

Featuring Fast Gating Function with Improved Time Response  
and High Switching Ratio

### FEATURES

- High Speed Gating by Low Supply Voltage (+10 V)
  - Gate Rise Time : 1 ns<sup>(A)</sup>
  - Gate Width : 5 ns
- Fast Rise Time : 180 ps
- Narrow TTS<sup>(B)</sup> : 90 ps
- High Switching Ratio:  $10^8$  at 500 nm
- Low Switching Noise
- Low Dark Noise
- Variety of Photocathode Available

### APPLICATIONS

- Environmental monitoring
- Satellite laser ranging
- Time resolve fluorescence decay analysis

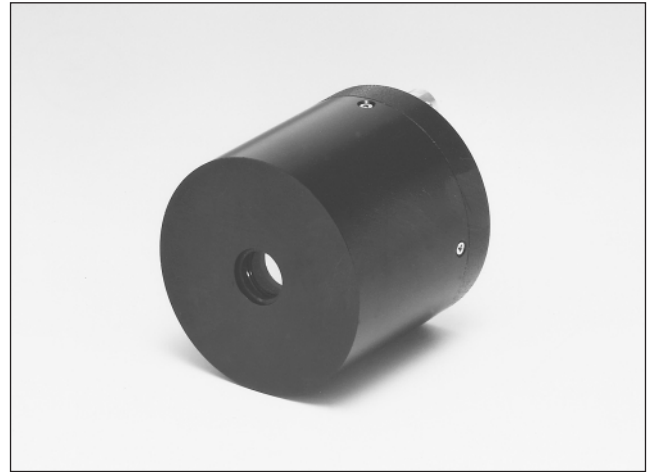


Figure 1: Typical Anode Output Waveform

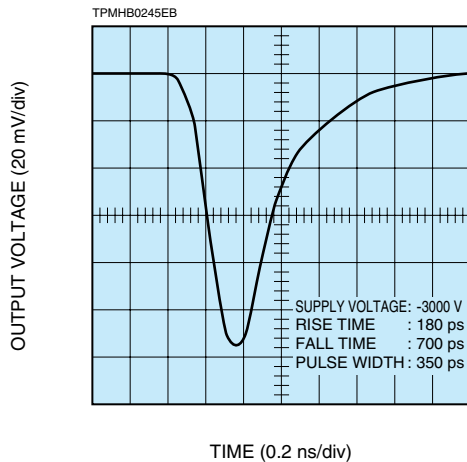


Figure 2: Block Diagram of Anode Output Waveform Measuring Apparatus

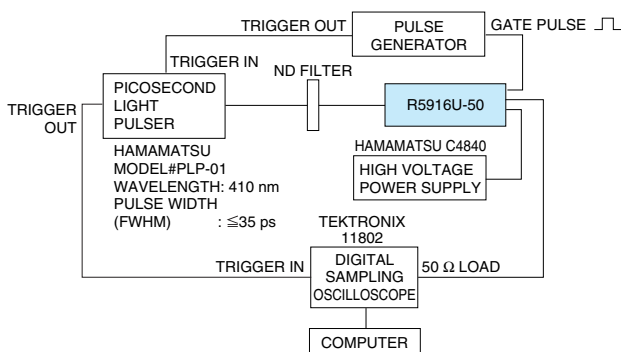
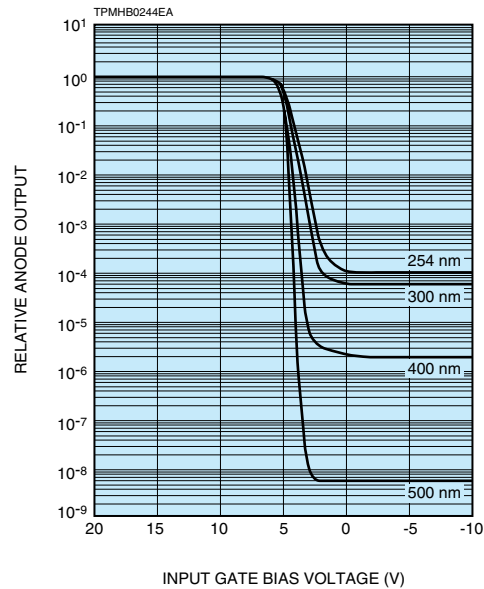


Figure 3: Typical Gate Bias Characteristics (R5916U-50)



These are the anode output ratios measured at the forward and reverse bias voltages with respect to the photocathode.

