TruPlasma Bipolar 4030 G2.1 2x15kW PECVD

Power Supply

USER MANUAL

Warning!
This operating manual is required for the safe operation of **TruPlasma Bipolar 4030 G2.1 2x15kW PECVD** Power Supplies. As a result, the operating manual should be kept close to the unit at all times.

Operating Instructions

for TruPlasma Bipolar 4030 G2.1 2x15kW PECVD Power Supply

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To ensure years of dependable service, TRUMPF Huettinger products are thoroughly tested and found to be among the most reliable and highest quality systems available.

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Returning Units for Repair

Before returning any product for adjustment or repairs please call **TRUMPF Huettinger Services** to discuss the problem with a service engineer representative. Be prepared to give the serial number of the unit and reason for return. This consultation call will help the Customer Service Department to determine if the unit needs to be returned. Such technical consultations are always available free of charge.

Table of contents

1. Safety Information

1.1. Important information

TruPlasma Bipolar 4030 G2.1 2x15kW PECVD generator is designed to power industrial vacuum process chambers in PECVD surface treatment technologies. Any other uses or any uses beyond these mentioned above are considered to be improper. TRUMPF Huettinger Company shall not be held liable for any losses or damages resulting in any improper usage.

Correct usage also includes:

- Full compliance with all instructions from operating manual.
- Full adherence to inspection and maintenance intervals.

Safe operating procedures and proper equipment usage are the sole responsibilities of the system's user.

1.2. Explanation of symbols and notes

Failure to comply with these precautions may cause physical injury or result in damage of equipment.

Failure to comply with these warnings may result in death, serious physical injury or damaged equipment.

Failure to comply with this information can affect the generator's performance.

Useful notices and tips regarding proper handling, operation and maintenance.

1.3. Personnel

Only qualified personnel should work with the **TruPlasma Bipolar 4030 G2.1 2x15kW PECVD.** "Qualified" is defined as personnel who are familiar with the safe installation procedures, maintenance and operation.

All of the personnel working with this equipment must take appropriate precautions to protect themselves against the possibility of electrical shocks or fatal injuries. They must be familiar with the entire **TruPlasma Bipolar 4030 G2.1 2x15kW PECVD** operating instruction manual and understand all of its contents.

Do not be careless around this equipment!

1.4. Safety standards profile

Power unit is intended to use in an industrial environment.

There may be potential difficulties in ensuring electromagnetic compatibility in other environment, due to conducted as well as radiated disturbances.

The **TruPlasma Bipolar 4030 G2.1 2x15kW PECVD** Power Supply was designed and constructed in compliance with the requirements outlined in the following standards and EC directives:

Standards:

- **EN 61010-1:** 2010 Safety requirements for electrical equipment for measurement, control, and laboratory use – Part 1: General requirements.
- **EN 61000-6-2:** 2005/AC:2005 " Electromagnetic compatibility (EMC). Part 6-2: Generic standards –Immunity for industrial environments.
- **EN 55011:** 2009/A1:2010 Class A and Group 2; Industrial, scientific and medical equipment – Radio-frequency disturbance characteristics – Limits and methods of measurement.

EC directives:

- **2014/35/EC** Low Voltage Directive of 26 February 2014 on the harmonization of the laws of the Member States relating to the making available on the market of electrical equipment designed for use within certain voltage limits.
- **2014/30/EC** EMC Directive of 26 February 2014 on the harmonization of the laws of the Member States relating to electromagnetic compatibility.

➲ **Check external fuse value and grounding circuit before switching mains on.**

➲ **Never unscrew or remove rear terminals covers before switching mains off..**

1.5. Transportation and storage

Transportation

TruPlasma Bipolar 4030 G2.1 2x15kW PECVD system must be firmly secured and placed in a horizontal position.

Very heavy! Lifting the power supply requires more than one person (weights are differentiated according to the output power)

Storage

Storage environments should be dry, free of aggressive vapours and not exposed to temperatures from beyond the 1K4 class range – EN 50178 (i.e.: -25, +55ºC). See table 'Environment'.

Before storage and transportation remove all cooling water residues from the generator by carefully blowing compressed air through the lines.

2. General information

Description

The **TruPlasma Bipolar 4030 G2.1 2x15kW PECVD** power supply is designed for plasma-assisted film deposition PECVD and dual cathode sputtering processes, where reliability and performance are critical. Its most important features are:

- high efficiency switched-mode power conversion performance,
- up to 600V operating output voltage,
- full output power capability at an output voltage as low as 320V,
- ultrafast arc switch-off and recovery,
- extremely low arc energy,
- wide variety of user adjustable parameters,
- two switchable outputs

The **TruPlasma Bipolar 4030 G2.1 2x15kW PECVD** power supply is assembled in one industrial steel enclosure ready to insert into a 19'' rack power system. All cable ends and electric terminals for user connections are located at the rear of the module.

Microprocessor

Power supply is microprocessor-controlled. All control-signal connections are digitally and opto-isolated providing high resistance against electromagnetic disturbances.

Interfaces

A multi-control system gives user a possibility of selecting from a variety of control sources.

Depending on configuration, there are available:

- Local: Standard Operator Panel located on the front panel of the **TruPlasma Bipolar**,
- Remote: RS-232,
- Remote: RS-485,
- Remote: Analog interface.

2.1. TruPlasma Bipolar 4030 G2.1 2x15kW PECVD block diagram

A block diagram of the **TruPlasma Bipolar 4030 G2.1 2x15kW** is shown below. This **TruPlasma Bipolar 4030 G2.1 2x15kW** block diagram consists of the following functional blocks:

- input EMI filter to reduce electromagnetic interferences delivered to mains,
- three-phase rectifier,
- circuit providing a soft switch-on,
- power factor correction circuit,
- MOSfet switch-mode DC/DC power converter,
- output sections,
- arc detection and arc switch-off circuitry,
- control electronics

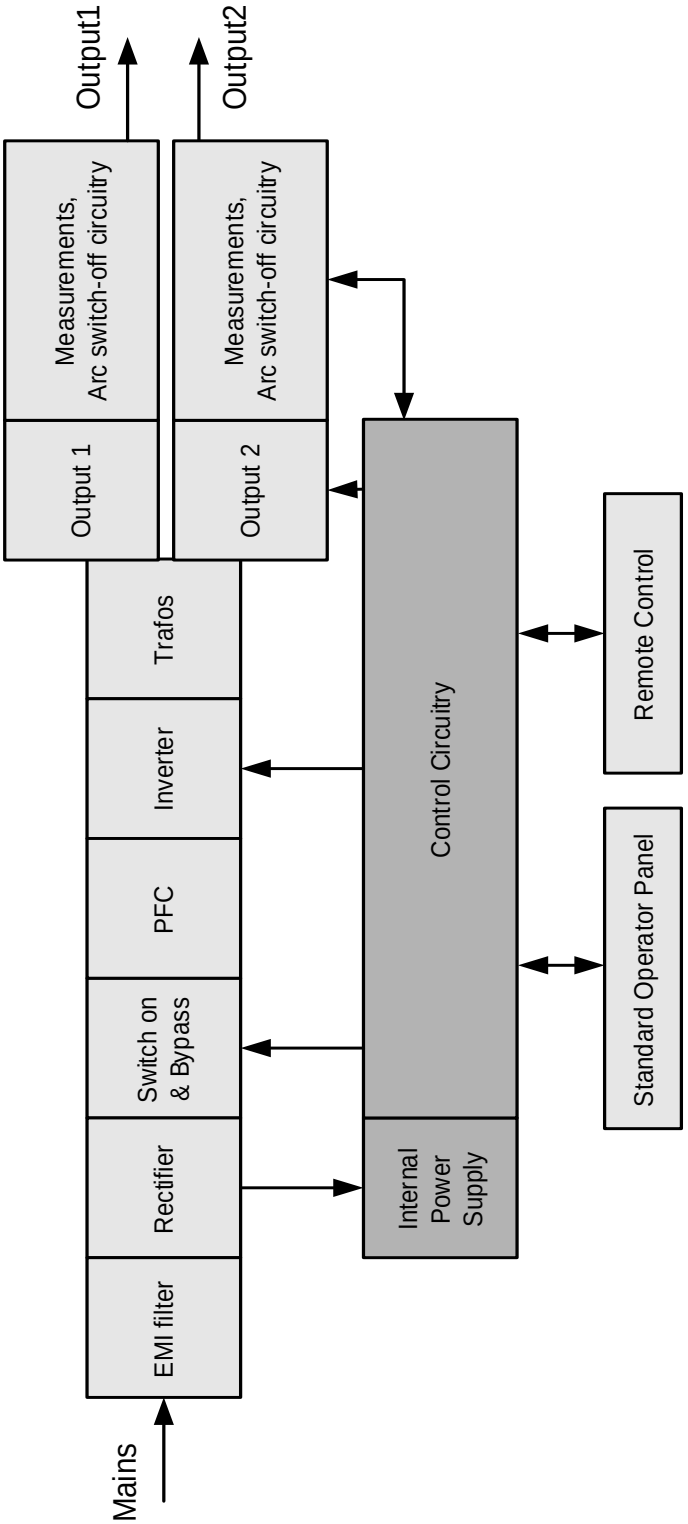


Fig.2.1. TruPlasma Bipolar 4030 G2.1 2x15kW PECVD

3. Electrical and mechanical specifications

3.1. Electrical and mechanical specification in tables

Electrical specification – Overall			
Mains voltage	**V AC**		3x380-480±10% **+PE** It is recommended to maintain a power quality according to EN 61000-2-4 (class 3).
Mains frequency	**Hz**		50/60 (range: 47 to 63)
Maximum mains input current	**A**		3 x 33 A
Recommended fusing	**A**		3 x 63, B-class
Efficiency	**%**		Approximately 91%
Warm-up delay	**second**		< 5

Electrical specification – Power supply section			
Nominal output values (both outputs)			**$P_{n\ mean}$ = 15 kW (Blink)** **$U_{n\ RMS}$ = 600 V** **$I_{n\ RMS}$ = 40A (43 A Blink)** **(see power characteristics Fig. 3.2)**
Output frequency	**kHz**		5-50
Control source options			Local - Standard Operator Panel located on the front panel Remote - RS-232 Remote - RS-485 Remote - Analog interface
Output control			P – power control U – voltage control I – current control

Mechanical Specification			
Size (Width x Height x Length)	**mm**		482 **(19")** x 178 **(4HU)** x 700
Weight	**kg**		Approx. 45

Arc detection criteria			
Imax **Overcurrent detection** an arc is detected when output current exceeds threshold value	**A** **%**		user adjustable: Imax Threshold 4,9 … 55,9 Imax offset 0 … 100
Dynamic U x I **Cross detection** reacts when output voltage drops while output current rises	**A** **V**		user adjustable: Ix 4,9 … 55,1 Ux 0 … 800
dU **Dynamic voltage change (microarc)** an arc is detected when output voltage immediately drops by the set value.	**%**		user adjustable: dU Thld 0 … 100
Usag **Voltage-based detector**	**%**		user adjustable: Uout Sag Factor 10 … 50
Breaktime and Ramp time	**µs** **ms** **µs**		Hard arc break time 10 … 2000 Hard arc Ramp Time 0 … 2 Micro arc break time 10 … 1000
Arc Burst	**us** **us**		BreakTime: 25 … 10000 Number in row: 1 … 100 On-Time Below 1 … 1000
Maximum amount of detected and suppressed arcs per second	**arc/sec**		20000

3.2. Environmental specification

Environmental Specification			
Ambient operating temperature	**°C** **°F**		+5 … +45 (Class 3K3, EN 50178) +41…+113
Storage temperature	**°C** **°F**		-25 … +55 (Class 1K4, EN 50178) -13 … +131
Relative humidity	**%** **g/m³**		5...85 Non-condensing 1…25 (Class 3K3, EN 50178)
Air pressure	**kPa** **mbar**		86-106 (Class 3K3, EN 50178) 860-1060 (max altitude: approximately 2000m above sea level)
Degree of Pollution			2 (see chapter 4.1. Installation site: contamination)

3.3. Cooling water specification

Cooling water parameters			
Temperature	**°C**		+20 to +35 The temperature must be higher than dew point.
Pressure	**bar**		< 7
Differential pressure input to output	**bar**		> 2
Flow rate	**l/min**		> 5
Flow rate in standby mode	**l/min**		1 … 2
Conductivity	**µS/cm**		50 … 600
Protection class IP			IP40

Total Hardness	**Max Ph-Value**
8 °dH	7.8
6 °dH	8.1
4 °dH	8.3

Description	**Limit Value**
Aggressive carbonic acid	must not be detected
Ammonia	must not be detected
Nitrite	< 1 mg/l
Iron	< 0.3 mg/l
Manganese	< 0.05 mg/l
Sulfate	< 250 mg/l
Chloride	< 250 mg/l
COD (chemical oxygen demand)	< 40 mg/l
Microbiologic growth: - number of colonies - sulfate reducing agents	 < 1000/ml must not be detected

Min. 1l/min of cooling water is required in standby mode.
If the minimal water flow for standby mode cannot be provided, mains must be switched off.

3.4. Compressed air specification

To avoid problems with humidity condensation it is recommended to connect the compressed air to the dedicated terminal in the power supply. It is especially important when generator operates in tropical areas with high humidity.
The condensed water could lead to internal short circuits and finally to damage of the power supply.

The table with air quality parameters with references to ISO 8573-1/2010 standard below:

Compressed air parameters				Quality class according to ISO 8573-1
Pressure	**bar**		0.1 … 0.2	
Pressure dew point	**°C**		max. +3 (see the next page for dew point diagram)	4
Oil content	**mg/m³**		< 0.1	2
Dust-free			Acc. to Tab. 2 ISO 8573-1/2001	2

Compressed air connector is placed on the rear side of the generator (see chapter *4.3. Connection terminals* and chapter *4.5. Cooling terminals descriptions*).

To prevent water condensation, connect compressed air 60 minutes before usage.

