SAM TECH

SWITCHING ACCELERATOR AND MODULATOR TECHNOLOGY

PRODUCTS & SERVICES GUIDE

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Introduction

Samtech Ltd is a company that specialises in the development and production of pulsed power products and the provision of pulsed power services. The company was formed in 1999 and is closely linked with the Pulsed Power research group in the Institute of Energy and Environment at the University of Strathclyde in Glasgow. The company was established to develop the group's research into commercial markets, and also to allow the group to respond to the growing interest in its research activities from industry.

Samtech personnel possess many combined years of experience in pulsed power research and its related fields. The company directors, Scott J MacGregor and Owen Farish were co-founders of the Pulsed Power research group in 1986 and over the last fifteen years the group has steadily grown through both fundamental and applied research, and has attracted significant research funding from both government and industry. This established and successful research base provides Samtech with a wealth of experience, knowledge and capability from which it can support the company products and services.

This brochure contains details on the types of products and services offered by Samtech, as well as information about the resources at the company's disposal. A list of products and services is given below with more details provided in the subsequent pages.

Turn-key Pulse Delivery Systems
- Modular design
- Transmission line and capacitor based
- Wide ranging applications

Generators
- Equipment Test Impulse Generators
- Compact Marx Generators
- Transmission Line Generators (Blumlein, Self-matched, PFN Marx, Bi-phase)
- Trigger Generators
- Insulation Testers

Diagnostic Equipment
- Electric Field Probes
- Liquid Resistive Probes
- Current Probes

Switches
- Sealed Spark Gaps and Trigatrons
- Rotary Spark Gaps
- High Repetition Rate Spark Gaps

Miscellaneous Items
- Passive Crowbars
- Aqueous-Electrolyte Resistors
- Visible and Ultra-Violet Light Sources

Services
- Equipment and Component Testing
- Electrostatic & Electromagnetic Transients Modelling
- Dielectric Analysis
- Pulsed Power Education

Personnel

Prof Scott J MacGregor Director

Prof Owen Farish Director

Mrs Mary Bennett Administrator

Mr James Paul Engineer (Pulsed Power)

Dr Martin Judd Engineer (Electromagnetics)

Mr Brian Preston Engineer (Product Development)

Dr John A Harrower Engineer (Electronics)

Mr Joe McKechnie Engineer (Production)

Facilities & Resources

Through its origins within the University of Strathclyde, Samtech Ltd has access to an impressive array of resources and facilities.

In terms of pulsed power facilities for research and development, Samtech has full access to engineering laboratories that are equipped with the following :-

- a number of fully filtered screened testing and experimental enclosures.
- a wide range of primary power supplies including 2kJ/s, 4kJ/s and 8kJ/s capacitor charging units, and high voltage power supplies up to 100kVdc.
- a comprehensive range of diagnostic and recording equipment (voltage and current probes, electric field sensors, high bandwidth digitising oscilloscopes, spectrum analysers, network analysers and spectrometers).

Other laboratories that the company have access to include a **Dielectrics Laboratory** that is equipped with thermal and electrical ageing facilities with appropriate diagnostics, and the University's **High Voltage Testing Laboratory**.

In terms of product manufacture and prototype development, Samtech has full access to engineering workshops staffed by expert and highly experienced operators. The workshop facilities include the necessary machinery to fully support the company's activities.

Samtech reserves the right to change any of the specifications within this catalogue. Operating parameters and performance specifications are only indicative and may not be obtainable simultaneously.

Contact Information

Enquiries :-

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Website: ***www.samtech.co.uk***

Computerised machining area

Manual machining area

Member of the workshop team

Screened measurement room

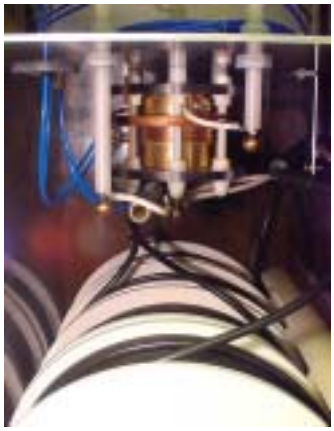
High voltage laboratory

Dielectrics laboratory

Turn-key Pulse Delivery Systems

Pulse Delivery System with straight forward front panel

Complete turnkey system, capacitive energy store at 50J per pulse, double exponential pulse profile of risetime 100ns and falltime 20μs.



Internal view of a pulse forming section, showing the network cables and high performance switch.

A wide range of flexible pulse delivery systems can be designed and constructed to suit specific customer requirements. Samtech have successfully delivered a number of these bespoke systems for a range of industrial and research based applications, including: -

- Anti-microbial control, Biocidal treatment and Pathogenic inactivation through systems that enable
  - *Pulsed Electric Field Treatment*
  - *Ozone Generation*
  - *Pulsed Ultra-Violet Light Sources*
  - *Cold Plasma Generation*
- High power ultrasound generation for acoustic source research
- Plasma and corona discharge generation
- Antennna Drivers

The Pulse Delivery Systems have a modular design, comprising: -

- Primary power supply (capacitor charging unit, 1kJ/s to 8kJ/s)
- Trigger generator (Samtech type TG-01)
- High performance switch (Samtech type CSS-01)
- Pulse forming section (or sections)

It is the **pulse forming section that is designed specifically for customer requirements**. This can take the form of a discrete capacitor store to provide a “double exponential” pulse shape, or can be based on co-axial transmission lines enabling different pulse profiles to be generated and electrically matched into a particular load. For example the load may be a Pulsed Electric Field (PEF) test cell that possesses an “electrical impedance”. In many cases the pulse forming section can be designed to exactly “match” this impedance, ensuring maximum power transfer to the test cell without any pulse reflection.

Most of the pulse delivery systems are housed within standard 19” rack units (600mm wide by 800mm deep), with the height depending upon the design, but usually in the range 1000mm to 2000mm. Optically de-coupled remote control options for the triggering system are also available.

Please contact Samtech engineers to discuss your particular application in more detail.

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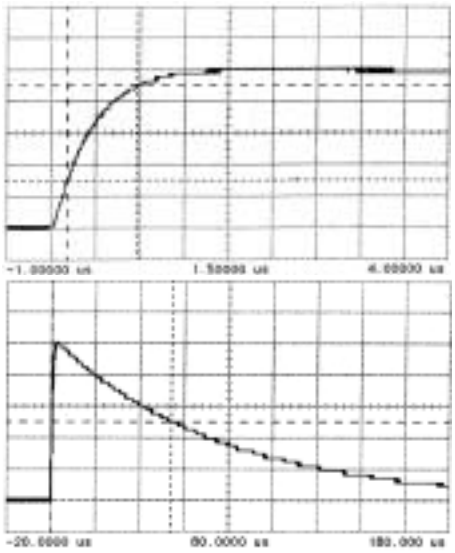
Impulse Generators for Equipment and Component Testing



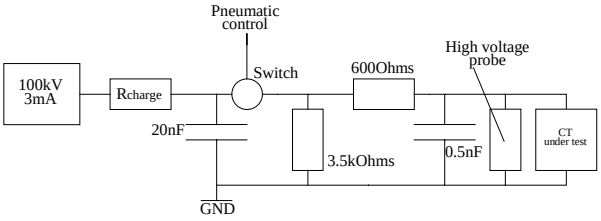
Example of a lightning impulse waveform.
Upper: Impulse front with risetime of 1.2μs (30%-90%*1.67)
Lower: Impulse tail with falltime of 54.4μs to 50% of peak value.