# GATED MICROCHANNEL PLATE PHOTOMULTIPLIER TUBE (MCP-PMTs) R5916U-50 SERIES

## SPECIFICATIONS

### PHOTOCATHODE SELECTION GUIDE

Suffix Number	Spectral Response (nm)		Photocathode Material	Photocathode Window Material
	Range	Peak Wavelength		
50	160 to 850	430	Multialkali	Synthetic Silica
51	160 to 910	600	Extended Red Multialkali	Synthetic Silica
52	160 to 650	400	Bialkali	Synthetic Silica
53	160 to 320	250	Cs-Te	Synthetic Silica

### GENERAL CHARACTERISTICS

Parameter	Description / Value	Unit
Photocathode Effective Area in Diameter	10	mm
MCP Channel Diameter	6	μm
Dynode Structure <sup>©</sup>	2-Stage Filmed MCP	—
Capacitance between Mesh Electrode and Photocathode	14.7	pF
Operating Ambient Temperature	-50 to +50	°C
Storage Temperature	-50 to +50	°C

### MAXIMUM RATINGS (Absolute Maximum Values)

Parameter	Value	Unit
Supply Voltage	-3400	V
Average Anode Current	100	nA
Pulse Peak Current <sup>®</sup>	350	mA

### ELECTRICAL CHARACTERISTICS (R5916U-50) at 25 °C <sup>®</sup>

Parameter		Min.	Typ.	Max.	Unit
Cathode Sensitivity	Luminous <sup>®</sup>	100	150	—	μA/lm
	Radiant at 430 nm	—	50	—	mA/W
Gain (at -3000 V)		$1 \times 10^5$	$2 \times 10^5$	—	—
Anode Dark Counts (at -3000 V) <sup>®</sup>		—	10	—	s <sup>-1</sup>
Voltage Divider Current		—	—	100	μA
Switching Ratio (at 500 nm)		—	$1.7 \times 10^8$	—	—
Time Response (at -3000 V)	Rise Time <sup>®</sup>	—	180	—	ps
	Fall Time <sup>①</sup>	—	700	1000	ps
	IRF (FWHM) <sup>②</sup>	—	95 <sup>®</sup>	—	ps
	TTS (FWHM)	—	90 <sup>③</sup>	—	ps

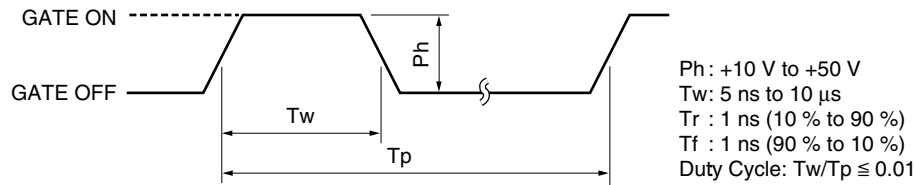
### GATING CHARACTERISTICS

Parameter		Min.	Typ.	Max.	Unit
Input Gate Pulse	Voltage	10	—	50	V
	Width	5	—	10 000	ns
	Duty Cycle	—	—	1	%
PMT response	Rise Time	—	1	—	ns
	Fall Time	—	1	—	ns

