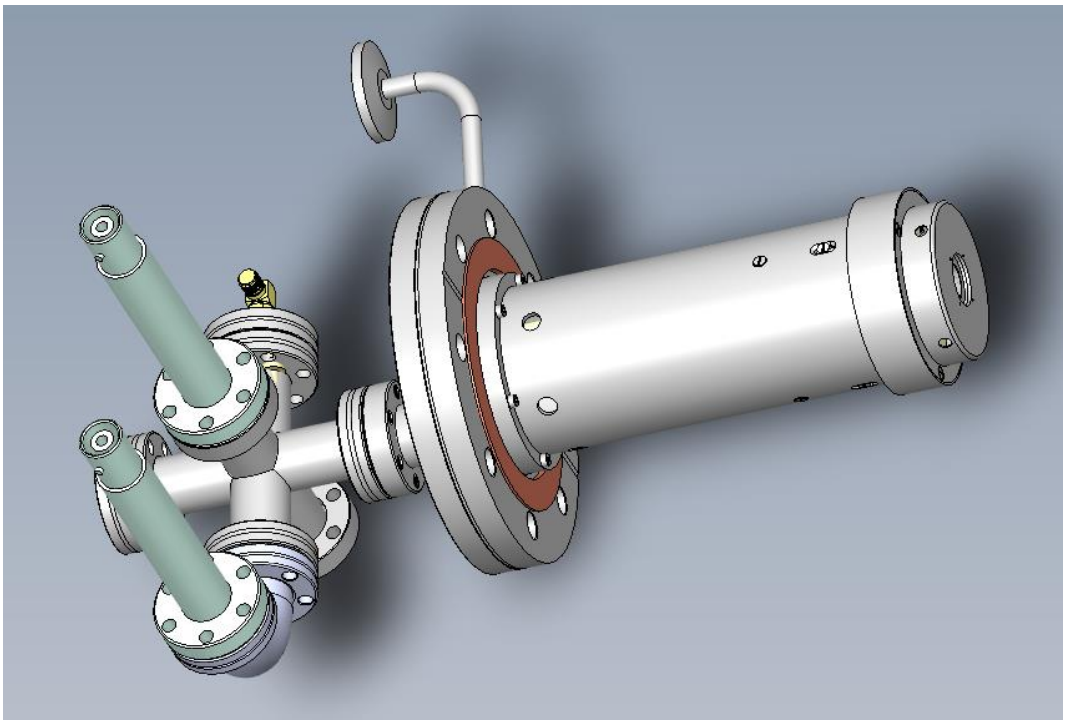
User Manual

TES-63 versions up to 15 kV with reverse polarity



DETAILED TABLE OF CONTENT:

1 Symbols definition

Human safety warnings are indicated by the following statements:

Danger Indicates an imminent hazardous situation, which, if not avoided, could result in death or serious injury.

Warning Indicates a potentially hazardous situation, which, if not avoided, could result in death or serious injury.

Caution Indicates a potentially hazardous situation, which, if not avoided, may result in minor or moderate injury or hardware damage.

For optimum machine operation, user attention is requested by the following statements:

Note indicates where particular attention should be paid to a certain section or area to ensure efficient operation or service of the equipment.

Default values indicates the values recommended by Polygon Physics for optimum operation of your machine.

2 General safety instructions

WARNING **Follow the safety and operating instructions to avoid the risk of personal injury and hardware damage.**

2.1 Intended use

WARNING **If this equipment is used in a manner not specified in this manual, the protection provided by the equipment may be impaired**

The TES63 is a sub module integrated in the customer equipment, the customer is responsible for the safety functions such as interlocks and emergency stops (EMO).

The TES63 product is intended for use in a controlled industrial indoor environment. Always maintain adequate ventilation and clearance. All air intakes of the control rack must remain free from obstruction.

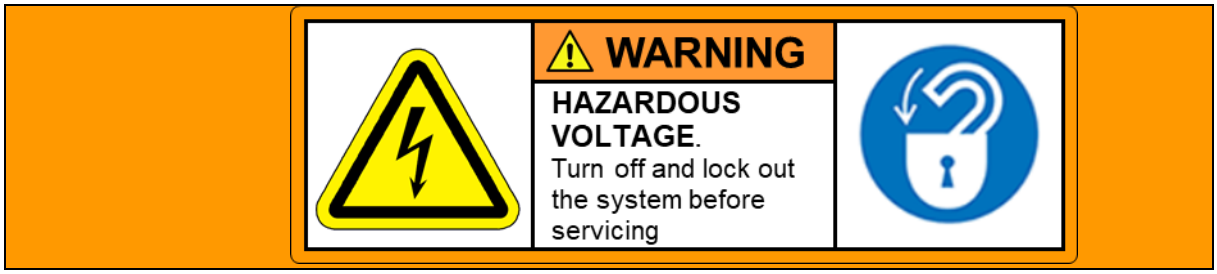
Do not operate the equipment in an explosive atmosphere.

The ion source is only designed to operate in a high vacuum chamber. Do not activate the High Voltage unless the source is under high vacuum.

2.2 Safety recommendations

CAUTION The chassis of the control rack must be grounded with a grounding strap (Safety Ground).

WARNING **In case of an intervention on the system of any kind, stop and unplug the entire system to prevent any electrical hazards (Lock Out Tag Out protocol).**



Do not disconnect any cables or hoses while the system is operating.

If liquid is spilled on the control rack, push the nearest EMO button.

2.3 List of hazards

hazard	consequences	localisation	Counter measure
Electrical shock High voltage 	Stored high voltage energy is below 45µC and 0.3J is under IEC 61010 threshold and can only cause very minor muscle contraction and no skin burn.	HV plugs at the back panel outputs HV plugs at the cable endings HV wires inside the rack HV plugs at the source body	A warning safety sticker is present at the rack back panel Perform a lock out tag out procedure before accessing live electrical parts inside the rack Perform a lock out tag out procedure before disconnecting high voltage cables
Electrical shock 	230V live parts present in the rack will cause medium skin burn and electrical shock if accessing without precaution during maintenance.	230V wires inside the rack	A warning safety sticker is present at the rack back panel Perform a lock out tag out procedure before accessing live electrical parts inside the rack
Electromagnetic waves 	2,45GHz electromagnetic radiation can disturb nearby sensitive electronics and cardiac assist devices, emission levels are under CISPR11 thresholds	2,45GHz electromagnetic radiation emitted inside the rack and circulating on the cable link to the source	Make sure that the rack is properly grounded Make sure that all the rack faces are properly installed and screwed after a rack maintenance
Hot surfaces 	Hots surfaces of some inner part of the ion source can cause skin burns during maintenance if not waiting for cooling time	Parts inside the ion source body under vacuum will get hot near 200degC	Wait a few minutes of cooling time after stopping the ion source and after source unmounting from the vacuum chamber before disassembly of the ion source body during maintenance.

Neutral gas 	Neutral gas can replace oxygen and cause operator dizziness in case of gas line leak	Near the gas line	Perform a leak check of the gas lines during installation/commissioning of the equipment

2.4 Decommissioning recommendation

a) Materials and MSDS information

The TES63 product does not contains any hazardous materials (no chemical compound, no liquid, no ionizing radiation), and can be recycled according to local national regulations for industrial products. The ion source is composed 80% metal stainless steel and contains few tens of grams of PEEK material and ceramics materials. The command control rack contains standards electronics parts, PCB, and UL insulating materials. Total weight of polymer is under 100g.

b) Definitive stop procedure

Apply a Lock Out Tag Out protocol when stopping the equipment before unmounting the ion source or the command control rack in order to avoid any electrical shock.