A range of impulse generators is available for impulse testing of a wide range of equipment and components, including :-

- Voltage and Current Transformers
- Cables
- Capacitors
- Ceramic insulating bushings
- Resistors
- Semiconductor components
- Telecomms equipment

The generators produce double exponential voltage waveforms as shown above, into a high impedance load. This particular waveform simulates a lightning impulse, as described in British Standard 923. The ristime (30%-90%*1.67) is 1.2μs and the falltime (to 50% of peak) is 54.4μs. Other typical waveforms would be switching impulse waveforms and waveforms for testing telecomms equipment, as described in CCITT recommendation K.20 - *Susceptibility of Telecommunications Switching Equipment to Overvoltages and Overcurrents*.

Rise and fall times of the voltage waveforms are flexible and can be altered over a limited range. Please contact Samtech to discuss your waveform and load requirements.



Schematic diagram of a typical set-up for lightning impulse testing of a current transformer

IG-01 Typical Specifications

Max operating voltage: 100kV
Voltage risetime: 1μs to 100μs
Voltage falltime: 50μs to 1ms

Physical dimensions(mm):
700x400x400

Comments: Pulse rise and fall times are quoted for open circuit loads.

IG-02 Typical Specifications

Max operating voltage: 75kV
Voltage risetime: 100ns to1μs
Voltage falltime: 10μs to 1ms

Physical dimensions (mm):
600x400x400

Comments: Pulse rise and fall times are quoted for open circuit loads.

IG-03 Typical Specifications

Max operating voltage: 50kV
Voltage risetime: 10ns to 100ns
Voltage falltime: 1μs to10μs

Physical dimensions (mm):
600x400x400

Comments: Pulse rise and fall times are quoted for open circuit loads.

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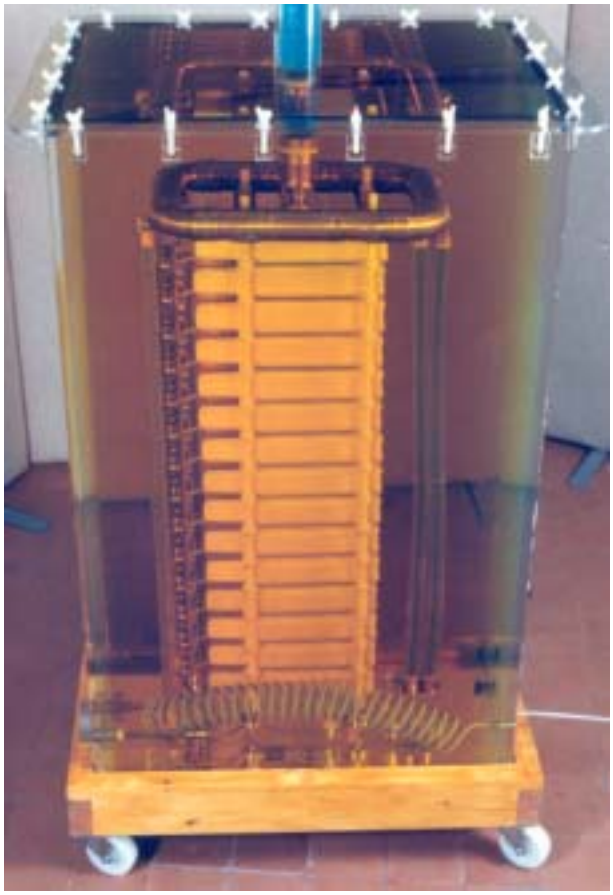
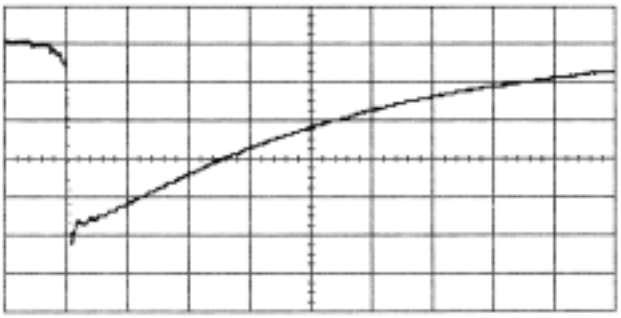
Compact Marx Generators



An oil-insulated 1.2MV Marx generator.

This range of compact Marx generators is built to be reliable, straightforward to use, portable and cost-effective to maintain. The basic design consists of a stack (4-15) of rapid discharge capacitors, which are commutated using a single spark gap column. The spark gap column consists of individual gaps for each stage, housed in a single pressurised vessel. The Marx can be operated simply by pneumatic control. In situations where timing is more critical, a triggered spark gap can be incorporated into the first stage. The typical specifications shown opposite represent generators that have been built to date. For each model type, there is some small degree of flexibility to enable adaptation of the specifications to suit customer requirements. The specifications are not necessarily obtainable simultaneously.



Marx generator output voltage waveform.
500ns/div
Pulse risetime: 30ns (10%-90%)
Pulse falltime: 1.5μs (to 50% of peak)

CMG-01 Specifications

Output voltage	1.2 MV	
Risetime/falltime		50ns / 5μs
Peak current		20 kA
Number of stages		15
Pulse repetition rate		1Hz
Approx. dimensions		$1m^3$
Comments:	Oil insulated	

CMG-02 Specifications

Output voltage	700 kV	
Risetime/falltime		30ns/5μs
Peak current		20 kA
Number of stages		10
Pulse repetition rate		1Hz
Approx. dimensions	$0.75m^3$	
Comments:	Air insulated	

CMG-03 Specifications

Output voltage	300 kV	
Risetime/falltime		20ns/5μs
Peak current		20 kA
Number of stages		6
Pulse repetition rate		1Hz
Approx. dimensions	$0.5m^3$	
Comments:	Air insulated	

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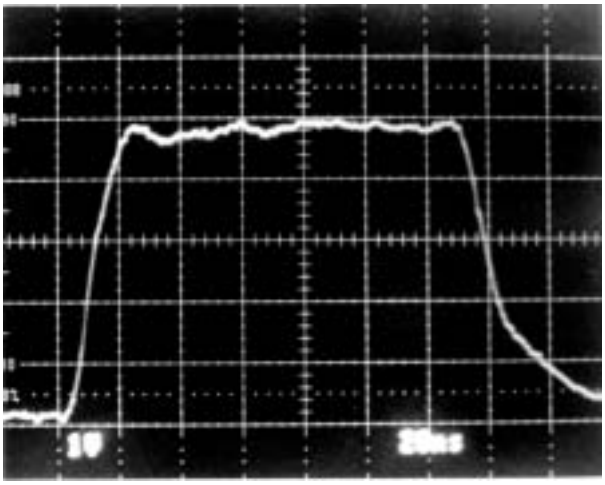
Transmission Line Generators
- Blumlein Generators



Typical output voltage pulse from a Blumlein generator. Matched load conditions.
Timebase: 20ns/div. Peak voltage: 125kV

Blumlein generators are flexible transmission line based devices that are suitable for low-power applications, such as high voltage testing of small-capacitive loads, trigger generators with low jitter and x-ray generator power supplies. They can be operated at pulse repetition frequencies up to 100s of Hz, and are compact and robust.

