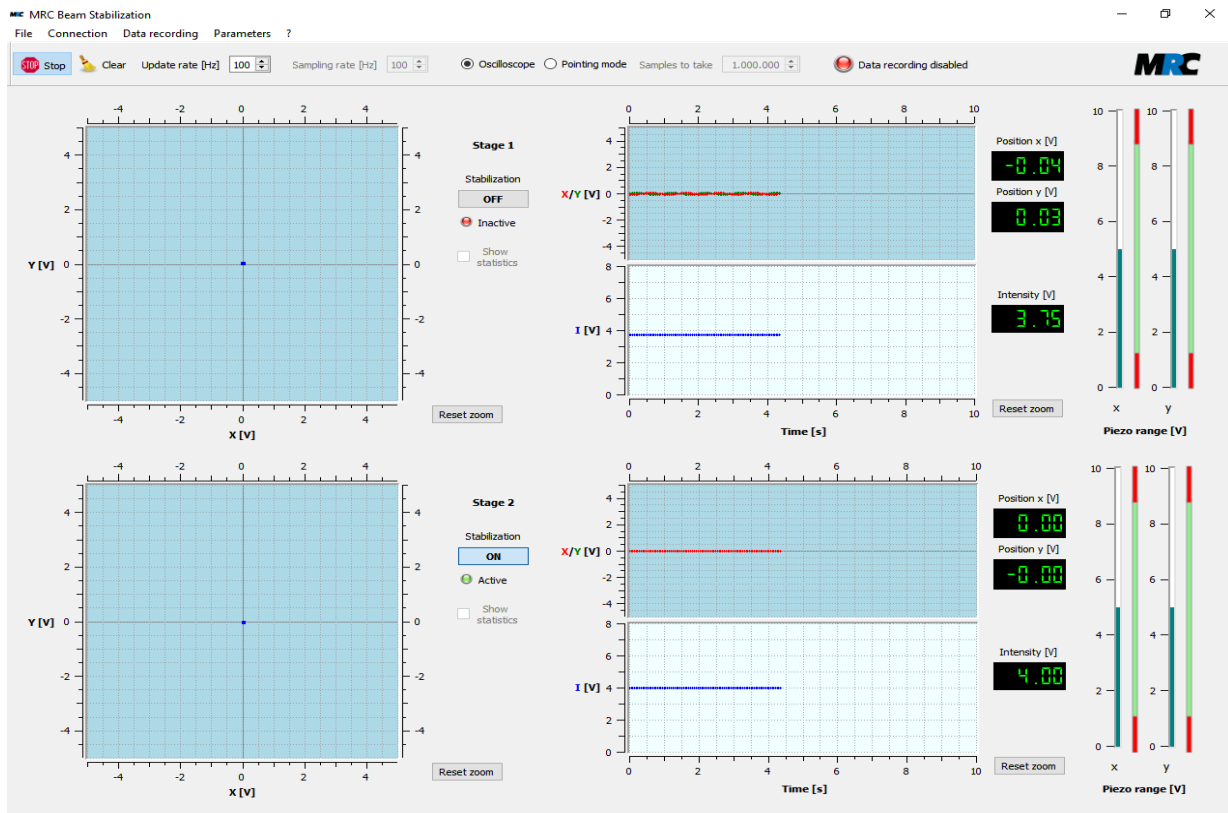


# Laser Beam Stabilization

## Description of the communication and visualization software



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## 1. Introduction

The *Compact* laser beam stabilization system can be equipped with a serial or a TCP/IP interface, which allow the setting of parameters and the read-out of values. The serial communication runs via USB or RS232. The TCP/IP communication makes use of an ethernet connection.

The software described here makes use of these interfaces and communicates with the stabilization system. It offers real-time displays of the positions, intensities, and piezo voltages and includes some functions to control the stabilization system.

## 2. System requirements, installation

The software works with one or more 4-axes stabilizations, i.e. *Compact* systems with two position detectors and two piezo-driven 2D actuators. It can be used on any PC with USB (2.0 or higher), RS232 or ethernet interface.

Versions are available for the following operating systems:

- Windows 10 and Windows 11, 64bit
- Linux Ubuntu (tar archive, Debian package)

In Windows you can start the installation by executing the Microsoft Installer .msi file. Depending on your installation it can be necessary to additionally install an FTDI driver. In most cases this takes place automatically. If you use the USB interface and want to reach higher data rates you can decrease the USB latency timer in the Windows driver from the default 16 to e.g. 2 or 1 ms. For that purpose, please start the Device Manager and find your USB port. Then call *Properties, Advanced*, and reduce the latency.

In Linux you can use the Debian package with `dpkg -i mrc-beamstabil_(single/multi)-2.3.x-byyyyy-X64.deb`. x stands for the subversion number, yyyyy for the respective build number.

Beam controllers equipped with ethernet are shipped with factory settings in DHCP mode. This means that a connection to the network can only be made via a DHCP server and not, without further measures, directly to the computer. If you are not familiar with your network architecture, you can ask a system administrator to determine the IP address of the device.

If you want to connect an ethernet device directly to a computer, you can disable the DHCP mode by using the [WIZS2E ConfigTool](#) and set a static IP address under which you will find the system when directly connected to the computer. For a further description of the ethernet option please see section 6.3.

