Kentech Instruments Ltd.

PG1000 Nanosecond Pulser

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Figure Captions

1 DECLARATION OF CONFORMITY

We:- Kentech Instruments Ltd
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Conforms with the requirements of European Community Directives:

2006/95/EC	Low Voltage Directive
2004/108/EC	EMC Directive
768/2008/EC	CE Marking Directive

The following harmonized standards have been applied:

BS EN55011:2009 +A1:2010 Radio-Frequency disturbance characteristics. Industrial, Scientific, Medical equipment

96/211711 DC Electromagnetic compatibility.
Generic Immunity Standard.
Part 2 Industrial environment (EN 50082-2)

BS EN 61010-1:2010 Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use

2 CAUTION

With an appropriate load, this unit is safe for use by an educated user in a laboratory environment. You are warned however that the radiation from the system with an antenna or inappropriate load attached can damage sensitive equipment and corrupt data stored in computer and microprocessor based systems. It can cause terminal failure of vital medical electronic systems such as pacemakers. This equipment is supplied on the understanding that the user will analyse these risks, accept responsibility for them and take appropriate precautions in the use of this instrument.

The output from this pulse generator will destroy many types of power attenuators and electronic test equipment. It is the users responsibility to ensure that any apparatus connected to the output is suitably rated.

Kentech Instruments Ltd accepts no responsibility for any damage or liabilities incurred in the operation of this equipment.

Please read the manual before applying power.

There are high voltages (4kV) present in this Pulser when the unit is operating. Do not remove the covers and return to Kentech Instruments Ltd or its appointed agent for servicing.

The accessible terminals of this instrument are protected from hazardous voltages by basic insulation and protective grounding via the IEC power input connector. It is essential that the ground terminal of this connector is earthed via the power lead to maintain this protection.

If cleaning is necessary this should be performed with a soft dry cloth or tissue only.

3 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 using certain types of output cable may exceed EC permitted levels.

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.

Figure 1 Front Panel controls, indicators and connections

4 INTRODUCTION

This system comprises a driver and suitable cables. The driver generates a pulse of adjustable length and amplitude. The output is designed to drive 50Ω and is AC coupled. The AC coupling will allow dc biases of ± 1kV maximum to be applied to the output.

The pulse is made by combining four individual pulses, a fast turn on, a fast turn off, a slow turn on and a slow turn off.

5 SPECIFICATION

Polarity	Negative AC coupled.
Bias	The output can be biased between ±350V with an external supply.
Amplitude	adjustable from -300 to -1000V into 50Ω in steps of ≤ 50V
Pulse shape	rectangular
Pulse width	<40ns to >1μs FWHM
Leading edge transition time	<1ns both modes
Trailing edge transition time	<1.5ns for pulse widths ≤45ns (short pulse mode) 8ns for pulse widths >45ns (long pulse mode)
Flatness	±10%
Post pulse noise	±10%
Maximum rep rate	≥50Hz
Start jitter	~ 20ps SD
Pulse width jitter	<500ps for pulses >45ns
Trigger requirement	5V into 50Ω, < 5ns rise time. Optional optical triggering see below.
Power supply:	90-240V AC 50/60 Hz
Outputs:	
Pulse output:	N Type Female
Monitor output:	BNC 50:1 divided from main output
Inputs:	
Trigger input:	BNC Female
Controls:	
Power:	Switches AC power in the pulser.
Communications:	Selectable: Ethernet/RS232
Indicators:	
Power:	Shows that AC power is applied and the unit is switched on.
Triggered:	Illuminates while the unit is being triggered.
Network	
Ethernet	10BASE-T, 100BASE-T
MAC address	00 80 A3 C2 06 B5

6 USE

The driver requires an AC supply and a trigger signal to operate. The trigger signal should be 5V into 50Ω with a rise time of less than 5ns in order to achieve minimum output jitter.

Although the unit is optimised for driving a 50Ω load, it is quite well reverse terminated and can be used to drive other load impedances without significant reflections from the pulser, i.e. secondary pulses will be of small amplitude. Note that the source impedance is about 50Ω so when driving loads other than 50Ω the output voltage will be different. If driving reactive loads the wave shapes will also be different.

The driver is also AC coupled to allow the addition of a bias voltage to the pulse of up to ±350V.

6.1 PULSE LENGTH CONTROL

The pulse length can be set over the range <40ns to 1μs via the computer interface, see Figure 4.

AMPLITUDE CONTROL

The amplitude is set via the computer interface. Figure 5 shows the variation over the whole range available.

6.2 MONITOR

The monitor output is a divided down version (~50:1) of the main output pulse. It should be run into a 50Ω load for optimum calibration. Figure 7 shows a comparison of the monitor output and the true output.

6.3 OUTPUT TIMING UNCERTAINTY [JITTER]

The output jitter is dependent upon the quality of the trigger pulse. For optimum jitter the trigger should have no variation in amplitude or shape.

6.4 PULSE SHAPE

Timing circuits on the main control board are used to set the shape to optimum. Figure 9 shows the pulser output when set to maximum amplitude and pulse length. Flatness is indicated by bars at ±10% around the pulse waveform.

6.5 NOTES ABOUT TEST MEASUREMENTS

In the measurements shown below the pulser was triggered with a Highland P400 pulse generator and the measurements were made with an Agilent oscilloscope DSO DSO80604B S/N MY46000902. The attenuators used on the main output were Barth s/n 226 and 228, plus a 20dB SMA attenuator and 20dB on the monitor output.

7 SOFTWARE INTERFACE

J1705161 software interface

Revisions

0.0 12 October 2017 PK

7.1 INTRODUCTION

The software provides a comprehensive set of commands to control the pulser remotely using a simple ascii text protocol. Communication with the processor is by means of either:-

a) an ethernet connection implemented by a Lantronix Xport XP1001000-04R.

b) TTL serial link. Serial comms uses 115,200 baud, 1 stop bit, no parity, no handshake.

