Kentech Instruments Ltd.

Programmable Pockels Cell Driver

SN J08*****

4th. September 2008

Kentech Instruments Ltd., Isis Building, Howbery Park, Wallingford, OX10 8BA, U.K.

RF emissions and EC directive 89/336/EEC

This equipment is a research tool that has been intentionally designed to generate short high energy electromagnetic pulses and the EM emissions will be highly sensitive to the load applied by the user, for example the radiation just from some types of output cable may exceed EC permitted levels.

The emissions from the pulser itself have been tested and found to be within certain EC limits, see the Declaration of Conformity. These tests were performed with a dummy load on the output. The level of RF radiation generated by the circuit boards within the instrument is inevitably high but the emissions are largely contained by the instrument enclosure. It is therefore very important that all fasteners are securely fastened, do not operate the pulser with the covers removed. The pulser may still interfere with sensitive equipment at short range.

We believe that with this type of unit it has to be the system builders responsibility to verify that his pulser/load system complies with the EC directive unless the system is used in a screened electromagnetic environment.

We are not able to guarantee compliance with arbitrary loads but to minimise emissions we recommend:-

1) that any load is fully contained within a conductive metal screened box, with all joint surfaces gasketed or fitted with conductive fasteners at less than 5cm intervals.

2) that the load is connected to the pulser output with semi-rigid cable, the cable outer must be carefully connected to the N type output connectors at one end, and must be connected directly to the screened box containing the load at the point of entry. Flexible cables should only be used with caution, in particular RG303 type cable will need additional screening to control emissions.

Declaration of Conformity

We:- Kentech Instruments Ltd
Isis Building, Howbery Park, Wallingford, OX10 8BA, U.K.

Certify that this apparatus:-

Kentech Programmable Pockels cell driver
serial no. J08***** only.

Conforms with the protection requirements of European Community Directives:-

73/23/EEC	Low Voltage Directive
89/336/EEC	Electromagnetic Compatibility Directive
93/68/EEC	CE Marking Directive

The following harmonised standards have been applied:-

BS EN55011 Emissions Specification (Group 2 Class A)
Industrial, Scientific and Medical equipment

BS EN50082-2 Generic Immunity Standard
Part 2 Industrial

BS EN 61010-1 Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use

The following documents contain additional relevant information:-

Kentech file reference J08*****

Name: A. K. L. Dymoke-Bradshaw
Signature:

On behalf of Kentech Instruments Ltd

Position: Director Issued: 4th. September 2008

PLEASE READ THIS MANUAL CAREFULLY BEFORE USING THE PULSER

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.

1 INTRODUCTION

This manual describes the operation and use of the Programmable Pockels Cell Driver. This driver is intended for use with one (or possibly two) pockels cells with a half wave voltage up to ~ 3.7kV. A very large number of wave forms can be generated within the following constraints: monotonically rising amplitude, steps speeds down to ~250ps, record lengths to > 6ns. There are 48 programmable steps which have one of six amplitudes, each step may be programmed to arrive at the load with a precision of ~10ps (jitter is ~10ps rms). After the 7ns record length the voltage is undefined but will be <4kV.

1.1 SPECIFICATIONS

1.1.1 GENERAL

Voltage range	approximately 0 to -3.7kV into 50Ω. Maximum repetition rate 40Hz.
Trigger input	5 volts 10ns f.w.h.m. into 50Ω for sub 100ps jitter. A somewhat larger and faster signal will result in improved jitter.
Synchronisation Output	-3.9 volts 14ns wide pulse into 50Ω approximately 8ns after trigger pulse.
Main outputs	~~9ns after trigger pulse*.~~
Power input	Universal
	85 to 264 volts A.C. at 47 to 440Hz.
	3.15 amp fuse, type T (anti-surge)
	This unit contains an auto-resetting thermal trip rated at 70°C
	Maximum average power consumption 25watts.

1.1.2 INDICATORS

Power	LED	Green
Triggered	LED	Yellow
Trigger Enabled	LED	Yellow
RS232 Active	LED	Green
Ethernet Active	LED	Green

1.1.3 FRONT PANEL CONNECTIONS

Trigger input	BNC
Sychronisation output	BNC
Trigger enable	Lemo Series 00 Short to enable, 5V on centre.
Main output	N type
Control interface	RS232 on 15 way D type connector and Ethernet on RJ45 connector.

1.2.4 REAR PANEL CONNECTIONS

Power inlet	IEC 85 to 264 volts A.C. at 47 to 440Hz.

1.1.5 FRONT PANEL CONTROLS

Power	Rocker switch
Control interface	Lockable toggle switch
Power Up Waveform	4 position Rotary switch

1.1.6 REAR PANEL CONTROLS

Boot Enable	Recessed momentary action push switch

2 GETTING TO KNOW THE INSTRUMENT

The programmable pockels cell driver consists of 48 small avalanche step generators. The steps are fast rising (~200ps) and last for more than 7ns. These are nominally identical and each is triggered from a common trigger generator via programmable delay generators. The 48 pulsers are configured onto 8 cards, each with six pulsers. Each group of six is combined resistively into two outputs, three pulsers driving each output. The combining is done in such a way that

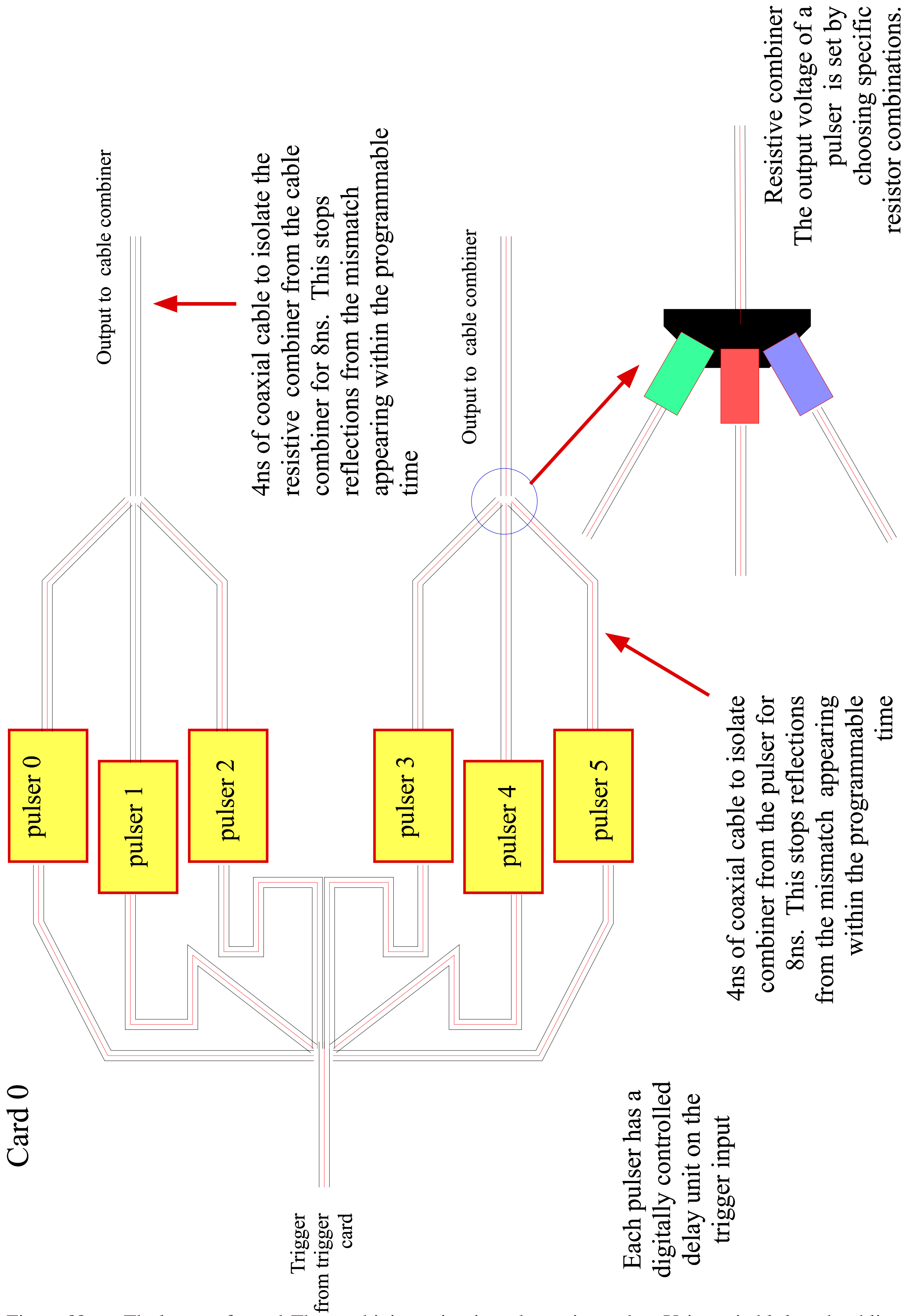
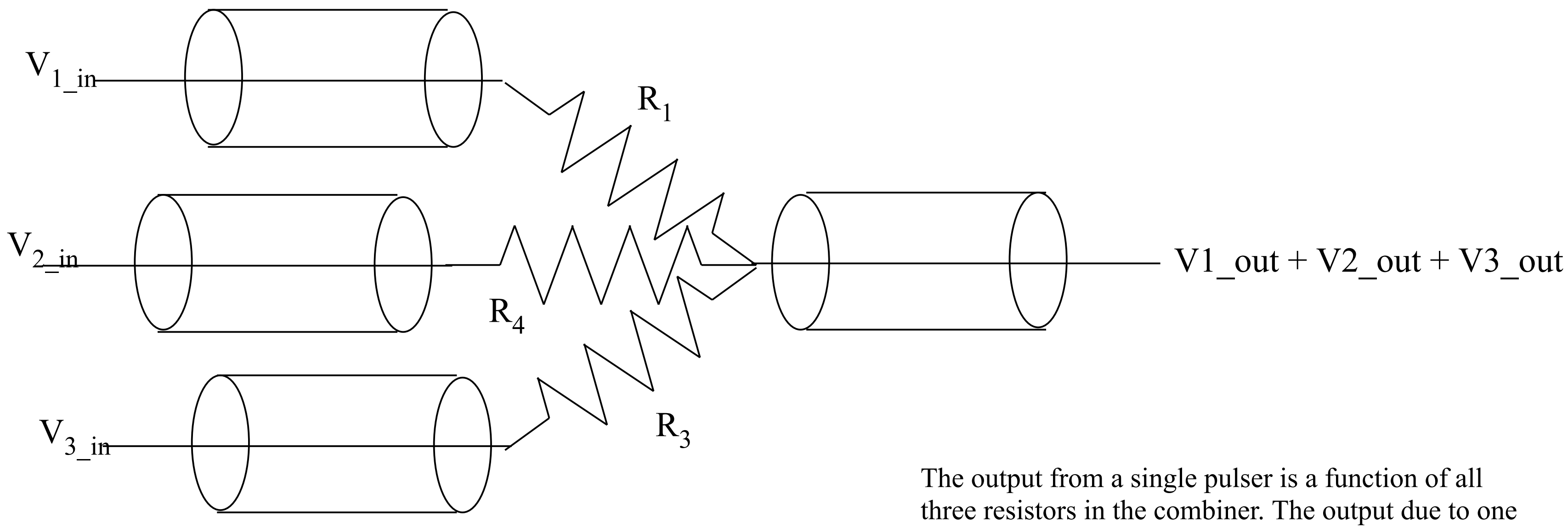


