Accessories
For Photomultiplier Tubes

HAMAMATSU

PURSUING THE POTENTIAL OF "LIGHT"

Over the past 40 years since its founding, Hamamatsu Photonics has been pursuing the most advanced areas of light research, as a company at the leading edge of photonics technology. This work has led to the development of a wide variety of innovative products used in diverse fields, such as industrial measurement and production, medical diagnosis as well as scientific research into unexplored areas.
Research is now expanding the potential of photonics technology beyond the range of visible light, towards the ultraviolet, infrared and X-ray regions, as well as ultra-fast events and extremely low light levels.
It is said that, human beings at present, understand less than 0.1 percent of the world of light. Light exists all around us yet is still a mystery containing endless amounts of useful information and potential discoveries.
Hamamatsu Photonics is continually expanding its research into "light" to reveal this unknown yet fascinating world in order to enrich all our lives as well as contribute to the progress of science and industry in biology, medicine, space, physics, and energy.

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PHOTOMULTIPLIER TUBE SOCKET ASSMEBLIES

Photomultiplier Tube Socket Assemblies

Hamamatsu provides a wide variety of socket assemblies specifically designed for simple and reliable operation of photomultiplier tubes (often abbreviated as PMTs). These socket assemblies consist primarily of a high quality socket and voltage divider circuit integrated into a compact case. Variant types are available with internal current-to-voltage conversion amplifiers, gate circuits and high voltage power supply circuits.

Types of Socket Assemblies

The circuit elements used in Hamamatsu socket assemblies are represented by the three letters below. The socket assembly types are grouped according to the combination of these letters.

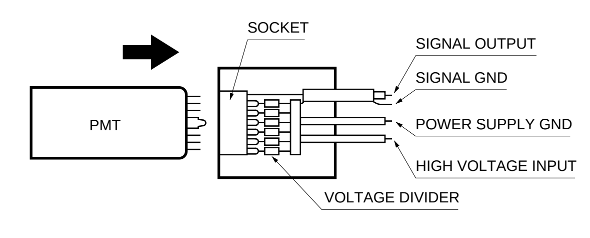
D : Voltage Divider
A : Amplifier
P : High Voltage Power Supply

D-Type Socket Assemblies (E717, E990 Series, etc.)

The D-type socket assemblies contain a voltage divider circuit along with a socket in a compact metallic or plastic case. Plastic case types are potted with silicone compound to ensure high environmental resistance. D-type socket assemblies also include gate circuits to turn the on and off, as for example in the C1392 series.

Refer to page 7 for the selection guide to D-type socket assemblies.

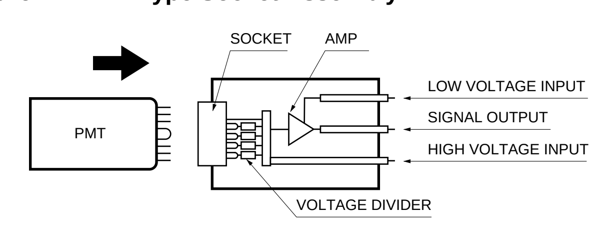
Figure 1: D-Type Socket Assembly



DA-Type Socket Assemblies (C7246, C7247 Series)

In addition to the circuit elements of the D-type socket assemblies, the DA-type socket assemblies include an amplifier that converts the low-level, high-impedance current output of a photomultiplier tube into a low-impedance voltage output. Possible problems from noise induction are eliminated since the high-impedance output of the photomultiplier tube is connected to the amplifier at the minimum distance.

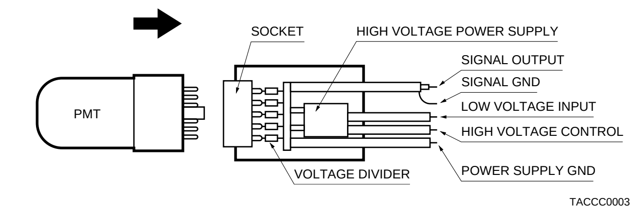
Figure 2: DA-Type Socket Assembly



DP-Type Socket Assemblies (C6270)

DP-type socket assemblies comprise a built-in high-voltage power supply circuit added to a D-type socket assembly.
The C6270 uses an active voltage divider circuit and a high voltage power supply.

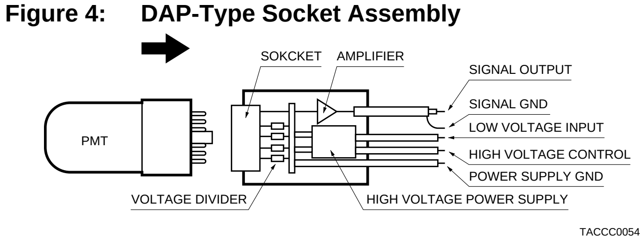
Figure 3: DP-Type Socket Assembly



DAP-Type Socket Assemblies (C6271)

This type of socket assembly has a current-to-voltage conversion amplifier and a high voltage power supply, efficiently added to the circuit components of the D-type socket assembly.

Figure 4: DAP-Type Socket Assembly



Basics of Voltage Dividers

The following information describes voltage divider circuits which are basic to all types of socket assemblies. Refer to this section for information on proper use of the socket assemblies.

Voltage Divider Circuits

To operate a photomultiplier tube, a high voltage of 500 volts to 2000 volts is usually supplied between the photocathode (K) and the anode (P), with a proper voltage gradient set up along the photoelectron focusing electrode (F) or grid (G), secondary electron multiplier electrodes or dynodes (Dy) and, depending on photomultiplier tube type, an accelerating electrode (Acc). Figure 5 shows a schematic representation of photomultiplier tube operation using independent multiple power supplies, but this is not a practical method. Instead, a voltage divider circuit is commonly used to divide, by means of resistors, a high voltage supplied from a single power supply.

Figure 5: Schematic Representation of Photomultiplier Tube Operation

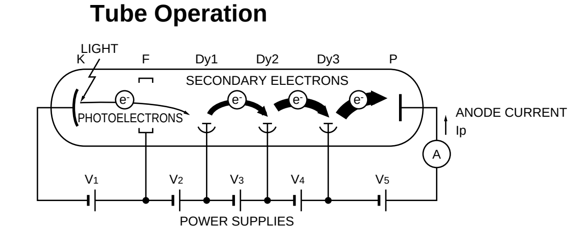
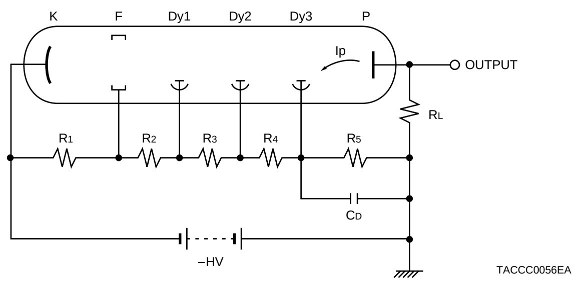


Figure 6 shows a typical voltage divider circuit using resistors, with the anode side grounded. The capacitor C_D connected in parallel to the resistor R_5 in the circuit is called a decoupling capacitor and improves the output linearity when the photomultiplier tube is used in pulse operation, and not necessarily used in providing DC output. In some applications, transistors or Zener diodes may be used in place of these resistors.

Figure 6: Anode Grounded Voltage Divider Circuit

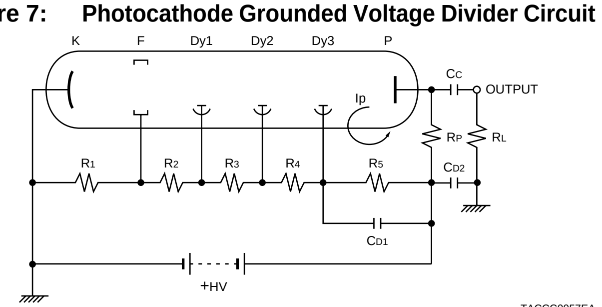


Anode Grounding and Photocathode Grounding

In order to eliminate the potential difference between the photomultiplier tube anode and external circuits such as an ammeter, and to facilitate grounding, the generally used technique for voltage divider circuits is to ground the anode and supply a high negative voltage (-HV) to the photocathode, as shown in Figure 6. This scheme provides the signal output in both DC and pulse operations, and is therefore used in a wide range of applications.

In photon counting and scintillation counting applications, however, the photomultiplier tube is often operated with the photocathode grounded and a high positive voltage (+HV) supplied to the anode mainly for purposes of noise reduction. This photocathode grounding scheme is shown in Figure 7, along with the coupling capacitor Cc for isolating the high voltage from the output circuit. Accordingly, this setup cannot provide a DC signal output and is only used in pulse output applications. The resistor R_P is used to give a proper potential to the anode. The resistor R_L is placed as a load resistor, but the actual load resistance will be the combination of R_P and R_L.

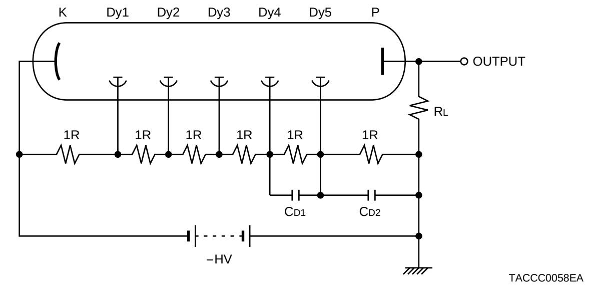
Figure 7: Photocathode Grounded Voltage Divider Circuit



Standard Voltage Divider Circuits

Basically, the voltage divider circuits of socket assemblies listed in this catalog are designed for standard voltage distribution ratios which are suited for constant light measurement. Socket assemblies for side-on photomultiplier tubes in particular mostly use a voltage divider circuit with equal interstage voltages allowing high gain.

Figure 8: Equally Divided Voltage Divider Circuit



Tapered Voltage Divider Circuits

In most pulsed light measurement applications, it is often necessary to enhance the voltage gradient at the first and/or last few stages of the voltage divider circuit, by using larger resistances as shown in Figure 9. This is called a tapered voltage divider circuit and is effective in improving various characteristics. However it should be noted that the overall gain decreases as the voltage gradient becomes greater. In addition, care is required regarding the interstage voltage tolerance of the photomultiplier tube as higher voltage is supplied. The tapered voltage circuit types and their suitable applications are listed below.

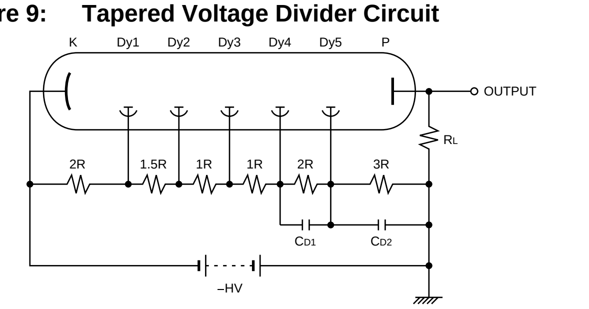
Tapered circuit at the first few stages (resistance: large → small)

Photon counting (improvement in pulse height distribution)
Low-light-level detection (S/N ratio enhancement)
High-speed pulsed light detection (improvement in timing properties)
Other applications requiring better magnetic characteristics and uniformity

Tapered circuit at the last few stages (resistance: small → large)

High pulsed light detection (improvement in output linearity)
High-speed pulsed light detection (improvement in timing properties)
Other applications requiring high output across the load resistor

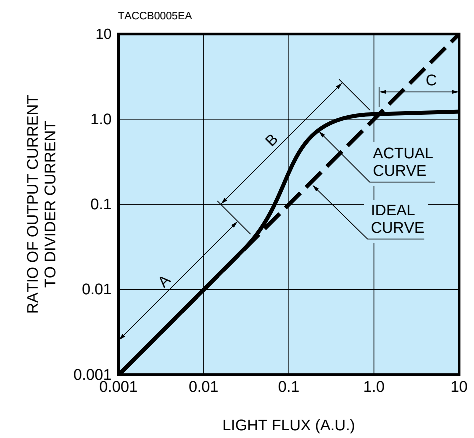
Figure 9: Tapered Voltage Divider Circuit



Voltage Divider Circuit and Photomultiplier Tube Output Linearity

In both DC and pulse operations, when the light incident on the photocathode increases to a certain level, the relationship between the incident light level and the output current begins to deviate from the ideal linearity. As can be seen from Figure 10, region A maintains good linearity, and region B is the so-called overlinearity range in which the output increase is larger than the ideal level. In region C, the output goes into saturation and becomes smaller than the ideal level. When accurate measurement with good linearity is essential, the maximum output current must be within region A. In contrast, the lower limit of the output current is determined by the dark current and noise of the photomultiplier tube as well as the leakage current and noise of the external circuit.

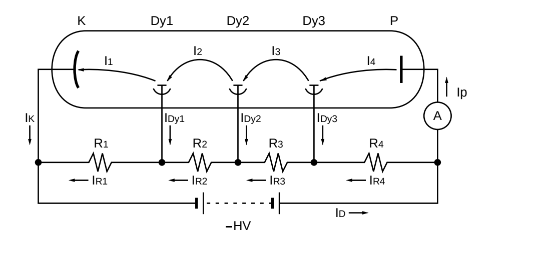
Figure 10: Output Linearity of Photomultiplier Tube



Output Linearity in DC Mode

Figure 11 is a simplified representation showing photomultiplier tube operation in the DC output mode, with three stages of dynodes and four dividing resistors R_1 through R_4 having the same resistance value.

Figure 11: Basic Operation of Photomultiplier Tube and Voltage Divider Circuit



[When light is not incident on the tube]

In dark state operation where a high voltage is supplied to a photomultiplier tube without incident light, the current components flowing through the voltage divider circuit will be similar to those shown in Figure 12 (if we ignore the photomultiplier tube dark current). The relation of current and voltage through each component is given below

Interelectrode current of photomultiplier tube

$I_1=I_2=I_3=I_4$ (= 0 ampere)

Electrode current of photomultiplier tube

$I_K=I_{Dy1}=I_{Dy2}=I_{Dy3}=I_P$ (= 0 ampere)

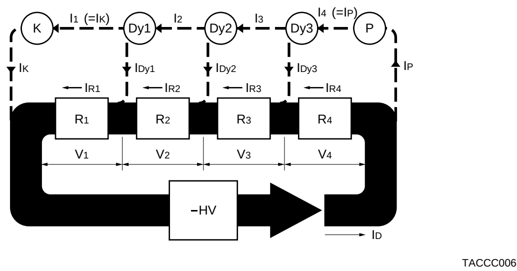
Voltage divider circuit current

$$I_{R1}=I_{R2}=I_{R3}=I_{R4}=I_D=(HV/\sum_{n=1}^{4} R_n)$$

Voltage divider circuit voltage

$V_1=V_2=V_3=V_4=I_D \cdot R_n$ (= HV/4)

Figure 12: Operation without Light Input



[When light is incident on the tube]

When light is allowed to strike the photomultiplier tube under the conditions in Figure 12, the resulting currents can be considered to flow through the photomultiplier tube and the voltage divider circuit as schematically illustrated in Figure 13. Here, all symbols used to represent the current and voltage are expressed with a prime ('), to distinguish them from those in dark state operation.

The voltage divider circuit current I_D' is the sum of the voltage divider circuit current I_D in dark state operation and the current flowing through the photomultiplier tube ΔI_D (equal to average interelectrode current). The current flowing through each dividing resistor R_n becomes as follows:

$I_{Rn}' = I_D' - I_n'$

Where I_n' is the interelectrode current which has the following relation:

$I_1' < I_2' < I_3' < I_4'$

Thus, the interstage voltage V_n' ($=I_{Rn}' \cdot R_n$) becomes smaller at the latter stages, as follows:

$V_1' > V_2' > V_3' > V_4'$

Figure 13: Operation with Light Input

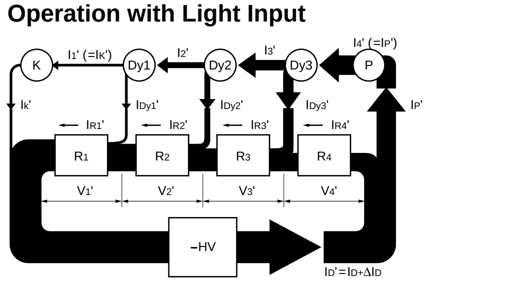
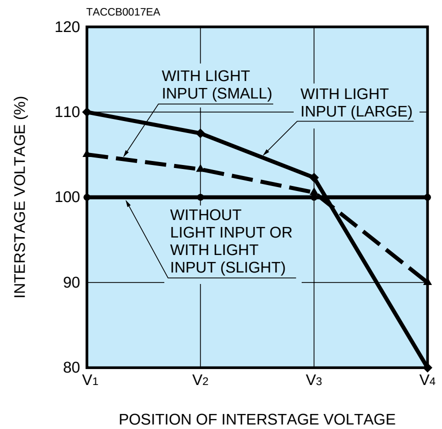


Figure 14 shows changes in the interstage voltages as the incident light level varies. The interstage voltage V_4' with light input drops significantly compared to V_4 in dark state operation. This voltage loss is redistributed to the other stages, resulting in an increase in V_1', V_2' and V_3' which are higher than those in dark state operation. The interstage voltage V_4' is only required to collect the secondary electrons emitted from the last dynode to the anode, so it has little effect on the anode current even if dropped to 20 or 30 volts. In contrast, the increases in V_1', V_2' and V_3' directly raise the secondary emission ratios (δ_1, δ_2 and δ_3) at the dynodes D_y1, D_y2 and D_y3, and thus boost the overall current amplification μ ($=\delta_1 \cdot \delta_2 \cdot \delta_3$). This is the cause of overlinearity in region B in Figure 10. As the incident light level further increases so that V_4' approaches 0 volts, output saturation occurs in region C.

Figure 14: Changes in Interstage Voltages at Different Incident Light Levels



Linearity Improvement in DC Output Mode

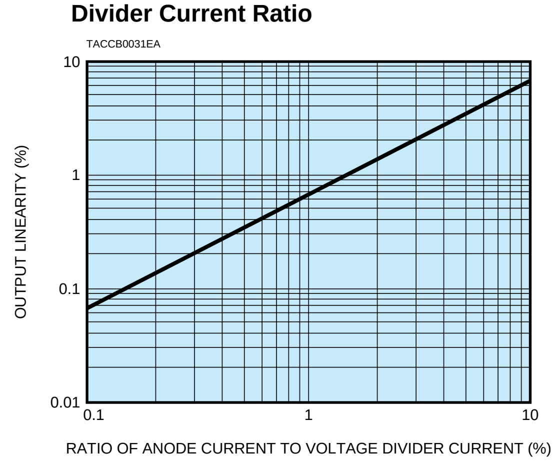
To improve the linearity in DC output mode, it is important to minimize the changes in the interstage voltage when photocurrent flows through the photomultiplier tube. There are several specific methods for improving the linearity, as discussed below.

① Increasing the voltage divider current

Figure 15 shows the relationship between the output linearity of a 28 mm (1-1/8") diameter side-on photomultiplier tube and the ratio of anode current to voltage divider current. This is a sample plot, so actual data may differ from tube to tube even for the same type of photomultiplier tube, depending on the supply voltage and individual dynode gains. To ensure high photometric accuracy, it is recommended that the voltage divider current be maintained at least twice the value obtained from this figure.

The maximum linear output in DC mode listed for the D-type socket assemblies in this catalog indicates the anode current equal to 1/20 of the voltage divider current. The output linearity at this point can be maintained within ±3 % to ± 5%.

Figure 15: Output Linearity vs. Anode Current to Voltage Divider Current Ratio

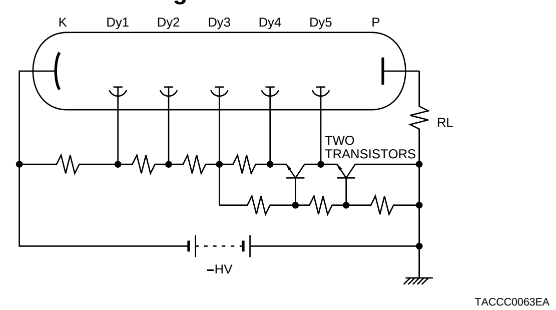


As stated above, good output linearity can be obtained simply by increasing the voltage divider current. However, this is accompanied by heat emanating from the voltage divider. If this heat is conducted to the photomultiplier tube, it may cause problems such as an increase in the dark current, and variation in the output.

② Using the active voltage divider circuit

Use of a voltage divider circuit having transistors in place of the dividing resistors in last few stages (for example, Hamamatsu E5815 series using FETs) is effective in improving the output linearity. This type of voltage divider circuit ensures good linearity up to an output current equal to 60 % to 70 % of the voltage divider current, since the interstage voltage is not affected by the interelectrode current inside the photomultiplier tube. A typical active voltage divider circuit is shown in Figure 16.

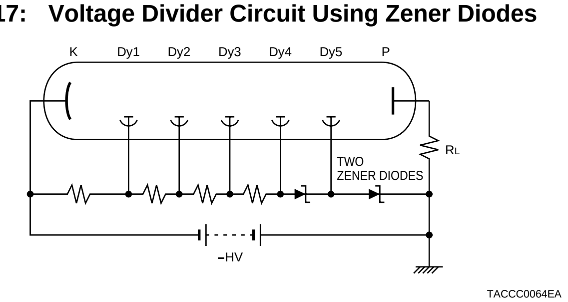
Figure 16: Active Voltage Divider Circuit



③ Using Zener Diodes

The output linearity can be improved by using Zener diodes in place of the dividing resistors in the last few stages, because the Zener diodes serve to maintain the interstage voltages at a constant level. However, if the supply voltage is greatly varied, the voltage distribution may be unbalanced compared to other interstage voltages, thus limiting the adjustable range of the voltage with this technique. In addition, if the supply voltage is reduced or if the current flowing through the Zener diodes becomes insufficient due to an increase in the anode current, noise may be generated from the Zener diodes. Precautions should be taken when using this type of voltage divider circuit. Figure 17 shows a typical voltage divider circuit using Zener diodes.

Figure 17: Voltage Divider Circuit Using Zener Diodes

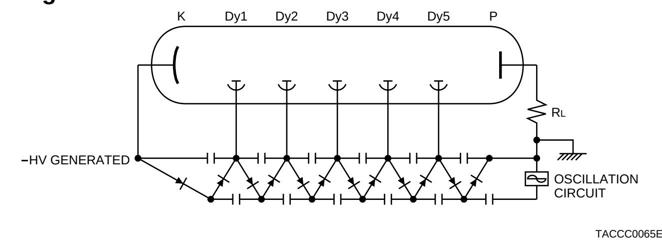


④ Using Cockcroft-Walton Circuit

When a Cockcroft-Walton circuit as shown in Figure 18 is used to operate a 28 mm (1-1/8") diameter side-on photomultiplier tube with a supply voltage of 1000 volts, good DC linearity can be obtained up to 200 μA and even higher. Since a high voltage is generated by supplying a low voltage to the oscillator circuit, there is no need for using a high voltage power supply.

This Cockcroft-Walton circuit achieves superior DC output linearity as well as low current consumption.

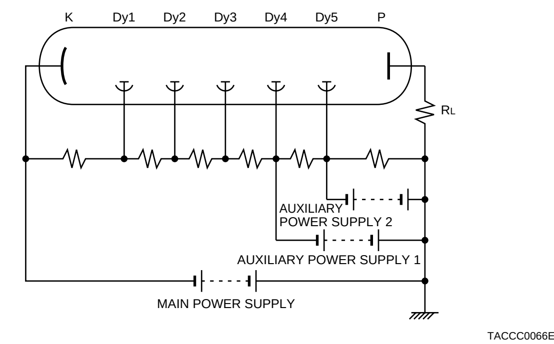
Figure 18: Cockcroft-Walton Circuit



⑤ Using multiple high voltage power supplies

As shown in Figure 19, this technique uses multiple power supplies to directly supply voltages to the last few stages near the anode. This is sometimes called the booster method, and is used for high pulse and high count rate applications in high energy physics experiments.

Figure 19: Voltage Divider Circuit Using Multiple Power Supplies (Booster Method)



Output Linearity in Pulsed Mode

In applications such as scintillation counting where the incident light is in the form of pulses, individual pulses may range from a few to over 100 milliamperes even though the average anode current is small at low count rates. In this pulsed output mode, the peak current in extreme cases may reach a level hundreds of times higher than the voltage divider current. If this happens, it is not possible to supply interelectrode currents from the voltage divider circuit to the last few stages of the photomultiplier tube, thus leading to degradation in the output linearity.

Improving Linearity in Pulsed Output Mode

① Using decoupling capacitors

Using multiple power supplies mentioned above is not popular in view of the cost. The most commonly used technique is to supply the interelectrode current by using decoupling capacitors as shown in Figure 20. There are two methods for connecting these decoupling capacitors: the serial method and the parallel method. As Figures 20 and 21 show, the serial method is more widely used since it requires lower tolerance voltages of the capacitors. The capacitance value C (farads) of the decoupling capacitor between the last dynode and the anode should be at least 100 times the output charge as follows:

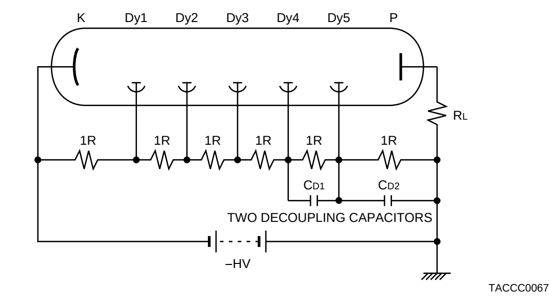
$$C > 100 \cdot Q/V$$

where Q is the charge of one output pulse (coulombs) and V is the voltage (volts) across the last dynode and the anode.