### 3. Configurations

The standard configuration of the software includes the following functions:

- a) Start and stop of control loop
- b) Activity display
- c) Display of x and y positions on both detectors (voltage values, x/y plots, position-time-plots)
- d) Display of intensities on both detectors (voltage values, intensity-time-plots)
- e) Display of voltages applied to the piezos of both actuators
- f) Data recording
- g) Setting of P factor values for stages 1 and 2 of the control loop
- h) Basic statistics of beam pointing
- i) Calculation of beam position in [mm/ $\mu$ m]

If your *Compact* system is equipped with the respective hardware, you can further use the following functions:

- j) Set&hold function
- k) Adjust-in function
- l) Adjustment of detector sensitivity

If you have more than one system, you can also manage the communication with multiple systems. For this purpose we have a separate software version (see section 9).

Note: This version 2.3.x of the software is compatible with older *Compact* systems. However, we have slightly changed the interface protocol with version 2.2 (October 2022). This leads to the limitation that the display of the *Active* status of the device and the software are not synchronized, but the status itself is transferred.

### 4. Program start, connection with the beam stabilization

When the program is started, the beam stabilization is connected automatically. If there is no saved connection, all serial ports of the PC are scanned and it is checked, if an MRC beam stabilization is connected. Such a scan is not possible with TCP/IP. To check the settings of the connection you can open the *Settings* dialog in the menu *Connection*. You can find more information on the settings in section 6.

## 5. Main window

Figure 1 shows the main window of the program. It includes a menu bar, a control bar, and the display area. The size of the window can be adjusted. If the window does not allow to display all contents, you can use the scrollbars to shift the visible part.

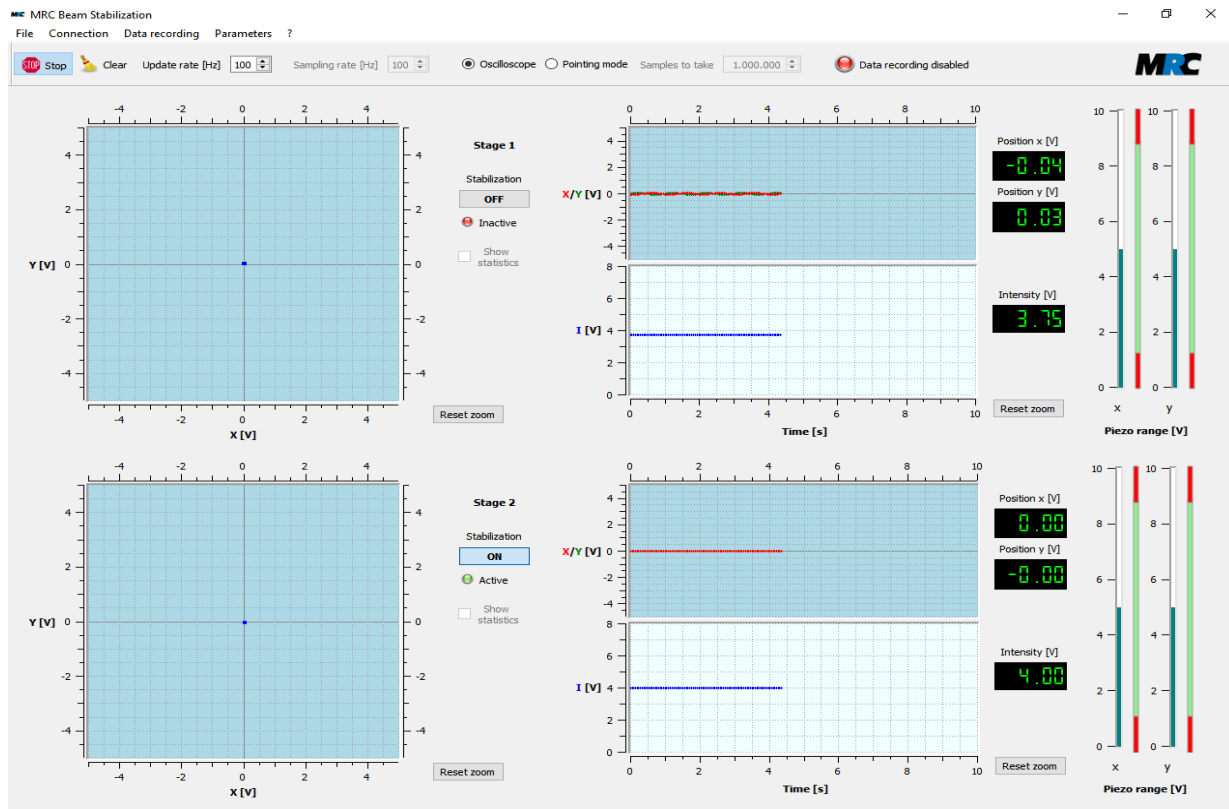


Figure 1: Main window of the communication and visualization software (Version for a single system)

### 5.1. Menu bar

You can call up further functions or dialog windows via the menu bar:

- *File*: This menu only includes the function *Exit* to exit the program.
- *Connection*: This menu includes items to (dis-)connect the interface for the beam stabilization. Furthermore you can call up the dialog window with the settings of the connection (see section 6). If you are connected to several systems, you can open an overview (see section 9.2).
- *Data recording*: In this menu you can call up the dialog window to set, start, and stop the data recording (see section 7).
- *Parameters*: In this menu you can call up the dialog window to display, insert, and transfer parameters (see section 8). (In the version for multiple systems the dialog window is opened via the submenu *System Configuration* – see section 9.2).
- Under *?* you can find information on the software and the manufacturer.