After reset or power up the processor will automatically select the port that has communications activity.

The software interface on J1705161 is the same as that on unit serial no. J1512151_1.

J1705161 has an identical command set but should be operated in long pulse mode only.

Setting the unit to short pulse mode will prevent correct operation but should not damage the pulser.

7.2 PULSER SYSTEM CONTROL

The pulser has no local/remote manual switch, it is remote control only.

The remote settings are stored in a set of variables:-

r_fine - fine width setting, default 0

r_coarse - coarsewidth setting, default 0

r_amp - amplitude setting range, default 0

r_trigen - trigger enable flag, true or false, default true

r_longf - long pulse mode flag, true or false, default true.

Commands are provided to read and write these variables and other values. The variables are volatile, they will be set to the default values at power up.

The readable values are:-

i) fine width

ii) coarse width

iii) amplitude

iv) trigger enable flag

v) triggered flag

vi) triggered latch

7.2.1 FINE WIDTH

This is the fine width setting in steps of 500ps. Range is 0 to 10.

7.2.2 COARSE WIDTH

This is the coarse delay setting in steps of 5ns. Range is 0 to 999.

7.2.3 AMPLITUDE

This is the amplitude setting in nominal steps of 50V from 300V to 1000V.

Values used are 0 to 14. For compatibility with J1212171 the accepted range of amplitudes is 0 to 15, but note that 14 and 15 give the same amplitude.

7.2.4 TRIGGER ENABLE FLAG

If true (-1) the pulser trigger is enable, if false (0) the trigger is disabled.

7.2.5 TRIGGERED FLAG

This is driven by a monostable on the trigger input. This flag will be true for a second or so after the pulser is triggered. There is a latched trigger signal available, see below.

7.2.6 TRIGGERED LATCH

This flag is latched. It is set when the pulser is triggered. It remains set until explicitly reset by the remote interface. See commands below.

7.3 THE PROTOCOL

The pulser will generate responses to valid commands and will not generate any unsolicited output. Invalid commands will be ignored. All commands and response will be in ASCII characters. Commands are case sensitive.

In the interest of simplicity all commands are parsed by the pulser using the Forth interpreter, so the parameters need to be delimited by spaces and the command line will be terminated by carriage return and linefeed characters. The Forth interpreter will not recognise commands other than those defined in the command set.

The pulser will not echo command characters as they are received, no output will be generated until a valid command is recognised. When a valid command is recognised, the pulser will output a response.

Responses are preceeded with a cr and lf, then an ascii { character and end with an ascii }. The response will be delimited into fields by an ascii ; character. The first field in the response will be a repeat of the command. If the command cannot be completed the pulser will return an error code in the second field. The possible error codes are:-

?stack - the command interpreter has detected a wrong stack depth error, ie the wrong

number of parameters have been received.

?param - the command interpreter has detected an out of range parameter

After any error, the command is not executed, the stack is cleared and no values are returned

other than the error code. Following a stack error, the stack is cleared than dummy parameters

(generally -1 or 65536) are added for the purpose of formatting the response only.

All status commands expect and deliver data as decimal numbers and all numeric data should be decimal, no decimal points or other punctuation is to be used.

For example:-

1) To set the pulser to minimum amplitude the command would be

0 !r_am

and the response would be

{0 !r_am}

2) as above but with a missing parameter

!c_mod

and the response would be

{-1 !r_am;?stack}

The command interpreter detects the wrong stack depth, corrects this by clearing the stack and adding some dummy parameters then flags the error. No execution will result.

3) as above with invalid parameter

16 !r_am;?param

and the response would be

{16 !r_am;?param}

Again no execution will result.

7.4 COMMANDS

Explanatory notes:-

1) In Forth terminology a @ character implies a fetch or read operation, a ! character implies a store or write operation.

2) For returned parameters, true = -1, false = 0.

7.4.1 COMMANDS WHICH ARE UNCHANGED FROM J1212171

Note that some of the parameters and returned values are no longer used, these are now just dummy values and are marked in blue below.

Also the range of values for some input parameters have been change, these are marked in red.

Name	**!r_fine**
Explanation	write remote fine width setting
Format	**p1 !r_fi**
parameter 1	p1 = fine setting, range 0 to 10
return value	none

Name	**!r_coarse**
Explanation	write remote coarse width setting
Format	**p1 !r_co**
parameter 1	p1 = coarse setting, range 0 to 999
return value	none

Name	**!r_amp**
Explanation	write remote amplitude setting
Format	**p1 !r_am**
parameter 1	p1 = amplitude setting, range 0 to 15
return value	none

Name	**+r_trigen**
Explanation	set remote trigger enable flag
Format	**+r_tr**
parameter	none
return value	none

Name	**-r_trigen**
Explanation	reset rmote trigger enable flag
Format	**-r_tr**
parameter	none
return value	none

Name	**!r_all**
Explanation	write all remote settings
Format	**!r_al**
parameter 1	p1 = remote fine width setting
parameter 2	p2 = remote coarse width setting
parameter 3	p3 = remote amplitude setting
parameter 4	p4 = remote trigger enable flag
parameter 5	p5 = dummy parameter provided for compatibiity with J1212171
returned value	none

Name	**@r_all**
Explanation	read all remote settings
Format	**@r_al**
parameter	none

returned value 1	r1 = remote fine width setting
returned value 2	r2 = remote coarse width setting
returned value 3	r3 = remote amplitude setting
returned value 4	r4 = remote trigger enable flag
returned value 5	r5 = 0 - dummy returned value provided for compatibiity with J1212171
Notes	this is just a readback of the written values

Name	**@r_fine**
Explanation	read remote fine width setting
Format	**@r_fi**
parameter	none
returned value 1	r1 = fine setting, range 0 to 10
Notes	this is just a readback of the written value

