



Typical Technical Data Short Pulse High Voltage Power Modulators

Typical Technical Data Short Pulse Modulator	
High voltage	up to over 500 kV
Overall efficiency	78 – 90 %
Repetition rate	up to several hundred Hz, depends on application
Mains power factor	0.98
Rise/fall time TR, TF	<1 μ s depends on output power and maximum specified pulse length
Pulse to pulse accuracy	<20 ppm
Pulse flatness	droop <1 % (optional bouncer system can be added to enhance this value if required)
Short circuit switch off time	<1 μ sec
Jitter between pulse	<5 ns

Key Features

- >200 Hz pulse repetition rate, depending on the application
- 1 μ s up to 8 μ s adjustable pulse length
- Programmable voltage ramp up for conditioning the load
- Short circuit energy at the load (<25 J)
- System efficiency (>75 %); trimmed to minimum rise and fall times
- Active pre-magnetization of the pulse transformer
- Multi current probe measurement
- Adjustable voltage accuracy (0.1 %)
- Wide pulse repetition capability
- Standard external control interface available
- EPICS, TINE, Tango, OPC, etc. interfaces available
- Full system integration and turnkey capability
- High pulse to pulse stability

Past Performance

Short Pulse High Voltage Power Modulators | List of References

Customer	Country	Application	Units	Rating	Contract Date
PSI Villigen	Switzerland	C-Band Modulator for FEL	12	130 MW, 6 μ s, 100 Hz	2016
CNISM	Italy	Pulsed High Power Microwave Station	1	140 MW, 6 μ s, 1 – 100 Hz	2014
PSI Villigen	Switzerland	C-Band Modulator for FEL	1	130 MW, 6 μ s, 100 Hz	2013
Radboud University	Netherlands	LINAC (Synchrotron Light Source)	1	70 MW, 18 μ s, 10 Hz	2011
NSRRC	Taiwan	LINAC (Synchrotron Light Source)	3	80 MW, 6 μ s, 10 Hz	2010
Physikalisch Technische Bundesanstalt	Germany	LINAC (Synchrotron Light Source)	1	80 MW, 6 μ s, 100 Hz	2007
Australian Synchrotron	Australia	LINAC (Synchrotron Light Source)	2	80 MW, 6 μ s, 10 Hz	2006
Diamond, DLS Ltd.	U.K.	LINAC (Synchrotron Light Source)	2	80 MW, 6 μ s, 10 Hz	2005
PSI Villigen	Switzerland	LINAC (Synchrotron Light Source)	2	80 MW, 6 μ s, 10 Hz	2000

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The Heartbeat of High Power



Short Pulse High Voltage Power Modulators

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Short Pulse High Voltage Power Modulators

Ampegon designs and delivers stand-alone, versatile and compact short pulse modulators for a wide range of applications

Ampegon has long experience with RF amplifier systems, high voltage as well as high current power supplies and modulators for world-class medical, industrial and research facilities. Our customers include particle accelerator and fusion research institutes, fundamental and applied physics, materials and life sciences engineering, notable providers of accelerator-based cancer treatment solutions, as well as innovative partners enhancing industrial processes. Offering its innovative and pioneering spirit with expertise of a century, Ampegon products stand for premium quality, reliability and best performance.

Unique Expertise and Innovation

Our expertise includes stand-alone high voltage power supply (HVPS) systems with voltages up to 200 kV and currents up to 2000 A, RF amplifier systems up to 55 MW power at frequencies up to s-band, short and long pulse modulators with voltages over 500 kV and currents up to 400 A, and stand-alone multi-channel digital low level RF control systems. Our technology base extends across the entire field of RF transmission.

In this wide application field, the short pulse modulator, based on solid state technology or pulse forming network (PFN) topology, complements Ampegon's product range for pulsed high voltage modulator applications, as well as RF amplifier systems. The solid state modulator design for broadcast application

began in the 1980's as a solid state replacement for tube based systems. Based on this experience and increased knowledge in high power solid state modulator technology, further topologies for long and short pulse applications have been successfully developed in the past 30 years. The modulator technology has been continuously enhanced, improved, integrated into various systems, and adapted for customer specific solutions. In the field of short pulse modulators, we have designed and taken short pulse modulators into operation, using continuously adjustable pulse durations with a flap top between 1 μ s and 8 μ s, in the power range of several tenths up to over 100 MW peak power.

Unlimited Flexibility

Ampegon short pulse modulators are valued for their high flexibility. Thanks to the modular design of the implemented technology, these systems are adaptable to meet practically any customer specification. The design is optimized for best performance, an ideal footprint, long term reliable operation by implementing the latest semiconductor technology.

The core component is a semiconductor power switch based on press pack technology. This solution can also be found in high voltage DC transmission line systems or wind power converters. We adapt the technology and synchronise the design for the best system integration.