Since this method directly supplies the pulse current with electrical charges from the capacitors, if the count rate is increased and the resulting duty factor becomes larger, the electrical charge will be insufficient. Therefore, in order to maintain good linearity, the capacitance value obtained from the above equation must be increased according to the duty factor, so that the voltage divider current is kept at least 50 times larger than the average anode current just as with the DC output mode.

The active voltage divider circuit and the booster method using multiple power supplies discussed previously, provide superior pulse output linearity even at a higher duty factor.

Figure 20: Equally Divided Voltage Divider Circuit and Decoupling Capacitors

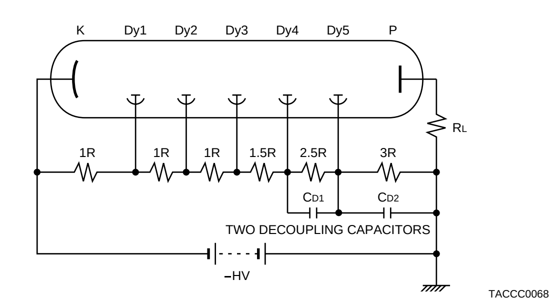


② Using tapered voltage divider circuit with decoupling capacitors

Use of the above voltage divider circuit having decoupling capacitors is effective in improving pulse linearity. However, when the pulse current increases further, the electron density also increases, particularly in last stages. This may cause a space charge effect which prevents interelectrode current from flowing adequately and leading to output saturation. A commonly used technique for extracting a higher pulse current is the tapered voltage divider circuit in which the voltage distribution ratios in the latter stages are enhanced as shown in Figure 21. Care should be taken in this case regarding loss of the current amplification and the breakdown voltages between electrodes.

Since use of a tapered voltages divider circuit allows an increase in the voltage between the last dynode and the anode, it is possible to raise the voltage across the load resistor when it is connected to the anode. It should be noted however, that if the output voltage becomes excessively large, the voltage between the last dynode and the anode may drop, causing a degradation in output linearity.

Figure 21: Tapered Voltage Divider Circuit Using Decoupling Capacitors



D-Type Socket Assemblies

The D-type socket assemblies are grouped as follows:

(a) For DC output (−HV supply)
Available only upon request

(b) For DC or pulsed output (−HV supply)
e.g. E717-63

(c) For pulsed output (+HV supply)
e.g. E990-08

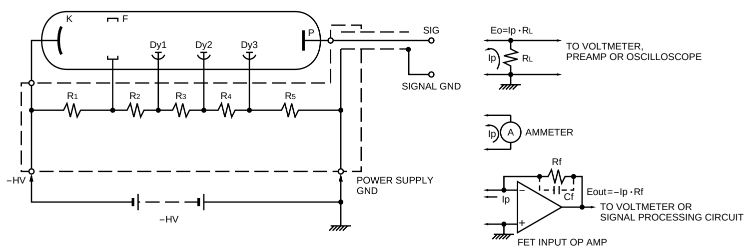
(d) For DC or pulsed output (−HV supply), or pulsed output (+HV supply)
e.g. E717-35

Connection of D-Type Socket Assemblies to External Circuits

Figure 22 shows typical examples of connecting various D-type socket assemblies to external circuits.

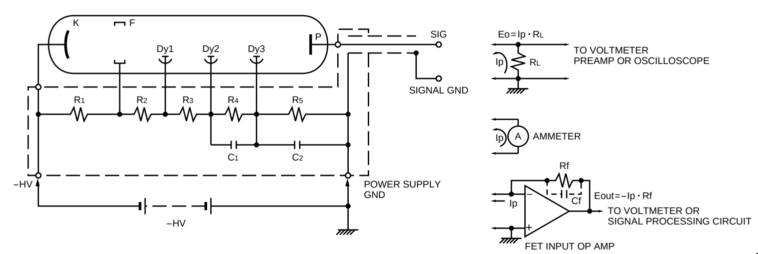
Figure 22: Connection of D-Type Socket Assemblies to Extrernal Circuits

(a) For DC output (−HV supply)



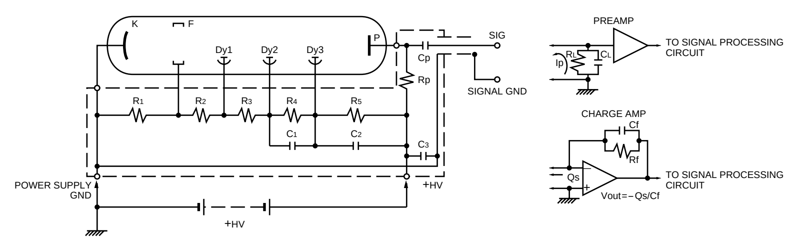
TACCC0069EA

(b) For DC or pulsed output (−HV supply)



TACCC0070EA

(C) For pulsed output (+HV supply)

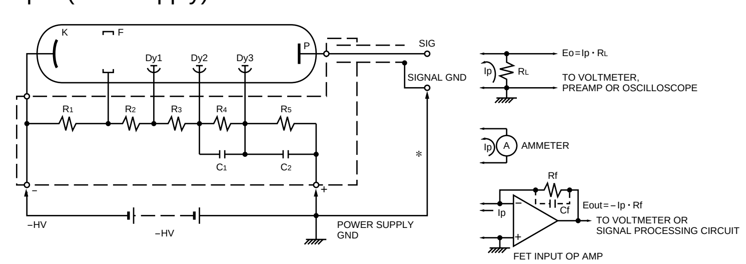


TACCC0071EB

(d) For DC or pulsed output (−HV supply), or pulsed output (+HV supply)

d-1. For DC or pulsed output (−HV supply)

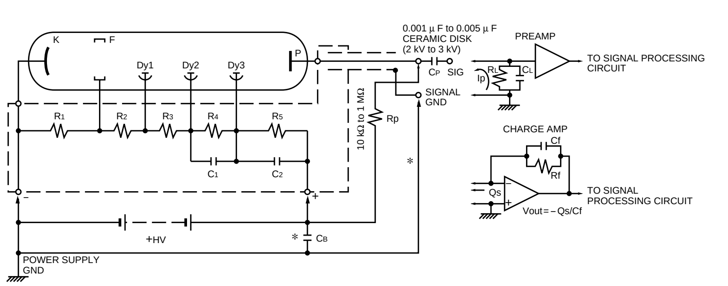
∗ GND should be connected externaly.



TACCC0072EA

d-2. For pulsed output/+HV supply
For general scintillation counting and photon counting applications, recommended values for C_P and R_P are 0.001 μF to 0.005 μF and 10 kΩ to 1 MΩ. Since a high voltage is supplied to these parts, care must be taken when handling this circuit.

∗ GND and C_B should be connected externally.



TACCC0073EC

For Side-on Types

PMT Type No.	PMT Diameter	Applicable Socket Assembly
1P21	28 mm (1-1/8")	E717-35, -63, E5815-01
1P28		
931A		
931B, R1516		
R105, R105UH		
R212, R106		
R636-10, R758-10		
R928, R955		
R1477-06		
R1527		
R2368		
R2658		
R2693		
R2949		
R3788, R4332		
R3810	13 mm (1/2")	E850-13
R3811		
R3896	28 mm (1-1/8")	E717-35, -63, E5815-01
R4220, R7447		
R4632		
R5108		
R6350	13 mm (1/2")	E850-13
R6351		
R6352		
R6353		
R6354		
R6355		
R6356		
R6357		
R6358		
R7154	28 mm (1-1/8")	E717-35, -63, E5815-01
R7446		

For Head-on Types

PMT Type No.	PMT Diameter	Applicable Socket Assembly
R316-02	28 mm (1-1/8")	E990-07, -08
R329-02, R5113-02, R2256-02	51mm (2")	E5859-01, -03
R331-05, R331		
R374, R376, R1104	28 mm (1-1/8")	E990-07, -08
R464, R585	51 mm (2")	E5859-05
R550	51 mm (2")	E1198-22, -23, E6316
R580	38 mm (1-1/2")	E2183-500, -502
R632-01	19 mm (3/4")	E974-13, -14, -17
R647, R760, R960	13 mm (1/2")	E849-35, -90, -92
R649	51 mm(2")	E5859-05
R759	13 mm (1/2")	E849-35, -90, -92
R821	19 mm (3/4")	E974-13, -14, -17
R877, R877-01	127 mm (5")	E1198-22, -23, E6316
R943-02	51 mm (2")	E2762-506 (See P.34)
R980	38 mm (1-1/2")	E2183-500, -502
R1166, R762, R750	19 mm (3/4")	E974-13, -14, -17
R1250, R4144	127 mm (5")	E7693

For Head-on Types

PMT Type No.	PMT Diameter	Applicable Socket Assembly
R1306, R2220	51 mm (2")	E1198-05, -20
R1307, R1307-07, R1307-01	76 mm (3")	E1198-05, -20
R1387, R1508, R1509	38 mm (1-1/2")	E2183-500, -502
R1450	19 mm (3/4")	E974-22
R1463	13 mm (1/2")	E849-35, -90, -92
R1464, R2027	19 mm (3/4")	E974-13, -14, -17
R1513	127 mm (5")	E1198-22, -23, E6316
R1617	19 mm (3/4")	E974-13, -14, -17
R1635, R3878	10 mm (3/8")	E1761-04, -21, -35
R1705	38 mm (1-1/2")	E2183-500, -502
R1767		
R1828-01, R2059	51 mm (2")	E2979-500
R1878, R2295	19 mm (3/4")	E974-18
R1893	10 mm (3/8")	E1761-04, -21, -35
R1894		
R1924A	25 mm (1")	E2924, -05, -500
R1925A, R1926A		
R2066A	38 mm (1-1/2")	E2183-500, -502
R2102	Special Envelope	E849-35, -90, -92
R2154-02, R3256	51 mm (2")	E1198-07
R2228	28 mm (1-1/8")	E990-07, -08
R2248	Special Envelope	E1761-04, -21, -35
R2257	51 mm (2")	E5859-01, -03
R2496	10 mm (3/8")	E1761-05
R2557	13 mm (1/2")	E849-52
R2801	19 mm (3/4")	E974-13, -14, -17
R3234-01, R3235-01, R3237-01	51 mm (2")	E2979-501
R3310-02	51 mm (2")	E2762-506 (See P.34)
R3478, R2076	19 mm (3/4")	E2253-05, -08
R3550A	25 mm (1")	E2924, -05, -500
R3886	38 mm (1-1/2")	E2183-500, -502
R3809U-50 Series	MCP-PMT	E3059-500 (See P.34)
R3998-02	28 mm (1-1/8")	E990-29
R4124, R4141	13 mm (1/2")	E849-68
R5070A	25 mm (1")	E2924, -05, -500
R5505	25 mm (1") for high magnetic field	E6133-03
R5900U	Metal package PMT	E5996
R5900U-00-C8	Metal package PMT	E6669-01
R5900U-00-L16	Metal package PMT	E6736
R5900U-00-M4	Metal package PMT	E7083
R5900U-01-L16	Metal package PMT	E6736
R5912	208 mm (8")	E7694
R5929	28 mm (1-1/8")	E990-07, -08
R6231, R6231-01	51 mm (2")	E1198-26, -27
R6233, R6233-01	76 mm (3")	E1198-26, -27
R6234, R6234-01	Special Envelope	E1198-26, -27
R6235, R6235-01		
R6236, R6236-01		
R6237, R6237-01		
R6249, R6248	28 mm (1-1/8")	E990-07, -08
R6427, R7056, R7057	28 mm (1-1/8")	E2624, -05
R6834	28 mm (1-1/8")	E990-07, -08
R7400U Series	Metal package PMT	E5770, E5780
R7401		
R7402		
R7899	25 mm (1")	E2924-11

D-TYPE SOCKET ASSEMBLIES FOR SIDE-ON PMTs

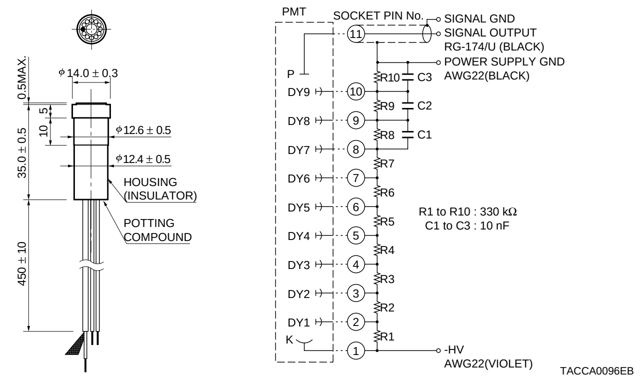
Type No.	Applicable PMT Diameter	Out-line and Dia-gram	Ground-ed Electrode/ Supply Voltage Polarity	Maximum Ratings Ⓓ Insulation Voltage between Case and Pins (V dc)	Maximum Ratings Ⓓ Supply Voltage (V dc)	Voltage Divider Current Ⓐ (mA)	Leakage Current in Signal Max. Ⓑ (A)	Total Voltage Divider Resistance (MΩ)	Maximum Linear Output in DC Mode Ⓒ (µA)	Signal Output	NOTE
For Side-on Types											
E850-13	13 mm (1/2")	①	Anode/-	1500	1250	0.38	1×10^{-10}	3.3	18 (at 1250 V)	DC/Pulse	
E717-63	28 mm (1-1/8")	②	Anode/-	1500	1500	0.45	1×10^{-10}	3.3	22 (at 1500 V)	DC/Pulse	
E717-35		③	Anode• Cathode /+•- Ⓔ	1500	1500	0.45	1×10^{-10}	3.3	22 (at 1500 V)	DC/Pulse	Pin output
E5815-01		④	Anode/-	1500	1500	0.45	1×10^{-10}	3.3 Ⓕ	100 (at 1500 V)	DC/Pulse	Low power consumption, high dc linearity
For Head-on Types											
E1761-04	10 mm (3/8")	⑥	Anode/-	1500	1500	0.41	1×10^{-10}	3.63	20 (at 1500 V)	DC/Pulse	
E1761-05		⑥	Anode/-	1500	1500	0.37	1×10^{-10}	4.02	19 (at 1500 V)	DC/Pulse	For R2496
E1761-21		⑥	Anode/-	1500	1500	0.41	1×10^{-10}	3.63	20 (at 1500 V)	DC/Pulse	E1761-04 with connector
E1761-35		⑤	Cathode/+	1500	1500	0.41	–	3.63	–	Pulse	For scintillation counting
E849-35	13 mm (1/2")	⑦	Anode/-	1500	1250	0.34	1×10^{-10}	3.63	17 (at 1250 V)	DC/Pulse	
E849-92		⑧	Cathode/+	1500	1250	0.34	–	3.63	–	Pulse	For scintillation counting
E849-90		⑦	Anode/-	1500	1250	0.34	1×10^{-10}	3.63	17 (at 1250 V)	DC/Pulse	E849-35 with connector
E849-52		⑦	Anode/-	1500	1250	0.31	1×10^{-10}	3.98	15 (at 1250 V)	DC/Pulse	For R2257, with connector
E849-68		⑦	Anode/-	1500	1250	0.27	1×10^{-10}	4.48	13 (at 1250 V)	DC/Pulse	For R4124
E974-13	19 mm (3/4")	⑨	Anode/-	1800	1800	0.47	1×10^{-10}	3.81	23 (at 1800 V)	DC/Pulse	
E974-14		⑨	Cathode/+	1800	1800	0.47	–	3.81	–	Pulse	For scintillation counting
E974-17		⑨	Anode/-	1800	1800	0.47	1×10^{-10}	3.81	23 (at 1800 V)	DC/Pulse	E974-13 with connector
E974-18		⑨	Anode/-	1500	1500	0.37	1×10^{-10}	3.98	18 (at 1500 V)	DC/Pulse	For R1878, with connector
E974-22		⑩	Anode/-	1800	1800	0.43	1×10^{-10}	4.16	21 (at 1800 V)	DC/Pulse	For R1450, with connector
E2253-05		⑪	Anode/-	1800	1800	0.35	1×10^{-10}	5.13	17 (at 1800 V)	DC/Pulse	For R3478, with connector
E2253-08		⑫	Cathode/+	1800	1800	0.35	–	5.13	–	Pulse	For R3478, For scintillation counting
E2924	25 mm (1")	⑬	Anode/-	1500	1500	0.35	1×10^{-10}	4.29	16 (at 1500 V)	DC/Pulse	
E2924-500		⑬	Anode/-	1500	1500	0.35	1×10^{-10}	4.29	16 (at 1500 V)	DC/Pulse	E2924 with connector
E2924-05		⑭	Cathode/+	1500	1500	0.35	–	4.3	–	Pulse	For scintillation counting
E2924-11		⑬	Anode/-	1800	1800	0.41	1×10^{-10}	4.47	20 (at 1800 V)	DC/Pulse	For R7899
E990-07	28 mm (1-1/8")	⑬	Anode/-	1500	1500	0.38	1×10^{-10}	3.96	18 (at 1500 V)	DC/Pulse	
E990-08		⑮	Cathode/+	1500	1500	0.38	–	3.96	–	Pulse	For scintillation counting
E990-29		⑬	Anode/-	1500	1500	0.34	1×10^{-10}	4.48	16 (at 1500 V)	DC/Pulse	For R3998-02
E2624		⑬	Anode/-	2500	2500	0.52	1×10^{-10}	4.8	25 (at 2500 V)	DC/Pulse	For R6427
E2624-05		⑬	Cathode/+	2500	2500	0.52	–	4.8	–	Pulse	For R6427, For scintillation counting

NOTE Ⓐ Measured with the maximum supply voltage
Ⓑ Measured with a supply voltage of 1000 V
Ⓒ The current at which the output linearity is kept within ±5 %
Ⓓ Operating temperature range -10 °C to +50 °C (Expect for E5780, E5770 and E5996 : -5 °C to +45 °C)
Ⓔ Refer to circuit diagram
Ⓕ Equivalent resistance

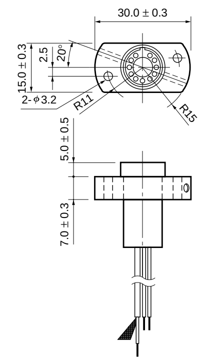
Type No.	Applicable PMT Diameter	Out-line and Dia-gram	Ground-ed Electrode/ Supply Voltage Polarity	Maximum Ratings Ⓓ Insulation Voltage between Case and Pins (V dc)	Maximum Ratings Ⓓ Supply Voltage (V dc)	Voltage Divider Current Ⓐ (mA)	Leakage Current in Signal Max. Ⓑ (A)	Total Voltage Divider Resistance (MΩ)	Maximum Linear Output in DC Mode Ⓒ (µA)	Signal Output	NOTE
For Head-on Types											
E2183-500	38 mm (1-1/2")	⑯	Anode/-	2000	1750	0.44	1×10^{-10}	3.97	21 (at 1750 V)	DC/Pulse	With connector
E2183-502		⑯	Cathode/+	2000	1750	0.45	–	3.96	–	Pulse	With connector, for scintillation counting
E5859-01	51 mm (2")	⑰	Anode/-	2700	2700	0.74	1×10^{-10}	3.63	37 (at 2700 V)	DC/Pulse	With connector
E5859-03		⑰	Cathode/+	2700	2700	0.74	–	3.63	–	Pulse	With connector, for scintillation counting
E5859-05		⑰	Anode/-	1500	1500	0.38	1×10^{-10}	3.98	18 (at 1500 V)	DC/Pulse	With connector
E1198-07		⑱	Anode/-	1750	1750	0.44	1×10^{-10}	3.98	15 (at 1250 V)	DC/Pulse	For R2154-02
E2979-500		⑲	Anode/-	3000	3000	0.7	1×10^{-10}	4.31	34 (at 3000 V)	DC/Pulse	For R1828-01, with connector, with magnetic shield
E2979-501		⑲	Anode/-	2500	2500	0.67	1×0^{-10}	3.75	32 (at 2500 V)	DC/Pulse	For R3234-01, with connector, with magnetic shield
E1198-22	51 mm (2") 76 mm (3") 127 mm (5")	⑱	Anode/-	2200	2000	0.51	1×10^{-10}	3.97	25 (at 2000 V)	DC/Pulse	
E1198-23		⑱	Cathode/+	2200	2000	0.51	–	3.97	–	Pulse	For scintillation counting
E6316		⑳	Cathode/+	2200	2000	0.51	–	3.97	–	Pulse	E1198-23 with connector, for scintillation counting
E1198-05		⑱	Anode/-	1500	1500	0.46	1×10^{-10}	3.3	22 (at 1500V)	DC/Pulse	
E1198-20		⑱	Cathode/+	1500	1500	0.46	–	3.3	–	Pulse	For scintillation counting
E1198-26		⑱	Anode/-	1500	1500	0.38	1×10^{-10}	4.01	18 (at 1500 V)	DC/Pulse	
E1198-27		⑱	Cathode/+	1500	1500	0.38	–	4.01	–	Pulse	For scintillation counting
E7693	127 mm (5")	㉒	Anode/-	3000	3000	1.02	1×10^{-10}	2.94	51 (at 3000 V)	DC/Pulse	For R1250, with connector
E7694	208 mm (8")	㉒	Anode/-	1800	1800	0.39	1×10^{-10}	4.711	18 (at 1800 V)	DC/Pulse	For R5912, with connector
E6133-03	25 mm (1") for high magnetic field	㉑	Anode/-	2300	2300	0.41	1×10^{-10}	5.61	19 (at 2300 V)	DC/Pulse	For R5505, with connector
E5780	Metal package PMT R7400U Series	㉓	Anode/-	1000	1000	0.36	1×10^{-10}	2.8	17 (at 1000 V)	DC/Pulse	
E5770		㉔	Anode· Cathode /+·- Ⓔ	1000	1000	0.36	1×10^{-10}	2.8	17 (at 1000 V)	DC/Pulse	On-board type
E5996	Metal package PMT R5900U Series	㉕	Anode/-	900	900	0.34	1×10^{-10} Ⓗ	2.64	22 (at 900 V)	DC/Pulse	For R5900U
E7083		㉕	Anode/-	900	900	0.33	1×10^{-10} Ⓗ	2.75	15 Ⓖ (at 900 V)	DC/Pulse	For R5900U-00-M4
E6736		㉕	Anode/-	900	900	0.38	1×10^{-10} Ⓗ	2.42	18 Ⓖ (at 900 V)	DC/Pulse	For R5900U-00-L16
E6669-01		㉕	Anode/-	900	900	0.31	1×10^{-10} Ⓗ	2.97	15 Ⓖ (at 900 V)	DC/Pulse	For R5900U-00-C8

NOTE Ⓖ Total current of all anodes.
Ⓗ Measured with a supply voltage of 900 V

❶ E850-13

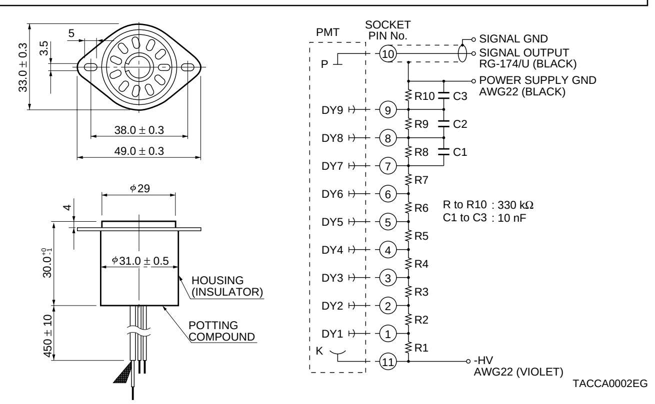


Mounting Flange(For E850-13 and E849 Series)

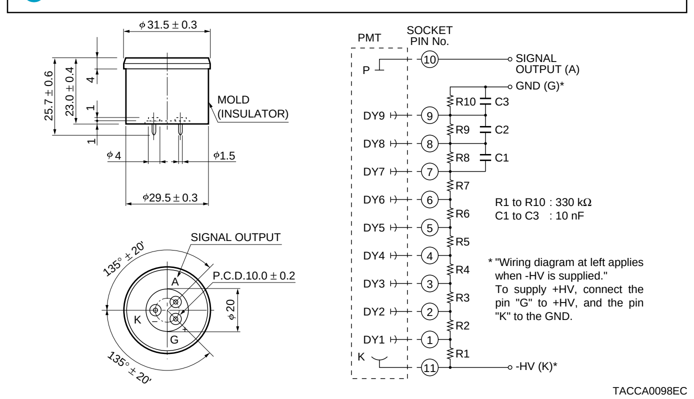


The E850-13 and E849 series (see page 10) are supplied with a plastic mounting flange, setscrews (2 pieces) and a hex wrench.