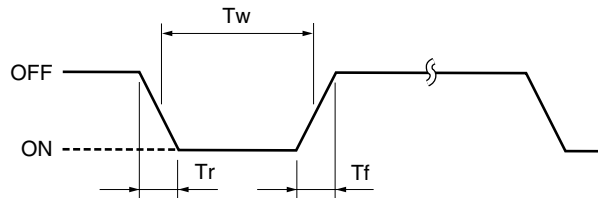
## NOTES

- Ⓐ This is defined at 10 % to 90 % of full pulse height.
- Ⓑ Transit time spread (TTS) is the fluctuation in transit time among individual pulses and specified as an FWHM (full width at half maximum) with the incident light having a single photoelectron state.
- Ⓒ Two microchannel plates (MCPs) are incorporated as a standard but we can provide it with either one or three MCPs as an option depending upon your request.
- Ⓓ This is specified under the operating conditions that the repetition rate of light input is 100 Hz or less and its pulse width is 70 ps or less.
- Ⓔ This is based on R5916U-50. All other types (suffix number 51, 52 and 53) have different characteristics based on photocathode sensitivity and anode dark counts.
- Ⓕ The light source used to measure the luminous sensitivity is a tungsten filament lamp operated at a distribution temperature of 2856 K. The incident light intensity is  $10^{-4}$  lumen and 200 V is applied between photocathode and all other electrodes shorted as an anode.
- Ⓖ This is specified at a duty cycle of 1 %.
- Ⓗ This is the mean time difference between the 10 % and 90 % amplitude points on the output waveform under full photocathode illumination.
- Ⓘ This is the mean time difference between the 90 % and 10 % amplitude points on the tailing edge of the output waveform under full photocathode illumination.
- Ⓝ IRF stands for Instrument Response Function which is a convolution of the  $\delta$ -function (H(t)) of the measuring apparatus and the excitation function (E(t)) of a laser. The IRF is given by the following formula:  $IRF = H(t) * E(t)$
- Ⓚ We specify the IRF as an FWHM of the time distribution taken by using the measuring apparatus in Figure 7 that is Hamamatsu standard IRF measuring set-up. It can be estimated by the following equation:  $(IRF \text{ (FWHM)})^2 = (TTS)^2 + (Tw)^2 + (Tj)^2$  where Tw is the pulse width of the laser and Tj is the time jitter of all equipments used in the measurement. An IRF is provided with the tube.
- Ⓛ TTS stands for Transit Time Spread (see Ⓑ). Assuming that the laser pulse width (Tw) and time jitter of all equipment (Tj) used in Figure 7 are negligible, IRF can be estimated as equal to TTS (see Ⓑ). Therefore, the TTS can be estimated to be 90 ps or so.

## INPUT GATE PULSE



## PMT OPERATING MODE



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R5916U-50 will be provided in a "normally off" mode configuration. It will be gated "on" only when the gate input pulse (+10 V to +50 V) is applied and gated "off" when it is grounded or left in open.

However, we can also provide this device in a "normally on" mode configuration which can be operated under the same operating conditions above to give inverse performance. Please specify if you require a "normally on" mode configuration when placing an order.

## TYPICAL PERFORMANCE DATA

Figure 4: Spectral Response Characteristics

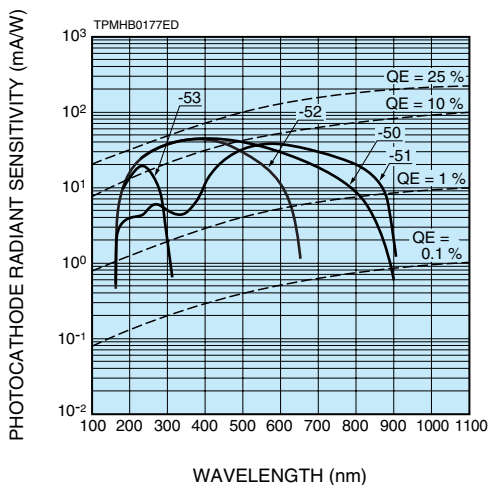
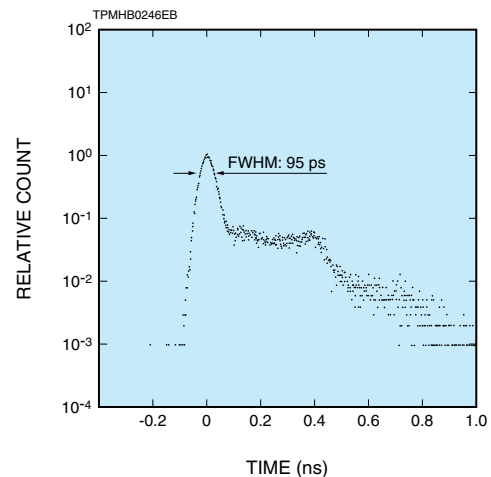


Figure 5: Instrument Response Function (IRF)