Blumlein generators produce a rectangular flat-top output voltage pulse with rise and fall times around 10-15ns. The output impedance is well defined and depends upon the transmission line configuration. These devices offer a degree of flexibility within their specifications, such as the pulse duration, input/output impedance and voltage gain. These can be altered to suit requirements. Variations of the Blumlein device include a double pulse system that can generate two successive pulses with down to 1μs separation, and a hybrid device that combines the high voltage pulse from the Blumlein with a following high current pulse from a capacitor bank.

TLG(B)-01 Specifications

Charging Voltage:	up to 30kV
Output Voltage	50kV (matched) 100kV (O/C)
Capacitance	5 nF
Pulse length	100 ns
Input/Output impedance	25Ω/200Ω
Physical dimensions	Dia: 300mm Length: 300mm

Comments: inverting and non-inverting configurations available.

TLG(B)-02 Specifications

Charging Voltage:	up to 70kV
Output Voltage	125kV (matched) 250kV (O/C)
Capacitance	5 nF
Pulse length	100 ns
Input/Output impedance	25Ω/200Ω
Physical dimensions	Dia: 600mm Length: 600mm

Comments: inverting and non-inverting configurations available.

TLG(B)-03 Specifications

Charging Voltage:	up to 70kV
Output Voltage	250kV (matched) 500kV (O/C)
Capacitance	10 nF
Pulse length	100 ns
Input/Output impedance	12.5Ω/400Ω
Physical dimensions	Dia: 600mm Length: 1200mm

Comments: inverting and non-inverting configurations available

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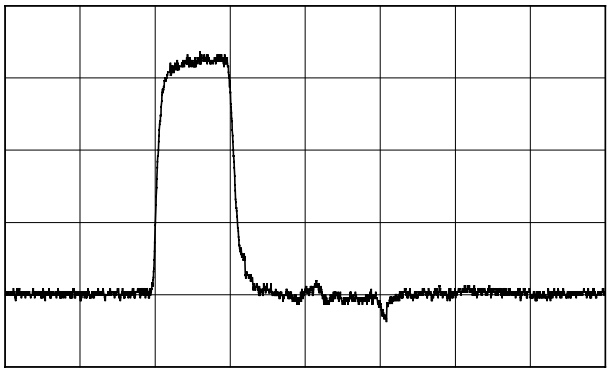
Transmission Line Generators
- Self-Matched Generators

A self-matched pulse generator in use driving a flash lamp load for electronic pasteurisation experiments.



10kV/div,250ns/div

Typical output voltage pulse from a self-matched pulse generator. Peak current: 8kA

These self-matched transmission line generators are designed to produce a single, high voltage pulse across a load with no reflection, even when the impedance of the load does not match the output impedance of the generator. This is particularly important in applications where the load has a time-varying impedance, for example in laser cavity pumping, flash-radiography and high speed photography.

These devices offer great flexibility and can be manufactured to meet the demands of specific applications, which may require alternative output pulse width, output impedance or higher output voltage.

The device in the above photograph has TLG(S)-01 specifications, and is commutated using a Samtech designed trigatron.

TLG(S)-01 Specifications

Max output voltage:		35 kV (O/C load)
Output impedance:		5Ω to 50Ω
Pulse width:		250 ns-500ns
Pulse risetime:	15 ns	
Max output current:		8 kA
Max. energy/pulse:		15J
Pulse repetition frequency:	5Hz	

TLG(S)-02 Specifications

Max output voltage:		70kV (O/C load)
Output impedance:		5Ω to 50Ω
Pulse width:		250 ns-500ns
Pulse risetime:	25 ns	
Max output current:		8 kA
Max. energy/pulse:		60J
Pulse repetition frequency:	1Hz	

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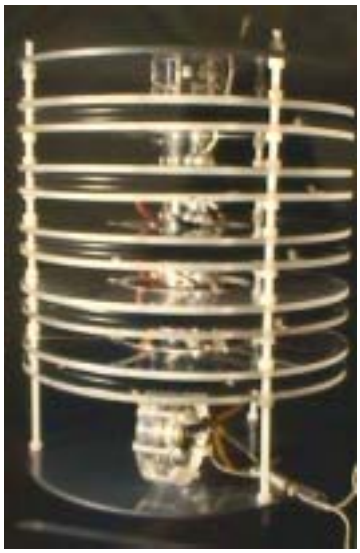
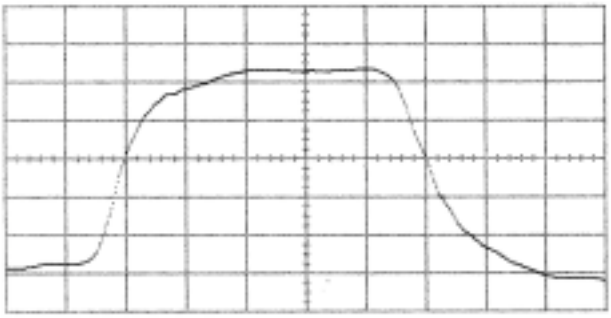
Transmission Line Generators
- PFN Marx Generators



A five stage PFN Marx generator.

PFN Marx generators are suitable for moderate to low energy applications (10-100J), including high speed triggering and drivers for x-ray or microwave generators.
PFN Marx generators produce a rectangular output pulse as shown in the waveform above. They possess a well-defined output impedance, which depends upon the number of stages, and a pulse duration dependent upon the length of transmission line comprising each stage. These devices can be operated at pulse repetition frequencies of a few tens of Hz.
A spark gap column is used as the switching element. This means that the generator can be operated simply by pneumatic control. In situations where timing is more critical, the first stage of the spark gap column can be substituted for a trigatron switch.
As with other transmission line based devices, there is significant flexibility available in terms of pulse duration, output impedance and voltage gain.



A typical output pulse from a Marx generator into a matched load. The peak voltage is 70kV and the pulse duration is 125ns.

TLG(P)-01 Specifications

Max output voltage	70 kV (matched) 140kV (O/C)
Pulse width	125 ns
Risetime	25 ns
Output impedance	125 Ω
Number of stages	5
Max PRF	100 Hz

TLG(P)-02 Specifications

Max output voltage	70kV (matched) 140kV (O/C)
Pulse width	250ns
Risetime	30 ns
Output impedance	125 Ω
Number of stages	5
Max PRF	100 Hz

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Trigger Generators (1)

Photograph of a TG-01 configured to fit into a standard 19 inch rack housing. The vertical height is 45mm (3U). The main controls are
- Frequency Range and Control (single shot and continuously variable from 1Hz-1kHz).
- LCD display indicating the operating frequency.
- Battery charging and full charge indicators
- Optical signal input connection (for use with the optical controller.

