Kentech Instruments Ltd.

Notes on the use of

Gated Photomultiplier Tube

(Gated PMT)

PLEASE READ THIS MANUAL CAREFULLY BEFORE USING THE UNIT

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1 DECLARATION OF CONFORMITY

Declaration of Conformity

We:- Kentech Instruments Ltd.
The Isis Building
Howbery Park
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Oxfordshire OX10 8BD, UK

Certify that this apparatus:-

Conform with the protection requirements of European Community Directives:-

73/23/EEC	Low Voltage Directive
89/336/EEC	Electromagnetic Compatibility
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:-

2 DISCLAIMER

There are high voltage power supplies present in this instrument when the unit is operating. Do not remove any covers from the unit or expose any part of its circuitry. In the event of malfunction, the unit must be returned to Kentech Instruments Ltd. or its appointed agent for repair.

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 connected to the local earth/screened enclosure via the power lead to maintain this protection.

Kentech Instruments Ltd. accepts no responsibility for any electric shock or injury arising from use or misuse of this product. It is the responsibility of the user to exercise care and common sense with this highly versatile equipment.

Photomultiplier tubes (PMT) are very delicate and very expensive and must be handled with great care both in use and in storage. Read this manual before unpacking and using the instrument. If cleaning is necessary this should be performed with a soft dry cloth or tissue only. Only use optical quality clothes or tissues on the input face of the PMT.

3 EMC CAUTION

This equipment includes circuits intentionally designed to generate short high energy electromagnetic pulses and the EM emissions will be sensitive to the details of the experimental set up.

In practice emissions may exceed E55011 and the unit may cause interference with other equipment in its immediate environment. It is therefore suitable for use only in a laboratory or a sealed electromagnetic environment, unless it is used in a system that has been verified by the system builder to comply with EC directive 89/336/EEC. Use of this apparatus outside the laboratory or sealed electromagnetic environment invalidates conformity with the EMC Directive and could lead to prosecution.

4 ABBREVIATIONS

ASCII	American Standard Code for Information Interchange
ADC or adc	Analogue to Digital Convertor
AF	Across Flats
CCD	Charge Coupled Device (camera)
cr	carriage return
EEPROM	Electrically programmable and erasable Read only memory, non-volatile
EHT or eht	Extra High Tension (high voltage)
EMC	Electromagnetic Compatibility
FO	Fibre Optic
FC	FO connector type
GXD	Gated X-ray Detector
IEC	International Electrotechnical Commission
JSON	Java Script Object Notation
lf	Line Feed
MCP	Micro Channel Plate
ND	Neutral Density
PC	Photo Cathode
PMT	Photo multiplier tube
PRF	Pulse Repetition Frequency
PSU or psu	power supply unit
SD	Standard Deviation
sw	software
URL	Uniform Resource Locator
w.r.t.	With Respect To
XML	Extensible Markup Language

5 INTRODUCTION

The gated PMT allows the photocathode of the PMT to be gated on or off for a short period. This is particularly useful when the light source under investigation has a very bright precursor or post cursor.

When gating the PMT there are problems associated with the following:

1 The tube gain is slightly dependent on the photocathode to MCP (input face) voltage.

2 The gate pulse can couple to the output signal as unwanted noise. With care this can be subtracted from the output signal after recording of signals.

3 The gate pulse can couple to the MCP directly to cause changes in the gain of the tube. This is not so predictable or so easy to remove. In order to mitigate against this the input and output electrodes of the MCP are decoupled with significant capacitance to each other and to ground. However, the current that charges the photocathode to MCP (input) gap has to flow in the surface coating of these elements. There will be a voltage drop radially while the charging occurs. As the MCP electrode coatings are quite resistive some electric field may enter the MCP and modify the gain. A more conductive coating would be able to reduce this effect by may also change the QE of the MCP detection.

4 The fast gate pulse can cause oscillations to arise in various parts of the system and it may be that the signal is not representative of the input light.

This package has been designed to mitigate all of these issues as much as possible without resorting to a specially coated MCP.

5.1 SPECIFICATIONS[1]

No. of PMTs	1
Gate sense	The triggering can be to gate ON or gate OFF for a period set by the trigger pulses.
CONTROLS	
Gain	Set with a 10 turn lockable potentiometer with counter.
Mode switch	OFF, Gate ON, Gate OFF, On DC
PC activate	Turn on photocathode. Us this in DC or Gate OFF modes.
Trigger delay	~70 ns
Maximum rep. rate	200 Hz
Gate rise time	~5ns
Jitter	<=100ps RMS
Gate pulse length forming	First edge derived from the leading edge of the trigger 1 applied pulse. The second edge is the earlier of the trigger 1 trailing edge and the trigger 2 leading edge.
Trigger requirements	= 5V into 50 ohms, <5ns rise time
Indicators LEDs	
	Power, green Trigger 1, yellow Trigger 2, yellow PC active, red HV ready, red
Dimensions	
CONTROL UNIT	330 wide x 270 mm deep or approx. 116 mm high including rubber feet.
HEAD	diameter 150mm, length 53.4mm plus N-type output connector.
Optical axis height	91 mm when used with the mount bracket.
Note	The head and control units are connected with a ~ 2m long umbilical. This is not easily disconnected.
Power supply	100 to 240 VAC, 50/60 Hz, 30 W max

1 These are the specifications of the power supply and gating unit, not those of the PMT. For the specification of the PMT please refer to the tube manufacture's data., see section 7 on page 12.

CONNECTORS	
Trigger 1 & 2	BNC
Power	IEC
Head output	N-type

ENVIRONMENTAL	
Ambient temperature	5 to 35 °C
Humidity	< 95% non-condensing
Altitude	< 3000 m

6 OPERATION OF THE GATED PMT

6.1 GENERAL OPERATION

We assume that users will be familiar with the general use of PMTs.

Before allowing any light to reach the PMT in an active state carefully estimate the amount of light that will be present and make sure it falls within the guide lines supplied by the PM tube manufacturer; in this case Photek.

Before powering the unit on make sure there is a suitable resistive load on the output connector of the PMT.

The head assembly, containing the PMT, has a plastic blanking plate fitted to the front. This also contains a FO input adaptor; type FC. The tube can be used with the plastic blanking plate removed.

It is recommended that the head be operated with the **metal** front cover fitted. If this restricts the rays of light arriving at the input window, then consider having an alternative cover made rather than running without one. With the front cover removed, high voltage connections to the tube are exposed. In addition the switching may cause excessive radiation of the gate pulse.

6.2 POWERING THE UNIT UP

Before powering the unit on make sure there is a suitable resistive load on the output connector of the PMT.