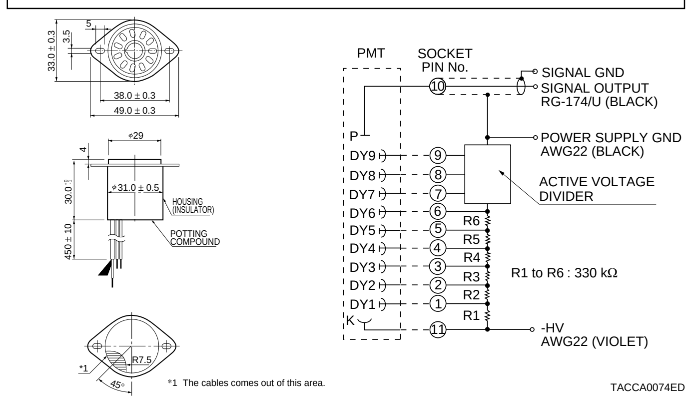
❷ E717-63



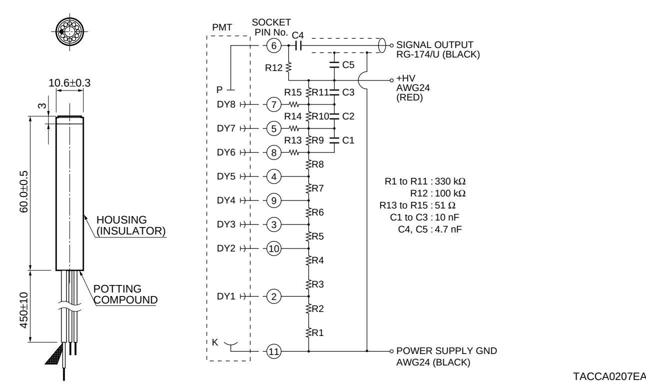
❸ E717-35



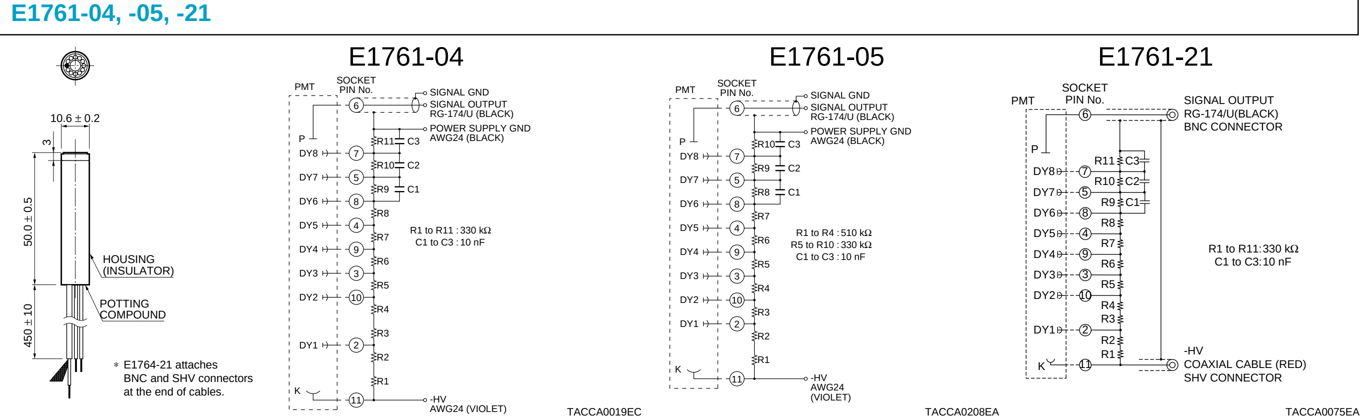
❹ E5815-01



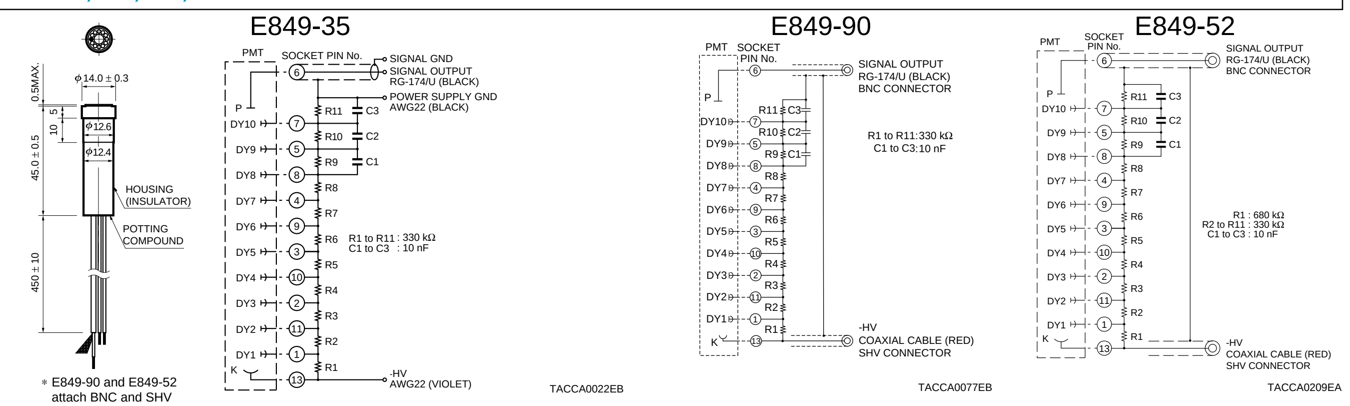
❺ E1761-35

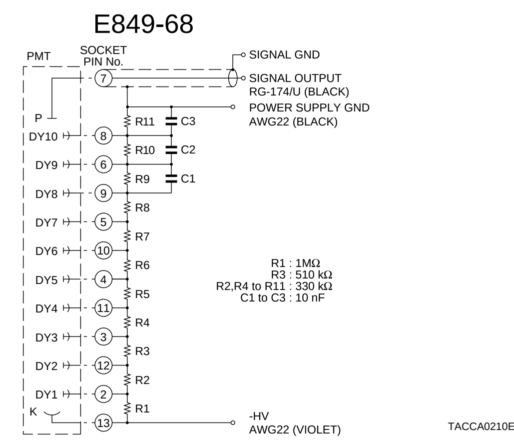


❻ E1761-04, -05, -21

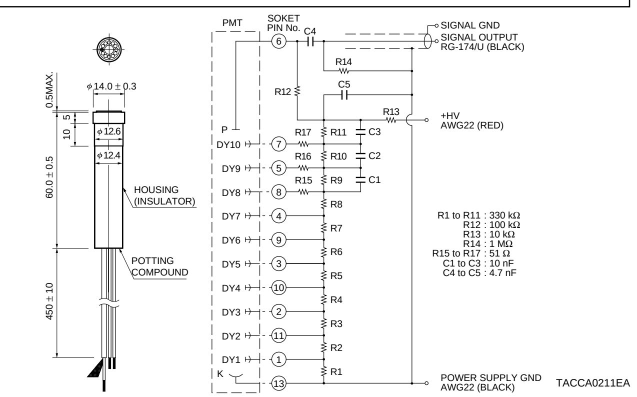


❼ E849-35, -90, -52, -68

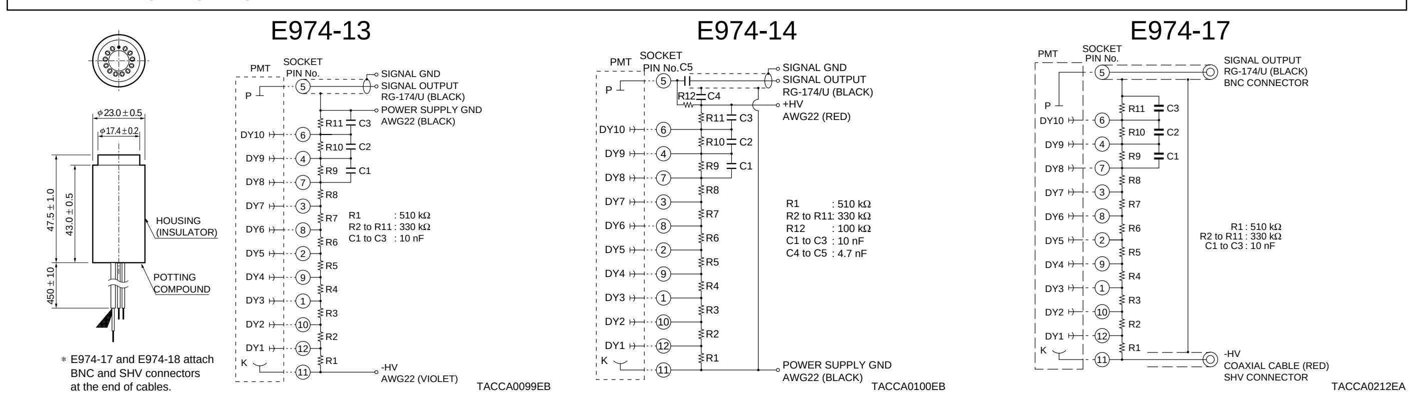


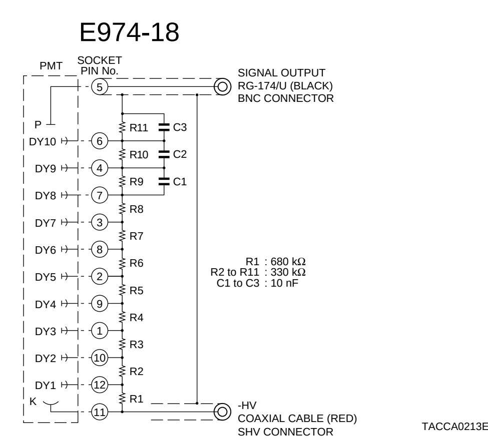


❽ E849-92

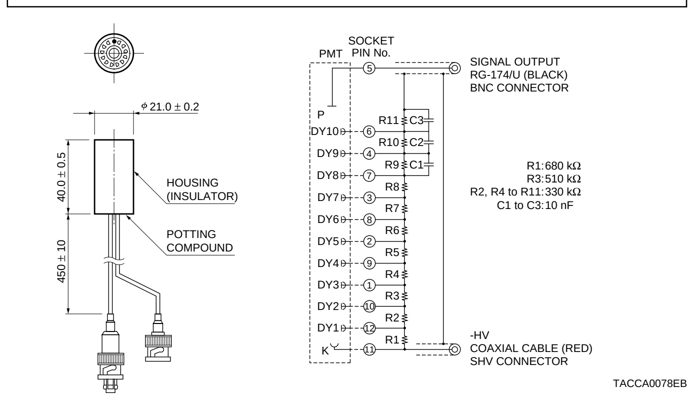


❾ E974-13, -14, -17, -18

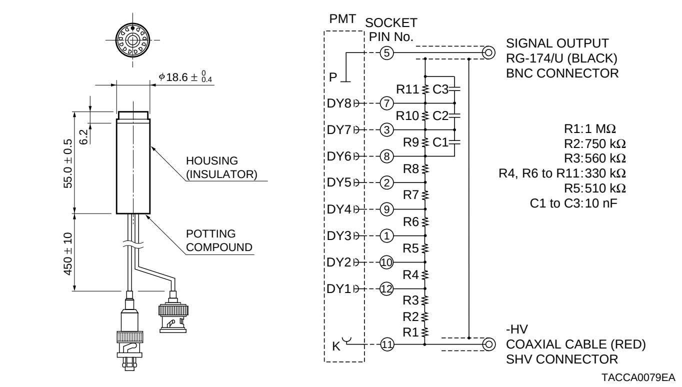




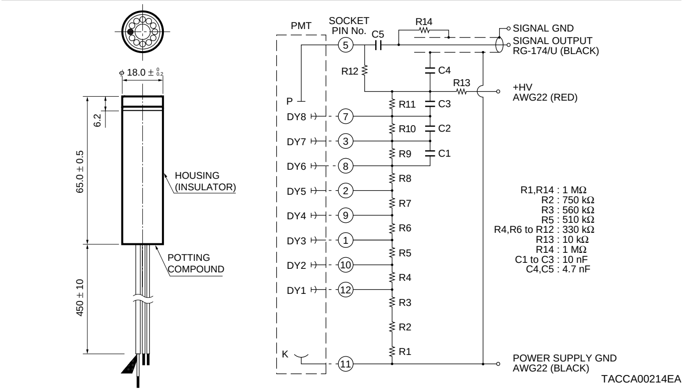
❿ E974-22



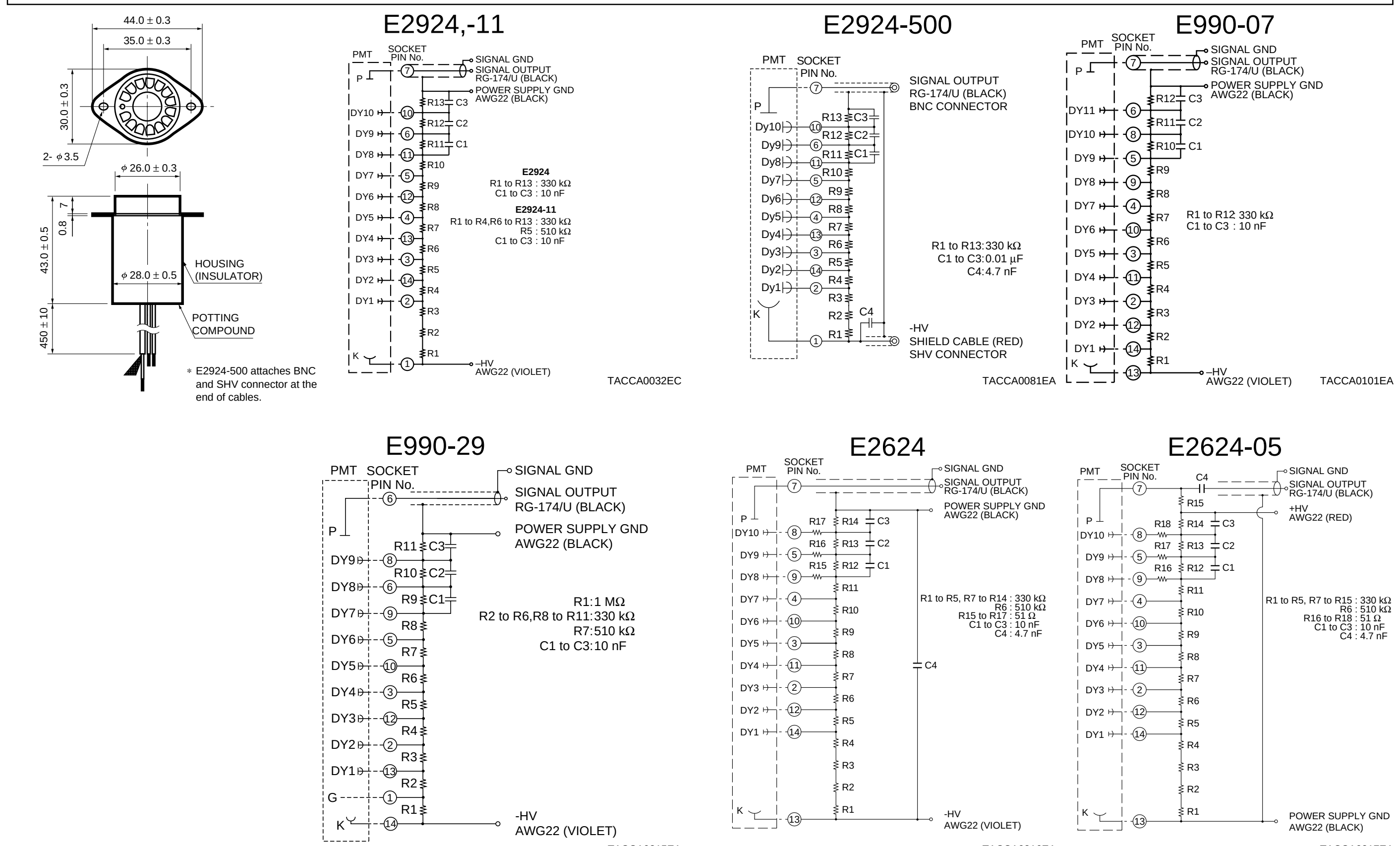
⑪ E2253-05



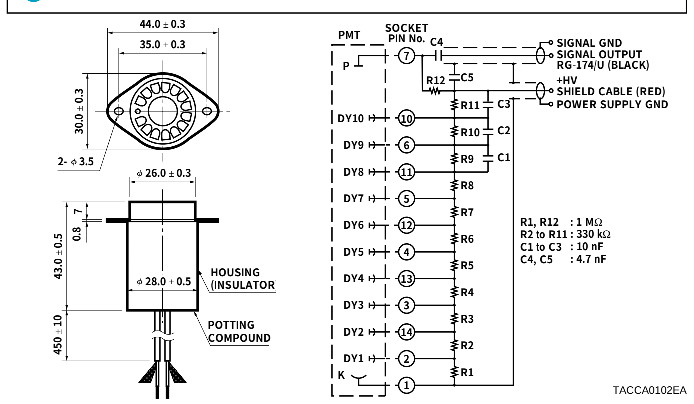
⑫ E2253-08



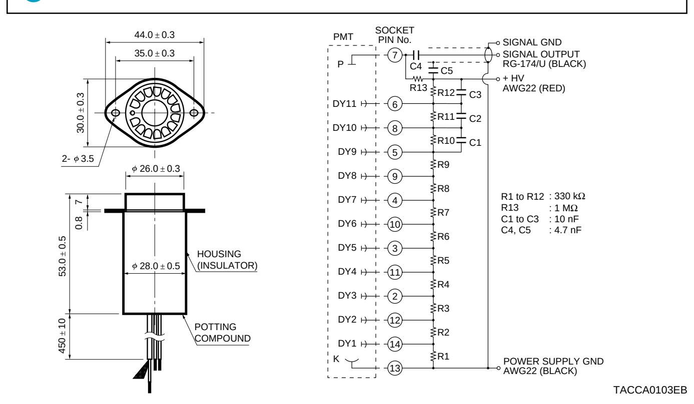
⑬ E2924, -11, -500, E990-07, -29, E2624, -05



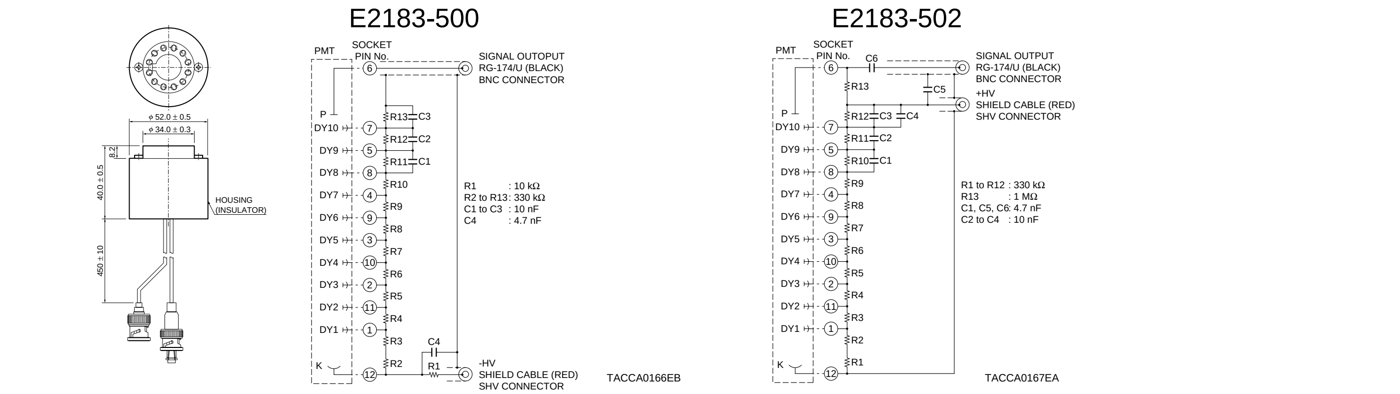
⑭ E2924-05



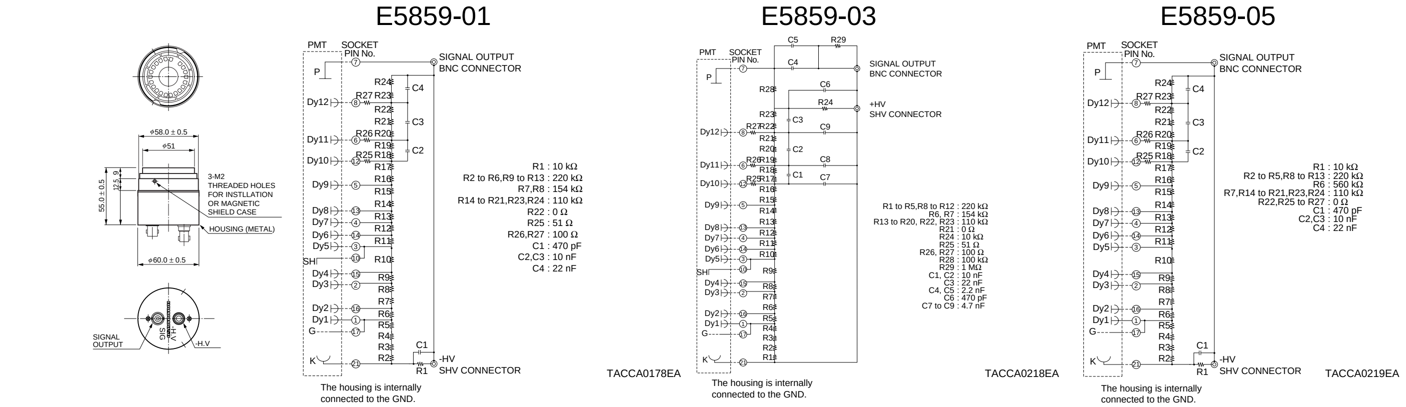
⑮ E990-08



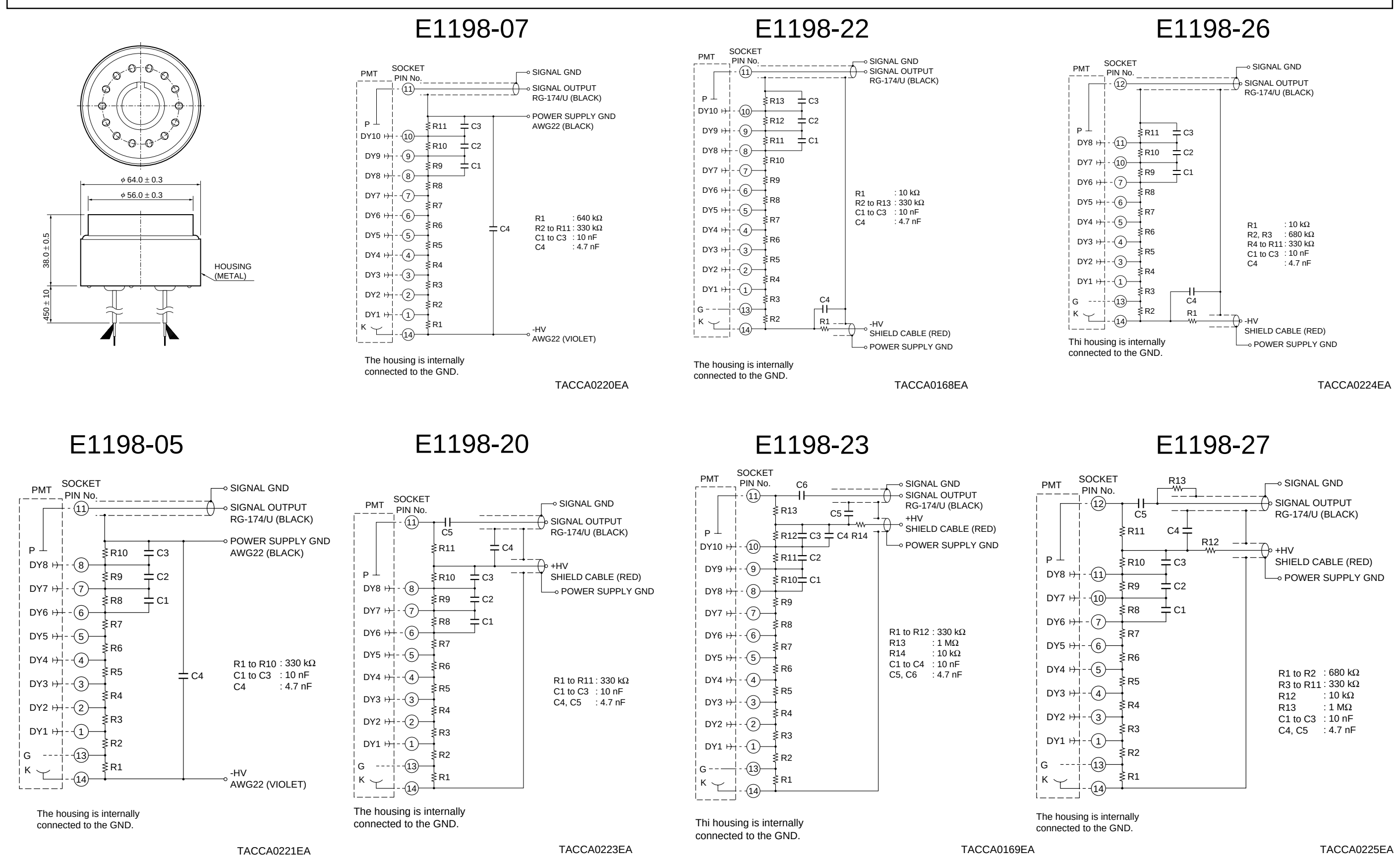
⑯ E2183-500, -502



⑰ E5859-01, -03, -05

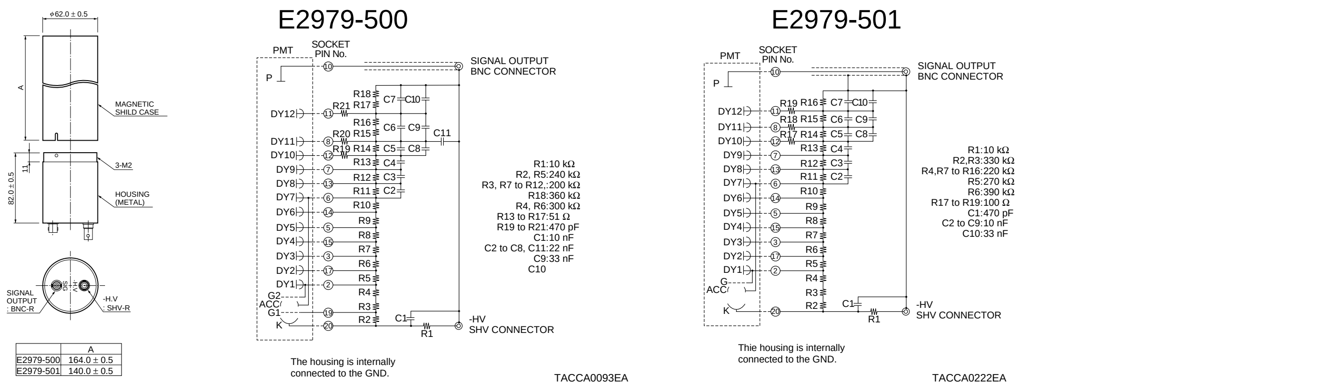


⑱ E1198-07, -22, -26, -05, -20, -23, -27

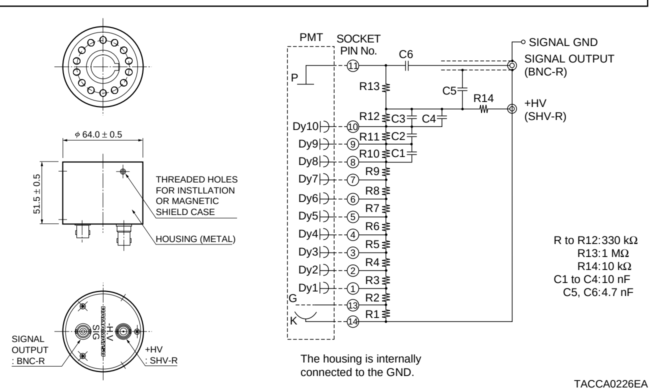


D-TYPE SOCKET ASSEMBLIES DIMENSIONA OUTLINES AND DIAGRAMS (Unit : mm)

