Kentech Instruments Ltd.

Dual Channel Pockels Cell Driver.

Principles of Operation
and
Instructions for Use

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Serial Number SN 93042

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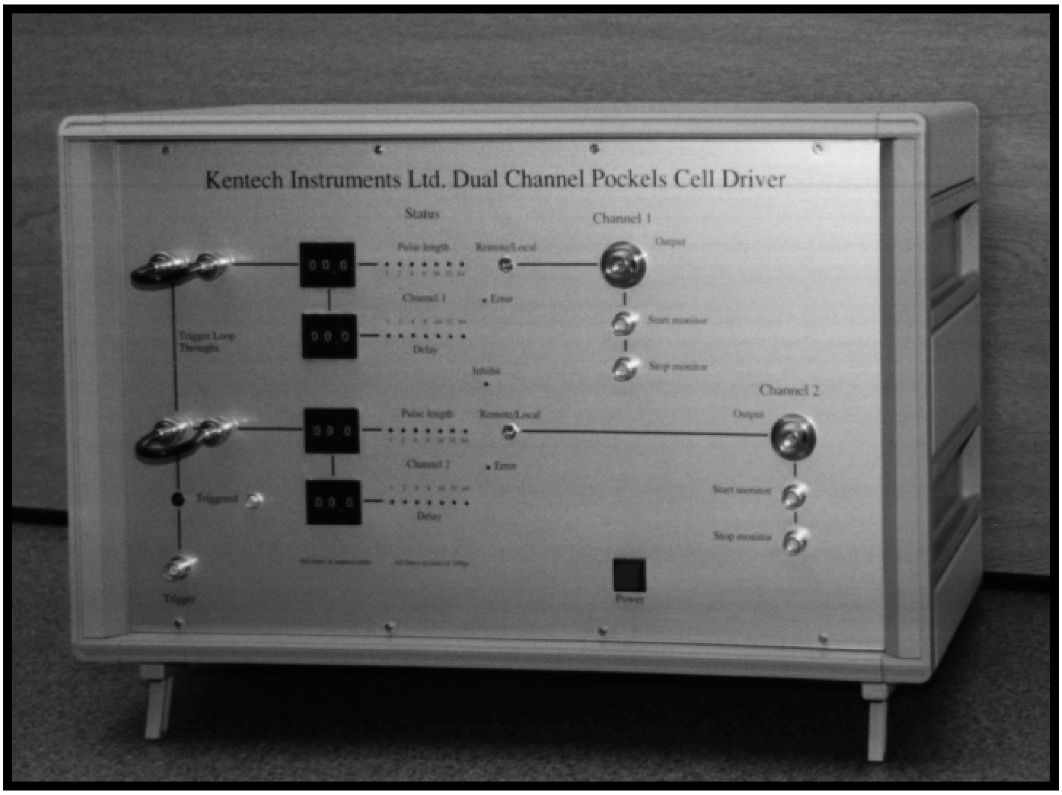


Pulse amplitude 3kV into 50Ω into 2 channels.

Ultra low inter-channel jitter, <10ps.

Pulse length adjustable in 100ps steps from ~300ps to 12.7ns

$\tau_{rise/fall}$ ~ 200ps.

Comprehensive self checking circuitry to prevent pulse length errors. Common high voltage power supply for fail safe operation.

Local and opto-isolated remote/computer controllable interface for pulse length and status.

Individual delay for each channel up to 12.7ns in 100ps steps.

Loop through triggers for longer interchannel delay or sub delay 100ps resolution.

Contents

Introduction

The Dual Channel Pockels Cell Driver is designed to provide for laser pulse chopping of two separate systems or channels with extremely low interchannel jitter. The driver is capable of supplying sufficient voltage to drive dual crystal KDP* pockels cells with lasers at 1.063µm wave length.

The system permits the selection of pulse length and delay on each channel in 100ps steps from zero (plus the internal inherent delay) to 12.7ns. The delay and pulse length are set on the front panel. In addition the pulse length may be set remotely. The remote facility is available separately for each channel. There is no remote control of the delays.

Facilities are available for the remote control to read the pulse length settings whether the channel is in local or remote mode. In addition the remote controller may inhibit the triggering of the unit and establish that pulse length and delay sections are behaving correctly.

Specification

Number of channels	2
Voltage on each channel	-3.4kV nominal see data at the end of this manual.
Pulse lengths	~300ps to 12.7ns in 100ps steps, independently on each channel. If pulse lengths are set to less than 300ps the amplitude will be reduced due to the finite risetime of the switches.
Delays	Adjustable over 0 to 12.7ns independently on each channel. (There is also in internal inherent delay) The delays to each channel may be modified by the user via the front panel loop through connectors.
Trigger input	10 volts rising in <3ns for low jitter.
Trigger to output jitter	<20ps RMS with a suitable trigger signal see data at the end of the manual.
Interchannel jitter	Too small to measure on Tektronix 7000 sampling systems, may be measurable in the laser pulse with streak cameras.
Pulse length jitter	as interchannel jitter.
Inherent minimum delay	With loop through cables supplied with the unit 48ns
Synch. Output	>80 volts into 50Ω rising in ~250ps approx. 32 ns before main outputs with supplied loop through cables.
Maximum repetition rate	>100Hz.
Connectors	
main outputs	"N" type
trigger input	BNC
monitors	BNC
trigger loop throughs	BNC
Synch. output	SMA
Remote interface	Full control of pulse lengths and remote interrogation of pulse length and error status. Remote inhibit and remote interrogation of inhibit state.
Power requirements	85 to 264 volts A.C. 47 to 440Hz. or 110 to 340 volts D.C. 2 amp fuse, via IEC rear panel connector.