The trigger generator TG-01 is suited to driving small capacitance loads, such as trigger pins in spark gaps. These generators are compact in design and incorporate a 5m fibre optic link between the small controller unit and the high voltage unit.
The trigger generators are fully controllable over a range of frequencies, typically 1Hz to 1kHz. They are also capable of operating at higher frequencies with a reduced output voltage, as is shown in the typical characteristic opposite.

Samtech have used this device to successfully operate both their corona stabilised switches (CSS) and their conventional plasma closing switches (PCS). Examples of operation include:

- Switched energy per pulse: 2J
  Pulse repetition frequency: 1kHz
  Operating voltage 25kV

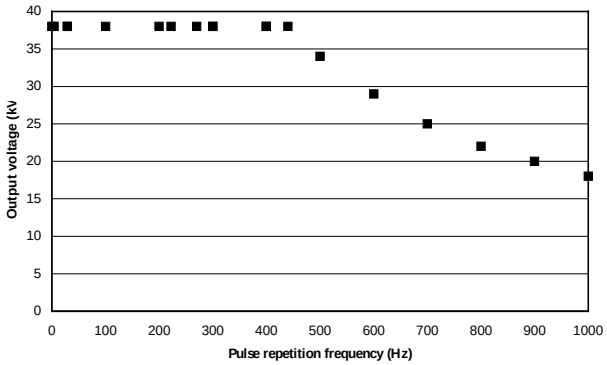
- Switched energy per pulse: 100J
  Pulse repetition frequency: 10Hz
  Operating voltage 35kV

TG-01(a) Generator Specifications

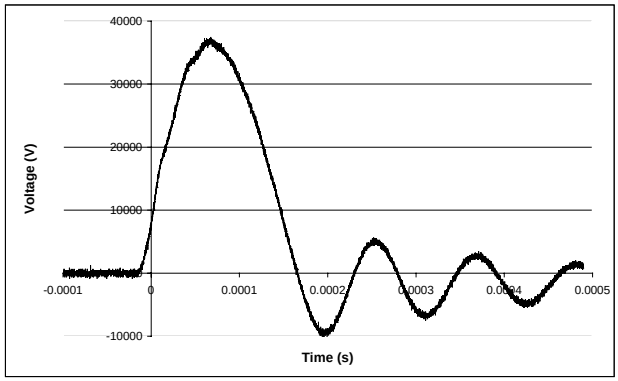
Output voltage: 37.5kV up to 400kHz (see characteristic below)
Pulse profile: Half sinewave
Risetime: 50μs
Polarity: Positive/negative/dual
Physical dimensions: 450mmx450mmx135mm
Power supply: Internal 12V rechargeable battery or external 12V power supply

TG-01(b) Remote Control Specifications

Optical fibre link to TG-01(a). Enables remote operation from single shot to 1kHz.



Variation in output voltage with frequency for the TG-01.



5kV/div, 50μs/div

Output from trigger generator into an open circuit at a PRF of 300Hz –positive pulse example.

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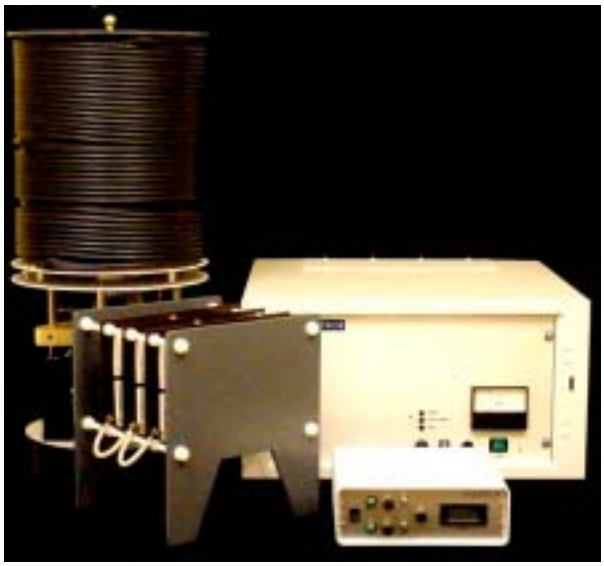
Trigger Generators (2)

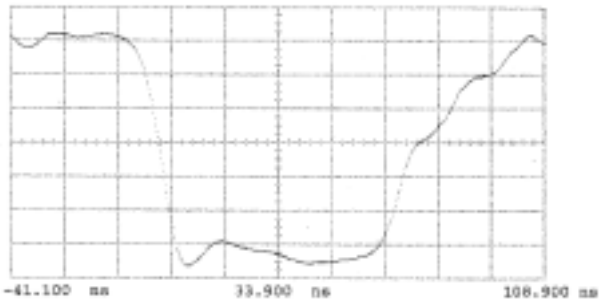


A photograph of the TG-02 system, showing the high voltage pulse generator, the primary power supply, an isolation resistor stack and the optically isolated remote control unit.

The TG-02 consists of three main components, a primary power supply (2kJ/s), an optically isolated remote control unit and a high voltage pulse generator unit. The high voltage pulse generating unit comprises of a Blumlein generator Samtech type TLG(B)-01, a sealed high rep-rate Corona Stabilised Switch (Samtech type CSS-01) and an OEM version of the battery powered trigger unit (Samtech type TG-01).
The trigger generator is controlled by a solid state remote unit via a 5m fibre-optic link, over the frequency range 1Hz-400Hz, and can be operated in burst mode up to 1kHz. The TG-02 can operate either in line or grounded.
The Blumlein output stage is a X4 configuration and generates a rectangular output voltage pulse up to 80kV into an open circuit for a charging voltage of 20kV. For matched conditions (200Ω), the output pulse is 40kV, and an example of the pulse profile for this type of load is shown opposite. Also shown is the high voltage unit charging waveform at a pulse repetition rate of 1kHz.

TG-02 Specifications

Output voltage:	up to 80kV
Pulse profile:	Rectangular 10ns rise, 70ns flat top (FWHM)
Pulse repetition rate:	typically 1000pps (burst)
Physical dimensions (mm):	Dia:230mm Length: 650mm Weight: 17kg
Power supply:	Internal 12V rechargeable battery or external 12V power supply
Charging voltage:	20kV
Switch fill gas:	SF_6 or air to a maximum pressure of 3bar.



