Kentech Instruments Ltd.

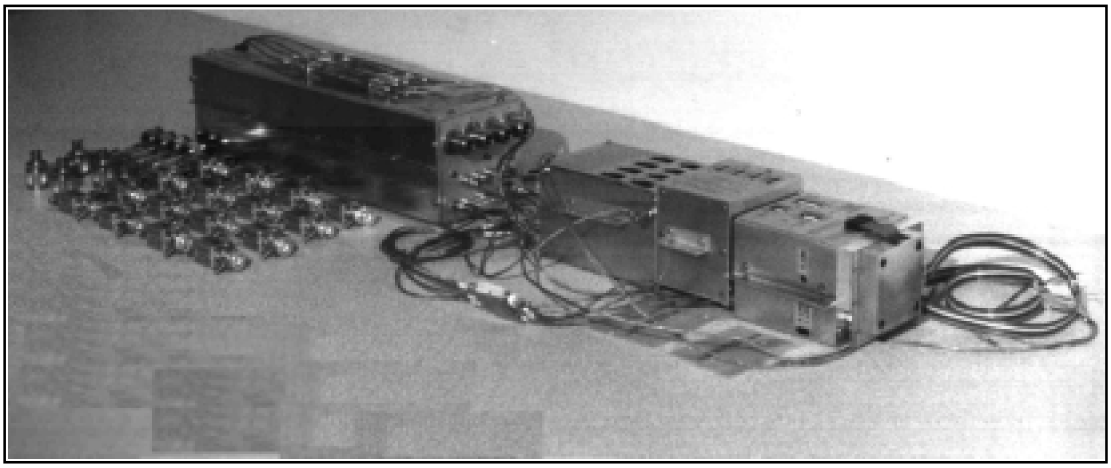
Instruction Manual
for
SIMCART pulse generator system

Serial Numbers SNJ9607291

28th. January 1997

PLEASE READ THIS MANUAL CAREFULLY

BEFORE USING THE PULSE GENERATOR



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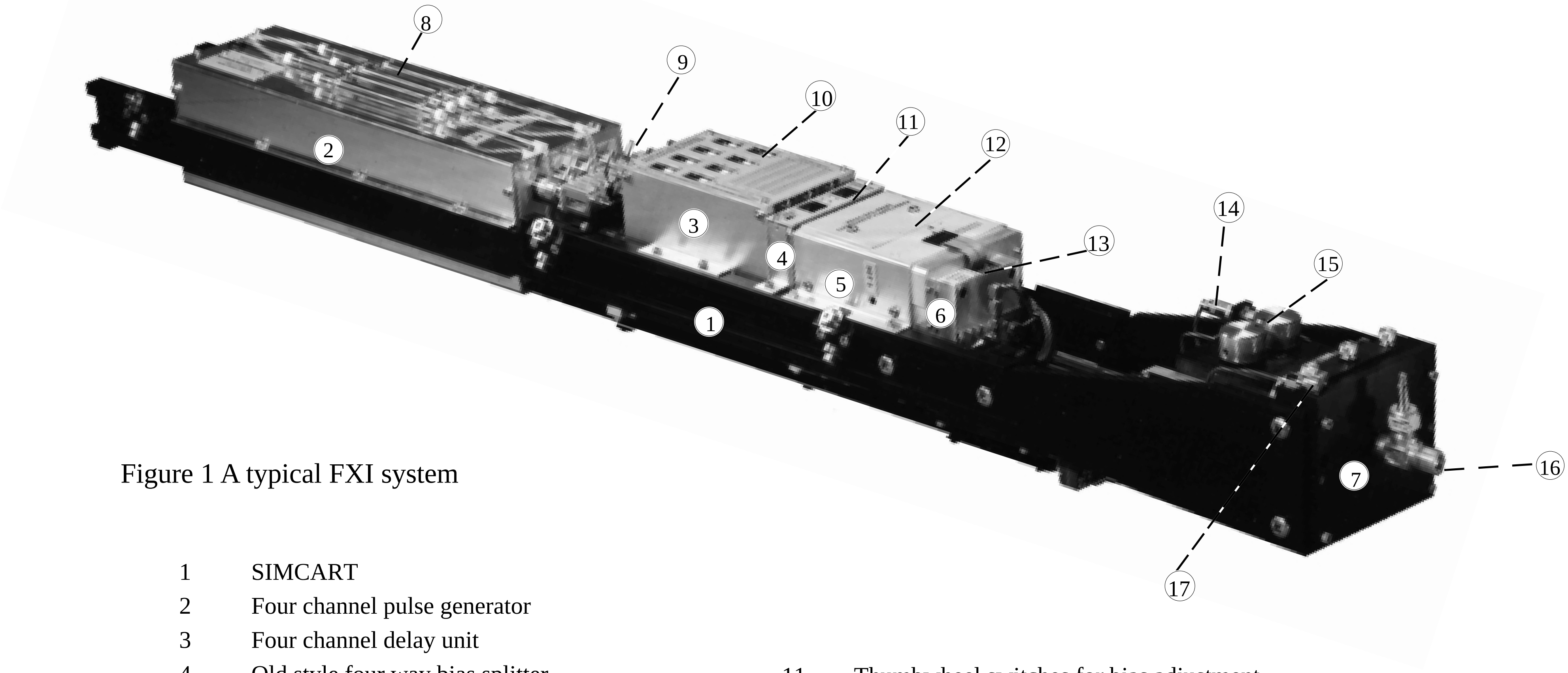


Figure 1 A typical FXI system

1	SIMCART
2	Four channel pulse generator
3	Four channel delay unit
4	Old style four way bias splitter
5	Six rail power supply
6	Remote control unit
7	Camera head with protective cover plate fitted
8	Sliding trigger lines for timing set up
9	Pulse forming modules
10	Thumbwheel switches for delay setting
11	Thumbwheel switches for bias adjustment
12	Power supply controls are under this protective cover
13	On / Off control of the power rails for local mode
14	HT connection to phosphor
15	Film wind on knobs
16	Evacuation point for transit
17	Diamond photoconductive sensor

Contents

1 INTRODUCTION

The FXI is a fast x-ray Imager for use in SIMTUBES used in a variey of laser target estabishments. It consists of a gated microchannel plate x-ray detector, phosphor with film readout and an electronics package to drive and monitor it.

This manual describes a complete system although Kentech Instruments is only supplying the electronics package. Some descriptions may not be relevant to other parts of the system, depending upon how it is assembled.

The whole package fits on a cart that will go through a six inch tube as used on laser target experiments. The system is designed to work under vacuum and the design has allowed as much as feasible for the cooling of electronics by thermally coupling them to the structure and also trying to avoid trapped volumes. However, the nature of electronics means that the surface area will be large and pump down times will be significant.

1.1 LAYOUT AND PRINCIPLES OF OPERATION

The system comprises a detection head with film back, and an electronics package to drive it. The electronics contains DC power supplies, gating and delaying electronics and monitoring circuitry.

The detection head consists of a specially coated MCP with fast connections, a phosphor screen and a film pack. The electronics is connected to this. On the electrical input side there is the pulse forming circuits and bias injection. On the output side the pulse monitoring circuitry including the signal from the photoconductive detector (PCD) which is added in to the pulse monitors to give the relative timing of when the source signal reaches the detector.

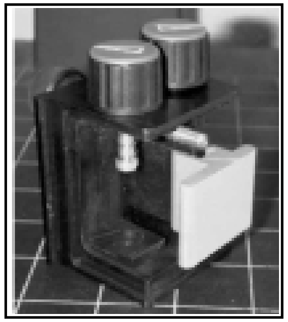
<u>Specification</u>

typical gate lengths	100ps to 2ns
Electrical specification	see section on power supply.
Detector	ø40mm, 4 x 12Ω strips on Galileo MCP. L/D = 40
PCD	Diamond 1 x 1 x 1 mm^3
Delays	Any channel 0 to 12.7ns in 100ps steps*
Gate pulses	The gate pulses from the pulser are 3 to 4kV depending upon gate length, see pulse shapes at the rear of the manual.
Monitor	Pulses are resistively combined with successive 2 ns relative delay along with the PCD monitor signal and fed to the simcart output coaxial connector.
Phosphor P11 on fibre optic window with no conductive coating.	
Film	35mm reverse wound into cassette
Image magnification	3X or 10X
Pin Hole spacing	10μm on center holes and 25μm on the two outer rows.

1.2 FAST GATING METHOD

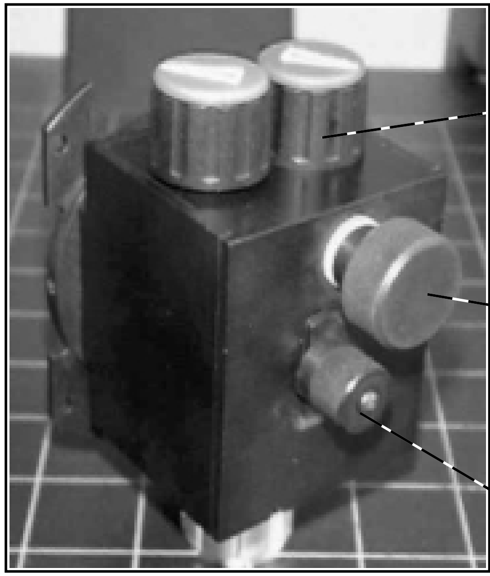
The X–rays which are incident on the MCP produce photoelectrons. With a voltage across the MCP some of these will be accelerated into the MCP and generally hit the sides of the holes in the

* Step size is nominally 100ps, the channel to channel differences are small.



