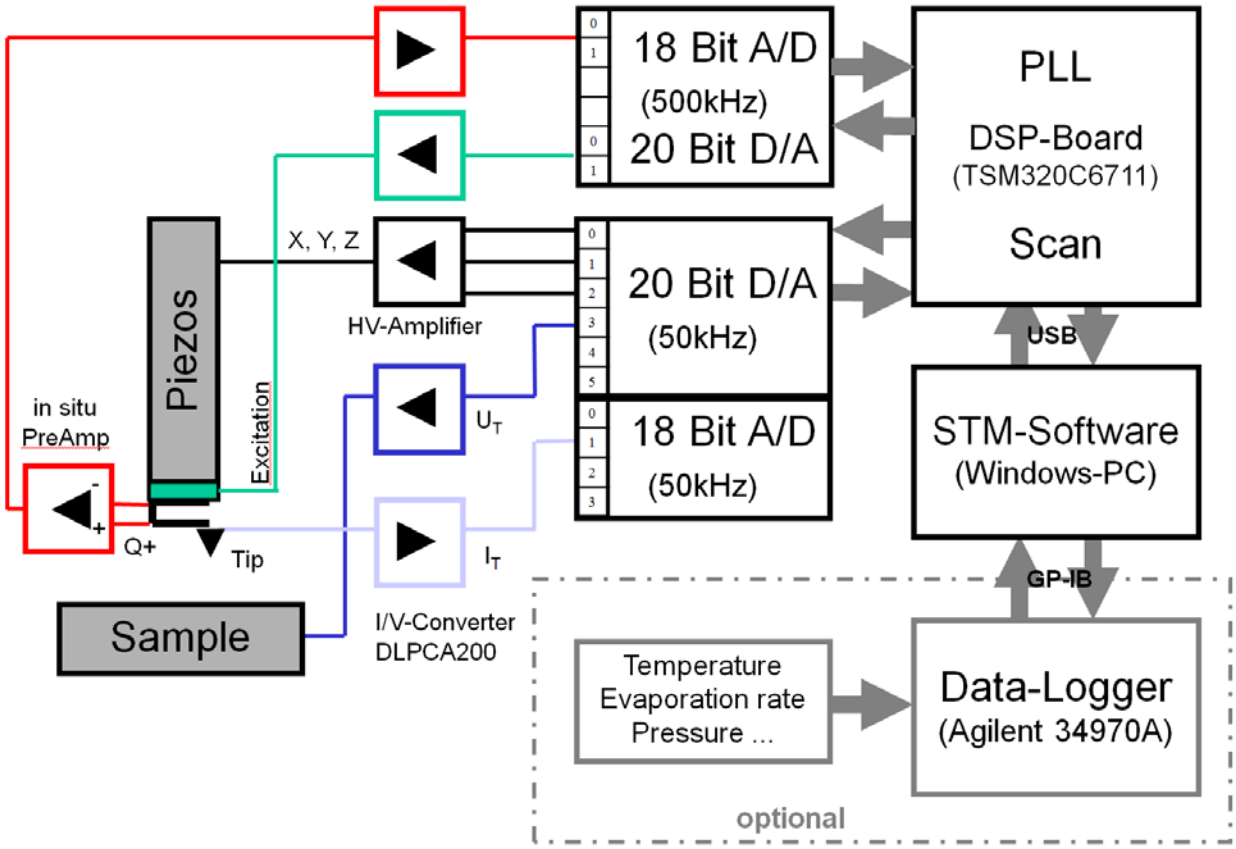
1 CreaTec-STM-Electronics, Installation

The STM-electronics are based on a digital design. A DSP (digital signal processor) controls the scanning parallel (X, Y) to the surface as well as the tip - sample separation. All scanning/feedback parameters are fully controlled through the STM program. An additional high voltage amplifier and a current preamplifier complement the electronics. There is an option to read data from an external Data-Logger (Agilent 34970A) into the program via the GPIB bus. The CreaTec LT-STM electronics is designed for a Besocke Beetle or Pan Slider Type STM (determined by the relays board of the HV-amplifier) allowing other approach mechanisms to be implemented as well.