Figure ?? The layout of a card. The combining points introduce mismatches. Using suitable length cabling between the mismatches moves the reflections until after the 6ns programmable duration of the output.



The output from a single pulser is a function of all three resistors in the combiner. The output due to one pulser will be higher if the outputs from the other two, in set of three, is lower.

We have used iterative processes to arrive at the optimum resistor values to obtain the output voltages specified.

The combining resistors are made from pulse withstanding resistors; up to three are used at any one position to fine tune the output voltage.

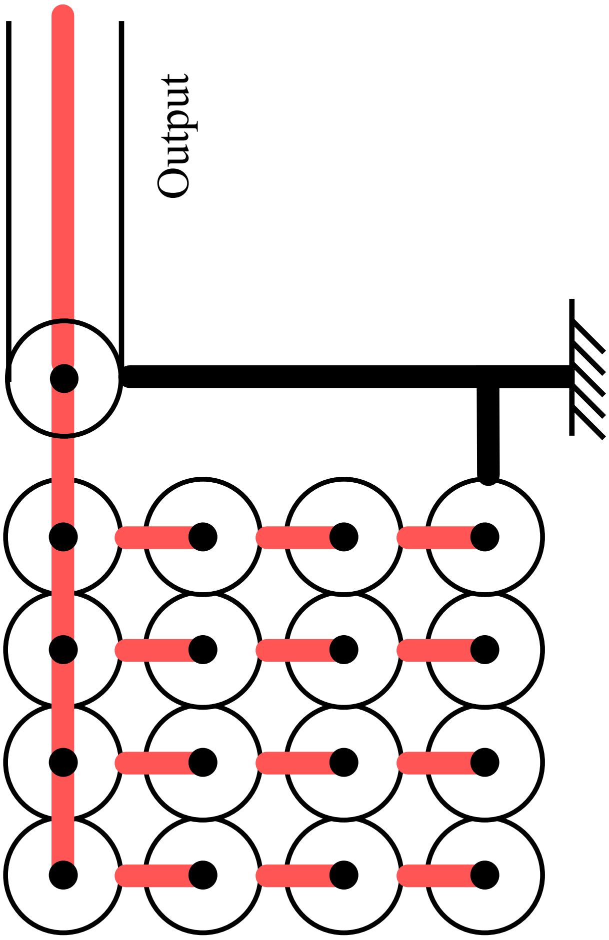
$$V_{n\_out} = V_{n\_in} \times Z_{n\_out} / (Z_{n\_out} + R_n)$$

where

$$1/Z_{n\_out} = 1/Z_0 + 1/(R_{n'} + Z_0) + 1/(R_{n''} + Z_0)$$

where $R_{n'}$ and $R_{n''}$ are the other two input resistors and Z_0 is the characteristic cable impedance (50Ω).

Figure?? Equations regarding the resistive combiner.



16 output cables from the 8 pulse cards are combined in a series parallel array to drive the 50Ω ouput. This arrangement is only matched if all the incident pulses are the same, which generally they will not be. Reflections from the mismatch reappear after ~8ns having been isolated by the length of the cabling from the card to the combiner.

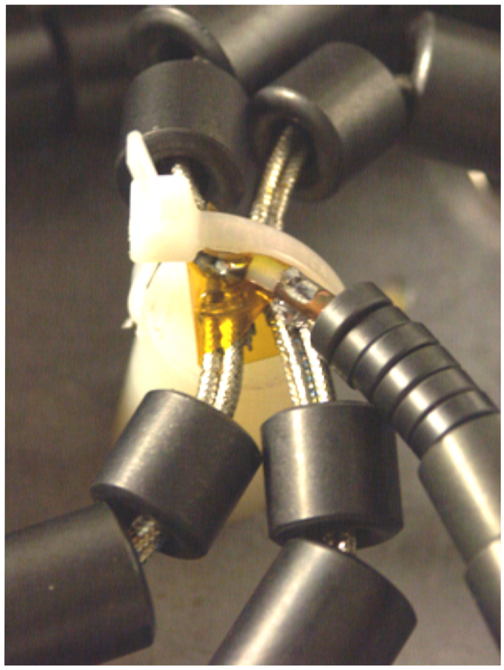


Figure ??   The cable combiner

from each card each pulser delivers a different voltage to the load. Nominally, the pulsers on a card will deliver voltages, 20, 40, 60, 80, 100, 160 volts. See figure?? The 16 outputs from the 8 cards are then combined with cable combiner, see figure??, into a single output. This is fed via a pulse forming network to the front panel.

As the arrival time of each step is programmable over the full 7ns, one can arrange for many different waveforms by deciding when to add in another pulse, and one has a choice of voltages to add in, subject to what has already been used.

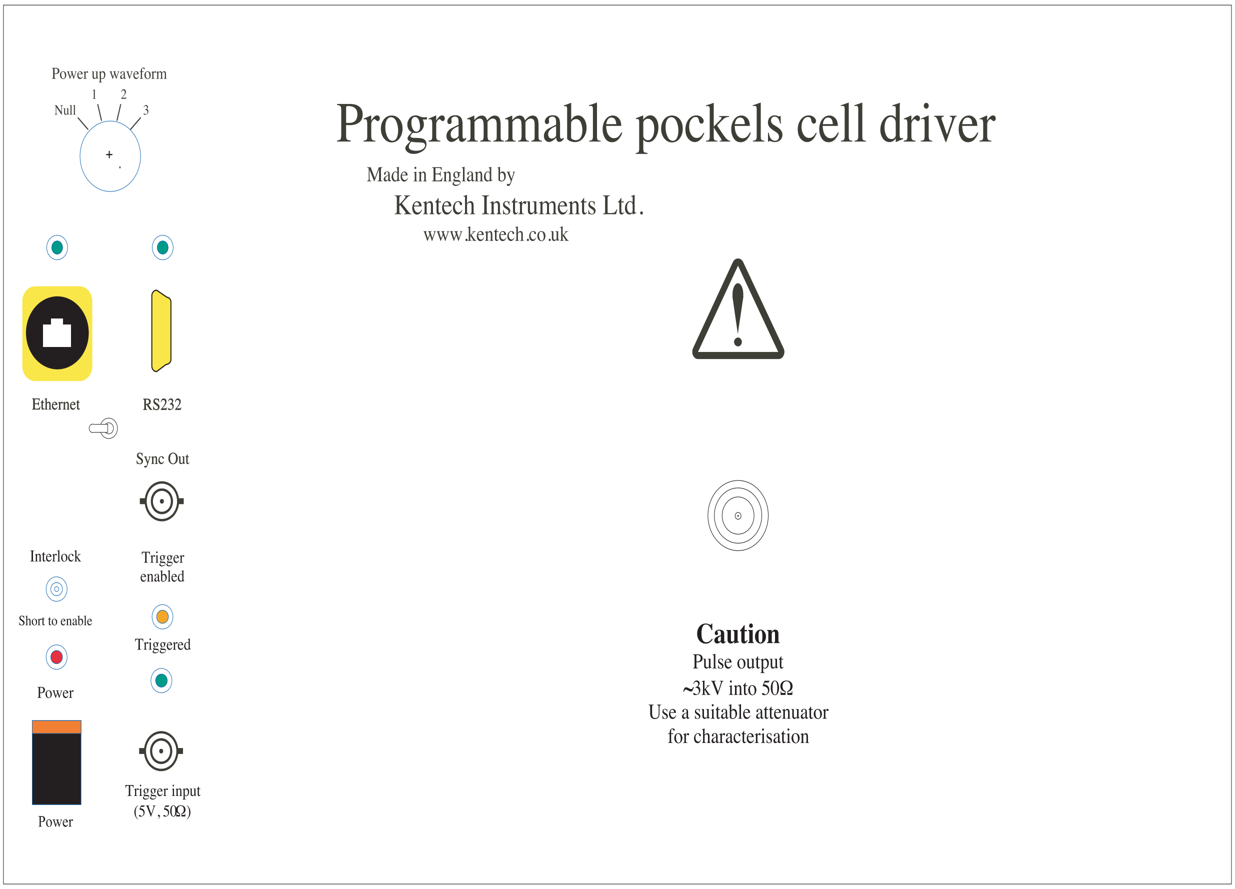
The total voltage available when all the steps are summed is ~3.7kV.

The generator voltages are made unequal as this device is designed to drive a pockels cell which will normally be used in a configuration that delivers a $\sin^2$ response, (possibly $\sin^4$ if two cells are used). This means that the cell is less sensitive to voltage changes at either end of its operating range. One can therefore use these larger steps at either end of the waveform in order to deliver similar optical sensitivity per step.

The generator is programmable via either a RS232 or Ethernet interface. Simple text commands are required to configure the unit.

