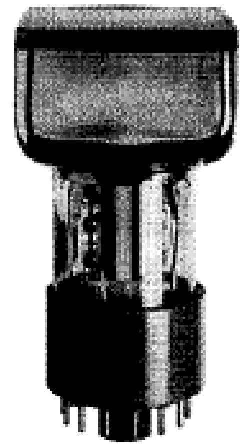
S83079E
Photomultiplier
76 mm (3 inch)-Square, 8-Stage, End-Window PMT

- **High Quantum Efficiency: Typically 32.6% at 370 nm**
- **Excellent Collection of Photoelectrons from all Areas of the Useful Photocathode**
- **Typical Pulse Height Resolution: 8.9%, ^{57}Co, NaI(TI) Scintillator**



The BURLE S83079E is a 76 mm (3 in)-square, 8-stage, end-window type of photomultiplier designed for use in scintillation counting applications and in photometric low-light level detection systems where photomultipliers with large photocathode areas are required.

The BURLE S83079E employs a potassium-cesium-antimonide (bialkali) photocathode and electron multipliers of the box and grid type. The multiplier dynodes are of the alkali antimonide type and are processed in a manner that provides well controlled overall gain. These tubes are designed primarily for application to medical diagnostic systems of the Anger camera type. They also have excellent characteristics for general scintillation-counting applications and in the detection and measurement of low-level light events in the blue region of the spectrum.

The S83079E has a permanently-attached base, the S83079EM1 is provided with a temporary base attached and the S83079EM2 is provided with no temporary base attached. **See Dimensional Outlines and Basing Diagrams** for further details.

General Data

Photocathade:
Type: Semi-transparent K-Cs-Sb (Bialkali).
Spectral Response: See Figure 1.
Wavelength of Maximum Response: 370 nm.

Dynodes:
Secondary-Emitting Surface: Alkali-antimonide.
Structure: Box and grid.

Direct Interelectrode Capacitances (Approx.):
Anode to Dynode No. 8: 6.5 pF.
Anode to all other electrodes combined: 7.1 pF.

Weight (Approx.):
S83079E: 242 g (8.5 oz).
S83079EM1: 229 g (8.1 oz).
S83079EM2: 179 g (6.3 oz).

Operating Position: Any.

Absolute Maximum Ratings[1]

DC Supply Voltage:
Between Anode and Cathode: 1200 volt.
Between Anode and Dynode No. 10: 300 volt.
Between Adjacent Dynodes: 250 volt.
Between Dynode No. 1 and Cathode: 300 volt.

Average Anode Current (Averaged over any 30-second interval): 0.1 mA.

Temperature:
Operating: -40ºC to +70 ºC.
Storage: See Note 2.

Test Parameters and Limits

In order to insure that BURLE Photomultipliers consistently meet exacting performance standards, each device is subjected to a series of tests that verify that its operating parameters conform to normal expectations for the tube type. Experience has shown that a tube satisfying the criteria indicated below can be expected to perform satisfactorily in a variety of applications.

Power supply voltage (E = 800 Volts unless otherwise noted) is applied to the tubes electrodes via a Voltage Divider Network (VDN) in accordance with the distribution listed in Table 1-A. Ambient temperature during testing is approximately 22 ºC.

	Min.	Typ.	Max.	Units
Cathode Responsivity[3]	9.3	11.3	--	µA/inc. lm
Anode Responsivity[4]	1.6	2.4	4.2	A/inc. lm
Anode Dark Current				
at E= 1000 Volts[5]	--	3.0	15	nA
Pulse Height[6]				
^{57}Cobalt	100	250	400	mV
or Equivalent	10.5	29.2	47.9	pC
Pulse Height Resolution[6]				
^{57}Cobalt	--	8.9	10.0	%
Count Rate Stability[7]	0.3	--	2.3	%

Typical Performance Characteristics

The following information is provided in order that customers may predict the typical performance of a tube of this type in an application where TEST PARAMETER data may not be directly relevant. This material has been derived from TEST PARAMETER values and from special evaluations conducted in BURLE's Application Engineering Laboratory. This information is supplied for guidance only and is not intended to supersede the limiting ranges given in the TEST PARAMETER section.