### 5.2. Control bar

The control bar offers the following functions:

- *Start/Stop*: This button enables to start and stop the display of values in the different plots.

- *Clear*: With this button you can clear the plots.
- *Update rate*: Here you can select the refresh rate to display the data.
- *Sampling rate*: Here you can select the data transfer rate.
- *Oscilloscope / Pointing mode*: This button allows to choose between different presentations in the x/y plots. “*Oscilloscope*” means a presentation which you are used from an oscilloscope, i.e. each displayed point is cleared immediately. In contrast, in the *Pointing* mode all points remain so that a cloud of points is built up over time.
- *Samples to take*: Here you can set the number of points which shall be sampled in the *Pointing* mode. The display automatically stops when the entered number is reached.
- *Data recording enabled / disabled*: This display shows if the data recording is currently activated or not.

#### Notes:

- 1) Please note that the update rate only indicates the cycle in which the data is drawn from the beam stabilization into the display areas. If the update rate is lower than the sampling rate, the data is buffered until the next display cycle.
- 2) The update rate can not be chosen higher than the sampling rate.
- 3) The sampling rate can only be changed if the display of values is stopped. It is limited in the software to 430 (serial) and 500 Hz (TCP/IP).
- 4) Depending on the speed of your computer/network the actual sampling rate can differ from the edited value.

### 5.3. Display area

In the display area there are x/y plots, position-time plots, intensity-time plots, big displays of the measured positions and intensities, as well as bar graphs of the piezo voltages of both control stages.

You can zoom into the x/y plots by dragging a rectangle with the left mouse button pressed. By clicking *Reset zoom* you can return to the standard zoom level. If you click into an x/y plot, the coordinates of the mouse cursor are displayed.

In the position-time plots the position signal is continuously displayed as with an oscilloscope. After a defined time the plot starts again from the beginning. You can open an entry mask by clicking on the time axis where you can define the desired time frame instead of the default interval of 10 s. The x/y axis and the I axis can also be zoomed. Just click on the axes to open the respective entry mask.

Further functions in the display area are:

- *Stabilization ON/OFF*: Here you can (de-)activate the control loop. The software switch has the same function as the “Start/Stop” button at the keyboard of the system's controller box. Switching at the box is still possible. The system always takes up the last action at the hardware or in the software.
- *Active/Inactive*: This signal indicates if the control loop is active or not. It has the same meaning as the “Active” signal on the keyboard of the controller box. You can find more information on this signal in the user manual of the *Compact* beam stabilization system.
- *Show statistics*: In the *Pointing* mode you can fade in additional information into the x/y plot (see the following section 5.4).

### 5.4. Beam pointing statistics

If you have sampled a cloud of points in the *Pointing* mode, you can display the centre and the variance (RMS deviation) of the points. The centre position (x, y), the number of samples, and the variance are displayed in the upper left corner of the plot. The centre and the variance are also visualised in the plot as a cross-hair and the diameter of a circle. The variance corresponds to the root mean square of the distances of the sampled points from the centre. Figure 2 shows an example.

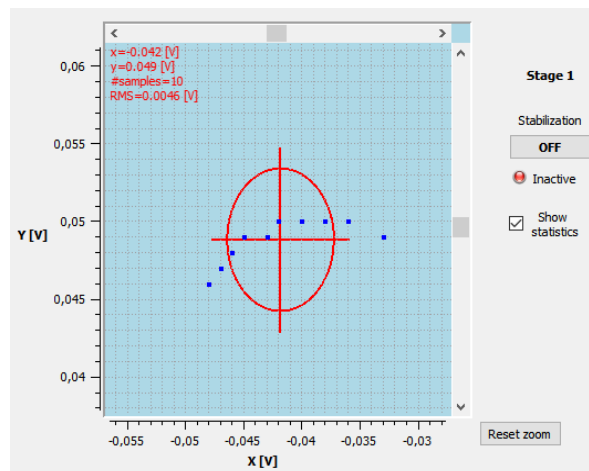


Figure 2: Presentation of beam pointing statistics in Pointing mode

## 6. Connection settings

You can disconnect and reconnect the beam stabilization system at any time. For this purpose there are the *Disconnect* and *Connect* items in the *Connection* menu. Alternatively, you can manage the connections via a dialog window which you reach via *Settings*. In this dialog you can save and load a connection for both, serial or TCP/IP communication. The connection settings are saved in the file “ConnectionSetup.xml” in the program path.

If you have multiple connections, the *Disconnect* and *Connect* items are omitted. Instead of these items you can use the *System Configuration* window to manage the beam stabilization systems. Please see section 9 for more information on this.

### 6.1. Serial interface

In the submenu *Serial* you can manage the connected beam stabilizations. If you have activated the beam stabilization after starting the software, click *Scan* to search for new connected devices. If you have more than one beam stabilization system which you want to control via the same software, you can select the desired one in the drop down menu.

At the option *Baudrate* you can change the baudrate. Please note that for a high baud rate the interface of the PC must be compatible and the beam stabilization must be adjusted. The other port parameters are pre-set as follows:

<i>Parameter</i>	<i>Values</i>
Data Bits	8
Parity	None
Stop Bits	1
Flow Control	On (Hardware CTS / RTS)

*Save Settings* in the *Connection Settings* dialog saves the current connection as the default configuration. *Save settings As* allows you to save to a user-defined configuration file, which can be loaded at a later time using *Load Settings*.