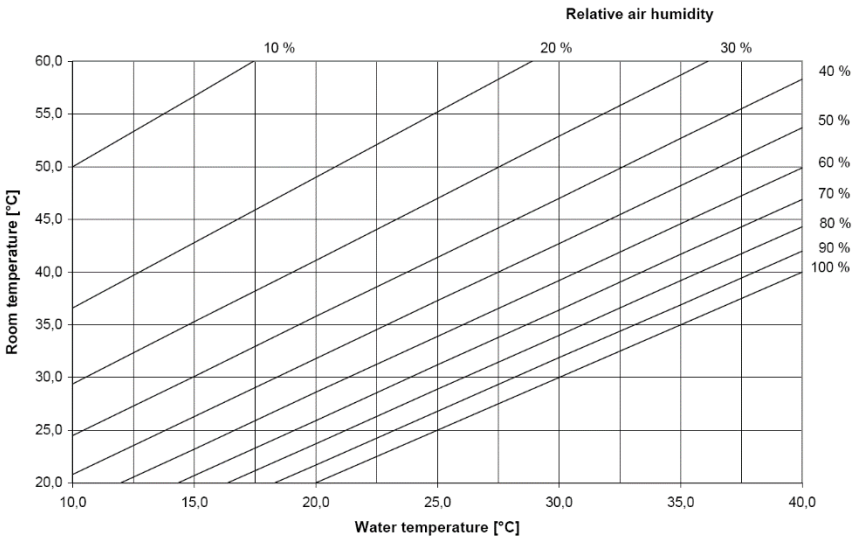


Fig. 3.1. Dew point diagram.

The dew point diagram has been created with an assumed air pressure of 1013 mbar.

3.5. TruPlasma Bipolar 4030 G2.1 2x15kW PECVD power characteristic

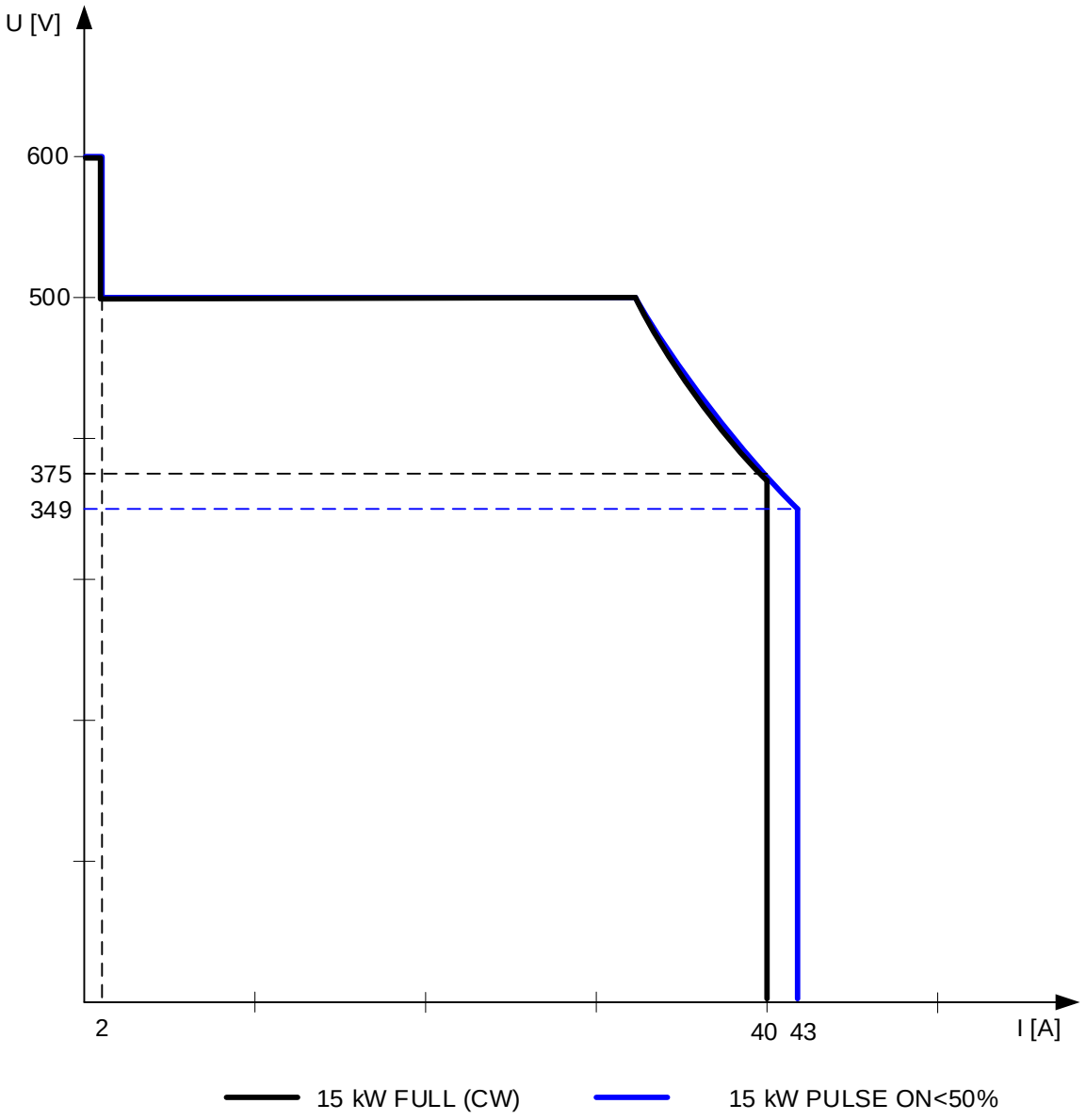


Fig. 3.2. Power characteristic of **TruPlasma Bipolar 4030 G2.1 2x15kW PECVD** module – each output.

3.6. Description of continuous working modes

Power supply can work in continuous mode on one of the outputs. In that case the current and power maximum values are shown below:

Output parameters				
Ton/(Ton+Toff) > 50 %	**A** **kW**		I max P max	**40** **10**
Ton/(Ton+Toff) < 50 %	**A** **kW**		I max P max	**43** **15**

FULL MODE

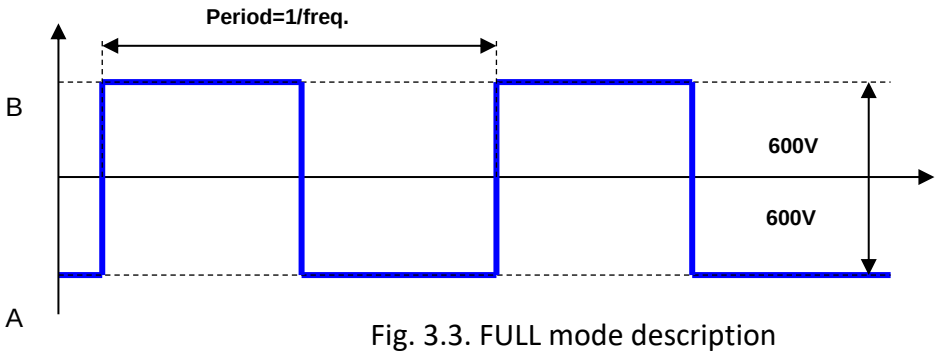


Fig. 3.3. FULL mode description

Parameter	Description	Range
Frequency	$\boldsymbol{Frequency} = \frac{\mathbf{1}}{\boldsymbol{Period}}$	5 kHz – 50 kHz
Duty	$\boldsymbol{Duty} = \frac{\boldsymbol{Pulse\ A}}{\boldsymbol{Pulse\ A} + \boldsymbol{Pulse\ B}}$	1 % - 99 %

Frequency of released power pulses (polarization A and B) can be changed with power on in range from 5 kHz to 50 kHz with 0,1 kHz step
Duty cycle for A and B polarization can be set from 1% to 99%.
Power supply controls and measures mean power, RMS current and RMS voltage on the output.

Outputs cannot be grounded!

BIPULSE MODE

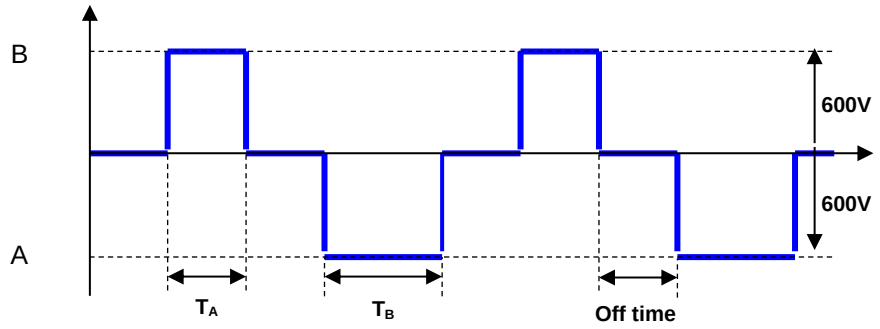


Fig. 3.4. BiPulse mode description

Parameter	Description	Range
Frequency	$\boldsymbol{Frequency = \frac{1}{Period}}$	5 kHz – 50 kHz
Duty	$\boldsymbol{Duty = \frac{Pulse\ A}{Pulse\ A + Pulse\ B}}$	1 % - 99 %
Off time	-	1 % - 20 %

Frequency of released power pulses (polarization A and B) can be changed with power on in range from 5 kHz to 50 kHz with 0,1 kHz step
Duty cycle for A and B polarization can be set from 1 % to 99 %.
Power supply controls and measures mean power, RMS current and RMS voltage on the output.

Outputs cannot be grounded!

TRAPEZ MODE

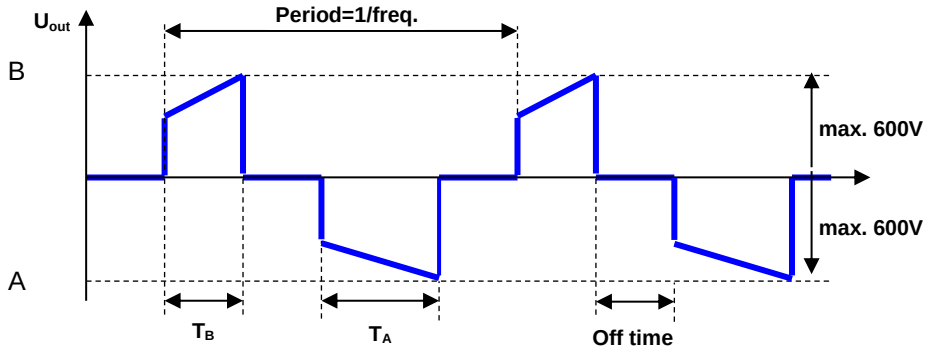


Fig. 3.5. TRAPEZ mode description

Parameter	Description	Range
Frequency	$\boldsymbol{Frequency = \frac{1}{Period}}$	5 kHz – 50 kHz
Duty	$\boldsymbol{Duty = \frac{Pulse\ A}{Pulse\ A + Pulse\ B}}$	1 % - 99 %
Off time	-	1 % - 20 %

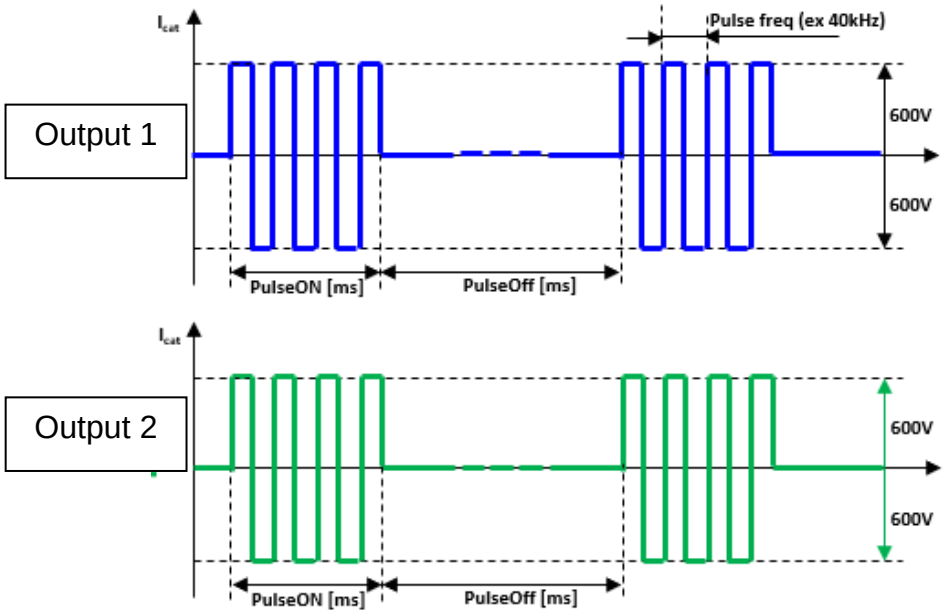
Frequency of released power pulses (polarization A and B) can be changed with power on in range from 5 kHz to 50 kHz with 0,1 kHz step and duty cycle for pulses can be set from 1 % to 99 %. Accretion speed is dependent on the off time value.
Power supply controls and measures mean power, RMS current and RMS voltage on the output.

Outputs cannot be grounded!

3.7. Blink mode

Power supply can work in blink mode on one of the outputs or in both outputs at the same time. In case of dual output working mode both outputs can work in the same time while not exceeding 24kW combined. Otherwise pulse on must be shifted:

$$P\ out1 + P\ out2 \leq 24\ kW$$



$$P\ out1 + P\ out2 > 24\ kW$$

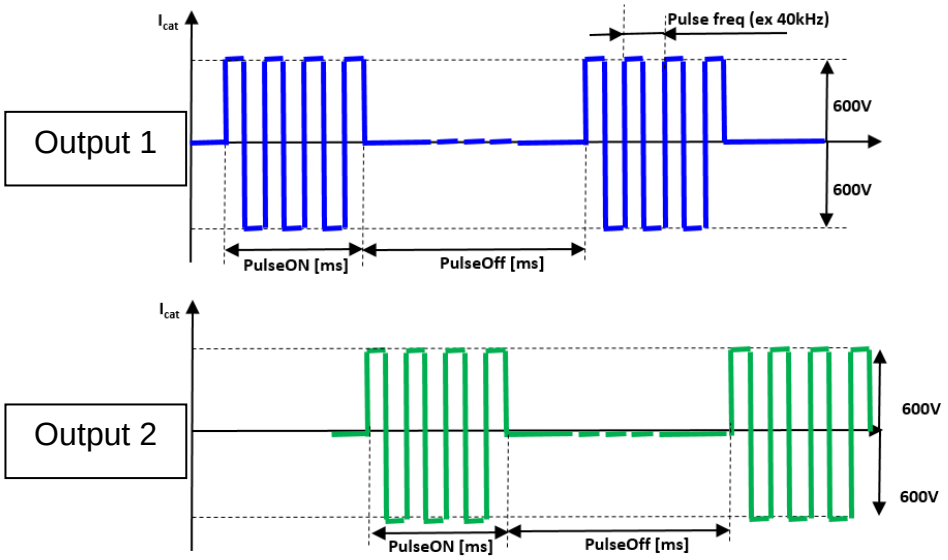


Fig. 3.6. Dual output blink mode

When two output's power exceeds 24 kW the following conditions must be met:
PulseOn_Out1 [ms]*n + PulseOff_Out1 [ms]*(n-1)+2 us (time necessary to switch outputs) <=PulseOff_Out2 [ms]
PulseOn_Out2 [ms]*n + PulseOff_Out2[ms] + 2 us <= PulseOff_Out1 [ms]
Blink_Out1 [ms] = Blink_Out2 [ms] *n or Blink_Out2 [ms] = Blink_Out1 [ms] *n

Where:
T_SWITCH – time of minimum break between switching outputs.
Blink_Out1= PulseOn_Out1 + PulseOff_Out1
Blink_Out2= PulseOn_Out2 + PulseOff_Out2

If any of the conditions is not met the "Blink wrong Configuration" bit will be active.

