



CeraPlas Element

Evaluation Kit 2

Series/Type:	HF and F series
Ordering code:	Z63000Z2910Z 1Z69
Date:	2020-04-28
Version:	1

Preliminary data

Content of evaluation kit / CeraPlas element cold plasma source

- Driver circuit for the CeraPlas element with jumper
- CeraPlas elements HF series (ordering code Z63000Z2910Z 1Z60) and F series (ordering code Z63000Z2910Z 1Z68) with package, wires and two pins connector
- Assembled FTDI 3.3V TTL USB to UART cable
- USB flash drive including datasheet for the CeraPlas elements (Z63000Z2910Z 1Z60, Z63000Z2910Z 1Z68), datasheet for the Evaluation Kit CeraPlas element, controlling software for using the driver with a PC and all necessary information/links.

Specifications/Features Driver Circuit

Parameter	Symbol	Value	Unit
Input-voltage DC	V_{in}	typ. 24	V
Maximum continuous operation input power	P_{in-max}	typ. 12	W
Typical continuous operation output power	$P_{out-typ}$	HF: typ. 4.5 F: typ. 7	W
Operating output frequency (2 nd harmonic anti-resonance)	f_{res} typ.	HF: 82 ¹⁾ F: 52 ¹⁾	kHz
Operating temperature range	T_{op}	0 ²⁾ ... +60	°C
Max. temperature	T_{max}	+85	°C
Weight	m approx.	22	g

Important note: EMC compliance not evaluated, laboratory use only

¹⁾ Automatic frequency control with resolution in the range of mHz

²⁾ Dew precipitation is inadmissible.

- Approximately 4.5 / 7 W CeraPlas element input power by default, selectable from approx. 2 W to 8.5 W by software
- Driver supports CeraPlas element
- Phase control with resolution of at least 1°

Introduction

The CeraPlas element driving circuit is intended to show the operating principle of the CeraPlas element. A unique control algorithm is used to drive the CeraPlas element at its maximum efficiency under any conditions. All logic levels are based on 3.3 V as well as the TTL level of the RS232 interface.

The driving circuit can be operated by a set of jumper or alternatively via COM-port commands using an RS232-adaptor and an additional graphical user interface which is a multi-platform software for adjusting the CeraPlas element to your specific application.

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Connection Setup

As shown in Figure 1 all possible interfaces are described. For running the CeraPlas element the first time the following steps have to be done to accomplish a stable ignition of the plasma:

1. Plug in the green connector of the CeraPlas element to the socket on the driving circuit
2. Connect a stabilized 24 V $\pm 5\%$ DC power supply with at least 500 mA current rating
3. Configure the output power P_{out} by shorting the user inputs 2-3 according to Table 2
4. Short-circuit User Input 1 by using a jumper to switch on the CeraPlas element

Since the voltage is applied the driver sends out different light pattern by using the build-in LED:
Standby (CeraPlas element is turned off):

LED is blinking – the amount of pulses correlates to the current operating mode.

Active (CeraPlas element is running):

LED is blinking each 280 ms for 140 ms.

Alternatively, the CeraPlas element can also be controlled using the serial RS232-interface, see below for the connection and commands.

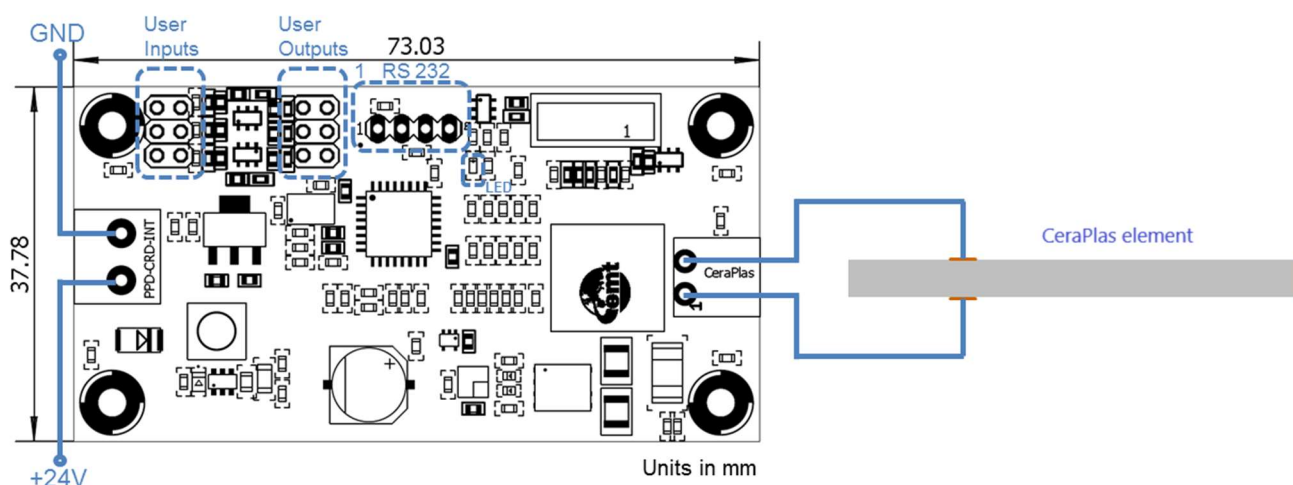


Figure 1: CeraPlas element driving circuit connection setup.

CeraPlas element Overload

If electrical conducting objects are brought close to the output of the CeraPlas element arcing could occur. Continued arcing can cause permanent damage to the CeraPlas element.

In order to prevent continues arcing, the driving circuit senses the CeraPlas element input signals. In case of an overload the CeraPlas element is protected by being switched off for a couple of seconds. During the period of protection, the LED is blinking.

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RS232 Connector

The pin assignment of the RS232 pin header is not compatible with common RS232-to-USB cables (Table 1), see for example FTDI TTL-232R-3V3, RS stock number 429-307. Take care to use an adapter with 3.3 V logic levels. Pins 2 and 6 (CTS# / RTS#) of the cable are not used in the current version of the driving circuit and can be left unconnected.

A pre-configured FTDI 3.3 V TTL USB to UART cable is content of the evaluation kit.

Table 1: RS232 connector pin assignment on the driver circuit

Pin	Description
1	not connected
2	ground
3	TxD
4	RxD

Using the User IOs

To get an impression of what the driving circuit can deliver directly without PC connection four different kinds of power settings are predefined. User Input 1 is used for switching on the driver. All other presets are listed in Table 2.

User outputs 1 to 3 give the user the opportunity to enhance the functionality of the evaluation kit by attaching an external status LED or an additional fan for a continuous air flow which correlates to internal parameter, like CeraPlas element is turned on. The levels of the User Outputs are depicted in Table 3.