1.1 DSP-Unit

The heart of the STM-electronics is a DSP (TSM320C6711) by Texas Instruments. It is integrated into a commercial Single Board Computer (SBC) from Innovative Integration and connects to a Windows ® operated PC via USB2.0. The DSP is electronically decoupled from the analog I/O board, which provides 6 D/A outputs (20bit, max. 100kHz, +/- 10V, max. 20mA, <0.3mV RMS, impedance < 100Ohm, DAC0-4 have 50kHz bandwidth, DAC5 has 250kHz), 4 A/D inputs (18bit, max. 100kHz, +/-10V, <100mV RMS, impedance > 10kOhm) and 32 digital I/O ports (16 input, 16 output, TTL-level, 5V, max. 10mA/bit, max. 50mA/8bit). 4 analogue output channels are used to control the piezo-voltages (X, Y, Z) and the sample bias voltage. One input channel records the tunneling current, the others may be used to read other signals (e.g. dI/dV from an external lock-in-amplifier).
There are 2 monitor outputs (ADC0[I] and DAC0[Z]) to connect an oscilloscope avoiding ground loop problems.

Please state the intended OS for the control PC during the order of the electronics.
Switching from one OS to another may involve changing the firmware of the electronics!

Installation under WinXP/Win2000 32bit:

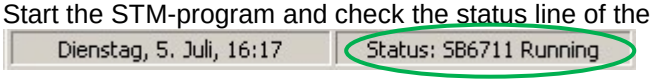
- Before connecting the electronics to the PC:
- Install the SBC6711 driver on the PC running Windows XP or Windows 2000.
- Install the Opal Kelly FPGA Board (adds USB 2.0 support) driver and reboot the PC.
- Switch on the DSP-unit before you connect it with the PC using the supplied USB cable. The maximum cable length for USB connections is 5m.
- The drivers for the SBC6711 and the FPGA should be installed automatically now.

Installation under WinXP/Win7 64bit:

- Before connecting the electronics to the PC:
- Install the Opal Kelly FPGA Board driver and reboot the PC.
- There is no driver for the SBC6711. The FPGA board takes full control of the communication between DSP and PC. The SBC6711 will initially boot from flash memory.
- Switch on the DSP-unit before you connect it with the PC using the supplied USB cable. The maximum cable length for USB connections is 5m.
- The driver for the FPGA should be installed automatically now.

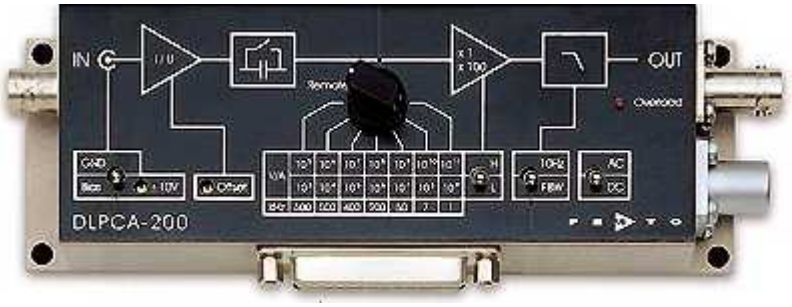
All versions:

- Install the STM-software (see software installation)
- Start the STM-program and check the status line of the main window. It should state this:



1.2 Pre-Amplifier (I/V-Converter)

Any I/V-converter with the desired specifications can be used with the STM-program, but it should be *externally gain switch able* to exploit the manipulation techniques implemented in the software. We supply the Femto DLPCA-200 (gain: 10^3 … 10^{11} V/A).



Installation

- Connect the *Input* of the DLPCA-200 with the STM-tip as close as possible and the *Output* to ADC0 (using a BNC cable).
- Connect the back of the DSP-box with the DLPCA200 using 2 cables. (power supply and gain control)
- Set the switches of the DLPCA-200 to: GND, Remote, FBW, HS, DC.

For the complete datasheet, please visit the manufacturer's website: www.femto.de

1.3 STM-Software

The software includes standard data acquisition, data analysis, I(z), I(V) spectroscopy (with internal/external Lock-In-Amplifier), 3d image rendering, flexible atomic manipulation, acquisition and analysis software with

lateral manipulation (in constant current and constant height mode) and nanostructuring support, tip forming and vertical manipulation. For details see software manual.