View of inside
of 35mm film
cassette showing
pressure plate

View of 35mm film
cassette showing
mounting flange
pressure plate



View of 35mm film cassette showing controls

View of 35mm film cassette showing film. Note that emulsion is outwards. The cassette must be loaded with film in the reverse to normal manner.

Figure 2 35mm Film Cassette Holder

1.2 FAST GATING METHOD

The X–rays which are incident on the MCP produce photoelectrons. With a voltage across the MCP some of these will be accelerated into the MCP and generally hit the sides of the holes in the plate where they will multiply as they cascade down through the MCP. At the output they are then accelerated onto the phosphor screen producing light which may be recorded on film. Gating is achieved by changing the voltage across the MCP very quickly. To do this the MCP is coated with a gold on copper strip to form a transmission line between the top (input) and bottom (output). The glass of the MCP forms the dielectric of the transmission line and determines the speed of propagation of the gate pulse across the face of the MCP. The dielectric constant of the MCP material is high, although this is reduced to a lower effective value by the holes. The result is a low velocity and a transmission line of low impedance. The combination of high gate voltage and low impedance means that the currents involved are considerable, making connections to the MCP particularly difficult. The gate drive electronics has to drive this impedance which will be only a few ohms for useful gated areas.

1.3 CARE AND ENVIRONMENTAL CONSIDERATIONS

PLEASE READ THIS SECTION CAREFULLY

The microchannel plate is an array of about $12.5 .10^6$ single channel electron multipliers fused into a precision matrix. It is fabricated from a lead doped glass and the performance can be affected greatly by adverse environmental conditions or other maltreatment.

The lining to the walls is about 1μm thick and is easily damaged. Consequently proper handling precautions must be observed to retain the performance.

No object should come into contact with the sensitive area of the MCP. When handled the MCP should be held only by the border. All tools and other implements that touch this area should be clean and degreased and made of materials compatible with a high vacuum environment

The heads or MCP containers should only be opened under class 100 laminar flow clean room conditions. Should any particles become affixed to the plate they should be removed using a single hair brush and an ionised dry nitrogen gun.

The MCP is hygroscopic and must be stored correctly. Ideally this means an oil free vacuum. Alternatively they may be stored in a dry inert gas. Desiccators using silica gel have proven **unacceptable.**

Some MCPs can bow if they absorb moisture. Should this happen the head may well not work properly due to the uneven spacing between the phosphor and the MCP and may even break down. Bowing may be corrected by heating the MCP in a vacuum oven at 300° C for 3 hours or until flat.

The phosphor screen is also a very delicate part of the head and should be treated with care. Nothing should be allowed to come in contact with the aluminium layer. Particulate contamination of the surface is best removed with an ionised dry nitrogen gun.

1.4 GENERAL ELECTRICAL LAYOUT

The electronics consists of several modules, namely:-

2 Pulse generator

9 pulse forming modules

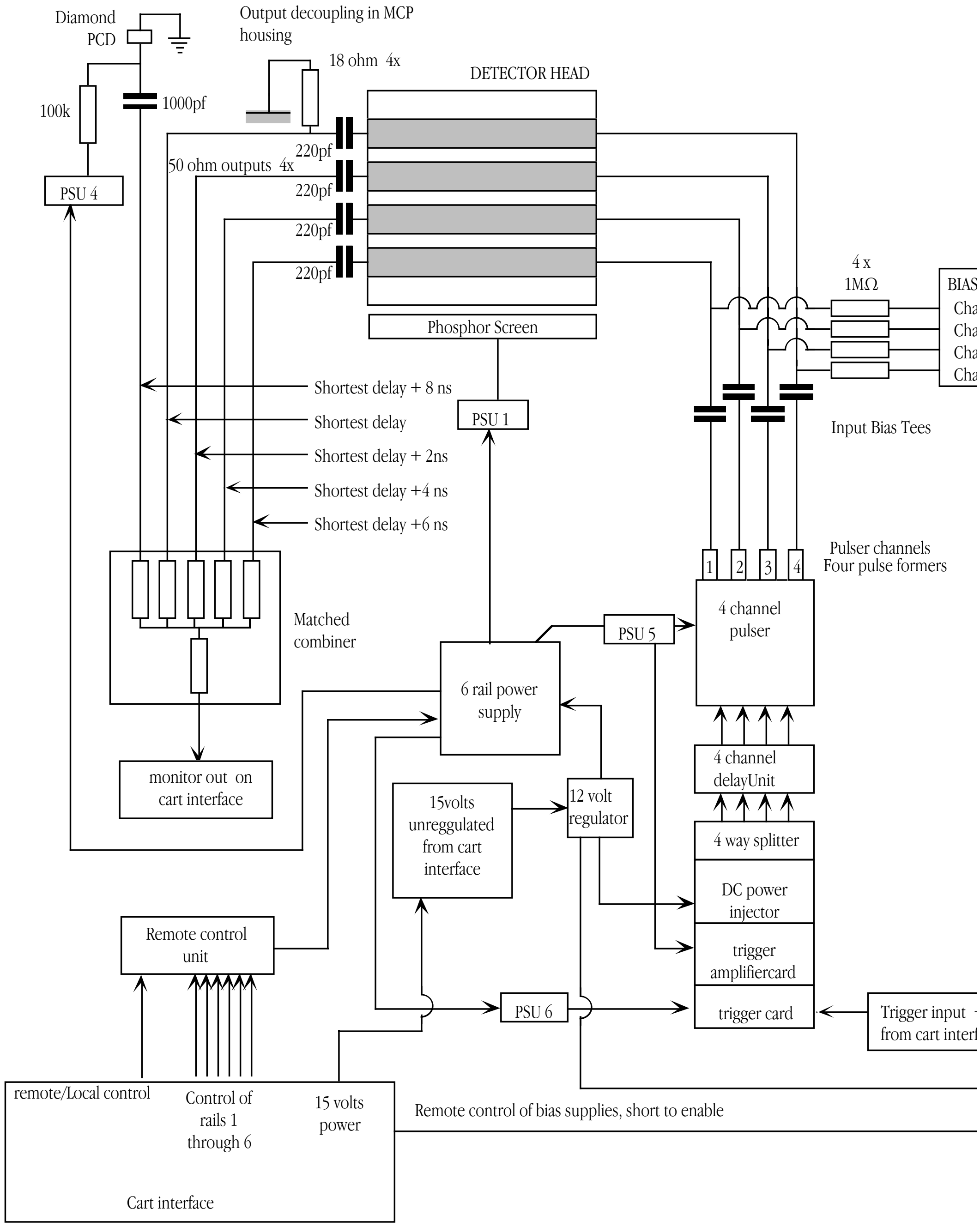
3 delay unit

4 bias unit

5 power supply

Note that the numbers refer to figure 1.

A schematic of the circuit is shown in below



2 THE POWER SUPPLY

This electronics package consists of two power supplies, and a pulse generator system. The pulse generator is a four channel system with independent delay control of each channel. The power supplies also offer outputs to bias a gated microchannel plate detector system.

The overall specification is as follows:-

2.1 POWER SUPPLY SECTIONS

Both have input voltages of 12 volts DC ±15%

Input current 1.8 amps average

Outputs

1 +4kV at 20µA adjustable in 500volt steps
2 +1kV at 100µA adjustable in 50volt steps
3 -1kV to +500volts at 100µA adjustable in 50volt steps.
4 +1kV 20µA adjustable in 100volt steps
5 -4kV at 2mA fixed (for pulse generator use only)
6 -3kV at 1mA fixed (for pulse generator use only)

New Bias supply

4 channels of -1kV to +1kV at 100µA

2.2 DELAY SECTION

Requires 12 volts .

Current 0 to 400mA depending upon delay settings.

2.3 PULSE GENERATOR SECTION

Trigger input 5 to 15 volts fast rising into 50Ω (will trigger from TTL)

DC supplies (from power supply section) -4kV at 2mA and -3kV at 1mA.

Trigger Delay approximately 31ns at minimum delay setting

Outputs. The outputs have been set up to deliver about -6kV unshaped pulses into 50Ω. They are designed to be used with the 24 pulse forming modules supplied.

2.4 REMOTE CONTROL SECTION

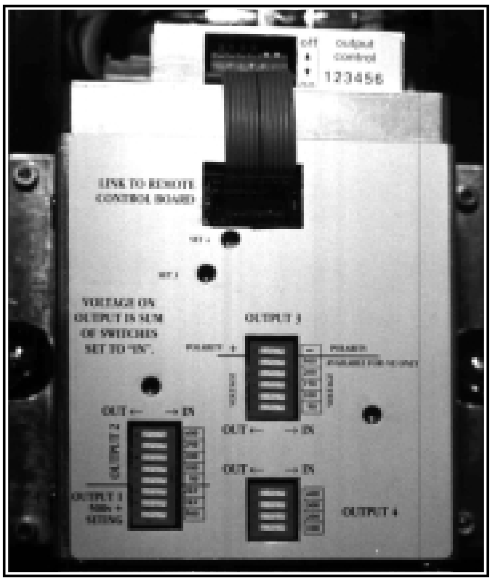
Each input requires 12 volts to activate it. There are seven inputs (one remote/local and six power rails to control) Current 0 to 84mA depending upon settings.