3 Hardware description

3.1 General specifications

Source inner size	150*40*40mm
Source outer size	300*300*200mm for cable clearance
Source flange	CF63, metal ring
Source weight	1 kg
Rack size	19 inches 3U rackable
Rack weight	10 kg
Rack power rating	110-230 V AC 2A
Cable bundle length	5 m
UHF power	2,45GHz 1-15W adjustable
High voltage power	15kV 0.8mA bipolar
Electrode plasma	CuNi 0.35mm diameter
Electrode focus	Mo Conical 1mm diameter
Electrode GND	SS 316L 1mm diameter
In vacuum materials	SS 316L, PEEK, Alumina, Kapton, Al 2024
Operating pressure	1e-6 mbar
Flow rate	0.01-1 SCCM
Suppressor (option)	Sm2co17

3.2 Functional specifications

Extracted current	4µA < ext. current < 5µA in positive polarity
Current stability	<1% pk pk over 1h, <5% pk pk over 24h
Source voltage	0-15kV
Charge state	1+, 1-

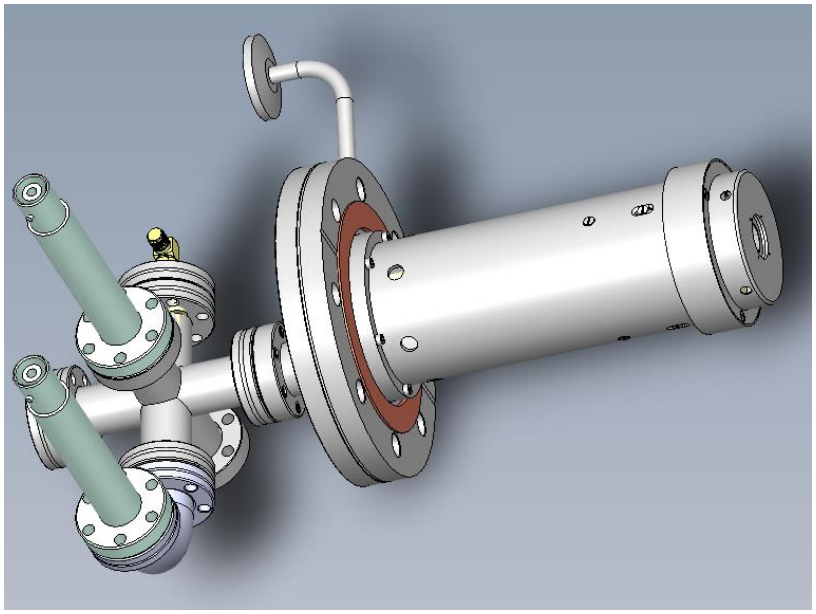
3.3 IE-GUN equipment components description

a) 19" control rack

The 19" control rack consists of two high voltage power supplies, the Ultra High Frequency (UHF) power generator, and the control units to operate the source.

b) Source flange

The source flange holds the source itself plus its feedthroughs for operating the source (gas, UHF power, high voltage). The flange is a CF 63 standard flange.



c) *Gas valve*

The Pfeiffer EVR 116 gas valve regulates the amount of gas entering the source.

d) *SMA extension cable (2)*

2.45GHz SMA cable Male/Male to transfer the UHF power from the rack to the source flange.

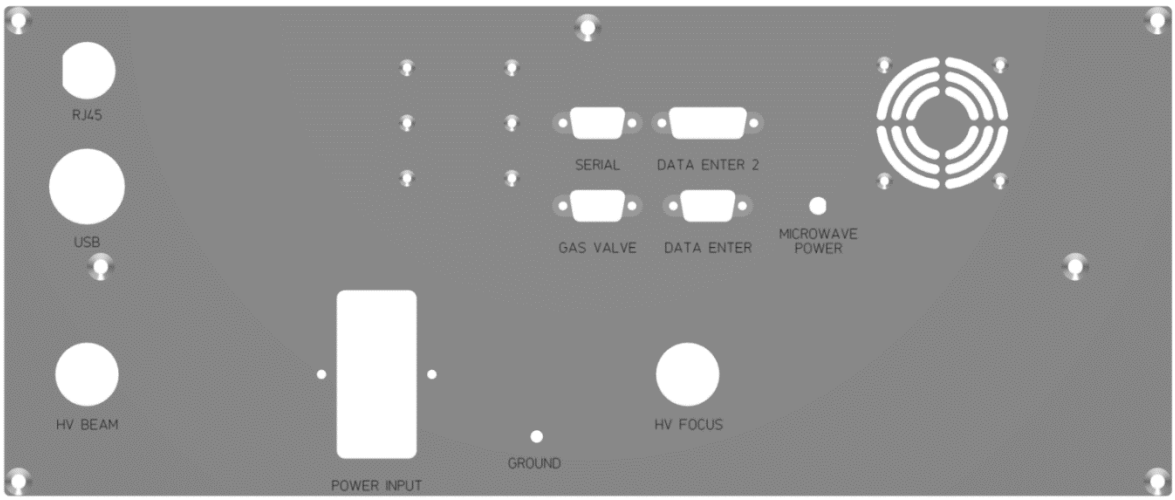
e) *Power cord (3)*

CE22 standard power cord to connect the rack to the grid.

f) *Gas valve cable (4)*

D-Sub 15 Male / DIN 5 cable to connect the gas valve with the control rack.

3.4 Identification of the connectors on the control rack backpanel



a) Power Input

IEC C14 inlet, 220V 50/60 Hz. This is the power inlet for the control rack, to plug the provided 220V power cord.

b) Ground

M4 threaded rod. This is the common ground of the control rack. It needs to be connected to earth with a ground strap (not included).

c) Mass Flow

Female D-Sub 15 connector to power and control the mass flow. Use the provided D-Sub female / male cable (4).

d) Data Enter

Female D-Sub 9 connector for the reading/control of user equipment. The terminal block wiring diagram:

Pin	DATA ENTER 1
1	Interlock 1
2	Interlock 2
3	Pressure input
4	Analog input 1 0-10V 24bits (Faraday cup)
5	Relay, normally closed state

6	Relay, signal to switch
7	Relay, normally open state
8	Ground
9	+24V, 1A max

Connect the reading of a pressure gauge controller (not included) to pin 3.

e) Data Enter 2

Female D-Sub 9 connector for the reading/control of user equipment. The terminal block wiring diagram:

Pin	DATA ENTER 2
1	Analog output 1, 0-10V, 16 bits
2	Analog output 2, 0-10V, 16 bits
3	Ground
4	Analog input 2, 0-10V, 24bits
5	Analog input 3, 0-10V, 24bits
6	Analog input 4, 0-10V, 24bits
7	Analog input 5, 0-10V, 24bits
8	Analog input 6, 0-10V, 24bits
9	Analog input 7, 0-10V, 24bits
10	Analog input 8, 0-10V, 24bits
11	Analog input 9, 0-10V, 24bits
12	Ground
13	Ground
14	+24V, 1A max
15	+5V, 1A max

f) USB

Female USB connector, only for factory use.

g) RJ45

Ethernet port allowing access to shared folder with microcontroller. The data and configuration files are stored in this folder.

h) Microwave Power

Female SMA connector, to transfer the Ultra High Frequency power between the control rack and the

source. Use the supplied SMA extension cable (2).

CAUTION	Never operate the rack without the SMA extension cable connected between the rack and the source flange (it could damage the UHF power generator).

i) High Voltage cable exit for the source

Rack output for the "HV Beam" cable, to connect to the corresponding HV feedthrough on the source flange.

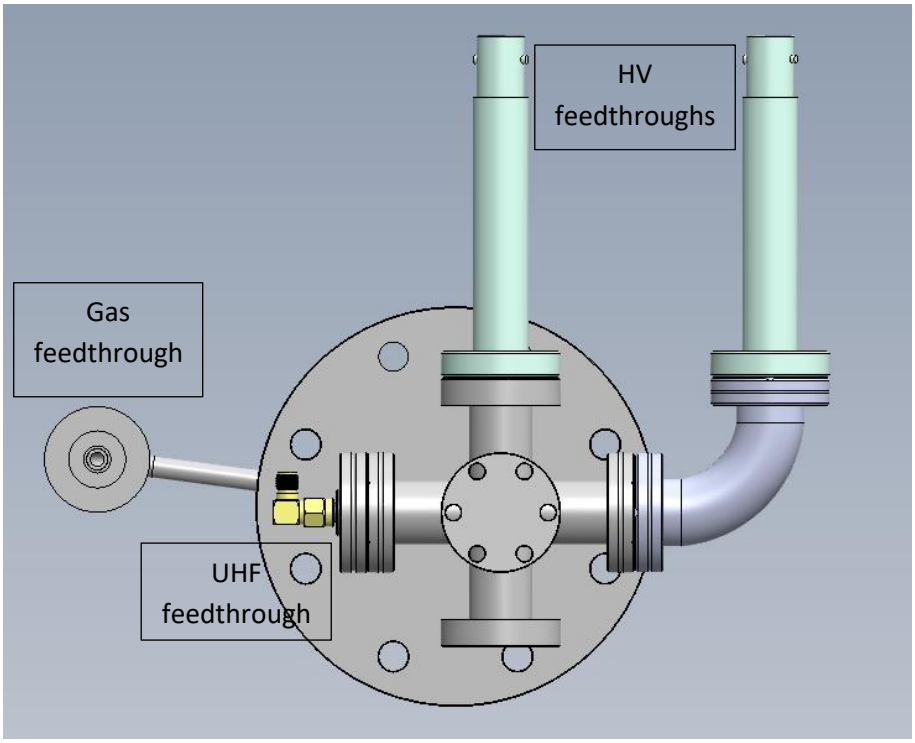
WARNING	NEVER DISCONNECT THE HIGH VOLTAGE CABLES WHEN THE CONTROL RACK IS OPERATING.

j) High Voltage cable exit for beam focusing

Rack output for the "HV Foc" cable, to connect to the corresponding HV feedthrough on the source flange.