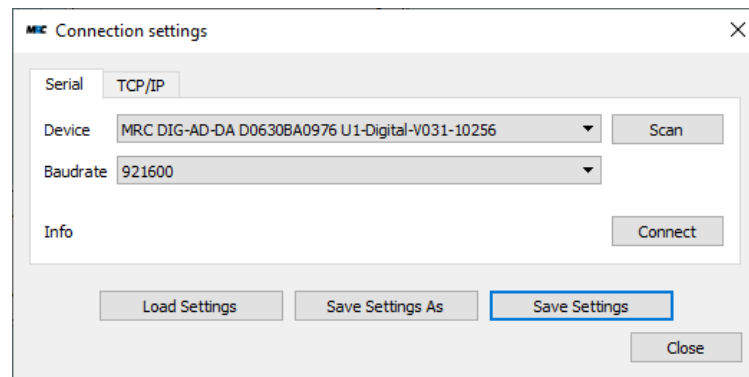


Figure 3: Dialog window for the serial interface

### Notes:

- 1) If you want to use higher sampling rates you need to adjust the port settings in Windows. Open the device manager of Windows and select the port to which the beam stabilization is connected. Go to configuration of this port and open the advanced settings. Reduce the latency from 16 to 1 or 2 ms.
- 2) For systems with RS-232, the baud rate up to which a stable connection is possible depends on the cable length. We recommend a baud rate of 115200. Please note that after changing the baud rate, you can only reset it on the controller itself by restoring the factory settings (available from firmware version 3.2).

## 6.2. TCP/IP interface

In the submenu *TCP/IP* you can establish a connection with the beam stabilization via ethernet. For this purpose you must determine the IP address of the beam stabilization in your network and enter it as *Address*. At *Port* you have to enter your selected settings. The port is set to 2000 in the factory settings.

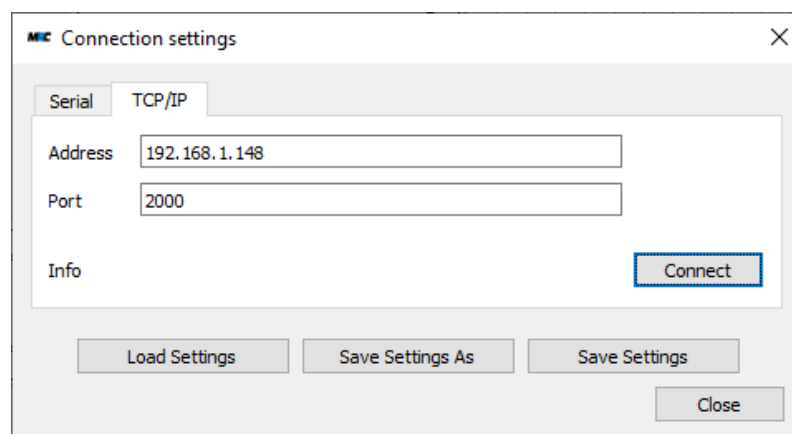


Figure 4: Dialog window for the TCP/IP interface

## 6.3. Ethernet module

If the ethernet module is integrated into your system, you can reconfigure it with an external software. You can download a suitable tool from [WIZS2E ConfigTool](https://www.mrc-systems.de/extern/transfer/BeamAlign/Tools/WIZS2E_ConfigTool_V1.0.1.3_Setup.zip) (https://www.mrc-systems.de/extern/transfer/BeamAlign/Tools/WIZS2E\_ConfigTool\_V1.0.1.3\_Setup.zip). To use the tool, turn on the beam stabilization and connect the computer with this tool to the device. As soon as you start the program, you

should see the MAC address of the connected beam stabilization on the left side of the screen (see figure 5). If this is not the case, try to find the beam stabilization with the *Search* button. Once you have found the beam stabilization, check the COM port settings as described in section 6.2.