2.5 12VOLT REGULATOR

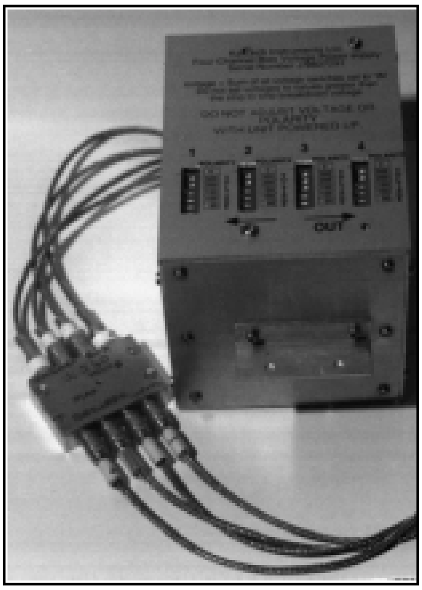
There is an on board 12 volt regulator rated at 2 amps. On board regulation has been found to be necessary as long leads are usually used from a power supply to the cart and four lead systems with sense return are two complex. Presently the on board power is configured so that the power supplies and delay unit are driven from the regulator. It is possible to drive the relays from the unregulated supply. Although the regulator is bolted to the body of the pulse generator it is obviously advisable to keep dissipation to a minimum by keeping the supply voltage to as low a value as maintains regulation. We recommend about 15 volts be used, up to 2.5 amps may be required.

2.6 USING THE POWER SUPPLIES

Each output on the main supply may be turned off or on individually via a set of DIP switches. These are accessed through a recess in the cover to the remote control board. They are suitably labelled. In addition the maximum voltage from each output may be set with a potentiometer. Outputs 3 and 4 are on the top panel whilst 1, 2 and 5 are on one side and 6 on the opposite side. It will be necessary to lift the power supply out of the SIMCART to change 1 and 2. In normal use (as set at the factory) the output in question should be switched to its maximum output and then the potentiometer used to set the maximum voltage. The indicated step voltage settings will only be accurate when the overall voltage is set to that specified above for each power supply.



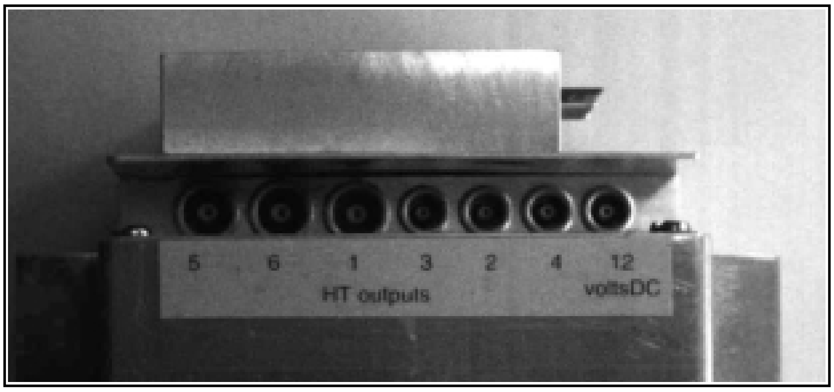
Above, the main psu, and below, the new 4 channel bias supply.



The new 4 channel bias supply is factory set to give ±1kV maximum. It is necessary to dismantle the unit to access the potentiometers to adjust this. The unit must be enabled by shorting out the remote control at the bottom of the unit. This could be done with a relay or simple open collector transistor (possibly optically activated). This control grounds one side of a relay coil that is connected to the 12 volt rail.

2.7 ADJUSTING THE VOLTAGES ON SUPPLIES 1 THROUGH 4 AND THE NEW 4 CHANNEL BIAS SUPPLY.

These four supplies are adjustable by means of dip switch settings on the top of the unit. A panel is screwed down over these switches to prevent inadvertent changing of the settings. The output voltage will be the sum of all the switches set to the “in” position, with the exception of supply 1 which is 500 volts plus the sum of such switches. Output 3 also has a polarity switch and can cover the range -1kV to +500 V. This output used to be available for biasing but this has been



Connections to the main psu.

taken over by a new bias power supply.

The outputs of the bias supply are similarly set. They also have a screwed down cover over the controls to prevent accidental adjustment.

2.8 CONNECTIONS TO THE POWER SUPPLIES.

The connections are made via Lemo connectors accessible from the bottom of the units as shown. Outputs 1, 5 and 6 which are higher voltages are on size '0' high voltage Lemo connectors. All the others and the 12 volt DC input are on size '00' Lemo connectors.

2.9 APPLICATION

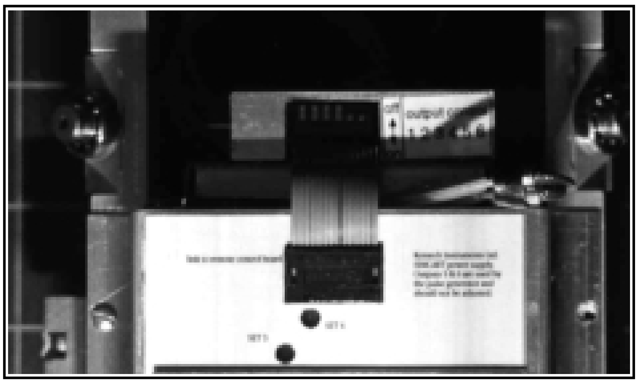
The four adjustable supplies were intended for the following applications although it is for the user to use them as he wishes.

Supply 1	phosphor bias
Supply 2	Bias for a second MCP
Supply 3	Spare bias supply.
Supply 4	Photodetector bias.

The two fixed supplies drive the pulse generator. Output 5 drives the four output cards and trigger amplifier card. Output 6 drives the trigger card . The preset potentiometers for these supplies should not be adjusted.

2.10 REMOTE CONTROL OF THE POWER SUPPLIES

The turning on and off of the main power supply rails can be performed remotely via an eight way lead. The eight leads are as follows, six to control the six rails, one to switch from local to remote mode and the ground. All controls are active high and require about 12 volts. All these controls are via fully isolated relays, *including the ground* which is kept separate from the pulser and chassis ground. In this way it is hoped that the pulser and other em radiation sources will not affect the control of the power supply. It should not be necessary to screen these leads.

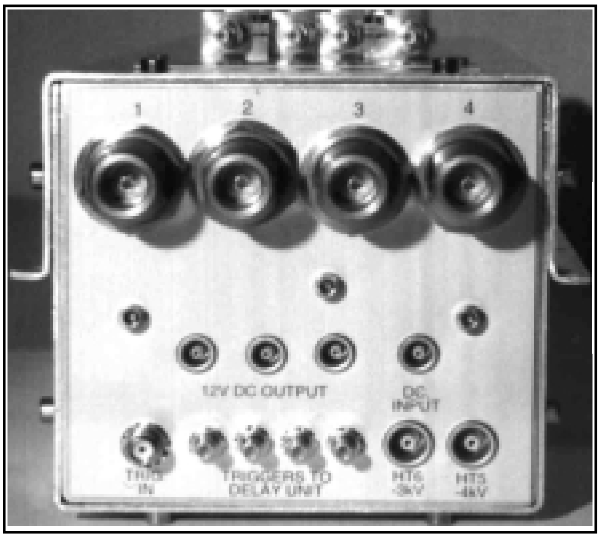


The colour code for the connections to the remote control board is marked on the cover and is as follows.

grey	remote mode on	yellow	output 1 on
lilac	isolated ground	orange	output 2 on
blue	output 6 on	red	output 3 on
green	output 5 on	brown	output 4 on

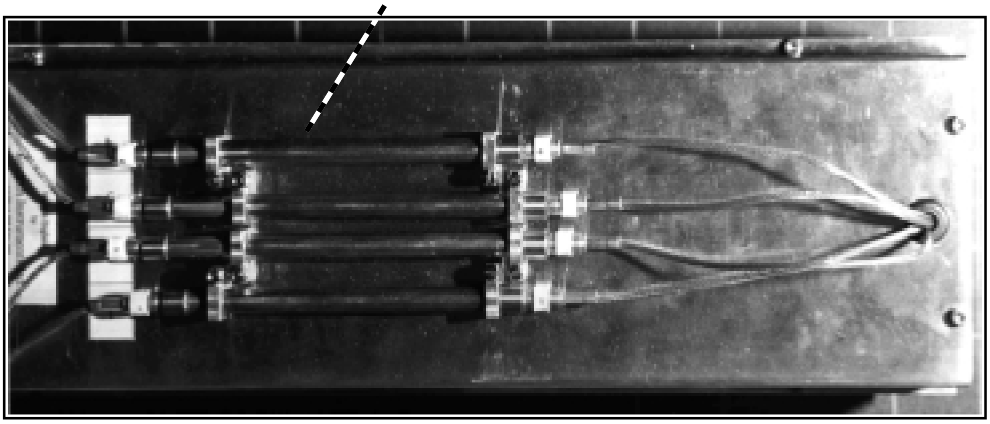
The remote control board is connected to the power supply by way of a short ribbon cable with a dual in line IDC connector. If required, this can be disconnected and the power supply controlled as normal. In this case a 6 or 7 way switch is required. If a seven way switch is installed then only 6 switches are used, the one on the left (when reading the text the right way up) is not used. Similarly if a 6 way switch is installed then it should be installed to the right of the 14 pin socket, leaving the left two pins free. This is because 12 way connectors are not available.

