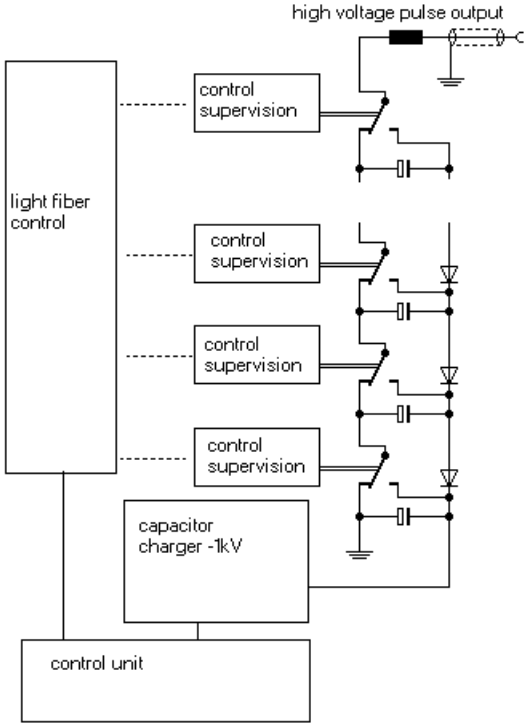
RUP6

Variable pulse generator system for high power, resistive and capacitive loads

- True square wave pulses with active switching off
- Pulse width freely adjustable
- Rise-/fall time adjustable
- frequency up to 3 kHz
- peak voltages in the range from –6 kV up to -35 kV available
- Two possible pulse modules with peak current of 60A or 200 A
- Primary power supplies for average power up to 2.5kW, 6 kW or 12 kW available
- short circuit proof

The RUP6 series is a universal solid state high voltage pulse generator system, which can be built for the voltage range of –6 kV to –35kV. Applications for the RUP6 are e.g. plasma immersion ion implantation, high voltage treatment of liquids and other applications which demand average power in the kW range and the loads are in the range 50Ω up to several kΩ. The RUP6 can also be used for isolation tests with capacitive loads. For this, the CL modules are recommended, also RUP6 versions with rise time adjustable over a large range are available.
Prominent properties are high pulse current, very high efficiency, scalability of voltage and fast arc switch off. The RUP6 consists of numbers of 1 kV pulse modules which are charged in parallel and are switched in series during pulse. Polarity is always negative. As synchronous switching of the modules is not necessary with this principle, stepwise switching can be used to make rise and fall times adjustable.



The newer versions “L” always have a defined output inductance and switch the modules in two groups to minimize switching losses and overshoot. Internally its also possible to set the control such that all modules are switched sequentially.
The version CL incorporates in contrast to the standard version current enhanced modules, which can handle up to 200 A, and not only forward, but also reverse during switching off. Combined with the adjustable rise and fall time it makes an excellent choice for capacitive loads.

02.01.17 Dr. Jörg Brutscher

GBS Elektronik GmbH
Bautzner Landstraße 22
01454 Großerkmannsdorf
Germany

Tel.: 0049 (0)351 21 70 07 - 0
Fax.: 0049 (0)351 21 70 07 - 21
E-Mail: kontakt@gbs-elektronik.de
Website: www.gbs-elektronik.de

RUP6

Variable pulse generator system for high power, resistive and capacitive loads

Technical Data

Current and Voltage

- Peak output pulse voltages available in the range –6...-35 kV, corresponding to 1 kV per pulse module. Preferred values are 6, 10, 12, 17, 20, 25 or 35 modules.
- 2 different modules are available, the standard module with 60A peak current or the high current module with 200A peak current which is also preferred for capacitive loads.

	standard module	high current module
Peak current during voltage rise and pulse	60A	200A
Peak current during falling voltage	8A	200A
short circuit current	<90A	<270A
pulse capacity	90µF	270µF
resistance	0.8 Ohm	0.4 Ohm
recommended minimum serial inductance	2µH per module	1µH per module
max. RMS current	3A	9 (12*)A
recommended power supply	2.5 kW max., > 25 modules also 6kW possible.	2.5 kW max. with pure reacive loads, otherwise 6 kW or 12kW*