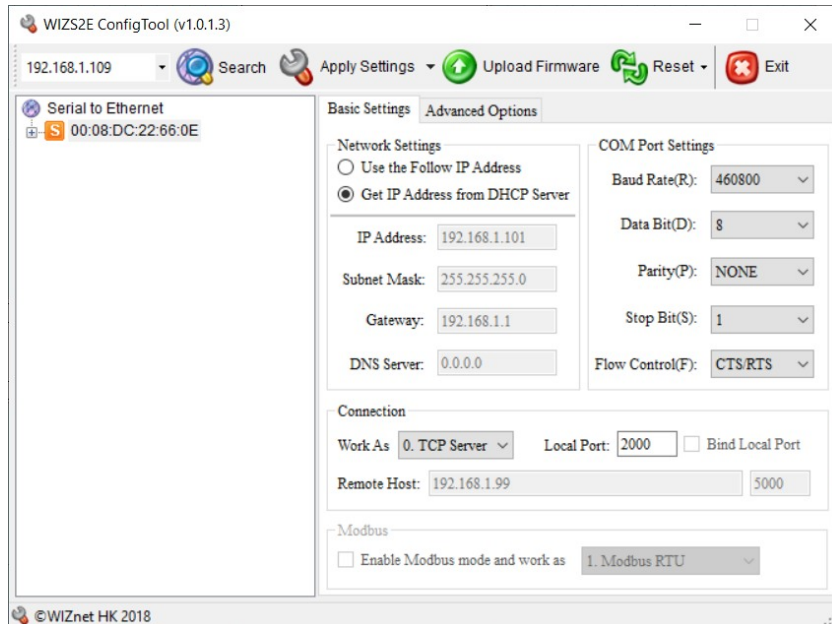


Figure 5: WIZS2E ConfigTool with dynamic IP address via a DHCP server

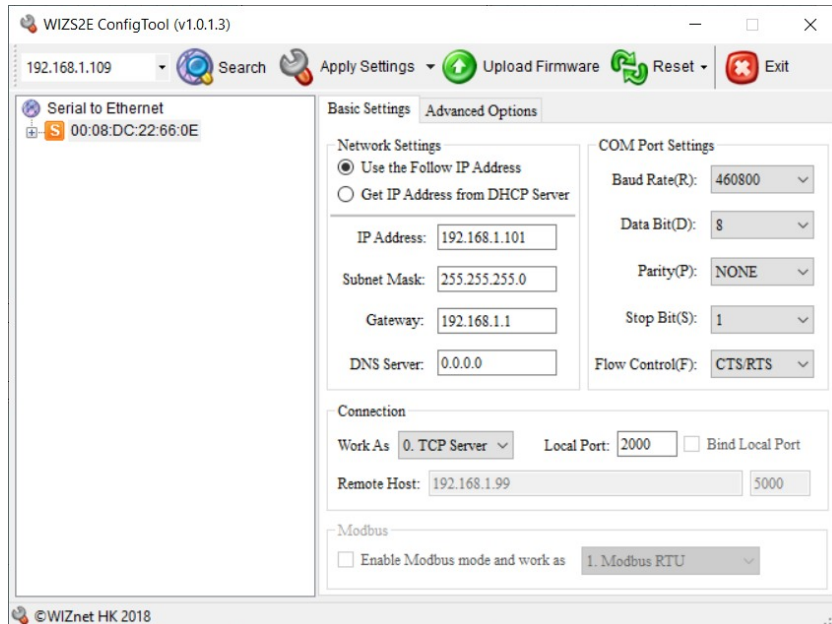


Figure 6: WIZS2E ConfigTool with static IP address

As *flow control parameter* you must select *CTS/RTS*. The default baud rate is 460800. You should not change it, as it affects the communication between the beam stabilization and the Ethernet adapter. Before changing it anyway, you have to adjust the baud rate of the beam stabilization via the interface protocol. In the *Connection* section, the TCP/IP server and the port 2000 must be selected. If you want to use a different port, make sure to specify the same port when establishing the connection in the software.

If the parameters are set correctly, you can adjust the network settings according to your wishes.

In the default setting of the beam stabilization the IP address is automatically assigned by your DHCP server. This setting is shown in figure 5. To find the newly assigned IP address you have to display all systems in the network via the command line of your operating system. If you need help with this, please contact your system administrator.

To connect directly to a computer you need a static IP address. You can set this as shown in the example in figure 6. Please note that your data may differ from the example depending on the settings on your computer.

## 7. Save function for data recording

With the software you can save measurement data in the same way as with a storage oscilloscope. For this purpose you can call up the *Data recording* dialog window via the menu item of this name.

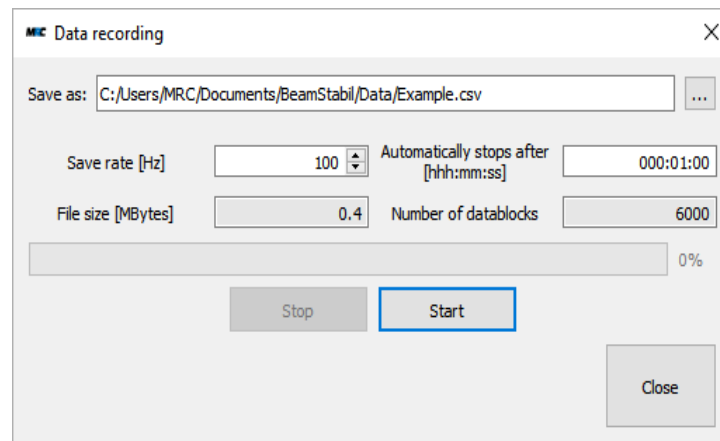


Figure 7: Dialog window to set the parameters for data recording

With the items behind *Save as* you can select a path and enter a file name.

In *Save Rate* you can enter the rate for the data storage. By default the update rate of the main window is entered here. Especially for long-term recordings it can make sense to enter a lower rate. You can define the duration of the recording by entering a time into the field *Automatically stops after*.

For the values entered into *Save rate* and *Automatically stops after* the software automatically calculates the expected file size and the number of datablocks. In this way you get an orientation on how large the file would get so that you can change the values if necessary. In case of file sizes larger than 2 GB you will get a warning. If you wish, you can record larger files anyway, as long as your operating system and your hard disk drive allow.

The recording is started by clicking *Start*. With *Stop* you can stop it even before it would stop at the time defined in *Automatically stops after*. On the right side of the control bar and in a progress bar directly in the dialog window you can see an indication if the data recording is currently running or not.

Figure 8 shows the structure of the data file. The time (counted in ms after the start of the recording and corresponding to the time at which the data package was received) is followed by the position and the intensity signals of both detectors as well as the piezo ranges (“R”). All values, except the positions, are

given in Volts [V]. The position can be specified in [V], [ $\mu\text{m}$ ] or [mm], depending on the parameter settings.

