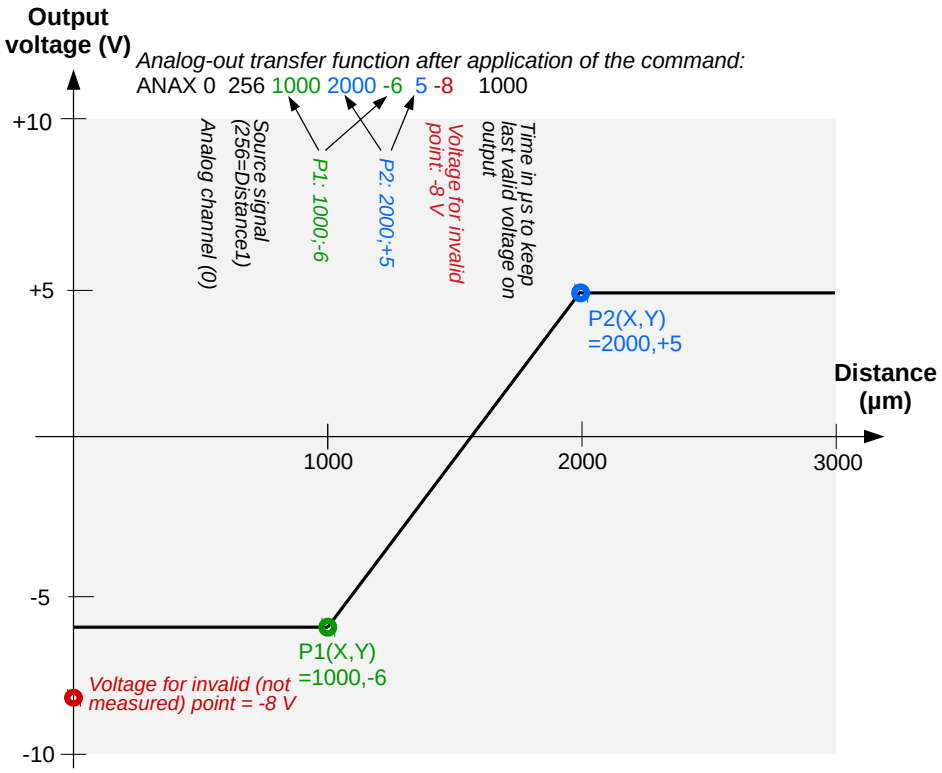
ANAX <arg0> to <arg7>

Argument quick info

No.	Type	Value	Default	Description
arg0	int	0, 1	-	Analog output to parameterize
arg1	int	u16	256, 257	Index of result value to be put on analog out (default depends on <arg0>)
arg2	float	-	0	Value that should result in output voltage/current given by <arg4>
arg3	float	-	1000	Value that should result in output voltage/current given by <arg5>
arg4	float	-10–10	0	Voltage attributed to value given by <arg2>
arg5	float	-10–10	10	Voltage attributed to value given by <arg3>
arg6	float	-10–10	-1	Invalid output value. Put to output after the hold time (see <arg7>) when no new valid value arrives in the meantime.
arg7	int	u32	0	Hold time of last valid result in µs, 0 means holding for one measurement interval. When no new valid value arrives during the hold time, the invalid value (<arg6>) is output.

Description

The analog output translates an interval given by <arg2>, <arg3> of an output signal defined by <arg1> linearly into a voltage or current range defined by <arg4>, <arg5>. Outside the interval the output voltage/current stays constant at the nearer limit value (<arg4> or <arg5>). When no new valid result is measured, the output changes after a hold time (<arg7>) to the invalid output voltage/current given by <arg6> (see also the following illustration).



Examples

Input	Comment
ANAX 0 256 0 1000 0 10 -1 1000	Distances 0 to 1000 µm are transmitted as 0 to 10 V on output 0. If during 1000 µs no valid result is measured, the last valid voltage is replaced by -1 V.
ANAX 0 ?	Queries settings of first analog out channel.
ANAX 1 ?	Queries settings of second analog out channel.
ANAX ?	Yields a complete list of all settings for both channels.

Related commands

ANAM (Analog output mode)

2.6 ASC (ASCII mode)

Scope	Dollar protocol only
Command format	ASC
Argument quick info	No arguments supported
Description	Sets the dollar protocol output in ASCII format.
Related commands	BIN (Binary mode)

2.7 AVD (Data averaging)

Command format

AVD <arg0>

Argument quick info

No.	Type	Value	Default	Description
arg0	int	0–10000	1	Data average depth

Description

This command relates to averaging of distance / intensity data. It averages the results of n samples before outputting. Averaging is not implemented as moving average, so it slows down the output rate by a factor of n. Invalid samples (due to low signal intensity, or low quality) are not taken into account for averaging and thus do not disturb the result. In the case of invalid samples, these are skipped, but the averaging interval is not extended! So, the output rate is not affected by invalid samples.

In Trigger each mode, one trigger event will start a sequence of AVD*AVS exposures. The AVD*AVS exposures are executed with the current sample rate (SHZ). One averaged result will be output after the exposure sequence. There will be only one trigger event on the Sync-out signal per n samples to be averaged. The pulse marks the beginning of the first exposure of the averaging interval. In the other trigger modes, there is one Sync-out pulse for every exposure, regardless of averaging.

Good to know

In double exposure mode (DCY other than 100 %), the intensity result value doesn't contain useful information when averaging is active, as intensities from short and from long exposures might be averaged.

Be careful when using the data averaging in the interferometric mode: The detected thicknesses in the interferometric mode may be ordered according to their signal quality (POD 0). These qualities tend to vary locally quite heavily. Hence, the thicknesses of different layers in a multilayer system could be erroneously mixed together by averaging!

AVD 0 activates the window averaging mode. In this mode, samples are averaged during the high period of the trigger signal, which means one high period of the trigger signal results in one output data sample. If encoder trigger is disabled (ETR 3 0), this signal is combined using the logical AND operator from the Sync-in hardware signal and the level of software trigger signal defined by command STR. Otherwise it reflects the encoder trigger signal.

Examples

Input	Comment
AVD 5	Average over 5 data samples
AVD 1	No data averaging is active.
AVD ?	Returns the current value(s).

Related commands

AVDS (Serial port averaging)
AVS (Spectra averaging)

2.8 AVDS (Serial port averaging)

Command format

AVDS <arg0>

Argument quick info

No.	Type	Value	Default	Description
arg0	int	u16	1	Indicates how many samples are averaged.

Description

The peak related values output on the serial port can be averaged in addition to the AVD averaging. If AVDS is set to 3, one sample is output on the serial port every 3 samples that are output on the TCP port.

Examples

Input	Comment
AVDS 5	Sets the serial port averaging factor to 5.

2.9 AVS (Spectra averaging)

Command format

AVS <arg0>

Argument quick info

No.	Type	Value	Default	Description
arg0	int	1–256	1	Spectra average depth

Description

During the signal processing, the spectra obtained from the spectrometer can be averaged in order to reduce the noise. This allows extending the dynamic range of the optical sensor as the noise is reduced by a factor of $\sqrt{\frac{1}{n}}$ while the saturation limit stays the same. To make use of the extended dynamic, the detection threshold (THR) should be lowered correspondingly.

In case of rapidly changing distances, the peak in the spectrum will be broadened by the spectra averaging and thus the calculation of the result might become less reliable.

In Trigger each mode, one trigger event will start a sequence of AVD*AVS exposures. The AVD*AVS exposures are executed with the current sample rate (SHZ). One averaged result will be output after the exposure sequence. There will be only one trigger event on the Sync-out signal per n samples to be averaged. The pulse marks the beginning of the first exposure of the averaging interval. In the other trigger modes, there is one Sync-out pulse for every exposure, regardless of averaging.

Good to know

In double exposure mode (DCY other than 100 %), spectra averaging is not possible!

In chromatic confocal mode, this step is done directly after the dark reference. In interferometric mode, it is done directly after the FFT.

Examples

Input	Comment
AVS 5	Average over 5 spectra
AVS 1	No spectra averaging is active.
AVS ?	Command returns the current value.

Related commands

AVD (Data averaging)

2.10 BCAF (Binary command argument format)

Command format BCAF <arg0>

Argument quick info

No.	Type	Value	Default	Description
arg0	int	0, 1	0	0: binary (default) 1: 2 HEX chars per byte

Description Format of data contained in commands or command responses. Examples:

- Spectrum download (DNLD)
- Firmware upload (ULFW)

2.11 BDR (Baud rate and hardware handshaking)

Command format

BDR <arg0> <arg1>

Argument quick info

No.	Type	Value	Default	Description
arg0	int	0–8, n	4	If <arg> ≤ 8: interpreted as a baud rate index, otherwise as a free custom baud rate.
arg1	int	0, 1	0	Hardware RTS/CTS handshake on/off

Response quick info

No.	Type	Value	Default	Description
arg0	int	-	-	Baud rate
arg1	int	-	-	Effective baud rate
arg2	int	-	-	Hardware handshake on/off

Description

As described in the section “Argument quick info” above, you can input a baud rate index or a free baud rate. Consider the following table when using index input:

Index	Baud rate [bit/s]
0	9600
1	19200
2	38400
3	57600
4	115200
5	230400
6	460800
7	921600
8	1843200

The baud rate of the serial port can be adjusted to values between 9600 and 1843200 (115200 is the default and recommended value). When entering a free custom baud rate, even higher baud rates are accepted.

The effective baud rate, which might be slightly different from the intended baud rate due to frequency dividing limitations, will be replied as second argument <arg1> for information.

The second argument <arg1> according to the command format definition enables or disables RTS/CTS hardware handshaking.

Good to know

The baud rate takes effect immediately after the command is sent and therefore a serial port sending the command cannot receive the response if the command changes the baud rate.

Examples

Input	Comment
BDR 4	Selects the baud rate by index.
BDR 115200 1	Enters baud rate directly and switches hardware handshaking on.
BDR ?	Returns the current value(s).

2.12 BIN (Binary mode)

Scope	Dollar protocol only
Command format	BIN
Argument quick info	No arguments supported
Description	Sets the dollar protocol data output to binary format.
Related commands	ASC (ASCII mode)

2.13 CONF (Send configuration)

Scope

The command is not supported in the dollar protocol as this protocol does not implement update packets.

Command format

CONF

Argument quick info

No arguments supported

Description

This command serves to publish all current parameter settings at once to a client. Though it has no direct reply arguments, it triggers the device to send out update packets of all parameter settings. As last update packet, a CONF update packet is sent in order to signal the termination of the parameter cycle to the client. The command affects only the client that has sent it, all other clients don't notice it.

Good to know

An equal update packet burst is sent unsolicited at the establishment of a new connection. It is recommended to wait until the CONF update is received before sending commands to the device.

2.14 CRA (Set active detector range)

Scope

Interferometric mode only

Command format

CRA <arg0> <arg1>

Argument quick info

No.	Type	Value	Default	Description
arg0	int	0–2048	0	Start pixel of the active detector range
arg1	int	0–2048	Detector specific	Stop pixel of the active detector range

Description

Sets start and stop pixel of the active detector range.

Good to know

The actual permitted range depends on the detector built into the respective device. Remember to confirm the result by monitoring the command response.

Examples

Input	Comment
CRA 40 600	Sets the detector range to start at pixel 40 and stop at pixel 600.

2.15 CRDK (Continuous refresh dark factor)

Command format

CRDK <arg0>

Argument quick info

No.	Type	Value	Default	Description
arg0	int	u16	0	Refresh factor

Description

This command configures the continuous refresh dark reference mode. The refresh factor 0 turns continuous refresh off. A refresh factor of 65535 configures that the dark reference data is always replaced completely by the spectrum of the preceding exposure. Typical values are quite low (1–10), which means that the dark reference is adapted quite slowly.

The continuous refresh dark reference mode is useful if either the raw spectrum changes quickly and permanently, as in interferometric mode when measuring high thicknesses, or if objects cross the measurement range only rarely and quickly.

Taking a dark reference by an FDK or DRK command ends the CRDK mode (equals CRDK 0).

Good to know

When CRDK is turned off (refresh factor = 0), a new DRK command needs to be executed.

Examples

Input	Comment
CRDK 8192	Sets the refresh factor to 8192. 8192 divided by 65536 gives 0.125. This means that the dark reference for each pixel is calculated as: 0.125*(current spectrum) + 0.875*(previous dark reference)
CRDK ?	Returns the current value.

Related commands

DRK (Dark reference)
FDK (Fast dark reference)

2.16 CTN (Continue in free run mode)

Command format	CTN
Argument quick info	No argument supported
Description	Recover from TRE/TRG/TRW command to go into free run mode. In this mode, new measurements are started periodically based on the sampling rate.
Related commands	TRE (Trigger each) TRG (Trigger once) TRW (Trigger window)

2.17 DCY (Duty cycle)

Scope

Chromatic confocal mode only

Command format

DCY <arg0>

Argument quick info

No.	Type	Value	Default	Description
arg0	float	1–49, 100	100	The value given in the command specifies the ratio of the shorter sub-interval to the whole sampling interval, expressed in percent.

Description

In order to obtain a higher dynamic range than offered by the detector, the sampling interval can be split in two sub-intervals of different lengths by the use of this command (double exposure mode). The result of the longer exposure interval is output as a result if the detector was not saturated, otherwise the short exposure result is taken into account.

As a consequence, the intensity values should be interpreted with care, because they don't reflect whether they were generated in the long or short exposure subinterval. In order to obtain exact intensity values, the according flag in the exposure flags signal (ID 76) should be regarded. It tells if the results come from the short or from the long subinterval. Alternatively, the exact exposure time can be output (signal ID 77). Nevertheless, saturation and low light conditions can be detected as usual.

The value given in the command specifies the ratio of the shorter sub-interval to the whole sampling interval, expressed in percent. There is a lower limit for the duty cycle, which is dependent of the current measuring rate as well as the specific detector in use. Values higher than 49 % are not permitted either, with the exception of 100 %, which enables the single exposure mode. Always check the result of a parameter change by using the command response or querying the current value using DCY ?.

Good to know

Not each combination of SHZ and DCY is valid, check the success by querying the parameters.

Examples

Input	Comment
DCY 10	Length of shorter exposure sub-interval in % of whole sampling interval is set to 10.
DCY ?	Returns the current value.

Related commands

SHZ (Set sample frequency in Hz)

2.18 DNLD (Download spectrum)

Scope

Packet protocol only

Command format

DNLD <arg0>

Argument quick info

No.	Type	Value	Default	Description
arg0	int	0–2	-	Spectrum ID

Response quick info

No.	Type	Value	Default	Description
arg0	int	0–2	-	Spectrum ID
arg1	int	u16	-	Exposure number
arg2	float	full range	-	Micrometers per bin
arg3	int	s32	-	Block exponent of spectrum data
arg4	blob	s16[]	-	Spectrum data, one s16 per pixel

In chromatic confocal measurement mode, <arg2> and <arg3> can be ignored.

Description

Clients use this command to request a spectrum from the device. Using <arg0>, you can specify the spectrum type as follows:

Spectrum ID	Spectrum type
0	Raw spectrum (unprocessed signal)
1	Spectrum (chromatic confocal mode)
2	FFT spectrum (interferometric mode)

Since acquiring the requested spectrum can take up several sample periods, a DNLD request from the client causes the device to first respond with a DNLD response that does not contain any spectrum data. It just acknowledges the request. Response arguments are always identical to the command's ones.

Later, when the spectrum is available, the device sends one or more update packets containing the spectrum data. Their arguments are specified in the block Response quick info.

Data packets may arrive in the meantime, i.e., between the response and the updates.

2.19 DRK (Dark reference)

Command format DRK

Argument quick info No argument supported

Description Takes a dark reference and stores the result in the non-volatile flash memory. The operation takes about 3 seconds.

The command response returns the result of the last DRK operation. This result indicates the amount of stray light that was registered. It represents in fact a virtual measuring rate in Hz at which the detector would just be saturated by the stray light.

Good to know

- The action takes place immediately after the command.
- While executing this command, the optical probe must not point to any object in the measuring range.
- If this value is very high (>100 Hz), try to get it lower by cleaning the fiber end faces (see the device´s User Manual for details).

Examples

Input	Comment
DRK	Takes the dark reference and returns the (virtual) measuring rate in Hz.

Related commands CRDK (Continuous refresh dark factor)
FDK (Fast dark reference)

2.20 DTF (Data format query)

Scope

Dollar protocol only

Command format

DTF

Response quick info

No.	Type	Value	Default	Description
arg0	int	-	-	Total length in bytes of a data telegram
arg1	int	-	-	1st signal ID
arg2	int	2–6	-	1st signal type
arg3	int	1–4	-	1st signal offset in bytes
...	...	...	...	Repeats the last 3 arguments for each of the signals.

Description

Query only. Mainly for dollar protocol connections, used to make binary telegram processing easier. In the dollar protocol there is no data format packet, so it can be explicitly queried by this command. Returns total length in bytes of a data telegram, ID, type and byte offset for every signal included in a telegram.

Type number	Type description
2	unsigned 16 bits integer
3	signed 16 bits integer
4	unsigned 32 bits integer
5	signed 32 bits integer
6	float

Examples

Input	Comment
DTF	Returns values in bytes for every signal included in the telegram.

2.21 DWD (Detection windows definition)

Command format

DWD <arg0> <arg1> ...

Argument quick info

No.	Type	Value	Default	Description
arg0	float	0–range (current probe)	0	Left edge of window 1 in micrometers
arg1	float	0–range (current probe)	0	Right edge of window 1 in micrometers
arg2	float	0–range (current probe)	0	Left edge of window 2 in micrometers
arg3	float	0–range (current probe)	0	Right edge of window 2 in micrometers
...	...	...	-	Max. 14 additional windows (16 max. in total)

Description

Using this command, up to 16 detection windows can be defined. If LMA is active (1), only the peaks inside the windows will be taken into consideration when calculating peaks and thicknesses.