WARNING	NEVER DISCONNECT THE HIGH VOLTAGE CABLES WHEN THE CONTROL RACK IS OPERATING.

3.5 Identification of the flange connectors



a) Source gas feedthrough

DN16 iso KF for mounting the gas valve.

b) Connector for the gas valve

Female D-Sub 15 connector to connect to control rack, to control the gas valve controller. Use the provided D-Sub 15 male / DIN5 cable.

c) UHF power feedthrough

SMA feedthrough suitable for 2.45 GHz, to transfer the UHF power from the control rack to the source flange. Use the provided SMA extension cable.

CAUTION Never operate the rack without the SMA extension cable connected between the rack and the source flange (it could damage the UHF power generator).

d) "HV beam" electrical feedthrough

CF16 flange with coaxial high voltage feedthrough to transfer the high voltage from the control rack to the source body.

WARNING NEVER DISCONNECT THE HIGH VOLTAGE CABLES WHEN THE CONTROL RACK IS OPERATING.

e) "HV focus" electrical feedthrough

CF16 flange with coaxial high voltage feedthrough to transfer the high voltage from the control rack to the focus electrode of the source.

WARNING NEVER DISCONNECT THE HIGH VOLTAGE CABLES WHEN THE CONTROL RACK IS OPERATING.

4 Hardware installation

WARNING The source and its control rack can exhibit hazardous voltage levels. They should be operated by properly trained staff only. Operators must follow the instructions in this manual..

CAUTION Never use the source or the control rack in a manner different from that described in this manual.

4.1 Installation pre-requisites

Electrical	Breaker	Differential
	Power plug	IEC 230V
	Fuse	2 Amp
Gas		
	Gas purity grade	99.995% purity or higher
	Gas input pressure	0.1-1 bar
	Gas flowrate	0.01-10 sccm
	Pumping speed	300-1000L/s
Ambient	Temperature,	15-35 degC
	humidity	40-60 % relative

4.2 Installation of the source

a) Mounting the ion source CF63

Mount the ion source flange according to the expected position of the gas inlet valve and cables.

CAUTION Avoid any significant mechanical shock on the ion source body. Do not let the ion source fall on the ground.

Avoid any dust/scratch/fiber on the vacuum seal surfaces in order to prevent any leak

Use the specified tightening torque of 20NM and star shape tightening pattern in order to prevent any leak

b) Mounting and connecting the gas valve

The gas valve comes with two DN16 iso KF flanges: one for the gas supply line, one for the gas input on source flange. Make sure the gas valve is mounted on the source flange in the correct orientation (bottom flange of the valve connected to the source flange).
Connect the gas valve cable on the back panel of the control rack with the provided D-Sub 15/ DIN 5 cable and fasten it.

Avoid any dust/scratch/fiber on the vacuum seal surfaces.

Perform a leak check of the gas lines to ensure proper gas inlet purity

4.3 Installation of the rack and connections

a) Ventilation

CAUTION

It is recommended to have at least 20cm clearance on the back panel, and 5cm clearance on the top of the control rack.

It is required to install an additional cooling system if ambient air temperature is above 40°C.

b) Orientation of the rack

The rack must be positioned horizontally. The hole-plate is the air intake and must be on top.

c) Connection to the grid

Make sure the power switch on the control rack is off before using the provided EC22 standard cable to connect to the grid.

Install a ground strap (not included) between the threaded rod "Ground" and the earth electrode of the building to properly ground the control rack.

WARNING

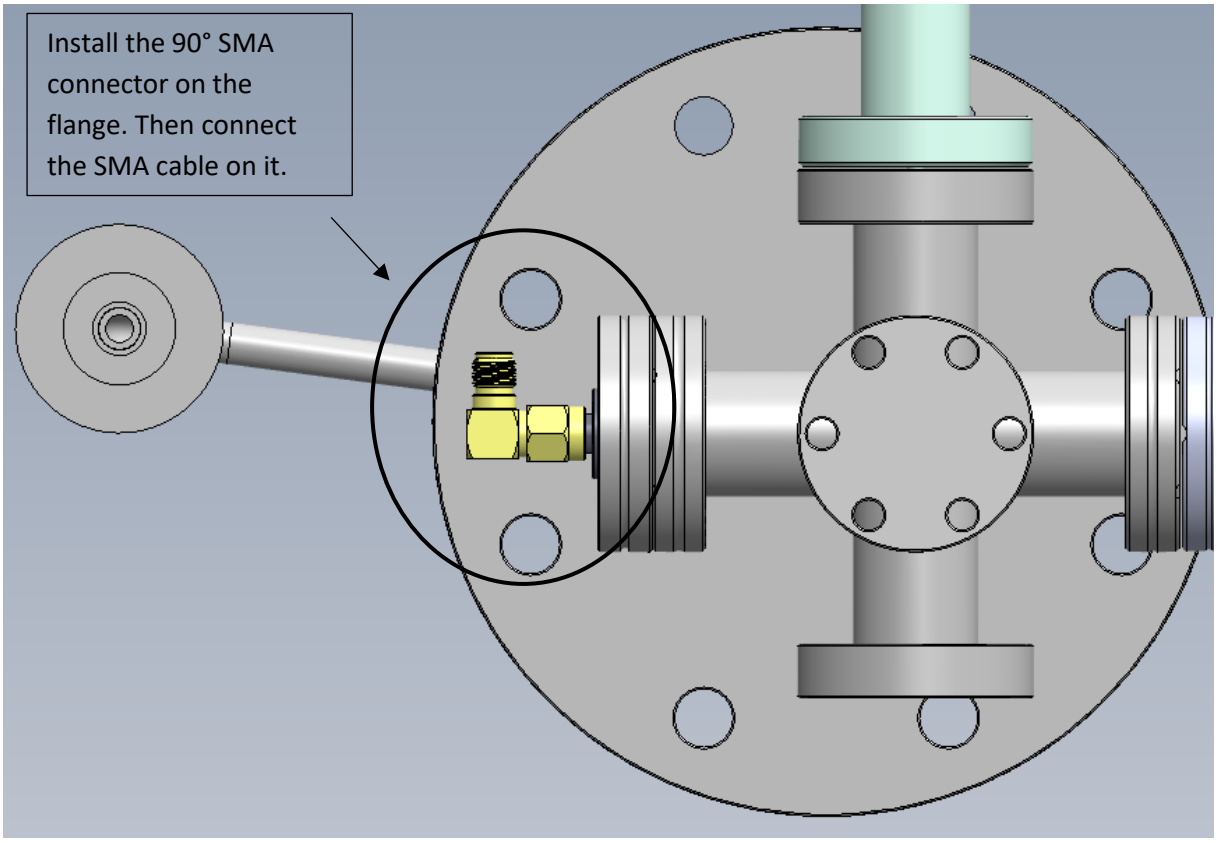
Before connecting to the grid, check that all the cover plates are fastened, the ground connections are made, and that there is proper ventilation.

d) UHF power connection

The transmission of the UHF power between the generator in the control rack and the source is

ensured by the provided SMA extension cable.
First, install the 90° SMA connector on the UHF power CF16 source flange.
Then, connect one side of the cable to the SMA 90° connector on the source flange and the other side on the SMA connector labelled "Microwave Power" on the back panel of the control rack.
Recommended torque: 1 Nm.

CAUTION Never operate the rack without the SMA extension cable connected between the rack and the source flange (it could damage the UHF power generator).



e) High Voltage connections

Connect the cables to the corresponding feedthroughs. Make sure the bayonet mount is properly locked.

f) RS232 connection

Install a crossover serial cable between the connector "serial" on the control rack and the computer.

g) RJ45 connection

Install a standard RJ45 cable between the connector "RJ45" on the control rack and the computer.