The maximum current and power parameters are the same as in the continuous mode.

Dual output blink mode parameters			
Blink on	ms		1 … 500
Blink off	ms		1 … 500

4. Installation and connections

4.1. Installation site

Enclosure

TruPlasma Bipolar 4030 G2.1 2x15kW PECVD power supply is built in a standard 19” enclosure and is designed to fit into a standard 19”, 800mm deep, rack cabinet. Weight of device is approx. 45kg and mechanical construction of cabinet should be strong enough to support it. Temperature inside cabinet should not exceed 45°C measured at front panel of module.

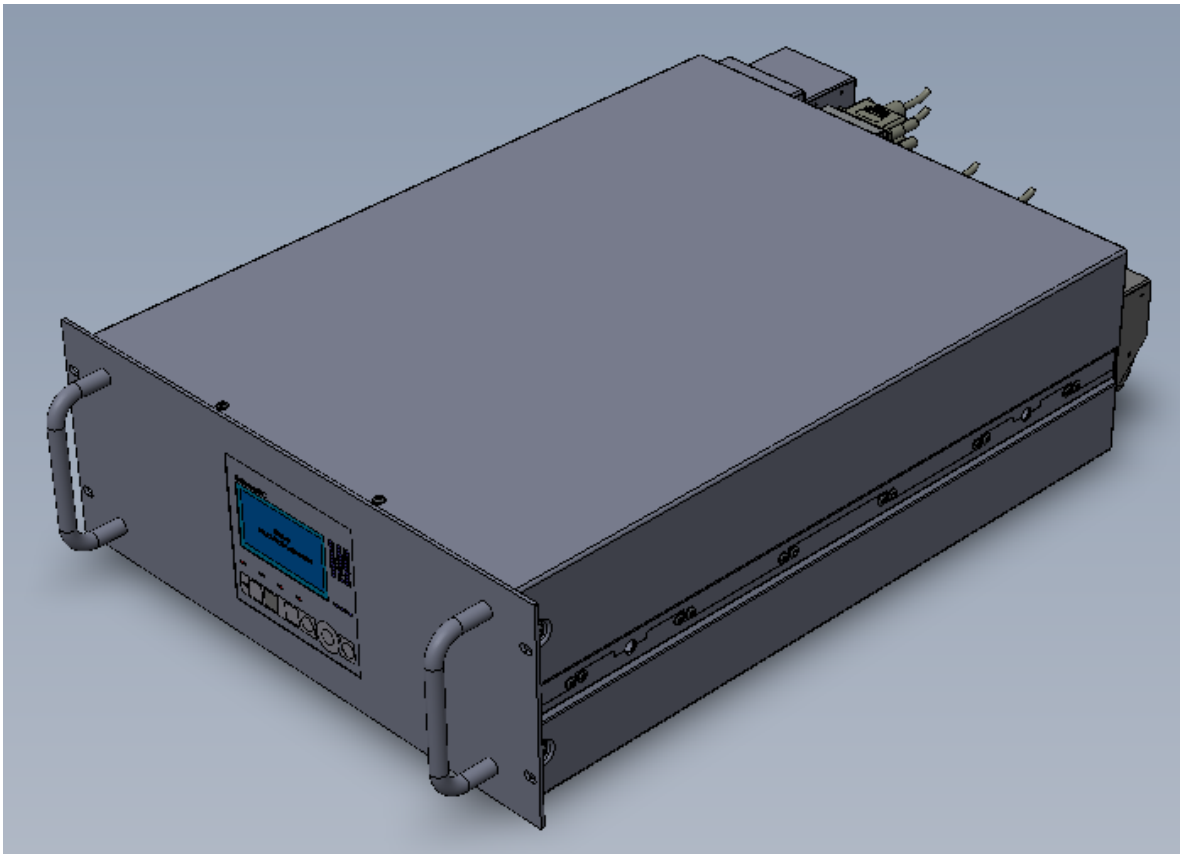


Fig. 4.1. TruPlasma Bipolar 4030 G2.1 2x15kW PECVD.

HEAVY OBJECT.
May result in severe injury.
Do not lift or move without adequate equipment.
Weight 45kg.

Contamination

Cooling air should be kept free from corrosive vapors and any particles that could become conductive after exposure to moisture.

Unpacking

Inspect the devices packaging for damage and compare its contents carefully with delivery documents**.**

4.2. Fusing

External mains fuses are highly recommended with respect to EN61010-1 standard. A set of three-phase 63A B-class fuses will provide necessary protection.

A set of fuses has to be provided for each power supply separately.

Usage of circuit breakers with the same tripping characteristic and rated current instead of fuses is also possible.

All terminal connection operations have to be made when power supply is not powered with mains and (if applicable) external 24V.

4.3. Connection terminals

All connection terminals are located on rear side of **TruPlasma Bipolar 4030 G2.1 2x15kW PECVD**. Output terminals should be covered by cap delivered with the device. Sufficient space for cables should be provided (at least ½U) between modules installed together inside one cabinet.

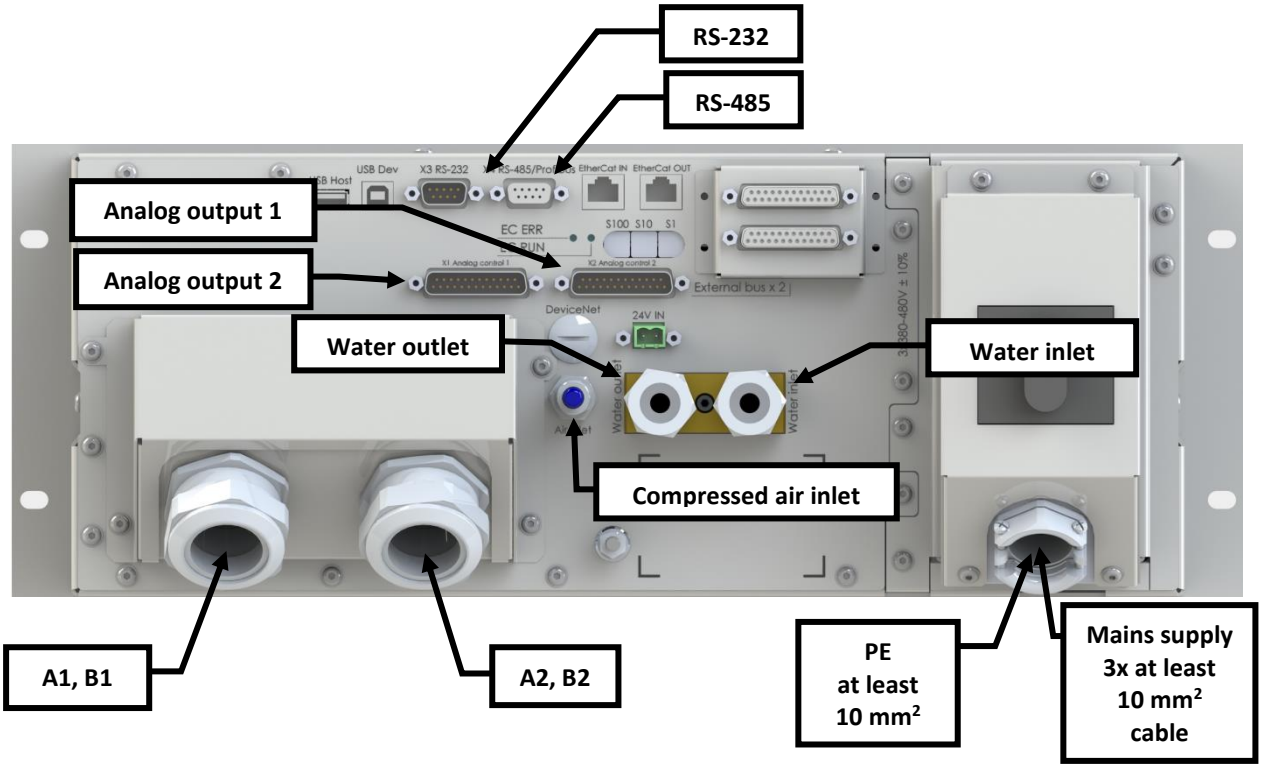


Fig. 4.2. Description of connectors and terminals on the rear panel.

Check inlet and outlet water connection. Changing water flow direction will cause power supply's malfunction!

To prevent water condensation, connect compressed air 60 minutes before usage.

4.4. Power terminals description

Terminal	Description	Cable	Cable endings
MAINS	3 x 380-480±10% V AC	3x min. 10 mm^2	3x ferrule
PE	Protective earth	min. 10 mm^2	M6
OUTPUT 1	600V / 43A	2x min. 16 mm^2 Copper twisted on entire length and shielded cable is recommended. Shielded output cables connected to power supply via EMC cable gland with tight and full 360-degree metal-to-metal contact of screen connection. Use dedicated cable (TRUMPF Huettinger cable type DC15).	2x M8
OUTPUT 2	600V / 43A	2x min. 16 mm^2 Copper twisted on entire length and shielded cable is recommended. Shielded output cables connected to power supply via EMC cable gland with tight and full 360-degree metal-to-metal contact of screen connection. Use dedicated cable (TRUMPF Huettinger cable type DC15).	2x M8

Do NOT turn on unit's power until the power supply is properly grounded!

Properly and firmly made connections and installation of Power Supply are necessary to fulfill safety and EMC standards.

4.5. Cooling connectors description

Terminal	Description	Hose ending
Water inlet	Stainless steel or polyurethane (PU)	ø 10 mm (G3.8 inch threaded holes)
Water outlet		
Compressed air inlet	Polyurethane (PU)	ø 8 mm (quick connect adaptor with $^1/_8$" external thread and stopper are attached)

4.6. Communication terminals description

Terminal	Description	Connection	Cable endings
RS-232	communication port	see below	SUBD 9pin female
RS-485	communication port	see below	SUBD 9pin male
Analog	communication port	see below	SUBD 25pin female
Others	not used in this application		n/a

4.7. Other connectors description

Terminal	Description	Cable endings
24V IN	External 24 V supply	MSTB 2,5/ 2-ST-5,08
Water valve control	Control of the water valve	MSTB 2,5/ 2-ST-5,08

4.7. RS-232 communication terminal

RS-232 port is located on the rear side of device and uses a 9-pin male SUBD connector. Table below provides description of pins.

Pin no.	Name	Type	Description
2	**RxD**	digital input	RS232 receives data
3	**TxD**	digital output	RS232 transmits data
5	**GND**	GND	Ground, can be used for cable shield
others	-	n/c	n/c

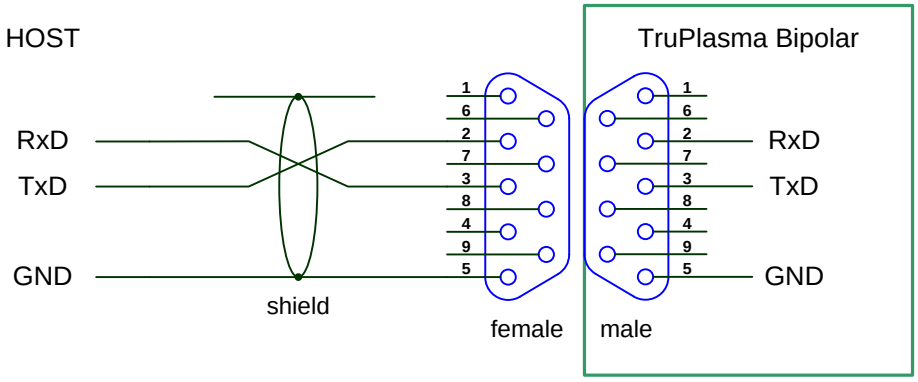


Fig. 4.3. RS-232 connection diagram.

Do NOT connect the shield with earth (PE).

Do not forget about the shield otherwise it will result in error occurrence

RS-232 communication baud rate can be set from the range: 9600, 19200, 38400, 57600 and 115200 bps, and it works in standard 8n1 (8 bits of data, non-parity, 1 bit of stop).
In order to get errorless communication, cable length shouldn't be longer than 3 m.

Default baud rate is 115200 bps.

4.9. RS-485 communication terminal

RS-485 port is located on the rear side of device and uses a 9-pin female SUBD connector. Table below provides description of pins.

Pin no.	Name	Type	Description
3	**A**	RxD/TxD-P	Differential I/O signal
5	**GND**	GND	Isolated RS-485 ground
6	**VP**	+5V DC	Isolated RS-485 supply voltage
8	**B**	RxD/TxD-N	Differential I/O signal
others	-	n/c	n/c

Termination resistors are necessary only at both ends of the cable.

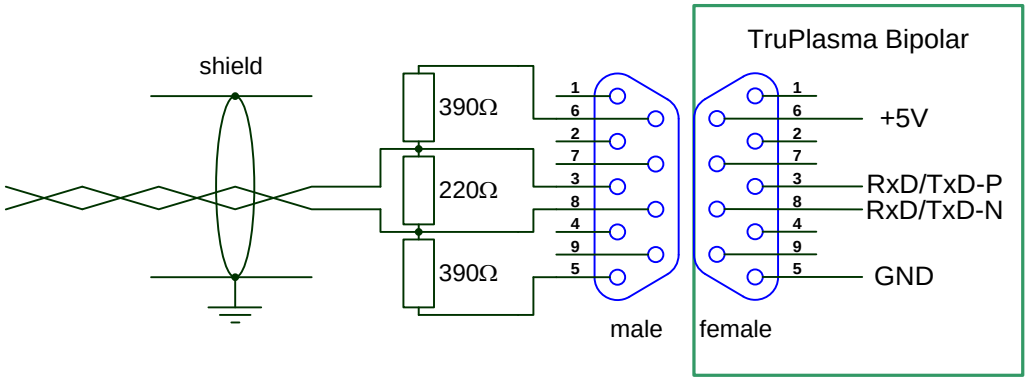


Fig. 4.4. RS-485 – 2 wire connection diagram.