Unless otherwise indicated, the power supply voltage (E) is applied to the tube's electrodes via a Voltage Divider Network (VDN) in accordance with the distribution listed in Table 1-A.

Cathode Responsivity at 370 nm: 100 mA/W.

Cathode Quantum Efficiency at 370 nm: 32.6%.

Multiplier Gain at E = 800 V:[8] 212000.

Gain Exponent:[9] 5.8.

Gain versus E: See Figure 5.

Anode Dark Current versus E:[10] See Figure 6

Anode Pulse:[11]

Rise Time: 14 ns.
Fall Time: 39 ns.
FWHM: 29 ns.
Transit Time: 73 ns.
Transit Time Spread:[12] 1.1 ns.

Peak Linear Anode Current:[13]
VDN per Table 1-A: 6 mA.
VDN per Table 1-B: 8 mA.

Notes

1. In accordance with the Absolute Maximum rating system as defined by the Electronic Industries Association Standard RS-239A, formulated by the JEDEC Electron Tube Council.

2. In general, these types can be operated successfully over the temperature range specified for storage. However, the user should be aware that photocathode resistivity increases at reduced temperature, resulting in possible loss of photocathode responsivity, as shown on Figure 2. Also, anode dark current tends to increase with operating temperature, as shown in Figure 3.

3. Under the following conditions: Light from a tungsten filament lamp operated at a color temperature of 2856 K is transmitted to the cathode through a blue filter (Corning CS. No.5-58, polished to 1/2 stock thickness). The value of flux incident on the filter is $1x10^{-4}$ lumen and 300 volts is applied between cathode and all other electrodes connected as anode.

   Cathode Responsivity = Cathode Current/Incident Flux

4. Under the following conditions: Light from a tungsten filament lamp operated at a color temperature of 2856 K is transmitted to the cathode through a blue filter (Corning CS. No.5-58, polished to 1/2 stock thickness). The value of flux incident on the filter is $1x10^{-5}$ lumen and test voltage (E) is 800 volts.

   Anode Responsivity = Anode Current/Incident Flux

5. Anode dark current is measured at an ambient temperature of 22 ºC. The tube under test is held in essentially complete darkness for a minimum of 30 minutes prior to the test, which is conducted in complete darkness. Test voltage (E) is 1000 volts. A second test is conducted with E = 1200 volts, under this condition, Anode Dark Current shall not exceed five times the value recorded with E = 1000 volts.

6. Power supply voltage during this test is 800 volts. This test is conducted with a gamma-ray source (^{57}Co) of sufficient intensity to produce between 5K and 15K counts per second from the tube under test when positioned on the back side of the scintillator and along its principle axis. The scintillator is a BURLE traceable encapsulated 3 inch long x 3 inch diameter NaI(TI) crystal. The faceplate end of the scintillator is coupled to the faceplate of the photomultiplier by a coupling fluid such as clear mineral oil. The anode of the photomultiplier is connected to a charge sensitive pre-amplifier. A multi-channel analyzer (MCA) characterizes scintillation events in terms of an amplitude histogram as illustrated in Figure 4, on which the Pulse Height and Pulse Height Resolution are defined. Pulse Height is measured in millivolts developed across a hypothetical load consisting of a capacitance of 100 pF shunted by a resistance of 100 k().

7. A light-emitting diode (LED) is employed as a light source. The LED is driven by a suitable pulse generator so as to produce an

anode pulse equivalent in amplitude and shape to that due to ^{57}Co excitation of A BURLE traceable NaI(Tl) scintillator. Following operation for at least 10 seconds at an LED pulse rate of 4000 Hz, pulse height is measured as a PHi. The LED pulse rate is changed to 40 kHz and pulse height is immediately measured and recorded as PHf. Count rate stability is defined as follows:

CRS = 100 x (PHf- PHi)/PHi

8. Gain (current amplification) is defined as:

   Gain = Anode Responsivity/Cathode Responsivity

9. The relationship between multiplier gain and power supply voltage (E) may be expressed as follows:

   Gain = CxE^{α}
   where C = a constant
   α = the gain exponent

10. Anode dark current is measured at an ambient temperature of 22 ºC. The tube under test is held in essentially complete darkness for a minimum of 30 minutes prior to the test, which is conducted in complete darkness.