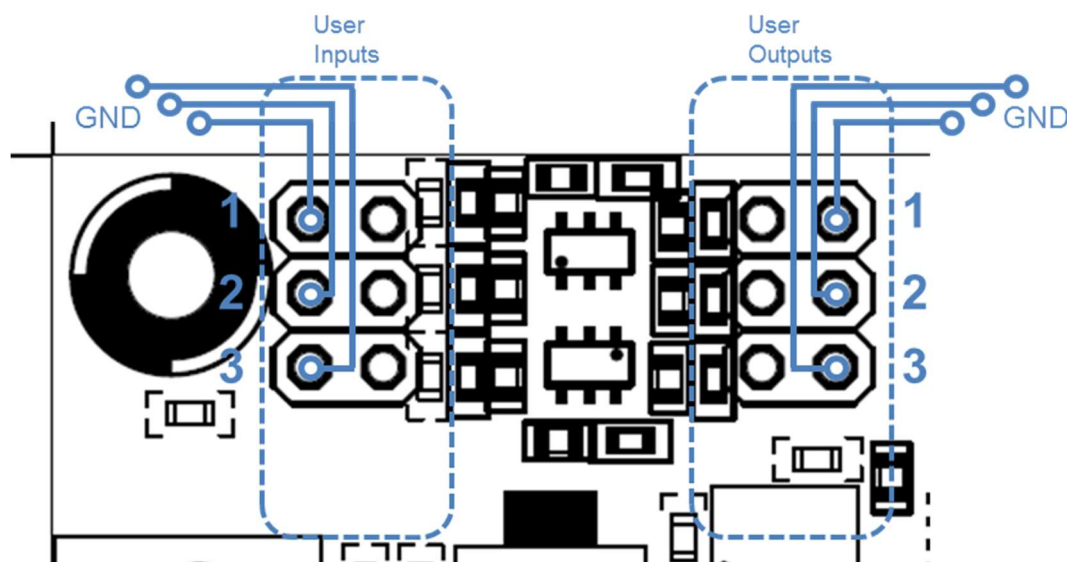


Figure 2: CeraPlas element driving circuit definition of the User IO.

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Table 2: Presets of the Evaluation Kit User Input

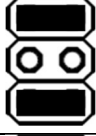
Jumper setting of user inputs	Driver presets
	(Default Mode) CeraPlas Type = HF (45 mm length) Frequency Range = 78-83 kHz Power = 4.5 W Phase = 0° Mode = 4
	CeraPlas Type = HF (45 mm length) Frequency Range = 78-83 kHz Power = 2 W Phase = 0° Mode = 2
	CeraPlas Type = F (70 mm length) Frequency Range = 48-54 kHz Power = 3 W Phase = 0° Mode = 3
	CeraPlas Type = F (70 mm length) Frequency Range = 48-54 kHz Power = 7 W Phase = 0° Mode = 1

Table 3: Presets of the Evaluation Kit User Output

User Output Pin	Functionality
1*	Replica of the LED pattern
2*	3.3 V - if the output voltage to the CeraPlas element is applied 0 V - 10 seconds after CeraPlas element is switched off
3*	3.3 V - if the resonance frequency of the CeraPlas element is found and is constant

*Please be aware of the maximal User Output current ratings which are limited from the microcontroller side (STM32F334K8T6). Due to the datasheet of STM do not exceed current ratings higher than 20 mA.

Using the COM-port

The additional functionalities which are listed below can be achieved when a communication between the driver and a PC is established.

- Measurement of 3 different temperatures by using PT-100 sensors
- Different power and phase settings
- Remote Access
- Control multiple drivers in parallel

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Measurement of the CeraPlas element Input Power

The output stage of the CeraPlas element driving circuit is outlined in Figure 3. The current is internally measured via a $0.1\ \Omega$ shunt resistor (R6) at the low side (FB_I test-pad on the backside of the driver). One way to measure the applied CeraPlas element power is to connect an oscilloscope probe on the test-pads of the backside of the driver. The mentioned test-pads are depicted in Figure 3 (right) highlighted in blue.

The applied voltage at the CeraPlas element can be measured via FB_V with respect to GND (TP19). The current at the CeraPlas element can be calculated by dividing the measured voltage at R6 by the resistor value of $0.1\ \Omega$. The corresponding power can be calculated by multiplication of the voltage and the calculated current value.

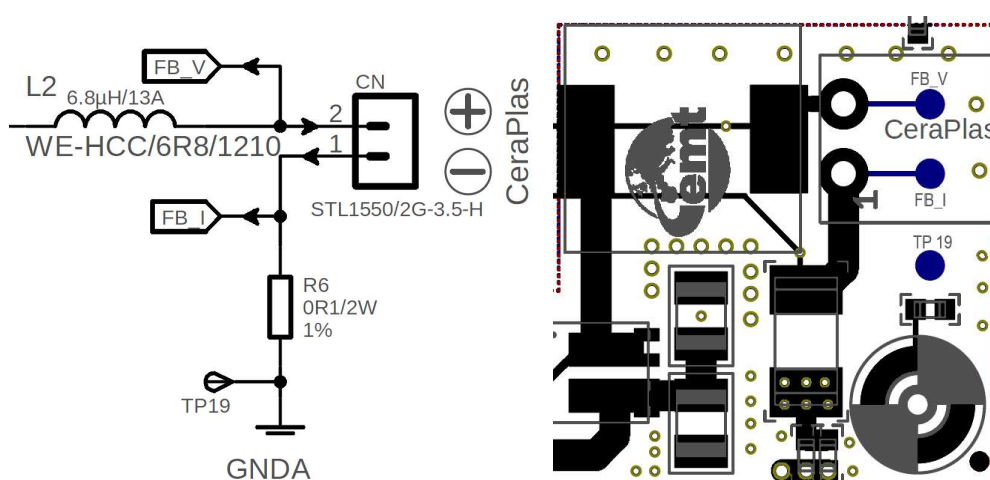


Figure 3: Output stage of the CeraPlas element driving circuit (schematic of the amplifier (left) and the outline of the PCB board (right))

User Guide for Driver

Installation Instructions

Step 1: Install Driver for the USB to TTL connection cable

To connect Drive F with a PC a USB to TTL converter is needed. The output TTL levels of the converter must not exceed 3.3 V due to the logic level of the Drive F circuit board.

On some windows versions or windows clients without internet connection the driver will not be installed automatically. On the USB flash drive an FTDI driver package can be found:



Figure 4: Compressed folder of the FTDI driver

Plug in the cable to the PC. Extract the FTDI Driver.zip and install the driver on your windows system. If it succeeds, a COM-port is assigned to the USB to TTL converter cable and can be found in the device manager. Otherwise contact your system administrator for getting administrator rights.