The waveform output is not changeable from the front panel with the exception that the start up waveform may be selected from one of 4 stored ones.

2.1 FRONT PANEL CONTROLS, CONNECTIONS AND INDICATORS.



2.1.1 INTRODUCTION

The front panel is shown in figure 1. Most controls etc. are self explanatory. The unit needs to be connected to a computer for control or programming and both Ethernet and RS232 are offered on the front panel and selected by means of the front panel switch. This is a lockable toggle switch, pull to unlock.

2.1.2 MODE SWITCH

The “Mode” switch sets up the waveform and trigger enable status on power up. The “Null” position is not user programmable and, in this mode, the unit powers up with the trigger disabled and the pulse shape set so that all the pulsers are timed to zero. Modes 1, 2 and 3 are user programmable so that the unit may be used without a computer.

2.1.2 INTERLOCK

The Interlock input needs the centre pin to be shorted to the outer to enable the triggering of the unit. For the unit to be triggerable both this interlock needs to be set and the trigger needs to be enabled in software. The data stored for use with the mode switch includes the state of the software trigger enable. The interlock connection may be connected to other equipment that has an open collector output or relay connection. The voltage on the centre pin is 5 volts ??? and can supply 50mA ???

2.1.3 TRIGGER INPUT

The unit requires a trigger signal of ~ 5 volts rising in <5ns for reliable triggering. For improved jitter performance ~10 volts rising in < 1ns can produce jitter of <10ps rms. The trigger threshold can be set with software but unless the factory settings have proved unsatisfactory it is recommended that it not be changed. No documentation of how to change the threshold is included here.

2.1.4 RS232 CONTROL

The unit may be programmed and controlled either via Ethernet or RS232. To select RS232 (on a 15 way D type connector) move the lockable toggle switch towards the RS232 connector and check that the LED over the connector illuminates. The protocol is:

9600 baud

1 stop bit

Flow control off

8 data bits

No Parity

2.1.5 ETHERNET CONTROL

The ethernet is available on the RJ45 socket on the front panel. To activate it, the toggle switch below the connector must be pointing towards the Ethernet connection and the LED over the RJ45 socket should be illuminated. The protocol is TCP/IP and the port used for control is 10001. Port 80 is used for HTTP and this can be accessed with a browser to configure the unit once the IP address is known.

The ethernet is implemented using a Netport LAN01 adapter from Alpha Micro. It supports 10/100 Mbits per second but as it feeds a standard RS232 connection to the unit this will limit the data rate.

The ethernet port needs to be configured for the user's network environment. Although it can be set up to obtain an IP address from a DHCP server this is rarely useful as the user needs to know the IP address in order to communicate with the device. Generally we advise the use of a fixed IP address in the same subnet as the controlling computer.

Lantronix supply a utility (Device Installer) to configure the unit.

System Requirements

Windows 98, 98SE, ME, NT 4.0 [Service Pack 6a or higher], 2000, XP [We have also used it under Vista]

Internet Explorer 5.01 or later, any standard browser.

Microsoft .NET Framework 1.1

30MB free hard drive space

The software is freely available from

http://www.alphamicro.net/resources/Lantronix/DI%2E3%2E6%2E0%2E6.zip

According to the instructions with this software some operating systems also need

http://www.alphamicro.net/resources/Lantronix/dotnetfx.zip

We have not needed this and so I have no experience about how or when to use this extra software patch.

After installing, run the "Device installer".

With the Pulser unit on the same LAN as your computer, click on the "Search" icon at the top left of the "Lantronix Device Installer" window. The program will search your LAN for Netport© Adapters.

It is possible you may have more than one such device on your LAN so use the MAC (Hardware) address to identify the correct one to configure. The MAC address is on the back of the pulser but is also on the Netport adapter itself, (inside the unit).

Select the relevant Netport adapter in the main window, click on "Assign IP" at the top of the window.

This will present you with a utility to either assign a fixed IP address (recommended if you can run on the same subnet) or use a DHCP server to obtain the address automatically.

You should not have to configure the RS232 port of the unit as this has already been done.

In this utility you also need to specify the subnet mask and Gateway address for your LAN.

Close the Lantronix Device installer application.

If possible check the connection by pinging the adapter. To do this from the desktop select Start, Run and then enter "ping IP " where IP = the IP address you assigned to the unit. If you do not know the IP address and you have set the unit to use a DHCP server, then you will have to find out by accessing the DHCP server and looking for the IP address associated with the MAC address of the adapter.

Hit return and the new window should indicate that the device is responding. If not check everything, cables, connectors, IP addresses etc. Or try having just the PC connected directly to the adapter and manually assign an IP address in the same subnet to the PC.

To ping the device from a Macintosh computer use the network utility.

The Netport adapter has several ports associated with the IP address and these are used for different things. Port 80 is a web server, Port 9999 is a telnet server and port 10001 is the RS232 serial output that is used by the pulser. Note that Safari seems not to work with the web server.

Once the port is configured the user may use simple communications programmes such as Hypertext to communicate with the unit. It will also be available over a VPN network. Alternatively the unit may be controlled by Labview or a similar programme but the control protocol is not very suitable for this. A revision of the software might be needed to make this a practicable approach.

We can also supply a simple terminal programme for typing at the unit and for sending files.

2.1.6 OUTPUT

The main output of the unit is on a "N" type connector. The output voltage is up to ~-3.7kV into 50Ω. If the connector is left unmated and the pulser run there is a likelihood that the connector will break down. If done repeatedly this will damage the insulators. It is recommended that the unit is not run with the output connector unmated.

When characterising the output waveform it is necessary to use an attenuator with suitable rating. The peak power is up to ~250kW and the average power up to ~ 0.5W at 50Hz. We recommend type 142 Barth attenuators for characterisation but be aware that they have an average power rating of 2W. Do not use the unit at a repetition rate higher than needed. Do not exceed 2W average power and do not use more than ~0.5W for extended periods. Note that the unit delivers quite a long pulse, significantly longer than the ~7ns record length.

The unit is supplied with a terminator which has a monitoring output. This is useful for waveforms without fast steps and for checking that the output waveform has not changed. Its primary use is as a terminator to be placed on the output cable after the pulse has passed through the pockels cell load.

2.1.7 SYNC. OUTPUT

The sync. output is intended for checking the triggering of the unit and for possible synchronisation of other equipment to the unit. The output is ~+4 volts into 50Ω, it lasts ~10ns and arrives ~ 8ns after the unit is triggered.???

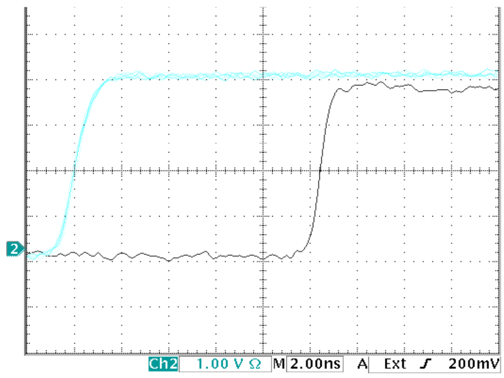


Figure ?? The sync output (black) compared to the trigger plus (turquoise), showing ~10.4ns delay

2.2 REAR PANEL CONNECTIONS

The only rear panel connection is the power inlet. This is filtered and will accept IEC leads. It uses a universal supply that will run from a variety of voltages. The fuse is rated at 3.15 amps.

3 CIRCUIT DESCRIPTIONS

The unit comprises 48 individually controllable pulse generators arranged as 8 cards of six pulsers each. They are controlable in the sense that each can be triggered at any time within a ~7ns window with a resolution of ~2ps, although the jitter is ~10ps. The delay is accomplished through biasing the gate of a FET which is then triggered from a ramp. Consequently there is some thermal drift, particularly when the unit is cold. The pulser circuit uses strings of avalanche transistors to switch a high voltage into the output. In order to avoid large DC voltages within the unit, each pulser is configured in two stages that are capacitively coupled. In this way the stage voltages can add up and the total output voltage can be larger than the DC voltage.

The pulsers are triggered from a single trigger card, this has 8 trigger outputs and the sync. output. One trigger pulse goes to each of the eight pulse cards where it is split into 6 to drive the 6 pulsers per card. The trigger pulse is then converted to a ramp for use with the delay circuit. A microprocessor is used to set up the pulser delays, manage the delay calibration, check the pulsers DC voltages for component failures and manage the trigger enable logic.

The outputs of the pulsers are combined resistively in threes and then with a transmission line (cable) transformer into a single output. The resistive combining is used to set the voltage of each pulser. The 48 pulsers are arranged in voltage so that the cards are nominally the same, however, this is not essential for the system and other configurations can be used by changing the combiner resistors. A simple Excel programme has been written to calculate the resistor values for a given resistor set. Doing the reverse, i.e. calculating the resistor values that give a set of voltages is most easily done iteratively.

The output from the cable combiner is passed through a compensating network that improves the squareness of the step.

4 PERFORMANCE

The output waveforms into a 50Ω load are shown in figures ????

The steps from each pulser are not perfect but unless all the pulsers are synchronous the deviations are not normally very noticeable.

5 SOFTWARE AND REMOTE CONTROL

The unit may be controlled and calibrated via Ethernet or RS232.

Internally the unit uses the Forth language. Externally one just needs to type commands at the unit. The help files, see section 5.X.Give details of each command. Note that some commands need a value to be entered before the command.

There are commands to set up waveforms, store and recall waveforms (up to 3) and a tweak command that enables the user to make adjustments to the waveform.

Another set of commands is to control the triggering of the unit. The unit has both hard and software trigger enable. Note that the software trigger enable state is stored along with a waveform. This is useful if the unit is to be used in a stand alone mode as one then does not need a computer to enable the triggering.

A test command is available to measure and display the voltages across the avalanche transistors. If a voltage has fallen significantly it may be necessary to replace a pulse card or repair the unit. However, for many applications the loss of some voltage is not significant.

5.1 HELP FILES

There are three help files available directly from the unit. These are return by entering the command, help, help+ or info. “help “just responds with a list of the available commands with no explanation, this is intended as a reminder. “help+” gives detailed help on how to use each command. “info” gives information on how to set up a new waveform from scratch.