4.4 Getting hardware ready for the first beam

The control software must be installed before in order to be able to operate the ion source. Please refer to the software installation section.

CAUTION Never operate the source (do not put it under High Voltage nor send any UHF power to it) when the source is at atmospheric pressure.

a) Evacuate

Pump down the system.
Wait for the pressure to reach $1 \cdot 10^{-6}$ mbar before operating the source for the first time.

Wait typically 1h for proper outgassing, limit void base pressure can only be reached if outgassing is finished.

Perform a leak check of the CF flange if the limit void base pressure cannot be reached within the usual expected time given the turbopump pumping speed.

b) High Voltage conditioning

CAUTION Perform a progressive voltage ramp up conditioning before the first utilization

WARNING NEVER DISCONNECT THE HIGH VOLTAGE CABLES WHEN THE CONTROL RACK IS OPERATING.

Procedure for conditioning the source before generating the first ion beam:

1. slowly ramp up the High Voltage while monitoring the supply current (1)
2. stop when the supply current spikes and reduce the voltage until the spikes disappear (2)
3. wait a few minutes and then slowly increase the voltage again (3)

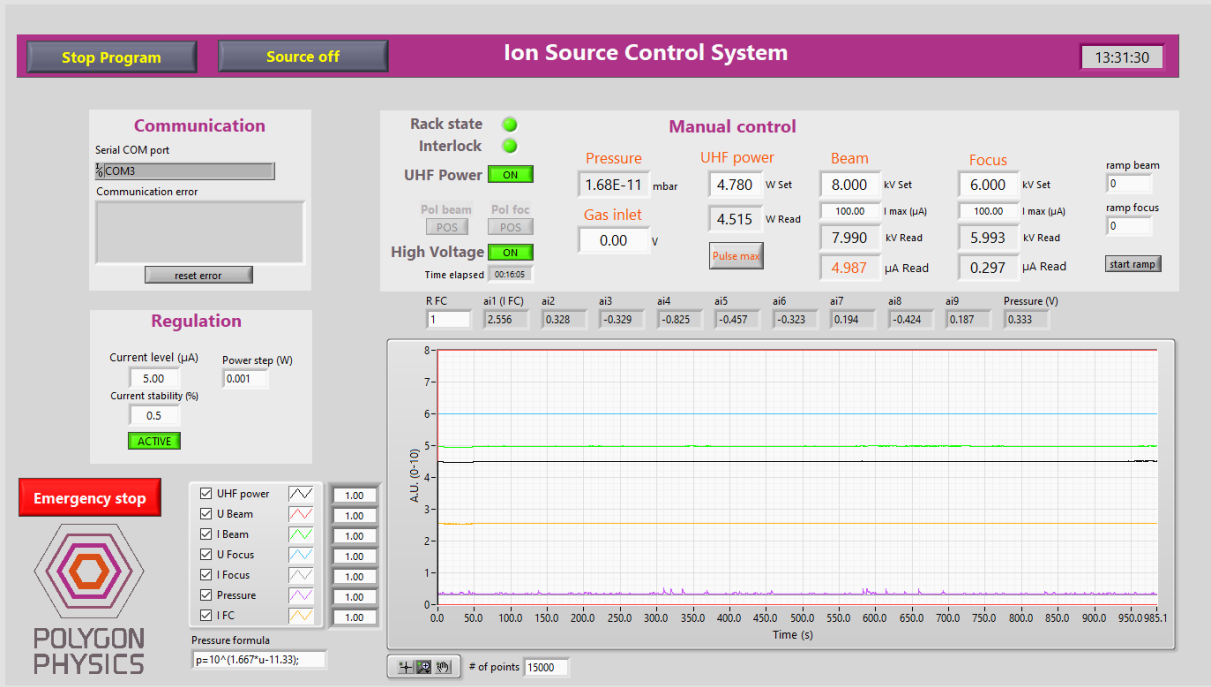
Repeat the above procedure until the desired voltage level has been reached with a stable supply current (4).

(1) high voltage steps of 300V, do the ramp 300V in 5 seconds.
(2) spikes of tens of µAmps, with typically 1s duration, there can be several consecutive spikes.
(3) same high voltage steps as (1)
(4) no spikes over a few minutes operation.

5 Software installation of the IE Gun application (drivers and LabVIEW Run-Time engine)

> Use a computer running Windows 7 or higher, with a minimum screen resolution of 1366 * 768 for the application program to function properly.

1. Check if the default windows decimal separator is set with a dot (.) and not a comma (,). You can find the option under:
   Control panel -> Regional and language options -> Modify the number format -> additional settings -> for decimal settings, enter a dot.
2. Plug the provided USB key, make a copy of the folder named "Install_IEGUN", and save it locally on the computer.
3. Open the folder "Install_IEGUN" on the computer and run the executable named "Setup.exe".
4. Install the two items (the IE Gun program and the National Instruments products) in your folder of choice.
5. Check if all cables between the rack and the flange are properly connected, the D-Sub connectors are fastened, and if applicable, if the chiller is powered and connected to the source flange.
6. The application program is now ready for use and can be found in the "IE Gun" folder on the desktop under the name "IE Gun.exe".



6 User guide of the IE gun application

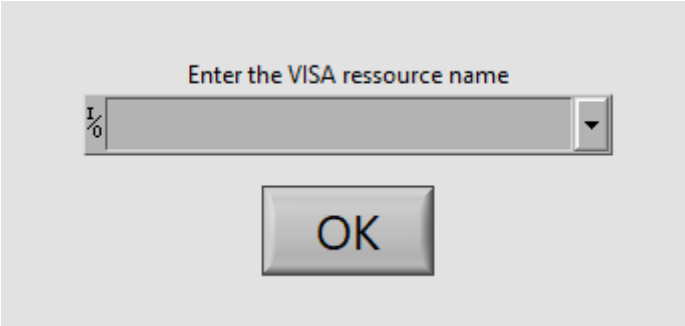
6.1 Starting and stopping

a) *Launching the program IE Gun*

ⓘ	Make sure the drivers have been installed before launching the program for the first time.

ⓘ	Make sure the serial connection between the control rack and the computer is established before lauching the program.

1. Find the executable program "IE Gun.exe" in the "IE Gun" folder on the computer desktop.
2. Turn on the rack.
3. Launch the executable program.
4. Wait for the following window to appear:



5. Select the proper COM port.
6. The program is now ready to start operating the source, provided all connections are in place.

⚠ CAUTION	Make sure that all cables are connected to the source before turning on any high voltage or any UHF power

b) *Stopping the program IE gun*

1. If the source is switched on, click on the “Source On” button to switch of the source. This will set all parameter values to zero and disable all signals to the source (UHF power, high voltages, gas valve).

2. Click on "Stop All". The Labview program stops and the rack is switched off.

3. Switch off the power button the rack.

CAUTION	Never leave the program running when the rack is off in order to avoid any hardware damage.

Now the computer can be turned off without any risk of hardware damage.

c) Disabling of the equipment components

The "Emergency stop" button is the way to stop all IE-GUN components in one click. All parameter values will be set to zero.

CAUTION	This software emergency stop button is not a safety function, it is just a quick way to stop all operations in case of abnormal functional behavior of the ion source.

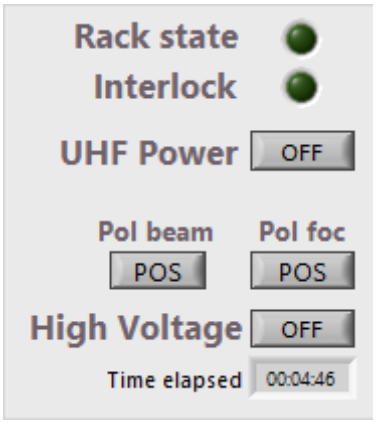
d) Enabling of the equipment components

First switch on the source by clicking on the “source off” button. It becomes green and reads “source on”.

If the source is properly switched on, the “Rack state” indicator and “interlock” indicator should switch to green.

To enable the equipment components there are two buttons: one for the UHF power generator, and one or both high voltage power supplies.

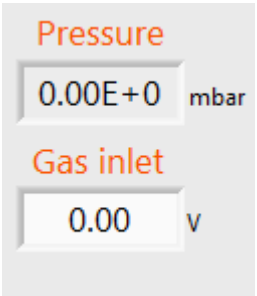
If the light is green (ON), the element is enabled, otherwise it is grey (OFF). These parameters are visible in the upper right part of the user interface.