Name	**@r_coarse**
Explanation	read remote coarse width setting
Format	**@r_co**
parameter	none
returned value 1	r1 = coarse setting, range 0 to 999
Notes	this is just a readback of the written value

Name	**@r_amp**
Explanation	read remote amplitude setting
Format	**@r_am**
parameter	none
returned value 1	r1 = amplitude setting, range 0 to 15
Notes	this is just a readback of the written value

Name	**@r_trigen**
Explanation	read remote trigger enable flag
Format	**@r_tr**
parameter	none
returned value 1	r1 = remote trigger enable flag, true (-1) or false (0)
Notes	this is just a readback of the written value

Name	**@r_all**
Explanation	read all remote settings

Format	**@r_al**
parameter	none
returned value 1	r1 = remote fine width setting
returned value 2	r2 = remote coarse width setting
returned value 3	r3 = remote amplitude setting
returned value 4	r4 = remote trigger enable flag
returned value 5	r5 = 0 - dummy returned value provided for compatibiity with J1212171
Notes	this is just a readback of the written values

Name	**@trigf**
Explanation	read triggered flag
Format	**@trfl**
parameter	none
returned value 1	r1 = triggered flag, true (-1) or false (0)
Notes	reads the trigger monostable

Name	**@trigl**
Explanation	read triggered latch flag
Format	**@trla**
parameter	none
returned value 1	r1 = triggered latch flag, true (-1) or false (0)
Notes	reads the latched trigger signal

Name	**@stat**
Explanation	read all current status
Format	**@r_al**
parameter	none
returned value 1	r1 = current fine width setting
returned value 2	r2 = current coarse width setting
returned value 3	r3 = current amplitude setting
returned value 4	r4 = 0 - dummy returned value provided for compatibiity with J1212171
returned value 5	r5 = 0 - dummy returned value provided for compatibiity with J1212171
returned value 6	r6 = triggered flag
returned value 7	r7 = riggered latch flag

Name	**0trigl**
Explanation	reset triggered latch flag

Format	**0trgl**
parameter	none
return value	none

7.4.2 COMMANDS THAT WERE INTRODUCED ON J1512151_1

These commands have been added to enable change of operation between short and long pulse modes

Note J1705161 should always be used with the long pulse mode flag true.

Name	**+r_longf**
Explanation	set long pulse mode flag
Format	**+r_lf**
parameter	none
return value	none

Name	**-r_longf**
Explanation	reset long pulse mode flag
Format	**-r_lf**
parameter	none
return value	none

Name	**@r_longf**
Explanation	read long pulse mode flag
Format	**@r_lf**
parameter	none
returned value 1	r1 = remote trigger enable flag, true (-1) or false (0)
Notes	this is just a readback of the written value

Name	**!r_2all**
Explanation	write all remote settings
Format	**!r_al**
parameter 1	p1 = remote fine width setting
parameter 2	p2 = remote coarse width setting
parameter 3	p3 = remote amplitude setting
parameter 4	p4 = remote trigger enable flag
parameter 5	p5 = long pulse mode flag
returned value	none

Name	**@r_2all**
Explanation	read all remote settings

Format	**@r_al**
parameter	none
returned value 1	r1 = remote fine width setting
returned value 2	r2 = remote coarse width setting
returned value 3	r3 = remote amplitude setting
returned value 4	r4 = remote trigger enable flag
returned value 5	r5 = long pulse mode flag
Notes	this is just a readback of the written values

7.4.3 COMMANDS PROVIDED FOR BACKWARDS COMPATIBILITY

These commands have been redefined to return remote settings as there is no local control with this pulser.

Name	**@fine**
Explanation	command provided for compatibiity with J1212171 - same action as @r_fine
Format	**@l_fi**
parameter	none
returned value 1	r1 = fine setting, range 0 to 10
Notes	returns -1 in slave mode

Name	**@coarse**
Explanation	command provided for compatibiity with J1212171 - same action as @r_coarse
Format	**@l_co**
parameter	none
returned value 1	r1 = coarse setting, range 0 to 999
Notes	returns -1 in slave mode

Name	**@amp**
Explanation	command provided for compatibiity with J1212171 - same action as @r_amp
Format	**@l_am**
parameter	none
returned value 1	r1 = amplitude setting, range 0 to 15

7.4.4 DUMMY COMMANDS FOR BACKWARDS COMPATIBILITY

For compatibility with J1212171

Name	**+r_slave**
Explanation	This is a dummy command provided for compatibiity with J1212171
Format	**+r_sl**

parameter none

return value none

Name **-r_slave**

Explanation This is a dummy command provided for compatibiity with J1212171

Format **-r_sl**

parameter none

return value none

Name **@slavef**

Explanation This is a dummy command provided for compatibiity with J1212171

Format **@slfl**

parameter none

returned value 1 r1 = 0 - dummy returned value provided for compatibiity with J1212171

Name **@remf**

Explanation This is a dummy command provided for compatibiity with J1212171

Format **@rmfl**

parameter none

returned value 1 r1 = 0 - dummy returned value provided for compatibiity with J1212171

7.4.5 EXAMPLE COMMS FROM UNIT TEST

Transmitted characters are in blue, response from the pulser is in red.