# GATED MICROCHANNEL PLATE PHOTOMULTIPLIER TUBE (MCP-PMTs) R5916U-50 SERIES

Figure 6: Gain

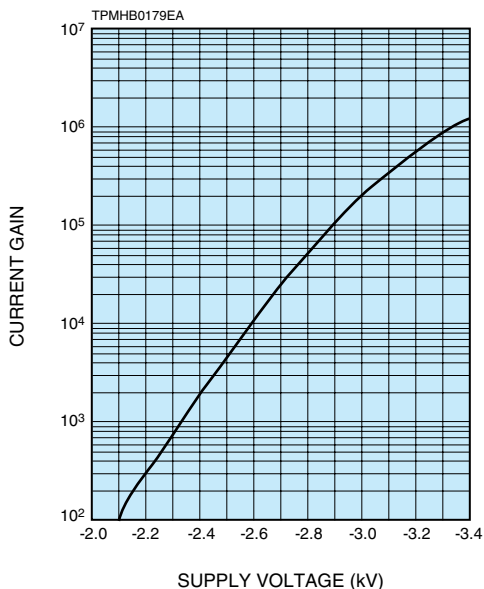


Figure 7: Block Diagram of IRF (Instrument Response Function) Measuring Apparatus

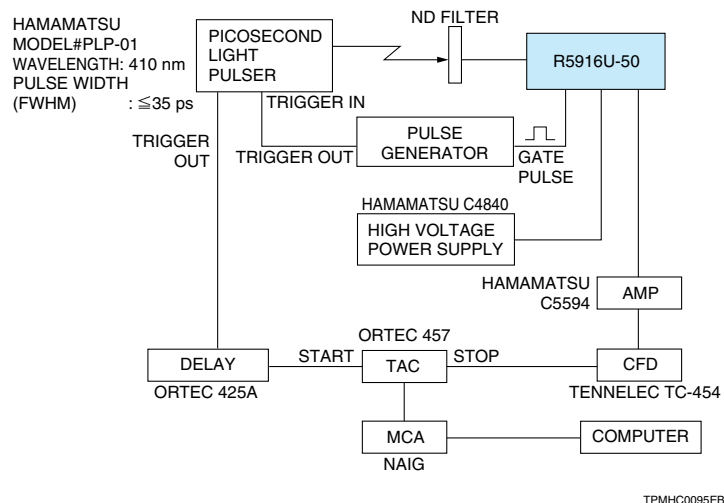


Figure 8: Pulse Height Distribution (PHD)