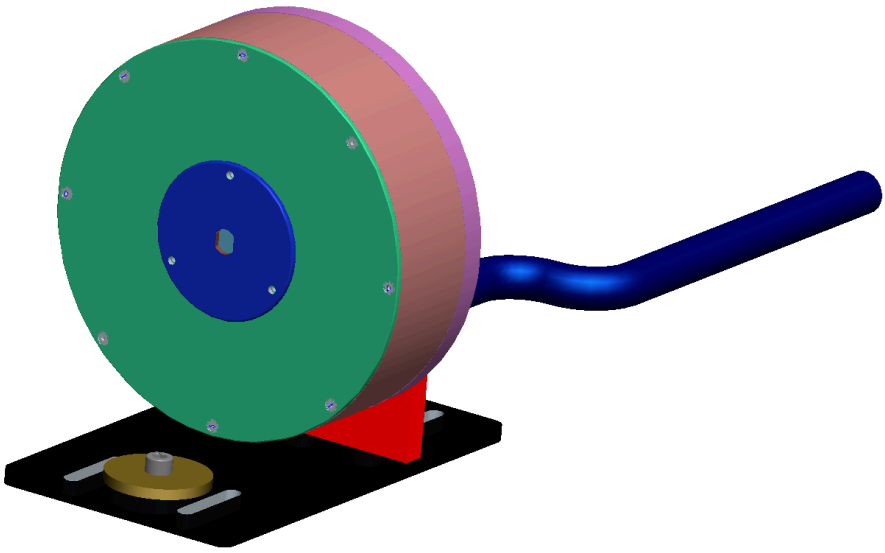


Figure 1 The head on a mount plate

When the unit is first switched on the DC bias voltages are raised slowly and the tube is not available for use until the HV “ready” indicator is illuminated. In this state the PC will be inactive, whatever

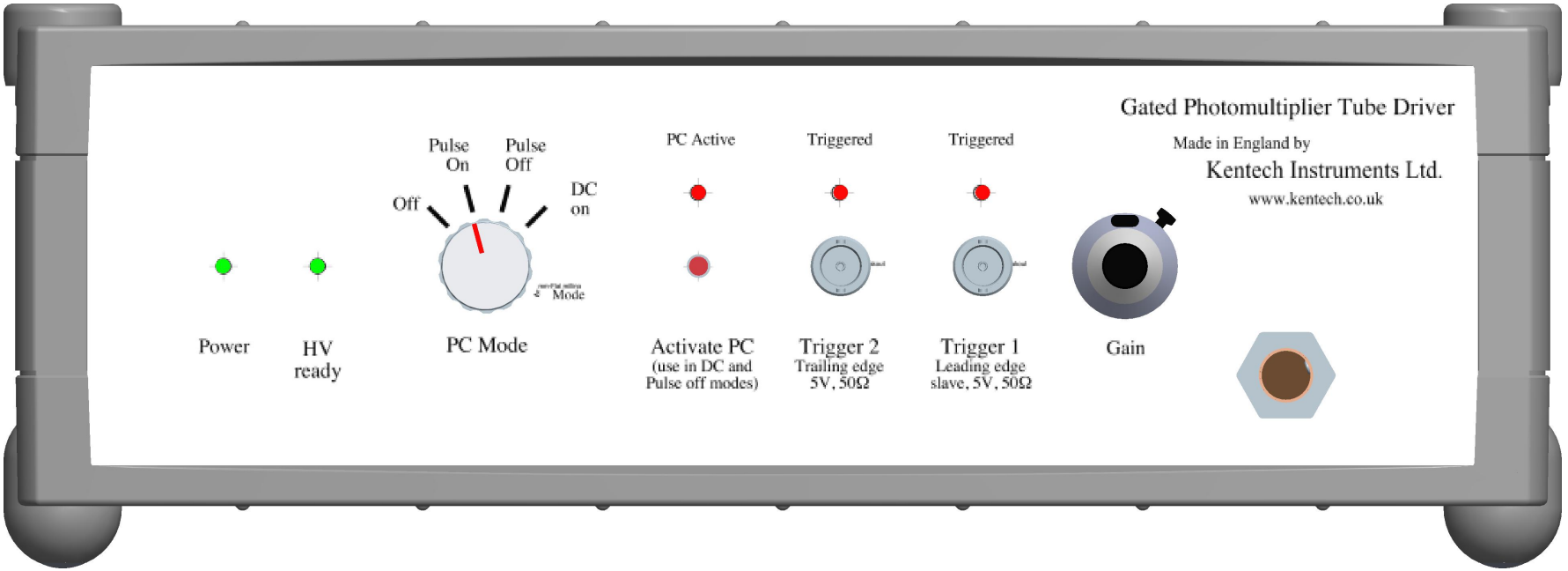


Figure 2 Front panel of the control unit.

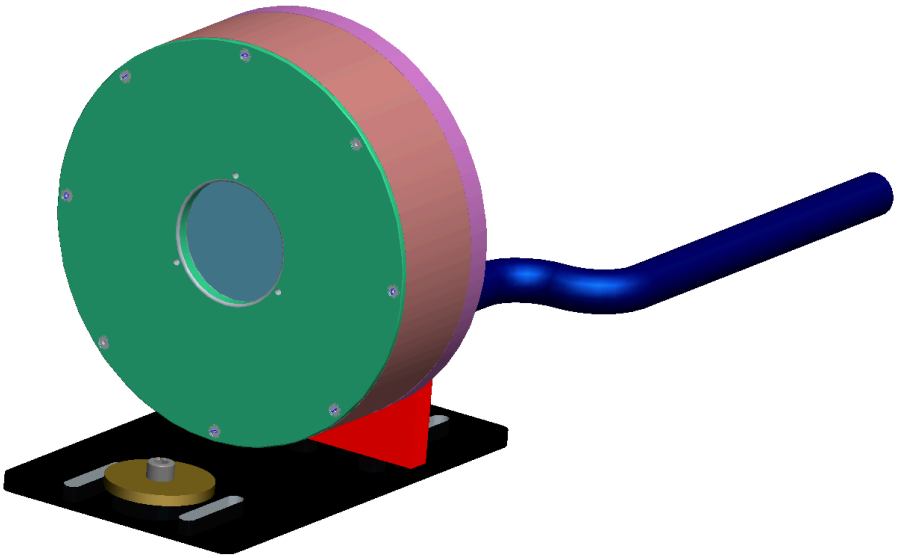


Figure 3 The head on a mount plate with the front plastic cover removed.