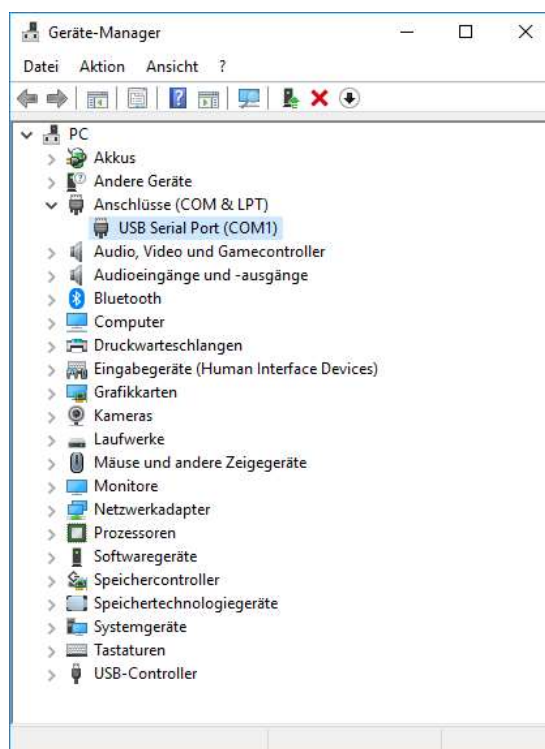


Figure 5: Device-Manager overview with listed recognized COM-Ports

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Step 2: Install Graphical User Interface

The interface is built on TCL. TCL is a simple script based programming language for all available platforms. More detailed information can be found under [1].

As well as the license terms which are listed under [2].

The software version of TCL which is recommended is 8.6.4 and can be found on the USB flash drive:



Figure 6: Installation binary for ActiveTCL

Thus newer versions of TCL are available online via [1], but TDK does not guarantee the fully working functions with different software versions. The software is used for exemplary demonstration of the serial interface communication between a PC and the driver. Do not use this script in your application.

After opening the ActiveTCL-EXE file the installation is started and the following steps have to be done to succeed successfully:

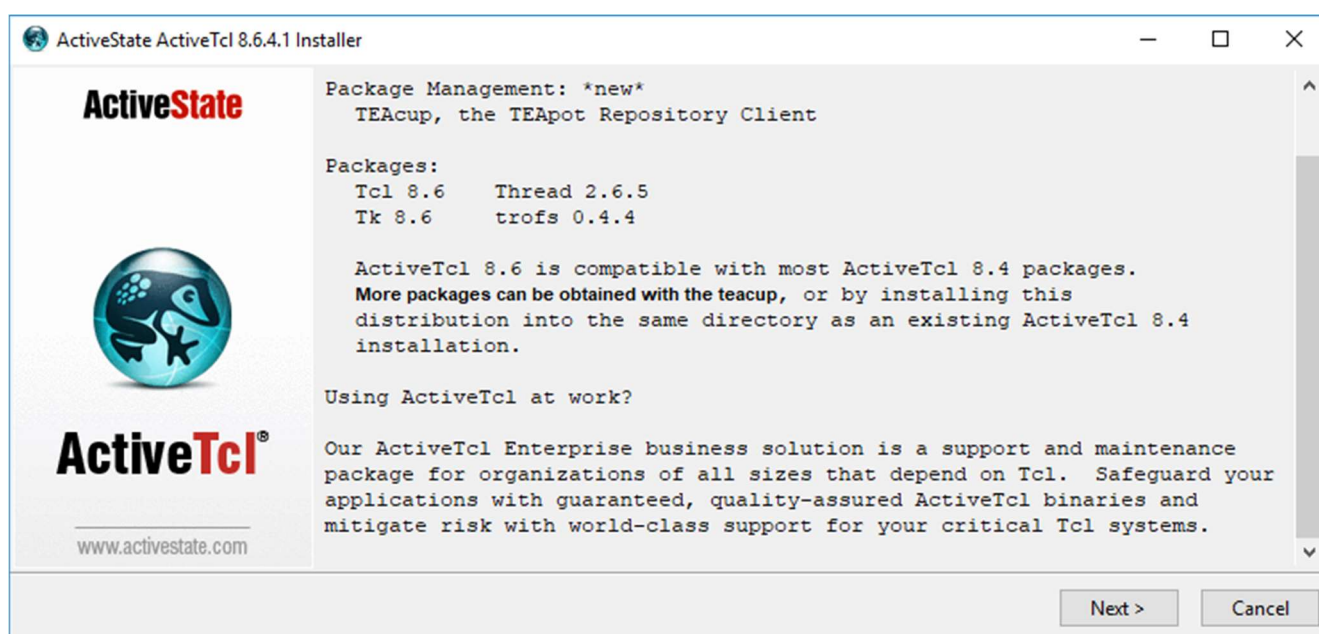


Figure 7: Press next to start the installation process.

Preliminary data

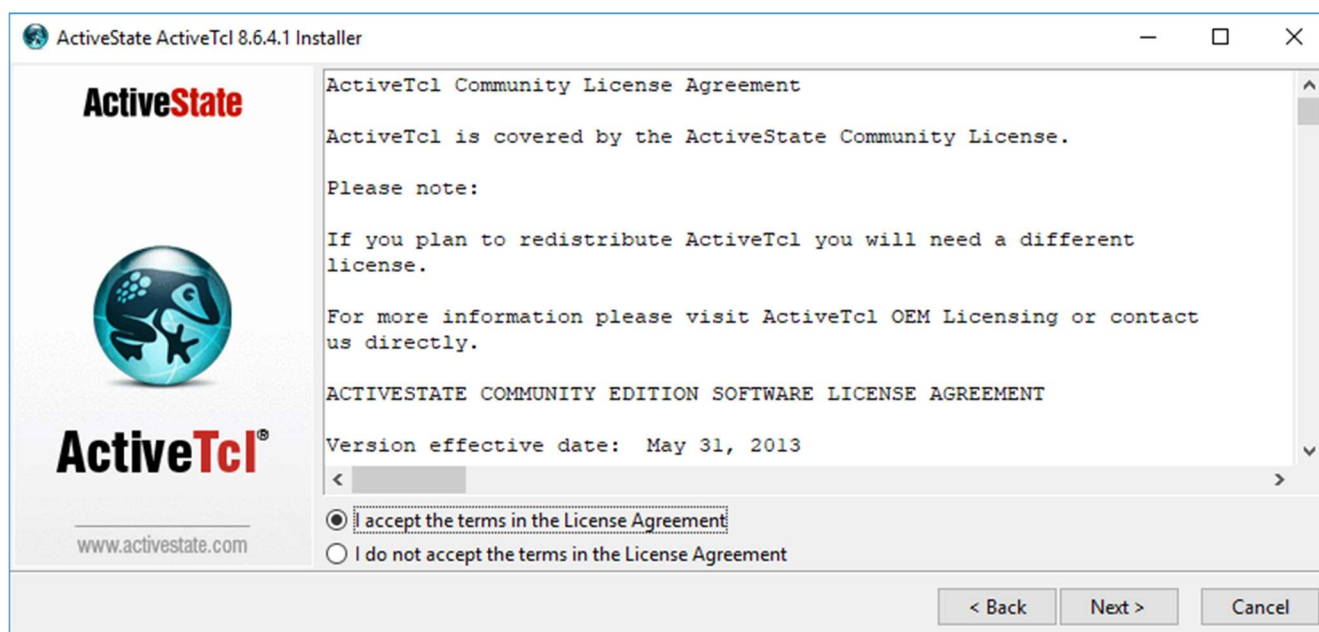


Figure 8: Accept the license agreement and press next.