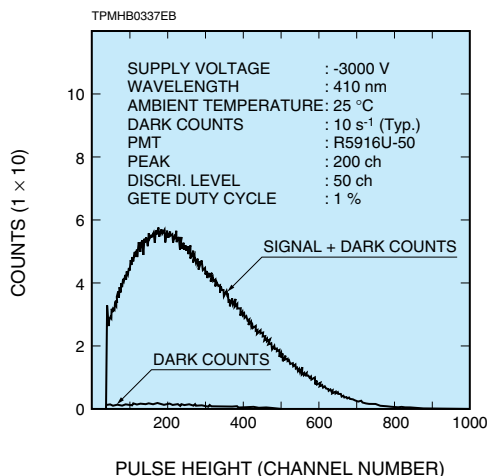


Figure 9: Block Diagram of PHD Measuring Apparatus

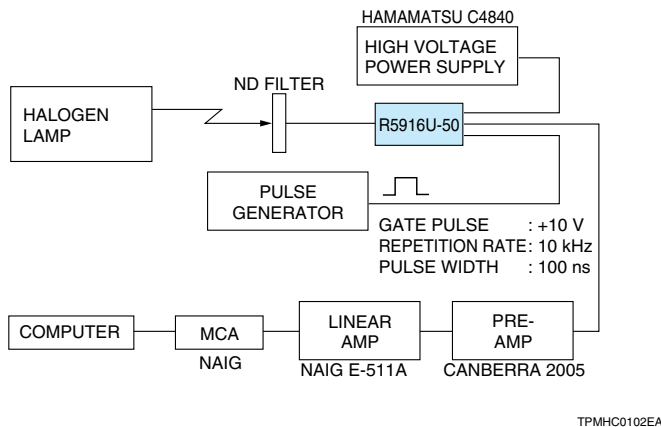


Figure 10: Gate Pulse Response

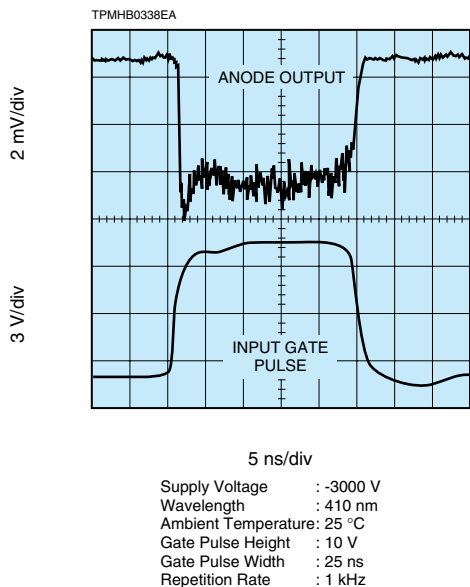


Figure 11: Block Diagram of Gate Pulse Response Measuring Apparatus

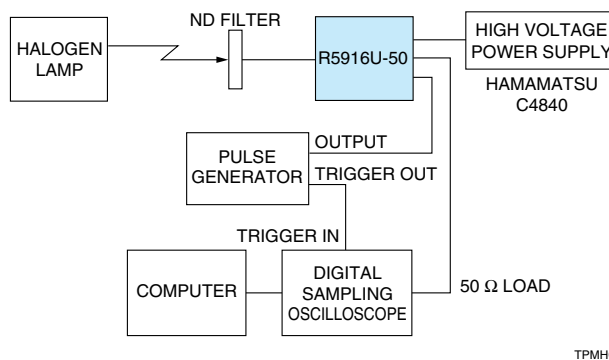
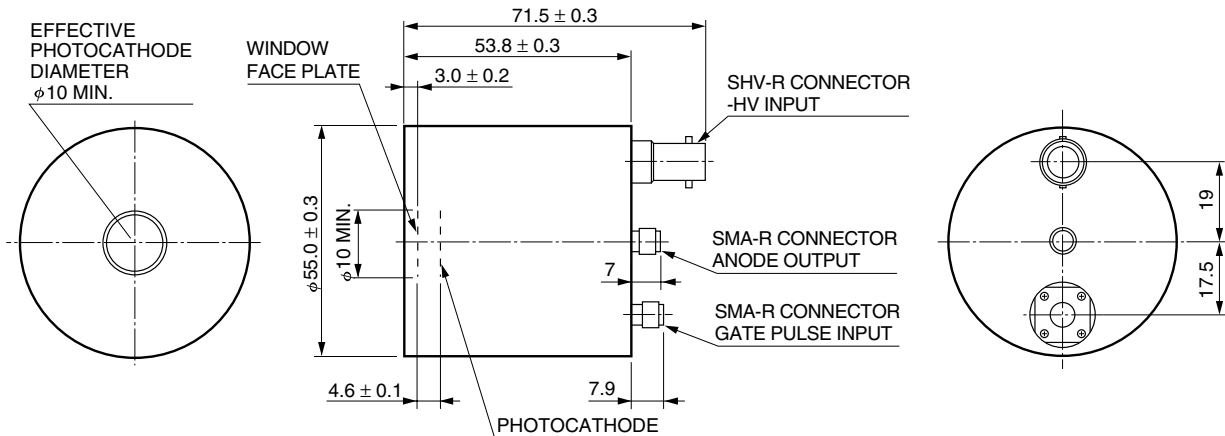
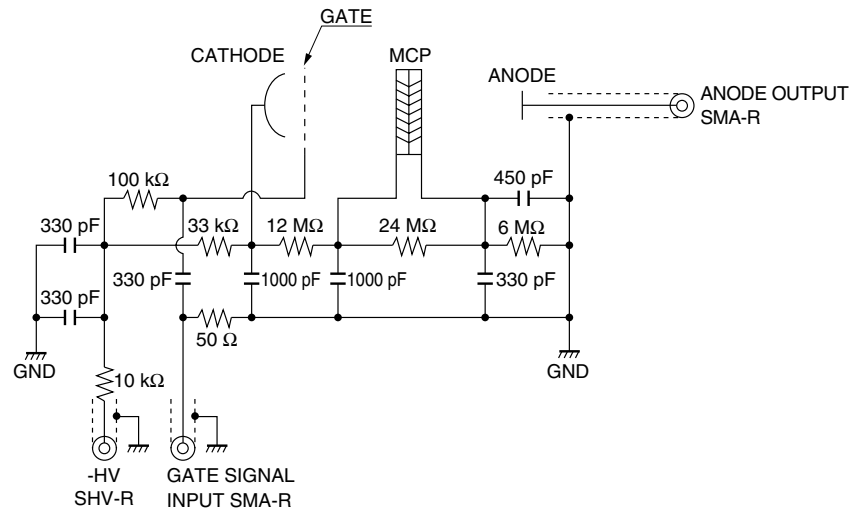


