HAMAMATSU

TECHNICAL DATA

HC120 SERIES

PhotoSensor Modules

REVISED JANUARY 1992

COMPLETE PMT-BASED PHOTOSENSOR MODULE INCLUDING DIVIDER, HIGH VOLTAGE POWER SUPPLY AND AMPLIFIER

FEATURES:
- COMPACT SIZE
- LOW POWER CONSUMPTION
- INTEGRATED PACKAGE
- NO EXPOSED HIGH VOLTAGE WIRING
- EASY TO USE

APPLICATIONS:
- BATTERY-POWERED, PORTABLE INSTRUMENTS
- SIZE REDUCTION
- WEAKEST LIGHT DETECTION
- WIDE DYNAMIC RANGE

PRODUCT HIGHLIGHTS:
- −350 TO −1100 VOLT OPERATING RANGE
- LESS THAN 7 mA. IDLE CURRENT
- OUTPUT LINEARITY OF 0.5% AT 10 uA SIGNAL CURRENT
- BUFFERED OUTPUT

PRODUCT DESCRIPTION:

The HC120 Series of integrated PhotoSensor Modules combines a 1/2 inch, side-on photomultiplier tube with a high voltage power supply, voltage divider and buffer amplifier to measure the weakest light signals. The user needs only to supply low voltage to operate the detector assembly. The high voltage needed to power the photomultiplier is generated with a 10 stage Cockcroft-Walton voltage multiplier with one stage per dynode. This unique design allows operation of the PMT to higher light levels with improved linearity and permits a remarkable reduction in power consumption which even enables battery-powered applications.

The design is implemented with surface mount components resulting in a very compact unit. The aluminum enclosure shields against electrical noise and is potted to protect the tube and circuitry against shock and moisture. This new HC120 Series provides designers with new solutions to old problems in the application of PMT's.

The assembly can be made with a wide variety of 1/2 inch side-on PMT's as well as different amplifier gain and bandwidth specifications. Please consult the factory on the availability of these assemblies. The following types are standard assemblies:

STANDARD PhotoSensors

Assembly	PMT	Spectral range	Amplifier gain	Bandwidth	ENI (typ.)
HC120-01	R1414	185 to 650 nm	1 megohm	20 kHz	0.10 fw @ 340 nm
HC120-05	R3823	185 to 900 nm	1 megohm	20 KHz	0.50 fw @ 530 nm

SPECIFICATIONS

MAXIMUM RATINGS[1]

HV output voltage	−1100	volts
Supply voltage	+/−18	volts
Operating temperature	+5 to +50	°C
Storage temperature	−20 to +50	°C

GENERAL SPECIFICATIONS

HV output voltage range[2]	−350 to −1100	volts
Supply voltage range	+/−11.5 to 15.5	volts
HV output/control input ratio	1000 to 1	volts/volt
Voltage divider ratio	1/10 of high voltage per stage	volts/volt
Warm-up time	10	minutes
HV output voltage decay time constant	10	seconds
Active area	4.0 × 13.0	millimeter
Overall dimensions	19.1 × 50.8 × 53.2	millimeter
Weight	107	grams typ.

PERFORMANCE SPECIFICATIONS (25°C, −1000 VOLTS)

Input current[3] @ +15 volts input @ −15 volts input	 7 1	 mA. max. mA. max.
Linearity of anode signal current @ 10 uA[4]	0.5	% typ.
Temperature coefficient of high voltage[5]	100	ppm/°C typ.
Supply current limit	20	mA. typ.
Peak output signal	10.0	volts, min.
Responsivity HC120-01 @ 340 nm HC120-05 @ 530 nm	 270 96	 volts/nanowatts, typ. volts/nonowatts, typ.

NOTES

1) Stresses above the Maximum Ratings may cause permanent damage to the device. Exposure to maximum conditions for extended periods may reduce device reliability.
2) Measurement of the high voltage by the user is not possible since the assembly is sealed. However, the operating high voltage at the photocathode can be determined by measuring the voltage at the monitor point (shown on the "Wiring Example" diagram) and multiplying by 1000 for an accuracy of within 1%.
3) Current consumption increases if high light levels are applied to the photomultiplier tube.
4) This measurement is for DC light input. Tube characteristics such as gain drop or hysteresis may cause additional inaccuracies when measuring high light levels at high signal current levels.
5) This is an average measurement. The maximum voltage is subtracted from the minimum voltage over the specified temperature range and divided by the temperature difference. The internal reference was used with an external, 10 kohm potentiometer to set the high voltage.