Note that the new bias supply also has a remote control facility but this is a simple short to enable accessed on the underside. The control is partially isolated with an internal relay but it still uses cart power for the relay.



The pulser bulkhead showing trigger input, HTs, and trigger loop throughs, DC inputs and outputs, to access the on board regulator, and the main pulse outputs.

The adjustable delay lines



3 THE PULSE GENERATOR

3.1 INTRODUCTION

The pulse generator provides four similar outputs from a single trigger input. It consists of several sections, a trigger card, a trigger amplifier, a four way trigger splitter, a four channel delay unit, four adjustable delay lines, four output pulse cards. The raw output from the pulse cards is then “pulse formed” by modules connected to the outputs. Pulse forming modules are available in the range 100ps to 2ns and give about half the voltage of the “raw” unshaped output.

3.2 THE PULSER

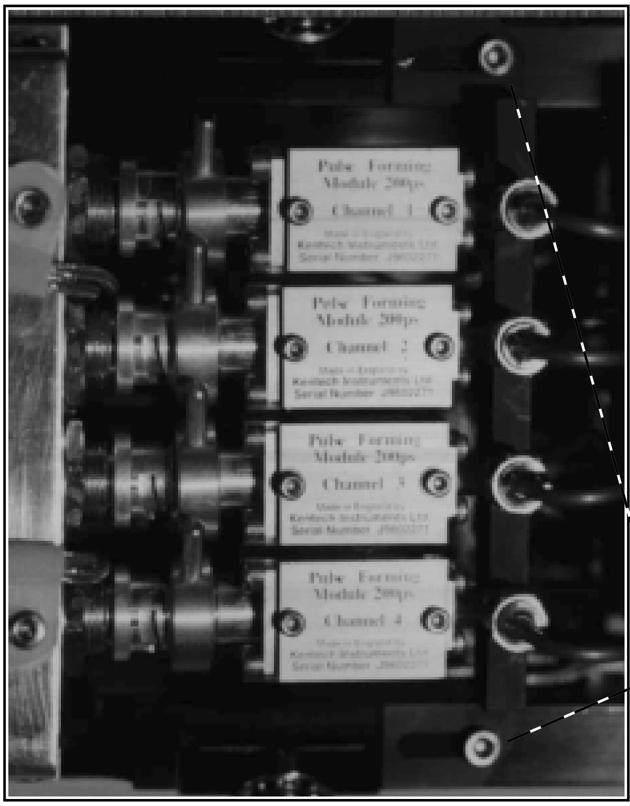
The trigger input is via an SMA bulkhead connector on the pulser bulkhead. This is fed directly to the trigger card where the low level signal triggers an avalanche transistor stack to provide an output of about 2kV. This is fed to a trigger amplifier stack which can deliver up to 5kV. This is then split 4 ways with a cable transformer to give about 2.0kV into each of four channels. These trigger signals are then fed to the output cards via adjustable delay lines and a switched delay system. The switch delay circuit uses relays to switch in and out various lengths of transmission line to delay the trigger signals. The adjustable delay lines are intended to be used to compensate for small differences in the overall trigger delay of each channel or in the cabling to the load. With these controls it is then possible to have all the outputs synchronous at the loads when the delay cards are set to the same values.

Due to difficulty in manufacture and the fact that the delay lines are not loss free and do not have an infinite bandwidth, it will be found that the delays are not quite correct. However, it should at least be monotonic over the whole range.

If the unit is under test, then individual pulse output cards can be made inoperative by removing the trigger lead. Ideally the trigger lead should then be shorted out to prevent large voltages appearing across the connector.

If it is necessary to dismantle the pulser box, note that the output of the trigger amplifier card is short circuited with about 35mm of wire. This should not be disturbed. The pulse length from the trigger amplifier card is set at an optimum so that reliable triggering occurs but that the relays in the delay section are not driven too hard.

To dismantle the pulser takes about ten minutes and reassembly perhaps 30 minutes. Make sure that the various components to the box are kept around the same way as when shipped.



Note the bridge with a screw at either end

Note that the trigger card operates from the -3kV rail whilst the pulse cards and the trigger amplifier card operate at -4kV.

The cards have been sprayed with an insulating lacquer. This can make it difficult to work on but not impossible. Beware of solvent cleaners as they can dissolve the lacquer and make a bad mess.

On no account try to measure voltage on the board other than the 4kV at the point of connection to the board. The capacitance of probes used to measure the voltage can upset the voltage sharing and lead to a false trigger of the board. If transistors are triggered inadvertently, in this manner they will fail.

If there are any suspected problems with the pulse cards they should be returned to us.

3.3 PULSE SHAPING MODULES

The raw pulse from each channel has a very fast edge with a slow decay. These pulses are then shaped with pulse forming modules connected to the bulkhead of the pulser unit. The pulse lengths available are nominally 100ps, 200ps, 500ps, 1ns and 2ns. There are 20 modules in all, four of each pulse length. Each is labelled with pulse length and the channel number. Although all channels are intended to be identical and modules may be mixed about, it is obviously good practise to keep a note of which modules are used on which channel.

In order to provide 100ps pulses several modifications have been made. Firstly the pulse cards have been improved to give faster risetimes and to overshoot on the rising edge. Secondly, as the BNC connectors were not thought adequate for 100ps use, the output bulkhead connectors are N type. Adapters to BNC are available so that the 200ps to 2ns modules can be fitted and are similar to previously supplied items. When fitting the 100ps modules the BNC to N type adapters should be removed and the 100ps modules with there N type to SMA connector leads fitted instead. The connector leads makes the output SMAs in the same place as the slower modules.

The new pulser card droops slightly more than the older type and to compensate for this the 2ns modules design has been modified. The result is significantly more voltage from this module. The user will have to bias the MCP suitably when this module is in use.

When fitting or changing modules do not forget to use and replace the bridge that supports the SMA connectors on the ends of the modules.

3.4 CHANGING THE SLOWER PULSE FORMING MODULES

The slower modules are attached to the bulkhead on BNC connectors. As they are closely mounted they have levers fitted to help with mating the connectors. The levers cross over slightly and it is easier to put modules in, in the sequence 1,2,3,4, whilst taking them out in the sequence 4,3,2,1. To help reduce mechanical loading on the BNC connectors, the ends of the modules are supported with a bridge. The bridge must be slid away from the bulkhead during mating and unmating. The bridge is held in place with a pair of M3 Allen headed screws.

3.5 GATE PULSE CHARACTERISATION

This requires certain specialist equipment. In particular a suitable high voltage fast rise time attenuator, we recommend a Barth® type 142B, and a suitable oscilloscope with rise time ~ 70ps. This may be a sampling oscilloscope or fast direct access type.

When using a sampling oscilloscope considerable pretrigger is required (~ 100ns for a Tektronix 7000 system). A suitable pulse generator giving a low jitter pretrigger signal with a delay will be needed, e.g. a Kentech APG1 pulse generator.

The gate pulse generator should not be driven above 100Hz. Also the pulse generator is designed to drive the pulse forming modules and the connector interface will not take the open circuit voltage from the pulse generator. The pulse outputs must be terminated. If it is necessary to characterise the raw pulse outputs then care should be taken to stop the connectors breaking down. Normally such a breakdown will occur late after the gate pulse start. However, repetitive breaking down will eventually damage the insulators and should be avoided.

If it is necessary to investigate the raw output, bear in mind that the output voltage can rise to 7kV into 50Ω and that this will double up into an open circuit for a short time. BNC connectors can be used if carefully wired up and cables are suitably terminated.

It is possible to run the pulse cards on the bench out of the box. However, the radiated em will be very high and suitable precautions with diagnostic equipment must be taken.

4 THE DELAY UNIT

The delay cards provide up to 12.7ns of additional delay into each channel. It is switchable in 100ps steps. In order to minimise component count and complexity the system uses seven relays per channel. The seven relays are controlled from two HEX coded switches. These have a total of 256 combinations of positions available. Only 128 are used. We recommend that all combinations that start with an '8' to 'F' are not used.