Good to know

- The left and right edges must be given as pairs.
- The arguments in the response might differ somewhat from the parameters given in the command. The cause of this deviation is that the edges are internally aligned to the detector pixels.
- The value of the right edge of each window must be larger than its left edge.
- DWD without parameters disables windowing so that the whole range is active.

Examples

Input	Comment
DWD 0 190.3 200.5 612.4 745 822	Defines 3 detection windows.
DWD ?	Returns the effective windows currently active.

2.22 ENC (Encoder functions)

Command format

ENC <arg0> to <arg2>

Argument quick info

No.	Type	Value	Default	Description
arg0	int	0–4	-	Axis index
arg1	int	0–4	-	Encoder subfunction index
arg2	int	s32	-	Encoder subfunction argument

Response quick info

No.	Type	Value	Default	Description
arg0	int	-	-	Axis index
arg1	int	-	-	Encoder subfunction index
arg2	int	-	-	Encoder subfunction argument response value

Description

This command defines all aspects of encoder counting. More information on the subfunctions will follow on the next pages.

Examples

Input	Comment
ENC n 0 ...	See ENC 0 (Set encoder counter value) for axis n.
ENC n 1 ...	See ENC 1 (Set encoder counter source) for axis n.
ENC n 2 ...	See ENC 2 (Set encoder preload value) for axis n.
ENC n 3 ...	See ENC 3 (Set encoder preload event) for axis n.
ENC n 4 ...	See ENC 4 (Set cut-off frequency for low-pass filter) for axis n or Sync-in.

Related commands

ETR (Encoder trigger control)

2.22.1 ENC 0 (Set encoder counter value)

Command format

ENC <arg0> 0 <arg2>

Argument quick info

No.	Type	Value	Default	Description
arg0	int	0–4	-	Axis index
arg1	int	0	-	Encoder subfunction index
arg2	int	s32	-	Counter value to be set

Description

Sets the encoder counter value immediately. The third argument <arg2> gives the value to be taken by the encoder counter.

Good to know

It is possible to shorten this command by skipping the second argument <arg1>. However, the command response will always contain three arguments.

Examples

Input	Comment
ENC 1 0 123	Sets the current Y axis counter value to 123.
ENC 1 123	Sets the current Y axis counter value to 123, short-hand version.
ENC 2 0 ?	Queries the current Z axis counter value.
ENC 2 ?	Queries the current Z axis counter value, short-hand version.

Related commands

ENC (Encoder functions)
ETR (Encoder trigger control)

2.22.2 ENC 1 (Set encoder counter source)

Command format

ENC <arg0> 1 <arg2>

Argument quick info

No.	Type	Value	Default	Description
arg0	int	0–4	-	Axis index
arg1	int	1	-	Encoder subfunction index
arg2	int	15, 0–10	15	Source index

Description

This command sets the input source for the encoder counter given by the axis index <arg0>.

The meaning of the third argument <arg2> is as follows:

Index	Input pin(s)	Count mode
0	A0	Pulse
1	B0	Pulse
2	A1	Pulse
3	B1	Pulse
4	A2	Pulse
5	B2	Pulse
6	A3	Pulse
7	B3	Pulse
8	A4	Pulse
9	B4	Pulse
10	Sync-in	Pulse
11–14	open	No counting
15	A<arg0> and B<arg0>	Quadrature

Quadrature count mode (15):

Quadrature input of the axis defined by the axis index argument (A/B encoder count). This is the standard case of operation and permits forward and backward position counting.

Pulse count mode:

Alternatively, single inputs A0, B0, A1 . . . can be used for pulse counting (see pulse count mode description in the CHRocodile User Manual). In that case, the counter only counts up.

For furter discussion and examples, please see also Chapter 4 Encoder Interface.

Examples

Input	Comment
ENC 0 1 10	Connects counter 0 to Sync-in for pulse counting.
ENC 2 1 15	Connects counter 2 to quadrature encoder input A2/B2.

Related commands

ENC (Encoder functions)
ETR (Encoder trigger control)

2.22.3 ENC 2 (Set encoder preload value)

Command format

ENC <arg0> 2 <arg2>

Argument quick info

No.	Type	Value	Default	Description
arg0	int	0–4	-	Axis index
arg1	int	2	-	Encoder subfunction index
arg2	int	s32	0	Preload value

Description

Sets the value that will be loaded into the encoder counter <arg0> when a preload event occurs. The preload event is defined with ENC 3, see Section 2.22.4. The third argument <arg2> gives the value that will be preloaded.
For further discussion and examples, please see also Chapter 4 Encoder Interface.

Examples

Input	Comment
ENC 0 2 4321	Sets preload value of counter 0 to 4321.

Related commands

ENC (Encoder functions)
ETR (Encoder trigger control)

2.22.4 ENC 3 (Set encoder preload event)

Command format

ENC <arg0> 3 <arg2>

Argument quick info

No.	Type	Value	Default	Description
arg0	int	0–4	-	Axis index
arg1	int	3	-	Encoder subfunction index
arg2	int	s32	0	Preload event specification

Description

Sets preload event. The preload functionality can be used to reference the incremental encoder counter. The preload event generation is defined by the third argument <arg2> where the bits have the following meaning:

Index	Preload condition
Bit 7	Turns preloading on/off / Inactive (0), Active (1)
Bit 6	Edge (0) / State (1)
Bit 5	Rising edge or high state (0) / Falling edge or low state (1)
Bit 4	Only once, first event (0) / Every event, always (1)
Bits [3..0]	Preload event source selector, see the following table.

Preload event source selector:

Index	Input pin
0	A0
1	B0
2	A1
3	B1
4	A2
5	B2
6	A3
7	B3
8	A4
9	B4
10	Sync-in
11–14	Reserved
15	Immediate preload

The <arg2>-value 178 from the example below is composed of the bit field as follows:

7	6	5	4	3	2	1	0	Decimal value
1	0	1	1	0	0	1	0	
128 +	0 +	32 +	16 +	0 +	0 +	2 +	0	= 178

For further discussion and examples, please see also Chapter 4 Encoder Interface.

Examples

Input	Comment
ENC 0 2 1234	Sets the preload value to 1234.
ENC 0 3 178	Configures the encoder counter to load the preload value 1234 into the counter register whenever a falling edge occurs on A1, i.e., the A input of encoder channel 1.

Related commands

ENC (Encoder functions)
ETR (Encoder trigger control)

2.22.5 ENC 4 (Set cut-off frequency for low-pass filter)

Command format

ENC <arg0> 4 <arg2>

Argument quick info

No.	Type	Value	Default	Description
arg0	int	0–5	-	Axis index (0–4), Sync-in (5)
arg1	int	4	-	Encoder subfunction index
arg2	int	0–7	2	Index of cut-off frequency of low-pass filter

Description

This command sets the cut-off frequency for a low-pass filter which is applied to the encoder and Sync-in signals in order to suppress high-frequency interferences on poor signal quality. Keep in mind that with a stronger low-pass filter setting, the maximum usable signal frequency also decreases.

The first argument <arg0> denotes the input signal. The low-pass filter can individually be parametrized for each encoder input or Sync-in signal.

The cut-off frequencies for the low-pass filter <arg 2> settings for signals with 50 % duty cycle are as follows:

Index	Cut-off frequency
0	17 MHz
1	10 MHz
2	5.6 MHz
3	2.9 MHz
4	1.5 MHz
5	0.77 MHz
6	0.38 MHz
7	0.19 MHz

For the quadrature signals of the encoders counting frequencies up to four times the specified signal frequencies are possible. The default setting of the low-pass filter is 2, which means that the maximum encoder count frequency is 22 million increments/sec.

Good to now

If the low-pass filter is set to a cut-off frequency of 17 MHz, 68 million increments/sec are possible in quadrature mode. This maximum value can only be achieved under the following conditions: The high and low phases of a signal in quadrature mode must be longer than $\frac{1}{2*17\ MHz}$.

For further discussion and examples, please see also Chapter 4 Encoder Interface.

Examples

Input	Comment
ENC 0 4 3	Sets the cut-off frequency of low-pass filter to 2.9 MHz to X axis.
ENC 5 4 5	Sets the cut-off frequency of low-pass filter to 0.77 MHz to Sync-in.

Related commands

ENC (Encoder functions)
ETR (Encoder trigger control)

2.23 EQN (Equalize Fourier noise)

Scope

Interferometric mode only

Command format

EQN <arg0> <arg1>

Argument quick info

No.	Type	Value	Default	Description
arg0	int	0, 1, 3141	-	Turn off, turn on or acquire new equalization function
arg1	float	-	-	Reserved

Description

This command determines the amplification function on FFT pixels in the interferometric mode to achieve the same noise level over the measuring range. It will be stored permanently in non-volatile memory.

This command may only be necessary after significant changes of the detector range in interferometric mode.

Good to know

No object shall be in the measuring range of the device. Required command sequence: DRK, FDK, EQN 3141, DRK

Examples

Input	Comment
EQN 0	Turns off equalization function.
EQN 1	Turns on equalization function.
EQN 3141	Takes a new equalization function and turns it on.

Related commands

DRK (Dark reference)
FDK (Fast dark reference)

2.24 ETR (Encoder trigger control)

Command format

ETR <arg0> <arg1>

Argument quick info

No.	Type	Value	Default	Description
arg0	int	0–5, 7	-	Encoder trigger subfunction index
arg1	...	...	-	See ETR subcommands

Description

The ETR command groups several functions related to encoder triggering.

The encoder trigger is implemented as a state machine. In the idle state, it waits for the encoder counter of the selected axis to pass the start position (in either direction) where it generates the first trigger event. Then the trigger interval value is added to the current position and when this position is reached, the next trigger event is generated. This step is repeated until the stop position is encountered. The generation of trigger events is now stopped.

If triggering during return movement is selected, the state machine waits for the stop position to be passed once again and generates trigger events similarly to the forward movement (the trigger interval is now subtracted instead of added) until the start position is reached. The state machine then goes back to the idle state. If no trigger during return movement is selected, the state machine waits for the start position to be passed over (during return movement) and then passes to the idle state.

Learn more about encoder triggering and triggered measurements in Chapter 5 Triggered Measurements.

Good to know

The state machine is reset by the ETR 0 (Encoder trigger start position) subcommand.

Examples

Input	Comment
ETR 0	See ETR 0 (Encoder trigger start position).
ETR 1	See ETR 1 (Encoder trigger stop position).
ETR 2	See ETR 2 (Encoder trigger interval).
ETR 3	See ETR 3 (Encoder trigger state control).
ETR 4	See ETR 4 (Encoder trigger active during return).
ETR 5	See ETR 5 (Encoder trigger source).
ETR 7	See ETR 7 (Encoder trigger roundtrip / endless mode).

Related commands

CTN (Continue in free run mode)
ENC (Encoder functions)
STR (Software trigger)
TRG (Trigger once)
TRE (Trigger each)
TRW (Trigger window)

2.24.1 ETR 0 (Encoder trigger start position)

Scope

Only relevant if roundtrip trigger is active (see ETR 7).

Command format

ETR 0 <arg1>

Argument quick info

No.	Type	Value	Default	Description
arg0	int	0	-	Encoder trigger subfunction index
arg1	int	s32	0	Start position value

Description

Sets start position and resets the encoder trigger state machine.

Good to know

This subcommand must be the last one in a sequence of ETR commands so that all encoder trigger configurations can be applied.

Examples

Input	Comment
ETR 0 100	Sets trigger start position to 100.

Related commands

CTN (Continue in free run mode)
ENC (Encoder functions)
STR (Software trigger)
TRG (Trigger once)
TRE (Trigger each)
TRW (Trigger window)

2.24.2 ETR 1 (Encoder trigger stop position)

Scope

Only relevant if roundtrip trigger is active (see ETR 7).

Command format

ETR 1 <arg1>

Argument quick info

No.	Type	Value	Default	Description
arg0	int	1	-	Encoder trigger subfunction index
arg1	int	s32	1000	Stop position value

Description

Sets the stop position for encoder trigger.

Examples

Input	Comment
ETR 1 1000	Sets trigger stop position to 1000.

Related commands

CTN (Continue in free run mode)
ENC (Encoder functions)
STR (Software trigger)
TRG (Trigger once)
TRE (Trigger each)
TRW (Trigger window)

2.24.3 ETR 2 (Encoder trigger interval)

Command format

ETR 2 <arg1>

Argument quick info

No.	Type	Value	Default	Description
arg0	int	2	-	Encoder trigger subfunction index
arg1	float	full range	100	Trigger interval value

Description

Sets trigger interval value. The argument <arg1> is a float so that the trigger interval can be given in fractions of encoder counts (e.g., 100.5).

Examples

Input	Comment
ETR 2 10.5	Sets trigger interval to 10.5.

Related commands

CTN (Continue in free run mode)
ENC (Encoder functions)
STR (Software trigger)
TRG (Trigger once)
TRE (Trigger each)
TRW (Trigger window)

2.24.4 ETR 3 (Encoder trigger state control)

Command format

ETR 3 <arg1>

Argument quick info

No.	Type	Value	Default	Description
arg0	int	3	-	Encoder trigger subfunction index
arg1	int	0, 1	0	Inactive / active

Description

Controls the encoder trigger state:

- <arg1> = 0: (default) Encoder trigger is inactive.
- <arg1> = 1: Encoder trigger is active.

Examples

Input	Comment
ETR 3 1	Activates encoder trigger.

Related commands

CTN (Continue in free run mode)
ENC (Encoder functions)
STR (Software trigger)
TRG (Trigger once)
TRE (Trigger each)
TRW (Trigger window)

2.24.5 ETR 4 (Encoder trigger active during return)

Scope

Only applicable for roundtrip trigger mode.

Command format

ETR 4 <arg1>

Argument quick info

No.	Type	Value	Default	Description
arg0	int	4	-	Encoder trigger subfunction index
arg1	int	0, 1	0	Inactive / active during return movement

Description

Enables trigger during return movement:

- <arg1> = 0: (default) Encoder trigger is only active during the movement from start position to stop position.
- <arg1> = 1: Encoder trigger is also active during the return movement from stop position to start position.

Examples

Input	Comment
ETR 4 0	Disables trigger during return movement.

Related commands

CTN (Continue in free run mode)
ENC (Encoder functions)
STR (Software trigger)
TRG (Trigger once)
TRE (Trigger each)
TRW (Trigger window)

2.24.6 ETR 5 (Encoder trigger source)

Command format

ETR 5 <arg1>

Argument quick info

No.	Type	Value	Default	Description
arg0	int	5	-	Encoder trigger subfunction index
arg1	int	0–4	0	Encoder counter axis index

Description

Chooses an encoder counter as trigger source using its index.

Examples

Input	Comment
ETR 5 0	Chooses axis 0 as encoder trigger source.

Related commands

CTN (Continue in free run mode)
ENC (Encoder functions)
STR (Software trigger)
TRG (Trigger once)
TRE (Trigger each)
TRW (Trigger window)

2.24.7 ETR 7 (Encoder trigger roundtrip / endless mode)

Command format

ETR 7 <arg1>

Argument quick info

No.	Type	Value	Default	Description
arg0	int	7	-	Encoder trigger subfunction index
arg1	int	0, 1	0	Roundtrip / endless trigger mode

Description

Roundtrip / endless mode:

- <arg1> = 0: (default) Roundtrip trigger. Start and stop positions are used.
- <arg1> = 1: Endless trigger. Generates one trigger event on every interval regardless of any start / stop position.

Examples

Input	Comment
ETR 7 1	Activates endless trigger.
ETR 7 0	Activates roundtrip trigger.

Related commands

CTN (Continue in free run mode)
ENC (Encoder functions)
STR (Software trigger)
TRG (Trigger once)
TRE (Trigger each)
TRW (Trigger window)

2.25 EWD (Exclude windows)

Command format

EWD <arg0> <arg1> ...

Argument quick info

No.	Type	Value	Default	Description
arg0	float	0–range (current probe)	0	Left edge of window 1 in micrometers
arg1	float	0–range (current probe)	0	Right edge of window 1 in micrometers
arg2	float	0–range (current probe)	0	Left edge of window 2 in micrometers
arg3	float	0–range (current probe)	0	Right edge of window 2 in micrometers
...	...	...	-	Max. 14 additional windows (16 max. in total)

Description

Using this command, measurement ranges can be ignored. Thus, up to 16 exclude windows can be defined.

Good to know

- The left edge and right edge must be given in pairs.
- The reply argument float of each window edge describes the physical distance (or thickness) corresponding to the detector pixel closest to the user input (affected by the calibration table). Therefore it may deviate slightly from the input value.
- The value of the right edge of each window must be larger than its left edge.
- EWD without parameters disables windowing so that the whole range is active.

Examples

Input	Comment
EWD 0 190.3 200.5 612.4 745 822	Excludes 3 windows with the mentioned edges.
EWD ?	Returns the effective positions of the currently active windows.

2.26 FDK (Fast dark reference)

Command format

FDK [<arg0> <arg1>]

Argument quick info

No.	Type	Value	Default	Description
arg0	int	1–255	-	Number of spectra to average for the dark reference
arg1	int	u16	-	Refresh factor

Response quick info

No.	Type	Value	Default	Description
arg0	float	-	-	(Virtual) measuring rate in Hz at which the detector would be saturated by the stray light

Description

This command takes a dark reference at the current measuring rate. This dark reference result is not stored in the non-volatile memory. It permits to take very fast dark references very frequently, for example in an inline application. You can specify the number of spectra that are averaged to obtain the new dark reference. If not given, the value of 100 is assigned.

With a second optional parameter you can specify a refresh factor which takes effect as follows:

$$newRef = \frac{RefreshFactor}{65535} * AverageOfSpectra + (1 - \frac{RefreshFactor}{65535}) * OldRef \tag{2.1}$$

A big value (65535) for refresh factor replaces the old reference by the new one, a small value modifies the old reference only by a small portion. When FDK is used with one parameter, this parameter gives the average number and the refresh factor defaults to 65535 (replace old dark reference completely).