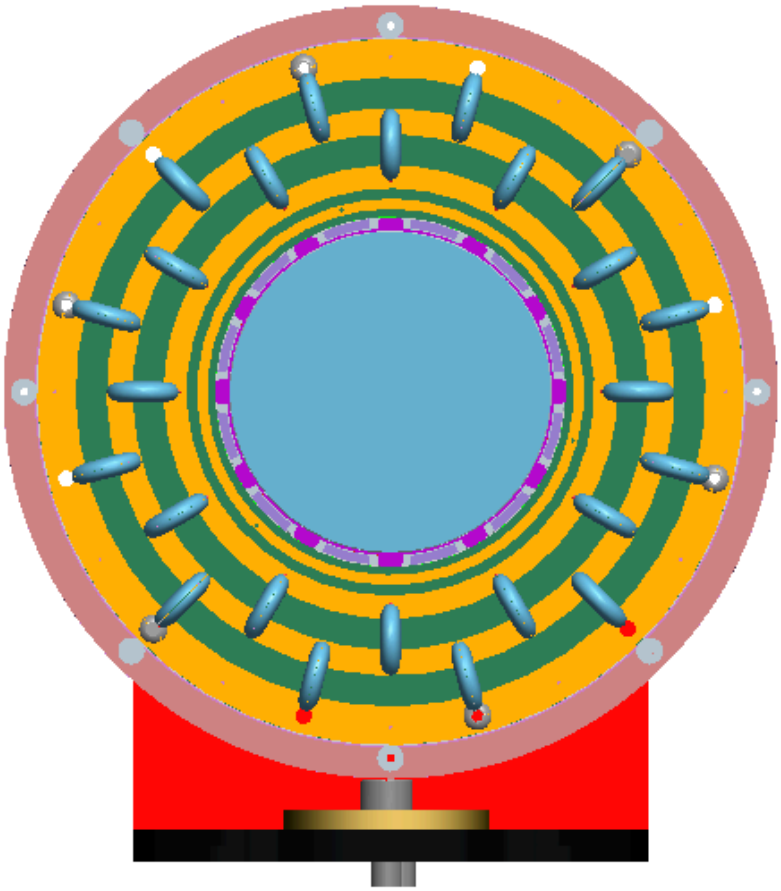


Figure 4 The head on a mount plate with the front cover removed.
This shows the high voltage connections to the tube.

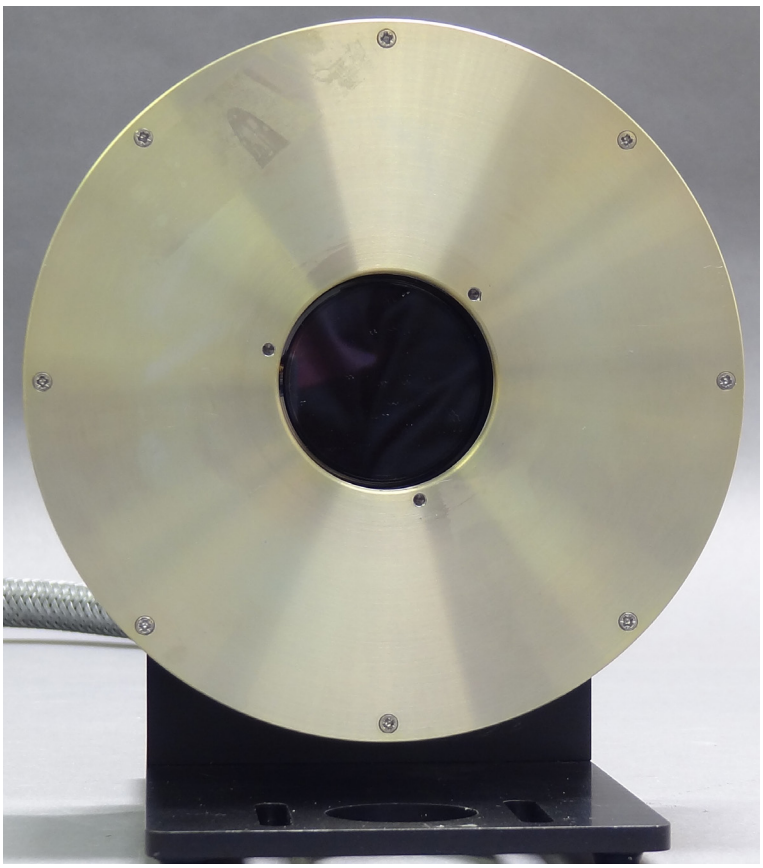


Figure 5 The head

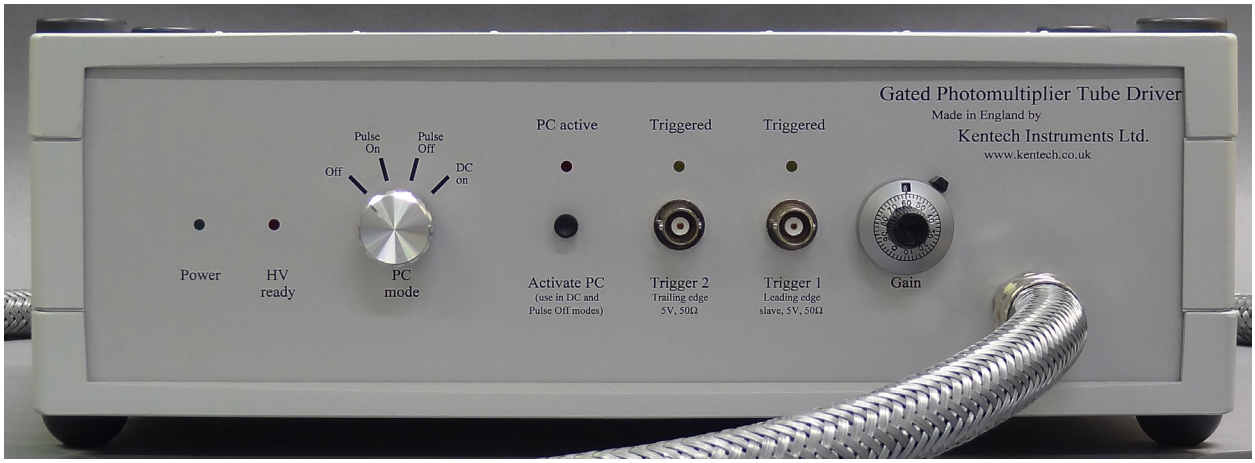


Figure 6 The control unit

the state of the mode switch. If the PC needs to be active for the selected mode then the “activate PC” button should be depressed for a short period. The PC active light will then illuminate.

The mode switch selects the control mode of the photo cathode from (i) PC off, (ii) PC off but gateable ON, (iii) PC ON but gateable OFF, and (iv) DC on.

When the mode switch position is changed the PC is switched off. If the mode requires the PC to be on in quiescently then the activate PC button should be depressed for a short period. This will turn on the PC and illuminate the PC active LED.

Generally the DC position is used for setting up and the light level allowed to reach the PC should be carefully controlled. Also the gain should not be run very high so that the anode current is restricted.

The duration of the gate in either gate ON or gate OFF modes, is set by the following:

The gate starts when the trigger 1 input rising edge is received. The gate stops when either the trigger 1 input falling edge is received or the trigger 2 rising edge is received, whichever is the earlier. By using two triggers very short gates can be achieved even if the user does not have access to a short gate trigger generator.

6.3 POWERING THE UNIT DOWN

Whilst the unit can just be switched off via the main power switch on the rear panel, it is safer to first put the mode switch into the OFF position and then turn the gain to the lowest value. This protects the tube form voltages arriving at the tube due to different power supplies collapsing at different rates. There are zener diodes to protect against this causing any problems but it is better to avoid relying on this.

6.4 GAIN CONTROL

The PMT gain is controlled with the gain control knob on the front panel. This has a counter and is lockable. Note that if the gain is adjusted the HV ready light will go out until the voltages have adjusted to the newly requested values. The triggering will not be inhibited during this change.