Channel delay codes in ns

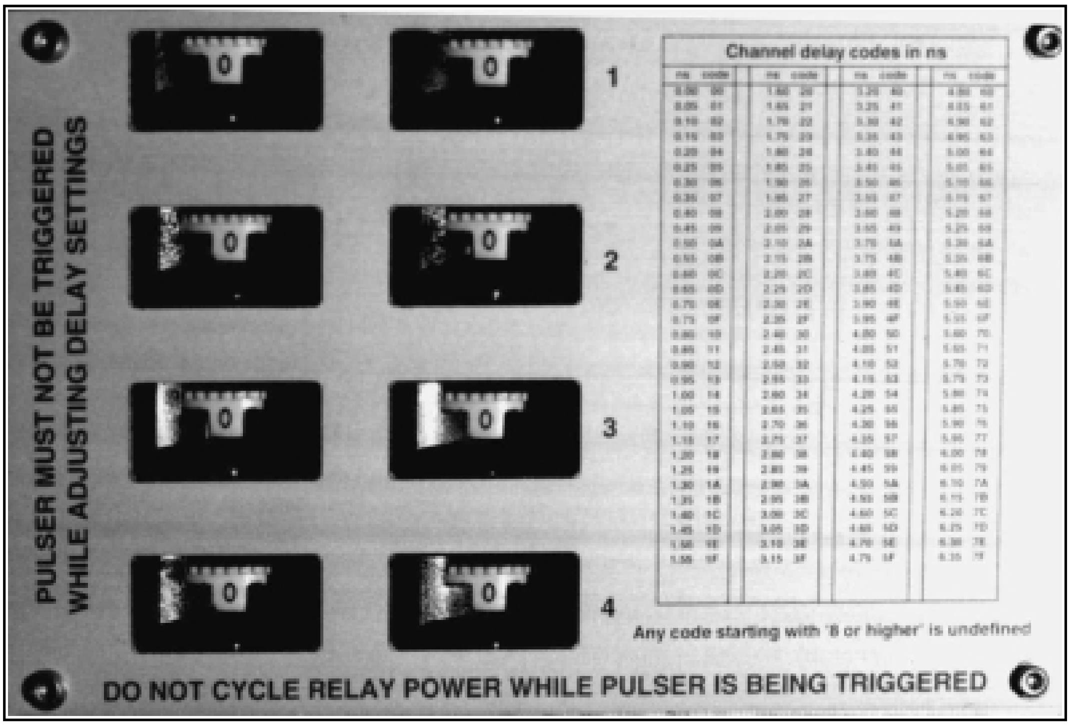
ns	code	ns	code	ns	code	ns	code
0.0	00	3.2	20	6.4	40	9.6	60
0.1	01	3.3	21	6.5	41	9.7	61
0.2	02	3.4	22	6.6	42	9.8	62
0.3	03	3.5	23	6.7	43	9.9	63
0.4	04	3.6	24	6.8	44	10.0	64
0.5	05	3.7	25	6.9	45	10.1	65
0.6	06	3.8	26	7.0	46	10.2	66
0.7	07	3.9	27	7.1	47	10.3	67
0.8	08	4.0	28	7.2	48	10.4	68
0.9	09	4.1	29	7.3	49	10.5	69
1.0	0 A	4.2	2A	7.4	4A	10.6	6A
1.1	0 B	4.3	2B	7.5	4B	10.7	6B
1.2	0 C	4.4	2C	7.6	4C	10.8	6C
1.3	0 D	4.5	2D	7.7	4D	10.9	6D
1.4	0 E	4.6	2E	7.8	4E	11.0	6E
1.5	0F	4.7	2F	7.9	4F	11.1	6F
1.6	10	4.8	30	8.0	50	11.2	70
1.7	11	4.9	31	8.1	51	11.3	71
1.8	12	5.0	32	8.2	52	11.4	72
1.9	13	5.1	33	8.3	53	11.5	73
2.0	14	5.2	34	8.4	54	11.6	74
2.1	15	5.3	35	8.5	55	11.7	75
2.2	16	5.4	36	8.6	56	11.8	76
2.3	17	5.5	37	8.7	57	11.9	77
2.4	18	5.6	38	8.8	58	12.0	78
2.5	19	5.7	39	8.9	59	12.1	79
2.6	1 A	5.8	3A	9.0	5A	12.2	7A
2.7	1 B	5.9	3B	9.1	5B	12.3	7B
2.8	1 C	6.0	3C	9.2	5C	12.4	7C
2.9	1 D	6.1	3D	9.3	5D	12.5	7D
3.0	1 E	6.2	3E	9.4	5E	12.6	7E
3.1	1F	6.3	3F	9.5	5F	12.7	7F

Any code starting with '8 or higher' is undefined

The delay cards work by switching in extra lengths of delay line into the trigger path of each signal. The bandwidth of the system is comparable to that of the trigger signal. As a result the actual delay on a channel will not be quite that indicated in the chart. However, the delay should increase monotonically throughout the range and also great effort has been made to make sure that the channels are the same. The outputs should be fairly synchronous at any delay setting as long as all four channels are set similarly.

The relays are driven directly from the supply rail. Also when a delay is "IN" the relay is energised. Consequently all relays of a channel are energised on a setting of (7,F) and none on (0,0). The maximum current is drawn when all relays are set to (7,F) and this will be about 400mA in total at 12 volts. (Note that the high voltage power supply takes about 1.6A. This means that the total dissipation of the system can be 24 watts.

The delay period can be extended beyond 12.7ns by extending the trigger loop through leads. A male to female lead is required. SMB connectors are used for the trigger signals between the modules. More of these are available from Kentech Instruments should they not be available locally. It is important that the risetime not be degraded significantly beyond about 500ps or jitter may be introduced. With poor triggering of the output pulse cards transistor failure may occur.



<u>NEVER CHANGE THE DELAY SETTING WHEN THE PULSER IS BEING TRIGGERED.</u>

The relays are powered from the regulated 12 volts DC which is fed from the on board regulator directly to the side of the relay unit. **<u>This set of electronics does not have power brought in with the trigger lead.</u>**

5 BIAS CONTROL SECTION

5.1 INTRODUCTION

The new bias power supply has been made to provide 4 separate bias voltages each in the range -1kV to +1kV in 50 volt steps. While this offers more flexibility than earlier designs it has one drawback, the ability to place up to 2kV across the strip to strip gap on the MCP. In order to overcome this and prevent accidental setting of high strip to strip voltages a "ZENNER BOX" has been provided. This takes all the outputs and couples them together via a pair of zenners in each line (back to back to allow for both polarities). The result is that no two outputs may be more than 540 volts apart.

Should the setting exceed this value the zenners will conduct and limit the voltages. Note that in this case the voltages will not correspond to those set and that the MCP gain will be different from that expected.

In principal the ZENNER BOX could be modified so that only adjacent voltages are limited not any pair. This would allow a greater dynamic range to be used but runs the risk of permitting larger strip to strip voltages if the channels are not connected in the right sequence.

5.2 DC BIAS BLOCKS

The DC bias blocks permit DC to be applied to the load without the DC supply being loaded by the pulse generator. Pulse generators with pulse forming modules or with very short duration outputs have a DC path to ground.

The block comprises an in line capacitor of 220pF and a DC injection point. The units have been tested for leakage current of around 1μA or less and DC hold off to >1.5kV. The pulse risetime through the block is around 30ps, i.e. far faster than any pulses likely to be used. The blocks can be fitted over the top of the pulse modules. The DC injection point is resistively decoupled from the transmission line but the resistor is a small value surface mount device and will not take more than a few hundred volts DC. It is important that they are not used with alternative DC bias supplies that are capable of significantly higher current output.

6 CONNECTIONS AND MECHANICS

6.1 THE FILM CASSETTE HOLDER.

The film should be loaded into the 35mm film cassette provided, so that when the cassette is placed in the holder the emulsion is facing outwards, see figure 2. This is the **opposite** to normal film loading of a cassette and consequently commercially loaded cassettes are not suitable.

The film may be processed after each exposure or several exposures taken together. In this case we strongly recommend that after loading the cassette holder onto the detector head, that all the film be wound onto the take up spool and then each frame wound back into the cassette immediately after each shot. In this way if there is any occurrence that lets light into the holder the exposed film will be protected. Always wind the film **slowly** to avoid the build up of static which can discharge and fog the film. The film should be advanced by four turns of the relevant spool. The film pressure plate should always be lifted when moving the film and lowered for taking an exposure. The film jacking control, see figure 2, should be rotated slowly and not flicked from one position another as this can lead to shocks onto the fibre optic output window of the head.

The preloaded cassettes may be loaded into the holder in daylight. Observe normal camera loading precautions and wind the film on sufficiently so that the portion of film in use is definitely unexposed.

The cassette holder is removed from the head by unscrewing the smaller stainless steel screw on the rear of the film back. Make sure that you have rewound any exposed film into the cassette first. When refitting the holder make sure it is up the correct way and that the pressure plate is in the '**jacked off**' position. Also ensure that the film is fairly taught as this will stop jamming problems.

6.2 POWER UP CHECKS AND PROCEDURE

The electronics package can run at atmospheric pressure or at vacuum (better than 10^{-4} torr). However, the detector head can only be run under vacuum conditions and we recommend better than 5 10^{-5} torr and this should be a sustained value for at least 30 minutes.

It is essential therefore that control of the power supply from outside of the vacuum chamber is available. We recommend the following arrangement. The 15 volts unregulated power to the cart is supplied through a vacuum interlock switch controlled by a gauge set to around 5 10^{-5} torr. In addition the power supply individual rails should be set to off locally (on the power supply remote control module). The remote control of the supply should also be set to local during pump down. When a suitable pressure is attained the supply can be switched remotely to remote mode and then the individual supplies can be switched as required.

6.3 POWERING UP THE HEAD

The first test that should be done under vacuum is to establish that the phosphor does not emit light when only it is powered.

With the head under vacuum and film loaded the phosphor supply should be turned on for a little while, then off and the system removed from vacuum and the film checked for fogging. Once this has past the test should be repeated with bias on the MCP as well. Both polarities should be checked.