Output voltage pulse from the TG-02 into a 200Ω matched load.
Timebase: 15ns/div
Volts: 5kV/div

Typical repetitive charging cycle of the trigger generator, at a pulse repetition rate of 1kHz.
Timebase: 5ms/div
Volts: 5kV/div

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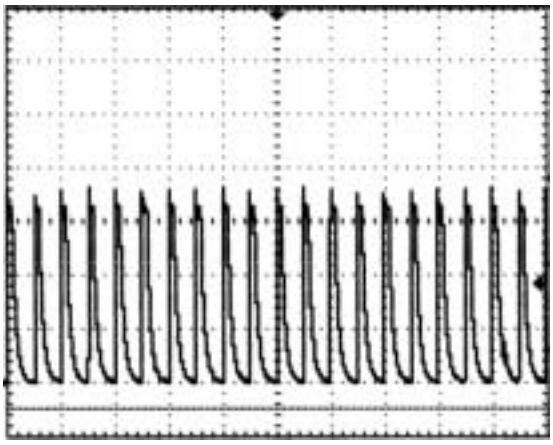
Insulation Testers

A three output, variable risetime insulation tester.



An oscillogram showing output pulses from the insulator tester into a 1nF load. The peak output voltage was set to 7kV and the PRF is 200 pps.

These insulation testers are suitable for lifetime testing of insulation materials, up to the point of failure. They are built to be reliable and straightforward to use. The PRF can be accurately controlled from 15pps to 200pps, with single shot capability also included. The maximum voltage available for testing is 10 kV. Multiple output generators are available, giving the user a choice of risetimes. The generator output is delivered to the load via a length of co-axial cable and the cable can be readily connected to the different outputs, using safe, high voltage BNC connectors.
Insulation testers are available with either negative or positive polarity outputs.

IT-01 Specifications

Max output voltage:	10 kV
Frequency range:	15pps to 200pps
Output capacitance:	20nF to 100 nF
Number of outputs:	1, 2 or 3
Output pulse risetime(s)	user specified
Physical dimensions(mm):	432x280x177
Input power:	240V mains

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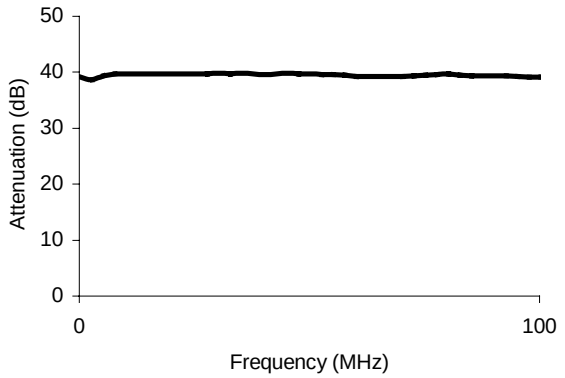
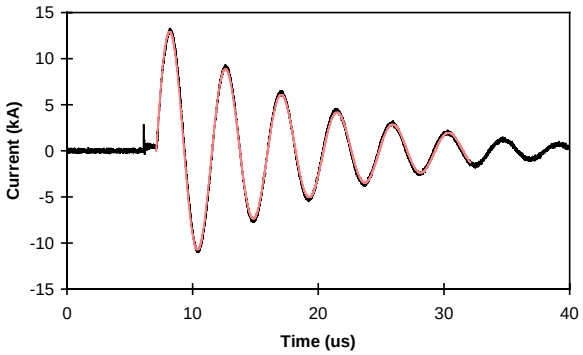
Diagnostic Equipment
- Current Probes



Frequency response characteristic of a 12kA co-axial current shunt with 5m of signal cable, measured using a network analyser.

The first of these current probes is of a standard co-axial design with an internal sensing element comprising of twenty parallel lengths of Cu/Ni resistive wire, which results in a total probe resistance of 30mΩ. The probe is generally for use under single shot applications, but can be used in low PRF or burst mode situations. It is supplied with a high power 20dB 50Ω attenuator to reduce the voltage to a level acceptable to most digitising oscilloscopes.
The second current probe has the same co-axial arrangement but the internal resistive sensing element consists of eight high power vitreous enamel resistors configured in parallel.
In both cases, the ouput signal cable is standard 50Ω co-axial cable.

Co-axial shunt current probe.



Oscillatory current waveform measured using the current probe. I_{peak}=12kA, 100% current reversal.

DE(CP)-01 Specifications

Sensing resistance:	30mΩ
Output voltage:	30V/kA
Peak current:	12kA (pulsed)
Risetime:	~20ns
Pulse repetition frequency:	single shot
Output connector:	50Ω

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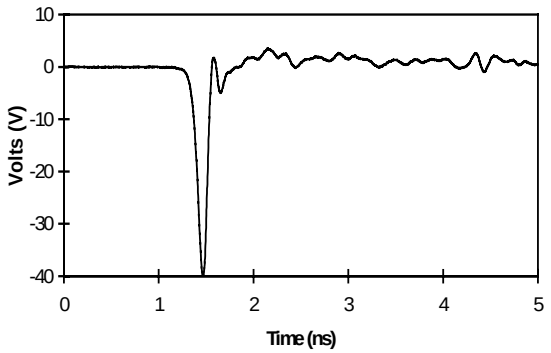
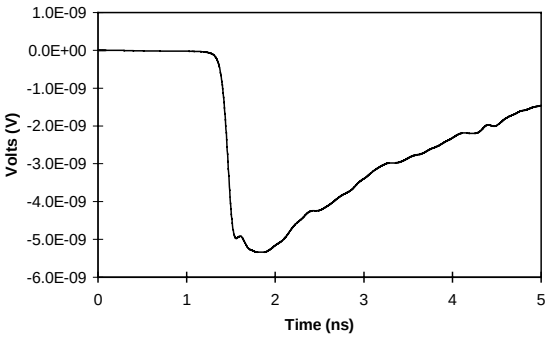
Diagnostic Equipment
- Electric Field (D-dot) probes



Flush plate D-dot probe output signal from a 120ps risetime, 6kV voltage pulse.



Integrated flush plate D-dot probe signal, which recaptures the 120ps risetime of the original pulse.

Electric field (or D-dot) probes are generally used for the measurement of transient broadband electromagnetic signals. This signal induces surface current on the probe sensing plate, resulting in a probe output signal that can be readily measured. The magnitude of the signal is dependent upon the equivalent area of the sensing plate.
The output signal is a derivative of the original signal and therefore has to be integrated. This can be done passively with R-C integrators or numerically as above, depending upon customer preferences and the frequency components of the signal. Both geometries can be incorporated into a range of equipment, including distribution gear, transformers and transmission lines. They operate successfully in gases, liquids and solids. A range of probe sizes is available and more information about these devices can be obtained by contacting the company (Product code DE(EF)-01) with your requirements. **Full calibration data** over the range **100MHz to 2.7GHz** is provided for each probe (see section on “Calibration of Electric Field Sensors”)

A conical D-dot probe complete with signal cable, and designed to match into standard 50Ω cable.

Example of a flush plate D-dot probe, mounted inside a spark gap switch to record ultra-fast (<500ps) switch closure times. The flush plate geometry is ideal in situations where minimal field perturbation is required.