4.10. Analog control terminal

Analog control connector is located on the rear side of device and uses a 25-pin male SUBD connector. Table below provides description of pins.

Pin no.	Name	Type	Description
1	**Uact**	Analog output	**0..10 V** against GND represents **0…600 V** output voltage
2	**Iact**	Analog output	**0..10 V** against GND represents **0…43 A** output current
3	**Pact**	Analog output	**0..10 V** against GND represents **0…15 kW** output power
14	**Pset**	Analog Input	**0..10 V** at input represents **0…15 kW** power setting
4	**GND**	Ground	Reference ground for all analog signals
5	**GND**	Ground	Reference ground for all digital signals
8	**PowerON**	Digital Input	Connect to 24V in order to switch the power ON
9	**Release**	Digital Input	Connect to 24V in order to INHIBIT output power pulses. When signal is high the power is on, when low the power is off
12	**Interlock**	Digital input	Interlock must be disabled (connected to +24V, pin 19) to enable power supply switch-ON. This is a relay-based hardware connection.
19	**+24V**	Supply output	24V supply for all digital inputs.
6	**Coll.**	Digital output (isolated)	All optocoupler collectors are connected to this common pin. **Max. voltage between this pin and the remaining isolated digital outputs must not exceed 30V.**
21	**Ready**	Digital output (isolated)	Ready acknowledge
22	**Alarm**	Digital output (isolated)	Alarm feedback signal
7	**Release confirmation**	Digital output (isolated)	Output pulse wave feedback signal

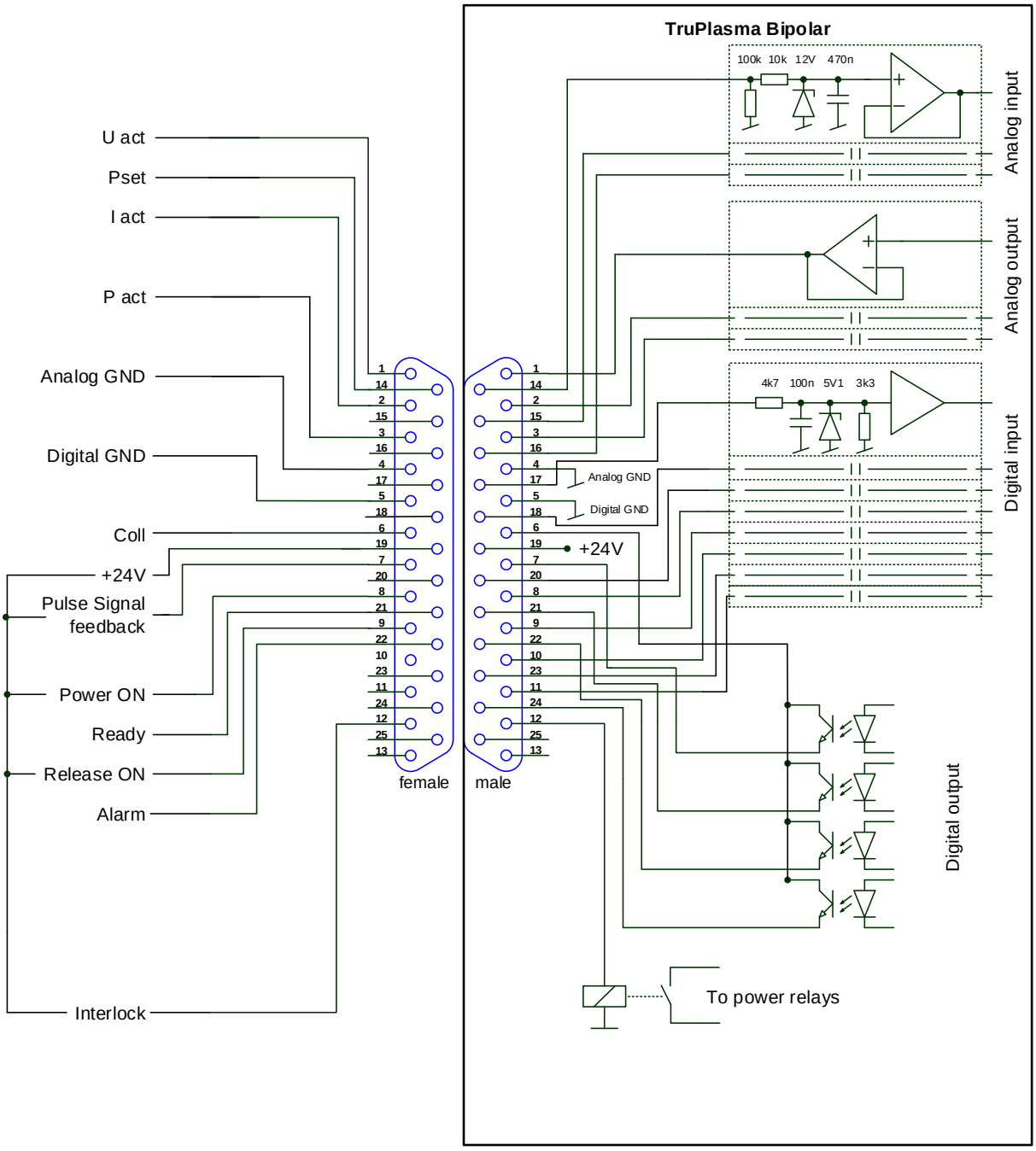
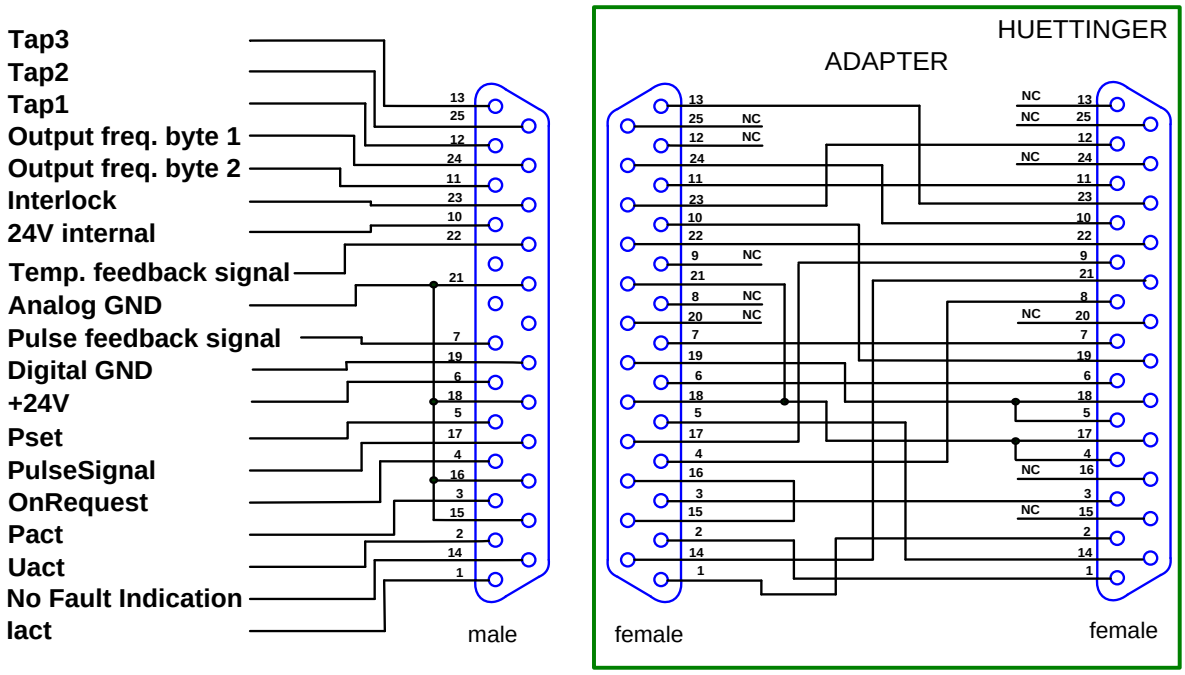


Fig. 4.5. Analog control connection and circuit diagram.



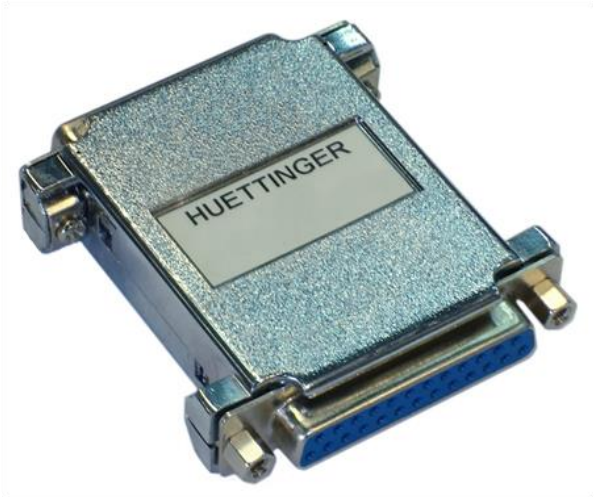


Fig. 4.6. Analog control adapter (not required for operation).

5. Arc management

Electric arcs, observed inside vacuum chamber during all stages of surface treatment process may affect treated surface in a negative manner. In such events arcs should be suppressed as fast as possible. From an electrical point of view, arc occurrence is defined as a rapid change of impedance in chamber's electric terminals.

TruPlasma Bipolar 4030 G2.1 2x15kW PECVD arc detection system is equipped with four kinds of arc detection criteria:

Imax – current-based detector – reacts when output current exceeds user defined Imax threshold. The threshold can be set as a fixed value (Imax Thld [A]) or as a percentage of set output current (Imax Offset [%]). If Imax Offset is set to "0" then threshold is defined as a set value by Imax Thld. Otherwise threshold is defined as a relative value of Iset by Imax Offset parameter.

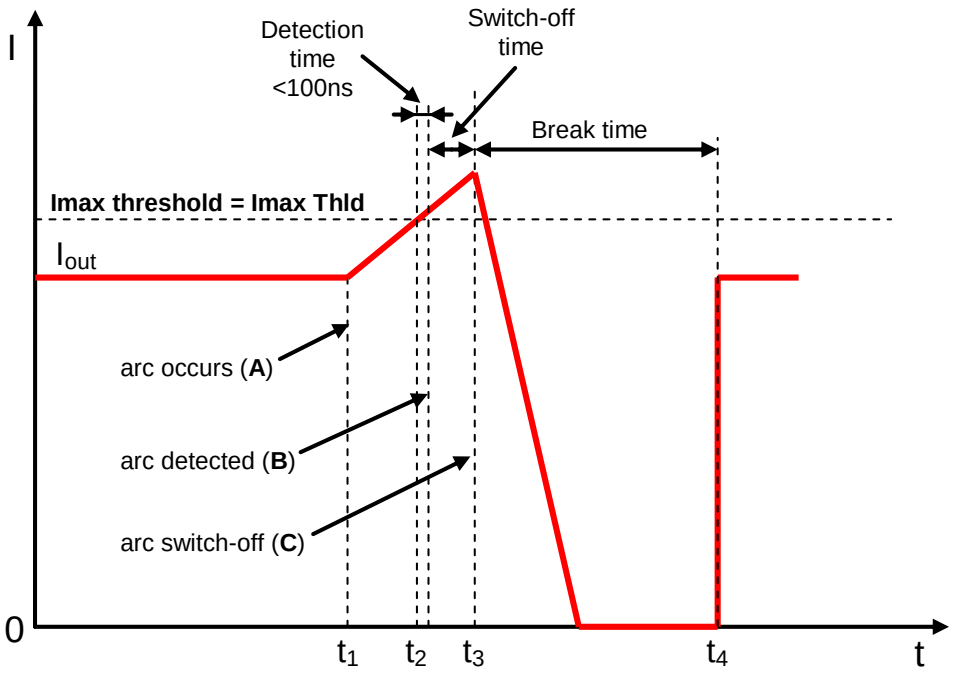


Fig. 5.1. I_{max} criterion arc detection example - **Imax Offset [%] = 0**.

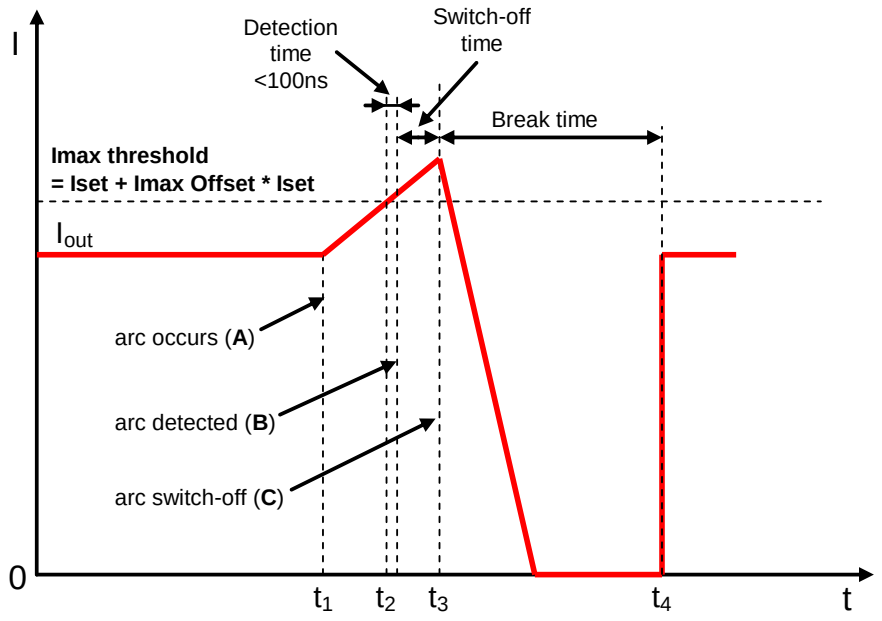


Fig. 5.2. I_{max} criterion arc detection example - **Imax Offset [%] ≠ 0**.