Principal of operation

A general layout of the unit is shown in the figure opposite.

Main outputs

The main outputs of the unit are based upon two pairs of Kentech PBG pulse cards. Each PBG pulse card is capable of delivering >6kV into 50Ω. The waveform from a card is not suitable for pulse chopping directly. The pulse has a fast rise but a slow decay. In order to produce a rectangular pulse shape, the outputs from two cards are combined with suitable delays. One card switches on and the other off. This is very wasteful of power, the voltage being reduced by a factor of two, but does provide a nice method of pulse length control via the trigger timing of the turn off card.

Trigger Levels

In order to maintain low jitter amongst the four output cards, the trigger levels are maintained at a respectable level with >1kV going into each output card. In order to avoid the complexity of making 1:2 transformers, triggers are simply split to generate the four trigger signals. This means that the initial trigger level is considerably higher. A Kentech CPS card delivering 2kV into 50Ω is used as the main trigger and this is amplified to >2.5kV into 25Ω in a Kentech HMPS card. This has two synchronous outputs into 50Ω.

Delays

Each channel has its own delay control permitting delays to be varied by 12.7ns in 100ps steps. In addition the trigger signal to each channel is fed to the front panel and looped back into the unit. This permits the user to change the delay further or put in different interchannel delays as required. The trigger signal here is >2kV. Very long delay cables may attenuate the signal too much and can lead to misbehaviour.

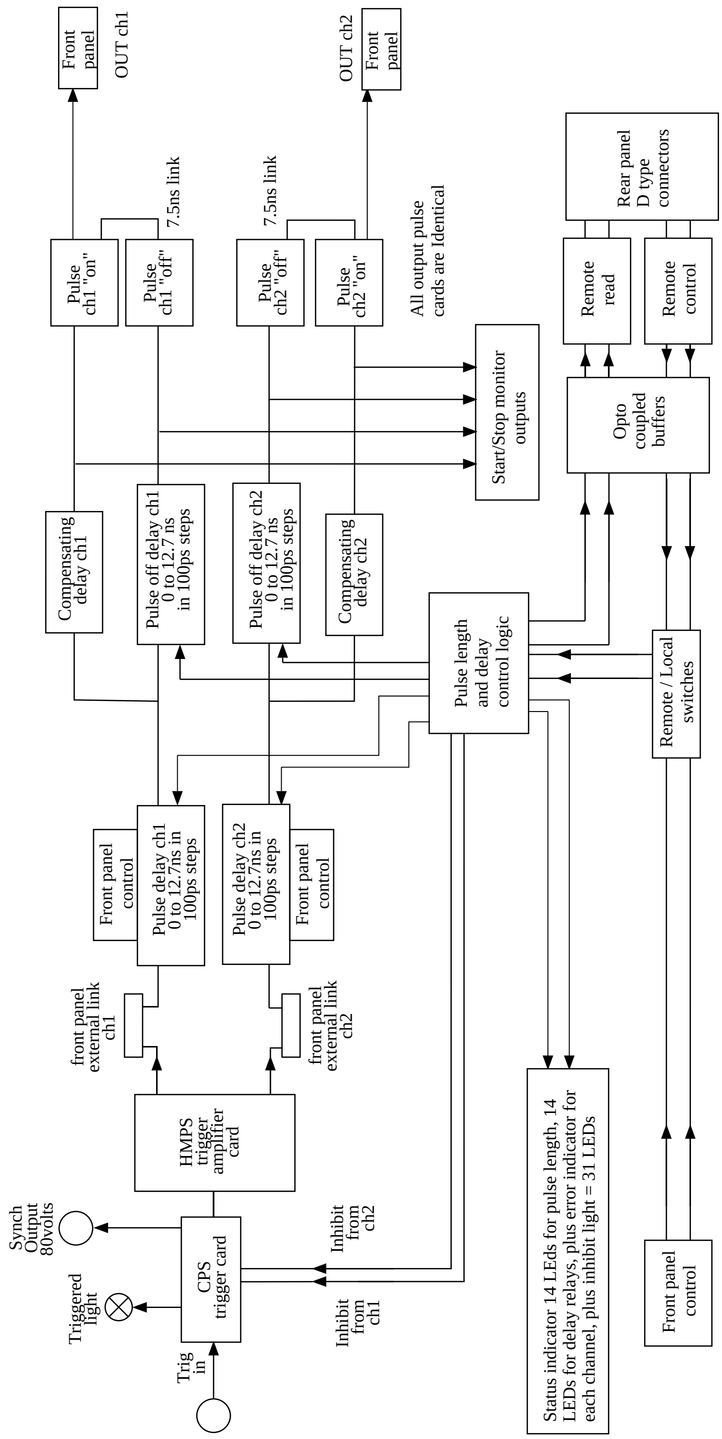
Delay Elements for Pulse Length Control and Channel Delays

To generate delays of several nanoseconds at pulse voltages of >2kV relays and delay lines are employed. This provides a very stable delaying technique and maintains the high trigger level that is required to keep interchannel jitter very low. Each successive relay in a module can switch in twice as much delay as the previous one, from 100ps to 6.4ns. This gives binary control of the delay via a seven bit control word.

Failure modes

Great care has been taken in the design to ensure that failures cannot result in a long gate pulse. Such an occurrence may result in the damage to optical components in a laser system set up for short pulse operation. Whist every eventuality cannot be accounted for, several have been addressed.

