Kentech Instruments Ltd.

Pulse Chopper System

J99***

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PLEASE READ THIS MANUAL CAREFULLY BEFORE USING THE PULSER

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DISCLAIMER

This equipment contains high voltage power supplies. Although the current supply capacity is small, careless use could result in electric shock. It is assumed that this highly specialised equipment will only be used by qualified personnel.

The manufacturers and suppliers accept no responsibility for any electric shock or injury arising from use or misuse of this equipment. It is the responsibility of the user to exercise care and common sense with this highly versatile equipment.

Contents

Figure Captions

1 INTRODUCTION

This manual describes the operation and use of the special pulse chopping system. This has been designed to chop the back end of a laser pulse at rates to 20kHz.

1.1 SPECIFICATIONS

Pulse output voltage range	-220 to -470 volts into 50 Ω.
Maximum repetition rate	~20kHz
Trigger input	>2 volts 10ns f.w.h.m. into 50Ω.
Jitter	Less than 50ps
Trigger delay	50ns to end of supplied cables (approx. 35ns plus 15ns in the cables)
Power input	Universal
	85 to 264 volts A.C. at 47 to 440Hz.
	2 amp fuse, type T (anti-surge)
	This unit contains an auto-resetting thermal trip rated at 70°C
	Maximum average power consumption 60 watts.
Connectors	
Power	IEC
Trigger input	BNC
Outputs	SMA

2 GETTING TO KNOW THE INSTRUMENT

The pulser consists of a trigger circuit, a variable voltage power supply and four pulsers. The trigger circuit processes the incoming trigger signal, and provides outputs to the four pulsers with provision for a small amount of individual delay adjustment. It also provides trigger pulses for the LED flashing (triggered light).

2.1 FRONT PANEL CONTROLS, CONNECTIONS AND INDICATORS.

The front panel is shown in figure 1.

The “Amplitude” control controls the pulse voltage in approximately 20 volt steps from 210 volts to 470 volts. All four channels are adjusted together. This is effectively the voltage into a 50Ω load. By mismatching the end of the cable to the load up to twice this voltage is available.

The pulser is not reverse terminated. Consequently a pulse reflected from the load will also be reflected from the pulser and arrive at the load again. The reflection arrives at the loads at a time equal to the round trip time of the cables. Several reflections occur.

There are five front panel connectors. The trigger input and the four main outputs. Note that the main outputs contain a DC path to ground and so if it is necessary to bias the load with a DC signal the pulser must be disconnected.

2.2 REAR PANEL CONNECTIONS

The power inlet is on the rear panel. The power inlet is filtered and will accept IEC leads. It uses a universal supply that will run from a variety of AC voltages, see specification.

3 USE

The unit is intended to pulse a small capacitive load for 30ns at repetition rates up to 20kHz. In particular for pulsing a pair of pockels cells using 25 ohm feed to each to keep the RC risetime good.

3.1 CONNECTIONS AND APPLICATIONS

The pulser is designed for use with Pockels cells between polarisers and consequently the pulse amplitude can be varied to adjust the operating point. The greatest contrast will be achieved when the pulse amplitude at the cells causes half wave relative retardation of the extraordinary ray and the polarisers are either parallel or perpendicular. In particular the system is intended for use with a pair of cells between one pair of polarisers. By using two cells only half the pulse power is needed as compared with achieving twice the voltage on one cell. (c.f $E = 0.5CV^2$).

Figure 1 The front panel

4 CIRCUIT DESCRIPTIONS

The circuit consists of four high voltage FET switches. These is driven by a single trigger pulse. The leading edge is speeded up using the non linear capacitance of silicon diodes. This is a proprietary circuit and details are not normally available to the user.

The HT is obtained from an array or small floating 30 volt supplies which are either switched in or out as the “Amplitude” switch is turned.

5 USING THE PULSER WITH POCKELS CELLS FOR LASER PULSE CHOPPING

The main application of this pulser is to chop the falling edge off a laser pulse. In order to achieve this the polarisers are mounted parallel and the cell arranged to switch the plane of polarisation of the light when energised.

The pockels cells work by using a material which is bifringent when placed in an electric field (transverse in this case). Plane polarised light entering the cell is split into two waves of equal amplitude polarised at 90° to each other. These travel at slightly different speeds in the excited medium and emerge with a relative phase shift of $\lambda/2$. In the unexcited medium there is no relative change in the phase and the polarisation is not affected. This means that the exit plane of polarisation is at 90° to the incident plane. The light can then be rejected on a polariser.