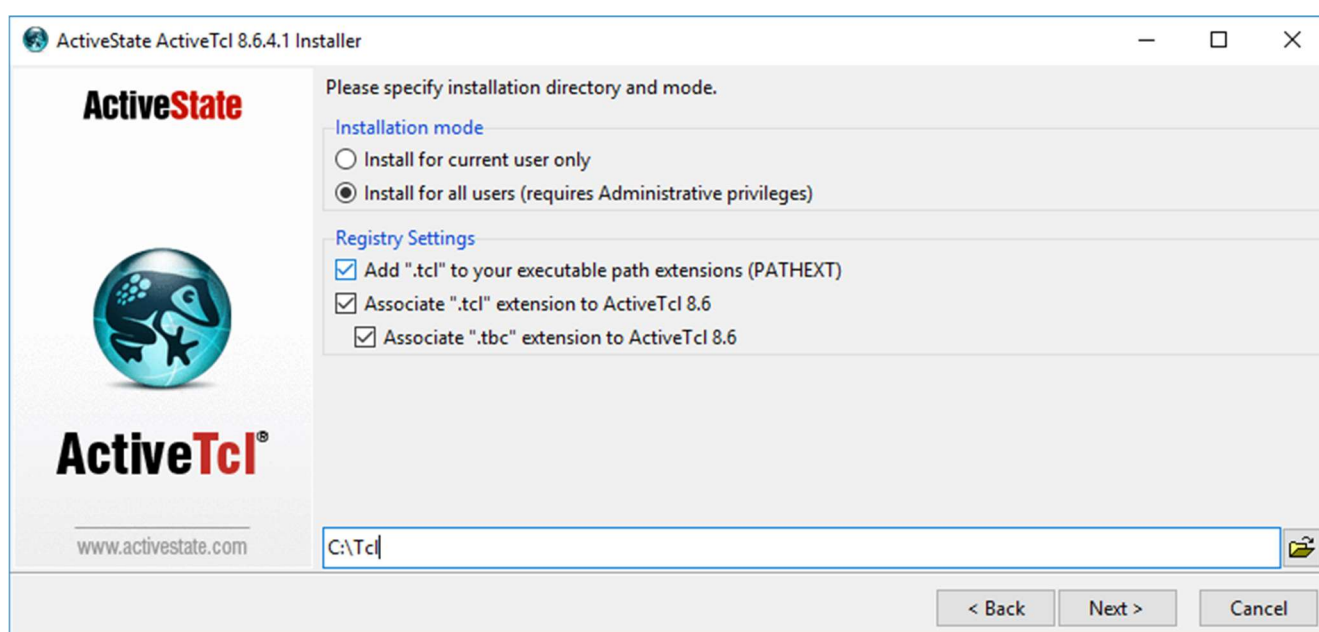


Figure 9: Select the association of "*.tcl" extensions and choose the working directory and press next.

Preliminary data

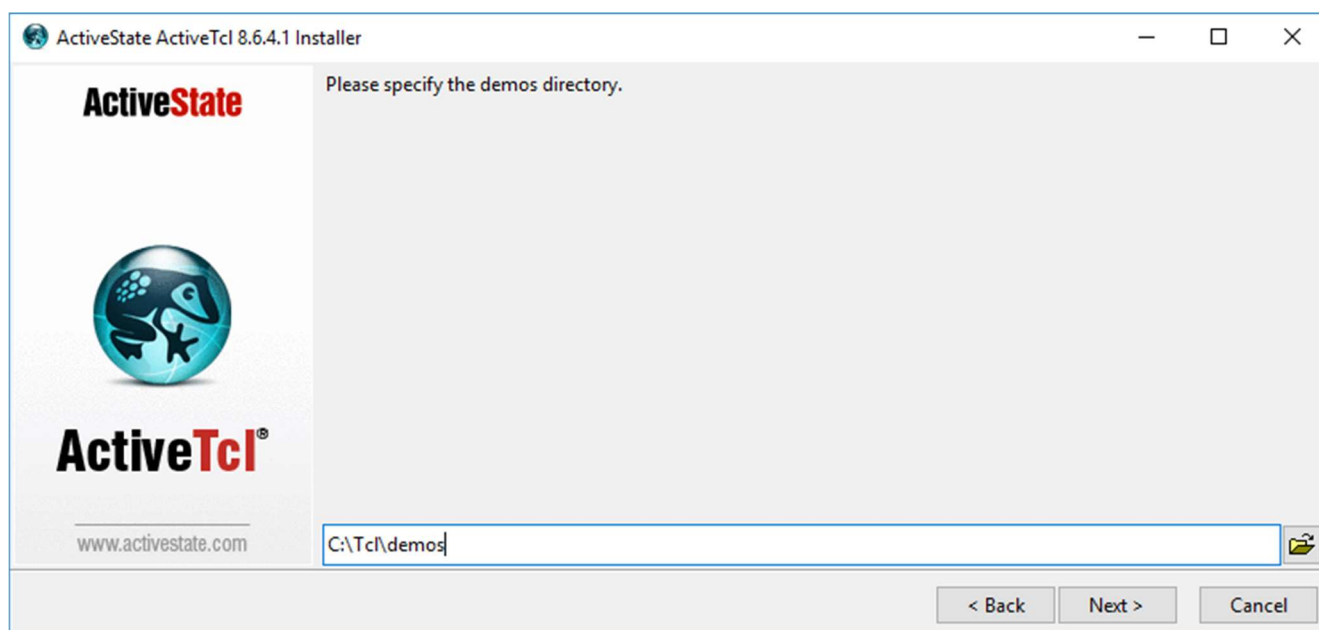


Figure 10: Press next to continue.

If you are interested of further programming in TCL language, some example scripts can be found in the “demos” directory.