UxI – voltage and current-based detector (cross-detector) – reacts when output voltage is lower than user-defined Ux_Thld while output current is higher than user-defined Ix_Thld

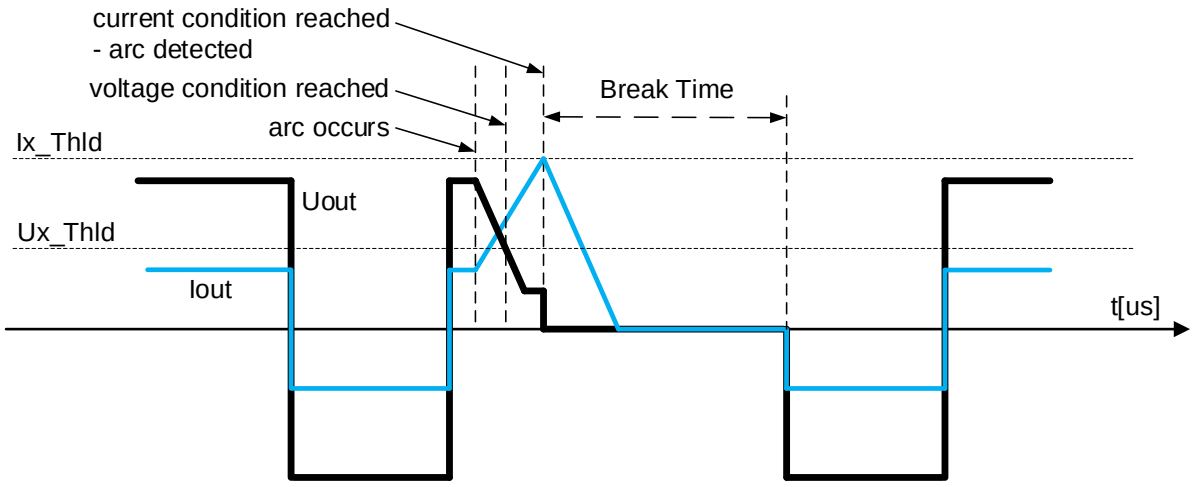


Fig. 5.3. **UxI** (cross detection) criterion arc detection example.

dU – voltage-based detector (microarc) – the generator remembers the shape of output voltage waveform from the last pulse. It compares momentarily output voltage value with corresponding value from the last pulse reduced by dU Thld %. If the present value is lower an arc is detected.

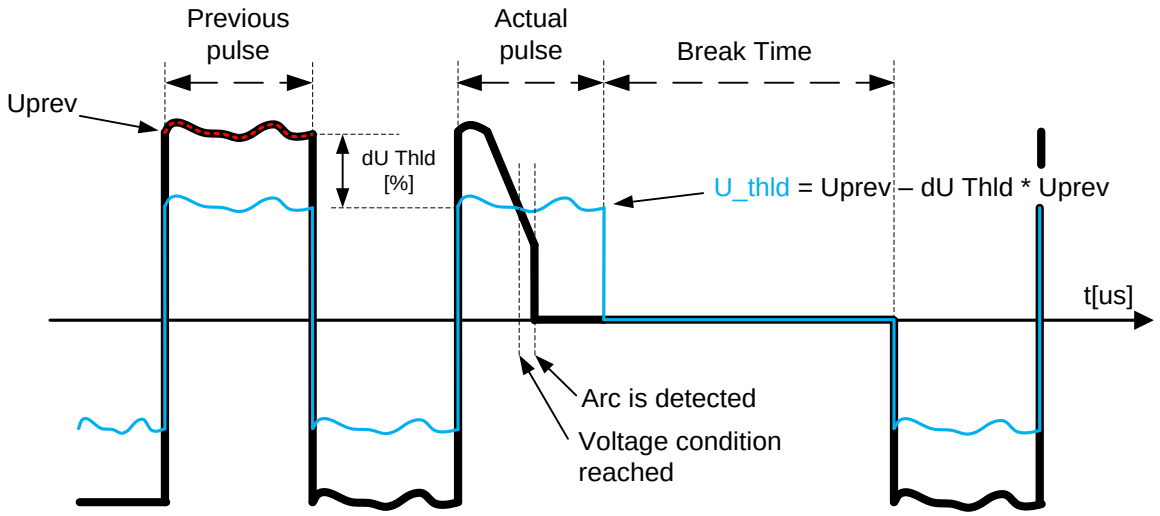


Fig. 5.4. **dU** (dynamic voltage change) criterion arc detection example.

Usag – Voltage-based detector – it compares RMS output voltage value of present pulse with RMS output voltage value of previous pulse reduced by Uout thld %. If present value is lower the sag is detected.

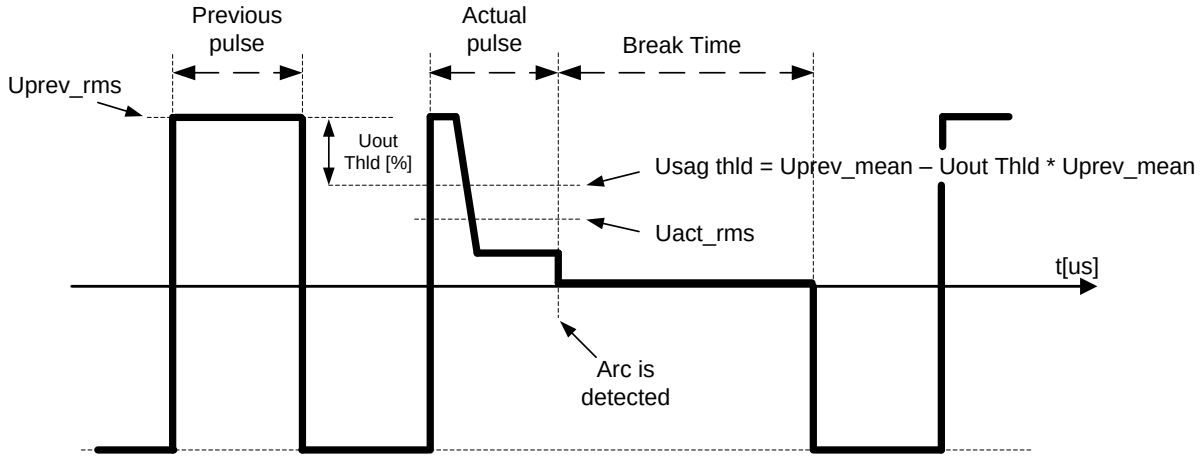


Fig. 5.5. **Usag** detection example.

Notes:

- In **TruPlasma Bipolar 4030 G2.1 2x15kW PECVD** maximum frequency of detected and suppressed arcs can be as high as 20000Hz. This is valid only when cable length between power supply and load is no longer than 10 meters, otherwise frequency is limited to lower values (overheating protection).

Number of detected arcs is displayed by the front panel display or can be read from communication interface with respect to the criteria which detects an arc.
Once an arc has been detected the output power is switched off. At the same moment, a time control procedure and **break time** counter are initiated.

After break time output power returns to its previous setting value. **Break time** parameter can be set through RS232 or RS485

6. Digital interfaces

6.1. RS232/RS485 transmission protocol description

MP acts as a slave device in the communication process. It never initiates any transmissions. Computer (PC) sends a command which is executed by MP and a reply is generated (see note 1). Standard commands are shown below. Additional commands can be implemented if necessary. Baud rate can be chosen by byte channel no. 28. Default value is 38400bps. The RS communication works in standard 8n1 (8 bits of data, non parity, 1 bit of stop, LSB first).

Frame general description

Command:

0	1	2	3	4	5	6	7	...	
LEN	~LEN	DST_H	DST_L	SRC_H	SRC_L	CMD_H	CMD_L	...	
							...	LEN-2	LEN-1
							...	CRC_H	CRC_L

Reply:

0	1	2	3	4	5	6	7	8	9
LEN	~LEN	DST_H	DST_L	SRC_H	SRC_L	ACK_H	ACK_L	CMD_H	CMD_L
...							...	LEN-2	LEN-1
...							...	CRC_H	CRC_L

Where: LEN, ~LEN: length and inverted length (byte, byte);

DST_H, DST_L: receiver number (word); - default value for RS232 is:

Output 1:

DST_H = 0x00;

DST_L = 0x01;

Output 2:

DST_H = 0x00;

DST_L = 0x02;

SRC_H, SRC_L: sender number (word); - default value for RS232 is:

SRC_H = 0x00;

SRC_L = 0x00;

CMD_H, CMD_L: command code (word);

CRC_H, CRC_L: checksum (word); - all bytes sum (without LEN and ~LEN);

ACK_H, ACK_L: reply code (word);

ACK == 0x4000 => OK.

ACK != 0x4000 => fault

6040 Normal run

PC to unit:

0	1	2	3	4	5	6	7	8-11	12-15
0x17	0xE8	DST_H	DST_L	SRC_H	SRC_L	0x60	0x40	$Uset_{0-3}$	$Iset_{0-3}$
16-19	20	21	22						
$Pset_{0-3}$	Ctrl Bits	CRC_H	CRC_L						

Where:

Uset (float)	Voltage set point [V]	0…U_n V
Iset (float)	Current set point [A]	0…I_n A
Pset (float)	Power set point [kW]	0…P_n kW

Ctrl Bits:

0: Mains relays ON (1), OFF (0) (edge sensitive 0⟶1), OFF (0)
1: Power ON (1), OFF (0) (edge sensitive 0⟶1), OFF (0)
2: Reset arc counters (1 transmission is sufficient)
3: RS controls the generator unit (edge sensitive 0⟶1)
4: -
5: -
6: -
7: Reset Alarms

IMPORTANT: When controlling Bipolar unit digitally, (by way of RS232) a command must be sent at least once every 3 seconds to keep power supply running. If, for any reason, transmission fails – an alarm "ActSourceFail " (code 61613) will appear after 4-5 seconds and power supply will be switched off.

unit reply to PC

0	1	2	3	4	5	6	7	8	9
0x2A	0xD5	DST_H	DST_L	SRC_H	SRC_L	ACK_H	ACK_L	CMD_H	CMD_L
10-13	14-17	18-21	22-25	26-27	28-29	30-31	32-33	34-35	36-39
$Uact_{0-3}$	$Iact_{0-3}$	$Pact_{0-3}$	$Bits_{0-3}$	$Imax_{0-1}$	UxI_{0-1}	dU_{0-1}	$Usag_{0-1}$	$ArcBurst_{0-1}$	Arc/s_{0-3}
40	41								
CRC_H	CRC_L								

Where:

Uact (float)	Output mean voltage [V]	0...U_n V
Iact (float)	Output peak current [A]	0...I_n A
Pact (float)	Output mean power [kW]	0...P_n kW

Bits0: Acknowledge bits.
- 0: Relays ON acknowledge (1), or OFF (0)
- 1: Power ON (1), INHIBIT (0)
- 2: Ready
- 3: RS232/485 control
- 4: -
- 5: MessageRead (1)
- 6: -
- 7: PlasmaBit ON (1), OFF (0)

Bits1: more acknowledge bits.
- 0: -
- 1: -
- 2: -
- 3: -
- 4: Full
- 5: BiPulse
- 6: Trapez
- 7: -

Bits2: more acknowledge bits.
- 0: Interlock (1), no interlock (0)
- 1: -
- 2: -
- 3: FPGA OK (1), error(0)
- 4: Power Off Sequence
- 5: -
- 6: Warning Active (1), inactive (0).
- 7: Alarm Active (1), inactive (0).

Bits3: more acknowledge bits.
- 0: RegU ON (1), OFF (0)
- 1: RegI ON (1), OFF (0)
- 2: RegP ON (1), OFF (0)
- 3: -
- 4: Blink Internal
- 5: Blink External
- 6: -
- 7: Arc occ.

Imax (integer)	Arc counter (Imax criterion)	0...65535
UxI (integer)	Arc counter (UxI criterion)	0...65535
dU (integer)	Arc counter (dU criterion)	0...65535
Usag (integer)	Arc counter (Usag criterion)	0...65535
Arc Burst	Arc counter (Arc Burst criterion)	0...65535
Arc/s(float)	Arcs per second counter	

6141 Set a floating point value

PC to unit:

0	1	2	3	4	5	6	7	8	9
0x10	0xEF	DST_H	DST_L	SRC_H	SRC_L	0x61	0x41	CHN_H	CHN_L
10	11	12	13	14	15				
VAL_0	VAL_1	VAL_2	VAL_3	CRC_H	CRC_L				

Where:

CHN (int)	Channel number
Val (float)	Value to be set

Unit reply:

0	1	2	3	4	5	6	7	8	9
0x0E	0xF1	DST_H	DST_L	SRC_H	SRC_L	ACK_H	ACK_L	0x61	0x41
10	11	12	13						
CHN_H	CHN_L	CRC_H	CRC_L						

Where:

CHN (int)	Channel number

6142 Read a floating point value

PC to unit:

0	1	2	3	4	5	6	7	8	9
0x0C	0xF3	DST_H	DST_L	SRC_H	SRC_L	0x61	0x42	CHN_H	CHN_L
10	11								
CRC_H	CRC_L								

Where:

CHN (int)	Channel number

Unit reply:

0	1	2	3	4	5	6	7	8	9
0x12	0xED	DST_H	DST_L	SRC_H	SRC_L	ACK_H	ACK_L	0x61	0x42
10	11	12	13	14	15	16	17		
CHN_H	CHN_L	VAL_0	VAL_1	VAL_2	VAL_3	CRC_H	CRC_L		

Where:

CHN (int)	Channel number
Val (float)	Value to be set

6151 Set an double integer value

PC to unit:

0	1	2	3	4	5	6	7	8	9
0x10	0xEF	DST_H	DST_L	SRC_H	SRC_L	0x61	0x51	CHN_H	CHN_L
10	11	12	13	14	15				
VAL_0	VAL_1	VAL_2	VAL_3	CRC_H	CRC_L				

Where:

CHN (int) Channel number
Val (int) Value to be set

Unit reply:

0	1	2	3	4	5	6	7	8	9
0x0E	0xF1	DST_H	DST_L	SRC_H	SRC_L	ACK_H	ACK_L	0x61	0x51
10	11	12	13						
CHN_H	CHN_L	CRC_H	CRC_L						

Where:

CHN (int) Channel number

6152 Read an double integer value

PC to unit:

0	1	2	3	4	5	6	7	8	9
0x0C	0xF3	DST_H	DST_L	SRC_H	SRC_L	0x61	0x52	CHN_H	CHN_L
10	11								
CRC_H	CRC_L								

Where:

CHN (int) Channel number

Unit reply:

0	1	2	3	4	5	6	7	8	9
0x12	0xED	DST_H	DST_L	SRC_H	SRC_L	ACK_H	ACK_L	0x61	0x52
10	11	12	13	14	15	16	17		
CHN_H	CHN_L	VAL_0	VAL_1	VAL_2	VAL_3	CRC_H	CRC_L		

Where:

CHN (int) Channel number
Val (float) Value to be set

6121 Set an integer value

PC to unit:

0	1	2	3	4	5	6	7	8	9
0x0E	0xF1	DST_H	DST_L	SRC_H	SRC_L	0x61	0x21	CHN_H	CHN_L
10	11	12	13						
VAL_H	VAL_L	CRC_H	CRC_L						

Where:

CHN (int) Channel number
Val (int) Value to be set

Unit reply:

0	1	2	3	4	5	6	7	8	9
0x0E	0xF1	DST_H	DST_L	SRC_H	SRC_L	ACK_H	ACK_L	0x61	0x21
10	11	12	13						
CHN_H	CHN_L	CRC_H	CRC_L						

Where:

CHN (int) Channel number

6122 Read an integer value

PC to unit:

0	1	2	3	4	5	6	7	8	9
0x0C	0xF3	DST_H	DST_L	SRC_H	SRC_L	0x61	0x22	CHN_H	CHN_L
10	11								
CRC_H	CRC_L								

Where:

CHN (int) Channel number

Unit reply:

0	1	2	3	4	5	6	7	8	9
0x10	0xEF	DST_H	DST_L	SRC_H	SRC_L	ACK_H	ACK_L	0x61	0x22
10	11	12	13	14	15				
CHN_H	CHN_L	VAL_H	VAL_L	CRC_H	CRC_L				

Where:

CHN (int) Channel number
Val (float) Value to be set

6111 Set a byte value

PC to unit:

0	1	2	3	4	5	6	7	8	9
0x0D	0xF2	DST_H	DST_L	SRC_H	SRC_L	0x61	0x11	CHN_H	CHN_L
10	11	12							
VAL	CRC_H	CRC_L							

Where:

CHN (int) Channel number
Val (int) Value to be set

Unit reply:

0	1	2	3	4	5	6	7	8	9
0x0E	0xF1	DST_H	DST_L	SRC_H	SRC_L	ACK_H	ACK_L	0x61	0x11
10	11	12	13						
CHN_H	CHN_L	CRC_H	CRC_L						

Where:

CHN (int) Channel number

6112 Read a byte value

PC to unit:

0	1	2	3	4	5	6	7	8	9
0x0C	0xF3	DST_H	DST_L	SRC_H	SRC_L	0x61	0x12	CHN_H	CHN_L
10	11								
CRC_H	CRC_L								

Where:

CHN (int) Channel number

Unit reply:

0	1	2	3	4	5	6	7	8	9
0x0F	0xF0	DST_H	DST_L	SRC_H	SRC_L	ACK_H	ACK_L	0x61	0x12
10	11	12	13	14					
CHN_H	CHN_L	VAL	CRC_H	CRC_L					

6301 Read alarm code and description

PC to unit:

0	1	2	3	4	5	6	7	8	9
0x0A	0xF5	DST_H	DST_L	SRC_H	SRC_L	0x63	0x01	CRC_H	CRC_L

Unit reply:

0	1	2	3	4	5	6	7	8	9
LEN	~LEN	DST_H	DST_L	SRC_H	SRC_L	ACK_H	ACK_L	0x63	0x01
10	11	12 to n-2				n-1	n		
$CODE_H$	$CODE_L$	Description				CRC_H	CRC_L		

6302 Read again last alarm code and description

PC to unit:

0	1	2	3	4	5	6	7	8	9
0x0A	0xF5	DST_H	DST_L	SRC_H	SRC_L	0x63	0x02	CRC_H	CRC_L

Unit reply:

0	1	2	3	4	5	6	7	8	9
LEN	~LEN	DST_H	DST_L	SRC_H	SRC_L	ACK_H	ACK_L	0x63	0x02
10	11	12 to n-2				n-1	n		
$CODE_H$	$CODE_L$	Description				CRC_H	CRC_L		

6101 Identification of device:

PC to unit:

0	1	2	3	4	5	6	7	8	9
0x0A	0xF5	DST_H	DST_L	SRC_H	SRC_L	0x61	0x01	CRC_H	CRC_L

Unit reply:

0	1	2	3	4	5	6	7	8	9
0x19	0xE6	DST_H	DST_L	SRC_H	SRC_L	ACK_H	ACK_L	0x77	0x01
10	...	22	23	24					
S_{00}	...	S_{12}	CRC_H	CRC_L					

Where: $S_{00} \div S_{12}$: device type (char[13]);

Channel numbers:

Byte:

Channel	Description	Range	Adjustable ?
20	Ctrl Src Act 0: RS232 1: Analog 3: Display 4: RS485 7: USB	1 ... 255	YES
19	Ctrl Src Ini 0: RS232 1: Analog 3: Display 4: RS485 7: USB	1 ... 255	YES
18	Active Interfaces 0: RS232 1: Analog 3: Display 4: RS485 7: USB	1 ... 255	YES
803	Power Equ Bits 0: Enable	0 ... 1	YES
202	Arc Cnt Overflow 0: Arc Cnt Ovfl	0 ... 1	YES
33	Bipulse Mode 2: Full 3: BiPulse 4: Trapez	4 ... 16	YES
265	Number in row	1 ... 100	YES
261	Imax Offset [%]	0 ... 100	YES
252	Uout Sag Factor [%]	10 ... 50	YES
604	Req Blink Stat 0: BlinkPwrOn Out1 OK 1: BlinkPwrOn Out2 OK 2: BlinkMultiply OK 3: Blink Wrong Config.	-	NO
200	Arc Enable Bits 0: dU En 1: UxI En 2: Imax En 3: Usag En 4: Arc Burst En	0 ... 31	YES
650	Off Time [%]	1 ... 20	YES
28	RS Speed 0: 9600 1: 19200 2: 38400 3: 57600 4: 115200	1 ... 255	YES

602	Blink Cfg 0: Internal Blink 1: External Blink	0 ... 2	YES
605	Act Blink Stat 0: BlinkPwrOn Out1 OK 1: BlinkPwrOn Out2 OK 2: BlinkMultiply OK 3: Blink Wrong Config.	-	NO
209	Arc Config Bits 0: Opposite Pulse	0 ... 1	YES

Word:

Channel	Description	Range	Adjustable ?
276	Arc Burst On-Time Below [us]	1 ... 1000	YES
13	This Module RS Address	-	NO
5	Communication Timeout [s]	0 ... 65	YES
275	Arc Burst Break Time [us]	25 ... 10000	YES
3	Base RS Address	1 ... 65535	YES

DWord:

Channel	Description	Range	Adjustable ?
100	Serial Number	-	NO
900	DSP SW ver.	-	NO
901	FPGA SW ver.	-	NO

Float:

Channel	Description	Range	Adjustable ?
938	T2 CC 1 [°C]	-	NO
937	T1 CC 1 [°C]	-	NO
936	T0 CC 1 [°C]	-	NO
234	Hard Arc Rate [arc/s]	-	NO
208	Ux Thld [V]	0 ... 800	YES
233	uRate [arc/s]	-	NO
920	CMPC Supply [V]	-	NO
256	dU Thld [%]	0 ... 100	YES
251	Micro Arc BT [us]	10 ... 1000	YES
207	Ix Thld [A]	$0.1I_n$ ... $1.0I_n$	YES
205	Imax Thld [A]	$0.1I_n$ ... $1.3I_n$	YES
600	Blink Power On Act [ms]	-	NO
921	+24V Ext. [V]	-	NO
51130	Frequency [kHz]	5 ... 50	YES
51141	Duty [%]	-	NO
932	T0 [°C]	-	NO
51131	Duty [%]	1 ... 99	YES

237	Hard Arc Ramp Time [ms]	0 ... 2	YES
51140	Frequency [kHz]	-	NO
617	Req Blink Power Off [ms]	1 ... 500	YES
939	T3 CC 1 [°C]	-	NO
250	Hard Arc BT [us]	10 ... 2000	YES
616	Req Blink Power On [ms]	1 ... 500	YES
601	Blink Power Off Act [ms]	-	NO
602	Blink Delay [ms]	0 ... 4	YES
933	T1 [°C]	-	NO

Acknowledge and failure codes (HEX format)

4000 Transmission OK and command executed.
4001 Transmission length error. Byte1 is not a cancellation of Byte0.
4002 Check sum error. The two byte checksum is not equal to sum of bytes no. 2 … (n-2).
4004 Unknown Command.
4006 Channel address not exist.
4010 Write EEPROM error.
4020 Write EEPROM disabled by slave mode (6141, 6121, 6111).
4030 Write EEPROM disabled.
4031 Written value is above upper limit.
4032 Written value is below lower limit.

7. Interface software

7.1. PVD Power requirements

Attached CD includes PVD Power control software.

Note: PVD Power requires .NET Framework version 4.0.
Microsoft .NET Framework Version 4.0 Redistributable Package (x86) is available at Microsoft Download Center:
http://www.microsoft.com/en-us/download/details.aspx?id=17718

System requirements

Supported operating systems:
- Windows XP SP3
- Windows Server 2003 SP2
- Windows Vista SP1 or later
- Windows Server 2008 (not supported on Server Core Role)
- Windows 7
- Windows Server 2008 R2 (not supported on Server Core Role)
- Windows 7 SP1
- Windows Server 2008 R2 SP1

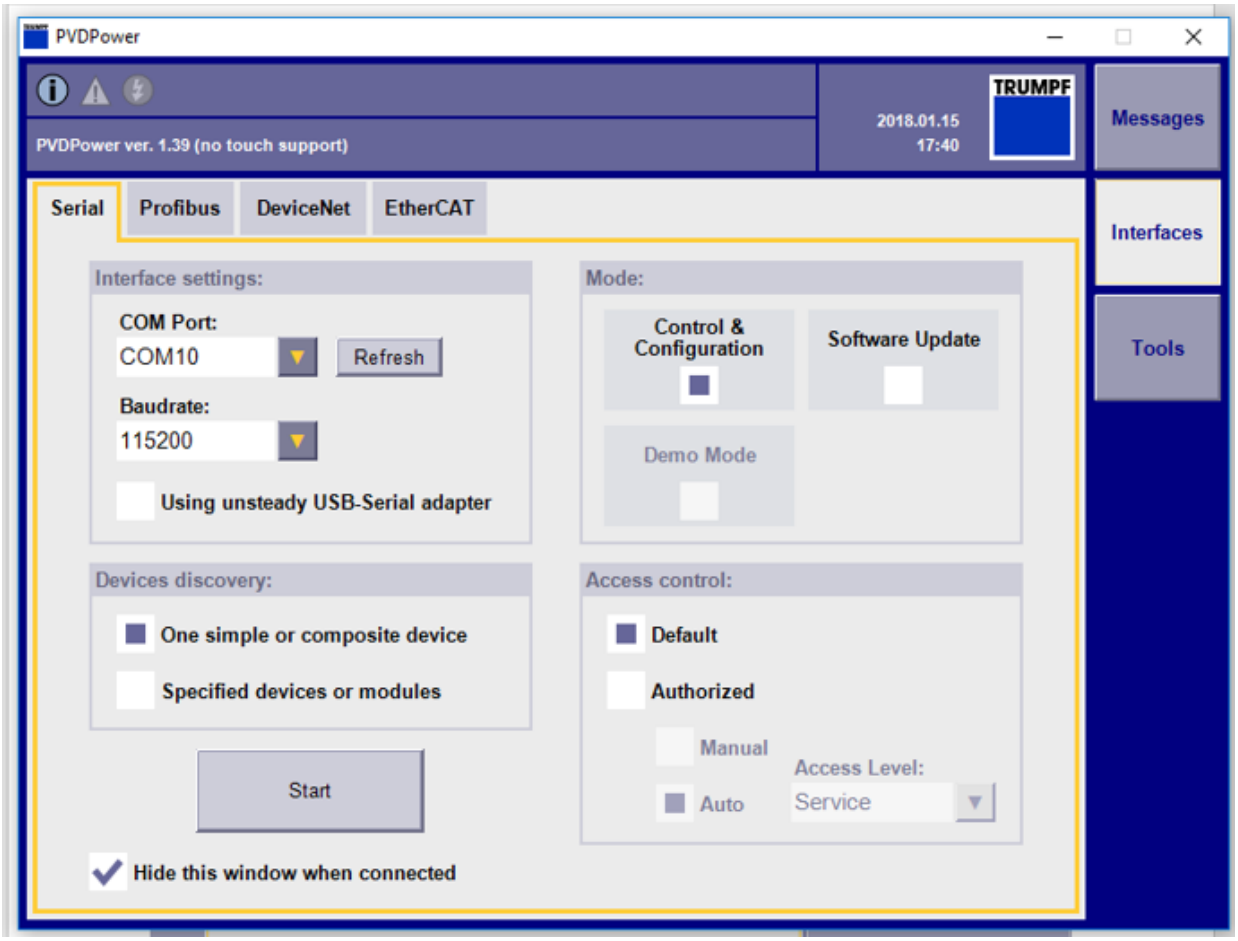
Supported Architectures:
- x86
- x64
- ia64 (some features are not supported on ia64 for example, WPF)

Hardware Requirements:
- Recommended Minimum: Pentium 1 GHz or higher with 512 MB RAM or more
- Minimum disk space:
- x86 – 850 MB
- x64 – 2 GB