These conditions only exist for a small range of angles for the light through the crystal. At other angles the light may not be split equally or there may be some intrinsic bifringence leading to partial or complete rejection in the absence of the electric field.

It is hard to set up this system in pulsed mode. Looking for extinguished light is far easier than looking for a peak of transmission. With the pulser running most of the time the system is still transmitting.

5.1 STATIC SETTING UP

A simple way to set up the pockels cells is to use a DC power supply. This can be set at the half wave voltage (quarter wave on each cell) and the cells and polarisers orientated for maximum extinction. A CW laser and a photodiode running into a high impedance (high sensitivity) connected to a DVM will suffice.

In order to keep the pulser power down the system is intended for use with two cells each being driven to the quarter wave voltage. Ideally these need to be set up independently. Here is a suggested method.

1. Align two polarisers perpendicular by looking for the maximum extinction.
2. Place one cell between the polarisers with the straight edge of the square aperture crystal at 45° to the plane of polarisation of the incoming light.

3 Orientate the cell for maximum extinction. Ideally this should be done by looking at the isogyre pattern obtained by scattering the incoming light over a range of angles. This can be done with suitable tape over the input face of the cell. The laser should pass through the centre of the pattern. Don't forget to remove the tape!

4 Repeat 3 with the second cell.

5 Rotate the output polariser so that it is parallel to the input polariser.

6 Apply the relevant half wave voltage DC to on cell and repeat 3. The position should be near to the existing position. Adjust the voltage so that the extinction is best. Note that misalignment and a higher voltage can achieve an extinction minimum also and one is looking for the minimum transmission near the existing position and at the lowest voltage.

7 Remove the voltage from the cell and repeat 3 on the second cell.

8 Remove the voltage from the second cell and now connect the quarter wave voltage to both cells. Now work with small movements of the cells to obtain the best extinction ratio. The ratio is easily obtained from the transmission obtained when the voltage is removed to the transmission when the voltage is applied. Note that some power supplies will not discharge the cells when they are turned off. It may be necessary to discharge the cell capacitance with a resistor (note that the capacitance of any cabling to the cell will be much bigger than the cell and will store a significant amount of energy.)

9 Remove the DC supply and connect the pulser. The light source may now be pulsed or DC to look for the relevant timing of the pulsers, the laser source and the detector display.

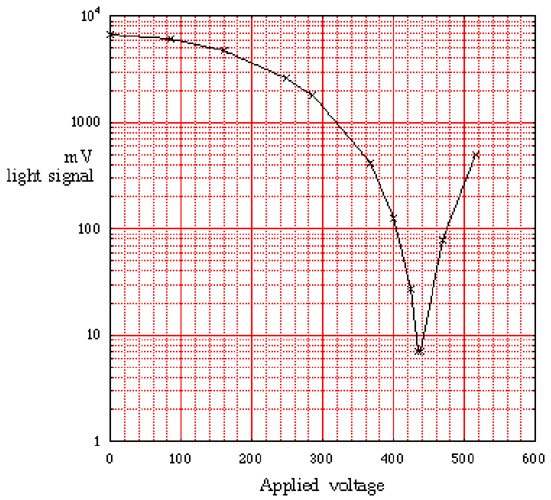


Figure 2 A plot of DC transmission against applied voltage. The voltage is applied to both cells simultaneously.

5.2 TIMING ADJUSTMENT

The relative timing of the four channels of the pulser must be set to obtain the best overall risetime.

It is assumed that the above alignment has been done and that the pulser, light source and detector are all suitably timed for fine adjustment work.

The KD*P material used in the cells has a dielectric constant of approximately 80 at the electrical drive frequencies which are up to around 500MHz. This results in a speed of propagation in the cell of around 7 times slower than the light. In addition as we are looking for transitions of the order of 700ps or less the separation of the cells in space will affect the required timing of each cell.

The following is a procedure we have used for timing the cells.