In particular if either the "turn on" card or the "turn off" card fails to trigger at the correct time the output pulse may be up to 15ns. If the turn on card fails the output polarity will be positive instead



General layout of the pulse generator

of the normal negative and the amplitude will only be about 2kV giving only about 80% transmission from the pockels cell. In addition the pulse will start at the normal stop time

All the pulse cards operate from a single high voltage power supply that is distributed amongst them. Consequently there is no possibility of the supply to one card failing unless the cabling is damaged. In addition all the DPCO relays that control the pulse length have their contact position monitored by injecting DC through the same relay contacts as are used to delay the trigger pulses. If the position of the contact does not correspond to the setting on the front panel (or in remote mode, to the remote input) then error signals are generated and the triggering of the unit inhibited. That this is operating can easily be seen when changing a setting. During the setting the error and inhibit LEDs will flash as the relays change over. These flashes are normal and should be confused with a true error signal.

The front panel display gives the status of every relay. By comparing these to the settings one can establish, in a fault condition, exactly which relay has failed. We have had no relay failures during the testing and setting up of this unit.

If either channel fails then the pulser is inhibited. If the user wishes to use the channel that has not failed then it will be necessary to set the failed channel in such a way that the error is not noticed, i.e. if a relay has welded one way then the settings should be made such that the relay should be that way. As long as the relay fails in this mode the other channel will be available. If a relay fails open circuit in both directions or shorts out to both outputs then it will not be possible to use the unit until the relay is replaced.

The only reasonable failure left is when one pulse generator card fails whilst the other is OK. There is no simple way to check this. The cards are however, very reliable and not prone to failures of this type. In spite of this Kentech Instruments cannot take responsibility for any damage, however, caused, by the use of this equipment. In very critical situations it may be wise to monitor the width of a low energy shot first although this cannot offer a complete guarantee of performance.

Changing Delay or Pulse Length Settings

The trigger pulses within the unit have to pass through many delicate relays. These relays are able to maintain a high breakdown voltage but are not designed to carry high currents and certainly not to switch high currents. We strongly advise that the unit is not triggered whilst the relays are being manipulated. When in local mode this can be accomplished by removing the trigger source. In remote mode, however, when this is not easy, the unit may be inhibited via either of the channel control inputs. The remote control unit may also interrogate the unit to establish that the unit is inhibited before changing any relay settings.

Note that the removal of one or both of the remote control cables from the rear of the unit will change the pulse length settings to their minimum (if the channel is set to remote). Consequently this should not be done when the unit is being triggered.

Use

General

The unit is very simple to use. Plug it in to the mains, connect loads to the main outputs, turn on and then apply a trigger pulse to the trigger input. Note that the "N" type output connectors will break down if they are not well mated to "N" type plugs. This can be avoided by using a short pulse length. So, if only one channel is required set the pulse length on the other to zero. If the connector breaks down there is unlikely to be any damage to the pulse circuits but eventually the insulators on the output connectors will be damaged such that they will not work with a mated connector.

Try not to change any settings or change connections to the unit whilst it is being triggered.

Use with a Pockels cell

The unit is designed to drive pockels cells at around 3kV and so is suitable for double crystal KDP* devices at 1.053µm or single crystal at 0.5µm. The non-linear response of the pockels cell to the applied voltage mean that the waveforms are smoothed near the peak and that post pulse noise is quite suppressed. The data at the end of this manual indicates what would be obtained with a perfect pockels cell having a $\lambda/4$ of 3.4kV and illuminated with a 20ns "Q" switched pulse. Note that for the longer pulse lengths the effect of the incident pulse envelope is significant. All the figures assume that the central part of the "Q" switched pulse is chopped out. For longer pulse lengths it will be necessary to trigger the unit earlier with respect to the incident pulse to use more effectively the available laser energy.

Monitor and Synch. Outputs

There are two monitor outputs for each channel. These deliver about 25volts in a 0.5 ns pulse. The timing of the pulses from the four outputs indicate the time that a pulse card is triggered. The pair for each channel are labelled "start" and "stop" monitors.

The main pulse is formed by linking two pulse cards with a cable about 7.5ns long (i.e. having a round trip time of 15ns, somewhat more than the maximum pulse length). The main output is taken from the "on" pulser consequently for a short pulse length the "off" card is triggered up to 7.5 ns before the "on" card.

When using the monitor outputs to establish the correct timing of the pulse cards it must be remembered that the off pulse has to travel the extra 7.5ns to the main output.

The "Synch." output is available from the SMA connector on the front panel. The waveform is shown in the data section at the end of this manual. This is a fairly large pulse, around 100volts peak and quite high for >20ns. This pulse is intended to be used to trigger various diagnostic equipment and has enough power to be split up several times and sent long distances.

Remote Control and Remote Interrogation

Introduction

The unit offers remote control of the pulse length setting of each channel, remote interrogation of each channel whether in "local" or "remote" mode, remote trigger inhibit and remote interrogation of error signals and inhibit status There are two rear panel connectors, one for each channel. Both error signals, the inhibit status and inhibit input are available on each channel.

Remote Control of Pulse Length Settings

The pulse length is set remotely by switching the relevant channel to "remote" on the front panel and then driving the opto-isolated diodes connected to the rear panel remote control inputs.

Setting the pulse length needs a seven bit binary word to permit all pulse lengths to be selected. In addition each remote input channel has an inhibit input which will stop the pulse generator triggering. Note that there is only an overall inhibit, individual inhibition of the channels is not available, although there is an inhibit input on each remote control channel.

In order to change the pulse length setting remotely the following sequence is recommended.

1 Establish that the unit is not in use.
2 Send a continuous inhibit signal to either channel
3 After about 1µs read the inhibit line.
4 Set the pulse length or lengths required.
5 After several ms read the pulse length, error signals.
6 If 5 is OK then turn off the inhibit signal.
7 Read the inhibit status after a few µs.