7 PHOTEK TUBE DETAILS

PHOTEK
ENVISAGE THE FUTURE

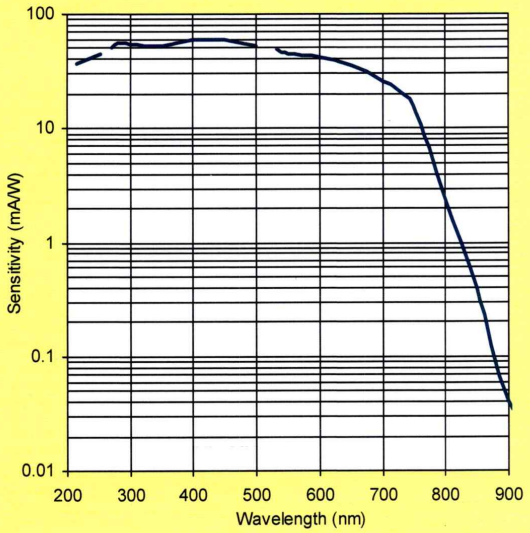
Test Data Summary

03 August 2020

DeviceType	Input Window	Cathode	Anode	Screen ITO
PMT140	Quartz	S20	SA	No

SerialNo: 82200703 Customer: SYDOR INSTRUMENTS LLC
PhotekRef: 19-335 Specification No: SPM140SY06-01, 24th Dec 2019

Spectral Response



Sensitivity: 274 µA/lm

	mA/W	%QE
214nm	37.30	21.61
254nm	45.00	21.97
270nm	50.20	23.05
290nm	55.80	23.86
300nm	53.60	22.15
350nm	51.80	18.35
400nm	59.70	18.51
450nm	58.90	16.23
500nm	51.90	12.87
532nm	49.90	11.63
550nm	45.30	10.21
650nm	35.30	6.73
750nm	15.90	2.63
800nm	2.45	0.38
850nm	0.40	0.06
900nm	0.04	0.01

Electron Gain 7.50E+03

Maximum OperatingVoltages:

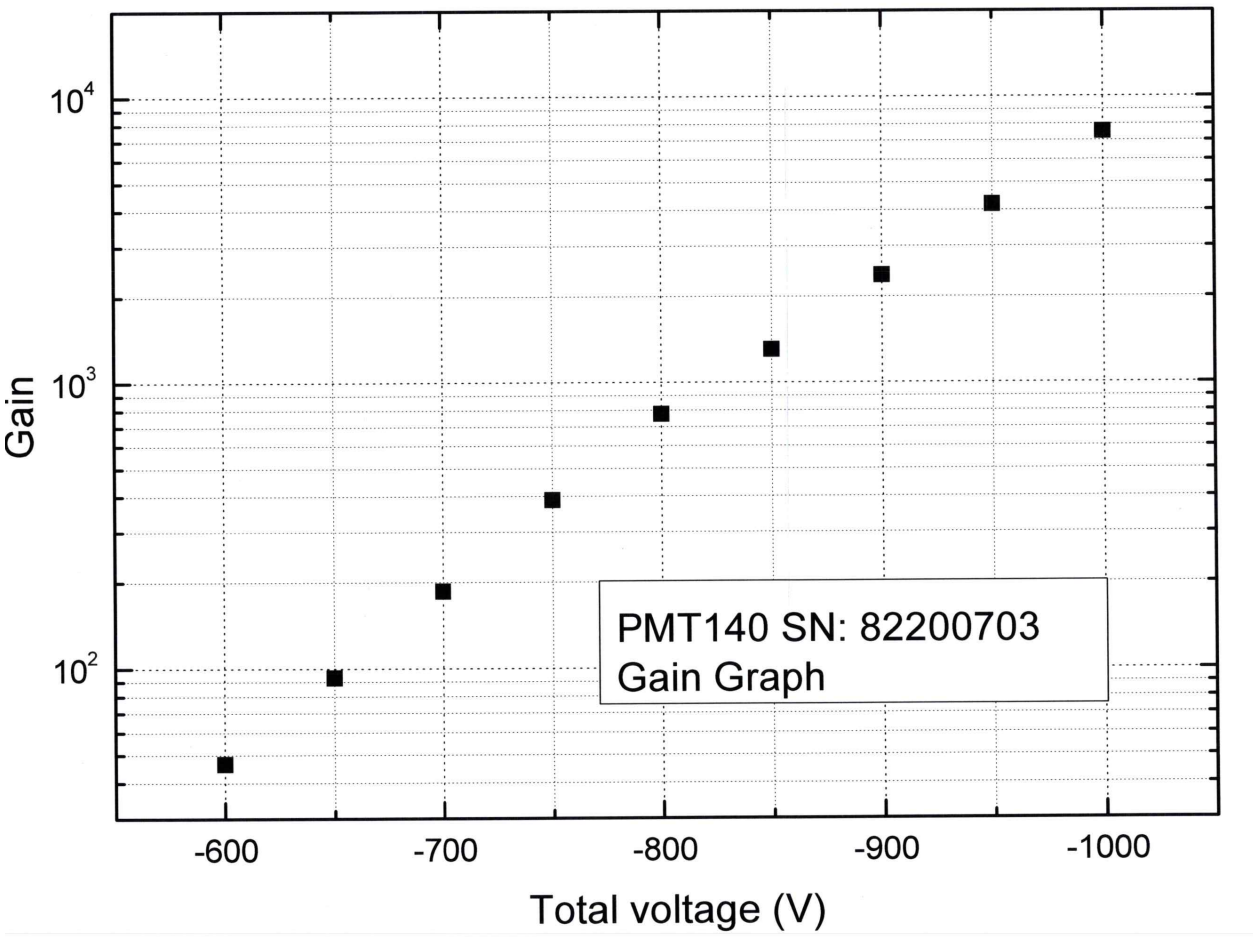
```
Maximum voltage:
Cathode: -200V
MCP In:  -1000V
MCP Out: -3000V
Anode: ground
```