Figure 12: Dimensional Outline (Unit: mm)



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Figure 13: Voltage Divider and Gate Circuit



Some of the values indicated in this circuit may be different from actual values to meet the specifications.

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## FUNDAMENTAL OPERATING PROCEDURE

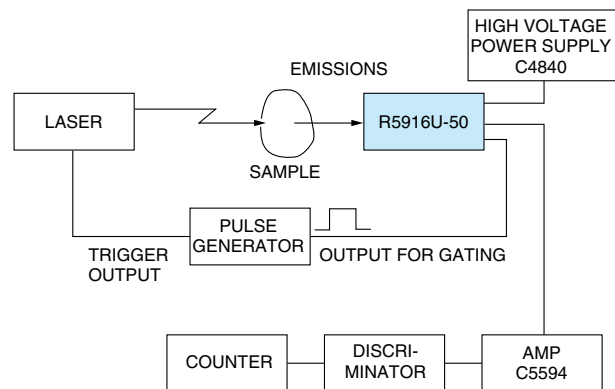
1) A general set-up for R5916U-50 is shown at right.

This is to perform a photon counting with gating function and to detect weak light generated from the samples by the laser excitation.

2) The pulse generator used in this set-up produce an output having +10 V in height and adjustable width which you require. It also produces a trigger signal synchronizing an output pulse to the laser output. The R5916U-50 is in gate off mode in the beginning to prevent unwanted signals caused by the laser light or some scattered light which may strike the photocathode directly.

3) The pulse generator required for gating function is very simple. The required specifications for the pulse generator is as follows:

- Output voltage is +10 V to +15 V.
- Pulse width is just what you require (between 5 ns and 10 ms).



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# GATED MICROCHANNEL PLATE PHOTOMULTIPLIER TUBE (MCP-PMTs) R5916U-50 SERIES

## EXAMPLE OF APPLICATIONS

### ENVIRONMENTAL MONITORING

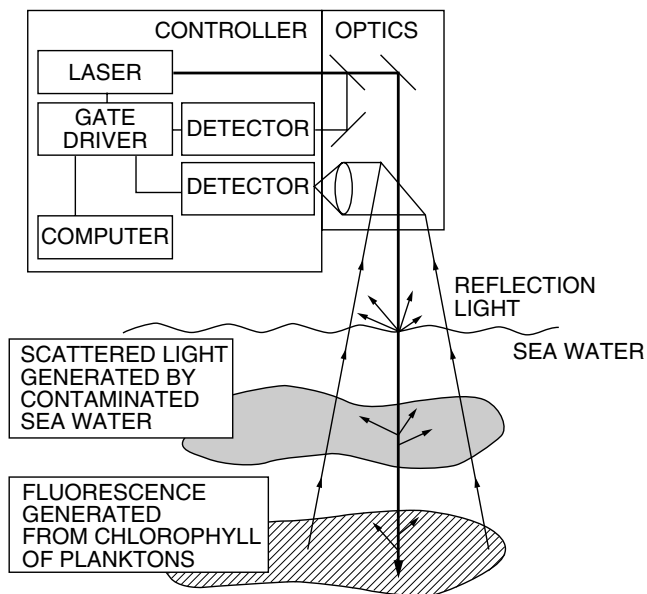
This is an example of laser radar (LIDAR) application where our gateable MCP-PMT has been used. The sketch at right shows a LIDAR system which includes a picosecond laser, electronics (gate driver), optics, computer and sensor (gateable MCP-PMT). This system is to investigate the distribution of planktons in the ocean for pollution monitoring.