@r_fi

{@r_fi;0 }

@r_co

{@r_co;0 }

@r_am

{@r_am;0 }

10 !r_fi

{10 !r_fi}

7 !r_co

{7 !r_co}

15 !r_am

{15 !r_am}

@r_sl

{@r_sl;0 }

@r_tr

{@r_tr;-1 }

@r_al

{@r_al;10 ;7 ;15 ;-1 ;0 }

@rmfl

{@rmfl;0 }

@trfl

{@trfl;-1 }

@trla

{@trla;-1 }

@slfl

{@slfl;-1 }

@slfl

{@slfl;0 }

@l_fi

{@l_fi;10 }

@l_co

{@l_co;7 }

@l_am

{@l_am;15 }

@stat

{@stat;10 ;7 ;15 ;0 ;0 ;-1 ;-1 }

@trfl

{@trfl;0 }

@trla

{@trla;-1 }

0trgl

{0trgl}

@trla

{@trla;0 }

@trla

{@trla;-1 }

@rmfl

{@rmfl;-1 }

5 3 8 -1 0 !r_al

{5 3 8 -1 0 !r_al}

@r_al

{@r_al;5 ;3 ;8 ;-1 ;0 }

@stat

{@stat;5 ;3 ;8 ;0 ;-1 ;-1 ;-1 }

+r_sl

{+r_sl}

@stat

{@stat;-1 ;-1 ;8 ;-1 ;-1 ;-1 ;-1 }

-r_sl

{-r_sl}

@stat

{@stat;15 ;7 ;8 ;0 ;-1 ;-1 ;-1 }

-r_tr

{-r_tr}

@stat

{@stat;5 ;3 ;8 ;0 ;-1 ;0 ;-1 }

@stat

{@stat;10 ;6 ;15 ;0 ;0 ;-1 ;-1 }

@stat

{@stat;5 ;3 ;8 ;0 ;-1 ;0 ;-1 }

+r_tr

{+r_tr}

@stat

{@stat;5 ;3 ;8 ;0 ;-1 ;-1 ;-1 }

0 !r_am

{0 !r_am}

16 !r_am

{16 !r_am;?param}

-1 !r_am

{-1 !r_am;?param}

-1 !r_fi

{-1 !r_fi;?param}

0 !r_fi