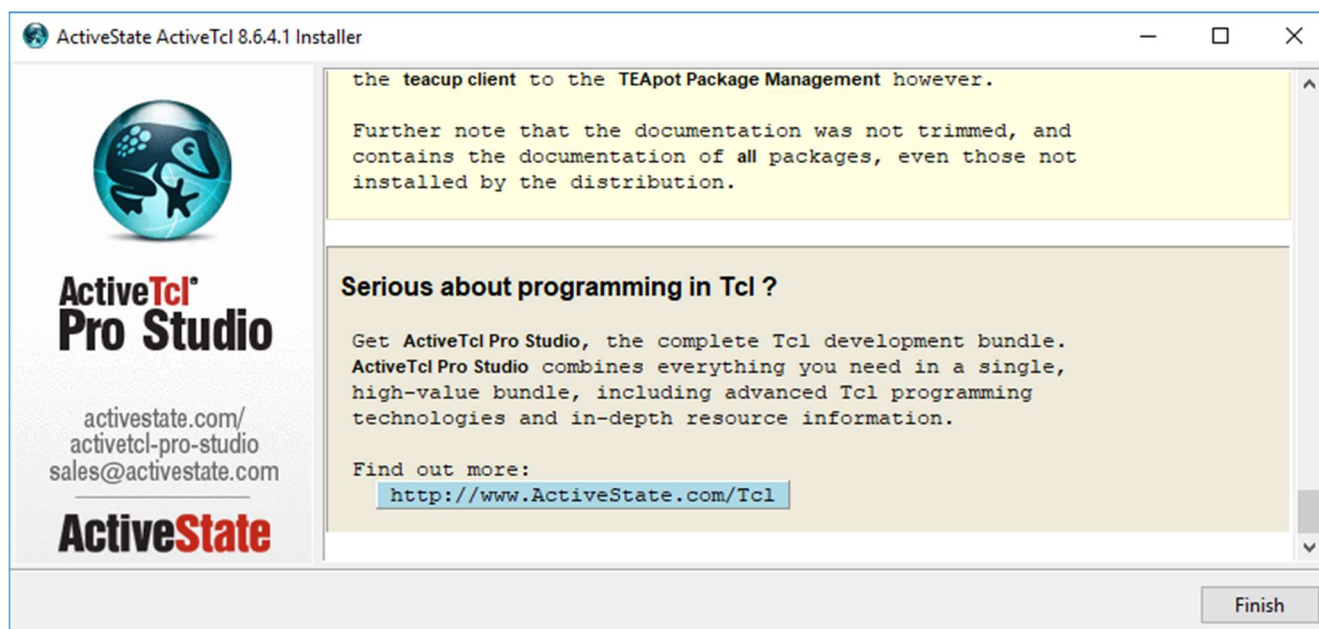


Figure 11: Installation is finished. ActiveTCL can be used now.

After a reboot of the windows client all *.tcl files are associated to ActiveTCL. Next step is to install an additional library. The library is necessary to use the CRC32 generator class. For installing this functionality extract the tcllib.xxx.zip folder first. . “xxx” describes the different version of the library.

Preliminary data



Figure 12: Compressed folder of the necessary library

Once open the install.tcl



Figure 13: Installer files for installing the library

Afterwards following window pops up:

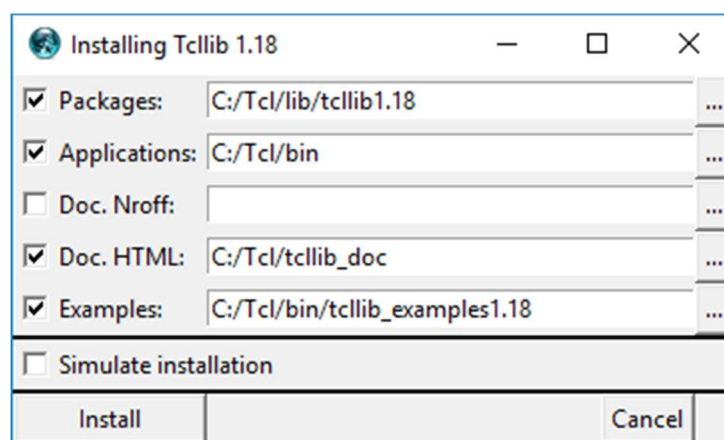


Figure 14: Press “Install”, the window disappears and another window is coming to the front.

Preliminary data

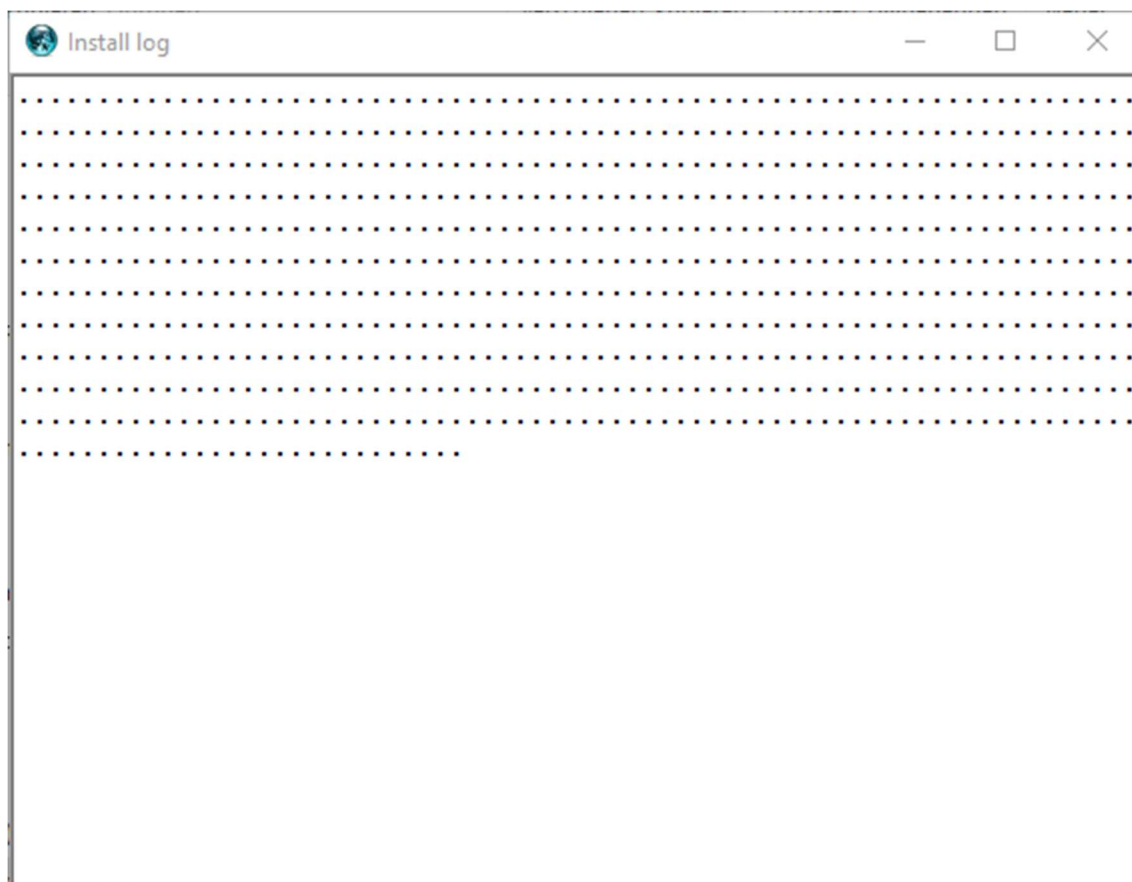


Figure 15: Window which shows the installation process.

As long as the install process is finished successfully the window closes automatically and the installation procedure of the ActiveTCL is completed.