11. The photocathode is fully illuminated by a delta function light pulse of approximately 1 ns duration and of intensity sufficient to create an anode current pulse of approximately 3 mA (peak value). Power supply voltage during the test is 1200 volts. Rise and Fall Times, the FWHM value, and Transit Time are as defined on Figure 7. For estimating the effect of power supply voltage on these parameters, the following approximate relationship may be used:

   Parameter value = $CxE^{ß}$
   where C = a constant
   where ß = -0.5 to -0.7

12. The photocathode is fully illuminated by a delta function light pulse of approximately 1 ns duration. Power supply voltage during the test is 1000 volts. Transit Time Spread is defined as the full-width-half-maximum of the distribution of transit times about the mean transit time, observed over a period of time encompassing a series of illumination events. This parameter is sensitive to the number of photoelectrons created during each event, increasing in value as the number of photoelectrons decreases. The value given applies to approximately 750 photoelectrons.

13. The photocathode is fully illuminated by a square light pulse of approximately 100 ns duration. Introduction of appropriate optical attenuation into the input light path allows determination of the peak pulse anode current at which space-charge effects cause deterioration of the normally linear light-in/current-out function. The indicated peak current values are associated with approximately 5% deviation from linearity and apply to the following power supply voltages:

   For VDN per Table 1-A, E = 1000 Volt
   For VDN per Table 1-B, E = 1100 Volt

   For estimating Peak Linear Anode Currents (PLAC) at other power supply voltages, the following approximate relationship may be used:

   PLAC = CxE^{δ}

   where C = a constant
   δ= 1.4

In designing a voltage divider network in accordance with either Column A or Column B of Table 1, precautions must be taken to maintain the appropriate voltage distribution in the presence of high average and/or high peak anode current values. This subject is treated in the BURLE Photomultiplier Tube handbook (TP-136) under the section titled “Photomultiplier Applications - Applied Voltage Considerations”.

Table 1

Voltage Distribution	**A**	**B**
Between the following Electrodes: K = Cathode P = Anode Dy = Dynode FE = Focus Electrode	**10% of K-P Voltage Multiplied By:**	**8.9% of K-P Voltage Multiplied By:**
K-FE	1	1
FE - Dy 1	1	1
Dy 1-Dy 2	1	1
Dy 2-Dy 3	1	1
Dy 3-Dy 4	1	1
Dy 4-Dy 5	1	1
Dy 5-Dy 6	1	1
Dy 6-Dy 7	1	1.125
Dy 7-Dy 8	1	2.00
Dy 8-Dy P	1	1.125
K-P	10	11.25

Operating Considerations

Average Anode Current

The operating stability of the tube is dependent on the magnitude of the average anode current. The use of an average anode current well below the maximum rated value of 0.1 milliampere is recommended when stability of operation is important. When maximum stability is required, the average anode current should not exceed 10 microamperes.

Average Cathode Current

An average cathode current of 1 x 10^{-9} ampere at a tube temperature of 22 ºC or 1 x 10^{-11} at -100 ºC should not be exceeded. The voltage drop caused by higher cathode currents may produce radial electric fields on the photocathode which can result in poor photoelectron collection by the first dynode because of the resistivity of the photocathode. Photocathode resistivity increases with decreasing temperature.

Peak Cathode Current

Larger peak cathode currents may be drawn provided the electric charge per pulse does not exceed 2.5 pC within the constraints of the average cathode current limitation given above. A peak cathode current of 25 µA may be drawn for a pulse duration of 100 ns.

Shielding

Electrostatic and magnetic shielding of the tube is ordinarily required. The application of negative high voltage to the cathode should be avoided unless materials outside the glass envelope and immediately surrounding the photocathode limit leakage current to 1 x 10^{-12} ampere or less. In addition to increasing dark current and noise output because of voltage gradients developed across the bulb wall, such high voltage may produce minute leakage current to the cathode, through the tube envelope and insulating materials, which can permanently damage the tube. In general, when a shield is used, it is recommended that it be connected to the cathode potential.

Magnetic shielding is necessary if the tube is operated in the presence of strong magnetic fields.

Ambient Atmosphere

Operation or storage of the tube, in environments where helium is present, should be avoided. Helium will permeate the tube envelope and may lead to eventual tube destruction.