Start: 2025-01-10T17:28:08

ms	X1( $\mu\text{m}$ )	Y1( $\mu\text{m}$ )	I1(V)	X2( $\mu\text{m}$ )	Y2( $\mu\text{m}$ )	I2(V)	RX1(V)	RY1(V)	RX2(V)	RY2(V)
0	-3.23	6.46	1.07	-16.98	-39.79	2.19	5.07	5.07	5.07	5.06
11	-3.21	6.87	1.07	-17.03	-36.46	2.21	5.07	5.07	5.07	5.07
20	-3.52	7.19	1.07	-17.35	-35.72	2.19	5.07	5.07	5.07	5.07
30	-3.50	6.85	1.07	-17.68	-37.43	2.21	5.07	5.07	5.07	5.06
39	-3.23	6.47	1.07	-18.29	-38.63	2.19	5.07	5.07	5.07	5.06
49	-3.49	6.55	1.08	-18.74	-38.21	2.21	5.07	5.07	5.07	5.06
59	-3.52	6.90	1.07	-19.10	-35.08	2.19	5.07	5.07	5.07	5.07
69	-3.50	6.57	1.07	-19.36	-36.22	2.20	5.07	5.07	5.07	5.06
79	-3.80	6.59	1.07	-19.59	-37.36	2.19	5.07	5.07	5.07	5.07
89	-3.80	6.57	1.07	-19.36	-36.96	2.20	5.07	5.06	5.07	5.07
99	-3.83	6.92	1.06	-19.01	-36.54	2.19	5.07	5.07	5.07	5.06
109	-3.50	6.85	1.07	-18.60	-35.91	2.20	5.07	5.07	5.07	5.06
118	-3.52	6.60	1.07	-18.27	-35.91	2.19	5.07	5.07	5.07	5.07
128	-3.80	6.44	1.07	-17.72	-37.96	2.20	5.07	5.07	5.07	5.06
138	-3.22	6.59	1.07	-17.30	-36.95	2.20	5.07	5.06	5.07	5.06
149	-3.51	6.59	1.07	-16.93	-36.03	2.20	5.07	5.07	5.07	5.07
159	-3.23	6.90	1.07	-16.58	-36.06	2.20	5.07	5.07	5.07	5.07
168	-3.52	6.60	1.07	-16.21	-36.62	2.20	5.07	5.07	5.07	5.06
178	-3.53	6.62	1.07	-15.85	-37.52	2.20	5.07	5.07	5.07	5.07
188	-3.51	6.59	1.07	-15.43	-37.25	2.20	5.07	5.07	5.06	5.07
198	-3.23	6.62	1.07	-15.15	-36.21	2.20	5.07	5.07	5.07	5.07
208	-3.22	6.59	1.07	-14.93	-36.21	2.20	5.07	5.07	5.07	5.06
217	-3.53	6.62	1.07	-14.86	-36.81	2.20	5.07	5.07	5.07	5.06
228	-3.52	6.60	1.07	-14.70	-36.77	2.20	5.07	5.07	5.07	5.07

Figure 8: Example of the typical content in a saved data file

Note: If the *save rate* is not identical to or a divider of the sampling rate, the data will not be recorded equally spaced. Instead the recording will always wait for the next datablock which corresponds to the sampling rate. If you need to have equally spaced data for a further analysis, you must choose a *save rate* which is identical to or a divider of the sampling rate.

## 8. Display, insertion, and transfer of control parameters

Via the menu *Parameters* you can call up the *Parameters* dialog window to display, insert, and transfer control parameters (see figure 9). In the version for multiple system you reach this menu via the *System Configuration* dialog window (see figure 11). When you call up this window the parameters are updated by the values currently set in the beam stabilization system. If you want to read in the currently set values from the system at a later time, you can click *Refresh*.

The respective entry masks for *P-Factors*, *Adjust-In* and the *Detector* parameters allow you to set new values which are transferred to the stabilization system after clicking *Apply*. When you close the window with *Close* without clicking *Apply* no parameters will be transferred. With *Save* you can save the detector properties in the "ConnectionSetup.xml" file, in which the connection data is also managed.