Prerequisites:
- Windows Installer 3.1 or later

7.2. PVD Power Operation

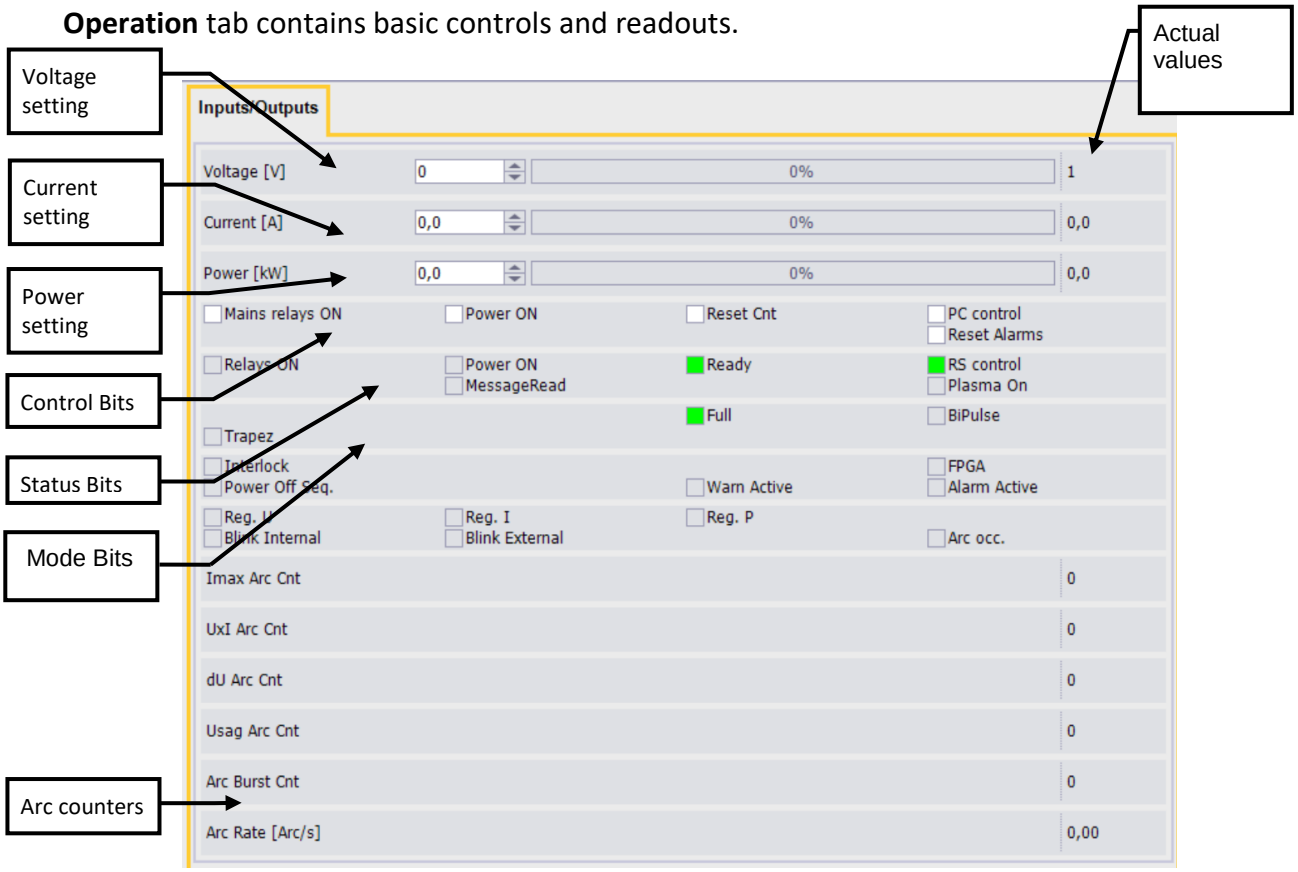
In order to activate PVD Power software, “PVDPower_x.xx.exe” file must be running. Check the correct COM port and baudrate to avoid error messages.
When RS232 is configured, press “Start” button to initiate communication with **TruPlasma Bipolar** unit.



In case of errors or alarms appearance search for solutions in the error list and alarm causes

Operation

Operation tab contains basic controls and readouts.



Booting the power supplies process:

If the Alarm Active Bit is on, find out what possible errors may have occurred and check the Reset Alarms bit in Control Bits section.

→ If the Interlock Bit is on, check all possible interlock causes (fig.4.2.)

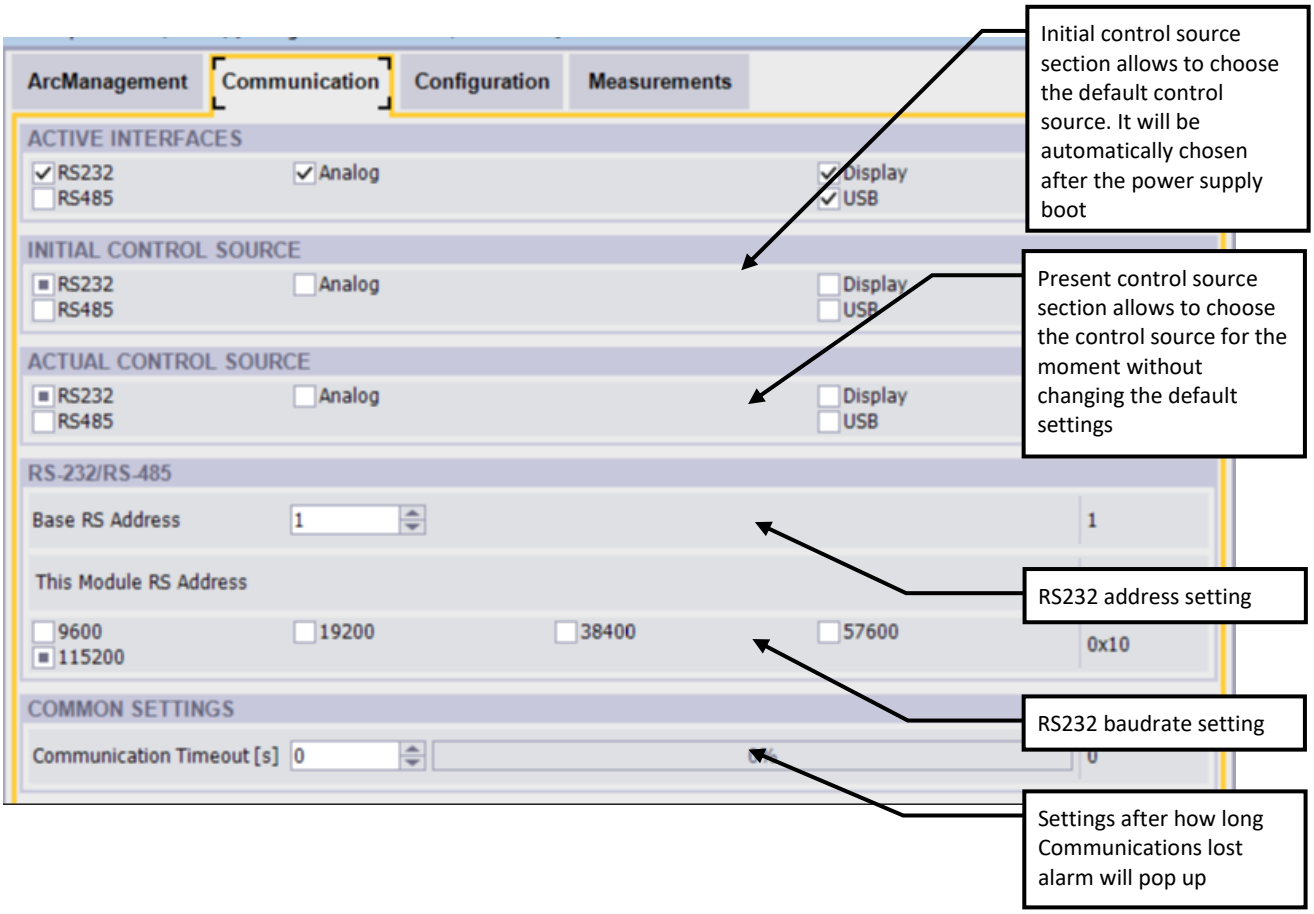
→ Set the Voltage, Current and Power on the chosen levels

→ Choose the desired work mode in the Mode Bits section

→ Check the Mains relays ON (wait for the “Relays ON” bit to turn green) and then Power ON Bit in Control Bits section.

Arc Management

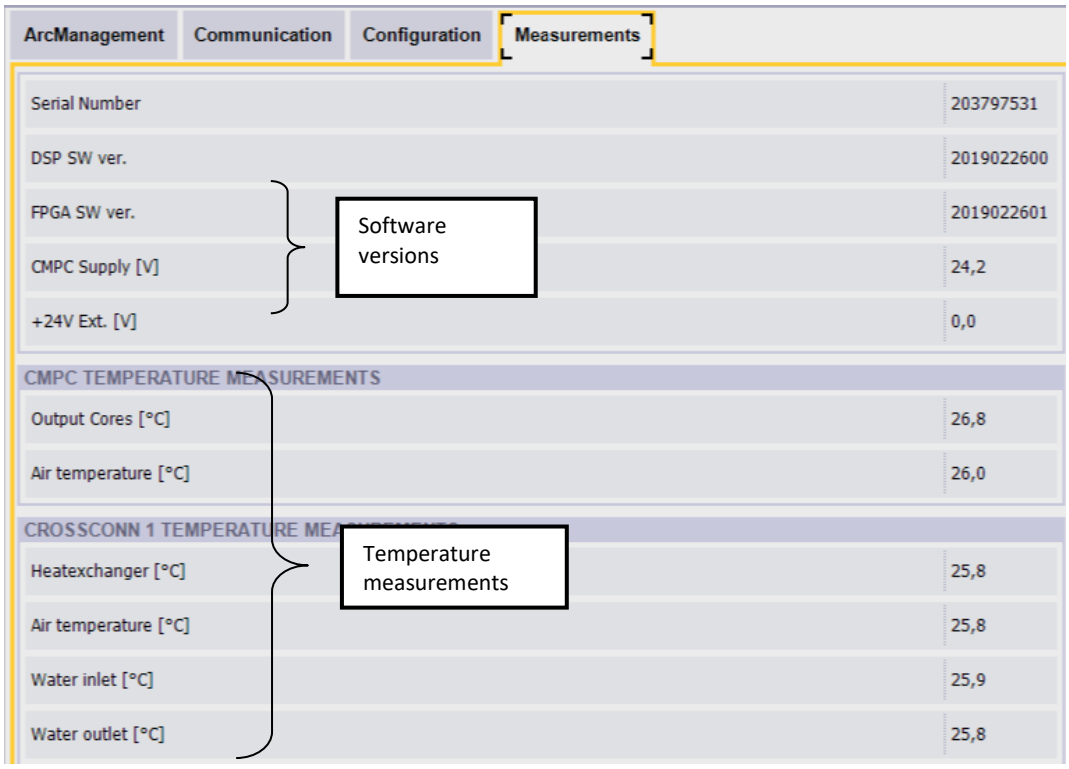
Communication



In order to permanently change the control source remember to check the correct box in the initial control source section

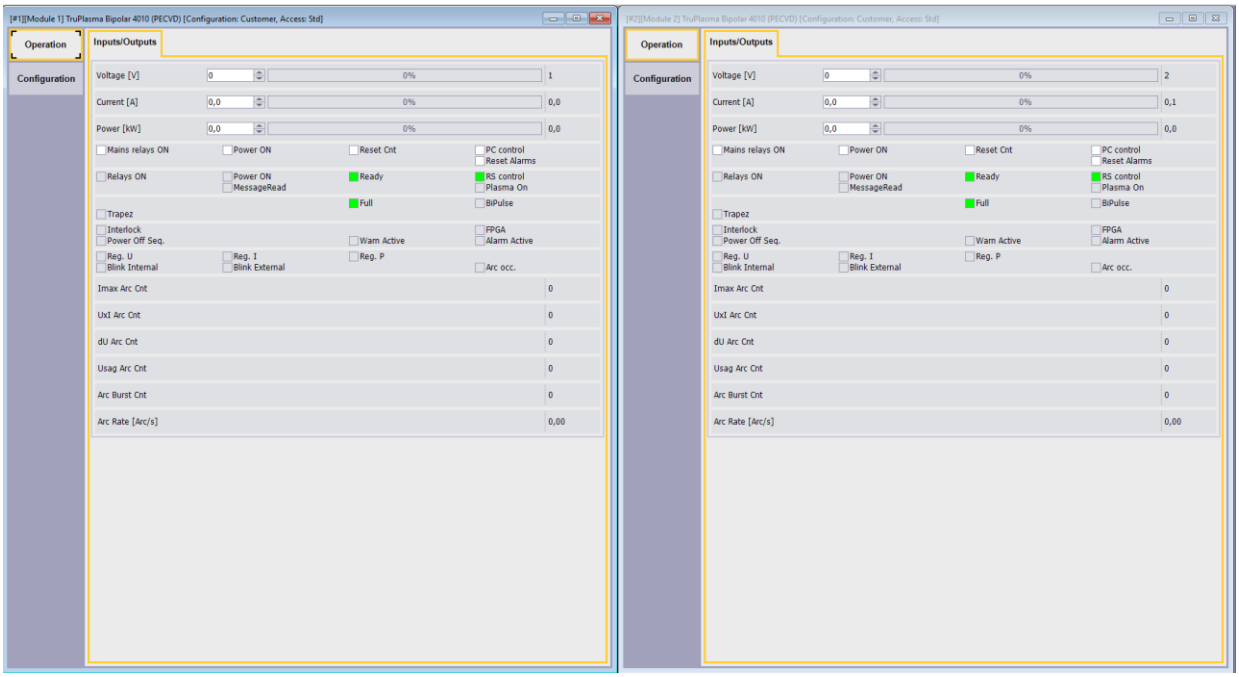
Configuration

Measurements



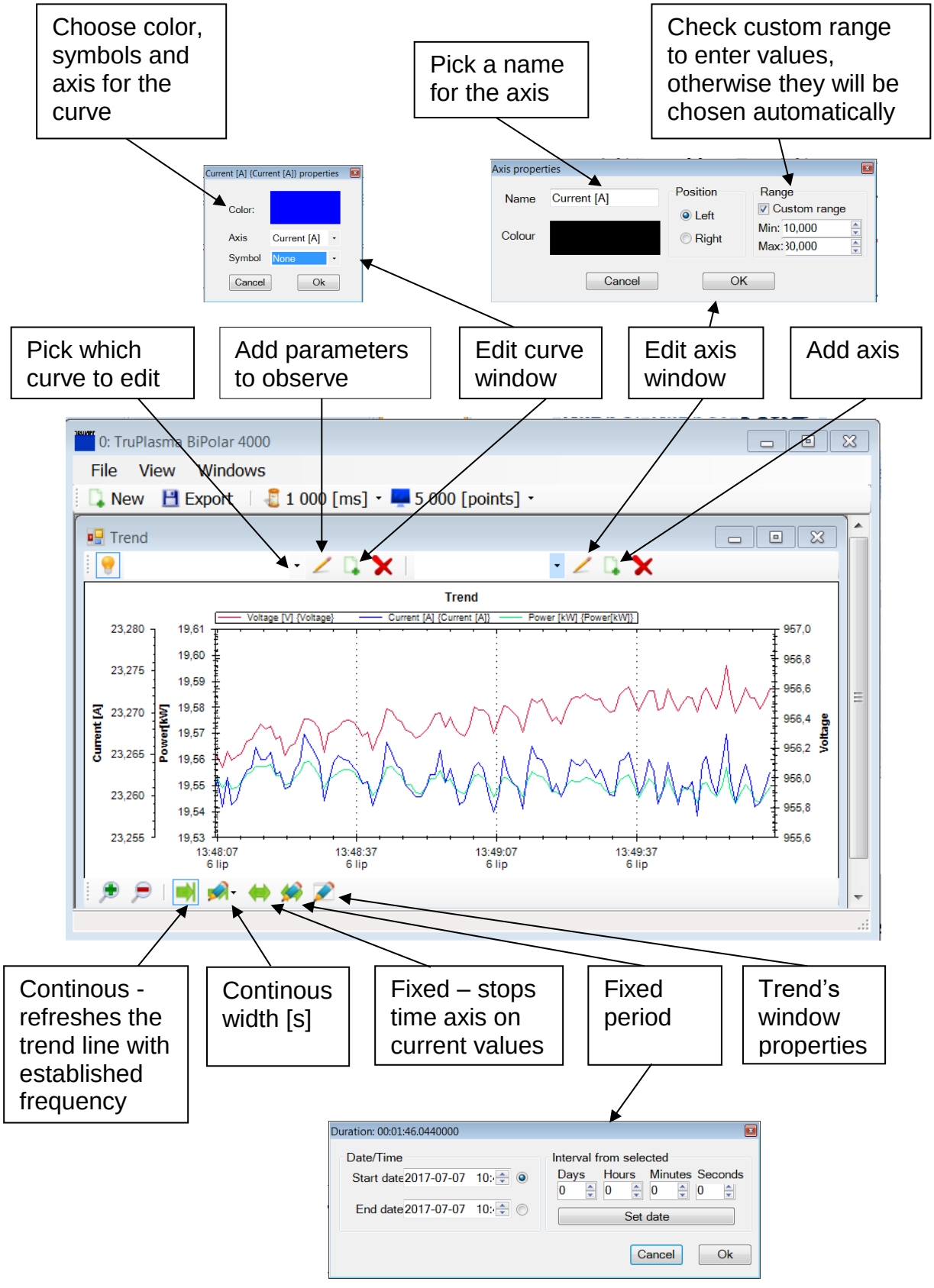
Dual output operation

Dual output independent operation can be controlled by two different windows in the PVD Power software.