Anode-Dark Current

A temporary increase in anode dark current by as much as 2 orders of magnitude may occur if the tube is exposed momentarily to high-intensity ultraviolet radiation from sources such as fluorescent room lighting even though voltage is not applied to the tube. The increase in dark current may persist for a period of 24 to 48 hours following such irradiation.

Cooling of the tube is recommended in those applications where maximum current amplification with minimum dark current is required.

The base of the tube and its socket should never be allowed to become contaminated by handling. Such contamination produces electrical leakage and increased dark current.

Warning - **Personal Safety Hazards**

Electrical Shock - Operating voltages applied to this device present a shock hazard

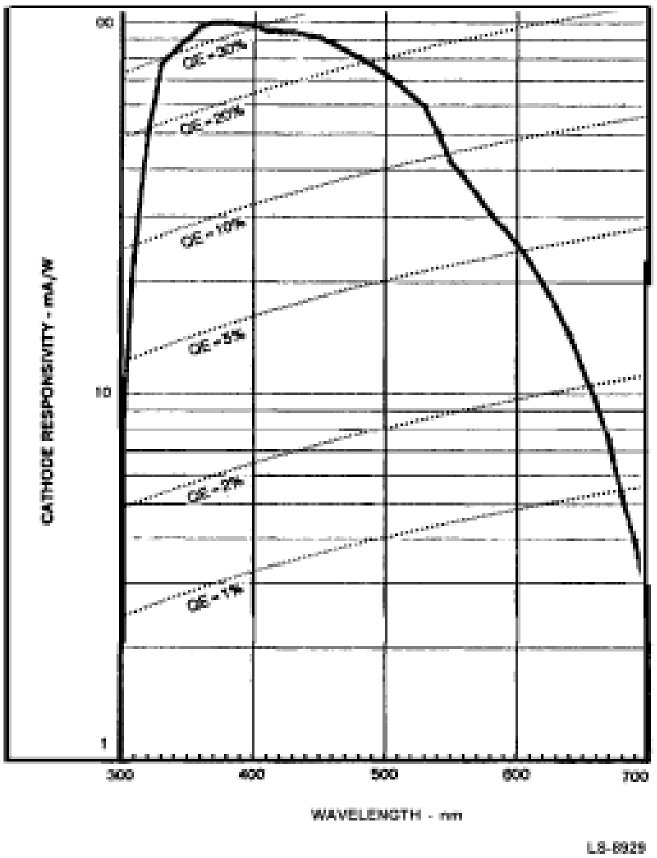


Figure 1: Typical Photocathode Spectral Response Characteristics

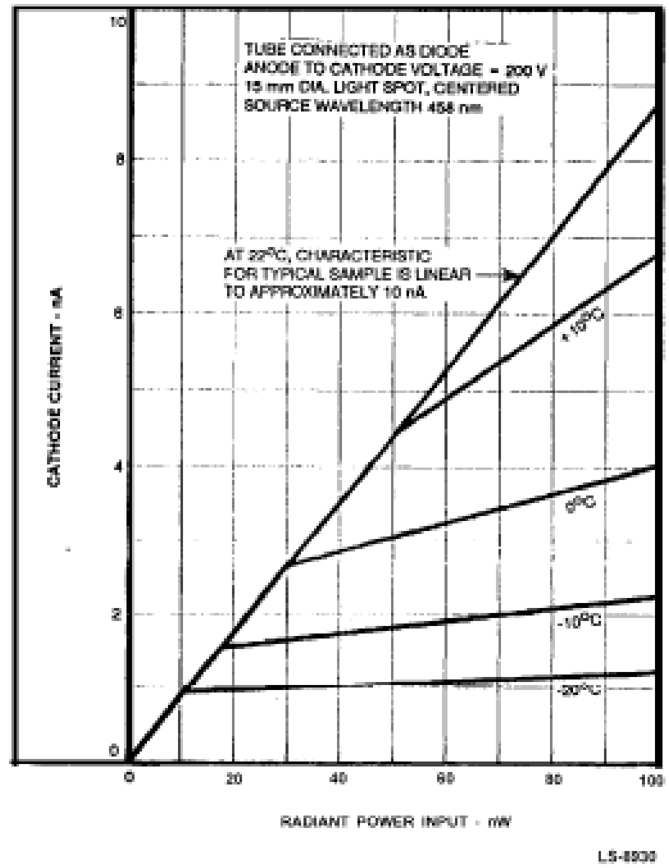


Figure 2: Effect of Temperature on Cathode Responsivity

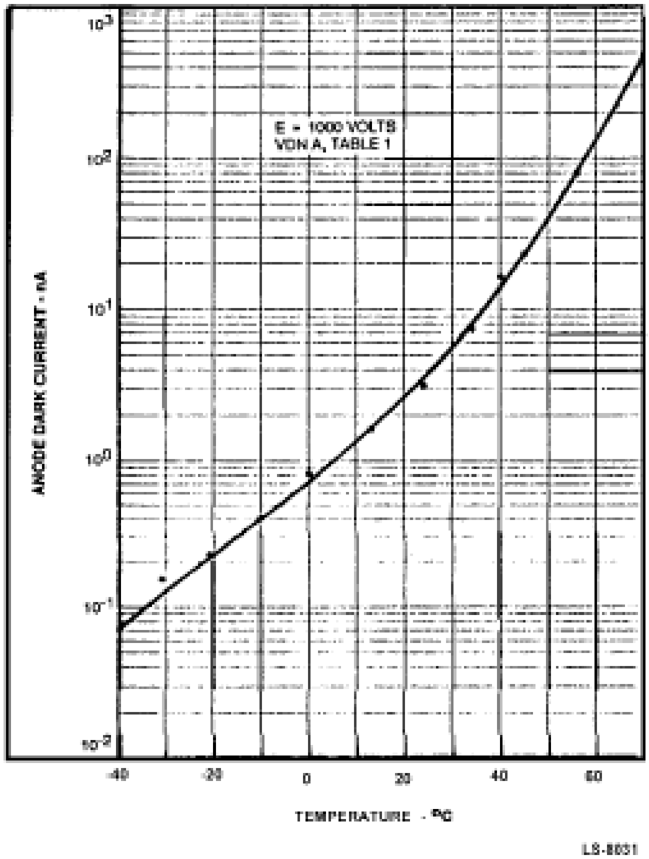


Figure 3: Effect of Temperature on Anode Dark Current

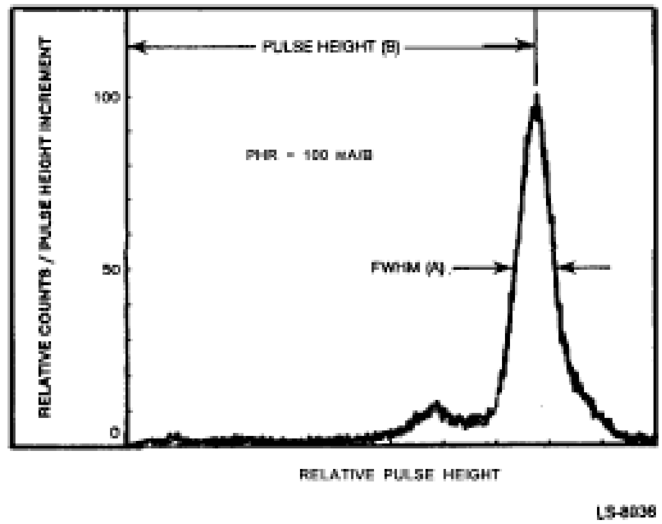
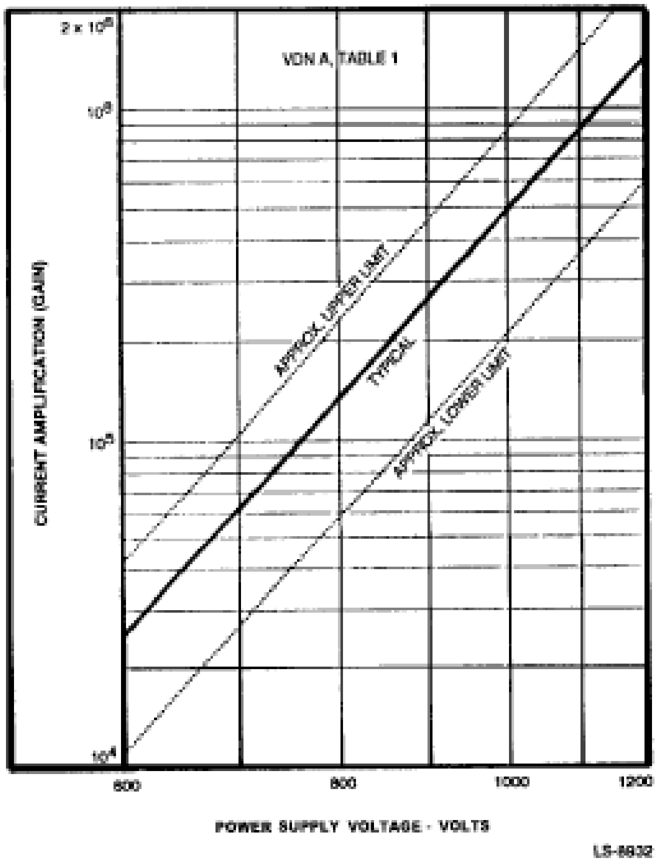