Open the Drive-F Gui.tcl script to run the graphical user interface for controlling the demo kit.



Figure 16: Script for the graphical user interface

If no error messages appear the installation is succeeded. Close the script.

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Step 3: Connect the USB-TTL-Converter to Drive F

The FTDI-driver is installed correctly and the PC recognizes a new COM-port in the device manager, the output wires of the converter has to be connected as following:

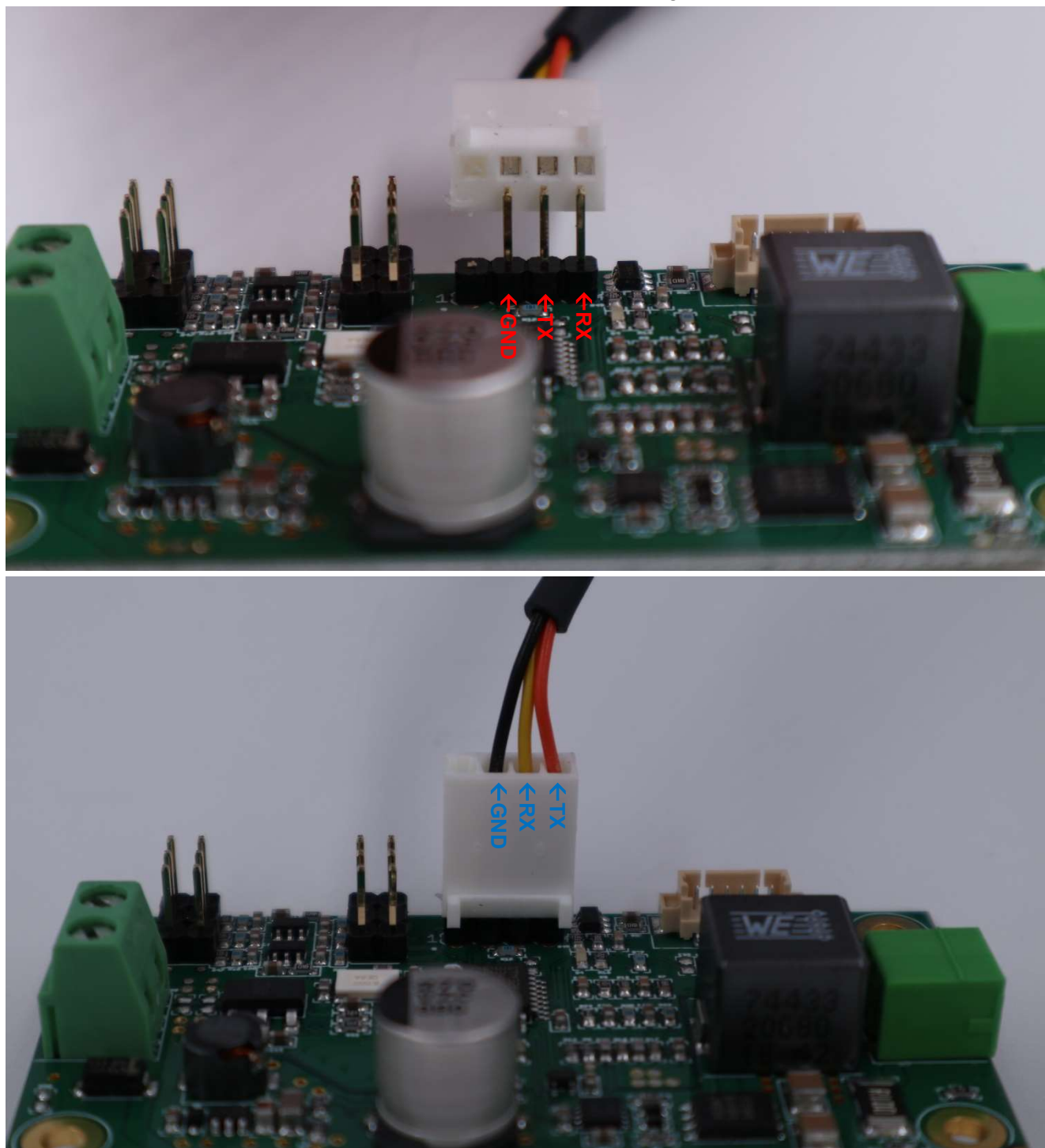


Figure 17: Drive F connection to the USB-TTL-Converter

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Afterwards the COM-port in the DriveF-GUI.tcl script has to be adapted to the current COM-port setting of the PC. Thus, the TCL-script can be opened with a simple text editor (Notepad++ is recommended) and line 8 has to be changed to the current configuration:

```

1  #!/bin/sh
2  #.the.next.line.restarts.using.tclsh.\
3  exec.wish."$0".${1+"$@"}
4
5  #.*****.PARAMETERS.*****
6
7  #.Windows:.comx,.Linux:./dev/ttyUSBx
8  set.COM_PORT.com1
9
10 #.use.4000000.for.fast.communication.(and.unsolder.C19).or.use.19200...
11 #set.BAUD_RATE.4000000
12 set.BAUD_RATE.19200
13
14 #.*****.end.of.PARAMETERS.*****
15
16 set.mode."undefined"
17
18 package.require.crc32
19
20 proc.send_message.{message} {

```

Tool length: 19.426 lines: 642 Ln: 14 Col: 32 Sel: 0 | 0 Unix (LF) UTF-8 INS

Figure 18: DriveF-GUI.tcl COM-Port settings

Note: COM-ports with higher numbers than 8 are not supported by TCL (windows version).

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Connect to the DC 24 V power supply of Drive F and open the DriveF-GUI.tcl. The connection is established if the message appears that the serial line was able to open. And a file id exists.