1. Set up the system and align as under static alignment.
2. It is much easier to look for transmission than extinction when one is using each channel of the pulser independently. For timing tests it is better to rotate the output polariser, so that it is perpendicular to that at the input.
3. Disconnect the DC cabling and connect one channel of the pulser to one cell. Note the timing of the edge of the transmission curve with an oscilloscope.
4. Disconnect the pulser and in turn work through the other three channels, one at a time. Note that the pulser must be connected to the cell that it will end up being used with. You cannot mix the channels and cells as the cells require slightly differently timed drive pulses to achieve the same output timing.
5. Once all the timings are noted use one in approximately the centre of the range as a reference and adjust all the others so that they are the same; see section 5.3.

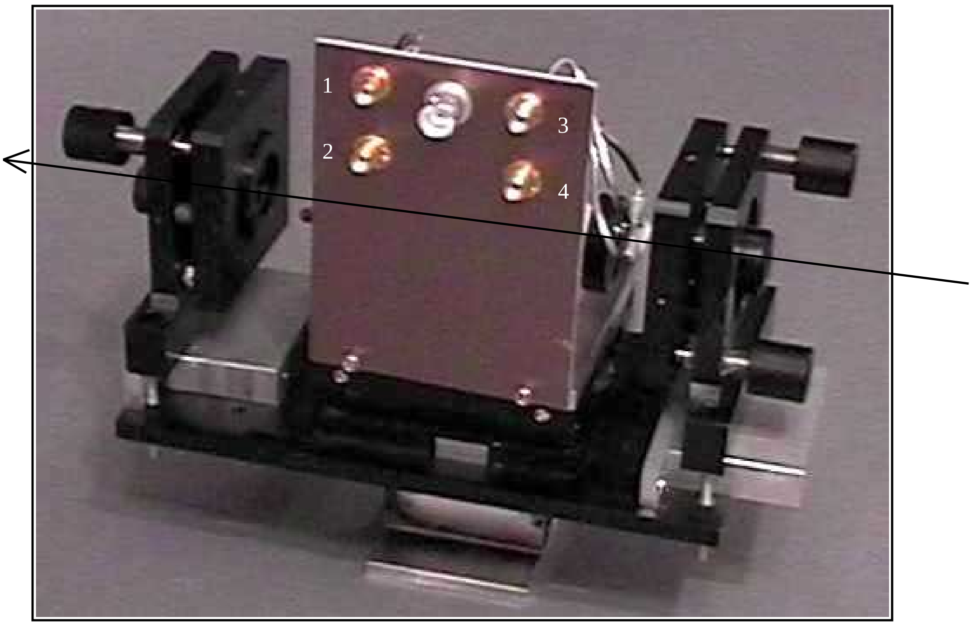


Figure 3 The head showing the connections and direction of light propagation

Note the unit supplied is set up so that the timing is correct when the light enters from the right in figure 3 and the pulser channels are connected as shown.

5.3 ADJUSTING THE TIMING OF THE CHANNELS.

The timing to each channel is adjusted by means of a set of four potentiometers on the trigger board. These are a little hard to access. Care must be taken if operating the unit without the covers on the pulser. We strongly recommend that the pulser is turned off and the mains disconnected before each adjustment is made, unfortunately continuous adjustment whilst observing the effect is not possible with the unit turned off. It is likely that only small changes to the timing will be necessary.

To change the timing:-

1. Turn off and remove the power from the unit
2. Remove the eight small cross point screws in the two sides of the unit.

View with bottom cover removed

There are four white adjusters

The adjuster at the top of this picture (closest to the bottom panel) is for output 4, outputs 3, 2 & 1 are progressively lower in this picture.

Figure 4 Locating the timing adjusters

3 Note the orientation of the side covers and remove them.

4 Remove two screws from the rear panel, the two should be those in the bottom centre. I.e. of the four along the bottom of the rear panel remove the central two.

5 Remove the bottom panel. It will need unclipping at the front and possibly opening out slightly at the sides.

6 With the help of figure 3 locate the four potentiometers that adjust the timing of the trigger signals.

7 The potentiometer nearest the edge of the board adjusts channel 4. The one next to it channel 3 etc.

8 Use the right angled tool provided with the unit to adjust the timing.

9 When replacing the covers make sure that the front of the bottom cover is clipped onto the chassis correctly. Also it is much easier to replace the lower cover if all the screws around the edge of the rear cover are slackened so that the rear cover can be moved back slightly. Make sure they are retightened after the lower cover has been replaced.

