Laser Beam Stabilization

Description of the communication interface for the beam stabilization system
"Compact"

1. UART settings:

Encoding type: ASCII / binary
Baudrate: 115200 Bit/s (default), 460800 Bit/s, 921600 Bit/s
UART Setting: 8-N-1-CTS-RTS (8 Data bits, no parity, one stop bit, by default handshaking is on)

Each command consists of three uppercase letters followed by optional parameters and return values. The commands can be set either via the GUI or via an external controller. The commands and the semicolons are sent as ASCII characters and the parameters are transmitted binary-coded as unsigned short, short or char values. The byte order of 2 byte parameters or values is high byte first. The return values are also transfered binary-coded. The return value 0; is the acknowledge and shows that the command was recognized or has been executed. If your execution loop needs several commands it is recommended to wait for the acknowledgement before sending the next command.

2. Type of values and parameters:

Type	Size
unsigned short	16 bits = 2 bytes
unsigned char	8 bits = 1 byte
short	16 bits = 2 bytes
char	8 bits = 1 byte

Command parameters	Description and valid values
m (unsigned short)	Number of data blocks to be transmitted in a live stream (1-65500, 0=endless)
r (unsigned short)	Sampling rate for data blocks in samples/s (1 – 500 samples/s)
s (unsigned char)	Stage number to be selected (1 = stage1, 2 = stage2, 3 = both (only for software trigger commands (STF**s**; , CTF**s**;)))
p (unsigned short)	P-factor of control loop (0 – 5000mV)
o (short)	Offset for target position on detector (-5000mV – +5000mV)
a (unsigned char)	Axis to be selected ("x" (0x78) or "y" (0x79))
d (short)	Drive value for direct piezo positioning (-5000mV – +5000mV)
b (unsigned char)	Baudrate (1 = 115200 bit/s, 4 = 460800 bit/s, 9 = 921600 bit/s)
l[25] (unsigned char)	User defined label for the beam stabilization system (max length: 25 ASCII characters)

Return values	Description
A1 (unsigned char)	Stabilization of stage1 active or not active, 1 = active, 0 = not active
A2 (unsigned char)	Stabilization of stage2 active or not active, 1 = active, 0 = not active
OnOff1 (unsigned char)	Stabilization of stage1 enabled or disabled, 1 = enabled, 0 = disabled
OnOff2 (unsigned char)	Stabilization of stage2 enabled or disabled, 1 = enabled, 0 = disabled
StatusFlag (unsigned char)	Encoded status byte of current system state (see Fig. 3)
DX1 (short)	Detector1, beam position on x-axis (-5000mV – +5000mV)
DY1 (short)	Detector1, beam position on y-axis (-5000mV – +5000mV)
DI1 (unsigned short)	Detector1, intensity (0 – 8000mV)
DX2 (short)	Detector2, beam position on x-axis (-5000mV – +5000mV)
DY2 (short)	Detector2, beam position on y-axis (-5000mV – +5000mV)
DI2 (unsigned short)	Detector2, intensity (0 – 8000mV)
RX1 (unsigned short)	Piezo range of x-axis, stage1 (0 – 10000mV)
RY1 (unsigned short)	Piezo range of y-axis, stage1 (0 – 10000mV)
RX2 (unsigned short)	Piezo range of x-axis, stage2 (0 – 10000mV)

Return values	Description
RY2 (unsigned short)	Piezo range of y-axis, stage2 (0 – 10000mV)
p (unsigned short)	P-factor of control loop (0 – 5000mV)
o (short)	Offset for target position on detector (-5000mV – +5000mV)
d (short)	Drive Actuator values (-5000mV – +5000mV)
l[25] (unsigned char)	User defined label for the beam stabilization system (max length: 25 ASCII characters)
StatusFlag (unsigned char)	System status information (see Fig. 3)
Device_id[47] (unsigned char)	Unique device id, length: 47 byte
CMD[3] (unsigned char)	Name of the command that provoked the last error, length: 3 byte
e (char)	Error code