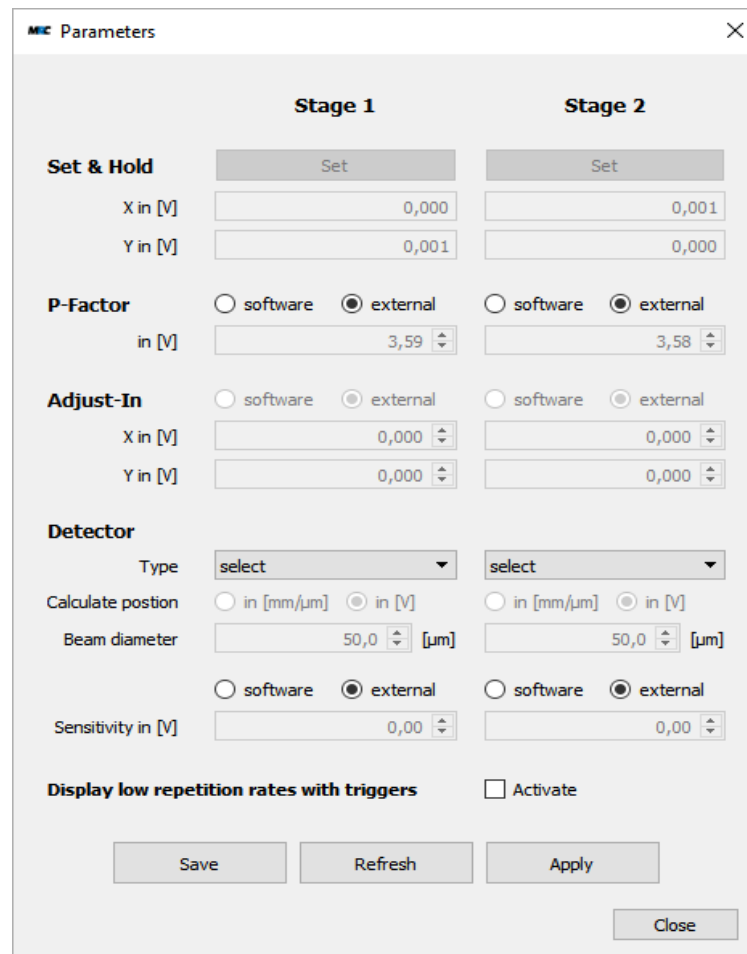


Figure 9: Dialog window to display, insert, and transfer control parameters

The functions have the following meaning and ranges:

- *Set&Hold*: With this function you can read in the current beam positions on the detectors and use them as the target positions for the beam stabilization. The position voltages are displayed in the respective fields. The function is only available if you have selected a PSD as the *Detector type* and the beam stabilization is *off*.
- *P-Factor*: The P factor function has the same meaning as the corresponding hardware function which is described in the user manual of the *Compact* beam stabilization system. You can insert values between 0.01 and 5 Volts.
- *Adjust-in*: The Adjust-in function is also similar to the function of the optional Adjust-in inputs at the controller box of the beam stabilization system. The function is only available if you have selected a PSD. You can insert values between -5 and +5 Volts.
- With the switches *software/external* you can define independently if the *P-Factor*, the *Adjust-in* function and the *Sensitivity* shall react to the adjustments at the controller box (hardware) or to the software. In case of the *P-Factor* the switches for stages 1 and 2 are synchronized.
- *Detector type*: Here you can select different detector types.
- *Calculate position*: You can decide to display the position data with their raw voltages or with calculated positions in mm/μm. In the latter case the software calculates the data with approximations which come close to the real values.
- *Beam diameter*: To calculate the real position data of a 4QD and WID the beam diameter is needed. Please enter the diameter as good as possible to guarantee a good approximation.

- *Sensitivity*: Some detectors are equipped with the option of setting the sensitivity electronically via an applied voltage or the computer interface. The line is only displayed for detectors and software configured for this purpose. You can enter voltages from 0.1 to 5 V (0.25 to 5 V for vacuum detectors) in the fields. If the voltage is not changed for more than 10 s, the detector saves the current sensitivity. If the sensitivity input is then set to *external*, the sensitivity does not change in case there is no voltage  $\geq 100$  mV at the sensitivity input.
- With the selection *Display low repetition rates with triggers - Activate* you can switch the data display of the plots, so that with lasers with small repetition rates new data are only displayed when laser light is on the detectors. If you confirm the selection with *Apply*, the display is synchronized with the trigger signals of the "Sample&Hold" circuit. Thereby, a data packet is always and only transmitted to the software when a system correspondingly equipped with the Sample&Hold receives a trigger HIGH signal. Please note that no data are displayed if no external trigger is transmitted to the beam stabilization.

#### Notes:

- 1) If you have set a position using the *Set&Hold* function you can further adjust it with the *Adjust-In* function.
- 2) If you set values with the *Set&Hold* function or enter voltages for the *Adjust-In* function, the control loop with the ADC might slightly change these values. I.e. if you click *Refresh* the actual values might slightly differ from the set or entered values. The accepted changes are very small so that they do not affect the stabilization accuracy.
- 3) When the *Adjust-In* values are set to 0 V for x and y, the controller switches to the *external* setting and accepts externally applied voltages. Without *Adjust-In* inputs, the offset corresponds to the entered 0 V.
- 4) The *P-Factor* and *Adjust-In* values are not saved permanently on the computer even after clicking *Save*. You can only send them to the beam stabilization system via *Apply* and save them there. If you want to continue working with the parameters saved there at a later time, you can import them into the software via *Refresh*.
- 5) For the calculation of the real position data the software makes use of the inverse error function in case of 4QDs and the simpler linear equation in case of PSDs. You can find further information on these approximations in the user manual of the *Compact* beam stabilization system and the description "Position and angular accuracy".
- 6) The normalization of the WID detector allows the calculation of the positions only in the range from -2.8 to 2.8 V. Outside this range it is not possible to get a valid position in  $\mu\text{m}$ .

## 9. Management of multiple systems

The software can also manage multiple systems. For this purpose it has an additional connection and display management. As soon as more than one system shall be displayed in the display area, the control is moved to the *System Configuration* window (see section 9.2). The voltage values and the *Range* displays are no more visible. The plots show the respective systems with the color which you can set in the *System Configuration* window.

### 9.1. Connection settings

As in the case of a single beam stabilization system there are two different dialogs to manage serial and TCP/IP connections, respectively.

To keep the overview of multiple systems, you can assign an individual *label* to each beam stabilization system when you create the connection. You will find this label in the *System Configuration* and the *Parameters* windows. To simplify the connection management, a list with all connections is displayed. The *Auto connect* switch controls for the respective system whether it shall be connected when the software is started. If you want to *disconnect* a system or the connection properties are no longer needed,

e.g. because the properties have changed, you can delete the entry in the list with a click on the *trash can*. If you want to change the label of a connection, you can click on the name in the list and change it as desired.