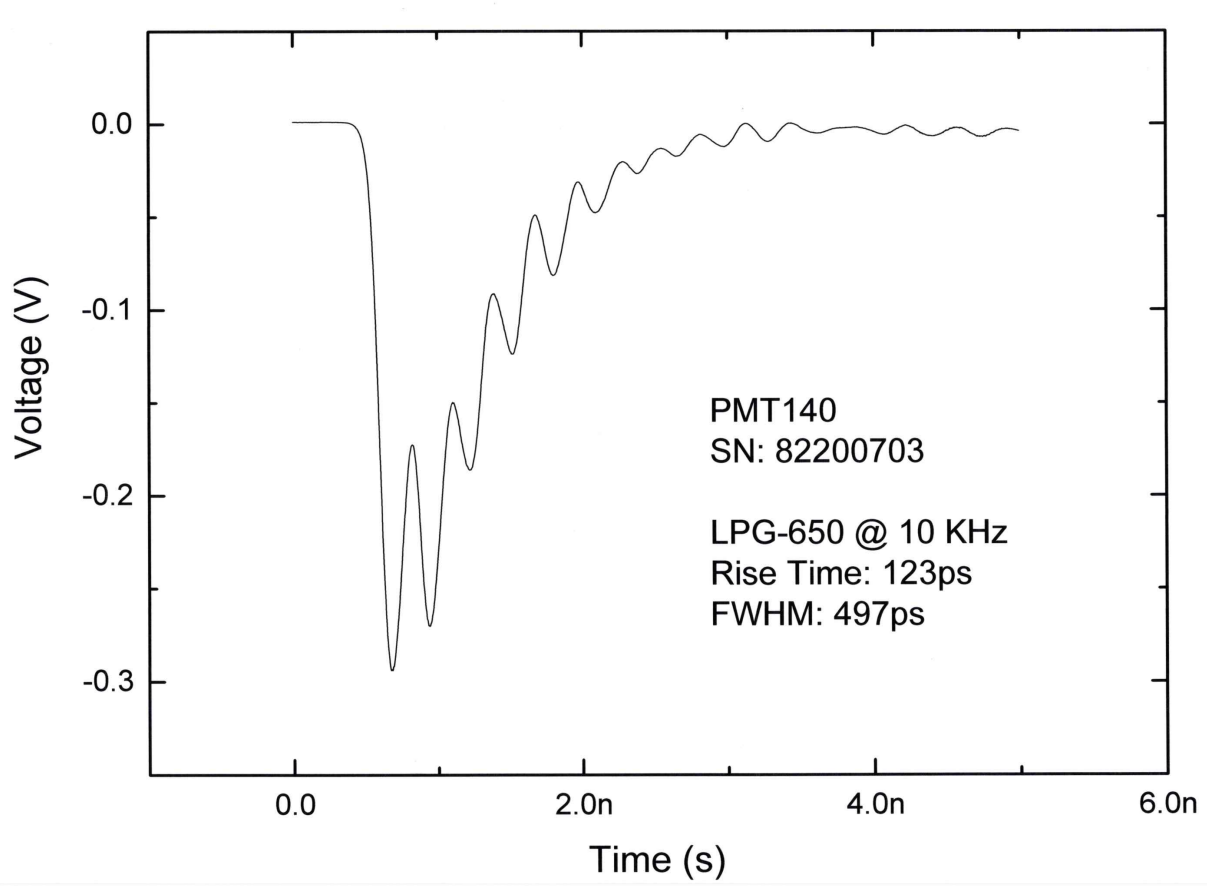
Comments:

- 7.5E3 Gain measured at maximum voltage
- Please see the gain graph supplied
- For general operational guidelines, please see the PMT user guide

Tested: QA:

Photek Ltd. Tel: +44 (0) 1424 850555 Fax: +44 (0) 1424 850051 E-mail: sales@photek.co.uk Web Site: http://www.photek.co.uk


Gain
10^4
10^3
10^2
-600
-700
-800
-900
-1000
Total voltage (V)
PMT140 SN: 82200703
Gain Graph


0.0
-0.1
-0.2
-0.3
Voltage (V)
PMT140
SN: 82200703
LPG-650 @ 10 KHz
Rise Time: 123ps
FWHM: 497ps
0.0
2.0n
4.0n
6.0n
Time (s)

8 TEST DATA

The PMT was illuminated with a pulse Green LED and the output from the anode recorded on an Agilent DSO81004A 10GHz 40Gs/s oscilloscope. No attenuation was used between the PMT and the scope. Note: caution should be exercised when doing this as the tube can deliver tens of volts into 50 Ω, well beyond the maximum input voltage of such oscilloscopes.

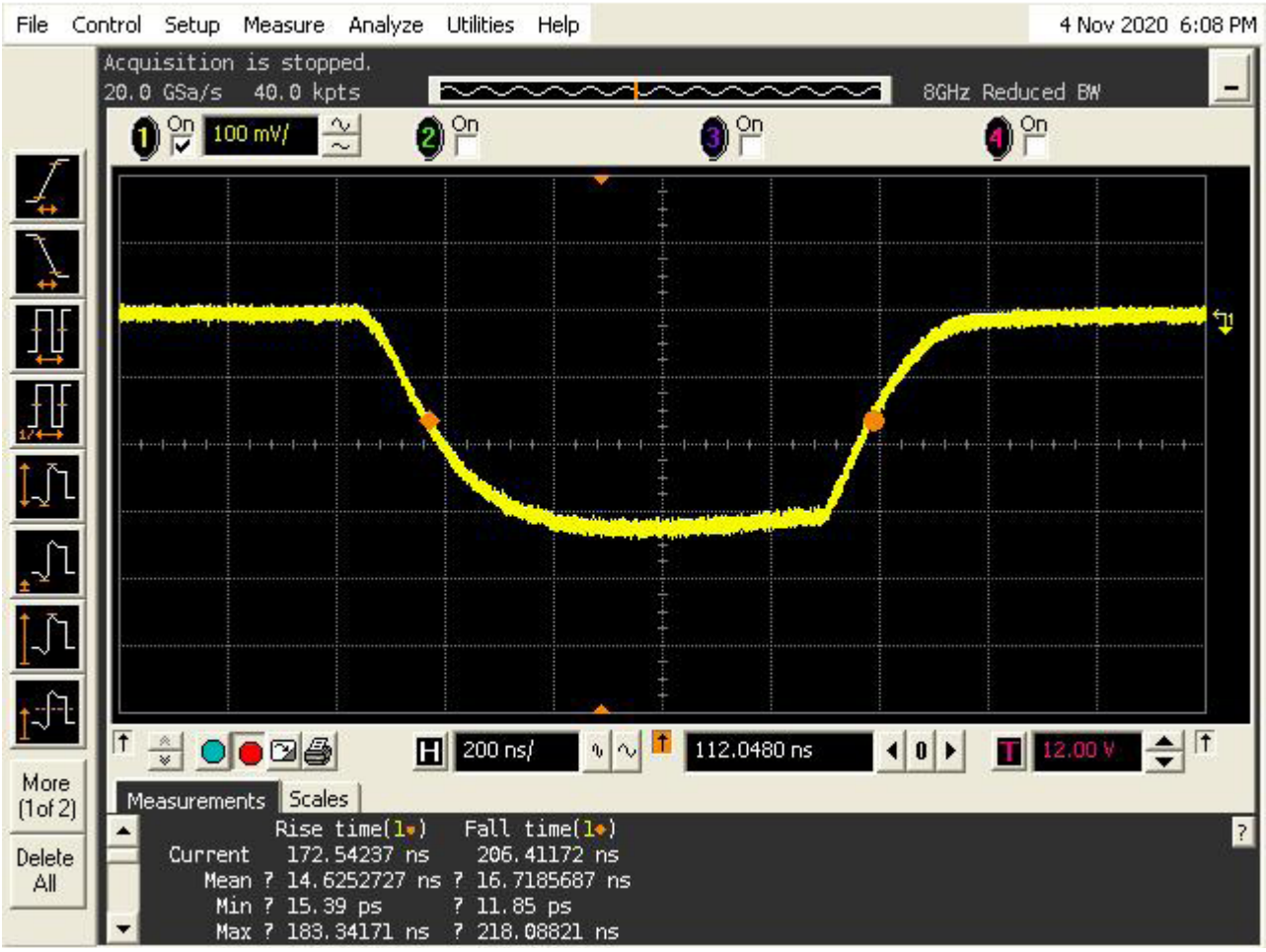


Figure 7 Mode DC on, showing the waveform of the pulsed LED.