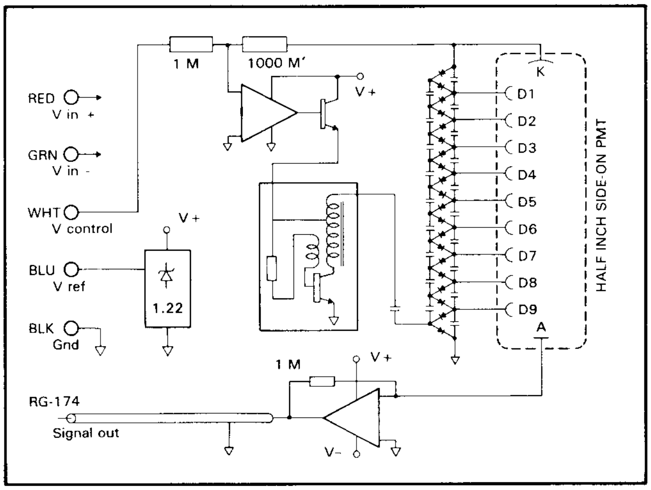


Figure 1. Schematic diagram

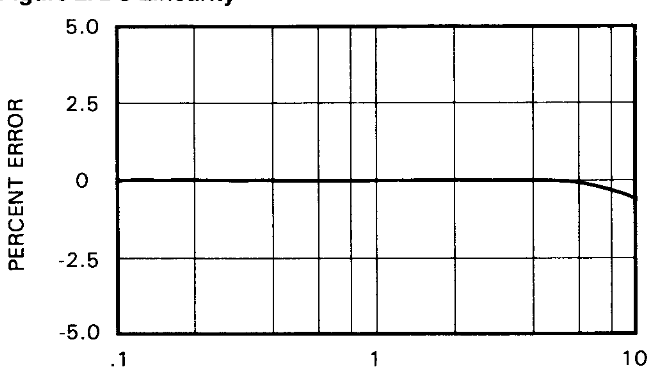
FUNCTIONAL DESCRIPTION

CIRCUIT OPERATION: The high voltage supply is composed of a power oscillator, a 10 stage voltage multiplier and feedback regulator. The power oscillator is a self-oscillating circuit that generates a 100 volt sine wave at 185 kHz. As shown in Figure 1, this voltage is applied to the Cockcroft-Walton multiplier, resulting in the generation of −1000 volts in 10 precisely divided, 100 volt steps. The feedback is set by a precision divider that reduces the negative high voltage by a 1000 times. This voltage is then added to an externally generated, positive control voltage to effect a null. The null signal is then amplified and used to control the voltage applied to the power oscillator through a pass transistor. Thus, the output voltage applied to the tube is set and regulated to a high accuracy by a low voltage input. There is a simple relationship between this control voltage and the high voltage output: 1 volt input will produce −1000 volts output.

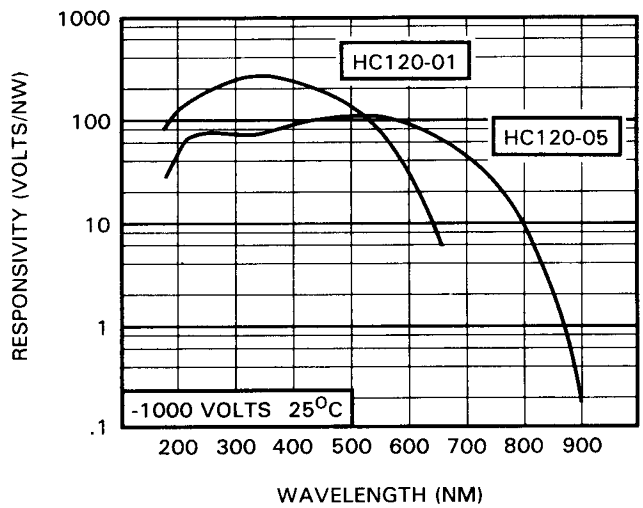
The anode signal current is amplified by a transimpedance amplifier having a conversion factor of 1 volt per microamp (a 1 megohm feedback resistor). The bandwidth of the circuit is set to 20 kHz. Amplifier offset is 0.8 millivolt typical.