When the high voltage is switched off, the polarity of each high voltage power supply can be changed with “Pol beam” and “Pol foc” buttons.

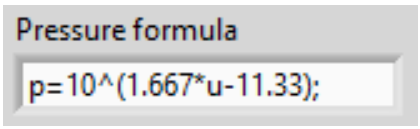
6.2 Setting the parameters

a) <u>Parameters related to the source gas regulation:</u>

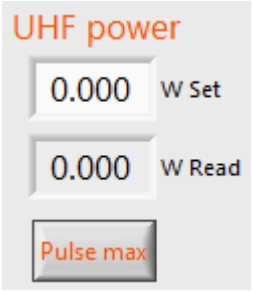


The program regulates the source gas through the command called "Gas Inlet" in units of volt. The associated flow will depend on the pressure in the gas supply line.

If a pressure gauge is installed and correctly connected to the control rack (Data Enter, see IX. Circuit diagram of the control rack), the chamber pressure will be shown in units of volt under "Pressure". You can also enter a formula to change the pressure value from volt to a given unit in the “Pressure formula” box located below the plot legends.



b) *Parameters related to the UHF power:*



The program controls the UHF power that is sent to the source, between 0 and about 18W (the maximum value can change, depending on the calibration mode, the cable and the generator itself. The value in Watt is the power at the entrance of the flange).

The top box (white) is where the requested power is entered. The lower box (grey) gives the power value that is being read. These two should be the same or very close. If that is not the case, there is a problem that needs to be identified.

By pressing the "Pulse max" button the UHF power will temporarily jump to his maximum power, until the button is released. The source ignition is discussed later in this manual.

ⓘ The 'Pulse max' button can be used to help ignite the plasma for manual start-up of the source.

c) *Beam parameters:*

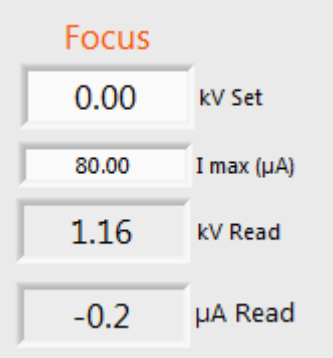
The beam voltage is defined by the high voltage that is applied to the source body. The high voltage applied to the source body is operated by the program and can vary between 0 and 15kV.

The top box (white) is where the requested high voltage should be entered.
The second box (white) is the maximum intensity the supply can go.
The third box (grey) gives the voltage value that is being read. These two should be the same or very close. If that is not the case, there is a problem that needs to be identified.

The fourth box (grey) is a reading of the current supplied by the high voltage power supply. This value is displayed in orange because it is an important parameter for the characterization of the beam.

> ⓘ You can change the polarity of the HV supply with the button “Pol. Beam”, but only when the HV button is off.

d) *<u>Focus parameters:</u>*

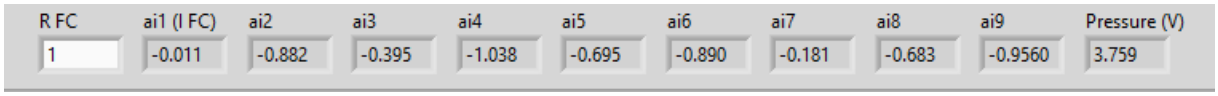


The beam focusing can be adapted by changing the high voltage applied to the focus electrode. Through the program the high voltage applied to the focus electrode can be tuned between 0 and 15kV. The program requires the user to choose a value lower than or equal to 99% of the value of the high voltage applied to the source body (see Beam parameters).

The top box (white) is where the requested high voltage should be entered.
The second box (white) is the maximum intensity the supply can go.
The third box (grey) gives the voltage value that is being read. These two should be the same or very close. If that is not the case, there is a problem that needs to be identified.
The fourth box (grey) is a reading of the current supplied by the high voltage power supply for the focus electrode. When the source parameters are correctly configured, the beam should not hit the focus electrode, and this current should stay very low.

> ⓘ You can change the polarity of the HV supply with the button “Pol. Foc”, but only when the HV button is off.

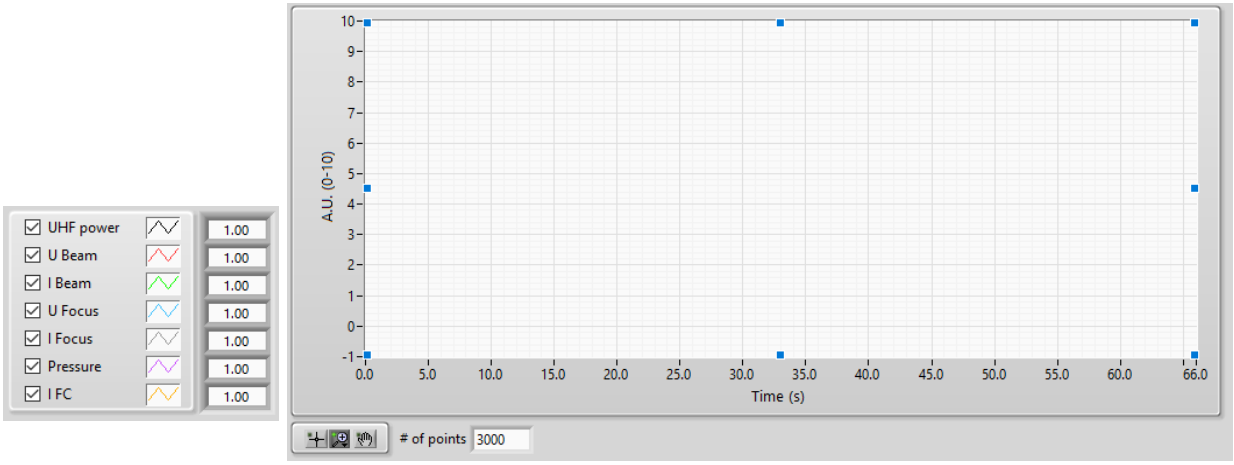
e) *<u>Parameters related to user equipment:</u>*



This dialog box is for the reading of user equipment (not included with IE-GUN).
The program offers ten 0-10V read channels. It is recommended to use one of the read channels for a Faraday cup to measure beam current.

You can enter a resistance value on the “R FC” box to make the conversion on intensity (only for input 1).

f) Parameters of the graph:



The graph enables monitoring of the key parameters of the IE-GUN in real time.
The horizontal axis of the graph gives the time in seconds. The total time displayed in the graph can be changed by changing the number of points ("# of points") at the bottom.
The plot legend is shown left of the graph. The check boxes allow the user to select which parameters to display. The value (default: 1.00) on the right side in the plot legend is a multiplication factor that can be used to scale the parameter for better visibility on the vertical axis, which has arbitrary units, and scales from 0 to 10.
Right-clicking on the graph gives access to the following options: pause the graph, reset the graph, and turn on/off the automatic scaling of the y-axis.
If "Automatic scaling of the y- axis" has been disabled, the minimum and maximum of the vertical axis can be edited by clicking on them.
There are three buttons at the bottom left of the graph, just right of the number of points. The middle one is the most relevant: clicking on it gives access to 6 different modes of data visualization. Zooming on the x-axis is only possible when the graph is paused.

6.3 Data recording

The data are recorded on the microcontroller memory.

Relevant data such as pressure, voltages, currents, UHF power are saved into Log files, Log files are accessible with the ethernet connector. This data can be accessed by creating a share folder according to the procedure below:

default network parameters: IP = 192.168.0.102 and subnet mask = 255.255.255.0

1. If the rack is off, switch on the rack and wait for 1 minute until the microcontroller is initialized.
2. If necessary, set the IP address and subnet mask of the microcontroller with the command *set network <value1>/<value2>* where <value1> is an IP v4 address and <value2> is the subnet mask. For example, if I want to set the IP address to 192.168.0.17 and subnet mask to 255.255.0.0, the command is: *set network 192.168.0.107/255.255.0.0*
3. If your computer is running under Windows:
    a. Go to "This PC".
    b. Under « Devices and drives », right click and select « add network location ».
    c. Follow the steps, in the box « network or internet address », write the location of the shared folder as: \\microcontroller ip address\SharedData. For instance, if the ip address of the microcontroller is 192.168.0.107, write \\192.168.0.107\SharedData.
    d. If your system requires a username, use *pi* (no password is needed).
    e. The shared folder is now accessible:
        i. The sub folder « data » contains all the measurements recorded while the source is functioning. A new file is created when the command « set rack_state 1 » is used or every 24 hours of functioning.
        ii. The sub folder « log » contains the log files in which all the commands received by the microcontroller and the microcontroller answers.