Figure 4: MCA Display, Illustrating Definitions of Pulse Height and Pulse Height Resolution



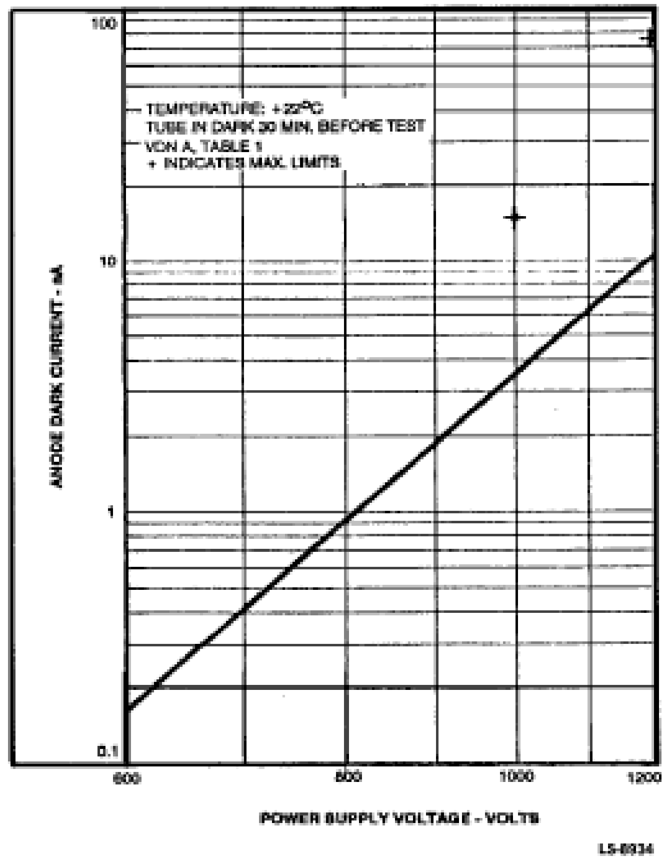


Figure 5: Typical Current Amplification Characteristics

Figure 6: Typical Anode Dark Current Characteristic

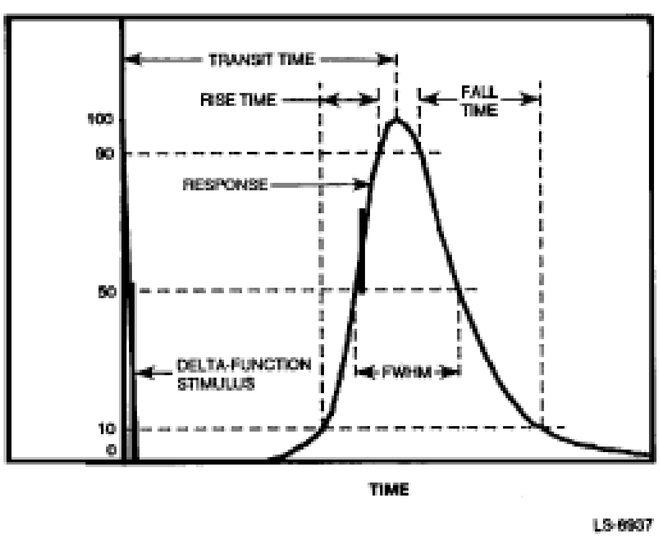