The modulator consists of the following mechanical units

- 1 modulator tank, housing the oil immersed pulse transformer, HV divider and current measurement
- 2 12 pulse power modules (IGBT modules), including pre-magnetisation circuits
- 3 modulator control, HV earthing, cap bank discharge, oil supervision and water manifold
- 4 19" rack housing the active PFC power supplies and focus power supplies
- 5 19" rack housing the precision boost converter, control system, klystron auxiliary power supplies
- 6 400 VAC / 50 Hz mains input and distribution cabinet



The integrated fast protection shut down circuit protects the sensitive load and guarantees a safe daily operation. The technical design advantages increase the equipment's lifetime and enables the users to save energy costs while having best output signal performance for their application.

Environmental Compatibility

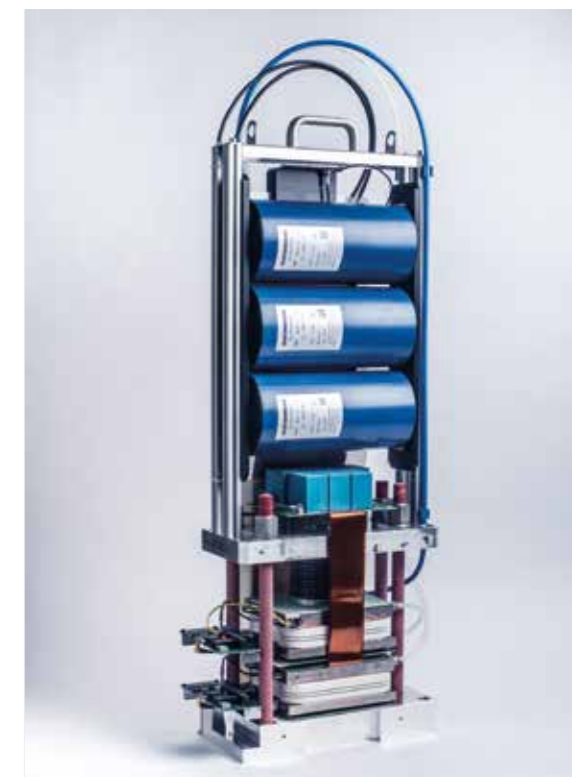
With very high peak energy levels, accelerator facilities are dependent on a highly stable mains power supply and very low Electromagnetic Interference (EMI) figures. The specified mains input current is regulated to keep the consumption during pulsed operation at a constant level. The excellent harmonic distortion characteristic of the integrated active Power Factor Compensation (PFC) ensures that loading of the mains supply with harmonics is kept to an absolute minimum. Ampegon's long pulse technology provides a high efficiency rate of better than 78 % and optimized pulse rise and fall time resulting in a considerable reduction of energy consumption and operating costs.

System Features

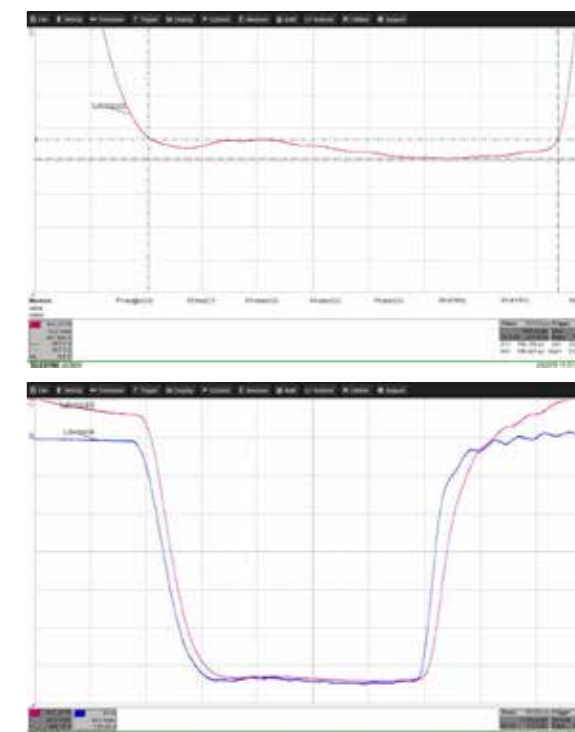
Unique features of the short pulse modulator include crowbar less operation for sensitive loads as well as typical short circuit energy of less than a few joules, stored in the system and output network. The fast protection device ensures a minimum short circuit switching off time after detection of a short circuit during pulsing.

Thanks to the modular design, the modulator system can be scaled to meet practically any specification. The basic concept is the addition of 2xN pulse power switch-modules via a N-cells matrix transformer. The achievable output power is adapted with the number of pulse power modules. Such systems can be designed from several MW pulse power up to hundreds of MW. The typical pulse length for the short pulse applications described above is between 1 μ s and 8 μ s.

An optional bouncer circuit can be used for pulse lengths higher than 10 μ s. The pulse length and repetition rate is continuously adjustable on the local control system or via an external interface. The ramping up and down time remains stable even when pulse width and repetition rate are changed. The regulated DC power supply on the input stage provides major advantages. It secures a low mains fluctuation even for applications with high pulse peak energies. The low output voltage ripple and pulse to pulse accuracy of less than <20 ppm (rms) is outstanding. These power supplies and control system are built into standard 19 inch rack chassis and are highly modular. The mechanical layout can easily be customized and the size can be kept to an absolute minimum, depending on the required average system power.



Pulse Power Module with Press Pack IGBT's



Pulse Performance Measurement on Klystron