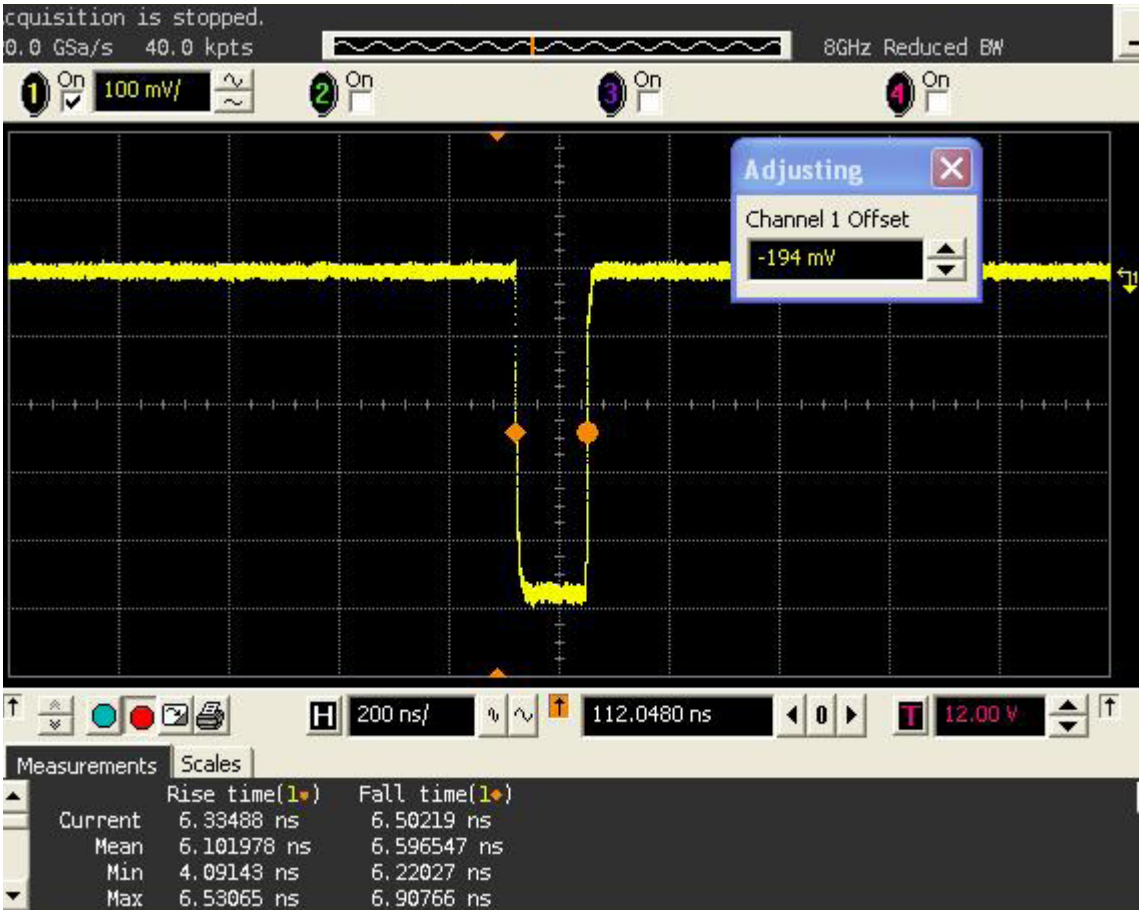


Figure 8 Mode, Gate ON.

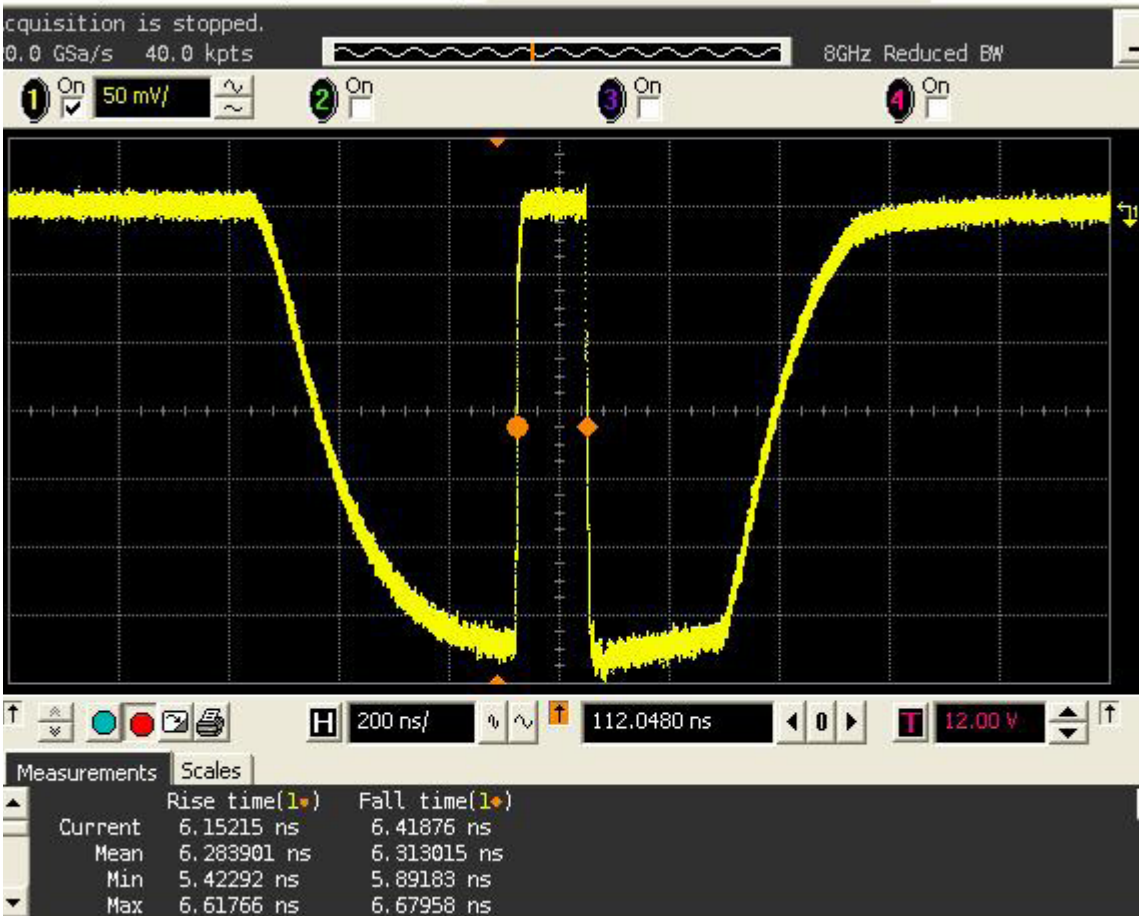


Figure 9 Mode, Gate OFF.