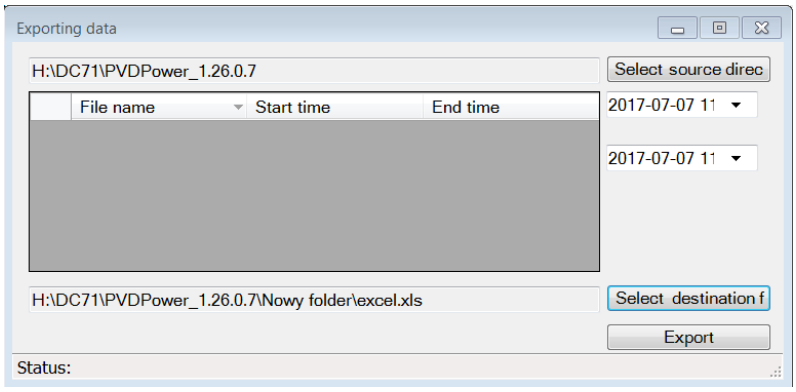


Trend function

In order to see the power supply's trend line go to tools->trend and click on new.



Trend line data export



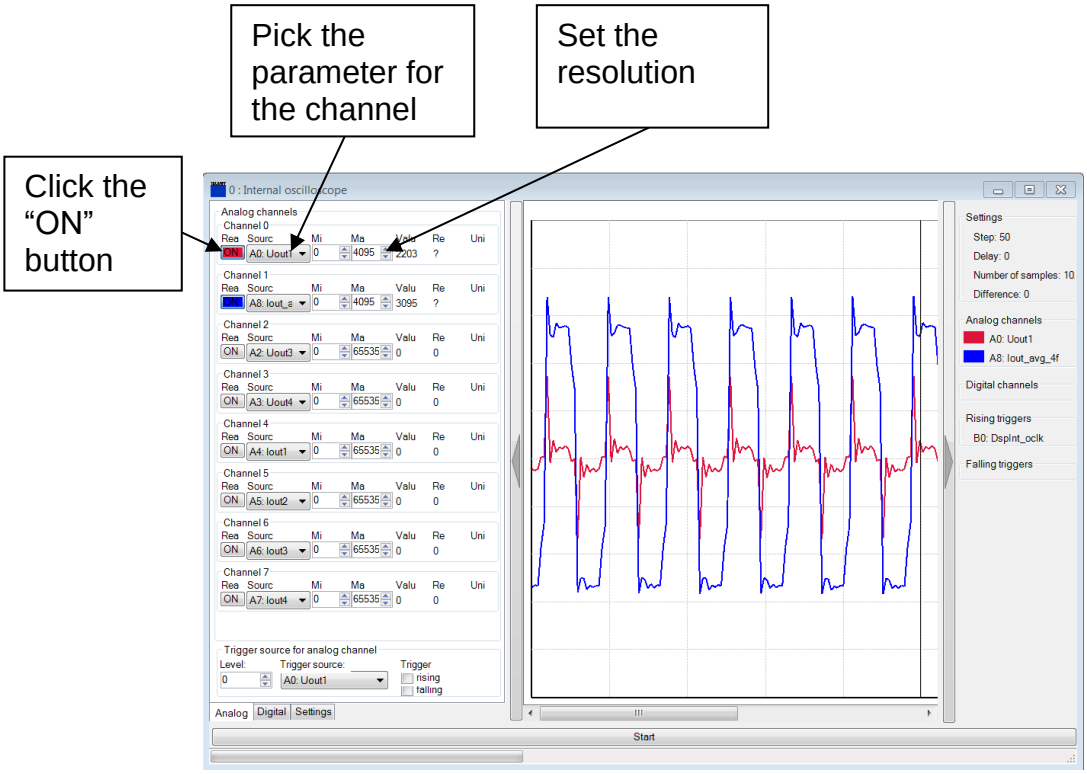
1 Select the source folder

2 Select the beginning and ending date

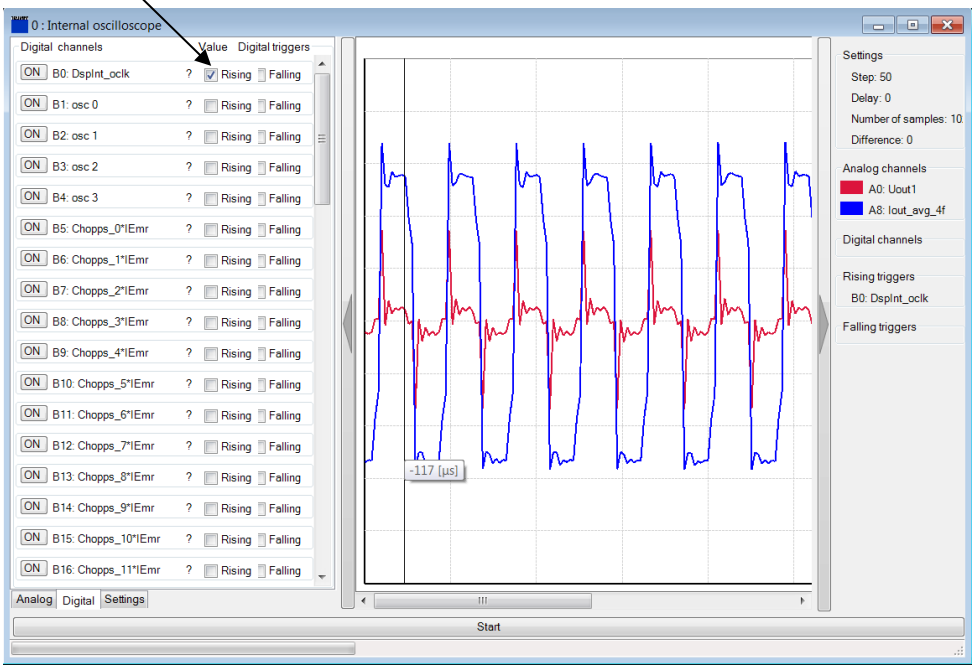
3 Select the destination folder

Internal Oscilloscope

PVDPower contains an 8-channel oscilloscope. It is available after choosing tools -> oscilloscope from the menu.

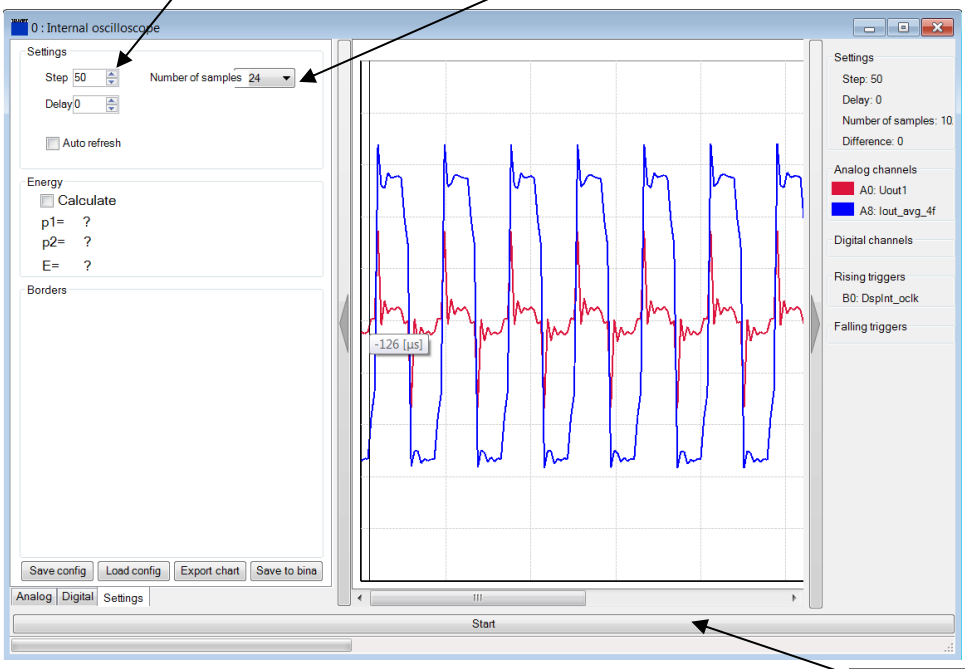


Turn on the digital signals, to trigger the analog ones



Set the step value – one step indicates 20 ns. Example: with the step parameter set on 50 acquisition will occur every 1 µs

Set the number of displayed samples



Press start

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8. Warning and alarm messages

Error codes description.

Error Number	SNr-Param	Description
61601	-	EEPROM error
61602	-	Wrong checksum of data stored in EEPROM
61603	-	FPGA configuration failed
61605	supply voltage (24V) * 100	Too high supply voltage (24V)
61606	supply voltage (24V) * 100	Too low supply voltage (24V)
61607	Sensor ID=xe6 + temperature value Tx*100	Too high temperature on sensor x
61608	-	no communication with DataFlash device
61609	kind of sag	Mains voltage sag detected
61613	2	no RS232 communication available anymore
	7	no communication with EtherCAT interface
	ID of interface, which is in use	no communication with Actual Control Source
61614	1	no communication with EEPROM device
	2	no communication with Temperature measurement module
	3	no communication with Mains measurement module
	4	no communication with RTC device
	5	no communication with Currents measurement module
61616	U500 voltage * 100	U500 Voltage too low
61617	U500 voltage * 100	U500 Voltage too high
61618	-	Inverter Error
61619	U800 voltage * 100	U800 Voltage too low
61620	U800 voltage * 100	U800 Voltage too high
61621	U800 voltage * 100	Too high U800 voltage during Power On sequence
61622	-	CAN configuration error
61623	-	No Load
61624	-	Short Circuit
61625	-	Arc Density exceeded the limit
61626	Minimum, required PLD SW version	PLD software version is too old
61627	Freq [Hz]	CLC switching frequency too high
61631	temperature value *100	Too low temperature of inlet water
61632	kind of wrong configuration	Wrong configuration
61633	U500 voltage * 100	U500fast high
61634	-	dU500/dt high
61635	U800 voltage * 100	U800fast high
61636	-	dU800/dt high
61642	-	Power fail IemrRate
61646	U500 voltage * 100	U500 fast low
61647	U800 voltage * 100	U800 fast low
61649	-	Chopper fail
61690	-	Device type mismatch
61691	-	FPGA regulator mismatch
61692	Freq [Hz]	Blink switching frequency too high
61694	-	PFC emergency error
61695	-	Reverse overcurrent

Error Number	SNr-Param	Description
61706	U800 voltage * 100	U800 shorted
61707	U800 voltage * 100	U800 is not increasing
61709	-	Output emergency error
61710	-	Fans off too long
61712	-	FPGA clock configuration error
61713	-	Internal error
61714	-	Test version. Internal use only
61716	-	No serial (0) or SAP (1) number
61724	-	Too high EEPROM usage

Warning codes description.

Warning Number	SNr-Param	Description
61651	-	No data In memory banks – default restored
61652	-	Checksum error in memory bank
61653	-	EEPROM write error
61654	-	Arc Density exceeded the limit
61655	-	Recalibration done
61656	-	Unauthorized recalibration attempt
61657	Sensor ID=xe6 + temperature value Tx*100	Temperature warning level exceeded Tx
61658	-	Cooling water flow is too low
61659	-	Cooling water flow wrong direction
61661	2,7	No communication with the Actual control source
61663	ID of interface, which is in use	communication fail with actual control source
61664	-	New version of memory map in EEPROM
61665	1	Exceeded maximum allowable difference between voltage set and actual values [mV]
	2	Exceeded maximum allowable difference between current set and actual values [mA]
	3	Exceeded maximum allowable difference between power set and actual values [W]
61666	-	Plasma not detected
61667	-	PlossMax value reached. Power loss cannot be compensated properly
61669	-	Internal CAN bus configuration fail
61670	temperature value *100	Low temperature of inlet water
61697	-	Blink input pulse too short
61698	-	Blink input pulse too long
61701	-	PWM PT too long
61702	-	PWM recipe not saved
61711	-	Test version. Internal use only
61723	-	High EEPROM usage

9. Scope of delivery

Contents of the box:

- TruPlasma Bipolar 4030 G2.1 2x15kW PECVD power supply
- Dummy plug (interlock removal)
- Output terminals cover
- Mains terminals cover
- Inlet air pipe adaptor with stopper
- User Manual
- Certificate of conformity
- CD (software and manual)

TruPlasma Bipolar 4030 G2.1 2x15kW PECVD power supply is delivered in ready-to-use condition.
Device is designed to operate correctly when all connections and installation procedures are followed in accordance with user manual. Default settings should assure proper behavior of device in the most commonly used system configurations.

Nevertheless, it would be useful to learn as much as possible about maintenance and operation principles before proceeding with startup. A full understanding of these system operating principles will help user to obtain the most useful information from controller's display as well as understand behavior of the entire power supply. Introducing any changes to device's settings requires full knowledge of system (and also the password).