Specifications

Area of sensing plate:	6mm^2
Frequency response:	>2.7GHz
Risetime:	typically 120ps
Output voltage	typically <1kV

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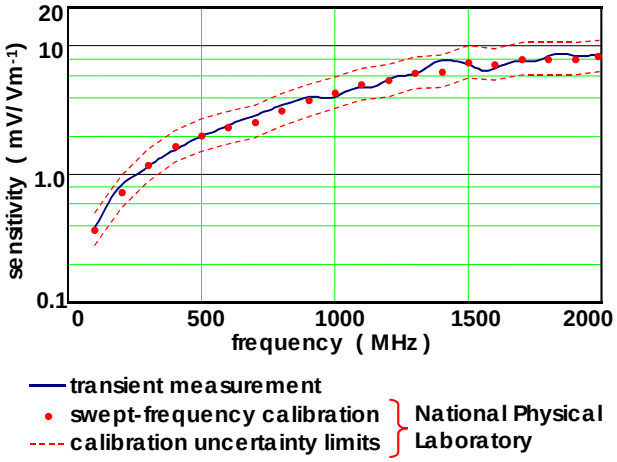
Calibration of Electric Field Sensors

Transient test cell and calibration system

A 45 ps step generator, transient digitiser and FFT signal processing are combined in this single-shot wideband measurement system.



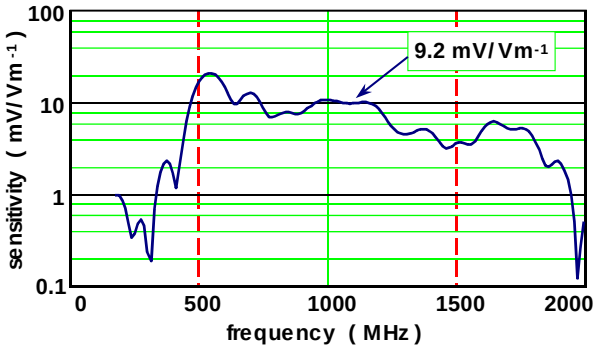
Measurements are referenced to a standard probe calibrated at the National Physical Laboratory using conventional methods.

Applications

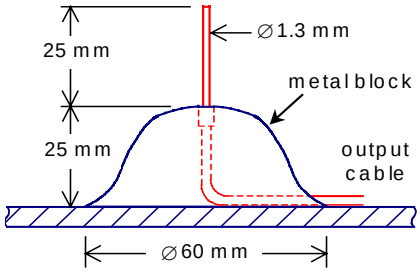
Electric field measurement including:

- Ultra-wide band
- RF
- VFT
- Partial discharge
- Pulsed power

Example: UHF coupler for PD detection
Operating band 500 – 1500 MHz
Average sensitivity (min.)6.0 mV / Vm^{-1}

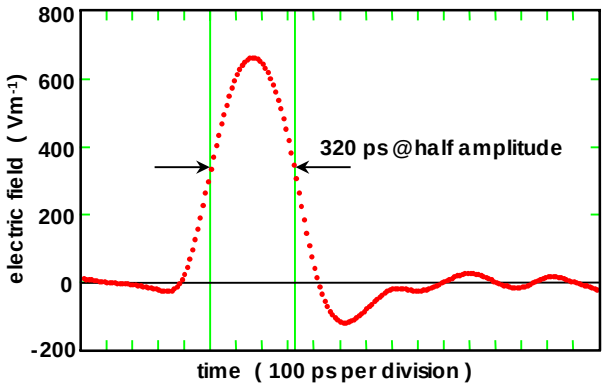


Reference probe for electric field measurement



Transient immunity testing

Using a contact discharge pulse source, the transient test cell can be used to subject items to sub-nanosecond electric field impulses.



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Diagnostic Equipment
- Liquid Resistive Probes

A 200kV liquid resistive probe DE(LRP)-01. The input impedance is 2kΩ, and the response time is down to 5ns.

A 500kV liquid resistive probe DE(LRP)-02. The input impedance is 10kΩ, and the response time is down to less than 25ns.

DE(LRP)-01 Specifications

Voltage rating	:	10 kV to 200 kV
Impedance:		1kΩ to 5 kΩ
Bandwidth:		up to 250MHz
Length of HV arm:		100mm – 400 mm
Output connection:		50Ω BNC
Risetime:		<10ns
Division ratio:		typically 200:1

DE(LRP)-02 Specifications

Voltage rating:		100 kV to 500 kV
Impedance:		5kΩ to 10kΩ
Bandwidth:		20MHz
Length	:	400mm – 1000mm
Output connection		50Ω BNC
Risetime:		25ns
Division ratio:		typically 200:1

These liquid resistive probes are designed specifically for measuring **impulse voltages** with total durations in the tens of μs timescale. They are low inductance probes that are cost effective and straightforward to use. The high voltage arm comprises of a flexible tube for ease of use with existing equipment, and which is filled with a resistive solution. The impedance of this arm is generally a few kΩ. The signal voltage is taken from a small "tap-off" plate within this solution that is situated near the ground plane of the probe. The output signal is transferred to the measuring device via a 50Ω signal cable.

Comments: The division ratio is determined by the length of the HV arm and the relative position of output voltage sensing plate. However, all of these devices are characterised by Samtech, who will supply the required attenuators to reduce the signal voltage down to an acceptable level.

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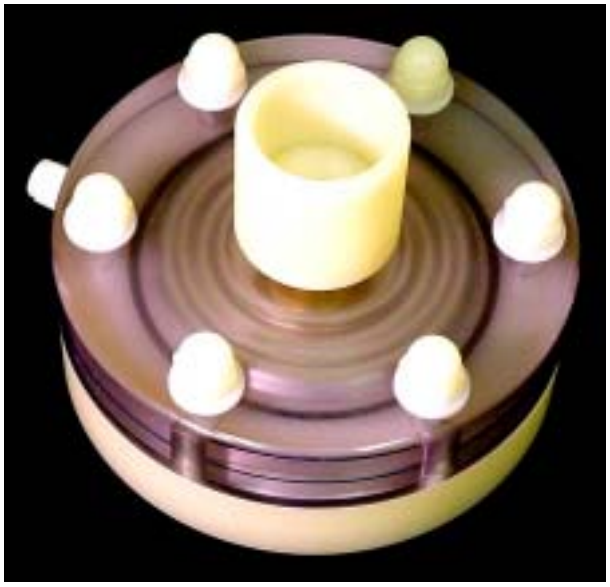
Plasma Closing Switches and Spark Gaps

- Conventional High Power Spark Gap Switches and Trigatrons



Photograph of a PCS(T)-01 gas filled spark gap switch.

PCS(S)-01 and PCS(T)-01 Specifications

Operating voltage:	15kV to 70 kV
Peak current:	10 kA
Insulating gas:	SF_6, Syn. Air, N_2
Gas pressure:	1atm to 3atm
Lifetime:	~10^6 shots
Charge transfer:	1000C
Dimensions (mm):	140 diameter 60-80mm deep

Self-closing spark gaps (PCS(S)-01)

These devices are 2-electrode, sealed spark gap switches that are suitable for a range of switching requirements and are capable of high rates of energy transfer with good lifetimes. They are designed to be inexpensive and simple to maintain. The operating voltage is adjustable over a wide range by simply varying the internal gas pressure.

Trigatron switches (PCS(T)-01)

These devices are 3-electrode, sealed spark gaps that possess an insulated trigger electrode, located centrally in the earth electrode. This is generally a narrow rod, but can be a ring or disc to extend the lifetime of the device.