CAUTION The sub folder « config » contains all the configuration files necessary to the proper functioning of the microcontroller. Do not modify these files!

6.4 Manual ignition of the ion source

a) Regulate the source gas and preset the HV set point

To ignite the plasma in the source, it is necessary to use a gas flow rate which is typically higher than the flow rate used for beam operation. Increase the gas valve setpoint to approximately 2.5V (for 0.5 bar inlet pressure) and wait until your pressure gauge indicates a stable pressure (the pressure should be on the order of $5x10^{-5}$ mbar but it depends on your configuration and pump system).
During setting the gas valve setpoint, turn on the UHF power to warm up the generator during the gas stabilization time.
Apply also an 'imax beam' (typically 200 µA) and 'imax focus' (typically 80 µA) values to be able to use the high voltages in the following.

b) Wait for the pressure and activate the UHF power

Wait for the stabilization of the pressure, then put the desired value for the UHF value.

Usually, this value is between 3 and 5W depending on the configuration.

c) *Cycle between HV and pulse HF to ignite plasma*

- Press the button Pulse UHF, then release the button. This will set the UHF power to its maximum to ignite the plasma.
- Then activate the HV button and set the HV beam to 2kV. Be careful to any arc than can happen, it is normal, but if there is too many, lower the HV setting until we lower the gas valve setpoint.
- Look at I Beam indicator, if it indicates a value > 1µA, that is the plasma and the beam are on.
- Turn off the HV.
- If the beam was on, continue the protocol, if the beam was off (I Beam still at 0 µA when HV on), restart this cycle

d) *Go down to the normal gas valve setpoint*

Now the plasma is on, go down to a lower value for the gas valve set point. The value is generally about 1.75V for 0.5bar inlet pressure and a 350µm plasma aperture.

e) *Ready to be used*

The source is ready to be used, plasma is on, and operating points are set.
Set the beam and focus high voltages. Modify the UHF power value to adjust I Beam. Modify U Focus to change the geometry of the beam (divergent, parallel, etc…)
The beam can be temporarily turned off and on again by deactivating and reactivating the "High Voltage" button. This can be useful for example to move a sample or Faraday cup in the beam path.

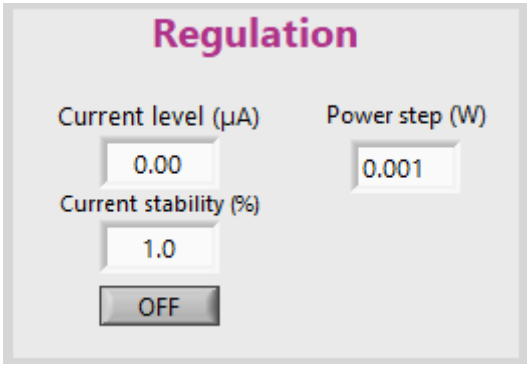
6.5 Operating an ion beam with active current stabilization

a) *Current stabilization mechanism*

The program offers the possibility to actively stabilize the current drawn from the high voltage power supply that feeds the source body. If the source is correctly operated this current is equivalent to the beam current.
Upon activation of the current stabilization, the current is modified by manipulation of the applied UHF power, to reach and then stay at the specified level within the specified precision.

The current stabilization mode should only be activated when the ion beam is on.

b) Stabilization dialogue box



Type in the desired target current level, and the maximum deviation between the actual value and the desired value in %.

Please note that the operating pressure and applied high voltage levels should be chosen such that it is possible to attain the desired current level by the regulation of the UHF power within its applicable range. If the value of the UHF power should go above 6W, the regulation will stop automatically but all other parameters will keep the same.

To activate the current stabilization, click on the "OFF" button. The button will become green and will read "ACTIVE". (Any UHF power adaptions will be visible in the grey UHF power reading box in the manual mode dialogue box.)

To deactivate the current stabilization, click on the "ACTIVE" button. The button will return to its original grey state, reading “OFF”, and the program will continue to apply the UHF power level applied at the moment of deactivation.

It is possible to set the value of the power step in Watt used during regulation

6.6 Limit values

parameter	Typical	Min Max
pressure	3e-6 mbar	3e-5 mbar minimum for ignition, 3e-6 mbar for source operation. 5e-4 mbar maximum for high voltage insulation
Gas valve setpoint for 0.35mm extraction	1.75 V	1.7 – 2 V
UHF power	5 W	5W continuous to avoid overheating of the ion source

Beam current for 0.35mm extraction	5 µAmp at 8kV beam voltage, 6kV focus voltage and 5W power	4 - 6 µAmp
Beam voltage	8 kV	0 - 15kV
Focus voltage	6 kV	0 - 15kV focus voltage must always be lower than beam voltage by at least 1kV (5kV maximum difference)

6.7 Login and access levels, advanced setup access management

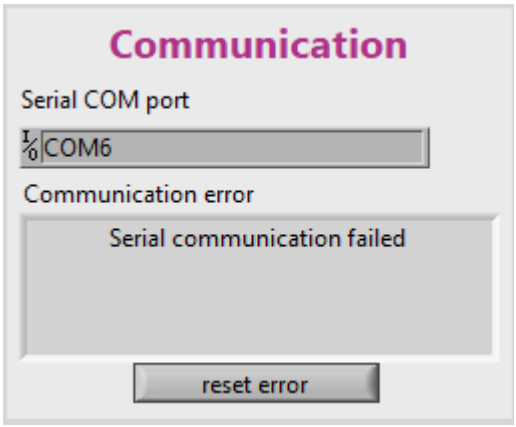
There is no login and no password for the Labview IE gun application program.

Current setpoints/parameters such as the flowrate, power, voltages are adjustable directly in the Labview graphical interface. It is advised to stay within limit parameters. Please refer to the parameters limit value section.

Advanced setpoints parameters are accessible in the configuration files. The configuration files are not crypted.

Changing advanced parameters can cause hardware malfunction or unstable operation and should be discussed with Polygon Physics first.

6.8 IE gun application program quick troubleshooting



This error message will appear if the serial communication between the rack and the computer is interrupted. Usually, it is still possible to control the ion source, simply click on “reset error” to erase the message.

If the error persists and the readings of HV, HF power… are not updated anymore, stop the program and then relaunch it.

Even if the communication is interrupted, the source may still run with the parameters previously defined.

For all other error messages such as “E00x” please refer to the section remote operation serial communication.

For other hardware related issues, please refer to the troubleshooting section.

7 Serial communication remote control

This section lists the available elementary functions that can be integrated into the customer's software for driving the ion source.

RS232 protocol

1. Baud rate: 115200
2. Parity check: no parity
3. Stop bit: 1 stop bit
4. Format: 8 bits
5. End of line character: <cr>

7.1 Starting up

Switch on the electronics rack. Wait about 30 seconds for microcontroller initialization.
Use the command « set rack_state 1 » to initialize the electronics cards inside the rack and start data acquisition. It takes few seconds before the microcontroller returns the ACK character <cr>.
Set the current limits of the beam and focus high voltage power supplies by using the commands « set imaxbeam <value> » and « set imaxfocus <value> » where <value> is the maximum allowed supplied current. By default, these limits are set to 0 and no voltage is delivered by the HV power supplies whatever the voltages set by the user.
Once it is done, the source is ready to be operated.

if the command « set rack_state 0 » is used or the rack switched off, the current limits must be set again. These limits are used to detect short circuits, for more details see the « HV security » part.

7.2 Commands library

There are 5 main commands to control the electronics unit.

Action	Command	Rack answer
1. Modify a setpoint	<set> <DeviceName> <value><cr>	No error: <cr> Error: E<code><cr> <code> is an integer related to an error type described in the section Error list.
2. Modify a setpoint by doing a ramp	<ramp> <DeviceName> <value><cr>	No error: <cr> Error: E<code><cr> <code> is an integer related to an error type described in the section Error list.
3. Get a setpoint	<get> DeviceName<cr>	No error: <cr> Error: E<code><cr> <code> is an integer related to an error type described in the section Error list.
4. Measure a value	<meas> <DeviceName><cr>	No error: <cr> Error: E<code><cr> <code> is an integer related to an error type described in the section Error list.
5. Switch off the microcontroller	<stopall><cr>	No error: <cr> Error: E<code><cr> <code> is an integer related to an error type described in the section Error list.