LINEARITY: Since the voltage division is not achieved by a resistive divider, the output impedance seen by the dynodes of the PMT is lower in this new supply. As the

Figure 2. DC Linearity

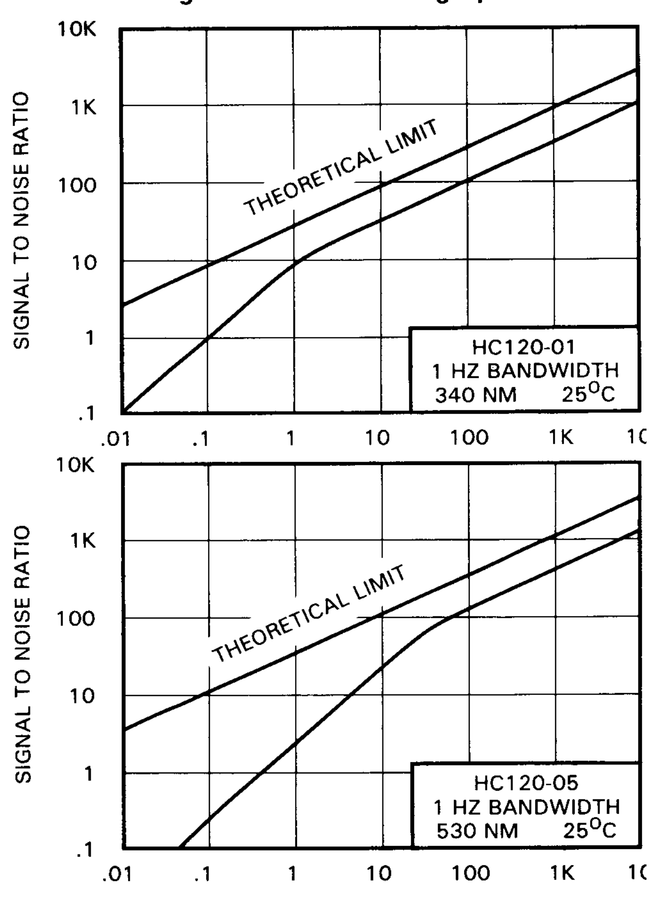


Responsivity vs. wavelength

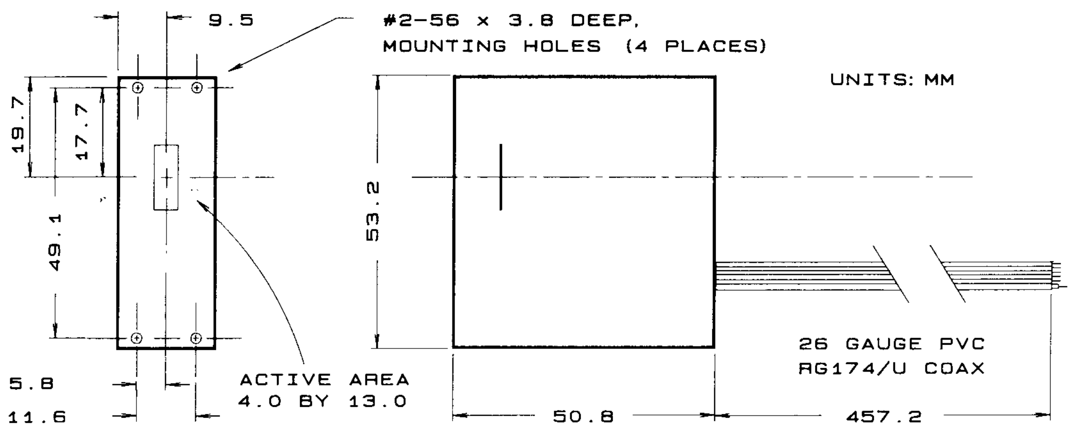


light level is increased and current flow increases, the dynode voltages show significantly less variation than dynode voltages supplied with conventional resistive dividers. The result is a much more linear response of the PMT to a wider range of light. The feedback regulation also helps to improve the linearity of the PMT by maintaining a stable high voltage during circuit loading. As shown in Figure 2, linearity of within 0.5% is achieved at an anode signal current of 10 uA. This test is based on light pulses of several seconds duration – long enough to let the feedback circuit stabilize, but short enough to limit gain drop of the PMT.