With no bias voltages on the head the pulse generator monitor should be checked (also under vacuum). The monitor sums all the pulse channels with relative delays so it should be obvious if there are any problems. Both short and long pulse modules should be checked.

Once all these tests have been passed then the system can be set up for looking at x-rays. Obviously some DC shots should be performed to achieve the right gain levels on each channel. The individual channel gain can be set by adjusting the individual bias voltages. The main limitation of the bias adjustment is that there is no way for some channels to have opposite polarity biases to others. This minor limitation is being addressed for a possible upgrade.

When considering how to set the gain of individual channels one should make allowance for the relative lengths of the total x-ray emission and the gate length. Also some assumptions or calibration of the gain versus voltage on the plate needs to be made. DC calibrations will be fine for application to the longer gate lengths. At short gate lengths the electron transit time becomes a significant fraction of the gate length and the gain at a given total voltage (bias plus gate voltage) will fall.

6.4 RECOMMENDED RATINGS

In order to make this unit flexible it is necessary to require the user to check that certain parameters are not exceeded. It is the users responsibility to check these. Without computer control to monitor every voltage setting it is not possible to prevent careless settings of the various voltage rails that could lead to component damage. The following guide lines are given on what are thought to be safe settings. If the user keeps well below them they should have no problems.

6.4.1 VACUUM

Better than 5 10^{-5} torr for 30 minutes

6.4.2 PHOSPHOR VOLTAGE

Lower than 3kV, start at 2.5kV and increase to 3kV after several cycles of the vacuum.

6.4.3 MCP BIAS

DC bias with no gating should not exceed ±700 volts

DC bias with gating should be in the range -350 volts to +700 volts.

The peak voltage should be less than 1600 volts during gating for short gates. For longer gates keep the bias lower. Breakdown has been observed with a 2ns gate with a zero bias voltage, so it is better to use a positive bias with long gate lengths.

6.4.4 PHOTO CONDUCTIVE DETECTOR

Keep the voltage below 600 volts

6.5 TRIGGER TIMING

One the gain has been set to an estimated value it will be necessary to set the trigger timing. By recording the output from the cart monitor it is possible to time the gate drive quickly. It is important to make sure that the PCD is illuminated with x-rays or other suitable radiation at the same time as the MCP. By using the 2ns gate width modules and setting the interframe delays to 2ns a total of 8ns of the event can be monitored.

These two traces show idealised possible outcomes. In the top one the gates are synchronous with each other and the PCD signal. In the lower one the PCD signal is about 4ns early, so the gates will have to be triggered 4 ns later to catch the event.

7 POSSIBLE FAULTS

1 MCP will not hold the bias voltage

(i) MCP plate or connections may be breaking down. Check that the MCP bias voltage is similar to that set by measuring the voltage at the bias output on the bottom of unit 4, see figure 1, with a >1GΩ voltmeter. If the MCP will not take the bias voltage then look for signs of breakdown in the various connectors and on the back of the MCP. Observe the handling conditions stated in section 1.3. Note that the SMA connectors must be able to hold off the d.c. bias voltage and must therefore be kept clean. In particular the insulators should be free of metal particles that come from the threads, especially on new connectors.

2 Phosphor will not hold bias voltage.

(i) Short circuit between MCP and phosphor. Measure impedance between Lemo centre contact and outer on the head. This should be >1GΩ.

Breakdown may be due to poor pressure (it should be better than $5 .10^{-5}$ torr).

Look for particulate contamination of the phosphor screen or rear surface of the MCP. Observe the handling conditions stated in section 1.3.

Check to see if the MCP is bowed, if so see section 1.3.

(ii) Breakdown of EHT feed.

3 No DC image

(i) Insensitive MCP. Replace

(ii) Bad connections to MCP. Check the connections and if possible measure both the reflections from the MCP and the shape of a transmitted pulse with a T.D.R. (time domain reflectometer).

(iii) Short circuit between MCP and phosphor. Measure impedance between Lemo centre contact and outer on the head. This should be >1GΩ.

(iv) Breakdown of EHT feed.

Breakdown may be due to poor pressure (it should be better than 5 .10^{-5}torr).

Look for particulate contamination of the phosphor screen or rear surface of the MCP. Observe the handling conditions stated in section 1.3.

Check to see if the MCP is bowed. If so see section 1.3.

(v) MCP d.c. bias not turned to negative. Switch

(vi) MCP bias too low. Increase

(vii) MCP plate or connections breaking down. If the MCP will not take the bias voltage then look for signs of breakdown on the back of the MCP. Observe the handling conditions stated in section 1.3.

(vii) Phosphor bias not on Switch on.

(viii) Phosphor bias set too low Increase

(ix) Check MCP bias lead, SMA connectors and Phosphor bias leads are mated correctly.

4 Bad focus.

(i) Image on MCP out of focus Check

(ii) Film contact with fibre optic faceplate is poor. Check operation of film pressure plate. Check for dirt on faceplate.

(iii) Film loaded with emulsion on wrong side. Reverse loading of film in cassette.

5 No gated image but d.c. image O.K.

(i) Gate drive triggering at wrong time from noise.

Block trigger diode and fire shot, electronics should not trigger.

(ii) Trigger signal not correctly timed

(iii) Gain too low

(iv) Gate leads incorrectly connected or cross connected.

SMA connectors should be tightened to a torque of 9.2 cmKg.

(v) Inadequate trigger signal causing jitter. Check with oscilloscope.

6 Image present without gate pulse.

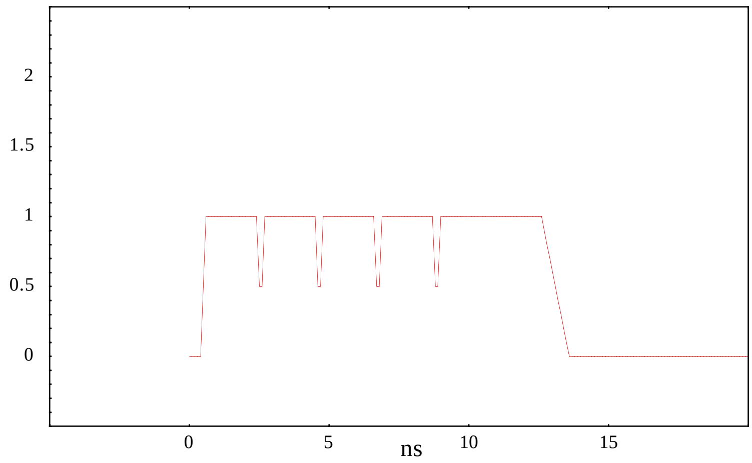
(i) MCP bias is too high Make less negative.

(ii) Power supply is being triggered by noise at such a time that x–rays are present at the detection head when the gate pulse arrives. Improve noise immunity.

(iii) X-rays are incident at MCP bias angle and are exciting the phosphor directly. If this happens there will be an image with the power supply turned off also.

(iv) Some other radiation e.g. neutrons or hard x-rays are exciting the phosphor directly. Remove source of radiation or improve screening.

7 Fogged film



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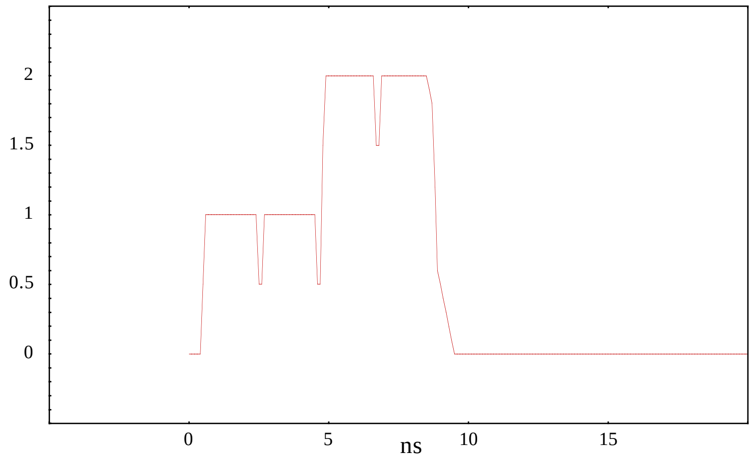
10
15