Remote Interrogation

In addition to remote control, remote interrogation is also available. This operates whether the channels are in local or remote mode. The pulse length on each channel may be read as well as the error status of each channel and the inhibit status. The inhibit status is on overall status but is available on each channel of the remote output. Similarly both error codes are available on each channel remote control connection.

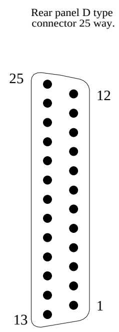
If only two 8 bit words are available for reading then the user will have to decide whether reading the error signals (one on each channel is preferable to reading the inhibit status. Note that a remote inhibit does not generate an error signal, only an inhibit status output.

Remote Interface.

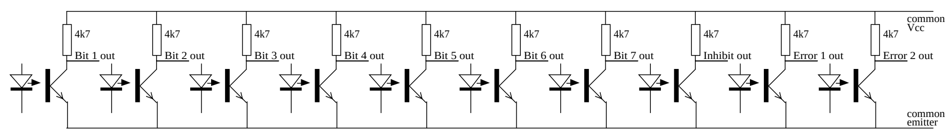
All remote connections to the unit are made via opto-isolators housed in a screened box in the rear of the unit. Write lines need to drive photodiodes and read lines are open collector outputs with a common pull up supply pin which may be used if required. All read and write lines work DC. There are no latches or clock signal to worry about. This has been done to reduce the possibility of any of the pulse outputs upsetting the system or getting into the remote control unit. The grounds for the remote control are isolated from the pulser ground.

Remote control connections are via two 25 pin D type connectors on the rear panel, one for each channel. The pin out is

pin number	use
1	Common emitter
2	Common Vcc
3	bit 1 out LSB
4	bit 2 out
5	bit 3 out
6	bit 4 out
7	bit 5 out
8	bit 6 out
9	bit 7 out MSB
10	inhibit out
11	error ch1 output
12	error ch2 output
13	not used
14	Common cathode
15	Inhibit input
16	bit 1 in LSB
17	bit 2 in
18	bit 3 in
19	bit 4 in
20	bit 5 in
21	bit 6 in
22	bit 7 in MSB
23	not used
24	not used
25	not used

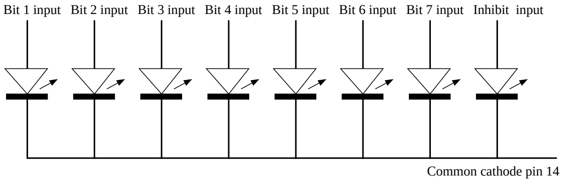


The ten outputs are configured as shown:-



The diodes are driven when the relays introduce extra delay, or when an error signal or inhibit is detected; so the outputs are active low. If the user wishes not to have a common pull up on the open collector outputs the 10 resistors in DIL packages are easily removed, (consult the factory).