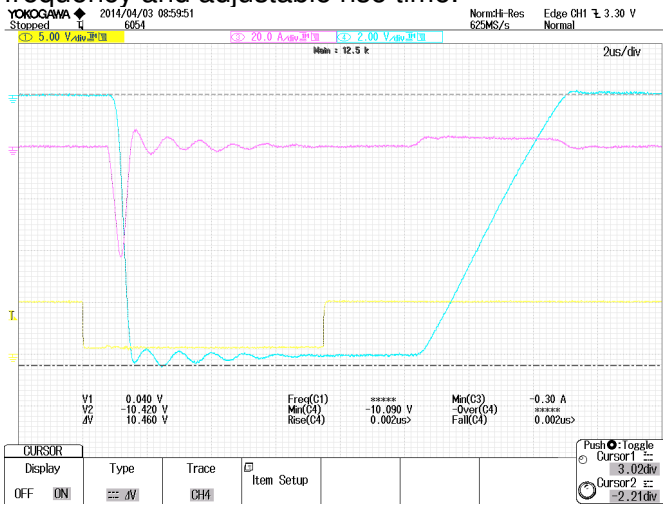
**increased cooling*

- The output impedance corresponds to the module impedance multiplied by the number of modules (e.g. RUP6-25: 25*0.8Ω=20Ω, Inductance 25*2µH=50µH)
- The effective pulse capacity corresponds to the module capacity divided by the number of modules (e.g. RUP6-25: 90µF/25=3.6µF).
- Maximum average output power (full voltage) 2.5 kW, optional 6 or 12 kW, decreasing with increasing duty cycle. Pout=Pmax *(1 - frequency * (pulse width + 150µs))
- The maximum average output current is depending on the internal power supply 2.5A, 6A or 12A divided by the number of modules (e.g. RUP6-10: 2.5A/10=250mA). With inductive loads, the average current may be higher.

An arc (sudden voltage breakdown during pulse) will limit current within 80 ns and will terminate pulse after 700 ns.
Optional it is internally settable that after an error (arc, RMS current too high, module error) high voltage is switched off and operation is shut down.

Waveform and frequency

Trapezoidal pulse with variable pulse width, frequency and adjustable rise time.



Output signal of a RUP6-35, without load. Blue: output voltage 1:3500, red: Output current, yellow: control signal.

- Pulse width adjustable in the range 0.5 µs ... 100 µs; with the external control input also longer pulses are possible. Without load, pulse width can be extended theoretically until around 2 seconds.
- Duty cycle can be chosen nearly arbitrarily, just that the average will decrease with increasing duty cycle. The reason for that is that the internal power supply will not work during a pulse and up to 150 µs after it.
- Maximum frequency 3 kHz. Concerning the versions with higher voltage, larger capacitive load and ramp operation, the maximum frequency may be reduced at full voltage.
- Controld of voltage, pulse width and frequency by knobs on the front plate. Pulse control also by TTL signal at the BNC control input.

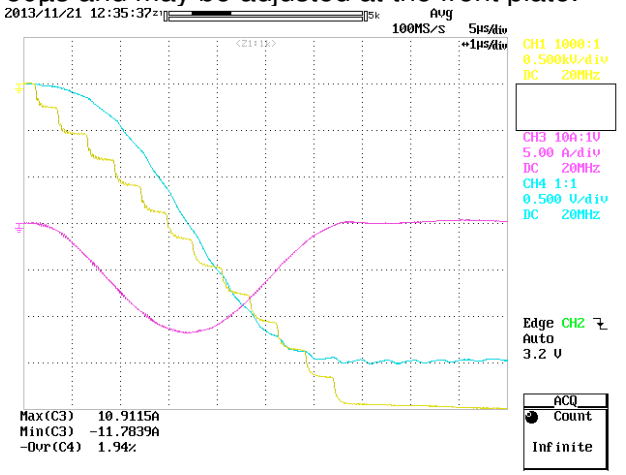
02.01.17 Dr. Jörg Brutscher

GBS Elektronik GmbH
Bautzner Landstraße 22
01454 Großerkmannsdorf
Germany

Tel.: 0049 (0)351 21 70 07 - 0
Fax.: 0049 (0)351 21 70 07 - 21
E-Mail: kontakt@gbs-elektronik.de
Website: www.gbs-elektronik.de