The laser light irradiates sea water and generates some scattered light due to contaminated water and fluorescence due to chlorophyll in planktons. By detecting these emissions, a distribution of quantitative and qualitative informations on these objects can be obtained. However, there are enormous back ground emissions due to reflections of the laser light off of the water's surface as well as from particles in an air or some unknown materials in the ocean. Sun light is also a source of back ground if the experiment has to be performed in day time.

In this application, fast gating function is very effective to minimize the back ground noise. The tube is gated on only during the time when essence emissions arrive at the detector.

The switching ratio characteristics are also very important to help minimize the noise. The R5916U-50 series tubes are superior on both characteristics.

Laser Radar (LIDAR) system a)



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### SATELLITE LASER RANGING (SLR)

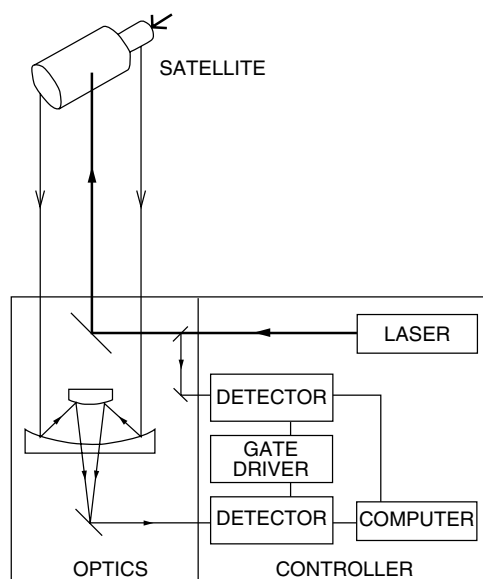
This is also an example of a LIDAR application where the gateable MCP-PMT has been used to measure the distance between the observatory and a satellite.

The operating principle is that a satellite is irradiated by the fast laser pulse and then a reflected light is directed to the detector through the optics placed on the ground. The time interval of the signals from the source to the detector in the system is the time of flight (TOF) from the observatory to the satellite and can be converted into a distance between them.

This entire system consists of fast laser, optics, electronics, gate driver and detectors. The data taken by experiments with this system are also utilized for geodesy or plate motion analysis on a world-wide level.

Because of the improved timing characteristics with R5916U-50 series, more precise measurements can be expected.

Laser Satellite Ranging system b)



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#### References

- a) Japan Marine Science and Technology Center: R&D of Laser Ranging Technology (Published in Japan)
- b) HITACHI: Laser Satellite Ranging System

## PRECAUTIONS FOR PROPER OPERATION

1. The photomultiplier tube (PMT) in this data sheet is a glass product under high vacuum. Excessive pressure or shocks to the tube from the surroundings could cause a permanent damage. Please pay special attention on insuring proper handling.
2. Do not expose the photocathode to direct sunlight and any light stronger than the room light even during of no operation.
3. Do not supply any voltage higher than specified. Also make sure the output current does not exceed the maximum current specified.
4. This device is very sensitive even with weak light input. When applying high voltage to the tube, gradually (ideally 100 V step) and carefully increase the voltage while monitoring the output using a current meter or oscilloscope (if the PMT has multianodes, please make all the anode summed when monitoring). Also make sure before use that the polarity of the applied voltage is correct.
5. Never touch the input window with your bare hands. In case the window contaminated by dust or grease, wipe it off using alcohol and a soft cloth or dust free tissue.
6. Do not remove any input or output cables when high voltage is applied.
7. Do not place any objects of ground potential closer than 5 mm to the photocathode window when negative high voltage is applied to the photocathode. It could generate extra noise and damage the photocathode permanently.
8. Do not operate or store in a place of unspecified temperature and humidity.
9. If the tube won't be used with a cooler, it is recommended to leave the tube in darkness (your instrument without any input light) for 30 minutes or so before start any measurements because it occasionally takes a little while until its dark noise settles down.