3. Error Handling

When an error occurred while calling a function, "1;" will be returned in contrast to "0;" when the function was called successfully. To investigate on the cause of an error, the command GER; can be used. It returns the last function that provoked an error as its name in ASCII characters. If the last command was not recognized, GER; will return "000". In addition to the name of the last function that provoked an error, GER; returns an error code that hints to the cause of the error. The error code is a signed char which can take the following values:

Error code **e**	Meaning	Comments
0 (0x00)	No error occurred since startup	The error code is only updated after an error occurred. Hence the error code is not reset to 0 when a function was called that did not provoke an error. Error code 0 is just the default value after startup.
-1 (0xff)	Command not recognized	The received command name does not match any of the specified commands. This is also the case if lowercase letters are sent instead of uppercase letters.
-2 (0xfe)	Parameter out of range	Please concern to section 2 for the allowed values of the parameters. If the parameters are in the specified range it could mean that they were sent as ASCII characters when hex numbers are needed or vice versa.
-3 (0xfd)	Wrong command length	This error code is set when a function was called with parameters that does not expect parameters. Calling a function that does expect parameters can also provoke this error code when the parameters sent exceed the specified length in byte (i.e. short was sent when char should have been sent). Note: If the total received bytes exceed 30, the error code -9 (Receive buffer overflow) is set.
-4 (0xfc)	Stream is running	After starting the stream with SLS no other command than CLS can be called. CLS will stop the stream and after that, other functions can be called. **Remark**: Calling GER while the stream is running will also set this error code. To investigate the error calling CLS to stop the stream is necessary first.
-5 (0xfb)	Stage is enabled	This error code is set when a function is called that needs a disabled stage while the concerning stage is enabled.
-6 (0xfa)	Stage is disabled	This error code is set when a function is called that needs an enabled stage while the concerning stage is disabled.
-7 (0xf9)	Stream is not running	Calling CLS while no stream is running will set this error code.
-8 (0xf8)	ADDA functions unavailable	This error code is set on Basic systems after trying to call a function that needs the optional ADDA-module. This concerns the commands CTF and STF. Note: The label on the backside of the controller indicates whether the system is equipped with an ADDA-module or not. In addition, the Device_Id returned by GID contains "AD-DA" for systems with an ADDA-module and "Basic" for those without.
-9 (0xf7)	Receive buffer overflow	The receive buffer can hold up to 30 byte. When the system receives more than 30 byte without a semicolon in between, the buffer will overflow and this error code will be set.

Remark: The error code is only updated after an error occurred. Hence the error code is not reset to 0 when a function was called that did not provoke an error.