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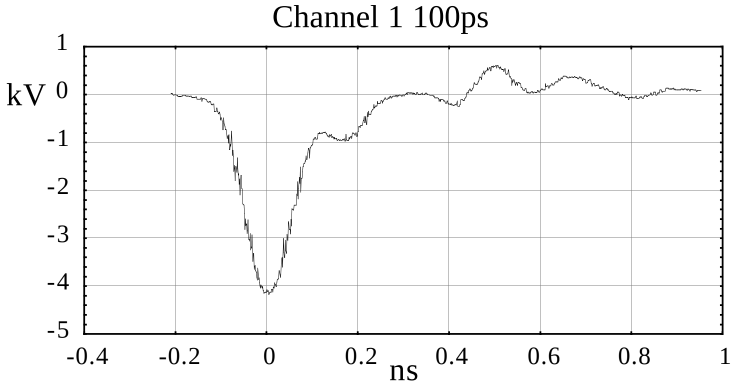
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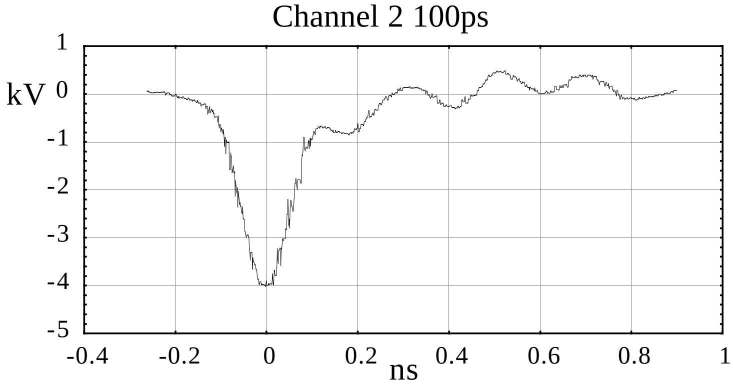
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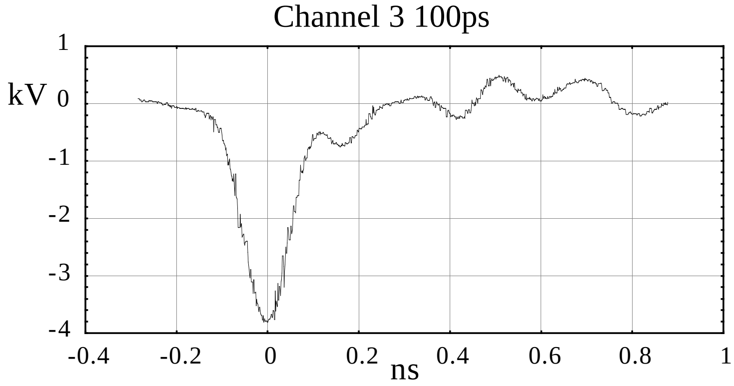
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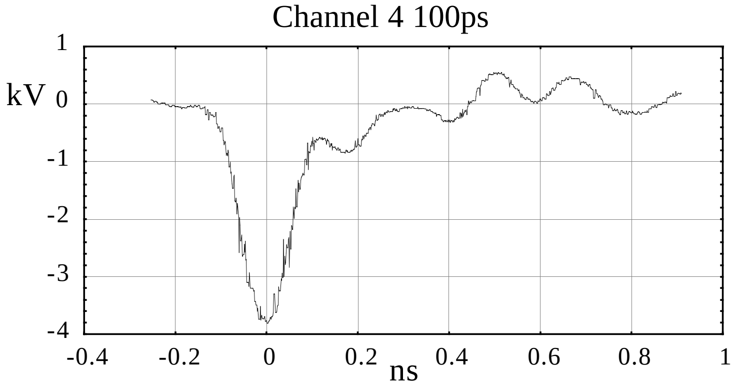
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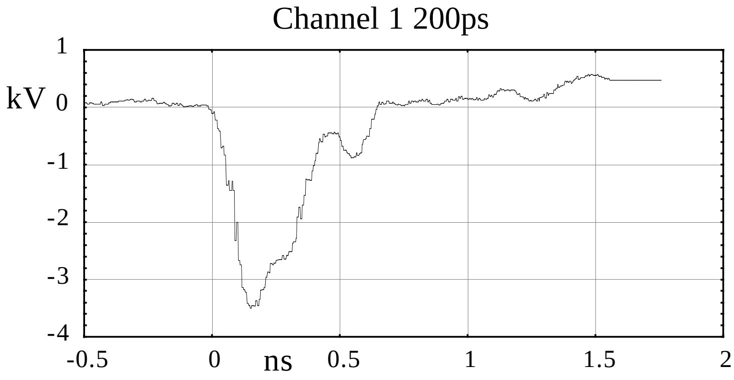
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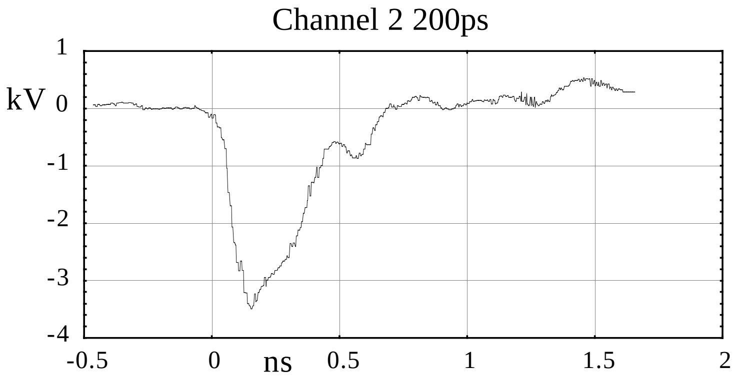
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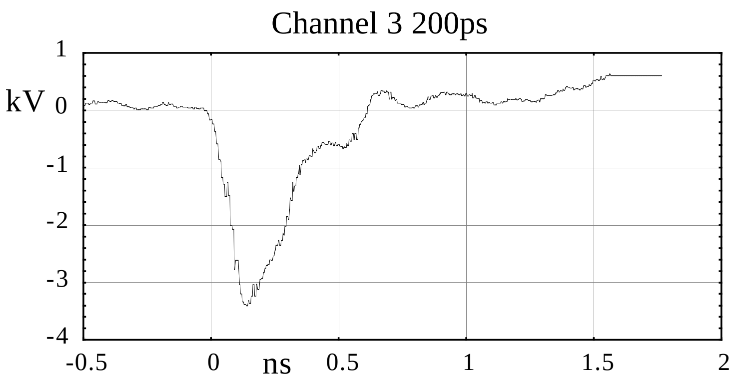
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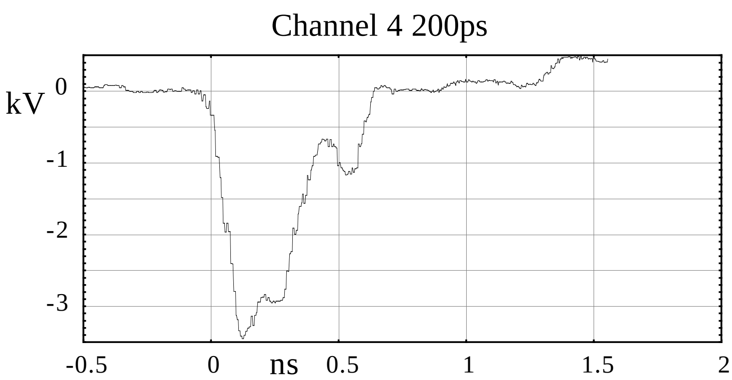
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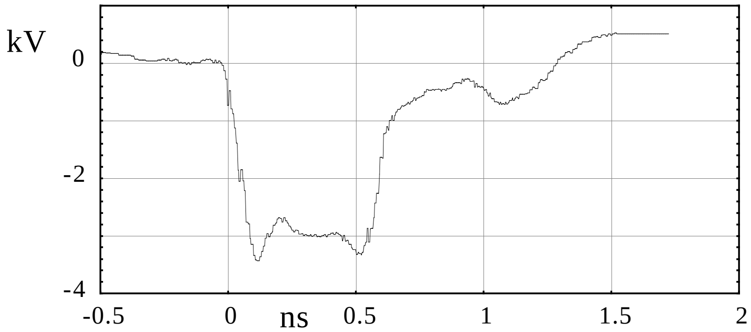
1.5
2

Channel 1 500ps



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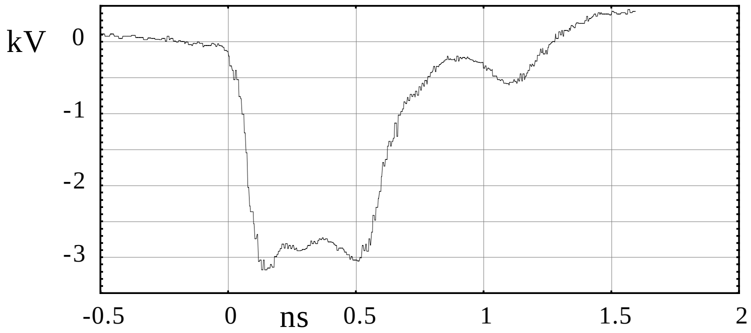

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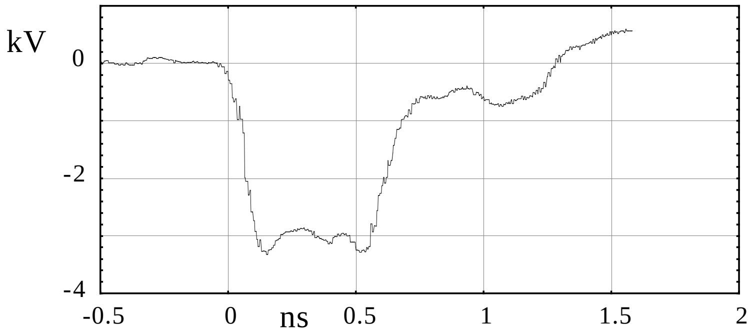

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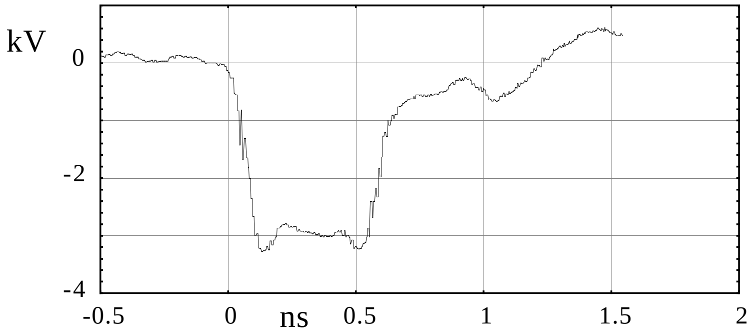