## WARRANTY

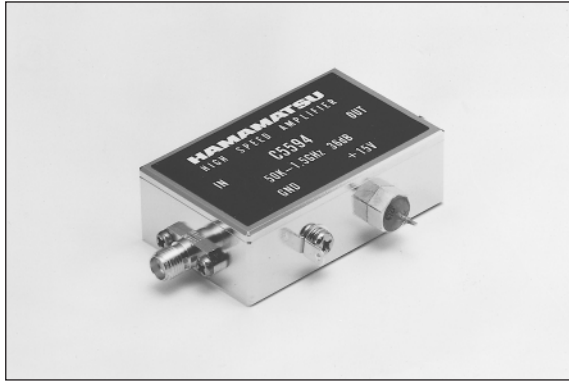
The detectors indicated in this data sheet are warranted to the original purchaser for a period of 12 months following the date of shipment. The warranty is limited to repair or replacement of any defective material due to defects in workmanship or materials used in manufacture.

1. Any claim for damage of shipment must be made directly to the delivering carrier within five days.
2. Customer must inspect and test all detectors within 30 days after shipment. Failure to accomplish said incoming inspection shall limit all claims to 75 % of invoice value.
3. NO credit will be issued for broken detector unless in the opinion of Hamamatsu the damage is due to a manufacturing defect.
4. NO credit will be issued for any detector which in the judgement of Hamamatsu has been damaged, abused, modified or whose serial number or type number have been obliterated or defaced.
5. NO detector will be accepted for return unless permission has been obtained from Hamamatsu in writing, the shipment has been returned repaired and insured, the detector is packed in their original box and accompanied by the original data sheet furnished to the customer with the tube, and a full written explanation of the reason for rejection of detector.

# GATED MICROCHANNEL PLATE PHOTOMULTIPLIER TUBE (MCP-PMTs) R5916U-50 SERIES

## ACCESSORIES

### HIGH SPEED AMPLIFIER C5594 Series



#### Suffix numbers and input / output connectors

Input Connectors	Output Connectors	
	SMA Jack	BNC Jack
SMA Plug (male)	C5594-12	C5594-14
SMA Receptacle (female)	C5594-22	C5594-24
BNC Plug (male)	C5594-32	C5594-34
BNC Receptacle (female)	C5594-42	C5594-44

#### Specifications

Parameters		Description / Value
Frequency Response Range		50 kHz to 1.5 GHz
Gain	Typ.	36 dB
Input / Output Impedance		50 $\Omega$
Noise Figure (NF)	Typ.	5 dB
Recommend Input Voltage		+12 V to 16 V
Supply Current	Typ.	95 mA
Absolute	Supply Voltage	+17 V
Maximum Ratings	Input Power	+10 mW

### BENCH-TOP HIGH VOLTAGE POWER SUPPLY C4840 Series



#### Specifications

Parameter		Description / Value
Output Voltage		0 V to $\pm 3000$ V
Maximum Output Current		10 mA
Line Regulation Against $\pm 10$ % Line Voltage Change <sup>(A)(B)</sup>	Max.	$\pm(0.005 \% + 10 \text{ mV})$
Load Regulation Against 0 % to 100 % Load Change <sup>(A)</sup>	Max.	$\pm(0.01 \% + 50 \text{ mV})$
Ripple / Noise (p-p) <sup>(A)(B)</sup>	Max.	0.0007 %
Drift (after 1 h Warm-up) <sup>(A)(B)</sup>	Max.	$\pm(0.02 \% + 10 \text{ mV})/8 \text{ h}$
Temperature Coefficient <sup>(A)(B)</sup>	Max.	$\pm 0.01 \% / ^\circ\text{C}$
AC Input Voltage	C4840-01	120 V ( $\pm 10$ %) (50 / 60 Hz)
	C4840-02	230 V ( $\pm 10$ %) (50 / 60 Hz)
Power Consumption <sup>(A)(B)</sup>	Approx. 100 V·A	
Operating Ambient Temperature / Humidity <sup>(C)</sup>	0 $^\circ\text{C}$ to +40 $^\circ\text{C}$ / below 80 %	
Storage Temperature / Humidity <sup>(C)</sup>	-20 $^\circ\text{C}$ to +50 $^\circ\text{C}$ / below 85 %	

**NOTE:** <sup>(A)</sup>At maximum output voltage  
<sup>(B)</sup>At maximum output current  
<sup>(C)</sup>No condensation

# HAMAMATSU

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