4. Commands from external devices to the stabilization system

Command	Description	Parameter	Return	Status Flag (see section 5) & Errors	Comment
Command set for the real-time representation of the measured data					
S1S;	Start One Shot	-	• 0; (1; for error) • **StatusFlag** • **Res. Byte** • **DX1, DY1, DI1** • **DX2, DY2, DI2** • **RX1, RY1** • **RX2, RY2** • ;	-	One time transmission of the measured data block. The measured data is transmitted in the given order one by one as a data block (see figure 2). The end of the block is marked with a semicolon. The "Res. Byte" is reserved for special applications.
SLS**mr**;	Start Live Stream	• **m**: Number of data blocks to be transferred • **r**: Sampling rate for data blocks	• 0; (1; for error) Stream: • **StatusFlag** • **Res. Byte** • **DX1, DY1, DI1** • **DX2, DY2, DI2** • **RX1, RY1** • **RX2, RY2** • ; ...	Status flags: • **EF** (End of Stream Flag) is only high with **m** > 0 when the last package is send. After that **EF** returns to low Error if: • **m, r** out of range	Starts continuous transmission of data blocks. The measured data is transmitted in the given order one by one as a data block (see figure 2). **m**-data blocks will be transmitted. The end of a block is marked with a semicolon. 1 ≤ **m** ≤ 65500, **m** = 0 for endless transmission. The sampling rate **r** specifies the time interval during the transmission of two measurement packages. 1 ≤ **r** ≤ 500 samples/s The "Res. Byte" is reserved for special applications. **Remark:** No Timestamp
CLS;	Clear Live Stream	-	• Rest of data block; • 0; (1; for error)	Status flags: • **EF** (End of Stream Flag) high while the last package is send. After that **EF** returns to low Error if: • stream is not running	Stops the transmission of measured data. The last data block of a stream has a flag (**EF**) which is set, when a clear live stream was accepted.
Command set for individual parameters					
SSH**s**;	Start Set&Hold	• **s**: Stage number	• 0; (1; for error)	Status flags: • **OnOff1** & **Adj1** high if **s** = 1 • **OnOff2** & **Adj2** high if **s** = 2 Error if: • stabilization on stage **s** is enabled • **s** out of range	Freezes the current position on detector of stage **s** as target position for closed loop stabilization. Activation of stage **s**. Position is stored in non-volatile memory.
CSH**s**;	Clear Set&Hold	• **s**: Stage number	• 0; (1; for error)	Status flags: • **OnOff1** & **Adj1** low if **s** = 1 • **OnOff2** & **Adj2** low if **s** = 2 Error if: • **s** out of range	Deactivation of stage **s**. Resets target position to "0" (default) on detector of stage **s**.

Command	Description	Parameter	Return	Status Flag (see section 5) & Errors	Comment
SPF**sp**;	Set P-Factor	• **s**: Stage number • **p**: P-factor of control loop	• 0; (1; for error)	Status flags: • **PF** high if p-factor is set via software, low when set to external Error if: • **s** out of range • **p** out of range	For setups with extreme short or long distances between mirrors and detectors it is possible to optimize the stabilization performance by changing the p-factor. 1 ≤ **p** ≤ 5000, **p** = 0 for external P-settings. Value is stored in non-volatile memory.
GPF**s**;	Get P-Factor	• **s**: Stage number	• 0; (1; for error) • **p**: P-factor of control loop • ;	Error if: • **s** out of range	Request for p-factor of stage **s**.
SAI**sao**;	Set Adjust-In	• **s**: Stage number • **a**: Axis for position shift • **o**: Offset for target position	• 0; (1; for error)	Status flags: • **Adj1,2** high if adjust value of stage 1,2 is set via software, low when set to external Error if: • **s** out of range • **a** out of range • **o** out of range	This command allows to align the laser beam electronically. An offset **o** is added to the detector signal to shift the target position for the closed loop stabilization. -5000 ≤ **o** ≤ 5000, **o** = 0 for external adjustment. Value is stored in non-volatile memory.
GAI**sa**;	Get Adjust-In	• **s**: Stage number • **a**: Axis for position shift	• 0; (1; for error) • **o**: Offset for target position • ;	Error if: • **s** out of range • **a** out of range	Request for offset value of the Adjust-In function.
SDA**sad**;	Set Drive Actuator	• **s**: Stage number • **a**: Axis for position shift • **d**: Drive value for piezo actuators	• 0; (1; for error)	Error if: • **s** out of range • **a** out of range • **d** out of range	This command allows to drive the piezo actuators directly while the stabilization is deactivated. That way the start position of the piezo actuators before activating the stabilization can be optimized to achieve a faster settling time in stabilised position. -5000 ≤ **d** ≤ 5000. The values for **d** will be cleared automatically when the concerning stage **s** is turned on or the system is turned off. **Remark**: Setting a drive value will only have a lasting effect if the stabilization on the stage is inactive. In case CEA is used to deactivate the stage **s**, please wait for at least 600ms before setting a drive value.
GDA;	Get Drive Actuator	-	• 0; (1; for Error) • **d**(x/stage1) • **d**(y/stage1) • **d**(x/stage2) • **d**(y/stage2) • ;	-	The return values are bundled to an 11 byte long package.