The command response indicates the amount of stray light that was registered. It represents in fact a virtual measuring rate in Hz at which the detector would just be saturated by the stray light.

Good to know

- The fast dark reference is only valid for the current measuring rate and LAI setting.
- The dark reference acquired by FDK won't be saved to non-volatile memory. It will be replaced by the previous reference acquired by the DRK command as soon as the device restarts.

Examples

Input	Comment
FDK	Carries out a fast dark reference and returns (virtual) measuring rate in Hz.
FDK 50	Carries out a fast dark reference (average of 50 spectra) and returns (virtual) measuring rate in Hz.
FDK 50 10020	Carries out a fast dark reference (average of 50 spectra, refresh factor 10020) and returns (virtual) measuring rate in Hz.

Related commands

CRDK (Continuous refresh dark factor)
DRK (Dark reference)

2.27 GAN (Detector gain setting)

Scope

Only supported by specific detectors (mainly SWIR InGaAs)

Command format

GAN <arg0>

Argument quick info

No.	Type	Value	Default	Description
arg0	int	Detector specific	0	Gain setting index

Description

This command changes the detector gain setting. Valid values of its argument are specific to each detector type.

Good to know

Currently only the detectors Sensors Unlimited SU512LC and LDB are supported.

Examples

Detector: SU512LC

Input	Comment
GAN 0	Feedback capacitance 0.1 pF, highest gain
GAN 1	Feedback capacitance 1 pF
GAN 2	Feedback capacitance 10 pF
GAN 3	Feedback capacitance 20 pF, lowest gain

Detector: LDB

Input	Comment
GAN 0	High-sensitivity mode: high gain capacitor
GAN 1	High dynamic range mode: low gain capacitor

2.28 GLE (Get last errors)

Command format

GLE [<arg0>]

Argument quick info

No.	Type	Value	Default	Description
arg0	int	-	-	Number of errors to be queried

Response quick info

No.	Type	Value	Default	Description
arg0	int	-	-	Error code
arg1	int	-	-	Sub-error code
arg2	int	-	-	ID of client causing the error
arg3	int	-	-	Ticket number of command causing the error
arg4	str	-	-	String of the command causing the error
arg5	str	-	-	String of error description

Description

Queries latest errors. If no argument is given, only the last error will be returned.

The following table gives detailed information about error and sub-error codes:

Error code	Sub-error code	Explanation
	0	Unknown_Error
1	1	Device_Cannot_Connect
1	3	Device_Not_Connected
3	1	Device_Unknown_CMD
3	2	Device_No_Support_CMD
3	3	Device_Invalid_Operation_CMD
3	4	Device_Operation_Failed_CMD
4	1	Device_Param_OverRange
4	2	Device_Param_WrongType
4	3	Device_Param_Invalid_Value
4	4	Device_Param_WrongArgCount
4	5	Device_Param_Mismatch
4	6	Device_Param_Malform
8		Client_Connect_Error
9		Packet_Error
10		High_Level_Error

Examples

Input	Comment
GLE 1	Returns the last error.

2.29 IDE (Identification)

Command format IDE

Argument quick info No arguments supported

Description Queries device specific parameters. The response has a string argument that contains key-value pairs.

Examples

Input	Comment

IDE	Returns for example the following string:
	
	`personality.caps.light=led/sld`
	`personality.caps.max_frequency=...`
	`personality.caps.spectrometer=...`
	`personality.channelcount=...`
	`personality.oem.devicetype=...`
	`personality.oem.id=...`
	`personality.proddate=...`
	`personality.revision=...`
	`personality.serial=...`
	`personality.softwareconfiguration=0`

Related commands VER (Version information)

2.30 IPCN (IP configuration)

Command format

IPCN <arg0> [<arg1> ... <arg9>]

Argument quick info

No.	Type	Value	Default	Description
arg0	int	0, 1	0	DHCP on (1)/off (0)
arg1	int	0–255	192	IP address byte 1
arg2	int	0–255	168	IP address byte 2
arg3	int	0–255	170	IP address byte 3
arg4	int	0–255	2	IP address byte 4
arg5	int	0–255	255	Subnet mask byte 1
arg6	int	0–255	255	Subnet mask byte 2
arg7	int	0–255	255	Subnet mask byte 3
arg8	int	0–255	0	Subnet mask byte 4
arg9	int	1500–9000	1500	Ethernet Maximum Transmission Unit (MTU)

Description

Command to define TCP/IP communication settings.

If DHCP is on (<arg0> = 1), you should neither specify an IP address nor a subnet mask. If DHCP is off (<arg1> = 0), IP address should be specified and subnet mask is optional (if not given, the default value is used). Common restrains on IP address and subnet mask also apply.

Good to know

- If the Ethernet Maximum Transmission Unit MTU (<arg9>) is set to values larger than 1530 bytes, the user must ensure that the network interface card supports jumbo frames. Jumbo frames might help to increase the data throughput when using a point-to-point connection, but must be individually tested.
- After the input of IPCN, the CHRocodile's Ethernet device will be reset and thus all TCP/IP connections will be closed, without receiving the response/update of IPCN.
- Power cycling the device after issuing this command is strongly recommended.

Examples

Input	Comment
IPCN 0 192 168 170 2 255 255 255 0	Turns DHCP client off, sets the IP address and subnet mask.
IPCN 192 168 170 2	Sets the IP address statically, implicitly turning off DHCP client.
IPCN 1	Turns DHCP client on.
IPCN ?	Returns the current value(s).

2.31 LAI (Lamp intensity)

Command format

LAI <arg0>

Argument quick info

No.	Type	Value	Default	Description
arg0	float	0–100	100	Lamp intensity in percentage

Description

This function sets the effective brightness of the light source. Depending on the device type, this takes place via changing either the intensity of the light source or the detector exposure time. In case of a LED/SLD as light source, a LAI value of 0 switches the LED/SLD off.

Halogen version: lamp voltage 12 V in %, 1–104 %

Good to know

- This command also disables the auto adapt mode.
- Because of detector's frame overhead time, a target value of 100 % can't always be reached. The maximum reachable value depends on the detector type and the current sample rate (SHZ).

Examples

Input	Comment
LAI 80	Sets the effective brightness of the light source to 80 %.
LAI ?	Queries the current parameter value.

Related commands

AAL (Auto adapt light source)

2.32 LMA (Detection limits active)

Command format

LMA <arg0>

Argument quick info

No.	Type	Value	Default	Description
arg0	int	0, 1	0	Status of detection limits (0 for inactive and 1 for active)

Description

Activates or deactivates the detection windows. If inactive, the full thickness/distance detection range is active. If active, the preset windows configured by DWD are used.

Examples

Input	Comment
LMA 1	Activates the detection limits.
LMA ?	Returns the current value(s).

Related commands

DWD (Detection windows definition)

2.33 LOC (Lock front panel keyboard)

Command format

LOC [<arg0>]

Argument quick info

No.	Type	Value	Default	Description
arg0	int	0, 1	0	Whether to lock the front panel inputs (jogwheel and keys)

Description

This command locks and unlocks the front panel, namely the input keys and the jogwheel. The locking state can be given explicitly using the single integer argument. Without argument, the command toggles the locking state.

Good to know

The locking state is not saved by the SSU command. After a power cycle, the keyboard is always accessible.

Examples

Input	Comment
LOC	Toggles the locking state.
LOC ?	Queries the locking state.
LOC 0	Unlocks inputs.
LOC 1	Locks inputs.

2.34 MAN (Manual)

Command format

MAN <arg0>

Argument quick info

No.	Type	Value	Default	Description
arg0	str	-	-	Command string

Description

Shows the description of the requested command on the display of the device.

Good to know

Not all commands are supported. Using MAN ?, a list of commands for which a manual entry exists can be queried.

Examples

Input	Comment
MAN ENC	Shows a description of the ENC command.
MAN ?	Lists supported commands.

2.35 MED (Median width)

Command format

MED <arg0>

Argument quick info

No.	Type	Value	Default	Description
arg0	int	0–30	7	Median width value

Description

This command defines how many measurement values are to be used for the calculation of the median. Calculating the median makes sense if a considerable number of outliers are to be expected which would unnecessarily falsify the average value of the measurement. Up to 8 median-filtered signals can be included in the output telegram.

Good to know

Only peak related signals can be considered in median calculation. The width setting is globally applied in all median calculations on all peaks being processed.

Examples

Input	Comment
MED 7	In this case 7 measured values are used for median calculation.

2.36 MESG (Message from device to client)

Scope Packet protocol only

Command format MESG <arg0> to <arg3>

Argument quick info

No.	Type	Value	Default	Description
arg0	int	-	-	Message type: 0: error 1: warning 2: info
arg1	int	-	-	Message severity: Lower number means higher severity with 0 representing the most severe event.
arg2	int	-	-	Message ID: reserved
arg3	str	-	-	Message content: individual content

Description This command is used to let the device inform the client about events/issues.

2.37 MMD (Measurement mode)

Command format

MMD <arg0>

Argument quick info

No.	Type	Value	Default	Description
arg0	int	0, 1	0	0: chromatic confocal mode 1: interferometric mode

Description

Sets the measurement mode to chromatic confocal (0) or interferometric (1) independent of the number of detected peaks.

Examples

Input	Comment
MMD 0	Sets the device to chromatic confocal mode.
MMD ?	Returns the current value(s).

Related commands

NOP (Number of peaks)

2.38 NOP (Number of peaks)

Command format

NOP <arg0>

Argument quick info

No.	Type	Value	Default	Description
arg0	int	1–max. NOP	1	Number of peaks

Description

Selects maximum number of peaks (surfaces) to be detected. The maximum NOP value is a characteristic of the device version and can be read back by the IDE command. It's the value after the `personality.caps.NOP` key.

Good to know

When reducing the NOP, signals related to then invalid peaks will automatically have a value of 0. NOP also affects the number of valid layers or thicknesses (NOP-1) and thus all signals referring to invalid layers will have a value of zero. Example: When changing from NOP 3 to NOP 2, eventually selected third distance and second thickness will have a value of zero.

In confocal mode, if less than NOP peaks are detected, all thickness signals will be invalidated because peak identification is not possible.

Examples

Input	Comment
NOP 3	Sets the number of peaks.
NOP ?	Returns the currently specified number of peaks.

2.39 OFN (Output function)

Command format

OFN <arg0> [<arg1>]

Argument quick info

No.	Type	Value	Default	Description
arg0	int	0–3	-	Output function index
arg1	int	0–15	0	Output function value

Description

This command is used to control the 4 digital outputs (AUX OUT) of a device.

OFN 0: Turns off all digital outputs.
OFN 0 <0..15>: Outputs [3..0] represent the given value.
OFN 1: Digital outputs represent 4 LSBits (least significant bits) of active calibration table index.
OFN 2: Output [0] represents LSBit of active calibration table index, output [1] represents measuring mode (0 for chromatic confocal, 1 for interferometric).
OFN 3: Outputs [2..0] represent 3 LSBits of active calibration table index, output [3] represents measuring mode (0 for chromatic confocal, 1 for interferometric).

Examples

Input	Comment
OFN 0	Sets digital outputs: output[3..0] = b0000
OFN 0 7	Sets digital outputs: output[3..0] = b0111
OFN 0 11	Sets digital outputs: output[3..0] = b1011

2.40 OPD (Operation data)

Command format

OPD <arg0>

Argument quick info

No.	Type	Value	Default	Description
arg0	int	0, 1, 2, 3, 5, 6	-	Subcommand index

Description

This command queries operational data (e.g., total operation time in seconds) and controls the time stamp synchronization (OPD 6).

Examples

Input	Comment
OPD 0 ?	See OPD 0 (Lamp lifetime).
OPD 1 ?	See OPD 1 (Alarm threshold for lamp lifetime).
OPD 2 ?	See OPD 2 (Total operation time).
OPD 3 ?	See OPD 3 (Number of power ups).
OPD 5 ?	See OPD 5 (Uptime since last power cycle).
OPD 6 ?	See OPD 6 (Time stamp synchronization).

2.40.1 OPD 0 (Lamp lifetime)

Command format

OPD <arg0> <arg1>

Argument quick info

No.	Type	Value	Default	Description
arg0	int	0	-	Subcommand index
arg1	int	314	-	Magic number

Response quick info

No.	Type	Value	Default	Description
arg0	int	0	-	Subcommand index
arg1	int	s32	-	Operation time since the last lamp change

Description

This command marks the point in time at which the last change of lamp was done. It always returns the device's operation time since the last lamp change. Resetting the lamp lifetime is carried out with a fixed magic number ("314").

Examples

Input	Comment
OPD 0 314	Marks that the lamp was changed.
OPD 0 ?	Returns operation time [s] since the last lamp change.

2.40.2 OPD 1 (Alarm threshold for lamp lifetime)

Command format OPD <arg0> <arg1>

Argument quick info

No.	Type	Value	Default	Description
arg0	int	1	-	Subcommand index
arg1	int	s32	-	Alarm threshold value [s]

Description This command sets or queries the alarm threshold for lamp lifetime.

Examples

Input	Comment
OPD 1 3600000	Sets the alarm threshold value for lamp lifetime to 1000 hours.
OPD 1 ?	Returns the alarm threshold value for lamp lifetime [s].

2.40.3 OPD 2 (Total operation time)

Command format OPD <arg0>

Argument quick info

No.	Type	Value	Default	Description
arg0	int	2	-	Subcommand index

Response quick info

No.	Type	Value	Default	Description
arg0	int	2	-	Subcommand index
arg1	int	s32	-	Total operation time [s]

Description This command queries the total operation time of the device.

Good to know Command must be a query.

Examples

Input	Comment
OPD 2 ?	Returns total operation time [s].

2.40.4 OPD 3 (Number of power ups)

Command format OPD <arg0>

Argument quick info

No.	Type	Value	Default	Description
arg0	int	3	-	Subcommand index

Response quick info

No.	Type	Value	Default	Description
arg0	int	3	-	Subcommand index
arg1	int	s32	-	Total number of power ups

Description This command queries the total number of power ups.

Good to know Command must be a query.

Examples

Input	Comment
OPD 3 ?	Returns total number of power ups.

2.40.5 OPD 5 (Uptime since last power cycle)

Command format

OPD <arg0>

Argument quick info

No.	Type	Value	Default	Description
arg0	int	5	-	Subcommand index

Response quick info

No.	Type	Value	Default	Description
arg0	int	5	-	Subcommand index
arg1	int	s32	-	Uptime of unit since last power on [s]

Description

This command queries the uptime of the device since the last power on.

Good to know

Command must be a query.

Examples

Input	Comment
OPD 5 ?	Returns uptime [s] since the last power on.

2.40.6 OPD 6 (Time stamp synchronization)

Command format

OPD <arg0> <arg1> <arg2>

Argument quick info

No.	Type	Value	Default	Description
arg0	int	6	-	Time stamp synchronization control
arg1	int	0, 1	0	Master function status: off (0) / on (1)
arg2	int	0, 1	0	Slave function status: off (0) / on (1)

Response quick info

No.	Type	Value	Default	Description
arg0	int	6	-	Time stamp synchronization control
arg1	int	0, 1	-	Master function status: off (0) / on (1)
arg2	int	0, 1	-	Slave function status: off (0) / on (1)
arg3	int	0, 1	-	Synchronization status: failure (0) / synchronized (1)
arg4	int	u16	-	Number of correctly received synchronization packets
arg5	int	u16	-	Number of “hard” synchronizations
arg6	int	u16	-	Number of erroneously received synchronization packets

Description

This command controls and queries the time stamp synchronization.

Good to know

A “hard” synchronization is executed if the time stamp of the slave differs too much from the master’s. In that case, the time stamp of the master replaces the time stamp of the slave. Otherwise, only the increment value of the time counter is adjusted.

Examples

Input	Comment
OPD 6 1 0	Activates the synchronization master function.
OPD 6 0 1	Activates the synchronization slave function.
OPD 6 ?	Returns the synchronization status: if master is active, if slave is active, if device time stamp is synchronized, how many packets were OK, how many “hard” synchronizations happened and how many packets were erroneous.

2.41 POD (Peak ordering)

Scope

Interferometric mode only

Command format

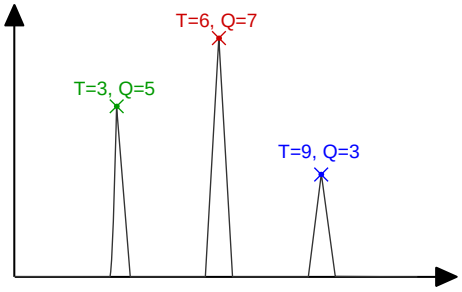
POD <arg0>

Argument quick info

No.	Type	Value	Default	Description
arg0	int	0–2	0	Peak order: 0: according to quality (peak quality descending) 1: according to position (ascending) 2: according to position (descending)

Description

This command sets the output peak order in interferometric mode (in confocal mode the output peak order is always according to increasing distance). If the value of <arg0> is 0, the peaks are sorted according to their peak quality, with the highest peak first. If <arg0> is 1, the peaks are sorted according to their position (i.e. layer thickness) in an ascending manner, with the thickest layer last. Conversely, if <arg0> is 2, peaks are sorted according to decreasing layer thickness.



POD setting	Peak 0	Peak 1	Peak 2
0	Thickness=6 Quality=7	Thickness=3 Quality=5	Thickness=9 Quality=3
1	Thickness=3 Quality=5	Thickness=6 Quality=7	Thickness=9 Quality=3
2	Thickness=9 Quality=3	Thickness=6 Quality=7	Thickness=3 Quality=5

Examples

Input	Comment
POD 0	Sets peak ordering according to the peak quality in a descending manner.
POD ?	Returns the current value.