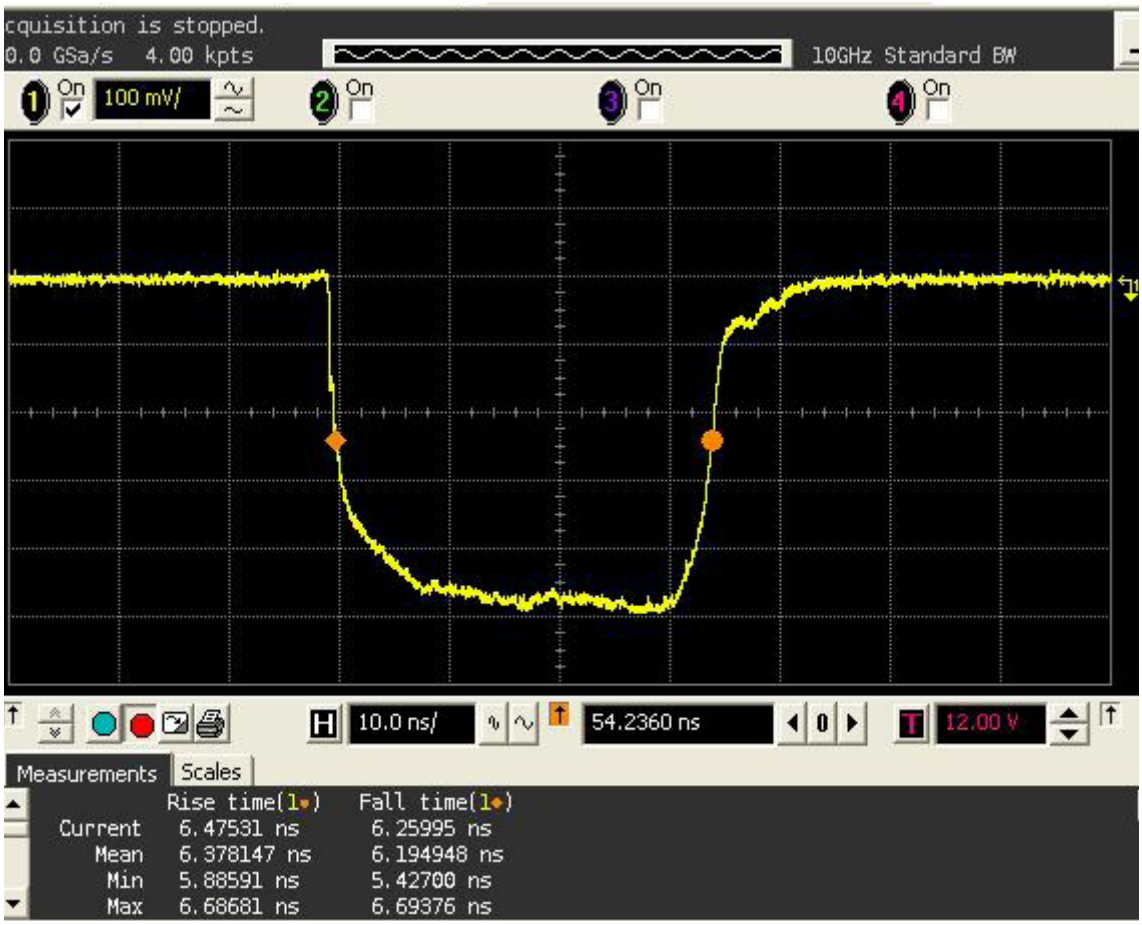


Figure 10 Mode, Gate ON with separate trigger pulses for On and OFF edges..

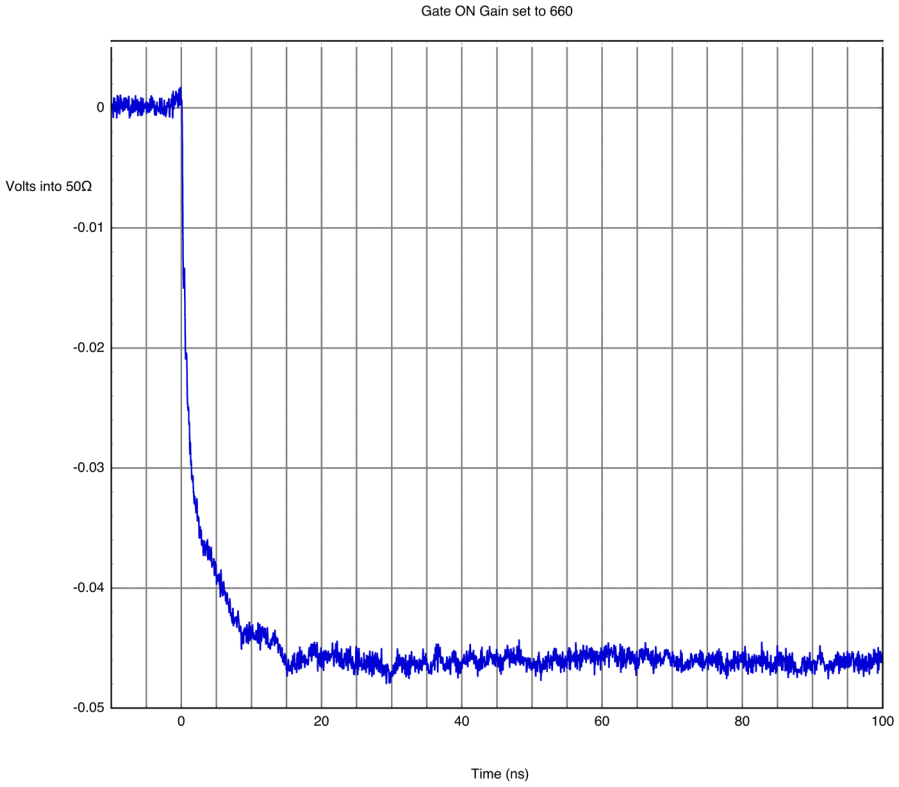


Figure 11 Mode, Gate ON showing turn on time.