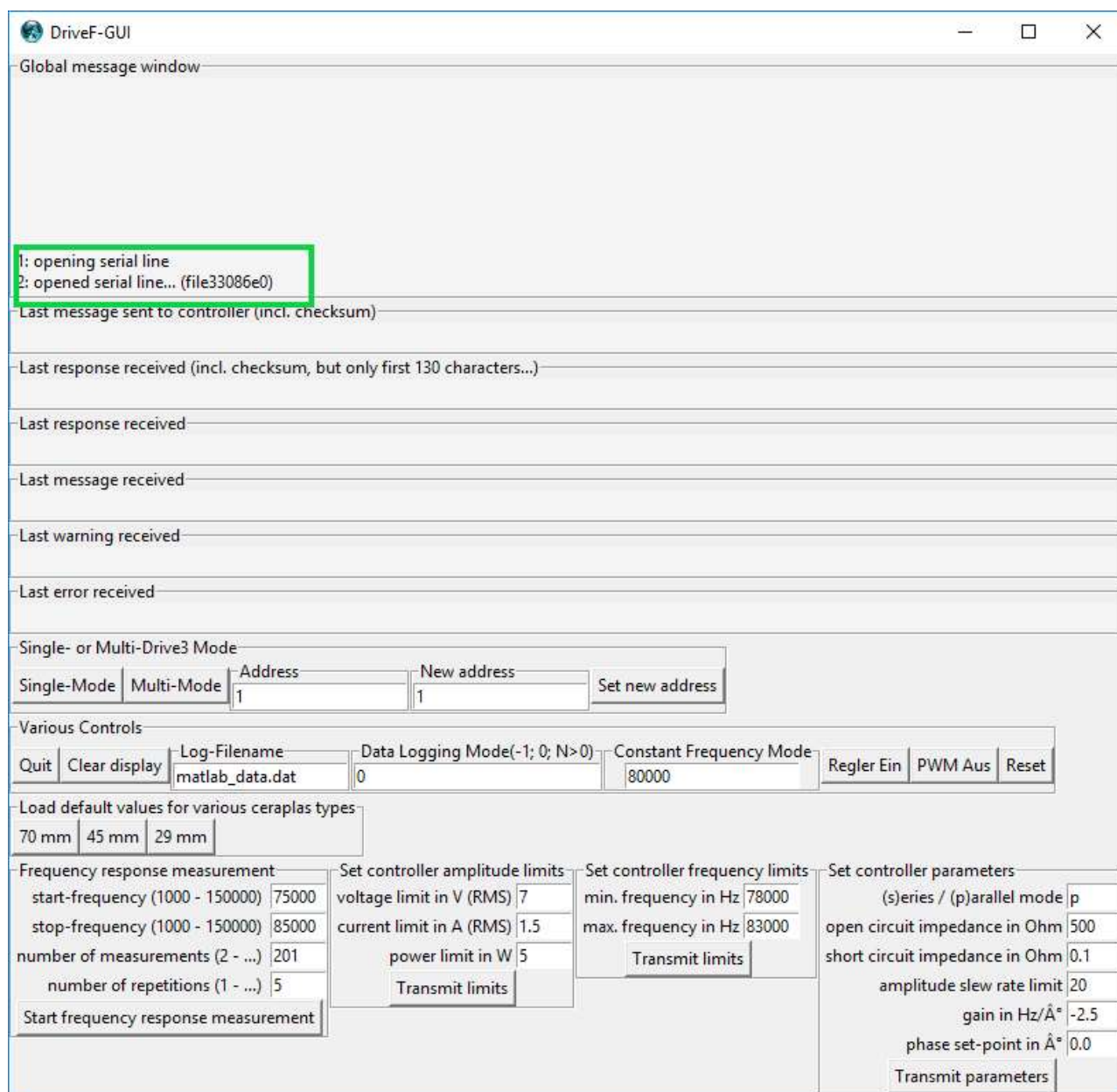


Figure 19: Graphical User Interface of DriveF-GUI.tcl with an established communication.

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Description of the Graphical User Interface

With the previous steps the connection is established. The user interface offers the opportunity to change the parameter of the CeraPlas element individually.

Firstly, choose the mode of your connection:



Figure 20: Selection of the connection mode

Single-Mode: Drive F is connected to a single host. If single mode is accepted by the driver the message ("activated single drive3 mode; CRC checksum") is depicted in the "last response received message box". Additionally, the blinking pattern of the LED on the circuit board changes to continuously blinking mode.

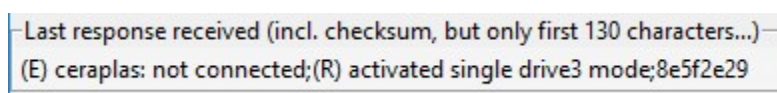


Figure 21: Response of the driver after sending the mode-command

Multi-Mode: More than one Drive F can be connected parallel. Each driver has to have a unique address number between 1 and 65533. 65534 is reserved as broadcast address and 65535 is the default address of the driver.

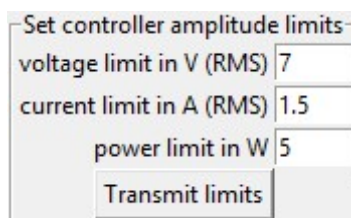


Figure 22: Power settings

Next, the power limits within the CeraPlas element have to be defined and transmitted to the driver via pressing "transmit limits". Again, a confirmation message pops up in the "last response received message box" if the command is processed correctly.

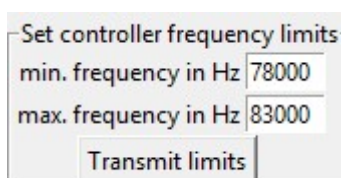
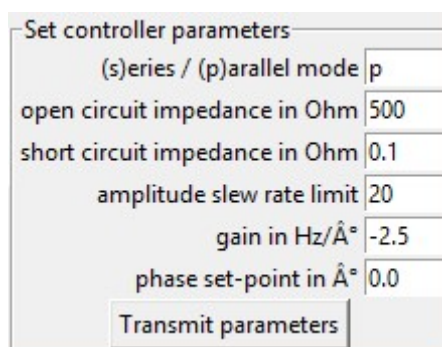


Figure 23: Frequency range settings

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Thirdly, the frequency range where the CeraPlas element has its 2nd harmonic has to be defined and afterwards clicking the button “Transmit limits”. The conformation follows in the same message box as in the previous step.



Set controller parameters	
(s)eries / (p)arallel mode	p
open circuit impedance in Ohm	500
short circuit impedance in Ohm	0.1
amplitude slew rate limit	20
gain in Hz/°	-2.5
phase set-point in °	0.0
Transmit parameters	

Figure 24: CeraPlas element and driving mode specific settings

Afterwards, the settings of algorithm for driving the CeraPlas element can also be adjusted. The default values are already written in the box. A short description of the parameter is shown below:

(s)eries / (p)arallel mode: defines the working point in the resonance or antiresonance peak (see datasheet for more details)

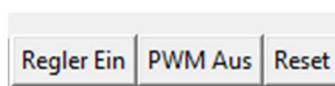
open circuit impedance / short circuit impedance: defines the impedance for detecting unconnected CeraPlas element or shorted connection wires

amplitude slew rate: defines the amplitude slew rate of the applied voltage during the power regulation

gain in Hz per degree: defines the increment of the frequency steps per degree phase shift

phase set-point in degree: defines the phase between voltage and current to be kept constant

After pressing the “transmit parameter” button all settings are done and finally pressing the “**Regler EIN**” button leads to starting the CeraPlas element.



Regler Ein	PWM Aus	Reset
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Figure 25: On/Off/Reset switch

PWM Aus: switches of the CeraPlas element

Reset: resets all settings before.

Preliminary data

Data collecting of the driver

The driver provides the ability to send all data of the algorithm which is used to control a constant input power to the CeraPlas element via the RS232. Besides the parameter of the CeraPlas element, three temperature sensors (PT100) can be attached to the user inputs (instead of the jumper) to measure different conditions in a certain application.