Related commands

SODX (Set output data extended)

2.42 PSM (Peak separation minimum)

Scope

Chromatic confocal mode only

Command format

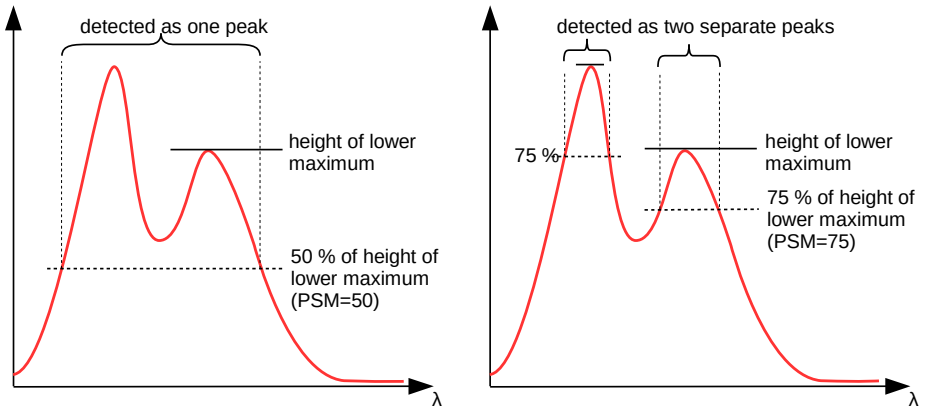
PSM <arg0>

Argument quick info

No.	Type	Value	Default	Description
arg0	float	10–90	50	Peak separation minimum in percent of the height of the lower peak

Description

The peak detection algorithm detects 2 neighbouring peaks as separate peaks if the signal minimum between the two peaks is less than a certain fraction of the lower peak height. This fraction (PSM value) is given in percent of the height of the lower peak.



Examples

Input	Comment
PSM 60	Sets the threshold for signal minimum value between two peaks to 60 % of the lower peak.
PSM ?	Queries the current value of this parameter.

2.43 QTH (Quality threshold, interferometric mode)

Scope

Interferometric mode only

Command format

QTH <arg0>

Argument quick info

No.	Type	Value	Default	Description
arg0	float	1–1000	15	Sets a quality threshold.

Description

This command lets you specify a quality threshold for the peak detection. The threshold parameter is used to tune the peak detection algorithm to the desired sensitivity. It should be set as low as possible to be able to measure dark surfaces, but high enough to suppress the detection of noise spikes when there is no object in the detection range.

The threshold is in arbitrary units.

If the sensor doesn't detect a signal which passes the threshold, 0 is output for distance and intensity. However, this behavior doesn't disturb the averaging algorithm, as invalid results are excluded from averaging.

Examples

Input	Comment
QTH 30	Sets a quality threshold of 30.
QTH ?	Displays the currently valid quality threshold.

Related commands

THR (Threshold, confocal mode)
POD (Peak ordering)

2.44 RST (Restart device)

Command format RST

Argument quick info No argument supported

Description Reboots the CHRocodile device. This may be useful after a software update or a calibration in order to reinitialize the system completely without switching the power off and on again.

Examples

Input	Comment
RST	Reboots the CHRocodile.

2.45 SCA (Scale)

Command format

SCA <arg0>

Response quick info

No.	Type	Value	Default	Description
arg0	int	u32	-	Full scale in micrometers

Description

For query only. Gives the full scale value for distances and thicknesses that are selected for transmission in 16 bit mode.

In 16 bit mode, the value is not transmitted in micrometer or nanometer but in normalized form. A distance value of 32768 would mean a distance of (Full Scale) micrometers in air. To convert the integer distance value (d) in air received from the serial interface to a value in micrometers (D), use Equation 2.2.

$$D[\mu m] = \frac{d[integer]}{32768} * FullScale \tag{2.2}$$

For thickness measurements the result has to be multiplied by the refractive index of the layer material.

Good to know

When using a refractive index table stored in the device (SRT different from 0), query the needed index from the device with the SRI ? command. When no table is used, the refractive index has to be provided by the user and must also be forwarded to the CHRocodile via the SRI command.

Examples

Input	Comment
SCA ?	Returns the scale in micrometers.

Related commands

ABE (Abbe number)
MMD (Measurement mode)
SRI (Set refractive indices)
SRT (Set refractive index table)

2.46 SCAN (Scanner control)

Scope

Packet protocol only

Command format

SCAN <arg0> ...

Argument quick info

No.	Type	Value	Default	Description
arg0	int	0–6	-	Scanner subcommand index
...	...	...	...	Individual argument lists, see the following descriptions of subcommands for more information

Description

This command controls the scanner mode of CHRocodile 2 devices. It can be used to control the Flying Spot Scanner (FSS). In the scanner mode, a CHRocodile 2 device uses its 2 analog outputs (analog mode) or the Sync-in / Sync-out pins (digital mode) to control 2 galvanometer scan axes (output 1 to axis X, output 2 to axis Y). The control mode (analog/digital) can be switched using the SCAN 6 command. Scan paths are to be predefined (called scan program) and are either stored as file on the internal SD card of CHRocodile 2 devices or executed directly. A limited number of device parameters can also be embedded into the scan programs.

Good to know

In the scanner mode, the current scanner set position (the position sent to scanner) can be read back using the encoder channel 3 (signal ID 68). The 32-bit value has to be interpreted as an array of 2 signed 16-bit integers, where the least significant 16 bits represent the X value and the most significant 16 bits the Y value.

Depending on the scanner support, its current position can be read back using encoder channel 0 (X value = signal ID 65) and channel 1 (Y value = signal ID 66).

Encoder channel 4 (signal ID 69) outputs a marker value that is controlled by the scan program. It serves to easily attribute measured results to the different parts of the scan path.

Please ensure that no other signal is routed to those channels to avoid interference. Disabling the encoder counting for ENC 3 and ENC 4 is achieved by selecting an undefined count source index like 14 using ENC 3 1 14 and ENC 4 1 14.

Examples

Input	Comment
SCAN 0 ...	See SCAN 0 (Activate / deactivate scanner mode).
SCAN 1 ...	See SCAN 1 (Scanner gain value).
SCAN 2 ...	See SCAN 2 (Scanner offset value).
SCAN 3 ...	See SCAN 3 (Scanner direct positioning).
SCAN 4 ...	See SCAN 4 (Raster scan parameters).
SCAN 5 ...	See SCAN 5 (Scanner coordinations alignment).
SCAN 6 ...	See SCAN 6 (Scanner control mode).
SCAN 7 ...	See SCAN 7 (Scanner XY-rectification coefficients).
SCAN 9 ...	See SCAN 9 (Scanner adapter status query).
SCAN 10 ...	See SCAN 10 (Scanner Z-correction coefficients).

Related commands

TRW (Trigger window)

2.46.1 SCAN 0 (Activate / deactivate scanner mode)

Scope

Form 3 is only supported via binary packet protocol.

Command format

Form 1: SCAN 0
Form 2: SCAN 0 <arg1>
Form 3: SCAN 0 <arg1> <arg2> <arg3>

Argument quick info

Form 1 (disable scanner mode):

No.	Type	Value	Default	Description
arg0	int	0	-	Scanner control subcommand index

Form 2 (select recipe or direct control):

No.	Type	Value	Default	Description
arg0	int	0	-	Scanner control subcommand index
arg1	str	-	-	“direct” or “raster” or filename of scan program on SD card

Form 3 (live recipe):

No.	Type	Value	Default	Description
arg0	int	0	-	Scanner control subcommand index
arg1	int	-	-	Byte offset of current blob in complete scan program being sent
arg2	int	-	-	Complete size in bytes of scan program being sent
arg3	blob	-	-	Current blob of scan program being sent

Description

This subcommand allows the user to activate or deactivate the scanner mode of the device. There are 3 forms of this subcommand.

- Form 1: Without any additional argument, this command deactivates the scanner mode.
- Form 2: Given a single additional string argument, there are 3 possibilities:
  If the string is `direct`, the device enters the direct positioning mode, where the scanner position is controlled by the SCAN 3 (Scanner direct positioning) command.
  If the string is `raster`, the device prepares a raster scan that was previously parametrized by the SCAN 4 (Raster scan parameters) command. The raster scan can then be started with a trigger event or a STR (Software trigger) command. At the beginning of the raster scan, the value of encoder 3 ("Marker") is set to 1, after the end of the scan it is set to -2 to indicate the end of the scan. In order to make use of these marker values, make sure that the encoder 3 does not count on an input signal by setting the encoder count source to "open" (ENC 3 1 14).
  If any other than the two above mentioned strings is passed, the device tries to load a scan program file with the name given by the string from the device’s SD card. After loading it successfully that scan program will be started.
- Form 3: External software may use the form 3 to send a scan program file to the device and activate it without saving it on the internal SD card. This mechanism is also known as live recipe. A blob (<arg 3>) must be less than 4 kbytes, which is a general limitation of the blob argument format. The scan program must thus be transmitted in several blobs if required by the total scan program size.

Examples

Form 1 and 2: Activate and deactivate scanner mode using an internal stored scan program.

Input	Comment
SCAN 0 scan.rec	Loads scan program file “scan.rec” from SD card and activates the scanner mode at the end.
SCAN 0 direct	Activates the direct positioning mode where the scanner position is controlled by the SCAN 3 command.
SCAN 0	Deactivates the scanner mode.

Form 3: Receive a 7000 bytes scan program from external software using 2 blobs with different lengths.

Input	Comment
SCAN 0 0 7000 blob	Loads the first blob of a scan program into device. In our example the blob length is 4096 bytes.
SCAN 0 4096 7000 blob	Loads the remaining blob (2904 bytes) of the scan program into device then activates the scanner mode.

Related commands

SCAN (Scanner control)

2.46.2 SCAN 1 (Scanner gain value)

Scope

Packet protocol only

Command format

SCAN 1 <arg1> <arg2>

Argument quick info

No.	Type	Value	Default	Description
arg0	int	1	-	Scanner control subcommand index
arg1	float	-1–1	1	Normalized gain value, X axis
arg2	float	-1–1	1	Normalized gain value, Y axis

Description

The normalized gain values specified using this subcommand are applied on the corresponding scanner coordinates that are stored in the scan program. Thus the defined scan path can be scaled up or down as needed.

This scaling operation is done after the internal coordination alignment defined by SCAN 5 but before the shifting operation defined by SCAN 2.

Good to know

The voltage that is available at an analog output of the sensor device is defined by three parameters:

- The position x given in scan programs, allowed range: [-32768,32767]
- The corresponding gain factor k, allowed range: [-1,1]
- The corresponding offset c, allowed range: [-1,1]

The output voltage is calculated as

$$X = 10V * (k * \frac{x}{32768} + c) \tag{2.3}$$

No further checks are performed hereafter so that the output voltage is only limited to [-10,10] V by the device electronics. The user is responsible for guaranteeing that the output voltage is within the allowed range of the specific application by defining feasible parameters.

Examples

Input	Comment
SCAN 1 1 1	Sets normalized gain value of both axes to 1.

Related commands

SCAN (Scanner control)
SCAN 2 (Scanner offset value)
SCAN 5 (Scanner coordinations alignment)

2.46.3 SCAN 2 (Scanner offset value)

Scope

Packet protocol only

Command format

SCAN 2 <arg1> <arg2>

Argument quick info

No.	Type	Value	Default	Description
arg0	int	2	-	Scanner control subcommand index
arg1	float	-1–1	0	Normalized offset value, X axis
arg2	float	-1–1	0	Normalized offset value, Y axis

Description

The normalized offset values specified using this subcommand are applied on the corresponding scanner coordinates that are stored in the scan program. Thus the defined scan path can be shifted as needed.

This shifting operation is done after the internal coordination alignment defined by SCAN 5 and the scaling operation defined by SCAN 1.

Good to know

The voltage that is available at an analog output of the sensor device is defined by three parameters:

- The position x given in scan programs, allowed range: [-32768,32767]
- The corresponding gain factor k, allowed range: [-1,1]
- The corresponding offset c, allowed range: [-1,1]

The output voltage is calculated as

$$X = 10V * (k * \frac{x}{32768} + c) \tag{2.4}$$

No further checks are performed hereafter so that the output voltage is only limited to [-10,10] V by the device electronics. The user is responsible for guaranteeing that the output voltage is within the allowed range of the specific application by defining feasible parameters.

Examples

Input	Comment
SCAN 2 1 1	Sets normalized offset value of both axes to 1.

Related commands

SCAN (Scanner control)
SCAN 1 (Scanner gain value)
SCAN 5 (Scanner coordinations alignment)

2.46.4 SCAN 3 (Scanner direct positioning)

Scope Packet protocol only

Command format SCAN 3 <arg1> <arg2>

Argument quick info

No.	Type	Value	Default	Description
arg0	int	3	-	Scanner control subcommand index
arg1	float	-1–1	-	Normalized X position
arg2	float	-1–1	-	Normalized Y position

Description Moves the measurement spot to the given coordination. The allowed range [-1,1] corresponds with the full voltage range [-10,10] V of the device.

Examples

Input	Comment
SCAN 3 0 0	Moves the measurement spot to the center of the scan area.
SCAN 3 1 1	Moves the measurement spot to the lower right corner of the scan area.

Related commands SCAN (Scanner control)

2.46.5 SCAN 4 (Raster scan parameters)

Scope Packet protocol only

Command format SCAN 4 <arg1> ...

Argument quick info

No.	Type	Value	Default	Description
arg0	int	4	-	Scanner control subcommand index
arg1	float	-1–1	-1	Start X coordinate
arg2	float	-1–1	-1	Start Y coordinate
arg3	float	-1–1	1	Stop X coordinate
arg4	float	-1–1	1	Stop Y coordinate
arg5	char	'x'/'y'	'x'	Axis parallel to scan direction
arg6	int	u16	11	Number of scan lines
arg7	int	u32	1000	Number of (averaged) measurement results per line
arg8	int	1–100000	10000	Scanner frequency
arg9	int	0–$\frac{2^{31}}{150*10^6}$	1000	Wait time in µs at the beginning of each line
arg10	int	0–$\frac{2^{31}}{150*10^6}$	1000	Wait time in µs at the end of each line

Description

This function supports users to quickly scan a surface to gather information about distance or thickness. During a scan, the measurement spot moves along lines that are parallel either to the X axis or the Y axis from the start towards the stop corner.

The device shall only measure while the spot is on a line, i.e., it shall not measure while the spot is jumping from the end of the current line to the beginning of the next line. In order to do this, the command TRW must be set in advance.

Additionally, it is possible to configure a wait time in µs after the scanner reaches the start position and another wait time (also in µs) after the scanner reaches the end position.

The scan program size for a given raster scan is calculated by Equation 2.5. Scan program sizes up to 4 mbytes are allowed. If the calculated scan program size is larger than the maximum allowed value, the given parameters are rejected with a command response being flagged as erroneous.

$$scan\_program\_size = 32 + arg7 * 4 + \frac{arg8 * AVS * AVD * arg9}{SHZ} \tag{2.5}$$

Good to know Measurement results can be mapped to lines using scanner markers.

Related commands

AVD (Data averaging)
AVS (Spectra averaging)
SCAN (Scanner control)
SHZ (Set sample frequency in Hz)
TRW (Trigger window)

2.46.6 SCAN 5 (Scanner coordinations alignment)

Scope

Packet protocol only

Command format

SCAN 5 <arg1> <arg2> <arg3>

Argument quick info

No.	Type	Value	Default	Description
arg0	int	5	-	Scanner control subcommand index
arg1	float	full range	0	Rotation, given in *radian*
arg2	float	-1–1	0	Shifting value, X axis
arg3	float	-1–1	0	Shifting value, Y axis

Description

This command sets parameters of the scanner internal coordination alignment. This operation is done before both the scaling and shifting operations defined by SCAN 1 and SCAN 2.

Good to know

These parameters are highly volatile. They will be reset to 0 every time the CHRocodile 2 device boots or a new scan program is updated either live or via the SD card.

Related commands

SCAN (Scanner control)
SCAN 1 (Scanner gain value)
SCAN 2 (Scanner offset value)

2.46.7 SCAN 6 (Scanner control mode)

Scope

Packet protocol only

Command format

SCAN 6 <arg1>

Argument quick info

No.	Type	Value	Default	Description
arg0	int	6	-	Scanner control subcommand index
arg1	int	0, 1	0	Scanner type: 0: analog 1: digital

Description

This command switches between two scanner control modes: analog and digital. Value 0 means analog, value 1 means digital. In analog control mode, the scanner position is determined by the analog output voltage and the actual position is fed back by the X and Y encoder inputs. In digital scanner mode, both scanner set point position transmission and position feedback are accomplished via a highspeed serial link.

The scanner control mode must be set before entering scan mode. Changes of the mode during scan mode active will not be recognized!

Good to know

In the analog control mode, both of the normal CHRocodile analog outputs are used by the scanner.

In the digital control mode, the Sync-in and Sync-out pins are occupied and thus can not be used as a trigger source. Instead, the differential A0+/- pins of the encoder interface are used for triggering. The time stamp synchronization feature also needs these two pins for its communication, thus no time stamp synchronization is possible in the digital scanner control mode.

Related commands

ANAX (Analog output function, extended)
OPD (Operation data)
SCAN (Scanner control)

2.46.8 SCAN 7 (Scanner XY-rectification coefficients)

Scope

Packet protocol only

Command format

SCAN 7 <arg1> to <arg14>

Argument quick info

No.	Type	Value	Default	Description
arg0	int	7	-	Scanner control subcommand index
arg1	float	full range	0	XY-rectification coefficient no. 1
…	…	…	…	…
arg14	float	full range	0	XY-rectification coefficient no. 14

Description

This command serves to set XY-coefficients of the XY-rectification. Following the subcommand index, 14 float values are listed, which are separated by space.