5.1.1 HELP

help+
?status
resettriglatch
+trig
-trig
awaiting_trigger

test
tweak
caltweak
.dcal
.dels
rampdels
caldump
!first_del
!next_del
xx setall
@wfm1, @wfm2 and @wfm3
ee!wfm1, ee!wfm2 and ee!wfm3
user>hw
movie

5.1.2 HELP+

This Help File is best displayed with a fixed width font

xxxx represents and integer in the range 0 to 7000

DAC is Digital to Analogue Converter

?status
Gives the status of the trigger enable, hardware inhibit and trigger latch

resettriglatch
Resets the trigger latch.
This can be used to detect a single trigger

+trig
enable trigger if unit is not inhibited

-trig
disable trigger

awaiting_trigger
wait for a trigger and indicate its arrival
any key will exit the routine

test
measures and lists the voltages on each of 96 avalanche stacks
the current, original and difference voltages are displayed

tweak
Manual Adjustment of the waveform
Allows the timing of individual pulsers to be adjusted (tweaked)
This command has units of ps
keys 1 and 2 increment and decrement the address of the selected pulser (range 0 through 47)
keys 3 and 4 increment and decrement the delay
keys - and + increment and decrement the step size used for keys 3 and 4

caltweak
This is used to calibrate the channel delays
This command works in DAC space, 0 through 4095
Whilst working on a selected pulser the delays of the other 47 are set to a high number
The calibration requires a DAC value for each 1000 ps from 0 through 7000
keys 1 and 2 increment and decrement the address of the selected pulser (range 0 through 47)
keys 3 and 4 increment and decrement the delay
applying the shift key makes the increments and decrements larger
keys 6 and 7 move to the next delay range to be calibrated

there are 8 delay setting to be calibrated for each pulser

.dcal

displays the delay calibration data (in DAC space), 8 numbers per pulser

.dels

displays the current 48 delay settings in ps

rampdels

sets unit to deliver a ramp with delay proportional to pulser number

!first_del

Stores the delay for pulser 0 in RAM, used to set up a waveform

!next_del

Used after !firststep to store the delay of the next pulser
There should be 47 of these statements
Note:- To use the waveform execute a data>hw command
To store the waveform use a ee!user1 (or 2 or3) command

For a more detailed explanation type info .

xx setall

sets all delays to xx where xx is in the range 0 through 7000 ps

ee!user1, ee!user2 and ee!user3

stores the current waveform and trigger enable state in the respective user memory from 1 through 3
the null waveform is not changeable

@wfm1 @wfm2 and @wfm3

fetches a stored waveform and writes it to the hardware

ee@user1 ee@user2 and ee@user3

fetches a stored waveform into RAM but does not write it to the hardware

user>hw

sends a waveform from RAM to the hardware

movie

cycles through the 4 stored waveforms, wfm1 through wfm3 and null

info

information on how to set up a waveform

5.1.3 INFO

The following demonstrates how to set up a new waveform

First calculate the optimum delay settings of each of the 48 pulsers (0 through 47)
in order to produce the desired waveform.
This will often be the output from a computer programme or an excel spread sheet.
The software should produce output of the following form:

```
x0 !first_del
x1 !next_del
x2 !next_del
    .
    .
    .
    .
```

.
x47 !next_del
user>hw

where x0, x1 etc are the delays for pulser 0, pulser 1 etc.
Note that the pulser voltages are nominally.
100 160 60 20 80 40 for pulsers 0 1 2 3 4 5
Each further group of six pulsers has the same voltage sequence

If it is desired to store the waveform in one of the three user memories
use ee!user1, use ee!user2 or use ee!user3

5.2 EXAMPLES OF SOFTWARE USE

In the examples below bold type is used to indicate a command sent to the unit and italic the response, the letters "cr" represent the return key.

5.2.1 STATUS COMMAND

This is used to check the trigger status. This comprises the state of the hardware enable (interlock), the software enable and the triggered latch. The triggered latch is set when a trigger signal is received. It is reset with a resettriglatch command. It is designed to enable the user to determine if a trigger has been received. It does not disable the trigger.

?status cr

trigger disabled
hardware enabled
awaiting trigger
ok

5.2.2 TEST COMMAND

The test command is used to check that the voltages on the avalanche transistors have not changed significantly. The response to the test command is shown below. The numbers are not voltage but ADC counts. The errors will be higher (in magnitude) if the unit is cold. If the error gets high than ~ 6 it is likely that a device has either failed or changed significantly. Generally it is not worthwhile changing a card unless there are several failed devices.

ok

test cr

TOP BOTTOM

Channel	*Measured*	*Stored*	*Error*	*Measured*	*Stored*	*Error*
0	246	246	0	151	151	0
1	244	246	2	151	150	-1
2	246	247	1	148	147	-1
3	244	245	1	149	149	0
4	245	246	1	150	149	-1
5	245	247	2	147	148	1
6	244	245	1	151	151	0
7	245	246	1	149	149	0
8	246	246	0	151	151	0
9	244	246	2	149	149	0
10	246	247	1	150	150	0
11	242	245	3	144	144	0
12	246	245	-1	150	149	-1
13	244	245	1	150	149	-1
14	244	244	0	148	147	-1
15	246	247	1	149	148	-1
16	247	246	-1	149	148	-1
17	243	244	1	150	149	-1
18	246	246	0	150	150	0
19	243	246	3	151	151	0
20	247	248	1	151	151	0
21	245	247	2	150	150	0
22	245	246	1	148	148	0
23	244	246	2	147	147	0
24	242	245	3	150	149	-1
25	244	244	0	148	147	-1
26	246	247	1	150	149	-1
27	243	244	1	150	149	-1
28	246	245	-1	152	150	-2

29	*243*	*244*	*1*	*147*	*147*	*0*
30	*244*	*243*	*-1*	*149*	*148*	*-1*
31	*247*	*246*	*-1*	*150*	*150*	*0*
32	*245*	*245*	*0*	*149*	*148*	*-1*
33	*245*	*246*	*1*	*150*	*149*	*-1*
34	*244*	*245*	*1*	*150*	*149*	*-1*
35	*242*	*246*	*4*	*148*	*148*	*0*
36	*246*	*246*	*0*	*150*	*149*	*-1*
37	*244*	*245*	*1*	*151*	*150*	*-1*
38	*245*	*247*	*2*	*150*	*149*	*-1*
39	*244*	*246*	*2*	*149*	*148*	*-1*
40	*244*	*244*	*0*	*149*	*148*	*-1*
41	*242*	*244*	*2*	*149*	*149*	*0*
42	*246*	*246*	*0*	*149*	*148*	*-1*
43	*244*	*246*	*2*	*149*	*150*	*1*
44	*245*	*246*	*1*	*147*	*148*	*1*
45	*245*	*247*	*2*	*149*	*149*	*0*
46	*246*	*248*	*2*	*149*	*149*	*0*
47	*246*	*247*	*1*	*149*	*150*	*1*

ok

6 CARD REPLACEMENT

6.1 INTRODUCTION

The unit has been found to be very reliable. The most likely component failure is an avalanche transistor although careless handling can damage some capacitors.

The voltage on each avalanche transistor can be measured with the software using the command “test”. This displays changes in the voltage on each avalanche stage. Should the voltage change be more than ~ 4 counts and the unit be well warmed up, it may be that a transistor has failed.

Whilst a failed device can be replaced fairly easily we have also supplied a spare card so that a whole group of 6 pulsers can be replaced.

If a transistor fails the unit will still work OK but if several fail within one pulser then the card should be replaced. Note that as the devices fail the output voltage will drop and consequently the failure on a large voltage pulser will be more significant. If the full output voltage of the unit is not required it is not worthwhile changing the card for a few transistors. The system that the user uses to calculate the pulser delays can easily be modified by giving it the reduced voltage of the affected pulser. This will compensate for the lost voltage in many cases.

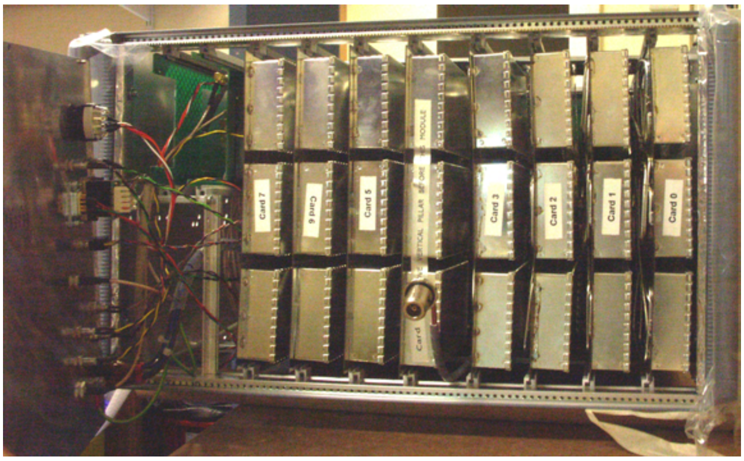
Should it become necessary to remove a card calculate which card has the failed pulser on it. The card number is given by the integer part of the pulser number/6, i.e. pulser 5 is on card 0, pulser 17 is on card 2, etc.

6.2 CARD REPLACEMENT

In order to replace a card there are several tasks

1. dismantling the unit and removal of the affected card.
2. preparing the replacement card to have the correct address.
3. fitting the replacement
4. reassembly
5. testing and calibration.

The whole process is likely to take 1 to 2 hours.



6.3 DISMANTLING THE UNIT

Remove the power lead, remove the side panels (4 screws each), remove the top and bottom covers (they unclip at the front and rear). Then remove the eight screws holding on the front panel. Undo and remove the nut holding the main output connector. With the front panel released hinge it away from the unit keeping the left side close to the unit. The main out cable and connector may need some manipulation to remove the connector from the front panel. You should now have access to the array of pulse cards and the trigger and control cards which are at top left looking into the unit.