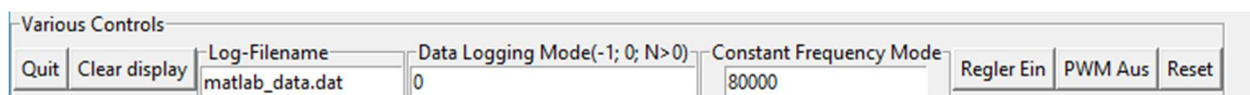


Figure 26: Data acquisition settings

If a log-filename and a data logging mode is defined (pressing enter in the data logging mode text box after editing the value sends the command) a dataset each millisecond is sent via the RS232 interface to the host.

Please be aware that the data is sent only if the CeraPlas element is running.

Log-filename: defines the filename where the data is stored. The root directory is the location of the DriveF-GUI.tcl file

Data logging mode: defines the logging mode. Values can be -1: continuously logging is set. The data receiving stops if the Ceraplas element is switched off. Value 0 means no data acquisition will start. Values > 0 can define the maximum number of lines which is wanted to receive.

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A single data line is separated by SPACES and the meaning of the values is described further in the following table:

Table 4: Dataset Description

Number of column	Parameter	Unit
1	Time since Driver is supplied	ms
2	Frequency of the driving signal	Hz
3	Mean frequency of the driving signal	Hz
4	Amplitude of the driving signal	a.u
5	Offset of the driving signal	a.u.
6	Not described	
7	Not described	
8	Not described	
9	Not described	
10	Applied RMS Voltage	uV
11	Not described	
12	Not described	
14	Not described	
15	Not described	
16	RMS Current	uA
17	Not described	
18	Not described	
19	Effective Power	uW
20	Reactive Power	uW
21	Apparent Power	uW
22	Magnitude of impedance	Ohms
23	Phase of impedance	Degree
24	Average value of phase of impedance	Degree
25	Controller state of frequency	a.u.
26	Controller state of amplitude	a.u.
27,28,29*	ADC Value of User Inputs 1,2,3	a.u.

*the UserInputs are connected by a pull-up resistors and a logic level of 3.3 V. If a PT100 is used instead of a jumper following equations transfer the ADC value to a temperature value:

$$R_{PT100,1} = R47 * \frac{\text{data}(27)}{10} * \frac{1}{4095 - \frac{\text{data}(27)}{10}}$$

$$T_{PT100,1} = \frac{R_{PT100,1}}{R28 - 1} * \frac{1}{\alpha_0}$$

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In this example UserInput 1 is used and the non-described variables are defined as

$R47 = 3.3 \text{ k}\Omega$,

$\text{data}(27) \dots$ value of column 27 of the collected dataset,

$R28 = 100 \text{ }\Omega$

$\alpha_0 = 3.851 \cdot 10^{-3} \text{ }^\circ\text{C}^{-1} \dots$ temperature coefficient of a PT100.

For using the full scope of the PT100 range the pull up resistor (e.g. R47) of the UserInput has to be changed from $3.3 \text{ k}\Omega$ to $150 \text{ }\Omega$.

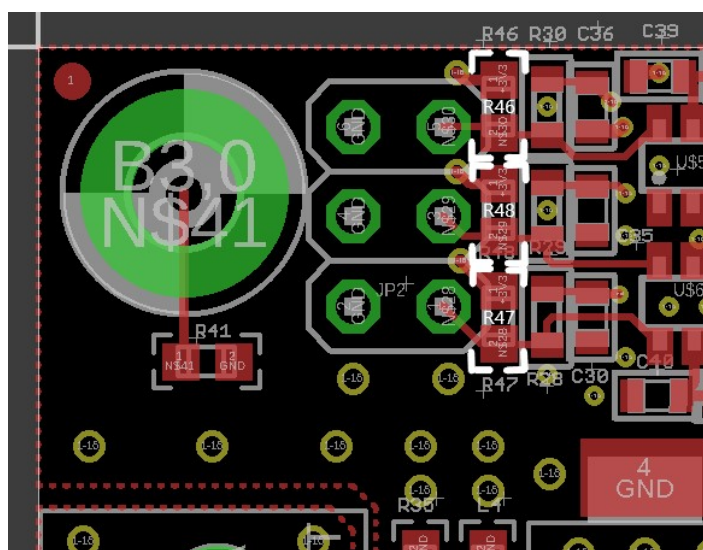


Figure 27: Board view of the pull up resistors for the UserInputs

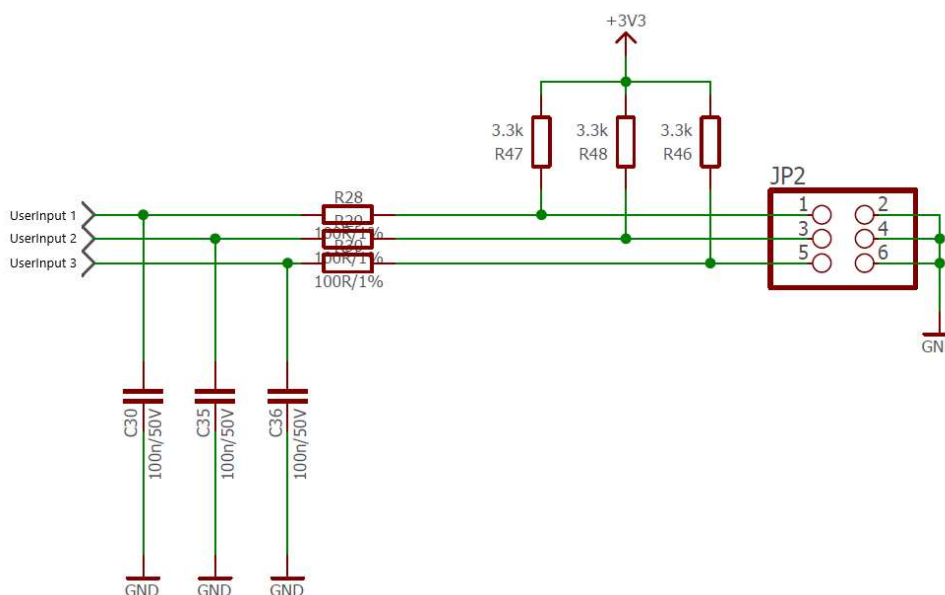


Figure 28: Schematic view of the pull up resistors for the UserInputs

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Cautions for Using the CeraPlas element Driving Circuit

- At high power and long operating time overheating of the driving circuit is possible.
- At high power and long operating time additional cooling of the driving circuit may be necessary.
- High voltage hazard! The output side of the CeraPlas element can reach voltages of up to 10 kV!
- Take special care of the toxicity of ozone! Use a ventilation system to remove the ozone. Depending on air-flow around the output of the transformer the ozone concentration can reach very high values!
- Use air or inert gases only! Do not use flammable working gases!
- TDK is not responsible for any harm during operating and testing of CeraPlas element!

List of references:

[1] <https://www.tcl.tk/> (2019)

[2] <https://www.tcl.tk/software/tcltk/license.html> (2019)

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Important notes

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