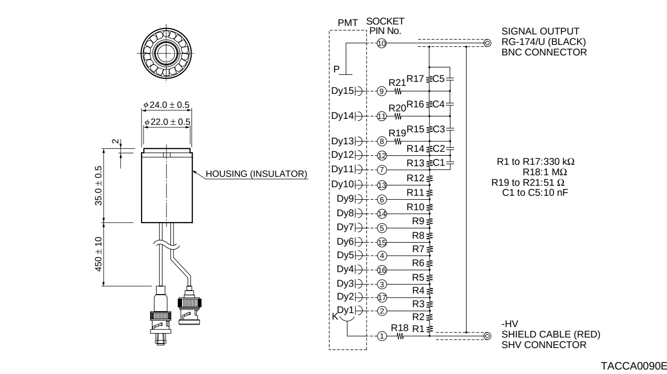
⑲ E2979-500, -501



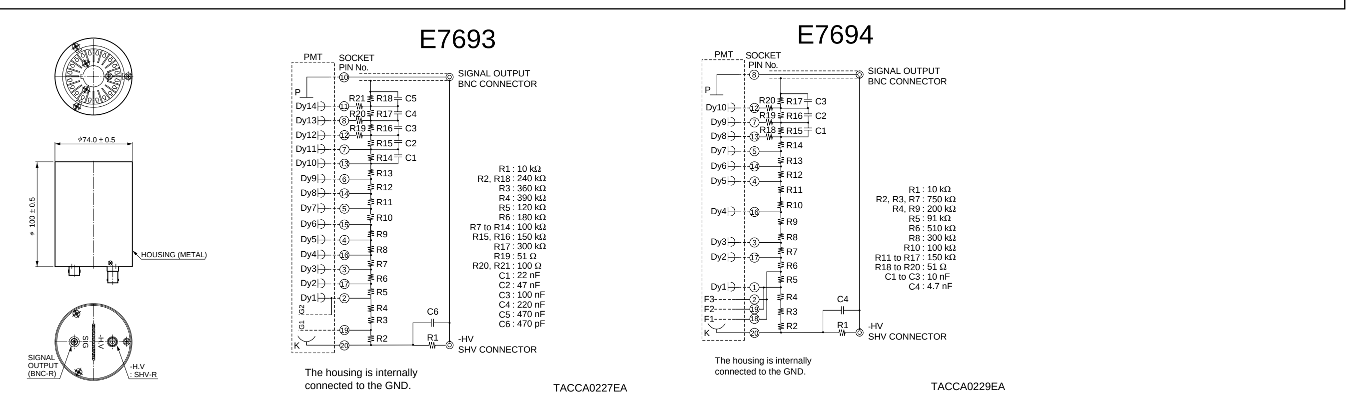
⑳ E6316



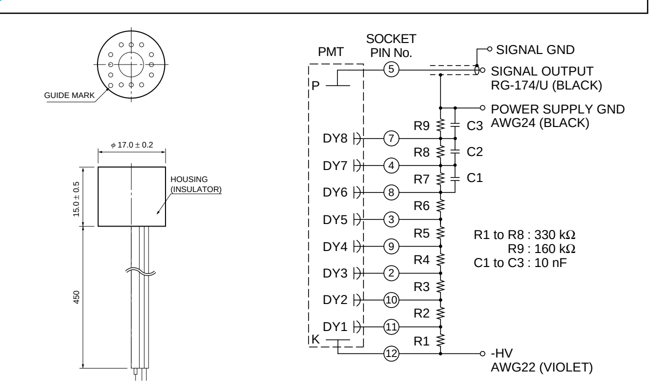
㉑ E6133-03



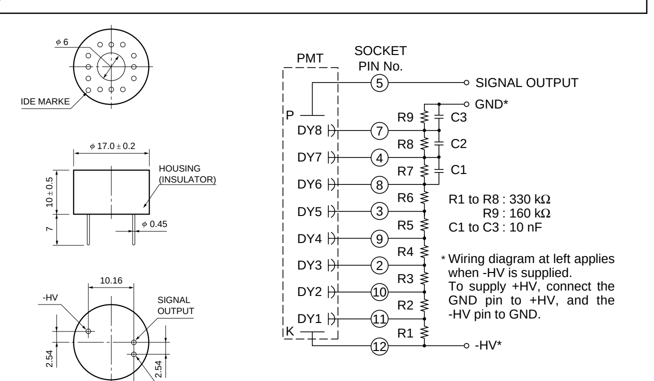
㉒ E7693, E7694



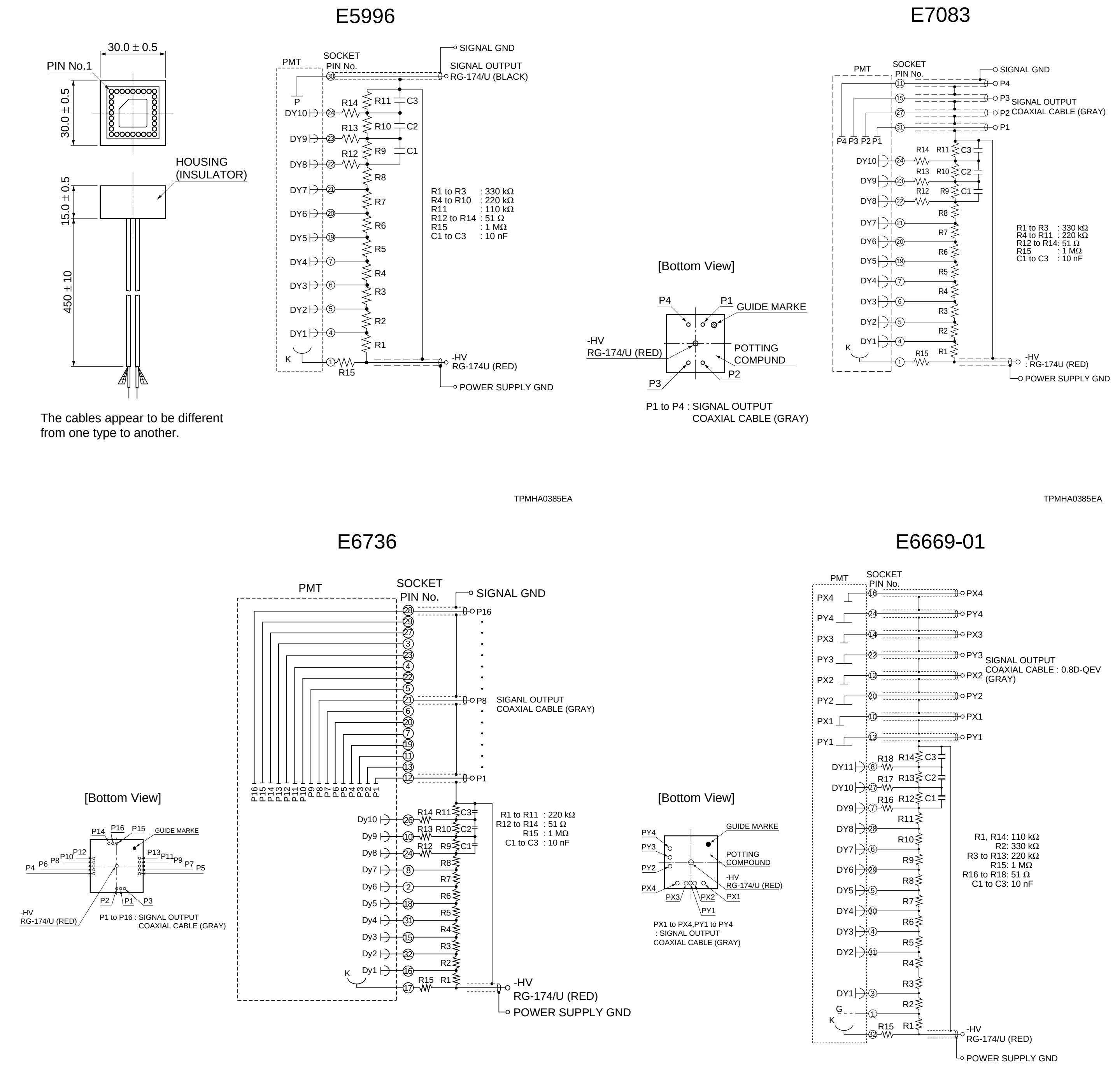
㉓ E5780



㉔ E5770

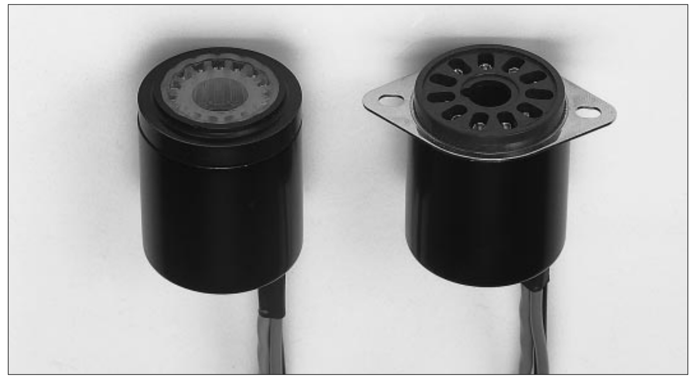


㉕ E5996, E7083, E6736, E6669-01



DA-TYPE SOCKET ASSEMBLIES C7246 SERIES, C7247 SERIES

The C7246 and C7247 series are DA type socket assemblies designed for 28 mm (1-1/8 inch) diameter side-on and head-on photomultiplier tubes. A voltage-divider circuit and an amplifier are incorporated in the same package.
The C7247 series uses an amplifier with a wide bandwidth of 0 Hz to 5 MHz, while the C7246 uses an amplifier with a practical bandwidth of 0 Hz to 20 kHz to improve the effective S/N ratio. The photomultiplier tube low-level, high-impedance current can be converted into a low-impedance voltage output by a factor of 0.3 V/μA.
Both the C7246 and C7247 series use an active voltage-divider circuit that ensures excellent DC linearity at low power consumption. The C7246 series also has a gain adjustment function that does not affect amplifier frequency bandwidth.



SPECIFICATIONS

Parameter	C7246	C7246-01	C7247	C7247-01	Unit
Applicable	ϕ28 mm Head-on	ϕ28 mm Side-on	ϕ28 mm Head-on	ϕ28 mm Side-on	–
PMTs	R374, R2228, R5929, R6095, etc	R928, R3788, R3896, R4220, etc	R374, R2228, R5929, R6095, etc	R928, R3788, R3896, R4220, etc	–

MAXIMUM RATINGS

Parameter	C7246	C7246-01	C7247	C7247-01	Unit
Input Voltage for Amplifier	±18		±18		V dc
Supply Voltage for Divider	-1500		-1500		V dc
Operating Temperature	0 to +40		0 to +40		°C
Storage Temperature	-15 to +60		-15 to +60		°C

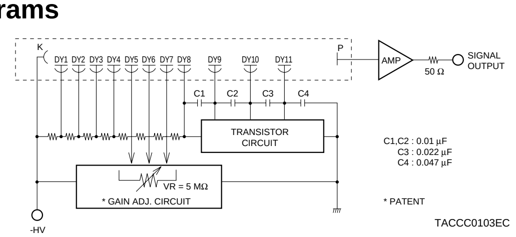
GENERAL

Parameter		C7246	C7246-01	C7247	C7247-01	Unit
Input Voltage for Amplifier		±12 to ±15		±12 to ±15		V dc
Input Current for Amplifier (at ±15 V)		0.53		12		mA Typ.
Recommended Supply Voltage for Divider		-400 to -1000 *	-300 to -1000 *	-400 to -900	-300 to -600	V dc
Divider Current		174 (at HV = -1000 V)	211 (at HV = -1000 V)	219 (at HV = -900 V)	166 (at HV = -600 V)	μA Typ.
Current to Voltage Conversion Factor		0.3		0.3		V/μA
Maximum Output Voltage (with no load resistor)		10		10		V
Output Voltage (with 50 Ω load resistor)		0.9		3		V
Maximum Input Signal Current (with no load resister)	DC	33		33		μA
	Pulse	33		33		μA
Frequency Bandwidth (-3 dB)		0 Hz to 20 kHz		0 Hz to 5 MHz		–
Output Impedance		50		50		Ω
Offset Voltage		±0.3		±3		mV Max.
Output Noise Voltage		0.09		9		mV rms. Typ.
Adjustable Gain Range		10	30	–	–	dB Min.
Total Power Consumption (at ±15 V)		190 (at HV = -1000 V)	227 (at HV = -1000 V)	558 (at HV = -900 V)	460 (at HV = -600 V)	mW Typ.
Weight		55	50	55	50	g Typ.

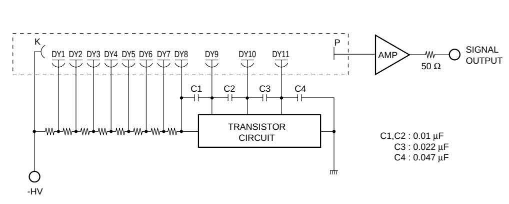
* Keep more than 600 V at -HV input when input signal gives more than 10 μA.

Circuit Diagrams

C7246(-01)Ⓐ



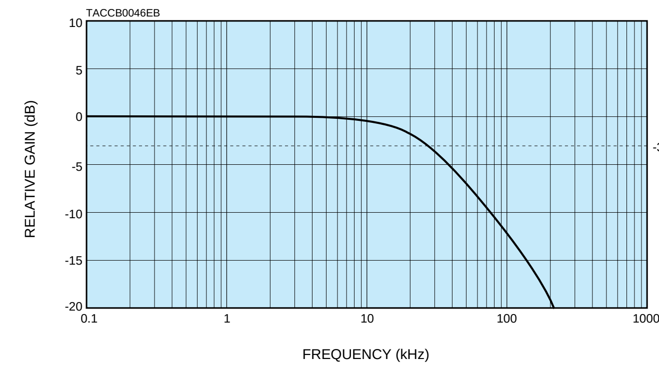
C7247(-01)Ⓐ



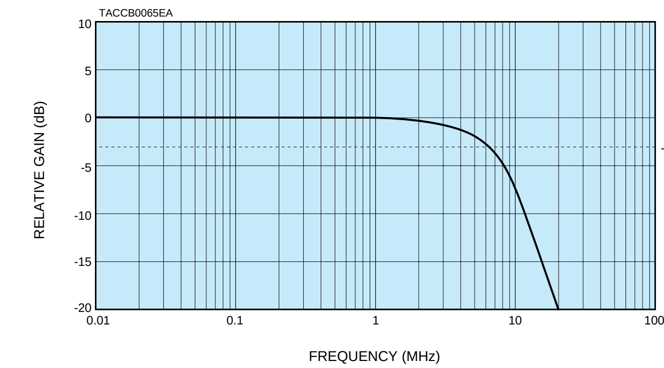
NOTEⒶ C7246-01 and C7247-01 are for 28 mm side-on PMT so that the last dynode number is "DY9"

Frequency Response of Built-in Amplifier

C7246,-01

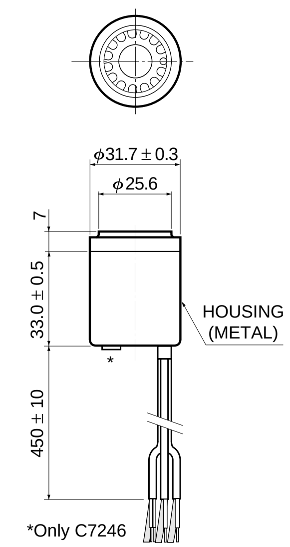


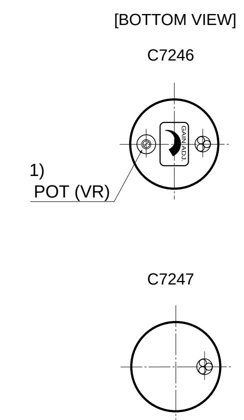
C7247,-01



Dimensional Outlines (Unit : mm)

C7246,C7247

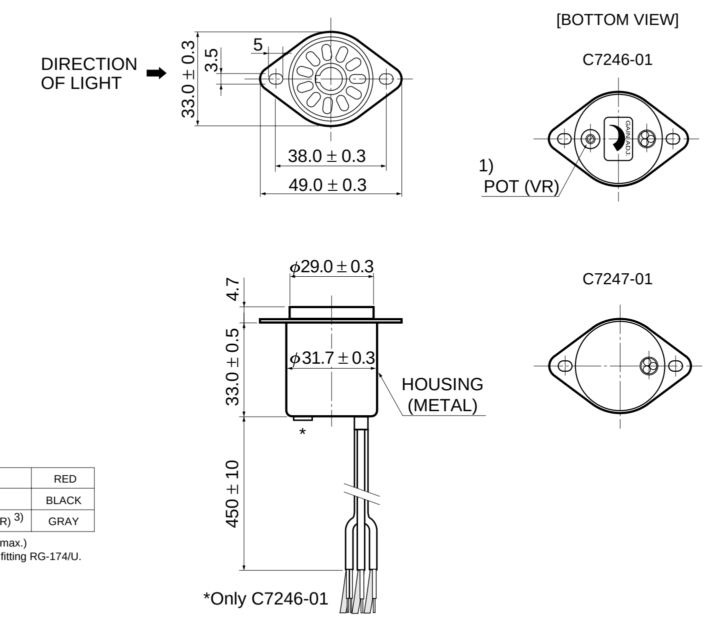




-HV	SHIELD CABLE 2)	RED
SIGNAL OUTPUT	COAX CABLE RG-174/U	BLACK
±15 V	SHIELDED CABLE (COVERING TWISTED PAIR) 3)	GRAY

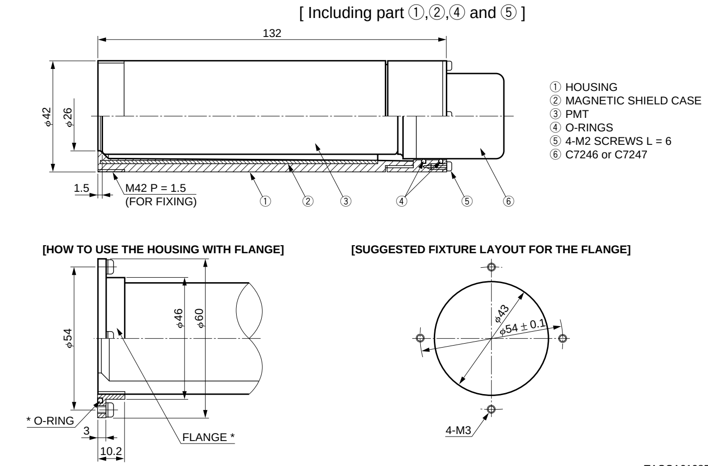
NOTES: 1) Turning this pot clockwise increases the PMT gain. (25 turns max.)
2) At the end of HV cable, it's possible to attach SHV connector fitting RG-174/U.
3) Connect as follow.
WHITE········ -15 V
ORANGE···· +15 V
SHIELD······· GND

C7246-01, C7247-01



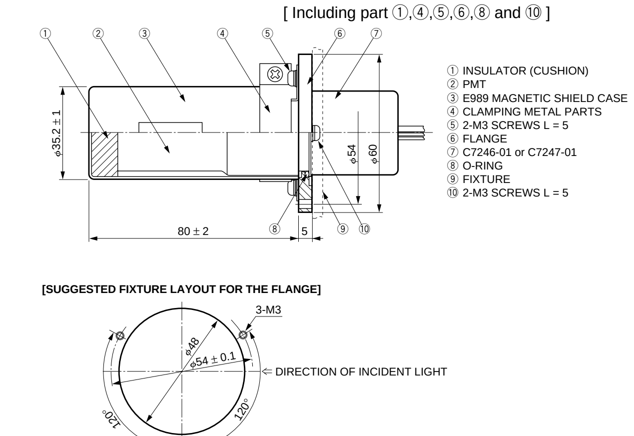
Options (Sold separately)

HOUSING E7718 (For C7246, C7247)
[Including part ①,②,④ and ⑤]



* THE FLANGE AND O-RING ARE AVAILABLE TO ORDER SEPARATELY AS P/N; A7719.

FLANGE A7709 (For C7246-01, C7247-01)Ⓐ
[Including part ①,④,⑤,⑥,⑧ and ⑩]



NOTEⒶ A7709 is also applicable for E717-63 and E5815-01.

HIGH VOLTAGE POWER SUPPLY SOCKE T ASSEMBLY C6270 (DP Type)
HIGH VOLTAGE POWER SUPPLY SOCKET ASSEMBLY WITH TRANSIMPEDANCE AMPLIFIER C6271 (DAP Type)

C6270 is a high voltage power supply socket assembly for 28 mm (1-1/8 inch) diameter side-on photomultiplier tubes (PMTs), incorporating a regulated high voltage power supply and an active voltage divider. It enables simple yet stable photomultiplier tube operations with extended DC output linearity by only supplying +15 Vdc and connectiong to a potentiometer or a 0 V to +5 V for high voltage adjustments.
C6271 further incorporates a transimpedance amplifier which converts the photomultiplier tubes high impedance current signal to low impedance voltage signal.

FEATURES (C6270)

- Superior DC Output Linearity
- Fast High Voltage Programming Response
- Low Power Consumption
- Wide High Voltage Output Range
- Low Ripple/Noise

FEATURES (C6271)

- With Transimpedance Amplifier
- Superior DC Output Linearity
- Fast High Voltage Programming Response
- Low Power Consumption
- Wide High Voltage Output Range
- Low Ripple / Noise

COMMON SPECIFICATIONS

Parameter	C6270	C6271	Unit
Applicable PMTs	ϕ 28 mm (1-1/8 inch) side-on types		–

● GENERAL

Parameter		C6270	C6271	Unit
Input Voltage		+15±1		V dc
Input Current		45	55	mA Typ.
Linear DC Output Current of PMT Ⓐ	at -1000 V	100	43	μA Typ.
	at -500 V	50	43	
Output Voltage Range		0 to -1250		V dc
Line Regulation Against ±1 V Input Change		±0.01		% Typ.
Ripple/Noise (p-p) in High Voltage Output Ⓑ		0.008		% Typ.
High Voltage Control		0 V to +5 V or external 50 kΩ potentiometer		—
High Voltage Programming Response Ⓒ		80		ms Typ.
Temperature Coefficient of High Voltage Output		±0.01		%/ °C Typ.
Operating Temperature		0 to +50		°C
Storage Temperature		-20 to +60		°C
Weight		50	53	g Typ.