Installation (preliminary versions):

- Unzip the CreaTec STM-software to a folder of your choice.
- Create a link from PSTMAFM.exe to your desktop.

The preliminary software versions do not contain an installation routine.

Installation (final version):

- Start the installation routine and follow the instructions.

If there is no driver of the DSP- or FPGA-board installed or the driver is occupied by another instance of the STM program, the software automatically switches to the *Analysis* mode. Therefore you can also install it to other Windows PCs to analyse your images. There is no extra license required for this.
The software is scriptable and may be controlled via OLE/COM from many programs directly or using LabView.

1.4 Options

Data-Logger

The STM-software is able to read data from the Agilent 34970 via the GPIB-interface or RS-232 into the program. For details refer to the software manual.

Lock-In-Amplifier

To use an external Lock-In-Amplifier for spectroscopy connect the frequency input of the Lock-In to the DAC5. The Lock-In in the STM-Program has to be set to '*External + Internal Ref*'. The additional data (from the external Lock-In) will be read at ADC1 (e.g. dI/dU) and ADC2 (e.g. d^2I/dU^2).
The STM-software is also able to read and store the parameters of the Stanford Research SR830 via the GPIB-interface into the program. For details refer to the software manual.

1.5 HV-Amplifier

Three channels (X, Y, Z) are amplified by a selectable factor of 1, 3, 10 or 30 to the dual voltage bipolar output. An offset voltage or a modulation voltage may be added to any channel by a potentiometer and via separate inputs. The maximum output voltage is ±200V. An interface to the DSP-board allows reading the gain settings into the STM-program to set the appropriate scaling in the images. The modulation voltage from the X- (Y-, Z-) Mod. will be added to the output with gain 1.
Bandwidth: 60kHz @3dB, <1mV RMS
Input impedance (X-in, Y-in, Z-in): 10kOhm
Mod. input impedance (X-mod, Y-mod, Z-mod): 100kOhm
Output impedance (rear outputs): 100Ohm
Output impedance (front outputs): 10kOhm
Digital input / output: TTL level, max. 2mA

Installation

- Connect the *HV-Amplifier* with the mains voltage. It is factory preset to 115V or 230V AC (stated at the back of the unit).
- Use the supplied 25pin (1:1) SubD (Besocke type STM) or the 37pin to 25pin SubD (Slider type STM) cable to connect the DSP-Board (*HV-Amplifier*) with the HV-Amplifier (*PC-Remote*).
- Use BNC cables to connect the inputs of the *HV-Amplifier*: DAC0 → Zin; DAC2 → Xin; DAC3 → Yin.
- DAC1 controls the tunneling voltage. It may be connected to the *Voltmeter*, but it can also be used directly. The software shows the actual tunneling voltage too.
- There are 2 plugs supplied with the HV-amplifier that may be used for wiring the STM scanner (see cabling section).

2 Electrical wiring of the HV-Amplifier

The HV-Amplifier was designed to work with a Besocke type or Slider type STMs. Both versions differ in the relays board switching the analogue outputs of the XY-channels to different pins of the output connectors.

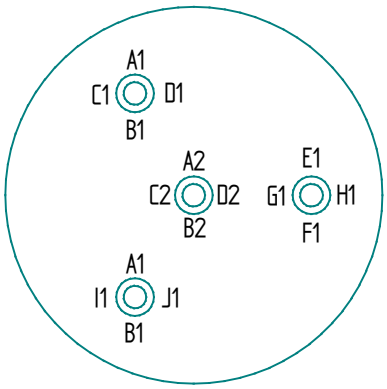
Besocke type STMs:

The output voltages of the HV-Amplifier can be switched by a relays board in order to move the ramp ring of a Besocke STM either in a rotation (**Rot**) or a translation (**XY**) mode. The switching between the two modes is done with a digital output of the DSP-board. The rotation mode is used to approach the tip to the sample. It is also possible to apply the scan voltages to the center piezo of a Besocke STM. Again the switching between **Coarse** and **Main** is done with a digital output of the DSP and the relays board.
The output of the Z-channel is not switched. Connect the electrodes for the feedback (+Zout or -Zout) to the front of the HV-Amplifier.
It's also possible to connect the output (+Zout and/or –Zout) internally to the spare contacts at the 6pin Fischer connector to avoid external cabling.