The trigatron versions of the device generally require around 50% of the operating voltage applied to the trigger pin to operate with a low jitter. Samtech supply a range of trigger pulse generators for this purpose.

Plasma Closing Switches and Spark Gaps
- Rotary Spark Gap Switches

Rotary switch with cooling jacket.
(Type RCS-01)

RCS-01 Specifications (atmospheric)

Operating voltage:	Up to 35 kV
Max energy transfer	100J / pulse
PRF range:	0.5Hz to 50 Hz
Max current	12 kA
Lifetime	> 10^6 shots

These switches are robust, inexpensive, low to moderate PRF switches that are capable of high charge transfer at high average powers. They use a 12VDC motor to drive an internal electrode. The operating voltage is readily adjustable by altering the position of the electrodes.
These switches operate at atmospheric pressure with air as the switching medium.

Pressurised Rotary Closing Switch
(Type RCS-02)

RCS-02 Specifications (pressurised)

Operating voltage:	Up to 60kV
Max energy transfer:	30J/pulse
PRF ranges:	1Hz-33Hz
	2Hz-66Hz
	3Hz-130Hz
Maximum current:	5kA
Lifetime:	>10^6shots
Fill gas	SF_6, N_2, Air (up to 3bar)

These rotary switches have low to moderate PRF capabilities and are pressurised to enable operation at pressures in excess of 50kV. They use a variable speed DC motor and a number of inter-changeable rotating rod electrodes to achieve the different PRF ranges. The operating voltage range can be adjusted by altering the gas pressure or gas type.

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Plasma Closing Switches and Spark Gaps
- High Repetition Rate Switches

A high PRF switch with cooling jacket.

CSS-01 Specifications

Voltage range : 15kV – 50kV
Max. current: 500A to 12kA
Internal dielectric gas: SF_6
Frequency range : continuous operation to 1000 pulses per second.

Operating requirements:

- Sulphur Hexafluoride available at pressures between (0.5atm and 1.5atm)
- Water cooling at higher PRFs and energies
- Trigger pulse generator (ie Samtech TG-01)

These switches are particularly suited to applications that require low to moderate energies per pulse, high pulse repetition frequency (PRF) switching. They utilise the phenomenon of corona stabilisation to achieve excellent inter-pulse voltage recovery characteristics and can operate in a continuous mode at PRFs of up to 1 kHz. The switches are sealed systems **(no gas flow)**, but do require water-cooling.
The corona stabilised switch offers an inexpensive alternative to thyratrons and semiconductors and is particularly useful for research purposes. It requires modest auxiliary equipment, it is extremely robust (current reversal of 100%) and has relatively low maintenance costs.

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Aqueous-Electrolyte Resistors

An aqueous copper sulphate resistor. This particular device had an impedance of 200Ω, a diameter of 50mm and a length of 750mm. It was used to limit the current from a Marx generator, and is therefore capable of absorbing several kilojoules of energy and of operating at voltages above 500kV.

Aqueous-electrolyte resistors can be used to dissipate large amounts of electrical energy. They have a very low level of self-inductance and the resistance value can be readily changed by adjusting the electrolyte solution concentration.
This type of resistor is suitable for applications including energy dumps, charging resistors and dummy loads. Samtech aqueous-electrolyte resistors use copper sulphate as the electrolyte. PB electrodes and a PVC housing ensures the electrolyte solution remains contaminant-free.

A range of resistance values and power ratings are available. Water-cooled versions are available for higher PRF and average power applications.

Impedance range:	100Ω to 1MΩ
Voltage drop:	Up to 500kV
Energy absorption:	Up to 70J per cc of solution

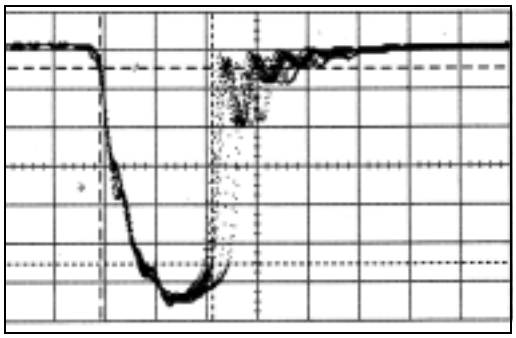
The overall flexibility of this type of resistor means that it is very
difficult to list typical device specifications. The customer is asked to contact Samtech to discuss particular requirements.

Passive Crowbars

Specifications

Operating voltage:	Up to 500 kV
Max energy:	1kJ/pulse
Delay time to crowbar operation:	200 – 400 ns
Max current:	10kA

Samtech self-activating, high energy crowbar switches are suitable for use with conventional Marx or Marx–like generators, where the H.V. stressing of a load beyond a particular time on a double exponential waveform is undesirable. Several versions are available, for different voltage and energy requirements. These crowbar switches are immune to external interference and the crowbar time is readily adjustable.



12 passively crowbarred output voltage pulses
Timebase: 100ns/div. Peak voltage measured at 450kV.
Average crowbar time was 222.5ns, with a jitter of 17ns.

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Pulsed UV and Visible Light Source

Specifications

Mains voltage:
110V/230Vac, 50/60Hz

Internal switched mode power supply voltage (user controllable):
400V-1000V (continuously)

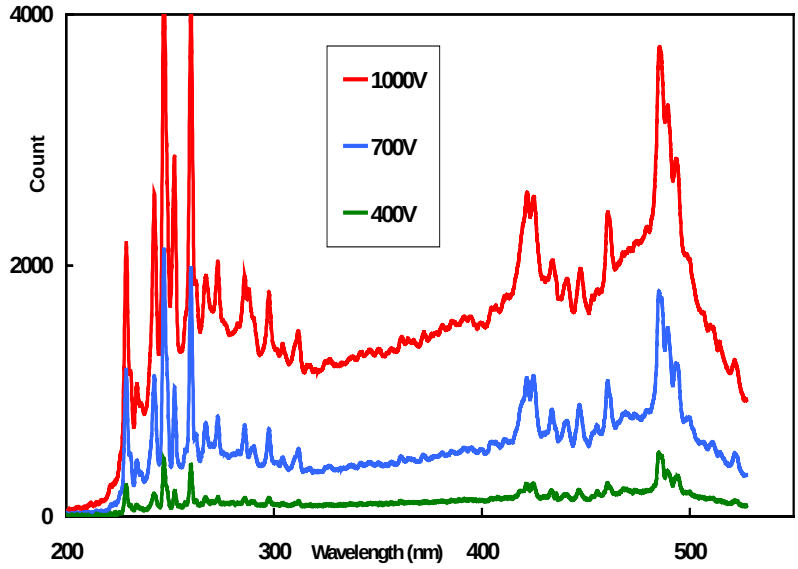
Electrical energy:
3.2J(400V) to 20J(1000V)

Pulse repetition rate:
10pps @ 400V to 600V
5pps @ 1000V

Dimensions:
405mm×360mm×150mm
(Pulsed power driver)
220mm×120mm×90mm
(Light source)

Weight:
approx. 15kg

This device provides a compact and portable source of intense pulsed light, with a **significant biocidal component in the UV**. The output intensity can be varied by changing the operating voltage. The pulse repetition rate is continuously variable between single shot and 5pps at 1000V. At lower voltages the pulse repetition rate can be increased up to a maximum of 10pps.