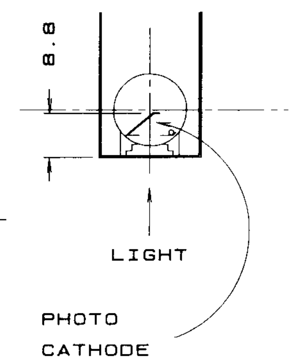
Signal-to-noise ratio vs. light power



DIMENSIONAL DATA



SENSITIVE AREA



CURRENT LIMIT: The low output impedance of this new supply means that high currents could flow under accidental exposure to bright light. To lessen the danger, a current limit was incorporated to protect the tube and power supply. Limiting action occurs at 20 mA. of input current or approximately 400 uA. of anode current. Extended exposure of bright light with the power on will still cause damage to the PMT.

RELIABILITY: All circuitry receives a 100 hour burn-in at 60°C and operating at −1800 volts to screen against weak components. All PMT's comply with standard catalog specifications unless otherwise negotiated. The completed assembly is given an additional 24 hour stability check before shipment. In applying these assemblies, the maximum ratings should be strictly observed since exceeding the ratings may cause permanent damage to the tube or power supply.

APPLICATION INFORMATION

1) In general, the electrical bandwidth of the detector should be reduced to match the speed of the light signal for the best signal-to-noise ratio. For example, when several seconds are available to get the measurement, a low pass filter added to the output of the detector assembly with a 1 Hz bandwidth will reduce the random fluctuation.

2) Higher light levels are usually accommodated by reducing the high voltage setting, perhaps as low as −400 or −500 volts to avoid saturating the amplifier.

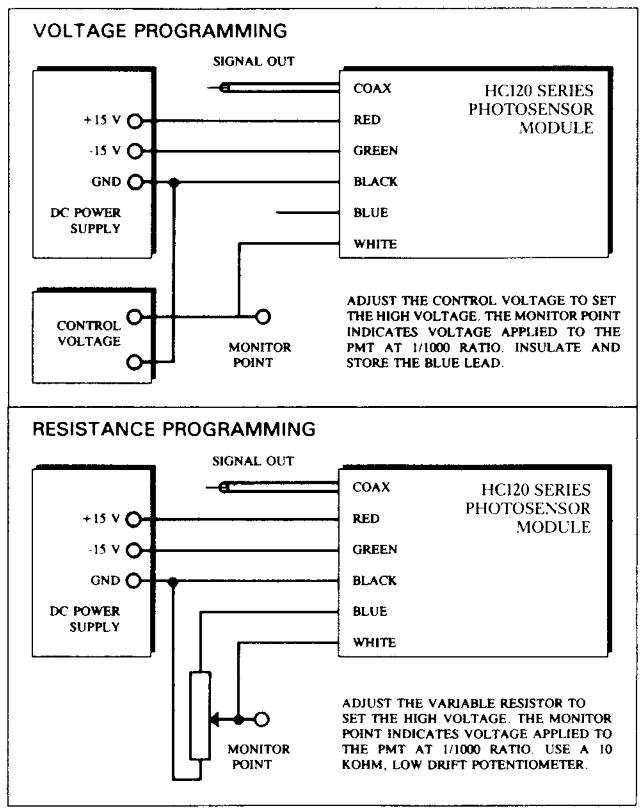
3) The high voltage can be set accurately with good stability by simply using a 25 turn, 10 kohm potentiometer. For computer control, good stability of the DAC output from the computer is essential. Also, be sure that the programming input is not driven beyond specification during start-up of the computer.

4) Do not expose the detector assembly to strong light—even if no power is applied.

5) Photomultiplier tubes are sensitive to small magnetic fields such as the earth's field or fields emitted from transformers and soleniods. This assembly is shielded to limit these effects: 10 gauss fields can cause a 1% change in gain of the PMT. Use caution when using the detector near magnetic components.

6) The window can be cleaned with lens tissue made damp with alcohol. Do not use other solvents.

WIRING EXAMPLES



For applications assistance call: 1-800-524-0504

For sales information call: 1-908-231-0960