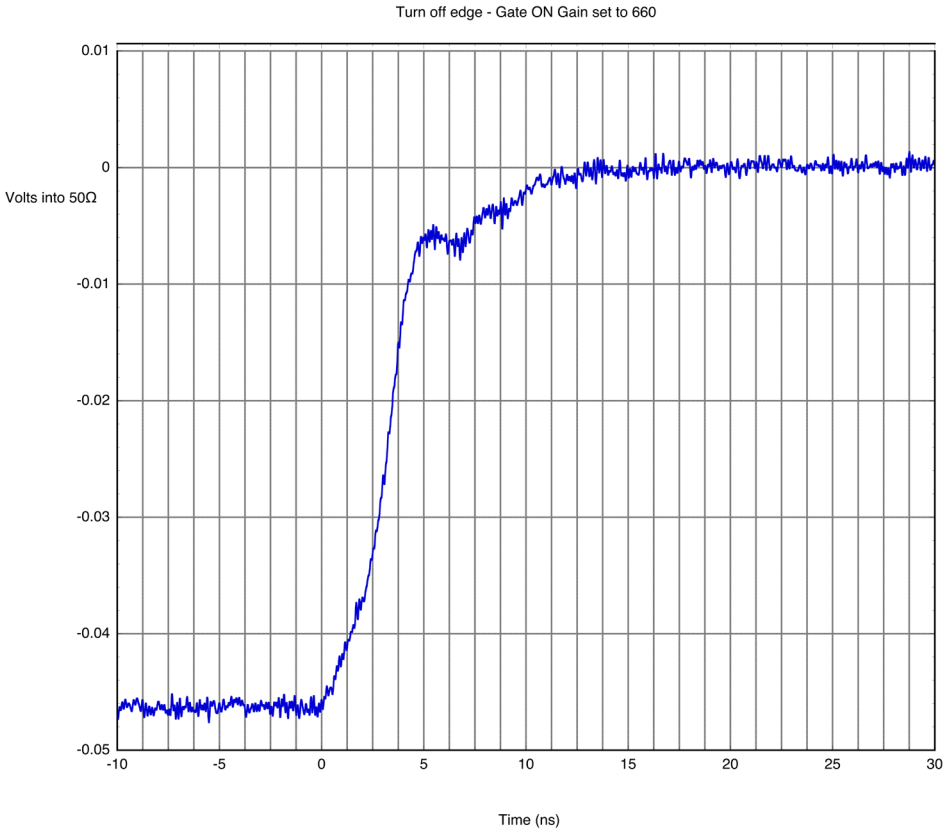


Figure 12 Mode, Gate ON showing turn off time.

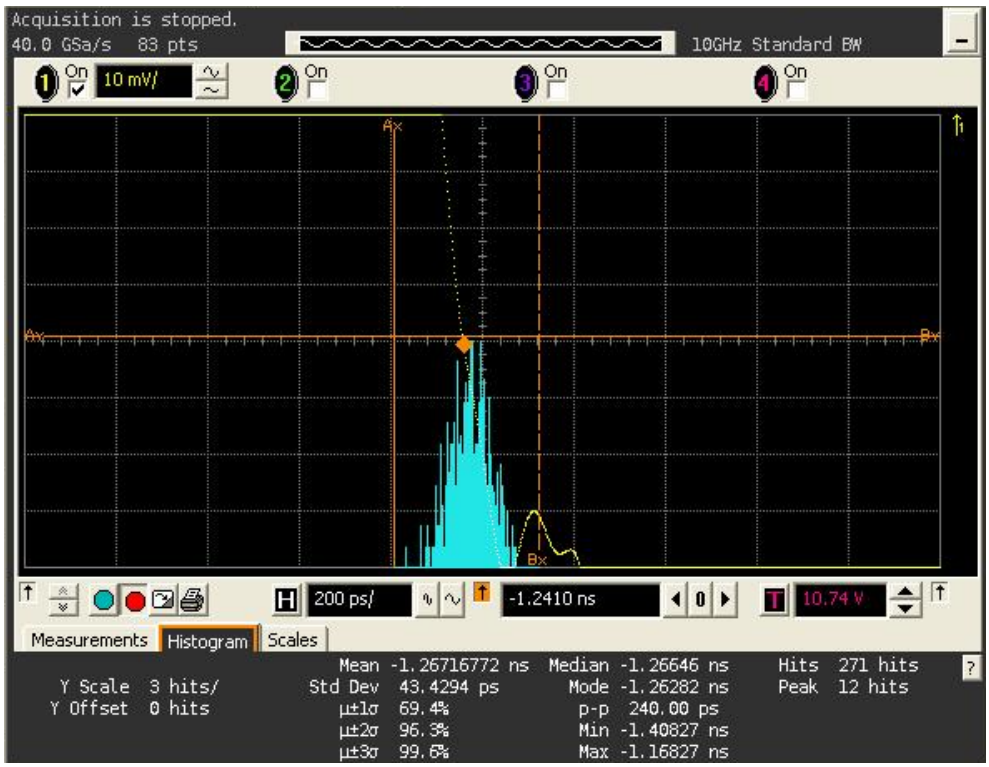


Figure 13 Jitter measurement made optically on the turn on edge.
Indicated figure is 43.4ps. There is likely to be a significant shot noise associated with this and the gate drive is likely to be better.

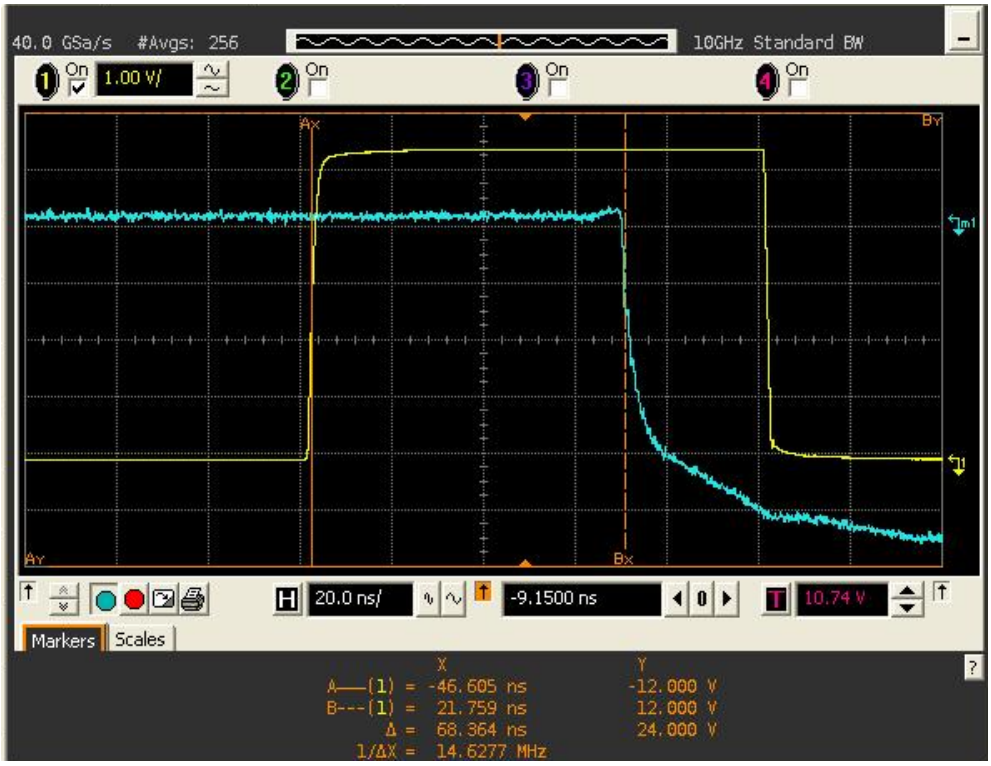


Figure 14 Trigger delay to turn on edge ~68ns.