Pulse rise and fall:
To limit switching losses and overshoot, switching is done in two steps.
At first, about 60% of the modules are switched. Due to the output inductor, the signal will have an overshoot close to the maximum value. Exactly at the peak of overshoot voltage the remaining modules are switched. Typically, the delay can be adjusted in the range 0...1.5µs internally, to minimize overshoot.
Typical rise times realized are in the order of 200 ns (RUP6-10) to 450 ns (RUP6-35); with higher maximum voltage and therefore bigger output inductor the rise will become slower.
Fall time with the standard modules is significantly slower (1-3µs, depending on voltage and load), as the switch off current with these is significantly limited.

ramp operation:
Alternatively, it is possible to set the module control to ramp operation, that is all pulse modules are switched sequentially with an adjustable ramp time. This will result in somewhat higher switching losses and therefore lower maximum frequency, but so the rise time is really free adjustable. This is especially interesting with capacitive loads and when the application need variable rise time. The high current modules are especially qualified for such operation, as they have the same switching power for switching on and off, and therefore with capacitive loads rise and fall times may be equal. Optionally the ramp time may be adjusted in a wide range from 0 to 50µs and may be adjusted at the front plate.



Output signal of a RUP6-12CL with capacitive load and ramp operation. Blue: output voltage 1:1200, red: output current, yellow: internal voltage at the last pulse module 500V7div.

Mechanical, included items

- 19" rack on wheels, 800mm deep * 553 mm wide. Height depends on the RUP6 version.

Height HE	height mm	Versions
16	837	RUP6-6, RUP6-10, RUP6-12
20	1115	RUP6-10CL, RUP6-12CL
25	1237	(RUP6-15)
34	1637	RUP6-25, RUP6-20, RUP6-22
38	1815	RUP6-17CL/12
43	2037	RUP6-35

- Grid supply depends on power of internal supply.

Max. average power	grid supply
2.5 kW	230V~, 16A
6 kW	3*400V~, 16 A
12 kW	3*400V~, 32 A

- Monitor outputs for voltage and current. The voltage monitor is typically calibrated such, that 10V corresponds to full output voltage (e.g. RUP6-25: 1:2500). The current monitor is calibrated to 100mV/A or 50 mV/A for versions with the high current modules.
- Display for voltage (0-1000V) and current of the internal power supply.
- LEDs for modules OK, overcurrent, RMS-current exceeded.
- High voltage output including 3m high voltage cable.
- Interlock connection.

Safety

- external Interlock.
- A fast short circuit detection protects the module from arcs and short circuits within the load. Further, any problem within the pulse modules (overcurrent, overtemperature, insufficient logic supply voltage) is detected and interupts pulse generation.
- The pulse generator is compatible to regulations about electromagnetic compatibility (EMC).

Naming conventions

The naming of a RUP6 follows the scheme
RUP6-xxaL/yy

xx is here the maximum voltage (kV) repectively the number of pulse modules.

a represents the implemented pulse module. „C“ stands for the high current module, omitted in case of the standard module.

L represents the adjustable rise time / switching delay time in combination with an output inductor, which is now standard for all newer devices.

/yy represents the average output power. /06 or /12 stand for 6kW resp. 12 kW, in case of the standard output power of 2.5 kW this is omitted.

Further possible options

- Analog remote control interface
- Internal controller, adressable by RS232
- Digital displays
- Further displays, e.g. for frequency, peak-peak voltage, RMS current ...
- High voltage relais in the output which grounds the output in case of high voltage switched off (additional safety) (zusätzliche Sicherheit).
- Additional DC bias in series to the pulse voltage.
- Further high voltage outputs using only a fraction of the internal pulse modules.
- Current feedback input / current feedback module for inductive loads.
- Adjustment of active pulse modules within operation.
- Operation hour counter
- external status lamps
- Documentation / labels in english.

Positive or bipolar output voltages are principally possible, but this is a different topology (RUP6 bipolar).
For faster rise times and smaller power the RUP3 series is more recommended.