6.0 MOUNTING THE CELLS

6.1 PHYSICAL MOUNTING

The cells are connected electrically so that their cases float with respect to ground and also they are mounted so that the stray capacitance between the case and ground is small. We have mounted the cells in thin plastic mounts which are then bolted to the positioner. This has been found to deliver around 728ps rise time. Improving the mounts further might improve the risetime (or not).

The further apart the cells are mounted the greater the timing for the second cell will have to be adjusted as it will have to be driven slightly later. It is possible that if the cells are sufficiently apart the cabling will have to changed as there is only about 500ps adjustment internally for the pulsers.

6.2 ELECTRICAL MOUNTING

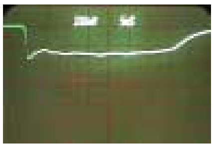
Each cell is connected to two 50Ω cables. It is important that the cells are connected around the same way so that the second cell does not cancel the first but adds to it. This is a wiring issue not a mounting orientation issue as these are transverse cells. When looking at the connector end of the cell make sure that the same connection is connected to ground for each one. The cells may be mounted with the connector ends adjacent, apart or both on one side.

It is also important that the orientation about the optical axis is the same so that the extra ordinary and ordinary rays do not swap identity from one cell to the next. Presumably one may swap identity if the wiring is reversed but we have not tried this.

6.3 DC CONNECTIONS

To aid alignment it is useful to have a DC connection to the cells. We recommend that separate DC connectors are made to each cell so that they can be activated independently. The DC connections should follow the pulsed connections regarding sense of connection etc. It is also necessary to put a resistor near the connection to isolate the cells pulsed response from the DC connection. The resistor needs to be able to hold off about 1kV and ought to have an impedance much greater than 25 ohms but not so big that the cells take a significant time to charge. E.g 1MΩ.

Figure 5 Output pulse shape one of four channels
100 volts per division and 5ns per division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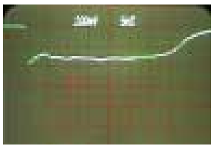
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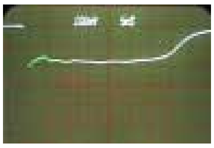
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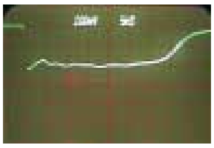
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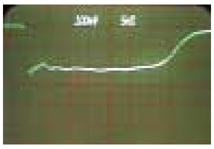
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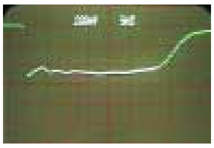
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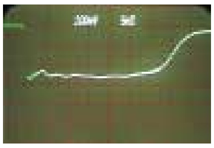
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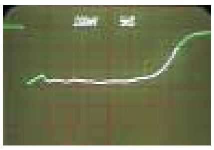
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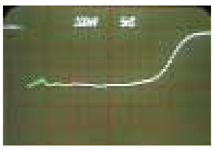
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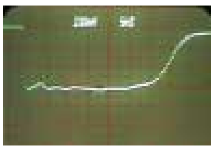
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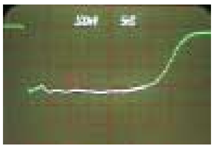
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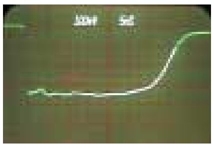
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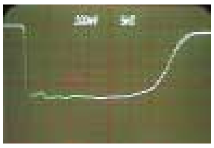
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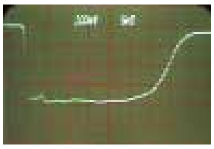
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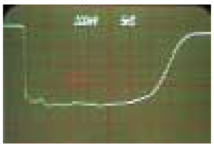
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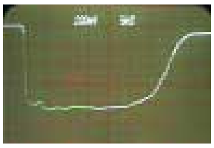
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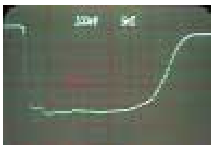
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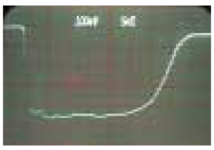
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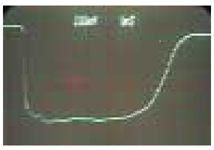
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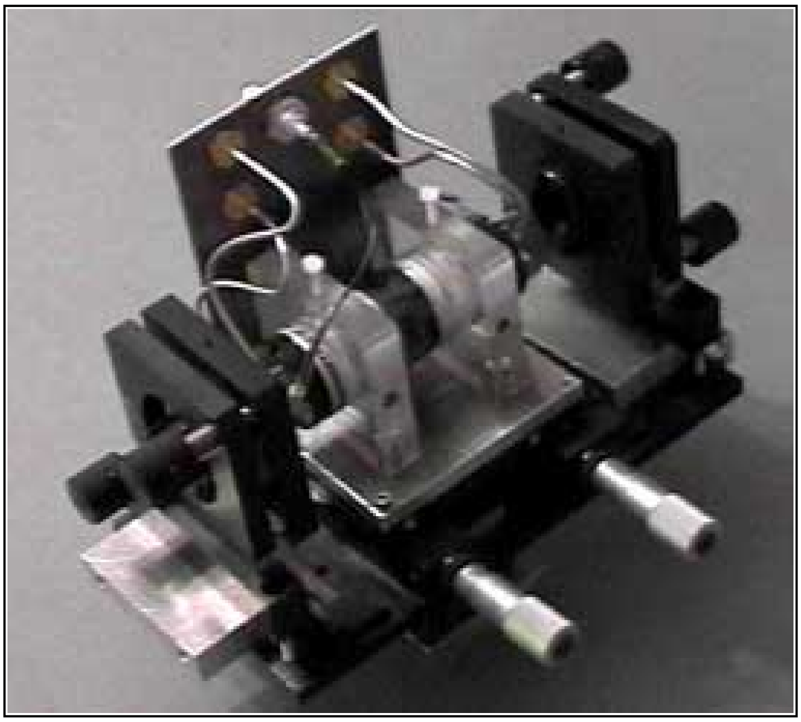