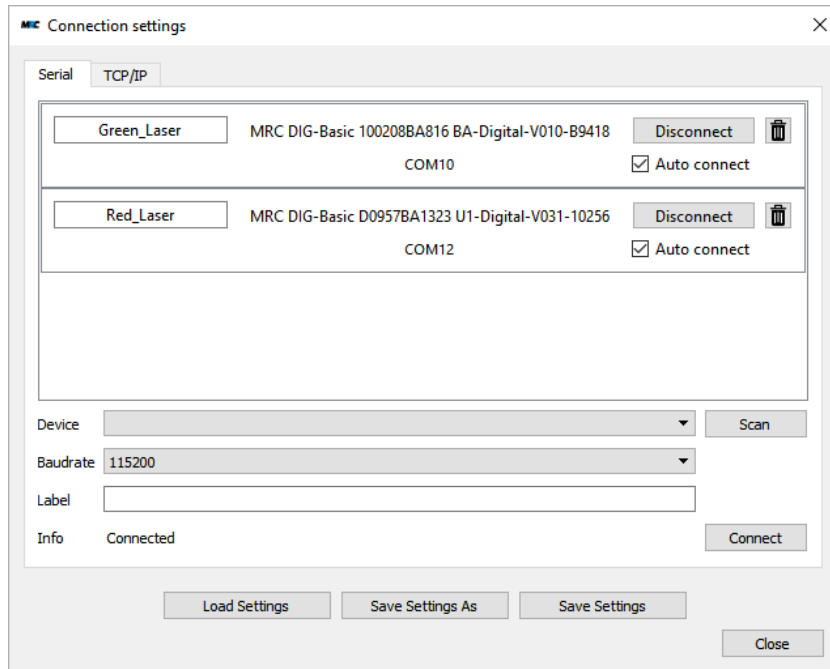


Figure 10: Dialog window to handle multiple connections

## 9.2. System configuration

For a better overview of multiple systems you can select the item *System Configuration* in the menu *Connection* which opens a configuration window (see figure 11). There you will find a list of all connections and their controls in the respective line. You can activate the different stages and check the *Active* status. To get to the parameter window (figure 9) of a specific system, you can press the button *Parameters*. This opens the window with the system's label in the header. In the last column you can set the colors of the graphs and decide whether or not the system is displayed in the main display area. If *Show* is unchecked, the system is not displayed, but still a continuous update of the status is performed.

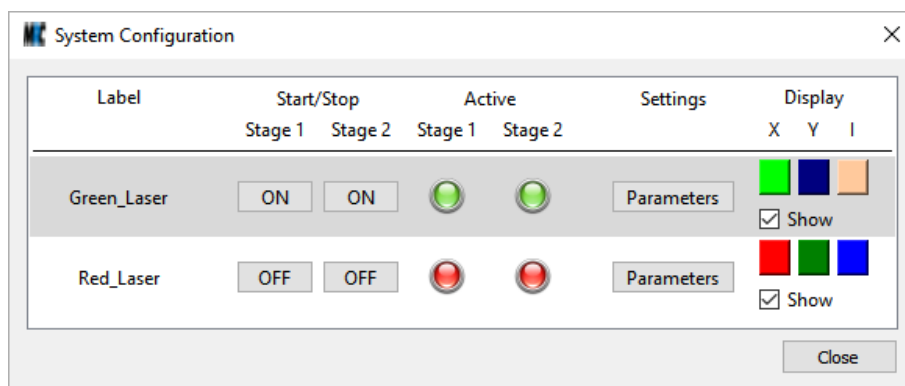


Figure 11: System Configuration window to manage multiple systems

### 9.3. Save function in case of multiple systems

To simultaneously save the data of multiple systems, there is a checkbox *Save all displayed systems* in the recording window (figure 12).

If the checkbox is selected, all systems that are displayed will be saved. If a system is not selected for display in the *System Configuration* window, the system will not be saved. To distinguish the different files, the respective label of each system is added to the selected file. The data on the file size and the number of blocks is valid for each of the files. If the checkbox is not selected, only the data of the system with the last recent changes will be saved.

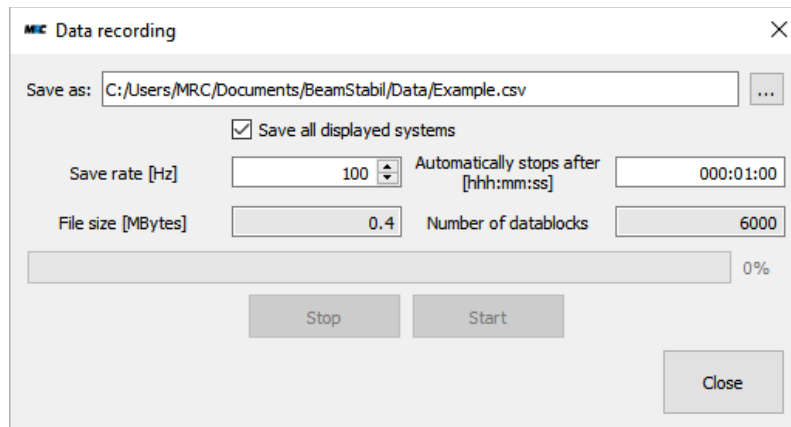


Figure 12: Dialog window to set the parameters for data recording in case of multiple systems

## 10. Error messages

In addition to the already mentioned error and warning messages there are a number of further messages which can occur in specific cases. Most messages concern errors or time delays of the communication. They shall not be reproduced here. If a message pops up frequently and you do not find a reason for that, please do not hesitate to contact us.

## 11. Contact

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