The HV-Amplifier gives the following output according to **Coarse/Main** and **XY/Rot**:

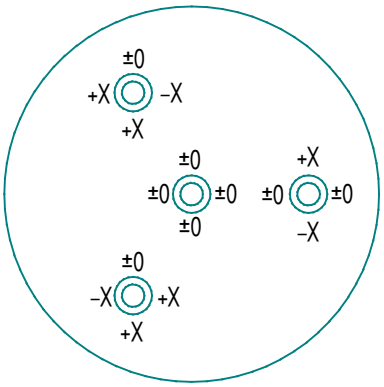
Connector	Voltage (Coarse, XY)	Voltage (Coarse, Rot)	Voltage (Main, XY/Rot)
HV-Amplifier (11 pin, Fischer) A1	+y	0	0
HV-Amplifier (11 pin, Fischer) B1	-y	+x	0
HV-Amplifier (11 pin, Fischer) C1	-x	+x	0
HV-Amplifier (11 pin, Fischer) D1	+x	-x	0
HV-Amplifier (11 pin, Fischer) E1	+y	+x	0
HV-Amplifier (11 pin, Fischer) F1	-y	-x	0
HV-Amplifier (11 pin, Fischer) G1	-x	0	0
HV-Amplifier (11 pin, Fischer) H1	+x	0	0
HV-Amplifier (11 pin, Fischer) I1	-x	-x	0
HV-Amplifier (11 pin, Fischer) J1	+x	+x	0
HV-Amplifier (6 pin, Fischer) A2	0	0	+y
HV-Amplifier (6 pin, Fischer) B2	0	0	-y
HV-Amplifier (6 pin, Fischer) C2	0	0	-x
HV-Amplifier (6 pin, Fischer) D2	0	0	+x

Recommended electrical wiring for a Besocke type STMs:

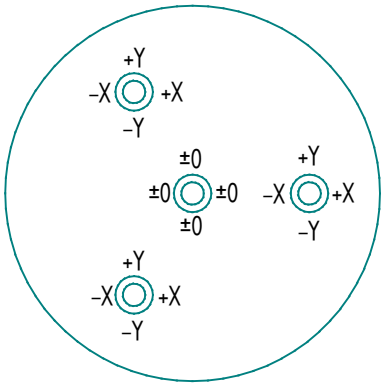


This gives you the following voltages at the electrodes of the STM when set to

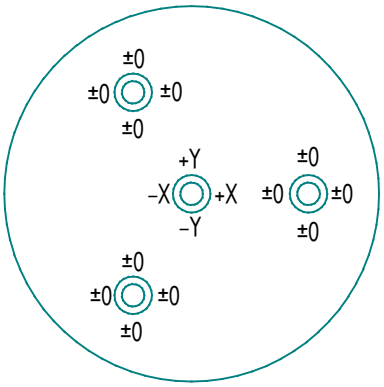
Coarse and **Rot**:



Coarse and **XY**:



Main and **XY** or **Rot**:



Slider type STMs:

The output voltages of the HV-Amplifier can be switched by a relays board in order to move the slider block of the STM for **Coarse** positioning in **X / Y / Z** direction or to drive the scan unit (**Main**). The switching between the different modes is done with a digital output of the DSP-board. (See software manual, section Ramp Controller)

The X / Y -Coarse mode supplies bipolar voltage pulses (saw tooth shape) to drive the slider block with a slip-stick-motion. The Z –Coarse mode drive the slider using two bipolar outputs.
In scan mode (Main) you may switch on an additional low pass filter (1kHz, first order passive) to smoothen the XY-voltages.
It's also possible to use the Z-slider instead of Z-Main and XY-Coarse instead of XY-Main for feedback and scanning. Refer to the software manual for that.