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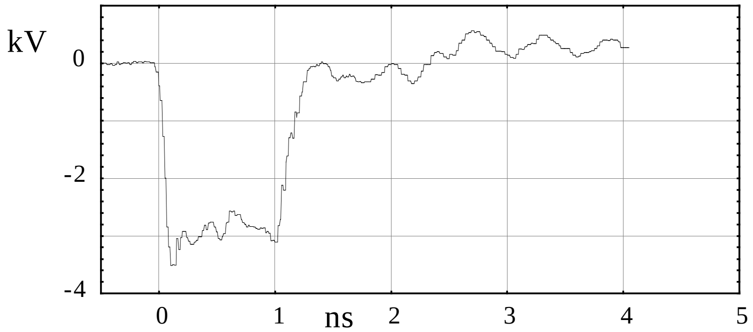

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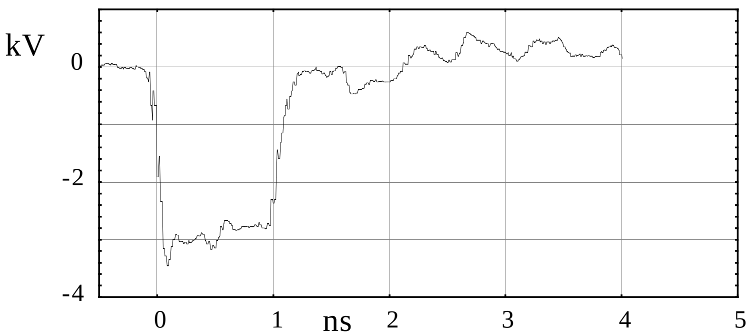

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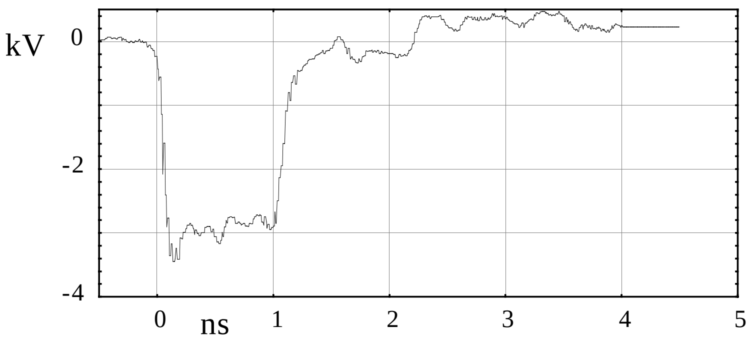

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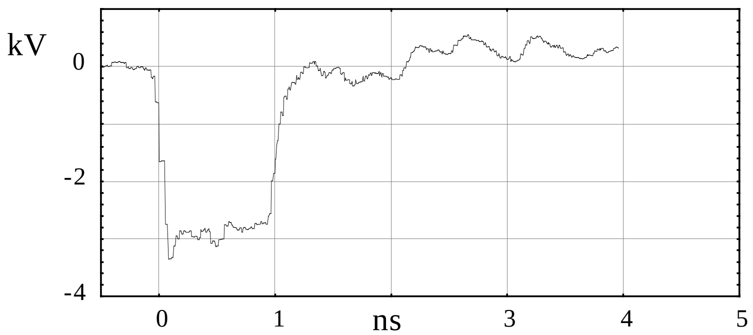

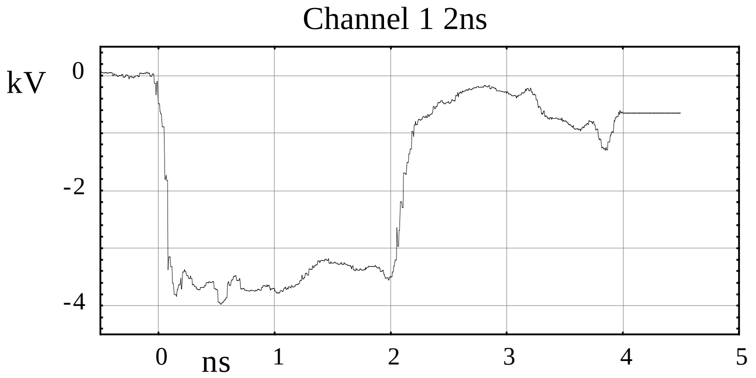
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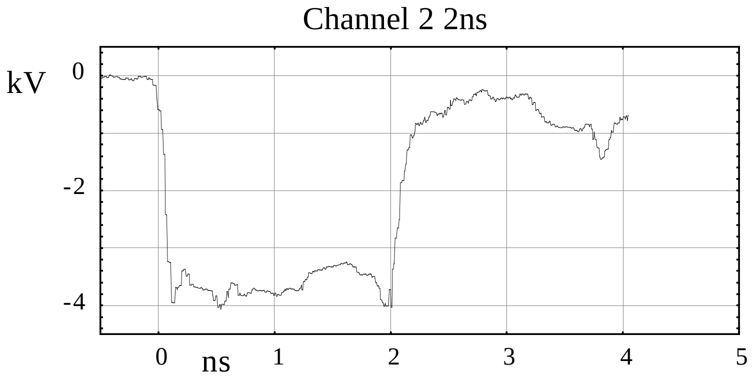
1
2
3
4
5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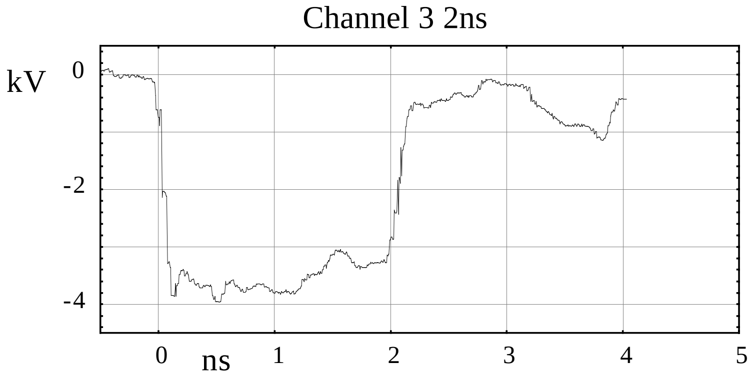
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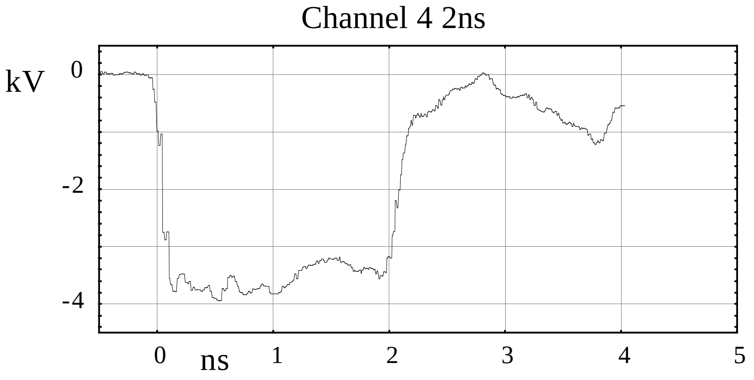
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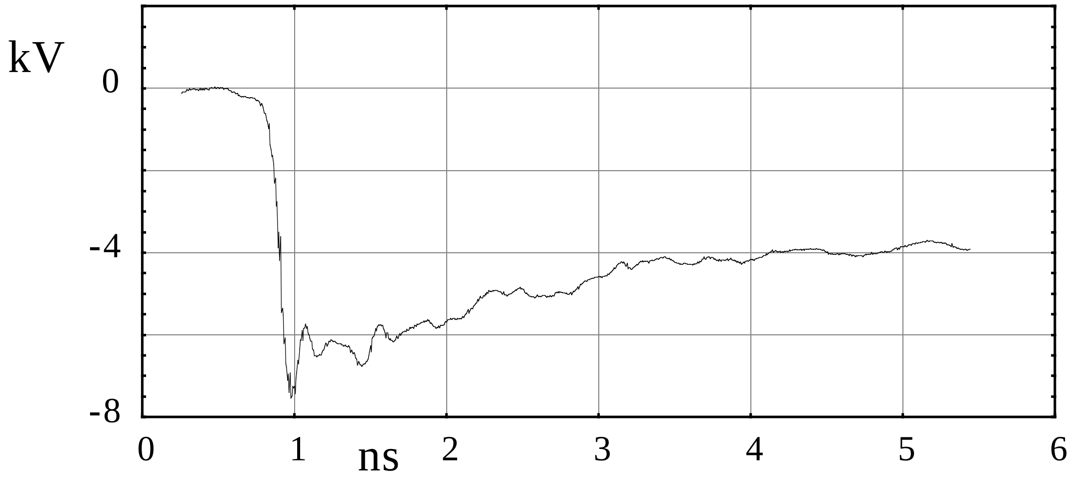
Channel 1 Unformed Pulse



Channel 1 Unformed Pulse