Spectral output from the light source at operating voltages of 400V, 700V and 1000V.

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Equipment and Component Testing

Samtech personnel have accumulated a great deal of expertise over the last fifteen years in testing a range of equipment and components. We are therefore able to offer this service to our customers. A broad range of test types are available and we would recommend that you contact us to discuss your particular requirements. In the past, we have undertaken a range of different test types including:-

- Lightning and switching impulse testing in accordance with British Standard 923
- High voltage AC (30kV) and DC (100kV) testing
- Telecommunications component testing in accordance with CCITT recommendations K.20

Some typical examples of components and equipment that have been tested include:-

- Voltage and current transformers
- Insulating cables
- Capacitors
- Ceramic bushings, insulators and feedthrough components
- Surge arrestors
- Current limiting devices
- Clamping circuits
- Discrete components – including transistors, resistors and Integrated Circuits

Electrostatic Field and Circuit Modelling and Analysis

3-D Model of the high voltage electrode in a corona stabilised switch, created to evaluate the field of the critical volume region.

Samtech offers an electrostatic modelling service that supports high voltage component and system design. Full 2-D and 3-D software packages enable accurate rendering of even complex component geometries and assemblies.
This level of detail allows accurate prediction of potential problem areas before final designs are submitted.
Potential problems that can be addressed via this type of modelling include:

- Effects of voids and cavities in insulation
- Prediction of corona discharge sites
- Component interaction within assemblies
- Capacitance assessment

As well as electrostatic field modelling, Samtech have the capability to provide comprehensive circuit modelling.

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Dielectric Analysis

Through its links with the University, Samtech has access to a well-equipped dielectrics laboratory. This enables us to offer a range of dielectric analysis techniques. Considerable expertise has been accumulated over the last 15 – 20 years on insulation ageing phenomena and the types of services we offer include :-

- Electrical ageing – high voltage DC and AC, the latter at accelerated frequencies.
- Repetitive impulse voltage ageing and testing.
- Thermal ageing, both static and cyclic.
- Synergistic application of ageing parameters allowing multifactor testing and parameter evaluation.
- Impulse and ramp breakdown testing to determine residual breakdown strengths.
- Measurement of loss tangent and DC conductivity parameters as a non-destructive means of evaluation of sample behaviour.

Taught Courses

Samtech offers a flexible Pulsed Power Technology lecture course. It is designed to cover the main aspects of Pulsed Power, and if requested, can also include a practical work component. The course can be held at Samtech within the University of Strathclyde in Glasgow, or at the customer's location.

The set of modules currently available is listed below. Each module typically lasts for three hours.

- Pulsed Power Generation Techniques
- Pulsed Power Components
- High Speed Gas Switching and Repetitive Switching
- Diagnostic Techniques
- High Power Switching
- Dielectric Materials, Radiation and Electrical Degradation
- Energy Storage and Media
- Safety
- High Voltage Generation Techniques
- Electromagnetic Modelling
- Experimental Considerations

Please contact Samtech regarding any particular areas of interest not covered in the above list.

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3D Electromagnetic Transient Modelling

Finite-Difference Time-Domain Code

The FDTD simulation space consists of a mesh of small cubic cells. Each of these can be designated as a conductor, a dielectric or free space in order to define the structure to be simulated.

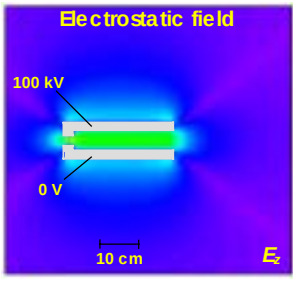
FDTD simulations can be used for:

- Design feasibility studies
- Antenna optimisation
- Determining frequency response
- Improving PD detection
- Modelling energy transfer

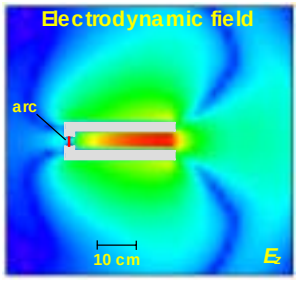
Example

Modelling transient radiation from a gas-switched HV pulse transmitter:

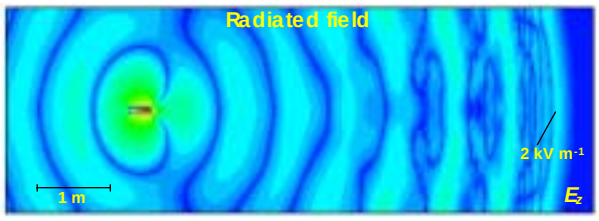
Simulation volume	2.4 × 2.4 × 8.0 m
Mesh spacing	20 mm
Time step	38 ps



t = 0 ns



t = 5 ns

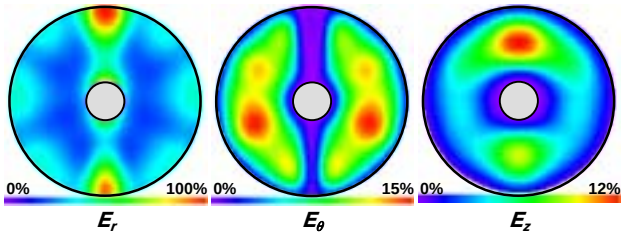


t = 20 ns

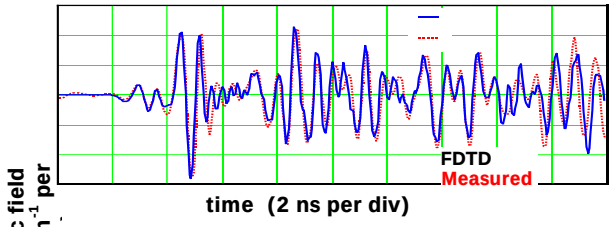
The transient wavefront is dominated by the temporal characteristics of the gas discharge, while subsequent oscillations are governed by the electrode geometry.

Cylindrical co-ordinates

The software can also operate in a cylindrical co-ordinate system. In this form, it has been used to study discharges in the gaseous insulation between coaxial conductors.



These plots show the integrated energy density of the radiated electric field components over the coaxial cross-section of a 400 kV gas insulated busbar. The signal source is a partial discharge located at the outer conductor, 1.2 m from this plane.



The time-domain comparison above illustrates the level of agreement that can be achieved between simulation and measurement.

Capabilities

Data output can take many forms, including:

- 2D snapshots of electric / magnetic fields
- Time-domain sampling of fields at any number of points within the structure
- Currents and surface charges

The simulation volume is truncated using absorbing boundaries. Spatial resolution is limited only by the available memory and processing power of the computer workstation. The number of cells is typically in the range 10^6 – 10^7 and simulation times can vary from fifteen minutes to several hours.

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