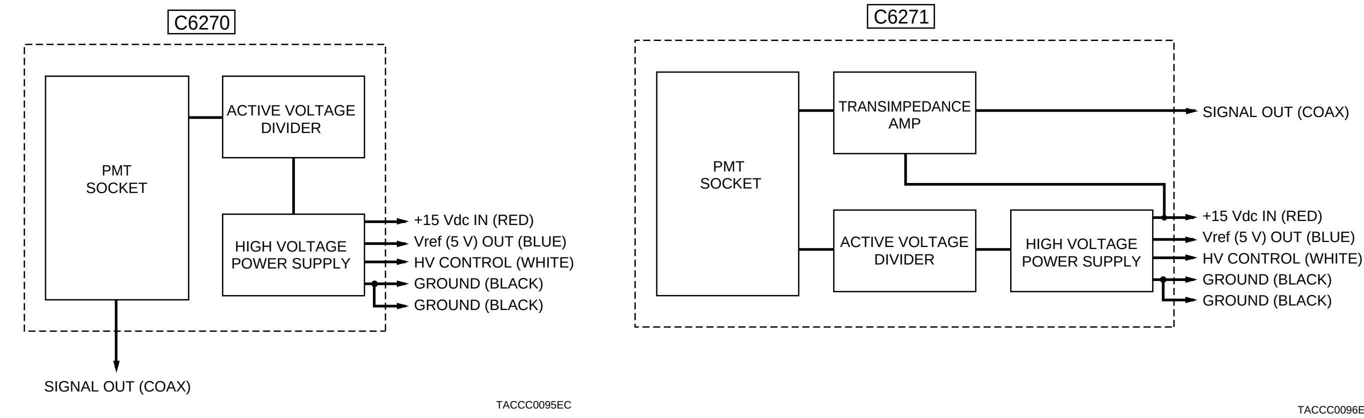
NOTE Ⓐ Within ± 2 % linearity
Ⓑ At maximum output voltage
Ⓒ For 0 % to 99 % HV change

C6271 SPECIFICATIONS

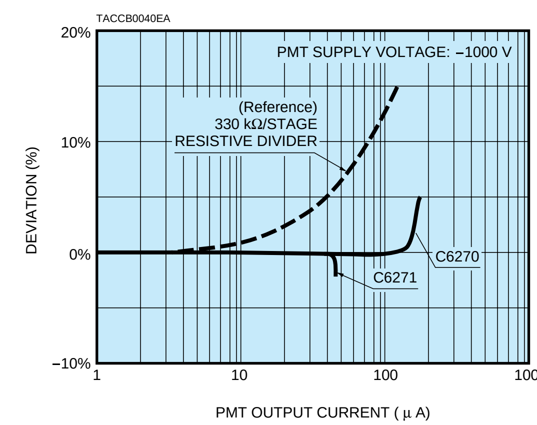
● TRANSIMPEDANCE AMPLIFIER SECTION

Parameter	Value	Unit
Current to Voltage Conversion Factor	0.3	V/ μA
Maximum Linear Signal Output Voltage	+13 (Anode Current=43 μA)	V Typ.
Bandwidth	0 Hz to 10 kHz	–
Signal Output Offset Voltage	-0.3 to +0.3	mV Typ.
Induced Ripple (p-p) on Signal Output	1	mV Typ.

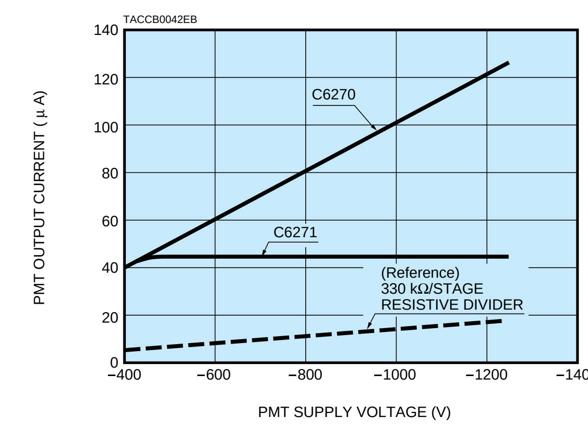
Schematic Diagrams



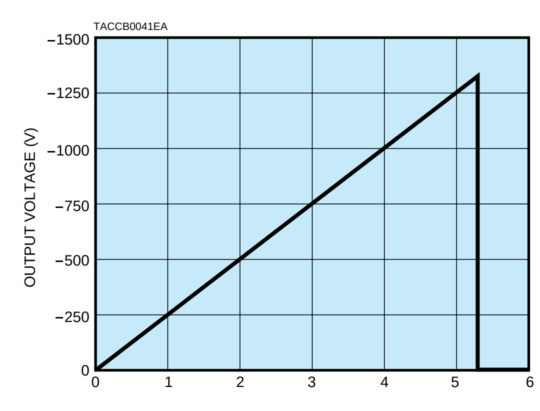
DC Linearity Characteristics



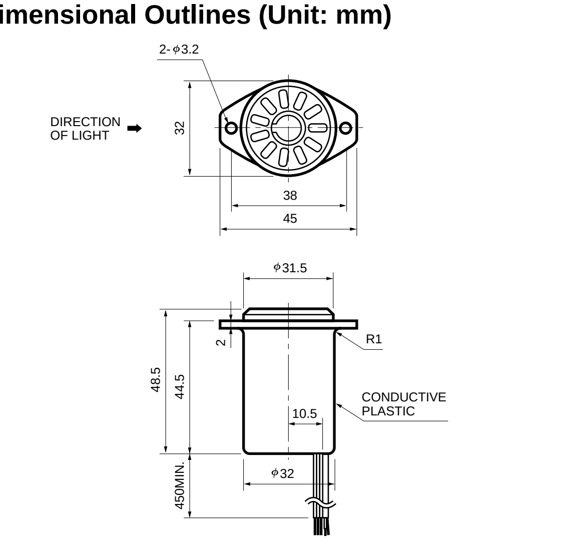
Practical PMT DC Output Limits



High Voltage Controlling Characteristic



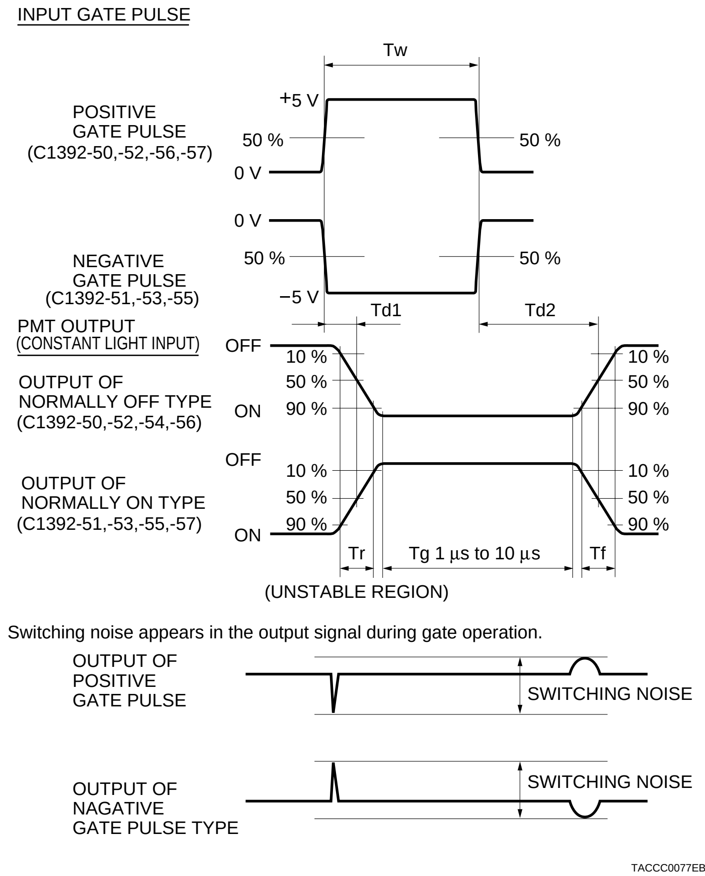
Dimensional Outlines (Unit: mm)



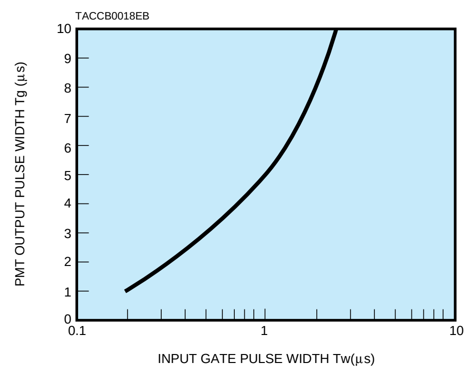
Gated D-Type Socket Assemblies C1392 Series

In applications such as fluorescence measurement, Raman spectroscopy and measurement of optical transmission path faults, the actual signal light to be measured is extremely weak in comparison with the primary excitation light. In these applications, since the sensitivity of the detection system is adjusted to a high range to measure extremely low signal light, if even part of the primary light is allowed to enter the detection system, excessive light input results. This saturates the output of the photomultiplier tube and the subsequent signal processing circuit, causing adverse effects.
A high-speed shutter can be used to cut off only the excessive light, but this is not very practical. The actual technique used is "gating" by which the photomultiplier tube is electrically switched so that its output is obtained only during the desired period. There are two modes in the gating operation: one is the "normally OFF" mode which keeps the photomultiplier tube off most of the time and turns it on when a gate signal is input; the other is the "normally ON" mode which keep the photomultiplier tube on most of the time and turns it off when a gate signal is input. The Hamamatsu C1392 series gated socket assemblies are available in both modes.

Gate Timing Chart

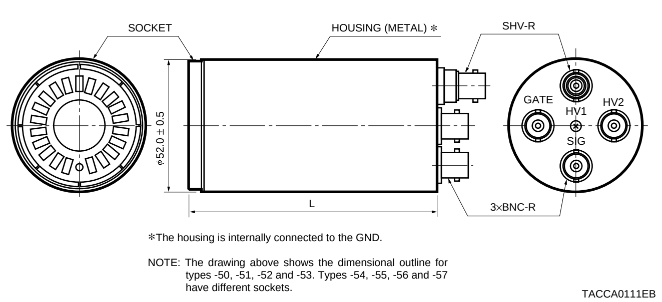


PMT Output Pulse Width vs. Input Gate Pulse Width



NOTE:For a convenient setting, it is recommended to set an input gate pulse roughly according to above data and make a further detail adjustment with looking an oscilloscope.

Dimensional Outline (Unit: mm)



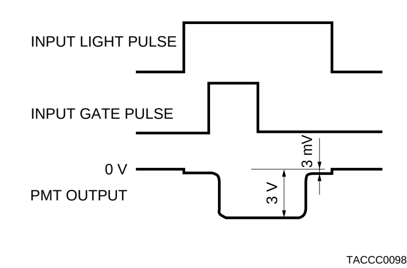
Specifications

Type No.		−50	−51	−52	−53	−54	−55	−56	−57	Unit
Applicable PMT		φ52mm Head-on R2257Ⓐ	φ52mm Head-on R2257Ⓐ	φ52mm Head-on R943-02	φ52mm Head-on R943-02	φ38mm Head-on R1387	φ38mm Head-on R1387	φ28mm Side-on R928	φ28mm Side-on R928	—
Normally ON/OFF State		OFF	ON	OFF	ON	OFF	ON	OFF	ON	—
Switching Ratio Ⓑ (Min.)		$1:10^3$ HV1=−1500 V HV2=+ 250 V	$1:10^3$ HV1=−1500 V HV2=− 250 V	$1:10^3$ HV1=−1500 V HV2=+ 188 V	$1:10^3$ HV1=−1500 V HV2=− 250 V	$1:10^4$ HV1=−1000 V HV2=+ 167 V	$1:10^4$ HV1=−1000 V HV2=− 250 V	$1:10^3$ HV1=−1000 V HV2=+ 200 V	$1:10^3$ HV1=−1000 V HV2=+ 250 V	—
Maximum Supply Voltage (HV1)		-2400	-2400	-2200	-2200	-1250	-1250	-1250	-1250	V
Maximum Supply Voltage (HV2)		+270	-270	+270	-270	+270	-270	+270	+270	V
Recommended Supply Voltage (HV2)		+250	-250	$\frac{\lvert HV1\rvert}{8}$	-250	$\frac{\lvert HV1\rvert}{6}$	-250	$\frac{\lvert HV1\rvert}{5}$	+250	V
Maximum Voltage Divider Current		1.9	1.7	1.6	2.0	1.0	1.0	0.4	0.4	mA
Peak Current of HV2 Ⓒ		7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	mA
Input Gate Pulse Conditions	Input Gate Pulse Polarity	+	-	+	-	+	-	+	+	—
	Maximum Gate Pulse Voltage	+6	-6	+6	-6	+6	-6	+6	+6	V Max.
	Recommended Gate Pulse Voltage	+5	-5	+5	-5	+5	-5	+5	+5	V
	Rise/Fall Times	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	µs Max
	Input Impedance	85	85	85	85	85	85	85	85	Ω
Output Gate Pulse Width		1 to 10	1 to 10	1 to 10	1 to 10	1 to 10	1 to 10	1 to 10	1 to 10	µs
Operating Temperature		0 to +40	0 to +40	0 to +40	0 to +40	0 to +40	0 to +40	0 to +40	0 to +40	°C
Dimensions	Diameter	52	52	52	52	52	52	52	52	mm
	Length L Ⓓ	100	100	100	100	102	102	96	96	mm
Weight		175	175	175	175	175	175	175	175	g

Timing Properties (Refer to the Gate Timing Chart on Page 20)

Type No.		-50	-51	-52	-53	-54	-55	-56	-57	Unit
Measurement Condition Ⓔ	Input Gate Pulse Voltage	+5	-5	+5	-5	+5	-5	+5	+5	V
	Tw Input Gate Pulse Width	2.4	2.9	2.5	2.8	2.8	3.1	2.8	2.7	µs
	High Supply Voltage (HV1)	-1500	-1500	-1500	-1500	-1000	-1000	-1000	-1000	V
	Medium Supply Voltage (HV2)	+250	-250	+188	-250	+167	-250	+200	+250	V
Tg Output Gate Pulse Width		10	10	10	10	10	10	10	10	µs Typ.
Td1		130	95	90	55	100	55	110	60	ns Typ.
Tr		50	50	20	20	20	20	20	55	ns Typ.
Td2		8.4	7.2	8	7.2	7.3	7	8	7.4	µs Typ.
Tf		240	530	90	420	60	280	80	380	ns Typ.
Switching Noise (p-p) Ⓕ		20	20	16	11	35	50	30	32	mV Typ.

NOTE
Ⓐ Since the HA coating (coating of conductive material on the glass bulb) tends to increase the induced noise when the photomultiplier tube is switched, it is not suited for gating operation. Please use photomultiplier tubes without an HA coating. In photon counting applications, switching noise may create problems, so please consult our sales offices for details.
Ⓑ Switching ratio is the output ratio when the photomultiplier tube is gated on and off at a constant incident light level.
For example, if the output during OFF state is 3 mV and that during ON state is 3 V, with a load resistance of 2 kΩ, the switching ratio is
3 mV : 3 V=1 : 1000
The listed switching ratios can be achieved when the duty factor is less than 1/1000.
Ⓒ Under HV2 (maximum voltage) input.
Ⓓ See the dimensional outline.
Ⓔ With load resistance of 50 Ω.
(All time characteristics are measured under this condition.)
Ⓕ Measured with a 100 MHz BW oscilloscope.



Preamplifier Unit C7319, C6438, C5594

Hamamatsu provides three types of preamplifier units for photomultiplier tubes. Features of each type are as follows.
Select the one that best matches your application.

● C7319
- Switchable frequency bandwidth (2 ranges) and current-to-voltage conversion factor (3 ranges)
- Ideal for applications requiring low noise and high gain

● C6438
- Wide bandwidth from 0 Hz up to 50 MHz

● C5594
- 1.5 GHz cutoff frequency for reliable amplification of high-speed output pulse from PMT
- Ideal for single photon fluorescence lifetime measurement using MCP-PMT and time characteristics measurements using various PMTs
- Choice of SMA or BNC input and output connector

Left : C7319, Center : C6438, Right : C5594

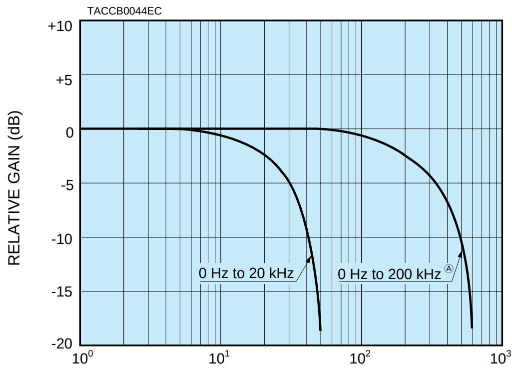
CHARACTERISTICS

Parameter	C7319	C6438	C5594	Unit
Supply Voltage	±5 to ±15	±5	+12 to +16	V dc
Supply Current	±8	±20	95	mA Typ.
Frequency Bandwidth (-3dB)	0 Hz to 20 kHz or 0 Hz to 200 kHz (selectable)Ⓐ	0 Hz to 50 MHz	50 kHz to 1.5 GHz	–
Current to Voltage Conversion Factor	0.1 V/μA , 1 V/μA or 10 V/μA (selectable)	0.5 V/mA Ⓒ	3.15 V/mA	–
Equivalent Noise Input (rms)	Conversion Factor \ Frequency Band width: 0 Hz to 20 kHz / 0 Hz to 200 kHzⒶ 0.1 V/μA: 1.5 nA Typ. / 3.0 nA Typ. 1 V/μA: 0.2 nA Typ. / 0.6 nA Typ. 10 V/μA: 0.02 nA Typ. / 0.2 nA Typ.	1 μA Max.	1 μA Max.	–
Gain	– Ⓑ	20 ± 3 Ⓒ (Approx. 10 times)	36 (Approx. 63 times)	dB
Input Impedance	– Ⓑ	50	50	Ω
Output Impedance	50	50	50	Ω
Weight	170	160	80	g

NOTE Ⓐ 10^7 V/A conversion ratio, to be limited to 0 Hz to 100 kHz frequency bandwidth.
Ⓑ C7319 is current to voltage conversion amplifier unit.
Ⓒ at 50 Ω Load resistor

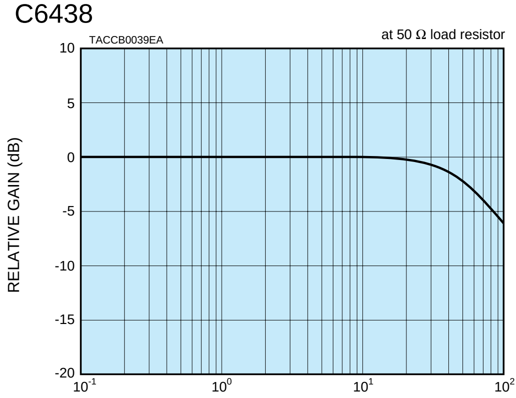
Frequency Response

C7319

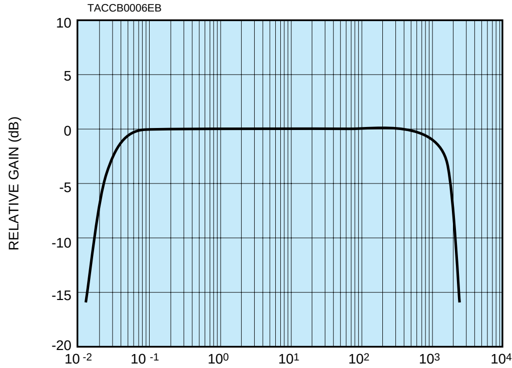


Ⓐ To be limited to 0 Hz to 100 kHz at 10 V/μA
(Current to voltage conversion factor)

C6438

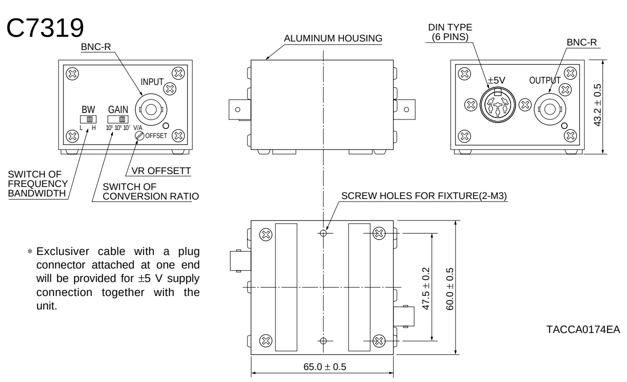


C5594

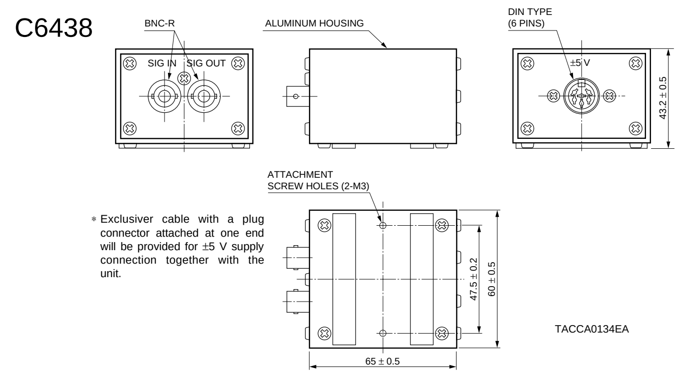


Dimensional Outlines (Unit : mm)

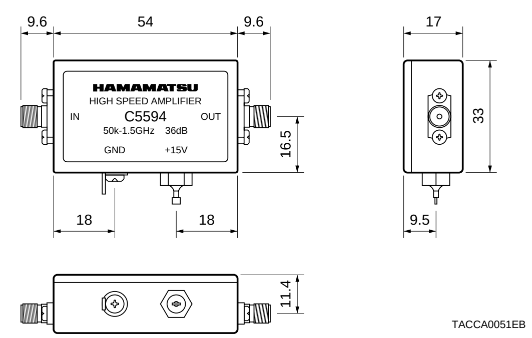
C7319



C6438



C5594



Voltage Dependence of Photomultiplier Tube Gain

The photoelectrons emitted from the photocathode of a photomultiplier tube are channeled by the electron lens to impinge on the first dynode where several times the number of secondary electrons are then emitted. This multiplicative increase of secondary electrons is repeated at the latter dynodes and as a result, the number of electrons reaching the anode is approximately 10^5 to 10^7 times the original number of photoelectrons emitted from the photocathode.
The relationship of the secondary electron emission δ for each dynode to the supplied voltage is expressed as follows:

$$\delta = A \cdot E^{\alpha}$$

where A is a constant, E is the interstage voltage, and α is another constant determined by the dynode material and geometric structure. The value of α is usually in the range 0.7 to 0.8. When a voltage V is supplied between the anode and the photocathode of a photomultiplier tube having n dynode stages, the overall gain μ is given by

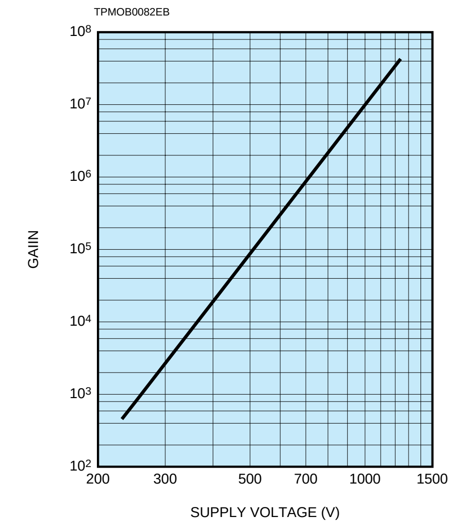
$$\mu = (A \cdot E^{\alpha})^{n} = \{A \cdot [V/n+1]^{\alpha}\}^{n} = \{A^{n}/(n+1)^{\alpha n}\}\, V^{\alpha n}$$

Here, if $\{A^{n}/(n+1)^{\alpha n}\}$ is substituted for K, μ becomes

$$\mu = K \cdot V^{\alpha n}$$

Typical photomultiplier tubes have 9 to 12 dynode stages and as shown in Figure 23, the gain is proportional to the 6th to 10th power of the voltage supplied between the photocathode and the anode. This essentially means that the output of a photomultiplier tube is extremely sensitive to variations in the supplied voltage. Thus the power supply stability such as drift, ripple, temperature regulation, input regulation and load regulation must be at least 10 times as stable as the output stability required of the photomultiplier tube.
Hamamatsu regulated high voltage power supplies are products developed based on our years of experience as a photomultiplier tube manufacturer and our leading edge technology. All models are designed to conform to stability requirements demanded of photomultiplier tube operations. Various models are provided, ranging from on-board unit types to general-purpose bench-top types, allowing you to choose the desired power supply that suits your application.

Figure 23: Gain vs. Supply Voltage



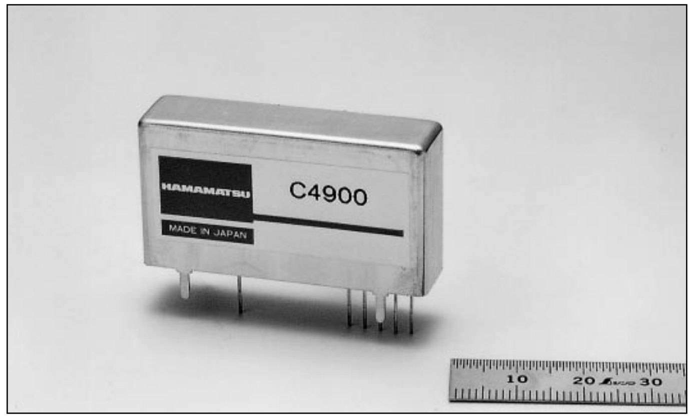
Selection Guide to High Voltage Power Supplies

Type	Type No.		Max. Output Voltage (V dc)	Output Current (mA)	Input Voltage	Dimensions (W×H×D) (mm) *	Weight
Unit Type	C4900	–	−1250	0.6	+15 V dc	46×24×12	31 g
		-01		0.5	+12 V dc		
		-50	+1250	0.6	+15 V dc		
		-51		0.5	+12 V dc		
	C4710	–	−1500	1	+15 V dc	65×27.5×45	105 g
		-01			+12 V dc		
		-02			+24 V dc		
		-50	+1500		+15 V dc		
		-51			+12 V dc		
		-52			+24 V dc		
	C1309	-01	−800	2	+15 V dc	77×21×54	140 g
		-02	−1100	0.7	+15 V dc		120 g
		-04	−1100	0.7	+15 V dc		
		-06	−1500	1	+15 V dc		
Bench-top Type	C3830		−1500	1	Line Voltages	255×54×230	2.8 kg
	C4720		+1500				
	C3350		±3000	10	Line Voltages	220×120×350	8 kg
	C3360		−5000	1	Line Voltages	210×99×273	3.5 kg

*Excluding projecting parts

Compact High Voltage Power Supply Units C4900 Series

The C4900 series is an on-board type high voltage power supply unit, with a design that aims at providing both "compactness and high performance".
The newly developed circuit achieves high performance and low power consumption. The C4900 series in addition provides enhanced protective functions yet is offered at lower costs.
The C4900 and -01 are designed for negative output, while the C4900-50 and -51 have positive output.