Examples

Input	Comment
SCAN 7 0 0 1 0 0 1 0 0 0 0 0 0 0 0	Sets XY-rectification coefficients.
SCAN 7 ?	Queries active XY-rectification coefficients. Note: Stored scanner coefficients will be loaded on detection of the connected adapter board.

Related commands

SCAN (Scanner control)

2.46.9 SCAN 9 (Scanner adapter status query)

Scope

Packet protocol only

Command format

SCAN 9

Argument quick info

No.	Type	Value	Default	Description
arg0	int	9	-	Scanner control subcommand index

Response quick info

No.	Type	Value	Default	Description
arg0	strg	-	-	Adapter status

Description

Queries the Flying Spot Scanner adapter status, which outputs to console a string as follows:

- Firmware version
- Down counter channel 0
- Down counter channel 1
- Shutter state (optional according to hardware)
- Configuration mode (optional according to hardware)
- Operation time in hours (optional according to hardware)
- Creation date for the stored scanner correction coefficients (optional according to hardware)

Note: A transmission error is issued if no (stable) connection between CHRocodile and Flying Spot Scanner adapter board is possible.

Examples

Input	Comment

SCAN 9 ?	Queries the adapter status. Example (Cyclone10LP hardware detected, which supports the tuneset-feature, handling scanner correction coefficients and firmware remote update):
	
	`Newson(127)firmware_version=1.1-0xc9fa261f`
	`down_ch0=2`
	`down_ch1=2`
	`shutter_state=0`
	`configuration_mode=application`
	`operation_time=171`
	`coefficients_created=7357`

Related commands

SCAN (Scanner control)

2.46.10 SCAN 10 (Scanner Z-correction coefficients)

Scope

Packet protocol only

Command format

SCAN 10 <arg1> to <arg15>

Argument quick info

No.	Type	Value	Default	Description
arg0	int	10	-	Scanner control subcommand index
arg1	float	full range	0	Z-coefficient no. 1
...	...	...	...	...
arg15	float	full range	0	Z-coefficient no. 15

Description

This command serves to set Z-coefficients of the Z-correction. For distance measurements, the different paths of the light beam through the telecentric lens cause a U-shaped height distortion. The polynomial Z-correction eliminates this distortion.
Following the subcommand index, 15 float values are listed, which are separated by space.

Examples

Input	Comment
SCAN 10 0.01 0.02 0.03 0.04 0.05 0.06 0.07 0.08 0.09 0.10 0.11 0.12 0.13 0.14 0.15	Sets Z-correction coefficients.
SCAN 10 ?	Queries active Z-correction coefficients. Note: Stored scanner coefficients will be loaded on detection of the connected adapter board.

Related commands

SCAN (Scanner control)

2.47 SEN (Select chromatic calibration)

Command format

SEN <arg0>

Argument quick info

No.	Type	Value	Default	Description
arg0	int	0–15	0	Index of currently used chromatic calibration table

Description

This command selects the chromatic calibration table by its index on the device.

Good to know

For exact measurements, assure that the calibration table selected by this command matches the probe serial number(s) as all probes are individually calibrated! If you are not sure about the serial number of the calibration table, use the SENX ? command which outputs more information.

Examples

Input	Comment
SEN 0	Selects the chromatic calibration table 0 with nominal measuring range.
SEN ?	Queries which calibration is active and if the extended measuring range is active.

Related commands

SENX (Extended chromatic calibration table query)

2.48 SENX (Extended chromatic calibration table query)

Command format

SENX [<arg0>]

Argument quick info

No.	Type	Value	Default	Description
arg0	str	enum	-	Indicates that properties of all calibrated optical probes shall be queried.

Response quick info

Response on SENX ?

No.	Type	Value	Default	Description
arg0	str	-	-	Properties of the current optical probe

Response on SENX enum ?

No.	Type	Value	Default	Description
arg0	str	enum	-	Indicates that properties of all optical probes will follow.
arg1	str	-	-	Properties of the first calibrated optical probe
arg2	str	-	-	Properties of the second calibrated optical probe
...	...	...	...	Repeats until all calibrated optical probes are displayed.

Description

Must be a query. Use SENX ? for querying active optical probe properties.
If called with the string parameter “enum” (SENX enum ?), properties of all calibrated optical probes are returned in a list of strings.
In the dollar protocol, the strings are separated by “,”.

Each response string is composed as follows:

1. Tableindex, followed by a “,”
2. “`SNr: `”, followed by the probe serial number
3. “`Range: `”, followed by the measuring range in micrometers, followed by “`µm`”
4. Items 2 to 5 can repeat multiple times on multi-channel configurations that use multiple probes. In these cases, the probe descriptions are separated by a “|” character.

Examples

Input	Comment
SENX ?	Gets properties of the current chromatic calibration table of a single channel device, for example: `0, SNr: 200001, Range: 2291 µm`
SENX enum ?	Gets properties of all chromatic calibration tables of a single channel device, for example: `0, SNr: 200001, Range: 2291 µm; 1, SNr: 200002, Range: 2320 µm`

Related commands

SEN (Select chromatic calibration)

2.49 SFD (Set factory defaults)

Command format

SFD [<arg0>]

Argument quick info

No.	Type	Value	Default	Description
arg0	int	0, 1	-	Whether network settings shall be reset

Description

This command resets all device parameters to their factory default values. The only exception are the network settings. They will not be reset, if no argument or “0” is given together with this command. Only SFD 1 will also reset those network settings.

Examples

Input	Comment
SFD	Sets parameters to factory default values except the network settings.
SFD 0	Sets parameters to factory default values except the network settings.
SFD 1	Sets parameters to factory default values including the network settings.

Related commands

SSU (Save setup)

2.50 SHZ (Set sample frequency in Hz)

Command format

SHZ <arg0>

Argument quick info

No.	Type	Value	Default	Description
arg0	float	Detector specific	4000	Sample frequency in Hz

Description

Using this command, users can set the sample rate to an arbitrary value in Hz. Every value between a lower boundary given by the parasitic light during dark reference and the upper boundary given by the detector type may be specified.

The upper boundary can be determined by issuing IDE and looking for the value of the key `personality.caps.max_frequency`.

Due to the nature of the internal time base, not every sample rate can be realized exactly. The exact frequency to which the sample rate has been “rounded” can always be queried with SHZ ?. The SHZ command response as well as its command updates also contains this information.

Good to know

If you don’t intend to use the double exposure mode, check that the duty cycle setting (DCY) is 100 % (or simply set it to 100 %).

Examples

Input	Comment
SHZ 400	Sets the sample frequency of the device in Hz.
SHZ ?	Returns the current value.

Related commands

IDE (Identification)

2.51 SOD (Set output data)

Scope

Dollar protocol only, for backwards compatibility

Command format

SOD [<arg0> to <arg15>]

Argument quick info

No.	Type	Value	Default	Description
arg0	int	0, 1	-	Enables (1) or disables (0) signal 0.
arg1	int	0, 1	-	Enables (1) or disables (0) signal 1.
arg2	int	0, 1	-	Enables (1) or disables (0) signal 2.
...	int	0, 1	-	...
arg15	int	0, 1	-	Enables (1) or disables (0) signal 15.

Description

This command is for dollar protocol backwards compatibility only. Only a subset of the result signals can be selected by this command. For the 16 possible 16 bit data words, 1 selects the word for transmission, 0 deselects the word. When less than 16 parameters are sent, the words with higher indices will not be included in the telegram.

A table describing the 16 data words can be found in Section 3.5.

Good to know

Do not use both SOD and SODX! Only use SOD for compatibility reasons. SODX should be used if possible.

Examples

Input	Comment
SOD 1 0 0 1	Includes the output words Distance 1 and Intensity 1 in the output telegram.
SOD ?	Returns the current values.

Related commands

SODX (Set output data extended)

2.52 SODX (Set output data extended)

Scope

For packet protocol, the sequence of signals in the response may be reordered. For dollar protocol, the data will be sent in the same order as SODX input.

Command format

SODX [<arg0> <arg1> <arg2> ...]

Argument quick info

No.	Type	Value	Default	Description
arg0	int	u16	-	Signal ID to be output
...	...	...	...	Up to 32 signal IDs

Description

This command selects the signal IDs that will be included in the output packet. This setting is specific to each individual client. Learn more about signal IDs in Chapter 3 CHRocodile Signal IDs.

Good to know

- Do not use both SOD and SODX! Use only SODX and new signal ID definitions if possible (as outlined in Chapter 3 CHRocodile Signal IDs).
- SODX without an argument lets the device send data packets with an empty payload. In order to stop the output data stream, use STO instead.

Examples

Input	Comment
SODX 83 256 257	Selects sample counter, first detected distance and intensity for output packets.
SODX ?	Queries the currently active signal IDs.

Related commands

STO (Stop data)

2.53 SRI (Set refractive indices)

Command format

SRI <arg0> <arg1> ...

Argument quick info

No.	Type	Value	Default	Description
arg0	float	1–4	1	Refractive index of layer 1
arg1	float	1–4	1	Refractive index of layer 2
...	...	...	...	As many as number of layers (NOP - 1)

Description

Command to correct display of thickness and correct dispersion model. The parameter is given in floating point format.

In order to obtain correct thickness values, the thickness results have to be multiplied (or divided in the case of interferometric measurements) by the refractive index in the user application according to the formula specified in the description of the SCA command. The SRI setting on the CHRocodile is responsible for the dispersion correction and a correct absolute value on the display. The thickness and position output values on the analog outputs and the serial interface are still normalized to the respective full scale value and are only slightly affected by this parameter through the dispersion correction function (Abbe number).

Good to know

- Changing the refractive index may fail in interferometric mode (if the dispersion model calculation fails). Monitor the response in order to detect this situation and try other settings for CRA.
- In interferometric mode, only one refractive index value will be applied.
- In chromatic confocal mode, you should give as many refractive indices as there are layers to be measured, that is (number of peaks - 1).
- If the number of arguments sent is lower than the number of activated peaks, remaining SRI arguments are set to default value (1).

Examples

Input	Comment
SRI 1.2 1.3 2.1	Sets the refractive index for three layers.
SRI ?	Returns the current value(s).

Related commands

ABE (Abbe number)
CRA (Set active detector range)
NOP (Number of peaks)
SCA (Scale)
SRT (Set refractive index table)

2.54 SRT (Set refractive index table)

Command format

SRT <arg0> <arg1> to <arg14>

Argument quick info

No.	Type	Value	Default	Description
arg0	int	0–14	0	Refractive index table of layer 1
arg1	int	0–14	0	Refractive index table of layer 2
...	...	...	...	As many as number of layers (NOP - 1)

Description

Instead of modeling the refractive index vs. wavelength function by a rather simple model based on n_d and the Abbe number ν_d, the CHRocodile offers up to 15 different user definable dispersion tables. These dispersion tables are stored in the non-volatile memory. With the SRT command, one of these tables can be activated (the table corresponding to the parameter is selected).
The parameter value 0 deselects any refractive index tables and instead enables the dispersion model based on n_d and the Abbe number ν_d.
If a selected table is not filled with valid data, the CHRocodile will default to the n_d/ν_d dispersion model. The user has to interpret the response of the CHRocodile to the SRT command in order to know if the selected setting was accepted and applied.
After the command the CHRocodile responds with the active table index and its name.
When the thickness is output in the normalized integer format (16 or 32 bit), then the thickness output values are normalized to a fixed reference refractive index value (as with the n_d/ν_d dispersion model, where n_d is the reference refractive index). This reference refractive index value is part of the table and has to be queried by the SRI ? command in order to scale the output values correctly.

Good to know

- In interferometric mode, only one refractive index table will be applied.
- In chromatic confocal mode, you should give as many refractive indices as there are layers to be measured, that is (number of peaks - 1).
- If the number of arguments sent is lower than the number of activated peaks, remaining SRT arguments are set to default value (0).

Examples

Input	Comment
SRT 3 1 2	Sets three refractive index tables by index.
SRT ?	Returns the current value(s).

Related commands

ABE (Abbe number)
NOP (Number of peaks)
SRI (Set refractive indices)

2.55 SSQ (Synchronization sequence)

Scope

Dollar protocol only

Command format

SSQ <arg0> <arg1>

Argument quick info

No.	Type	Value	Default	Description
arg0	int	u8	255	Synchronization sequence byte 1
arg1	int	u8	255	Synchronization sequence byte 2

Description

Allows the user to set a customized telegram start sequence (instead of the default $FFFF) in dollar protocol and binary data mode. The 2 bytes immediately following the command will be used to indicate the beginning of every new data telegram (in binary mode). These bytes must follow the command directly with no separation character in between and must not be sent in hexadecimal notation.

There can be a permanent ambiguity about the start of the telegram when using this default sequence and the last telegram value is an intensity and the CHRocodile is in saturation. Under these circumstances, external data acquisition software will not be able to synchronize safely and it is good practice to change the synchronization sequence.

Good to know

A custom synchronization sequence will not be saved in non-volatile memory even after a SSU command.

Examples

Input	Comment
SSQxy	Sets the new telegram synchronization sequence to xy.

2.56 SSU (Save setup)

Command format	SSU
Argument quick info	No argument supported
Description	Saves the current setting to non-volatile memory. The sensor will start on the next power up with the saved configuration.

2.57 STA (Start data)

Command format	STA
Argument quick info	No argument supported
Description	Starts output data stream. This command only applies to the connection through which this command was received. E.g., if the command was received from the serial interface, the serial data output is started.
Good to know	Use STO to stop output data stream.
Related commands	STO (Stop data)

2.58 STO (Stop data)

Command format	STO
Argument quick info	No argument supported
Description	Stops output data stream. This command only applies to the connection through which this command was received. E.g., if the command was received from the serial interface, the serial data output is stopped. Note that with this command, only the output of measurement data is stopped, the device still performs measurements.
Good to know	Use STA to start output data stream.
Related commands	STA (Start data)

2.59 STR (Software trigger)

Command format

STR [<arg0>]

Argument quick info

No.	Type	Value	Default	Description
arg0	int	0, 1	0	0 = Sets the software trigger state to low. 1 = Sets the software trigger state to high. Without parameter = Generates trigger event

Description

There are two forms of this command: without parameters or with one parameter.

If used without parameter, a single trigger event is generated.

If issued with a parameter, the command sets the software trigger state according to the parameter value. As the internal trigger state is an XOR combination of the software trigger state and the input state of the Sync-in input, the software trigger state can be used to choose if the rising or falling edge of the Sync-in signal generates a trigger event:

If the software trigger state is set to 1, the CHRocodile will trigger on the falling edge of the Sync-in signal, whereas it triggers on the rising edge if STR is set to 0.

This parameter is not stored to nonvolatile memory and always initializes with 0 after power up.

Related commands

TRG (Trigger once)
TRE (Trigger each)
TRW (Trigger window)

2.60 TABL (Table handling)

Scope

Packet protocol only

Command format

TABL <arg0> <arg1> <arg2> <arg3> [<arg4>]

Argument quick info

No.	Type	Value	Default	Description
arg0	int	1–15	-	Table type or ID
arg1	int	0–16	-	Table index
arg2	int	u32	-	Offset in bytes of <arg4> within the complete table
arg3	int	u32	-	Table total size in bytes
arg4	blob	-	-	Fragment of table data in binary format

Description

This command is used to upload (or download in case of TABL <arg0> ?) various binary data blocks, e.g., calibration or spectral correction tables.

Tables that are larger than 4096 bytes have to be split in chunks of 4096 bytes or smaller. Each of the chunks shall be uploaded or downloaded by a separated TABL command. Note the correct ordering of those commands. No other command is allowed in between.

The blob argument <arg4> must be given if an upload is intended. The corresponding command response will not reflect that blob back to a client. In case of a download, a given <arg4> in the command will be simply ignored. The binary data is contained in the blob argument of the command response.

Available table types are specified in the following table:

ID	Indices	Bytes	Query	Name
1	0–15	4096	Yes	Confocal calibration
2	0	4096	Yes	Interferometric calibration
3	1–16	420	Yes	Refractive index table
4	0	2048	Yes	Constant dark correction
7	0	2048	Yes	Fourier amplifier table
9	0	2048	Yes	Exposure dark correction
10	0	2048	Yes	Exposure lighting dark correction
11	0	2048	Yes	White correction
13	0	2048	No	Simulated input spectrum

Further details on selected tables can be found in Appendix A.1 and A.2.

Good to know

Accidental erroneous application of this command may lead to incorrect adjustment of the device (e.g., by overwriting the calibration). To prevent property damage when uploading tables, please contact Precitec Optronik for further information.

2.61 THR (Threshold, confocal mode)

Scope

Chromatic confocal mode only

Command format

THR <arg0>

Argument quick info

No.	Type	Value	Default	Description
arg0	int	0–1000	40	Confocal peak detection threshold

Description

This command lets you specify an intensity threshold for the peak detection. The threshold parameter is used to tune the peak detection algorithm to the desired sensitivity. It should be set as low as possible to be able to measure dark surfaces, but high enough to suppress the detection of noise spikes when there is no object in the detection range.

The threshold is in arbitrary units.

If the sensor doesn't detect a signal which passes the threshold, 0 is output for distance and intensity. However, this behavior doesn't disturb the averaging algorithm, as invalid results are excluded from averaging.

Good to know

In most cases, high <arg0>-values are not very useful, since noise is no longer detected even at small values. Especially for weak signals or high measuring rates, you should choose a small threshold and increase the threshold empirically upwards.

Examples

Input	Comment
THR 30	Sets the threshold to 30.
THR ?	Returns the current values.