The eight inputs are:-

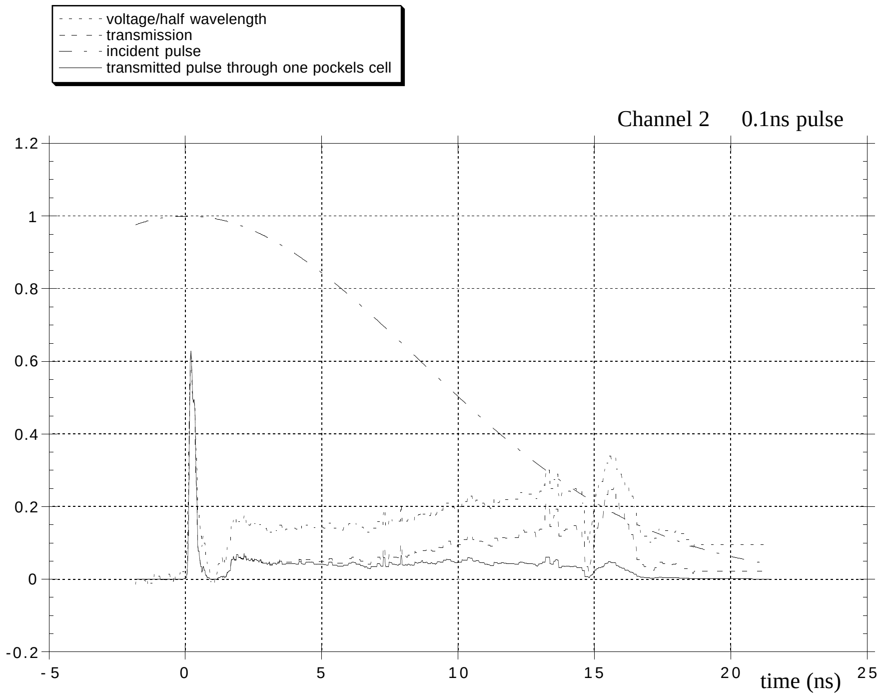


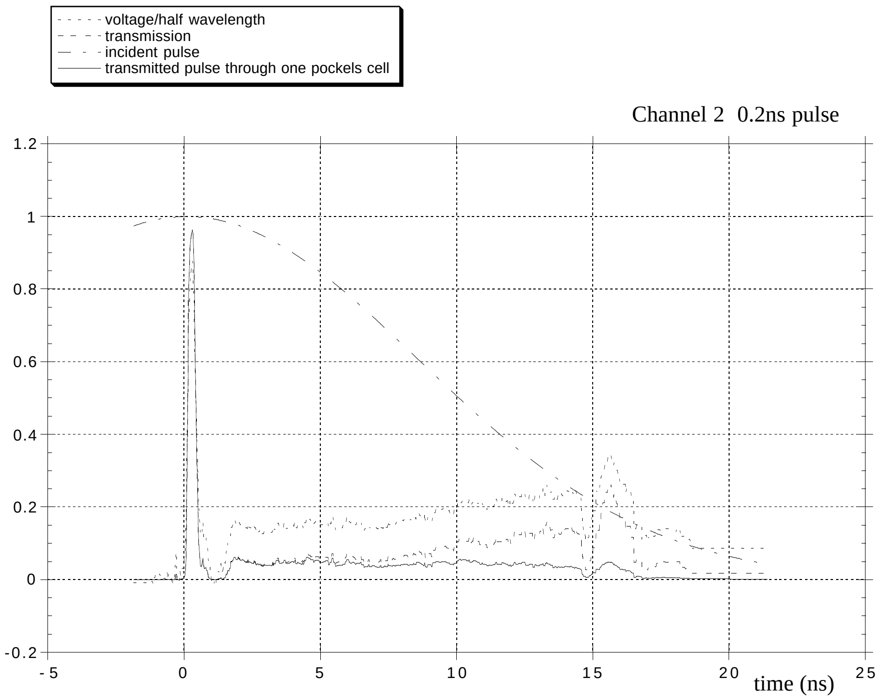
The relays and inhibit are driven when the diodes are driven; so the input is active high.

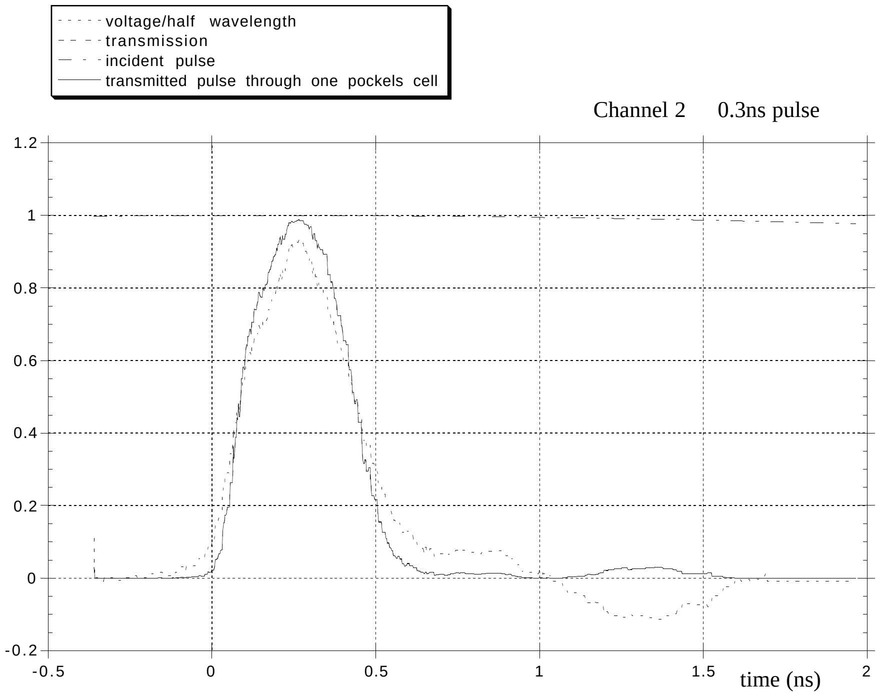
The opto decoupled diodes do not have current limiting resistors in series with them. They will take 80mA but will operate at a few mA. The diodes have a common ground but it is isolated from all other grounds including the other channel.

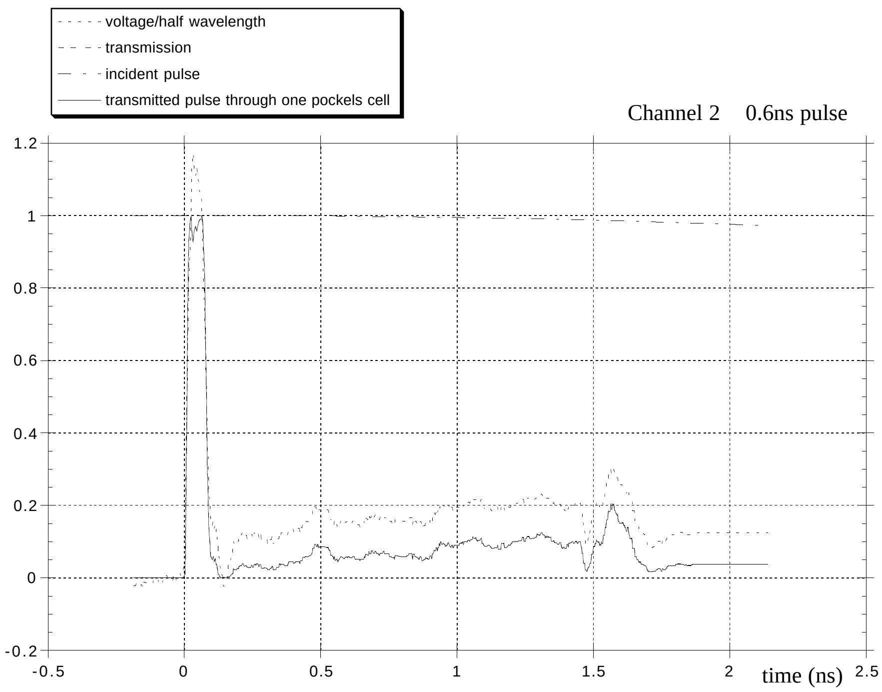
Pulse and Transmission Characteristics of the Kentech Dual Channel Pockels Cell Driver.