The HV-Amplifier gives the following output according to the settings **Coarse/Main/Scan**:

Connector	Voltage (Coarse, XYZ)	Voltage (Scan Main)	Voltage (Scan Coarse XYZ)
HV-Amplifier (11 pin, Fischer) A1	+X (X)	0	+X
HV-Amplifier (11 pin, Fischer) B1	-X (X)	0	-X
HV-Amplifier (11 pin, Fischer) C1	+Y (Y)	0	+Y
HV-Amplifier (11 pin, Fischer) D1	-Y (Y)	0	-Y
HV-Amplifier (11 pin, Fischer) E1	0	+X	0
HV-Amplifier (11 pin, Fischer) F1	0	-X	0
HV-Amplifier (11 pin, Fischer) G1	0	+Y	0
HV-Amplifier (11 pin, Fischer) H1	0	-Y	0
HV-Amplifier (6 pin, Fischer) A2	+X (Z)	0	+Z
HV-Amplifier (6 pin, Fischer) B2	-X (Z)	0	-Z
HV-Amplifier (6 pin, Fischer) C2	+Y (Z)	0	+Z
HV-Amplifier (6 pin, Fischer) D2	-Y (Z)	0	-Z

3 Supplied electrical wiring

Femto DLPCA-200

Sub D Connector (25 pin)	Cable	Sub D Connector (9 pin)	Use	DSP-Board
9	green	4	Gain GND	Dig. GND
10	brown	1	Gain1	Digital OUT (DX0)
11	white	2	Gain2	Digital OUT (DX1)
12	pink	3	Gain3	Digital OUT (DX2)
13	grey	9	AC/DC	Digital Vcc (+5V)
14	yellow	8	HighSpeed/LowNoise	Digital OUT (DX5)

Lemo (3 pin)		Tuchel (3 pin)	
1	brown	3	Vcc +15V
3	green	2	±0V
2	white	1	Vcc -15V

Digital I/O connection

Header 40 pin AD/DA	According to Manual	SubD 37-pin Digital I/O	Used for the STM as	SubD 25 pin HV-Amplifier	Sub D 9 pin DLPCA200
1	Digital OUT (DX0)	1	GainPreAmp1		1
2	Digital OUT (DX1)	20	GainPreAmp2		2
3	Digital OUT (DX2)	2	GainPreAmp3		3

4	Digital OUT (DX3)	21	Main/Coarse (Besocke)	4	
5	Digital OUT (DX4)	3	XY/ROT (Besocke)	5	
6	Digital OUT (DX5)	22	LowNoise/HighSpeed		8
7	Digital OUT (DX6)	4			
8	Digital OUT (DX7)	23	Approach		
9	Digital OUT (DX8)	5	Decode XY (Slider)		
10	Digital OUT (DX9)	24	Decode XY (Slider)		
11	Digital OUT (DX10)	6	Z-Main/-Coarse (Slider)		
12	Digital OUT (DX11)	25	XY-Coarse/-Main (Slider)		
13	Digital OUT (DX12)	7	Filter XY-Main (Slider)		
14	Digital OUT (DX13)	26			
15	Digital OUT (DX14)	8			
16	Digital OUT (DX15)	27			
17	Digital IN (DX16)	9	GainHV X	9	
18	Digital IN (DX17)	28	GainHV X	10	
19	Digital IN (DX18)	10	GainHV Y	11	
20	Digital IN (DX19)	29	GainHV Y	12	
21	Digital IN (DX20)	11	GainHV Z	13	
22	Digital IN (DX21)	30	GainHV Z	14	
23	Digital IN (DX22)	12			
24	Digital IN (DX23)	31			
25	Digital IN (DX24)	13			
26	Digital IN (DX25)	32			
27	Digital IN (DX26)	14			
28	Digital IN (DX27)	33			
29	Digital IN (DX28)	15			
30	Digital IN (DX29)	34			
31	Digital IN (DX30)	16			
32	Digital IN (DX31)	35			
33					
34					
35					
36					
37					
38					
39	Digital +5V	37		24	9
40	Digital Ground	19		25	4

CreaTec Fischer & Co. GmbH
Industriestr. 9
D-74391 Erligheim
Germany

Tel: + 49 7143 9670 - 0
Fax: + 49 7143 9670 - 27
sales@createc.de
www.createc.de

Managing Directors:
Stephan Krinke, Dr. Christoph Rüdt,
Dr. Sven Zöphel
District court Stgt, no. HRB 301240

Kreissparkasse Ludwigsburg
IBAN DE77 6045 0050 0006 8135 90
BIC SOLADES1LBG
VAT no. DE 144 995 873