Related commands

QTH (Quality threshold, interferometric mode)

2.62 TRE (Trigger each)

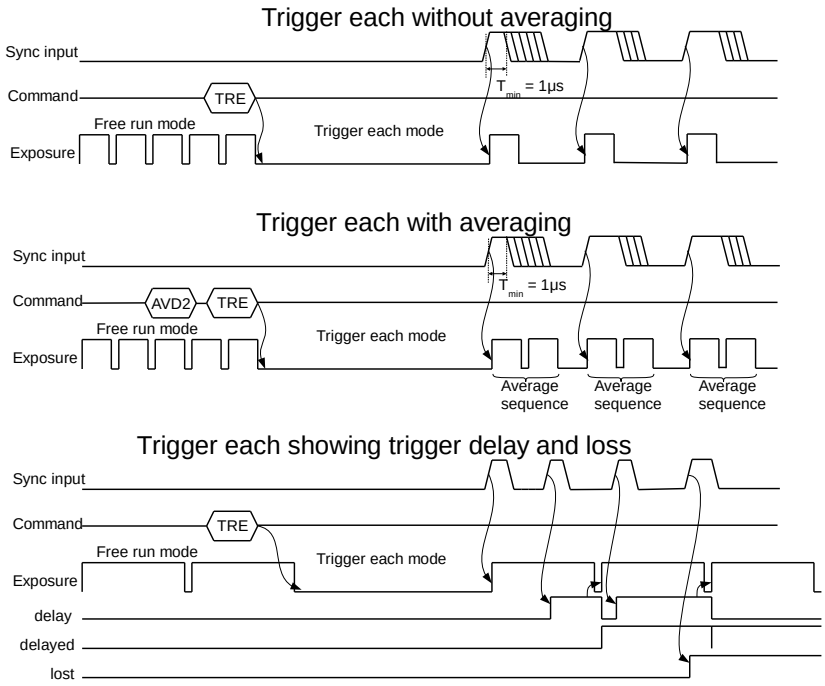
Command format TRE

Argument quick info No argument supported

Description Switches to Trigger Each mode: In this mode, every trigger event triggers one exposure or a burst of AVD*AVS exposures, if averaging has been activated by setting AVD (Data averaging) and/or AVS (Spectra averaging) to values >1. Each exposure (or the first exposure of an averaging burst, respectively) will begin exactly at the trigger event.

If the previous exposure is still ongoing, the trigger will be delayed until the detector is ready. If the device receives a trigger event while the preceding delayed trigger still waits for execution, the trigger event will be lost and the trigger lost counter will be incremented. Delayed and skipped trigger events are flagged in the "Exposure-flags" result signal (ID 76, see Section 3.4).

Data (AVD) and spectral (AVS) averaging is possible in Trigger Each mode. In Trigger each mode, one trigger event will start a sequence of AVD*AVS exposures. The AVD*AVS exposures are executed with the current sample rate (SHZ). One averaged result will be output after the exposure sequence. There will be only one trigger event on the Sync-out signal per n samples to be averaged. The pulse marks the beginning of the first exposure of the averaging interval. In the other trigger modes, there is one Sync-out pulse for every exposure, regardless of averaging.



Good to know The command CTN resumes normal operation (free run mode).

Related commands AVS (Spectra averaging)
AVD (Data averaging)

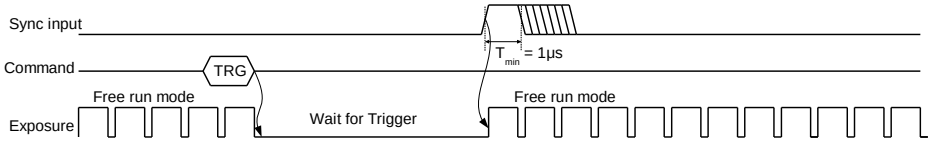
CTN (Continue in free run mode)
STR (Software trigger)
TRG (Trigger once)
TRW (Trigger window)

2.63 TRG (Trigger once)

Command format TRG

Argument quick info No argument supported

Description Switches to Trigger Once mode: Stops the free run mode and waits for a trigger event. The trigger event restarts the free run mode. The first exposure will occur immediately at the trigger event.



Good to know In addition to a trigger event, the CTN command can be used to resume normal operation (free run mode).

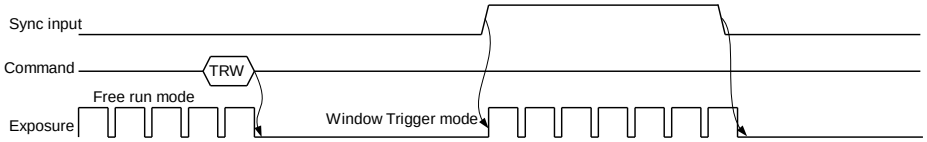
Related commands CTN (Continue in free run mode)
TRE (Trigger each)
TRW (Trigger window)

2.64 TRW (Trigger window)

Command format TRW

Argument quick info No argument supported

Description Switches to Window Trigger mode: The device is in free run mode as long as the trigger signal is high. The first exposure starts synchronously with the trigger event.



Good to know The command CTN resumes normal operation (free run mode).

The Window Trigger mode can be combined with the window average mode (AVD 0). In this case, one result sample is produced for each high period of the trigger signal. This sample averages all measurements started between a rising and a falling edge of the trigger signal.

Related commands

AVD (Data averaging)
CTN (Continue in free run mode)
STR (Software trigger)
TRE (Trigger each)
TRG (Trigger once)

2.65 ULFW (Upload firmware)

Command format

ULFW <arg0> <arg1> <arg2>

Argument quick info

No.	Type	Value	Default	Description
arg0	int	-	-	Offset of the current chunk within the firmware file
arg1	int	-	-	Total firmware file size in bytes (not size of the current chunk)
arg2	blob	-	-	Blob argument containing the current chunk

Description

A firmware can be uploaded by this command. The data packets must be sent in sequential order.

The maximum allowed blob size is 4096 bytes. All chunks must be sent in their correct order. The offset of the first chunk must be 0. For the next chunks:

start offset current chunk = start offset previous chunk + blob size previous chunk

2.66 VER (Version information)

Command format VER

Argument quick info No argument supported

Description This command queries identification key-value pairs. It returns value pairs of the form:
<key1>=<value1><crlf><key2>=<value2><crlf>...

In case of CHRocodile 2, the following keys are defined:

- “firmware_version”: X.Y.Z, where X, Y, Z are version major/minor numbers
- “build”: Additional build information
- “hardware_serial_number”: Mainboard serial number
- “device_serial_number”: Device serial number

Examples

Input	Comment

VER	Returns for example the following string:
	
	`firmware_version=1.0.0-CMV_2000`
	`build=r # d15da113af # 386 #`
	`2017-09-13T13:55:09+0200`
	`2017-09-13T14:20:59+0200`
	`hardware_serial_number=0046`
	`device_serial_number = 0`

Related commands IDE (Identification)

Chapter 3

CHRocodile Signal IDs

3.1 Introduction

Overview

The following chapter describes the use of signal IDs. These IDs are used together with the SODX (Set output data extended) command to control the composition of the output packet that is produced for every measured sample.

First, an overview diagram is provided that explains how the signal ID is composed. Then, examples for defining some signal IDs are given, followed by a list of global signals (with detailed description of the ExposureFlags signal). Finally, a list is appended with the signal ID range from 0 to 63, which serves for compatibility to CHRocodile devices of older generations.

Peak/global signals

Signals are either peak signals or global signals. Peak signals relate to measured surfaces. There can be several peak signals (belonging to different measurement channels and/or surfaces) in one sample, whereas global signals represent information that is common for all channels of a sample.

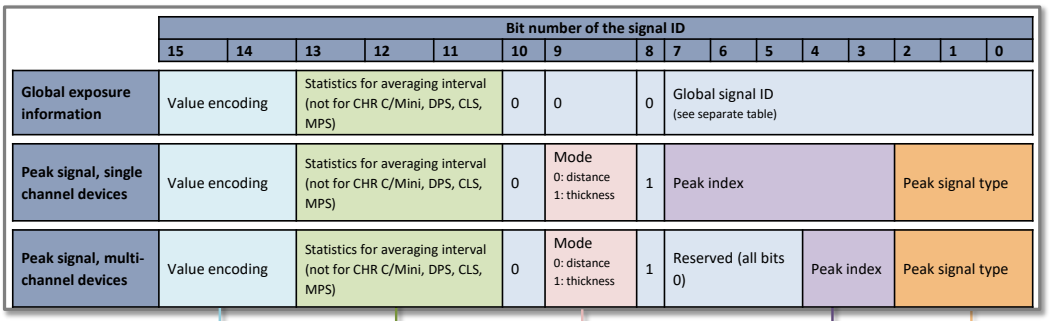
Examples global signals	Examples peak signals
Time stamp, encoder values, sample counter ...	Distance, Thickness, Intensity ...

Thus, while some values are defined only once per sample, others can be specified for each detected peak. In contrast to a global signal, a peak signal is always a combination of the measured value and the number of the corresponding peak.

Selecting signals

Signal IDs to be included in the output packet can be selected with the SODX command, see SODX (Set output data extended) command for details.

3.2 Signal ID definition



	Bit number of the signal ID															
	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Global exposure information	Value encoding		Statistics for averaging interval (not for CHR C/Mini, DPS, CLS, MPS)			0	0	0	Global signal ID (see separate table)							
Peak signal, single channel devices	Value encoding		Statistics for averaging interval (not for CHR C/Mini, DPS, CLS, MPS)			0	Mode 0: distance 1: thickness	1	Peak index					Peak signal type		
Peak signal, multi-channel devices	Value encoding		Statistics for averaging interval (not for CHR C/Mini, DPS, CLS, MPS)			0	Mode 0: distance 1: thickness	1	Reserved (all bits 0)			Peak index		Peak signal type		

Bit number			Statistics (in case of averaging, see AVD)
13	12	11	
0	0	0	Raw value / Average of raw values
0	0	1	Standard deviation (in average interval)
0	1	0	Number of valid values (in average interval)
0	1	1	Minimum (in average interval)
1	0	0	Maximum (in average interval)
1	0	1	Peak-to-Peak difference (max-min) (in average interval)

Note: Statistics are not available for CHR C/Mini, DPS, CLS, MPS!

Bit number					Peak number
7	6	5	4	3	
0	0	0	0	0	1st peak
0	0	0	0	1	2nd peak
0	0	0	1	0	3rd peak

Bit number	Mode
9	
0	Distance (in confocal mode) Thickness (in interferometric mode)
1	Thickness in confocal mode (distance difference between selected and next peak)

Bit number			Signal Name	Description
2	1	0		
0	0	0	PeakValue	Distance / Thickness
0	0	1	PeakIntensity / PeakQuality	Confocal mode: Intensity of peak Interferometric mode: Quality of FFT peak
0	1	0	CCDSaturation	Confocal mode: Peak height on detector in percent of full well
0	1	1	PeakPos	Confocal: detector pixel position Interferometric mode: Bin position of FFT peak
1	0	0	PeakValue Median	Median of PeakValue (median depth defined with MEDX/MED command)
1	0	1	PeakWidth	Confocal mode only: peak width, given in pixels

Bit number		In case of geometrical quantities (e.g. distance or thickness)	In case of non-geometrical quantities	
15	14		Native number values (e.g. peak intensity)	Native integer values (e.g. encoder)
0	0	Float in µm, including refractive index (geometrical thickness)	Float (IEEE 754)	32-bit integer
0	1	Integer 16 bit, scaled as fraction of measurement range, without refractive index. Distance and thickness values are given as: d[µm] = value * SCA[µm] / 2^{15}. To get the geometrical thickness, the value has to be multiplied (chrom. confocal case) or divided (interferometric case) by the index of refraction of the material.	Truncated 16-bit integer	Least significant 16-bit
1	0	32-bit integer value in nanometers, including refractive index (geometrical thickness)	32-bit integer value	Most significant 16-bit
1	1	Integer 32 bit, scaled as fraction of measurement range, without refractive index. Distance and thickness values are given as: d[µm] = value * SCA[µm] / 2^{31}. To get the geometrical thickness, the value has to be multiplied (chrom. confocal case) or divided (interferometric case) by the index of refraction of the material.	undefined	undefined

3.3 Examples of some signal IDs

What is the signal ID of Distance 1 in 16-bit integer format?

Bit number	Binary value	Description
15 to 14	0 1	For 16-bit integer format
13 to 11	0 0 0	Average, in case averaging is activated by AVD
10 to 09	0 0	For Distance
8	1	For a peak signal
7 to 3	0 0 0 0 0	For the first peak = Distance 1 / Thickness 1
2 to 0	0 0 0	For the distance or thickness value
Total signal ID	0 1 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0	= 16640 (decimal)

To request Distance 1 in 16-bit integer format, the command is SODX 16640.

What is the signal ID of Distance 2 in float format?

Bit number	Binary value	Description
15 to 14	0 0	For float format
13 to 11	0 0 0	Average, in case averaging is activated by AVD
10 to 09	0 0	For Distance
8	1	For a peak signal
7 to 3	0 0 0 0 1	For the second peak = Distance 2 / Thickness 2
2 to 0	0 0 0	For the distance or thickness value
Total signal ID	0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 1 0 0 0	= 264 (decimal)

To request Distance 2 in float format, the command is SODX 264.

What is the signal ID of Thickness 1 in float format?

Bit number	Binary value	Description
15 to 14	0 0	For float format
13 to 11	0 0 0	Average, in case averaging is activated by AVD
10 to 09	0 1	For Thickness
8	1	For a peak signal
7 to 3	0 0 0 0 0	For the first peak = Distance 1 / Thickness 1
2 to 0	0 0 0	For the distance or thickness value
Total signal ID	0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0	= 768 (decimal)

To request Thickness 1 (in chromatic confocal mode) in float format, the command is SODX 768.

What is the signal ID for the encoder counter X in 32-bit integer format?

Bit number	Binary value	Description
15 to 14	0 0	For 32-bit integer format
13 to 11	0 0 0	Average, in case averaging is activated by AVD
10 to 09	0 0	In case a global signal is selected
8	0	For global signal
7 to 0	0 1 0 0 0 0 0 1	For the x-encoder, decimal value = 65
Total signal ID	0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 1	= 65 (decimal)

To request the value of encoder counter X in 32-bit integer format, the command is SODX 65.

3.4 Global signals

Signal ID	Signal name	Native type	Remarks
64	StartTime	u32	In ns, free running time base
65	Start_PositionX	s32	X-encoder position at the beginning of the exposure
66	Start_PositionY	s32	Y-encoder position at the beginning of the exposure
67	Start_PositionZ	s32	Z-encoder position at the beginning of the exposure
68	Start_PositionU	s32	U-encoder position at the beginning of the exposure
69	Start_PositionV	s32	V-encoder position at the beginning of the exposure
70	Stop_PositionX	s32	X-encoder position at the end of the exposure
71	Stop_PositionY	s32	Y-encoder position at the end of the exposure
72	Stop_PositionZ	s32	Z-encoder position at the end of the exposure
73	Stop_PositionU	s32	U-encoder position at the end of the exposure
74	Stop_PositionV	s32	V-encoder position at the end of the exposure
75	ExposureCount	u16	Exposure number of the first exposure in of the averaging cycle
76	ExposureFlags	u16	Bits containing information about the exposure (see details below)
77	RealExpTimeNs	u32	Exposure time of detector (ns)
78	RealLightingTimeNs	u32	Time when the light source is on during exposure (ns)
79	TriggerLostCounter	u16	Number of trigger events that have been ignored since the last sample because the detector was not ready to be triggered
80	NumberOfValidPeaks	u16	Number of peaks that have been found in the spectrum
81	TicketNumber	u16	Command ticket number, for diagnosis
82	InterferomIntensity	float	Highest intensity on detector in percent of full well
83	SampleCounter	u16	Counts samples that have been processed
84	Reserved	-	Reserved
85	interfEnergy	float	Accumulated energy of the completed spectrum (interferometric mode only)
86	Health_DSPLoad	u32	DSP load in 1/1000 of full load
87	Health_TicketWrongOrder	u32	Error counter
88	Health_UPPLostCount	u32	Error counter: spectrum lines lost during transmission
89	Health_ExposureLostCount	u32	Error counter
90	Health_UPPNotFinished	u32	Error counter
91	PacketTimestampOffset	s32	Only defined for packet protocol; never ordered by SODX. For detailed description see below.
92	Reserved	-	Reserved
93	Internal temperature	s16	Format: degree Celsius * 100; measurement location is device specific.
94	LostAnalogValues	s16	Counts result values written to analog output that have been lost because of buffer overflow.
95	PixelBlackValue	u16	Signal value on a black pixel of the detector
96	Counter80MHzMSB	u16	16 most significant bits of a counter running at 80 MHz (for backwards compatibility reason)
97	Counter80MHzLSB	u16	16 least significant bits of a counter running at 80 MHz (for backwards compatibility reason)

Signal ID	Signal name	Native type	Remarks
...	Reserved	-	Reserved
240	CALC0Result	float	Result of calculation defined by CALC 0 (applies only to double channel devices (CHRocodile 2 DPS))
241	CALC1Result	float	Result of calculation defined by CALC 1 (applies only to double channel devices (CHRocodile 2 DPS))
242	CALC2Result	float	Result of calculation defined by CALC 2 (applies only to double channel devices (CHRocodile 2 DPS))
243	CALC3Result	float	Result of calculation defined by CALC 3 (applies only to double channel devices (CHRocodile 2 DPS))

ExposureFlags (ID 76)

In case of averaging, the ExposureFlags (ID 76) value is the bitwise OR combination of the ExposureFlags of the averaged exposures.

Bit number	Description
0 (LSB)	**Saturation** occurred on at least one detector pixel in current sample.
1	At least one **trigger was skipped** since last sample (Trigger lost).
2	Present sample based on a **delayed Trigger** event (system was not ready when trigger occurred).
3	Reserved
4	Reserved
5	Reserved
6	Reserved
7	Reserved
8	Second exposure (in double exposure mode)
9	Double exposure active
10	State of the Sync-in input (if usable for trigger)
11	Short Sync Pulse (2.5 µs) sent on Sync-out. Occurs every 2 s if time stamp synchronization (see OPD 6) is not active.
12	Short Sync Pulse (<3.5 µs) received from Sync-in. Can occur only if time stamp synchronization (see OPD 6) is not active.