{0 !r_fi}

10 !r_fi

{10 !r_fi}

11 !r_fi

{11 !r_fi;?param}

-1 !r_fi

{-1 !r_fi;?param}

-1 !r_co

{-1 !r_co;?param}

0 !r_co

{0 !r_co}

15 !r_co

{15 !r_co;?param}

7 !r_co

{7 !r_co}

3 !r_co

{3 !r_co}

1 3 !r_co

{-1 !r_co;?stack}

```
!r_co
{-1 !r_co;?stack}
```

8 TEST DATA

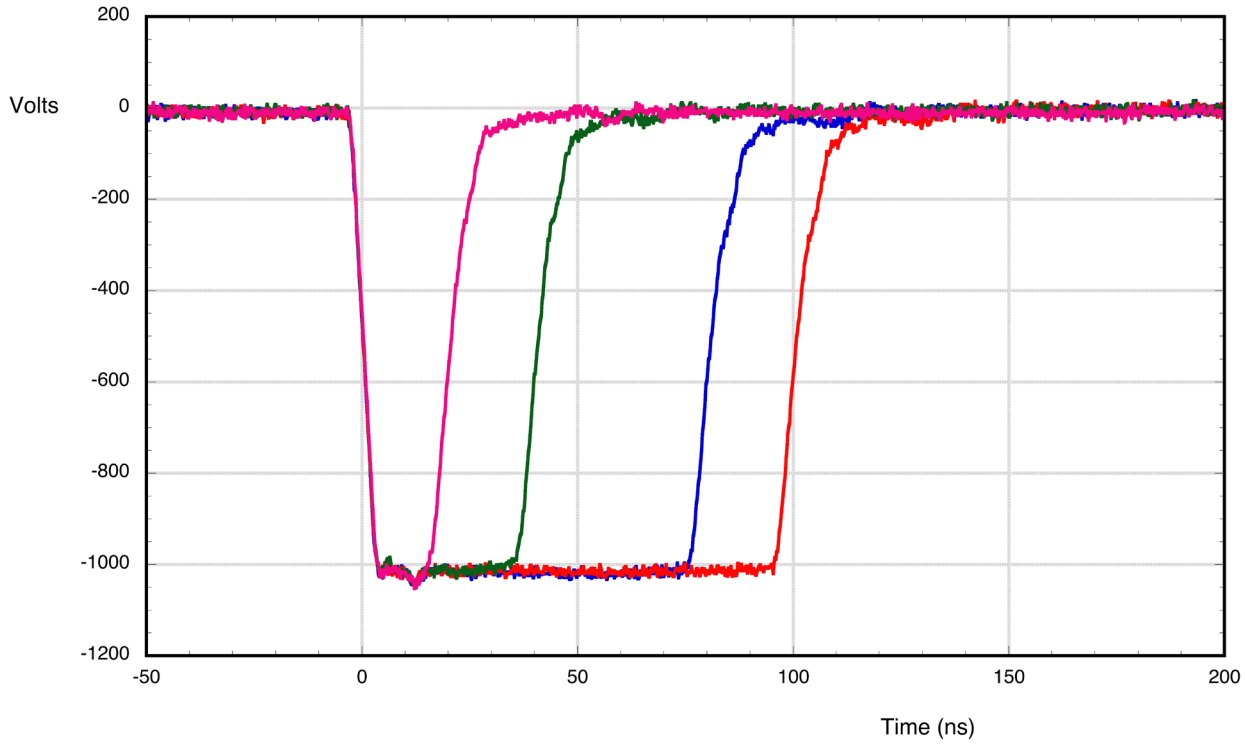

Figure 2 Variation of output pulse length 20ns to 100ns

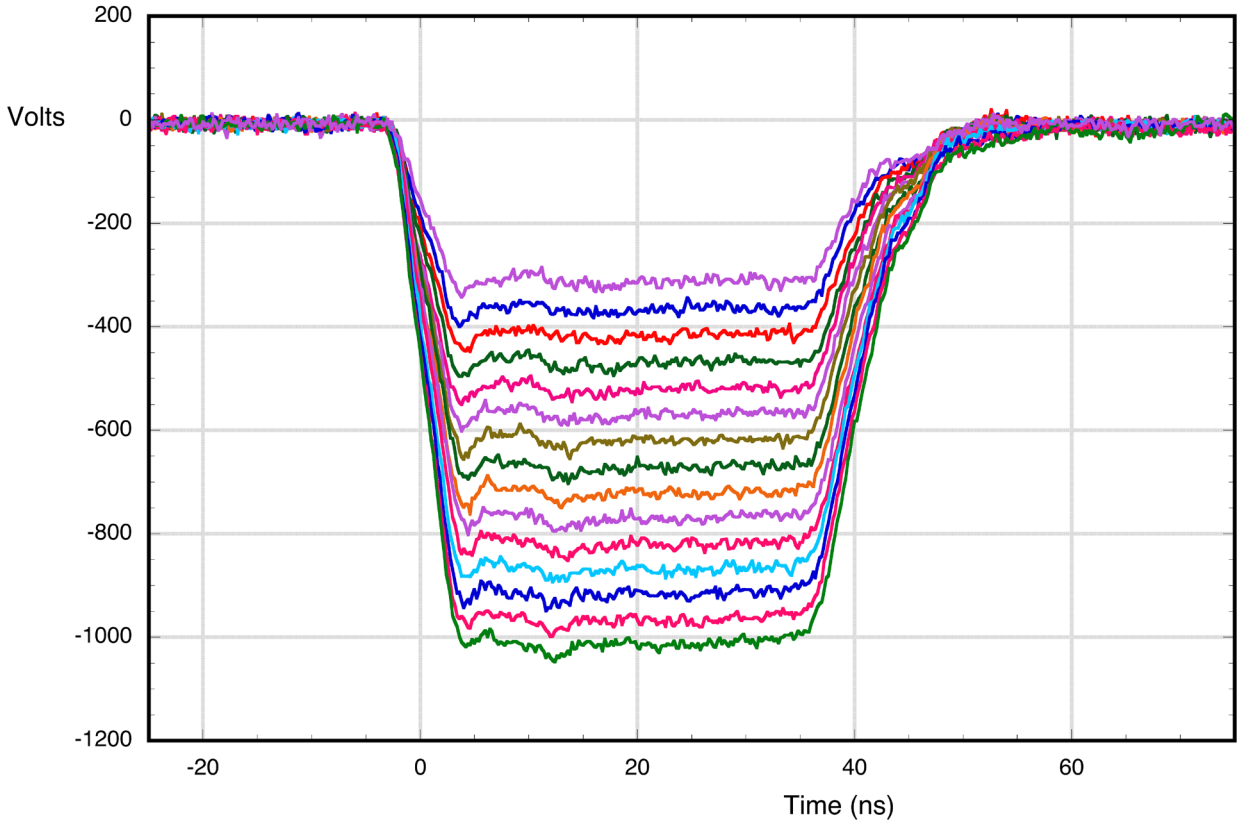

Figure 3 Variation of output pulse amplitude, 40ns pulse

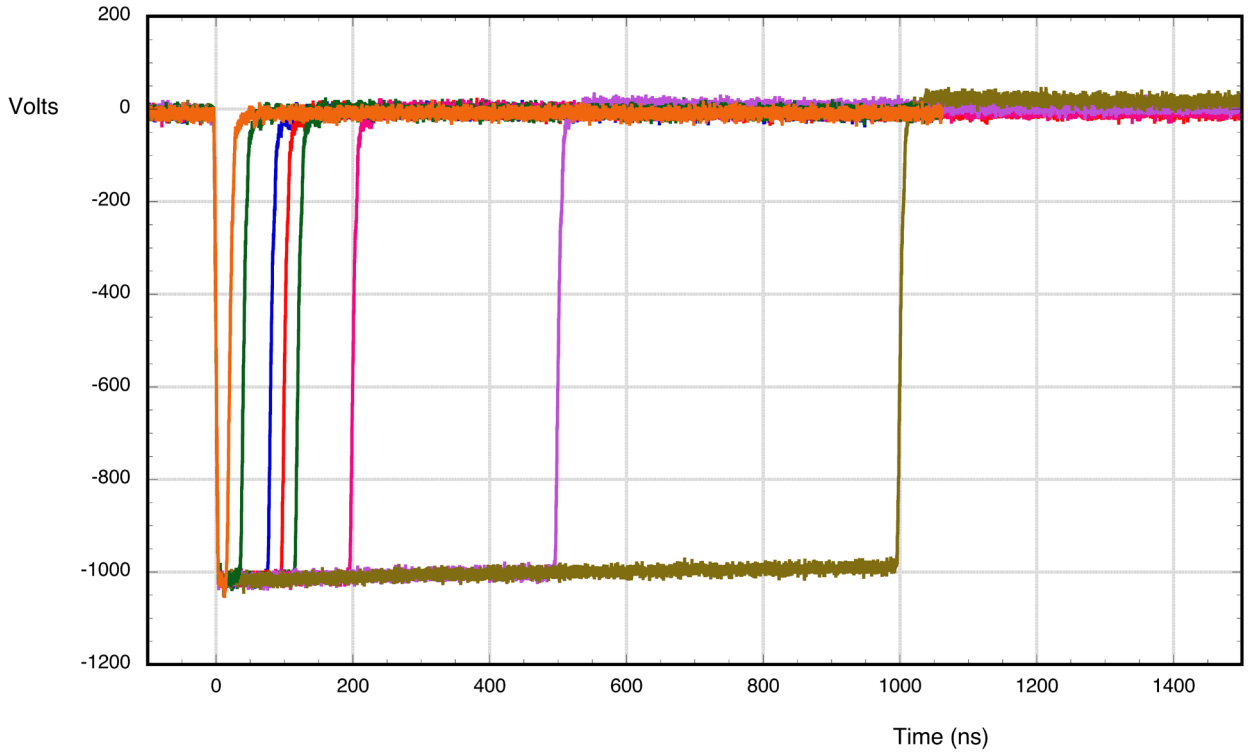