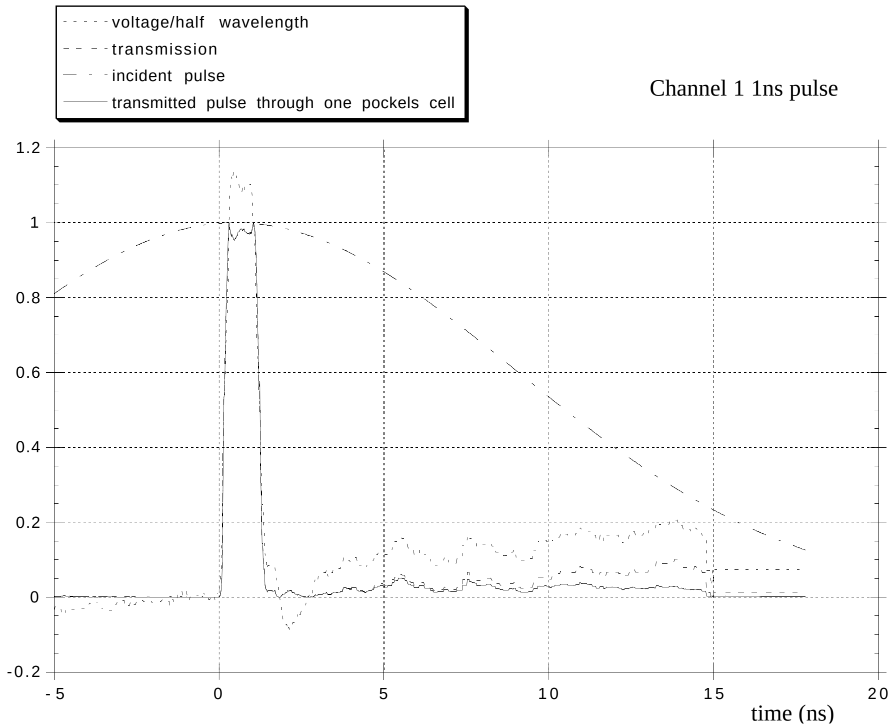
The following data has been obtained with Tektronix™ 7000 series sampling equipment and Barth™ attenuators. The pockels cell transmission was approximated by assuming the transmission was related to the applied vltage according to $T=Sin^2((V/V_{\lambda 1/2})\pi/2)$. No attempt has been made to correct for the finite bandwith of a pockels cell. The transmited pulse shapes assume that the incident pulse is a 20ns (fwhm) gaussian beam. For longer pulse lengths it is advantageous to start switching out ealier in the pulse

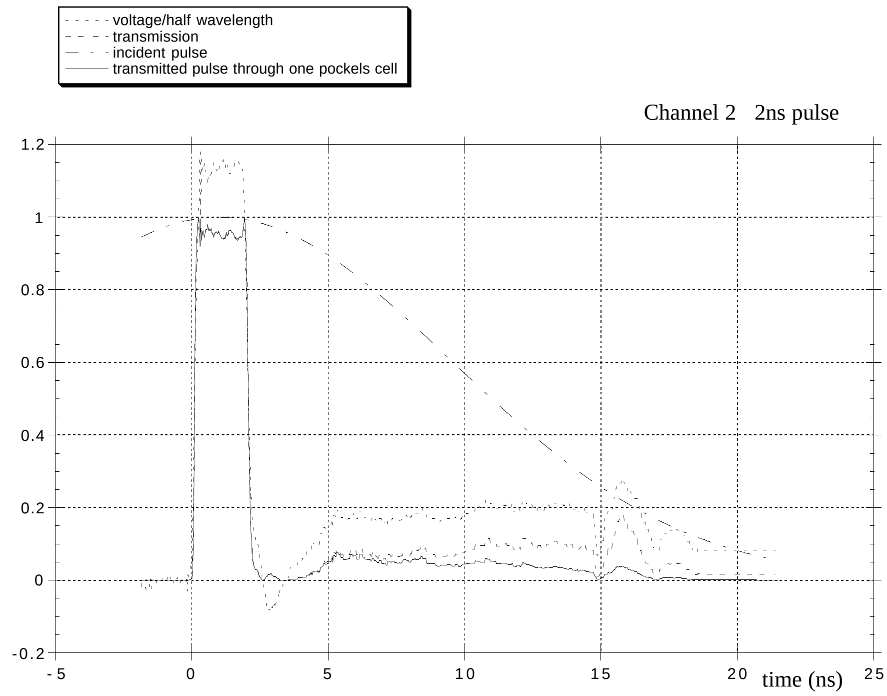

voltage/half wavelength
transmission
incident pulse
transmitted pulse through one pockels cell
Channel 2 0.1ns pulse
1.2
1
0.8
0.6
0.4
0.2
0
-0.2
-5
0
5
10
15
20
25
time (ns)