PacketTimestampOffset (ID 91)

In “Trigger Each” mode, sample time stamps are not equidistant as in free run mode and therefore cannot be defined in terms of a starting time stamp and a sample frequency inside a data packet. Instead, every sample starts with a time stamp offset (32bit) which has to be added to the data packet time stamp (64bit) to obtain the effective time stamp of the sample:

Effective time stamp in seconds: $t_{sample} = \frac{t_{packet}+t_{offset}}{2^{32}}$

3.5 Definition of signal ID in range 0 to 63

The IDs of the global signals do not start at 0 but at 64. The range from 0 to 63 is reserved for compatibility with older CHRocodile generations that supported only 16 bit integer signals. It aliases a subset of the normal signals.

Example:
ID 0 is an alias for ID 16640: Peak 0 distance value, 16 bit integer
Signals as defined for the CHRocodile 2 device.

For a complete list, see the following table:

Signal ID	Alias for signal in mode 0 (1 peak, distance)	Alias for signal in mode 1 (2 peaks, thickness)	Alias for signal in mode 2 (3 peaks, interferometric)
0	16640 (Distance 1 / 16 bit)	17152 (Thickness 1 / 16 bit)	16640 (Thickness 1 / 16 bit)
1	–	16640 (Distance 1 / 16 bit)	16648 (Thickness 2 / 16 bit)
2	–	16648 (Distance 2 / 16 bit)	16656 (Thickness 3 / 16 bit)
3	16641 (Intensity 1 / 16 bit)	–	16641 (Quality 1 / 16 bit)
4	–	16641 (Intensity 1 / 16 bit)	16649 (Quality 2 / 16 bit)
5	–	16649 (Intensity 2 / 16 bit)	16657 (Quality 3 / 16 bit)
6	16643 (peak 1 position, pixels)	16643 (peak 1 position, pixels)	16466 (Intensity / 16 bit)
7	–	–	–
8	32844 (ExposureFlags)		
9	32832 (Exposure time in 12.5 ns units)		
10	32833 (Encoder 0 position, 16 bit, most significant word)		
11	16449 (Encoder 0 position, 16 bit, least significant word)		
12	32834 (Encoder 1 position, 16 bit, most significant word)		
13	16450 (Encoder 1 position, 16 bit, least significant word)		
14	32835 (Encoder 2 position, 16 bit, most significant word)		
15	16451 (Encoder 2 position, 16 bit, least significant word)		
16	83 (Sample Counter)		
17	93 (internal temperature in °C * 100)		
32	75 (Exposure count)		
33	96 (Timecounter, 80 MHz most significant word)		
34	97 (Timecounter, 80 MHz least significant word)		

Chapter 4

Encoder Interface

4.1 Encoder interface

Overview

The CHRocodiles support interfacing incremental encoders in order to relate real world positions to the measurements in real time. Depending on the CHRocodile type 5 or 3 (CHRocodile C) encoder channels are supported. The encoder inputs are digital differential RS422-level A/B quadrature inputs. 120 Ohm termination resistors can be activated through control pins for subgroups of the encoder signals (see device manual).

The encoder interface records the exact position of the encoder-equipped axes at the acquisition moment of the measurement. Furthermore, it allows to trigger measurements at defined positions (see Section 5.2)

The encoder interface is controlled with the ENC command, which has several subfunctions.

The encoder functions let the user set and query the current encoder position, define the source signals for the encoder counters and provide means to automatically set (preset) the encoder counter to a programmable value based on external signals.

The encoder command has the following format: ENC <*axis*> <*function*> <*arg*> where *axis* is the axis index 0..4, and *function* is:

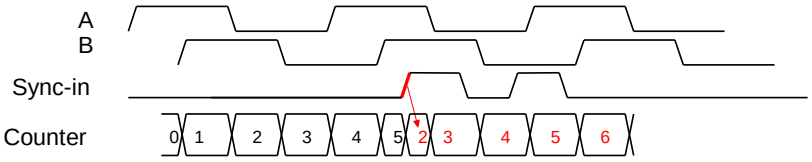
- **Function 0:** Set the encoder counter immediately to *arg* (example: `ENC 1 0 123` – sets the current axis 1 counter position to 123).
- **Function 1:** Set count source for counter:
  - *arg* = 15: Quadrature input of the axis defined by the axis argument (A/B encoder count). This is the standard case of operation and permits forward and backward position counting.
  - Alternatively, single inputs A0, B0, A1, . . . , B4 and Sync-in can be used for pulse counting (see pulse count mode below). In that case, the counter only counts up. The meaning of *arg* is as follows:

0:	A0
1:	B0
2:	A1
3:	B1
. . .	. . .
. . .	. . .
. . .	. . .
9:	B4
10:	Sync-in

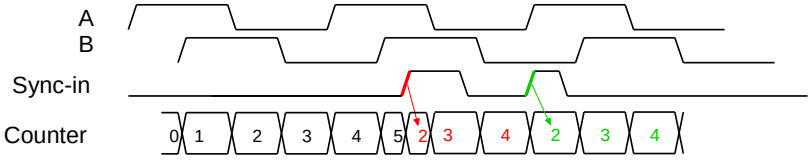
- **Function 2:** Set preload value. *arg* sets the value that will be loaded into the counter when a preload event occurs. The preload event is selected with function 3, see below.
- **Function 3:** Set preload event. The preload event generation is defined by *arg* where the bits have the following meaning:
  - Bit 7: active (1) / inactive (0) – turns preloading on / off
  - Bit 6: State (1) / Edge (0) – determines whether the preload event is triggered on state or edge of the selected input. Please note that the state mode only works in conjunction with Bit 4 (always) set to 1.
  - Bit 5: Falling edge (or low state) (1) / Rising edge (or high state) (0)
  - Bit 4: always (at every event) (1) / single (only once) (0)
  - Bits 3..0: Preload Event selector:

0:	A0
1:	B0
2:	A1
3:	B1
...	...
...	...
...	...
9:	B4
10:	Sync-in
11–14:	Reserved
15:	Immediate preload

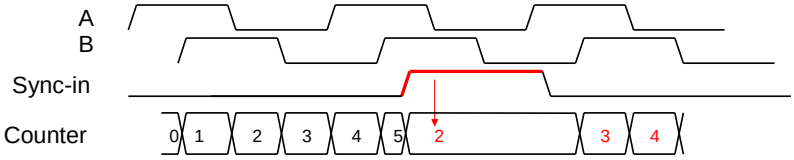
The following waveforms illustrate different preload scenarios. In all examples, the preload value register has been preloaded with the value of 2. The preload event is derived from the Sync-in input.



Preload event behaviour after Command ENC0 3 138 (active/edge/rising/single/Sync-in)



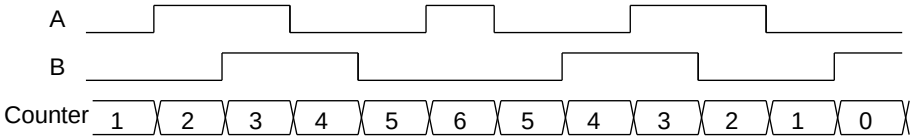
Preload event behaviour after Command ENC0 3 154 (active/edge/rising/multiple/Sync-in)



Preload event behaviour after Command ENC0 3 202 (active/state/high/single/Sync-in)

Quadrature count mode

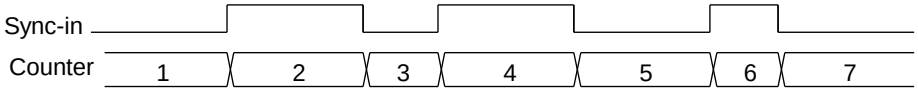
In quadrature mode (default), the phase shift between the rectangle signals on A and B decides if the counter is incremented or decremented. As an example, we assume a quadrature signal on encoder channel 0 (`ENC 0 1 15`):



Pulse count mode

If a single encoder signal Ax or Bx or Sync-in is selected as count source, then the counter is in pulse count mode. It increments on every edge and never counts down. Another speciality of this mode is that the bit 0 of the count value always reflects the current state of the selected input: If the input is low, the count will always be odd and if the signal is high, the count will always be even. Thus, the state of an input can be monitored. For the example below we assume that Sync-in has been selected as count source for counter 0 (`ENC 0 1 10`):

Note: Odd count value on low, even on high signal!



Examples

Examples:

`ENC 0 1 15`	Connects counter 0 to quadrature encoder input A0/B0.
`ENC 3 1 15`	Connects counter 3 to quadrature encoder input A3/B3.
`ENC 4 1 10`	Connects counter 4 as pulse counter to Sync-in.
`ENC 0 2 1234`	Sets the preload value of counter 0 to 1234.
`ENC 0 3 178`	(178 = 128 + 0 + 32 + 16 + 2) Configures the encoder counter to load the preload value 1234 into the counter 0 whenever a falling edge occurs on A1, i.e. the A input of encoder channel 1. Can be used e.g. for axis referencing.

Chapter 5

Triggered Measurements

5.1 Triggered measurements

Overview

The CHRocodile can perform measurements either in regular intervals (the so-called free running mode) or as a reaction on trigger events in one of the so-called trigger modes. There are 3 different trigger modes: *Trigger once* (TRG), *Trigger each* (TRE) and *Trigger window* (TRW).

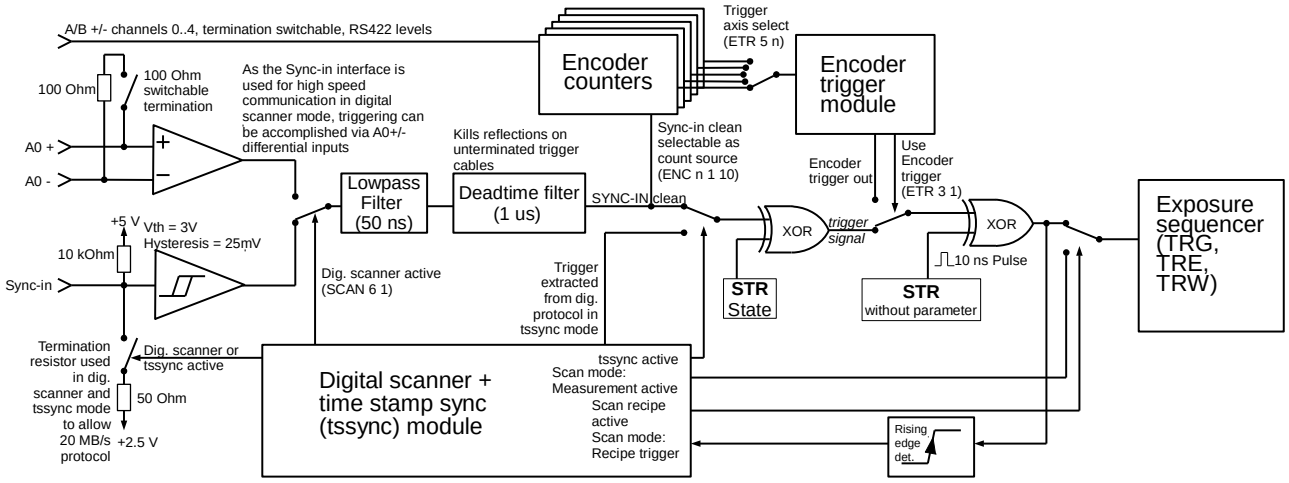
Trigger event

Trigger events can be generated by external signals, via software command or by the encoder trigger module. If encoder based trigger generation is disabled by ETR 3 0 (normal trigger), a trigger event is generated at each rising edge of the *trigger signal*. Otherwise, if encoder triggering is enabled using ETR 3 1, a trigger event occurs every time the specified encoder counter reaches the next trigger position. For details on encoder triggering, see Section 5.2.

Trigger signal

The trigger signal is a logical XOR combination of the digital input signal Sync-in and the software trigger signal set by command STR. Thus, the signal edge of the Sync-in signal that generates a trigger event can be selected (STR 0: rising edge, STR 1: falling edge). The STR state is initialized to 0 when the device boots up. For details, see STR (Software trigger). The level of Sync-in signal is pulled high +5 V by an internal pullup resistor (10 kOhm) if the connector is left open.

The following figure illustrates the trigger signal treatment:



Setting trigger mode

The following table lists commands to set the trigger mode:

Command	Description
TRG (Trigger once)	This command stops data acquisition. The sensor waits for a trigger event. When the trigger event occurs, data acquisition will continue in free run mode with the currently selected sample rate.
TRE (Trigger each)	With this command the sensor enters the trigger each mode. Every trigger event will generate one single sample. This mode is particularly useful in conjunction with encoder based trigger generation.
TRW (Trigger window)	With this command, the sensor enters the window trigger mode. The signal acquisition is stopped as long as the trigger signal is low. During the high periods of the trigger signal, the device's behavior is identical to the free run mode. The first exposure of a high period is synchronized to the rising edge of the trigger signal. When the signal goes low again, the acquisition stops.
CTN (Continue in free run mode)	The command CTN resumes free running operation mode.

TRE and averaging

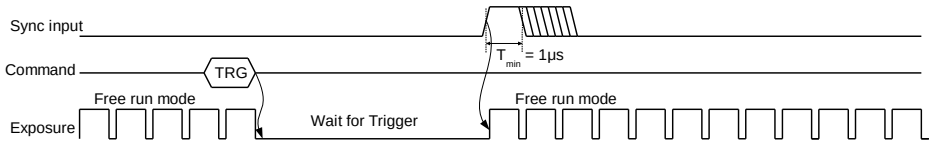
In Trigger each mode, one trigger event will start a sequence of AVD*AVS exposures. The AVD*AVS exposures are executed with the current sample rate (SHZ). One averaged result will be output after the exposure sequence. There will be only one trigger event on the Sync-out signal per n samples to be averaged. The pulse marks the beginning of the first exposure of the averaging interval. In the other trigger modes, there is one Sync-out pulse for every exposure, regardless of averaging.

Notice

The window trigger mode (TRW) can not be used meaningfully in combination with encoder triggering (ETR 3 1).

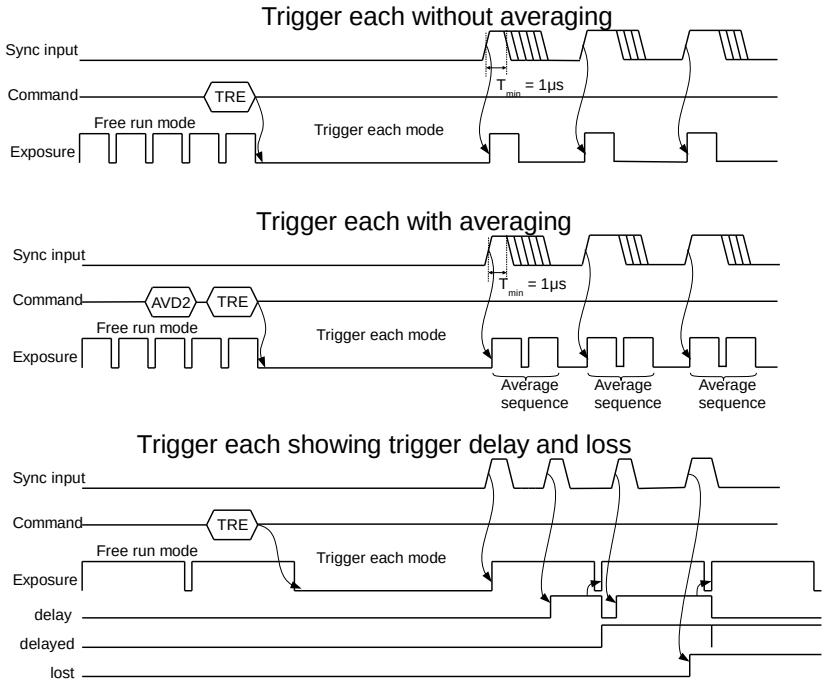
Trigger once

The figure below illustrates Trigger once mode:



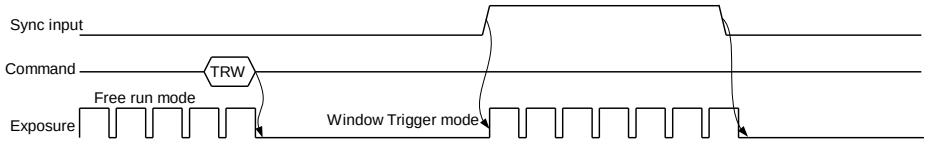
Trigger each

The figure below illustrates Trigger each mode:



Trigger window

The figure below illustrates Trigger window mode:



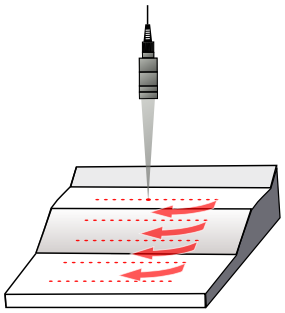
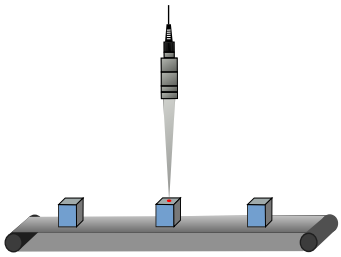
5.2 Encoder trigger control

Overview

The following sections deal with the use of the encoder trigger. Encoder positions are captured via the encoder input and allow precise allocation of the measuring points to the axis positions. In addition to just recording the axis position at the measurement moment, the encoder unit can be used to trigger measurements at exact positions.