Figure 4 Variation of output pulse length 20ns to 1000ns

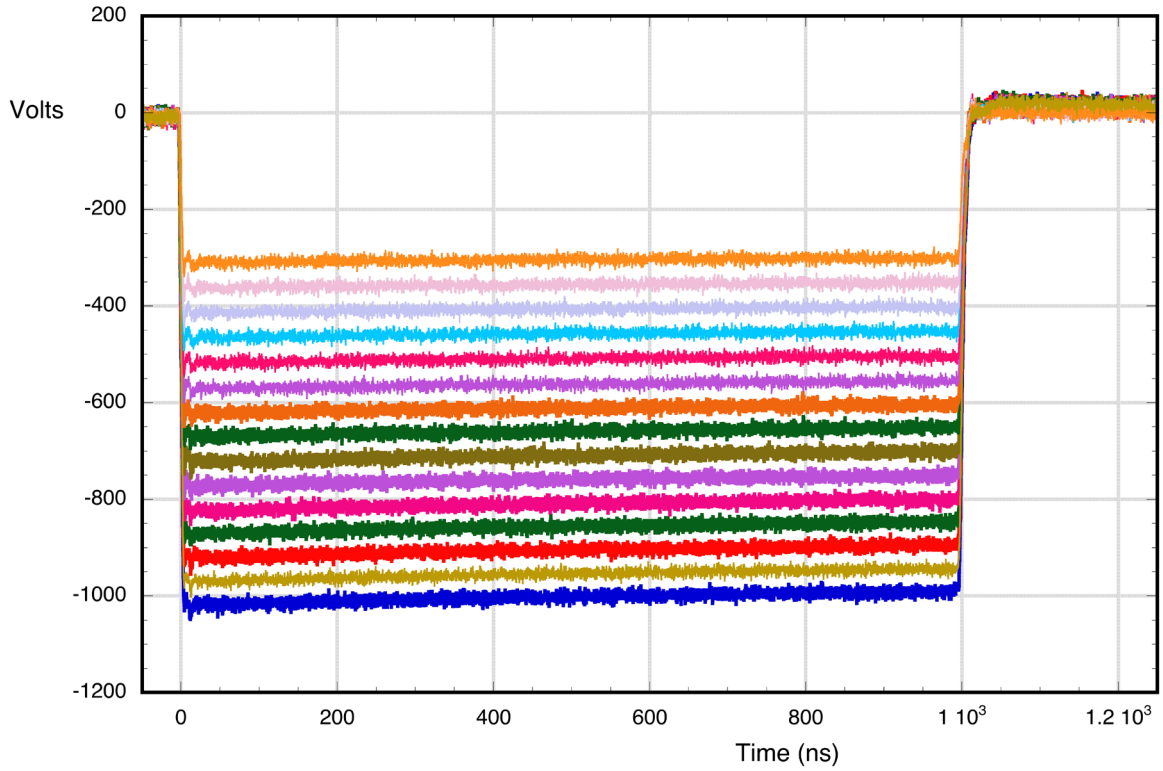

Figure 5 Variation of output pulse amplitude, 1000ns pulse

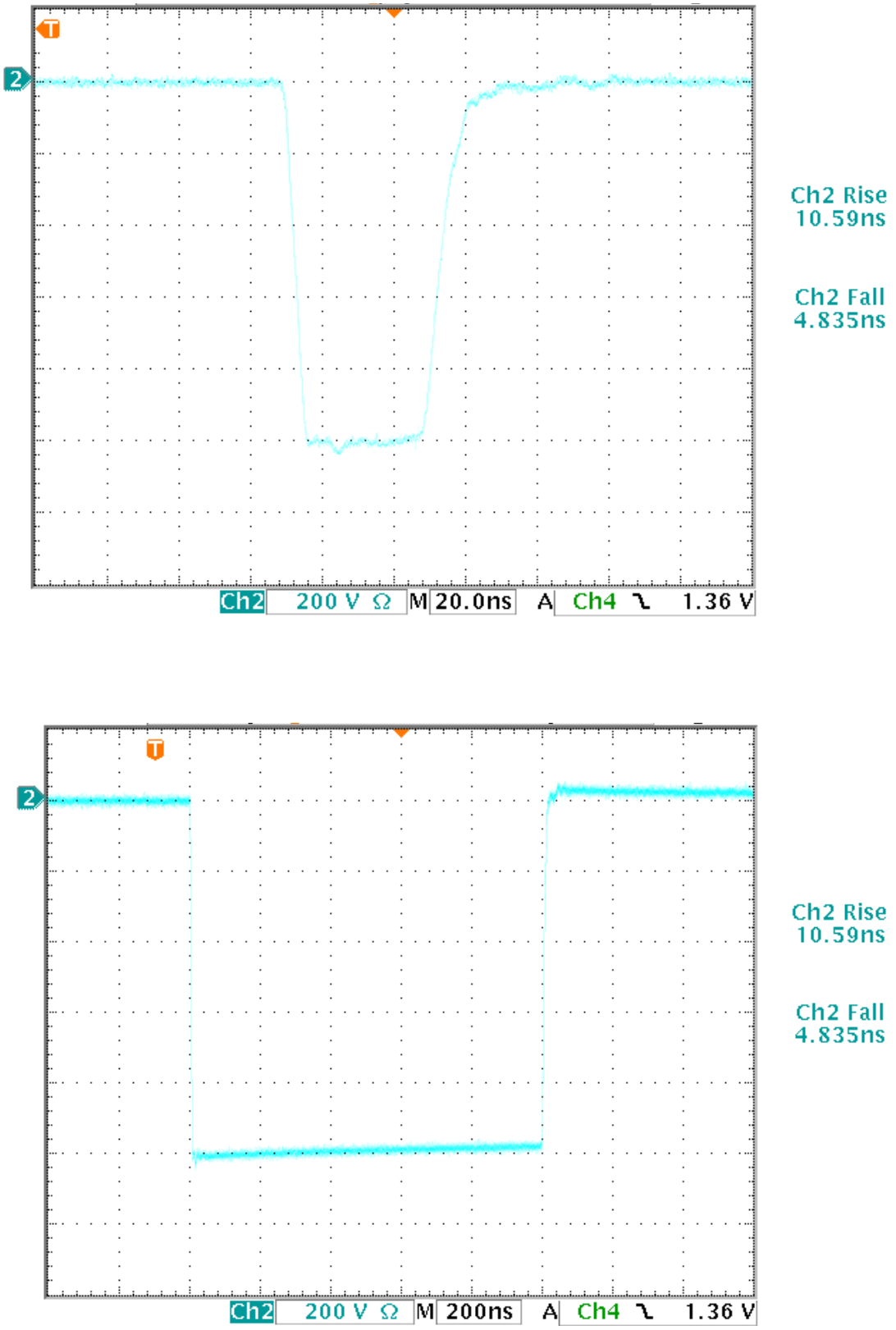

Figure 6 Transition times for 40ns and 1000ns pulses

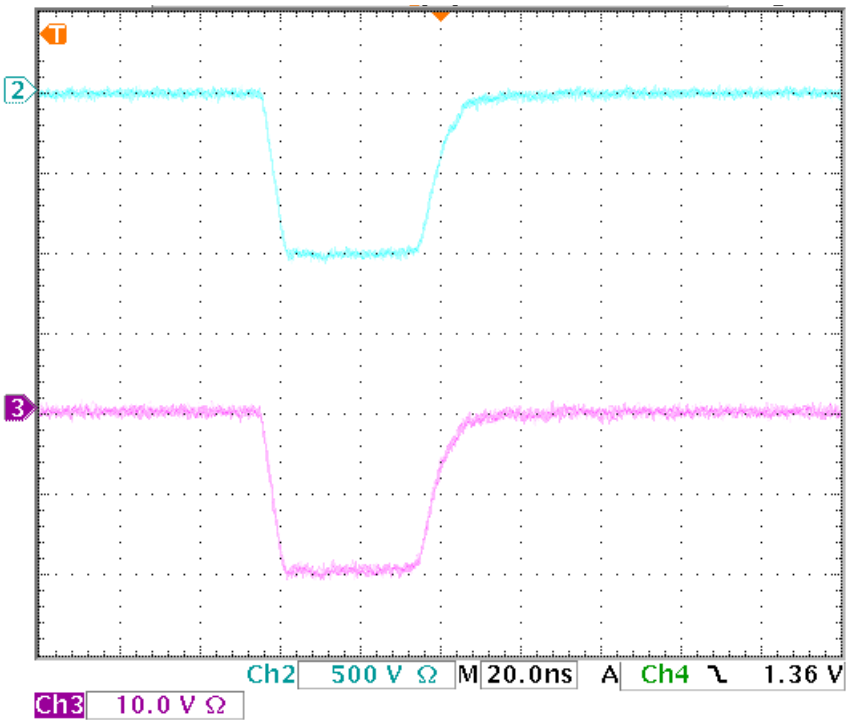

Figure 7 Comparison of monitor output (magenta) to main output (blue) for 40ns pulse

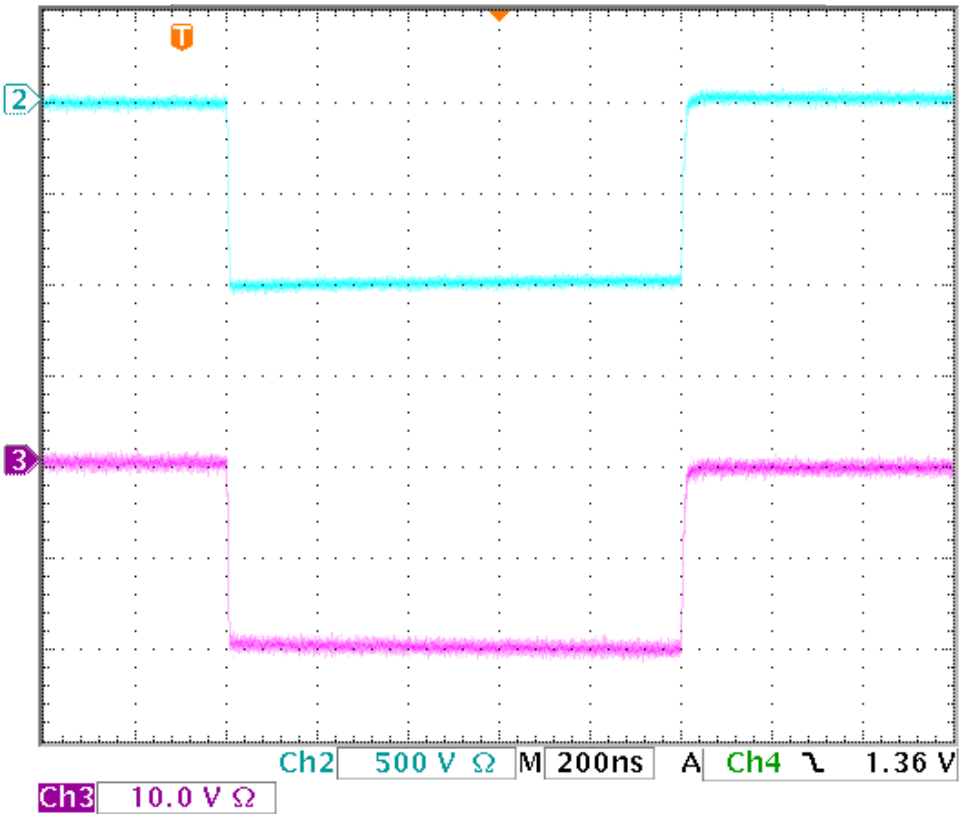

Figure 8 Comparison of monitor output (magenta) to main output (blue) for 1000ns pulse