FEATURES

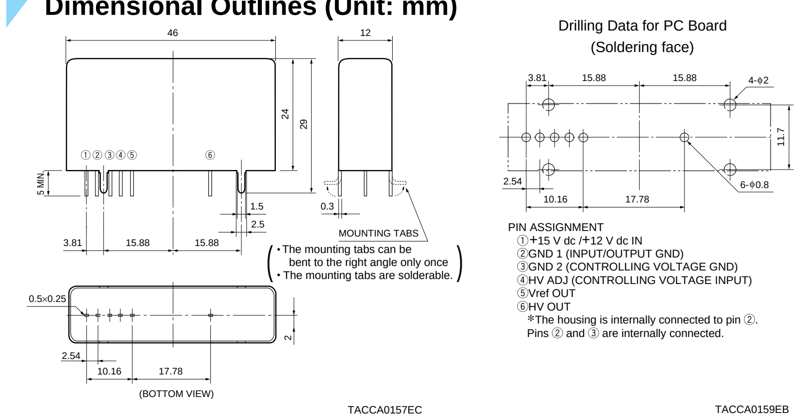
- Very compact and lightweight
- Low power consumption
- Variable output voltage range from 0 V
- High stability
- Quick response
- Ample protective functions

Specifications

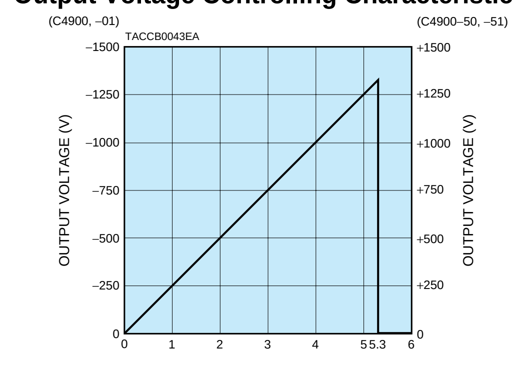
Parameter		C4900	C4900-01	C4900-50	C4900-51	Unit
Input Voltage Range		+15±1	+12±0.5	+15±1	+12±0.5	V dc
Input Current Ⓐ	with no load	14	15	14	15	mA Typ.
	with full load	90	95	90	95	
Variable Output Range		0 to −1250		0 to +1250		V dc
Specification Guaranteed Output Voltage Range		−200 to −1250		+200 to +1250		V dc
Output Current		0.6	0.5	0.6	0.5	mA Max.
Line Regulation against ±1 V/0.5 V Input Change Ⓑ		±0.01				% Typ.
Load Regulation against 0 % to 100 % Load Change Ⓐ		±0.01				% Typ.
Ripple/Noise (p-p) Ⓑ		0.007				% Typ.
Output Voltage Control		By external controlling voltage (0 V to +5 V) or external potentiometer (50 kΩ ±2.5 kΩ)				—
Controlling Voltage Input Impedance		80				kΩ Typ.
Output Voltage Setting (Absolute Value)		(Controlling Voltage ×250) ±0.5%				V Typ.
Output Voltage Rise Time (0 %→99 %) Ⓑ		50				ms Typ.
Temperature Coefficient Ⓑ		±0.01				%/°C Typ.
Operating Temperature Ⓑ		0 to +50				°C
Storage Temperature		−20 to +70				°C
Weight		31				g
Protective Functions		Units protected against reversed power input, reversed/excessive controlling voltage input, continuous overloading/short circuit in output				—

NOTE Ⓐ At maximum output voltage.
Ⓑ At maximum output voltage and current.

Dimensional Outlines (Unit: mm)

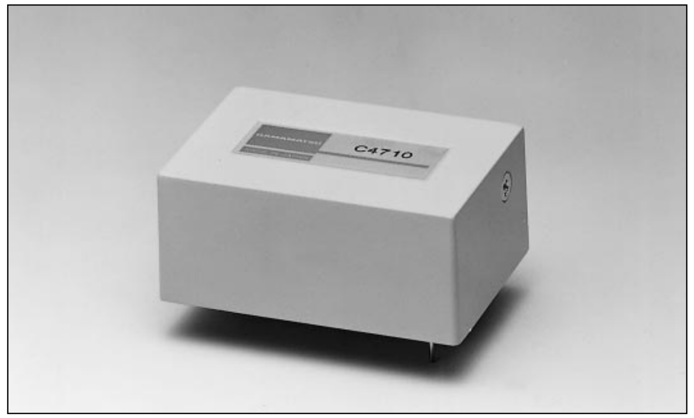


Output Voltage Controlling Characteristic



Compact High Voltage Power Supply Units C4710 Series

The C4710 series comprises on-board type high voltage power supply units, designed specifically for photomultiplier tube operations. The C4710 series is designed for ease of use and high performance, and can be selected from among 6 models to meet your various needs.



FEATURES

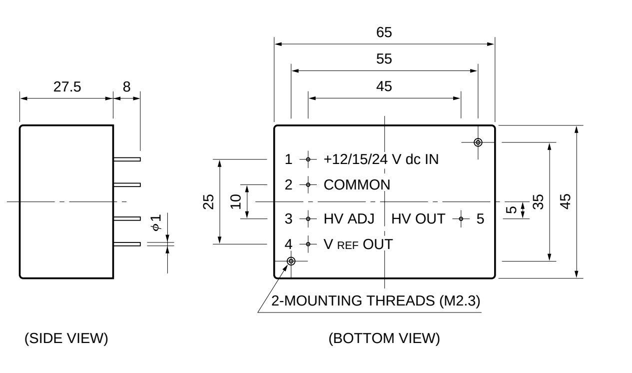
- Compact and lightweight
- High stability
- High output voltage up to 1500 V
- Ample protective functions
- Fully enclosed metal-shielded package

Specifications

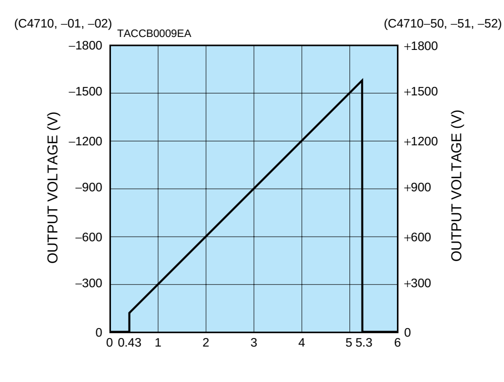
Parameter		C4710	C4710-01	C4710-02	C4710-50	C4710-51	C4710-52	Unit
Input Voltage		+15±1	+12±1	+24±1	+15±1	+12±1	+24±1	V dc
Input Current Ⓐ	with no load	95	120	65	95	120	65	mA Typ.
	with full load	260	340	145	260	340	145	
Specification Guaranteed Output Voltage Range		−240 to −1500			+240 to +1500			V dc
Output Current		1						mA Max.
Line Regulation against ±1 V Input Change Ⓑ		±0.01	±0.015	±0.015	±0.02	±0.02	±0.015	% Typ.
Load Regulation against 0 % to 100 % Load Change Ⓐ		±0.01	±0.015	±0.01	±0.01	±0.01	±0.01	% Typ.
Ripple/Noise (p-p) Ⓑ		0.005						% Typ.
Output Voltage Control		By external controlling voltage (+0.8 V to +5 V) or external potentiometer (10kΩ)						—
Controlling Voltage Input Impedance		40			56			kΩ Typ.
Output Voltage Setting (Absolute Value)		(Controlling Voltage ×300) ±0.5%						V Typ.
Output Voltage Rise Time (0 %→99 %) Ⓑ		100						ms Typ.
Temperature Coefficient Ⓑ		±0.01						%/°C Typ.
Operating Temperature Ⓑ		0 to +40						°C
Storage Temperature		−20 to +60						°C
Weight		105						g
Protective Functions		Units protected against reversed power input, reversed/ excessive controlling voltage input, continuous overloading/short circuit in output.						—

NOTE Ⓐ At maximum output voltage.
Ⓑ At maximum output voltage and current.

Dimensional Outlines (Unit: mm)



Output Voltage Controlling Characteristic



Compact High Voltage Power Supply Units C1309 Series

FEATURES

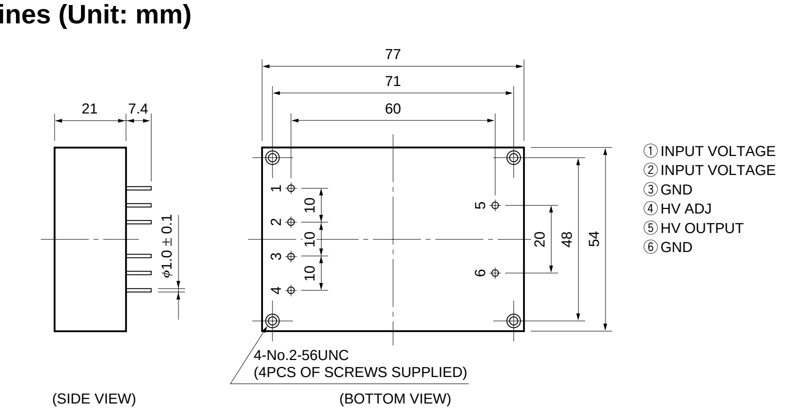
- **Compact and lightweight**
  Allows direct mounting on a PC board.
- **High stability**
  Ensures excellent input regulation, load regulation and drift.
- **Fully enclosed metal-shielded package**
  Provides effective noise shielding

Specifications

Parameter	C1309-01	C1309-02	C1309-04	C1309-06	Unit
Input Voltage Ⓐ	+12 to +16	+14 to +16	+14 to +16	+14 to +16	V dc
Input Current ⒶⒷ	300	170	170	250	mA Max.
Output Voltage	−400 to −800	−200 to −1100	−200 to −1100	−400 to −1500	V dc
Specification Guaranteed Output Voltage Range	−500 to −800	−400 to −1100	−400 to −1100	−500 to −1500	V dc
Output Current	2	0.7	0.7	1	mA Max.
Line Regulation ⒷⒸ	±0.1	±0.06	±0.06	±0.05	% Typ.
Load Regulation against 0 to 100% Load Change Ⓓ	±0.1	±0.15	±0.15	±0.2	% Typ.
Ripple/Noise (p-p) Ⓑ	300	100	100	150	mV Typ.
Drift (After Warm-up) Ⓑ	±0.2	±0.1	±0.02	±0.1	%/h Typ.
Programming Resistance	1	10	10	10	kΩ
Programming Voltage	+4.8 to +7	0 to +1.4	0 to +1.4	0 to +1.4	V dc
Output Voltage Rise Time (10 %→90 %) Ⓑ	30	200	200	200	ms Typ.
Temperature Coefficient ⒷⒺ	±0.05	±0.03	±0.005	±0.02	%/ °C Typ.
Warm-up Time	15	15	15	15	min Typ.
Operating Temperature Ⓑ	+5 to +40	+5 to +40	+5 to +40	+5 to +40	°C
Storage Temperature	−5 to +60	−5 to +60	−5 to +60	−5 to +60	°C
Weight	140	120	120	120	g

NOTE Ⓐ With single supply voltage.
Ⓑ Maximum output voltage and current.
Ⓒ ±2 V input change for C1309-01.
±1 V input change for C1309-02, -04 and -06.
Ⓓ Maximum output voltage.
Ⓔ Operating temperature: +5 °C to +40 °C

Dimensional Outlines (Unit: mm)



Compact Bench-Top Regulated DC Power Supplies C3830, C4720

The C3830 and C4720 are multipurpose power supplies designed to provide a high voltage output for photomultiplier tube operation and low voltage outputs (±5 V, ±15 V) for peripheral devices such as Hamamatsu preamplifiers and photon counting units. The C3830 provides a negative high voltage of −200 V dc to −1500 V dc, and the C4720 a positive high voltage of +200 V dc to +1500 V dc. In either model, the high voltage output is accurately displayed in four digits on the digital panel meter.

Specifications

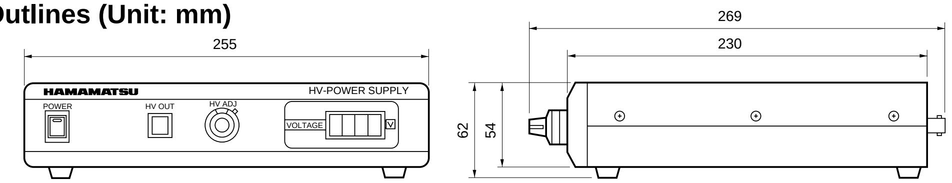
Parameter	Hight Voltage Power Supply Section		±5 V Power Supply Section	±15 V Power Supply Section
	C3830	C4720		
Specification Guaranteed Output Voltage	-200 V dc to -1500 V dc (variable)	+200 V dc to +1500 V dc (variable)	±4.75 V dc to ±5.25 V dc (fixed)	±14.25 V dc to ±15.75 V dc (fixed)
Maximum Output Current	1mA		500mA	200 mA
Line Regulation Against ±10 % Line Voltage Change Ⓐ	±0.005 % Typ.		±0.005 % Typ.	±0.015 % Typ.
Load Regulation Against 0 % to 100 % Load Change Ⓑ	±0.01 % Typ.		±0.5 % Typ.	±0.5 % Typ.
Ripple/Noise (p-p) Ⓐ	0.005 % Typ.		0.16% Typ.	0.06 % Typ.
Drift (after 30 min Warm-up) Ⓐ	±0.03 %/h Typ.		±0.05 %/h Typ.	±0.05 %/h Typ.
Temperature Coefficient Ⓐ	±0.03 %/°C Typ.		±0.03 %/°C Typ.	±0.03 %/°C Typ.
High Voltage Output Monitor	4-digit display		—	—
High Voltage Output Monitoring Accuracy Ⓑ	±0.5 % Typ.		—	—
Output Receptacle	One SHV receptacle		Two 4-pin receptacles (HIROSE SR30-10R-4S)	One 4-pin receptacle (MIYAMA MC-032)
Input Voltage	C3830: 100 /120 /230 V ac ±(10%), C4720: 100 /115 /220 V ac(±10%)			
Power Consumption Ⓐ	Approx. 50 V·A			
Operating Temperature/Humidity ⒶⒸ	0 °C to +40 °C / 90 % RH Max.			
Specification Guaranteed Temperature/Humidity ⒶⒸ	+5 °C to +35 °C / 85 % RH Max.			
Storage Temperature/Humidity Ⓒ	−20 °C to +50 °C / 95 % RH Max.			
Weight	Approx. 2.8 kg			

NOTE Ⓐ At maximum output voltage and current.
Ⓑ At maximum output voltage.
Ⓒ Without moisture condensation.

Accessories

① High voltage output cable (1.5m long) terminated with SHV-P plugs E1168-17 1
② Spare fuses 2
③ ±5 V matching plugs (HIROSE SR30-10PE-4P) 1
④ ±15 V maching plugs (MIYAMA MC-032) 1

Dimensional Outlines (Unit: mm)



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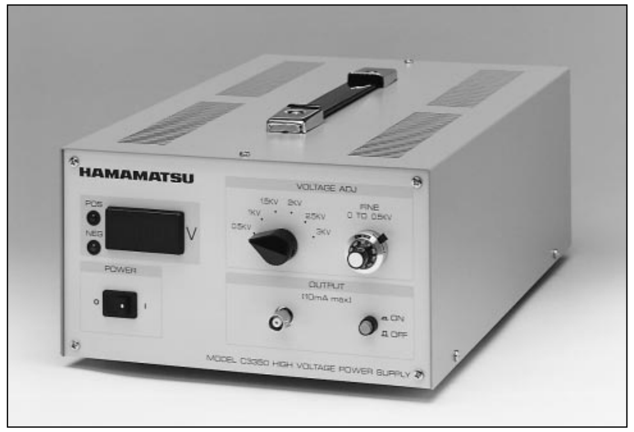
Bench-Top High Voltage Power Supply C3350 (±3 kV Output)

The C3350 is a highly regulated, bench-top power supply that provides high output voltage up to ±3 kV/10 mA. The LED panel meter on the front panel allows easy and precise voltage monitoring. The C3350 is ideally suited for operating photomultiplier tubes or proportional counter tubes.



Specifications

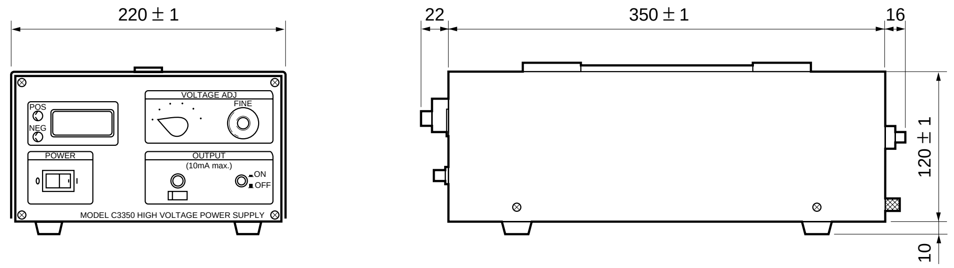
Parameter	Value • Description
Output Voltage	0 V dc to ±3000 V dc
Specification Guaranteed Output Voltage	±250 V dc to ±3000 V dc
Maximum Output Current	10 mA
Line Regulation Against ±10 % Line Voltage Change Ⓐ	± (0.005 %+10 mV) Max.
Load Regulation Against 0 % to 100 % Load Change Ⓑ	± (0.01 %+50 mV) Max.
Ripple/Noise (p-p) Ⓐ	0.0007 % Max.
Drift (after 1 h Warm-up) Ⓐ	± (0.02 %+10 mV) /8 h Max.
Temperature Coefficient Ⓐ	±0.01 %/°C Max.
Output Voltage Monitor	4-digit digital meter
Output Voltage Monitoring Accuracy Ⓑ	± (0.1 %±3 V) Max.
Protection Circuit	For short circuit and excess output current
Input Voltage	100 /115 /220 /230 V ac (±10%), 50Hz/60Hz
Power Consumption Ⓐ	Approx. 100 V·A
Specification Guaranteed Temperature/Humidity ⒶⒸ	+5 °C to +35 °C / 85% RH Max.
Storage Temperature/Humidity Ⓒ	−20 °C to +50 °C / 95 % RH Max.
Output Receptacles	Two SHV receptacles
Weight	8 kg

NOTE Ⓐ At maximum output voltage and current.
Ⓑ At maximum output voltage.
Ⓒ Without moisture condensation.

Accessories

AC line cable (2.4 m long) 1
High voltage output cable (1.5 m long) terminated with SHV-P plugs E1168-19 1
Spare fuses 2

Dimensional Outlines (Unit: mm)



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Bench-Top High Voltage Power Supply C3360 (-5 kV output)

The C3360 is a highly regulated, bench-top power supply that provides high output voltage up to -5 kV/1 mA. The C3360 is especially developed for operation of MCP-PMTs, electron multipliers and MCPs. The LED panel meter on the front panel allows easy and precise voltage monitoring.

Specifications

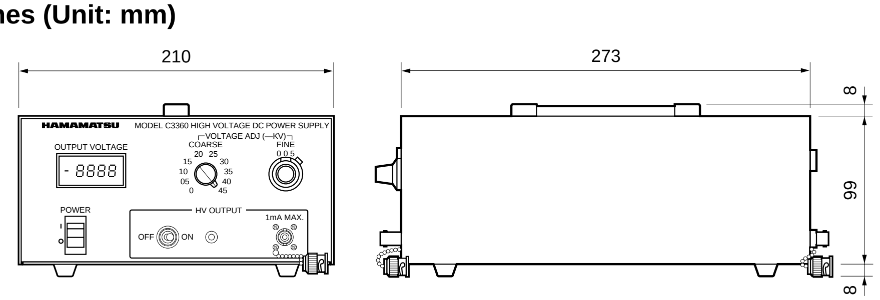
Parameter	Value • Description
Output Voltage	0 to −5000 V dc
Maximum Output Current	1 mA
Line Regulation Against ±10 % Line Voltage Change Ⓐ	± (0.001 % +0.05 V) Max.
Load Regulation Against 0 % to 100 % Load Change Ⓑ	± (0.001 % +0.05 V) Max.
Ripple/Noise (p-p) Ⓐ	0.0004 % Max.
Drift (after 1 h Warm-up) Ⓐ	±0.05 %/8 h Max.
Temperature Coefficient Ⓐ	±0.01 %/°C Max.
Output Voltage Monitor	4-digit digital meter
Output Voltage Monitoring Accuracy Ⓑ	± (0.2 %+2 V) Max.
Protection Circuit	For short circuit and excess output current
Input Voltage	85 V ac to 132 V ac/170 V ac to 264 V ac, 47 Hz to 66 Hz
Power Consumption Ⓐ	Approx. 21V·A
Operating Temperature/Humidity ⒶⒸ	0 °C to +40 °C / 90 % RH Max.
Specification Guaranteed Temperature/Humidity ⒶⒸ	+5 °C to +35 °C / 85 % RH Max.
Storage Temperature/Humidity Ⓒ	−20 °C to +50 °C / 90 % RH Max.
Output Receptacles	Two SHV receptacles
Weight	3.5 kg

NOTE Ⓐ At maximum output voltage and current.
Ⓑ At maximum output voltage.
Ⓒ Without moisture condensation.

Accessories

AC line cable (2.4 m long) 1
High voltage output cable (1.5 m long) terminated with SHV-P plugs E1168-19 1
Spare fuses 2

Dimensional Outlines (Unit: mm)



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Photomultiplier Tube Dark Current and Cooling Effect

Causes of Dark Current

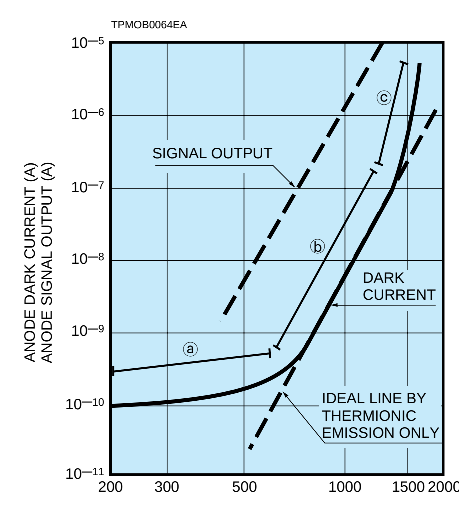
A small amount of current flows in a photomultiplier tube operated at a high voltage even when no light enters it. This output current is called the dark current. Since the dark current degrades the S/N ratio, it is the factor that determines the lower limit of detection when the output current is extremely low such as in low-level-light measurement. Major causes of the dark current can be classified into the seven described below. The extent to which each of these causes affects the dark current depends on the type of photomultiplier tube and varies from tube to tube or according to operating conditions.

Specific Causes

① Thermionic emission of electrons from the photocathode and dynode surfaces
② Leakage current between electrodes and lead pins (Mainly due to impurities on the electrode supporting materials, glass stem, plastic base surfaces and on the socket surface)
③ Ion current flowing as a result of ionization of residual gases inside the bulb
④ Photoelectron emission caused by internal electrons and ions colliding with the electrode support materials and glass
⑤ Photoelectron emission by the glass scintillation as a result of gamma rays emitted from radioactive elements (chiefly ^{40}K) inside the bulb
⑥ Photoelectron emission caused by Cherenkov radiation due to cosmic rays passing through the glass
⑦ Field emission of electrons from the photocathode and dynode surfaces

Figure 24 shows the relationship between the voltage supplied across the photomultiplier tube cathode and anode, and the anode dark current. This characteristic curve can be divided into three regions. In the low-voltage region ⓐ, the major cause of dark current is the leakage current ② and in the high-voltage region ⓒ, ③, ④ and ⑦ become the governing factors that determine the dark current. In contrast, in region ⓑ which approximates actual operating conditions, thermal electron emission is predominant. From this behavior, it can be seen that cooling the photocathode and dynodes would be very effective in reducing the dark current when the photomultiplier tube is operated at the normal voltage range.

Figure 24: Dark Current vs. Supply Voltage

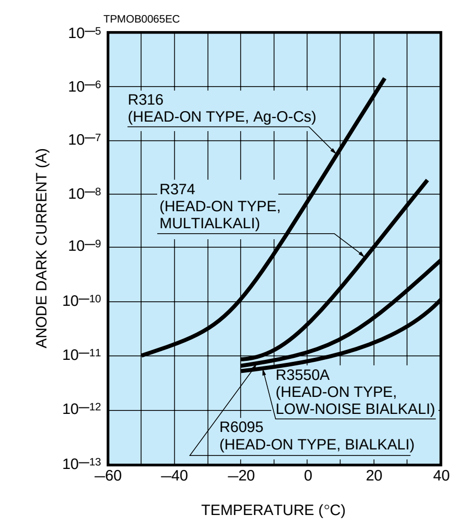


Thermal Electron Emission and Cooling Effect

Figure 25 shows a comparison of the temperature characteristics of dark current for various photocathode materials used in photomultiplier tubes of the same configuration and dynode structure. From this figure, it is clear that photocathodes with higher sensitivity at longer wavelengths (multialkali and Ag-O-Cs) exhibit larger dark currents as the temperature increases. In other words, the cooling effect on the dark current and S/N ratio is more remarkable in such photocathodes. In this figure, the cooling effect is limited in the region below -20 °C to -30 °C, due to the fact that contribution of factors other than thermionic emission becomes relatively large in this region. In photon counting applications, since the leakage current can be ignored, greater cooling effect can be achieved.