Command	Description	Parameter	Return	Status Flag (see section 5) & Errors	Comment
SEA**s**;	Set External Activation	• **s**: Stage number	• 0; (1; for error)	Status flags: • **OnOff1** high if **s** = 1 • **OnOff2** high if **s** = 2 Error if: • **s** out of range	Enable closed loop laser beam stabilization of stage **s** to go active when laser power is high enough or ADDA is triggered.
CEA**s**;	Clear External Activation	• **s**: Stage number	• 0; (1; for error)	Status flags: • **OnOff1** & **A1** (Active Flag Stage 1) low if **s** = 1 • **OnOff2** & **A2** (Active Flag Stage 2) low if **s** = 2 Error if: • **s** out of range	Disable closed loop laser beam stabilization of stage **s**.
GEA;	Get External Activation	-	• 0; (1; for error) • **OnOff1** • **OnOff2** • ;	-	Request if closed loop stabilization is enabled (**OnOff1,2** = 1) or disabled (**OnOff1,2** = 0) to go active when laser power is high enough or ADDA is triggered.
GAS;	Get Active Signal	-	• 0; (1; for error) • **A1** • **A2** • ;	-	Request if closed loop stabilization is active (**A1,2** = 1) or not (**A1,2** = 0). Please note that the stabilization will be inactive automatically if the laser is off, the intensity on detectors < 0,5V or ADDA freezes actuators (even for **OnOff1,2** = 1).
STF**s**;	Set Trigger Freeze	• **s**: Stage number (1, 2, or 3 for both)	• 0; (1; for error)	Status flags: • **A1** (Active Flag Stage 1) low if **s** = 1 • **A2** (Active Flag Stage 2) low if **s** = 2 • **A1** & **A2** low if **s** = 3 Error if: • stage **s** is disabled • **s** out of range • system has no ADDA-module	Starts the ADDA-module to freeze the last position of actuator of stage **s**. **Remark**: This trigger command corresponds to the external hardware trigger (TTL=low) with the same priority.
CTF**s**;	Clear Trigger Freeze	• **s**: Stage number (1, 2, or 3 for both)	• 0; (1; for error)	Status flags: • **A1** (Active Flag Stage 1) high if **s** = 1 • **A2** (Active Flag Stage 2) high if **s** = 2 • **A1** & **A2** high if **s** = 3 Error if: • stage **s** is disabled • **s** out of range • system has no ADDA-module	Deactivates ADDA-module of stage **s** to return to closed loop stabilization. **Remark**: This trigger command corresponds to the external hardware trigger (TTL=high) with the same priority.
SHS;	Set Handshaking	-	• 0; (1; for error)	-	Activates hardware handshaking for serial communication. Adjustment is stored in non-volatile memory.