7.3 Changing a device state with <set> < devicename_state> <value><cr>

Important i: <value> is an integer and can take only two values: 0 or 1

Important ii: there is a delay of few seconds before the microcontroller returns the ACK character when the commands <set> < beampolar_state> <value><cr> or <set> < beampolar_state> <value><cr> are used because the voltages are first set to 0 using a ramp.

Command	Description	Comments
set rack_state 1	- Initialize the electronics cards used for control and measurements -Starts log files recording -Starts data recording	
set rack_state 0	- Stops the electronics cards used for control and measurements - Stops data recording	Once this command used, the rack is in idle state. Use the command set rack_state 1 to use again the source.
set hf_state 1 set hf_state 0	Switch one (1) or switch off (0) HF generator.	
set beam_state 1 set beam_state 0	Switch one (1) or switch off (0) HV beam.	
set focus_state 1 set focus_state 0	Switch one (1) or switch off (0) HV focus.	
set beampolar_state 1 set beampolar_state 0	Allows switching of the HV beam power supply between positive polarity (0) and negative polarity (1).	Beam and focus voltages are first set to 0, then polarity is changed.
set focuspolar_state 1 set beampolar_state 0	Allows switching of the HV focus power supply between positive polarity (0) and negative polarity (1).	Beam and focus voltages are first set to 0, then polarity is changed.
set focuspolar_state2 1 set focuspolar_state2 0	Allows switching of the HV focus power supply between positive polarity (0) and negative polarity (1) without changing the beam voltage.	Only focus voltages is set to 0, then polarity is changed.

7.4 Changing a setpoint with <set> <devicename> <value><cr>

Command	Description	Comments
set hf <value>	Set the HF power in Watt.	<value> must be in the range [0,20]. Resolution = 1 milliWatt. Ex: *set hf 3.654* set HF power to 3.654 Watt.
set beam <value>	Set the beam high voltage in kiloVolt.	<value> must be in the range [0,15]. Resolution = 1 volt. Ex: *set beam 8.231 set the beam high voltage to* 8.231 kiloVolt
set imaxbeam <value>	Set the maximum current delivered by the HV beam power supply in microAmpere.	<value> must be in the range [0,800]. Resolution = 0.1 microAmpere.
set focus <value>	Set the focus high voltage in kiloVolt.	<value> must be in the range [0,15]. Resolution = 1 volt. Ex: *set focus 8.231* set the focus voltage to 8.231 kV
set imaxfocus <value>	Set the maximum current delivered by the HV focus power supply in microAmpere.	<value> must be in the range [0,800]. Resolution = 0.1 microAmpere.
set gasflow <value>	Set the gas valve opening in volt.	<value> must be in the range [0,10]. Resolution = 1 milliVolt
set hfpulse 1	Set the HF power to its maximum (about 20W) for 1 second.	
set network <value1>/<value2>	Allows modifying the IP address and subnet mask.	<value1> is an IP4 address <value2> is the subnet mask Ex: set network 192.168.0.101/255.255.255.0
set totaltime 0	Set the total time of use of the ion source to 0.	

7.5 Changing a setpoint using a ramp with <ramp> <DeviceName> <value><cr>

Important i: <value> is a float.

Commande	description	comments
ramp hf <value>	Modify the HF power using a ramp up to <value> by step of 0.1W.	<value> must be in the range [0,10]. Resolution = 1 milliWatt. Ex: if HF power is set to 2W, *ramp hf 3.654* will increase HF power from 2W to 3.654 W by step of 0.1W Can be used to decrease HF power.
ramp beam <value>	Modify the beam high voltage using a ramp up to <value> by step of 0.1 kV.	<value> must be in the range [0,15]. Resolution = 1 Volt. Ex: if beam high voltage is set to 8.563kV, *ramp beam 12.789* will increase the voltage from 8.563 kV à 12.789 kV by step of 0.1 kV Can be used to decrease voltage.
ramp focus <value>	Modify the focus high voltage using a ramp up to <value> by step of 0.1 kV.	<value> must be in the range [0,15]. Resolution = 1 Volt. Ex: if focus high voltage is set to 8.563kV, *ramp focus 12.789* will increase the voltage from 8.563 kV à 12.789 kV by step of 0.1 kV Can be used to decrease voltage.
ramp hv <value1>/<value2>	Modify both beam and focus high voltages using a ramp up to <value> by step of 0.1 kV.	<value1> and <value2> must be in the range [0,10]. Resolution = 1 Volt. Ex: to set beam voltage to 8.56kV and focus voltage to 5.89kV, the command is: *ramp hv 8.56/5.89*.

		Can be used to decrease voltages.

7.6 Getting state and setpoints with <get> <devicename><cr>

Command	Desciption	Comments
get id	Returns rack name.	
get version	Returns the software version.	
get rack_state	Returns the rack state.	0 = rack idle 1 = rack ready to operate
get hf_state	Returns the HF generator state.	0 = off 1 = on
get beam_state	Returns beam high voltage state.	0 = off 1 = on
get focus_state	Returns focus high voltage state.	0 = off 1 = on
get beampolar_state	Returns beam high voltage polarity state.	0 = positive polarity 1 = negative polarity
get focuspolar_state	Returns focus high voltage polarity state.	0 = positive polarity 1 = negative polarity
get hf	Returns HF power setpoints in W.	
get beam	Returns beam high voltage setpoint in kV.	
get imaxbeam	Returns the maximum current setpoint delivered by the beam power supply in microampere.	
get focus	Returns focus high voltage setpoint in kV.	
get imaxfocus	Returns the maximum current setpoint delivered by the focus power supply in microampere.	
get gasflow	Returns the gas valve opening setpoint in V.	
get network	Returns the IP address and subnet mask.	
get totaltime	Returns the total time of use of the source in hours.	Ex.: the answer « 65.3 » means the source has been functioning 65.3h since previous reset of totaltime.
get source	Returns all the states and	See list here after.

	setpoints.	

Description of the list returned by <get source><cr>

This command returns a list whose elements are:

1.	rack_state
2.	hf_state
3.	beam_state
4.	focus_state
5.	beampolar_state
6.	focuspolar_state
7.	de_state
8.	state7 (Not connected)
9.	state8 (Not connected)
10.	HF
11.	beam
12.	focus
13.	imaxbeam
14.	imaxfocus
15.	gasflow
16.	ao1 (data enter 2, pin 1)
17.	ao2 (data enter 2, pin 2)

7.7 Measuring a value with <meas> <devicename><cr>

Command	Description	Comments
meas hf_state	Returns the measurement of the HF generator state.	
meas beam_state	Returns the measurement of the beam power supply state.	
meas focus_state	Returns the measurement of the focus power supply state.	
meas beampolar_state	Returns the measurement of the beam power supply polarity state.	0 = positive polarity 1 = negative polarity
meas focuspolar_state	Returns the measurement of the focus power supply polarity state.	0 = positive polarity 1 = negative polarity

meas hf	Returns the measurement of the high frequency power delivered by the HF generator in W.	
meas beam	Returns the measurement of the beam voltage kV.	
meas ibeam	Returns the measurement of the current delivered by the beam power supply in µA.	
meas focus	Returns the measurement of the focus voltage kV.	
meas ifocus	Returns the measurement of the current delivered by the focus power supply in µA.	
meas interlock	Returns a measurement of the interlock state. If the result is greater than or equal to 4.9V, interlock is closed (HF power and high voltages are available).	
meas source	Returns all the measured states and setpoints. The values should very close (equal for states) to the values returned by <get source><cr>.	See list here after.