Thermal electrons are emitted not only from the photocathode but also from the dynodes. However, thermal electrons emitted from the latter dynodes multiply less, and therefore the real problems are electrons from the photocathode and the first or second dynode. Cooling these portions can considerably reduce the dark current.

Figure 25: Dark Current vs. Temperature for Various Photocathodes



Selection Guide

Type No.	Applicable PMTs
C4877 Series	ϕ38 mm (1-1/2") and ϕ51 mm (2") Head-on
C4878 Series	MCP-PMT (R3809U-50 series)
C659-50 Series	ϕ38 mm (1-1/2") and ϕ28 mm (1-1/8") Head-on
C659-70 Series	ϕ28 mm (1-1/8") Side-on

High Performance Thermoelectric Coolers C4877, C4878 Series

The C4877 series and C4878 series are thermoelectric coolers constructed with enhanced electrostatic and magnetic shielding. This minimizes the influence of external noise on the photomultiplier tube and thus significantly improves photometric accuracy. These coolers offer user-friendly functions such as easy temperature control and pilot lamp blanking. The C4877 series is designed for use with 51 mm (2") or 38 mm (1-1/2") diameter head-on photomultiplier tubes, and the C4878 series for MCP-PMTs.

Left : C4877 Power Supply
Right : C4877 Cooled PMT Housing

FEATURES

- Thermoelectric cooling using Peltier elements
- About –30 °C cooling temperature (with +20 °C cooling water)
- Evacuated, double-pane window with heater for frost prevention
- Built-in electrostatic and magnetic shielding (C4877 Series)
- Water shut-off protection to guard the Peltier elements
- Stable operation due to a regulated power supply

Specifications

[Cooled PMT Housing]

Parameter		Value • Description
Cooling		Thermoelectric effect
Heat Exchange Medium		Water (1 L/min to 3 L/min)
Cooling Temperature (with cooling water at +20 °C)		Approx. −30 °C
Temperature Controllable Range (with cooling water at +20 °C)		−30 °C to 0 °C (continuously adjustable)
Cooling Time		Approx. 120 min
Optical Window Material		Evacuated double-pane fused silica window with heater
Applicable PMTs (Optional)	C4877 Series	ϕ 38 mm (1-1/2") and ϕ 51 mm (2") Head-on
	C4878 Series	MCP-PMT (R3809U −50 Series)
Applicable Socket Assembly or PMT Holder (Optional)	C4877 Series	E2762 Series
	C4878 Series	E3059-500
Weight		5.8 kg

[Power Supply]

Parameter		Value • Description
Input Voltage	C4877, C4878	100 V ac ±10 % (50/60 Hz)
	C4877-01, C4878-01	120 V ac ±10 % (50/60 Hz)
	C4877-02, C4878-02	230 V ac ±10 % (50/60 Hz)
Power Consumption		270 V·A
Output Voltage		28 V dc
Output Current		4.3 A
Protection Circuit		Functions against cooling water suspension and over current/short circuit
Weight		8.5 kg

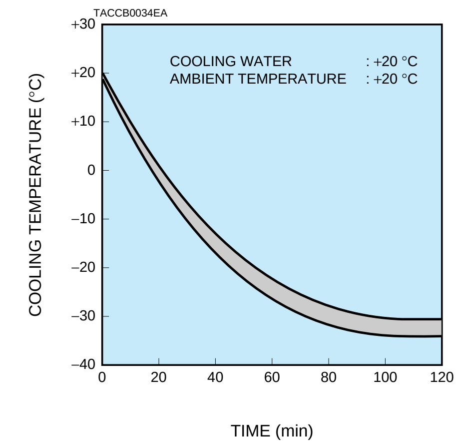
[Components and Accessories]

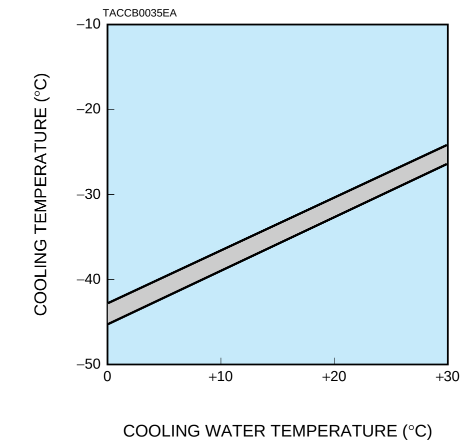
- Cooled PMT Housing (Including a magnetic shield and input window)
- Power Supply
- Light Shield Cap
- Spare fuse
- Water Hose Clamps
- Connection Cable (1.5 m)
- AC Line Cable (2 m)

✻Socket assemblies and PMT holders are available optionally. (Ref. to P.34)

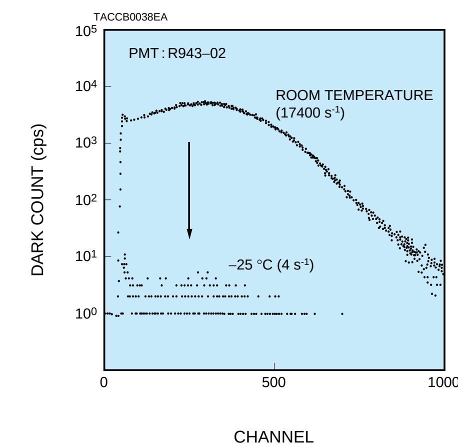
NOTE Water hose is not attached, so please prepare it at the user side.

Cooling Characteristics

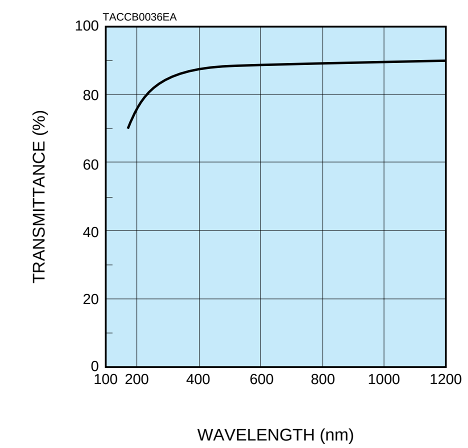




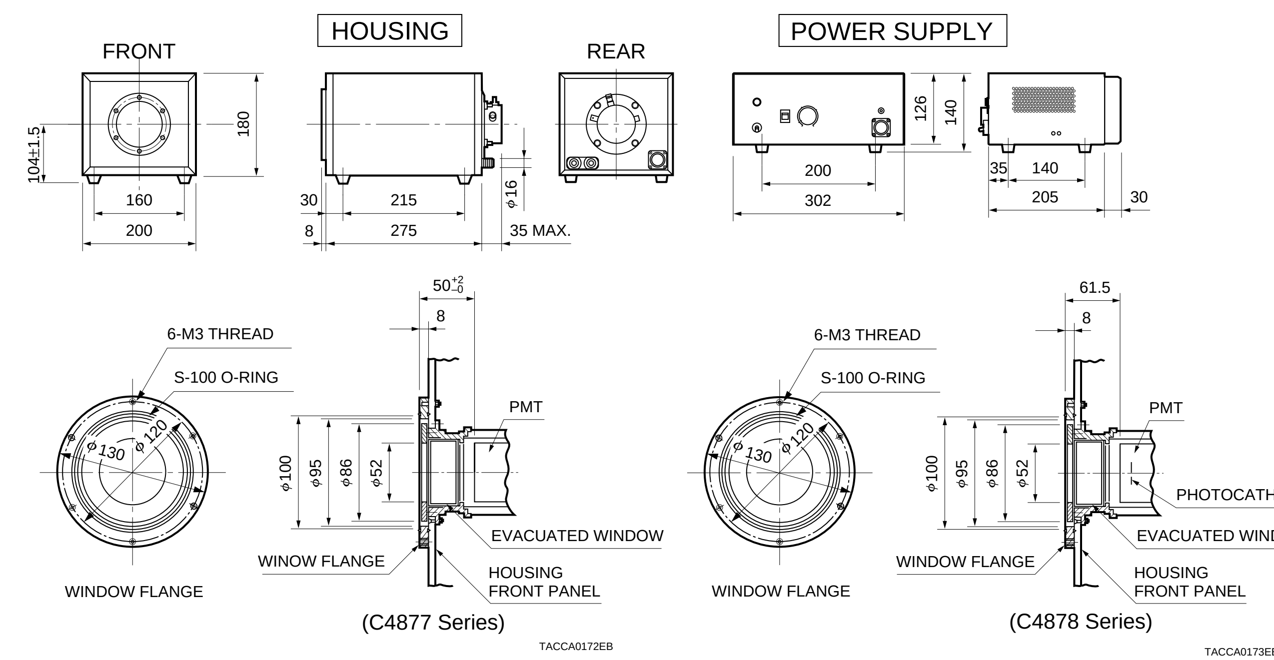
Cooling Effect on Dark Count



Spectral Transmission Characteristic of Optical Window



Dimensional Outlines (Unit: mm)



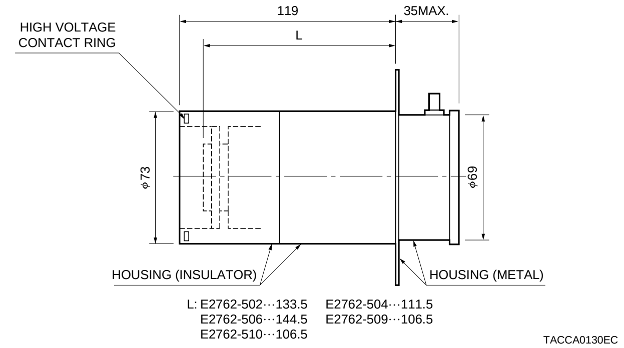
* CE C4877-02 and C4878-02 conform to the EMC directive (89/336/EEC) and the LVD (73/223/EEC) of the European Union.

Socket Assemblies for C4877 Series (Optional)

E2762 Series (D Type)

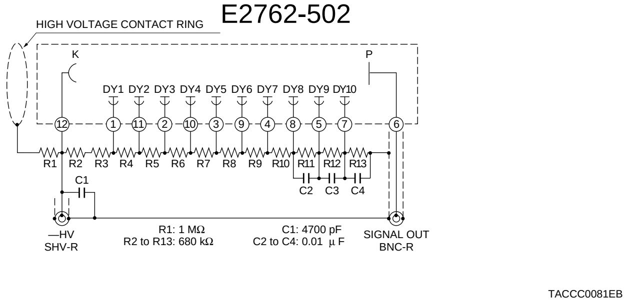
E2762-502 ... For ϕ38 mm (1-1/2") PMTs
E2762-504 ... For R3236
E2762-506 ... For R943-02, R3310-02
E2762-509 ... For R464, R585, R649
E2762-510 ... For R329, R331, R2257

Dimensional Outline (Unit: mm)

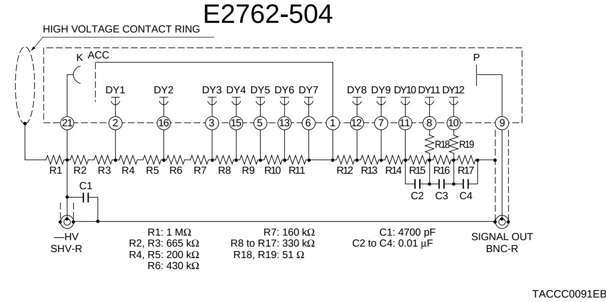


Circuit Diagrams

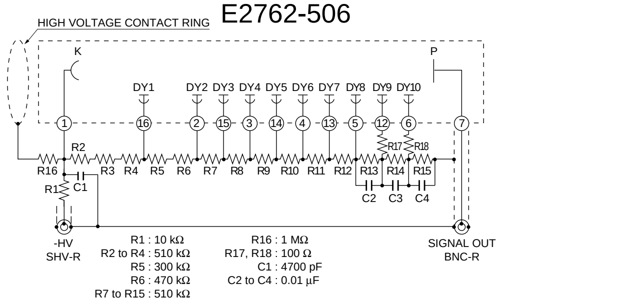
E2762-502



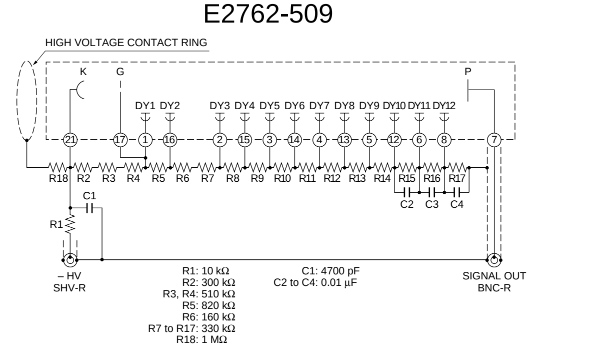
E2762-504



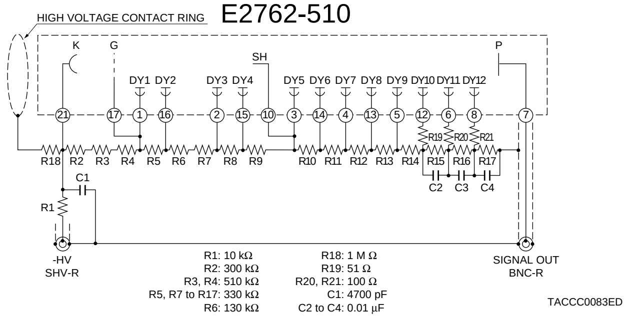
E2762-506



E2762-509



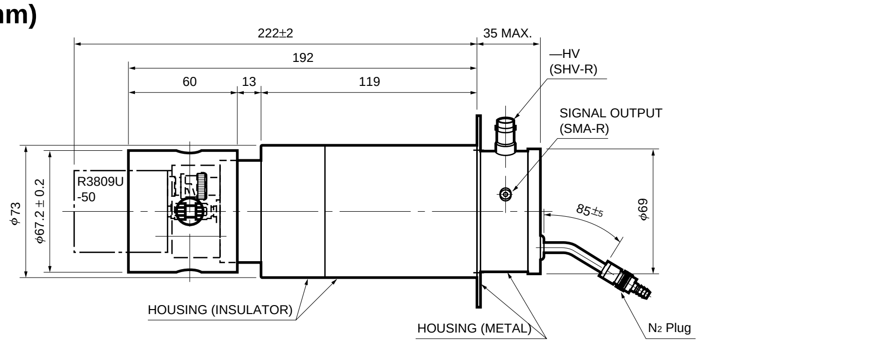
E2762-510



PMT Holder for C4878 Series (Optional)

E3059-500 (For R3809U-50 Series)

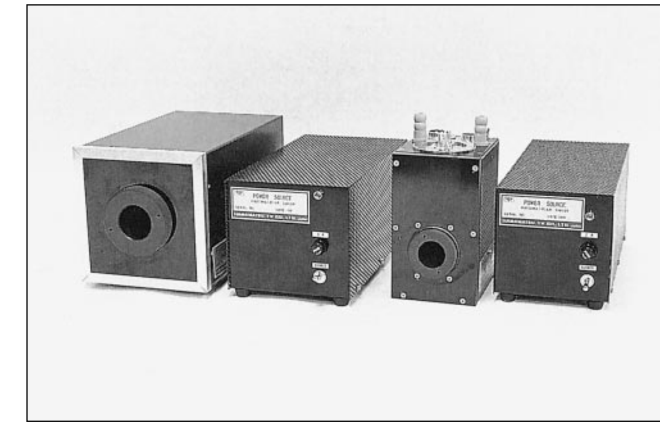
Dimensional Outline (Unit: mm)



Thermoelectric Coolers C659 Series

FEATURES

- Thermoelectric cooling using Peltier elements
- Evacuated, double-pane window with heater for frost prevention
- Water shut-off protection to guard Peltier elements
- Built-in magnetic shield



The C659 series is a thermoelectric cooler designed to reduce photomultiplier tube dark current and to enhance the photomultiplier tube lower detection limit. When used with a photomultiplier tube having an Ag-O-Cs photocathode in DC mode, the dark current can be reduced to 1/200 of its normal level at room temperature.
In cooling a photomultiplier tube one sometimes encounters problems such as dewing on the incident window and leakage current on the socket or base of the tube. But these problems are eliminated by use of an evacuated, double pane window and custom socket assembly. The C659-50 series is designed for 38 mm (1-1/2") and 28 mm (1-1/8") diameter head-on photomultiplier tubes. The C659-70 series is specifically intended for use with 28 mm (1-1/8") diameter side-on photomultiplier tubes.

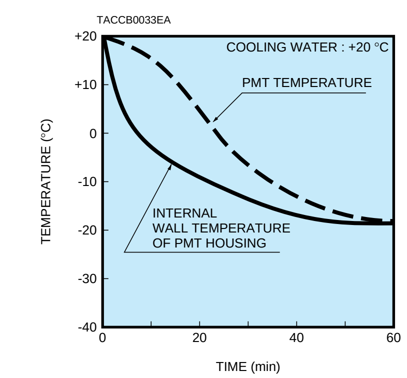
Specifications

[Cooled PMT Housing]

Parameter		Value • Description
Cooling		Thermoelectric effect
Heat Exchange Medium		Water (1 L/min to 3 L/min)
Cooling Ⓐ Temperature	C659-50 Series	Approx. −20 °C
	C659-70 Series	Approx. −15 °C
Cooling Time		Approx. 60 min
Optical Window Material		Evacuated double-pane fused silica window with heater
Applicable PMTs	C659-50 Series	ϕ38 mm (1-1/2") and ϕ28 mm (1-1/8") Head-on
	C659-70 Series	ϕ28 mm (1-1/8") Side-on
Applicable Socket Assemblies	C659-50 Series	E1135-500, -501, -502 (Optional)
	C659-70 Series	E1135-503 (Optional)
Weight	C659-50 Series	4.8 kg
	C659-70 Series	2 kg

NOTE Ⓐ Cooling water: +20 °C, Cooling temperature differs depending on photomultiplier tube type.

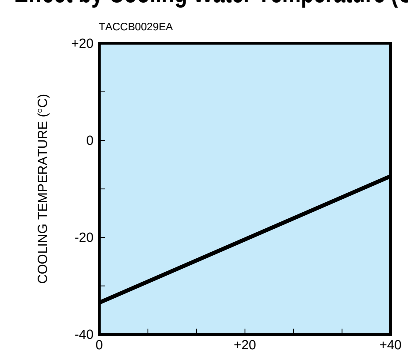
Cooling Characteristics (C659-50 series)



[Power Supply]

Parameter		Value • Description
Input Voltage	C659-51, -71	115 V ac ±10 % (50/60 Hz)
	C659-52, -72	220 V ac ±10 % (50/60 Hz)
Power Consumption	C659-50 Series	160 V·A
	C659-70 Series	110 V·A
Output Voltage	C659-50 Series	6 V dc
	C659-70 Series	3.4 V dc
Output Current	C659-50 Series	12 A
	C659-70 Series	12 A
Protection Circuit		Functions against cooling water suspension
Weight	C659-50 Series	10.7 kg
	C659-70 Series	8.5 kg

Effect by Cooling Water Temperature (C659-50 Series)



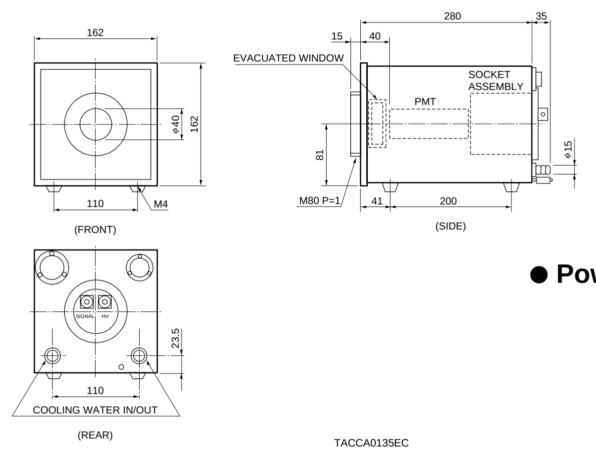
[Components and Accessories]

- Cooled PMT Housing (including a magnetic shield and input window)
- Power Supply
- Light Shield Cap
- Connection Cable (2 m)
- Protective Circuit Cable (2 m)
- AC Line Cable (2 m)

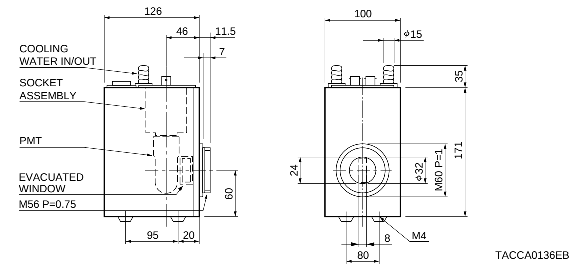
* When placing an order, please specify the photomultiplier tube type you want to use with the C659. We can provide the ideal socket assembly for your needs as an option. To operate the C659 series, water hoses with an inner diameter of 15mm are required.

Dimensional Outlines (Unit:mm)

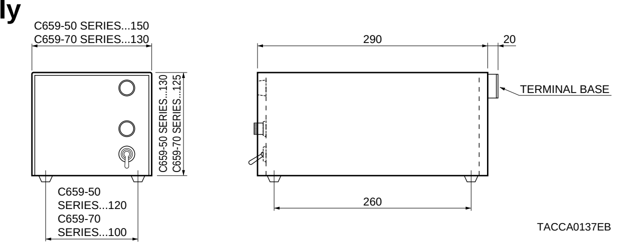
● **Cooled PMT Housing (C659-50 Series)**



● **Cooled PMT Housing (C659-70 Series)**



● **Power Supply**



Socket Assemblies E1135 Series (Optional) for Use with C659

Basically, the E1135 series socket assemblies have the same components as the D-type socket assemblies. (See pages 8 through 13.) However, the assembly body is made of insulating material with a long length to sufficiently isolate the photomultiplier tube side from the connector side. This is to prevent the external atmospheric heat from conducting to the photomultiplier tube through the connector panel of the socket assembly. The assembly body length differs depending on the type of E1135, so that the photomultiplier tube to be used is installed with its photocathode set at the same position.
Note that the cooling temperature may slightly vary because the thermal capacity of each socket assembly and the photomultiplier tube used are not identical.

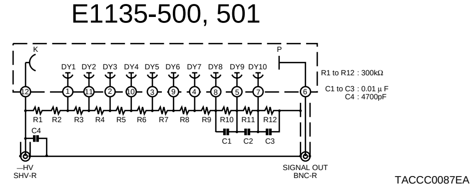
E1135 Selection Guide

Socket Assembly	Applicable Photomultiplier Tube Type	Photomultiplier Tube Examples	Cooler
E1135-500	φ38 mm (1-1/2") Head-on	R980, R1387, etc.	C659-50 Series
-501	φ38 mm (1-1/2") Head-on	R580, etc.	
-502	φ28 mm (1-1/8") Head-on	R6249, R316, R374, etc.	
-503	φ28 mm (1-1/8") Side-on	1P21, R212, R928, etc.	C659-70 Series

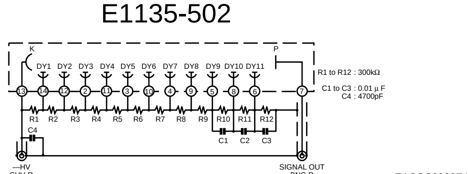
Circuit Diagrams

(For C659-50 Series)

E1135-500, 501

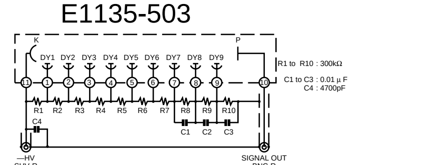


E1135-502



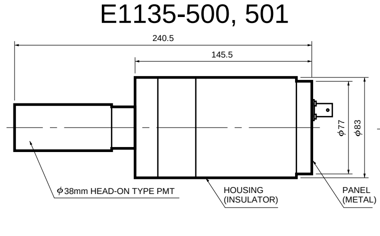
(For C659-70 Series)

E1135-503

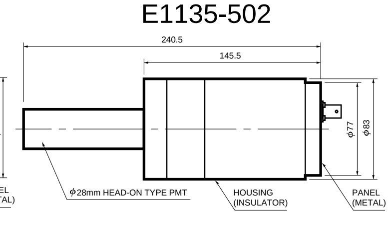


Dimensional Outlines (Unit: mm)

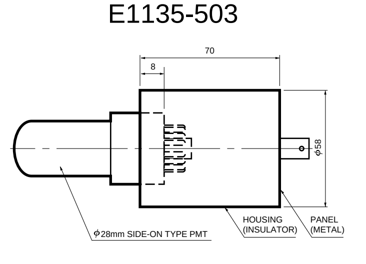
E1135-500, 501



E1135-502



E1135-503



Influence of Magnetic Fields and Magnetic Shielding

Influence of Magnetic Fields

The photomultiplier tube is a kind of vacuum tube in which photoelectrons emitted from the photocathode repeatedly impinge on the dynodes and are thus multiplied before reaching the anode. The degree of multiplication varies significantly depending on the position of the dynode on which electrons impinge. Therefore, external magnetic fields may deflect these electrons from their normal paths, causing a loss in the electron multiplication factor. This means that the photomultiplier tube output is extremely susceptible to the effects of magnetic fields. For example, since even the earth's magnetism exerts a considerable effect, merely rotating the position of a photomultiplier tube will result in a noticeable change.
Due to these characteristics the photomultiplier tube must be magnetically shielded if it must operate near any magnetic material or in the vicinity of a magnetic flux leaking from devices such as transformers.