| Command	Description	Parameter	Return	Status Flag (see section 5) & Errors	Comment
CHS;	Clear Handshaking	-	• 0; (1; for error)	-	Deactivates hardware handshaking for serial communication. Clears the previous value. Adjustment is stored in non-volatile memory.
SBR**b**;	Set Baudrate	• **b**: Baudrate (1, 4 or 9)	• 0; (1; for error)	Error if: • **b** is neither 1, 4 nor 9	Reinitialises the UART-module with a new baudrate. (if **b** = 1 then baudrate = 115200 bit/s, if **b** = 4 then baudrate is 460800 bit/s, if **b** = 9 then baudrate = 921600 bit/s) Adjustment is stored in non-volatile memory. **Remark:** The baudrate 460800 bit/s is not supported by the BeamStabilization GUI version ≤ 2.1
GSF;	Get Status Flag	-	• 0; (1; for error) • **StatusFlag** • ;	-	Request for system status information (see Figure 3).
GID;	Get Identifier	-	• 0; (1; for error) • **Device_id[47]** • ;	-	Request for device and product information. **Remark**: The model, serial number and firmware version are transferred as 47 ASCII characters.
SLA**l**;	Set Label	• **l[25]**: Label for the system	• 0;(1; for error)	Error if: • **l[25]** is longer than 25 characters • at least one character in **l** out of range	Sets a char array **l[25]** of variable length (maximum of 25 characters) in the non-volatile memory. This allows the user to establish an individual identification label to separate the systems. Allowed are all printable ASCII characters (0x20 to 0x7E) except the semicolon (0x3b) as it signals the end of command.
GLA;	Get Label	-	• 0;(1; for error) • **l[25]**: Label of the system • ;	-	Request for the label **l[25]** in the non-volatile memory. The label is transferred as ASCII characters. Always returns 25 bytes. If the label set before is shorter than 25 characters, the rest is filled with space characters (0x20).
GER;	Get Error	-	• 0; (1; for error) • **CMD[3]** (default value: "000") • **e** (default value: 0) • ;	-	Returns the name of the last command that caused an error in **CMD[3]**, if the command was recognized. Otherwise **CMD[3]** = "000". In addition the error code **e** should hint to the cause of the error. Please refer to section 3 for more details on the different error codes.

5. Transmit / receive logic
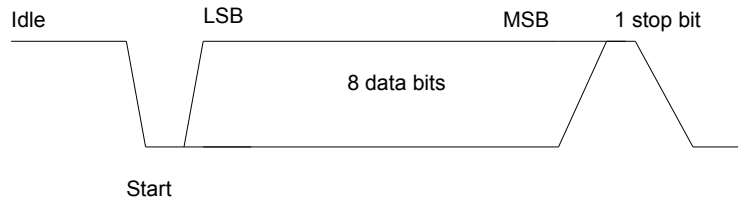
Figure 1: Character Frame

The transmit logic to the hardware performs parallel to serial conversion on the data read from the external device. The control logic outputs the serial bit stream beginning with the start bit and follow by 8 data bits (LSB first) and one stop bit (s. figure 1). The byte order for 2 byte values is high byte first.

Figure 2 shows the order and length of the received data with the command SLS**mr**;.

0	;	Status Flag	Res. Byte	DX1	DY1	DI1	DX2	DY2	DI2	RX1	RY1	RX2	RY2	;
1byte	1byte	1byte	1byte	2byte	...								2byte	1byte

Figure 2: Stream Frame

Figure 3 shows the order and length of the received data with the command GSF;

0	;	EF	A2	A1	OnOff2	OnOff1	Adj2	Adj1	PF	;
1byte	1byte	StatusFlag - 1byte								1byte

Figure 3: 4 Byte long answer of GSF; command

Where bits A1 & A2 show if stages are active (1) or inactive (0), bits OnOff1 & OnOff2 if stages are enabled (1) or disabled (0), bits Adj1 & Adj2 if adjust function is set for software (1) or external signal (0) and bit PF shows if p-factor function is set for software (1) or external signal (0). The bit EF (End of Stream Flag) indicates the last stream package of SLS-command (always zero except in last stream package).

Please note that the return values of the command GAS; represent the status bits A1, A2 with the same notation but are converted into a byte of type char. The return values of the command GEA; represent the status bits OnOff1, OnOff2 with the same notation but are converted into a byte of type char.

6. Changes compared to the previous version

- Error Handling: The new command GER; returns information regarding the cause of an error that occurred previously. Please refer to section 3 for more details.
- Added support for an additional baudrate (460800 Bit/s) (not supported by the BeamStabilization GUI version ≤ 2.1).
- Correction: Individual label set by SLA; and read via GLA; has a uniform length of 25 Bytes.
- Names of the values returned by GEA; and the corresponding status flag bits unified to OnOff1,2 as they mirror each other.
- Names of the values returned by GAS; and the corresponding status flag bits unified to A1,2 as they mirror each other.