Figure 6 The head connected for testing

Figure 7 Gating off and looking for good extinction. Tested with a Kentech Gated Optical Imager with a 1ns gating module

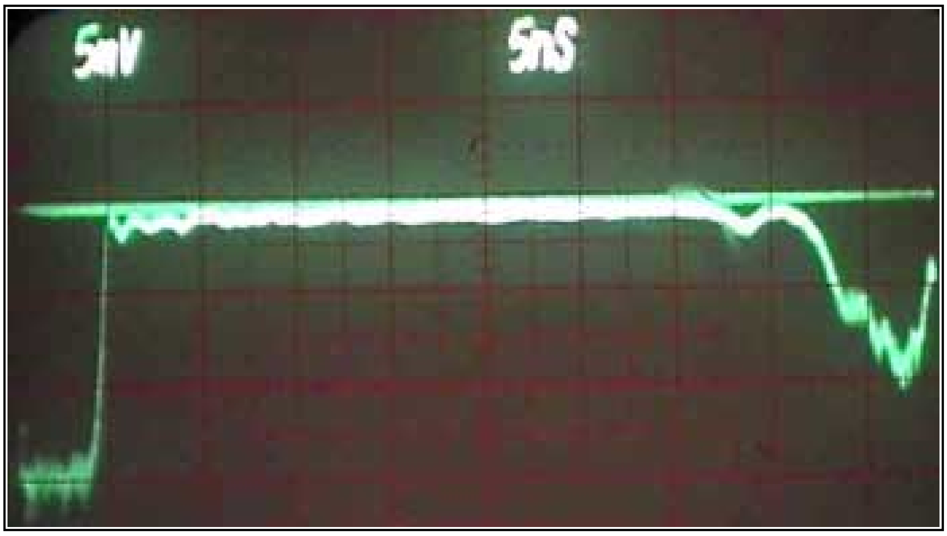

Figure 8 Testing for long term extinction. Showing that reasonable extinction persists to 30ns