Magnetic Characteristics

The degree of change in output with respect to magnetic fields varies greatly depending on the type of photomultiplier tube. Figure 26 shows the magnetic characteristics of typical photomultiplier tubes. In general, photomultiplier tubes having a large distance between photocathode and anode (in particular, those having a large distance from the photocathode to the first dynode) or a relatively small dynode opening compared to the photocathode area, exhibit large variations. Therefore, head-on photomultiplier tubes which are usually separated by a long distance from the photocathode to the first dynode are more vulnerable to this effect than side-on photomultiplier tubes. And of these, types having a large photocathode area tend to show particularly large variations.
Electrons mainly receive the effects of a magnetic field in the region between the photocathode and the first dynode. This is because the distance between the subsequent dynodes are relatively short and also because the dynodes themselves are usually made of nickel or other magnetic materials which provides a shielding effect for electrons traveling through the dynodes.

Figure 27: Direction of Magnetic Fields (For data shown in Figure 26)

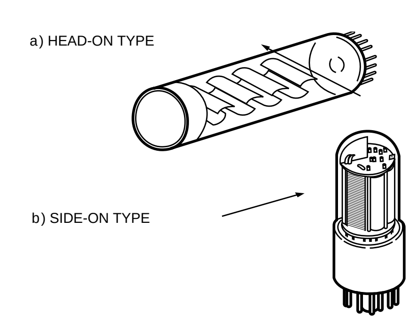
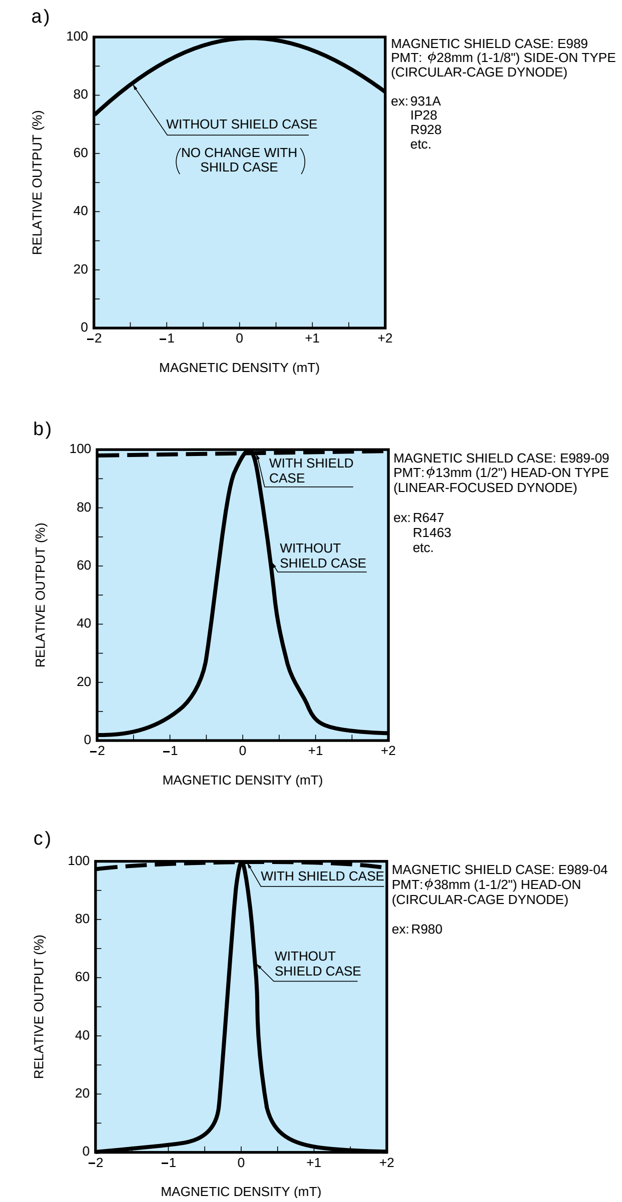


Figure 26: Example of Magnetic Shield Effect



Saturation Characteristics

Using a magnetic shield case (Hamamatsu E989 with 0.8 mm thickness), to plot the relationship (B-H curve) between the external magnetic field (H) and the magnetic flux density (B) inside the magnetic material indicates a saturation characteristic like that shown in Figure 28. Since the permeability μ is given by the B/H ratio, the relationship of H to μ, as shown in Figure 29, varies depending on the external magnetic field intensity, with subsequent changes in the shielding effect. Accordingly, in extremely high magnetic fields, it is recommended that a soft-iron magnetic shield case having a thickness of 3 mm to 10 mm be used since this material exhibits a high saturation flux density.

Frequency Characteristics

The above described shield case characteristics are for DC magnetic fields. In contrast, the magnetic flux leakage from a transformer creates an AC magnetic field effect which must also be taken into account. The permeability of a magnetic material decreases with increasing frequency. This is particularly noticeable in thick materials, even at low frequencies.
Hamamatsu E989 series shield cases are designed to provide sufficiently effective permeability even at normal line frequencies (50 Hz/60 Hz), as shown in Figure 30.
If magnetic fields of high frequencies such as 1 to 10 kHz are applied, a thin shielding material (0.05 mm to 0.1 mm) having good frequency characteristic should be used in combination with the normal shielding.

Edge Effect

Since the actual shield case has a finite length, there is a degradation of the shielding effect at both ends which must be taken into account. For this reason, as shown in Figure 31, it is necessary to install the photomultiplier tube at an inner position somewhat from the end of the shield case. For head-on photomultiplier tubes, this depth should be approximately equal to the shield case radius. However, when the magnetic field direction in parallel to the tube axis, the edge effect becomes extremely prominent, so that the photomultiplier tube should be installed at a position equivalent to at least the shield case diameter depth.

Figure 28: B-H Curve

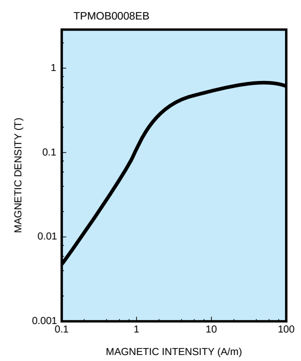


Figure 29: Permeability and Magnetic Field

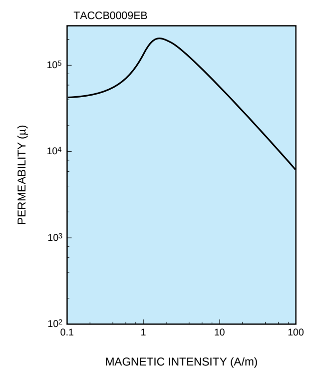


Figure 30: Frequency Characteristic

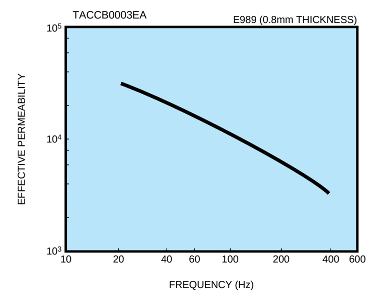
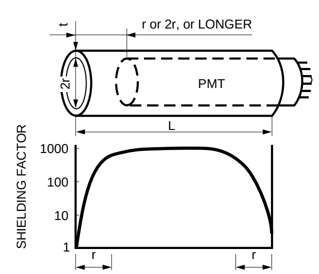


Figure 31: Edge Effect



Magnetic Shield Cases E989 Series

Photomultiplier tubes are extremely sensitive to magnetic fields and exhibit output variations even from sources such as terrestrial magnetism.
Hamamatsu E989 series magnetic shield cases are designed specifically to protect photomultiplier tubes from the influence of such magnetic fields. The E989 series uses permalloy, a material that has an extremely high permeability (approximately 10^5). The magnetic field intensity within the shield case can be attenuated from 1/1000 to 1/10000 of that outside the shield case (this ratio is called the shielding factor). The E989 series ensures a stable output for photomultiplier tubes operating in proximity to magnetic fields.

FEATURES

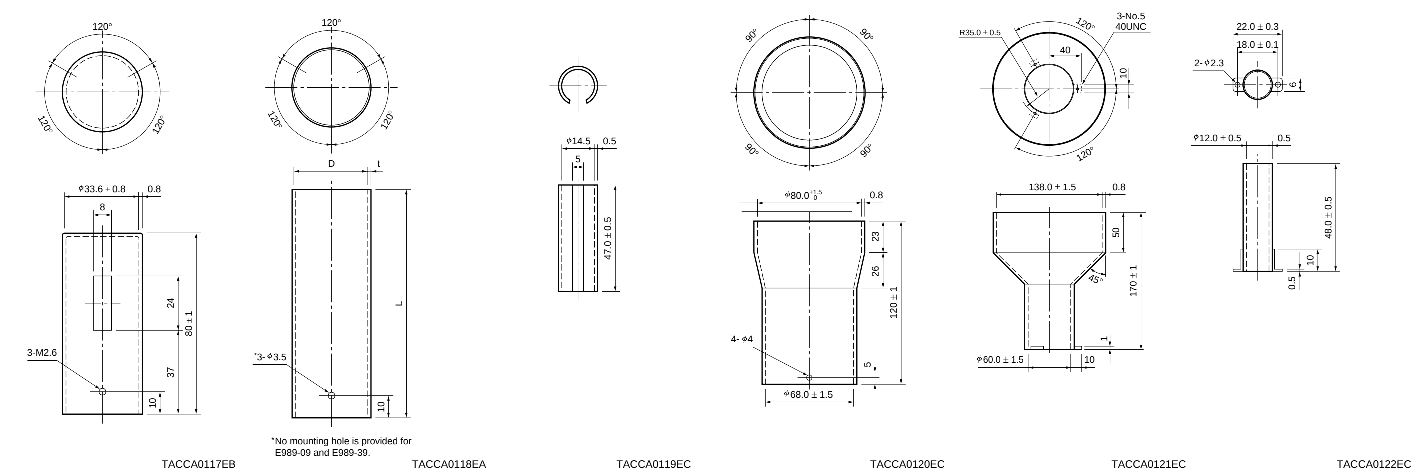
- Made of high-permeability permalloy (Ni: 78 %, Fe and others: 22 %)
- Optimum thickness of 8 mm (or 5 mm) provides highly effective shielding
- Various sizes available with inner diameters from 12 mm to 138 mm
- Lusterless black paint finish

Specifications

Photomultiplier Tube Diameter		Type No.	Internal Dia. D (ϕ mm)	Thickness t (mm)	Length L (mm)	Weight (g)
Side-on	ϕ 13 mm (1/2")	E989-10	14.5	0.5	47.0 ± 0.5	10
	ϕ 28 mm (1-1/8") *	E989	33.6 ± 0.8	0.8	80 ± 1	66
Head-on	ϕ 10 mm (3/8")	E989-28	12.0 ± 0.5	0.5	48.0 ± 0.5	9
	ϕ 13 mm (1/2")	E989-09	16.0 ± 0.5	0.8	75.0 ± 0.5	28
	ϕ 19 mm (3/4")	E989-02	23.0 ± 0.5	0.8	95 ± 1	50
	ϕ 25 mm (1")	E989-39	29.0 ± 0.5	0.8	48.0 ± 0.5	32
	ϕ 28 mm (1-1/8")	E989-03	32.0 ± 0.5	0.8	120 ± 1	90
	ϕ 38 mm (1-1/2")	E989-04	$44 \pm ^{1}_{0}$	0.8	100 ± 1	102
	ϕ 51 mm (2")	E989-05	$60 \pm ^{1}_{0}$	0.8	130 ± 1	180
	ϕ 76 mm (3")	E989-15	$80 \pm ^{1.5}_{0}$	0.8	120 ± 1	200
	ϕ 127 mm (5")	E989-26	138.0 ± 1.5	0.8	170 ± 1	600

* Photomultiplier tubes with HA coating extending to the base portion cannot be used. Please consult our sales offices for details.

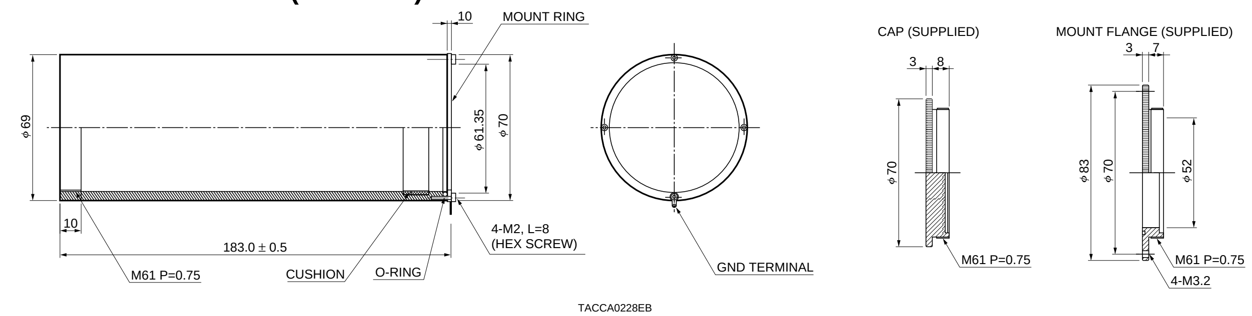
Dimensional Outlines (Unit: mm)



Housing E1341-01

The E1341-01 is a metal housing designed for 51 mm (2") diameter head-on photomultiplier tubes operated at room temperature. The E5859 series D-type socket assembly is also available, which can be housed in the E1341-01 along with a PMT. (See page 13.) The E1341-01 ensures complete light-shielding and also accommodates a magnetic shield case (E989-62 sold separately).
The E1341-01 housing can be easily attached to a monochromator by preparing a simple adapter. The Copal No. 3 shutter can be directly attached to the E1341-01.

Dimensional Outlines (Unit: mm)



Power and Signal Cables E1168 Series, Connector Adapters A4184 Series

Hamamatsu offers the E1168 series cables for connection of photomultiplier tube assemblies and their accessories. A variety of cables are available, for handling high voltage, low voltage and signals.
In addition, Hamamatsu also provides the A4184 series connector adapters designed for SHV/MHV connector conversion.

Selection Guide

● For High Voltage

Type No.	Cable Type	Cable Diameter	Maximum Voltage	Connector Types	Dimensional Outline
E1168	RG-59B/U (Red)	φ6.2 mm	2.3 kV dc	MHV-P—MHV-P	①
E1168-10				MHV-P—SHV-P	②
E1168-17				SHV-P—SHV-P	③
E1168-18	Custom High Voltage Cable (Red)	φ6.15 ±0.3 mm	5 kV dc	MHV-P—MHV-P	①
E1168-19				SHV-P—SHV-P	③
E1168-20				MHV-P—SHV-P	②

● For Signal

Type No.	Cable Type	Impedance	Connector Types	Dimensional Outline
E1168-01	3D-2V	50 Ω	N-P—N-P	④
E1168-02			N-P—BNC-P	⑤
E1168-03	3C-2V	75 Ω	BNC-P—BNC-P	⑥
E1168-05	3D-2V	50 Ω	BNC-P—BNC-P	⑥

● For Low Voltage

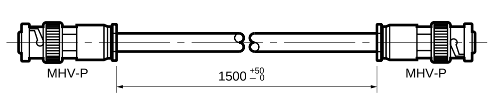
Type No.	Cable Type	Connector Types	Dimensional Outline
E1168-13	MVVS 3×0.3	MC-032—MC-032	⑦
E1168-14	MVVS 2×0.3	SR30-10PQ-4P SR30-10PQ-4P	⑧

● Connector Adapters

Type No.	Connector Types	Dimensional Outline
A4184-02	MHV Plug—SHV Jack	⑨
A4184-03	SHV Plug—MHV Jack	⑩

Dimensional Outline (Unit: mm)

① E1168, -18



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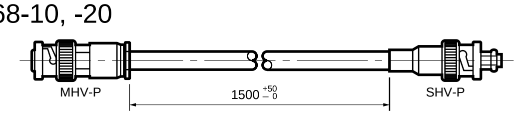
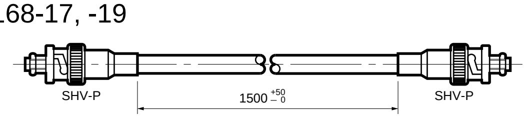
② E1168-10, -20



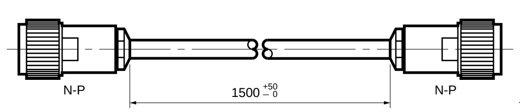
TACCA0146EA

③ E1168-17, -19



TACCA0142EA

④ E1168-01



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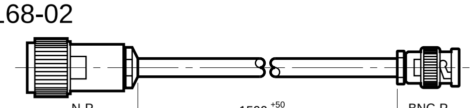
⑤ E1168-02



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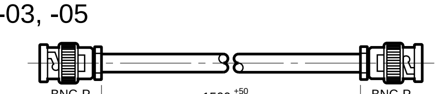
⑥ E1168-03, -05



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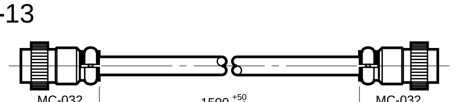
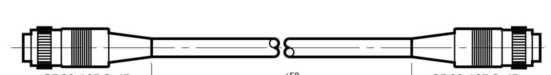
⑦ E1168-13



TACCA0144EA

⑧ E1168-14



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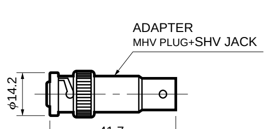
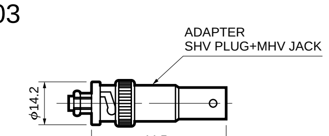
⑨ A4184-02



TACCA0145EA

⑩ A4184-03



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Integrated Photon Counting Heads H6180 Series, H7360 Series, H6240 Series

These photon counting heads consist of a photomultiplier tube, voltage divider, high-speed amplifier, discriminator and high-voltage power supply, all included in a compact metallic case. Since the photomultiplier tube supply voltage and discrimination voltage are preset at the optimal levels, there is no need for adjustments such as measurement of plateau characteristics before use. The H6180, H7360, and H6240 series require a +5 V supply. Photon counting can be performed by simply connecting the output to an external pulse counter.
The H6180 and H7360 series contain a head-on photomultiplier tube, while the H6240 series uses a side-on photomultiplier tube.

▲Left: H6240
Right: H6180-01 with optional mounting frange

Photon Counting Units C3866, C6465

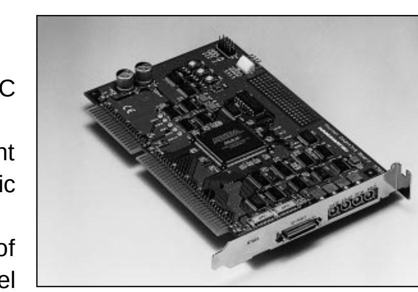
The C3866 photon counting unit converts photomultiplier tube photoelectron pulses into a 5 V digital signal by using a built-in amplifier/discriminator. Photon counting with high S/N ratio can be easily performed by connecting an external pulse counter to the output of the C3866 and supplying a low voltage. The high-speed electronic circuit used in the C3866 ensures high-precision photometry with high linearity up to 10^7 cps. Due to the built-in prescaler (division by 10), the C3866 does not require a high-speed pulse counter.
The C6465 offers high output linearity up to 10^6 s^{-1} (cps) and an output pulse width of 30 ns, allowing use with a general-purpose pulse counter.

Left : C3866, Right : C6465

TPHOF0020

Photon Counting board M7824

The photon counting board M7824 is designed for direct plug-in to the ISA bus slot in a PC (Windows95/98).
Photoelectron pulses converted into logic (TTL) signals are counted by the counter and sent to a PC. A gate function is also included to make photon counting easier over a wide dynamic range.
The counter applies a double count method that allows time-resolved photon counting of high-speed optical phenomena with no dead time between gates. Simultaneous 2-channel measurements are also possible by using two M7824 boards.



TPHOF0023

WARNINGS

HIGH VOLTAGE

- High voltage power supplies and other products contained in this catalog generate or exhibit hazardous voltages and may present an electric shock hazard.
- The products contained in this catalog should be installed, operated, or serviced only by qualified personnel that have been instructed in handling high voltages.
- The products contained in this catalog should be installed, operated, or serviced in accordance with what are instructed in their instruction manuals and other relevant Hamamatsu publications.
- Designs of equipment utilizing the products contained in this catalog should incorporate appropriate interlocks to protect the operator and service personnel from electric shocks.

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INDEX BY TYPE NO.

MEMO

HAMAMATSU PHOTONICS K.K., Electron Tube Center
314-5, Shimokanzo, Toyooka-village, Iwata-gun, Shizuoka-ken, 438-0193, Japan
Telephone: (81)539-62-5248, Fax: (81)539-62-2205
http://www.hamamatsu.com/

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Sales Offices

ASIA:
HAMAMATSU PHOTONICS K.K.
325-6, Sunayama-cho,
Hamamatsu City, 430-8587, Japan
Telephone: (81)53-452-2141, Fax: (81)53-456-7889

U.S.A.:
HAMAMATSU CORPORATION
Main Office
360 Foothill Road, P.O. BOX 6910,
Bridgewater, N.J. 08807-0910, U.S.A.
Telephone: (1)908-231-0960, Fax: (1)908-231-1218
E-mail: usa@hamamatsu.com

Western U.S.A. Office
Suite 110, 2875 Moorpark Avenue
San Jose, CA 95128, U.S.A.
Telephone: (1)408-261-2022, Fax: (1)408-261-2522
E-mail: usa@hamamatsu.com

United Kingdom:
HAMAMATSU PHOTONICS UK LIMITED
2 Howard Court, 10 Tewin Road, Welwyn Garden City,
Hertfordshire AL7 1BW, United Kingdom
Telephone: (44)1707-294888, Fax: (44)1707-325777
E-mail: info@hamamatsu.co.uk

France, Portugal, Belgiun, Switzerland, Spain:
HAMAMATSU PHOTONICS FRANCE S.A.R.L.
8, Rue du Saule Trapu, Parc du Moulin de Massy,
91882 Massy Cedex, France
Telephone: 33(1) 69 53 71 00, Fax: 33(1) 69 53 71 10
E-mail: infos@hamamatsu.fr

Swiss Office
Richtersmattweg 6a
CH-3054 Schüpfen, Switzerland
Telephone: (41)31/879 70 70, Fax: (41)31/879 18 74
E-mail: swiss@hamamatsu.ch

Belgian Office
7, Rue du Bosquet
B-1348 Louvain-La-Neuve, Belgium
Telephone: (32)10 45 63 34, Fax: (32)10 45 63 67
E-mail: epirson@hamamatsu.com

Spanish Office
Centro de Empresas de Nuevas Tecnologias
Parc Tecnologico del Valles
08290 CERDANYOLA (Barcelona), Spain
Telephone: (34)93 582 44 30, Fax: (34)93 582 44 31
E-mail: spain@hamamatsu.com

Germany, Denmark, Netherland:
HAMAMATSU PHOTONICS DEUTSCHLAND GmbH
Arzbergerstr. 10,
D-82211 Herrsching am Ammersee, Germany
Telephone: (49)8152-375-0, Fax: (49)8152-2658
E-mail: info@hamamatsu.de

Danish Office
Erantisvej 5
DK-8381 Tilst, Denmark
Telephone: (45)4346-6333, Fax: (45)4346-6350
E-mail: lkoldbaek@hamamatsu.de

Netherland Office
PO Box 50.075,1305 AB Almere The Netherlands
Telephone: (31)36-5382123, Fax: (31)36-5382124
E-mail: hamamatsu_NL@compuserve.com

North Europe:
HAMAMATSU PHOTONICS NORDEN AB
Smidesvägen 12
SE-171-41 Solna, Sweden
Telephone: (46)8-509-031-00, Fax: (46)8-509-031-01
E-mail: info@hamamatsu.se

Italy:
HAMAMATSU PHOTONICS ITALIA S.R.L.
Strada della Moia, 1/E,
20020 Arese, (Milano), Italy
Telephone: (39)02-935 81 733, Fax: (39)02-935 81 741
E-mail: info@hamamatsu.it

Hong Kong:
HAKUTO ENTERPRISES LTD.
Room 404, Block B,
Seaview Estate, Watson Road,
North Point, Hong Kong
Telephone: (852)25125729, Fax: (852)28073155

Taiwan:
HAKUTO Taiwan Ltd.
3F-6 No.188, Section 5, Nanking East Road
Taipei, Taiwan, R.O.C.
Telephone: (886)2-2753-0188, Fax: (886)2-2746-5282

KORYO ELECTRONICS CO., LTD.
9F-7, No.79, Hsin Tai Wu Road
Sec.1, Hsi-Chih, Taipei, Taiwan, R.O.C.
Telephone: (886)2-2698-1143, Fax: (886)2-2698-1147

Republic of Korea:
SANGKI TRADING CO., LTD.
Suite 431, World Vision Bldg.,
24-2, Yoido-Dong, Youngdeungpo-ku,
Seoul, 150-010, Republic of Korea
Telephone: (82)2-780-8515, Fax: (82)2-784-6062

Singapore:
HAKUTO SINGAPORE PTE LTD.
Block 2, Kaki Bukit Avenue 1, #04-01 to #04-04
Kaki Bukit Industrial Estate, Singapore 417938
Telephone: (65)7458910,Fax: (65)7418201

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