The pulse cards are numbered 0 though 7 with lower numbers on the right of the unit looking onto the front panel. Although any card will fit in any of the 8 slots it is important to maintain the sequence of connections both from the trigger card and to the combining transformer at the rear of the unit so that the delay calibration is not changed.

In order to remove a card it is first necessary to disconnect the trigger input (SMB on the trigger card, do not pull on the cable, use a screwdriver or forceps if necessary to pry the plug from the socket.) Also remove the two pulse outputs (SMAs on the combining transformer). Depending upon which card is to be replaced it may be necessary to remove the rear panel. Access to the cable combiner is awkward and access through the rear, top and bottom may be needed. There are no connections on the card. It is necessary to disconnect the leads at their far ends and unthread the leads as the card is pulled out. Note that if it is necessary to remove card 4, then first remove the vertical pillar holding the bars across the top and bottom. The pillar is removed by removing the screws (one at each end of the pillar) and then manipulating the pillar out of the unit. The screws are marked.

6.4 PREPARING THE REPLACEMENT CARD

It is important that the replacement card has the same address as the old card. On the 8 cards supplied in the unit the address is set by some hard wired resistors, see figure ??? On the spare card it is set with three DIL slide switches. These set a binary code from 0 through 7. There is a label on the card showing the switch positions for each possible address, see figure ?? This must be done. The address of the initial cards is shown on the end of the card facing the front panel.

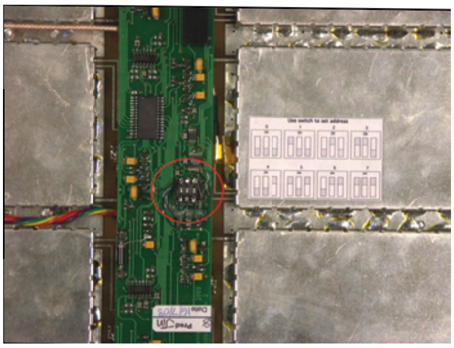


Figure ?? The address switch and label indicating address settings

6.5 FITTING THE REPLACEMENT

The replacement card is slid into place with careful attention to the following:

a) the trigger and output leads must be threaded through to behind the back plane.

b) the card must be in its guides, this can be tricky as the card is made from thin PCB material that flexes easily. Be very careful to flex it as little as possible as this can cause components to fail, particularly capacitors.

c) guide the card along the guides and ensure the back plane connector is well mated.

d) thread the trigger lead round behind the back plane and up onto the trigger card and plug in to the vacant socket.

e) feed the two output leads onto the transformer combiner. Note that each input of the combiner is labeled with a card number and a lead length (short or long). The two output leads are of different lengths. The SMAs should be tightened to 99 - 106 N-cm. This is generally a little more than finger tight.

6.6 REASSEMBLY

Reassembly is the reverse of disassembly. As you push the front panel back onto the unit be careful not to trap any wires in such a way that they could get damaged, particularly around behind the ethernet/ RS232 switch which fits into a recess in the card mounting hardware.

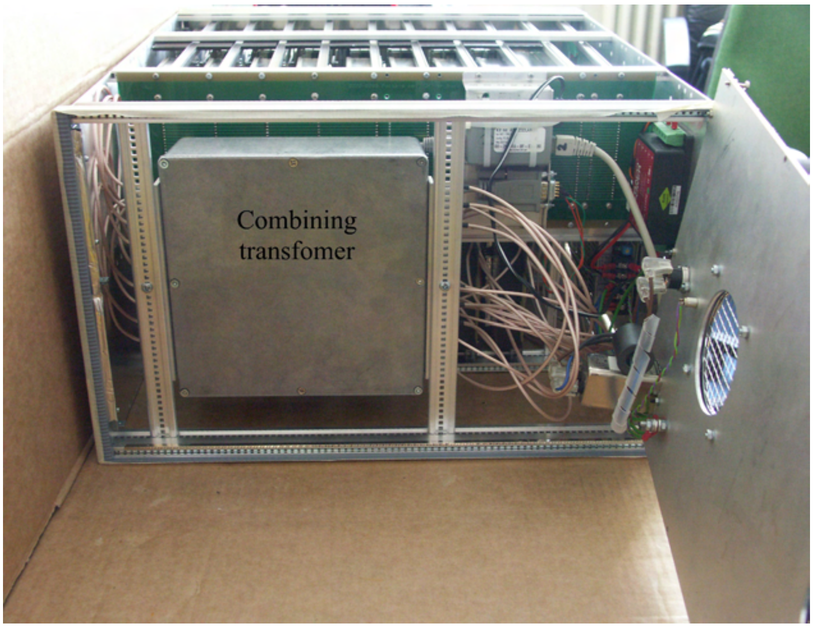


Figure ?? The rear panel removed showing the combining transformer.

6.7 TESTING AND CALIBRATION

Once reassembled the replacement card should be tested. It may well be that the calibration of the old card is adequate but the range of the existing calibration is ±250 ps.

Before proceeding with the calibration, test the card by running the unit as normal. With a computer controlling the unit type “x alone” where “x” represents a pulser number on the replacement card (0 through 47). This command will place the new pulser at time slot zero and all the others at ~7ns. One can then establish that the new pulser is working. Repeat this for each pulser on the new card and establish that the voltages that each produces are close to the nominal set, i.e. 100 160 60 20 80 40 volts. The pulser numbers are given by:

for card number x the pulsers are 6x through to card number 6x + 5.

e.g. for card 4 the pulsers are 24, 25, 26, 27, 28 and 29.

Once it is established that the six new pulsers on the new card are working OK it is necessary to calibrate their delays. This requires several steps:

1 Set up a suitable trigger source, oscilloscope and attenuators so that the output waveforms can be monitored.

2 Establish whether the intrinsic delay of the new card is within the range covered by the other cards. If it is **not** covered then all the cards will have to be calibrated with a new zero position. If it **is** covered then only the new card need be calibrated and the others left as they are.

3 Perform the delay calibration and save the results to EEPROM.

6.7.1 USING CALTWEAK

Caltweak is used to measure delays, set up the delay calibration data and save it to EEPROM. A suitable oscilloscope and attenuator will be required to monitor the main output. The terminator supplied with the unit may be used but preferably a set of three 20dB attenuators should be used with the first two in the chain being Barth type 142 or similar. These have good bandwidth and can take >3.5kV. However, note that they are only suitable for up to 2 watts and the pulser should not be run at high rates into these attenuators, ~40Hz is OK.

The numbers that CALTWEAK uses are not ps but internal counts that are delivered to the DAC (Digital to Analogue converter). They can be in the range 0 to 4095 and will cover a delay range ~ 7000ps.

The calibration requires 8 numbers per pulser. These are the counts for each ns of delay from 0 through 7ns. For delays between these values the software interpolates to find the optimum count to send to the DAC. The response of the delay circuit to count is not linear and hence the need for 8 values.

The format for starting CALTWEAK is

xx caltweak

where xx represents the pulser number (0 through 47)

If xx is omitted a value of zero is used.

Once CALTWEAK is running the delay for the pulser xx is set to its calibrated zero time position and the count that delivers this delay will be displayed.

The keys that manipulate CALTWEAK are:

3	increases the count applied to the DAC
4	decreases the count
1	moves to the pulser with the next lower time to calibrate
2	moves to the pulser with the next higher time to calibrate
5	moves to the previous time slot
6	moves to the next time slot
s	saves the data to EEPROM

The procedure for calibrating a channel is to set the time to calibrate to zero ns, adjust the actual delay with the keys 3 and 4 to be the desired delay, then move to the next time position and adjust keys 3 and 4 for that time slot, etc. When all 8 time slots have been found, move to the next pulser and repeat. This means that there are 48 x 8 times to find in order to calibrate the unit from scratch. When recalibrating a pulser CALTWEAK uses the previously stored value at each time slot as the starting position and so the process can be quite quick.

6.7.2 CHECKING THE INTRINSIC DELAY FOR THE PULSERS ON THE NEW CARD

It is important that all the pulsers can be set to the zero delay position. Due to small differences in the intrinsic delay of each channel they will not all have the same delay when the counts sent to the DACs are zero. So there is a count for the zero time for each pulser. It is important that the time chosen is accessible to each pulser, obviously a pulser cannot go earlier than a zero count to its DAC. When installing a new card it is necessary to check that each of the 6 pulsers can be made to coincide in time with the zero points of the other 42 pulsers. If this is not possible then a later zero time will have to be selected and all the cards will need to be recalibrated. Note that if a late zero time is used the total record length available is reduced, however, the specification is for a 6ns record length and generally up to ~ 7ns is available after the zero points are set.

Launch CALTWEAK with xx = the first pulser in the new set of 6, i.e. if the card is x enter yy CALTWEAK where y= 6x.

The response will be (for pulser 0):

0 caltweak

sample # = 0 delay = 0 ns , value = 192

[key 4 is hit to increment count to DAC]

sample # = 0 delay = 0 ns , value = 272
sample # = 0 delay = 0 ns , value = 352
sample # = 0 delay = 0 ns , value = 272
sample # = 0 delay = 0 ns , value = 192

[key 6 is hit to move to next delay value to be calibrated]

sample # = 0 delay = 1 ns , value = 837
sample # = 0 delay = 1 ns , value = 917
sample # = 0 delay = 1 ns , value = 837

[key 2 is hit to move to the same delay time on the next pulser]

sample # = 1 delay = 1 ns , value = 963

[key 2 is hit to move to the same delay time on the next pulser]

sample # = 2 delay = 1 ns , value = 749

[key s is hit to move to the saving routine]

Type y to save calibration Saved

[key s was not hit as the calibration was already stored]

sample # = 2 delay = 1 ns , value = 749

[key esc was hit to exit the routine]
ok

Summary of CALTWEAK keys

-	reduce step size
+	increase step size
1	previous pulser
2	next pulser
3	subtract step from DAC count
shift 3	subtract 10* step from DAC count
4	add step to DAC count
shift 4	add 10* step to DAC count
5	move to previous delay time to calibrate
6	move to next time to calibrate
s	save data, follow with y to confirm.
escape	exit routine

If a full new calibration is needed then it is easiest to calibrate pulsers in the following order:

0,6,12,18,24,30,36,42

1,7,13,19,25,31,37,43

2 etc

..