Description of the list returned by <meas source><cr>

This command returns a list whose elements are:

1.	hf_state
2.	beam_state
3.	focus_state
4.	beampolar_state
5.	focuspolar_state
6.	de_state
7.	state7 (Not connected)
8.	state8 (Not connected)
9.	HF

10.	beam
11.	ibeam
12.	focus
13.	ifocus
14.	pressure
15.	ai1 (data enter, pin 4, can be used to read a Faraday cup current)
16.	ai2 (data enter 2, pin 4)
17.	ai3 (data enter 2, pin 5)
18.	ai4 (data enter 2, pin 6)
19.	ai5 (data enter 2, pin 7)
20.	ai6 (data enter 2, pin 8)
21.	ai7 (data enter 2, pin 9)
22.	ai8 (data enter 2, pin 10)
23.	ai9 (data enter 2, pin 11)
24.	interlock (if the measured value is equal or greater than 4.9V, interlock is closed)

7.8 Errors list

Code	Description	Comments
E001	Rack state is 0. To activate the rack, use *set rack_state 1*	This error is returned if the user sends a setpoint or state whereas rack state is 0.
E002	Rack state is already 1.	This error is returned if the user sends the command *set rack_state 1* whereas rack state is already 1.
E003	Impossible to initialize measurement cards.	Check USB connection between cards and microcontroller inside the rack. Switch off and on the rack.
E004	Impossible to initialize control cards.	Check USB connection between cards and microcontroller inside the rack. Switch off and on the rack.
E005	Impossible to initialize relay cards.	Check USB connection between cards and microcontroller inside the rack. Switch off and on the rack.
E006	Impossible to disconnect measurement/control/relay cards.	Switch off and on the rack.
E007	Setpoints or state not recognized. And/or measurement/control/relay cards not working.	If the command used is set *xxx_state <value>,* make sure <value> is an integer being either 0 or 1. If the command used is *set xxx <value>,* make sure <value> is a float. Check USB connection between cards and microcontroller inside the rack. Switch off and on the rack.
E008	Control/relay cards not working.	Check USB connection between cards and microcontroller inside the rack. Switch off and on the rack.
E009	Measurement cards not working.	Check USB connection between cards and

		microcontroller inside the rack. Switch off and on the rack.
E010	Command does not exist.	Check the syntax.
E011	Impossible to access to shared folder.	Switch off and on the rack.
E012	Short circuit detected for beam and/or focus power supplies. All setpoints and states are set 0. High voltage security mode is activated, setpoints and state commands are ignored. Error code E012 is returned.	To quit the high voltage security mode, use *set rack_state 0* then *set rack_state 1*. For more details, see 7. HV security.

7.9 Details about the HV security

CAUTION The 'HV security' functionality cannot be considered as a safety function: it is intended for hardware protection only.

The microcontroller can detect if a high voltage power supply is experiencing a short circuit. To do so, the measured currents « ibeam » and « ifocus » are compared the current limits « imaxbeam » and « imaxfocus » set by the user. If the measured currents are equal or greater than the current limits, all setpoints and states are set to 0. Therefore, HF power generator and high voltage power supplies are switched off.
The rack answer will be « E012 » for any command received: the high voltage security mode is activated.
To escape the HV security mode, use *set rack_state* 0 then *set rack_state* 1. Then it is necessary to set again the current limits.

The HV security mode can be triggered by too low current limits. Make sure the limits are compatibles with functioning point of the source.

The HV security mode can also be triggered by electrical discharge inside the source. It does not mean the source has been damaged.
However, when restarting the source, if the HV security mode is again triggered by an electrical discharge, it is necessary to inspect the source to check for insulators damages. Please refer to the troubleshooting section.

8 Support

8.1 Contact for RMA process

Please fill the following RMA number request template before shipment of defective parts to factory, either for parts under guaranty or another repair order after the guaranty period.

Please ship free of charge by DHL – account # 963897121

FROM (Company Name sending goods):	**TO** **POLYGON PHYSICS SAS** 19 rue de Sassenage 38600 Fontaine France Attn : Intracom VAT FR19799584453

It.	Item name	Brief description of problem
01		
02		
03		
04		
05		

Please, add any information helping to repair

8.2 Troubleshooting guide

Issue	Possible root cause	Corrective action
No ignition or the source turns off	Too low gas flow, or no gas flow	• Change the empty gas cylinder, • Increase the input pressure before the regulating valve / flowmeter, • Make sure the gas valve cable is plugged
	Too high pressure	• Check for air leak in the vacuum chamber • Perform a turbopump maintenance • Set a lower gas flowrate setpoint
	No HF power	• Make sure the interlock is closed
	Dirty surfaces, unstable ion source operating point, too much acceleration voltage	• Perform a high voltage conditionning sequence • reduce the voltages
No high voltage	Interlock open or shortcut to ground	• Make sure the interlock is closed • check for high voltage overcurrent
Current drift	Unstable ion source operating point	• Change the operating pressure • Change the operating UHF power
Current jumps	Not enough UFH power, not enough gas	• Increase the UHF power • Increase the gas flow rate
Beam current is too low	Not enough UFH power, not enough gas, voltage difference between beam and focus is too low	• Increase the UHF power • Increase the gas flowrate • Lower the focus voltage compared to the beam voltage (maximum allowed difference = 5kV. Will make the ion beam more divergent)
Pressure reading does not change when changing the valve setpoint	Valve not connected; rack not powered.	• Make sure that the D-Sub 9 cable the rack and the gas regulating valve is properly connected • Make sure that the rack is powered, and that its power switch is on
Message 'serial connection failed when lauching the IE gun Labview application program	RS232 cable not connected, I/O board freeze, Labview freeze.	• Make sure that the RS232 cable between the rack and the PC is properly connected • Close the program, disconnect and reconnect the serial and restart the program

Voltage reading stays to 0kV when changing the high voltage setpoint	HV button is not ON	• Make sure to click on the high voltage ON button • Make sure to click outside the setpoint adjustment box • Press enter after changing the setpoint
The Labview software freezes	Rack is not powered, RS232 connection lost	• Make sure the rack is powered • Restart the program

8.3 Maintenance plan

There are no wearing parts. There are no advised periodical maintenances. The ion source runs to fail until its performance gets unstable because of contamination accumulation on surfaces, then it is cleaned/refurbished. Please refer to the refurbish section.

In case of early failure of a defective part, please contact Polygon Physics.

8.4 Spare part list

	size	Amp	type
Fuse	20*5mm	2Amp	No temporisation

There are no wearing parts, but some critical parts can fail. Below is the list of part kits to be ordered to PP for repair.

Critical parts kits	PP reference
- 0.35mm CuNi plasma electrode	P-ELP-CP
- 1mm Mo focus electrode	P-ELF-MO
- 1mm Stainless steel ground electrode	P-ELL-SS

8.5 Ion source refurbishing information

The refurbishing of the ion source is a combination of cleaning and exchanging the parts that cannot be cleaned such as insulators or the electrodes. Cleaning is done by mechanical and solvent removal of the contamination layers deposited on stainless steel parts. Cleanroom grade tissue is required for drying the parts after cleaning. Baking the parts in oven at 150degC is advised to dry the parts for faster outgassing in the vacuum chamber. Ceramic, Teflon, and Peek insulators are not easily cleanable and thus it is advised to exchange them.

9 Information to user about radio technology in the TES 63 driver (FCC statements)

CAUTION The user that changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

Number of radio modules inside	**1**	
Frequency band	2.3-2.6 GHz	
Radiated power and frequencies	**MHz**	**dBµV/m at 1m**
	2357.000	41.4
	6911.125	53.0
	1881.300	35.4
	2304.250	41.5
	2334.312	41.6
	2392.625	41.5
	4602.469	43.6
	4819.812	51.3
	7229.875	53.9
Number of antenna	0	
Country restrictions	none	

CAUTION This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications.

CAUTION Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

This device complies with Part 18 of the FCC Rules.

RF Exposure: This device complies with FCC RF radiation exposure limits set forth for general population. This device must be installed to provide a separation distance of at least 20cm from all persons and must not be co-located or operating in conjunction with any other antenna or transmitter.

10 Declaration of conformity

Manufacturer: Polygon Physic
19, rue de Sassenage
F 38600 Fontaine

Product: TES 63 15kV
Specifications: Ion source TES-63-15-B unit
Control unit with 15kV bipolar power supplies

This product complies with the emissions and immunity requirements of IEC 61326 related to electromagnetic compatibility in an industrial electromagnetic environment.

The following standards were used to assess the product:

EN 61326-1 (2013) / IEC 61326-1 (2012)
EN 61000-3-2 (2019) / IEC 61000-3-2 (2018)
EN 61000-3-3 (2013 + A1/2019)
IEC 61000-3-3 (2013 + A1/2017)
FCC CFR 47 Part 18

The tests were conducted by third party: LCIE Veritas
170 Rue de Chatagnon
38430 Moirans

Place and date of issue: Grenoble, 08 October 2020

Pascal Sortais, CEO