Encoder trigger

The encoder trigger can operate in two ways (see the following pages for details):

Mode	Description	Illustration
Roundtrip trigger	For the use in raster scanning applications, where one scanning axis goes back and forth and the trigger is used to align the measurement to the axis positions	
Endless trigger	For applications where the encoder primarily moves in one direction as for example in production lines or on rotation tables	

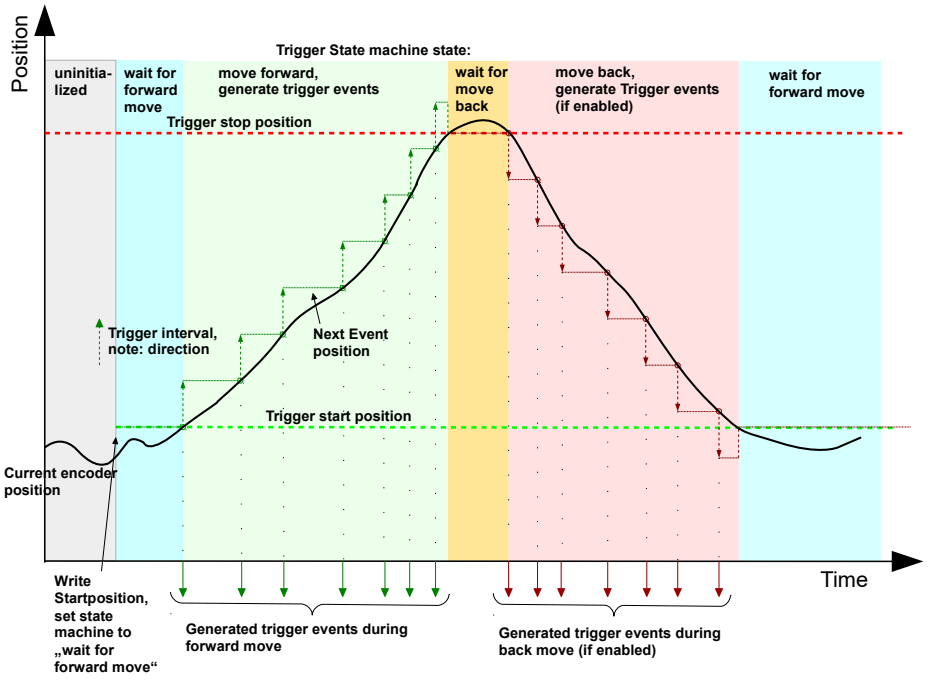
5.2.1 Encoder roundtrip trigger

Overview

The roundtrip trigger mode is provided for the use in raster scanning applications, where one scanning axis goes back and forth and the trigger is used to align the measurement of the CHRocodile to the scan axis positions. You can generate trigger events at programmable regular position intervals beginning with a starting position and ending with a stop position. You can select if trigger events are only generated during the move in one direction or also during the return movement.

Illustration

The following figure illustrates the operating principle of the roundtrip trigger. In this mode the encoder trigger is implemented as a state machine:



- In order to function correctly, the state machine has to be initialized to the “wait for forward move” state. This is accomplished automatically when setting the start position.
- In the “wait for forward move” state, the encoder trigger state machine waits for the encoder counter of the selected axis to pass the start position (in either direction) where it generates the first trigger event. The state machine changes to the “move forward” state. The trigger interval is added to the start position in order to calculate the next trigger position.
- If the trigger position is reached, a trigger event is generated. The trigger interval is added to the trigger position in order to generate the next trigger position. This step is repeated until the stop position is encountered. The generation of trigger events is then stopped and the state machine changes to the “wait for move back” state.
- If triggering during return movement is selected, the state machine waits for the stop position to be passed once again and then changes to “move back” state. It then generates trigger events similarly to the forward movement (the trigger interval is now subtracted instead of added) until the start position is reached. The state machine then goes back to the “wait for forward move” state.

If no trigger during return movement is selected, the state machine waits for the start position to be passed over (during return movement) and then passes to the “wait for forward move” state.

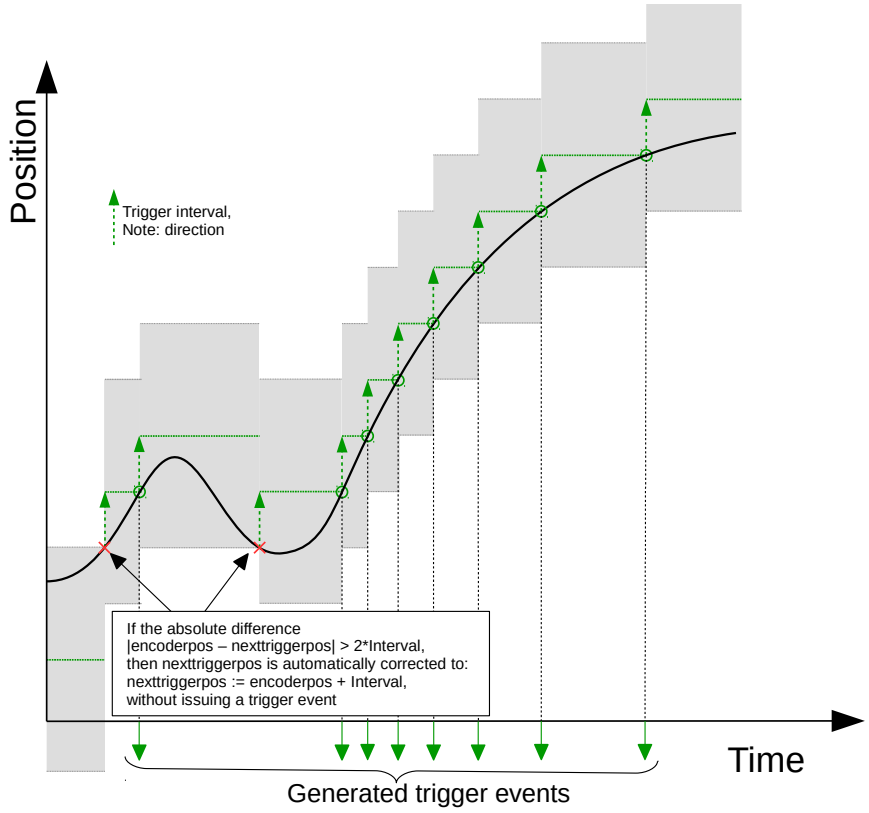
5.2.2 Encoder endless trigger

Overview

The endless trigger mode is designed for applications where the encoder primarily moves in one direction as for example in production lines or on continuously rotating samples. In order to use this mode, only a trigger interval has to be parametrized.

Illustration

The following figure illustrates the operating principle of the endless trigger:



5.2.3 Encoder trigger programming

ETR command family

The ETR (Encoder trigger control) command groups several functions related to encoder triggering. It controls how encoder counters can generate trigger events. For more information about trigger modes, see TRG (Trigger once), TRW (Trigger window) and TRE (Trigger each) description. The command format is as follows:

ETR <*function*> <*arg*>

where *function* is:

- 0: Set start position (*arg* = start position (int) to set, see figure)
- 1: Set stop position (*arg* = stop position (int) to set, see figure)
- 2: Set trigger interval (*arg* = trigger interval (float)). Note that the interval can be given in fractions of encoder counts! (e.g. float value 100.5). The next trigger position is calculated by adding the Interval value to the last trigger position. **If (Stop position) - (Start position) is negative, the trigger interval value must also be negative!**
- 3: Select encoder trigger source
  - *arg* = 0: (default) Deactivate encoder trigger, trigger by Sync-in or software (STR command).
  - *arg* = 1: Activate encoder trigger.
- 4: Enable trigger during return movement
  - *arg* = 0: (default) Encoder trigger is only active during the movement from start position to stop position.
  - *arg* = 1: Encoder trigger is also active during the return movement from stop position to start position.
- 5: Choose axis: *arg* = index of the encoder counter used as trigger source. Default source is encoder counter 0.
- 6: Reserved (0)
- 7: Endless/Roundtrip trigger
  - *arg* = 0: (default) Round trip trigger. Start/stop positions are used.
  - *arg* = 1: Endless trigger. Generate one trigger event on every interval regardless of any start/stop position.

Examples

Example command sequence 1:

No.	Command	Type Description
1	`ENC 0 0 0`	(Re-)Set current encoder position of axis 0 to 0.
2	`ETR 4 0`	Don't trigger during return movement.
3	`ETR 5 0`	Choose axis 0 as encoder trigger source.
4	`ETR 7 0`	Round trip trigger mode (for back and forth movements, as opposed to continuous movements)
5	`ETR 1 1000`	Set trigger stop position to 1000.
6	`ETR 2 10.5`	Set trigger interval to 10.5 counts.
7	`ETR 0 100`	Set trigger start position to 100 (must come after ETR 2 and ETR 1 in order to reset the trigger state machine).
8	`ETR 3 1`	Activate Encoder Trigger (deselect Sync-in / software as trigger source).
9	`TRE`	Set CHRocodile to trigger each mode.

This command sequence sets the current counter 0 to zero and configures the trigger logic to start triggering at position 100 of encoder counter 0, stop counting at position 1000, and fire one trigger every ten counts. The last command TRE (Trigger each) sets the device to trigger each mode. At positions 100, 110, 121, . . . , 971, 982 and 992 one sample will be acquired every 10 or 11 counts (10.5 as interval, 85 samples in total).

Example command sequence 2:

No.	Command	Type Description
1	`ENC 2 0 0`	(Re-)Set current encoder position of axis 2 to 0.
2	`ETR 5 2`	Choose axis 2 as encoder trigger source.
3	`ETR 1 2000`	Set trigger stop position to 2000.
4	`ETR 2 -100`	Set trigger interval to -100 (negative, as start position is greater than stop position.
5	`ETR 0 2950`	Set trigger start position to 2950 (must come after ETR 2 and ETR 1 in order to reset the trigger state machine).
6	`ETR 3 1`	Activate encoder trigger (deactivate Sync-in / software as trigger source).
7	`TRE`	Set CHRocodile to trigger each mode.

In example 2, the start position is greater than the stop position. Therefore, a negative value must be given to the interval value. In this setting, 10 samples will be generated.

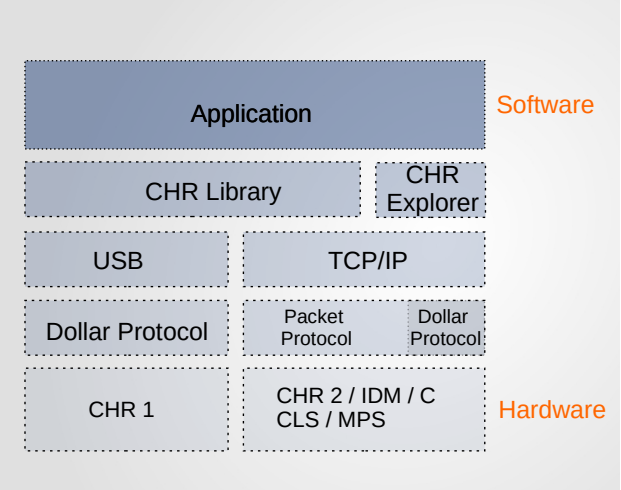
Chapter 6

CHRocodile Library

6.1 Using the CHRocodile Library (CHRocodileLib)

Overview

The following figure gives a general overview on integration of the CHRocodile device into the application running on measuring systems. As illustrated, communication with the CHRocodile device can be carried out on the hardware side (using packet protocol or dollar protocol) or on the software side (using CHRocodile Library or CHR Explorer):



Note: Multi-channel devices such as CHRocodile MPS and CLS as well as the double channel device CHRocodile DPS do not fully support the dollar protocol. Only the binary packet protocol is available for data transfer with those devices.

CHRocodile Library

The library provides a universal interface for integrating CHRocodile devices. It encompasses basic functions for communicating with devices to acquire data and to set up the CHRocodile. This is an enormous advantage, as the different communication protocols mentioned in the previous chapters (dollar protocol, packet protocol) are device-specific and support a different set of commands.

Further features

Main features of the CHRocodile Library are:

- Multi-device support: Multiple devices can be operated in parallel and independently.
- Multi-connection support: One device can be operated by multiple library-hosted logical connections where each connection can send commands, receive replies, updates, and data independently.
- Synchronous / asynchronous operation

- Multi-threading support: Sending commands asynchronously and receiving data can be done in different threads.

Which devices?

The CHRocodile Library supports all kinds of CHRocodile devices:

- CHRocodile 1
- CHRocodile 2
- CHRocodile CLS/MPS/DPS
- CHRocodile C/Mini
- Precitec IDM

The CHRocodile Library provides the same interface for all these devices. Therefore, to connect to a different CHRocodile device, the client software does not need to change anything.

Which platform?

The CHRocodile Library is available as:

- Dynamic Link Library (DLL) for Windows XP, 7, 8, 10
- Shared object library for the Linux platform

Please contact our Support team for details.

Further details

For a more detailed description of the CHRocodile Library features and functions, refer to the document “CHRocodileLibAPI.pdf” (see the USB stick included in delivery).

Appendix A

Further Information

A.1 Specification of selected tables for single channel devices

Confocal calibration

A confocal calibration table yields a micrometer value for every pixel of the spectrum. The table descriptor contains some additional data such as the calibration date. A confocal calibration table for a single channel device is structured as follows:

```
typedef struct
{

u32 Calib_Date;          // simple date coding:
                         //      byte 0 / 5 LSBs: day;
                         //      byte 1 / 4 LSBs: month;
                         //      byte 2         : year - 2000
u32 TableMagicNumber;    // 0x6F4F960A
s32 MeasurementRange;    // in micrometers
u32 SerialNumber;        // of the probe
} ts_ConfocTableDescriptor

typedef struct
{
float LUT[n];                                    // in micrometers
ts_ConfocTableDescriptor ConfocTableDescriptor; //as declared above
} ts_ConfocTable
```

Note that n is not statically defined. Instead, the constant size of the table descriptor is subtracted from the total size of the binary data block. The remaining size divided by four is the number of spectral pixels of the calibration.

Interferometric calibration

This table provides a translation from CCD pixels to wavelengths and is structured as follows:

```
typedef struct
{
    float Lambda[1024 - 1];      //in nanometers
    s16 Reserve;
    s16 LastCCDPixel;            // number of detector pixels
} ts_Lambda_Pix;
```

Refractive indices

A user-defined table provides the wavelength-dependent index of refraction for a given material. 32 $n(\lambda)$ pairs can be passed to this list. For wavelengths between two such pairs, n will be interpolated. Each table can be named with a string of up to 32 characters. The checksum is the ones complement of the sum of the whole table (without the leading “checks” member), casted as 32 integers.

```
typedef struct
{
    float lambdanm; // lambda in nm
    float RI;       // refractive index, real part
    float RI_imag;  // refractive index, imag. part (reserved)
} ts_lambdaRI;

typedef struct
{
    u32 checks;                 //not used
    s8 name[32];                //0-terminated ASCII string
    ts_lambdaRI lambdaRI[32];   //as declared above
}ts_RI_Sourcetable;
```

A.2 Specification of selected tables for multi-channel devices

Confocal calibration

There are several formats for multi-channel calibration tables. One can differentiate between calibrations with a single optical probe and thus a common measuring range for all channels (CLS) and a multi-channel device using different single and multi-channel probes at the same time (MPS). In the first case, there is one common header (MCLUTDescriptor) for all channels. In the second case, which is signaled by the measurement range entry in the main header being 0, every channel has its own subheader that carries channel specific data.

For the actual calibration data of the channels, there are 2 formats which are distinguished by the “degree” entry of the main header. If “degree” is smaller than or equal to 9, the calibration data is in polynomial format, otherwise it is in sampled format.

Polynomial format

This format is deprecated.

In order to save table space, multi-channel calibrations are defined by polynomials for every channel. Polynomials of 8th degree (max.) are used. The complete calibration structure for one probe consists of a descriptor containing some meta information and the polynomial coefficients in the order:

```
(a8, a7, a6,..., a0) channel0,
(a8, a7, a6,..., a0) channel1,
...
```

Sampled format

For higher precision, the sampled format is used which consists of sampled distance values as 16 bit integers, normalized to the measuring range (unsigned short d16=(u16)(dist*65536.0/measuringrange)). The degree entry of the main header is used to describe the number of samples.

Notice: All the following structures are “packed”. Make sure that the compiler does not add any alignment padding!

Main header

```
typedef struct
{

    u32 Calib_Date;          // simple date coding:
                             //      byte 0 / 5 LSBs: day;
                             //      byte 1 / 4 LSBs: month;
                             //      byte 2         : year - 2000
    u32 MCLUTMagicNumber;    // = utCLSConfocalCalibration (5)
    s32 MeasurementRange;    // in micrometer
    u32 SerialNumber;        // serial number of the probe
    s16 degree;              // degree of polynomial or number of sampled points
    s16 NrOfChannels;        // number of channels (fibers) actually used

    u32 spectrumlength;      // only used with sampled format:
                             // length of the spectrum in pixels
                             // covered by the ''degree'' samples
    float channelpitch_um;   //
    u32 reserve[25];         // Reserved words for alignment reasons
} ts_MCLUTDescriptor
```

Subheader (MPS)

```
typedef struct
{
    u16 MeasurementRange;       // in micrometer
    s16 res16;                  // = 0, reserve for alignment
    u32 SerialNumber;           // serial number of the probe
    float DistToNextChannel_um;
} ts_MCLUTChannelDescriptor;
```

Channel specific (MPS)

Don’t use any `sizeof()` construct of this type as the actual size is determined by the number of samples given by the “degree”-entry in the main header.

```
1
2
3       typedef struct
4       {
5           ts_MCLUTChannelDescriptor MCLUTChannelDescriptor;
6           u16 distances[1];              //array of "degree" distances in micrometers
7       }t_sMCLUT_indiv_Channel;
```

Appendix B

Topic-Related Command Lists

B.1 Timing related commands

B.2 Dark/white reference related commands

B.3 Peak detection related commands

B.4 Trigger related commands

B.5 Dispersion related commands

B.6 Communication settings related commands