..

5,11,17,23,29,35,41,47

This is because each pulser in the groups above will have the same amplitude and it will not be necessary to change the oscilloscope settings when calibrating the pulsers within each group.

When changing groups the oscilloscope will need the gain and vertical position of the trace adjusting to centre the transition.

Note that the save command of CALTWEAK can be used at any time without exiting the routine. It is good practice to do it fairly often as there are 384 numbers to find and a lot of work can be lost.

TEST DATA

The following pages show test results using a Agilent DSO80804A oscilloscope [8Ghz, 40GSa/s]

The output of the unit was attenuated with two Barth type 142 attenuators followed by a Radiall 20dB 18GHz SMA attenuator. Where shown the supplied terminator was also used. The unit was triggered from a Highland P400 delay generator. For jitter measurements ~10 volts was used rising in ~ 1ns with the oscilloscope being triggered with the same signal split from the unit trigger signal. The skew in the oscilloscpe was adjusted so that the trigger and signals arrived within a few tens of ps.

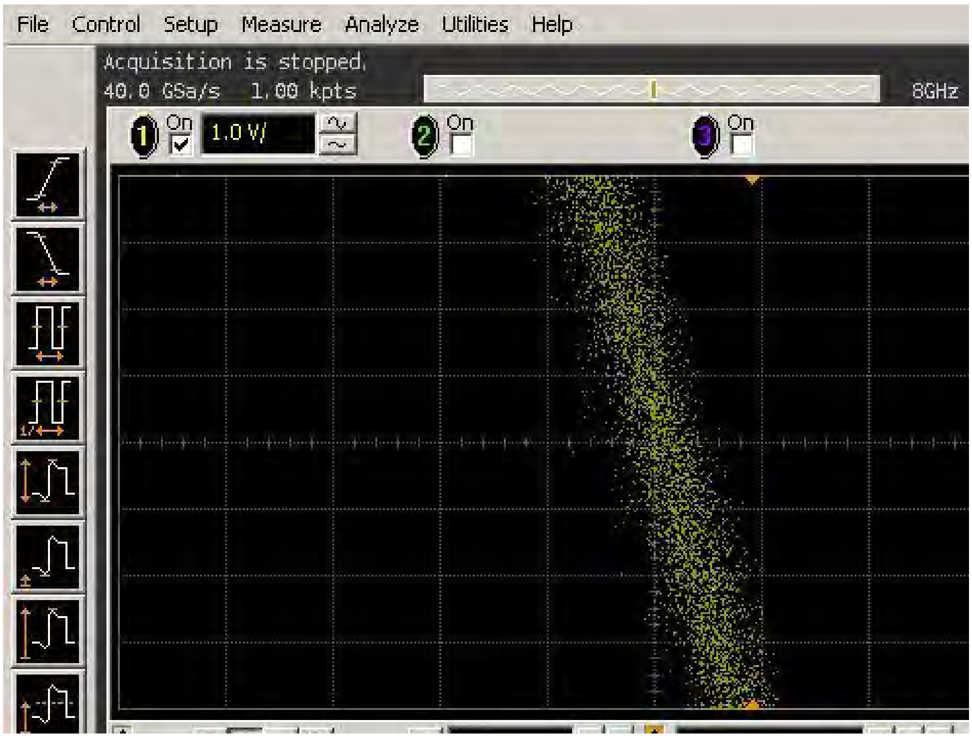


Figure ?? Jitter at zero delay position

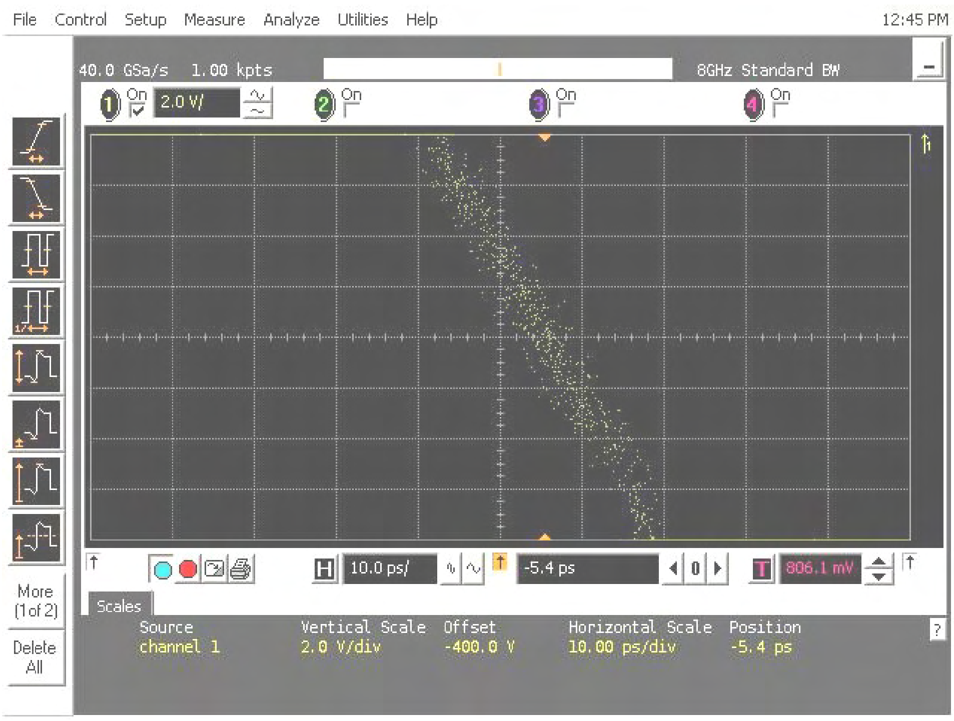


Figure ?? Jitter at 6ns delay

Figure ?? Drift over 1 hour

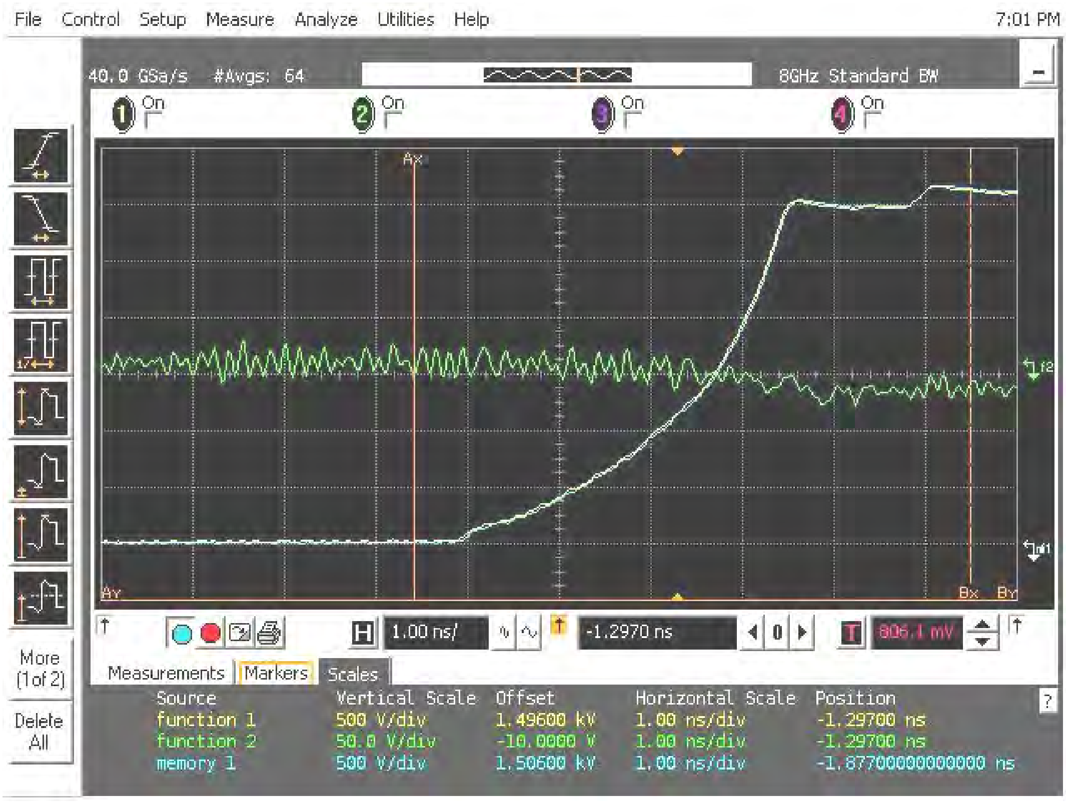


Figure ?? Comparison of Barth attenuators and the supplied terminator and monitor with a slow waveform; the green trace is the difference at 10 x the sensitivity.

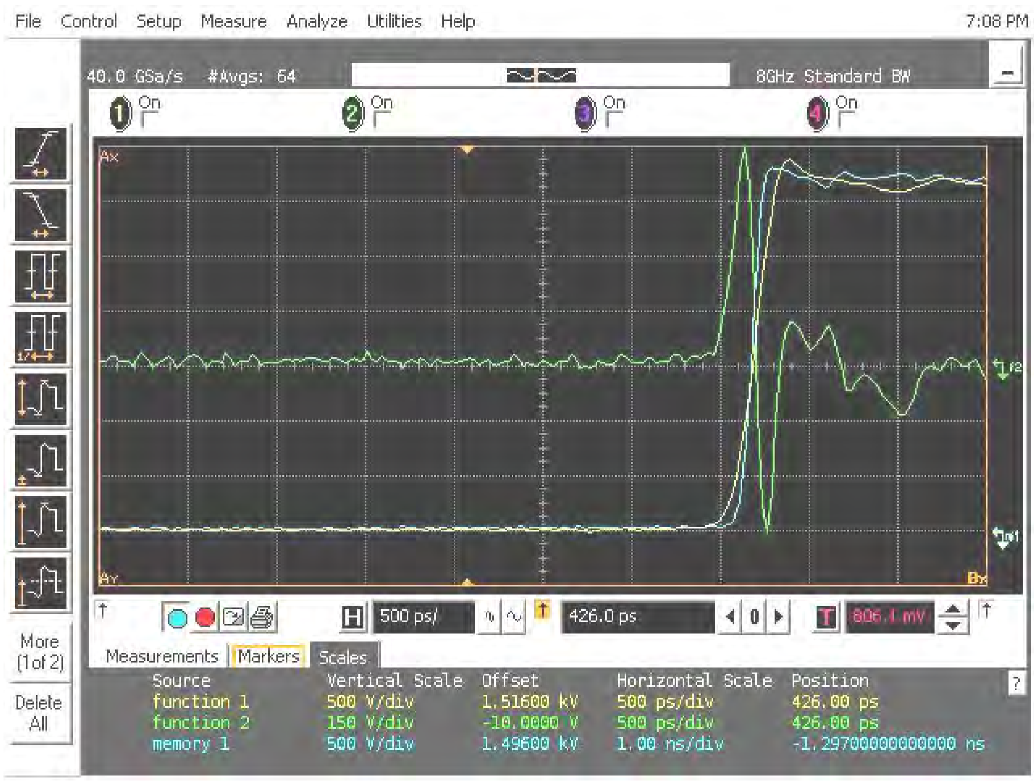


Figure ?? Comparison of Barth attenuators and the supplied terminator and monitor with a fast waveform; the green trace is the difference at 3.33 x the sensitivity.