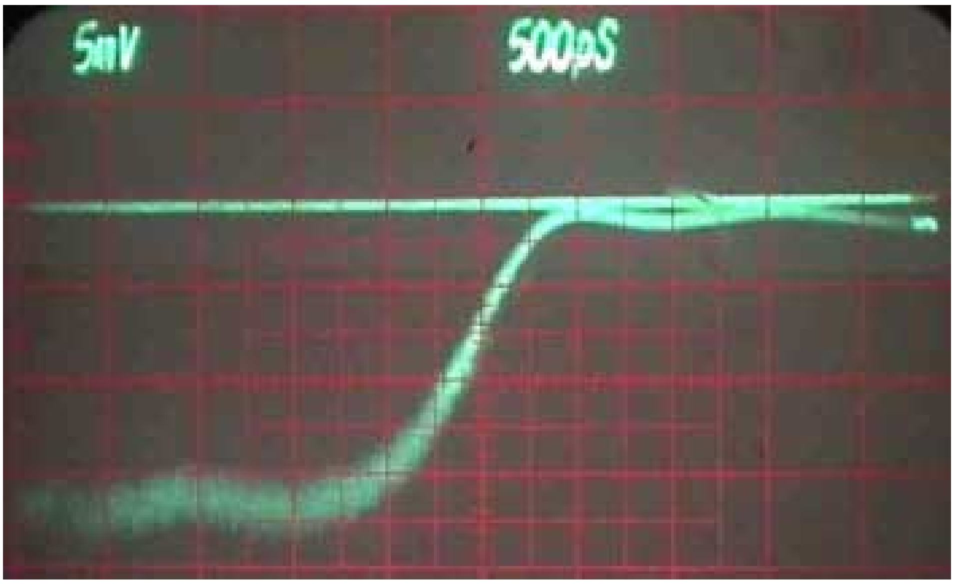

Figure 9 The gate off fall time. Measured with a Kentech Gated Optical Imager fitted with a 100ps gating module

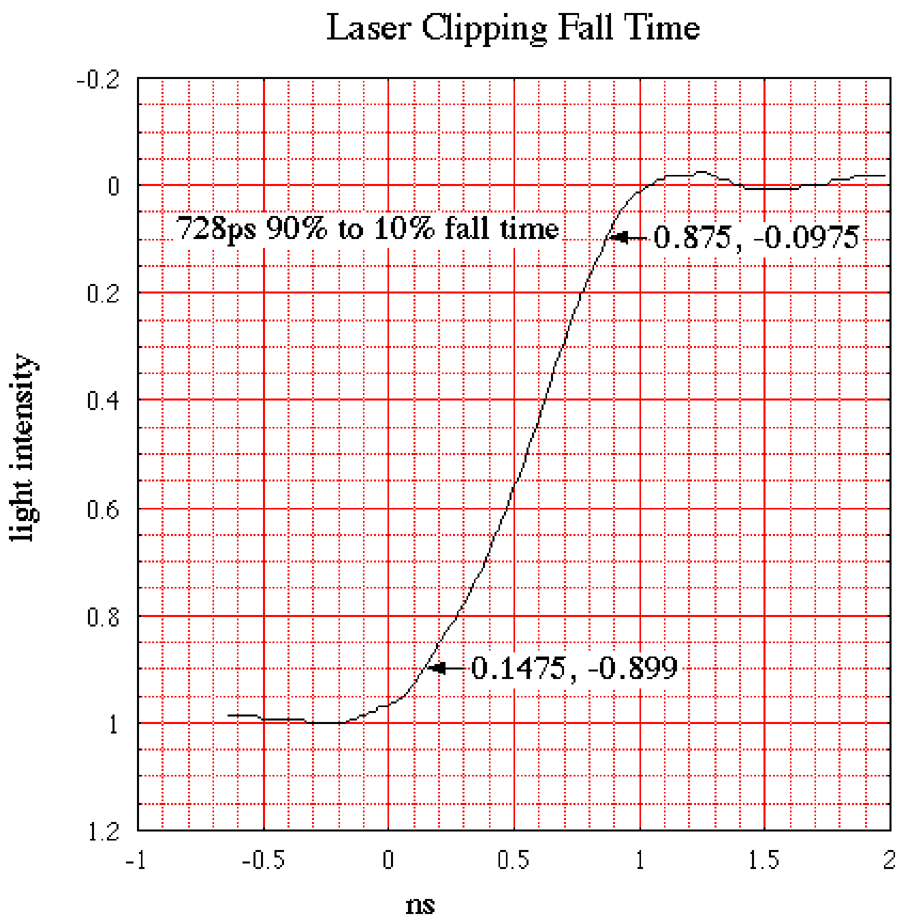

Figure 10 The gate off fall time is measured at 728ps