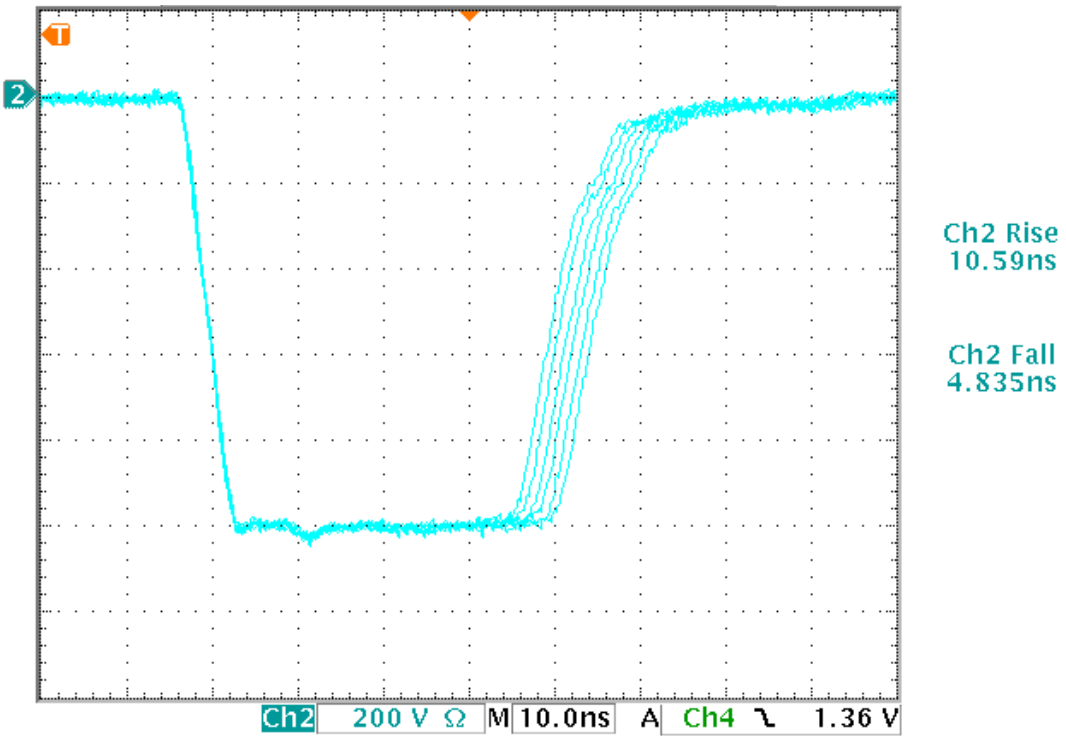

Figure 9 Fine pulse width control 0 to 10 in steps of 2.

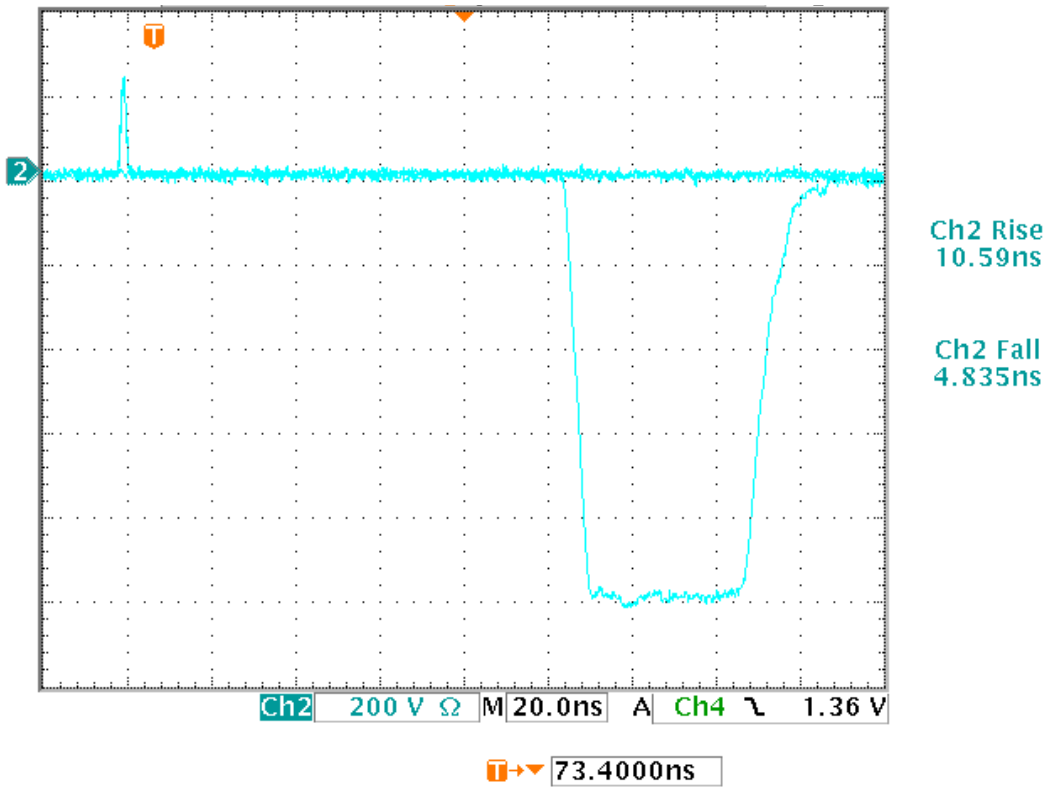

Figure 10 Trigger delay 73.4ns