Figure ?? The delay at regular intervals showing the linearity of the calibration.

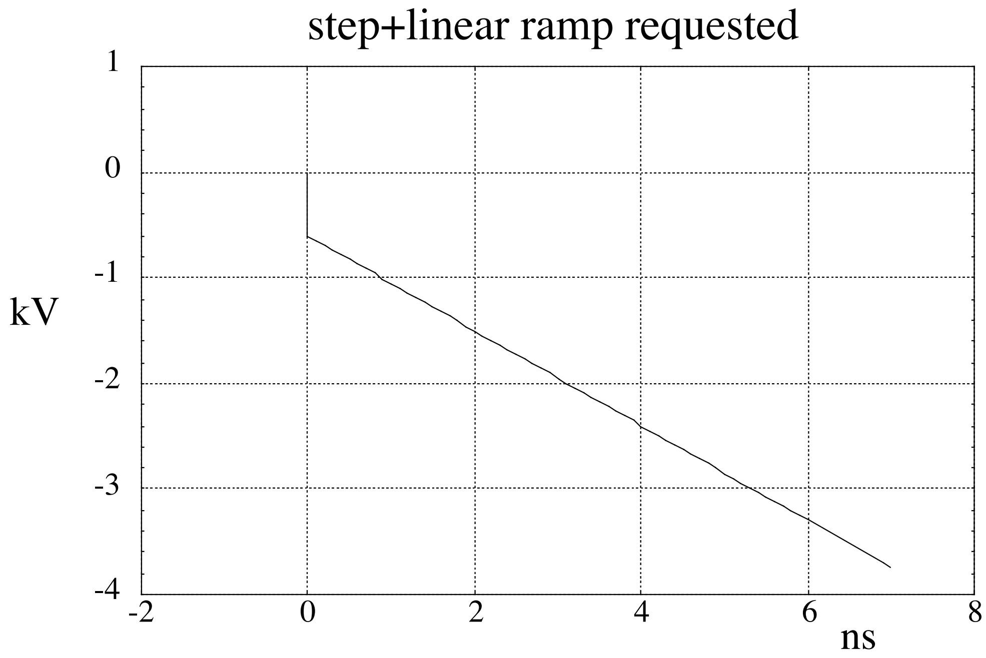


Figure ??   A requested waveform

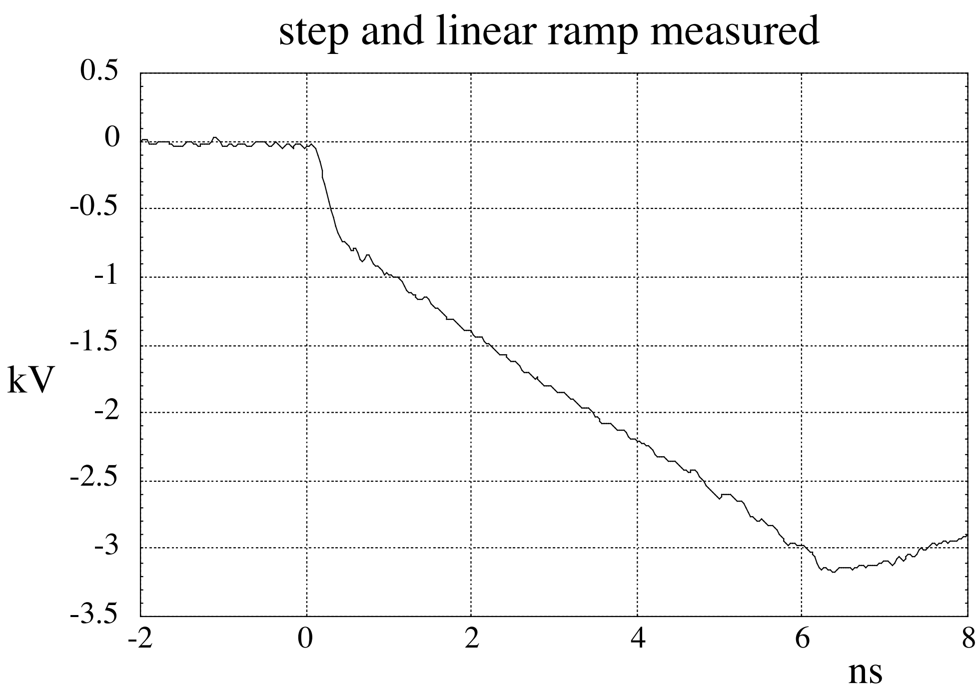
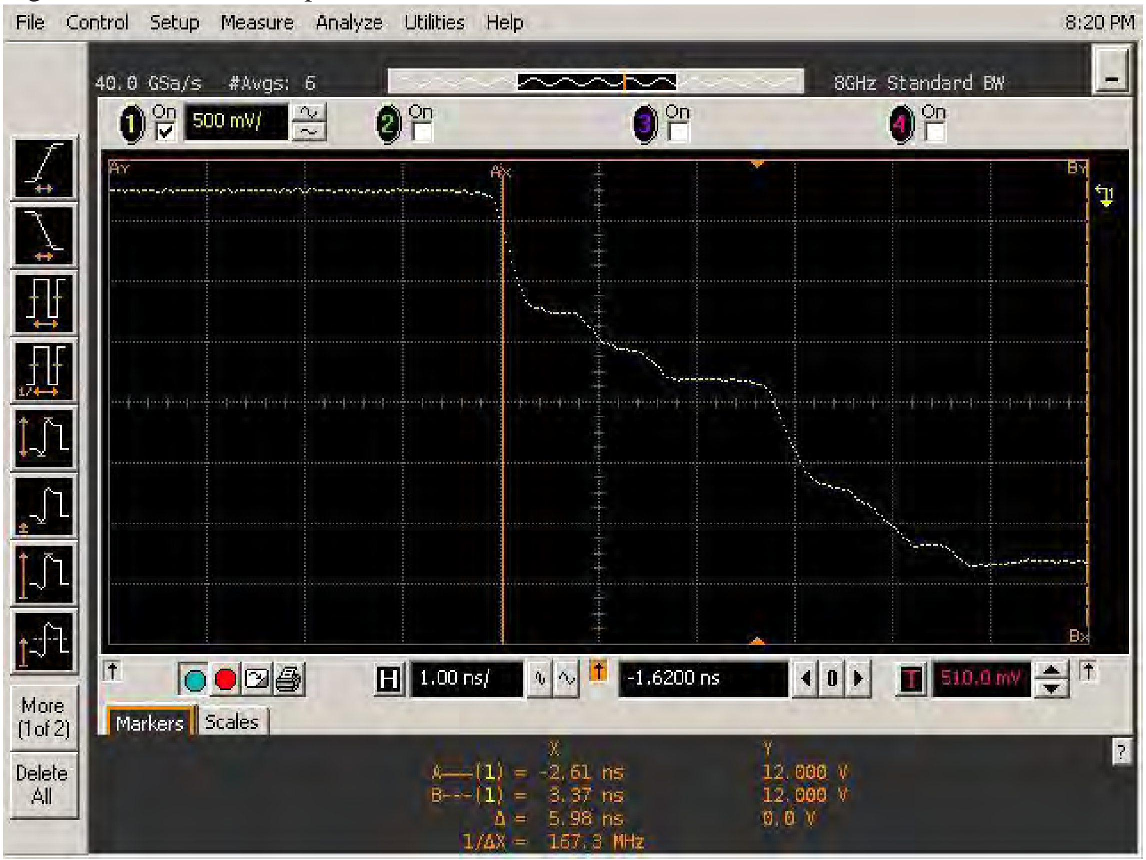
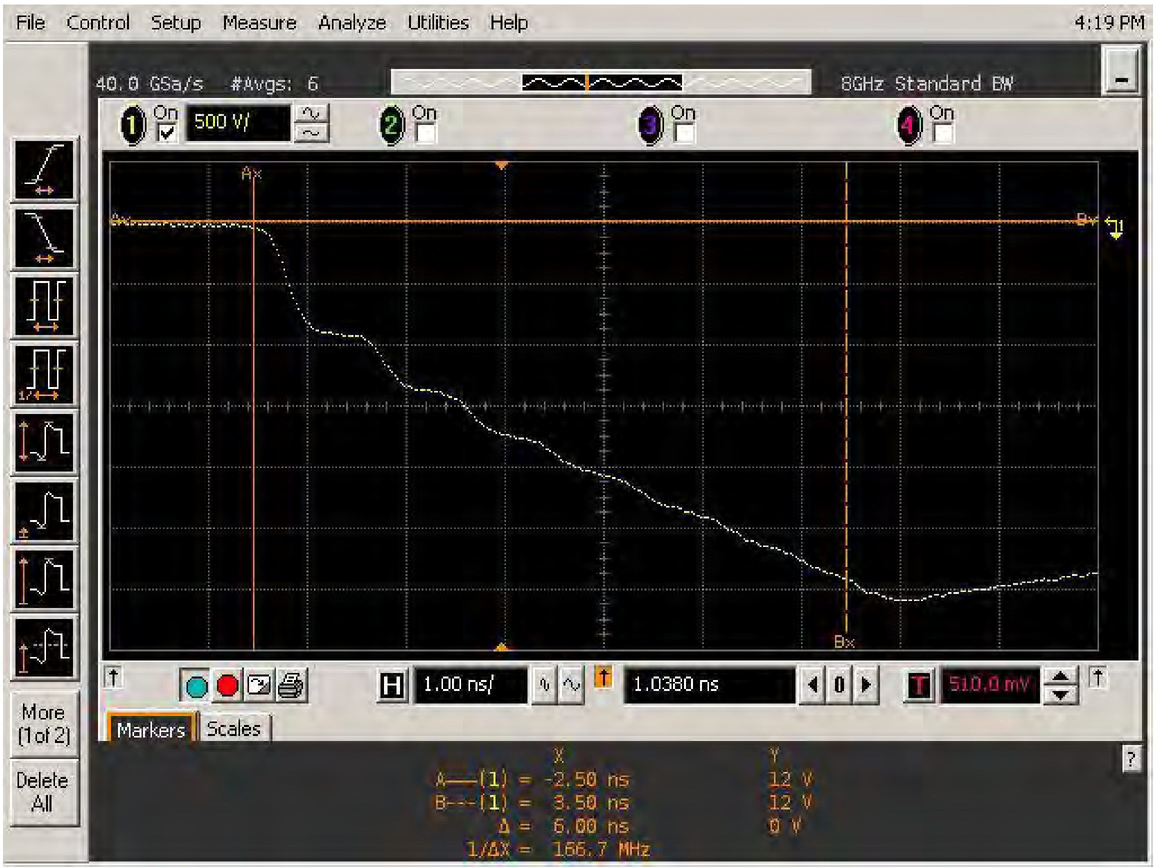
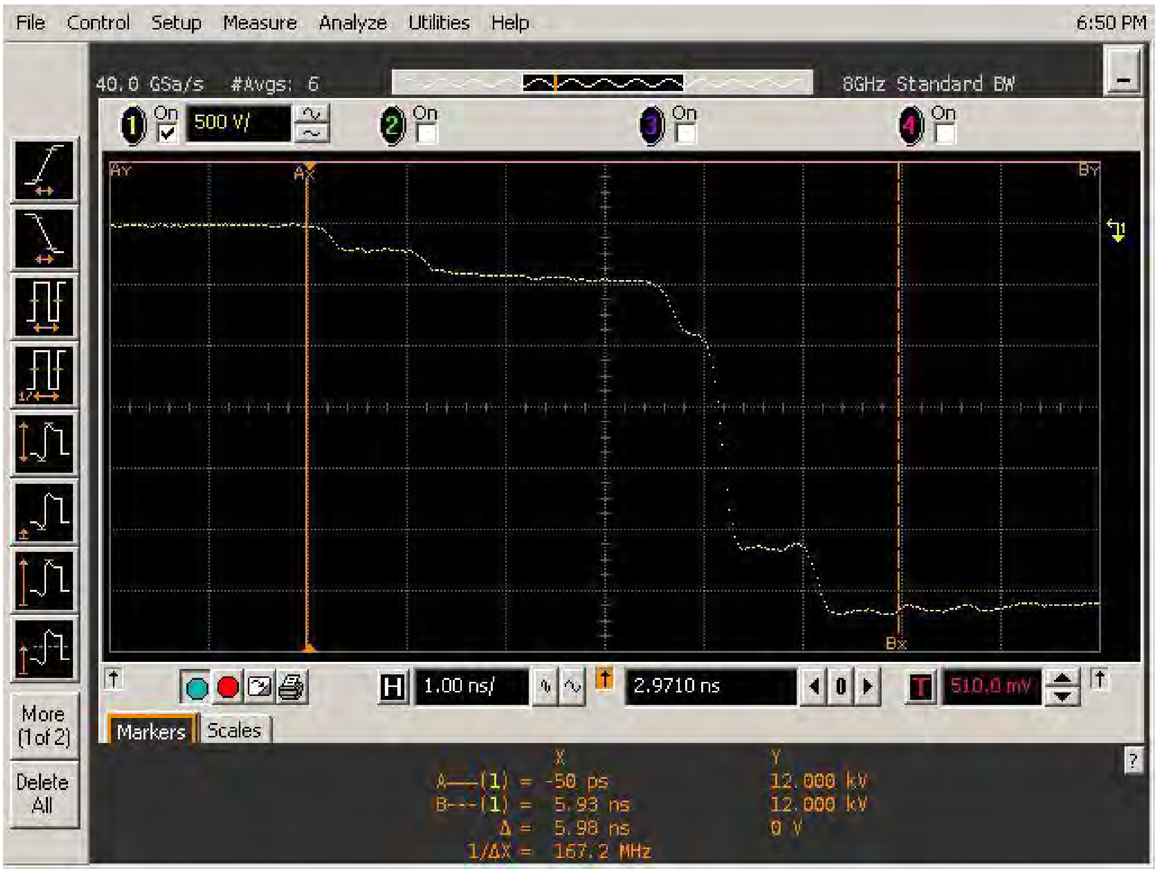