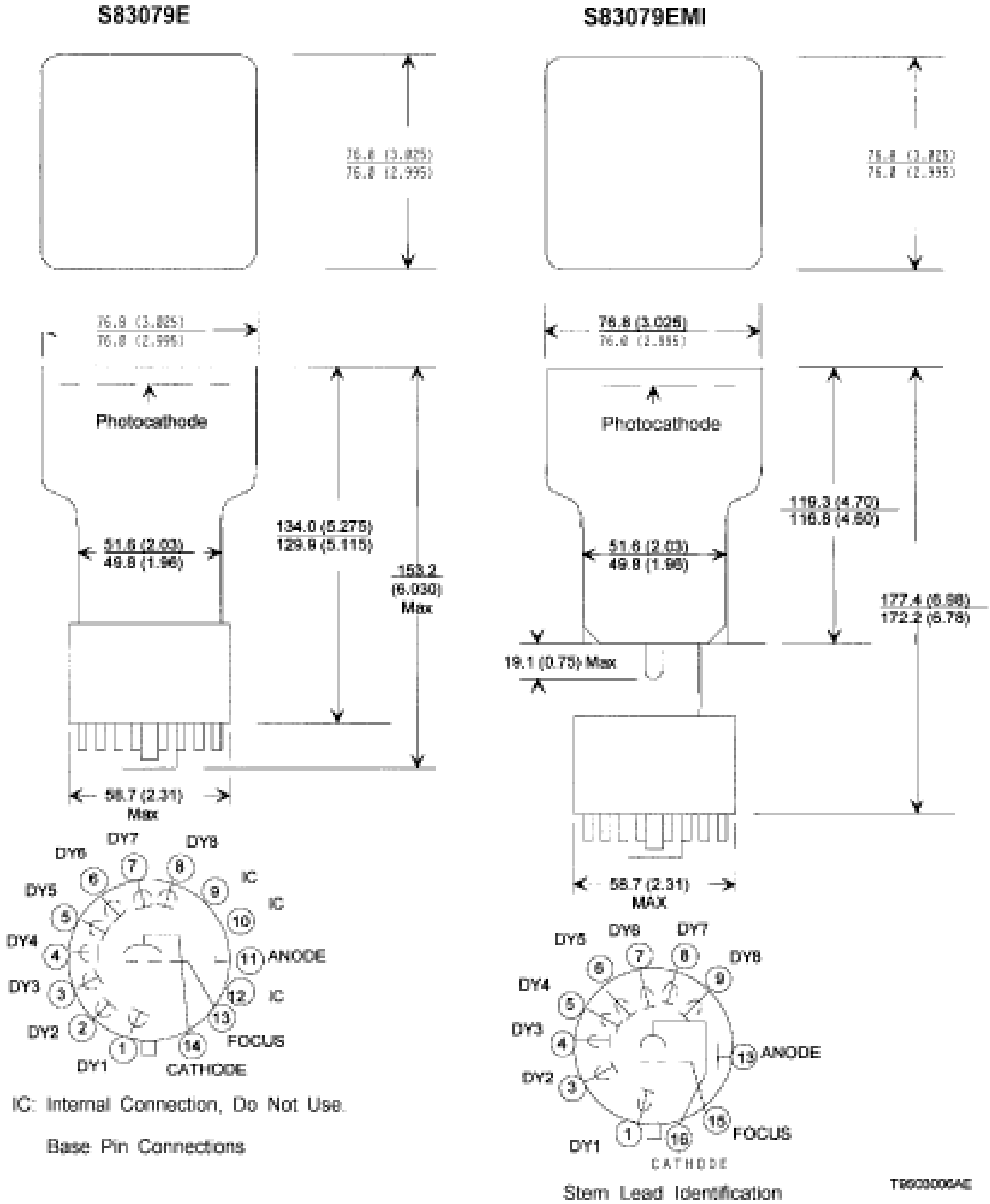


Figure 7 - Response to Delta-Function Light Stimulus



Note 1: Dimensions are in millimeters unless otherwise stated Dimensions in parentheses are in inches.

Figure 8: Dimensional Outlines and Basing Diagrams