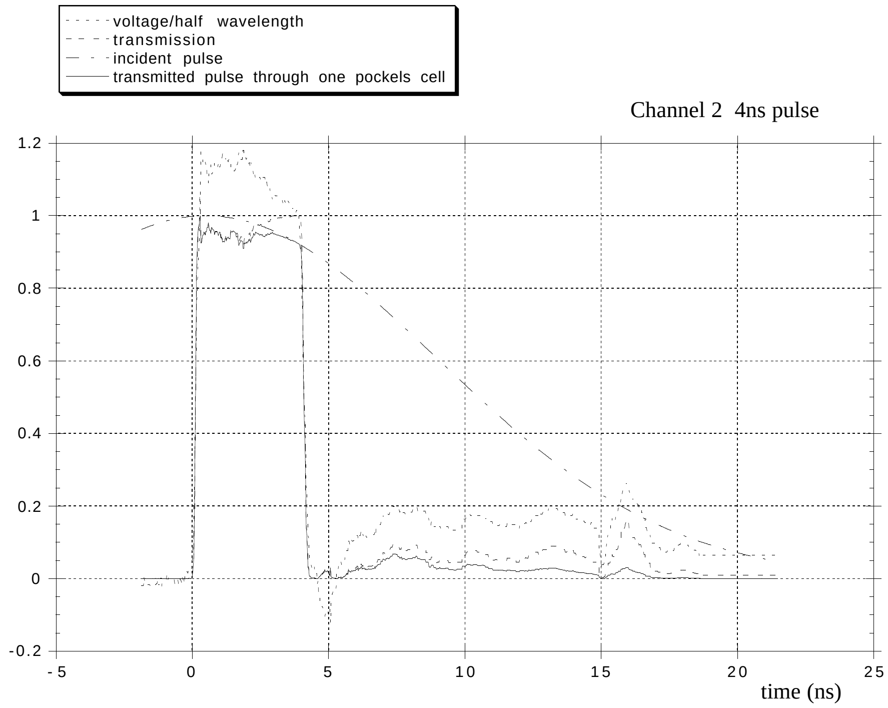

voltage/half wavelength
transmission
incident pulse
transmitted pulse through one pockels cell
Channel 2 0.2ns pulse
1.2
1
0.8
0.6
0.4
0.2
0
-0.2
-5
0
5
10
15
20
25
time (ns)


voltage/half wavelength
transmission
incident pulse
transmitted pulse through one pockels cell
Channel 2 0.3ns pulse
1.2
1
0.8
0.6
0.4
0.2
0
-0.2
-0.5
0
0.5
1
1.5
2
time (ns)

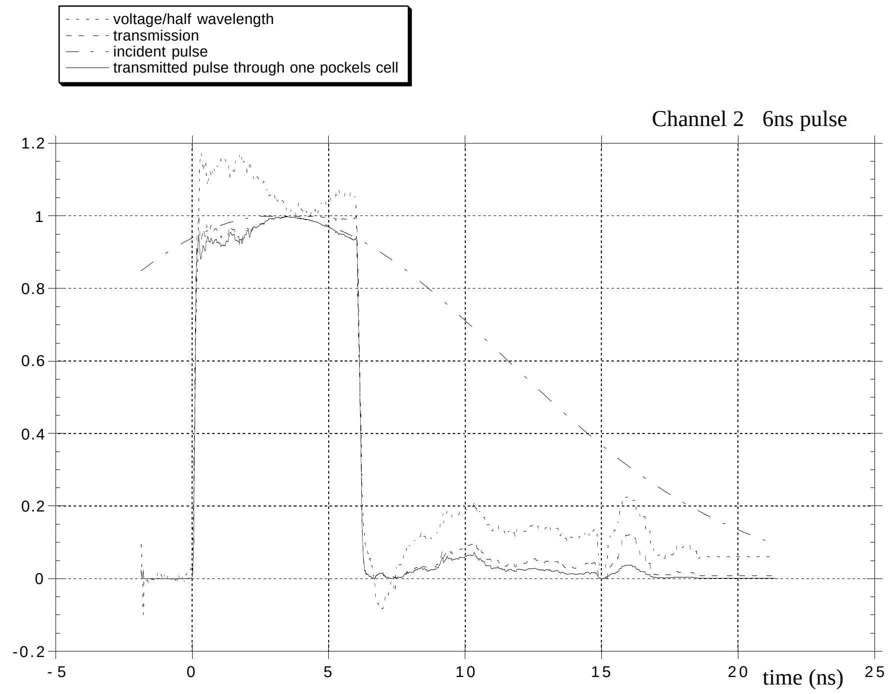

voltage/half wavelength
transmission
incident pulse
transmitted pulse through one pockels cell
Channel 2 0.6ns pulse
1.2
1
0.8
0.6
0.4
0.2
0
-0.2
-0.5
0
0.5
1
1.5
2
2.5
time (ns)


voltage/half wavelength
transmission
incident pulse
transmitted pulse through one pockels cell
Channel 1 1ns pulse
1.2
1
0.8
0.6
0.4
0.2
0
-0.2
-5
0
5
10
15
20
time (ns)