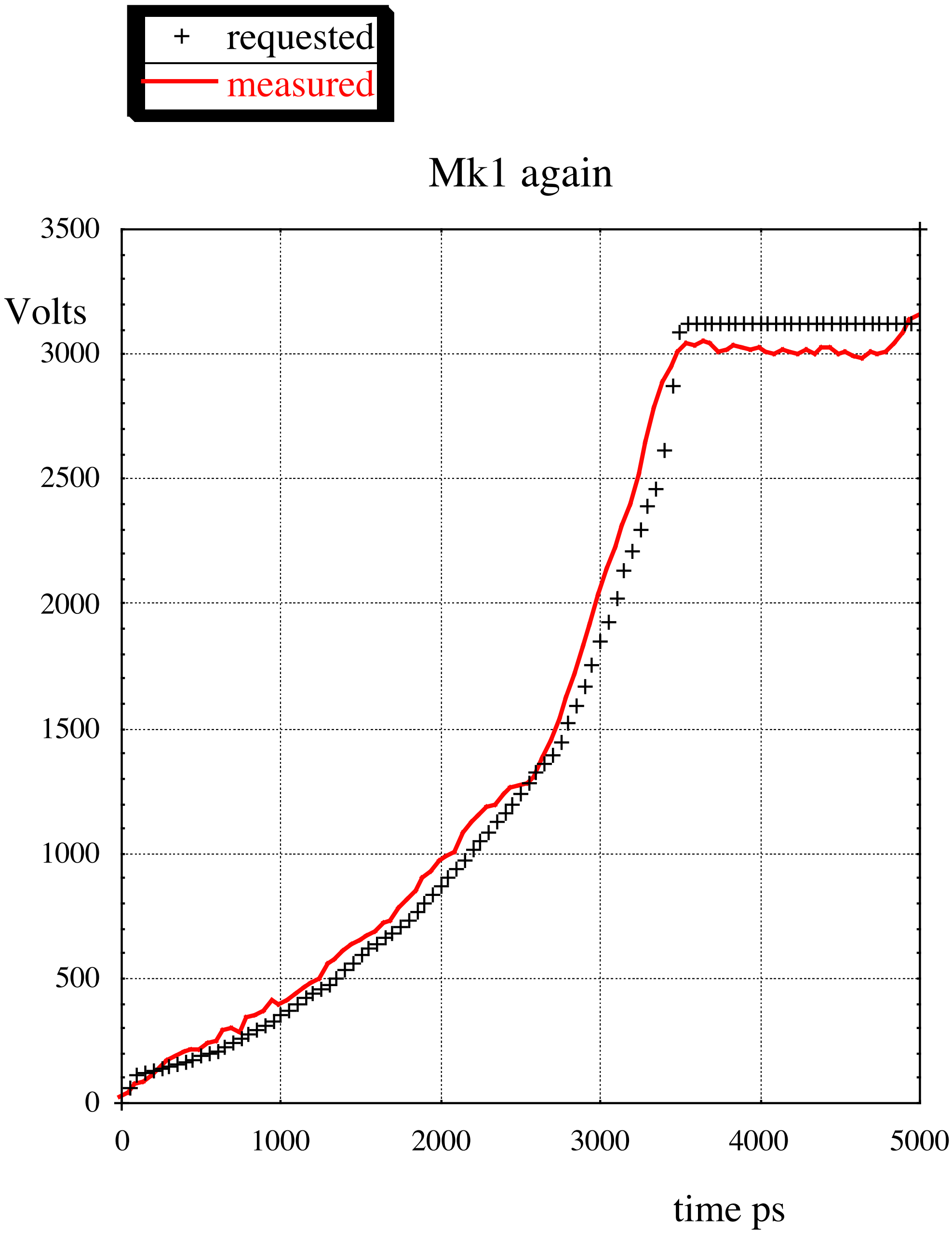
Figure ??   The measured waveform

Figure??   Some example waveforms




File Control Setup Measure Analyze Utilities Help 4:19 PM
40.0 GSa/s #Avgs: 6
8GHz Standard BW
500 V/
1.00 ns/
1.0380 ns
510.0 mV
Markers Scales
More (1of 2)
Delete All
A—(1) = -2.50 ns 12 V
B---(1) = 3.50 ns 12 V
Δ = 6.00 ns 0 V
1/ΔX = 166.7 MHz


File Control Setup Measure Analyze Utilities Help 6:50 PM
40.0 GSa/s #Avgs: 6
8GHz Standard BW
500 V/
1.00 ns/
2.9710 ns
510.0 mV
Markers Scales
More (1of 2)
Delete All
A—(1) = -50 ps 12.000 kV
B---(1) = 5.93 ns 12.000 kV
Δ = 5.98 ns 0 V
1/ΔX = 167.2 MHz


+ requested
measured
Mk1 again
Volts
3500
3000
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