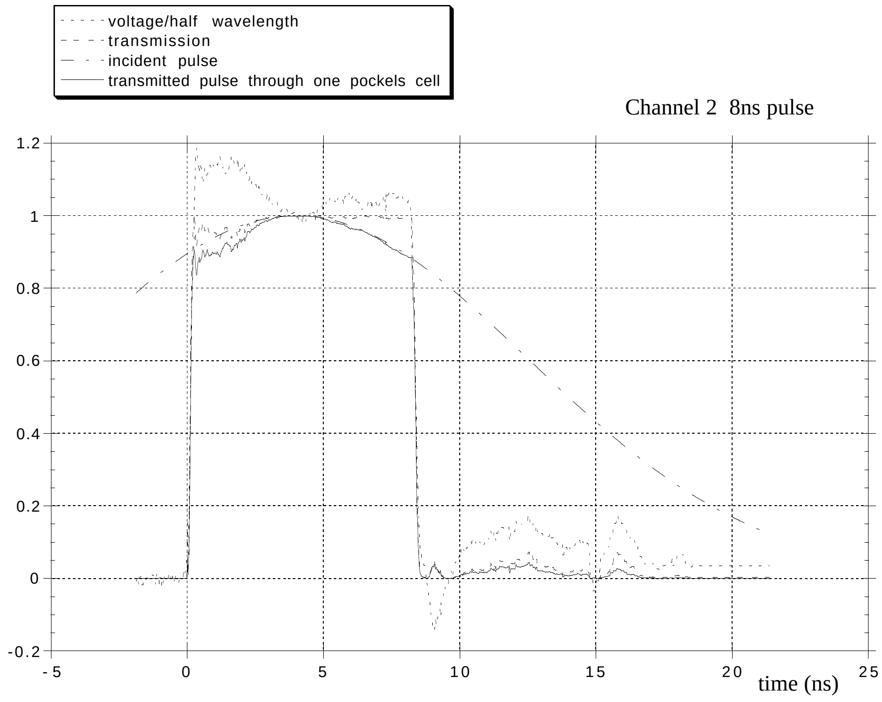

voltage/half wavelength
transmission
incident pulse
transmitted pulse through one pockels cell
Channel 2 2ns pulse
1.2
1
0.8
0.6
0.4
0.2
0
-0.2
-5
0
5
10
15
20
time (ns)
25

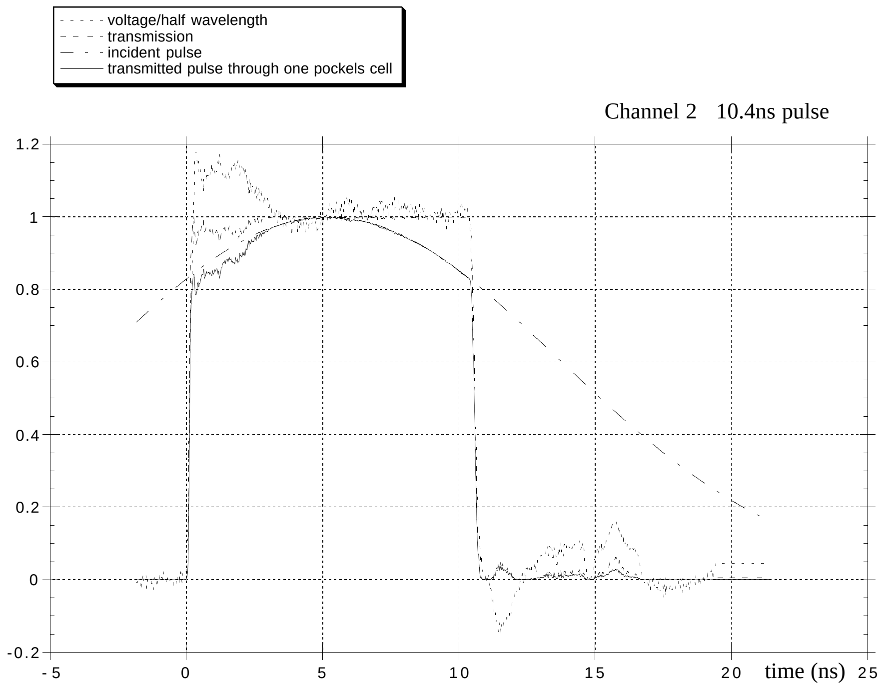


voltage/half wavelength
transmission
incident pulse
transmitted pulse through one pockels cell
Channel 2 4ns pulse
1.2
1
0.8
0.6
0.4
0.2
0
-0.2
-5
0
5
10
15
20
25
time (ns)

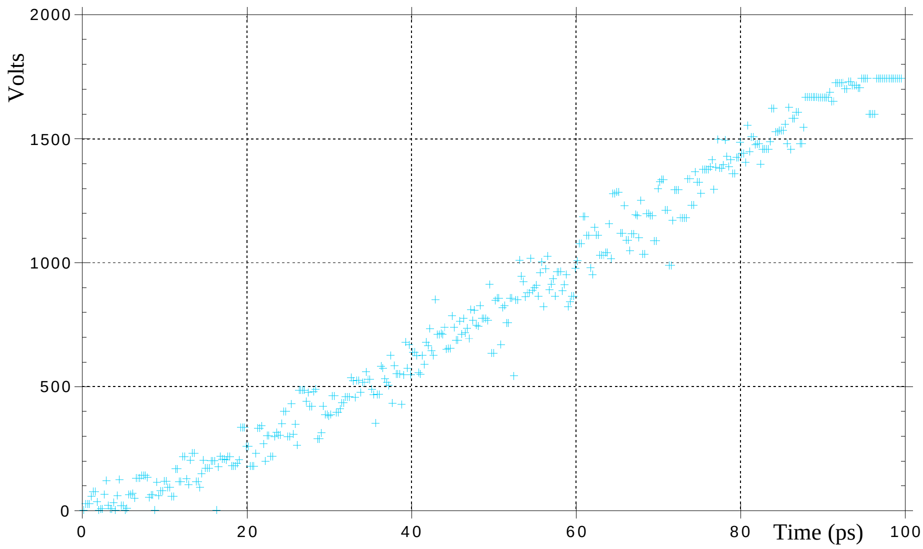


voltage/half wavelength
transmission
incident pulse
transmitted pulse through one pockels cell
Channel 2 6ns pulse
1.2
1
0.8
0.6
0.4
0.2
0
-0.2
-5
0
5
10
15
20
25
time (ns)


voltage/half wavelength
transmission
incident pulse
transmitted pulse through one pockels cell
Channel 2 8ns pulse
1.2
1
0.8
0.6
0.4
0.2
0
-0.2
-5
0
5
10
15
20
25
time (ns)


voltage/half wavelength
transmission
incident pulse
transmitted pulse through one pockels cell
Channel 2 10.4ns pulse
1.2
1
0.8
0.6
0.4
0.2
0
-0.2
-5
0
5
10
15
20
25
time (ns)

Channel 2 jitter with respect to input trigger



Synchronisation Output